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Mineral-chemistry of silicates, Fe-Ti oxides and sulfides in gabbro and magnetitite of the Archean Nuasahi complex (India): Implications for magma fractionation, thermometry and oxygen fugacity of re-equilibration and Ni-Cu mineralization

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The Nuasahi igneous complex, situated in the south-eastern part of the Singhbhum craton composed of a lower chromitite bearing ultramafic unit and an upper magnetitite-bearing gabbro unit. The gabbro unit in both the eastern and western side of the ultramafic body shows cumulate texture with plagioclase and pyroxene as cumulus phase, and Fe-Ti oxide and sulfide minerals are present as intercumulus phases. In the eastern gabbro plagioclase is mostly andesine ($An_{32.3-47.8}$) and albite ($An_{1.0-3.0}$) with a very minor amount of oligoclase ($An_{11.4}$), and clinopyroxene is compositionally diopside ($En_{27.9}Fs_{24.6}Wo_{43.9}$) to ferro-augite ($En_{16.8-38.3}Fs_{35.4-54.8}Wo_{25.5-27.8}$) with Mg# ranges from 23.24 - 51.47. The western gabbro has plagioclase ($An_{0.5-3.8,\ 40.2-46.5}$), clinopyroxene ($En_{32.9-33.9}Fs_{20.8-24.2}Wo_{41.7-43.6}$; Mg# = 56.5 – 60.1) and orthopyroxene ($En_{44.6-45.5}Fs_{50.9-51.3}Wo_{1.9-2.1}$; Mg# = 45.5 – 46.5) as the major phases. The presence of quartz and alteration of pyroxene to amphibole and chlorite suggest modification of igneous assemblages by a hydrothermal liquid. The calculated temperature (349 - 944ºC) and fO_2 (11.43 - 41.02) of the co-existing oxide minerals indicate various stages of cooling history with sub-solidus re-equilibration with a low-temperature hydrothermal liquid. The gabbros and the overlying magnetitites are the product of fractional crystallization of a tholeiitic basalt where the sequence of crystallization was- plagioclase, clinopyroxene, orthopyroxene and Fe-Ti oxide, and at the advance stage, magnetitite layer was formed due to enrichment of Fe_2O_3 in the residual melt. The depletion of V_2O_3 (0.06 – 0.61 wt.%) in magnetite of the magnetitite ores due to the partitioning of vanadium into clinopyroxene of the underlying gabbros. The enrichment of Cr_2O_3 (0.01 – 5.82 wt.%) in the magnetites of the magnetitite suggest late-stage alteration by a fluid-rich melt that formed the gabbroic groundmass of the breccia zone in the Nuasahi complex. Disseminated pyrite grains in the eastern gabbro suggest a primary magmatic origin but the presence of chalcopyrite along the veins in the western gabbro suggests secondary origin due to hydrothermal activity. The sulfarsenides within the magnetitite layer suggest a solid solution between cobaltite and gersdorffite and the high Ni (1.31 – 3.54 wt.%), Co (29.91 – 31.98 wt.%) and As (38.24 – 44.32 wt.%) concentration reveals their hydrothermal origin.