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

Mingyue Wu and Sam Purkis

PROJECT OBJECTIVES

- To employ time-separated remote sensing to quantify rates of facies migration over multiple decades in the Andros tidal-flats of Great Bahama Bank.
- To explore the geological implications of facies dynamics on subsurface analogs.

PROJECT RATIONALE

The proposed work, which will consider a low-energy carbonate depositional system, follows a study which considered the dynamics of high-energy grainy facies in the Chagos Archipelago (Indian Ocean). A key finding of the Chagos work was that facies migration is controlled by the physical environment and wave energy, in particular. Whereas the Andros tidal flats are not subject to meaningful wave energy, we hypothesize that their dynamics are similarly controlled, as has been reported in analogous studies. 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 1940s can be paired with modern high-resolution satellite imagery to quantify temporal change to allow meaningful extrapolation to geological timescales. We have remote sensing data spanning 75 years for the Andros tidal flats (Fig. 1).

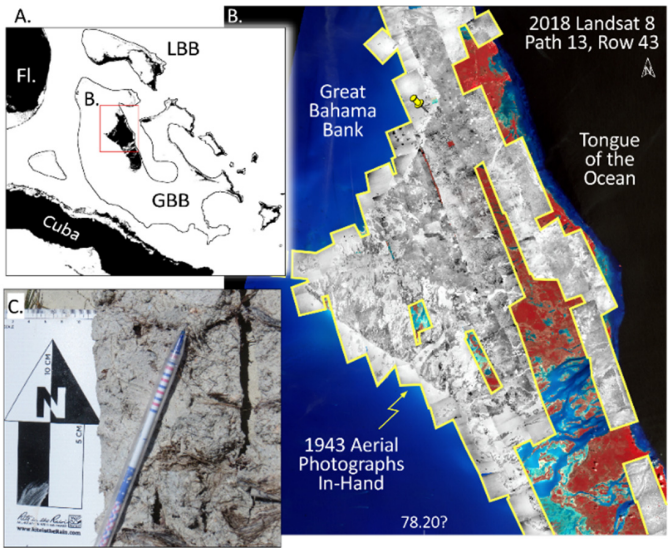

Figure 1. The Andros Island tidal flats. (A) Andros Island is the largest landmass atop the GBB. (B). Red color in this 2018 Landsat image denotes vegetation. The yellow polygon denotes coverage by 1943 aerial photographs acquired by the Royal Airforce against which landform change can be quantitatively assessed over 75 years. (C) A core sample acquired in 2019 (location marked by yellow pin in B) located within an abandoned tidal channel. Note 'sediment lag'-gastropods indicative of high-energy conditions prior to channel abandonment.

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 the Andros tidal flats, an observation in conflict with studies conducted by Rankey (2002), Maloof and Grotzinger (2012) who conclude long-term stability of the tidal-flat architecture. We aim to resolve this contradiction.

APPROACH

Following the protocols of Purkis et al. (2016), the tidal channels will be manually extracted from the vintage and modern imagery. Calibration for the interpretation of the remote sensing data is provided by field observations from a recent fieldtrip to the Triple Goose Creek area which consists of GPS measurements, short cores, and abundant digital photographs. Drivers of the change in facies configuration through time will consider allogenic factors, such as gradients in prevailing hydrodynamic energy, as well as autogenic processes, such as organism-environment feedbacks.

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. 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.

REFERENCES

Fagherazzi, S., 2008, Self-organization of tidal deltas. Proceedings of the National Academy of Sciences, PNAS 0806668105.

Maloof, A.C., and Grotzinger, J.P., 2012, The Holocene shallowing-upward parasequence of north-west Andros Island, Bahamas. Sedimentology 59:1375-1407.

Purkis, S.J., Gardiner, R., Johnston, M.W., and Sheppard, C.R.C., 2016, A half-century of coastline change in Diego Garcia – the largest atoll island in the Chagos. Geomorphology 261:282–298.

Rankey, E., 2002, Spatial patterns of sediment accumulation on a Holocene carbonate tidal flat, northwest Andros Island, Bahamas. Journal of Sedimentary Research 72:591-601.

Shinn, E.A., Lloyd, R.M., and Ginsburg, R.N., 1969, Anatomy of a modern carbonate tidal-flat, Andros Island, Bahamas. Journal of Sedimentary Research 39.