Received: 20 July 2022 | Revised: 13 April 2023 | Accepted: 24 April 2023

DOI: 10.1111/bre.12774

RESEARCH ARTICLE

Basin Research | IAS EAGE | WILEY

Differentiating reefal ridges from relict coastal ridges: Lessons from the seismic geomorphologic study of buried Miocene buildups (North West Shelf, Australia)

Rosine Riera[1,2] | **Ulysse Lebrec**[1,2] | **Simon C. Lang**[2] | **Victorien Paumard**[2,3]

[1]Norwegian Geotechnical Institute, Perth, Western Australia, Australia

[2]Centre for Energy and Climate Geoscience, School of Earth Sciences, The University of Western Australia, Perth, Western Australia, Australia

[3]UWA Oceans Institute, The University of Western Australia, Perth, Western Australia, Australia

Correspondence
Rosine Riera, Norwegian Geotechnical Institute, 40 St Georges Terrace, Perth, WA 6000, Australia.
Email: rosine.riera@ngi.no

Funding information
norges geotekniske institutt; University of Western Australia

Abstract

Linear buildups formed in tropical carbonate environments are often interpreted as bioconstructed reefs. Nevertheless, coastal processes can also form extensive sedimentary ridges exhibiting buildup morphologies. This study investigates two Miocene ridges developed along the Australian North West Shelf using 3D seismic and well data. *Ridge 1* is ca. 30 m thick and >60 km long, and it is made of foraminiferal pack-grainstones. It protects a lagoon with pinnacle morphologies. *Ridge 2* is ca. 150 m thick and >80 km long. It is composed of quartz sand forming lobes. Both ridges have a continuous curvilinear front and are in a mid-shelf setting. They mimic the modern Australian coastline. It is then proposed that *Ridge 1* is either: (1) a barrier reef developed on a drowned shoreline, or (2) stacked carbonate aeolianites and beachrocks acting as a barrier. *Ridge 2* is interpreted as stacked deltaic sands. This study demonstrates that lithified and buried coastal features of carbonate and siliciclastic nature can form extensive ridges exhibiting buildup morphologies. It is proposed that ridges formed by stacked coastal features are overall continuous with a curvilinear front, while reefal ridges are more discontinuous and exhibit deeper and more stable passes.

KEYWORDS
aeolianite, Australia, beach ridges, carbonate buildup, Miocene, palaeoshorelines, reef

1 | INTRODUCTION

Geomorphology, the description and classification of the Earth surface and of the processes that shaped it, has traditionally been focused on emerged landforms due to limited data availability offshore. Over the last century, continuous progress in technology-enabled imaging the seafloor with an increasing level of detail and supported advancement in the understanding of submarine landforms (Micallef et al., 2018). Nevertheless, most of the ocean floor remains poorly surveyed, with large portions of submarine landforms still unobserved and non-documented (Wölfl et al., 2019). As a result, the origin and nature of numerous marine sedimentary features are still uncertain, which has direct consequences for the interpretation of ancient strata that rely on modern analogues.

Tropical shallow-water coral reefs reaching the sea level have been documented by European scientists since

---

Cook's voyage in the Pacific in 1769 (Stoddart, 1976). They have since attracted tremendous research effort and represent some of the most studied marine features to the point of relagating to the background other tropical environments (Longhurst & Pauly, 1987). Today, their geomorphology and locations are well-known from the scientific community through published mapping surveys (e.g., Maxwell, 1968; UNEP-WCMC et al., 2021) and satellite images publicly available online (e.g., Sentinel, Landsat). Interest for fossil reefs (*sensu* Lowenstam, 1950) emerged in Europe following the publication of Darwin's treatise (1842), with for example the term reef reportedly first used in a geological sense by Murchison (1847) to describe Silurian strata (Cumings & Shrock, 1928). Multiple publications on ancient reefs dominantly based on a zoological approach followed during the late 19th and early 20th century. The study of ancient reefs has further developed after the 1950's—and expanded to their study through seismic reflection and well data—when the petroleum industry identified their hydrocarbon reservoir properties (Montaggioni & Braithwaite, 2009). Hence, researchers working in carbonate sedimentology and stratigraphy are now well aware of the ability of corals and other organisms to build seafloor ridges.

While it is becoming well documented that non-reefal accumulations, such as stacked aeolianites and beachrocks, also have the ability to form bathymetric highs on the modern seafloor (e.g., Brooke et al., 2017; Bufarale et al., 2019; Green et al., 2020; Lebrec et al., 2022a, 2022b; O'Leary et al., 2020; Passos et al., 2019) and can misleadingly exhibit reefal morphologies in seismic-reflection data (Bubb & Hatlelid, 1977; Salzmann et al., 2013), pre-Quaternary carbonate aeolianites and other relict coastal features are rarely documented in the geologic literature (e.g., Abegg & Handford, 2001; Dodd et al., 2001; Kindler & Davaud, 2001; Loope & Abegg, 2001; McKee & Ward, 1983; Smith et al., 2001), and non-reefal carbonate buildups are seldom described by seismic interpreters. This is particularly puzzling given the ability of drowned coastal features to exhibit buildup morphologies and to form both carbonate and siliciclastic barrier complexes—composed of beachrocks, aeolianites and other coastal sedimentary deposits preserved through early cementation—forming seafloor ridges enclosing lagoons, bays or estuaries (e.g., Alcántara-Carrió et al., 2013; Brooke et al., 2010; De Falco et al., 2015; Gardner et al., 2007; Lebrec et al., 2022a; Locker et al., 1996; Mellett et al., 2012; Passos et al., 2019; Sade et al., 2006; Wenau et al., 2020). As an example, the islands of the Bahamas are largely formed by aeolianites (Carew & Mylroie, 2001; Nelson, 1853). It is also well documented that many ancient rimmed shelves do not have reefs at their shelves, but high energy shoals (James & Mountjoy, 1983). This begs the questions, what is the true nature of seafloor ridges found in ancient strata and how can we discriminate reefal ridges from drowned coastal features?

Highlights

- Drowned coastal ridges and coral reefs present geomorphological similarities.
- Carbonate coastal features are rarely described in pre-Quaternary studies.
- Coastal aeolianites and stacked shorelines can build linear ridges 100's km long and 10's m thick.
- Drowned reefs present discontinuous and patchy morphologies associated with deep passes.
- Coastal ridges present continuous curvilinear morphologies, associated with shallow and mobile passes.

In this context, the North West Shelf (NWS) of Australia, which is surveyed by >325,000 km^2 of high-resolution 3D seismic data (Paumard, Bourget, Lang, et al., 2019), is an ideal location to study the origin of seafloor ridges formed in tropical carbonate environments. Indeed, a ca. 2000 km long buried seismic reef province, composed of ridges and circular buildups, respectively, interpreted as barrier reefs and atolls, developed during the Miocene (Anell & Wallace, 2020; McCaffrey et al., 2020; Ryan et al., 2009). The scientific objective of this study is to investigate the nature of two Miocene ridges buried along the Northern Carnarvon Basin area (southernmost part of the NWS) using 2D and 3D seismic geomorphology, complemented by the analysis of available well data and seismic profiles (Figure 1). The results of this study are then utilised to support a broader discussion on the ability of drowned coastal features—such as beach ridges, coastal aeolianites and other geological objects formed along palaeoshorelines through wave, tidal, fluvial, and aeolian processes—to form continental margin-scale seafloor ridges, and on their potential morphological similarities to reefal buildups. A list of criteria for differentiating reefal ridges from coastal ridges is then presented and discussed.

2 | GEOLOGICAL SETTING

The North West Shelf (NWS, Purcell & Purcell, 1988) is a ca. 2400 km long passive continental margin located along the north-western border of Australia, between ca. 11 and ca. 22°S, that has been dominated by carbonate sedimentation since the Late Eocene (Apthorpe, 1988).

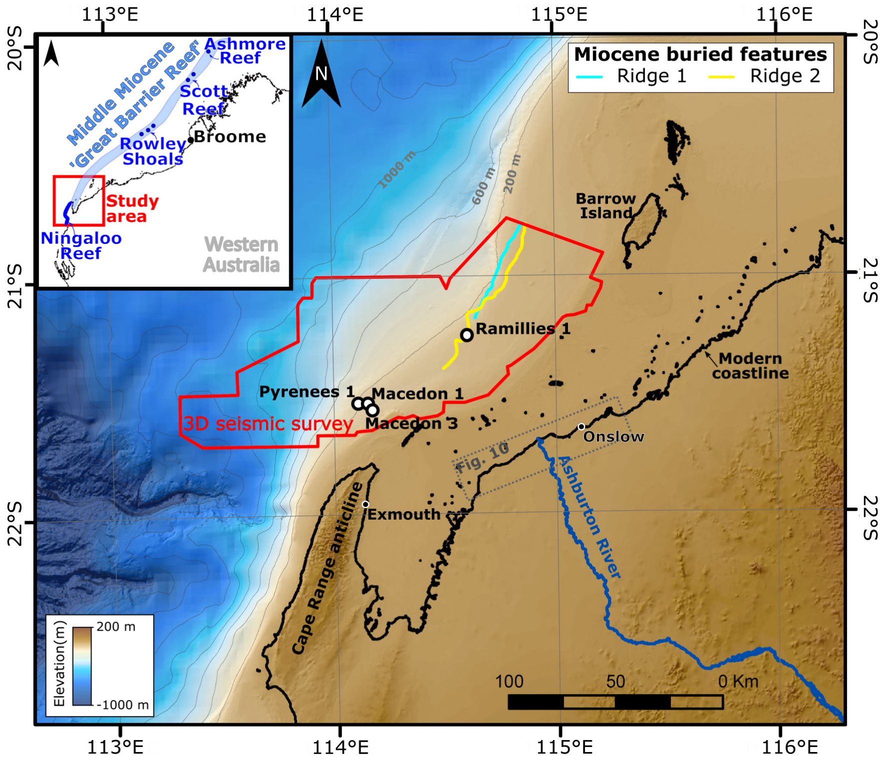


FIGURE 1 Location map presenting the two Miocene buried ridges in relation to the modern Australian coastline. Regional elevation is from Whiteway (2009), location of the Ashburton River is based on Crossman and Li (2015) and extent of the middle Miocene reef track follows McCaffrey et al. (2020).

The margin is divided in basins and sub-basins formed through multiple rifting and aborted rifting events between the Cambrian and the Early Cretaceous (Keep et al., 2007; Purcell & Purcell, 1988; Yeates et al., 1987). These basins were filled and buried by thick sedimentary units and have had a limited impact on Cenozoic sedimentation (Apthorpe, 1988). Basin and sub-basins names are however often used in Cenozoic strata studies to designate geographic areas and are here used accordingly. While the NWS has been dominantly in a passive state during the Cenozoic (Apthorpe, 1988; Marshall & Lang, 2013), localised structural inversion events occurred from ca. 25 Ma to present, with an apex during the late Miocene (Cathro et al., 2003; Keep et al., 2007; Keep & Haig, 2010; Malcolm et al., 1991; Saqab et al., 2017).

From the late Oligocene to early Miocene, an extensive carbonate ramp was covering the NWS (Apthorpe, 1988; Cathro et al., 2003; Moss et al., 2004; Rankey, 2017). It was formed dominantly of micropackstones and foraminiferal wacke-packstones (Riera et al., 2022), respectively designated as Mandu Limestone and Tulki Limestone in the Northern Carnarvon Basin area (Romine et al., 1997). Subsequently, at the end of the early Miocene (mid/late Burdigalian), small aggradational reefal buildups locally formed along this ramp in the northern part of the NWS (i.e., Timor Sea and Browse Basin; Belde et al., 2017; Gorter et al., 2002; Rosleff-Soerensen et al., 2012; Saqab & Bourget, 2016; MioR-0 on Figure 2). During the middle Miocene, from 16 Ma onward, ridges of inferred reefal origin, locally associated with circular buildups, developed over ca. 2000 km, thus evolving the ramp into a rimmed platform (Anell & Wallace, 2020; Belde et al., 2017; Bradshaw et al., 1988; Collins et al., 2003; Gorter et al., 2002; Jones, 1973; McCaffrey et al., 2020; Romine et al., 1997; Rosleff-Soerensen et al., 2012, 2016; Ryan et al., 2009; Young et al., 2001). These ridges extended southward to the Cape Range anticline, which was not yet formed (McCaffrey et al., 2020; Young et al., 2001; Figure 1, MioR-1 and MioR-2 on Figure 2). The Miocene ridges present there, which are the focus of this study, are only documented from 2D seismic lines (McCaffrey et al., 2020; Young, 2001), as 3D seismic geomorphologic studies are limited to the Browse Basin and Timor Sea, in the northernmost portion of the NWS (Belde et al., 2017; Gorter et al., 2002; Rankey, 2020; Rosleff-Soerensen et al., 2012; Saqab & Bourget, 2016; Thronberens et al., 2022; Van Tuyl et al., 2018a, 2018b, 2019), where both ridges and circular buildups are present. The presence of middle Miocene outcrops of a tropical lagoon with corals in the Cape Range anticline, designated as Trealla Limestone and adjacent to the ridges studied here (Figure 1), indicates that the environment was warm, and possibly favourable to coral reef development (Riera et al., 2019, 2021).

Miocene reefal ridges are not documented in strata younger than ca. 10 Ma, but buildup development may have been locally sustained in the northern part of the NWS, with Rowley Shoals, Scott Reef, Seringapatam Reef and Ashmore Reef possibly being modern survivors of the Miocene buildups (McCaffrey et al., 2020; Ryan et al., 2009). In the southern part of the NWS

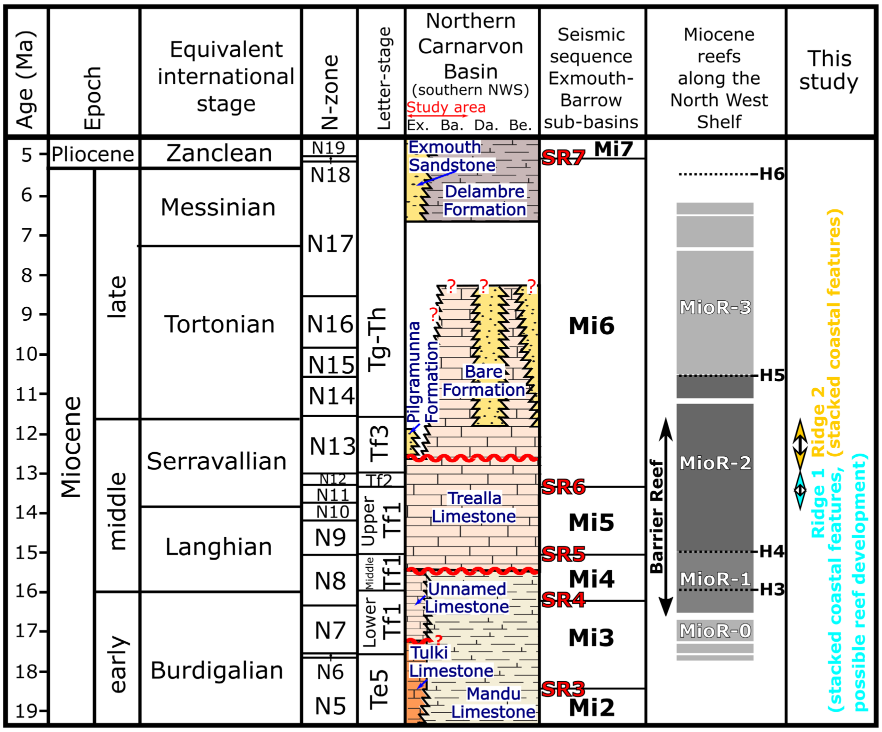


FIGURE 2 Chronostratigraphic framework of the offshore seismic units. N-zones follow Blow (1969) calibrated using Wade et al. (2011), Australasian 'Letter-stages' follow BouDagher-Fadel (2018), stratigraphy of the Northern Carnarvon Basin is modified from Kelman et al. (2013), seismic sequences follow Riera et al. (2023), nomenclature and ages of Miocene reefs along the North West Shelf follow McCaffrey et al. (2020). Abbreviations for the sub-basins of the Northern Carnarvon Basin (from south-west to north-east): Ba, Barrow; Be, Beagle; Da, Dampier; Ex, Exmouth.

