AAPG Search and Discovery #90106©2010 AAPG Rocky Mountain Section, Durango, CO 13-16 June 2010

Influence of Natural Fractures from Second-Order Faults on Low-Permeability Oil Reservoir (Turner Sandstone), Powder River Basin, Wyoming, USA

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The Upper Cretaceous Turner Sandstone is a low-permeability oil reservoir that has produced 32 million BO from about 1,000 vertical wells in multiple fields in the southern Powder River Basin of NE Wyoming, USA. Economics for vertical wells have been marginal, but recently Abraxas Petroleum Corporation and other operators have attempted to exploit the known Turner oil accumulations utilizing horizontal wells and 3D seismic data.

In the Brooks Draw field, Abraxas attempted to better characterize the Turner reservoir by reviewing outcrops, taking and analyzing a 137-ft full-diameter core, and acquiring 24 square miles of 3D seismic data. The Turner reservoir may be characterized as about 120 ft of inter-bedded, very fine-grained sandstone and shale. At the base of the interval, fine- to medium-grained sandstone that is 0-20 ft thick provides the best reservoir quality. Most of the upper interval is bioturbated and the biologic mixing of sandstone and shale beds greatly diminishes permeability and prevents oil saturation. However, where bioturbation is absent, the sandstone beds are oil saturated. In the cored well, matrix permeability in the Turner sandstone is too low for commercial oil production. Fractures are required for commercial oil production.

Structural interpretation of 3D seismic data indicates two, prominent right-lateral strike-slip faults. The data set also contains numerous small faults that intercept the Turner reservoir. The small faults are short (1500-4000 ft), curved, have variable azimuth, display both normal and reverse movement, and are limited in vertical extent. These faults are likely second-order deformation related to the larger strike-slip faults.

Abraxas drilled five horizontal Turner wells before acquiring the 3D seismic data. The best well, serendipitously, crossed a small fault. Subsequently Abraxas drilled and completed two horizontal wells to intercept two other small faults. As predicted, the small faults caused fracturing and apparent enhancement of the Turner reservoir in the horizontal wellbore. The three wells that targeted small faults are the three best wells in the field.

Interpretation of small, second-order faults from 3D seismic data allows operators to locate areas of natural-fracture enhancement. The presence of natural fractures may be the key to economically exploiting an oil-saturated, low-permeability reservoir like the Turner.