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ORIGIN OF LATE PALEOZOIC CYCLOTHEMS

Cyclic sedimentary sequences of similar origin but diverse manifestations are widespread in later Mississippian, Pennsylvanian, and early Permian successions of the northern hemisphere. They are best developed in cratonic areas, and vary from wholly marine through marine-non-marine alternations, to wholly non-marine. They are associated with widespread coals in many areas, but are equally evident in successions lacking coal.

Their origin has been assigned to (1) intermittent downwarping of sedimentary basins; (2) continuous downwarping; (3) periodic elevation and depression of both source areas and basins; (4) eustatic changes of sea-level associated with (a) alternate growth and wastage of late Paleozoic glaciers in the southern hemisphere and in India, or (b) controlled by diastrophism in the ocean basins; (5) climatic oscillations, and (6) the superposition of subdeltas such as those of the Quaternary in Louisiana.

The present paper attempts to resolve their origin by (1) study of the varied tectonic conditions in areas displaying cyclic successions; (2) environmental mapping of the separate beds of cyclothems through several states; (3) determination of the time and frequency of late Paleozoic glaciers; and (4) critical appraisal of the various mechanisms proposed.

The kinds and quantities of sediment composing a cyclothem at any place are held to be controlled by (1) rate of downwarping; (2) type and quantity of clastic sediment available; (3) distance between sediment source and basin. The varied number of cyclothems in basins and adjacent shelves suggests that many nondepositional periods occurred both between and within cycles.

Eustatic shifts in sea-level through 100 feet or less, controlled by glacial episodes or submarine diastrophism, and climatic oscillations, are judged to be the most probable causes of these cycles.

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TRACE ELEMENT COMPOSITION OF DOLOSTONES AND DOLOMITES AND ITS BEARING ON THE DOLOMITE PROBLEM

Three hundred specimens of "primary" and "secondary" dolostones and 150 specimens of dolomite quantitatively analyzed in triplicate for 20 trace and minor elements statistically yield separate populations of the two major lithologic varieties of dolomitic carbonate rocks for certain trace elements. Histograms, probability plots and measure of the coefficient of variation suggest a lognormal distribution for the trace-element data, which when tested statistically at the 1 per cent level of significance, indicate higher concentrations of Al, Ba, Fe, K, Li, Zn, and Na in the "primary" dolostones. Sr is significantly concentrated in the secondary dolomites separated from the dolostones. On the basis of carbon-oxygen isotope ratios and crystallo-chemical considerations, the dolomite is considered to be a replacement mineral after calcite or aragonite, and the abundance of Sr in "secondary" dolomite is interpreted as a minor impurity originally derived from metastable aragonite and entrapped in the dolomite structure. For the samples studied, trace element patterns appear to suggest that "primary" dolostones (characterized by very fine and uniform grain size; complete absence of fauna, relict textures and phantom structures; lack of appreciable porosity; relatively light color; frequent fine lamination; conchoidal fracture; and association with evaporitic sequences) may represent the early replacement of predominantly calcitic limestones under conditions of somewhat above normal salinity; "secondary" dolostones (characterized by relatively coarse and non-uniform grain size; euhedral dolomite rhombs; frequent oölith, pellet, and fossil relict textures; or organic fossil remains) may represent the early replacement of predominantly aragonitic limestones under normal marine conditions. A specific example of Ordovician Nittany dolostone comprising alternating zones of "primary" and "secondary" dolostones confirms the relationship evident in samples differing widely in age and geographic location.

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PETROLOGY AND LITHOSTRATIGRAPHY OF THE CYNTHIANA AND EDEN FORMATIONS OF THE OHIO VALLEY

Two hundred to three hundred feet of highly fossiliferous limestone, interbedded with abundant shale, are exposed in the Ohio Valley. The monotonous apparent uniformity of these Ordovician rocks (Cynthiana and Eden) has long discouraged lithostratigraphic work. Studies of the past several years have demonstrated that lithostratigraphic analysis is possible and useful.

Petrographic conclusions are based on standard methods. Lithostratigraphic methods of greatest effect are the computation of curves of clastic ratio, bedding index, and frequency of limestone types from detailed measured sections.

The "shales" include beds of shale, siltstone, and some mudstone. They consist largely of clay and fine and medium silt of illite, chlorite, quartz and pyrite, and about 15 per cent calcite. The fineness of these evenly layered muddy rocks and the variety of thicknesses of the beds indicate that the persistent sedimentary accumulation in the region was fine terrigenous detritus that was locally and intermittently interrupted by accumulation of biogenic carbonate debris.

Biogenic limestones in a limited variety of textures and structures occur in beds ranging from thin laminae to ledges about a foot thick. The silty limestones are laminated and cross-laminated. Pararipples are common in the coarse shell-fragment ledges and are thought to have been formed by surf and tidal currents augmented by waves. Submarine slump structures are conspicuous at several levels in the Cynthiana limestone, and occur typically in the fine-grained silty limestones. The principal diluent of calcite in the limestones is quartz silt, much of which is authigenic.

Several limestone texture-structure systems are repeated many times. These form the basis of a practical classification of the limestones which aids environmental interpretations. Limestone beds were formed of debris originating in local colonies of benthos on the sea floor, which appear to have been concentrated on low swells along the shoal forming the incipient Cincinnati arch. Such colonies were intermittently destroyed and the debris sorted into lenses of different texture. Continual alteration of the topography of the sea floor and the sites of colonies of benthos led to the interbedded limestones and shales preserved today.

For the future, attention to the pararipples and pos-