# Extend Well Life by Optimizing Well Completion and Pumping Operation*

**Xingjin Wang**[1]

Search and Discovery Article #41647 (2015)**
Posted June 30, 2015

*Adapted from oral presentation given at AAPG Asia Pacific Region, Geoscience Technology Workshop, Opportunities and Advancements in Coal Bed Methane in the Asia Pacific, Brisbane, Queensland, Australia, February 12-13, 2015


[1]Austar Gas Pty Ltd., Sydney, New South Wales, Australia (xwang@austargas.com.au)

## Abstract

Production from coalbed methane (CBM) wells is especially sensitive to changes in how pumps are operated. Even when reservoir parameters are highly favourable, production can decline dramatically because of improper pumping operations. The most commonly used completion method for vertical CBM wells is fracture treatment. Successful fracture treatment can result in high peak gas production. However, fractures may close and if production declines too abruptly, bottom hole pressure may not be controllable. In order to optimise pumping operations in fractured wells, it is necessary to first analyse possible changes in permeability and conductivity and how these might affect production. Adsorbed gas saturation is also relevant in any change in permeability and conductivity of fractured formation during production.

This study uses data from the Bowen and the Surat Basins in Australia; the Ordos Basin in China, as well as CBM pilot projects in Russia, to analyse the relationship between gas saturation, mechanical properties of coal, gas saturation, and conductivity of fracture systems. Petroleum engineers are often confronted with the difficulty of trying to optimise production wells that have been damaged by improper operation. This study presents typical cases showing how production has been improved through refinement of the pumping system while keeping in mind the specific attributes of individual reservoirs.

This study provides useful engineering methodologies in diagnosing well behaviours using case studies. Inflow Performance Relation (IPR) can be used to analyse the drainage efficiency of CBM wells. For example, if production data scatters when plotted on an IPR graph, this would indicate that coal fines have blocked gas flow within fracture network. Alternatively, if, the fractures have efficient conductivity this would be manifest on an IPR plot as a clear linear trend. Experience shows that control on annulus pressure is helpful in protecting fracture from collapse.

Austar Gas Pty Ltd

THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

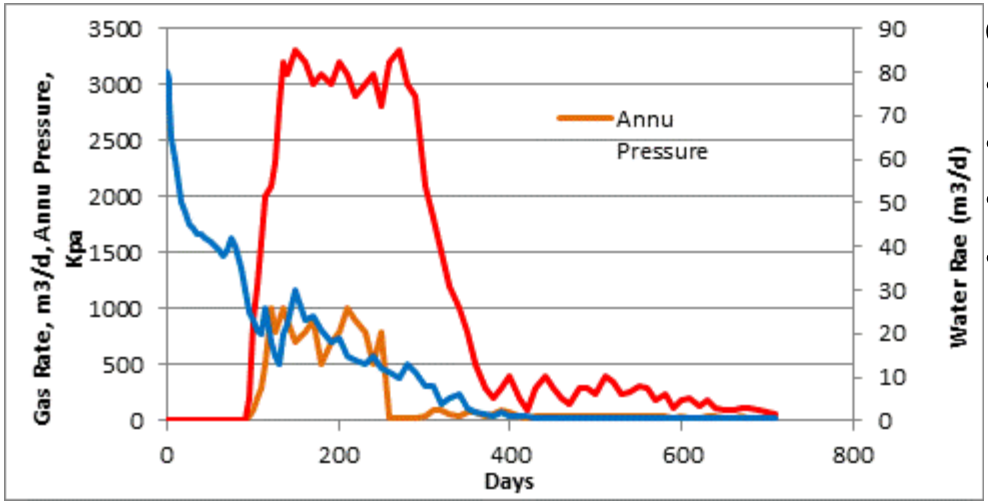
# EXTEND WELL LIFE BY OPTIMIZING WELL COMPLETION AND PUMPING OPERATION


**XINGJIN WANG**


13 February 2015, Brisbane


Email: xwang@austargas.com.au

# CHALLENGE IN SUSTAINING PRODUCTION LIFE OF CBM WELL




Commonly happen

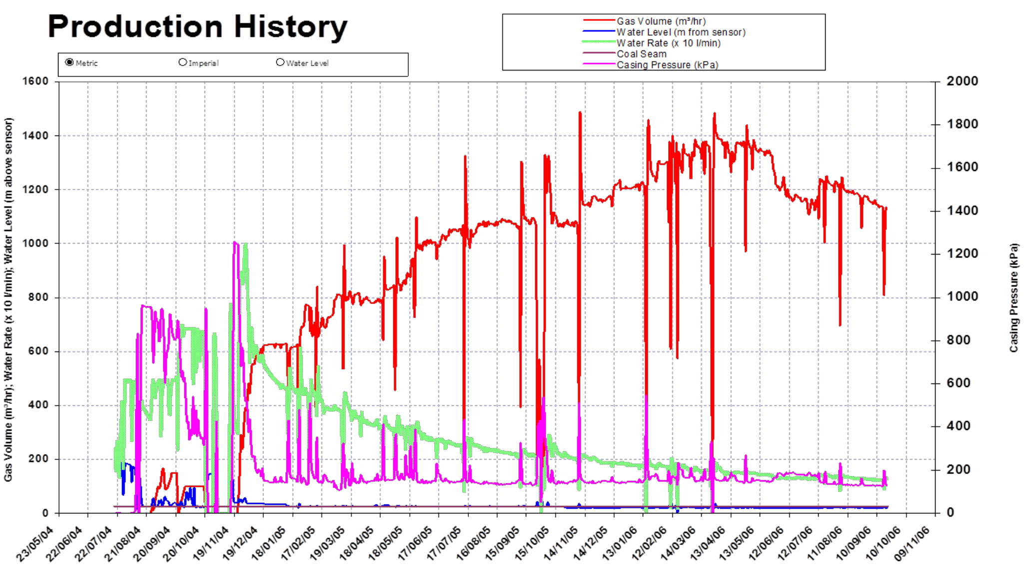
- The well life is shorter than 2 years
- High initial rate and then decline abruptly
- Then little gas and water produced
- No improvement after re-stimulation

| Basin | Country | Well No involved the study | Well No dropping to 35 mcfd in 2 years | Percentage of life shorter than 2 years |
|---|---|---|---|---|
| Ordos Basin | China | 330 | 180 | 55% |
| Qinshui Basin | China | 340 | 90 | 26% |
| Kunetskiy Basin | Russia | 30 | 21 | 70% |
| Surat Basin | Australia | 220 | 30 | 14% |
| Bowen Basin | Australia | 120 | 12 | 10% |

