Two oil fields in the Williston basin and one potential gas field in Algeria are interpreted to be reservoirs in fractured strata beneath buried impact structures.

In addition to fractured domal structures, impact events in water-bearing, poorly consolidated materials can produce large bodies comparable to sand-flow volcanoes and clastic dikes. Such permeable features, after burial and lithification, may or may not be found in sedimentary environments, such as starved basins, deltas, or lagoonal areas, in which petroleum reservoirs normally occur.

Impact features with petroleum accumulations are most likely to be formed in relatively young, shallow-marine depositional environments (water depths less than 200 m) merely because these structures are most favorably located relative to the time and place of petroleum origin and its later migration. Terrestrial impact sites in well-lithified ancient strata, even crystalline rocks, however, may become reservoirs if a subsequent transgression results in deposition of a basal marine sequence of petroleum-generating sediments.

The best means of recognizing subsurface-impact features are detailed stratigraphic analyses, local structural-anomaly recognition, and high-recognition seismic data. Potential reservoirs of impact origin will be randomly distributed geographically and temporally throughout stratigraphic sequences; prediction of their location will therefore be difficult. Lack of trends, preferential location, or predictable distribution of impact sites precludes systematic search strategies during petroleum exploration. Commonly, magnetic and gravimetric signatures of buried impact features tend to be so subtle as to be ignored by geologists and geophysicists, although known large surface impact sites typically display gravity deficiencies. Only those isolated anomalies which show an obvious circularity can be readily distinguished as possible subsurface impact features. Constant alertness for subtle clues to the presence of subsurface impact structures during routine stratigraphic, structural, and seismic data analyses will be most effective in achieving their discovery.

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Oil- and Gas-Producing Configurations in Trenton Limestone, Northwestern Ohio

Five types of petroleum-producing configurations are present in the Middle Ordovician Trenton Limestone around the Lima-Indiana field in northwestern Ohio. The first, an anticlinal trap, is present along the Findlay arch. Closure is provided on top of the Trenton by regional carbonate bank buildup, folded with and capped by the Utica Shale. The second, a faulted anticline, is present along the Bowling Green fault in Wood, Hancock, and Lucas Counties. A high-angle reverse fault along the crest of the Findlay arch juxtaposes dolomitized Trenton rock with the overlying Utica Shale. This configuration has accounted for significant oil and gas production. The third trap type consists of an updip facies change from Trenton Limestone to Utica Shale, with draping of the thickened shale over the Trenton Limestone. The fourth type, in the Michigan basin, is the fracture systems and dolomitization in the Albion-Scipio trend. The fifth, and less well documented, is a porosity trap in dolomitized upper parts of the Trenton. Dolomitization may function in two ways, both as a prerequisite to formation of sufficiently porous reservoir rock with other trapping mechanisms. Other Trenton fields are not accounted for by these five configurations.

Stratigraphic and structural cross sections from the top of the Trenton to the Knox unconformity, as well as structural and isopach maps of the area, show a major carbonate buildup of the Trenton in a northeast-southwest trending arc in northwestern Ohio. A broad carbonate platform with wedge-top dolomitization in an island environment is postulated as an alternative to a regional erosional unconformity between the Trenton Limestone and Utica Shale.

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Interaction of Proppants with Crack Formation and Propagation in Hydraulic Fracturing

In many wells, productivity can be increased by repeated hydraulic fracturing. Repeated flow cycling has also been shown to increase productivity, sometimes significantly above what can be obtained with a single cycle. The increased productivity from repeated flow cycling suggests that a predictive capability for treating specific wells could be developed if the controlling parameters and their interactions in the flow/cycle treatment process were better understood. Although the primary role of the proppant in hydraulic fracturing is to maintain fracture opening, the proppants may have other effects such as altering the pressure distribution along the fracture (e.g., by blocking the tip) and hence significantly affecting the fracture mechanics.

Although proppant transport by fluids has been studied intensively, the coupled interaction problem of fracture propagation, fluid flow, and proppant transport has not been previously investigated. In SRI International's program to analyze the coupled interactions of proppants and fracture mechanics, proppant distributions are being determined for the coupled problem of fluid-proppant-fracture interaction, and the effects of the proppant distributions on fracture production are being evaluated for the flow/cycle treatment.

Scaled experiments in several media (PMMA and rock simulant) will check the correlation of fluid penetration and fracture propagation rate with a calculational model for the fluid-fracture interactions. The scaled experiments will also constrain the relation between the proppant distributions and the fluid-fracture interactions. The computational model will be verified by comparing calculations of the proppant distributions in the scaled experiments, for which viscous or gravitational effects are dominant, with the scaled experiments.

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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 handpicked 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