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Uraniferous Black Shale and Related Uranium Mineralization Features in South China

ZHANG Qiuying

Bureau of Geology, China National Nuclear Corporation, P.O. Box 762, Beijing 100013

Abstract Black shales are marine sediments with argillaceous, silty and siliceous compositions and high contents of organic materials, disseminated pyrite and uranium. Uraniferous black shale has uranium content of more than 20 ppm.

Black shales are widely distributed in 17 provinces or autonomous regions in northwestern and southern-central China. Their sedimentary ages are from the Sinian to the Tertiary and uraniferous black shales are mainly exposed in Yunnan, Guizhou, Sichuan, Hunan, Hubei, Jiangxi, and Zhejiang provinces and Guangxi Zhuang Autonomous Region and the economically significant uranium deposits associated with black shale occur in Hunan and Jiangxi provinces and Guangxi Zhuang Autonomous Region.

Uranium mineralization associated with black shale has the following main features: (1) forming stratabound deposits; (2) controlled by structures such as interlayer and intersected faults and fractures; (3) associated with different ore-forming processes such as leaching and hydrothermal reworking; (4) occurring in five periods, namely 120–110 Ma, 84–74 Ma, 75–65 Ma, 48–39 Ma and 30–24 Ma.

Key words: Uraniferous black shale, uranium mineralization features, leaching and hydrothermal reworking

1 Stratigraphic and Geographic Distribution of Black Shale

Black shale refers to marine sedimentary rocks composed of argillaceous, silty and siliceous substances with high contents of organic materials and disseminated pyrite. If its uranium content is more than 20×10^{-6}, it is called uraniferous black shale.

In China, black shale is widely distributed in the northwestern and southern-central areas, covering 17 provinces (autonomous regions), and deposited in a period from the Sinian to the Tertiary. Uraniferous black shale is distributed only in Yunnan, Guizhou, Sichuan, Hunan, Hubei, Guangxi, Jiangxi, and Zhejiang in southern China. However, the economic uranium deposits associated with black shale occur only in Guangxi, Hunan and Jiangxi (Bureau of Geology and Mineral Resources of Guangxi Zhuang Autonomous Region, 1985; Hunan Bureau of Geology and Mineral Resources, 1989; Jiangxi Bureau of Geology and Mineral Resources, 1984), and their formation ages are confined to the period from the Late Sinian to Early Cambrian, which are similar to the Alum shale of Sweden (Є), but different from the Chattanooga shale (D) of the United States and the Bakken shale ($D\text{-}C_1$) of Canada .

In southern China, the Yangtze landmass, through the Sibao tectonic movement (c.a. 1000 Ma B.P.), evolved into the southeastern marginal island arc-bearing folded belt including the Jiangnan massif. Later, affected by the Jinning tectonic movement (c.a. 800 Ma B.P.), the Yangtze landmass and the Cathaysia landmass partly joined together in Zhejiang province and maintained their western part as relic sea basins. As a result, in southern China there appeared three depositional regions from north to south: the Yangtze landmass, Jiangnan landmass and Zhujiang (Nanhua) relic sea basin (Fig. 1). In the Yangtze depositional region, impure argillaceous dolomite and dolomitic mudstone are dominant and phosphorite and vanadium deposits are common. In this region uraniferous black shale is widely distributed but no economic uranium deposits have been found so far. In the Jiangnan depositional region, the most important region for black shale- related uranium deposits in China, siliceous mudstone and argillaceous-siliceous rocks

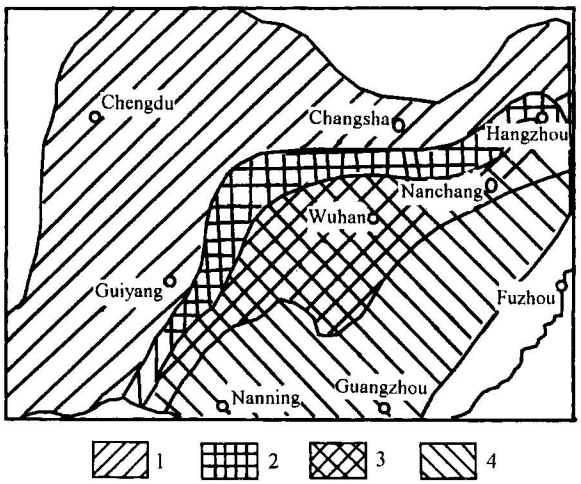

Fig. 1. Distribution of Upper Sinian-Lower Cambrian black shales in southern China (modified after Chen Nansheng, 1980).
1 Yangtze region; 2. northern subregion of the Jiangnan region; 3. southern subregion of the Jiangnan region; 4. Zhujiang region.