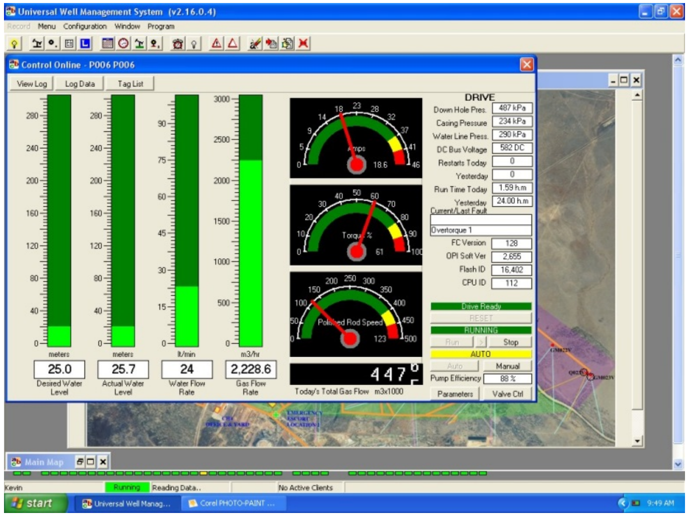
The wells life both in China and Russia is short

# PRODUCTION LIFE OF CBM WELL IN AUSTRALIA SOUNDS GOOD BECAUSE OF PRODENT OPERATION SYSTEM

The gas rate is still increasing after 5 years in the Bowen Basin



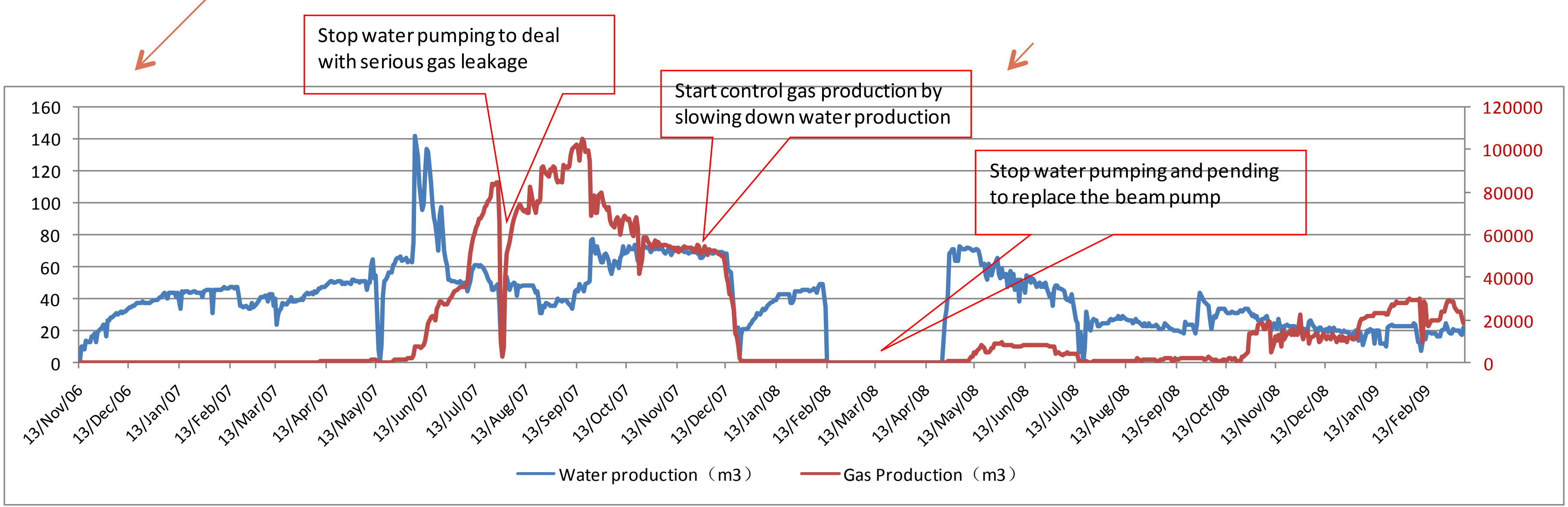




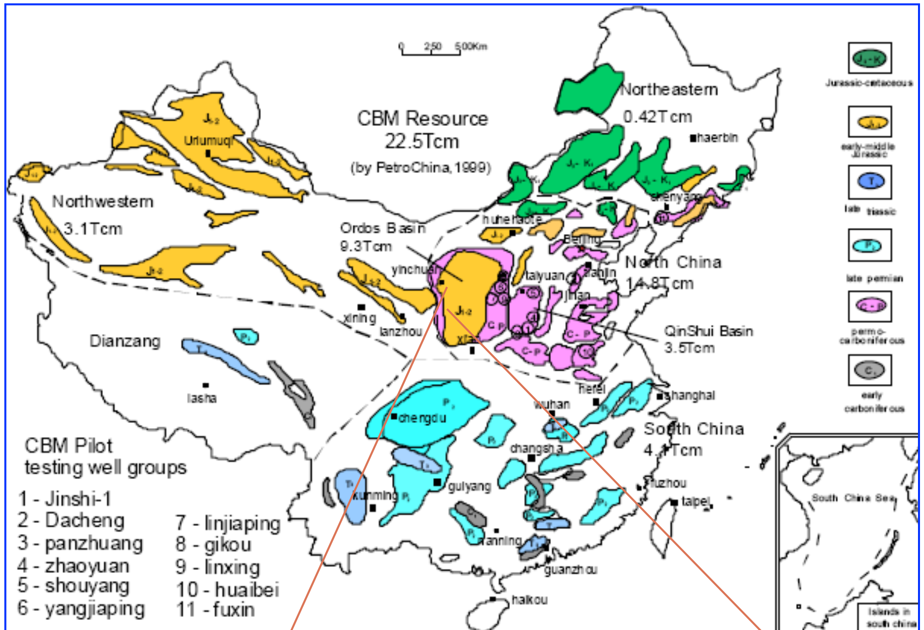

- Horizontal Well
- Dual Laterals
- Production is stable
- Pump rate and pressure were managed properly
- No stop during pumping

