NIEM, A. R., Dept. Geol., Oregon State Univ., Corvallis, Ore.

Patterns of Flysch Deposition of Lower Stanley Group (Mississippian), Ouachita Mountains, Oklahoma and Arkansas

A southern proximal and a northern distal flysch facies are recognized in lower Stanley strata over an area of 5,000 sq mi in the southern and central Ouachita Mountains. Four distinctive tuffs (25–120 ft thick) interbedded with marine graywackes and shales serve as key units for detailed correlation of 8 sections 500–1,500 ft thick. Sandstone geometry, lithology, sedimentary structures, and ratio of sandstone to shale in the proximal and distal facies are similar to modern deep sea fans and associated basin sediments off the southern California coast. Individual sandstones appear to be discontinuous finger- to fan-shaped bodies on isopach and paleocurrent maps.

A gradational contact (10–100 ft) between the Arkansas Novaculite and the overlying lower Stanley strata over most of the Ouachitas records a gradual change from predominantly biological/chemical precipitation to clastic sedimentation. A local high, or highs, in the Ouachita trough is indicated by (1) novaculite conglomerate lenses, (2) an angular unconformity, and (3) thinning of the tuffs and strata between the tuffs.

The lower 500 ft of the Stanley Group is predominantly a distal flysch facies of shales and thin (6-in.) siltstones over much of the Ouachitas. The distal facies was superseded by a prograding wedge of proximal flysch facies in the southern Ouachitas. The proximal facies changes laterally to a distal flysch facies in the central Ouachitas. The source area may have been a northeastern extension of the buried Luling overthrust front of Texas.

NIXON, R. P., Mobil Field Research Lab., Dallas, Tex.

Relation of Oil Occurrence to Source-Bed Distribution in Mowry Shale

Rocks rich in organic matter are widespread in the Lower Cretaceous Mowry Shale and its marine time equivalents throughout much of the northern part of the western interior of the United States. In contrast, true source beds in which petroleumlike hydrocarbons have been formed have a restricted distribution due, apparently, to variations in the thermal history of the strata. Only in samples from areas where the Mowry has been buried more deeply than approximately 7,000 ft have petroleumlike hydrocarbons been found. Depth-of-burial studies, therefore, provide a valuable means for anticipating source bed development.

All known oil fields in the Muddy, Frontier, and other sandstone reservoirs associated with the Mowry interval are either within or updip and adjacent to areas where source beds have been found. Thus, the regional distribution of oil accumulations in these reservoirs is predictable with knowledge of the source-bed distribution.

NORBY, R. D., Dept. Geol., Univ. Illinois, Urbana, Ill., and R. F. LUNDIN, Dept. Geol., Arizona State Univ., Tempe, Ariz.

Mississippian Conodont Zones of Southeastern Arizona

Analyses of conodont faunas from Mississippian rocks in southeastern Arizona differentiate 7 conodont zones and 1 zone essentially barren of conodonts. Based on this conodont zonation, the Escabrosa Limestone ranges in age from late Kinderhookian (*Siphonodella isosticha-S. cooperi* zone) to late Meramecian (*Taphrognathus varians-Apatognathus-Cavusgnathus* zone). The Paradise Formation, represented by only the *Gnathodus girtyi-Cavusgnathus* zone, is middle Chesterian in age. Accordingly, the boundaries of both formations are represented by unconformities. The conodont fauna is large and diversified: 387 samples from 7 localities yielded 6,600 specimens representing 118 form species of 30 form genera. Species of *Siphonodella, Pseudopolygnathus, Polygnathus, Gnathodus, Cavusgnathus, Apatognathus,* and *Taphrognathus* are especially important in the zonation. The zonation recognized suggests relatively rapid transgression of Mississippian seas across a shelf of low relief in southeastern Arizona.

O'DONNELL, E., Dept. Geol., Univ. South Florida, Tampa, Fla.

Paleogeography of Cincinnati Arch Area in Early Silurian Time

The Cincinnati arch is a platformlike structure located between the Michigan, Illinois, and Appalachian basins. Lower Silurian (Llandoverian) rocks crop out along the flanks of the arch but were removed almost completely from the central part of the structure by pre-Middle Devonian erosion. They consist primarily of marine limestone and dolostone. Paleontologic and lithologic evidence indicates that the Cincinnati arch area was the locale of a marine transgression in the early Llandovery, and regression and transgression during the late Llandovery. These events are summarized as follows.

1. Early Llandovery (A_1-A_4): There is an erosional unconformity between the Lower Silurian and Upper Ordovician; A_1 rocks are missing from this area. Silty A_2-A_4 dolomites are found solely on the east side of the Cincinnati arch.

2. Middle Llandovery (B_1-B_3): The arch was covered by a shallow epeiric sea resulting in the deposition of limestones and dolostones.

3. Late Llandovery (C_1-C_6): The depositional pattern of the area changed with the introduction of shales from the east (C_1-C_2). Shallow-water carbonates were deposited on the northern, western, and southern parts of the present arch. The interval from C_2-C_4 is marked by erosion and nondeposition, except for a few localities in southeastern Indiana where silty dolomites are found. The close of the Llandovery was marked by a second transgression of the sea with the deposition of shales on the southeastern side of the arch and carbonates on the northern, western, and southern sides.

OERTEL, G. F., II, and J. D. HOWARD, Skidaway Inst. Oceanog., Savannah, Ga.

Working Model for Barrier-Island Development along Low-Energy Coast of Georgia

Studies of water-mass circulation and sediment transport adjacent to barrier islands of the Georgia coast indicate a more complex pattern of barrier-island development than has been previously suggested. The model here proposed emphasizes that shoal formation seaward from estuarine entrances is critical to development and growth of barrier islands.

