Slope Facies Controlling Processes Along Western Great Bahama Bank*

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Abstract

Models for carbonate platform slope deposition are generally thought to be line-sourced sediments with the grainsize distribution controlled by down-dip orientation of sediment transport. Increased sedimentation is expected on the leeward side of the platform, such as the western slope of GBB, that receives the fines from the producing platform. High-resolution multibeam, subbottom profiles, and a new map based on morphological classification of the area from attributes of bathymetry data reveal the duality of the slope processes in an unprecedented way. The slope facies distribution is a result of: 1) platform-derived gravity-driven sediment transport and 2) the sediment distribution parallel and down-slope by benthic and cascading density currents, respectively. The classic interpretation of the platform margin acting as line-source for slope sediment facies distribution should be refined. Karst features produced during platform emergence influences cascading density currents by confining and channelizing the flow. The regular nature of these karst features (grooves) is responsible for the regular spacing of the plunge pools and gullies. As such, the gullies dissecting the upper slope along southwestern GBB have a hydrodynamic origin. Grain-size distribution is not solely controlled by down-dip, but rather reflects the complex interplay of bathymetry and sediment-transporting currents. Changes in inclination provide hydraulic jumps to transform current regime of downslope currents, which ultimately results in the deposition of characteristic bedforms. Slope-parallel currents erode and redistribute the sediment along platform strike (winnowing), leaving the coarse-grained sediment fraction behind.

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The Evolution of the Holocene Sediment Wedge and its Plunge Pool

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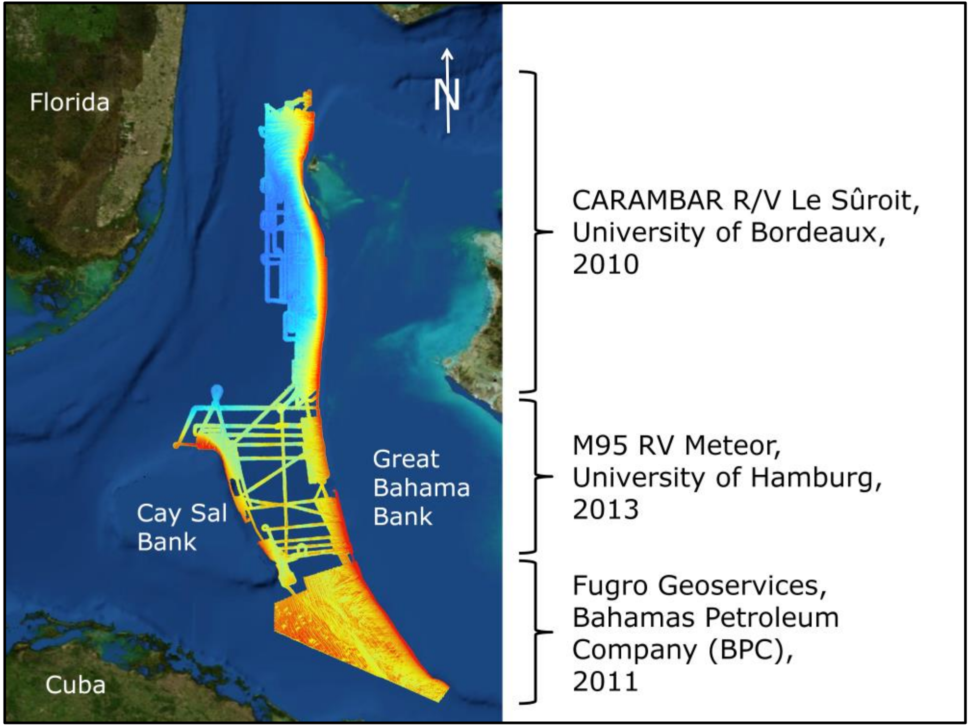
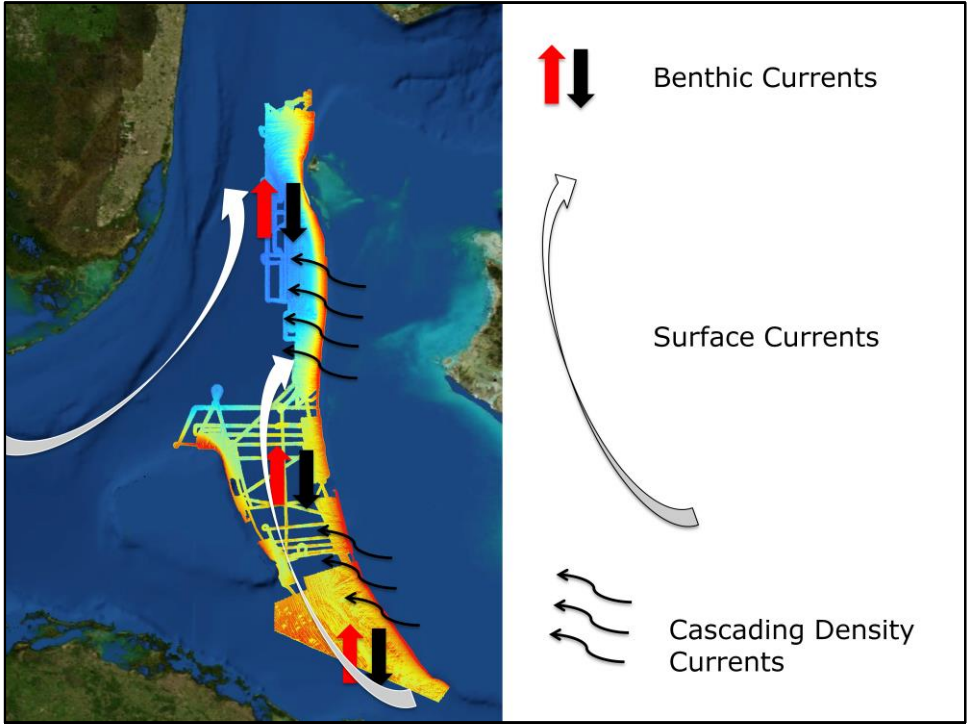


