

A Collection of Revolutionary Technologies for Low Permeability Cocoon Breaking in Changqing Oilfield

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Abstract

What we want to summarize here is a low permeability oil and gas field. After 50 years of polishing, those revolutionary technologies branded with low permeability marks. In terms of its contribution, it is such a technical sequence from one row to six: first, oil and gas exploration technology that infinitely approximates the migration and accumulation law of Ordos hydrocarbon sources; The second is the brand-name, customized and service-oriented drilling fluid completion hydraulic fracturing technology; Third, natural fractures are not developed, and artificially created fracturing technology for low permeability oil and gas reservoirs; Fourth, the advanced water injection and pressure boosting development technology of ultra-low permeability oil fields, which is deficient in nature and then compensated by nature; Fifth, the large-scale cluster well technology that low-permeability oil and gas fields must be developed at low cost; The sixth is the horizontal well technology that allows the longest possible well section to lie flat in the oil and gas reservoir. It is these technologies that have exerted their effects on the low-permeability oil and gas reservoirs, resulting in many changes in the low-permeability oil and gas reservoirs in line with people's wishes. It is these gratifying changes that converge into a continuous flow of oil and gas in Changqing Oilfield.

Keywords: Low permeability features; Revolutionary technology; Fifty years; Changqing Oilfield

2020 coincides with the 50th anniversary of Changqing Oilfield. On December 27 of that year, the oilfield's output exceeded 60 million tons (reaching 60 million tons, of which 24.518 million tons of crude oil and natural gas 44.531 billion cubic meters) [1]. The output of an oil field can reach this order of magnitude, which is the first in our country that has never been seen before. This year, this day, this oil field, added a strong touch to the magnificent historical picture of the republic's petroleum industry. This pen belongs to the magical Ordos, this one belongs to the oil technology with low permeability characteristics, and this one belongs to the Changqing Oilfield, which is late in life.

The reason why Changqing Oilfield can have today, the reason why it has achieved such extraordinary performance, the specific reasons are diverse, there are many local factors, however, no matter how many kinds of specific and local factors, with the theory of systems engineering to summarize them in the end, boil down to one point, that is: deeply understand the low permeability of Changqing people and their related parties, start suitable for low penetration of the machine, through a variety of surface equipment and wells Under the tool, the specific artificial energy is transported from the ground through the wellbore, with the help of the medium, to the ground, and applied to the low-permeability oil and gas layer, so that the low-permeability oil and gas layer has undergone many changes in line with people's wishes under the artificial induction; It is these gratifying changes in the low-permeability oil and gas reservoir that converge the continuous flow of oil and gas in the Changqing oilfield. Looking at the problem from this perspective is a

bit of a technical theory, but the author chooses to believe it.

