Field Tests of Geomechanical Models of Natural Rock Deformation: Insights from the Bargy Anticline, France

Ferrill, David A.[1]; Morris, Alan P.[1]; McGinnis, Ronald N.[1]; Smart, Kevin J.[1] (1) Geosciences & Engineering Division, Southwest Research Institute, San Antonio, TX.

Predicting deformation mechanisms and the distribution of extension fractures and faults in the subsurface is important to oil and gas exploration and production, CO_2 sequestration, and acid gas disposal. We use finite element modeling to replicate laboratory and natural deformation, and to develop methodologies that permit prediction of natural rock deformation features, specifically fractures and subseismic faults, in a massive limestone reservoir. The Bargy anticline in the northern Subalpine Chain of France is a 5-8 km wide and >30 km long anticline in Cretaceous platform carbonates. This fold offers excellent exposure that allows for structural characterization at a wide range of deformation scales. The massive Urgonian Limestone is the dominant competent layer in the section and reservoir analog in this study. The Hauterivian Limestone, a thick bedded to massive limestone and argillaceous limestone beneath the Urgonian, overlies the Berriasian Shale, which serves as the detachment for this structure. Fold geometry and outcrop-scale deformation are characterized from field observations of minor folds, fractures, faults, and cleavage at various sites around the fold. In addition, the mechanical stratigraphy of the principal deformed units was logged in stratigraphic profiles using an N-type Schmidt hammer. The Urgonian Limestone exhibits extension fractures (veins and joints) and primarily normal or normal-oblique faulting. The extension fractures and faults generally accommodate bed parallel extension that is both fold-axis-parallel and fold-axis-perpendicular. Field observations combined with existing microstructural analyses from the Urgonian Limestone constrain the range of deformation scales, against which finite element modeling results are compared. Schmidt rebound data are used to define the mechanical stratigraphy, primarily the spacing of potential bedding-plane slip horizons and relative strengths of the various model layers. Finite element modeling results show that overall fold geometry and complex lithologically dependent deformation can be successfully replicated. Incorporation of mechanical stratigraphy into geometric models interpreted from reflection seismic and other data allows geomechanical modeling of this type to be applied to fracture and subseismic fault prediction in the subsurface.