and calcification of dolomite and anhydrite or gypsum have occurred.

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PALEOECOLOGIC ASPECTS OF TRACE FOSSILS[1]

Many physical aspects of the depositional environment in which some rocks are formed may be reconstructed with the aid of trace fossils such as tracks, trails, borings, or other evidences of organism activity. Trace fossils are extremely abundant in sedimentary rocks of all ages, but commonly have not been used by geologists as an aid in paleoecologic interpretation. Water depth, salinity, current action, relative acidity, kinetic energy of the depositional environment, rate of sedimentation, and mode of life of the organisms may be deduced by using trace fossils as an interpretation tool.

Orientation of trace fossils in beds may indicate approximate directions of current action, whereas the type of trace preserved connotes the habitat preferred by the organism. Vagile, benthonic, filter-feeding organisms commonly build nearly vertical burrows; detritus-feeding organisms tend to burrow horizontally. Filter-feeders live in an environment where the current velocity is sufficient to winnow fine particles; detritus-feeders live where fine-grained sediments and finely divided organic matter slowly settle from the water. Delicate tracks and trails preserved in rocks are indicators of a calm environment and slow sedimentation rate, whereas tubes, burrows, and borings are built and preserved in current-activated waters.

In sedimentary rocks that are lacking skeletal or body fossils, trace fossils are valuable aids for use in reconstructing the physical history of the depositional environment.

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UPPER DEVONIAN AND LOWER MISSISSIPPIAN SEDIMENTARY RECORD, WESTERN CANADA SHELF

Western Canadian Upper Devonian and Lower Mississippian shelf rocks, several thousand feet thick, are characterized by three sedimentary domains: a carbonate-evaporite area on the southeast (Saskatchewan), a central area dominated by carbonates (Alberta), and a terrigenous clastic and argillaceous carbonate area on the north (northeastern British Columbia). The carbonate-evaporite and carbonate domains include sabkha-type microdolomite-evaporite cycles, as well as barriers and blankets of skeletal and nonskeletal limestones. Although many of these rocks compare closely with sediments of certain Holocene carbonate settings, the makeup of these fossil sediments tends to be distinctive at various stratigraphic levels.

To illustrate: within the carbonate domain (Alberta), the Frasnian Stage contains wave-resistant organic reefs in which stromatoporoids and colonial corals are abundant. In contrast, reefs, stromatoporoids, and colonial corals are almost unknown in Fammenian strata, most of which form an extensive blanket of nonskeletal limestone with evaporites and redbeds on the east. A widespread black shale unit caps the Fammenian. Kinderhookian rocks are argillaceous carbonates in which echinoderm detritus increases upward. Although colonial corals reappear in the Kinderhookian, the Mississippian lacks organic reefs. The Osagian is distinguished by an explosive and geologically unique development of echinoderms—the main source of the enormous volumes of skeletal sands of this age which cover much of the area—and also contains well-developed cyclic lagoon-sabkha sediments.

Two dominant factors that influenced Late Devonian–Early Mississippian sedimentary patterns on this continuous shelf are oscillatory variations in water depth (probably tectonically controlled) and change in composition of the dominant fauna and flora from frame-builders to sediment-contributors.

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FORAMINIFERAL TEST AS AN ENVIRONMENTAL BUFFER

Despite many studies of foraminifers, very few suggestions have been made concerning the function of the test. If the adaptive significance of the test were known, this would provide a theoretical basis for understanding the ecological importance of test shape and construction.

Observation of the behavior of many shallow-water species in response to environmental changes indicates that the test may function as a chemical and physical buffer between the organism and the environment. Shallow-water foraminifers construct a test of much larger volume than needed merely to house the living protoplasm. Under conditions of stress, *Sorites, Planorbulina, Bolivina, Discorbis,* and miliolids occupy only the inner chambers of the test; the outer chambers may be filled with a less dense, highly vesiculate cytoplasm, or may be empty. If the individual chambers of the test are connected only through one or a few small openings, adverse osmotic effects produced by changes in salinity can affect the protoplasm only slowly. Complex tests may thus serve as a baffle to reduce the rate of chemical diffusion.

Some chambers are sites of concentration of symbiotic algae. In *Elphidium,* algal-filled chambers are in communication with each other, but the apertures of the final chamber are sealed. The foraminifer communicates with the outside only through the tortuous passageways of the canal system except during relatively brief intervals of chamber addition. The test functions as a protected greenhouse for the foraminifers' symbiotic algae.

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ENVIRONMENTAL INTERPRETATION OF UPPER PART OF MESAVERDE FORMATION, NORTHWESTERN COLORADO, FROM OUTCROP, CORE, AND SUBSURFACE STUDY

Various lines of evidence, such as the vertical succession of gross lithologic character, textures, and sedimentary structures, the fauna, and the geometry of rock stratigraphic units, indicate that the upper part of the Hayden Gulch outcrop section of the Mesaverde Formation in northwestern Colorado is a sequence of former barrier islands and lagoons intertonguing with overlying offbeach marine shale of the Lewis Formation. The collective criteria used to recognize the different depositional environments at the outcrops were readily apparent in a core taken along depositional

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