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Timothy L. Clarey, PhD
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Notes:

Persistence of dolomite in the Coconino Sandstone, northern Arizona

Stephen Cheung and Raymond Strom
Calgary Rock and Materials Services, Inc., #3, 3610 – 29th St NE, Calgary, Alberta, T1Y 5Z7

John H. Whitmore
Cedarville University, 251 N. Main St., Cedarville, OH 45314

Study of hundreds of thin sections, in conjunction with x-ray diffractometry data, from numerous outcrops located in northern and central Arizona has revealed the occasional, but persistent, presence of dolomite as detrital sand grains and as ooids (cored with quartz and feldspar grains) within the Coconino Sandstone. Additionally, four thin beds of dolomite were discovered at Andrus Point, Arizona. This is a surprising finding because the Coconino is conventionally thought to represent an eolian (wind-blown) desert deposit. Dolomite is rather soft (H = 4 on Mohs' scale), compared to quartz (H = 7), and probably would not survive the eolian processes as particles. Beds of almost pure dolomite would also be unexpected within the eolian desert environment. Although the synthesis of dolomite is not well understood, the minerals and, more specifically, the elements required for dolomite genesis are generally unavailable in an eolian desert environment. Previous studies done on the Coconino Sandstone, in particular at Andrus Point, have indicated the presence of carbonate rock but did not detail the nature of the carbonates (Fisher, 1961). These discoveries, along with some others, suggest it may be time to reevaluate depositional models of the Coconino Sandstone. This study is being undertaken as part of the Flood-Activated Sedimentation and Tectonics (FAST) project of the Coconino Sandstone; funded by the National Creation Science Foundation (NCSF) and Calgary Rock and Materials Services. We thank them for their generous support.

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Grain size and textural characteristics of sediments from modern sandwaves: a literature review

Paul Garner (Biblical Creation Ministries)
54 Frank Bridges Close
Soham Cambs
CB7 5EZ
United Kingdom

Introduction. Sandwaves are extremely common bedforms in tidally-dominated shallow marine and estuarine environments and have been suggested as a possible modern analogue for certain cross-bedded sandstones in the stratigraphic record. This includes some sandstones previously interpreted as eolian in origin. An earlier review looked at the range of environments and conditions in which sandwaves develop, as well as published data on external morphologies and internal sedimentary structures (Garner 2008). This review extends that study with a consideration of the grain size and textural characteristics of sediments sampled from modern sandwaves. This study is being undertaken as part of the Flood-Activated Sedimentation and Tectonics (FAST) project funded by the National Creation Science Foundation (NCSF).

Methods. Using the GeoRef database and a variety of other sources, several studies reporting the sampling and characterization of sediments from modern sandwaves were identified. Particular attention was paid to those describing the distribution of grain sizes within individual sandwaves in order to discern any obvious patterns or trends.

Results. Sandwaves typically develop where the most prevalent sediment size range is from 0.25-0.5 millimetres and they are absent where mud comprises more than about 10-15 percent of the bottom sediment (Garner 2008). Harvey (1966) reported sandwaves from the Irish Sea in which finer and better sorted sand was found on the crests than in the troughs. Likewise, Drapeau (1970) reported sandwaves on Browns Bank, Nova Scotia, in which the crests were dominated by well-sorted and medium sand, while the troughs contained coarser sand and shell fragments. King (1964) noted that there was little difference in sediment size from crest to trough in sandwaves at Gibraltar Point, Lincolnshire, England, but the trough material was less well-sorted and slightly coarser.

Field et al. (1981) noted that the sediment on the crests and flanks of sandwaves in the North Bering Sea was fine to medium, moderately well-sorted sand. The troughs contained very fine sand, silt, and local patches or lag surfaces of gravel.

However, by contrast, Houbolt (1968) found that the coarser material in sandwaves off the Dutch coast was on the crests and the finer material was in the troughs and on the flanks. This was also the case in sandwaves on the Middle Ground Shoal in Vineyard Sound, Massachussetts (Smith 1969). Terwindt (1971) found that in two of four study locations in the southern bight of the North Sea, the coarser grain sizes occurred on the crests, with finer sediment in the troughs. However, he found the reverse trend in the third location, and no systematic trend in the fourth.

Different again were the sandwaves in the Bisan Strait described by Ozasa (1974). He noted that the crests were composed of fine, well-sorted sand, the slopes composed of coarse, poorly-sorted sand, and that intermediate size sediment occurred in the troughs.

Finally, Ludwick and Wells (1974) described sandwaves in Chesapeake Bay. They noted that the asymmetrical, migrating sandwaves had coarse sediment on their crests and finer material in the troughs. By contrast, the near-symmetrical, non-migrating sandwaves had fine sediment on their crests and coarser material in the troughs. A bimodal distribution of grain sizes was noted on the crests of the migrating sandwaves and in the troughs of the stationary sandwaves, with a progressive decrease in the percentage of bimodal samples in the direction of net sediment transport.

