フェンジャイトの変形によるアルゴン離散機構
Argon release mechanism of deformed phengite

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The author has proposed the argon release from phengites in HP-UHP metamorphic rocks by their ductile deformation in the exhumation and cooling of the metamorphic sequences to explain the relationships between K-Ar phengite ages and the metamorphic grade since Itaya and Takasugi (1988). This argon release hypothesis has not been accepted for 20 years until Nuong et al. (2008) described the age (K-Ar phengite)-temperature-structure relations in the Ishigaki high-pressure schist belt, southern Ryukyu Arc, Japan. Its main reason would be that the argon release mechanism is vague. Recently, the author made its mechanism clear in the literature that is in submission to journal. This paper will focus on the argon release mechanism of deformed phengites.

Cosca et al. (2011) described the effect of deformation on radiogenic argon retentivity from high pressure experiments (10kb and 600 ˚C over a period of 29 hours, giving ca. 10% shortening) performed on rock samples of peraluminous granite containing euhedral muscovite and biotite. Intragrain in-situ $^{40}Ar/^{39}Ar$ analyses for deformed muscovite provided 309 to 264 Ma, consistent with 0-16 % argon loss relative to the undeformed muscovite (311 Ma). They interpreted that the reduction in the effective diffusion length scale in naturally deformed rocks occurs most probably through productions of mesoscopic and submicroscopic defects such as stacking faults. The extreme size reduction of phengite observed at domains close to the rigid garnet in pelitic schists of the Sanbagawa belt are identical to the reduction in the effective diffusion length scale described by Cosca et al. (2011), likely enhancing the argon release. The Sanbagawa pelitic schists suffered extremely long deformation (longer than 31 million years) during the exhumation and had the extremely slow exhumation rate (slower than 0.7 mm/y). In this case, the phengite could grow up with “Ostwald ripening phenomenon” consuming the extremely fine-grained phengite close to the rigid garnet. The size reduction and “Ostwald ripening” growth would continue to become final stage of static phengite crystal size (0.02-0.06 mm in width and 0.4-1.0 mm in length) observed in matrix. During these processes phengite could experience chemical change depending on local bulk chemistry under the P/T conditions changing from moment to moment during the exhumation, making heterogeneous chemistry. On the other hand, Lago di Cignana UHP unit in western Alps suffered relatively quick deformation (shorter than 5 million years) during the exhumation and had the extremely fast exhumation rate (15 - 26 mm/y). In this case, the phengite crystals could record heterogeneously deformed domains in a crystal as well as among the grains, resulting in heterogeneous argon release. In fact, the laser step heating $^{40}Ar/^{39}Ar$ analyses of single phengite crystal in the UHP schists of Lago di Cignana provided significantly irregular age spectrum in comparison with the phengite from the Sanbagawa schists of which the age spectra show the perfect plateau for both the phengite separates and a phengite crystal.

A muscovite in metagranitoid from Grand Paradiso Massif in western Alps yielded heterogeneous age values, giving 54 to 218 Ma (Beltrando et al., 2013). The dated points by the crystal edge are significantly younger than the ages in the part far from the edge. These features suggest that the submicrosopic defects occurring preferentially near the crystal edges are affected by the rubbing with other phases, enhancing preferentially the argon release.

キーワード：白雲母の変形、変形時間、白雲母アルゴン点年代、上昇速度、アルゴン離散機構、実行拡散距離
Keywords: deformation of phengite, duration of deformation, in-situ Ar-Ar ages, exhumation rate, argon release mechanism, effective diffusion length scale

