27th WORLD GAS CONFERENCE | JUNE 25-29 | WASHINGTON DC | 2018
IGU

Construction of UGS In Low Permeability and Sulfur-Bearing Depleted Gas Reservoir

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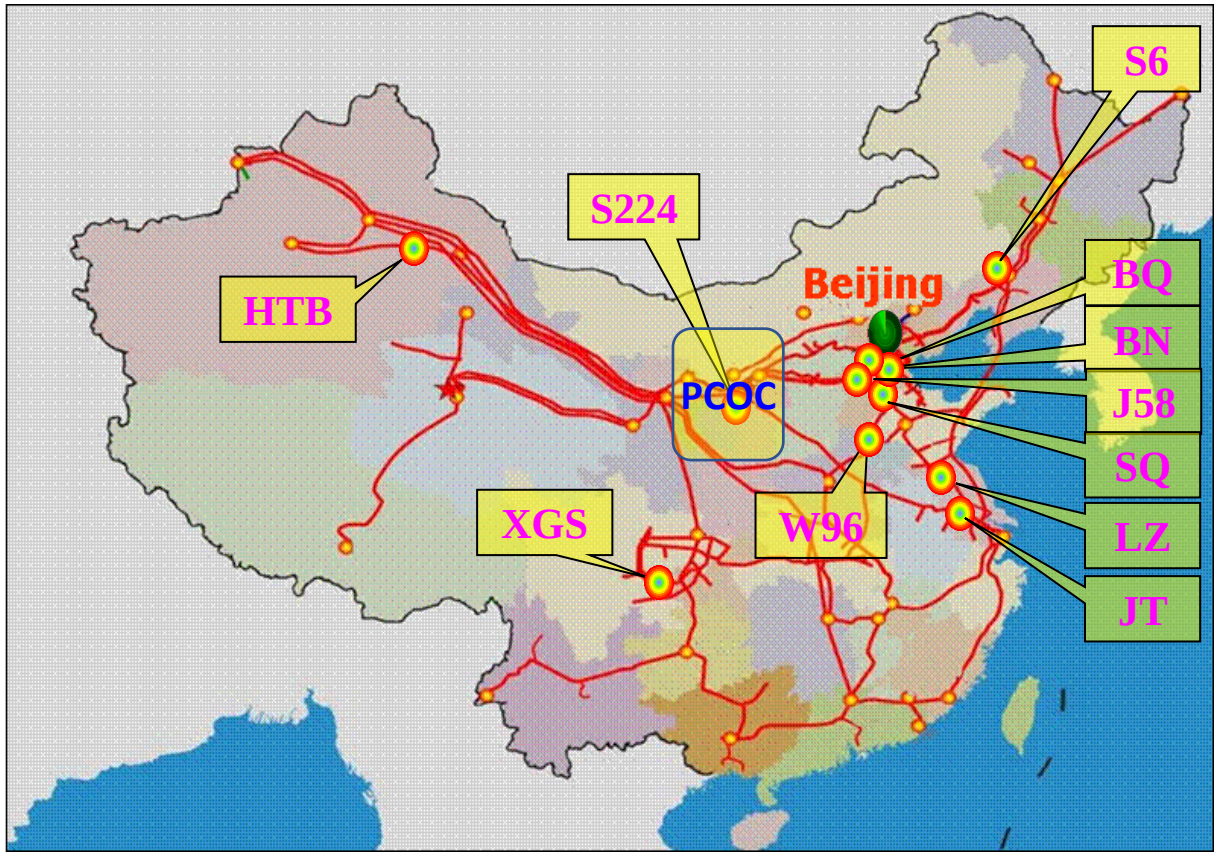
Due to the influence of air pollution control policies such as coal-to-gas conversion in China, the demand for natural gas has increased significantly, and the peak shaving capacity is critically important.

- Put into operation 12 gas storages(clusters) and built 17.4 Bcm.
- Mainly oil/gas field UGS, only one salt cavern UGS.
- In 2017, it exceeded 7 Bcm, accounting for about 3% of the consumption.



