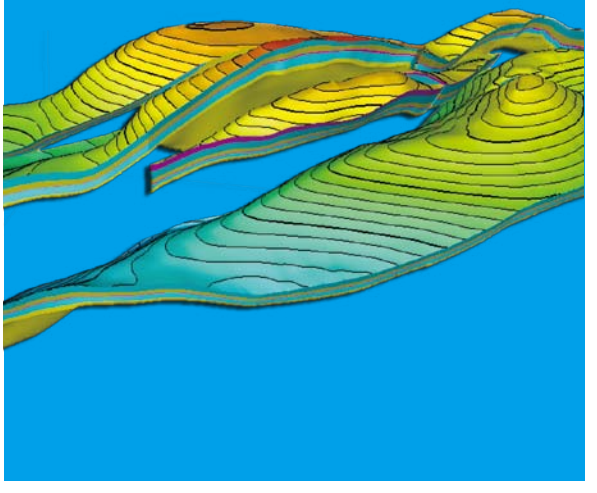
Magazine



Tight Gas Reservoirs

Economical Solutions for Sulige Gas Field

China National Petroleum Corporation

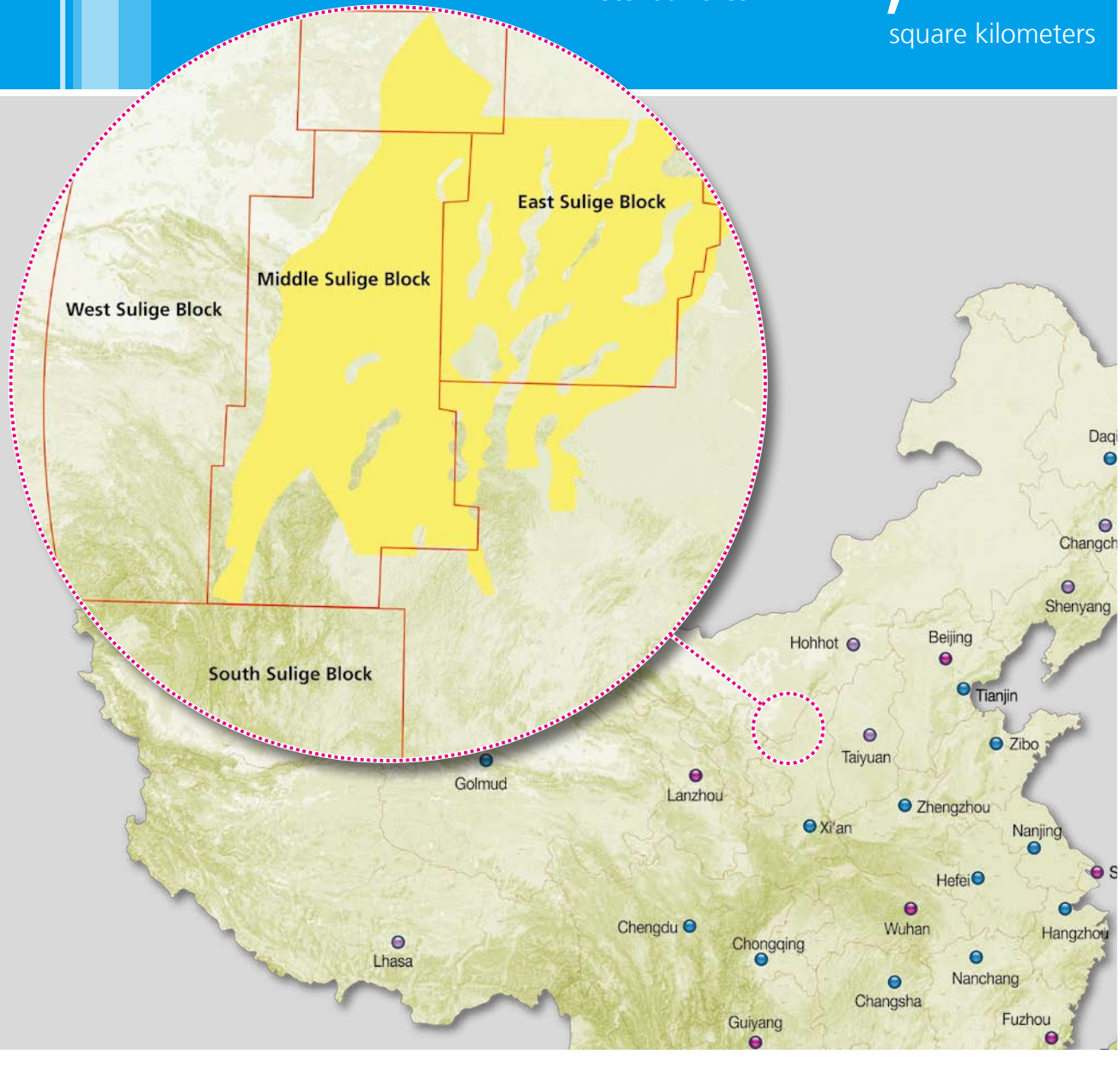
Tight Gas Reservoirs

Economical Solutions for Sulige Gas Field

Sulige Gas Field is located in the north central area of the Ordos Basin, with a potential area of 40,000 square kilometers and cumulative proven gas in place of 1.68 trillion cubic meters. So far, it is China's largest onshore gas field characterized by low permeability, low pressure and low abundance.

