Sino Australia Oil and Gas Ltd

An Introduction to

Enhanced Oil Recovery Techniques

To better understand the differences and advantages of Sino Australia's best practice Enhanced Oil Recovery (EOR) technologies and services, it can be useful to gain insight into the issues EOR seeks to address, how these issues have been addressed previously and how technology has provided significant improvements to EOR processes and outcomes.

This document provides a brief introduction to the various popular techniques of EOR that have been in use since the 1960's, through to the best practice technology provided by Sino Australia in the current day.

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Enhanced Oil Recovery (EOR) Technical Concepts

In an effort to minimise their dependence on imported oil, China is attempting to maximise the contribution their domestic oil reserves make to their total oil supply. As such, a primary focus is on improving the performance of existing oil fields, by using technical recovery methods, known as EOR, to access reserves that were previously unattainable due to geology or expense.

EOR is chiefly concerned with affecting the mobility of the oil through the drilling process, late in the life span of the well. It primarily does this through the use of injecting fluids in the drilling process. EOR processes can result in 30-60 per cent or more of the reservoir's original oil being extracted, compared to just 20-40 per cent using primary or secondary recovery methods.

Note: The **volumetric sweep efficiency** at any time is the fraction of the total reservoir volume contacted by the injected fluid during the recovery. When using water, consideration of the mobility of the fluids is an important factor when determining the area and vertical sweep efficiencies. This would help to determine the mobility ratio. If M is less than one (1), then oil is capable of travelling at a rate equivalent to the water. An increase in the viscosity of the oil would mean that M would increase and this would lead to the injected fluid moving around the oil. This would also make it harder for the oil to penetrate the pore. To improve this ratio, the viscosity of the water has to be increased. When M is greater than one, the displacing fluid has greater mobility than the displaced fluid. Also the position of the water injection and the flooding patterns would go a long way to determining the recovery patterns. Another point to consider in oil recovery is the position and orientation of the injection wells around the production well. As the mobility ratio increases, the sweep efficiency decreases. Once a channel of water exists between the injector and the producer, then little additional oil would be recovered.

If permeability varies vertically then an irregular vertical fluid front can develop and this is as a result of the differing permeability and the mobility ratio.

Displacement efficiency refers to the fraction of oil that is swept from unit volume of reservoir upon injection. This depends on the mobility ratio, the wettability of the rock and the pore geometry. The wettability is determined by whether or not the grains preferentially absorb oil over water.

Other Earlier EOR Methods

Sino Australia Oil & Gas' main business is deploying its patented technology for directed water jet drilling technology. This technology can be adapted to the needs of different types of geological conditions. In order to do so, the technology must be re-engineered with theoretical research and on-site practical production testing in order to promote the application of a large area of industrialisation.

As there are different kinds of oil fields in the world, there are different EOR methods used to improve the long-term drilling results.

Essentially these can be determined in four basic methods:

1. Chemical Method

- **Polymer flooding**

Polymer flooding is one of the most widely used EOR methods to retrieve oil left behind after conventional recovery processes. It's an augmented water flooding technique introduced in the 1960's, mainly used for heterogeneous reservoirs, to retrieve oil after areas in the reservoir with high permeability have been highly water flooded.

As explained by CNPC: *"Polymer flooding is a tertiary recovery method by adding high-molecular-weight polyacrylamide into injected water, so as to increase the viscosity of fluid, improve volumetric sweep efficiency, and thereby further increase the oil recovery factor.*

When oil is displaced by water, the oil/water mobility ratio is so high that the injected water fingers through the reservoirs. By injecting polymer solution into reservoirs, the oil/water mobility ratio can be much reduced, and the displacement front advances evenly to sweep a larger volume. The viscoelasticity of polymer solution can help displace oil remaining in micro pores that cannot be otherwise displaced by water flooding."

See detailed diagrams from CNPC here:
http://www.cnpc.com.cn/resource/english/images1/pdf/Brochure/Polymer%20flooding%20and%20ASP%20flooding%20in%20Daqing%20Oilfield.pdf?COLLCC=867486911&

Caustic flooding is the addition of sodium hydroxide to injection water to aid recovery. It does this by lowering the surface tension, reversing the rock wettability, emulsifying the oil, mobilising the oil and helping to draw the oil out of the rock.

