Marine Geology

Neogene to Quaternary evolution of carbonate and mixed carbonate-siliciclastic systems along New Caledonia's eastern margin (SW Pacific)

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Response to Reviewers:	

REPLY TO REVIEWERS' COMMENTS

Authors' replies are in blue

Reviewer #1:

Dear Editor,

I went through the revised manuscript by Tournadour et al. Most of the comments regarding the initial submission have been addressed, and in my opinion the manuscript now is almost ready for publication.
I do, however, have some minor comments:

- Line 18: tilt of which margin?

➢ Eastern margin ("eastern" added).

- I would avoid e.g. when referring to work from other people, it may give an impression of superficiality

➢ "e.g." has been removed when referring to other studies, except in the data and methods section of the manuscript (lines 219-223), where we only give a few references of the tens of cruises that acquired bathymetric data in our study area, notably those conducted within the ZoNéCo research program.

- Lines 52: not sure why cool-water carbonates are discussed here?

➢ This was a suggestion from R2 to add the Brachert et al. study on mixed cool water carbonate platforms to highlight that the reciprocal sedimentation concept is not always applicable.

- Line 68: siliciclastic

➢ Spelling corrected.

- Fig. 1. Not sure if there is a vertical exaggeration in Fig. 1C? In any case the cross section only differentiates the green color of the peridotite. Difficult to assess, but there should be further colors in there? See map in Fig. 1B.

➢ Fig. 1C is a schematic geological cross-section of Grande Terre that is not to scale. It is thus not possible to specify a vertical exaggeration. This cross-section illustrates the structure of the ophiolite relatively to autochthonous units. We voluntarily represented the ophiolite as a single unit that comprises both the mantle peridotites and oceanic crust nappes of Fig. 1B. However, we agree that the green colour chosen for the ophiolite was misleading as it was the same color as the peridotites of 1B. We have thus changed this colour to grey and made Fig 1C a grey-shaded figure.

- Line 95: could not find Ponérihouen and Antigonia in Fig. 1.

➢ "Pn" and "A" in Fig. 1 respectively stand for "Ponérihouen" and "Antigonia Seamount", as mentioned in the figure caption.

- Figure caption Fig. 3: Not sure what is meant by "restricted" deltas (I think you can delete the word terrigenous...).

➢ The term "restricted deltas" is mentioned in the manuscript to describe small deltas restricted to the coastal domain that are interpreted to result from low terrigeneous sedimentation rates (see lines 655-657). Terrigenous has been removed from the figure caption.

- Fig. 4. I am not sure if I understand what is meant with the hatched area where erosion is evoked? Is it eroding now, has there be some erosion? What is the evidence that differential subsidence has acted or acts?

➢ This hatched area corresponds to the elevation difference between bathymetrical profiles from the southern (profile E-01) and central (E-02) parts of the eastern margin (see Fig. 2 for profile locations). This difference is due to the fact that in the central part of the margin, the Mio-Pliocene unit ("eastern terrace" on Fig. 3) is almost entirely lacking, and is likely eroded by slope canyons that reach the external barrier reef. The timing of this erosion is yet poorly constrained. For clarity, we have specified this in the figure caption.

- Lines 531. A strong statement here about the controlling factor, which is, however, not really supported by data presented in the manuscript. What would be the subsidence rate in the region? Is the dip of surface S1 due to tilting, or is this just the drowning unconformity tracing the depositional relief = paleoseafloor?

➢ We agree that the dip of surface S1 could be partly depositional. However, this surface caps a Mio-Pliocene shallow water succession that presently lies at 300-600m water depth and, considering maximum amplitudes of RSL fluctuations during the Neogene-Quaternary, tectonic subsidence must be involved. This subsidence is likely due to Neogene extensional tectonics, as supported by a wealth of studies (Lagabrielle et al., 2005; Chardon & Chevillotte, 2006, Lagabrielle & Chauvet, 2008; Collot et al., 2017; Moretti & Turcotte, 1985, Chardon et al., 2008, Patriat et al., 2018).

I still think that the written English would benefit from the support by a native speaker, as the sentences in many cases are very difficult to follow.

➢ The manuscript has been checked by all co-authors (including native English speakers) and also benefited from a very careful editing from R2 during this second review round. We thus believe that it is now written in proper scientific English.

Reviewer #2:

Dear editor,

The authors have adequately addressed all issues raised in the earlier review. Some minor things left to do that can be addressed without any problem; no new review needed.

Stay safe.
Kind regards,
John Reijmer

MARGO-D-20-00350_R1
Tournadour et al.

General
1. All review remarks are addressed adequately.

Text edits
2. Some suggestions for text edits marked in the text. See PDF.

➢ We went through all these suggestions and accepted almost all of them.

Regarding the comment on line 707 "carbonate platform/ramp/shelf?"; unfortunately we do not think that we have sufficient data to characterise the type of carbonate platforms that cap lowstands prims.

Note that we are grateful to the reviewer for his careful editing of the written English.

532: Please do introduce first that you interpret the submerged bank to be drowned. Subsidence does not equal drowning.

➢ We agree that drowning is inappropriate since we do not show that the bank was drowned. We therefore prefer the term subsidence. "This important **drowning** cannot be explained…" is changed to "This important **subsidence** cannot be explained…".

578: References needed to support the statement.

➢ References are provided in the two following sentences (Ehrenberg et al., 2008; McCaffrey et al., 2020; Tcherepanov et al., 2008), lines 587-593.

634 ... with aggrading to retrograding shallow water carbonate transgressive sequences? Do you intend to say: ... aggrading and retrograding carbonate sequences that developed during a transgression?

➢ Yes this is exactly what we meant. The sentence has been modified accordingly.

651: Why not cite earlier studies instead of a study that is on-line since March 2021?

Tcherepanov, E.N., Droxler, A.W., Lapointe, P., Dickens, G.R., Bentley, S.J., Beaufort, L., Peterson, L.C., Daniell, J. and Opdyke, B.N. (2008) Neogene evolution of the mixed carbonate-siliciclastic system in the Gulf of Papua, Papua New Guinea. Journal of Geophysical Research: Earth Surface, 113, F01S21.

Tcherepanov, E.N., Droxler, A.W., Lapointe, P. and Mohn, K. (2008) Carbonate seismic stratigraphy of the Gulf of Papua mixed depositional system: Neogene stratigraphic signature and eustatic control. Basin Research, 20, 185-209.

Tcherepanov, E.N., Droxler, A.W., Lapointe, P., Mohn, K. and Larsen, O.A. (2010) Siliciclastic influx and burial of the Cenozoic carbonate system in the Gulf of Papua. Marine and Petroleum Geology, 27, 533-554.

- References added.

JR 21.04.30

HIGHLIGHTS

- An extensive Miocene-Pliocene shallow water carbonate bank currently lies at 300 to 600 m water depths around the main island of New Caledonia.
- This Mio-Pliocene bank evolved into Quaternary rimmed platforms following regional subsidence and/or a carbonate producers change.
- Coeval terrigenous inputs with carbonate production are evidenced as early as the Serravalian.
- The architectures of mixed carbonate-siliciclastic systems vary widely alongshore, from north to south.
- Terrigenous inputs, paleo-drainage network or by-pass transport influenced the mixed system architectures.

Neogene to Quaternary evolution of carbonate and mixed carbonate-siliciclastic systems along New Caledonia's eastern margin (SW Pacific)

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ABSTRACT

Neogene and Quaternary shallow-water carbonate records surrounding New Caledonia main island, Grande Terre, provide a good example for understanding the stratigraphic architecture of tropical mixed carbonate-siliciclastic systems. Due to a southeastern tilt of the eastern margin, the eastern shelf of Grande Terre has been better preserved from erosion than the western part, favouring the development and preservation of shallow-water carbonates. Based on the integration of bathymetric and seismic data, along with paleoenvironmental and biostratigraphic constraints derived from dredged carbonate rocks, a comprehensive geomorphological and architectural characterization of the offshore eastern margin of Grande Terre has been made. During the Mio-Pliocene, a wide, up to 750 m-thick carbonate build-up developed and extended over at least 350 km from north to south. This Mio-Pliocene build-up, currently lying at 300 to 600 m water depths, is overlain by a Pleistocene-Holocene barrier reef-lagoon complex and associated slope deposits. The switch from aggrading Neogene carbonate banks to backstepping Quaternary platforms likely reflects an increase in accommodation due to a high subsidence rate or to relative sea-level rise, and/or results from a switch in carbonate producers associated with global environmental changes. The internal architecture of the Quaternary barrier reef-lagoon complex is highlighted, especially the development of lowstand siliciclastic prisms alternating with transgressive shallow-water carbonate sequences. This pattern agrees with the reciprocal sedimentation model typically invoked for mixed sedimentary systems. This stratigraphic pattern is well developed in front of the Cap Bayes inlet in the north of our study area, yet it is not observed southward along the eastern margin. This difference suggests that other factors than relative sea-level variations directed the architecture of the margin, such as low terrigenous inputs, lagoon paleo-drainage networks or sediment by-pass towards deep basins.