# QUICK DECLINE IN GAS RATE, IN THE QINSHUI BASIN, CHINA


- The Production of a Horizontal Well Dropped quickly
- Due to the frequent stop. After stop, the gas rate can not recover.
- Failure in control in annulus pressure causing coal fine migration
- Pump was stuck frequently

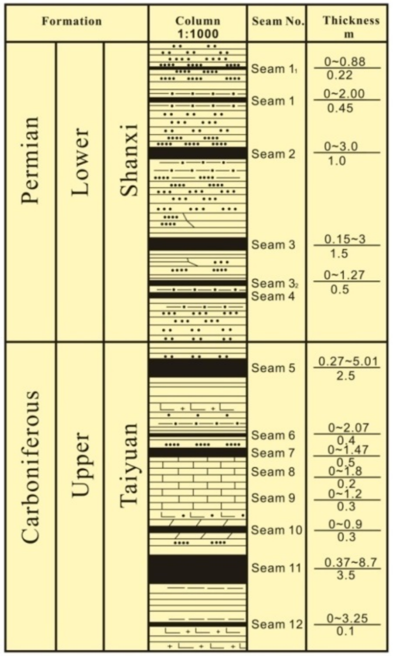


# VERTICAL FRACTURED WELL IN ORDOS BASIN

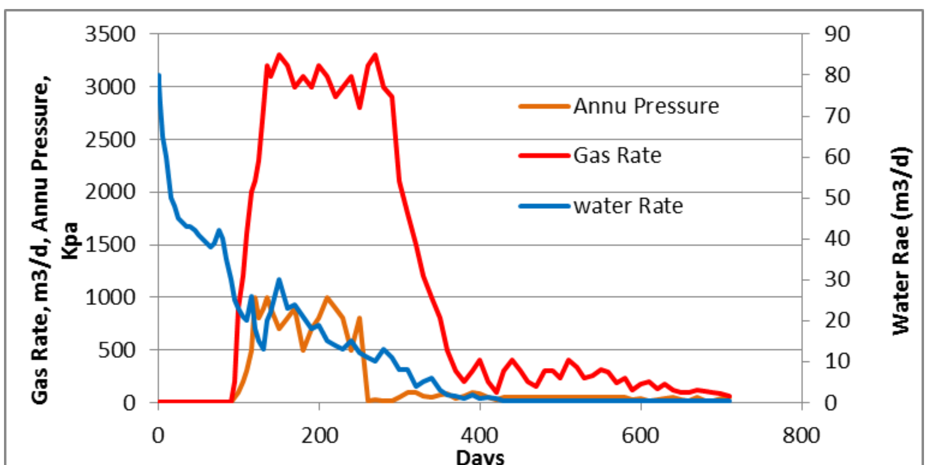


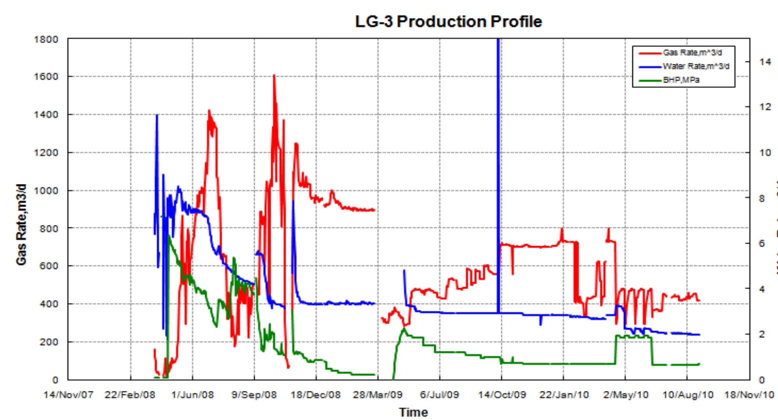

- In Ordos Basin, the completion type for majority of CBM wells are vertical well with fracturing stimulation.
- The Fracking achieved success
- The initial rat is encouraging
- However, the gas rate drops to 100 m3/d for 2000 m3/d in 1 year.

# VERTICAL FRACTURED WELL IN ORDOS BASIN

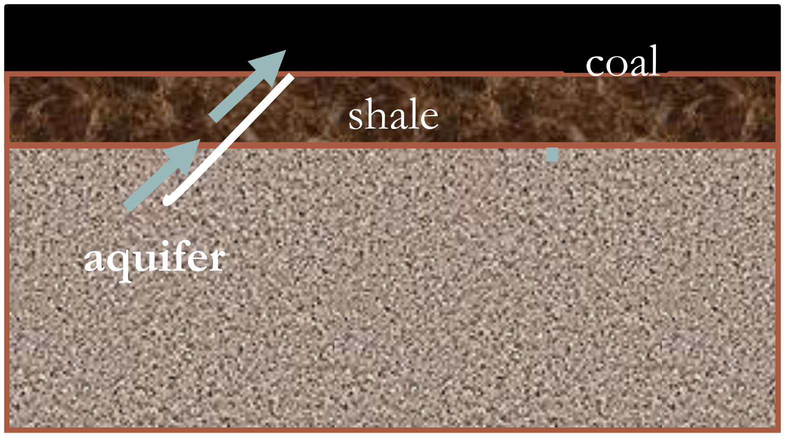



- In Ordos Basin, the completion type for majority of CBM wells are vertical wells with fracturing stimulation.
- However, the gas rate of over 50% wells falls dramatically in one year.
- Due to failure in controlling annulus pressure and stabilizing pump rate



