The Anthraxolite Evolution and Vanadium Enrichment Mechanism of the Upper Ordovician in the Northern Qaidam Basin, Northwest China

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Abstract

Researchers have been discovering the original relationship between organic matter and metal elements for a long time. During our geological survey in the northern Qaidam Basin, we have found that anthraxolite in the Member a of Tanjianshan Group of upper Ordovician (O3tna) contains more vanadium than that in the crust, making us think it over: what role does vanadium play and how does it enrich in the process of petroleum generation from hydrocarbon source rocks, and the evolution of light oil to heavy oil, bitumen, and anthraxolite, a highly thermal evolution product of organic matter? Samples were collected from the O3tna in Saishiteng mountain and Tanjianshan area of Qaidam basin. Our tests included heating value determination, organic geochemistry tests, fluid inclusions tests, scanning electron microscopy-energy spectroscopy, zircon U-Pb dating and major and trace elements analysis. Tanjianshan Group, upper Ordovician in the northern margin of Qaidam Basin is mainly composed of marine carbonate rocks, clastic rocks and medium-basic volcanic rocks, and some of them experienced shallow metamorphism. The Tanjianshan group is vertically divided into five lithology members of Member a, Member b, Member c, Member d and Member e. Anthraxolite is mainly developed in the sandstone, limestone and phyllite of the O3tna. The spherical, flaky, and mosaic anthraxolite is filled in cracks, dissolved pores, and intergranular pores of the rocks. The content of soluble organic matter in anthraxolite is low, and non-hydrocarbons and asphaltenes in the group components are

dominant. The thermal evolution of bitumen is extremely high, and the equivalent vitrinite reflectance is even up to 4.9%, which is the product of high thermal evolution of oil and gas.The regular sterane C27 is dominant, and the triaromatic sterane is dominated by C2620R+C2720S, followed by C2620S and C2820S, reflecting that the parent material of anthraxolite is derived from lower plankton and is formed in an oxygen-poor saline water environment. The distribution characteristics of terpane and sterane and the contents of triaromatic sterane and tricyclic terpane in anthraxolite are well correlated with the mudstone of the O3tna. Fluid inclusions indicate that there were two phase hydrocarbon charges during late Devonian and Carboniferous. Zircon U-Pb dating of the granite shows that multiple magmatic thermal events took place after late Devonian, resulting in hydrocarbon fluid cracking, metamorphism, and final anthraxolite formation. The relative contents and correlation ratios of major and trace elements in sediments indicate that the enrichment of vanadium minerals was irrelevant to marine hot water deposition. It is inferred that vanadium originated during biological and biochemical processes, then migrated and accumulated with hydrocarbon formation and evolution, and finally enriched in anthraxolite.