Reaction of subducted sediment with peridotite produces saline fluid inclusions in diamonds

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Diamonds often contain inclusions of highly saline fluids. These fluids are thought to emerge from seawater[1], trapped within the subducted slab and are also likely to be involved in the generation of some of the kimberlite magmas that transport diamonds to the surface. However, the mechanisms of transport and inclusion into diamonds are unresolved.

We have reacted carbonate-bearing siliciclastic marine sediment (IODP) with depleted peridotite (dunite) in high-pressure experiments, and demonstrate that Na-K chlorides are stable within the mantle lithosphere under reducing conditions at depths of >110 km. These Na-K chlorides are formed when subducted marine sediments react with peridotite. Their compositions show high K/Na ratios, identical to those of saline fluid inclusions in diamond. These Na-K chlorides are unstable at T >1100 ºC at 4–6 GPa and do not form at P <4 GPa. Instead, at high temperature and low pressure, K is accommodated in mica, while chlorine is distributed between mica, melt, and a fluid phase. This delineates an upper boundary of Na-K chloride stability between 3 and 4 GPa, which coincides with the mid-lithospheric seismic discontinuities.

The reaction of subducted sediments with peridotite also consumes CO_2 from the sediment to produce magnesite. Both magnesite and Na-K chlorides are found in alkali chloride-bearing kimberlites such as Udachnaya-East. Melting experiments[2] of Udachnaya-East kimberlite at 4.5–6.5 GPa and 1000–1100 °C are close in composition to phases formed in the sediment–dunite reaction zone of our experiments.

[1] Y. Weiss, J. McNeill, D. G. Pearson, G. M. Nowell, C. J. Ottley, Highly saline fluids from a subducting slab as the source for fluid-rich diamonds. Nature. 524, 339 (2015).

[2] I. S. Sharygin et al., Melting phase relations of the Udachnaya-East group-I kimberlite at 3.0–6.5 GPa. Gondwana Research. 28, 1391–1414 (2015).