UNIVERSITY OF MIAMI
ROSENSTIEL SCHOOL of MARINE, ATMOSPHERIC & EARTH SCIENCE

Exploring tropical marine sediments for geochemical and mineralogical evidence of ichthyocarbonate

Katelyn Arista, Amanda Oehlert

Introduction

Marine fish ichthyocarbonates are an important component of the carbonate pump, which influences atmospheric pCO_2. Sedimentological studies show that fish contribute to the mud grade carbonate sediment, mainly as high-Mg calcite (Salter et al., 2012, 2014). Given their HMC composition, ichthyocarbonate is likely to dissolve in seawater (Woosley et al., 2012). However, recent work suggests that Mg-content alone is not the primary control on ichthyocarbonate dissolution (Folkerts et al., *in prep*), understanding of the preservation of ichthyocarbonate in the sediments is currently lacking.

The goals of this study are to:

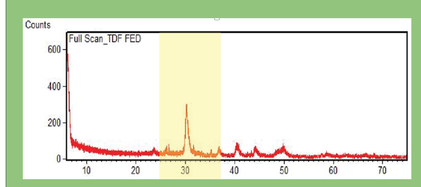
1. **Test a new workflow incorporating sediment mineralogy and stable carbon and oxygen isotope values of sediments from Fiji, French Polynesia, Little Iguana, and Hogsty Reef to create geochemical criteria for likelihood of ichthyocarbonate presence**

2. **Conduct a micro–CT mapping study of the distribution of organic matter in ichthyocarbonate, as a potential control on sedimentary preservation**

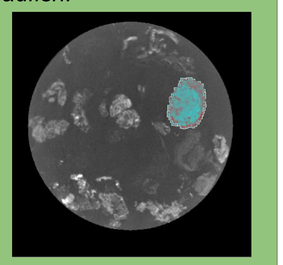
Methods

- Samples collected from Global Reef Expedition (Purkis et al., 2019)
- Mineralogy of samples were analyzed on an X'Pert Pro XRD (PANalytical Inc, Almelo, The Netherlands; Oehlert et al., 2019)
- The $\delta^{13}C$ and $\delta^{18}O$ values of bulk sediments were analyzed using a Finnigan MAT 251 (Thermo Fisher Scientific, Bremen, Germany; Oehlert and Swart, 2014)
- Volumetric analysis of organic matter in ichthyocarbonate was mapped using micro-CT scans collected on a SkyScan 1273 in the College of Engineering using CTan.

Examples of methods conducted on ichthyocarbonate produced by Gulf toadfish:

