Albian marine transgression were epicontinental sandstones, known as the Hollin Formation, which are the primary drilling objectives in the Subandean basin. As subsidence continued, the relief of the Guyana shield was reduced by erosion, and finer-grained uppermost Albian to Cenomanian sediments were deposited. These beds, called the Napo Formation, are mainly interbedded shale, glauconitic sandstone and bituminous limestone. They form an important oil-producing section. The source of Napo and Hollin sediments was on the east in the Guyana shield. The sub-Hercynian orogeny terminated the cycle of sedimentation and led to the beginning of deposition in a fluviatile and lacustrine environment. The predominantly freshwater environment persisted throughout Tertiary time and sediments were derived from the newly uplifted Andes on the west.

Commercial production was established in Colombia in 1967 and the producing trends have been extended south to the northern border of Peru. Oil has accumulated in mountain-front and mid-basin traps that are most commonly fault-associated anticlines.

All crude discovered has been of the "sweet" type. There is an increase in oil gravity from the eastern shelf to the western basin axis. Gas-oil ratios are low. No gas fields have been discovered.

FRIEDMAN, G. M., Rensselaer Polytechnic Inst., Troy, N. Y.

CORAL REEF ROCK FROM RED SEA: SEQUENCE AND TIME SCALE FOR PROGRESSIVE DIAGENESIS AND ITS EFFECT ON POROSITY AND PERMEABILITY

In modern Red Sea coral reef rock, pore spaces of corals are partly filled with fibrous aragonite precipitated subaqueously. By contrast, subaerially exposed reef rock about 115,000 years old, but with corals still composed of aragonite, lacks cement. Its porosity and permeability exceed those of modern reef rock. Emerged reef rock dating back 200,000–250,000 years may still consist of aragonite, but corals older than 250,000 years consist mostly of calcite. In these older corals dissolution removed the aragonite. Precipitation of a calcite mosaic preserved the outlines of the original corals, but the total skeletal framework preserved as calcite was less than that originally occupied by aragonite. Therefore porosity and permeability of the older reef rocks are markedly increased compared with all younger reef rocks. The waters that passed through the older emerged reefs must have been barely saturated with respect to $CaCO_3$.

As the emerged reef rocks lack interstitial fibrous cement, the corals must have been raised out of the sea before the onset of submarine cementation. An arid climate dating back 250,000 years prevented the dissolution of the aragonite of the corals. Although climatic changes more than 250,000 years ago were such that percolating fresh waters removed aragonite and precipitated calcite, the waters tended to remain undersaturated with respect to $CaCO_3$. Hence the progressive sequence of emergence of reef rock before onset of submarine cementation, dissolution of aragonite, and minor calcite precipitation by fresh water led to increase in porosity and permeability.

FRIEDMAN, G. M., A. J. AMIEL, M. BRAUN, and D. S. MILLER, Rensselaer Polytechnic Inst., Troy, N. Y.

ALGAL MATS, CARBONATE LAMINITES, OOIDS, ONCOLITES, PELLETS, AND CEMENTS IN HYPERSALINE SEA-MARGINAL POOL, GULF OF AQABA, RED SEA

A bar isolates the hypersaline pool from the Gulf of Aqaba. Finely laminated algal mats carpet the shallow shelf of the pool and gypsum floors the slope and bottom. Algae secrete pellets, ooids, oncolites, grapestones, flakes, and carbonate laminites. The ooids have a radial texture; hence, contrary to statements in the literature, ooids with a radial texture are formed in the depositional environment. The carbonate laminites occur between the gray and black algal mats. Although some of them are fibrous, most are cryptocrystalline. Cryptocrystalline laminites which consist of high-Mg calcite mimic the micrite of the geologic rock record; these laminites can preserve the morphology of the mats even after the organic matter has disappeared. Scanning electron micrographs show the laminites to consist of a mosaic of micron-size rhombohedrons which, during diagenesis, would stabilize to low-Mg calcite. Hence, the origin of some ancient stromatolitic limestones (pelmicrites) may be explained in terms of secretion of cryptocrystalline high-Mg calcite laminites. These laminites are lithified within the algal mats; hence, their origin does not necessitate the introduction of later cement and establishes algal secretion as a potent force in lithification. This inference may supersede the concept that all micrites result from neomorphic replacement of aragonite.

