Mechanism of Casing Damage and Control Method in Daqing Oil Field

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Outline

① Overview of Casing Damage in Daqing

② Mechanism of Casing Damage

③ Numerical Modelling of Casing Damage

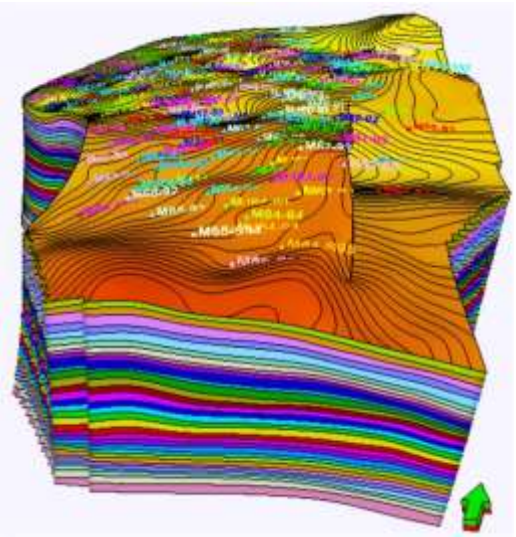
④ Advertisement about Petroleum Journal

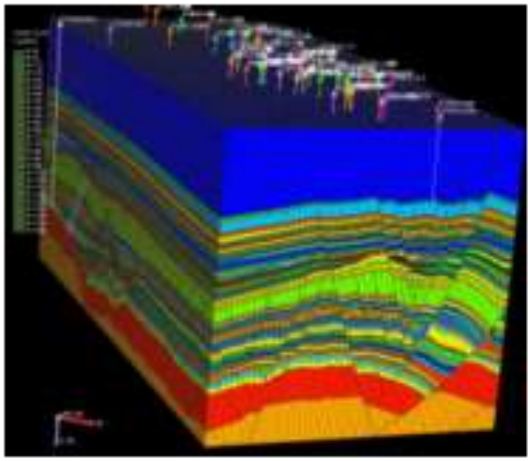
Introduction of Daqing Oilfield

- **Daqing oilfield** is the largest oilfield in China, which has produced over 10 billion barrels of oil since production started in 1960. The current production rate is about 1 million barrels per day, making it the fourth most productive oil field in the world.

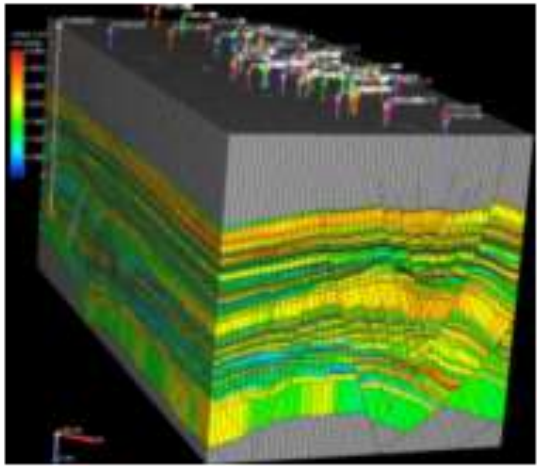
Geological Conditions and Production Methods

- Daqing oilfield is a large anticline construction reservoir, located in the central of Songliao plain. The oil rock is sandstone, and the burial depth is 900-1200m. Usually, the oil reservoir contains more than 100 oil-bearing sandstone layers, the maximum thickness is 20 m, and the minimum is 0.2m. Most interlay rock is mudstone.
- The production methods are water-flooding, polymer flooding (1996-) and ASP flooding (2012-). In recent years, high pressure injection and hydraulic fracturing are used to improve recovery ratio.





网格模型



属性模型

1. Overview of Casing Damage in Daqing

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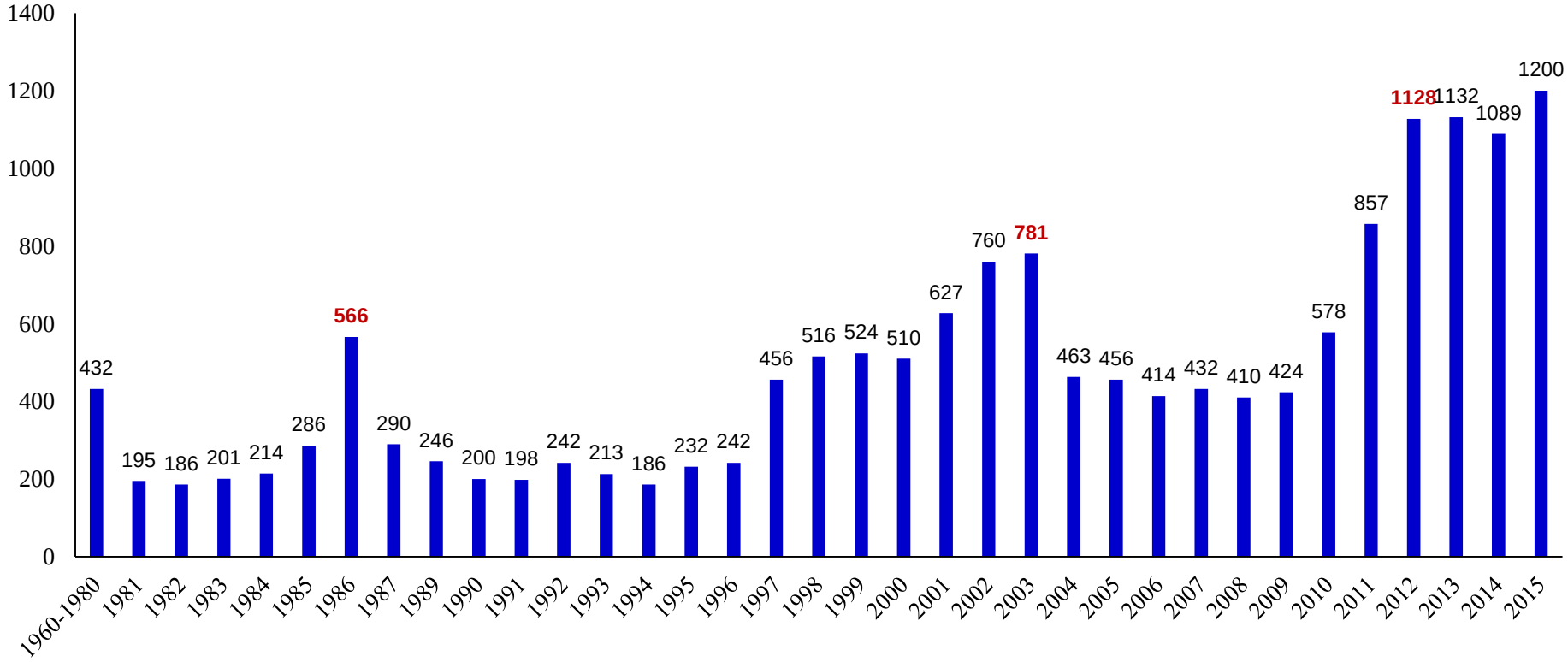
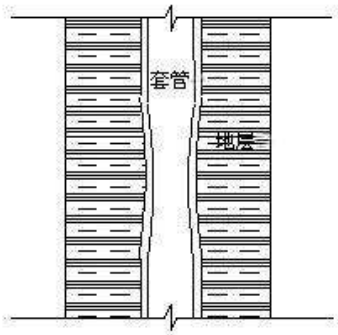
Casing Damage has become a serious Problem in Daqing

