State suggest a probable density-flow mechanism for the deposition of the sandstones which were subsequently modified to form HCS units.

A 150-m (500-ft) thick section of flat Ithaca sediments is well exposed in the Finger Lakes region where the formation can be traced for kilometers both parallel and normal to the paleoshoreline. This shallow marine sequence is composed largely of fine sandstones and mudstones deposited in an Upper Devonian epicontinental sea. Detailed examination of the sandstone beds at the base of the Ithaca Member reveals a marked transition over a distance of 40 km (25 mi) normal to the shoreline from a hummocky cross-stratified sequence within the more proximal facies to a sequence of interbedded sandstones and shales displaying turbidite features in the more distal western exposures. The section also indicates shallowing paleodepths upsection, with vertical sequences suggesting a progression of environments increasingly dominated by the encroaching shoreline of a regressing sea.

One explanation for the observed lateral transition of sedimentary features normal to paleoshoreline is that the hummocky cross-stratified beds and the turbidites were deposited concurrently. Subsequent reworking of the HCS unit by storm waves would account for its variant internal sedimentary features. This is in accord with the results presented in 1979 by Hamblin and Walker.

POLLASTRO, RICHARD M., and JEFFREY W. BADER, U.S. Geol. Survey, Denver, CO

Clay-Mineral Relationships in Some Low-Permeability Hydrocarbon Reservoirs and Their Use as Predictive Resource Tools

Detailed mineralogical characterizations, using X-ray diffraction and scanning electron microscopy of sand-shale and carbonate-shale-bentonite sequences, of some classic low permeability hydrocarbon reservoirs reveal basic clay-mineral relationships that are helpful in evaluating the extent of diagenesis and petroleum resource potential.

Gas-potential units of the El Paso Natural Gas 1 Wagon Wheel and BELCO 3-38 (formerly INEXCO 1-A WASP) wells, Green River basin, Wyoming, contain shales composed primarily of altered detrital clay suites of various origins and compositions that are consistently different than authigenic clays formed within adjacent sandstones. Commonly, discrete illite is abundant in the shales as a major detrital component; the percentage of illite is lower in the sandstones. Chlorite typically comprises a high percentage of the clay-size ($<2\mu m$) material of sandstones and is primarily authigenic, however, little chlorite ($<8\%$) is inherent in the shales. Authigenic interstratified illite-smectite (I/S) formed in relatively clean sandstones is typically less illitic and more restricted in composition range than I/S clay of various origins within shales or shale-laminated sandstones.

Therefore, because of these primary differences in clay mineral assemblages between sandstones and shales from these units, log interpretations of low permeability sand reservoirs should not be extrapolated from the log response of adjacent shales. The composition of I/S clay from relatively cleaner sands also may give a better indication of diagenetic "minimums."

Indigenous gas and oil are produced from low-permeability chalk beds of the Upper Cretaceous Niobrara Formation within the Denver basin of eastern Colorado and western Kansas. Clay-mineral studies of I/S clay in insoluble residues of shaly chalk sampled throughout the basin show that the starting composition of the I/S clay in these strata is highly variable due to a complex mixing of I/S clays from many different sources at the time of deposition. However, the composition of I/S clay from thin bentonites in these strata is quite consistent throughout a section from any one specific location and/or depth, and these clays become progressively more illitic and ordered with increasing temperature due to increased burial. At approximately 60% illite layers in I/S, the I/S of bentonites proceed from random (R = 0) to short-range ordered (R = 1) interstratification. I/S clay formed in thin, discrete bentonite beds within Niobrara strata, where original starting compositions were nearly fixed and uniform and there was little or no contribution from detrital clays, is the best indicator of the extent of diagenetic reactions. The presence (or absence) of regular interstratified clay minerals in thin bentonite beds of the Niobrara can, therefore, be used as relative geothermometers for constructing predictable petroleum resource maturation maps of the Denver basin and adjacent areas.

