planning the exploration programs, it can be a link which coordinates data from conventional sources, and it can be an interpretation tool in its own right.

Landsat is currently used to map and plan data acquisition programs. It can be processed to provide accurate map quality displays and its continuous coverage makes it a prime source for current information in remote areas and on a worldwide basis.

Feature extraction from the Landsat data helps identify and locate crops, forest, marsh, and other factors which affect operations cost. Data-processing techniques which permit the extraction of depth over coastal waters make this tool useful in marine-acquisition programs as well. Remote bathymetry is providing accurate up-to-date hydrographic information in many areas of the world. Cost savings from this application of Landsat can offset the cost of Landsat data processing.

Frequently displayed at conventional map scales, the Landsat image itself becomes an excellent working document for compiling and integrating other sources of information. It provides the basis for confirming or questioning data quality and accuracy as they are completed. Landsat data can be processed to enhance the surface expressions of geologic features. This then aids the interpreter in the detection of faults, folds, lineaments, and other expression of subsurface geology.

The data lends itself to independent geologic interpretation which can then be compared to interpretations made from gravity or seismic data. The spectral characteristics of the multi-spectral sensor data can be processed to extract information, to enhance edges, and to aid in the detection of lineaments which aids the structural interpretation of the area. Also, the data can be processed to enhance spectral differences which aid in identifying surface rock types. Water-related features can be enhanced to aid in analyzing drainage and drainage patterns. With false color imagery, Landsat data will aid in analyzing vegetation, cultural features, accent faults, folds, and other geologic structures.

HUERTA, RAUL, and RICHARD T. BUFFLER, Univ. Texas Marine Science Inst., Galveston, TX

Seismic, Stratigraphic, and Structural Analysis of Northeast Campeche Escarpment, Gulf of Mexico

Multifold reflection seismic profiles and DSDP core holes allow a detailed structural and stratigraphic analysis of the northeast Campeche Escarpment. The escarpment, in the central Gulf of Mexico, marks the northern edge of the massive Campeche carbonate platform.

A major middle Cretaceous unconformity occurs within the sedimentary section both on the platform and in the deep gulf and represents a major change in sedimentation rate and type. Pre-middle Cretaceous sedimentary rocks in the deep gulf are characterized by weakly developed halokinetic structures (salt pillows and associated faulting), suggesting evaporites in the section. Lower Cretaceous (carbonate-prone) sedimentary rocks overlie these evaporites and are deep-water equivalents of the Lower Cretaceous bank sediments. Sedimentary rocks overlying the middle Cretaceous unconformity consist mainly of Pleistocene turbidites, hemipelagics, or laminites which represent the distal part of the Mississippi fan complex. On the platform, Lower Cretaceous bank sediments are shallow-water carbonate rocks while the post-middle Cretaceous is composed mainly of pelagic sediments, foraminiferal nannofossil oozes and chalks.

The seismic reflection data indicate that the northeast Campeche Escarpment is a fault-controlled feature probably related to the early rifting of the Gulf of Mexico. It trends northeast-southwest for approximately 500 km and is modified by local slumping, secondary faulting, and current erosion. The major structural feature on the bank proper is normal faulting, an expression of regional extensional forces. Differential movement between major adjacent fault blocks controlled local sedimentation style.

HUNT, JOHN M., and ALAIN Y. HUC, Woods Hole Oceanographic Inst., Woods Hole, MA

Petroleum Source-Rock Evaluation by Thermal Distillation and Pyrolysis

Thermal distillation involves releasing the pore-water hydrocarbons and adsorbed hydrocarbons from a rock sample by heating to temperatures around 300°C. Further heating to 800°C (pyrolysis) causes cracking of the kerogen to form additional hydrocarbons. The present petroleum-source capability and evidence for primary migration can be evaluated from these data. Well cuttings from two COST wells in the Gulf Coast and miscellaneous samples from other areas were analyzed for individual hydrocarbons in the C_6 to C_{15} range by these techniques. The depth threshold of intense hydrocarbon generation was identified in one COST well along with some evidence for primary migration. The second COST well showed no evidence of hydrocarbon migration probably because the organic-carbon content and quantity of hydrocarbons generated were too low to cause migration.

HUTCHEON, IAN, Univ. Calgary, Calgary, Alta.

Water-Rock Interaction During Clastic Diagenesis in Both Open and Closed Systems

Studies have shown that the composition of ocean water may be controlled by reactions with clay minerals which act as solid phase buffers. The compositions of interstitial brines are subject to similar controls, but at least two boundary conditions can be established. In permeable sandstones (open system) it has been proposed that reactions of the form (1), clay mineral + dolomite + $H_2O \rightarrow$ chlorite + calcite + CO_2, produce large quantities of CO_2 as a vapor which may migrate, causing production of secondary porosity during later diagenesis. In this case the mineralogy is clearly controlled by the composition of interstitial waters.

In a closed system, represented by over-pressured shales from the Gulf Coast, published water compositions can be correlated with mineral reactions inferred from X-ray diffraction. Equilibria of the form (2), kaolinite + $K^+ \rightleftharpoons$ clay mineral or feldspar + H^+, can be used to document the path of fluid phase compositional buffering with increasing depth. Theoretical phase relations predict a decrease in the concentrations of K^+, Na^+, and CA^{++} such that $K^+ < Na^+ < Ca^{++}$ in buffering capacity. This phenomenon is actually observed. Reactions such as from (2) also provide a mechanism to produce H^+, lowering pH, and perhaps also forming secondary porosity during later diagenesis of clastic rocks.