(Northern Carnarvon Basin area), the shelf was exposed and karstified at ca. 12 Ma, and an episode of mixed siliciclastic-carbonate sedimentation established during the late middle/late Miocene, leading to the deposition of coastal quartz sandstones locally forming deltas and barriers, that are now partially dolomitised (i.e., Bare Formation and Pilgramunna Formation; Condon et al., 1955; Heath & Apthorpe, 1984; Hocking et al., 1987; Sanchez et al., 2012; Tagliaro et al., 2018). Those mixed deposits are overlain by the detrital carbonates of the Delambre Formation, that locally interfingers with the siliciclastic intervals of the Exmouth Sandstone (Hocking et al., 1987). Sustained siliciclastic influx in the Northern Carnarvon Basin area ceased at ca. 2.4 Ma (early Pleistocene) possibly due to climatic changes (Tagliaro et al., 2018).

3 | DATA AND METHODS

Seismic interpretation is based on the analysis of a seismic volume of ca. 11,000 km^2 extracted from the much broader PGS Carnarvon MegaSurvey (Edwards et al., 2006), and on the re-interpretation of the regional 2D seismic line s136-05, previously described in McCaffrey et al. (2020) and Young et al. (2001). The seismic volume has a spatial resolution of 50 × 50 m, and a vertical sampling rate of 4 ms. Seismic interpretation was performed in PaleoScan™ software, in two-way time (TWT), and hundreds of seismic horizons representing chronostratigraphic surfaces were generated following the workflow from Paumard et al. (2019a).

To complement the seismic data analysis, well cuttings, side-wall cores (SWC) and thin sections from the offshore well Ramillies-1 (Zaunbrecher, 1992) were analysed both at a macro and micro scale. Carbonate texture description follows the classification from Dunham (1962), with the terms dominant, abundant, common, few and rare indicating that the grains represent respectively >90%, 50–90%, 10–50%, 1–10% and <1% of the rock volume. Grain grades, sphericity and sorting follow respectively Wentworth (1922), Powers (1953) and Pettijohn et al. (1972). Age calibration is based on the review of the well completion reports and re-analysis of foraminiferal content of the wells Pyrenees-1, Macedon-1 and Macedon-3 (Riera et al., 2023). In order to integrate well data with seismic data, well data were loaded in PaleoScan™ and converted to time domain using publicly available sonic velocity logs (e.g., Katelis & Hernandianto, 1991).

4 | RESULTS

4.1 | Seismic stratigraphic framework

The two buried ridges are present in a mid-shelf setting. They are overlying the Oligo-Miocene prograding clinoforms of the Mandu Limestone and Tulki Limestone that form an early Miocene distally steepened ramp (Figure 3, Riera et al., 2022). The ridges are present in two distinct stratigraphic intervals. The older ridge, *Ridge 1*, is developed within the regional seismic sequence Mi5 (Riera et al., 2023). The identification of *Orbulina suturalis* and

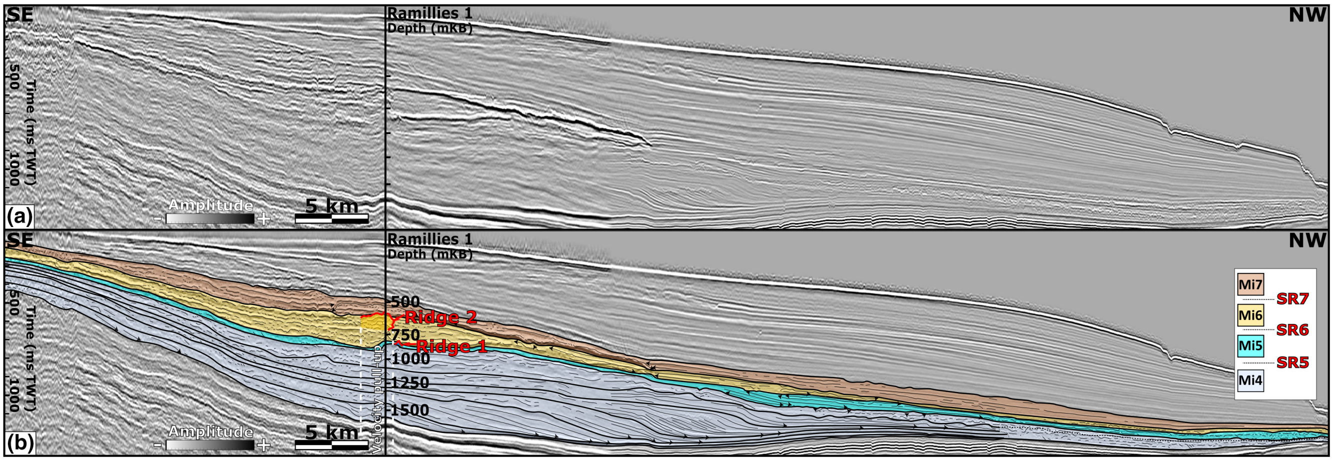


FIGURE 3 Un-interpreted (a) and interpreted (b) seismic line highlighting the general stratigraphic framework (modified from Riera et al., 2023). Note that *Ridge 1* is developed within the sequence Mi5, that is time equivalent to the outcropping tropical lagoon, while *Ridge 2* is within the sequence Mi6, that is time equivalent to the Bare Formation (see Figure 2). Data courtesy of PGS.

Praeorbulina glomerosa at the very base of the sequence in the well Pyrenees-1, and of the larger foraminifera *Lepidocyclina (Nephrolepidina)* and *Flosculinella* sp. around the top of the sequence, respectively from the wells Macedon-3 and Ramillies-1, indicate an accumulation between 15.10 Ma (base of the planktonic foraminiferal N9 zone; Blow, 1969; Wade et al., 2011) and ca. 13 Ma (last known occurrence of *Flosculinella* sp., BouDagher-Fadel, 2018). Hence, *Ridge 1* is time equivalent to the coral-rich tropical lagoonal limestones outcropping in the Cape Range anticline (Riera et al., 2021) and to the seismic barrier reef 'MioR-2' (McCaffrey et al., 2020; Figure 2).

Ridge 2 is embedded in the much thicker regional seismic sequence Mi6 (Riera et al., 2023), which reaches a thickness of ca. 250 m at Ramillies-1 and is composed of sub-parallel to chaotic seismic reflectors draping the thin seismic sequence bearing *Ridge 1* (Figure 3). The minimum age of this sequence is poorly constrained, but it is considered older than 5.48 Ma because it is overlain by deposits accumulated during the planktonic foraminiferal N18 zone in the well Macedon-1 (Rexilius & Powell, 1994). As a result, Ridge 2 belongs to a seismic sequence time equivalent to the Bare Formation and Pilgramunna Formation. As with *Ridge 1*, *Ridge 2* appears to be time equivalent to seismic barrier reef 'MioR-2', but it is younger than the tropical lagoonal limestones outcropping in the Cape Range anticline.

4.2 | Morphology, seismic facies and lithology

4.2.1 | *Ridge 1*

Ridge 1 is a high-amplitude feature associated with underlying velocity anomalies. It is formed by a single sub-horizontal to undulating seismic reflection that locally becomes chaotic to transparent (Figure 4) and has a height of ca. 20 to ca. 40 ms TWT. Ramillies-1 intersects *Ridge 1* between ca. 810 and ca. 840 mKB (metres measured below Kelly Bushing Height), in an area where *Ridge 1* has a height of ca. 30 m. The limited height of *Ridge 1* with respect to the seismic vertical resolution prevents any detailed analysis of its seismic facies from seismic profiles.

Display of seismic amplitudes along the horizons passing through *Ridge 1* reveals that the bright horizon forming the ridge and time-equivalent landward strata are covering an area at least 60 km long and 5.5 km wide. *Ridge 1* has a crenulate, continuous front, which is composed of concave, convex, straight and V-shaped features (Figure 5a–c). The front of *Ridge 1* in itself does not particularly stand out from the rest of the structure, but it is well recognisable as it marks the transition from the high-amplitude seismic reflectors forming *Ridge 1* to the low-amplitude reflectors present seaward of the ridge. The seismic character of *Ridge 1* is also remarkable as the feature is covered with small, <100-to-400-m-wide, high amplitudes, rounded-to-ovoid, evenly spaced pinnacle morphologies (Figure 5). Examination of seismic profiles intersecting those features show that they are created by undulations of the seismic reflectors forming *Ridge 1* (Figure 5d). The total length of *Ridge 1* is unknown, as it extends beyond the limit of the data towards the north west and is masked by a seismic artefact from *Ridge 2* both southward and eastward.

One single SWC, Ramillies-1 810 mKB, is available from *Ridge 1* (Figures 4b and 6a–c). It is composed of a foraminiferal packstone to grainstone with dominantly fine-to-medium size carbonate bioclasts, and rare granule to pebble-size carbonate lithoclasts. Quartz grains were not observed. Bioclasts include porcelaneous foraminifera

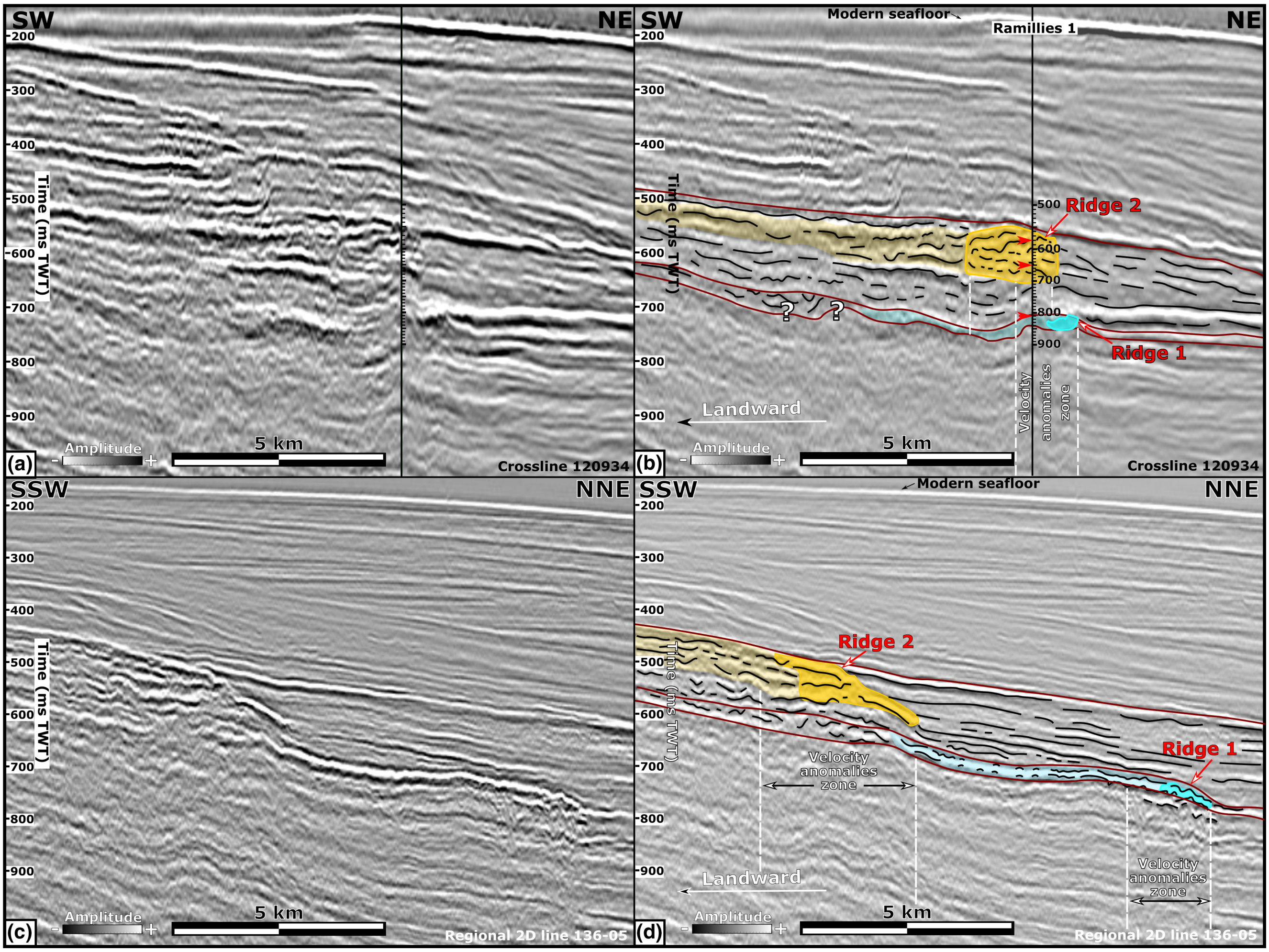


FIGURE 4 Un-interpreted and interpreted seismic lines displaying the seismic expression of the two ridges and time-equivalent strata. (a,b) Crossline extracted from the 3D seismic data. Data courtesy of PGS. (c,d) Regional 2D line 136-05. Location of the seismic lines are displayed on Figures 5b (*Ridge 1*) and 7D (*Ridge 2*). Note the presence of velocity anomaly zones below the two ridges.

(few small miliolids, few broken and entire juvenile to adult *Sorites* sp.), hyaline foraminifera (common *Amphistegina* sp., few undifferentiated small hyaline foraminifera, rare acervulinids), rare, agglutinated foraminifera, few debris of coralline algae, few mollusc debris and few echinoderm debris. A micritic matrix is locally present. No corals or coralgal crust were observed from well cuttings.

4.2.2 | *Ridge 2*

Ridge 2 (Figures 4 and 7) is formed by undulating seismic reflectors of high-to-medium amplitudes, and locally presents a mound-like morphology along 2D seismic profiles, with bi-directional downlaps on both sides (Figure 7e). As with *Ridge 1*, *Ridge 2* induces velocity pull-ups in underlying strata. Overall, *Ridge 2* has a height of ca. 50 to ca. 100 ms TWT and is therefore much thicker than *Ridge 1*. At Ramillies-1, where its actual height is measurable, it extends from 560 to 710 mKB, and therefore has a height of 150 m (Figure 4b).

Seismic amplitude maps along horizons passing through *Ridge 2* reveals a feature at least 80 km long (Figure 7). The front of *Ridge 2* is overall curvilinear and continuous, but the morphology of the ridge front varies between its lower (Figure 7a), middle (Figure 7b) and upper (Figure 7c) intervals. At its base, *Ridge 2* is characterised by the presence of three asymmetric convex-outward features developing lobes and cuspate morphologies (Figure 7a,d), with the larger one ca. 5 km long and ca. 10 km wide. Those convex-outward features become less and less prominent in younger strata (i.e., central and upper part of *Ridge 2*; Figure 7b,c). Smaller high-amplitude stacked ridges with an overall linear-to-crenulate morphology are very locally present in *Ridge 2* (Figure 7f). Those smaller ridges are locally discontinuous (Figure 7g). The total extent of *Ridge 2* is unknown, and as for *Ridge 1*, it extends outside the area investigated. *Ridge 2* is well imaged around Ramillies-1, which intersects it (Figure 7).

