Characterizing Fracture Sets at Outcrop Exposures Using High Resolution Remote Sensing Data; Developing a Fracture Model as Input into a Static Geomodel

Zaeff, Gene D.[1]; Liu, Chingju [1]; Soofi, Khalid A.[1]; Hassan, Torhan [2]; Hennings, Peter H.[1]; Morris, Alan P.[3]; Ferrill, David A.[3]; McGinnis, Ronald N.[3] (1) ConocoPhillips, Houston, TX. (2) North Oil Company, Kirkuk, Iraq. (3) Southwest Research Institute, San Antonio, TX.

Plate-to-plate compression formed two elongated, steeply-dipping, anticlinal structures in northern Iraq. Oil fields associated with these structures produce from open-hole completions in thick, naturally fractured carbonate reservoirs of Tertiary and Cretaceous age. Creation of a full-field 3D static model required characterization of reservoir fracturing. The geomodel was used as input in reservoir simulation to match production history and forecast future volumes.

Numerous well penetrations delimit the fields and define the basic structural features. A large volume of data was collected during field development; however, a critical piece of data not readily available was the intensity and distribution of fractures in these highly productive reservoirs. Traditional fracture identification tools, such as borehole image logs, oriented core, dipole sonic data and modern seismic data do not exist. Conducting onsite field studies within the project’s time frame was not possible; therefore, an alternative method was necessary to help define the fracture density and orientation.

Surface geology shows exposure of a similar carbonate sequence analogous to the main productive Tertiary reservoir in an anticline immediately adjacent to the producing fields. This provided a unique opportunity to analyze the fractures observed on the outcrop as an analogue to the fracture patterns in the producing fields. ConocoPhillips acquired state-of-the-art satellite imagery to generate high resolution images, as well as, detailed topographic maps to generate a model of the exposed Tertiary units and to identify all the surface fractures at the highest detail possible. The measured fracture sets along with ancillary data such as Maximum Curvature and structural location on the outcrop were used to generate a model to predict the orientation and density of fractures in the subsurface reservoirs.

The critical parameters derived from this technique were used in generating one of the primary project deliverables, a full-field reservoir model to evaluate the resources under various field development scenarios. Results from the remote sensing technology and workflow include: (i) the identification and characterization of multiple fracture sets at the outcrop, (ii) the distribution of fracture sets in a static 3D geocellular model, and (iii) upscaling the fracture model to a permeability multiplier for full-field dynamic reservoir simulation.