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Research on Development Characteristics of Ancient Interlayer Oxidized Sandstone in Northeastern Ordos Basin

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1 Introduction

The Northeastern Ordos Basin is one of important metallogenic belt for sandstone-type uranium deposits in China and is rich in uranium resources. Previous study shows that uranium deposits in the area are closely related to ancient interlayer. Previously discovered uranium deposits are located in the lower member of the Zhiluo Formation Middle Jurassic. Regionally uranium deposits are apparently controlled by ancient interlayer oxidation zone (Xiao et al., 2004; Miao et al., 2010). So, the research on development characteristics of the ancient interlayer oxidized sandstone is of particular importance.

2 Petrological and Organic Geochemical Characteristics

The traditional interlayer oxidation sandstone shows yellow, brown or red, but the uranium mineralization in Ordos is controlled by the boundary between the green and gray sandstone, occurring in gray sandstone near the interface. Green sandstone shows characteristics of interlayer oxidation sandstone both on the plane and profile. Grain size of green sandstone is fine, and contains less carbonate and reducing agents (such as pyrite and carbon debris).

Clay content in green sandstone is slightly higher than that in original gray and mineralized sandstone, suggesting the postsedimentary strong epigenetic modification. It is pointed out that green sandstone is originated from the ancient interlayer oxidation and the secondary reduction caused by oil-gas escaping. The green color is mainly due to the needle shaped chlorite covering the surface of grains caused.

According to major element analysis of green sandstone and original gray sandstone, the activity of Si, Al, Fe and Ca in green sandstone is relatively strong, with obvious introduction and removal of certain elements. The introduction and removal of major elements are closely related to clayization caused by diagenesis and water-rock interaction, uranium metallogenesis and oil-gas reduction. Of them, the content change of Si, Al, Fe is more closely related to oil and gas, while uranium metallogenesis is linked more closely with the content change of Ca.

Green sandstone and gray sandstone shows significant difference in total rock S content and organic carbon content. Green sandstone has much lower total rock S content and organic carbon content is far lower than those in gray sandstone, reflecting the oxidition green sandstone has experienced, and the consumption of large amount of reducing substances during the process of oxidation.

3 Characteristics of Space and Stratigraphic Distribution of Ancient Oxidation Zone

Generally, green sandstone is distributed at the edge of the ordos basin and shallow subsurface of the basin. In the northeast of Ordos Basin green sandstone mainly occurs in Zhiluo Formation Middle Jurassic, and the lower member of Zhiluo Formation is a main uranium-producing stratum. The lower member of the Zhiluo Formation is further divided into two submembers, ancient oxidation zone in 2 submembers is spatially distributed in planar form, with the redox front of NW-SE striking, the ancient interlayer oxidation front line shows "embayment" distribution. In vertical, the ancient interlayer oxidation sandstone shows a tongue shaped body inserted into the original gray sandstone. The discovered uranium deposit is located at

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the redox area in general, and in the ancient interlayer oxidation sandstone and original sandstone border area in vertical in particular. Most of the uranium mineralization is distributed near the boundary between the green and gray sandstones.

4 Formation Mechanism of Ancient Interlayer Oxidation Sandstone

Based on the tectonic evolution and the hydrodynamics of the basin it can be concluded that this ancient interlayer oxidation occurred prior to the Hetao down-faulting event. Yanshan movement led to the basin uplifting in late Early Cretaceous to Middle Eocene, resulting in outcropping of Zhiluo Formation Middle Jurassic in the north of Ordos Basin. Atmospheric precipitation and surface water by infiltrated into permeable Zhiluo sandstone making, and continuously kept oxidation, consuming large amount of reducing substances, making Fe^{2+} oxidized into Fe^{3+}, changing rock color into purple and brown-red. In addition, water-rock interaction generated some clay minerals. With the migration of the U and O_2 containing water, the oxidizing capability of the ground water was getting weakened and uranium became be precipitated at the redox front. The uranyl carbonate complex in the water chemically reacted with the Ca^{2+} resulting from the alteration led to the precipitation of both calcite and U-mineral（Fan et a l., 2007; Li et a l., 2006）.

The formation of Hetao down-Faulted Depression cut off the supply of the U and O_2 containing water in Late Paleogene, and basin uplift movement Starting to wane in Himalayan Period, so that ground water to the formation of oxidation are also weakened. At the same time, the oil and gas up from the deep reduction transformed early oxidation of sandstone, making Fe^{3+} into Fe^{2+} and the Si, Al, Fe be generated or introducted, the color of ancient oxidation sandstone reducted into green. Due to the incomplete reduction, it still visible to early oxidation of purple, brown-red ancient oxidation residue spots in some area. In the Daying area, you can still be seen the remains of early oxidation sandstone in green sandstone in the lower member of Zhiluo Formation.

5 Discussion

After the modification of U and O_2 containing water, the sandstone in the lower member of Zhiluo Formation experienced the secondary reduction to form the ancient interlayer oxidation sandstone. Whether U and O_2 containing water is able to oxidize strata is a prerequisite for the formation of the ancient interlayer oxidation sandstone. On the basis of previous research results, it is suggested that the development of permeable channel sandstone, the heterogeneity of strata and the development of fault structures are main factors for constraining the distribution of ancient interlayer oxidation sandston. Of them, the development situation of the main channel sand body has restricted space distribution of the ancient interlayer oxidation sandstone, the heterogeneity of uranium-producing formation is restrictes vertical distribution of the ancient interlayer oxidation sandstone（Miao et a l., 2010; Yi et a l., 2013）, and fracture structure as a special influencing factors restricts both space and vertical distribution characteristics of ancient interlayer oxidation sandstone. While the development of the ancient interlayer oxidation sandstone restricted the uranium mineralization in this area, being one of the main prospecting indications.

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