PERMEABILITY VARIATIONS IN CROSS-STRATIFIED OOLITIC GRAINSTONES (LATE PLEISTOCENE MIAMI OOLITE)

Donald F. McNeill

PROJECT OBJECTIVES

- To conduct whole-core constant-head hydraulic conductivity measurements on outcrop cores of cross-stratified Late Pleistocene barrier bar facies of the Miami Oolite to assess the range and variability of matrix porosity.
- To provide a flow comparison to solution-enhanced (touching vug) ichnogenic-influenced permeability of the burrow-mottled oolitic pack/grainstones of the tidal shoal complex.

PROJECT RATIONALE

That interest in porosity and permeability of oolitic grainstone still exists can be attributed to both the variability of depositional lithofacies and diagenetic evolution (Harris and Purkis, 2020; Goodner et al., 2020). Harris and Purkis (2020) maintain that the Late Pleistocene Miami Oolite is representative of a grainstone-rich unit that has been surficially karsted and can be used as an analogue for similar units with high permeability. They report that both marine facies and early meteoric diagenesis can impart a potentially long-lived control on fluid flow properties as related to heterogeneity. Two main motifs have long been recognized in the Miami Oolite (Fig. 1) and Harris and Purkis (2020) summarize these as the dip-oriented, tidal bar belt of shoals and shallow channels, and a strike-oriented barrier bar that lies just seaward of the tidal bar belt. The tidal bar belt is commonly burrow mottled packstone/grainstones, whereas the barrier bar (35 km long by 1 km wide, Harris and Purkis 2020) is largely cross-stratified grainstone with lesser, burrowed grain/packstones. From a flow standpoint, the most significant impact is from solution-enhancement of the burrowed facies that leads to touching-vug macropores within a host sediment with matrix pores. Flow is, however, dominated by the touching vug macropores that formed by solution-enhancement of the early burrows (Cunningham et al., 2009).

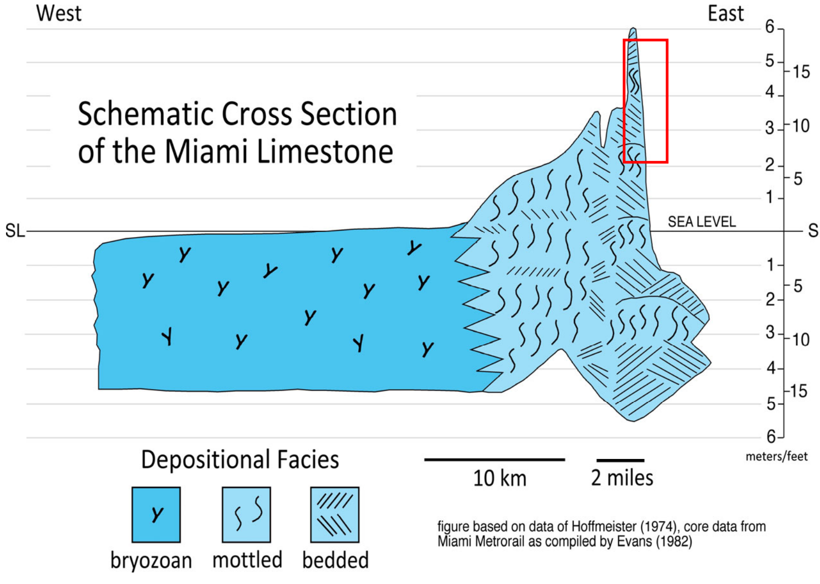

figure based on data of Hoffmeister (1974), core data from Miami Metrorail as compiled by Evans (1982)

Figure 1. Generalized depositional facies for the Miami Oolite tidal shoal and bar complex. This study will focus on the cross-stratified barrier bar deposits along the eastern side of the geobody.

APPROACH

The unit of interest is the Late Pleistocene Miami Oolite (~120 ka), that crops out throughout the greater Miami area. The formation is well studied from the standpoint of the depositional facies, lithology, petrography, sedimentary structures, and diagenesis (Hoffmeister et al., 1967; Halley and Evans 1983; Neal et al. 2008). Parts of the Miami Oolite, generally the burrow-mottled facies, have been well characterized (porosity, permeability) as part of the main drinking-water aquifer (unconfined Biscayne Aquifer) for southeastern Florida. However, flow characteristics of the cross-stratified components (mainly along the eastern barrier bar lithofacies) where matrix flow is dominant has been less studied (Truss et al., 2007; Neal et al., 2008). This is especially true at the bed scale where distinct lithologies occur (e.g. coquina beds at crossbed bounding surfaces) that may influence flow. Several outcrop cores of cross-stratified barrier bar facies, some already collected, will be used for whole-core constant-head hydraulic conductivity measurement (Fig. 2). Core sections up to 50 cm in length will be first analyzed and then sub-sectioned in ~10-15 cm intervals to assess the intra-bed scale variability. A constant-head measurement technique will be used to determine hydraulic conductivity and data will be collected for 4-6 days to allow for full water saturation and flow stabilization. This multi-day flow profile is usually consistent with, and characteristic of the pore types within the bedded oolite.