However, the gas reservoirs developed in Ordos Basin are poor for UGS construction.

Challenges

- Burial Depth 3500 m
- Low permeability
- Low porosity
- Low abundance
- No obvious lateral boundary
- Strong heterogeneity
- H_2S

Geological parameters of some typical UGS

Storage	Depth (m)	K (mD)	Lithology	H_2S Content (mg/m^3)
MoBay(USA)	580	4500	sandstone	none
Gorenigen（Holland）	2000	700	sandstone	none
TIGF（France）	900	600	sandstone	none
Schönkirchen (Austria)	2470	500-7000	carbonate rock	none
Diadema(Argentina)	650	2000	sandstone	none
XGS(China)	2500	1151	carbonate rock	2
S224(China)	3500	1.74	carbonate rock	554

CONTENT

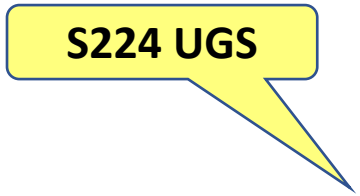
1. Evaluation of Lateral Trap Sealing
2. Improvement of Injection-Withdrawal Capacity
3. Prediction of Variation of Acid Gas Content

1 Evaluation of Lateral Trap Sealing

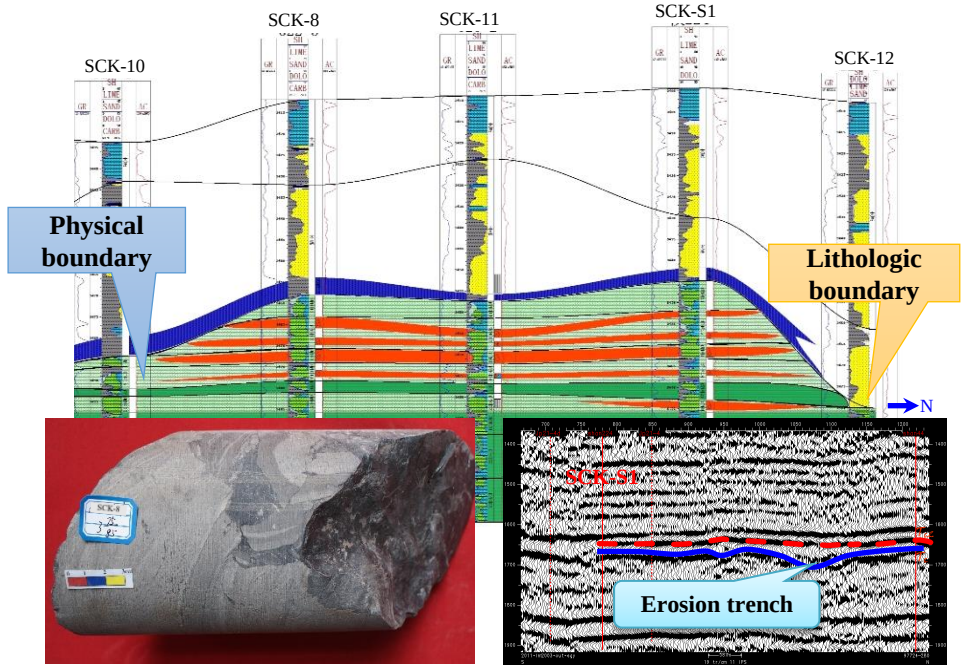
Challenge: Stratigraphic-lithologic trap, no obvious lateral boundary.

Methods: Seismic interpretation and geological profiles, unstable well testing, test on breakthrough pressure.

