

Computational tools such as numerical geomechanical modeling offer the opportunity to couple physically realistic and mechanically rigorous numerical analyses with existing geometric and kinematic data to yield testable predictions. Geomechanical modeling is capable of handling complex geometries and realistic material models to temporally and spatially analyze stress and deformation. Depending on the problem of interest, either continuum or discontinuum mechanics-based approaches can be used.

Southwest Research Institute® (SwRI®) has developed effective approaches to building and analyzing geomechanical models of complex geologic structures, including:

- An extensional fault-tip monocline in west Texas
- A contractional fault-related fold in the North American Cordillera
- A 3D analysis of subsurface stress development following faulting and erosion

## Mechanics-Based Approaches

Oil and gas exploration and production have many problems that are well-suited to a geomechanical modeling approach, at scales ranging from the field or reservoir down to the borehole. For example, regional stress fields are an important control on fault slip and fracture dilation potential, which in turn affects reservoir sealing and permeability anisotropy.

Once the initial geometry is established, appropriate boundary conditions are defined. Loading conditions are problem-dependent and can include a combination of displacements, velocities,

accelerations or stresses. Initial conditions may also include temperature or pore pressure distributions. Constitutive relationships must be selected to represent the rheological behavior of the simulated rocks. They can range from simple linear elastic to complex inelastic materials.

When coupled with realistic rock properties, geomechanical simulation provides a valid forward model that can be used to validate a geometric and kinematic restoration. The complete 3D spatial and temporal distribution of variables (e.g., stress, strain, temperature, pore pressure, etc.) is available at all stages during the simulation.

## Capabilities

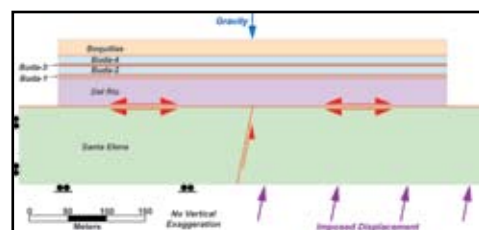
SwRI scientists model geologic structures from borehole- to large-scale in 2D and 3D.

### Continuum approach

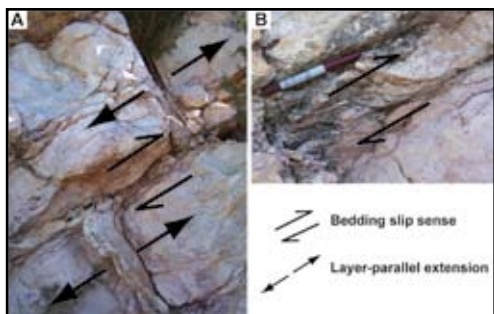
- Folding
- Salt tectonics
- Macroscale faulting

### Discontinuum approach

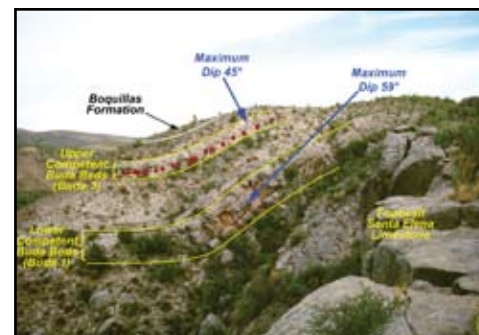
- Fracturing
- Fault initiation



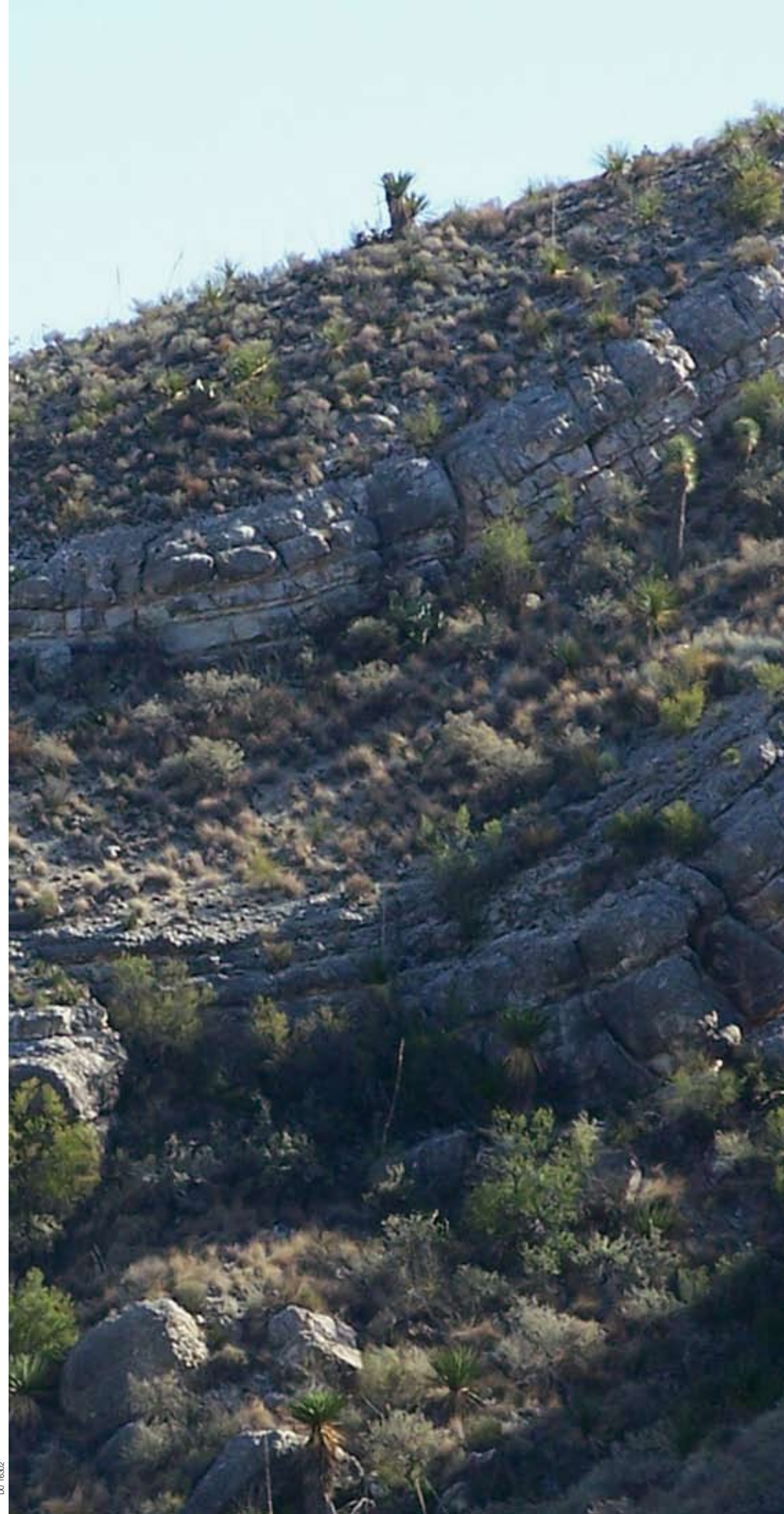
Geometry and boundary conditions for finite element models. Red lines show locations of frictional sliding interfaces.