In areas with relatively poor physical properties and low permeability, there will still be a lot of residual oil left behind underground after using artificial water drive (eg. generally heterogeneous sandstone reservoir results in ultimate oil recovery of only about 30 per cent).

According to theoretical predictions, the ultimate recovery of an oilfield can be increased to above 50 per cent or more by using a polymer flooding solvent. The polymer flooding solvent acts to significantly drop the surface tension of the underground crude oil, thereby greatly increasing the displacement efficiency. This converts the original viscous well block of residual oil into moveable oil, in the stagnation zone of residual oil wells. The water content of the oil well declines and the capacity for production steadily rebounds.

It’s a complex method with the potential for numerous factors to simultaneously affect the result. Many characteristics of the polymer flow in porous mediums are yet to be fully understood.

The weaknesses and limitations of polymer flooding include:

i. Nearly half of the remaining underground oil reserves will be left behind after polymer flooding. Current technology does not provide a method to deal with these remaining reserves.
ii. After polymer flooding for a long time, (usually two to three years), the oil reservoir will have serious scaling (i.e. materials sticking to metal surfaces - one of the major problems in the development of oil and gas fields). This ultimately leads to a large number of oil and water wells that are no longer operational.
iii. Thirdly, the complex requirements of the project make polymer flooding an expensive option and therefore difficult for small or medium enterprises to put into action.

- **Chemical Flooding**

In a chemical flood, chemicals are injected with the water flood to improve the displacement efficiency. A chemical solvent is specially developed for adaptation to the specific structural characteristics and physiochemical properties of a reservoir.

After injecting with water, chemical reactions form new chemical sediment, which can reduce the contradiction between layers, increase volume and amount of water injected. This can improve the degree to which reserves can be recovered, while improving production efficiency.

However, this type of chemical reaction would take place in a poor reservoir so it will also produce oil pollution and the capacity for water absorption would be damaged.

Most wells cannot achieve a satisfactory result using these methods, making it counterproductive, with the effects outweighing the benefits.

- **Liquid Carbon Dioxide Flooding**

When a reservoir's pressure is depleted through primary and secondary production, carbon dioxide flooding can be an ideal tertiary recovery method. It's particularly effective in reservoirs deeper than 2,000ft., where CO2 will be in a supercritical state.

Carbon dioxide flooding works on the premise that by injecting CO2 into the reservoir, it dissolves in oil, the oil swells and the viscosity of any hydrocarbon will be reduced and hence, it will be easier to sweep to the production well.

If an existing well has been designated suitable for CO2 flooding, the pressure within the reservoir must first be restored to that of one suitable for production by injecting water (with the production well shut off).

Once the reservoir is at this pressure, liquid CO2 is injected into the same injection wells used to restore pressure to generate H2CO3, soluble Ca and Mg ionic components in the reservoir. The CO2 gas is forced into the reservoir and is required to come into contact with the oil.

This creates a miscible zone that can be moved more easily to the production well. Normally the CO2 injection is alternated with more water injection, with the water acting to sweep the oil towards the production zone.

In these applications, between one-half and two-thirds of the injected CO2 returns with the produced oil. This is then usually re-injected into the reservoir to minimise operating costs. The remainder is trapped in the oil reservoir by various means. Carbon dioxide as a solvent has the benefit of being more economical than other similarly miscible fluids such as propane and butane.

This type of technology can be good to enlarge volume and improve recovery efficiency, but unless natural CO2 exists in the neighbourhood area, it's generally difficult to collect sufficient amounts of CO2 for industry use.

- **Hydrocarbon displacement**

Hydrocarbon displacement is where a slug of hydrocarbon gas is pushed into the reservoir in order to form a miscible phase at high pressure. This however, suffers from poor mobility ratio, and the solvent's ability to dissolve the oil is reduced as it goes through. As with all methods, this is only attempted when it is deemed economical.

