A Joint Report by the OECD Nuclear Energy Agency
and the International Atomic Energy Agency

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Uranium 1999
Resources, Production and Demand

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NUCLEAR ENERGY AGENCY
ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

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Pursuant to Article 1 of the Convention signed in Paris on 14th December 1960, and which came into force on 30th September 1961, the Organisation for Economic Co-operation and Development (OECD) shall promote policies designed:

- to achieve the highest sustainable economic growth and employment and a rising standard of living in Member countries, while maintaining financial stability, and thus to contribute to the development of the world economy;
- to contribute to sound economic expansion in Member as well as non-member countries in the process of economic development; and
- to contribute to the expansion of world trade on a multilateral, non-discriminatory basis in accordance with international obligations.

The original Member countries of the OECD are Austria, Belgium, Canada, Denmark, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The following countries became Members subsequently through accession at the dates indicated hereafter: Japan (28th April 1964), Finland (28th January 1969), Australia (7th June 1971), New Zealand (29th May 1973), Mexico (18th May 1994), the Czech Republic (21st December 1995), Hungary (7th May 1996), Poland (22nd November 1996) and the Republic of Korea (12th December 1996). The Commission of the European Communities takes part in the work of the OECD (Article 13 of the OECD Convention).

NUCLEAR ENERGY AGENCY

The OECD Nuclear Energy Agency (NEA) was established on 1st February 1958 under the name of the OEEC European Nuclear Energy Agency. It received its present designation on 20th April 1972, when Japan became its first non-European full Member. NEA membership today consists of 27 OECD Member countries: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Luxembourg, Mexico, the Netherlands, Norway, Portugal, Republic of Korea, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The Commission of the European Communities also takes part in the work of the Agency.

The mission of the NEA is:

- to assist its Member countries in maintaining and further developing, through international co-operation, the scientific, technological and legal bases required for a safe, environmentally friendly and economical use of nuclear energy for peaceful purposes, as well as
- to provide authoritative assessments and to forge common understandings on key issues, as input to government decisions on nuclear energy policy and to broader OECD policy analyses in areas such as energy and sustainable development.

Specific areas of competence of the NEA include safety and regulation of nuclear activities, radioactive waste management, radiological protection, nuclear science, economic and technical analyses of the nuclear fuel cycle, nuclear law and liability, and public information. The NEA Data Bank provides nuclear data and computer program services for participating countries.

In these and related tasks, the NEA works in close collaboration with the International Atomic Energy Agency in Vienna, with which it has a Co-operation Agreement, as well as with other international organisations in the nuclear field.

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URANIUM 1999
RESSOURCES, PRODUCTION ET DEMANDE – ÉDITION 2000

Photo Credit: Aerial view of the Lago Real Uranium Mine and Production Centre, Brazil. Courtesy of Industrias Nucleares do Brasil.

PREFACE

Since the mid-1960s, with the co-operation of their Member countries and states, the OECD Nuclear Energy Agency (NEA) and the International Atomic Energy Agency (IAEA) have jointly prepared periodical updates (currently every two years) on world uranium resources, production and demand. These updates have been published by the OECD/NEA in what is commonly known as the "Red Book". This 18th edition of the Red Book replaces the 1997 edition and reflects current information on 1 January 1999.

The Red Book presents a comprehensive assessment of the uranium supply and demand situation at present and periodically up to the year 2015. The basis for the assessment consists of estimates of uranium resources in several categories of assurance of existence and economic attractiveness, and projections of production capability, installed nuclear capacity, and related uranium requirements. Annual statistical data are included on exploration expenditures, uranium production, employment and uranium stocks. In addition to the global analysis, detailed national reports are provided concerning uranium resources, exploration, production, environmental activities and relevant uranium policies.

This publication also reviews the uranium supply situation throughout the world by evaluating and compiling data on uranium resources, past and present production, and plans for future production. The data, provided by 49 countries, are then compared with possible future reactor-related uranium requirements. Recent levels of exploration for uranium are also reported and analysed.

Information on short-term uranium demand has been provided by national authorities up to the year 2015. Longer-term projections of uranium demand, based on expert opinion rather than on information submitted by national authorities, are qualitatively discussed in the report.

This publication has been prepared on the basis of data obtained through questionnaires sent by the NEA to its Member countries and by the IAEA to its participating Member states that are not OECD Member countries. Although some countries prepared comprehensive national reports, which are presented essentially in their original form in Part III, a number of these reports were prepared by each agency based on the responses to the questionnaire and/or on some other official response. Parts I and II (Uranium Supply and Uranium Demand) were drafted by separate working parties composed of members of the NEA-IAEA Uranium Group and chaired by the Vice-Chairmen of the Group (see Annex 1). Preparation of the remaining sections of the report was divided equally between the two agencies under the general guidance of the NEA-IAEA Uranium Group.

The opinions expressed in Parts I and II do not necessarily reflect the position of the Member countries or international organisations concerned. This report is published on the responsibility of the Secretary-General of the OECD.

ACKNOWLEDGMENT

The OECD Nuclear Energy Agency (NEA), Paris, and the International Atomic Energy Agency (IAEA), Vienna, would like to acknowledge the co-operation of those organisations (see Annex 2), which replied to the questionnaire submitted to them.

Following an agreement between the NEA and the IAEA, the NEA Uranium Group was reconstituted as the Joint NEA-IAEA Uranium Group during 1996. This provides the opportunity of full participation by representatives of all Member countries of the two organisations with an interest in uranium related activities. It has resulted in increased participation of IAEA Member states in preparation of this Red Book.

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EXECUTIVE SUMMARY

This report, ***Uranium 1999 – Resources, Production and Demand***, presents results of the 1999 review of uranium supply and demand in the world and provides a statistical profile of the world uranium industry as of 1 January 1999. It contains data on uranium exploration activities, resources and production for 49 countries, updating the 1997 edition of the Red Book. The report contains information from all 23 uranium producing countries. For the first time, it includes official reports from Armenia, Malawi and Poland. This report also provides projections of nuclear generating capacity and reactor related uranium requirements through 2015.

World uranium market

After a recovery from October 1994 through mid-1996, uranium prices have followed a net declining trend. From its high of USD 42.90/kgU (USD 16.50/lb U_3O_8) in July 1996, the restricted spot price fell to nearly half of that level or USD 22.75/kgU (USD 8.75/lb U_3O_8) by December 1998. While the price recovered modestly to USD 27.30/kgU (USD 10.50/lb U_3O_8) in January 1999, by July 1999 it had fallen back to USD 26.52/kgU (USD 10.20/lb U_3O_8). The 1998 prices represent a decrease over prices reported in 1996 in the unrestricted and restricted markets of 35% and 32%, respectively.

Although the world uranium industry showed signs of change and renewal over the 1994-1996 period, the current events characterising the uranium market illustrate the persistent uncertainty faced by uranium producers and consumers. With world nuclear capacity expanding and uranium production satisfying about 60% of the demand since 1990, uranium stockpiles have continually been depleted at a high rate. The uncertainty related to the remaining levels of world uranium stockpiles and the amount of surplus defence material that will be entering the market make it difficult to determine when a closer balance between supply and demand will be reached, and what will be the price equilibrium that develops between the new supplies and uranium buyers. However, new information discussed in this report suggests that the upward pressure on uranium prices may be relatively modest over the next decade, or more, because of the continuing availability of low priced uranium.

Known conventional resources (RAR and EAR-I)

As of 1 January 1999, Known Conventional Resources (RAR and EAR-I) recoverable at costs of ⇔$130/kgU amount to about 3 954 000 tU. Compared to the last edition of the Red Book (1997), the total decreased by about 345 000 tU. The decrease is due to downward revisions in several countries, production in the last two years and the exclusion of resources from India.

In the RAR and EAR-I categories recoverable at costs of ⇔$80/kgU, the world total decreased by about 66 000 tU (3%) and 17 000 tU (2%) over 1997, respectively. By contrast, at ⇔$40/kgU, there were increases of about 38% to 916 000 tU in the RAR category and 32% to 338 000 tU in the EAR-I category. These increases resulted mainly from Canadian resources reported for the first time in this cost category. Total known conventional resources at this low cost category total 1.25 million tU or are equivalent to about 20 years of current reactor requirements.

Undiscovered conventional resources (EAR-II and speculative resources)

Compared to the last edition, only minor changes have been reported in both EAR-II and Speculative Resources. Almost all of these resources are reported as in situ. In the EAR-II category, about 2.3 million tU are estimated at ≤ $130/kgU, and about 1.5 million tU at ≤ $80/kgU. This is slightly less than those reported in the 1997 Red Book.

Information regarding Speculative Resources is incomplete on a worldwide scale. The estimated amount for countries reporting at ≤ $130/kgU is 3.04 million tU. About 6.12 million tU of additional resources are reported without an estimate of production cost. The total reported Speculative Resources is about 9.16 million tU.

Uranium exploration

In 1997 a total of 24 countries reported exploration expenditures of about USD 153 million, or almost 37% higher than in 1996. In 1998 only 20 countries reported exploration activities costing about USD 131.8 million.

Expenditures increased from 1996 to 1997 following the 1994 to 1996 increases in market prices. The expenditure increases resulted from activities associated with advanced projects in Canada, Australia, the USA, the Russian Federation and India. Exploration activities and expenditures in most reporting countries decreased from 1997 to 1998. However in some countries small increases have been reported. For most reporting countries, expected exploration expenditures for 1999 show a downward trend. Currently, most of the exploration activities are taking place in Canada, the USA, Australia, India, the Russian Federation and Uzbekistan, and to a lesser extent in Egypt, Ukraine, France and Romania.

A slight increase in exploration expenditures abroad took place from 1996 to 1997. However, a marked decrease is shown for 1998.

Uranium production

In 1998, twenty-three nations produced uranium of which the major ten (Australia, Canada, Kazakhstan, Namibia, Niger, the Russian Federation, South Africa, Ukraine, USA and Uzbekistan) produced over 90% of the world's output. Germany and Hungary recovered uranium incidental to environmental restoration activities. In comparison, thirty-two nations currently consume uranium in commercial reactors.

World uranium production increased 1.6% from 36 149 tU in 1996 to 36 724 in 1997, and then decreased by 4.7% to 34 986 tU in 1998. In the OECD area, production increased slightly from 21 184 tU in 1996 to 21 391 in 1997, and then declined to 19 088 tU in 1998. Increases in production from 1996 to 1998 in a few countries including Uzbekistan, Gabon, Namibia and Niger could not compensate for reductions in other countries such as the USA, Canada, South Africa, Hungary, and France. Closures of facilities were reported in Brazil, France, Hungary and South Africa in 1997; in Belgium and the USA in 1998; and in Canada, Gabon and the USA in 1999. New mines opened in the USA in 1998 and in Australia, Brazil and Canada in 1999. The capacity of Olympic Dam and the Ranger mill in Australia, and of Key Lake mill in Canada, were expanded respectively in 1997, 1998 and 1999. New facilities are planned to become available in the next few years in Australia, Canada and the Russian Federation.

Employment associated with uranium production, reported by 18 countries, fell from 52 486 in 1996 to 46 213 by 1998, a decrease of 11.9%.

Projected production capabilities

A projection of world uranium production capability through 2015 is provided in this report based on plans of 22 producing countries. Two projections are given: Existing and Committed production centres, and Planned and Prospective facilities. Both projections are made using RAR and EAR-I resources recoverable at costs of $80/kgU or less, and which are tributary to the production centres. However, for the first time a large proportion of these resources are reported as recoverable at $40/kgU or less. For example, of the 674 000 tU of cumulative Existing and Committed production capability through 2015, over 75% is based on resources recoverable at $40/kgU or less. Furthermore nearly 65% of the 974 000 tU of cumulative Existing, Committed, Planned and Projected capability through 2015 is based on resources recoverable at $40/kgU or less.

The total Existing and Committed capability in 1999 is 45 800 tU. The expected closure of existing mines due to resource depletion would cause Existing and Committed capability to slowly fall to 37 600 tU by 2010 and to continue to decline to about 33 000 tU by 2015. Existing and Committed capability would be about 50 to 60% of projected requirements by 2010. The projected continued reduction through 2015 implies that between 40 and 60% of world requirements, expected to range between 54 500 and 79 800 tU/year, would be covered.

Total Existing, Committed, Planned and Prospective capability would be about 64 800 tU in 2010. This exceeds the low requirements projection for this year but falls short of the high projection by about 8 400 tU. By 2015 the total capability would then decline to about 55 000 tU. This about equals the total world requirements in the low case and is about 69% of the high case requirements.

Additional supplies would be necessary to fill the potential production shortfall indicated by some of the projections. Significant additional material would likely come from alternative supplies including low enriched uranium (LEU) obtained from the blending of highly enriched uranium (HEU) from warheads, excess inventory drawdown, fuel reprocessing and the re-enrichment of depleted tails from enrichment. In the long term, however, the largest contributor would be the development of new uranium mines and mills.

Uranium inventories

Inventory drawdown has supplied most of the worldwide imbalance since 1990, which totals about 187 000 tU. It is clear that the downward pressure on uranium market prices over the period since 1987 resulted from the large amounts of uranium that exceeded demand and were offered for sale at low prices.

A major source of supply comes from the drawdown of accumulated stockpiles. The civilian inventories include strategic stocks, pipeline inventory and excess stocks available on the market. Few countries have provided detailed information on the size of the uranium stockpiles that are held by producers, consumers or governments. Utilities are believed to hold the majority of commercial stocks. Many utilities either hold or have policies that require carrying the equivalent of one to four years of natural uranium requirements.

For several years there were indications that the amount of uranium in the commercial inventory was decreasing. However, recent reports indicate that the inventory was larger than previously believed and that it has increased in both the European Union (EU) and the USA over the period 1996 to 1999. Some of the apparent increases are from: 1) shipments of uranium from the New Independent States (NIS) to the European Union (EU), 2) uranium entering the commercial inventory from US Government stockpiles, and 3) LEU from blending of Russian HEU that has been delivered to the US, but not yet sold. While some of the material from each of these sources has been delivered to utilities, a significant amount has not been sold, and by the year-end 1998 was being held in various stocks.

The available information indicates that inventory levels in both the European Union (EU) and the USA expanded from 1996 to 1998. The Euratom Supply Agency reports that 41 400 tU of natural uranium or feed contained in enriched uranium products (in tU) were imported by European Union operators from the NIS. Judging by the level of production in Kazakhstan, Uzbekistan and the other NIS during the period in question, a large portion of the imports to the EU must have originated in the Russian Federation.

In the USA it is reported that the year-end commercial uranium inventory of all types increased from 30 786 tU in 1996, to 40 864 tU in 1997, and further to 52 910 tU in 1998. This includes inventories owned by the 1998 privatised United States Enrichment Corporation (USEC) for year-end 1997 and 1998 only.

Another potential source of uranium supply is expected to come from military stockpiles. This material is helping to meet market demand in addition to excess inventories. Significant amounts of uranium from the conversion of nuclear weapons material are expected to enter the civilian market after 2000 as the result of purchase agreements between the USA and the Russian Federation.

Radiation safety and environmental aspects

Radiation safety and environmental aspects of uranium mining and production are becoming more important due to two developments: first, the increasing number of production facilities which have recently been taken out of operation, and second, the increasing requirement for environmental clearance approvals for new projects. In addition, environmental aspects need to be considered for production sites which were abandoned at a time when legal provisions for proper decommissioning and rehabilitation had not been established. Many of these sites were abandoned without taking into consideration any safety or reclamation and restoration measures. Important environmental activities were reported by several countries, among others Australia, Canada, Czech Republic, France, Hungary, Kazakhstan, the USA and Ukraine.

Uranium demand

World annual uranium requirements in 1998 were estimated at about 59 600 tU. An increase of about 2 000 tU was expected for 1999. By the beginning of 1999, there were 434 nuclear power units operating in the world with a total net capacity of 351 GWe (net gigawatts electric) connected to the grid. A total of 36 new reactors are under construction with a capacity of about 28 GWe. In recent years, however, the growth in nuclear power has slowed considerably.

Improvements and modifications to nuclear reactor technology may also affect requirements; however, these factors are not likely to have a major impact before 2015. Fuel utilisation in thermal reactors can primarily be improved by: optimising in-core management, lowering the tails assay in the depleted stream of enrichment plants, and recycling plutonium. In addition, reactor availability, power levels and burnup can affect requirements.

Uranium demand projections

The world nuclear capacity is expected to grow in the high case to 457 GWe and to decline in the low case to 333 GWe by the year 2015. The different trends depicted in these two cases reflect the uncertainties that exist in relation to the life expectancy of operating nuclear units and potential nuclear capacity additions. In the high case, the increase represents a 31% growth from current capacity or an annual growth rate of 1.6% for the forecasting period. The low projections show a net decrease of 18 GWe by 2015. Several factors, including the importance given in the future to the debate on global warming, may have an impact on these projections.

World reactor-related uranium requirements are expected to rise in the high case to about 79 800 tU, or to decrease in the low case to 54 500 tU, by the year 2015. The growth in the high case corresponds to an annual growth rate of 1.7%. The cumulative uranium requirements over the period 1999 to 2015 range from 1 066 000 tU to 1 267 000 tU.

Uncertainties in the projections arise from different assumptions about construction schedules of nuclear power plants, cancellations, new orders, and the potential for reactor life extension. In addition, changes in national economic and regulatory policies and in the structure of the electricity supply industry may also have an increasing impact on nuclear plant lifetimes with a corresponding impact on uranium requirements.

Supply-demand relationships

The world uranium market continues to experience dramatic changes due to important trends observed in nuclear power generation, and political and economic developments in uranium producing and consuming regions of the world. In particular, several events that have taken place since the publication of the 1997 Red Book may well foreshadow developments in the next decades.

The changes in uranium supply, which have been ongoing, were accelerated in 1997 and 1998, and are expected to continue over the next several years. The modifications involve the relatively rapid market introduction of new supplies from non-production sources, as well as major changes within the uranium production industry. The availability of information regarding the amount of uranium held in inventory by utilities, producers and governments has increased. As a result the market uncertainty regarding these inventories has decreased. Uncertainty still exists, however, regarding the magnitude of the inventory in the Russian Federation and the availability of secondary supplies from other sources.

Between 1990 and 1994 there were severe reductions in many sectors of the world uranium industry including exploration, production and production capability, despite the continuous growth in world uranium requirements. This decreasing supply situation combined with growing demand for new uranium purchases resulted in a recovery in uranium prices from October 1994 through mid-1996. This trend, however, has reversed and uranium prices have fallen sharply through mid-1999.

The lower prices benefit utilities, but has ended the optimism among producers that accompanied the price peak in mid-1996. Since then some planned facility expansions and newly announced projects have been cancelled or delayed. Furthermore, some operating plants have had cutbacks in their production.

In 1998, world uranium production provided only about 59% of the world reactor requirements. In OECD countries, the 1998 production could only satisfy 39% of the demand. The rest of the requirements are being satisfied by secondary sources including civilian and military stockpiles, uranium reprocessing and re-enrichment of depleted uranium.

The cumulative impact of the difference between uranium production and requirements is substantial. Much of the uranium production shortfall has been met by the worldwide drawdown of inventory. Currently there are no indications that this condition of a large difference between production and requirements has significantly changed.

For nearly two decades, large amounts of uranium in the form of excess inventories have supplied the market. While some uncertainty still remains, it is apparent that inventory will continue playing an important role as a secondary supply in the coming years. The recent market introduction of low enriched uranium blended from highly enriched uranium from Russian warheads, is another major new supply becoming available. To these supplies are added the increasing but limited use of mixed oxide fuel and reprocessed uranium, as well as the re-enrichment of tails from enrichment.

Therefore, it is probable that most of these alternative supplies will continue to supplement uranium production for the next 10 to 15 years or more. Uranium production will, however, continue to fill a majority of the requirements. This supply will primarily come from more efficient, lower cost producers that have developed in response to the declining market prices. Many less efficient, usually smaller, facilities producing from higher cost resources have suspended production. These have been replaced by larger facilities that employ economies of scale and improved technology to produce uranium from resources recoverable at low costs. The continued availability of alternative supplies, together with the increased availability of uranium from low cost producers, suggest that upward pressure on uranium market prices may be relatively modest over the next decade or longer. It should be noted, however, that interruption of any of the major supplies could result in a market imbalance and higher prices, until market forces develop a new equilibrium.

Uranium demand over the short-term is fundamentally determined by nuclear capacity. Although there are uncertainties related to potential changes in world nuclear capacity, short-term uranium requirements are fairly predictable. Most of nuclear capacity is already in operation; there is only a limited degree of uncertainty regarding construction lead times and in the implementation of plans for new units in some countries. Another potential source of uncertainty is the possibility of early retirement of nuclear reactors. The potential for reductions of nuclear capacity exists in a few countries that have some relatively inefficient old nuclear units and where restructuring of the electricity supply industry may have an impact on nuclear plant lifetimes.

Concerns about longer term security of supply of fossil fuels and the heightened awareness that nuclear power plants are environmentally clean with respect to acid rain, global warming, and ozone depletion might contribute to even higher than projected growth in uranium demand over the long-term. In particular, the increasing importance of the debate on greenhouse gases and global warming points toward accepting nuclear power as a valid alternative within the framework of long-term sustainable development.

DEFINITIONS AND TERMINOLOGY

Only minor changes have been made to the NEA/IAEA resource terminology and definitions since the modifications that were introduced in the December 1983 edition of the Red Book. An exception was the introduction in the 1993 Red Book edition of a new lower-cost category, i.e., resources recoverable at $40/kgU or less. This category was introduced to reflect a production cost range that is more relevant to current uranium market prices.

RESOURCE ESTIMATES

Resource estimates are divided into separate categories reflecting different levels of confidence in the quantities reported. The resources are further separated into categories based on the cost of production. *All resource estimates are expressed in terms of metric tons (t) of recoverable uranium (U) rather than uranium oxide (U_3O_8).* Estimates refer to quantities of uranium recoverable from mineable ore, unless otherwise noted (see d).

a) Definitions of resource categories

Resources are classified as either conventional or unconventional. Conventional resources are those that have an established history of production where uranium is either a primary product, co-product or an important by-product (e.g., gold). Very low grade resources or those from which uranium is only recoverable as a minor by-product are considered unconventional resources. Conventional resources are further divided, according to different confidence levels of occurrence, into the following categories:

Reasonably Assured Resources (RAR) refers to uranium that occurs in known mineral deposits of delineated size, grade and configuration such that the quantities which could be recovered within the given production cost ranges with currently proven mining and processing technology, can be specified. Estimates of tonnage and grade are based on specific sample data and measurements of the deposits and on knowledge of deposit characteristics. Reasonably Assured Resources have a high assurance of existence.

Estimated Additional Resources – Category I (EAR-I) refers to uranium in addition to RAR that is inferred to occur, mostly on the basis of direct geological evidence, in extensions of well-explored deposits, or in deposits in which geological continuity has been established but where specific data, including measurements of the deposits, and knowledge of the deposits' characteristics are considered to be inadequate to classify the resource as RAR. Estimates of tonnage, grade and cost of further delineation and recovery are based on such sampling as is available and on knowledge of the deposit characteristics as determined in the best known parts of the deposit or in similar deposits. Less reliance can be placed on the estimates in this category than on those for RAR.

Figure 1. **Approximative correlations of terms used in major resources classification systems**

<table>
<tr><th></th><th colspan="3">← Known Resources →</th><th colspan="3">← Undiscovered Resources →</th></tr>
<tr><td>NEA/IAEA</td><td colspan="2">Reasonably Assured</td><td>Estimated Additional I</td><td>Estimated Additional II</td><td colspan="2">Speculative</td></tr>
<tr><td>Australia</td><td colspan="2">Reasonably Assured</td><td>Estimated Additional I</td><td colspan="3">Undiscovered</td></tr>
<tr><td>Canada (NRCan)</td><td>Measured</td><td>Indicated</td><td>Inferred</td><td>Prognosticated</td><td colspan="2">Speculative</td></tr>
<tr><td>France</td><td>Reserves I</td><td>Reserves II</td><td>Perspective I</td><td>Perspective II</td><td colspan="2"></td></tr>
<tr><td>Germany</td><td>Proven</td><td>Probable</td><td>Possible</td><td>Prognosticated</td><td colspan="2">Speculative</td></tr>
<tr><td>United States (DOE)</td><td colspan="2">Reasonably Assured</td><td colspan="2">Estimated Additional</td><td colspan="2">Speculative</td></tr>
<tr><td>Russian Federation, Kazakhstan, Ukraine, Uzbekistan</td><td>A + B</td><td>C 1</td><td>C 2</td><td>P1</td><td>P2</td><td>P3</td></tr>
</table>

The terms illustrated are not strictly comparable as the criteria used in the various systems are not identical. "Grey zones" in correlation are therefore unavoidable, particularly as the resources become less assured. Nonetheless, the chart presents a reasonable approximation of the comparability of terms.

Estimated Additional Resources – Category II (EAR-II) refers to uranium in addition to EAR-I that is expected to occur in deposits for which the evidence is mainly indirect and which are believed to exist in well-defined geological trends or areas of mineralization with known deposits. Estimates of tonnage, grade and cost of discovery, delineation and recovery are based primarily on knowledge of deposit characteristics in known deposits within the respective trends or areas and on such sampling, geological, geophysical or geochemical evidence as may be available. Less reliance can be placed on the estimates in this category than on those for EAR-I.

Speculative Resources (SR) refers to uranium, in addition to Estimated Additional Resources – Category II, that is thought to exist, mostly on the basis of indirect evidence and geological extrapolations, in deposits discoverable with existing exploration techniques. The location of deposits envisaged in this category could generally be specified only as being somewhere within a given region or geological trend. As the term implies, the existence and size of such resources are speculative.

The correlation between the resource categories defined above and those used in resource classification systems is shown in Figure 1.

b) Cost categories

The cost categories used in this report are the same specified in the 1997 edition of the Red Book. The categories are defined as: \$40/kgU or less; \$80/kgU or less; \$130/kgU or less; and \$260/kgU or less. In this edition, the current year costs are expressed in terms of 1st January 1999 USD.

NOTE: It is not intended that the cost categories should follow fluctuations in market conditions.

To convert from costs expressed in \$/lb U_3O_8 to \$/kg U, a factor of 2.6 has been used (e.g., \$40/kg U = \$15.38/lb U_3O_8, \$80/kg U = \$30.77/lb U_3O_8, \$130/kg U = \$50/lb U_3O_8).

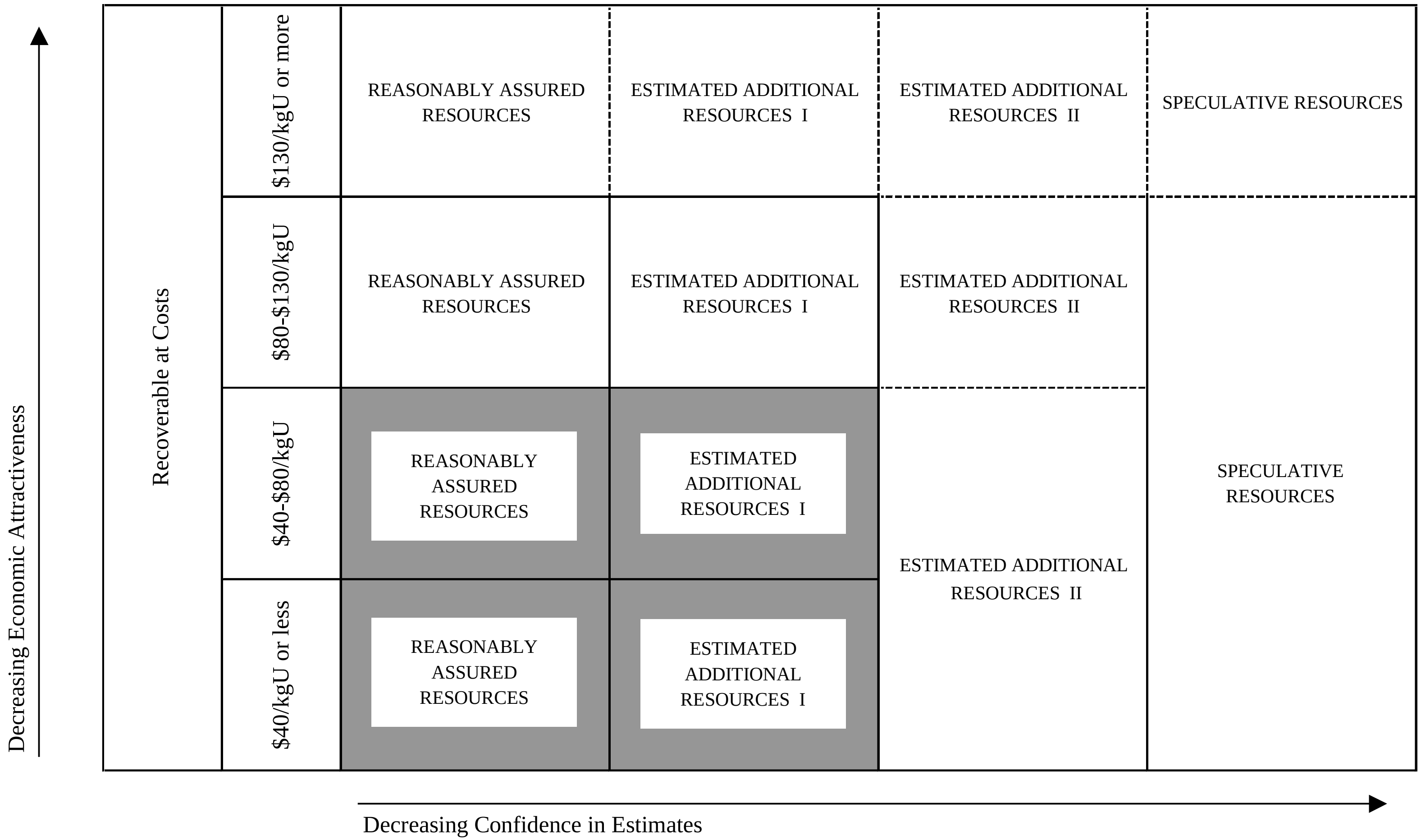
Conversion from other currencies into USD should be done using the exchange rates of 1st January 1999. All resource categories are defined in terms of costs of uranium recovered at the ore processing plant.

When estimating the cost of production for assigning resources within these cost categories, account has been taken of the following costs:

- the direct costs of mining, transporting and processing the uranium ore;
- the costs of associated environmental and waste management during and after mining;
- the costs of maintaining non-operating production units where applicable;
- in the case of ongoing projects, those capital costs which remain unamortized;
- the capital cost of providing new production units where applicable, including the cost of financing;
- indirect costs such as office overheads, taxes and royalties where applicable; and
- future exploration and development costs wherever required for further ore delineation to the stage where it is ready to be mined.

Sunk costs were not normally taken into consideration.

Figure 2. **NEA/IAEA Classification scheme for uranium resources**



c) Relationship between resource categories

Figure 2 illustrates the inter-relationship between the different resource categories. The horizontal axis expresses the level of assurance about the actual existence of given tonnages based on varying degrees of geologic knowledge while the vertical axis expresses the economic feasibility of exploitation by the division into cost categories.

The dashed lines between RAR, EAR-I, EAR-II and SR in the highest cost category indicate that the distinctions of level of confidence are not always clear. The shaded area indicates that known resources (i.e., RAR plus EAR-I) recoverable at costs of $80 kgU or less are distinctly important because they support most of the world's EXISTING and COMMITTED production centres. RAR at prevailing market prices are commonly defined as "Reserves".

Because resources in the EAR-II and SR categories are undiscovered, the information on them is such that it is not always possible to divide them into different cost categories and this is indicated by the horizontal dashed lines between the different cost categories.

d) Recoverable resources

Resource estimates are expressed in terms of recoverable tonnes of uranium, i.e. quantities of uranium recoverable from mineable ore, as opposed to quantities contained in mineable ore, or quantities in situ. Therefore both expected mining and ore processing losses have been deducted in most cases. Deviations from this practice are indicated in the tables. In situ resources are recoverable resources in the ground not taking into account mining and milling losses.

e) Types of resources

To obtain a better understanding of the uranium resource situation, reference is made to different geologic types of deposits containing the resources and a distinction is drawn between conventional and unconventional resources, as follows:

Geologic types of uranium deposits

The major uranium resources of the world can be assigned on the basis of their geological setting to the following 15 ore types:

1. Unconformity-related deposits;
2. Sandstone deposits;
3. Quartz-pebble conglomerate deposits;
4. Vein deposits;
5. Breccia complex deposits;
6. Intrusive deposits;
7. Phosphorite deposits;
8. Collapse breccia pipe deposits;
9. Volcanic deposits;
10. Surficial deposits;
11. Metasomatite deposits;
12. Metamorphic deposits;
13. Lignite;

14. Black shale deposits;
15. Other types of deposits (phosphates, monazite, coal, etc.)

(See Annex 3 for a more detailed discussion of deposit types.)

PRODUCTION TERMINOLOGY[1]

a) Production centres

A PRODUCTION CENTRE, as referred to in this report, is a production unit consisting of one or more ore processing plants, one or more associated mines and the resources that are tributary to them. For the purpose of describing production centres, they have been divided into four classes, as follows:

i) EXISTING production centres are those that currently exist in operational condition and include those plants which are closed down but which could be readily brought back into operation.

ii) COMMITTED production centres are those that are either under construction or are firmly committed for construction.

iii) PLANNED production centres are those for which feasibility studies are either completed or under way, but for which construction commitments have not yet been made. This class also includes those plants that are closed which would require substantial expenditures to bring them back into operation.

iv) PROSPECTIVE production centres are those that could be supported by tributary RAR and EAR-I, i.e., "known resources", but for which construction plans have not yet been made.

b) Production capacity and capability

PRODUCTION CAPACITY denotes the nominal level of output, based on the design of the plant and facilities over an extended period, under normal commercial operating practice.

PRODUCTION CAPABILITY refers to an estimate of the level of production that could be practically and realistically achieved under favourable circumstances from the plant and facilities at any of the types of production centres described above, given the nature of the resources tributary to them.

Projections of production capability are supported only by RAR and/or EAR-I. One projection is presented based on those resources recoverable at costs up to $80/kgU.

DEMAND TERMINOLOGY

REACTOR-RELATED REQUIREMENTS refer to uranium acquisitions *not* consumption.

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(1) *Manual on the Projection of Uranium Production Capability*, General Guidelines, Technical Report Series No. 238, IAEA, Vienna, Austria, 1984.

UNITS

Metric units are used in all tabulations and statements. Resources and production quantities are expressed in terms of metric tons (t) contained uranium (U) rather than uranium oxide (U_3O_8).

1 short ton U_3O_8	=	0.769 tU
$1/lb U_3O_8	=	$2.6/kgU

Exploration expenditures are reported in US dollars. Conversions from other currencies have been done using exchange rates for June of the year in which the expenditures were incurred.

GEOLOGICAL TERMS

a) Uranium occurrence

A naturally occurring anomalous concentration of uranium.

b) Uranium deposit

A mass of naturally occurring mineral material from which uranium could be exploited at present or in the future.

I. URANIUM SUPPLY

This chapter summarises the current status of uranium resources, exploration and production in the world. In addition, production capabilities in reporting countries for the period ending in the year 2015 are presented and discussed. The last section of the chapter describes relevant environmental issues relating to uranium mining and milling and decommissioning of production facilities.

A. URANIUM RESOURCES

Known conventional resources

Known Conventional Resources (KCR) consist of Reasonably Assured Resources (RAR) and Estimated Additional Resources Category I (EAR-I) recoverable at a cost of $130/kgU or less (≤ $130/kgU). Changes in different resource and cost categories of KCR, reported for this edition of the Red Book as compared to the 1997 edition, are given in Table 1. Current estimates of RAR and EAR-I per country are presented in Tables 2 and 3, respectively. Additional resources not included in these tables are 70 000 tU reported by China, as KCR with no further resource or cost classification, and 77 750 tU reported by India, of unassigned cost, of which 52 550 tU are classified as RAR, and 25 200 tU as EAR-I.

Table 1. **Changes in known conventional resources 1997-1999 (1 000 tU)**

Resource category	1997	1999	Changes
KCR (Total)			
≤ $130/kgU	4 299	3 954	- 345
≤ $80/kgU	3 085	3 002	- 83
≤ $40/kgU*	> 923	> 1 254	> 331
RAR			
≤ $130/kgU	3 220	2 964	- 256
≤ $80/kgU	2 340	2 274	- 66
≤ $40/kgU*	> 666	> 916	> 250
EAR-I			
≤ $130/kgU	1 079	990	- 89
≤ $80/kgU	745	728	- 17
≤ $40/kgU*	> 257	> 338	> 81

* Resources in the cost categories of ≤ $40/kgU are higher than reported, however several countries have indicated that either detailed estimates are not available, or the data are confidential.

Table 2. **Reasonably Assured Resources (in 1 000 tU, as of 1.1.1999)**

COUNTRY	Cost Ranges				
	≤ $40/kgU	$40-80/kgU	≤ $80/kgU	$80-130/kgU	≤ $130/kgU
Algeria (a) (e) *	–	–	26.00	–	26.00
Argentina	2.64	2.60	5.24	2.24	7.48
Australia	NA	NA	607.00	109.00	716.00
Brazil (a)	56.10	105.90	162.00	0	162.00
Bulgaria (a) **	2.22	5.61	7.83	0	7.83
Canada	284.56	41.86	326.42	–	326.42
Central African Republic (e) *	–	–	8.00	8.00	16.00
Czech Republic (b)	0	4.11	4.11	2.88	6.99
Denmark (e) *	0	0	0	27.00	27.00
Finland (a)	0	0	0	1.50	1.50
France	NA	–	12.46	1.78	14.24
Gabon**	4.83	–	4.83	0	4.83
Germany	0	0	0	3.00	3.00
Greece *	1.00	–	1.00	–	1.00
Hungary (a)	0	0	0	0	0
India (a)	NA	NA	NA	NA	NA
Indonesia (a)	–	–	–	–	6.27
Italy (e) *	–	–	4.80	0	4.80
Islamic Republic of Iran	0	0	0	0.49	0.49
Japan (e)	NA	NA	NA	–	6.60
Kazakhstan (a)	320.74	115.88	436.62	162.04	598.66
Malawi (a)	–	–	11.70	–	11.70
Mexico (a) (e) *	0	0	0	1.70	1.70
Mongolia (a) **	10.60	51.00	61.60	–	61.60
Namibia	67.24	82.03	149.27	31.24	180.51
Niger	43.59	27.53	71.12	0	71.12
Peru (a)	–	–	1.79	0	1.79
Portugal (b)	–	–	7.47	0	7.47
Romania	–	–	–	–	6.61
Russian Federation (a)	64.30	76.60	140.90	–	140.90
Slovenia	0	–	2.20	0	2.20
Somalia (a) (e) *	–	–	0	6.60	6.60
South Africa	121.00	111.90	232.90	59.90	292.80
Spain	0	–	3.10	3.62	6.72
Sweden (e)	0	0	0	4.00	4.00
Thailand	–	–	–	–	0.01
Turkey (a) (e)	–	–	9.13	–	9.13
Ukraine (a)	–	–	42.60	38.40	81.00
United States	NA	–	106.00	249.00	355.00
Uzbekistan	65.62	0	65.62	17.49	83.09
Viet Nam (e)	–	NA	–	–	1.34
Zaire (a) (e) *	–	–	1.80	–	1.80
Zimbabwe (a) *	NA	NA	1.80	0	1.80
Total (c)	> **1 044.44**	> **625.02**	**2 515.31**	**729.88**	**3 266.00**
Total adjusted (d)	> **916.00**	> **531.00**	**2 274.00**	**660.00**	**2 964.00**

– No resources reported. NA = Data not available.
(a) In situ resources. (b) Mineable resources.
(c) Totals related to cost ranges ≤$40/kgU and $40–80/kgU are higher than reported in the tables because certain countries do not report resource estimates, mainly for reasons of confidentiality.
(d) Adjusted by the Secretariat to account for mining and milling losses not incorporated in certain estimates.
(e) Assessment not made within last 5 years or not reported in 1999 responses.
* Data from previous Red Book. ** Data from previous Red Book, depleted by past production.

Table 3. **Estimated Additional Resources – Category I (in 1 000 tU, as of 1.1.1999)**

COUNTRY	Cost Ranges				
	≤ $40/kgU	$40-80/kgU	≤ $80/kgU	$80-130/kgU	≤ $130/kgU
Algeria (a) (e) *	–	–	0.70	1.00	1.70
Argentina	2.03	0.35	2.38	0.07	2.45
Australia	NA	–	147.00	47.00	194.00
Brazil (a) (e)	NA	–	100.20	0	100.20
Bulgaria (a) *	2.20	6.20	8.40	–	8.40
Canada	87.01	19.58	106.59	0	106.59
Czech Republic (b)	0	–	1.11	21.55	22.66
Denmark (e) *	–	–	0	16.00	16.00
France	NA	–	0.55	–	0.55
Gabon	1.00	–	1.00	–	1.00
Germany	0	0	0	4.00	4.00
Greece *	–	–	6.00	0	6.00
Hungary (a)	0	0	0	18.40	18.40
India (a)	NA	NA	NA	NA	NA
Indonesia (a) *	–	–	–	–	1.67
Islamic Republic of Iran	–	–	–	–	0.88
Italy (e) *	–	–	0	1.30	1.30
Kazakhstan (a)	113.20	82.40	195.60	63.70	259.30
Mexico (a) (e) *	–	–	0	0.70	0.70
Mongolia (a) *	11.00	10.00	21.00	0	21.00
Namibia (a)	70.55	20.27	90.82	16.69	107.51
Niger*	0	0	0	18.58	18.58
Peru (a)	–	–	1.86	0	1.86
Portugal (a)	–	–	–	–	1.45
Romania	–	–	–	–	8.95
Russian Federation (a)	17.20	19.30	36.50	0	36.50
Slovenia	–	–	5.00	5.00	10.00
Somalia (a) (e) *	–	–	0	3.40	3.40
South Africa	48.10	18.70	66.80	9.60	76.40
Spain	0	0	0	7.54	7.54
Sweden (e)	0	0	0	6.00	6.00
Thailand	–	–	–	–	0.01
Ukraine (a)	–	–	20.00	30.00	50.00
Uzbekistan	39.85	0	39.85	7.14	46.99
Viet Nam (e)	NA	–	0.49	6.25	6.74
Zaire (a) (e) *	-	–	1.70	0	1.70
Total (c)	> **392.14**	> **176.80**	**853.55**	**283.92**	**1 150.43**
Total adjusted (d)	> **338.00**	> **145.00**	**728.00**	**250.00**	**990.00**

– No resources reported. NA = Data not available.

(a) In situ resources. (b) Mineable resources.

(c) Subtotal and totals related to cost ranges ≤$40/kgU and $40–80/kgU are higher than reported in the tables because certain countries do not report resource estimates, mainly for reasons of confidentiality.

(d) Adjusted by the Secretariat to account for mining and milling losses not incorporated in certain estimates.

(e) Assessment not made within last 5 years or not reported in 1999 responses.

* Data from previous Red Book.

Distribution of known conventional resources by categories and cost ranges

Some of the most significant changes between 1997 and 1999 in known conventional resources occurred in Australia, Canada and South Africa as shown in Table 4. Distributions of RAR and EAR-I among countries with major resources are shown in Figures 3 and 4, respectively.

In the RAR category recoverable at costs ≤ \$130/kgU, the world total (adjusted for estimated mining and milling losses) decreased by about 256 000 tU, compared to the previous edition. The reduction results from downward revisions in several countries, the removal of Indian resources and a decrease due to production (about 70 000 tU) in the reporting period. Overall increases were insufficient to balance the decreases. Similar observations are relevant for the RAR recoverable at ≤ \$80/kgU. In contrast, the RAR recoverable at ≤ \$40/kgU increased by 250 000 tU. This mainly results from Canadian resources reported for the first time in this cost category.

The decrease in the EAR-I category recoverable at ≤ \$130/kgU of 89 000 tU, is less pronounced. EAR-I at ≤ \$80/kgU decreased by about 17 000 tU. However, in the cost category ≤ \$40/kgU, EAR-I increased by 81 000 tU. Again, the increase is due to the first time report of resources in this cost category by Canada.

Availability of resources

In order to estimate the availability of resources for production, countries were asked to report the percentage of KCR (RAR and EAR-I), recoverable at costs of ≤ \$40/kgU and ≤ \$80/kgU, that are tributary to existing and committed production centres. Of a total of 23 producing countries, 12 provided estimates. Others did not report mainly for reasons of confidentiality. Countries reported resources tributary to existing and committed production centres of over 330 000 tU at ≤ \$40/kgU, and of over 1 270 000 tU at ≤ \$80/kgU.

Table 4. **Major conventional resource changes (1 000 tU)**

Country	Resource category	1997	1999	Changes	Reasons
Australia	RAR ≤ \$80/kgU	622	607	-15	Mainly due to production
	EAR-I ≤ \$80/kgU	136	147	11	Reassessment
Canada	KCR ≤ \$40/kgU	Not reported	371.57	371.5	New estimates
South Africa	RAR ≤ \$40/kgU	110.5	121	10.5	Reassessment mainly due to rand/dollar exchange rate changes

Other known resources

In previous editions of the Red Book a category of **other known resources** was included to accommodate reported resource data that were not strictly consistent with the standard NEA/IAEA terminology. The corresponding table has been eliminated in this report.

Figure 3. **Distribution of reasonably assured resources (RAR) among countries with major resources**

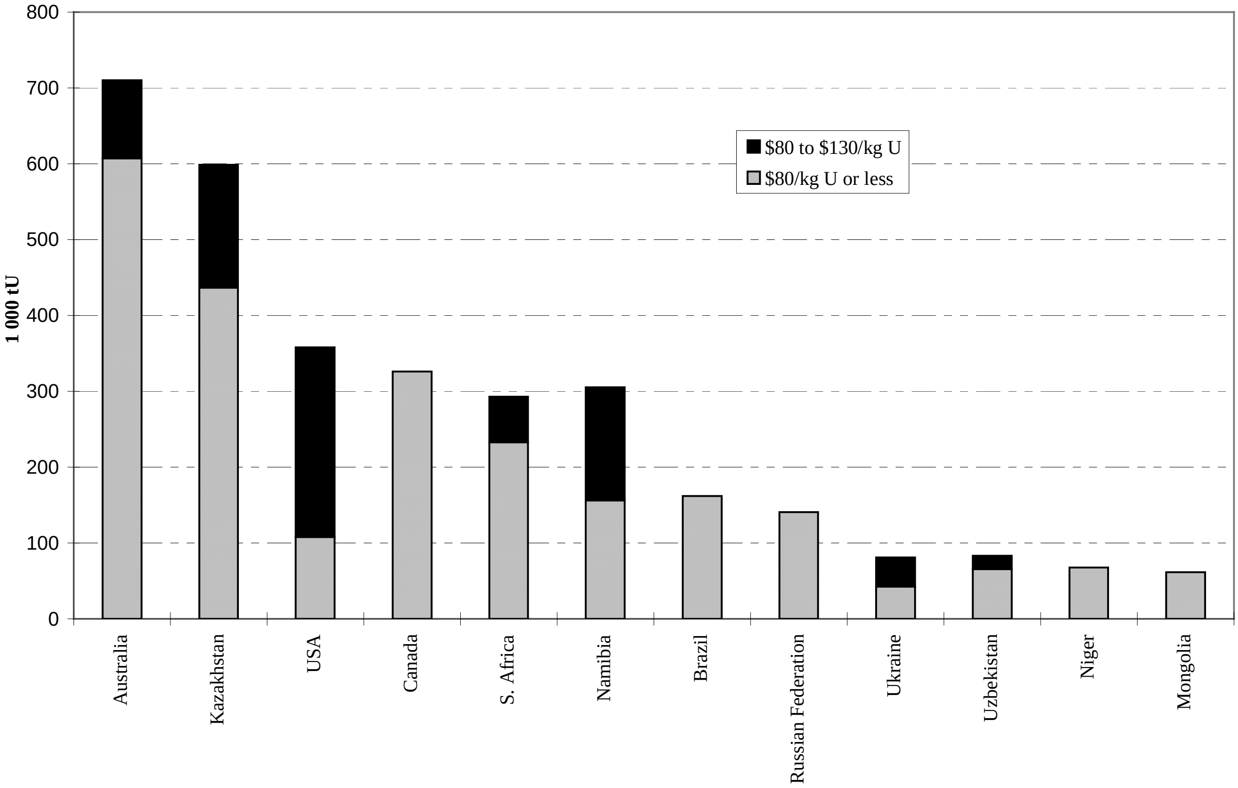


Figure 4. **Distribution of estimated additional resources – category I (EAR-I) among countries with major resources**

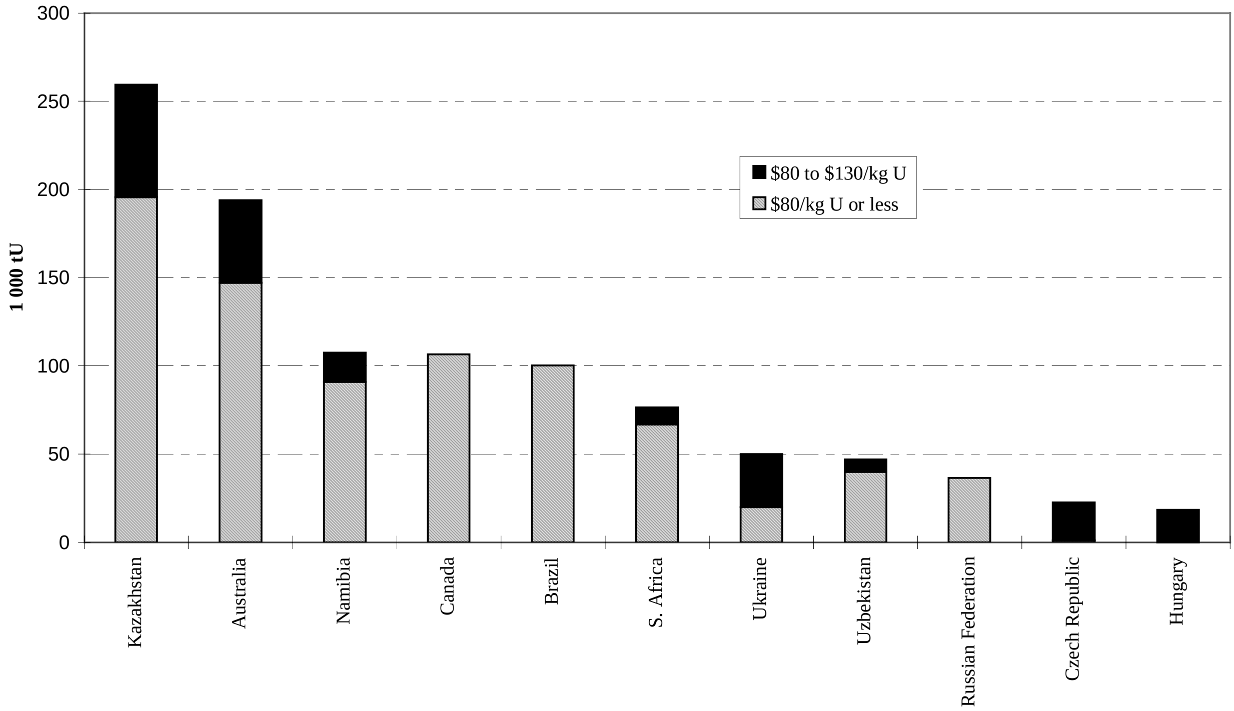


Table 5. **Reported undiscovered conventional resources (in 1 000 tU, as of 1.1.1999)***

COUNTRY	Estimated Additional Resources Category II		Speculative Resources		
	Cost Ranges		Cost Ranges		
	£ $80/kgU	£ $130/kgU	£ $130/kgU	Cost Range Unassigned	Total
Argentina	0	1	NA	NA	NA
Brazil	120	120	0	500	500
Bulgaria (a)	2	2	16	–	16
Canada (b)	50	150	700	–	700
China (a)	NA	NA	–	1 770	1 770
Chile (a)	NA	NA	NA	5	5
Colombia (a)	–	11	217	–	217
Czech Republic	5	10	0	179	179
Denmark	–	–	50	10	60
Gabon (a)	2	2	0	0	0
Germany	0	0	0	74	74
Greece (a)	6	6	0	0	0
Hungary	0	13	0	0	0
India (e)	NA	13	NA	17	17
Indonesia	–	–	–	2	2
Islamic Republic of Iran	0	5	5	5	10
Italy (a)	–	–	–	10	10
Kazakhstan	290	310	500	0	500
Mexico (a)	–	3	–	10	10
Mongolia	0	0	1 390	–	1 390
Peru	7	20	20	6	25
Portugal	–	2	5	0	5
Romania	–	2	3	0	3
Russian Federation	56	105	544	456	1 000
Slovenia	–	1	–	–	–
South Africa	35	148	NA	1 113	1 113
Ukraine	NA	4	NA	231	231
United States (c)	839	1 273	858	1 340	2 198
Uzbekistan (d)	48	68	–	102	102
Venezuela (a)	–	–	–	163	163
Viet Nam	NA	6	100	130	230
Zambia (a)	0	22	0	0	0
Zimbabwe (a)	0	0	25	0	25
Total (reported by countries)**	1 460	2 295	3 043	6 121	9 164

* Undiscovered resources are generally reported as in situ resources.

** Totals do not represent a complete account of world Undiscovered Conventional Resources. Totals may not equal sum of components due to independent rounding.

– No resources reported. NA = Data not available.

(a) Data from previous Red Book.

(b) Mineable resources.

(c) USA reports all EAR-I and EAR-II as EAR-II.

(d) EAR-II and Speculative Resources are expressed as recoverable.

(e) Cost data not assigned.

Undiscovered conventional resources

Undiscovered Conventional Resources include Estimated Additional Resources Category II (EAR-II) and Speculative Resource (SR). EAR-II refers to uranium that is expected to occur in well-defined geological trends of known ore deposits, or mineralised areas with known deposits. SR refers to uranium that is thought to exist in geologically favourable, yet unexplored areas. Therefore EAR-II are assigned with a higher degree of confidence than are SR. Both categories of undiscovered conventional resources are reported together in Table 5. A number of countries did not report undiscovered conventional resources for the 1999 Red Book, with some specifying that they do not perform systematic evaluations of this type of resources.

Only a few countries report EAR-II recoverable at ≤ $40/kgU. Therefore the category is not included in Table 5.

Compared to the last edition only minor changes have been reported in both EAR-II and Speculative Resources. Almost all of these resources are reported as in situ.

From data reported in the EAR-II category, about 2.3 million tU are estimated at ≤ $130/kgU, and about 1.5 million tU at ≤ $80/kgU. This is slightly less than those reported in the 1997 Red Book.

It should be noted that the USA does not report EAR-I and EAR-II separately. For the purpose of this report, all the EAR reported by the USA are classified under EAR-II. An unknown portion, however, belongs to EAR-I.

Information regarding SR is incomplete on a worldwide scale. The estimated total for countries reporting at ≤ $130/kgU is 3.04 million tU. About 6.12 million tU of additional resources are reported without an estimate of production cost. The total reported SR is about 9.16 million tU.

Unconventional resources and other materials

No specific compilation of Unconventional Resources is provided in this report, as only a few countries reported relevant information.

Uranium resources and sustainability

The extensive uranium resources believed to exist and their effective management through the use of efficient fuel cycle strategies and advanced technologies will allow these resources to be used for many generations to come.

Uranium exists widely dispersed over the earth's crust and in the oceans. As specified in this report, estimates of uranium resources are classified into conventional and unconventional categories. Current estimates of total Conventional resources of uranium amount to about 15.4 million tonnes or over 250 years of today's rate of usage (around 60 000 tonnes). There are additional resources classified as unconventional, in which uranium exists at very low grades, or is recovered as a minor by-product. The most important unconventional resources include about 22 million tonnes that occur in phosphate deposits and up to 4 billion tonnes contained in sea-water.

In the long term, natural uranium requirements would depend on the fuel cycle strategies and reactor technologies adopted. Fuel cycle strategies that reduce uranium consumption per kWh include lowering enrichment plant tails assays (thereby recovering more of the ^{235}U present in natural uranium); and recycling uranium and plutonium recovered from reprocessed spent fuel (thereby reducing the needs for fresh natural uranium). By reprocessing spent fuel about 30% of the potential energy in the initial fuel can be re-utilised in thermal reactors.

The introduction of fast reactors (liquid metal cooled fast reactors) could further reduce total uranium requirements. Plutonium breeding allows fast reactors to extract 60 times as much energy from uranium as do thermal reactors. Other advanced technologies that could be developed in the future, combined with appropriate management, may extend the useful life of the uranium resources over several centuries, even if uranium requirements were to increase considerably.

B. URANIUM EXPLORATION

As in recent years the exploration efforts are unevenly distributed geographically. The distribution depends on the specific uranium requirements of individual countries, as well as the reasonable likelihood for the discovery of economically attractive deposits. After a continued decrease of exploration activities for more than ten years, a low of about USD 70 million was reached in 1994. In the following years an increase was reported in a few countries as indicated by exploration expenditures of USD 83.6 million in 1995 and of USD 111.4 million in 1996. In 1997 a total of 24 countries reported exploration expenditures of about USD 153 million, or almost 37% higher than in the previous year. In 1998 only 21 countries reported exploration activities costing about USD 131.8 million (see Table 6).

The increase of expenditures from 1996 to 1997 was the result of activities associated with advanced projects in Canada, Australia, the USA, the Russian Federation and India. Exploration activities and expenditures in most reporting countries decreased from 1997 to 1998. However in some countries small increases have been reported. For most reporting countries, expected exploration expenditures for 1999 show a downward trend.

Currently, most of the exploration activities are taking place in Canada, the USA, Australia, India, the Russian Federation and Uzbekistan, (listed by decreasing expenditure) and to a lesser extent in Egypt, Ukraine, France and Romania. It should be noted that the increase in exploration expenditures in Uzbekistan since 1996 includes annual maintenance expenditures of about USD 13.3 million to USD 14.5 million.

China does not report exploration expenditures. It does report, however, that it has an active exploration programme.

Exploration efforts by Canadian, French, German, Japanese, South Korean and US companies in countries outside their national boundaries are reported in Table 7. A slight increase in exploration expenditures abroad took place from 1996 to 1997. However, a marked decrease is shown for 1998. Exploration expenditures for German companies in 1998 are zero. This occurred due to the sale to a non-German owner of the German company that had in recent years conducted exploration.

The trends in domestic and abroad exploration expenditures for selected countries are depicted in Figure 5.

Table 6. **Industry and government uranium exploration expenditures (domestic) in countries listed – USD 1 000 in year of expenditure**

COUNTRY	Pre-1992	1992	1993	1994	1995	1996	1997	1998	1999 (Expected)
Argentina	45 232	1 330	1 242	700	950	0	0	0	0
Australia	423 458	10 273	5 790	4 904	5 942	11 841	18 038	12 031	NA
Bangladesh	453	NA	NA	NA	NA	NA	NA	NA	NA
Belgium	1 685	0	0	0	0	0	0	0	0
Bolivia	9 368	NA	NA	NA	NA	NA	NA	NA	NA
Botswana	640	NA	NA	NA	NA	NA	NA	NA	NA
Brazil	189 920	0	0	0	0	0	0	0	414
Canada	944 490	38 417	31 825	26 087	32 353	28 467	42 029	41 096	29 870
Central African Rep.	20 000	–	–	NA	NA	NA	NA	NA	NA
Chile	7 990	117	115	94	218	143	154	196	178
Colombia	23 935	–	–	0	0	0	0	NA	NA
Costa Rica	361	–	–	–	–	–	–	–	–
Cuba	0	236	230	228	142	86	50	NA	NA
Czechoslovakia	311 900	660	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
Czech Republic	xxxx	xxxx	579	468	282	201	163	90	77
Denmark	4 350	–	–	0	0	0	0	0	0
Ecuador	2 055	NA	NA	NA	NA	NA	NA	NA	NA
Egypt	28 528	4 505	6 647	3 245	3 264	6 528	7 418	7 976	8 831
Finland	14 777	0	0	0	0	0	0	0	0
France	861 952	14 984	9 963	6 217	2 882	7 960	1 742	1 040	0
Gabon	85 261	2 011	1 839	1 050	939	1 338	343	NA	NA
Germany	144 765	0	0	0	0	0	0	0	0
Ghana	90	NA	NA	NA	NA	NA	NA	NA	NA
Greece	15 868	389	403	154	148	273	290	NA	NA
Guatemala	610	–	–	NA	NA	NA	NA	NA	NA
Hungary	3 700	0	0	0	0	0	0	0	0
India	178 757	9 010	9 519	9 363	9 536	9 250	11 183	14 445	13 704
Indonesia	10 098	1 230	1 523	648	574	695	632	114	229
Ireland	6 800	–	–	0	0	0	0	NA	NA
Italy	75 060	–	–	NA	NA	NA	NA	NA	NA
Jamaica	30	–	–	NA	NA	NA	NA	NA	NA
Japan	8 640	0	0	0	0	0	0	0	0
Jordan	433	36	13	10	30	100	100	150	170
Kazakhstan	NA	2 500	2 525	1 290	113	242	160	105	NA
Korea, Republic of	4 670	NA	NA	0	0	0	0	0	0
Lesotho	21	NA	NA	NA	NA	NA	NA	NA	NA
Madagascar	5 243	NA	NA	NA	NA	NA	NA	NA	NA

Table 6. **Industry and government uranium exploration expenditures (domestic) in countries listed (continued) – USD 1 000 in year of expenditure**

COUNTRY	Pre-1992	1992	1993	1994	1995	1996	1997	1998	1999 (Expected)
Malaysia	8 559	310	368	399	163	0	245	187	186
Mali	51 637	–	–	NA	NA	NA	NA	NA	NA
Mexico	24 910	0	0	0	0	0	0	0	0
Mongolia	NA	48	60	700	1 650	2 560	3 135	NA	NA
Morocco	2 752	–	–	NA	NA	NA	NA	NA	NA
Namibia	15 522	364	0	0	2 044	0	0	0	0
Niger	198 900	1 343	440	1 481	1 665	427	1 653	NA	NA
Nigeria	6 950	NA	NA	NA	NA	NA	NA	NA	NA
Norway	3 180	–	–	0	0	0	0	0	0
Paraguay	25 510	NA	NA	NA	NA	NA	NA	NA	NA
Peru	4 188	9	0	4	0	0	0	0	0
Philippines	3 367	10	10	30	30	19	19	13	13
Portugal	16 602	277	135	106	130	114	154	102	NA
Romania	0	NA	NA	2 998	2 448	1 776	1 198	926	NA
Russian Federation	xxxx	9 710	2 828	4 197	5 581	4 271	10 052	8 650	7 909
Somalia	1 000	–	–	NA	NA	NA	NA	NA	NA
South Africa	108 993	NA	NA	NA	NA	NA	NA	NA	NA
Spain	131 823	4 119	2 872	891	0	1 388	0	12	0
Sri Lanka	33	–	–	NA	NA	NA	NA	NA	NA
Sweden	46 870	0	0	0	0	0	0	0	0
Switzerland	3 868	–	–	0	0	0	0	0	0
Syria	1 068	0	0	NA	NA	NA	NA	NA	NA
Thailand	10 485	63	138	116	119	0	0	0	0
Turkey	20 581	–	–	0	0	0	200	1 200	NA
Ukraine	NA	NA	NA	NA	NA	1 376	1 611	1 940	3 644
United Kingdom	2 600	0	0	0	0	0	0	0	0
United States	2 629 800	16 000	12 000	4 329	6 009	10 054	30 426	21 724	NA
Uruguay	231	NA	NA	NA	NA	NA	NA	NA	NA
USSR	247 520	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
Uzbekistan*	NA	NA	NA	472	6 197	22 067	21 954	19 651	18 686
Viet Nam	815	252	324	137	161	208	227	120	120
Yugoslavia	1 006	NA	NA	NA	NA	NA	NA	NA	NA
Zambia	170	21	NA	4	NA	NA	NA	NA	NA
Zimbabwe	6 384	518	0	0	0	0	0	NA	NA
TOTAL (a)	7 006 464	118 742	91 388	70 321	83 570	111 384	153 176	131 768	84 031

(a) Of available data only.
NA Data not available.
xxxx National entity not in existence or politically redefined.
* Includes maintenance expenditures since 1996.
– No expenditures reported.

Table 7. **Non-domestic uranium exploration expenditures (abroad) by countries listed (USD 1 000 in year of expenditure)**

COUNTRY	Pre-1992	1992	1993	1994	1995	1996	1997	1998	1999 (Expected)
Belgium	4 500	0	0	0	0	0	0	0	0
Canada	–	–	–	1 449	1 471	3 650	3 986	2 740	2 597
France	582 665	19 438	32 619	30 959	10 245	6 808	8 972	8 777	7 933
Germany (FRG)	384 419	2 898	3 107	2 646	2 951	3 137	4 000	0	0
Italy	NA	–	–	–	–	–	–	–	–
Japan	329 991	12 010	11 620	12 923	14 771	7 533	4 752	2 275	1 470
Korea, Rep. of	21 652	260	225	175	178	511	603	445	–
Spain	20 400	0	0	0	0	0	0	0	0
Switzerland	28 046	482	502	627	0	0	0	0	0
United Kingdom	60 209	899	155	0	0	0	0	0	0
United States	228 770	0	0	W	NA	422	3 050	3 616	NA
TOTAL	**1 660 652**	**35 987**	**48 228**	**48 779**	**29 616**	**22 060**	**25 363**	**17 853**	**12 000**

– No expenditures reported.
NA Data not available.
W Withheld to avoid disclosure of company specific data.

Current activities and recent developments

North America. In Canada and the USA, exploration activities continued at a relatively high level in 1997 and 1998. In **Canada** annual expenditures were about CAD 60 million. A significant portion is attributable to projects awaiting production approvals. Basic “grass-roots” expenditures were on the order of CAD 25 million annually, of which CAD 22 million were spent in Saskatchewan.

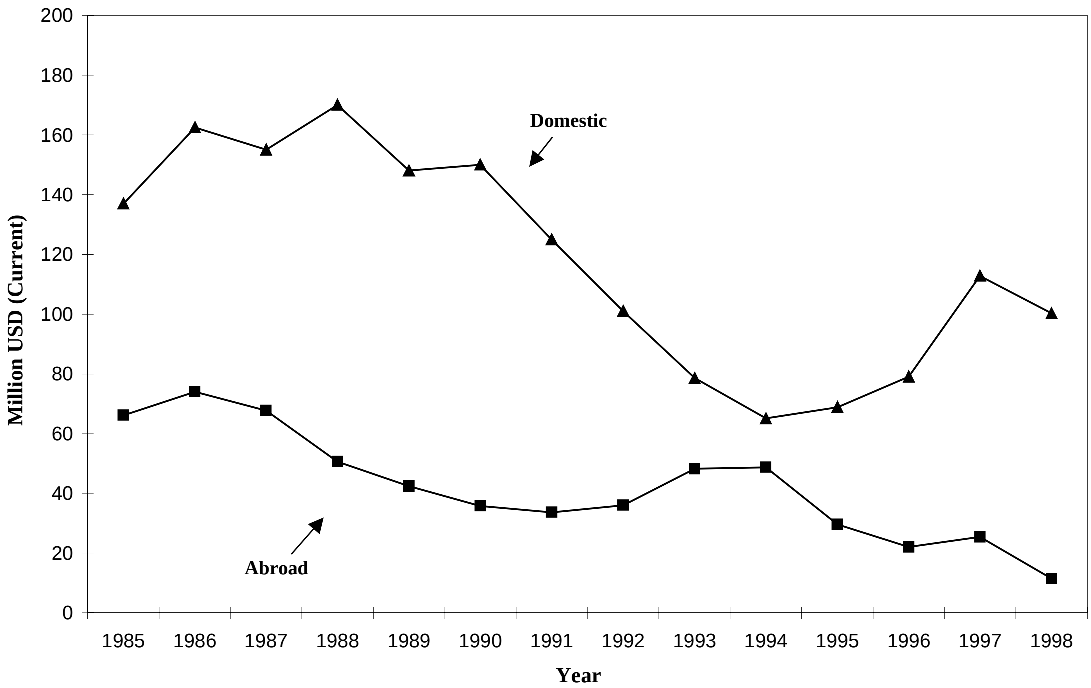
In the **USA** in 1997 about USD 30.4 million are attributable to surface drilling and about USD 8 million to land acquisition. In 1998 about USD 21.7 million were spent for surface drilling.

Central and South America. In **Argentina** continued exploration involved surface drilling on the Cerro Solo sandstone deposit. However no expenditures are reported. No exploration was carried out in **Brazil**, where efforts were concentrated on preparing Lagoa Real facilities to start mining and milling. Limited exploration took place in **Chile**.

Western Europe and Scandinavia. Exploration efforts in the area continued to decline. In **France** the only activities reported are concentrated around the Le Bernardan mine. Cogema continues exploration abroad, mainly in Australia, Canada, Central Asia, Niger and the USA, with annual expenditure of about 52 million FRF. In **Germany** no exploration was carried out. Exploration abroad by German companies was terminated in 1998. Limited drilling programmes are being conducted in **Portugal**.

Central, Eastern and South East Europe. No field work was undertaken in the **Czech Republic**, and only archiving and processing of previously obtained data continued. In **Romania**, drilling programmes continued. In favourable areas, however, there was a downward trend in both expenditures and footage. The **Russian Federation** has concentrated its activities on sandstone deposits amenable for in situ leaching (ISL). Major drilling programmes continue in the Transural District, the West Siberian District and in the Vitim Region. Annual expenditures total more than 50 million Roubles. An increase to 166 million Roubles is expected for 1999. Limited exploration (mainly "grass roots") is reported in **Turkey**. **Ukraine** is maintaining its basic exploration, with extensive drilling mainly in the crystalline shield. The annual expenditures were 2.9 to 3.9 million Grivnas. An increase to 12.5 million Grivnas is expected for 1999.

Figure 5. **Trend in uranium exploration expenditures for selected countries (excluding China, Cuba, NIS and Eastern Europe)**



Africa. As in recent years, exploration in **Egypt** is concentrated in mineralised areas in the Eastern Desert and Sinai (drilling and airborne surveys). Annual expenditures are between EGP 25 and 27 million. No exploration activities are reported in other African countries.

Middle East, Central and South Asia. In **India** active programmes are being conducted in several provinces. Annual drilling exceeded 30 km. Exploration expenditures were between USD 11 million and USD 14 million. The work focused on Proterozoic basins, Cretaceous sandstones and several other geologic environments. In **Jordan** limited work continued, mainly to evaluate promising areas. Some exploration continues in **Kazakhstan** in areas favourable for unconformity-type deposits. In **Uzbekistan**, exploration was primarily focused on drilling in established ore fields and for delineating new resources. In 1996 and 1997 expenditure amounted to USD 7.6 million and USD 6.2 million, respectively. In addition, maintenance expenditures of USD 14.3 million and USD 13.4 million respectively, were made. A total of about 2 700 exploration and development drills holes were completed in 1997 and 1998.

South East Asia. Exploration activities in **Indonesia**, the **Philippines** and **Vietnam** were maintained at a low level. This work was done to evaluate previously discovered mineralisation.

Pacific. Exploration continued in several regions of **Australia** with annual expenditures of AUD 23.6 million in 1997 and AUD 19.4 million in 1998. Annual drilling programmes of 63 km and 78 km respectively were conducted. The main focus of exploration is on unconformity-type deposits in Arnhem Land (NT) and the Paterson Province (WA), as well as for sandstone and calcrete-type deposits in South and Western Australia.

East Asia. **China** continues exploration for sandstone-type deposits amenable for ISL in Xinjiang, Inner Mongolian Autonomous Regions and Northern China. China co-operated with Japanese organisations in exploration projects for volcanic and unconformity type deposits. These projects were completed respectively in 1997 and 1998. **Japan** has no domestic exploration programme. However, Japanese companies continued exploration in Canada, Australia, the USA, Niger and Zimbabwe. Exploration continues in **Mongolia**, although no details have been reported. The **Republic of Korea** has no domestic exploration but Korean companies continue exploration joint ventures in Canada and the USA.

C. URANIUM PRODUCTION

World uranium production increased 1.6% from 36 149 tU in 1996 to 36 724 in 1997, and then decreased by 4.7% to 34 986 tU in 1998. In the OECD area, production increased slightly from 21 184 tU in 1996 to 21 391 in 1997, and then declined to 19 088 tU in 1998. Production in selected countries and reasons for major changes between 1996 and 1998 are listed in Table 8. Historical uranium production per country is given in Table 9 and shown in Figures 6 and 7.

Present status of uranium production

Uranium production in **North America** decreased by about 10% from 1997 to 1998. The region contributed about 37% of the world total in 1998. **Canada** remained the leading world producer. Since 1997, all production has come from three mines in Saskatchewan, following closure of the Stanleigh mine in Ontario in 1996. In the **USA**, about 78% of the production came from 6 ISL operations, with the remaining portion from other sources (mine water, restoration activities and as a by-product of phosphate processing). Two facilities producing uranium as a by-product of phosphate processing were in operation in 1998. However, one facility was closed at the end of 1998 while the other closed early in 1999.

Argentina was the only producing country in **South America**. **Brazil** planned to re-start uranium production in the second half of 1999.

Production in **Western Europe** decreased from 899 tU in 1997 to 826 tU in 1998 representing only 2.4% of the world production. **France** produced 572 tU and 507 tU, respectively, in 1997 and 1998. **Spain**'s production remained stable at 255 tU annually. The remaining production in Western Europe was either from clean-up operations (**Germany**), by-product of phosphate (**Belgium**) or small open pit operations (**Portugal**).

Uranium production in **Central, Eastern and South East Europe** decreased only slightly from 4 490 tU in 1997 to 4 282 tU in 1998. The **Czech Republic** produced about 610 tU in 1997 and 1998. Production in **Hungary** decreased from 200 tU to 10 tU (1998) due to the closure of the Mecsek mine. In **Romania** production was 107 tU in 1997 and 132 tU in 1998. The production in the **Russian Federation** remained rather stable at 2 580 tU and 2 530 tU, respectively in 1997 and 1998. All production came from the Krasnokamensk mine. **Ukraine** reports annual production of 1 000 tU in 1997 and 1998. This region contributed about 12% to world production in 1998.

Table 8. **Production in selected countries and reasons for major changes**

Country	1998 production in tU	Reasons for changes in production since 1996
Australia	4 910	The output of Ranger increased from 3 509 tU in 1996, to 4 063 tU in 1997, and then decreased to 3 434 tU in 1998. At Olympic Dam production continued at about 1 450 tU/year.
Canada	10 922	Key Lake production continued at about 5 400 tU/year. Rabbit Lake output was between 3 973 tU/year and 4 633 tU/year; Cluff Lake decreased from above 1 900 tU to about 1 000 tU in 1998.
France	507	Output was down from 930 tU in 1996, due to closure of Lodève.
Hungary	10	Reduced from 200 tU/a, due to closure of the Mecsek mine.
Kazakhstan	1 270	Decrease from 1 210 tU in 1996, to 1 090 tU to 1997, followed by increase in 1998.
Namibia	2 780	Increased output at Rössing from 2 447 tU in 1996.
South Africa	994	Termination of production at Western Areas in 1997. 1996: 1 436 tU; 1997: 1 100 tU
United States	1 810	Reduction from 2 432 tU in 1996 to 2 170 tU in 1997.
Uzbekistan	1 926	Increases of 305 tU from 1996 to 1997, and 162 tU from 1997 to 1998, due to higher output of ISL-mines, the only production method operating since 1995.

Four countries in **Africa**, Gabon, Namibia, Niger and South Africa contributed about 25% of world production in 1998. This region produced 8 213 tU, an increase of 251 tU over 1997. Both **Gabon** and **Niger** increased their output by about 250 tU each, offsetting a decline in **South Africa** of about 100 tU and in **Namibia** of about 125 tU. In 1999 Gabon terminated its production due to the exhaustion of economical deposits. The future of uranium production in South Africa depends on the price of gold. One production centre, Western Areas, was closed at the end of 1997. Namibia and Niger could either maintain production at current levels, or increase it, if market conditions improve.

In the **Middle East, Central and South Asia** production increased by about 500 tU from 1997 to 1998, reaching 3 469 tU, or about 10% of the world total. The increase is due to a higher output, respectively, of about 200 tU in **Kazakhstan** and 162 tU in **Uzbekistan**. **India** and **Pakistan** do not report production. Their 1998 output is estimated to remain constant at about 210 tU and 23 tU, respectively.

Australia is the only producing country in the **Pacific** region. Its production decreased from 5 489 tU in 1997 to 4 910 tU in 1998, due to cutbacks at the Ranger mine.

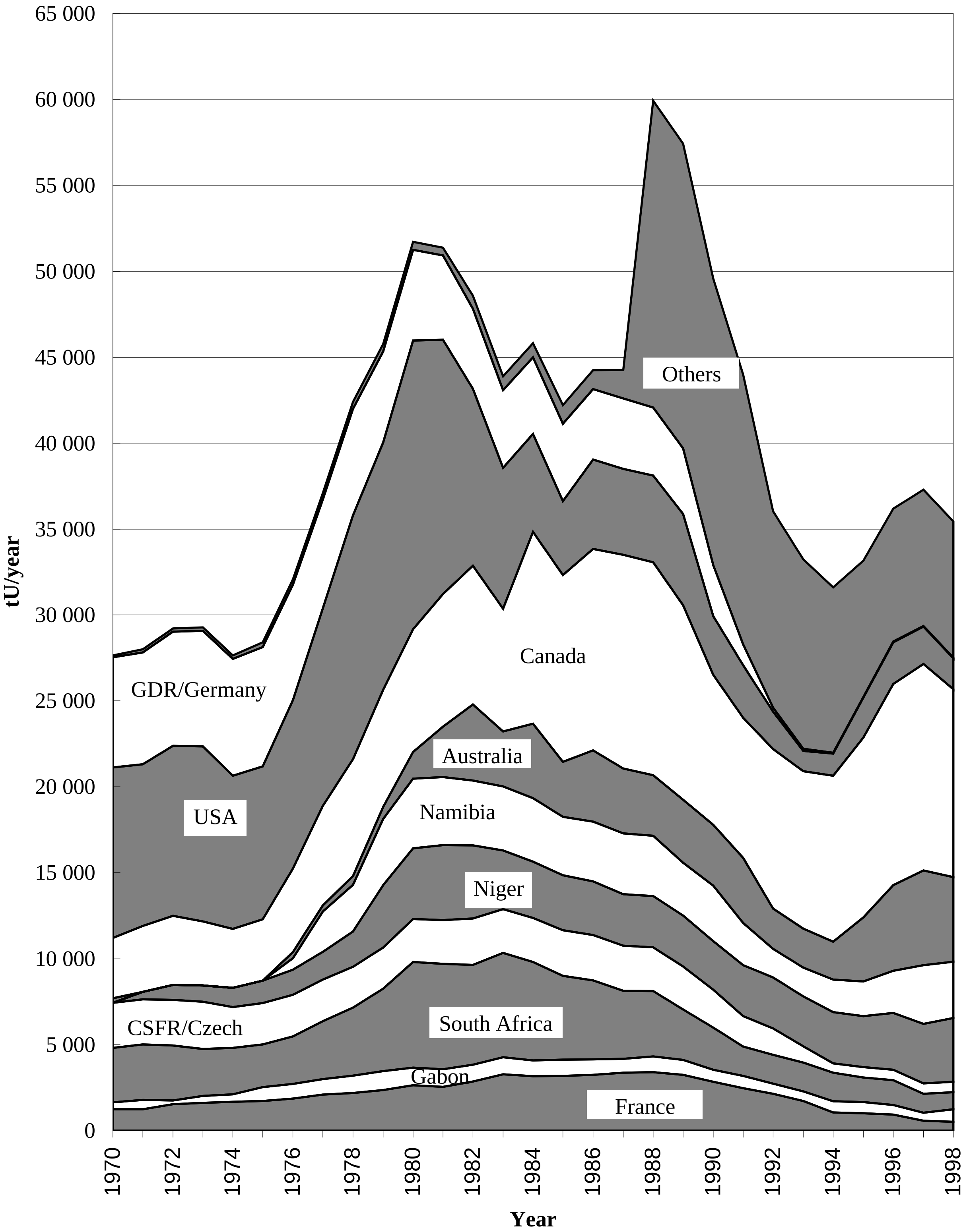
In **East Asia, China** is the only producing country. However, official production figures are not reported. Its production for 1997 and 1998 are estimated at 570 tU and 590 tU, respectively.

Table 9. **Historical uranium production**
(in metric tons U)

COUNTRY	Pre-1996	1996	1997	1998	Total to 1998	Expected 1999
Argentina	2452	16	30	7	2505	6
Australia	62 319	4 975	5 488	4 910	77 692	6 445
Belgium	616	28	27	15	686	0
Brazil	1 030	0	0	0	1 030	150
Bulgaria	16 720	0	0	0	16 720	0
Canada	286 967	11 706	12 031	10 922	321 626	8 500
China*	4 315 (a)	560	570	590	NA	650
CSFR	102 245	xxxx	xxxx	xxxx	102 245	xxxx
Czech Republic	104 144	604	603	610	105 961	606
Finland	30	0	0	0	30	0
France	71 973	930	572	507	73 982	465
Gabon	24 133	568	470	725	25 896	295
Germany	218 688	39	28	30	218 785	30
GDR	213 380	xxxx	xxxx	xxxx	213 380	xxxx
Hungary	17 811	200	200	10	18 221	10
India*	6 238	207	207	207	6 859	210
Japan	87	0	0	0	87	0
Kazakhstan	81 372	1 210	1 090	1 270	84 942	2 000
Mexico	49	0	0	0	49	0
Mongolia	535	0	0	0	535	NA
Namibia	58 590	2 447	2 905	2 780	66 722	2 905
Niger	65 456	3 329	3 487	3 714	75 986	2 910
Pakistan*	722	23	23	23	791	23
Poland	660	0	0	0	660	0
Portugal	3 642	15	17	19	3 693	25
Romania	17 210	105	107	132	17 554	107
Russian Federation	101 378	2 605	2 580	2 530	108 653	2 600
Slovenia	2	0	0	0	0	0
South Africa	148 071	1 436	1 100	994	151 601	950
Spain	3 686	255	255	255	4 451	255
Sweden	200	0	0	0	200	0
Ukraine	5 000 (b)	1 000	1 000	1 000	NA	1 000
United States	344 086	2 432	2 170	1 810	350 498	1 800
Uzbekistan	86 422	1 459	1 764	1 926	91 571	2 300
Yugoslavia	380	0	0	0	380	0
Zaire	25 600	0	0	0	25 600	0
OECD	992 343	21 184	21 391	19 088	1 054 006	18 136
TOTAL	********	**36 149**	**36 724**	**34 986**	********	**34 242**

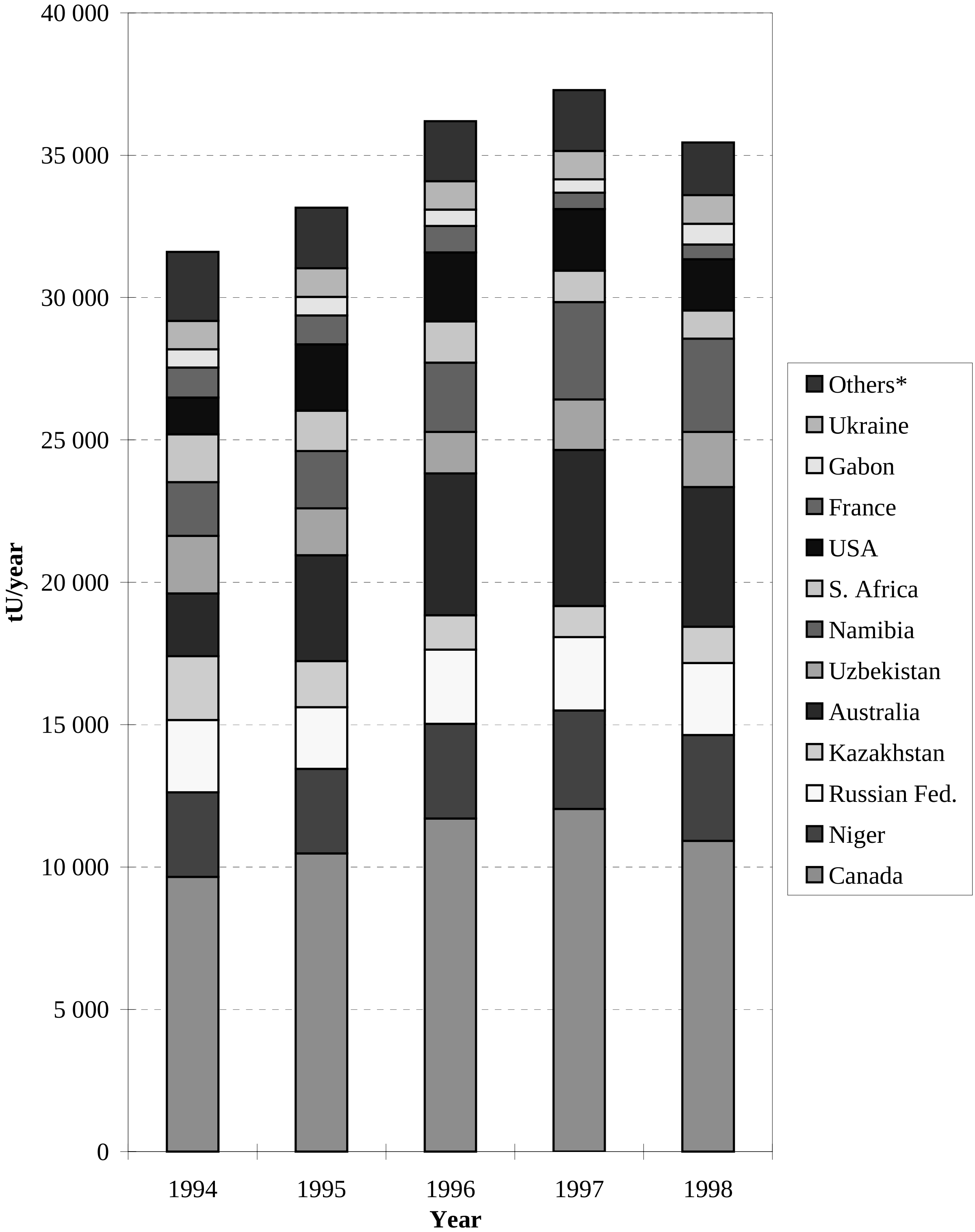
* Secretariat estimate.
(a) Production in China since 1990.
(b) Production in Ukraine since 1992.
xxxx National entity not in existence or politically redefined.
**** No estimate due to insufficient information.

Figure 6. **Historical uranium production**



Note: "Others" data correspond to other remaining producers. Only partial data are available on other producers before 1988.

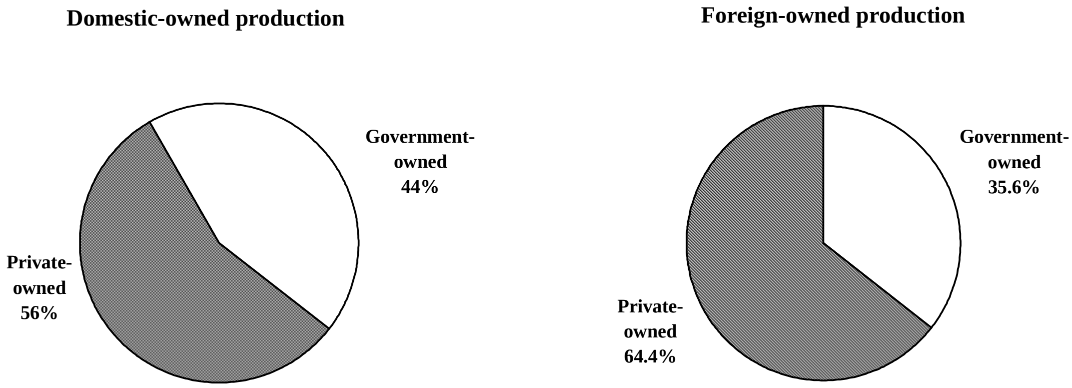
Figure 7. **Recent world uranium production**



* "Others" includes the remaining producers. Values for China, India and Pakistan in "Others" are estimated.

Figure 8 and Table 10 show the ownership in 1998 of the world's uranium production, which took place in 23 countries. Although the shares of government and private ownership in domestic production remained about the same as compared to 1996 (Figure 8), the private share of foreign owned production increased by about 6% (64.4%) as compared to the share (58.4%) reported in 1996. Worldwide, domestic mining companies owned about 74% of the uranium produced in 1998 (Table 10).

Figure 8. **Ownership of world uranium production**



The changes of employment levels from 1992 to 1998 in existing production centres of reporting countries are shown in Table 11. Employment associated with uranium production, reported by 18 countries, fell from 52 486 in 1996 to 46 213 by 1998, a decrease of 11.9%. In Germany and Slovenia all activities are related to industry closure, reclamation and restoration.

Production techniques

Uranium is produced using both conventional mining and ore processing (milling) and unconventional production techniques. Unconventional techniques include in situ leaching (ISL) technology, phosphate by-product recovery and heap leaching.