Structure map of K1 marker bed of S224 UGS

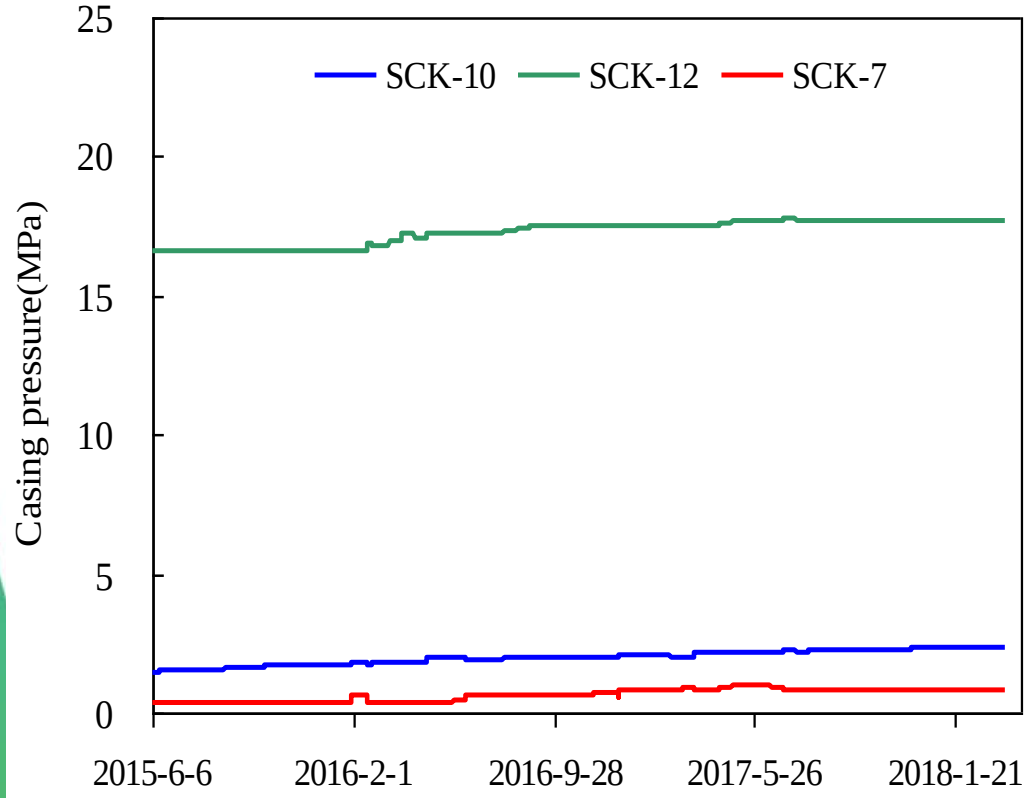


Strata profile of S224 UGS

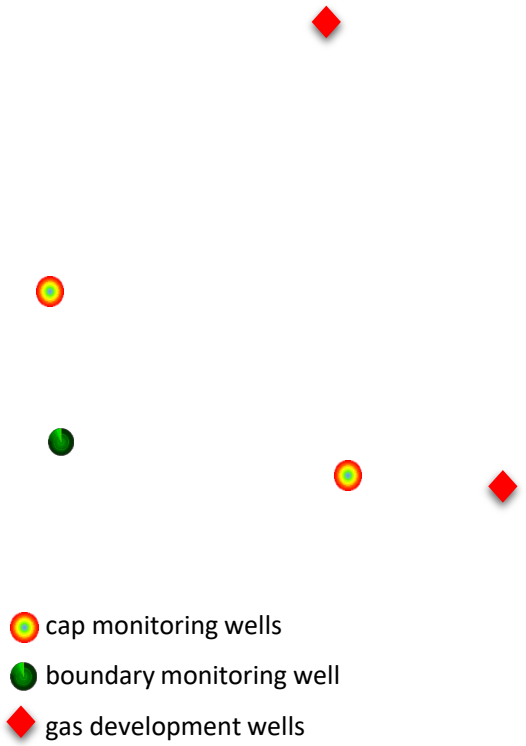


The monitoring data of three injection-withdrawal cycles indicates good sealing of the UGS under current operating pressure.

