that "symmetric" and "asymmetric" ripple marks are not wave- and current-formed, respectively. Rather, most ripple marks possess some degree of asymmetry, either in shape or internal structure, and are formed by currents (including most waves in shallow water). Truly symmetric ripple marks formed by standing oscillatory waves probably are rare. Being current-formed, asymmetric ripple marks should prove increasingly important in reconstructing paleocurrent systems and paleogeography.

PICHEL, GEORGE B., Union Oil Co. of California, Los Angeles, Calif.

TRADING BAY COMPLEX, ALASKA'S GIANT

(No abstract submitted)

PIPPIN, L., Exploration Geologist, Amarillo, Texas

PANHANDLE-HUGOTON FIELD, "FIRST FIFTY YEARS"

A detailed study of the geometry and an understanding of the mechanics of entrapment are essential to unravel the complexities of the Panhandle-Hugoton field.

The reservoir in the Panhandle-Hugoton field is usually considered to be rocks of Wolfcamp age. Gas and oil appear to have migrated from Pennsylvanian marine shales in the Anadarko basin through granite wash into the Panhandle field.

The trap is primarily structural in the Panhandle field, and stratigraphic in the Hugoton field, with a hydrodynamic component in both.

Red Cave reservoirs above the Wolfcamp and Pennsylvanian reservoirs below the Wolfcamp usually are not considered to be a part of the Panhandle-Hugoton field pay. It is the writer's opinion, however, that these reservoirs could be considered to be Panhandle-Hugoton field pays, because they appear to have had the same source areas, initial pressure, and similar water contacts.

POMMIER, GILBERT, CFP(A), Neuilly, France, AND ALDO M. BALDUCCHI, S.N. REPAL, Algiers, Algeria

CAMBRIAN OIL FIELD OF HASSI MESSAOUD, ALGERIA

The Hassi Messaoud oil field was discovered in 1956 by S.N. REPAL on the Saharan permits of the CFP(A) and S.N. REPAL Association, following a seismic-refraction study, which was the only method able to give, at that time, valuable data beneath the thick Mesozoic cover.

Regional and local geological studies showed that this high zone of the Saharan platform has remained relatively high during geologic time. The field structure covers an area of about 600 sq mi of this high platform zone.

At reservoir depth, the structure is a large, flat anticline, irregularly undulating eroded at the top; and its general orientation is south-southwest—north-northeast.

The stratigraphic succession may be described as follows: (1) On the granitic basement, the Paleozoic is represented by the Cambrian "Hassi Messaoud sandstones," about 1,700 ft thick; it is divided into three units: R3, R2, and Ra. Ordovician sediments are present around the structure; the most complete Ordovician deposits are on the flanks. (2) The Mesozoic formations cover the field to the ground surface. About 10,000 ft thick, they are unconformable on the Paleozoic. (3) The Tertiary is represented, away from the structure, by Eocene and Mio-Pliocene deposits.

The main Cambrian reservoir, Ra, is formed by sandstone-quartzite, the thickness of which ranges from 0 to 480 ft, according to the degree of pre-Triassic erosion. The average thickness is 200–330 ft.

Oil was trapped in the Cambrian reservoir mainly during the Mesozoic Period; had entrapment occurred earlier, hydrocarbons would have escaped during the pre-Triassic erosion.

The Hassi Messaoud oil field is operated jointly by S.N. REPAL and CFP(A); it has produced, since 1958, more than 600 million bbl of oil.

The primary-recovery mechanism at first was gas expansion in undersaturated oil; later, the field gas has been injected in order to maintain the pressure and to improve the final recovery ratio. Compression plants have been operating since January 1964. Tests of alternate injection of gas and water have been made.

PRAY, L. C., AND H. E. COOK, Denver Research Center, Marathon Oil Co., Littleton, Colo., E. W MOUNTJOY, McGill University, Montreal, Quebec, AND P. N. MCDANIEL, Denver Research Center, Marathon Oil Co., Littleton, Colo.

ALLOCHTHONOUS CARBONATE DEBRIS FLOWS AT DEVONIAN BANK ("REEF") MARGINS, ALBERTA

Field work suggests that allochthonous carbonate-debris flow deposits containing large blocks occur locally in the upper Perdrix and Mt. Hawk basinal strata adjacent to three Devonian bank complexes—Ancient Wall, Miette, and Southesk (Mt. MacKenzie). The deposits are mostly pebble to boulder carbonate mudstone conglomerate and breccia with pervasive, dark, interstitial micrite.

The largest of the deposits interpreted as debris flows occur southeast of Mt. Haultain (Ancient Wall). Here, disoriented blocks (as large as 20 by 50 m in cross section) of shoal-water limestone occur in two sheet-like deposits of irregular thickness (up to 25 m); these deposits are exposed for 1 km from the bank edge. Similar, possibly correlative, deposits up to 12 m thick and containing disoriented blocks 10 m across occur 3 km from the bank edge. The allochthonous clasts mostly are limestone and range from nonfossiliferous mudstone to grainstone rich in normal marine fossils. Some clasts are coral-growth frameworks several meters across. Smaller debris lenses commonly rich in basinal clasts fill channels adjacent to bank edges at all localities. Most debris deposits of both sheet and channel form have graded calcarenite-to-calcilutite tops a few inches thick.

The writers believe that these allochthonous materials were transported largely by submarine-debris flows from upslope basinal and bank environments. Many flows were followed by density currents. The larger debris deposits probably formed when the relief and slope at the bank margin were higher than normal, perhaps involving 30 m or more of relief and slopes of 5°–10°; some may be related to bank-margin unconformities.