Conventional production involves ore extraction by open pit and underground mining. ISL mining uses either acid or alkaline solutions to extract the uranium. The solutions are injected into, and recovered from, the orebearing zone through wells constructed from the surface. ISL technology is only being used to extract uranium from suitable sandstone-type deposits. The distribution of production by technology types or material sources for 1996 to 1998 is shown in Table 12. "Other" includes production by phosphate by-product, heap and in-place (in-stope) leaching. Uranium produced as a by-product of South African gold production is included in "Other". In-place leaching involves leaching of broken ore without removing it from an underground mine, while heap leaching is done once the ore is extracted using conventional mining, and moved to the leaching facility located on the surface.

Table 10. **Ownership of uranium production based on 1998 output**

COUNTRY	Domestic Mining Companies				Foreign Mining Companies				TOTAL
	Government-owned		Private-owned		Government-owned		Private-owned		
	tU/year	%	tU/year	%	tU/year	%	tU/year	%	
Argentina	7	100	0	0	0	0	0	0	7
Australia	0	0	4 026	82	196	4	688	14	4 910
Belgium	0	0	15	100	0	0	0	0	15
Canada	939	9	8 944	82	1 039	9	0	0	10 922
China*	590	100	0	0	0	0	0	0	590
Czech Republic	610	100	0	0	0	0	0	0	610
France	413	82	94	19	0	0	0	0	507
Gabon*	181	25	51	7	493	68	0	0	725
Germany	30	100	0	0	0	0	0	0	30
Hungary	10	100	0	0	0	0	0	0	10
India*	207	100	0	0	0	0	0	0	207
Kazakhstan	1 270	100	0	0	0	0	0	0	1 270
Namibia	83	3	0	0	278	10	2 419	87	2 780
Niger	1 236	33	0	0	1 311	35	1 167	32	3 714
Pakistan*	23	100	0	0	0	0	0	0	23
Portugal	0	0	19	100	0	0	0	0	19
Romania	132	100	0	0	0	0	0	0	132
Russian Federation	2 530	100	0	0	0	0	0	0	2 530
South Africa	NA		NA		NA		NA		994
Spain	0	0	255	100	0	0	0	0	255
Ukraine	1 000	100	0	0	0	0	0	0	1 000
United States	0	0	602	33	270	15	938	52	1 810
Uzbekistan	1 926	100	0	0	0	0	0	0	1 926
TOTAL	11 187	33	14 006	41	3 587	11	5 212	15	34 986

* Secretariat estimate.

Table 11. **Employment in existing production centres of countries listed (in persons-years)**

COUNTRY	1992	1993	1994	1995	1996	1997	1998	Expected 1999
Argentina	220	220	180	120	100	80	80	80
Australia	376 (a)	405 (a)	412	413	464	468	502	555
Belgium	5	5	5	5	5	6	6	6
Brazil	430	410	408	390	305	280	180	380
Bulgaria	13 000	8 000	NA	NA	NA	NA	NA	NA
Canada (b)	1 310	1 320	1 370	1 350	1 155	1 105	1 134	1 100
China	9 500	9 300	9 100	8 000	8 500	8 500	8 500	8 500
Czechoslovakia/CSFR	6 600	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
Czech Republic	xxxx	5 900	5 400	4 500	3 600	3 580	3 410	3 300
France	1 368	824	496	468	441	141	144	NA
Gabon	207	193	263	276	259	150	NA	NA
Germany	6 093 (c)	4 895 (d)	4 613 (d)	4 400 (d)	4 200 (d)	3 980 (d)	3 450 (d)	3 000
Hungary	1 855	1 755	1 766	1 250	1 300	900	0	0
India	3 780	3 898	NA	NA	NA	4 000	4 000	NA
Kazakhstan	11 800	10 550	8 050	6 850	6 000	5 100	4 800	4 200
Namibia	1 266	1 240	1 246	1 246	1 189	1 254	1 104	1 009
Niger	2 340	2 118	2 104	2 109	2 070	2 033	2 002	1 942
Portugal	94	52	46	52	56	57	61	61
Romania	xxxx	xxxx	6 500	6 000	5 000	4 550	3 400	2 867
Russian Federation	xxxx	15 900	14 400	14 000	13 000	12 900	12 800	12 500
Slovenia (d)	150	145	145	140	115	105	NA	NA
Spain	232	186	185	183	178	172	148	135
United States	682	380 (e)	452 (e)	535 (e)	689 (e)	793 (e)	911 (e)	NA
Uzbekistan	NA	NA	6 688	7 378	8 201	8 230	8 165	8 230
TOTAL	****	****	63 829	59 665	56 827	57 279	53 663	****

NA Data not available.
xxxx National entity not in existence or politically redefined.
**** No estimate due to insufficient information.
(a) Olympic Dam does not differentiate between copper, uranium, silver and gold production. Employment has been estimated for uranium related activities.
(b) Data as of end of year, for mine site employment only.
(c) Data includes former GDR.
(d) Employment related to decommissioning and rehabilitation.
(e) Does not include 491 person-years in 1993, 528 in 1994, 573 in 1995, 429 in 1996, 303 in 1997, and 209 in 1998 for employment in reclamation work relating to exploration, mining, milling, and processing.

Table 12. **Percentage distribution of world production by material source**

Material Source	1996	1997	1998
Open Pit	39%	49%	47%
Underground	40%	32%	34%
ISL	13%	13%	14%
Other*	8%	6%	5%

* Phosphate and gold by-product, heap and in-place leaching and mine water recovery.

As shown, conventional mining and milling has remained the dominant technology for producing uranium. Conventional mining contributed about 80% of the uranium production in 1996 to 1998. In 1997 and 1998 the relative proportion of open pit mining contributed substantially more than underground mining. This resulted from a large increase in production at Key Lake, Canada, as well as increases in Niger and Namibia. The share produced by ISL technology increased modestly from about 13 to 14% of total world production.

The share from “Other” declined from about 8 to 5% of the total. This occurred because of decreasing use of in-stope leaching in the Russian Federation, as well as decreasing production from phosphate processing. On a worldwide scale recovery of by-product uranium during phosphate processing is of minor importance. As of 1 January 1997, only 3 phosphate by-product plants, with a total aggregate production capability of about 495 tU per year, were reported to be in operation. This included two plants in the USA and one in Belgium, with respectively, 450 and 45 tU annual capability. This aggregate capability is equivalent to about 1.4% of 1998 production. However, by early 1999 production at these 3 plants had been suspended. Most of the remaining production in “Other” was by heap and stope leaching.

It is expected that the use of conventional production technology will increase, with particular emphasis on underground mining. ISL technology could maintain its relative share if planned new projects are brought into production. Recent start-ups include Smith Ranch, USA, and Beverley, Australia, which began production in 1998 and 1999, respectively. Additional projects are planned in Australia, China, Kazakhstan, the Russian Federation and Uzbekistan.

The prevailing low market prices of recent years have, in most cases, meant that only those deposits amenable to competitive low cost production are being operated and/or developed for future production. Low-cost uranium production from new projects is expected to be primarily from high-grade unconformity-type deposits and sandstone-type deposits amenable to ISL mining technology. Australia and Canada are the only countries with known unconformity-type resources. In Canada, four projects designed to exploit this type of deposit are in various stages of the development process, or are in production.

Three of the four new Canadian projects (e.g., Cigar Lake, McArthur River, Midwest Lake and McClean Lake) currently employ or will employ underground mining technology to produce ore. McClean Lake will also rely on open pit mining. With the exception of Cluff Lake, which is expected to close in 2000, these are the first mines in Canada to exploit high-grade unconformity-type deposits using underground mining technology.

Following the change of government policy in March 1996 the development of new uranium projects in Australia was launched. Two of the new mines exploit unconformity-type deposits. Jabiluka is to be mined underground and Ranger-3 is being mine by open pit. Kintyre, planned as an open pit mine, has been deferred to await more favourable market conditions. The new Beverley project in south Australia is being developed using acid ISL technology. This is the first commercial scale acid leach ISL uranium project in the western world.

Projected production capabilities

To assist in developing projections of future uranium availability, member countries were asked to provide projections of their production capability through 2015. Table 13 shows the projections for Existing and Committed production centres (A-II columns) and for Existing, Committed, Planned and Prospective production centres (B-II columns) in the $80/kgU or less category through 2015 for all uranium producing countries.

A total of 12 countries, including the major producers (Australia, Canada, Kazakhstan, Niger, Russian Federation, South Africa, USA and Uzbekistan) plus Brazil, Gabon, Mongolia and Portugal reported their production capability based on RAR and EAR-I in the $40/kgU or less cost category. This includes first time reports in this category for Canada. Therefore, a large proportion of the production capability through 2015 in Table 13 is based on resources recoverable at costs of $40/kgU or less. In the A-II category, these proportions are: 1999 (81%), 2000 (76%), 2001 (77%), 2005 (77%), 2010 (63%) and 2015 (64%); and in the B-II category they are: 1999 (81%), 2000 (80%), 2001 (79%), 2005 (63%), 2010 (55%) and 2015 (57%).

Uranium producing countries not reporting projected production capabilities include China, India, Pakistan and Romania. For India, Pakistan and Romania, the projections are made based on the reports that these countries intend to meet their future domestic reactor requirements. China reports capability to meet only its short-term requirements unless new resources are discovered. There is no assurance, however, that these four countries have enough RAR and EAR-I resources to meet their requirements through 2015.

In 1999, the production capability of Existing and Committed production centres, reported by selected countries, was about 45 800 tU per year. For comparison, the 1998 uranium production for these selected countries was 35 000 tU, or about 76% of the 1999 production capability. In 1999 with projected plant capacity utilisation at about 75%, Existing and Committed capability was about 74% of 1999 world uranium requirements (Table 15). The total capability for 1999, including Planned and Prospective centres, was about 46 000 tU. This was below the capability level expected for 1999 (between 48 500 tU to 59 800 tU) in the 1997 Red Book.

By 2000, the production capability of Existing and Committed production centres was expected to decrease to about 43 800 tU. Planned and Prospective centres could add another 1 900 tU (or 4%), giving a total capacity of about 45 750 tU.

By 2001, production from Existing and Committed centres is expected to remain constant. About 46%, or 20 030 tU, of this capacity is located in two countries - Canada (27%) and Australia (19%). An additional 45% (19 590 tU) of the total is located in Kazakhstan, Namibia, Niger, the Russian Federation, South Africa, the USA and Uzbekistan. Planned and Prospective centres are expected to add about 4 470 tU for a total of about 47 200 tU. This is about 12 500 tU (or 20%) below the total production capability that was projected for 2000 in the 1997 Red Book.

The uranium production industry will continue experiencing rapid change over the next 5 to 10 years. By 2005, Existing and Committed capability would decline to about 41 700 tU, or about 60 to 70% of requirements, depending on the development of nuclear power over the next 6 years. However, additions of Planned and Prospective centres would make available an additional 19 400 tU per year or about 32% of total annual capability. The total capability would be 61 200 tU for this year. This would exceed the low world uranium requirement projections by 4 000 tU, but would fall short of the high requirement projections by about 9 200 tU.

The expected closure of existing mines due to resource depletion would cause Existing and Committed capability to slowly fall to 37 600 tU by 2010 and to continue to decline to about 33 000 tU by 2015. Existing and committed capability would be 50 to 60% of projected requirements by 2010. The projected continued reduction through 2015 implies that only between 40 and 60% of world requirements, expected to range between 54 500 and 79 800 tU/year, would be covered.

Total Existing, Committed, Planned and Prospective capability would be about 64 800 tU in 2010. This exceeds the low requirements projections for this year but falls short of the high projection by about 8 400 tU. By 2015 the total capability would then decline to about 55 000 tU. This exceeds total world requirements in the low case, but is only 69% of the high case requirements.

An important conclusion from this analysis is that there is sufficient projected capability at the low cost level to satisfy a considerable part of the expected uranium requirements through 2015. Based on the reported data, between 40% and 60% of the expected uranium requirements in 2015 could be satisfied with resources recoverable at $40/kgU or less. Resources recoverable at higher costs and additional supplies would be necessary to fill the potential production shortfall indicated by some of the projections. Significant additional material would likely come from alternative supplies including fuel reprocessing, excess inventory drawdown, re-enrichment of depleted tails from enrichment, and low enriched uranium (LEU) obtained from the blending of highly enriched uranium (HEU) from warheads and from government stockpiles. It is probable that LEU from HEU weapons material would be the second largest supply source after production.

Changes in production facilities

A review of the information reported in 1999 indicates that while some Planned and Prospective capability has been added, some facilities existing in 1997 were closed before their resource base was exhausted. In some cases, these closures correspond to higher cost producers unable to economically compete with lower cost producers. In general, there has been a replacement of smaller and higher cost facilities with larger and more cost effective facilities.

Because the addition of new capacity has about offset the closing of already Existing capacity there has been little change between the amount of Existing and Committed production capability in recent years. In addition, some Planned and Prospective capacity was not added as planned. For example, the production capability of the USA in 1999 is less than had been projected in the 1997 Red Book.

Some of the changes that occurred or are expected to occur in uranium production facilities in the 1997-1999 period and following years include:

Facility closures

- 1997: Brazil (Poços de Caldas, 425 tU); France (Lodève, 1 000 tU); Hungary (Pécs, 650 tU); South Africa (Western Areas, 200 to 300 tU);
- 1998: Belgium (PRT Phosphate, 45 tU); USA (Uncle Sam Phosphate, 290 tU);
- 1999: Canada (Eagle Point, 3 900 tU); Gabon (Mounana, 540 tU); USA (Kingsville Dome ISL, 500 tU; Rosita ISL Mine, 380 tU; Sunshine Bridge Phosphate, 160 tU);
- 2000: Canada (Cluff Lake, 1 900 tU); Spain (Fe Deposit, 800 tU)

New mines opening

- 1998: USA (Smith Ranch ISL, 769 tU).
- 1999: Australia (Beverley, 760 tU); Brazil (Lagoa Real, 300 tU); Canada (McClean Lake, 2 300 tU).

Table 13. **World uranium production capability to 2015** (in tU/year, from resources recoverable at costs up to $80/kgU, except as noted)

COUNTRY	1999		2000		2001		2005		2010		2015	
	A-II	B-II	A-II	B-II	A-II	B-II	A-II	B-II	A-II	B-II	A-II	B-II
Argentina	40	40	40	40	40	40	NA	NA	NA	NA	NA	NA
Australia (d)	5 700	5 700	8 200	9 000	8 200	9 900	10 500	13 200	10 500	15 800	7 300	12 600
Brazil (c)	150	150	250	250	250	250	250	575	250	575	250	575
Canada (d) (f)	17 150	17 150	11 830	11 830	11 830	11 830	11 045	17 945	7 550	15 650	7 550	13 350
China (b) (g)	740	740	740	840	740	1 040	740	1 560	740	1 560	740	1 560
Czech Republic	680	680	680	680	660	660	110	110	84	84	87	87
France	600	600	600	600	300	300	0	0	0	0	0	0
Gabon (c)	295	295	0	0	0	0	0	0	0	0	0	0
India (a) (b) (e)	207	207	210	210	210	210	210	560	210	860	210	860
Kazakhstan (d)	2 000	2 000	2 500	2 500	2 800	2 800	3 500	4 500	3 500 b)	4 500 b)	3 500 b)	4 500 b)
Mongolia (c) (h)	150	150	150	250	150	500	150	1 100	150	1 100	150	1 100
Namibia	4 000	4 000	4 000	4 000	4 000	4 000	4 000	4 000	4 000	4 000	4 000	4 000
Niger (c)	2 910	3 110	2 910	3 410	2 910	3 410	NA	NA	NA	NA	NA	NA
Pakistan (b) (e)	30	30	30	65	30	65	30	110	30	110	30	300
Portugal (d)	170	170	170	170	170	170	170	170 b)	170	170 b)	170	170 b)
Romania (a) (b) (e)	300	300	300	300	300	300	300	300	300	300	300	300
Russian Fed. (c)	2 500	2 500	2 500	2 500	2 500	2 700	2 500	3 500	2 500	5 000	2 500	5 000
South Africa (b) (c)	1 700	1 700	1 700	1 700	1 700	1 700	1 700	1 700	1 700	1 700	1 700	1 700
Spain	255	255	255	255	NA	NA	NA	NA	NA	NA	NA	NA
Ukraine (e)	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 500	1 000	2 000	1 000	2 000
United States (d)	2 930	2 930	3 468	3 852	3 660	4 045	3 235	7 362	2 608	8 358	1 258	3 920
Uzbekistan (c)	2 300	2 300	2 300	2 300	2 300	2 300	2 300	3 000	2 300	3 000	2 300	3 000
TOTAL	45 807	46 007	43 833	45 752	43 750	47 220	41 740	61 192	37 592	64 767	33 045	55 022

A-II Production Capability of Existing and Committed Centres supported by RAR and EAR-I recoverable resources.

B-II Production Capability of Existing, Committed, Planned and Prospective Centres supported by RAR and EAR-I recoverable resources.

NA Data not available.

(a) From resources recoverable at costs of $130/kgU or less.

(b) Secretariat estimate.

(c) From resources recoverable at costs of $40/kgU or less.

(d) From resources partially recoverable at costs of $40/kgU or less.

(e) Projections for India, Pakistan, Romania and Ukraine are based on the countries' stated plans to produce to meet domestic requirements.

(f) From resources recoverable at costs of $40/kgU or less in A-II for all years. In B-II resources recoverable at costs between $40/kgU and $80/kgU are 6 900, 8 100 and 5 800 tU in 2005, 2010 and 2015, respectively.

(g) Projections are based on China's report of enough capability to meet its short term requirements.

(h) OECD/NEA-IAEA, "Uranium 1997 – Resources, Production and Demand", OECD, Paris, 1998.

Expansion of exiting facilities

- 1999: Australia (Olympic Dam facility expansion by 2 290 tU to 3 900 tU and Ranger mill expansion of 1 270 tU to 4 240 tU); Canada (Key Lake mill).

New mines planned

- 2000: Australia (Honeymoon, 850 tU); Canada (McArthur River, 6 900 tU to be processed through expanded Key Lake mill); Russian Federation (Transural ISL project, capacity not published).
- 2002: Canada (Cigar Lake, 4 600 tU to be processed though McClean Lake and Rabbit Lake mills).

D. RADIATION SAFETY AND ENVIRONMENTAL ASPECTS

This section presents an overview of the varied uranium mining efforts dedicated to radiation safety and environmental protection (additional information can be found in the country reports). In general, efforts are directed to four main areas of emphasis. One is the rehabilitation of mine and mill sites no longer in operation, in many instances where project operators no longer exist and where legal provisions for proper decommissioning and rehabilitation were insufficient. A second relates to the increasing attention paid to environmental protection and environmental monitoring in ongoing or planned operations, as well as the decommissioning of recently closed sites. A third relates to efforts to update or establish legislation and a regulatory regime that is consistent with recently introduced international standards. Overlaid on the latter two activities is the increased use of environmental assessments as a planning tool for evaluating all phases of uranium operations prior to the approval, start-up or closure of the operation. A joint OECD/NEA-IAEA report on “Environmental Activities in Uranium Mining and Milling” containing more detailed information from participating countries was published by the OECD/NEA in 1999.

North America. In **Canada**, the Joint Federal Provincial Panel on Uranium Mining Developments in Northern Saskatchewan presented its final report to governments in November 1997. The federal and provincial governments responded in early April 1998, agreeing with the Panel that the Midwest and Cigar Lake uranium mines should proceed to the licensing stage, subject to certain site specific conditions. This brings to a close the comprehensive environmental assessment process for all currently planned uranium mine developments in northern Saskatchewan. Since release of the final Joint Panel report, however, Cameco announced plans to mill a portion of the Cigar Lake ore at Rabbit Lake, rather than at McClean Lake as originally planned. Since this is a significant departure from the project reviewed by the Joint Panel, an environmental assessment of this new milling plan is required, as is COGEMA Resources Inc.'s plan to suspend operations at Cluff Lake. Both of these environmental assessments are ongoing. In following the recommendations of the environmental assessment panels and regulatory requirements, uranium-mining companies devote significant resources and effort to environmental protection. To date, Canadian uranium producers have committed over CAD 100 million to the environmental management of existing uranium mines (over CAD 20 million in 1998 alone). Beyond this significant financial and operational commitment to environmental protection, uranium producers make significant contributions to the sustainable development of these resources through training, employment and increased business opportunities for northern Saskatchewan residents, as well as training and funding for local environmental monitoring committees, and the development of a community health and vitality database. In addition, uranium mining companies have committed over CAD 70 million to the decommissioning of the Elliot Lake mine sites (over CAD 8 million in 1998). Uranium mining companies operating in Canada have also posted letters of credit amounting to over CAD 135 million for the decommissioning and closure of the uranium mining and milling sites currently in operation. Uranium producers in Canada will soon be operating under a new regulatory regime, as it is anticipated that the *Nuclear Safety and Control Act (NSCA)* will come into force in 2000.

In the **USA**, since no conventional mills and half the non-conventional plants were on standby at the end of 1998, decommissioning was the main focus of environmental efforts. The Uranium Mill Tailings and Radioactive Control Act of 1978 vests the U.S. Environmental Protection Agency with the power to establish standards for decommissioning uranium production facilities, while the U.S. Nuclear Regulatory Commission licenses and regulates decommissioning, along with uranium production and related activities. A 1995 U.S. study found that, on average, reclamation of uranium mill tailings accounted for approximately 54% of overall decommissioning costs for conventional uranium mill sites. Total decommissioning costs averaged USD 14.1 million per site. This includes USD 7.7 million for tailings reclamation, USD 2.3 million for groundwater restoration, USD 0.9 million for mill dismantling, and USD 3.2 million for indirect costs. For non-conventional (in situ leach) sites, the average decommissioning cost was USD 7.0 million (USD 2.8 million for groundwater restoration, USD 0.9 million for well field reclamation, USD 0.6 for dismantling of buildings and plant structures, USD 1.2 million for reclaiming evaporation ponds, disposal wells, radiometric surveys, etc., and USD 1.4 million for indirect costs). Reclamation of some U.S. abandoned uranium production facilities, including mine plant and spoil sites, is performed by State agencies.

Central and South America. In **Argentina**, the final cost for clean-up and restoration of the Malargüe mill amounted to about USD 12 million. Efforts are now focused on rehabilitation of the closed Los Gigantes mine and mill complex. In **Brazil**, site monitoring and development of a decommissioning plan for the Poços de Caldas mine and mill complex, and completion of an environmental impact assessment of the planned Lagoa Real production centre, were the dominant environmental activities in recent years.

Western Europe and Scandinavia. In **Finland**, both major power companies, Teollisuuden Voima Oy (TVO) and Imatran Voima Oy (IVO, now part of the Fortum Group), established the Posiva Oy company to develop a nuclear waste disposal programme. Studies related to the concept of disposing spent nuclear fuel in Finnish bedrock continue. In **France**, efforts are focused on closed mining and milling sites. Total expenditures for decommissioning the Forez, Hérault, La Crouzille, Vendée and other sites amounted to almost FRF 675 million to the end of 1998, with an additional FRF 90 million budgeted in 1999. In **Germany** uranium mining ended in 1990, and WISMUT GmbH has been actively carrying out major decommissioning and restoration activities since then. By the end of 1998, about 90% of underground rehabilitation work had been completed. Remediation of waste rock piles, stabilisation of mine spoil, chemical processing of uranium ores at the milling facilities, rehabilitation of tailings and disposal facilities, demolition of production plants and buildings, water treatment, and monitoring of air and water quality in the vicinity of these facilities are ongoing. By the end of 1998, approximately 5.7 billion DEM of the estimated 13 billion DEM required to complete all decommissioning and remediation needs had been spent. In **Spain**, decommissioning and restoration of La Haba mining and milling centre is complete, and a five-year supervision programme for the verification of the decommissioning design criteria for the centre was approved in January 1998. Restoration work of twelve closed uranium mines in the Extremadura region, expected to be completed in 1999, is proceeding on schedule. Restoration of six additional uranium mines in the Andalucia region is scheduled to be completed early in the year 2000. Total costs for these remediation activities amounted to 1 330 million ESP to end of 1998, with an additional 3 660 million ESP devoted to the environmental management of existing uranium production operations. In **Sweden** the decommissioning and rehabilitation of the Ranstad mine is now complete. It is estimated to have cost a total of 150 million SEK. Monitoring of the site is ongoing. In **Portugal**, decommissioning the Urgeiriça, Castelejo, Cunha Baixa, Sevilha and Quinta do Bispo mines continues. Studies are being carried out to characterise the local geochemical and hydrochemical setting and to establish mitigation measures for the waste piles of the Cunha Baixa mine and the Quinta do Bispo heap leaching mine. In 1998, a total of 23 million PTE was devoted to these activities, with an additional 32 million PTE spent on the environmental management of the single operating heap leaching mill at Urgeiriçia.

Central, Eastern and South East Europe. Uranium mining and milling in the **Czech Republic** led to serious environmental impacts that will require significant resources over the next several years to mitigate. With reduced uranium production, this is now the central DIAMO activity. Efforts are focused on decommissioning the Hamr, Olší, Jasenice-Pucov, Zadní Chodov, Okrouhlá Radoun and Licomerice-Brezinka mines, remediation of the Stráz ISL mine and tailings impoundments and the tailings impoundments at Príbram, and recultivation of the tailings impoundments of the MAPE Mydlovary ore processing plant. One of DIAMO's major remediation measures is the construction of a mine water processing plant at Horní Slavkov, which was expected to begin 1999. The total cost of these remediation efforts amounted to 954 million CZK in 1998, with an additional 28.6 million CZK devoted to environmental management at the one remaining production centre in operation. In **Hungary**, a feasibility study of stabilising and remediating tailing ponds in the Mecsek region was finalised following closure of the mines in 1998. Demolition of the ore processing plant began in 1999, and the remediation programme will continue until the end of 2002. The total cost of environmental management was over 7.0 billion HUF to the end of 1998. Because mining and processing activities in **Poland** ceased more than 25 years ago and the companies responsible for the associated environmental problems no longer exist, remediation activities are entirely government funded. Only a limited number of serious impacts have been identified, the most important of which is the tailings pond in Kowary. This 1.3 ha facility is dammed on three sides and is considered to be at the limit of geotechnical stability. A remediation programme has been developed to construct drainage systems and cover the tailings pond. In addition, a remediation programme for uranium liabilities in the Lower Silesia region is currently being prepared by local authorities. In **Romania**, the environmental protection programme is currently focused on increasing water treatment capabilities in the Eastern Carpathians, Apuseni and Banat Mountains, increasing tailings impoundment capacities, processing and closure of ore storage areas at various mines, as well as the long-term stabilisation, reclamation and revegetation of waste dumps and surrounding environs. In **Ukraine**, although mines are not currently being decommissioned, a programme is being conducted by VostGOK to clean up and rehabilitate sites in Zheltiye Vody contaminated by uranium mill tailings. In addition, a State Programme for Improvement of Radiation Protection at Facilities of the Atomic Industry of Ukraine has been established. With a budget of USD 360 million, this programme will cover all sites and environmental issues associated with uranium mining and milling.

Africa. In **Gabon,** following the March 1999 termination of all uranium mining, the Government initiated a programme to rehabilitate seven sites comprising the 60 hectare Mounana mining and milling operational area. The programme, planned for 1999 and 2000, involves dismantling the mill and related facilities, closure of tailings impoundments, site clean-up and revegetation. The programme objective is to assure a residual radiological impact that is as low as is reasonably achievable, while insuring the physical stability of the impoundments, and to the extend possible, provide for the future utilisation of the effected area. A long-term programme for monitoring and surveillance of the tailings impoundment will also be implemented. In **Namibia** environmental activities are currently governed by policy directives, but an Environmental Act and an Integrated Pollution Control and Waste Management Bill are in preparation. An associated Environmental Fund will be established to ensure that financial resources are available for mine rehabilitation. Including 1998, environmental management costs amounted to over 40 million ZAR, with an additional 1.8 million ZAR budgeted for 1999. **South Africa** has strict environmental legislation that ensures that areas contaminated by radioactivity are suitably rehabilitated, in particular where uranium plants are or were located. Environmental issues related to gold/uranium mining on the Witwatersrand are dust pollution, surface and groundwater contamination and residual radioactivity. Closed gold-uranium plants are currently being decommissioned. Although the by-product status of all uranium production in South Africa makes it impossible to allocate environmental costs specifically to uranium mining activities, the mining industry in general expends considerable resources on environmental aspects in all stages of their activities.

Middle East, Central and South Asia. In **Jordan**, a systematic study and evaluation of the uranium concentration in Jordan's phosphate deposits was conducted to assess the environmental effects of the uranium. In **Kazakhstan**, efforts are focused on wastes associated with closed and operating uranium production facilities, as well as on the environmental impacts of in situ leach mining. All uranium mine and mill sites were inventoried in 1997 and 1998, and it was determined that out of 100 waste storage sites only 5 or 6 have exerted significant environmental impacts, mainly related to the uncontrolled use of waste materials for construction by local inhabitants. Currently, a study of in situ leach acquifer interaction is being conducted in conjunction with the International Atomic Energy Agency. In **Uzbekistan**, the focus is also on areas affected by past conventional mining and milling, as well as the environmental impacts associated with the operation of in situ leach facilities. The Navoi Mining and Metallurgical Complex has implemented a step-by-step programme for evaluating and, where necessary, reclaiming areas impacted by over thirty years of uranium production. For example, at Navoi's hydrometallurgical plant a system of wells has been installed to monitor and control potential groundwater contamination from the tailings impoundment, and research is underway to develop a tailings impoundment burial system for implementation by 2005. In **India**, the management of environmental impacts is the responsibility of the Health Physics Group of the Bhabha Atomic Research Centre in Bombay. This Group monitors radiation, radon and dust impacts at uranium production facilities as well as operating an Environmental Survey Laboratory at Jaduguda.

Pacific Area. In **Australia**, the Ranger mine is currently the only operating mine in the Northern Territory. The Nabarlek mine ceased production and has been successfully rehabilitated, and environmental monitoring of the site is ongoing. The Commonwealth Government is responsible for supervising the environmental management of both these mines and the planned Jabiluka mine. The Supervising Scientist of the Commonwealth Office has consistently attested to the high level of environmental protection achieved and noted that mining operations have had a negligible impact on the surrounding environment. Construction at the Jabiluka mine commenced in June 1998 following a comprehensive joint Commonwealth/Northern Territory environmental impact assessment process. Efforts to obtain the consent of traditional Aboriginal owners to implement the preferred option to mill Jabiluka ore at the Ranger mill is ongoing but, because consent has not been granted, an alternative option of developing a stand alone mill at Jabiluka is being developed. The Olympic Dam project is regulated under South Australian State Government legislation. This legislation requires the operator to draft and implement an Environmental Management Programme. In 1996, Western Mining Corporation announced its intention to expand its Olympic Dam project to produce up to 350 000 t/year of copper plus associated products (uranium, gold and silver). The expansion proposal underwent a joint Commonwealth/South Australia environmental assessment process, and the first phase of the expansion of Olympic Dam to 200 000 t/year of copper was completed ahead of schedule by the end of the first quarter of 1999. The Heathgate Resources Pty Ltd (Heathgate) plan to develop an in situ leaching (ISL) uranium mine at Beverley was the subject of a joint Commonwealth/South Australia environmental assessment process and, after confirmation that the northern component of the Beverley aquifer is effectively sealed from surrounding groundwater, the project was approved, with certain site specific conditions. The Southern Cross Resources Australia Pty Ltd's plan to develop an ISL uranium mine at Honeymoon is also undergoing a joint Commonwealth/South Australia environmental assessment process, with the EIS scheduled to be released for public comment in late 1999. A joint Commonwealth/Western Australia environmental assessment process was initiated in response to the proposal submitted in 1996 by Canning Resources Pty Ltd (a subsidiary of Rio Tinto Ltd) to develop the Kintyre uranium deposit. However, in August 1997 Rio Tinto announced Kintyre's development had been put on hold because of falling uranium prices and delays in native title approvals.

East Asia. In **China**, many years of experience in uranium production led to the development of new regulations to control, monitor and reduce the environmental impacts of uranium production. Control measures utilised include backfilling waste rock and tailings into mined out areas, the treatment of mine water and used process water, and covering waste and tailings piles to reduce radon release. Extra high voltage electrostatic filters have been installed at the Fuzhou and Hengyang ore processing plants to reduce the release of fly dust. In addition to the environmental measures introduced at operating production centres, five closed uranium mines and mills have been completely decommissioned, and a number of others are in the process of being decommissioned.

II. URANIUM DEMAND

This chapter summarises the current status and projected growth in world nuclear generating capacity and commercial reactor-related uranium requirements. Relationships between uranium supply and demand are analysed and important developments related to the world uranium market are described. Particular attention is given to certain issues related to secondary supplies that are significantly affecting the uranium market. These issues include the availability of excess inventories, the disposition of surplus defence material by the Russian Federation and the United States, and the restrictions on the sale of NIS produced uranium in the United States and in the European Union. The last section of the chapter explores the potential impact of recent developments on the long-term perspective.

A. CURRENT NUCLEAR GENERATING CAPACITY PROGRAMMES AND COMMERCIAL REACTOR-RELATED URANIUM REQUIREMENTS [1]

World (351 GWe net on 1 January 1999). World nuclear electricity generation has roughly doubled over the last decade, and the cumulative nuclear electricity generation now exceeds 34 000 TWh. Nuclear power plants supply about 5% of the world's total energy consumption and some 16% of the world's electricity. By the beginning of 1999, there were 434 nuclear power units operating in the world with a total net capacity of 351 GWe (net gigawatts electric) connected to the grid (see Table 14 and Figures 9 and 10). A total of 36 new reactors are under construction with a capacity of about 28 GWe. In recent years, however, the growth in nuclear power has slowed considerably.

In 1997, three new reactors totalling 3.6 GWe were connected to the grid and construction of five reactors with a total capacity of 4.4 GWe started in China (3) and the Republic of Korea (2). In 1998, four reactors were connected to the grid with a capacity of 2.9 GWe, three in the Republic of Korea and one in the Slovak Republic, and construction of four reactors (3.6 GWe) started in China (2), Chinese Taipei (1) and Japan (1). In 1999, six additional reactors (4.1 GWe) were expected to achieve grid connection.

World annual uranium requirements in 1998 were estimated at about 59 600 tU (see Table 15 and Figure 11). An increase of about 2 000 tU was expected for 1999.

While the world's nuclear capacity and uranium requirements have steadily increased each year, the growth rates within various regions of the world vary considerably (see Figures 12 and 13).

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1. Some of the statistical data provided in the following sections are from: IAEA, *Nuclear Power Reactors in the World*, Reference Data Series No. 2, 1999, IAEA, Vienna, Austria.

Table 14. **Installed nuclear generating capacity* to 2015 (MWe net)**

COUNTRY	1998	1999	2000	2005		2010		2015	
				Low	High	Low	High	Low	High
Algeria	0	0	0	0	0	0	0	0 a)	300 a)
Argentina	940	940	940	940 a)	1 630 a)	600 a)	1 290 a)	600 a)	1 290 a)
Armenia	408	408	408	0	408	0	408	0 a)	600 a)
Bangladesh	0	0	0	0	0	0	0	0 a)	300 a)
Belarus	0	0	0	0	0	0	0	0 a)	1 000 a)
Belgium	5 713	5 713	5 713	5 713	5 713	5 713	5 713	5 713	5 713
Brazil	630	1 875	1 875	3 120	3 120	3 120	3 120	1 250 a)	3 740 a)
Bulgaria	3 538 c)	3 538 a)	3 538 a)	2 720 a)	3 538 a)	2 310 a)	3 680 a)	1 910 a)	3 270 a)
Canada	10 300	10 300	10 300	10 300	13 100	10 300	14 700	10 300	11 700
China (d)	2 100	2 100	2 100	7 700	8 700	15 000	18 000	18 000	23 000
Croatia	0	0	0	0	0	0	0	0 a)	600 a)
Cuba	0	0	0	0	0	0 a)	410 a)	0 a)	820 a)
Czech Rep.	1 648	1 648	2 560	3 472	3 472	3 472	3 472	3 472	3 472
Egypt	0	0	0	0	0	0	0	0 a)	1 200 a)
Finland	2 650	2 650	2 650	2 650	2 650	2 650	2 650	2 650	2 650
France	61 700	63 100	63 100	62 900	62 900	62 900	62 900	62 900	62 900
Germany	21 100	21 100	21 100	21 000	21 000	21 000	21 000	21 000 a)	21 000 a)
Hungary	1 800	1 800	1 800	1 800	1 800	1 800	1 800	1 800	1 800
India	1 695	2 099	2 503	2 503	2 503	4 525	5 647	5 647 a)	5 647 a)
Indonesia	0	0	0	0	0	0	0	0 a)	1 800 a)
Iran	0	0	0	0 a)	1 000 a)	1 000 a)	2 000 a)	1 000 a)	2 000 a)
Japan	45 082	45 082	45 082	45 400 b)	45 400 b)	70 500	70 500	70 500 a)	79 340 a)
Kazakhstan	70 c)	0	0	0 a)	0 a)	0 a)	0 a)	0 a)	1 200 a)
Korea, DPR	0	0	0	0	0	0 a)	950 a)	950 a)	1 900 a)
Korea, Rep.	12 000	13 700	13 700	17 700	17 700	23 400	23 400	27 700	27 700
Lithuania	2 760	2 760	2 760	2 370 a)	2 370 a)	2 370 a)	2 370 a)	1 190 a)	2 370 a)
Malaysia	0	0	0	0	0	0	0	0 a)	1 000 a)
Mexico	1 308	1 308	1 370	1 370	1 370	1 370	1 370	1 370	1 370
Morocco	0	0	0	0	0	0	0	0 a)	600 a)
Netherlands	449	449	449	0 a)	0 a)	0 a)	0 a)	0 a)	0 a)
Pakistan	125 c)	125 a)	430 a)	300 a)	730 a)	600 a)	600 a)	600 a)	2 000 a)
Philippines	0	0	0	0	0	0	0	0 a)	900 a)
Poland	0	0	0	0	0	0	0	0 a)	1 200 a)
Romania	650	650	650	1 300	1 300	1 300	1 950	1 300	1 950
Russian Federation	21 242	21 242	21 242	21 242	24 240	21 242	25 240	17 500	25 300
Slovak Republic	2 025	2 430	2 430	1 620	2 430	1 620	2 025	810	1 620
Slovenia	632 c)	632 a)	632 a)	632 a)	632 a)	632 a)	632 a)	632 a)	632 a)
South Africa	1 842	1 842	1 942	1 842 a)	1 942 a)	1 942 a)	1 942 a)	1 942 a)	2 340 a)
Spain	7 300	7 400	7 650	7 650	7 730	7 650	7 730	7 650	7 730
Sweden	10 000	10 000	9 400	8 800	8 800	8 900 b)	8 900 b)	6 090 a)	9 440 a)
Switzerland	3 117	3 179	3 300	3 300	3 300	3 300	3 300	3 300	3 300
Thailand	0	0	0	0	0	0	0	0 a)	1 000 a)
Turkey	0	0	0	1 300	1 300	2 600	2 600	2 600 a)	2 600 a)
Ukraine	12 880	12 880	12 880	12 880	14 800	14 800	15 800	14 800	15 880
United Kingdom	12 900	12 900 b)	12 100 b)	9 300 b)	9 300 b)	7 000 b)	7 000 b)	8 150 a)	11 750 a)
United States	97 089	97 089	95 605	63 881	95 555	49 217	93 525	22 154	86 800
Viet Nam	0	0	0	0	0	0	0	0 a)	1 000 a)
OECD TOTAL	294 156	297 418	295 879	266 536	301 090	281 772	330 560	257 349	340 465
WORLD TOTAL	350 573	355 819	355 089	331 885	377 913	360 313	425 404	332 960	457 104

(a) IAEA Secretariat estimate. * Capacity installed at end of year.
(b) OECD/NEA, Nuclear Energy Data 1999, Paris, 1999.
(c) IAEA, Nuclear Power Reactors in the World, RDS No. 2, Vienna, Austira, 1999.
(d) The following data for Chinese Taipei are included in the World Total but not in the totals for China: 4 880 MWe until 2000, 6 180 MWe for 2005 low case and 7 480 MWe for 2010 and 2015 low case; and in the high case 7 480, 8 780 and 11 380 MWe for 2005, 2010 and 2015, respectively.

Figure 9. **World Nuclear Electricity Generating Capacity: 351 GWe**
(1 January 1999)

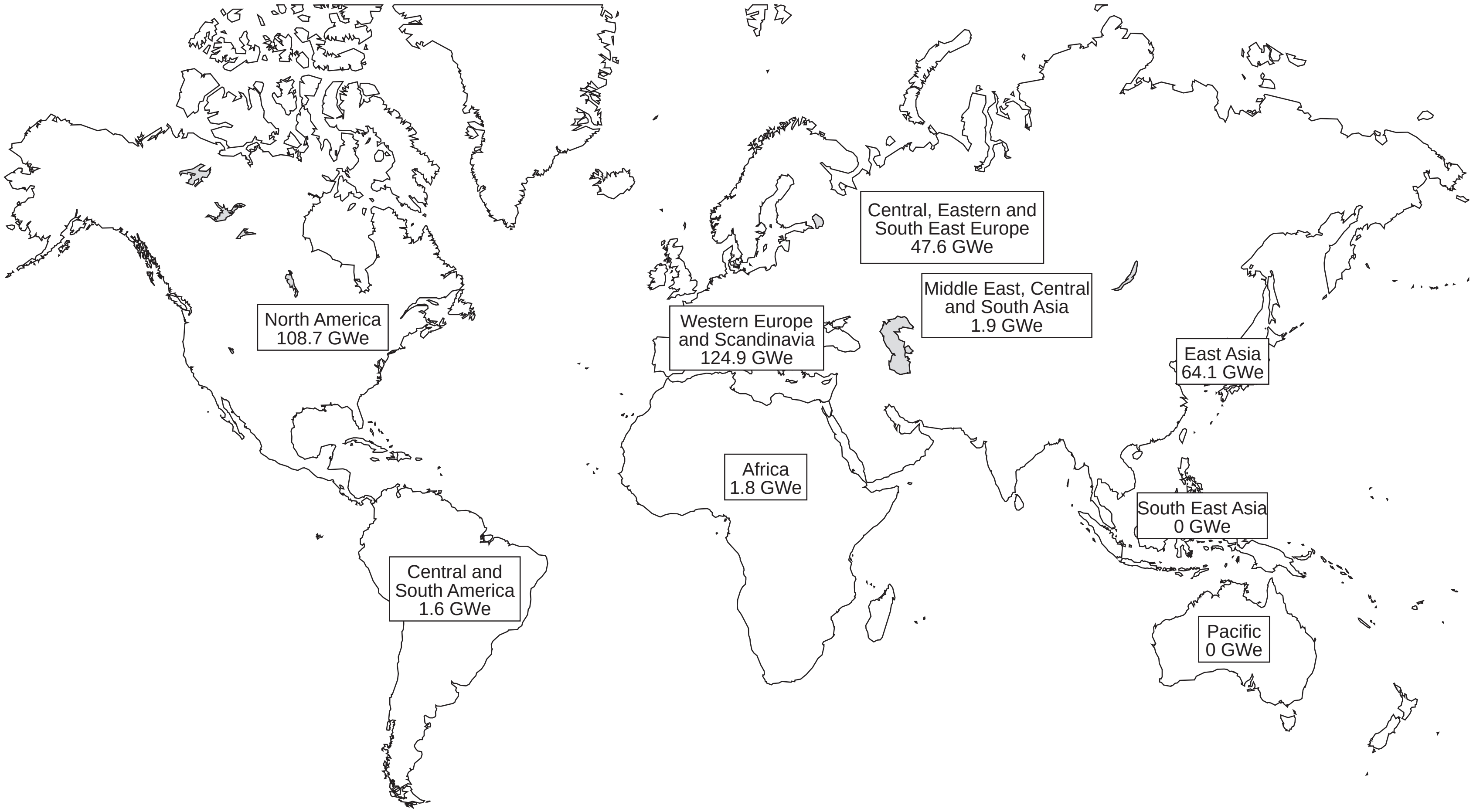


Figure 10. **World Installed Nuclear Capacity: 351 GWe (As of 1 January 1999)**

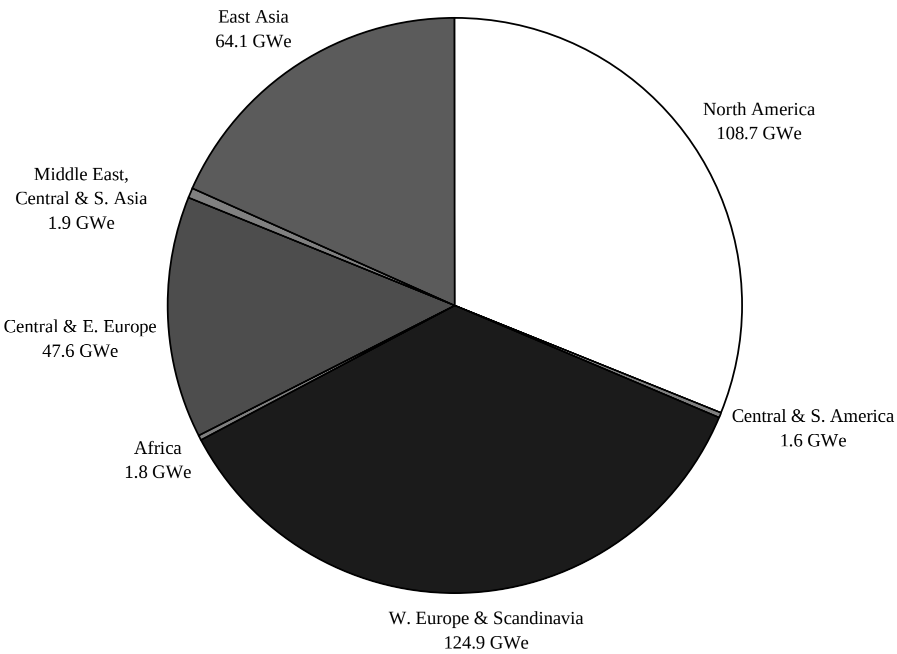


Figure 11. **World uranium requirements: 59 551 tU (as of 1 January 1999)**

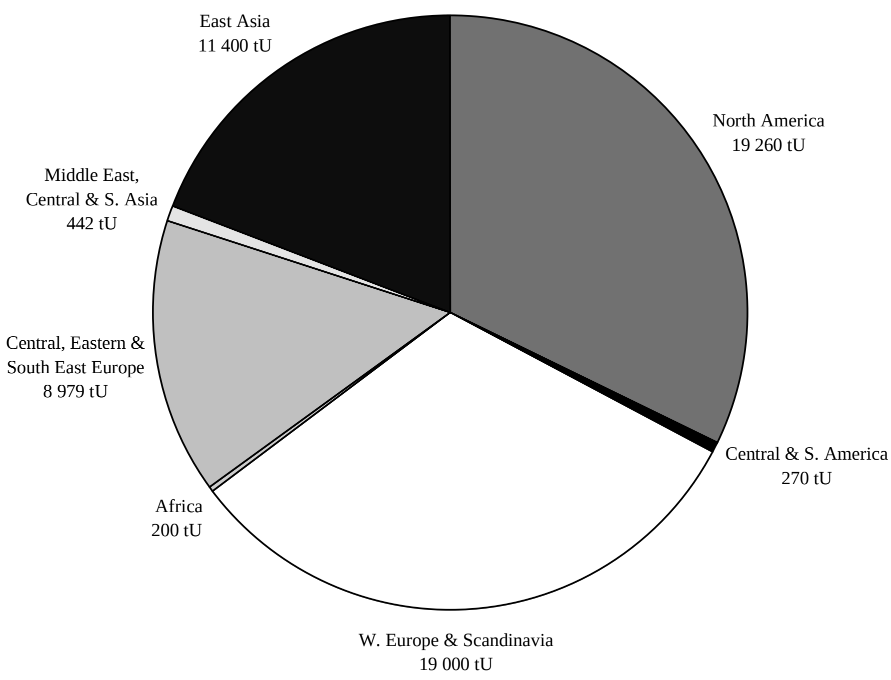


Table 15. **Annual reactor-related uranium requirements to 2015**
(Tonnes U)

COUNTRY	1998	1999	2000	2005 Low	2005 High	2010 Low	2010 High	2015 Low	2015 High
Algeria	0	0	0	0	0	0	0	0 a)	50 a)
Argentina	150	150	150	150 a)	260 a)	96 a)	206 a)	96 a)	206 a)
Armenia	89	89	89	0	89	0	89	0 a)	131 a)
Bangladesh	0	0	0	0	0	0	0	0 a)	50 a)
Belarus	0	0	0	0	0	0	0	0 a)	170 a)
Belgium	1 050	1 050	1 050	1 050	1 050	1 050	1 050	1 050	1 050
Brazil	120	310	450	420	1 040	470	810	470	810
Bulgaria	844 a)	844 a)	844 a)	649 a)	844 a)	551 a)	878 a)	456 a)	780 a)
Canada	1 200	1 300	1 800	1 300	1 800	1 300	2 000	1 300	2 000
China (c)	380	380	380	1 380	1 560	2 700	3 200	3 200	4 000
Croatia	0	0	0	0	0	0	0	0 a)	100 a)
Cuba	0	0	0	0	0	0 a)	70 a)	0 a)	140 a)
Czech Rep.	440	516	602	690	705	690	705	690	705
Egypt	0	0	0	0	0	0	0	0 a)	210 a)
Finland	550	550	557	548	548	545	545	545	545
France	8 200	8 200	8 200	7 800	8 300	7 800	8 300	7 800	8 300
Germany	3 100	3 100	3 200	3 100	3 100	3 000	3 000	3 000 a)	3 000 a)
Hungary	400	400	400	400	400	400	400	400	400
India	376	433	407	560	855	618	861	861	861
Indonesia	0	0	0	0	0	0	0	0 a)	310 a)
Iran	0	0	0	0	170 a)	170 a)	340 a)	170 a)	340 a)
Japan	7 810	9 290	9 700	11 800	11 800	13 000	13 000	14 000	14 000
Kazakhstan	50 a)	0	0	0 a)	0 a)	0 a)	0 a)	0 a)	210 a)
Korea, DPR	0	0	0	0	0	0 a)	160 a)	160 a)	330 a)
Korea, Rep.	2 400	2 500	3 500	3 900	3 900	4 600	4 600	5 200	5 200
Lithuania	480	640	680	412 a)	412 a)	412 a)	412 a)	207 a)	412 a)
Malaysia	0	0	0	0	0	0	0	0 a)	170 a)
Mexico	360	190	184	180	360	178	356	182	365
Morocco	0	0	0	0	0	0	0	0 a)	100 a)
Netherlands	74	74	84	0 a)	0 a)	0 a)	0 a)	0 a)	0 a)
Pakistan	16 a)	16 a)	66 a)	46 a)	112 a)	92 a)	92 a)	92 a)	306 a)
Philippines	0	0	0	0	0	0	0	0 a)	150 a)
Poland	0	0	0	0	0	0	0	0 a)	200 a)
Romania	100	100	100	200	200	200	300	200	300
Russian Federation	3 600	3 600	3 600	3 600	4 100	3 600	4 250	3 000	4 300
Slovak Rep.	566	618	515	347	521	347	434	174	347
Slovenia	110 a)	110 a)	110 a)	110 a)	110 a)	110 a)	110 a)	110 a)	110 a)
South Africa	200	200	220 a)	200 a)	220 a)	220 a)	220 a)	220 a)	300 a)
Spain	1 500	1 150	1 500	1 100	1 500	1 100	1 500	1 100	1 500
Sweden	1 600	1 600	1 500	1 400	1 400	1 400 b)	1 400 b)	1 000 a)	1 500 a)
Switzerland	570	480	480	580	580	580	580	580	580
Thailand	0	0	0	0	0	0	0	0 a)	170 a)
Turkey	0	0	0	260 b)	260 b)	520 b)	520 b)	520 a)	520 a)
Ukraine	2 350	2 433	2 823	2 480	2 823	2 480	2 705	2 705	2 800
United Kingdom	2 356	2 356	2 500 b)	1 764 b)	1 764 b)	1 262 b)	1 262 b)	1 470 a)	2 400 a)
United States	17 700	18 100	17 700	9 800	18 400	8 600	17 500	2 300	17 700
Viet Nam	0	0	0	0	0	0	0	0 a)	170 a)
OECD TOTAL	49 310	50 856	52 957	45 672	55 867	46 025	56 718	41 137	59 965
WORLD TOTAL	59 551	61 589	64 201	57 226	70 383	59 291	73 155	54 458	79 798

(a) Secretariat estimate.
(b) OECD/NEA, Nuclear Energy Data 1999, Paris, 1999.
(c) The following data for Chinese Taipei are included in the World Total but not in the totals for China: 810 tU/year until 2000, 620 tU/year until 2015 for low case, and 620, 830 and 1 040 tU/year for high case until 2005, 2010 and 2015, respectively.

OECD (294.2 GWe). The countries constituting the OECD hold about 84% of the world's nuclear capacity. The installed nuclear generating capacity was reduced by 3.3 GWe over the period from 1996 to 1998 reflecting the permanent and temporary shutdown of nuclear reactors in some OECD countries. A total of 11 reactors are under construction with a capacity of 10.9 GWe. The OECD reactor-related uranium requirements were 49 300 tU for 1998 and they were expected to increase by 3.1% in 1999 to about 50 900 tU.

North America (108.7 GWe). The nuclear generating capacity in this region decreased by 9.2 GWe between 1996 and 1998. In the **United States** the operable capacity was reduced from 100.6 GWe at the end of 1996 to 97.1 GWe in 1998 due to the permanent retirement of 6 nuclear reactors. The remainder is due to the temporary shutdown of 7 nuclear reactors in **Canada**. Annual requirements for North America were about 19 300 tU in 1998 and were expected to increase to 19 600 tU in 1999.

Central and South America (1.6 GWe). By the beginning of 1999, there were 3 nuclear units operating in two countries of the region – Argentina and Brazil. There are two units under construction, one in **Argentina** (0.7 GWe) and one in **Brazil** (1.2 GWe). The unit in Brazil was expected to be connected to the grid in 1999. In **Cuba** the construction of two units, of the WWER-440 type, was suspended in 1994 due to financial constraints and to the reduction of technical assistance from the Russian Federation. The uranium requirements for Central and South America were 270 tU in 1998 and were expected to increase to 460 tU in 1999.

Western Europe and Scandinavia (124.9 GWe). **France** and **Belgium** continue to produce more than 50% of their electricity from nuclear reactors with nuclear shares of 75% and 55%, respectively, in 1998. **France** connected two units in 1997 – the Chooz-B2 (1 455 MWe) and the Civaux-1 (1 450 MWe). Three new reactors totalling 3 274 MWe are under construction in this region. In 1997, one reactor in the **Netherlands,** the Dodewaard (55 MWe), was retired and in 1998 one reactor in **France**, Creys-malville (1.2 GWe), was closed. Although there have been reactor performance upgrades in several Western European and Scandinavian countries, the installed nuclear capacity has remained essentially constant over the last two-year period. The reactor-related uranium requirements for Western Europe and Scandinavia in 1998 amounted to about 19 000 tU and were expected to decrease slightly to 18 600 tU in 1999.

Central, Eastern and South East Europe (47.6 GWe). The very large nuclear power programmes under development in the region have slowed significantly due to financial and political difficulties that have arisen in some countries from the transition process to market economies. Since 1996 only one additional unit has been connected to the grid in this region – the Mochovce-1 (388 MWe) in the **Slovak Republic**. The **Russian Federation** and **Ukraine** have by far the largest installed nuclear capacities in the region at 21.2 GWe and 12.9 GWe, respectively. **Lithuania** led the world in 1998 in terms of its 77% nuclear share of electricity generation. Most of the reactors in operation in the region are Soviet design RBMK and WWER types. However, **Slovenia** jointly with **Croatia**, operates a Western-supplied 650 MWe PWR, while **Romania** operates a PHWR (CANDU) reactor and has an additional reactor of the same type under construction. Fourteen reactors are under construction in the region (two in the Czech Republic, one in Romania, four in the Russian Federation, three in the Slovak Republic and four in Ukraine) representing a total capacity of 10.8 GWe. **Turkey** is planning to build its first nuclear plant within the next 10 years. The 1998 reactor-related uranium requirements for this region were about 9 000 tU and were expected to reach around 9 400 tU in 1999.

Africa (1.8 GWe). Nuclear capacity has remained constant in Africa since the 1997 Red Book. The region's only two reactors are located in **South Africa**. Annual reactor-related uranium requirements were about 200 tU/year in 1998 and were expected to remain the same in 1999.

Middle East, Central and South Asia (1.9 GWe). India, Kazakhstan and Pakistan are the only three countries with nuclear reactors in this region. In **India**, ten commercial reactors are presently operating with a total capacity of 1.7 GWe. Four PHWR units, with a total capacity of 808 MWe, are under construction in India, two of which were expected to be connected to the grid before the end of 1999. **Kazakhstan** operates a 70 MWe, FBR unit that it is planning to close around 2000. **Pakistan** currently operates the Karachi (125 MWe) CANDU type reactor. A 300 MWe PWR unit under construction imported from China was expected to be connected to the grid by 1999. There are a total of seven nuclear reactors under construction in this region including two in **Iran**. Reactor-related uranium requirements for the Middle East, Central and South Asia region were about 440 tU in 1998 and were expected to remain the same in 1999.

East Asia (64.1 GWe). East Asia is currently the strongest nuclear growth region in the world with about 4.8 GWe of new capacity added between 1997 and 1998. In **Japan,** there are two nuclear units under construction (1.9 GWe) and the government and industry are maintaining a strong focus on the development of an indigenous fuel cycle industry. Also, the Republic of Korea and China have very active nuclear construction programmes underway. The **Republic of Korea** has 6 units (5.7 GWe) under construction and **China** continues construction of six units totalling 4.4 GWe. In the **Democratic People's Republic of Korea**, two nuclear reactors are planned for construction using Western technology. The construction is to be financed by the US, Japan, the Republic of Korea and Euratom under the International KEDO project. The 1998 reactor-related uranium requirements for the East Asia region were 11 400 tU, and for 1999 they were expected to increase to about 13 000 tU.

South East Asia (0 GWe). This region has no current nuclear capacity. However, **Indonesia** and **Thailand** are considering the construction of nuclear reactors to satisfy the expected increasing electricity demand. The future operability of the only nuclear unit in the **Philippines**, the PNPP-1 620 MWe reactor, remains uncertain.

Pacific (0 GWe). This region has no current nuclear capacity. **Australia** has only one small research reactor. Australian Government policy prohibits development of further stages of the nuclear fuel cycle, thus no domestic demand for uranium is anticipated. The Government of **New Zealand** also has a policy prohibiting the development of nuclear power.

B. PROJECTED NUCLEAR POWER GROWTH AND RELATED URANIUM REQUIREMENTS

Projections of nuclear capacity and reactor-related uranium requirements are based on official responses from Member countries and States to questionnaires circulated by the Secretariat. However, for countries that did not provide this information, projections from the IAEA Secretariat are used. Because of the uncertainty in nuclear programmes in the years 2005, 2010 and 2015, high and low values are given, unless a single projection was provided in the official response.

Figure 12. **Projected installed nuclear capacity to 2015 low and high projections**

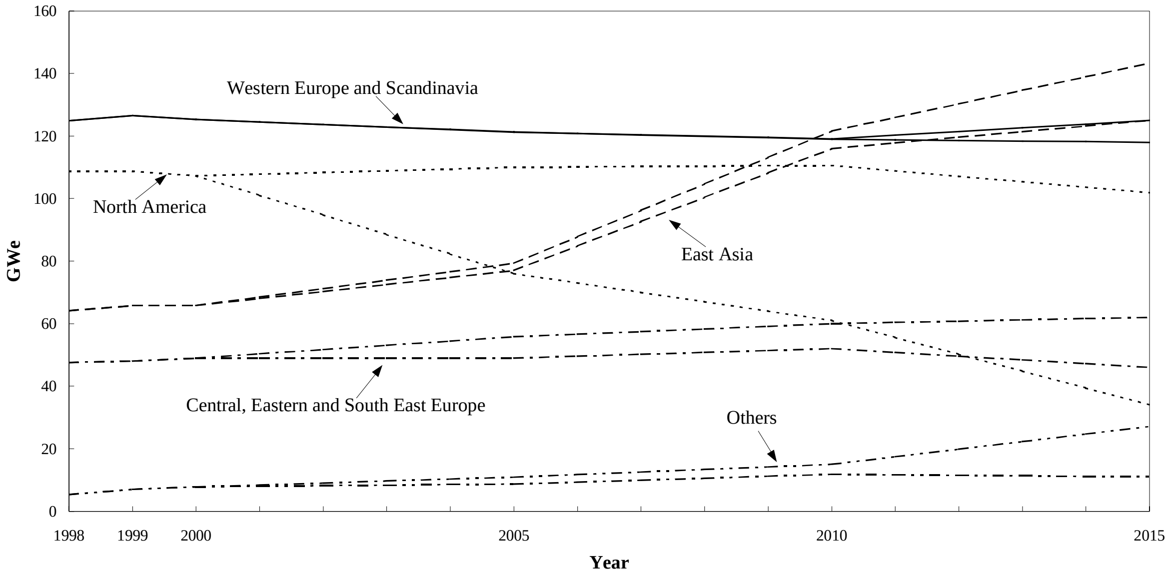
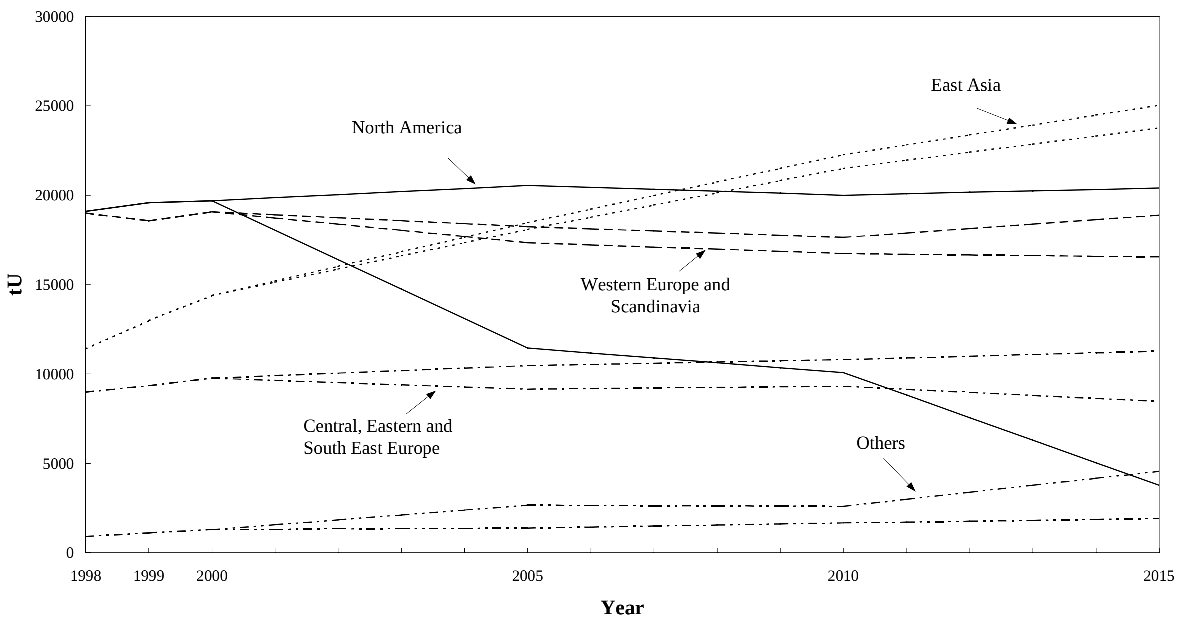


Figure 13. **Annual reactor uranium requirements to 2015 low and high projections**



The world nuclear capacity is expected to grow in the high case to 457 GWe and to decline in the low case to 333 GWe by the year 2015. The different trends depicted in these two cases reflect the uncertainties that exist in relation to the life expectancy of operating nuclear units and potential nuclear capacity additions. In the high case, the increase represents a 30% growth from current capacity or an annual growth rate of 1.6% for the forecasting period. The low projection shows a net decrease of 18 GWe by 2015. Several factors, including the importance given in the future to the debate on global warming, may have an impact on these projections.

The nuclear capacity projections vary considerably from region to region (Figure 12). Table 14 summarises the projected installed net nuclear electricity generating capacity on a country by country basis. The **East Asia** region will experience the largest increase in nuclear capacity. By the year 2015, this region would have incorporated between 61 GWe and 79 GWe of new capacity. **Central and Eastern Europe** will follow, with a high case forecast of 15 GWe of new capacity by 2015. Other regions experiencing moderate growth include the **Middle East and South Asia**, **Central and South America**, **South East Asia** and **Africa**. By contrast, **North America** and the **Western Europe and Scandinavia** region will experience a net reduction in available nuclear capacity by the year 2015. For these regions the projected number of additional nuclear units will not be sufficient to offset the expected retirement of older reactors. The capacity in **North America** would experience a dramatic reduction in the low case of about 75 Gwe, and in the high case of 9 Gwe, by 2015. In **Western Europe** nuclear capacity would remain fairly constant in the high case, or would be reduced in the low case by about 8 GWe.

World reactor-related uranium requirements are expected to rise in the high case to about 79 800 tU or to decrease in the low case to 54 500 tU by the year 2015 (see Table 15 and Figure 13). The growth in the high case corresponds to an annual growth rate of 1.7%. The cumulative uranium requirements over the period 1999 to 2015 range from 1 066 000 tU to 1 267 000 tU.

As in the case of world nuclear capacity, the uranium requirements will vary considerably from region to region (see Figure 13). In contrast to the rest of the world, **North America** and the **Western Europe and Scandinavia** region will either remain fairly constant or experience declines in uranium requirements through the year 2015. The increase in uranium requirements will be largest in the **East Asia** region, where expected accelerated nuclear capacity expansion will almost double the 1998 uranium needs by the year 2010.

Variation in uranium demand may arise due to changes in the performance of nuclear power plants and fuel cycle facilities, even if the installed base capacity remains the same. In recent years there has been a trend toward higher nuclear plant energy availability factors and capacity factors worldwide. The average energy availability factor for reactors worldwide has been generally increasing since the end of the 1970s. In 1998, the average energy availability factor was at a very high level of 79.2%. This followed a steadily increasing trend since 1989 when the factor was 70.1%.[2] Energy availability factor improvements directly affect uranium requirements. Enrichment tails assay variations may also affect natural uranium requirements.

In the fuel cycle itself, recycling of recovered plutonium in mixed oxide (MOX) fuel (and to a lesser extent reprocessed uranium) is common practice in some countries. Use of this technology improves the overall efficiency of the fuel cycle but will not dramatically alter world uranium

2. Some of the statistical data provided in the following sections are from: IAEA, *Nuclear Power Reactors in the World*, Reference Data Series No. 2, 1999, IAEA, Vienna, Austria.

demand in the short term because the quantities involved are rather small. This supply source could contribute 3 500, 4 000 and 5 000 tU (natural equivalent), respectively in the years 2000, 2005 and 2010 [1]. The fuel supply from reprocessing is based on projections by the IAEA of MOX fuel fabrication capacities. Therefore it represents a maximum level of use. The Euratom Supply Agency reported that the use of MOX fuel in 1996, 1997 and 1998 in the European Union were estimated to be equivalent to 500 tU, 700 tU and 1 100 tU, respectively. This also represents total world MOX use.

Reactor-related requirements over the short term are fundamentally determined by the installed nuclear capacity, or more specifically kilowatt-hours of operation. As noted, the majority of the anticipated capacity is already operating, thus short-term requirements may be predicted with greater certainty.

The largest uncertainties arise in the different assumptions about schedules for the construction of nuclear power plants, cancellations, new orders for reactors, and to what degree the operating life of existing plants can be extended. Construction time spans for the 1984-1997 period average about 99 months worldwide as measured from first concrete pouring to grid connection. Construction starts have averaged about 8 reactors per year over the last decade but only 2.9 reactors per year between 1991 and 1998. About 80 nuclear units have been permanently retired worldwide. Because of the variety of designs and the fact that some of these units were built as experimental or prototype reactors, the average lives experienced by these reactors do not provide a suitable indication of the life expectancy of nuclear reactors presently in operation.

A number of countries are considering new construction. However, there are factors that are influencing the installation of new nuclear generating capacity, including:

- the lack of sufficient financial resources in developing countries;
- problems with public acceptance which result in governmental proscription, deferral or postponement of new projects in some countries of Western Europe;
- weakening of investor confidence due to uncertainties in the return on investment; and
- competitive alternatives for electricity generation.

While nuclear plant owners are extending or are currently exploring mechanisms to extend the lives of their facilities, changes in national economic and regulatory policies and in the structure of the electricity supply industry may have an increasing impact on nuclear plant lifetimes, thereby impacting uranium requirements.

C. URANIUM SUPPLY AND DEMAND RELATIONSHIPS

The world uranium market continues to experience dramatic changes due to important trends observed in nuclear power generation, and political and economic developments in uranium producing and consuming regions of the world. In particular, several events that have taken place since the publication of the 1997 Red Book may well foreshadow developments in the next decades.

The changes in uranium supply, which have been ongoing, were accelerated in 1997 and 1998, and are expected to continue over the next several years. The modifications involve the relatively rapid market introduction of new supplies from non-production sources, as well as major changes within the uranium production industry. The availability of information regarding the amount of uranium held in inventory by utilities, producers and governments has increased. As a result the market uncertainty regarding these inventories has decreased. Uncertainty still exists, however, regarding the magnitude of the inventory in the Russian Federation and the availability of secondary supplies from other sources.

Since the beginning of commercial exploitation of nuclear power in the early sixties and up to the mid-eighties, the uranium market, in world regions excluding Eastern Europe and the Former Soviet Union, was characterised by an over supply situation (see Figure 14). Over supply was mainly the consequence of a lower than expected nuclear electricity generation growth rate. Although limited information is available, it also appears that production substantially exceeded reactor requirements in Eastern Europe and the Former Soviet Union extending to 1994. The political and economic reorganisation of this region in the early nineties resulted in major steps toward development of an integrated world uranium market. A consequence of the decrease in political tensions between the East and West has been greater availability of uranium supplies from the Former Soviet Union and the successor republics of Kazakhstan, the Russian Federation, Ukraine and Uzbekistan.

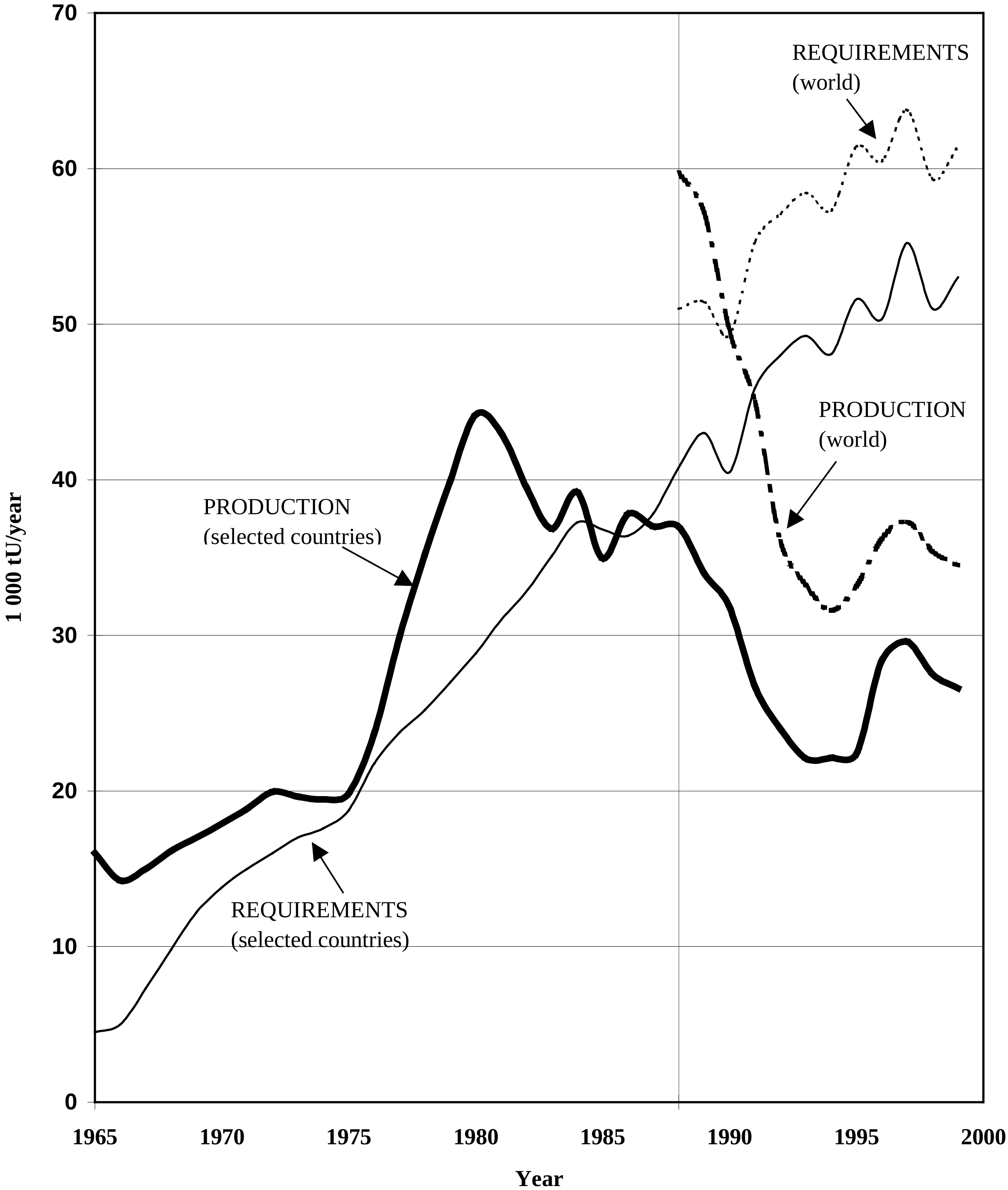
World over-production, lasting until 1990 (see Figure 14), and the availability of excess inventories resulted in uranium spot prices dropping in 1994 to their lowest level in 20 years. Between 1990 and 1994 there were severe reductions in many sectors of the world uranium industry including exploration, production and production capability, despite the continuous growth in world uranium requirements. This decreasing supply situation combined with growing demand for new uranium purchases resulted in a recovery in uranium prices from October 1994 through mid-1996. This trend, however, has reversed and uranium prices have fallen sharply through mid-1999.

The drop in spot prices has been followed by declines in other market prices. The lower prices benefit utilities, but have ended the optimism among producers that accompanied the price peak in mid-1996. Since then some planned facility expansions and newly announced projects have been cancelled or delayed. Furthermore, some operating plants have had cutbacks in their production. During the period 1994 to 1997 uranium production increased 16% to about 36 700 tU in 1997. It then fell 5% to about 35 000 tU in 1998. Projections suggest that the 1999 uranium production will remain around the same level.

In 1998, twenty-three nations produced uranium of which the major ten (Australia, Canada, Kazakhstan, Namibia, Niger, the Russian Federation, South Africa, Ukraine, USA and Uzbekistan) produced over 90% of the world's uranium mine output. In comparison, thirty-two nations currently consume uranium in commercial reactors. Figure 15 shows the uneven distribution between countries producing uranium and those consuming uranium. In 1998, world uranium production (34 986 tU) provided only about 59% (see Figure 14) of the world reactor requirements (59 551 tU). In OECD countries (see Figure 16), the 1998 production (19 088 tU) could only satisfy 39% of the demand (49 310 tU). The rest of the requirements are being satisfied by secondary sources including civilian and military stockpiles, uranium reprocessing and re-enrichment of depleted uranium.

In addition to the civilian inventories, the fact that large amounts of uranium involved in military applications in both the USA and the Russian Federation will become available for commercial applications is influencing the market. Highly Enriched Uranium (HEU) and natural uranium held in various forms by the military sector could total a few years' supply of natural uranium equivalent for commercial applications. While the rate at which this material may enter the civilian market is still uncertain, recent developments serve to reduce this uncertainty. Some of the laws, plans and contractual arrangements that are affecting its delivery are currently being defined and are discussed in a following section of this report entitled "Disposition of Surplus Defence Material." Another secondary source of importance is the re-enrichment of depleted tails from enrichment.

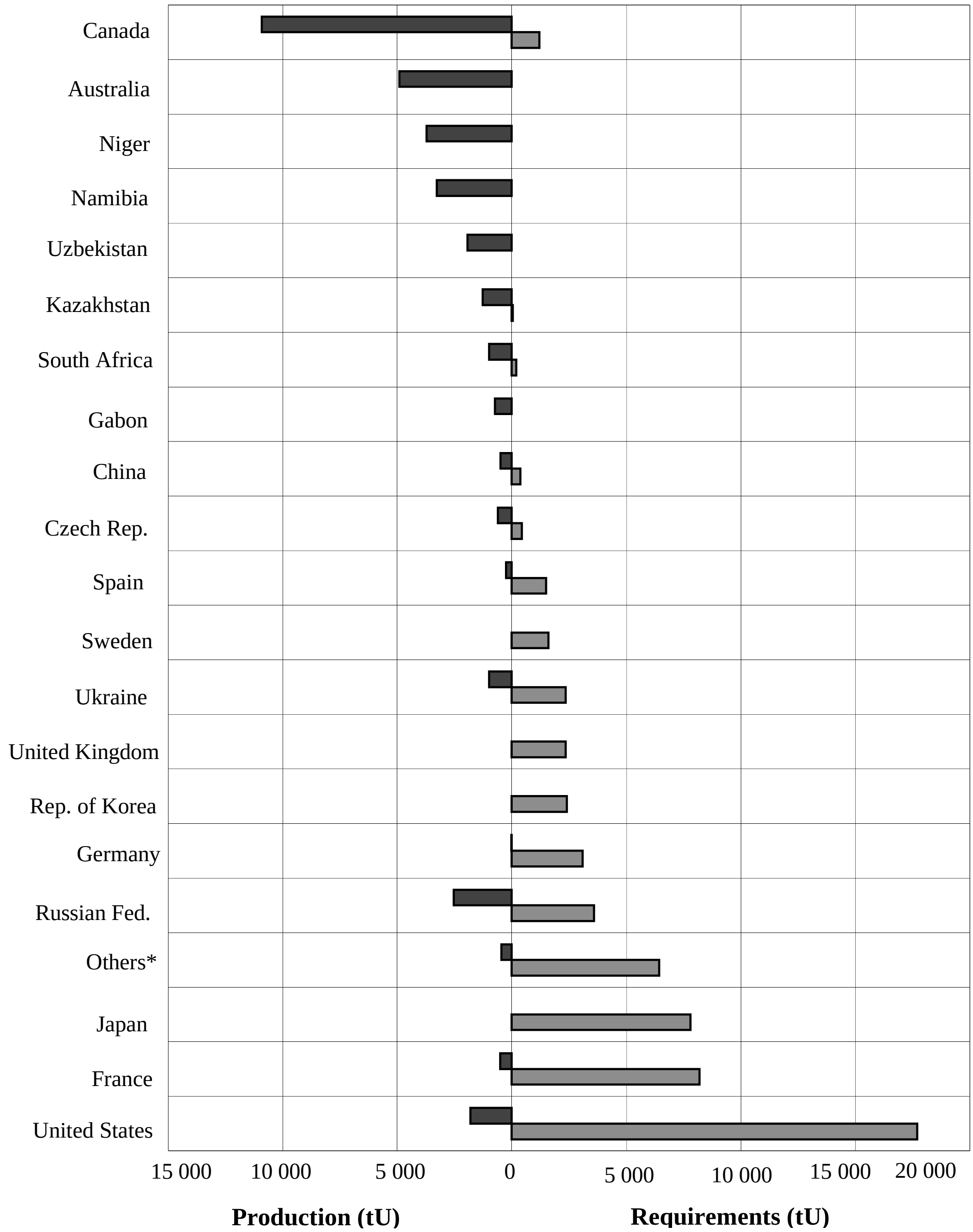
Figure 14. **Historical uranium production and requirements in selected countries*(1965-1999) and world (1988-1999)**



* Excludes the following countries because detailed information is not available: Bulgaria, China, Cuba, Czech Republic (and preceding states), GDR, Hungary, Kazakhstan, Mongolia, Romania, Russian Federation, Slovenia, Tajikistan, Ukraine, USSR, Uzbekistan, and Yugoslavia.

1999 production values are estimated.

Figure 15. **Estimated 1998 uranium production and reactor-related requirements**



* "Others" producers include: Argentina, Belgium, Hungary, India, Pakistan, Portugal, Romania.
"Others" consumers include: Argentina, Armenia, Belgium, Brazil, Bulgaria, Finland, Hungary, India, Lithuania, Mexico, the Netherlands, Pakistan, Romania, Slovak Republic, Slovenia, Switzerland.

Figure 16. **OECD uranium production and requirements***

* 1999 production values are estimated.

The events that characterised the uranium market in the last several years illustrate the persistent uncertainty faced by uranium producers and consumers worldwide. Some of the uncertainty is the result of political decisions that are, in part, defining the fundamental nature of the future uranium market. The political decisions include the conversion of HEU from warheads to Low Enriched Uranium (LEU) for use as civilian fuel, sale of the US government stockpile material and the changing restrictions imposed by both the USA and the European Community on the sale of uranium produced in the New Independent States (NIS).

Evolution of uranium supply and demand in Central Asia and Eastern Europe

The uranium supply programmes in countries located within the territory of the Former Soviet Union and Eastern Europe have undergone great changes in the last decade. While there are still unanswered questions about some aspects of the nuclear activities in this region, including existing uranium inventories in the Russian Federation, new information continues to be released.

In 1988, the Former Soviet Union and Eastern Europe region (which included the German Democratic Republic) produced about 23 000 tU, or nearly 40% of world production and about 260% of reactor requirements in these countries. By the time of the dissolution of the Soviet Union and the Council for Mutual Economic Assistance (CMEA) in 1991, production in this region had fallen to about 16 100 tU/year, but was still 168% of reactor requirements. The breakdown of historic trading patterns and the termination of uranium purchase agreements by the Russian Federation in 1992 resulted in an abrupt production decline to about 11 500 tU. Production continued to decline through

1998 to about 7 478 tU, or 21% of world production. Since 1994, production in the CIS and Eastern Europe has been below regional reactor requirements, estimated in 1998 at about 9 000 tU. The cumulative excess production over reactor requirements for the period 1988 to 1994 was estimated to be about 53 000 tU.

The only countries from the group that continue to produce uranium are: the Czech Republic, Kazakhstan, Romania, the Russian Federation, Ukraine and Uzbekistan. Ukraine has maintained its production at 1 000 tU per year since 1992. Following several years of declining production, the levels stabilised in Czech Republic and Romania in the mid-1990s. The Czech Republic now plans to phase out uranium production over the next few years. Romania plans to continue production to meet its domestic needs. After several years of decline, production increased in the Russian Federation, Uzbekistan and Kazakhstan, respectively, in 1996, 1997 and 1998. Following the increase in 1996 from 2 160 tU to 2 605 tU, the Russian Federation is maintaining production around 2 500 tU per year. Uzbekistan's production of 1 926 tU in 1998 is an increase of about one third over 1996 levels. Uzbekistan reports its production will increase to 2 300 tU in 2000. Kazakhstan also reports plans to further increase its production level.

The market structure

There are several sources of fissile material that may enter the market. Some of these are summarised in the table below and described in the following sections.

SOURCE	MARKET IMPACT
• Fresh mine production	Essential in short, medium and long term
• Civilian stockpiles of natural and enriched uranium	Important in the short term
• Reprocessed uranium and plutonium	Regional importance in the short term May be important in the long term
• Military stocks of highly enriched uranium	May be important in the short and medium term
• Military stocks of plutonium	Little or no importance in the short term Minor importance in the medium term
• Re-enrichment of depleted uranium	May be important in the short and long term
• New sources from exploration	Important in the medium and long term

Today, the market structure is characterised by:

1. increased availability of non-traditional supplies;
2. increased utilisation of fissile material stocks and inventories;
3. increasing recycling activities;
4. restricted trading activities in some regions; and
5. changes in spot market activities.

1. Availability of non-traditional supplies

Kazakhstan, the Russian Federation and Uzbekistan have emerged as potentially significant suppliers of uranium in the world market. However, supply activities from these countries have until recently been affected by decreasing production, by concerns related to the long-term reliability and by restrictions imposed by some Western countries on the purchase of these supplies. In addition, the uranium supply capability of other Eastern European countries is very limited because of facility closures and environmental concerns.

2. Utilisation of fissile material stockpiles

A major source of supply comes from the drawdown of accumulated stockpiles. The civilian inventories include strategic stocks, pipeline inventory and excess stocks available on the market. Few countries have provided detailed information on the size of the uranium stockpiles that are held by producers, consumers or governments. Utilities are believed to hold the majority of commercial stocks. Many utilities either hold or have policies that require carrying the equivalent of one to four years of natural uranium requirements.

The imbalance between world production and reactor requirements in 1997 and 1998 was 27 047 tU and 24 565 tU, respectively. Inventory drawdown has supplied most of the worldwide imbalance since 1990, which totals about 187 000 tU. Inventory also supplied reactor requirements in the non-WOCA (world outside of centrally planned economic areas) between 1987 and 1990. It is clear that the downward pressure on uranium market prices over the period since 1987 resulted from the large amounts of uranium that were offered for sale at low prices and exceeded demand. By far the largest contributor to this supply was from inventory. Therefore, having an understanding of uranium inventories contributes to anticipating future uranium market trends.

The information on the world uranium inventory from the country responses to the questionnaire used in preparing this report is limited. However, a review of recently published reports provides an insight into some apparent trends in the level of commercial inventory over the period 1996 to 1998.

For several years there were indications that the amount of uranium in the commercial inventory was decreasing. However, recent reports indicate that the inventory was larger than previously believed and that it has increased in both the European Union (EU) and the USA over the period 1996 to 1999. In its report "The Global Nuclear Fuel Market 1998" the Uranium Institute reported the year-end 1997 commercial inventory at 168 500 tU [2]. This amount was higher than anticipated before the report was prepared. Other reports indicate that some of the apparent increases are from: 1) shipments of uranium from the New Independent States (NIS) to the European Union (EU), 2) uranium entering the commercial inventory from US Government stockpiles, and 3) LEU from blending of Russian HEU that has been delivered to the US, but not yet sold. While some of the material from each of these sources has been delivered to utilities, a significant amount has not been sold, and by the year-end 1998 was being held in various stocks.

The available information indicates that inventory levels in both the European Union (EU) and the USA expanded from 1996 to 1998. The Euratom Supply Agency reports that 41 400 tU of natural uranium or feed contained in enriched uranium products (in tU) were imported by European Union operators from the NIS. Of this, 17 100 tU were delivered to EU utilities leaving a balance of 24 300 tU. Euratom explains the balance between imports and EU consumption first by identified exports, secondly by storage pending fulfilment of contracts with EU utilities and, thirdly by market operators' inventories awaiting sale. It was concluded "that the total inventories of natural uranium in the EU have increased significantly in spite of the utilities' reduction of their own stocks [3]." Judging by the level of production in Kazakhstan, Uzbekistan and the other NIS during the period in question, a large portion of the imports to the EU must have originated in the Russian Federation.

In the USA it is reported the year-end commercial uranium inventory of all types increased from 30 786 tU in 1996, to 40 864 tU in 1997, and further to 52 910 tU in 1998. This includes inventories owned by the 1998 privatised United States Enrichment Corporation (USEC) for year-end 1997 and 1998 only. Essentially all of this increase held by USEC is the result of US Department of Energy (USDOE) inventories that were transferred to USEC in 1997 and 1998. During the 1996 to 1998 period inventories held by U.S. utilities remained nearly constant between 25 339 and 25 733 tU [4].

Reports of comparable inventory levels are not available for the rest of the world. However, available information suggests that no significant excess inventory is held in Eastern Europe and Central Asia, outside of the Russian Federation. The most significant remaining area with uranium inventories is in the Far East. The inventory of enriched uranium product and natural uranium held by the Russian Federation has not been officially reported.

Another potential source of uranium supply is expected to come from military stockpiles. This material is helping to meet market demand in addition of excess inventories. Significant amounts of uranium from the conversion of nuclear weapons material are expected to enter the civilian market after 2000 as the result of purchase agreements between the USA and the Russian Federation.

Disposition of surplus defence material

Highly Enriched Uranium from the Russian Federation

The United States and the Russian Federation signed in February 1993 a government-to-government agreement concerning the disposition and purchase of 500 t HEU extracted from dismantled nuclear weapons. Under this agreement USEC, the executive agent for the United States, and Techsnabexport (TENEX), the executive agent for the Russian Federation, signed in January 1994 a USD 12 billion, 20-year HEU contract to purchase LEU derived from HEU from nuclear weapons dismantled in the Russian Federation.

