The complex melt-fluid-rock interaction history of a dismembered cumulate dunite from eastern Singhbhum Craton, India

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Serpentinized Cr-spinel bearing dunite to cpx-dunite rocks are found as a dismembered N-S trending unit within multiply deformed metasedimentary rocks of Mid-Proterozoic belonging to the North Singhbhum Mobile Belt, in the eastern margin of Archaean Singhbhum Craton, India. The elongated, lenticular unit occurs close to the Bangriposi Shear Zone. The northern part of the unit is significantly more serpentinized than the southern part, where serpentinization is restricted to veins. The unusual mineral assemblages and reaction relationships observed in these rocks can be grouped into three types- Type 1 assemblage is made up of relict olivine + diopside + apatite ±clinochlore + ferrichromite + serpentine + magnetite ±metal sulphides-oxides and is from the southern part. Type II assemblage consists of diopside + hydrous augite + clinochlore + Ca-amphiboles + ferrichromite ±apatite + serpentine + magnetite ±metal sulphides-oxides, and Type III is hydrous augite + clinochlore + Ca-amphiboles + ferrichromite + serpentine + magnetite ±metal sulphides-oxides. Relict olivines from Type I are zoned (core- Fo_{82-84} & rims- Fo_{76-80}) and have unusually high NiO and MnO. They display cumulus textures and are accompanied in places by inter-cumulus diopside (Mg no. 87-93) having very low Al_2O_3, TiO_2, Cr_2O_3 and Na_2O. Diopsides from Type II have similar compositions except lower Mg no. (76-80). Augites from Type II and III contain high OH with low TiO_2, Cr_2O_3, Na_2O and variable Al_2O_3. They occur as aggregates enveloping serpentine pseudomorphs accompanied by interstitial Fe-rich clinochlore (Mg no. 74-88). Ca-amphiboles (Edenite and pargasite) occur exclusively with hydrous augite. Serpentines from Type I have higher Mg no. than Type II and III. Fe-Ni sulphides and Mn-oxides occur as accessories, more frequently in Type II and III. Bulk-rock chemistry of these rocks shows high LOI and FeO. Also, a significant enrichment in LREE is observed. Apart from the effects of serpentinization (serpentine growth, magnetite formation and Cr-spinel recrystallization) there are additional textural and chemical evidences of prior fluid-melt-rock interactions. The NiO and MnO rich olivines from the relict areas suggest secondary enrichment via a metal-rich fluid phase, which could've been responsible for the metal-rich accessory phases. Textural evidence suggests that clinochlore and hydrous augite formed simultaneously, and along with formation of Ca-amphiboles, indicates involvement of a hydrated melt-fluid. Bulk-rock LREE enrichment without conspicuous enrichment in LILEs also point towards an enriched melt-fluid phase. Interstitial apatite requires infiltration of a Ca-rich melt-fluid. Single clinopyroxene thermobarometry yields almost similar temperature but varying pressure ranges for the three assemblage types- Type I: 0.3-0.7 GPa & 1140-1240 ˚C, Type II: 1-1.2 GPa & 1275-1300 ˚C, and Type III: 0.6-1.1 GPa & 1270-1330 ˚C. Ca-amphiboles from Type II and III yield average P-T ranges of 0.9 GPa & 1000 ˚C. The discussed evidences paint a very complex history of melt-fluid-rock interaction of these rocks. However, some facts and constrains can be established- (i) The protolith was a cumulate dunite to cpx-dunite unit possibly from the lower crust, (ii) The rocks experienced high-T melt-fluid-rock interaction either in a single or multiple stage leading to formation of hydrous silicates, Ni and Mn enrichment of olivines and bulk-rock LREE enrichment, and (iii) Serpentinization was the final event to affect these rocks, possible during their transport and emplacement. Considering lower oceanic crustal heritage of these rocks, possible sources of the melt-fluid of the high-T event could've been high-T hydrothermal fluids or melt-fluids from rising from the mantle. This study highlights the importance of deciphering the melt-fluid-rock interaction histories of Precambrian ultramafic rocks.

Keywords: Melt-fluid-rock interaction, Cumulate dunite, Ni-rich olivine, Hydrous silicate