- After more than 70 years' development, the oil production declines, but the casing damage well number increases quickly.
- The total casing damage well numbers exceeds 16 000, in recent 4 years the number exceeds 1000 per year, which caused huge economic losses.

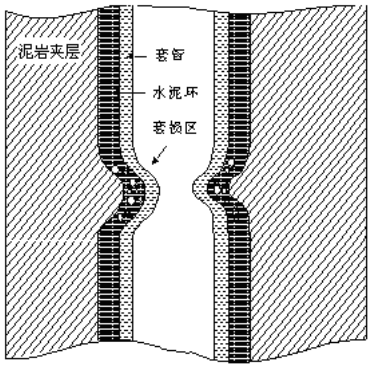


2. Mechanism of Casing Damage

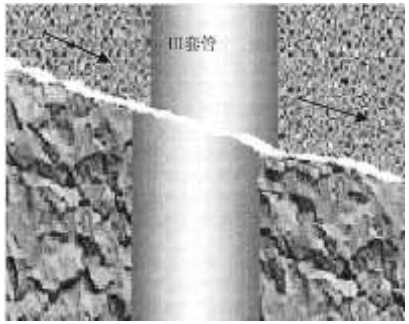
- From 2004-2016, we finished serval projects collaborated with Daqing Oilfield Company to reveal the mechanism, and find controlling method of casing damage.
- Through field data analysis, we found that mudstone rheology, block pressure difference and fault slip are the main influence factors of casing damage.



tensile failure



collapsing failure



shear failure

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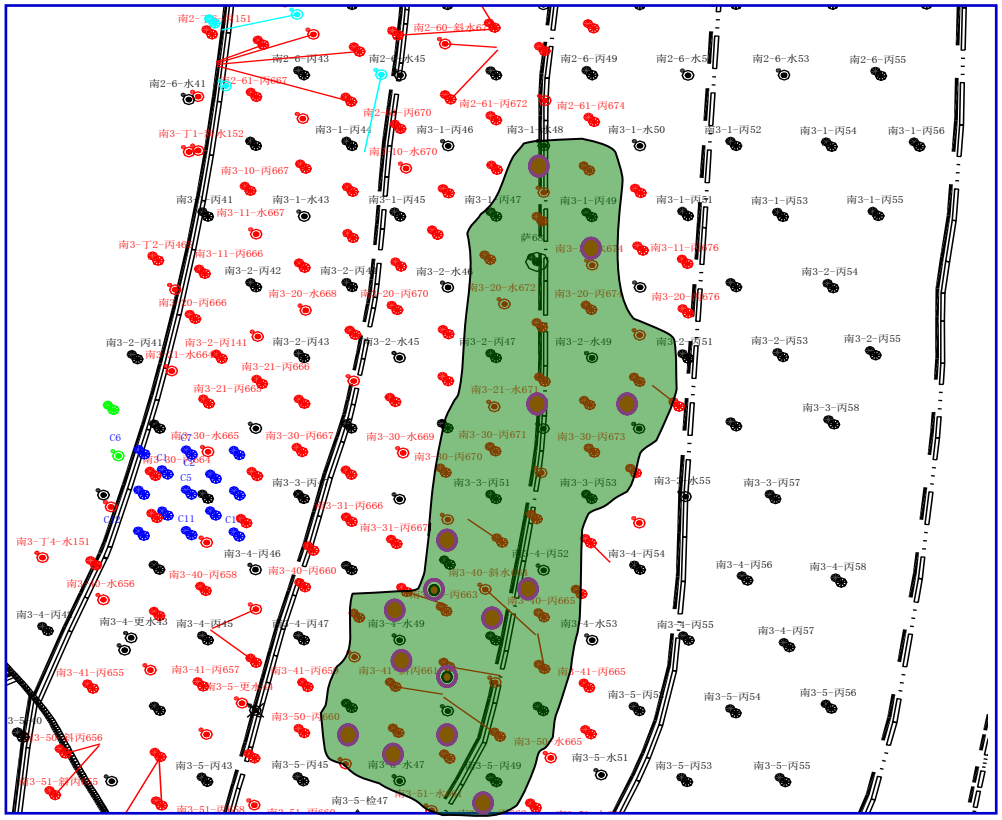
Mudstone rheology induced casing collapsing failure