POPPER, GEORGE H. P., U.S. Bur. Mines, Pittsburgh, PA, and THOMAS A. BAILLIEUL*, U.S. Dept. Energy, Columbus, OH

Patterns of Uranium Mineralization in Reading Prong

Recent studies of uranium occurrences in the Precambrian crystalline terrain of the Reading Prong show a definite correlation between the presence of uranium and late stage magmatic activity during the Grenville orogeny. All uranium concentrations examined show a close spatial association with catazonally emplaced granitic, alaskitic, or pegmatitic rock of anatectic origin. Published age dates indicate that uranium concentrations developed during the period 975 to 950 m.y. The ultimate source of the uranium is a granitic magma formed by partial melting of the metasediments in the root zones of the Reading Prong. Emplacement of granitic layers into a variable metamorphic sequence has resulted in different types of uranium occurrences. (1) Anatectic granite association: granitic stocks and sheets intruded into the metasedimentary section near the zone of anatexis may show internal enrichments of uranium. (2) Magnetite association: magnetite ore bodies provide locally reducing conditions ("oxygen-sink") to precipitate uranium released from nearby intrusions. (3) Metasedimentary contact association: granitic intrusion into a lower pressure zone in a metasedimentary sequence may result in release and concentration of uranium from a fluid phase along the intrusive contact. (4) Skarn association: similar to type 3, uranium concentrations may develop where uraniferous granites intrude a calc-silicate assemblage. (5) Massive sulfide assemblage: uranium concentrations can develop in the reducing environment where a granitic magma intrudes or abuts a massive sulfide body.

PREZBINDOWSKI, DENNIS, Amoco Production Co., Tulsa, OK

Burial Cementation—Is It Important? A Case Study—Stuart City Trend, South-Central Texas

The Stuart City trend is a shelf-edge buildup of Lower Cretaceous bioclastic and reefal carbonates that is currently buried to depths of between 3,300 and 5,000 m (11,000 and 16,000 ft). Compaction and cementation have generally reduced rock porosities to less than 9%. Sediments were cemented in the marine environment by finely crystalline bladed, isopachous cement and volumetrically important (14 volume %) coarse to very coarsely crystalline, fibrous to bladed, isopachous, Mg-calcite cement. These cements have been neomorphically altered

to low Mg-calcites forming an unusual radiaxial texture observed in the coarse to very coarsely crystalline, bladed, calcite cement. Evidence of their marine origin consists of a relative 1 mole % Mg^{++} memory, a marine-like isotopic character ($\delta^{18}O \approx -2.5$ and $\delta^{13}C \approx +2.0$), and early relative timing of precipitation. Diagenetic alteration of these carbonate sediments by the interaction with meteoric water in lenses that formed within topographic highs along the shelf margin changed the initial marine chemical, isotopic, and textural character of the sediments. Secondary porosity formation, mineral stabilization, aggrading neomorphism, and equant spar calcite cementation are the important products of meteoric diagenesis. The equant spar calcite cements make up approximately 16% by volume of the limestones studied. They are iron and manganese poor. The majority have a $\delta^{13}C$ composition which falls in the range of modern marine carbonates, i.e., 0.9 to +3.5‰. The $\delta^{18}O$ compositions range from −1.3 to −6.6‰ relative to the PDB standard. Oxygen stable isotopic and petrographic data suggest that over 50% of the equant spar calcite cements were formed in a near-surface meteoric environment. A large percentage of the remaining equant spar calcite cements formed at shallow burial depths in a water-limited system where mass transfer was dominated by diffusional processes. Thermally induced $\delta^{18}O$ depletion of the equant spar calcites, indicating significant fluid flow, was of minimal importance. Pyrobitumen pore fillings and inclusions in the outer 1.0 mm-thick rims of the very coarsely crystalline, equant spar calcite cements indicate that only minor amounts of cementation have occurred since the introduction of hydrocarbons. Deep burial diagenesis (i.e., post-hydrocarbon migration) consisted of the precipitation of minor amounts of galena, fluorite, and Sr^{++}-rich equant spar calcites. These diagenetic products can be directly related to the present-day formation water.

The chemical, isotopic, and textural characteristics of the Stuart City trend limestones contain the imprints of their initial marine composition and shallow diagenetic alterations in a hydrodynamic system. Burial diagenesis has not significantly altered these limestones. Fault and fracture control on the movement of formation waters in this system determine the location and intensity of late stage diagenetic events.

