Case Study 1: Earthquake-induced stress modelling

**Background**

Slip on a fault alters the surrounding stress field, and can cause nearby faults to fail, causing aftershocks (King et al., 1994).

**Objective**

Model the slip event that led to the M6.5 earthquake in Kyrgyzstan in 2008 (Teshebaeva et al., 2014); compare predicted displacements and stress changes to satellite data and aftershock distribution.

**Figure 1**

- A) Similar apparent displacements from “observed” satellite data and “Modeled” using Fault Response Modelling. b) Double cumulative displacements on optimally oriented planes following the modelling (grey mesh). Distribution of observed aftershocks (black points) reinterpreted reasonably well along strike and dip, except along strike to the northwest.

**Figure 2**

- a) “Observed” and “Modeled” data. b) Stress in maximum compressive direction (σ1) and strain in maximum lengthening direction (ε1).

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Case Study 2: Fracture prediction in a hydrocarbon reservoir

**Background**

Fracture systems influence porosity/permeability and the connectivity of hydrocarbon reservoirs.

**Objective**

Use Fault Response Modelling to predict the orientations of fractures in a pop-up block within the La Concepción oilfield in the north-western Maracaibo Basin of Venezuela. Compare to observed fractures to assess whether they are controlled by dip-slip faulting.

**Figure 3**

- a) Slip gradients on the faults bounding the pop-up block were based on the displacement of the Maraca horizon (blue) and were calculated using the Allan Mapper tool in Move. Black lines show well location. b) Comparison between measured (in orange) and modelled (black) slip vectors. c) Stress isochrones from modelled “observed” displacements (grey mesh) and modelled (red mesh). d) Stress isochrones from modelled (red mesh) and observed displacements (blue mesh).

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Case Study 3: Ore body formation controlled by fault-related damage

**Background**

Fracturing in damage zones around listric normal faults can control ore body formation (Micklewaite 2004).

**Objective**

Use geomechanical forward modelling to predict the orientations of fractures in a pop-up block extending 15 km laterally from the fault, using an interpreted listric normal fault by forward modelling the fault geomechanically to determine whether it is feasible that forward model fault reproduces it cannot be reproduce it cannot be correct. Fault Response Modelling can geomechanically forward model fault-related deformation whilst considering the mechanical properties of the rock (including any spatial variations).

**Figure 4**

- a) Fracture orientation from Fault Response Modelling. b) Comparison between modelled and observed fracture orientations. c) Fracture orientation from Fault Response Modelling (left); dilation tendency near fault coincides with high Coulomb stress change and identifies a potential target (indicated with black cross).

**Figure 5**

- a) Total displacement around a modelled listric normal fault. b) Magnitude of σ from the modelled induced stress. c) Theoretical Coulomb stress change around the modelled horizons (black), for Poisson’s ratio of 0.25 (grey) and 0.30 (green). d) 3D stress isochrones from modelled faulting (blue mesh) and faulting isochrone modelled from 3D stress forward model faulting (black mesh). e) Stress isochrones from forward model faulting (blue mesh) and stress isochrones from faulting (black mesh). f) 3D stress couplets from forward model faulting (blue mesh) and stress couplets from faulting (black mesh).

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Case Study 4: Geomechanical forward modelling of faults

**Background**

Forward modelling is a three-dimensional validation technique; if an interpretation cannot be reproduced it cannot be correct. Fault Response Modelling can geomechanically forward model fault-related deformation whilst considering the mechanical properties of the rock (including any spatial variations).

**Objective**

Geomechanically validate an interpretation of a listric normal fault by forward modelling the fault-related deformation. In particular, determine whether it is geomechanically feasible that hangingwall rlover could extend 15 km laterally from the fault.

**Figure 6**

- a) Fracture intensity, calculated by the Fault Response Modelling. b) Comparison between modelled (in orange) and observed (in blue) fracture intensity. c) Stress in maximum compressive direction (σ1) and strain in maximum lengthening direction (ε1). d) Stress isochrones from modelled (red mesh) and observed displacements (blue mesh).