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The geothermal rebirth journey of mature oil wells: A practical case from the Shengli Oilfield, SINOPEC

Xiaorui Yun[1,2,3]*, Ying Zhang[1,2,3], Jianyun Feng [1,2,3], Jun Luo[1,2,3], Dawei Liao[1,2,3], Qiaoxun Zhang[1,2,3]
1 State Key Laboratory of Deep Geothermal Enrichment Mechanisms and Efficient Development, Beijing,, China
2 Petroleum Exploration and Production Research Institute of SINOPEC, Beijing, China
3 Petroleum Exploration and Production Research Institute corporation of SINOPEC, Beijing, China

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INTRODUCTION

- Petroliferous sedimentary basins usually have good geothermal resource potential, as well as rich geological data and oil wells.
- By utilizing mature and abandoned oil wells to strengthen the development of geothermal resources in oil fields, it can significantly reduce the impact and promote the coordinated development of Petroleum and geothermal resources.
- This study systematically analyzed the geothermal geology, distribution of thermal reservoirs, and geothermal field in the Gudong area of Shengli oilfield, SINOPEC. Based on the distribution of mature and abandoned oil wells and energy demand, two mature oil wells were selected for renovation and testing.

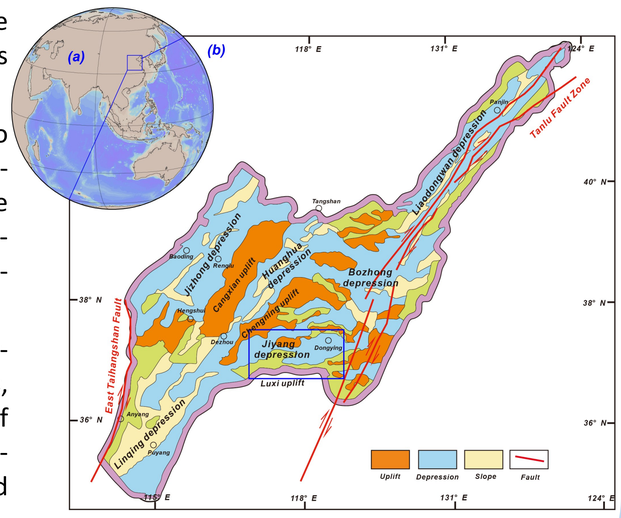


Fig. 1. Tectonic Position of the Jiyang Depression

GEOLOGICAL BACKGROUND

- **Tectonic Setting:** The Bohai Bay Basin, where the Jiyang Depression is located, lies within the high-temperature geothermal belt of eastern China, making it a typical hot basin and a concentrated area for geothermal resources.
- **Geothermal Field:** The terrestrial heat flow in the Jiyang Depression ranges from 45.33 to 95.48 mW/m². Measurements from drilling reveal a geothermal gradient of 32.2 °C/km.
- **Geothermal Reservoirs:** Guantao-Dongying Formation sandstone geothermal reservoir, the Cambrian-Ordovician carbonate buried-hill geothermal reservoir, and the Archean metamorphic rock geothermal reservoir.
- **Carbonate Geothermal Reservoir** can maintain favorable physical properties at great depths. They are characterized by high reservoir quality, excellent conditions for thermal fluid circulation, and significant development potential.

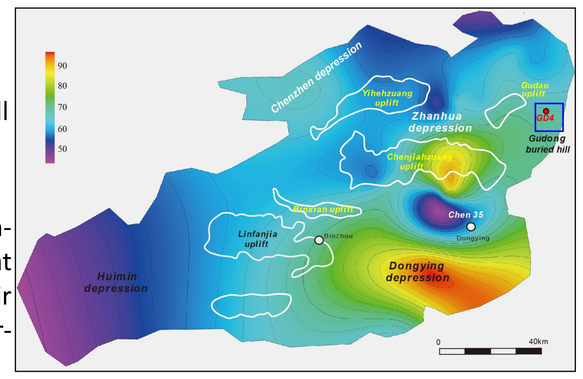


Fig. 2. Terrestrial heat flow values in Jiyang Depression

METHODS AND RESULTS

- **Two Mature Oil Wells**: Two wells encountered carbonate reservoirs in the Gudong buried hill: the GD4 well (drilled in 1984) penetrated 39.4 m of Ordovician strata, and the GDG1 well (drilled in 1987) penetrated 122.5 m of Ordovician strata. The distance between the two wells is 600 m.
- **Methods**: The oil and gas wells were repurposed into geothermal wells to obtain data on temperature and water yield. Based on 3D seismic and well logging data, a detailed characterization of the geothermal reservoir was conducted, a 3D geothermal geological model was constructed, and the geothermal resource potential was calculated.
- **Results**:
  - **GDG4 Well**: At a depth of 3110 m, the measured formation temperature was **136.8°**C. The cumulative water production was 8884.8 m³, with a wellhead back pressure of 0.89 MPa, a temperature of 132°C, and a flow rate of 75 m³/h.
  - **GDG1 Well**: At a depth of 3220 m, the measured formation temperature was 134.64°C. The cumulative water production was 4450 m³, with a wellhead back pressure of 0.6 MPa, a casing pressure of 0.4 MPa, a temperature of 104°C, and a flow rate of 31.5 m³/h.

