## Deep diamonds and inferences on the role of aluminium in the transition zone and lower mantle.

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The São Luiz alluvial deposit of Mato Grosso State, Brazil, contains diamonds whose syngenetic inclusions of 50 - 400 µm diameter, not only exhibit shallow upper mantle mineralogies, but also reveal mineral parageneses only stable at pressures corresponding to depths of >300 km within the earth (Harte and Harris, 1994; Harte et al. 1994). These diamonds, therefore, provide a unique opportunity to gleen information on the stable phases and the compostional characteristics of areas of the earth normally innaccesible for direct measurement. Many of the inclusion phases correspond to those obtained as run products from high pressure and high temperature experiments appropriate to the deep earth. For example, majorite (Si-rich, Al-deficient garnet), which is an experimentally determined transition zone mineral (eg. Akaogi et al. 1987), has been found; whilst the assemblage of (Mg,Fe)O ferropericlase in association with (Mg,Fe)SiO3 and CaSiO3, as observed in experimental work on lower mantle conditions (eg. Irifune and Ringwood, 1987), has also been recovered. In addition it is apparent that some of the assemblages appear to be sourced around the boundary between these two regions approximating to a depth of 670 km. For example one diamond yielded a ferropericlase in addition to an Fe-rich olivine, and another a ferropericlase in association with a quartz composition. If the SiO2, (Mg,Fe)2SiO4 and (Mg,Fe)O are all in equilibium, then they correspond to a pressure range of 16-20 GPa at 1273K within the (Mg,Fe)SiO<sub>3</sub> system and in the range of 17-20 GPa at 1273K within (Mg,Fe)<sub>2</sub>SiO<sub>4</sub> system (Yagi et al. 1978; Jeanloz and Thompson, 1983).

One of the main debates relating to lower mantle mineralogy is the nature of the phase carrying aluminium. Does Al stabilise its own phase or is Al incorporated into other phases? Early experimental work on pyrolite and MORB starting compositions (Irifune and Ringwood, 1987; Ito and Takahashi, 1987) constrained an Al-rich phase which could not be identified. More recently, Al has been shown experimentally to be incorporated into perovskite structured (Mg,Fe)SiO3 (Irifune, 1994; Kesson et al. 1995) although other workers (O'Neill and Jeanloz, 1994; Ahmed-Zaid and Madon, 1995; Yagi et al. 1996) suggest that a separate Al-rich phase coexists with a mildly aluminous perovskite structured (Mg,Fe)SiO3. All these experiments involve some degree of uncertainty, whether in the measurement of run conditions of pressure or temperature or the relevence of bulk composition employed to those of mantle regions. Clearly there is still much controversy over the role of Al and, although pressures and temperatures cannot explicitly be constrained at this stage, the São Luiz diamonds provide an opportunity to shed light on some of this controversy.

Al is found here in three different phases; dominantly orthopyroxene or clinopyroxene compositions with amounts of Al<sub>2</sub>O<sub>3</sub> up to 12.6 wt %; corundums of both sapphire and ruby varieties and a new tetragonal mineral of pyrope-almandine composition, particularly distinguished by a lack of Ca and majorite substitution. This new phase has provisionally been called haitchite (Harris *et al* 1996). The Al-bearing phases occur in three distinct associations; Group 1, ferropericlase + CaSiO<sub>3</sub> + type I pyroxene + haitchite; Group 2, ferropericlase + type II pyroxene + ruby; Group 3, ferropericlase + type III pyroxene + haitchite.

Within Group 1, Al<sub>2</sub>O<sub>3</sub> appears as up to 2.7 wt % in the essentially (Mg,Fe)SiO<sub>3</sub> composition type I pyroxene and 20-24 wt % in haitchite. Experimentally, there has been evidence based on pyrolite to suggest that majorite starts to lose its majoritic component at pressures greater than 19 GPa and remains stable with ferropericlase (Mg,Fe)SiO<sub>3</sub> + CaSiO<sub>3</sub> partly into the lower mantle (Irifune and Ringwood 1987). As yet, however, haitchite has not been observed.

Groups 2 and 3 involve grains of Al-rich pyroxenes. These grains lie on a trend of increasing Al content with increasing Ca, Cr and Na and decreasing Mg and Fe.

In Group 2, type II pyroxene consists of 10 wt% Al<sub>2</sub>O<sub>3</sub>, 1 wt% Na<sub>2</sub>O and 0.7 wt% CaO. Of the inclusions recovered, one is a composite grain of type II pyroxene and ruby. Yagi et al. (1996),

Ahmed-Zaid and Madon (1995) and O'Neill and Jeanloz (1994) allude to similar associations.

In Group 3, type III pyroxene involves 11 wt % Al<sub>2</sub>O<sub>3</sub>, 4.5 wt% Na<sub>2</sub>O and 4.5 wt% CaO. Of the inclusions recovered, one is a composite grain of type III pyroxene and haitchite.

In addition, a sapphire inclusion has been recovered which is the first example of this variety of corundum to be found in a diamond. Its lack of association with another phase, however, makes its position of origin in the mantle unclear.

From the parageneses obtained from São Luiz diamonds it is clear that both régimes involving a separate Al phase and régimes involving Al incorporation into predominantly ferro-magnesian minerals are present; their relative stability is probably depth-related.

Ahmed-Zaïd, I. and Madon, M. 1995 Earth and Planetary Science Letters 129, 233-247 Akaogi, M. et al. 1987 High Pressure Research in Mineral Physics Ed. Manghnani and Syono TERRAPUB, Tokyo 251-260

Harris, J. W. et al. 1996 A new tetragonal silicate mineral from the lower mantle Nature Submitted Harte, B. and Harris, J. 1994 Mineralogical Magazine 58A, 384-385

Harte, B. et al. 1994 Mineralogical Magazine 58A, 386-386

Irifune, T. 1994 Nature 370, 131-133

Irifune, T. and Ringwood, A.E. 1987 High Pressure Research in Mineral Physics Ed. Manghnani and Syono TERRAPUB, Tokyo 231-242

Jeanloz, R. and Thompson, A. 1983 Reviews of Geophysics and Space Physics 21, 51-74

O'Neill, B. and Jeanloz, R. 1994 Journal of Geophysical Research 99, B10, 19901-19915

Kesson, S.E. et al. 1995 Earth and Planetary Scinece Letters 134, 187-201

Yagi, T. et al. 1978 Carnegie Institute of Washington Yearbook 1978, 614-618

Yagi, T. et al. 1996 EMPG-VI Abstracts 1996, 7





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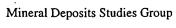
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