2. Physical method:

Thermal recovery

Thermal methods raise the temperature of regions of the reservoir to heat the crude oil in the formation and reduce its viscosity and/or vaporise part of the oil and thereby decrease the mobility ratio. Thermal methods include the injection of hot water, steam or other gas, or by conducting combustion in situ of oil or gas.

The increase in heat reduces the surface tension and increases the permeability of the oil and improves the reservoir seepage conditions. The heated oil may also vaporise and then condense forming improved oil.

This approach however, requires substantial investment in special equipment. Both thermal recovery methods also severely damage the underground well structure, as well as pose safety risks in the larger production process. For these reasons, the methods are not generally used very often.

The two main types of thermal recovery are:

- **Steam Flooding**

Steam flooding methods include cyclic steam injection, steam drive and combustion to introduce heat to the reservoir.

These methods improve the sweep efficiency and the displacement efficiency. Steam injection has been used commercially since the 1960s in California fields. In 2011, solar thermal enhanced oil recovery projects were started in California and Oman. This method is similar to thermal EOR, but uses a solar array to produce the steam.

Steam flooding introduces heat to the reservoir by pumping steam into the well in a pattern similar to that of water injection. Eventually the steam condenses to hot water. In the steam zone the oil evaporates and in the hot water zone the oil expands. As a result, the oil expands, the viscosity drops and the permeability increases. To ensure success, the process has to be cyclical. This is the principal enhanced oil recovery program in use today.

In situ combustion of oil on site or fire flood, works best when the oil saturation and porosity are high. Combustion generates the heat within the reservoir itself. Continuous injection of air, or other gas mixture with high oxygen content, will maintain the flame front. As the fire burns, it moves through the reservoir towards the production wells. Heat from the fire reduces oil viscosity and helps to vaporise reservoir water to steam. The steam, hot water, combustion gas and a bank of distilled solvent all act to drive oil in front of the fire toward production wells.

There are three methods of combustion: Dry forward, reverse and wet combustion. The dry forward method uses an igniter to set fire to the oil. As the fire progresses, the oil is pushed away from the fire toward the producing well. In the reverse method, the air injection and the ignition occur from opposite directions. In the wet combustion method, water is injected just behind the front and turned into steam by the hot rock. This quenches the fire and spreads the heat more evenly.

The conditions of use for this kind of technology are very strict. Underground ignition is extremely difficult, so this technology is rarely applied.

- **Gas Drive Oil**

Gas injection or miscible flooding is a general term for injection processes that introduce miscible gases into the reservoir. A miscible displacement process maintains reservoir pressure and improves oil displacement because the interfacial tension between oil and water is reduced. This refers to removing the interface between the two interacting fluids. This allows for total displacement efficiency.

Gases used in this process include CO2, natural gas or nitrogen. The fluid most commonly used for miscible displacement is carbon dioxide because it reduces the oil viscosity and is less expensive than liquefied petroleum gas. Oil displacement by carbon dioxide injection relies on the phase behaviour of the mixtures of that gas and the crude – these behaviours are strongly dependent on reservoir temperature, pressure and crude oil composition.

As oil and gas have a cognate symbiosis in the same structural trap, their physical and chemical properties are similar. As such, the Gas Drive Oil method has the potential to deliver better displacement process efficiency and higher recovery rates than other techniques. However, this theory is relevant only under specific reservoir conditions. If these specific conditions are present, then the volume expansion of the injected gas which acts to move the oil, takes precedent over the smaller chemical reactions from the gas drive process at the oil and gas interface.

3. Biological Method

- **Microbial injection**

These days there is also a new biological theory which involves injecting bacteria into the oil reservoir to improve the recovery efficiency. Experimental results using a particular species in a reservoir have shown that through the metabolism of large population, large amounts of organic acids can be produced. These organic acids may act to restore vitality to an aging well, increase its productivity and thereby act to induce a substantial increase in oil recovery.

Three approaches have been used to achieve microbial injection. In the first approach, bacterial cultures mixed with a food source (a carbohydrate such as molasses is commonly used) are injected into the oil field.

