mineral assemblages, temperature, and fluid compositions. Volumes of fluid necessary to form 5 wt. % of kaolinite are presented as a function of $fCO_2$ and the above variables.

Formation of kaolinite can be related to hydrocarbon maturation. Decrease in O/C atomic ratios of different types of kerogen during maturation initiates the eventual release of oxygen as $CO_2$ into the pore fluids. Subsequent precipitation of kaolinite is thus an indicator of hydrocarbon maturation. To quantify this indicator, more research is needed to delineate the controls on the formation of $CO_2$ during maturation.

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Synsedimentary Tectonic Controls on Facies Evolution of Late Miocene Barrier Reef Complex: Upper Coralline Limestone, Maltese Islands

The central Mediterranean Maltese Islands constitute a local high on the Malta-Ragusa platform, a positive bathymetric feature extending northward to southeastern Sicily. Three main structures are recognizable within the islands and adjacent offshore areas: (1) a prominent north-south structural high through Malta which has been a positive feature since at least the Oligocene; (2) a northwest-southeast fault that has formed the western margin of the islands and controlled facies patterns since the late Miocene; and (3) east-west normal faults of post-Miocene age that form horst and graben structures in north Malta and south Gozo.

The upper Coralline Limestone was deposited in a shallow basin bounded to the east by north-south structure. Evolution of facies patterns with progressive shallowing started with open circulation and deposition of relatively condensed glauconitic grainstones and foraminiferal rudstone shoals. These shoals were then colonized and stabilized by a *Lithophyllum-Thalassia*? association, which on further shallowing was replaced by frame-building coralgal reef and associated facies, or high-energy oolitic and bioclastic grainstones. Terminal stages of deposition are represented by shallow intertidal/supratidal sediments, followed by complete subaerial uplift.

High-energy frame-built and grainstone facies are localized by the northwest-southeast fault. Restricted circulation and shoreline sediments initially formed close to the north-south structure. As basin filling continued, more open-circulation, higher energy facies extended eastward until finally, highest units of the formation are represented 15 km east of the north-south structure. This apparent eastward "transgression" concurrent with shallowing to the west can be explained in terms of regional hinging about the north-south structure. Rotation to the east would allow transgression eastward while simultaneously uplifting western areas.

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Isotope Geochemistry of Calcite and Clay Minerals in Volcanogenic Rocks, Great Valley Sequence, Northern California: Implications for Organic Diagenesis

Petrographic and isotopic data from an 8,500-m thick section of the Great Valley sequence indicate that widespread calcite cement in sandstones and mudstones was precipitated during at least two distinct stages that are linked to organic and clay-mineral diagenesis.

The range of $\delta^{13}C$ values for calcite in mudstone is $-11.6$ to $+1.0$ ppt PDB, in sandstones is $-9{,}7$ to $+4.5$ ppt PDB, and in veins is $-16.7$ to $-2.2$ ppt PDB. The $\delta^{13}C$ values are heavier in progressively older and, presumably, more deeply buried strata. A strong shift to heavier $^{13}C/^{12}C$ ratios of calcite in mudstones and sandstones corresponds with an abrupt 20 ppt shift to more enriched $\delta D$ values of OH-hydrogen in diagenetic smectite and a 10A clay-mineral from mudstones. Clay D/H ratios range between $-69$ to $-49$ ppt SMOW. The stratigraphic position of the shift corresponds to a modeled burial temperature estimate of about 80 to 100°C. This is interpreted to be the burial temperature for late-stage dehydration and conversion of smectite to a 10A clay-mineral phase.

Theoretical considerations indicate that a shallow burial phase of predominantly pore-filling calcite formed in association with bacterial production of methane ($<80°C$), or with migrated thermogenic gas. A second stage of calcite, found in deeper strata, and mostly of replacement origin, formed from deep formation waters ($>80°C$) that contained thermogenically produced low $C_2+$ gases. Release of dry gas at increasingly elevated temperatures was characterized by continuous $^{13}C$-enrichment in $CH_4$. Depleted calcite carbon in the most basal strata was derived from $CH_4$-rich basement fluids. Estimation of $\delta D$ values of formation waters indicates that $CH_4$-$H_2O$ equilibrium was not attained.