Conclusion. Relatively little is known about the textural characteristics of the sediments found in modern sandwaves, although this review suggests a lack of consistent patterns. There is perhaps a tendency to bimodality, but it is unclear whether this bimodality exists within or between individual laminae in the sandwaves that were sampled. This hampers our efforts to make meaningful comparisons between modern sandwaves and ancient sandstones. Furthermore, unlike modern sandwaves, it is usually not possible to determine whether there are significant grain size differences from trough to crest in ancient sandstones because in most cases the crests are not preserved in the stratigraphic record. This is another confounding factor that needs to be taken into account. Evidently more work on the grain size and textural characteristics of modern sandwaves and ancient cross-bedded sandstones would be desirable.

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Kilometer-scale horizontal movement of fluidized sand associated with uplift of the Colorado Front Range

William A. Hoesch
Independent Researcher

An estimated 1.2 cubic kilometers of fluidized Cambrian sand was mobilized and emplaced in a swarm of dikes along the southeast margin of the Colorado Front Range (Hoesch & Harms, in review, 2009). The parent bed for the sand dikes is the Upper Cambrian Sawatch Sandstone, which rests on beveled crystalline rocks and has a regional thickness of generally less than 20 m. This body supplied sand to dikes of up to 300 m in thickness, indicating considerable lateral flow of sand to injection sites prior to vertical emplacement. This adds to an increasing body of evidence for large-scale sediment remobilization along the margin of the Denver Basin during the Laramide orogeny. The belt of sand dikes closely parallels kilometer-scale reverse faults that raised Precambrian crystalline rocks over up-turned Denver Basin strata. The dikes occupy hanging-wall positions, usually within a kilometer of the main line of displacement, and tend to dip in the same direction but more steeply than the large faults. Dike fissure orientation appears genetically related to reverse fault geometry, and is consistent only with faults that steepen rather than shallow with depth. Approximately 200 dikes have been mapped that range in thickness from one to 300 m, in height to 300 m, and in length to 8 km. Most are under 10 m in thickness, yet collectively the dike complex represents an estimated 1.2 cubic kilometers of injected sand. Dike petrology is very consistent from one end of the 75 km long dike belt to the other, and matches well with only the Cambrian Sawatch Sandstone. Exotic material in the dikes includes angular granite fragments to 15 cm that had obviously been broken from host-rock walls during injection, and rounded mudstone clasts to 5 mm. It is significant that the composition of these mudstone clasts compares favorably with no strata older than Pennsylvanian, and supports an injection event that was Pennsylvanian or younger. An intrusive origin for these sand bodies has been acknowledged by dozens of workers since 1896 yet the mode and timing of emplacement remain controversial. Regardless of whether the Cambrian sand was sourced from the hanging-wall or footwall blocks (both are possible), the question of how dikes to hundreds of meters in thickness were supplied from a parent bed on the order of 20 m thick has not been addressed. Unless reverse faulting was accompanied by a great degree of echanical crowding of Cambrian strata in the footwall block, lateral sand movement on the order of 4 km or greater is indicated for the largest of the dikes. Such large along-dip sand movement has not yet been documented in the strata of the Denver Basin. Injectites of sill-morphology are likely to exist in the subsurface.

Hoesch, W.A., & Harms, J.C. (2009) Sandstone dikes of the Colorado Front Range and their possible bearing on Denver Basin petroleum geology (in review). Invited paper in Basin Research, 16 p.

Persistence and significance of micas in the Coconino Sandstone, northern Arizona

John H. Whitmore
Cedarville University, 251 N. Main St., Cedarville, OH 45314
Raymond Strom
Calgary Rock and Materials Services, Inc., #3, 3610 – 29th St NE, Calgary, Alberta, T1Y 5Z7

The Permian Coconino Sandstone is conventionally interpreted as an eolian deposit; its large cross beds representing the slip faces of fossil wind-blown desert sand dunes. The Coconino generally is composed of 95% quartz sand with feldspars, plagioclase and heavy minerals making up the remaining volume. Thin section analysis from dozens of localities from all over northern and central Arizona has shown the occurrence of rare, but persistent, mica grains (mostly muscovite) from many localities. Often the mica grains are just as large, if not larger, than the fine and medium-grained quartz sand which comprises much of the Coconino. The underlying Hermit Formation contains an abundance of mica, but the grains are on the order of silt and very fine sand size; much smaller than those found in the Coconino. It is unlikely that this was the source of the mica. Muscovite has a hardness of about 2.5; biotite about 2.5 – 3.0; and quartz is 7.0.

