Nearshore sediment transportation mechanisms, Bonaire, Southern Caribbean

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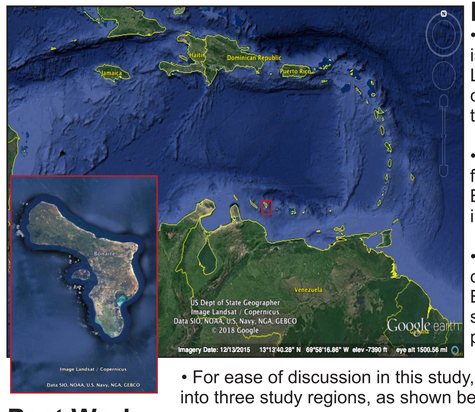
1. Introduction/Background



Geologic Background

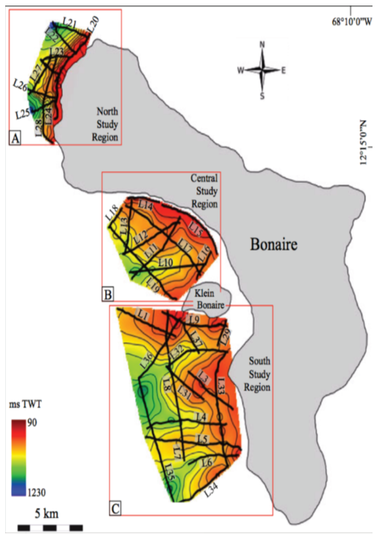
- Bonaire is one of the three islands that makes up the Leeward Antilles and is located roughly 60 miles off the coast of Venezuela.
- Composed of Carbonate formed during the Miocene, Bonaire is a platform overlying an igneous basement.
- Initially formed due to volcanism in the Cretaceous, Bonaire uplifted due to the subduction of the Carribean plate during the Oligocene.
- For ease of discussion in this study, we divided the nearshore into three study regions, as shown below.

Past Work

- The high-resolution dataset was located on the leeward side of the island to try and show the sedimentary pathways and nearshore slope environment and the connection of the nearshore carbonate factory to the deepwater survey.
- Developing a coherent profile was initially complicated by shallow water depth, a thin and spare sedimentary cover, and a hard carbonate seafloor.

Current Work

- Through reprocessing, we hoped to define the morphology that drives sedimentation along the coast.
- Using a series of predictive deconvolution to minimize the bubble pulse and source and receiver ghosts we were able to create a clearer image of the faults, the igneous basement beneath the carbonate platform and the accumulation of sediment in troughs.
- The definition of these features identifies the main sediment mechanisms in the region as gravity drive downslope movement and mass transport.



from Bales (2016)

2. Methodology

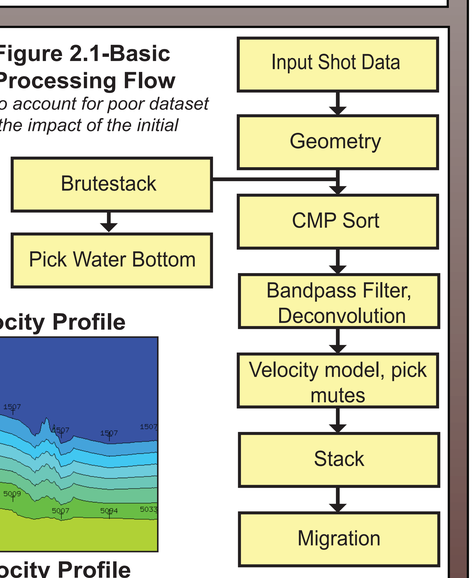
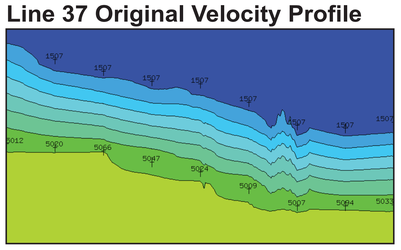


Figure 2.1-Basic Processing Flow

Processing flow redesigned to account for poor dataset depth penetration by limiting the impact of the initial water column to rock boundary — the final processing flow for this dataset based on the work of Kluesner(2018). Black arrows indicate flow direction and include steps not expanded.

