equilibrium vapor pressure, and for durations of days to months. Solution compositions were varied to examine the effects of ionic strength, Mg^{2+}/Ca^{2+} ratio, and SO_4^{2-} concentration on the direction and/or rate of reaction. The starting solid for these experiments was a stoichiometric and well-ordered synthetic dolomite; several experiments were also seeded with solid reagent-grade calcium carbonate (calcite).

In pure $CaCl_2$ solution (0.1 M) replacement was complete in less than one week at temperatures of 100° C (212° F) and greater. Replacement was minor after several weeks at 50° C (122° F). Longer term experiments at 50° are still underway. A series of experiments established that dedolomitization only occurs at Mg^{2+}/Ca^{2+} ratios of less than 1/10 (total ionic strength = 0.1) at all temperatures from 100° to 200° C (212° to 392° F). Because this reaction proceeds far faster than the reverse reaction (dolomitization), we believe this result establishes the most precise calcite/dolomite phase boundary to date. The presence of SO_4^{2-} was found to strongly inhibit the dedolomitization reaction, even at concentrations far less than in seawater. Seeding the reaction with a small amount of calcite had little effect on the rate of reaction, suggesting that nucleation is not rate-limiting in dedolomitization. Finally, increasing ionic strength from 0.01 up to 0.5 increased the rate of reaction.

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Diagenetic Evolution of a Silurian Limestone Reef: Geochemical Documentation of Mixed-Water Dolomitization

Examination of a partially dolomitized Silurian platform reef (Pipe Creek Jr.) indicates that the timing of dolomitization is tightly constrained within the calcite diagenetic sequence. Cathodoluminescence and isotopic analysis of calcite diagenetic components define the diagenetic environment and fluid chemistries at the time of dolomitization.

Abundant syntaxial and fibrous calcite marine cements suggest synsedimentary lithication of the reef complex. Multiple episodes of subaerial exposure are recorded both in the petrologic fabric as well as in the geochemical signatures of altered marine components and equant calcite cements. In the upper reef, marine components are corroded, and resulting porosity is partially infilled by red geopetal vadose silts. Resubmergence and continued marine cementation establishes a Silurian timing for this initial episode of exposure.

Evidence for subsequent exposure is contained in the isotopic and cathodoluminescent patterns of later marine cements and overlying equant calcite spars. Marine cement isotopic compositions deviate from an initial marine composition (-4.0 ‰ $\delta^{18}O$; + 2.0 ‰ $\delta^{13}C$ PDB) along covariant trends that reflect alteration by diagenetic pore waters. Equant calcite cements are restricted to the upper reef and partially occlude primary porosity. These cements exhibit invariant oxygen compositions between -7.0 to -8.0‰ and variable carbon which shows progressive depletion toward the upper reef. On this basis we interpret these cements as having formed within a shallow meteoric phreatic lens with light carbon derived from soil-gas CO_2 at the exposure surface. Cathodoluminescent patterns and sulfide mineralization indicate progressive reduction of pore waters in the meteoric lens. The latest stage of phreatic cementation records anaerobic fermentation during which the oxygen composition remains unchanged with carbon varying up to + 7.0 ‰ following precipitation of pyrite.

Dolomitization occurs within this sequence of meteoric phreatic diagenesis. Early zoned meteoric spars, reflecting initial fluctuations in reducing conditions, are corrosively overlain by dolomite. The earliest formed dolomite is luminescent, signifying reduction of manganese, and is overlain by an outer ferroan dolomite. A progressive increase in reducing conditions is further indicated by the reduction of sulfate and concomitant precipitation of pyrite. The heavy carbon equant calcites, which postdate pyrite, suggest anaerobic fermentation during the final stages of phreatic cementation.

Because dolomitization is bracketed by events of meteoric phreatic cementation and diagenesis, and its chemical evolution mimics the progressive reduction of the pore-water system, we suggest a mechanism of meteoric-marine water mixing to account for partial dolomitization of the Pipe Creek Jr. reef. This does not, however, imply a similar mechanism for the pervasive dolomitization of adjacent shelf reefs. Rather, this study emphasizes the complex early diagenetic history of shelf sequences with implications for late Silurian sea level fluctuations.

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A Community Model for Coalbed Methane Utilization

The University of Alabama at Tuscaloosa provides a model for community utilization of coalbed methane and energy independence. A feasibility study for coalbed methane development has been completed through a grant from the U. S. Department of Energy. The total resource available beneath the 760-acre (310-ha.) campus is estimated to be nearly 10 bcf. The Mary Lee Coal Group alone contains more than 3.4 mcf of gas, assuming 75% recovery.

As a result of an economic analysis, two exploration/research wells have been completed to depths of 2,289 and 2,760 ft (698 and 841 m) respectively.

The university is currently in the process of unitizing with Bryce and Partlow Hospitals. The combined acreage is approximately 2,000 acres (800 ha.). It is anticipated that coalbed methane could meet the gas demands of all three facilities for many decades. The methane will be used for space heating, domestic hot water, and for compressed natural gas (CNG) to operate the university's vehicle fleet.

