



The Development of Puguang Sour Gas Field

September, 2009



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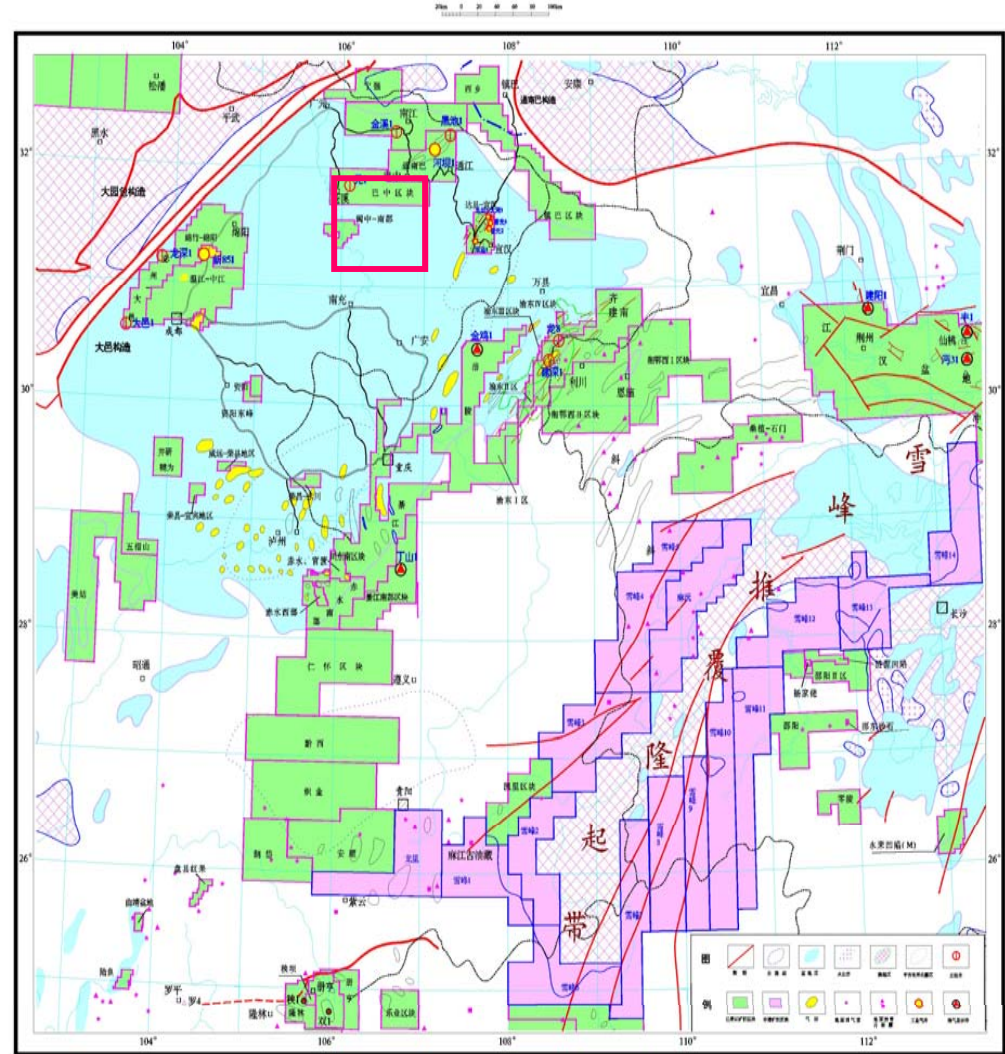
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An overview of Puguang sour gas field

Puguang Gas field, located at Xuanhan county , Sichuan province, is the largest sour gas field in China at present.

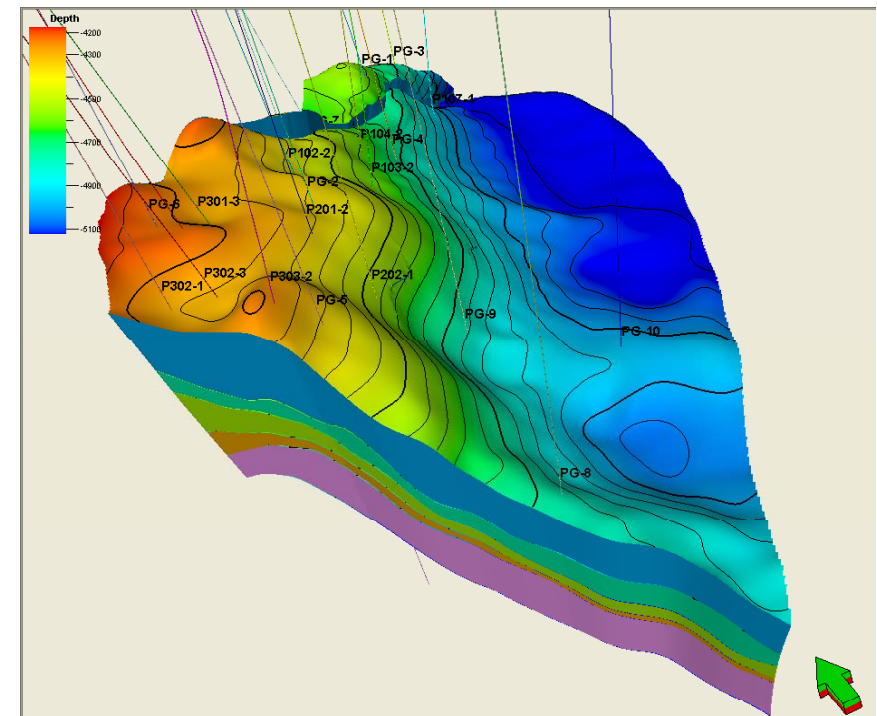
It was discovered in 2003. The GIIP is more than $300 \times 10^9 \text{m}^3$.





