Gallery of Geology - Pennsylvanian paleosol in Sierra County, New Mexico

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Errata: Please note that this is a correction for the February issue of *New Mexico Geology's* Gallery of Geology where the thin section photographs were incorrect. We have reprinted the Gallery of Geology section again here and replaced them with the correct thin section photographs.

Late Pennsylvanian sedimentation in New Mexico was in part affected by global glacio-eustasy, as the ice sheets of Late Paleozoic Gonwana waxed and waned. A primary effect of the glacial cycles may be seen in shallowing upward marine successions in the Pangean tropics, which is exactly where New Mexico was located during the Late Pennsylvanian. The top of one such cycle is very well exposed in Mine Canyon in the Caballo Mountains of Sierra County (section 32, T16S, R3W).

Here, strata of the middle part (Virgilian) of the Bar B Formation include a bed first described by Soreghan (1992) in her unpublished dissertation as a cryptokarst (this is her Caballo Mountains section; also see Soreghan, 1994) The succession begins with about 4.5 m of cherty limestone that is a crinoid-brachiopod wackestone with some shale interbeds. The overlying 1.5 m of limestone is also a crinoid-brachiopod wackestone but lacks chert and the shale interbeds. A sharp and wavy contact surface at the top of the chert-free limestone separates it from 0.6 m of overlying nodular limestone. Above that is 2.9 m of marly yellow shale.

On face value, in the field, this looks like a shallow marine facies (the lower limestones) that was subarerially exposed so that the nodular limestone weathered in a subaerial setting to form a paleosol with calcrete. This is thus a dramatic shallowing upward, often explained as the effect of a glacial drawdown of sea level. However, we should note that this bed succession is only found locally (in Mine Canyon), not in other outcrops of the Bar B Formation (Lucas et al. 2012), so whether or not it represents a widespread, glacio-eustatic event can be questioned. It more likely reflects a very local tectonic or autocyclic depositional event.

If we look at the nodular limestone bed in thin section, it is a mudstone displaying an inhomogeneous texture of nodular fabric, partly clotted fabric with dark gray micritic grains (peloidal grains, glaebules; mostly 0.1–0.5 mm in diameter, some larger grains are present) floating in a light gray micritc matrix. Some of the micritic grains are coated by darker micritic rims. Locally, sparite-filled circumgranular shrinkage cracks are well developed. The mudstone is locally fractured by abundant wrinkled microcracks. A few irregular pores are present that are filled with sparite and separated by interconnecting micritic bridges. We interpret these irregular pores as root structures. All these features indicate that this limestone bed is a paleosol of calcrete nodules.

Soreghan (1992, 1994) noted the presence of numerous exposure surfaces in Upper Pennsylvanian strata in southern New Mexico. These exposure surfaces are marked by laminar calcrete crusts, and features resembling terra rossa, paleosol, and regolith development. Soreghan (1992) identified cryptokarst surfaces but did not define the term cryptokarst, and also did not describe these cryptokarst surfaces in detail.

Field (2002) defined cryptokarst as, "a karst term used to describe (a) the result of subsurface removal of limestone taking place beneath permeable loess resulting in a loss of limestone and subsequent slow subsidence of the loess without noticeable surface expression, (b) the initial effects of intergranular solution of rock when there is practically no movement of water from microcavity to microcavity, (c) the karst that develops in chalk beneath a mantle of its residual clay and chert, and (d) pockets in limestone which are filled with terra rossa or other residual material and which may be actively forming, arrested in development, or 'inherited.' Because this term has been used for at least four different meanings, it is recommended that it be abandoned."

The bed in Mine Canyon illustrated and described here is thus better referred to as a paleosol with calcrete nodules. It represents subaerial exposure of a shallow marine carbonate bed during the Late Pennsylvanian, perhaps by glacio-eustatic causes, though because of its very local occurrence, more likely by tectonic or autocyclic processes.