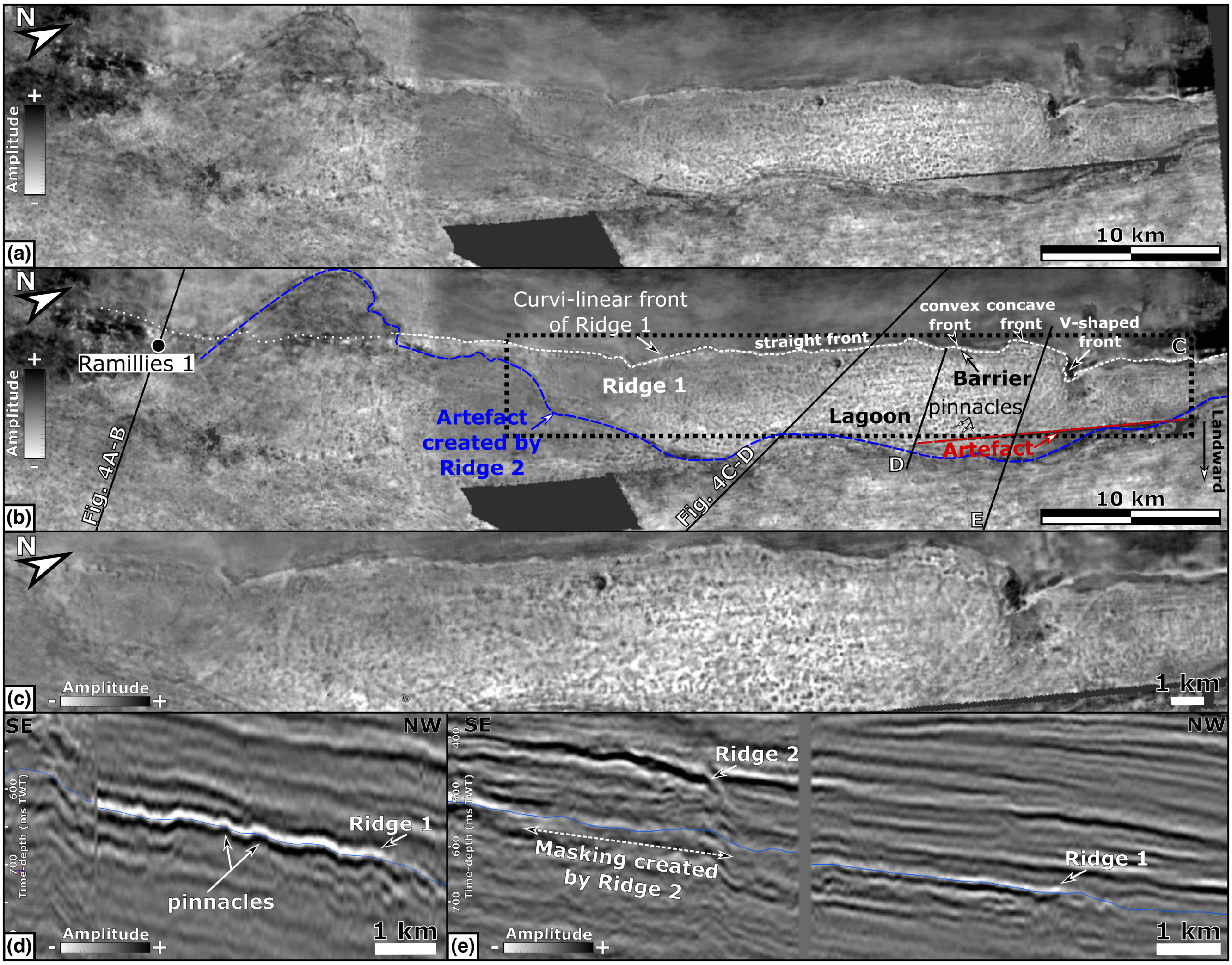


FIGURE 5 Seismic geomorphology of the Miocene *Ridge 1*. (a,b) Un-interpreted and interpreted amplitude maps extracted from the 3D seismic horizon cross-cutting *Ridge 1*. (c) Close-up view of *Ridge 1* and time-equivalent lagoon with pinnacle morphologies. (d) Seismic cross-sections illustrating the relationship between *Ridge 1* and the pinnacles present landward of the ridge. (e) Seismic cross-section illustrating the relationship between *Ridge 1* and *Ridge 2*, note that *Ridge 2* is masking the most landward portion of the lagoon time-equivalent to *Ridge 1*. Data courtesy of PGS.

Analysis of the SWC collected at 580 and 650 mKB (Figures 4b and 6d–f), indicates that *Ridge 2* is composed of quartz grains in a dark matrix, which appears locally dolomitized. Quartz grains are very fine to coarse and are very poorly to well sorted with sphericity ranging from sub-angular to well-rounded. Scarce carbonate bioclasts represented by debris of articulated coralline algae and echinoids were also identified in the interval. No coral, coralgal or otherwise bioconstructed crust were observed from well cuttings.

5 | DISCUSSION

This study has revealed the geomorphology of the two Miocene ridges, hence allowing their comparison with analogues present along modern continental shelves. It is here investigated whether the geomorphology of the ridges indicates a reefal origin or not. Results are then utilised to discuss more largely the morphological differences between reefal ridges and coastal ridges. Lastly, we conclude with a note on the ambiguity that sometimes accompanies the uses of the term reef.

5.1 | Nature of *Ridge 1*

The main seismic elements characterising *Ridge 1* along seismic profiles are its high-amplitude and the velocity anomalies underlying it (Figure 4), which can be observed in reefal carbonate buildups (including seismic reefs, *sensu* Schlager, 2005) but also non-reefal

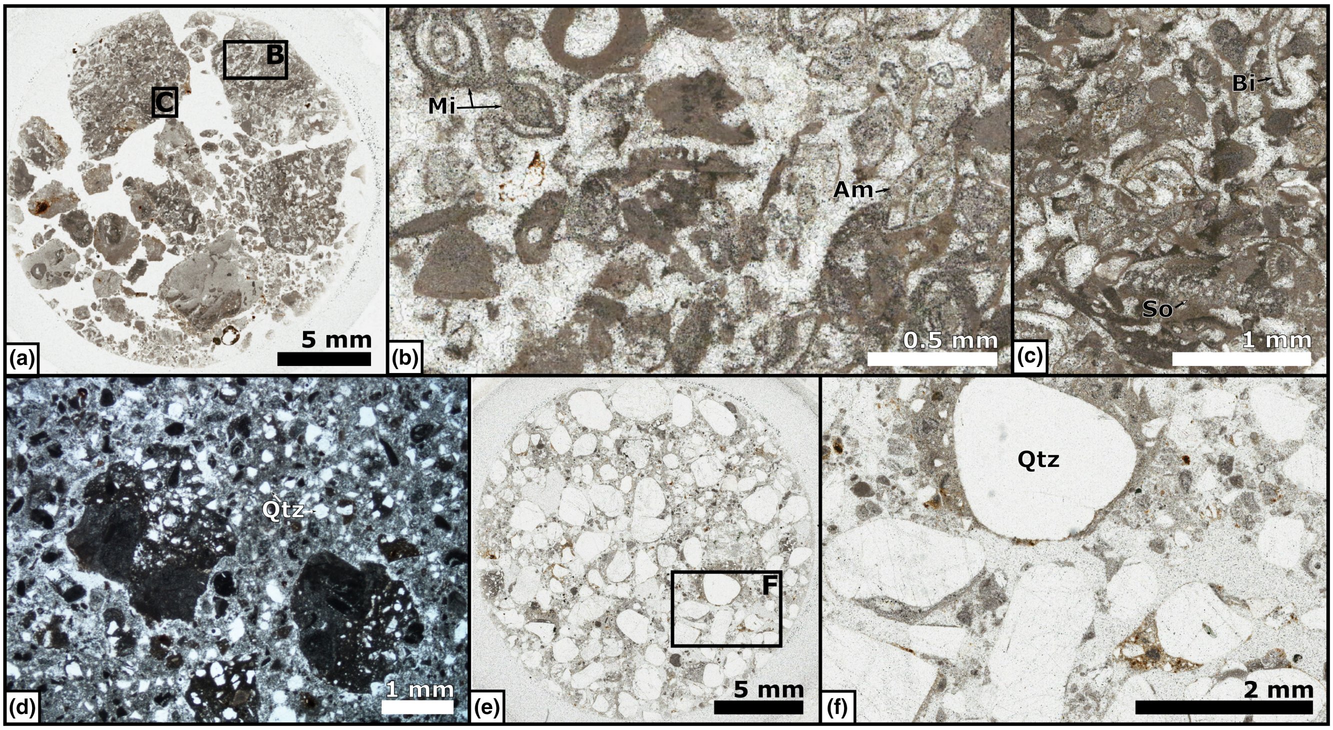


FIGURE 6 Photomicrographs in plane-polarised light presenting the facies observed in side-wall cores (SWC) from Ramillies-1. (a–c) Foraminiferal packstone to grainstone from *Ridge 1* (SWC at 810 m), (d–f) Mix of matrix and quartz sand from *Ridge 2* (d is from SWC at 650 m and e,f are from SWC at 580 m). Am, *Amphistegina* sp.; Bi, bivalve debris; Mi, miliolid; Qtz, quartz grain. See Figure 4b for location of SWC.

carbonate accumulations (Bubb & Hatlelid, 1977; Marfurt & Alves, 2015). However, the limited height of the ridge—it is only identified from one reflector—and the absence of clear stacking pattern prevents any conclusion on its nature based on seismic profile observation alone. The comparison of spatial morphologies with modern analogues, however, provides material to assess whether *Ridge 1* was bioconstructed or not.

Morphological comparison between *Ridge 1* and the individual coral reefs of the Great Barrier Reef (GBR), which is the only modern reef province similar in size to the Miocene seismic reef track buried along the NWS, highlights several elements that contradict a purely reefal origin of *Ridge 1*. First, the GBR is not formed by ridges, but by ca. 2900 individual reefs (Bridge et al., 2012; Figure 8). Additionally, *Ridge 1*, like the other ridges of the Miocene reef track (Anell & Wallace, 2020), is located in a mid-platform setting. This is another dissimilarity with the GBR, because there the more linear reefs are located at the shelf edge, whereas only smaller linear and circular reefs are present in a mid-platform setting (Figure 8d,e; Maxwell, 1968). Moreover, even in areas where the reefs of the GBR have a relatively linear morphology and form barrier reefs (e.g. Ribbon Reefs area; Figure 8e), barrier reefs are continuous over only a few kilometres, separated by passes hundreds of metres to several kilometres wide, often >40 m deep, and with curved margins (Beaman, 2017; Hopley, 2006). The longest linear individual reef of the GBR, Ribbon Reef #10, is 28 km long and surrounded by smaller reefs (Figure 8e; Whiteway et al., 2014). This length is much smaller than the length of *Ridge 1*, that has a length of at least 60 km (Figure 8a). The geomorphological elements from the Miocene reef track that have the more similarities with the GBR are the ovoid buildups. Those are interpreted as atolls and are sometimes associated with the Miocene ridges in the northern part of the NWS (Rosleff-Soerensen et al., 2012, 2016). However, ovoid buildups are absent from the area investigated here, hence indicating that the reefs of the GBR are not a possible analogue for *Ridge 1*.

The linearity of *Ridge 1* and its geomorphological similarity to the modern NWS coastline (Figure 8b,c) might illustrate an influence of coastal features on its formation. Given that *Ridge 1* is ca. 30 m thick, a thickness documented for both coral reefs and lithified shoreline ridges (Salzmann et al., 2013), *Ridge 1* could therefore either be: (1) a bioconstructed reef developed on drowned coastal features; or (2) a lithified coastal ridge. Some elements are in favour of a reefal origin, such as the presence of pinnacles, which can be interpreted as small patch reefs or reef knolls within a lagoon (Figure 8a). In addition, *Ridge 1* is time equivalence to the coral-rich tropical lagoonal

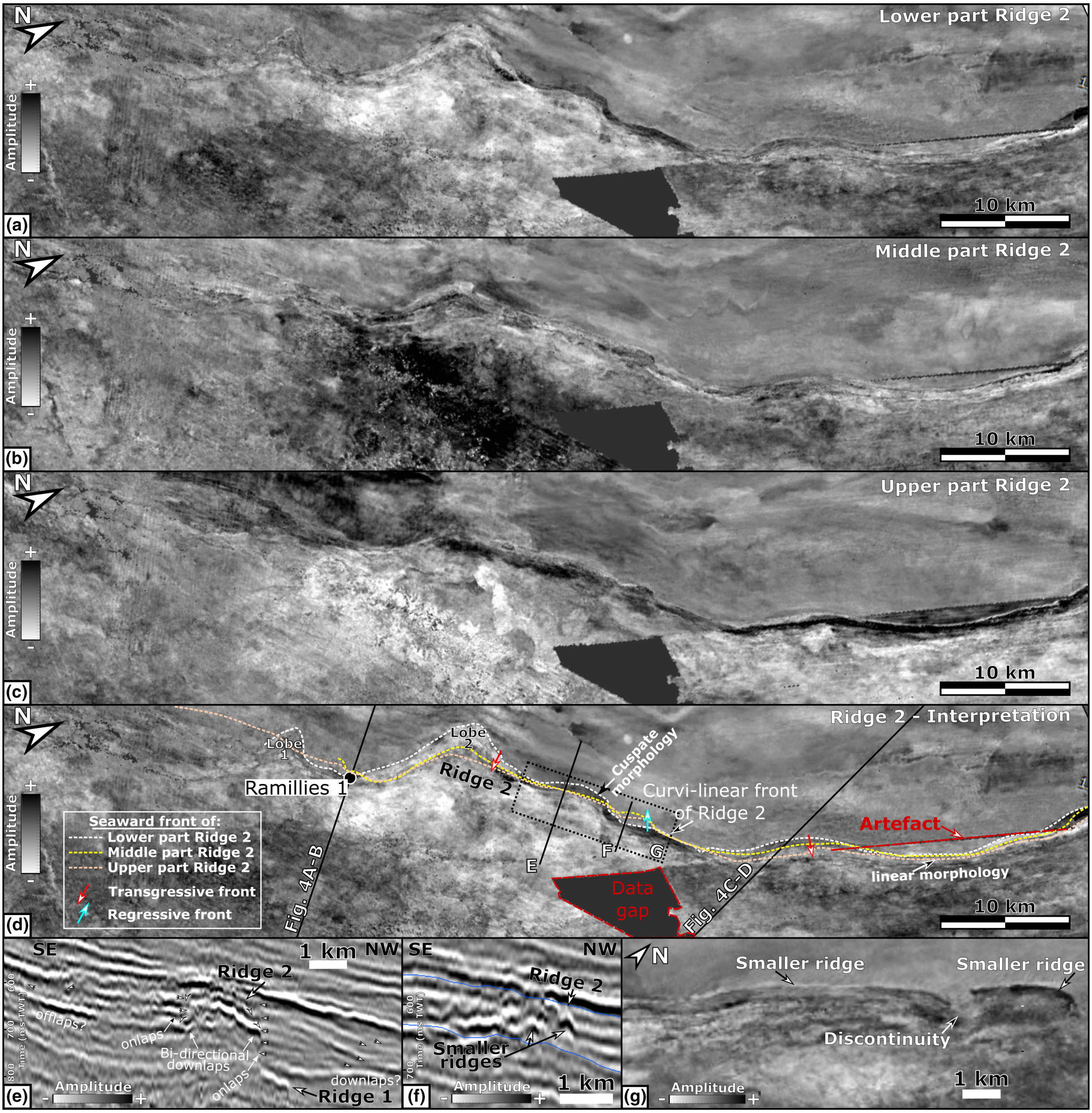


FIGURE 7 Seismic geomorphology of *Ridge 2*. (a–c) Un-interpreted amplitude maps derived from three 3D seismic horizons respectively crossing the base, middle and upper parts of *Ridge 2*. (d) Interpreted amplitude map derived from the horizon crossing *Ridge 2* at its base superimposed with the location of the front of *Ridge 2* through time. (e) Seismic cross-sections highlighting reflector terminations around *Ridge 2*, note the mounded morphology of the ridge with bi-directional downlaps. (f) Seismic cross-section illustrating the complex 2D morphology of the smaller stacked ridges present in *Ridge 2*. (g) Close-up view of an un-interpreted amplitudes map derived from a seismic horizon crossing *Ridge 2* in its central part and illustrating the geomorphology of the smaller ridges. Data courtesy of PGS.

limestones outcropping in Cape Range anticline (Riera et al., 2021). The ridge also has geomorphologic similarities to the central part of the Belize Barrier Reef (BBR; Figure 8f), which is composed of a bioconstructed reefal system developed on beach ridges (Droxler & Jorry, 2013). As such, corals, or other reef-building organisms, may have colonised pre-existing seafloor ridges formed through coastal processes to build=- *Ridge 1* (as described in Droxler & Jorry, 2013; Jarrett et al., 2005; Mohana Rao et al., 2001; Ramsay, 1994; Figure 9).