During 1995, the first year of the contract, 6 t HEU diluted in the Russian Federation to 186 t LEU were purchased and received by USEC as fuel for nuclear power plants. The 1996 LEU shipments were derived from 12 t HEU. Also in 1996, USEC and TENEX signed a contract amendment which implements agreement for five years on quantities and prices. It provided for purchasing 18 t HEU in 1997, 24 in 1998, and 30 in 1999, 2000 and 2001. This process speeded up deliveries over the years 1997-2001 from previous goals by about 50% and accounts for about one-third of the 500 metric tons covered by the original agreement when 1995 and 1996 shipments were included. USEC pays the Russian Federation for the separative work unit (SWU) value contained in the LEU; however, USEC also paid USD 161 million for the natural uranium components of LEU, the equivalent of about 5 400 tU, that was purchased and delivered from the Russian Federation in 1995 and 1996. This uranium was transferred at no cost to the USDOE for subsequent sale.

Under U.S. law, the natural uranium component of LEU derived from HEU from dismantled Russian nuclear warheads is deemed to be of Russian origin. To provide for the delivery of Russian HEU-derived natural uranium to U.S. consumers, a direct quota, separate from the antidumping suspension agreement with the Russian Federation, was set by the USEC Privatisation Act. That quota increases incrementally from 769 tU equivalent in 1998 to 7 690 tU equivalent in 2009. The Act also frees USEC of responsibility for the natural uranium material related to LEU shipments and stipulates its return to TENEX, with restrictions on its sale in the United States as described above.

The 1997 shipments to USEC of 481 t LEU derived from 18 t HEU, were completed by early 1998. However, the 1998 shipments amounted to only 450 t LEU derived from 14.5 t HEU, and the natural uranium component from 1997 and 1998 shipments was stockpiled in the United States. TENEX continued to negotiate an agreement with commercial partners to sell this uranium and the natural uranium component for post-1998 deliveries.

In March 1999, the United States and the Russian Federation signed a government-to-government agreement facilitating return of the Russian natural uranium component to the Russian Federation. The USDOE paid the Russian Federation USD 325 million for the natural uranium component of the Russian Federation's 1997 and 1998 LEU shipments and agreed to keep it off the market for ten years as well as the uranium that was declared as surplus to U.S. defence needs.

The Russian Federation also signed a long-term commercial agreement with the Cogema/Cameco/Nukem consortium, dealing with the sale of the natural uranium component for post-1998 deliveries. Of the 9 100 metric tons of uranium to be made available annually as the natural uranium component of the LEU shipments, the consortium has an option to purchase annually up to 6 700 tU. Uranium not used by the consortium or by the Russian Federation will be stockpiled for future use. The 1998 LEU deliveries were completed in July 1999, amounting to 724.5 t LEU blended down from 24 t HEU. Shipments for the remainder of 1999 are expected to total 624 t LEU derived from 21.3 t HEU.

To facilitate the signing of the Russian HEU feed contract, the United States Government agreed in 1998 to take the following actions: (1) delay the sale of certain USDOE inventories for 10 years, and (2) appropriate USD 325 million to purchase HEU feed from the Russian Federation that was stockpiled in 1997 and 1998. The sale of the HEU feed acquired by the U.S. Government would also be delayed for 10 years. Bilateral agreements were reached between the United States and the Russian Federation to permit the transport of the HEU feed to the United States from the Russian Federation.

United States Highly Enriched Uranium

The USDOE and Tennessee Valley Authority (TVA) signed a letter of intent in April 1999 whereby TVA would utilise LEU derived from blending down U.S. surplus HEU. This LEU is considered "off-specification" because it contains ^{236}U in excess of the specifications established for commercial nuclear fuel. In May 1999, four lead test assemblies of the off-specification LEU were loaded into unit 2 of the Sequoyah Nuclear Power Plant. TVA plans to fuel its nuclear reactors with the off-specification LEU derived from U.S. HEU by 2003.

The blending down of 50 t HEU transferred from USDOE to USEC is expected to begin in 1999. The transfer was authorised by the USEC Privatisation Act. Both sides of the HEU blending point will be available for safeguard monitoring by the IAEA.

Plutonium

The USDOE reported in February 1996 that the US Plutonium inventory was 99.5 t Pu, of which 38.2 t was declared excess to national security needs [5]. The US government is investigating ways of disposing of this material. If used in MOX fuel, 38.2 t Pu would be equivalent to about 6 500 tU (natural equivalent). In addition, the government is investigating a proposal to burn this material in reactors at the rate of about 2.25 t Pu/year over the period 2007 to 2022 [6]. This rate of burn-up is equivalent to 385 tU (natural equivalent) per year, equivalent to about 2 to 5% of US reactor fuel requirements over the period.

3. *Recycled materials*

A third, potentially substantial source of fissile material lies in the constituents of spent fuel from power reactors. As of January 1999, over 210 000 tonnes of heavy metal have been discharged from power reactors. About 133 000 tonnes remain in storage as spent nuclear fuel. The remainder has been reprocessed. The quantity of accumulated spent fuel is 20 times the present total annual reprocessing capacity [7]. To date, no country has licensed a permanent geological repository for spent fuel. The majority of the spent fuel is currently stored at reactor sites in special holding pools. In some countries such as France, Japan, the Russian Federation, Germany, Belgium, Switzerland, Korea, and the United Kingdom, spent fuel has been viewed as a national energy resource. In some of these countries, the use of recycled material is already taking place. There are 32 reactors worldwide licensed to use MOX fuel, and facilities for the fabrication of this type of fuel exist in Belgium, France, Japan and the United Kingdom [8].

4. *Trading restrictions in the uranium market*

Some of the largest influences in uranium trade have arisen as a result of restrictions in the USA and in the European Community on sales of uranium produced in the New Independent States (NIS).

Restrictions in the United States

Since 1991, the United States has restricted uranium imports from the former Soviet Union republics. At the end of 1998, agreements were in place with the Russian Federation, Kyrgystan, and Uzbekistan whereby imports from these republics would be limited in exchange for the suspension of antidumping investigations by the U.S. Department of Commerce (DOC). The suspension agreement with the Russian Federation requires that under a specific quota, an import of Russian-origin uranium or separative work units (SWU) in a U.S. market transaction must be matched with a corresponding quantity of newly produced U.S. origin uranium or SWU. The suspension agreement with Uzbekistan established an import quota based on levels of U.S. uranium production. Uranium mined in the Russian Federation or Uzbekistan for sale in the United States is counted directly against each country's quota, notwithstanding whether the material has been imported as natural uranium or as feed component in a third-country-enriched product. An import quota has not been determined for Kyrgystan because no uranium mining had taken place in that country since the antidumping investigations were initiated. Kazakhstan, Tajikistan, and Ukraine have terminated their prior suspension agreements with the DOC, and tariffs can be imposed on uranium exports from those countries to the United States.

In July 1999, the U.S. International Trade Commission (ITC) ruled that uranium imports from Kazakhstan did not harm the uranium industry of the United States. ITC's ruling gives Kazakhstan free access to the U.S. market. However, tariffs remain in place for uranium imports from Tajikistan and Ukraine.

Since late 1997, the DOC has developed procedures for administering and enforcing the quota for Russian HEU-derived natural uranium. No restrictions, however, have been placed on the SWU component of LEU derived from Russian HEU.

Restrictions in the European Union

The Euratom Supply Agency (Euratom), established under the provisions of Chapter VI of the Euratom Treaty, must ensure through a common supply policy that all users in the European Community (EC) receive a regular and equitable supply of ores and nuclear fuels. These supply provisions contain no “community preference” for community production [9].

In order to ensure regular and reliable supply, the Agency policy aims at avoiding over-dependence of the European Union (EU) on any single source of supply (diversity of sources), and at market related prices.

In practical terms:

- diversity of sources means that EU users should not depend, on average, for more than *about one quarter of their natural uranium needs and for more than around one fifth of their enrichment needs* from the NIS;

- market related prices means prices covering production cost in a market economy environment and compatible with prices offered by the best market economy producers.

In order to avoid supply disruption, if secondary supply sources are reduced for political or other reasons, the Euratom recommends that EU users maintain a portfolio of diversified, long-term contracts on equitable terms with primary producers and limit reliance on secondary sources at prices bearing no relation to production costs. Otherwise the continuation of some existing mines and the opening of new deposits could become uneconomic and this would jeopardise the supply from primary production in the long term. However, no contract conclusion was ever refused for price consideration alone.

Since its inception the policy has been applied [10] on a case-by-case basis, taking into account the specific merits of each case. This has allowed a high degree of flexibility, e.g.:

- by allowing users to consume more than one year entitlement in a given year (and carrying forward a negative balance for some years);

- by allowing advance deliveries under long term contracts,

- by allowing combined purchases of EU production and NIS materials without accounting the latter against the users' individual entitlement;

- by “grandfathering” deliveries under contracts concluded before the policy was announced;

- by allowing very small users to acquire more than their entitlement.

Since 1998, Euratom has been following closely how material from two new secondary sources, namely the feed component of the HEU deal between the Russian Federation and the United States and re-enrichment in the Russian Federation of tails material arising from enrichment in the EC, is introduced in the market.

As the arrangements are expected to improve market stability and predictibility, Euratom welcomed the intergovernmental agreement signed on 24 March 1999 between the US and Russian ministeries as well as the related purchase option contract between Minatom and Western uranium suppliers (Cameco from Canada, Cogema from France and Nukem from Germany). Under this contract a major part of the HEU feed component (9 000 tU per year) can be purchased by the Western suppliers, and the remainder must be either sold under the US quota limitation, stockpiled, or used for blending. Following consultations with all the parties concerned, Euratom will allow EU users to acquire freely HEU feed, through specific or open origin contracts without affecting their normal NIS entitlements.

With regard to equivalent natural uranium from re-enrichment of western origin tails material, Euratom announced [11], following a recommendation of its Advisory Committee, that such material can be freely sold if it is further enriched in the EU. Euratom expects that this material could provide a supply in the order of 1 000 to 2 000 tU per year as equivalent natural uranium. Part of this is sold to EU users and the remainder is exported. The impact of the sales of re-enriched tails is being monitored, and the policy could be revised if a need arises.

Euratom’s policy [12] has been clearly confirmed by the European Court of First Instance and Court of Justice in the Kernkraftwerke Lippe-Ems case [13]. In this case Euratom had refused the unconditional conclusion of a contract for the supply of natural uranium to a German user, because it would have resulted in an excessive level of dependence on the NIS and because of the low price. The Court underlined the tasks and role of Euratom and insisted on its broad margin of discretion. The Courts accepted that three legal obstacles allowed Euratom to oppose the contract: the excessive level of dependence which could jeopardise the security of supply (diversification), the price which was not a “market related price” as prescribed by Article 14 of the EU/USSR Agreement [14] of 1989, and the risk that allowing an individual company more than its proportional share would create a privileged position forbidden by Article 52 of the Euratom Treaty.

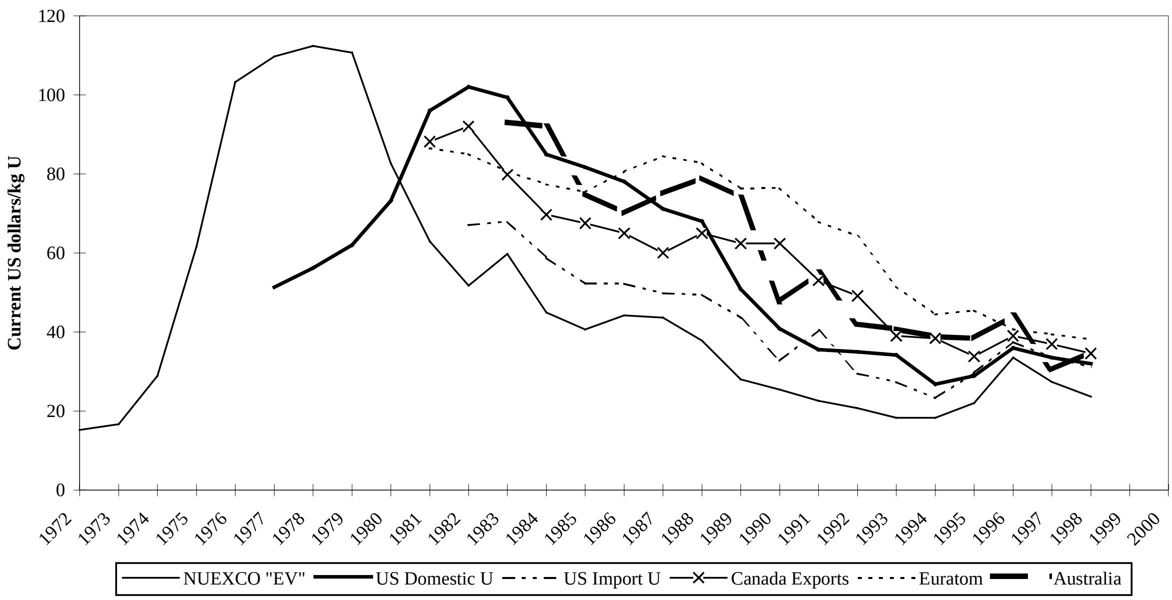
5. Spot market activities

The uranium market no longer conforms to the traditional supply and demand model of producers selling only to utilities. Secondary market transactions have also been important in recent years. Such transactions include sales, loans and exchanges of natural and enriched uranium by utilities and brokers, including all transactions except direct purchasing by a utility from a domestic or foreign supply.

Some national and international authorities make available aggregated price data which reasonably illustrate term contract price trends. Additionally, spot price estimates for immediate or near-term delivery are regularly provided by industry sources such as the TradeTech (NUEXCO), NUKEM and others. Figure 18 shows a comparison of historical annual average delivered prices reported by TradeTech (NUEXCO), Euratom, the US Energy Information Agency (EIA), Canada and Australia. With the exception of Euratom, the prices are based on variable amounts of both spot- and long-term sales. The Euratom prices correspond to multi-annual contracts. The TradeTech (NUEXCO) prices correspond to the NUEXCO Exchange Value (EV), and beginning in 1992 the prices represent the “unrestricted market”. The US prices are for both domestic and foreign purchases. Figure 18 clearly depicts the overall decreasing trend in world uranium prices that has characterised the market since 1982.

From its high of USD 42.90/kgU (USD 16.50/lb U_3O_8) in July 1996, the restricted spot price fell to nearly half of that level or USD 22.75/kgU (USD 8.75/lb U_3O_8) by December 1998. While the price recovered modestly to USD 27.30/kgU (USD 10.50/lb U_3O_8) in January 1999, by July 1999 it had fallen back to USD 26.52/kgU (USD 10.20/lb U_3O_8). The average NUKEM uranium spot price in 1998 (Table 13) for the unrestricted market was USD 24.00/kgU (USD 9.23/lb U_3O_8) and for the restricted market was USD 27.18/kgU (USD 10.45/lb U_3O_8). Similar prices were reported by TradeTech as the 1998 average exchange values. The 1998 prices represent decreases over prices reported in 1996 in the unrestricted and restricted markets of 35% and 32%, respectively.

Figure 17. **Development of Uranium Prices**



Notes:

1) NUEXCO Prices refer to the "Exchange Value". The values for 1992-1998 refer to the unrestricted market.
2) Euratom prices refer to deliveries during that year under multiannual contracts.

Sources: NUEXCO (TradeTech), EIA, Nukem and Euratom, Canada and Autralia.

Table 16. **Average uranium spot prices**
USD/kgU (USD/lb U_3O_8)

	1998	Last quarter 1998	First half 1999
Unrestricted market value			
Nukem uranium spot price	24.00 (9.23)	22.88 (8.80)	22.70 (8.73)
Tradetech exchange value	23.61 (9.08)	22.36 (8.60)	23.10 (8.88)
Restricted market value			
Nukem uranium spot price	27.18 (10.45)	23.76 (9.14)	27.64 (10.63)
Tradetech exchange value	26.57 (10.22)	23.10 (8.88)	27.56 (10.60)

Outlook to 2015

Uranium demand over the short-term is fundamentally determined by nuclear capacity. Although there are uncertainties related to potential changes in world nuclear capacity, short-term uranium requirements are fairly predictable. Most of nuclear capacity is already in operation; there is only a limited degree of uncertainty regarding construction lead times and implementation of plans for new units in some countries. Improvements and modifications to nuclear reactor technology may also affect requirements; however, these factors are not likely to have a major impact before 2015. Fuel utilisation in thermal reactors can primarily be increased by: improving in-core management, lowering the tails assay in the depleted stream of enrichment plants, and recycling plutonium. In-core management considerations such as higher capacity factor and reactor power levels increase uranium requirements of existing plants, while increased burnup reduces requirements.

Another source of uncertainty is the possibility of early retirement of nuclear reactors. The potential for reductions of nuclear capacity exists mainly in countries that have some old nuclear units and where restructuring of the electricity supply industry may have an impact on nuclear plant lifetimes. It is expected that the projected number of additions of nuclear plants worldwide would be sufficient to offset potential early plant retirements in the high case. Therefore, overall world reactor-related uranium requirements are expected to continue rising in the high case from about 59 551 tU in 1998 to about 79 800 tU per year by the year 2015. In the low case, retirements would cause a net reduction in uranium requirements to about 54 500 tU by 2015.

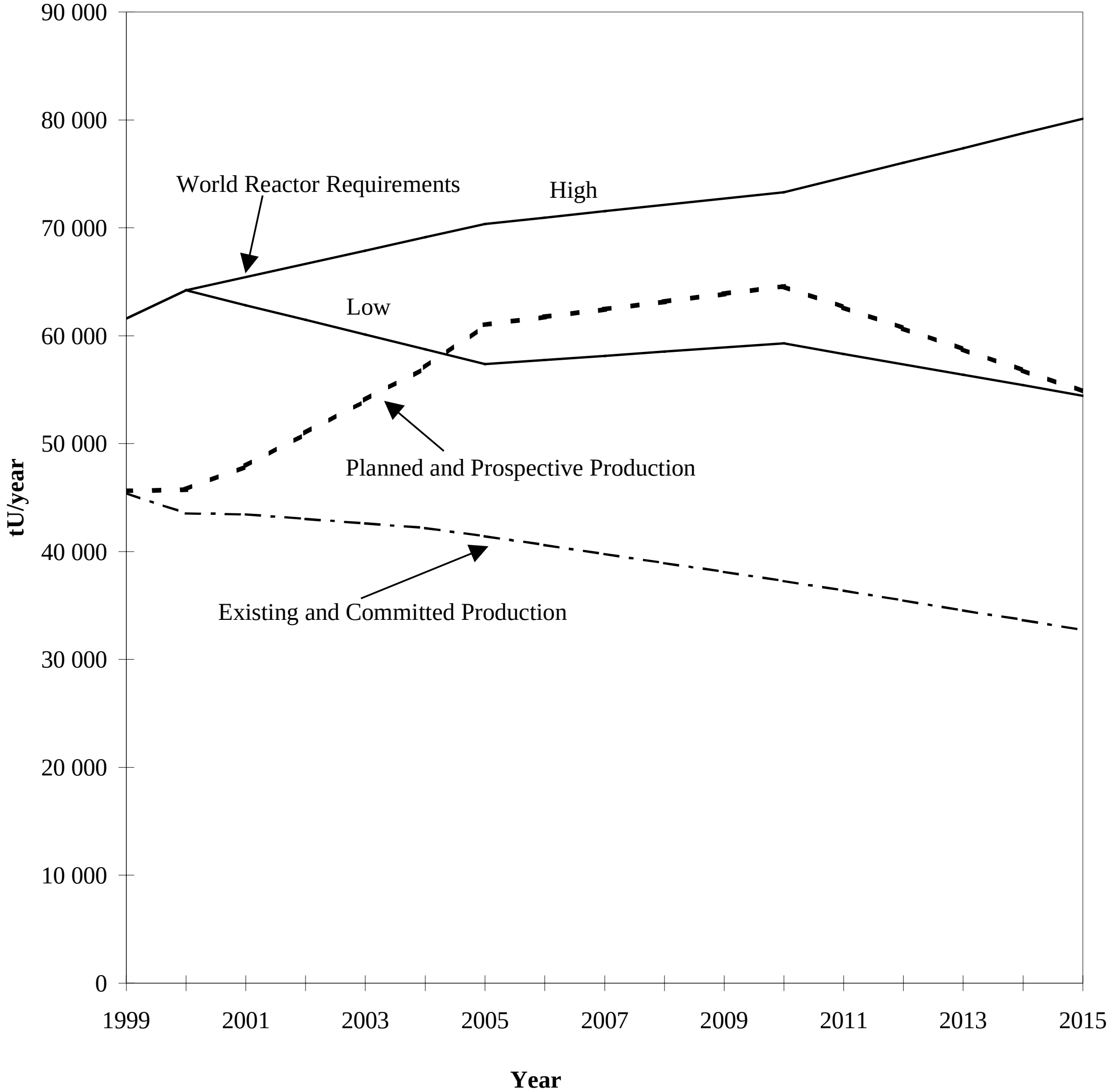
The supply side in the uranium market over the mid-term remains uncertain. The uncertainties are related to where these supplies will come from and the amount of defence-related uranium that may eventually reach the commercial market. Mine production is expected to continue to be the supply source satisfying the largest share of requirements.

The increasing availability of new supplies from the conversion of warhead material, together with recent increases in the commercial inventory, imply a continuing oversupplied, low priced market and the possibility of further delays in the expansion of the production capacity. This situation is reducing the prospects of a market recovery in the short-term. On the other hand, the low production levels and the drawdown of civilian and military inventories may continue for several years. When the excess inventory is exhausted a market with restricted uranium supply may develop creating a steadily increasing price trend and consequently a revival of production activity.

As shown in Figure 18, production capability for all uranium producing countries, based on Existing, Committed, Planned and Prospective production centres supported by RAR and EAR-I recoverable at a cost of $80/kgU or less, could satisfy future world uranium requirements in the low case starting in 2005. Nearly 65% of this production capability is based on RAR recoverable at $40/kgU or less. However, the world production capability based on these resources would not be sufficient to satisfy the world reactor requirements indicated by the high case during the forecasting period. Excess commercial inventories, the expected delivery of LEU derived from HEU warheads, re-enrichment of tails and spent fuel reprocessing are expected to continue meeting the gap during the short and mid-term.

In the long-term, when supplies from excess stockpiles are no longer available, the requirements could be met through the expansion of existing projects, together with the development of additional production centres. Nevertheless, the lead time for the development of new uranium production facilities is several years. Developing new uranium projects has become more difficult because of increasingly demanding radiation safety and environmental regulations, as well as the additional time required to meet licensing, permitting and environmental review procedures. Any extended production shortfall in the absence of excess inventory could destabilise the market thereby increasing upward pressure on uranium prices.

Figure 18. **Annual world uranium production capability through 2015* (RAR & EAR-I resources recoverable at $80/kgU or less) and world reactor requirements**



* Includes all current and identified potential uranium producers.
Source: Tables 13 and 15.

D. THE IMPACT OF RECENT DEVELOPMENTS ON THE LONG-TERM PERSPECTIVE

Concerns about longer term security of supply of fossil fuels and the heightened awareness that nuclear power plants are environmentally clean with respect to acid rain and greenhouse gas emissions might contribute to even higher than projected growth in uranium demand over the long-term. In particular, the increasing importance of the debate on global warming points toward accepting nuclear power as a valid alternative within the framework of long-term sustainable development.

Factors that are expected to have a significant impact on the long-term supply/demand balance include: the rate of orders for new nuclear capacity, the rate of retirement of the existing world nuclear generating stock, the deployment of advanced reactor technologies and of advanced reprocessing and enrichment technologies.

World electricity use is expected to continue growing over the next several decades to meet the needs of rising population and sustained economic growth. In fact, electricity is expected to remain the fastest growing form of end-use energy worldwide through 2020 [15]. The growth on electricity consumption will be strongest in developing nations. Per-capita consumption of electricity in non-OECD countries is expected to double to 1.8 MWh in 2020 [16].

Nuclear electricity generation might play a significant role in the future growth of electricity consumption in some regions. From 1990 until the year 2020, the World Energy Council expects the global production of nuclear electricity to grow by approximately 0.9% to 2.8% annually, depending on the scenario assumed [17]. Efforts are also underway in countries with nuclear power programmes to preserve or extend the lifetime of their nuclear facilities.

Reprocessing is a technology that is currently available which could make a significant impact on uranium requirements in the long-term, assuming that it is fully implemented. Implementing a programme to recycle all plutonium in Light Water Reactors would reduce uranium requirements by 17% [18]. Also, there has been a trend toward higher fuel burnups in commercial reactors which has the effect of reducing requirements for fresh uranium. For example, improving burnup from 40 to 50 Gigawatts day/tU decreases uranium requirements by 4-5% [19]. Other technologies under development that could also make noticeable impacts if they are implemented include tandem cycle reactors such as the PWR-CANDU concept (which re-burns PWR spent fuel in CANDU reactors and thereby reduces CANDU uranium requirements by about 40%) and new enrichment technologies. In France, Japan, South Africa and the USA, work has continued on the development of the Atomic Vapour Laser Isotope Separation (AVLIS) and Molecular Laser Isotope Separation (MLIS) enrichment technologies. These approaches are believed to have economic advantages over the current centrifuge and diffusion enrichment technologies. They could also result in reducing natural uranium requirements.

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III. NATIONAL REPORTS ON URANIUM EXPLORATION, RESOURCES, PRODUCTION, DEMAND AND THE ENVIRONMENT

INTRODUCTION

Part III of the report presents the national submissions on uranium exploration, resources and production. These reports have been provided by the official government organisations (Annex 2) responsible for the control of nuclear raw materials in their respective countries and the details are the responsibility of the individual organisations concerned. In countries where commercial companies are engaged in exploration, mining and production of uranium, the information is first submitted by these companies to the government of the host country and may then be transmitted to the NEA or the IAEA at the discretion of the government concerned. In certain cases, where an official national report was not submitted and where deemed helpful to the reader, the Secretariat has provided additional comments or estimates to complete the Red Book. Where utilised, the Secretariat estimates are clearly indicated. See Annex 8 for technical abbreviations.

The Agencies are aware that exploration activities are currently proceeding in a number of other countries which are not included in this report. They are also aware that in some of these countries uranium resources have been identified. It is believed that the total of these resources would not significantly affect the overall conclusions of this report. Nevertheless, both Agencies encourage the governments of these countries to submit an official response to the questionnaire for the next Red Book exercise.

Finally, it should be noted that the national boundaries depicted on these maps are for illustrative purposes and do not necessarily represent the official boundaries recognised by the Member countries of the OECD or the Member states of the IAEA.

Additional information on the world's uranium deposits is available in the IAEA publications: "World Distribution of Uranium Deposits" (STI/PUB/997), together with the "Guidebook to accompany the IAEA Map: World Distribution of Uranium Deposits" (STI/PUB/1021). The location of 582 uranium deposits is given on a geologic base map at the scale 1:30 000 000. The guidebook (which is available at no cost with purchase of the map) and map provide information on the deposit: type, tectonic setting, age, total resources, average uranium grade, production status and mining method. They may be ordered from:

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Sales & Promotion Unit, Division of Publications
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• Argentina •

URANIUM EXPLORATION AND MINE DEVELOPMENT

Historical review

Uranium exploration activities in Argentina began in 1951-1952. The Huemul sandstone type deposit was found in 1954, while exploring for red bed type copper mineralisation. The Tonco district with the sandstone type deposits Don Otto and Los Berthos was discovered by an airborne geophysical survey conducted in 1958. During the late 1950s and the early 1960s, airborne surveys also led to the discovery of Los Adobes sandstone type deposit in Patagonia.

During the 1960s, the vein-type Schlagintweit and La Estela deposits occurring in granitic rocks were found by ground exploration. The resources hosted in these deposits were subsequently mined in the production centres of Los Gigantes and La Estela, respectively. In 1968, the Dr. Baulies deposit, occurring in volcanoclastic sediments, was discovered by an airborne survey as part of the Sierra Pintada district in the Province of Mendoza.

During the 1970s, follow-up exploration in the vicinity of the previously discovered uranium occurrences in Patagonia, led to the discovery of two new sandstone type deposits: the Cerro Condor and Cerro Solo. An airborne survey carried out in 1978 in Patagonia contributed to the discovery of the small Laguna Colorada deposit located in a volcanic environment.

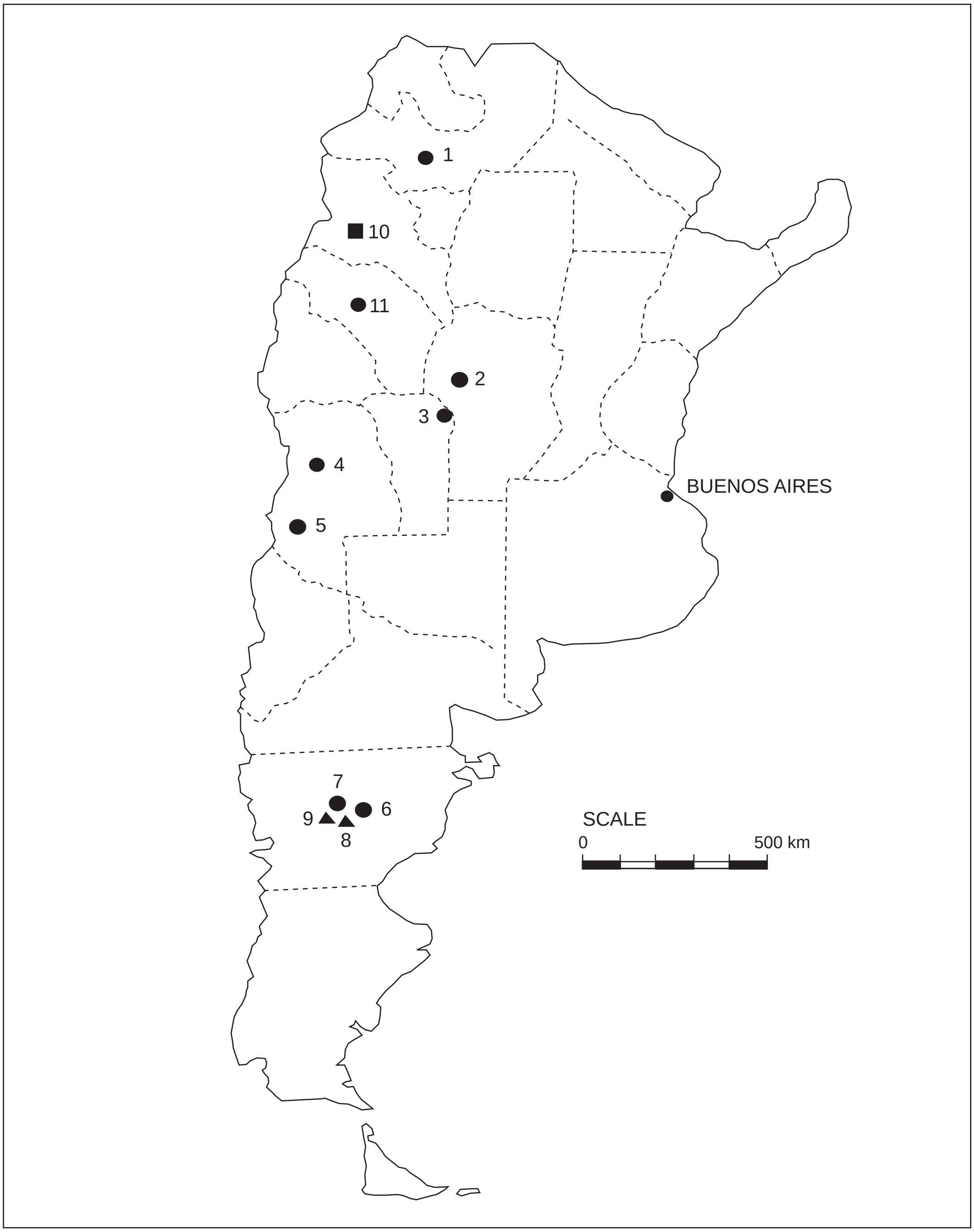
During the 1980s, an airborne survey conducted over granitic terrain identified a number of strong anomalies. These included some located over the Achala batholith which were selected for further investigation. This resulted in the identification of several vein-type mineralisations, among them those extending the Schlagintweit and La Estela deposits. Subsequently in 1986, ground exploration identified the vein-type Las Termas mineralisation. At the end of the 1980s, a nationwide exploration programme was started to evaluate those geological units that were believed to have uranium potential.

In 1990, exploration was initiated in the vicinity of the Cerro Solo deposit in Patagonia. Through 1996, more than 52 000 metres were drilled to test the potential of the favourable portions of the paleochannel structure. The results include the delineation of several additional ore bodies containing resources of several thousand tonnes. In addition to this work, the assessment of the favourable geological units and the exploration of Las Termas mineralisation continued.

Recent and ongoing uranium exploration and mine development activities

During 1997 and 1998, exploration continued both at the regional and local scales. The regional assessment of the uranium potential of favourable geological units also continued. Geological radiometric surveys have been conducted to investigate uranium anomalies related to granites (Las Termas).

Uranium deposits of Argentina



⧗ Being mined; uranium mill	1. Don Otto (Sandstone)	7. Cerro Condor (Sandstone)
● Mined out	2. Schlagintweit (Vein)	8. Cerro Solo (Sandstone)
■ Being studied	3. La Estela (Vein)	9. Laguna Colorada (Volcanoclastic)
▲ Exploration	4. Dr. Baulies (Volcanoclastic)	10. Las Termas (Vein)
	5. Huemul (Sandstone)	11. Los Colorados
	6. Los Adobes (Sandstone)	

Local investigations were directed at the further evaluation of the Cerro Solo deposit where additional drilling of about 3 800 metres contributed to the re-estimation and reclassification of resources from higher to lower cost categories. Results of previous and recent work have been evaluated in pre-feasibility studies.

Regional activities included the continuation of the geological assessment of the country's uranium potential. In addition, the invitation for tender of the exploitation of the Cerro Solo deposit was prepared and it was expected that an invitation to bid might be published in 1999.

Uranium drilling statistics

	1996	1997	1998	1999 (Expected)
Government surface drilling in metres	8 332	3 841	0	3 700
Number of holes drilled by government organisations	96	27	0	28

URANIUM RESOURCES

Known conventional uranium resources (RAR & EAR-I)

Argentina's known resources in the RAR and EAR-I categories, recoverable at costs below $130/kg U, total 9 930 tU as of 1 January 1999, as recoverable resources. This compares with an estimate of 11 950 tU, reported as of 1 January 1997. The resource estimates represent net resources adjusted for past production.

The 1999 estimate includes 2 640 tU RAR recoverable at below $40/kgU, 5 240 tU recoverable below $80/kgU and 7 480 tU recoverable below $130/kgU. Compared to the previous estimate, there is an overall decrease of 1 360 tU in the below $130/kgU category and an increase of 2 640 tU in the below $40/kgU category. An increase of 620 tU in the below $80/kgU can be attributed to the further upgrading of resources in the Cerro Solo deposit where prefeasibility studies were conducted.

While the overall EAR-I estimate for the cost category below $130/kgU has decreased by 740 tU to 2 450 tU as of 1 January 1999, most of these resources, now have lower cost assignments: 2 380 tU were transferred to the below $80/kgU category and 2 030 tU to the below $40/kgU category.

Almost all of Argentina's known resources recoverable at costs below $80/kgU are tributary to existing and committed production centres. The recent changes in cost estimates are the result of prefeasibility studies carried out in the interim period.

Reasonably Assured Resources *

(tonnes U)

Cost ranges		
<$40/kgU	<$80/kgU	<$130/kgU
2 640	5 240	7 480

Estimated Additional Resources – Category I *

(tonnes U)

Cost ranges		
<$40/kgU	<$80/kgU	<$130/kgU
2 030	2 380	2 450

* As recoverable resources adjusted for mining and processing losses (25%).

Undiscovered conventional resources (EAR-II & SR)

As of 1 January 1999, the EAR-II resources of Argentina are reported to total 1 440 tU as recoverable resources at the cost category of up to $130/kgU. No Speculative Resources are reported.

The recent EAR-II estimate of 1 440 tU compares with 1 100 tU reported in the previous report.

Estimated Additional Resources – Category II

(tonnes U)

Cost ranges	
<$80/kgU	<$130/kgU
0	1 440

URANIUM PRODUCTION

Historical review

Argentina has been producing uranium since the mid-1950s. A total of seven commercial scale production centres were in operation at different times. In addition, a pilot plant operated from about 1953 to 1970. A diagram detailing the history of Argentine uranium production centres was published in the 1997 edition of the Red Book.

Between the mid-1950s and 1996, the cumulative uranium production was 2 482 tU. The 1995 production came from the Los Colorados and San Rafael centres, while the 1996 production was mined in the San Rafael centre after the closure of Los Colorados. Production data are given in the following table.

Los Colorados mine and mill complex, located in La Rioja province, was shut down at the end of 1995. Los Colorados started production in 1993 and was owned and operated by Uranco S.A., a private company. Ore was mined from a small sandstone type deposit located in the area and treated in the attached IX recovery plant that was relocated to Los Colorados from La Estela project. The nominal annual capacity of Los Colorados mill was 30 tU.

The closure of Los Colorados operation, resulted in a change of the ownership structure of uranium production in Argentina. Since 1996, the uranium mining industry is wholly owned by the Government Agency CNEA.

Historical uranium production

	Pre-1996	1996	1997	1998	Total to 1998	Expected 1999
Mining method	(tonnes U contained in ore)					
Conventional mining:						
• Open-pit	2 052	16	30	7	2 105	6
• Underground	400	0	0	0	400	0
By-product – underground						
Sub-total	2 452	16	30	7	2505	6
Production method	(tonnes U contained in concentrate)					
Processing plant	702	0	0	0	702	0
Heap leaching	1 750	16	30	7	1 803	6
TOTAL	**2 452**	**16**	**30**	**7**	**2 505**	**6**

Status of production capability

At present, the only operating production centre is the San Rafael facility. Its annual production capability is about 120 tU. The technical details of the San Rafael mine/mill complex are summarised in the following table.

Uranium production centre technical details

Name of production centre	Complejo Minero Fabril San Rafael
Production centre class	Existing
Operational status	In operation
Start-up date	September 1979
Source of ore: • Deposit name • Deposit type	 Sierra Pintada Volcanoclastic
Mining operation: • Type • Size (tonnes ore/day) • Average mining recovery (%)	 Open pit 700 NA
Processing plant: • Type • Size (tonnes ore/day) • Average processing capacity (tU/year)	 IX 700 83
Nominal production capacity (tU/year)	120
Plans for expansion	NA

Employment in the uranium industry

Employment in Argentina's uranium industry continues to decline. While employment in 1980 was approximately 450 persons, it had decreased to 100 in 1996 and 80 in 1997.

Employment in existing production centres

(persons-years)

1996	1997	1998	Expected 1999
180	80	80	80

Short-term production capability projection

Argentina does not provide short-term uranium production capability projections beyond the year 2001. The available data are summarised in the following table.

Short-term production capability

(tonnes U/year)

1999				2000				2001			
A-I	**B-I**	**A-II**	**B-II**	**A-I**	**B-I**	**A-II**	**B-II**	**A-I**	**B-I**	**A-II**	**B-II**
0	0	40	40	0	0	40	40	0	0	40	40

ENVIRONMENTAL ASPECTS

Contractual arrangements related to the return of the land occupied by the decommissioned Malargüe mill existed between the Government of Argentina (as owner of the previous operator) and the Province of Mendoza (as owner of the surface rights). This led to expenditures of about USD 12 million by CNEA in the final clean-up and restoration of the disturbed mill area. In addition, the return of the land occupied by the shut down of Los Gigantes mine and mill complex is being investigated.

Further information on environmental management and measures undertaken to minimise environmental impact during operation and decommissioning of mines and plants is not available.

URANIUM REQUIREMENTS

Argentina's uranium requirements have been modified due to the uncertainty in the date of the completion of the Atucha II nuclear power plant. The currently available information on the installed nuclear electricity generating capacity and the related uranium requirements are summarised in the following tables.

Installed nuclear generating capacity to 2015

(MWe)

1998	1999	2000	2005	2010	2015
940	940	940	NA	NA	NA

Annual reactor-related uranium requirements

(tonnes U)

1998	1999	2000	2005	2010	2015
150	150	150	NA	NA	NA

NATIONAL POLICIES RELATING TO URANIUM

The recently approved nuclear legislation provides for the privatisation of the nuclear power plants currently owned by the CNEA. In this event, the uranium requirements will increase as the party acquiring the two nuclear power plants currently in operation will also be committed to completing the construction and bringing into operation the third plant, Atucha II.

Under the uranium supply and procurement strategy followed by CNEA, it was decided to take advantage of the low uranium prices, and to reduce the domestic portion to a minimum. Based on this strategy, approximately 100 tU/year are being bought on the spot market. It is expected that this strategy will be maintained until the current market situation changes.

URANIUM STOCKS

At the end of 1998 total uranium stocks held by the Federal Government amounted to 2 tU in the form of uranium concentrates.

URANIUM PRICES

Information on uranium prices is not available.

• Armenia* •

URANIUM REQUIREMENTS

There have been no changes in Armenia's nuclear energy programme during the past two years. Armenia's short-term uranium requirements of 89 tU/year are based on the operation of one WWER-440 unit at the Metsamor NPP. The unit's installed capacity is 407.5 MWe (376 MWe net).

The uranium requirements for 2015 are not yet planned. They will depend on the country's policy for the nuclear energy sector.

Installed nuclear generating capacity
(MWe net)

1998	**1999**	**2000**	**2005**		**2010**		**2015**	
			Low	*High*	*Low*	*High*	*Low*	*High*
376	376	376	0	376	0	376	NA	NA

Annual reactor-related uranium requirements
(tonnes U)

1998	**1999**	**2000**	**2005**		**2010**		**2015**	
			Low	*High*	*Low*	*High*	*Low*	*High*
89	89	89	0	89	0	89	NA	NA

SUPPLY AND PROCUREMENT STRATEGY AND STOCKPILES

Nuclear fuel for the Metsamor NPP is supplied by the Russian Federation. Armenia's nuclear fuel procurement strategy has remained the same during the past two years, and will continue for the foreseeable future. Armenia does not maintain a stockpile of natural uranium. Information about uranium purchase prices is not available.

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*	This is the first time Armenia has provided a report for the Red Book.

• Australia •

URANIUM EXPLORATION

Historical review[1]

Exploration for uranium in Australia can be divided into two distinct periods: 1947 to 1961, and 1966 to the present. During the first period, the Australian Government introduced measures to encourage exploration, including a system of rewards for the discovery of uranium ore. There was active exploration, particularly by prospectors in most Australian mineral fields and many of the discoveries were made by prospectors equipped with Geiger counters. Several of the deposits discovered during this period produced uranium, the largest being Mary Kathleen, Rum Jungle and Radium Hill.

Uranium requirements for defence purposes decreased in the early 1960s and uranium demand fell sharply. As a result, there was virtually no exploration for uranium between 1961 and 1966.

The second phase of uranium exploration in Australia commenced in 1966. This revival was encouraged by the announcement in 1967 of a new export policy designed to encourage exploration for new deposits. Most of this exploration was undertaken by companies with substantial exploration budgets, utilising the more advanced geological, geochemical and geophysical techniques now available. Several major discoveries were made through the use of airborne multi-channel gamma ray spectrometers. These discoveries resulted in large increases in Australia's low cost (<USD 80/kgU) RAR from 6 200 tonnes U in 1967 to 622 000 tU in 1996. The major uranium deposits which were discovered during the second phase of exploration included:

Unconformity related deposits

Alligator Rivers uranium field:	Ranger (1969)[2], Nabarlek (1970), Koongarra (1970), Jabiluka (1971)
Paterson Province:	Kintyre (1985)

Breccia complex deposit

Stuart Shelf:	Olympic Dam (1975)

Surficial deposits

Calcrete deposits in tertiary sediments overlying the Yilgarn Block:	Yeelirrie (1971), Lake Way (1972), Lake Maitland (1972)

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1. For a summary of the history of uranium exploration in Australia, please refer to Lambert, I., McKay, A., & Miezitis, Y., 1996: *Australia's Uranium Resources: "Trends, Global Comparisons and New Developments"*. Bureau of Resource Sciences, Canberra.

2. Year of discovery shown in parentheses.

Sandstone deposits

Frome Embayment uranium field:	Beverley (1970), East Kalkaroo (1971), Honeymoon (1972)
Westmoreland/ Pandanus Creek uranium field:	Junnagunna (1976)
Ngalia Basin:	Bigrlyi (1970), Walbiri (1970)
Amadeus Basin:	Angela (1973), Pamela (1973)
Carnarvon Basin:	Manyingee (1974)
Officer Basin:	Mulga Rock (1978)

Volcanic deposits

Georgetown/Townsville uranium field:	Maureen (1971), Ben Lomond (1976)

Following the uranium exploration boom in Australia during the late 1970s exploration expenditure declined sharply from the peak level of AUD[1] 89 million in 1980 to AUD 26.4 million in 1983. This sharp fall in exploration was due to decreases in uranium prices and energy conservation policies in response to the oil shocks of the 1970s.

In 1983, the Labour Government introduced what became known as the “three mines” policy. Under this policy, exports of uranium were permitted only from the Nabarlek, Ranger and Olympic Dam mines. Despite the dampening effect of the “three mines” policy on uranium exploration, the discovery of the Kintyre deposit in the Paterson Province, Western Australia, in 1985 led to an increase in exploration expenditure from 1985 to 1988. Exploration subsequently declined from 1989 onwards to an historic low of AUD 7.2 million in 1994. This decline was due to the fall in spot market prices from 1976 onwards, excess uranium inventories in Western world countries, and the sales of uranium from the former USSR countries.

Recent and ongoing uranium exploration and mine development activities

From 1994 onwards, uranium exploration expenditure has increased to AUD 19.37 million in 1998. Australia has been one of the few countries where expenditure increased. These increases were due to the abolition of the ‘three mines’ policy by the Liberal/National Party Coalition following its election to government in 1996, and improved prices for uranium during 1996.

The main areas where uranium exploration was carried out during 1997 and 1998 included:

- Arnhem Land (Northern Territory) – exploration for unconformity-related deposits in Palaeoproterozoic metasediments below a thick cover of Kombolgie Sandstone.

- Paterson Province (Western Australia, WA) – exploration for unconformity-related deposits in Palaeoproterozoic metasediments of the Rudall Metamorphic Complex which hosts the Kintyre orebody.

- Frome Embayment (South Australia) and Officer Basin (WA) – exploration for sandstone uranium deposits.

1. Expenditures in 1997 AUD.

- Westmoreland area (northwest Queensland) – exploration for sandstone type deposits in Proterozoic sediments of the McArthur Basin.

- Olympic Dam area – exploration drilling along the southern margins of the deposit.

- Mount Isa Inlier (northwest Queensland) – exploration continued at the Valhalla deposit where mineralisation is in a brecciated sequence of ferruginous shales, tuffaceous sediments and basalts (Proterozoic), which show hematite and sodic alteration.

- Calcrete deposits – exploration for uranium mineralisation within calcrete occurring in Tertiary drainage systems overlying granitic rocks of the Yilgarn Block (WA).

Uranium exploration expenditures and drilling effort – domestic

	1996	1997	1998	1999 (Expected)
Industry expenditures: AUD (x 1000) USD (x 1000)	 14 920 11 842	 23 630 18 754	 19 370 15 373	 NA NA
Industry surface drilling in metres	19 293	63 418	78 085	NA
Number of industry holes drilled	Not known	Not known	Not known	NA

URANIUM RESOURCES

Known conventional resources (RAR & EAR-I)

Over the two-year period from 1 January 1997 to 1 January 1999, estimates of Australia's uranium resources in the RAR and EAR-I categories have changed as follows:

- RAR recoverable at costs of <USD 80/kgU have decreased by 15 000 tU.
- EAR-I recoverable at costs of <USD 80/kgU have increased by 11 000 tU.
- RAR recoverable at costs in the range USD 80-130/kgU have increased by 1 000 tU.
- EAR-I recoverable at costs in the range USD 80-130/kgU have increased by 14 000 tU.

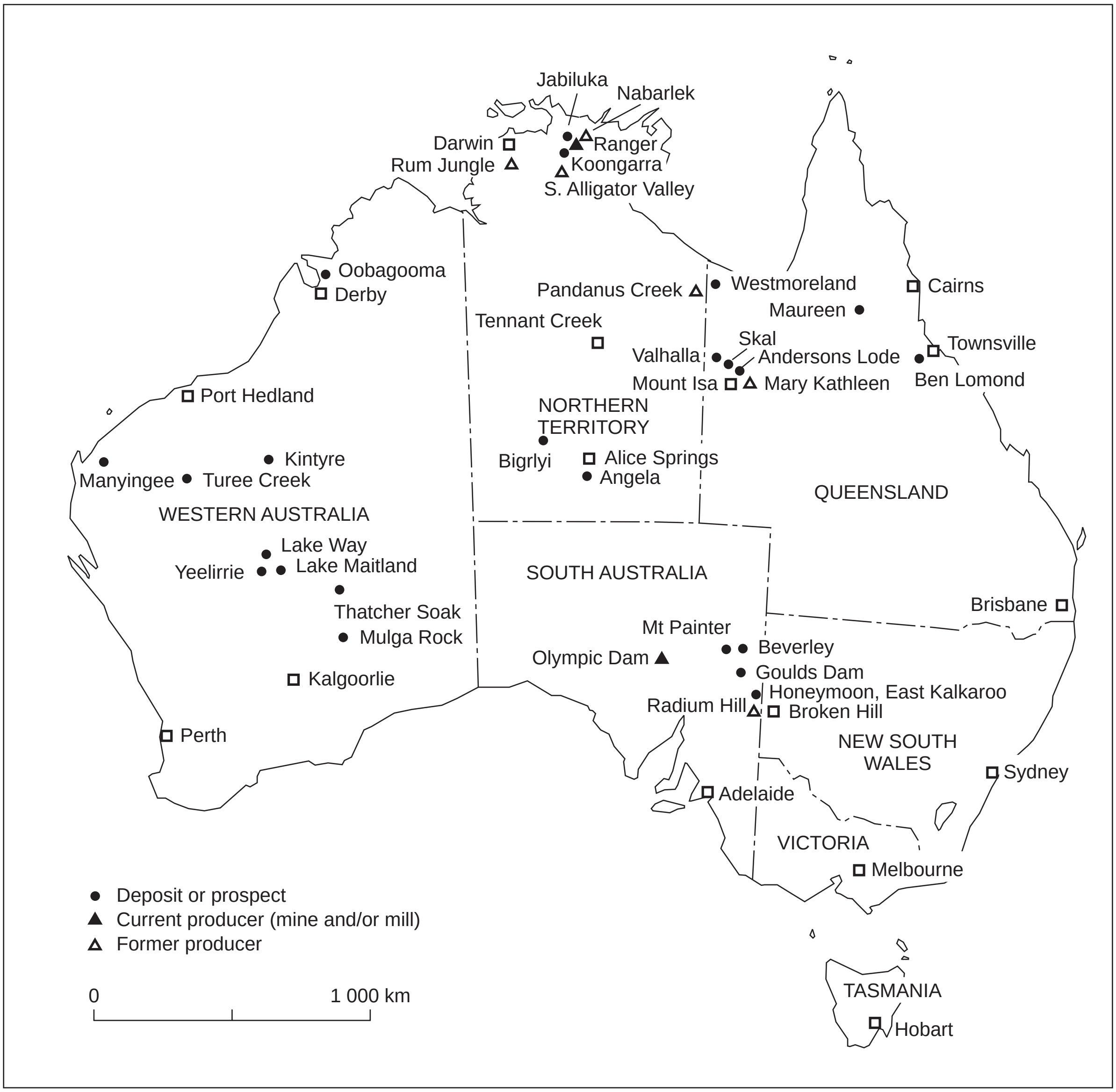
These changes were due to:

- reassessments of the resources for the Olympic Dam, Beverley, Honeymoon and Valhalla orebodies. The latest estimates for these orebodies were calculated either by the mining companies, or by the Australian Geological Survey Organisation in conjunction with the mining companies;

- improved metallurgical recoveries achieved by Ranger mill (85.51% in 1997 to 86.77% in 1998), have increased the estimates of recoverable resources for Ranger No. 3 orebody;

- low cost RAR were reduced by uranium production from Ranger and Olympic Dam mines which totalled 10 399 tU for 1997 and 1998.

Uranium deposits and prospects in Australia



The uranium resources for the Olympic Dam deposit contain copper as co-product, and associated by-products of gold and silver.

Australia's uranium resources in the RAR and EAR-I categories do not include any uranium recoverable as a by-product of the extraction of other minerals.

Deductions for anticipated mining and ore processing losses are determined for each deposit. The percentage of losses for mining and ore processing are dependent upon: mining methods (or proposed methods for undeveloped deposits), metallurgical processes (or proposed processes for undeveloped deposits), and mineralogy of the ore and gangue.

For Ranger and Olympic Dam deposits, the latest figures for mining and ore processing losses, as reported by the companies, were used to calculate recoverable resources.

Eighty-four per cent of the known uranium resources recoverable at costs below 80/kgU are tributary to existing production centres.

Undiscovered conventional resources (EAR-II & SR)

Estimates are not made of Australia's uranium resources within the EAR-II & SR categories.

URANIUM PRODUCTION

Historical review

Production of uranium in Australia commenced in 1954. During the period 1954 to 1971, some 7 800 tU were produced to fulfil contracts with the UK Atomic Energy Authority or the Combined Development Agency (a joint UK-US defence purchasing agency). The major production was from two mines, Rum Jungle in the Northern Territory and Mary Kathleen in Queensland. The remainder of the production was from a number of small deposits in the South Alligator Valley in the Northern Territory and from Radium Hill in South Australia. Production ceased when the existing contracts were completed although at Rum Jungle production continued until the orebodies were mined and the production in excess of that required to meet contracts was stockpiled.

The second phase of uranium production in Australia commenced in 1976 with the re-start of production from Mary Kathleen. Production commenced at Nabarlek (Northern Territory) in June 1980; at Ranger (Northern Territory) in August 1981; and at Olympic Dam (South Australia) in September 1988. The Nabarlek orebody was mined in 1979 and stockpiled for later treatment. Production ceased in 1988 when the final portions of the stockpile were processed.

Status of production capability

Uranium oxide is currently produced at the Ranger and Olympic Dam operations. Australia's total production for 1998 was 5 790 t U_3O_8 (4 910 tU), of which Ranger produced 4 050 t U_3O_8 and Olympic Dam produced 1 740 t U_3O_8. Total production for 1998 was 11% less than in 1997.

Ranger

Full-scale mining at the Ranger No. 3 orebody commenced in mid 1997. The orebody has total proven plus probable reserves of 16.3 Mt ore with an average grade of 0.29% U_3O_8 (47 200 t U_3O_8), as at June 1998. No. 3 orebody is 1 km north of the mined-out No. 1 open pit, which has been used as a repository for mill tailings since August 1996.

In August 1997, Energy Resources of Australia Ltd (ERA) completed the expansion of milling capacity at Ranger to 5 000 t U_3O_8 per year. ERA decided to temporarily shutdown the new ball mill from 8 January 1999 in view of depressed market conditions. Production for 1999 is estimated to be approximately 4 000 t U_3O_8.

Uranium production centre technical details

(as of 1 January 1999)

	Centre # 1	Centre # 2	Centre # 3	Centre # 4	Centre # 5	Centre # 6
Production centre name	Ranger	Olympic Dam	Jabiluka	Beverley	Honeymoon	Kintyre
Production centre class	Existing	Existing	Planned	Planned	Planned	Planned
Operational status	Mine and processing plant operating	Mine and processing plant operating	Mine construction commenced June 1998	NA	Government approval yet to be obtained	Government approval yet to be obtained
Start-up date	1981	1988	2001	2000	–	–
Source of ore						
• Deposit name	Ranger 1, No. 3 orebody	Olympic Dam orebody	Jabiluka, orebody	Beverley orebody	Honeymoon orebody	Kintyre orebody
• Deposit type	Unconformity-related	Breccia complex	Unconformity-related	Sandstone	Sandstone	Unconformity-related
Mining operation						
• Type (OP/UG/ISL)	OP	UG	UG	ISL	ISL	OP
• Size (tonnes ore/year)	2.4 million (a)	4 million	450 000 (e)	NA	NA	0.6 million
• Average mining recovery (%)	NA	NA	NA	65	65	NA
Processing plant (acid/alkaline):	Acid	Acid	Acid			Acid (crush, rad-sort, Dens-sep)
• Type (IX/SX/AL)	CWG, AL, SX	CWG, FLOT, SX, AL	CWG, SX, AL	IX, AL	SX, AL	SX, AL
• Size (tonnes ore/year) For ISL (kilolitre/day or litre/hour)	2 million	3.4 million	450 000	NA 450 litres/sec	NA	45 000
• Average process recovery (%)	85	66 (c)	NA	NA	NA	NA
Nominal production capacity (tU/year)	4 240	1 442	2 290	848	848	1 020
Plans for expansion	(b)	(d)	(e)		NA	NA

a) Historically the tonnages of ore mined annually have ranged up to a maximum of 2.4 million tonnes.

b) Expansion of the milling capacity to 2.0 million tonnes ore per year (4 240 tU/y) was completed in August 1997. In the event that ERA's proposal to process Jabiluka ore at the Ranger mill is approved, capacity of the mill would be increased further to approximately 5 090 tU/y (6 000 t U_3O_8/y). Under an agreement with the Commonwealth Government, ERA can increase production to 5 090 tU/y when the company considers it commercially viable to do so.

c) Source: WMC Holdings Report to the Securities and Exchange Commission Washington DC, 1992.

d) Production capacity of the mill is to be expanded to 8.5 million tonnes ore per year with production of 3 900 tU/y (4 600 t U_3O_8/y) by end 1999.

e) Production from Jabiluka will be limited until the Ranger orebody is exhausted. Full-scale commercial mining at Jabiluka will be reached in 2009.

Historical uranium production

	Pre-1996	1996	1997	1998	Total to 1998	Expected 1999
Mining method	(tonnes U contained in ore)					
Conventional mining: • Open-pit • Underground	62 319 (a)	3 509 1 466 (b)	4 063 1 425(b)	3 434 1 476 (b)	73 325 4 367	3 392 3 053
TOTAL	**62 319**	**4 975**	**5 488**	**4 910**	**77 692**	**6 445**
Production method	(tonnes U contained in concentrate)					
Processing plant	62 319	4 975	5 488	4 910	77 692	6 445
TOTAL	**62 319**	**4 975**	**5 488**	**4 910**	**77 692**	**6 445**

a) Total for pre-1996 is the combined production from both open cut and underground mining operations.

b) Production from Olympic Dam is reported by the company as tonnes of uranium ore concentrates. The grades of these concentrates are not reported but are usually higher than 98% U_3O_8. No allowance is made here for the grade of these concentrates.

Olympic Dam

The Olympic Dam copper-uranium-gold-silver deposit is the world's largest deposit of low-cost uranium. Total proved plus probable reserves amount to 336 000 t U_3O_8, as of December 1998. Uranium production is linked to copper production.

The Olympic Dam expansion project commenced in January 1997 and construction work continued through 1998. The expansion will increase annual production capacity to 200 000 t of refined copper and 4 600 t U_3O_8, which will triple current production levels. At this production rate the mill will process 9 Mt of ore per year. This expansion is South Australia's largest development project with the final cost of the expansion estimated to be AUD 1.94 billion.

Features of the expansion include: an automated electric rail haulage system and a new crusher station; a new autogenous mill incorporating the latest grinding technology; a new smelter; an enlarged hydrometallurgical plant; and a third haulage shaft.

Jabiluka

ERA Ltd proposes to mine the Jabiluka orebody by underground mining methods. Jabiluka has total proved and probable ore reserves of 19.5 million tonnes averaging 0.46% U_3O_8 (90 400 t U_3O_8).

ERA's preferred option is for an underground mining operation, with the ore to be processed at the Ranger mill. The ore would be trucked for a distance of 22 km to Ranger via a haul road entirely within the lease area, and the tailings would be disposed of into the open pits at Ranger. This option is referred to as the Ranger Mill Alternative.

As an alternative, ERA proposed in the Jabiluka environmental impact statement (EIS) that a mill be built adjacent to the mine, and that the ore would be milled and processed within the Jabiluka Mineral Lease. This option is referred to as the Jabiluka Mill Alternative (JMA).

In August 1998, after considering recommendations from the Environment Minister on the JMA, the Minister for Resources and Energy formally cleared the way for the development of milling operations at Jabiluka. This decision completes the Commonwealth approvals process under the *Environmental Protection (Impact of Proposals)* Act for the Jabiluka mine and for the options to mill the ore either at Jabiluka or at Ranger. ERA considers that the option of milling the ore at Ranger is more environmentally beneficial than milling the ore at Jabiluka. The company is seeking to find common ground with the Traditional Owners, through their legal representatives, the Northern Lands Council, on where the ore should be processed.

Construction work at the Jabiluka site commenced in June 1998. The water retention pond has been completed. Construction of the 1 150 m decline was completed in early 1999.

Beverley

The Beverley uranium deposit has total resources recoverable by in situ leach (ISL) mining of at least 10 600 t U_3O_8. The deposit occurs in uncemented, fine to medium grained sands with inter-bedded clays and silts (Upper Tertiary Namba Formation). Uranium mineralisation forms three lenticular zones, designated North, Central and South ore lenses. The North and Central ore lenses are within the central of three palaeochannels, while the South ore lens is situated in the south palaeochannel. Mineralisation occurs at an average depth below surface of 107 metres, and the combined thickness of the mineralised sand is typically 20-30 metres.

In January 1998, Heathgate commenced in situ field leach trials to confirm the viability of ISL methods. On the basis of the success of these trials, it is proposed that the commercial operation, will use sulphuric acid and oxygen to dissolve the uranium in situ, and resin type ion exchange techniques are to be used to recover uranium in the processing plant.

Heathgate proposes that liquid wastes be collected initially in the plant holding ponds. Two options exist for disposal of these liquids: re-inject the liquids into the Beverley aquifer in areas already mined out; or evaporate the water in surface ponds, and disposal of the resulting solids in an engineered disposal facility.

The company considers that re-injection into the mineralised aquifer is the best method for disposal from both environmental and operational perspectives.

As part of the environmental assessment process, the Bureau of Rural Sciences completed an independent assessment of the Beverley aquifer for Environment Australia. The findings were that the Beverley aquifer is a bounded, and confined aquifer which contains semi-stagnant groundwater. From the assessment it was concluded that disposal of liquid waste into the northern mineralised zone is the best option when compared to the other options for disposal of these wastes. In April 1999, the Minister for Industry, Science and Resources formally cleared the way for commercial ISL operations to commence at Beverley.

Drilling of the wellfields commenced in mid 1999 and construction of the ISL plant is progressing. Production is scheduled to commence in mid 2000 at an annual rate of 1 000 t U_3O_8.

Ownership structure of the uranium industry

As at August 1998, ERA the operating company for the *Ranger* mine and mill, was owned by the following companies:

	% of issued capital
North Limited	68.39
Other "A class" Shareholders	6.51
Cameco	6.45
UG Australia Developments Pty Ltd	4.19
Interuranium Australia Pty Ltd	1.98
Cogema Australia Pty Ltd	1.31
OKG Aktiebolag	0.54
Japan Australia Uranium Resources Development Co. Ltd	10.64

The *Olympic Dam* project is wholly-owned by WMC.

Employment in the uranium industry

Employment in Australia's production centres has increased marginally in response to the resumption of continuous milling at Ranger and the expansion of Olympic Dam.

Future production centres

The resources recoverable by ISL methods for Honeymoon and nearby deposits owned by Southern Cross Resources Australia P/L are:

Deposit or prospect	Resource category	Resources (t U_3O_8)	Grade (% U_3O_8)
Honeymoon (including Honeymoon Extension)	Measured	3 700	0.156
East Kalkaroo	Indicated	900	0.14
Goulds Dam	Inferred	18 000	0.098

The Honeymoon deposit has a roll-front shape and occurs at an oxidation-reduction interface within coarse-grained sands of Tertiary age, along the lateral margins of a bend in a palaeochannel. The deposit is between 100 m and 120 m below surface.

In May 1996, the project was acquired by Southern Cross Resources Incorporated. Refurbishment of the solvent extraction plant (which was built by the previous owners) commenced in the latter part of 1997, and it was commissioned in early 1998.

In April 1998, approval was granted by the South Australian Department of Primary Industries and Resources for the company to carry out field leach trials. These used sulphuric acid and an oxidant to mobilise the uranium from the basal aquifer. The oxidants tested were oxygen gas, hydrogen peroxide and ferric sulphate [$Fe_2(SO_4)_3$].

Uranium recovery at the plant is by a solvent extraction and precipitation circuit. Both solvent extraction and ion exchange (resin) techniques were investigated; however, the results obtained using solvent extraction were far superior, because the extremely high chloride content of the groundwaters prevented the ion exchange process from working effectively.

A draft EIS for the project was expected to be released in late 1999. The proposed commercial operation will produce up to 1 000 t U_3O_8 per year.

ENVIRONMENTAL CONSIDERATIONS

Northern Territory

The Ranger mine is currently the only operating mine in the Northern Territory. The Nabarlek mine ceased production and has been successfully rehabilitated. Environmental monitoring of the site is continuing. Both these mines and the planned Jabiluka mine, where construction commenced in June 1998, are in the Alligator Rivers Region (ARR).

While the Commonwealth Government owns uranium in the Northern Territory and maintains responsibility for supervising environmental management and research in the ARR, the Northern Territory Government has responsibility for day to day regulation of mining activities. The responsibilities of both Governments are imposed by a suite of legislation and agreements between the two Governments to minimise the environmental impacts from mining.

The Commonwealth's Office of the Supervising Scientist (OSS), has overseen the environmental aspects of uranium mining operations in the ARR since mining commenced at Ranger and Nabarlek in the early 1980s. The Supervising Scientist, supported by the Environmental Research Institute of the Supervising Scientist (ERISS), co-ordinates and supervises measures for the protection and restoration of the environment of the ARR from the effects of uranium mining. The OSS measures environmental performance of the mines, including the rehabilitation of Nabarlek, through twice-yearly audit processes.

The Supervising Scientist has consistently attested including in his report for the year ended 30 June 1998, to the high level of environmental protection achieved in the ARR and noted that mining operations have had a negligible impact on the surrounding environment.

Jabiluka

The Jabiluka deposit is located on the adjoining lease to Ranger and the company's preferred option is to integrate development with existing operations at Ranger. ERA's proposal is to start production in 2001, gradually increasing to approximately 4 000 t U_3O_8 /year. The proposal underwent a joint Commonwealth/Northern Territory environmental impact statement (EIS) process. An EIS was released for public comment in October 1996 and a response document, the Supplement, in June 1997.

In August 1997, the Commonwealth Environment Minister advised the Minister for Resources and Energy that on the available evidence there did not appear to be any environmental issue, which should prevent ERA's preferred Jabiluka proposal from proceeding. The advice included over 70 recommendations by the Environment Minister to be implemented as conditions in relation to the project to ensure the protection of World Heritage and Ramsar values, flora and fauna and cultural heritage (including sacred sites). The Minister for Resources and Energy formally advised ERA of his requirements relating to the project which give full effect to the Environment Minister's recommendations.

ERA is continuing to seek the consent of traditional Aboriginal owners to implement its preferred option to mill Jabiluka ore at Ranger. In the meantime, ERA is progressing the alternative option of developing a stand alone mill at Jabiluka.

In April 1998, the Environment Minister determined that a Public Environmental Report (PER) was required for the proposed mill at Jabiluka to supplement information already included in the previous environmental assessment process. Assessment of the proposal was completed in August 1998 when the Environment Minister advised the Resources and Energy Minister that the proposal to mill uranium ore at Jabiluka could proceed provided 100% of the mill tailings are placed back underground. The Resources and Energy Minister subsequently advised ERA of his endorsement of the Environment Minister's advice, imposing additional requirements relating to the development of the proposed mill at Jabiluka. On the basis of environmental approvals that had already been given, ERA commenced construction at Jabiluka in June 1998.

In July 1999, UNESCO's World Heritage Committee was planning to consider whether the World Heritage values of Kakadu National Park are "in Danger" as a result of the Jabiluka development. The Australian Government does not accept that Kakadu is "in Danger", and believes that an objective assessment of the extensive body of information available clearly demonstrates this. The World Heritage Committee decided not to place Kakadu on the "in danger" list.

South Australia

Olympic Dam

The Olympic Dam project is regulated under South Australian State Government legislation, principally through the *Roxby Downs (Indenture Ratification) Act 1982 as amended* (the Indenture). The Indenture requires the operator (WMC Ltd) to draft and implement an Environmental Management Programme which must be revised and submitted for State Government approval every three years. Approval has been given for the new plan for the three years commencing 1 March 1999. This document (the Environmental Management Manual) and supporting Environmental Management Programmes (EMPs), together with annual reports submitted in accordance with the EMPs, are all publicly available documents.

In July 1996, WMC Ltd announced its intention to seek the necessary regulatory and environmental approvals to expand its Olympic Dam project to produce up to 350 000 t/y of copper plus associated products (uranium, gold and silver). The company proposed to initially increase copper production from 85 000 t/y to 200 000 t/y plus associated products (uranium, gold and silver) by 2001. Uranium output would increase from 1 700 t/y to about 4 600 t/y of U_3O_8. In February 1997, WMC announced that the expansion would be accelerated to achieve the planned output level of 200 000 t/y of copper by the end of 1999.

The expansion proposal underwent a joint Commonwealth/South Australia EIS assessment process. An EIS was released for public comment in May 1997 and a response document, the Supplement, in October 1997. In December 1997, the Commonwealth Environment Minister advised the Resources and Energy Minister that, on the available evidence, the expansion appeared to be environmentally acceptable and made a number of recommendations to ensure the project continued to operate under stringent environmental controls. In June 1998 the Resources and Energy Minister formally advised WMC of his requirements relating to the expansion to give effect to the Environment Minister's recommendations.

The expansion of Olympic Dam to 200 000 t/y of copper was completed ahead of schedule by the end of the first quarter of 1999. The project has environmental clearances to produce up to 350 000 t/y of copper (with associated production of about 7 700 t/y of U_3O_8) provided there will be no significant change in the technology used. There are, however, currently no plans for any major expansion of the project beyond 200 000 t/y of copper.

New Commonwealth/State/Community consultative arrangements were also introduced in 1998 to facilitate effective mutual exchange of information on environmental and related matters relating to the Olympic Dam project. These consist of the Olympic Dam Environment Consultative Committee (ODECC) and Olympic Dam Community Consultative Forum (ODCCF). The ODECC comprises WMC, South Australian and Commonwealth Government representatives. The ODCCF is made up of members representing environmental organisations, Aborigines, the State Arid Areas Water Resources Committee, pastoralists, residents of Roxby Downs (the local purpose-built town for the Olympic Dam project) and members of the ODECC.

Beverley

Heathgate Resources Pty Ltd (Heathgate) plans to develop an in situ leaching (ISL) uranium mine at Beverley to produce up to 1 000 t U_3O_8/y commencing in mid-2000. The proposal was subject to a joint Commonwealth/South Australia EIS assessment process. An EIS was released for public comment in June 1998 and a response document, the Supplement, in September 1998.

In December 1998, the Commonwealth Environment Minister advised the Minister for Industry, Science and Resources[1] that, on the evidence available to him, the Beverley mine was environmentally acceptable provided the mine operated under stringent environmental controls. However, with regard to the company's proposal to dispose of liquid residues by injection in the Beverley aquifer, the Environment Minister recommended that no Commonwealth approvals for the project be granted until Heathgate confirmed that there is no hydraulic connection between the aquifer and surrounding groundwaters.

In March 1999, after further consideration of an additional investigation and report by the Land and Water Sciences Division of the Bureau of Rural Sciences, the Commonwealth Environment Minister wrote to the Minister for Industry, Science and Resources to advise his conclusion that the northern component of the Beverley aquifer sequence is effectively sealed from surrounding groundwater and is thus suitable for injection of liquid residues from the Beverley mine. In April 1999, the Minister for Industry, Science and Resources formally advised Heathgate of his requirements relating to Beverley's development that give effect to the Environment Minister's recommendations to ensure the mine is properly managed and monitored. These requirements include Heathgate preparing a comprehensive Environment Management and Monitoring Plan for consideration and approval by the South Australian Government.

1. Following the Federal election on 3 October 1998, the responsibility for minerals and energy issues, including uranium, resides with the Minister for Industry, Science and Resources.

Honeymoon

Southern Cross Resources Australia Pty Ltd plans to develop an ISL uranium mine at Honeymoon that will produce up to 1 000 t/y of U_3O_8. The proposal is undergoing a joint Commonwealth/South Australia EIS assessment process. An EIS was scheduled to be released for public comment in late 1999.

Western Australia

A joint Commonwealth/Western Australia EIS assessment process was initiated in response to the proposal submitted in 1996 by Canning Resources Pty Ltd (a subsidiary of Rio Tinto Ltd) to develop the Kintyre uranium deposit. However, in August 1997 Rio Tinto announced Kintyre's development had been put on hold because of falling uranium prices and delays in native title approvals.

NATIONAL POLICIES RELATING TO URANIUM

No significant changes have occurred in the last two years. The 1997 Red Book described policy changes made following the election in March 1996 of the Liberal/National Coalition Government which was re-elected in October 1998.

URANIUM STOCKS

For reasons of confidentiality, information on producer stocks is not available.

URANIUM PRICES

Average annual export prices for Australian uranium have been:

1990	AUD	61.08/kgU
1991	AUD	71.01/kgU
1992	AUD	57.43/kgU
1993	AUD	60.28/kgU
1994	AUD	53.06/kgU
1995	AUD	55.74/kgU
1996	AUD	53.96/kgU
1997	AUD	48.93/kgU
1998	AUD	57.28/kgU

• Belgium •

URANIUM EXPLORATION

Historical review

Until 1977, just a few uranium occurrences were known in Belgium. These were mainly connected with black shales of the Upper Visean-Namurian, in the Dinant Basin, and of the Revinian, in the Stavelot mountains, and also with breccia, in Visean and Frasnian chalk, in the Visé mountains.

From 1977 to 1979, there was renewed interest in uranium exploration, leading to a study of the uranium occurrences in the Visé mountains and a study on the uranium content of the phosphates in Cretaceous formations in the Mons Basin.

From 1979 to 1981, the European Communities and the Ministry of Economic Affairs financed a general reconnaissance survey for uranium in the areas of Paleozoic formations in Belgium. The Geological Service co-ordinated three types of exploration, covering an area of approximately 11 000 km^2: carborne radiometric survey, geochemical survey on alluvial deposits, and hydrogeochemical survey. The Belgian universities of Mons, Louvain (UCL), and Brussels (ULB), respectively, were entrusted with the work. The general report was published in 1983.

From 1981 to 1985, this research was conducted chiefly at the Mons Laboratory, with the aim of studying the geological environment of the main anomalies discovered in the course of general exploration (Visean-Namurian and Lower Devonian).

From 1985 to 1988, an exploration programme financed by the Underground Resources Service (Walloon Region) led to the discovery of anomalies and deposits (over 1% uranium equivalent at certain points) in schist sandstone formations of the Lower Devonian and surface formations in Upper Ardenne.

Strategic and tactical uranium exploration was pursued in the Lower Devonian, in the Belgian Ardenne and on the basis of isolated anomalies discovered during preliminary carborne prospecting. This project was jointly financed by the EEC and the Geological Service of Belgium, during 1979-1982. Different geochemical and geophysical methods were used (radon in spring water, ground radon survey, gamma spectrometry) for indications discovered during the second phase, and trenching and short drilling (about 10 metres). Deeper core sampling and drill hole-logging surveys were conducted on a regional basis by the Geological Service.

Currently, it is estimated that none of the areas investigated are of economic interest. Although the occurrences are numerous and varied, the uranium content of each indication showing more than 100 ppm amounts to less than one tonne.

The uranium content of phosphates in the Mons Basin have also been evaluated, and a new estimate of the P_2O_5 resources in the Basin put unconventional uranium resources at approximately 40 000 tU metal. This includes approximately 2 000 tU of resources in areas suitable for phosphate mining, although the contents are below 10% P_2O_5 and 100 ppm uranium equivalent.

URANIUM RESOURCES

No significant uranium resources were reported by Belgium.

URANIUM PRODUCTION

Belgium reported a production capacity of 45 tU/year from imported phosphates. Production for 1997 and 1998 was reported at 27 and 15 tU/year, respectively. No production is anticipated for 1999. Prayon-Rupel Technologies (PRT) has decided to stop recovering uranium from imported phosphates. The facility shall be decontaminated and then dismantled.

Uranium production centre technical details

(as of 1 January 1999)

	Centre # 1
Name of production centre	PRT
Production centre class	Existing
Operational status	Decommissioning
Start-up date	1980
Source of ore: • Deposit name • Deposit type	Phosphates from Morocco
Mining operation: • Type (OP/UG/in situ) • Size (tonnes ore/year) • Average mining recovery (%)	None
Processing plant: • Type (IX/SX/AL) • Size (tonnes ore/year) • Average processing ore recovery (%)	DEPA-TOPO Process 130 000 TP_2O_5/year
Nominal production capacity (tU/year)	45
Plans for expansion	None

Ownership structure of the uranium industry

Since the 1997 Red Book, there have been no changes in the Belgian uranium production ownership structure or uranium production employment sector. The 45 tonnes of uranium production capacity is 100% owned by PRT, a private company.

Future production

No new uranium production capability is currently foreseen in Belgium over the 1999-2015 period.

URANIUM REQUIREMENTS

The installed nuclear generating capacity in Belgium is unchanged at 5 713 MWe (net). The current uranium demand of 1 050 tU is not expected to change over the 1999-2015 period.

In 1990, the three largest private utilities in Belgium merged to form a single private electric utility named Electrabel. Synatom is the Belgian company entrusted by Electrabel with the management of the nuclear fuel cycle for the seven commercial reactors. Until 1994, Synatom was owned 50% by the private sector, through Electrabel, and 50% by the public sector, through SNI (Société Nationale d'Investissement). In 1993, the Belgian State decided to privatise SNI and to sell to Tractebel, the mother company of Electrabel, the shares owned by SNI in the energy sector, including Synatom. The State has kept a "golden share", giving it a veto right on any decision that would be contradictory with the governmental energy policy.

URANIUM STOCKS

Synatom is holding a strategic U-stockpile equivalent to two years requirements. This inventory consists of U_3O_8 , natural UF_6 and enriched UF_6 .

NATIONAL POLICIES RELATING TO URANIUM

At the end of 1993, the Belgian Parliament held an extensive debate on the back-end of the fuel cycle and passed a resolution approving the continuation of the reprocessing contract signed in 1978 by Synatom with Cogema. This enables the recycling of plutonium arising as MOX in Doel-3 and Tihange-2, which will reduce the annual demand for natural uranium by around 4% in the coming years.

URANIUM PRICES

Information on uranium prices is not available for reasons of confidentiality.

• Brazil •

URANIUM EXPLORATION AND MINE DEVELOPMENT

Historical review

Systematic prospecting for radioactive minerals began in 1952 by the Brazilian National Research Council. More information on the history of uranium exploration is reported in the 1997 Red Book.

As a consequence of the reorganisation of the Brazilian nuclear development programme in 1988, the uranium activities were delegated to a special organisation known as Urânio do Brasil S.A., which was organised as a subsidiary of a holding company, Industrias Nucleares do Brasil (INB), responsible for all nuclear fuel cycle activities. Since 1991, all uranium exploration was stopped. From the formation of Nuclebras in 1974 to 1991, the total spent in uranium exploration expenditure was about USD 189 million. Following another reorganisation in 1994, Urânio do Brasil was disbanded and its activities were transferred to INB.

Recent and ongoing uranium exploration and mine development activities

Feasibility studies for the Lagoa Real mining project carried out in 1995 and 1996 led to a production decision. The start of the Lagoa Real development operation was delayed and scheduled for 1999. Planned exploration expenditures for 1999 by INB were about BRL 500 000 (or USD 414 000).

URANIUM RESOURCES

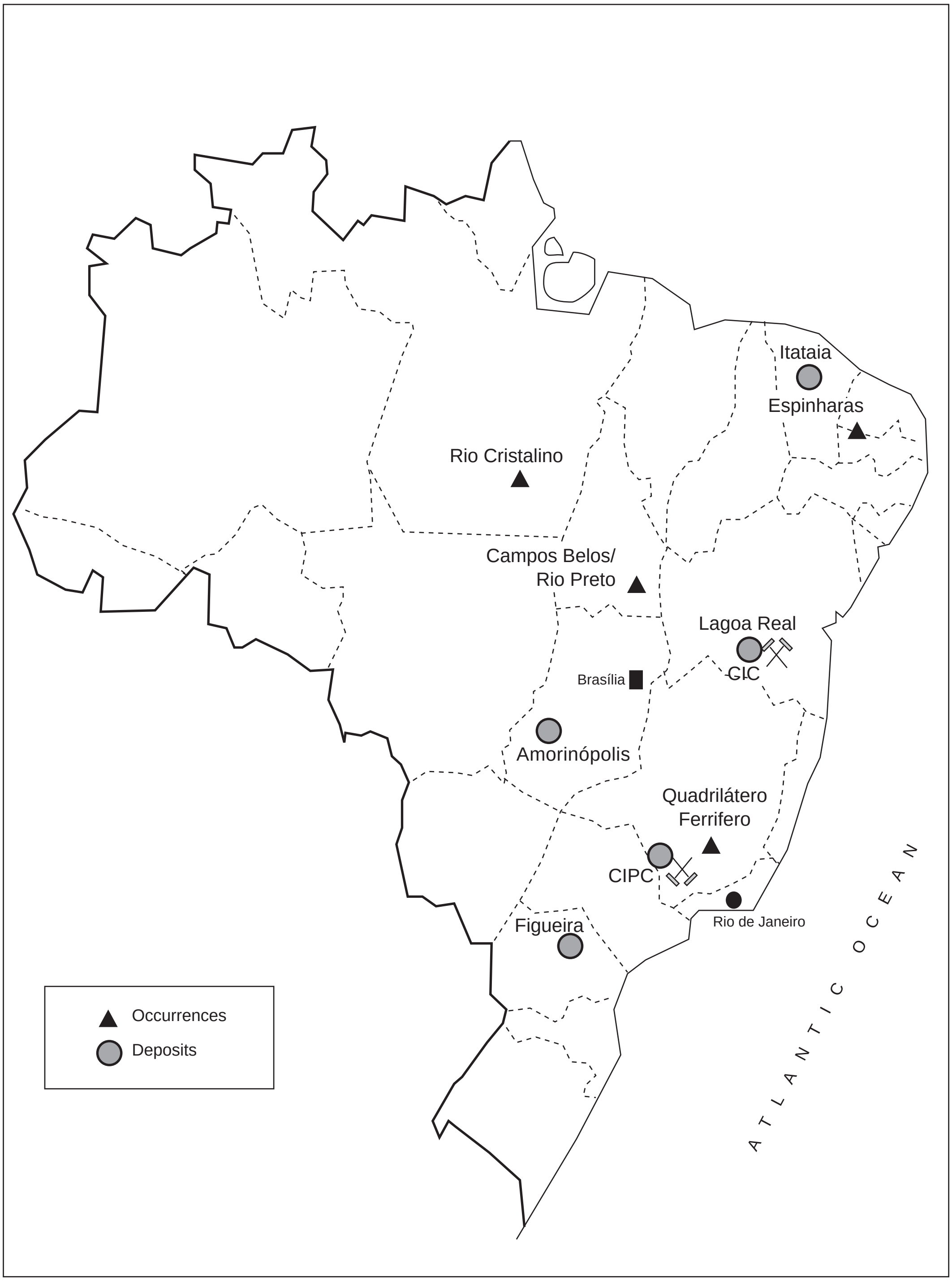
Brazil's conventional known and undiscovered uranium resources are hosted in the following deposits:

- Poços de Caldas (Osamu Utsumi Mine) with the orebodies A, B, E and Agostinho (collapse breccia pipe-type).
- Figueira and Amorinópolis (sandstone).
- Itataia, including the adjoining deposits of Alcantil and Serrotes Baixos (metasomatic).
- Lagoa Real, Espinharas and Campos Belos (metasomatic-albititic).
- Others including the Quadrilátero Ferrifero with the Gandarela and Serra des Gaivotas deposits (quartz pebble conglomerate).

Known conventional uranium resources (RAR & EAR-I)

Brazil reported known conventional resources that were estimated prior to 1992. As of 1 January 1999, RAR and EAR-I of Brazil total 262 200 tU as in situ resources recoverable below $80/kgU. This estimate is unchanged from the previous report.

Uranium deposits and occurrences of Brazil



Reasonably Assured Resources*

(tonnes U)

Cost ranges		
<$40/kgU	<$80/kgU	<$130/kgU
56 100	162 000	162 000

* As in situ resources.

Estimated Additional Resources – Category I*

(tonnes U)

Cost ranges		
<$40/kgU	<$80/kgU	<$130/kgU
0	100 200	100 200

* As in situ resources.

Undiscovered conventional resources (EAR-II & SR)

The estimates of the undiscovered resources are summarised in the following tables.

Estimated Additional Resources – Category II*

(tonnes U)

Cost ranges		
<$40/kgU	<$80/kgU	<$130/kgU
0	120 000	120 000

* As in situ resources.

Speculative Resources*

(tonnes U)

Cost Range		Total
<$130/kgU	Unassigned	500 000
0	500 000	

* As in situ resources.

URANIUM PRODUCTION

The Poços de Caldas uranium production facility, which started production in 1981 with a design capacity of 360 tU/year, belonged to the state-owned company Nuclebras until 1988. At that time Brazil's nuclear activities were restructured. Nuclebras was liquidated and its assets transferred to Urânio do Brasil S.A. With the dissolution of Urânio do Brasil in 1994, the ownership of uranium production is 100% controlled by Industrias Núcleares do Brasil, a state-owned company.

Between 1990 and 1992, the production centre at Poços de Caldas was on stand-by because of increasing production costs and reduced demand. Production restarted in late 1993 and continued until October 1995. After 2 years of stand-by, the Poços de Caldas production centre was shut down in 1997. A decommissioning programme started in 1998.

Historical uranium production

(tonnes U contained in concentrate)

Production method	Pre-1996	1996	1997	1998	Total through 1998	Expected 1999
Conventional mining: • Open pit	1 030	0	0	0	1 030	150

Status of production capability

After the closure of the Poços de Caldas centre in 1997, production of the Lagoa Real is planned to start in 1999.

Uranium production centre technical details

Name of production centre	Poços de Caldas	Lagoa Real	Itataia
Production centre class	Existing	Committed	Planned
Operational status	Shutdown	Pre-operational	Feasibility
Start-up date	1981	1999	NA
Source of ore: • Deposit names • Deposit types	Cercado Mine Collapse Breccia Pipe	Cachoeira Metasomatic	Itataia Phosphorite
Mining operation: • Type • Size (tonnes ore/day) • Average mining recovery (%)		OP/UG 1 000 90	OP NA 50
Processing plant: • Type • Size (tonnes ore/day) • Average ore processing recovery (%)	AL/SX 2 500 80	HL/SX 1 000 80	Flot./AL/SX NA 70
Nominal production capacity(tU/year)	360	250	325
Plans for expansion	No	Yes	NA
Other remarks	Closed 1997	Start up in 1999	Co-product

Ownership structure of the uranium industry

The Brazilian uranium mining industry is 100% owned by the State company Industrias Nucleares do Brasil. This company also controlled the Poços de Caldas facility referred to as Complexo Minero-Industrial do Planalta de Poços de Caldas (CIPC). Information on the ownership of the committed and planned production centre is not available.

Employment in the uranium industry

During the period 1988-1998 CIPC reduced its staff by about 70%. For 1999, an increase is expected to staff the Lagoa Real project.

Employment in existing production centres

(persons-years)

1996	1997	1998	Expected 1999
305	280	180	380

Future production centres

The start of production at the Lagoa Real production centre is planned for 1999. The deposit was discovered in 1977 and its known resources were estimated to total 85 000 tU at the below $80/kgU cost category. The ore will initially be mined by open pit methods from the Anomaly 13, now referred to as the Cachoeira deposit. The uranium will be extracted by acid heap leaching. A capital investment of USD 23 million is reported. At start-up, this centre will have a nominal production capacity of 250 tU/year and there are plans for expansion to 430 tU/year.

In the planned Itataia production centre, uranium would be recovered as a co-product together with phosphate from apatite and collophanite bearing episyenites. Development of the uranium-phosphate Itataia project will depend on numerous factors including the markets for both products. A production start-up date has not been set. A projection of production capability through the year 2015 is shown in the following table.

Short-term production capability

(tonnes U/year)

1999				2000				2001			
A-I	**B-I**	**A-II**	**B-II**	**A-I**	**B-I**	**A-II**	**B-II**	**A-I**	**B-I**	**A-II**	**B-II**
150	150	–	–	250	250	–	–	250	250	–	–

2005				2010				2015			
A-I	**B-I**	**A-II**	**B-II**	**A-I**	**B-I**	**A-II**	**B-II**	**A-I**	**B-I**	**A-II**	**B-II**
250	575	–	–	250	575	–	–	250	575	–	–

ENVIRONMENTAL ASPECTS

The main environmental issues associated with the current uranium mining industry include monitoring of the Poços de Caldas post-operational status, as well as planning for the decommissioning of the mine-mill complex. In addition, an environmental impact assessment of the Lagoa Real production centre has been prepared.

A review of the licensing procedure for the Lagoa Real uranium mining and milling centre follows. The main emphasis is on the radiation and environmental protection aspects of the project. From the beginning, all planning for this centre, referred to as the Complexo Minero Industrial de Caetité/Lagoa Real (CIC), is to ensure that the specific systems for the treatment and disposition of effluents are in accordance with the national and international regulations and standards.

