ture or depositional environment is intended, this study graphically shows that even in a mature province, low-cost, closely spaced data can indicate new minor structures and delineate new areas for profitable and productive testing with the drill.

CLAYPOOL, GEORGE E., and CHARLES N. THRELKELD, U.S. Geol. Survey, Denver, CO

Methane Hydrate in Slope Sediments on West Coast of Central America

Offshore Mexico and Guatemala slope sediments are classic sites of deep-sea gas hydrate occurrence. Gassy, frozen sediment was recovered in cores from this region on Legs 66, 67, and 84 of the Deep Sea Drilling Project. In addition, a massive 3 to 4-m thick layer of nearly pure methane hydrate at a depth of 250 m was cored on Leg 84 and preserved for study. The gas from the hydrate is 99+ % methane with a few tenths percent carbon dioxide and traces (10^{-4} v/v) of ethane. Most of the sites with gas hydrate in the sediments have methane with $\delta^{13}C$ of -70 to -60 ‰, indicating origin from methane-generating bacteria. The massive gas hydrate contained methane with $\delta^{13}C$ of -40 ‰, and the surrounding sediment had bicarbonate in the pore water with $\delta^{13}C$ of $+35$ ‰. The 75 ‰ separation in $\delta^{13}C$ between coexisting methane and bicarbonate is consistent with kinetic fractionation during bacterial reduction of carbon dioxide to methane, with continuous replenishment of carbon dioxide by fermentation processes.

The areal extent of the massive gas hydrate is not known, but the single point yields a gas-in-place estimate of 5.2×10^8 m^3/km^2 or 48 bcf/mi^2.

COLEMAN, DENNIS D., Illinois State Geol. Survey, Champaign, IL

Applications of Geochemistry to Production, Storage, and Use of Natural Gas

Geochemistry has become a standard tool in the exploration for oil and gas. Many of the concepts and techniques developed for exploration can be used with equal effectiveness in identifying environmental problems related to the production, storage, and use of natural gas.

Contamination of shallow aquifers as a result of improperly completed gas or oil wells is a problem in some areas. Similarly, gas which has migrated from underground gas-storage reservoirs also can contaminate shallow aquifers. Many shallow aquifers contain relatively high concentrations of microbially generated methane, and therefore detection of hydrocarbons is not sufficient to determine the source of the gas. Although microbial gas can frequently be distinguished from thermogenic gases by the absence of ethane and heavier hydrocarbons, migration through hundreds or thousands of feet of porous sediments can result in changes in the chemical composition of the gas, analogous to the changes that occur as gas passes through a chromatographic column. Therefore, the absence of heavier hydrocarbons is not always an indicator of source. Carbon isotopic composition of methane, however, appears to be relatively unaffected by migrational changes and can generally be used to distinguish between microbial and thermogenic methane.

Questions also frequently arise as to the source of gas from gas and oil wells around the margins of gas-storage reservoirs. Although chemical analysis can sometimes be useful in distinguishing between storage gas and native gas, these gases are sometimes chemically quite similar. In the event that the gases cannot be distinguished chemically, determination of the carbon and/or the hydrogen isotopic composition of the methane may still provide positive identification.

Gases generated in sanitary landfills or marshy areas sometimes can be interpreted as being the result of leakage from pipelines. In addition to the techniques already mentioned, radiocarbon dating of methane can be used to identify gases from these sources.

COLEMAN, JAMES L., JR., Amoco Production Co., New Orleans, LA

Stratigraphic Evolution of Paleozoic Erathem, Northern Florida

Unmetamorphosed Paleozoic sedimentary and volcanic rocks have been drilled in numerous wells throughout northern Florida and southern Georgia, in what is today a gently folded and block-faulted relict continental fragment of northwest Africa and northeast South America. Stratigraphic and lithologic equivalents of these North American Paleozoic units are prolific hydrocarbon producers in North Africa.

The northern Florida Paleozoic sediments were deposited on Pan-African and Cadoman basement. Widespread continental glaciation from late Precambrian to Early Cambrian introduced a thick sequence of fine-grained marine sandstones ("glacial flour"), which overlie medium to coarse-grained glaciofluvial sandstones. Basinward of the sand shelf, the accretion of a volcanic island arc complex began during the Ordovician. A fluctuating transgression, accompanying a major glacial minimum, brought open-marine, graptolitic, black shales onto the sand shelf, producing an interbedded shoreface-shelf sand and black shale section during the Middle and Late Ordovician. At the Ordovician-Silurian boundary, renewed continental glaciation lowered sea level, producing a widespread unconformity. A Late Silurian major marine transgression returned black, graptolitic, highly organic shales onto the sand shelf. Devonian deltaic sands from Avalonia(?) to the north and the craton to the south closed the Paleozoic sedimentary record of northern Florida.

COLLETT, TIMOTHY S., U.S. Geol. Survey, Menlo Park, CA

Evaluation of Local Geothermal Gradients on North Slope of Alaska

The U.S. Geological Survey is conducting a detailed assessment of worldwide natural-gas hydrate occurrences. Thermodynamic conditions controlling hydrate occurrences of northern Alaska have been examined. Pressure and temperature conditions on the North Slope indicate that hydrates would be potentially stable both above and below the permafrost base. Geothermal gradients needed to predict the thickness of the hydrate stability zone are not easily obtained. A survey of preliminary data suggested wide variations in averaged regional geothermal gradients across the North Slope.

To evaluate regional variations of geothermal gradients, 2 techniques were employed to calculate local gradients. The first method used bottom-hole temperatures recorded during successive wireline logging runs and corrected by Horner crossplots to determine undisturbed formation temperatures. The Horner crossplot method requires a series of recorded bottom-hole temperatures. However, in most of the North Slope production wells, only 2-3 log runs are conducted per well, thus limiting the number of bottom-hole temperatures. To overcome this limiting factor, a second method has been developed to evaluate local geothermal gradients. This new technique uses permafrost depths delineated from well-log data to project geothermal gradients. Gradients within the permafrost zone have been projected from the base of permafrost, which is in equilibrium at $-1°C$. A series of mean ground temperatures has been used to project the upper extent of each gradient. Geothermal gradients change abruptly at the base of the permafrost. In order to calculate the gradient below the permafrost base, a constant generated from subsurface temperature data was used to correct for this change in geothermal gradient. Data from 398 wells were examined by each method to develop a series of geothermal gradient maps. The gradient maps generated by the 2 methods compare favorably; trend-surface comparisons indicate a high degree of similarity.

CONEL, JAMES E., HAROLD R. LANG, and EARNEST D. PAYLOR, Jet Propulsion Lab., Pasadena, CA

Post-Laramide Uplift and Erosional History of Northern Wind River Basin, Wyoming

Landsat Thematic Mapper (TM) multispectral scanner images together with aerial photographs have been used to infer Laramide to Holocene tectonic events along the northern fringe of Wind River basin near Wind River Canyon, Wyoming.

TM images reveal the presence of a large system of alluvial fans, terraces, and residual tongue-shaped debris deposits covering an area of 90 mi^2 at the base of Copper Mountain. The debris system contains predominantly dark metasedimentary clasts. Both Eocene (Wind River and Wagon Bed Formations) and Quaternary deposits are present, and some Eocene gravel has been reworked into the later units. These deposits contrast sharply in brightness and color with rocks in adjacent areas.

Detailed topographic analysis of the terraces and fan remnants disclosed an episodic history of post-Wagon Bed (upper to middle Eocene)