WILLIAMS, DOUGLAS F., and RICHARD H. FILLON, Univ. South Carolina, Columbia, SC

High Precision Absolute Age Determinations Within the Plio-Pleistocene in Gulf of Mexico

Absolute ages can be determined from Plio-Pleistocene sequences in the Gulf Coast using an $^{18}O/^{16}O$ analytical approach. The technique is based on the fact that glacial/interglacial cycles possess uniquely shaped "fingerprints." The character of the isotopic record in the Gulf of Mexico is exaggerated because the Gulf has periodically received extreme riverine discharges of meltwater products from the Laurentide ice sheet which covered large portions of North America during the Plio-Pleistocene. The ^{18}O record thus allows age determinations with a precision of ±20,000 to ±50,000 years in the Plio-Pleistocene. Close sampling via sidewall cores is required for initial calibration in a given basin. Sections ranging from middle shelf to bathyal depths can be reliably zoned, independent of regional or local biostratigraphic and lithostratigraphic zonations. Once an absolute age framework is established, stratigraphic correlations, sedimentation rates, and structural effects on sediment distribution can be determined. The technique has been developed using holes drilled from the MV *Eureka* (part of an early Shell Oil offshore study in the Gulf) as well as strategically placed piston cores and DSDP sites. Both benthic and planktonic foraminiferal shell carbonate should be suitable for these age determinations. A similar Plio-Pleistocene zonation can be established worldwide based on analysis of DSDP material. Preliminary data suggest that a similar zonation may be established throughout the Tertiary and perhaps the Mesozoic. Effects of diagenesis are unknown.

WILLIAMS, JOHN D., Consultant, Austin, TX

Interactive Flattening as an Exploration Tool

As exploration progresses in a basin, the effort to find new reserves compels the explorationist to look for traps too subtle to have been discovered in earlier efforts. Many such traps are rendered obscure by diapirism or regional deformation. The most common approach used in finding these traps entails the preparation of isopach maps and cross sections referenced to a common stratigraphic marker. Although these methods are generally effective in revealing paleostructural trends, they are tedious and require initial determination of the best horizons to use. An analogous situation often confronts the geophysicist in areas with minor structural relief and relatively major velocity anomalies.

A faster and often more revealing technique involves interactive flattening of cross sections or seismic data on a microcomputer. This allows the explorationist to view any horizon as a paleostructural reference, thereby eliminating horizons that do not effectively depict the underlying structural trends. This technique can also provide a clearer understanding of basin development in areas that were significantly deformed after producing zones were deposited.

The utility of interactive flattening in the delineation of subtle traps is shown in the restoration of the paleostructure of salt domes in Louisiana, where significant accumulations occur on the flanks of younger structures. Examples of basin development are derived from offshore California, where wrench faulting has obscured the structural setting that existed during the deposition of important Miocene reservoirs. The application of flattening seismic profiles to remove false structure induced by shallow velocity changes is illustrated for several areas in the Mid-Continent.

WILLIAMS, JONATHAN D., Exxon Co. USA, Oklahoma City, OK, and RONALD C. SURDAM, Univ. Wyoming, Laramie, WY

Depositional and Provenance Controls on Diagenesis of Sandstones Associated with Green River Formation of Wyoming

Synchronous sandstones associated with the lacustrine Eocene Green River Formation of Wyoming from three distinct provenance areas and two general depositional environments were studied to determine provenance and depositional controls on diagenesis.

Quartzitic fluvial sands in an area dominated by ground water flow were cemented early with calcite. Marginal lacustrine sands of the same detrital mineralogy became cemented with calcite and ankerite. Lacustrine sandstones with a micritic matrix contain no porosity, whereas fluvial sandstones with well developed secondary porosity registered porosities as high as 25% and permeabilities above 2,300 md.

Arkosic sands deposited from rivers meandering across a fluvial floodplain developed mostly authigenic clay cement from the dissolution of feldspars. In contrast, arkosic beach sands intercalated with lacustrine carbonates were cemented with ankerite.

Volcanogenic fluvial sands were cemented with zeolite and clay minerals, reducing the effective porosity to zero. On the other hand, environmentally controlled carbonate forms the principal cement of marginal lucustrine volcanogenic sandstones. Cementation by carbonate halted the degradation process of volcanic rock fragments to pore-filling clays and zeolites. Furthermore, some of these rocks exhibit excellent secondary porosity and permeability.

In conclusion, provenance set the stage for diagenesis by providing the raw materials for subsequent sandstone alteration. However, depositional environment can cause sands of similar detrital mineralogy to follow different diagenetic courses leading to the development of significantly different porosity and permeability characteristics. Diagenetically produced porosity differences in a marginal lacustrine setting can yield a wide variety of reservoirs, seals, and traps.

