

(4) Progressively cooling and fluctuating climates typify the late Pliocene (with *Globorotalia tosaensis*) which ended with the cold climax of the first intense Pleistocene glaciation and extreme low sea level stand.

ROWLAND, T. L., Oklahoma Geol. Survey, Norman, OK 73069

**ALGAL MUDSTONE MOUNDS IN MORROWAN STAGE (LOWER PENNSYLVANIAN) IN NORTHEASTERN OKLAHOMA**

The middle of the Morrowan Stage is marked by the development of an algal carbonate mudstone. The area of exposure covers 700 sq mi in northeastern Oklahoma with a maximum development of 60 ft in the southwestern 30 sq mi of the outcrop. A broad algal bank and smaller algal mounds developed within the area of maximum thickness, on the southwestern margin of the Ozark uplift. This area has high faunal diversity and the bank is cut irregularly by channels of skeletal sandstone. Northeastward, the faunal diversity of the unit is low, and the mudstone thins owing to replacement by skeletal grainstones and shale.

The algal mounds are up to 6 ft high and 10 ft across. The core material consists of *Archaeolithophyllum* and *Cuneiphyucus* mudstone and boundstone, whereas the flank and intermound material consists of coarse skeletal packstone and wackestone. Influx of fine terrigenous clastics occurred during formation of this unit, as shale is present in small thin streaks and pockets. Locally, oolitic packstones and beds of algal oncoliths are found in the top. The mudstone is encompassed between skeletal grainstone throughout the areas of exposure.

The overall dearth of skeletal debris, abundance of algae, occurrence of stromatolite-type boundstone, burrowing, and occurrence of dolomite indicate that the mudstone was formed in a shallow subtidal or tidal-flat environment. Abundant recrystallization of matrix mud to microspar and pseudospar has taken place, and dolomite, ferroan dolomite, and siderite are present locally as replacement of skeletal debris and mud matrix.

ROZENDAL, ROGER A., Shell Oil Co., Houston, TX 77001, and RICHARD L. NICHOLAS, Shell Development Co., Houston, TX 77001

**POSITIVE ELEMENTS WITHIN OUACHITA TECTONIC BELT IN TEXAS**

Two major positive elements south and east of the foreland basins marginal to the Ouachita tectonic belt in Texas have been confirmed by wells drilled by Shell Oil Company and by seismic data in and adjacent to the concealed structural belt.

Foreland facies sediments (dominantly carbonates) of early and possibly middle Paleozoic age were drilled on the Devils River uplift in southwest Texas. In addition, much of the Devils River uplift is apparently underlain by a Precambrian intrabasement basaltic flow(?) which has been mapped from seismic reflections and penetrated in Shell No. 1 Stewart.

The presence of a second major linear positive element covered by lower Paleozoic foreland rocks has been established in east-central Texas by seismic records and by Shell No. 1 Barrett. This faulted anticlinal structure, herein named the Navarro uplift, is at least 25 mi behind the leading edge of overthrust Ouachita facies rocks. It appears to be similar in structural position and history to the Devils River uplift but the

data are insufficient to determine definitely the structural style of either.

Foreland strata are metamorphosed to greenschist facies. Some formation fluids and minor hydrocarbon shows were recovered but the quality of the reservoir was generally poor. The carbonates on the Navarro uplift contain extensive shear and flowage structures and resemble the marbles in wells on the south flank of the Devils River uplift.

Isotopic age dates from both Ouachita facies and foreland rocks record multiple Paleozoic thermal events and probable accompanying deformation along the tectonic belt. The isotopic data also suggest the presence of a post-Precambrian, pre-Late Cambrian volcanic and metasedimentary province in the area of the Devils River uplift.