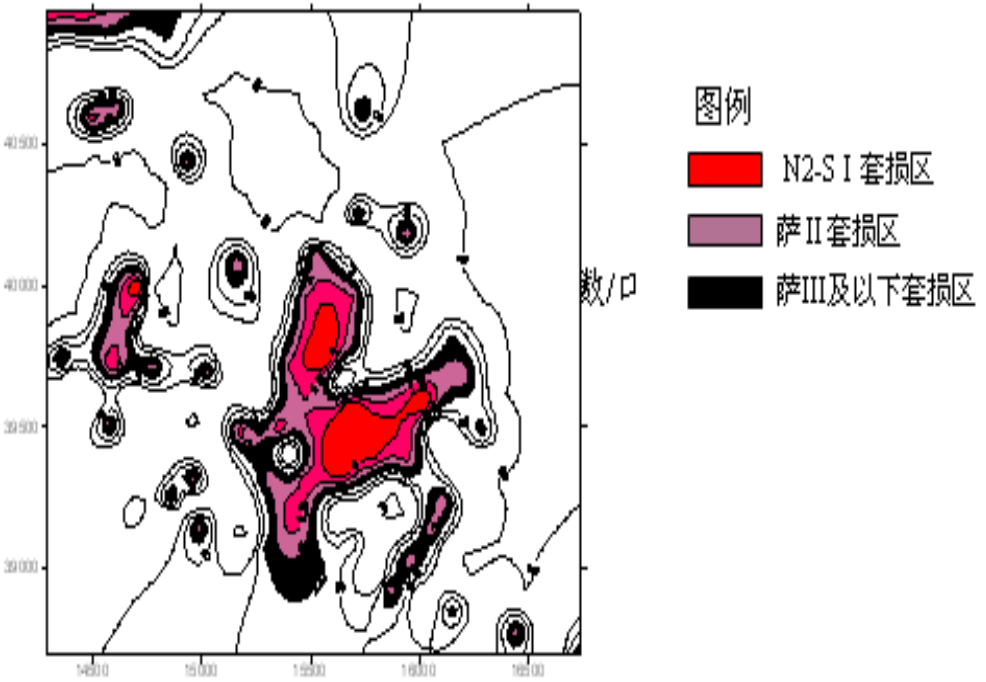


- ✓ In the plane, the casing damage wells concentrated in a north-south strip.
- ✓ Vertically, the casing damage points concentrated in the upper part of the mudstone layer.
- ✓ Casing failure type is collapsing failure.

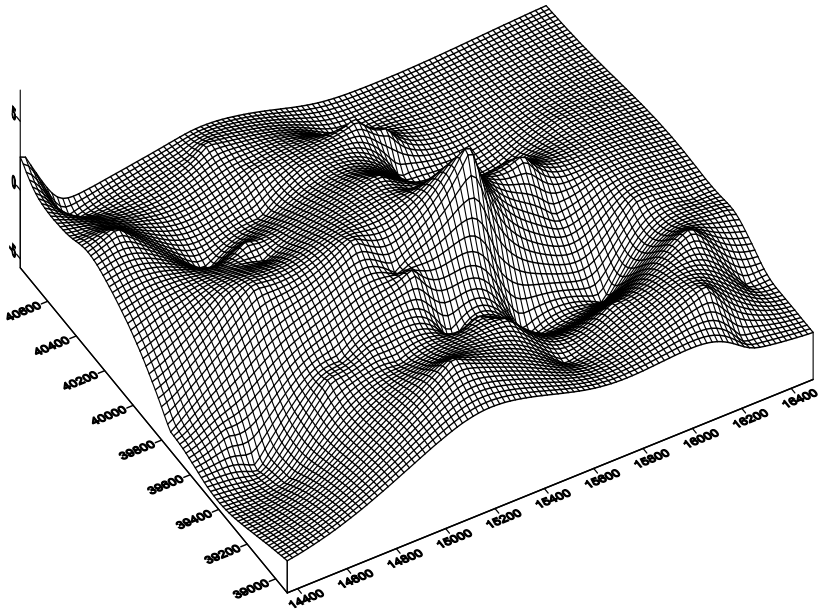
- Red point represents oil well
- Black point represents water well
- Big red point represents casing damage well

- **High pressure difference induced tensile failure**

The distribution of casing damage wells in South-6 zone of No.2 oil production factory is relatively scattered. Through the pressure analysis, it is found that the wells concentrated in high pressure or pressure difference areas.