Keywords: mixed carbonate-siliciclastic system, reciprocal sedimentation, tropical carbonates, terrigenous inputs, New Caledonia, SW Pacific.

1. INTRODUCTION

Mixed carbonate-siliciclastic depositional systems are characterized by a high variability in facies and architectures resulting from several factors, such as relative sea-level change, tectonic motions, carbonate production, terrigenous inputs, sediment transfer and hydrodynamic conditions, complicating the sequence stratigraphy interpretation (Droxler and Jorry, 2013; Zeller et al., 2015). According to the classical “reciprocal sedimentation” model (Wilson, 1967), mixed systems in the tropical realm have been commonly subdivided into alternating temporal phases where siliciclastic deposits would prevail during low sea-level periods whereas carbonates would dominate during transgressions and highstands. This reciprocal concept is yet relevant for several ancient and some modern cases studies (Kerans & Tinker, 1999; Toomey et al., 2016), but has been shown to be inadequate in describing several others examples. This model appears not applicable for some mixed cool-water carbonate platforms, where sandstones can be deposited when wave abrasion depth rises above the seafloor during transgressions, whereas shell-beds formed during lowstands (Brachert et al., 2003). Another example is the Great Barrier Reef, where siliciclastic deposits are released to the slope and basin during late transgression, possibly due to the reworking of significant amounts of fine-grained terrigenous sediment stored on the shelf during lowstand (Wallace et al., 2002; Dunbar and Dickens, 2003; Mitchell et al., 2007; Harper et al., 2015). In addition, wave and/or current energy might prevent the infill of the lagoon during highstands, during which carbonate production is thought to be maximal, inducing, thus, an “empty bucket” pattern (Schlager, 1989; Purdy and Gischler, 2005; Zinke et al., 2001; Weij et al., 2019). This variability in the sedimentological response of mixed systems to relative sea-level changes demonstrates that other controlling parameters should also be considered in order to improve the prediction of their complex depositional architectures.

Around the main island of New Caledonia, “Grande Terre”, Neogene to Quaternary shallow-water carbonate systems occur coeval with high terrigenous fluxes derived from the erosion of rugged mountain ranges located all across the island and primarily composed of obduction-related thrust sheets. The oldest known Neogene shallow-water carbonates on Grande Terre are lower Miocene mixed carbonate-siliciclastic series cropping out in the Népoui area, on the western part of the island, close to the present day coastline (Fig. 1). These outcrops were interpreted as reflecting sediment deposition on Aquitanian and Burdigalian ramps where seagrass-related and scleractinian carbonate production occurred simultaneously to strong fluvio-deltaic terrigenous inputs (Maurizot et al., 2016; Tournadour et al., 2020). However, the offshore extent of this Miocene mixed system remains unknown.

At the present day, Grande Terre is surrounded by one of the largest modern barrier reef in the world. This barrier reef has been drilled on the western margin and past studies (Coudray, 1975; Cabioch et al., 2008b ; Montaggioni et al., 2011) showed that it initiated at 400 cal kyr B.P. or Marine Isotope Stage 11 (MIS 11), over non-reefal shallow water carbonates that were deposited as of *ca.* 1.2 Ma ago on a carbonate ramp or non-rimmed platform (Montaggioni et al., 2011). The inner lagoon, in turn, started its infill only since 200 cal kyr, B.P. or Marine Isotope Stage 7 (MIS7) (Le Roy et al., 2008). This points to the fact that the southwestern shelf of New Caledonia does not follow a classic reciprocal sedimentation pattern but constitutes a unique mixed carbonate-siliciclastic tropical system with a strong temporal and spatial partitioning between the outer coral plateau and the inner lagoon depression where terrigenous clastic sediments prevail (Le Roy et al., 2019).

In contrast, the Neogene to Quaternary shallow-water mixed systems of the eastern margin of Grande Terre are much less documented than their western counterparts, largely because of a lack of boreholes, rare outcrops onshore and few acoustic data offshore. However, this margin is thought to have a very different tectonic history than the western margin, probably a higher subsidence that would have resulted in a better preservation of shallow-water systems on the shelf, thus allowing to improve our understanding of the onset of Neogene carbonate systems and the transition to Quaternary barrier reef lagoon in the regional tectonic context. In addition, those sedimentary records allow to discuss the potential controlling factors determining the stratigraphic architectures along the margin, such as terrigenous inputs or paleo-drainage networks. With that aim, we have compiled both existing and newly acquired geophysical data and dredged carbonate rock samples from Ponérihouen to Antigonia seamount (Fig. 1) to perform a comprehensive analysis of slope morphologies and to reconstruct the depositional environments and ages of the main terraces and seismic units observed along the eastern margin.

2. GENERAL SETTINGS

2.1. Geography

New Caledonia is a remote archipelago located in the South West Pacific (Fig.1). Its main island, Grande Terre, is a 50 to 80 km wide and approximatively 400 km long land stripe oriented in a N140° direction. Highest summits are *ca.* 1600 m high. Because of dominant southeastward trade winds (N110-120°) its eastern margin is positioned on the windward side, whereas the western margin is the leeward side. Its eastern part is typified by steep reliefs, deeply incised valleys and short coastal plains, whereas the western part has more extended valleys, wider alluvial lowlands and large coastal plains. This landform dissymmetry impacts the spatial distribution of rainfall, with the eastern windward coast receiving twice as much precipitation than the western leeward coast. Such differences induce a one-and-a-half-time higher river discharge along the eastern coast compared to the western coast (Terry & Wolting, 2011).

2.2. Tectonics

Grande Terre marks the northeastern tip of Zealandia (Mortimer et al., 2017), a mostly submerged fragment of continental crust isolated from Gondwana during the Late Cretaceous to Paleocene due to regional rifting followed by seafloor spreading in the Tasman Sea (Hayes & Ringis, 1973; Gaina et al., 1998). During the Eocene Grande Terre underwent a convergence phase that led to the NE-SW emplacement of several tectonic nappes and finally, in the late Eocene-early Oligocene, to the obduction of a prominent kilometres-thick ophiolite mostly constituted of serpentinized peridotites (Paris, 1981; Maurizot et al., 2020). Once obduction terminated, extensional tectonics prevailed all over Grande Terre (Lagabrielle et al., 2005; Chardon & Chevillotte, 2006; Lagabrielle & Chauvet, 2008). During this post-obduction extensional phase, that may still be active today, widespread normal faulting affected both island margins. The assymetric morphology of Grande Terre is likely the result of these obduction and post-obduction tectonics. Drivers of the extension are either attributed to a plate tectonic divergent phase (i.e. far-field stresses related to initiation of east-verging subduction of the Australian plate beneath the Pacific Plate, Chardon & Chevilotte, 2006) and/or to post-orogenic collapse, dismantling and combined isostasic rebound (Lagabrielle et al. 2005, Lagabrielle & Chauvet, 2008; Moretti & Turcotte 1985; Collot et al., 2017). In this second hypothesis, unroofing the ridge of dense allochthonous mantle material and loading the adjacent basins resulted in subsidence of the basins and uplift of the ridge. The latter uplift is thus interpreted as being at the origin of the steepening of both the western and eastern margins of Grande Terre. The deep structure of the eastern margin has not been imaged by seismic data but is interpreted to be structured by a series of normal faults (see simplified geological cross-section of Fig. 1 and Collot et al. (1987)). Timing and amplitudes of these extensional events and vertical motions over the post-obduction period are not constrained as no continuous Oligocene to present day geological records exist. The Neogene to Quaternary carbonates that are the focus of this paper have developed on these structures. Offshore, towards the south, major listric normal faults bordering the obducted mantle sheets are imaged by seismic data along Pines Ridge (Chardon & Chevillotte, 2006; Flamand, 2006; Chardon et al., 2008; Patriat et al., 2018) (Fig.1). Apart from post-obduction extension, since the late Miocene, the southern part of Grande Terre and the Loyalty Islands are the foreland area of the Vanuatu Subduction Zone where the Australian Plate subducts beneath the Pacific Plate. A lithospheric flexure associated to this process is observed and results in the uplifts of the Loyalty Islands, the southern tip of Grande Terre and the Isles of

Pines. As a result, Quaternary 125 ka fringing reefs around Yaté and Isle of Pines are uplifted and now are positioned 10 to 20 m above present-day sea level (Cabioch et al., 1996).

2.3. Miocene mixed carbonate siliciclastic systems

On land, the post-obduction geology is characterized by an Oligocene sedimentary hiatus and the oldest known marine sediments that overlie allochthonous units are Miocene mixed carbonate-siliciclastic sedimentary rocks only cropping out in a restricted nearshore area located west of Grande Terre, in the region of Népoui (Coudray, 1975; Maurizot et al., 2016; Tournadour et al., 2020). These successions have been interpreted to reflect deposition of an Aquitanian carbonate ramp dominated by seagrass-related carbonate production, overlain by Burdigalian fan delta deposits that laterally evolve towards a carbonate ramp dominated by seagrass meadows and small-sized coral bioconstructions (Tournadour et al., 2020).

