vertical mixing and consequent high productivity. Therefore, the presence and fluctuation of the concentration of opaline silica in deep-sea sediments can be an important indicator of paleo-oceanographic conditions. Upward changes from sediments low in opaline silica to sediments high in opaline silica about 2 m. y. ago in the Antarctic region and about 4.5 m. y. ago in the North Pacific suggest an increase of vertical mixing at these times in these areas.

The widespread occurrence of middle Eocene cherts in the Atlantic indicates a strikingly different circulation pattern for Eocene time than exists today. A modified Eocene circulation pattern is suggested on the basis of the probable shape of the Eocene Atlantic.

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THIN-SECTION EXAMINATION OF OIL SOURCE-ROCK SAMPLES

Thin sections of 388 fine-grained rocks, which had been chemically analyzed for hydrocarbon content, were examined for details of lithology and paleontology. Three general types of thin-section observations were found to correlate with source-rock quality as determined chemically: (1) abundant visible organic matter, (2) dark-brown thin-section color, and (3) microlaminations (bedding <1 mm thick). Of the clastic potential oil source rocks (>500 ppm heavy hydrocarbon extractable) used in this study, 75% contain all 3 criteria. None of the nonoil-source rocks (<150 ppm HC) have all 3 criteria. The "typical" potential oil source rock is described as *"dark-brown, abundantly organic, microlaminated shale."* This "typical" rock is commonly barren of fossils, but it may contain a sparse benthonic fauna and (or) abundant pelagic microfossils concentrated in microlaminae. One set of depositional conditions able to produce this rock is a stable basin setting of relatively slow sedimentation, far from a major coarse clastic source, with no appreciable bottom currents, and with a low oxygen content at the sediment-water interface.

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DISSOLVED SILICA AND ITS RELATION TO DEEP-SEA SEDIMENTS

Neither the concentration nor distribution of dissolved silica in the ocean is controlled by equilibria with solid silica or silicates. Rather, the observed pattern results from horizontal and vertical movements of oceanic water masses interacting with the formation, sedimentation, and dissolution of opaline tests of diatoms and radiolarians. Because the forces controlling this dynamic system are complex and in many cases poorly understood, it is difficult to construct a quantitative model of the present distribution pattern, or to deduce the distribution of silica in ancient oceans.

The residence time of silica in seawater, a few thousand years, is short from a geologic point of view. Consequently, the ocean can have little buffering effect on the dissolved-silica cycle. The rate of supply from continental weathering, submarine weathering, or volcanism, and upward diffusion of interstitial waters must therefore be balanced by the depositional removal of opal. Because there is little evidence for dramatic changes in the rate of supply of dissolved silica to the oceans during the Cenozoic, changes in the locus of sedimentation, rather than variations in the global budget of dissolved silica, probably were responsible for variations in the nondetrital silica content of Tertiary deep-sea sediments.

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MORPHOLOGIC VARIATION IN RECENT PLANKTONIC FORAMINIFERA

Intraspecific variation of *Globigerinoides ruber* and *Globigerinoides trilobus-Globigerinoides sacculifer* was investigated in 20 core top samples from the Atlantic Ocean and Gulf of Mexico. Such samples come from the top centimeter of cores and represent about 1,000 years accumulation. The average number of specimens measured for each sample was 50 and the size of the specimens was coarser than 250μ. Specimens are largest in the Gulf of Mexico and Caribbean Sea, smaller in the equatorial Atlantic, and smallest in the North Atlantic. Between 15 and 25°C, specimen size is correlated with mean sea surface temperature. Above 25°C large size variations occur within a narrow temperature range. Expansion rates, as measured by the relative increase in chamber diameters in both species. are correlative with available nutrients. The highest expansion rates occur in the Atlantic Undercurrent (0–5°N), and in the North Atlantic north of 30°N. Between 5 and 30°N in the Sargasso Sea, expansion rates are lower than in the equatorial or North Atlantic. Thus, for both species temperature and nutrient availability affect maximum size attained and rate of chamber growth.

Comparison of size and expansion rates for *G. trilobus* and *G. sacculifer* distinguished by the presence or absence of a saclike final chamber show the 2 phenotypes to be statistically similar. Within populations of *G. ruber*, the width/height ratio of the test, and of the primary aperture show a general trend of increasing values with increasing latitude. Variations in aperture size are linearly correlated with mean sea surface temperatures.

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TRANSPORT AND DEPOSITION OF COARSE CLASTICS IN TURBIDITE BASIN IN FRENCH ALPS

Marine breccias of Jurassic to Early Cretaceous ages are present in the Breccia Nappe of the French Prealps. Breccia types Ia and Ib are restricted to the lower part of the sequence in the Lower Shale, Lower Breccia, and Upper Shale formations. Type Ia breccias occur in beds from a few centimeters to tens of meters thick. They contain clasts up to more than 1 m in diameter, and are sometimes graded. Sole markings occur but are not common. Tops of some beds have large scale cross-stratification or parallel bedding, usually in granule-pebble grade material. Individual beds are of limited lateral extent—of the order of 1–2 km along the depositional strike and in places up to 7–8 km across it. The breccias have a clast framework and interstitial material is usually pebble or granule size. There is a continuous spectrum, with change in relative proportions of gravel and sand, from the breccias to pebbly turbidite sandstones.

