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Re-Os Systematics of Sulphide Inclusion Bearing Diamonds from Continental Mantle Roots

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The Re-Os isotope system holds the key to future progress in understanding continental mantle evolution (Carlson et al., 1999). Re-Os data for peridotitic and eclogitic sulphide inclusions in diamonds from continental mantle roots cover essentially the entire range of Os isotope space. Given recent developments in analytical technique (Pearson et al., 1998; Shirey et al., in prep.), age determinations are now possible on single inclusions containing only 100 femtograms of radiogenic Os.

Diamonds from the 85 Ma old Kimberley kimberlites on the Archean Kaapvaal craton in southern Africa have been targeted with a view to constraining the time scale on which multiple generations of diamond were formed and stored in the cratonic mantle keel. Peridotitic garnet inclusion bearing diamonds from this classic locality, where the keel is particularly well-developed (James et al., 1999; Carlson et al., 2000), have previously yielded Sm-Nd and Rb-Sr model ages coinciding with craton stabilisation around 3.2 Ga ago (Richardson et al., 1984; de Wit et al., 1992). Surprisingly, all the sulphide inclusion bearing diamonds from Kimberley investigated thus far have proved to be eclogitic, not peridotitic. The suite comprises both common-Os-bearing and common-Os-free sulphides, the latter containing only Os derived from in-situ Re decay. The two sulphide types are found in separate diamonds with no obvious differences in mineral chemistry or host diamond morphology. The extreme range in 187Re/^{188}Os allows for absolute age determinations on single common-Os-free grains as well as an isochron age and initial ratio determination for the common-Os-bearing grains.

In the case of the Kimberley eclogitic diamonds, the common-Os-free sulphides yield absolute ages that overlap the 2.9 Ga isochron age defined by the common-Os-bearing sulphides. The age agreement and syngenetic inclusion morphology confirm this as the age of diamond crystallisation rather than an inherited age. The initial ^{187}Os/^{188}Os derived from the isochron systematics (gamma Os = +45) is considerably higher than expected for the mantle at 2.9 Ga, indicating that the sulphides formed from an older source with high Re/Os. One possible source would be a basaltic precursor for the eclogite in which the sulphide inclusion bearing diamonds crystallised, regardless of the ultimate derivation of the carbon. This is consistent with a late Archean origin for this generation of eclogitic diamonds, well after craton stabilisation in the middle Archean.

Kimberlite emplacement effects can complicate the analysis of sulphide inclusions as seen in the results for fragments of individual grains. These include (1) sulphide extrusion into rosette fracture systems developed around inclusions during decompression and (2) Re and Os partitioning between pyrrhotite, chalcopyrite and pentlandite produced by exsolution from original monosulphide solid solution during cooling. Fragments of an inclusion can thus record an internal age of kimberlite emplacement whereas the bulk inclusion records the age of diamond crystallisation. In short, complete sampling is paramount in deriving reliable age information from single sulphide inclusion.

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