Purpose of study

In preparation for the NASA Psyche mission, we have modeled the partitioning of sulfur in primary chondritic planetesimal cores under a range of oxygen fugacities [1-3]. Sulfur is highly siderophile and immiscible in Fe-Ni liquid. It could make up a large part of a planetesimal core or form an immiscible sulfide liquid that could escape into the mantle, or potentially the surface of an exposed core [4]. We consider how the degree of melting of the planetesimal [1, 2, 6, 7] might affect the sulfur content of the core. If Psyche is a core or part of a core, which seems like the most likely scenario [5], we can predict potential sulfur contents of the core before impact stripping from its mantle if it formed from materials tested in this model.

Figure 1

Modelled at 1250°C (1523 K) and 0.1 GPa.

Results

Figure 2

Our model predicts that an oxidized planetesimal would form a small and sulfur-rich core, while a reduced body would form a large and sulfur-poor core. The partition coefficient of sulfur (D_S) decreases linearly with increasing log C_s, meaning that sulfur partitions into reduced bodies more than oxidized bodies (Fig. 1A). Reduced bodies will form larger cores than oxidized bodies (1B), and oxidized cores will have more sulfur-rich cores than reduced bodies due to the lack of free metallic iron and nickel (1C).

Conclusions

1. Sulfur partitions more into a reduced parent body’s core than oxidized parent body’s core.
2. Oxidized parent bodies form small, sulfur-rich cores while reduced parent bodies form larger, sulfur-poorer cores [8].
3. All chondritic compositions make cores with >9 wt.% sulfur, which will cause a sulfide-rich immiscible liquid to form [9].
4. If Psyche is sulfur-rich, it could have formed before or after its parent body’s silicate components totally melted (see top row below) [6].
5. If Psyche is sulfur-poor, it would have formed from a reduced body after the planetesimal totally melted (see bottom row below).