Casing pressure change curve of monitoring wells



Well location map for trap sealing monitoring of S224 UGS

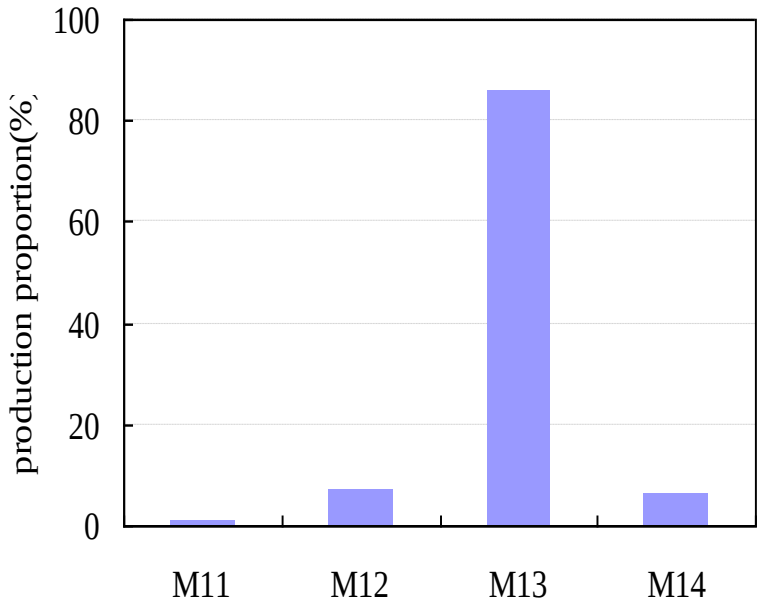


2 Improvement of Injection-Withdrawal Capacity

2.1 Optimization of Design and Orientation of Horizontal Section

- Horizontal wells are designed as injection-withdrawn wells.
- M_1^3, main production layer, designed as target of horizontal well.
- Geosteering, e.g. formation dip prediction, to improve the drilling rate.

