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Magma Sources and Ore Formation in the Radio Hill Complex, West Pilbara Craton: a Re-Os Isotope Study

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The source of metals and the processes which lead to the formation of ore deposits are fundamental questions that we seek to answer for a range of ore deposits. In the case of magmatic sulphide ore deposits, ore formation is critically linked to a magma attaining sulphide-saturation. This may be achieved by one of several processes resulting from changes in magma chemistry and/or temperature by contamination with crustal material. Once a sulphide liquid is formed, the tenor of the ore deposit, and the value of the contained metals is dependent on the degree of dynamic mixing between the sulphide liquid and the emplaced or erupted magma. This process is expressed as the R-factor, defined as the mass ratio of silicate magma to sulfide magma that it has equilibrated with. The Re-Os isotope system is ideally suited for the study of such processes due to its highly siderophile nature, and to the investigation of magma sources due to the distinctive characteristics of the various crustal and mantle reservoirs. We have applied this system to the study of the layered mafic-ultramafic complexes of the west Pilbara Craton.

Several layered mafic-ultramafic intrusions were emplaced into the west Pilbara Craton at ca. 2.9Ga, that are believed to be genetically related (Hoatson et al. 1992). Only one of these intrusions is known to contain economic quantities of Ni and Cu at the present time. The Radio Hill Complex is a relatively small intrusion (~1200 m stratigraphic thickness) that may be divided into two zones, an upper gabbroic zone and a lower ultramafic zone, the base of which possesses massive magmatic sulfide mineralisation (pyrrhotite, pentlandite, chalcopyrite and magnetite).

Re-Os isotopic data have been obtained for a suite of the samples from the massive sulfide mineralisation of the Radio Hill Complex. Os concentrations are very high, ranging from 19 to 191ppb Os, with low Re/Os ratios (<2.3). These characteristics are atypical of most low tenor, basalt-hosted magmatic sulfides (Lambert et al. 1999), which generally possess both higher Re/Os ratios and lower Os concentrations. The isotopic data yield a precise Re-Os isochron with an age of 2892 ±34Ma (MSWD = 1.06) and an initial $^{187}Os/^{188}Os$ = 0.1265 ±0.0028. This age is in agreement with the Sm-Nd age of 2927 ±13Ma of the nearby Munni Munni Complex that is believed to be genetically related to the Radio Hill Complex (Hoatson et al. 1992). The Radio Hill massive ores yield a relatively nonradiogenic initial Os isotopic composition (γOs = +17.6), compared with the ores from other Ni-Cu-PGE deposits (e.g., Voisey's Bay γOs = +1100, Duluth γOs = +800, Sudbury γOs = +500; Lambert et al. 1999). The Radio Hill data are more similar to Re-Os isotopic data from Noril'sk-Talnakh where γOs is also low (Walker et al. 1994).

It has been demonstrated by Lambert et al. (1999) that turbulent ore forming/deposition processes are capable of masking the effects of crustal contamination, if the immiscible sulfide ore magma experiences a high R-factor (e.g. >10,000). However, modelling of the Radio Hill ore system using Re, Os and PGE (Hoatson et al. 1992) concentrations suggests that the R-factor in the Radio Hill ore was low (100-200). The initial Os isotopic composition of the ore should therefore be radiogenic (high γOs >+500) if local crustal contamination triggered sulfide saturation. It is therefore unlikely that the parental magma to the Radio Hill Complex experienced bulk contamination with crust just prior to emplacement.

The slightly radiogenic initial Os isotopic composition suggests that the parental magma from which the massive sulphide ore later formed was a not a pure mantle derived melt (γOs = 0) but a crustally-contaminated magma. R-factor modelling further suggests that the parental magma to this intrusion was neither a basalt nor a pure komatiite, but more likely a contaminated komatiite, with a relatively high Os concentration. A parental magma of siliceous high-magnesium basalt (SHMB) composition was proposed for this and other intrusions in the region by Hoatson et al. (1992). Re-Os isotope modelling agrees with these findings, that contamination of a komatiite with 3.5Ga crust of granodioritic composition can yield a SHMB magma which could be parental to the Radio Hill Complex ore system.

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