Recently the university, along with Southern Company Services, Kaneb Services, and the Gas Research Institute, has embarked on a demonstration project to evaluate the feasibility of using coalbed methane as a primary fuel source for a fuel-cell power plant. A 40-kW fuel cell will be utilized to provide both electricity and hot water for the student recreation building.

These coalbed methane utilization activities should provide planning information for communities located over coal lands to develop independent resources and provide long term energy alternatives.

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Tide-Dominated Delta Model for Coal-Bearing Wilcox Strata in South Texas

Coal-bearing Wilcox strata near Uvalde in south Texas are the deposits of a tide-dominated delta. The delta of the Klang and Langat Rivers, Malaysia, provides a modern analog for these strata. Five facies have been identified from a study of core and well logs: (1) lignite, (2) underclay, (3) interbedded sand and mud with lenticular, wavy, and flaser bedding, (4) ripple-laminated or cross-bedded sand, and (5) greenish, very strongly bioturbated sand. On the Klang-Langat delta, the modern equivalents of these facies are (1) peat formed in freshwater swamps, (2) root horizons developed beneath the peat (3) interbedded sand and mud deposited on tidal flats, (4) channel sands, and (5) shallow marine sand and mud.

Tidal flat deposits are the most abundant type of sediment on the Klang-Langat delta and in the coal-bearing Wilcox strata. The tidal flats of the modern delta are crossed by small tidal creeks and by larger tidal streams. The tidal channels are cut into tidal flat sediments and separate peat-forming areas. Channel sands in the Wilcox are cut into tidal flat deposits and form washouts in the lignite. Two types of channel-fill sand are present in the Wilcox, sands 5-15 ft (1.5-4.5 m) thick and sands more than 30 ft (9 m) thick. The thinner sands, deposits of small tidal creeks, have sharp, erosive bases, fine upward and pass into interbedded sand and mud. The thicker sands have sharp tops as well as sharp bases and show no grain-size trends; they are fills of larger tidal streams.

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Depositional Environments, Conodont Biostratigraphy, and Porosity Diagenesis of Montoya Group (Upper Ordovician), Sacramento Mountains, South-Central Mexico

Intensely dolomitized and siliceous marine carbonates comprise Upper Ordovician strata in the Sacramento Mountains, New Mexico. Pray subdivided these units into lower Montoya, upper Montoya, and Valmont formations. These strata are more appropriately designated the Montoya Group which includes 3 formations: Second Value, Aleman, and Cutter.

The subrounded, medium to coarse-grained sandstone rests disconformably on the Lower Ordovician El Paso Formation. This thin sand (Cable Canyon Member of the Second Value Formation) represents a transgression following Middle Ordovician erosion. The transition into the overlying Upham Member of the Second Value is gradational, but can be locally abrupt. The massive, finely crystalline dolostone was originally coral (tabulate and rugose forms) and crinoidal wackestone-packstone. Fossils are poorly preserved by chalcedony replacement. The transition from the relatively shallow-marine sediments into the deeper water strata of the Aleman Formation occurs over several meters. The very finely crystalline, cherty dolostone hosts rynchonellid and dalmanellid brachiopods and bryozoan colonies. Ribbon cherts developed around clusters of fossils. The Aleman changes sharply into chert-free, thin to medium-bedded Cutter. The argillaceous dolomicrite is nonfossiliferous except for conodonts, isolated brachiopods, and a *Favosites*-type coral horizon. Tidal channels, intraclasts, and cyclic bedding indicate peritidal deposition during Cutter deposition. Erosion preceded Fusselman (Silurian?) deposition.

Conodont faunas represent shallower conditions than the Montoya faunas of Sweet, but compare favorably for correlation. *Panderodus* and *Belodina* faunas characterize the shallow-marine Second Value Formation; deeper water *Plectodina* and *Phragmodus* characterize the Aleman; and very shallow-water *Rhipidognathus* characterizes the Cutter. Ages for the Second Value, Aleman, and Cutter Formations are late Eden-early Maysville, Maysville-early Richmond, and middle-late Richmond, respectively.

Dolomitization interrupted early silica replacement of shells, matrix, and sulfates. Mosaic dolomite and epitaxial rims on dolomite cement virtually destroyed all effective porosity.

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Depositional Environments and Oil Shale Genesis in Eocene Green River Formation: Retrospect and Prospect

Geologic studies of oil shale were pioneered by W. H. Bradley in 1929. His basic model for the genesis of oil shale called for a deep stratified lake in which anaerobic conditions in the hypolimnion ensured the preservation of organics and accounted for the finely laminated character of the oil shale. Until recently, studies involving the depositional environment and genesis of oil shale were based on the stratified lake model.

In 1973 Eugster and Surdam presented an alternate model (playa lake model) that accounted for the origin of oil shale in a shallow lake fringed by broad mud flats or playas. The playa lake model accounted for observed shallow-water sedimentary structures and evidence of a low topographic gradient. This abrupt change in basic concepts was not readily accepted by many workers. Views have polarized, primarily because of the variety of depositional conditions that existed in separate but geographically related basins of deposition.

