REE Geochemical Evolution and Its Significance of Early Precambrian Metamorphic Terrain, Wuyang, Henan

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Abstract

The supracrustal rocks of the Wuyang metamorphic terrain are divided into the Zhao'anzhuang, Tieshanmiao and Yangshuwan Formations. These three Formations were dated at 3000-2550 Ma, 2550-2300 Ma and 2300-2200 Ma, respectively. ΣREE and La/Yb of the Zhao'anzhuang Formation volcanic rocks are obviously higher than those of the Tieshanmiao Formation equivalents, suggesting a sedimentary gap (2550 Ma boundary) between these two formations. The Zhao'anzhuang Formation is older than the Tieshanmiao Formation. The sediments of these two Formations show no obvious differences in REE and are generally characterized by low ΣREE and positive Eu anomalies. On the contrary, the sediments of the Yangshuwan Formation are characterized by high ΣREE and negative Eu anomalies. Detailed discussions demonstrate that the Yangshuwan Formation was deposited in an oxidizing environment whereas the other two formations were formed in a reducing environment. At the end of the evolution of the Tieshanmiao Formation about 2300 Ma ago, the sedimentary environment was transformed from reducing to oxidizing. On the basis of the SHAB (soft/hard acid and base) theory, an oxidation-reduction model for sedimentary REE evolution has been established. It is proposed that the mantle tends to become gradually depleted in REE, especially in LREE, and the indices ΣREE and La/Yb of mantle-derived volcanic rocks also tend to become lower and lower.

Geological Setting

The Wuyang Early Precambrian metamorphic terrain is located in the Huaxiong block at the southern margin of the North China craton. In the 1950's, the Tieshanmiao-type Fe deposits were found in this terrain by Chu Xinchun et al. In 1960 a larger Fe deposit — the Zhao'anzhuang deposit was found there by Zhang Yuanyou et al. Since then, much work has been done on the geology of those Fe deposits. The metamorphic strata of the terrain are subdivided from the bottom upwards into the Zhao'anzhuang Formation, the Tieshanmiao Formation and the Yangshuwan Formation. These three formations were dated at Archaean. The correlation between the stratigraphic division and the stratigraphic sequence has further been confirmed. It follows that the ages of these three formations are 3000-2550 Ma, 2550-2300 Ma and 2300-2200 Ma respectively, and are petrographically distinguished as the primary greenstone belt, the secondary greenstone belt and the k-homealite series (Fig. 1) (Chen et al., 1988, 1989, 1991; Hu, 1988).
Samples and Analysis

Listed in Table 1 are the contents of major and rare-earth elements in the supracrustal rocks of different horizons in the Wuyang metamorphic terrain. The major element data were provided by Zhang Yuanyou. The REE contents were analyzed with the ICP technique at the geological laboratory of Hubei Provincial Geological Bureau. Most of the samples were collected from drill cores, with no sign of being weathered. In the following are the petrography and mineralogy data for the samples:

No. 1, Wo26: diopside 10%; carbonate minerals 90%; chemical sediment.
No. 2, Wo30: diopside 40%; quartz 40%; magnetite 20%; chemical sediment.
No. 3, Wo03: diopside 57%; quartz 20%; magnetite 20%; hematite 3%; chemical sediment.
No. 4, Wo33: graphite 6%; carbonate minerals 10%; quartz 20%; feldspar 20%; others (actinolite, epidote, chlorite, biotite) 44%; biocalcitilitue.
No. 5, Wo34: quartz 40%; feldspar 20%; calcite 5%; biotite 35%; calcareous shale.
No. 6, Wo14: quartz 90%; feldspar 10%; clastic rock.
No. 7, Wo15: quartz 97%; feldspar 2%; muscovite 1%; migmatized metamorphic clastic rock.
No. 8, Wo27: quartz 20%; andesine 20%; garnet 30%; amphibole 30%; pyroxene 10%; komatiite.
No. 9, Wo21: magnetite 45%; serpentine 48%; calcite 6%; apatite 1%; altered ultrabasic volcanic rock.
No. 10, Wo24: magnetite 5%; serpentine 50%; pyroxene 35%; olivine 10%; altered ultrabasic volcanic rock.
No. 11, Wo31: magnetite 13% serpentine 85%; phlogopite 2%; altered ultrabasic volcanic rock.
No. 12, Wo03: magnetite 5%; pyroxene 95%; ultrabasic volcanic rock.

Environments of the Sediments in Special Reference to Their REE Geochemistry

From Tables 1–2 and Figs. 1–2 it is shown that all the samples, except No. 7 which was migmatized, share the following two characteristic features: (1) The index $Eu/Eu^*$ for the sediments younger than 2300 Ma (Nos. 4–5) is