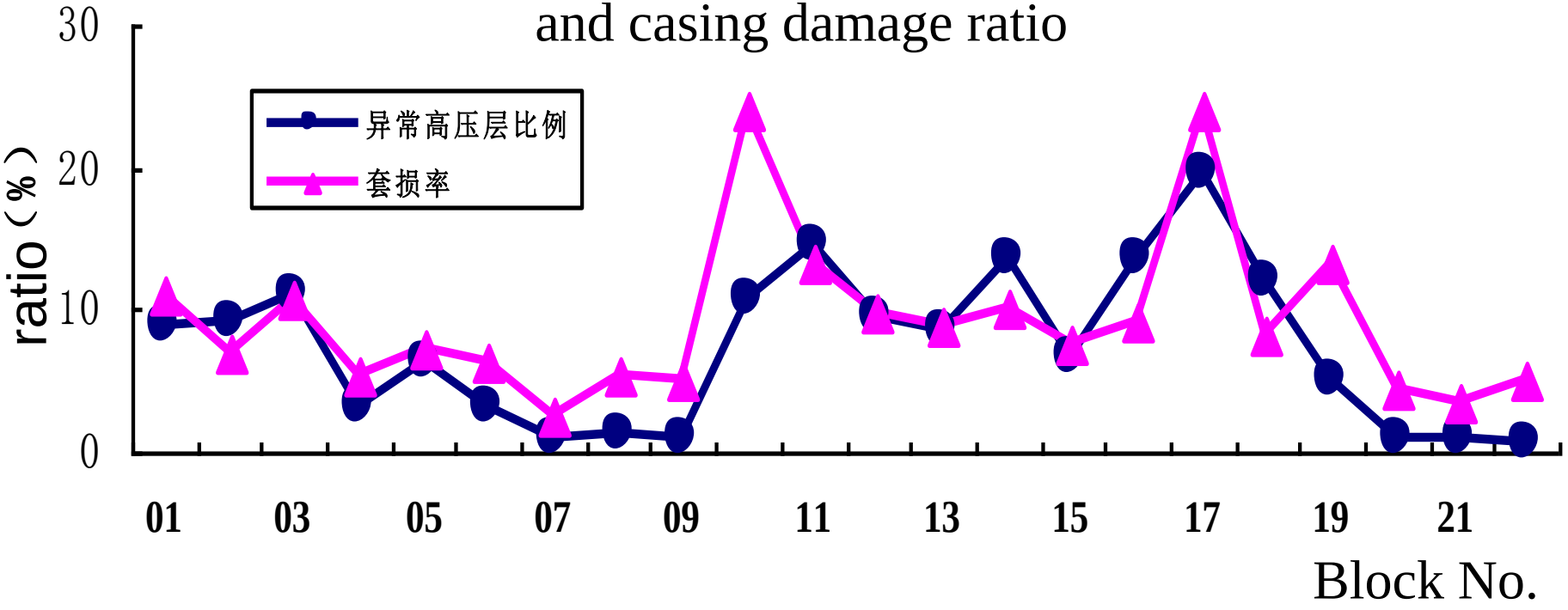
Casing damage distribution map



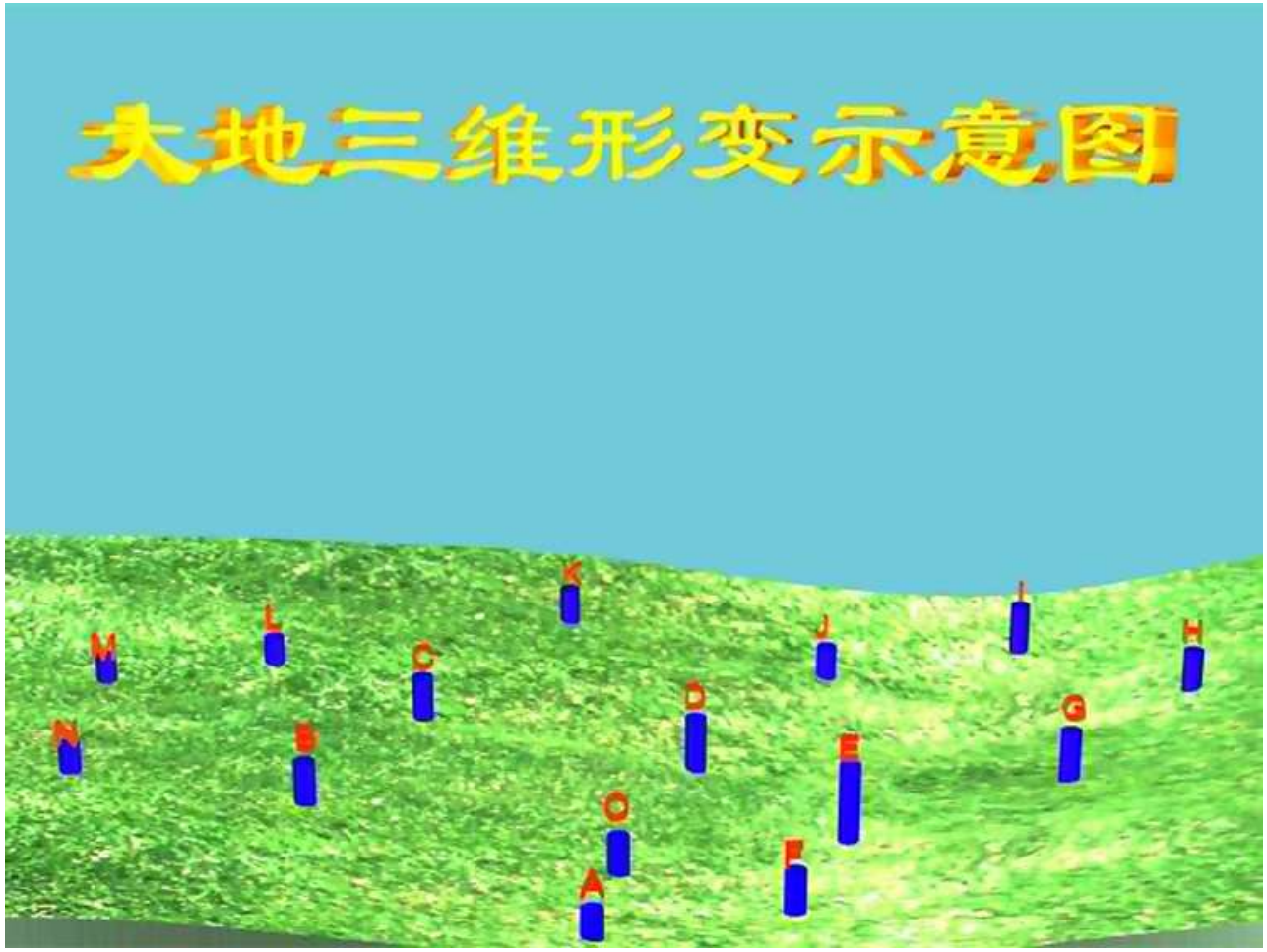
Pressure difference distribution map

- **The casing damage ratio increases with the abnormal high pressure.**
- **The casing damage type is tensile failure.**

Relation between abnormal high pressure proportion and casing damage ratio



