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U-Pb dating of Mafic Dyke Swarms of the Bastar craton, India

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Mafic dyke swarms preserved in Precambrian shield areas are often the only surviving relics of ancient Large Igneous Provinces (LIPs), and precise determination of their emplacement history is pivotal in unravelling the crustal evolution of Archean cratons. Specifically, these dykes represent excellent regional time markers that can be used to define reliable apparent polar wander paths, and piercing points in the reconstruction of ancient supercontinents. Defining the original extent of early Precambrian LIPs is difficult because most Archean cratons have been affected by multiple Wilson cycles, and so remnant mafic dyke swarms may be highly fragmented and dispersed during supercontinent break-up or are partially obliterated during continent-continent collisions. Moreover, there are currently a number of Archean cratons worldwide that contain multiple generations of Precambrian mafic dyke swarms for which there exists a marked paucity of precise and accurate age determinations (e.g., South Indian Shield).

From field relationships and geochemical constraints, there is evidence for at least two prominent, distinct suites of Precambrian mafic dyke swarms in the central Bastar craton of the South Indian Shield, both of which trend NW-SE to WNW-ESE and appear to have been emplaced in continental rift environments. We present the results of a geochronological investigation focussed on determining their emplacement age, employing two techniques; high precision U-Pb TIMS dating and high spatial resolution Electron Microprobe (EM) U-Th-total Pb chemical dating. Reconnaissance EM dating of three dolerite dykes and one gabbro dyke from the younger swarm, yield igneous monazite or baddeleyite crystallization ages which cluster at ~1.9 Ga. The gabbro dyke sample dated by EM, was also chosen for an isotopic U-Pb TIMS dating study, and a large number of baddeleyite and zircon crystals were recovered. A discordia line constrained by two zircon, and three baddeleyite analyses yielded a highly precise upper-intercept age of 1883.0+/-1.4 Ma, which we interpret as the best estimate for the emplacement age of that swarm. These ages provide important new constraints for elucidating the Paleoproterozic crustal evolution of the Bastar craton and also provide the first indication that previously recognized ca. 1883 Ma mafic magmatism (i.e.: Molson dyke swarm and Fox River sill, Canada) is more globally widespread than previously thought.

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Variations in the composition of clinopyroxene from the basalts of various geodynamic settings of the Antarctic region

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A study of clinopyroxenes from the basalts of various geodynamic settings of the Southern Ocean provide insight into the specific conditions of magma formation. Numerical modeling based on the dependence of clinopyroxene composition on pressure and temperature of crystallization [1] allowed us to estimate the depth of melt fractionation in transitional magma chambers. Three crystallization levels of magmas of various origins were distinguished: (1) a shallow level (1-5 km) characteristic of the Mesozoic flood basalts of Antarctica; (2) a deep level (up to 20 km) revealed in some compositions of Quaternary alkaline magmas from the Antarctic Peninsula (Hobbs Province); and (3) an intermediate level (10-12 km) typical of the majority of magmas from the Hobbs region and tholeiites formed under spreading-zone conditions at the western termination of the Southwest Indian Ridge near Bouvet Island. The clinopyroxenes from various olivine-bearing magmas show similar lithophile element distribution patterns. The concentrations of most elements increase with decreasing magnesium and increasing aluminum and sodium contents. The ratio of less compatible to more compatible elements increases in the course of fractionation. The estimated clinopyroxene/melt partition coefficients for the most aphyric alkaline magmas of the Hobbs province increase by an order of magnitude in the sequence from Ba to Yb and show relative Zr and Sr minima, which is consistent with experimental data.

References

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