Several elements are nevertheless in disfavour of a reefal origin. Those elements include the absence of

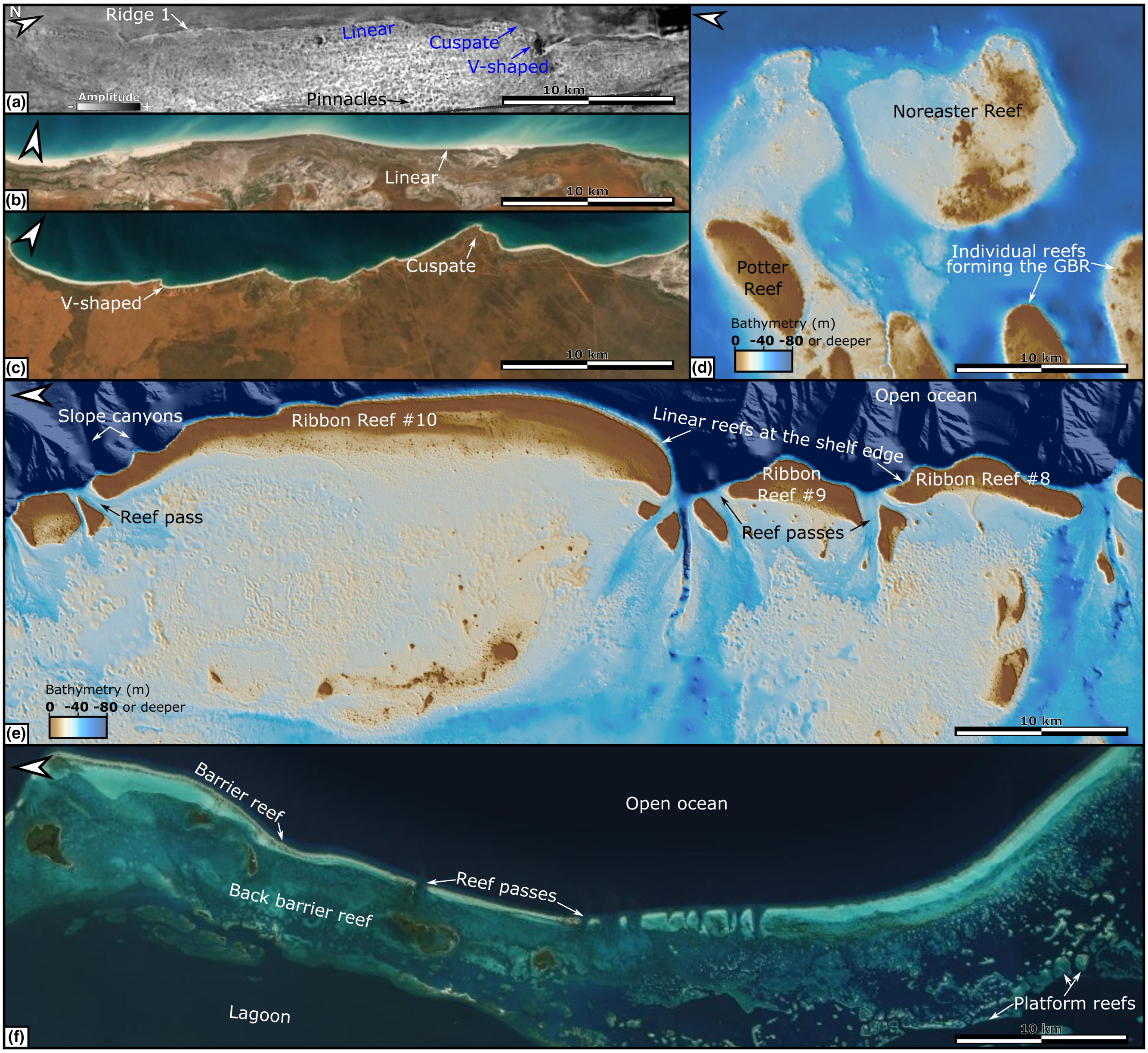
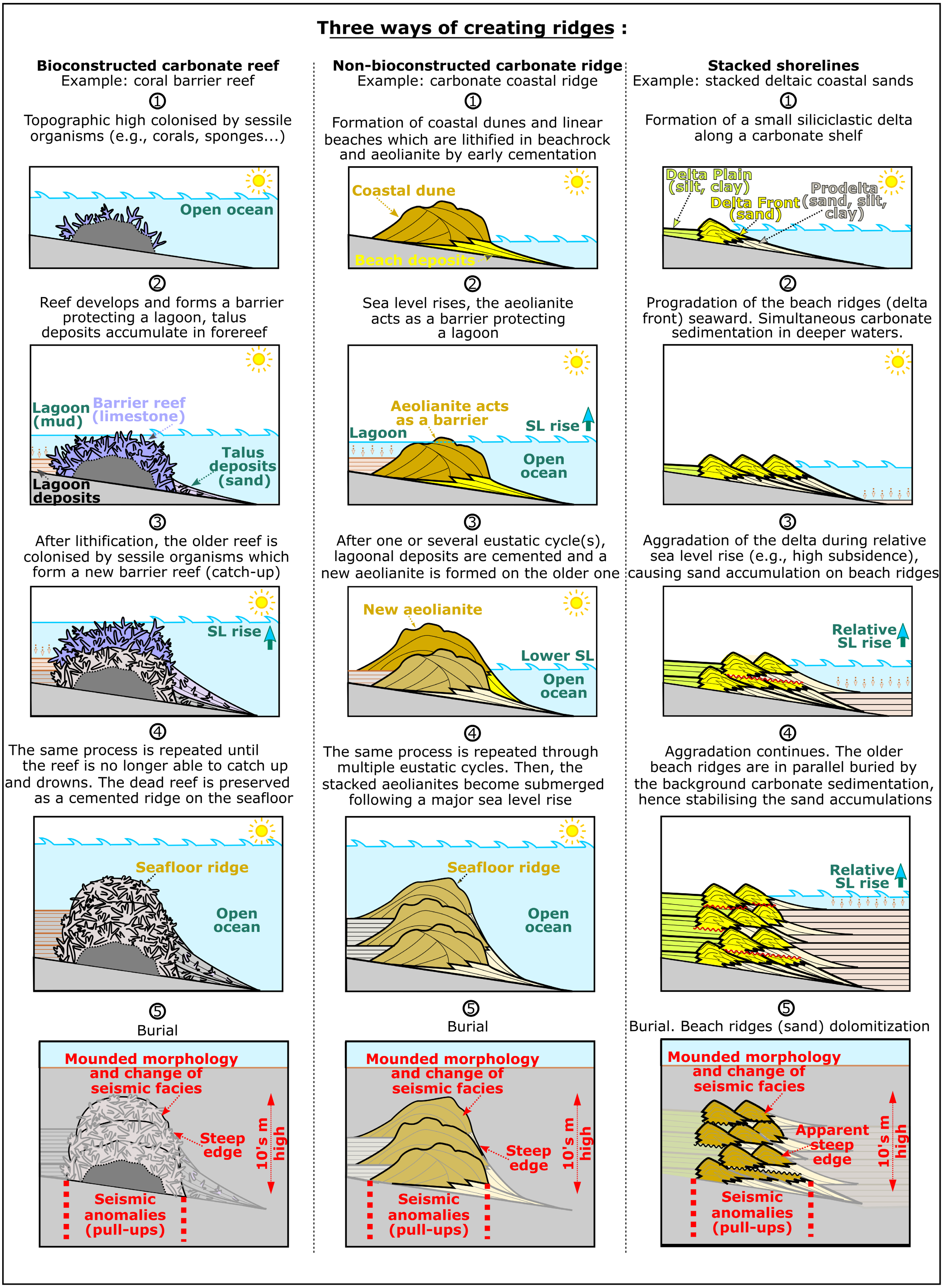


FIGURE 8 Comparison between the seismic geomorphology of *Ridge 1* (a; Data courtesy of PGS) and modern geomorphologies. (b,c) Aerial photographs of the modern coastline of the Australian North West Shelf at the southern extent of Eighty Mile Beach (b) and in the vicinity of Lagrange, ca. 40 km south-east of Broome (c), aerial photographs are from EarthExplorer. (d,e) Close-up view of the present-day Great Barrier Reef in its central part, where the reefs are in a mid-platform setting (d) and in its northern part, where reefs have a linear morphology and are located along the shelf edge (e), note that in both cases the morphology of the individual reefs is clearly discernible; bathymetry is from Beaman (2017). (f) Aerial photograph of the central portion of the Belize Barrier Reef, where it forms a detached coral barrier reef with a linear morphology, aerial photography is from EarthExplorer (source: Esri, i-cubed, USDA, USGS, AEX, GeoEye, Getmapping, Aerogrid, IGN, IGP, UPR-EGP, and the GIS User Community, ESRI).

FIGURE 9 Conceptual sketches illustrating how both reefs and stacked coastal features can form sedimentary ridges tens of metres thick. Those ridges can exhibit buildup morphologies when observed from seismic-reflection profiles. The sketch of the non-bioconstructed carbonate ridge builds on the coastal ridges outcropping along the modern NWS (Lebrec et al., 2022a). The stacked shoreline sketch builds on the Miocene Bare Formation, a Miocene deltaic deposit locally >500 m thick which accumulated along a carbonate shelf undergoing a strong subsidence (Tagliaro et al., 2018) and which is locally associated with dolomite causing high-velocity seismic zones (Wallace et al., 2003).



Three ways of creating ridges :

Bioconstructed carbonate reef
Example: coral barrier reef

① Topographic high colonised by sessile organisms (e.g., corals, sponges...)

② Reef develops and forms a barrier protecting a lagoon, talus deposits accumulate in forereef

③ After lithification, the older reef is colonised by sessile organisms which form a new barrier reef (catch-up)

④ The same process is repeated until the reef is no longer able to catch up and drowns. The dead reef is preserved as a cemented ridge on the seafloor

⑤ Burial

Non-bioconstructed carbonate ridge
Example: carbonate coastal ridge

① Formation of coastal dunes and linear beaches which are lithified in beachrock and aeolianite by early cementation

② Sea level rises, the aeolianite acts as a barrier protecting a lagoon

③ After one or several eustatic cycle(s), lagoonal deposits are cemented and a new aeolianite is formed on the older one

④ The same process is repeated through multiple eustatic cycles. Then, the stacked aeolianites become submerged following a major sea level rise

⑤ Burial

Stacked shorelines
Example: stacked deltaic coastal sands

① Formation of a small siliciclastic delta along a carbonate shelf

② Progradation of the beach ridges (delta front) seaward. Simultaneous carbonate sedimentation in deeper waters.

③ Aggradation of the delta during relative sea level rise (e.g., high subsidence), causing sand accumulation on beach ridges

④ Aggradation continues. The older beach ridges are in parallel buried by the background carbonate sedimentation, hence stabilising the sand accumulations

⑤ Burial. Beach ridges (sand) dolomitization smaller reef geomorphologies (e.g., back-reef and atolls), such as circular buildups. Such geomorphologies are present in BBR (Figure 8f; James et al., 1976), which is therefore not an exact analogue for *Ridge 1*. Additionally, *Ridge 1* is continuous and there are no indicators of sediment flow, such as inter-platform seaway, reef passes or slope debris, in contrast to other reefs described from seismic data (e.g., Courgeon et al., 2016; Posamentier et al., 2010, 2022; Schlager, 2005). Drowned reefal ridges described in the literature tend to be only a few 100's metres or a few kilometres long (e.g., Jorry et al., 2016; Khanna et al., 2017; Mallarino et al., 2021; Rovere et al., 2018) or to be composed of joint and isolated pinnacles (Abbey et al., 2011), and as such are dissimilar to *Ridge 1*. Finally, lithological data do not fully support a reefal origin, as no bioconstructed crust, lithified coral conglomerate or other indicators of reefal bioconstruction were observed along the time-equivalent outcrops (Riera et al., 2021) or from well data. Those elements are known not only from modern reefs (Braga et al., 2019; James et al., 1976; Webster et al., 2018) but also from fossil ones (James & Jones, 2015).

It is hence conceivable that *Ridge 1* is composed exclusively of coastal features, similarly to the submerged sedimentary ridges present along the modern seafloor of Western Australia (Brooke et al., 2014; Lebrec et al., 2022a). Indeed, drowned and cemented wave- and wind-built beach ridges can form linear ridges composed of beachrocks and aeolianites reaching heights >30 m (Salzmann et al., 2013) and lengths >1000 km (Lebrec et al., 2021, 2022a). Those non-bioconstructed ridges can form barriers several 100's km long (Dillenburg et al., 2020), and protect lagoons, hence exhibiting morphologies similar to drowned barrier reefs (Salzmann et al., 2013; Figure 9). In addition, it is well documented from outcrop studies that coastal deposits, and in particular aeolianites, can be stacked on top of each other and reach significant thicknesses (Figure 9; Carew & Mylroie, 2001). For example, shore-parallel barriers composed of Quaternary stacked dunes reaching thicknesses of 200 m above sea level are documented in South Africa (Bateman et al., 2011). Most of the Bahamian Islands are built by aeolianites, that can form ridges up to 63 m high (Carew & Mylroie, 2001). Similarly, Pleistocene carbonate aeolianites, composed of palaeodunes interbedded with calcretes and palaeosols, form cliffs up to ca. 80 m high in South Australia (James & Bone, 2015). Quaternary carbonate aeolianites are widespread along the present-day Western Australian coast (Brooke, 2001), and they can form massive carbonate structures. For example, Shark Bay is protected by stacked aeolianite islands up to 150 km long and >250 m thick (Frébourg et al., 2008; Le Guern & Davaud, 2005; Logan et al., 1970; Vimpere et al., 2022).

The marine nature of the sediment forming *Ridge 1* does not contradict a formation by coastal features, as coastal carbonates, including aeolianites and beachrocks, have a marine provenance (Abegg et al., 2001). As a result, aeolianites and beachrocks can be undistinguishable from subtidal carbonate at the thin section scale, due to the absence of observable sedimentary structures (Frébourg et al., 2008). As an example, Pleistocene and Holocene aeolianites composed of coralline algae, corals, molluscs, echinoderms and foraminifera are documented in Hawaii (Blay & Longman, 2001). The present-day Western Australian coastline is a 'hot spot' of beachrock occurrence (Vousdoukas et al., 2007), and the observation of grains >4 mm in SWC from *Ridge 1* could indicate a formation by stacked beachrocks. Nevertheless, a coarse grain size does not necessarily contradict an aeolianite origin, as carbonate aeolianites are often composed of heterogenous and coarse-grained material (Frébourg et al., 2008). The absence of documentation of middle Miocene outcrops of aeolianites and carbonate beachrocks in Western Australia is not a proof of their absence, as Miocene outcrops are largely understudied, and because carbonate coastal features are often misinterpreted as shallow-water deposits (Abegg et al., 2001; Frébourg et al., 2008). In addition, the absence of observation of shoal morphologies from 3D seismic data raises the question of whether middle Miocene outcrops interpreted as shoals in Cape Range anticline and Barrow Island (McNamara & Kendrick, 1994; Riera et al., 2021; Figure 1) could be formed by beachrocks and/or coastal aeolianites. As such, *Ridge 1* could well be composed of coastal ridges, which acted as a barrier and protected a lagoon. In this case, corals might have been present on the ridge as a veneer, and within the lagoon as small patch reefs and knolls, but the core of *Ridge 1* would be composed of carbonate coastal features. Aeolianites colonised by a thin coral veneer (not forming reef) are for example documented in the Bahamas (Carew & Mylroie, 2001) and in Western Australia (Playford, 2004).

5.2 | Nature of *Ridge 2*

Ridge 2 exhibits several seismic characteristics known from both carbonate bioconstructed and non-bioconstructed buildups along seismic profile, such as high seismic amplitudes, velocity anomalies underlying it and a mound-like morphology (Bubb & Hatlelid, 1977; Burgess et al., 2013; Esker et al., 1998; Paumard et al., 2017). However, those seismic characteristics are not exclusive to carbonate buildups and can be created by buried coastal sands. Mound-like morphologies have for example been observed in coastal barriers (Passos et al., 2019). In addition, the siliciclastic sands of the Miocene Bare Formation, which are time equivalents to *Ridge 2*, are also known to exhibit a mounded geometry along seismic profiles, and to locally reach thickness > 500 m (Tagliaro et al., 2018). It is furthermore documented that sandstone bodies present within finer lithologies can cause pull-up effects (Grasseau et al., 2019). Hence, it appears that aggrading coastal sands undergoing early cementation and/or early burial, can form mounded seismic features with apparent steep slope associated with velocity anomalies (Figure 9).

The seismic geomorphology of *Ridge 2* clearly differs from modern bioconstructed reefs. Indeed, *Ridge 2* is characterised by the presence of convex-outward features similar to the deltaic lobes of the present-day Ashburton River delta coastline, which is composed of active and abandoned deltas with well-defined lobes, as well as asymmetrical cuspate forelands (Figure 10). The location of *Ridge 2* in front of the present-day Ashburton River delta complex further supports a connection between the formation of the ridge and the palaeo-activity of the Ashburton River during the Miocene (Figure 1). The Miocene asymmetrical cuspate morphologies may indicate the presence of a palaeo-longshore drift that shaped the front of *Ridge 2*. A tidal influence on the formation of *Ridge 2* may also be indicated by the presence of the smaller ridges observed within *Ridge 2* (Figure 7f,g). They could represent stacked linear beach ridges locally developing wave-dominated barrier complexes incised by tidal channels (i.e., inlet, Figure 10d; also see comparison with Figure 2i from Nyberg & Howell, 2016). Those observations indicate that *Ridge 2* contains geomorphologic elements characteristic of wave processes with a local river input and affected by tidal processes, leading to the development of wave-dominated, fluvial-influenced and tide-affected shorelines (*sensu* Ainsworth et al., 2011).

