Born Again Prospecting

Now may be the time for geochemistry to aid again in the search for oil and gas

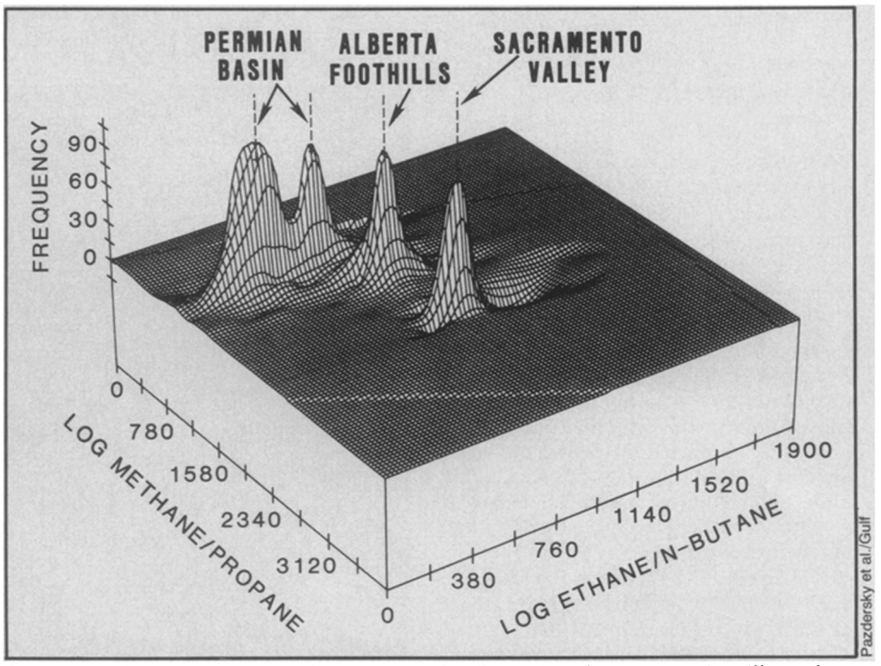
BY LINDA GARMON

The U. S. petroleum industry depended on geochemistry for its start; now it may need that science to keep it going.

The U. S. petroleum industry began when a 69.5-foot well was drilled near observed surface seeps of hydrocarbons in Titusville, Pa. The Titusville prospectors struck oil using a geochemical technique —analyzing the surface for signs of hydrocarbons that could have migrated from reserves below — and for a long time thereafter, geochemistry reigned supreme in the search for petroleum. As the shallow reserves of oil easily detected by surface seeps were exhausted, though, prospectors were forced to crown geology king, searching for oil under faults, folds and other structural traps. The next coup in petroleum science was led by geophysicists, and ever since then, the petroleum industry has been bouncing seismic waves, inducing electromagnetic fields or employing radioactivity in petroleum exploration.

Now, while the geophysics reign is hardly over, things look grim in the hydrocarbon kingdom. A recently concluded study by the Rand Corp. research group of Santa Monica, Calif., for example, indicates that "the petroleum industry is gradually running out of ideas as to where oil and gas may still be found in the United States, not because of lack of creativity and imagination, but because of the increasing exhaustion of geological possibilities." It is this pessimistic petroleum outlook that has inspired certain petroleum researchers and prospectors from at least one major oil company to travel backward through hydrocarbon history. The petroleum industry's salvation, these oil explorers believe, depends in part on a geochemical revival. Believers in this revival gathered in Atlanta at the recent meeting of the American Chemical Society to discuss new geochemical techniques and applications for petroleum exploration

For example, Victor T. Jones of Gulf Research and Development Co. in Pittsburgh, Pa., is developing geochemical techniques to test the controversial deep-earth gas theory of Cornell University's Thomas Gold. While conventional petroleum wisdom holds that most naturally occurring gas is organic in origin—formed when the complex mixture of subsurface organic matter called kerogen decomposes first to heavy oil, then to light oil and finally to gas — Gold theorizes there is a sizeable portion of naturally occurring methane that is inorganic in origin, having been trapped deep within the earth at its birth 4.5 billion years ago. If Gold's deep-earth gas theory is correct, then the petroleum industry's search strategy should include not only those tried-and-true areas thick with organic-rich, hydrocarbon-generating sediments, but also potential "inorganic," or deep, gas-source areas.