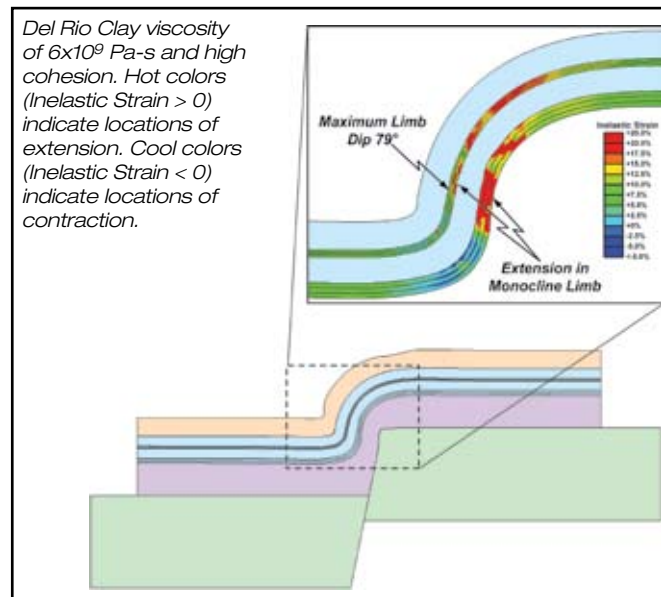
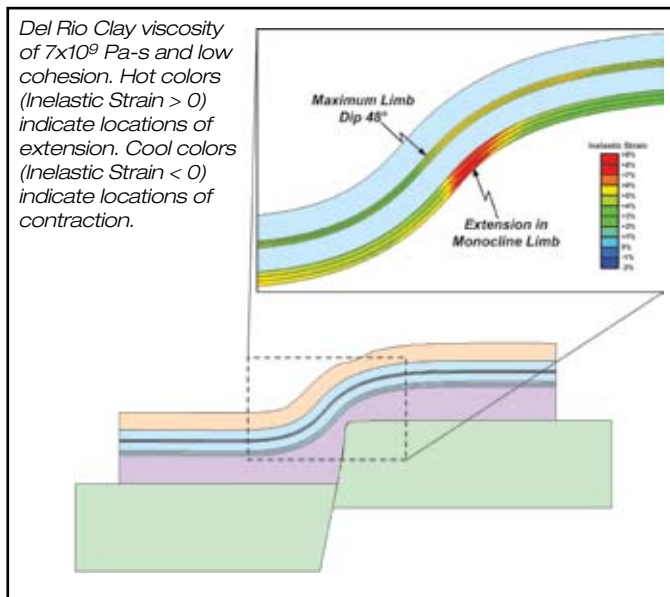
Outcrop photographs of mesoscale structures. (A) Bedding-perpendicular extension veins are offset along bedding-parallel slip surface. (B) Asymmetric vein records an up-dip sense of shear. Observations and measurements of structures like these provide field confirmation of model fidelity.



Outcrop photograph of the Big Brushy Canyon monocline. Mechanical stratigraphy is shown as well as the location of the field traverse (red dots indicate locations of field measurements). At right: Field photograph of the lower hinge of Big Brushy Canyon monocline.



# Geomechanical Modeling



Finite element model results. The deformed model geometry is shown with an enlargement of Buda Limestone layers with contours of layer-parallel inelastic (i.e., permanent) strain in the competent Buda-1 and Buda-3 layers displayed.

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