Gold, Noble & Crucial Metals of the Mantle; a Zealandia Peridotite Study

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Au is a unique noble metal and necessary mineral resource with behaviours that are not fully understood in a geological context, particularly within the deep Earth. With known economic gold deposition and a variety of exposed mantle rock localities—including an extensive ophiolite belt and myriad occurrences of mantle-derived xenolith emplacements—New Zealand is ideal for exploring the geochemistry of deep-Earth gold. This study aims to better understand the behaviours of mantle Au within the context of the noble metal suite, which includes Ag & PGEs, by analysing their concentrations within major mineral phases and exploring samples' fine sulphide and alloy mineral sites from a suite of Zealandia mantle rocks at varying degrees of chemical enrichment and metasomatic alteration. Synthesising SEM, LA-ICP-MS, and XFM analyses informs the investigation into the geochemical conditions that promote Au retention and mobility beneath Earth's surface, and the relationship between Au and the other noble highly siderophile elements. Analysis by LA-ICP-MS shows that major peridotite minerals are capable of holding trace metals in their structures and we find Au within silicates and spinels throughout the sample suite with an average Au concentration pattern of spinel >> clinopyroxene > orthopyroxene > olivine in primary peridotites, with high variation within secondary materials such as dikes. Higher Au concentrations were hypothesized to reside within finely dispersed metallic phases, however analysis via XFM has shown little to no Au association with peridotite metallic sulphide and alloy mineralization. Analysed mantle sulphides do however appear to be rich in 'crucial' elements such as Ni, Co and Cu, suggesting possible mining potential in large bodies of mantle exposure such as ophiolites. Preliminary characterization of these metallic minerals identifies the sulphides: millerite (NiS), heazlewoodite (Ni_3S_2), pentlandite ($(Fe,Ni)_9S_8$), pyrite (FeS_2), pyrrhotite ($Fe_{1-x}S$), chalcopyrite ($FeCuS_2$), chalcocite (Cu_2S); and the metal alloy awaruite (Ni_3Fe), often containing a variation of minor and trace Fe, Ni, Cu, Co, Hg and Zn. Patterns are emerging with respect to locality, lithology and chemistry.