WISE, SHERWOOD W., JR., Florida State Univ., Tallahassee, FL, and DSDP LEG 93 SHIPBOARD SCIENTIFIC STAFF

Lower Cretaceous Deep-Sea Fan Complex Beneath the Lower Continental Rise Off North Carolina

Deep Sea Drilling Project Hole 603B, the first deep (1,585 m, 5,200 ft) penetration of the lower continental rise off the eastern United States, intersected an extensive (218 m, 715 ft) Lower Cretaceous deep-sea fan complex. Drilled 435 km (270 mi) east of Cape Hatteras, North Carolina, about 320 km (200 mi) seaward of the Lower Cretaceous shelf break, the continuously cored Hauterivian to Barremian turbidite sequence consists of 47% terrigenous sand. The sand turbidites are generally poorly consolidated and porous except where locally cemented by calcite. The sands appear fresh and are dominated by subangular quartz with abundant feldspar, mica, heavy minerals, wood fragments (locally up to 20%), glauconite, and shallow-water bioclastics. The turbidites exhibit the entire range of Bouma textures and include plastically deformed blocks of sediments up to 25 cm (10 in.) across which indicate channelization and slumping within the fan. Interbedded with the sand turbidites are pelagic limestones and black claystone turbidites, the latter containing up to 13.6% organic carbon in overlying units.

The relatively immature micaceous sands were apparently derived from deep erosion of the piedmont which fed large deltas that prograded across the continental shelf at several points along the central eastern seaboard. There they overwhelmed the fringing reef/carbonate bank and spilled their loads into the deep sea. Coeval deltaic or fan deposits within the circum-North Atlantic (for example, Wealden beds of England or DSDP Site 370/416 off Morocco) suggest either that eustatic sea levels were not rising appreciably (as is generally believed) or that there was synchronous or coincidental uplift and drainage diversion in these various areas.

WOODRUFF, C. M., JR., Consulting Geologist, Austin, TX

Geothermal Gradients of Texas—A New Look

The heat flow equation shows that geothermal gradient varies directly with conductive heat flow and inversely with thermal conductivity. Because of the second of these functions, geothermal gradient values have limited validity wherever bottom-hole temperature (BHT) readings are reduced without regard for ambient rock type. Thus, I present a geothermal gradient map of Texas using new data from selected geologic formations of generally uniform rock type. Four carbonate rock units provide the data base for most of the state inland of the Lower Cretaceous shelf edge. These include, for the inner Gulf Coast Basin region, the Jurassic Smackover Formation and the Cretaceous Sligo and Edwards Formations. For most of the remainder of the state west of the Balcones/Ouachita trend, data were obtained for the Ordovician Ellenburger Group. Coastward of the Cretaceous shelf edge, data from the 1976 AAPG and U. S. Geol. Survey map were employed owing to the paucity of carbonate-rock horizons at reasonable depths there.

Despite this selective use of BHT data, the geothermal gradient contours do not necessarily represent areal variations in heat flow. Since all the horizons charted are petroleum reservoirs (and in their updip reaches, some are also aquifers), hydrodynamics also must be involved. High gradient anomalies may thus be due to upwelling of basinal waters; low anomalies may be a result of recharge. Hydrodynamic influences also provide a local means for delimiting structures, with uplifts commonly being the loci of upwelling and thus registering relatively high geothermal gradients. High anomalies are even more consistently correlated with fault zones, as seen along the Luling-Mexia trend in south-central Texas where there is an overlap of gradient highs among the three horizons contoured.

WORK, PHILLIP L., GTS Corp., Houston, TX

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Some exploration philosophies dictate "If it's not new—it's not good" when referring to seismic exploration data. Costs for new data acquisition have skyrocketed. With oil demand down, less money is available for exploration. Prudent exploration management judgment must now consider and use a variety of data sources. Existing seismic data (conventional or 100%) is a viable alternative. Ninety-five percent of exploration is for shallow, small structures. Conventional data is very effective at depths less than 15,000 ft (4,600 m), and its tight data grid allows for detailed exploration. Systems are in operation to enhance the 100% conventional data using modern computer technology. Data recorded in the early 1940s when enhanced by today's state-of-the-art technology, is comparable in many cases to recently acquired data costing as much as 100 times more; in some cases, the results are better. Considerable time, effort, and expense have gone into the acquisition of this mass of valid exploration data. It cannot replace modern CDP data in some areas, but it can complement many exploration activities while stretching exploration dollars.

WRIGHT, ROBYN, Univ. New Mexico, Albuquerque, NM

Cyclic Sedimentation Within Point Lookout Formation (Upper Cretaceous)—A Model for Strandline Progradation and Sandstone Distribution

The regressive marine Point Lookout Sandstone in the southeastern San Juan basin, New Mexico, was deposited under conditions of relatively low wave energy, moderate tidal strength, and locally moderate fluvial input. Two idealized coarsening-upward vertical profiles characterize the preserved lithologic record. The first profile, documenting strike-aligned sandstones dominated by wave processes, is composed of the upward progression: offshore mudstone—offshore transition mudstone to sandstone—lower shoreface sandstone—upper shoreface sandstone—estuarine sandstone. The second vertical profile, reflecting local fluvial input and dip-aligned sandstone bodies, is typified by the upward progression: offshore mudstone—offshore transition (prodelta) mudstone to sandstone—delta-front sandstone—estuarine and tidal distributary sandstone. In both profiles, subaerial beachface and shallowest marine lithofacies are rarely preserved due to erosion and replacement by estuarine sandstones during seaward strandline migration.

