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The Roles of Hydrocarbon in the Formation of Sandstone-hosted Uranium Deposits in the Northern Ordos Basin, China

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1 Introduction

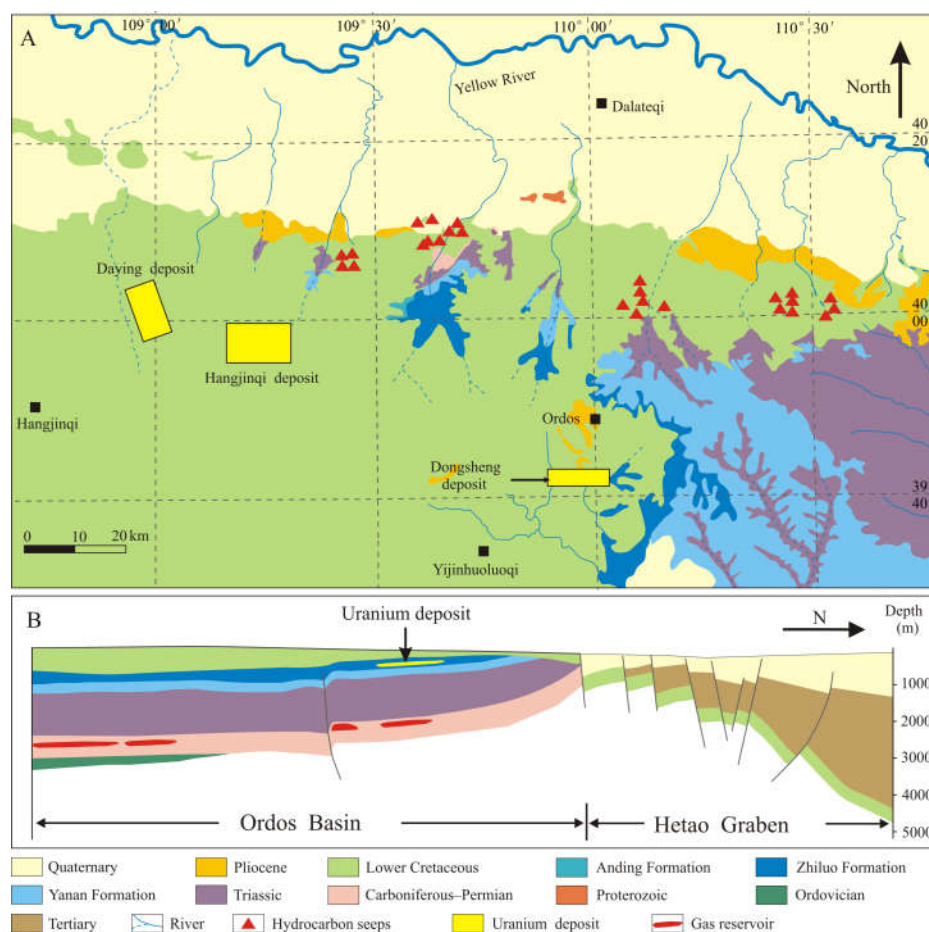


Fig.1. A. Geological map of the northern Ordos Basin, showing the locations of uranium ore deposits and hydrocarbon seeps. B. Cross section of the northern Ordos Basin (modified after Zhang et al., 2017).

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In recent years, several giant sandstone-hosted uranium deposits were discovered in the northern Ordos Basin, including Hangjinqi, Nalinggou and Daying deposits (Fig.1). In addition to the previously discovered Dongsheng deposit, the area has become one of the most uraniferous regions in North China. Meanwhile, a large number of Upper Paleozoic gas accumulations, including Dongsheng, Daniudi, Sulige, Wushenqi and Shenmu gas fields, were found in and near the uraniferous region of the northern Ordos Basin. Hydrocarbon-related phenomena, including oil seeps, bleached sandstones, green-altered sandstones are also pervasive in this region, and it has been proved the hydrocarbons originated from the Upper Paleozoic reservoirs (Liu Youmin, 1992; Ma Yanping et al., 2007). Moreover, a lot of hydrocarbon inclusions were recognized in the calcite and quartz of the ore-bearing sandstones. The close association of uranium deposits and hydrocarbon accumulations and the presence of hydrocarbons in ore fluids likely suggest hydrocarbon played important roles in the formation of the sandstone-hosted uranium deposits in this region. However, there is a lack of direct evidence that demonstrates the genetic relationships between these two types of energy resources.

2 Uranium Mineralization and Effects of Hydrocarbons

Core characteristics, petrography, and geochemistry show that there are two distinct types of ore-bearing sandstones in the uranium deposits of the northern Ordos Basin. Type I, primarily composed of green-colored sandstone, contains rare carbonized plant debris and calcite. Uranium minerals of type I is characterized by enrichment of V and light REE, with low contents of Fe and Y (Zhang et al., 2017). On the contrary, Type II, primarily composed of gray sandstone, contains abundant carbonized plant debris and coarse-crystalline calcite. Uranium minerals of this type is enriched in Fe, Y and heavy REE, and contains much lower content of V than that of type I. The primary aqueous inclusions in ore-stage calcite, which are associated with highly matured hydrocarbon inclusions, exhibit high temperatures over 100 °C and high

salinities over 8.00 wt% NaCl equivalent (Zhang et al., 2017). These evidences indicate that there are two types of ore-forming conditions in the study area: oxygenated groundwater related redox genetic and hydrocarbon-bearing, hydrothermal fluids related conditions. Both the two mineralization processes show close relationships with hydrocarbons from the deep basin. Hydrothermal fluids from Upper Paleozoic gas reservoirs were enriched in carbonate ligands, and can extract and concentrate uranium during transport. The uranium in hot brines was precipitated due to a drop in fluids migrated to near-surface conditions. Meanwhile, natural gas was massively released from the hydrocarbon saturated, hydrothermal fluids, which can serve as a reductant agent for uranium reduction and lead to the formation of type I uranium ore. The hydrocarbons also protected uranium ore from remobilization by later oxidizing fluids after ore formation.

Acknowledgements

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