An evaluation on using the Nd–Hf isotopic systematic as an indicator for the protolith characteristics of eclogites

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The nature of protolith of eclogites is one of the critical elements for re-constructing regional tectonic evolutions. However, identifying protolith characteristics of eclogites has been subjected to complications from metamorphic modifications on the protolith compositions, since a large number of constituent elements of eclogitic protoliths are mobile during metamorphism at high P–T conditions. Jahn (1999) postulated that the positive and negative metamorphic initial εNd values of eclogites can be protolith indicators of oceanic and continental affinities, respectively. However, the metamorphic initial εNd values alone cannot determine whether the protoliths were generated by subduction-related or intra-plate magmatism, handicapping investigations on tectonic evolution. In contrast to the εNd(t) values that evolve with rates depending on the abundance ratios of two REE (Sm/Nd), the εHf(t) values are sensitive to REE–HFSE (Lu–Hf) fractionation, providing additional constraints on protolith characteristics. This contribution presents an evaluation on using the Nd–Hf isotopic systematic to characterize the nature of the protoliths of eclogites from the Sulu terrane at eastern China.

Based on major and trace element compositions, the analyzed Sulu ultra-high pressure (UHP) eclogites are classified as high-Fe-Ti eclogites, group I high-Al eclogites, group II high-Al eclogites, and garnetites. Despite the compositional differences, these eclogites all deviate from the terrestrial εNd–εHf array, implying metamorphic modifications on the Sm–Nd or Lu–Hf or both of these two isotope systems. All these UHP rocks define an $^{143}Nd/^{144}Nd$–$^{147}Sm/^{144}Nd$ errorchron of 232 ± 36 Ma (MSWD = 4.6), which largely overlaps with the peak metamorphism age of 220–245 Ma. The U-shaped LREE patterns of the high-Fe-Ti eclogites and group I high-Al eclogites provide additional evidence for the metamorphic modifications on the Sm–Nd isotope system of the protoliths. In contrast, the Lu/Hf ratios of these eclogites are generally within the range for basalts and do not vary systematically with the $^{176}Hf/^{177}Hf$ ratios. The range for the protolith initial $\varepsilon_{Hf}(780)$ values calculated from the Lu/Hf ratios of the samples is nearly identical to that for the ~780 Ma magmatic zircon grains from the Yangtze craton, suggesting the dominance of protolith

characteristics on the Lu–Hf isotope system. Being controlled by different processes, the Sm–Nd, and Lu–Hf isotope systems of the samples therefore are decoupled. Since the Sm/Nd ratios of the eclogites were modified by metamorphism, the protolith initial calculated from these values, $\varepsilon_{Nd}(780)_{meta}$, are not protolith indicators. The protolith initials, $\varepsilon_{Nd}(780)_{ig}$, calculated from the metamorphic initials using the Sm/Nd ratios inferred from the Sm/Nd–Lu/Hf trend of igneous rocks better characterize the protoliths. In the $\varepsilon_{Nd}(t)$–$\varepsilon_{Hf}(t)$ plot, the protolith initials and metamorphic initials of the eclogites distribute similarly with respect to the trend defined by the rocks formed at 0–1382 Ma by continental magmatism; specifically, higher ε_{Hf} values at a given ε_{Nd} and within the field for arc lavas. Metamorphosed from protoliths generated by backarc rifting is finally proposed for the eclogite samples to account for their arc signatures and the felsic–mafic bimodal compositions of the Sulu UHP rocks.

References

Jahn, B.-M., 1999. Sm–Nd isotope tracer study of UHP metamorphic rocks: implications for continental subduction and collisional tectonics. *International Geology Review* 41, 859–885.