3. Low pressure tight gas reservoir stimulation measures featured by vertical well multi-layer continuous separate fracturing and horizontal well multi-stage fracturing helped increase single well output greatly.
4. Innovative low-to-medium pressure gas gathering mode based on high temperature high pressure downhole choking and gas recovery by water drainage addressed the difficulties in hydrate prevention.
5. Full-digital management covering all the well sits, gathering stations and processing facilities helped improve production efficiency and save labor use.
6. The experiences of Sulige have been applied to and greatly facilitated tight gas exploration and development in Liaohe, Sichuan, Dagang and Huabei.

Development scale

Large cluster well group: averagely 8 wells per cluster and maximally 23

Over 10,000 wells: average well depth of 3,683m and maximally 4,040m

Gas output at early stage: averagely 17,000 m^3/d and maximally 116,000 m^3/d per well

Mileage of gas gathering pipeline: 1,064km-long trunks and 1,734km-long branches, totally 2,798km

Tight gas production: 2014–21.2bcm, 2015–23.5.bcm, 2016–23.7bcm, 2017–22.9bcm

Cumulative production: 168.4bcm as of the end of 2017

Sulige Gas Field

Energize · Harmonize · Realize

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China National Petroleum Corporation

Located in the north-central region of the Ordos Basin, Sulige is by far the largest onshore gas field in China with accumulatively proven gas in place of 4.7 trillion cubic meters across an area of 40,000 square kilometers. The gas-bearing layers are mainly Permian sandstone developed in upper Paleozoic clastic strata at a depth of 2,800-3,700m, with porosity of 5-12%, permeability of 0.01-2mD and effective thickness of 3-15m.

Geological Characteristics

Large gas-bearing area and low reserve abundance

Large amount development well drilling proved that the gas layer encountering rate within the exploration area is above 95%. However, the gas abundance of different blocks varies largely, with an average value of 0.11-0.15bcm/km^2.

Lithologic trap

Reservoir distribution in the Sulige gas field has suffered minor influence of geological structure, but mainly controlled by lateral stretch of sand bodies and changes in reservoir physical property. The reservoirs are complex channel sandstone of lithological type.

Tight reservoirs with low porosity and low permeability

The gas reservoirs have an effective porosity of 5-12% and permeability of 0.01-2mD, averagely 8.9% and 0.73mD respectively.

Low pressure factor

In Sulige gas filed, the reservoir pressure factor varies from 0.771 to 0.864, with an average value of 0.82.

Low production rate per well

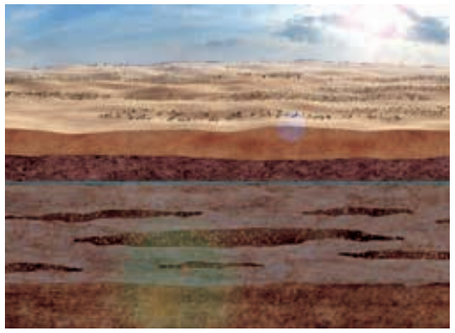
Except for a small amount of wells (about 10%), over 90% wells have an open flow rate of less than 150,000m^3/d and mostly less than 50,000 m^3/d. The formation pressure drops quickly and builds up slowly in later stage, showing poor reservoir connectivity and low controlled reserves per single well.

Small effective sand body and poor horizontal continuity

Although the reservoir sand bodies are superimposed vertically (40-60m) and consecutive horizontally for 2-3km, the effective thickness of gas layers is only 3-15m.

Challenges in Gas Field Development

1. Effective reservoirs are difficult to identify and well location decision hard to make due to strong heterogeneity.
2. Cost-efficient development faces with great difficulties due to poor single-well controlled reserves, low individual well production rate and rapid pressure drop.
3. High irreducible water saturation results in frequent water producing during gas production in some blocks, with average water/gas ratio at 0.5m^3/104m^3.
4. Satisfactory effect did not achieved in primary evaluation and pilot test period by using new technologies such as 2D/3D multi-wave seismic, underbalanced drilling, air drilling, and CO2 fracturing etc.



Light Spots

1. Thanks to applicable techniques such as high-density wide-azimuth 3D seismic and high-precision logging data acquisition, processing and interpretation, the accuracy of reservoir prediction and coincidence rate in data interpretation increased dramatically.
2. Fine reservoir description, massive deployment of large cluster well group and well pattern optimization helped improve land resource utilization and enhance gas recovery.