The Comissao Nacional de Energia Nuclear (National Commission of Nuclear Energy, CNEN), the Instituto Brasileiro de Recursos Naturais Renováveis e Meio Ambiente (Brazilian Institute for the Preservation of Natural Resources and Environmental Protection, IBAMA), and the Council of Environmental Resources of the State Bahia (CRA/BA) are the authorities responsible for the licensing of the CIC. As the first step, INB has submitted to IBAMA and to CRA/BA and to the municipal authorities of Caetité County, the required Environmental Impact Study, or the corresponding Environmental Impact Report. The Final Safety Analysis Report is to be filed with CNEN.

The additional steps taken by INB to apply for a license to operate the uranium mine/mill complex are as follows:

1989: an environmental base line study defined by the three organisations IBAMA, CNEN and CRA, was initiated covering 100 km^2 around the site.

1995: the construction decision was made by INB for the Lagoa Real Project at an estimated cost equivalent of USD 20 million.

1997: INB presented the required Environmental Impact Study and the Environmental Impact Report to CNEN and IBAMA.

Following the review of the Study and Report, IBAMA conducted a public hearing to discuss the Study and Report in the town of Caetite. Approximately 1 000 persons from Caetite, Lagoa Real and other settlements located in a radius of 100 km participated in this hearing, at which the project was approved.

IBAMA granted INB a preliminary license. While this document did not authorise INB to proceed with the construction phase, it did acknowledge that the applicant had fulfilled important requirements of the licensing procedure.

1998: IBAMA/CNEN granted the Construction License for the mine-mill complex.

During this period, INB also presented the required Site Report, as well as a Preliminary Safety Analysis Report, and applied for the Mining License. Once this license is granted, the operation can proceed.

1999: Construction of the mill, mine and tailings impoundment was started in June.

URANIUM REQUIREMENTS

Brazil's present uranium requirements for the Angra I nuclear power plant, a 630 MWe PWR, are about 120 tU/year. With the completion and start-up of the Angra II nuclear power plant, a 1 245 MWe PWR, the uranium requirements will increase by 310 tU/year after the first core, which requires 560 tU. It is expected that Angra II will be completed in 1999.

In addition, a third nuclear power plant, referred to as Angra III, of similar type and capacity as Angra II, is planned to come into operation around 2004.

Installed nuclear generating capacity

(MWe net)

1998	1999	2000	2005	2010	2015	
					Low	*High*
630	1 875	1 875	3 120	3 120	NA	NA

Annual reactor-related uranium requirements

(tonnes U)

1998	1999	2000	2005		2010		2015	
			Low	*High*	*Low*	*High*	*Low*	*High*
120	310	450	420	1 040	470	810	470	810

NATIONAL POLICIES RELATING TO URANIUM

After the completion of the construction phase and the successful start-up of the Lagoa Real Project, INB will concentrate on the development of the Itataia deposits. These deposits host the largest uranium resource of Brazil. However, since uranium would be a by-product of phosphate, the economics of the project depend mainly on the phosphate market.

Brazil, through INB, is willing to consider entering into joint projects with national and international partners. Currently, the Rio Cristalino deposit is being evaluated by international uranium producers that may consider entering into a co-operation agreement with INB.

URANIUM STOCKS

No current information is available on uranium stockpiles.

• Canada •

URANIUM EXPLORATION

Historical review

Uranium exploration in Canada began in 1942, with the focus of activity traceable through several distinct phases from Great Bear Lake, Northwest Territories, to Beaverlodge, Saskatchewan, to Blind River/Elliot Lake, Ontario, and back to Saskatchewan's Athabasca Basin in the late 1960s. These latter two areas have been Canada's most prolific, supporting all domestic uranium production until the closure of the Stanleigh mine at the end of June 1996. Following this closure, that brought to an end over 40 years of uranium production in the Elliot Lake area of Ontario, Saskatchewan is Canada's sole producer of uranium.

Recent and ongoing activities

As in previous years, uranium exploration remains concentrated in areas favourable for the occurrence of deposits associated with Proterozoic unconformities, most notably in the Athabasca Basin of Saskatchewan, but also in the Thelon Basin of the Northwest Territories.

In 1998, overall Canadian uranium exploration expenditures reached CAD 60 million, while uranium exploration and surface development drilling approached 95 000 m, down from about 104 500 m reported for 1997. As in recent years, most of the overall exploration expenditures can be attributed to advanced underground exploration, deposit-appraisal activities, and care-and-maintenance expenditures associated with those Saskatchewan projects awaiting production approvals. Basic "grass-roots" uranium exploration therefore likely reached CAD 25 million in 1998, down slightly from some CAD 27 in 1997. In recent years, the number of companies with major exploration programmes in Canada has declined.

Uranium exploration and development expenditures and drilling effort – domestic

	1996	1997	1998	1999 (Expected)
Industry expenditures in million CAD	17	27	25	16
Government expenditures in million CAD	<0.1	<0.1	<0.1	<0.1
Sub-total exploration expenditures	17	27	25	16
Sub-total development expenditures	22	31	35	30
Total expenditures:				
• in million CAD	39	58	60	46
• in million USD	28.5	42	41.1	30
Industry exploration drilling in metres	79 000	104 000	89 000	67 000
Sub-total development drilling in metres	NA	500	6 000	2 000
Total drilling in metres	79 000	104 500	95 000	69 000

Well over 90% of the combined exploration and surface development drilling in 1997 and 1998 took place in Saskatchewan. In 1999, total combined uranium drilling is expected to decline to less than 70 000 m.

The top three operators, accounting for nearly all of the CAD 60 million expended in 1998 were: Cameco Corporation, Cigar Lake Mining Corporation and COGEMA Resources Inc. Expenditures by COGEMA Resources Inc. include those of Urangesellschaft Canada Limited.

Uranium exploration continues in essentially the same areas as in the recent past, with geophysical and geochemical surveys and surface drilling focused on the extensions of mineralised zones, and on deeper targets in frontier areas of Saskatchewan's Athabasca Basin. Similarly, in the Northwest Territories, exploration was carried out on the Kiggavik Trend and along the western edge and northeastern portion of the Thelon Basin. Geological research and grass roots exploration continues in the Great Bear Magmatic Zone, NWT, and in the western Athabasca Basin.

URANIUM RESOURCES

Known conventional resources (RAR & EAR-I)

Estimates of Canada's "known" domestic uranium resources as of 1 January 1999, recoverable at a cost of $80/kgU or less, increased to about 433 000 tU, compared with 419 000 tU assessed as of 1 January 1998. The upward adjustment of some 2.5% relates mainly to increased McArthur River resources. As of 1 January 1999, uranium resources recoverable at a cost of $40/kgU or less amounted to about 372 000 tU.

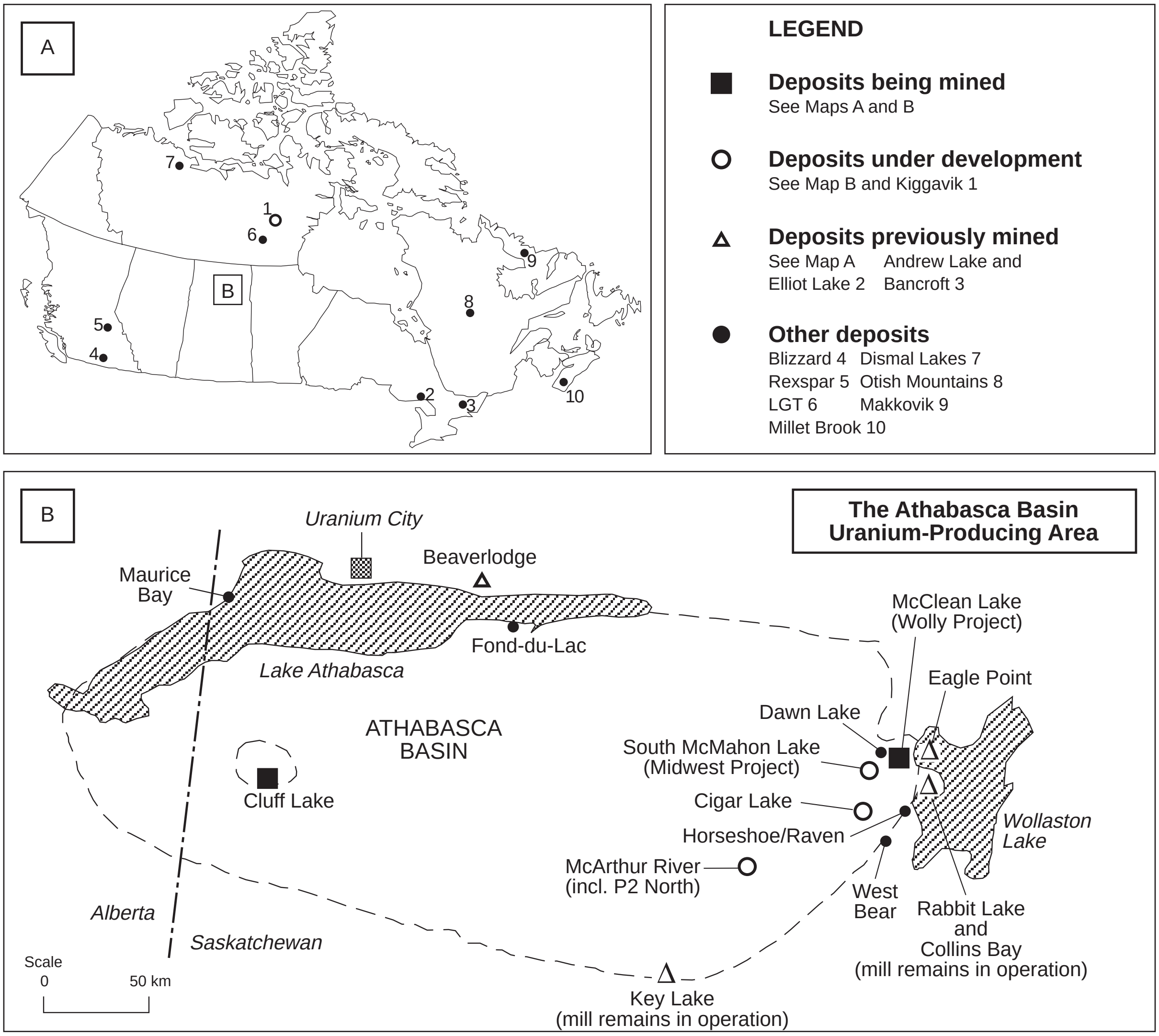
The bulk of Canada's "known" uranium resources occur in Proterozoic unconformity-related deposits of the Athabasca Basin, Saskatchewan, and the Thelon Basin, Northwest Territories. These deposits host their mineralisation at the unconformity boundary, or above and/or below it, in either monometallic or polymetallic mineral assemblages. Pitchblende prevails in the monominerallic deposits, whereas uranium-nickel-cobalt assemblages prevail in the polymetallic assemblages. The average grade varies from less than 1% uranium to those grading between 2% and 5% uranium, although parts of some deposits exceed 10% uranium.

None of the uranium resources referred to or quantified herein are associated with co-product or by-product output of any other mineral of economic importance.

Undiscovered conventional resources (EAR-II & SR)

The 1 January 1999 assessment did not result in any change to EAR-II and SR tonnages reported as of 1 January 1997. Areas favourable for the discovery of uranium resources continue to be examined in the Athabasca Basin, Saskatchewan, and in the Thelon Basin, Northwest Territories, where deposits associated with Proterozoic unconformities are most likely to occur. Continued work has led to positive results in the eastern Athabasca Basin, and along the Kiggavik trend in the Northwest Territories, where discoveries have been made in areas with previously estimated prognosticated (EAR-II) resources.

Uranium deposits in Canada



Source: Uranium and Radioactive Waste Division, NRCan.

URANIUM PRODUCTION

Historical review

Canada's uranium industry began in the Northwest Territories with the 1930 discovery of the Port Radium pitchblende deposit. Exploited for radium from 1933 to 1940, the deposit was re-opened in 1942 in response to demand for uranium for British and U.S. defence programmes. A ban on private exploration and development was lifted in 1947, and by the late 1950s some twenty uranium production centres had started up in five producing districts. Production peaked in 1959 at 12 200 tU. No further defence contracts were signed after 1959 and production began to decline. Despite government stockpiling programmes, output fell rapidly to less than 3 000 tU in 1966, by which time only four producers remained. While the first commercial sales to electric utilities were signed in

1966, it was not until the mid-1970s that prices and demand had increased sufficiently to promote expansions in exploration and development activity. By the late 1970s, with the industry firmly re-established, several new facilities were under development. Annual output grew steadily throughout the 1980s, as Canada's focus of uranium production shifted increasingly from east to west. In the early 1990s, the poor markets and low prices led to the closure of three of four Ontario production centres. The last remaining Ontario uranium production centre closed in mid 1996.

Historical uranium production

	Pre-1996	1996	1997	1998	Total to 1998	Expected 1999
Mining method	(tonnes U contained in ore)					
Conventional mining:						
• Open pit	NA	6 528*	9 266*	7 637*	NA	3 250
• Underground	NA	5 178*	2 765*	3 285*	NA	5 250
TOTAL	**286 967****	**11 706****	**12 031**	**10 922**	**321 626**	**8 500**

* Estimated split between open-pit and underground.

** Primary output. In 1996, an additional 48 tU was recovered at Elliot Lake from Cameco's refinery/conversion facility by-products. With the closure of Rio Algom's Stanleigh operation at Elliot Lake in mid-1996, by-products from Cameco's refinery/conversion facilities in Ontario are no longer processed in Canada.

Status of production capability

Overview

Production capability from Canada's existing operations declined in the early 1990s with the closure of several Elliot Lake facilities. However, increased output in Saskatchewan through the mid 1990s, particularly at the Rabbit Lake and Cluff Lake operations, returned Canadian uranium production capability to the levels of the late 1980s. Canadian uranium output remains below full capability. Producers in Canada announced 1999 production cutbacks in response to the low uranium market price and to ease the transition to the new high-grade uranium mines that are poised to enter into production. As a result, Canada's production, which in 1997 exceeded 12 000 tU, declined to 10 922 tU in 1998 and can be expected to drop below 9 000 tU in 1999, before returning to levels closer to full capacity.

Saskatchewan

Cameco Corp. fully owns and operates the Rabbit Lake production facility where, in 1998, output was 4 491 tU, down slightly from 1997 production level of 4 633 tU. In October 1998, the Atomic Energy Control Board (AECB) approved a two-year renewal of the Rabbit Lake operating licence. Mining operations at the Rabbit Lake Eagle Point underground mine were suspended on 31 March 1999, as part of Cameco's production cutbacks.

The Rabbit Lake mill, which was slated to close early in the next decade, will likely continue operating for an additional 15 years, owing to Cameco's intention to process a portion of the Cigar Lake ore at the Rabbit Lake mill. Cameco began an environmental assessment of this proposal early in 1999. Until ore from the Cigar Lake mine arrives, sometime in 2002, the Rabbit Lake mill will process stockpiled ore and operate at half capacity.

The Key Lake production facility is a joint venture operated by Cameco Corp. In 1998, production from stockpiled Deilmann ore amounted to 5 392 tU, down marginally from 1997 output of 5 434 tU. On 6 November 1998, the AECB amended the Key Lake operating licence to permit conversion of the Deilmann in-pit tailings management facility to the subaqueous deposition mode and to permit construction of receiving and blending facilities to handle ore from the McArthur River mine. An extended shutdown of the Key Lake mill, beginning in July 1999, is required to finalise the construction of these facilities. The Key Lake mill is expected to resume production in the last quarter of 1999, processing high-grade ore from the McArthur River mine.

Cameco Corp. is the operator of the McArthur River joint venture, where construction is on budget and on schedule. The McArthur River mine is expected to enter into production in the last quarter of 1999. On 29 May 1998, the AECB amended the McArthur River construction licence to allow the fabrication and installation of an underground ore reclamation and milling system and surface ore handling facilities. Cameco received initial consideration for an operating licence for McArthur River at the 19 May 1999, AECB Board meeting.

On 4 February 1999, Cameco announced that reserves at McArthur River have increased by 35% to 98 000 tU. McArthur River reserves and resources now total over 185 000 tU, with an average grade of 12%.

The Cigar Lake mine, a joint venture operated by the Cigar Lake Mining Corporation, cleared the environmental review process early in 1998. Testing of mine equipment and mining techniques continued on schedule through the remainder of the year. The mine is scheduled to begin production in late 2002. The Cluff Lake uranium-production facility is fully owned and operated by COGEMA Resources Inc (CRI). Open pit mining of the south extension of the Dominique-Janine orebody was completed in July 1997, and mining operations were entirely underground in 1998 (Dominique-Peter and Dominique-Janine West orebodies). Production in 1998 amounted to 1 039 tU, almost half of 1997 production. This sharp decline relates in part to the reduced rate of production required to avoid reaching full capacity in the tailings management area.

On 20 August 1998, CRI announced that it will suspend operations indefinitely at Cluff Lake in 2000, owing to the low market price and insufficient local reserves to support the investment required to create the new tailings management facility needed in 2001. However, CRI has indicated that it will be conducting a vigorous exploration programme in the Cluff Lake area and, if sufficient reserves are discovered and the market improves, it could re-open the facility.

On 18 December 1998, the AECB granted a two-year renewal of the Cluff Lake operating licence. CRI provided the AECB with a detailed decommissioning plan on 30 June 1999. This decommissioning plan is the subject of an ongoing environmental assessment.

The McClean Lake facility, a joint venture operated by CRI, began production in July 1999. Construction of the mill was completed late in 1997, but production was held up due to licensing delays. On 14 August 1998, the AECB amended the McClean Lake operating licence to allow specified preparatory work to convert the mined-out JEB pit for use as a tailings management facility (TMF). Construction was stopped twice in the fall of 1998 due to problems with materials used in the filter drain. These problems were resolved early in 1999. The AECB amended the McClean Lake operating licence on 25 March 1999, to allow completion of the TMF construction and, on 18 June 1999, to permit processing stockpiled ore. Production began shortly thereafter.

Uranium production centre technical details

(as of 1 January 1999)

	Centre # 1	Centre # 2	Centre # 3	Centre # 4
Name of production centre	Key Lake	Rabbit Lake	Cluff Lake	McClean Lake
Production centre class	Existing	Existing	Existing	Existing
Operational status	Operating	Operating	Operating	Operating
Start-up date	1983	1976	1980	1999
Source of ore: • Deposit names • Deposit types	Deilmann Unconformity	Collins Bay & Eagle Point Unconformity	Dominique-Peter/Janine Unconformity	Sue A-C, JEB & McClean Unconformity
Mining operation: • Type (OP/UG/ISL) • Size (tonnes ore/day) • Average mining recovery (%)	Stockpile	Underground NA 90 estimated	Underground NA 85 estimated	OP, Underground NA NA
Processing plant: • Type (IX/SX/AL) • Size (tonnes ore/day) • Average processing recovery (%)	AL-SX >800 97	AL-SX >2 500 97	AL-SX >900 98	AL-SX NA
Nominal production capacity (tU/year)	5 400	3 900	1 900	2 300
Plans for expansion	Relates to McArthur River	Relates to Cigar Lake		Relates to Cigar Lake
Other remarks	McArthur River ore to feed mill	Eagle Point mining suspended 31/03/1999	Operations to be suspended in 2000	

Mining waste rock at the McClean Lake Sue C pit was completed late in 1998. Since CRI did not at that time have the necessary licensing to begin processing the ore, it laid off 45% of the McClean Lake workforce in early January 1999. When construction of the TMF resumed, CRI brought back many of the construction and mill workers. On 19 August 1999, CRI received initial consideration for amending the McClean Lake licence to begin mining the Sue C deposit.

Ownership structure of the uranium industry

In April 1998, the corporate structure of uranium mining in Canada was significantly altered when Cameco Corp. announced that it had entered into an agreement in principle to purchase Uranerz Exploration and Mining Limited and Uranerz USA Inc. from their parent company, Uranerzbergbau GmbH (UEB) of Germany. The transaction was subsequently approved by anti-competition regulatory agencies in Canada, Germany and the United States, and on 11 August 1998, the acquisition was completed at a total cost of CAD 489 million. The acquisition strengthened Cameco's position as the world's largest uranium producer, increasing the company's uranium reserves, resources and uranium production levels by about 30%. The principal Canadian assets purchased by Cameco included a 33.33% interest in the Key Lake and Rabbit Lake uranium mines, a 27.92% interest in the McArthur River mine, and a 20% share in the Midwest mine.

Uranium production centre technical details (continued)

(as of 1 January 1999)

	Centre # 5	Centre # 6	Centre # 7	Centre # 8
Name of production centre	McArthur River	Cigar Lake	Midwest	Kiggavik
Production centre class	Committed	Planned	Planned	Planned
Operational status	Final construction and licensing stage	Environmental assessment completed in 1998	Environmental assessment completed in 1998	Feasibility study ongoing
Start-up date	Late 1999	Late 2002	2003	Unknown
Source of ore: • Deposit names • Deposit type	 P2N *et al*, Unconformity	 Cigar Lake, Unconformity	 Midwest, Unconformity	 Kiggavik, Andrew Lake, Unconformity
Mining operation: • Type (OP/UG/ISL) • Size (tonnes ore/day) • Average mining recovery (%)	 Underground NA NA	 Underground NA NA	 Underground NA NA	 Open pit NA NA
Processing plant: • Type (IX/SX/AL) • Size (tonnes ore/day) • Average processing ore recovery (%)	Ore will be processed at Key Lake	Ore will be processed at Rabbit Lake and McClean Lake	Ore will be processed at McClean Lake	 NA NA NA
Nominal production capacity (tU/year)	6 900 (estimated)	4 600 (estimated)	2 300 (estimated)	1 200 (estimated)

On 27 April 1999, Cameco and CRI purchased KEPCO's (Korea Electric Power Corp.) 2% non-voting interests in the Cigar Lake uranium joint venture for an undisclosed price. On 5 May 1999, Cameco sold interests in select uranium assets in Saskatchewan (17% of the Key Lake mill, 14% of the McArthur River mine and, subject to rights of first refusal, 20% of the Midwest mine) to CRI for a total CAD 250 million. On 25 August 1999, Denison Mines Ltd. announced that it had exercised its right of first refusal to purchase an additional 5.17% interest in the Midwest property.

Following these transactions, Cameco retains an 83.33% interest in the Key Lake operation, 69.805% in the McArthur River project, and 50.025% in Cigar Lake project. CRI retains a 16.67% interest in Key Lake, 30.195% in McArthur River, 37.1% in Cigar Lake, and 70.83% in Midwest. Denison Mines Ltd. and OURD (Canada) Co., Ltd. (a subsidiary of Overseas Uranium Resources

Development Corporation of Japan) retain 24.67% and 4.5% interests, respectively, in the Midwest project. Idemitsu and TEPCO (Tokyo Electric Power Co., Inc.) retain 7.875% and 5% interests, respectively, in Cigar Lake.

Employment in the uranium industry

Direct employment in Canada's uranium industry in 1997 amounted to 1 105. Losses caused by the closure of the last uranium mining operation at Elliot Lake and the completion of mining activities at Key Lake were partially offset by increases in the labour force associated with development at McClean Lake and McArthur River. In 1998, the workforce increased marginally to 1 134 as development of the McArthur River and Cigar Lake projects proceeded. Employment can be expected to be maintained at a similar level in 1999. In the near term, the start up of these new high-grade operations in Saskatchewan should maintain direct employment levels close to current levels, even with the suspension of operations at Cluff Lake.

Future production centres

Of the uranium mining projects in Saskatchewan that have cleared the environmental review process, only the McClean/Midwest Joint Venture project is being developed as a single new production centre. The remaining projects under development will simply extend the lives of the existing production centres. Cigar Lake will provide feed to the McClean Lake and Rabbit Lake mills, and McArthur River will extend the life of the Key Lake mill. Beyond these Saskatchewan projects, Kiggavik in the Northwest Territories is the only other project currently envisaged as an additional production centre in Canada, but it is unlikely to proceed until well into the next decade.

ENVIRONMENTAL CONSIDERATIONS

Environmental assessments

On 13 November 1997, the Joint Federal-Provincial Panel on Uranium Mining Developments in Northern Saskatchewan presented its report to governments on the Midwest and Cigar Lake projects. The federal and provincial governments released responses to the Joint Panel's report in early April, 1998, agreeing with the Joint Panel that the Midwest and Cigar Lake uranium mines should proceed to the licensing stage, subject to certain site specific conditions. The submission of the final Joint Panel report brought to a close the comprehensive environmental assessment of new uranium mine developments in northern Saskatchewan.

Since release of the final Joint Panel report, Cameco has announced its intention to mill a portion of the Cigar Lake ore at Rabbit Lake (not at McClean Lake, as originally planned). Since this represents a significant departure from the project reviewed by the Joint Panel, an environmental assessment of this new milling plan is required and is currently in progress. CRI's plan to suspend operations at the Cluff Lake uranium production centre is also the subject of an ongoing environmental assessment. Both of these assessments are following procedures outlined in the 1995 Canadian Environmental Assessment Act. Unlike the previous round of environmental assessments, which were conducted by panel review, the two ongoing environmental assessments are comprehensive studies conducted by the proponent.

With Canada's position as the world's leading uranium producer and exporter comes the responsibility to demonstrate that its uranium producers meet a high level of health, safety and environmental standards. Federal-provincial environmental assessment processes contribute significantly toward meeting this responsibility.

Operating mines

In following the recommendations of the environmental assessment panels and the regulatory requirements of the Saskatchewan provincial government and the AECB, uranium-mining companies devote significant resources and effort to environmental protection. To date, Canadian uranium producers have committed over CAD 100 million to the environmental management of existing uranium mines (over CAD 20 million in 1998 alone). If capital costs, such as the construction of tailings management facilities and water treatment plants, and other costs, such as the staffing of and technical support required to maintain environment departments are included, these figures rise to over CAD 300 million and over CAD 50 million, respectively.

Beyond this significant financial and operational commitment to environmental protection, uranium producers contribute to the sustainable development of Canadian uranium resources. For example, uranium producers train and employ northern Saskatchewan residents, whose numbers have grown to 48% of minesite employees, with plans in place to increase this figure to 67%. Uranium mining companies provide increased business opportunities for northern residents, contributing more than CAD 250 million to the local economy in 1998 alone. In addition, uranium producers provide support and training for local environmental monitoring committees and contribute financial resources toward the development of a community health and vitality database. Such efforts ensure that the extraction of uranium resources will result in long-term benefits to local residents without producing significant health and environmental impacts.

Decommissioning

The closure of Rio Algom's Stanleigh mine in 1996 brought to an end 40 years of uranium production in Ontario, and likely brings to an end the exploitation of the relatively low-grade, deep underground, quartz-pebble conglomerate uranium deposits in Canada.

Decommissioning and rehabilitation of Denison Mines Ltd.'s Elliot Lake properties was essentially completed in 1998 with the construction of the final dam and revegetation of the tailings surface at Stanrock. Rio Algom reported in 1998 that it was in full compliance for discharges to waterways from its five closed mines at Elliot Lake (Pronto, Nordic, Quirke, Panel and Stanleigh), and that significant reductions in contaminant loadings to the Serpent River watershed had occurred following closure of the Stanleigh mine. One existing dam was raised and construction of three new low permeability dams and an overflow spillway was completed at the Stanleigh waste/tailings management area in 1998. Water levels have been raised to cover the tailings and create a water barrier to minimise acid formation and prevent airborne radiation release.

On 23 April 1999, the AECB amended decommissioning licences for the Denison and Stanrock mine sites. The changes involved extending site boundaries to encompass areas that presently exceed limits defined in the clean-up criteria and to acknowledge the decommissioning work performed at the Denison mine site over the last six years.

To date, uranium mining companies have committed over CAD 70 million to the decommissioning of the Elliot Lake mine sites; over CAD 8 million in 1998 alone. In addition, uranium mining companies in Canada have posted letters of credit amounting to over CAD 135 million for the decommissioning and closure of the uranium mining and milling sites currently in operation.

Cost of environmental management

(in million CAD)

	Pre-1998	1998	1999	2000	Total
Existing operations	>100	>20	>20	>20	>160
After closure	>65	>8	>1.5	>0.5	>75
TOTAL	>165	>28	>21.5	>20.5	>235

URANIUM REQUIREMENTS

On 13 August 1997, the Ontario Hydro Board of Directors announced its Nuclear Asset Recovery Plan which entailed the lay-up of seven of its 19 operating CANDU reactors in order to dedicate resources to bringing the other 12 units back to their previous standard of excellence. Since that announcement, four units at Pickering and three operational units at Bruce A were laid up (Bruce A unit 2 was mothballed in 1995). Decisions regarding re-start of Pickering A are expected in 1999. Decisions relating to the Bruce A re-start will depend upon the overall success to the 12 unit recovery plan, system needs, and a business case analysis. The lay-up of the seven CANDU units has reduced Canada’s uranium requirements to some 1 200-1 300 tU/year for 1998 and 1999, respectively.

On 1 April 1999, Ontario Hydro, once North America's largest power company, was split into five separate entities. The two largest of the successor companies are Ontario Power Generation Inc., the entity that will run the province's 80 generating stations (including 19 CANDU reactors), and Ontario Hydro Services Co., which will run the province's 29 000-kilometre transmission network and supply electricity to about one million customers, mostly in rural Ontario.

Supply and procurement strategy

From the late 1960s through to 1995, Ontario Hydro purchased >99% of its uranium requirements through long-term contracts with Canadian suppliers. In 1996, this pattern was broken with the import of 150 tU from Australia. This increased to about 250 tU in 1997, as a result of long-term contracts with Australian suppliers. Ontario also entered into a long-term contract with a U.S. uranium broker for the supply of 100 tU/year beginning in 1997. Through these and other long-term contracts, Ontario Power Generation Inc. has filled about 90% of its uranium requirements to the end of 2000 (about one-third from foreign suppliers). The remaining 10% of its requirements are being met with spot market purchases.

NATIONAL POLICIES RELATING TO URANIUM

On 20 March 1997, Bill C-23, the Nuclear Safety and Control Act (NSCA), received Royal Assent. Proposed regulations for the NSCA were posted by the AECB for comment in July 1998. Early in 1999, the AECB began consultations to address concerns raised by stakeholders regarding the proposed regulations. At the same time, the AECB proceeded with the preparation of Regulatory Guidelines. It is anticipated that the NSCA will come into force in 2000.

On 13 March 1998, after almost ten years of study and an extensive public review process, the Nuclear Fuel Waste Management and Disposal Concept Environmental Assessment Panel (also known as the Seaborn Panel) released its recommendations. The Seaborn Panel concluded that, from a technical perspective, safety of the disposal concept developed by Atomic Energy of Canada Ltd. (AECL) had been, on balance, adequately demonstrated for a conceptual stage of development but that, as it stands, the disposal concept had not been demonstrated to have broad public support. The Panel also found that the concept, in its current form, did not have the required level of acceptability to be adopted as Canada's approach for managing nuclear fuel wastes.

On 3 December 1998, the Government of Canada responded to the Seaborn Panel recommendations and laid out its objectives on the establishment of a Waste Management Organisation (to be established as a separate legal entity of waste producers and owners) and federal oversight for the next steps towards the long-term management, including disposal, of nuclear fuel waste. The Minister of Natural Resources Canada is expected to return to Cabinet within 12 months with recommended options for federal oversight mechanisms.

On 16 December 1998, AECL announced that budgetary constraints had brought it to a decision to terminate its nuclear research activities at Whiteshell Laboratories in Pinawa, Manitoba, by December 2001. Nuclear facilities at the site will be decommissioned, but two key scientific research programmes will be continued. The reactor safety research programme will be consolidated at AECL's facilities at Chalk River and Sheridan Park, Ontario, and the nuclear waste management programme will be privatized, following consultations with key stakeholders.

URANIUM STOCKS

The Canadian government does not maintain any stocks of natural uranium and data are not available for producers and utilities. Since Canada has no enrichment or reprocessing facilities, there are no stocks of enriched or reprocessed material in Canada.

Although Canadian reactors use natural uranium fuel, small amounts of enriched uranium are used for experimental purposes and in booster rods in certain CANDU reactors. Small amounts of depleted uranium are occasionally imported into Canada for custom fabrication of depleted metal castings by Cameco.

No significant changes to utility stockpiling practices have been made since those reported in the 1989 Red Book.

URANIUM PRICES

Uranium export price* statistics (in Canadian dollars – CAD)

	1992	1993	1994	1995	1996	1997	1998
Average price CAD/kgU	59	50	51	47	53.60	51.30	51.10
Average exchange rate	1.2083	1.2898	1.366	1.373	1.364	1.384	1.483
Average price USD/lb U_3O_8	19	15	14	13	15.10	14.20	13.30
Percentage spot deliveries	<1%	<1%	<1%	2%	1%	<1%	<2%

* Average price of all deliveries under export contract.

• Chile •

URANIUM EXPLORATION

Historical review

Uranium exploration activities in Chile started in the early 1950s. Over the next few years the US Atomic Energy Commission, working in co-operation with several Chilean state organisations, discovered uranium mineralisation associated with hydrothermal and high temperature vein-type copper deposits, copper-molybdenum tourmaline breccia pipes, as well as pegmatitic dykes.

Little follow-up work was done until 1970, when a joint uranium exploration programme was initiated by the Chilean Nuclear Energy Commission (CCHEN) and the Spanish Nuclear Energy Organisation (JEN). The objective of this project was a two years' investigation of the uranium potential of the Cu-Fe-Co-district of the Tambillos, IV Region.

Between 1976 and 1980 CCHEN with the support of the UNDP/IAEA carried out a regional exploration programme covering an area of 150 000 km^2. Applying geochemical drainage surveys, as well as aerial and ground radiometric methods, this project resulted in the discovery of 1 800 airborne anomalies, 2 000 geochemical and ground radiometric anomalies and the definition of 120 areas of interest. Follow-up work was done covering 84 areas of interest resulting in the discovery of 12 uranium occurrences of which 2 were selected for further detailed study. In addition to this regional programme, the joint CCHEN-UNDP/IAEA Project evaluated unconventional uranium resources associated with copper ores and phosphates.

Between 1980 and 1984, CCHEN in co-operation with the Pudahuel Mining Company carried out a drilling programme at the Sagasca Cu-U deposit, III Region. In addition, a technical and economical investigation of the U potential of the Cu-deposit Huinquintipa, northern Chile was completed.

The 1983 postponement of the planned Chilean nuclear power programme until the year 2000 and the weak international uranium market resulted in severe CCHEN budget and staff reductions which limited further activities.

In 1986/1987, CCHEN and the Production Development Organisation (CORFO) investigated the phosphate deposit Bahia Inglesa (latitude 27 degrees, 45 minutes south).

Further work done by CCHEN during 1990-1996 included the geological and uranium metallogenic investigation of areas mainly in the northern part of the country.

In 1990, CCHEN in co-operation with the National Mining Corporation (ENAMI) initiated a programme to investigate the U-Th potential of Rare Earth Elements (REE) occurrences. This project covered tens of occurrences of which the Anomaly 2, also referred to as Diego de Almagro was selected as high priority target for further work. This area covering a surface of 180 km^2 hosts stratiform and vein-type mineralisation consisting of an association of davidite, ilmenite, magnetite, sphene, rutile and anatase, with 3.5-4 kg/tonne rare earths, 20-40 kg/tonne Fe and 0.3-0.4 kg/tU.

Recent and ongoing activities

This REE-project is scheduled to continue through 1999. As parallel project, CCHEN started in 1998 an assessment of the national uranium potential. This project combines metallogenic research with the setting up of a geological data base with the objective of establishing a portfolio of research projects whose implementation would improve the assessment of the national uranium potential. This activity is planned to continue through 1999.

The staff of the geology and mining unit of CCHEN during 1997-1998 included two geologists, two surveyors as well as one field assistant.

Uranium exploration expenditures

	1997	1998	1999 (expected)
Government expenditures (USD x 1000)	153.58	196.36	178.43

The above expenditures include wages and salaries, operational costs incurred by both ENAMI and CCHEN as well as CCHEN’s costs for administration.

URANIUM RESOURCES

Known conventional resources (RAR & EAR-I)

Chile reports known conventional resources totalling 954 tU without differentiating between the two resource categories and without cost categories. The new resource estimate compares with 296 tU reported in the previous report. The 1 January 1999 estimate includes 68 tU mainly in the low grade

(0.02%U) surficial type occurrences Salar Grande and Quillagua and 886 tU in Upper Cretaceous metasomatic occurrences including mainly the Estacion Romero and Prospecto Cerro Carmen (REE) occurrences whose grade range between 0.02 and 0.17%U.

Undiscovered conventional resources (EAR-II & SR)

Undiscovered conventional resources are estimated to total 4 500 tU with no assigned resource or cost category. The bulk of this resource (4 380 t) is expected to occur in the Upper Cretaceous metasomatic type occurrences. Within this group the majority of the resource, totalling 3 220 tU, is assigned to the REE occurrence Prospecto Cerro Carmen.

URANIUM REQUIREMENTS

At present, no uranium is required for commercial energy generation. However, CCHEN´s fuel element fabrication plant started the fabrication of 50 MTR type fuel elements in March 1998. This project is expected to end in 2001 and then the fuel elements will be loaded into the La Reina research reactor. The required uranium raw material, 60 kgU enriched to 19.75% ^{235}U was supplied by the Russian Federation.

NATIONAL POLICIES RELATING TO URANIUM

As provided for in Law 16 319 the CCHEN has the mandate to advise the Supreme Government in all matters related to the peaceful use of nuclear energy. It is also responsible for developing, proposing and executing the national plans for research, development, utilisation and control of all aspects of nuclear energy.

The mining law (Law 18 248 of 1983) allows private parties to acquire uranium claims and subsequently produce uranium. However, in view of the strategic importance of uranium and other radioactive materials the law provides for CCHEN the right of first refusal in any uranium sale. As private parties did not show any interest in uranium activities due to the depressed markets, the assessment of the country’s potential and its periodic update remains the mandate of CCHEN within the framework of the National Nuclear Development Plan, as confirmed by Supreme Decree No. 302 of 1994.

• China •

URANIUM EXPLORATION AND MINE DEVELOPMENT

Historical review

Uranium prospection and exploration began in China in 1955. A description of the history, methods and organisation of uranium exploration in China is given in the 1997 Red Book.

Recent and ongoing uranium exploration and mine development activities

Uranium exploration continues to be directed at the discovery of sandstone deposits. The majority of projects are carried out in the Xinjiang and Inner Mongolian Autonomous Regions, as well as in north-eastern China. Only a few projects are carried out in south-western China.

Up to now, one ISL amenable sandstone-type deposit and two occurrences have been found in the Yili Basin, Xinjiang. The known resources in Deposit 512 are approximately 6 000 tU without classification by cost of production.

At present, most exploration projects consist of geological and geophysical surveys aimed at the assessment of favourable areas or basins in Xinjiang, Inner Mongolia and north-eastern China.

In 1997 and 1998, respectively, 75 and 113 exploration projects were carried out by the Bureau of Geology (BOG) of the China National Nuclear Corporation (CNNC). Most of these are located in the three regions mentioned above.

The concentration of China's exploration efforts on sandstone-type deposits has led to a substantial reduction in exploration for other deposit types in South China. The few projects still underway in granitic and volcanic terrains are directed at either the regional evaluation of the uranium potential, or with experiments at heap leaching hard rock uranium ores.

In addition to the exploration projects, conducted by BOG itself, two joint venture projects were carried out in co-operation with Japanese organisations. One of these projects concentrated on establishing an exploration model for volcanic-type deposits. The second was concerned with the exploration for unconformity-related deposits in the eastern part of the Liaoning Province. The joint venture projects terminated in 1997 and 1998, respectively.

Detailed information on uranium exploration expenditures and drilling activities is not provided.

URANIUM RESOURCES

The known uranium reserves are divided into types according to the host rock lithology (see table that follows). The known granite-type uranium deposits are mainly located in the Guidong granite massif, Guangdong Province, and the Zhuguanshan granite massif in Southern China; in the Taoshan granite massif, Jiangxi Province and the Jiling Caledonian granite massif in North-western China. The discovered volcanic-type uranium deposits are primarily distributed in Xiangshan, Jiangxi Province; Xiaoqiuvuan, Zhejiang Province; Baiyanghe, Xinjiang Autonomous Region, and at the northern margin of the North China Platform. Sandstone-type uranium deposits predominantly occur in Yili Basin, Xinjiang Autonomous Region; Hengyang Basin, Hunan Province; Xunwu, Jiangxi Province; Jianchang, Liaoning Province and the western part of Yunnan Province. Carbonaceous-siliceous-pelitic rock-type uranium deposits are mainly situated in Huangcai, Laowolong, Central-South China; Canziping, Guangxi Province; and Ruoergai at the boundary between Sichuan and Gansu Provinces.

Host Rock	% of reserves
Granite type	37.05
Sandstone type	23.53
Volcanic type	18.97
Carboneous-siliceous-pelitic rock type	15.94
Migmatic, pegmatitic type	2.96
Quartzite type	0.59
Alkaline rock type	0.59
Phosphate type	0.30

China reports a total of 70 000 tU as known in situ resources not classified by cost category. The recent estimate compares to 64 000 tU reported in the 1997 Red Book. These 70 000 tU of reported known uranium resources in China are listed in the following table. When compared to the information presented in the previous report, the increase of 6 000 tU is due to the addition of the Yili deposit, Xinjiang, to the resource base.

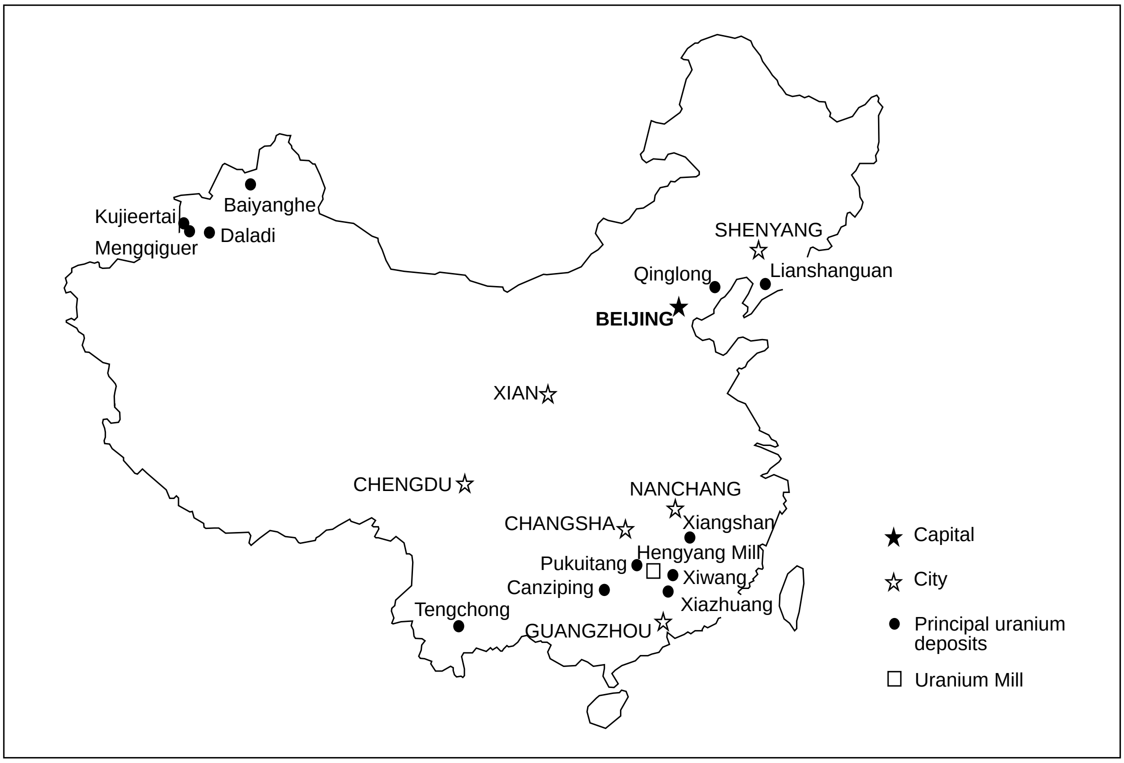
1.	Xiangshan uranium field in Jiangxi Province	26 000 t
2.	Xiazhuang uranium field in Guandong Province	12 000 t
3.	Qinglong uranium field in Liaoning Province	8 000 t
4.	Canziping uranium deposit in Guanxi Province	5 000 t
5.	Cengxian uranium deposit in Hunan Province	5 000 t
6.	Tengchong uranium deposit in Yunnan Province	6 000 t
7.	Lantian uranium deposit in Shanxi Province	2 000 t
8.	Yili uranium deposit in Xinjiang Autonomous Region	6 000 t

URANIUM PRODUCTION

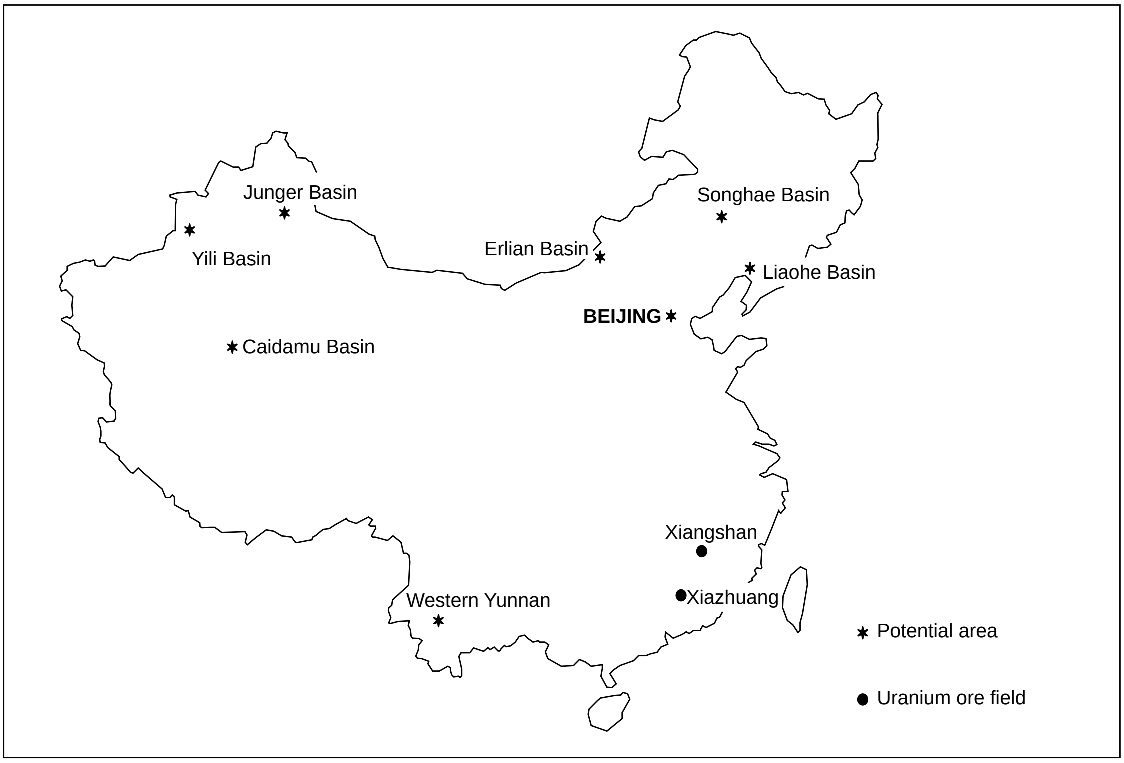
Historical review

From the early 1980s to 1996, China’s uranium industry introduced a number of improvements designed to better meet both the conditions of a market economy and the uranium requirements of the country’s nuclear power programme. These improvements cover reduced uranium production, including closure of uneconomic uranium mines and mills. The remaining producers are required to further improve both their technology and management, with the objective of increasing China’s competitive position by reducing uranium production costs.

Principal uranium deposits in China



Active exploration areas in China



In the 1990s, new production centres including the Yining ISL facility in the Xinjian Autonomous Region, the Lantian heap leaching facility in the Shanxi province and the Benxi mine in the Liaoning province, came into production. While the total Chinese uranium production declined, a certain scale is maintained.

The use of more efficient equipment and improved operational technology for cost cutting purposes includes, for example, trackless mining methods, first introduced at the Quzhou mine and now also used in the Benxi mine. In addition to the single boom hydraulic drill jumbo H-104, and LHD-loaders (load-haul-dump) ST-1.5, a newly designed mine truck and service vehicle were introduced in 1997. This measure led to a production increase from 5.8 tonnes ore/man shift in 1996 to 8.4 tonnes in 1998.

Radiometric sorters, which have been used since the beginning of the Chinese uranium mining industry, have been further developed. The latest model (#5421-2), put in operation in the Fuzhou mine, treats 150 000 tonnes ore/year.

Heap leaching is widely used in Chinese uranium production centres. Currently, the entire production of the Lantian, Chongyi, Quzhou and Benxi mines, and partial production of the Fuzhou, Renhua and other mines, are being treated by heap leaching. Various types of heap leaching have been developed for the different local conditions. Surface heap leaching is easier to operate and is therefore more widely used. Underground heap leaching is also being successfully used in the Lantian and Chongyi mines. Concentrated acid curing and ferric sulphate leaching used at the Benxi mine simplifies the leaching process and reduces the amount of waste water. In 1998, heap leaching following ore crushing, obtained good results at the Benxi mine. The leaching cycle was reduced by 30% while the uranium recovery increased by about 5%.

Since 1970 special attention has been placed on ISL technology in China. Small-scale tests were conducted in the Guangdong province until 1979, and in Deposit 381 in Tengchon, Yunnan province between 1978 and 1981. A pilot mine with an annual production capacity of 3-5 tU was installed in 1991.

From 1989 to 1991, ISL production tests were carried out at Deposit 512 in Yili, Xinjiang Autonomous Region. The pilot plant used sulphuric acid leaching and had a 10 tU/y production capacity. This was expanded to 40 tU in 1994. Annual production in 1998 reached 150 tU/year and a second plant with a 100 tU annual capacity is being constructed. Another test programme is underway at Deposit 511. It is planned to expand the total ISL capacity in the Yili area to approximately 400 tU/year in the short-term.

In 1997 and 1998, the uranium production from heap leaching and ISL accounted for about two thirds of the total Chinese uranium production.

Status of production capability

In 1997 and 1998 the annual production increased slightly. The Yining, Lantian and Benxi production centres produced a total of 300 tU in 1998 as compared to 260 tU in 1996.

The modernisation of the Hengyang uranium refinery was completed in 1998, to produce UO_2 to meet the higher specification of the fuel manufacturing plant.

The technical details of the uranium production centres are provided in the following tables.

Uranium production centre technical details

(as of 1 January, 1999)

	Centre #1	Centre #2	Centre #3
Name of production centre	Hengyang	Fuzhou	Chongyi
Production centre class	Existing	Existing	Existing
Operational status	Stand-by	Operating	Operating
Start-up date	1963	1966	1979
Source of ore: • Deposit names • Deposit type	 Chenxian and other mines Siliceous Schist and sandstone	 Volcanic	 Chongyi mine Granite
Mining operation: • Type (OP/UG/ISL) • Size (tonnes ore/year) • Average mining recovery (%)	 UG 3 000 85-90	 UG, OP 700 92	 UG, OP 350 90
Processing plant: • Type (IX/SX/AL) • Size (tonnes ore/year) For ISL (kilolitre/day or litre/day) • Average processing recovery (%)	Conventional IX, AL 3 000 85-88	Conventional IX, AL 700 90	Heap leach IX, AL 350 NA
Nominal production capacity (tU/year)	500-1 000	300	120
Plans for expansion	NA	NA	NA

	Centre #4	Centre #5	Centre #6
Name of production centre	Yining	Lantian	Benxi
Production centre class	Existing	Existing	Existing
Operational status	Operating	Operating	Operating
Start-up date	1993	1993	1996
Source of ore: • Deposit name • Deposit type	 Dep. 512 Sandstone	 Lantian Granite	 Benxi Granite
Mining operation: • Type (OP/UG/ISL) • Size (tonnes ore/year) • Average mining recovery (%)	 ISL NA NA	 NA 200 80	 NA 100 85
Processing plant: • Type (IX/SX/AL) • Size (tonnes ore/year) For ISL (kilolitre/day or litre/day) • Average processing recovery (%)	 IX, AL NA NA	Heap Leaching IX, AL NA 90	Heap Leaching SX, AL NA 90
Nominal production capacity (tU/year)	150	100	120
Plans for expansion	to 400 tU/year	NA	NA

Ownership structure of the uranium industry

No changes in ownership of China's uranium industry have occurred since 1994. It is 100% government owned.

Employment in the uranium industry

Following the decline of the level of employment between 1994 and 1996, the employment numbers have stabilised since 1996 as shown in the following table.

Employment in existing production centres

(persons-years)

1996	1997	1998	Expected 1999
8 500	8 500	8 500	8 500

Future production centres

At present, the most promising production centre is the Yining ISL facility, which produces from the Jurassic sandstone Deposit 512. The current expansion project will increase its production capacity from 150 tonnes to 250 tU/year. A feasibility study is being done for the production from Deposit 511. Initially, the capacity of this production centre is planned to be in the 100 to 200 tU/year range.

ENVIRONMENTAL ASPECTS

As most Chinese uranium deposits are small, low grade and irregular in shape, the resulting waste constitutes an environmental burden. It is reported that in order to produce 1 tU, between 1 200 and 5 000 tonnes waste rock and 1 200 tonnes tailings must be disposed of. In addition to the physical waste there is the radioactive exposure associated with uranium mining and milling. The Chinese Authorities estimate that the radon release amounts to 5 million Bq/tU produced.

Using the experience derived from many years of production, numerous measures have been introduced to control, monitor and reduce the harmful environmental impact of uranium production at the levels determined by regulations.

These measures include the backfilling of waste rock and tailings into mined out areas, the treatment of mine and used process water, and the covering of waste and tailings piles with soil, concrete, etc., to reduce the radon release. To combat the release of fly dust, extra high voltage electrostatic filters have been installed at the Fuzhou and Hengyang ore processing plants.

In addition to the environmental measures introduced at operating production centres, a large amount of work has been done to decommission uranium mines and mills. Since the late 1980s a number of production centres have been closed. Of these, five have been completely decommissioned, while a number of centres are in the process of being cleaned up and decommissioned. Information on the costs related to environmental management in existing and closed down operations is not available.

URANIUM REQUIREMENTS

China has two nuclear power plants in operation. They include the 300 MWe Qinshan plant in the Zhejiang province, designed and built by Chinese suppliers, and the Chinese-French joint venture project Daya Bay NPP in Guangdong Province with an installed capacity of 2 x 900 MWe. The Qinshan NPP reached full power in July 1992, while the Daya Bay plant was connected to the grid in 1994. The total annual uranium requirements for the aggregated nuclear generating capacity of 2 100 MWe amounts to 380 tonnes.

In 1996, a number of far reaching decisions were made regarding China's nuclear development. It was decided to build 8 additional nuclear units between 1996-2002 with an aggregate generating capacity of 6 600 MWe. The current status of this programme is as follows:

- The Qinshan Phase II consisting of 2 units with a total capacity of about 1 200 MWe is being constructed by CNNC. The units are scheduled to be connected to the grid in 2002 and 2003, respectively.
- The Qinshan Phase III consisting of 2 Candu-type reactors with an aggregate capacity of 1 400 MWe. Construction by a Chinese-Canadian joint venture and is expected to be completed in 2003.
- The Guangdong Lingao nuclear power plant project started construction in 1997 and includes two French-designed units with a total capacity of 2 000 MWe. They are planned to be operational in 2002 and 2003, respectively.
- The Lianyungang nuclear power plant project includes two units under construction with an aggregate capacity of 2 000 MWe. The plans are to complete the two units in 2004 and 2005, respectively.

These projects will increase the total nuclear generating capacity to about 8 700 MWe in 2005. Additional nuclear capacity is being planned for some time between 2005 and 2015, as shown in the following tables.

Installed nuclear generating capacity

(MWe net)

1998	1999	2000	2005		2010		2015	
			Low	*High*	*Low*	*High*	*Low*	*High*
2 100	2 100	2 100	7 700	8 700	15 000	18 000	18 000	23 000

Annual reactor-related uranium requirements

(tonnes U)

1998	1999	2000	2005		2010		2015	
			Low	*High*	*Low*	*High*	*Low*	*High*
380	380	380	1 380	1 560	2 700	3 200	3 200	4 000

SUPPLY AND PROCUREMENT STRATEGY

The known uranium reserves and resources, together with the recently expanded uranium production capability, will be sufficient to fill the requirements for China's nuclear development programme for the short term. Further reactor-related uranium requirements will have to be met by still undiscovered resources. To convert this uranium potential into known resources and reserves, China is placing emphasis on its uranium exploration activities. Subsequent to the numerous technical, organisational and managerial improvements in the industry, uranium is now being produced at a cost level that is competitive on the international market.

• Czech Republic •

URANIUM EXPLORATION

Historical review

Following its start in 1946, uranium exploration in Czechoslovakia (CSFR) grew rapidly and developed into a large scale programme in support of the country's uranium mining industry. A systematic exploration programme including geological, geophysical and geochemical surveys and related research, was carried out to assess the uranium potential of the entire country. Areas with identified potential were explored in detail using drilling and underground methods.

Exploration continued in a systematic manner until 1989 with annual exploration expenditures in the range of USD 10-20 million and an annual drilling effort in the range of 70-120 km. Exploration has traditionally been centred around vein-type deposits located in metamorphic complexes (Jáchymov, Horní Slavkov, Príbram, Zadní Chodov, Rozná, Olsí and other deposits), granitoids (Vítkov deposit) of the Bohemian massif and around the sandstone-hosted deposits in northern and north-western Bohemia (Hamr, Stráz, Brevniste, Osecná-Kotel, Hvezdov, Vnitrosudetská pánev, Hájek and other deposits).

In 1989, the decision was made to reduce all uranium related activities. Following this decision, in 1990, expenditures decreased to about USD 7 million and have continued to decline, reaching USD 660 000 in 1992 and USD 201 000 in 1996.

Recent and ongoing activities

No field exploration has been carried out since the beginning of 1994. Exploration activities have been focused on the conservation and processing of previously collected exploration data.

Processing the exploration information data and building the exploration database will continue in 1999.

Uranium exploration and development expenditures and drilling effort – domestic

	1996	1997	1998	1999 (Expected)
Industry expenditures (Million CZK)	0.50	0.40	0.50	0.70
Government expenditures (Million CZK)	5.00	5.00	2.50	1.60
Total expenditures (Million CZK)	5.50	5.40	3.00	2.30
Total expenditures (USD 1 000)	201	163	90	77

URANIUM RESOURCES

Historically, the main part of known uranium resources of the Czech Republic occurred in 24 deposits, of which 20 have been mined out or closed. Of the four remaining deposits, two are being mined (Stráz and Rozná), and two, including Osecná-Kotel and Brzkov have resources that may be mined in the future.

Undiscovered uranium resources are believed to occur in the Rozná, Brzkov vein deposits in the metamorphic complex of Western Moravia, as well as in the sandstone deposits of Stráz block, Tlustec block and Hermánky region in the Northern Bohemian Cretaceous basin.

Known conventional resources (RAR & EAR-I)

Known conventional resources as of 1 January 1999 decreased by 19 530 tU in comparison with the previous estimate.

In detail, the RAR recoverable at cost below $80/kgU decreased by 2 520 tonnes and the RAR below $130/kgU decreased by 23 230 tonnes. The decrease in RAR was the result of the re-evaluation of the Hamr and Stráz deposits in connection with their closure in 1995 and 1996 and the depletion of resources at the Rozná and Stráz operating production centres.

EAR-I resources increased by 3 700 tonnes to 22 660 tU as of 1 January 1999. EAR-I resources below $80/kgU declined slightly by 70 tonnes to 1 110 tU as a result of the depletion at the Rozná deposit and EAR-I resources between $80-$130/kgU increased by 3 770 tonnes in connection with the re-evaluation of the Hamr deposit. Sixty-nine per cent of the known uranium resources recoverable at cost below 80/kgU are tributary to existing and closed production centres, the remainder occurs in the Brzkov deposit.

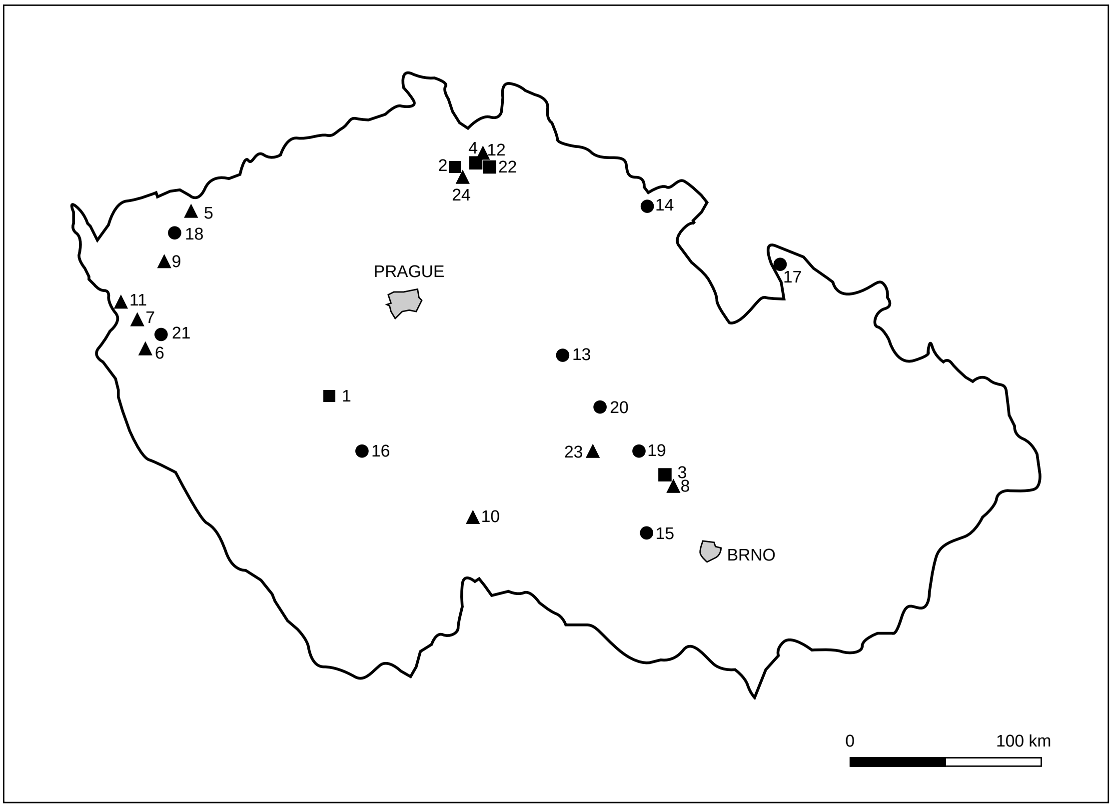
The known uranium resources between $80-$130/kgU are partly associated with the Osecná-Kotel deposit. These resources are estimated at somewhat less than 15 000 tU.

Reasonably Assured Resources

(tonnes U – as of 1 January 1999)*

Cost ranges		
≤$40/kgU	≤$80/kgU	≤$130/kgU
0	4 110	6 990

Major uranium deposits in the Czech Republic



No.	Deposit		Size	Status	Type	No.	Deposit	Size	Status	Type
1.	PříGram		B	V	H	13.	Licoměřice–Březinka	S	V	H
2.	Stráž	*	B	T	S	14.	Vnitrosudetská pánev	S	V	S
3.	Rožná	*	B	T	Z	15.	Jasenice	S	V	Z
4.	Hamr		B	V	S	16.	Předbořice	S	V	H
5.	Jáchymov		M	V	H	17.	Javorník-Zálèsi	S	V	H
6.	Vítkov		M	V	M	18.	Hájek	S	V	S
7.	Zadní Chodov		M	V	Z	19.	Slavkovice–Petrovice	S	V	H
8.	Olsí		M	V	Z	20.	Chotěbor	S	V	H
9.	Horní Slavkov		M	V	H	21.	Svatá Anna	S	V	H
10.	Okrouhlá Radoun		M	V	Z	22.	Osečná–Kotel	B	P	S
11.	Dyleň		M	V	Z	23.	Brzkov	M	P	H
12.	Břevniště		M	V	S	24.	Hvězdov	M	P	S

Legend

Size:
- ■ B > 10 000 tU
- ▲ M > 1 000 and < 10 000 tU
- ● S > 100 and < 1 000 tU

Type:
- H = vein deposits («classic» veins)
- Z = vein deposits («zone» deposits)
- M = vein deposits (metasomatic deposits)
- S = stratiform, sandstone – type

* Milling plant

Status:
- V = mined out
- T = being exploited
- P = planned, prospective

Estimated Additional Resources – Category I

(tonnes U – as of 1 January 1999)*

Cost ranges		
≤$40/kgU	≤$80/kgU	≤$130/kgU
0	1 110	22 660

* The estimate refers to mineable resources. Mining losses of 5% were deducted for resources to be mined by conventional methods. Ore processing losses were not taken into account.Undiscovered conventional resources (EAR-II & SR)

No new areas favourable for the discovery of resources have been identified in the last two years.

EAR-II increased by 1 200 tonnes to 9 680 tU as of 1 January 1999 as a result of the re-evaluation of part of the Brzkov deposit in the cost range between $80-$130/kgU. The resources associated with the Rozná and Hvezdov deposits are the same as of 1 January 1997.

Estimated Additional Resources – Category II

(tonnes U – as of 1 January 1999)*

Cost ranges	
≤$80/kgU	≤$130/kgU
5 180	9 680

* As in situ resources.

In addition to the EAR-II, there are SR totalling 179 000 tU as in situ resources, unassigned to any cost category. The SR are believed to exist in the Stráz block, Tlustec block and Hermánky region, all in the Cretaceous basin of the Northern Bohemia.

URANIUM PRODUCTION

Historical review

The industrial development of uranium production in Czechoslovakia began in 1946. Between 1946 and the dissolution of the Soviet Union, all uranium produced in Czechoslovakia was exported to the Soviet Union.

The first production came from Jáchymov and Horní Slavkov mines, which completed operations in the mid-sixties. Príbram, the main vein deposit, operated in the period 1950-1991. The Hamr and Stráz production centres, supported by sandstone-type deposits, started operation in 1967. The peak production of about 3 000 tU was reached in about 1960 and production remained between 2 500 and 3 000 tU/year from 1960 until 1989/1990, when it began to decline. During the period 1946-1998, a cumulative quantity of 105 961 tU was produced in the Czech Republic. 86% of the total was produced by conventional mining methods while the remainder was recovered using in situ leaching (ISL). The uranium production statistics for the period 1994-1998, together with the planned production for 1999 are summarised in the following table.

Status of production capability

Production capability has not changed in the last two years. The decommissioning and restoration of Stráz ISL mine in the Northern Bohemian Cretaceous basin has continued. Together with deposit restoration, a decreasing amount of uranium will be extracted in the course of the next years. In addition to the Stráz deposit, only one mine remains in operation at present, Rozná underground mine in the metamorphic complex of western Moravia.

Historical uranium production

	Pre-1996	1996	1997	1998	Total to 1998	Expected 1999
Mining method	(tonnes U contained in ore)					
Conventional mining:						
• Open-pit	348**	0	0	0	348**	0
• Underground	98 110**	314	313	313	90 050**	326
By-product – underground*	2	6	16	23	47	26
TOTAL	**98 460****	**320**	**329**	**336**	**99 445****	**352**
Production method	(tonnes U contained in concentrate)					
Processing plant	90 011	304	313	320	90 948	336
In situ leaching	14 133	300	290	290	15 013	270
TOTAL	**104 144**	**604**	**603**	**610**	**105 961**	**606**

* Clean-up of mining water.
** Estimation.

Ownership structure of the uranium industry

All uranium related activities, including exploration and production have been carried out by the government-owned enterprise, DIAMO, s.p., based in Stráz pod Ralskem. Consequently, the entire production in 1998, totalling 610 tU was owned by the National government.

Employment in the uranium industry

With the continuing reduction of uranium-related activities, direct employment in the Czech uranium industry has declined to some 3 410 workers, as of the end of 1998. This employment is engaged in uranium production, decommissioning and restoring activities.

Employment in existing production centres

(persons-years)

1996	1997	1998	Expected 1999
3 600	3 580	3 410	3 300

Future production centres

In compliance with the valid Government decision, uranium production will continue at a reduced level. Under the current scenario, Rozná underground mine will continue annual production of 310 tU until 2000. The Stráz ISL operation will produce a decreasing amount of uranium under the remediation regime and expected production in 2000 is 240 tU. The economic viability of the exploitation of some parts of Hamr underground mine in the next years is under consideration at present.

A future production centre could be reactivated at Brzkov deposit. Brzkov is a vein-type deposit with known resources in the RAR and EAR-I categories. It is located in the western part of the Moldanubian in Moravia. The mine was closed but could be reopened under more favourable market conditions.

Uranium production centre technical details

(as of 1 January 1999)

Production centre name	Dolní Rozínka (Rozná)	Stráz
Production centre class	Existing	Existing
Operational status	Operating	Closed*
Start-up date	1957	1967
Source of ore: • Deposit name • Deposit types	 Rozná Vein	 Stráz Sandstone
Mining operation: • Type (OP/UG/ISL) • Size (tonnes ore/day) • Average mining recovery (%)	 UG 660 95	 In situ – 60 (estimated)
Processing plant: • Type (IX/SX/AL) • Size (tonnes ore/day) • Average processing recovery (%)	 ALKAL**/IX/CWG 580 95	 ISL/AL/IX 50 000 kl/day –
Nominal production capacity (tU/year)	370	300

* Extraction under remediation regime.
** ALKAL: Alkaline Atmospheric Leaching.

Short-term production capability

The projected production capability to the year 2015 is shown in the following table:

Short-term production capability

(tonnes U/year)

1999				2000				2001			
A-I	**B-I**	**A-II**	**B-II**	**A-I**	**B-I**	**A-II**	**B-II**	**A-I**	**B-I**	**A-II**	**B-II**
0	0	680	680	0	0	680	680	0	0	660	660

2005				2010				2015			
A-I	**B-I**	**A-II**	**B-II**	**A-I**	**B-I**	**A-II**	**B-II**	**A-I**	**B-I**	**A-II**	**B-II**
0	0	110	635	0	0	84	335	0	0	87	334

ENVIRONMENTAL ASPECTS

Mining and milling of uranium ores in the Czech Republic led to serious impacts on the environment, the removal of which will require a long-lasting remediation procedure. It will continue for many years beyond 2000 and will necessitate considerable financial resources.

Currently, in conjunction with the reduction of uranium production, DIAMO’s main programme consists in decommissioning and restoration activities which are described below.

Decommissioning of the Hamr mine

Underground work is being carried out where the mined-out space is being backfilled. The backfilling is planed to be finished in 2001.

Remediation of the Stráz tailings impoundments

The projected remediation measures have been started. Free water from the tailings pond No.1 was eliminated and the elimination of the free water in the tailings pond No.2 is being planned. The tailings mass deposited in the pond No.2 and other contaminated material from the Hamr-Stráz region will be transferred into the tailings pond No.1.

Remediation of the Stráz ISL mine

The remediation objective, after ISL extraction, is to gradually lower the content of dissolved solids in the underground water of the Cenomanian and Turonian aquifers and gradually integrate the surface of the leaching fields into the ecosystems in compliance with the regional systems of ecological stability.

In 1996, the preparatory period of the remediation started and the evaporation station was put into operation. In the course of 1997 and 1998 the level of Cenomanian water subsided and the process of reducing the contaminated underground area has begun. In 1999 the extraction of dissolved solids from Cenomanian water will start at the desalination plant.

Decommissioning of the Olší mine

The continuing work involves the recultivation of the dumps and of the plant area and also the continuation of mine water processing.

Decommissioning of the Jasenice-Pucov, Zadní Chodov and Okrouhlá Radoun mines

The recultivation is finished, the processing of mine water for the removal of radionuclides is on-going.

Decommissioning of the Licomerice-Brezinka mine

The recultivation project has been approved. At the site, mine water is processed to remove U, Ra, and Mn. A peculiarity of the site is the continuing biological leaching in the shaft.

Remediation of tailings impoundments at Príbram

Restoration activities are being carried out to prevent higher gamma dose on the surface and dust.

Construction of a mine water processing plant at Horní Slavkov

This is one of DIAMO's major remediation measures. The need for this construction emerged from the stocktaking of old liabilities. The water will be decontaminated by removing radionuclides, Fe, Mn and some other elements. Processed water will be from abandoned Horní Slavkov shafts. The operation of the mine water processing plant is planned to start in May 1999.

Recultivation of the tailings impoundments of the MAPE Mydlovary ore processing plant

This is one of DIAMO's most extensive remediation projects, the duration of which is estimated at several decades. The technical projects of the recultivation were approved in the last two years and recultivation has started.

Cost of environmental management

(in million CZK)

Existing operations	Pre-1998	1998	1999	2000	Total
Pre-operational environmental assessment	NA	2.7	NA	NA	NA
Monitoring	NA	2.6	2.6	3.0	NA
Stabilising waste dumps and/or impoundments	NA	28.6	13.7	0	NA
Decontamination of replaced equipment	0	0	0	0	0
Effluent management (gas, liquid)	NA	1.6	NA	NA	NA
Site rehabilitation	0	0	0	0	0
Radwaste disposal	0	0	0	0	0
Regulatory activities	NA	NA	NA	NA	NA
TOTAL	**NA**	**NA**	**NA**	**NA**	**NA**

After closure	Pre-1998	1998	1999	2000	Total
Monitoring	NA	12.1	12.1	12.6	NA
Closing out tails impoundments	431.1	65.5	18.7	18.7	534.0
Decommissioning/decontamination	921.9	320.5	305.0	234.5	1 781.9
Effluent management (gas, liquid)	995.8	431.1	407.0	218.6	2 052.5
Site rehabilitation	183.1	62.0	31.3	30.2	306.6
Radwaste disposal	NA	0	0	0	NA
Regulatory activities	NA	63.3	78.1	40.2	NA
TOTAL	**NA**	**954.5**	**852.2**	**554.8**	**NA**

URANIUM REQUIREMENTS

The main electricity producer in the Czech Republic, CEZ, a.s. operates currently four units of 440 MW each at NPP Dukovany with the total net operating capacity of 1 648 MWe. Two units under completion at NPP Temelín, (net capacity 2 x 912 MW) should start operation in September 2000 and December 2001. The current annual requirements are roughly 355 tU. When NPP Temelín is in full operation the total requirements will fluctuate between 690-705 tU.

Installed nuclear generating capacity

(MWe net)

1998	1999	2000	2005	2010	2015
1 648	1 648	2 560	3 472*	3 472*	3 472*

* Best estimate.

Annual reactor-related uranium requirements

(tonnes U)

1998	1999	2000	2005		2010		2015	
			Low	*High*	*Low*	*High*	*Low*	*High*
440	516	602	690	705	690	705	690	705

SUPPLY AND PROCUREMENT STRATEGY

CEZ, a.s., purchases uranium concentrates from the domestic producer DIAMO, s.p., on the basis of two mid-long term contracts.

NATIONAL POLICIES RELATING TO URANIUM

DIAMO, s.p., the state-owned enterprise, has exclusive rights for the exploration, mining and processing of uranium. Continued production is planned at both Stráz (under decommissioning and restoration programmes) and Rozná mines, which still have sufficient resources for several years of production. CEZ, a.s., the only uranium consumer for energy purposes in the Czech Republic, is obliged to purchase uranium concentrates from domestic sources according to the current governmental policy. The government strategy is to balance uranium production with reactor-related uranium requirements.

URANIUM STOCKS

Stocks in the form of natural uranium are held by the Government (> 2 000 tU) as well as by DIAMO (700 tU). The utility company, CEZ, a.s., prefers to hold uranium inventory in the form of already fabricated fuel.

• Egypt •

URANIUM EXPLORATION

Historical review

The Nuclear Materials Authority started uranium exploration in the early 1960s. The main prospection methods included airborne, carborne and footborne surveys over outcrop and subcrop terrains. Hundreds of radioactive anomalies have been discovered in various geological environments. As a result of these regional prospecting efforts a number of uranium occurrences were found in granitoid rocks of the late Proterozoic age. In addition, other occurrences have been delineated in Paleozoic clastic sediments. These uranium occurrences represent the targets for the recent and ongoing exploration, development and evaluation activities.

Recent and ongoing activities

The Nuclear Materials Authority concentrated its main exploration activities in the development of three mineralised areas discovered in the Eastern Desert and Sinai: Gabal Gattar, El Missikat and El Erediya, and Abu Zeneima. Generally the operations include deep trenching, tunneling, core and percussion drilling, and well logging, supported by laboratory analyses. The extent of the operations during the 1990-1998 period is listed in the table below. The activities also include detailed topographic, geologic and radiometric mapping and sampling of the uraniferous lenses for the purpose of grade estimation and resource assessment.

An airborne spectrometric survey is being carried out covering mainly promising areas in Sinai and the Eastern Desert of Egypt.

Uranium exploration by areas and methods 1990-1998

Areas	Trenching (m^3)	Drilling in metres	Exploration addits and pits in metres
Gabal Gattar	600	300	800
El Missikat and El Erediya	0	1 243	4 950
Um Ara	2 500	230	0
Abu Zeneima	100	0	0

Details on activities in the areas listed above are described below:

Gabal Gattar

Exploratory mining operations, including vertical and horizontal workings, are on-going and have the objective of following a uranium-bearing shear zone in granitic rocks. Work in the vertical shaft is continuing which provides access to horizontal tunnels (Location 1 on map).

El Missikat and El Erediya

These occurrences have already been explored by approximately 4 000 m of tunnels. Subsurface core drilling was started in 1991 and is continuing to delineate and evaluate the uranium-bearing veins in granite in both areas (Locations 2 and 3).

Um Ara

This area features closely spaced joints and fractures in highly tectonised microcline granite and a shear zone spatially associated with the contact between granite and intruded Precambrian sediments and volcanics. The uranium is present as secondary fracture fillings. The area is now being evaluated by close spaced drilling (Location 4).

The annual exploration expenditures and drilling efforts for the period 1996-1999 are given in the table below.

Uranium exploration expenditures and drilling statistics

	1996	1997	1998	1999 (Expected)
Government exploration expenditures: (EGP x 1000) (USD x 1000)	 22 000 6 530	 25 000 7 420	 27 000 7 980	 30 000 8 830
Government exploration drilling in metres	230	1 243	300	2 000
Number of government exploration holes drilled	2	12	4	15

The recent exploration activities resulted in the discovery of new uranium occurrences in the West Sinai. Uranium occurs here in siltstone and shale of upper Paleozoic age. The thickness of the uraniferous horizon ranges from 0.5 to 3.5 m and the uranium content varies between 200 and 500 ppm. The uranium minerals are of secondary origin and include phosphates, sulphates, vanadates, arsenates and carbonates. They are associated with copper and manganese minerals. The areal extent of the uranium mineralisation in the siltstone and shale measures approximately 10 by 15 km.

URANIUM RESOURCES

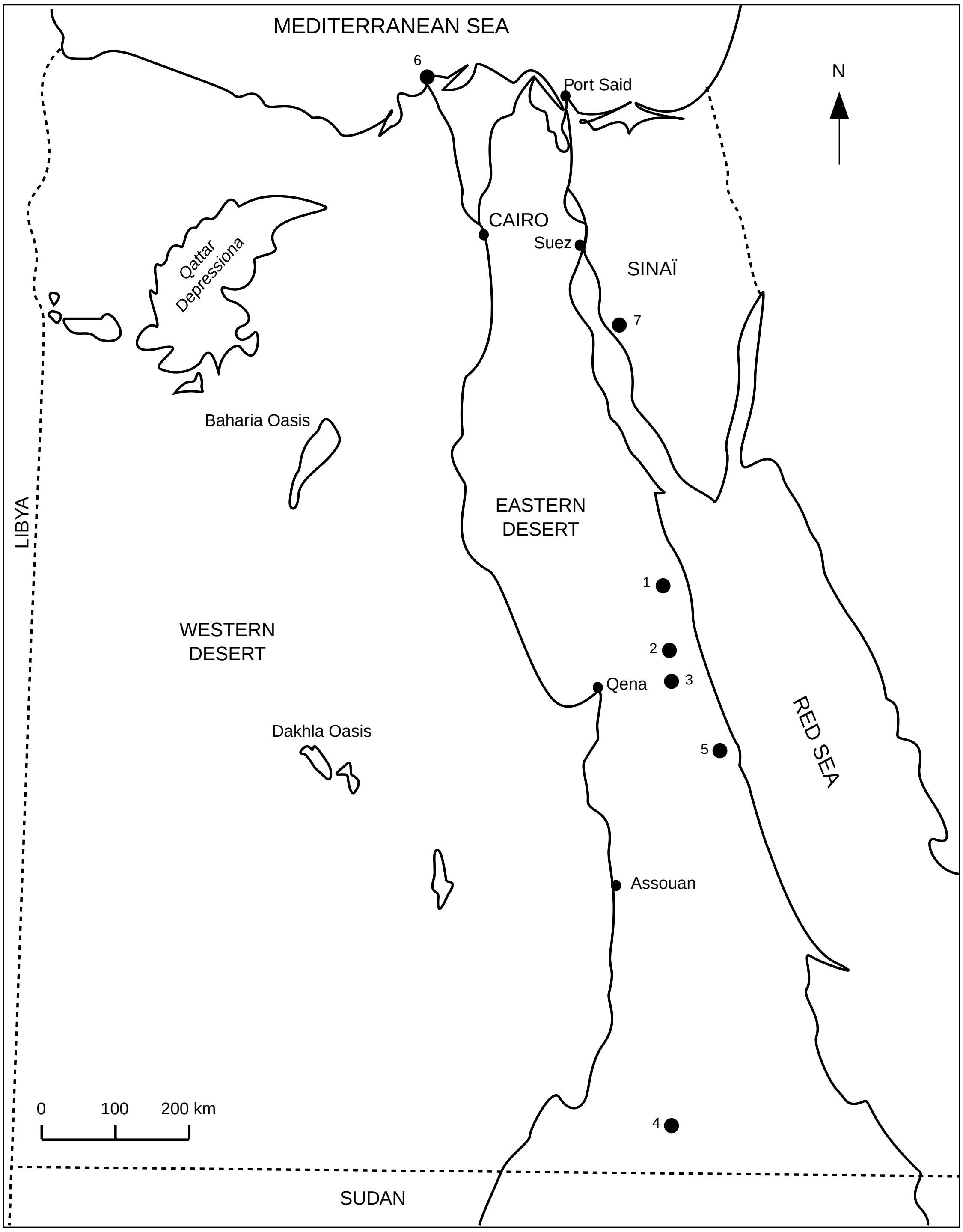
Known conventional uranium resources (RAR & EAR-I)

Egypt does not report any known uranium resources according to the standard IAEA/NEA classification system.

Undiscovered conventional uranium resources (EAR-II & SR)

Undiscovered resources of the SR category amounting to 15 000 tU have been estimated to occur in the Younger Granite environment. No cost category was assigned to these resources.

Uranium occurrences in Egypt



Uranium occurrences:

1. G. Gattar
2. El Missikat
3. El Ereidya
4. Um Ara
5. G. Kadabora
6. Rosette
7. West Sinai

Unconventional and by-product uranium resources

Unconventional resources occur in Egypt in sedimentary phosphate deposits, as well as in association with monazite deposits. These undiscovered resources include:

4 000 tU as EAR-II subdivided into	3 000 tU in phosphates, and 1 000 tU in monazite deposits, and
4 000 tU as SR subdivided into	3 000 tU in phosphates, and 1 000 tU in monazite deposits.

URANIUM PRODUCTION

Historical review

Egypt reports no uranium production at present. All uranium occurrences are undergoing detailed exploration and evaluation.

Status of non-conventional uranium production capability

- The construction of a semi-pilot plant for the extraction of uranium from phosphoric acid has been completed and was expected to be commissioned during 1999. The design capacity of the plant is about 15 m^3/day of acid containing about 65 ppm uranium. The process is in the adjustment stage.

- The Nuclear Materials Authority is taking over the responsibility for the exploitation of the black sand deposits at the Rosetta beach on the Mediterranean coast. These deposits contain monazite, zircon and rutile, as well as ilmenite and magnetite. The proposed project includes wet and dry mills with a capacity for treating 200 m^3/hour of wet sand. The area to be evaluated is estimated to contain about six million tonnes of economic heavy minerals at an average grade of 2%. This resource contains about 3 000 tonnes of monazite whose U content could be classified as EAR-II. The monazite contains 0.46% U and 6.05% Th, as well as 65% REE at location 6. There has been no uranium production from these deposits.

• Finland •

URANIUM EXPLORATION

Historical review

Uranium exploration was carried out in Finland from 1955 to 1989, first by several organisations but from the late 1970s mainly by the Geological Survey (see the 1995 Red Book). The regional aerogeophysical and geochemical mapping programmes have played an important role in uranium exploration since their beginning in the early 1970s.

The distribution of uranium provinces and the geological settings of uranium deposits including grades (per cent U) and tonnages of (in situ) uranium are summarised as follows:

1. The Kolari-Kittilä province in western Lapland, including the Kesänkitunturi sandstone-type deposit (0.06%; 950 tU) and the Pahtavuoma vein deposit (0.19%; 500 tU) in Paleoproterozoic quartzite and greenstone-associated graphitic schists, respectively.

2. The Kuusamo province in north-eastern Finland, with metasomatite uranium occurrences associated with mineralisations of Au and Co in a sequence of Paleoproterozoic quartzites and mafic volcanics.

3. The historical Koli province in eastern Finland, with several small sandstone-type (Ipatti, Martinmonttu and Ruunaniemi: 0.08-0.14%; 250 tU) and epigenetic uranium deposits (the former Paukkajanvaara mine) and occurrences of U and Th-bearing quartz-pebble conglomerate in Paleoproterozoic quartzites, with an additional prospect of unconformity-related type in a Paleoproterozoic regolith.

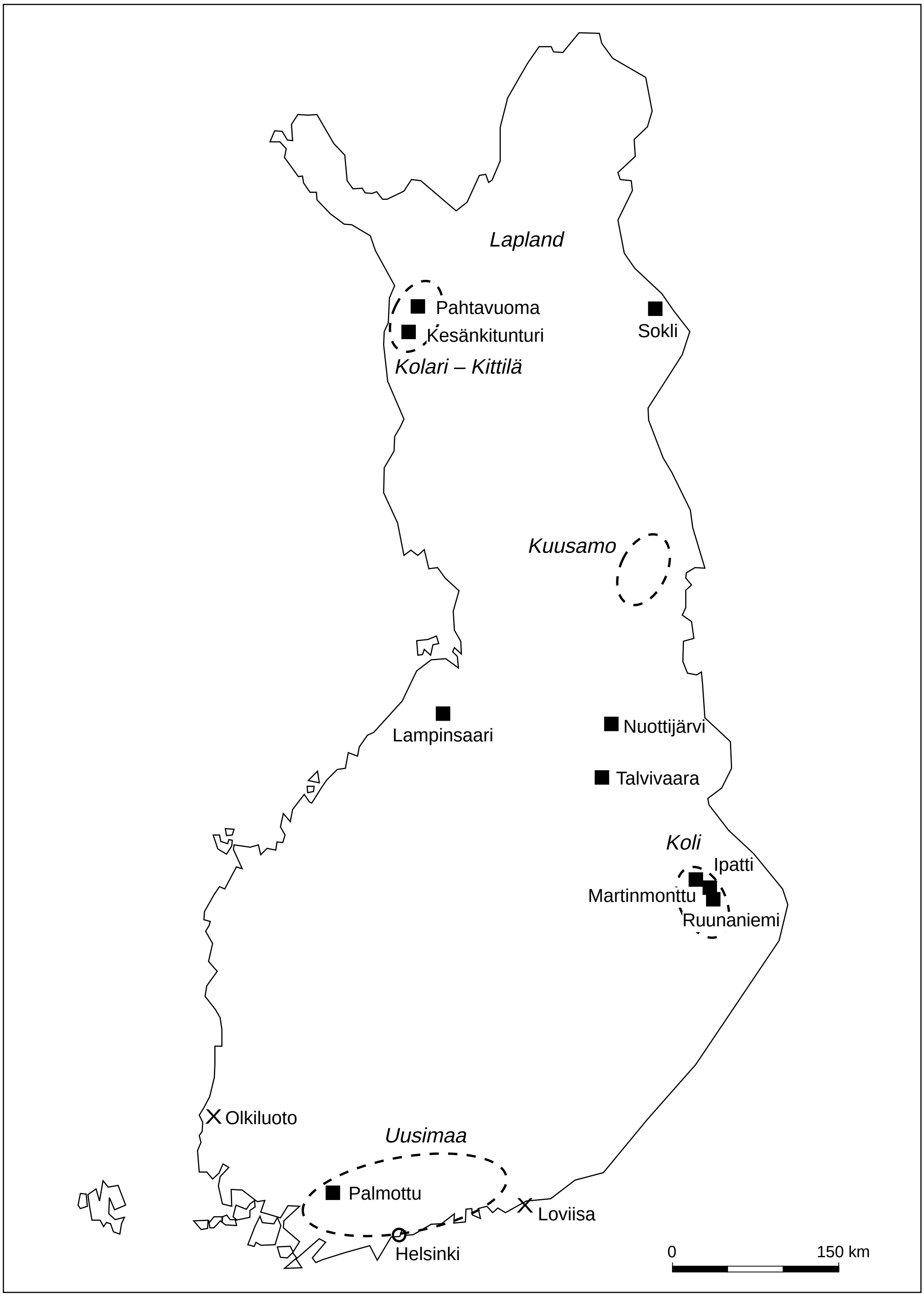
4. The Uusimaa province of intrusive-type uranium occurrences in Paleoproterozoic granitic migmatites of southern Finland, represented by the Palmottu deposit (0.1%; 1 000 tU).

