trough cross-bedded and ripple-bedded top. The lower sandstone unit is interbedded with black to dark-gray, carbonaceous shale and siltstone, whereas the upper sandstone unit is recognized by associated basal conglomerate or interbedded lenticular conglomeratic beds, and poorly bedded, plant-disturbed sandstones. The boulder beds between the sandstone units are composed of novaculite, limestone, sandstone, and conglomerate, and are interstratified with black, carbonaceous shale and gray siltstone. The boulders are considered to be of tectonic origin, probably derived as a result of faulting and/or uplift of the source area.

The environment of deposition of this facies is shown by features associated with the sandstone units. The erosion channels, occurrence of conglomeratic beds with the sandstones, poorly bedded and plant-disturbed sandstones, interstratification with carbonaceous shale, lack of marine fossils, and development of large-scale cross-bedded sandstones in general suggest a very restricted shallow-water to transitional deep-water depositional environment for these strata.

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Danian Planktonic Foraminifera from Cannonball Formation, North Dakota

Seven species of planktonic Foraminifera occur sporadically through 395 ft of the Cannonball Formation at Garrison Dam, North Dakota. Samples were obtained from a damsite core drilled by the U.S. Army Corps of Engineers. The species are: *Globigerina edita* Subbotina, *Globorotalia pseudobulloides* (Plummer), *Globoconusa daubjergensis* (Brönnimann), *Subbotina triloculinoides* (Plummer), *Subbotina varianta* (Subbotina), *Chiloguembelina midwayensis* (Cushman), and *Chiloguembelina morsei* (Kline).

This assemblage is indicative of the *Globigerina edita* Zone of Hollebrandt, 1965 (=*Globorotalia pseudobulloides* Zone of Bolli, 1966), and it generally is recognized as representing the lower parts of the Danian Stage (below the *Globorotalia trinidadensis* Zone). This precise correlation of the Cannonball with the lower Danian indicates a similar age for the nonmarine equivalents of the Cannonball (Ludlow and Tullock) on the west. The Ludlow in western North and South Dakota has been dated as Paleocene by plants, spores, and pollen. The Tullock has been dated previously as Paleocene on plant evidence and more recently as Puercan (early Paleocene) on the basis of mammals from eastern Montana. Therefore, the evidence presented here suggests that the Puercan is equivalent to the early Danian.

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Carbonate Sediments in Clastic Environment: Reefs of Veracruz, Mexico

Lying on an extremely narrow continental shelf in the southwest Gulf of Mexico are two groups of living patch reefs in the vicinity of Veracruz and Antón Lizardo, Mexico. Extending from the shoreline to water depths of 50 m, these are the only major reef buildups in the clastic province of the Gulf of Mexico west of the Yucatán and Florida carbonate provinces. Terrigenous clastic sediments are the major sediments in the interreef areas, and are primarily mud and silt brought in by high-gradient rivers which drain a narrow coastal basin and high mountains within 150 km of the coast. Some sand may be left from the last Pleistocene low sea level. The clastic sediments also contain 1–2% carbonate material from planktonic and benthonic fauna. Reef-derived carbonate sediments are present only in a narrow zone around each reef patch. The carbonate percentage ranges from 100 in the living coral areas to less than 5 within 100 m, although traces of reef-carbonate material extend considerably farther. Several areas of dead reefs are also present. If these results are applied to ancient deposits, the location of reefs by sampling from either outcrops or well cuttings would be difficult, although the presence of reefs could be inferred as being in an upcurrent direction.

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Facies Variations in Ordovician Sediments of Southeast Ireland and their Paleogeographic Significance

A continuous section through the Ordovician belt in southeast Ireland is exposed in southwestern County Wexford. There an unconformity separates Lower Ordovician (mainly Arenigian) sediments from an Upper Ordovician (Caradocian) sequence.

The thick Lower Ordovician sequence contains four facies, of which the most important is alternating siltstone and shale. Interfingered as minor facies are thick shale beds, paraconglomerate, and interbedded sandstone and shale. The siltstone and sandstone are interpreted as deposits from axial turbidity currents, with associated bottom-current activity, in an otherwise low-energy environment. Paleoslope data indicate that deposition was near the southeast flank (the "Irish Sea landmass") of a northeast-trending basin. Only the paraconglomerates were derived from this border area; the dispersal pattern and petrology indicate a northeastern source for the other detrital sediments.

Volcanic rocks (laterally equivalent to the more westerly Tramore limestones) are at the base of the Caradocian. An initial nearshore environment, progressively deepening, is probable for this sequence. The overlying sediments contain three facies; quantitatively, the most important is interbedded siltstone (turbidite) and shale. Paleocurrent directions indicate a southwestern source and deposition in a northeast-aligned basin. A close mineralogical similarity with the Arenigian sediments suggests that the Arenigian composed much of the source area. This facies shows an upward increase in shale, and is overlain by two facies of less importance—a pyritic siltstone and silty mudstone facies, and a black shale facies. This upward change implies diminishing supply of terrigenous material and a change in basin geometry to quiet, restricted, shallow depositional areas. These probably were near shore, because overlying rhyolite flows were extruded subaerially.

