Thin chert-rich conglomerates and sandstones and the absence of much of the Lower Triassic in eastern Nevada indicate a positive area in that region. Evidence of Lower Triassic volcanism is present in western Utah and eastern Nevada.

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SEDIMENT FACIES PATTERNS AND GEOLOGIC HISTORY OF COASTAL MARSH

Preliminary facies studies in the Great Marsh, on the southwestern shore of Delaware Bay, show a complex history of marsh-lagoonal facies forming the leading edge of the late Holocene marine transgression. A molluscan fauna (*Crassostrea virginica, Macoma balthica,* and *Nassarius obsoletus*) found in a dark-gray sand-mud, indicates a tidal creek–shallow coastal lagoon environment surrounded below, landward, and above by medium-dark-gray organic mud with variable amounts of *Spartina* grass and peat. Shallow cores, supplemented by deeper auger borings and reflection seismic surveys, indicate that the morphology of the Holocene transgression wedge and the present drainage patterns are a reflection of topography on a deeply eroded pre-transgression unconformity incised into Pleistocene sediments.

Late Holocene geologic history and the resulting sediment facies patterns therefore are associated closely with fluvial drainage patterns on the pretransgression surface. A relative sea-level-rise curve has been used to place facies patterns and vertical sequences into a time-space perspective showing the migration of environments landward and upward over this dendritic erosion surface. The initial transgression of the fringing marsh and tidal creeks, and their widening into lagoons were followed by an increased sedimentation rate. This increase led to infilling of lagoons and formation of the present tidal creek-marsh system.

The transgressive sequence, because of continuing sea-level rise, is being partly obliterated and buried by a rapidly advancing washover barrier and shallow marine-estuary complex (Delaware Bay).

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EARLY EVOLUTION OF OCEANS—A WEATHERING MODEL

The long-term chemical composition of seawater is controlled by the generalized reaction: primary igneous rocks + water + acid volatiles = sediments + oceans + atmosphere. Unstable crustal minerals are weathered by water and acid volatiles, and local equilibrium between the products of the reaction—oceanic sediments, seawater and the atmosphere—is attained.

To obtain a better picture of the evolution of the oceans as this reaction proceeds (minerals formed, mass transfers involved, changes in seawater composition), we simulated with a model calculation on a high speed computer the irreversible attack of "average igneous rock"—represented by an idealized mineral assemblage—by water and acid volatiles. We assumed a single-stage degassing process under reducing conditions at 25°C and 1 atm. The predicted final solid products at equilibrium, ranked according to decreasing mass, are amorphous silica (chert), clay minerals, carbonates, and K-feldspar. The predicted composition of the early ocean resembles that of present seawater except that (1) the dissolved sulfur is in reduced form, (2) the solution is saturated with amorphous silica, and (3) the salinity is about twice that of today because of nonremoval of NaCl as evaporites.

Extension of these results to more realistic systems can at best be semiquantitative because of lack of sufficient thermochemical data. Furthermore, the recycling of sediments makes it very difficult to estimate early environmental conditions from present remnants of Precambrian sediments. Some generalizations can nevertheless be made with confidence. A more basic initial crustal material such as oceanic basalt would lead to larger amounts of clays and carbonates in the sediments at the expense of chert, and to a large concentration of dissolved ferrous iron in the ocean. Degassing of water preferentially to other volatiles would not affect the outcome of the weathering process unless the escape rates of the volatiles differed by several orders of magnitude. Although our model clearly represents one extreme, rapid degassing, the available geologic evidence does not preclude its having taken place. It is encouraging that the results of the calculation are in general accord with what has been reported previously.

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DEEP-SEA CHERT IN GULF OF MEXICO

Chert from at least 9 different stratigraphic zones, ranging in age from Cenomanian (Late Cretaceous) through late Oligocene, was recovered at 4 sites in the southeastern Gulf of Mexico during Leg 10 of the Deep Sea Drilling Project. The sites are on the northern and eastern edges of the Campeche Scarp, in the Catoche Tongue area of the Yucatan Channel, and on the western approach to the Straits of Florida.

Chert formation in all locations took place by late postdepositional replacement of deep-water, calcareous, foraminiferal nannoplankton oozes. At each site the degree of silicification of the carbonates increases with increasing age. Depth of burial and/or thickness of the overlying water mass appears to be independent of the degree of silicification.

Preliminary petrographic analyses of the cherts reveal the presence of amorphous (opaline) silica; fibrous quartz (variety chalcedony); fibrous cristobalite; and anhedral, subequant, microcrystalline quartz. The type of silica present is dependent upon the stage of silicification and on the composition and texture of the components being replaced. Finely comminuted plant material and other forms of organic detritus are locally common but are unaltered by silicification.

The exact source of silica for these cherts is not presently established. Radiolaria and other siliceous organisms are generally common in overlying sediments and may be important silica sources. Although drill-core data in the Gulf of Mexico are incomplete and far from conclusive, there is a suggested increase in the amount of silica both in the form of siliceous organisms and in chert—in the southeastern Gulf of Mexico.

