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Re-Os Isotope Constraints on the Age of Siberian Diamonds

D. Graham Pearson[1], **Galina Bulanova**[1], **Steve Shirey**[2], **Richard Carlson**[2], **Judith Milledge**[3] & **Yuri Barashkov**[4]

[1] Department of Geological Sciences, South Road, Durham, DH1 3LE, UK
[2] Carnegie Institution of Washington, Department of Terrestrial Magnetism, Washington DC, 20015, USA
[3] Department of Geological Sciences, University College London, Gower Street, London, UK
[4] Yakutian Institute of Geosciences, 39 Lenin Pr., Yakutsk 67789, Russia

The growing database of diamond crystallisation ages indicates strong links between diamond growth and tectono-thermal events affecting the crust and lithospheric mantle. Diamonds thus might preserve the ancient records of cratonic processes that have been otherwise obscured. In this study we report Re-Os isotope constraints on the age and origin of a suite of syngenetic sulfide inclusion-bearing diamonds from the Mir, Aikhal and Udachnaya kimberlites, Siberian craton, Yakutia. The inclusions are exposed in polished plates. They are faceted and many are of the central inclusion type (Bulanova, 1995). Sulfide paragenesis in most cases was established by the co-existence of silicate or oxide mineral inclusions within the same diamond. At Udachnaya, minerals of peridotitic association (P-type) dominate the diamond inclusion paragenesis and 9 separate sulfide inclusions from 6 different diamonds have been analysed. A single P-type inclusion from an Aikhal diamond was also analysed. At Mir, minerals of eclogitic paragenesis (E-type) form as much as 30% of the whole diamond population. We have analysed sulfide inclusions from 5 separate eclogitic diamonds. The state of nitrogen aggregation in each host diamond was determined by FTIR spectroscopy.

Central inclusion P-type sulfides from the Udachnaya diamonds have Os concentrations ranging from 1.1 to >20 ppm. The central inclusions have relatively uniform, non-radiogenic Os isotope compositions, $^{187}Os/^{188}Os$ 0.1052 to 0.1089, with Re-Os model ages (TMA ages) ranging from 3.1 to 3.5 Ga. $^{187}Re/^{188}Os$ values are low (0.011 to 0.1), consistent with the P-type nature of the inclusions. The P-type sulfide from Aikhal is much more radiogenic, $^{187}Os/^{188}Os = 0.2255$, supported by an elevated $^{187}Re/^{188}Os$ of 2.02, giving a model age of 3.4 Ga, in agreement with the model ages for the sub-chondritic P-type sulfides. Regression of the entire suite of 10 separate inclusions from the 7 diamonds yields a model 3 isochron of 3480 ±210 Ma (2 s), with a close to chondritic $^{187}Os/^{188}Os_I$ of 0.1047 (MSWD = 26). Exclusion of the Aikhal samples yields a similar (3274 ±970 Ma) but less precise isochron age. These systematics confirm previous suggestions of a meso-Archean age for Siberian P-type sulfide-bearing diamonds and are in accord with Re depletion ages obtained from Udachnaya peridotite xenoliths, but contrast with the c. 2.0 Ga Sm-Nd isochron for sub-calcic garnet inclusions obtained by Richardson and Harris (1997). The highly aggregated nitrogen present in many Siberian P-type diamonds is in broad agreement with an ancient age for both the sulfide- and silicate-bearing diamonds but cannot easily differentiate between a meso-Proterozoic and meso-Archean age due to the relative insensitivity of N-aggregation to mantle residence times in excess of 100 Ma (Navon, 1999). Further studies are needed to address the apparent age difference between the low-Ca garnet bearing diamonds and sulfide-bearing diamonds.

E-type sulfide inclusions from Mir have considerably lower Os concentrations than P-type sulfides (2.85 to 748 ppb) and generally higher, but varied $^{187}Re/^{188}Os$ (0.28 to 213). $^{187}Os/^{188}Os$ ranges from 0.42 to 1.46 and although more radiogenic than the P-type sulfides, these values do not extend to the high values reported for other E-type sulfide inclusions in diamonds (Pearson et al, 1998; Shirey et al, 1999). One Mir sample has an unsupported Os isotope composition and 4 others give young model ages (213 to 582 Ma) compared to P-type sulfides. The E-type sulfides define a correlation with a, Phanerozoic age (323 ±22 Ma), close to the kimberlite eruption age (350 Ma). Short mantle residence times for some of these diamonds are consistent with their low levels of N aggregation. The present data set thus indicates a possible young age for Mir E-type diamonds. The most likely mantle event that could have lead to crystallisation of these diamonds so recently would be activity related to the kimberlite magmatism. A possible young age for Mir E-type diamonds is surprising and contrasts to the Archean Re-Os isochron and model ages obtained for eclogite xenoliths from Udachnaya (Pearson et al, 1995). Further work is in progress to evaluate how representative these analyses are of the Mir diamond suite.

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