depths exceeding 2,000 fathoms. All sand-silt layers have sharp contacts, with no visible gradation between layers.

The texture and composition of these layers is fairly uniform. The sediments are well sorted. Quartz is the predominant light fraction; feldspar the next in abundance. The heavy-mineral content of these layers ranges approximately from 5 to 15 per cent. Hornblende is predominant and hypersthene is abundant in the northern part of the region, whereas biotite and muscovite are abundant in the southern part of the region. Chemical decay has had little or no effect on the minerals during and after deposition.

The source of these sand-silt layers is considered to be continental, judged from their texture and composition. Each layer appears to have a similar transportation and depositional history, and each is probably a turbidity-current deposit. Differences in heavy-mineral composition occur because of differences in provenance.

Carbon-14 dating of sediment cores collected near these layers and the stratigraphic position of these layers show them to have been deposited during part of Wisconsin time.

OFF, TED, Ojai Oil Company, Ventura, Calif.

Rhythmic Linear Sand Bodies Caused by Tidal Currents

A study was made of bathymetric charts of those coastlines characterized by large vertical tidal ranges (greater than 10 feet). In these areas tidal currents are strong (1–5 knots) and may significantly affect sedimentation. Two characteristic types of sand accumulation were found which appear to be formed by these tidal currents. Both exhibit wave-like profiles, and are of a scale significant to oil exploration.

The first type is here called "tidal current ridges." These are a rhythmic series of ridges oriented parallel with a tidal current. They are 25–100 feet high, 5–40 miles long, and spaced 1–6 miles apart. Most are composed of sand, but some may be mud or silt. Their spacing is proportional to the depth of water and current velocity. This suggests that their origin is related to the similar problem of the hydraulic geometry of stream channels. Although best developed in the Bay of Korea and the Gulf of Cambay, these ridges appear to be present wherever tidal current velocities range between 1 and 5 knots and a supply of sediment is available.

The second type is sand waves. These are large ripple marks oriented perpendicular to the current direction. Recent evidence by European oceanographers has indicated that, whereas in rivers these waves are fairly small-scale features, in the open ocean they commonly have heights greater than 25 feet. Cartwright and Stride have shown a wide distribution of sand waves of this size, particularly in the North Sea. Their relationship to tidal current ridges is not known, although they appear to occur in the same environment.

Since tidal currents are now significant in shallow ocean areas, their effect should be visible in a large percentage of the shallow-water deposits of the geologic past. In particular it is suggested that some of the lenticular sands of the Chester Series of Illinois, of the Cardium Formation of Canada, and of the Clinton sands of Ohio show tidal current effects. The rhythmic pattern of tidal current ridges and sand waves should be considered in the study of the distribution of these and other shoestring sands.

PARKS, JAMES M., The Pure Oil Company, Crystal Lake, Ill.

Reef-Building Biota from Late Pennsylvanian Reefs, Sacramento Mountains, New Mexico

An unusual biota of reef-building organisms occurs in biohermal limestones of Virgilian age in the Sacramento Mountains. Some are organisms not known before from this area, and the reef-building potentialities of others have not previously been recognized.

Tubular unchambered Foraminifera (*Paleonubecularia* and *Calcitornella*) together with algae (*Girvanella* and others) form extensive (several square feet) flat to hummocky "pavements" and large "heads." A distinctive tabular siliceous (?) sponge (*Stereodictyon* Finks, 1960) occurs as fragments of three-dimensional reticulate meshwork up to 18 inches long and 1½ inches thick. Stromatoporoids have been considered to be rare in Pennsylvanian rocks, perhaps only because the Pennsylvanian reef facies is not well known: one genus (*Parallelopora*) occurs here as large hemispherical colonies and as encrusting masses and fragments. Branching stems and tabular to domal crusts composed of cellular tissue and cone-shaped radiating tubes are tentatively referred to a Russian genus of hydractinoid (*Paleoaplysina* Krotov; Riabinin, 1955). In addition to several varieties of stromatolitic algae and algal plates, there are finger-like masses made by a filamentous alga (*Girvanella*), nodular algal masses (*Ortonella*), and a branching encrusting alga (*Tubiphytes* Maslov, 1956). Dark-colored fibrous radiate calcite resembling the problematic *Stromatactis* of lower Paleozoic reefs occurs in tabular encrusting masses with smooth bottom surfaces and botryoidal upper surfaces.