Line 37 Original Velocity Profile



Line 37 Updated Velocity Profile

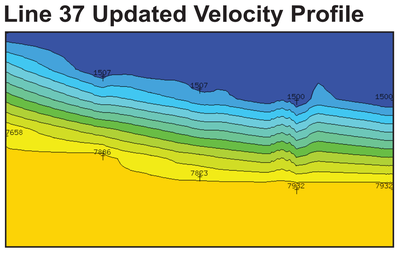


Figure 2.2 (Left)-Velocity Profiles

Comparison of the previously used velocity profiles, and currently used velocity profiles. Increased velocities at shallower depths led to an increase in depth penetration in multiple lines. Each line of the survey had a velocity profile rework.

Key Techniques

- A trio of predictive deconvolutions helped reduce the impact of the bubble pulse and the source and receiver ghosts(**Figure 2.1**).
- Reworked velocity profiles, removal of CDPs smoothed anomalies in the original velocity profiles(**Figure 2.2**).
- Sea floor retrace to account for the presence of out of plane features.

3. Processing Improvements

Figure 3.1-Line 06 Original and New Profiles

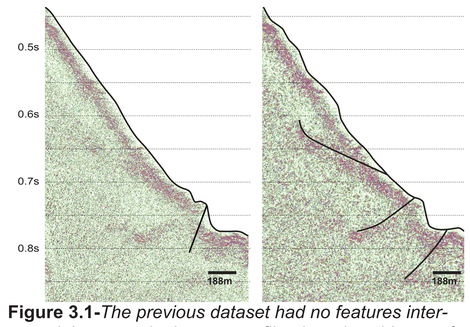


Figure 3.1-*The previous dataset had no features interpreted; however, in the new profile, there is evidence of downslope movement.*

Figure 3.2-Line 37 Original and New Profiles

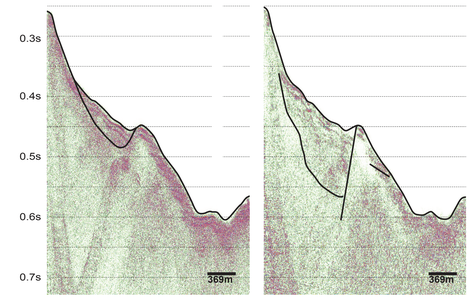


Figure 3.2-*Reprocessing resulted in the resolution of a sediment catchment larger than previously identified, additional indications on a profile of a fault and striations indicative of regional faulting.*

Figure 3.3-Line 13 Original and New Profiles

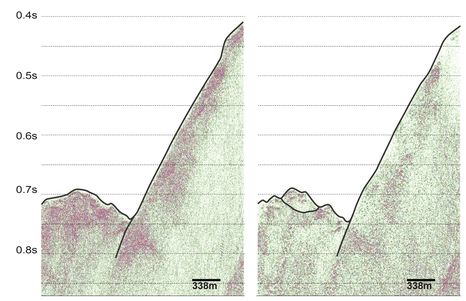


Figure 3.3-*Discovery of a sediment deposit in the reprocessed profile in addition to the clarification of the bounds between facies.*

Figure 3.4-Line 29 Original and New Profiles

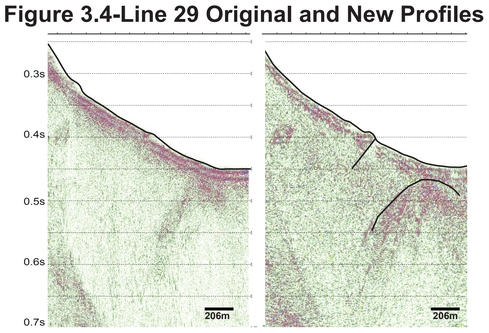


Figure 3.4-*Previous section had no features identifiable, however reprocessing has resolved a fault at the surface and a high amplitude reflector buried beneath sediment.*

