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Evolution of a Modern Ooid Sand Island - South Joulter Cay, Great Bahama Bank

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Key Findings

• Islands like South Joulter Cay (SJC) lead to the development of a new suite of facies in the otherwise subtidal record of the host sand body and act to armor the sand body at its most energetic margin, while influencing local water movement and depositional patterns and imparting a spatially constrained meteoric diagenetic overprint.

• High resolution drone imagery and a DTM better delineate the morphology of Holocene ooid sand ridges forming SJC than previous mapping, allowing a detailed interpretation of the timing and processes that formed the island.

• SJC records a period of higher ooid production or lower ooid export than is seen locally in the sand body today. The ridge topography suggests active sand bars built to beaches and back-beach dune ridges formed repeatedly, and channels adjacent to and cutting through the island influenced sediment transport.

Significance

The Joulters ooid sand body covers some 400km^2 of Great Bahama Bank north of Andros Island. It is famous as a site for the study of high-energy carbonate sediments and is a central analog for understanding oolitic grainstone reservoirs due to the clearly observable interplay between vast stabilized sand flats and active ooid bars (Harris, 2019). The geological story of the three Joulter Cays (low lying islands), however, deserves equal attention. Previous field mapping and local coring placed island development within the story of sand body development and established they are a very recent feature with radiocarbon dating showing ages from ~2000ybp to present (Harris, 1979).

These islands, while small in areal extent, act to extensively modify the distribution of energy across the top of the Joulters sand body, blocking wave energy from the open ocean to the east, and confining tidal flow to the channels that lie to the south, the north, and between each island (Figure 1). This aspect of an energy barrier introduces a sudden shift towards muddy facies in the immediate lee of the islands and isolates ooid production to tidal channels and their associated ebb and flood lobes. As such, the most recent geologic record shows a facies transition that, if seen out of context, may be misinterpreted as being caused by a sudden increase in water depth, when the truth is exactly the opposite. The development of islands like Joulters also introduces locally meteoric diagenetic modification to the underlying sediments (Halley and Harris, 1979).

Methods and Preliminary Results

Our ongoing examination of SJC (Figure 2), the largest of the islands, targets a better delineation of the timing and processes that formed the island. High resolution imagery and a DTM constructed from a drone survey improve on previous maps. The new data shows SJC is nearly 2.5 km long, has a maximum width >600 m and comprises a series of more than 40 elongate ridges and their intervening lows formed from primarily oolitic sands. Major ridges diverge toward the southern end of the island, and bankward-dipping foresets Indicate primarily seaward to bankward deposition. The ridges generally crest ~2 m above MSL and are closely spaced (tens of meters apart). An abandoned tidal channel cuts through the southern third of the island. The channel is filled with muddy sands (packstone equivalent) and floods from the bankward direction during very high tides through a mangrove-lined network of channels.

Historically, SJC records a period of higher ooid accumulation rate than occurs locally in the sand body today; ooid sand production was greater than the system's ability to hydrodynamically redistribute these sediments. Ridge topography on the island suggests that active sand bars locally built to beaches and back-beach dune ridges formed repeatedly. A scenario for island development based on existing data is presented (Figure 3) emphasizing growth stages reflecting variations in dispersal of ooid sands by tidal channels, wind and wave energy, and longshore and storm-related currents. Topographic profiles extracted from our new DTM shows higher than average beach ridges are associated with the initiation of each of island growth stage, suggesting that the island's morphological evolution is closely integrated into the wider evolution of sediment generation and transport within the Joulters sand body.

Implications

This study focuses specifically on the process by which a key facies transition occurs, namely the nucleation and growth of islands within accommodation-restricted sand bodies. It has particular impact on facies interpretation and correlation within subsurface grainstone reservoirs as well as the interpretation of their sequence stratigraphic and diagenetic development.

The Joulter Cays, built of lightly cemented oolitic and peloidal sediments, form along the eastern, windward-facing margin of the ooid sand body. The islands, and SJC in particular, introduce a new suite of Holocene facies (beach, back-beach storm ridges, tidal flats) into the dominantly subtidal record of the overall sand body. Their presence also armors the sand body at its most energetic margin and the topography of the islands significantly influences the local water movement and thus depositional patterns. In addition, the islands introduce an element of spatially constrained meteoric diagenesis (cementation and dissolution) contemporaneous to sand generation and deposition.

