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Tectonic evolution of the West Qinling Orogen from ocean spreading to IBM type subduction

Yang, L.M.¹, Song, S.G.¹

¹ MOE Key Laboratory of Orogenic Belt and Crustal Evolution, School of Earth and Space Sciences, Peking University, Beijing 100871, China

The West Qinling Orogen (WQO) is located in the middle part of the Qinling-Qilian-Kunlun orogenic belt, and plays important role in linking Qilian orogenic belt and Qinling orogenic belt. The early-Paleozoic accretionary complex in WQO consists of two lithological groups: (1) The mid-ocean ridge basalt (MORB) unit; (2) The island-arc unit (including island arc tholeiitic basaltic-andesites, and boninites).

The mid-oceanic ridge basalts in the Guanzizhen ophiolite, display N-MORB geochemical characteristics. On the Nb/Yb vs. Th/Yb diagram, they plot within the unmodified mantle array. Zircon U-Pb SIMS and LA-ICP-MS dating shows the ages of meta-gabbro are 548-503 Ma, which are coincide with the formation age (from ca. 534 Ma at least to ca. 457 Ma) of Shangdan oceanic crust [1].

The island arc rock assemblage consists of tholeiitic basalts and andesites with low Ti/V ratios (14.4~16.5), high LILE and fluid-solute elements (Cs, Rb, Ba, Th, U, Pb), and negative Nb-Ta and Zr-Hf anomalies, suggesting that they were derived from more depleted SSZ mantle wedge with the contribution of an arc-like component (enriched in fluid mobile elements and LILE). Zircon U-Pb dating results show the subduction along the Shangdan zone occurred from ca. 514 to ca. 422 Ma [1].

The boninites are magnesian ($MgO = 8.00\text{--}14.42\text{ wt \%}$) andesitic ($SiO_2 = 52.98\text{--}57.62\text{ wt \%}$) with exceedingly low TiO_2 ($0.29\text{--}0.49\text{ wt \%}$) and high Ni ($177\text{--}469\text{ ppm}$) and Cr ($547\text{--}2068\text{ ppm}$). They were formed by partial melting of a depleted, cpx-poor Iherzolite source with the involvement of slab-derived hydrous fluids/melts. The evolution from high-Ca boninite (HCB) to low-Ca boninite (LCB), featured by obvious L-MREE enrichment, relatively decreased CaO/Al_2O_3 and TiO_2/Zr ratios with increased SiO_2 and Na_2O values, reflect the slab-derived enriched components transformed from LILE-rich hydrous fluid to silicate melts including Si, Na, LILE and LREE[2].

The N-MORB volcanic rocks, plus cumulate gabbro and peridotite, with the ages of 548Ma and 503Ma, compose a typical ophiolite assemblage, and are interpreted as the products of mid-oceanic ridge during the spreading of Shangdan Ocean in Cambrian. While the island-arc-type rocks are considered to represent the earliest products of infant arc magmatism by advanced degree of mantle melting influx with from slab-derived hydrous fluids to silicate melts during “late protorearc spreading”, which is just like the third stage of “subduction initiation rule” mentioned in the modern IBM arc-trench system [3]. Therefore, the WQO is a key record of the tectonic evolution from ocean spreading to Izu-Bonin-Mariana (IBM)-type subduction.

References:

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