to analyze geological information intelligently, including well cuttings, surface samples, surface and subsurface geological maps, seismic records, gravity information, and magnetic information in order to determine whether or not the local geological environment is conducive to oil accumulation. Modern exploration techniques make possible the localization of potential oil reservoirs in such sedimentary features as limestone reef complexes, deltas, beaches, *etc.* The most difficult aspects of this modern exploration concept are the correlation of geological and geophysical data and the reduction of geophysical data into meaningful geology.

The past decade has witnessed a rebirth of sedimentary petrology in oil-finding. This renaissance involves the study of Recent sediments as a key to the past and the application of geochemistry, paleontology, and petrology to the definition of sedimentary depositional patterns. During the past 10 years, geophysicists not only have improved their equipment for better measurements of the properties of sediments but also have made significant progress in developing methods of presenting geophysical data in geological form.

18. A. B. SHAW, Pan American Petroleum Corporation Research Center, Tulsa, Oklahoma

PALEONTOLOGY IN MID-CONTINENT EXPLORATION

Paleontology (including both invertebrate paleontology and palynology) is the natural complement to the use of structure and stratigraphy in oil exploration. The decision to use it or not is fundamentally economic as is the decision to use structure (seismic) or stratigraphy. However, the changing pattern of exploration makes the use of fossils increasingly appropriate. Fossils can be used to supply evidence of time correlation and original environmental conditions that is independent of the data obtained from the rocks themselves. It is also being found that fossils themselves in many instances provide the trapping mechanism.

Fusulines are the only fossil group with a long history of application in the Mid-Continent, but many other microfossils are now becoming more useful as their study matures. There is no universally applicable fossil group because no organism was ever able to survive everywhere, but each System and many environments contain organic remains especially suitable to use therein. Thus, competence in several fossil groups is necessary to cope with normal exploration problems. Multiple competence also assures that for most subsurface problems enough usable fossils will be available to provide answers. The increased sophistication of lithostratigraphy and production techniques has made coring more commonplace. This makes available the whole range of macrofossils, which are especially valuable because in many cases their significance already is understood.

19. L. R. WILSON, University of Oklahoma, Norman, Oklahoma

PALYNOLOGICAL EVIDENCE FOR FOLDING, FAULTING, AND EROSIONAL CONTACTS IN SUBSURFACE

Palynological studies, conducted on exposed rocks illustrating various degrees of folding, faulting, and other expressions, have been used to interpret conditions observed in subsurface samples. Palynological evidence of rock folding or faulting is shown by degrees of spore and pollen preservation and progressive color changes from yellow to black. Folded structures generally can be distinguished from fault structures by more uniform and widespread occurrence of specific palynological physical changes. Regions containing igneous intrusions show similar palynological changes, but differ in proportion to type and distribution of igneous bodies. Unconformities are detected by marked palynological assemblage changes and in many instances by recycled fossils above an erosional surface. Recognition of palynological physical aspects can be useful in the identification of paleogeographic features, direction and approximate location of stratigraphic traps, paleotemperature conditions within an area, and probable oil or gas potentials.

20. K. H. ANDERSON, Missouri Geological Survey, Rolla, Missouri

FOREST CITY BASIN OF MISSOURI, KANSAS, NEBRASKA, AND IOWA

The Forest City basin of Missouri, Kansas, Nebraska, and Iowa is the area of the first oil and gas production west of the Mississippi River. Production was found near Paola, Kansas, within a few years of the birth of the American oil industry at Titusville, Pennsylvania.

Initial movements of the Ozark uplift and the Chautauqua arch began in Late Ordovician time. Attendant subsidence in the northern Kansas area formed an ancestral basin which was later bisected by the Nemaha anticline, forming the Salina basin on the west and an unnamed basin on the east. Post-Mississippian, Pre-Atokan peneplanation of the entire region took place before renewed activity along the Nemaha anticline uplifted the area west of the anticline while downwarping east of the Nemaha scarp formed the Forest City basin. Thus, it is defined as a Pennsylvanian-age basin. Movement along the Nemaha structure may have begun as early as pre-St. Peter time but certainly during Early Mississippian time and continued intermittently until at least the Early Permian.

The Cherokee and Forest City basins were separated by a low arch until middle Cherokee time when the Forest City basin filled with sediments and the two basins joined across the Bourbon arch.

Northeast-trending folds developed after Mississippian deposition, whereas previous structural orientation had been toward the northwest.

21. G. H. WEBER, Oil And Gas Journal, Tulsa, Oklahoma

HEAVY OIL IN MID-CONTINENT

Heavy oil is nothing new, and it has been known since the early days of the oil industry. There has never been a practical method by which these low-gravity crudes could be recovered in commercial amounts.

However, the advent of steam flooding and fire flooding has provided a means by which these oils can now be driven to the bore hole and produced on a practical basis.

There are vast amounts of these deposits through the Mid-Continent area with especially attractive accumulations centering in eastern Oklahoma, eastern Kansas, and western Missouri. They range from barely producible heavy oil to solids. Some of the sandstones in which these hydrocarbons occur contain 700–800 barrels per acre-foot in-place reserves. As a rule, the sandstones are lenticular and almost defy generalization.

Their advent on the United States industrial scene has been termed "The Quiet Revolution." At least 7 steam and fire-recovery projects are known to be active now; 10 have been terminated; and at least 4 are in the planning stage. Success or failure of these projects will determine the future of heavy oil in the Mid-Continent.