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$_{6.8}$Fs$_{54.4}$Wo$_{35.8}$) 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 - 944°C) and f\({}_O_2\) (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$_2$O$_3$ in the residual melt. The depletion of V$_2$O$_5$ (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$_2$O$_3$ (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.