Offshore, despite a lack of drill core data, a few dredged carbonate samples were recovered from the outer slope of the eastern margin of Grande Terre (Chardon et al., 2008; Yamano et al., 2015) and close to *Munida* and *Crypthelia* seamounts (Daniel et al., 1976; Bitoun and Recy, 1982) (Fig. 2). These samples, collected between 400 m and 800 m water depths, are the only evidences of Miocene shallow-water carbonate deposits along the eastern margin of Grande Terre and Pines Ridge. Based on the interpretation of seismic profiles along Grande Terre's southeastern margin, Chardon et al. (2008) identified several normal faults that they interpret as being related to Late Miocene extensional tectonics. These authors also interpreted two planar surfaces as post-obduction erosional lateritic land surfaces resulting from weathering processes overlain by shallow-water carbonate deposits.

2.4. Quaternary carbonate systems

Our knowledge on the nature, structure and chronology of the New Caledonian Quaternary carbonate systems primarily comes from coring investigations carried out through the western parts of the New Caledonian barrier system (Coudray, 1976, Cabioch et al., 2008b;

Montaggioni et al., 2011). Four cores, 120 to 226 m-long, reached the upper Cretaceous and Eocene bedrock and allowed to characterize the Quaternary development history of the western carbonate shelf margin. The recovered carbonate sequences result from stacking of about ten sedimentary carbonate units that were deposited during successive transgressive and high sea-level stands corresponding to interglacial periods (Cabioch et al., 2008b). These units are separated from each other by unconformities formed during sea-level drops in glacial periods. The succession of depositional events was reconstructed using lithostratigraphy, magnetostratigraphy, uranium-series dating and nannofossil stratigraphy (Cabioch et al., 2008b; Montaggioni et al., 2011). Carbonate sediment production was initiated prior to 1.2 Ma within an open shallow-water shelf margin, which acted as a carbonate ramp system until 0.48 Ma. Corresponding deposits forming the lower units recovered in boreholes (red dots on Fig. 1) include grainstone, packstone and wackstone rich in corals, coralline algae, encrusting foraminifera with locally thick rodoliths accumulations (Montaggioni et al., 2011). The ramp system is assumed to have evolved into a rimmed, reef platform as of 0.40 Ma. The initiation of coral reef tracts and the associated reef-rimmed platform are thus considered to have begun after MIS 11 (Montaggioni et al., 2011), i.e. the Mid-Brunhes Event. Corresponding sedimentary units are made up of stacked *poritid*-rich framework beds correlated to reef-flat environments with moderate to lower-water energy, and coralgal frameworks partly including arborescent acroporids suggesting deposition in a protected reef-flat setting (Montagggioni et al., 2011). Complementary studies of the Quaternary evolution of the south-west lagoon obtained seismic, bathymetric and coring data (Le Roy et al., 2008; Le Roy et al., 2019). Results showed that infill is composed of two or three 100 ka sedimentary sequences with a first significant flooding of the lagoon assumed to have started during MIS7, at 220 cal kyr B.P. The disparate ages of the lagoon and reefs can be reconciled with the fact that the first reefs were probably initially fringing structures without a significant lagoon that has expanded later in response to subsidence of the margin and reef growth (Le Roy et al., 2018). Offshore, the outer barrier reef slopes of Grande Terre are marked by five marine terraces located between ca. 20 and ca. 120 m water depths that Flamand (2006) tentatively correlated to the five reefal lithological sequences cored on the western barrier reef and interpreted as the morphological expressions of Quaternary interglacials. However, a younger, last deglacial origin for these terraces located above 120 m water depth cannot be ruled out. Note that these Quaternary marine terraces are located in the area indicated by the blue arrow on bathymetrical and seismic data (Figs. 5 to 8).

2.5. Quaternary subsidence rates

Based on cores of the Quaternary barrier reef of the western margin of Grande Terre, subsidence rates are estimated to range between 0.03 to 0.20 $mm.yr^{-1}$ since the last 400 ka (Coudray, 1975; Cabioch et al., 1996; Flamand, 2006; Frank et al., 2006) and display mean rates of ≤0.08 $mm.yr^{-1}$ over the past 1 Ma (Montaggioni et al., 2011). Such values possibly reflect a long-term subsidence of the western margin of Grande Terre suggesting that post-obduction extensional tectonics are still active and allowing sufficient accommodation space to record most Quaternary sea-level highstands. Unfortunately, the lack of core data on the eastern margin does not allow reconstructing any Neogene to Quaternary vertical motions.

3. DATA AND METHODS

Our morphological and stratigraphic analyses are based on the integration of existing and newly acquired bathymetrical and 2D seismic reflection data supplemented by dredged rock samples (Fig. 2). Existing bathymetrical data are derived from four datasets. The former covers the lagoon of Grande Terre and was essentially acquired during hydrographic surveys of the French Navy (SHOM), compiled by the New Caledonia Government within a 25 m resolution grid. The second dataset corresponds to data acquired between 2002 and 2006 onboard RV *Alis* (EM1002 multibeam echosounder) along all the outer slopes of Grande Terre and Loyalty islands, as well as on seamounts of the Pines Ridges (down to *ca.* 1000 m of water depth), in the framework of the ZoNéCo program (*e.g.* Pelletier et al., 2002, 2004, 2012; Perrier et al., 2004a, 2004b, 2004c, 2005) and IRD research projects (*e.g.* Cabioch et al., 2002a, 2002b). The third dataset consists of data acquired in the 90's and 2000's in deeper waters (>1000 m of water depth), such as in the South Loyalty Basin, onboard RV *L'Atalante* (EM12D multibeam echosounder), again through ZoNéCo (*eg.* ZoNéCo-1, Pautot et al., 1993; ZoNéCo-2, Lafoy et al., 1994; and ZoNéCo-3; Missègue et al., 1996). These two multibeam datasets were compiled in 2009 in 25 m (EM1002) and 100 m (EM12D) resolution grids by New Caledonia Government (Juffroy, 2009) and included in the 2012 atlas of New Caledonia (Pelletier et al., 2012). The fourth dataset is the global seafloor topography derived from satellite altimetry and ship depth soundings (Smith and Sandwell, 1997). Newly acquired bathymetrical data corresponds to those gathered by the KANACONO cruise onboard R/V *Alis* (Puillandre & Samadi, 2016).

The seismic dataset mainly consists of published multichannel seismic reflection profiles located on the upper slope of the eastern margin of Grande Terre, acquired onboard R/V *Alis* during the NEOMARGES cruise (Chardon et al., 2007), using a 24 channel streamer and a 20 cubic-inch air gun source. The high-resolution images have a maximum penetration of 0.25 s two way time (twt) (Table 1) and were reinterpreted in this study through detailed line drawings. Seismic profiles 206-04 (Lafoy et al. 1998) and AUS-104 (Bitoun & Recy et al. 1982), which are publicly available in the *Tasman Frontier seismic database* (Sutherland et al., 2012), were also interpreted. These profiles were acquired using lower frequency seismic devices (see Table 1) and hence have a lower resolution but a higher penetration, reaching 3 s twt in the offshore basins. Seismic stratigraphic analysis was performed on these profiles including identification of seismic facies, unconformities and sequences following Mitchum et al. (1977). To estimate the thickness of the carbonate units on the Pines Ridge, we assumed that they are composed of shallow-water carbonates with a low-porosity, affected by early compaction and dissolution, for which we attributed a mean velocity of 3000 $m.s^{-1}$ (Anselmetti & Eberli, 2001).

Sedimentary facies determinations were made on 17 carbonate rock samples dredged during the DR-2005-NC and KANACONO cruises onboard R/V *Alis* (Pelletier et al., 2006; Puillandre & Samadi, 2016; respectively) in water depths between 250 and 900 m (Table 2). Samples were described from large thin sections in order to identify textures and main components and ultimately reconstruct depositional environments. Biostratigraphic datings and paleoenvironmental reconstructions were based on the interpretation of foraminiferal assemblages (larger benthic and planktonic foraminifera). In our definitions of stratigraphic ranges, the planktonic foraminiferal zonal scheme of BouDagher-Fadel (2015, 2018a) is used. This scheme is tied to the time scale of Gradstein et al. (2012) and the revision by Cohen et al. (2017).

4. PHYSIOGRAPHY, STRUCTURE AND STRATIGRAPHY OF THE EASTERN MARGIN

4.1. Lagoon

The eastern lagoon, extending from the shoreline to the external barrier reef, is 10-15 km wide between Poindimié and Yaté with an average water depth of 40 m, whereas the western lagoon does not exceed a width of 5-10 km with an average water depth of 20 m, except in its southern part where it is deeper and wider (Le Roy et al., 2008, 2019). Another difference with the western lagoon, which is bounded by continuous barrier reefs, is that the eastern lagoon is typified by a discontinuous external barrier reef with drowned segments in its southern part, off Yaté (Cabioch et al., 1996; Andrefouet et al., 2009) (Fig. 2). The eastern lagoon can be divided into three morphological domains: (1) the shallow-water coastal zone, (2) the median lagoon and (3) the external barrier reef (Fig. 3B).