References

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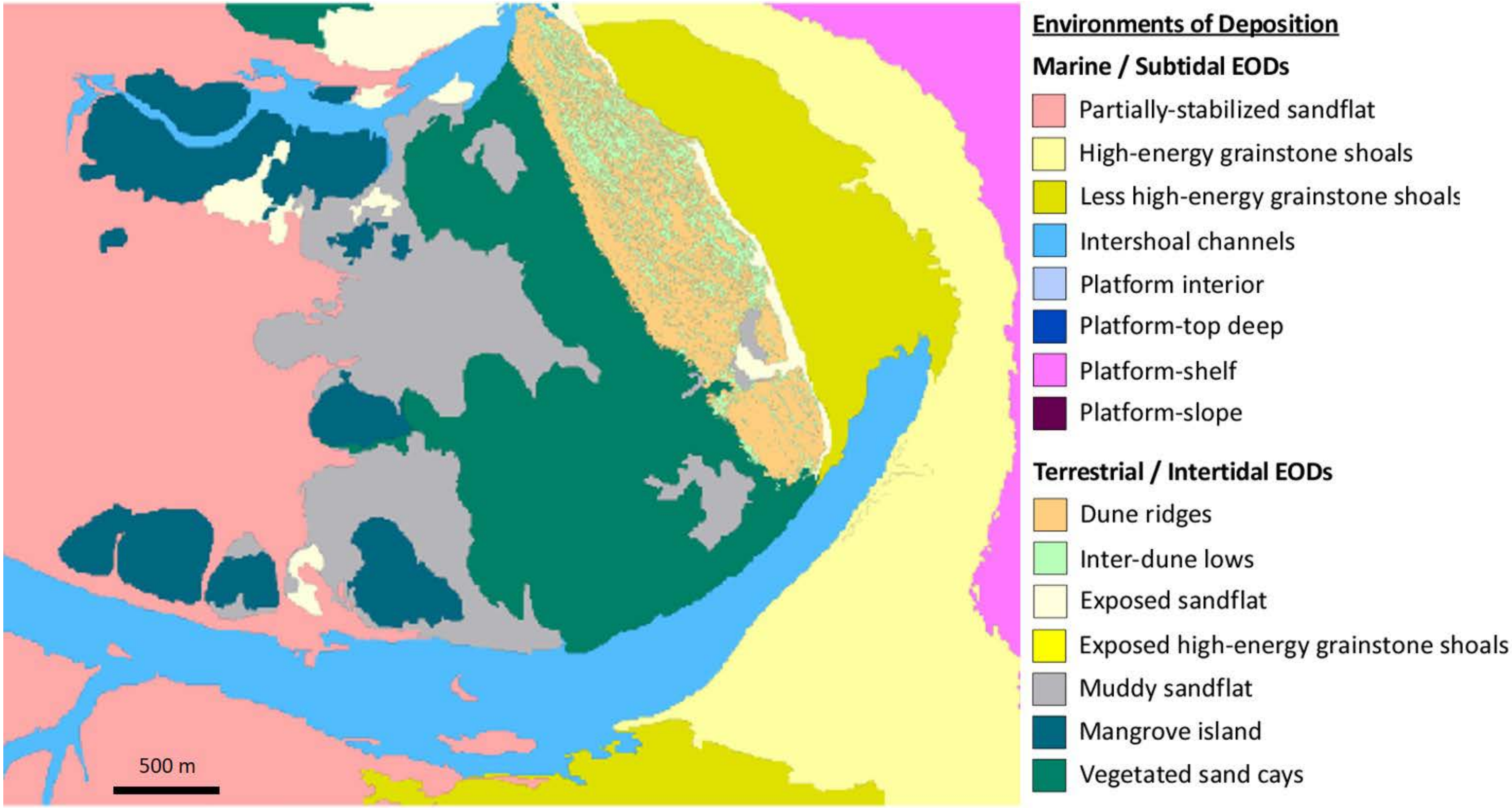


Figure 1. Environment of deposition map for SJC and surroundings. The island is bounded at the south by the largest and deepest tidal channel observed within the Joulters sand body and fronted by an active ooid sand shoal. Variably vegetated muddy sandflats develop on the lower energy, lee side of the island. Map generated by Purkis Partnerships Ltd for Chevron ETC.