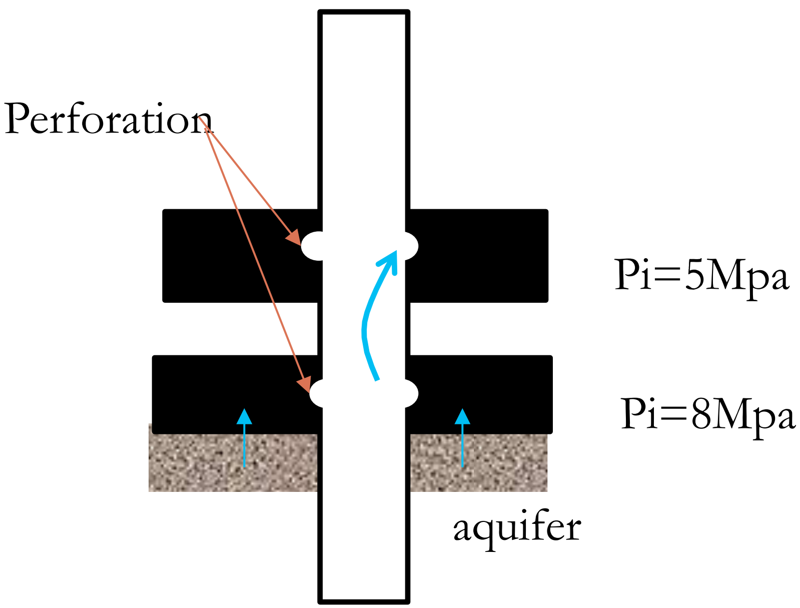



# WATER CONING OR SEAM INTERFERENCE FOR COMINGLED COMPLETION




**Water Coning**

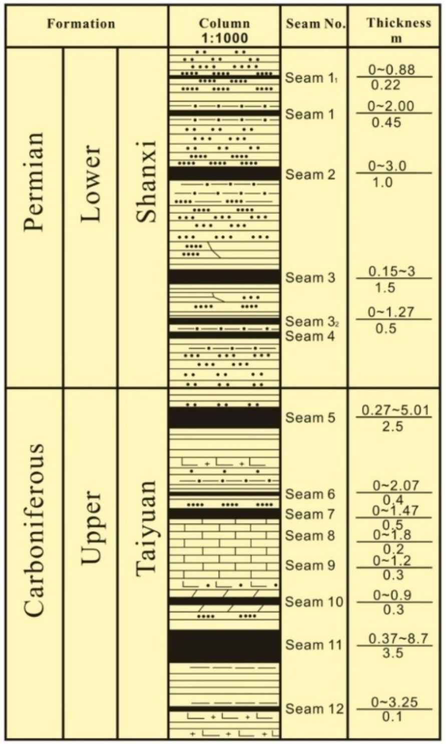
- The aquifer may communicate with the reservoir though fault or unconformity or direct contact
- It is difficult to drop the pressure to the desorption point if there is constant water charge



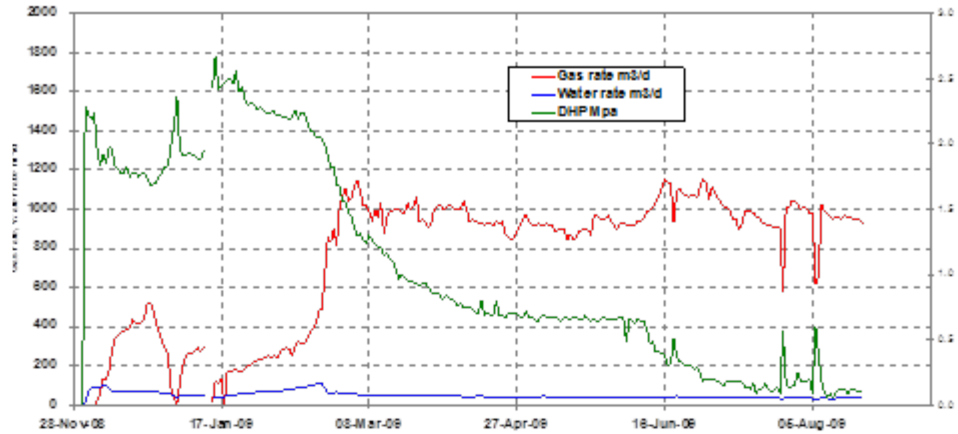

**Seam Interference**

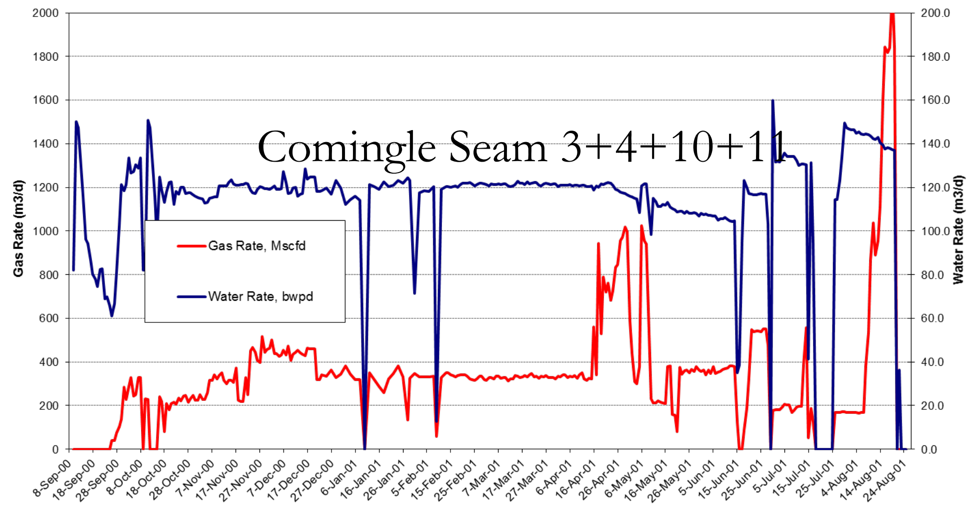
- The upper seam has no connection to the aquifer
- The lower seam is in communication with an aquifer.
- Comingle completion may bring the water from the lower seam to the upper seam
- The production of the upper seam will be blocked by the interference

