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Multiple Phases of Mafic Magmatism in Gyangze-Kangma Area: Implications for the Tectonic Evolution of Eastern Tethyan Himalaya

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A number of E-W trending subparallel mafic dikes of diabase composition occurred in Gyangze-Kangma area, eastern Tethyan Himalaya, southern Tibet. They intruded into the Tethyan Himalaya sedimentary sequence. Whether they belong to the ~132 Ma Comei LIP (Zhu et al., 2009) or formed in a different tectonic setting is an open question that could be important to test the tectonic model of the evolution of the Himalayan orogen. We report whole-rock element and isotope (Sr and Nd), and zircon U-Pb data for four typical diabasic intrusions from north to south to constrain their timing and mechanism of formation. Zircon U-Pb analyses show that these mafic dikes formed at three episodes of magmatism: ~140 Ma (T0907 and T0902 series), ~120 Ma (T0904, series) and ~90 Ma (T0901 series), respectively.

Though both T0907 and T0902 series mafic dikes formed at ~140 Ma, they show substantial differences in element as well as in isotope compositions. T0907 series rocks formed at 142.0±1.4 Ma (N=12, MSWD=0.82) are characterized by moderate MgO contents of 4.6-5.2% (Mg#=43.6-44.4) and OIB-like trace element patterns with positive εNd (t) values (+3.3~+4.1). In contrast, the other intrusion of T0902 series formed at 140.6±1.4 Ma (N=10, MSWD=0.42) is more primitive with high MgO contents (10.3-15.0%) and Mg# values (68.2-71.7), and shows strong negative Nb-Ta anomalies and negative εNd(t) values from -3.3 to -1.6. Sr-Nd isotopic systematics and trace element geochemistry modeling indicate that they formed through different source regimes and melting processes. T0907 series could be produced by 2-4% partial melting of garnet lherzolite, in contrast with 5% partial melting of enriched hornblende-garnet lherzolite for T0902 samples. Similarities in the geochemical characteristics between T0907 samples and the ~132 Ma Comei LIP to the east (Zhu et al., 2009) suggest that they also could be the products associated with the Kerguelen plume, whereas T0902 samples could represent the melts due to the interaction between Kerguelen plume and enriched lithospheric mantle beneath the eastern Gondwana. Relatively long period of mafic magmatism (> 10 myr) in the Tethyan Himalaya furthered the long-lived incubating Kerguelen plume model beneath eastern Gondwana (Kent, 1991).

Zircon U-Pb analyses yield that the dikes of T0904 series formed at 121.1±0.7 Ma (N=16, MSWD=0.62), substantially younger by at least 10 myr than those in the Comei LIP. This series rocks are characterized by moderate MgO contents (6.5-7.2%), N-MORB-like trace element patterns with positive but relatively larger scattered εNd(t) values (+2.0~+6.7), and enrichment in LILE (Rb, Ba, Th, U, K) and Pb. Such geochemical characteristics could be explained by the presence of crustal materials in the depleted mantle source. Though this suite of rocks shows trace element characteristics resembling N-MORB basalts, it can not be produced through one stage melting of spinel lherzolite. Plate reconstruction indicates that at ~120 Ma, the Indian Ocean was already opened and Kerguelen plume had moved to the south of Great Indian Plate (Powell et al., 1988), therefore this suite of rocks is best interpreted as partial melting products from a depleted source regime variously contaminated by the Gondwana lithosphere fragments in the newly-formed mid-oceanic ridges between Great Indian and Australia.

T0901 series samples are the northmost suite of mafic dikes examined in this study. This suite of rocks is located within the sedimentary-matrix tectonic mélanges (Ding et al., 2005), south of Yarlung Zangbo suture. Though limited number of zircon grains available for precisely constraining their formation age, the youngest age suggests that they should formed less than ~91 Ma, from which we assigned ~90 Ma as the timing to form this suite of rock. This suite of rock displays the features as following: (1) elevated Sr isotope compositions (87Sr/86Sr(t): 0.7055-0.7077), possibly due to seawater alteration; (2) positive and uniform εNd(t) values (+5.0-+5.9); and (3) E-MORB-like

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trace element patterns with low (La/Yb)N rations ranging from 1.81 to 2.35. Trace element modeling suggests that 2% partial melting of a lherzolite source with a spinel/ garnet ration of 4:1 could generate T0901-like melts. Slightly enriched Nd isotopic compositions relative to N-MORB but nearly uniform Nd values argue against a crustal contamination origin, but rather reflect the nature of its source. It could represent magmas produced either during forearc extension or during seafloor spreading of the Neo-Tethys Ocean.

In summary, data presented above demonstrate that mafic dike swarms within the Tethyan Himalaya were developed through multiple mafic magmatic events in rather different tectonic settings. These rocks provide valuable records for refining the models for the tectonic evolution of the Himalayan orogen as well as the Neo-Tethys Ocean.

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