The shallow-water coastal zone is particularly well-developed between Ponérihouen to Thio, where coastal bays are shallow and have gentle slopes, due to terrigenous deltas located at river and estuarine mouths (Fig.3). The deltaic deposits extend for 2.5 to 7 km and can reach the central part of the lagoon. Between Côte Oubliée and Yaté, deltas are very restricted and do not exceed 2 km in length (Fig.3A). Previous studies on unconsolidated seafloor sediments revealed that these deltas are mainly composed of terrigenous sediments (Chevillon, 1997).

The deeper median lagoon, is relatively flat in its central part and contains isolated patch reefs as well as sandy islets aligned parallel to the coastline (Fig.3A). Southeast of the East Ngoé Pass, the median lagoon deepens (with an average water depth of 60-70 m) and contains a meandering channel that runs parallel to the coastline (Fig. 3A). This channel extends over 30 km, incises the lagoon up to 40 m deep and is connected to the Kouakoué Pass, where it runs perpendicular to the coastline thanks to a *ca.* 90° bend (Fig.3A).

The barrier reef domain comprises the reef crest, close to sea level, as well as a back-reef and reef flats within a 5 km-wide shallow-water area (20 to 40 m water depths). The latter is dominated by carbonate sediments of heterogeneous grain size, ranging from fine-grained sands to gravels (Chevillon, 1997). The barrier reef domain is interrupted by numerous passes (ie. inlets) connected to lagoonal channels that cross-cut the back-reef domain and are oriented roughly perpendicular to the coastline and the reef crest (Fig.3).

4.2. Outer slope

4.2.1 Overall slope profile

The outer slope morphologies of Grande Terre were previously described by Bitoun and Récy (1982), Rigolot (1989), Flamand (2006) and Pelletier et al. (2012). The outer slope of the western margin is very steep with values up to 20° between 0 to 2000 m water depths. This margin is very abrupt as the upper part of the slope is also very steep (see W-01 and W-02 profiles Fig.4). In comparison, the outer slope of the eastern margin, from Poindimié to Yaté, is smoother and extends over 15 to 20 km from the platform edge to the toe of slope at a water depth of approximately 2200 m (Fig. 4). It is composed of 3 domains: (1) the upper slope, characterized by a slope gradient lower than 3°, between 100 to approximately 500 m water depths and extending up to 20 km in areas preserved from the erosion (*e.g.* offshore Côte Oubliée and Yaté, see E-01 profile Fig.4). On the contrary, some areas are devoid of an upper slope domain and canyon heads are in direct contact with the external barrier reef (e.g. offshore

Houaïlou, see E-02 profile Fig.4); (2) the middle slope shows a slope gradient of up to 10° between 400-500 m to approximately 2200 m water depth; (3) the lower slope and toe-of-slope domain shows a gentle slope gradient ranging from 0.5 to 1°. This slope section starts approximately at 2200 m water depth, which corresponds with the transition to the Loyalty Basin floor. The slope section contains numerous erosional by-pass features such as submarine canyons that incise the slope up to a depth of 200 m. Backscatter imagery reveals depositional lobes at canyon mouths, offshore Thio and Yaté, as previously reported by Cotillon et al. (1989, 1990). The cut off angles are intended to characterize the morphology of the slope and have no universal value. Even in the case of a Gaussian slope angle evolution (*sensu* Adams and Kenter, 2013) angle values may vary between different carbonate systems.

4.2.2 Physiography of the upper slope

The upper slope is delimited by a major scarp located at 300-400 m water depth close to the Cap Bayes Pass (Fig. 5A) and the Nakéti Pass (Fig. 6A), at 400-500 m water depth in front of Côte Oubliée (Fig. 7A) and at 500-600 m water depths close to the Yaté Pass. The low-angle upper slope is only 3 to 4 km wide close to Nakéti Pass and widens southward to reach a width of 20 km in the vicinity of Yaté (Fig. 3A). Arcuate scars occur along the scarp, suggesting slope failure processes along the upper slope (Fig.5A and 6A). In front of Côte Oubliée, the 5-6 km wide upper slope is incised by low sinuosity, U-shaped, 40 to 80 m deep gullies (Fig.7A). Gullies are of variable extension along the upper slope, some start at 150 m water depth close to the outer reef slope, whereas others, shorter, gullies start at 300 m water depth, 3-4 km away from the shelf edge. The majority of gullies are located in front of Kouakoué Pass through which they are connected to the meandering lagoonal channel (Fig.3A).

4.2.3 Stratigraphy of the upper slope

Seismic profiles covering the platform edge to the upper slope region reveal two main seismic units, U1 and U2 separated by unconformity S1 (Fig. 5, 6 and 7). These profiles also show that U1 is exposed on the seafloor along a major scarp (see red arrows on maps and profiles of Fig. 5, 6 and 7). U1 comprises wavy reflections and is delimited at its top by erosional truncations and toplap terminations at bounding surface S1. The latter is overlain by unit 2 (U2) which shows well-layered reflections downlapping onto S1 (Figs. 5, 6 and 7). The maximal thickness of U2 varies between 0.1 to 0.25 s twt. In front of Côte Oubliée, on profile NM-13, at the mouth of the Kouakoué Pass, U2 is twice as thick than on profile NM-12b located 20 km further north at distance from any pass (Fig. 7).

Seismic profile NM1 at the mouth of the Cap Bayes Pass displays a well-developed unit U2 which forms a 0.2-0.25 s twt thick sedimentary prism (Fig. 5) composed of five stratigraphic sequences each composed of retrogradational sets (in pink on Fig. 5) overlain by progradational clinoform foresets (in beige on Fig. 5), noted 1 to 5. The slope break of the youngest (5^{th}) clinoform foreset (annotated "Clinoform slope break" on Fig. 5) is located at 150 m water depth. Retrogradational sets contain low-amplitude, mound-shaped seismic reflections that are only observed in topsets. Progradational sets show high-amplitude sigmoidal oblique reflections that downlap onto the underlying unit and are mainly located in the distal part of the sedimentary prism.

4.3. Pines Ridge

The Pines Ridge corresponds to the structural extension of the eastern margin of Grande Terre towards the South (Fig. 2). It is a NNW-SSE trending structure extending from the Isle of Pines to the Cook Fracture Zone.

4.3.1 Basement structure and first-order seismic stratigraphy of the Pines Ridge

The Pines Ridge is a horst of peridotite bounded by normal faults (Bitoun & Recy, 1982; Patriat et al., 2018) and is the southern offshore extension of the Peridotite Nappe cropping out onland (Patriat et al., 2018). In this paper, we have studied the area comprised between the Isle of Pines and Antigonia seamount, where Pines Ridge is the shallowest (Fig. 8A). Seismic profile

AUS-104 (Fig. 8B) reveals that the Pines Ridge comprises at its top high-amplitude subparallel reflections between 0.7 and 0.9 s twt, which contrast with the transparent seismic character of the underlying acoustic basement. Along the eastern flank of the Pines Ridge, the acoustic basement crops out on the seafloor at 2000 m water depth and was sampled by dredge GEO-I-3D (Daniel et al., 1976; Bitoun & Recy, 1982) (Fig. 8). The samples comprised altered basalt pebbles within a carbonate mud matrix containing planktonic foraminifera from the late Oligocene – earliest Miocene (Daniel et al., 1976). At that location, the acoustic basement forms a slightly tilted plateau located between 2.5 and 2.7 s twt, interpreted as an erosional weathering surface on top of peridotites by Bitoun and Recy (1982). This peridotite platform constitutes the western edge of the South Loyalty Basin (Figs. 8B and 8C). The peridotite basement is covered by a seismic unit composed of discontinuous low-amplitude subparallel reflections that is about 0.2 s twt thick at the crest of the ridge and up to 0.6 s twt-thick on its eastern flank. This unit is interpreted as a post-obduction sedimentary sequence (Bitoun & Recy, 1982 ; Patriat et al., 2018). The unit is incised by several submarine canyons along the eastern slope that extend from the Pines Ridge to the South Loyalty Basin (Fig. 8).

4.3.2 Physiography of the Pines Ridge

Along the northern part of the Pines Ridge, on the upper slope, the terrace identified on the eastern outer slopes of Grande Terre is continuously present between 300 to 600 m water depths (red arrows on Fig. 8A). East of the Isle of Pines, this terrace is affected by arcuate scarps most likely corresponding to submarine gravity collapses. Towards the Antigonia seamount, the top of the Pines Ridge is capped by this terrace (Fig. 2). Indeed, between the Banc de la Torche and Antigonia seamounts, the ridge's top remains positioned at 400-500 m water depth and its eastern slope is again characterized by a steep gradient and collapse features (red arrows on Fig. 8A). In turn, the Banc de la Torche and Antigonia display flat tops in 30 m to 60 m water depths (blue arrows on Fig. 8A). These two submerged isolated banks are surrounded by two terraces at 80-90 m and 120 m water depth.