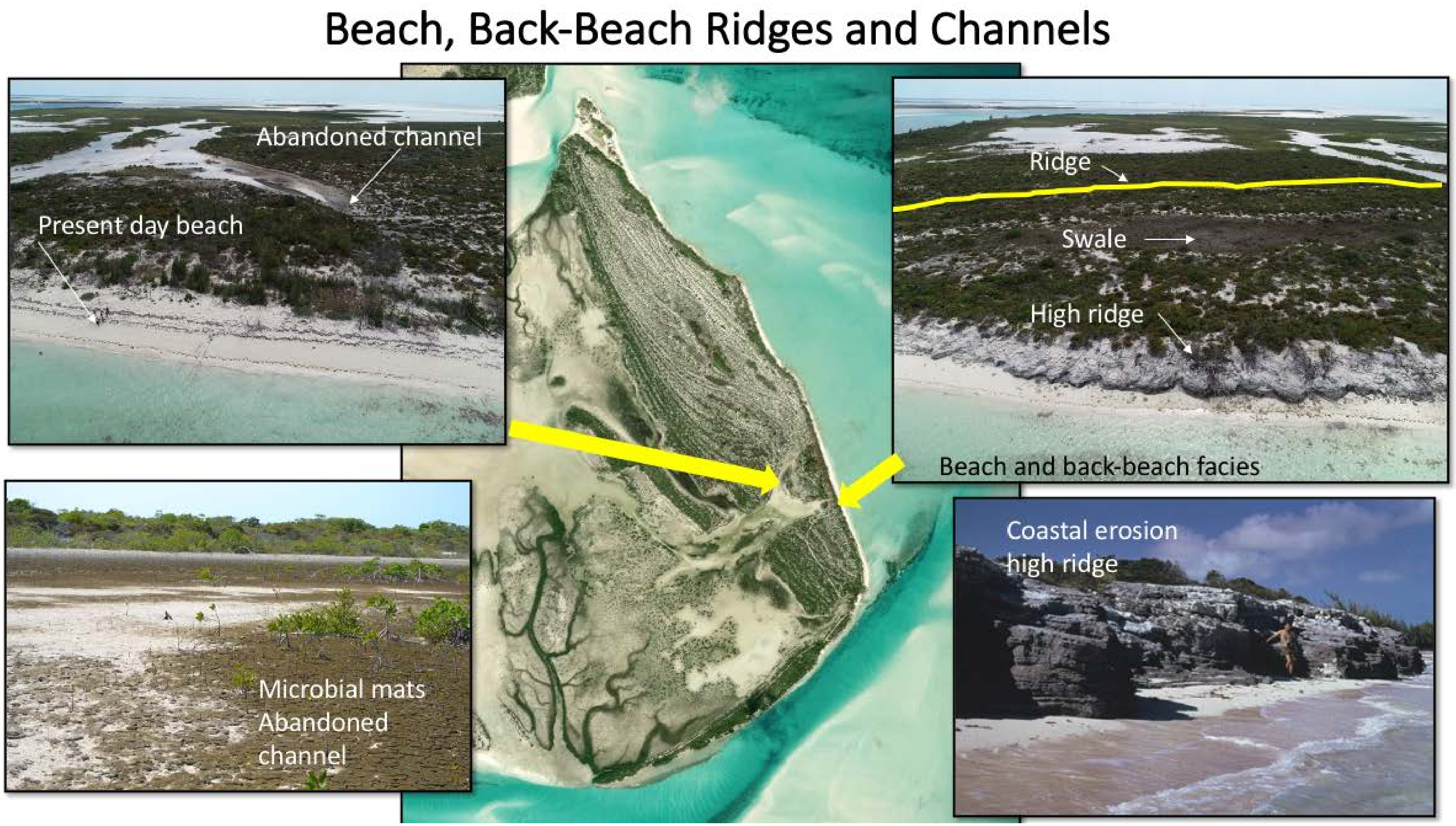
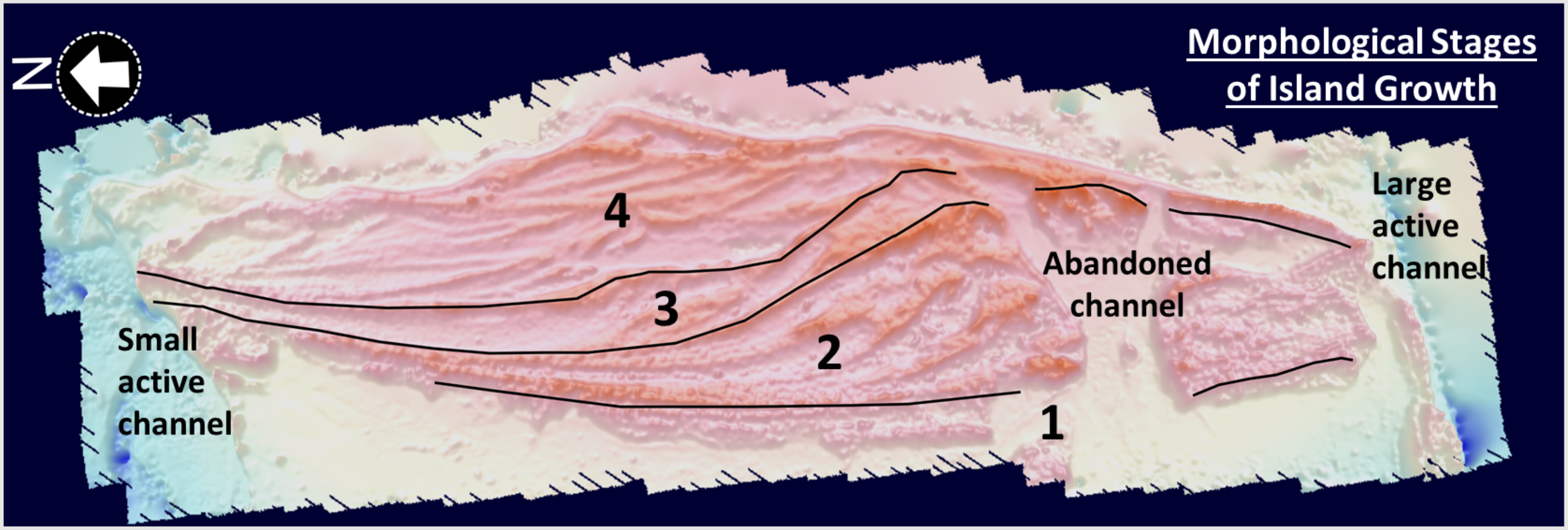


Figure 2. Photomosaic showing key features of South Joulter Cay including lightly cemented ridges and intervening lows, present-day beach and abandoned tidal channels. Image in center sourced from Google Earth © 2020 Google/Google image source (Landsat).



1. Linear ridges: An oolitic shoal, bounded by channels, begins to overfill available accommodation. At its shallowest part, a thin linear sand cay forms which is reinforced with a back beach ridge.

2. Early Arcuate Ridges: The linear sand cay is breached by a small channel. An ebb tidal delta lobe forms in front of the channel. Longshore currents transport ebb-lobe sediments northwards and waves push this material towards the stage 1 ridge, building an arcuate ridge complex.

3. Later Arcuate Ridges: Longshore transport begins to dominate over ebb delta growth, potentially due to closure or redirection of the associated channel. This pushes the locus of ridge further north.

4. Irregular ridge complex: Development of multiple prograding beach ridge sets grow the island to the NE. The complexity of this ridge complex suggests dynamic changes in sediment supply and strength of longshore transport, potentially effected by changes in the large active channel to the south.

Figure 3. DEM of South Joulter Cay produced by this study, annotated to show interpreted growth stages based on ridge morphology.