MERRILL, WILLIAM R., Petroleum consultant, Catawba International, Inc., Manila, Philippines
McNAUGHTON, DUNCAN A., Petroleum consultant, Dallas, Tex.

GEOLOGY AND EXPLORATION IN PHILIPPINE ISLANDS

The Philippine Archipelago located along the border between the sialic Asiatic mainland and the simatic Pacific basin forms the southern segment of the western circum-Pacific mobile belt. Typical island arc features are well developed in the southern part of the Archipelago.

Most of the Philippine islands appear to be closely related geologically and to have geologic affinities with Taiwan, Borneo, and the other islands of the Indonesian Archipelago. These affinities include similarities in the quartz-deficient basement suites and in ages and characteristics of younger sediments.

Thick accumulations of sediments of Miocene and Pliocene ages are present in most large Philippine basins. Paleo-environmental studies of the Central Valley basin in Luzon have established that the basal deposits were deposited in paralic environments. These sediments grade upward into bathyal deposits which, in turn, grade upward into paralic and continental deposits. Richly organic, bathyal mudstones are possible source beds and the coarser clastic facies (both paralic deposits and turbidites) as well as biohermal limestones have reservoir rock characteristics in outcrop. Other basins with comparable marine sections have Eocene and possibly Cretaceous objectives.

The Philippine rift, the major structural feature in the Philippines, resembles the San Andreas rift in California. It can be traced southward from Northern Luzon through Mindanao. Structural trends are oblique to the rift with the expectable orientation of secondary structures arising from left-lateral movement along the rift. The amount of displacement is not known.

Many oil seepages originating in Miocene and Eocene rocks were investigated during the initial phase of Philippine exploration. Although some companies continue these operations, several are using modern techniques to evaluate deeper prospects. Three discoveries have been made in sandstones and a limestone of Miocene age. The results of drilling to date suggest that delineation of potential reservoirs is the most difficult task confronting exploration in the Philippines.

The Republic of the Philippines is now spending about 90 million dollars annually for imports of crude oil. The internal demand is accelerating and foreign exchange reserves are low. A major disovery will alleviate this serious financial problem.

MIRSKY, ARTHUR, The Ohio State University, Columbus, Ohio
TREVES, SAMUEL B., University of Nebraska, Lincoln, Nebr.

HEAVY MINERALS OF PRE-MORRISON JURASSIC ROCKS, LUCERO UPLIFT, NORTHWESTERN NEW MEXICO

A heavy-mineral study was made of the following formations in the Lucero uplift: Triassic: Chinle Formation and Wingate Sandstone; Jurassic: Carmel Formation, Entrada Sandstone, Todilto Formation (not analyzed), Summerville Formation, Bluff Sandstone, and Morrison Formation; Cretaceous: Dakota Sandstone. Emphasis was placed on the pre-Morrison Jurassic rocks.

Heavy minerals identified from these rocks consist dominantly of zircon, garnet, tourmaline, rutile, and several opaque minerals, and very minor epidote, biotite, staurolite, and apatite. This limited suite of mostly rounded, stable heavy minerals indicates that the rocks concerned are multicycle sediments, and agrees with the conclusion previously derived from utilizing other stratigraphic tools in studying these rocks. Thus, in this respect, the usefulness of heavy minerals as a stratigraphic tool is demonstrated.

Furthermore, the pre-Morrison part of the section, in which relatively abundant amounts of magnetite-ilmenite occur, is readily distinguishable from the Morrison Formation in which these minerals are virtually absent. When the pre-Morrison Jurassic rocks are viewed in sequence, it appears that the Carmel and lower Entrada are characterized by a low zircon-garnet and high magnetite-ilmenite content, the upper Entrada by a high zircon-garnet and low magnetite-ilmenite content, and the Summerville and Bluff by a high zircon-low garnet and variable magnetite-ilmenite content. Nevertheless, with the exception of the upper Entrada, the differences in per cent distribution of the heavy minerals are not sufficient to unequivocally characterize any single pre-Morrison unit. Thus, in this respect, the heavy minerals are not as useful a stratigraphic tool as they might be if the suite were mineralogically more varied.

Prior to the determination of the heavy-mineral content by using standard techniques of counting individual grains, an attempt was made to estimate the heavy-mineral content. A comparison of the results of the two methods shows that, even with a simple suite of easily identifiable heavy minerals, an estimated per cent distribution is not reliable and does not justify the apparent saving in time.

MOBERLY, RALPH, JR., University of Hawaii, Honolulu, Hawaii

CALCIUM CARBONATE FROM NON-CORALLINE ALGAE

In addition to the red or crustose coralline algae, some other simple marine algae secrete carbonate in tropical seas. Secretion of aragonite by *Halimeda discoidea* Decaisne, a calcareous green alga, and *Padina japonica* Yamada, a calcareous brown alga, was investigated in shallow Hawaiian waters. Along traverses between reef and shore, *Padina* is most abundant close to shore, whereas *Halimeda* flourishes in the deepest water, generally midway between shore and reef front. In *Padina*, the proportion of calcium carbonate to total body weight is inversely proportional to abundance of the algae on the sea floor, whereas for *Halimeda* the proportion is directly related to relative abundance. For *Halimeda* as much as 70 per cent of the body weight may be aragonite.

Production of calcium carbonate and of total organic material has been compared for shallow water specimens, for specimens dredged from deeper water, and for calcareous and noncalcareous algae described by Doty recently. Aragonite secreted by algae contributes an important volume of material for subsequent diagenesis in tropical carbonate sediments that are ultimately converted to limestones.

NAYUDU, Y. RAMMOHANROY, University of Washington, Seattle, Wash.

ORIGIN AND DISTRIBUTION OF DEEP-SEA SAND-SILT LAYERS IN NORTHEAST PACIFIC

The cores of sediments in the northeast Pacific Ocean, collected by the University of Washington, contain several sand-silt layers. Most of the layers and cores occur at locations 500–700 miles from the shores and at

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