Geophysical Research Abstracts, Vol. 7, 05288, 2005
SRef-ID: 1607-7962/gra/EGU05-A-05288
© European Geosciences Union 2005

Fluid involvement in low-angle normal fault weakening: short- and long-term processes

C. Collettini (1), R.E. Holdsworth (2) and C.J. Spiers(3)

(1) Geologia Strutturale Geofisica, Dipartimento di Scienze della Terra Università di Perugia, Perugia, Italy , (colle@unipg.it).

(2) Reactivation Research Group, Department of Geological Sciences, University of Durham, Durham, England, UK.

(3) High pressure and Temperature Laboratory, Faculty of Earth Sciences, Utrecht University, Netherlands.

The influx of fluids into fault zones can trigger two main types of weakening processes - mechanical and chemical – that operate over different timescales and facilitate movement on severely misoriented faults such as low-angle normal faults, LANF.

In the short term, i.e. during the seismic cycle, crustal fluids can be trapped within mature fault zones where a clearly defined, fault-bounded core region of highly deformed, fine-grained, often strongly foliated phyllosilicate- or clay-rich fault rock has developed. These cores may exhibit low permeability and act as effective seals favouring the development of fluid overpressures that make the fault weaker then the adjoining crust. The microseismic activity of a LANF, located in the active region of the Northern Apennines, is likely to be related to localized fluid overpressures within the fault zone favoured by the documented large mantle-derived CO2 degassing. In addition, the same area shows fossil examples of fluid overpressuring in the core regions of exhumed LANF, where complex systems of hydrofractures testify to the cyclic build-up of fluid pressures synchronous with fault movements.

Long-term weakening processes related to syntectonic fluid-rock interactions are now well documented from field-based and microstructural studies of the exhumed low-angle normal faults of the Northern Apennines. These studies suggest that during fault activity in the brittle crust below 3-5 km depths, fluids react with the fine-grained cat-

aclasites in the fault core to produce fine-grained aggregates of weak, phyllosilicate-rich fault rocks that promote low-grade alteration and the onset of stress-induced dissolution-precipitation processes (pressure solution). The frequently observed localization of later fault displacements along these foliated layers suggest that these processes lead to important fault weakening. Independent support for this hypothesis comes from the results of laboratory experiments carried out on fault rock analogue materials that simulate the behaviour of phyllosilicate-rich fault rocks. Significant strain weakening is documented in the presence of saturated brine fluids with a switch from a cataclastic deformation to a pressure solution-accommodated deformation. The resulting fault rock textures formed during pressure-solution-accommodated creep are very similar to those preserved in the cores of some phyllosilicate- and clay-rich fault zones. Lab experiments and microphysical models show that the switch in rheology is associated with a decrease in friction from Byerlee's values ($0.6< \mu s<0.85$) to ~ 0.2 or less.

The decrease in friction produced by the long-term weakening processes allow movements on severely misoriented LANF in a stress field characterized by vertical σ_1. In terms of slip-behaviour, the pressure solution-accommodated creep along the weak low-angle normal fault is likely to be an aseismic process with the recorded microseismicity related to local short-lived attainment of fluid overpressure. These observations suggest that fluids play a key role in allowing LANF to accommodate many kilometres of crustal extension in currently active regions such as the Northern Apennines of Italy.