

# Direct dating of fabric forming events: resolving a continuous record of Alpine tectonic events in the Aegean region

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$^{40}\text{Ar}/^{39}\text{Ar}$  laserprobe dating allows direct dating of discrete deformational and kinematic events, as long as; regional thermal conditions are well constrained, deformational fabrics and kinematics are carefully characterized, and the fabric forming mineral used for dating can be related to the right fabric and the right metamorphic assemblage. Considering the metamorphic stability field and the closure temperature ranges for the main K-bearing minerals that can be used for  $^{40}\text{Ar}/^{39}\text{Ar}$  age dating (Fig. 1), it is shown that two temperature windows exist at which white mica and hornblende respectively may (re-)crystallize below their closure temperature ranges, which is of interest as discrete fabric forming events might be directly datable. In this study  $^{40}\text{Ar}/^{39}\text{Ar}$  laserprobe dating has been applied to white mica bearing fabrics in greenschist and blueschist facies settings, because:

1) the high sensitivity and low blank characteristics of the laserprobe technique allows small sample fractions or single crystals to be analysed (e.g. Wijbrans *et al.*, 1990), 2) white mica may crystallize in deformation fabrics below its argon closure temperature (e.g. Dunlap *et al.*, 1991), 3) the degree of deformation of white mica is an important factor in the resetting of the argon isotopic system (e.g. Scaillet *et al.*, 1990), and 4) metamorphic temperatures in blueschist and greenschist facies settings tend to fall near the argon closure temperature in white mica.

In our approach, ductile deformational structures which formed in the metamorphic sequences during the Alpine and post-Alpine tectonic events were identified in the field and their kinematic characteristics were investigated. Subsequently, integrated

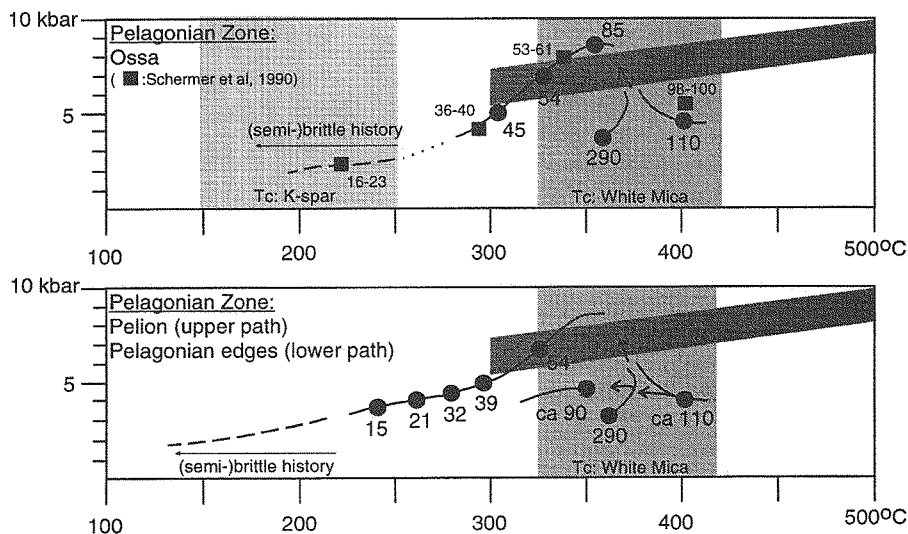


FIG. 1. HP-T-t paths from two massifs of the Pelagonian Zone, Internal Hellenides, mainland Greece.

(micro-)structural and metamorphic investigations were applied to obtain a careful characterization of the deformational fabrics. Mineral separates of white mica, which formed in these fabrics, were analysed by applying  $^{40}\text{Ar}/^{39}\text{Ar}$  laserprobe dating (both incremental heating experiments and spot fusion experiments) to obtain absolute ages of fabric forming events. Muscovite porphyroclasts in mylonite zones were used to deduce the protolith thermal histories (310–280 and 120–100 Ma). After establishing these, recrystallized white micas, associated with the mylonitic foliation were selected to date the fabric development of the mylonite. Formation of Alpine deformational structures in parts of the Aegean region occurred at metamorphic temperatures which failed to reset most pre-Alpine  $^{40}\text{Ar}/^{39}\text{Ar}$  cooling ages in muscovite porphyroclasts. The low metamorphic temperatures at Alpine times have preserved the argon isotopic signature in white mica bearing deformational structures, which allows direct dating of these structures and refinement of the Alpine tectonic history in the region.

By this approach we have been able to obtain a continuous record of Alpine tectonic events in the Aegean region of the Eastern Mediterranean (Fig. 1).

Ultimately the exact timing of the main regional tectonic episodes in the Aegean region will serve to quantify tectonic models of the circum Aegean region and/or the Mediterranean as a whole. The recorded Alpine tectonic events not only document the onset of high pressure metamorphism in the Cretaceous (pre 85 Ma) and episodes of deformation of the high pressure rocks both at blueschist and greenschist facies conditions in the Tertiary but also place time constraints on episodes of ductile deformation, related to the exhumation of the metamorphic domains (dominantly at 54 Ma and 15–20 Ma).

## References

- Dunlap, W.J., Teyssier, C., McDougall, I. and Baldwin, I. (1991) *Geology*, **19**, 1213–16.
- Scaillet, S., Feraud, Lagabrielle, G.Y., Balleuvre, M., Ruffet, G. (1990) *Geology*, **18**, 741–4.
- Schermer, E.R., Lux, D.R. Burchfield, B. (1990) *Tectonics*, **9**, 1165–95.
- Wijbrans, J.R., Schliestedt, M. and York, D. (1990) *Contrib. Mineral. Petrol.*, **104**, 582–93.