Diamond crystallization from carbonatitic melts by metasomatic reducing reactions

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Studies of inclusions in natural diamonds suggest a genetic link between diamond formation and volatile- and alkali-rich mantle melts or fluids, broadly similar to carbonatite to kimberlite compositions (Navon, 1999). The incipient melt of a carbonate-bearing mantle peridotite is carbonatitic in composition (Dalton and Presnall, 1998). Diamond can be synthesized from graphite in the presence of nonmetallic solvent-catalysts such as carbonate melts, kimberlitic silicate melts, C-O-H fluids, and CO_2 fluids under high-pressure and high-temperature conditions in the thermodynamically stable region of diamond (Arima et al., 2002 for references). However, because graphite was a part of the starting assemblage in all these experiments, these do not provide a clear demonstration for direct crystallization of diamond from volatile- and alkali-rich mantle melts or fluid. Arima et al., (2002) report experimental results of nucleation and growth of diamond from carbonatitic melts in graphite-free systems and provide an important link for deciphering the genesis of diamond in the Earth's mantle. They demonstrated that diamond is formed from the carbonatitic melt by reducing reactions of the following form: $CaMg(CO_3)_2 + 2Si = CaMgSi_2O_6 + 2C$ in the $CaMg(CO_3)_2$-Si system and $CaMg(CO_3)_2 + 2SiC = CaMgSi_2O_6 + 4C$ in the $CaMg(CO_3)_2$-SiC system.

Although α-SiC (moissanite) and β-SiC are reported as inclusions in natural diamonds, and silicon metal was reported as an inclusion of moissanites in kimberlites, these are very rare and represent extremely reducing conditions in the Earth's mantle. Nevertheless, it is probable that carbonate may be reduced under less extreme conditions and diamond grows spontaneously from such melts and that carbonate-bearing melts actually supply the carbon for diamond formation. The extremely low viscosity of carbonate-bearing melts allows them to percolate easily through mantle rocks, to transport the carbon into more reduced host mantle regions, and to crystallize diamond by reducing reactions.

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Geochemical constraints on fluids present during thrust faulting, Rundle thrust, Alberta, Canada

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Geochemical properties of fracture-filling cements may be employed to elucidate conditions prevalent at the time of vein formation (Rye and Bradbury, 1988; McCaig *et al.*, 1995; others). Here, stable isotopes and fluid inclusion analysis, combined with petrographic and field-based structural investigations of syntectonic carbonate veins, are used to unfurl the history of fluid movement during emplacement of the Rundle thrust sheet. The Rundle thrust one of five major thrusts comprising the Foreland Fold and Thrust Belt (FFTB) of the Canadian Cordillera.

Relationships can be drawn between the fluid composition (delineated by quadrupole mass spectrometry and isotopic data) and structural and petrographic observations and measurements. Oxygen isotopes in cement samples vary systematically with vein orientation. Veins normal to thrust strike display greater variability in ^{18}O content and tend to have more negative $\delta^{18}O$ values (up to 10‰ lower than related host rocks), while veins parallel to thrust strike tend to have $\delta^{18}O$ values close to that of the host rock. The degree of twinning is employed as an indicator of timing, with earlier cements being more twinned due to continued deformation after fracture filling. Many early cements contain significant quantities of methane, and may indicate that hydrocarbons were expelled or over-matured during pre- or early thrusting.

Carbon and oxygen isotopes in host rock samples vary with stratigraphic position and confirm precipitation from contemporaneous seawater and subsequent minor burial diagenesis. Cements are interpreted as being derived from connate fluids at burial temperatures, and/or enriched fluids resulting from continued water-rock interaction within a closed system. This is in marked contrast to previous studies that interpret thrust fluids in the FFTB as being meteoric-sourced (Nesbitt and Muehlenbachs, 1993; Price *et al.*, 2001), and potentially far-travelled (Knoop *et al*., 2002).

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