Presenter's notes: In noting the western slope of Great Bahama Bank (GBB), I mean the entire extent of the western slope. This is satellite image of the study area with the bathymetry. This absolutely spectacular dataset, with resolutions from 3m up to 30m, allows studying geomorphology in unprecedented detail.



Presenter's notes: Besides two main surface currents, through the Straits of Florida and the Santaren Channel, benthic bottom currents and so-called cascading density currents, driven through water-salinity gradient in summer and water-temperature gradient in winter, influence the sediment patterns and distribution along the slope

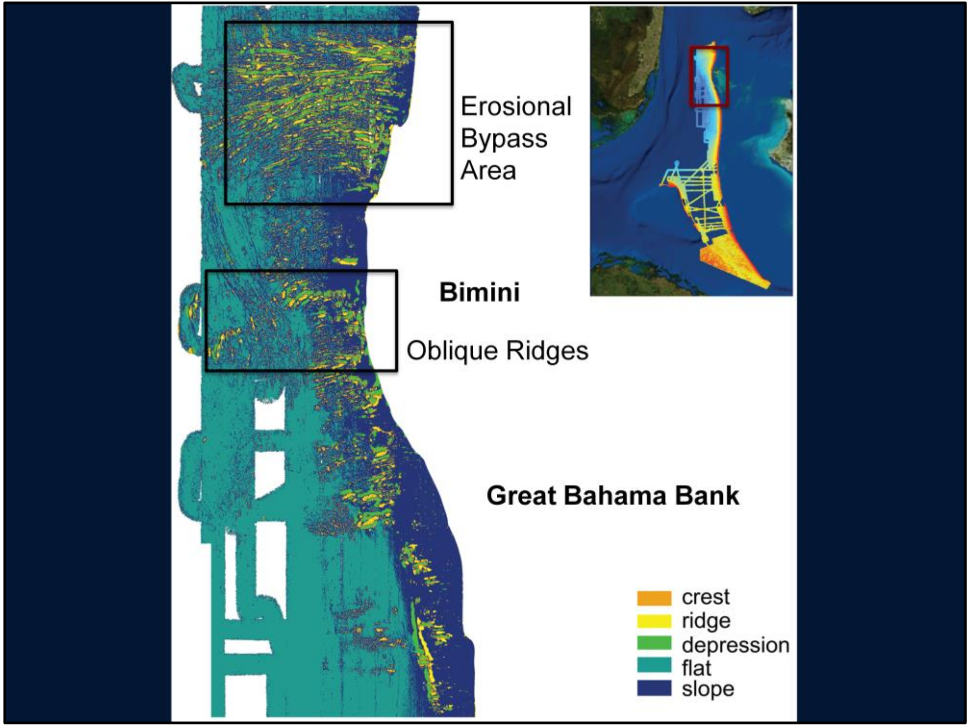
Key Findings

The slope facies distribution is a result of the complex interplay between gravity-driven sediment transport, benthic and cascading density currents, and the platform geometry itself.

The classic view of platform margin acting as line-source for slope sediment facies distribution in facies-belts is too simplified.

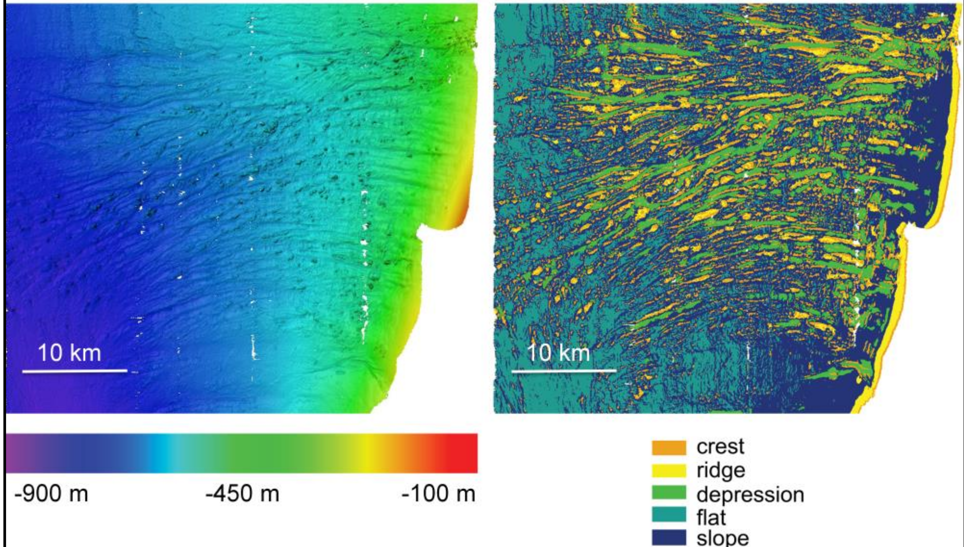
Highly regular spacing of gullies, furrows, plunge pools, and groove marks all along the western slope.