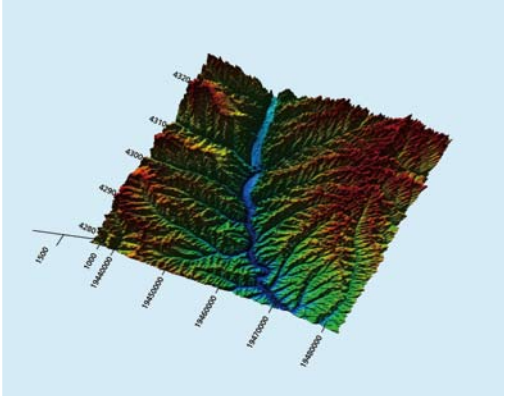
Proven gas in place **1.68** trillion cubic meters

Potential area **40,000** square kilometers

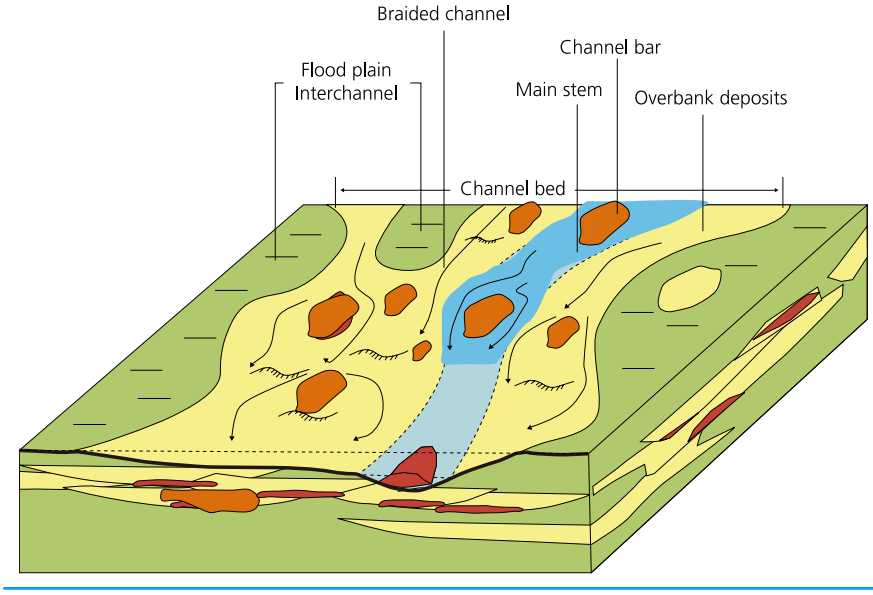


Sulige Gas Field is a large sandstone lithologic trap gas field developed in upper Paleozoic clastic formations. The gas reservoirs have a burial depth of 3,200-3,500 meters. The gas-bearing layers are mainly Permian sandstone with the air permeability of 0.1-2.0mD ($10^{-3}\mu m^2$).