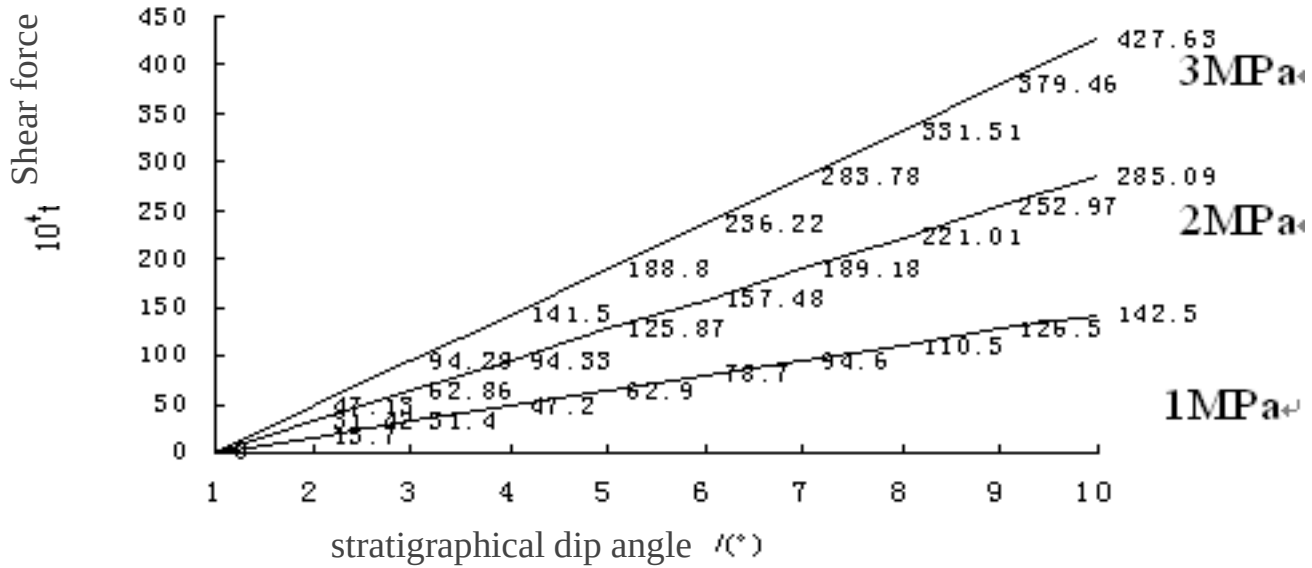
- **The monitoring results of surface deformation shows that oilfield injection-production can cause land surface rise or sink, which make the casing endure tensile or compressive stress.**



- **Fault slip caused casing shear failure**

In Xingbei zone, totally 80 wells, 45% casing damage wells are located near strike-slip faults.

