On closure temperature of phengite K-Ar system

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Phengites are common in UHPM and HPM rocks and have been ubiquitous in geochronological study to reveal cooling histories of host rocks. In particular, the systematic K-Ar age determinations on them have often made important constraints on understanding tectono-metamorphic history of orogenic belts. In the last decade, however, some serious discordant K-Ar phengite ages have been realized in the subduction-related metamorphic rocks of SW Japan (Itaya & Takasugi, 1988; Takami et al., 1993; Itaya & Fukui, 1994; Itaya & Fujino, 1999). Scaillet et al. (1992) and Scaillet (1996) also discussed variable phengite Ar-Ar ages due to their chemistry and excess argon in the Dora-Maira massif of western Alps. These discordant age relations have also been reported from further more metamorphic sequences in the world (e.g. Giorgis et al., 2000; Jahn et al., 2001; Sherlock and Arnaud, 1999; de Jong, 2001).

The authors and their colleagues have carried out K-Ar and Ar-Ar age determinations of phengite separates from blueschist-facies calcschists in the Piemonte zone and UHPM rocks in the Zermatt-Saas zone, western Alps, and from UHPM rocks in the Tso Morari dome, western Himalara, Inida. In the process of these projects, the authors obtained variable K-Ar white mica ages ranging from 115 Ma to 41 Ma, and anomalously large chemical variations of white mica in the blueschist-facies calcschists. The petrographical and chemical observations on white mica strongly suggest that most mica crystals in the chlorite zone is of detrital origins and were derived from the pre-Alpine high-temperature metamorphic sequence such the Caledonian and/or Variscan. The detrital white mica in the chlorite zone has been not reset well during the Alpine subduction-related metamorphism. This feature is also observed in the chloritoid zone though the age variation is not so large in comparison with that in the chlorite zone. In contrast, the rutile zone, which was higher than 450 degrees in grade, has a uniform age. The complete resetting of detrital micas required at least 450 degrees in temperature, suggesting the closure temperature higher than 450 degrees because the resetting was achieved with the metamorphic reaction from detrital mica to metamorphic one.

Many cases of discordant ages in UHPM and HPM rocks are due to excess argon inherited from the host lithologies consisting of continental crust materials. This also suggests that the closure temperature was siginificantly higher than 350 degrees, which has been believed since Jager (1967). Recently, Villa (1995) proposed that the closure temperature was about 500 degrees. Our experiences for petrology and geochronology of UHPM rocks also prefer the high closure temperature close to 600 degrees because UHPM rock (600-630 degrees) from the Lake Cignana area, western Alps gives a SHRIMP U-Pb zircon age (44.0+/-0.7 Ma), Ar-Ar age (44.4+/-1.5Ma and 43.2+/-1.1Ma) of phengites included in garnet and Ar-Ar plateau ages (38-40 Ma) of matrix phengites.