The algae create a microenvironment in which Mg becomes enriched in the organic matter, and in which high-Mg calcite with up to 40% molecular $MgCO_3$ is secreted. The total molecular percent of $MgCO_3$ in the Mg-organic complex and high-Mg calcite combined may reach 60. This preferential concentration of Mg may explain the high level of dolomitization of stromatolitic rocks in the geologic record. Amino acids devoid of sulfur, especially aspartic acid, as part of the biologic system may exert considerable influence in the precipitation of the carbonate laminites and particles.

FÜCHTBAUER, H., Ruhr-Universität, Bochum, Germany.

SAND DIAGENESIS: SOME RESULTS AND APPLICATIONS

No abstract available.

GAITHER, A., and L. D. MECKEL, Shell Oil Co., Denver, Colo.

MUDDY FORMATION OF NORTHERN POWDER RIVER BASIN—A STRATIGRAPHIC PARADOX

The Muddy Formation in the northern Powder River basin contains a stratigraphic paradox whereby the oldest basal sandstones appear to be the youngest and vice versa. Subsidence history is the underlying cause of the paradox. Relating depositional events as determined from physical and paleontologic data to the subsidence leads to a simple and consistent depositional history.

On lithology, the Muddy is subdivided into lower and upper units. The lower unit consists of thick basal sandstones and thin contemporaneous siltstones and shales that were deposited by a single southeast-to-northwest regression. These thick sandstones are important Muddy reservoirs and consist of coastal barriers (Bell Creek and Rozet fields) and distributary or estuarine channels (Recluse field).

When the lower Muddy regression had proceeded to a point northwest of the currently producing area, the character of the shoreline changed from a high-energy sandy shoreline to a low-energy muddy and tidal-flat shoreline. The shoreline remained northwest of the productive area throughout the rest of Muddy deposi-

tion, although subsidence was greater there than in the southeast. This differential subsidence caused the southeast thinning of the nonmarine upper Muddy sediments. Muddy deposition was terminated by the rapid eastward advance of the Shell Creek or lower Mowry sea. This transgression reworked the uppermost nonmarine Muddy sediments, producing a thin, widespread sandy zone that constitutes the principal reservoir at Hilight field.

Because the lower Muddy was deposited during a southeast to northwest regression, the sandstones are progressively younger toward the northwest. However, the overlying nonmarine upper Muddy thickens northwestward, causing the underlying regressive sandstone to appear to be stratigraphically lower and, hence, older in that direction. This stratigraphic paradox has caused much confusion and difficulty in resolving Muddy stratigraphy.

GALLEY, J. E., Consultant, Kerrville, Tex.

GEOLOGIC FRAMEWORK FOR SUCCESSFUL UNDERGROUND WASTE MANAGEMENT

Abstract *in* Am. Assoc. Petroleum Geol. Bull., v. 55, no. 11, p. 2084.

GALLOWAY, W. E., Continental Oil Co., Ponca City, Okla.

DEPOSITIONAL SYSTEMS OF CISCO GROUP: THEIR RELATION TO RESERVOIR DISTRIBUTION AND PETROLEUM PRODUCTION ON EASTERN SHELF, MIDLAND BASIN

The Cisco Group is a mixed terrigenous clastic and carbonate rock stratigraphic unit deposited on the Eastern shelf, a late Paleozoic constructional platform developed on the margin of the sediment-starved Midland basin. Detailed facies mapping of the Harpersville format, a boundary-defined unit within the Cisco Group, outlines 3 depositional systems that are differentiated by gross lithologic composition and position relative to the equivalent shelf edges. They are the (1) Cisco fluvial-deltaic system, (2) Sylvester shelf-edge bank system, and (3) Sweetwater slope system. The Cisco fluvial-deltaic system is composed of dip-fed fluvial and deltaic facies and associated strike-fed interdeltaic embayment facies. The Sylvester shelf-edge bank system consists of an offlapping series of elongated, prismatic limestone banks that lie along the shelf margin. The Sweetwater slope system is composed of numerous slope wedges, or fans, which include shelf-margin, slope-trough, and distal-slope sandstone facies. The eastern shelf prograded into the Midland basin by local upbuilding through fluvial, deltaic, and shelf-edge bank deposition contemporaneous with outbuilding by slope-fan deposition.