Basinwide regression of the Point Lookout formation consists of numerous small-scale asymmetric transgressive-regressive cycles. Mappable erosive and/or non-depositional surfaces characterize transgressive events which separate genetically equivalent progradational sandstones. Duration of these small-order cycles is broadly estimated in the range of 10^4 years, probably at less than 50,000 years each. Cycle geometry is dependent upon the interplay of sedimentation rate and submergence, such that sedimentation rate controls the down-dip progradational sandstone width, and submergence influences the total cycle thickness. Because differences in thickness within the overall Point Lookout formation result from variability in cycle overlap (stacking), an understanding of cycle geometry allows prediction of local stratigraphic pinchouts which may serve as stratigraphic traps for hydrocarbons.

YANCEY, THOMAS E., and NOEL L. KENNEDY, Texas A&M Univ., College Station, TX

Relative Depth Position of Fusulinids and Ammonoids in Late Pennsylvanian Regressive Sequences in North Texas

Fusulinid foraminifers and ammonoid cephalopods occur in mutually exclusive positions in the regressive portions of Late Pennsylvanian cycles exposed on the eastern shelf of the Midland basin in north Texas. Ammonoids occur consistently in deeper water parts of the cycles than fusulinids do, and are common in phosphate nodule-bearing dark shales that occur immediately over transgressive limestones. Their abundance rapidly decreases upward in the overlying gray shales of the regressive sequence. Fusulinids are absent from ammonoid-rich dark shales, and first appear in overlying gray shales where ammonoids are rare and of small size. Fusulinids found in these strata are small juveniles, and not transported. Full-size fusulinids occur in overlying gray shales containing high diversity biotas. Concentrations of unabraded fusulinids occur in shales located at the margins of limestones and sand sheets in the mid portions of the regressive sequences, and are formed by current winnowing of mud or accumulation in areas of reduced sedimentation. Fusulinids are rare in unequivocal shoal-water deposits, occurring mostly as transported, worn, and fragmented individuals in sandstones capping regressive sequences. These occurrences suggest that fusulinids are indicators of moderate depth, mid-shelf environments in Late Pennsylvanian north Texas sequences, while ammonoids are indicators of deeper water environments. The lack of mature fusulinids in deeper water deposits containing small juveniles lends support to the conclusion that fusulinids contained symbiotic microalgae, and were restricted in life occurrence to the photic zone.

YEAGER, JOHN G., John G. Yeager and Associates, Houston, TX

Significant Trends in the Downstream Sector

The characteristics of the downstream sector of the petroleum industry have changed significantly over the past decade. This paper describes the reduction in supplies of overseas equity crude available to integrated companies, decline in consumption of fuel products, changing configuration of United States refineries to use heavy and sour crude, disappearance of subsidies for small refiners in the United States, changing structure of the crude oil market and crude pricing mechanisms, and the growing importance of petroleum futures markets. The paper also discusses effects of these changes, particularly as they relate to demand for and pricing of domestic crude oil, and draws conclusions regarding the future paths these trends may take, resulting changes that may occur in this sector of the industry, and possible effects on the exploration and production sectors of the industry.

YOCUM, ERIC T., Texas Tech Univ., Lubbock, TX

Cyclic Sedimentation in Middle and Upper Holder (Upper Pennsylvanian) Formation, New Mexico

The Middle and Upper Holder Formation (Upper Pennsylvanian), Sacramento Mountains, New Mexico, comprises terrigenous and carbonate facies that accumulated on a narrow open-marine to restricted-marine shelf. Differential subsidence of the shelf combined with eustatic sea level changes caused cyclic deposition.

Deposition began with a varying supply of terrigenous sediments from shifting delta lobes. Several carbonate facies, lateral equivalents of the terrigenous strata, are distinguished on the basis of their allochemical constituents. Bioclastic wackestones to grainstones with cortoids and oncoids characterize open-marine intervals. Laminoid-fenestral mudstones and wackestones with oncoids were common in restricted-marine intervals. Fusulinids and algal and peloidal grainstones are common marginal-marine facies. Restricted-marine sediments were deposited after clastic influxes and during marine transgressions.

The division between the Middle and Upper Holder members can be placed beneath a channel conglomerate an unconformity that developed on a restricted platform. Deposition of predominantly restricted-marine sediments with erosional clastic influxes characterize the Upper Holder. The upward increase both in reworked and encrusted allochems might