RABINOWITZ, P. D., Texas A&M Univ., College Station, TX, and J. I. EWING, Gulf Research and Development Co., Pearl River, NY

Ocean Margin Drilling Project Data Synthesis off Eastern North America: 34° to 41° N Latitude

An atlas of geological and geophysical maps has been compiled for the east coast of the North American continent covering an area from well onshore to the ocean crust, and from 34° to 41°N as part of the Ocean Margin Drilling Project.

Included in the atlas are maps of the depth to continental and oceanic basement, depth to the top of Lower and Middle Jurassic (reflectors J_M/J_3 and J_S/J_2), to the top of Jurassic (reflectors J/J_1), to the top of Neocomian (reflector Beta), to the top of Cretaceous (reflector A*), to the top of Paleogene (reflector A_u), and to the top of lower Miocene (reflector X). Isopach maps between these reflectors and between them and the sea floor are also included. Contours are two-way traveltime with a contour interval of 0.25 to 1 sec.

The atlas also contains a tectonic map of basement, a pre-Quaternary geologic map, and lithofacies maps for six time slices.

There are geophysical maps of magnetic and gravity anomalies and compressional wave velocities in sediments and basement.

RABINOWITZ, PHILIP D., Texas A&M Univ., College Station, TX, and Lamont-Doherty Geol. Observatory, Palisades, NY, DENNIS E. HAYES, Lamont-Doherty Geol. Observatory, Palisades, NY, and KARL HINZ, Bundensanstalt für Geowissenschaften und Rohstoffe, Hannover, Federal Republic of Germany

A Synthesis of Marine Geological/Geophysical Data for Ocean Margin Drilling on Continental Margin of Morocco

The continental margin of Morocco represents the conjugate segment to the North American margin south of Nova Scotia. The total sedimentary cover in the continental margin province is considerably thinner off Morocco than it is off the east coast of North America. Further, selected portions of the Morocco continental margin have undergone major tectonics, either exposing or bringing near the surface older elements of the stratigraphic section. Thus, scientific objectives requiring sampling of the earliest drift phase sediments, the oldest oceanic crust, and the basement rocks in the ocean-continental transition zone can be more easily addressed off Morocco than off North America.

We have recently compiled a synthesis of marine geological/geophysical data for the offshore regions bordering the continental margin of Morocco. The synthesis was undertaken in order to evaluate future scientific deep-sea drill sites. The final product of the synthesis is a set of maps on Mercator projection for the area 29° to 35°N, 5° to 22°W. The maps include: bathymetry contours, free-air gravity anomaly contours, total intensity magnetic anomalies plotted normal to the ship's tracks, seismic velocity crustal structure, reflection time to basement, blue reflector (upper Jurassic) and red reflector (upper Cretaceous), isopach (in seconds of two-way reflection time) of sea floor to basement, sea floor to blue reflector, sea floor to red reflector, and blue reflector to red reflector, locations of surface sediment samples, hazards, and tectonics. In addition, seismic crustal sections from the nearshore across the disturbed piercement structure province to the deep ocean floor have been compiled.

Our synthesis reveals that the continental margin of Morocco consists of several unique segments. A dominant structural unit is the NNE-SSW-trending zone of salt diapirs and piercement structures observed on the continental shelf and slope. The salt is presumed to be of Late Triassic to Early Jurassic age. A prominent magnetic anomaly which may represent a magnetic edge effect anomaly can be traced along most of the western boundary of the Moroccan diapiric zone. On the conjugate continental margin south of Nova Scotia, a diapir zone is also observed. The seaward edges of the Moroccan and eastern North American diapiric zones match very well in pre-drift reconstructions, thus suggesting that before the separation of the African and North American plates a single evaporite basin existed. The magnetic and seismic data suggest that the seaward boundaries of the piercement fields mark the likely boundary between oceanic and continental basement.

The westernmost portion of the synthesis area is characterized by the well-defined Mesozoic sequence of magnetic anomalies from M0 (≅ 108 m.y.B.P.) to M25 (≅ 152 m.y.B.P.). These anomalies are situated on seismically observed oceanic crust formed by sea-floor-spreading processes. Between the seaward edge of the diapiric zone and magnetic anomaly M25 we observe a broad structural arch beneath which our single-channel seismic records in general fail to resolve the underlying basement. This is the region of the Jurassic magnetic quiet zone.