The geological settings further include:

- uraniferous phosphorites associated with sedimentary carbonates of the Paleoproterozoic sequences: e.g., the Lampinsaari and Nuottijärvi uranium deposits (0.03%; 700 tU and 0.04%; 1 000 tU);
- uranium mineralisations and uraniferous carbonate veins in Paleoproterozoic albitite and albite diabase dykes, mostly in northern Finland;
- U and Th-bearing dykes and veins of Paleoproterozoic pegmatite granites;
- surficial concentrations of young uranium in recent peat.

Possible by-product uranium occurs in the low-grade Ni-Cu-Zn deposit of Talvivaara (0.001-0.004% U), hosted by Paleoproterozoic black schists, in central Finland, and in pyrochlore of the Paleozoic Sokli carbonatite (0.01% U) in eastern Lapland.

Uranium deposits and occurrences in Finland



Recent and ongoing uranium exploration activities

There are no ongoing exploration activities in Finland for uranium. Regional low altitude aerogeophysical mapping is being continued, with an annual coverage of 10 000 to 15 000 km^2.

URANIUM RESOURCES

Known conventional resources (RAR & EAR-I)

Finland reports 1 500 tU of Reasonably Assured Resources in the \$80-\$130/kgU cost range, included in the Palmottu and Pahtavuoma deposits.

Additional 2 900 tU in the RAR \$130-\$260/kgU cost range are contained in the Nuottijärvi, Lampinsaari and Kesänkitunturi deposits, and in those of the Koli area (Ipatti, Martinmonttu and Ruunaniemi).

Unconventional resources and other materials

As by-product resources, from 3 000 to 9 000 tU could be recovered from the Talvivaara black schists, and another 2 500 tU from the Sokli carbonatite.

URANIUM PRODUCTION

Historical review

Uranium production in Finland has been confined only to the now restored Paukkajanvaara mine, operated as a pilot plant between 1958 and 1961. A total of 40 000 tonnes of ore was hoisted, and the amount of the concentrates produced equalled to about 30 tonnes U.

ENVIRONMENTAL CONSIDERATIONS

A research programme on radionuclide transport analogy continues in the surroundings of the Palmottu deposit, where the remaining prospecting drill holes offer suitable sites for hydrogeological and geochemical studies. Five European countries are participating in this project.

According to the present legislation in Finland, export of spent nuclear fuel is not permitted after the year 1996. Both major Finnish power companies, Teollisuuden Voima Oy (TVO) and Fortum Power and Heat Oy (FPH, former Imatran Voima Oy), are co-operating in studying the final disposal of spent nuclear fuel into the Finnish bedrock. At the beginning of 1996, they established a joint company (Posiva Oy) for a nuclear waste disposal programme. Posiva has performed detailed studies in four investigation sites. The final site will be selected in 2000.

Low and intermediate wastes are being disposed in underground repositories. A repository has been operational since May 1992 at the TVO power plant site in Olkiluoto. The other repository, at the FPH power plant site in Loviisa, has been operational since April 1998.

URANIUM REQUIREMENTS

At the beginning of 1999, Finland had four reactors in operation: Olkiluoto-1 and Olkiluoto-2 owned by TVO, and Loviisa-1 and Loviisa-2, owned by IVO. The installed capacity was 2.65 GWe, as of 31 December 1998. No new reactors are under construction or planned.

Uranium requirements for the four reactors have been about 550 tU/year.

Supply and procurement strategy

TVO procures natural uranium, enrichment services and fuel fabrication from several countries. IVO purchases fuel assemblies from the Russian Federation but lead test assemblies have been ordered from an alternative source.

NATIONAL POLICIES RELATING TO URANIUM

There have been no significant changes to the Finnish uranium policies since the publication of the 1997 Red Book.

URANIUM STOCKS

The nuclear power utilities maintain reserves of fuel assemblies for about one year’s use (720 tonnes of natural uranium equivalent). TVO also possesses abroad enriched uranium for another year's use (400 tonnes natural uranium equivalent) and 730 tonnes natural uranium. Stockpiling of feed uranium in Finland is not considered necessary.

URANIUM PRICES

Due to confidentiality aspects the price data are not available.

• France •

URANIUM EXPLORATION

Background

Uranium prospecting in France began in 1946, focusing on already known uranium ore deposits and the few mineralisation occurrences discovered during radium exploration.

In 1948, exploration work based on foot, carborne and airborne radiometric surveys, and very early on geological mapping, led to the discovery of the La Crouzille deposit, formerly of major importance. By 1955, deposits had been identified in the granite areas of Limousin, Forez, Vendée and Morvan.

Based on geological mapping and radiometric, geophysical and geochemical techniques, prospecting activities first concentrated on the areas surrounding known deposits. They were subsequently extended to sedimentary formations in small intragranitic basins and terrigeneous formations, arising from eroded granite mountains and mainly located north and south of the Massif Central.

Between 1977 and 1981, prospecting was subsidised by the government (Plan for Uranium Exploration Aid) for a total of approximately USD 38 million. The purpose of this aid was to encourage exploration activities in France and abroad, at sites considered to be promising but with a significantly high risk. In theory, there was a subsidy ceiling of 35% of the total cost of the project, and the subsidy was to be reimbursed if a commercially viable discovery were made within the specified sites.

Recent and ongoing activities

Since 1987, uranium exploration activities have been declining in France. After focusing on areas around production centres in the hope of finding, in their vicinities, deposits more likely to be mineable, exploration activities are now restricted to those only connected with exploitation.

The work is confined to the north-western part of the Massif Central (where the Société des Mines de Jouac, a subsidiary of Cogema, is continuing to mine the Bernardan deposit). The exploration activities confirmed in 1998 that the deposit's reserves were insufficient to envisage extending commercial exploitation beyond the year 2001.

Abroad, Cogema has been focusing on targets aimed at the discovery of exploitable resources, even in a difficult market economy.

In Australia, Canada, Niger, the United States and Central Asia, Cogema is directly or indirectly involved in uranium exploration or development activities through subsidiaries. In Canada, the United States and Niger, it is also involved in uranium mining operations. In addition, without being an operator, it holds shares in several mining operations and research projects in different countries.

French exploration companies, operating in mainland France or abroad, are all private companies in which the French Government holds shares through the parent companies.

Uranium exploration expenditures and drilling effort – domestic

	1996	1997	1998	1999 (Expected)
Exploration expenditures	5 992	0	0	0
Development expenditures	35 400	10 000	6 207	0
TOTAL EXPENDITURES:				
French francs (x 1 000)	41 392	10 000	6 207	0
USD (x 1 000)	7 960	1 742	1 040	0
Total drilling in metres	24 400	28 400	3 000	0
Total number of holes	NA	NA	15	0

Uranium exploration expenditures abroad

	1996	1997	1998	1999 (Expected)
TOTAL EXPENDITURES(1)				
French francs (x 1 000)	35 400	51 500	52 400	44 600
USD (x 1 000)	6 808	8 972	8 777	7 933

(1) The companies involved in uranium exploration in France are private companies in which the French Government has a majority shareholding and in which shares are also held by private investors. If, for statistical reasons, expenditures were to be split into two parts corresponding to public and private participation in the capital of companies, the values indicated should be multiplied by a factor of 0.815 and 0.185, respectively.

URANIUM RESOURCES

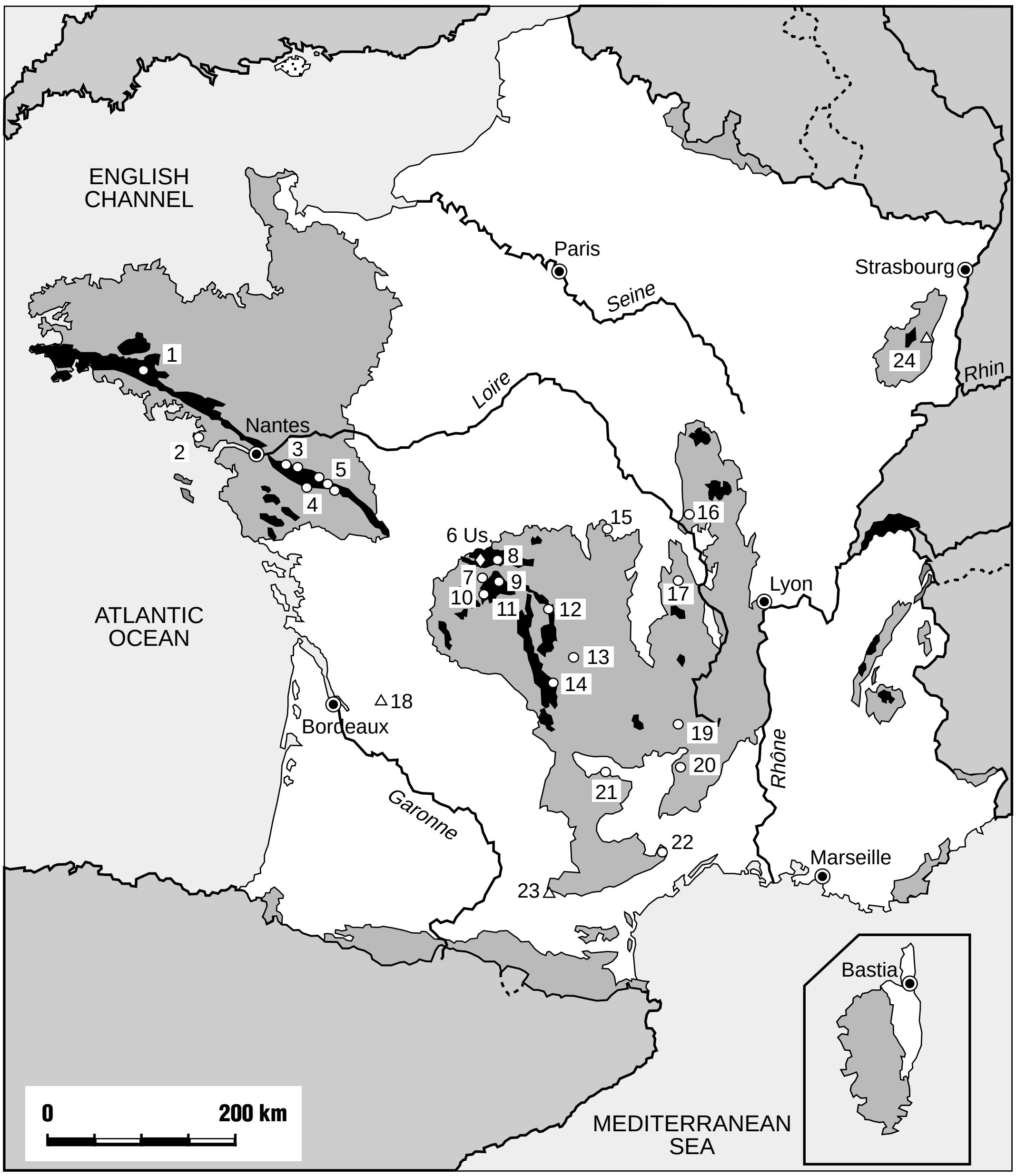
Known conventional resources (RAR and EAR-I)

The depletion of resources through mining in 1997 and 1998 has not been offset by new discoveries. As uranium exploration activities have ceased outside the immediate vicinity of existing production centres, this process is unlikely to be reversed.

Known resources (RAR and EAR-Category I) as of 1 January 1999 are 19% down from 1 January 1997.

The known resources belonging to the cost category below $80/kgU are reassessed each year. Most of the RAR and EAR-I resources in the cost category $80/kgU-130/kgU (those not located in orebodies actually mined) were assessed more than 5 years ago.

Main uranium deposits in France



Uranium deposits:

- ◊ Being mined
- △ To be mined
- ○ Mined out
- Us. Operating uranium mill
- ■ Leucogranite
- ▭ Variscan Massif

1. Pontivy
2. Pennaran
3. Le Chardon
   L'Écarpière
4. Beaurepaire
5. La Chapelle Largeau
   La Commanderie
   La Dorgissière
6. Le Bernardan (Maihac)
7. Le Brugeaud
8. Bellezane
9. Fanay
   Le Fraisse
10. Magnac
    Vénachat
11. Henriette
12. Hyverneresse
13. S^t-Pierre-du-Cantal
14. La Besse
15. Cerilly
16. Grury
17. Les Bois Noirs
18. Coutras
19. Le Cellier
    Les Pierres Plantées
20. Les Bondons
21. Bertholène
22. Mas Laveyre
23. Tréville
24. S^t-Hyppolyte

Source: CEA-DCC/MNC, June 97.

Undiscovered conventional resources (EAR-II and SR)

No systematic appraisal is made of undiscovered resources in France.

URANIUM PRODUCTION

Background

As a result of the mine closures mentioned in the previous editions of the Red Book, French uranium production has declined since 1990. From 1 106 tU in 1995, mill production declined to 930 tU in 1996, and with the closure of the Lodève mining site in 1997, Le Bernardan remained the only mining site in operation in 1998 and production dropped to 507 tU. In 1999, it is expected to be around 465 tU.

Status of production capability

There is only one ore-processing plant still in operation with a nominal capacity of 600 tU/year. No other production centre is under construction, planned or envisaged.

Uranium production centre technical details

(as of 1 January 1999)

	Centre # 1	Centre # 2
Name of production centre	Lodevois Simo (Cogema)	Le Bernardan SMJ (Cogema)
Production centre class	Stopped	Existing
Operational status	Closed	Operating
Start-up date	1981	1979
Source of ore • Deposit name • Deposit type	Mas Laveyre Orebodies in faults in pelites	Bernardan Veins & orebodies in granites
Mining operation • Type (OP/UG/in situ) • Size (tonnes ore/year) • Average mining recovery (%)	UG 165 000	OP/UG 83 000
Processing plant • Type (IX/SX/AL) • Size (tonnes ore/day) • Average processing ore recovery (%)	ALKPL/SX 1 400 90	AL/IX 500 97.1
Nominal production capacity (tU/year)	1 000	600
Plans for expansion	NIL	NIL
Other remarks	Closed in October 1998	

Ownership structure of the uranium industry

With the exchange of shares between Cogema and Total S.A. in June 1993, Cogema, which has acquired all of Total's uranium mining operations, is the only French group operating in the uranium mining field. In France, its subsidiary, the "Société des Mines de Jouac", has been operating the Bernardan deposit whereas the Lodève deposit, now under restoration, was operated by Cogema directly.

Employment in the uranium industry

The decline in the uranium mining industry in France since 1984 has resulted in job losses in this sector, a trend that has been accelerated by subsequent mine closures.

Future production centres

Given the current status of the uranium market, there are no plans to develop new production centres in the near future.

ENVIRONMENTAL CONSIDERATIONS

There are three main phases in the working of an area containing commercial deposits of uranium. The environmental aspects which must be taken into account to avoid adverse impacts on the environment are as follows:

Mining and milling phase

The problems identified during the mining and milling phase relate to:

- The large volumes of products generated and handled:

  Solid products such as mine wastes, mill tailings and residual sludges arising from effluent treatment. Because of their chemical composition, some of these products are source terms that can potentially generate pollutants; the main problem is the possible air-borne or water-borne dispersal of pollutants such as radionuclides and associated heavy metals which they contain.

  Liquid products consisting primarily of mine water, process discharges and effluents from the dewatering of managed solids; because the quality of such effluents can vary substantially, they may require monitoring and treatment, where necessary, prior to discharge to the environment.

- Underground mining work which can temporarily alter the local hydrogeological environment and create a risk of instability. A network of piezoelectric sensors and stability checks are required.

- Open-pit mining activities whose impact on the landscape must be minimised. These activities require the stabilisation of mine workings and the monitoring of air quality in facilities and the surrounding environment in order to limit the dispersion of polluting dusts.

Post-mining and milling phase: remediation

Environmental problems are the direct consequence of past activities; the remediation of sites therefore corresponds to the period during which work is carried out to reduce, and preferably eliminate, the residual impact on the environment of the various source terms as well as mining and industrial facilities.

The measures to be taken primarily consist in:

- installation of a selective discharge drainage system;
- geotechnical work to make the wells safe and levels closest to the surface in order to prevent rocks from caving in at a later date;
- contouring of mine waste dumps in order to stabilise them and blend them into the surrounding landscape;
- covering tailing impoundments with a rock sterile, protective material and, if necessary, contouring embankments;
- decommissioning of plants and disposal of non re-usable products;
- revegetation to complete stabilisation of the surface layer and landscaping.

Post-remediation phase: continued monitoring

This phase is primarily one of active surveillance following the completion of reclamation work and is aimed at ensuring the perennial limitation of the residual impact of the site on its surrounding environment.

This objective is achieved through continued monitoring of:

- air quality (gamma radiation, radon, dust) in the surrounding environment;
- the chemical composition of different types of water discharge, in particular that of acid mine drainage, prior to release into the natural environment;
- the stability of mine workings that have been secured;
- the residual impact of the site through analyses of plants, wildlife and the food chain in the natural environment of the site.

Those data can be used together with forecasting models to predict the medium and long-term behaviour of the site and to adjust preventive and remedial measures to be taken during a period long enough to allow a satisfactory environmental equilibrium to be restored.

Experience has shown that problems related to water quality and soil stability, particularly for mines that have been closed for a very long time, are the most important ones.

The status of the site will gradually move towards that of passive surveillance. At this point monitoring activities and analyses can be reduced, subject to a detailed review of the results achieved. At present, the monitoring of mill impoundments must still be maintained in view of the decay period of the radionuclides they contain. However, reliable simulation models of their anticipated behaviour are currently being designed.

Cost of environmental management

Forez	Pre-1998	1998	1999	2000	Total
Pre-operational environmental assessment	0	0	0	0	0
Monitoring	1 274	1 648	2 200	2 000	7 122
Closing out tails impoundments	0	0	0	0	0
Decommissioning/decontamination	0	0	0	0	0
Effluent management (gas, liquid)	0	0	1 000	1 000	2 000
Site rehabilitation	0	0	200	0	200
Radwaste disposal	0	0	0	0	0
Regulatory activities	0	0	0	0	0
TOTAL in FRF (x 1 000)	**1 274**	**1 648**	**3 400**	**3 000**	**9 322**

Hérault	Pre-1998	1998	1999	2000	Total
Pre-operational environmental assessment	0	0	0	0	0
Monitoring	4	0	0	1 758	1 762
Closing out tails impoundments	0	0	0	0	0
Decommissioning/decontamination	5 176	1 307	23 118	5 105	34 706
Effluent management (gas, liquid)	0	0	10 613	183	10 430
Site rehabilitation	59 448	40 154	19 088	3 918	122 608
Radwaste disposal	0	0	0	0	0
Regulatory activities	0	0	0	0	0
TOTAL in FRF (x 1 000)	**64 628**	**41 461**	**52 819**	**10 964**	**169 506**

La Crouzille	Pre-1998	1998	1999	2000	Total
Pre-operational environmental assessment	0	0	0	0	0
Monitoring	11 502	3 672	3 833	4 956	23 963
Closing out tails impoundments	0	0	0	0	0
Decommissioning/decontamination	22 088	263	200	125	22 676
Effluent management (gas, liquid)	13 468	5 771	6 050	6 231	31 520
Site rehabilitation	242 457	18 083	15 415	172	276 127
Radwaste disposal	0	0	0	0	0
Regulatory activities	0	0	0	0	0
TOTAL in FRF (x 1 000)	**289 515**	**27 789**	**25 498**	**11 484**	**354 286**

Vendée	Pre-1998	1998	1999	2000	Total
Pre-operational environmental assessment	0	0	0	0	0
Monitoring	9 409	2 815	2 820	2 050	17 094
Closing out tails impoundments	0	0	0	0	0
Decommissioning/decontamination	14 889	0	0	0	14 889
Effluent management (gas, liquid)	5 630	1 559	2 193	1 458	10 840
Site rehabilitation	176 576	576	2 118	270	179 540
Radwaste disposal	0	0	0	0	0
Regulatory activities	0	0	0	0	0
TOTAL in FRF (x 1 000)	**206 504**	**4 950**	**7 131**	**3 778**	**222 363**

Others	Pre-1998	1998	1999	2000	Total
Pre-operational environmental assessment	0	0	0	0	0
Monitoring	6 324	1 069	1 474	884	9 751
Closing out tails impoundments	0	0	0	0	0
Decommissioning/decontamination	16	0	0	0	16
Effluent management (gas, liquid)	0	23	0	0	23
Site rehabilitation	27 547	76	0	0	27 623
Radwaste disposal	0	0	0	0	0
Regulatory activities	0	0	0	0	0
TOTAL in FRF (x 1 000)	**33 887**	**1 168**	**1 474**	**884**	**37 413**

URANIUM REQUIREMENTS

Uranium requirements and supply strategy

The total number of nuclear power plants should not change now that the four N4 reactors have been put into service. The total capacity of nuclear power plants and the uranium requirements should also remain the same as no reactor will be shut down in the next 15-20 years.

Since France is a net importer of uranium, its policy towards procurement is one of supply diversification. French mining operators participate in uranium exploration and exploitation outside France within the regulatory framework of the host countries. They also purchase uranium, under short or long-term contracts, either from mines in which they have shareholdings or from mines operated by third parties.

NATIONAL POLICIES RELATING TO URANIUM

There have been no significant changes to national policy since the last report. Uranium exploration and production in France are unrestricted within the framework of existing regulations. On the whole, France is mainly a uranium importing country and there are no tariff barriers for imports.

URANIUM STOCKS

Électricité de France (EDF) possesses strategic uranium inventories, the minimum level of which has been fixed at the equivalent of three years' forward consumption to face possible supply interruptions.

URANIUM PRICES

Information on uranium prices is not available.

• Gabon •

URANIUM EXPLORATION

Historical review

Prompted by the sudden demand for uranium following World War II, the French Commissariat à l'Énergie Atomique (CEA) initiated uranium exploration in Central Africa. Based in the then Congo, CEA geologists extended their activities into Gabon. In 1956 using surface scintillometry a uranium discovery was made in Precambrian sandstones of the Franceville Basin in the vicinity of the village of Mounana. For additional information on the history of uranium exploration and production see the 1997 edition of this report.

Recent and ongoing activities

No exploration is reported.

URANIUM RESOURCES

With the closure of uranium production facilities in Gabon the uranium resource estimates are no longer updated.

URANIUM PRODUCTION

Historical review

The uranium production of COMUF has experienced significant fluctuations since the company started production in 1961. Impacting parameters were the ore processing capacity as well as the international uranium market. The main changes were:

- 1961-1969: attainment of a production level of approximately 400 U/year;
- 1970-1973: gradual production increase to 500 tU/year;
- 1974-1979: rapid production increase to 1 250 tU/year;
- 1980-1989: production decrease to 900 tU/year;
- 1990-1993: further reduction to 550 tU/year;
- 1994-1996: maintenance of a production level of 600 tU/year with the possibility of an adjustment to 550 tU/year.

Historical uranium production*

(tonnes U)

Production method	Pre-1996	1996	1997	1998	Total to 1998	Expected 1999
Conventional mining:						
• Open pit	11 242	0	180	725	12 147	295
• Underground	14 867	568	290	0	15 725	0
TOTAL	26 109	568	470	725	27 872	295

* Of the total production, 94 tU were found to be depleted in ^{235}U. The uranium was produced from the natural reactor sites of the Oklo deposits.

Status of production capability

The last ore from the Okelobondo underground mine was produced in November 1997. Ore production from the Mikouloungou open pit mine continued from June 1997 until March 1999, when all mine production was stopped at the COMUF production centre.

Ownership structure of the uranium industry

COMUF operated under a mutual agreement (“Convention d’Établissement”) between the Government of Gabon and the company.

Short-term production capability

Gabon reported its short-term production capability through to March 1999, when all mining was terminated.

Uranium production centre technical details

(as of 1 January 1999)

	Centre # 1	Centre # 2
Name of production centre	Mounana	Mikouloungou
Production centre class	Existing	Existing
Operational status	Closed; being reclaimed	Producing until March 1999; then closed
Start-up date	1988	June 1997
Sources of ore: • Deposit name • Deposit type	 Okelobondo Sandstone	 Mikouloungou Sandstone
Mining operation: • Type • Size (tonnes ore/day) • Average mining recovery (%)	 UG 800 80	 OP 850 90
Processing plant: • Type (IX/SX/AL) • Size (tonnes ore/day) • Average processing ore recovery (%)	 SX 1 300 95	 SX 1 300 95
Nominal production capacity (tU/year)	0	1 500
Plans for expansion	No	No

ENVIRONMENTAL CONSIDERATIONS

The most important environmental concerns are related to the impacts caused by the mining and milling activities. This includes the long-term management of the tailings and other waste produced at the mill site.

With the termination of all uranium production in Gabon, the Government started a programme for rehabilitation of the complete Mounana mining and milling operation. There are seven sites covering a total surface of about 60 hectares to be rehabilitated. The work to be done consists of:

- the closure of all impoundments for tailings and other residues;
- the development of a lateritic cover over the tailings; and
- revegetation of the sites.

The objective of this remediation work is to assure a residual radiological impact that is as low as is reasonably achievable (i.e. following the ALARA principal). The work is intended also to ensure the physical stability of the impoundments of the residues, and if possible, to provide for the future utilisation of the area effected.

The plans are to complete the dismantling of the mill and restoration of the site in 1999 and 2000. A programme for long-term monitoring and surveillance of the tailings will then be implemented.

• Germany •

URANIUM EXPLORATION

Historical review

A review of historical events was given in the 1991 Red Book.

Recent and ongoing uranium exploration activities

No exploration activities were performed in Germany during 1997 and 1998 and the national government is not involved in uranium exploration abroad. There are no future plans for exploration activities. There have been no German companies involved in uranium exploration since 1997.

Uranium exploration expenditures – abroad

	1996	1997	1998	1999 (Expected)
Industry expenditures:				
DEM (x 1 000)	4 800	6 800	0	0
USD (x 1 000)	3 137	4 000	0	0

URANIUM RESOURCES

Known conventional resources (RAR & EAR-I)

Due to the termination of uranium mining and the closure of production centres, the known conventional resources were reassessed in 1993. The reassessment resulted in a shift of both RAR and EAR-I from the less than $80/kgU cost category into the $80-130/kgU cost category and an overall decrease of known conventional resources in the less than $130/kgU cost category.

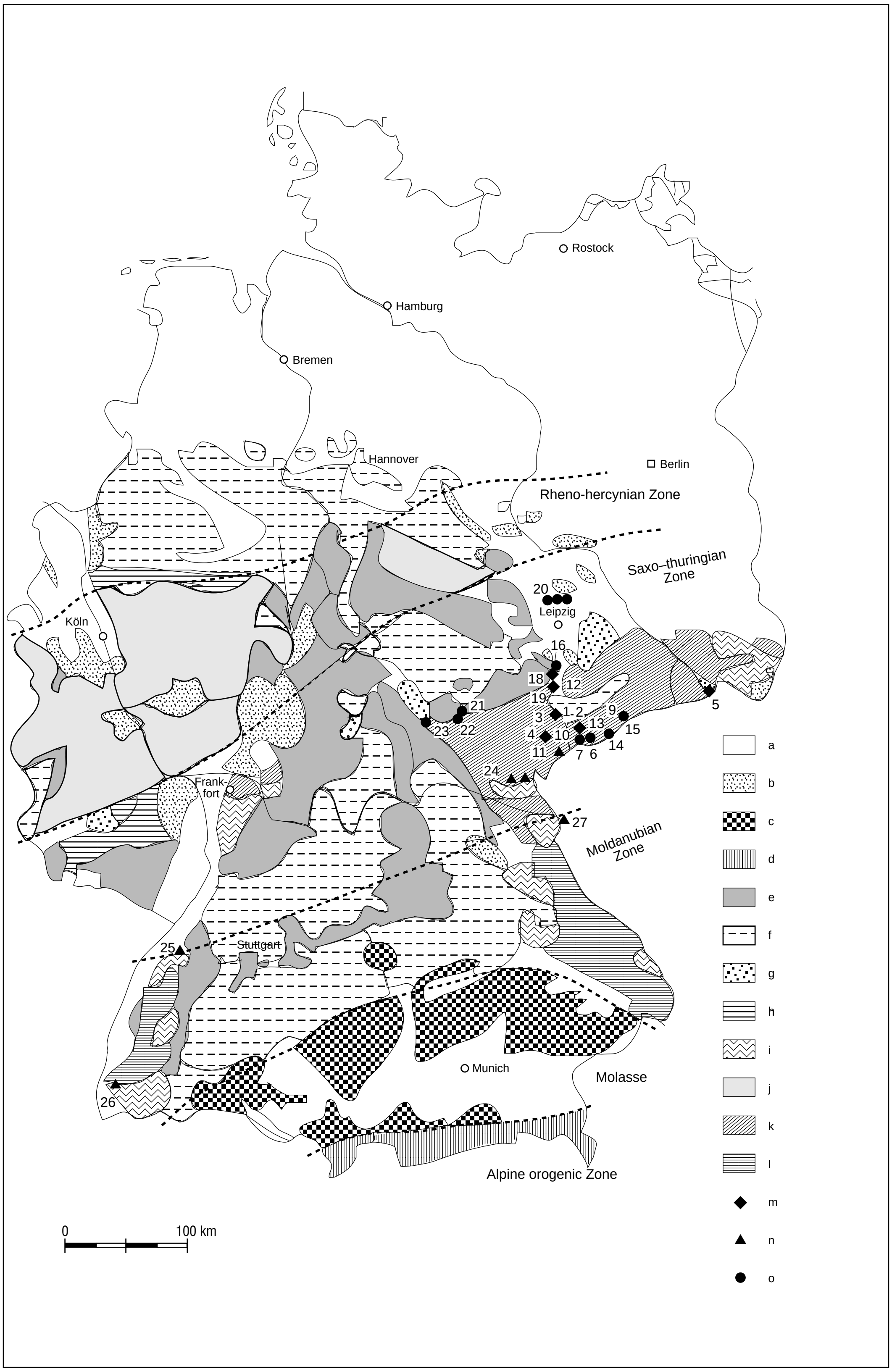
The known conventional resources in the above $130/kgU cost category remain unchanged from those reported in the 1991 Red Book.

The known conventional resources occur mainly in the closed mines which are in the process of being decommissioned. Their future availability remains uncertain.

Undiscovered conventional resources (EAR-II & SR)

Due to a reassessment, all EAR-II are reported in the cost category above $130/kgU. A minor portion, yet unassessed, may be recoverable at costs between $80/kgU and $130/kgU.

Uranium deposits and occurences in the Federal Republic of Germany



LEGEND

I GEOLOGY

a. Quaternary
b. Tertiary
c. Alpine molasse (Tertiary)
d. Alpine orogenic zone (Mesozoic)
e. Mesozoic sandstones
f. Mesozoic
g. Permian vocanics (rhyolite)
h. Permocarboniferous
i. Variscian granites
j. Rheno-hercynian zone (Paleozoic)
k. Saxo-thuringian zone (metamorphic)
l. Moldanubian zone (metamorphic)
m. Uranium deposits > 5 000 tonnes of uranium
n. Uranium deposits 500 - 5 000 tonnes of uranium
o. Uranium occurrences

II URANIUM DEPOSITS AND OCCURRENCES

1 Ronneburg/Thuringia
2 Schlema/Saxony
3 Culmitzsch-Sorge-Gauern/Thuringia
4 Zobes/Saxony
5 Königstein/Saxony
6 Tellerhäuser/Saxony
7 Johanngeorgenstadt/Saxony
8 Freital/Saxony
9 Annaberg/Saxony
10 "Weisser Hirsch" (Antonsthal) Saxony
11 Schneckenstein/Saxony
12 Hauptmannsgrün-Neumark/Saxony
13 Rittersgrün/Saxony
14 Bärenstein/Saxony
15 Marienberg/Saxony
16 Zeitz-Baldenhain/Thuringia
17 Prehna/Thuringia
18 Untitz/Thuringia
19 Gera-Süd/Thuringia
20 Serbitz, Kyhna-Schenkenberg and Werben/Saxony
21 Rudolfstadt/Thuringia
22 Dittrichshütte/Thuringia
23 Schleusingen/Thuringia
24 Grossschloppen/Bavaria
25 Müllenbach/Baden-Württemberg
26 Menzenschwand/Baden-Württemberg
27 Mähring-Poppenreuth/Bavaria

URANIUM PRODUCTION

Historical review

A description of historical production was given in the 1991 Red Book.

Status of production capability

There is no commercial production of uranium in Germany. Uranium recovered from clean-up operations is estimated at 30 tU for 1998.

Two production centres, Ellweiler mill and Crossen mill, were closed permanently in 1989. Both mills will be dismantled and the areas reclaimed. At the Seelingstädt mill in Thuringia, only parts remained operational for the treatment of slurry produced by underground leaching at the Königstein mine. Production since 1992 is derived from clean-up operations of the underground leaching mine at Königstein, Saxony.

Ownership structure of the uranium industry

In August 1998, Cameco completed its acquisition of Uranerz Exploration and Mining Ltd. (UEM), Canada, and Uranerz USA Inc. (UUS), from their German parent company Uranerzbergbau GmbH (Preussag and Rheinbraun, 50% each). In Canada, Cameco acquired UEM's 33.3% ownership of Key Lake and Rabbit Lake, 28% of McArthur River and 20% of Midwest. In the United States, Cameco acquired from UUS its 58% ownership of Crow Butte. In Australia, Cameco acquired the 6.45% ownership held by Rheinbraun in Energy Resources of Australia (ERA).

Employment in the uranium industry

All present employment is engaged in decommissioning and rehabilitation activities. At the end of 1998, employment totalled 3 450 persons, decreasing from 3 980 at the end of 1997 and 4 200 at the end of 1996.

Future production centres

There are no future production centres planned for Germany.

ENVIRONMENTAL CONSIDERATIONS

Since 1991, WISMUT GmbH has been carrying out major decommissioning and restoration activities, described hereafter.

Mine rehabilitation

At the end of 1998 about 90% of underground rehabilitation work had been completed. This included the cleaning and closure of about 1 400 km of mine tunnels and the placement of about 4.8 million m^3 of backfilling into shafts and shallow mine workings to stabilise the surface and to avoid negative effects on the hydrogeology. In the Aue-Schlema area the rehabilitation of near to surface underground voids is of particular importance and will continue for several years.

The flooding process at Ronneburg started in 1998 and is in progress at 3 mines: Gittersee, Aue-Schlema and Ronneburg. The flooding of the 1 800 m deep Aue-Schlema mine started in 1991. At the end of 1998 approximately 65% (25 million m^3) of open mine voids were flooded. The Pöhla mine has been completely flooded since November 1995. The flooding of the Ronneburg mine will take approximately 12 years to complete. At the Königstein ISL mine, an experimental flooding procedure is being carried out with the aim of starting the actual flooding process in 2001.

Restoration of mine dumps and Lichtenberg open pit

During mining, mine spoil with a total volume of 300 million m^3 was piled up at surface. Remediation of waste rock piles is preferably conducted on site. This includes profiling/ landscaping, covering and vegetation of the heaps.

At Ronneburg most of the mine spoil is relocated into the Lichtenberg open pit to geomechanically stabilise the pit and to reduce the effect of acid rock drainage from the spoil materials. During the mining period approximately 150 million m^3 were excavated to a depth of 240 metres. Until 1990 the open pit was partly backfilled with about 76 million m^3. By the end of 1998, 32% of the available volume of the pit were filled. The area will be completely restored in 2009/2010.

Restoration of tailings

The chemical processing of uranium ores at the milling facilities at Crossen and Seelingstädt resulted in about 160 million m^3 of residue which were deposited in tailings ponds. The tailings and disposal facilities at Trünzig, Culmitzsch, Helmsdorf and Dänkritz will be rehabilitated in situ. By the end of 1998, 41% of the tailings area were covered with an intermediate cover.

Surface environmental restoration activities

A volume of 735 000 m^3 of production plants and buildings have to be demolished. At the end of 1998, 53% had been demolished. In 1998 approximately 76 000 m^3 of rubble resulted from demolition activities and 22 000 t of scrap metal were recycled. 14% of the mine site has already been restored.

Water treatment

Before mine waters can be discharged into the environment, pollutants have to be removed by water treatment. At the Aue-Schlema and Pöhla sites waste water treatment plants have been installed. Plants at Königstein and Seelingstädt are being planned and will be in operation by the year 2001. At Ronneburg, seepage waters are treated by using ash. Mine water treatment will start with completion of the flooding process. A major programme is being conducted to develop site specific passive water treatment systems.

Monitoring

The emphasis is on monitoring air and water quality in the vicinity of Wismut facilities. Pollutant discharges into surface water bodies and the resultant concentrations are monitored by periodic sampling at a large number of established measuring points. In addition, a network of ground water monitoring stations has been installed to detect seepage from waste rock piles and tailings ponds as well as ground water quality. The monitoring of radioactive mine exhaust air from ventilation shafts and exhaust fans has shown significant air quality contaminant reduction following the shutdown of shafts and mine fans.

All environmentally relevant data are stored in a central environmental database. These quality assured data are continuously updated and made available to supervisory and regulatory authorities.

Funding

The decommissioning and remediation activities of WISMUT GmbH are funded from resources available from the federal budget. The overall cost is estimated at 13 billion DEM. Up to the end of 1998, a total of approximately 5.7 billion DEM had been spent including major expenditures for company restructuring, socially acceptable reduction of workforce and job creation schemes.

Cost of environmental management in million DEM

After closure	Pre-1998	1998	1999	2000	Total
Monitoring	94.0	29.5	30.5	25.0	179.0
Closing out tails impoundments	166.5	36.0	43.0	45.0	290.5
Decommissioning/decontamination	252.5	23.5	20.5	19.5	316.0
Effluent management (gas, liquid)	182.5	59.0	52.5	64.0	358.0
Site rehabilitation	189.0	30.0	31.0	42.5	292.5
Radwaste disposal	NA	NA	NA	NA	NA
Regulatory activities	NA	NA	NA	NA	NA
TOTAL (including overheads)	**884.5**	**178.0**	**177.5**	**196.0**	**1 436.0**

URANIUM REQUIREMENTS

There are no significant changes to future uranium requirements described in previous editions of the Red Book. The annual reactor-related requirements are adjusted to present conditions.

Supply and procurement strategy

There are no changes to the supply and procurement strategy.

NATIONAL POLICIES RELATING TO URANIUM

There is no restriction for private and/or foreign participation in uranium exploration, production and marketing as long as these activities are carried out under existing laws.

Government funding of uranium exploration was terminated by the end of 1990.

URANIUM PRICES

See information from the Euratom Supply Agency.

• Hungary •

URANIUM EXPLORATION

Historical review

The first reconnaissance for uranium started in 1952 when, with Soviet participation, material from Hungarian coal deposits was checked for its radioactivity. The results of this work led in 1953 to a geophysical exploration programme (airborne and surface radiometry) over the western part of the Mecsek mountains. The discovery of the Mecsek deposit in Permian sandstones was made in 1954. Further work aimed at the evaluation of the deposit and its development. The first shafts were placed in 1955 and 1956 for the mining plants 1 and 2. In 1956, the Soviet-Hungarian uranium joint venture was dissolved and the project became the sole responsibility of the Hungarian State. In the same year, uranium production from the Mecsek deposit started.

Exploration conducted by the geological staff of the Mecsek uranium mine continued until 1989 when it was terminated because of changes in market conditions.

URANIUM RESOURCES

Hungary's reported uranium resources are limited to those of the Mecsek uranium deposit.

The ore deposit occurs in Upper Permian sandstones that may be as thick as 600 metres. The sandstones were folded into the Permian-Triassic anticline of the Mecsek mountains. The ore bearing sandstone occurs in the upper 200 metres of the unit. It is underlain by a very thick Permian siltstone and covered by a Lower Triassic sandstone. The thickness of the green ore bearing sandstone, locally referred to as the productive complex, varies from 15 metres to 90 metres. The ore minerals include uranium oxides and silicates associated with pyrite and marcasite.

Known and undiscovered conventional resources

The uranium resources include both known and undiscovered resources. The known uranium resources, as of 1 January 1999, include 18 399 tU classified as EAR-I recoverable at costs equal or below $130/kgU. Hungary reports 12 858 tU classified as undiscovered resources of the EAR-II category recoverable at the same cost level. Speculative resources are not estimated.

All known uranium resources recoverable at costs equal or below $130/kgU are tributary to the Mecsek production centre.

URANIUM PRODUCTION

Historical review

The Mecsek mine, an underground facility, was the only uranium producer in Hungary. Prior to 1 April 1992, it was operated as the state-owned Mecsek Ore Mining Company (MÉV). The complex began operation in 1956 and was producing ore from a depth of 600-800 metres in 1997 when it was permanently shutdown. It has been producing about 500 000 to 600 000 tonnes ore/year at an average mining recovery of 50-60%. The ore processing plant has a capacity of 1 300 to 2 000 tonnes ore/day and employs radiometric sorting, agitated acid leach (and heap leaching) with ion exchange recovery. The nominal production capacity of the plant is about 700 tU/year.

The Mecsek mine consisted of 5 sections with the following history:

Section I: operating from 1956 to 1971.
Section II: operating from 1956 to 1988.
Section III: operating from 1961 to 1993.
Section IV: operating from 1971 to 1997.
Section V: operating from 1988 to 1997.

The ore processing plant became operational in 1963. Until that time, raw ore was exported to the USSR. A total of 1.2 million tonnes ore was shipped to the Sillimäe metallurgy plant in Estonia. After 1963, uranium concentrates were shipped to the Soviet Union.

Uranium mining and milling operations in sections IV and V were closed down at the end of 1997. The total production from the Mecsek site including the heap leaching is about 21 000 tU.

Heap and in situ leaching activities

Mecsek Ore Mining Enterprise actively prepared heap leaching of low grade uranium ores from 1965 until 1989 when the building of heaps was stopped. During this period about 7.2 million tonnes of low-grade ore with a uranium content of 100-300 grammes U/tonne were crushed to under 30 millimetres and placed in 2 piles for leaching. The first pile, designated Site Number I, containing 2.2 million tonnes, is no longer being leached. Rehabilitation of the site is being planned.

Site Number II, including 5.0 million tonnes, is located in an isolated basin. Following leaching with sodium carbonate solutions, uranium was recovered using ion exchange resins. Annual uranium production ranged from 5.5 tU, in the first year of operation, to 24.2 tU recovered in 1980. Production continued in 1994 with 8.2 tU recovered. Total production for the project is estimated at 525.2 tU. The average recovery was about 60%.

During the early 1980s, Hungary conducted exploration for sandstone hosted uranium deposits amenable to in situ leaching. A potentially favourable deposit was identified at the Dinnyeberki site about 20 km west of Pecs in south-western Hungary. The uranium deposit occurs in an organic rich non-consolidated tuff layer in a sedimentary sequence of Tertiary age. The associated sediments occupy troughs of structural and erosional origin developed in the pre-Cenozoic basement. During 1988 test leaching was carried out using acid solutions injected through wells. The tests were discontinued and no further in situ leaching was conducted.

Status of production capability

The Mecsek Company decreased its production because of changing delivery and market conditions. Production decreased from over 400 tU in 1994 to about 200 tU in 1995, 1996 and 1997. In addition, the Hungarian government decided in December 1994 to stop uranium mining as of 31 December 1997. An earlier decision to suspend uranium mining was made in September 1989. This decision was later reversed following a reassessment of the situation.

Uranium production centre technical details

(as of 1 January, 1999)

	Centre # 1
Name of production centre	Mecsekuran Ltd.
Production centre class	Existing
Operational status	Shutdown
Start-up date	1956
Sources of ore: • Deposit name • Deposit type	 Mecsek Sandstone
Mining operation: • Type • Size (tonnes ore/day) • Average mining recovery (%)	 UG 1 000 70
Processing plant: • Type (IX/SX/AL) • Size (tonnes ore/day) • Average processing ore recovery (%)	 IX 1 000 90
Nominal production capacity (tU/year)	500

Ownership structure of the uranium industry

The Mecsek operation had been an affiliate of the state-owned property agency through 1992. Following an evaluation of all the assets, Mecsekuran Ltd. was incorporated. The assets were divided between the state and the company in such a way that the resources remained state property, while the mining concession was transferred to Mecsekuran.

ENVIRONMENTAL CONSIDERATIONS

In 1996, Mecsekuran Ltd. and the former Mecsek Ore Mining Company (MÉV), more recently the Mecsekérc Environmental Corporation, prepared the conceptual plan for the decommissioning of the uranium industry in the Mecsek region. This plan sets out the methodology and schedules for the shutdown of mines and processing plants. It also contains details on dismantling and demolition together with land restoration and environmental rehabilitation.

The competent Hungarian authorities (mining, environmental and water agencies) have accepted this plan and the financing requirements. In 1998 after the closure of the mines, the feasibility study for the stabilisation and remediation of the tailing ponds was finalised.

In 1999 the planning works on the tailing ponds and demolition of the buildings of the ore processing plant started. The programme for the total remediation will continue until the end of 2002.

Cost of environmental management

	Pre-1998	1998	1999	2000*
Closing of underground spaces	NA	1 266 730	841 167	243 360
Reclamation of surficial establishments and areas	NA	156 347	303 100	297 031
Reclamation of waste rock piles and their environment	NA	62 657	160 286	196 637
Reclamation of heap-leaching piles and their environment	NA	195 375	705 566	853 432
Reclamation of tailing ponds and their environment	NA	167 893	370 310	1 664 752
Water treatment	NA	156 740	469 909	209 389
Reconstruction of electric network	NA	0	0	27 000
Reconstruction of water and sewage system	NA	0	1 000	98 006
Other infrastructural service	NA	172 000	170 000	92 616
Other activities including monitoring, staff, etc.	NA	241 398	339 808	358 217
SUBTOTAL	5 406 468	2 419 140	3 361 146	4 040 440
Reserves for the amount of 1998-2000	0	52 435	86 685	284 211
TOTAL in HUF (x 1 000)	**5 406 468**	**2 471 575**	**3 447 831**	**4 324 651**

* Planned.

URANIUM REQUIREMENTS

Hungary operates the Paks nuclear plant which consists of four WWR-230 type NPPs with a total net nuclear electricity generating capacity of 1 800 MWe. At present, there are no firm plans for the construction of additional plants.

The annual uranium requirements for these NPPs are reported to be about 400 tU. Until 1994, the requirements could be met by uranium mined domestically. As production ceased in 1997, uranium requirements are solely satisfied by imports.

• India •

URANIUM EXPLORATION AND MINE DEVELOPMENT

Historical review

The history of uranium exploration in India dates from 1949. A review of uranium exploration and geologic environments hosting uranium is given in the 1997 Red Book.

During the early 1990s, a near-surface deposit was discovered adjacent to the unconformity surface of basement granites with overlying Proterozoic Srisailam Quartzite at Lamabapur in the Nalgonda district, Andhra Pradesh. This and other showings were further followed up, and by 1996 the following areas had been identified on the basis of favourable geological criteria and promising exploration results. They were consequently selected for intensive investigations: Cuddapah Basin, Andrah Pradesh; Cretaceous sandstones of Meghalaya; Son Valley, Madhya Pradesh and Uttar Pradesh; Singhbhum, Bihar and Orissa; and Aravallis, Rajasthan.

Exploratory drilling in the environs of the Lambapur area has established an additional 1 950 tU as EAR-I at the Peddagattu area in the northwestern part of the Cuddapah Basin. Cretaceous sandstones in Meghalaya have been identified as potential horizon for uranium concentration. Surveys and prospection in the area around the Domiasiat uranium deposit have revealed further promising anomalies.

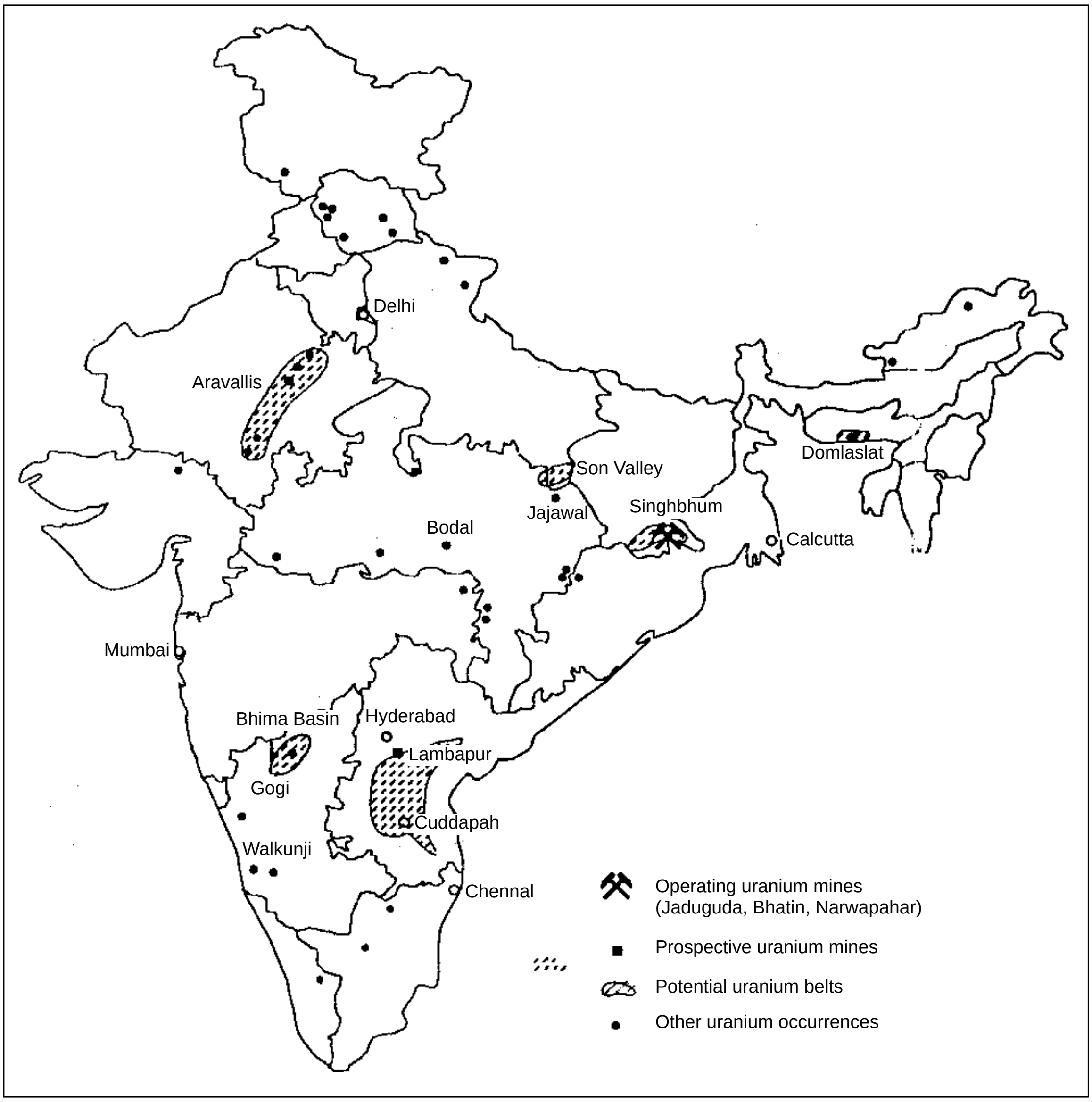
Recent and ongoing uranium exploration and mine development activities

Uranium exploration activities in India are keeping pace with developments in other countries. At present, previously outlined priority areas have been targeted for intense and more detailed investigations. They include:

- Proterozoic basins such as in Cuddapah, Bhima, Chattisgarh and Vindhyan for hosting unconformity-related deposits.

- The Cretaceous Mahadek sandstone of Meghalaya for sandstone-type deposits.
- The Singhbhum Shear Zone of Bihar for vein-type deposits in basement granitoids, in parts of Andhra Pradesh, Orissa, and Madhya Pradesh.
- Albites of Rajasthan and migmatites of Uttar Pradesh for igneous intrusive-related deposits.

Uranium occurrences in India



Cuddapah basin

Evaluation and exploratory drilling of the mineralised unconformity between the granitic basement and the overlying Srisailam Quartzite are continuing. At the north-western margin of the Cuddapah Basin, a medium size deposit of moderate grades has already been delineated in the Lambapur-Peddagattu area.

Extensive surface showings in a similar geological environment have been located along the unconformity within 60 km^2 outlier at Chitrial. Exploration drilling was planned for 1999.

Banganapalli Quartzite (Kurnool Group) and its contact with the basement granite near Koppunuru hosts scattered uranium mineralisation over 50 km^2. Exploration drilling has confirmed the continuity of this mineralisation along the unconformity. Hydrogeochemical and geophysical surveys, ground surveys and drilling are being carried out to discover concealed deposits.

Bhima basin

Brecciated limestone along a major fault proximal to the unconformity contact of sediments of the Neoproterozoic Bhima Basin with the underlying basement granites is mineralised near Gogi, Gulbarga district, Karnataka. Drill holes have intercepted grades up to 0.85% U in a mineralised zone where the greatest thickness is large. During 1998-1999, extensive drilling and further exploration, including airborne radiometric and magnetic surveys, continued throughout the Bhima Basin.

Other Proterozoic basins

Led by the recent successful discoveries of uranium occurrences related to unconformities, the combined survey and exploration efforts over other Proterozoic basins were given first priority. Promising among them are Kaladgis in Karnataka, Vindhyans in Uttar Pradesh, and Chattisgarhs and Indravatis in Madhya Pradesh and Orissa. An airborne survey over the Vindhyan Basin and exploration drilling to test the continuity of unconformity-contact mineralisation is planned in 1999.

Createaceous sandstones of Meghalaya

Fluviatile sandstones of the Mahadek Formation, covering an area of over 1 100 km^2, have been recognised as a potential host for sandstone-type uranium deposits. They are under intense investigations, but access is hampered by difficult logistics and heavy rainfall. Apart from the proven deposits at Domiasiat and Tyrnai, exploration drilling continues at Wahkyn, where promising indications for new resources were recently made. Further discoveries are expected in the same geological environment.

Vein-type occurrences

As with the Singhbhum Shear Zone, basement fractures in granitoids near the margins of the Cuddapah Basin of Andhra Pradesh, the Chattisgarh Basin in the Raigarh district of Madhya Pradesh and in the Bargarh district of Orissa have been found to be extensively mineralised on the surface. Geological indications suggest they continue beneath the cover rocks. The exploration effort will also be intensified in these areas.

Intrusive occurrences

Albititic intrusives within rocks of the Aravalli Supergroup (Lower Proterozoic) and the Delhi Supergroup (Middle Proterozoic) are widespread within the northern and central parts of Rajasthan. They are exposed for a length of 270 km along a north-northeast/south-southwest trend. They are invariably uraniferous and are being explored in detail.

Uranium exploration expenditures and drilling statistics

	1996	1997	1998	1999 (Expected)
Government expenditures: Rupees (x 1000)	3 145 000	3 970 000	5 697 000	5 794 000
USD (x 1000)	9 230	11 200	14 440	13 700
Government surface drilling in metres	32 762	34 645	30 070	32 550

URANIUM RESOURCES

Known conventional resources (RAR & EAR-I)

As in previous Red Books, India's uranium resources have been classified as RAR and EAR-I without assigning any cost category. These resources are located mainly in the following deposits:

- Vein and disseminated-type deposits associated with the Singhbhum Shear Zone, Bihar.
- Sandstone-type deposits in the Cretaceous sediments of Meghalaya.
- Unconformity-related type deposits at the base of the Proterozoic sediments in the north-western part of the Cuddapah Basin in Andra Pradesh.
- Dolostone-hosted stratabound-type of the Cuddapah Basin in Andra Pradesh.

The known resources as of 1 January 1999 include 52 745 tU RAR and 25 202 tU EAR-1 as in situ resources. Since the publication of the last resource estimates in 1997, RAR have increased by 665 tU and EAR-I by 957 tU. This results from exploration work carried out (1) along the Proterozoic unconformity of the Srisailam Quartzite of the Cuddapah Basin with the basement granite at Peddagattu, Andhra Pradesh, and (2) in the Cretaceous sandstones at Wahkyn, in the West Khasi Hills district of Meghalaya. Further additions to the resource base are expected in these areas in the near future.

Known uranium resources (tonnes U)*

Cost range unassigned	
RAR	EAR-I
52 745	25 202

*　As in situ resources.

Undiscovered conventional resources (EAR-II & SR)

As a result of continuing exploration in Meghalaya, Andhra Pradesh, Karnataka, Rajasthan, Bihar and Orissa, additional potential areas have been identified. The degree of confidence in their potential has increased based on results from ongoing activities for these areas. Following the results of new compiled data many deposits were reclassified. However, within the EAR-II resource category, the unconventional by-product resources of phosphorites estimated at 1 695 tU for the country (see Red Books 1993, 1995, 1997) are no longer included. They have been reclassified in the Speculative Resources resulting in a reduction in the EAR-II figure from 14 725 tonnes as of 1997 to 13 030 tU.

While some previous resources of the SR category have been reassigned to the EAR-I category, the total SR remain at the same level due to the addition of the phosphorite by-product and some new promising uranium finds in the following areas: Bhima Basin in the Gulbarga district; Karnataka, in the Chattisgarh Basin; and in fractures in the basement located in the Raigarh district of Madhya Pradesh and in the Bargarh district, Orissa.

Undiscovered resources (tonnes U)*

Cost range unassigned	
EAR-II	Speculative Resources
13 030	17 000

* As in situ resources.

Unconventional or by-product resources

Deposit	Location	Production centre name	Tonnes U (recoverable)
Copper deposits of the Singhbhum Thrust Belt	Singhbhum district, Bihar	Jaduguda	6 615

URANIUM PRODUCTION

Historical review

The Uranium Corporation of India Limited (UCIL) was formed in October 1967 under the administrative control of the Department of Atomic Energy, Government of India. UCIL is now operating three underground mines at Jaduguda, Narwapahar and Bhatin in the eastern part of the Singhbhum district, Bihar State. The ore is treated in the processing plant located at Jaduguda about 150 km west of Calcutta.

In addition, uranium is recovered as a by-product from the tailings available from the copper concentrator plants of M/s Hindustan Copper Ltd., at Rakha, Mosaboni mines. The uranium is then further processed in the Jaduguda mill.

Status of production capability

The total installed capacity of the Jaduguda mill is about 2 100 tonnes ore/day. Additional information for the Jaduguda, Narwapahar and Bhatin Mines and the Jaduguda mill is given in the 1997 Red Book. Information on uranium recovery from tails of copper production is also given.

Uranium production centre technical details

(as of 1 January 1999)

	Centre #1	Centre #2	Centre #3	Centre #4	Centre #5
Name of production centre	Jaduguda	Bhatin	Narwapahar	Rakha and Mosaboni uranium recovery plants	Domiasiat
Production centre class	Existing	Existing	Existing	Existing	Planned
Operational status	Operating	Operating	Operating	Operating	Development
Start-up date	1968	1986	1995	1970 & 1980	2004
Source of ore: • Deposit name • Deposit type	Uranium ore Jaduguda Vein	Uranium ore Bhatin Vein	Uranium ore Narwapahar Vein	Copper mine tailings	Domiasiat Sandstone
Mining operation: • Type (OP/UG/ISL) • Size (tonnes ore/day) • Average mining recovery (%)	UG 850 80	UG 250 75	UG 1 000 80	By-product of copper production	ISL NA NA
Processing plant: • Type (IX/SX/AL) • Size (tonnes ore/day) • Average processing ore recovery (%)	Jaduguda IX/AL 2 100 95	Jaduguda	Jaduguda	U-mineral concentrate recovered by tabling copper mill tailings	NA
Nominal production capacity (tU/year)	207			90 t mineral concentrate per day	NA
Plans for expansion	NA			NA	NA
Other remarks	All ore processed in Jaduguda	Ore processed in Jaduguda	Ore processed in Jaduguda	Concentrate shipped to Jaduguda for processing	

Employment in the uranium industry

About 4 000 people are engaged in uranium mining and milling activities.

Future production centres

The uranium deposit located at Domiasiat in the West Khasi Hills District, Meghalaya State, north-eastern India, is now proposed for development using ISL technologies. Field tests and other investigations are in progress. Information on this project is included in the table summarising the production centres technical details.

URANIUM REQUIREMENTS

Supply and procurement strategy

In India, the exploration for uranium is carried out by the Atomic Minerals Directorate for Research and Exploration, a wholly owned government organisation. Neither private nor any foreign companies are involved in exploration, production and/or marketing of uranium. The Uranium Corporation of India Limited (UCIL), a Public Sector Undertaking under the Department of Atomic Energy, is responsible for the production of yellow cake. The rest of the fuel cycle, up to the manufacture of fuel assemblies, is the responsibility of the Nuclear Fuel Complex, a wholly owned government organisation.

The investment in uranium production in India is directly related to the country's nuclear power programme. For planning purposes the lead-time from uranium exploration and development to production is assumed to be seven years.

Installed nuclear generating capacity

(Mwe net)

1998	1999	2000	2005		2010		2015	
			Low	*High*	*Low*	*High*	*Low*	*High*
1 695	2 099	2 503	2 503	–	4 525	5 647	5 647	–

Annual reactor-related uranium requirements

(tonnes U)

1998	1999	2000	2005		2010		2015	
			Low	*High*	*Low*	*High*	*Low*	*High*
376	433	407	560	855	618	861	861	861

• Indonesia •

URANIUM EXPLORATION

Historical review

Uranium exploration by the Nuclear Minerals Development Centre of the Indonesian National Atomic Energy Agency (BATAN) started in the 1960s. The first stage regional reconnaissance covered approximately 78% of a total of 533 000 km^2 estimated to be favourable for uranium mineralisation. Methods employed during the reconnaissance phase included integrated geochemical stream sediment, heavy mineral and radiometric surveys. Several geochemical and radiometric anomalies were found in granitic, metamorphic and sedimentary environments. Subsequently, uranium occurrences were identified in Sumatra, the Bangka Tin Belt and Sulawesi. A more detailed evaluation of these occurrences has not been made.

All exploration activities conducted since 1988 were concentrated in the Kalan area, West Kalimantan. During 1991-1992, exploration continued in this area directed both at the surroundings of and at the uranium occurrence at Kalan. A significant drilling programme was completed in 1992. The results of the exploration were evaluated and incorporated in a pre-feasibility study for a possible uranium mining operation at Kalan. In 1993-1996, BATAN continued its uranium exploration activities at the Kalan uranium occurrence and in the surrounding West Kalimantan region. During 1993–1994, exploration including drilling was concentrated at several sectors of Kalan referred to as Jeronang, Kelawai Inau and Bubu. In addition, work was done in the Seruyan and Mentawa areas and in the surroundings of Kalan, where similar geological conditions were found.

The follow-up work carried out in the favourable areas since 1993 included systematic geological and radiometric mapping, radon surveys, deep trenching and drilling of several hundred metres. These programmes covered relatively small areas in Tanah Merah-Dendang Arai (0.06 km^2), the Mentawa sector (0.3 km^2), and the Upper Rirang Valley (0.008 km^2).

Surface mapping discovered several uranium mineral occurrences in veinlets. The thickness of the mineralised veins ranges from some millimetres (Dendang Arai), to 1-15 cm (Tanah Merah) and 1-100 cm (Jumbang I). The veins are filled with uraninite associated with molybdenite, pyrite, pyrrhotite, magnetite, hematite and ilmenite. Several drill holes in Tanah Merah intersected 5 metres of mineralisation at about 33 m, 40 m and 50 m depth. In the Mentawa sector the encountered mineralisation was identified as horizontal to vertical multiple lenticular zones. The radiometric surface expressions ranged from 300-1 500 counts per second on a SPP2 scintillometer.

Ten shallow non-core holes and deep trenching were performed in the Upper Rirang Valley where boulders mineralised with rich monazite-bearing ores had been discovered. The boulder type mineralisation was proven to derive from in situ sources dispersed within the 30-metre wide valley.

In 1993-1995, BATAN also carried out a reconnaissance over 3 000 km^2 on Irian Jaja Island. In 1995 and 1996 reconnaissance mapping was completed over a total area of 3 000 km^2 and 3 050 km^2, respectively.

Recent and ongoing activities

As a consequence of the Indonesian economic crisis the exploration budget has been reduced since 1997 resulting in no significant additional field work.

The verification of the ore reserves outlined in the Kalan area was the only activity performed during 1997 and 1998. This study included essentially the re-logging of ore holes and the subsequent correlation of the radiometric values with chemical results. Only minor discrepancies affecting the specific gravity of ores and some logging data were found but these did not require a revision of the previous resource estimates.

Uranium exploration expenditures and drilling efforts

	1996	1997	1998	1999 (Expected)
Government expenditures: (Ruphias x 1 000 000) (USD x 1000)	 1 619.55 695.09	 1 515.13 631.83	 1 334.43 114.05	 1 693.16 228.62
Government surface drilling in metres	470	509	0	0
Number of government holes drilled	4	2	0	0

URANIUM RESOURCES

Known conventional resources (RAR & EAR-I)

RAR and EAR-I resources occur in the Eko Remaja, Lembah Hitam, Lemajung and Rabau sectors. Pre-feasibility studies of Kalan concluded that the reserves needed to be verified. The verification work consisted of re-logging and re-assessment of ore grades and the specific gravity. As there are no significant changes of the physical and chemical character of the ores, no further revision of the resources is needed.

As of 1 January 1999, RAR amount to 6 273 tU, as in situ resources, recoverable at costs below $130/kgU. EAR-I of the same cost category are reported as 1 666 tU as in situ resources. When compared to the previously published resources, there is no change to report.

Undiscovered conventional resources (EAR-II & SR)

The undiscovered conventional resources, mainly from the Kalan prospect, belong to the SR category and remain practically unchanged. The Mentawa sector, a new area located some 50 km south-east of Kalan, has geologically the same high favourability as Kalan and could host an additional potential. To evaluate this resource potential a delineation drilling programme is needed. Speculative resources amount to 2 057 tU; recovery cost has not been assessed.

ENVIRONMENTAL ASPECTS

No significant environmental issues relating to uranium exploration and resource development have been identified yet.

• Islamic Republic of Iran •

URANIUM EXPLORATION

Historical review

Uranium exploration began in Iran in support of an ambitious nuclear power programme launched in the mid-1970s.

The programme continued over the last two decades despite sharp fluctuations in the level of activities and suspension of the nuclear power programme for a period of time.

The main activities started with airborne surveys conducted by foreign companies being accompanied by field reconnaissance of geologists and prospectors of the Atomic Energy Organisation of Iran (AEOI). These surveys covered the one third of the area of Iran judged to be most favourable for uranium deposits. The airborne geophysical data were processed in format of digital and hardcopy maps by contractors and within the framework of a technical co-operation project with AEOI.

This work was followed up by reconnaissance and detailed ground surveys. Regional and detailed exploration activities were started in the most prospective regions, depending on the available infrastructure and exploration manpower. Follow-up of about one-sixth of the area covered by the airborne surveys led to the definition of a few small prospects.

Recent and ongoing activities

New concepts and methodologies were generated during the 1998-1999 period including multi-discipline analyses, remote sensing, metallogenic prognosis and integration of multi-source exploration data in support for identification of sandstone type and polymetallic uranium deposits. Development of infrastructure, new manpower and advanced technical facilities were implemented to modernise exploration approaches and provide the basis for a more up-to-date prospection.

In the 1998-2000 period, the Exploration Division of AEOI is continuing uranium exploration in central Iran (Narigan, Khoshumi and Sechahun) and northwest Iran. Ground radiometric and magnetic surveys, geological mapping, trenching, drilling and logging as well as geochemical surveys are being carried out in parts of Precambrian ore bearing formations (Central Iran), and in Tertiary rock units (volcanics, intrusives and sediments) in north-western Iran. Ground checks of airborne anomalies and formational evaluation of Mesozoic-Cainozoic sedimentary units are the main directions of activities aiming at collecting data requested by the special groups for data integration and metallogenic evaluation.

Systematic exploration research such as compiling and integrating geodata, metallogenic prognosis, and prediction of prospective areas are considered principal methods for the evaluation of sedimentary sequences of Mesozoic-Cainozoic age, the Pan-African metallogenetic structural zones, and Alpine polymetallic uranium bearing volcano-plutonic systems.

Uranium exploration expenditures and drilling efforts

	1996	1997	1998	1999
Government expenditures	NA	NA	NA	NA
Government surface drillling in metres	0	0	800	1 000
Number of government holes drilled	0	0	4	6

URANIUM RESOURCES

On the basis of the geological setting and host rock types, the most favourable area for uranium deposits is the central province. In this area, late Precambrian basement and Pan-African metallogenic rock series are present.

The Saghand ore field and a few uranium and uranium/thorium prospects (Narigan, Sechahun, Zarigan, Khoshumi) are located in this area. Three types of radioactive mineralisations have been distinguished:

- albite-amphibole metasomatic type with U-Th-REE mineralisation;
- hydrothermal-metasomatic veins with U (Mo, Y) mineralisation;
- hydrothermal polymetallic uranium mineralisation.

The first two types belong to the Pan-African metallogenic stage while the third is considered Alpine type.

Among the known resource bearing prospects the Saghand, Narigan, Sechahun and Zarigan occurrences have an Pan-African age, while the Talmessi, Khoshumi, Kale-Kafi and Arusan prospects have been developed during the Alpine phase. These deposits including the Bandarabass calcrete-type host the known and undiscovered resources.

Known conventional resources (RAR & EAR-I)

Deposits with RAR and EAR-I resources have been evaluated. The total estimated resources in the Saghand 1 and 2 amount to 1 367 tU. The production costs for these resources are between $80 and $130/kgU.

Reasonably Assured Resources*

(tonnes U, as of 1 January 1999)

Cost ranges		
<$40/kgU	<$80/kgU	<$130/kgU
0	0	491

* As in situ resources.

Estimated Additional Resources – Category I *

(tonnes U, as of 1 January 1999)

Cost ranges		
<$40/kgU	<$80/kgU	<$130/kgU
0	0	876

* As in situ resources.

Undiscovered conventional resources (EAR-II & SR)

A total of 9 500 tU additional resources have been estimated for the EAR-II and SR categories as of 1 January 1999. Their distribution and cost category are specified in the tables below.

Undiscovered Resources

(tonnes U)

Estimated Additional Resources – Category II		**Speculative Resources**	
Cost ranges		Cost ranges	
<$80/kgU	<$130/kgU	<$130/kgU	Unassigned
0	4 500	5 000	0

• Italy •

URANIUM RESOURCES

In the present situation, with no nuclear power plants in operation, there are no uranium exploration and production activities. With respect to uranium resources, the estimates published in the 1991 Red Book are still valid.

URANIUM REQUIREMENTS

In 1987, a National Energy Conference was held during which there were intense discussions concerning the nuclear option. Consequently, the Government decided on a nuclear moratoria and in 1988 issued the National Energy Plan.

The last National Energy Conference was held in Rome on 25-28 November 1998. This conference was organised by ENEA on behalf of the Ministry of Industry, in agreement with the Ministry of Environment and the Ministry of University and Scientific and Technological Research and the Council of Ministries. During this conference the nuclear debate was not resumed and only nuclear waste issues were considered. Given this situation and an international market characterised by low oil prices, no nuclear plants are planned at present. Nevertheless, a research programme concerning safety aspects of innovative reactors and the development of an Accelerator Driven System (ADS) are under way.

• Japan •

URANIUM EXPLORATION

Historical review

Uranium exploration has been carried out by the Power Reactor and Nuclear Fuel Development Corporation (PNC) and its predecessor since 1956. About 6 600 tU of uranium reserves have been detected in Japan. These reserves are classified as Reasonably Assured Resources recoverable at less than $130/kgU. The domestic uranium exploration in Japan ended in 1988.

Overseas uranium exploration began in 1966. The exploration activities were carried out mainly in Canada and Australia, and in other countries such as the United States, Niger, China and Zimbabwe.

In October 1998, PNC was reorganised into the Japan Nuclear Cycle Development Institute (JNC). Based on the decision by the Atomic Energy Commission in February 1998, uranium exploration activities which were carried out by PNC, will be discontinued after a certain period, and mining interests and technologies which remain in JNC will be transferred to the private sector.

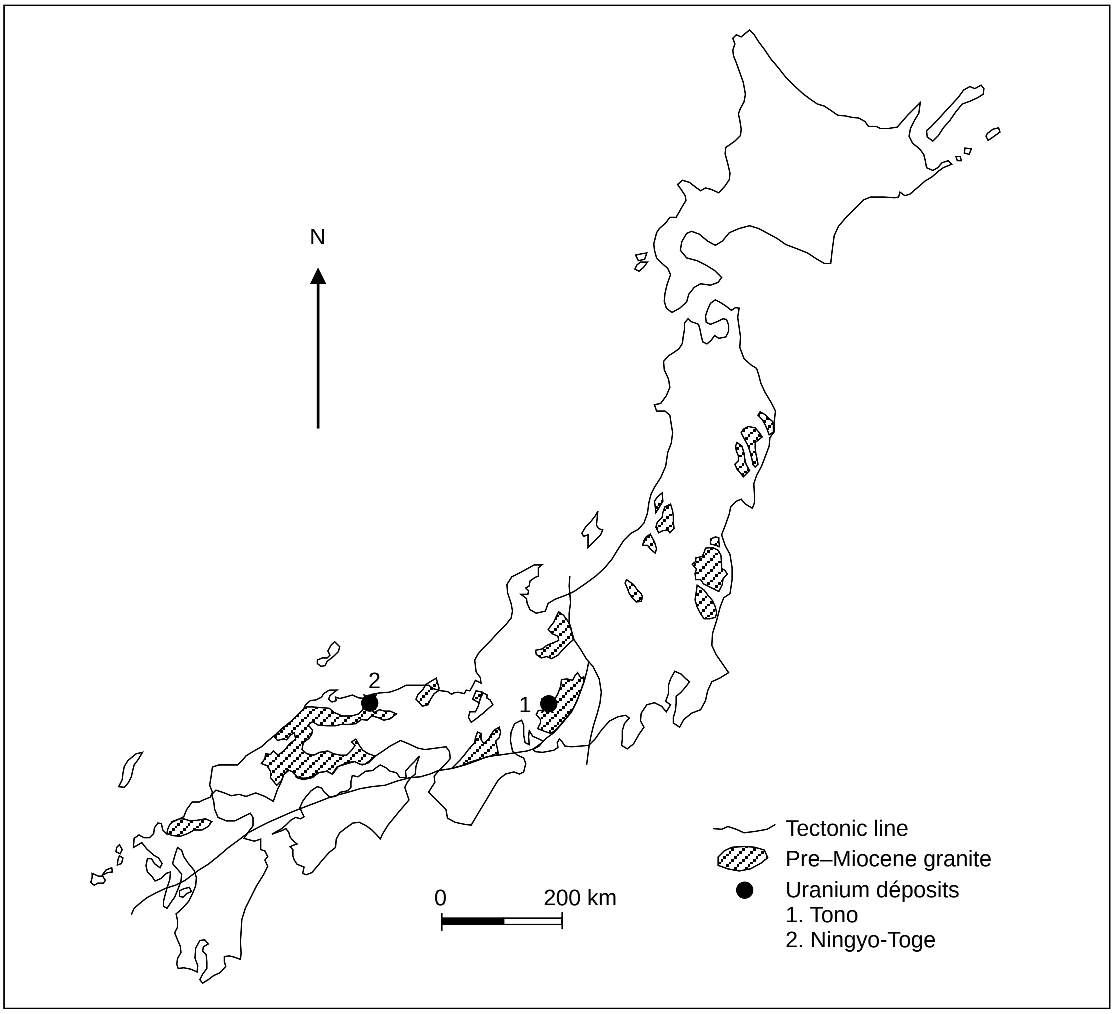
Recent and ongoing activities

Currently, JNC has about 40 000 tU in mining interests in Canada, Australia, the United States, Niger and Zimbabwe. These projects will be transferred to private companies.

Uranium exploration expenditures – abroad

	1996	1997	1998	1999 (Expected)
Government expenditures:				
Million JPY	806	556	314	169
USD (x 1000)	7 533	4 752	2 275	1 470

Distribution of major granitic bodies and uranium deposits in Japan



URANIUM PRODUCTION

Historical review

A test pilot plant with a capacity of 50 tonnes ore per day was established at the Ningyo-toge mine in 1969 by PNC. The operation ceased in 1982 with a total production of 84 tU. In 1978, the vat leaching test of the Ningyo-toge ore began on a small scale with a maximum capacity of 12 000 tonnes ore per year, consisting of three 500 tonne ore vats. The vat leaching test was terminated at the end of 1987.

URANIUM REQUIREMENTS

As of 1 January 1999, 52 nuclear power reactors were being operated in Japan. Total (gross) electric generating capacity was 45 082 MWe, providing approximately one third of the electricity generated in Japan. Three additional reactors were under construction and three reactors were planned.

As for the future scale of development of nuclear power generation, electric generation capacity is expected to be 70.5 GWe by 2010 and 100.0 GWe (gross) by 2030.

The cumulative requirement of natural uranium is expected to reach about 160 000 tU by 2000, about 280 000 tU by 2010 and about 600 000 tU by 2030.

Supply and procurement strategy

Japan has relatively scarce domestic uranium resources and, therefore, must depend to a great extent on overseas supply of uranium. A stable supply of uranium resources is to be ensured through long-term purchase contracts with overseas uranium suppliers, direct participation in mining development and other ways of diversification of sources of supply.

NATIONAL POLICIES RELATING TO URANIUM

There is no special legislation for uranium exploration and exploitation under the Japanese Mining Laws and Regulations. Uranium exploration and exploitation is open to private companies incorporated in Japan. However, no private company has pursued uranium exploitation in Japan.

URANIUM PRICES

Uranium import prices are contracted by private companies. Government information is not available for these data.

• Jordan •

URANIUM EXPLORATION

Historical review

In 1980 an airborne spectrometric survey covering the entire country was completed. By 1988 ground based radiometric surveys of anomalies identified in the airborne survey were completed. During the 1988-1990 period, Precambrian basement and Ordovician sandstone target areas were evaluated using geological, geochemical and radiometric mapping and/or surveys.

During the period 1990-1992 a regional geochemical sampling programme, involving stream sediments and some rock samples, was completed over the basement complex area. Geological and radiometric follow-up was carried out at locations within the basement complex and Precambrian sandstone areas.

Recent and ongoing exploration and mine development activities

All uranium exploration activities in Jordan are conducted by the Natural Resources Authority (NRA), and projects have been funded by the government. The main findings from exploration activities are described below:

- Radiometric measurements (gamma and radon) and chemical analysis defined several surficial uranium occurrences in central, southern and south-eastern Jordan. In central Jordan, the occurrences are closely related to varicoloured marble. They occupy an area of about 350 km^2.
- Uranium occurs as minute mineral grains disseminated within fine calcareous Pleistocene sediments and as yellowish films of carnotite and other uranium minerals coating fractures of fragmented chalk marl of Mastrichtian-Paleocene age. In the southern and southeastern area uranium occurs only as yellowish stains associated with chalk marls.
- Dolomite is the major constituent of the uranium bearing rocks. The Calcite and clay content are low.
- Preliminary leach tests using the alkaline method indicate leachability of more than 90%.
- Results of channel sampling in three areas in central Jordan indicate uranium contents ranging from 140 to 2 200 ppm over an average thickness of about 1.4 m. The average thickness of the overburden is about 0.5 m.

At present, the data are insufficient to estimate and categorise contained uranium resources.

Uranium exploration expenditures

	1996	1997	1998	1999 (Expected)
Total government expenditures in USD	100 000	100 000	150 000	170 000

URANIUM PRODUCTION

Jordan does not produce uranium. In 1982, a feasibility study for uranium extraction from phosphoric acid was presented by the engineering company LURGI A.G., of Frankfurt, Germany, on behalf of the Jordan Fertiliser Industry Company. This company was later on purchased by the Jordan Phosphate Mines Company (JPMC). One of the extraction processes evaluated was found to be feasible. At that time no decision was taken for the construction of an extraction plant. As uranium prices fell drastically, the process became uneconomic.

The work in this field was resumed in 1989 through the use of a micro pilot plant. The testing was terminated in 1990. The result of the work was the preparation of a project document for a uranium extraction pilot plant from phosphoric acid.

ENVIRONMENTAL CONSIDERATIONS

A systematic study and evaluation of the uranium concentration in Jordan's phosphate deposits was conducted to assess the environmental effects of the uranium. This study was completed in September 1997. Eshidiya phosphate deposits, which constitute most of the phosphate reserves in Jordan, are characterised by relatively low uranium grades (i.e. averaging 38gU/t). More details on the uranium phosphates of Jordan are given in the 1993 edition of the Red Book.

• Kazakhstan •

URANIUM EXPLORATION AND MINE DEVELOPMENT

Historical review

The main results of exploration for the last 30 years are discoveries of large uranium deposits associated with Cretaceous and Paleocene sediments of the Chu-Sarysu and Syr-Darya basins which significantly increased the resource base of Kazakhstan. In addition, the ISL amenable resources have placed Kazakhstan in a position to compete with other low cost uranium producers in the world. Because of the very large resource base, early stage exploration has declined. It is now restricted to the northern part of the country. A review of the history of uranium exploration and production in Kazakhstan is given in the 1997 Red Book.

Recent and ongoing uranium exploration and mine development activities

Since 1995 the exploration organisation Stepgeologia has been carrying out early stage exploration (without drilling) in northern Kazakhstan aimed at the discovery of unconformity-related deposits.

Uranium exploration expenditures and drilling statistics

	1996	1997	1998	1999 (Expected)
Government expenditures:				
Tenge (x million)	16	12	8	NA
USD (x million)	242	160	105	NA

The exploration enterprise Volkovgeologia has been contracted by Chinese government authorities to perform exploration in China for uranium deposits amenable to ISL extraction techniques.

URANIUM RESOURCES

The uranium resources of Kazakhstan occur in several types of deposits. The two main uranium deposit types include vein-stockwork and sandstone deposits. Both types are further subdivided according to their geological settings.

The vein-stockwork deposits include two subtypes: vein-stockwork deposits in folded sedimentary complexes of the Silurian-Devonian age, and those associated with continental effusive volcanics of the Devonian age.

The sandstone hosted uranium deposits in Kazakhstan are of the roll-front type. These epigenetic sandstone deposits are named “bed oxidation type” by Kazak geologists.

The epigenetic sandstone uranium subtype occurs in two approximately north-south trending sedimentary basins: the Chu-Sarysu and the Syr-Darya, separated by the Karatau uplift. In both basins, the uranium mineralisation is associated with Cretaceous-Paleocene clastic sediments, consisting of several sandstone-clay sequences. In the case of the Chu-Sarysu basin, there are about six sandstone-clay sequences with sandstone horizons between 50-70 metres thick and separated by impermeable clays. In both districts, the uranium mineralisation occurs along oxidation-reduction interfaces forming asymmetric rollfronts and lenses. High porosity and permeability of the host horizons, and their separation by impermeable clays, make this deposit subtype amenable to ISL methods. The deposits in the Chu-Sarysu district include Zhalpak, Uvanas, Mynkuduk, Inkay and Budyonovskoe in the northern part of the basin and Kandjugan and Moynkum in the southern part.

The Syr-Darya district includes roll-front deposits in Cretaceous sediments with the deposits Irkol, North-Karamurun (Severny Karamurun), South-Karamurun (Yuzhny Karamurun) and Zarechnoe.

There are 51 uranium deposits in Kazakhstan (see map). These include 26 deposits which have been investigated and for which uranium resource estimates have been prepared. The deposits occur in 6 uranium bearing districts: I. Kokchetau, II. Pribalkhash, III. Ily, IV. Chu-Sarysu, V. Syr-Darya, and VI. Pricaspian.

Known conventional uranium resources (RAR & EAR-I)

The known uranium resources of Kazakhstan recoverable at costs of below $130/kgU total 857 960 tU as of 1 January 1999. The resources are reported as in situ. When compared to the estimate of 1 January 1997 published in the previous Red Book, there is a small decrease of 2 600 tU caused by depletion of the deposits from mining and extraction. The 2 600 tU is greater than the total of 2 360 tonnes extracted for this period. The balance reflects the mining and milling losses. The known resource portion which can be recovered at costs of below $40/kg U amounts to 433 940 tU, or about 50% of the total.

About 50% of Kazakhstan's known resources recoverable at costs below $40/kgU are tributary to existing and committed production centres. This percentage increases to 74% when the $80/kgU known resources are included.

Reasonably Assured Resources (in tonnes U)*

Cost ranges		
<$40/kgU	<$80/kgU	<$130/kgU
320 740	436 620	598 660

* As in situ resources adjusted for depleted resources.

Estimated Additional Resources – Category I*

(tonnes U)

Cost ranges		
<$40/kgU	<$80/kgU	<$130/kgU
113 200	195 900	259 300

* As in situ resources.

Undiscovered conventional uranium resources (EAR-I & SR)

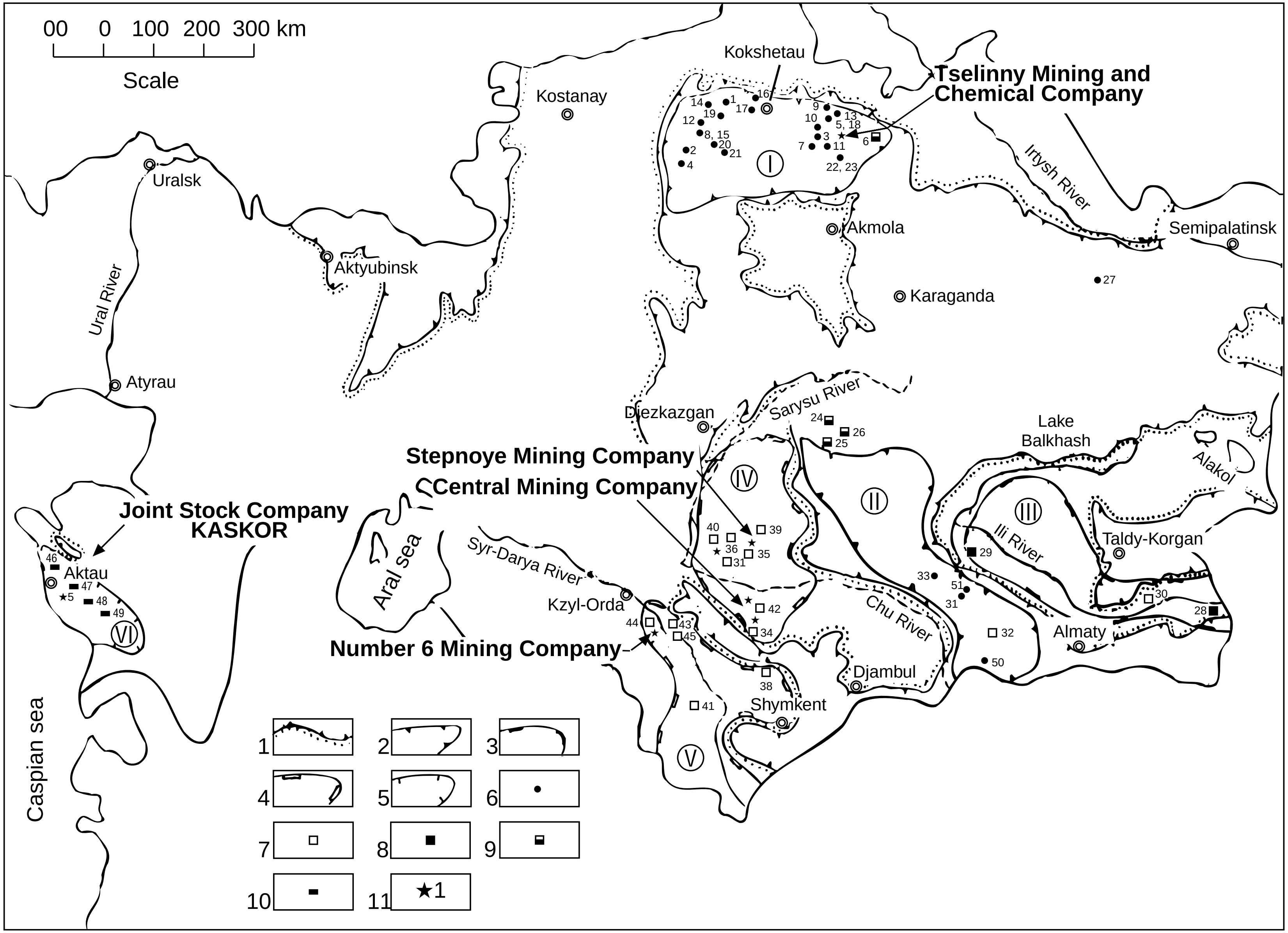
As no exploration was carried out in Kazakhstan during the 1997-1998 reporting period, both the EAR-II and SR recoverable at costs below $130/kgU, remained unchanged. Both estimates are reported as in situ resources.