In the second approach, used since 1985, nutrients are injected into the ground to nurture existing microbial bodies. These nutrients cause the bacteria to increase production of the natural surfactants they normally use to metabolise crude oil underground. After the injected nutrients are consumed, the microbes go into near-shutdown mode, their exteriors become hydrophilic, and they migrate to the oil-water interface area where they cause oil droplets to form from the larger oil mass. This then makes the oil droplets more likely to migrate to the wellhead.

The third approach is used to address the problem associated with the paraffin wax components of the crude oil, which tend to precipitate as the crude flows to the surface. Since the Earth's surface is considerably cooler than the petroleum deposits, a temperature drop of 9-10-14 °C per thousand feet of depth is usual.

Microbial injection is part of microbial enhanced oil recovery and is rarely used because of its higher cost and because the developments are not widely accepted. These microbes function either by partially digesting long hydrocarbon molecules and generating bio-surfactants, or by emitting carbon dioxide, which then functions as described in Gas Injection above.

Many field trials of the theory in the Daqing oilfield have proved ineffective. Preliminary analysis found that the main reason for ineffectiveness is that after mass propogation of the bacteria in the reservoir, the dead bodies and waste produce secondary pollution to the reservoir porosity – pore clogging.

4. Technical Method

- **Comparison to the common hydraulic fracturing**

Hydraulic fracturing technology is only applicable to the oil reservoir which does not contain water. It cannot be used on a reservoir mixed with underground water. Using hydraulic fracturing technology on a reservoir with water will cause a sharp increase in the water ratio and thereby decrease oil production.

The fracture direction during the hydraulic fracturing process cannot be controlled. It can only produce cracks that conform to the in-situ fracturing direction or high permeability area – however the fracture direction may not be the one needed. Because the injected water is flowing generally along the direction of primary cracks in high permeability area, if an opening fractures in this direction it may result in large water mix in the reservoir.

Radial hydraulic jet drilling technology can artificially control the direction and depth in the reservoir, avoiding the area containing high water, extracting the remaining oil, in order to improve the seepage condition and increase oil production.

- **Comparison with infill well and horizontal well**

The cost of drilling a new well around the existing ones is three times higher than using the radial hydraulic jet drilling technology.

The cost of drilling a horizontal well is over 10 times higher than the radial hydraulic jet drilling technology and the time of the work is comparable in length.

If the costs of adding the ground matching process, the equipment and the completion of drilling work are also considered, then the costs will be even higher.

The cost of Radial Hydraulic jet drilling is low. No new wellhead facilities are required to be built, it has a shorter construction period and the improvement in results is significant and immediate.

Comparing Various EOR Methods

In the discussion of the effect of enhanced oil recovery, we must first understand that these technologies are adapted to the specific geological conditions of the area of application. The transformation of the reservoir must be:

Layer heterogeneity: reservoir layer thickness (HS ≥ 2.0m), serious (non-uniformity coefficient ≥ 10). It is usually very difficult to assess the top 10 metres of a reservoir thickness, but with Sino technology they can assess the permeability of every reservoir layer in a previously flooded well. This means that Sino technology can identify remaining oil reserves and effectively retrieve them.

Secondly, is to look at the physical conditions of the crude oil reservoir. If it is high density heavy oil (Ǖ0 ≥ 1000mps), then application of this modified tapping technique with thermal recovery technology can be most effective.

Comparing the Sino EOR technology to other recovery methods is not simple or straightforward, as other measures are limited in their application range. On the other hand, Sino’s technology is adaptable to varying geological conditions.

The list below outlines the approximate recovery rates of several of the alternative recovery techniques discussed above:

1. Elastic + dissolved gas drive mining: ultimate recovery ≤ 10%
2. Water flooding: the ultimate oil recovery can be increased to 30 to 35%
3. Other manual techniques including: chemical flooding - polymers, tertiary flooding, carbon dioxide flooding, thermal recovery (physical drive) – in-situ combustion, the injection of high-pressure superheated steam 35-40%
4. Biological drive - bacteria, oil recovery technology. (Mostly indoor experiments, no formal field test results.)

