

Deep-mantle-derived noble gases in metamorphic diamonds: evidence of mantle plume involvement in UHP metamorphism

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Metamorphic diamonds from the Kokchetav massif in northern Kazakhstan are considered to have crystallized from C-O-H fluid during ultra-high-pressure metamorphism of metasedimentary rocks subducted to 190-280 km depth [1]. Noble gas isotopes offer great potential to constrain the origin of diamond-forming media. Previous studies have revealed that secondary processes during the diamond residence in the host rock drastically modified the original noble gas signature of the diamonds [2]. Nanometric solid/fluid inclusions in the microdiamonds, which represent the former diamond-forming fluid [1], are potential candidates to preserve the noble gas trapped during the diamond crystallization. Sumino et al. (2011) [3] analyzed noble gas isotopic compositions of the Kokchetav metamorphic microdiamonds using two gas extraction techniques: in vacuo crushing and stepwise heating. The latter selectively extracts noble gases from inclusions with less noble gas extraction from the diamond lattice.

Most ³He was extracted by diamond crushing what indicates that ³He occurs within inclusions trapped during diamond formation. The estimate of the inclusion-hosted ³He/⁴He of $(3.3-6.5) \times 10^{-5}$ is significantly higher than that of the MORB-source mantle (1.1×10^{-5}), but close to the highest value observed in OIBs (ca. 7×10^{-5} [4]) containing primordial noble gases derived from deep mantle. Neon isotope ratios obtained using stepwise heating also support the presence of a plume-like component [3].

Results show the involvement of plume-like, primordial-enriched noble gases in the Kokchetav microdiamond formation, implying metasomatism of the continental lithosphere by a plume prior to its subduction [5], or interaction of the continental slab and a fragment of the very deep mantle, in the latter of which the fragment might have been delivered to the mantle wedge of the subduction channel by large-scale mantle convection originating from a deeper lower mantle source. If the former is the case, the plume-derived noble gases could be ubiquitous in continent-continent convergent margins where continental crust was subducted such as in Hindu Kush and Burma [5]. Further noble gas investigation of diamonds from other ultrahigh-pressure metamorphic terranes is required in order to confirm which one of the two possibilities is correct, namely the metasomatism of subducting continental lithosphere by a plume or the large-scale mantle convection in a subduction channel.

[1] Dobrzhinetskaya et al. (2006) EPSL 243, 85-93. [2] Verchovsky et al. (1993) EPSL 120, 87-102. [3] Sumino et al. (2011) EPSL 307, 439-449. [4] Stuart et al. (2003) Nature 424, 57-59. [5] Seno and Rehman (2011) Gondwana Res. 19, 327-333.

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