Primary characteristics

- ◇ carbonate reservoir
- ◇ giant reservoir thickness, good porosity and permeability but strong heterogeneity.
- ◇ high content H_2S (15.16%) & CO_2 (8.64%)
- ◇ formation depth: 5000~5900m
- ◇ high pressure: 55—60MPa

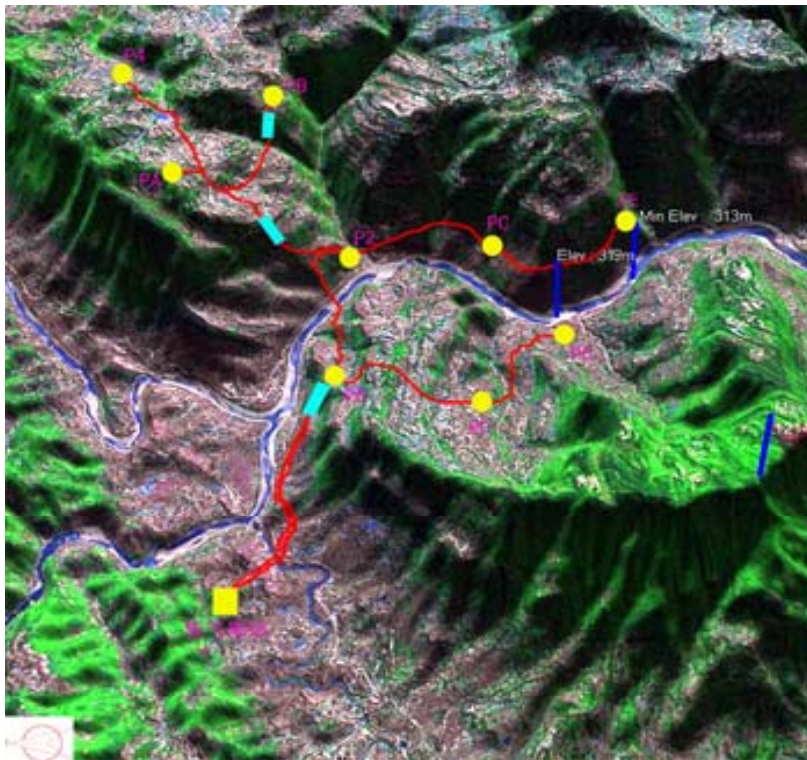


3D model of Puguang



Productivity of Puguang gas field

Because of large reserve, great thickness, etc, the designed annual productivity is more than $10 \times 10^9 \text{ m}^3$. The beginning of product is at the end of year of 2009.



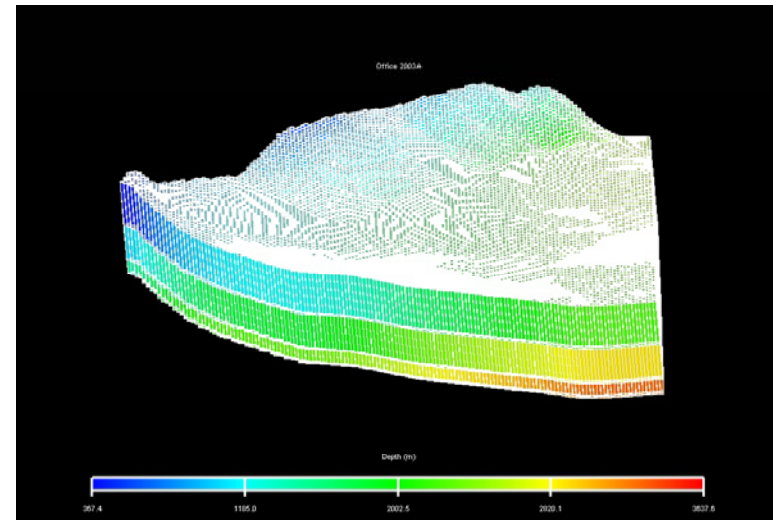


Main strategies to CDM

- Made more than 50 company criteria on Puguang gas field development;
- Improve gas field development design requirement, preventing corrosion & dangerous gas leakage;
- Strengthen tail gas management, decreasing tail gas emission;
- Synthetically treat industrial rubbish, purify produced water and reinject.