Sino Australia Oil and Gas Radial Hydraulic Jet Drilling

Sino Australia Oil and Gas Limited hold patents over two ‘sidetrack drilling’ technologies for EOR. These two highly versatile technologies work together to optimise production from existing oil and gas wells by enhancing both production efficiency and the productive life of the well.

Unlike many other conventional tapping technologies, Sino’s EOR technology can effectively tap trapped reserves, allowing full or close to full exploitation of the wells productive potential. Through application of Sino’s EOR technology, exhausted wells can be resurrected and inefficient wells with low outputs can be restored to a more productive state.

Sino’s technology is suitable for application on all of the various types of lithological oil and gas fields in China. The technology has been proven to increase the yield from mature wells by up to three to five tonnes/day (3-5 t/day) and extend the production life of a well by at least one to two years.

Sino’s EOR technology is continually being updated and improved to adapt to the newly identified drilling situations and challenges that emerge from the ever-changing natural rock and geology.

Technical Advantages of the Sino technology:

- Improves flow rates by increasing porosity and permeability of the original wellbore
- Reduces flow resistance by increasing the drainage radius
- Improves penetrability of natural barriers in productive formation (eg. lithology variations and faults)
- Capability of multi-directional jetting across various levels
- Improves penetrability beyond wellbore formation damage
- Improves access to intra-well reservoir pockets
- Easier jet delivery compared to other recovery enhancement methods (eg. acidification and fracture stimulation)

Recent experiments have shown and proven that, compared with other exploration methods, Sino’s patented technology delivers the following benefits:

Precision: The ‘Status Monitoring Device’ provides site operation personnel with precise, real time information about the ‘depth calibration’ and ‘orientation’ of the downhole radial drilling construction.

The ability to monitor the process of construction downhole and the condition of the hydraulic jet drilling device allows for fast, accurate decision making in the construction process – saving time and costs.

Infiltration: The technology acts to make the ‘stagnant zone’ productive. Where traditional water-flooding methods are generally ineffective in late-stage oilfield development, Sino’s technology can transform the ‘stagnant oil’ into ‘movable oil,’ and thereby recover otherwise unrecoverable oil resources.

This advantage is something that the other technologies cannot guarantee.

Maintains integrity of well: The use of a small caliber scraper drill bit tapping to rotation casing means that there is no, or minimal damage to the casing of the oil well. This delivers both time and cost savings.

Environmentally friendly: Unlike other conventional recovery methods, the whole construction process can be executed with zero pollution and without plugging. In drilling, a protective fluid is used to complete the open well and rock debris is returned along with the drilling jet. **This is an exclusive feature compared to other methods**.

Lower Cost: Once implemented, no other investment is required. It is a low cost procedure, with a quick repayment period – based on four holes of sidetrack drilling for a single well and a typical improvement in production of two tons per day, the investment in the technology can be recovered within about two months.

Tangible benefits to the user:

Sino’s innovative drilling technology can reduce the time frame of the well construction cycle, eliminate pollution during the construction process and lessen the costs associated with well drilling – including logging, sidetracking and perforating. In total, the costs associated with using Sino’s EOR technology are about one-third that of the more traditional technology. Further, no other additional production operations are required thereafter.

Sino’s technology is suitable for application at all of the various types of lithologic oil and gas fields. It has been proven to achieve significant effects, improving recovery of reserves and delivering substantial value-add benefits to the customer.

In existing technical conditions, the Sino technology can gain access to far more of the remaining oil reserves than the conventional techniques of exploitation. Even if the recoverable reserves of the wells are increased by one percentage point, it means that a huge improvement in production.

However, in a typical oil field there can be a variety of reservoir characteristics which determine the ultimate oil recovery. Reservoirs which have high water content are generally low-yielding in terms of the ultimate oil recovery. Conventional water flooding to enhance oil recovery from mature oil fields is relatively ineffective in these high water content cases. Generally when traditional water flooding techniques are used, a significant amount of stranded residual oil remains in the reservoir.

