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Paleo-stress inversion using a full mechanical scenario and multiple types of data

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Methods for stress inversion, using measured striations and/or throw on faults, are mainly based on on the assumptions that: (i) the stress field is uniform within the rock mass embedding the faults (assuming no perturbed stress field), and that (ii) the slip on faults has the same direction and sense as the resolved far field stress on the fault plane (Wallace-Bott hypothesis). However, it has been shown that slip directions are affected by: (i) anisotropy in fault compliance caused by irregular tip-line geometry; (ii) anisotropy in fault friction (surface corrugations); (iii) heterogeneity in host rock stiffness; and (iv) perturbation of the local stress field mainly due to mechanical interactions of adjacent faults. Mechanical interactions due to complex faults geometry in heterogeneous media should be taken into account while doing the stress inversion. Determining the parameters of such paleostress in the presence of multiple interacting faults requires running a lot of simulations, and therefore a huge amount of computation time in order to fit the observed data.

Here, we investigate this approach with a 3D boundary element method using the principle of superposition that applies to linear elasticity for heterogeneous, isotropic whole- of half-space media. Given a fault system and some measures of the (1) fault throw, (2) dip-slip and/or (3) slickenline directions, (4) stress measurements, (5) breakout orientation, (6) micro seismicity, (7) GPS and (8) InSAR data, (9) fold axis, (10) focal mechanisms, (11) fractures orientation (joints, veins, dikes, pressure solution seams with stylolites) or (12) secondary fault plane orientations, we recover for the Andersonian remote stress state for multiple tectonic events in a fast way (< 2mn) using a Monte-Carlo simulation. It is worth mentioning that in this modeling, the Wallace-Bott hypothesis is not used since a full mechanical scenario is employed. We provide some natural examples using different kind of data.