論文名 : Petrogenesis and paleomagnetism of mafic dykes in the Western Dharwar Craton, South India: implications for late Archean to early Proterozoic lithospheric mantle evolution and cratonic correlations

新潟大学大学院自然科学研究科
氏名　AMMINI SASIDHARAN SILPA

Mafic dyke swarms are one of the major geologic features that represent crustal extension and rifting episodes during which basaltic material from the mantle is transferred to the continental crust. They are extensively intruded into Earth’s continental crust, especially in the Precambrian terranes across the world. Dharwar craton (DC) of Southern Peninsular India is one such Precambrian terrane, where well-preserved dyke occurrences have been reported. DC is mainly composed of basement Tonalite-Trondhjemite-Granodiorite (TTG) type gneiss called Peninsular gneiss (3.40–2.56 Ga), two different generations of greenstone belts (older 3.35–3.20 Ga and younger 2.90–2.54 Ga) and is intruded by high potassic granites (2.62–2.52 Ga). Based on the age and lithological characteristics, the Dharwar craton is subdivided into two as Eastern Dharwar craton (EDC) and Western Dharwar craton (WDC) along a N-S trending shear zone, called the Chitradurga shear zone. The entire craton is profusely invaded by mafic dykes. Although dykes are distributed throughout in the Dharwar craton, only those in the EDC have been extensively studied and less attention has been given to those in the WDC. Studying the mafic dykes in the WDC will help to understand the activity of the craton during Late Archean to Early Proterozoic and this will help to obtain a complete picture of the tectonic evolution of Dharwar craton. The major dyke swarms in the WDC are concentrated in Udupi area, Tiptur area and around Chitradurga area where NE-SW as well as NW-SE dykes are densely distributed. A detailed study of major dyke swarm in the Tiptur area was carried out, because this area has abundant mafic dyke occurrences, which can be considered as representative for the whole WDC. Based on detailed field, petrological and geochemical (major, trace and rare earth elements) studies of 45 localities and 64 samples, two distinct groups were identified and five isolated dykes of geochemically varying characteristics. Petrographic observations revealed that the NW-SE trending dolerite dykes were unaltered, composed predominantly of plagioclase and pyroxenes with minor opaque minerals. The NE-SW trending meta-doleritic dykes showed high degree of metamorphic alteration with the preservation of only 50% or less original igneous texture as well as mineralogy. These dykes are characterized by the occurrence of amphibolite and chlorite. Mineral chemistry and textural characterization of all major minerals were carried out using an electron probe micro analyzer and the major elements were found to be clinopyroxene (En_{43-59}) olivine (Fo_{74-77}), and plagioclase and minor minerals include magnetite and titanite.

Bulk geochemistry of 45 samples were carried out using XRF and trace and rare earth elements using ICP-MS. The major oxides of SiO_2, CaO, Fe_2O_3 and alkalies shows only minor variations whereas MgO and Al_2O_3 show large differences (Fig. 1). The overall chemical composition of the dykes indicated sub-alkaline tholeiitic nature with the meta-dolerites falling in the basaltic field and dolerites in basaltic andesite fields. In the trace element geochemical characteristics, dolerites and meta-dolerites show two different patterns (Fig. 2). Primitive mantle-normalized multi-element diagram of dolerite dykes showed an LILE enriched pattern with a negative Nb and Ta anomaly along with positive correlations for Zr and Sr. Meta-dolerite dykes show a slight LILE enrichment. Chondrite-normalized REE diagram shows that the dolerite dykes have an LREE enrichment and flat HREE pattern whereas a relatively flat pattern for both LREE and HREE was observed for meta-dolerite dykes. Immobile incompatible element (Th-Yb-Nb) distribution also indicates an enriched mantle source for dolerite dykes and a depleted or more primitive mantle source for meta-dolerite dykes. Rb/Sr and Sm/Nd isotope geochemistry were carried out for 21 samples, representing all types of dykes. Present day $^{87}Sr/^{86}Sr$ ratios of meta-dolerites varies from 0.701578 to 0.702848 and the initial ratio is calculated as 0.7006 which is far lower than dolerites (0.703). Although with large errors, the isochron relations show an older age for the meta-dolerites (ca. 2.87 Ga) and a younger age (ca. 2.3 Ga) for the dolerites. The initial $^{143}Nd/^{144}Nd$ ratio is slightly lower for meta-dolerites (0.5086) as compared to dolerites (0.5088). The εNd values are positive and are high for meta-dolerites as compared to dolerites. A high εNd

