Seismogenic strain rates during ductile deformation: The example of South Cyclades Shear Zone, Greece

M.A. FORSTER[1] AND G.S. LISTER[3]

[1 1] Research School of Earth Sciences, The Australian National University; <marnie.forster@anu.edu.au>

The potential role of shear heating during orogenic processes has remained contentious. The consensus view is that effects associated with this process are of little relevance. Heat production associated with ductile deformation may be readily dissipated, and have no impact if deformation rates in the crust are in the range 10^{-11} to 10^{-14} s^{-1} and deviatoric stress values remain <~100 MPa. Yet data that suggests a non-trivial role for shear heating continues to emerge, in particular associated with the operation of major ductile shear zones. This data can be interpreted in terms of the effects of a short-lived thermal pulse that takes place during shear zone operation. It can be supposed that the duration of the thermal pulse is not long enough to allow transformation of metamorphic minerals to new parageneses (except where deformation and fluids facilitate the process - normally within the shear zone itself). Similarly it can be supposed that the duration of the thermal pulse is not long enough to allow complete diffusional loss of argon from relict mineral grains, which therefore display anomalously older ages, except where these relicts have been substantially deformed and/or recrystallized.

A previous study in the South Cyclades Shear Zone, Aegean Sea, Greece, constrains cooling rates from 450°C to 350°C, spanning the range of temperature during which ductile mylonites accumulated ~300% stretching. By inference strain rates in the mylonite must have been considerably higher than values normally envisaged (by as many as 4-5 orders of magnitude), although these high strain rates may only be transiently maintained. This is of interest because by implication deviatoric stress levels must be also correspondingly at least an order of magnitude greater, implying that we cannot ignore heat production as the result of the conversion of the mechanical work necessary to accomplish plastic deformation during operation of such shear zones.

Therefore we have conducted detailed thermochronology and geothermometry traverse through the km-scale South Cyclades Shear Zone to assess the significance of shear heating during operation of this crustal-scale movement zone. K-feldspar thermochronology allow constraints on the cooling history at different locations in the shear zone, and estimates as to the duration of thermal events. Data suggest that the shear zone operated at rates that would seem appropriate to the period of relaxation after major seismic events. P-T conditions that allow growth of garnet+biotite could endure for only short time periods, estimated here as not exceeding one thousand to ten thousand years.