Oil pools are found in all 3 depositional systems. Productive facies include fluvial, distributary channel, and distributary-mouth bar sandstones of the fluvial-deltaic system and distal-slope and shelf-margin sandstones of the slope system. Production is concentrated in areas where 2 broad, subparallel, structurally-related NE-SW trends intersect the mapped fluvial-deltaic lobes. The complex, lenticular geometry of these thin deltaic sandstones affords maximum opportunity for development of stratigraphic and combination traps.

GAUCHER, L. P., Consulting Engineer, Fishkill, N.Y.

ORIGIN OF PETROLEUM

As more and larger oil and natural gas deposits are found throughout the world—some in unlikely places —it becomes increasingly difficult to continue to believe that those hydrocarbons originated drop by drop through the transformation of the remains of minute animals and plants that were locked in marine sediments in relatively recent years. This "organic theory" of petroleum genesis was propounded many years ago when the number and extent of oil and gas discoveries were relatively small and when knowledge of cosmology, chemistry, and other sciences was far less sophisticated than it is today.

It is now suggested that oil and natural gas could have been formed in much larger quantities than was ever considered plausible before, through chemical reactions among components of the atmosphere that existed billions of years ago when the earth was still hot —long before there was any plant or animal life.

During the period 3–4 billion years ago, when the earth's surface was cooling from 1,000°F to about 400°F, the formation of hydrocarbons through the reaction (on catalytic surfaces) of atmospheric hydrogen and carbon monoxide seems inevitable. During that period, when the surface was still too hot for water to exist as a liquid, the earth probably was surrounded with dense clouds of hydrocarbons which literally "rained oil." This oil together with the sediments that it carried with it filled all the surface depressions that existed at the time.

Through this same kind of reaction, it is probable that several simple oxygenated compounds formed simultaneously. These acids, alcohols, aldehydes, *etc.* could well have been the source of amino acids, nucleic acids, and proteins, the precursors of cells and life itself.

The recent discovery of amino acids on a meteorite lends credence to this hypothesis and further proof may not be far off. If it can be confirmed that the clouds around the planet Venus are truly hydrocarbons, as many scientists have suggested, and if further exploration of the surface of Venus, which is reported to be at 720–885°F, discloses evidence of "oil rains" there, then the theory of petroleum genesis now proposed will be lent very strong support.

GEBELEIN, C. D., Dept. Earth and Space Sci., State Univ. New York, Stony Brook, N.Y.

BIOLOGIC CONTROL OF STROMATOLITE MICROSTRUCTURE: IMPLICATIONS FOR PRECAMBRIAN TIME-STRATIGRAPHY

Studies of Holocene stromatolitic sediments indicate that the biologic makeup of surficial blue-green algal mats controls the microstructure (features less than several centimeters in size) of stromatolites. Microstructural features include relief along a single growth surface, grain-to-grain relations within laminae, and distribution of organic matter. Recent stromatolitic sediments are basically an intertidal phenomenon. Within the intertidal zone, blue-green algal species are organized into distinct biologic communities. Each community occupies the sediment surface within a specific flooding-frequency range, and each community produces a distinctive microstructure. Recent algal communities have a wide geographic range. Similar communities and zonations may be hundreds and thousands of miles apart, but only where the areas are connected by rapidly flowing open water or wind currents (*e.g.*, areas connected by the Indian Ocean North Equatorial Current). Therefore, major stromatolite-forming algal communities do not have a worldwide distribution.

These data may be applied to the assemblages of stromatolitic microstructures which characterize 100–300 m. y. intervals in the late Proterozoic (Ri-