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Oceanographic Controls on Organic Matter in Miocene Monterey Formation, Offshore California

Analyses of the type and amount of organic matter in Tertiary through Quaternary sediments drilled during DSDP Leg 63, off the coast of California, can be used to provide insights into the controls of deposition of the Monterey Shale. The regional oceanography, rather than basin silling, controls the accumulation of organic matter in these sediments. The laminated, siliceous, and organic-rich Monterey Shales were deposited under anoxic conditions within a well-developed oxygen minimum zone like that in today's Gulf of California. The oxygen minimum zone became strongly developed in response to increased upwelling and productivity caused by global cooling following development of an Antarctic ice sheet 13 to 14 m.y. ago. A drop in sea level 10 to 11 m.y. ago lowered the base of the anoxic oxygen minimum zone to water 2,500 to 3,000 m deep permitting substantial accumulation of organic matter in the late Miocene and early Pliocene of the California borderland at DSDP Site 467. The base of the minimum stayed near this level until the Quaternary, then rose to 1,500 to 2,000 m, where it remains today. Phosphorite, indicative of a high rate of supply of nutrients, formed at the same time as the Monterey Shale, during the period of intensive upwelling from 13 to 14 m.y. into the Pliocene. A lessening of upwelling and supply of nutrients, and development of the oxygen minimum zone from the early Pliocene into the Quaternary, is implied by these data. The changes are associated with a warming trend and a rise in sea level.

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Diagenesis and Migration of Hydrocarbons in Monterey Formation, Pismo Syncline, California

Kerogen in the Miocene Monterey Formation in the Pismo syncline consists of amorphous material of algal orgin. Most of the rocks presently contain 1 to 5 wt. % total organic carbon. Thermal alteration index determinations and pyrolysis (thermal extract) data suggest that the organic material at the center of the fold is mature, whereas the organic material on the limbs of the fold is immature. The Monterey Formation in this region entered the liquid hydrocarbon window at a present day depth of approximately 1,700 m. The liquid window appears to be coincident with the opal-CT to quartz reaction ($80 \pm 10°C$).

Hydrocarbons were expelled from the Monterey rocks deep in the center of the fold and began migrating as a result of microfracturing. The hydrocarbons migrated up into the southwest limb of the fold through macrofractures. This limb of the fold is characterized by brittle dolomitic and opal-CT rich rocks that were intensely fractured prior to hydrocarbon migration. The potential reservoirs on this limb of the fold are in fractured Monterey. In contrast, on the northeast limb of the fold, Monterey rocks consist of silty and sandy siliceous rocks that tend to be more resistant to fracturing; hydrocarbons migrate up into this limb of the fold through relatively low angle faults and spread into structural traps along the fault in the adjacent Pliocene Pismo Formation through conjugate shears. The potential reservoirs on this limb are in structural traps in the Pismo Formation. A third potential hydrocarbon target is the basal sand in the Pismo Formation; almost everywhere in the fold this unit is highly bituminous.

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Sedimentologic Framework of Green River Formation, Wyoming

During deposition of the Green River Formation, ancient Lake Gosiute began as a freshwater lake, evolved to a saline, alkaline lake, and ended as a freshwater lake. This evolution reflects the change from a closed-basin to an open-basin hydrologic regime; as a result, sedimentation in the Lake Gosiute system was strongly influenced by the relation between evaporation and inflow of water into the basin. In the Green River Formation, stratification sequences, sedimentary structures, and mineralogy of lithofacies provide important insights into the evolution of the system and the competing factors that determined the type of sediment accumualated in the lake and fringing environments. Carbonate sedimentation was strongly influenced by lacustrine transgressions and regressions across a low topographic gradient. Terrigenous rocks reflect progradation of beach and deltaic shorelines during wetter climatic intervals when detritus that was produced and stored in upland areas during preceding drier intervals was transported to the lake.