The isolated Crypthelia and Munida seamounts are delimited by a main scarp at 400-500 m water depths (Figs.2 and 8). Their tops are located at 194 m and 93 m water depths, respectively. The Crypthelia seamount is 3 km wide and 12 km long elongated in a N160° direction (Fig. 9A and 9B). Three fault scarps located approximatively in 250, 350 and 500 m water depth affect the seamount across its entire length. Fault scarp heights are comprised between 30 m and 100 m (see map and cross section of Fig. 9B). In the northern part, the eastern fault scarp is associated with a channel probably formed by bottom currents circulating along the footwall of the fault (Fig. 9A and 9B). The southern edge of the seamount is marked by two 2-3 km wide failure scars, evidenced by arcuate headscarps located between 350 to 600 m water depth. The Munida seamount, located further to the northeast, extends over 8 km wide and 18 km long with a N60° direction (Fig. 9C). Its edges are bordered by N60° and N160° oriented fractures. On its southern flank, a terrace (M1) bordered by fault scarps is identified between 400 m and 600 m water depth. Above 200 m water depth, the top of the seamount (M2) is relatively flat (Fig. 9C) but still shows terraces at 100 m and 120-130 m water depth.

4.3.3 Stratigraphy of the Pines Ridge

The internal architecture of the post-obduction sedimentary sequence overlying basement of Pines Ridge and Munida seamount are imaged by seismic profile 206-04 (Fig.10). Over the Pines Ridge, the capping sedimentary unit reaches up to 0.5 s twt thick, i.e. approximately 750 m thick considering a velocity of 3000 $m.s^{-1}$ for a 30% porosity limestones according to Geldart (2004). In details, this interval is composed of 3 units, UP1 to UP3 (Fig.10C and 10D). Unit UP1 mainly developed on the SW edge of the ridge and is composed of low-amplitude reflections northeastwardly downlapping on basement. Unit UP2 downlaps basement on the eastern edge of the ridge with very low-amplitude reflections that form mounded morphologies. To the west, the seismic character of UP2 laterally evolves into low-amplitude, wavy to horizontal parallel reflections onlapping onto UP1 towards the southwest. Unit UP3 is typified by low-amplitude, sub-parallel and nearly horizontal reflections with low relief, mounded morphologies on the eastern edge of the ridge. Because seismic line 206-04 runs along the south-eastern slope of Munida Seamount (Fig. 9C), seismic imaging is poor due to 3D lateral effects. However, the profile intersects a part of the seamount with less slope that reveals that the sedimentary sequence has a minimum thickness of 0.4 s twt, i.e. approximately 600 m-thick (Fig.10A and 10B). It is composed of two distinct seismic units, UM1 and UM2 (Fig.10). Unit UM1 overlies the basement and comprises low-amplitude subparallel mounded reflections with downlapping and onlapping terminations. Unit UM2 overlies UM1 and comprises high-amplitude subparallel reflections with downlapping terminations.

4.4. Lithologies and biostratigraphic ages

4.4.1 Eastern margin of Grande Terre

Seven carbonate rock samples have been collected along the upper slope of the eastern margin (Table 3, see location on Fig. 2). DR44 and DR45 were recovered on scarps located at 400 m and 600 m water depths, at the seafloor exposure of seismic unit U1 (see location on Figs. 6A and 6B). DR44 is a micritic packstone with recrystallised algae, large benthic foraminifera (LBF) of Serravallian age (PZ N12, Tf2, 13.82 Ma to 12.00 Ma) (see BouDagher-Fadel, 2018b) and corals. These elements are reworked within a pelagic mud dominated by plancktonic foraminifera (Table 4) that comprise *Globigerinoides quadrilobatus* (Fig.11A, b.), *Dentoglobigerina altispira* (Fig.11B, b.), *Globorotalia menardii* (Fig.11B, c.), *Globigerinoides conglobatus* (Fig.11B, d.), *Globigerinoides ruber* (Fig.11B, e.), *Truncorotalia crassaformis*, *Orbulina universa, Globorotalia plesiotumida* (Fig.11C, a), *Sphaeroidinella dehiscens* of Early Pliocene age (N19-N20a, 5.3 Ma to 3.6 Ma). DR45 comprises ultramafic pebbles and gravels encrusted by algae incorporated in a micritic packstone similar to that of DR44 and also includes *Lepidocyclina* sp. (Fig. 11D) and *Alveolinella praequoyi*, with the same Serravallian age. DR46, DR47 and DR48 were collected on the edge of the terrace located between 200 to 400 m water depths near the Nakéti Pass (Figs. 6A and 6C). These three samples consist of micritic wackestone/packstones with patches of reworked pelagic micritic facies. DR46 assemblages are dominated by planktonic foraminifera such as *Truncorotalia crassaformis* (Fig, 11E, a.) *T.*

truncatulinoides, *Globorotalia inflata, Globorotalia menardii* and *Orbulina univesa* of Pleistocene age (N22, 1.8 Ma to 0.12 Ma). DR47 sample shows numerous terrigenous grains (quartz, altered serpentine and undifferentiated clasts). Planktonic foraminifera are common and include *Globoquadrina dehiscens* (Fig. 11F, a.), *Globigerinoides quadrilobatus, Globigerinoides trilobus, Globigerinoides ruber, Globorotalia tumida, Globigerinoides spp.*, and *Pulleniatina obliquiloculata* of Late Pliocene age (N20a, 3.8 Ma to 3.6 Ma). DR48 contains numerous recrystallized algae and reworked LBF, such as *Alveolinella praequoyi* (Fig. 12A, a.) of Serravallian age (see Adams, 1984; BouDagher-Fadel and Banner, 1999; BouDagher-Fadel, 2018b), planktonic foraminifera of Pleistocene in age (N22, 1.8 Ma to 0.12 Ma) such as *Pulleniatina obliquiloculata* (Fig. 12A, b.), *P. primalis* and *Neogloboquadrina dutertrei*. DR49 sample was collected along the scarp at 500 m water depth, near the East Ngoé pass. The lower part of this scarp corresponds to the top of seismic unit U1 (Table 3, see location Figs.7A and 7B). Recovered samples comprise a micritic packstone with algae and LBF of Serravallian age, such as *Alveolinella praequoyi* (Fig. 12B, a.) and planktonic foraminifera such as, *Globorotalia tumida* (Fig12C, a.), *Sphaeroidinellopsis subdehiscens*, *Globorotalia menardii* and *Globorotalia inflata* of Early Pliocene age (N19b, 4.2 Ma to 3.8 Ma) after BouDagher-Fadel (2018a). DR53 is located further south, in front of the Yaté Pass, in ca. 280 m water depth, and is a micritic packstone containing planktonic foraminifera such as *Pulleniatina primalis* (Fig.12D, a.), *Prosphaeroidinella parkerae, Pulleniatina praecursor, Globigerinoides obliquus* and *Truncorotalia crassaformis* of Late Miocene to Early Pliocene age (Table 3, see location Fig.2).

4.4.2 Pines Ridge

Seven carbonate rocks were sampled along the Pines Ridge (Table 3, see location Fig. 2 and Fig.8A). These samples are mainly micritic wackestones/packstones with planktonic foraminifera and algae. Samples DW4737-B, DW4745-B, DW4746-B, DW4747-B1 and DW4747-X have ages ranging from Pliocene to Late Pleistocene (N19 to N22, 5.33 Ma to 0.12 Ma). Planktonic foraminifera assemblages of these samples include *Neogloboquadrina pachyderma, Sphaeroidinella dehiscens, Truncorotalia truncatulinoides, Truncorotalia tosaensis,* and

Pulleniatina obliquiloculata and LBF, such as *Alanlordia* sp. (Fig.12E, a.), are found reworked together with Pliocene planktonic foraminifera into the younger assemblages. Further south, samples DW4757-A and DW4782-A were collected along the eastern slope of Pines Ridge (Table 3, see location Fig.8A and Fig.10). DW4757-A includes Oligocene to earliest middle Miocene LBF such as *Lepidocyclina* sp. and *Planorbulinella solida* (Fig.12F, a.), while DW4782-A comprises late Miocene to Pleistocene (N17-N20, 8.6 Ma to 3.4 Ma) planktonic foraminifera such as *Neogloboquadrina humerosa, Sphaeroidinellopsis seminulina, Sphaeroidinellopsis subdehiscens*.

4.4.3 Munida seamount

Three carbonate rock samples have been collected along the edges of *Munida* (Table 3, see location on Fig. 8A and Fig. 9C). Samples from DW4770, located on the northeast flank of the seamount, comprise micritic and sparitic packstones composed of algae and planktonic foraminifera, such as *Truncorotalia truncatulinoides* (Fig.12F, a) and *Truncorotalia tosaensis* (Fig.12F, b) of Pleistocene age (N22, 1.8 Ma to 0.12 Ma). DR4772-A and DR4773-A samples, located on the southern flank, are grainstones cemented by sparite, with planktonic foraminiferal assemblages including *Sphaeroidinellopsis subdehiscens*, *Sphaeroidinella dehiscens, Truncorotalia tosaensis* and *Pulleniatina obliquiloculata* of Pliocene to Pleistocene age (N21-N22, 3.4 Ma to 0.12 Ma). These samples also reveal many reworked Miocene and Pliocene planktonic foraminifera.

