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Subbottom profiling and growth patterns of Kimberley coral reefs, North West Australia *

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The Kimberley region is located in the north western continental margin of Australia and is characterised by unique and complex geology and geomorphology that spans almost 2 billion years. The modern marine environment, considered as one of the world's greatest biodiversity hotspots, is significantly influenced by the interaction of long term processes, such as pre-existing rock foundation (Proterozoic Sandstone), Quaternary subsidence and Holocene/Pleistocene sea level fluctuations, and short term factors, like macrotidal range systems (up to 11 m), tropical monsoonal climate, high turbidity (related to terrigenous inputs from active rivers) and warm ocean temperatures.

Due to the remoteness, vastness and complexity of the Kimberley region, the marine and coastal environment is still poorly investigated. In 2011, the Western Australia State Government funded through the Western Australia Marine Science Institution (WAMSI) an extensive marine research program, in order to fill the present gap in the scientific knowledge and support the management of the coastal waters in the southern Kimberley. This research, as part of the plan (project 1.3.1, WAMSI Kimberley Marine Research Program), aims to study the morphostratigraphic evolution and distribution of various southern Kimberley reef settings, and determine their internal reef architecture and interaction with the environmental elements.

294 km of high-resolution shallow imaging data represent the first detailed seismic study in the region. Acoustic datasets were collected with an AA201 boomer SBP and interfaced with a dual frequency Differential Global Positioning System (DGPS) in order to obtain an accurate position (decimetric accuracy).

The survey sites were predetermined and targeted in order to evaluate most of the reef types represented in a preliminary classification scheme developed for the southern Kimberley coral reefs. The classification comprises a hierarchical subdivision of the reefs. In the first order the reefs are divided into high intertidal (elevated reefs whose surface is several metres above Mean Low Water Spring tides), intertidal and subtidal on the basis of their vertical position in relation to the sea level. The second rank is based on reef geomorphology and comprises fringing reefs, planar reefs, patch reefs and shoals. The third level further subdivides each reef type, accordingly to their configuration in relation to the shoreline and architecture. In this level, five main types of fringing reef are described (bay head, interisland, circum island, headland and narrow beach base) and two for each other reef (planar reefs: sand lagoon or coralgal; patch reefs: irregular or unbroken margins; shoal: sand or coral).

Solihuddin *et al*. (2015) examined in detail the stratigraphy and geochronology of Cockatoo Island and this research refers to their results as starting point to calibrate the seismic data. Within the Buccaneer Archipelago, besides the Cockatoo fringing reef, the neighbouring fringing reefs of Irvine and Bathurst islands were also surveyed to verify the consistency of the calibration of the internal reflectors and acoustic reflection characteristics. Montgomery was selected as special type of planar reef. Turtle, Sunday and Tallon reefs were targeted because of their variety of fringing reef types. In the offshore (mid shelf ramp) southern Kimberley region, the planar reefs around the Adele complex were surveyed and correlated with the results of a well drilled in 1982, in the northern tip of Adele Island.

During the post processing and interpretation of the acoustic datasets, significant seismic reflectors were considered on the basis of their relative position, acoustic reflection and architectural characters and identified through the correlation with the Cockatoo mine pit sections.

Within the inner shelf reefs, the deepest acoustic horizon depicted in the seismic profiles is reflector RF. It forms deep valley-like depressions and ridges and caps a Proterozoic rock foundation which is the acoustic basement of the inshore reefs. Between RF reflector and the seafloor, reflector R1 is present and represents the top of the Pleistocene calcretised reef unit, related to the last interglacial (LIG, MIS 5e, ~ 125 ky BP) sea level highstand. The reflector R1 displays a similar trend to the modern reef morphology (seafloor), with a quasi-horizontal reef flat and a steep forereef. The seismic unit bounded by the seafloor and reflector R1 represents the Holocene reef/sediment buildup, characterised by a series of internal discontinuous, subparallel reflectors (H1, H2 and H3) which could be interpreted as hiatuses or temporary pauses in reef growth. The thickness of the Holocene and the LIG reefs vary in relation to the depth of the Proterozoic bedrock. In the Buccaneer Archipelago, Turtle and Montgomery reefs, the rock foundation lies at

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30 – 40 m below sea level and is relatively flat. The LIG sequence is mainly present below the Holocene reef, where it is approximately 10 – 15 m thick. The Holocene reef buildup averages around 15 m, but it reaches 22-25 m of thickness immediately under the platform of Montgomery and Cockatoo reefs. Under Sunday and Tallon reefs, the pre-existing Proterozoic topography rises from below 30 m to 10 – 15 m below the seafloor, significantly reducing the reef development and resulting in Last Interglacial and the Holocene reefs being relatively thin (about 7 m).

In the mid shelf reefs, the Proterozoic basement is at 798 m and, within equipment limitations, seismic profiles of the Adele platform identified two further reflectors. The deepest acoustic horizon is reflector R3, at 65 m below the sea level, capping an older reef unit, tentatively considered to be MIS 9 (about 300 ky BP). At 35 – 41 m below the sea level, a further reflector (R2) can be detected. As would be predicted by the Marine Isotope Curve, reflector R2 could represent the top of MIS 7 (~ 190 ky BP) carbonate unit, about 25 m thick. As found in the inner shelf reefs, reflector R1 can be observed also in the northern portion of Adele, separating the LIG reef (about 3 – 10 m thick) and the Holocene package (usually 20 – 30 m thick).

These new datasets provided a better understanding of Quaternary reef growth. Some of the key interacting factors in coral reef classification and growth include morphology, setting, physical processes, antecedent topography and sea level change. By developing an understanding of seismostratigraphic events, it has been possible to document the subsurface evolution and growth history of diverse reef systems for a range of reef types mapped in the southern Kimberley, at the scale of multiple reef building stages correlated to the Marine Isotope Curve.