Dipmeter data can provide a link between large-scale seismic and small-scale core information that is being used to identify structural and stratigraphic traps of the mature, highly faulted Gulf Coast area. This information is available on the first well drilled and can help unravel complexities inevitably uncovered in field development.

FIELD, MICHAEL E., and KEITH A. KVENVOLDEN, U.S. Geol. Survey, Menlo Park, CA

Gas Hydrates Beneath Continental Slope off Northern California

The continental slope and plateau off northern California are underlain by a well-defined and extensive acoustic reflector that crosses other reflectors and mimics the surface of the sea floor. This bottom-simulating reflector (BSR) lies at an average subsurface depth of 250 m and is laterally continuous beneath the Klamath Plateau (water depths of 800-1,200 m) off northernmost California. Limited data show that it extends northward into offshore Oregon and seaward at least to the base of the slope (3,000 m water depth). The BSR has been mapped along the continental margin for a distance of over 130 km and underlies an area of at least 3,000 km^2.

The water depths and sediment depths of the BSR, as well as its pervasiveness, all suggest that it represents the base of a natural-gas hydrate. Using standard phase-boundary diagrams for hydrate stability, we estimate that the geothermal gradient in this area is about 50°/km. Such a gradient is higher than found along most subduction margins, possibly because the subducting oceanic crust in this region is young. This acoustically inferred gas hydrate is the first mapped along the western United States conterminous continental margin.

FIGUEIREDO, A. M. F., M. J. PEREIRA, W. U. MOHRIAK, P. C. GAGLIANONE, and L. A. F. TRINIDADE, PETROBRÁS, Rio de Janeiro, Brazil

Salt Tectonics and Oil Accumulation in Campos Basin, Offshore Brazil

Salt tectonics were responsible for the development of optimum conditions for accumulation of large hydrocarbon reserves in Campos basin.

The salt movements, triggered by basin tilting and differential loading, initially formed low-relief salt pillows that controlled the porous facies of the shallow-water Macaé limestones. The continuous evolution of halokinetic processes produced growth faults, rollover crests, and faulted anticlines. Upper Cretaceous turbidite sandstones were channelized in the downthrown blocks of growth faults. Salt-collapse, residual, and relief-inversion features were formed in areas where the salt was sufficiently thick.

The oil, generated in the Neocomian shales of Lagoa Feia Formation, migrated to upper formations through normal faults associated with the rift phase, stratigraphic conduits such as porous rocks and regional unconformities, and gaps created by salt flowage in the Aptian evaporite section. Oil migration to the post-salt rocks was favored by active growth faults and by the presence of a regional unconformity developed at the Cretaceous-Tertiary boundary and covered by turbidite sheet sands.

The oils underwent progressive alteration along their paths to the post-salt reservoirs. Oil-oil and oil-source rock correlations suggest that the hydrocarbons trapped in many diverse plays, although affected by bacterial degradation and water washing, belong to only one oil family. The oil degradation was probably enhanced by meteoric water invasions during Tertiary low stands of sea level in areas close to the paleocoastline. These phenomena resulted in large amounts of oil becoming heavier and enriched in sulfur, resins, asphaltenes, and cycloparaffins.

FINLEY, ROBERT J., Bur. Econ. Geology, Austin, TX, and LEWIS R. LADWIG, Colorado Geol. Survey, Denver, CO

Depositional Systems of a Tight Gas-Productive Barrier-Strandplain Sequence: Corcoran and Cozzette Sandstones, Northwest Colorado

The Corcoran and Cozzette sandstones (Campanian) are members of the Price River Formation within the Mesaverde Group of the Piceance Creek basin, and consist of marginal-marine facies between the underlying Mancos Shale and the overlying continental Mesaverde. Log-interpreted facies within the Corcoran-Cozzette vary from shale with thin siltstone to sandstone interbeds (shelf to lower shoreface), through upward-coarsening sequences (upper shoreface to foreshore), to interbedded thin coal, sandstone, and shale (alluvial plain to bay or lagoon). Plateau and Shire Gulch are the largest fields that produce gas from low-permeability (0.002-0.08 md), fine-grained to very fine grained sandstone of the Corcoran and Cozzette (over 8.4 bcf produced through 1982).

Within these fields, 7 distinct northeast-trending strandplain and barrier units have been identified. Strandplain sandstones form the lower half to two-thirds of each member, and barrier sandstones form the upper depositional units. Net sandstone thickness of the strandplain units increases from less than 20 ft southeast of the fields to more than 80 ft within Plateau field. Along the southeastern Plateau field margin, upper units in each member contain 30-55 ft thick sandstones that repeat the shoreface sequence.

Most completions are in the lower (39%) and upper (33%) Corcoran, whereas the lower and upper Cozzette each account for 14% of perforated intervals. The underlying Mancos Shale and overlying coal may account for the greater gas production of the Corcoran. Gas productivity of individual depositional units cannot be defined due to commingled production from multiple intervals in most wells.