Estimated Additional Resources – Category II

(tonnes U)

Cost ranges		
<$40/kg	<$80/kg	<$130/kgU
200 000	290 000	310 000

Uranium metallogenic provinces, deposits and production facilities of Kazakhstan



1. Borders of (a) Pre-Mesozoic and (b) Mesozoic-Cenozoic sediments

2. Uranium ore provinces with endogenic deposits in Pre-Mesozoic sediments
(I- Kokshetau, II- Pribalkhash)

3-5. Uranium ore provinces with exogenic deposits in Mesozoic to Cenozoic sedimentary formations:
3- with soil oxidation of coal beds (III- IIy)
4- with stratal oxidation (roll-front) in sandstone sequences (IV- Chu-Sarysu, and V- Syr-Darya)
5- with phosphatic fossil fish bone detritus (VI- Pricaspian)

6-10. Uranium deposits:
6- endogenic of different ore types
7- infiltration with stratal oxidation (i.e. roll-front)
8- infiltration with soil oxidation
9- infiltration with stratal oxidation (i.e. roll-front) in sediments of paleovalley
10- with phosphatic fossil fish bone detritus.

11. Production Centres/Mines:
1) Central Mining Company (Kandjugan)
2) Stepnoye Mining Company (Uvanas)
3) Number 6 Mining Company (Mynkuduk)
4) Tselinny Mining and Chemical Company (Grachev and Vostok)
5) Joint Stock Company “Kaskor” (Melovoye)

Deposits shown on map:
1. Grachev*
2. Shokhpak
3. Zaozyornoe
4. Kamyshevoe*
5. Shatskoe
6. Semizbay*
7. Tastykol
8. Akkan-Burluk
9. Glubinnoe
10. Koksorskoe
11. Vostochno-Tastykolskoe
12. Victorovskoe
13. Agashskoe
14. Fevralskoe
15. Burlukskoe
16. Slavyanskoe
17. Chaglinskoe
18. Shatskoe-I
19. Kosachinoe
20. Vostok*
21. Zvyozdnoe
22. Manybaysk*
23. Yuzhno-Manybayskoe
24. Shorly
25. Talas
26. Granitnoe
27. Ulken-Akzhal
28. Koldjat*
29. Nizhne-Iliyskayay*
30. Suluchokinskoe
31. Djusandalinskoe
32. Kopalysayskoe
33. Kyzyltas
34. Kandjougan*
35. Uvanas*
36. Mynkuduk*
37. Sholak-Espe
38. Kyzylkol
39. Zhalpak
40. Inkay* (planned)
41. Zarechnoe
42. Moynkum* (planned)
43. South Karamurun
44. Irkol*
45. North Karamurun*
46. Melovoe*
47. Tomak
48. Taybogar
49. Tasmurun
50. Kurdai
51. Botaburum

* Operating or closed mines.

Speculative Resources

(tonnes U)

Cost Range		Total
<$130/kgU	Unassigned	500 000
500 000	0	

URANIUM PRODUCTION

Historical review

The uranium production in 1997 and 1998 totalled 1 090 and 1 270 tU, respectively. Plans for 1999 indicate a significant increase to 2 000 tU.

Historical uranium production

(tonnes U)

Production method	Pre-1996	1996	1997	1998	Total through 1998	Expected 1999
Conventional mining:						
• Open pit	21 618	0	0	0	21 618	0
• Underground	38 333	0	140	190	38 663	0
Conventional mining and processing	59 951	0	140	190	60 281	0
In situ leaching	21 421	1 210	950	1 080	24 661	2 000
TOTAL	81 372	1 210	1 090	1 270	84 942	2 000

Status of production capability

In 1995, the Tselinny Mining and Processing Company stopped production at its Grachev and Vostok underground operations. It consequently suspended the operation of the ore processing plant located at Stepnogorsk. All installations were mothballed. After a short re-activation of work in 1997 and 1998 Tselinny Mining and Processing Company again stopped uranium production, and currently its assets are for sale as the company filed for bankruptcy.

To replace the conventional uranium production in 1996, two additional ISL operations, Katko and Inkay, initiated preparation for production, each with a production capability of 700 tU/year. The first is being developed by a joint venture between the Kazak National Atomic Company Kazatomprom and Cogema, the second one by Kazatomprom and Cameco Corporation.

In summary, the entire current uranium production capability is associated with the five ISL production centres of Tsentralnoe, Stepnoye, No. 6, Katko and Inkay with an aggregated production capacity of 4 000 tU/year. The technical details of the operating and planned ISL production centres are summarised in the first part of the relevant table, while the technical characteristics of the mothballed production centres are listed in the second part.

Uranium production centre technical details

Part 1: existing and committed centres

Name of production centre	Tsentralnoe Mining Co	Stepnoye Mining Co	No. 6 Mining Company	Katko	Inkay
Production centre class	Existing	Existing	Existing	Committed	Committed
Operating status	Operating	Operating	Operating	Development	Development
Start-up date	1982	1978	1985	2000	2000
Source of ore: • Deposit names • Deposit type	Kandjugan Sandstone	Uvanas, Mynkuduk Sandstone	Karamurun Sandstone	Moynkum Sandstone	Inkay Sandstone
Mining operation: • Type • Size (tonnes ore/day) • Average mining recovery (%)	ISL NA NA	ISL NA NA	ISL NA NA	ISL NA NA	ISL NA NA
Processing plant: • Type • Size (tonnes ore/day) For ISL (kilolitre/day or litre/hour) • Average processing recovery (%)	IX NA NA	IX NA NA	IX NA NA	NA NA NA	NA NA NA
Nominal production capacity (tU/year)	1 000	1 000	600	700	700
Plans for extension	None	None	None	None	None

Part 2: mothballed centres

Name of production centre	Joint Stock Co. Kaskor	Tselinny Mining & Processing Co.
Production centre class	Existing	Existing
Operational status	Mothballed since 1993	Mothballed since 1995
Start-up date	1959	1958
Source of ore: • Deposit name • Deposit type	Tomak, Melovoye Fish bone detritus	Grachev, Vostok Stockwork-vein
Mining operation: • Type • Size (tonnes ore/day) • Average mining recovery (%)	OP NA NA	UG NA NA
Processing plant: • Type • Size (tonnes ore/day) For ISL (kilolitre/day or litre/hour) • Average ore processing recovery (%)	IX NA NA NA	IX NA NA NA
Nominal production capacity (tU/year)	2 000	2 500

Ownership structure of the uranium industry

The mining companies Tsentralnoe, Stepnoye and No. 6 are controlled by the State Company Kazatomprom which was created at the end of 1996. The Inkay and Katko companies are joint operating companies with Cameco and Cogema, respectively, as partners.

Employment in the uranium industry

The development of the employment in the existing production centres between 1996 and 1999, is compiled in the following table. Between 1992 and 1998, the employment continuously decreased from 11 800 persons in 1992 to 4 800 in 1998, or by nearly 60%. The decrease in employment can be largely attributed to the closure of the Tselinny Company.

Employment in existing production centres

(persons-years)

1996	1997	1998	Expected 1999
6 000	5 100	4 800	4 200

Future production centres

Following closure of the Tsellinny Mining and Processing Company all uranium produced in Kazakhstan after 1999 will be recovered by ISL methods.

For the near future, two more production centres are planned at the Irkol and Zarechnoe deposits. Based on the existing, committed and planned production capabilities, the capability projections through the year 2005 are summarised in the following table. The production programme for 2010 and beyond has not been established.

Short-term production capability

(tonnes U/year)

1999				2000				2001				2005			
A-I	**B-I**	**A-II**	**A-I**	**A-I**	**B-I**	**A-II**	**B-II**	**A-I**	**B-I**	**A-II**	**B-II**	**A-I**	**B-I**	**A-II**	**B-II**
2 000	2 000	2 000	2 000	2 500	2 500	2 500	2 500	2 800	2 800	2 800	2 800	3 500	3 500	4 500	4 500

In general, Kazakhstan's known uranium resources could support a relatively rapid increase in production in response to an increase of international demand.

Environmental aspects

Kazakhstan has significant environmental concerns about the wastes associated with its previous and presently operating uranium production facilities. It is also concerned about the environmental aspects of its large volume of sandstone hosted uranium resources that are amenable to in situ leach extraction.

The sandstone hosted uranium deposits occur in sedimentary basins that also host large groundwater resources. The contamination of groundwater related to the uranium deposits, both naturally occurring and resulting from leaching, led to the development of an exclusion zone equal in size to 150 by 15 km. The extraction of drinking water is prohibited from this zone.

In addition, uranium mining and ore processing over 40 years have accumulated low-level radioactive waste rock dumps and mill tailings. The total volume of radioactive waste from mining and ore processing is estimated to be 200 million tonnes. A large portion of this waste was generated by operations which are now closed. The previous operators, in this case Soviet State Enterprises, do not accept responsibility for the clean-up. As no financial provisions were made to pay for the required remedial activities, the Republic of Kazakhstan must provide the necessary funding.

In 1997 and 1998, within the framework of the TACIS programme, special investigations have been carried out to establish an inventory of all existing mine and mill radioactive waste storage sites in Kazakhstan and measure the potential associated environmental hazard. It has been determined, that of 100 waste storage sites, only 5 or 6 sites have a significant environmental impact. The main danger and concern for all sites is the possibility of uncontrolled use of the waste for construction purposes.

The exclusive adoption of ISL methods of uranium production in Kazakhstan has led to the elimination of radioactive mill tails associated with uranium production. At the same time, the risk of ore-bearing aquifers being contaminated by ISL extraction solutions have increased. Currently, a study of the effect of ISL extraction on aquifers is under way. This is being done in an IAEA technical co-operation project to determine the optimal ISL processing parameters for conditions in Kazakhstan. In addition, an investigation is under way to better understand the process of natural attenuation or self-adjustment of the aquifer following leaching.

URANIUM REQUIREMENTS

Some significant changes in the projection of Kazakhstan’s uranium requirements have occurred as compared to the data submitted in the previous Red Book. Kazakhstan has operated the fast-breeder reactor BN-350, with a net capacity of 70 MWe, at Aktau on the Mangyshlak Peninsula at the Caspian Sea. The electricity produced is primarily used for a desalination plant. The shutdown of the reactor is now under serious consideration. This means that Kazakhstan may have no uranium requirements for the next several years.

The State Programme for the developing atomic energy in co-operation with the Russian Federation has not received full approval. Consequently all plans for the construction of nuclear power plants have been indefinitely delayed. Future uranium requirements are therefore not available.

Installed nuclear generating capacity

(MWe net)

1998	**1999**	**2000**	**2005**		**2010**		**2015**	
			Low	*High*	*Low*	*High*	*Low*	*High*
70	0	0	NA	NA	NA	NA	NA	NA

Annual reactor-related uranium requirements

(tonnes U)

1998	1999	2000	2005		2010		2015	
			Low	*High*	*Low*	*High*	*Low*	*High*
50	0	0	NA	NA	NA	NA	NA	NA

SUPPLY AND PROCUREMENT STRATEGY

At the present time all uranium produced in Kazakhstan is exported for sale on the world market. The country does not maintain uranium stockpiles in any form.

NATIONAL POLICIES RELATING TO URANIUM

The main emphasis of the national policy of Kazakhstan relating to uranium is directed at significantly increasing ISL uranium production for sale on the world market. The second objective supports the manufacture of enriched uranium pellets and other products at the Ulba plant in Kazakhstan. This is to be done in co-operation with the Russian Federation.

In accordance with the Government Decree, the National Atomic Company Kazatomprom is designated as the responsible authority for all uranium related export-import issues in Kazakhstan.

• Republic of Korea •

URANIUM EXPLORATION

Recent and ongoing activities

The Korea Electric Power Corporation (KEPCO), as part of its exploration programme, participated in the three mines in Canada and the United States. In 1999, KEPCO decided to dispose of its shares in the three mines. Another Korean company, Dae Woo Corporation, has participated in the Baker Lake project in Canada since 1983.

Uranium exploration expenditures – abroad

	1996	1997	1998	1999 (Expected)
USD (x 1 000)	401	531	601	–

URANIUM REQUIREMENTS

KEPCO had fourteen nuclear power plants in commercial operation as of 31 December 1998. The nuclear generating stock includes 11 PWR and 3 PHWR plants. The nuclear installed capacity of 12 016 MWe accounted for 28% of the country's total generating capacity in 1998. According to the long-term power development plan in Korea, 16 additional nuclear power plants, including 5 PWR and 1 PHWR plants already under construction, will be on line by the year 2015, with a total nuclear capacity of 27 650 MWe.

Along with the steady increase in nuclear capacity, the requirements for uranium concentrates and fuel cycle services are rising continuously.

Installed nuclear generating capacity

(MWe)

1998	1999	2000	2005	2010	2015
12 000	13 700	13 700	17 700	23 400	27 700

Annual reactor-related uranium requirements

(tonnes U)

1998	1999	2000	2005	2010	2015
2 400	2 500	3 500	3 900	4 600	5 200

NATIONAL POLICIES RELATING TO URANIUM

In order to support the nuclear expansion programme effectively, KEPCO has pursued a stable, economic and secured programme of uranium procurement. Accordingly, the uranium requirements are mostly supplied through long-term contracts with suppliers in various countries such as Canada, Australia, France, the United States, etc. KEPCO also procures its uranium through its subsidiary company, KEPRA, which owns a 10% share in the Crow Butte project in the United States.

URANIUM STOCKS

KEPCO maintains a stock level of one-year forward reactor-consumption for the operating plants, as a strategic inventory. One half of the stock is stored as natural uranium in overseas conversion facilities and the remainder is stored as enriched uranium in the PWR fuel fabrication facilities and as fuel assemblies at PHWR plants in Korea.

• Lithuania •

URANIUM EXPLORATION, RESOURCES AND PRODUCTION

Lithuania has no uranium resources and is not currently undertaking any uranium exploration.

URANIUM REQUIREMENTS

The short-term nuclear generating capacity projections for Lithuania are based on 2 RBMK units with a total capacity of 2 760 MWe at Ignalina. The future of the Ignalina nuclear power plant is under review by the Parliament of Lithuania. The projected uranium requirements for the plant will depend on the decision of the Parliament. The short-term projections of related uranium requirements are given in the following table. There is no stockpile of natural uranium material in Lithuania. A six-month stock of enriched fuel is generally maintained by the Ignalina NPP.

Annual reactor-related uranium requirements

(tonnes U)

1998	1999	2000	2005	2010	2015
480	640	680	NA	NA	NA

SUPPLY AND PROCUREMENT STRATEGY AND URANIUM PRICES

A bilateral agreement, under which the Russian Federation could supply fuel for the Ignalina nuclear plant over the long term, was signed in 1999 between the two countries. No information concerning uranium prices is reported.

• Malawi* •

URANIUM EXPLORATION

Historical review

Uranium exploration carried out by an international company during the 1980s led to the discovery of the Kayelekera uranium deposit. The deposit is located in the northern part of Malawi. No exploration is reported for 1996 to 1998.

The Kayelekera deposit is stratiform and of the sandstone type. The deposit occurs in a arenite-shale sequence of the Lower Karoo formation of Permian age. The deposit has identified resources of 11 700 tU with an average uranium grade of 0.159% U.

URANIUM RESOURCES

The only known conventional uranium resources of Malawi are in the Kayelekera deposit.

Known conventional resources (RAR & EAR-I)

Malawi reports known resources in the $80/kgU or less RAR category. No other uranium resources are reported, either known or undiscovered.

Reasonably Assured Resources*

(tonnes U)

Cost ranges		
<$40/kgU	<$80/kgU	<$130/kgU
–	11 700	11 700

* As in situ resources.

* This is the first time Malawi provides a report for the Red Book.

• Malaysia •

URANIUM EXPLORATION

Historical review

The early history of uranium exploration in Malaysia is described in the 1983 and 1991 editions of the Red Book. No uranium exploration has been conducted in either Sabah or Sarawak since 1984, as these areas are judged to have a low potential to host uranium deposits. Exploration has continued, however, on the Malaysian Peninsula using limited funds.

During 1991and 1992, the Geological Survey of Malaysia (GSM) conducted an integrated ground exploration programme over 8 600 km^2 of granitic terrain in the Pahang, Perak, Selangor, Negeri Sembilan, Johore and Kelantan States. Five fertile granitic plutons were identified through this work. In addition to the field work, the digital data from the airborne radiometric survey completed in 1980 was reprocessed. The results were used to produce stacked profiles and new maps.

During 1995 and 1996, carborne radiometric survey was carried out in parts of the states of Pahang and Kelantan utilising the GR650 Spectrometer System provided by the IAEA. A total of 1 000 km of traverse line was covered with the collection of about 11 500 gamma ray readings. Fourteen areas totaling about 100 km of traverse line were found to have uranium potential.

Recent and ongoing activities

Exploration activities by the GSM continued during 1997 and 1998 on the Malaysian Peninsula. The programme was expected to continue in 1999. Carborne radiometric surveys were conducted in the states of Selangor, Pahang and Negri Sembilan in 1997 and 1998.

No uranium resources have been discovered in Malaysia. Estimates of speculative resources have not been reported.

Uranium exploration expenditures

	1996	1997	1998	1999 (Expected)
Government expenditures:				
Ringgit malaysian (x 1 000)	0	604	699	702
USD (x 1 000)	0	245	187	186

• Mexico •

URANIUM EXPLORATION

Uranium exploration ended in May 1983, and URAMEX, the organisation responsible for this activity, was dissolved in February 1985. Some of URAMEX's responsibilities have been taken over by the Mineral Resources Board (Consejo de Recursos Minerales). According to the Mexican Law on Mining (Art.5, II) exploration and exploitation of radioactive minerals are restricted activities. This kind of minerals is included in the "National Mining Reserve Zone System".

URANIUM RESOURCES

Estimates of Mexico's uranium resources were prepared in 1982. Known uranium resources total 2 400 tU recoverable at costs between $80/kgU and $130/kgU. Additional undiscovered resources include 12 700 tU, of which 2 700 are EAR-II and 10 000 are Speculative Resources. In addition, there are unconventional resources in marine phosphates in Baja California, totalling 150 000 tU, as well as approximately 1 000 tU, which were previously classified as conventional resources. This last resource is associated with hydrothermal non-ferrous mineralization in Tayata (Oaxaca), Noche Buena (Sonora) and La Preciosa (Durango).

URANIUM PRODUCTION

From 1969 to 1971, the Mining Development Commission operated a plant in Villa Aldama, Chihuahua. The facility recovered molybdenum and by-product uranium from ores mined in the Sierra de Gomez, Domitilia (Peña Blanca) and other occurrences. A total of 49 tU was produced. At present, there are no plans for additional uranium production.

URANIUM REQUIREMENTS

Mexico's only uranium requirements are for the two units at Laguna Verde nuclear power plant, with a capacity of 654 MWe each.

The uranium requirements are based on the Energy Utilisation plan for the plant whose objectives are to enhance fuel utilisation by using advanced fuel designs and also by reducing spent fuel production.

Uranium deposits of Mexico

Installed nuclear generating capacity

(MWe net)

1998	1999	2000	2005		2010		2015	
			Low	*High*	*Low*	*High*	*Low*	*High*
1 306	1 306	1 370	1 370	1 370	1 370	1 370	1 370	1 370

Annual reactor-related uranium requirements

(tonnes U)

1998	1999	2000	2005		2010		2015	
			Low	*High*	*Low*	*High*	*Low*	*High*
360.25	189.48	184.22	180.01	360.02	178.19	356.38	182.44	364.88

Supply and procurement strategy

All the purchases made by the Mexican utility, the Comisión Federal de Electricidad (CFE), must be realised by an open call for bids. In the case of uranium, the strategy has been to have contracts for five years or less. The current uranium supply contracts were awarded in 1996 to CAMECO and NUKEM and they include supply of 1 137 559 KgU (as UF_6) for the period from 1998 to 2001.

URANIUM STOCKS

The purchases are generally made one year before the scheduled date of delivery of the fuel bundles, at the Laguna Verde plant site.

The natural uranium stocks correspond to one or two reloads at the enrichment facilities based on the purchase schedule.

The policy has been not to have stockpiles of enriched or fabricated fuel.

• Namibia •

URANIUM EXPLORATION AND MINE DEVELOPMENT

Historical review

The first significant discovery of radioactive mineralisation within Namibia was made in 1928 in the Rössing region by autoradiograph tests on a sample containing supposed pitchblende minerals.

As a result of an upswing in the uranium market demand and prices, extensive uranium exploration started in Namibia in the late 1960s. Several airborne radiometric surveys were conducted by the Geological Survey during this period and numerous uranium anomalies were identified. One of these developed into the Rössing deposit, where Rio Tinto Zinc had obtained exploration rights in 1966. This deposit was developed into a large scale open-pit mine which started production in 1976.

The development of Rössing, combined with a sharp upward trend in uranium prices, stimulated extensive exploration activity, mainly in the Namib Desert. Two major types of deposits were identified including the intrusive type, associated at Rössing, with alaskite and the surficial, calcrete type.

Of the intrusive deposits other than Rössing, the Trekkopje deposit has significant resources. The Langer Heinrich deposit is the most promising deposit of the surficial, calcrete type. Feasibility studies were carried out on several of these low-grade deposits but the fall in the market saw the cessation of any further work.

The combined effect of political uncertainty and the decline of uranium prices caused the rapid curtailment of exploration and development work in the early 1980s. This was indeed unfortunate as the refinement of exploration techniques which had proved so successful in the Namib Desert were poised to locate a number of new deposits.

Since that time, the continued weakness of the uranium market discouraged further exploration activities, except in the immediate vicinity of the Rössing mine.

However, should a sustained upturn in demand for uranium occur, it remains possible that the development of one of the identified deposits may prove commercially viable, with Langer Heinrich generally regarded as having the best potential.

Recent and ongoing uranium exploration and mine development activities

Since the end of the 1970s exploration boom, limited uranium exploration has been carried out. At present two mineral deposit retention licences are valid over the Valencia (intrusive alaskite type) and Langer Heinrich (calcrete hosted surficial) deposits. An exclusive exploration licence is valid over the Trekkopje deposits but details on the exploration work done and its results remain confidential as long as the licence is active.

Figure 1.**Uranium deposits of Namibia**

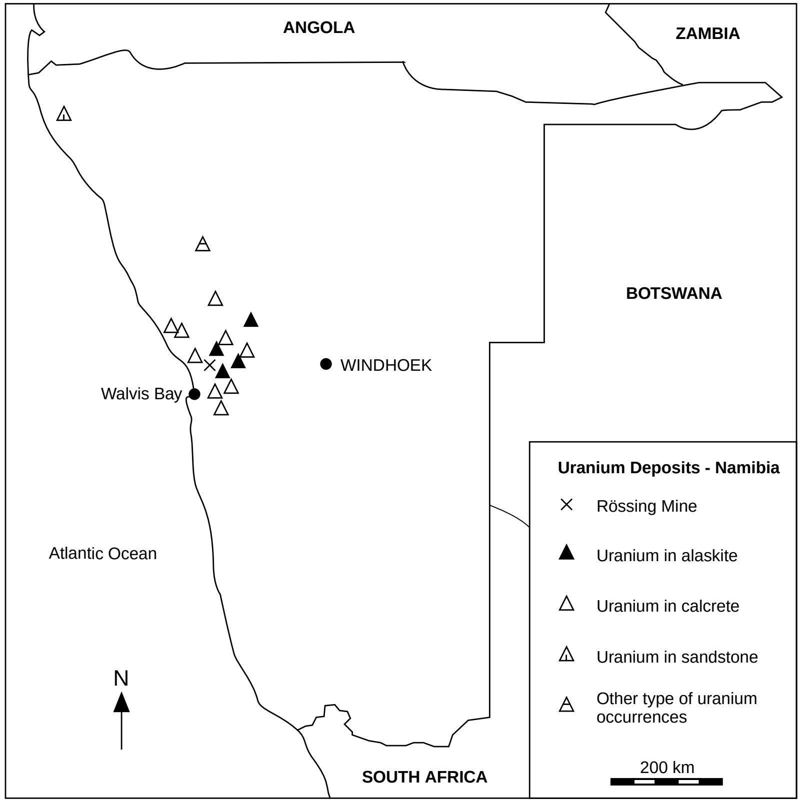
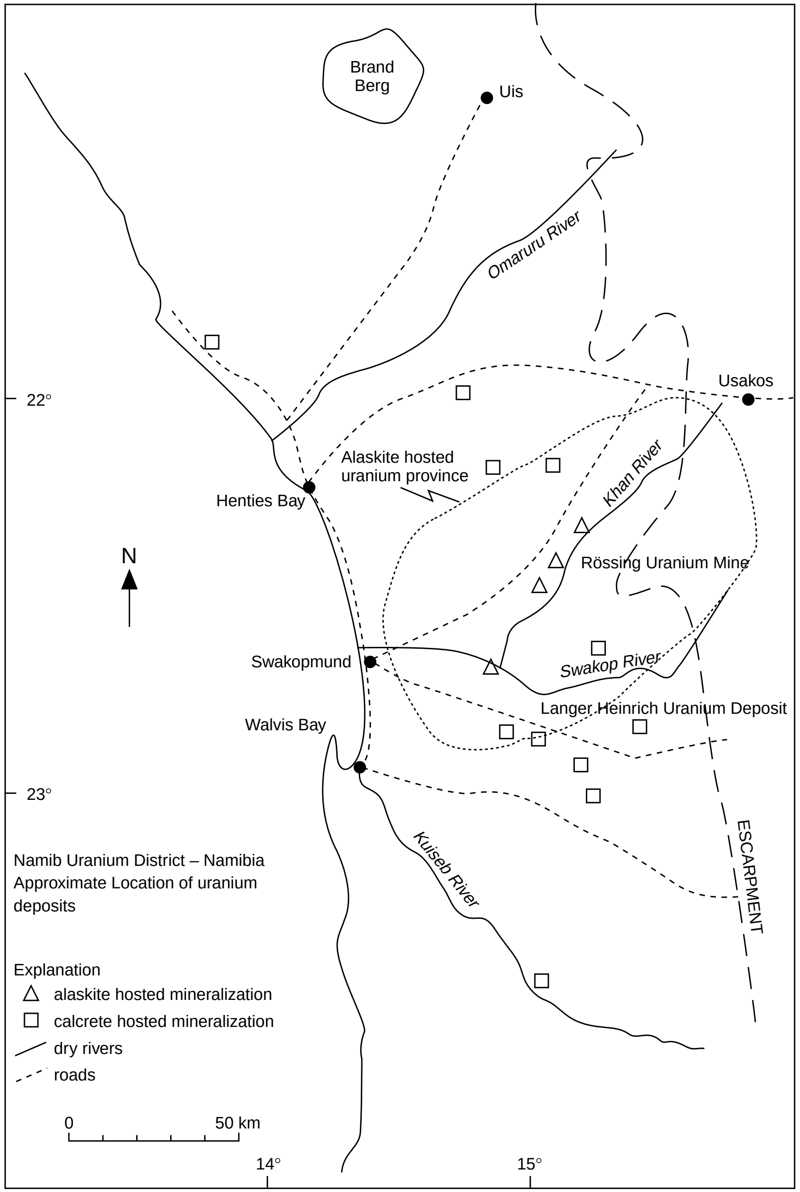


Figure 2.**Location of uranium deposits in the Namib Uranium District**



URANIUM RESOURCES

The uranium resources of Namibia, including both known and undiscovered categories, occur in a number of geological environments and consequently belong to several deposit types. The known resources are mainly associated with the intrusive deposit type. In addition, about 10% of the total known resources are hosted in surficial type deposits.

In addition to the known resources in the intrusive-type Rössing and Trekkopje deposits, located in the granite associated district of the Precambrian Damara Orogenic Belt, and those associated with surficial calcretes of the Langer Heinrich deposit, there is a large undiscovered uranium potential. Although it is not quantitatively assessed, the potential is in the following geological environments:

- The granitic terrain of the Damara Belt covers 5 000 km^2. This area is largely overlain by surficial deposits and/or wind-blown semi-consolidated sand. Past investigations concentrated on follow-up of airborne radiometric anomalies. Substantial additional resources, potentially the size of the Rössing deposit, are suspected under the post-mineral cover.

- Tertiary to recent surficial sedimentary terrains exist in semi-arid areas. This environment has further potential for calcrete-type deposits. Eleven of 38 identified regional airborne anomalies were successfully investigated by intensive drilling. This drilling provided known resources included in the estimate. In most cases the drilling encountered low-grade mineralisation associated with calcrete-filled palaeo-river channels. Although the presence of additional resources within Tertiary sediments is not discounted, the existence of large undiscovered resources is considered unlikely.

- Another type of potentially favourable geological environment is the sandstone basins. The corresponding model includes the Permo-Triassic Karoo sediments which were intensively investigated in neighbouring countries in the early 1970s. These basins were explored to a limited extent in Namibia as well. These sediments are extensively dissected by river systems in the north-western part of Namibia and the airborne radiometric expressions are very pronounced. Ground follow-up including substantial drilling delineated nearly 6 million tonnes of low-grade uranium mineralisation. However, this was excluded from the known resources due to high costs of recovery. It is believed that economically recoverable resources may be present within similar age sedimentary basins in other unexplored parts of Namibia.

Known conventional resources (RAR & EAR-I)

Namibia's known resources as of 1 January 1999 total 288 022 tU recoverable at costs below $130/kg U. While the RAR portion amounting to 180 509 tU is expressed as recoverable resources adjusted for mining (10-16%) and ore processing losses (14-30%), the EAR-I are reported as in situ resources.

As the last assessment was done before 1995, the RAR are identical to those reported in the last edition of this report except for the adjustments of the depletion resulting from 1997 and 1998 cumulative production of 6 850 tU.

Reasonably Assured Resources*

(tonnes U)

Cost ranges		
<$40/kgU	<$80/kgU	<$130/kgU
67 239	149 274	180 509

* As recoverable resources.

The EAR-I as of 1 January 1999 amount to 107 513 tU recoverable below $130/kg U, as in situ resources. Lack of exploration has resulted in these resources remaining unchanged from the previous report.

Estimated Additional Resources – Category I*

(tonnes U)

Cost ranges		
<$40/kgU	<$80/kgU	<$130/kgU
70 546	90 815	107 513

* As in situ resources.

Undiscovered conventional resources (EAR-II & SR)

Due to the availability of only limited data, EAR-II and SR were not estimated. The undiscovered potential, however, is considered excellent, especially for intrusive-type deposits.

URANIUM PRODUCTION

The only uranium producer in Namibia is the Rössing production centre of Rössing Uranium Limited.

Historical review

In 1928, Captain G. Peter Louw prospected and found uranium mineralisation in the vicinity of the Rössing Mountains in the Namib Desert. Over many years he tried to promote the prospect, but it was only in the late 1950s that Anglo-American Corporation of South Africa prospected the area by drilling and by some underground exploration. Due to erratic uranium values and poor economic prospects for uranium the Anglo-American Corporation abandoned the search.

In August 1966, Rio Tinto Zinc (RTZ) acquired the exploration rights and conducted an intensive exploration programme until March 1973. Surveying, mapping, drilling, bulk sampling and metallurgical testing in a 100 tonne/day pilot plant indicated the feasibility of establishing a production centre.

Rössing Uranium Limited was formed in 1970 to develop the deposit. RTZ was the leading shareholder with 51.3% of the equity (at the time of the formation of the company).

Mine development commenced in 1974, and the commissioning of the processing plant and the initial production was in July 1976 with the objective of reaching full design capacity of 5 000 short tons of U_3O_8/year (3 845 tU/year) during 1977. Due to the highly abrasive nature of the ore, which was not identified during the pilot plant testing stage, the production target was not reached until 1979 after some major plant design changes.

Historical uranium production

	Pre-1996	1996	1997	1998	Total through 1998	Expected 1999
Production method	(tonnes U contained in ore)					
Conventional mining: • Open-pit	58 590	2 447	2 905	2 780	66 722	3 425
TOTAL	58 590	2 447	2 905	2 780	66 722	3 425

Ownership structure of the uranium industry

Rössing Uranium Limited is a mixed enterprise with private and governmental shareholders as detailed in the following list:

RTZ Corporation	56.3%
Namibian Government	3.5%
Rio Algom Limited	10.0%
IDC South Africa	10.0%
Others	20.2%

The uranium production is 100% owned by domestic private organisations.

Status of production capability

During 1997 and 1998 production was close to 75% of capacity, having increased from 41% in the early 1990s. Similar rates of production are expected in 1999 and 2000.

Over the last two years substantial capital investment has been made to improve cost efficiency. The major capital expenditure items have been the replacement of the haultrucks and the installation of a pre-screening facility ahead of the fine crushing plant. In addition computerised commercial and management systems have been installed to improve operational efficiency and provide for internal Y2K compliance in the commercial and management systems. Similar levels of capital expenditure are expected in the next two years.

Employment in the uranium industry

As part of general performance improvements in order to cut production cost it is expected that employment levels will further decline over the next few years.

Employment in existing production centres

(persons-years)

1996	1997	1998	Expected 1999
1 189	1 254	1 104	1 009

Uranium production centre technical details

(as of 1 January 1999)

Name of production centre	Rössing
Production centre class	Existing
Operational status	Operating
Start-up date	May 1976
Source of ore: • Deposit name • Deposit type	 Rössing Intrusive
Mining operation: • Type • Size (tonnes ore/day) • Average mining recovery (%)	 OP 42 000 84
Processing plant: • Type • Size (tonnes ore/day) • Average ore processing recovery (%)	 Al/IX/SX 30 000 86
Nominal production capacity (tU/year)	4 000

Future production centres

No future production centres are envisaged.

Short–term production capability

Namibia has provided the following projection of its short-term production capability.

Short-term production capability

(tonnes U/year)

1999				2000				2001			
A-I	**B-I**	**A-II**	**B-II**	**A-I**	**B-I**	**A-II**	**B-II**	**A-I**	**B-I**	**A-II**	**B-II**
0	0	4 000	4 000	0	0	4 000	4 000	0	0	4 000	4 000

2005				2010				2015			
A-I	**B-I**	**A-II**	**B-II**	**A-I**	**B-I**	**A-II**	**B-II**	**A-I**	**B-I**	**A-II**	**B-II**
0	0	4 000	4 000	0	0	4 000	4 000	0	0	4 000	4 000

Long-term production capability

Under favourable market conditions Rössing, the only uranium producer in Namibia, could return to full production of close to 4 000 tU/year. The known resources could support this level of production at least through the year 2017.

Favourable market conditions would allow the development of one additional production centre with a production capacity of 1 000 tU/year. However, among the parameters which would impact upon a production decision is also the availability of water.

ENVIRONMENTAL CONSIDERATIONS

The Namibian environmental legislation is not specific to the uranium mining industry alone but covers all aspects of mining.

Currently, the environment activities are governed only by an environmental policy. However, an Environmental Act and an Integrated Pollution Control and Waste Management Bill are in a draft form. Furthermore, an Environmental Fund will be established to ensure that financial resources are available for mine rehabilitation.

Cost of environmental management

(open-cast production centre)

Existing operations	Pre-1998	1998	1999	2000	Total
Pre-operational environmental assessment	170	0	0	0	170
Monitoring	19 750	1 131	842	864	22 587
Stabilising waste dumps and/or impoundments	2 978	799	339	246	4 362
Decontamination of replaced equipment	0	0	0	0	0
Effluent management (gas, liquid)	11 670	309	448	474	12 901
Site rehabilitation	4 062	174	170	185	4 591
Radwaste disposal	0	0	0	0	0
Regulatory activities	190	10	10	10	220
TOTAL in ZAR (x 1 000)	38 820	2 423	1 809	1 779	44 831

NATIONAL POLICIES RELATING TO URANIUM

The Namibian Government recognises that the country's uranium deposits represent a major economic resource both for Namibia and uranium consumers of the world. It is thus committed to develop the deposits in a manner, which is safe for its workers and environmentally sustainable in the long term. This policy has been expressed through legislation in the Minerals (Prospecting and Mining) Act of 1992.

Namibia achieved independence on 21 March 1990 and the Act was promulgated on 1 April 1994. With the introduction of the Act, a number of South African laws that previously regulated uranium production activities were repealed or amended. These laws include the Nuclear Installations (Licensing and Security) Act of 1963, the Atomic Energy Act of 1967 and their amendments.

While the repeal of the South African uranium-related legislation was justified, due to its complexity and reference to issues which were not relevant to Namibia, the provisions of the Namibian Minerals (Prospecting and Mining) Act of 1992 are not sufficiently detailed to control the safety or the environmental aspects of the uranium industry. The introduction of a new act, or amendments to existing legislation, is presently being considered.

URANIUM STOCKS

No uranium stocks are held in Namibia.

URANIUM PRICES

The Rössing Uranium Limited is the only uranium producing company in Namibia. The release of contract price information could be detrimental to the company's long term interest.

• Netherlands •

NATIONAL POLICIES RELATING TO URANIUM

The Netherlands has no uranium resources and is not currently undertaking any uranium exploration.

URANIUM REQUIREMENTS

At present, the Netherlands has one nuclear reactor connected to the grid. That is the Borssele PWR reactor (449 MWe net). Provisional final reload for the Borssele reactor will be manufactured in 2001. The uranium requirements by this time will be 140 tU and the date of decommissioning is set at 2004.

URANIUM STOCKS

The natural uranium stocks were disposed of by 31 December 1995. Since then, the Netherlands have held no further stocks.

• Niger •

URANIUM EXPLORATION AND MINE DEVELOPMENT

Historical review

Uranium exploration in the Arlit area of Niger began in 1956 and was conducted by the *Commissariat à l'Energie Atomique* (CEA), later followed by Cogema. Discovery of mineralised areas eventually led to the mining of the Arlette, Artois and Ariège deposits by the *Société des Mines de l'Air* (Somaïr), and the Akouta and Akola deposits by the *Société des Mines d'Akouta* (Cominak). Exploration along the northwest extension of the Arlette flexure fault resulted in the discovery of the Taza deposit. The *Société Minière de Tassa N'Taghalgue* (SMTT) was organised to own the deposit, but assigned part of its mining rights to Somaïr in 1986.

In subsequent years, both Somaïr and Cominak were involved in exploration solely for the purpose of better evaluating known deposits. Somaïr delineated the Taza Nord. Cominak evaluated a mineralised area located southeast of the Akola deposit.

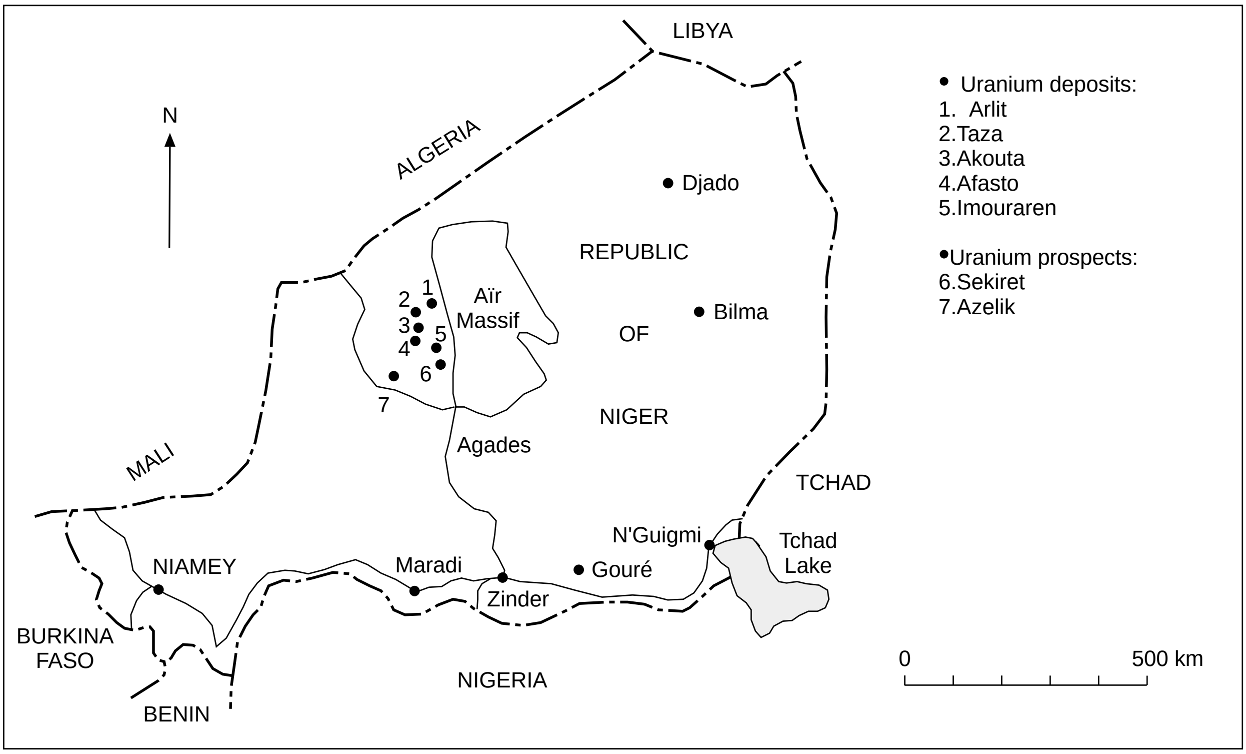
Since 1993, both Somaïr and Cominak have carried out significant drilling programmes. Part of the drilling results led to a reassessment of the resource estimate of the Takriza and Tamou deposits by Somaïr and further evaluation of the South Akouta and Akola deposits by Cominak. In 1996, the *Société Minière de Tassa N'Taghalgue* (SMTT) was dissolved and its assets, including mining properties, were sold to Somaïr.

Recent and ongoing uranium exploration and mine development activities

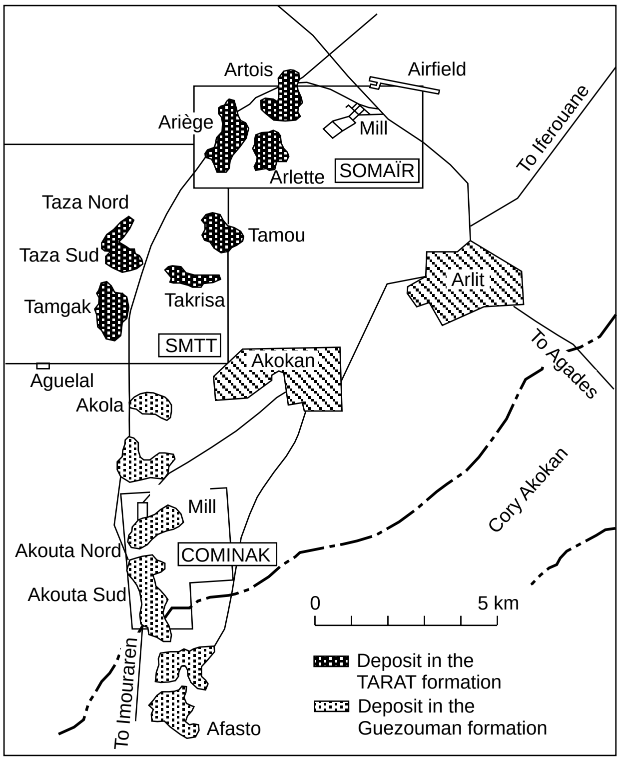
In 1997 and 1998, Somaïr drilled 598 percussion holes, totalling 47 431 metres, focusing on the Tamou deposit. A drill pattern of 25 metre spacings was used to delimit the deposit. The limits of mineralisation were established to the north and further reconnaissance was done within the adjacent barren cover. No additional drilling is planned.

To investigate the Akola deposit further, Cominak drilled 100 bore holes, totalling 20 659 metres (partly cored). An additional 8 000 m of drilling was planned for 1999.

Uranium deposits and prospects in Niger



Uranium deposits in the Arlit region, Niger uranium producing district



Uranium exploration drilling efforts

	1996	1997	1998	1999 (expected)
Total development drilling in metres	16 103	52 660	15 430	8 000
Total number of holes drilled	83	605	93	–

URANIUM RESOURCES

Known conventional resources (RAR & EAR-I)

Niger's known resources, estimated as of 1 January 1999, total 89 702 tU, recoverable at costs of below $130/kgU. These recources are reported as in situ.

A direct comparison with the resource estimates as of 1 January 1997, recoverable at the same cost category, is difficult as the previous estimate includes a 16-18% reduction to account for estimated mining and processing losses. There was a decline in the RAR by some 10 000 tU primarily due to the cumulative 1997 and 1998 production of about 7 200 tU. However, a considerable increase in the known conventional resources is the consequence of a new EAR-I estimate. The increase is in the higher cost class of $80-130/kgU.

Niger's known resources are mainly RAR. In the cost category of below $130/kgU they amount to 71 173 tU, as in situ resources. Of the 1999 total, approximately 60% are low cost resources of below $40/kgU. The remainder are resources mineable below $80/kgU.

There are no further low cost EAR-I resources as compared with 1 200 tU reported in 1997. However, there is a significant addition of 18 579 tU in the high cost EAR-I category. This probably results from the recent drilling conducted to define extensions of the Tamou and Akola deposits.

Reasonably Assured Resources*

(tonnes U – as of 1 January 1999)

Cost ranges		
<$40/kgU	<$80/kgU	<$130/kgU
43 594	71 123	71 123

* As in situ resources.

Estimated Additional Resources – Category I*

(tonnes U – as of 1 January 1999)

Cost ranges		
<$40/kgU	<$80/kgU	<$130/kgU
0	0	18 579

* As in situ resources.

In addition to the known resources reported above, there are about 100 000 tU EAR-I unassigned to any cost category. They are controlled by companies other than Somaïr and Cominak. All of Niger's known uranium resources (RAR plus EAR-I) recoverable at both $40/kgU and $80/kgU or less, are tributary to the existing production centres Arlit (Somaïr) and Akouta (Cominak).

Undiscovered conventional resources (EAR-II & SR)

Although Niger does not officially report undiscovered resources, there are about 80 000 tU unassigned to any cost and resource category that have been estimated by companies other than Somaïr and Cominak.

URANIUM PRODUCTION

The uranium in Niger is produced by two companies: Somaïr and Cominak. They have operated mines on sandstone-type deposits since 1970 and 1978, respectively. A third company, the *Société Minière de Tassa N'Taghalgue* (SMTT) assigned its mining rights to Somaïr in 1996. SMMT was subsequently dissolved.

Somaïr has a production capability of 1 500 tU/year from open-pit operations. Cominak's production capability totals 2 300 tU/year and is supported by underground mining.

Details of the two Arlit and Akouta production centres are summarised in the following table.

Uranium production centre technical details

(as of 1 January, 1999)

	Centre #1	Centre #2
Name of production centre	Arlit (Somaïr)	Akouta (Cominak)
Production centre class	Existing	Existing
Operational status	Operating	Operating
Start-up date	1970	1978
Source of ore: • Deposit names • Deposit type	 Arlette, Takriza, Tamou Sandstone	 Akouta, Arkola Sandstone
Mining operation: • Type • Size (tonnes ore/day) • Average mining recovery (%)	 OP 2 000 NA	 UG 1 800 NA
Processing plant: • Type • Size (tonnes ore/day) • Average processing recovery (%)	 AL/Solvent Extraction 2 000 95	 AL/Solvent Extraction 1 900 93
Nominal production capacity (tU/year)	1 500	2 300
Plans for expansion	Mining of Tamou deposit planned for 1999	NA

Niger’ s historical uranium production is shown in more detail in the following table.

Uranium production in tonnes U

Production method	Pre-1996	1996	1997	1998	Total to 1998	Expected 1999
Open pit (Somaïr)	25 281	1 215	1 353	1 510	29 359	1 000
Heap leaching*	5 786	0	0	0	5 789	0
Underground (Cominak)	34 389	2 114	2 134	2 204	40 841	1 910
TOTAL	65 456	3 329	3 487	3 714	75 989	2 910

* In previous editions, the heap-leach production was included in Somaïr’s open-pit production.

Ownership structure of the uranium industry

There were practically no changes of ownership in the uranium industry during 1997 and 1998. The ownership shares of the production companies are:

Somaïr	Cominak
36.6% Niger (Onarem)	31% Niger (Onarem)
37.5% Cogema (France)	34% Cogema (France)
19.4% CFMM (France)	25% OURD (Japan)
6.5% Urangesellschaft	10% Enusa (Spain)

Employment in the uranium industry

Restructuring of the production industry has been implemented progressively since 1990. This has resulted in a continuous decrease in employment from 3 173 in 1990 to 2 002 persons at the end of 1998. This number is expected to fall below 2 000 employees in 1999.

Employment in existing production centres

(persons-years)

Company	**1996**	**1997**	**1998**	**Expected 1999**
Somaïr	824	814	810	800
Cominak	1 246	1 219	1 192	1 142
TOTAL	**2 070**	**2 033**	**2 002**	**1 942**

Environmental considerations

The environmental impact of Niger’s uranium mining industry results from corresponding activities spanning more than 25 years. During this period, a large amount of waste material has accumulated from both mining and milling activities. In addition, existing surface disturbances caused by the uranium mining industry include 4 depleted open-pit mines.

Short-term production capability

Figures have only been released for the years 1999-2001. No further estimates for the following period were given.

Short-term production capability

(tonnes U/year)

1999				2000				2001			
A-I	**B-I**	**A-II**	**B-II**	**A-I**	**B-I**	**A-II**	**B-II**	**A-I**	**B-I**	**A-II**	**B-II**
2 910	3 110	0	0	2 910	3 410	0	0	2 910	3 410	0	0

NATIONAL POLICIES RELATED TO URANIUM

One of the main objectives of Niger's national uranium policy is to achieve a higher degree of international competitiveness in the uranium industry.

• Pakistan •

URANIUM EXPLORATION

Historical review

Extensive uranium exploration has been conducted in Pakistan using techniques including surface prospecting through systematic geological and geophysical surveys. A wide variety of geologic environments have been investigated including the igneous and metamorphic rocks of northern Pakistan and the sedimentary Siwalik Group. The Siwalik Group extends across the country from Kashmir in the northeast to the Arabian Sea in the southwest.

Igneous and/or metamorphic rocks of northern Pakistan have been evaluated including granites, graphitic metapelites and carbonatites. Extensive prospecting has been carried out over both the metapelites and granite terrain. Although a large number of radioactive anomalies have been discovered in these rocks there has been little success in locating any significant uranium concentrations.

During routine prospecting activities some of the carbonatites have been found to be radioactive. The main source of radioactivity is the mineral pyrochlore. Preliminary analysis of one carbonatite body indicates the presence of uranium in the rock samples, which also contain rare metals, rare earths, phosphate and to a lesser degree magnetite. Geological investigations were therefore undertaken to determine the trend and size of the radioactive zones in the carbonatite body and to evaluate its potential for exploitation as a multi-mineral prospect.

Pakistan's geographic (geologic) position is in a tectonicly active collision zone where the Indo-Pakistan Plate, located to the south is subducting under the Island Arc Assemblage along the Main Mantle Thrust, which in turn is subducting under the Eurasian Plate. This siltation is of particular importance in northern Pakistan where the tectonic activity is responsible for both the very rugged terrain and the unstable geologic environment. The rugged topography makes exploration very difficult. In addition, the tectonically active conditions have left few stable areas to trap and preserve uranium deposits.

Recent activities

Recent developments in the field of uranium geology and exploration/exploitation technology in Pakistan include the discovery of a new uraniferous horizon in Kamlial Formation in the Salt Range and the discovery of a uranium bearing vein system in the granitic rocks of Maraghzar area in the Swat District.

Kamlial formation

The Kamlial Formation is a sedimentary sequence of Middle to late Miocene age. The rocks are widely distributed in the Kohat and Potwar areas, and have also been recognised in Azad Kashmir. The formation consists of purple grey and dark brick red sandstones interbedded with purple shales.

Although some minor anomalies have been reported in the past, the latest discovery of a mineralised zone near Kallar Kahar in the Salt Range has aroused considerable interest due to several factors considered favourable for the occurrence of uranium mineralisation. These include the:

- Anomalous radioactivity and chemical uranium found in the middle and upper parts of the formation hosted in partly calcified sandstone.
- Association of anomalous radioactivity and chemical uranium with both calcified and non-calcified sandstones.
- Abundance of organic material in the host sandstone.
- Abundance of devitrified to partly devitrified volcanic material in the host sandstone.

Surface sampling of the anomalous horizon was followed by trenching in the area. Samples define an array of leaching patterns, varying from strongly leached, highly radioactive sandstone, with low concentrations of chemical uranium, to unleached rocks. The latter have escaped leaching, possibly due to calcification following the deposition of uranium. Petrographic data suggest an abnormally high abundance of volcanic debris, hitherto not reported from any of the other known formations hosting uranium deposits.

Shallow drilling has confirmed the occurrence of similar anomalies in the subsurface. Because of its apparently oxidised nature, this formation has not been previously explored for uranium. Therefore, this discovery has helped define a new geological environment with prospective areas for uranium exploration. Considering the large areas underlain by this formation in the Salt Range, and the Potwar and Kohat plateaux, the potential for discovering additional uranium in the country has increased.

Maraghzar area

Several years ago a vein system cutting across the Swat granitic gneiss complex was discovered in the Maraghzar area. This discovery also opened up new avenues for uranium exploration in the country. Since the discovery was made in the very high mountains of the Swat region, attempts were made to trace the vein system to lower altitudes, as they are logistically more favourable for exploratory activity. This has been successfully achieved, and the initial exploration activity in the area is in progress. The vein system has been geologically investigated and some drilling to shallow depths is now in progress. Preliminary results indicate these veins host high concentration of uranium. However, the continuity at depth, as well as along the strike, has not been established. Work continues to establish the significance of this prospect.

URANIUM RESOURCES

No quantitative account of uranium resources is reported.

URANIUM PRODUCTION

No quantitative information on uranium production is reported.

In situ leach mining

A major portion of the uranium deposits outlined at various locations in Sulaiman Range has been mined out. The ore bodies discovered at Nangar Nai, Bannu Range, are being tested for mining using in situ leach (ISL) mining technology.

The uranium ore bodies outlined in Bannu Basin are hosted by poorly consolidated sandstones. Their exploitation through conventional mining methods was considered impracticable and hazardous due to bad ground conditions and the influx of large quantities of water. Alternatively, application of ISL technology was investigated. It was found to be feasible because the ore bodies are located below the water table in highly permeable sandstones. Some less favourable geologic characteristics in the area include a dipping rather than horizontal sandstone hosts and structural imperfections. Furthermore confining shale is frequently not present below the orebearing horizon.

Subsequently, ISL tests were conducted on several 5 spot patterns over a period of 4 years. Based on the test results ISL parameters were established to plan for the start of semi-commercial scale operations in mid-1995. Research and development is continued at the site to fine-tune the operations with a view to improving recovery and reducing production costs.

The ISL mining technique employs both 5 and 7 spot well patterns. Ammonium bi-carbonate and hydrogen peroxide are used, respectively, as the lixiviant and oxidant. They are injected at atmospheric pressure. The uranium bearing leach liquor is recovered using submersible pumps. The system operates at low pH to forestall mobilisation of calcium. The lateral excursion of the leaching fluids is controlled by maintaining a balance between injection and production. The wellfield is regularly monitored using monitor boreholes.

• Peru •

URANIUM EXPLORATION

Historical review

Uranium exploration carried out by the Peruvian Nuclear Energy Institute (IPEN) resulted in the discovery of more than 40 uranium occurrences in the Department of Puno, in the southeastern part of Peru.

The main occurrences include Chapi, Pinocho, Chilcuno VI, Cerro Concharrumio, and Cerro Calvario. Of these, Chapi is considered the most important occurrence. Consequently, most exploration activities took place in this area. These investigations resulted in the identification of uranium mineralisation associated with nearly vertically oriented structures. They are distributed in structural lineaments measuring 15-190 m in length and 20-30 m in width. The uranium grades vary between 0.03 and 0.75% with an average of 0.1% U. The mineralisation consists of pitchblende, gummite, autunite, meta-autunite, and other minerals filling nearly vertically and nearly horizontally oriented fractures. Based on the geological information obtained, it is estimated that the Chapi occurrence has a potential of about 10 000 tU. The entire district of Macusani is estimated to host a potential resource of 30 000 tU.

Due to budgetary reductions at IPEN, all uranium exploration activities were stopped in 1992. However, small exploration expenditures (Soles 10 500) were reported for 1994.

URANIUM RESOURCES

The conventional uranium resources of Peru are primarily located in the Macusani area, Department of Puno. In this area the uranium mineralisation is associated with acid volcanics of the Miocene to Pliocene age, underlain by Palaeozoic basement rocks.

Known conventional resources (RAR & EAR-I)

Peru reports known resources of both RAR and EAR-I categories, located in the Macusani uranium district.

Reasonably Assured Resources

(tonnes U)

Cost ranges		
<$40/kgU	<$80/kgU	<$130/kgU
0	1 790	1 790

Estimated Additional Resources – Category I*

(tonnes U)

Cost ranges		
<$40/kgU	<$80/kgU	<$130/kgU
–	1 860	1 860

* As in situ resources estimated within the last 5 years.

Undiscovered conventional resources (EAR-II & SR)

Total undiscovered uranium resources are estimated to be 26 350 tU. They are further subdivided by resource and cost category in the following tables.

Estimated Additional Resources – Category II*

(tonnes U)

Cost ranges		
<$40/kgU	<$80/kgU	<$130/kgU
–	6 610	6 610

* As in situ resources.

Speculative resources*

(tonnes U)

Cost ranges		Total
<$130/kgU	Unassigned	19 740
19 740	0	

* Based on the distribution of the volcanic host rock over a surface of 1 000 km^2.

NATIONAL POLICIES RELATING TO URANIUM

All state-owned mining properties in Peru are in the process of being offered for privatisation within a political and economical framework that ensures long-term stability and guarantees to private investors. Currently, the Peruvian Government is expecting offers from foreign and national private companies interested in the exploration and exploitation of mineral resources including uranium. To facilitate the assessment of the potential of the uranium occurrences, IPEN is prepared to provide geological information.

• Philippines •

URANIUM EXPLORATION

Recent and ongoing activities

During 1997 and 1998 reconnaissance and semi-detailed uranium geochemical exploration were continued by the Philippine Nuclear Research Institute (formerly PAEC) in Palawan Island. At least two prospective geochemical anomalies were identified in the San Vicente area. Uranium occurrences are related to granitic and metamorphic rocks (phyllite and schist).

Available funds for this project amounted to USD 32 000 for the two-year period. For 1999, it was planned to conduct a geological exploration programme in north-western Palawan with the modest budget of USD 10 000.

Uranium exploration expenditures

	1996	1997	1998	1999 (Expected)
Government exploration expenditures:				
(PHP x 1 000)	775	500	500	400
(USD x 1 000)	30.0	19.0	13.0	10.3

URANIUM RESOURCES

Known conventional resources (RAR & EAR-I)

There are no significant known uranium resources in the country. Minor occurrences have been identified in association with pyrometasomatic replacement and hydrothermal metalliferous deposits related to middle Miocene intrusives of acid to intermediate composition.

Undiscovered conventional resources (EAR-II & SR)

No formal estimation of undiscovered resources has been made so far.

The northern part of Palawan, located southwest of Luzon, was identified in the 1991-1992 period as a geologically favourable area for discovery of uranium resources. Northern Palawan is considered to be a rifted portion of a continental terrain where the oldest basement formations consist of folded sedimentary and metamorphic rocks. The age of the basement rock is thought to be Lower Proterozoic or older.

The basement rocks were intruded by Tertiary granitic bodies and ultramafics. They are partly covered by Tertiary sedimentary formations. Major thrust faults separate these formations. The granitic intrusive bodies are thought to be prospective and the metamorphic formations near these intrusives are also considered to be geologically favourable for uranium mineralisation.

ENVIRONMENTAL CONSIDERATIONS

As there are no uranium resources established yet, no current significant environmental issues related to the country‘s uranium development and exploitation have been identified.

URANIUM REQUIREMENTS

The Philippines has a 620 MWe PWR nuclear reactor, designated PNPP-1, which was built but never completed. There are plans to convert this facility to a fossil fuel fired power plant. There are therefore no uranium requirements for the foreseeable future.

NATIONAL POLICIES RELATING TO URANIUM

By law, uranium exploration and mining is open to private enterprise. These activities are subject to nuclear safety regulations and existing production sharing schemes including financial or technical assistance agreement schemes as provided for in the new mining law. All exploration and mining activities are monitored by the Mines and Geosciences Bureau (formerly Bureau of Mines).

• Poland* •

URANIUM EXPLORATION

Historical review

Prospecting for uranium in Poland was initiated in 1947 when a bilateral agreement between Poland and the USSR government was signed. Extensive exploration and mining activities were carried out in the Lower Silesia region under the direction of Soviet Union experts. A systematic exploration programme, including geological, geophysical and geochemical surveys and related research, was carried out until 1966. According to the bilateral agreement, all uranium produced in Poland was transported to the Soviet Union. Extensive uranium exploration was undertaken in a number of localities in the Lower Silesia. Uranium mining took place in Kowary Podgórze, Radoniow and Kletno.

URANIUM PRODUCTION

Historical review

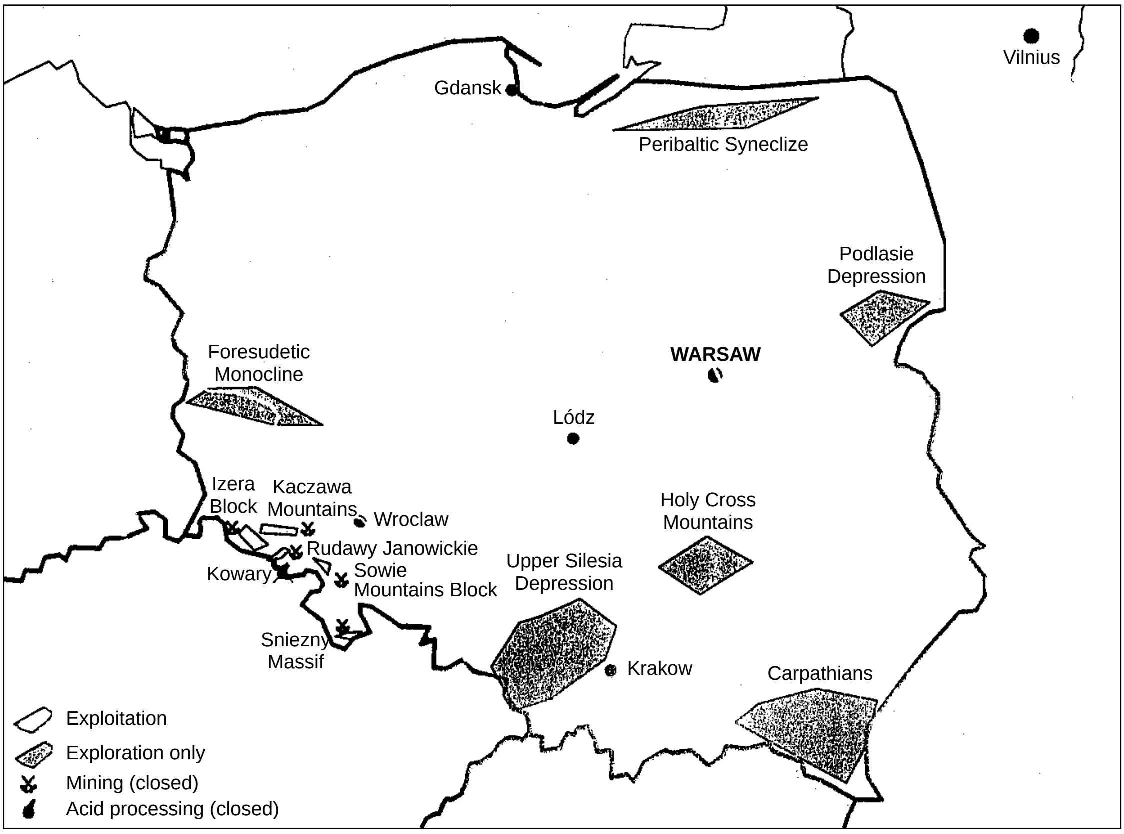
Uranium production in Poland was confined only to the Low Silesia mines operated between 1948 and 1963. In total, 660 tonnes of uranium were extracted. The town of Kowary was both a centre of uranium mining activities and the headquarters of the uranium mining company "Zaklady Przemyslowe R-1 (ZPR-1)". Uranium ores from underground mines were transported directly to the Soviet Union.

Mining of uranium in Poland terminated in 1963. Chemical treatment of low-grade ores started in Kowary in 1969 at the only uranium processing plant in Poland. The processing of low-grade ore continued until 1972. It produced a significant volume of waste and consequently, a tailing pond was constructed in Kowary to accommodate them. Data related to uranium mining activities are listed in the table below.

	Number	**Area (km^2)**	**Volume (m^3)**
Shafts and adits	156		
Waste rock and ore dumps	102	0.32	1 412 500
Tailings ponds	1	0.01	130 000

* This is the first time Poland provides a report for the Red Book.

Historical uranium mining activities in Poland



ENVIRONMENTAL CONSIDERATIONS

All mining and processing activities in Poland ceased more than 25 years ago, and the companies responsible for the associated environmental problems no longer exist. However, there is still a real need to remediate the environment. The Geological and Mining Law stipulates that the State Treasury is accountable for liabilities from all ceased uranium production activities in Poland. Therefore, the government is responsible for the funding of remediation, either from the national or the district Environmental Protection Fund.

The regional authority of the Voivodship and its special inspectorates or offices are responsible for the different aspects of remediation. Finally, the local authority has to approve the remediation plans and supervise their execution and effects. The inspectorates of Environmental Protection of Voivodship are responsible for environmental monitoring. The President of the National Atomic Energy Agency is responsible for the radiological monitoring which is considered part of the environmental monitoring.

According to the Polish regulations, there are no specific maximum admissible concentrations defined for natural radioisotopes, with few exceptions. Limits for chemotoxic contaminants are partially available from several regulations. The admissible exposure for members of the critical group is derived by calculation from the general limit for the additional effective dose equivalent: 1.0 mSv/year.

Since 1996 Poland has taken part in the PHARE multi-country Environmental Sector Programme on “Remediation Concepts for the Uranium Mining Operations in CEEC”. In the framework of the Programme, the inventory and a common database for the CEEC have been executed. According to this inventory, the situation in Poland is characterised by a large number of small-scale liabilities from uranium exploration, distributed over several locations in the country, and generally causing minor impacts on the environment.

There are only a limited number of issues related to mining and milling causing serious impacts. The most important is the tailing pond in Kowary. The tailing pond covers an area of 1.3 ha. It is a hydrotechnical construction closed on three sides by a dam that has been modified a number of times over the years. The dam is now 300 metres long (the sum of the three sides), with a maximum height of 12 metres. The overall facility is considered to be at the limits of geotechnical stability. As a result of the uranium processing activities, the tailing pond has been filled with about 2.5 x 10^5 tonnes of disposed fine-grained gneisses and schists with average uranium content of 30 ppm. In the early seventies, the WrocIaw University of Technology (WUT) received by governmental decision the ownership of both the area and facilities of the former uranium mining company ZPR-1. Subsequently, the ZPR-1 company (owned by WUT) has continued to use the existing chemical plant for various experimental processes on rare metals, chemical production and galvanic processes. As a result, about 300 tonnes of remnants of rare metals processing and 5 x 10^3 m^3 of post-galvanic fluids with up to 30 tonnes of solids with a high content of Al, Ni, Zn and Na sulphates, have also been disposed of in the pond. The specific objectives of the remediation programme are related to the construction of the drainage systems, the design and construction of the tailing pond cover and the final site reclamation. The remediation programme of the tailing pond prepared in 1997 by the WUT is still being carried out. The remediation programme for the historic uranium liabilities in the Lower Silesia region is being prepared by the local authorities.

• Portugal •

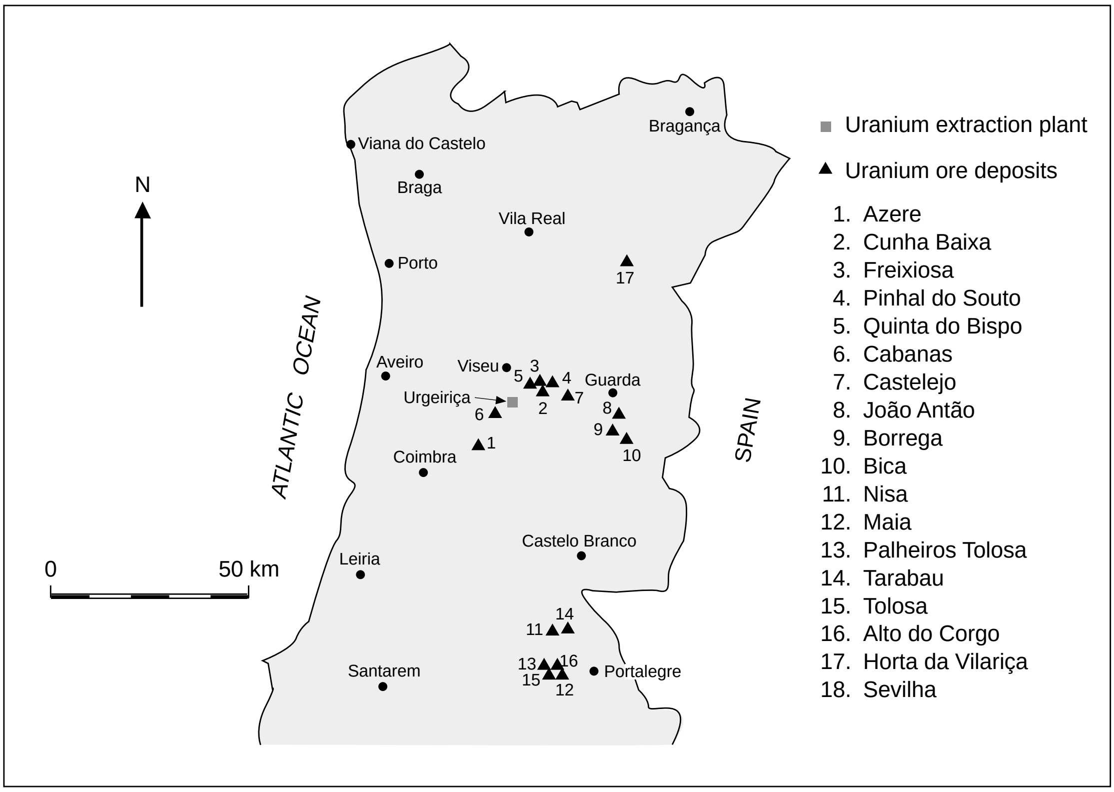
URANIUM EXPLORATION

Historical review

Uranium exploration first began in Portugal with the discovery in 1912 of the Urgeiriça deposit which contained radium and uranium. Radium was mined until 1944 and uranium has been mined since 1951. Between 1945 and 1962, a foreign privately-owned enterprise, Companhia Portuguesa de Radium Limitada (CPR) carried out radiometric surveys, detailed geological mapping, trenching and core drilling with gamma-ray logging in the granitic formations of the Beiras districts. In 1955 the Government started uranium exploration on a systematic basis using geological mapping, carborne and ground radiometric surveys, geophysics (resistivity surveys), trenching, diamond and percussion drilling. By 1961, the Junta de Energia Nuclear (JEN) had discovered about 100 deposits in the Hercynian granitic or perigranitic zones in the districts of Beiras and Alto Alentejo. The Beiras areas with its numerous small deposits together with the Urgeiriça mill constitute an integrated uranium production district. The Alto Alentejo area would also support another production centre in the future. Since 1976 prospecting has been continued in the crystalline regions with known uranium resources. Exploration in sedimentary regions started in 1971, employing geological, radiometric, geochemical, emanometric and drilling surveys in the western Meso-Cenozoic fringe of the Portuguese basin.

Responsibility for uranium mining and exploration activities were transferred respectively from JEN to the publicly-owned enterprise "Empresa Nacional de Urânio, S.A." (ENU), in 1977, and to the "Direcção-Geral de Geologia e Minas (DGGM)", in 1978. ENU carried out prospecting activities in areas adjacent to uranium deposits with their extensions.

Uranium deposits and occurrences in Portugal



Recent and ongoing activities

The Instituto Geológico e Mineiro (former Direcção-Geral de Geologia e Minas) has ceased all uranium exploration activities. A radiometric background map of Portugal (scale 1/200 000) is being prepared (six out of eight sheets have been produced) under contract with the General Directorate of the Environment. A rare earth exploration project is also being conducted.

ENU's exploration activities have remained at a very low level with a slight increase in 1995, related to the reappraisal of the Nisa project.

Uranium exploration expenditures and drilling effort – domestic

	1996	1997	1998	1999 (Expected)
Industry expenditures:				
PTE (x 1 000)	18 000	26 212	18 624	NA
USD (x 1 000)	114	154	102	NA
Industry surface drilling in metres	4 116	4 627	2 634	NA
Number of industry holes drilled	108	111	79	NA

URANIUM RESOURCES

Known and undiscovered conventional resources

Portugal reports total RAR of 7 470 tU recoverable at costs of $80/kgU or less. Additionally, 1 450 tU are reported as EAR-I recoverable at costs equal or below $130/kgU. Undiscovered conventional resources include 1 500 tU of EAR-II and 5 000 tU of speculative resources at a recoverable cost equal or below $130/kgU

URANIUM PRODUCTION

Historical review

Between 1951 and 1962, the CPR produced a total of 1 123 tU from 22 concessions, of which 1 058 tU were milled at the Urgeiriça plant and 65 tU at mines by heap leaching. The uranium at that time was precipitated using magnesium oxide. During the period 1962 to 1977 the JEN took over the mining and milling activities from CPR, introducing organic solvent extraction. A total of 825 tU were produced from the Urgeiriça plant and the pilot plant at Senhora das Fontes. Between 1977 and 1994, ENU produced 1 651 tU.

Status of production capabilities

At present the Urgeiriça production mill, whose nominal production capacity is 170 tU/year, is operating at reduced capacity. The produced concentrate (25 tU/year) comes from low grade ore treatment by heap leaching and minor proportion from in situ leaching.

Ownership structure of the uranium industry

All mining and milling activities are entrusted to ENU, a fully state-owned company which also carried out uranium exploration activities in areas surrounding present and future mining sites by the end of 1992. Meanwhile the exploration permit has expired and all the exploration activities have ceased. ENU was integrated in 1992 into the Portuguese state mining holding, Empresa de

Desenvolvimento Mineiro (EDM). A new development programme is expected after extensive manpower reduction and financing restructuring activities are completed. DGGM/IGM ceased all exploration activities for uranium by the end of 1994 and the operating capacity has been allocated to other projects.

Historical uranium production

	Pre-1996	1996	1997	1998	Total to 1998	Expected 1999
Mining method	(tonnes U contained in ore)					
Conventional mining:						
• Open-pit	1 384	0	0	21	1 405	10
• Underground	2 090	0	0	0	2 090	0
TOTAL	**3 474**	**0**	**0**	**21**	**3 495**	**10**
Production method	(tonnes U contained in concentrate)					
Processing plant	3 127	0	0	0	3 127	0
In situ leaching	248	1	0	1	250	0
In-place leaching	0	0	0	0	0	0
Heap leaching	267	14	17	12	310	9
Other methods	0	0	0	6	6	16
TOTAL	**3 642**	**15**	**17**	**19**	**3 693**	**25**

Future production centres

The Nisa project (south of Portugal) is planned to yield 100 tU/year, revised from 160 tU/year. The start of production is dependent on the evolution of the international uranium markets. Feasibility and environmental studies are ongoing.

Uranium production centre technical details

(as of 1 January 1999)

	Centre # 1
Name of production centre	Urgeiriça
Production centre class	Existing
Operational status	Operating
Start-up date	1951
Source of ore: • Deposit name • Deposit type	Bica, Sevilha, Quinta do Bispo, Nisa Iberian
Mining operation: • Type (OP/UG/in situ) • Size (tonnes ore/day) • Average mining recovery (%)	Open pit, heap leaching, vat leaching
Processing plant: • Type (IX/SX/AL) • Size (tonnes ore/day) • Average processing ore recovery (%)	IX/SX
Nominal production capacity (tU/year)	170

ENVIRONMENTAL CONSIDERATIONS

ENU has been monitoring several environmental parameters such as air quality, mining effluents (underground mine and surface drainage waters) and collecting data samples on soil, sediments and vegetation for further analysis on the following decommissioning mines: Urgeiriça, Castelejo, Cunha Baixa, Sevilha and Quinta do Bispo.

Every mine has wells and piezometers and the operation of analysing underground and surface drainage waters is being assessed along several monitoring sites upstream and downstream on every watercourse near the mines. Underground waters are being monitored at a distance of 300 to 400 metres beyond the tailings dam perimeter of Urgeiriça plant and the cleared waters are being monitored downstream at a distance of 3 km. In the radiological protection field, several analyses are being carried out to detect any radio element in water. The waters in the underground mines are pumped to the surface to precipitate the metals, to eliminate the uranium and the radioactive contents, and to correct the pH.

Several studies are being carried out to characterise geochemical and hydrochemical aspects and to establish the mitigation measures for negative effects that the waste piles of the Cunha Baixa mine (decommissioning mine) and Quinta do Bispo mine (heap leaching mine) may have had on the environment. The studies and the operation in Quinta do Bispo are finished but the leaching system is still operating. Feasibility of the Nisa mine is completed and the decision of the States Services is pending.

Cost of environmental management (in PTE x 1 000)

Existing operations	Pre-1998	1998	1999	2000	Total
Pre-operational environmental Assessment		4 765	7 127	NA	
Monitoring		5 636	3 769	NA	
Stabilising waste dumps and/ or impoundments		0	0	NA	
Decontamination of replaced equipment		0	0	NA	
Effluent management (gas, liquid)		13 246	14 515	NA	
Site rehabilitation		0	6 300	NA	
Radwaste disposal		6 308	3 300	NA	
Regulatory activities		2 576	5 856	NA	
TOTAL	**NA**	**32 531**	**40 867**	**NA**	**NA**

After closure	Pre-1998	1998	1999	2000	Total
Monitoring		5 294	5 654	NA	
Closing out tails impoundments		0	0	NA	
Decommissioning/decontamination		4 820	6 389	NA	
Effluent management (gas, liquid)		10 468	19 000	NA	
Site rehabilitation		0	0	NA	
Radwaste disposal		0	4 235	NA	
Regulatory activities		2 476	3 904	NA	
TOTAL	**NA**	**23 058**	**39 182**	**NA**	**NA**

URANIUM REQUIREMENTS

No uranium requirements are presently envisaged.

NATIONAL POLICIES RELATING TO URANIUM

The national authorities responsible for national policies concerning uranium are the State Secretariat of Energy and the General Directorate of Energy. All mining and milling activities are entrusted to the Empresa Nacional de Urânio, a fully state-owned company and now a subsidiary of Empresa de Desenvolvimento Mineiro, SA, a state holding for mining. Exploration is free and is granted by the Instituto Geológico e Mineiro, in accordance with Portuguese mining law. ENU has the exclusive right for mining and milling under Decree 120/80, as of 15 May 1980.

• Romania •

URANIUM EXPLORATION

Historical review[1]

Prospecting for uranium in Romania was initiated in about 1950 when a bilateral agreement between the Romanian and USSR governments (the Romanian-Soviet Joint Venture SOVROM-CUARTIT) was concluded. A series of radiometric surveys were then completed to identify uranium occurrences of industrial value.

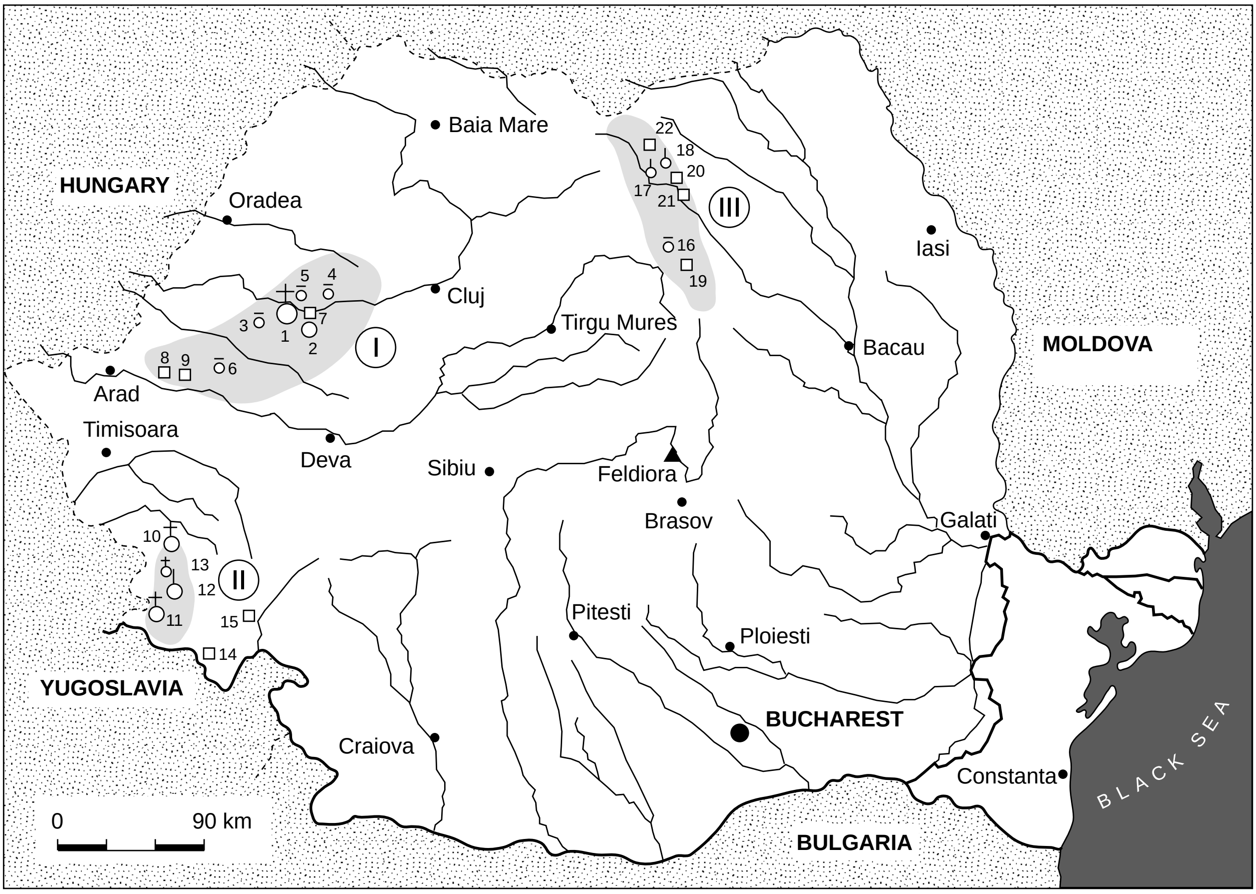
Mine production started in 1952 at the Bihor and Ciudanovita deposits, in 1962 at the Avram Iancu and in 1983 at the Crucea and Botusana deposits. Other deposits including the Tulghes, Ranusa, Padis, Arieseni, and Milova have been explored in detail to establish their full potential. Underground mining technology has been used in all of the deposits mined, with the exception of the Banat Mountains deposits, where open-pit mining was used. Since 1978 all of the produced ores have been processed at the Feldiora mill.

Recent and ongoing uranium exploration activities

The amount of work fell in 1998 because of decreasing budgets. In Romania all uranium-related activities are carried out by state-owned companies. No exploration is conducted outside the country.

1. Additional information is available from the 1993 and 1997 editions of this publication.

Uranium deposits in Romania



I. APUSENI MOUNTAINS

Deposits
1. Baita Bihor
2. Avram Iancu
3. Ranusa
4. Rachitele
5. Budureasa
6. Paiuseni

Occurrences
7. Arieseni
8. Milova
9.Conop

II.BANAT MOUNTAINS

Deposits
10.Ciudanovita
11.Natra
12.Dobrei South
13.Dobrei North

Occurrences
14.Ilisova
15.Mehadia

III.EASTERN CARPATHIANS

Deposits
16.Tulghes
17.Crucea
18.Botusana

Occurrences
19.Bicazul Ardelean
20.Piriul Lesu
21.Holdita
22.Hojda

▲ Uranium processing plant – Feldiora
Uranium provinces
Ⓘ Western Carpathians
Ⓘⓘ Banat Mountains
Ⓘⓘⓘ Eastern Carpathians

○ Large deposits: > 20 000 t metal
○ Medium deposits: 5 000–20 000 t metal
○ Small deposits: < 5 000 t metal

Ore deposits depleted
Ore deposits in exploitation
Ore deposits in exploration
□ Mineralisation in exploration

Uranium government exploration and development expenditures, and drilling statistics

	1996	1997	1998	1999 (Expected)
Exploration expenditures (Lei x 1 000)	3 561 414	4 579 509	4 620 148	1 009 800
Exploration expenditures (USD x 1 000)	1 236.60	648.66	543.48	95.71
Development expenditures (Lei x 1 000)	1 554 815	3 875 200	3 253 600	NA
Development expenditures (USD x 1 000)	539.86	548.89	382.73	NA
Total (Lei x 1 000)	5 116 229	8 454 709	7 873 748	NA
Total (USD x 1 000)	1 776.46	1 197.55	926.21	NA
Government exploration drilling in metres	9 286	6 532	3 520	1 902
Development drilling in metres	8 051	7 959	5 125	22 350
Total drilling in metres	17 337	14 491	8 645	24 252

URANIUM RESOURCES

Known conventional resources (RAR & EAR-I)

A total of 15 557 tU of Known Conventional Resources are reported from ores with an average uranium content of 0.11% U. This includes 6 607 tU RAR and 8 950 tU EAR-I with a production cost of less than $130/kgU. No resources with lower production costs are reported.

Undiscovered conventional resources (EAR-category II and speculative resources)

A total of 4 970 tU of undiscovered resources are reported. This includes 1 970 tU of EAR-II and 3 000 tU of speculative resources in the less than $130/kgU production cost category.

URANIUM PRODUCTION

Historical review

From 1950 to 1960, all uranium operations were carried out by the Romanian-Soviet Joint Venture SOVROM-CUARTIT. Additional information on the history of uranium production in Romania is given in the 1997 Red Book.

In 1985 the circuit of the Feldiora plant was extended to include a refining section capable of producing uranium dioxide. The oxide is used in the fabrication of fuel for the Candu-type reactors under construction at Cernavoda.

Status of production capability

Three mining plants are now in operation: E.M. Banat, E.M. Bihor and E.M. Crucea. The Feldiora hydrometallurgical plant uses a pressure alkaline leach circuit with recovery by ion exchange to produce sodium diuranate. This product is then further processed at the plant to produce uranium dioxide powder that may be sintered to produce fuel pellets. This process is conducted in the "R" mill at Feldiora.

A second production unit was planned at the Feldiora plant. Construction was about 50% complete when it was suspended because of the lack of funds. Completion of this facility would increase capacity to 600 tU of UO_2 concentrate.

Consideration is being given to the development of a mine in the Tulghes area.

Uranium production centre technical details

(as of 1 January, 1999)

Name of production centre	Feldiora mill, fed from 3 mines
Production centre class	Existing
Operational status	Operating
Start-up date	1978
Source of ore: • Deposit names • Deposit type	 Banat, Bihor and Crucea Hydrothermal
Mining operation: • Type • Size (tonnes ore/year) • Average mining recovery (%)	(Three mines) Underground NA NA
Processing plant: • Type • Size (tonnes ore/year) • Average processing recovery (%)	Feldiora ALKPL/IX 150 000 80
Nominal production capacity (tU/year)	300
Plans for expansion	Suspended

Ownership structure of the uranium industry

In Romania all uranium exploration, research, exploitation and processing activity is conducted by the state.

Employment in the uranium industry

The number of people employed in the production centres have decreased from 5 000 in 1996, to 4 550 in 1997; 3 400 in 1998; and 2 867 in 1999.

ENVIRONMENTAL CONSIDERATIONS

The Romanian uranium industry has a systematic programme for protection of the environment. Potential sources of the environmental impacts during uranium exploration, exploitation and milling activities include:

- mine and mill effluents containing natural radioactive elements above the maximum admissible concentration;
- waste rock from mining operations;
- low grade ore with a uranium content of 0.02-0.05%, which at present is not processed, but stored at the mine site;
- tailings from processing activities, stored in the dewatering ponds at the Feldiora mill;
- metal and wooden wastes contaminated with radioactivity during exploitation and processing of radioactive minerals.

The closure of the Ciudanovita mine in the Banat area is being done under a PHARE pilot project. This PHARE programme is sponsored by the European Commission and is called "Remediation Concepts for the Uranium Mining Operations in CEEC".

URANIUM REQUIREMENTS

Based on the known uranium requirements of the CNE-Cernavoda nuclear power plant, no problems are expected in supplying the required fuel from domestic production.

Installed nuclear generating capacity

(MWe net)

1998	1999	2000	2005		2010		2015	
			Low	*High*	*Low*	*High*	*Low*	*High*
650	650	650	1 300	1 300	1 300	1 950	1 300	1 950

Annual reactor-related uranium requirements

(tonnes U)

1998	1999	2000	2005		2010		2015	
			Low	*High*	*Low*	*High*	*Low*	*High*
100	100	100	200	200	200	300	200	300

Supply and procurement strategy

The Ministry of Electrical Energy planned to construct five nuclear power plants of the PHWR type (Candu) at the Cernavoda site. Construction of the five units started between 1980 and 1986. The installed nuclear electricity generating capacity of each of these units is 650 MWe net. The first unit of CNE Cernavoda nuclear power plant was connected to the grid and started commercial generation in 1996. The second unit is scheduled to start commercial operation in 2002.