SIGNIFICANCE

The cross-stratified barrier bar component of the Miami Oolite, an excellent reservoir analog, makes up a significant part of the whole oolitic geobody. The barrier bar component has a predictable geometry (elongate) and orientation relative to the shoal and channel component. Several studies (Harris and Purkis, 2020 and Goodner

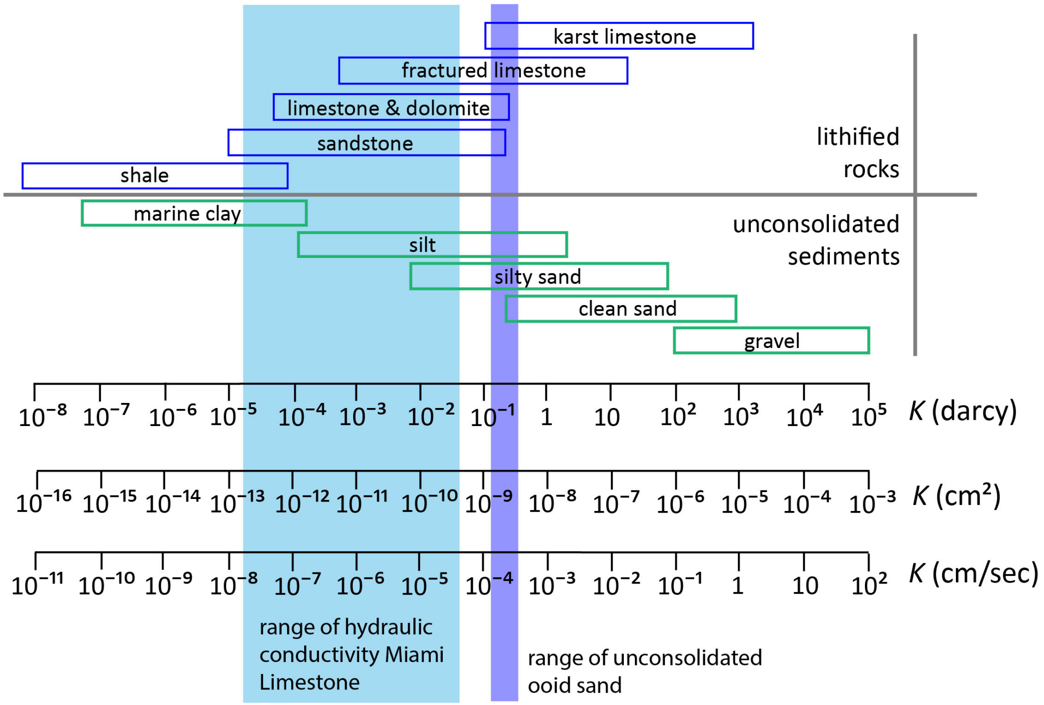

Figure 2. An initial comparison of unconsolidated ooid sand (purple) with preliminary values of the Late Pleistocene Miami Oolite (blue shaded).

et al. 2020) suggest that original sediment texture (grain size, sorting) and early diagenesis have long-lived controls on porosity and permeability even after burial and compaction. Deposition of cross-stratified ooids sand and subsequent meteoric diagenesis (interparticle cementation and ooid dissolution) has produced a predominantly matrix-type pore system (inter- and intra-particle porosity). Goodner et al. (2020) in their study of multi-aged oolitic grainstones have found the pore attributes and permeability are better correlated with grain texture than with cementation and compaction. This study will provide a dataset of hydraulic conductivity values (converted to permeability) that evaluates the flow properties of ooid grainstones that retain both original depositional bedding and the influence of early, pre-burial meteoric diagenesis.

REFERENCES

Cunningham, K.J., Sukop, M.C., Huang, H., Alvarez, P.F., Curran, H.A., Renken, R.A. and Dixon, J.F., 2009. Prominence of ichnologically influenced macroporosity in the karst Biscayne aquifer: Stratiform "super-K" zones. Geological Society of America Bulletin, 121(1-2), pp.164-180.

Goodner, H.M., Rankey, E.C., Zhang, C. and Watney, W.L., 2020. Rock fabric controls on pore evolution and porosity-permeability trends in oolitic grainstone reservoirs and reservoir analogs. AAPG Bulletin, (20,200,127). Halley and Evans 1983 Miami Geological Society Guidebook, 67 p.

Halley, R.B. and Evans, C.C., 1983. The Miami Limestone: A Guide to Selected Outcrops and Their Interpretation: with a Discussion of Diagenesis in the Formation (p. 67). Miami, Florida: Miami Geological Society.

Harris, P. and Purkis, S., 2020. Impact of facies and diagenetic variability on permeability and fluid flow in an oolitic grainstone—Pleistocene Miami Oolite. The Depositional Record, 6(2), pp.459-470.

Hoffmeister, J.E., Stockman, K.W. and Multer, H.G., 1967. Miami Limestone of Florida and its recent Bahamian counterpart. Geological Society of America Bulletin, 78(2), pp.175-190.

Neal, A., Grasmueck, M., McNeill, D.F., Viggiano, D.A. and Eberli, G.P., 2008. Full-resolution 3D radar stratigraphy of complex oolitic sedimentary architecture: Miami Limestone, Florida, USA. Journal of Sedimentary Research, 78(9), pp.638-653.

Truss, S., Grasmueck, M., Vega, S. and Viggiano, D.A., 2007. Imaging rainfall drainage within the Miami oolitic limestone using high-resolution time-lapse ground-penetrating radar. Water Resources Research, 43(3).