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40Ar/39Ar systematics of high-strain eclogite-facies shear zones in the Lofoten islands, Norway

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During the Caledonian Orogeny (~480 Ma), Precambrian (ca. 2.6-1.7 Ga) granulite-facies rocks of Baltica were subducted underneath Laurentia to great depths and subjected to eclogite-facies metamorphism (ca. T=680 ºC and P=15 kbar). Resulting shear zones in the basement rocks were major pathways for hot fluid infiltration partially transforming the host rocks into eclogite. Eclogite-facies shear-zone rocks in the Lofoten Islands, Norway, were strongly overprinted by amphibolite-facies retrogression caused by hot-fluid infiltration producing localised injections of syn- and post-kinematic leucocratic rocks. This study examines five eclogite-facies shear zones present in different lithologies (gabbros, anorthosites and felsic gneisses) on the islands of Vestvagøy (Vågje) and Flasktadøy (Myrland, Skagen, Sommartuva and Nusfjord).

Retrogression of the eclogitic rocks resulted in the breakdown of omphacite to a fine-grained clinopyroxene-plagioclase symplectite, which was progressively replaced by hastingsitic to pargasitic amphibole. These amphiboles also coexist with biotite (annite), plagioclase, epidote and titanite in amphibolites. Zr-in-rutile geothermometry from eclogites indicates metamorphic temperatures of 647±33 °C for peak eclogite-facies conditions. For the retrogression, this calibration yields 554±22 °C, and the Al-in-amphibole geobarometer yields a metamorphic pressure of 8.2±0.5 kbar.

40Ar/39Ar laser step-heating of biotites yield flat age spectra. The biotites from eclogite rocks range from 845 Ma to 3230 Ma and 401 Ma to 1460 Ma in the amphibolite rocks, indicating the presence of variable amounts of excess 40Ar (40ArE). In each shear zone, biotites from the eclogite rocks are older than the ones in the amphibolites. Garnets from the eclogites also contain high quantities of 40ArE. 40Ar/39Ar step-heating of amphiboles formed at amphibolite facies yield plateaus ranging from 414 Ma to 720 Ma, which are generally younger than the coexisting biotite, suggesting that they were less affected by 40ArE. In two of the shear zones, amphiboles yield excellent plateaus of ~416 Ma, which is interpreted as a new cooling age for the timing of retrogression.

These results indicate that, during the eclogitization event, fluids with sufficiently high argon concentration were introduced throughout shear zones leading to significant argon partitioning into biotite. This is likely due to two important factors: i) the very high argon solubility in biotite, and ii) elevated ambient temperatures well above the biotite Ar closure temperature.

During retrogression, hot fluids with lower 40ArE concentrations and with an atmospheric Ar component were added. In the shear zones hosted by felsic gneiss, as in Myrland and Skagen, localised reheating by syn- and post-kinematic injections led to the redistribution of 40ArE throughout the matrix of the amphibolite-facies rocks which are more permeable than the eclogite lenses due to deformation. In the Vågje gabbro, biotites formed at amphibolite facies yield plateau ages of 1127 Ma in a garnet-amphibolite and 472 Ma in a garnet-free amphibolite, suggesting that the 40ArE concentrations of the fluids changed through continued retrogression. In Sommartuva, reheating by a local monzodioritic injection associated with decompression appears to have resulted in the release of 40ArE acquired during eclogitization, where late-stage biotites replacing amphibole and garnet from amphibolitic lenses yield Scandian ages of 413 and 401 Ma.