Sino technology can effectively tap the previously unattainable reserves of exhausted wells to resurrect them and restore them to an efficient productive state. **For a single well, the technology extends productive life of the well by at least one to two years and increases output by up to three to five tonnes per day.** Essentially, the technology extends the time frame for which the oil field is in a stable productive state.

From a technical perspective, the radial water jet drilling technology is an oil well stimulation and augmented injection technology which acts on existing productive wells with radial hole lengths of up to 100m-150m, and pore sizes of up to 50mm. Crude oil in the reservoir along the radial aperture, flows into the wellbore, thereby reducing the resistance of the crude oil in the reservoir. The wellbore circulation process significantly increases production from oil wells.

This technology is especially effective when used in the late stage of development, to tap the unattainable reserves in a reservoir. In many cases, significant oil reservoirs that are highly water-flooded exist between injection wells and production wells in a mature field. Despite being high in water content, these can still contain significant amounts of stranded oil. These formations generally contain irregular low-resistance (low permeability) flow channels, are unaffected by an initial water injection process. As a result, the remaining oil is very difficult to recover using traditional methods. In these cases, application of the radial hydraulic jet drilling technology is able to overcome this technical hurdle.

There are three obvious advantages:

- Fixed depth directional radial drilling avoids injecting into water flooded parts of the native fracture azimuth of the reservoir, so the remaining parts of the oil drilled, can effectively improve oil recovery;
- Sino radial drilling increases the directional length of the drill segment by up to 100-150 metres, increasing flow and therefore the scope to increase yield; and
- Lower construction costs – equivalent to about one-third of the investment in drilling a new well.

Measures to increase production from more traditional EOR techniques are inadequate compared with the radial water jet drilling technology. If the commonly used hydraulic fracturing technology is continually used on a flooded reservoir, the risk is in damaging the well with a substantial increase in water. This is because humans cannot control the natural extension; rather they can only control the direction of the reservoir in-situ.

The radial water jet drilling technology is not subject to stress constraints. It can be artificially controlled in the reservoir at fixed depths and orientations.

While the late reformation tapping method, such as encrypted fill drilling a new well, can improve the extraction of remaining reserves, the cost of implementation is more than three times higher than the radial water jet drilling technology. In contrast to other methods that do increase production, the radial water jet drilling technology is lower in cost, quick and as, if not more effective in improving yield.

The Cost Benefits of Using this Technology:

Comparison based on general costs and economic benefits:
One-off input – a single well with four sidetrack drilling holes:
Every hole is 100,000 Yuan (RMB), so the total cost is 400,000 Yuan. ($61,500) according to the current highest bid.

As evident in the chart below, if the technology delivers an increase in yield of one tonne of oil per day, then it would take approximately three months to recover the costs of the investment. Generally the investment in EOR can be recouped within one year.

The growing amount of oil per day		**Daily output according to the international oil price.**		**Expected Payback period of investment is**	**Remark**
Ton/day	barrel/day	RMB(Yuan)	US Dollars	Day	1. One ton equals to 7.4 barrel for Daqing crude oil. 2. $100 dollars per barrel according to international oil price. 3. Single well cost (4 holes): RMB 400000 yuan
0.5	3.7	2405	370	166	
1.0	7.4	4810	740	83	
2.0	14.8	9620	1480	41	
3.0	22.2	14430	2220	27.7	
4.0	29.6	19240	2960	20.8	
5.0	37..0	24050	3700	16.6	

Sino compared to other EOR suppliers

The Sino Australia Oil and Gas business involves activities associated with oilfield development, production engineering, radial direction drilling and well repairing, predominantly in the Daqing and north-east regions of China. At present there is no other operator with whom to draw a direct comparison.

Due to its unique technical advantages in oil drilling fields and its service advantages, Sino has become a member of China's onshore oilfield services market network and dominated a certain amount of the market share.

Sino is a technology service enterprise for CNPC and its subordinate oil fields. The Company has also passed the Certification of the Quality Management System, Occupational Health and Safety System and Environment Management System.

Sino has a highly qualified team with expertise in technology research and development in well drilling and oil recovery, geology, oil recovery engineering and field production management.