FLETCHER, CHARLES H., III, Univ. Delaware, Newark, DE

Coding, Storage, and Retrieval of Stratigraphic Data: FORTRAN Mapping Technique

A unique technique of coding, storing, and plotting descriptive stratigraphic data uses a series of FORTRAN programs. The basis for the technique is a search-and-store algorithm that may be modified to produce a time-series sequence of lithologic or environmental maps. Coded data are displayed as a 2-dimensional output array in the form of an inked, line-drawn planimetric view of the research area. User-specified intervals of the range of data are represented by symbology, color code, or literal string. The final product is a time series of computer-constructed surfaces representing the geologic evolution of a particular area. These surfaces may emphasize environments of deposition, sediment lithology, or any other stratigraphically derived information (porosity, permeability, consolidation, mineralogy, biostratigraphy, geochemistry).

Stratigraphic data are stored as an alphanumeric code. Data are presumed to have been derived from cores or some similar means of vertical sequence control. A single core occupies one line of a data file with an operating field width of 132 columns. Columns 1-9 and 122-132 contain location and identification data. The remaining locations (columns 10-121) consist of repeating 14-column groups. Each group contains codes describing a single stratigraphic unit. Thus, each line of the data file may describe a sequence of 8 stratigraphic units.

This technique was used to display the development of the Bay and Atlantic coasts of Delaware from 10,000 b.p. to present. A series of maps has been produced that details the geomorphology of the coast at regular chronologic intervals. This allows a detailed analysis of the evolution of a complex region as a response to known Holocene conditions of rising sea level.

FLEXER, A., and A. LIVNAT, Tel Aviv Univ., Tel Aviv, Israel

Evolutionary Importance and Economic Potential of Mesozoic Unconformities of Levant

Six unconformities are discerned in the Mesozoic section of Israel and adjacent countries. Four unconformities (mid-Triassic, Late Triassic, Late Jurassic, and Aptian-Albian boundary) are genetically related to global sea level drops and divergence of the Tethys. The divergent processes are associated with faulting, volcanism, and clastic accumulations along the passive margins of the Arabian craton.

The Late Cretaceous unconformity is associated both with global sea level drop and convergence of the Tethys. The late Middle Jurassic unconformity is related to a global eustatic low without any apparent tectonic activity in the region. All the unconformities are widely distributed and, except the one at the Jurassic-Cretaceous boundary, mark only short periods. Therefore, they serve as markers and correlation guides for the geologic evolution of the Middle East. Their economic importance can be summarized as follows. (1) The tectonic setting of the blocks overlying

the unconformity plane and the duration of subaerial exposure periods associated with meteoric flushing and karst development is of prime importance for petroleum exploration. The Late Jurassic–Early Cretaceous angular unconformity brings into juxtaposition a deep Paleozoic aquifer and an overlying Mesozoic aquifer. Problems of salinity, reserves estimate, and exploitation arise. Karstic phenomena that developed during the Late Cretaceous exposure time contribute to the excellent storage capacity of the Cenomanian-Turonian aquifer. (3) Alumina-rich lateritic soils, formed under subaerial tropic conditions at the Triassic-Jurassic boundary, are used by the ceramic industry.

FLORES, RICHARD L., Exxon Co., U.S.A., Houston, TX

Computer-Generated Graphic Displays of Commercial Production History and Reservoir Data

Many types of digital information are available commercially for use by the petroleum industry. Two particularly useful types of data are production history and reservoir information. Computer files of production history information typically contain monthly production figures and periodic test results where they are available. Computer files of reservoir information commonly include such data as producing formation, discovery date, average depth, net pay, porosity, permeability, lithology, trap type, fluid contacts, drive type, and chemical analyses of crude oil, gas, and formation-water samples.

It is often difficult to assimilate these large volumes of information by merely listing the data. Computer-generated production decline curves, P/Z gas plots, maps, bar graphs, and other such graphic displays allow one to analyze these data with less time and effort.

FLOWERS, BILLY S., Shell Offshore Inc., New Orleans, LA

Corsair Trend—Exploring for Deep Geopressured Gas, Middle Miocene, Offshore Texas

(No abstract)

FLY, STERLING H., III, Cities Service Oil & Gas Corp., Midland, TX

Siliciclastic-Carbonate Interactions in Laborcita Formation, Sacramento Mountains, New Mexico

Outcrop exposures of the Laborcita Formation (Wolfcampian) reveal an active depositional environment with abrupt lateral and vertical changes between fan-deltaic and carbonate sediments. The siliciclastic source area was to the east, in the Pedernal uplift. Fan-delta lobe shifting was important in producing the cyclic nature of deposition.

