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超高圧変成作用起源ダイヤモンド中の深部マントル起源希ガスとその意義
Deep-mantle-derived noble gases in metamorphic diamonds: evidence of mantle plume involvement in UHP metamorphism

角野 浩史 [1*], Larissa F. Dobrzhinetskaya[2], 鍵 裕之 [1], Ray Burgess[3]
Hirochika Sumino[1*], Larissa F. Dobrzhinetskaya[2], Hiroyuki Kagi[1], Ray Burgess[3]

[1] 東京大学理学系研究科地殻化学実験施設, [2] カリフォルニア大学リバーサイド校, [3] マンチェスター大学
[1]GCRC, Grad. Sch. Sci., Univ. Tokyo, [2]Department of Earth Sciences, UC Riverside, [3]SEAES, Univ. Manchester

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 ^{3}He was extracted by diamond crushing what indicates that ^{3}He occurs within inclusions trapped during diamond formation. The estimate of the inclusion-hosted $^{3}He/^{4}He$ of (3.3-6.5) x 10^{-5} is significantly higher than that of the MORB-source mantle (1.1 x 10^{-5}), but close to the highest value observed in OIBs (ca. 7 x 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) Gondowana Res. 19, 327-333.

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