Genesis of Volatile-rich High-Mg Olivine Cumulates with Low Ni and Cr in Achankovil Shear Zone, South India

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The final phase of amalgamation of the Gondwana supercontinent witnessed the collision of continental blocks along transcrustal suture zones. Achankovil Shear Zone (ACSZ) in South India is one among the major shear/suture zones that received significant global attention owing to its key position in correlating the juxtaposition of continental fragments in East Gondwana ensemble. Predominant lithological units in ACSZ include intensely deformed ultra-high to high temperature metamorphic rocks mainly of Neoproterozoic in age. These rocks were at places invaded by ultramafic to felsic igneous rocks emplaced during late Neoproterozoic-Cambrian orogeny, associated with the post-collisional extension of the Gondwana-forming event. We mapped an unusual ultramafic intrusive complex intruded into high-grade metasedimentary rocks in this shear zone. This intrusive complex is mostly composed of dunite (olivine-rich cumulates), glimmerite and spinellite with minor hibonite-bearing ultrapotassic and baddeleyite-apatite-spinel-phlogopite rocks. The dunite in this complex is very special, volatile-rich composed of cumulus olivine with intercumulus spinel, ilmenite, phlogopite, graphite, Ni-bearing pyrrhotite and calcite. The pyroxenes are virtually not present. The olivine is Mg-rich (Fo ˜96) and unusually poor in Ni. Spinel is Mg-Al spinel (Mg# ˜92) and impoverished in Cr (Cr# {Cr/Cr+Al} is less than 0.01). Phlogopite again is highly magneisan (Mg# (Mg/{Mg + Fe} atomic ratio) around 0.95-0.97) and ilmenite is dominated by geikielite end member, the Mg# of which varies from 0.56 to 0.62. Calcites exhibit LREE-enriched nature with a pronounced negative Eu anomaly. The rock is highly magnesian with bulk rock Mg# (molar MgO/MgO+FeO) of 0.94 with MgO and FeO contents of ˜41 wt. % and 6 wt. %, respectively. Al2O3 contents are in 6-7 wt. % range. CaO contents vary from 0.12 to 4 wt. % depending on the modal abundance of calcite. The dunites are highly depleted in large ion lithophile elements (LILEs) and hi, however the concentration of Sr contents ranges from 26 to 121 ppm, a factor depends on the modal abundance of calcite. They are also poor in transition elements, Cr (133-210 ppm) and Ni (90-136 ppm) when compared to normal mantle-derived dunites. The LREE contents are elevated, for calcite-rich samples than the calcite poor ones (2.3 to 67 ppm). This indicates an excellent positive correlation of LREE with Ca, as typified by the La-CaO relationships. On a chondrite normalized diagram the dunite samples display a fractionated pattern with enrichment of LREEs over HREEs, and patterns mimic those of calcite. These features propose a significant control of calcite in the behavior of REEs. The S content of rocks is usually in the range of 1 wt %, whereas the C content varies from 0.8 to 2.28 wt. % along with significant CO2 contents (1.5 to 5 wt. %.) Stable isotope studies on calcite, graphite and sulfides yielded values revelatory of mantle-derived source. High-Mg# and K/(K+Na) values of phlogopite are akin to phlogopite in mantle-derived peridotites. The MgO-rich nature of cumulus and intercumulus phases in the rock together with whole-rock geochemical data implies volatile-rich high-MgO nature of the involved melts with low Ni and Cr in the upper mantle. We propose a model in which an earlier extraction of Fe-Ni sulfide and chrome-rich spinel under extremely reduced environments resulted in depletion of Fe, Cr and Ni and enrichment of Mg and Al in the residual melts from which the crystallization of high-Mg olivine and Mg-Al spinel took place. Fe and Ni partition to sulfide phase rather than olivine in the upper mantle in highly reducing environment with high sulfur fugacity. This partitioning behavior also lead the residual melts to be enriched in magnesia. An interaction with minor carbonatitic melts prior to the crystallization with the redox conditions resulted in the formation of this unusual rock.