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High Geotherm and Its Impact on the Hydrocarbon Generation Evolution in the Fushan Sag, Beibuwan Basin, Northern South China Sea

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The Fushan Sag (FSS) locates in the southern area of the Leizhou-Qiongzhou Rift Valley, Northern South China Sea (NSCS). Due to the extension caused by the subduction of the Pacific Ocean Plate, the FSS features a crust thinning, a negative magnetic anomaly, a bouguer gravity anomaly, and a high geothermal setting, and also associated with frequent shallow earthquakes and hydrothermal events. The multi-level graben-horst structures formed during the intensive tectonic events since the Mesozoic make the FSS a favorable zone for both the petroleum and the hot dry rock (HDR) exploration.

The geothermal and geochemical tests were conducted to facilitate the understanding of how the high geotherm influenced the hydrocarbon generation evolution in the FSS. The measured data collected from the wells in the study area show that the heat flow values in the FSS are significantly higher than the Chinese mainland, and also higher than the average level of the NSCS. Among which the geotherm is higher in the eastern and northern area of the FSS. An unsteady formation temperature of 185 °C was measured in the Paleocene gravelly sandstone of the HDR test well. Since no volcanic rocks were recovered in this heat storage interval, the genesis of the high geotherm is considered to be the rifting and deep-sourced thermal activities in the study area.

The Eocene lacustrine shales within the burial depth range from 3 000 m to 3 500 m have proven to be the main source rock in the FSS. The light crude oil and heavy hydrocarbon based natural gas discovered in the overlying Oligocene reservoir indicates a high thermal maturation status of the source rock. However, the pyrobitumens originated from the thermal alteration of the liquid hydrocarbon was generally found in the joints and fractures of the underlying Paleocene gravelly sandstones and conglomerates around 4 500 m, which suggest the thermal evolution of the hydrocarbon has entered over-maturation.

Based on these results, the impact of the high geotherm on the hydrocarbon generation evolution in the FSS can be drawn: as a companion for the shallow bury and limited evolution period, the high geotherm considerately reduced the threshold burial depth for hydrocarbon generation and accelerated the thermal maturation rate of the organic matter, and thus made contributions to the commercial breakthroughs in the shallow reservoirs; the extremely high thermal, on the other side, led to the reformation of the pre-existed liquid hydrocarbon and compromised the hydrocarbon retention in deep reservoirs. This study can serve as a case for future global offshore petroleum exploration works under same geological setting.