profile of tubing corrosion



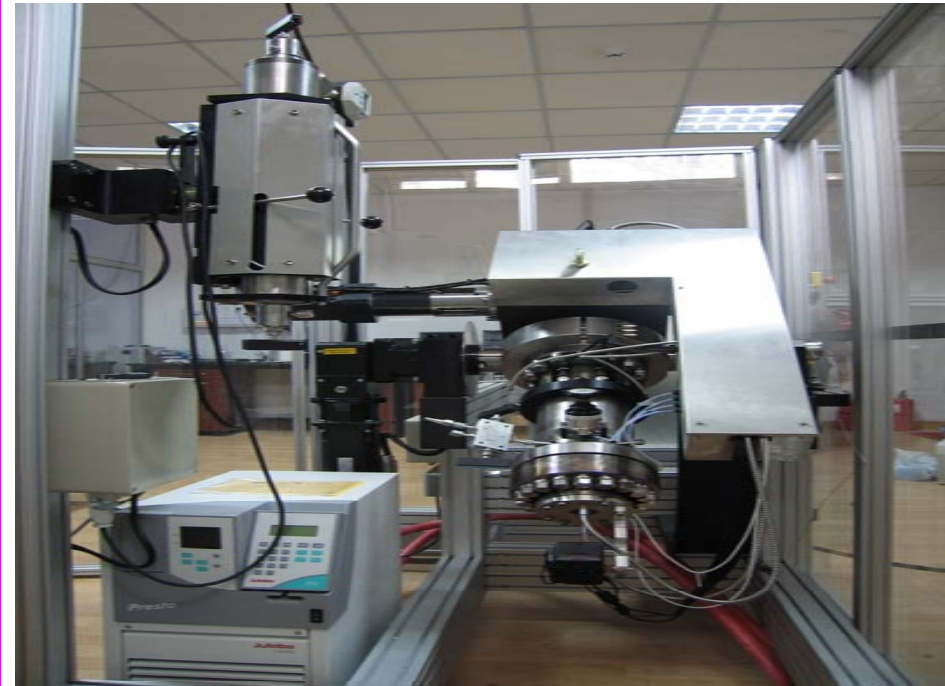
3D geological model of water reinjection



Development of Puguang sour gas phase behavior

Nowadays, some professional laboratories of sour gas phase behavior, anticorrosive, ect, are established in research institutes, which can satisfy the requirement of sour gas field experiments.

It, However, is still lack of correlative experiment experience.