The construction of the 3 remaining units in Cernavoda depends on the interest of the foreign investors, the availability of heavy water for the units and the electrical needs of Romania.

The fuel supply strategy will be developed coincidentally with the plans for constructing and commissioning the 3 remaining units of the CNE Cernavoda nuclear power plant.

NATIONAL POLICIES RELATING TO URANIUM

Since 1998 there is a new "Law of Mines" and a government agency for mineral resources. There is no participation of private or foreign companies in exploration, production and marketing of uranium in Romania. There are no uranium exploration and production activities of governmental or private companies abroad. Currently no uranium is imported or exported from Romania.

URANIUM STOCKPILES

Romania does not maintain a stockpile of uranium.

• Russian Federation •

URANIUM EXPLORATION

Historical review

Since 1944, when uranium exploration started, 15 uranium bearing districts including more than 100 uranium deposits have been discovered in the Russian Federation. They are subdivided into four groups:

- Streltsovsk district includes 19 molybdenum-uranium deposits of the structure-bound volcanic type within a caldera. This is the site of the operating Priargun uranium producing centre.

- Vitim, Transural, and West-Siberian districts contain medium to small sized sandstone basal-channel type deposits (paleo-valley type in Russian classification) with resources recoverable at less than $80/kgU. Some of the deposits are amenable for in situ leach (ISL) technology and there is potential for starting new ISL production centres.

- Stavropol district hosted two small vein-type uranium deposits that have been mined out. Current activities at the site are connected with restoration and rehabilitation.

- Ten uraniferous districts mainly including small deposits of vein, volcanic and metasomatite types with high cost resources (≥$80/kg U) and low uranium grades. They are unfavourable for production at current market prices.

The locations of the main districts are shown on the map. Descriptions of several of these deposits are available in a number of IAEA publications.[1]

Recent and ongoing uranium exploration activities

The exploration and development activities in the Russian Federation in 1997 and 1998 were primarily concentrated within three uranium districts – Vitim, Transural and West Siberia – and they were directed at deposits of the sandstone basal channel type amenable for ISL.

The Transural uranium district is situated in the Kurgan region. An installation for ISL production has been completed at the Dolmatovskoye deposit. The initial annual production will be 100 tU. The processing plan has been installed and the well-field unit prepared for leaching. The Khokhlovskoye deposit is being explored and assessed for ISL extraction. EAR-II resources at this deposit amount to 10 000 tU.

The West Siberian uranium district is situated within the Kemerovo and Novosibirsk regions. Detailed drilling on a 100-25 x 400-200 m network has been conducted in the central section of the Malinovskoye deposit. The total resources of the deposit are estimated as 15 000 tU.

The Vitim district is situated in the Autonomous Republic of Buryatia. The basal channel (valley-type) sandstone Sheglovskoye deposit, with 8 000 tU EAR-II resources, was discovered in 1998. Its evaluation is in progress. Experimental ISL testing was started at the Khiagda deposit.

Annual uranium exploration expenditures in the Russian Federation were between USD 4.271 million and USD 10.052 million in the period from 1996 to 1999. However these values do not reflect the real level of exploration activities because of the high variation of the rouble currency exchange rate in 1997. A total of 66 826 metres were drilled in 1998. This is more than four times the drilling done in 1997.

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1. IAEA (1997), Ischukova, L.P., "The Streltsovskoye Uranium District", IAEA-TECDOC 961, Vienna, Austria.

   IAEA (1995), Loutchinin, I.L., "Valley-Type Uranium Deposits in Russia", IAEA-TECDOC 823, Vienna, Austria.

   Boitsov, A.V., Nikolsky, A.L. "Characteristics of Uranium Deposits in Russia", presented at IAEA Technical Committee Meeting, Vienna, Austria, 10-13 June 1997.

All uranium exploration activities are conducted by the governmental organisation “Geologorazvedka”. No exploration expenditures were made outside the Russian territory during the 1996-1999 period.

Uranium exploration expenditures and drilling statistics

	1996	1997	1998	1999 (Expected)
Industry expenditures (roubles x 1 000)	NA	20 800 000	26 700*	130 000
Government expenditures (roubles x 1 000)	21 400 000	36 700 000	26 600*	36 000
Total expenditures (roubles x 1 000)	21 400 000	57 500 000	53 300*	166 000
Total expenditures (USD x 1 000)	4 271	10 052	8 650	7 909
Industry drilling in metres	NA	11 200	35 257	NA
Number of industry holes drilled	NA	NA	NA	NA
Government drilling in metres	29 000	4 436	31 569	NA
Number of government holes drilled	240	NA	NA	NA
Total drilling in metres	29 000	15 636	66 826	NA
Total number of holes	240	NA	NA	NA

* In 1998 the Russian rouble was denominated by 1 000.

URANIUM RESOURCES

Known conventional resources (RAR & EAR-I)

An assessment has not been made within the last 5 years of either the RAR or EAR-I resources. However, minor changes are reported mainly due to production. There were no major changes in this category in the last two years. Most of the changes are related to deposits of the Streltsovsk uranium ore district, which are being mined by the Priargun producing centre. From 1997 to 1999, RAR resources were reduced from 145 000 to 140 900 tU. About 4 100 tU were produced.

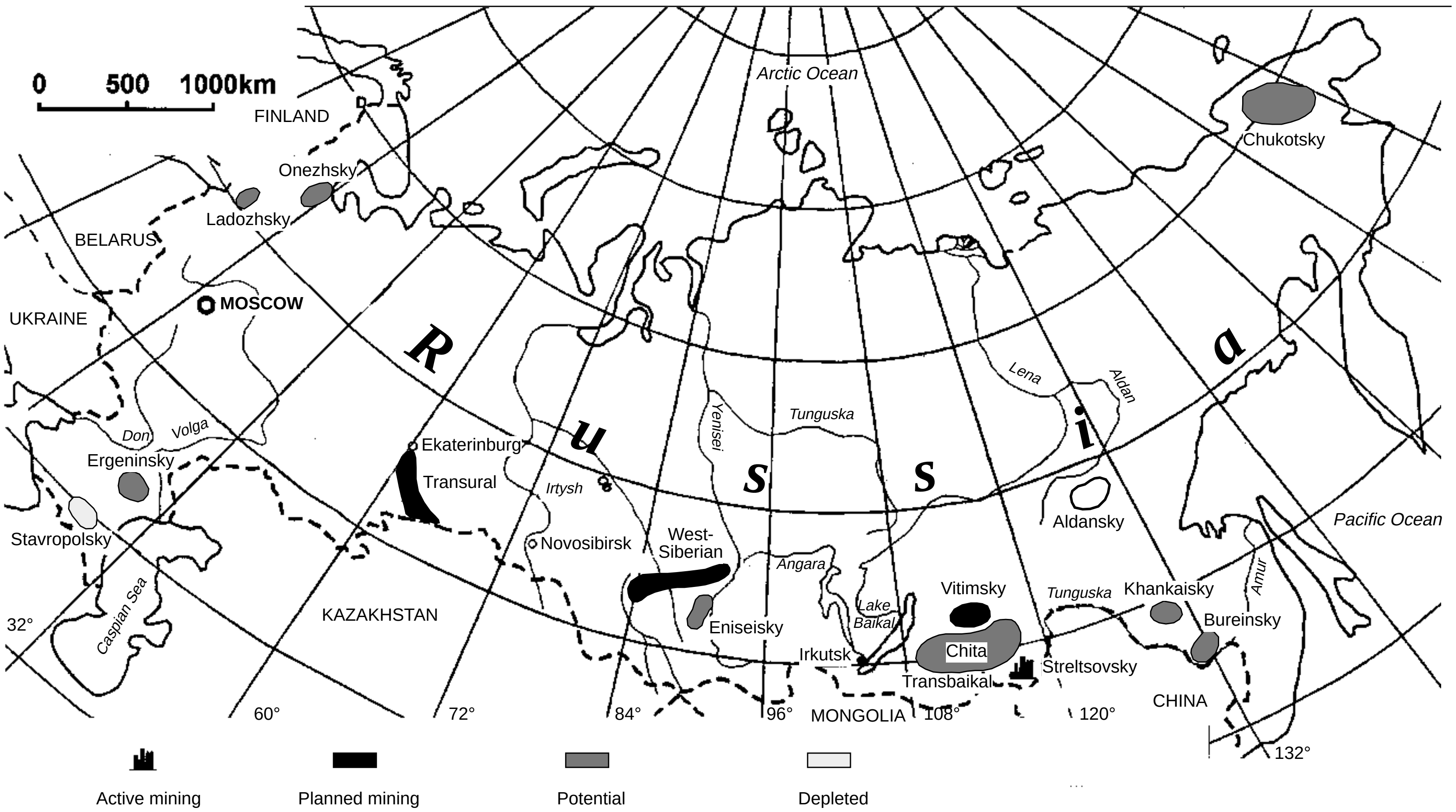
Some 10 200 tU of RAR in the <$80/kg cost category refer to the Dolmatovskoye deposit in the Transural District. Some additional RAR and EAR-I resources have been estimated in the <$80/kg U cost category; however, they are not included since they have not been examined by the State Reserves Committee. In the Vitim region, resources amount to about 2 600 tU of RAR and 50 000 tU of EAR-I related to the Khiagda ore field. In the Transural District such resources comprise about 7 700 tU in the EAR-I category (Dobrovolnoe deposit) and 7 500 tU in the EAR-II category (Khokhlovskoe deposit).

Reasonably Assured Resources*

(tonnes U – as of 1 January 1999)

Cost ranges		
<$40/kgU	<$80/kgU	<$130/kgU
64 300	140 900	NA

* As in situ resources.



Uranium regions in the Russian Federation

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Reasonably Assured Resources*

(tonnes U – as of 1 January 1999)

Cost ranges		
<$40/kgU	<$80/kgU	<$130/kgU
64 300	140 900	NA

* As in situ resources.

Estimated Additional Resources – Category I*

(tonnes U – as of 1 January 1999)

Cost ranges		
<$40/kgU	<$80/kgU	<$130/kgU
17 200	36 500	NA

* As in situ resources.

Undiscovered conventional resources (EAR-II & SR)

The assessment of the undiscovered conventional resources for the <$80/kgU and the <$40/kgU categories was completed in 1998. They are considered to be most favourable for the future taking into account the current and prospective world uranium prices and demand.

The majority of these resources (92%) refers to deposits of two types:

- the paleo-valley (basal channel) sandstone type within the Transural (40 000 tU), West-Siberian (180 000 tU) and Vitim (100 000 tU) uranium districts. Details are available in the 1997 Red Book; and
- deposits and occurrences of unconformity type within the Baltic shield (Republic of Karelia) and in the southeast of the Aldan shield (Yakutia).

Estimated Additional Resources – Category II*

(tonnes U – as of 1 January 1999)

Cost ranges		
<$40/kgU	<$80/kgU	<$130/kgU
44 000	56 300	104 500

* As in situ resources.

Speculative Resources

(tonnes U – as of 1 January 1999)

Cost ranges			
<$40/kgU	<$80/kgU	Unassigned	Total
98 000	544 000	450 000	1 000 000

URANIUM PRODUCTION

The Russian Federation reported detailed information about uranium production in the 1997 Red Book. Since 1997 the situation has not changed significantly.

Historical review

Up to 1998 the Russian Federation has produced 108 653 tU. This level of production places the Russian Federation as the fifth largest uranium producing country in the world.

The first organisation responsible for uranium production was the Lermontov Complex, presently Lermontov State Enterprise (Almaz). Almaz is located 1.5 km from the town of Lermontov, in the Stavropol region. The region included the Beshtau and Byk vein-type uranium deposits with total uranium resources of 5 300 tU, at 0.1% U grade. These resources were extracted in two underground mines starting in 1950. Mine 1 (Beshtau) was closed in 1975 and Mine 2 (Byk) in 1990. The ore was processed using sulphuric acid leaching starting in 1954. From 1965 to 1989 in-place (in-stope) leaching and heap leaching were used. From the 1980s until 1991 uranium ore transported from Ukraine and Kazakhstan was also processed at Almaz. The production totalled 5 685 tU, with 3 930 tU extracted by underground mining and 1 755 tU using ISL technology.

From 1968 to 1980, 440 tU were produced by the ISL method from the Sanarskoye deposit in the Transural district. The Malyshevsk Mining Enterprise operated the project.

The Joint Stock Company "Priargun Mining-Chemical Production Association" (PPGHO) has been the only active uranium production centre in the Russian Federation in the last decade. The centre is located in the Chita region about 10-20 km from the town of Krasnokamensk which has a population of about 60 000. The production is based on 19 volcanic-type deposits of the Streltsovsk uranium region. This region has an area of 150 km^2, with an average uranium grade of about 0.2%. Mining in two open pits (both are depleted) and four underground mines (2 are active and 2 are on stand-by) has been conducted since 1968. Milling and processing has been carried out since 1974 at the local hydro-metallurgical plant using sulphuric acid leaching with subsequent recovery by a ion exchange solvent-extraction scheme. Since the 1990s, low-grade ore has been processed by heap and in-place (in-stope) leaching.

In 1998, more than 100 000 tU were produced at Priargunsky. This high level of total production marks the volcanic type Streltsovsk deposits as one of the outstanding uranium producing districts worldwide.

Status of production capability

The "Priargun Mining-Chemical Production Association" remains the only producing centre in the Russian Federation. The annual production at Priargunsky in 1996-1998 averages 2 500 to 2 600 tU. All uranium produced is being exported since 1992. The main part comes from underground mining while a small amount is produced from the low-grade ores by heap and in-place leaching methods. Open pit mining was stopped in 1997.

The RAR of the Streltsovsk deposits can satisfy the planned requirements for the next 20 years. Low world uranium prices make it necessary to mine relatively high-grade ores using a 0.28% U cut-off grade. Therefore, the remaining low-grade ores are unfavourable for current mining. Nevertheless, the annual production of the Priargunsky Association is planned to reach 3 500 tU in about 5 years, equally divided between conventional milling and the heap and underground block leaching methods.

Historical uranium production

	Pre-1996	1996	1997	1998	Total to 1998	Expected 1999
Mining method	(tonnes U contained in ore)					
Conventional mining:						
• Open-pit	38 555	100	0	0	38 655	0
• Underground	59 197	2 025	2 460	2 470	66 152	2 400
TOTAL	97 752	2 125	2 460	2 470	104 807	2 400
Production method	(tonnes U contained in concentrate)					
Processing plant (from mined ore)	97 752	2 125	2 460	2 470	104 807	2 400
In situ leaching	3 186*	0	0	0	3 186	0
In-place leaching	NA	80	90	20	190	100
Heap leaching	NA	400	30	40	470	100
TOTAL	100 938	2 605	2 580	2 530	108 653	2 600

* Including production by in-place and heap leaching in the Stavropol district.

Ownership structure of the uranium industry

The Ministry of Atomic Energy of the Russian Federation owns the entire uranium production of the country.

Uranium production centre technical details

(as of 1 January, 1999)

	Centre #1	Centre #2	Centre #3	Centre #4
Name of production centre	Priargun Mining-Chemical Production Association	Transural	Vitim	West-Siberian
Production centre class	Existing	Committed	Planned	Planned
Operational status	Operating	Stand-by		
Start-up date	1968	2000	Early 2000s	Early 2000s
Source of ore: • Deposit names • Deposit types	 Antei, Streltsovskoe, Oktyabrskoe Volcanic, vein-stockwork	 Dolmatovskoye Sandstone, basal channel	 Khiagda Sandstone, basal channel	 Malinovskoye Sandstone, basal channel
Mining operation: • Type • Size(tonnes ore/day)	 UG, IPL, HL 6 700	 ISL NA	 ISL NA	 ISL NA
Processing plant: • Type • Size (tonnes ore/day) • Average process recovery (%)	 AL, IX 4 700 95	 IX NA NA	 IX NA NA	 IX NA NA
Nominal production capacity (tU/year)	3 500	Under consideration	Under consideration	Under consideration
Plans for expansion	IPL, HL processing	Khokhlovskoye Dobrovolnoye deposits	Zheglovskoe deposit	

Employment in the uranium industry

In 1998, the staff of Priargun Mining-Chemical Production Association included 12 800 employees. This represents a reduction of 200 people since 1996.

Employment in existing production centres

(persons-years)

1996	1997	1998	Expected 1999
13 000	12 900	12 800	12 500

Short-term production capability projection

The short-term production capability projection through 2015 is given in the following table:

Short-term production capability

(tonnes U/year)

1999				2000				2001			
A-I	**B-I**	**A-II**	**B-II**	**A-I**	**B-I**	**A-II**	**B-II**	**A-I**	**B-I**	**A-II**	**B-II**
2 500	2 500			2 500	2 500			2 500	2 700		

2005				2010				2015			
A-I	**B-I**	**A-II**	**B-II**	**A-I**	**B-I**	**A-II**	**B-II**	**A-I**	**B-I**	**A-II**	**B-II**
2 500	3 500			2 500	5 000			2 500	5 000		

Future production centres

Three new ISL production centres are planned to come into operation in the next 5 years in order to increase uranium production in the Russian Federation (See 1997 Red Book).

In the Transural district, one production centre is committed. Installations have been completed at the Dolmatovskoye deposit. Its starting production of 100 tU can be increased to 700 tU in 5 to 7 years. In the West-Siberian region, ISL tests started in 1998 at the Malinovskoye deposit. In the Vitim region experimental ISL work has started at the Khiagda deposit.

URANIUM DEMAND

The uranium demand in the Russian Federation has not changed since the publication of the last Red Book; 29 industrial power units located at 9 nuclear power plants with a total gross installed capacity of 21 242 MWe are in operation:

- 13 water cooled, water moderated, pressure vessel-type reactors (6 VVER-440 units and 7 VVER-1 000 units);
- 15 uranium-graphite channel-type reactors (11 RBMK-1 000 units and 4 EGP-6 units);
- 1 BN-600 fast breeder reactor unit.

Russian nuclear power plants produced 103.5 TWh in 1998 (48.9 TWh produced by VVER reactors and 54.6 TWh by RBMK, BN and EGP). This amount represents 13% of the total electric energy production in the Russian Federation. The plan for 1999 is 115 TWh.

The annual requirements of domestic nuclear power plants amount to 3 600 tU. Another 2 200 tU are needed to supply fuel for Russian design power plants in Eastern European countries. Thus the total requirements is estimated at 5 800 tU.

Installed nuclear generating capacity

(MWe)

1998	1999	2000	2005		2010		2015	
			Low	*High*	*Low*	*High*	*Low*	*High*
21 242	21 242	21 242	21 242	24 240	21 242	25 240	17 500	25 300

Annual reactor-related uranium requirements

(tonnes U)

1998	1999	2000	2005		2010		2015	
			Low	*High*	*Low*	*High*	*Low*	*High*
3 600	3 600	3 600	3 600	4 100	3 600	4 250	3 000	4 300

• Slovak Republic •

URANIUM RESOURCES

Prior to the dissolution of the Czech and Slovak Republic, the uranium potential of the whole region which was to become the Slovak territory was investigated. Based on the results of the evaluation it was concluded that the Slovak Republic has no known uranium resources.

URANIUM PRODUCTION

In the 1960s and 1970s, small quantities of uranium ore were mined in Eastern Slovakia. However, production was stopped because it did not prove to be economically viable and the grade of the ore was low.

URANIUM REQUIREMENTS

The Slovak Republic has two nuclear power plants (NPP) located at Bohunice and Mochovce. The Bohunice plant has four units of the VVER-440 type in operation, each with a capacity of 408 MWe net. The Mochovce plant has one VVER-440 type unit in operation with a capacity of 388 MWe net.

One additional VVER-440 type unit with a capacity of 388 MWe net is under construction at Mochovce. The expected date of commissioning was in 1999. No additional reactor units are expected to be built in the near future. The plans are for the first two Bohunice units to continue operation through 2001 or 2002. Decommissioning will then begin.

Installed nuclear generating capacity

(MWe net)

1998	1999	2000	2005		2010		2015	
			Low	*High*	*Low*	*High*	*Low*	*High*
2 025	2 430	2 430	1 620	2 430	1 620	2 025	810	1620

Annual reactor-related uranium requirements

(tonnes U)

1998	1999	2000	2005		2010		2015	
			Low	*High*	*Low*	*High*	*Low*	*High*
566	618	515	347	521	347	434	174	347

SUPPLY AND PROCUREMENT STRATEGY

All fuel required for the Slovak nuclear power plants has been procured from abroad in the form of fuel assemblies. This procurement strategy is expected to continue.

NATIONAL POLICIES RELATING TO URANIUM

As there is no uranium production in the Slovak Republic, the enriched uranium in fuel assemblies is purchased from the Russian Federation. The present contractual arrangement with the Russian Federation extends through 2004. Because of the assured supply of fuel there is no need to maintain a sizeable emergency stockpile.

URANIUM STOCKS

At present, 14 tU of enriched uranium are stockpiled at the Bohunice nuclear power plant and 4 tU at the Mochovce nuclear power plant. The 18 tU of total enriched uranium are contained in fabricated fuel assemblies. This is equivalent to 102 tU natural.

• South Africa •

URANIUM EXPLORATION AND MINE DEVELOPMENT

Historical review

Uranium exploration in South Africa commenced in the late 1940s when a worldwide investigation of uranium resources focused attention on the uranium content of the Witwatersrand quartz-pebble conglomerates. For additional information on the history of uranium exploration and mine development in South Africa see the 1997 Red Book.

Recent and ongoing uranium exploration activities

No exploration for uranium as a primary product has been carried out in South Africa for more than a decade, including 1997 to 1998. Exploration activities in the Witwatersrand Basin targeted gold. The depressed gold market severely limited these activities. Information regarding the distribution of uranium exploration inside and outside South Africa by South African companies is not available, because of company confidentiality.

URANIUM RESOURCES

Known conventional resources (RAR & EAR-I)

As no exploration for uranium as a primary product has been carried out in South Africa the changes in the country’s uranium resources are the result of the re-evaluation of working costs, and changes in the gold price and rand/dollar exchange rate. A large proportion of South Africa's uranium resources occur as a by-product of gold in the Witwatersrand quartz-pebble conglomerates. Consequently uranium is discovered during gold exploration. The gold industry in South Africa has been experiencing difficult business conditions and as a result, exploration has been severely curtailed. Therefore, this source has added little to South Africa's uranium resource base.

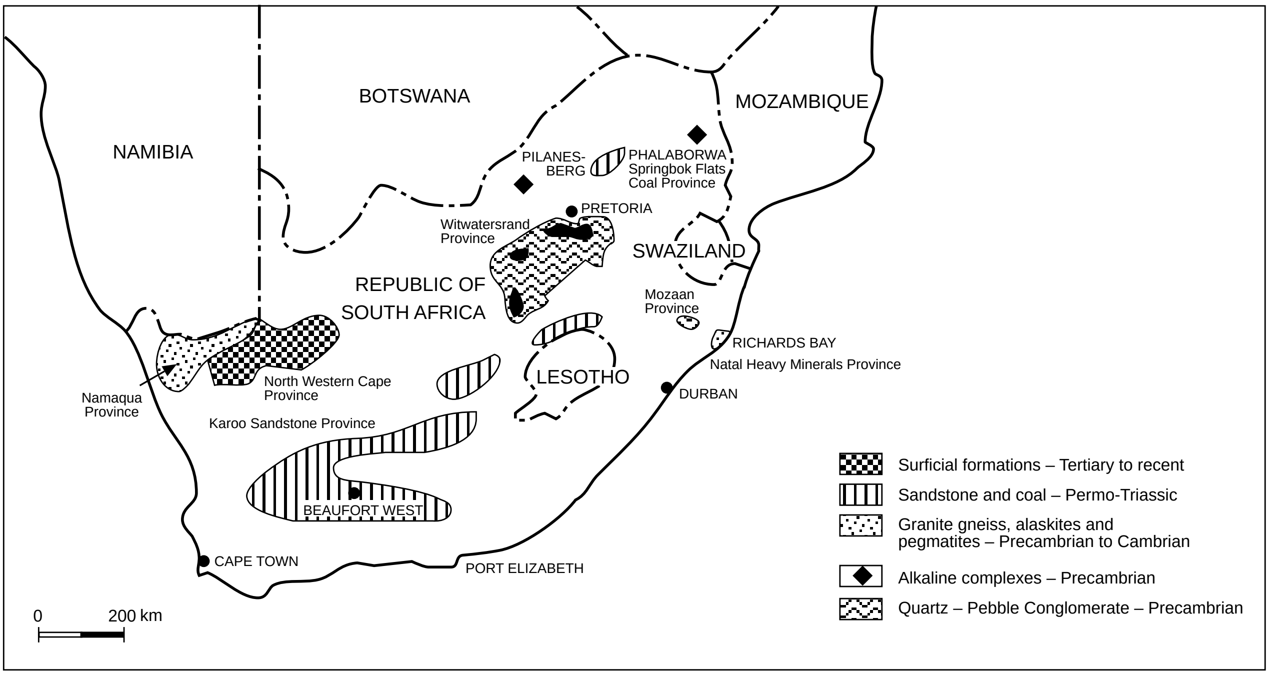
The major influences on South Africa's uranium resources are the gold price, mine working costs, the dollar/rand exchange rate, and the uranium price. Following the near doubling of the spot market uranium price in the last reporting period, it has fallen back in the last two years to almost its previous low levels. This has dampened any interest in resuscitating the uranium industry in South Africa that may have been encouraged by the price rise in 1996.

The revenue derived by uranium from a tonne of Witwatersrand ore is only about 10% of the total revenue, thus it would take a substantial increase in the sales price to stimulate any interest in uranium exploration and production. The dollar gold price fell by 22% from January 1997 to January 1999. This would have depressed South Africa’s uranium resources significantly in the lower cost categories, had it not been for the fact that the rand/dollar exchange rate increased by 20% in the same period. The working cost per tonne ore milled on the Witwatersrand gold mines has increased by 10% in the last two years, but this had little effect on the resources as some of the more well endowed mines had minimal increases in working costs. In the case of the Karoo deposits, the increase in the rand/dollar exchange rate and the working costs resulted in a move of some of the resources into lower cost categories.

For the purposes of this analysis, a dollar/rand exchange rate of R5.90 to the dollar and a gold price of $290/oz are used.

The positive and negative effects of the factors discussed above have largely cancelled each other out and the "known" resources as of 1 January 1999 (i.e. RAR and EAR-I recoverable at costs less than $80/kg U) have increased only marginally (i.e. by 5.4%) since the 1997 estimates were made.

Localities of uranium provinces in South Africa



Reasonably Assured Resources*

(tonnes U)

Cost ranges		
<$40/kgU	<$80/kgU	<$130/kgU
121 000	232 900	292 800

* Mining and ore processing losses deducted – variable percentage.

Estimated Additional Resources – Category I*

(tonnes U)

Cost ranges		
<$40/kgU	<$80/kgU	<$130/kgU
48 100	66 800	76 400

* Mining and ore processing losses deducted – variable percentage.

Undiscovered conventional resources (EAR–II & SR)

The depressed state of exploration for both gold and uranium has resulted in little or no work being carried out to identify new areas where uranium deposits may potentially be discovered. Limited efforts have been made to identify subsidiary Witwatersrand-type basins outside of the currently known limits of the main basin. The lack of exploration funding for this speculative type of work has, however, hindered the achievement of any meaningful results.

The EAR-II at a production cost of less than $80/kgU are 34 900 tU as of 1 January 1999, which is the same as the 1 January 1977 estimate. There is also no change in the Speculative Resources which total 1 113 000 tU with no cost range assigned.

Estimated Additional Resources – Category II*

(tonnes U)

Cost ranges		
<$40/kgU	<$80/kgU	<$130/kgU
27 900	34 900	147 900

* Mining and ore processing losses deducted – variable percentage.

"Availability" of "known" (RAR and EAR-I) resources

A large portion of South Africa's RAR and EAR-I resources, recoverable at $80/kg or less, is tributary to existing gold production centres and are mined for their gold content. However, only a small portion of the uranium is extracted; the rest ends up in the gold mine tailings dams. The availability of these resources in the tailings dams depends on the degree of dilution by non-uraniferous tailings and the possible usage of the tailings to backfill mined areas.

About 46% of the RAR plus EAR-I resources recoverable at ≤$40/kg U are tributary to existing production centres. About 28% of the RAR plus EAR-I resources recoverable at ≤$80/kg U are tributary to existing production centres.

URANIUM PRODUCTION

Historical review

South African uranium production commenced in 1952 when a uranium plant was commissioned at the West Rand Consolidated Mine which exploited quartz-pebble conglomerates of the Witwatersrand Supergroup. This was closely followed by the commissioning of four more uranium plants at various centres in 1953. Production accelerated until 1959 when 26 mines around the Witwatersrand Basin were feeding 17 uranium plants for a total production of 4 954 tU. Production subsequently declined to 2 262 tU in 1965.

In 1971, Palabora Mining Company became the first non-Witwatersrand uranium producer in South Africa. This company produces uranium as a by-product of copper at its open-pit mining operation in the Northern Province.

The world oil crisis in the 1970s stimulated interest in uranium as an energy source. South African uranium producers responded by almost trebling production to 6 143 tU in 1980.

Many decades of gold mining and milling generated vast amounts of tailings around the Witwatersrand Basin containing substantial reserves of gold and uranium. The boom in the uranium market lead to the establishment of tailings reprocessing plants at Welkom (Joint Metallurgical Scheme – 1977), in the East Rand (ERGO – 1978), and at Klerksdorp (Chemwes – 1979).

The collapse of the uranium market in the early 1980s has had serious repercussions in the South African uranium industry which has resulted in the closure of 16 uranium plants since 1980. This includes the Western Areas plant, closed at the end of 1997. At year end 1998, only three plants were producing uranium from three mines.

Historical uranium production

(tonnes U contained in concentrate)

Production method	Pre-1996	1996	1997	1998	Total to 1998	Expected 1999
By product production	148 071	1 436	1 100	994	151 601	950

Status of production capability

The three mines producing uranium at the end of 1998 were the Hartebeestfontein and Vaal Reefs at Klerksdorp, and Palabora in the Northern Province (previously Northern Transvaal). All these produce uranium as a by-product, gold being the primary product in the first two, and copper in the last. Western Areas mine ceased uranium production in 1997.

Hartebeestfontein has one uranium plant with a capacity to treat 3.2 million tonnes of ore per year. The plant operates on a reverse leach cycle which enhances the gold production. For the last few years the plant has operated at a recovery factor of 65% which optimises the recovery costs of the uranium. Financial losses are made on the production of uranium, but the significant increase in gold recovery enhances the overall profitability of the operation.

Vaal Reefs has only one remaining uranium plant operating out of three. The three plants had a cumulative capacity to treat 9 million tonnes of ore per year. The plant has a capacity of 2.8 million tonnes of ore per year. In spite of the reduced capacity, the mine produced over 75% of the country's total uranium production.

Palabora is a large open-pit copper producer which produces uranium as a by-product. The uranium ore mineral uranothorianite is first concentrated in a gravity separation plant, along with other heavy minerals. The uranium is then recovered using an acid leach and solvent extraction process. The uranium plant has an annual capacity of 2 million tonnes to produce a gravity concentrate from ore.

Major reductions in production capacity in the Witwatersrand took place in the late 1980s and early 1990s, but the situation has stabilised in recent years and in the 1995/1996 period no plant closures took place. However, the negative trend resumed in 1997 with the closure of two further plants. In 1998, for the first time in over 45 years, South African uranium production has fallen below 1 000 tonnes U.

Western Areas was the highest grade uranium producer on the Witwatersrand prior to ceasing uranium production at the end of 1997. It had one plant with a capacity to treat 650 000 tonnes of ore per year. It is an indication of the depressed state of the uranium market that the management of this mine decided to terminate uranium production.

The status of plants where uranium production has stopped may be summarised as follows. The nine uranium production plants which have been shut down and are being dismantled include: Beisa, Blyvooruitzicht, Buffelsfontein, Dreifontein, Ergo, Freegold, Harmony (Merriespruit), Stilfontein and West Rand Consolidated. Uranium production could not be restarted at these plants without completely rebuilding them. The Randfontein (Cooke) uranium plant was converted for the extraction of gold.

The status of the three uranium plants in operation as well as of the recently closed Western Areas centre is summarised below.

Ownership structure of the uranium industry

The uranium producers are all owned by various public sector companies. As these are companies quoted on various stock exchanges it is impossible to determine the proportion of domestic and foreign ownership. No significant changes have taken place in the ownership of individual uranium producers since 1990, but substantial rationalisation has taken place within the gold mining industry as a whole. This has seen the merging of all of Anglo American's gold mines into a single entity and the effective withdrawal of Gencor from active participation in the gold mining industry in South Africa. Gencor's major mines have been merged into the Gold Fields stable of mines. Gencor's marginal mines have been sold to Randgold. Anglovaal's two mines, including the uranium-producing Hartebeestfontein, have been merged into a new company called Avgold. The State does not participate in any uranium mining activities.

Employment in the uranium industry

Uranium is only produced as a by-product and therefore no exact employment figures are available for uranium production.

Uranium production centres technical details
(as of 1 January, 1999)

	Centre # 1	Centre # 2	Centre # 3	Centre # 4
Name of production centre	Hartebeestfontein	Vaal Reefs	Western Areas	Palabora
Production centre class	Existing	Existing	Existing	Existing
Operational status	Operating	Operating	Closed	Operating
Start-up date	1956	1977	1982	1979
Source of ore: • Deposit names • Deposit type	Vaal Reefs Quartz-pebble Conglomerate	Vaal Reefs Quartz-pebble Conglomerate	Elsburg Reefs Quartz-pebble Conglomerate	Palabora, Intrusive deposit
Mining operation: • Type • Size (tonnes ore/day) • Average mining recovery (%)	Underground 9-10 000 Variable	Underground 24-31 000 Variable	Underground 33 800 Variable	Open pit 80 000 Variable
Processing plant: • Type • Size (tonnes ore/day) • Average processing recovery (%)	AL/SX 9-10 000 Variable	AL/SX 9-10 000 Variable	AL/SX 9-10 000 Variable	AL/SX 10 000 Variable
Nominal production capacity (tU/year)	200-500	800-1 000	200-300	100-250
Plans for expansion	None	None	None	None

Future production centres

There are no committed or planned uranium production centres in South Africa. The by-product character of the majority of uranium resources in South Africa makes it impossible to predict whether prospective production centres could be supported by the existing known resources in the RAR and EAR-I categories recoverable at costs of ≤$80/kg U. The cost classification of a great part of South African uranium resources is based on the associated gold values, working costs and dollar/rand exchange rate, which have little to do with the uranium market. Given favourable conditions in all these variables, South Africa would be able to return to the production levels achieved during the late 1970s and early 1980s, that is to say, in excess of 6 000 tU per year. If the gold price and, more importantly, the uranium price do not improve substantially, then this level of uranium production will not be attainable.

It takes a substantial period of time to reconstruct uranium plants at production centres where production was stopped in the past, or to construct new production centres. In addition to the conditional conventional producers, the Karoo sandstone and coal-hosted deposits may be able to support production levels of about 2 000 tU per year.

ENVIRONMENTAL ASPECTS

South Africa has areas of mine related land which have been contaminated by radioactivity, particularly where existing or previously existing uranium plants are, or were located. If development takes place on former mine land, the area is radiometrically surveyed and, where necessary, clean-up is conducted. The South African Council for Nuclear Safety is the regulatory body responsible for the implementation of nuclear legislation related to these activities, and the standards conform to international norms. Vast areas around the gold/uranium mines are covered with slimes dams and rock dumps. South Africa has, however, a strict environmental legislation which ensures that these areas are suitably rehabilitated. Environmental issues relating to gold/uranium mining on the Witwatersrand are dust pollution, surface and groundwater contamination and residual radioactivity. Old gold-uranium plants are being decommissioned. Scrap materials from these operations are decontaminated to internationally acceptable levels and then sold.

Cost of environmental management

The by-product status of all uranium production in South Africa makes it impossible to allocate environmental costs specifically to uranium mining activities. The South African mining industry expends considerable resources on environmental considerations at all stages of mining activity, from exploration to mine and mill closure

URANIUM REQUIREMENTS

South Africa has one nuclear power plant designated Koeberg. This plant includes two reactors: Koeberg I, commissioned in 1984, and Koeberg II which came on stream in 1985. Together they consume 200 tU/year.

Supply and procurement strategy

South Africa's internal uranium requirements are met from South African mines.

Installed nuclear generating capacity to 2010

Koeberg has an installed capacity of 1 842 MWe. Sites for further nuclear stations have been identified but no plans for future construction have been made because of current over-capacity in conventional coal-fired power stations.

ESKOM is actively pursuing the so-called Pebble Bed Reactor concept. These are small nuclear reactors producing 100 MWe. They are of modular design. A number of these units can operate in tandem to produce the power requirements demanded by specific situations. There is a plan to have a plant in operation in 2000.

Annual reactor-related requirements to 2010

Koeberg reactor uranium requirements are expected to remain constant at 200 tU/year. No additional large nuclear plants similar to Koeberg are planned. The expansion of the use of nuclear power depends on the success of the Pebble Bed Reactor Project.

NATIONAL POLICIES RELATING TO URANIUM

South Africa's national policies affecting the production and export of uranium are defined in the Nuclear Energy Act, 1993, as amended. This Act covers the activities of the Atomic Energy Corporation of South Africa Ltd (AEC) and the national nuclear regulatory body, the Council for Nuclear Safety (CNS). This lead to the perception that the AEC and CNS were one and the same body. It is clearly unsatisfactory for a regulatory body and a participatory body to be controlled by a single Act. Two new Acts are therefore before Parliament for consideration at present. These Acts are aimed at separating the functions of the CNS and AEC, and establishing more transparent and accountable governance in both organisations. If passed, these new Acts will supersede the current Act. The relevant conditions mandated by the current Act are discussed below.

No person may prospect or mine for uranium without the permission of the Minister of Mineral and Energy Affairs. Such permission may be withheld only if the Minister is satisfied that the security of the State could be endangered if the applicant were given permission to proceed.

There are no restrictions on foreign participation in uranium prospecting and mining, and foreign-based operations are subject to the same legal requirements as domestic companies. In a practical sense, uranium prospecting and mining are subject to the same laws and regulations applied to other material.

The State does not actively undertake prospecting operations. It limits its activities to general research, national resource assessment, geological mapping, airborne surveys and regional hydro-geological, geochemical and geophysical investigations.

The Nuclear Energy Act also provides that no person may dispose of uranium, or export it from South Africa, except under the authority of the Minister. In exercising this control, the Minister is required to consult the Atomic Energy Corporation of South Africa Limited (AEC), the members of which represent various national interests, including the uranium mining industry. In practice, the Minister's functions are exercised by the chairman of the AEC.

• Spain •

URANIUM EXPLORATION

Historical review

Uranium exploration started in 1951 and was carried out by the Junta de Energía Nuclear (JEN). Initial targets were the Hercynian granites of western Spain. In 1957 and 1958, the first occurrences in precambrian-cambrian schists were discovered, including the Fe deposit, located in the province of Salamanca. In 1965, exploration in sedimentary rocks started and the Mazarete deposit in Guadalajara province was discovered. Exploration activities by the Empresa Nacional del Uranio, S.A. (ENUSA) ended in 1992. Joint venture exploration between ENUSA and other companies continued until the end of 1994. During this period, most of the Spanish territory had been surveyed using a variety of exploration methods, adapted to different stages. An ample coverage of airborne and ground radiometrics of the most interesting areas has been achieved.

Recent and ongoing uranium exploration activities

No exploration activities were carried out in 1997 and 1998. Only a few close-spaced holes, in ENUSA's Fe mine were drilled during 1998.

URANIUM RESOURCES

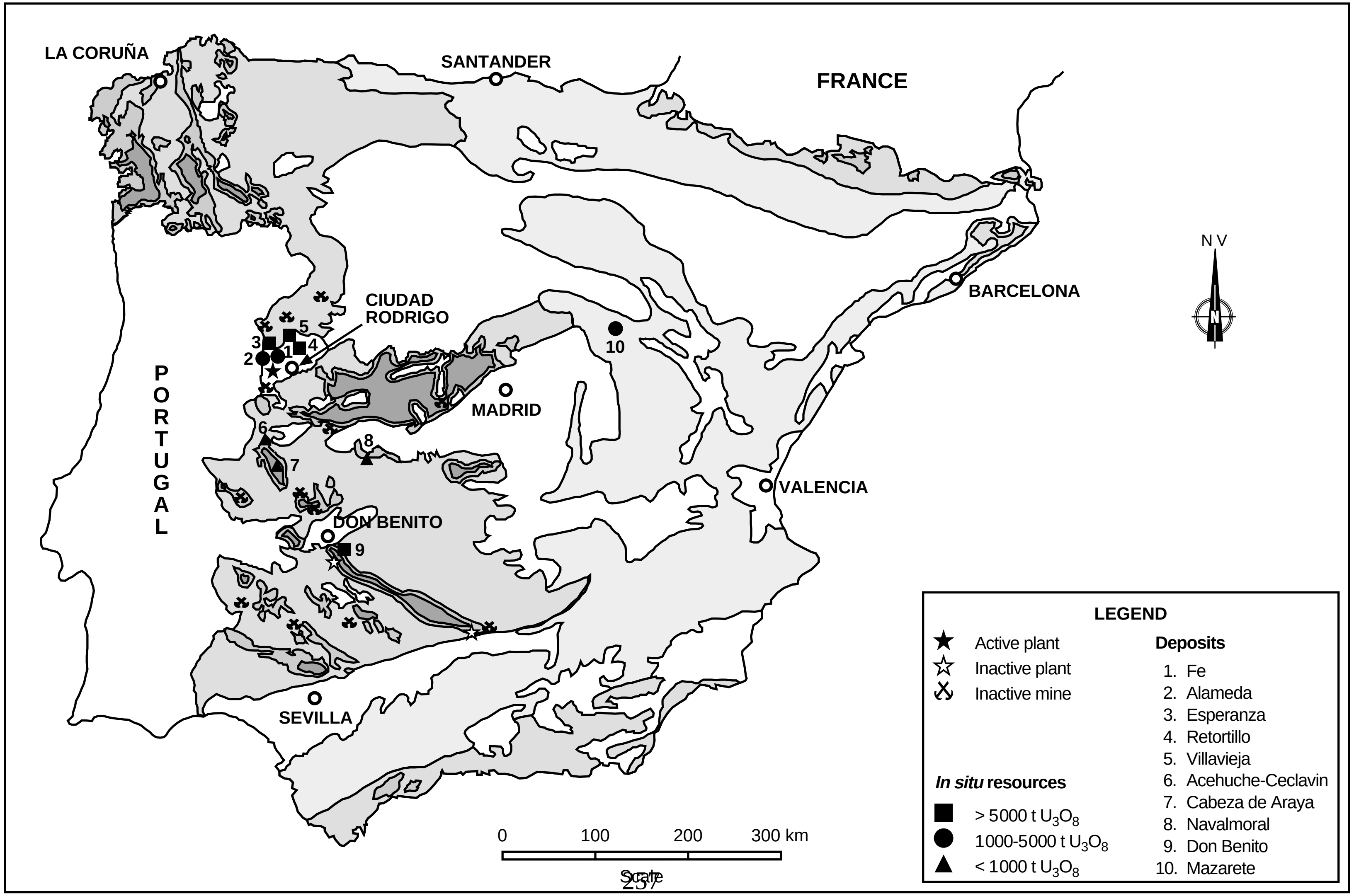
Known conventional resources (RAR & EAR-I)

From 1993 to 1996, ENUSA made a substantial effort to update the data on uranium deposits in the Ciudad Rodrigo area, Salamanca province. This task was undertaken by intensifying close-spaced development drilling, with over 100 000 metres being drilled each year, and by updating the feasibility studies and mining projects of the more important orebodies in the area.

In order to achieve this, a full update of the data processing capabilities was satisfactorily completed in 1992-1993, with new data acquisition systems, grade estimation, open pit optimisation and design programmes. New figures are being obtained for the recoverable resources in the RAR and EAR-I categories. Between 1997-1998, feasibility studies and mining projects have continued to provide information on the uranium deposits in the Ciudad Rodrigo area, Salamanca province. The RAR estimates are the result of economic open pit optimisation at different price levels, carried out during the update of the mining project.

In the EAR-I category, where no detailed mining project is available, recoverable resources have been estimated as ratios for each cost from the in situ resources. All the known uranium resources recoverable at cost below $80/kgU are tributary to existing production centres.

Uranium deposits in Spain



Undiscovered conventional resources (EAR-II & SR)

No resources within these categories have been estimated.

URANIUM PRODUCTION

Historical review

Production started in 1959 at the Andujar plant, Jaen province, and continued until 1981. The Don Benito plant, Badajoz province remained in operation from 1983 to 1990. Production at the Fe deposit, Salamanca province started in 1975 with heap leaching. A new dynamic leaching plant started production in 1993 and is still operating.

Status of production capability

The production capability of the Fe deposit in Salamanca province is 800 tU/year. Mining operations are planned to be discontinued at the end of the year 2000. The processing plant will continue production at a reduced level.

Historical uranium production

	Pre-1996	1996	1997	1998	Total to 1998	Expected 1999
Mining method	(tonnes U contained in ore)					
Conventional mining: • Open-pit	NA	364	364	364	NA	364
TOTAL	**NA**	**364**	**364**	**364**	**NA**	**364**
Production method	(tonnes U contained in concentrate)					
Processing plant	3 686	255	255	255	4 451	255
TOTAL	**3 686**	**255**	**255**	**255**	**4 451**	**255**

Future production centres

No new centres are being considered.

Ownership structure of the uranium industry

The only active production centre in Spain belongs to ENUSA, a state company, 60% owned by the Sociedad Estatal de Participaciones Industriales (SEPI) and 40% by the Centro de Investigaciones Energéticas Medioambientales y Tecnológicas (CIEMAT).

Uranium production centre technical details

(as of 1 January 1999)

	Centre # 1
Name of production centre	Saelices El Chico
Production centre class	Existing
Operational status	Operating
Start-up date	1975
Source of ore: • Deposit name • Deposit type	 Fe, D Vein (Iberian type)
Mining operation: • Type (OP/UG/ISL) • Size (tonnes ore/day) • Average mining recovery (%)	 OP 2 600 (a)
Processing plant: • Type (IX/SX/AL) • Size (tonnes ore/day) • Average processing ore recovery (%)	 AL/SX 5 000 (b) 70 (c)
Nominal production capacity (tU/year)	800
Plans for expansion	None
Other remarks	Plant works intermittently

(a) Mining losses negligible due to type of open- pit operation.
(b) Ore capacity depends on particle size, reaching 10 000 t/day for 10% of particles less than 1 mm.
(c) Includes heap leaching on 24% of the ore.

Employment in the uranium industry

The number of employees at the Fe mine was 148 at the end of 1998.

ENVIRONMENTAL CONSIDERATIONS

ENUSA finalised in July 1997 the decommissioning and restoration of its own La Haba Mining and Milling Centre which was in operation until 1990. La Haba Centre was situated in the Badajoz province of Extremadura.

In January 1998 a five-year supervision programme for the verification of the decommissioning design criteria for La Haba Mining and Milling Centre was approved. After this period, the closure will be authorised and ENUSA will be exempted from any radiological control responsibility.

The environmental restoration work of thirteen old uranium mines located in the Extremadura region and six more in the Andalucia region is being carried out. The responsibility was assigned to ENRESA (the Spanish Radioactive Waste Management Agency) who awarded the restoration activities to ENUSA in September 1997 and July 1998, respectively. The work is scheduled to be completed in early 2000. These uranium mines were active both as investigation and production centres operated by the former Junta de Energía Nuclear between the fifties and the seventies.

Cost of environmental management (in millions of pesetas, ESP)

Existing operations	Pre-1998	1998	1999	2000	Total
Pre-operational environmental Assessment	✓	✓	✓	✓	
Monitoring	✓	✓	✓	✓	
Stabilising waste dumps and/ or impoundments	✓	✓	✓	✓	
Decontamination of replaced equipment					
Effluent management (gas, liquid)	✓	✓	✓	✓	
Site rehabilitation	✓	✓	✓	✓	
Radwaste disposal					
Regulatory activities	✓	✓	✓	✓	
TOTAL	**2 995(1)**	**665**	**600**	**600**	**4 860**

After closure	Pre-1998	1998	1999	2000	Total
Monitoring	✓	✓	✓	✓	
Closing out tails impoundments	✓	✓	✓	✓	
Decommissioning/decontamination	✓	✓	✓	✓	
Effluent management (gas, liquid)	✓	✓	✓	✓	
Site rehabilitation	✓	✓	✓	✓	
Radwaste disposal					
Regulatory activities	✓	✓	✓	✓	
TOTAL	**1 300(2)**	**30**	**25**	**25**	**1 380**

(1) This amount includes investment (ESP 1 620 million), 1996 expenses (ESP 788 million) and 1997 expenses (ESP 587 million).

(2) This amount represents 1991-1997 closures expenses.

URANIUM REQUIREMENTS

Uranium requirements

There are nine reactors operating in Spain, with a total net capacity of more than 7.6 GWe. Additional nuclear reactors which were in moratorium have definitely been cancelled and no new orders are expected by the year 2000.

Supply and procurement strategy

The strategy is to maintain the same level of domestic production until the year 2000 and beyond if the market situation makes that advisable; otherwise, procurement will be based mainly on imports, with a diversified portfolio of contracts.

NATIONAL POLICIES RELATING TO URANIUM

The uranium import policy provides for diversification of supply sources. Spanish legislation leaves uranium exploration and production open to national and foreign companies.

• Sweden •

URANIUM EXPLORATION

Historical review

Uranium exploration was carried out during the period 1950-1985. However, at the end of 1985, exploration activities were stopped due to availability of uranium at low prices in the world market.

There are four main uranium provinces in Sweden. The first is in the Upper Cambrium and Lower Ordovicium sediments in southern Sweden and along the border of the Caledonian mountain range in central Sweden. The uranium occurrences are stratiform, in black (alum) shale. Billingen (Västergötland), where the Ranstad deposit is located, covers an area of more than 500 km^2.

The second uranium province, Arjeplog-Arvidsjaur-Sorsele, is immediately south of the Arctic Circle. It comprises one deposit, Pleutajokk, and a group of more than 20 occurrences. The individual occurrences are discordant, of a vein or impregnation type, associated with soda-metasomatism.

A third province is located north of Östersund in central Sweden. Several discordant mineralisations have been discovered in, or adjacent to, a window of Precambrium basement within the metamorphic Caledonides.

A fourth province is located near Åsele in northern Sweden.

Recent and ongoing exploration and mine development activities

There are no ongoing uranium exploration or mining activities in Sweden.

URANIUM RESOURCES

Known conventional resources (RAR & EAR-I)

There are small resources in granitic rocks (vein deposits) in Sweden.

Undiscovered conventional resources (EAR-II & SR)

There are no estimates on EAR-II or SR in Sweden.

Unconventional resources

There are large resources in alum shale; however, these deposits are very low grade and the cost of recovery is above $130/kgU.

URANIUM PRODUCTION

Historical review

In the 1960s, 200 tU were produced from the alum shale deposit in Ranstad. This mine is now being restored to protect the environment.

Status of production capability

There is no uranium production in Sweden and there are no plans for such production.

ENVIRONMENTAL CONSIDERATIONS

The Ranstad mine was rehabilitated in the 1990s. The open pit was transformed into a lake and the tailings area was covered with a multilayer top to prevent the formation of acid from sulphur in the shale tailings. An environmental monitoring programme is now being carried out. The total cost of restoration of the Ranstad mine was 150 million SEK. The current monitoring programme represents only minor costs.

URANIUM REQUIREMENTS

The Swedish uranium requirements are around 1 600 tU per year. This amount will decrease by 100 tU in 2000 and by another 100 tU in 2005 due to the premature closure of the two reactors at Barsebäck.

Supply and procurement strategy

The utilities are free to negotiate their own purchases.

NATIONAL POLICIES RELATING TO URANIUM

Sweden has joined the Euratom Treaty and adjusted its policy accordingly.

URANIUM STOCKS

The Swedish Parliament decided in 1998 to replace the previous obligation that utilities had to keep a stockpile of enriched uranium corresponding to the production of 35 TWh with a reporting mechanism.

URANIUM PRICES

As Sweden is now part of the deregulated Nordic electricity market, costs of nuclear fuel are no longer reported.

• Switzerland* •

URANIUM EXPLORATION

Background

In June 1979, the Federal Government decided to encourage uranium exploration by awarding a grant of 1.5 million Swiss francs during the 1980-1984 period. During 1980 and 1981 about 1 000 metres of galleries were excavated for prospection by a private company in the Hercynian Massif of Aiguilles Rouges and the surrounding gneisses. The limited work so far has not allowed a clear picture of the factors controlling the mineralization which is of low grade and disseminated in an area which is geologically very complex.

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* The background information in this report was drawn mainly from the 1991 Red Book response.

In 1982, the Federal Government supported surface prospecting to the South of Iserables and drilling at Naters (Valais). Between 1982 and 1984, in the framework of the five-year programme financed by the Federal Government, uranium exploration was carried out in the rugged region of the Penninic Bernhard nappe, in the western Valais. The radiometric and chemical investigations concentrated mainly on the detrital deposits of Permo-carboniferous and schists of older age (series of Nendaz and the underlying series of Siviez). Owing to strong alpine tectonism, the uranium is generally irregularly disseminated in the rock. Radioactive anomalies seem to be bound to the carbonatic and chloritic facies of the Nendaz series, but their practical value could not be confirmed.

Recent and ongoing activities

Since 1985 all domestic exploration activities have been halted. Private industry, however, has engaged in uranium exploration in the Arizona Strip, USA since 1983.

URANIUM RESOURCES

No uranium resources have been reported for Switzerland.

URANIUM PRODUCTION

Status of production capability

Switzerland does not produce uranium.

Future production centres

No future production centres in Switzerland are envisaged in the short term.

URANIUM REQUIREMENTS

Switzerland has five operating nuclear power stations located at Beznau (Units 1 & 2), Muehleberg, Goesgen and Leibstadt. In 1996, total installed net nuclear capacity was 3 055 MWe. In September 1990, a national referendum was held and the Swiss rejected an initiative to phase out the use of nuclear energy as soon as possible. This was the third time in ten years that the Swiss had voted against a phase-out of nuclear power. However, at the same time, the electorate did approve a ten-year moratorium on the construction and operation of new plants.

Supply and procurement strategy

Switzerland reported that uranium is currently procured from one or several of the following sources: partnership/joint venture production; long-term contracts; spot market contracts.

Installed nuclear generating capacity

(MWe)

1998	1999	2000	2005	2010	2015
3 117	3 179	3 300	3 300	3 300	3 300

Annual reactor-related uranium requirements

(tonnes U)

1998	1999	2000	2005	2010	2015
570	480	480	580	580	580

URANIUM POLICIES

No changes to the Swiss uranium policy were reported for this edition of the Red Book. Switzerland does not produce uranium and does not export uranium. There is no official import policy as private companies handle procurement entirely. Regarding uranium stocks, it is the policy of nuclear plant operating companies to maintain a stockpile of fresh fuel assemblies at the reactor site equivalent to the fuel requirement for one to two years.

URANIUM STOCKS

In Switzerland, uranium stocks, if they exist, are held only by the utilities. No detailed information is available on utility uranium stocks

• Thailand •

URANIUM EXPLORATION

Historical review

Uranium exploration was carried out in the early 1970s by the Royal Thai Department of Mineral Resources (DMR). Uranium occurrences were found in various geological environments including sandstone and granite host rocks. Sandstone-type mineralisation occurs in the Phu Wiang district of the Khon Kaen province, northeastern Thailand. This area had been independently investigated by DMR. The Cupertino area was investigated in co-operation with foreign organisations. The granite hosted uranium occurrences associated with fluorite were discovered in the Doi Tao district, Chiang Mai province and the Muang district of Tak province, northern Thailand. These occurrences have received the most attention.

The most important uranium exploration activity carried out in Thailand is the nation-wide airborne geophysical survey completed between 1985 and 1987. The survey was conducted by Kenting Sciences International Limited Canada, as contractor to the Canadian International Development Agency (CIDA).

Recent and ongoing activities

No government agencies or companies have been involved in uranium exploration activities from 1996 to 1999.

URANIUM RESOURCES

Known conventional resources (RAR & EAR-I)

A small uranium occurrence found in Jurassic sandstones in the Phu Wiang district is estimated to contain about 4.5 tU based on a cut-off grade of 0.01% U. This estimate is classified as RAR recoverable at a cost of less than $130/kgU.

Granitic areas in the Doi Toa and Om Koi districts (Chiang Mai province) in northern Thailand are considered to have some uranium potential. Uranium minerals have been identified in fluorite veins. Uranium assays yielded values between 0.02 and 0.25% U. The estimate of EAR-I is about 7 tU in the cost category below $130/kgU with a cut-off grade of 0.05% U.

Undiscovered conventional resources (EAR-II & SR)

No undiscovered conventional resources are reported.

• Turkey •

URANIUM EXPLORATION

Historical review

Uranium exploration in Turkey began in 1956-1957 and was directed towards the discovery of vein-type deposits in crystalline terrain, such as acidic igneous rocks and metamorphics. As a result of these activities, some pitchblende mineralisations were found but they did not form economic deposits. Since 1960, studies have been conducted in sedimentary rocks that surround the crystalline rocks and some small orebodies containing autunite and torbernite mineralisations have been found in different parts of the country. In the mid-1970s, the first hidden uranium deposit with black ore below the water table was found in the Köprübasi area. As a result of recent exploration activities, uranium mineralisation has been found in Neogene sediments in the Yozgat-Sorgun region of Central Anatolia.

Recent and ongoing activities

A ground radiometric and geochemical prospection (taking stream sediment samples) was carried out in south-west Anatolia in 1995, 1996 and 1997 and in north-west Anatolia (Thrace Basin) with negative results. The results of chemical analysis of stream sediment samples were expected to be ready in 1999. The continuation of the project will depend on the results of these analyses. Government expenditures on uranium exploration were USD 200 000 in 1997 and USD 1.2 million in 1998.

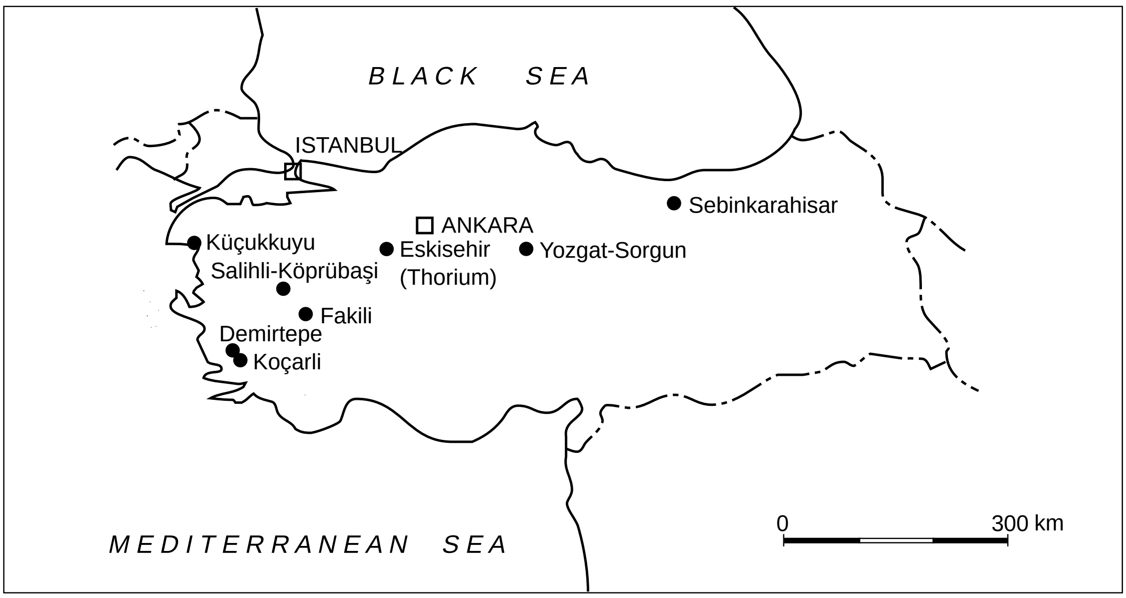
URANIUM RESOURCES

Known conventional resources (RAR & EAR-I)

A total RAR of 9 129 tU occurring in the ≤$80/kgU category (as in situ resources) are reported from the following deposits:

- Salihli-Köprübasi: 2 852 tU in 10 orebodies and at grades of 0.04-0.05% U_3O_8 in fluviatile Neogene sediments.
- Fakili: 490 tU at 0.05% U_3O_8 in Neogene lacustrine.
- Koçarli (Küçükçavdar): 208 tU at 0.05% U_3O_8 in Neogene sediments.
- Demirtepe: 1 729 tU at 0.08% U_3O_8 in fracture zones in gneiss.
- Yozgat-Sorgun: 3 850 tU at 0.1% U_3O_8 in Eocene deltic lagoonal sediments.

Uranium deposits and occurrences in Turkey



• Ukraine •

URANIUM EXPLORATION

Historical review

The exploration for commercial uranium deposits started in Ukraine in 1944. A description of the early history of uranium exploration is given in the 1997 Red Book.

In 1995 a strategic decision was made placing strong emphasis on exploration for deposits with low production costs. This includes deposits with higher ore grades and complex uranium-rare metal mineralisation. Some emphasis is placed on unconformity, as well as vein and vein stockwork hosted deposits. The activity is primarily conducted in crystalline and metamorphic rocks of the Ukrainian Shield.

In 1996, exploration for iron ore in the northern part of the Krivoy Rog basin coincidentally delineated uranium mineralisation containing up to 1.2%U over a thickness of 6.7 metres. The mineralisation occurs in veins in a metasomatized schistose-quartzite. The State Geological Enterprise Kirovgeology is carrying out an evaluation of this area.

Specialised maps at a scale 1:50 000 are being prepared for areas thought to have good potential for new discoveries. These include areas of the Ukrainian Shield covered by younger sediments with a thickness of 20-100 metres or more. This initial evaluation of the more prospective areas includes geophysical surveys (gravity, magnetic and electric prospecting, as well as isotope surveys) and extensive parametric drilling. Kirovgeology began direct exploratory drilling after the construction of a geological-structural map of the prospective area. This system has been found to be the most effective.

Recent and ongoing uranium exploration and mine development activities

Current activities include annual drilling programmes of approximately 20 000 metres in 1997 and 1998, a decrease from the footage drilled in 1996. Drilling planned for 1999 is expected to be more than double the 1998 amount. Details on exploration expenditures and drilling statistics are shown in the following table.

Uranium exploration development expenditures and drilling effort

	1996	1997	1998	1999 (Expected)
Government expenditures:				
Hryvnias (x 1 000)	2 600	2 900	3 900	12 500
USD (x 1 000)	1 420	1 610	1 940	3 640
Government exploration drilling in metres	45 630	19 675	21 000	52 500
Number of government holes drilled	443	208	298	559

URANIUM RESOURCES

Known conventional resources (RAR & EAR-I)

As compared with the previous report, only minor changes occur in the RAR and EAR-I estimates as of 1 January 1999. RAR now total 81 000 tU recoverable at costs below $130/kgU. This is a decrease of 3 000 tU in the RAR <$80/kgU cost category. The resource estimates are expressed as in situ resources.

EAR-I as of 1 January 1999 amount to 50 000 tU recoverable at $130/kgU or less. When compared to the previous estimates there is an increase of 3 000 tU in the <$80/kgU cost category.

Estimates of RAR and EAR-I of the below $40/kgU cost category have not been made by Ukraine. The reported estimates of known resources were made within the last 5 years.

Reasonably Assured Resources*

(tonnes U)

Cost ranges		
<$40/kgU	<$80/kgU	<$130/kgU
–	42 600	81 000

* As in situ resources.

Estimated Additional Resources – Category I*

(tonnes U)

Cost ranges		
<$40/kgU	<$80/kgU	<$130/kgU
–	20 000	50 000

* As in situ resources.

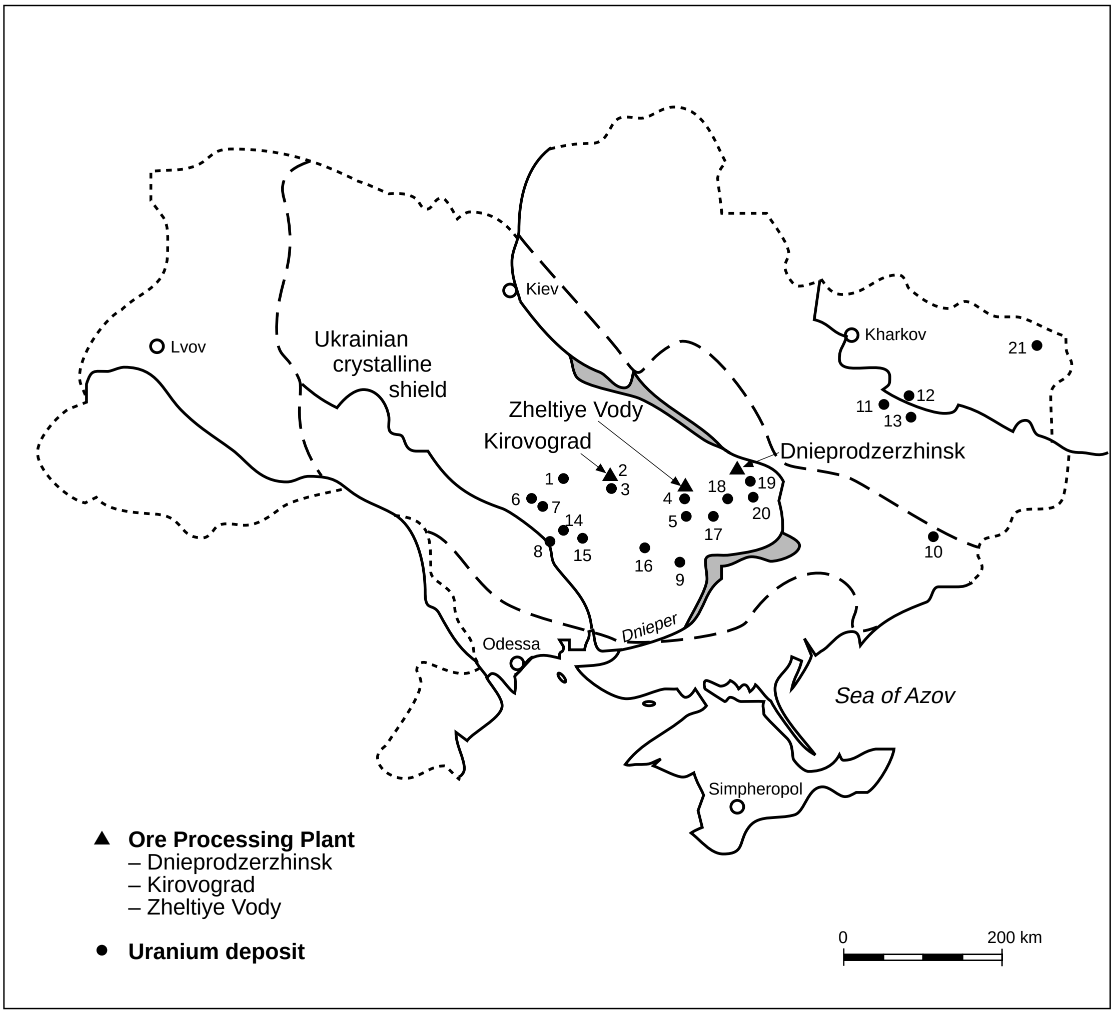
The low cost portion of the known resources is hosted in the albitite deposits Vatutinskoye and Michurinskoye, as well as in small low grade sandstone deposits in the sedimentary cover of the Ukranian Shield. The sandstone deposits are amenable to ISL methods.

The higher cost known resources, recoverable at costs between $80-130/kgU, are contained in the albitite Severinskoye deposit, in the pegmatite Yuzhnoye, Kalinovskoye and Lozovatskoye deposits as well as in the bitumen Adamovskoye, Krasnooskoiskoye and Berekskoye deposits. Of the known resources recoverable at costs of below $80/kgU, 83.9% are tributary to existing and committed production centres.

Undiscovered conventional resources (EAR-II & SR)

Total undiscovered resources (EAR-II and SR) of 235 000 tU as of 1 January 1999, compared to 241 000 tU published in the previous Red Book.

Uranium deposits of Ukraine



1. Vatutinskoye
2. Severinskoye
3. Michurinskoye
4. Zheltorechenskoye
5. Pervomaysskoye
6. Lozovatskoye
7. Kalinovskoye
8. Yuzhnoye
9. Nikolokozelskoye
10. Nikolayevskoye
11. Berekskoye
12. Krasnooskoiskoye
13. Adamovskoye
14. Sadovokonstantinovskoye
15. Bratskoye
16. Safonovskoye
17. Devladovskoye
18. Novoguryevskoye
19. Surskoye
20. Chervonoyarskoye
21. Markovskoye

As reported in 1997, the largest portion of the undiscovered resources are postulated to occur in the following types of deposits: albitite (133 500 tU), pegmatite (15 000 tU), bitumen (16 500 tU), and sedimentary cover of the Ukrainian Shield (20 000 tU), proposed unconformity-related deposits (20 000 tU) and vein-stockwork type (30 000 tU). Information is not available on the assignment of the remaining 6 000 tU undiscovered resources.

Estimated Additional Resources – Category II*

(tonnes U)

Cost ranges		
<$40/kgU	<$80/kgU	<$130/kgU
NA	NA	3 900

* As in situ resources.

Speculative Resources*

(tonnes U)

Cost range		Total
<$130/kgU	Unassigned	231 000
NA	231 000	

* As in situ resources.

URANIUM PRODUCTION

Historical review

The uranium mining and milling industry of the Ukraine was established in 1946 by a special decree of the Soviet Council of People's Deputies. More information on the history of uranium production in Ukraine is given in the 1997 Red Book.

Short-term production capability

(tonnes U/year)

1999				2000				2001			
A-I	**B-I**	**A-II**	**B-II**	**A-I**	**B-I**	**A-II**	**B-II**	**A-I**	**B-I**	**A-II**	**B-II**
0	1 000	0	0	0	1 000	0	0	0	1 000	0	0

2005				2010				2015			
A-I	**B-I**	**A-II**	**B-II**	**A-I**	**B-I**	**A-II**	**B-II**	**A-I**	**B-I**	**A-II**	**B-II**
0	1 500	0	0	0	2 000	0	0	0	2 000	0	0

Uranium production centre technical details

Name of production centre	Zheltiye Vody
Production centre class	Existing
Operational status	Operating
Start-up date	1959
Source of ore: • Deposit names • Deposit type	 90% Ingul'skii mine/Michurinskoye deposit 10% Vatutinskii mine/Vatutinskoye deposit Albitite
Mining operation: • Type (OP/UG/in situ) • Size (tonnes ore/day) • Average mining recovery (%)	 UG NA NA
Processing plant: • Type (IX/SX/AL) • Size (tonnes ore/day) • Average processing recovery (%)	Zheltiye Vody AL/IX and SX NA 95
Nominal production capacity (tU/year)	1 000
Plans for expansion	Doubling the capacity to 2 000 tU/year

Uranium mining

At present two mines are producing uranium ore (i.e. Ingul'skii and Vatutinskii). A third mine is planned to be developed on the Severinskoye deposit for production after 2000. About 90% of the current uranium production is coming from the Ingul'skii mine developed on the Michurinskoye orebody. The remaining 10% of production are from the Vatutinskii mine located near Smolina. ISL mining was also previously conducted at three sites (i.e. Devladovskoye, Bratskoye and Safonovskoye).

Michurinskoye orebody

The Michurinskoye orebody was discovered in 1964 during water well drilling. Kirovgeology conducted exploration in 1965 and began development of the Ingul'skii mine in 1967.

The uranium deposits occur in a major tectonic zone that extends for hundreds of kilometres and is about 10 kilometres wide, striking northwest-southeast. The ore-bearing zone is about 10 metres thick by 1 km long and extending 1.5 km deep. The ore grade decreases with depth and the best grades occur between 90 and 150 metres below the surface. Sixty percent of the uranium occurs in brannerite, with the oxides nasturum and uraninite contributing most of the rest.

Ingul'skii mine

The Michurinskoye orebody is mined by the Ingul'skii mine. The main shaft is located 2 kilometres from Kirovograd. Current production is less than 1 million t ore/year. The initial plan was for 1 million t/year with a 25 year life based on resources of 19.1 million tonnes ore. Mine production started in 1971. It reached the target level of 1 million t/year in 1976 and continued at this level until 1989.

The ore occurs in about 30 zones. Original planned reserves of 19.1 million tonnes ore, were increased after 1967 by delineation of an additional 7 million tonnes. On 1 January 1995 the reserves were about 13 million tonnes ore, using a cut-off grade of 0.03% U. The in-place grade is about 0.1% U. Dilution during mining is about 29%. The grade is increased to between 0.1 and 0.2% U using radiometric ore sorting of mine-car sized lots conducted within the mine.

Access to the mine is through two 7 metre diameter shafts, designated North and South. Ore is hoisted at the North shaft using two 11 tonne capacity skips. The South shaft is for hoisting workers, supplies and for technical access. A ventilation shaft provides 480 m^3 air/second. The principal mine levels are developed at about 60 to 70 metre intervals, designated 90, 150, 210, 280, and 350.

Ore is mined using conventional drilling and blast operations with backfill. The mine is operated by 3 shifts with a total staff of about 850. Large ore blocks are sub-divided into 10-12 metre high blocks for mining. A ring of test holes is drilled every 4 to 5 metres. Following blasting, the ore is moved to loading pockets for transfer to the sub-level tracked haulage. The ore is transported by electric powered trams to the main shaft where it is crushed prior to hoisting to the surface.

Severinskoye deposit

The Severinskoye deposit, located about 20 km from the Michurinskoye deposit, has been evaluated for future mining after 2000. It is in the largest deposit class with RAR and EAR-I of 68 400 tU and an average grade of about 0.1% U. These resources are in the $80 to $130/kg U cost class.

Zheltiye Vody hydrometallurgical plant

The Zheltiye Vody Hydrometallurgical Plant is operated by VostGOK. Construction was started in 1958 and the mill came into production in January 1959. The design capacity of the mill is 1 million tonnes ore/year. In recent years the mill has been operating at about half capacity. A total of 30 to 35 persons/shift operate the mill.

Ore is hauled to the mill by dedicated trains from the 2 mines Ingul'skii and Vatutinskii, one at Kirovograd (100 km west) and the other at Smolina, near Beriozovka (150 km west). Ninety percent of the ore is produced at Kirovograd. Following grinding and spiral classification, ore is leached in autoclaves using sulphuric acid. Leaching conditions are at 150 to 200°C under 20 atmospheres pressure with a 4-hour residence time. Acid consumption is 80 kg/tonne ore.

In-pulp ion exchange resin is used to recover uranium. Following elution with a mixture of sulphuric and nitric acid, the uranium-bearing solution is further concentrated and purified using solvent extraction technology. Ammonia gas is used for precipitation. The dewatered precipitate is calcined at 800°C to give a dark coloured product. By 1994 the large Zheltiye Vody plant had produced 41.1 million t tailings from its uranium processing operations.

In situ leach mining

ISL uranium mining was conducted at the Devladovskoye, Bratskoye, and Safonovskoye sites. The mining took place from 1966 to 1983 using acid leach technology. Uranium was recovered from sandstone-hosted deposits occurring at depths of about 100 metres. Additional information is available in previous editions of this report.

Ownership of the uranium industry

All activities related to the nuclear fuel cycle in Ukraine are organised and owned by the State. Prior to 1997 all related activities were conducted under the State Committee for Utilization of Nuclear Energy (GASCOMATOM). In 1997 a new Ministry of Energy of Ukraine was given the responsibility for uranium mining and production. The geological department of the uranium industry is also being reorganised.

The State Geological Enterprise "Kirovgeology" is responsible for all uranium exploration and development activities leading up to full scale production. The organisation is a subsidiary of the State Committee of Geology and Utilization of Natural Resources. The headquarters of Kirovgeology is in Kiev. The organisation has six district offices, or "expeditions", for conducting uranium exploration throughout prospective areas in Ukraine.

VostGOK, a subsidiary of the Ministry of Energy, is the organisation responsible for uranium mining and milling in Ukraine. In support of its mining and milling activities, VostGOK operates a large sulphuric acid plant, manages the energy and electrical supply and produces mining equipment and related spare parts. VostGOK also has a rail transport division, two geological expeditions and controls 100% of the Ukrainian uranium production.

ENVIRONMENTAL ASPECTS

The accumulations of waste associated with uranium production in Ukraine have a negative impact upon the environment. The impact is primarily related to the tailing disposal areas where wastes from the hydrometallurgical processing are located. Additional impacts may also be associated with waste rock, low grade ores and tails from radiometric ore concentration within the areas of uranium mining. At present, no mines are being decommissioned in Ukraine.

In 1996 Ukraine enacted a new constitution which provides a legislative base to conduct rehabilitation activities related to nuclear activities. The new laws provide for regulation of radiation safety; radioactive waste management and environmental cleaning. The environmental cleaning activities relate to industrial activity modifications and to liquidation and permanent closure of facilities for mining, processing and handling of radioactive ores (SP-LKP-91).

A programme is being conducted by VostGOK to clean up and rehabilitate sites in Zheltiye Vody contaminated by uranium mill tailings. The programme was established by the Council of Ministers of Ukraine on 8 July 1995. It is the basis for cleaning and liquidation contaminated land, decreasing the concentration of radon in houses, and conducting environmental monitoring in the city.

A State programme for improvement of radiation protection at facilities of the atomic industry of Ukraine was also established. The programme, covering all sites and environmental issues of uranium mining and milling in Ukraine, has a budget of USD 360 million. It provides for: decontamination of contaminated lands, environmental monitoring, installing personnel monitoring systems where required; and for improving technology for treatment of effluents, uranium bearing waste rock and contaminated equipment and land. It also provides for improving national regulations, scientific and design support for the programme, and liaison with international organisations regarding the programme.

URANIUM REQUIREMENTS

Reactor-related uranium requirements for Ukraine are based upon an installed nuclear generating capacity of 12 880 MWe in 1998, through 2005 in the low case, and increasing to 15 800 MWe in the years between 2010 and 2015 in the high case. Annual uranium requirements are expected to increase correspondingly.

Installed nuclear generating capacity

(MWe net)

1998	1999	2000	2005		2010		2015	
			Low	*High*	*Low*	*High*	*Low*	*High*
12 880	12 880	12 880	12 880	14 800	14 800	15 800	14 800	15 800

Annual reactor-related uranium requirements

(tonnes U)

1998	1999	2000	2005		2010		2015	
			Low	*High*	*Low*	*High*	*Low*	*High*
2 350	2 433	2 823	2 480	2 823	2 480	2 705	2 705	2 800

SUPPLY AND PROCUREMENT STRATEGY

Ukraine’s operating uranium production facilities provide approximately 50% of its reactor-requirements. All uranium concentrate produced in Ukraine is shipped to the Russian Federation for conversion, enrichment and fuel fabrication. The shortfall between the national production and reactor-related requirements is met through purchases from the Russian Federation. No uranium stockpiles are kept in Ukraine.

Ukraine plans to increase its uranium supply capability to meet 100% of its requirements. This programme requires substantial increases of activities ranging from uranium exploration to production. In addition, the Ukraine Government announced a programme for establishing the technical capabilities for a complete fuel cycle in Ukraine by 2010.

• United Kingdom •

URANIUM EXPLORATION

Recent and ongoing activities

Despite some earlier systematic exploration, no significant uranium reserves are known to exist in the United Kingdom. Since 1983 all domestic exploration activities have been halted. Exploration in overseas countries is carried out by private companies operating through autonomous subsidiary or affiliate organisations established in the country concerned (e.g. members of the Rio Tinto group of companies). There were no industry expenditures reported for domestic exploration from 1988 to the end of 1998, nor were any government expenditures reported for exploration either domestic or abroad.

URANIUM RESOURCES

Despite some sideline mining of uranium in Cornwall during the nineteenth century in association with tin extraction, no uranium deposits have been located in the United Kingdom. Two districts, the metalliferous mining region of SW England, and the north of Scotland, however, are believed to contain some uranium resources. The reader is referred to the 1989 Red Book for more information on uranium resources in the United Kingdom. There has been no geological reappraisal of UK uranium resources since 1980 and no significant discoveries have occurred since that time. The Reasonably Assured Resources (RAR) and Estimated Additional Resources – Category I (EAR-I) are essentially zero. There are small quantities of in situ Estimated Additional Resources – Category II (EAR-II) and Speculative Resources.

URANIUM PRODUCTION

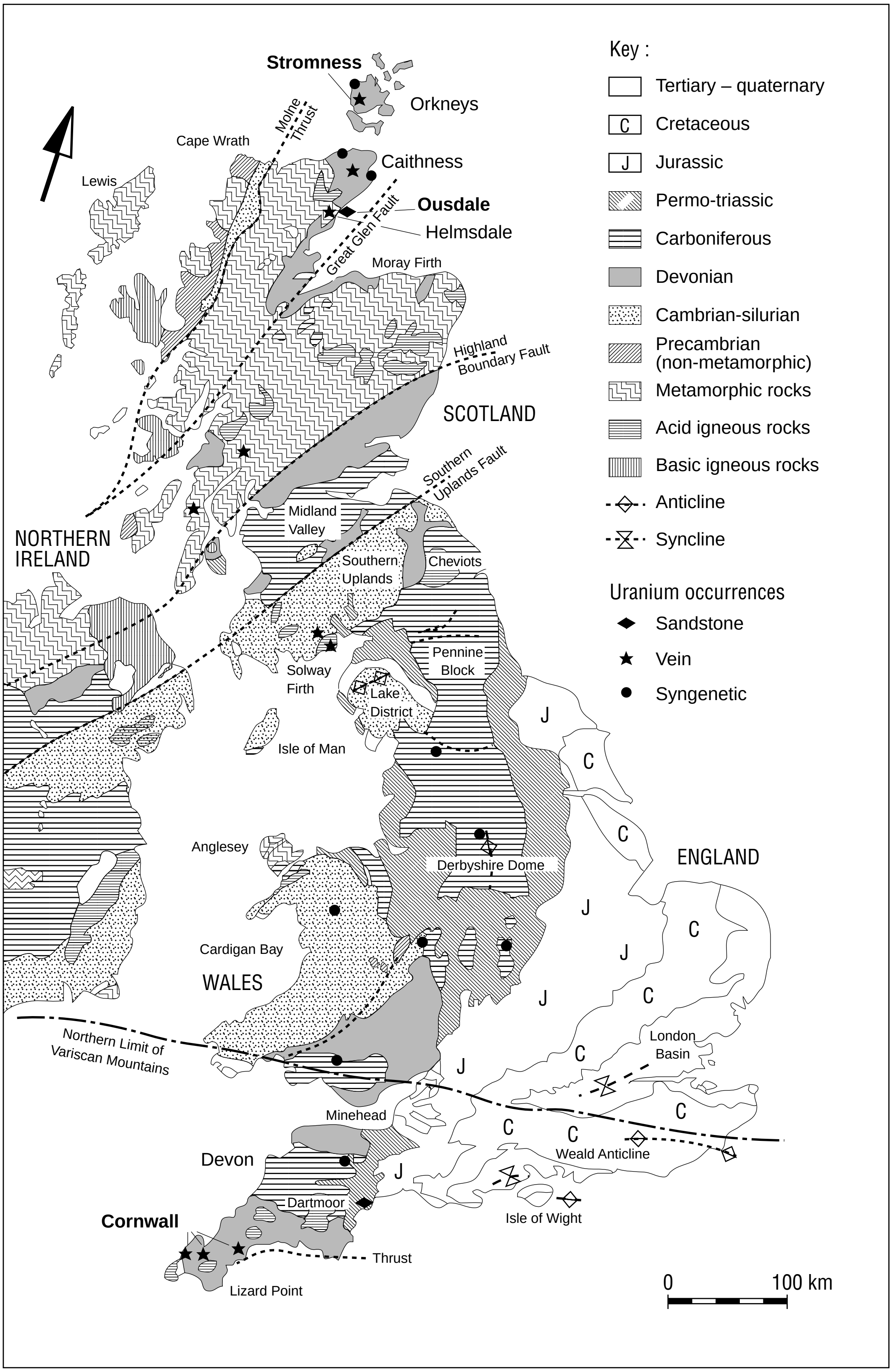
Status of production capability

The United Kingdom is not a uranium producer and is unlikely to become a uranium exporter in the foreseeable future.

URANIUM REQUIREMENTS

The UK's nuclear power stations supplied over 90 TWh in 1998, some 2.0% more than in 1997, and representing about 27% of the electricity generated in the UK in 1998. Total output from British Energy's eight stations for the 97/98 financial year, at 66.7 TWh, confirmed the company's position as the UK's leading generator, with a market share of 21%.

Uranium occurrences in the United Kingdom



Urenco, the UK based British-Dutch-German centrifuge enricher, continued to expand its enrichment capacity through 1998 in line with increased business commitments. In particular, further capacity has entered into operation at Capenhurst, UK, where a new plant was commissioned in December 1997. Total capacity at Urenco plants in all three countries at end 1998 was 3 950 tonnes of separative work per annum.

In April 1994, British Nuclear Fuels plc (BNFL) began construction of the Sellafield MOX Fuel Plant (SMP) which will fabricate mixed oxide (MOX) fuel from a blend of plutonium and uranium. The final decision on whether to commence operation of the SMP is currently awaited. Once operating, the Plant has the capability to produce 120 tonnes of MOX fuel per year.

BNFL's Thermal Oxide Reprocessing Plant (Thorp) at Sellafield in Cumbria began operation in March 1994 and has so far sheared and dissolved more than 2 000 tonnes of spent fuel. Thorp currently has an order book valued at GBP 12 billion over 15 years.

In March 1997, the then Secretary of State for the Environment rejected Nirex' application to construct an underground rock characterisation facility at the site adjacent to BNFL's Sellafield works which it was investigating for its proposed deep disposal facility for intermediate level radioactive waste. Consideration continues to be given to the consequences of this decision for intermediate level waste disposal policy and its implementation.

Supply and procurement strategy

In its latest White Paper on energy, published on 8 October 1998, the government considered that nuclear power "makes a valuable contribution to diversity of supply and emissions reduction". The Paper goes on to say however that the cost of new construction means nuclear power's share of generation is expected to decrease in the first decades of the next century as existing capacity is retired. In the meantime, any proposals for nuclear construction are to be considered against the same objectives as those for other types of stations – the ability to ensure secure, diverse and sustainable supplies of energy at competitive prices.

In 1997 the government announced proposals for the merger of Magnox Electric plc, which owned and operated the UK's six operating and three decommissioning civil magnox stations, and BNFL. The aim of the merger is to improve the arrangements for managing public sector nuclear liabilities by ending the mismatch where BNFL has responsibility for dealing with the majority of magnox liabilities while Magnox meet the costs. The merger is taking place in two key stages, the first of which, transfer of the government's shares in Magnox to BNFL, took place in January 1998. The second stage, full merger of the combined businesses of the two companies is expected to be completed during 1999, subject to the companies meeting the requirements of the relevant regulators.

BNFL is a public limited company wholly owned by the UK government. The government is committed to giving greater commercial freedom to commercial organisations within the public sector. In this light, fresh consideration has been given to options for BNFL's future. In July 1999 the government announced that in principle it had decided that a public private partnership (PPP) would be good for the company, the employees, the UK taxpayer, and the wider community. The PPP will depend on BNFL achieving a range of safety, health, environmental, and business performance targets. Subject to BNFL's progress towards these targets, the government will look to introduce the PPP into BNFL before the end of the current Parliament.

The process of integrating Nuclear Electric Ltd and Scottish Nuclear Ltd, who between them operated the UK's seven AGR stations and one PWR station, has been concluded; the two companies now trade under the name of British Energy.

BNFL Uranium Asset Management Company Limited (UAM) was established in 1996 as a 100% owned subsidiary company of BNFL with the mandate to control all of BNFL's uranic supply requirements. Following the integration of Magnox Electric into BNFL in January 1998, UAM is now responsible for the supply of uranic materials for all the operating magnox stations as well as for two of British Energy's AGR stations in Scotland. British Energy retains responsibility for supplying five AGRs plus the PWR at Sizewell B.

In June 1998 the government announced that commercial reprocessing at Dounreay would cease. The reprocessing plants will continue to operate, subject to the necessary regulatory consents, only for as long as necessary to deal with the existing liabilities and committed work. No new commercial contracts for reprocessing at Dounreay will be accepted. Supply and procurement strategy continues to utilise excess stocks where they exist and to seek a measure of supply diversity whilst maintaining the lowest cost of supply possible.

URANIUM POLICIES

No changes to uranium policy were reported in the United Kingdom. As regards the current policy on participation of private and foreign companies, the UK Atomic Energy Act 1946 gives the Secretary of State for Trade and Industry wide-ranging powers in relation to uranium resources in the United Kingdom, in particular to obtain information (section 4), to acquire rights to work minerals without compensation (section 7), to acquire uranium mined in the United Kingdom on payment of compensation (section 8), and to introduce a licensing procedure to control or condition the working of uranium (section 12A).

