Formation of Polygonal Fractures in Ooid-rich Carbonate Sand

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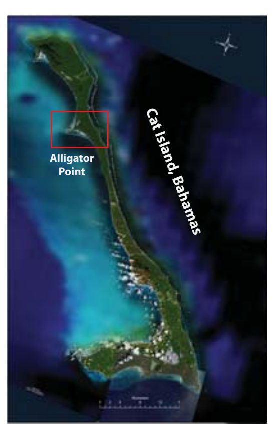
INTRODUCTION

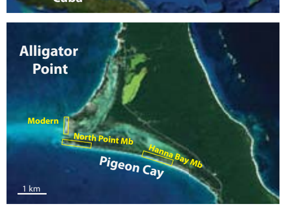
Polygonal fractures are common in lithified carbonate dune and backshore beach sand of Recent to early Holocene age on Cat Island, Bahamas. These fractures are similar to mudcracks that form by drying of muddy sediment, but on Cat Island the fractures are in fine-grained, rounded and well-sorted sand.

OBJECTIVES

This project aims at characterizing the texture and composition of deposits with these unusual fractures and at conducting experiments with sand collected on Cat Island to determine the causes of fracturing.

STUDY AREA





Polygonal cracks were studied in Holocene carbonate deposits of the North Point Member and the overlying Hanna Bay Member of the Rice Bay Formation on Cat Island, Bahamas. (Mylroie et al., 2006) (Images from GoogleEarth)

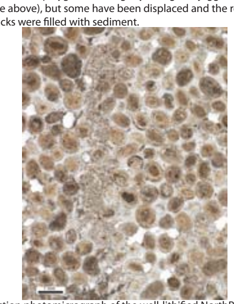
FIELD AND PETROGRAPHIC OBSERVATIONS

4 to 6-sided polygons with jagged edges were observed on horizontal to steeply dipping (35°) bedding planes of:

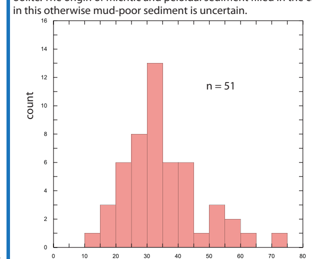
Older Holocene North Point Mb Eolianite

Polygons are present in the North Point Member eolianites, but are not as common nor as obvious as in the overlying Hanna Bay Member deposits.

Most of the polygons have tightly fitting and jagged sides (see above), but some have been displaced and the resulting cracks were filled with sediment.



Thin section photomicrograph of the well-lithified NorthPoint eolian oolite. The origin of micritic and peloidal sediment filled in the crack in this otherwise mud-poor sediment is uncertain.



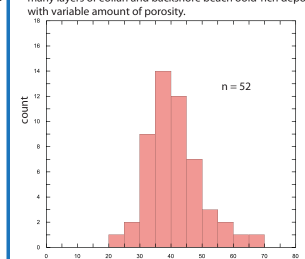
Representative histogram showing the range and distribution of maximum polygon sizes along a bedding plane of North Point Mb deposits.

Younger Holocene Hanna Bay Mb Eolianite

Polygonal cracking is common in Hanna Bay eolianites. The presence of wind ripples supports eolian deposition of carbonate sand.

Some of the bedding planes in the Hanna Bay eolianites are characterized by two-tiered polygons: many smaller polygons are present within a larger one.

Individual cracks can be traced vertically for 80cm through many layers of eolian and backshore beach ooid-rich deposits with variable amount of porosity.



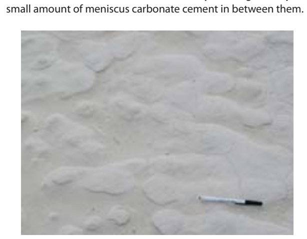
A comparison between the North Point Mb eolianites (to the left) and the Hanna Bay deposits reveals a similarity in the range and distribution of polygon sizes.

Modern Beach Backshore Deposits

Polygons were observed in poorly lithified ooid-rich sand from the backshore beach and its transition into eolian dune deposits.

Polygons produced by cracking of poorly lithified ooid-rich backshore beach sand are very friable and crumble easily.

Thin section photomicrograph of a polygon in backshore beach sand reveals the abundance of ooids barely held together by a small amount of meniscus carbonate cement in between them.



The beginning of porosity reduction causing modern polygonal fractures.

EXPERIMENTAL RESULTS

Polygonal fractures were produced by drying of ooid-rich sand collected on the beach at Pigeon Cay, Cat Island, Bahamas:

The sand is fine to medium grained, fairly well sorted, and composed mainly of rounded, spherical or elliptical ooid grains. Drying resulted in reduction of the pore space in between grains, compaction of sediment by repacking of sand grains (from loose to close packing) and in polygonal cracks that resemble in shape those observed in the field.

To reproduce these results, the dry sand was moistened and placed in 20x20 cm pyrex glass containers as layers of different thickness:

Moist sand:

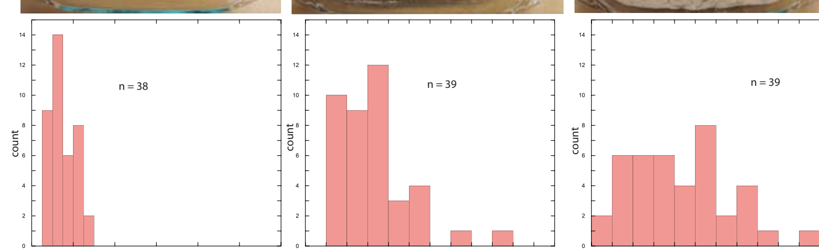
Dry sand:

Layers of moist sand had a substantial amount of porosity. Drying resulted in porosity reduction and polygon cracking.

Dry sand: 1 cm thick

3 cm thick

5 cm thick



The relationship between layer thickness and polygon size was examined by measuring the longest polygon diameter for 1, 3 and 5 cm thick layers.

INTERPRETATIONS AND IMPLICATIONS

- Polygonal cracks are easily produced in mud-free fine grained, well sorted, ooid-rich carbonate sand.
- Cracks form by stresses generated by the reduction of interparticle porosity and repacking of grains due to the loss of cohession during drying of moist sand.
- Such cracks can be preserved in the geological record due to early lithification of carbonate sand.
- The observed positive relationship between sand layer thickness and polygon sizes in the experimental setting is similar to the relationship documented in muddy deposits with dessiccation cracks or mudcracks.

FUTURE WORK

- Petrography of Hanna Bay deposits
- Additional field work to document more ancient and modern examples.
- Experiments involving sand-size particles of different texture or composition.
- Explore relationships between polygon formation and sand layer thickness, sand moisture and pore water chemistry, and the presence or absence of mud.

ACKNOWLEDGMENTS & REFERENCES

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Mylroie, J.E., Carew, J.L., Curran, H.A., Freile, D., Sealey, N.E., and Voegeli, V.J., 2006, Geology of Cat Island, Bahamas: A Field Trip Guide: San Salvador, Bahamas, Gerace Research Centre, 44 p.