

# Damage Factors and Protection of Low Permeability Reservoir

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**Abstract:** With the development of science and technology and the progress of society, people's production level has been significantly improved. In this context, people have also put forward higher requirements for the application and development of technology and processes in various production fields. The relevant construction technology of oilfield enterprises is no exception. Low permeability reservoir occupies a large proportion in China's reservoir resources. However, due to the small pore space and large fluid flow resistance of low permeability reservoir, it is more prone to reservoir damage in the development process, and even causes the reservoir to fail to produce in serious cases. Therefore, research on the potential damage factors and damage mechanism of low permeability reservoir and propose corresponding protection strategies are conducive to improving the development effect of low permeability reservoir. The potential damage factors of low permeability reservoir are systematically analyzed, which is of great significance to guide the efficient exploitation of low permeability reservoir.

**Keywords:** Low Permeability Reservoir; Protection Strategies; Improve the Efficiency of Oil Development; Related Construction Technology of Oilfield Enterprises.

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## 1. Introduction

In the actual oilfield development process, it is not difficult to find that the low permeability reservoir is affected by many factors such as large burial depth, high formation temperature, strong compaction, etc., and its reservoir permeability is low, its abundance is low, and its production per well is low, which makes it put forward higher requirements for mining technology in the development process. There are many factors that affect the development effect, and these factors affect the development effect in different degrees. Therefore, we need to conduct in-depth research and analysis on it, and propose more reasonable reservoir protection measures.

## 2. Damage Factors of Low Permeability Reservoir

As we all know, the main factors affecting the development effect of low permeability oilfield cover many aspects: first, the pore throat of oil reservoir is relatively small, and the permeability is relatively low; Second, the seepage law does not conform to Darcy's law. In the process of seepage, the smaller the reservoir permeability, the larger the starting pressure gradient; Third, the formation energy of this reservoir is relatively small, and the formation pressure needs to be supplemented by water injection and other ways. Moreover, in the process of fluid flow, the pressure drops fast; Fourth, the reservoir water absorption and oil production capacity is poor, the water displacement effect is not obvious, the overall seepage speed is very slow; Fifthly, the oil recovery index drops sharply after the oil well reaches water. Finally, for fractured low permeability reservoirs, the heterogeneity is serious and the natural energy is low. In addition, we can also analyze the damage of low permeability reservoirs and the related reservoir protection technology is not reasonable and perfect. Therefore, we should carefully and effectively study the following main factors that cause reservoir damage in low permeability reservoirs, so as to give reasonable control to relevant factors and adopt reasonable

technology and protection measures to further create favorable conditions for reservoir protection in low permeability reservoirs and better develop such reservoirs.

### 2.1. Formation Damage Caused by Liquid Phase Intrusion

We know that the pores of low permeability reservoirs are narrow and the capillary effect is strong, so we are often subject to the influence of capillary effect in the process of development and utilization, which is easy to lead to water lock effect. In addition, low permeability reservoirs do not have too many channels, and a large number of filtration losses will directly cause great damage to the reservoir. Water sensitive injuries are also common. Water sensitive damage is mainly a kind of reservoir damage caused by liquid phase intrusion. In this process, once the liquid phase intrudes into the reservoir, the clay minerals in it will disperse, expand and fall off due to hydration reaction, which will easily cause the seepage channel of the oil layer to be blocked, thus greatly reducing the permeability of the oil layer to a certain extent and affecting the seepage effect of the oil layer fluid.

### 2.2. Reservoir Damage Caused by External Solid Blockage

External solid phase blockage is also an important factor causing reservoir damage, such solid particles can directly block the seepage channel of the reservoir. However, in general, the influence probability of foreign solid particles on low permeability reservoirs is relatively small, mainly because in low permeability reservoirs, most of the void diameters are relatively small, usually under 1 micron in diameter, while in the commonly used working fluid, the diameter of solid particles is mostly more than 2 microns. Although in the process of drilling, due to the difference between the effective fluid column pressure and formation pressure in the well, some solid particles directly invade the reservoir of low permeability reservoir, the reservoir damage caused by such intrusion is mainly concentrated in the surface layer. We can reduce this damage to a certain extent by

applying stimulation means such as perforation and fracturing.

### **2.3. Reservoir Damage Caused by Sensitive Minerals**

In low permeability reservoirs, the reservoir is also affected by different classes of sensitive minerals. Common sensitive minerals include carbonate cements and clay rich minerals. These minerals themselves do not cause direct damage to the reservoir of low permeability reservoir, but once they are stimulated by external factors, such as physical and chemical reaction with the well fluid, they may cause damage to the reservoir. Therefore, it can be said that sensitive minerals are the basic cause of other reservoir damage. In view of the damage of sensitive minerals to the reservoir, we can take reasonable measures to reasonably control or avoid the content of sensitive minerals and their reaction with the outside world, so as to effectively avoid this kind of reservoir damage.

