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Diamonds and Highly Reduced Minerals from Chromitite of the Ray-Iz Ophiolite of the Polar Urals: Deep Origin of Podiform Chromitites and Ophiolitic Diamonds

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The Uralide orogenic belt is a major early Paleozoic suture zone extending more than 3000 km in a N-S direction, and geographically divides Europe from Asia (Chemenda et al., 1997). Ophiolites, podiform chromitites and high pressure metamorphic rocks are well developed in the orogenic belt (Leech and Ernst, 2000). The Ray-Iz ophiolite occurs at the NE end of the Paleozoic Voikar-Syninsk ophiolite belt in the Polar Urals, where it consists chiefly of mantle peridotite containing over 200 podiform chromitite orebodies (Garuti et al., 1999). We sampled the Ray-Iz ophiolite and associated chromite deposits for comparison with the Tibetan ophiolites.

Over 60 mineral species, including diamond, moissanite, native elements and metal alloys have been separated from ~1500 kg of chromitite collected from two orebodies in the Ray-Iz ophiolite. Of great importance is the discovery of diamond, a typical UHP mineral previously reported in the Luobusa chromitites of Tibet. Other mineral groups from the Ray-Iz chromitite include: (1) native elements: Cr, W, Ni, Co, Si, Al and Ta; (2) carbides: SiC and WC; (3) alloys: Cr-Fe, Si-Al-Fe, Ni-Cu, Ag-Au, Ag-Sn, Fe-Si, Fe-P, and Ag-Zn-Sn; (4) oxides: wüstite, periclase, eskolaite, rutile, baddeleyite, ilmenite, corundum, chromite, NiO and SnO_2; (5) silicates: kyanite, pseudomorphs of octahedral olivine, zircon, garnet, feldspar, and quartz; (6) sulfides of Fe, Ni, Cu, Mo, Pb, Ab, AsFe, FeNi, CuZn, and CoFeNi; and (7) iron groups: native Fe, FeO, and Fe_2O_3. In this report we focus on the composition and character of the diamonds, native elements and metal alloys.

Some in situ diamonds and moissanite occur as euhedral to subhedral crystals, mostly 200-500 μm across, that are hosted in small patches of carbon within chromite grains. Both the diamond and moissanite have extremely low carbon isotope values $\delta^{13}C_{PDB}$ (-18 to -28), distinctly different from kimberlitic diamonds, suggesting a separate carbon reservoir in the mantle.

All of the minerals discussed here are very similar to those reported from the Luobusa chromitites, indicating that they are not restricted to one ophiolite or geographic region, rather they may be widespread in the oceanic mantle. The diamonds recovered from these ophiolites are completely different from those in kimberlites and ultra-high pressure (UHP) metamorphic rocks and represents a new class of diamonds on Earth.

Previous work suggests that both the diamonds and chromitites of Luobusa crystallized in the diamond stability field at depths greater than ~150 km, possibly deeper than 300 km, thus raising questions regarding the current models for the formation of ophiolites and podiform chromitites. It is possible that the diamonds formed from C-rich fluids with highly reduced phases and low $\delta^{13}C_{PDB}$ values derived from previously subducted slabs.

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