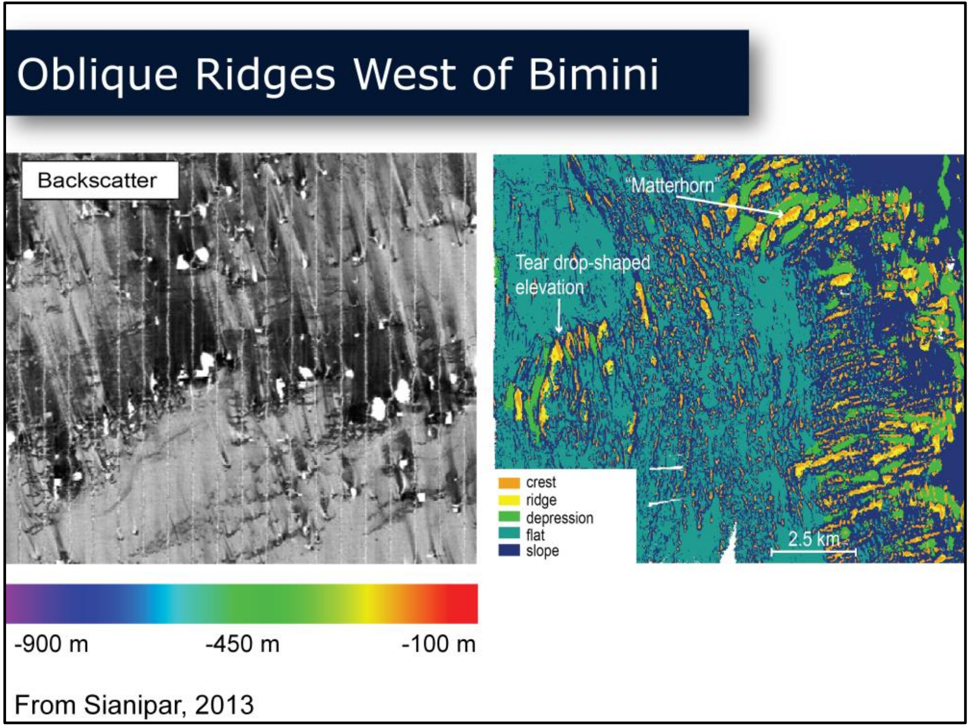
Changes in slope effect changes in grain-size.



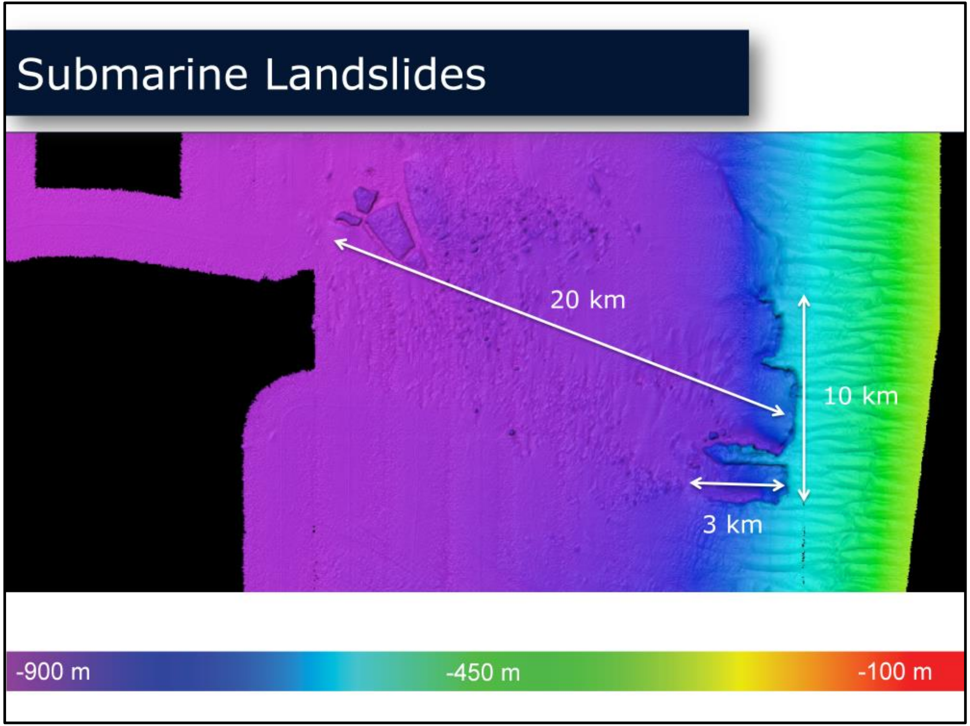
Presenter's notes: Bathymetry alone is a good starting point to perform certain analyses. One first step is classification and, therefore, quantification of geomorphology. This is a small excerpt of a map with the subdivision into five geomorphological classes. From this view it becomes clear that the variety or variation of morphologies and ultimately facies along the slope is absolutely stunning. --Dense system of channels, coarse-grained levees; Ridges inhabited by cold water corals along the slope; Coral rubble fields aligning with current directions;
Block boulders, mass-transport deposits, pockmark fields.

