Uranium Enrichment in Tuff of Upper Triassic in the Ordos Basin*

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The Ordos Basin is the western block of North China Craton and called as intercratonic basin. It lies in transitional zone between extensional rift basin and compressional basin, thus its tectonic position is effected by tectonic activities of eastern and western China. The N-S striking fold, faults, depression and uplifts separate the eastern China and the western China confirmed by the study of geophysical as well as stratigraphic and structural characteristics. The Ordos Foreland Basin was formed as a result of collision of Tethys tectonic field of southwest China and the impact of North China and Yangtz blocks. It is stable rigid block with no major faulting and having prominent deformation on the magins. Tectonic framework of Ordos basin is stable, as it is surrounded by active tectonic belts. It is bounded to the north by Inner Mongolia-Dxing'anling fold system, to the south by Qilian-Qinling fold system, to the east seperated from Shanxi block and to the west from Alashan block.

Basement rocks of Ordos Basin are metamorphic crystalline rocks of Neoarchean, Paleoproterozoic, Meso-Neoproterozoic series with cover sedimentary layers of Paleozoic to Meso-Cenozoic series with average thickness of 4~5 km. One side of Ordos Basin is steep with turbidite sequence while the other one is gentle slope. This gentle slope side is basically fluvial facies sandstone, which is more favourable for uranium mineralization. Sediments of Ordos Basin starts to deposit on a crystalline basement in Archean to Early Proterozoic time and this depositon ended in Meso-Cenozoic time. The thickness of sediments deposited on the crystalline basement rocks from middle-upper Proterozoic and from Meso-Cenozoic, is up to 6000 m.

During Late Triassic-Early Cretaceous, collision of China blocks and Qiangtang Block occurred with Eurasian plate. As a result of this collision, interaplate Ordos Basin was developed which experienced different evolutionary stages and changed the overall depositional environment. In late Triassic, due to erosion of Liupan mountain, basin experienced an isostatic rebound which resulted an unconformity between Triassic and Jurassic strata. In Upper Triassic, Yanchang Formation deposited in fluvial-detaic and lacustrine environment by eroded sediments of Yinshan and Qinling Mountains. Yanchang Formation is composed of sandstone, siltstone, mudstone and tuff layer with an estimated thickness of about 1000~1300 m. PetroChina Changqing Oilfield Company subdivided the Yanchang Formation into 10 members (Chang 10 to Chang 1) on the basis of reservoir characteristics. Chang 7 is lacustrine black shale deposit with tuff interval of high gamma ray values.

In Ordos Basin, Permian, Triassic, Jurassic and Cretaceous periods show high gamma anomalies which is the indication of presence of uranium. Large scale uranium deposits formed in Zhilou Formation of Jurassic time in Dongsheng and Huangling areas of Ordos Basin. However, recently the discovery of high potential hydrocarbon reservior with high gamma ray values in Yanchang Formation has also become an interesting and controversial topic among scientists.

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Yanchang Formation is divided into ten members from top to bottom Chang 10 ~ Chang 1 on the basis of reservior characterestics. The high gamma ray values were found in Chang 8, Chang 7, Chang 6 and Chang 4+5 in different regions of the Ordos Basin. There has been no exact definition of high gamma ray reservior and different authors have given different argues for this high gamma ray reservior of Triassic age. High gamma ray sandstone of Yanchang formation might be the result of re-deposition of sedimentary tuff. High gamma ray content in sedimentary rocks can be measured by pelite, as rocks with normal gamma ray content show pelite values upto 30%. However, if the value exceed upto 40% or more, then it is called high gamma ray sandstone. So the mud and clay content of sedimentary rock is important to find high gamma ray sandstone. Moreover, high gamma ray values might be due to high content of feldspar, uranium and thorium of tuffaceous interval in Yanchang Formation. High gamma logging of well Y91 showed very few tuff samples with high gamma values sandstone so they proposed that tuff should not be the reason of radioactive anomalies. Further they proposed that the high gamma ray values of Yanchang Formation are due to high content of heavy elements like zircon with uranium and thorium, instead of feldspar and clay minerals.

In order to find the formation machanism of tuffaceous layer of Yanchang Formation, its silica (SiO_2) content is plotted against TiO_2. As previous studies show that few elements in tuffaceous material remain unaltered by the effect of weathering or other diagenic processes such as TiO_2 element is very resistant, showing that almost all samples fall in sedimentary rock area except of one in Igneous rocks. It means that tuff layer was formed as a result of deposition of vocanic ashes and other sedimentary material that cover a long distance from source area to host rock. Due to transportation through long distance and diagenetic effects, vocanic ashes also altered to be sedimentary material. As explosive volcanoes produce large amount of volcanic ashes and very fine grained material that has a tendency to move a long distance before its deposition. So if such type of fine material or volcanic ashes deposit in sedimentary basins, then they change to clay particles. In other case, if these vocanic ashes or fine particles remain unaltered, then proved to be helpful to determin the composition and mineralogy of source magma.Moreover, these unaltered volcanic ashes can be used to find the tectonomagnetic setting of source magma by plotting discrimination diagrames. To find the tectonic setting of volcanoes which provide the source material for this tuffaceous anomaly in Yanchang Formation of Upper Triassic age, data are plotted on discrimination diagrams of Th/Yb versus Ta/Yb and Th/Hf versus Ta/Hf, showing that all samples fall in area of an active continental margin, thus the tectonic setting of source volcanoes are discriminated as an active continental margin.

In order to find the composition of source arc granite, TiO_2 versus Zr is ploted in which most of samples fall in area of calc- alkaline arc related magma. The results of REE distribution paterns are with negative Eu anomaly, enrichment of LREE and depletion of HREE, supporting the same results from compositional discrimination of source magma. Consequently, it is accepted that source magma of tuff layer is calc-alkaline arc related. There is one question that either this arc- related magma belongs to island arc or continental arc? To solve this problem, Th/Yb versus Nb/Yb is plotted, which shows that all tuff samples fall within continental arc field. So it is concluded that source rocks of tuff layer belongs to calc- alkaline, continental arc- related volcanoes. As in south of Ordos Basin Qinling Orogenic Belts lie in continental arc- related setting and are calc-alkaline in their composition. So the Qinling Orogenic Belts of Southern Ordos Basin are the source of this tuff interval of Yanchang Formation of Upper Triassic.

Finally, a mechanism has been proposed for uranium enrichment in tuff layer that is supported by oxidation-reduction process, showing that the high gamma ray tuff interval hosted by Upper Triassic Yanchang Formation of Ordos Basin belongs to felsic magma. Tectonic and compositional disrimination diagrams show that the tuff layer of Yanchang Formation belongs to calc – alkaline continental arc related magma.

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关键词：鄂尔多斯盆地；上三叠统；铀矿