in northern latitudes were developing in late Miocene time approximately 15 million yr ago, that the Pliocene-Pleistocene boundary is approximately 1.8 million yr old, and that the warm latitudinal belt postulated for the Tertiary must be extended to at least 46°00′N. If these conclusions are valid, they demand a re-evaluation of paleoclimatology, paleogeography, and paleoceanography.

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Clay Mineralogy of Kope and Fairview Formations (Cincinnatian) in Cincinnati Area

Detailed clay mineralogical analyses were conducted on shales and mudstones of the Kope and Fairview Formations in the Upper Ordovician standard of the Cincinnati area. X-ray-diffraction, electron-microscopy, cation-exchange, and DTA studies reveal a suite composed mainly of illite, chlorite, and lesser amounts of illite-montmorillonite and vermiculite.

Clay-mineral ratios show consistent changes approximately 3–4 ft above the presently accepted and mappable boundary between the Kope and Fairview Formations. Increases in combined chlorite-vermiculite amount to about 15 percent and are accompanied by a general increase in the proportion of limestone in the section.

In addition, cation-exchange and X-ray data reveal up to 3 percent vermiculite in the upper part of the Fairview, compared with 0–1 percent in the lower part. These clays probably represent degraded flakes of chlorite due to weathering in the source area.

Paleocurrent measurements reported by Hofmann (1966) show a dominantly eastern source direction for the Kope carbonates and a dominantly northern source for the Fairview carbonates. Differences in clay-mineral constituents in the associated shales and mudstones appear to correspond to these data and may indicate differences in source-area lithologic characteristics in those directions. Further, it is not unlikely that some volcanic influence may account for variations in mixed-layer illite-montmorillonite.

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Sho-Vel-Tum Oil Field, Oklahoma

Prolific oil and gas production is obtained in the Sho-Vel-Tum area of eastern Stephens and western Carter Counties, Oklahoma, from rocks of Permian, Pennsylvanian, Mississippian, Siluro-Devonian, and Ordovician ages. This large, complexly folded and faulted area is in the northwest part of the Ardmore basin between the Arbuckle Mountains on the east and Wichita Mountains on the west. The first production was discovered in July 1914 from Permian rocks at a depth of 400 ft in Sec. 21, T. 3 S., R. 2 W. The area has had two periods of major structural movement: post-Morrow, pre-Deese; and post-Hoxbar, pre-Cisco. Production is from stratigraphic traps, fault closures, anticlines, and combinations of these. Geologically this is one of the most interesting areas of the world, and economically it has produced 742,835,000 bbl of oil with an estimated reserve of 158,288,000 bbl. The area is still active and new reserves are being found.

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Selective Solution in Planktonic Foraminifera: Liability and Asset in Reconstruction of Ancient Environments

On the ocean floor, solution of foraminiferal ooze takes place at depths considerably above the $CaCO_3$ compensation depth. Solution is selective and the common planktonic Foraminifera are dissolved in the following order (least resistant species listed first): *Globigerinoides ruber, Orbulina universa, Globigerinella siphonifera, Globigerinoides sacculifer, G. conglobatus, Globigerina bulloides, Globigerinita glutinata, Globorotalia hirsuta, G. truncatulinoides, G. inflata, G. menardii, Globoquadrina dutertrei, Globigerina pachyderma, Pulleniatina obliquiloculata, Globorotalia crassaformis, Sphaeroidinella dehiscens,* and *Globorotalia tumida.*

Selective solution will change the apparent latitudinal origin of a sample toward higher or lower latitudes, depending on the original composition of a sediment assemblage. Solution also will change the aspect of the sample with respect to the original depth habitat of the Foraminifera. This is true especially for morphological variants. Any argument resting on the comparison of living planktonic faunas and their counterparts in the sediment must take these solution effects into account.

The selectivity of solution provides a tool with which the relative $CaCO_3$ undersaturation of the ocean water may be measured. In the central Atlantic, the depth at which this undersaturation increases markedly is at about 4,400 m. In the past this depth fluctuated between at least 4,500 and 4,000 m, which reflects the changing thickness of the Antarctic bottom-water layer.

Similar studies are possible for the more distant past. The bases for such studies are laboratory experiments establishing the relative solution resistance of the extinct species.

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Shelf-to-Basin Lower Triassic Sediments Across Las Vegas Hingeline, Nevada

Lower Triassic Moenkopi (Formation of McKee, 1954; Group of Poborski, 1954) changes facies with increase in thickness from mostly nonmarine and minor marine character east of Las Vegas, Nevada, to progressively more marine character toward the west as the Las Vegas hingeline is crossed. The thickness of Moenkopi strata east of this hinge in the Rainbow Garden area (east of Frenchman Mountain) is 1,810 ft, of which about 350 ft is the marine Virgin Limestone. About 20–22 mi farther east, Moenkopi aggregates about 1,250 ft; this section contains more redbed but less carbonate and gypsiferous facies than at Rainbow Gardens.