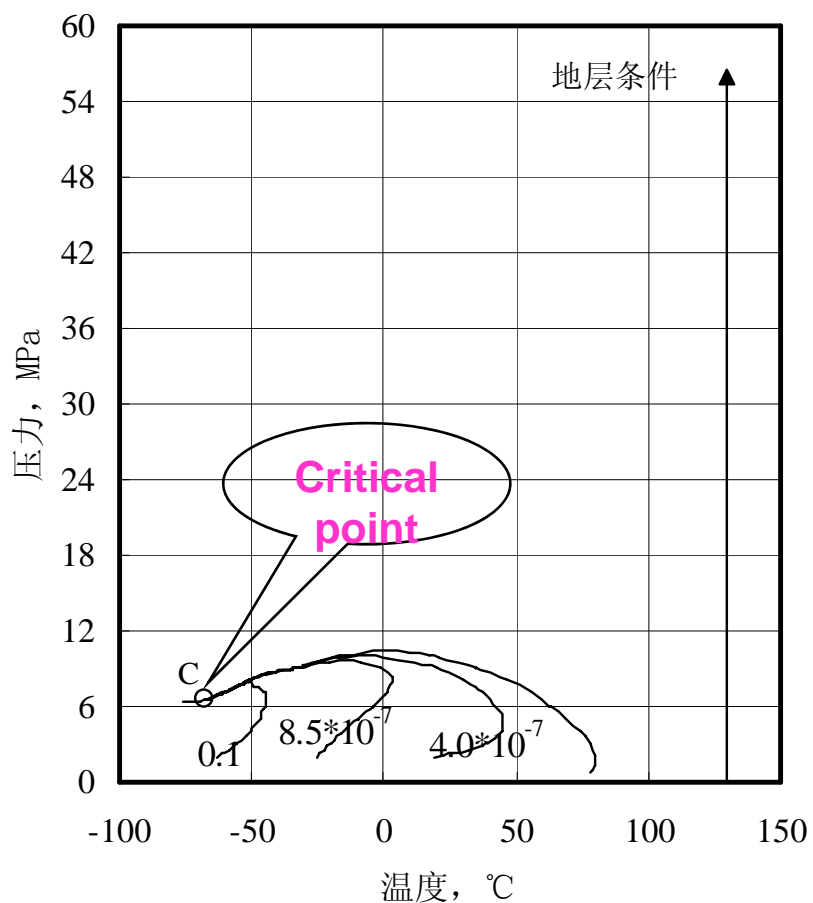


Sour gas PVT experiment equipment

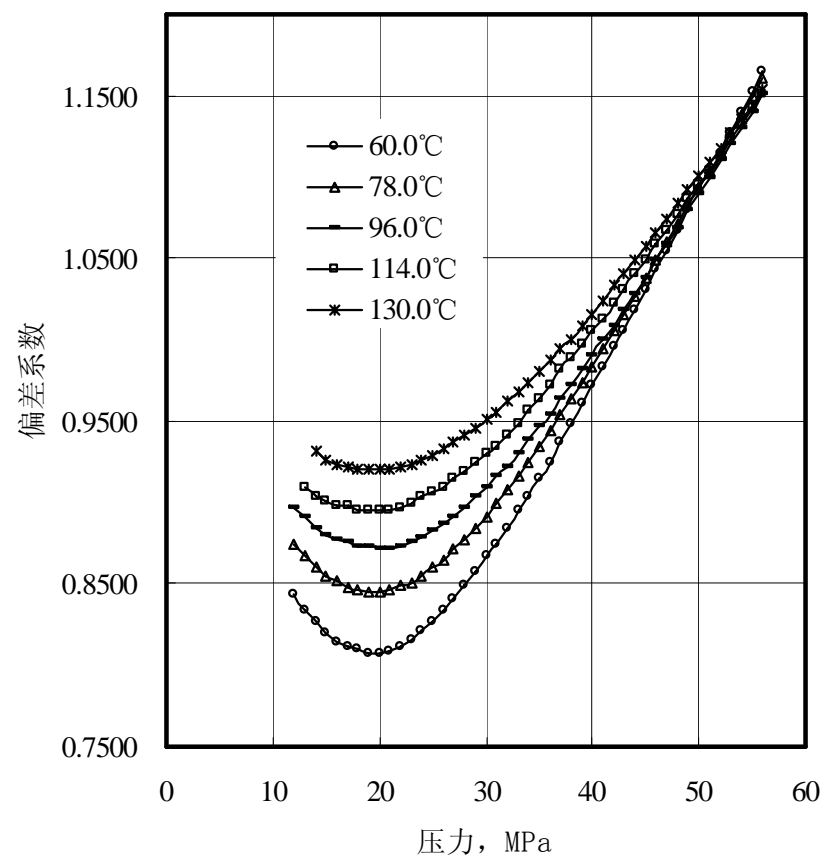


PVT phase behavior characteristic

It conducted experiments on sour gas phase behavior and high-pressure physical property parameters.



Profile of P-T Phase Behavior



The relationship between change factor and pressure



Experiment results show

- No dew point with some dry gas samples,
- liquid drops separate from gas when pressure & temperature decrease with another samples.
- The lower P&T, the faster liquid drops precipitate.



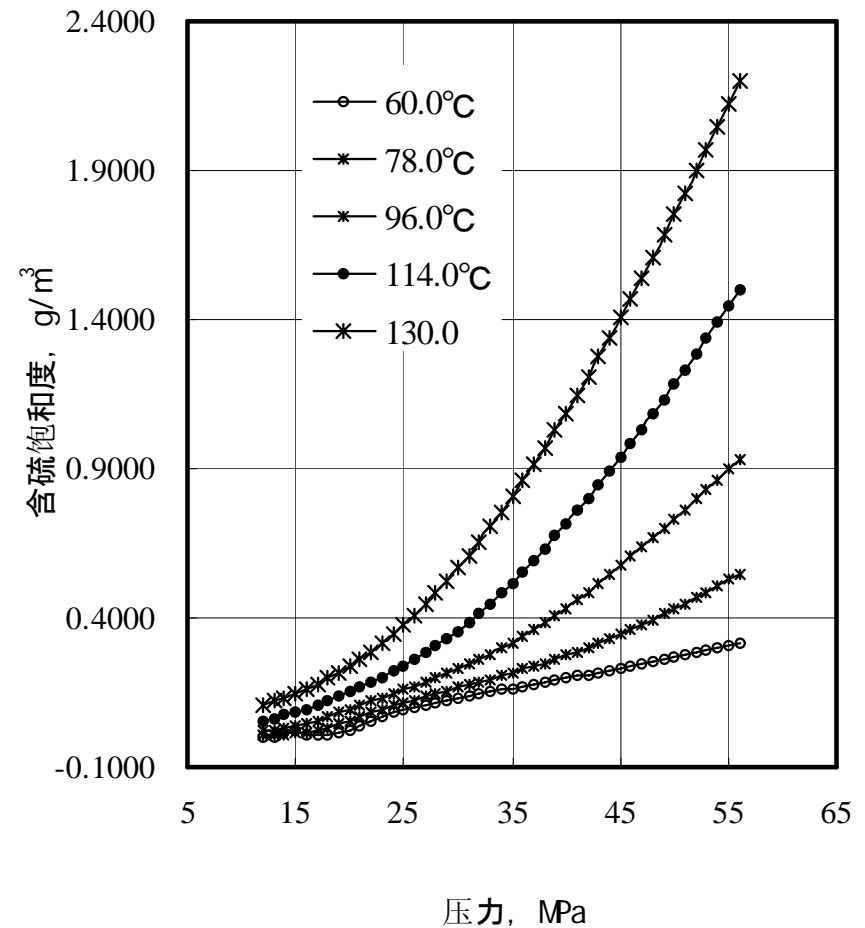


Solubility of sulfur in sour gas

The solubility of sulfur in sour gas greatly affects on elemental sulfur deposition while gas wells produced.

When the content of H₂S in gas is constant, experiments indicate that :

- the solubility of sulfur in natural gas increases, while the pressure increases,
- the solubility of sulfur in gas raise when temperature increases under the same gas components and pressure.



