Dating of deformation using microsampling techniques

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Deformation of rocks within fault zones produces a mixture of deformationally-induced mineral growth and older porphyroclasts inherited from the precursor rock. Conventional mineral separation techniques based on different grain size are usually not capable of sampling only minerals that are unequivocally related to deformation.

Microsampling techniques, however, allow sampling of minerals from specific microstructural sites, which in mylonites include pressure shadows around rigid objects and mineral fibres grown between stretched porphyroclasts. In pseudotachylytes, minerals crystallized from the frictional melt have to be distinguished from partially resorbed porphyroclasts. Techniques that are capable of sampling on the sub-mm scale include laser-spot $^{40}Ar/^{39}Ar$ analyses and Rb-Sr microsampling, which utilizes a microscope-mounted drill for sampling directly from rock thick sections.

Rb-Sr microsampling

In case of the Rb-Sr system, significantly improved chemical and mass spectrometric procedures allow the precise analysis of Sr amounts as low as ~100 pg (Sr blanks ~10 pg). Sample weights can therefore be reduced to ~5 microgram, both because of the relatively high Rb and Sr concentrations and the concomitantly high Rb/Sr-ratios in certain minerals like white mica. Under the middle greenschist facies metamorphic conditions recorded by the analysed mylonites, white mica Rb-Sr ages represent formation rather than cooling ages (Cliff, 1993). Due to texturally controlled microsampling, white mica ages can be directly considered as ages of deformation.

This approach is illustrated by mylonite DAV9 collected from the contact aureole of the ~31 Ma old Rieserferner tonalite intrusion along the DAV-fault S of the Tauern window, Eastern Alps (Borsi *et al.*, 1978). Contact metamorphic andalusite was transformed into σ-clasts during subsequent mylonitization, accompanied by white mica growth in the pressure shadows on both sides (Fig. 1 a,b). Microgram-sized white mica and inclusion-free andalusites from two positions in thick section ~1 cm apart have been analysed to constrain the age of mylonitization (Fig. 1c). The internally different white mica Rb/Sr ratios (12.0 to 35.3) together with the low-Rb/Sr-andalusites define an errorchron, whose slope indicates a relatively imprecise age of 30.1 $\pm$ 4.6 Ma (95% c.l.; MSWD = 33.6). The main reason for the observed scatter are small differences in initial $^{87}Sr/^{86}Sr$-ratios among the two andalusites sampled at distances of ~1 cm. The 30 Ma age of mylonitization agrees well with the age of the tonalite (31 $\pm$ 3 Ma, Borsi *et al.*, 1978) and indicates deformation subsequent to the magmatic event. The mylonite quartz fabrics also record higher deformational temperatures when compared to other mylonites outside the contact aureole.

Laser-spot $^{40}Ar/^{39}Ar$ analyses

Pseudotachylytes have been analysed by laser-spot $^{40}Ar/^{39}Ar$. Following frictional melting, a secondary (K-)Ar-isotopic equilibration is likely to be achieved, since the major K-bearing minerals (mica, amphibole, K-feldspar) melt at relatively low temperatures (Spray, 1992). Therefore, mainly quartz and Ca-rich plagioclase occur as porphyroclasts. The high-spatial resolution of the laser-probe allows for in-situ discrimination between newly formed matrix formed during frictional melting and inherited porphyroclasts, provided the latter are not too fine-grained.

Pseudotachylyte JAU34 was collected along the Jaufen fault within the Austroalpine unit of the

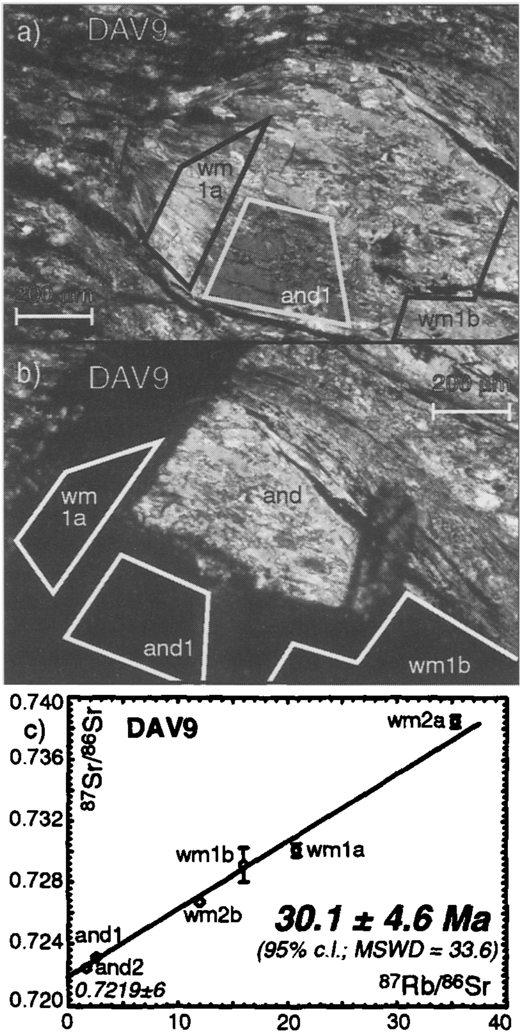

FIG. 1. Photomicrographs of thick section of mylonite DAV9 prior (a) and after sample preparation (b) by microsampling. and...andalusite, wm...white mica. The size of analysed samples is given by the black and white contours. c) Rb-Sr isochron diagram for two andalusites and their corresponding two white mica.

Eastern Alps. It is a 10 mm thick fault vein that contains mainly quartz and rare plagioclase clasts.

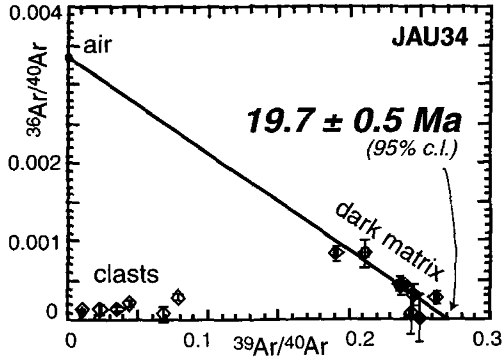

FIG. 2. Isochron plot of laser-spot analyses of pseudotachylyte JAU34.

Fifteen individual laser-spot analyses were obtained from a polished thick section. The corresponding ages clearly fall into two groups depending on whether melt or clasts have been analysed (Fig. 2). The mean apparent age of all melt-related spots is 19.7 ± 0.5 Ma ('dark matrix'; 95% c.l.), whereas apparent ages of the clasts range between 60 and 430 Ma ('clasts').

Conclusions

Microsampling techniques on the sub-mm scale allow dating of minerals that are unequivocally related to deformation. Compared to conventional techniques, the resulting ages are more accurate and reliable, although not necessarily very precise. It will be interesting to expand the direct dating of deformation techniques to other targets such as the dating of strain fringes around e.g. pyrite in carbonate mylonites or the dating of calcite fibres grown during slickenside formation.

References

Borsi *et al.* (1978) *Geol. Rundschau*, **68**, 41–60.

Cliff, R.A. (1993) Proc. VI Summer School, Siena, 131–40.

Spray, J. (1992) *Tectonophysics*, **204**, 205–21.