County, has revealed a complex history. The presence of abundant freshwater microfossils (megaspores, chrysomonad cysts, diatoms, sponge spicules), together with only limited evidence of authigenesis, indicates that most of the claystone originated as detrital clay deposited in shallow ponds or marshes. Weathered horizons, at least one of which may represent a remnant of a fossil soil, and other evidence of surficial processes, such as root tubes (and roots) and nearly ubiquitous illuvial-clay coatings in pores, indicate that the ponds dried up periodically.

The dominant claystone lithofacies of the Valley Springs Formation, together with interbedded fine-grained sandstone (channel deposits?) and tuff, can be interpreted as the deposits of a poorly drained coastal plain that was occasionally blanketed by ash deposits and that extended westward from the present Sierra Nevada foothills to at least the present Coast Ranges foothills.

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Reaction Kinetics of Laboratory-Simulated Kerogen Maturation

Application of time and temperature evaluations to maturation and hydrocarbon formation requires knowledge of the chemical kinetics of the maturation process. Lopatin and others have used first-order kinetics, assuming linear dependence of maturation on time for a given temperature and have derived a rate constant whose temperature dependence is governed by the Arrhenius equation. This model may be inadequate as maturation data used in such first-order kinetic equations have generally yielded Arrhenius factor activation energies which vary widely with temperature.

We report here a detailed kinetic analysis of the laboratory-simulated maturation of several distinct kerogens having different source organic compositions and utilizing data for the production of CO_2, CH_4, and higher hydrocarbon gases as a function of time and temperature. In all cases, the dependence of maturation on time departs from linearity. Empirically a dependence on $t^{1/2}$ gives the best fit to the data, indicating possible product inhibition of the maturation process. We develop a simple chain reaction model incorporating this feature for both short and long reaction times. The model yields an effective rate constant which should obey the Arrhenius equation and consistently gives temperature-independent composite activation energies of the same approximate magnitude as is implied by Lopatin's model. The nature of the mineral substrate present with the kerogen influences the rate of maturation, both directly by catalytic action in some cases and indirectly by adsorption of product.

Our results suggest a marked difference in kerogen maturation kinetics between closed and open systems, which must be considered in interpreting and comparing laboratory simulations and which may be of considerable significance for hydrocarbon genesis in the field. This may be reflected in a dependence of the kinetics on lithology and porosity of the source or rock unit.

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New Age Determinations in Franciscan Limestone Blocks, Northern California

This paper documents age assignments for two widely separated and isolated northern California Franciscan "formation" limestone pods that have not previously been reported in published literature. These assignments, the first definite early Eocene fauna thus far recognized, and the most northeasterly occurrence of a Late Cretaceous Cenomanian stage fauna, were made by examining planktonic Foraminifera in thin sections.

In northern California, the Franciscan is divided into three broad northwest-trending belts: an eastern metamorphic belt, a central melange belt, and a western and youngest coastal belt. The occurrences of *Rotalipora appenninica, R. cushmani, Praeglobotruncana stephani,* and *P. stephani* var. *turbinata* in a limestone pod in the melange belt, about 10 mi (16 km) east of Covelo, indicate a Late Cretaceous (Cenomanian) age. Other limestone blocks in the same area contain Late Jurassic (Tithonian) megafossils.

In the coastal belt, a limestone pod from an abandoned quicksilver mine about 6 mi (10 km) north of Branscomb includes *Globorotalia subbotinae = G. rex, G. aragonensis, G. caucasica?* and *G. pseudotopilensis,* indicative of an early Eocene age.

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Sandstone Diagenesis as Function of Depositional Environment and Plate Tectonic Setting—Comparison Between Jurassic Sandstones from North Sea Basin and Some Oligocene Sandstones from Coast Ranges of California

Jurassic sandstones from the North Sea and Oligocene sandstones from the Coast Ranges of California are characterized by very different diagenetic mineral composition, which can be explained by differences in source rocks, sedimentary facies, climate, and ultimately in terms of plate-tectonic setting. The Jurassic sandstones from the North Sea were deposited in a rifted basin and were mostly derived from uplifted Precambrian terrane. A high content of diagenetic kaolinite in these sandstones can be attributed to meteoric water flushing through fluvial and deltaic sediments, causing the breakdown of feldspar and mica and the formation of kaolinite. Montmorillonite and zeolites are rare as authigenic minerals in these sandstones. In California, the rapid subsidence of the basins in this subduction regime caused marine sandstone facies to predominate. These sandstones contain smaller amounts of kaolinite, probably because they did not experience any strong flushing by meteoric water after deposition. In addition, a drier climate in this region explains why fluvial sandstones such as the Sespe Formation show less evidence of meteoric water diagenesis than the Jurassic North Sea sandstones. Basin subsidence and marine transgression after the deposition of the Sespe Formation also limited the time these sandstones were exposed to meteoric water and thereby the formation of kaolinite. A higher content of mafic clastic minerals and chert, which formed unstable mineral assemblages in the California sandstones, favored extensive growth of diagenetic montmorillonite.

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Weathering Statics Problem and First-Arrival Time Surfaces

Where organized by shot and receiver coordinates, the collection of picks of the first arrivals forms a jagged surface. It is thus crucial that the properties of the time surface of first arrivals be studied for various situations. It is particularly useful to analyze two projections of the time surface: one to a constant shot plane and one to a constant receiver plane. For each fixed shot or receiver, there is a distribution of time picks. Comparisons with real data distributions show a good match to theory as the time surface is manipulated. The study of these projections enables us to derive criteria for estimating the accuracy, precision, and consistency of any solution to the statics problem for the simple model of a linear refractor and high frequency statics. In this case the specific criteria are: (1) the expected value of each distribution is constant along each axis, (2) the variance of each distribution is zero along both shot and receiver axes, and (3) the shot and receiver statics are equal.

