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Microtexture and formation mechanism of impact diamonds from the Popigai crater, Russia

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Large meteoritic impact occasionally produces an extensive amount of diamond on the surface of the Earth [1, 2]. Popigai crater located in the north central Siberia is a typical example of such diamond-forming shock events and has recently been brought back into the spotlight due to its vast estimated reserves of the impact diamonds [2-4]. Authigenic impact diamonds occur in shocked graphite-bearing garnet-biotite gneisses that are found as inclusions in impact melt rocks, so-called tagamites and suevites. Popigai diamonds occur as irregular to tabular grains of 0.5-2 mm size (up to 10 mm) and usually show yellow, gray or black colors [3]. Electron microscopic (SEM and TEM) observations in previous studies described that they are polycrystalline aggregates of 0.1-1 μm grains and show a distinct preferred orientation along the [111], which is in a coaxial relation to the [001] of the original graphite source [2-4]. This crystallographic feature as well as the occasional coexistence of lonsdaleite, a metastable carbon polymorph, suggest the Martensitic phase transformation for the potential formation process of the impact diamonds from Popigai crater. However, the textural feature of the impact diamonds and its variation has not fully been examined. Here, we present the result of detailed microtextural observations of impact diamonds from the Popigai crater by transmission electron microscopy (TEM) and discuss the formation mechanism and condition in comparison with those of synthetic diamonds obtained by high pressure and high temperature experiments.

In total 10 diamond grains (7 transparent yellowish and 3 black samples) from the Popigai crater were studied. Each sample was first analyzed by a micro-focus XRD equipped with a Mo target and an IP detector. The results showed that transparent samples consist mostly of diamond and occasionally contain lonsdaleite, while black ones are a mixture of graphite, lonsdaleite and diamond, which are all in a coaxial relation as shown by 2D diffraction patterns collected in transmission geometry. Each sample was then transferred to a focused ion beam (FIB) system to cut out TEM foil sections perpendicular to the surface (of the tabular grains). TEM observation revealed that although all the samples commonly possess layered structures and preferred orientation (mostly along [111] of diamond), there are varieties in crystallite (grain) size (down to 10-20 nm) and degree of preferred orientation. Taking into account the similarity in texture and preferred orientation feature between the Popigai diamonds and synthetic diamond, the variation is likely derived from the small difference in crystallinity of the starting graphite sources and perhaps more significantly from the difference in shock temperature.

According to the shock features recorded in the silicate minerals of the diamond-bearing impactites, the threshold pressure for the onset of the graphite-diamond transformation is estimated to be 34-36 GPa [3]. However, our recent experimental synthesis [5] demonstrated that a similar phase assembly (mostly diamond + traces of lonsdaleite) and microtexture can be produced at much lower pressures of 15-25 GPa at $>$2000 ℃. The shock pressure as well as shock- and post-shock temperature accompanied with the formation of the Popigai crater might be needed to be reevaluated carefully to understand the real nature of the giant impact.

[1] Masaitis V.L. (1998) Meteoritics & Planetary Science. 33. 349-359.
[2] Langenhorst F., Shafranovsky G.I., et al. (1999) Geology. 27. 747-750.
[3] Deutsch A., Masaitis V.L., et al. (2000) Episodes. 23. 3-11.
[4] Koeberl C., Masaitis V.L., et al. (1997) Geology. 25. 967-970.
[5] Isobe F., Ohfuji H., et al. (2013) Journal of Nanomaterials. 2013. 380165.