# CASE 1: IN ORDOS BASIN CHINA




Comingle Seam 3 + 4

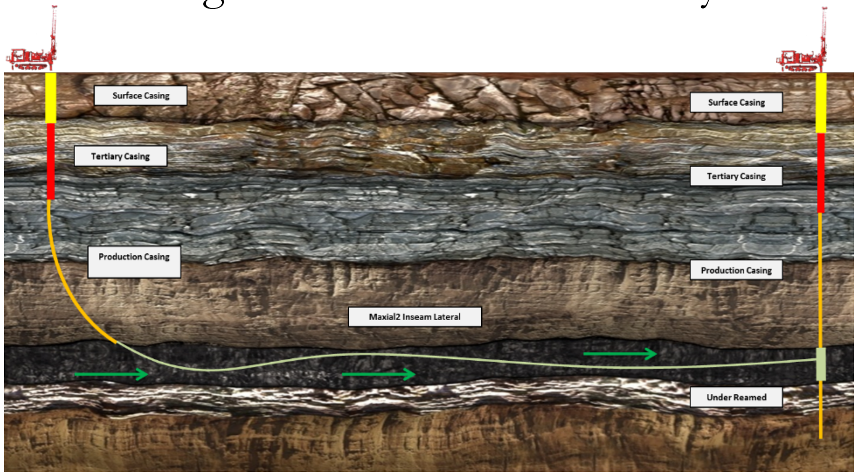


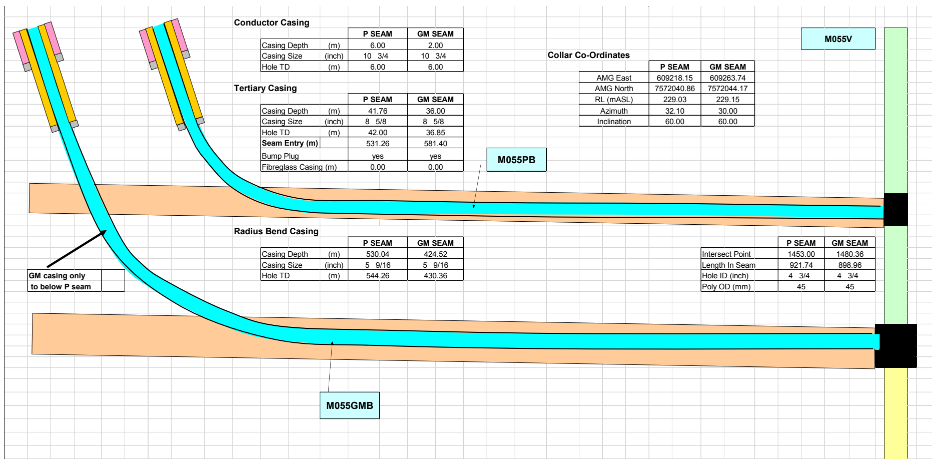




**Below Seam 11, there a limestone aquifer**
**Up left: perforated only upper seam, with higher production**
**Low Left: Perforated all seams, low gas and higher water**

# AUSTRALIA CASES: COMINGLE OR SEPARATE

Single Later in the P seam only




**Conductor Casing**

| | | P SEAM | GM SEAM |
|---|---|---|---|
| Casing Depth | (m) | 6.00 | 2.00 |
| Casing Size | (inch) | 10 3/4 | 10 3/4 |
| Hole TD | (m) | 6.00 | 6.00 |

**Tertiary Casing**

| | | P SEAM | GM SEAM |
|---|---|---|---|
| Casing Depth | (m) | 41.76 | 36.00 |
| Casing Size | (inch) | 8 5/8 | 8 5/8 |
| Hole TD | (m) | 42.00 | 36.85 |
| **Seam Entry (m)** | | 531.26 | 581.40 |
| Bump Plug | | yes | yes |
| Fibreglass Casing (m) | | 0.00 | 0.00 |

**Collar Co-Ordinates**

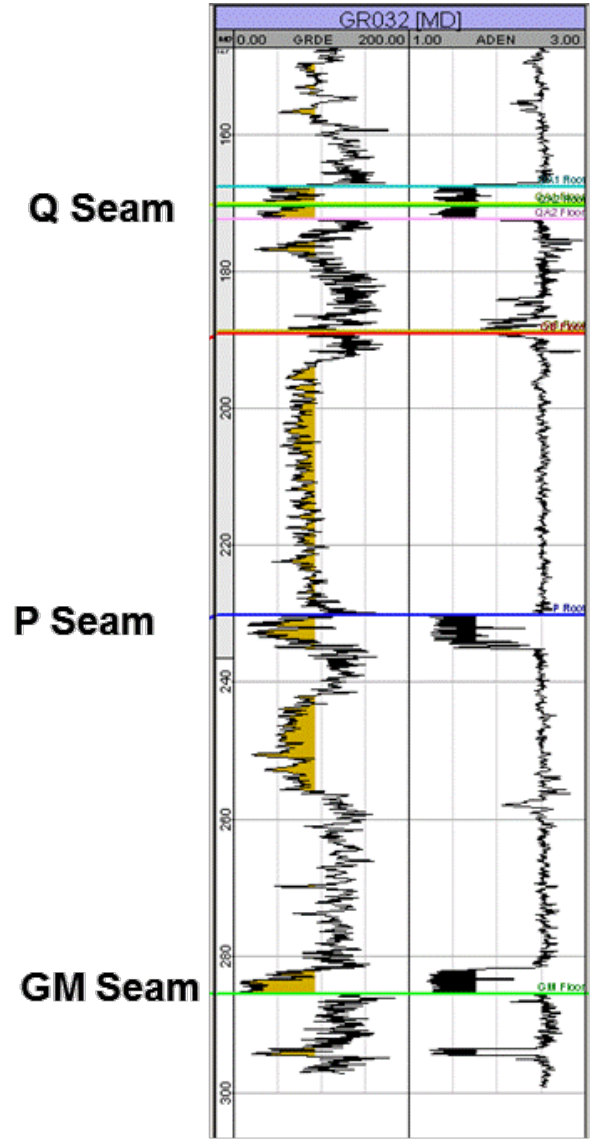
| | P SEAM | GM SEAM |
|---|---|---|
| AMG East | 609218.15 | 609263.74 |
| AMG North | 7572040.86 | 7572044.17 |
| RL (mASL) | 229.03 | 229.15 |
| Azimuth | 32.10 | 30.00 |
| Inclination | 60.00 | 60.00 |

**Radius Bend Casing**

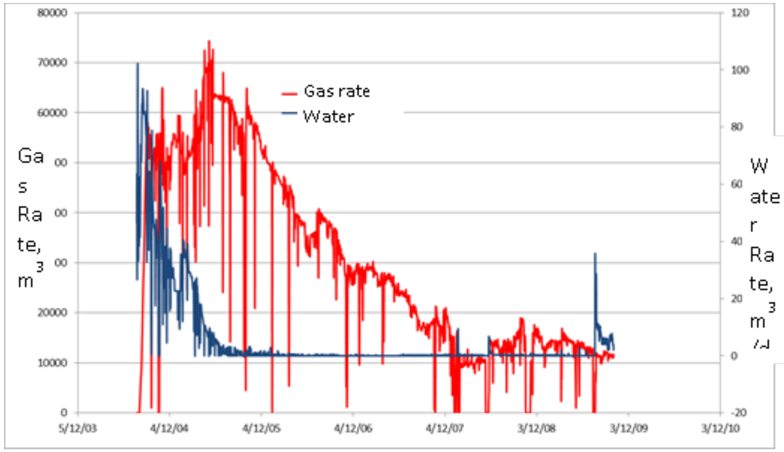
| | | P SEAM | GM SEAM |
|---|---|---|---|
| Casing Depth | (m) | 530.04 | 424.52 |
| Casing Size | (inch) | 5 9/16 | 5 9/16 |
| Hole TD | (m) | 544.26 | 430.36 |

| | P SEAM | GM SEAM |
|---|---|---|
| Intersect Point | 1453.00 | 1480.36 |
| Length In Seam | 921.74 | 898.96 |
| Hole ID (inch) | 4 3/4 | 4 3/4 |
| Poly OD (mm) | 45 | 45 |

