hydraulic energy has the strongest influences on the morphotypes and distributions of the macroborings. An equivalent macroboring assemblage dominated by sponges and bivalves prevails in both the shallow back-reef zone and the deep fore-reef zone, both of which are low-energy settings. Boring assemblages in more turbulent zones within the reef consist of polychaete and sipunculid worms, sea urchins, and barnacles, with sponges and bivalves less dominant and less abundant. Other environmental factors which may be important locally include: nutrient availability, photic energy, sediment size and sedimentation rate, competition for substrate, and predation pressure upon the live coral tissue. Shape parameters for different boring types are provided as a means of identification and as an indication of the environmental control upon boring shape. An understanding of the variability of boring types with respect to the ambient environment within modern reefs facilitates the use of borings as paleoenvironmental indicators within Cenozoic carbonate systems.

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Early Diagenesis, Atherton Formation (Quaternary), Northern Indiana: A Guide to Understanding Early Cement Distribution in Nonmarine Sandstones

In the area studied, the Atherton Formation accumulated primarily as outwash deposits dominated by trough and wedge cross-bedding. Within sand (86% of deposits; $Q_{77}F_8L_{15}$) and polymictic pebble gravel (14%) units, local cements of calcite (99%) and limonite/hematite (1%) are present. The distribution of these cements was controlled by at least three factors: (1) position within the deposit relative to the land surface, (2) average grain size, and (3) primary stratification.

Over 90% of cement zones are within 7 m (23 ft) of the present land surface. Meteoric waters made more acidic by decaying organic material locally dissolved carbonate framework grains. As pore fluids continued to move downward and laterally, cementation occurred. On a second level, higher permeability zones associated with sediment of larger grain sizes was an important factor influencing the location of cementation. Cemented horizons are present in 48% of pebble and sandy pebble gravels (contact and pore lining types) and 17% of sands and pebbly sands (contact, pore lining, and occluded types). Moreover, within sand units primary stratification was a parameter that influenced the location of cementation sites. In wedge cross-bed sets, cement zones parallel inclined laminations; in trough cross-beds, 79% of the cement is concentrated in the lower one-third of bed sets near trough axes or immediately below a trough's basal erosion surface. Cement zones were preferentially developed along internal curved laminations within cross-bed sets. Higher permeability concordant with stratification, the result of excellent sorting and coarser grain sizes within individual sand laminations, primarily controlled cement distribution at this level.

Carbonate cements in the Atherton range from a trace to 6 mole % $MgCO_3$ ($\overline{X} = 3.6$ mole %) with traces of Fe in 16% of the samples analyzed (205 total analyses). The calcite and Mg-calcite generally form a mosaic of anhedral crystals, although distinct rhombohedra are present in some pores. The source for Mg and Fe is believed related to the dissolution of dolomite and Fe-bearing silicate framework grains. The limonite/hematite cements are present as rare, pore-filling patches.

A comparison of the percent of carbonate grains in uncemented sand ($\overline{X} = 10 \pm 1\%$) and within cemented zones ($\overline{X} = 7 \pm 1\%$) of similar grain size indicates an information loss during very early diagenesis on the order of 20 to 30% of the carbonate framework component. Therefore, the original proportion of carbonate framework grains in ancient calcite-cemented sandstones may be greatly underestimated due to grain destruction during diagenesis.

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Depositional Environments of Pennsylvanian Upper Strawn Group in McCulloch and San Saba Counties, Texas

Upper Strawn Group (Desmoinesean) represents a transition to fluvial facies from progradational deltaic facies. The lower part of the upper Strawn is composed mostly of horizontally bedded, fine-grained sandstones and shales of a distal delta-front origin. These sandstones and shales exhibit foreset bed dips of up to 15°. In addition to the dipping foreset beds, the delta-front facies on occasion contain small listric normal faults, resulting from periodic higher rates of sedimentation. The middle parts of the upper Strawn consist predominantly of massive, fine to medium-grained, mature sandstones which represent distributary-mouth-bar deposits, as well as other proximal delta-front deposits such as distributary channels. The upper part of the upper Strawn consists of fluvial trough cross-bedded sandstones and chert-pebble conglomerates. These overlie the deltaic facies and indicate the final stages of upper Strawn deposition. The upper Strawn is overlain by the Adams Branch limestone and shales which represent marine transgression and subsequent shallow-marine deposition.

The upper Strawn Group in McCulloch and San Saba Counties, Texas, represents continued filling of the Fort Worth basin during Desmoinesean time. The upper Strawn overlies the lower Strawn, an older, deeper water facies, in most parts of the study area. The upper Strawn overlies the Atokan age Marble Falls Limestone in an isolated section of the study area due to its position there on the Concho arch.

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Prediction of Fracture Development as a Function of Structural Position

Fracturing is a mechanism for strain in rock. In many folds developed in sedimentary rock, fracturing is the primary mechanism of strain. The amount of strain produced by fracturing is a function of the amount of offset on individual fractures and the fracture spacing. As a consequence, the assessment of strain in the rock, either by direct measurement or with models, can be used to predict relative fracture density or spacing through a structure. The radius of curvature approach, commonly used to assess fracture distribution on folds, is based on this strain approach, but it is appropriate only for special situations. The shortcomings of the radius of curvature approach are demonstrated, qualitatively, with outcrop examples of thrust-associated anticlines.

Numerical modeling is an alternative and more general technique for predicting the strain, and hence fracture density, developed in geological structures. Comparison of measured shear fracture (microfault) density with the strain derived from numerical models of forced-folded sandstone illustrates the viability of this approach. In addition to strain, numerical models predict the orientation of the principal stress and the magnitude of the mean stress. Whereas it is accepted that principal stress orientations dictate fracture orientation and sense of offset, the effects of mean stress on fracture development are not well established. It appears, however, that mean stress influences the amount of off-