Honors Thesis Proposal

Working Title:
Analyzing Carbonate Strandplain on Crooked Islands, Bahamas by implementing Ground Penetrating Radar (GPR) Imaging and Core Sampling

Project Purpose
The purpose of this thesis is to create an atlas of GPR facies of modern carbonate depositional systems. The Bahamas are one of the few references for carbonate studies (others include Australia and Arabian Gulf). There are several geological anomalies in Bahamas that we wish to emphasize and uncover. For example, my thesis will go in-depth about the strandplains shown on satellite imaging (fig. 1). We already have data collected from San Salvador and Andros Island, which will greatly aid the study on Crooked Islands.

Project Importance
Overall, carbonates and carbonate systems are complex subfields in geological sciences. By understanding modern carbonate environments, like what we currently see in the Bahamas, we can interpret ancient carbonate systems and the processes that were involved. For my thesis, carbonate strandplains make up much of the terrestrial Bahamas platform and are thus important architectural components. Carbonate strandplains can be difficult to identify in the rock record because of its vertical depth and the fine-grain scale of the internal structure. The information found from this project will also be relevant to oil and gas reservoirs.

Project Overview
Current Research. There is a published BYU paper on an island (Andros)[1] and currently, there is a BYU grad student who is implementing a similar study on another island (San Salvador). We already know the basic geologic background of the Bahamas, such as the islands are part of a huge platform- which is why it is shallow-water and then suddenly gains depth when you go 100m out. The carbonate sands are made of ooids and peloids, which are grains that have coated layers of calcium carbonate. In addition, carbonate sand has high porosity and a medium to low permeability[2] which is why they are good reservoirs for oil and gas.

We have already traveled and collected GPR images (fig. 2) and sample cores from Crooked Island. We selected a few regions on the island to conduct our field survey based on 1) how well

[1] Hazard, Colby S., et al. "Ground-Penetrating-Radar Characterization and Porosity Evolution of an Upper Pleistocene Oolite-Capped Depositional Cycle, Red Bays, Northwest Andros Island, Great Bahama Bank." *Journal of Sedimentary Research*, vol. 87, no. 5, May 2017, pp. 523–545. *EBSCOhost*, doi:10.2110/jsr.2017.9.
[2] Simplified, porosity is the presence of holes in a rock while permeability is the tunnels that connect those holes. A high porosity rock can gather fluid easily. Low permeability is the lack of paths that the fluid can escape. Oil/gas reservoirs have rocks that can trap the oil/natural fluid while not letting it escape which makes it ideal for drilling.

the strandplains are preserved, and 2) if we can transverse through overgrown vegetation with the GPR instrument (fig. 3). So far, we have established some basic facts from the preliminary research. For example, the strandplains are caused by the ocean regressing and progressing on the shoreline. The blue and red lines (from fig. 2) are clinoforms that are stacked at ~10 degrees towards the Atlantic Ocean.

Future Research: Sedimentology and grain size analysis will compare vertical and horizontal facies patterns. We will use the samples to do a chemical and physical analysis of the ooid sand we gathered. We can base it on how well it matured, meaning how round and well-sorted the ooid sand is[3]. With chemical analysis, we can see calculate the diagenesis of aragonite turning into calcite[4] which can reduce the porosity in these samples. The less porous a rock is, it might mean that it had time to be exposed to rainwater. We can categorize the levels of porosity and then correlate them the rain cycle in Bahamas.

I want this thesis to assist in developing an atlas of GPR facies on carbonate systems. This project can help compare the similarities and differences between the islands. By doing this thesis, we can discover what major processes created Bahamas- see if each island was made similarly or not. If not, then what makes this island different from the rest? Once that can be satisfied, we can then implement those discoveries on other carbonate regions (like the Great Salt Lake). While studying these sites, we might discover more about oil and natural gas reservoirs which is something a lot of gas/oil companies are interested in.

Thesis Committee

- Advisor: John McBride
- Faculty Reader: Scott Ritter
- Department Honors Committee: Brooks Britt

Qualifications of Thesis Committee

Dr. John McBride is my faculty advisor because I currently his Research Assistant, so he is already involved with a lot of my geological studies. He is a BYU Professor for the Department of Geological Sciences. He went to Cornell University for his graduate degree in Geophysics and was a co-author several GPR articles, including articles about Andros Island, Bahamas. He is a long-time member of AAPG (the American Association of Petroleum Geologists) and collaborated with the Illinois State Geological Survey and the US Geological Survey. He was the one who got me started on the Crooked Island project.

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[3] The more round a grain is, the more is had time to be eroded into a smooth ball. Well-sorted means if the grains are uniform in size- if they are, that means they had more time thus they are older.

