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Neoproterozoic Magmatism Related to Lithospheric Delamination: Implications from Three Episodes of Mafic Dykes and Associated Granitoids in the Pengguan Complex, Western Sichuan Province, Yangtze Block

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The research on dyke swarms is very important, for it can not only shed light on within-plate geological processes of some regions but also contribute to our understanding on evolution of a specific orogenic belt. The Yangtze Block, which is one of the most enigmatic cratons in Eastern Asia, has experienced significant crustal arccretion and orogenic processes during Neopreoterozoic, with some mafic dyke swarms also occurring on the margins of the block. Many of them intruded into the Neoproterozoic granitoids and basements. Figuring out the geological processes and relationships of mafic dyke sand related felsic rocks is believed to be extremely meaningful for understanding the Neoproterozoic tectonic-magmatic evolution of the whole Yangtze Block.

Voluminous mafic-felsic complexes are located in western margin of the Yangtze Block, western Sichuan Province, and their ages range from 860 Ma to 750 Ma. Among them, some mafic dyke swarms, together with a small number of ultramafic rocks, intruded the grantoids and provide an ideal opportunity for studying the role of dyke swarms in understanding the orogenic cycles on the western margin of the Yangtze Block. In this study, we focused on the Pengguan Complex and conducted a synthetic research on the mafic dyke swarms and their associated granitoids. Three episodes of basic dyke swarms are identified in the complex, and each episode is associated with the nearly contemperaneous granitoids based on the their field relationships and (or) LA-ICP-MS dating results.

The first episode of basic dyke swarms was formed between 835 Ma and 820 Ma. They show enrichments in light REEs (LREEs) and slightly fractionation of middle REEs (MREEs) and heavy REEs (HREEs). The associated granitoid rocks show significant enrichment in LREEs and slightly fractionation of HREEs, and all the samples display slightly negative Eu anomalies. In the primitive mantle-nomalized trace element diagrams, the mafic rocks show evidently enrichment of large-ion lithosphile elements (LILEs) and depletions of Nb-Ta and Zr-Hf, with negative Ti and positive Sr anomalies. While the associated granitoids show slightly enrichment of LILEs and depletions of Nb-Ta, with negative Ti and slightly positive Sr and Zr-Hf anomalies. As indicated by above geochemical characteristics, both mafic rocks and associated granitoid rocks present subduction-related signatures.

The second episode of basic dyke swarms was formed between 810 Ma and 800 Ma. The mafic rocks are enriched in LREEs with significant fractionation of HREE and LREE, showing steep REE patterns, and all samples basically display no negative Eu anomalies. While for the granitoid rocks, they show evidently enrichment in LREEs and flat HREE patterns, and all the samples display negative Eu anomalies, generally presenting "seagull"-REE patterns. In the primitive mantle-nomalized trace element diagrams, the mafic rocks become to present less obvious negative Nb-Ta anomalies, and the samples with high trace elements contents show gradual weakening negative amomalies of Nb-Ta and Zr-Hf. In addition, the samples also display positive Sr anomalies while the negatIve anormalies of Ti turn to not really obvious. For the granitoid rocks, all the samples show significantly negative Nb-Ta, Sr and Ti anormalies, with positive Zr-Hf anormalies. The geochemical characteristics of mafic and granitoid rocks of this period is different from the first-period rocks, implying that their geological settings may have changed. The mafic rocks show signatures of extensional setting so that this set of rocks mostly likely formed in post-orogenic extension environment.

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The third period of basic dyke swarms was formed between 795 Ma and 750 Ma. The mafic rocks show steep REE patterns, with slightly negative Nb-Ta anomalies, positive Sr anomalies and without Zr-Hf anormalies. Their overall geochemical features are similar to OIB. However, for the associated granitoid rocks, they show more steep REE patterns basically without Eu anomalies. Moreover, they all have high Sr, low Y and high Sr/Y ratios, similar to typical adakitic rocks. Previous studies suggested that this period of adakitic magmas were formed in a collisional setting and were likely derived from partial melting of a subducted oceanic slab (Zhou et al., 2006). But in view of the above analyses, after ca. 800 Ma, the regional tectonic setting should turn to be extensional. Besides, slab melting couldn't well explain the formation of large-scale, OIB-type basic dyke swarms. In these regards, we propose a delamination model to better explain the formation of this set of rocks. The adakitic granitoids were likely derived from partial melting of delaminated lower crust, while the OIB-type basic dyke swarms were likely derived form upwelling of the asthenosphere materials associated with the delamination.

In conclusion, the analyses on mafic dyke swarms together with associated granitoids play an very useful role in tracing tectonic- magmatic background on the western margin of the Yangtze Block. They record a normal wilson cycle from ca. 830-820 Ma orogenesis to 810-800 Ma post-collisional extension and the 790-750 Ma post-orogenic orogenic collapse due to upwelling of asthenospheric mantle. There was no orogenic process on the western Yangtze Block since 790 Ma, and peri-Rodinia crustal accretion at this place did not continued after 790 Ma.

References

Zhou MF, et al., 2006. Earth Planet. Sci. Lett. 248, 286–300.