Challenges



- Gas reservoirs: low permeability and tight, thin effective thickness of single layer, dispersive longitudinal distribution
- Strong heterogeneity of reservoirs and low single-well control reserves
- Quick pressure drop and low single-well production
- Short stable production period and low average single-well production



Discovery

On August 26, 2000, a commercial open gas flow was obtained from well Su-6 with a daily output of 1.202 million cubic meters, marking the discovery of the Sulige Gas Field. Proven recoverable reserves of 163.278 billion cubic meters in the central part of the field were reported for the first time in 2001.

Evaluation

In 2002, a pilot development area was built. In November 2006, a development program was prepared for the central part of the Sulige Gas Field to reach an annual production capacity of 5 billion cubic meters.

Production capacity construction and operation

In December 2006, the first gas processing plant was put into operation with a processing capacity of 3 billion m^3/a.

On October 15, 2007, daily output of Sulige Gas Field exceeded 10 million cubic meters, which means that it has a production capacity of 4 billion m^3/a.

In June 2008, the second gas processing plant was put into operation with a processing capacity of 5 billion m^3/a.

In July 2009, the third gas processing plant was put into operation with a processing capacity of 5 billion m^3/a.

Development prospects

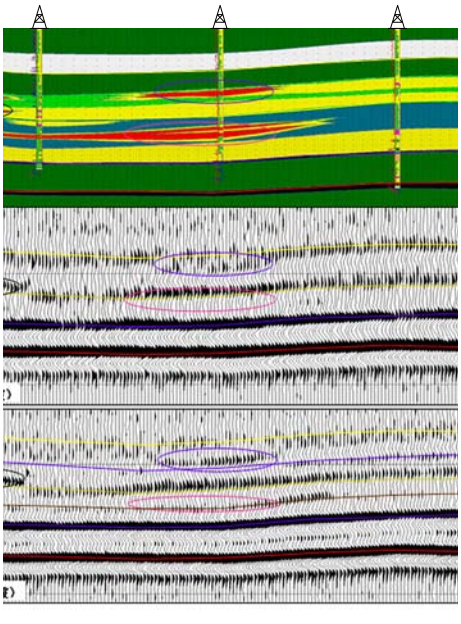
With progress in exploration, the gas reserve volume of Sulige Gas Field is increasing. It is predicted that Sulige will have proven gas reserves of 2.5 trillion cubic meters and a development scale up to 23 billion cubic meters.

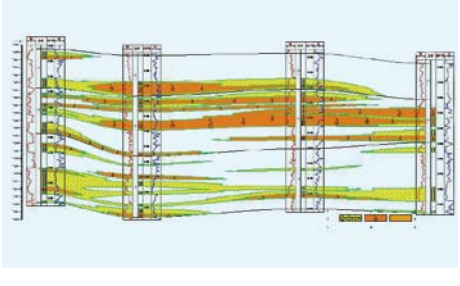
Technology and Innovation

Because of its complicated geologic conditions and low-grade resources, Sulige Gas Field is required to seek technical innovation and low-cost solutions for economical and effective development. At each stage in the development, great importance has been attached to the integration, improvement and innovation of conventional development technologies, so as to achieve best technical performance. Six core technologies are playing important roles in the economical and effective development of the Sulige Gas Field.

Well Location Optimization

Single-well control reserves and production have been increased and the proportion of relative high yield wells is above 80% thanks to fine analysis of geologic and seismic data, selection of relative enrichment zones, utilization of high-precision 2D seismic technology, prediction of effective reservoirs, and optimization of favorable target layers and well locations.





