

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 trilocolinoides* (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 nar-

row 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. Interfingering 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 "UNIFORMITARINISM"

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