Erosional Bypass Area





Presenter's notes: Ridges aligned downslope, associated with depressions in proximity to the margin. Clusters of crests oriented parallel to bottom currents a bit farther away from the slope. What seems to be evident in the classified map is confirmed by backscatter data, showing sediment orientation parallel to the orientation of the coral rubble fields. Coral mounds using the ridge-depression. Classified map adds detail.



Presenter's notes: Another factor controlling slope facies is instability. Submarine landslides of this extent are spectacular. Indicators for creeping and slumping can be seen all along the slope. Gullies all along the slope from very north tol very south show a spectacularly organized trend of equally spacing of 350 m.

Slope Facies Controlling Processes along Western Great Bahama Bank

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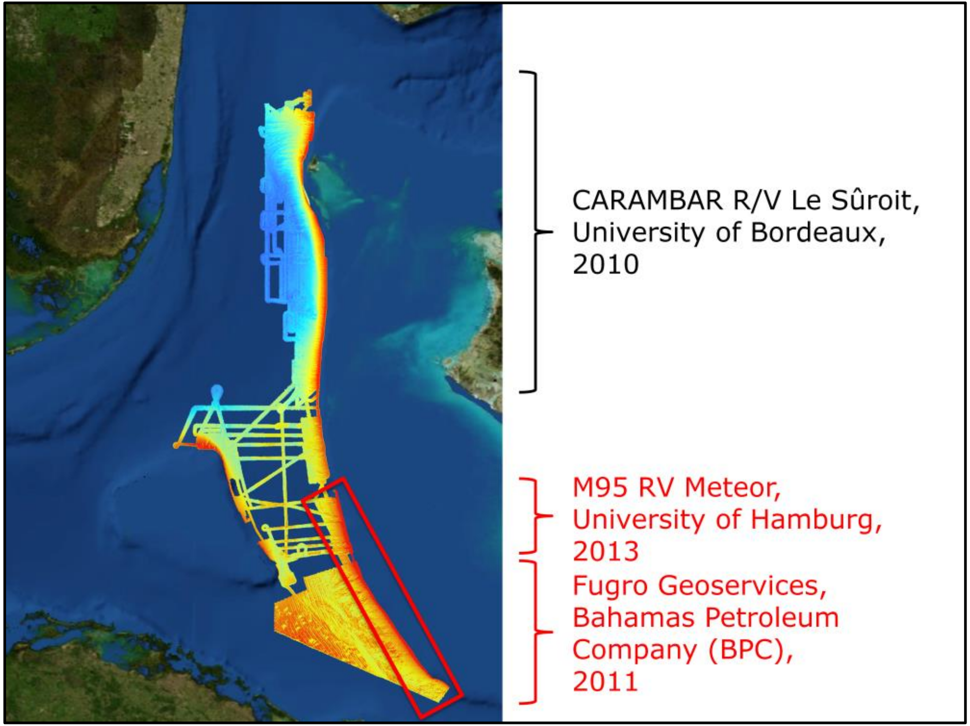
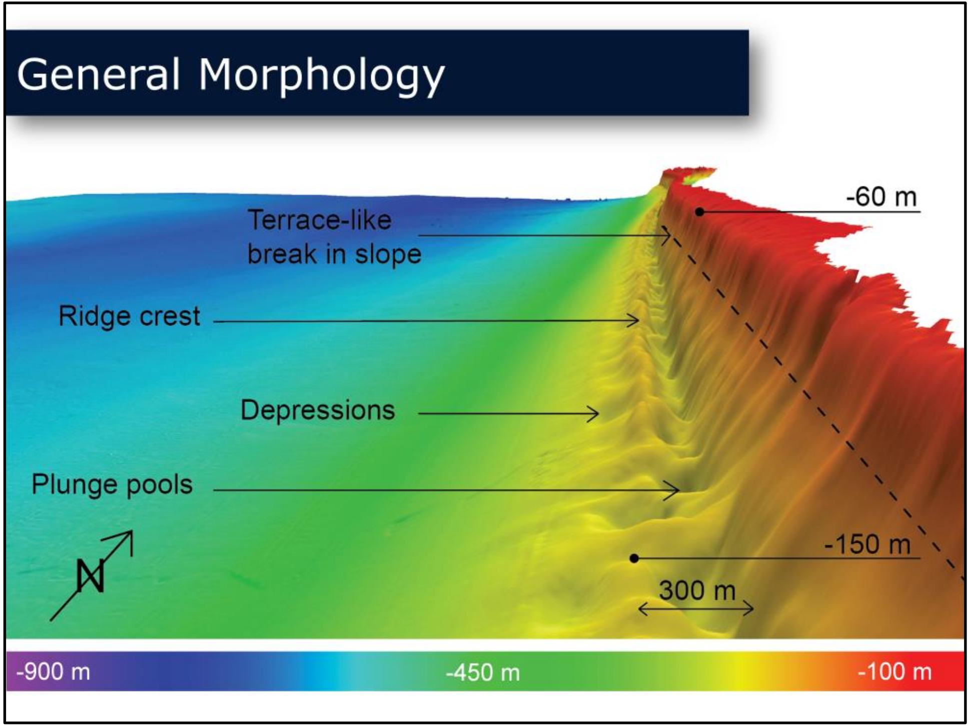
The Evolution of the Holocene Sediment Wedge and its Plunge Pool