Sino has established strategic cooperative relations with several petroleum universities and laboratories for ongoing research and development of the technology. At the same time, the Company comprises geologists and engineers with years of industry specific experience, as well as other leading professionals in the field of the oil exploration technology. The Company also has a construction work team with a strong spirit and professional competence.

During recent years, Chinese eastern onshore oilfields have gradually entered a period whereby there is a large number of ageing, high water-cut wells and newly discovered complex oilfields. This transition brings about many problems with regards to appropriating mining technology for the different or complex geological landscape.

The core technology owned by Sino can be widely applied to most of the wells that belong to the vertical wells in China. This includes the oil wells in poor condition (exhausted wells that have ceased long-term production) and the peripheral difficult oil layer where the oil reservoir is especially low, has low permeability, has plugging issues, has high water cut and a low liquid oil layer etc.

Sino's EOR technology has revolutionised the traditional oil and gas well drilling process. The technology reduces the costs of well drilling (including for logging, sidetrack and perforating), reduces the timeframe of the construction cycle, minimises pollution impacts on the environment and retains the integrity of the well throughout the construction process. No further construction is required, so in total, **the technology is approximately one-third of the cost of traditional technology.** The patented technology can be applied to all of the various types of lithology and already completed oil and gas wells and CBM field.

5. Case Study

Daqing Oilfield

The Daqing oil plant development block in northeastern China has been the primary focus for the successful implementation of the force jet horizontal drilling technology. Eight wells were involved in the field trials, including seven recovery wells and one injection well. The technology has achieved a substantial increase in well flow and oil recovered.

1.1 Well and reservoir selection

The X1 well in Figure 1 below is a polymer flooding well, which mainly targeted the Portuguese I 1-3 reservoir with a gross sandstone thickness of 16.7m, (12.9m effective thickness).

In November 2006 the wells were pressure fracture stimulated but did not achieve the desired results. Liquids production did not increase as a result of this method, Further analysis indicated that the well is located at the fault edge. Traditional injection systems are imperfect in this instance as the fracturing around the effective radius is smaller.

Electrical logging curve interpretation described the X1 well reservoir as deposited as a thick layer of river sand. It was characterised as having banded lithology morphology of fine sandstone with high permeability.