There are no specific policies relating to restrictions on foreign and private participation in uranium exploration, production, marketing and procurement in the United Kingdom nor exploration activities in foreign countries. There is no national stockpile policy in the UK. Utilities are free to develop their own policy. Exports of uranium are subject to the Export of Goods (Control) Order 1970 (SI No. 1 288), as amended, made under the Import, Export and Customs Powers (Defence) Act 1939.

URANIUM STOCKS

As mentioned above, the UK stockpile practices are the responsibility of the individual bodies concerned. Actual stock levels are commercially confidential.

URANIUM PRICES

Uranium prices are commercially confidential in the United Kingdom.

• United States •

URANIUM EXPLORATION

Historical review

From 1947 through 1970, the development of a private-sector uranium exploration and production industry in the United States was fostered by the U.S. Atomic Energy Commission (AEC) to procure uranium for the U.S. Government, continue development of atomic energy for military uses, and to promote research and development for peaceful applications of atomic energy. In late 1957, when private-industry exploration was increasing and new deposits were being brought into production, the AEC ended its uranium exploration efforts. The Government has continued a programme to monitor private-sector uranium exploration and development activities and to periodically assess uranium reserves and resources commensurate with requirements for Federal policy-option evaluations and for basic information.

Exploration by the domestic industry increased rapidly in the 1970s in response to rising uranium prices and the projected large demand for uranium to fuel an increasing number of nuclear reactors being built or planned for civilian electric power stations. The peak total surface drilling (exploration and development) was reached in 1978, when 14 700 km of bore hole drilling were completed. During the period from 1966 through 1982, U.S. surface drilling totalled some 116 400 km in the search for new uranium deposits. From 1983 through 1997, industry has completed an additional 9 860 km of surface drilling. Surface drilling is the primary method of delineating uranium deposits, and the total for annual drilling has proved to be a reliable indicator of overall U.S. exploration activity.

In the United States, exploration has been primarily for sandstone-based uranium deposits in districts such as the Grants Mineral Belt and Uravan Mineral Belt of the Colorado Plateau region and in the Wyoming Basins and Texas Gulf Coastal Plain regions. Vein-type and other structure-controlled deposits were developed in the Front Range of Colorado, near Marysvale in Utah, and in northeastern Washington State. Since 1980, large sandstone-hosted deposits have been mined in northwestern Nebraska, and additional relatively high-grade deposits associated with breccia-pipe structures have been mined in northern Arizona. A large deposit was discovered in southern Virginia in the early 1980s, but a moratorium imposed on uranium mining by the State has pre-empted its exploitation.

Recent and ongoing uranium exploration and mine development activities

Total U.S. surface drilling (exploration and development) completed during 1998 was 1 415 kilometres, a decrease of 5% below the 1997 total. The 1998 total does not include drilling completed for uranium production control at in situ leach, underground, and open pit mine projects.

In 1998, U.S. industry companies reported exploration expenditures of USD 21.7 million, a decrease of 29% from the level reported for 1997. Of the total expenditures, “other exploration” accounted for USD 3.50 million (16%), “surface drilling” for USD 18.08 million (83%), and “land acquisition” activities for USD 0.15 million (< 1%). There were no exploration expenditures by the U.S. Government during 1998. Foreign participation in U.S. exploration declined to USD 0.27 million and accounted for only 1% of total exploration expenditures in 1998.

The total area of land held for uranium exploration at the end of 1998 in the United States by domestic and foreign companies was about 3 339 km^2. Companies acquired only about 26 km^2 for exploration during 1998, a sharp decrease from the total land acquired in 1997 (2 226 km^2). The U.S. Government does not reserve land for uranium exploration, and it does not provide financial assistance for that purpose.

Uranium exploration expenditures and drilling effort – domestic

(currency reported USD 1 000)

	1996	1997	1998	1999 (Expected)
Industry exploration expenditures	1 602	3 544	2 261	NA
Government exploration expenditures	0	0	0	0
Sub-total exploration expenditures	1 602	3 544	2 261	NA
Sub-total development expenditures	5 549	16 448	15 814	NA
Total expenditures*	**10 054**	**30 426**	**21 724**	**NA**
Industry exploration drilling in metres**	269	405	271	NA
Number of industry exploration holes drilled	1 118	1 935	1 370	NA
Sub-total exploration drilling	269	405	271	NA
Sub-total exploration holes	1 118	1 935	1 370	NA
Sub-total development drilling	659	1 083	1 144	NA
Sub-total development holes	3 577	5 858	5 231	NA
Total drilling in metres	**928**	**1 488**	**1 415**	**NA**
Total number of holes	**4 695**	**7 793**	**6 601**	**NA**

* Includes land acquisition and other exploration and development costs not broken out by category.
** Rounded to nearest thousand metres.
NA Not available.

Uranium exploration expenditures and drilling effort – abroad

(currency reported USD 1 000)

	1996	1997	1998	1999 (Expected)
Industry exploration expenditures	422	3 050	3 616	NA
Government exploration expenditures	0	0	0	0
Sub-total exploration expenditures	422	3 050	3 616	NA
Sub-total development expenditures	NA	NA	NA	NA
Total expenditures	**422**	**3 050**	**3 616**	**NA**

NA Not available.

URANIUM RESOURCES

Known conventional resources (RAR)

For the United States, the estimate of RAR for the $80/kgU category at year-end 1998 was 106 000 tU, a decrease of about 4 000 tU below the level reported for the same resource category in the 1997 Red Book at year-end 1996. The estimate of RAR for the $130/kg U at year-end 1998 was 355 000 tU, a decrease of about 6 000 tU below the level reported for 1996.

For 1998, active uranium mine properties and other selected properties were re-evaluated to account for annual production and to incorporate updated costs and mining technology information. The result was a reduction in identified resources for each cost category. The 1998 RAR estimates have been adjusted to account for mining dilution and processing losses.

Undiscovered conventional resources (EAR & SR)

United States estimates for 1998 for EAR and SR are unchanged from 1996. It should be noted that the United States does not separate EAR as EAR-I and EAR-II.

URANIUM PRODUCTION

Historical review

Following the passage of the Atomic Energy Act of 1946, designed to meet the U.S. Government’s uranium procurement needs, the Atomic Energy Commission (AEC) from 1947 through 1970 fostered development of a domestic uranium industry, chiefly in the western United States, through incentive programmes for exploration, development, and production. To assure that the supply of uranium ore would be sufficient to meet future needs, the AEC in April 1948 announced a domestic ore procurement programme designed to stimulate prospecting and to build a domestic uranium mining industry. The AEC also negotiated concentrate procurement contracts, pursuant to the Atomic Energy Acts of 1946 and 1954, with guaranteed prices for source materials delivered within specified times. Contracts were structured to allow milling companies that built and operated mills the opportunity to amortise plant costs during their procurement-contract period. By 1961, a total of 27 privately owned mills were in operation. Overall, 32 conventional mills and several pilot plants, concentrators, up graders, heap-leach, and solution-mining facilities were operated at various times. The AEC, as the sole Government purchasing agent, provided the only U.S. market for uranium. Many of the mills were closed soon after completing deliveries scheduled under AEC purchase contracts, though several mills continued to produce concentrate for the commercial market after fulfilling their AEC commitments. The Atomic Energy Act of 1954 made lawful the private ownership of nuclear reactors for commercial electricity generation. By late 1957, domestic ore reserves and milling capacity were sufficient to meet the Government’s needs. In 1958, the AEC’s procurement programmes were reduced in scope, and, in order to foster utilisation of atomic energy for peaceful purposes, domestic producers of ore and concentrate were allowed to sell uranium to private domestic and foreign buyers. The first U.S. commercial-market contract was finalised in 1966. The AEC announced in 1962 a “stretch out” of its procurement programme that committed the Government to take only set annual quantities of uranium for 1967 through 1970: this also assisted in sustaining a viable domestic uranium industry. The U.S. Government's natural uranium procurement programme was ended on 31 December 1970, and the industry became a private-sector, commercial enterprise with no Government purchases.

Since 1970, domestic uranium production has supported the commercial market. After achieving peak production of 16 800 tU in 1980, the U.S. industry experienced generally declining annual production between 1981 and 1993. U.S. uranium concentrate production from 1994 through 1996 increased each year. Concentrate production in 1997 was 2 171 tU, which was nearly 11% less than in 1996. Production in 1998 was 1 810 tU, which was nearly 17% below the level reported for 1997. In situ leach mining and other non-conventional technologies for uranium recovery have dominated U.S. production since 1991. Non-conventional production was 1 685 tU in 1998 and came largely from six in situ leach plants in Nebraska, Texas, and Wyoming and one by-product plant in Louisiana. Uranium was recovered also in 1997 from mine water (one mill, New Mexico) and from site clean-up materials (one mill, Washington). One conventional mill was operated during 1997, but it was again placed on standby status late in 1997. Three U.S conventional mills recovered uranium from waste stream materials and from mine water during 1998.

Status of production capability

At the end of 1998, no conventional uranium mills were being operated in the United States; six mills with a combined capacity of 13 060 tonnes of ore per day were on standby. At year end, the status of the 14 non-conventional plants (combined capacity 4 860 tU/year) in the United States was as follows: 6 in situ leach plants (combined capacity 3 060 tU/year) and 1 by-product plant (capacity 290 tU/year) were being operated; the remaining plants (4 in situ leach and 3 by-product) were being maintained in standby mode.

Ownership structure of the uranium industry

Foreign privately held firms accounted for the largest part of the total U.S. uranium concentrate production in 1998; firms controlled by foreign governments and by U.S. privately-held firms accounted for the remainder.

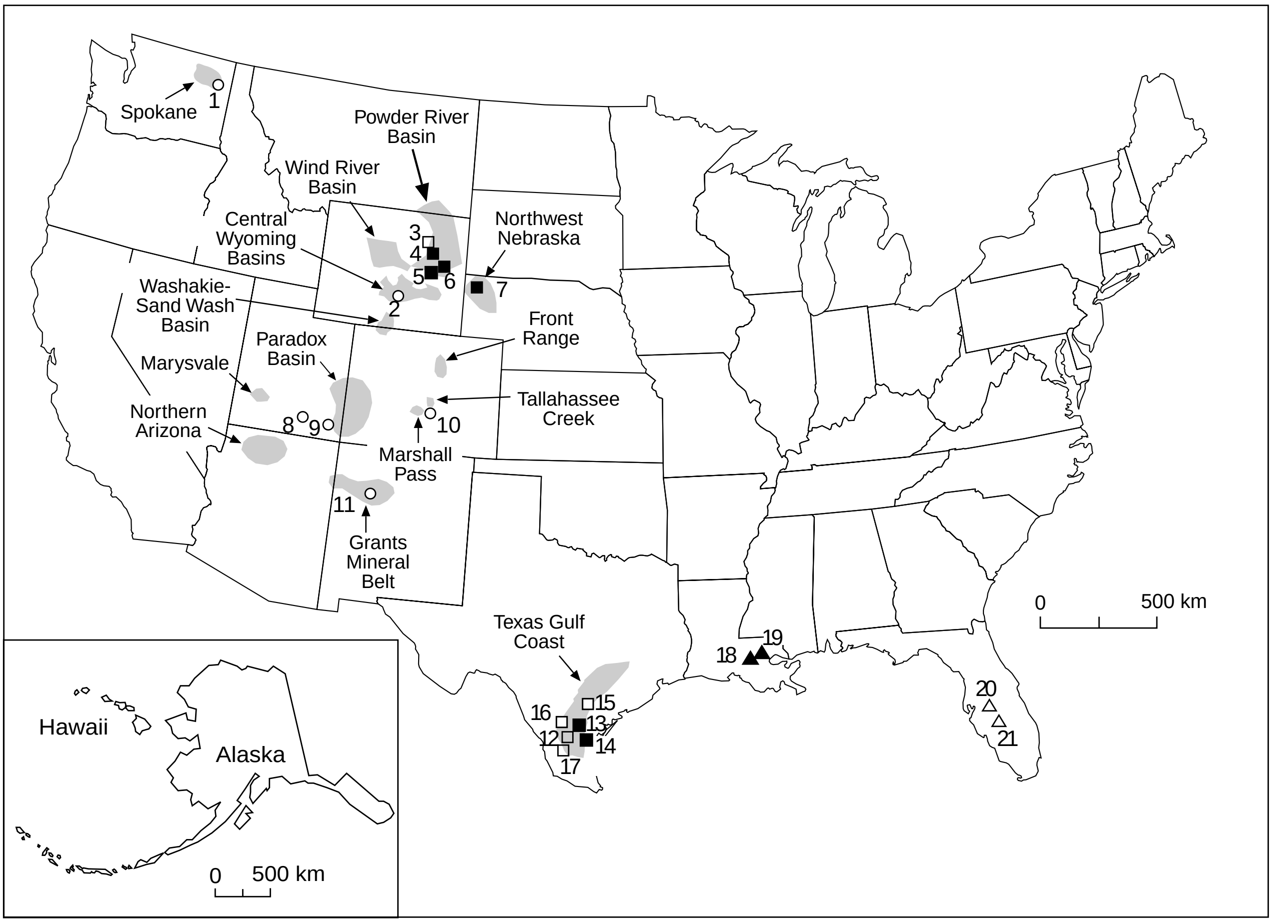
Uranium production for 1998 attributed according to the percentages of ownership for firms that owned and operated production facilities is shown below:

Foreign private ownership:	52%
U.S. private ownership:	33%
Foreign government ownership:	15%

Employment in the uranium industry

In the U.S. uranium raw materials industry, employment (person-years expended) increased each year in the period 1993-1998. Total employment for combined activities "exploration-mining-milling-processing" increased to 911 person years in 1998 from 793 in 1997 person years, an upturn of 15%. Reclamation activities during 1998 decreased 31%, from 303 person years in 1997 to 209 person years in 1998.

Major uranium reserve areas and status of mills and plants, 1998



Active at the end of 1998

4. Malapai Resources, Christensen Ranch
5. Rio Algom Mining, Smith Ranch
6. Converse County Mining Venture, Highland
7. Crow Butte Resources, Crow Butte
13. Uranium Resources, Rosita
14. Uranium Resources, Kingsville Dome
19. IMCAgrico, Uncle Sam

Inactive at the end of 1998

1. Dawn Mining, Ford[a]
2. Green Mountain Mining Venture, Sweetwater
3. Malapai Resources, Irigaray[b]
8. U.S. Energy, Shootaring
9. International Uranium (États-Unis), Whith Mesa[c]
10. Cotter Corp., Canon City
11. Rio Algom Mining, Ambrosia[d]
12. Malapai Resources, Holiday-El Mesquite[b]
15. Everest Minerals, Hobson
16. COGEMA Mining, West Cole[b]
17. Malapai Resources, O'Hem
18. IMC-Agrico, Sunshine Bridge
20. IMC-Agrico, Plant City
21. IMC-Agrico, New Wales

Uranium production centers

Active	Inactive	
●	○	Conventional mill
■	□	In situ leach plant
▲	△	By-product from phosphate processing
	←	Major uranium reserve areas[e]

a. Recovered uranium by processing the waste stream at a mine-water treatment plant during 1998.
b. Recovered uranium by processing water from in situ leach restoration during 1998.
c. Recovered uranium by processing from waste stream materials during 1998.
d. Recovered uranium by processing mine-water solution during 1998.
e. Major areas containing reasonably assured resources at USD 50-per-pound U_3O_8 or less.

Sources: Based on U.S. Department of Energy, Grand Junction Project Office (GJPO), *National Uranium Resources Evaluation*, *Interim Report* (June 1979) Figure 3.2; GJPO data files; Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1998).

Uranium production centre technical details

(as of 1 January 1999)

	Centre # 1	Centre # 2	Centre # 3	Centre # 4
Name of production centre	Ambrosia Lake	Canon City	Christensen Ranch	Crow Butte
Production centre class	Existing	Existing	Existing	Existing
Operational status	Stand-by	Stand-by	In operation	In operation
Start-up date	1958	1979	1989	1991
Source of ore: • Deposit names • Deposit types	 Various Sandstone	 Schwaltzwalder Vein	 Christensen Ranch, Irigaray Sandstone	 Crow Butte Sandstone
Mining operation: • Type (OP/UG/ISL) • Size (tonnes ore/day) • Average mining recovery (%)	 UG NA NA	 UG NA NA	 ISL NA NA	 ISL NA NA
Processing plant: • Type (IX/SX/AL) • Size (tonnes ore/day) (ST ore/day) • Average processing ore recovery (%)	 AL/SX 6 350 7 000 NA	 AL/SX 1 090 1 200 NA	 ISL NA NA NA	 ISL NA NA NA
Nominal production capacity (tU/year) (ST U_3O_8/year)	3 300 4 290	620 810	250 330	380 500
Plans for expansion	Unknown	Unknown	Unknown	Unknown

Uranium production centre technical details *(continued)*

	Centre # 5	Centre # 6	Centre # 7	Centre # 8
Name of production centre	Converse Co. Mining Vent.	Ford	Hobson	Holiday-El Mesquite
Production centre class	Existing	Existing	Existing	Existing
Operational status	In operation	Stand-by	Stand-by	Stand-by
Start-up date	1988	1957	1979	1979
Source of ore:				
• Deposit names	Converse Co. Mining Vent.	Midnite	Various	Various, El Mesquite
• Deposit types	Sandstone	Vein, Disseminated	Sandstone	Sandstone
Mining operation:				
• Type (OP/UG/ISL)	ISL	OP	ISL	ISL
• Size (tonnes ore/day)	NA	NA	NA	NA
• Average mining recovery (%)	NA	NA	NA	NA
Processing plant:				
• Type (IX/SX/AL)	ISL	AL/SX	ISL	ISL
• Size (tonnes ore/day)	NA	410	NA	NA
(ST ore/day)	NA	450	NA	NA
• Average processing ore recovery (%)	NA	NA	NA	NA
Nominal production capacity (tU/year)	770	200	380	230
(ST U_3O_8/year)	1 000	260	500	300
Plans for expansion	Unknown	Unknown	Unknown	Unknown

Uranium production centre technical details *(continued)*

	Centre # 9	Centre # 10	Centre # 11	Centre # 12
Name of production centre	Irigaray	Kingsville Dome	New Wales	Plant City
Production centre class	Existing	Existing	Existing	Existing
Operational status	Stand-by	In operation	Stand-by	Stand-by
Start-up date	1978	1988	1980	1981
Source of ore: • Deposit names • Deposit types	 Irigaray Sandstone	 Kingsville Dome Sandstone	 NA Phosphorite	 NA Phosphorite
Mining operation: • Type (OP/UG/ISL) • Size (tonnes ore/day) • Average mining recovery (%)	 ISL NA NA	 ISL NA NA	 OP NA NA	 OP NA NA
Processing plant: • Type (IX/SX/AL) • Size (tonnes ore/day) (ST ore/day) • Average processing ore recovery (%)	 ISL NA NA NA	 ISL NA NA NA	 DEPA/TOPO NA NA NA	 DEPA/TOPO NA NA NA
Nominal production capacity (tU/year) (ST U_3O_8/year)	130 180	500 650	290 380	230 300
Plans for expansion	Unknown	Unknown	Unknown	Unknown

Uranium production centre technical details *(continued)*

	Centre # 13	Centre # 14	Centre # 15	Centre # 16
Name of production centre	Rosita	Shootering	Smith Ranch	Sunshine Bridge
Production centre class	Existing	Existing	Planned	Existing
Operational status	In operation	Stand-by	In operation	Stand-by
Start-up date	1990	NA	1986	1981
Source of ore: • Deposit names • Deposit types	 Rosita (Rogers) Sandstone	 Various Sandstone	 Smith Ranch Sandstone	 NA Phosphorite
Mining operation: • Type (OP/UG/ISL) • Size (tonnes ore/day) • Average mining recovery (%)	 ISL NA NA	 UG NA NA	 ISL NA NA	 OP NA NA
Processing plant: • Type (IX/SX/AL) • Size (tonnes ore/day) (ST ore/day) • Average processing ore recovery (%)	 ISL NA NA NA	 AL/SX 680 750 NA	 ISL NA NA NA	 DEPA/TOPO NA NA NA
Nominal production capacity (tU/year) (ST U_3O_8/year)	380 500	380 750	100 130	160 210
Plans for expansion	Unknown	Unknown	Unknown	Unknown

Uranium production centre technical details *(continued)*

	Centre # 17	Centre # 18	Centre # 19	Centre # 20
Name of production centre	Sweetwater	Uncle Sam	West Cole	White Mesa
Production centre class	Existing	Existing	Existing	Existing
Operational status	Stand-by	In operation	Stand-by	Stand-by
Start-up date	1981	1978	1981	1980
Source of ore: • Deposit names • Deposit types	Various Sandstone	NA Phosphorite	Various Sandstone	Various Sandstone
Mining operation: • Type (OP/UG/ISL) • Size (tonnes ore/day) • Average mining recovery (%)	OP/UG NA NA	OP NA NA	ISL NA NA	UG NA NA
Processing plant: • Type (IX/SX/AL) • Size (tonnes ore/day) (ST ore/day) • Average processing ore recovery (%)	AL/SX 2 720 3 000 NA	DEPA/TOPO NA NA NA	ISL NA NA NA	AL/SX 1 810 2 000 NA
Nominal production Capacity (tU/year) (ST U_3O_8/year)	350 –	290 380	80 100	1 650 2 140
Plans for expansion	Unknown	Unknown	Unknown	Unknown

Notes: Conversion factors: 1 short ton U_3O_8 = 0.769 metric tU.

UG:	Underground mine(s)
OP:	Open-pit mine(s)
AL/SX:	Acid Leach/Solution Exchange
ISL:	In situ leach mine(s)
DEPA:	Di (2-ethyl-hexyl) phosphoric acid
TOPO:	Tri octyl phosphine oxide
NA:	Not Available
t ore/day:	Tonnes of ore per day, rounded to nearest 10 tonnes
ST ore/day:	Short tons of ore per day, rounded to nearest 10 tons
tU/year:	Tonnes U per year, rounded to nearest 10 tonnes
ST U_3O_8/year:	Short tons of U_3O_8 per year, rounded to nearest 10 tons
–:	Not applicable. Original value in SI units.

Future production centres

In 1992, Rio Algom's Smith Ranch in situ leach property in Wyoming was licensed for commercial operation. The property is on standby status and no production start-up date has been announced. In 1993, Pathfinder Mines was granted a commercial uranium production license for its North Butte-Ruth in situ leach project in Wyoming; a start-up date for that project has not been announced.

ENVIRONMENTAL CONSIDERATIONS

The Uranium Mill Tailings and Radioactive Control Act of 1978 (UMTRA) vests the U.S. Environmental Protection Agency (EPA) with overall responsibility for establishing standards for decommissioning of uranium production facilities. Under UMTRA the U.S. Nuclear Regulatory Commission (NRC) has the responsibility for licensing and regulating uranium production and related activities, including decommissioning. In the United States, regulatory control is achieved through the NRC licensing procedure, wherein a licensee, before issuance of a license, is required to present a decommissioning plan to the NRC. When the plan is approved, a licensee is required to post a surety to guarantee that adequate funding will be available to finalise eventual site reclamation and provide for its long-term monitoring when responsibility for the site passes to the U.S. Department of Energy or to the appropriate agency of the State concerned. A study published in 1995 of U.S. reclamation projects found that, on average, reclamation of uranium mill tailings accounted for approximately 54% of overall decommissioning costs for conventional uranium mill sites. For 33 conventional mill site reclamation projects, the average decommissioning costs incurred was USD 14.1 million: USD 7.7 million for tailings reclamation, USD 2.3 million for groundwater restoration, USD 0.9 million for mill dismantling, and USD 3.2 million for indirect costs. For reclamation of U.S. non-conventional (in situ leach) sites, the greater share (40%) of decommissioning costs were incurred for groundwater restoration work. The average cost for decommissioning non-conventional sites was USD 7.0 million, of which USD 2.8 was incurred for groundwater restoration, USD 0.9 million for well field reclamation, USD 0.6 for dismantling of buildings and plant structures, USD 1.2 million for reclaiming evaporation ponds, disposal wells, radiometric surveys, etc., and USD 1.4 million for indirect costs.

Reclamation of some U.S. abandoned uranium production facilities, including mine plant and spoil sites, is also performed by State agencies. These activities are authorised and funded under Title IV, the Abandoned Mine Land Programme, of the Federal Surface Mining Control and Reclamation Act of 1977 (SMCRA). Data relating to reclamation of uranium production sites under the SMCRA legislation are compiled by the various State agencies.

Current data for the work performed since 1994 under UMTRA and State-level data for work completed under SMCRA have not been compiled.

URANIUM REQUIREMENTS

In 1997, the Maine Yankee and the Big Rock Point plants were permanently closed. In 1998, the Millstone 1 and the Zion 1 and Zion 2 plants were permanently closed.

Annual uranium requirements for the period out through 2015 are projected to peak at 18 100 tU in 1999 and to then decline through 2015. By 2015, annual requirements are projected to decline to about 11 200 tU (reference case), in line with the anticipated closings of nuclear power plants for which operating licenses will not be renewed, and 2 300 tU in a low case.

Supply and procurement strategy

There is no national policy in the United States on uranium supply or on uranium procurement. Decisions about uranium production, supply, and sales and purchases are made solely in the private sector by firms involved in the domestic uranium mining and nuclear power industries.

NATIONAL POLICIES RELATING TO URANIUM

Since 1991, the United States has restricted uranium imports from the former Soviet Union republics. At the end of 1998, agreements were in place with the Russian Federation, Kyrgystan, and Uzbekistan whereby imports from these republics would be limited in exchange for the suspension of antidumping investigations by the U.S. Department of Commerce (DOC). The suspension agreement with the Russian Federation requires that under a specific quota, an import of Russian-origin uranium or separative work units (SWU) in a U.S. market transaction must be matched with a corresponding quantity of newly produced U.S. origin uranium or SWU. The suspension agreement with Uzbekistan established an import quota based on levels of U.S. uranium production. Uranium mined in the Russian Federation or Uzbekistan for sale in the United States is counted directly against each country's quota, notwithstanding whether the material has been imported as natural uranium or as feed component in a third-country-enriched product. An import quota has not been determined for Kyrgystan because no uranium mining had taken place in that country since the antidumping investigations were initiated

Kazakhstan, Tajikistan, and Ukraine have terminated prior suspension agreements with the DOC. By terminating the suspension agreements, these countries accepted the imposition of tariffs by the DOC. In July 1999, the U.S. International Trade Commission (ITC) ruled that uranium imports from Kazakhstan did not harm the uranium industry of the United States. ITC's ruling gives Kazakhstan free access to the U.S. market. However, tariffs remain in place for uranium imports from Tajikistan and Ukraine.

Under U.S. law, the natural uranium component of LEU derived from HEU taken from dismantled Russian nuclear warheads is deemed to be of Russian origin. To provide for the delivery of Russian HEU-derived natural uranium to U.S. consumers, a direct quota, separate from the antidumping suspension agreement with the Russian Federation, was set by the USEC Privatisation Act. That quota increases incrementally from 769 tU equivalent in 1998 to 7 690 tU equivalent in 2009. Since late 1997, the DOC has developed procedures for administering and enforcing the quota for Russian HEU-derived natural uranium. No restrictions, however, have been placed on the SWU component of LEU derived from Russian HEU.

HEU Agreement

In February 1993, the United States and the Russian Federation signed *The Agreement between the Government of the United States and the Government of the Russian Federation Concerning the Disposition of Highly Enriched Uranium Extracted from Nuclear Weapons* (the Russian HEU Agreement). The Russian HEU Agreement provided for the United States to purchase 500 metric tons of Russian HEU over a 20-year period. In November 1995, the first fuel derived from HEU taken from dismantled nuclear weapons was delivered to a U.S. utility. The United States Enrichment Corporation (USEC), the U.S. executive agent for the Russian HEU Agreement, currently purchases only the SWU component of the LEU derived from HEU for sale to its commercial customers. USEC returns the equivalent natural uranium component of the LEU to the Russian executive agent for the Russian HEU Agreement.

In March 1999, a consortium of Western uranium suppliers and the Russian government signed a contract involving the natural uranium feed component of the LEU derived from Russian HEU. Of the 9 100 tonnes U in HEU feed to be made available per annum, the Western suppliers have an option to purchase up to 6 700 tonnes U from the Russian Federation. Uranium not used by the Western suppliers or the Russian Federation will be stockpiled for future use as specified in the contract. To facilitate the signing of the Russian HEU feed contract, the United States Government agreed in 1998 to delay the sale of certain U.S. Department of Energy (DOE) inventories for 10 years and to purchase HEU feed from the Russian Federation that was stockpiled in 1997 and 1998. The sale of the Russian HEU feed acquired by the U.S. Government would also be delayed for 10 years. Bilateral agreements were reached between the United States and the Russian Federation to permit the transport of the HEU feed to the United States from the Russian Federation.

U.S. HEU

The DOE and Tennessee Valley Authority (TVA) signed a letter of intent in April 1999 whereby TVA would utilize LEU derived from blending down U.S. surplus HEU. This LEU is considered "off-specification" because it contains 236U in excess of the specifications established for commercial nuclear fuel. In May 1999, four lead test assemblies of the off-specification LEU were loaded into unit 2 of the Sequoyah Nuclear Power Plant. TVA plans to fuel its nuclear reactors with the off-specification LEU derived from U.S. HEU by 2003. The blending down of approximately 50 tonnes HEU transferred from DOE to USEC was scheduled to begin in 1999. The transfer was authorized by the USEC Privatization Act. Both sides of the HEU blending point will be available for safeguard monitoring by the IAEA.

URANIUM STOCKS

At the end of 1998, total commercial stocks of uranium (natural and enriched as uranium equivalent) were about 52 910 MT U, an increase of 29% above that category at the end of 1997. Utility held stocks at year-end 1998, about 25 730 MT U, increased by 2% from year-end 1997, and supplier stocks at year-end 1998, about 27 180 MT U, increased by 75% over the same period. Supplier reported enriched uranium stocks at year-end 1998 were about 13 790 MT U, and increase of about 19% above the level held at year-end 1997. Uranium stocks held by the Government and the U.S. Enrichment Corporation at the end of 1998 were about 9 410 MT U natural uranium stocks, which was about 54% below year-end 1997. Their enriched uranium stocks were 0 at year end 1997 and 1998.

Total uranium stocks*

(tonnes natural U-equivalent)

Holder	Natural uranium stocks in concentrates	Enriched uranium stocks	Depleted uranium stocks	Reprocessed uranium stocks	Total
Government	9 410	0	NA	NA	9 410
Producer	13 390	13 790	NA	NA	27 180
Utility	16 280	9 450	NA	NA	25 730
Total	**39 080**	**23 240**	**NA**	**NA**	**62 320**

* Preliminary data for 1998. Totals are rounded to the nearest 10 tonnes U.
Note: Totals might not equal sum of components because of independent rounding.

URANIUM PRICES

Average US uranium prices, 1990-1998 (US dollars per kilogram U equivalent)		
Year	Domestic utilities from domestic suppliers	Domestic utilities/suppliers from foreign suppliers
1998	31.99	29.08
1997	33.46	30.69
1996	35.91	34.19
1995	28.89	26.52
1994	26.79	23.27
1993	34.17	27.37
1992	34.96	29.48
1991	35.52	40.43
1990	40.82	32.63

Prices shown are quantity-weighted averages (nominal US dollars) for all primary transactions (domestic – and foreign-origin uranium) for which prices were reported.

• Uzbekistan •

URANIUM EXPLORATION AND MINE DEVELOPMENT

Historical review

Uranium exploration in Uzbekistan pre-dates the 1945 start-up of the uranium mining at the small vein deposits (Shakaptaz, Uiguz Sai, and others) in the Fergana valley of eastern Uzbekistan. Exploration, including airborne geophysical surveys, ground radiometry, underground workings, etc., conducted during the early 1950s, over the remote Kyzylkum desert in central Uzbekistan, led to the discovery of uranium in the Uchkuduk area. Drilling confirmed the initial discovery and development of the first open pit mine at Uchkuduk began in 1961.

Following the development of a model for uranium deposits hosted by unconsolidated oxidised Meso-Cenozoic sediments, core drilling and a range of geophysical bore hole logging methods became the main exploration tools for exploring the sedimentary environment. Based on the knowledge of the deposit characteristics and using the improved drilling techniques, large areas in the Karakata depression located in the Bukinai area and the southern rim of the Zirabulak-Ziaetdin mountains were explored. This led to the discovery of major sandstone uranium deposits including Bukinai, Sabyrsai, Yuzhny (Northern) Bukinai, Sugraly, Lavlakan, and Ketmenchi. In addition, exploration for uranium deposits in metamorphic schists in the Auminza-Beltau and Altyntau areas started in 1961. This resulted in the discovery of the Rudnoye and Koscheka U-V-Mo deposits.

The development of the in situ leach (ISL) mining technique for the recovery of uranium from sandstone-type deposits in the beginning of the 1970s led to a re-evaluation of those previously ignored deposits including Lavlakan and Ketmenchi, and to an increase of exploration efforts in the sedimentary environments of the Central Kyzylkum desert.

Exploration concentrated upon the northwest portion of the Nuratau mountains, as well as upon the southeastern part of the Zirabulak-Ziaetdin mountains. The discoveries made in these areas include the Alendy, Severny and Yuzhny (South) Kanimekh deposits (Nuratau mountains) and the Shark and Severny (North) Maizak deposits (Zirabulak-Ziaetdin mountains).

One of the main technical achievements at this time was the recognition of the polymetallic nature of the sandstone-type uranium deposits. This led to the recovery of the by-products selenium, molybdenum, rhenium and scandium.

Uranium exploration is the responsibility of two organisations. Exploration in and around known deposits is the responsibility of the geological division of the production company. Exploration in new areas is the mandate of the Krasnokholms exploration organisation. Since the beginning of the 1990s, drilling has been limited to the delineation of known deposits and to the search for the extension of known deposits.

Since 1994, the Navoi Mining and Metallurgical Complex (NMMC) have funded all uranium exploration activities. These activities include both the exploration in and around known deposits and the search for new deposits, carried out by the Krasnokholms Exploration Organisation and later by its successor, the State Geological Company Kyzyltepageologia.

Recent and ongoing uranium exploration and mine development activities

In 1997-1998, SGE Kyzyltepageologia evaluated the known resources (RAR and EAR-I) of the Kendykijube, Severny Kanimekh, Tokhumbet and Ulus deposits. Drilling to further determine the RAR and EAR-I was expected to continue in 1999 on the Kyzyltepageogogiya deposit of the Northern Mining Division, and on the Tokhumbet deposit of Mining Division No. 5 near Nurabad.

The following tables provide statistical data on uranium exploration between 1996 and 1999. It includes the activities and expenditures of both the industrial organisation NMMC and the government exploration branch Kyzyltepageologia.

Uranium exploration expenditures and drilling statistics

	1996	1997	1998	1999 (Expected)
Industry expenditures (sum x 1 000)*	253 655	459 673	543 866	587 720
Government expenditures (sum x 1 000)	0	0	0	0
Development expenditures (sum x 1 000)	542 980	862 009	1 180 784	1 467 738
Total expenditures (sum x 1 000)	796 635	1 321 682	1 724 650	2 055 458
Total expenditures (USD x 1 000)	22 067	21 955	19 652	18 686
Industry surface drilling in metres*	121 946	168 471	183 525	201 230
Number of industry holes drilled	539	552	588	670
Government surface drilling in metres	0	0	0	0
Number of government holes drilled	0	0	0	0
Development drilling in metres	303 985	350 154	347 871	481 540
Number of development holes drilled	1 563	1 736	1 728	2 427
Total surface drilling in metres	425 931	518 625	531 396	682 820
Total number of holes drilled	2 102	2 288	2 316	3 097

* By state-owned companies.

Expenditures and drilling activities of the state geological enterprise “Kyzyltepageologia”

	1996	1997	1998	1999 (Expected)
Expenditures in sum (x 1 000)	204 000	432 350	490 333	495 383
Expenditures in USD (x 1 000)	5 651	7 182	5 587	4 503
Surface drilling in metres	81 409	136 907	128 978	120 000
Number of holes drilled	423	456	432	420

Expenditures and drilling activities of NMMC

	1996	1997	1998	1999 (Expected)
Expenditures in sum (x 1 000) Expenditures in USD (x 1 000)	49 655 1 375	27 323 454	53 533 610	92 377 840
Surface drilling in metres	40 537	31 564	54 547	71 230
Number of holes drilled	116	96	156	230

URANIUM RESOURCES

Uzbekistan's uranium resources occur in a large number of uranium deposits some of which have been depleted. All of the significant resources are in the central Kyzylkum area, comprising a 125 km wide belt extending over a distance of about 400 km from Uchkuduk in the northwest, to Nurabad in the southeast. The deposits are located in four districts: Bukantausky or Uchkuduk, Auminza-Beltausky or Zarafshan, West-Nuratinsky or Zafarabad, and Zirabulak-Ziaetdinsky or Nurabad.

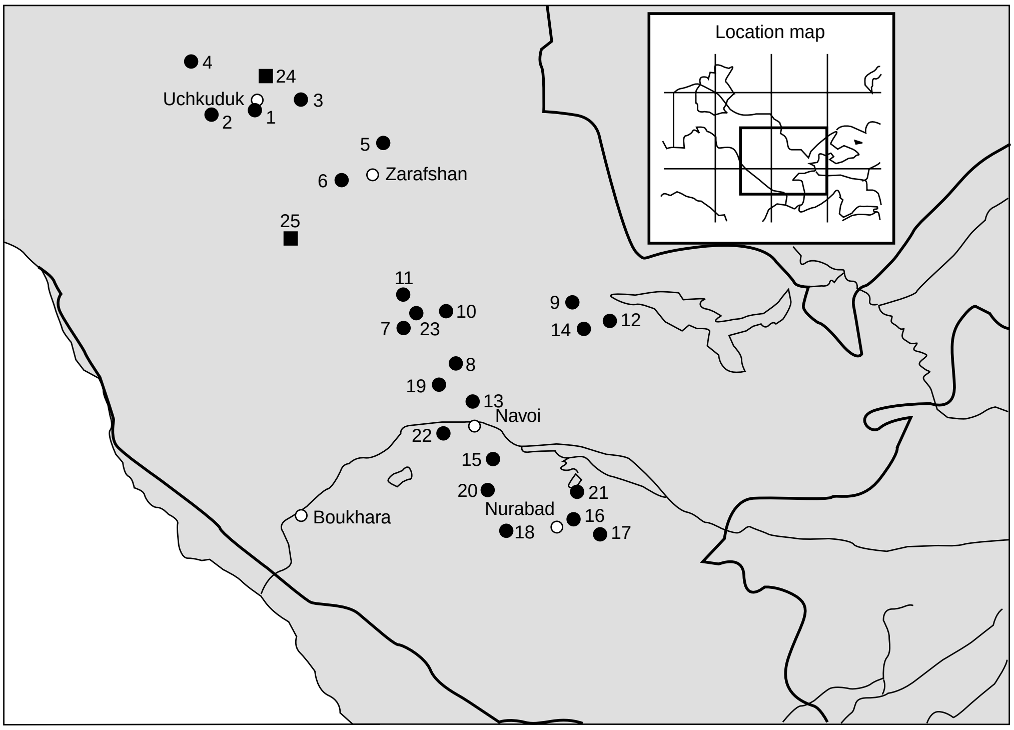
Uranium occurs in two deposit types, referred to as sandstone type and black shale type. The sandstone type occurs in Mesozoic-Cenozoic depressions filled with up to 1 000 m of clastic sediments of Cretaceous, Paleogene and Neogene age. The mineralisation consists of pitchblende and sooty pitchblende with some occasional coffinite. The average ore grades vary between 0.026 and 0.18% U. Associated elements include selenium, vanadium, molybdenum, rhenium, scandium and lanthanides in commercial concentrations. The depth of the ore bodies is between 50 and 610 metres. Twenty-five uranium deposits belonging to this type are reported (see map), and many of these are amenable to ISL extraction techniques.

The black shale type deposits are hosted by metamorphosed and tectonically deformed black carbonaceous and siliceous schists of Precambrian to Lower Paleozoic age. Mineralisation includes uranium-vanadium-phosphate ores. The average uranium grade is between 0.06 and 0.132%, associated with up to 0.024% Mo, 0.1-0.8% V, 68 g Y/tonne and 0.1-0.2 g Au/tonne. The ore bodies occur at depths ranging from 20 to 450 metres. There are 5 deposits of this type (Rudnoye, Koscheka, etc). Most of these deposits could be mined by open pit and processed by heap leaching.

Known conventional resources (RAR & EAR-I)

As of 1 January 1999, the known uranium resources (RAR + EAR-I) recoverable at costs below $130/kgU total 130 078 tU as recoverable resources adjusted for depletion. Compared with the previous estimate as of 1 January 1997, the resource base changed very little. The depletion by production was about balanced by the addition of new reserves.

Uranium deposits of Uzbekistan



Deposits in sandy-argillaceous sediments

1. Uchkuduk
2. Meylisai
3. Kendykijube
4. Bakhaly
5. Aktau
6. Sugraly
7. Severny Bukinai
8. Yuzhny Bukinai
9. Beshkak
10. Alendy
11. Aulbek
12. Terekuduk
13. Yuzhny Kanimekh
14. Varadzhan
15. Sabyrsaj
16. Ketmenchi
17. Shark
18. Agron
19. Severny Kanimekh
20. Tutly
21. Nagornoe
22. Severny Maizak
23. Tokhumbet
24. Ulus

Deposits in crystalline basement

25. Altyntau ore field
26. Auminza-Beltau ore field

Reasonably Assured Resources*

(tonnes U)

Cost ranges		
<$40/kgU	<$80/kgU	<$130/kgU
65 616	65 616	83 085

* As recoverable resources adjusted for depletion.

Estimated Additional Resources – Category I*

(tonnes U)

Cost ranges		
<$40/kgU	<$80/kgU	<$130/kgU
39 852	39 852	46 993

*	As recoverable resources adjusted for depletion.

Of the known resources recoverable at costs below $40/kgU, a total of 65% are tributary to existing and operating production centres.

Known conventional resources and undiscovered conventional resources (in situ)*

(tonnes U – as of 1 January 1999)

Uranium ore region	Deposit types	Category	
		RAR + EAR-I	EAR-II + SR
Bukantausky (Uchkuduk)	Sandstone type Black shale	23 630 33 120	37 382 11 234
TOTAL Bukantausky		**56 750**	**48 616**
Auminza-Beltausky (Zarafshan)	Sandstone type Black shale	45 600 13 880	47 744 42 660
TOTAL Auminza-Beltausky		**59 480**	**90 404**
West-Nuratinsky (Zafarabad)	Sandstone type Black shale	55 820 0	53 542 0
TOTAL West-Nuratinsky		**55 820**	**53 542**
Zirabulak-Ziaetdinsky (Nurabad)	Sandstone type Black shale	13 750 0	50 141 0
TOTAL Zirabulak-Ziaetdinsky		**13 750**	**50 141**
SUBTOTAL	Sandstone type Black shale	138 830 47 000	188 809 53 894
TOTAL		**185 830**	**242 703**

*	As recoverable resources.

The known conventional in situ resources recoverable at costs below $130/kgU are summarised in the following table by uranium district and deposit type. As of 1 January 1999 the total of RAR + EAR-I amounts to 185 800 tU. It shows the significance of the sandstone type deposits, with an aggregate resource base of 138 831 tU corresponding to nearly 75% of the total. Of this 114 700 tU can be mined by in situ leaching at costs below $40/kgU. The remainder of 24 200 tU would require higher costs up to $130/kgU due to complicated mining and technical conditions.

The total RAR + EAR-I of the black shale deposits amount to 47 000 tU, of which 36 000 tU can be extracted by open pit mining with subsequent heap leaching at costs below $40/kgU. The remaining resources of 11 000 tU would require deep mining at higher costs of up to $130/kgU.

Although the results of the last two years exploration work have led to an increase of resources, the grand total remained about the same due to concurrent depletion by mining.

Undiscovered conventional uranium resources (EAR-II & SR)

Total undiscovered in situ resources amount to 242 703 tU, of which 97 594 tonnes are EAR-II recoverable at costs of $130/kgU, while the remaining 145 109 tonnes are SR unassigned to any cost category. Minor changes in the resource status resulted from an upgrading transfer into the EAR-I category. Of the total undiscovered resources, 188 800 tU or nearly 80% are assigned to sandstone-type uranium deposits and are nearly equally divided among the four uranium districts: Bukantausky (Uchkuduk), Auminza-Beltausky (Zarafshan), West-Nuratinsky (Zafarabad) and Zirabulak-Ziaetdinsky (Nurabad). The best potential for black shale deposits is thought to be in the Auminza-Beltausky (Zarafshan) district.

The tables below show the resource categories EAR-II and SR not per in situ but as recoverable resources after deduction of 30% for mining and processing losses.

Estimated Additional Resources – Category II*

(tonnes U)

Cost ranges		
<$40/kgU	<$80/kgU	<$130/kgU
48 254	48 254	68 316

* As in situ resources.

Speculative Resources*

(tonnes U)

Cost Range		Total
<$130/kgU	Unassigned	101 576
–	101 576	

* As in situ resources.

URANIUM PRODUCTION

Historical review

Uranium production in Uzbekistan began in 1946 at several small volcanic hosted vein deposits in the Fergana valley and Kazamazar uranium district. The mines are no longer in operation and the deposits are depleted. The ore was processed in the Lenenabad uranium production centre in Tadjikistan.

Commercial uranium mining began at Uchkuduk in 1958 with the development of both open pit and underground mines. The ore was stockpiled until the completion in 1964 of the hydrometallurgical uranium processing plant in Navoi, located some 300 km southeast of Uchkuduk. The mill and all mines have been operated by NMMC. ISL experiments conducted at this deposit started as early as 1963, leading to the commercial application of ISL in 1965.

Conventional underground mining operations started at the Sabyrsaj and Sugraly deposits in 1966 and 1977, respectively. In 1975 the ISL technique began to replace the underground mining of the Sabyrsaj mine. Conventional underground mining at Sabyrsaj was stopped completely in 1983. The Ketmenchi ISL plant began operation in 1978. In 1994 the reduction of uranium demand led to the closure of the open pit Uchkuduk mine as well as both the underground and ISL Sugraly mines.

Uranium production in the Kyzylkum area peaked in the 1980s when 3 700 to 3 800 tU/year were being produced.

Historical uranium production

(tonnes U)

	Pre-1996	1996	1997	1998	Total to 1998	Expected 1999
Production method						
Conventional mining:						
• Open-pit	36 249	0	0	0	36 249	0
• Underground	19 719	0	0	0	19 719	0
Sub-total	55 968	0	0	0	55 968	0
In situ leaching	30 454	1 459	1 764	1 926	35 603	2 450
TOTAL	86 422	1 459	1 764	1 926	91 571	2 450

Status of production capability

Since 1994, NMMC has been producing uranium using only ISL technology. Operating and planned facilities in 1999-2000 are located at the Kendykijube, Sabyrsaj, Ketmenchi, Severny (North) Bukinai, Yuzhny (South) Bukinai, Lyavlyakan and Beshkak deposits. These ISL centres are organised in three divisions of NMMC. They are referred to as: “Northern Mining Division”, located in Uchkuduk, with the Uchkuduk and Kendykijube centres; as “Southern Mining Division” in Zafarabad with Sabyrsaj and Ketmenchi, and as “Mining Division No. 5” in Nurabad with Severny (North) Bukinai, Yuzhny (South) Bukinai, Lyavlyakan and Beshkak.

The production of the three mining divisions is transported by rail to the central metallurgical plant located at Navoi. The plant has a nominal production capacity of 3 000 tU/year.

The available technical details of the production centres of the three active mining divisions, as well as those of the inactive Eastern Mining Division, are summarised in the following table.

Ownership structure of the uranium industry

NMMC is part of the government holding company Kyzylkumredmetzeloto. Consequently, the entire uranium production of NMMC is owned by the Government of Uzbekistan. All of the 1 926 tU produced in 1998 was government owned.

Employment in the uranium industry

Five towns were constructed on the basis of the uranium production activities: Uchkuduk, Zarafshan, Zafarabad, Nurabad and Navoi. Those towns provide the infrastructure, including roads, railway and electricity, required to support a combined population of 500 000 persons. This population is the source of NMMC's stable and highly skilled work force.

Employment in existing production centres

(persons-years)

1996	1997	1998	Expected 1999
8 201	8 230	8 165	8 230

Future production centres

The future uranium production of Uzbekistan will come entirely from ISL operations. There is no information as to the expected life time of the operating ISL plants. However, it is reported that a new ISL facility at the Severny (North) Kanimekh deposit will be in operation in the near future. NMMC plans to increase production to 2 300 tU in 1999 and then maintain this level to 2004. It will then expand production to 3 000 tU/year in 2005. Uzbekistan then plans to continue uranium production through 2040 at a rate of about 3 000 tonnes/year.

Uranium production centre technical information

(as of 1 January 1999)

Name of production centre	Northern Mining Division	Southern Mining Division	Mining Division No. 5	Eastern Mining Division
Production centre class	Existing	Existing	Existing	Existing
Operational status	Operating	Operating	Operating	Mothballed
Start-up date	1964	1966	1968	1977
Source of ore: • Deposit names	Uchkuduk Kendykijube	Sabyrsaj Ketmenchi	North Bukinai South Bukinai Beshkak Lyavlyakan	Sugraly
• Deposit type	Sandstone	Sandstone	Sandstone	Sandstone
Mining operation: • Type • Size • Average mining recovery (%)	ISL NA 70	ISL NA 75	ISL NA 80	NA NA NA
Processing plant: • Type • Size • Average process recovery (%)	Navoi Acid leaching NA 99.5			
Nominal production capacity (tU/year)	3 000			

Short-term production capability

(tonnes U/year)

1999				2000				2001			
A-I	**B-I**	**A-II**	**B-II**	**A-I**	**B-I**	**A-II**	**B-II**	**A-I**	**B-I**	**A-II**	**B-II**
2 300	2 300	–	–	2 300	2 300	–	–	2 300	2 300	–	–

2005				2010				2015			
A-I	**B-I**	**A-II**	**B-II**	**A-I**	**B-I**	**A-II**	**B-II**	**A-I**	**B-I**	**A-II**	**B-II**
2 300	3 000	–	–	2 300	3 000	–	–	2 300	3 000	–	–

Long-term production capability

Internal plans include the continuation of uranium production through the year 2040 at a level of approximately 3 000 tU/year. An increase of production above this level is not foreseen.

ENVIRONMENTAL CONSIDERATIONS

More than 30 years of uranium production related activities by NMMC have impacted Uzbekistan's natural environment. This includes the areas affected by conventional mining and processing of uranium ores, as well as the operation of in situ leach facilities. In addition to the areas directly affected by these activities, there are surface accumulations comprising an estimated 2.42 million m^3 of sub-economic uranium bearing material. The uranium content of this material is estimated to be 2-5 mg/kg (0.002 to 0.005% U). This is in addition to the 60 million tonnes of tailings located near the Navoi Hydrometallurgical Plant Number 1, and ground water impacted by in situ leach mining. The total area impacted by ISL mining is 13 million m^2. The related contaminated material recovered from the surface of these operations is about 3.5 million m^3.

In order to fully evaluate the extent of any contamination and develop a programme for reclamation and restoration, NMMC is working with Uzbekistan's leading experts, specialists from the Commonwealth of Independent States, as well as with international organisations.

The results of radiation monitoring of NMMC's uranium mining and processing activities indicate that the average annual effective equivalent radiation dose of the critical population group living in these regions does not exceed 1 mSv/year relative to a sum of all radiation-hazard factors.

NMMC’s environmental policy regarding its uranium production activities is to:

- Provide for the ecological safety for all NMMC objects by using the most ecologically acceptable and cleanest in situ leach mining method;
- Close those mining and processing enterprises that are economically and environmentally less effective;
- Isolate and properly dispose of all accumulated radioactive wastes, and;
- Reclaim land disturbed by the enterprise's uranium activities.

To realise these objectives, NMMC has been developing and carrying out a step-by-step programme for evaluating and, where necessary, reclaiming the environment which may have been impacted over more than thirty years of its uranium production operations.

At Navoi's hydrometallurgical plant, a system of wells has been installed to monitor and control potential ground water contamination from the tailings impoundment. Recovered waters are returned to the plant for use in processing. An investigation is underway to obtain the data necessary for the selection and development of a tailings impoundment burial system. Following radioactive decontamination and reclamation of any contaminated lands surrounding the impoundment including the pipeline route from the plant to the impoundment, plans are being made to cover the tailing sites in the 2000 to 2005 period.

URANIUM REQUIREMENTS

As there are no national uranium requirements the whole production is committed for export.

NATIONAL POLICIES RELATED TO URANIUM

As a member of the IAEA, Uzbekistan complies with all international agreements related to the peaceful use of the uranium produced on its territory.

The uranium production is owned by the Republic of Uzbekistan, and private entities including domestic and foreign companies and individuals are not permitted by law to become active in uranium exploration and production.

• Viet Nam •

URANIUM EXPLORATION

Historical review

Uranium exploration in selected areas of Viet Nam has been carried out starting in 1955. Since 1978, a systematic regional exploration programme has been underway throughout the entire country.

About 330 000 km^2, equivalent to almost 100% of the country, have been explored at the 1:200 000 scale using surface radiometric methods combined with geological observations. About 103 000 km^2 (31% of the country) have been explored at the 1:50 000 scale. Nearly 80 000 km^2, or 24% of the country, has been covered by an airborne radiometric/magnetic survey at the 1:25 000 and 1:50 000 scales. Selected occurrences and anomalies have been investigated in more detail by drilling 75 000 m and underground exploration workings.

Recent and ongoing activities

Uranium exploration is being undertaken by the Geological Division for Radioactive and Rare Elements and the Geophysical Division of the Department of Geology and Minerals of the Ministry of Industry. The total staff employed in uranium exploration activities ranges from 300 to 500 people. They work from several regional offices. In 1997, 1998 and 1999 exploration concentrated on the further evaluation of the uranium potential of the Nong Son basin, Quang Nam province. Exploration activities are concentrated on two projects: (1) exploration of sandstone terrain in the Tabhing area, in the western part of the Nong Son basin; and (2) exploration of the An Diem area, where uranium occurrences are present in a volcanic environment.

The following table lists exploration expenditures and drilling statistics for the 1996-1999 period.

Uranium exploration expenditures and drilling statistics

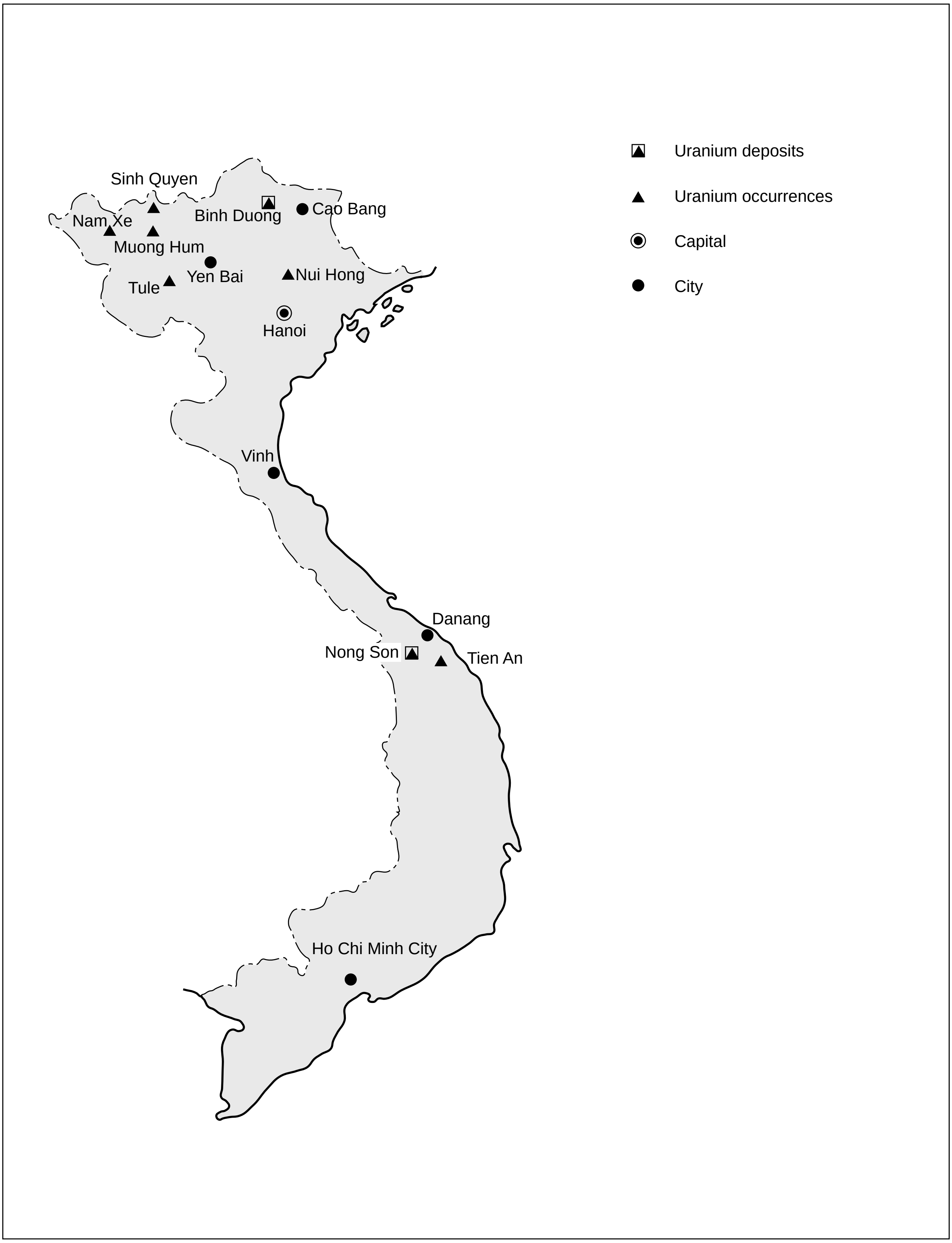
	1996	1997	1998	1999 Expected
Government expenditures (USD x 1 000)	208	227	120	120
Government surface drilling in metres	800	NA	NA	NA

URANIUM RESOURCES

Known conventional resources (RAR & EAR-I)

RAR recoverable at $130/kgU or less, of 1 337 tU, as in situ resources, are reported. EAR-I of 6 744 tU are reported in the Khe Hoa-Khe Cao deposit, Nong Son basin.

Principal uranium deposits and occurrences in Viet Nam



Reasonably Assured Resources *

(tonnes U)

Cost ranges		
<$40/kgU	<$80/kgU	<$130/kgU
NA	NA	1 337

* As in situ resources.

Estimated Additional Resources – Category I*

(tonnes U)

Cost ranges		
<$40/kgU	<$80/kgU	<$130/kgU
NA	491	6 744

* As in situ resources.

Undiscovered conventional resources (EAR-II & SR)

Both the EAR-II and speculative resources are the same as reported in the 1997 Red Book. The EAR-II recoverable at costs below $130/kgU consist mainly of the 5 000 tU in the Tabhing occurrence of the Nong Son basin.

Estimated Additional Resources – Category II*

(tonnes U)

Cost ranges		
<$40/kgU	<$80/kgU	<$130/kgU
NA	NA	5 700

* As in situ resources.

The speculative resources are estimated at 230 000 tU, of which 130 000 tU are not assigned to any cost category (see table).

Speculative Resources*

(tonnes U)

Cost ranges		Total
<$130/kgU	Unassigned	230 000
100 000	130 000	

* As in situ resources.

Unconventional and by-product resources

Unconventional resources are reported to occur in: coal deposits of the Nong Son basin; rare earth deposits; the sedimentary Binh Duong phosphate deposit; and the Tien An graphite deposit.

NATIONAL POLICIES RELATING TO URANIUM

Viet Nam is a country with few fossil fuels. Therefore, in its energy policy for the next century, the Government includes nuclear power as one of the alternatives. The Government is planning to construct a nuclear power plant before 2015. However, no long-term plans for developing a domestic uranium supply have been established.

Annex 1

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Portugal	Ministério da Economia, Instituto Geológico e Mineiro, 38 Rua Almirante Barroso, P-1000 Lisbon
Romania	Uranium National Company S.A., 68 Dionisie Lupu Street, Bucharest
Russian Federation	Ministry for the Russian Federation of Atomic Energy, JSK "Atomredmetzoloto", Bolshaya Ogdynka st. 24/26, Moscow, 109017
	Geologorazvedka Concern, Marshala Rybalko 4, Moscow, 123436
Slovak Republic	Nuclear Regulatory Authority of the Slovak Republic, Bajkalská 27, P.O. Box 24, 820 07 Bratislava 27
South Africa	Atomic Energy Corporation of South Africa Limited, P.O. Box 582, Pretoria 0001
Spain	ENUSA, Gestión de Uranio – Dirección Comercial, 12 Santiago Rusiñol, E-28040 Madrid
Sweden	KOM Nuclear Fuel and Environment Project (NFE), P.O. Box 5810, S-102 48 Stockholm
Switzerland	Nordostschweizerische Kraftwerke AG, Parkstrasse 23, CH-5401 Baden
Thailand	Department of Mineral Resources, Economic Geology Division, Rama VI Road, Bangkok 10400
Turkey	Turkish Atomic Energy Authority, Eskisher Yolu No. 9, 06530 Ankara
Ukraine	The State Geological Enterprise "Kirovgeology", 8 Kikividze Street, 252103 Kiev
United Kingdom	Department of Trade and Industry, London SW1H OET
	British Energy plc, 10 Lochside Place, Edinburgh EH12 9DF
	British Nuclear Fuels plc (BNFL), Risley, Warrington, Cheshire WA3 6AS
United States	Energy Information Administration, Coal, Nuclear, Electric and Alternate Fuels (EI- 50), U.S. Department of Energy, Washington, D.C. 20585

Uzbekistan	The State Committee of the Republic of Uzbekistan on Geology and Mineral Resources, 11 Shevchenko st., 700060 GSP, Tashkent
	The Navoi Mining and Metallurgical Complex, 27 Navoi st., 706800 Navoi
	The State Geological Enterprise "Kyzyltepageologia", Tashkent, 7a Navoi st., 700000 Tashkent
Viet Nam	Viet Nam Atomic Energy Commission, 59 Ly Thuong Kiet, Hanoi
	Geological Division for Radioactive and Rare Elements, Department of Geology and Minerals

Annex 3

GEOLOGIC TYPES OF URANIUM DEPOSITS[1]

The uranium resources of the world can be assigned on the basis of their geological setting to the following fifteen main categories of uranium ore deposit types arranged according to their approximate economic significance:

1. Unconformity-related deposits;
2. Sandstone deposits;
3. Quartz-pebble conglomerate deposits;
4. Vein deposits;
5. Breccia complex deposits;
6. Intrusive deposits;
7. Phosphorite deposits;
8. Collapse breccia pipe deposits;
9. Volcanic deposits;
10. Surficial deposits;
11. Metasomatite deposits;
12. Metamorphic deposits;
13. Lignite;
14. Black shale deposits;
15. Other types of deposits.

The main features of these deposits are described below:

1. Unconformity-related deposits

Deposits of the unconformity-related type occur spatially close to major unconformities. Such deposits most commonly developed in intracratonic basins during the period about 1 800-800 million years ago, but also during Phanerozoic time. Type examples are the ore bodies at Cluff Lake, Key Lake, and Rabbit Lake and others in northern Saskatchewan, Canada, and those in the Alligator Rivers area in northern Australia.

2. Sandstone deposits

Most of the ore deposits of this type are contained in rocks that were deposited under fluvial or marginal marine conditions. Lacustrine and eolian sandstones are also mineralised, but uranium deposits are much less common in these rocks. The host rocks are almost always medium to coarse-grained poorly sorted sandstones containing pyrite and organic matter of plant origin. The

1. This classification was developed by the IAEA in 1988-89 and replaces the classification defined and used in the Red Books 1986, 1988, 1990 and 1992.

sediments are commonly associated with tuffs. Unoxidised deposits of this type consist of pitchblende and coffinite in arkosic and quartzitic sandstones. Upon weathering, secondary minerals such as carnotite, tuyamunite and uranophane are formed.

The Tertiary, Jurassic and Triassic sandstones of the Western Cordillera of the United States account for most of the uranium production in that country. Cretaceous and Permian sandstones are important host rocks in Argentina, Europe (Germany, Czech Republic, Hungary) and Central Asia (Kazakhstan, Uzbekistan). Other important uranium deposits are found in Carboniferous deltaic sandstones in Niger; in Permian lacustrine siltstones in France; and in Permian sandstones of the Alpine region. The deposits in Precambrian marginal marine sandstones in Gabon have also been classified as sandstone deposits.

3. Quartz-pebble conglomerate deposits

Known quartz-pebble conglomerate ores are restricted to a specific period of geologic time. They occur in basal Lower Proterozoic beds unconformably situated above Archaean basement rocks composed of granitic and metamorphic strata. Commercial deposits are located in Canada and South Africa, and sub-economic occurrences are reported in Brazil and India.

4. Vein deposits

The vein deposits of uranium are those in which uranium minerals fill cavities such as cracks, fissures, pore spaces, breccias and stockworks. The dimensions of the openings have a wide range, from the massive veins of pitchblende at Jachymov (Czech Republic), Shinkolobwe (Democratic Republic of the Congo) and Port Radium (Canada) to the narrow pitchblende filled cracks, faults and fissures in some of the ore bodies in Europe, Canada and Australia.

5. Breccia complex deposits

Deposits of this group were developed in Proterozoic continental regimes during anorogenic periods. The host rocks include felsic volcanoclastics and sedimentary rocks. The uranium mineralisation occurs in rock sequences immediately overlying granitoid basement complexes. The ores generally contain two phases of mineralisation, an earlier stratabound and a later transgressive one. The main representative of this type is the Olympic Dam deposit in South Australia. Deposits in Zambia, Democratic Republic of the Congo and the Aillik Group in Labrador, Canada, may also belong to this category.

6. Intrusive deposits

Deposits included in this type are those associated with intrusive or anatectic rocks of different chemical composition (alaskite, granite, monzonite, peralkaline syenite, carbonatite and pegmatite). Examples include the Rössing deposit in Namibia, the uranium occurrences in the porphyry copper deposits such as Bingham Canyon and Twin Butte in USA, the Ilimaussaq deposit in Greenland, Palabora in South Africa as well as the deposits in the Bancroft area, Canada.

7. Phosphorite deposits

Sedimentary phosphorites contain low concentrations of uranium in fine grained apatite. For the purpose of this report uranium of this type is considered an unconventional resource. Examples include the deposits in Florida, USA, where uranium is recovered as a by-product, and the large deposits in North African and Middle-Eastern countries.

8. Collapse breccia pipe deposits

Deposits in this grouping occur in circular, vertical pipes filled with down-dropped fragments. Uranium is concentrated in the permeable breccia matrix and in the accurate fracture zones enclosing the pipe. Type examples are the deposits in the Arizona Strip in Arizona, USA.

9. Volcanic deposits

Uranium deposits of this type are stratabound and structurebound concentrations in acid volcanic rocks. Uranium is commonly associated with molybdenum, fluorine, etc. Type examples are the uranium deposits Michelin in Canada, Nopal I in Chihuahua, Mexico, Macusani in Peru and numerous deposits in China and the CIS.

10. Surficial deposits

Uraniferous surficial deposits may be broadly defined as uraniferous sediments, usually of Tertiary to Recent age which have not been subjected to deep burial and may or may not have been calcified to some degree. The uranium deposits, associated with calcrete, which occur in Australia, Namibia and Somalia in semi-arid areas where water movement is chiefly subterranean are included in this type. Additional environments for uranium deposition include peat and bog, karst caverns as well as pedogenic and structural fills.

11. Metasomatite deposits

Included in this grouping are uranium deposits in alkali metasomatites (albitites, aegirinites, alkali-amphibole rocks) commonly intruded by microcline granite. Type examples are the deposits Espinharas in Brazil, Ross Adams in Alaska, USA, as weIl as the Zheltye Vody deposit in Krivoy Rog area, Ukraine.

12. Metamorphic deposits

Uranium deposits belonging to this class occur in metasediments and/or metavolcanics generally without direct evidence of post-metamorphic mineralisation. Examples include the deposits at Forstau, Austria.

13. Lignite

Deposits of this type, generally classified as unconventional uranium resources occur in lignite and in clay and/or sandstone immediately adjacent to lignite. Examples are uraniferous deposits in the Serres Basin, Greece, North and South Dakota, USA and Melovoe, in the CIS.

14. Black shale deposits

Low concentrations of uranium occur in carbonaceous marine shales. Also these resources are considered unconventional resources for the purpose of this report. Examples include the uraniferous alum shale in Sweden, the Chatanooga Shale in the USA, but also the Chanziping deposit of the “argillaceous-carbonaceous-siliceous-pelitic rocks” type in the Guangxi Autonomous Region in China and the deposit of Gera-Ronneburg, in the eastern portion of Germany.

15. Other deposits

Included in this grouping are those deposits which cannot be classified with the deposit types already mentioned. These include the uranium deposits in the Jurassic Todilto Limestone in the Grants district, New Mexico, USA.

Annex 4

INDEX OF NATIONAL REPORTS IN RED BOOKS 1965-1999

The following index lists all national reports and the year in which these reports were published in the Red Books. A detailed listing of all Red Book editions is shown at the end of this Index.

Algeria						1975	1977	1979	1982									
Argentina		1967	1969	1970	1973	1975	1977	1979	1982	1983	1986	1988	1990	1992	1994	1996	1998	2000
Armenia																		2000
Australia		1967	1969	1970	1973	1975	1977	1979	1982	1983	1986	1988	1990	1992	1994	1996	1998	2000
Austria							1977											
Bangladesh											1986	1988						
Belgium									1982	1983	1986	1988	1990	1992	1994	1996	1998	2000
Benin													1990					
Bolivia							1977	1979	1982	1983	1986							
Botswana								1979		1983	1986	1988						
Brazil				1970	1973	1975	1977	1979	1982	1983	1986			1992	1994	1996	1998	2000
Bulgaria													1990	1992	1994	1996	1998	

Cameroon							1977		1982	1983								
Canada	1965	1967	1969	1970	1973	1975	1977	1979	1982	1983	1986	1988	1990	1992	1994	1996	1998	2000
Central African Republic				1970	1973		1977	1979			1986							
Chile							1977	1979	1982	1983	1986	1988		1992	1994	1996	1998	2000
China													1990	1992	1994	1996	1998	2000
Colombia							1977	1979	1982	1983	1986	1988	1990			1996	1998	
Costa Rica									1982	1983	1986	1988	1990					
Ivory Coast									1982									
Cuba												1988		1992		1996	1998	
Czech Republic															1994	1996	1998	2000
Czech & Slovak Federal Rep.													1990					
Denmark (Greenland)	1965	1967	1969	1970	1973	1975	1977	1979	1982	1983	1986		1990	1992		1996	1998	
Dominican Republic									1982									
Ecuador							1977		1982	1983	1986	1988						
Egypt							1977	1979			1986	1988	1990	1992	1994	1996	1998	2000
El Salvador										1983	1986							
Estonia																	1998	
Ethiopia								1979		1983	1986							
Finland					1973	1975	1977	1979	1982	1983	1986	1988	1990	1992	1994	1996	1998	2000
France	1965	1967	1969	1970	1973	1975	1977	1979	1982	1983	1986	1988	1990	1992	1994	1996	1998	2000
Gabon		1967		1970	1973				1982	1983	1986					1996	1998	2000
Germany				1970		1975	1977	1979	1982	1983	1986	1988	1990	1992	1994	1996	1998	2000

Ghana							1977			1983								
Greece							1977	1979	1982	1983	1986	1988	1990	1992	1994	1996	1998	
Guatemala											1986	1988						
Guyana								1979	1982	1983	1986							
Hungary														1992	1994	1996	1998	2000
India	1965	1967		1970	1973	1975	1977	1979	1982	1983	1986		1990	1992	1994	1996	1998	2000
Indonesia							1977				1986	1988	1990	1992	1994	1996	1998	2000
Iran							1977										1998	2000
Ireland								1979	1982	1983	1986			1992			1998	
Italy		1967		1970	1973	1975	1977	1979	1982	1983	1986	1988		1992	1994	1996	1998	2000
Jamaica									1982	1983								
Japan	1965	1967		1970	1973	1975	1977	1979	1982	1983	1986	1988	1990	1992	1994	1996	1998	2000
Jordan							1977				1986	1988	1990	1992	1994	1996	1998	2000
Kazakhstan															1994	1996	1998	2000
Korea, Republic of						1975	1977	1979	1982	1983	1986	1988	1990	1992	1994	1996	1998	2000
Kyrgyzstan																1996	1998	
Lesotho												1988						
Liberia							1977			1983								
Libyan Arab Jamahirya										1983								
Lithuania															1994	1996	1998	2000
Madagascar						1975	1977	1979	1982	1983	1986	1988						
Malawi																		2000

Malaysia										1983	1986	1988	1990	1992	1994	1996	1998	2000
Mali											1986	1988						
Mauritania													1990					
Mexico				1970	1973	1975	1977	1979	1982		1986		1990	1992	1994	1996	1998	2000
Mongolia															1994	1996	1998	
Morocco	1965	1967				1975	1977	1979	1982	1983	1986	1988	1990				1998	
Namibia								1979	1982	1983	1986	1988	1990			1996	1998	2000
Netherlands									1982	1983	1986		1990	1992	1994	1996	1998	2000
New Zealand		1967					1977	1979										
Niger		1967		1970	1973		1977				1986	1988	1990	1992	1994	1996	1998	2000
Nigeria								1979										
Norway								1979	1982	1983				1992		1996	1998	
Pakistan		1967															1998	2000
Panama										1983		1988						
Paraguay										1983	1986							
Peru							1977	1979		1983	1986	1988	1990	1992	1994	1996	1998	2000
Philippines							1977		1982	1983	1986		1990		1994	1996	1998	2000
Poland																		2000
Portugal	1965	1967	1969	1970	1973	1975	1977	1979	1982	1983	1986	1988	1990	1992	1994	1996	1998	2000
Romania														1992	1994	1996	1998	2000
Russian Federation															1994		1998	2000
Rwanda											1986							

Senegal									1982									
Slovak Republic															1994	1996	1998	2000
Slovenia															1994	1996	1998	
Somalia							1977	1979										
South Africa	1965	1967	1969	1970	1973	1975	1977	1979	1982	1983	1986			1992	1994	1996	1998	2000
Spain	1965	1967	1969	1970	1973	1975	1977	1979	1982	1983	1986	1988	1990	1992	1994	1996	1998	2000
Sri Lanka							1977		1982	1983	1986	1988						
Sudan							1977											
Surinam									1982	1983								
Sweden	1965	1967	1969	1970	1973	1975	1977	1979	1982	1983	1986	1988	1990	1992	1994	1996	1998	2000
Switzerland						1975	1977	1979	1982	1983	1986	1988	1990	1992	1994	1996	1998	2000
Syrian Arab Republic									1982	1983	1986	1988	1990		1994			
Tanzania													1990					
Thailand							1977	1979	1982	1983	1986	1988	1990	1992	1994	1996	1998	2000
Togo								1979										
Turkey					1973	1975	1977	1979	1982	1983	1986	1988	1990	1992	1994	1996	1998	2000
Ukraine															1994	1996	1998	2000
United Kingdom						1975	1977	1979	1982	1983	1986	1988	1990	1992	1994	1996	1998	2000
United States	1965	1967	1969	1970	1973	1975	1977	1979	1982	1983	1986	1988	1990	1992	1994	1996	1998	2000
Uruguay							1977		1982	1983	1986	1988	1990					
USSR														1992				
Uzbekistan															1994	1996	1998	2000

Venezuela											1986	1988						
Viet Nam														1992	1994	1996	1998	2000
Yugoslavia														1992				
Zaire		1967			1973		1977					1988						
Zambia											1986	1988	1990	1992	1994	1996	1998	
Zimbabwe									1982			1988		1992	1994	1996	1998	

SUCCESSIVE RED BOOK EDITIONS SINCE 1965

OECD/ENEA: World Uranium and Thorium Resources, Paris, 1965;
OECD/ENEA: Uranium Resources, Revised Estimates, Paris, 1967;
OECD/ENEA-IAEA: Uranium Production and Short-Term Demand, Paris, 1969;
OECD/ENEA-IAEA: Uranium Resources, Production and Demand, Paris, 1970;
OECD/NEA-IAEA: Uranium Resources, Production and Demand, Paris, 1973;
OECD/NEA-IAEA: Uranium Resources, Production and Demand, Paris, 1975;
OECD/NEA-IAEA: Uranium Resources, Production and Demand, Paris, 1977;
OECD/NEA-IAEA: Uranium Resources, Production and Demand, Paris, 1979;
OECD/NEA-IAEA: Uranium Resources, Production and Demand, Paris, 1982;
OECD/NEA-IAEA: Uranium Resources, Production and Demand, Paris, 1983;
OECD/NEA-IAEA: Uranium Resources, Production and Demand, Paris, 1986;
OECD/NEA-IAEA: Uranium Resources, Production and Demand, Paris, 1988;
OECD/NEA-IAEA: Uranium Resources, Production and Demand, Paris, 1990;
OECD/NEA-IAEA: Uranium 1991: Resources, Production and Demand, Paris, 1992;
OECD/NEA-IAEA: Uranium 1993: Resources, Production and Demand, Paris, 1994;
OECD/NEA-IAEA: Uranium 1995: Resources, Production and Demand, Paris, 1996;
OECD/NEA-IAEA: Uranium 1997 : Resources, Production and Demand, Paris, 1998.
OECD/NEA-IAEA: Uranium 1999 : Resources, Production and Demand, Paris, 2000.

Annex 5

ENERGY CONVERSION FACTORS

The need to establish a set of factors to convert quantities of uranium into common units of energy appeared during recent years with the increasing frequency of requests for such factors applying to the various reactor types.

The NEA and the IAEA have therefore asked organisations from its Member countries to provide such factors to be published in this report.

The contributions of these organisations are presented in the following table.

ENERGY VALUES FOR URANIUM USED IN VARIOUS REACTOR TYPES[1]

COUNTRY	CANADA	FRANCE	GERMANY		JAPAN		RUSSIAN FEDERATION		SWEDEN		UNITED KINGDOM		UNITED STATES	
REACTOR TYPE	CANDU	N4 PWR	BWR	PWR	BWR	PWR	WWER-1000	RBMK-1000	BWR	PWR	MAGNOX	AGR	BWR	PWR
Burn-up [MWday/tU]														
a) Natural Uranium or Natural Uranium Equivalent	7 770	5 848	5 665	5 230	5 532	4 694	4 855	4 707	6 250	5 780	5 900	NA	4 996	4 888
b) Enriched Uranium	–	42 500	40 000	42 000	33 000	43 400	42 000	22 000	40 000	42 000	–	24 000	33 000	40 000
Uranium Enrichment [% ^{235}U]	–	3.60	3.20	3.60	3.00	4.10	4.23	2.40	3.20	3.60	–	2.90	3.02	3.66
Tails Assay [%^{235}U]	–	0.25	0.30	0.30	0.25	0.30	0.25	0.25	0.25	0.25	–	0.30	0.30	0.30
Efficiency of Converting Thermal Energy into Electricity	30%	34.60%	33.50%	34.20%	33%	34%	33.30%	31.20%	34.00%	34.50%	26%	40%	32%	32%
Thermal Energy Equivalent of 1 Tonne Natural Uranium [in 10^{15} Joules] [2]	0.671	0.505	0.490	0.452	0.478	0.406	0.419	0.406	0.540	0.500	0.512	0.360	0.432	0.422
Electrical Energy Equivalent of 1 Tonne Natural Uranium [in 10^{15} Joules] [2]	0.201	0.175	0.164	0.155	0.158	0.140	0.139	0.127	0.184	0.173	0.133	0.144	0.138	0.135

(1) Does not include Pu and U recycled. Does not take into account the requirement of an initial core load which would reduce the equivalence by about 6%, if based on a plant life of about 30 years with a 70% capacity factor.

(2) Does not take into account the energy consumed for ^{235}U enrichment in LWR and AGR fuel. The factor to be applied to the energy equivalent under the condition of 3% ^{235}U enrichment and 0.2% tails assay should be multiplied by 0.957.

NA Data not available.

Conversion factors and energy equivalences for fossil fuel

(for comparison)

1 cal		=	4.1868 J
1 J		=	0.239 cal
1 tonne of oil equivalent (net, LHV)		=	42 GJ[1] = 1 TOE
1 tonne of coal equivalent (standard, LHV)		=	29.3 GJ[1] = 1 TCE
1 000 m^3 of natural gas (standard, LHV)		=	36 GJ
1 tonne of crude oil		=	approx. 7.3 barrels
1 tonne of LNG		=	45 GJ
1 000 kWh (primary energy)		=	9.36 MJ
1 TOE		=	10 034 Mcal
1 TCE		=	7 000 Mcal
1 000 m^3 natural gas		=	8 600 Mcal
1 tonne LNG		=	11 000 Mcal
1 000 kWh (primary energy)		=	2 236 Mcal[2]
1 TCE		=	0.698 TOE
1 000 m^3 natural gas		=	0.857 TOE
1 tonne LNG		=	1.096 TOE
1 000 kWh (primary energy)		=	0.223 TOE
1 tonne of fuelwood		=	0.3215 TOE
1 tonne of uranium:	light water reactors	=	10 000-16 000 TOE
	open cycle	=	14 000-23 000 TCE

1. World Energy Council standards conversion factors (from WEC, *1998 Survey of Energy Resources*, 18th edition).

2. With 1 000 kWh (final consumption) = 860 Mcal as WEC conversion factor.

Annex 6

CURRENCY EXCHANGE RATES*

(in national currency units per USD)

COUNTRY (currency abbreviation)	June 1996	June 1997	June 1998	January 1999
Argentina (ARS)	1.000	1.000	1.000	1.000
Australia (AUD)	1.260	1.310	1.610	1.634
Austria (ATS)	10.900	11.900	12.400	11.793
Belgium (BEF)	31.500	34.800	36.700	34.574
Brazil (BRL)	0.987	1.070	1.153	1.207
Bulgaria (BGL)	135.000	1 500.000	1 745.000	1 665.000
Canada (CAD)	1.370	1.380	1.460	1.540
Chile (CLP)	405.000	415.000	450.000	468.000
China (CNY)	8.280	8.280	8.270	8.266
Colombia (COP)	1 050.000	1 058.000	1 300.000	1 460.000
Costa Rica (CRC)	201.000	225.000	253.550	270.650
Cuba (CUP)	1.000	1.000	1.000	1.000
Czech Republic (CZK)	27.300	33.100	33.260	30.012
Denmark (Greenland) (DKK)	5.920	6.470	6.770	6.490
Egypt (EGP)	3.370	3.370	3.385	3.397
Finland (FIM)	4.730	5.110	5.400	5.096
France (FRF)	5.200	5.740	5.970	5.622
Gabon (GBF)	520.000	574.000	597.000	562.209
Germany (DEM)	1.530	1.700	1.780	1.676
Greece (GRD)	243.000	274.000	305.000	282.000

* Source: Bureau for Financial and Administrative Services of the United Nations Development Programme, New York.

COUNTRY (currency abbreviation)	June 1996	June 1997	June 1998	January 1999
Hungary (HUF)	146.000	182.000	206.000	217.000
India (INR)	34.000	35.500	39.440	42.280
Indonesia (IDR)	2 330.000	2 398.000	11 700.000	7 406.000
Italy (ITL)	1 560.000	1 665.000	1 740.000	1 659.540
Japan (JPY)	107.000	117.000	138.000	115.000
Jordan (JOD)	0.708	0.708	0.708	0.708
Kazakhstan (KZT)	66.000	75.000	76.000	82.000
Korea (Republic of) (KRW)	785.000	881.000	1 352.000	1 209.200
Lithuania (LTL)	4.000	4.000	4.000	4.000
Malawi (MWK)	–	15.200	25.890	43.333
Malaysia (MYR)	2.500	2.460	3.728	3.766
Mauritania (MRO)	136.000	143.000	176.300	202.830
Mexico (MXN)	7.350	7.890	8.500	9.700
Mongolia (MNT)	495.000	790.000	822.000	900.000
Morocco (MAD)	8.610	9.390	9.610	9.159
Namibia (ZAR)	4.340	4.470	5.170	5.869
Netherlands (NLG)	1.710	1.910	2.000	1.888
Niger (XOF)	520.000	84.200	84.800	86.000
Norway (NOK)	6.550	7.080	7.520	7.580
Peru (PEN)	2.350	2.630	2.840	3.120
Philippines (PHP)	25.900	26.200	38.600	38.750
Portugal (PTE)	158.000	170.000	182.000	171.829
Romania (ROL)	2 880.000	7 060.000	8 501.000	10 551.000
Russian Federation (RUR)	5 010.000	5 720.000	6.162	20.990
Slovak Republic (SKK)	30.100	32.500	34.080	36.233
Slovenia (SIT)	130.000	154.000	160.000	160.000
South Africa (ZAR)	4.340	4.470	5.170	5.869
Spain (ESP)	129.000	144.000	151.000	142.606

COUNTRY (currency abbreviation)	June 1996	June 1997	June 1998	January 1999
Sweden (SEK)	6.750	7.680	7.700	8.000
Switzerland (CHF)	1.260	1.410	1.480	1.370
Syria (SYP)	26.600	43.300	45.000	46.000
Tajikistan (TJR)	–	400.000	754.000	1 198.330
Thailand (THB)	25.100	25.900	40.000	36.700
Turkey (TRL)	77 050.000	138 000.000	252 000.000	315 000.000
Ukraine (UAH)	189 000.000	1.800	2.010	3.430
United Kingdom (GBP)	0.650	0.612	0.600	0.600
United States (USD)	1.000	1.000	1.000	1.000
Uruguay (UYU)	7.710	9.260	10.300	10.710
Uzbekistan (UZS)	36.100	60.200	87.760	110.000
Viet Nam (VND)	11 000.000	11 640.000	12 975.000	13 843.000
Yugoslavia (YUN)	5.050	5.610	11.080	10.057
Zambia (ZMK)	1 240.000	1 280.000	1 670.000	2 300.000
Zimbabwe (ZWD)	9.800	11.000	17.920	36.233

Annex 7

GROUPING OF COUNTRIES AND AREAS* WITH URANIUM RELATED ACTIVITIES

The countries and geographical areas included in each grouping are listed below.

1. North America

Canada**	Mexico**	United States of America**

2. Central and South America

Argentina	Bolivia	Brazil
Chile	Colombia	Costa Rica
Cuba	Dominican Republic	Ecuador
El Salvador	Guatemala	Guyana
Panama	Paraguay	Peru
Uruguay	Venezuela	

3. Western Europe and Scandinavia

Austria**	Belgium**	Denmark**
Finland**	France**	Germany**
Ireland**	Italy**	Netherlands**
Norway**	Portugal**	Spain**
Sweden**	Switzerland**	United Kingdom**

4. Central, Eastern Europe and South East Europe

Armenia	Belarus	Bulgaria
Croatia	Czech Republic**	Estonia
Greece**	Hungary**	Lithuania
Poland**	Romania	Russian Federation
Slovak Republic	Slovenia	Turkey**
Ukraine	Yugoslavia	

* This list has been compiled to describe countries on a geographical basis, 1996.

** OECD Countries.

5. Africa

Algeria	Botswana	Cameroon
Central African Republic	Democratic Republic of the Congo (formerly Zaire)	Egypt
Ethiopia	Gabon	Ghana
Ivory Coast	Lesotho	Liberia
Libyan Arab Jamahiriya	Madagascar	Malawi
Mali	Mauritania	Morocco
Namibia	Niger	Nigeria
Rwanda	Senegal	Somalia
South Africa	Sudan	Togo
Zambia	Zimbabwe	

6. Middle East, Central and South Asia

Bangladesh	India	Iran, Islamic Republic of
Jordan	Kazakhstan	Kyrgyzstan
Pakistan	Sri Lanka	Syrian Arab Republic
Uzbekistan		

7. South East Asia

Indonesia	Malaysia	Philippines
Thailand	Viet Nam	

8. Pacific

Australia**	New Zealand**

9. East Asia[1]

China	Democratic People's Republic of Korea	Japan**
Korea, Republic of**	Mongolia	

1. Includes Chinese Taipei.

Annex 8

TECHNICAL TERMS

The following abbreviations for technical terms in mining and ore processing were used in some tables:

	Type	Abbreviation
Mining Operation	Open Pit Underground	OP UG
Processing	a) Feed Preparation Crush-Wet Grind Semi-Autogenous Grind	 CWG SAG
	b) Sorting and Preconcentration Radiometric Sorting Density Separation Magnetic Separation Flotation	 Rad-Sort Dens-Sep Mag-Sep Flot.
	c) Leaching Acid Leaching Two-stage Acid Leaching Alkaline Pressure Leaching In Situ Leaching In Place Leaching Heap Leaching Percolation Leaching Alkaline Atmospheric Leaching	 AL 2 AL ALKPL ISL IPL HL Perc L ALKAL
	d) Extraction Ion Exchange Solvent Extraction	 IX SX

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