RYAN, WILLIAM B. F., Lamont-Doherty Geol. Observ., Palisades, NY 10964

**CAN AN OCEAN DRY UP? RESULTS OF DEEP-SEA DRILLING IN MEDITERRANEAN**

Between 5 and 6 m. y. ago, at the climax of an episode of evaporite deposition, a series of events occurred on the floor of the Mediterranean Sea which left a fossil imprint reminiscent of a parched salina. The primary evidence of this unexpected happening was unearthed in the uppermost layers of a bedded sequence of evaporite salts of late Miocene age which were retrieved from beneath the present sea floor during Leg 13 of the Deep Sea Drilling Project. In continuous sections of core the shipboard scientific team discovered a remarkable transition from sterile chemical precipitates (gypsum, anhydrite, and halite) to deep-sea pelagic sediment. At all the sites drilled, the transition occurred between Miocene salts and Pliocene biogenic ooze.

In the eastern Mediterranean, the transition consisted of a 10-cm thick zone of dolomite gravel containing littoral benthonic fauna. Beneath the Balearic abyssal plain in the western Mediterranean, the corresponding zone is a 2-m thick bed of flat-pebble conglomerate directly overlying a massive unit of current-bedded gypsiferous sandstone. In the central Tyrrhenian basin the transition involved a pebbly breccia composed of lateritic soils, strikingly similar in lithology to the *limons rouges* of littoral sequences in North Africa and Italy.

The most plausible explanation of these findings is that a once actively precipitating deep brine basin became choked off from the open ocean and evaporation continued to the point of desiccation. Thereafter, the newly formed desert disappeared under a major marine inundation.

SABINS, FLOYD F., Chevron Oil Field Research Co., La Habra, CA 90631

**GEOLOGIC APPLICATIONS OF REMOTE SENSING**

For optimum geologic application of remote sensing, the user should understand the advantages, limitations, and characteristics of the various types of imagery. Selection of the optimum sensor or combination of sensors will depend upon these factors plus the nature of the terrain, geology, and the problem at hand.

Newer types of films and image processing have greatly expanded the geologic potential of conventional black and white aerial photography. Infrared color film and multiband photography extend the sensitivity range and provide greater spectral discrimination. These techniques can enhance subtle variations in soil, vegetation,

and moisture content which may be geologically significant. The newer photographic methods from earth orbiting satellites provide broad regional coverage that may reveal major geologic trends and features not apparent on conventional photography.

Airborne infrared scanners image the thermal radiation patterns of the earth's surface. Geologic applications that have been demonstrated for this new technology are (1) mapping faults, (2) distinguishing different rock types, (3) recognition of subtle structural patterns, (4) mapping near-surface groundwater distribution, (5) monitoring of volcanic areas, (6) detection of geothermal resources, and (7) monitoring of arctic sea ice.

Radar is a day or night technique that penetrates fog or clouds to provide strips of imagery with broad regional coverage and a uniform oblique illumination of the terrain. Radar has generated imagery of areas that hitherto have not been photographed from the air because of persistent cloud and fog cover such as in eastern Panama. The major geologic advantage of radar imagery is the enhancement of faults, fractures, and lineaments that may be obscure on other forms of imagery. The polarization capability of radar can discriminate subtle surface textural differences.

SAITO, TSUNEMASA, Lamont-Doherty Geol. Observ., Columbia Univ., Palisades, NY 10964

#### DISTRIBUTION OF CARBONATES IN DEEP-SEA SEDIMENTS

Carbonate sediments, which consist largely of the skeletal remains of microplankton (calcareous nannoplankton, planktonic foraminifers, pteropods and heteropods) cover nearly 47% or 126 million sq km of the ocean floor. Their distribution is particularly dominant in the warm-water belt between approximately 45°N and 45°S and over submarine topographic elevations such as the mid-oceanic ridge systems and isolated seamounts. This distributional pattern is affected both by conditions controlling production of microplankton in the overlying surface waters and by their postmortem dissolution or destruction in the water column, either at the sediment-water surface or within the sediment column. In areas where the dissolution rate of carbonates exceeds supply, a "compensation condition" is reached and, in general, carbonates are not accumulating in depths greater than 4,000 m. Because of low productivity of calcareous microplankton in surface waters coupled with greater water depth, the lowest sedimentation rates of biogenous carbonates occur under the North and South Pacific central water masses. A general distribution pattern of carbonate sedimentation in the past can be pieced together on the basis of nearly 1,000 pre-Pleistocene piston cores and from the results of the U.S. Deep Sea Drilling Project. A considerable part of the abyssal floor once received calcareous sediment. Carbonate sediments were later replaced by clays as the basin deepened and the dissolution rate exceeded supply. The resulting facies boundary is broadly time-transgressive with increasing age away from the axes of the mid-oceanic ridge systems.