Production logging of typical wells

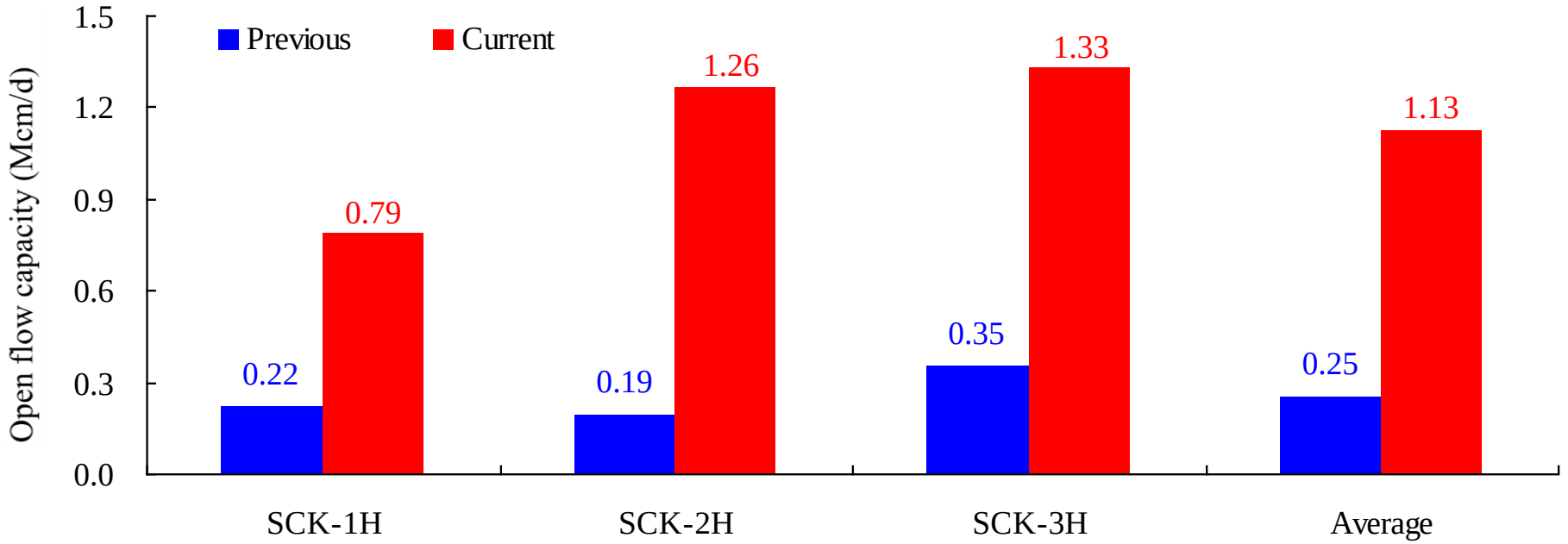


Drilling data of horizontal wells

Well name	Drilling depth (m)	Horizontal section length (m)	Dolomite reservoir length (m)	Reservoir drilling rate (%)
SCK-1H	5329	1652	1494	90.4
SCK-2H	4887	1177	1115	94.7
SCK-3H	5215	1500	1366	91.1
Average	5143	1443	1325	91.8

2.2 Optimization of Coiled Tubing Jet Acidizing

- Reservoir pressure coefficient 0.3, severe reservoir pollution.
- Optimization on jet spout mode and parameters of coiled tubing to increase mud cake washing efficiency.
- Improvement of acid system, formulation and dosage for better acid etching.

