Rare earth element patterns of modern stromatolites from Hamelin Pool, Shark Bay, Western Australia

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INTRODUCTION

Stromatolites are critical evidence of the earliest traces of life on Earth, yet consensus has not yet been reached regarding the mechanisms by which stromatolites form.

Understanding the significance of Rare Earth Element (La-Lu), Yttrium, and Thorium (REY + Th) records in stromatolites may represent a breakthrough in the understanding of the processes by which stromatolites form and provide insight into the ancient depositional environments in which the stromatolites formed.

This study had two main objectives:

- **Analyze and interpret previously collected REY data analyzed by LA-ICP-MS and sequential leach analysis from modern and ancient stromatolites to determine the most effective method of extraction**
- **Analyze eight samples from Hamelin Pool using the selected method of REY+Th extraction identified in the first objective to assess whether different morphologies across the eight Hamelin Pool Stromatolite Provinces display different rare earth element patterns.**

STUDY SITE

The samples in this study were collected from Hamelin Pool- a hypersaline basin in Shark Bay, Western Australia that contains the highest concentration of modern stromatolites in the world

Suosaari et al., (2015) defined the eight Stromatolite Provinces in Hamelin Pool by distinct stromatolite morphological structures and shelf physiography, and this study used one representative stromatolite head from each of the provinces.

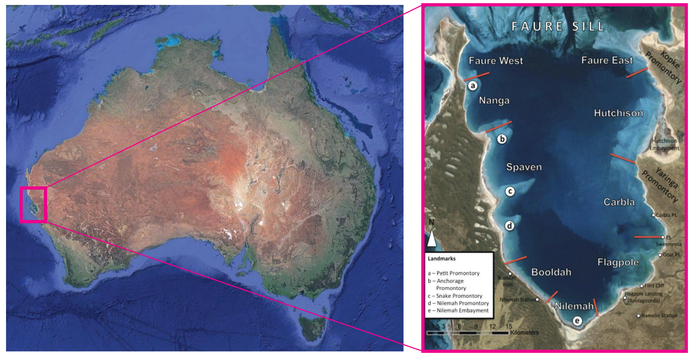

Figure 1: Hamelin Pool in Western Australia, and the eight Stromatolite Provinces within Hamelin Pool as defined by Suosaari et al., 2015. (Image on the right is Figure 5.1 from Suosaari et al., 2015)

METHODS

Determination of appropriate methods

To assess the best method of REY+Th extraction from stromatolites, eight different extraction methods were used on five different stromatolite samples of varying age, level of microbial influence, TOC, and mineralogy. Samples were analyzed on a Neptune HR-ICP-MS at RSMAS, and an Element at Yale University:

- Hamelin Pool Stromatolites
- Bock Cay Stromatolites
- Bahamas Ooids
- Two samples from the Ediacaran in China (LYJP-7-1 and NSP-59)

Hamelin Pool Stromatolites

Samples were drilled from a variety of the 16 different microfabrics found in Hamelin Pool stromatolites as defined by Hagan et al., (2015) within the stromatolites selected to represent each of the Hamelin Pool Stromatolite Provinces.

A sequential leach using Nitric Acid and H_2O_2 was performed on these samples, and they were analyzed on the Agilent 8900 Triple Quadrupole ICP-MS

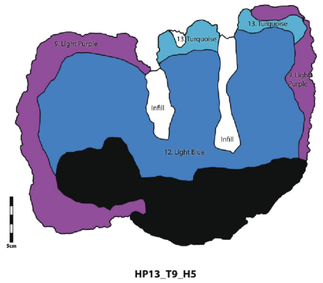

Figure 2: A cartoon of one of the stromatolite heads used in this study, color-coded based on the microfabrics found within the head (Image is in Appendix 1 from Hagan et al., 2015)