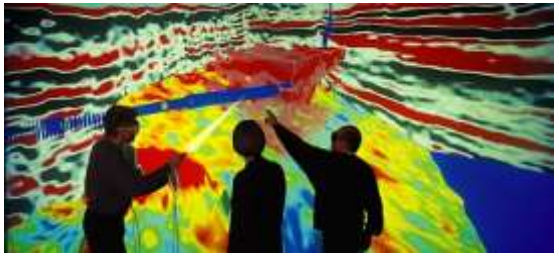
Relation between shear force and dip angle

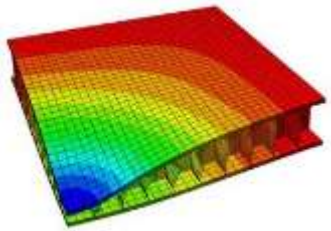


Casing damage is a hydro-mechanical coupling process

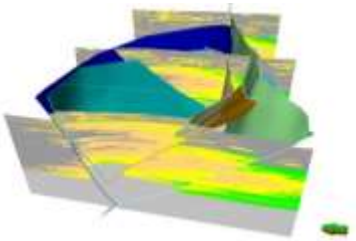
- **The interaction between porous flow field and geostress field is the main reason, which causes geo-stress evolves during oil field development and may lead to stress concentration near wellbore. During water flooding exploitation process, pressure difference, fault sliding and mudstone immersion is direct cause of tensile, shear and extrusion failure respectively.**
- **To simulate the multi-field coupling and multiscale process is difficult. We combined 3 mature commercial software to simulate the coupling process. The 3 softwares are Petrel (a famous oilfield geological modelling software), Eclipse (a famous oil reservoir simulator) and Abaqus (a finite element software)**

Petrel
Shared earth—critical insight





- **Use Petrel-Eclipse-Abaqus to Simulate Casing damage**



Use Petrel to build model

Import Geomodel

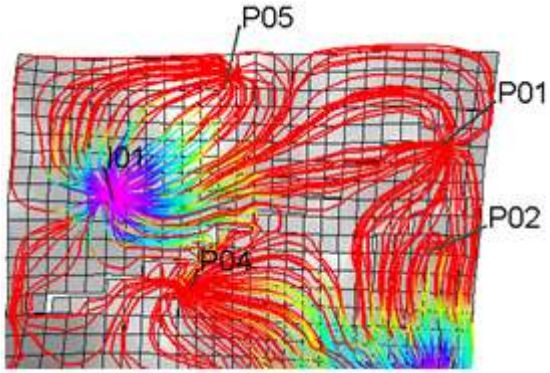
Grid to Element

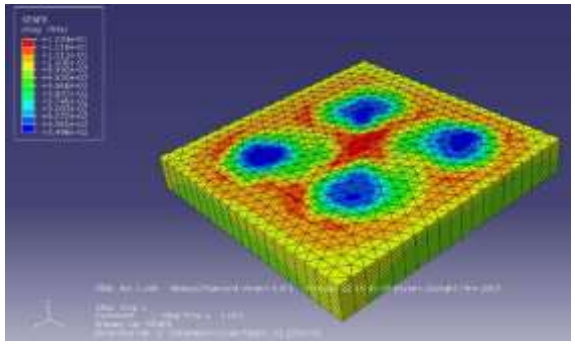
Use Eclipse to do reservoir simulation

Use P as body force

Use Ɛ to adjust k

Use Abaqus to simulate Stress





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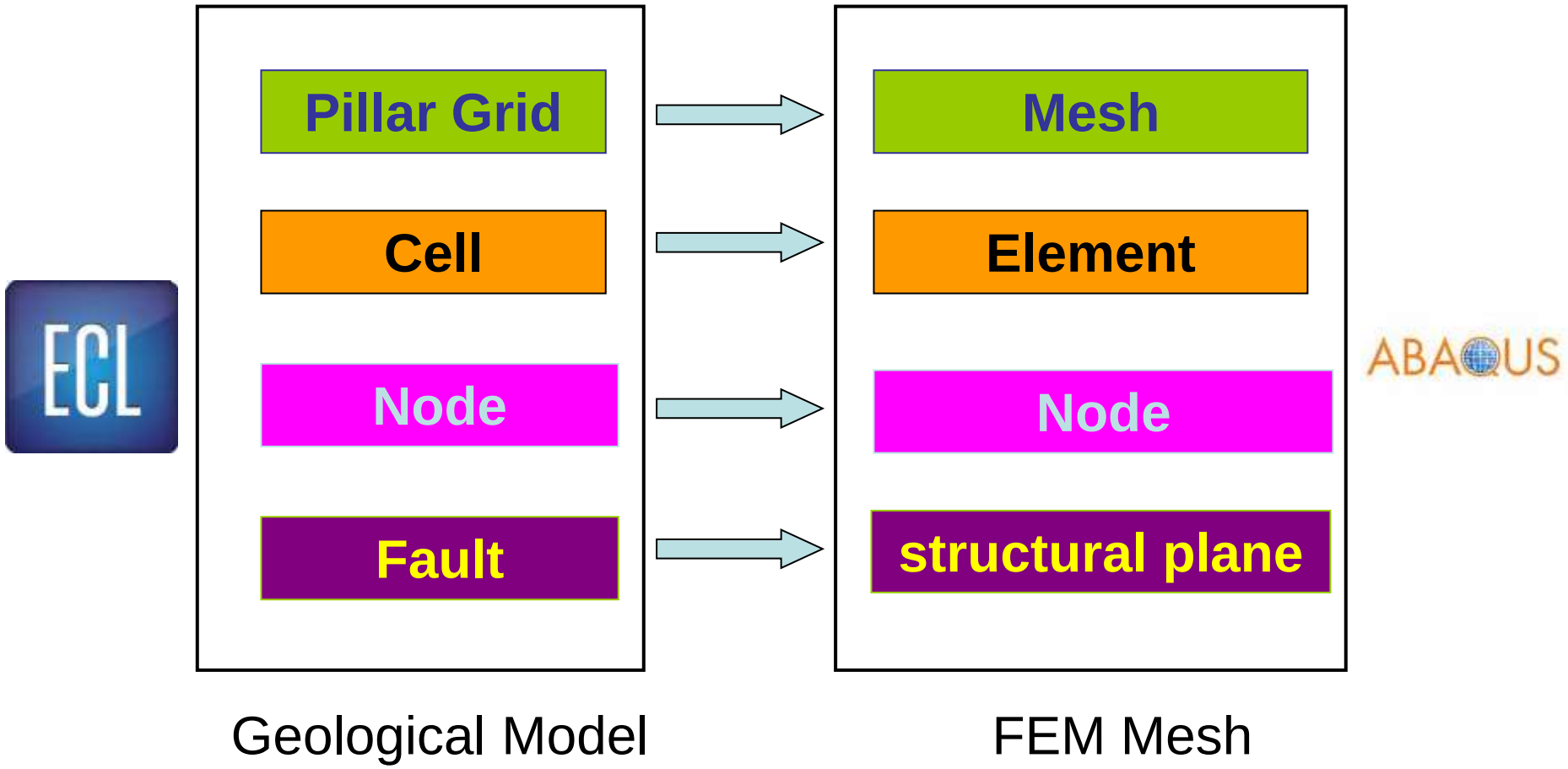

