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Evidence for recycled surface-derived sulfur in Earth's oldest mantle peridotites from southern West Greenland

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Eoarchean geodynamic processes are not well understood yet and it is debated if modern-style plate tectonics existed. Recently though, trace element geochemistry of Eoarchean supracrustal rocks from the 3.7-3.8 Ga Isua Supracrustal belt (ISB; e.g., [1]) and adjacent >3.8 Ga mantle peridotites [2] have been inferred to retain evidence for modern-like subduction processes.

Here we investigate the multiple sulfur (^{32}S, ^{33}S, ^{34}S, ^{36}S) isotope composition of well-characterized Eoarchean harzburgites and dunites from the area south of the ISB. We determined the sulfur isotope composition of mono- and disulfides of nine peridotite samples. Most samples show small, but significant MIF-S signals, whereas $\delta^{34}S$ values range from -0.2 to +4.9‰. This MIF-S signal provides evidence for incorporation of surface-derived sulfur of >2.4 Ga of age. In addition, Platinum-group-element (PGE) abundances, major and trace element compositions of these peridotites show evidence for variable degrees of melt refertilization [2,3], possibly related to a subduction overprint. Interestingly, the most depleted peridotites show the most positive $\Delta^{33}S$ values similar to the range obtained from amphibolites with tholeiitic composition from the ISB [4]. The $\Delta^{33}S_{monoS}$ are correlated with parameters indicative for melt refertilization as reflected by strong correlations with e.g., Fo# in olivine, Al_2O_3, Pt and Sc abundances indicative of an overprint with basaltic melts with zero or negative $\Delta^{33}S$ values. Such correlations strongly argue for a magmatic rather than a secondary origin of the sulfides. Mineralogical investigations reveal that most sulfides are pentlandite and pyrrhotite, showing exsolution textures, also pointing to a primary magmatic origin.

Overall, these findings are best explained in a subduction-related context, in which these peridotites may resemble fragmented lenses of mantle wedge that were incorporated into horizontally thickened mafic crust prior to the intrusion of tonalites at ca. 3.8 Ga.

[1] Jenner et al. (2009) *Chem. Geol.,* 261, 83-98.

[2] van de Löcht et al. (2020), *GCA* 280, 1-25.

[3] van de Löcht et al. (2018), *Geology* 46, 199-202.

[4] Siedenberg et al. (2016), *Precamb*. Res. 283, 1-12.