UNIVERSITY OF MIAMI
ROSENSTIEL SCHOOL of MARINE & ATMOSPHERIC SCIENCE

Elemental Analysis of Lime Mud on Great Bahama Bank: Implications for the formation mechanisms of whitings?

Samantha Abelson, Dr. Amanda Oehlert, Dr. Peter Swart
University of Miami Rosenstiel School of Marine and Atmospheric Science

ABSTRACT

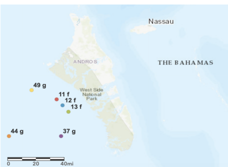
The origin of whitings has been a sedimentological dilemma for many decades despite continued research. "Whiting" describes areas of light, cloudy waters where lime-mud (calcium carbonate) is suspended and eventually deposited. Great Bahama Bank (GBB), a large isolated carbonate platform in the Bahamas, is an area with notable whiting formation particularly in the winter. This study aims to identify if African dust contributes to the formation of whitings in GBB by analyzing the chemical compositions, specifically dust relevant elements (Mg, P, S, Fe, Cu, rare earth elements), in the fine fraction of sediment samples from across the platform top. The results show variability in dust-related elements, and further work is focused on resolving these variations. Lime mud is especially important in early Earth history because it is the primary type of carbonate observed in deep time before the evolution of shell-bearing organisms. Understanding how lime mud forms allows for better understanding of lime mud in the geologic record.

OBJECTIVE

To determine whether African dust contributes to the formation of whitings by looking at dust relevant elements (especially iron and rare earth elements, etc).

STUDY SITE

The six samples analyzed in this study were collected from stations around Great Bahama Bank off of the Bahamas, as shown below.



METHODS

- Samples were previously collected by several research cruises around the Bahamas in the early 2000s by Dr. Peter Swart on the RV Bellows using a Shipek Sampler
- Samples were sieved with the <63 micron sediment subsamples separated and powdered using an agate mortar and pestle
- 100-150 mg of subsample was weighed using a Mettler Toledo XSR Analytical Balance scale
- Powdered samples were then diluted in 1% ultra trace grade nitric acid and again with HCl in a class 100 clean room
- An Agilent 8900 Triple Quadrupole ICP-MS was used to analyze the elemental concentrations of the samples

RESULTS

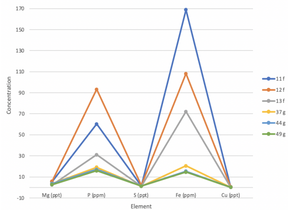


Figure 1: Concentrations (ppm) of the dust relevant elements (Magnesium, Phosphate, Sulfur, Iron, and Calcium) analyzed in the six samples from Great Bahama Bank used in this part of research.

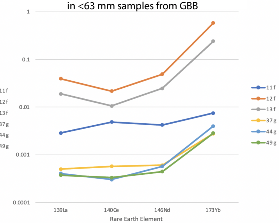
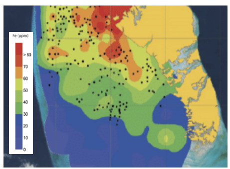


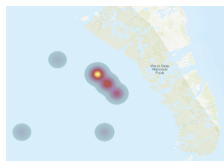
Figure 2: Concentrations (ppm) of PAAS-normalized (Pourmand et al 2012) rare earth elements (Lanthium, Cerium, Neodymium, Ytterbium) analyzed in the six samples from Great Bahama Bank used in this part of research.

Table 1 (Right): Concentrations of all elements analyzed in the six samples from Great Bahama Bank used in this part of research. Values have been rounded. REE concentrations were normalized to values of Post-Archaean Australian Shale (PAAS, Pourmand et al., 2012).

Sample	Mg (ppt)	P (ppm)	S (ppt)	Fe (ppm)	Cu (ppt)	La (ppm)	Ce (ppm)	Nd (ppm)	Yb (ppm)
11 f	5.41	60.28	1.42	168.92	0.27	0.003	0.005	0.004	0.007
12 f	5.75	93.27	1.88	108.15	0.69	0.04	0.02	0.05	0.58
13 f	2.32	31.14	1.07	72.08	0.18	0.02	0.01	0.025	0.24
37 g	3.54	19.14	1.16	20.46	0.23	0.0003	0.0005	0.0006	0.003
44 g	3.54	17.04	1.30	15.43	0.11	0.0003	0.0003	0.0005	0.004
49 g	2.67	15.90	1.17	14.67	0.07	0.0003	0.0003	0.0004	0.003



Figures 3 (left) and 4 (right): Comparison of iron concentration (ppm) of samples analyzed by Swart et al., 2014 and samples analyzed in this research, using subsamples from Swart et al., 2014.



CONCLUSIONS

- Iron present in each sample **supports that nutrients from African dust** transported from the Sahara via wind and deposited in surface waters may be a controlling factor for whiting formation
- All element concentrations are highest in Sample 12 f except for iron, suggesting **spatial heterogeneity in nutrient concentrations** which may be related to cyanobacterial uptake
- Phosphorus present in each sample may have **enhanced primary productivity of picoplankton or phytoplankton** which would lead to a decrease in pCO_2 and increase in $CaCO_3$
- Initial REE results suggest a **seawater-like REE profile** and not African Dust is the main source of REEs to lime mud on GBB, but further analyses including all REEs are required
- Iron concentration is higher in the < 63 µm size fraaction closer to coast of Andros Island, consisent with findings of Swart et al., 2014

ONGOING & FUTURE RESEARCH

- **Increased analyses for more spatial coverage of dataset**
- **Future work could compare:**
  - sediments from core samples
  - additional size fractions
  - whiting samples from the water column
  - seasonal changes in dust concentrations in whitings

Significance

Identifying locations and periods of increased whiting formation could imply times of increased cyanobacteria activity, and vice versa, which could be looked at in the fossil record.

ACKNOWLEDGEMENTS & REFERENCES

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