Geochemical characteristics and crustal evolution of the Archaean high-grade Kongling terrain in the Yangtze Craton, Southern China

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The North China and Yangtze cratons are two most important continental blocks in eastern China, and collided in Late Palaeozoic-Early Mesozoic with the formation of the Qingling-Dabie-Sulu orogenic belt. The early geological history of both cratons is essential for understanding the evolution of the belt. However, geological and geochemical data on Archaean rocks of the Yangtze have not been available due to lack of known exposures. The recently confirmed Archaean Kongling terrain in the north of the Yangtze craton provide an opportunity to study the nature of the Yangzte crust in the Archaean (Gao and Zhang, 1990; Ling *et al.*, 1998).

This paper reports results of a systematic study on Sm-Nd isotopes of associated felsic gneisses amphibolites and metapelites from the Kongling terrain. Based on these data, tectonic environments and early crustal evolution of the Yangtze craton are discussed.

Geological setting

Rocks in the Kongling terrain (150 km^2) can be subdivided into three main groups, the felsic gneisses, amphibolites and supracrustal rocks. Felsic gneisses are composed mainly of TTG and granitic gneisses. Amphibolites occur in the felsic gneisses as veins and lens and their outcrops range from more than 100 m to several metres. The supracrustal rocks consist of graphite bearing gneiss, garnet-sillimanite gneiss, marble, quartzite and iron bearing-quartzite. Mafic granulites are locally preserved. The supracrustal rocks show a typical assemblage of khondalite.

Sample and analysis

According to the petrographic examination and chemical analyses, fresh, representative samples of 7 amphibolites, 8 felsic gneisses as well as 14 metapelites are selected for Sm-Nd isotopic analysis. Samples were crushed down to grain size smaller than 200 meshes in an agate mill. The HDEHP method was used to separate Sm and Nd for isotopic analysis. The Sm-Nd isotopic ratios were measured by a MAT261 mass spectrometer at the isotopic laboratory of China University of Geosciences. Blanks of the whole procedure are Sm 3×10^{-11} and Nd 1.2×10^{-10}. The $^{143}Nd/^{144}Nd$ ratios were normalized to $^{146}Nd/^{144}Nd = 0.721900$. Analysis of the La Jolla standard during the run gives $^{143}Nd/^{144}Nd = 0.511846 \pm 0.000010$ (2σ). Elemental analyses were conducted at the Geochemical Institute, University of Goettingen and Mineral and Rock Analysis Institute of Hubei Province, China. Major elements except CO_2 and H_2O^+ were analysed by XRF with the analytical errors <2%. Trace elements and *REE* were analysed by the ICP-MS or ICP-AES after the sample digestion in the sealed Teflon breakers with the analytical errors <10%.

Results and discussion

Most of the TTG gneisses from the Kongling terrain are trondhjemite. Amphibolites fall in the field of tholeiite in FeO-(Na_2O+K_2O)-MgO diagram. In the primary mantle-normalized spider diagrams, Ba, Nb, P, Zn and Ni in amphibolites and U, Nb, P, Ti, V and Ni in TTG gneisses show negative anomalies.

The Sm-Nd isochron of both the amphibolite and the TTG gneiss give ages close to 2750 Ma, which is similar to their U-Pb zircon ages. However, the two rock types differ in T_{2DM} (two-stage depleted mantle model age), ε_{Nd} and Eu/Eu*. The T_{2DM} ages of TTG gneisses are about 0.4 Ga older than those of the amphibolites. ε_{Nd} (2.75Ga) values reflect an enriched source for the TTG gneisses and slightly depleted one for the amphibolites. Granitic gneisses are also characterized by a weakly depleted source, and their T_{2DM} are reasonably similar to those of the amphibolite within the analytical error. The TTG gneisses and amphibolites show no Eu anomaly, which is in contrast to remarkable negative anomaly of the granitic gneisses.

The Nb negative anomaly implies that the TTG gneisses and amphibolites might be related to the subduction, while the T_{2DM} of the TTG gneisses suggests presence of crust as old as about 3.4 Ga.

Metapelites can be subdivided into three groups geochemically. The first did not suffer from strong chemical weathering, which suggests a short distance of transport and a low degree of maturity. In contrast, the second group shows strong chemical weathering, implying a longer distance of transport and a higher degree of maturity. The third group exhibits an extreme variable composition as a result of anatexis, which is supported by field and microscopic observations.

The high Cr, Co and Ni contents in metasedimentary rocks indicate a significant contribution from a mafic source. A. two-component mixing calculation shows that amphibolite can explain >70% of Co, Ni and ~60% of Cr in the first group of metapelites, and that 4–25% of komatiite is required to fully explain the high Cr, Ni and Co conents in the first group metapelites.

This geochemical evidence, together with a similar T_{2DM} to the TTG gneisses, demonstrates that the Group 1 metapelites represent the first-cycled material of the crust. Their TTG-like character resulted from the rapid erosion and short distance of transport before deposition. This infers that the Group 1 metapelites would have been deposited not much later than 2728 ± 118Ma age of the TTG gneisses in an unstable tectonic setting. Moreover, the *REE* patterns of the Group 1 metapelites reveal that the early crust of the Yangtze craton was felsic and had no Eu anomaly.

Besides cratonic nature and post-Archaean *REE* pattern of the Group 2 metapelites, the intrusion of Quanqitang potash granite (21 km^2 in scale) with the U-Pb zircon age of 1840 ± 4 Ma reveals that cratonization of the Yangtze Block should be earlier than the Mesoproterozoic. In addition, studies of Nd model ages of Mid-Neoproterozoic granic complex (120 km^2) in the region shows that the majority of the underlying basement is NeoArchaean in age. The T_{2DM} of these granitic rocks can be classified into two groups, the NeoArchaean Group of 2.5–2.7 Ga and the Palaeoproterozoic Group of 2.1–2.3 Ga. Geochemical data also indicate that Palaeoproterozoic is another important period of crustal growth in the Yangtze craton.

Conclusion

(1) Amphibolite from the Kongling terrain originated from a primitive mantle source, while the granitic gneisses correspond to a weakly depleted source. The Nb negative anomaly, negative εNd values and older T_{2DM} ages imply the existence of the crust older than 2.7 Ga.

(2) Three types of metapelites are recognized: the first group was derived from the first-cycle sediments of the juvenile crust. The second group is characterized by geochemical resemblance to post-Archaean cratonic sedimentary rocks. The third group shows extremely variable *REE* due to anatexis.

(3) Although the major source of the first group metapelite were from the TTG gneisses, the transitional elements should mainly came from contemporary ultramafic and/or mafic rocks. Simple two-component mixing calculations show that 4–20% of komatiite or 60–75% of amphibolite are needed to fit the Cr, Ni and Co contents in the first group metapelites.

(4) The first group metapelites might have a NeoArchaean deposition age around 2.7 Ga. The completion of cratonization of the Yangtze block is earlier than the Mesoproterozoioc.

(5) Nd isotopic studies on the Mid-Neoproterozoic batholiths in the area show that the majority of the underlying basement is the NeoArchaean Kongling terrain.

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