Field Investigation and Numerical Modeling of Pressure Solution Seam Growth and Evolution Observed in Clastic Rocks, County Cork, Ireland

Nenna, Filippo A.[1]; Zhou, Xiaoxian [1]; Aydin, Atilla [1] (1) Geological and Environmental Sciences, Stanford University, Stanford, CA.

Pressure solution seams (PSSs) are closing mode volume reduction structures that occur perpendicular to the greatest compressive stress. Their formation mechanism is intragranular pressure solution which occurs in three steps: dissolution of solid material, diffusion of dissolved material, and precipitation of dissolved material. Previous studies have inferred that PSSs grow laterally due to further dissolution at the tip and by thickening due to dissolution at the seam boundary. However, the processes and conditions required for growth to occur and the effect of neighboring seams upon each other are not well known.

We present new observations that constrain the processes by which PSSs initiate and grow in low porosity clastic rocks from County Cork, Ireland. These rocks were subjected to mechanical and chemical shortening during the Variscan Orogeny, a time equivalent event to that which deformed deep marine units in the Gulf of Mexico and the Appalachians.

We elucidate the details of PSSs initiation at grain to grain contacts of quartz minerals. As quartz dissolves, clay remains as a residue along the grain contacts and fills the adjacent pore spaces to form incipient PSSs of more than one grain boundary and associated pores in between them. Further growth of PSSs occurs by lateral and transverse linkage and coalescence of neighboring incipient PSS segments and results in lengthening and thickening of the seam, respectively.

Multiple PSS segments concentrate in thin tabular zones that appear as single macroscopic PSSs visible in hand samples, thereby providing an indication for the role of PSSs interaction in their growth process. We use a finite element model to investigate the stress distribution associated with idealized PSSs in the form of elliptical bodies within a linear elastic medium. For a single PSS, the normal stresses at the tip of the elliptical body is compressive and significantly amplified with respect to the remote stresses, whereas on the flanks they are slightly reduced. We have calculated stresses associated with parallel and echelon PSSs and found that, relative to a single PSS, the normal stresses at the tip areas of two PSSs are further increased and the normal stresses on their flanks can also increase.

Macroscopic PSSs have significantly lower porosity than the surrounding rock and may be responsible for anisotropic permeability and acoustic velocity, which may be of interest considering these rocks form off shore reservoirs.