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Dolomitization of Upper Cambrian Bonneterre Formation, Southeast Missouri

The Bonneterre Formation of southeast Missouri contains a wide variety of dolomites and dolomite textures which are the results of multiple episodes of dolomite formation. The Bonneterre Formation crops out near the St. Francois Mountains at the core of the Ozark dome and is host for several large Mississippi Valley-type Pb-Zn deposits. The Bonneterre is predominantly a dolomite where it crops out, but contains limestone in the subsurface.

The Bonneterre was deposited by a series of shoaling-upward depositional cycles. A complete cycle was terminated by a tidal-flat complex which prograded basinward. The top of a completed cycle is a disconformity. Recognition of major transgressions which begin some of the larger cycles provides a basis for correlating the Bonneterre throughout southeast Missouri.

Several cores from diamond-drill holes drilled for Pb-Zn ore were logged and sampled for thin sections and trace-element geochemistry. Based on petrographic and stratigraphic relationships observed in the cores, the dolomites of the Bonneterre Formation can be separated into six types. (1) Tidal-flat dolomites are light gray and fine crystalline. These rocks are finely laminated and contain features indicative of evaporitic environments. (2) White-rock dolomites are coarse crystalline and very light gray. Individual crystals of this rock usually have sweeping or undulose extinction when viewed under crossed nicols. (3) Brown-rock dolomites are generally brownish gray to olive gray and fine to medium crystalline. Sedimentary features are well preserved in some of the fine-crystalline examples of this lithology. (4) Clear rims or zones of dolomite that are epitactic overgrowths on other dolomite crystals are another type of dolomite found in the Bonneterre. This dolomite contains ferroan zones (as determined by staining with potassium ferrocyanide), and is associated with stylolites. (5) Saddle dolomite was deposited in all types of diagenetic pores. (6) Hydrothermal dolomite is associated with Pb-Zn sulfide minerals.

Stratigraphic and paragenetic relationships combined with trace-element geochemistry provide a basis for interpreting the origins of the Bonneterre dolomites. Tidal-flat and white-rock dolomites formed in the near-surface diagenetic environment. Tidal-flat dolomites formed in evaporitic environments similar to modern sabkha environments. White-rock dolomites formed in freshwater-saline water mixing zones. Clear dolomite rims with ferroan zones are interpreted to have formed in the subsurface diagenetic environment and are the results of pressure solution. The formation of brown-rock dolomites involves both near-surface and subsurface diagenetic environments. Saddle dolomite formed late in the diagenetic history of the Bonneterre formation and may be related to the introduction of basinal brines to the southeast Missouri region.

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Occurrence and Significance of Sedimentary Structures in Limestone Concretions, Greenhorn Formation, Northwestern Black Hills

It is now recognized that depositional environments of shales can be expanded beyond the phrase "quiet-water" deposition. One of the difficulties in delineating different depositional environments in fine-grained sediments is that descriptions of sedimentary structures in shales are not common. If the structures are preserved by some diagenetic process, then they can be more readily used in the interpretation of depositional environments. Diagenetic carbonate concretions that formed by the localized precipitation of cement in pore spaces of sediment would be expected to preserve original fabrics. Because of good exposure and greater resistance to weathering, concretions may exhibit features that are difficult to see in the less resistant surrounding shale.

The Greenhorn Formation (Upper Cretaceous) north and west of the Black Hills is predominantly a shale with abundant limestone concretions. The concretions are generally restricted to certain zones. Shale exposures are generally unspectacular. The concretions, which are more resistant to weathering, contain a variety of physical and biogenic sedimentary structures. Commonly the structures are subtle. Polished slabs enhance or reveal structures not apparent in the field. Concretions from a given layer exhibit similar sedimentary structures. Parallel lamination is the most abundant physical sedimentary structure. Laminae range from 0.1 mm (.003 in.) to 1 cm (.4 in.) in thickness. They can be continuous with a constant thickness, continuous with a variable thickness, or discontinuous. Low-angle ripple cross-stratification is present in some laminae. Graded bedding, cut-and-fill structures, and flame structures are also present. Biogenic structures include distinct burrows, burrow-disrupted layering, and thoroughly bioturbated textures.

Depositional textures of the Greenhorn concretions include mudstone, wackestone, and packstone. Major grain types are inoceramid prisms and fragments, foraminifera, quartz, fish debris, and pellets. In some concretions, pellets are deformed indicating compaction occurred prior to cementation.

The range of sedimentary structures, depositional textures, and abundance of quartz in Greenhorn concretions suggests variations in depositional conditions. Some laminae must have been deposited in quiet water with a current velocity close to zero while other laminae must have been deposited by currents of higher velocities. Cross-stratification is evidence that tractive currents were active in depositing and/or reworking the bottom sediments. The biogenic structures provide evidence of infaunal life and bioturbation.

Where shale exposure is good, the same structures are observed in the shale as in the concretions. Therefore, structures in concretions are representative of the surrounding shale at that level. Concretions should not be ignored as a source of information regarding sedimentary structures. They can be valuable in the interpretation of paleoenvironments of shale.

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Cathodoluminescence in Carbonate Petrography: Some Aspects of Geochemical Interpretation

Commonly only Mn^{2+} and Fe^{2+} are considered to be responsible for the luminescence behavior of calcite and dolomite. However, a fairly large number of trace elements interact to produce certain luminescence characteristics in these minerals (as described by Gies in 1975 and 1976). The ions of these elements can be grouped into activators, sensitizors, and quenchers.

Activators are those ions that lead to active luminescence, undergoing excitation (entrapment of energy), temporary storage, and emission. Main activators in carbonates are Mn, Pb, and several rare earth elements. Sensitizors are those ions that undergo excitation and transmit some of this energy to the activators. Main sensitizors in carbonates are Pb and Ce. Quenchers