The solubility of sulfur in sour gas



Problems

Although the sour gas PVT experiment equipments have already been established preliminarily, there are some problems as followings:

➤ **Wellhead sampling. Because of the strong corrosion and toxicity, it can't put the sampling devices into well bottom to collect gas sample.**

The compositions of gas sample getting from wellhead ,therefore, many be very different from that in real reservoir condition.

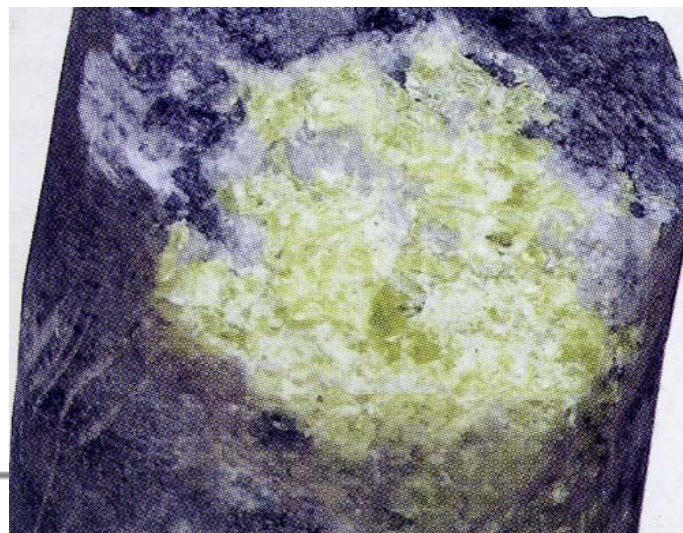
➤ **The theory calculation methods are necessary to be improved. The error from sampling may induce the lack of verification of theory models.**



Prediction of elemental sulfur deposition & treatment

Current research

As mentioned, elemental sulfur separates out from saturated sour gas and may be deposited in transporting medias when reservoir's temperature and pressure reduce. It studied on simulation model to calculate sulfur deposition in porous media, fractured well and tubing. Meanwhile, treatments of preventing & removing elemental sulfur were developed.





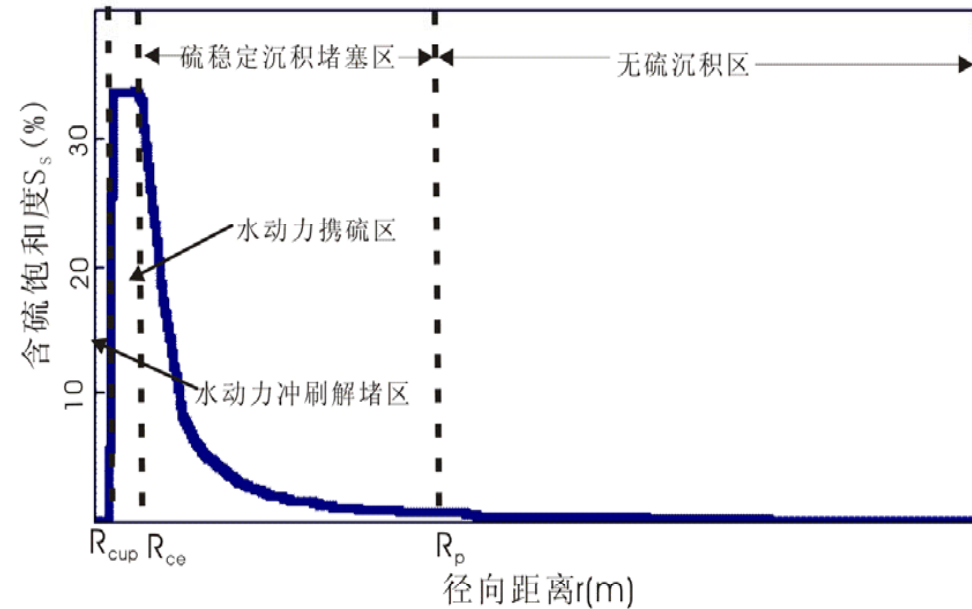
**Sulfur plugging of some wells in Sichuan basin
(H_2S 6.87%, CO_2 2.76%)**



sulfur deposition prediction in porous media

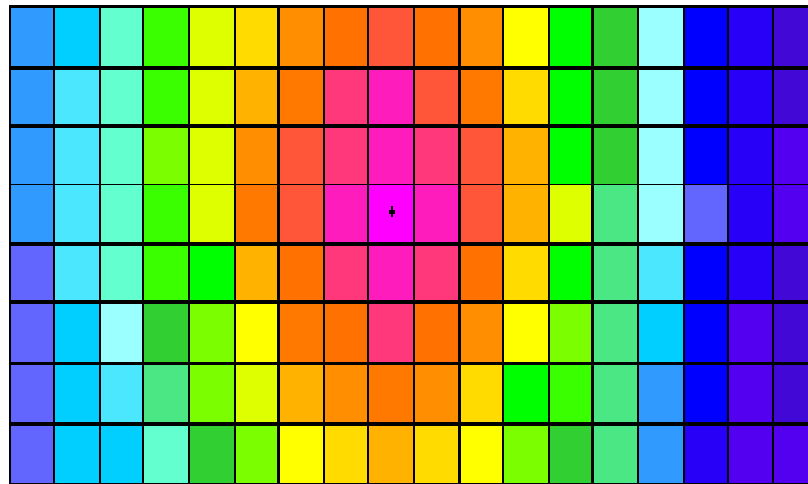
Gas saturation , power of gas current & size of transporting channel are key factors impacting on elemental sulfur deposition in reservoir. the deposition of sulfur in formation is partitioned as four areas,

- Non-sulfur deposited area;
- Sulfur particles steadily deposited area;
- Sulfur particles hydrodynamic carry area;
- Sulfur particles hydrodynamic erosion area.

