Melt Inclusions and Chemistry of Detrital Titanomagnetites at Orokolo Bay, Papua New Guinea: Evidence for Genesis by Magmatic Immiscibility

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Orokolo Bay in the Gulf of Papua (GoP) is known for its extensive placer deposits rich in titanomagnetite ores derived from igneous sources within the Central Range of Papua New Guinea (PNG). However, identifying the specific hinterland source of the detrital ore within the PNG Central Range is problematic owing to its complex history of orogenesis, bimodal arc magmatism, and varying subduction dynamics during the Cenozoic driven by successive arc-continent collisions. In this study, we analyzed grain textures, chemistry, and melt inclusions of 271 detrital titanomagnetites to investigate their source rocks and petrogenesis. The titanomagnetites exhibit rounded globular grain morphologies, and their textures indicate post-formation reequilibration processes. Titanomagnetites also host abundant apatite, zircon, pyrrhotite, and silica-rich glass (SG) melt inclusions. The SG melt inclusions have compositions resembling trachyandesite-rhyolite (55-73% SiO_2). Zircon inclusions are exclusive to high-Ti titanomagnetites (>10 wt% Ti), and pyrrhotite inclusions only occur in low-Ti titanomagnetites, while both apatite and SG inclusions are ubiquitous. Magnetite-ilmenite thermobarometry revealed two main stages of titanomagnetite formation, an initial stage below the NNO buffer at 1,054°C and a later stage commencing above NNO at 834°C. The results revealed liquid immiscibility processes, including separation of immiscible Si-Al-K-Na-rich and Fe-Ti-P-HFSE-S-rich melts, the latter hosting an Fe-S-(Ni-Cu-Co) residual melt. The varying titanomagnetite compositions, especially in terms of Ti, were interpreted to have been the result of immiscible Fe- and Si-rich melts under changing fO_2 and temperature conditions. Existing discriminant models classify the titanomagnetites as being derived from either an Fe-Ti-(V) or kiruna-type IOA deposit. The results of this study provide insight into the immiscible Fe- and Si-rich melts and discrimination of source rock type using detrital titanomagnetites. Furthermore, the study proposes the existence of a previously unknown IOA-type mineralization in the PNG Central Range as the primary source of detrital Fe-Ti oxides in the GoP.