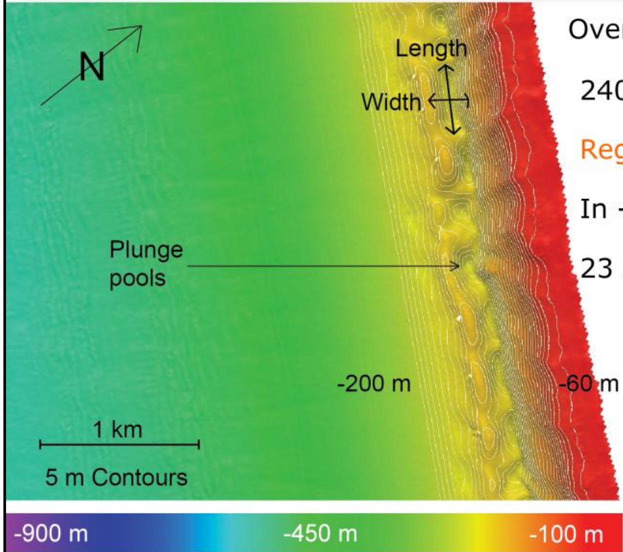


Presenter’s notes: We concentrate on area where we mapped 240 plunge pools over the distance of 90 km.



Presenter's notes: 25° up to 70° inclination; Regular spacing: 350 m; Grooves in steep escarpment; Terrace at around -120 m; Depression with plunge pools; Sediment ridge; Second depressions, gullies.

Plunge Pools



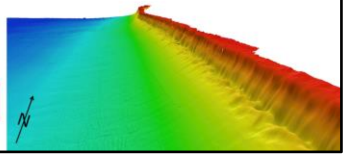
Over 90-km-long depression.

240, regularly spaced.

Regular spacing: 350 m.

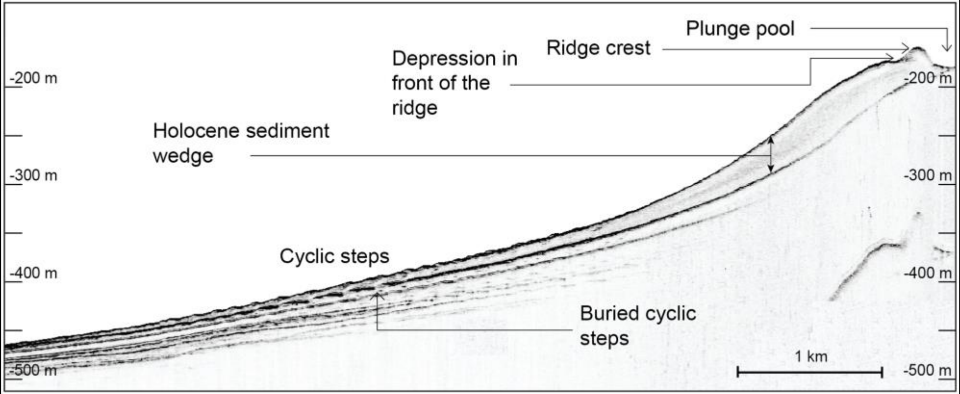
In -180 m water depth.

23 m deep on average.



Presenter's notes: Overall we counted 240 plunge pools, regularly spaced: 350 m

Holocene Sediment Wedge

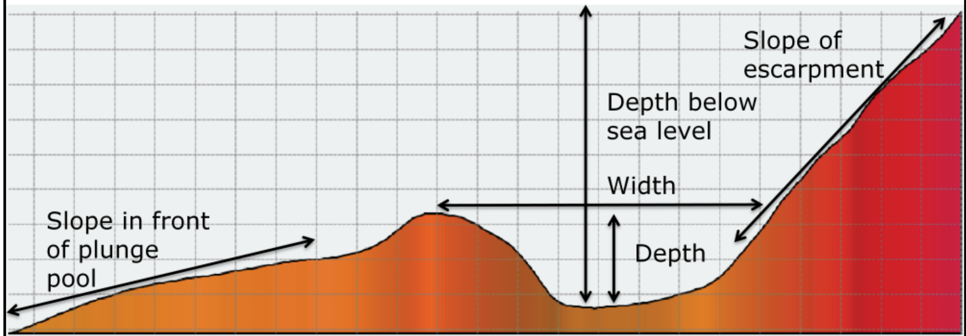


Concave sediment wedges thinning basinwards.

Sediment waves (cyclic steps) in lower slope.