Hydrochemistry of lake Gosiute during the deposition of the Wilkins Peak member was controlled by ground water discharge; during the deposition of the Tipton and Laney Members it was controlled largely by surface water. Calcite precipitated as a result of mixing calcium-rich inflow and saline-alkaline lake waters. Dolomite formed as a result of periodic flooding and drying of the playa fringe (carbonate mud flat), where carbonate muds were saturated with saline-alkaline lake waters and underwent evaporitive pumping. Some surface waters were preconcentrated by dissolution of efflorescent crusts in alluvial plain and mud-flat sediments. Trona and halite precipitated from brine pools as the lake shrank during periods of intense aridity. During himid periods the lake expanded and oil shale was deposited.

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Wave-Dominated Deltaic Sedimentation in Devonian Bokkeveld Basin of South Africa

In the Devonian Bokkeveld basin on the southwestern periphery of Gondwanaland, over 3,000 m of mudstones and sandstones were deposited as a southerly prograding clastic wedge. Five thick regressive sequences record processes on arcuate deltas along a mixed wave and tidal energy coastline. Variations among the upward-coarsening sequences are the result of differential preservation and transgressive reworking caused by uneven rates of relative sea level rise.

The base of each sequence is represented by dark shelf-prodelta shales which grade upward through mudstones to graywackes and lithic arenites of river-mouth bar facies. This upward-coarsening deltaic package is topped by tidal flat, shallow subtidal, and interdistributary bay deposits of the delta plain. These delta plain deposits are extensively bioturbated and contain brackish invertebrate taxa of the Malvinocaffric province. Reworked sands are present largely as tidal channel and tidal inlet quartzarenites that unconformably overlie the distributary-mouth bar facies and in places the delta plain facies. Plane-bedded sheet sands locally occur below the quartzarenites and are attributed to storm washover processes.

It is suggested that deposition of the Bokkeveld Group occurred on arcuate deltas similar to the modern Brazos and Niger deltas. Rates of relative sea level rise were high and were punctuated by periods of near stillstand. The duration of these stable periods increased through time, culminating in stable shelf conditions in Witteberg time.

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Paleogeographic Setting and Depositional Environments of Santa Margarita Formation, Ventura County, California

The Santa Margarita Formation in Ventura County, California, represents a transgressive-regressive sequence of rock deposited in a late Miocene shallow marine and paralic environment. A relatively steady low rate of subsidence with an initially low rate of sedimentation produced the transgressive phase. Increased rate of sedimentation produced a seaward progradational sequence or regressive phase.

Rocks that represent the transgressive sequence are herein divided into two facies: (1) facies A, a basal conglomerate zone and thick beds of bioturbated, locally fossiliferous, fine-grained sandstone with some large-scale cross bedding; and (2) facies B, laminated mudstone, phosphatic mudstone, and pelletic phosphate. Rocks that represent the regressive sequence conformably overlie facies B and are herein divided into three facies: (1) facies C, medium to very coarse-grained fossiliferous sandstone characterized by small to large-scale cross bedding; (2) facies D, thin to thick beds of laminated, nodular, and honeycomb gypsum and intercalated claystone, and lenticular-bedded and interlaminated mudstone and very fine-grained sandstone; (3) facies E, medium to thick-bedded mudstone and medium to very coarse-grained sandstone characterized by cross bedding.

Facies A represents marine deposition in a high-wave-energy, shoreface environment. Facies B represents deposition in a low-wave-energy, embayed, inner-shelf environment. Facies C was deposited in a high-wave-energy, east-west-trending, shoreface environment consisting of barriers, bars,