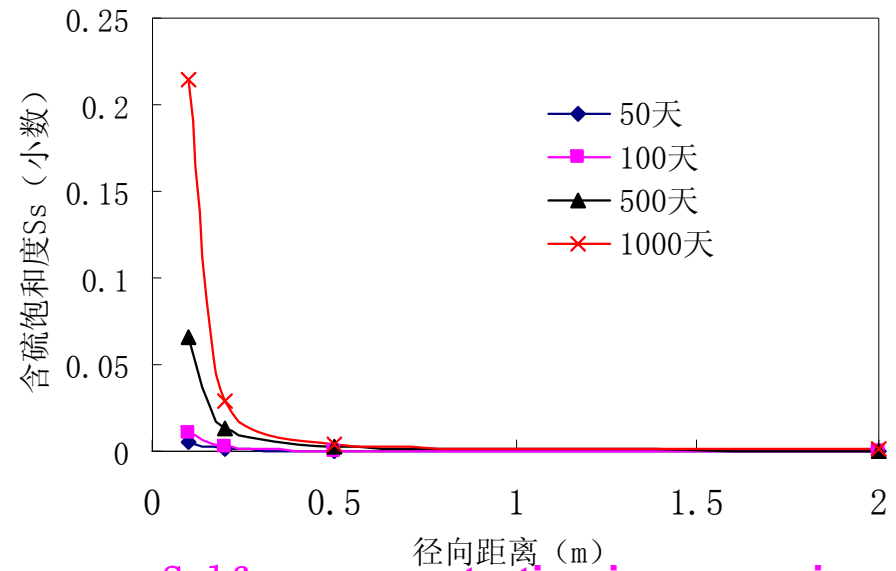




On the condition that gas current power is not enough to carry sulfur separated out from saturated sour gas, simulation shows elemental sulfur deposits primarily in the area closed to well bore and the precipitation rate becomes higher and higher while gas well continuously produced.