These limestones were described by Plumley and Graves (1953) as a "cryptozoon stromatolitic reef." Wray (1959) and Konishi and Wray (1961) ascribed these biohermal buildups to the sediment trapping and binding effect of an erect-growing leaf-like calcareous alga (*Eugonophyllum*) similar to *Ivanovia* and *Anchicodium*.

Neither the stromatolitic algae nor the leaf-like algal plates appear to be capable of constructing these bioherms by themselves. More effective reef-builders are present: frame-builders (tubular foram "heads," stromatoporoid, and *Stromatactis*); sediment-catchers (tabular sponge); detritus-binders (hydractinoid, *Tubiphytes*); and sediment-binders (tubular foram and algal "pavements"). These and the small but significant amounts of reef-debris deposits indicate that these were true reefs growing above wave base.

PATTON, WILLIAM W., Jr., and GRANTZ, ARTHUR, U. S. Geological Survey, Menlo Park, Calif.

Tectonic Implications of Some New Mesozoic Stratigraphic Data on Alaska

Increased geological exploration of Alaska during the past decade has produced a wealth of new stratigraphic data. Some of these data, particularly from Mesozoic rocks, are of fundamental importance in the interpretation of the tectonic history of Alaska. The U. S.:Geological Survey is compiling a comprehensive correlation chart of all known Mesozoic sedimentary, volcanic, and intrusive rocks. Preliminary work on the chart indicates the need for revising or refining present concepts of the stratigraphy and tectonics in several areas.

For example, recent studies in northwestern Alaska suggest that the mid-Cretaceous Koyukuk geosyncline was not, as previously supposed, a single depositional trough stretching from the Brooks Range to the Yukon delta but consisted of a narrow east-trending trough along the Kobuk and upper Koyukuk Rivers and a larger southwest-trending trough that extended from the lower Koyukuk River to the Yukon delta. The two troughs were separated by an east-trending geanticline along Lat 66° N. The volcanics and granitic intrusives of Late Jurassic and Early Cretaceous age that are now exposed along this geanticlinal trend were an important source of the sediments in both troughs.

Important data are also being developed by restudy of long-known Mesozoic terranes in southern Alaska. For example, the Talkeetna Formation of the southeastern Talkeetna Mountains was thought to consist mainly of marine volcanics of Pliensbachian (Early Jurassic) age. However, it is now known to range in age at least from early Sinemurian to late Toarcian. Radioactivity dates indicate that, in the Talkeetna Mountains, plutons began to be intruded into the Talkeetna Formation shortly after it was deposited. Intrusion began at about the time the Matanuska epi-eugeosyncline was established in earliest Middle Jurassic time within the area of the more extensive eugeosyncline of the Talkeetna Formation. Intrusion probably continued into Late Jurassic and possibly Early Cretaceous time, although the adjacent Matanuska geosyncline was concurrently receiving a relatively complete sedimentary section.

PERKINS, RONALD D., Indiana University, Bloomington, Ind.

Petrology of Jeffersonville Limestone (Middle Devonian) of Southeastern Indiana

Thin-section, polished-surface, and X-ray analyses of 500 samples collected from the Jeffersonville Limestone at 14 localities in southeastern Indiana have permitted detailed correlation of carbonate facies. The Jeffersonville can be subdivided into 5 zones, each with its characteristic fauna and carbonate rock types. These zones overlap one another successively from south to north.