A brief review of the 50-year history of Changqing Oilfield

Ten years of entrepreneurship from scratch

The 10 years from 1970 to 1979 were the entrepreneurial period of Changqing Oilfield from scratch. The birth of Changqing Oilfield is closely related to the historic breakthrough in Longdong Petroleum exploration. The historic breakthrough in Longdong petroleum exploration is the antecedent, and the birth of Changqing oilfield is the consequence. The breakthrough of this historic breakthrough is the Sanpu people. With the establishment of New China, the large-scale oil search in the Ordos Basin began. The Northern Shaanxi Geological Brigade of the General Administration of Petroleum Administration and the Third Census Brigade of the Ministry of Geology (referred to as Sanpu) have successively entered the Ordos Basin for oil exploration. Except for the Northern Shaanxi Geological Brigade, which made a slight harvest at the western edge of the basin, the Sanpu Brigade did not appear until the end of the 1960s, although it accumulated a large amount of valuable information and positive and negative experience. The so-called substantial progress refers to either seeing the industrial oil and gas flow on a certain well to find an oil and gas field, or finding a high probability target area although the industrial oil and gas flow is not seen, laying a solid foundation for the next step. Neither of these scenarios has occurred, and oil exploration is in a dilemma of where to go [2]. At the end of 1968, the Sanpu people Sun Zhaocai, Li Haiyun, and Liu Xinzong went to Beijing to report to Minister Li, and Li Siguang's sentence "The central part of the Yishan Basin is very favorable" suddenly awakened the Sanpu people, so there was a major adjustment of "fighting back to their hometown". In early 1969, the Sanpu people deployed two exploration wells in Qingcanjing and Huacan yi jing in Tianjiacheng in Qingyang County and Donghuachi in Huachi County, respectively [3]. Longdong oil exploration is about to usher in its historic breakthrough, and Sanpu people's visit to Longdong is a key step to achieve this breakthrough. Although the Sanpu people arrived in Longdong a full year earlier than the Yumen people, the god of Longdong Petroleum clearly favored the Yumen people. The first well to see the industrial oil flow in the early days of Longdong petroleum exploration was lost to the Sanpu people twice, but the 1858 team from Yumen was taken the lead in The Qingsan Well in Zhaogou Gate of Huachi, and the time to obtain the industrial oil flow was August 1970 7th. The four wells related to the historical starting point of Changqing Oilfield are sorted in the order of obtaining the time point of industrial oil flow, namely Qingsanjing -August 7, and Qingcanjing -August On the 23th, Huacan Erjing -August 28, Qingyijing -September 26.

From the zero breakthrough of Qingsanjing in 1970 to the output of Changqing Oilfield exceeding 1 million tons at the end of 1979, it took nearly 10 years [4].

Ten years of wandering period

The entire 1980s of the last century was a ten-year wandering period in which the Changqing oil field was not up and down. Production is around 1.4 million tons, forming a platform period of long-term stagnation. The prospects for the fields are far from the large or very large oil fields expected in the early days of the battle. The ideal is very full, the reality is very bone. The root cause of this contrast is that the main oil reservoir discovered at that time belongs to the Jurassic Yan'an Group, the volume of this reservoir is not large, the output of express delivery is also fast, cannot hold back no staying power, the so-called "Old Zhu (Jurassic oil layer) is not interesting enough" refers to this situation. During the war period, the structure was downsized, and more than 20,000 employees were transferred to support the Liaohe, Jizhong, north China, central China, central plains, Shengli and other brother oil fields [5]. At that time, when people talked about oil fields, no one knew Daqing, but not many people knew About Changqing. At that time, there was a widely circulated passage in the Liupu Kang Petroleum Compound about the Changqing Oilfield, which said that "no call, no no, no noise, every meeting, sitting last, the earliest report", the image of the obscure, respectful and trembling small oilfield jumped on the paper.

Ten-year energy storage period for both oil and gas

The entire 1990s of the last century was a ten-year energy storage period for the Changqing Oilfield to combine oil and gas. Because before, there was a major breakthrough in the Ansai oil field discovered by the Saiyi well, and there was also a major breakthrough in the Jingbian gas field discovered in the Shaanxi Ginseng well, so that the oil and gas were both feasible and the oil and gas were both

harvested and water was completed. Thick water, negative boat, Changqing oil and gas production by the end of the 1990s exceeded 5 million tons.

Ten-year upward period of continuous climbing

The first decade of the twenty-first century was a ten-year period of continuous climbing. In 2003, the oil and gas production of Changqing Oilfield exceeded 10 million tons, in 2007 it exceeded 20 million tons, and in 2009 it exceeded 30 million tons.

Gorgeous turning period of breaking the cocoon into a butterfly

In the second decade of the 21st century, Changqing Oilfield has broken through the cocoon into a butterfly and achieved a magnificent turnaround. In 2013, the output exceeded 50 million tons, and on December 27, 2020, with a weight of 60 million tons, it set a new benchmark for the history of the development of the republic's petroleum industry.

The struggle of Changqing Oilfield for more than 50 years is similar to the process of a pupae that has finally turned into a beautiful butterfly after painful struggle, unremitting efforts, and finally transformed into a beautiful butterfly, flapping its wings and dancing like.