[4] Aragonite is already in carbonate sand, but it is unstable. So when it is dissolved by rainwater- it will reform into calcite (a stable form). Calcite is a well-known cement for rocks.

Dr. Scott Ritter has research centered on biostratigraphy and sequence stratigraphy of carbonates. Every two to three years, Dr. Ritter has founded the Spring Bahamas field trip to study limestone depositional environments and their petroleum potential. He was also the co-author for the published article on Andros Island, Bahamas. His contribution to the carbonate sedimentology of the islands will be beneficial to this project.

Dr. Brooks Britt is a paleontologist whose love for vertebrate fossils knows no bounds. He was featured in a multitude of journal publications and was recently famed for discovering the oldest known pterosaur fossil (i.e. Nature Ecology & Evolution). He was appointed a member of the 'Bears Ears National Monument Advisory Committee' and received the Myron G. Best Teaching Award in 2019. There will be marine fossils in the samples we have gathered, so his expertise in ancient biological creatures will be needed.

Project Timeline

February 2019

- Gather GPR data and samples from Crooked Islands

March 2019

- Present preliminary research at the BYU Student Research Conference

April-July 2019

- Work on deciphering GPR dataset (and everything related to the GPR process) in correlation with other resources (i.e. Andros and San Salvador Island)

August 2019

- Research and refine current literature reviews
- Prep for GSA conference

September 2019

- Present research at the GSA conference

October 2019

- Analyze the sample sand gathered from Crooked

November-December 2019

- Write thesis draft (including data on samples)

January 2020

- Polish thesis paper & then publish

February 2020

- Work on poster

March ~~2020~~ 20th, 11th 2020

- Presentation poster and thesis defense

Funding

I will not require outside funding for this project.

Culminating Experience

Already presented:

- 2019 SRC (Student Research Conference) - Brigham Young University, Provo
- 2019 GSA (Geological Society of America) Conference - Phoenix, Arizona

Will present:

- 2020 SRC (Student Research Conference) - Brigham Young University, Provo

Figures

Figure 1. Rough sketches on a satellite image of Majors Bay, Crooked Island. The highlighted red shows the location and orientation of the strandplains.

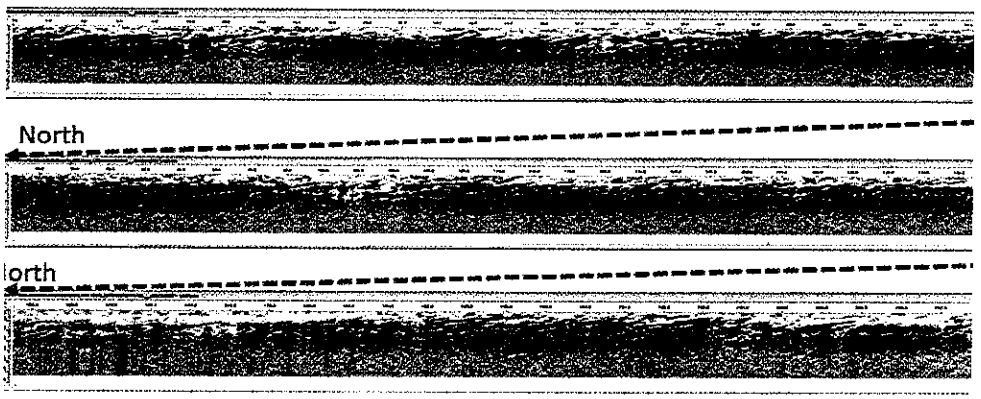

Figure 2. A sample GPR profile that shows the subsurface in the map area shown in figure 1.

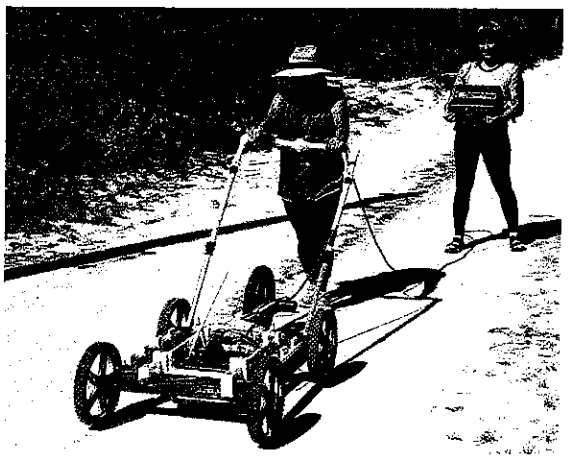

Figure 3. I am pushing the radar portion of the GPR instrument in a custom-made vehicle. This is where the signal is transmitted into the ground. My colleague is holding a device that receives the signal and then displays the images like in figure 2