Away from the area affected by the fan-deltas, deposits are increasingly calcareous. Shales are the predominant lithology in the Laborcita Formation, due to the abundance of carbonate-inhibiting terrigenous matter, especially in restricted areas. A few digitate stromatolites and *Archeolithophyllum* sp. mounds indicate subaerial exposure. Toward the edge of the narrow shelf, large phylloid-algal buildups (20 m or 65 ft thick) occur. An exposure in Coyote Canyon, near the northern end of the Laborcita exposure, shows an onlapping sequence of several mounds. This mound zone was terminated when muds and fine to medium-grained terrigenous sands migrated in and inhibited growth of the carbonate-producing organisms. The terrigenous sediments were in turn overlain by grainstones exhibiting long, low-angle (15°) cross-bedding, which dips landward (southeast). Individual grainstone beds are thin (0.5-1.5 m or 1.6-5 ft), extend along strike laterally for about 2.5 mi (4 km), and are composed largely of bioclastic carbonate grains (not oolitically coated) with 5% quartz grains. Direction of migration was southwest to northeast.

Gradual emergence is recorded by the Laborcita Formation. With continual progradation of terrigenous deposits, interrupted by marine incursions resulting in deposition of shallow-water carbonated deposits, the transitional Laborcita Formation was ultimately overlain by the terrigenous Abo Formation.

FOLK, ROBERT L., Univ. Texas at Austin, and PAMELA A. TIEZZI, Exxon, New Orleans, LA

Diagenesis and Dolomitization in Triassic (Rhaetian) "Portoro" Limestone, Portovenere, Liguria, Italy

The Portoro Limestone is jet black with white veinlets and gold stylolites, and is much used as ornamental stone. Vague, pale-gray nodules represent precocious lithification at shallow depths below the sediment surface, probably the result of bacterial colonies consuming organic matter and mobilizing carbonate. Gnocchi (now turned upside down) are partly filled with geopetal, fine dolomite sediment; original tops are filled with sparry calcite and baroque dolomite. These probably represent dissolved evaporite nodules. Despite the black color, the rock contains very little organic matter. The rock is made of 10-20 μm metamicrite as the result of thermal metamorphism; crystals are so clear that the minute amount of organic matter is readily visible. There are many generations of dolomite; most abundant is postmetamorphic, post-fracturing dolomite that contains inclusions of metamicrite and has ragged crystal form. Earlier dolomite behaved as a mechanical sediment, accumulating as geopetal filling within cavities, on top of clasts, and within tectonic fractures.

FORSTHOFF, G. M., Gulf Oil Exploration and Production Co., Casper, WY, and T. L. HOLCOMBE, National Geophysical Data Center, Boulder, CO

Controls of Bioclastic Turbidite Deposition in Eastern Muertos Trough–Northeast Caribbean Sea

A study of seismic-reflection profiles and sediment cores establishes regional bathymetric and source area control over the composition, transport, and distribution of turbidites in the eastern Muertos Trough. Bioclastic (carbonate) turbidites dominate the eastern portion of the trough. Analyses of carbonate content and sand-sized components suggest that the bioclastic turbidites (characterized by planktonic foraminifera, pteropods, and sponge spicules) are reworked pelagic oozes originally deposited on the outer-shelf and upper-slope areas south of St. Croix and eastern Puerto Rico. The presence of several intrashelf and upper-slope basins prohibits shallow-water carbonate sediments from entering the Muertos Trough.

Volcanic rock fragments derived from Puerto Rico are transported to the trough via the Guayanilla Canyon system. Mixing of the volcanic fragments with outer-shelf and upper-slope lutites results in mixed bioclastic-terrigenous turbidites south of central and western Puerto Rico. The paucity of shallow-water carbonate sediments in the trough suggests that the submarine canyons are effective conduits for the "rapid" transport of volcaniclastic sands across the shelf and thereby prevent extensive mixing with inner- and middle-shelf carbonate sediments.

Sediment transport within the trough is primarily axial in an east-west direction. Outer trench-wall fault scarps, south of Guayanilla Canyon, limit the southerly progradation of the trench-wedge facies and deflect incoming gravity flows in a down-axis (westward) direction. Where no faults exist, the trench wedge progrades southward and interfingers with the pelagic sediments of the northern Venezuelan basin.

FURST, MARIAN J., Schlumberger Well Services, Dallas, TX

Quantitative Sedimentologic Application for Dipmeter Data

Traditionally, interpretation of dipmeter computations has required considerable expertise. Although dip angles and directions were computed precisely, relationships between successive correlations were left to qualitative visual inspection.

Now, with new software, 4- or 8-button data can be output in a form that allows routine quantitative analysis. This new program computes curves that provide measures of the thickness between dip correlations, planarity of correlations, parallelism of successive bedding planes, and grain-size trends from resistivity curve shapes.

Uses for this information are varied. To the extent that dipmeter correlations reflect bedding planes, the thickness between correlations can be used to study vertical changes in bed thickness. Combining grain-size trends with bedding characteristics and thickness, one obtains a sedimentologic description of the formation that can be displayed with easy-to-understand graphics. An appropriate depth scale allows a macroscopic view of several hundred to several thousand feet of log data or a microscopic examination of a short interval in great detail.

The dipmeter data can also be incorporated into computerized analysis of other wireline log data. Laminated formations can be identified, and the direction and dip of the laminations can be indicated on a lithofacies