SCHMIDT, GENE W., Pan American Petroleum Corp., Tulsa, OK 74135

#### INTERSTITIAL WATER COMPOSITION AND GEOCHEMISTRY OF GULF COAST DEEP SHALES AND SANDSTONES

Interstitial water from shales and sandstones shows a marked contrast in concentration and composition. Sidewall core shales were taken every 500 ft between 3,000 and 14,000 ft from a well in Calcasieu Parish,

Louisiana, which encountered abnormally high fluid pressures just below 10,000 ft. Significant differences between the concentrations of water from normally pressured sandstones (63,000–180,000 mg/l TDS) and high pressured sandstone (16,000–26,000 mg/l TDS) were noted. Shale pore water has a lower salinity than the water in the adjacent normally pressured sandstone, but the concentrations are more similar in the high pressure zone. Shale pore water generally has a concentration order of  $\text{SO}_4^{2-} > \text{HCO}_3^- > \text{Cl}^-$ , whereas, water in normally pressured sandstone has a reversed concentration order. Water in high-pressure sandstone has low salinity with the  $\text{HCO}_3^-$  and  $\text{SO}_4^{2-}$  concentrations being intermediate between the water from normally pressured sandstone and that from shale.

Conversion from predominantly expandable to non-expandable clays accelerates near the top of the high-pressure zone which appears correlative with a major temperature gradient change, an increase in shale porosity (decrease in shale density), a lithologic change to massive shale, an increase in shale conductivity, an increase in fluid pressure, and a decrease in the salinity of the interstitial waters. These differences and correlations may have a bearing on the processes which alter subsurface waters, cause electric log responses, and could allow an understanding of the diagenesis and migration of petroleum.

SCHREIBER, ALFRED, DEMINEX (Canada) Ltd., Calgary, Alta., and DIETRICH WEIPPERT, HANSPETER WITTEKIND and REINHOLD WOLF-ART, Bundesanstalt für Bodenforschung, Hannover, West Germany

#### PETROLEUM POSSIBILITIES OF CENTRAL AND SOUTH AFGHANISTAN

Afghanistan is situated within a broad mobile belt extending mainly east-west between the old shield of Fennosarmatia in the north and Gondwanaland in the south. Four major geotectonic units separated by deep-seated fault systems can be recognized. These units are: (1) North Afghan-Tadjikian unit, (2) East Iran-Central Afghan unit, (3) East Afghan-West Pakistan unit, and (4) marginal region of the Indian shield.

In central and south Afghanistan the following blocks can be distinguished: East Iran-Central Afghan unit with the Farah block, Helmand block, and Seistan block; East Afghan-West Pakistan unit with Nooristan block; and marginal region of the Indian shield with Katawaz block.

None or only poor prospects exist for the discovery of economically exploitable occurrences of petroleum in the Farah, Helmand, Seistan, and Nooristan blocks. Petroleum possibilities are assumed to exist in the Katawaz block of southeastern Afghanistan.

The Katawaz block is the only one of southern Afghanistan in which a maximum of 9,000 m of Paleozoic, Mesozoic, and Paleogene sediments have been deposited on the basement. The facies are predominantly marine.

Potential reservoir rocks are probably represented by clastic strata deposited at the Cretaceous-Tertiary transition and by sandstones intercalated in the Paleogene sequence. Good to excellent trapping conditions could exist in regularly folded Oligocene anticlines as much as 50 km long. Depositional wedges within the subsurface Mesozoic and Paleogene formations could be present.

Seismic reconnaissance surveys would provide more