Effects of deformation and recrystallization on the K-Ar isotopic system of white micas: a model for interpretation.

G. Ruffet
G. Féraud
UMR Géosciences Azur, UNSA, Parc Valrose, 06108 Nice Cedex 2, France

A. Cheilletz
Ecole Nationale Supérieure de Géologie-INPL et CRPG-CNRS, 20 rue Notre Dame des pauvres, BP 20, 54501, Vandoeuvre-lès-Nancy, France.

S. Castonguay
Institut National de la Recherche Scientifique-Géoressources, C.P. 7500, Sainte-Foy, Québec, G1V 4C7, Canada

Whereas deformation mechanisms and kinematics of fault zones are generally well understood, their timing remains poorly constrained by geochronological data mainly because of incomplete reequilibration of the isotopic systems and/or to the presence in the analysed material of intermingled phases belonging to different stages of deformation. It is most often difficult to separate pure mineral phase synchronous of a tectonic event leading one to question geochronological data obtained on fault zones. The laser probe $^{40}Ar/^{39}Ar$ step-heating technique may in some cases provide a solution because of (i) the small size of the analysed samples and (ii) informations obtained from the step-heating technique. This work is a contribution to the interpretation of $^{40}Ar/^{39}Ar$ spectra obtained on shear fault systems.

White micas separated from deformed samples analysed with the laser probe $^{40}Ar/^{39}Ar$ step-heating technique frequently display disturbed age spectra which are far from fulfilling age plateau criteria, suggesting that 'intensity' of the deformation event was not sufficient to reset totally their K-Ar isotopic system. The striking feature of the obtained age spectra is a saddle shape, generally ascribed to the existence of an excess argon component (Harrison and McDougall, 1981) but which can be related, in these cases, to the 'complexity' of the deformed samples. Such disturbance results from the polycrystalline nature of the analysed samples with neocrystallizations of white mica sub-grains clearly related to the deformation event. Therefore, the $^{40}Ar/^{39}Ar$ experiments reflect the mixing of distinct components of radiogenic argon trapped in distinct reservoirs and three domains can be identified in the saddle-shaped age spectra obtained, according to the degassing temperatures: the low, intermediate and high-temperature domains.

The intermediate-temperature domain, showing the lowest apparent ages (foot of the saddle) would correspond to the main degassing pulse of the neocrystallized white micas. Their degassing occurs concurrently with that of the preexisting (inherited) muscovites and the decrease of their contribution increases, by a balance effect, the relative contribution of the degassing of the inherited phase, resulting in variable saddle shaped age spectra minima. These minima are therefore maximum estimates of the age of the deformation.

The degassing of the inherited muscovites is mainly expressed in *the high-temperature domain*, probably because degassing of the neoformed white micas, with lower sizes, and lower diffusion radius, is decreasing or achieved. The corresponding apparent ages are minimum estimates of the age of the inherited phase.

The higher apparent ages from *the low-temperature domain* can express the degassing of a radiogenic/inherited component trapped within the newly created voids provoked by the kinks and the small neoformed grains within the structure of the deformed crystal or a recoil phenomenon during irradiation.

This model relies on the results of the study of a ductile shearing event recognized in gneisses and baryte veins of the crystalline internal massifs of alpine Maghrebides in Algeria (Cheilletz *et al*, submitted). In association with this deformation event, neoformation of small phengite crystals is systematically observed, either along the boundaries or inside the crystals. Microprobe analyses show a clear difference between earlier porphyroclastic grains and small neoformed crystals, the latter being enriched in the phengitic component.

Dating of the shearing movement, at 128 Ma, is provided by $^{40}Ar/^{39}Ar$ laser-probe experiments

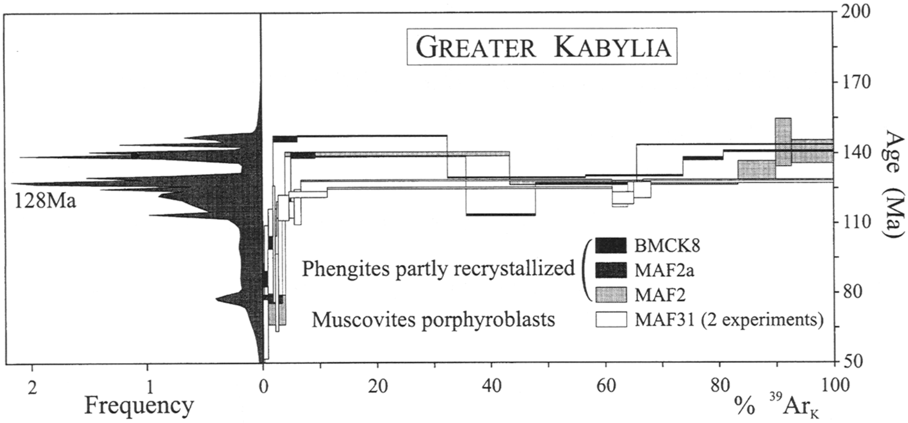

FIG. 1. $^{40}Ar/^{39}Ar$ age spectra and frequency diagram of the apparent ages of white micas.

(Fig. 1) performed on synchronous neoformed porphyroblasts of white micas. The model is supported by the concordance between the $^{40}Ar/^{39}Ar$ plateau ages displayed by these porphyroblasts and the minimum apparent ages displayed by the saddle-shaped age spectra obtained on the deformed and partly recrystallized phengite porphyroclasts (One lower apparent age excepted).

This model could allow to explain the results of a regional-scale ^{39}Ar-^{40}Ar laser probe study of muscovites single-grains (*c.* 80 analyses) within the Notre-Dame Mountains Anticlinorium (NDMA; Quebec Appalachians internal Humber zone). The NDMA is delineated on its northwestern flank by the Bennett backthrust fault, and to the southeast by the St. Joseph normal fault. The regional metamorphic grade is of greenschist facies. Most of the obtained age spectra display plateau ages with nevertheless very slight saddle shapes. These plateau ages scatter in the range *c.* 430–410 Ma whithout any spatial coherence. On the other hand, the frequency study of all the measured significant apparent ages clearly shows that the frequency of younger apparent ages (saddle minima) increases towards the faults. These age variations are interpreted as representing cooling and exhumation of the NDMA in Silurian time, controlled by the two faults associated with two distinct deformation histories. The event may have lasted at least 20 Ma from the hinterland-verging deformation (estimate at ca. 430 Ma) embodied by the Bennett backthrust fault, until the end (?) of the extension deformation period (estimate at *c.* 410 Ma) which was accommodated by movement on the St. Joseph normal fault.

References

Cheilletz, A., Ruffet, G., Marignac, C., Kolli, O., Gasquet, D., Féraud, G. and Bouillin, J.P. Submitted to *Tectonophysics*.