The formation of *Ridge 2* by mechanical processes, and not by bioconstruction, is further supported by the mobility of the lobe and cuspate morphologies through time and space. Indeed, the front of *Ridge 2* is overall transgressive, while it can be locally regressive (Figure 7a–d). The ridge also appears to be continuous over at least 80 km, except along the smaller stacked ridges (Figure 7g), which is typical of transgressive non-reefal barrier complexes protecting lagoons or tidal flats (Green et al., 2013; Otvos, 2012; Storms et al., 2008; Wenau et al., 2020). No platform reef morphologies or deep passes are observed along *Ridge 2*.

SWC and well cutting analysis further supports the formation of *Ridge 2* by mechanical processes along a palaeoshorelines, as the ridge is dominantly composed of quartz grains. The siliciclastic nature of *Ridge 2* implies a formation by sediments supplied from rivers, marine currents and/or wind. The most common bioclasts are debris of articulated coralline algae, occurring in most marine environments receiving light (i.e., photic zone, ca. 0–80 m; James & Jones, 2015), and echinoid debris indicating carbonate production in a normal marine environment (i.e., neither brackish nor hypersaline; Heckel, 1972). Hence, despite a buildup-like morphology along 2D seismic profiles, both the geomorphology and lithology of *Ridge 2* point towards a formation driven by the mechanical accumulation of siliciclastic sediments along an overall carbonate coast. Modern examples of siliciclastic delta developed in carbonate environments, that can be used as analogues, are documented along the NWS (Lebrec et al., 2023; Semeniuk, 1993). Therefore, it is proposed that *Ridge 2* is an accumulation of stacked coastal siliciclastic sands, possibly related to the palaeo-Ashburton delta.

5.3 | Differentiating reefal ridges from coastal ridges

Reefal ridges can, in some instances, be difficult to differentiate from drowned and/or buried coastal ridges, as both can form barriers that protect lagoons

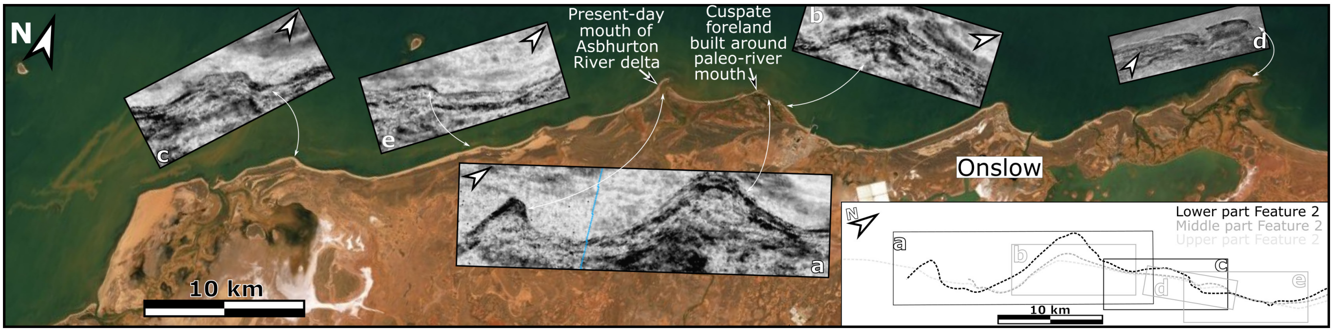


FIGURE 10 Aerial photography of the Ashburton River delta and surrounding shoreline (colour image) compared with selected close-ups from the Miocene *Ridge 2* displayed along envelope attribute maps (grey images), extracted from the 3D seismic volume (Data courtesy of PGS). Close-ups of the Miocene *Ridge 2* are displayed at the same scale than the aerial photograph. Aerial photograph is from EarthExplorer (source: Esri, i-cubed, USDA, USGS, AEX, GeoEye, Getmapping, Aerogrid, IGN, IGP, UPR-EGP, and the GIS User Community, ESRI).

(Gardner et al., 2005; Figure 9). Examples of drowned non-reefal ridges that form such structures on the present-day seafloor are numerous (e.g., Alcántara-Carrió et al., 2013; Brooke et al., 2010; De Falco et al., 2015; Lebrec et al., 2022a, 2022b; Mellett et al., 2012; Wenau et al., 2020), and they should be considered as possible analogues for seafloor ridges observed along continental shelves. Additionally, identification of corals or other reef-building organism on the inside part of a ridge is not infallible evidence of a reefal origin, as loose corals or other sessile organisms can also be reworked to form ridges (e.g., Spiske, 2016), which may lead to their misinterpretation as a bioconstructed ridge.

It is possible to interpret the origin of a seafloor ridge when geomorphologic elements characteristic of coastal or reefal environments are present. Elements characteristic of reefal development include atoll morphologies (Khanna et al., 2017), spurs and grooves (Duce et al., 2016; Gischler, 2010; Stoddart, 1969) that can be detected from high-resolution bathymetry (Khanna et al., 2017), but also knoll morphologies within the lagoon, which can be formed by pinnacle reefs or coral heads (Kennedy et al., 2021). Elements characteristic of coastal environments include prograding beach ridges, tidal or fluvial channels, recurved spits, blow-outs and washover deposits (e.g., Brooke et al., 2017; Lebrec et al., 2022a; Passos et al., 2019). However, those elements might be visible only where data resolution is good, and not often observable from seismic-reflection data.

When performing seismic interpretation or working on low-resolution bathymetry data, larger elements might help to discriminate between coastal ridges and reefal ridges. Indeed, coastal ridges are accumulated along palaeoshorelines, and as such they tend to exhibit linear morphologies continuous over extensive lengths, potentially reaching hundreds of kilometres, that reproduce the shoreline along which they were accumulated (e.g., Brooke et al., 2014; Lebrec et al., 2022a). Conversely, reefs are organic features that can develop on any topographic high, and as such, reefal development is often not limited to the barrier along modern continental shelves, and smaller platform reefs with circular morphologies often develop simultaneously to the barrier reef (James et al., 1976; Maxwell, 1968). Finally, as coastal features are dynamic objects, the position of tidal passes is not stable through time, while the location of reefal passes is relatively stable. It is hence proposed here that the main elements to differentiate between coastal and reefal ridges using seismic-reflection data is not the thickness of the ridge in itself, as both coastal ridges and reefal ridges can reach significant thicknesses (Figure 9), but: (1) the continuity of the ridge; (2) the presence or absence of circular buildups (atolls) associated with the ridge; and (3) the dimensions of the passes, as the observation of deep passes along a barrier can be a sign of a stable, bioconstructed origin.

Reefs that are developed on drowned coastal features are hybrid sedimentary objects, that can have geomorphologic characteristics of both reefs and coastal features. Present-day coral reefs enhancing the deltaic morphologies underlying them are well documented, with examples from the Great Barrier Reef, Belize Barrier Reef and New Caledonia shelf (Choi & Ginsburg, 1982; Droxler & Jorry, 2013; Ferro et al., 1999; Le Roy et al., 2019; Maxwell, 1970). Those hybrid features can be identified using 3D seismic data by the observations of coastal geomorphologies whose thickness has been enhanced by reefal development (e.g., Mathew et al., 2020). In this case, the location of coastal features, such as channel levees, bars and deltaic lobes is stable upward, hence indicating that those coastal features are colonised by aggrading reefs.

5.4 | Note regarding the use of the term reef

While geologists and most researchers working on modern coral reefs restrict the use of the term reef to rigid and wave-resistant structures that are bioconstructed by frame building, sediment retention and binding, following the definition from Lowenstam (1950), this is not the case of the entire scientific community. Indeed, at least two other definitions of the term reef exist, which can sometimes cause confusion. Reef was originally a nautical term designating a topographic high on the seafloor, independently of its nature (Cumings, 1932). This definition is still used today by government agencies and researchers working on marine habitat mapping, marine policies and fishery. The term reef is, for example, defined by the European Commission as a hard substrate of either bioconstructed or geogenic origin arising from the seafloor (European Commission, 2013, p. 13). As a consequence, the term reef is sometimes used to designate non-bioconstructed bathymetric highs, such as igneous rock outcrops (e.g., granite reef; Campbell et al., 2014), drowned aeolian dunes (e.g., Broken Reef; Beaman et al., 2005) or undifferentiated bedrock outcrops (e.g., rocky and geogenic reefs; Brooke et al., 2014; Diesing et al., 2009; O'Sullivan et al., 2020). A more restrictive, yet widely used definition, limits the use of the term reef to any type of rock lying near or at the surface of the sea, which can constitute a hazard to surface navigation (e.g., Harris & Baker, 2020). Those two definitions do not have biological implications, and they contrast with the definition from Lowenstam (1950), which explicitly excludes features not bioconstructed.

Even among geologists, there is a degree of uncertainty on the exact definition of reef. As an example, Schlager (2005) stats that 'the question of what is a reef continues to fuel heated discussions among geologists' (Schlager, 2005, p. 115). Indeed, according to Schlager (2005), seismic features having morphologies similar to modern coral reefs should be designated as *seismic reefs*, as those seismic features may contain a significant portion of non-bioconstructed material. It can indeed be difficult to prove that a seismic structure is bioconstructed, even when sedimentary cores are available (Burgess et al., 2013; Montaggioni & Braithwaite, 2009). Debates on what is a reef are not restricted to *seismic reefs*, and over the last century, ambiguity surrounding the term reef in geological studies has been consistently pointed out, and repeated attempts were made to homogenise its use (e.g., Cumings, 1932; Cumings & Shrock, 1928; Dunham, 1970; Nelson et al., 1962; Riding, 2002; Wilson, 1975). For example, a debate occurred during the 60's and 70's on whether the Capitan reef was a reef, even though its structure is extensively outcropping and has been considerably studied, making it one of the most famous ancient reefs in the world (Saller et al., 1999). Identifying a fossil reef based on the definition of Lowenstam (1950) can be subjective, and Dunham (1970) advises to differentiate between the observational term *stratigraphic reef*, which designates masses of carbonate sediments either organically or inorganically bound, and the interpretative term *ecologic reef*, which designates purely bioconstructed structures (i.e., organically bound).

Debates on the definition of reef also concern present-day reefs, with for example discussion on the minimum size a structure must have to be designated as a reef (Montaggioni & Braithwaite, 2009), or on the amount of bioconstruction in modern reefs (Montaggioni, 2001). Furthermore, when corals and other sessile organisms colonise topographic highs, they sometimes only form a veneer of bioconstructed material at their surfaces. This gives those features the appearance of bioconstructed reefs from shallow observations (e.g., visual description based on photographs, surficial sampling), while their internal structure is non-reefal (e.g., Jarrett et al., 2005; Mohana Rao et al., 2001; Ramsay, 1994), hence raising the question of whether or not such features should be regarded as reefs. Discoveries of deep water bioconstructed structures also question whether the term reef should be restricted to wave-resistant structures (Heckel, 1974; Schlager, 2005), or if it can be used to designate deep water azooxanthellate coral bioherms (e.g., Roberts et al., 2006) and coral bioherms living in mesophotic environments (e.g., Bridge et al., 2012). Hence, it is here recommended to specify which definition of reef is followed when working on reefal structures.

6 | CONCLUSION

Despite the well-known ability of relict coastal features to build massive structures along present-day carbonate coasts, those features formed by winds, waves, tides and currents are not often described in pre-Quaternary strata. This study investigates the nature of two Miocene ridges formed along a carbonate shelf that were previously interpreted as reefal ridges based on 2D seismic profiles. Here, new information derived from 3D seismic volume and well data highlight the role of coastal processes in the formation of those ridges.

The older ridge, namely *Ridge 1*, is a curvilinear carbonate feature protecting a lagoon with pinnacles, which exhibits a geomorphology reminiscent of the modern Australian coastline. The ridge is time equivalent to the nearby outcrops of a coral-rich tropical lagoon; however, no indicators of bioconstruction by coral, algae or microbial mats were identified from field or well data. The ridge is not associated with ovoid buildup morphologies (atolls), and no discontinuities (passes) were observed along its front. As such, it is proposed that *Ridge 1* could either be: (1) a bioconstructed reef developed on drowned coastal features, similar to the Belize Barrier Reef; or (2) stacked aeolianites and/or beachrocks accumulated along the Miocene palaeoshoreline, similar to the relict coastal ridges present along the modern Western Australian coast.

The younger ridge, namely *Ridge 2*, is curvilinear and contains several lobes and cuspate landforms. Those features appear mobile, as their morphology evolves throughout the different stratigraphic intervals. Overall, *Ridge 2* has striking morphological similarities to the modern Ashburton River delta complex, hence pointing towards a formation by the accumulation of coastal sand. This interpretation is further supported by the abundance of quartz grains within the ridge. Hence, *Ridge 2* is here re-interpreted as a drowned siliciclastic coastline developed in an overall carbonate environment. As such, it is proposed that this ridge belongs to the palaeo-Ashburton River delta complex.

Those observations illustrate that corals and other reef-building organisms are not the only builders of sedimentary seafloor ridges in tropical environments, and that aeolianites and other coastal features are capable of creating massive structures along carbonate coasts. As such, their scarcity of documentation in pre-Quaternary strata might be a description bias, as ridges formed by stacked coastal features can be misinterpreted as bioconstructed reefs. Indeed, coastal features subject to early cementation and/or rapid burial are capable of creating high-velocity seismic ridges 10's of metres thick. It is proposed that coastal ridges can be identified from their continuous front and from the presence of coastal geomorphologies. When several coastal ridges are stacked on top of each other, the location of finer-scale geomorphologic elements present within the ridges, such as lobes or channels, is expected to evolve upward. In contrast, it is proposed that reefal ridges are more discontinuous, with deeper and more stable passes. Reefal ridges developed on drowned coastal features might contain geomorphologic elements characteristic of coastal environments, whose thickness has been enhanced by reefal development, and whose location remains stable upward.

ACKNOWLEDGEMENTS

The authors would like to thank the Centre for Energy Geoscience (University of Western Australia) and the Norwegian Geotechnical Institute for providing financial support to the project. The authors are also obliged to PGS and Eliis for providing access to the PGS Carnarvon MegaSurvey and PaleoScan™ software, respectively. The Department of Mines, Industry Regulation and Safety, Western Australia is also acknowledged for providing access to offshore well material (sampling approval N00832) and archived thin sections. The authors are grateful to the School Earth Science (UWA) for providing equipment access. Two anonymous reviewers, Stephan J. Jorry and Prof. Peter Burgess are greatly thanked for their very constructive feedbacks on the manuscript.

CONFLICT OF INTEREST STATEMENT

The authors are not aware of any conflicts of interest relating to this work.

DATA AVAILABILITY STATEMENT

3D reflection seismic data used for this research consist of public and PGS-owned seismic-reflection data combined in a regional dataset by PGS. 2D seismic lines are available through the Australian National Offshore Petroleum Information Management System. SWC and well cuttings can be accessed through the Perth Core Library.

ORCID

Rosine Riera https://orcid.org/0000-0002-9179-4330
Victorien Paumard https://orcid.org/0000-0001-7606-7293

REFERENCES

Abbey, E., Webster, J. M., & Beaman, R. J. (2011). Geomorphology of submerged reefs on the shelf edge of the Great Barrier Reef: The influence of oscillating Pleistocene sea-levels. *Marine Geology*, *288*, 61–78. https://doi.org/10.1016/j.margeo.2011.08.006

Abegg, F. E., & Handford, C. R. (2001). Deflation origin of Mississippian Carbonate Eolianites, Southwestern Kansas, USA. In F. E. Abegg, D. B. Loope, & P. M. Harris (Eds.), *SEPM special publication* (Vol. *71*, pp. 183–204). SEPM Society for Sedimentary Geology. https://doi.org/10.2110/pec.01.71.0183

Abegg, F. E., Loope, D. B., & Harris, P. M. (2001). Modern and ancient carbonate eolianites: Sedimentology, sequence stratigraphy, and diagenesis. In *SEPM Special Publication* (Vol. *71*, p. 207). SEPM Society for Sedimentary Geology.

