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Editorial

Exploring the mysteries of deep oil and gas formation in the South China Sea to guide Palaeocene exploration in the Pearl River Mouth Basin

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Abstract:
Deep oil and gas resources in the South China Sea have drawn increasing attention in recent years, involving several essential challenges such as favorable zone prediction, deep burial, poor data quality, non-homogeneous reservoir properties, low drilling rate, and the low research degree of Paleozoic strata. These issues vastly affect the exploration and development of deep oil and gas resources in this area. Specifically, the Lufeng and Huizhou Depressions exhibit rich hydrocarbon accumulation and distribution areas in the Pearl River Mouth Basin, thereby possess great resource potential. The seven papers discussed here propose a set of practical techniques that can be applied to the exploration of deep Paleogene in the shallow layers of the Pearl River Mouth Basin. All of these works make important contributions deepening the theory of Paleogene reservoir formation and promoting further exploration of Paleogene in the Pearl River Mouth Basin, to increase the hydrocarbon storage and production prospects.

1. Introduction

The South China Sea is extremely rich in oil and gas resources (Metelitsa and Kupfer, 2014). To date, 48 oil and gas reservoirs have been discovered in the Zhu I Depression, with proven oil and gas reserves of 7.7 billion tons, which are mainly distributed in Neoproterozoic sandstone reservoirs (Liang et al., 2021). As China's oil and gas needs are on the rise, oil and gas exploration in the Pearl River Mouth Basin is expanding into the surrounding depressions, as well as into the deeper Palaeogene (Xia et al., 2019). A large proportion (80%) of the discovered oil and gas reserves in the Zhu I Depression are distributed in the Lufeng Depression and the Huizhou Depression. The number of exploratory wells drilled in the Paleozoic and deeper strata is high at more than 50. The seismic information includes good quality three-dimensional data covering an area of 11,000 km^2, which comprises the most significant favorable window to explore deep oil and gas resources in the South China Sea.

The characteristics of deep burial, poor data quality, non-homogeneous reservoir properties, low drilling rate, and low research degree of Paleozoic strata in the Zhu I Depression, have led to inconsistent results from evaluations of the oil and gas resource potential of Lufeng and Huizhou depressions, inconclusive characteristics of the spreading sand body reservoir, the lack of definitive criteria for effective reservoir identification, uncertain boundaries of buoyant and non-buoyant reservoir formation, and difficulties in predicting the distribution of conventional and unconventional oil and gas reservoirs. To solve these scientific challenges, the research group of Prof. Pang from the China University of Petroleum (Beijing) and experts from the Research Institute of Shenzhen Branch of China National Offshore Oil Corporation (CNOOC)

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have cooperated to carry out the research of "Comprehensive evaluation of 'source-migration-accumulation' of the Paleocene system in shallow water and the exploration direction of medium and large oil and gas fields". The seven papers published in this issue summarize the results of preliminary exploration on the above listed scientific problems.

2. Comprehensive evaluation of source-migration-accumulation

In the paper "Quantitative prediction of structural fractures in the Paleocene lower Wenchang formation reservoir in the Lufeng Depression", Hui Li et al. simulated the distribution characteristics of stress field and fracture development during the key Paleocene tectonic change in the Lufeng Depression, and a planar distribution of reservoir fracture development intensity was determined, creating conditions for the prediction of deep oil and gas rich zone and target.

Kuiyou Ma et al. delivered an essay on "Hydrocarbon dynamic field division and its relevance to oil and gas exploration for Paleogene reservoir in Lufeng depression". Based on the large volume of drilling results, oil and gas production test data and statistical analysis of the reservoir physical resources, the authors determined the lower limit of buoyant reservoir formation in the Lufeng Depression, and divided the hydrocarbon free dynamic field and restricted dynamic field, providing a theoretical basis for predicting the distribution of conventional and tight unconventional reservoirs.

In the article titled "Controlling effect of tectonic-paleogeomorphology on deposition in the south of Lufeng sag, Pearl River Mouth Basin", delivered by Mengya Jiang et.al., the impression method is used to recover the paleogeomorphic pattern of the Paleoproterozoic period, which clarifies the role of tectonic-paleogeomorphology in controlling the type and scale of the depositional system, and finally obtain a tectonic-paleogeomorphology controlled model of deposition in the south of Lufeng sag. The findings provide theoretical guidance for hydrocarbon source rock and reservoir distribution prediction.

In a paper entitled "Potential resources of conventional, tight, and shale oil and gas from Paleogene Wenchang Formation source rocks in the Huizhou Depression", Tao Hu et al. adopted the hydrocarbon generation potential method to predict the original hydrocarbon volume and planar distribution characteristics of conventional, tight, and shale oil and gas from the source rocks of Huizhou Depression in a more comprehensive way than previous researches.

Bowei Guo et al. conducted a study on the "Quantitative prediction of palaeo-uplift reservoir control and favorable reservoir formation zones in Lufeng Depression". The relationship between palaeo-uplift and oil and gas reservoir formation and distribution is clarified and a quantitative relationship model is established, which is utilized to predict the distribution range and reservoir formation probability of palaeo-uplift-controlled reservoirs in the Lufeng Depression.

In the essay on "Criteria and favorable distribution area prediction of Paleogene effective sandstone reservoirs in the Lufeng sag, Pearl River Mouth Basin", Sa Yu et al. utilized a novel method to predict and evaluate deep effective reservoirs based on the ratio method of pore throat radius of sandstone and mudstone, providing a scientific basis for determining the oil and gas-rich reservoir formation and target zone.

In the paper "Hydrocarbon accumulation model based on threshold combination control and favorable zone prediction for the lower Enping Formation, Southern Lufeng sag", Lili Zhang et al. applied geostatistical methods and numerical simulation techniques to determine the boundary, extent and probability of hydrocarbon distribution by the key elements of hydrocarbon formation. Moreover, they constructed the functional element combination reservoir model to quantitatively predict the boundary, extent and probability of reservoir formation in the lower Enping Formation, which provides a theoretical groundwork for the optimal selection of drilling targets.

3. Conclusions

Taking the Huizhou Depression and the Lufeng Depression as examples, the seven papers discussed here constitute a complete set of research methods and application results, from basic studies on tectonics, sedimentation and hydrocarbon generation, to analyzing reservoir characteristics, determining the main control factors, establishing reservoir formation models, to forming favorable zone prediction and evaluation techniques, and to finally determining favorable reservoir formation zones and selecting drilling targets. On the whole, new theoretical guidance and exploration targets are provided by these quality studies for deep-seated oil and gas exploration in the South China Sea.

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Conflict of interest

The authors declare no competing interest.

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