Geochemistry of Oil-Field Waters from Northern Gulf of Mexico Basin

Detailed chemical analyses of 120 formation-water samples from 25 oil and gas fields in coastal Texas and Louisiana show that the salinity of water in the geopressured zones ranges from about 10,000 to 270,000 mg/L dissolved solids and may be higher or lower than the salinity of water in the overlying normally pressured zones. All the waters are of the Na-Cl type; Na generally constitutes more than 90% of the total cations and Cl constitutes more than 90% and up to 99.8% of the total anions. Ca concentrations increase with increasing salinity and bicarbonate increases with decreasing Ca concentrations. Magnesium and sulfate concentrations are generally low. The concentrations of copper, lead, and other heavy metals are generally less than 10 $\mu g/L$.

Hydraulic fluid potentials and δD and $\delta^{18}O$ values indicate that the formation waters are most probably modified connate waters representing the original marine water of deposition. The chemistry of these waters, however, is markedly different from that of ocean water. The differences in composition are shown to result from (1) interaction of the waters with evaporites, (2) interaction of the waters with minerals and organic matter present in the enclosing sedimentary rocks, and (3) membrane-squeezing and membrane-filtration properties of shales.

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Stable Carbon Isotopes in Oil-Field Waters and Origin of Carbon Dioxide

The $\delta^{13}C$ values of dissolved HCO_3^- in 75 water samples from 15 oil and gas fields were determined in a study of the source of carbon dioxide of the dissolved species and the carbonate cements that modify the porosity and permeability of many petroleum reservoir rocks. The fields are located in the San Joaquin Valley, California, and the Houston-Galveston and Corpus Christi areas of Texas. The reservoir rocks are sandstones ranging in age from Eocene through Miocene. The $\delta^{13}C$ values of total HCO_3^- indicate that the carbon in the dissolved carbonate species and carbonate cements is mainly of organic origin.

The range of $\delta^{13}C$ values for the HCO_3^- of these waters is -20 to 28 permil relative to the PDB standard. This wide range of values is explained by three mechanisms. Microbiologic degradation of organic matter appears to be the dominant process controlling the extremely low and high $\delta^{13}C$ values (-20 to 28 permil) of HCO_3^- in the shallow production zones where the subsurface temperatures are less than 80°C. The extremely low $\delta^{13}C$ values are obtained in waters where the concentration of SO_4 is more than 25 mg/L and probably result from the degradation of organic acid anions by sulfate-reducing bacteria ($SO_4^{2-} + CH_3COO^- \rightarrow 2HCO_3^- + HS^-$). The high $\delta^{13}C$ values probably result from the degradation of acetate by methanogenic bacteria ($CH_3COO^- + H_2O \rightleftharpoons HCO_3^- + CH_4$).

For samples from production zones with subsurface temperatures greater than 80°C, thermal decarboxylation of short-chain aliphatic acid anions (principally acetate) to produce CO_2 and CH_4 is probably the major source of CO_2. The $\delta^{3}C$ values of HCO_3^- for waters from zones with temperatures greater than 100°C result from isotopic equilibration between CO_2 and CH_4. At these high temperatures, $\delta^{13}C$ values of HCO_3^- decrease with increasing temperatures and decreasing concentrations of these acid anions.

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Deposition of Marble Falls Formation, Central Texas

The Marble Falls Formation (Lower Pennsylvanian) records normal marine conditions and widespread limestone deposition over the Llano uplift and the adjacent Concho platform in Texas. Examination of depositional environments of the outcropping Marble Falls facilitates interpretation of the oil-producing Lower Pennsylvanian shelf and shelf-edge carbonate rocks along the western margin of the Fort Worth basin.

Most of the outcropping Marble Falls can be divided into two units separated by an unconformity. Lower Marble Falls is entirely Morrowan. Upper Marble Falls becomes younger westward: Morrowan in the east and Atokan in the west.

Marble Falls deposition began with establishment of an open marine platform centered at the Llano uplift. Incipient calcarenite shoals developed at some slight break in slope. The northeast part of the platform resembled the modern Bahamian Platform, although platform–off platform relief was less than 9 m. Platform margins were approximately coincident with present outcrops on the north and east sides of the Llano uplift.

The upper Marble Falls was deposited primarily as algal buildups and calcarenite shoals and as shale and spiculitic biomicrite in topographic lows. While the older lower Marble Falls Platform was subaerially exposed, deposition continued on the off-platform shelf adjacent to the rapidly filling Fort Worth basin. Progressive subsidence of the old platform allowed these facies to onlap the erosional surface. Strawn deltas simultaneously prograded across the upper Marble Falls shelf from the east. Marine energy levels and depositional relief were less than during deposition of the lower Marble Falls.

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Statfjord Field, North Sea Giant

Statfjord, the largest single oil field in the North Sea, is located on the United Kingdom-Norwegian boundary between 61 and 61°30′ N lat. About 11% of the field extends into United Kingdom waters. Its discovery, in March 1974, was based on interpretation of seismic reflection surveys and extrapolation of a productive regional trend. Two principle sandstone reservoirs, Middle Jurassic Brent and Lower Jurassic to Upper Triassic Statfjord, contain reserves on the order of 3 billion bbl within a productive area of approximately 20,000 acres (8,094 ha.). Reservoir properties are excellent with permeabilities in darcys. The field extends northeastward 15.5 mi (24.9 km) and averages 2.5 mi (4 km) in width.

