Evaluation of Atlantic Coastal Plain Geothermal Reservoirs Using Seismic Reflection Data

Ongoing studies of the moderate-temperature hydrogeothermal resource potential of the Atlantic coastal plain use seismic reflection data to evaluate potential reservoirs. Resource evaluation is dependent upon the determination of temperature and reservoir characteristics. The temperature of a potential reservoir can be estimated accurately if heat flow and thermal conductivity of the overlying sediments are known. Heat flow was determined in 51 shallow (300 m) exploratory holes. Equilibrium geothermal gradients in these holes indicate that thermal conductivity is a function of bulk composition, and can be characterized by the relative proportions of quartz sand, clay minerals, and water.

Seismic reflection data are being correlated with thermal conductivity of cores and cuttings from drill holes by making use of the relations between seismic velocity and bulk composition, and thermal conductivity and bulk composition. Seismic lines tied into drill holes allow interpretation of thermal conductivities between holes by correlating velocities to sedimentary units with known compositions and thermal conductivities. The seismic data are also being used to estimate the distribution and size of potential hydrothermal reservoirs by interpreting compositional differences between acquifers and aquitards.

Thus, the location, size, and temperature of potential hydrothermal reservoirs are estimated from seismic data. Preliminary results suggest that water at temperatures exceeding 60°C may occur in many areas in the eastern United States. Results of a deep test at Crisfield, Maryland, are encouraging. Brackish water at a temperature of 57°C was produced from an acquifer at a depth of 1.2 km. Further testing of the transmissibility of the deep aquifers beneath the Atlantic coastal plain is necessary.

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Origin and Evolution of Saline Formation Waters, Lower Cretaceous Carbonates, South-Central Texas

Systematic chemical variations exist in formation waters collected from a dip section through Lower Cretaceous rocks of south-central Texas. These chemical variations can be explained by an interactive water-rock diagenetic model.

Cyclic Lower Cretaceous shelf carbonates of the Edwards Group that dip into the Gulf Coast geosyncline act as an aquifer contained by basement beneath, and relatively impermeable Upper Cretaceous clays and chalks above. The hydrodynamic character of this carbonate system is strongly controlled by major fault systems which serve as pathways for the vertical movement of brines into the Lower Cretaceous section. Formation-water movement in this system has strong updip and upfault components.

The parent Na-Ca-Cl brine originates deep in the gulf basin, at temperatures between 200 and 250°C, by the reaction: halite + detrital plagiocalse + quartz + water → albite + brine. Other dissolved components originate by reaction of the fluid with the sedimentary phases, K-feldspar, calcite, dolomite, anhydrite, celestite, barite, and fluorite. Significant quantities of lead, zinc, and iron have been mobilized as well.

As the brine moves updip out of the overpressured deep gulf basin, encountering limestones of the Stuart City reef trend (the buried platform margin), small amounts of galena precipitate in late fractures. Updip and up-fault, the brine becomes progressively diluted with downward-moving meteoric water. On encountering significant quantities of dolomite in the backreef facies, the Ca-rich brine causes dedolomitization. Although thermochemical considerations suggest that small amounts of several authigenic phases should precipitate, they have yet to be found, except for minor amounts of calcite spar. As the brine evolves by dilution cooling, no systematic changes in any cation/Cl ratio occur, except for regular updip gain in magnesium as a result of progressive dedolomitization. The high-diluted formation water eventually discharges along faults as hot mineral water.

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Downward Vertical Fluid Flow in Subsurface: Implications at Kitty Field, Powder River Basin, Wyoming

Drill-stem test pressure data and subsurface geologic studies permit interpretation of fluid-potential relations in the Kitty field area of the Powder River basin. These relations provide substantiation of significant downward fluid flow from Mowry Shale source rocks to Muddy reservoirs in areas where maximum thicknesses of permeable sandstone are developed. Potentiometric contours indicate vertical flow becomes lateral and radiates outward from areas of high potential once confined to the Muddy aquifer system. Pressure distribution within individual reservoir beds is consistent with this interpretation. Vertical flow is presumably sustained by a combination of the following: (1) expulsion of bonded water during thermal alteration of mixed-layer clays in the Mowry Shale; (2) water generation associated with catagenesis and oil generation in the Mowry Shale; and (3) aquathermal pressuring at temperatures in excess of 200°F (94°C).

Local downward vertical flow of water at Kitty field may provide the means for hydrocarbon migration from Mowry source beds to Muddy reservoirs. Additionally, pressure gradients associated with this flow may be responsible for trapping approximately 75% of the total oil column in the field. Capillary pressures can account for a maximum of about 200 ft (61 m) of the total observed 835 ft (255 m) oil column. Calculations suggest that an additional 460 ft (140 m) of oil represents the minimum hydrodynamic column and that fluid-potential gradients necessary to trap the additional 175 ft (53 m) probably exist in the field.

The Muddy potentiometric surface implies a dynamic aquifer system of downdip inter-formational and vertical, cross-formational fluid flow. Early fluid migration is obscured by this present flow, but can be pressured to be updip toward the basin flanks in response to initial compaction processes. Post-Laramide (Eocene?) exposure of the Muddy aquifer resulted in recharge by meteoric waters. The interaction between meteoric downdip regional flow and local vertically downward flow at Kitty field suggests late accumulation of hydrocarbons.

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Imaging Beneath Complex Structure: Case History

Migration is recognized as the essential step in converting seismic data into a representation of the earth's subsurface structure. Ironically, conventional migration commonly fails where migration is needed most—when the data are recorded over complex structures. Processing field data shot in Central America and synthetic data derived for that section.