Geophysical Research Abstracts
Vol. 12, EGU2010-2872, 2010
EGU General Assembly 2010
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# Diamond Formation in Dehydration Zones in the deep Upper Mantle and Lower Mantle

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Introduction.
During the last 25 years a series of publications have documented the occurrence of inclusions in diamonds that show mineral compositions and mineral associations predicted for mantle rocks at deeper levels than the mantle lithosphere (e.g Harte et al., 1999; Harte & Cayzer, 2007). Although the diamonds bearing deep mantle inclusions are not abundant in absolute terms they are widespread and have been reported from cratonic blocks on all major continents. As with natural diamonds in general these deep diamonds appear to have grown in fluids/melts.

Depth Zones indicated by inclusion suites.
The silicate inclusions and their mineral associations form a series showing good correlation with mineral assemblages expected in basic and ultrabasic rock compositions at depth. However, there is a strong bias towards assemblages from two principal zones:
(1)uppermost Transition zone and Asthenosphere (upper TZ group))
(2)lowermost Transition Zone and uppermost Lower Mantle (UM/LM group)
In the case of (1) the assemblages are predominantly of majorite garnet, and majorite garnet + cpx with an affinity to eclogitic bulk compositions. In many of these inclusions the cpx appears to have exsolved from the majoritic garnet and the depth of origin of the initial inclusions may often be near the top of the Transition Zone.
The assemblages from (2) are predominantly of peridotic affinity and involve fPer as well as silicates. They indicate material from three depth zones near the upper mantle to lower mantle boundary (UM/LM boundary).
2a) Upper/Lower Mantle Boundary association - inclusions of: Mg2SiO4, fPer, maj/tapp, mpv, cpv
2b) uppermost Lower Mantle association with: Mpv(Al-poor) with fPer and cpv,maj/tapp
2c)lower Mantle association with: Mpv(Al-rich) with fPer, and crn
[fPer:ferropericlase; maj:majorite; tapp:tetragonal-almandine-pyrope phase; mpv:MgSiperovskite; cpv:CaSiperovskite]

Discussion.
The above features show that the formation of deep mantle diamonds is concentrated in a zone around the top of the Transition Zone (ca 400 kms deep), and a zone at 600-800 kms embracing the bottom of the Transition Zone and the top of Lower Mantle. Associations including Mg2SiO4 with and fPer + MgSi-perovskite indicate the preservation of UM/LM boundary reaction, which from experimental data is expected to be sharply constrained in depth, though the presence of H2O will broaden the reaction zone due to the potential stability of hydrous ringwoodite. Considerations of the preservation of hydrous peridotitic assemblages in subduction zones (Komabayashi, 2006, AGU monograph), show that an initially cool subducted slab may preserve hydrous assemblages to the lower part of the upper mantle and into the lower mantle. Here stagnation and warming of the slab may cause dehydration with the formation fluids/melts. Such fluids/melts provide the potential location for diamond formation and thereby provide an explanation for the abundance of inclusion assemblages from around the UM/LM boundary.
At the top of the Transition Zone, there is potential for dehydration to occur where hydrous wadsleyite converts to olivine. The intersection with the upper surface of a subducting slab with potential dehydration zone provides an ideal location for the crystallisation of the majorite assemblages from around the top of the Transition Zone. This also accords with the crustal carbon isotpe signatures in the host diamonds and the wide variations in REE

abundances in the majorites.