4. Processing results

Mass transport deposits (MTDs)

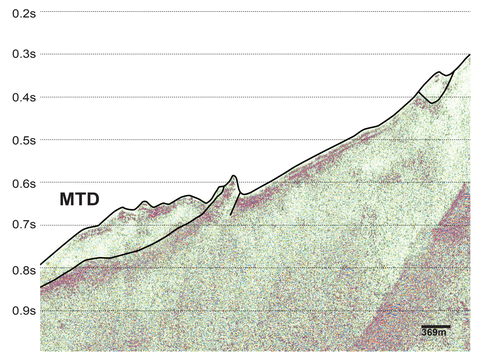


Figure 4.1-*Seismic reflection package on line 32 located in the southern study region. Sediment package from mass transport complex in a trough.*

Seafloor Slumping

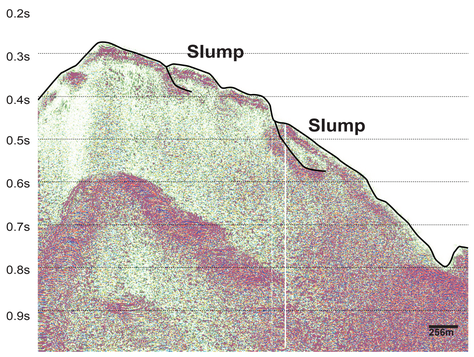


Figure 4.2-*Seismic reflection package on line 31 located in the southern study region. Slumping imaged in the side of a mound.*

Faults, troughs

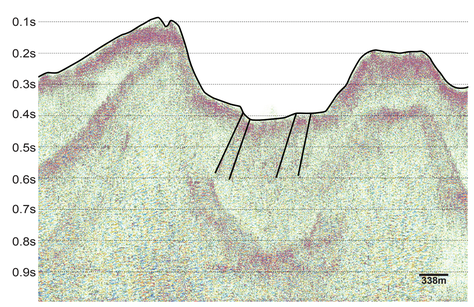


Figure 4.4-*Seismic reflection package of line 15 located in the central study region. Evidence of nearshore reef deposits with sediment-filled troughs.*

Nearshore reef

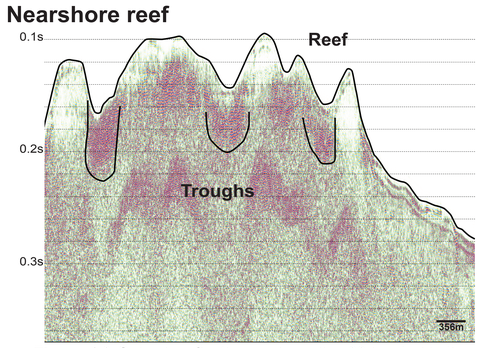


Figure 4.3-*Seismic reflection package line 09 located in the southern study region. Extensional faulting with a low level of sediment accumulation in the trough due to the arid climate of the island.*

Key reprocessing results

- Reprocessing resulted in additional depth penetration of approximately 50 (?)meters in profiles in the southern and central study region.
- The first image of mass transport deposit top and bottom in the study region.
- Additional depth penetration allowed for the differentiation between faults and slumps.
- Sediment depth more fully constrained in the southern study region.