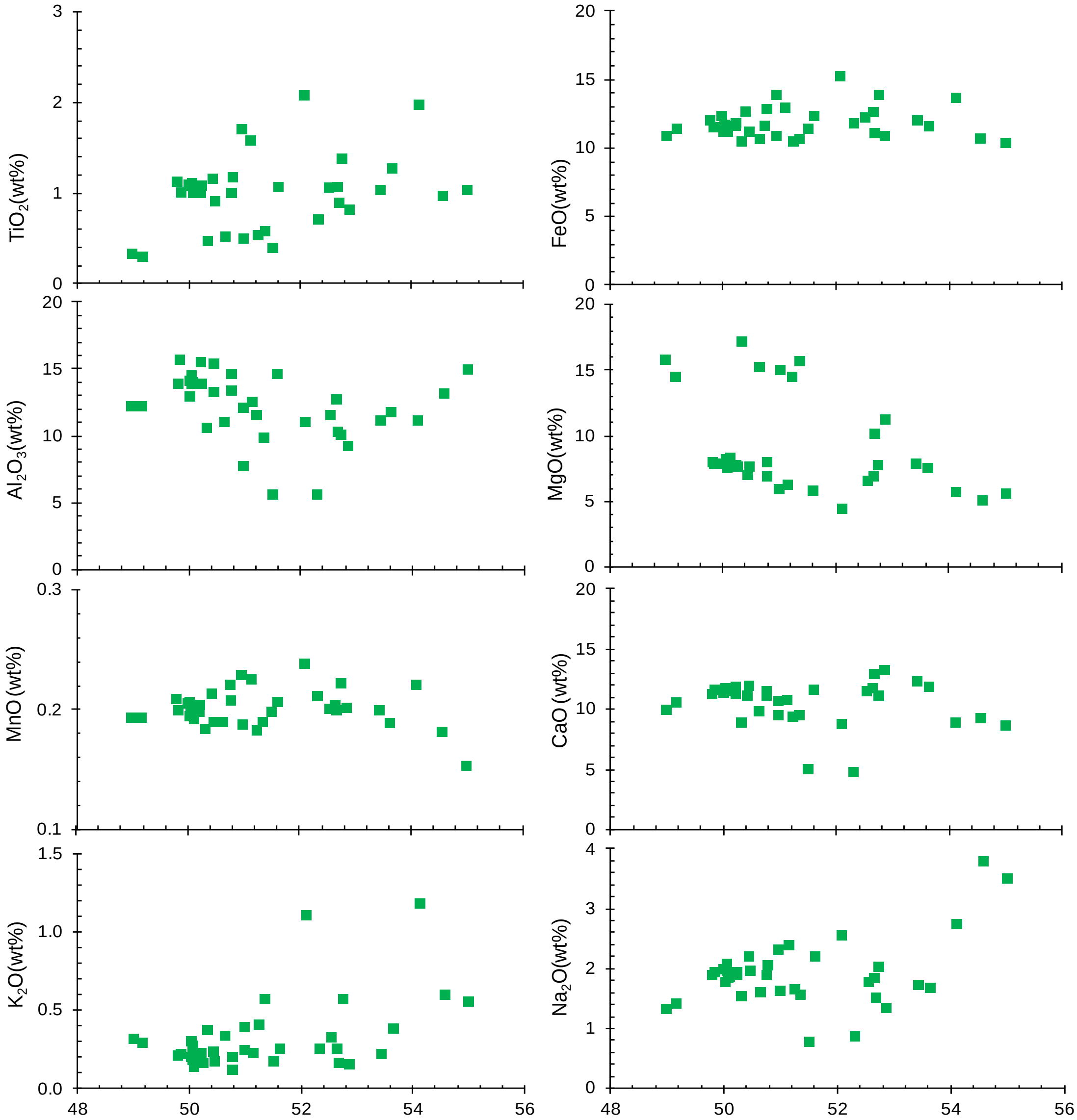

Figure 1. Harker diagrams of major oxides versus SiO_2 for the studied dykes. All values in weight percentage.

value in general for these dykes indicates derivation from a depleted mantle, with highest depletion observed in source mantle for meta-dolerites. The difference in petrography, major, trace and rare earth element geochemistry between the dolerites and meta-dolerites leads to the inference that these two suits of rocks are not co-genetic rather formed from different batches of melting or source magma and therefore suggesting variations in mantle sources.

