hydrodynamic conditions. In general, canyons in the upper slope have relatively broad flat thalwegs distinguished by relatively bright surfaces; tonal gradations indicate that the thalweg surfaces lap smoothly onto sharply etched border terrane. Terrane bordering the canyons typically has a simple gully and ridge trellis pattern; one or both sides of this bordering terrane may be spectacularly etched and extended. Individual gullies typically extend up to faceted back slopes. The extent and pattern of etched terrane, as shown in the midrange images, varies considerably from canyon to canyon suggesting the influence of multiple erosional events involving different mechanisms, and a substratum of varied erosional resistance.

OMNES, GILDAS, Compagnie Generale de Geophysique, Denver, CO

What Can Elasticity Moduli Tell Us About Lithology and Diagenesis?

Because rocks have a certain rigidity, the displacement and velocity associated with pressure waves are not, for a given density, functions of the incompressibility alone, but also of the rigidity which links particles to each other.

In the shear waves, displacement occurs without volume change and the velocity is, for a given density, a function of rigidity alone.

For isotropic media:

$$V_p = \frac{(k + 4/3\mu)^{1/2}}{\varrho} \text{ and } V_S = (\mu/\varrho)^{1/2}$$

where V_p, V_S = velocities of pressure and shear waves; k = incompressibility modulus; μ = rigidity modulus; and ϱ = density.

The knowledge of V_p alone is not enough to separate the effects of changes of incompressibility and rigidity. Though seismic velocities are proportional to the reciprocal of the square root of the density, statistical evidence shows that pressure and shear-wave velocities increase with density.

This must be attributed mainly to the effect of cementation. Cementation fills pores with solid material, thus increasing incompressibility, and cements particles together, increasing rigidity. However, compaction, the process of volume reduction, has much less effect on the rigidity increase than on the incompressibility increase. Where cementation is not important, low shear-wave velocities can be expected. Lower shear-wave velocities can also be expected where fracturing decreases rigidity, or where the shaliness of a horizon increases. Compressibility changes can be detected in shaly intervals.

The velocity of pressure waves may remain fairly constant when ridigity increases and incompressibility decreases, as when voids occur where the matrix is better cemented than in contiguous formations. The knowledge of V_S might attract attention to such situations.

OREMLAND, RONALD S., U.S. Geol. Survey, Menlo Park, CA

Geochemical Prospecting for Oil and Gas: Microbiologist's Viewpoint

Microorganisms are important factors in the processes that govern the distribution of numerous chemical elements in the earth's crust. Carbon in particular undergoes an enormous variety of transformations as a consequence of microbial synthetic and degradative reactions. These reactions have importance in the study of organic geochemistry. Geochemical prospecting, however, has been limited by a lack of understanding of specific types of microbially mediated reactions and the extent to which they occur within the geosphere. Geochemical data interpretation for the purpose of finding oil and natural gas deposits would be enhanced by future research directed at: (1) defining the extent to which geochemically active microbes penetrate the earth's crust; (2) reinterpreting carbon isotope data in light of microbial reactions of formation, oxidation, and competition; (3) identifying novel microbial biomarkers; and (4) determining whether microbes can produce significant quantities of C_2+ gaseous hydrocarbons.

ORIFE, JAMES M., and AKPO A. AVBOVBO, Nigerian National Petroleum Corp., Lagos, Nigeria

Stratigraphic and Unconformity Traps in Niger Delta

Although hydrocarbons are dominantly trapped in rollover anticlines and fault closures in the Niger delta, some stratigraphic traps have also been recognized. Three types of stratigraphic accumulations are recognized in the Niger delta: (1) crestal accumulations below mature erosion surfaces; (2) canyon fill accumulations above unconformity surfaces; and (3) facies-change traps.

Several important oil discoveries in offshore southeastern Nigeria are associated with crestal accumulations below erosional surfaces. In addition, canyon fill accumulations have been observed in offshore southeastern Nigeria within the Qua Iboe Shale. Recent discoveries have also shown accumulations within the Opuama Clay in the western flank of the Niger delta. Facies-change traps have also been observed in the central part of the Niger delta. The various stratigraphic traps observed in the Niger delta are identified by interpretation of seismic data.

OSWALT, JACK M., Gulf Oil Exploration and Production Co., U.S., Midland, TX

Evaporites as Seals for Hydrocarbon Accumulations in Carbonate Provinces of North America: Case Histories

Evaporites are an important factor as the seal for hydrocarbon accumulations in carbonate provinces throughout North America. In the Silurian of the Michigan basin, dolomitized Niagaran pinnacle-reefs have been effectively sealed with evaporite cycles composed of anhydritic sabkha deposits of the Ruff Formation and cleaner evaporites of the Salina units. In the Williston basin of North Dakota and Saskatchewan, successive regressions of the Mississippian sea have resulted in the subsequent basinward migration of anhydritic sabkha deposits over algal-pelletal limestone banks that were formerly shoals at the seaward edge of the sabkhas. The anhydrite has halted the updip migration of hydrocarbons in these limestones. In the Permian of west Texas, over 731 million bbl of oil have been produced from the San Andres Formation against a porosity barrier along the eastern side of the Central Basin platform where anhydrite has plugged the porosity of the dolomite. The McElroy field is an excellent example of this important trend.

The environmental conditions that provide the typical setting for the formation of shallow-marine carbonates are also ideal for the formation of evaporites whenever marine waters become sufficiently restricted. The occurrence of excellent evaporite seals in close proximity to porous carbonate reservoirs can provide many opportunities for entrapment of