Presenter's notes: This is a subbottom profile across the slope. In general, during highstands, the platform produces sediment, and currents transport the fines downslope where they accumulate in a so-called sediment wedge. The strong reflectors delimit the wedge and are lithified lowstand surfaces. Behind the plunge pool, on top of the wedge there is a coarse-grained ridge.

Plunge Pools

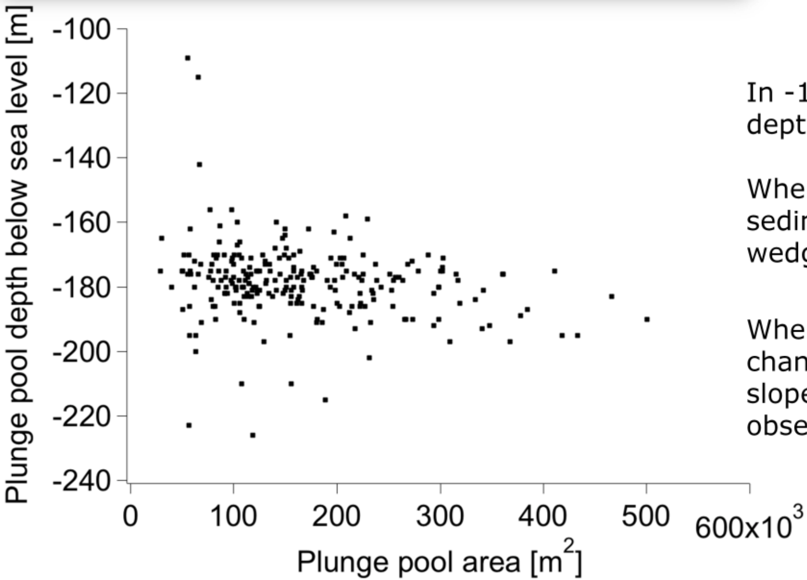


Change in slope = Slope(Escarpment) – Slope(Front of Plunge Pool)

Area = π x Length x Width

Presenter's notes: To quantify the plunge pool morphologies we measured the features noted here.

Plunge Pools

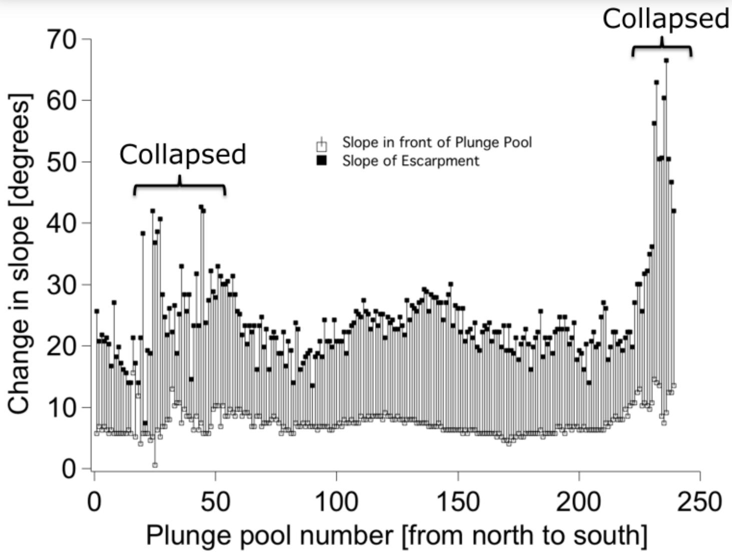


In -180 m depth.

Where sediment wedge onlaps.

Where largest change in slope is observed.

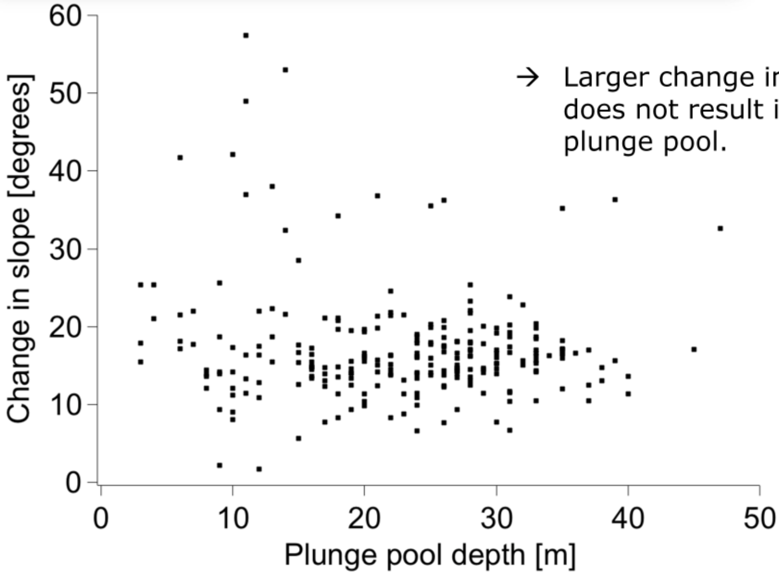
Plunge Pools



On average 17° change in slope.

Steeper slope due to collapses.