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Sediment Distribution, Differential Sedimentary Cycling, and Geochemical "Uniformitarianism"

Sediments have been deposited and destroyed continuously throughout geologic time. The writers constructed simplified models of world sediment distribution as a function of time and compared these models with the actual distribution. The results suggest that approximately half of the sediments existing today are younger than 600 million years (m.y.), whereas the remainder is distributed irregularly through a stratigraphic column representing 2,500 to 3,000 m.y. Such a distribution means that the total mass of sediments deposited during geologic time would have to be 4 to 6 times the existing mass and that sedimentary material is rapidly recycled forward in time. Thus, one may think of the half-mass age of all sedimentary rocks as approximately 600 m.y.; however, the half-mass age of carbonate rocks is less, about 300–400 m.y., and that of evaporites even less, about 200–300 m.y.

The relatively high percentage of carbonate rocks, and the almost complete restriction of evaporites to the post-Precambrian result from the fact that the components required to make these rocks are cycled forward at a rate 1.5 to 2 times the rock mass as a whole. Geochemical "uniformitarianism"—the concept that the total mass of sediments existing at any one time in the geologic past had about the same composition as observed today—should be considered when geological conclusions are drawn that are based on the proportions of sedimentary rock types in the geologic column.

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Mobility of Atlantic Coastal Plain and Shelf[1]

Although the Atlantic margin of the United States has been considered to have a similar but less mobile history than the Gulf margin, new data and reevaluation of existing data indicate quite different histories for the two areas. The Atlantic margin is a mobile area with sediment thicknesses approaching those of the Gulf margin, but most of the deposition along the Atlantic margin occurred during the Mesozoic whereas the Gulf received the largest amount of sediments during the Cenozoic. Mobility, however, continued in the Atlantic margin during the Cenozoic, but this mobility did not always parallel that occurring in the Gulf; times of transgression in the Gulf Coast may correspond to regressions in the Atlantic Coast and *vice versa.*

Cenozoic mobility of the Atlantic margin is illustrated by a consideration of Miocene paleoenvironments and stratigraphic data. Several basins existed along the Atlantic margin during the Miocene; some of the basins were open to the ocean, but others were restricted from open circulation. Among those basins, mobility was differential throughout the Miocene. Miocene deposition took place in water as deep as upper bathyal within the present coastal margin, and primary phosphorite is associated with the deeper parts of the basins.

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New Evidence for Dating Carboniferous Flysch Deposits of Ouachita Geosyncline, Arkansas and Oklahoma[1]

Ammonoids and other invertebrate fossils from the Stanley Shale, Jackfork Sandstone, and Johns Valley Shale provide new information on the ages and correlations of these three stratigraphic units. The Stanley Shale is Late Mississippian (Chesterian) in age through most of the Ouachita Mountains region, except for a basal part, approximately 75 ft thick, of probable Meramecian age. In Saline and Perry Counties, Arkansas, Pitkin Limestone fossils, most of them in reworked boulders, are present about 500 ft below the top of the Stanley. Near Little Rock, Arkansas, ammonoids in the upper part of the Stanley represent the *Reticuloceras tiro* zone of the lower Hale.

The Jackfork Sandstone is of Early Pennsylvanian (Morrowan) age in Arkansas, but near Talihina, Oklahoma, its basal plant-bearing beds are of Late Mississippian (Chesterian) age. *Cymoceras,* an early Morrowan ammonoid genus, has been recognized in the lower part of the Jackfork near Amity, Arkansas. The Game Refuge Formation of Harlton at the top of the Jackfork has yielded Morrowan brachiopods and trilobites in Atoka County, Oklahoma.

The Johns Valley Shale contains indigenous ammonoid assemblages representing the *Branneroceras branneri, Axinolobus modulus,* and *Diaboloceras neumeieri* zones. These three zones are present also in the type section of the Bloyd Shale, indicating a direct equivalence of the two formations. Masses of Caney Shale in the Johns Valley, some of them enormous, as well as boulders of Lower Ordovician to Lower Pennsylvanian rocks, were introduced largely by turbidity flow and gravity gliding.

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Geology of Continental Margins: Introduction and Review

Continental margin is assumed here to include the continental shelf, the continental slope, the continental rise, and other equivalent features in less mature margins such as marginal troughs, marginal plateaus, outer ridges, and continental borderlands. Petroleum industry's interest in continental margins is based on the same factors that delineate oil provinces on land: (1) zones of thick fine-grained sediment deposition with high organic content (source rocks); (2) lenses, layers, and wedges of sandstone (reservoir rocks); and (3) active tectonism to produce the necessary structure and to provide driving forces for the migration of petroleum into reservoirs. These factors occur in an area that encompasses more than 20% of the earth's surface area. If the shelves are considered to be regions of erosion and transport, the slopes and rises still occupy 10–15% of the earth's surface; this is an area larger than that of major onshore oil production. Present technology makes it possible to drill about 35% of the continental margin areas. Such projects as JOIDES and similar projects being planned can provide at least preliminary data on the remaining 65%. The advent of deep submersibles makes it possible for geologists to see the surface of the entire area as other techniques are used to probe beneath the surface.

Historically, the investigation of the margins began when the first measurement of water depth was made as an aid to navigation in shallow coastal water. However, the major contribution of modern workers can be restricted to the last 30 years in which the expansion of knowledge has been exponential. It is no exaggeration to say that the time necessary for the publication of these abstracts is sufficient to include new basic discoveries and interpretations. Thus earth scientists are in

[1] Publication authorized by the Director, U.S. Geol. Survey.