Both examples demonstate that authigenic mineral assemblages, not the appearance or disappearance of single minerals, must be documented to relate diagenetic changes to burial depth. Also, diagenetic mineral assemblages are strongly controlled by water compositions in open systems and these are not a simple function of burial depth. This also implies that any disturbance of fluid compositions during drilling or well completion may profoundly affect mineralogy.

INGERSOLL, RAYMOND V., Univ. New Mexico, Albuquerque, NM

Temporal Changes in Depositional Facies in Great Valley Forearc Basin of California—Influence of Basin Evolution and Tectonics

The Great Valley forearc basin began in the Late Jurassic as a residual forearc basin on top of oceanic crust, and evolved into a composite forearc basin on top of both oceanic and continental crust in the Late Cretaceous and Paleogene. The depositional basin widened through time owing to the westward and upward growth of the subduction complex and the eastward migration of the coeval magmatic arc. Depositional facies reflect changes in shape, size, tectonic activity, and inherited characteristics of the basin.

Late Jurassic depositional environments primarily consisted of slope with locally incised channels. The basin was relatively narrow and a steep slope allowed sediment movement from the shoreline on the east directly into the trench to the west. By the Early Cretaceous, a bathymetric barrier was formed by the upward- and outward-building subduction complex, thus trapping arc-derived sediment within the forearc basin. Basin-plain environments dominated in this terraced forearc. The subduction complex continued to grow, and the magmatic arc migrated eastward during the Late Cretaceous, resulting in a wider, composite basin. Complex interbedded submarine fan, slope, and basin-plain facies formed in this setting. Submarine fan systems became larger owing to the concentration of sediment gravity flows within submarine canyons incised into the widening shelf on the east side of the basin. The basin evolved into a broad ridged forearc and, eventually, into a broad shelved forearc during the Paleogene as the subduction complex emerged above sea level and the forearc basin filled. As a result, Upper Cretaceous submarine fan complexes are overlain by slope facies, which are overlain by shelf facies. Nonmarine environments have persisted following filling of the basin and sequential termination of subduction by the northward migration of the Mendocino triple junction during the Neogene.

INKOLLU, S. N. MURTY, GeoSource Inc., Houston, TX, MARTHA O. WITHJACK, Cities Service Co., Tulsa, OK, and J. J. GALLAGHER, Cities Service International, Houston, TX

Basins of East India: Tectono-Stratigraphic Facies

Rocks and structures of east India result from both global and local processes. Global sea level and the breakup of Gondwanaland control the broad aspects of sedimentation and deformation, and local sedimentologic and tectonic variables determine specific lithologic and structural variations. The concept of tectono-stratigraphic facies is convenient in the interpretation of different suites of rocks and structures which are related ultimately to the same global processes. Three tectono-stratigraphic facies are recognized for east India. *Facies 1* is on the craton. It consists of very long, narrow grabens or half grabens containing small normal faults. Most faults are Early Triassic to Early Cretaceous in age but some may be older. Sediments are restricted to the grabens and are late Carboniferous through Early Cretaceous fluviatile or lacustrine clastics. *Facies 2* is in broad basins along the continental margin. Major Late Jurassic to Early Cretaceous normal faults divide the basins into a series of elongate blocks. Sediments are predominantly Late Jurassic through Early Cretaceous marine, paralic and continental clastics. *Facies 3* is found along the continental margin. Faults are Late Cretaceous to early Tertiary in age, while sediments are marine, paralic, and continental deposits of Late Cretaceous to recent age. Marine sediments are more dominant offshore.

The ten most prominent basins of east India can be classified in terms of tectono-stratigraphic facies. The Godavari, Mahanadi, Damodar, and Satpura basins are dominated by facies 1, and the Cauvery, Palar, Godavari-Krishna, and Mahanadi-Brahmani basins are characterized by facies 2 and 3. The Bengal basin is dominated by facies 3. Observed dominant facies may grade into one of the other facies in unexplored parts of these basins or at depths yet to be probed.

IVEY, JOHN B., Consultant, Denver, CO

Geologic Framework for Development, Production, and Reclamation of Coal Properties

Today, geology plays an increasingly important role in the development, production, and reclamation of coal properties. The geologic framework of a property is defined by geologic mapping, drilling, logging samples, downhole geophysics, correlation of lithologic units, and review of laboratory analyses. These activities form a data base which is needed by the mine design engineer, the development and production engineers, and the reclamation specialist.

A detailed surface geologic map will be of use throughout the life of a coal mine. This map can best be prepared (after preliminary photogeology) by field mapping, which includes measuring sections and defining structure and stratigraphy. The identification of lithologic units and determination of their engineering characteristics are important because they bear a relation to excavation and slope stability in surface mines, and to roof, pillar, and floor stability in underground mines.

A typical drilling program includes rotary, spot-core, and full-core drilling, geophysical logging, and sample logging. Bulk sampling of coal for physical testing can