MGS Luncheon Meeting

Tuesday, April 5th 2016

11:45 am – Billings Petroleum Club

Please join us for lunch ($14) and the talk (no charge)

RSVP – montanageologicalsociety@gmail.com , or 406-259-8790
An email reminder will be sent 3 days prior to the talk

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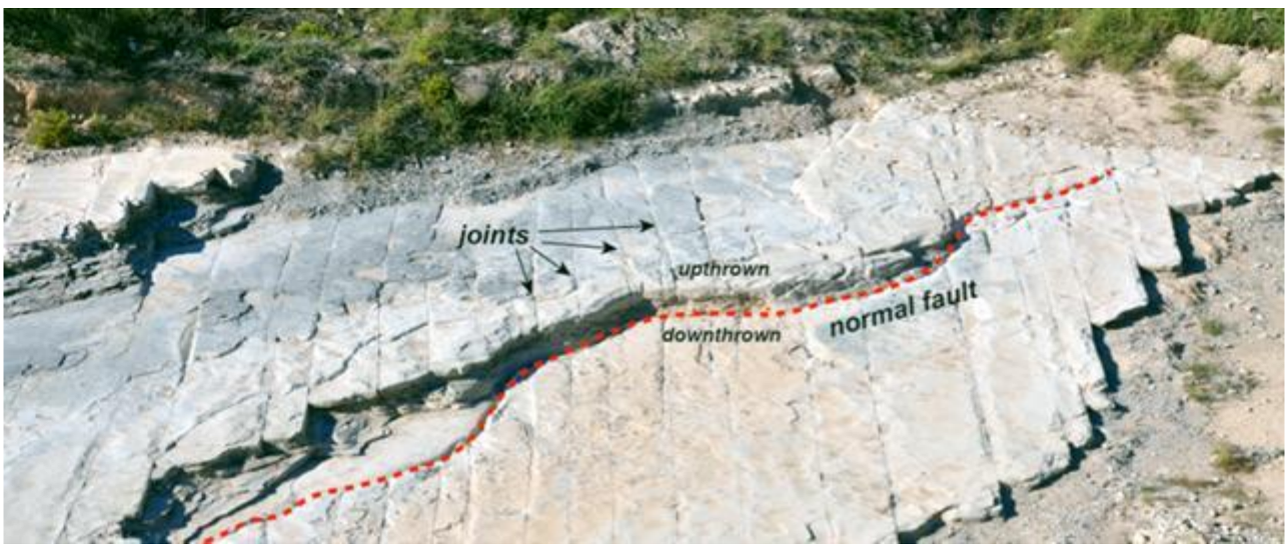
Abstract: Mechanical Stratigraphic Controls on Fracturing (Jointing) and Normal Faulting in the Eagle Ford Formation, South-Central Texas, U.S.A.



Production from self-sourced reservoirs relies on natural and induced fracturing to enhance permeability and produce connected pathways for hydrocarbons to flow back to producing wellbores; thus, natural or induced fracturing is key to the success of unconventional reservoir plays. In addition to enhancing production, large or well-connected fractures or faults may cause undesirable complications for production.

Natural and induced fractures are influenced by: (i) mechanical stratigraphy, (ii) preexisting natural deformation such as faults, fractures, and folds, and (iii) in situ stress conditions, which includes both natural stresses and stresses modified by stimulation and pressure depletion (Ferrill et al. 2014b). Understanding the occurrence and controls on natural and induced faulting and fracturing in self-sourced reservoirs is a key component for developing effective approaches for exploiting hydrocarbons within self-sourced reservoirs.

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Outcrop investigation of the Eagle Ford Formation in south-central Texas reveals a distinctive influence of bed-scale mechanical layering on fracture system development (Ferrill et al. 2014a). Well-developed joint networks are present in subhorizontal competent carbonate (chalk) beds. Joint systems are less well-developed in interlayered incompetent calcareous mudrock beds. All observed joints terminate vertically in incompetent mudrock beds (Figure 1). Abutting relationships between joint networks allow determination of the relative timing sequence between joint sets and between joints and faults. Normal faults are common but less abundant than joints (Figure 2). The faults dominantly dip north, northwest, or southeast and joint sets abut against the faults, indicating that the faults formed prior to the joint networks. In addition, the faults cut multiple competent and incompetent beds, providing vertical connectivity across mechanical layering. These faults are products of both hybrid and shear failure. Consequently, the fault dips are steep through competent beds and moderate through incompetent beds, resulting in refracted fault profiles with dilation and calcite precipitation into dilational cavities along steep segments. Fluid inclusions in calcite from the fault zone commonly contain liquid hydrocarbons or in rare two-phase fluid inclusions homogenization temperatures suggest trapping of aqueous fluids at elevated temperatures (40-100° C) and depths on the order of 2 km (6562 ft). Fluid inclusions and stable isotope geochemistry analyses suggest that faults transmitted externally derived fluids. These faults likely formed at depths equivalent to portions of the present-day oil and gas production from the Eagle Ford play in south Texas. Faults connect across layering and provide pathways for vertical fluid movement within the Eagle Ford Formation, in contrast to vertically restricted joints which produce bed-parallel fracture permeability but have limited vertical connectivity.

Natural fracture systems, along with mechanical stratigraphy and in situ stress conditions, are the context within which hydraulic stimulation programs are performed. The natural faults and joints are preexisting weaknesses that are likely to reactivate before stress conditions required for failure of intact rock are reached. Open or mineral-filled faults and fractures have contrasting porosity and permeability with respect to the host rock layers and will potentially dilate, slip, or compartmentalize fluid pressure increase during induced hydraulic fracturing.

Biography

David A. Ferrill is director of the Department of Earth Material and Planetary Sciences at Southwest Research Institute. He received his B.S. degree in geology from Georgia State University in 1984, his M.S. degree in geology from West Virginia University in 1987, and his Ph.D. in geology from the University of Alabama in 1991, and he is a licensed professional geoscientist (geology) in the state of Texas. Dr. Ferrill is a structural geologist with international research experience in contractional, extensional, and strike-slip tectonic regimes, and international oil and gas exploration and production experience. He has analyzed geometric and kinematic folding and faulting processes, curvature of mountain belts, regional tectonics, hydrocarbon trap integrity, and induced hydraulic fracturing in unconventional reservoirs. He has characterized reservoirs and aquifers, and interpreted tectonic stress fields, rock deformation, and fracture mechanisms and has published extensively on these topics. Study areas have included the French Alps, the Appalachians, the Basin and Range Province and Colorado Plateau of the western United States, the Gulf of Mexico, Trinidad, Iceland, offshore Vietnam, offshore Turkey, the Persian Gulf, plus other planetary bodies including Mars and Ganymede. Dr. Ferrill works with staff to develop execute projects for a wide range of clients related to oil and gas exploration and production, groundwater resource analysis, natural hazard assessment, and planetary research. He leads SwRI's Eagle Ford structural geology and geomechanics joint industry project, and performs contract consulting and structural geology training for the oil industry that includes regularly teaching structural geology and geomechanics field seminars. Dr. Ferrill led development of the award winning 3DStress® computer program for interactive analyses of the effects of stresses on faults and fractures, which received an R&D 100 award from R&D Magazine, designating it as one of the world's 100 most significant technical accomplishments. Before joining Southwest Research Institute in 1993, he was an exploration geologist at Shell Offshore Incorporated, and prior to that an assistant professor at Georgia Southern University. He is editorial board member and former editor of Journal of Structural Geology, and current Chairman of Petroleum Structure and Geomechanics Division of American Association of Petroleum Geologists.