Six revolutionary technologies for low penetration to break the cocoon into a butterfly

Oil and gas exploration technology that infinitely approximates the law of transport and accumulation of hydrocarbon sources in Ordos

Changqing Oilfield relied on the discovery of the Jurassic Yan'an Formation reservoir to achieve from scratch; Rely on the discovery of the Triassic extension group reservoir to achieve a firm foothold; Relying on the discovery of the Ordovician weathered shell natural gas reservoir in the Paleozoic society to achieve leapfrog development... One after another oil and gas reservoirs with different geological properties, different transport paths of hydrocarbon sources, and different reservoir formation conditions have been discovered, discovered, controlled, and passively used, and behind it is the continuous progress of oil and gas exploration technology. For any oil and gas field, oil and gas exploration technology belongs to a type of science and technology that solves problems strategically, from the direction, and fundamentally solves the problem, and its innovation, its development, and its progress bring not only breakthroughs at points but breakthroughs in the surface, not only local breakthroughs but overall breakthroughs, not only technological breakthroughs but theoretical breakthroughs, so oil and gas exploration technology is a strategic technology. If oil and gas exploration technology is not developed, it will not be possible to find oil and gas reservoirs that can be controlled and available; There is no controllable and available oil and gas reservoir to develop, oil test fracturing, water injection, oil production and workover; and many other engineering techniques will be useless, just as the so-called skin will not be hairy, which is obvious. The latest result of oil and gas exploration in Changqing Oilfield is 1 billion tons of shale oil reserves. The Triassic extension of the Ordos Basin is a set of source rock layers dominated by mud shale during the heyday of the late Triassic Lake Basin, with a thickness of about 110 meters. Whether this layer system can form a large-scale oil-containing enrichment and whether it can form industrial production capacity requires comprehensive geological research. This major achievement of 1 billion tons is the product of the combination of comprehensive geological research and exploration technology practice in Changqing Oilfield [6].

Brand customized service-oriented drilling fluid completion hydraulic cracking technology

It is necessary to meet the requirements of balancing the formation pressure to ensure the safety of well control and to liberate the drilling speed as much as possible; Continuously matching wellbore drilling to maintain stability and avoid complex requirements in the face of formations; To maximize the need to protect the oil and gas layer from damage; As far as possible, meet the requirements of the down hole tool for the basic conditions of the whole wellbore, especially for the well section near the bottom of the well; These requirements are even more stringent, given the need for a large number of horizontal wells in the ultra-long horizontal section. There is no such thing as the liquid soft technology of Shangshan like water and soft energy when so many constraints and requirements are met. Engineering fluid technology composed of continuous phase fluids that can be circulated and fed back is a type of technology

that applies chemical principles to lay the foundation for the smooth implementation of other projects, is a technology in technology, is a project in engineering, and is the blood or soft gold of petroleum engineering. This technology is an indispensable revolutionary technology for the exploration and development of low-permeability oil and gas fields. Non-chemical professional engineering and technical personnel, unable to recognize the basic status of engineering fluid technology and the role of paving stones, are often accustomed to or blind to the high-tech characteristics and ubiquitous importance of drilling fluid completion hydraulic cracking fluid. Just as people often take water and air for granted or turn a blind eye. In fact, without the support of this technology, all kinds of stone oil projects cannot be implemented.

Natural cracks do not develop artificially to create low-permeability oil and gas layer fracturing technology