1. The lowest, or coralline zone, contains 3 distinct carbonate rock types, including (ascending) grain-supported biomicrite, biosparite, and biomicrudite. The lower biomicrite and biosparite units contain many branching corals, large colonial corals, and mound-like stromatoporoids. These fossils are found both *in situ* and overturned but generally are not fragmented. The upper biomicrudite contains a profusion of solitary corals and branching coral fragments. These strata are believed to have accumulated as a coral bank which was ripped occasionally by storm activity.

2. The *Amphipora* zone comprises biosparrudite in the lower part and biomicrudite in the upper part. Fragments of *Amphipora* and mat-like stromatoporoids are abundant. This zone reflects a shallowing of the water over the bank and may have resulted from upward growth of the coralline zone into a zone of greater wave activity. In Bartholomew County these strata swell to form a stromatoporoid bank with associated pelsparites and biopelsparites.

3. The *Brevispirifer gregarius* zone is characterized by mud-supported biomicrite containing *Brevispirifer gregarius* and charophyte oögonia. Corals and stromatoporoids are smaller and fewer. In Jennings County, the position of these biomicrites is occupied by laminated and mud-cracked dolomites. These strata were deposited in water that was shallow enough to sustain the sessile algae and periodically expose the laminated beds.

4. The fenestrate bryozoan-brachiopod zone is composed of grain-supported biomicrite which intertongues northward in Jennings County with laminated dolomite beds. This zone contains fenestrate bryozoan fragments, small corals, and a diverse brachiopod fauna. Although shallow waters persisted toward the north, more normal marine conditions were re-established south of Jennings County.

5. The *Paraspirifer acuminatus* zone consists mainly of grain-supported biomicrite that contains *Paraspirifer acuminatus*, fenestrate bryozoans, small corals, and abundant echinoderm debris. This widespread zone overlaps the laminated beds toward the north and reflects deepening of the waters over the entire area and return to more normal marine conditions.

PRATT, W. L., University of Southern California, Los Angeles, Calif.

Origin and Distribution of Glauconites and Related Clay Aggregates on Sea Floor off Southern California

Studies have been made of about 1,300 glauconitic samples from the sea floor off southern California, in Monterey Bay, California, and off Cedros Island, Baja California. The principal depositional environments are continental terraces, banks, ridges, and basin slopes.

Clay aggregates that probably would be designated as glauconite, according to contemporary field usage of the term by geologists, grade from relatively soft, pale yellow-green, highly expandable montmorillonitic types to dark green, illitic types. As lattice thickness [d(001)] of these different types increases, the refractive index and potassium content decreases. The organic nitrogen content is greatest in highly expandable varieties.

Glauconite may compose from less than 1 per cent to about 80 per cent of the upper few centimeters of sediment. Maximum concentrations occur in the sediments from the outer shelf and upper slope areas, but the distribution is patchy, both areally and vertically, within these sediments. Glauconite is rare in water depths of less than 100 feet. Off southern California, glauconites that probably have been deposited from turbidity currents occur in near-surface sediments from the continental rise and on the abyssal floor.

Living benthonic Foraminifera of the same species as those that are filled with expandable glauconite occur in water depths that range from approximately 100 feet to 6,000 feet. Specimens of the genus *Cassidulina* are common in Foraminiferal faunas that contain abundant glauconite-filled tests.

Glauconite replaces argillaceous sedimentary rock, mineral grains, organic carbonate, and probable fecal pellets. Some spheroidal-ellipsoidal and irregular-papillate forms appear to be of accretionary origin. The mineralogy and morphology of fillings in Foraminifera indicate that they are probably deposited by direct precipitation. Distinctive morphological varieties of glauconite are not everywhere randomly distributed, but are commonly concentrated in localized areas, which indicates that variations in morphology may be caused by local conditions of origin.

Glauconites have been recognized that are reworked from Pliocene, and perhaps Miocene, submarine outcrops. Foraminiferal tests that are filled with glauconite range in age from Pliocene to Recent and from Pleistocene to Recent. No direct evidence of present-day formation of glauconite has been found.