tral Montana. Two of those exposed in the Big Snowy Mountains were selected for a detailed study of diagenesis in ancient carbonate sandstones.

Evidence suggests that these sediments were deposited in a shallow marine-shelf environment. Diagenesis of the carbonate sands began with cementation in the intertidal or submarine environment. Partial cementation was followed by partial silicification of bioclastic debris and ooids. No definite order could be determined for later diagenetic events; they may have proceeded more or less simultaneously. Dolomitization appears to have postdated silicification and shows preferential replacement of ooid coatings and mud. The sandstones are compacted and stylolitized, and pressure solution may have served as a source for the coarse, blocky calcite which fills the remaining pore space. The distinctive red color of the upper grainstone layer may be due to recent weathering.

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Lower Permian Limestones of Southern New Mexico and West Texas

Detailed petrographic and stratigraphic analyses of samples from the Lower Permian (Wolfcampian) of southern New Mexico and West Texas demonstrate the effects of major tectonic elements on redbed and carbonate sedimentation. Regional correlations are based on 3 informal stages (upper, middle, and lower Wolfcampian), as determined by fusulinid zonation.

Uplifted areas, such as the Pedernal landmass, Diablo platform, and the Florida islands, display unconformable surfaces, limestone and chert conglomerates, and shallow-water carbonates facies consisting of foraminiferal-algal packstones and grainstones (shoal water), algal plate wackestones (bioherm), and ostracod-molluscan packstones and wackestones (lagoon). These highs were flanked by carbonate shelf deposits of normal marine wackestones and packstones which rim the Orogrande and Pedregosa basins. The former was a shallow water intracratonic basin in which about 2,000 ft of Wolfcampian sediments accumulated. The latter basin is less understood, but had a well-defined shelf margin and received at least 4,000 ft of Wolfcampian sediments.

Distant uplifts on the north of the Orogrande basin shed thick redbed deposits which intertongued with carbonates on the south. Generally, this resulted in 3 major sedimentary phases (2 carbonate phases separated by a redbed phase) which correspond to the original threefold division of the type Hueco Limestone. This interpretation together with fusulinid zonation permits correlation of stratigraphic units of southeastern Arizona with those of West Texas and New Mexico: youngest Horquilla Limestone with Hueco Canyon Formation, Earp Formation with Abo Redbeds and Cerro Alto Limestone, and Colina Limestone with Alacran Mountain Formation.

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South Pacific Planktonic Foraminiferal Biogeography and Late Cenozoic Paleo-Oceanography

Distinct changes in the character of South Pacific planktonic foraminiferal faunas occur at the 2 major water-mass boundaries. The southern limits of at least 10 species occur at or near the Subtropical Convergence which marks the southern limit of subtropical water. An additional 8 species have their southern limits approximately coincident with the Antarctic Convergence, leaving only 1 species characteristic of Antarctic waters.

Micropaleontologic and sedimentologic studies of South Pacific deep-sea cores have enabled partial definition of the climatic and glacial history of Antarctica and the South Pacific. Pliocene and Pleistocene cores can be divided into zones on the basis of upward sequential appearance of planktonic Foraminiferida, upward sequential disappearance of Radiolaria, and stratigraphic succession of calcareous nannofossils. A chronology of South Pacific Pliocene and Pleistocene climatic oscillations has been established, based on paleomagnetic and thorium-230 dating. Alternations of cold and warm water planktonic Foraminiferida distinguish 6 intervals of climatic warming during the last 700,000 years (Brunhes epoch) and 10 between 2.4 m.y. and 700,000 years ago (Matuyama epoch). The relative magnitudes of climatic warmings were considerably greater during the last 500,000 years than between 2.4 m.y. and 500,000 years ago. Cooling was at times as intense during the Matuyama epoch as during the Brunhes epoch. This determination conflicts with previous paleotemperature determinations based on radiolarians which suggest somewhat warmer conditions throughout the Matuyama. Several present subtropical radiolarian species, however, apparently lost their environmental tolerance for subpolar temperatures about 0.7 m.y. ago. Climatic curves for planktonic forams and radiolarians are essentially the same for the late Pleistocene, confirming the usefulness of both groups in paleoclimatic studies. Fluctuations of certain calcareous nannofossil species closely follow radiolarian and foraminiferal paleotemperature oscillations for the last 400,000 years but diverge strongly in older core sections. Abundances of the silicoflagellate genera, *Dictyocha* and *Distephanus*, clearly mark warm- and cold-water intervals respectively in late Pleistocene cores.

The first appearance of ice-rafted quartz in the sub-Antarctic, about 5 m.y. ago, coincides with increases in bottom-transported quartz, suggesting a relation between increased bottom-water activity and Antarctic glaciation. Distinct changes in the radiolarian assemblages also occur at this time.

Studies of land-based marine sections in New Zealand and of deep-sea cores have shown that the first major late Cenozoic cooling occurred during the late Miocene and earliest Pliocene when south-central sub-Antarctic planktonic foraminiferal faunas (approximately 55°S equivalent lat.) spread over central New Zealand. A further major cooling during the middle Pliocene spans the Gauss-Matuyama boundary ($t = 2.43$ m.y. ago). This cooling was followed by more fluctuating climatic conditions in the late Pliocene and early Pleistocene (lower and middle Matuyama; $t = 2.43$ to 1.60 m.y. ago). Evidence of possibly synchronous late Miocene cooling has also been reported in California, Italy, Japan, and the equatorial Pacific.