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HISTORY OF CIRCULATION IN PACIFIC OCEAN

Present evidence indicates that the Pacific Ocean is the remnant of a larger, pre-Mesozoic ocean basin, since restricted by drifting continents. Similar Paleozoic faunas were distributed widely throughout this basin and interconnecting seaways. Zoogeographic distinctions were few, and seem attributable chiefly to isolation in restricted seaways rather than by oceanographic dissimilarities within the basin. Currents in the basin were slow and water mass distinctions poorly developed. As the assembled continents drifted apart in the early middle Mesozoic, faunal endemism increased in response to the development of different water masses through increased circulation and a restricted basin. Since the late Mesozoic, water mass distributions and current patterns have been analogous to modern ones although not as sharply defined. By the beginning of the Tertiary the configuation, but not the size of the basin, was established. This basin configuration, together with an increasing climatic gradient, intensified oceanic and atmospheric circulation, upwelling, and biotic provinciality and speciation. Imposed on this trend were periods of climatic amelioration (early Paleocene and Oligocene) that allowed planktonic biotas to disperse widely, suggesting decreased circulation and weakened water mass boundaries. Upwelling intensity and primary production decreased, the calcium-carbonate compensation depth increased, and extinction occurred among pelagic organisms as habitats and nutrient supplies to which they were adapted disappeared. Provincialism of plankton and shelf benthos increased during the later Tertiary as circulation intensified in response to cooling high-latitude marine climates.

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Petrology and Stratigraphy of Earp Formation, Pima and Cochise Counties, Arizona

Stratigraphic and petrologic studies show that the Earp Formation of Pennsylvanian and Permian ages in southeastern Arizona and southwestern New Mexico consists of fluvial clastic rocks that interfinger with supratidal, intertidal, and subtidal marine carbonate rocks. The clastics encroached initially from the northwest into the shallow Earp sea during Missourian time and continued migrating eastward during Virgilian and Wolfcampian time.

Clastic-ratio and isopach maps, a convex-upward geometry shown by a thinning of the overlying Colina Limestone, and primary sedimentary structures indicate that the clastic-dominated part of the Earp Formation was deposited as a delta.

In the carbonate lithologies, 3 environments of deposition are recognizable: supratidal, intertidal, and subtidal. The supratidal environment is characterized by pelmicrites filled with sparry calcite surrounded by a micrite envelope; desiccated, interlaminated carbonates of algal origin (biomicrites); the absence of fossils; evidence of dedolomitization; and "bird's-eye" structure (dismicrite). The intertidal environment is composed of pelmicrites, biomicrites, micrites, and biosparites. Fusulinid biomicrites and biomicrites that have delicate tests preserved are characteristic of the subtidal environment.

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Quantitative Basin Analysis of Permo-Carboniferous Dunkard Group in Ohio, Pennsylvania, and West Virginia

It long has been known that the depositional strikes of some facies variables in ancient fluvial regimes are generally perpendicular to the inferred paleoslope. We propose that this is an effective criterion for selecting facies components whose regional distributions were primarily slope induced. A statistical model based on the postulated geometric relation between the paleocurrent pattern and the regional facies trends provides a means of identifying the trend components that were controlled by the depositional slope.

On the basis of 134 measured sections in the Permo-Carboniferous Dunkard Group, paleoslope response components of 5 facies variables were selected using this model. Examination of these trends in conjunction with crossbed readings made at 389 localities reveals (1) a high concentration of clastics on the southeast, consisting primarily of thick belt sandstones (subgraywackes) and red mudstones, (2) a northern drainage outlet characterized by abundant freshwater limestone, coal, sheet sandstone, and gray-green shales, and (3) a second drainage basin to the west with sheet sandstones, red mudstones, and few limestones or coals. Analysis of the slope-induced facies trends indicates that sandstone geometry and distribution were controlled by the configuration of the paleoslope whereas the formation of limestone, coal, red mudstone, and nonred shale depended primarily on the relative positions of the groundwater table and the depositional surface. The Dunkard Group was deposited on a northward to westward sloping alluvial plain from which distributaries emptied into seas on the northeast and southwest of the present Dunkard basin.

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Sea-Floor Spreading and Structural Evolution of Southern Red Sea

The Red Sea is in the early to intermediate stages of continental breakup, and its structural evolution has been fundamentally the rifting and breaching of continental lithosphere by normal faulting attendant to the process of sea-floor spreading. In Oligocene time, the continental lithosphere of the Red Sea area was bowed into a large regional arch with normal faults across the crest. Subsequently, rifting by normal faults that propagated upward from the base of the lithosphere caused strong subsidence on horst and graben and tilted blocks; this rifting led to an extensive marine incursion, and a thick evaporite sequence was deposited in the restricted, hot, arid, low-latitude setting of the Miocene Red Sea trough. A second rift westward of the earlier central or axial Miocene rift originated in the southern Red Sea area in Pliocene time, and the 2 features are now evolving concurrently over a distance of at least 400 km. An evaporite section of very shallow marine origin accumulated in the western rift during the Quaternary; it constitutes a modern example of salt accumulating in a narrow, restricted, rifted trough which is forming as a consequence of continental breakup.

The present opposing coastlines of the Red Sea were never in contact, because the fragmentation of continental lithosphere was attained very largely by normal faulting. Only if a vertical fault surface cut the entire thickness of lithosphere could points on opposite coastlines ever have been contiguous.