Low permeability formations are not only low or even no primary production due to low formation pressure, but also because of the low development of fracture gaps in formations and poor formation connectivity, oil and gas fluids are firmly bound to the reservoir environment in the formation and difficult to flow, so there is almost no natural production capacity. In order to change this situation, it is necessary to change the seepage conditions of the formation by artificial methods, that is, to generate artificial cracks in the formation through hydraulic high pressure, and sand addition is to let the man-made cracks be filled in time to avoid crack closure after pressure relief. Known as fracturing retrofit technology, this technology is a revolutionary technology for the development of low-permeability oil and gas reservoirs. The Changqing people likened the development of low penetration to “singing fracking songs, eating fracking rice, and making revolutions on the whetstone.” “That is to say, in the development of low-permeability oilfields, each well needs to undergo fracturing transformation, and the wells that do not undergo fracturing transformation do not produce oil, and the wells that have undergone fracturing transformation produce oil.” On hundreds of wells, after small-scale, medium-scale and large-scale multi-scheme tests, the amount of small-scale sand addition is below 20m³, the amount of medium-scale sand is 25-30m³, and the amount of large-scale sand is more than 50m³, after comprehensive comparison and optimization screening Finally, the classic model of low-permeability oil and gas reservoir fracturing transformation was found. Today, horizontal well volumetric fracturing has become the latest achievement of this revolutionary technology, which has entered a new stage of “multi-layer system, three-dimensional, large well cluster, factory”, using three-dimensional geological models of dense reservoirs with long 6 and 7 long sections In China, the H60 platform is aimed at 3 sets of small layers, and 22 horizontal wells are arranged in three dimensions, with an average section length of 1500 meters and a single-layer well spacing of 300 meters, which can be realized 3.9 million tons of petroleum geological reserves are used at one time, 1 million tons of production capacity saves 0.93 square kilometers of land resources, and the fracturing efficiency is increased by 30% [7].

Development technology of ultra-low permeability oilfield with advanced water injection and pressurization for congenital deficiency and natural supplementation

Once the borehole formed by drilling reaches the destination layer, if the oil and gas fluid pressure of the destination layer is high, the fluidity is good, and the formation fractures are developing normally, the oil flow will automatically flow into the wellbore at this time, and then through the auxiliary role of the pumping machine and the oil production pump, the oil will continue to flow from the oil layer to the wellbore, from the wellbore to the surface, becoming the oil that people can use. For low permeability, due to the low pressure of the formation, the energy of the formation is insufficient, and it is not possible to form a primary production. Advance water injection technology refers to the early betting of water injection wells 3 to 6 months before the production of oil production wells, so that the original formation pressure is maintained at 110%-120%. After the injection well is bet, the surface equipment injects the surface water that has been tested to be compatible with the formation fluid into the formation through the injection well, artificially increasing the pressure of the low-permeability formation. This is another revolutionary technology for the development of low-permeability reservoirs. Its significance lies in the successful solution of two world-class problems encountered in the development of low-permeability reservoirs: one is the common problem of low pressure and insufficient energy in low-permeability reservoirs; The other is the problem of the decline in the oil production index after the low-permeability oilfield is put into operation. The technology is used for low permeability, so that more than a dozen oil-bearing areas that were originally considered undevelopable outside the border have now become several small oil fields with an annual output of more than 300,000 tons. There are two most typical cases:

one is the Jiyuan oilfield, which was almost sentenced to the “death penalty” after five up and five down, because of the support of the technology, the sixth time it went up again, and finally won a big victory, taking a medium-sized oilfield, the production breakthrough of the Jiyuan oilfield in 2012 3 million tons; The other is the Xifeng Oilfield, which was previously regarded as a “forbidden area” after three up and three downs, but due to the support of this technology, the fourth time it went up again, and finally succeeded, and the output of the West Peak Oilfield in 2012 reached 150 Tons.

Low-permeability oil and gas fields must develop large-scale cluster well technology at low cost

Cluster well drilling refers to a drilling method in which several oil wells are drilled on a well site or platform, and the wellheads of each well are concentrated in a narrow area several meters apart, while the bottom of the well extends to different directions underground. After a variety of modes of testing of straight wells, small displacement wells, small bush well groups, and medium bush well groups, and finally formed a large cluster well ancestor, after joint research, the drilling, logging, fracturing, oil testing, oil production and other technologies have been transformed into bush wells, forming supporting technologies. Cluster well sets can significantly reduce land acquisition, reduce pre-drilling costs, and simplify surface processes. In the past 20years, Changqing Oilfield has drilled a total of 4410 clusters of various types of cluster wells, with a well number of 20,250, reducing the investment in the construction of million tons of production capacity by 32 million yuan; A total of 80,880 mu of land resources are saved (1 mu = 666.7m²) [8]. In the 12years from 2010 to 2021, 88,000 new oil and gas wells were built in Changqing Oilfield, saving land in total 640,000 acres, equivalent to 60,000 standard football fields [9].

