Title: Identifying Cotectic and Xenomelt Magmatic Sulfides Using R-factor and S-isotope Variability in the Mount Keith MKD5 Komatiite-Hosted Nickel Deposit.

Authors: Anne Brandt Virnes, Marco Fiorentini, Stephen J. Barnes, Laure Martin, Nicolas Thebaud and Quentin Masurel.

Corresponding author: Anne Brandt Virnes, Centre for Exploration Targeting, School of Earth Science, The University of Western Australia, 35 Stirling Highway, Crawley, WA 6009, Australia, anne.virnes@research.uwa.edu.au

Komatiitic melts are inherently sulfur-undersaturated and must assimilate external sulfur in order to segregate a sulfide liquid that can equilibrate with the silicate melt and form nickel-sulfides. Multiple sulfur isotopic signatures of orthomagmatic sulfides, specifically the mass-independent signature (MIF-S, denoted $\Delta^{33}S$), inform us of the nature of external sulfur reservoirs and elaborate on the relative amount of assimilated sulfur. Predicting the S-isotopic composition of external sources can be used in exploration targeting for favourable host rocks. However, internal isotopic variations due to magma-sulfide liquid interactions must be considered in order to use magmatic S-isotopic compositions to infer the isotopic composition of the external source.

Recent work on samples from the world-class Mount Keith MKD5 komatiite-hosted nickel deposit discovered that sulfides in komatiite adcumulates can be classified between two distinct endmembers: 1) small, cotectic sulfide blebs, which form from in-situ nucleation in equilibrium with crystallising olivine. Upon crystallisation, these blebs are trapped by the crystallising olivine pile. As a result, the blebs have equilibrated with small amounts of silicate magma (low R-factors) and display relatively low Pd content; 2) large blebs of sulfide melt, called xenomelts, which are formed due to direct melting of sulfide minerals in assimilated sulfidic country rocks. These xenomelts can be transported in the magma over varying distances, resulting in high Pd tenors strongly dependent on R-factors. Both types will display mixed, non-zero S-isotopic signatures between that of the mantle and contaminant reservoirs. But, as cotectic sulfides crystallise directly out of the magma, the S-isotopic signature of this type will reflect that of the magma, independent of R-factors. In contrast, the S-isotopic signature of assimilated xenomelt blebs will be determined by the amount of silicate melt they can equilibrate with and are as such highly dependent on R-factors. Hence the relationship between PGE tenor (R factor dependent) and S-isotopic composition can discriminate between these genetic processes. Identifying the xenomelt sulfides with R-factor-dependent $\Delta^{33}S$ values informs us on the amount of assimilant and its original S-isotopic signature (Figure 1A).

Our work presents new in-situ multiple sulfur isotope data and sulfide metal contents from samples of the MKD5 nickel deposit from the Archean Agnew-Wiluna Greenstone Belt, Western Australia. We employ detailed petrography, mineral chemistry and multiple sulfur isotope analysis to identify distinct cotectic and xenomelt populations (Figure 1B). R-factor for each sample is estimated using Pd in pentlandite analysed by LA-ICP-MS as a proxy for metal tenor, and S-isotope signatures are measured using the in-situ SIMS technique. The resulting relationship between R-factor and S-isotopic signatures is used to discriminate between cotectic and xenomelt sulfide blebs and estimate the original isotopic signatures of the contaminant. Accurately predicting the contaminant isotopic signature can in turn aid camp-scale targeting for favourable host rocks to komatiites.

Figure 1: A) Relationship between final (measured) and initial sulfide melt isotopic composition as a function of R-factor and silicate melt sulfur composition, for an assimilated xenomelt equilibrating at varying R values. B) Polished mount and photomicrograph of sample MKD153-618 displaying both cotectic and xenomelt sulfide blebs.