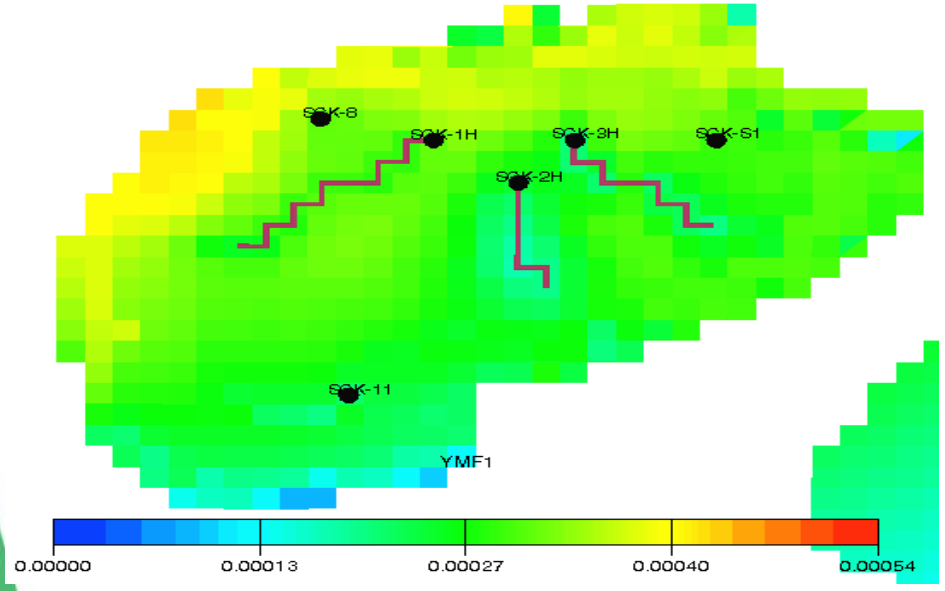


3 Prediction of Variation of Acid Gas Content

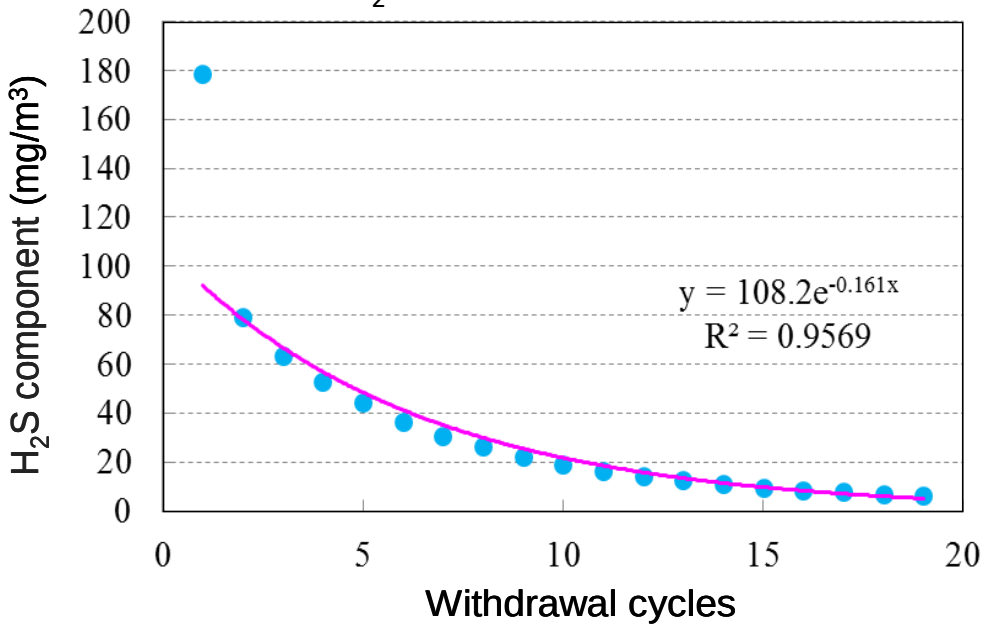
3.1 Numerical Simulation

- The content of H_2S decreased significantly (48.8%) after the first cycle.
- The H_2S content decreases by power exponent.
- The variation of CO_2 content is similar to that of H_2S.