Understanding the paleo-geographic positions in which the dykes were emplaced is key while correlating the present, spatially distant cratons. Paleomagnetic studies will help to understand the paleo-position of the cratons and mafic dykes are expected to provide excellent records of the earth's magnetic field as they cool rapidly when emplaced. For the preliminary paleomagnetic analyses, 86 core specimens were prepared from 33 sites including both dolerite and meta-dolerites

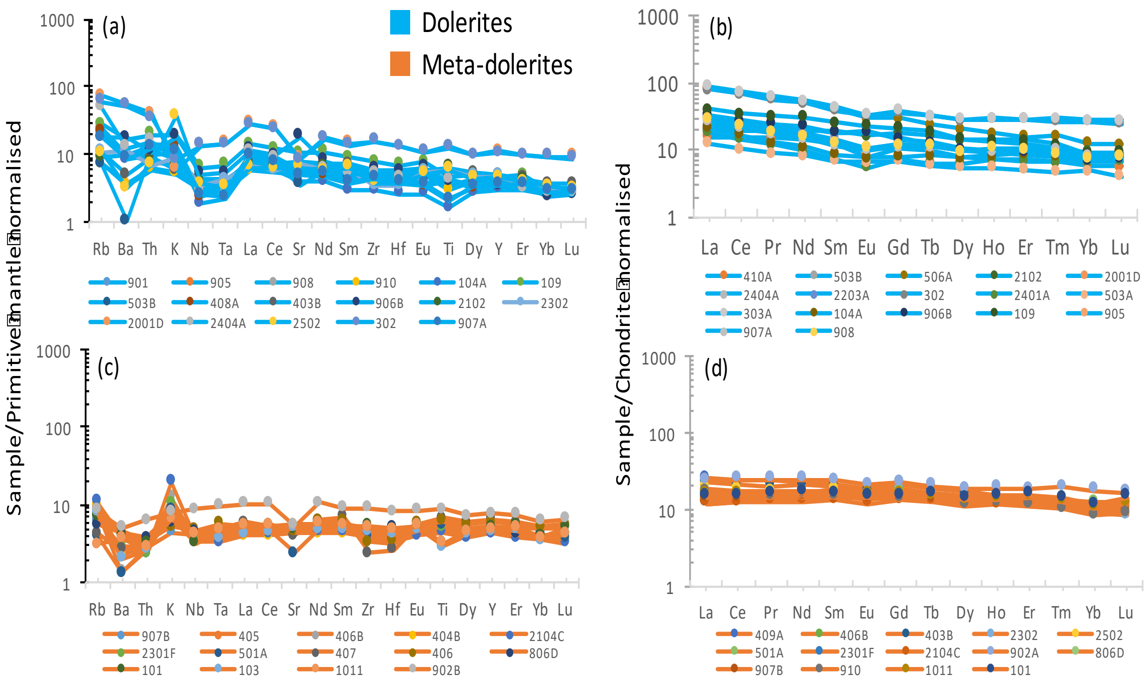

Figure 2. Primitive mantle-normalized multi-element diagram, and chondrite-normalized REE diagram for dolerite (a and b) and meta-dolerites (c and d)

and progressive demagnetization experiment has been conducted to assess the stability of natural remnant magnetization (NRM). Pilot specimens were subjected to alternating-field or thermal demagnetization and the NRMs were measured with a spinner magnetometer. Dolerite specimens yielded better magnetic behaviors with stable magnetic components, magnetite being the prime carrier which is observed to become unstable at 560°C during the thermal demagnetization experiment. Mean direction of these dykes was similar to the dolerites reported from the EDC. On the other hand, meta-dolerites show magnetic components probably carried by pyrrhotite (unstable at 510°C) and the magnetic behaviors were very unstable.

The dolerites of the current study have geochemical similarities to the dykes in 2.3 Ga dykes reported in the EDC. In the trace and rare earth element distribution, both the groups are showing significant negative Nb, Ti and Ta anomalies as well as positive Sr anomalies. Both the groups also show an enrichment of LILE indicating an enriched source. Initial paleomagnetic data suggests that the mean direction of these dykes can be correlated best with the 2.3Ga dykes reported in EDC. The 2.3 Ga event in the EDC has been correlated with the other cratons also. The Western Australian craton and Napier complex in Antarctica as well as Greenland portion of North Atlantic craton also has reported similar dykes. The origin of this event is attributed to a long-lived stationary plume which lead to the breakup of Yilgarn craton and several other cratons from the pre-existed super craton Superia. This event can be thought to be responsible for the dolerites in the current study. However, meta-dolerites from WDC do not have equivalents. The tectonic evolution of the Dharwar craton suggests that the WDC is older and thicker than that of EDC, both were separate during the Precambrian and later amalgamated along the Chitradurga shear zone. It is possible to assume that the meta-dolerites might be a part of an older event, restricted to WDC and therefore might have emplaced prior to the amalgamation of WDC and EDC. From the geochemical similarities of the meta-dolerites with the one of the meta-volcanics in the WDC, it can be assumed to be the feeder dykes for the meta-volcanics and the dykes might have got metamorphosed during the period of metamorphism of the entire craton. The correlation of WDC with supercontinent Ur and possible coexistence with Pilbara and Kaapvaal cratons or the Slave craton has been discussed by various researchers. This might have been the period of emplacement of the meta-dolerites. Hence the study of the dykes in WDC will give a better understanding of the evolution of the cratons and the crustal processes during early Archean to Proterozoic.