In addition, several basic types of anomalies can be recognized by their effects upon the first-arrival time surface. These basic types are: (1) geometric variation in the refractor, (2) velocity variation in the weathering, and (3) velocity variations in the subweathering. The combination of these three is a complete description of the general weathering statics problem.

The effects of these anomalies may be studied via the shot and receiver projections. Type (1) can lead to a blurring of the first-arrival time distribution. Type (2) can lead to a lens shape within the first-arrival projections. The lens is formed by a splitting of the left-hand and right-hand shots. Since the lens is composed of both time-rise and time-fall segments, it will be split under certain circumstances. Type (3) can appear as a change in the trend of the projections and a discrepancy between shot and receiver statics.

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Provenance and Depositional Mode of Upper Cretaceous Chatsworth Formation Conglomerates, Simi Hills, California

Conglomerates of the Upper Cretaceous Chatsworth Formation occur as lenses of concentrated clasts in channels and as clasts dispersed at the base of thick, coarse-grained, graded sandstone beds. The matrix of the conglomerates consists of grains ranging from silt to granule size (4 mm) and comprises between 20 and 78% of any one conglomerate unit. The matrix composition ranges from 30 to 80% quartz, 25 to 60% feldspar, and 5 to 20% lithic fragments, with accessory biotite up to 5%. The conglomerate clast population is composed principally of clasts in the pebble size range. Five distinct rock types are recognized within the conglomerate clast population: blue-black argillite, 4 to 20%; felsic volcanites, 4 to 28%; felsic plutonites, 16 to 24%; arkosic sandstones and siltstone, 0 to 12%; and a group of genetically related quartz-rich clasts, 17 to 46%. The quartz-rich clasts include sandstones and siltstones with continuous textural gradation from well-preserved sandstone through partially recrystallized sandstone with sutured grains, into metamorphosed, foliated quartz sandstone and quartz schist types. In addition, a conglomerate unit may contain between 0 and 14% authigenic rip-up clasts.

The Chatsworth Formation, as a whole, is recognized to be a deep-sea fan complex upon which the primary depositional agent for sand was turbidity currents. Lenses of concentrated pebble conglomerates originated as debris flow, whereas beds of dispersed pebble clasts are of turbidity current origin. Paleocurrent data and the conglomerate clast composition for the Chatsworth Formation indicate that its detritus was derived from a source terrane to the south of the Simi Hills.

The Santa Monica Mountains basement complex contains a large mass of argillite and felsic plutonite, but contains no felsic volcanite or quartz-rich suite of rocks. The basement in the northern Peninsular Ranges includes representatives of the principal rock types recognized in the clasts of the Chatsworth Formation conglomerates and, therefore, it is the best possible choice for the provenance. Extensive Franciscan terrane also lies south of the Chatsworth conglomerates, but no Franciscan detritus is recognized in the Chatsworth Formation.

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Cal Canal Field, San Joaquin Basin, California

Cal Canal is the northernmost of the 26 Miocene Stevens sandstone fields in the southern San Joaquin basin. Since discovery in 1977, at initial rates of 6,000 mcf gas/day plus 2,697 bbl of 41° condensate, the field has been fully developed and 17 wells are producing at sharply declining rates.

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Upper Cambrian Stratigraphic Cycles, Southwestern Great Basin

One megacycle and numerous minicycles are recorded in the stratigraphic interval comprising the Dunderberg Shale and overlying Halfpint Member of the Upper Cambrian Nopah Formation in southeastern California and southern Nevada. The retrogradational leg of the megacycle is expressed by the succession: Bonanza King Formation (peritidal carbonate strata), Dunderberg Shale (outer ramp to peritidal shales and interbedded carbonates), and lower Halfpint (subtidal carbonates). The progradational leg is developed within the Halfpint, above the shale-carbonate boundary, as peritidal cryptalgal boundstone overlying subtidal shelf micrites and pelmicrites. Biostratigraphic data suggest this cycle is the result of regional transgression-regression. The Dunderberg-Halfpint contact, representing the boundary between shale and carbonate half-cycles within an apparent grand cycle, does not reflect a major shift in depositional environments, but rather the availability of terrigenous mud and the delicate nature of the carbonate "factory." The main environmental shift occurred during later deposition of the Halfpint carbonate lithosome when a peritidal algal thrombolite complex prograded seaward (see figure).

Coarsening-upward, meter-thick minicycles are abundant in peritidal and shallow subtidal facies in the Spring Mountains and Goodsprings, Nevada district and less common in more distal, deeper, outer ramp facies west of the Spring Mountains. Shallow-marine minicycles are expressed as micrite or shale, and occasionally cryptalgal boundstone, overlain by bioclastic packstone and grainstone as well as intraclastic beds. Deeper subtidal minicycles are expressed as bioclastic wackestone overlying shale or micrite. The minicycles are the products of fair weather-storm cyclicity on the open, deep to shallow subtidal ramp, as well as tidal influences within a peritidal algal-bank complex; as such they do not represent shallowing phases and shifting environments, but rather fluctuating conditions within their respective environmental settings.

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Electro-Magnetic Oil Exploration Research Using Commensurate Frequency Phase Difference Technology