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Transformation of Fe-bearing minerals from Dongsheng sandstone-type uranium deposit, Ordos Basin, north-central China: Implications for ore genesis

Liang Yue[1,2,3,†], Yangquan Jiao[1,2,*], Mostafa Fayek[3], Liqun Wu[1,2], Hui Rong[1,2], and Huili Xie[4]

[1]Key Laboratory of Tectonics and Petroleum Resources (China University of Geosciences), Ministry of Education, Wuhan 430074, China
[2]School of Earth Resources, China University of Geosciences, Wuhan 430074, China
[3]Department of Geological Sciences, University of Manitoba, Winnipeg R3T 2N2, Canada
[4]CNNC Beijing Research Institute of Uranium Geology, Beijing 100029, China

Abstract

Iron-bearing mineral assemblages and their distribution patterns directly reflect the redox environment in sediments, which plays a decisive role in the migration and precipitation of U. The Dongsheng sandstone-type U deposit hosted in fluvial and/or deltaic sandstones of the lower member of the Middle Jurassic Zhiluo Formation in the northeastern Ordos Basin has experienced multiple fluid events that impacted the redox conditions. Highly enriched in barren gray sandstones, pre-ore U (U_{mean} = 12.05 ppm) associated with Fe-Ti oxides, clay minerals, and organic matter is likely one of the key sources of U for the mineralization. Different contents of Fe-bearing minerals, including biotite, Fe-Ti oxides, pyrite, hematite, goethite, and chlorite that were formed or altered under different redox conditions, resulted in sandstone units with distinct colors. The red sandstone is hematite-rich, indicating a highly oxidizing environment. The green sandstone is chlorite-rich and formed because of reducing hydrocarbon-rich fluids that overprinted the hematite-rich sandstone. The barren and mineralized gray sandstones consist of pyrite (with a higher content in mineralized sandstones), Fe-Ti oxides, and carbonaceous debris, which are indicators of a reducing environment. Based on the paragenetic relationship and sulfur isotopic compositions of ore-stage pyrite, bacterial sulfate reduction was responsible for the formation of framboidal pyrite ($\delta^{34}S$ = –31.2 to –3.8‰), and the sulfur of this pyrite mainly came from the oxidation of pre-ore pyrite ($\delta^{34}S$ = –19.1 to +20.3‰). Euhedral and cement pyrite overprinting framboids were produced via Ostwald ripening with $\delta^{34}S$ values ranging from –56.9 to –34.3‰, lower than any values of framboidal pyrite. Therefore, these mineralogical and geochemical characteristics of the Dongsheng deposit suggest U mineralization involves both biogenic and abiogenic redox processes.

Keywords: Pyrite, $\delta^{34}S$, Fe-bearing minerals, alteration, sandstone-type U deposit, Ordos Basin