diameter per 100 square microns surface. *Globigerina bulloides* is roughly finished, and possesses only large conical pores spaced widely apart over the surface.

TUBB, J. B., Jr., GEDNETZ, D. R., GLOVER, A. D., MANOS, C. T., ORLOPP, D. E., ROSEMAN, C., and WEINER, J. L., University of Illinois, Urbana, Illinois

Interpretation of Some Pennsylvanian Cyclothems through Environmental Mapping

Regional mapping of the sedimentary environments of the different stages within the Liverpool, Summum, St. David, Brereton, Sparland, Gimlet, Exline, Trivoli, and Carlinville cyclothems of Illinois has been completed, or is in progress, for western Kentucky, western Indiana, Illinois, Missouri, Iowa, eastern Kansas, and northeastern Oklahoma. These cyclothems cover the upper half of the Des Moinesian Series and the basal part of the Missourian Series of the Mid-Continent region. The maps are based on approximately 1,100 control points which, where possible, have a preferred geographic spacing of one point per township. Lithofacies maps were prepared for each depositional stage by placing, at each control point, the lithology, thickness, and other characteristic features such as fossils—plant and animal, color, and sedimentary structures. After the lithofacies maps were completed, the sedimentary environments were inferred.

A sequential viewing of the environmental maps gives an idea of the dynamic changes that occurred within the area and illustrates the alternate predominance of the opposing forces of marine transgressions and deltaic growth. The maps show that the western part of the region experienced predominantly marine conditions while the eastern part was subjected to predominantly non-marine conditions. The non-marine sands and shales of the delta and fluviatile environments followed the north, northeast, and east paleoslope in the region and formed platforms on which coal swamps could develop later. The marine water transgressed from the Mid-Continent, north of the Ozarks, into the Illinois basin, depositing marine limestones and shales.

VAN HOUTEN, F. B., Princeton, New Jersey

Cyclic Lacustrine Sediments in (Upper Triassic) Lockatong Formation, Central New Jersey and Adjacent Pennsylvania

Two kinds of cycles: "detrital" and "chemical" can be recognized in the Lockatong Formation, a lacustrine deposit of Late Triassic age in central New Jersey and adjacent Pennsylvania.

"Detrital" short cycles, averaging 17–22 feet thick, comprise several feet of black shale succeeded by platy carbonate-rich mudstone in the lower part and gray massive calcareous silty argillite in the upper. The argillite has a small-scale crenulate fabric produced by crumpled casts of shrinkage cracks and burrows. Thicker, coarser-grained "detrital" cycles contain 3–5-foot layers of thin-bedded, commonly cross-stratified, fine-grained sandstone. Some sandstone has small-scale convolute bedding.

More common "chemical" short cycles average 7–14 feet thick. Lower beds are alternating platy carbonate-rich mudstone and marlstone $\frac{1}{2}$–3 inches thick, extensively broken by crumpled shrinkage cracks. Locally, initial deposits are crystalline pyrite or dolomite (rarely calcite) as much as an inch thick. In the middle, several feet of dark gray mudstone encloses 1–3-inch layers of disrupted gray marlstone fragmented by syneresis. The upper part is massive gray analcime- and carbonate-rich argillite containing as much as 7 per cent soda, as little as 47 per cent silica, and a maximum of 35–40 per cent analcime. The argillite is brecciated on a microscopic scale, probably the product of syneresis. Much of the argillite is also disrupted by crumpled shrinkage cracks irregularly filled with crystalline dolomite and analcime.

Some thinner "chemical" cycles are reddish brown, especially in the uppermost part of the formation. These contain thin greenish gray beds of mosaic intraformational breccia produced by mud-cracking, and small lozenge-shape pseudomorphs of dolomite and analcime after glauberite(?).

Varve-counts in black mudstone suggest that short cycles resulted from 21,000-year precession cycles.

Groups of "detrital" and "chemical" short cycles in couples 325–350 feet thick apparently resulted from alternating wetter and drier phases of a long climate cycle, producing through-flowing drainage and a group of "detrital" short cycles or a closed basin and a group of "chemical" short cycles.

VAN LOPIK, JACK R., and FEDER, ALLEN M., Geoscience Department, Texas Instruments Incorporated, Dallas, Texas

Extending Photogeologic Horizons

Interpretation of aerial images, produced on photographic emulsions by radiation in the visible portion of the electromagnetic spectrum, is a well known and important tool of the exploration geologist. Visible light, however, comprises an extremely small portion of the electromagnetic spectrum. Airborne systems have been developed that are capable of recording images produced by radiation in the infrared, radar, and other spectral regions. Most infrared systems, as well as those employed in conventional aerial photography, are passive. In this case, radiation emitted by the material itself and reflected or reradiated energy, originating in some natural source such as the sun, are recorded. Radar, on the other hand, is an active system, i.e., energy of known characteristics is artificially propagated and the reflected or reradiated energy recorded.

Photographic emulsions are only sensitive to radiation having wavelengths of less than 1.35 microns (near infrared). The majority of infrared and radar systems, therefore, utilize various types of scanning devices which translate fluctuations in received energy into fluctuations in electrical currents. These electrical currents may be recorded directly or converted to light energy to produce images on photographic emulsions. Such images thus present the infrared or radar energy intensities of the viewed materials and differ from conventional visible-light aerial photographs. As in photogeology, identification of specific geologic conditions from infrared and radar images should be possible by analysis of such factors as image tone, texture, and pattern. Interpretation of infrared and radar strip maps holds great promise for complementing photogeologic investigations and increasing the amount of geologic data obtainable by airborne methods.

VAN MELLE, F. A., FAASS, D. L., KAUFMAN, S., POSTMA, G. W., and SERIFF, A. J., Shell Development Company, Houston, Texas

Geophysical Research and Progress in Exploration

This is the fifth of a series of review papers on the subject of research and progress in geophysical exploration.

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