European Mineralogical Conference
Vol. 1, EMC2012-751, 2012
European Mineralogical Conference 2012

Eclogites, Amphibolites and Argon: Tracking Argon through a Metamorphic Cycle

C. S. McDonald (1), C. J. Warren (1), S. C. Sherlock (1), and S. P. Kelley (2)

(1) Department of Environment, Earth and Ecosystems, CEPSAR, The Open University, Walton Hall, Milton Keynes, MK7 6AA, UK (christopher.mcdonald@open.ac.uk), (2) Department of Physical Sciences, CEPSAR, The Open University, Walton Hall, Milton Keynes, MK7 6AA, UK, (3) SUERC, Rankine Avenue, Scottish Enterprise Technology Park, East Kilbride, G75 0QF, Scotland, UK

^{40}Ar/^{39}Ar dating, based on the radioactive decay of potassium to argon, is commonly used to constrain the timing and rate of cooling in metamorphic terranes. The recent data suggesting that the diffusion of Ar in muscovite is pressure-dependant as well as temperature-dependant has profound implications for the interpretation of ^{40}Ar/^{39}Ar ages in metamorphic rocks, particularly those which form at high pressures in orogenic settings. In low-temperature, high pressure (LT-HP), rocks such as eclogites, careful interpretation of the data is needed to determine the meaning of Ar-Ar ages.

"Excess" ^{40}Ar, decoupled from its parent ^{40}K, may either be incorporated into the K-bearing mineral of interest during crystallisation or may diffuse into the grain from a grain boundary fluid during cooling. This excess ^{40}Ar acts to artificially increase the apparent grain age, and may not be identifiable using classic ^{40}Ar/^{39}Ar techniques such as step heating or isochron analysis. High pressure metamorphic mafic rocks are particularly prone to contamination with excess argon due to a combination of high pressures and rapid pressure-temperature-time pathways which act to hinder diffusion. The lack of grain boundary fluid acts to hinder efficient removal. It is commonly assumed that the Ar ages of more felsic host lithologies will behave more systematically due to an increase in available grain boundary fluid during the metamorphic cycle.

We have analysed K-bearing and non K-bearing minerals from both mafic and felsic lithologies from across the Nordfjord Ultrahigh-Pressure Domain of the Western Gneiss Region to determine: 1) the variation in apparent ^{40}Ar/^{39}Ar age with variations mineralogy across the terrane; 2) the variation in apparent age due to the varying P-T paths of the different lithologies and 3) to determine the variation on the apparent ^{40}Ar/^{39}Ar age due to the effects of variable overprinting during the exhumation path.

Both single grain fusion and in situ laser ablation analyses show that the mafic lithologies produce highly variable ages with minerals such as biotite yielding ages up to 3x greater than the age of peak metamorphism meanwhile, the felsic lithologies yield ages that are more consistent with the cooling and decompression, yet still yield highly scattered ages. These data indicates that Ar distribution is heterogeneous throughout this terrane and that the simple models of diffusion are insufficient to explain the behaviour of Ar during a LT-HP metamorphic cycle.

The ages are still older than models of simple volume diffusion in an open system. Overall the data suggests heterogeneous Ar distribution at all scales, despite the P-T conditions, in theory, being suitable for efficient diffusion. This suggests that the full details of the fluxes of Ar within a metamorphic rock during the pressure-temperature cycle are still unclear, and critical for directing future ^{40}Ar/^{39}Ar analyses and interpretations in metamorphic rocks.