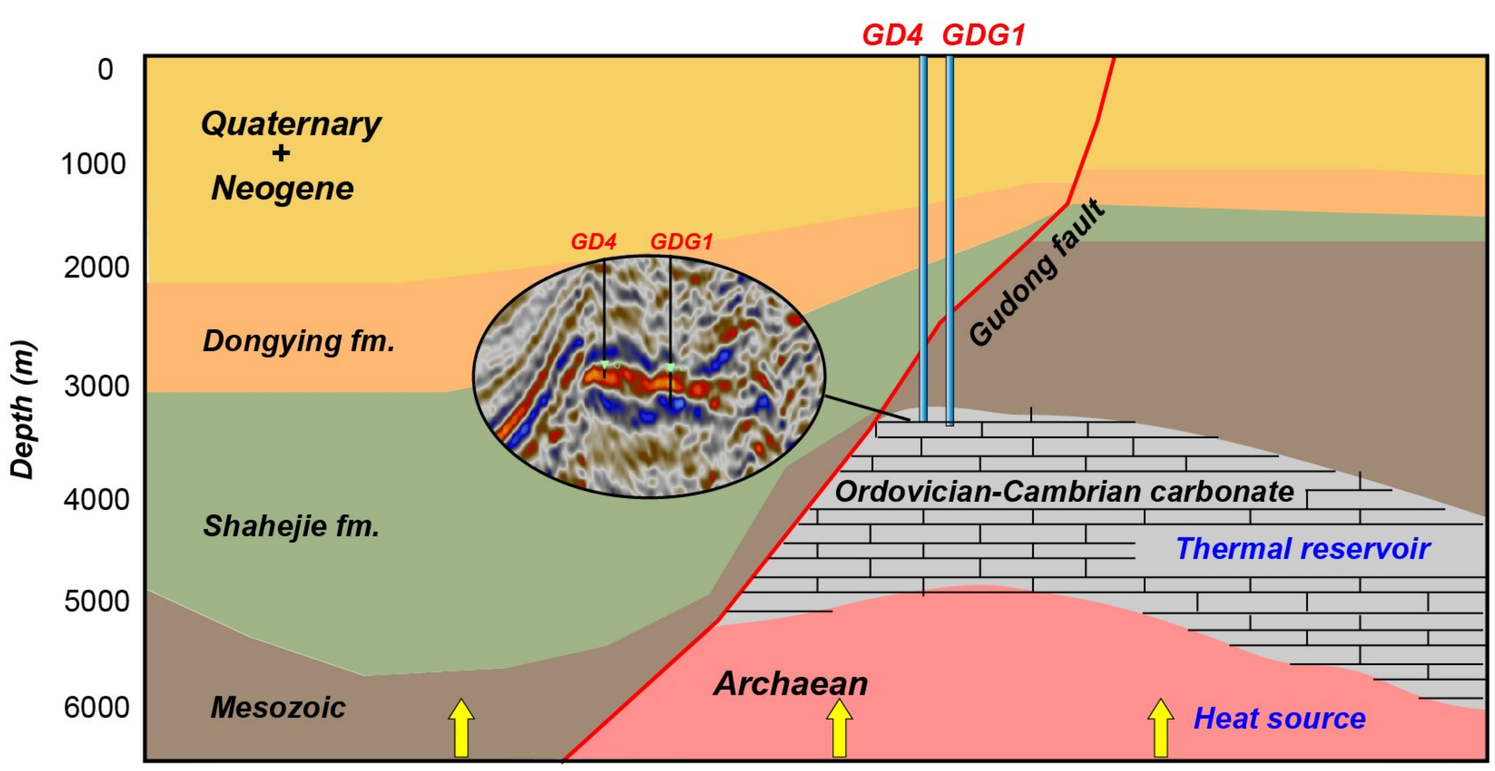


Fig. 3. E-W Reservoir Profile of Gudong buried hill

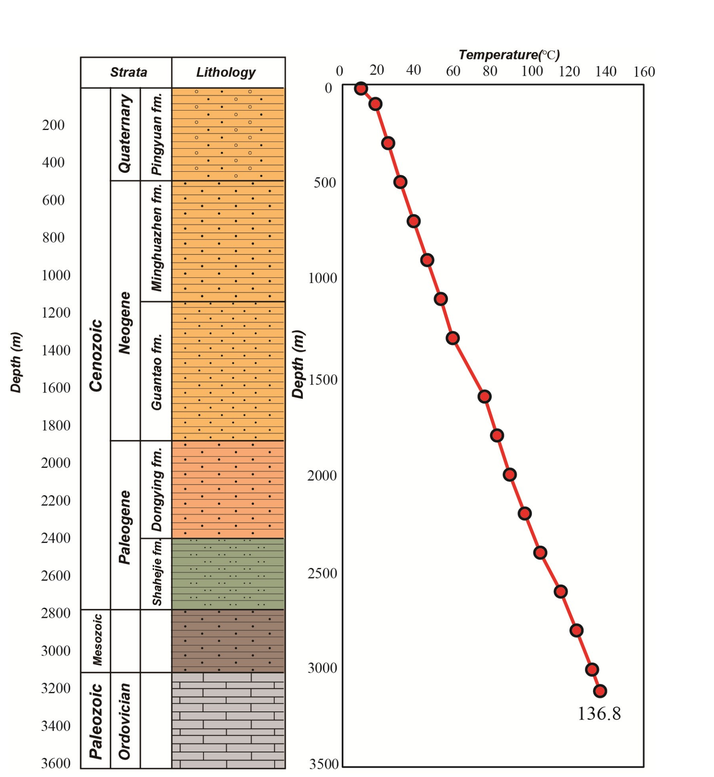


Fig. 4. Lithologic Column and Depth-Temperature Curve of Well GD4

GEOTHERMAL RESOURCE POTENTIAL

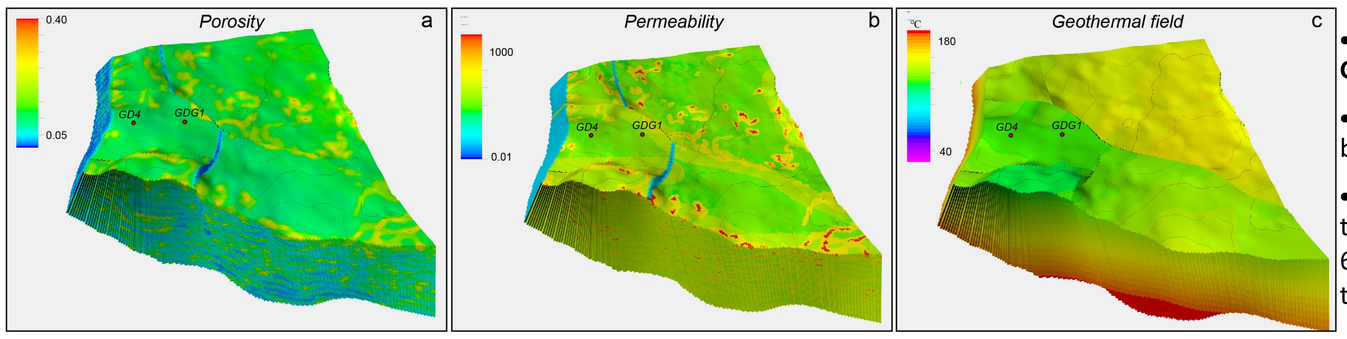


Fig. 5. Three-dimensional geothermal geological model

- **Geological model area:** 14.7875 km², **Grid Dimensions:** 20 m × 20 m × 3 m, **Number of Grid Cells:** 194 × 245 × 400 (total of 1.901 × 10^7 cells) .
- The total resource volume of the Ordovician–Cambrian thermal reservoir in the Gudong buried hill is 6.48 × 10^{18} J, equivalent to 2.21 × 10^8 tons of standard coal.
- Based on the measured data from production well GD4, which yields water at a wellhead temperature of 132 °C and a flow rate of 75 m³/h, the annual water production reaches 657,000 m³. The recoverable heat energy amounts to 3.08 × 10^{14} J, equivalent to 10,508 tons of standard coal, resulting in a carbon dioxide emission reduction of 25,849 tons.

CONCLUSION

- The Ordovician carbonate thermal reservoir in the Gudong Buried Hill exhibits significant geothermal potential, with a measured temperature of 136.8°C at a depth of 3,110 meters. This discovery demonstrates promising prospects for deep geothermal exploration and represents a breakthrough in unlocking new geothermal plays within the Jiyang Depression.
- The GD4 and GDG1 wells can be configured in various schemes, such as a production-injection doublet or as multiple production/injection wells, to directly supply geothermal heat for local oilfield production processes.

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