Allochthonous-debris deposits containing large blocks may occur at other Devonian bank margins in both the surface and subsurface. Recognition of such deposits can assist in determining bank proximity; in better interpretation of bank and bank-margin genesis; in determining time of diagenesis, particularly cementation and dolomitization; and in correlation.

PRYOR, WAYNE A., Dept. of Geology, University of Cincinnati, Cincinnati, Ohio

PERMEABILITY-POROSITY PATTERNS OF SOME RECENT SEDIMENTS

Permeability, porosity, and textural analyses were conducted on 1,016 sand samples collected from river point bars, beaches, and dune fields undergoing active sedimentation. A total of 326 samples are from point bars on the Whitewater River in southwestern Ohio and the Wabash River in western Indiana; 531 samples are from beaches on the Bolivar Peninsula in Texas, Ship Island in Mississippi, and Santa Rosa Island in Florida; and 159 samples are from dunes on Santa Rosa Island and St. Andrew's Beach in Florida.

River point-bar sand samples have permeability values ranging from 160 md to more than 500 d and average 93 d. Porosity values range from 17 to more than 50 percent, and average 38. Permeability-porosity values for point bars are highly variable and show a systematic pattern related to positions on the bars.

Beach and dune sand samples have very similar permeability values, which range from 3,600 md to 166 d and average 60 d. Porosity values range from 30 to more than 65 percent, and average 45. Permeability-porosity values for beaches and dunes show a low variability and a poorly developed pattern related to positions within the environments.

Permeability and porosity values in all three depositional environments have low correlations with textural parameters. In some point-bar sands, high percentages of silt and clay account for low permeability values. However, high permeability and porosity in river-bar, beach, and dune sands are not well correlated with large grain sizes and good sorting; instead, packing seems to be the primary controlling factor.

Comparison of permeability-porosity values of these Recent sediments with available values from comparable ancient sediments shows that the Recent sediment values are several orders of magnitude higher; however, Recent sediments do show the same degrees of variability and distribution patterns as those in the ancient sediments.

PRYOR, WAYNE A., AND JIM L. BARR, Dept. of Geology, University of Cincinnati, Cincinnati, Ohio

SOLE MARKS IN SILTSTONE OF NONTURBIDITE ORIGIN

Sole marks and other directional structures generally assumed to be of turbidite origin have been found as common features in shallow marine siltstone and shale of Ordovician to Mississippian age in Ohio, Kentucky, and Indiana. The sole marks include: flute casts, load casts, groove casts, current crescents, prod marks, bounce marks, brush marks, and channel casts. Other directional features include: micro-ripple marks, micro-cross lamination, oriented fossils, ripple marks, and cross-bedding.

Comparison of sole-mark orientations with associated cross-bedding directions, shows a high degree of directional similarity. In those fine-grained sequences, where cross-bedding is rare to absent, the ubiquitous sole marks are the only reliable and available indicators of paleocurrent pattern.

This study suggests that paleocurrent investigations of shallow marine sequences need not be restricted to the coarse-grained sediments, since the fine-grained siltstone and silty shale also may have abundant directional features in the form of sole marks.

PRYOR, WAYNE A., AND NORMAN C. HESTER, Dept. of Geology, University of Cincinnati, Cincinnati, Ohio.

X-RAY DIFFRACTION ANALYSIS OF HEAVY MINERALS

Suites of heavy-mineral samples from the Upper Cretaceous sediments and Recent littoral sediments of the eastern Gulf coastal plain have been analyzed by X-ray diffraction techniques and conventional optical methods. Initial results indicate that X-ray diffraction can be used as a routine, rapid, and supplementary method of analysis for large numbers of heavy-mineral samples. Distinctive patterns for specific mineral suites are produced and meaningful associations are thereby determined, from which smaller numbers of samples are selected for detailed, conventional, optical analysis. Detailed identification and quantification of individual mineral elements in each of the irradiated samples are not the immediate purposes, but are possible.

Techniques have been developed to yield reproducible results and to overcome some of the problems inherent to the X-ray diffraction analysis of small, highly cleavable, and high iron content mineral samples. This technique requires uniform grinding of samples to less than 4 microns and the randomly oriented mounting of the particles in an X-ray transparent medium. Variables important to reproducibility and interpretation of data produced by this technique have been studied and their effects determined. These variables include mineral composition, texture of original sample, superimposition of peak positions, size of sample, grinding, orientation of mounted grains, mounting media, and irradiation variables.

Heavy-mineral samples from the Upper Cretaceous sediments in the eastern Gulf coastal region can be separated readily into several distinctive X-ray diffraction-pattern associations that are identical with associations determined by detailed and time-consuming optical analysis.

REYNOLDS, WILLIAM R., Pan American Petroleum Corp., New Orleans, La.

MINERALOGY, STRATIGRAPHY, AND ORIGIN OF LOWER TERTIARY CLAYS AND CLAYSTONES OF ALABAMA

The Alabama Tertiary rock units studied include, in ascending order, the Clayton, Porters Creek, and Naheola Formations of the Paleocene, and the Nanafalia Formation, Tuscahoma Sand, and the Hatchetigbee and Tallahatta Formations of the lower Eocene.

Throughout the area the lower and middle part of the Clayton Formation and the upper part of the Nanafalia Formation contain the zeolites clinoptilolite, heulandite, and a "mixed form" with structural characteristics of both clinoptilolite and heulandite. These occur with cristobalite and montmorillonite. Heulandite and montmorillonite occur in the thicker clays of the Porters Creek Formation in western Alabama. Clinoptilolite is the predominant constituent of a lower Tallahatta clay in western and central Alabama. A cristobalitic claystone makes up the upper