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

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The Upper Cretaceous-aged 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.

Using outcrop, cores and logs, the Turner reservoir may be characterized as about 120 ft of inter-bedded very fine-grained sandstone and shale with fine- to medium-grained basal sandstone. Most of the interval is bioturbated, and the biologic mixing of sand and shale beds greatly diminishes permeability and prevents oil saturation. However, where bioturbation is absent, the sandstone beds are oil saturated. The basal sandstone provides the best reservoir quality, but its thickness varies from 0 to 20 ft. In an attempt to improve individual well performance, Abraxas drilled and completed six horizontal wells in the Turner and acquired a 26 sq mi 3D seismic data set.

Structural interpretation of 3D seismic data indicates two, prominent right-lateral strike-slip faults through the study area. The data set also contains numerous small faults that intercept the Turner reservoir. The small faults are: short (1500-4000 ft), curved, variable azimuth, both normal and reverse movement and 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 one of the small faults. Recently another horizontal well was located to cross another small fault. As planned, the small fault caused fracturing and apparent enhancement of the Turner reservoir in the horizontal wellbore. The latest well is now the best well in the field.

Interpretation of small, second-order faults from 3D seismic data allows operators to locate areas of natural fracture enhancement. Natural fractures greatly enhance the economics of an oil saturated low-permeability reservoir like the Turner.