stratigraphically the highest coal bed in the section; the uppermost part of the Conemaugh is not present. Structurally, the basin in Maryland is the southern termination of the Youghiogheny syncline, which is asymmetrical and plunges to the northeast.

The coal beds of the basin were traced using new data from surface mines, water well logs, a mine-drainage pollution study, recent aerial photographs (May 1979), and unpublished data from the Maryland Geological Survey. Field checking, where possible, substantiated the available data. Two marine intervals, the Ames and the Brush Creek shale, aided in the correlation of the coal beds. A structure contour map of the top of the Upper Freeport coal bed was used to project the outcrop patterns of coal beds onto a topographic map.

Fourteen coal beds were identified in the Lower Youghiogheny basin. Of these, five are minable or potentially minable, the Upper Freeport and the Lower Kittanning being the more important. On the basis of this study, the Barton and Clarion coal beds are newly recognized in the basin. The Clarion coal bed has been mined in conjunction with the Lower Kittanning coal bed and knowledge of its existence adds a significant tonnage to calculated coal resources of the basin. A revised stratigraphic column for the basin shows the stratigraphic position of the Barton and Clarion coal beds. A map showing the coal beds indicates minable and potentially minable areas in the basin.

JORDAN, JOHN E., JR., Wright State Univ., Dayton, OH

Geologic/Geophysical Study of Fluvial Delta in Offshore Louisiana

The purpose of the paper is to define the geologic features of a delta lobe in offshore Louisiana and relate them to seismic characteristics. The seismic facies found in the delta sequence were also studied and compared to the different subdivisions of the delta lobe and its respective geologic features.

The data consisted of a grid of eleven seismic lines which covered an area of 550 sq mi (1,430 sq km). Four wells with various geophysical logs, and paleontologic determinations of their environments, were also included in the data.

A synthetic seismogram and two models were developed: a depositional model, and a seismic facies model. The synthetic seismogram was made from Well C using a velocity log and a density log to obtain the reflection coefficients. These reflection coefficients were then filtered using a time-variant filter. The depositional model was constructed on the basis of the correlation and interpretation of SP logs, the paleoenvironments, and a dip log. The seismic facies model was developed by correlating the seismic reflection characteristics found in the synthetic seismogram with the seismic lines.

MCCOLLOUGH, WILLIAM FERRELL, Univ. Maryland, College Park, MD

Structural Variations in Wissahickon Group

Four phases of deformation have been recognized along a 16-km transect perpendicular to strike from Mt. Airy to Sykesville in the Maryland Piedmont. Axial plane foliations, S_1, S_2, S_3, S_4, and associated lineations, L_1, L_2, L_3, L_4, are the result of successive superposition of four deformations, D_1, D_2, D_3, D_4. The three phases, D_1, D_2, D_3, vary systematically in orientation across the region. The D_4 phase occurs only locally.

The oldest deformation, D_1, developed a major foliation across the region. The major foliation is represented by a schistosity in the southeast and a slaty cleavage in the northwest. Primary bedding is isoclinally folded, with the major foliation parallel to the limbs of these folds. The folds were most likely rendered isoclinal owing to flattening during successive phases of deformation. In the southeast, the S_1 surface dips steeply southeast and then flattens northwestward to become part of a recumbent fold system. The associated L_1 lineations plunge gently to the southwest or northeast.

The D_2 deformation developed a near-vertical foliation which remains uniform in orientation across the region. In the southeast, the S_2 surface is a crenulation cleavage while northwestward, it changes into a fracture cleavage, locally obliterating the major foliation, S_1. The preexisting S_1 surface was cylindrically folded coaxial with F_1, about an axis that plunges gently southwest. The F_2 folds are commonly the best developed and vary from open to tight.

The D_3 deformation is characterized by a northwest-dipping crenulation cleavage, S_3, and associated crenulation lineations, L_3. The degree of development of the crenulation cleavage is locally variable, but, in general S_3 becomes better developed to the southeast.

The D_4 deformation is not continuous across the region. This can be attributed either to its overall weak development or to its parallel orientation with the preexisting structures. In the extreme northwest, kink bands grade into broad folds that disappear in the extreme southeast.

Studies of the microfabric across the region allowed fold styles to be characterized for each phase of deformation, as well as the determination of metamorphic grade. Although the metamorphic grade increases to the southeast, the peak of metamorphism at any location was coincident with D_1.

D_1 utilized nearly horizontal flow, while D_2 and D_3 were dominated by near-vertical movements. The D_1, D_2, and D_3 phases were probably generated during the Taconic and Acadian orogenies. The D_4 structure was probably a result of the Appalachian orogeny.

MOORE, TIMOTHY A., Univ. Maryland, College Park, MD

Structural, Optical, and Chemical Relations in Upper Freeport Coal of West-Central Pennsylvania

A direct relation in trends has been made between the structural deformation of west-central Pennsylvania and two petrographic properties of the Upper Freeport coal. Using samples collected by the U.S. Geological Survey, data for vitrinite reflectance and fixed-carbon percentage were generated and contour maps developed. It was found that the values increased in a near-linear northwest to southeast trend—the same trend as that of increasing regional deformation. Further development and refinement of these kinds of contour maps give the means for coal companies to infer the probable rank of a particular coal in areas where there has not necessarily been extensive analysis. The results and conclusions in this paper point to a possible method of predicting certain optical and chemical parameters of coals on the basis of their structural history and scattered samples collected in the basin.

