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Modern Analytical Techniques for Fault Surface Seal Analysis: A Gulf Coast Case History

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Today's exploration and, particularly, exploitation methods, with a major reliance placed on mapping with 3-D seismic data, generate a great deal of potential information about prospective reservoirs. Effective prospect evaluation requires consideration of the sealing characteristics of faults, and techniques have been developed to improve fault surface analysis. "Allen" fault surface profiles permit assessment of sand juxtaposition across the fault, and can be prepared by manual mapping methods if adequate structural maps are available from 3-D seismic interpretation and well control. Commercial software is available to perform similar analyses directly from the 3-D seismic interpretation.

Vermilion Block 331 Field, operated by Marathon, was selected for a pilot study. The field consists of a low-relief anticline, downthrown to a regional growth fault. Numerous small faults, with limited vertical separation, cross the crest of the anticline and compartmentalize reservoir sands of *Trimosina A* (Pleistocene), *Angulogerina B* (Pleistocene), and *Lenticulina* (Miocene) age. Faulted reservoirs with multiple, stacked sands are particularly prone to loss of hydrocarbons by leakage across fault surfaces, so that this field was considered ideal for testing the effectiveness of fault surface analysis. Both lateral and top seal risk were evaluated by means of fault surface profiles along five of the crestal faults to determine the limits of trapping potential and paths for vertical migration. A detailed review of actual hydrocarbon distribution was then compared with the predictions made from fault surface analysis. 70% of a total of 83 predicted hydrocarbon/water contacts were found to be correct within 10 meters (30 feet).

The role of faults in permitting up-fault migration along the fracture surface, or in providing shale smear barriers to cross-fault migration from sand to sand, may confound interpretations based only on fault surface profile geometries. For this reason, shale smear factors were also determined and used in assessing trapping potentials. A critical value of shale smear factor appropriate for this field was found empirically to be between 1.85 and 2.0. Capillary-limited cross-fault migration was blocked in all cases where the value was lower than critical, while spill point-limited traps occur where values are above critical. This analysis explained all the remaining discrepancies between predicted and actual hydrocarbon/water contacts mentioned in the preceding paragraph. ■

Mary Jennemann Broussard received a B.S. degree in Geology and Geophysics from the University of Tulsa in 1984. Upon graduation, she joined Ward Exploration in Tyler, Texas as a processor of 2-D seismic data. She has also worked for SRS-Geosource in marketing, and, since 1987, with Marathon Oil Company in Lafayette, Louisiana. She pursued an M.S. degree in Geology from the University of Southwestern Louisiana while working full-time. She received her M.S. degree in 1995 with her thesis work also serving as the subject of this paper, which received the A. I. Levorsen Award (GCAGS).

Mary presently works as a petroleum geologist in an Offshore Gulf of Mexico Development Team, where her primary focus is developing a 3-D reservoir characterization model, integrating geological, geophysical, and engineering data. She is a member of the American Association of Petroleum Geologists, Society of Exploration Geophysicists, and the Southwest Louisiana Geophysical Society.