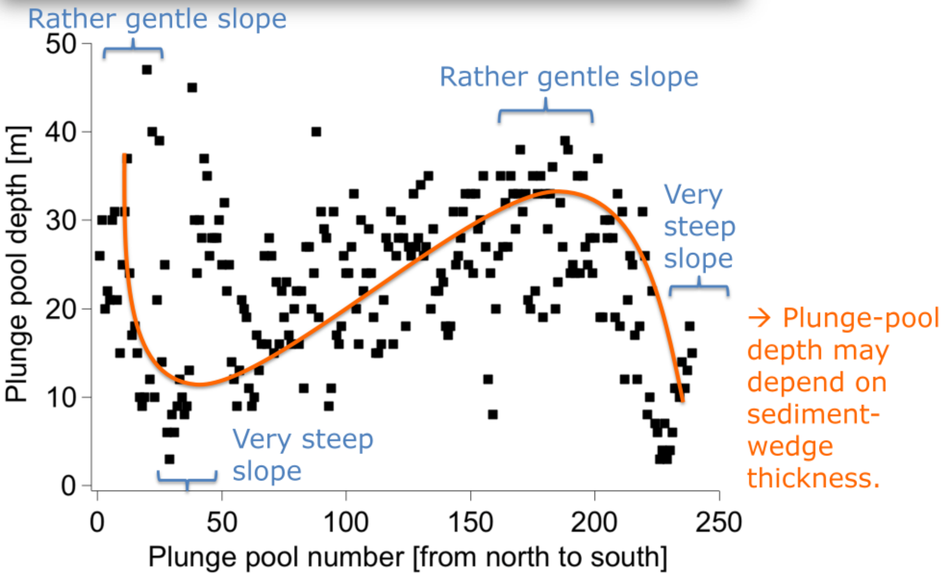
Plunge Pools



→ Larger change in slope does not result in deeper plunge pool.

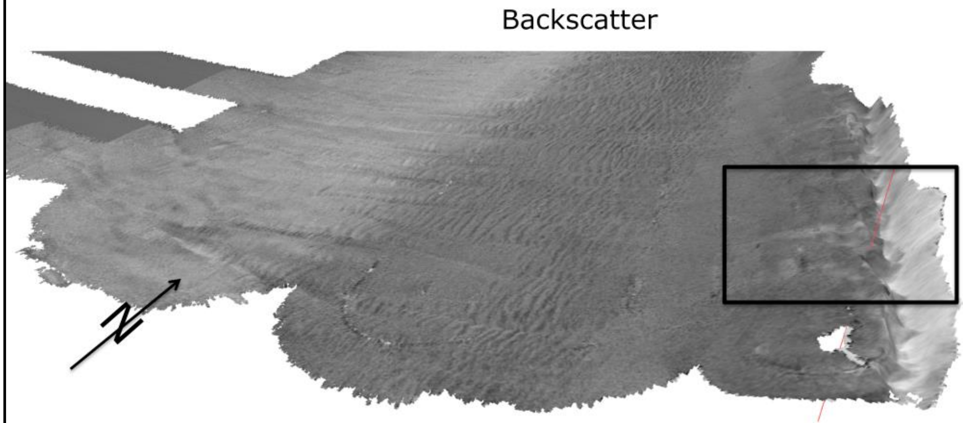
Presenter’s notes: A steeper slope does not mean an deeper plunge pool.

Plunge Pools



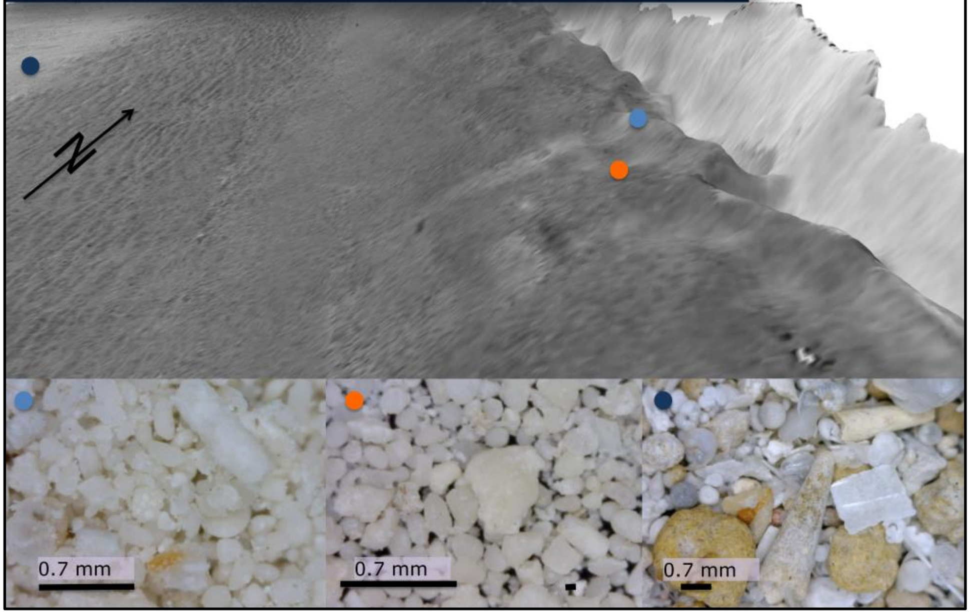
Presenter's notes: On the contrary, rather gentle slopes (20) result in deeper plunge pools, because more sediment can be retained on the slope.