4.5. Paleoenvironmental interpretations

The assemblages of DR44 and DR45 are dominated by Early Pliocene planktonic foraminiferal assemblages (e.g. *Sphaeroidinellopsis paenedehiscens, Globoquadrina dediscens, Orbulina universa, Globorotalia plesiotumida, G. tumida* and *Dentoglogigerina altispira*)*.* These mixed, globular and heavily keeled planktonic foraminifera are indicative of inner to outer neritic environments (BouDagher-Fadel, 2015). Miocene larger benthic foraminifera (e.g. *Lepidocyclina* sp., *Katacycloclypeus martini*, *Cycloclypeus* sp.) and fragments of corals and rodophyte species are also frequently reworked within the deeper Early Pliocene platform. These larger benthic foraminifera are flat in shape and are associated with symbiont-bearing diatoms (Leutenegger 1984; Romero et al. 2002). They are common in forereef environment where they adapted to light attenuation with increasing habitat depth (Hottinger, 1983; Hallock and Schlager, 1986; Hohenegger, 1995; 2005; Yordanova & Hohenegger, 2002; 2007; BouDagher-Fadel, 2018b).

The Late Pliocene to Pleistocene deposits of DR46, DR47 and DR48 contain mainly planktonic foraminifera of mixed assemblages of globular forms (e.g. *Globigerinoides quadrilobatus, Orbulina universa*) and keeled globorotalids (e.g. *Truncorotalia truncatulinoides, Globorotolia tumida).* These assemblages are indicative of an inner to outer neritic environment (see BouDagher-Fadel, 2015). Micritic patches of older Miocene deposits with mainly globular small globigerinids (e.g. *Catapsydrax cf. dissimilis, Globigerina praebulloides*) are also present indicating the reworking of an inner neritic Miocene platform within the deeper deposits of the Pliocene.

DR 49 is interpreted as being deposited in an Early Pliocene inner to outer neritic platform. It contains planktonic foraminifera assemblages dominated by globular forms (e.g. *Globorotalia menardii, G. inflata, Globigerinoides trilobus, Gldes quadrilobatus)* with occasional occurrences of keeled forms (e.g., *Globorotalia tumida, G. menardii*) and thickly coated forms in a thick, smooth cortex of calcite, *Sphaeroidinerlla dehiscens.* The latter is an extant thermocline dweller found rarely in subsurface, tropical, and subtropical waters (Chaisson and Ravelo, 1997; BouDagher-Fadel, 2018b). Reworked reefal Miocene larger benthic foraminifera (e.g., *Alveolinella praequoyi, Lepidocyclina sp., Planorbulina larvata, Amphistegina lessonii, Operculinoides spp., Gypsina sp*.) are also present. The presence of the large fusiform miliolid, *A. praequoyi* indicates the reworking of shallow reefal facies into the deeper Early Pliocene neritic environments.

The assemblages of DR53 are dominated by Late Miocene to Early Pliocene globular planktonic foraminifera species (e.g., *Neogloboquadrina pachyderma, N. acostaensis, Orbulina universa, Prosphaeroidinella parkerae, Pulleniatina praecursor, P. primalis, Globigerinoides obliquus*). Occasional keeled forms (e.g., *Truncorotalia crassaformis, Globorotalia menardii, Globorotalia tumida*) are also present. Larger benthic foraminifera such as *Amphistegina spp*. and *Sphaerogypsina spp.* are also found. The extant *Amphistegina* has adapted to high energy conditions, however, it is also found in mud free sands in areas of sea grass or coralline algae and in reefal areas down to depths of 35m (McKee et al, 1959), while *Sphaerogypsina* is generally common in shallow-water reefal environments (Nebelsick et al. 2001). These assemblages are interpreted as being deposited in an inner to outer neritic platform.

All samples from Pines Ridge point to inner to outer neritic settings, except DW4757-A which is typified by a forereef environment because of the occurrence of larger benthic foraminifera, such as *Amphistegina lessonii, Lepidocyclina sp., and Planorbulinella solida.* All samples from Munida seamount contain mixed assemblages of globular and keeled planktonic foraminifera (e.g., *Sphaeroidinellopsis subdehiscens, Sphaeroidinella dehiscens, Truncorotalia tosaensis, Pulleniatina obliquiloculata, Globorotalia inflata*) and are thought to reflect inner to outer neritic settings.

5. CARBONATE SYSTEM EVOLUTION ON THE EASTERN MARGIN OF NEW CALEDONIA

5.1 Mio-Pliocene carbonate banks

Carbonate rocks sampled on the upper slope scarp along the eastern margin contain algae, benthic foraminifera and coral fragments evidencing shallow-water carbonate production as early as the middle Miocene (Serravalian) and up to the Pliocene (Table 3, Fig. 13). This scarp corresponds to the top of seismic unit U1, which is bounded by the gently downslope dipping surface S1 (Figs. 5, 6 and 7). Because of its planar character, Chardon et al., (2008) interpreted this surface, topping a clastic continental wedge, as a lateritic land surface formed by weathering during emersion. Because none of the dredges that sampled this scarp (and thus U1) contained any traces of lateritic deposits, we propose an alternative interpretation where seismic unit U1 corresponds to a Mio-Pliocene carbonate bank, presently located at 300-600 m water depth. This important subsidence cannot be explained only by eustatism and we suggest that the post-obduction normal faulting that affected the Peridotite Nappe is likely the main driver of the subsidence. Surface S1 is interpreted as the top of the carbonate bank characterized by low-inclination features (Fig. 13A and B). The numerous ultrabasic pebbles/gravels and quartz grains within the carbonate matrix of samples DR45 and DR47 suggest coeval siliciclastic input with the carbonate buildup development. A similar mixed carbonate-siliciclastic system also occurs along the coastal domain of the western margin of Grande Terre in the well-constrained Burdigalian Népoui system (Tournadour et al., 2020) (Fig.13B). The onset of these mixed systems indicates that both margins of Grande Terre experienced shallow marine conditions during the Miocene. However, their current positions, up to 20 m above present day sea level for the Lower Miocene Népoui outcrops of the western margin and up to 500 m water depth for the middle Miocene samples of the eastern margin, suggest a contrasted tectonic evolution of the margins.

Our results suggest that the Mio-Pliocene carbonate platform (Table 3, Fig.13) extended southward along the Pines Ridge, over peridotite horsts, which were at that time located in shallow-water (Fig.13A and B). Within this sedimentary succession, unit UP1 is interpreted as an attached carbonate platform developing on the western edge of the ridge. The eastward thickening of unit UP2, which unconformably overlies unit UP1 (Fig.10D), suggests deposition simultaneous or subsequent to the eastward tectonic tilting of Pines Ridge. The aggrading mounded reflections of the lower part of UP2 on the eastern edge of the ridge, may be interpreted as shallow-water, reefal bioconstructions (e.g. Miocene from the Browse basin, Australia: Belde et al., 2017), or as an oligo-mesophotic bank with dominant algal and foraminiferal production (e.g. Lower Miocene from Myanmar: Teillet et al., 2020a and 2020b). However, in the upper part of UP2, the upward change from mounded to flat-topped morphologies on the eastern margin strongly suggests the development of reef-flat environments aggrading up to sea-level. Finally, subunit UP3 is also characterized by a slight overgrowth along the eastern edge as evidenced by low-relief mounded reflectors (Fig.10). Such an asymmetric feature could be explained by the continuation of an eastward tectonic tilt or could be related to eastward winds driving carbonate growth (Fig.10).

Based on seismic interpretation, two stages of carbonate growth are identified on the Munida seamount (seismic units UM1 and UM2). A carbonate sample, collected 15 km away from the seamount (GEO-I-13D; location on Fig.2), contains benthic foraminifera indicative of shallow-water environment, that can be dated Early Miocene (Daniel et al., 1976; Bitoun and Recy, 1982). This sample suggests a first stage of carbonate growth (UM1) of Miocene age coeval with carbonate platforms from Pines Ridge (UP1 and/or UP2) (Fig.13A and B). A Miocene carbonate platform also likely developed on the Crypthelia seamount as suggested by a Middle to Late Miocene carbonate sample exhibiting forereef facies (GEO-I-9D, see location Fig.2 and Fig.9A) (Daniel et al., 1976; Bitoun and Recy, 1982).

Based on aforementioned observations, we propose the following palaeogeographical reconstruction of the distribution of Mio-Pliocene shallow-water carbonate systems along the margin of New Caledonia (Fig. 13B). The Mio-Pliocene carbonate systems extend for about 350 km, along the southeastern margin to Antigonia Seamount. On the western margin, the Quaternary carbonate reef-lagoon system directly overlies Eocene allochthonous units (see Fig.1). At that location, the absence of Miocene shallow-water deposits could be explained by a non-deposition or by erosion in relation to the uplift of the western margin. The thickness of the Miocene ramp is a least 200 m on the Nepoui area (Maurizot et al., 2016; Tournadour et al., 2020), but remains unknown along the eastern margin. However, it can be estimated to be around 750 m on the Pines Ridge (Fig.10B). Similar Miocene carbonate growth rates have been reported for the southwestern Pacific suggesting that, in addition to local tectonic control (subsidence) allowing significant volumes of sediments to accumulate, larger-scale oceanographic or global factors favoured a sufficiently high carbonate production to fill the created accommodation. For example, the 600 m-thick Marion Plateau platforms, northeast of Australia, result from robust carbonate growth through early and middle Miocene up to its terminal demise in the late Miocene (Ehrenberg et al., 2008). Along the northwestern shelf of Australia, seismic profiles reveal a giant middle Miocene prograding barrier reef that backstepped in the late Miocene (McCaffrey et al., 2020). Finally, the Gulf of Papua is also structured by large-scale isolated long-lived carbonate platforms during the late Oligocene-early Miocene and which demised during late Miocene-early Pliocene (Tcherepanov et al., 2008b). In our study, the prolific Mio-Pliocene carbonate accumulation is favoured by the subsidence of the shelves of New Caledonia and Pines Ridge, most likely in relation to post-obduction extensional tectonics (Lagabrielle and Chauvet, 2008; Patriat et al., 2018).