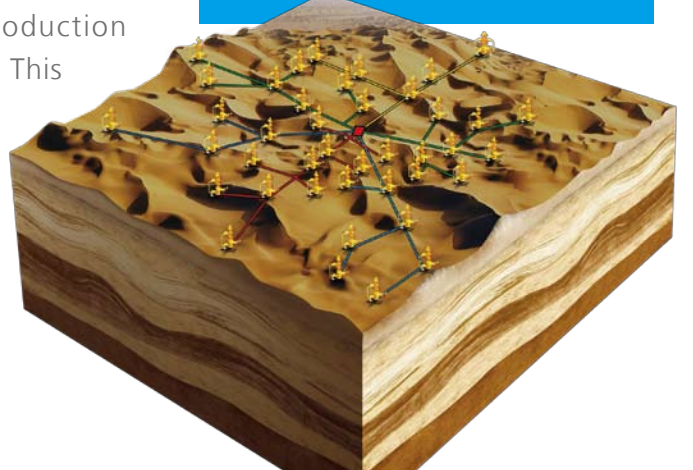
Proportion of relative high yield wells above **80%**

Fast Drilling

The rate of penetration has been greatly speeded up, the average single-well drilling cycle has been reduced from 35 days to about 14 days and single-well drilling costs have fallen by more than one-third by using compound drilling technology with PDC drill bits, along with the optimization of hole structure, drilling parameters and mud system.

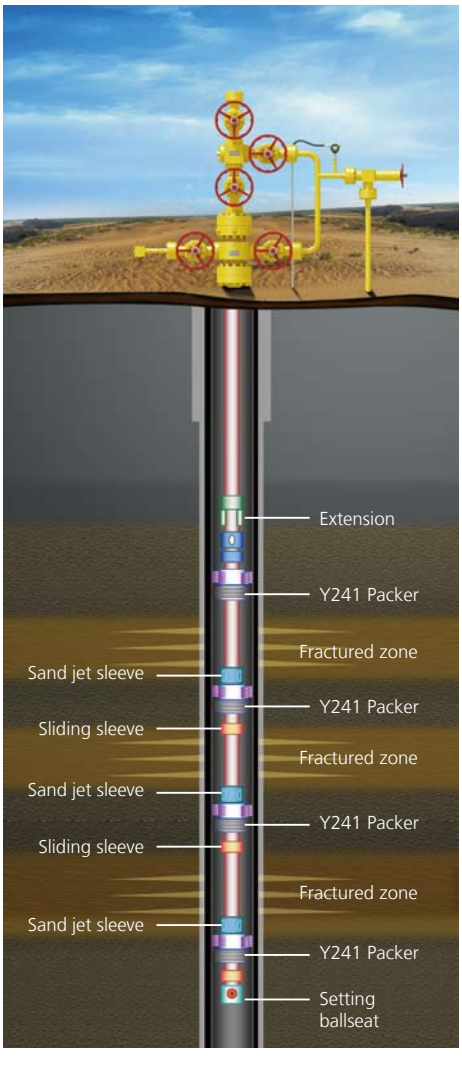
Inter-well Concatenation

Inter-well concatenation technology replaces the conventional method using a single-well pipeline to transport gas from individual wells to a gas gathering station with a new method using gas gathering pipes to concatenate adjacent individual well into a gas gathering trunk and then transport the gas from wells to a gas gathering station, simplifying and optimizing the gas production and gathering pipeline network system. This technology shortens gas gathering pipeline length, thus reducing average single well pipeline investment by 32% and improving the adaptability of the gas gathering pipeline network to progressive development.



