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場所：6 号館　303

講演者 D.R. Faulkner 博士　（Senior Lecturer）
Rock Deformation Laboratory
Department of Earth and Ocean Sciences
University of Liverpool, UK

講演題目：　On the Structure, Mechanics and Fluid Flow Properties of Fault Zones

Abstract
The mechanics and fluid flow properties of faults are controlled by their fault zone structure and physical properties. In order to try to characterize both fault zone structure and to predict the physical properties of various components of fault zones, detailed field studies combined with laboratory high pressure experiments have been performed. In this contribution, I outline some recent work from the field and laboratory that has been conducted by the group in Liverpool.

Faults have generally been thought of as discrete structures with a very localized fault core (<50 cm thick) surrounded by a fracture damage zone on the order of 100 m thick. Recent work on the Carboneras fault in southeastern Spain and the Caleta Coloso fault from northern Chile has established that much more complex fault zone structures are possible, where multiple anastomosing strands of high strain material (gouges or cataclasites/ultracataclasites) surround lenses of fractured protolith that have become entrained in the fault core. This complex fault zone structure has major implications for the mechanical, hydraulic and seismological properties of fault zones.

In order to establish the hydraulic properties of faults, the permeability of both the fault core materials and the fracture damage zone have been analysed in the laboratory. Surface-derived samples of phyllosilicate-rich fault gouge from the Carboneras fault were collected in orthogonal directions relative to the orientation of the fault. The permeability showed marked anisotropy, up to three orders of magnitude, produced by

microlayering of clay-rich bands with more granular porous layers. The anisotropy increases with the effective pressure, indicating that the clay-rich layers compact more readily as pressure increases. The ultralow permeability of these rocks, coupled with the complex fault zone structure suggests that faults similar to the Carboneras fault can impound high pore fluid pressure within the fault core for geologically significant periods of time.

We also studied the intensity of damage surrounding the Caleta Coloso fault. The density of a particular type of microfracture (fluid inclusion planes) was found to decease exponentially with distance away from the fault core. We sought reproduce this microfracture damage in experimental samples to place constraints on what the microfracture permeability of the damage zone was while the fault was active at depth. To this end triaxial deformation experiments were performed on initially intact samples of crystalline rock. We measured the permeability and the pore volume change during loading to failure. The permeability increased by up to 3 orders of magnitude immediately prior to failure, indicating that the microfracture permeability in fault damage zones is capable of favouring advective fluid transport in the Earth's crust.

Finally, in order to explain high pore fluid pressure weakening of faults without inducing hydrofracture as the least principal stress is pushed into the tensile field, it is shown how microfracture damage surrounding the fault core leads to a change on the elastic properties of the rock. These elastic property changes have been modelled to show that the stress field in the damage zone can be rotated as the fault core is approached, thereby circumventing the problem of hydrofracture as pore fluid pressure is increased to the levels necessary to facilitate the slip on such unfavourably oriented 'weak' faults.