Ainsworth, R. B., Vakarelov, B. K., & Nanson, R. A. (2011). Dynamic spatial and temporal prediction of changes in depositional processes on clastic shorelines: Toward improved subsurface uncertainty reduction and management. *AAPG Bulletin*, *95*(2), 267–297. https://doi.org/10.1306/06301010036

Alcántara-Carrió, J., Albarracín, S., Montes, I. M., Flor-blanco, G., Bouzas, Á. F., & Rey Salgado, J. (2013). An indurated Pleistocene coastal barrier on the inner shelf of the Gulf of Valencia (western Mediterranean): evidence for a prolonged relative sea-level stillstand. *Geo-Marine Letters*, *33*(2–3), 209–216. https://doi.org/10.1007/s00367-012-0316-9

Anell, I., & Wallace, M. W. (2020). A fine balance: Accommodation dominated control of contemporaneous cool-carbonate shelf-edge clinoforms and tropical reef-margin trajectories, North Carnarvon Basin, Northwestern Australia. *Sedimentology*, *67*(1), 96–117. https://doi.org/10.1111/sed.12628

Apthorpe, M. (1988). Cainozoic depositional history of the North West Shelf. In P. G. Purcell & R. R. Purcell (Eds.), *The North West Shelf, Australia. Proceedings of the Petroleum Exploration Society of Australia Symposium*, Perth, WA (pp. 55–84). PESA.

Bateman, M. D., Carr, A. S., Dunajko, A. C., Holmes, P. J., Roberts, D. L., McLaren, S. J., Bryant, R. G., Marker, M. E., & Murray-Wallace, C. V. (2011). The evolution of coastal barrier systems: a case study of the Middle-Late Pleistocene Wilderness barriers, South Africa. *Quaternary Science Reviews*, *30*(1–2), 63–81. https://doi.org/10.1016/j.quascirev.2010.10.003

Beaman, R. J. (2017). High-resolution depth model for the Great Barrier Reef—30 m. *Commonwealth of Australia (Geoscience Australia)*. https://doi.org/10.4225/25/5a207b36022d2

Beaman, R. J., Daniell, J. J., & Harris, P. T. (2005). Geology–benthos relationships on a temperate rocky bank, eastern Bass Strait. *Australia. Marine and Freshwater Research*, *56*(7), 943–958. https://doi.org/10.1071/MF04306

Belde, J., Back, S., Bourget, J., & Reuning, L. (2017). Oligocene and Miocene carbonate platform development in the browse basin, Australian Northwest Shelf. *Journal of Sedimentary Research*, *87*(8), 795–816. https://doi.org/10.2110/jsr.2017.44

Blay, C. T., & Longman, M. W. (2001). Stratigraphy and sedimentology of Pleistocene and Holocene Carbonate Eolianites, Kaua'i, Hawai'i, USA. In F. E. Abegg, D. B. Loope, & P. M. Harris (Eds.), *SEPM special publication* (Vol. *71*, pp. 93–116). SEPM Society for Sedimentary Geology. https://doi.org/10.2110/pec.01.71.0093

Blow, W. H. (1969). Late middle eocene to recent planktonic foraminiferal biostratigraphy. In P. Bronnimann & H. H. Renz (Eds.), *Proceedings of the 1st International Conference on Planktonic Microfossils, Geneva* (Vol. *1*, pp. 199–422).

BouDagher-Fadel, M. K. (2018). *Evolution and geological significance of larger benthic foraminifera* (2nd ed.). UCL PRESS. https://doi.org/10.14324/111.9781911576938

Bradshaw, M. T., Yeates, A. N., Beynon, R. M., Brakel, A. T., Langford, R. P., Totterdell, J. M., & Yeung, M. (1988). Palaeogeographic evolution of the north west shelf region. In P. G. Purcell & R. R. Purcell (Eds.), *The North West Shelf, Australia. Proceedings of the Petroleum Exploration Society of Australia Symposium, Perth, WA* (pp. 29–54). PESA.

Braga, J. C., Puga-Bernabéu, Á., Heindel, K., Patterson, M. A., Birgel, D., Peckmann, J., Sánchez-Almazo, I. M., Webster, J. M., Yokoyama, Y., & Riding, R. (2019). Microbialites in Last Glacial Maximum and deglacial reefs of the Great Barrier Reef (IODP Expedition 325, NE Australia). *Palaeogeography, Palaeoclimatology, Palaeoecology*, *514*, 1–17. https://doi.org/10.1016/j.palaeo.2018.10.007

Bridge, T., Beaman, R., Done, T., & Webster, J. (2012). Predicting the location and spatial extent of submerged coral reef habitat in the great barrier reef world heritage area, Australia. *PLoS ONE*, *7*(10), e48203. https://doi.org/10.1371/journal.pone.0048203

Brooke, B. (2001). The distribution of carbonate eolianite. *Earth-Science Reviews*, *55*, 135–164. https://doi.org/10.1016/S0012-8252(01)00054-X

Brooke, B., Creasey, J., & Sexton, M. (2010). Broad-scale geomorphology and benthic habitats of the Perth coastal plain and Rottnest Shelf, Western Australia, identified in a merged topographic and bathymetric digital relief model. *International Journal of Remote Sensing*, *31*(23), 6223–6237. https://doi.org/10.1080/01431160903403052

Brooke, B. P., Nichol, S. L., Huang, Z., & Beaman, R. J. (2017). Palaeoshorelines on the Australian continental shelf: Morphology, sea-level relationship and applications to environmental management and archaeology. *Continental Shelf Research*, *134*, 26–38. https://doi.org/10.1016/j.csr.2016.12.012

Brooke, B. P., Olley, J. M., Pietsch, T., Playford, P. E., Haines, P. W., Murray-Wallace, C. V., & Woodroffe, C. D. (2014). Chronology of Quaternary coastal aeolianite deposition and the drowned shorelines of southwestern Western Australia—A reappraisal. *Quaternary Science Reviews*, *93*, 106–124. https://doi.org/10.1016/j.quascirev.2014.04.007

Bubb, J. N., & Hatlelid, W. G. (1977). Seismic stratigraphy and global changes of sea level, part 10: Seismic recognition of carbonate buildups. *AAPG Memoir*, *26*, 185–204. https://doi.org/10.1306/M26490C12

Bufarale, G., Leary, M. J. O., & Bourget, J. (2019). Sea level controls on the geomorphic evolution of Geographe Bay, South-West Australia. *Journal of the Royal Society of Western Australia*, *102*, 83–97.

Burgess, P. M., Winefield, P., Minzoni, M., & Elders, C. (2013). Methods for identification of isolated carbonate buildups from seismic reflection data. *AAPG Bulletin*, *97*(7), 1071–1098. https://doi.org/10.1306/12051212011

Campbell, M. S., Stehfest, K. M., Votier, S. C., & Hall-spencer, J. M. (2014). Mapping fisheries for marine spatial planning: Gear-specific vessel monitoring system (VMS), marine conservation and offshore renewable energy. *Marine Policy*, *45*, 293–300. https://doi.org/10.1016/j.marpol.2013.09.015

Carew, J. L., & Mylroie, J. E. (2001). Quaternary carbonate eolianites of the Bahamas: Useful analogues for the interpretation of ancient rocks? In F. E. Abegg, D. B. Loope, & P. M. Harris (Eds.), *SEPM special publication* (Vol. *71*, pp. 33–46). SEPM Society for Sedimentary Geology. https://doi.org/10.2110/pec.01.71.0033

Cathro, D. L., Austin, J. A. J., & Moss, G. D. (2003). Progradation along a deeply submerged Oligocene-Miocene heterozoan carbonate shelf: How sensitive are clinoforms to sea level variations? *AAPG Bulletin*, *87*(10), 1547–1574. https://doi.org/10.1306/05210300177

Choi, D. R., & Ginsburg, R. N. (1982). Siliciclastic foundations of quaternary reefs in the southernmost Belize Lagoon, British Honduras. *GSA Bulletin*, *93*(2), 116–126. https://doi.org/10.1130/0016-7606(1982)93%3C116:SFOQRI%3E2.0.CO;2

Collins, L. B., Zhu, Z. R., Wyrwoll, K. H., & Eisenhauer, A. (2003). Late Quaternary structure and development of the northern Ningaloo Reef, Australia. *Sedimentary Geology*, *159*(1–2), 81–94. https://doi.org/10.1016/S0037-0738(03)00096-4

Condon, M. A., Johnstone, D., & Perry, W. J. (1955). Cape range structure Western Australia, part 1. In *Bureau of mineral ressources, geology and geophysics of the commonwealth of Australia*, Bulletin No. 21 (2nd ed., pp. 7–48). Commonwealth of Australia.

Courgeon, S., Bourget, J., & Jorry, S. (2016). A Pliocene-Quaternary analogue for ancient epeiric carbonate settings: The Malita intrashelf basin (Bonaparte Basin, northwest Australia). *AAPG Bulletin*, *100*, 565–595. https://doi.org/10.1306/02011613196

Crossman, S., & Li, O. (2015). *Surface hydrology lines (national)*. Commonwealth of Australia (Geoscience Australia) http://pid.geoscience.gov.au/dataset/ga/83130

Cumings, E. R. (1932). Reefs or bioherms? *Bulletin of the Geological Society of America*, *43*(1), 331–352. https://doi.org/10.1130/GSAB-43-331

Cumings, E. R., & Shrock, R. R. (1928). Niagaran coral reefs of Indiana and adjacent states and their stratigraphic relations. *Bulletin of the Geological Society of America*, *39*(2), 579–620. https://doi.org/10.1130/GSAB-39-579

Darwin, C. (1842). *The structure and distribution of coral reefs, Being the first part of the geology of the voyage of the Beagle, under the command of Capt. Fitzroy, R.N. during the years 1832 to 1836*. Smith Elder and Co.

De Falco, G., Antonioli, F., Fontolan, G., Lo Presti, V., Simeone, S., & Tonielli, R. (2015). Early cementation and accommodation space dictate the evolution of an overstepping barrier system during the Holocene. *Marine Geology*, *369*, 52–66. https://doi.org/10.1016/j.margeo.2015.08.002

Diesing, M., Coggan, R., & Vanstaen, K. (2009). Widespread rocky reef occurrence in the central English Channel and the implications for predictive habitat mapping. *Estuarine, Coastal and Shelf Science*, *83*(4), 647–658. https://doi.org/10.1016/j.ecss.2009.05.018

Dillenburg, S. R., Hesp, P. A., Keane, R., da Silva, G. M., Sawakuchi, A. O., Moffat, I., Barboza, E. G., & Bitencourt, V. J. B. (2020). Geochronology and evolution of a complex barrier, Younghusband Peninsula, South Australia. *Geomorphology*, *354*, 107044. https://doi.org/10.1016/j.geomorph.2020.107044

Dodd, J. R., Hunter, R. E., & Merkley, P. A. (2001). Eolianite-bearing depositional cycles in the Ste. Genevieve Limestoneof Indiana and Kentucky: Evidence for Mississippian Eustasy. In F. E. Abegg, D. B. Loope, & P. M. Harris (Eds.), *SEPM special publication* (Vol. *71*, pp. 151–166). SEPM Society for Sedimentary Geology. https://doi.org/10.2110/pec.01.71.0151

Droxler, A. W., & Jorry, S. J. (2013). Deglacial origin of barrier reefs along low-latitude mixed siliciclastic and carbonate continental shelf edges. *Annual Review of Marine Science*, *5*, 165–190. https://doi.org/10.1146/annurev-marine-121211-172234

Duce, S., Vila-Concejo, A., Hamylton, S. M., Webster, J. M., Bruce, E., & Beaman, R. J. (2016). A morphometric assessment and classification of coral reef spur and groove morphology. *Geomorphology*, *265*, 68–83. https://doi.org/10.1016/j.geomorph.2016.04.018

Dunham, R. J. (1962). Classification of carbonate rocks according to depositional texture. *AAPG Memoir*, *1*, 108–121. https://doi.org/10.1306/M1357

Dunham, R. J. (1970). Stratigraphic reefs versus ecologic reefs. *American Association of Petroleum Geologists Bulletin*, *54*(10), 1931–1932.

Edwards, H., Davidson, K., Loader, C., Westlake, S., & Maingarm, S. (2006). PGS MegaSurveys: Enhanced regional imaging of hydrocarbon provinces. In *Proceedings of the 8th SEGJ International Symposium*, Kyoto, Japan, 26–28 November 2006. https://doi.org/10.1190/segj082006-001.116

Esker, D., Eberli, G. P., & McNeill, D. F. (1998). The structural and sedimentological controls on the reoccupation of quaternary incised valleys, Belize Southern Lagoon. *AAPG Bulletin*, *82*(11), 2075–2109. https://doi.org/10.1306/00AA7BE4-1730-11D7-8645000102C1865D

European Commission. (2013). *Interpretation Manual of European Union Habitats—EUR 28*. European Commission https://ec.europa.eu/environment/nature/legislation/habitatsdirective/docs/Int_Manual_EU28.pdf

Ferro, C. E., Droxler, A. W., Anderson, J. B., & Mucciarone, D. (1999). Late quaternary shift of mixed siliciclastic-carbonate environments induced by Glacial Eustatic sea-level fluctuations in Belize. In P. M. Harris & J. A. Simo (Eds.), *SEPM special publication* (Vol. *63*, pp. 385–412). SEPM Society for Sedimentary Geology. https://doi.org/10.2110/pec.99.11.0385

Frébourg, G., Hasler, C.-A., Le Guern, P., & Davaud, E. (2008). Facies characteristics and diversity in carbonate eolianites. *Facies*, *54*, 175–191. https://doi.org/10.1007/s10347-008-0134-8

Gardner, J. V., Calder, B. R., Hughes Clarke, J. E., Mayer, L. A., Elston, G., & Rzhanov, Y. (2007). Drowned shelf-edge deltas, barrier islands and related features along the outer continental shelf north of the head of De Soto Canyon, NE Gulf of Mexico. *Geomorphology*, *89*(3–4), 370–390. https://doi.org/10.1016/j.geomorph.2007.01.005

Gardner, J. V., Dartnell, P., Mayer, L. A., Hughes Clarke, J. E., Calder, B. R., & Duffy, G. (2005). Shelf-edge deltas and drowned barrier-island complexes on the northwest Florida outer continental shelf. *Geomorphology*, *64*(3–4), 133–166. https://doi.org/10.1016/j.geomorph.2004.06.005

Gischler, E. (2010). Indo-Pacific and Atlantic spurs and grooves revisited: the possible effects of different Holocene sea-level history, exposure, and reef accretion rate in the shallow fore reef. *Facies*, *56*, 173–177. https://doi.org/10.1007/s10347-010-0218-0

Gorter, J. D., Rexilius, J. P., Powell, S. L., & Bayford, S. W. (2002). Late early to mid Miocene patch reefs, Ashmore platform, timor sea—Evidence from 2D and 3D seismic surveys and petroleum exploration wells. In M. Keep & S. J. Moss (Eds.), *The Sedimentary Basins of Western Australia 3: Proceedings of Petroleum Exploration Society of Australia Symposium* (pp. 355–375).

Grasseau, N., Grélaud, C., López-Blanco, M., & Razin, P. (2019). Forward seismic modeling as a guide improving detailed seismic interpretation of deltaic systems: Example of the Eocene Sobrarbe delta outcrop (South-Pyrenean foreland basin, Spain), as a reference to the analogous subsurface Albian-Cenomanian Torok-Nanushuk Delta of the Colville Basin (NPRA, USA). *Marine and Petroleum Geology*, *100*, 225–245. https://doi.org/10.1016/j.marpetgeo.2018.11.010

Green, A. N., Cooper, J. A. G., Dlamini, N. P., Dladla, N. N., Parker, D., & Kerwath, S. E. (2020). Relict and contemporary influences on the postglacial geomorphology and evolution of a current swept shelf: The Eastern Cape Coast, South Africa. *Marine Geology*, *427*, 106230. https://doi.org/10.1016/j.margeo.2020.106230

Green, A. N., Cooper, J. A. G., Leuci, R., & Thackeray, Z. (2013). Formation and preservation of an overstepped segmented lagoon complex on a high-energy continental shelf. *Sedimentology*, *60*(7), 1755–1768. https://doi.org/10.1111/sed.12054

Harris, P. T., & Baker, E. (2020). *Seafloor geomorphology as benthic habitat, GeoHab atlas of seafloor geomorphic features and benthic habitats* (2nd ed.). Elsevier Science & Technology. https://doi.org/10.1016/C2017-0-02139-0

Heath, R. S., & Apthorpe, M. C. (1984). *New formation names for the late cretaceous and tertiary sequence of the southern North West Shelf (Record 7)*. Geological Survey of Western Australia.

