perature deposits. Present data do not preclude association of these suites with high-temperature or mechanically concentrated uranium deposits.

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Diagenesis in Volcanogenic Rocks of Great Valley Sequence, Northern California—Isotopic and Chemical Data

Diagenesis of volcanogenic sandstone and mudstone of the 8,500 m thick Great Valley sequence (Tithonian to Hauterivian) involved extensive mass transfer during burial in the outer-arc basin.

The clay mineral assemblage of mudstone is characterized by (1) disappearance of discrete smectite at a relative stratigraphic depth of 6,600 m, and (2) a gradational increase of illite/smectite with increasing stratigraphic depth over the lowermost 4,500 m of strata. $\delta^{18}O$ for illite/smectite changes with descending stratigraphic position from 21.9 to 15.5 ppm and is temperature dependent. Potassium and sodium enrichment and uniform aluminum composition in the clay-size fraction of the mudstone relative to the whole rock indicates that the dominant reaction was: smectite + potassium → illite/smectite + silica. Authigenic quartz with $\delta^{18}O \cong$ 21.6 ppm throughout the sequence indicates that this reaction is temperature triggered. Calcite derived from primary biogenic carbonate acquired $\delta^{18}O$ values from +0.2 to −10.5 ppm PDB during successive mobilizations as temperature increased with burial.

In sandstones, the sequence of mineral authigenesis is: (1) chlorite cutans ($\delta^{18}O$ = 13.2 to 13.9 ppm) around framework grains formed during shallow burial; (2a) precipitation of radiating pore-fill chlorite ($\delta^{18}O$ = 11.1 to 13.3 ppm) as iron and magnesium were released from mudstone by illitization of smectite at temperatures as low as 60°C, or (2b) precipitation of calcite ($\delta^{18}O$ = −4.2 to −10.8 ppm PDB) as calcium was released from nearby shales and albitized plagioclase; (3) late replacement of framework grains by chlorite ($\delta^{18}O$ = 6.5 to 13.0%) or by calcite ($\delta^{18}O$ = −8.3 to −12.7 ppm PDB) at more elevated temperatures.

Prehnite, laumontite, and quartz veins ($\delta^{18}O$ = 17.2 to 20.5 ppm) are found only in the most basal strata, and were derived from the ophiolitic basement. These phases do not imply zeolite-grade burial metamorphism of the basal sediment.

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Organic Facies of Mid-Cretaceous Black Shales in Deep North Atlantic

The mid-Cretaceous black shales of the deep North Atlantic consist of alternating layers of sediment rich in total organic carbon (TOC) that contain abundant amorphous types of organic matter, and sediment poor in TOC that contain mostly woody and coaly types of organic matter. The amorphous materials are derived mostly from marine organisms in the eastern North Atlantic off Africa, in the Caribbean, and on the Demarara Rise off Surinam, and from higher land plants in the western North Atlantic and off Europe. Marine amorphous material is important off Africa because this was an area of upwelling and highly productive surface water. Amorphous marine organic matter was deposited across the entire North Atlantic basin in the Cenomanian in response to an ocean-wide upwelling event connected with the opening of the equatorial Atlantic. The difference between the TOC-rich and background TOC layers reflects deposition of the former under reducing conditions, which allowed the preservation of labile amorphous materials of marine and terrestrial origin, and of the latter under oxidizing conditions, when all that was preserved was refractory organic material.

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Submarine Carbonate Cementation and Pisolith Growth in Silurian Reefs of Northern Indiana

Peloidal grainstone and pisolite fill crevices on the flanks of several Silurian reefs in northern Indiana, producing intersecting dikes and veins. Internal dike structures and cross-cutting show that the cycle of crevice formation, sediment trapping, and lithification was repeated several times during the life of the reefs. Significantly, where younger dikes cut across older dike material, their walls have sharp boundaries and matching wall structures, showing that each earlier crevice sediment became lithified before the next fracturing event occurred.

The grainstone clasts appear to have been mechanically swept into the crevices and initially lithified by the precipitation of sparry calcite cement around the grains. Most of the crevice fill now consists of calcite or dolomite pisoliths, however, some exhibit concentric structure, suggesting concretionary growth. Other pisoliths exhibit radial structure in which blades of cloudy calcite encroach on peloids and fossil fragments of the grainstones, suggesting growth by replacement. Petrographic evidence thus favors in-situ growth of the pisoliths, and suggests that lithification of the grainstone was completed by this process.

Evidence favoring vadose cementation of the grainstone, or favoring vadose origin of the pisoliths, is absent, and fresh-water phreatic cementation is considered unlikely. However, the repeated alternation of cementation events with marine reef sediment-producing conditions strongly suggests that initial grainstone cementation and pisolith growth occurred under shallow-water marine conditions.

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Diagenesis in Monterey Formation, Pismo Syncline, Coast Ranges of California

A predictive model of diagenesis, involving hydrocarbon migration, for the Monterey Formation in the Pismo syncline, Coast Ranges of California, includes (1) diagenetic history, (2) lithofacies relations, and (3) tectonic setting. The diagenetic reactions control mineralogy, mass transfer, and provide the hydrodynamics for hydrocarbon migration. Facies control the distribution of significant chemical components, including hydrocarbon sources. The tectonic setting controls fracture porosity, thermal gradients, and timing of hydrocarbon migration.