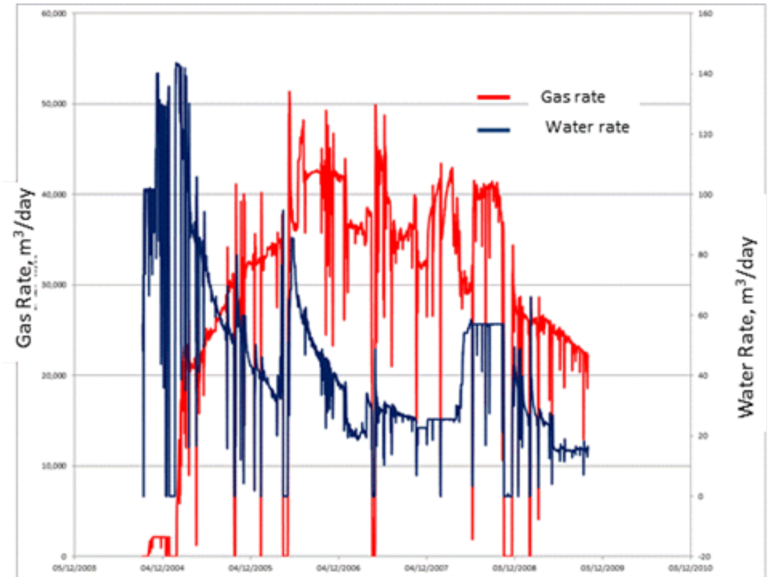
Comingle two seams together



# COMINGLE TWO SEAMS DELAYING THE PRODUCTION




**Single Seam: Achieve peak rate in half year at 65000m3/d**



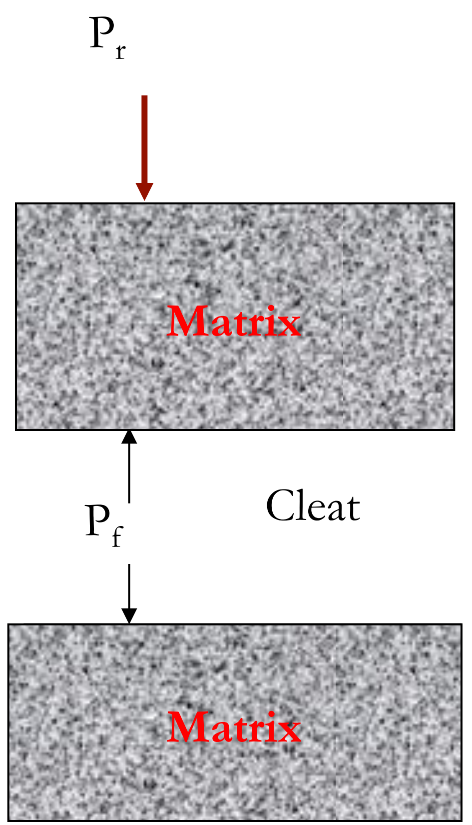

Comingling two Seams: delay the peak for year and the reduce the peak rate to 45000 m3/d

# DECREASE IN PERMEABILITY MAY CAUSE DEAD OF CBM WELL

- In China, majority of coal seam reservoir has very low gas saturation, lower than 50%
- Low saturation leads to long dewatering process
- Cleat and artificial fracture may close when the pore pressure falls with dewater
- The drainage area is constrained when the permeability venues were plunged during dewater
- Lower water production does not mean low water saturation, because the permeability venues were blocked and the water can not flow to well bore.
- The well can not be recovered if the permeability venues collapse

# Pressure depletion results in increase in pore stress, consequently, leads in closure of cleat

The pore pressure ($P_f$)falls gradually when the water flows into well bore during dewatering
The oerlaid pressure (Pr) will be constant during dewatering
As result, the cleat close and permeability decreases



