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Fresh look at geochemistry for oil searching

Increasing oil costs and dwindling known reserves have sparked renewed interest in geochemical methods for petroleum exploration

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One of the oldest methods of locating oil and gas deposits is having a revival. The method is surface geochemistry. Long eclipsed by more purely geological procedures, such as seismic testing, geochemistry is still the stepchild among the high-technology petroleum exploration methods. But rising oil costs and shrinking known reserves have rekindled interest among oil exploration companies in tracking down the clues to unknown deposits that geochemical techniques can provide.

A look at what the science has to offer and how one oil company in particular is employing these techniques comes from a symposium on advances in geochemical techniques for oil exploration sponsored by the Division of Geochemistry. (The division was elevated from probationary to full divisional status by the ACS Council during its meeting in Atlanta.)

Analyzing the ground surface for signs of oil or other hydrocarbons that seeped up from deposits below is probably the oldest method of locating oil deposits. However, as very shallow deposits were depleted, obvious surface signs of oil below became unusual. Prospectors began instead to study the subsurface geology looking for formations that could trap oil or natural gas in reservoirs, particularly in regions where other geologic markers showed conditions would have been right for petroleum formation. Usually such conditions induce an impermeable capping layer, which, many prospectors believed, would prevent seepage of hydrocarbon molecules from the oil deposit to the surface.

Now that picture is changing. Few rocks are entirely impermeable, and improved analytical techniques now allow detection of indicator molecules at the parts-per-million level in ground and water samples. According to one current theory, hydrocarbons are most likely to escape from the edges of a subsurface deposit, creating a characteristic "halo" of increased hydrocarbons in the soil gases above a deposit.

Although soil bacteria and other factors unrelated to subsurface oil deposits also can put hydrocarbons into the soil, these confounding factors generally can be separated out—by isotopic analysis, for example. In fact, the techniques for detecting and identifying surface hydrocarbons are now so good, says Victor T. Jones, director of the physical geochemistry and minerals section of Gulf Research & Development Co., that "the geochemical evidence is irrefutable if you have hydrocarbons at the surface. The only question is where the source is." However, he adds, it is dangerous to condemn a project on the basis of a lack of geochemical evidence that something is there.

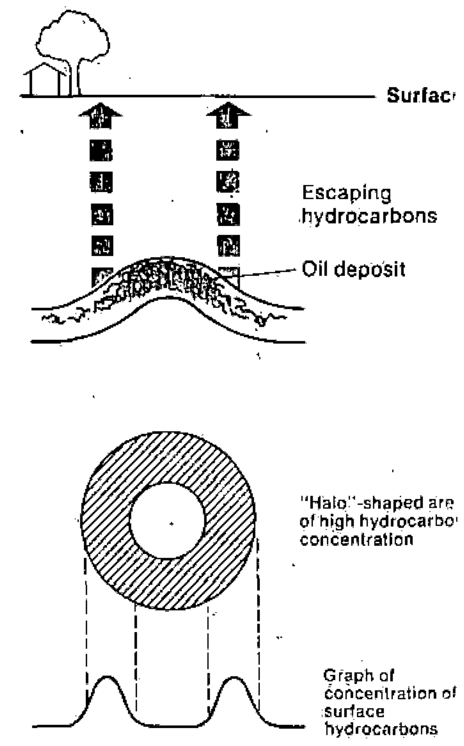
Gulf Research & Development is using surface geochemical techniques to search for oil in several ways. Ted J. Weismann, manager of the firm's geochemistry and minerals department, outlined some of the ways the company uses surface geochemistry. The presence of relatively high concentrations of hydrocarbons in soil gases indicates a petroleum deposit somewhere below the surface, he says. In addition, the relative abundance of different hydrocarbons gives an indication of the chemical composition of the deposit below.

For instance, analysis of near surface gases at the predominantly oil producing Permian Basin in West Texas; the oil condensate region of the Alberta Foothills, and the dry methane gas production of Sacramento Valley, Calif., give quite different ratios of methane to propane and ethane to butane, explains senior geologist Gregory J. Pazdersky. Such surface gas analysis might be useful for exploration, particularly in regions where no earlier wells have been drilled, he suggests.

Deposits in the offshore continental shelf also send up hydrocarbon markers that can be measured in the water column above them, says Gulf's John C. Williams, supervisor of the marine geochemistry section. Gulf's research vessel, the *Hollis Hedberg*, samples ocean water at three depths—the surface, 450 feet down, and as much as 600 feet down. The samples are analyzed for methane and propane and compared with average concentrations for these compounds in open ocean water.

In areas that are known to contain petroleum deposits, the levels of the measured hydrocarbons are much greater than the average ocean value, he finds. For example, in the Gulf of Mexico, 22% of the samples taken have more than 2 nanoliters of propane per liter of seawater, compared to an open ocean average of 0.34 nanoliter. For methane, 80% of the Gulf of Mexico samples show more

Hydrocarbon "halos" can mark oil deposits below



than 100 nanoliters per liter, compared to 8% of open ocean samples.