Prediction of distribution of H_2S content in S224 UGS

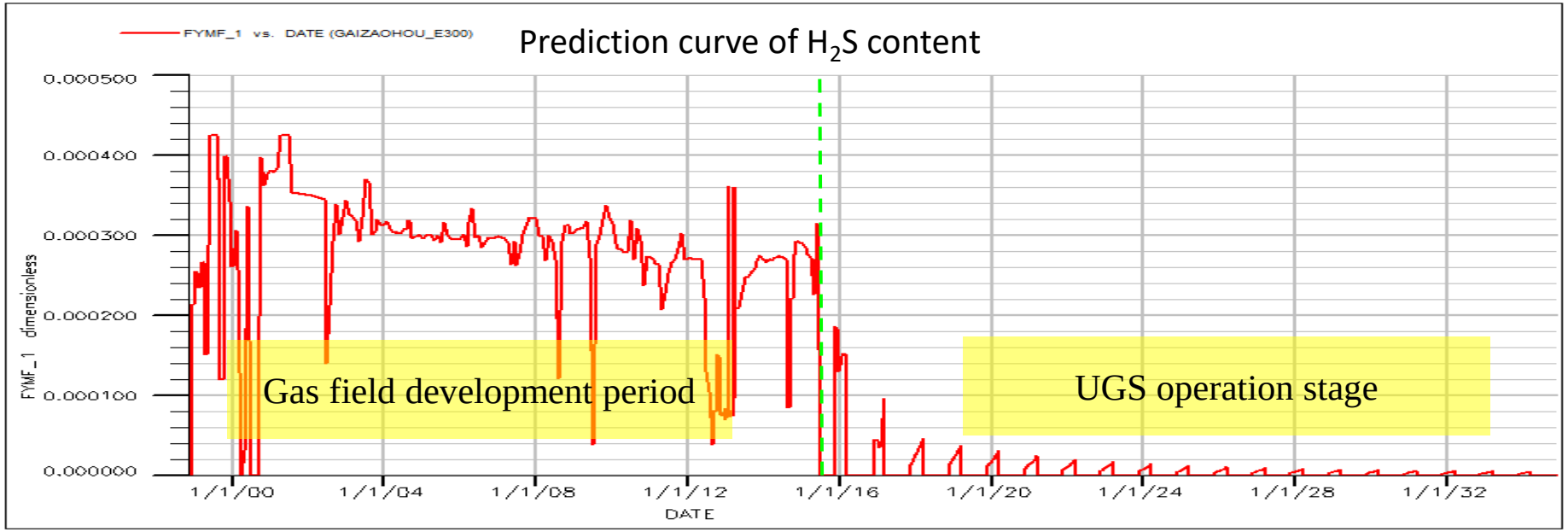


Prediction of H_2S content of withdrawal Gas



3.2 Prediction of Variation of Corrosion Type

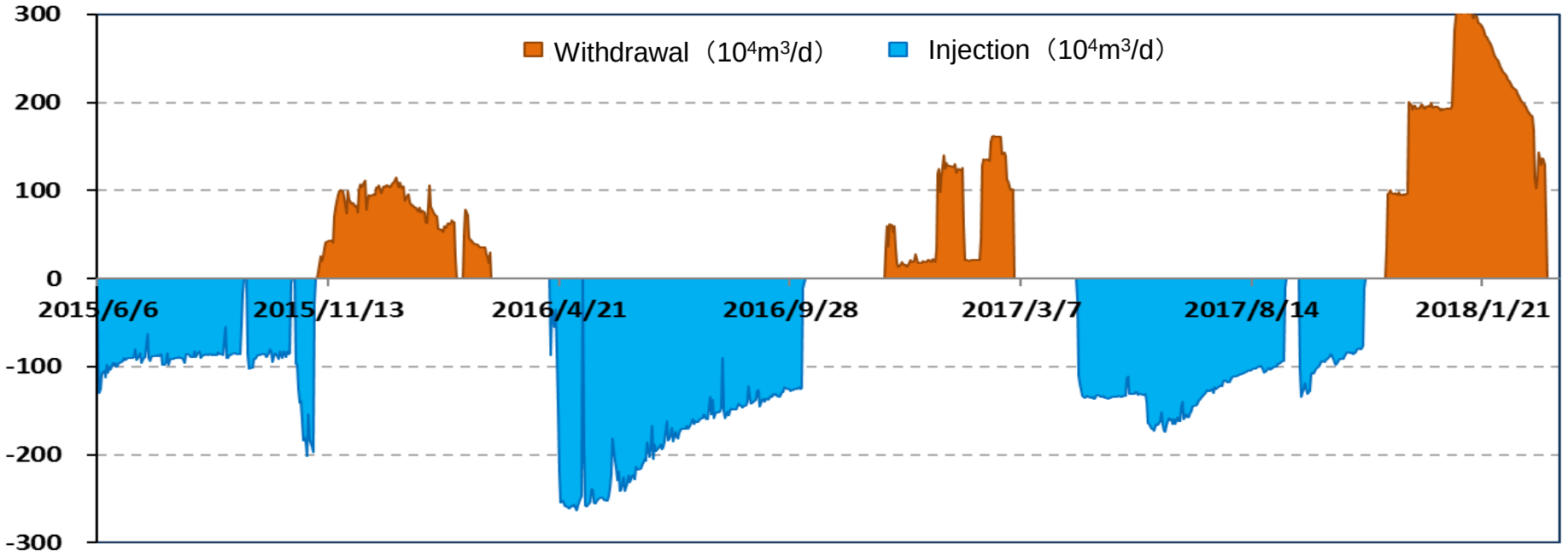
- In the initial of withdrawal period, the corrosion type is sulfide stress corrosion cracking (SSCC) and CO_2 electrochemical corrosion.
- In the later of withdrawal period, there is CO_2 corrosion.



PCOC adopts life-cycle economical material selection and anti-corrosion technique to cut the construction cost of single well with RMB 14.9 million.

- S224 UGS was successfully put into operation in June 2015.
- A pioneering UGS in low permeability and sulfur-bearing reservoir in the world.
- The working gas volume was 260 Mcm in 2017.

Injection-withdrawal operation curve of S224 UGS



Conclusions

- Although there is no obvious trap boundary in lithologic gas reservoirs, lateral tight formations can play a good role in sealing the gas.
- For UGS construction in depleted gas fields, in order to reduce bottomhole pollution in drilling, it is better to increase formation pressure through gas injection in old wells before drilling.
- With more cycles, the content of acid components of withdrawal gas will rapidly decrease by power exponent, and the type of corrosion changes from SSCC and CO_2 corrosion into CO_2 corrosion.

Thanks for your attention !