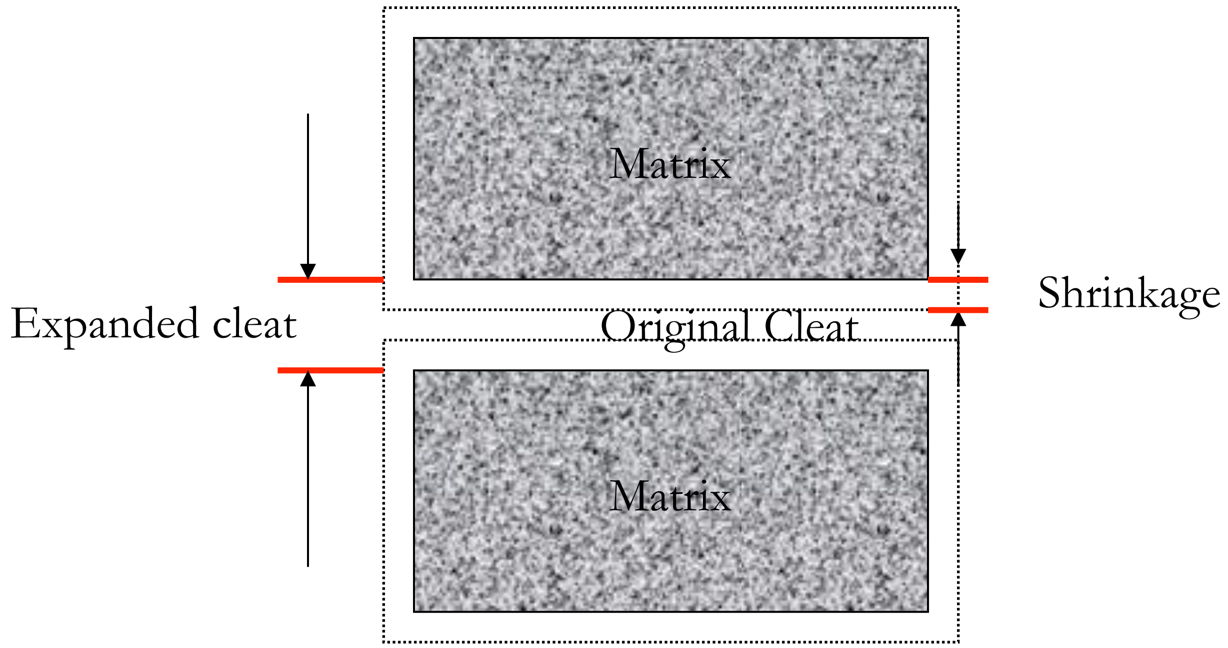

$P_r$ : pressure caused by load of overlaid rock

$P_f$ : fluid pressure

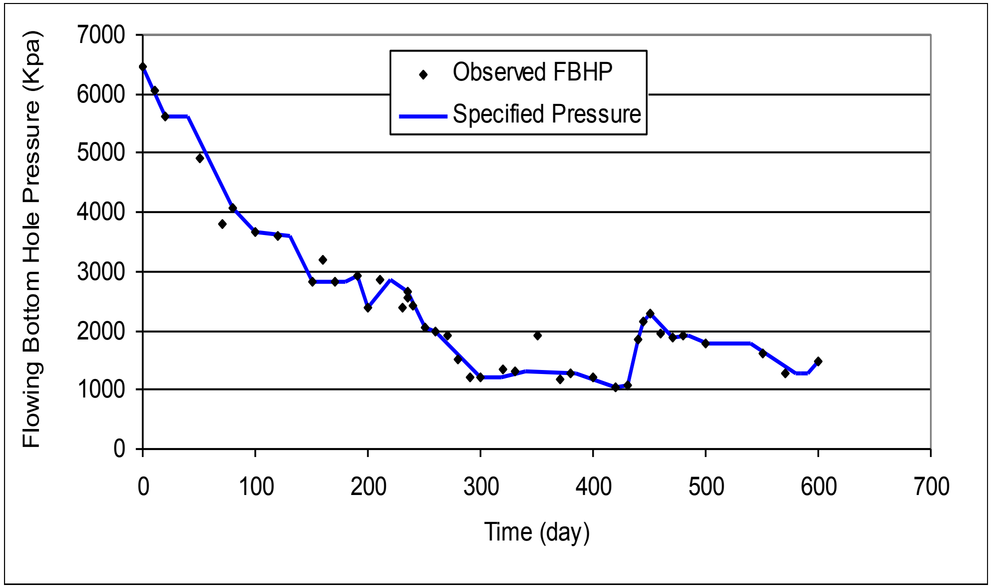
Stress: $P_s = P_r - P_f$

# Desorption Causes Shrinkage of Matrix and Expansion of Cleat

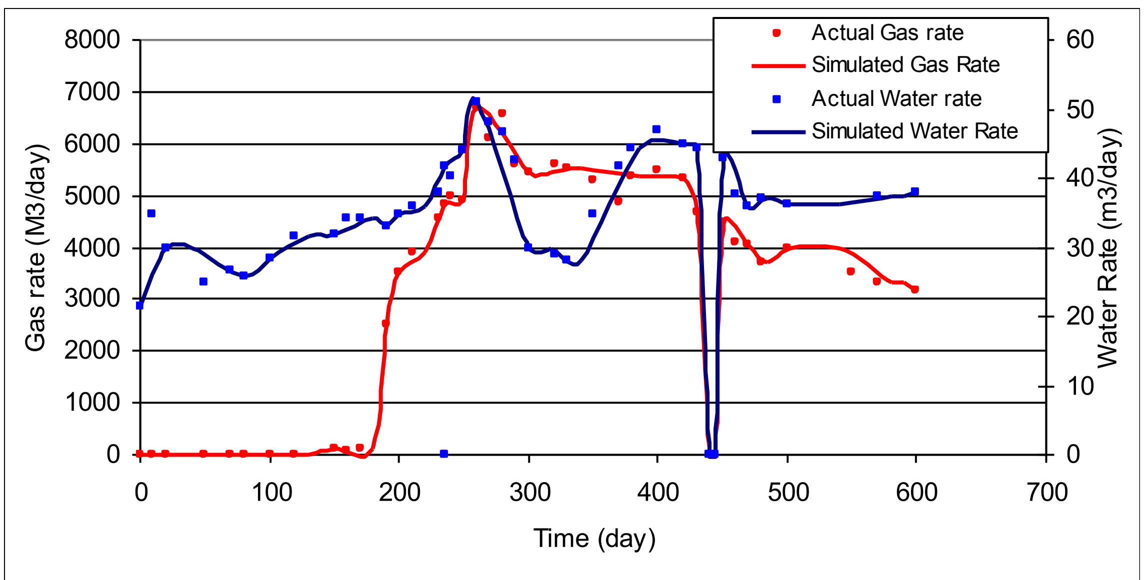
The matrix may shrink when gas desorbs from the matrix. As result, the cleat may expend and permeability increase



