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Influence of anisotropy on the variation of the stress field on fault systems: an experimental approach

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Many natural rocks can be considered as mechanically anisotropic. This anisotropy can be characterized by either a compositional layering or a penetrative foliation due to preferred orientation of crystal fabrics.

Previous studies have shown that the presence of anisotropy produces a variation on the stress and strain magnitudes in relation to the applied boundary conditions. Many authors have focused on the study of partitioning of kinematics components or on properties contrast between materials. Nevertheless, the influence of anisotropy on the development of fault systems has not been deeply studied. One question could be if fault system patterns are related either to regional processes or to local scale conditions. At a first glance it seems that anisotropy produces a variation of the local stress field, but how important is it?.

As a preliminary approach, this contribution presents the results of some experiments performed using anisotropic analogue materials, deformed under coaxial conditions. Results are compared to other non-coaxial models and some field examples.

The influence of the α_0 angle between anisotropy planes and the extension axis has been studied for two cases (0º and 40º). In both situations two conjugate sets of shear faults develop. For α_0=0º models both arrays are approximately symmetrical while one set dominates for oblique cases. Stress inversion methods have been applied to calculate the theoretical stress field from fractures distribution. The obtuse bisector between both arrays of faults coincides with the maximum shortening stress (σ_1). Two cases can be distinguished: (a) for α_0=0º models the local stress field is parallel to the boundary conditions while (b) for $\alpha_0 \neq$0º models the obtuse bisector is approx. perpendicular to layering. In this case, with increasing deformation, both fault sets rotate in the same sense as foliation does, and the obtuse angle slightly increases. These results show that the highest deviations occur for low strain, while increasing deformation leads to parallelization of the local stress field with the boundary conditions.

The conclusions obtained from these experiments are compatible with previous non-coaxial experimental studies. They are also congruent with several field case studies, from brittle to ductile rock mechanical behaviour and from distributed to localized deformation settings. All these comparisons indicate that conjugate fault systems are approx. symmetrical regarding to anisotropy and, when they form, the local stress field may be different from the expected regional conditions.