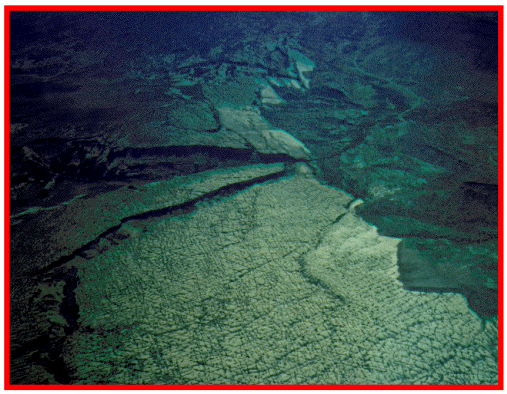
Sandia National Laboratories

Geomechanics for Reservoir Management

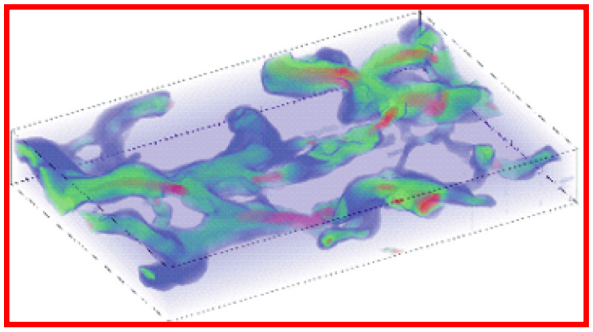
Cost-effective improvements in the technology to develop and manage reservoirs in difficult and complex environments require a better understanding of how the mechanical and fluid-flow behavior of reservoirs evolve with production-induced changes in effective stress state. The objective of this project to develop a more complete understanding of these coupled processes through an integrated geomechanics effort involving field activities, laboratory investigations, and numerical model simulations; and to apply this approach to selected reservoirs.

The Description and Quantitative Analysis of Fracture Systems

Natural fractures influence or control production in many, if not all, oil and gas reservoirs; thus, it is imperative to understand their distribution, characteristics, and origin. Our studies of regionally-fractured reservoirs have defined the controls on the fracture susceptibility of strata, and have shown that fracture-related permeability is sensitive to the changes in stress that occur during draw-down. Models of fracture origin and distribution, derived from field studies, have assisted in target delineation in hydrocarbon exploration and have explained apparent anomalies in production from fractured reservoirs.



Arial photograph of complex fracture pattern in exposed rock near Mesa Verde, CO. Studies are focused on understanding how such fracture patterns form and the implications for oil and gas production.



Simulation of fluid flow through the pores of a rock. Locations where the flow is low or stagnant are blue. High velocity (red) flow is seen in the small channels that connect the larger pores. The rock sliver in this model is approximately 0.2 mm long by 0.02 mm thick.

Microscale Modeling of Pore Structure and Fluid Flow

Advances in the application of laser scanning confocal microscopy to volumetrically image, statistically characterize, and simulate transport processes in porous rocks has led to a more complete understanding of how fluids (oil and gas) move through the rock pores and fractures to the well and how changes in stress and fluid pressure affect this process. The porous rock model used in computer simulations of flow is developed from three-dimensional images of actual rock. The flow calculations are performed using the Lattice-Boltzmann method on a massively parallel computer system.

Sandia is a multiprogram laboratory operated by Sandia corporation, a Lockheed Martin Company, for the United States Department of Energy under contract DE-AC04-94AL85000.

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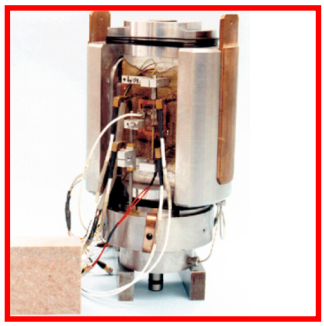

True triaxial testing allows independent control of all three principal stress components. Deformation of the sample and changes in permeability are also measured precisely.

Advanced Laboratory Testing

We apply advanced laboratory testing capabilities to develop an understanding of inelastic deformation mechanisms in rock. Both conventional triaxial testing and true triaxial testing are used in conjunction with permeability measurements to examine the effect of stress state and stress path on inelastic rock deformation with associated changes in rock permeability. The recent discovery of the formation and evolution of rock failure along bands of concentrated deformation, such as in the formation of compaction bands has led to new theories of how changes in formation production may result in trapping gas or oil by the formation of thin zones of low permeability.

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