### **2.4. Reservoir Damage Caused by Pore Structure**

The shape and distribution uniformity of pore throats are closely related to the damage degree of solid particle intrusion and fluid-related injury. Generally, if the throat size is large, mismatched solid particles can invade deeper reservoirs and cause more serious damage, but on the other hand, the possibility of water lock and jamming injury caused by filtrate intrusion is reduced. When there are more flaky and curved throats, the invasion depth of foreign solid particles is reduced and the damage caused by them is reduced. However, due to the zigzag of the throats, the particles are more likely to be blocked, which increases the potential damage degree of dispersed particle migration to a certain extent. Injuries associated with fluid-interface phenomena, such as clay hydration expansion, water locking, jamming and emulsion plugging, are more likely to occur when pores and throat sizes are small and connectivity is poor.

## **3. Low Permeability Reservoir Protection Measures**

### **3.1. Reservoir Protection During Drilling Phase**

The work of reservoir protection in drilling stage is particularly important, and its role is mainly conducive to the output of oil well production in the future. Therefore, in the drilling stage, we need to approach from multiple angles to ensure the effectiveness of reservoir protection work at this stage. There are usually the following aspects: First, it is necessary to optimize the drilling fluid formula according to the actual drilling requirements on the site, so as to minimize the damage caused by drilling fluid to the reservoir. Effective and reasonable adjustments should be made to the drilling fluid formula according to the specific properties of different formations, so that it can have better compatibility with formation fluids; The second is the use of temporary plugging measures, which can avoid the formation from deeper damage to a certain extent; Third, we need to take reasonable and effective means to control the fluid loss, so as to reduce the damage caused by liquid phase intrusion to the reservoir more effectively to a certain extent. At the same time, during the drilling process, we can also use some lubricants to change the lubricity of the formation, so as to change the relevant

properties of its filtrate. In this way, the formation of organic precipitation can be effectively controlled to a certain extent.

### **3.2. Reservoir Protection during the Cementing Phase**

Cementing operation has relatively high technical requirements for cementing personnel, and the processes involved are also very complicated, and the operation time is relatively short, but the operation process is relatively complex. If these characteristics are not well obeyed, they will directly harm the reservoir to varying degrees. Therefore, in order to effectively avoid the damage to the reservoir caused by the cementing operation, it is necessary to comprehensively consider the various characteristics and various factors of the reservoir before the cementing operation starts, and propose perfect reservoir protection measures according to different actual conditions. Looking at the current exploitation status of low permeability oil fields, it is not difficult to find that the reservoir protection measures in the cementing stage mainly include two ways. One is to add fluid loss agent in cement slurry to effectively control the water loss to reduce the damage of cementing operations to the reservoir. Another way is to construct a complete shielding ring for the well wall through temporary plugging technology to prevent and control the liquid and solid phase erosion.

### **3.3. Reservoir Protection during Perforation**

Through the above brief elaboration, we know that the perforation operation is essentially to avoid the effect of reservoir solid damage. The purpose of perforation is to form an inflow channel between the oil and gas layer and the wellbore, and to make reasonable avoidance for the low permeability of the reservoir. However, the perforation operation has high requirements for perforation accuracy. Once perforation fails or is mislocated, the blockage degree of oil and gas reservoir will be further worsened, resulting in the increase of oil flow pressure difference, and thus the occurrence of bottom hole collapse accident. Therefore, in the process of perforating operation, it is necessary to combine the logging data and strengthen the technical requirements, so as to improve the success rate and accuracy of perforating operation more effectively to a certain extent, and avoid the adverse impact of perforating failure or perforating position deviation on the reservoir.

### **3.4. Reservoir Protection during Oil Testing**

For most complex oil and gas fields, it is necessary to determine the geological data such as productivity, pressure and fluid properties of the target reservoir through oil testing, but if The Times of oil testing are too many, or the well fluid is not compatible with the formation fluid, it will cause great damage to the oil reservoir. Therefore, in the process of oilfield development, some measures need to be taken to ensure both thorough oil testing and minimum damage to the reservoir. At present, the methods used in domestic oil fields are mainly to select and optimize the well fluid reasonably, and shorten the time of oil test as far as possible according to the situation, so as to achieve effective protection of the reservoir. However, there are still some problems in the whole process of oil testing, which requires us to combine the formation conditions and ground conditions to further optimize and improve the oil testing work, only in this way can ensure that the damage to the reservoir can be reduced as much as possible.

## 4. Conclusion

Through the summary of the above four methods, we find that in view of the diversification of reservoir damage factors, whether solid plugging, pore structure and sensitivity damage, etc., will directly affect the exploitation effect of low permeability reservoirs, and thus have a great impact on the economic interests and social benefits of oil enterprises. Low permeability reservoir protection is complicated, and it is easy to neglect one thing and lose another. Therefore, we should fully investigate related issues and think comprehensively in the development of low permeability oilfield, and on this basis, put forward effective protection measures to achieve effective protection and development of low permeability reservoir, so as to maximize economic benefits.

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