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Geologic Factors that Control Thickness and Composition of Upper Pennsylvanian Coals in Appalachian Basin

Most of the sulfur and ash in the Pittsburgh coal of southeastern Greene County, Pennsylvania, are thought to be syngenetic. Variations in sulfur and ash probably were controlled by paleoenvironmental factors. Northeast-trending belts of thin, low-sulfur, low-ash coal coincide with structurally high areas; and a belt of thicker, higher sulfur, higher ash coal coincides with the trough of a major syncline. The thickness relations suggest that folding was contemporaneous with peat accumulation, and that the folds produced linear northeast-trending paleotopography which was covered by the ancient peat-producing swamps. The slight local relief would have affected water depths and associated anaerobic conditions. Sandstone-filled stream channels in the rocks below and above the Pittsburgh coal trended northwest across the old topographic grain. Compositional variations in the coal are independent of variations in type of overlying rock.

Northeast of Pittsburgh, Pennsylvania, the upper Freeport coal has no partings on depositional and structural highs; it has one parting on the flanks of the highs; and it has two partings in lows. Between Pittsburgh, and Brookville, Pennsylvania, northeast-trending areas of high sulfur in the upper Freeport and lower Kittanning coals coincide with each other and with areas that were topographically and structurally low when the coals were deposited.

Penecontemporaneous structural control of coal thickness and composition is evident within and east of a northeast-trending zone on the east side of the Appalachian basin, across which 300-ft fold amplitudes increase abruptly to 600 ft. The control was not effective in areas west of the zone. Folds on the west probably are younger than those on the east, and they did not affect deposition of Upper Pennsylvanian coal.

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PATTERNS OF COASTAL SEDIMENTATION: CARBONATE MUDS OF FLORIDA BAY

Muddy carbonate sediments of Florida Bay have accumulated in response to hydraulic processes characteristic of coastal environments. These processes are reflected in faunal distribution as well as physiography of the accumulations. The frequently encountered coastal sedimentary pattern of "banks," "lakes," and mainland veneer is expanded laterally in Florida Bay because of topography of the underlying Pleistocene rock surface.

In Florida Bay the dominant physiographic pattern consists of circular "lakes" of deeper water surrounded by curvilinear banks and islands. The banks, composed predominantly of mud sediment, reach within a foot or so of mean sea level and are largest in the western bay nearest the open Gulf of Mexico. The northeastern ("interior") segment of the bay is characterized by narrower banks, in many places exposed subaerially as islands.

Spitlike accretion is apparent from growth lines on islands and some banks. This indicates locally directed currents; however, overall randomness of orientation and circular patterns of sediment distribution suggest that significant currents develop in all directions. The larger submerged banks of the "outer" bay display prominent accretion lines and are in addition elaborately channeled. The channeling follows a distinctive cycle of establishment and decline that seems closely related to bank growth.

Current control of deposition of muddy sediments is reflected also in the ancient sedimentary record, notably the Pennsylvanian Virgil "mounds" near Alamogordo, New Mexico, and Pennsylvanian Lansing "mounds" in southeastern Kansas. Sediment-baffle processes previously proposed for the construction of mound-topography appear unneeded inasmuch as current processes may achieve similar results.

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CHANNEL SEQUENCE DEVELOPMENT IN AGGRADATIONAL STREAMS WITH EXAMPLE FROM SOUTH CANADIAN RIVER, TEXAS

At least 8 channel sequences of varying relative age have been observed in the floodplain of the South Canadian River. These sequences initially identified by vegetational differences on aerial photographs probably represent deposition during major flood events. Surface features on the most recent channel sequences include longitudinal bars, elongate scour marks, and extensive ripple-marked areas near bars. Within an individual sequence the only sedimentary structure types observed are plane bed, trough cross-stratification, and ripple cross-stratification. Channel sequences, or small divisions within them, are punctuated by mud or silt-mud layers. These layers or clay drapes are deposited as the result of the settling out of fine sediment during waning flood conditions.

Channel sequences older than the most recent 2 or 3 flood events are heavily vegetated and commonly discontinuous downstream. Moving correlation coefficient (r) analysis indicates that the sinuosity and position within the floodplain of channel sequences or remnants of all ages are controlled by the confinement of the South Canadian River valley and location within the valley of earlier sequences. This shows that major floods with a strong aggradational effect are probably a valley-wide phenomenon within this depositional system.

Daily discharge data show that floods, with a discharge of greater than 10,000 cu ft/sec, occur less than 1% of the time in the South Canadian River. These floods are catastrophic events which cause major changes in the configuration of the river floodplain.

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NONSKELETAL CARBONATES FROM BAFFIN BAY, TEXAS

Twenty-five piston cores were taken from Baffin Bay, Texas, and 1 piston core was taken from an adjacent blue-green algal mat lagoon. The cores ranged in length from 85 to 670 cm. X-ray diffraction analyses and scanning electron microscope examination of the carbonate-rich layers in the sediment show that aragonite, calcite, Mg-calcite, and dolomite are all present as nonskeletal carbonates. Each varies from 0 to 100% in the individual samples studied.

Aragonite is the most common carbonate constituent, and occurs as needles less than 4μ in length. However, it also occurs as clusters of radiating needles, whose delicacy seems to indicate that the aragonite formed *in situ* and is not of a detrital origin. Aragonite also occurs as friable, partly lithified material and in 1-mm thick flakes. Calcite and Mg-calcite are found in unlithified muds in the form of anhedral to euhedral crystals $1\text{–}10\mu$ in size. One sample composed of 100% Mg-calcite was semilithified. Dolomite has been reported from the subsurface where it occurs as lithified,