profile of sulfur concentration around well bore



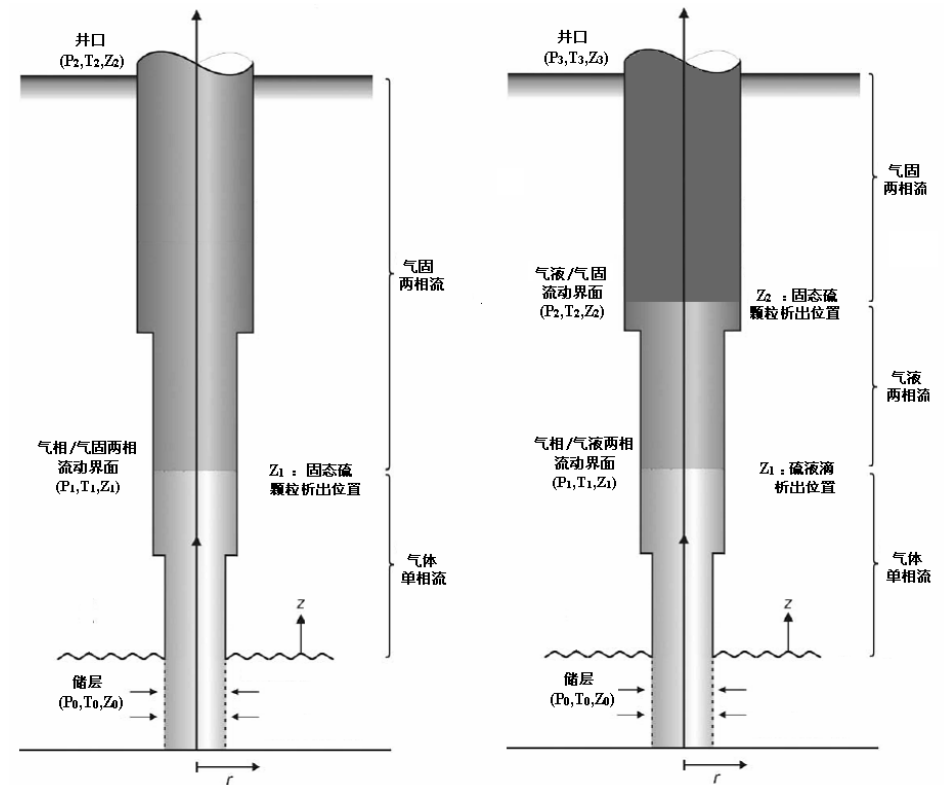
Sulfur concentration in reservoir



Sulfur deposition prediction in well hole

The main influence factors

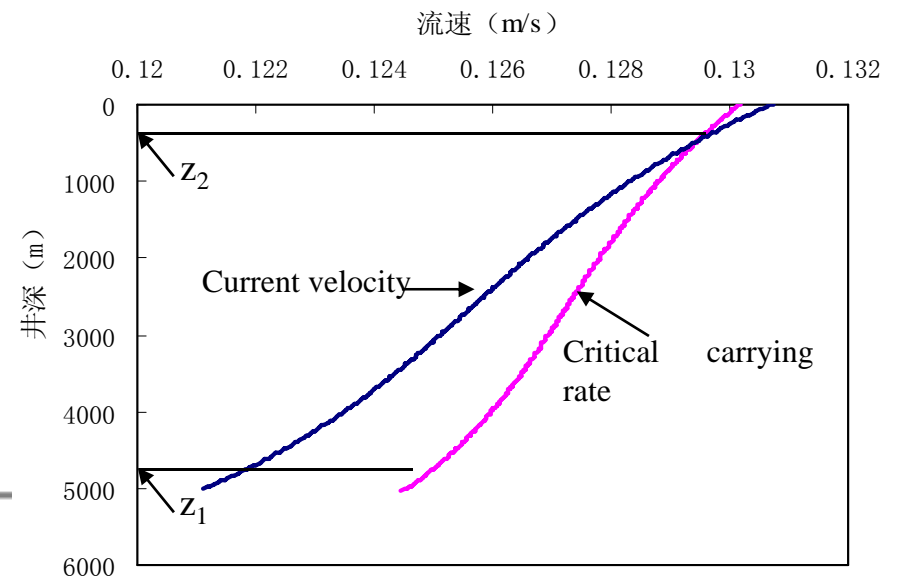
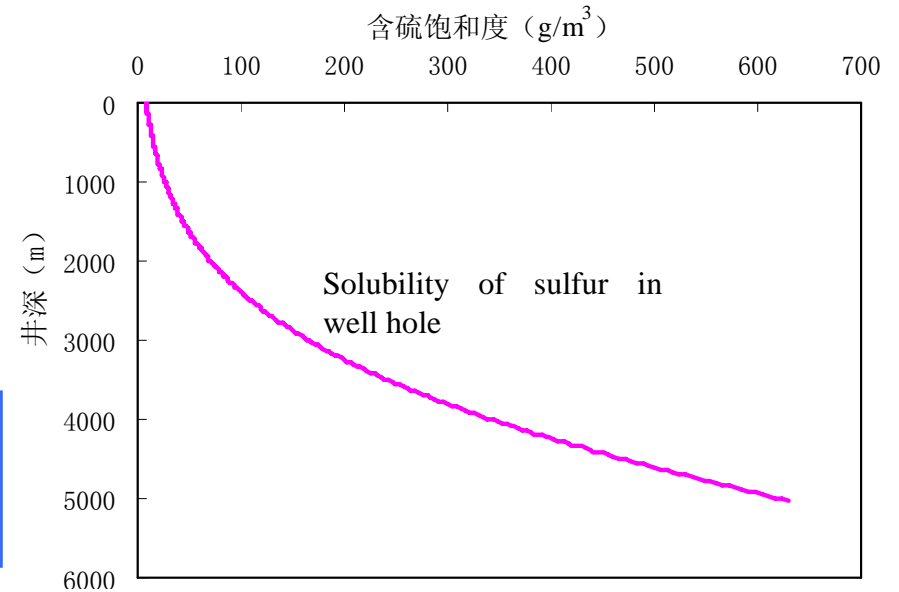
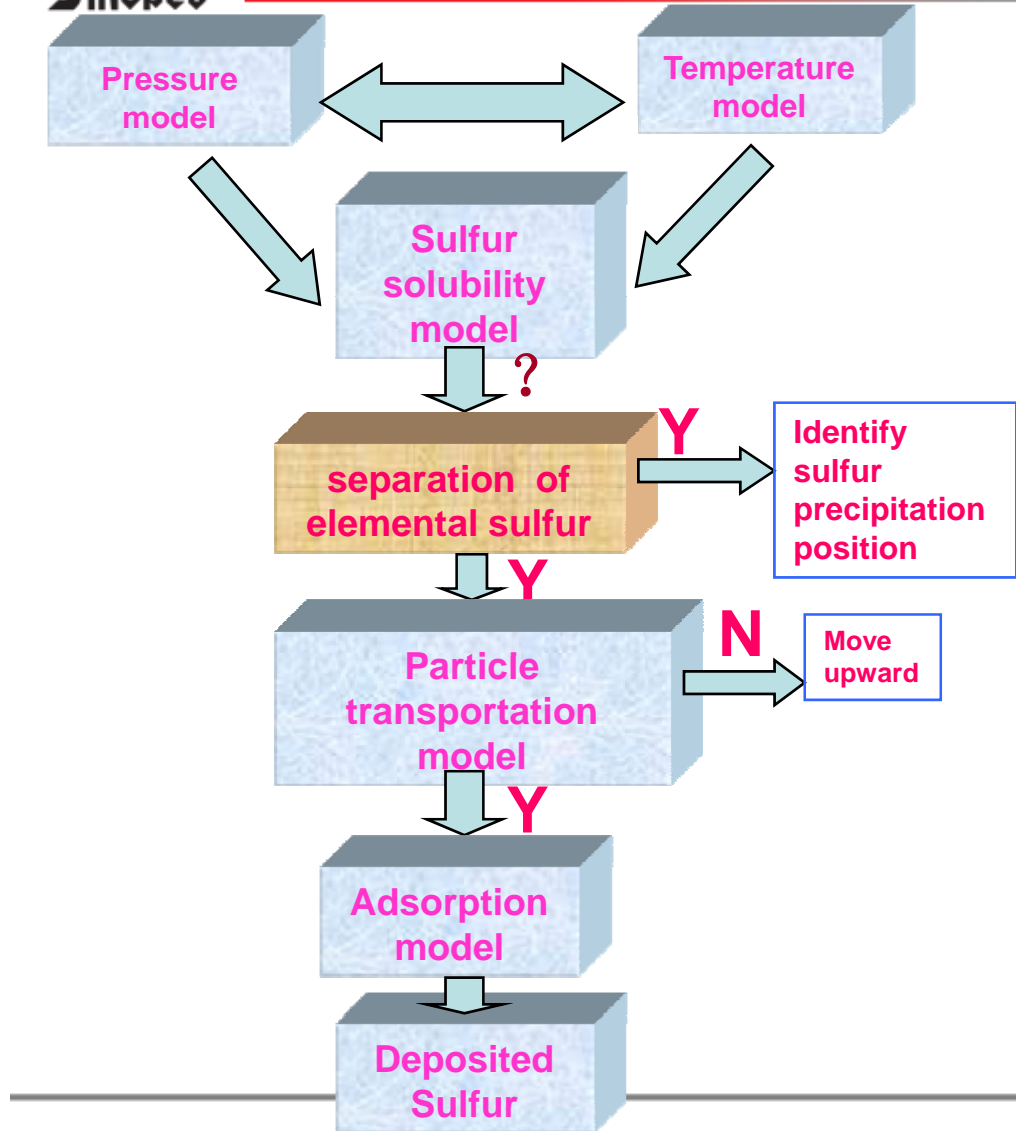
- Well hole pressure
- Well hole temperature
- Flow rate in tubing
- Roughness of tubing



