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Primary Study of Genesis about Strong Kaolinization of Ore-bearing Sandstone, Mengqiguer Uranium Deposit

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According to clay minerals statistical results in low-middle Jurassic Shuixigou group($J_{1\text{-}2}sh$) which is the target layers of Mengqiguer uranium deposit, ore-bearing sandstone of Mengqiguer deposit suffered from strong clay alteration. The clay content of samples in interlayer oxidation zone sandstone change from 7.2% to 30.4%, strong oxidation subzone is 13.2% ~ 19.7%, moderate oxidation zone is 7.2%～14.3%, weak oxidation zone is 8.4%～24.7%, redox transitional subzone is 11.7%～13.7%, primary subzone is 8.5%～30.4%. Type of clay minerals kaolinite(K) is mainly illite(I), ill-smect mixed-layer(I/S) followed.

1 Kaolinite Feature

1.1 Content of kaolinite

Through the contrast of clay content in different geochemical subzones, gray-white sandstone was the highest, reaching 75.93%. The content of kaolinite increased obviously, from strong oxidation subzone 63.50% to weak oxidation subzone 75.93, and then to the primary subzone decreased slightly, but the overall change is not big, suggesting that kaolinit alteration is widespread. The feature reacted that target layers suffered strong water-rock interaction at post-diagenetic. At the environment of low pH acidic media, sandstones formed strong feldspar alteration, formation of kaolinite, which is also related to acidic fluid in coal measures strata.

1.2 Morphology of kaolinite

Morphology of kaolinite is related to acidic aqueous medium (organic acids and carbon dioxide or supergene leaching). Kaolinite formed during burial process and diagenesis shows good crystal morphology, a book like or vermicular, and better crystallinity, while the kaolinite formed during epidiagenesis always shows poor crystal morphology , and thin, scattered.

2 Formation Mechanism of Kaolinization

2.1 Relationship of kaolinization and oil/gas

Through horizontal comparison and comparing the oil soaked sandstone at Karamay area where northwestern margin of Junggar basin, clay mineral characteristic is similar with the kaolinization of Mengqiguer uranium deposit (Table 1). The clay mineral assemblages in the oil soaked sandstone is K+I+I/S(+C), and kaolinite is most of clay mineral, this feature is generally considered to be the total organic content and kaolinite content was positively correlation (Zhao et al, 1994), and that the Jurassic stratum restored with typical acidic aqueous medium alteration in Karamay. Similarly, Yili Basin and Junggar basin containing the same type of multi-energy sedimentary basins of oil, coal and uranium, and low-middle Jurassic Shuixigou group ($J_{1\text{-}2}sh$) is a good reservoir because of sandstone body formation. Therefore, Mengqiguer interlayer oxidation zone maybe suffered superimposed transformation of reducing fluid.

2.2 Thermal evolution of organic matter and kaolinization

Organic vitrinite reflectance tests show that organic maturity (R_o) in Shuixigou group ($J_{1\text{-}2}sh$) of low-middle from 0.4% to 0.74% in Mengqiguer deposit, with an average value of 0.58, organic matter in a semi-mature - mature stage. With burial depth increasing, the degree of thermal evolution of organic matter is higher.

Under normal circumstances, organic matter in the rock began to decarboxylation, when R_o=0.35%, in the basin sedimentation evolution process. And it formed

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organic acids and CO_2, and hot fluid of organic acid. When Ro reached 0.6%, organic matter began to natural gas (shale gas) conversion, generates CH_4, H_2S, H_2, CO_2, CO, etc.

2.3 Relationship between reducing substances and kaolinization and uranium mineralization

In sedimentary basin subsidence deposition hydrology phase, after the construction of ore formation, gravity load due to subsidence caused by compaction is the main driving force for fluids to discharge. Fluids of basin flowed from low permeability shale rock to high permeability sandstone, bottom-up, from the center of the basin to basin edge flow. After the fluid which contains lots of organic matter and reducing entering the sand, on the one hand, aluminum silicate minerals in rocks and carbonate minerals occurring are dissolution, formed secondary porosity, while producing worm-like kaolinite, quartz secondary increase and other authigenic minerals. According to clay mineral content and scanning electron microscopy in sandstone of ore target layer in Mengqiguer deposit, the sandstone body's transformation from acidic fluid is universality. On the other hand, organic acids and strong reducing substances (such as: H_2S, H_2, CO) changed the sandstone environmental systems via oxidation-reduction potential. Along with the dissolution of feldspar, deposition of kaolinite, oxidation of iron oxide, Fe^{3+} transformed for Fe^{2+} and easy to migrate out or formed pyrite, so that oxidative sandstone suffered oxygenated water oxidation and faded into occurrence of white or gray. It is likely the formation mechanism of clay alteration which is emerged in oxidation sandstone body of oxide-reduction zone at Mengqiguer deposit. Organic acidic fluid has greatly increased the capacity reduction and permeability of sandstone body, which created a good ore-space for surface water which containing oxygen and uranium to long-term transform. Because of reducing substances involved in, sandstone body enhanced the reduction of capacity. While U^{6+} in the water of containing uranium and oxygen precipitated and enrich near the redox geochemical barriers. Further studies are required to determine the exact relationship between this kaolinite alteration and rich ore body.

2.4 Relationship between kaolinization and other metal elements

In addition, through the different oxidation zone sandstone samples' test results of trace element in Mengqiguer uranium deposit P3 exploration line, it can be seen that U and metal elements including Cu, Pb and Zn have a good relevance, but the high-field region of these elements does not coincide with the U. But the content of these metal elements is abnormally high in gray alteration zone and native sandstone zone, Cu up to 42.3×10^{-6}, Pb up to 32.3×10^{-6}, Zn up to 124×10^{-6}, and galena and sphalerite can be wrapped in organic by microscopy and electron probe, indicating that these metal elements had migrated before uranium enrichment.

Experiments show that hydrocarbon and organic acidic fluid are strong extraction functions with Cu, Sb, Hg, Pb, and Zn, ect. at a temperature in the range of 110℃~150℃, when extraction amount maintained above 40% and has strong stability (Gu, 2007).

Table 1 Jurassic rocks' analysis results of relative content of clay minerals in Karamay region

No.	sample number	Position	Lithology	The relative content of clay minerals（%）						mixed-layer（%S）	
				S	I/S	I	K	C	C/S	I/S	C/S
1	DH03-17	ZK16001 331m	Gray conglomerate		10	17	58	15		40	
2	DH03-22	ZK15001 218m	Contain thick oil sandstone		15	20	54	11		45	
3	DH03-28	ZK15002 146m	Contain thick oil tight sandstone		10	17	66	7		45	
4	DH03-30	ZK47001 104m	Blue-gray conglomerate		25	15	60			45	
5	DH03-37	ZK47002 96.5m	Gray coarse sandstone		14	8	78			30	
		average			14.8	15.4	63.2			41	

Note：According to the Nuclear Industry Brigade 216，2003。