5.2 Transition from Mio-Pliocene to Quaternary platforms

Along the eastern margin of Grande Terre, the Quaternary rimmed platform is thought to have backstepped onto a Mio-Pliocene carbonate bank (Fig. 13A and 13C). Southward, along the Pines Ridge and associated seamounts, the Mio-Pliocene carbonate banks are drowned but several Quaternary flat-topped isolated platforms survived and aggraded.

In the vicinity of the study area, the carbonate platform of Maré, on the Loyalty Ridge, records a significant change in the nature of carbonate production which is rhodalgal-dominated during the late Miocene, and coralgal-dominated during the Pliocene (McNeill and Pisera, 2010; Maurizot et al., 2020). These authors explain the switch of carbonate production by the trend of decreased coralline red algae species richness (Aguirre et al., 2000) combined with the global-scale Zanclean Flood Event (McKenzie et al., 1999). The exposure of these carbonate records would result from the local tectonic uplift of the Loyalty Ridge related to Pliocene-Pleistocene lithospheric flexure associated with the New Hebrides subduction (Dubois et al., 1974 and 1975).

Along the western margin of Grande Terre, the coral reef flourished from 400 ky (MIS-11) considered as a period of luxuriant reef expansion in the southwest Pacific (Cabioch et al., 2008b). Nevertheless, during the Quaternary, non-reefal carbonates were identified prior to MIS-11 as early as 1.4 Ma, overlapping the Eocene allochtonous units and could form the foundation of the Quaternary rimmed platform (Cabioch et al., 2008b; Montaggioni et al., 2011).

Along the eastern margin, the occurrence of a Mio-Pliocene platform below the eastern barrier reef-lagoon suggests that an older carbonate platform developed similarly to what is observed in Maré Island. The common occurrence of normal faults suggests that the eastern margin and Pines Ridge were dominated by tectonic subsidence that would have promoted accommodation for Neogene carbonate deposition and preservation, by opposition to the western margin where the Quaternary carbonates are found on top of Eocene peridotites.

However, high subsidence rates could also explain the demise of the Mio-Pliocene carbonate systems along the Pines Ridge and the backstepping of Quaternary platforms. After 125 ky, the southeastern margin is slightly uplifted in the Yaté area and the Isle of Pines (Launay, 1985; Cabioch et al., 1996). This uplift could be due to the isostatic rebound of the central part of Grande Terre (Cabioch et al., 1996; Lagabrielle and Chauvet, 2008) or alternatively, could be associated with the lithospheric bulge of the New Hebrides subduction which is known to have a regional impact from the Loyalty Islands to the Isle of Pines (Dubois et al., 1974 and 1975; Cabioch et al., 1996). Hence, both margins of New Caledonia seem to have been affected by long-term subsidence during the Quaternary which, together with high-amplitude eustatic sea-level variations, allowed the aggradation and preservation of the reef-lagoon successions.

5.3 Quaternary carbonate platform

5.3.1 Late Quaternary mixed carbonate siliciclastic systems along the eastern margin

At the mouth of the Cap Bayes Pass, seismic unit U2 forms a 200 m-thick prism comprising five stratigraphic sequences (Fig. 5). In detail, the internal geometries of these parasequences are characterized by successive sets of aggrading to retrograding mounded reflections and progradational inclined reflections. We interpret these parasequences as mixed carbonate-siliciclastic prims that developed at the mouth of the pass, with aggrading and retrograding shallow-water carbonate sequences that developed during a transgression (pink colour on Fig. 5C), deposited during the last glacial-interglacial Quaternary cycles. This interpretation is consistent with core data collected on the western barrier reef (see location of Fig. 1), which revealed that the barrier reef itself consist of four to five lithological sequences deposited during successive transgressions and highstands in sea level since the Mid-Brunhes, each transgressive reefal units being separated by subaerial unconformities (subaerial exposures) (Cabioch et al., 2008b; Montaggioni et al., 2011). The prograding seismic patterns (yellow colour on Fig.5C) thus can be interpreted as lowstand siliciclastic wedges that formed during Late Quaternary glacial lowstands.

Siliciclastics might have developed contemporaneously with the Quaternary barrier reef bordering the eastern lagoon (Figs. 5, 6B and 7). This observation is consistent with the reciprocal sedimentation concept traditionally developed for carbonate-siliciclastic mixed systems (see review by Chiarella et al., 2017). According to this concept, siliciclastic deposits prevailed on the upper slope during sea-level lowstands and at the beginning of the shelf reflooding, whereas carbonate facies dominate during transgressions and highstand periods. This configuration is currently observed on the platform edge of Quaternary mixed carbonate-siliciclastic systems such as the Australia and Papua New Guinea Reef (Tcherepanov et al., 2008a; 2008b; 2010; Harper et al., 2015; Mallarino et al., 2021) or the Belize Barrier Reef (Esker et al., 1998; Ferro et al., 1999; Gischler et al., 2010; Droxler and Jorry, 2013). However, the reciprocal pattern is not expressed everywhere along the upper slope of the eastern margin. Near the Côte Oubliée, seismic unit U2 is not characterized by sedimentary prograding clinoforms but rather by a downlapping aggrading wedge with a maximum thickness of 200 m in front of the Kouakoué Pass (Fig.7). The lack of prograding features associated with the lowstand clastic wedge could be explained by low terrigenous sedimentation rates as suggested by small deltas restricted to the coastal domain (Fig. 3A). Moreover, the southeastern part of the lagoon is characterized by a meandering channel network parallel to the coast and to the barrier reef, suggesting an alongshore transport which can partly intercept outgoing sedimentary flux from lagoon (Fig. 3A). In addition, the numerous gullies cutting the upper slope suggest high off-bank sediment transport toward the deep basin and thus the accumulation of sediments along the upper slope (Fig. 7A). This off-bank sediment transport could result from density cascading processes driven by seasonal meteorological conditions (Wilson and Roberts, 1992, 1995). The alongslope heterogeneity of the eastern margin upper slope deposits clearly shows that the behaviour of a mixed carbonate-siliciclastic margin is difficult to predict and is not only dependent of relative sea-level changes, as mentioned previously (Chiarella et al., 2017; O'Connell et al., 2020).

5.3.2 Quaternary isolated flat-topped banks of Pines Ridge and seamounts

Along the Pines Ridge, dredged carbonate rock samples show that shallow-water carbonate deposition occurred on the Banc de la Torche and Antigonia seamounts during the Quaternary (Fig.13A and C). The two marine terraces at 80-90 m and 120 m water depth might evidence reef backstepping during the last deglacial sea-level rise, as reported around the Great Barrier Reef (Webster et al., 2018), the Gulf of Mexico (Khanna et al. 2017), the Maldives (Fürstenau et al., 2010; Rovere et al., 2018), the SW Indian Ocean (Jorry et al., 2016), the Marquesas Island (Cabioch et al., 2008a) and in Tahiti (Camoin et al., 2012). Carbonate rock samples dated at the youngest from the Pleistocene and collected on the flat-top of the Munida seamount that is currently submerged in 93 m water depth, are thought to be representative of seismic unit UM-2 which would correspond to the last stage of the carbonate platform's growth. Similarly to the Banc de la Torche and Antigonia, the flat-top of the eastern part of the Munida seamount is currently located in the photic zone which suggests continuous carbonate aggradation from the Miocene to the Quaternary. Such a continuous deposition was possibly favoured by a slower subsidence at that location compared to other seamounts (Fig.13). The Crypthelia seamount that is submerged at 194 m water depth is affected by three N160°E normal faults scarps, leading to an overall eastward deepening of the seamount topography along several stepped terraces at ca 200 m, 300 m and 350 m water depths (Fig.9A). The lack of samples on these stepped terraces does not allow us to determine if the carbonate factory was active during the Quaternary and when the isolated carbonate platform was drowned (Fig.13A).

6. CONCLUSIONS

The eastern margin of Grande Terre records the evolution of a shallow-water mixed carbonate-siliciclastic system, with the successive development an aggrading Mio-Pliocene carbonate bank and a backstepping Quaternary barrier reef.

- A Mio-Pliocene shallow-water carbonate platform, presently drowned at 300 to 600 m water depth, extends about 350 km from Ponerihouen to Antigonia seamount and can be up to 750 m thick along the Pines Ridge.

- In front of Grande Terre, the Mio-Pliocene carbonate sediments are mixed with quartz grains and ultrabasic pebbles, which document terrigenous inputs resulting from high relief of the island topography dismantling coeval with carbonate production as early as the Serravalian.