Elemental sulfur transport in tubing



Sulfur deposition analysis and prediction in well hole





Sulfur deposition prevention measures

Treatments

Physical measures:

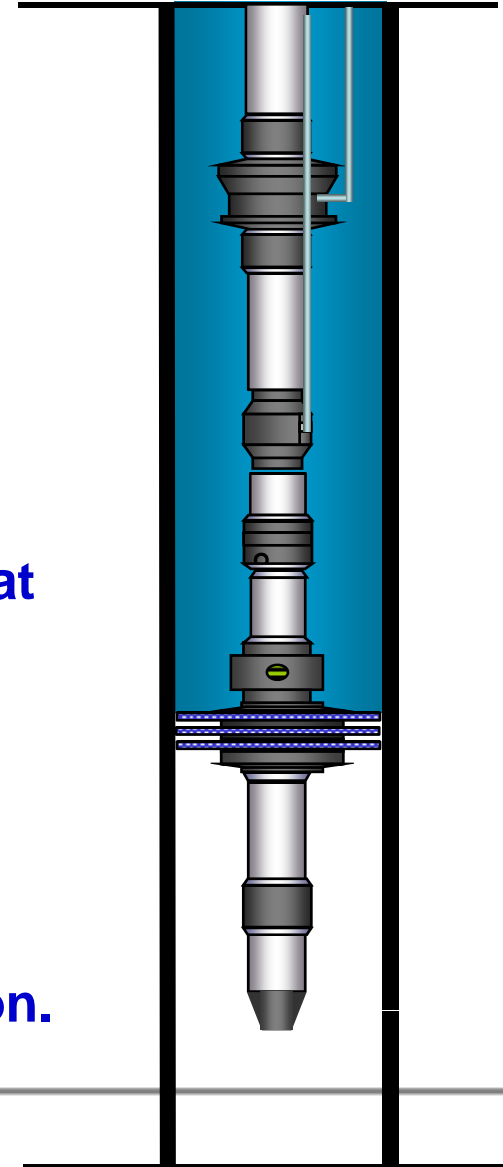
heating, scraping

Chemical measures:

dissolution with solvent

Injecting **chemical agents** is the measure that takes in Puguang gas field to prevent and remove deposited sulfur .

The injection mode is capillary transportation.

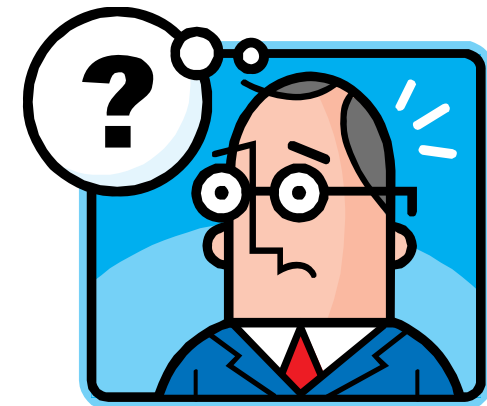




Problems

- Sulfur concentration or saturation in original reservoir condition
- Sulfur deposition identification & monitoring measures
- Cost of treatment

We sincerely hope we can cooperate and communicate with relative companies or CCOP MC.





THANK YOU!

