Petroleum Geochemistry and Geology of Southeast Georgia Embayment and Florida-Hatteras Slope

Petroleum geochemical and geologic studies were carried out on the COST GE-1 well (Southeast Georgia Embayment), and on the Atlantic Margin Coring Project (AMCOR) core 6004 on the Florida-Hatteras slope. Mud additives contaminated some of the COST GE-1 samples, but by analyzing several duplicate hand-picked sample suites the effect, although not totally removed, was minimized.

In the COST well, the Tertiary shale-chalk-limestone section to a depth of approximately 1,088 m contains very small quantities of indigenous, biogenic hydrocarbons that are not believed to have had a thermal-chemical history. Upper Cretaceous rocks (Maestrichtian, Campanian, Santonian, Coniacian, and Turonian) from 1,088 to 1,814 m consist of gray, calcareous deep-water shales that contain the most organic-rich intervals in the well which are composed of thermally immature, amorphous, hydrogen-rich algal marine kerogens. If these Upper Cretaceous rocks were buried more deeply or found in a region of higher thermal gradient, they could be significant potential oil and gas source rocks. The Lower Cretaceous sedimentary rocks from 1,814 to 2,700 m are dominantly of continental origin with intercalated marine carbonate and sand units that contain very small amounts of terrestrial organic matter (less than 0.1% organic carbon). Although the kerogen in these rocks is of marginal thermal maturity, it promises little as a potential petroleum or natural-gas source.

Sediments in the AMCOR hole 6004 range from Holocene to Upper Cretaceous and are of a predominantly outer shelf–upper slope depositional character. The hydrocarbon and fatty-acid distributions and molecular compositions are typical of marine biogenic sources that are thermally immature with regard to petroleum generation. The organic geochemistry of Paleocene sediments taken from the AMCOR core 6004 may reflect the influence of erosion by the ancestral Gulf Stream.

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Devonian Shale Characterization—Evaluation of Some Significant Exploitation Properties

Hundreds of trillions of cubic feet of natural gas are contained in the Upper Devonian black shales of the Eastern Interior basins. These organically rich (up to 15 wt. %) shales have porosities and permeabilities substantially lower than conventional clastic reservoirs. To exploit this "unconventional" resource, the results of a detailed physiochemical characterization of this shale are being used to obtain the following project goals: assess basin natural gas potential, select basin regions with relatively high potential, and design and/or improve exploration and production techniques. To date, over 500 core and drill cuttings samples are being evaluated. Appalachian, Illinois, and Michigan basin Devonian shales were obtained from eight, six, and one well, respectively, in each basin.

Evaluations of the shale by physical properties, biostratigraphy, and chemical characteristics have shown that the most significant amounts of natural gas have been associated with sediments rich in thermally mature organic matter. This organic matter is characterized as having been deposited in a restricted marine environment where restricted is used in a faunal context—precisely, an unusual environment in which a very restricted faunal assemblage was formed, deposited, and preserved within the sediment. The analyses lead to a determination of whether the organic matter is of the type suitable for optimum gas production.

The lateral and vertical continuity of the hydrocarbon resource is being investigated. The results of this investigation will have a significant impact on assessing the true potential of the Eastern Interior basin as well as aiding basin exploration.

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Lithology Studies of Upper Devonian Well Cuttings in Eastern Kentucky Gas Field

Well cuttings from 14 wells in the Eastern Kentucky gas field, studied under reflected light, permit comparison of lithology changes across the field and between stratigraphic units. Comparison is made with formation density logs, gas production studies, and geochemistry. Such field-study approach, in more detail, is valuable for future exploration and evaluation in production of gas from Upper Devonian shales in this area.

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Inorganic Geochemical Studies of Eastern Kentucky Gas Field and Comparison with Gas Production

The Upper Devonian Ohio Shale sequence, including the Cleveland, Three Lock, and upper, middle, and lower Huron, and the Mississippian Berea-Bedford sequence were studied by using XRF and XRD on 14 well samples from the Eastern Kentucky gas field. Elements studied were Mg, Al, Si, P, K, Ca, Ti, Mn, Fe, S, Cu, Zn, Sr, and Na. Minerals studied were chlorite, illite, gypsum, kaolinite, anhydrite, szomolnokite ($FeSO_4 \times H_2O$), quartz, orthoclase, plagioclase, calcite, dolomite, siderite, pyrite, coquimbite ($Fe_2(SO_4) \times 9H_2O$), and secondary quartz.

The data were studied in terms of average values for the total producing sequence, for the Ohio Shale sequence, and for each stratigraphic unit. Computer-drawn maps, using six contour levels, were compared with final open-flow data patterns from a hand-contour map using 4,750 data points and with maps showing density contours of highly productive wells.

A striking pattern match is shown by comparison of several element and mineral maps with the highly productive well density maps. The predictive value of such an investigation is obvious.

Changes of given elements and minerals, within and between wells, were compared across Eastern Kentucky gas field. The pattern relations are not obvious from graphs, nor from the formation density logs of the wells.

Further refinements of this work are in process. To