# HIGHLIGHTS AND BREAKTHROUGHS

## Bottled samples of Earth's lower mantle

**Abstract:** Inclusions in diamonds that have been kept in isolation as they were carried up to the surface from great depths are a valuable source of information. When combined with the results from high pressure-temperature experiments they are able to provide an ever clearer picture of Earth's interior. A paper by Felix V. Kaminsky and Jung-Fu Lin reports a new interpretation of lower-mantle composition using published data from these two sources. Some inclusions in diamond with deep-mantle origin have exceptionally high iron concentrations that they attribute to a more iron-rich lower mantle than predicted by the pyrolite model. They suggest that the unexpectedly low nickel contents in ferropericlase inclusions indicate the presence of elemental iron in sufficient abundance to dissolve nickel. These results, in turn, may throw doubt on a chondritic model for Earth's composition. **Keywords:** Deep-mantle composition, diamond inclusions, bridgmanite, ferropericlase

Felix V. Kaminsky and Jung-Fu Lin (Reference) have introduced a new model for the composition of Earth's lower mantle by pulling together data from two important sources. The first of these is the detailed analyses of inclusions found in diamonds that originated deep within Earth's mantle. These analyses not only provide data for determining the depth of origin but also provide a valuable source of information about the composition of the surrounding mantle material that was incorporated and isolated within their diamond hosts. The other important source of data comes from high pressure-temperature experiments on samples having the same or related compositions. These experiments conducted in mineral physics labs provide detailed information about crystal structure as well as physical and chemical properties at the pressure-temperature conditions existing in the mantle at the time the inclusions were captured by their diamond hosts. Even if those inclusions undergo changes due to drop in pressure and temperature during ascent to the surface, it is generally a safe assumption that their isolation in the diamonds prevents chemical change and that their structures and properties were those determined by experiments run at the same conditions.

Although a variety of phases have been found in inclusions, Kaminsky and Lin concentrate on two very important ones, ferropericlase (Mg,Fe)O and bridgmanite (Mg,Fe)$SiO_3$, particularly when they coexist within the same diamond. Ferropericlase is found in its unchanged structure and composition; however, bridgmanite is typically found in its low-pressure structure, that of orthopyroxene, but with unchanged composition. If the composition of the lower mantle is to be understood, not only the crystal structure but physical and chemical properties at the conditions in the lower mantle must be taken into consideration as well. This is why experimental results at high pressure and temperature are so important.

Although ferropericlase has an unchanged structure at mantle conditions, orthopyroxene has been known to have the perovskite structure at mantle conditions ever since Lin-gun Liu synthesized it (1974). From 1974 to 2014 this high-pressure phase was known as silicate perovskite or MgSi-perovskite or Si-perovskite or $MgSiO_3$-perovskite or Mg-silicate perovskite or Fe, Mg silicate perovskite or sometimes just perovskite in spite of the fact that perovskite is the name of a different mineral with a different composition, $CaTiO_3$. In 2014 Tschauner et al. identified silicate perovskite with $(Mg,Fe)(Si,Al)O_3$ composition in Tenham chondritic meteorite and attributed its origin to pressure and temperature resulting from shock loading. They named it bridgmanite in honor of physicist Percy Bridgman, pioneer in high-pressure research.

Now that this important phase has the single mineral name of bridgmanite, Kaminsky and Lin have adopted the new name when discussing partitioning of iron between it and ferropericlase. It was observation of disparities in the iron concentrations in these two phases that attracted their attention. They suggest that the high concentrations of iron in both of the phases is indicative of large increase of iron with depth in the lower mantle. They pay particular attention to the ratio of iron concentration in bridgmanite ($Fe_{bridg}$) to that in ferropericlase ($Fe_{fper}$). One group of inclusions found in diamonds of very deep origin show an increasing $Fe_{bridg}/Fe_{fper}$ with depth which they attribute to selective substitution of aluminum for iron. One particularly interesting conclusion is that low Ni concentrations that they observe in ferropericlase can be attributed to the presence of metallic iron and its alloys dissolving the missing Ni in the metal phase – again suggesting a lower mantle richer in iron than postulated by the pyrolite model.

On the basis of the analyzed inclusion compositions and experimental studies carried out at mantle conditions, the authors conclude that the lower mantle, especially the lowermost lower mantle contains more iron than predicted by the pyrolite model and that observed low nickel concentrations in the ferropericlase suggests that nickel was less available because it was dissolved in significant quantities of elemental iron alloy. These results, in turn, imply that the bulk composition of Earth is non-chondritic.

## REFERENCES CITED

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