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Use Petrel-Eclipse-Abaqus to Simulate Casing damage

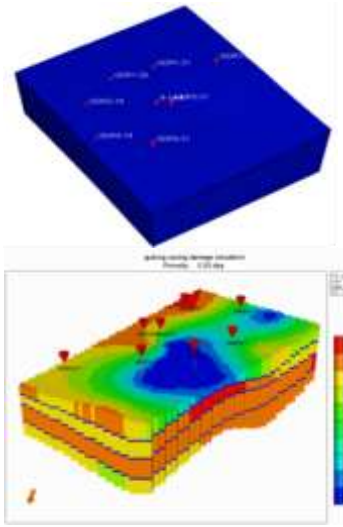
Calculation Model

- ✓ Real geological condition and well location
- ✓ HM Coupling model
- ✓ Equivalent method to simulate well element stress

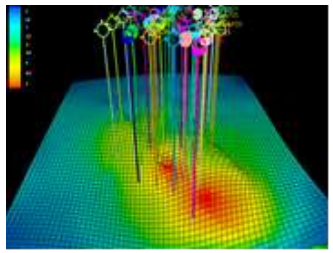
Simulation results

- ✓ Reservoir simulation
- ✓ Geostress simulation
- ✓ Casing force analysis

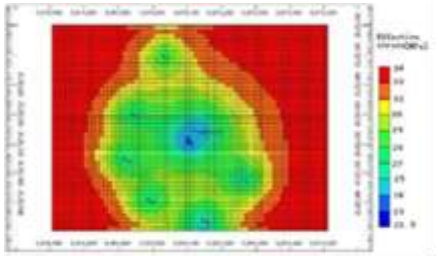
Calculation model



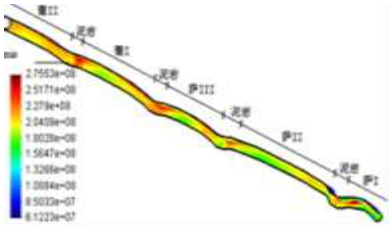
Coupling Analysis



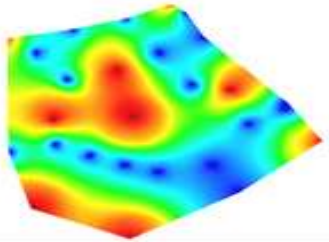
Reservoir Simulation



Geostress Simulation



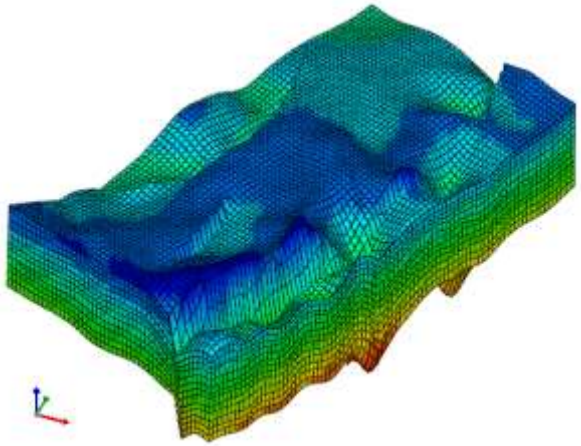
Casing Force Analysis



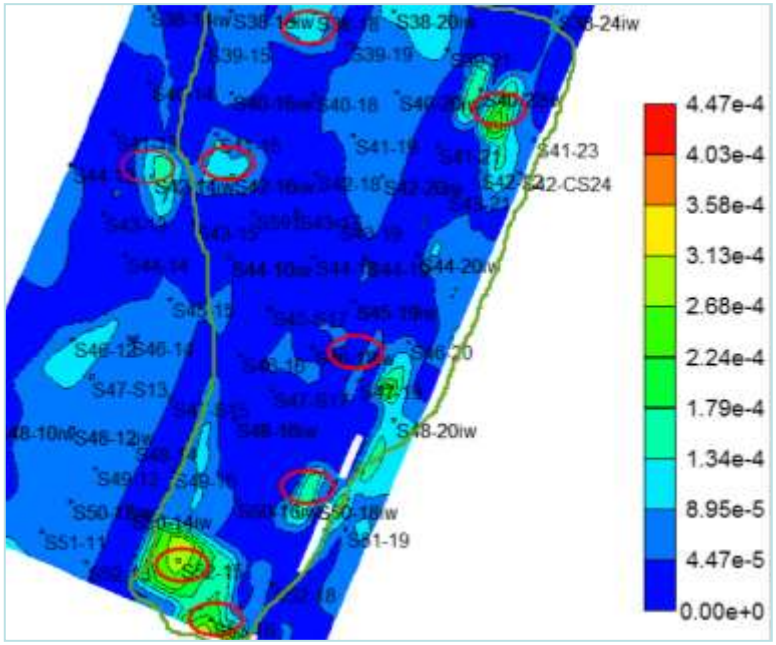
Casing damage danger division

Use Petrel-Eclipse-Abaqus to Simulate Casing damage

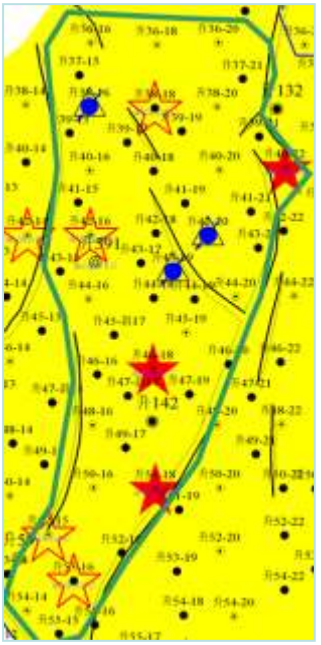
- **Example 1 – Shengping Oilfield S142 block: The prediction result is consistent with the actual situation.**



Geological model of S143 block



Predicted casing damage well location



Actual casing damage well location

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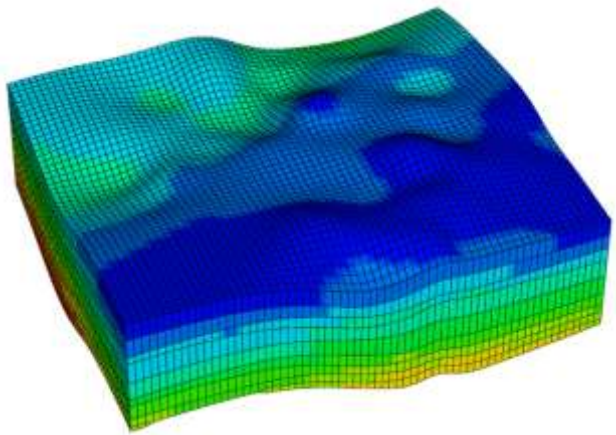
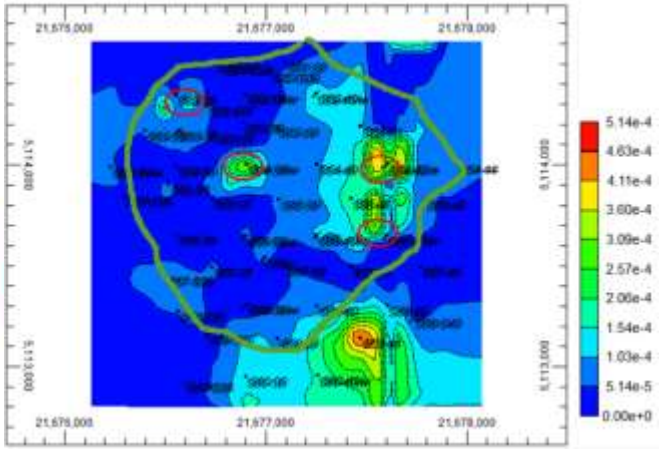
Use Petrel-Eclipse-Abaqus to Simulate Casing damage

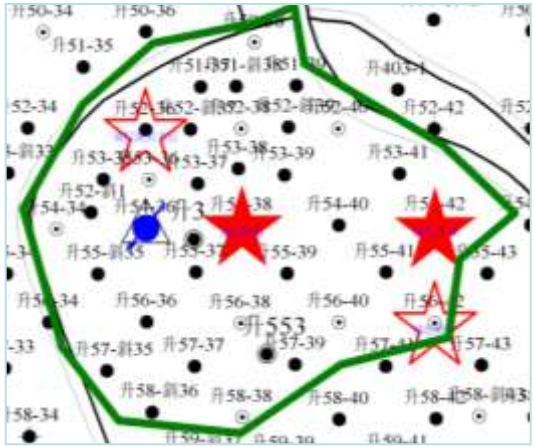
- **Example 2 –S155 block: The prediction result is consistent with the actual situation.**



Geological model of S143 block



Predicted casing damage well location



Actual casing damage well location

Controlling method

- Controlling the water injection pressure, in No.1 and No.2 oil production plant, the value should be less than 15MPa, in low permeability oil field, the water injection pressure limit is 20 MPa.
- Reducing the production pressure difference. Changing well type, adjusting well distribution etc. can make reservoir pressure field more smooth, which can prevent casing damage.
- Improving cementing quality, separated layer water flooding can prevent the injected water flow into mudstone, and prevent the mudstone rheology cause collapsing casing damage.
- The distance between well and fault should be greater than 15-30m.
- Dual combined casing is suitable for Daqing oilfield.

Several important scientific problems to be solved

- **What is the mudstone immersion mechanism, how to calculate the immersion process, and how to calculate the force?**
- **What is the fault activation mechanism? It is a The old question has been puzzling human being for centuries. How to simulation the casing force change during the fault activation?**
- **How to design a new type of casing that can auto adjust the stress around wellbore.**

