The Impact of Fault Zone Architecture in Modelling the Fluid Overpressure Driven Faulting and Seismicity of the Colfiorito Seismic Sequence

T. Snell[1], N. De Paola[1], J. van Hunen[1], and S.Nielsen[1]

[1]Department of Earth Sciences, Durham University, Durham, UK.
Thomas.snell@durham.ac.uk

The mainshocks of the 1997-98 Colfiorito seismic sequence nucleated at 6km depth within the Triassic Evaporites. It has been proposed that the maishocks and their aftershock sequenece was driven by supercritical CO_2 overpressures, measured in two deep boreholes drilled in the epicentral area. Here, we present a numerical invesitigation about the effects of overpressured supercritical CO_2 on earthquake nucleation processes, using natural fault zone architecture in Triassic Evaporites rocks and laboratory derived permeability values as modelling input parameters.

Outcropping faults in Triassic evaporites in the Umbria-Marche Apennines, analogous to the nucleation site for the Colfiorito seismic sequence, exhibit lithologically heterogeneous and anisotropic fault zones comprising: a fault core made of an inner domain, where most of the shear displacement is accommodated, encompassed within an outer domain of foliated fault rocks; a damage zone, where the intensity of fracturing decreases as one moves away from the fault core and towards the intact protolith rocks. The inner fault core is characterized by fault gouges, cataclastites, often showing the development of very fine-grained ultracataclastites associated with thin, a few millimetres, slip zones of localized slip. Fault-parallel foliated cataclasites are the dominat fault rocks in the outer fault core. Distributed extensional/shear fractures and subsidiary faults are the dominant structures in the damage zone.

Fluid flow from high pressure reservoirs in the damage zone have been modelled across the fault core, using its internal architecture and the mechanical and permeability values measured during laboratory experiments from previous studies.
A finite difference method is used with a time dependent solver to solve a nonlinear Darcy flow model with a pore pressure and stress dependent permeability.

A comparison of the time evolution of pore pressure fields is attempted for a fault assuming both a homogenous and a heterogeneous structure. Predictions of the fault patches undergoing failureand the effective stresses acting upon them are made and used to calculate earthquake nucleation length.

The inclusion of heterogeneous fault zone architecture within numerical simulation can be shown to alter the predictions of the length of the interseismic period, by producing failure patches which exhibit unstable behaviour more readily.