This polarization will not be resolved until a more adequate and comprehensive model is developed. It must account for most of the pertinent observations, including preservation of organic matter, sedimentary structures, carbonate deposition and diagenesis, vertical and lateral facies relationships, and paleontology of the Green River Formation, all of which are critical to an understanding of oil shale genesis.

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Diagenetic Carbonate Concretions from Late Cretaceous Active Margin Slope Deposits, Southern California—Origin and Use in Paleoenvironmental Reconstruction

Fine-grained rocks of Late Cretaceous, West Coast, active margin strata have generally been ignored in paleoenvironmental analyses because of the highly fragmented and apparently homogeneous nature of outcrops. Recent studies on Holz Shale (Ladd Formation, Santa Ana Mountains) fine-grained slope strata have shown that diagenetic carbonate concretions which occur in this unit are useful for understanding primary sediment fabric and hence paleoenvironments. Usefulness of concretions to such paleoenvironmental studies can only be evaluated, however, after their diagenetic history is fully understood.

Holz Shale concretions most commonly occur as ellipsoids 0.05-1.5 m (0.2-5.0 ft) in diameter. Concretions generally consist of amorphous shale clay and quartz sediment cemented by calcite. Organic materials such as mollusk valves and terrestrial plant material commonly served as concretion nuclei. On the basis of this association with preserved organic materials and the abundance of pyrite preserved within concretions, it appears highly probable that decomposition of organic materials by sulphate-reducing bacteria was an important factor in the formation of these concretions. Lack of compaction of trace fossils within concretions, bending of strata around concretions, presence of septarian structures, and penecontemporaneous slumping of concretions in surrounding sediments indicate an early diagenetic origin where original sediment fabrics were preserved.

Many other Late Cretaceous, deep-marine, active margin, fine-grained strata on the West Coast contain similar concretions. If these concretions prove to have an early diagenetic origin like those in the Holz Shale, they may be the key to a better understanding of depositional mechanisms of these widespread deposits.

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Paleoenvironmental Analysis of Late Cretaceous Active Margin Continental Slope Deposits, Southern California

Extensive active margin, continental slope and upper fan deposits are not commonly preserved in the rock record. The Holz Shale (Ladd Formation, Black Star Canyon, Santa Ana Mountains) represents such a sequence where shale and mudstone strata are dissected by numerous coarse-grained channel-fill deposits. Channels preserve evidence of filling primarily by conglomerate debris flows, high-density turbidites, and classic Bouma low-density turbidites; slumping and traction-current mechanisms were less important. Associated with channels are submarine chutes, pebbly mudstones, and poorly developed levee facies. Interbedded turbidites, contourites, and hemipelagic sediments dominate interchannel strata. Hemipelagic sediments exhibit sedimentologic textures that range from biologically dominated (homogenous, bioturbated) to physically dominated (fine-scale, planar-laminated, anaerobic) fabrics. This variation in texture and associated diagenetic information indicates that the anaerobic/aerobic boundary was generally at some depth below the sediment-water interface, but at times migrated up into the overlying water column.

Foraminiferal assemblages within hemipelagic sediments are dominated by agglutinated forms which indicate deposition at bathyal depths. Macroinvertebrates include (1) the interchannel paleocommunity, dominated by the bivalve *Inoceramus* and the deposit-feeding trace fossil *Chondrites*, and (2) the submarine channel paleocommunity, comprised mainly of the trace fossils *Thalassinoides* and *Ophiomorpha*.

Previous studies have demonstrated that these active margin environments included a narrow continental shelf. Abundance of terrestrial plant material, paucity of displaced shelf faunas, well-rounded conglomerate clasts, and the coarse-grained texture of these deposits suggest that one or more of the Holz Shale submarine channels was receiving sediment directly from terrestrial environments.

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Dedolomitization in Tectonic Veins and Stylolites: Evidence for Rapid Fluid Migration During Deformation

Jurassic through Tertiary thrust-belt deformation of the Mississippian Madison Group has introduced complex fracturing, stylolitization, and carbonate vein mineralization. Host rocks are dominantly dolostone and dolomitic limestone. Tectonic veins are mineralized first by dolomite and then by multiple calcite phases. Dolomite and some generations of calcite which line veins are highly luminescent, while host-rock dolomite is nonluminescent. Both vein-lining dolomite and host-rock dolomite have been corroded and replaced by subsequent generations of calcite mineralization. These textural relationships suggest that fluids associated with thrust-belt deformation were in part extraformational and had not equilibrated with host-rock dolomite.

Because thrust-belt deformation moved from west to east with time, the isotopic composition (^{18}O, ^{13}C) of vein and stylolite mineralization can be used to evaluate fluid migration during deformation. In three sections located along an east-west transect in the southern overthrust belt, calcite vein mineralization displays a wide range of isotopic compositions that are distinctly depleted relative to the host-rock composition. These