Horizontal well technology that allows the longest possible well segment to lie flat in the oil and gas reservoir

Compared with the oil discharge area exposed by the borehole that passes vertically through a certain oil layer on that formation compared to the wellbore that passes obliquely through the oil layer, there is no doubt that the oblique discharge area is larger than the vertical area, what if the wellbore is allowed to pass horizontally through the oil layer? The size of the wellbore discharge area is directly related to the production of the well, and the larger the discharge area, the higher the production of the well under the condition that other factors remain unchanged. Horizontal wells have the largest oil discharge area, followed by inclined wells, and the smallest straight wells; Moreover, the oil discharge area of horizontal well borehole will continue to increase with the extension of the horizontal section, and the size of the oil discharge area can be controlled to a certain extent, while the oil discharge area of straight wells and inclined wells is dead and cannot be artificially controlled. A horizontal well is a well with an inclined angle of near or equal to 90°, which is capable of horizontally passing through the oil layer for several hundred meters to thousands of meters. With the maturity of guiding instruments, directional technology and the continuous improvement of drilling tools, the drilling construction of horizontal wells is no longer a problem, coupled with fracturing, oil testing, oil production to horizontal wells, the formation of supporting technology. Horizontal wells are at least equal to the production of three straight wells under the same conditions as other factors. Horizontal well technology is another revolutionary technology for the development of low-permeability reservoirs. In 1993, the first horizontal well in the history of Changqing Oilfield was born, with a depth of 1658.27 meters and a horizontal section length of only 236.17 meters. Wells with a horizontal length of between 1500 meters and 3000 meters are ordinary horizontal wells, and wells with a horizontal length of more than 3000 meters are considered high-level horizontal wells. On June 8, 2021, the Hua H90-3 well of the national shale oil development demonstration area undertaken by Changqing Oilfield was successfully completed, with a well depth of 7339 meters and a horizontal section length 5,060 meters, the longest record in Asia’s land level segment; However, this record was not maintained for long, and on July 22, it was again refreshed by an ultra-long horizontal section horizontal well deployed in the Surig gas field, which was 8528 meters deep and 5256 meters long.

A ideographic form of six techniques

The above 6 technologies can be divided into three types, oil and gas exploration technology is the leading technology, is the technology to solve problems at the strategic level, can be called the leading technology, while giving it a capital letter K as the code name; The engineering fluid technology composed of drilling fluid, completion fluid and fracturing fluid is the technology that lays the foundation for creating conditions for other projects, which can be called the technology of the bottom, and also gives it a capital letter L

as the code name; Fracturing technology, water injection technology, cluster well technology and horizontal well technology can all be regarded as tool technology in instrumental theory, and these four technologies are assigned a lowercase letter as the code name, that is, fracturing m water injection n bush well o horizontal well p, hence the following ideographic form that resembles a mathematical formula:

$$Q=K(m+n+o+p)L$$

What does the capital letter Q in this ideographic form represent? Let the reader friends define it for themselves!

Conclusions

Xiong Guan Man Dao is really like iron, and now he steps forward from the beginning. Changqing Oilfield from the obscure, respectful and last small oilfield a few decades ago, after half a century of hard work and forge ahead, to now finally achieve a cocoon into a butterfly, and finally achieve a gorgeous turnaround, set a new benchmark for PetroChina. The internal and external factors that have brought about this huge change are numerous and difficult to describe. Looking at the problem from an engineering perspective, it is probably the easiest way to approach the essential characteristics of the dynamics of this huge change. Exploration technology leads, engineering liquid technology paves the way, fracturing, water injection, bush wells and horizontal wells the four major engineering technologies show their own power, which is the driving force behind this huge change.

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