Type Ib is much less common than Ia. It has clasts of the same composition and size but it is characterized by more than 50% sand-grade matrix. Beds are less than 200 cm thick, parallel-sided, and have an uppermost sand-silt layer with convolute lamination.

Type Ia is interpreted as a deposit from mass flow of coarse granular debris where internal shear was extensive enough to allow development of grading. For the transport of Type Ib beds, a slide mechanism is favored.

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DOWN-CURRENT BED THICKNESS AND GRAIN-SIZE VARIATIONS ALONG GRAYWACKE BEDS, GAULT FORMATION, EASTERN ALPS

Paleocurrent directions indicate that deposition of 52 continuous graywacke beds in the 200 m thick Gault Formation (Lower Cretaceous) was from a western source. Down-current decrease in bed thicknesses over 115 km along the Eastern Alpine flysch belt is slight and usually cannot be detected within individual layers. Bed-by-bed correlation between each section, however, provides a basis for mathematical treatment of the thickness data.

If calculated as average deviations from a standard section, most individual sections show a systematic down-current decrease in graywacke bed thickness. The standard section was obtained by using the average thickness of each graywacke bed and each claystone layer and should, therefore, theoretically provide a medial section approximately midway between the proximal and the distal sections. The decrease in thickness appears more pronounced, if thickness ratios (thickness of the graywacke bed divided by thickness of the overlying claystone layer) are taken into account. The average deviation of these thickness ratios from the standard section thus provides an index for the proximality.

Similarly slight down-current changes were observed in grain sizes. For instance, a feldspar-rich marker bed shows a nonuniform decrease of the median grain size at its base from 535μ in the west to 176μ at the easternmost section, 115 km east.

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BARRIER BAR SEDIMENTATION IN UPPER CRETACEOUS FACIES SEQUENCE, SOUTHEASTERN USA

Upper Cretaceous (Campanian) clastic strata in eastern Alabama indicate deposition in a shallow-marine littoral environment. Fluctuations of strand in a predominantly regressive cycle have produced at least 4 heteropic facies, one of which includes sediments of barrier-bar origin. Interpretation is based on detailed studies of sedimentary petrology supported by paleontological evidence.

Distinguishing characteristics of the facies sequence recognized from top to bottom are: (1) barrier bar (regressive)—moderately sorted, medium-grained sand; *Ophiomorpha;* low-angle crossbedding; lag concentrates; channels; (2) offshore clay (transgressive)—calcareous, sandy clay grading upward to clayey fine sand; high planktonic to benthonic ratio; (3) marginal shelf sands (transgressive)—fine- to medium-grained, calcareous, glauconitic sand; distinct burrows; high faunal diversity; and (4) delta front (regressive)—very poorly sorted, sandy, carbonaceous silt; bioturbate; low faunal diversity; low planktonic to benthonic ratio.

The delta-front deposits accumulated as part of a clastic wedge which was built out into eastern Alabama. Sediment source was the Appalachian Mountains and the Piedmont Plateau. A reduction in supply of detritus allowed transgression which reworked the delta-front sediments and resulted in the development of marginal-shelf sands and/or offshore clays. Sand transported from the east by longshore currents became concentrated as barrier bars wherever waves, tidal currents, and longshore currents attained a balance with available sand.

The filled channels, large-scale crossbedding, and lag concentrates suggest that some of these clean sandstone bodies of the barrier-bar facies may be complex shoal deposits or inlet channel fillings resulting from destruction and reworking of barrier islands.

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NEARSHORE FACIES RELATIONS, EOCENE LAKE UINTA, UTAH

Fluvial through "deep" lacustrine transitions are present in the Green River Formation (Eocene) of the Uinta basin, Utah. Characteristic sedimentary features useful for reconstructing specific subenvironments are (in approximate order of usefulness):

Fluvial Channel.—Small- and medium-scale cross-stratification; horizontal stratification; channels; poorly sorted sublitharenite, lithic arenite and subarkose; intraformational and chert-pebble conglomerate.

Fluvial Floodplain.—Earthy silty claystone; paleosoil.

Lagoonal.—Thin horizontal lamination; waxy claystone; clastic lenses of oolitic sandstone; algal mat; carbonate pebble conglomerate.

Shoal.—Horizontal and small- to medium-scale cross-stratification; oolite; algal mat; ripple marks; shrinkage polygons; chert-pebble conglomerate; ripple stratification; bone fragments.

Beach, Shoreface.—Horizontal and small- to medium-scale cross-stratification; quartz-arenite and subarkose; ripple marks; incomplete shrinkage cracks; ripple stratification; burrowing; chert-pebble conglomerate; large-scale cross-stratification; disturbed bedding; small channels.

Nearshore.—Horizontal and wavy stratification; fine-grained sandstone and siltstone; small-scale cross-stratification; disturbed bedding; incomplete shrinkage cracks; ripple marks; ripple stratification.

Offshore.—Horizontal stratification; varves; oil shale and claystone; syneresis cracks; oolitic sandstone; stromatolites.

Sedimentary cycles are present in each of these depositional environments. Lacustrine cycles consist of a lower regressive clastic phase and an upper transgressive carbonate phase. Specific lithologies and sequences differ in each lacustrine subenvironment. Fluvial cycles consist of a basal erosional episode followed by channel filling and floodplain development. Fluctuations in the level of Lake Uinta are interpreted to have caused these cyclical deposits.

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EVAPORITES—CLUE TO CHEMISTRY OF SEAWATER DURING PHANEROZOIC

(No abstract submitted)