Heckel, P. H. (1972). Recognition of ancient shallow marine environments. In J. K. Rigby & W. K. Hamblin (Eds.), *SEPM special publication* (Vol. *16*, pp. 226–286). SEPM Society for Sedimentary Geology. https://doi.org/10.2110/pec.72.02.0226

Heckel, P. H. (1974). Carbonate buildups in the geologic record: A review. In L. F. Laporte (Ed.), *SEPM special publication* (Vol. *18*, pp. 90–154). SEPM Society for Sedimentary Geology. https://doi.org/10.2110/pec.74.18.0090

Hocking, R. M., Moors, H. T., & Van De Graaff, W. J. E. (1987). *Geology of the Carnarvon Basin, Western Australia (Bulletin 133)*. Geological Survey of Western Australia.

Hopley, D. (2006). Coral Reef Growth on the Shelf Margin of the Great Barrier Reef with Special Reference to the Pompey Complex. *Journal of Coastal Research*, *221*, 150–158. https://doi.org/10.2112/05a-0012.1

James, N. P., & Bone, Y. (2015). Pleistocene aeolianites at Cape Spencer, South Australia; record of a vanished inner neritic cool-water carbonate factory. *Sedimentology*, *62*(7), 2038–2059. https://doi.org/10.1111/sed.12216

James, N. P., Ginsburg, R. N., Marszalek, D. S., & Choquette, P. W. (1976). Facies and fabric specificity of early subsea cements in shallow Belize (British Honduras) reefs. *Journal of Sedimentary Research*, *46*(3), 523–544. https://doi.org/10.1306/212F6FDC-2B24-11D7-8648000102C1865D

James, N. P., & Jones, B. (2015). *Origin of carbonate sedimentary rocks*. Wiley. ISBN: 978-1-118-65270-1.

James, N. P., & Mountjoy, E. W. (1983). Shelf-slope break in fossil carbonate platforms: An overview. In D. J. Stanley & G. T. Moore (Eds.), *SEPM special publication* (Vol. *33*, pp. 189–206). SEPM Society for Sedimentary Geology. https://doi.org/10.2110/pec.83.06.0189

Jarrett, B. D., Hine, A. C., Halley, R. B., Naar, D. F., Locker, S. D., Neumann, A. C., Twichell, D., Hu, C., Donahue, B. T., Jaap, W. C., Palandro, D., & Ciembronowicz, K. (2005). Strange bedfellows—A deep-water hermatypic coral reef superimposed on a drowned barrier island; Southern Pulley Ridge, SW Florida platform margin. *Marine Geology*, *214*(4), 295–307. https://doi.org/10.1016/j.margeo.2004.11.012

Jones, H. A. (1973). *Marine geology of the Northwest Australian continental shelf (Bulletin 136)*. Commonwealth of Australia (Geoscience Australia).

Jorry, S. J., Camoin, G. F., Jouet, G., Le Roy, P., Vella, C., Courgeon, S., Prat, S., Fontanier, C., Paumard, V., Boulle, J., Caline, B., & Borgomano, J. (2016). Modern sediments and Pleistocene reefs from isolated carbonate platforms (Iles Eparses, SW Indian Ocean): A preliminary study. *Acta Oecologica*, *72*, 129–143. https://doi.org/10.1016/j.actao.2015.10.014

Katelis, Z., & Hernandianto, A. (1991). *Schlumberger well seismic processing report, Ramillies 1*. Commonwealth of Australia (Geoscience Australia) https://www.ga.gov.au/nopims

Keep, M., & Haig, D. W. (2010). Deformation and exhumation in Timor: Distinct stages of a young orogeny. *Tectonophysics*, *483*(1–2), 93–111. https://doi.org/10.1016/j.tecto.2009.11.018

Keep, M., Harrowfield, M., & Crowe, W. (2007). The Neogene tectonic history of the North West Shelf, Australia. *Exploration Geophysics*, *38*(3), 151–174. https://doi.org/10.1071/EG07022

Kelman, A. P., Nicoll, R. S., Kennard, J. M., Mory, A. J., Mantle, D. J., le Poidevin, S., Bernardel, G., Rollet, N., & Edwards, D. (2013). *Northern carnarvon basin biozonation and stratigraphy, Chart 36*. Commonwealth of Australia (Geoscience Australia).

Kennedy, E., Phinn, S., & Roelfsema, C. (2021). *Reef cover classification (v1): Internal coral reef class descriptors for global coral reef habitat mapping*. Dryad. https://doi.org/10.5061/dryad.7h44j0zrr

Khanna, P., Droxler, A. W., Nittrouer, J. A., Tunnell, J. W., Jr., & Shirley, T. C. (2017). Coralgal reef morphology records punctuated sea-level rise during the last deglaciation. *Nature Communications*, *8*, 1046. https://doi.org/10.1038/s41467-017-00966-x

Kindler, P., & Davaud, E. (2001). Recognizing eolianites in thin section. Review and case study—The lower cretaceous chambotte formation, Salève chain, Southeastern France. In F. E. Abegg, D. B. Loope, & P. M. Harris (Eds.), *SEPM special publication* (Vol. *71*, pp. 141–150). SEPM Society for Sedimentary Geology. https://doi.org/10.2110/pec.01.71.0141

Le Guern, P., & Davaud, E. (2005). Recognition of ancient carbonate wind deposits: lessons from a modern analogue, Chrissi Island, Crete. *Sedimentology*, *52*, 915–926. https://doi.org/10.1111/j.1365-3091.2005.00700.x

Le Roy, P., Jorry, S., Jouet, G., Ehrhold, A., Michel, G., Gautier, V., & Guérin, C. (2019). Late Pleistocene evolution of the mixed siliciclastic and carbonate southwestern New Caledonia continental shelf/lagoon. *Palaeogeography, Palaeoclimatology, Palaeoecology*, *514*, 502–521. https://doi.org/10.1016/j.palaeo.2018.10.014

Lebrec, U., Lang, S. C., Paumard, V., O'Leary, M. J., Yokoyama, Y., Hacker, J., & Webster, J. (2023). Discovery of Holocene ooid shoals in a siliciclastic delta, De Grey River, North West Shelf, Australia. *Geology*, *51*(4), 366–371. https://doi.org/10.1130/G50840.1

Lebrec, U., Paumard, V., O'Leary, M. J., & Lang, S. C. (2021). Towards a regional high-resolution bathymetry of the North West Shelf of Australia based on Sentinel-2 satellite images, 3D seismic surveys, and historical datasets. *Earth System Science Data*, *13*, 5191–5212. https://doi.org/10.5194/essd-13-5191-2021

Lebrec, U., Riera, R., Paumard, V., O'Leary, M. J., & Lang, S. C. (2022a). Morphology and distribution of submerged palaeoshorelines: Insights from the North West Shelf of Australia. *Earth-Science Reviews*, *224*, 103864. https://doi.org/10.1016/j.earscirev.2021.103864

Lebrec, U., Riera, R., Paumard, V., O'Leary, M. J., & Lang, S. C. (2022b). Automatic mapping and characterisation of linear depositional bedforms: Theory and application using bathymetry from the North West Shelf of Australia. *Remote Sensing*, *14*(2), 280. https://doi.org/10.3390/rs14020280

Locker, S. D., Hine, A. C., Tedesco, L. P., & Shinn, E. A. (1996). Magnitude and timing of episodic sea-level rise during the last deglaciation. *Geology*, *24*(9), 827–830. https://doi.org/10.1130/0091-7613(1996)024<0827:MATOES>2.3.CO;2

Logan, B. W., Read, J. F., & Davies, G. R. (1970). History of carbonate sedimentation, Quaternary epoch, Shark Bay, Western Australia. *AAPG Memoir*, *13*, 38–84. https://doi.org/10.1306/M13369C1

Longhurst, A. R., & Pauly, D. (1987). *Ecology of tropical oceans*. Academic Press.

Loope, D. B., & Abegg, F. E. (2001). Recognition and geologic preservation of ancient carbonate eolianites. In F. E. Abegg, D. B. Loope, & P. M. Harris (Eds.), *SEPM special publication* (Vol. *71*, pp. 3–16). SEPM Society for Sedimentary Geology. https://doi.org/10.2110/pec.01.71.0003

Lowenstam, H. A. (1950). Niagaran reefs of the Great Lakes Area. *The Journal of Geology*, *58*(4), 430–487.

Malcolm, R. J., Pott, M. C., & Delfos, E. (1991). A new tectono-stratigraphic synthesis of the North West Cape Area. *The APPEA Journal*, *31*(1), 154–176. https://doi.org/10.1071/AJ90013

Mallarino, G., Francis, J. M., Jorry, S. J., Daniell, J. J., Droxler, A. W., Dickens, G. R., Beaufort, L., Bentley, S. J., Opdyke, B. N., & Peterson, L. C. (2021). Timescale dependent sedimentary record during the past 130 kyr from a tropical mixed siliciclastic—Carbonate shelf edge and slope: Ashmore Trough (southern Gulf of Papua). *Sedimentology*, *68*, 2606–2648. https://doi.org/10.1111/sed.12867

Marfurt, K. J., & Alves, T. M. (2015). Pitfalls and limitations in seismic attribute interpretation of tectonic features. *Interpretation*, *3*(1), SB5–SB15. https://doi.org/10.1190/INT-2014-0122.1

Marshall, N. G., & Lang, S. C. (2013). A new sequence stratigraphic framework for the North West Shelf, Australia. In M. Keep & S. Moss (Eds.), *The Sedimentary Basins of Western Australia IV: Proceedings of the Petroleum Exploration Society of Australia Symposium*.

Mathew, M., Makhankova, A., Menier, D., Sautter, B., Betzler, C., & Pierson, B. (2020). The emergence of Miocene reefs in South China Sea and its resilient adaptability under varying eustatic, climatic and oceanographic conditions. *Scientific Reports*, *10*, 7141. https://doi.org/10.1038/s41598-020-64119-9

Maxwell, W. G. H. (1968). *Atlas of the great barrier reef*. Elsevier.

Maxwell, W. G. H. (1970). Deltaic patterns in reefs. *Deep Sea Research and Oceanographic Abstracts*, *17*(6), 1005–1012. https://doi.org/10.1016/0011-7471(70)90050-1

McCaffrey, J. C., Wallace, M. W., & Gallagher, S. J. (2020). A cenozoic great barrier reef on Australia's North West shelf. *Global and Planetary Change*, *184*, 103048. https://doi.org/10.1016/j.gloplacha.2019.103048

McKee, E. D., & Ward, W. C. (1983). Eolian environment. *AAPG Memoir*, *33*, 131–170. https://doi.org/10.1306/M33429C7

McNamara, K. J., & Kendrick, G. W. (1994). Cenozoic Molluscs and Echinoids of Barrow Island, Western Australia. *Records of the Western Australian Museum*, *51*, 50p.

Mellett, C. L., Hodgson, D. M., Lang, A., Mauz, B., Selby, I., & Plater, A. J. (2012). Preservation of a drowned gravel barrier complex: A landscape evolution study from the north-eastern English Channel. *Marine Geology*, *315–318*, 115–131. https://doi.org/10.1016/j.margeo.2012.04.008

Micallef, A., Krastel, S., & Savini, A. (2018). Introduction. In A. Micallef, S. Krastel, & A. Savini (Eds.), *Submarine Geomorphology. Springer Geology*. Cham: Springer. https://doi.org/10.1007/978-3-319-57852-1_1

Mohana Rao, K., Murthy, K. S. R., Reddy, N. P. C., Subrahmanyam, A. S., Lakshminarayana, S., Rao, M. M. M., Sarma, K. V. L. N. S., Premkumar, M. K., Sree, A., & Bapuji, M. (2001). Submerged beach ridge lineation and associated sedentary fauna in the innershelf of Gopalpur coast, Orissa, Bay of Bengal. *Current Science*, *81*(7), 828–833.

Montaggioni, L. F. (2001). Anatomy of shallow-water carbonate bodies: Lessons from the Recent coral reef record. *Géologie Méditerranéenne*, *28*(1–2), 127–131. https://doi.org/10.3406/geolm.2001.1704

Montaggioni, L. F., & Braithwaite, C. J. R. (2009). *Quaternary coral reef systems: History, development processes and controlling factors*. Elsevier. ISBN: 9780080932767.

Moss, G. D., Cathro, D. L., & Austin, J. A., Jr. (2004). Sequence biostratigraphy of prograding clinoforms, Northern Carnarvon Basin, Western Australia: A proxy for variations in oligocene to pliocene global sea level? *PALAIOS*, *19*(3), 206–226. https://doi.org/10.1669/0883-1351(2004)019<0206:SBOPCN>2.0.CO;2

Murchison, R. I. (1847). On the Silurian and Associated Rocks in Dalecarlia, and on the Succession from Lower to Upper Silurian in Smoland, öland, and Gothland, and in Scania. *Quarterly Journal of the Geological Society*, *3*, 1–48. https://doi.org/10.1144/GSL.JGS.1847.003.01-02.04

Nelson, H. F., Brown, C. W., & Brineman, J. H. (1962). Skeletal limestone classification. *AAPG Memoir*, *1*, 224–252. https://doi.org/10.1306/M1357

Nelson, R. J. (1853). On the geology of the Bahamas and on coral formation generally. *Quarterly Journal of the Geological Society*, *9*, 200–215. https://doi.org/10.1144/GSL.JGS.1853.009.01-02.35

Nyberg, B., & Howell, J. A. (2016). Global distribution of modern shallow marine shorelines. Implications for exploration and reservoir analogue studies. *Marine and Petroleum Geology*, *71*, 83–104. https://doi.org/10.1016/j.marpetgeo.2015.11.025

O'Leary, M. J., Paumard, V., & Ward, I. (2020). Exploring Sea Country through high-resolution 3D seismic imaging of Australia's NW shelf: Resolving early coastal landscapes and preservation of underwater cultural heritage. *Quaternary Science Reviews*, *239*, 106353. https://doi.org/10.1016/j.quascirev.2020.106353

O'Sullivan, D., Leahy, Y., Guinan, J., Ross, R., Sacchetti, F., Howell, K., Lyons, D., & O'Dowd, L. (2020). The geomorphology and biology of a submarine canyon system incising Ireland's shelf edge in the Northeast Atlantic Ocean. In P. T. Harris & E. K. Baker (Eds.), *Seafloor geomorphology as benthic habitat, GeoHab atlas of seafloor geomorphic features and benthic habitats* (2nd ed., pp. 783–792). Elsevier Science & Technology. https://doi.org/10.1016/B978-0-12-814960-7.00047-6

Otvos, E. G. (2012). Coastal barriers—Nomenclature, processes, and classification issues. *Geomorphology*, *139–140*, 39–52. https://doi.org/10.1016/j.geomorph.2011.10.037

Passos, T. U., Webster, J. M., Braga, J. C., Voelker, D., Renema, W., Beaman, R. J., Nothdurft, L. D., Hinestrosa, G., Clarke, S., Yokoyama, Y., Barcellos, R. L., Kinsela, M. A., Nothdurft, L. N., & Hubble, T. (2019). Paleoshorelines and lowstand sedimentation on subtropical shelves: a case study from the Fraser Shelf, Australia. *Australian Journal of Earth Sciences*, *66*(4), 547–565. https://doi.org/10.1080/08120099.2018.1558417

Paumard, V., Bourget, J., Durot, B., Lacaze, S., Payenberg, T., George, A. D., & Lang, S. (2019). Full-volume 3D seismic interpretation methods: A new step towards high-resolution seismic stratigraphy. *Interpretation*, *7*(3), B33–B47. https://doi.org/10.1190/int-2018-0184.1

Paumard, V., Bourget, J., Lang, S. C., Wilson, T., Riera, R., Gartrell, A., Vakarelov, B. K., O'Leary, M., & George, A. D. (2019). Imaging past depositional environments of the North West Shelf of Australia: Lessons from 3D seismic data. In M. Keep & S. J. Moss (Eds.), *The sedimentary basins of Western Australia V: Proceedings of the Petroleum Exploration Society of Western Australia Symposium*.

Paumard, V., Zuckmeyer, E., Boichard, R., Jorry, S. J., Bourget, J., Borgomano, J., Maurin, T., & Ferry, J.-N. (2017). Evolution of late oligocene—Early Miocene attached and isolated carbonate platforms in a volcanic ridge context (Maldives type), Yadana field, offshore Myanmar. *Marine and Petroleum Geology*, *81*, 361–387. https://doi.org/10.1016/j.marpetgeo.2016.12.012

Pettijohn, F. J., Potter, P. E., & Siever, R. (1972). *Sand and sandstone*. Springer.