Shoal development on the north and south sides of estuarine entrances gives rise to 2 structurally different types of barrier islands. South-side shoals are triangular sand bodies attached to the shoreline. Through time these shoals prograde seaward and form arcuate beach ridges. Shoal and beach ridges are partly eroded during periods of high wave energy. The development of barrier islands (Type I) results when renewed shoal and beach ridge formation occurs seaward from these terminated ridges. Shoals on the north sides of entrances are detached from the shoreline and are segmented as a result of longshore spillover of channel water. Longshore trending shoals form seaward of "spillover channels." These shoals are the forerunners of recurving beach ridges which form barrier islands (Type II) on the north side of the channel. At the present time Type I and Type II barrier islands are developing on the Georgia coast.

OSBORN, E. F., U.S. Bur. Mines, Washington, D.C.

GOVERNMENT'S EXPECTATIONS AS TO NATIONAL MINING AND MINERALS POLICY

There is a need for Congress to have a continuing evaluation of the nation's mineral and fuel position, as described in the Mining and Minerals Policy Act of 1970. Steps are being taken by the Department of the Interior and the Bureau of Mines to provide this evaluation.

PAINE, W. R., Univ. Southwestern Louisiana, Lafayette, La.

COMPUTER MAPPING IN LOWER FRIO FORMATION (OLIGO-MIOCENE), SOUTHWESTERN LOUISIANA

The usefulness of a computer in mapping the complex structure and stratigraphy of the Oligo-Miocene of the Gulf Coast has been questioned. During a regional study of the lower Frio by Paine, Meyerhoff, and Furrer, the writer had an opportunity to computerize the data used for the study (hand-contoured maps), and to produce a set of computerized maps from the same data. Four sandstone isolith maps, 1 isopach map, and 1 structure map of 1 zone were constructed, as well as 4 isopach maps and 4 structure maps of other zones.

The computer's sandstone isolith map of the *Nodosaria* "A" sandstone showed a marked difference from the hand-contoured map, because the writer had introduced a major distributary system into the eastern half of the area. The computer plotted this distributary system as a series of east-west, elongate, barlike bodies parallel with (1) thinner sandstone bodies in the western part of the area and (2) the shoreline of massive continental sandstone bodies on the north. In the growth-fault area of the *Nodosaria* embayment, computer maps and handmade maps are very similar.

The structure maps show less similarity. Only the large regional faults and the large domes appear on the computer maps. Smaller faults and closures do not appear on the computer maps. The differences between shallow and deep structure are evident on both the computer and hand-contoured maps.

This study revealed that computer maps are useful in stratigraphic work—both on regional and local scales. For structural work, the computer maps are less useful, but do reveal major features. The great number of maps which the computer can produce in a short time is an obvious advantage. Clearly, the geologist's prejudices are reflected in the computer output. The writer strongly recommends the use of computerized maps in studies of Gulf Coast geology.

PAINE, W. R., Univ. Southwestern Louisiana, Lafayette, La., A. A. MEYERHOFF, Am. Assoc. Petroleum Geologists, Tulsa, Okla., and M. A. FURRER, Creole Petroleum Corp., Caracas, Venezuela

STRATIGRAPHY, SEDIMENTATION, AND PETROLOGY OF OLIGO-MIOCENE LOWER FRIO FORMATION, SOUTHWESTERN LOUISIANA

The Frio Formation, a major productive unit in South Louisiana, never has been described petrographically, although conventional cores and thousands of sidewall cores have been collected.

The lower Frio consists of about 1,000 ft of alternating sandstone and shale in the updip stable shelf area, but it thickens to an observed maximum of 7,000 ft in the downdip unstable shelf (*Nodosaria* embayment) area. The lower Frio is mainly a regressive sequence, and has been divided into 4 units (designated A, B, C, and D from top to bottom) on the basis of electric-log correlations and other characteristics.

Three lithologic sequences characterize each unit: a massive sandstone facies on the north (updip); an interbedded sandstone-shale (deltaic?) facies exhibiting considerable lateral variation; and a downdip sequence of alternating sandstone and shale in which the shale content increases markedly downdip. The sandstone bodies are thin and relatively persistent.

Unit D, at the base, marks the beginning of the regression, has the least amount of sandstone, and has smallest amount of production. Shoreline and deltaic sandstone bodies are poorly developed. Unit C shows an increase in sandstone content and production. The deltaic facies is well developed, and shows a marked increase in volume and areal extent. Most of the production is associated with this facies, although production does occur in marine sandstone facies. Unit B shows only limited southward regression, but exhibits considerable development of marine facies. Numerous fields produce from this unit. Significant production also comes from channel-like bodies with erosional lower contacts. These bodies may be bar fingers or distributary channel deposits. Unit A is the most regressive. It contains the largest amount of massive continental and deltaic plain sandstones, as well as a well-developed delta system. As a result, marine sandstones are limited in number and extent. The distributary sandstone bodies account for major production and several giant fields.

Independent stratigraphic, petrographic, and paleontologic studies demonstrate that the lower Frio contains strata deposited in continental, deltaic, and inner to middle neritic environments. Production, although primarily controlled by structure, is definitely affected by sedimentation and depositional patterns. Because structure in the Frio is now well known, future discoveries will be determined primarily by stratigraphic, petrographic, and paleontologic studies similar to this one.

PAKISER, L. C., U.S. Geol. Survey, Denver, Colo., R. W. BROMERY, Univ. Massachusetts, Amherst, Mass., C. KISSLINGER, St. Louis Univ., St. Louis, Mo., and P. L. LYONS, Atlantic-Richfield Oil Co., Tulsa, Okla.

EXPANDING HUMAN HORIZONS IN GEOSCIENCES