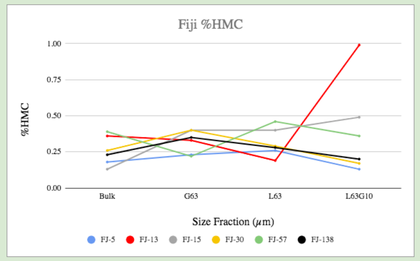


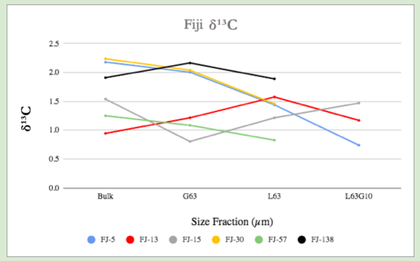
Diffractogram from XRD analysis

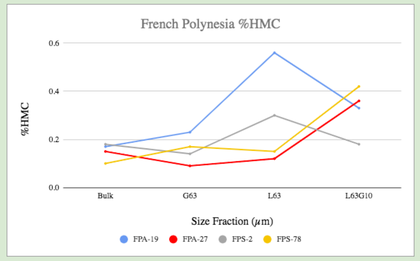


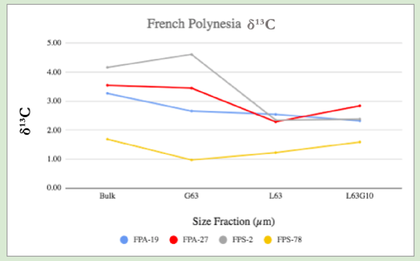
Grain tracing using CTan

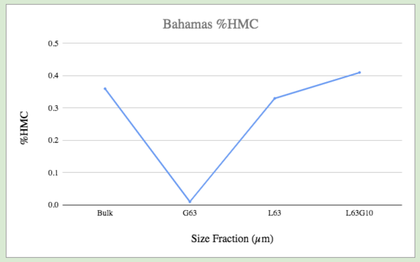
Results: Geochemical Analyses

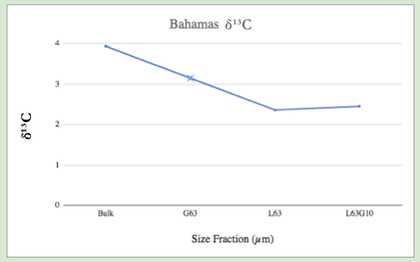




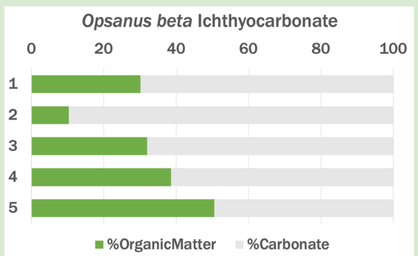








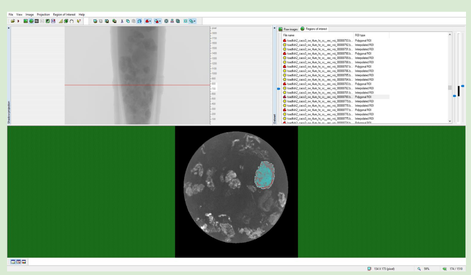
Results: Micro-CT



%Organic matter by volume

3D model of ichthyocarbonate

SkyScan 1273



Workflow in CTan Micro-CT Software

Interpretation

1.Geochemical Analyses

- Low $\delta^{13}C$ values as size fraction decreases is indicative of ichthyocarbonate presence (Oehlert et al., *submitted*)
- Increasing high-Mg calcite content as size fraction decreases is indicative of ichthyocarbonate presence

2. Micro-CT Analysis

- Organic matter comprises 10-45% of toadfish ichthyocarbonate volume, significantly more than indicated by mass (Oehlert et al., *submitted*).
- Organic matter exists as a coating and embedded within the particle, likely to play a role in dissolution rate

Conclusions

- Geochemical criteria tested here shows promising future use in detecting signatures of ichthyocarbonate in sediment
- Distribution of organic matter within the ichthyocarbonate is variable, and hypothesized to be important to dissolution rate and preservation in shallow marine sediments

Acknowledgments

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References

Folkerts, E.J., Oehlert, A.M., Stieglitz, J.D., Heuer, R.M., Grosell, M. (*in prep*). Ichthyocarbonates and the marine inorganic carbon cycle: investigating the potential fates of marine fish-derived carbonates in oceanic environments

Oehlert, A. M., & Swart, P. K. (2014). Interpreting carbonate and organic carbon isotope covariance in the sedimentary record. *Nature Communications*, *5*(1).

Oehlert, A. M., Swart, P. K., Eberli, G. P., Evans, S., & Frank, T. D. (2019). Multi-proxy constraints on the significance of covariant $\delta^{13}C$ values in carbonate and organic carbon during the early Mississippian. *Sedimentology*, *66*(1), 241–261.

Oehlert, A.M., Garza, J., Nixon, S., Frank, L., Folkerts, E.J., Heuer, R.M., Benetti, D.D., del Campo, J., Gomez, F., Grosell, M. (*submitted*). Implications of dietary carbon incorporation in fish carbonates for the global carbon cycle.

Purkis, S. J., Gleason, A. C., Purkis, C. R., Dempsey, A. C., Renaud, P. G., Faisal, M., Saul, S., & Kerr, J. M. (2019). High-resolution habitat and bathymetry maps for 65,000 sq. km of earth's remotest coral reefs. *Coral Reefs*, *38*(3), 467–488.

Salter, M. A., Perry, C. T., & Wilson, R. W. (2012). Production of mud-grade carbonates by marine fish: Crystalline products and their sedimentary significance. *Sedimentology*, *59*(7), 2172–2198.

Salter, M. A., Perry, C. T., & Wilson, R. W. (2014). Size fraction analysis of fish-derived carbonates in shallow sub-tropical marine environments and a potentially unrecognised origin for peloidal carbonates. *Sedimentary Geology*, *314*, 17–30.

Woosley, R. J., Millero, F. J., & Grosell, M. (2012). The solubility of fish-produced high magnesium calcite in seawater. *Journal of Geophysical Research: Oceans*, *117*(C4).