LAULE, SUSAN WUNDERLICH, Amoco Production Co., Denver, CO

Tectonics and Sedimentation Along Antler Orogenic Belt of Central Nevada

The Antler orogenic belt of central Nevada is a zone of tectonic activity which profoundly affected sedimentation patterns during the late Paleozoic. Lower Paleozoic through Middle Devonian strata indicate deposition in miogeosynclinal to eugeosynclinal environments with deposition of carbonate rocks on the east and shale, chert, and volcanic rocks on the west. In Late Devonian time, the depositional sequence was interrupted by eastward thrusting of the Roberts Mountains system which carried siliceous eugeosynclinal sediments onto miogeosynclinal carbonate rocks in the Antler belt. Debris eroded and transported eastward from this thrust system overwhelmed carbonate deposition during latest Devonian and earliest Mississippian time. Early Mississippian through Early Pennsylvanian tectonism with a strong vertical component provided a source terrane which again shed coarse to fine detritus eastward. These synorogenic sediments are herein interpreted as having been deposited in a shallow-marine and marginal-marine environment although carbonate rocks were at times deposited. This interpretation differs significantly from others that interpret the rocks as deep-water flysch deposits. As tectonism slowed, carbonate deposition recurred in central Nevada and the Antler belt was overlapped by Lower Permian sediments. With the overlap, shelf-to-basin sedimentation similar to that of the early Paleozoic was resumed. Antler tectonism is thus interpreted as having interrupted a well-established depositional system which persisted in a fragmentary manner throughout the time of deformation, and which finally was reestablished across the deformed zone.

LAW, B. E., C. W. SPENCER, and N. H. BOSTICK, U.S. Geol. Survey, Denver, CO.

Evaluation of Organic Matter and Subsurface Temperature and Pressure with Regard to Gas Generation in Low-Permeability Upper Cretaceous and Lower Tertiary Sandstones in Pacific Creek Area, Sublette County, Wyoming

Investigations of Upper Cretaceous and lower Tertiary rocks in the Pacific Creek area of the northeastern Green River basin show that studies of organic matter content, type, maturity, subsurface temperature, and reservoir pressure will help define prospective gas-saturated intervals and delineate areas of maximum gas-resource potential not included in previous U.S. Geological Survey resource estimates.

The onset of overpressuring occurs at about 11,600 ft (3,500 m), near the base of the Upper Cretaceous Lance Formation. Drill-stem test data indicate that at about 12,800 ft (3,900 m) the pressure gradient is as high as 0.84 psi/ft (19.0 kPa/m). Current data indicate that the active generation of large amounts of wet gas is important to the development of this overpressuring. A reversal of the spontaneous potential curve is nearly coincident with the top of overpressuring and is probably caused by a reduction of formation-water salinity. Very small amounts of water produced during thermochemical decomposition of organic matter and the dehydration of clays may provide enough low-salinity water to dilute effectively the original formation water, so that the resistivity of the formation water (Rw) is greater than that of the mud filtrate (Rmf).

Humic-type kerogen dominates the organic matter. Total organic carbon contents range from 0.25 to 7.84 wt. %, averaging 1%. The top of overpressuring and beginning of important wet-gas generation occur at vitrinite reflectance values of 0.76 to 0.84 and color alteration values of about 2.8 on a scale of 1 to 5. The present minimum temperature at the top of overpressuring is 190°F (88°C; determined from uncorrected bottom-hole temperatures). The preservation of abnormally high pressures is probably due to presently active generation of gas in a thick interval of discontinuous, very low-permeability shales, siltstones, and sandstones.

The U.S. Geological Survey is studying gas-bearing intervals in the very few wildcat penetrations of deep tight sandstone intervals in Rocky Mountain basins to better define a possible major gas resource.

LEDGER, ERNEST B., and THOMAS T. TIEH, Texas A&M Univ., College Station, TX

Opal-Cristobalite-Cemented Sands in Catahoula Formation—Implications on Source of Silica Cementation of Quartzose Sandstones

Channel sands and sand lenses in the Catahoula Formation, an Oligocene-Miocene fluvial unit of the Gulf Coast, are in places cemented by an opaline material. Petrographic, X-ray diffraction, and electron microscopy studies indicate that the cement (1) shows poorly developed banding of varying birefringence (or degree of crystallinity); (2) has shrinkage cracks apparently resulting from ordering and dehydration; and (3) consists of opal and crypto- to micro-crystalline cristobalite which occurs as lephispheres about 2 μm in diameter. The cement developes in sands that are encased in tuffaceous silty mudstones. The development is apparently restricted to outcrops and near-surface zones of high permeability and appears to be pedogenic in origin.

Pervasive alteration of the rhyolitic tuffaceous mudstones to clay minerals gives rise to excessive free silica, which is carried by groundwater to the permeable sandy zones. The silica was initially precipitated in sand interstices as a silica gel. Subsequent dehydration and ordering produces the opal-cristobalite observed. Further cystallization of opal-cristobalite during burial diagenesis may result in chalcedony or quartz cements.

Calculations show that for a rhyolite ash to alter completely to 2:1 layer clay minerals (smectites), as much as 35 wt. % of the ash may be released as hydrogen silicate. This suggests that ash beds are significant sources of silica cement in sandstones.