Although there are many examples of a correlation between high hydrocarbon measurements and successful drilling, Williams points out that there also have been some failures. The area off the Washington-Oregon coast, for example, has very high methane and moderately high propane levels in the seawater, but 14 exploratory wells have shown only minor gas and oil deposits. The Gulf of Alaska, too, should have petroleum deposits, based on hydrocarbons found in the water, but drilling to date has not located deposits.

A preliminary look at what happens to hydrocarbons as they migrate from the source deposit to the surface comes from Gulf's Richard J. Drozd, research geochemist, and colleagues at West Virginia University. High bicarbonate and methane concentrations in water taken from aquifers near the surface are an indication of hydrocarbon migration from gas reservoirs below, Drozd says. The migrating hydrocarbons would lead to increased evaporation of the water. This, in turn, leads to an isotopic fractionation of the oxygen and an increase in ^{18}O. The process also involves an enrichment in ^{12}C in the carbon dioxide that is released, with a resulting increase in ^{13}C in the residual dissolved carbonate.

Monitoring the soil and ocean water for indicator gases does have some drawbacks, however. "The correspondence is not one-to-one between soil gas anomalies and oil deposits below," Weismann says. Sometimes geologic features deflect the gases as they migrate to the surface, so that a well sunk where the gases reach the surface may fail to tap the petroleum source they come from. A history that includes a few such misses is one reason why geochemical techniques are not being used more widely in today's exploration.

There are two important factors needed to decide whether an oil source can be tapped profitably that surface gas analysis does not provide. Surprisingly, it does not give much information on the size of a deposit. The concentration of gases in the soil is more a function of the ease of migration through the material that separates the source from the surface than it is of the size of the oil reservoir, Weismann says. And the technique does not tell how deep the deposit may be. Some early dry holes dug on the basis of geochemistry may have failed to tap oil because they did not go deep enough. □

Trace organics are thrust of water cleanup

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For the past five to 10 years, scientists and engineers have been laying the groundwork for the technology of treating drinking water with granular activated carbon. That technology promises to form the basis for a new phase in water treatment history. First came the removal of particulates, then the removal of bacteria, and now the removal of trace organic compounds, particularly trihalomethanes.

As evidenced by a three-and-a-half-day Division of Environmental Chemistry symposium on treatment of water by granular activated carbon, work has been progressing along a broad front, ranging from carbon adsorption theory to commercial economics. Three studies described at the symposium point up the variety of work currently under way at an applications level.

In Florida, researchers have been studying the removal of trihalomethanes in a 150,000 gal-per-day pilot plant with bacteria-activated towers. The project has been funded and operated jointly by the Environmental Protection Agency's Municipal Environmental Research Laboratory, Miami-Dade Water & Sewer Authority, Dade County Department of Public Health, and the Drinking Water Research Center at Florida International University.

Paul Wood of the Florida International research center noted that granular-activated carbon can't be used economically for removal of trihalomethanes, formed during chlorination from generally natural precursor substances. Thus, the objective of the pilot plant is to see whether bacteria-activated towers of granular activated carbon would be suitable for removing precursors.

The pilot plant includes an ozone generating and contacting section. The study is seeking to determine if ozonation of the water will modify

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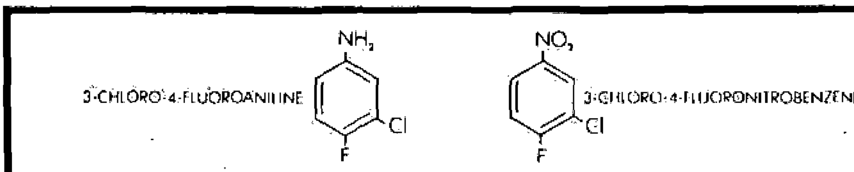

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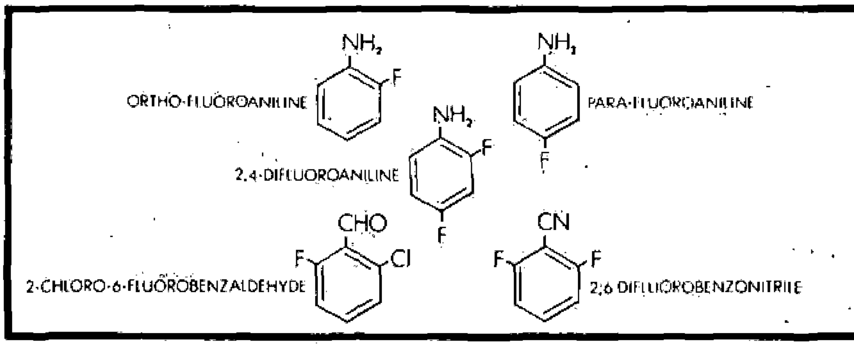

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