Recent Geokinematic and Geodynamic Research on Intracontinental Stress Fields: New Tools for Fractured Reservoirs

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For many years correspondence of the maximum principal horizontal stress field (Sigma-1) with plate motion in “hotspot” reference frames has been an active working hypothesis. Sigma-1 can be viewed as a background stress field, and as such, may play a significant role in controlling formation of both natural and induced fractures within intracontinental basins.

Sigma-1, based on plate-hotspot kinematics, shows distinctive variations from Cretaceous-Present, and significant correspondence with observed and dated fractures, including dated dikes, veins, and stratigraphically-constrained fractures from North America and Africa. Additional work implies that plate-hotspot models represent not so much plate motions relative to hotspots as to the surrounding mantle in which hotspots are “embedded”. That is, deeper asthenospheric (which has also be termed “mesospheric”) mantle is moving very slowly, and the orientation of stress across the boundary between lithospheric mantle (plates) and the lower asthenospheric mantle is what is manifested in intracontinental Sigma-1. Other oriented stress sources overprint regional Sigma-1 including tectonic or active basin-margin faulting and salt tectonics. Particular basinal geohistories can produce distinctive fracture-related reservoirs with fracture orientations reflecting both regional and local paleostress orientations. In a subsiding basin, compaction and overpressuring in the absence of faulting can produce fracturing with orientations controlled only by regional Sigma-1. Similarly, In basin experiencing broad, regional uplift in the absence of faulting can produce unloading-related fracturing with orientations controlled only by regional Sigma-1.

In an extensive sedimentary sequence, fracture presence and orientation represent the peculiar geohistory of subsidence, compaction, overpressuring, along with hydrocarbon maturation and migration. With the apparent correspondence of plate-hotspot models and regional paleostress histories, explorationists can take regional stress fields into account while attempting to characterize potential intracontinental fracture reservoirs. Further, the predicted contemporary stress field provides critical control on induced fracturing as part of development of the reservoirs. Several exemplars of this approach can be offered to illustrate its applicability.