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Diamond formation mechanisms and the record of the processes involved

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Diamonds provide a window into the deep Earth. But what does this window reveal? The silicate mineral inclusions in diamonds have long been interpreted to reflect the geochemistry of rock types in the diamond-forming substrate [1]. However, the importance of high density fluid inclusions in upper mantle diamonds establishes that diamonds are metasomatic - the agents of metasomatism being either melt-like or fluid-like. Such metasomatic agents suggest that the mineral inclusions in diamonds are also metasomatic, i.e. they do not necessarily reveal the rock types at depth. During the last ten years, the application of quantitative mass transfer models of aqueous fluid metasomatism at upper mantle conditions strongly supports a metasomatic origin for diamonds and their silicate inclusions [2-5]. Diamonds could have formed during fluid-rock interaction by pH changes [2], fluid mixing [3], or complex metasomatism [4,5]. For example, when a fluid initially in equilibrium with mafic eclogite encounters peridotite, irreversible chemical mass transfer must take place. Even at constant temperature, pressure and fO_2, such fluid-rock interactions may produce diamond and must involve progressive changes in fluid chemistry and product minerals. In this example, early garnets produced will reflect an eclogite-sourced fluid but will become progressively Mg-rich due to the peridotitic environment. If only the early garnets are preserved in diamond, the diamond would traditionally be labelled "eclogitic" and inferred to have formed in eclogite. But in fact it formed in peridotite. In some cases, diamonds in a single eclogite xenolith preserve a range of predictable garnet compositions [5,6], which is explained by fluid-rock interaction. Overall, we infer that the diamond window into the deep Earth may often reveal the fluids involved, and the extent of fluid-rock reaction, rather than the particular geologic rock environment in the deep Earth.

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