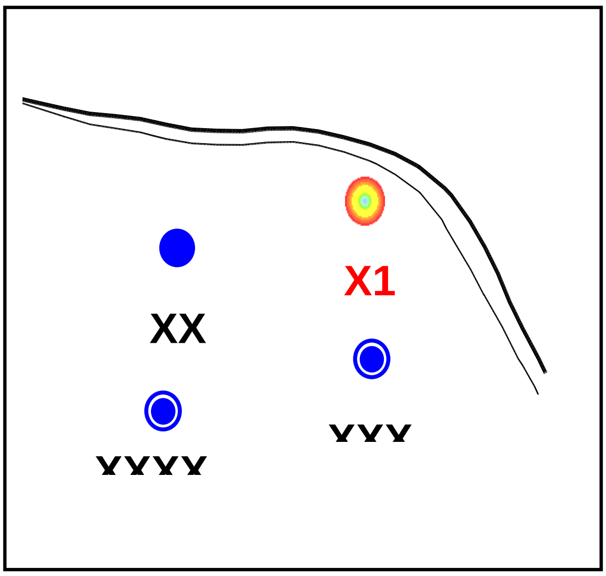

Figure 1 X1 well group well schematic

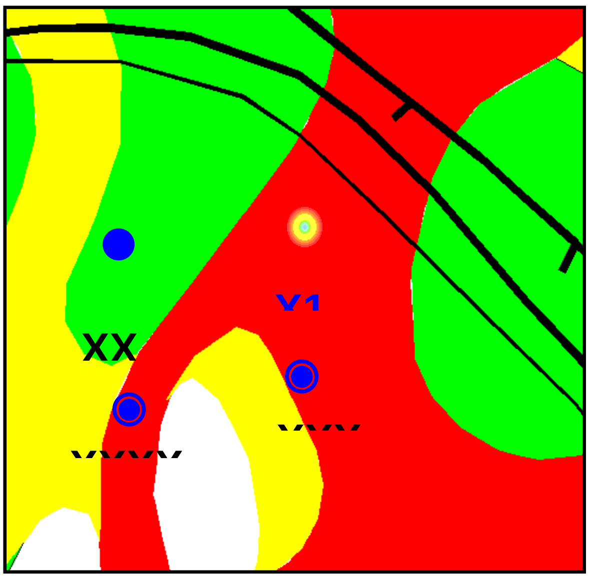

Figure 2 X1 well group the Portuguese

1.2 The Construction Process

Preliminary work completed through the well included, scraping wax, sand washing and a measured orientation. The process lasted five hours, had a jet length 70m, and an injection pressure of 50 MPa. The hydro-jet process pressure was 45-50MPa with the actual footage 3-7m/min. Jet construction time is about two days.

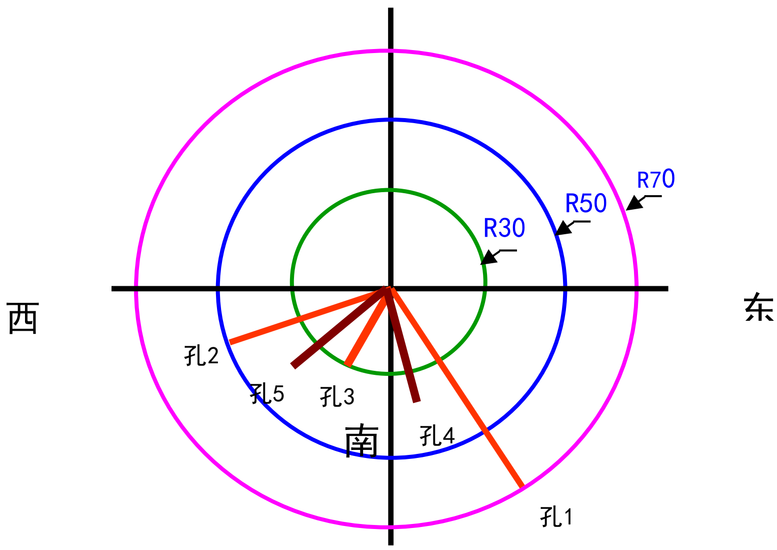

Figure 3 X1 WELL jet orientation diagram

Table 1 X1 WELL jet design interval data

Item	Designed depth (m)	Actual depth (m)	Designed hole length (m)	Actual hole depth (m)	Designed direction (es	Actual direction (ct
Hole 1	1060.5	1060.5	70	70	154	160
Hole 2	1060.7	1060.7	50	50	257	261.4
Hole 3	1060.9	1060.9	30	30	196	198.57
Hole 4	1061.0	1061.0	38	38	173	175
Hole 5	1060.8	1060.8	38	38	224	225
In total			226	226		

1.3 Effects Analysis

After the X1 well injection construction was complete, all suction parameters and water jet pumps were installed.

For 10 days, subsequent to the measures being implemented, the well liquid production increased, with decreased water content. The increased oil production was immediate. Average daily gain over the three months since injection reached the 13t.

Table 2 directional water jet technology test performance statistics

Well No.	Before jet				After jet				Effectivity	
	Daily fluid output (t)	Daily oil output (t)	Containing water (%)	submergence(m)	Daily fuild output (t)	Daily oil output (t)	Containing water (%)	submergence(m)	Daily enhanced fuild (t)	Daily enhanced oil (t)
X1	29	7	75.8	0	54	20	63.3	69	25	13

Market conditions: the current set of technologies and practical experience is contained by a large number of field trials in China's Daqing Oilfield region, (including the surrounding geological conditions similar to Jilin, Liaohe Oilfield) each oil extraction factory, recognised as competing for advanced EOR services which are in short supply.

Even if the capacity of our existing equipment were to expand 10 times, it's difficult to meet the domestic demand.

For further technical information and expertise please email info@sinoaustoil.com

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