MRKVICKA, STEVEN R., Univ. Oklahoma, Norman, OK

Thermal and Subsidence History of Williston Basin

The Williston basin is a large intracratonic basin located in North Dakota, Montana, and Saskatchewan. The sedimentary and tectonic histories of the Williston basin have been resolved

through the analysis of well data. Sedimentation rates, sediment lithologies and densities, and structural imprinting have all influenced the geometry of the Williston basin. With this background information, a subsidence model for the basin has been proposed. Mechanisms controlling the subsidence history appear to be a combination of a thermal mode and a mechanical mode. The thermal aspect of basin subsidence is related to factors associated with subsurface heating and cooling of the lithosphere through time. A noted property of thermal-induced subsidence is the relation of square root of age to depth of sediments. The mechanical aspect of basin subsidence is related to tectonic rifting and normal faulting.

An important component of the thermal history of the Williston basin is the relation between thermal heating and hydrocarbon maturation of the sediments within the basin. The organic-rich sediments accumulating within the subsiding basin will be subjected to increasing depth of burial through time, and concurrently experience increased heating induced by the geothermal gradient. Application of the "liquid-window" concept to hydrocarbon generation in the Williston basin gives an indication of the potential for hydrocarbon accumulation. Petroleum production data have confirmed this hypothesis.

MULLETT, DOUGLAS J., Wright State Univ., Dayton, OH

Geology of Albion Group of Tuscarawas County, Ohio

The Albion Group is the Lower Silurian sequence that was deposited along the northwestern edge of the Appalachian basin. The Albion Group is composed of the Brassfield Limestone and the Clinton Sandstone Formations. The Clinton Sandstone is the major petroleum producing formation in Ohio.

Cross sections and isopachous and lithofacies maps indicate that the Clinton Formation occurs as a "blanket" deposit or a series of overlapping sandstone bodies which intertongue with the Cabothead Shale to the west. Deposition is commonly interpreted to have occurred in a marine-deltaic environment. The sand bodies represent delta channel sands and offshore bars. Hydrocarbon accumulations are stratigraphically controlled by sand-bed facies changes or porosity pinch-outs. The key to petroleum exploration in the Clinton Sandstone is determining the orientation and extent of the sandstone bodies through subsurface mapping.

NEESE, DOUGLAS G., and ROBERT K. GOLDHAMMER, Univ. Oklahoma, Norman, OK

Constructional Framework in Buttress Zone: Role of *Acropora cervicornis* and *Agaricia,* Discovery Bay, Jamaica

The fore-reef buttress zone is composed of broad, terrace-like outgrowths at depths between 12 and 28 m. Coral-dominated buttresses—20 m wide, 50 m long, and less than 10 m vertical relief—are transected by regularly dispersed carbonate-sand channels cut subperpendicular to the strike of the reef slope. The width of the channels ranges from 12 to 20 m.

The construction buttresses are the result of vigorous outgrowth and lateral accretion, and can be divided into two major zones based on the contribution of the corals to the reef framework. In zone 1, water depths range from 12 to 17 m. *Acropora cervicornis* is dominant, and intergrown colonies exhibit polyp fusion creating a thicket that is an effective stabilizer. An abundance of broken, dead *A. cervicornis* rubble infills voids between primary hermatypic corals such as *Agaricia.* Species of *A. agaricites* are found commonly filling voids in the *Acropora cervicornis* meshwork. *Agaricites* colonies range in size from 4 to 30 cm, growing in close nonrandom distribution. This growth pattern reflects a defense mechanism for more aggressive corals, substrate preference (commonly dead *Acropora cervicornis*), and preference for a shaded environment. Along the steepsided flanks of the buttress *A. cervicornis* is of limited abundance and *Agaricia agaricites* is dominant. Interspecific aggression was not observed and it appears that growth of many *Agaricites* colonies is subsequent to the meshwork of *Acropora cervicornis.* Water depths in zone 2 range from 18 to 28 m. The predominance of *A. cervicornis* diminishes with depth and *A. cervicornis* occurs as loosely aggregated rubble piles and smaller living meshworks adjacent to the buttress. *Agaricia lamarki* replaces *A. agaricites* as a dominant primary hermatype. Rapid growth and fusion generally occur on vertical overhangs of the buttress and the change in species reflects diminishing illumination. The ability of broken *Acropora cervicornis* to regenerate, and its high growth rate, contribute to lateral outgrowth. Subsequent growth of *Agaricia* sp. in newly created preferential niches strengthens the buttress.

ORRELL, STANLEY ANDREW, Univ. Maryland, College Park, MD

Dynamic Analysis of Deformation Lamellae Occurring in Vein Calcite

Detailed stress analysis is of great importance to the structural geologist in the interpretation of various structural features. Of the many methods which have been devised to aide in dynamic analysis, the more promising has been in the use of calcite twin lamellae for the derivation of principal stress orientations.

Most work to date has centered on the analysis of detrital calcite grains in experimentally and naturally deformed limestones.

This paper summarizes research on the dynamic analysis of calcite twin lamellae occurring in calcite-filled fractures.

Four hand samples containing calcite-filled fractures were removed from the Lincolnshire Formation, an Ordovician limestone of the central Appalachians near Strasberg, Virginia. Before removal of the samples, the fracture type, relative age, and orientation were recorded. The standard techniques of dynamic analysis developed for such studies were applied to data from thin sections prepared from each sample.

It is presumed that the development of fractures and the subsequent filling with calcite occur in progressive stages throughout the phase of deformation. It is expected that the dynamic analysis of each calcite-filled fracture will yield information concerning the stress orientations present at the time of the associated stage of fracture development.

By sampling calcite-filled fractures of differing ages it is possible to follow the principal stress orientations throughout the progressive stages of deformation. Thus, by this method it is possible to derive the incremental stress orientations for each stage of fracture development. Present methods of dynamic analysis using detrital calcite provide only the principal stress orientations of the finite deformation.

By being able to derive the incremental stress orientations of a progressive deformation, a more detailed deformational history is obtained.

SMITH, SUSAN L., Univ. Oklahoma, Norman, OK