The important diagenetic reactions are interpreted on the basis of five phases: (1) silica, (2) carbonate, (3) clay, (4) organics, and (5) seawater. From the reactions characterizing these five phases, paragenetic sequences can be derived for each of the four solid components (opal, carbonate, clay, and organics) in the presence of seawater as temperature increases. Integration of paragenetic sequences results in an interpretive model of the diagenetic history of the Monterey Formation.

Three significant Monterey facies are: (1) sandstone-diatomite, (2) diatomite, and (3) carbonate-diatomite. The carbonate-diatomite facies in the Monterey has outstanding source rock potential; some of the mud and siltstone contain 18 wt. % organic carbon.

Hydrocarbons evolve when source rocks are buried to or below 6,500 ft (1,981 m). The hydrocarbon migration path is controlled by fracture porosity along active tectonic zones, particularly near fault systems at the margin of the fold (basin). The reaction, organic matter → hydrocarbons, provides pressure buildup and hydrocarbon expulsion, whereas the reactions, opal A → opal CT, and opal CT → quartz, provide the fluid drive for the hydrocarbon migration.

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Late Mesozoic to Early Cenozoic Foreland Sedimentation in Southwest Montana

Stratigraphic variations in the petrology of Upper Jurassic through lower Tertiary sandstones from southwest Montana, and inferred dispersal patterns and depositional environments, reflect the tectonic evolution of a foreland basin in response to gradually increasing orogenesis. Upper Jurassic to Lower Cretaceous (Aptian) chert-litharenites were largely derived from an older folded and faulted miogeoclinal prism of terrigenous and carbonate rocks farther west in Idaho. Volcanic and plutonic sources were negligible. Deposition was on a broad coastal plain extending east toward the craton. Subordinate admixtures of sediment containing low-rank metamorphic rock fragments derived from an intrabasinal reactivated Precambrian structure (Belt arch) and regionally extensive intercalated fresh to brackish-water limestones are unique characteristics of this retroarc sequence.

Marked upward increase in the quantity of locally derived plutonic and volcanic rock fragments in Blackleaf (Albian) and younger sandstones indicates the progressively more important role of nearby comagmatic sources. A transition in time from paralic sedimentation to dominantly alluvial sedimentation, was associated with the increase in igneous detritus. Dispersal patterns were complex because of local topographic barriers.

Early Tertiary sedimentation occurred in extensional fault-bounded basins in an intra-arc setting. Highly immature lithic sandstones and arkoses with a complex plutonic-volcanic-gneissoid provenance accumulated in a variety of high- and low-energy alluvial environments.

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Comparison of Gulf Coast Late Jurassic Ostracoda with Those of Western Europe

More than 30 genera of Ostracoda are represented in the Upper Jurassic rocks of the central Gulf region, United States. Most of these occur in the Schuler Formation, Dorcheat Member (Portlandian-Tithonian). About 12 of the genera are of European origin and, of these, several (e.g., *Nophrecythere, Galliaecytheridea*) began in earlier Late Jurassic or in Middle Jurassic of the European province. Emigration to the Gulf of Mexico region probably occurred around the northern margin of the opening Atlantic Ocean.

About 10 of the other Jurassic ostracode genera were endemic to the northern Gulf of Mexico or the western Atlantic. Most of these remained in those areas, some extending into the Cretaceous. Only a few Gulf forms, particularly *Hutsonia* and *Paraschuleridea* dispersed sparsely eastward to Europe. *Schuleridea,* which became abundant on both sides of the Atlantic, may have migrated eastward from the Gulf region in the Oxfordian or Kimmeridgian, as indicated from occurrences in offshore wells in the western Atlantic where it is associated with index foraminifera.

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State of the Art in Conodont Taxonomy

Two taxonomic schemes have been available to students of conodonts for more than 120 years. Until about 1970, most taxonomists opted for a "nuts-and-bolts" approach, or form-taxonomy, which emphasized similarities and differences in the morphology of discrete skeletal elements. Since the mid-1930s, however, it has been known that skeletal apparatuses of many conodonts included mineralized elements of more than one morphologic type. Beginning about 1964, clues to assembly of at least parts of multi-element apparatuses from collections of morphologically diverse discrete specimens came to be more systematically explored. In recent years with empirical reconstruction of a rather small number of skeletal-apparatus plans, and repeated confirmation of the general applicability of these in samples through much of the known range of conodonts, emphasis has shifted away from form-taxonomy to multi-element taxonomy. Major problems that remain include (1) standardization of descriptive and locational terminology for components of multi-element apparatuses, (2) resolution of nomenclatural problems that arise because multi-element affinities of numerous type specimens cannot be (or have not been) established, and (3) correction of errors introduced by application of multi-element models to collections in which they cannot be objectively justified. The advantage of