Monday, September 28, 2015

HGS North American Explorationists Dinner Meeting

Westchase Hilton • 9999 Westheimer
Social Hour 5:30–6:30 p.m.
Dinner 6:30–7:30 p.m.

Cost: $45 Preregistered members; $50 non-members/walk-ups

To guarantee a seat, pre-register on the HGS website & pre-pay by credit card.
Pre-registration without payment will not be accepted.
Walk-ups may pay at the door if extra seats are available.

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Mineralogy, Petrology and Hydrocarbon Saturation in the Three Forks Reservoir, North Dakota

The Three Forks reservoir forms the lower part of the "Bakken pool" in the North Dakota portion of the Williston basin. The upper portion of the Three Forks Formation (1st and 2nd Benches) consist dominantly of dolomite, with secondary amounts of quartz or feldspar sand and silt grains, and variable amounts of clay minerals (mostly illite). Anhydritic and calcareous beds occur in the lower half of the formation (3rd and 4th Benches).

In most oil-productive areas of western North Dakota, three reservoir rock types can be defined in the 1st Bench based on mineralogy, capillary pressure characteristics and water saturation distributions. The best Three Forks hydrocarbon saturations occur in brown to brownish-orange to tan, sandy to silty, clay-poor dolostone. Within the oil column, this end-member lithology typically has 2-7% porosity (4.3% average) and 5-40% water saturation. The average mineral content is 63% dolomite, 31% quartz-feldspar and 3% illite (values less than 1% not listed). A second end-member rock type is green, silty, dolomitic mudstone that typically has 5-11% porosity (8.9% average) and 40-90% water saturation. The average mineral content is 35% dolomite, 31% quartz-feldspar, 30% clay minerals (23% illite, 4% chlorite, 3% illite-smectite), and 2% pyrite-marcasite. The third rock type consists of mixed brown and green, sandy to silty dolostone, with intermediate reservoir rock properties. It includes laminated and brecciated lithologies.

Below the 1st Bench, several reservoir rock types occur; however, the brown, clay-poor sandy-silty dolostone lithology is the main oil-bearing rock type in all portions of the Three Forks. The brown dolostone rock type is common in laminae, uniform beds and breccia beds that are interbedded with clay-rich dolostone. The thickest brown dolostone unit, informally referred to as the "Basal Clean" portion of the 1st Bench, is typically 2-3 meters thick, consists of 60-90% brown dolostone and can be correlated regionally. It is the horizontal drilling target in many areas. Porosity occurs in intercrystal spaces between planar-s dolomite crystals. Permeability (Ka) is typically between 0.001 and 0.01 md in the central portion of the oil-producing area. Porosity and permeability increase gradually updip into shallow, water-bearing areas.

Due to small pore-throat sizes, oil column heights greater than 3,000 feet would have been needed to achieve observed hydrocarbon saturations in a water-wet system. Under these conditions, the oil column is too thin to be explained by simple buoyancy-driven oil emplacement. Based on an analogy with low permeability, continuous gas reservoirs, it is inferred that overpressure (current or ancient) that developed during maturation of overlying Bakken shales was required to emplace oil in rocks with existing low permeability. The brown dolostone rock type is a reservoir in basinal areas with overpressure, but it acts as a baffle or seal in normal-pressured flank areas. On a regional scale, hydrocarbon migration was primarily vertical; oil was forced downward under pressure from overlying Bakken shales and there was limited oil migration outside of overpressure areas or areas with regional fracture conduits. ■

Biographical Sketch

David Petty has 36 years of industry experience working as a petroleum geologist in the Williston, Permian, and Michigan basins of the U.S., as well as Tunisia and Egypt. He received a B.S. degree in Geology from Texas A&M University in 1976 and a M.S. degree in Geology from New Mexico Tech in 1979. He has worked for Tenneco Oil Company (1979-1989), British Gas (1989-1994), American Exploration (1994-1996), Belco Energy (1996-2001), Westport Oil & Gas (2001-2004), Kerr-McGee Corporation (2004-2006), Anadarko Petroleum (2006), and Hess Corporation (2006-present). Most of his work experience has been in the North Dakota and Montana portions of the Williston basin, and most of his research has focused on the stratigraphy, diagenesis and reservoir rock properties of early to middle Paleozoic strata in the Williston basin and surrounding outcrop areas. Since 2006 he has worked both Bakken and non-Bakken North Dakota assets for Hess Corporation.