5.Interpretation Results

Map intepretation Symbols

New Faults · New Sediment Packages · Confirmed Faults · Comfirmed Sediment Packages · Refuted Faults · Refuted Sediment Packages

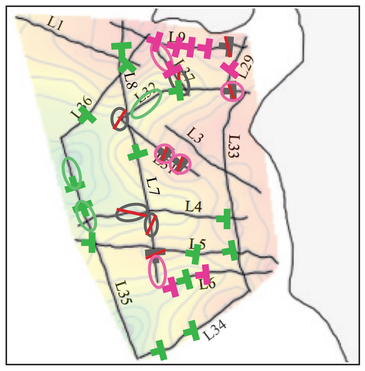


Figure 5.3. *Southern Study region with preliminary interpretation*

Southern Study Region Results

- The southern study region also contains igneous ridges, but have more sediment retention in smaller areas than the central study region.
- Bales (2016) reported that packages are confined to topographic lows, but additional depth penetration shows small deposits located at various depths of profiles.
- Additional regional faulting found closer to the nearshore of Klein Bonaire, is believed to be the result of regional faulting in the South Caribbean Plate Boundary Zone.

Central Study Region Results

- Data within this study region does not show a distinct basin drop off, but it is believed that the elongated topographic highs span beyond our data coverage in the offshore (Bales, 2016).
- The refuting of a large number of faults in this area leads us to believe that this region is less active than previously reported, however, the discovery of additional sediment packages may indicate the bulk of the nearshore sedimentation factory.
- Deeper seismic profile penetration allows for confirmation of the presence of valley-like features consisting of igneous ridges and low level of sedimentation. This sedimentation correlates with current offshore pattern studies and is evidence of mass transport complexes

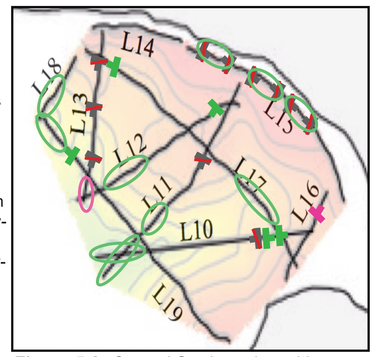


Figure 5.2. *Central Study region with preliminary interpretation*

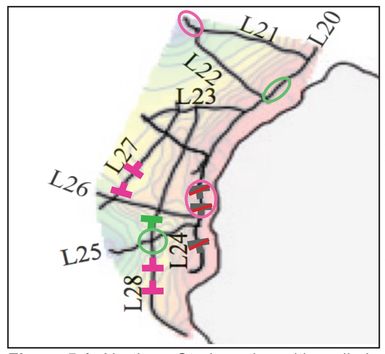


Figure 5.1. *Northern Study region with preliminary interpretation*

Northern Study Region Results

- Steeply dipping seafloor is a result of the early Cretaceous igneous basement uplift in this region (Bales, 2016).
- No evidence was found of carbonate deposits except for small catches along the edge of the island in lines 20 and 24, and a potential small deposit at the bottom of line 21.
- Additional carbonate material present in the northern study region may have been ripped off by high wave energy and transported basinward out of the study region (Engel et al., 2013).

Key results

- Sediment production and transportation to the deepwater is concentrated mainly in the central study region and to a lesser degree in the southern study region.
- Steeply dipping seafloor in the northern study region retains less sediment other regions; however, there is also more regional faulting than previously believed.
- It is now possible to trace the sediment pathways from the sediment producers in the nearshore through the troughs eventually into the deepwater basins.

6. Future Work

- Update work by Bales (2016) and submit for publication.
- Use reprocessed dataset to connect nearshore sedimentary systems to deepwater systems imaged in a legacy USGS seismic survey.

References/Acknowledgments

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- Paradigm for the donation of seismic processing and interpretation software.

- Bales, M., 2016, Geophysical Analysis of Quaternary Marine Sedimentary Processes, Bonaire, Netherland Antilles [Masters Thesis]: Texas A&M University.
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- Kluesner, J., et al., 2018, Practical approaches to maximizing the resolution of sparker seismic reflection data. *Springer Netherlands*, 1-23, https://doi.org/10.1007/s1100