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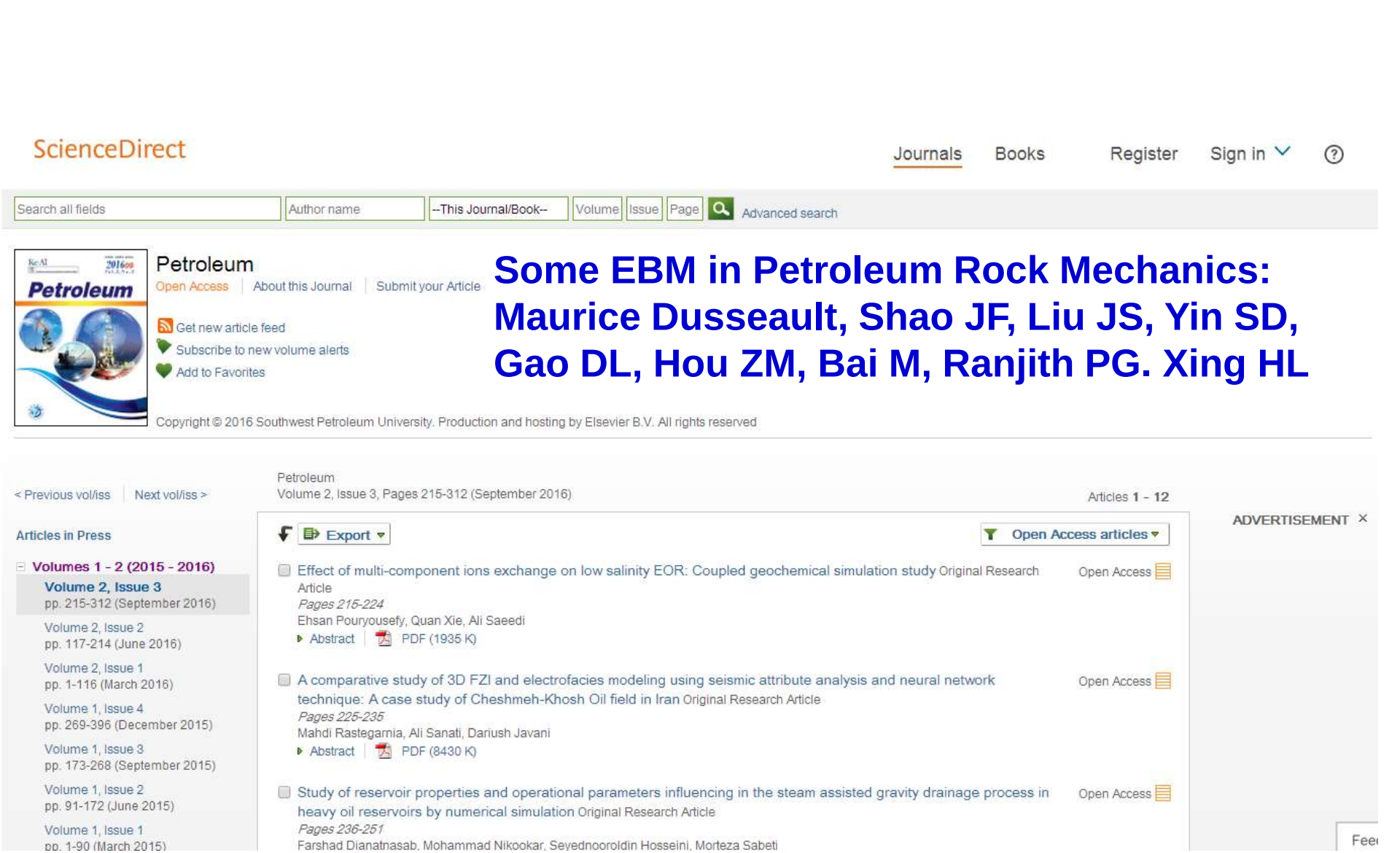

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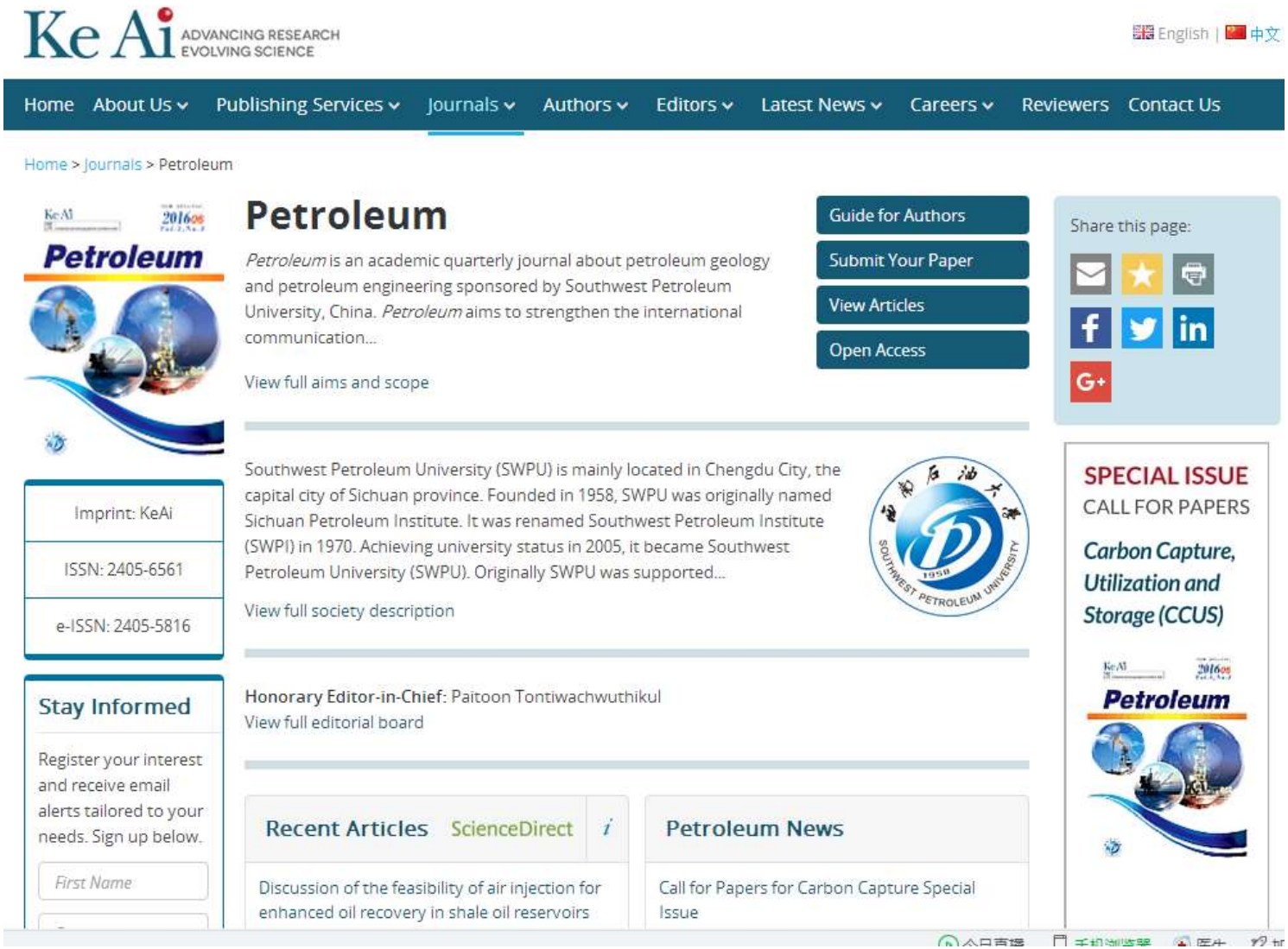

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