RESULTS

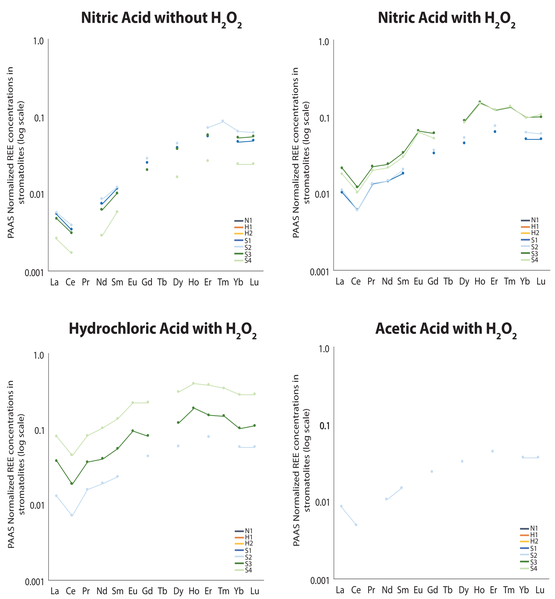

Figure 3: A comparison of four different methods of sequential leach from Bock Cay Stromatolites.

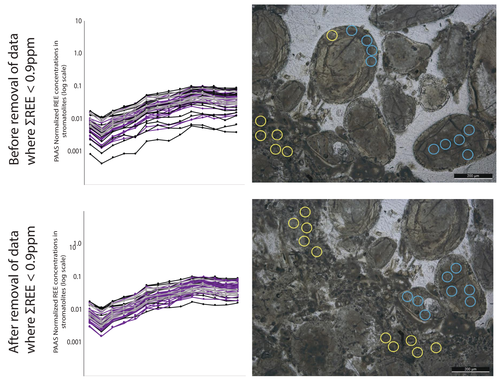

Figure 4: Laser ablation data for the Bahamas Ooids sample and petrographic images of the sampling locations. REY+Th patterns above represent all data collected, and patterns below represent samples where the total REY+Th concentration was greater than or equal to 0.9ppm). According to Li et al., (2019), samples with a ΣREE concentration >0.9ppm contain more reliable data and are better proxies for seawater data than samples with lower total concentrations. Laser ablation is made complicated by the fact that samples are spatially complex three-dimensionally, as well as by the intimate juxtaposition of micrite, ooid cortices, ooid nuclei, and epoxy within the sample.

CONCLUSIONS

Across the eight methods used to extract REY+Th data from stromatolites, **Nitric Acid with H_2O_2 was the most effective** in terms of completely digesting the samples and providing a consistent REY+Th pattern across each sequential leach. This method is therefore recommended for future studies analyzing REY+Th data in stromatolites.

While laser ablation was able to provide the most data points of each of the methods, it is unclear whether the epoxy present in these samples impacted the fidelity of the results as there were high concentrations of REY+Th measured in the epoxy present in the samples.

ONGOING STUDIES

Using the recommended method of REY+Th extraction from this study (Nitric Acid with H_2O_2) seven stromatolite heads from Hamelin Pool will be analyzed to determine the REY+Th patterns of different microfabrics within modern stromatolites.

These samples have undergone the sequential leach process and are currently being dried down on a hot plate, and will be prepped for analysis as soon as they are completely dry.

Understanding the REY+Th patterns across different stromatolite morphologies has implications for understanding the significance of REY+Th signatures collected from microbialites throughout the geological record.

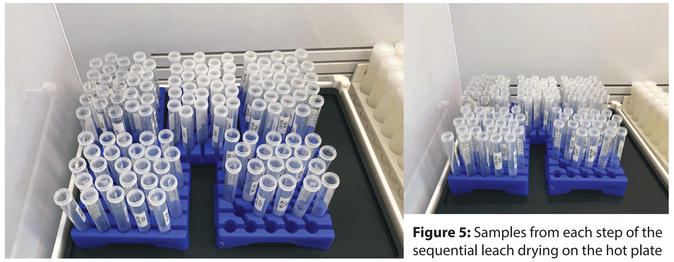

Figure 5: Samples from each step of the sequential leach drying on the hot plate

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