Playford, P. E. (2004). Chapter 27—Geology and hydrogeology of Rottnest Island, Western Australia. In H. L. Vacher & T. M. Quinn (Eds.), *Developments in sedimentology* (Vol. *54*, pp. 783–810). Elsevier. https://doi.org/10.1016/S0070-4571(04)80049-9

Posamentier, H. W., Laurin, P., Warmath, A., Purnama, M., & Drajat, D. (2010). Seismic stratigraphy and geomorphology of Oligocene to Miocene carbonate buildups, offshore Madura, Indonesia. In W. A. Morgan, A. D. George, P. M. Harris, J. A. Kupecz, & J. F. Sarg (Eds.), *Cenozoic Carbonate Systems of Australasia, SEPM Special Publication* (Vol. *95*, pp. 175–194). SEPM Society for Sedimentary Geology. https://doi.org/10.2110/sepmsp.095.175

Posamentier, H. W., Paumard, V., & Lang, S. C. (2022). Principles of seismic stratigraphy and seismic geomorphology I: Extracting geologic insights from seismic data. *Earth-Science Reviews*, *228*, 103963. https://doi.org/10.1016/j.earscirev.2022.103963

Powers, M. C. (1953). A new roundness scale for sedimentary particles. *Journal of Sedimentary Petrology*, *23*(2), 117–119.

Purcell, P. G., & Purcell, R. R. (1988). The North West Shelf, Australia—An introduction. In P. G. Purcell & R. R. Purcell (Eds.), *The North West Shelf, Australia. Proceedings of the Petroleum Exploration Society of Australia Symposium, Perth, WA* (pp. 3–16).

Ramsay, P. J. (1994). Marine geology of the Sodwana Bay shelf, southeast Africa. *Marine Geology*, *120*(3–4), 225–247. https://doi.org/10.1016/0025-3227(94)90060-4

Rankey, E. C. (2017). Seismic architecture and seismic geomorphology of heterozoan carbonates: Eocene-Oligocene, Browse Basin, Northwest Shelf, Australia. *Marine and Petroleum Geology*, *82*, 424–443. https://doi.org/10.1016/j.marpetgeo.2017.02.011

Rankey, E. C. (2020). Eustatic, climatic, and oceanographic influences on geomorphology and architecture of isolated carbonate platforms: Miocene, Northwest Shelf, Australia. *Lithosphere*, *2020*(1), 8844754. https://doi.org/10.2113/2020/8844754

Rexilius, J. P., & Powell, S. L. (1994). *Micropalaeontological analysis Macedon-1, Permit WA-155P, Carnarvon Basin*. Commonwealth of Australia (Geoscience Australia) https://www.ga.gov.au/nopims

Riding, R. (2002). Structure and composition of organic reefs and carbonate mud mounds: concepts and categories. *Earth-Science Reviews*, *58*(1–2), 163–231. https://doi.org/10.1016/S0012-8252(01)00089-7

Riera, R., Bourget, J., Allan, T., Hakånsson, E., & Wilson, M. E. J. (2022). Early Miocene carbonate ramp development in a warm ocean, North West Shelf, Australia. *Sedimentology*, *69*(1), 219–253. https://doi.org/10.1111/sed.12917

Riera, R., Bourget, J., Håkansson, E., Paumard, V., & Wilson, M. E. J. (2021). Middle Miocene tropical oligotrophic lagoon deposit sheds light on the origin of the Western Australian coral reef province. *Palaeogeography, Palaeoclimatology, Palaeoecology*, *576*, 110501. https://doi.org/10.1016/j.palaeo.2021.110501

Riera, R., Haig, D. W., & Bourget, J. (2019). Stratigraphic revision of the Miocene Trealla Limestone (Cape Range, Western Australia): Implications for Australasian foraminiferal biostratigraphy. *Journal of Foraminiferal Research*, *49*(3), 318–338. https://doi.org/10.2113/gsjfr.49.3.318

Riera, R., Paumard, V., Bourget, J., Allan, T., & Lebrec, U. (2023). Evolution of the Exmouth-Barrow carbonate margin through the Miocene: Insights from 3D seismic data and field investigations (North West Shelf, Australia). *Sedimentary Geology*, *449*, 106371. https://doi.org/10.1016/j.sedgeo.2023.106371

Roberts, J. M., Wheeler, A. J., & Freiwald, A. (2006). Reefs of the deep: The biology and geology of cold-water coral ecosystems. *Science*, *312*(5773), 543–547. https://doi.org/10.1126/science.1119861

Romine, K. K., Durrant, J. M., Cathro, D. L., & Bernardel, G. (1997). Petroleum play element prediction for the cretaceous-tertiary basin phase, northern carnarvon basin. *The APPEA Journal*, *37*(1), 315–339.

Rosleff-Soerensen, B., Reuning, L., Back, S., & Kukla, P. (2012). Seismic geomorphology and growth architecture of a Miocene barrier reef, Browse Basin, NW-Australia. *Marine and Petroleum Geology*, *29*(1), 233–254. https://doi.org/10.1016/j.marpetgeo.2010.11.001

Rosleff-Soerensen, B., Reuning, L., Back, S., & Kukla, P. A. (2016). The response of a basin-scale Miocene barrier reef system to long-term, strong subsidence on a passive continental margin, Barcoo Sub-basin, Australian North West Shelf. *Basin Research*, *28*(1), 103–123. https://doi.org/10.1111/bre.12100

Rovere, A., Khanna, P., Bianchi, C. N., Droxler, A. W., Morri, C., & Naar, D. F. (2018). Submerged reef terraces in the Maldivian Archipelago (Indian Ocean). *Geomorphology*, *317*, 218–232. https://doi.org/10.1016/j.geomorph.2018.05.026

Ryan, G. J., Bernardel, G., Kennard, J. M., Jones, A. T., Logan, G. A., & Rollet, N. (2009). A pre-cursor extensive Miocene reef system to the Rowley Shoals reefs, WA: evidence for structural control of reef growth or natural hydrocarbon seepage? *The APPEA Journal*, *49*(1), 337–364. https://doi.org/10.1071/AJ08021

Sade, A. R., Hall, J. K., Amit, G., Golan, A., Gur-Arieh, L., & Tibor, G. (2006). The Israel national bathymetric survey—A new look at the seafloor off Israel. *Israel Journal of Earth Sciences*, *55*(3), 185–187.

Saller, A. H., Harris, P. M., Kirkland, B. L., & Mazzullo, S. J. (1999). Introduction. In A. H. Saller, P. M. Harris, B. L. Kirkland, & S. J. Mazzullo (Eds.), *Geologic framework of the capitan reef, SEPM special publication* (Vol. *65*, pp. 1–13). SEPM Society for Sedimentary Geology. https://doi.org/10.2110/pec.99.65.0001

Salzmann, L., Green, A., & Cooper, J. A. G. (2013). Submerged barrier shoreline sequences on a high energy, steep and narrow shelf. *Marine Geology*, *346*, 366–374. https://doi.org/10.1016/j.margeo.2013.10.003

Sanchez, C. M., Fulthorpe, C. S., & Steel, R. J. (2012). Middle Miocene-Pliocene siliciclastic influx across a carbonate shelf and influence of deltaic sedimentation on shelf construction, Northern Carnarvon Basin, Northwest Shelf of Australia. *Basin Research*, *24*(6), 664–682. https://doi.org/10.1111/j.1365-2117.2012.00546.x

Saqab, M. M., & Bourget, J. (2016). Seismic geomorphology and evolution of early–mid Miocene isolated carbonate build-ups in the Timor Sea, North West Shelf of Australia. *Marine Geology*, *379*, 224–245. https://doi.org/10.1016/j.margeo.2016.06.007

Saqab, M. M., Bourget, J., Trotter, J., & Keep, M. (2017). New constraints on the timing of flexural deformation along the northern Australian margin: Implications for arc-continent collision and the development of the Timor Trough. *Tectonophysics*, *696–697*, 14–36. https://doi.org/10.1016/j.tecto.2016.12.020

Schlager, W. (2005). *Carbonate sedimentology and sequence stratigraphy, SEPM concepts in sedimentology and paleontology* (Vol. *8*). SEPM. https://doi.org/10.2110/csp.05.08

Semeniuk, V. (1993). The Pilbara Coast: a riverine coastal plain in a tropical arid setting, nortwestern Australia. *Sedimentary Geology*, *83*, 235–256. https://doi.org/10.1016/0037-0738(93)90015-W

Smith, L. B., Al-Tawil, A., & Read, J. F. (2001). High-resolution sequence stratigraphic setting of Mississippian Eolianites, Appalachian and Illinois Basins. In F. E. Abegg, D. B. Loope, & P. M. Harris (Eds.), *SEPM special publication* (Vol. *71*, pp. 167–182). SEPM Society for Sedimentary Geology. https://doi.org/10.2110/pec.01.71.0167

Spiske, M. (2016). Coral-rubble ridges as dynamic coastal features—Short-term reworking and weathering processes. *Advances in Geosciences*, *38*, 55–61. https://doi.org/10.5194/adgeo-38-55-2016

Stoddart, D. R. (1969). Ecology and morphology of recent coral reefs. *Biological Reviews*, *44*(4), 433–498. https://doi.org/10.1111/j.1469-185X.1969.tb00609.x

Stoddart, D. R. (1976). Darwin, Lyell, and the geological significance of coral reefs. *The British Journal for the History of Science*, *9*(2), 199–218 https://www.jstor.org/stable/4025807

Storms, J. E. A., Weltje, G. J., Terra, G. J., Cattaneo, A., & Trincardi, F. (2008). Coastal dynamics under conditions of rapid sea-level rise: Late Pleistocene to Early Holocene evolution of barrier-lagoon systems on the northern Adriatic shelf (Italy). *Quaternary Science Reviews*, *27*(11–12), 1107–1123. https://doi.org/10.1016/j.quascirev.2008.02.009

Tagliaro, G., Fulthorpe, C. S., Gallagher, S. J., McHugh, C. M., Kominz, M., & Lavier, L. L. (2018). Neogene siliciclastic deposition and climate variability on a carbonate margin: Australian Northwest Shelf. *Marine Geology*, *403*, 285–300. https://doi.org/10.1016/j.margeo.2018.06.007

Thronberens, S., Back, S., Bourget, J., Allan, T., & Reuning, L. (2022). 3-D seismic chronostratigraphy of reefs and drifts in the Browse Basin, NW Australia. *GSA Bulletin*, *134*(11–12), 3155–3175. https://doi.org/10.1130/B36286.1

UNEP-WCMC, WorldFish Centre, WRI, & TNC. (2021). *Global distribution of warm-water coral reefs, compiled from multiple* *sources including the Millennium Coral Reef Mapping Project. Version 4.1. Includes contributions from IMaRS-USF and IRD (2005), IMaRS-USF (2005) and Spalding et al. (2001).* UN Environment World Conservation Monitoring Centre. https://doi.org/10.34892/t2wk-5t34

Van Tuyl, J., Alves, T., Cherns, L., Antonatos, G., Burgess, P., & Masiero, I. (2019). Geomorphological evidence of carbonate build-up demise on equatorial margins: A case study from offshore northwest Australia. *Marine and Petroleum Geology*, *104*, 125–149. https://doi.org/10.1016/j.marpetgeo.2019.03.006

Van Tuyl, J., Alves, T. M., & Cherns, L. (2018a). Geometric and depositional responses of carbonate build-ups to Miocene sea level and regional tectonics offshore northwest Australia. *Marine and Petroleum Geology*, *94*, 144–165. https://doi.org/10.1016/j.marpetgeo.2018.02.034

Van Tuyl, J., Alves, T. M., & Cherns, L. (2018b). Pinnacle features at the base of isolated carbonate buildups marking point sources of fluid offshore Northwest Australia. *GSA Bulletin*, *130*(9–10), 1596–1614. https://doi.org/10.1130/B31838.1

Vimpere, L., Del Piero, N., Le Cotonnec, A., Kindler, P., & Castelltort, S. (2022). Depositional timing and palaeoclimate interpretation of the Tamala Limestone aeolianites in Shark Bay, Western Australia. *Aeolian Research*, *54*, 100770. https://doi.org/10.1016/j.aeolia.2021.100770

Vousdoukas, M. I., Velegrakis, A. F., & Plomaritis, T. A. (2007). Beachrock occurrence, characteristics, formation mechanisms and impacts. *Earth-Science Reviews*, *85*, 23–46. https://doi.org/10.1016/j.earscirev.2007.07.002

Wade, B. S., Pearson, P. N., Berggren, W. A., & Pälike, H. (2011). Review and revision of Cenozoic tropical planktonic foraminiferal biostratigraphy and calibration to the geomagnetic polarity and astronomical time scale. *Earth-Science Reviews*, *104*(1–3), 111–142. https://doi.org/10.1016/j.earscirev.2010.09.003

Wallace, M. W., Condilis, E., Powell, A., Redfearn, J., Auld, K., Wiltshire, M., Holdgate, G., & Gallagher, S. (2003). Geological controls on sonic velocity in the cenozoic carbonates of the Northern Carnarvon Basin, North West Shelf, Western Australia. *The APPEA Journal*, *43*(1), 385–399. https://doi.org/10.1071/AJ02020

Webster, J. M., Braga, J. C., Humblet, M., Potts, D. C., Iryu, Y., Yokoyama, Y., Fujita, K., Bourillot, R., Esat, T. M., Fallon, S., Thompson, W. G., Thomas, A. L., Kan, H., McGregor, H. V., Hinestrosa, G., Obrochta, S. P., & Lougheed, B. C. (2018). Response of the Great Barrier Reef to sea-level and environmental changes over the past 30,000 years. *Nature Geoscience*, *11*, 426–432. https://doi.org/10.1038/s41561-018-0127-3

Wenau, S., Preu, B., & Spiess, V. (2020). Geological development of the Limpopo Shelf (southern Mozambique) during the last sealevel cycle. *Geo-Marine Letters*, *40*, 363–377. https://doi.org/10.1007/s00367-020-00648-6

Wentworth, C. K. (1922). A scale of grade and class terms for clastic sediments. *The Journal of Geology*, *30*(5), 377–392.

Whiteway, T. (2009). *Australian bathymetry and topography grid*. Commonwealth of Australia (Geoscience Australia). https://doi.org/10.4225/25/53D99B6581B9A

Whiteway, T. G., Smithers, S., Potter, A., & Brooke, B. (2014). *Geological and geomorphological features of outstanding universal value in the Great Barrier Reef World Heritage Area*. Commonwealth of Australia (Geoscience Australia). https://doi.org/10.11636/Record.2014.002

Wilson, J. L. (1975). *Carbonate facies in geologic history*. Springer. https://doi.org/10.1007/978-1-4612-6383-8_2

Wölfl, A.-C., Snaith, H., Amirebrahimi, S., Devey, C. W., Dorschel, B., Ferrini, V., Huvenne, V. A. I., Jakobsson, M., Jencks, J., Johnston, G., Lamarche, G., Mayer, L., Millar, D., Pedersen, T. H., Picard, K., Reitz, A., Schmitt, T., Visbeck, M., Weatherall, P., & Wigley, R. (2019). Seafloor mapping—The challenge of a truly global ocean bathymetry. *Frontiers in Marine Science*, *6*, 283. https://doi.org/10.3389/fmars.2019.00283

Yeates, A. N., Bradshaw, M. T., Dickins, J. M., Brakel, A. T., Exon, N. F., Landford, R. P., Mulholland, S. M., Totterdell, J. M., & Yeung, M. (1987). The Westralian Superbasin, an Australian link with Tethys. In *International Symposium on Shallow Tethys 2, Wagga, 15 September 1986* (pp. 199–213).

Young, H. C. (2001). *The sequence stratigraphic evolution of the exmouth-barrow margin, Western Australia* (PhD thesis). University of South Australia.

Young, H. C., Lemon, N. M., & Hull, J. (2001). The middle cretaceous to recent sequence stratigraphic evolution of the Exmouth-Barrow Margin, Western Australia. *The APPEA Journal*, *41*, 381–413.

Zaunbrecher, M. L. (1992). *WA-155-P, Ramillies-1, well completion report (Volume 2), Interpretative Data*. Commonwealth of Australia (Geoscience Australia) https://www.ga.gov.au/nopims

How to cite this article: Riera, R., Lebrec, U., Lang, S. C., & Paumard, V. (2023). Differentiating reefal ridges from relict coastal ridges: Lessons from the seismic geomorphologic study of buried Miocene buildups (North West Shelf, Australia). *Basin Research*, *00*, 1–22. https://doi.org/10.1111/bre.12774