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Stratigraphic architecture and evolution of a barrier seagrass bank in the mid-late Holocene, Shark Bay, Western Australia

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Shark Bay is located approximately 800 km north of Perth, Western Australia, and was awarded World Heritage Status in 1991. One of the most important geological features in Shark Bay is the Faure Sill complex, which is a well-developed carbonate-clastic barrier bank that lies east-west across the axis of the Hamelin Pool and L'Haridon Bight. Faure Sill has had a critical role in the evolution of the local ecosystems, in particular in restricting the water exchange between the southern embayments and Hopeless Reach. These environmental settings, along with a a semi-arid to arid climate, have produced and preserved the metahaline and hypersaline conditions in the Hamelin and L'Haridon basins, providing a basis for the development of a variety of biogenic and physical structures such as microbial communities (stromatolites) and oolitic shoals that proliferate in the southern basins.

A combination of remote sensing images, high-resolution shallow seismic data and lithostratigraphic information provided new insights into the internal architecture, sediment bodies, lithofacies and Holocene development of the Faure Sill. By integrating these data with radiocarbon dating, information concerning the sediment accumulation rates was obtained, together with an estimated chronology, bank onset and growth history.

An initial remote sensing analysis of high-resolution aerial photos of the Faure Sill allowed mapping of the sediments and benthic substrates and the morphological elements, demonstrating the interconnection between channel – fan – levee – bar morphology.

A high-resolution shallow geophysical survey was successively carried out using a subbottom profiler. The seismic profiles provided useful information on the thickness, lateral distribution and acoustic characteristics of the sediment packages and geometry of the seismic reflectors, giving good quality data on the Holocene and Pleistocene morphostratigraphic features, down to a depth of about 15 m below the seafloor.

Key acoustic reflectors were identified and, in order to integrate and assess their nature and occurrence, a follow-up coring study was performed. A total of 32 cores, up to 6 m long, was collected with a vibracorer, along the seismic lines. The sediment cores were then logged and the composition and mineralogy of the lithofacies were analysed. Samples from four cores were collected for radiocarbon dating in order to calculate accumulation rates and assess the age of reflectors and facies. With this information, it was also possible to estimate the Mid-Late Holocene history of bank and create a local stratigraphic model of the seagrass bank growth.

The results indicate that:

- Acoustic reflectors in the seismic profiles coincide with an abrupt variation of sediment types, which is evident from the sediment core analyses, and only minor differences in terms of position and frequency occur.
- The Faure Sill is composed of three different types of sediment: sand, mud and clay. Bioclastic muddy sediments are by far the most common bank lithofacies. Sands are predominately bioclastic and the particle size ranges from coarse (generally cross bedded) to fine (mainly thinly laminated). Seagrass peats are also a significant component. Bioclastic, muddy facies are associated with lower parts of the seagrass bank buildup and are succeeded by sandy facies. Fringing banks associated with the Wooramel Delta are muddy and contain a significant component of terrigenous clays.
- On the basis of internal architecture, facies and distribution and morphological features, the sediment bodies can be classified into five main types: 1) Channel-associated; 2) Tidal fan-associated; 3) Banks; 4) Bank top; and 5) Shoreline-attached sand lobes.
- With radiocarbon dating, information about the accumulation rates was obtained. A number of hiatuses were recognised and correlated to seismic and lithological boundaries, and these data assisted in the development of bank accumulation curves. Accumulation rates varied in time and magnitude, in accordance with seagrass productivity, local hydrodynamic conditions, water depth and facies. The average accumulation rate, considering all facies of the Faure Sill, is 1.3 m/ka, ranging from 0.7 m/ka in the eastern part, adjacent to the Wooramel Delta, to 1.7 m/ka in the central and western sector of the carbonate bank. Within the cut-and-fill channel, bank accumulation rates significantly accelerated, peaking at 6.9 m/ka.

The study demonstrated that the evolution of the marine ecosystems of Shark Bay resulted from an interconnection between sediment body morphologies, seagrass, which produced and trapped a large amount of sediments, and pre-existing topography that shaped the initial deposition. Sea level fluctuations have also

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largely controlled the hydrodynamic conditions, such as the amount of flushing waters and their velocity, influencing the erosion, transportation and deposition of the sediments.

Combining the data, a model of the Holocene chronology of the Faure Sill was generated. The development of the bank can be seen in three sea level stages.

1) *Early Holocene*. As the sea level has risen (not earlier than 8000 years BP), a pre-Holocene irregular topography was flooded. During this period, the first seagrass communities started their colonisation, contributing to the initiation of an early bank, trapping quartz, shed from eroding pre-existing topography, and producing *in situ* bioclastic sediments and muddy carbonate deposits.
2) *Middle Holocene*. The sea level peaked (about 2.5 m above the present sea level), completely flooding the bank region; under these conditions, the seagrass meadows reached their apex and muddy sediment accumulation peaked around 6800 years BP, corresponding to the sea level maximum highstand.
3) *Late Holocene*. As the sea level dropped in the period up until the present time, several distinct erosional and depositional events took place, and sandy bank top facies developed. During this time, the deposits continued to fill the available accommodation space and channel bank morphology continued to develop.

A fuller account of this work can be found in: Bufarale, G and Collins, L B, 2015, Stratigraphic architecture and evolution of a barrier seagrass bank in the mid-late Holocene, Shark Bay, Australia, *Marine Geology*, **359**: 1–21.