Sediment distribution



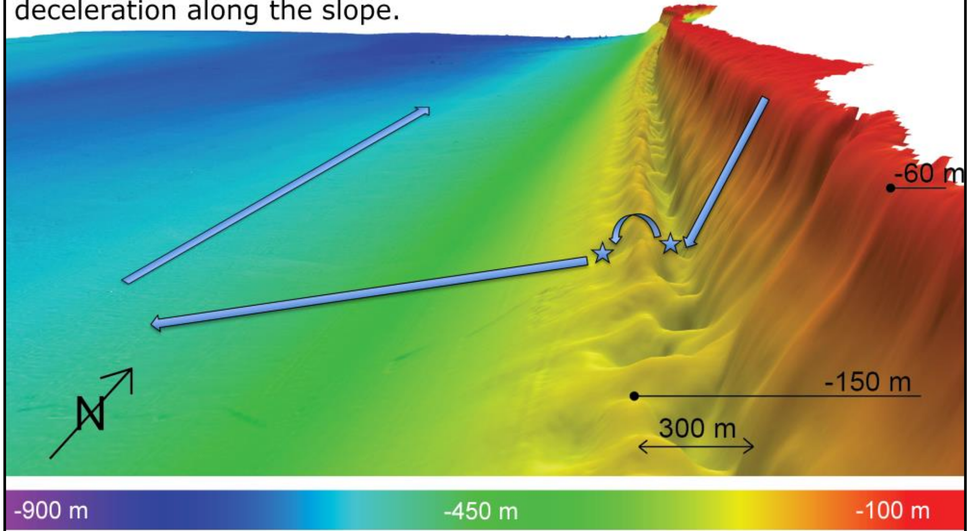
Courtesy of University of Hamburg

Sediment distribution



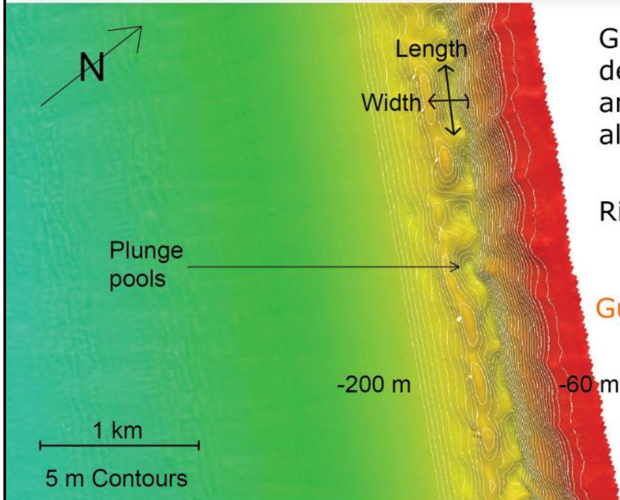
Cascading Density Currents

A system of current acceleration and deceleration along the slope.



Presenter's notes: Cascading density currents are known to be active on the slope. The steep escarpment provides the ideal geometry to accelerate those.

Cascading Density Currents

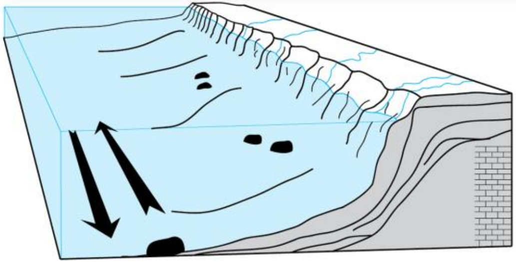


Groove, maximum depression, ridge peak, and second depression aligned.

Ridge often breached.

Gullies with 350 m spacing.

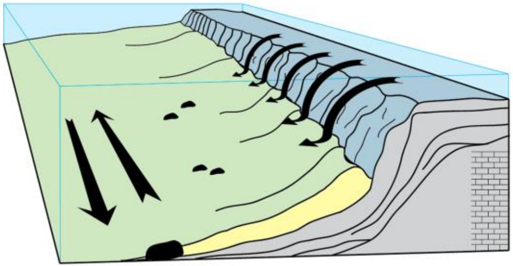
Slope Processes



Limited off-platform sediment transport.

No carbonate production on shelf.

Karstification of exposed platform and slope.



Cascading density currents.

Deposition of periplatform sands and mud.

→ Pleistocene topography mantled by Holocene.

Conclusion

Karst features produced during platform emergence influences cascading density currents by confining and channelizing the flow.

The regular nature of these karst features (grooves) is responsible for the regular spacing of the plunge pools and gullies.

Grain-size distribution is not solely controlled by down-dip, but rather reflects the complex interplay of bathymetry and sediment-transporting currents.

Changes in inclination provide hydraulic jumps to transform current regime of downslope currents, which ultimately results in the deposition of characteristic bedforms.

Presenter's notes: 1) Pleistocene topography influencing the current pattern. 2) Plunge Pools show us where the maximum current impact is located. 3) The classic coarse to fine does not work in this environment. We see coarse, fine, coarse.

Thank you!

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