are dominant. In its northern subregion, abundant potential uranium resources of low grade (about 0.03%) and accompanied molybdenum have been found; while in the southern subregion, characterized by favourable rock associations of soft shale and hard siliceous rocks, a series of important economic uranium deposits have been explored. In the Zhujiang depositional region, turbidite is in dominance, and there occasionally occur carbonaceous siltstone-shale rhythmic assemblages, which were deposited probably under bogan environment. Uranium deposits explored in this region are mostly in the exocontact of the granite batholith.

2 Uranium Mineralization Features

(1) Stratabound mineralization

Uranium mineralizations are mostly located in black shale or in layers of alternating black shale and black siliceous rocks from the Late Sinian to Early Cambrian.

(2) Structural control

The ore-controlling structures mainly include interlayer structures, layer-shearing structures and fractures and the intersections of these structures are specially favourable for uranium mineralization.

(3) Genetic types

In China, there are two types of uranium mineralizations associated with black shale: the leaching type and thermal reworking type (Zhang Daishi et. al., 1993). In thermal transform type uranium deposits, hydrothermal alterations such as silicification, chloritization and fluoritization are extensively developed. Temperatures of the hydrothermal solutions range from 150°C to 300°C. The isotopic dating of uranium ores shows that the uranium mineralization occurred mostly in the following five periods: 120–110 Ma, 84–74 Ma, 75–65 Ma, 48–39 Ma and 30–24 Ma.

3 Discussions

(1) In the formation of uranium deposits, black shale serves firstly as the uranium source. The initial enrichment at the diagenetic stage of sedimentary rocks is of significance for the formation of leaching type uranium deposits. It serves secondly as a geochemical reduction barrier for the formation of uranium deposits.

(2) As viewed from a broader angle, the deposition and formation of uraniferous black shale usually indicate that the region studied is in a transitional process from an unstable geotectonic environment to relatively stable geotectonic environment. Black shales of the same age occur in various parts in the world, which shows that a global anoxic event once happened in oceans. Based on the study of the evolution of uranium mineralizations it is concluded that sedimentation of uraniferous black shale was always prior to the uranium mineralization of vein type deposits in granite and volcanic rocks in the same region. Therefore, it is suggested that the distribution pattern and the scale of uraniferous black shale in a region be taken as an important reference for the delimitation of uranium metallogenetic provinces.

(3) Black shale often contains various kinds of associated elements of industrial value besides uranium. Therefore, great attention should be paid to the distribution features of these associated elements in the study of ore-forming conditions of uranium in black shale and in the exploration of rich uranium ore. A typical example is Bakken uraniferous black shale in Canada, in which Zn concentration is as high as 5%. In China, geochemical anomalies of platinum group elements have also been found in uraniferous black

shale of the Early Cambrian in the Yangtze region and the northern subregion of the Jiangnan depositional region. This is a interesting problem for further study.

Manuscript received Jan. 2000
edited by Liu Xinzhu

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About the author

Zhang Qiuying Born in October, 1960; graduated from East China Geological College in 1984 with a M.S. degree. He once went to Japan, France, Russia and Uzbekistan in 1994, 1995, 1997 and 1999 respectively to join scientific exchanges and co-operation and attend scientific symposia and professional training with regard to the geology of uranium ore deposits. He is currently engaged in the research on metallogenic laws of uranium deposits hosted in interlayer oxidized zones and the abyssal ore-forming theory of uranium ore deposits related to granite and volcanic rocks. Tel: 64201122-256.