Outcrops west of the hinge in the expanse between Las Vegas and east Blue Diamond Mountain show a progressive increase in Moenkopi thickness, with more marine sediments; Virgin Limestone is about 500 ft thick. A much more striking change takes place westward, toward the west side of Blue Diamond Mountain, where the Virgin Limestone consists of 900 ft of marine limestone, dolostone, claystone, and shale; weaker units in the Moenkopi are covered largely by alluvium. About 6–8 mi farther south, in the Cottonwood Wash-Bird Spring Range area, total Moenkopi is about 2,000 ft, of which Virgin Limestone consists of 1,025 ft of cyclically accumulated marine limestone, dolostone, claystone, and shale.

The leading edge of the Keystone overthrust is 2–3 mi west of Triassic outcrops of the Blue Diamond Mountain-Bird Spring Range localities; Triassic strata on the upper plate are exposed superbly in the Lovell Wash-Lovell nose area, and in the Grapevine Springs locality near Kyle Canyon, about 10–15 mi west and northwest, respectively, from the Blue Diamond locality. Total thickness of interbedded and cyclically accumulated marine limestone, shale, and claystone is at least 2,435 ft; west-dipping strata are beneath Quaternary alluvium.

Lower Triassic strata of the autochthonous sections east of the Keystone overthrust are disconformable on the Harrisburg Member (gypsiferous) of the Kaibab Formation in most localities, and in turn are overlain disconformably by Shinarump Conglomerate. In the allochthonous block, however, the Harrisburg Member is absent, and only locally do Lower Triassic sediments lie on the Kaibab; elsewhere, channels were cut through the Kaibab and Toroweap, and the Mesozoic sediments have thick cobble and boulder conglomerate resting with marked unconformity on Permian redbeds.

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AN APPLICATION OF UPPER PENNSYLVANIAN PALYNOLOGICAL DATA TO INTERPRET ENVIRONMENT OF DEPOSITION

Spore assemblages from samples of three known environments—(1) coal (fresh-water) swamp, (2) nonmarine, and (3) offshore-marine of the Upper Pennsylvanian—are described to the generic level. The number and types of spore and pollen genera are different in each assemblage.

The five dominant genera from each of six coals were placed in one group representing a fresh-water environment. The airborne saccate pollen were put in another group representing an offshore-marine environment. The two groups were combined into a ratio that indicates the predominance of one of the two environmental groups. This is termed the "swamp-marine ratio" which, combined with a third assemblage variable—generic diversity—was used to construct an environmental chart. Spore and pollen assemblages from each of the known environments occupy mutually exclusive areas on the chart.

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BRYOZOAN ECOLOGY AND SEDIMENTARY ENVIRONMENTS IN CENTRAL APPALACHIAN UPPER ORDOVICIAN

Trepostomatous bryozoans are abundant in the upper Reedsville Formation (Ordovician) in the central Appalachians from Pennsylvania to Tennessee. A study of their faunal associations and zoogeographic distribution has emphasized the close relation between sedimentary environments and bryozoan morphology, abundance, and diversity. Reconstruction of the Late Ordovician environmental setting outlines a broad, gently sloping shelf with a prominent clastic wedge or deltaic complex in south-central Pennsylvania. Coarse sand and silt were common on the shelf in the north, and graded southward into silty mud and mud.

The external morphology of the central Appalachian trepostomes shows little change along the north-south shoreline. The zoarial types usually are branching, either subcylindrical or flattened plates; such forms are most common today in quiet sublittoral waters. The Ordovician trepostomes are abundant only north and south of the clastic wedge. Recent bryozoans usually are found in nonturbid environments on a slightly mobile surface of attachment; therefore, they are abundant only away from delta fronts and sediment-laden currents. Similarly, there is no reason to expect that the Upper Ordovician bryozoans reflect any lesser sensitivity to substratum mobility or to have been more tolerant of turbidity.

Where taxonomic diversity is mapped in Recent environments, those bryozoan assemblages with the highest diversity are found only where the rates of deposition are moderate to low. Generic diversity along the central Appalachian Upper Ordovician shoreline shows a sharp gradient from low diversity in the north to high diversity in the south. Two genera are common in the north, each isolated from the other but both equally abundant on the flanks of the clastic wedge. In southwestern Virginia and northern Tennessee, well off the apron of the clastic wedge, as many as 5 to 7 genera may be abundant at any one locality.

The distributional pattern of the Upper Ordovician trepostomes in the central Appalachians, especially the pronounced diversity gradient, appears to be directly related to areas of sediment influx and to rates of sedimentation.

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DIGITAL SIMULATION MODELS OF EVAPORITE SEDIMENTATION

The factors that control evaporite sedimentation include basin configuration and tectonics, basin-water circulation, supply and composition of brine, rainfall, and evaporation, and the periodic variation of each. There are basin-center, basin-margin, shelf, and nonmarine types. All have their own controlling factors with peculiar magnitudes and variations.

The evaporite sedimentation system thus had tectonic, physical, and chemical subsystems as its main components. Their dimensioned associations are the conceptual evaporite model. Tectonic, physical, and chemical components, their spatiotemporal gradients, and their dynamic interaction define the simulation model. It is four dimensional and time variant.

Geology of evaporite deposits provides the setting, evaporite components, and facies to be simulated through the model. Experimental variation in spatiotemporal gradients of the controlling parameters explicitly defines the association of factors that produce the evaporite deposit, whose distribution patterns most clearly approximate those of the geologic sys-