# History Match to Define the Permeability

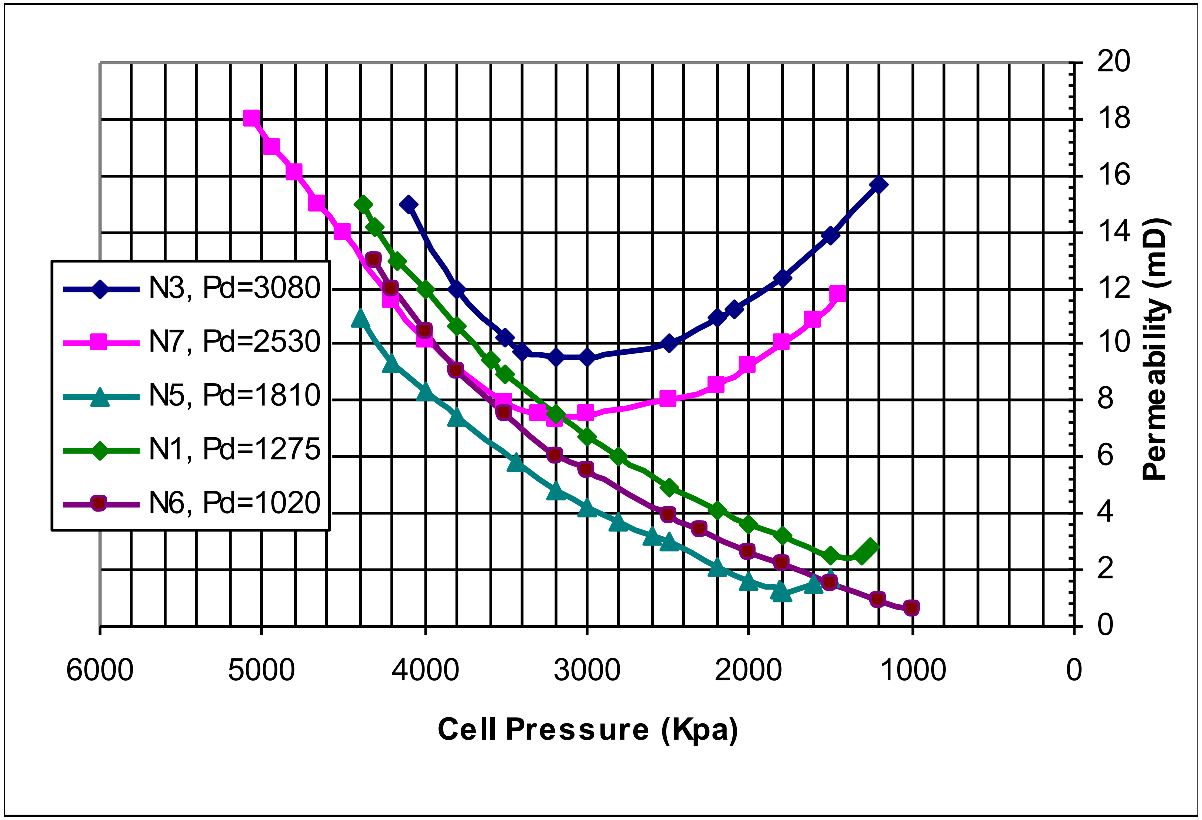



Assigned the model BHP as the actual BHP



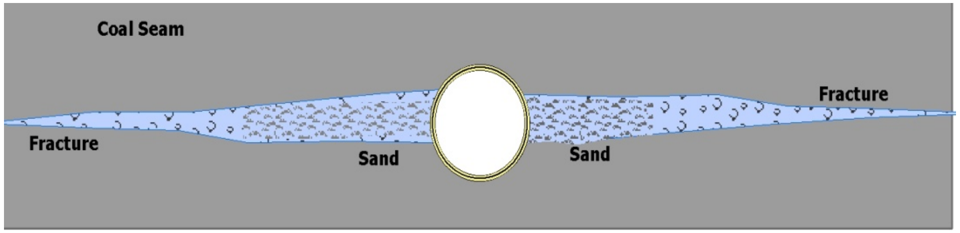

Match the production by adjusting the shrinkage factor and compressibility and initial permeability

# Example: Changing Permeability Related to Saturation, Ordos Basin China

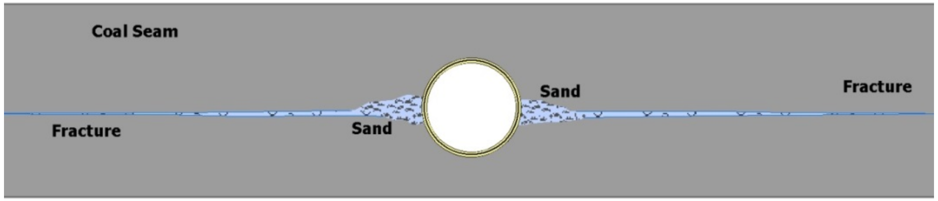



For the low saturation coal seam, there is long process for dewatering, which could cause the closure of cleats in large magnitude. For such case, the operation pressure should be controlled

# Mechanism of Abrupt Decline
# Course 2: Fracture Closed After Fracture

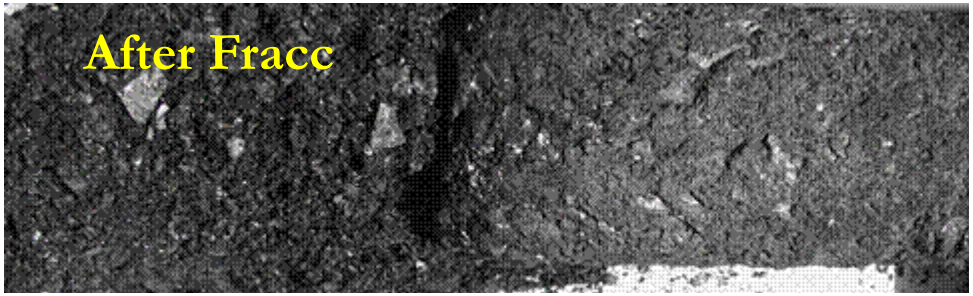



The fracture was extended and kept open when the operation is high

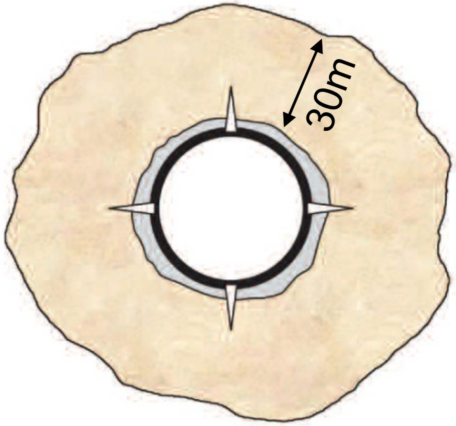



The fracture collapse when the operation pressure falls abruptly.

# Failure to creating effective Fracture


- Original Coal has well connected fracture
- After fracture, the coal become coal powder with permeable channel
- During pumping, failure in controlling bottom hole pressure, the coal fine flow with water and block the fracture.
- After closure of the fracture, the drainage area is constraint



# Conclusions

- Properly control in pumping rate and pressure will extend the well life
- Failure in controling pump rate and annulus pressure result in abrupt decline in gas rate.
- Permeability changes during production. The proper control in pump operation is helpful in keeping positive effect on the change of permeability
- After fracture, the formation is sensitive to bottom hole pressure, the failure in controling pressure results in closure of the fracture