RATES OF INTERTIDAL FACIES-BELT MIGRATION FROM TIME-SEPARATED REMOTE SENSING

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PROJECT OBJECTIVES

- To use time-separated remote sensing to quantify rates of facies migration on multi-decadal time-scales for two case studies: an isolated carbonate platform in the central Indian Ocean and the tidal-flat carbonates of Andros Island (Great Bahama Bank - GBB)
- Examine the auto- vs. allogenic drivers of facies dynamics

PROJECT RATIONALE

Facies-belt dynamics are poorly understood at timescales of decades to centuries because of the lack of quantitative data spanning these time periods. A wealth of vintage-military aerial photography acquired in the years surrounding the Second World War exist, however, and can be paired with modern high-resolution satellite imagery to quantify temporal change over sufficiently long periods to allow meaningful extrapolation to geological timescales. This project will focus on quantifying the dynamics of intertidal carbonates at two ends of the energy spectrum. Following Purkis et al. (2016), for Peros Banhos atoll (Chagos Archipelago, Central Indian Ocean), the coastline dynamics of 19 atoll islands situated in the high-energy platform-margin environment will be quantified over a period of 40 years. For the low-energy example, the Andros tidal flats will be examined for a period covering 75 years (Fig. 1).

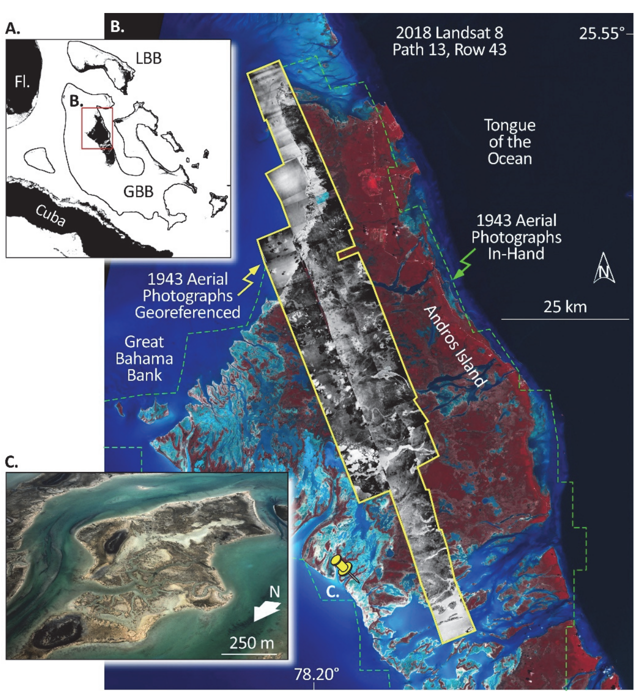

Figure 1. The Andros Island tidal flats. (A) Andros Island is the largest landmass atop the GBB. (B). Red color in this 2018 Landsat image denotes vegetation. The green polygon denotes coverage by 1943 aerial photographs acquired by the Royal Airforce against which landform change can be quantitatively assessed over 75 years. (C) An oblique aerial photograph acquired in 2018 from the southwest of Andros Island (location marked by yellow pin in B.) emphasizes the complex facies mosaic of tidal channels, intertidal muds, and bio-stabilized mangrove islands.

Beyond quantifying rates and motifs of facies migration, this project will examine the role of emergent behavior in structuring intertidal carbonates. Systems displaying emergent behavior manifest significantly different characteristics from those resulting from simply adding up all the constituent parts - an example being how small perturbations can have radical consequences to the system's overall depositional architecture. Whereas numerical modelling by Fagherazzi (2008) demonstrates emergent behavior in intertidal siliciclastic deposits, its presence in equivalent carbonate environments remains controversial. For instance, coring conducted by Shinn et al. (1969) suggests frequent reconfiguration of Andros tidal flats, an observation in conflict with studies conducted by Rankey (2002) and Maloof and Grotzinger (2012) who conclude long-term stability of the tidal-flat architecture. We aim to resolve this contradiction.

APPROACH

Drivers of the change in facies configuration through time will consider allogenic factors, such as gradients in prevailing hydrodynamic energy and creation of accommodation space through relative sea-level rise, as well as autogenic processes, such as organism-environment feedbacks. An example of the latter being sediment stabilization by biota ranging from microbial biofilms to mangrove stands.

SIGNIFICANCE

Migrating facies belts deliver lateral and vertical heterogeneity in carbonate deposits which can be difficult to replicate using forward models. Autogenic dynamics are particularly poorly understood, yet, through emergent behavior, are capable of spontaneously producing coherent spatial facies patterns through internal interactions. Systems configured as such lie close to their point of criticality whereby subtle changes in underlying processes can yield sudden and pronounced shifts in depositional architecture. Understanding these processes and their characteristic length and time-scales has the potential to yield insight into the variability of depositional facies that consistently challenge outcrop and subsurface interpretations.

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