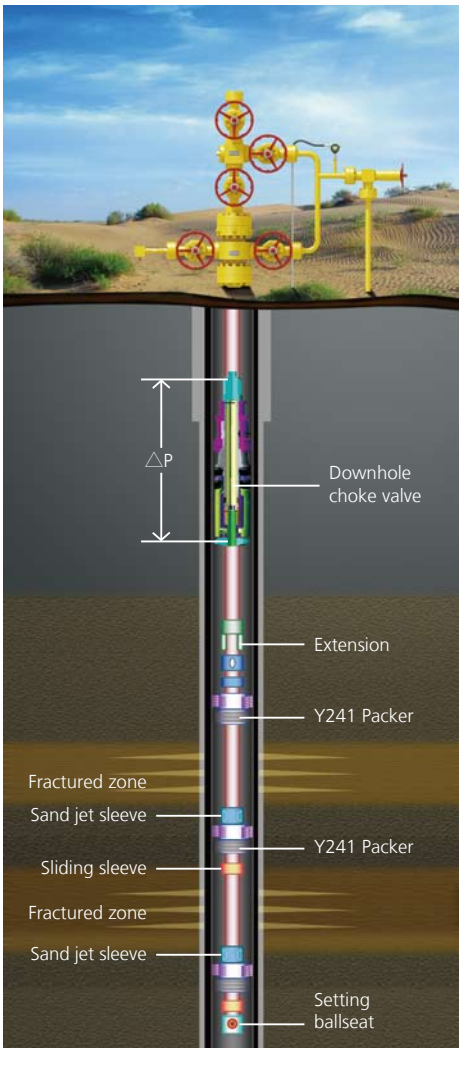
Separate Layer Fracturing and Commingled Production

With our independently developed separate layer fracturing renovation technology with Y241 and Y344 packers, and mechanical packing, separate layer fracturing and commingled production strings, we have successfully realized the continuous separate fracturing of three layers. Separate layer fracturing and commingled production can effectively communicate vertical reservoirs, increase the net pay/gross thickness ratio, minimize damage to reservoirs, significantly increase productivity and effectively enhance single-well production.



Downhole Choking

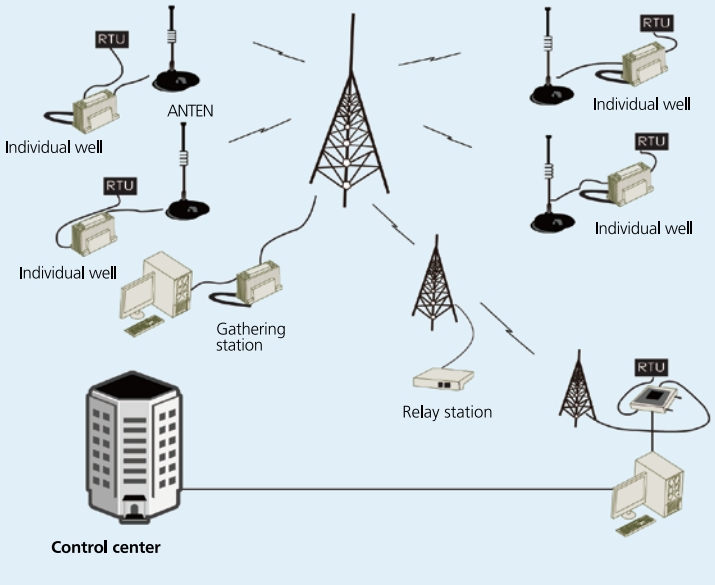
CNPC independently developed downhole chokes were used to realize downhole choking and drop in pressure, provide conditions for the simplification and optimization of the surface flow process, and lower the pressure grade of surface facilities and pipelines, so as to form a medium and low pressure “no heating, no alcohol injection and no thermal insulation” gas gathering mode and cut surface construction investment by 50%.



Cut surface construction investment by 50%

Remote Control

Remote control integrates wireless data transmission and remote emergency shutoff of gas wells, establishes communication between individual well and gas gathering stations through a wireless bridge, sends gas well production data, well-head solenoid valve status and wellsite video images collected by RTU wellhead collectors to the control center in real time, and realizes the automatic collection and transmission of gas well data, electronic inspection of individual well, wellsite video monitoring and remote switch control of gas wells, thus increasing gas field management efficiency, assuring safe and stable production and reducing the operating costs of the gas field.



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