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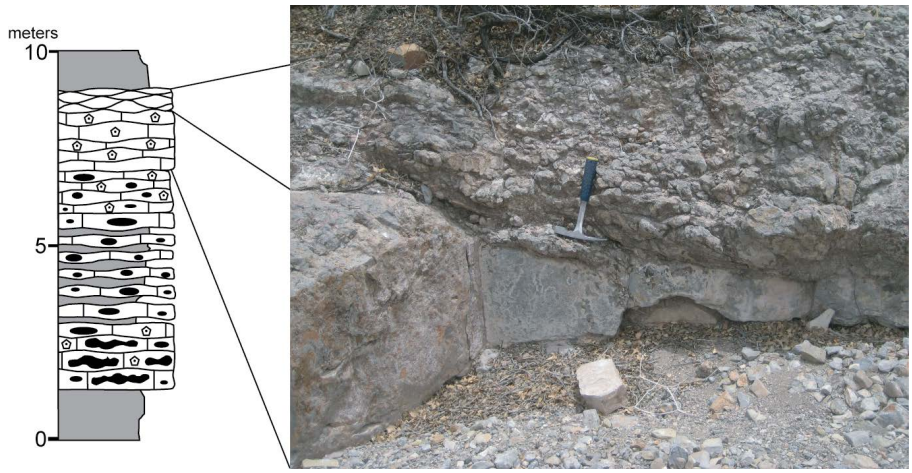
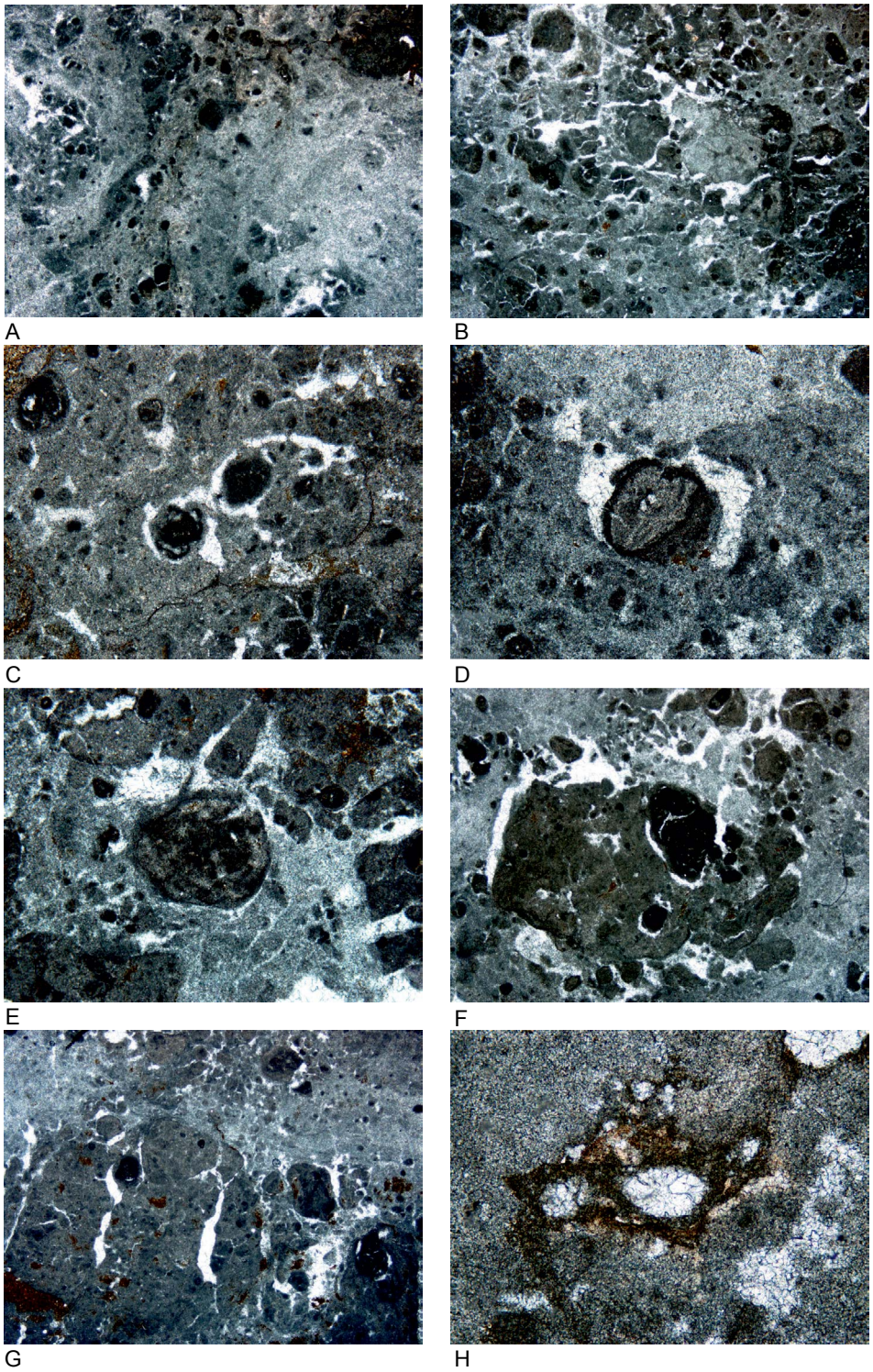


Measured section (on left) at Mine Canyon in the Caballo Mountains, Sierra County, New Mexico, of a portion of the Bar-B Formation (interval 10 meters thick) and corresponding outcrop photograph (on right) of the shallowing upward succession described in the text. The section begins with shale, followed by interbedded cherty limestone and shale, followed by chert-free limestone. There is then a very sharp surface overlain by the nodular limestone here interpreted as a paleosol with calcrete. The photograph shows the sharp surface separating chert-free limestone (below) from nodular limestone (above).



These are thin section photographs of the nodular limestone bed in the Bar B Formation at Mine Canyon in the Caballo Mountains here interpreted as a paleosol with calcrete (all under plane light). A) Shows nodular and clotted fabric containing abundant dark-gray micritic grains floating in inhomogeneous micritic matrix (width of photograph is 6.3 mm). B) Displays clotted fabric abundant microfractures (width of photograph is 6.3 mm). C) Illustrates micritic grains floating in a light-gray micritc matrix. The two grains in the center show well developed circumgranular cracks filled with calcite spar (width of photograph is 3.2 mm). D Shows a micritic grain in the center that has a rim of dark gray micrite surrounded by circumgranular cracks filled with calcite spar (width of photograph is 3.2 mm). E) Illustrates micritic grains of various sizes floating in an inhomogenous micritic matrix. Circumgranular cracks are visible around the grain in the center (width of photograph is 3.2 mm). F) Shows the calcrete with microcracks, partly around micritic grains (width of photograph is 6.3 mm). G) Displays clotted fabric and shrinkage cracks filled with calcite cement (width of photograph is 6.3 mm). H) Illustrates pores filled with calcite cement that are surrounded and separated by interconnecting micritic bridges (root structures) (width of photograph is 1.2 mm).