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Sublithospheric Diamonds and Deep Earthquakes Demonstrate an Arc-Avoiding Subduction Pathway for C-O-H-N-S Volatiles

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Deep earthquakes have potential to trace C-O-H-N-S fluid release in the mantle transition zone like shallower subduction zone earthquakes trace fluid and melt release from the slab. Our new models of the thermal structures of subducted slabs to mantle transition zone depths permit a detailed comparison between slab pressure/temperature (*P/T*) paths and hydrated/carbonated mineral phase relations [1]. Cold slabs capable of transporting water to transition zone depths in dense hydrous magnesium silicates (DHMS) correlate well with slabs that produce seismicity primarily between 500 and 700 km. This depth range also coincides with the *P/T* conditions at which oceanic crust in cold slabs are predicted to intersect the carbonate-bearing basalt solidus to produce carbonatitic melts. Both types of fluids are well represented by sublithospheric diamonds whose inclusions record the existence of melts, fluids, or supercritical liquids derived from hydrated or carbonate-bearing slabs at depths (~300 to 700 km) generally coincident with deep focus earthquakes. We suggest that hydrous and carbonated fluids released from subducted slabs at these depths lead to fluid-triggered seismicity, fluid migration, diamond precipitation, and inclusion crystallization. Deep focus earthquake hypocenters would then track the general region of deep fluid release and migration in the mantle transition zone [1]. The thermal modeling and mineralogy of cold slabs correlated with sublithospheric diamond formation demonstrates a deep subduction pathway to the mantle transition zone for carbon and volatiles that bypasses shallower dehydration processes in the wedge and arc. This pathway has been shown by the heavy iron (δ^{56}Fe = 0.79–0.90‰) and unradiogenic osmium (187Os/188Os = 0.111) isotopic compositions of metallic inclusions in sublithospheric diamonds [2] which were derived from magnetite and/or Fe-Ni alloys crystallized during serpentinization of oceanic lithospheric peridotite [2].

[1] Shirey SB, Wagner LS, Walter MJ, Pearson DG, and van Keken PE (2021) Slab Transport of Fluids to Deep Focus Earthquake Depths – Thermal Modeling Constraints and Evidence From Diamonds. AGU Advances DOI: 10.1029/2020AV000304. [2] Smith EM, Ni P, Shirey SB, Richardson SH, Wang W, and Shahar, A (2021) Heavy iron in large gem diamonds traces deep subduction of serpentinized ocean floor. Science Advances DOI:10.1126/sciadv.abe9773.