We are in the process of studying modern sand dunes, some in the immediate proximity of crystalline mica sources to see if they contain mica grains. In our approximately 30 sample study from a wide variety of outcrops in the Nebraska Sand Hills we have yet to find any mica; it is the largest concentration of eolian sand in the western hemisphere (Ahlbrandt and Fryberger, 1980). It does contain plenty of other remnants of crystalline rocks such as plagioclase and feldspar. We predict that our further studies of modern eolian dunes will not yield much mica because the relatively soft and easily cleaved mica should quickly be destroyed by eolian processes. The presence of widespread, but rare, mica within the Coconino may suggest the deposit accumulated in an aqueous environment, which was able to buffer the destruction of the mica. This study is being undertaken as part of the Flood-Activated Sedimentation and Tectonics (FAST) project of the Coconino Sandstone; funded by the National Creation Science Foundation (NCSF) and Calgary Rock and Materials Services. We thank them for their generous support.

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The Hypogene Speleogenesis of the Cumberland Plateau Grassy Cove Saltpeter Cave System, Cumberland County, Tennessee

Kurt P. Wise
Independent Researcher

Recent review (Klimchouk 2007) and discussion (GSA Technical Session 240 at the 2008 Annual GSA Meeting) of hypogenic process suggests a paradigm shift may be underway in speleogenesis theory. In the old (hypergenic process) paradigm, dissolution occurs at water table, as water from the surface dropping through the vadose zone reaches the top of the phreatic zone. Under these conditions speleogenesis must await the country rock to rise to the water table and the permeability of the overburden to rise enough to allow water from the surface to access the country rock. The rate of dissolution is also limited by the flow rate and acidity of the sinking water. In a creation model such a mechanism limits speleogenesis to late post-Flood times and – especially in dry environments – drops the rate of speleogenesis to impossibly low values.

In the new paradigm, caves form from rising water (hypogenic process). In this paradigm speleogenesis does not have to await unroofing of country rock or even the dewatering of the continents at the end of the Flood. In fact, the creation model provides orders of magnitude more water and dissolution conditions for hypogenic speleogenesis than conventional geological models. Extra water is derived from the degassing of igneous bodies intruded many times faster than conventional models and the dewatering of thousands of feet of rapidly deposited and rapidly buried water-lain sediments. Water is mobilized at very much higher rates due to the water-cooling of magmas and rapid vertical displacements of water-soaked sediments. Dissolution rates are higher due to a greater number of sources of low pH, more mixing zones of waters of different chemistries, and higher cooling rates of rising waters.

Whereas hypogenic speleogenesis is accepted now for ‘atypical’ caves such as Wind and Jewel Caves in South Dakota, the caves of the Guadeloupe Mountains of New Mexico and the gypsum mazes of western Ukraine, the mechanism has not yet been applied to the more ‘typical’ caves of the world – in particular to the thousands of limestone caves in the Cumberland Plateau of Tennessee and Kentucky. This paper examines one of these cave systems, containing the Grassy Cove Saltpeter Cave (GCSC) of Cumberland County, Tennessee – a cave with most of its eight miles of mapped passage cut into the Mississippian St. Genevieve Limestone – and two other connected caves (Gouffre, Banshee Hole), with more than four miles of additional cave passage.

The following GCSC cave system features are explainable by hypogene and not hypergene speleogenesis: [*rising feeder evidences*:] 1) common low-wall and floor openings with ear-like and domed orifices; 2) fissure openings in some passage floors; 3) common rising wall channels; 4) one gravel-blocked passage bypassed by country rock erosion around and *over* it; 5) most of the verticality of the GCSC system being in the form of rising shafts; [*transverse hypogenic evidences*:] 6) sediment fill is dominantly fine-grained; 7) common ceiling channels, some of them anastomosing; 8) network maze pattern of the ‘attic’; 9) common abrupt terminations of lateral passages; [*rising outlet evidences*:] 10) common blind rising chains of cupolas; 11) rising chains of cupolas and domes leading to upper passages; 12) 3-D branching tree pattern of cave passage in the GCSP system; 13) GCSP system entrances showing no genetic relationship to the modern landscape and seemingly unexplainable by hypergenic process. That the cave is relict landform is further suggested by the fact that 14) active domepits tend to occupy peripheral positions to the overall cave morphology.

I conclude that the GCSP cave system is a relict landform, currently the site of unconstrained vadose drainage, but eroded originally by hypogenic speleogenesis sometime following deposition of Mississippian sediments during Noah's Flood.

The fact that a vast percentage of the thousands of caves in the TAG region have vertical entrance shafts with no genetic connection with surface topography and drainage, suggests that at least a majority of caves in the southern Cumberland Plateau may actually be of hypogenic origin.

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