Tilted Jurassic fault blocks form the primary hydrocarbon trap at Statfjord as throughout the East Shetland basin. Statfjord field is a structural/stratigraphic trap formed by westward tilting and erosion of a major fault block. Brent deltaic sandstones and underlying Statfjord fluvial to continental sandstones are truncated by mid-late Kimmerian unconformities on the crest and east flank of the structure, which is marked by a major fault system. Overlying and onlapping Jurassic and Cretaceous shales seal the trap. Organically rich Upper Jurassic shales provide an excellent oil source. Reservoirs have separate oil/water contacts. Normal faulting separates Statfjord field from the Brent field on the southwest.

Joint Norwegian and United Kingdom development utilizes "condeep" type gravity platforms and initial offshore loading. Development drilling from Statfjord "A" platform, towed to the location in May 1977, began in late 1978. First production is expected late in 1979.

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Calcification and Significance of Soil Filamentous Microorganisms in Quaternary Calcretes, Eastern Spain

Petrographic studies reveal the presence of various soil-dwelling organisms preserved as calcified filaments in Pleistocene to Holocene calcretes from coastal regions of eastern Spain.

On the basis of gross morphology, occurrence, abundance, and chemistry of relic organic tissues, four organomineral associations may be recognized. The mineral phase is low-magnesian calcite; its fabric occurs as micron-sized needles and rhombs. The organic phase includes four taxonomic groups: filamentous soil fungi (dominant); filamentous soil algae (rare); actinomycetes (common); and root hairs of vascular land plants (common). Filamentous soil fungi are generally 1 to 10μ in diameter, branch dichotomously and are nonseptate. Filamentous soil algae are 2 to 10μ in diameter, unbranched or show false ramifications, and are septate. Actinomycetes are less than 1μ in diameter, branch irregularly and are nonseptate. Root hairs of vascular land plants are 5 to 15μ in diameter, unbranched and nonseptate. All four groups are dominantly chasmolithic.

Morphology of calcified filaments depends on whether calcification is determined by physicochemical or biochemical processes, or both. The calcified product may be a hollow tube or a solid rod, depending on the condition of the organic substrate before, during, and after its calcification. Biochemical control of calcification produces filaments whose morphologies are related closely to those of the organic substrate; physicochemical control of calcification produces filaments whose morphologies may or may not be related to those of the organic substrate.

Calcretes containing calcified filaments indicate that they functioned, at some stage in their evolution, as biologic soils. Such calcretes are paleosols; they record the presence of a former land surface, colonization by terrestrial organisms, and subaerial vadose conditions in ancient successions.

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Slumping in Intercanyon Areas, Middle Atlantic Continental Slope

Analyses of high-resolution seismic reflection profiles show that slump deposits are ubiquitous within the intercanyon areas of the continental slope of the Middle Atlantic Bight. Of 15 widely spaced 3.5-kHz profiles obtained between Hudson Canyon and Chesapeake Bay, 12 define slump deposits that vary from thin, homogeneous or parallel-bedded lenses of sediments, to masses of intermediate thickness containing contorted bedding, to relatively thick slump blocks with discontinuous bedding. These deposits constitute the upper 10 to 90 m of sediments, extend downslope for 2 to 7 km, and are present at water depths ranging from 545 to 1,500 m. Minisparker profiles obtained during a detailed survey of a 9 by 28 km area of the slope between Hudson and Wilmington Canyons define 19 slump deposits in water depths of 398 to 2,190 m that comprise 12% of the survey area. Individual masses are as much as 50 m thick, cover as much as 5.3 sq km, and contain a maximum of 0.11 cu km of sediments. Although some of the slump deposits on the Middle Atlantic slope undoubtedly are relict, stemming from sediment instability produced by rapid deposition during Pleistocene sea-level regressions, the acoustic characteristics of others suggest recent formation. Data from this study indicate that slumping in the intercanyon areas may be quantitatively important in transporting sediments to the deep sea and suggest that recent mass movements may constitute a geologic hazard to future economic development of this part of the continental slope.

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Simple Pyrolysis Technique Using Well Cuttings to Map Source Rocks, Gas-Condensate Maturity, and Abnormal Fluid Pressures Associated with Fracture Reservoirs: Example from Anadarko Basin

P. Trask showed that when small samples of kerogen-rich rock are pyrolyzed in a test tube, oil-like material may be generated and condensed as a brown residue around the walls of the tube. This technique is adaptable to the use of well cuttings and may be utilized to identify source rocks capable of generating oil. For any given source rock, the amount of pyrolysis yield decreases with increased thermal maturity as verified by vitrinite reflectance analysis. Samples from stages of maturity corresponding to the gas-condensate and dry-gas generation "windows" yield no pyrolysis residue because of their inability to generate dark oily liquids.

We have used the test-tube-pyrolysis technique to map quickly and accurately (1) source rocks capable of generating oil, and (2) the maturity threshold of gas-condensate generation in part of the Pennsylvanian section of the Anadarko basin.

The area of gas-condensate generation within the Atoka Formation, as mapped by the pyrolysis technique, is coincident with the presence of (1) abnormally