Three-Dimensional Simulation of Basin Evolution, Geothermal History, and Hydrocarbon Generation and Accumulation Potential—New Tool in Petroleum Exploration

Increasing demand and decreasing supply of hydrocarbon products require increased activities in petroleum exploration and production and especially improvement in exploration success. Improvement in exploration success both in previously explored and unexplored areas can only be possible with the integration of all the information and data obtained from geologic, geophysical, geochemical, hydrodynamic, and thermodynamic studies.

A three-dimensional deterministic, dynamic model is constructed to calculate all the above measurable values with the help of mass and energy transport equations, and by equations describing the physical and/or physico-chemical changes in organic matter as a function of temperature in sedimentary sequences. Input data consist of heat flux, initial physical and thermal properties of sediments, paleobathymetric estimates, sedimentation rate and amount, and type of organic matter. Then, the model computes pressure, temperature, physical and thermal properties of sediments, maturity of organic matter, and generation and accumulation potential of hydrocarbons as a function of space and time.

This model has been successfully applied to four basins with different lithologies (clastics, carbonates, and cyclic sediments) and various structural patterns (halokinesis, faulting, and folding). The allowable error limits are ± 3°C for temperature, and ± 10% for maturity of organic matter.

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Petrology and Diagenesis of Early Miocene Deep-Sea Fan Deposits near Point Arena, California

Early Miocene deep-sea fan deposits of the Skooner Gulch and Gallaway Formations near Point Arena, California, were examined to determine which factors influence or control diagenesis in fine-grained turbidite deposits. Well-preserved sedimentary structures (including complete Bouma T_{a-e} beds) are nearly continuously exposed in a vertical sequence along the coast. This sequence is interpreted to represent outer fan depositional lobes, lobe fringe, and basin plain deposits.

Four representative stratigraphic sections were sampled and analyzed using the scanning electron microscope, energy dispersive X-ray, X-ray diffraction, nuclear magnetic resonance, electron microprobe, and thin section analysis. Rock types examined include medium to very fine-grained arkoses, lithic arkoses, mudstones, siltstones, and hemipelagites.

Diagenesis of a turbidite sequence is complex and does not involve uniform changes in detrital and authigenic minerals. Factors affecting diagenesis include variations in the original depositional environment, sediment composition, texture, stratification, frequency of interbedded shale beds, bioturbation, degree of compaction, and original porosity and permeability. Diagenetic changes recognized were: (1) alteration and resorption of unstable detrital grains, such as feldspar, rock fragments and detrital clay; (2) formation of authigenic quartz, potassium feldspar, and clay cements which reduced porosity and permeability; (3) formation of iron oxide and pyrite; and (4) incorporation of detrital and authigenic minerals in late-stage carbonate cement. All of the observed diagenetic changes can occur at relatively low temperatures and shallow to moderate burial depths.

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Methane Concentration and Distribution in Pressurized Core Samples from Mississippian Delta Sediments

Elevated concentrations of shallow biogenic methane are common in regions of rapid sediment deposition. A pressure core barrel was designed and implemented by Texas A&M University, in conjunction with the U.S. Geological Survey Mississippi Delta Project, to study these gas-charged shallow sediments of the continental shelf. Methane measurements were made on 10 pressurized cores taken in the South Pass region of the Mississippi delta. The results of these measurements indicated methane was present in concentrations ranging from 3,450 to 137,140 ppm (μl CH_4(STP)/l wet sediment). Methane values were generally higher than found in comparative samples taken with conventional wire-line equipment. However, these values were lower than predicted by theoretical calculations and also lower than pressure corrected saturation values for methane solubility in seawater. Stepwise decompression experiments were performed on selected samples to study the rate of methane release into the surrounding inert atmosphere of the pressurized sampling container. Results showed that at least 98% of the methane was released from the sediment matrix within 3 to 5 hours after opening the pressurized core. Samples containing higher total methane concentrations demonstrated no change in concentration with pressure during stepwise decompression while those containing lower total methane concentration demonstrated a marked change in concentration with pressure. These experimental results, successfully obtained with pressurized core barrel techniques, provide further insight into the physical and chemical properties of gas in sediments.

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File Management System for Resource Evaluation in Frontier Area—National Petroleum Reserves of Alaska Case Study

A computerized geologic data base can by used to evaluate petroleum resources in a frontier province. The National Petroleum Reserve of Alaska (NPRA) covers 37,000 sq mi (96,000 sq km) on the Arctic slope west of Prudhoe Bay. In 1977, the U.S. Geological Survey was assigned responsibility to determine the hydrocarbon and mineral resources in NPRA. Significant petroleum resources were thought to be present, but were not substantiated by sparse wildcat and stratigraphic test wells. A comprehensive data acquisition program including seismic, gravity, surface geology, stratigraphic test wells, geochemistry, paleontology, petrography, and borehole logs was defined to support the study. Although lower than 125 wells were involved, large and diverse amounts of interpretive data were generated and evaluated by associated field and laboratory analyses. Consequently, a computer data management system was developed to capture, edit, maintain, retrieve, and display various combinations of data on a minicomputer. The system includes an online daily drilling file, digital base map, well data file, digitized borehole logs, outcrop descriptions, organic geochemistry, paleontology, petrography, seismic, and gravity. Subsystems permit stratigraphers, paleontologists, and geochemists to process and display their individiual files. The data management system permits the interpreter to combine data from multiple files and to generate reports, histograms, maps, and graphical displays. Benefits of the computerized system for evaluation