LEGALL, FRANKLYN D., and CHRISTOPHER R BARNES, Univ. Waterloo, Ontario

Application of Conodont and Palynomorph Color Alteration Studies to Thermal Maturation History, Southern Ontario

Micropaleontologic studies were undertaken to establish the burial temperature of the Paleozoic sedimentary sequence in southern Ontario through investigation of color alteration of conodonts and palynomorphs. Over 500 samples were used from surface localities and several hundred from 20 wells that penetrated various units of Ordovician, Silurian, and Devonian age in the subsurface.

The results showed the existence of at least two thermal alteration zones defined along the surface and in the subsurface. The first identifiable thermal alteration zone extends from the top of the Paleozoic sedimentary sequence to depths coinciding with the base of the Silurian and possibly extending into uppermost Ordovician strata. In this zone, the conodont alteration index (CAI) is 1.5 and reflects a burial temperature of 50 to 90°C. The second zone includes the remainder of the Ordovician section in southwestern Ontario and part of the Ottawa Valley in eastern Ontario. The CAI values for this zone lie in range 2 to 2.5 and suggest burial temperatures of about 60 to 140°C.

Superimposed on this broad scale thermal alteration pattern that reflects burial depth, are several areas with higher alteration indices of 2.5 to 3 in the Ottawa Valley. These are interpreted as being the result of unusually high heat flow occurring after the main burial phase of alteration and probably related to Cretaceous rifting that produced the Ottawa-Bonnechere graben.

Study of palynomorphs (acritarchs) shows a change in color from light yellow to dark yellow in the first zone and to brown in the second zone. These paleontologic studies of thermal maturation are being integrated with studies of the isotopic composition of natural gases (by J. F. Barker and P. Fritz, Univ. Waterloo) and of the organic geochemistry of the oils (by T. G. Powell, Geol. Survey Canada) for southwestern Ontario hydrocarbon deposits.

LEHMANN, PATRICK J., Exxon Production Research Co., Houston, TX

Porosity Evolution of Niagaran Pipe Creek Jr. Reef, Grant County, Indiana

Tarry residues within porous zones in the upper 15 m of the erosionally truncated Pipe Creek Jr. reef attest to it being a fossil oil reservoir. The radially arranged, steeply dipping (25 to 40°) flank beds of this large (1.4 km diameter) limestone buildup are composed of crinoidal grainstone, packstone, and wackestone with minor stromatoporoid and coral boundstone. Interparticle, intraparticle and shelter pores of all sizes accounted for depositional porosity of 60 to 80%. Syndepositional submarine and marine phreatic cementation, including palisade and monocrystalline syntaxial overgrowth-cements, reduced depositional porosities to 5% or less. The abundance of hardgrounds, isopachous palisade-cemented grainstones, and lithoclasts indicate the syndepositional genesis of these cements. Syndepositional and younger fractures, some extending at least 215 m laterally, cut through the tightly cemented reef. Sedimentary dikes resulted as these fractures were filled with syndepositional reef sediment and later with Devonian quartzarenites. The tightly cemented dikes form permeability barriers that may inhibit lateral fluid flow altering reservoir quality. Dolomite selectively replaced the finer sediment and partly replaced many skeletal grains in zones within the reef-interreef transition and along the present unconformity. Leaching of the remaining calcite in dolomitized skeletal grains produced localized porous zones (up to 15%). Meteoric phreatic sparry calcite cementation further reduced reef porosity to under 2%. Further quarrying of this beautifully preserved limestone reef will insure its value to geologists studying reef facies, diagenesis, and porosity evolution for many decades.

LEKAS, MITCHELL A., Geokinetics Inc., Concord, CA

Lofreco Process—Tailoring Shale Oil Extraction Method to Available Geology

Geokinetics Inc., in cooperation with the Department of Energy, is developing an in-situ process for extraction of shale oil from shallow deposits of oil shale. The oil shale is fragmented by explosives emplaced in surface drill holes. The fragmented zone constitutes the in-situ retort. The fragmented zone is ignited and the generated heat releases the shale oil which drains to the bottom of the retort and flows along the sloping bottom to the oil production wells.

The Mahogany oil shale zone at this location is 30-ft (9 m) thick and averages 23 gal/ton. The beds strike east-west and dip to the north at 120 ft/mi (36.6 m/km). Groundwater in the oil shale zone is very limited. Field work was initiated in April 1975 at a test site 70 mi (113 km) south of Vernal, Utah, and has continued without interruption to date. Twenty-four test retorts have been blasted and 15 retorts have been burned. By June 1982 the R & D phase will be completed, and construction of a commercial plant will begin.

LEVEY, R. A., J. C. HORNE, J. K. BALSLEY, et al, Univ. South Carolina, Columbia, SC

Wave-Dominated Deltas—Important Economic Depositional Setting in Upper Cretaceous of Western Interior

In the western interior basin, wave-dominated, deltaic deposits provide an important economic model for exploration of oil and gas and thick, laterally extensive economic coals. Recent studies in the Upper Cretaceous Mesaverde Group (Rock Springs Formation of southwestern Wyoming and Blackhawk Formation of eastern Utah) provide insight to the characteristics of wave-dominated, deltaic environments. Widespread, delta-front, sheet sandstones provide significant reservoirs for oil and gas and a platform upon which thick laterally continuous coals can develop.

Wave-dominated deltas are characterized by thick, prodelta deposits composed of graded, bedded siltstones and mudstones. Capping the prodelta deposits are distributary-mouth, bar sandstones at the mouth of distributary channels. In the interchannel areas, delta-front, sheet sandstones accumulate owing to high wave energy. They are laterally continuous along depositional strike as well as dip. Coeval, distributary channels tend