In search of a method to predict how much oil a subsurface reservoir will produce, geochemists graphically display the results of a near-surface gas analysis.

To determine whether Gold's theorized deep-gas source is "a viable energy alternative for the nation or in fact just pie in the sky," Jones and colleagues are searching for surface-soil seeps of hydrogen and helium where the potential exists for gas migration from great depths — such as along faults and fractures. The hydrogen in Jones's two-gas indicator signals a subsurface gas deposit; the helium signals migration from the deep, because it is generated by the radioactive decay of uranium or thorium "in the basement of the earth," he explains. Thus far in their soil-gas geochemical analyses, Jones and co-workers have found helium-hydrogen signals along the San Andreas Fault in California, the Duchesne Fault Zone in the Uinta Basin and a fault near Glacier National Park in Montana. To test the use of a helium-hydrogen seep to signal a deep-gas source, however, the researchers next must look for that signal in areas such as the Canadian Shield, where due to the thin layer of sediment, the researchers not only can go to the basement rock more easily, but also can rule out the possibility that seeping gases come from the sediment-associated decomposition of kerogen.

Gulf's researchers also are searching the marine environment for hydrocarbon seeps that may signal petroleum deposits in the offshore continental shelf. Using the latest system installed on Gulf's research vessel, the *Hollis Hedberg*, John C. Williams and colleagues sample the ocean-water column near the surface and at 450 feet and 600 feet below. The *Hollis Hedberg* project involves sampling from basins where petroleum productivity is known in an attempt to relate "the petroleum productive potential of a basin to dissolved hydrocarbon concentrations." In other words, Williams and co-workers are comparing their analyses of basins with known gas and oil accumulations to develop a predictive hydrocarbon-ratio method of screening frontier offshore areas for their petroleum potential. Regardless of how close a correlation the researchers can establish between their ratios and basin potential, the screening ability of the method is limited, Williams says, because "the lack of an anomaly may only indicate the lack of a conduit between source and sea floor."

Despite this and other limitations of petroleum geochemistry, certain oil explorers still feel the time is right for its revival. One reason is that "most of the oil left to be

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found probably is in stratigraphic traps," Jones says.

Basically, petroleum can accumulate under structural traps — physical enclosures such as anticlines — or stratigraphic traps — changes in the lithology, or composition, of rocks so that they become impermeable to migrating hydrocarbons. While various geophysical methods can easily detect structural traps, "The seismic people can't always see a stratigraphic trap," explains Jones. On the other hand, since even highly impermeable rocks allow some hydrocarbon migration, geochemical prospecting could detect these traps.

But the real petroleum pièce de résistance of geochemistry, says Jones, is its ability to distinguish, via surface analysis, the largely oil- from the largely gas-producing hydrocarbon reservoirs. "Oil is worth a lot more than gas now," he says. "For example, in a foreign country like Pakistan, there is absolutely no commercial value in our hitting gas, because we can't take it anywhere. We can't move it to market; pipelines are needed."

To avoid drilling economically "dry" wells, Gulf's Gregory J. Pazdersky and co-workers have devised a soil-gas analysis that indicates the type of hydrocarbons present in the subsurface reservoir. Unlike past soil-gas analyses, Pazdersky's method does not depend on the soil concentration of methane — a gas that could seep from a near-surface biogenic (bacteria, for example) source, rather than a hearty hydrocarbon pool. Instead, Pazdersky's method involves comparing the methane-propane with the ethane-normal butane surface ratio. Using this technique, the Gulf researchers have been able to graphically distinguish among the gas-only Sacramento Valley, the condensate (gasoline-like mixture of light and heavy hydrocarbons)-containing Alberta Foothills and the largely oil-producing Permian Basin. "This data treatment might be useful to explorationists in advance prediction of hydrocarbon reservoir composition," Pazdersky says, "particularly in frontier areas."

Again, however, the geochemical method is limited in its prospecting abilities: Although they can successfully characterize reservoir types, the soil-gas ratios cannot predict the size of the reservoirs. "The magnitude of the anomaly could be proportional to the efficiency of migration," Jones explains, "so we have to take into account the tectonics — the faults, joints and other disturbances in the earth that allow the gases to escape."

Geochemistry is not a "stand-alone tool," he says. "You don't build a house with just a hammer — you use a saw, nails and other tools. What we're saying is that geochemistry is just one tool, but it is needed." □