- The transition between the aggrading Mio-Pliocene carbonate bank and the backstepping Quaternary carbonate platforms along the eastern margin could be explained by the regional subsidence context driven by an extensional tectonic regime or by global climate change associated with Late Quaternary high-amplitude sea-level variations and/or changes of carbonate producers through time.

- The stratigraphic architectures of mixed carbonate-siliciclastic systems, represented by the Quaternary reef-lagoon complex along the upper slope, vary widely from north to south. In front of the Cap Bayes Pass, this contribution evidences for the first time in New Caledonia the presence of a lowstand terrigenous prism alternating with transgressive shallow-water carbonate sequence, typical to reciprocal sedimentation models. Nevertheless, this configuration is not observed southward, probably because other control parameters prevailed such as low terrigenous inputs, the particular morphology of the paleo-drainage network, which appears parallel to the coastline, or the high by-pass sediment transport toward the deep basin.

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FIGURE AND TABLE CAPTIONS

Figure 1: A. Regional location map of the study area. **B.** Simplified geological map of Grande Terre, New Caledonia (modified after Maurizot and Vendé-Leclerc, 2009) and shaded bathymetric map of surrounding offshore areas with the southern extensions of the Peridotite Nappe and metamorphic belt (Pines and Félicité ridges, respectively; after Patriat et al., 2018). Drill sites of the Quaternary barrier reef (Coudray, 1975; Cabioch et al., 2008; Montaggioni et al., 2011) and outcrops of the Lower Miocene mixed carbonate siliciclastic systems of Népoui are also indicated (Maurizot et al., 2016 ; Tournadour et al., 2020). **C.** Simplified SW to NE oriented geological cross-section of Grande Terre (modified after Lagabrielle et al., 2005 and Collot et al., 1987). N: Nouméa ; Pn: Ponérihouen ; Th: Thio ; Yt: Yaté ; IP: Isle of Pines ; T : Banc de la Torche ; S : Stylaster seamount ; B : Brachiopod seamount ; A : Antigonia seamount ; C : Crypthelia seamount ; M : Munida seamount.

Figure 2: Bathymetric map of the eastern margin of Grande Terre, from Poindimié to the Pines Ridge with location of the dataset used in this study including seismic profiles AUS-104 (Bitoun & Recy, 1982), 206-04 (dashed black lines), NEOMARGES (Chardon, 2006; Chardon et al. 2008, black lines), and dredged carbonate samples (yellow circles). T : Banc de la Torche ; S : Stylaster seamount ; B : Brachiopod seamount ; A : Antigonia seamount ; C : Crypthelia seamount ; M : Munida seamount.

Figure 3: A. Bathymetric map of the eastern lagoon of Grande Terre from Ponérihouen to Yaté. On the outer slope, note the terrace mapped in orange between 300 to 600 m water depths. **B.** Bathymetrical profile across the lagoon from the coast of Houailou to the outer barrier reef (see location on Figure A) showing three main morphobathymetric zones: 1) a shallow-water coastal zone dominated by fine-grained terrigenous sediments; 2) a deeper median lagoon with aligned islands and a coast-parallel channel network in front of Cote Oubliée; 3) a barrier reef domain cross-cut by passes, dominated by coarse-grained carbonate sedimentation. D: Deltas; D*:

Restricted deltas; SI: Sandy Islets; PR: Patch Reefs. Red lines are positions of seismic profiles. Yellow circles are positions of dredged carbonate samples.

Figure 4: Typical bathymetric profiles of the outer slopes of Grande Terre (location on Fig.2) highlighting the very steep character of the western margin (dashed green lines; W-01 and W-02) contrasting with the more gently inclined eastern margin (solid blue lines; E-01 and E-02). The latter illustrate the main morpho-bathymetric domains of the eastern margin slope, which can be divided into a low gradient (2-3°) upper slope mostly preserved from erosion, a middle slope affected by numerous submarine canyons and a lower slope to to-of-slope region. The hatched area shows the elevation difference between the southern and central parts of the eastern margin (E-01 and E-02, respectively), highlighting that the slope is better preserved from retrogressive erosion by slope canyons processes towards the south.

Figure 5: **A.** 3D bathymetrical map of the outer slope in front of Cap Bayes Pass with location of dip-oriented seismic profile NM-1. **B.** Seismic profile NM-1 profile with location of quaternary terraces (blue arrow, see details in Flamand, 2006), clinoform slope break of U2 prism (green arrow) and the bathymetrical scarp associated with the top of U1 seismic unit (red arrow). **C.** Interpretation of seismic profile NM-1 highlighting five sub-units inside U2, interpreted as parasequences (numbered from 1 to 5). Each parasequence is typified by an alternation of lowstand forced regressive wedges (in beige) and aggrading to retrograding shallow-water carbonate transgressive sequences (in pink), consistent with the pattern of reciprocal sedimentation model.

Figure 6: **A.** 3D bathymetrical map of the outer slope in front of Canala with location of seismic profiles NM-4 and NM-9 and dredged carbonate rocks (see Table 3). **B.** Uninterpreted seismic profile NM-4. **C**. Interpreted seismic profile NM-4. **D.** Uninterpreted seismic profile NM-9. **E.** Interpretation of seismic profile NM-9. Both profiles show U1 seismic unit overlain by downlapping U2 seismic unit interpreted as external slope deposits derived from the quaternary barrier reef.

Figure 7: A. 3D bathymetrical map of the outer slope in front of Côte Oubliée with location of seismic profiles NM-12B and NM-13 and dredged carbonate rock DR-49 (see Table 3). **B.** Uninterpreted seismic profile NM-12B. **C.** Interpretation of seismic profile NM-12B. **D.** Uninterpreted seismic profile NM-13. **E.** Interpretation of seismic profile NM-13. The upper slope is characterized by a thick downlapping U1 sedimentary unit incised by numerous gullies suggesting significant off-bank transport from the lagoon towards the basin.

Figure 8: A. 3D bathymetrical map of the southeastern slope of Grande Terre and Pines Ridge with location of AUS-104 and 206-04 seismic profiles. T : Banc de la Torche ; S : Stylaster seamount ; B : Brachiopod seamount ; A : Antigonia seamount ; C : Crypthelia seamount ; M : Munida seamount. **B.** Seismic profile AUS-14 across the Loyalty Basin bordered by the Loyalty and Pines ridges. **C.** Line drawing interpretation of profile AUS-14 showing spectacular normal faults affecting the peridotite nappe overlain by post-obduction sedimentary units. This study focuses on shallow-water carbonates that cover peridotite horsts of the Pines Ridge and which are currently at 300-400 m water depths.

Figure 9: Bathymetric map (**A**) and profile (**B**) of Crypthelia seamount located from 200 to 800 m water depth and marked by N160° oriented faults (f) associated with a channel (Ch) and large collapses on its southern edge. Bathymetric map of Munida seamount (**C**) marked by a southern terrace noted M1, located between 400 to 600 m water depth, and by a relatively flat top above 200 m water depth, noted M2.

Figure 10: A. Seismic profile 206-04 through the Pines Ridge and Munida seamount (see location on Fig.8A and 10C). **B.** Interpretation of profile 206-04 showing the normally faulted geometry the Peridotite Nappe and HP-LT Metamorphic complex resulting from post-obduction extensional tectonics (Patriat et al., 2018). Associated flat-topped horsts are capped by a shallow water carbonate ramp interpreted as being of Mio-Pliocene age based on biostratigraphic analysis of DW-4757 and DW-4782-A dredged samples (see Table 3). **C**. Close-up view on seismic profile 206-04 on the Pines Ridge. **D**. Detailed line drawing interpretation of C. showing

3 subunits UP1 to UP3 and an overall asymmetric configuration suggesting a tilt of Pines Ridge before and during deposition of the Mio-Pliocene carbonate ramp. The eastern part of UP2 subunit is characterized by buid-up geometries that could be interpreted as aggrading platform.

Figure 11: **A.** DR44 sample, (a.) *Katacycloclypeus martini*, (b.) *Globigerinoides quadrilobatus*. **B.** DR44 sample, (a.) *small rotaliid* in reworked micrite, (b.) *Dentoglobigerina altispira*, (c.) *Globorotalia menardii*, (d.) *Globigerinoides conglobatus*, (e.) *Globigerinoides ruber*. **C.** DR44 sample, (a.) *Globorotalia plesiotumida*. **D.** DR45 sample, (a.) *Lepidocyclina sp.*. **E.** DR46 sample, (a.) *Truncorotalia crassaformis.* **F.** DR47 sample, (a.) *Globoquadrina dehiscens.* G. DR47 sample, (a.) *Globorotalia tumida.*

Figure 12: **A.** DR48 sample, (a.) *Alveolinella praequoyi* (b.) *Pulleniatina obliquiloculata.* **B.** DR49 sample, (a.) *Alveolinella praequoyi*. **C.** DR49 sample, (a.) *Globorotalia tumida* **D.** DR53 sample, (a.) *Pulleniatina primalis* **E.** DW4737-B sample, (a.) *Alanlordia sp.* **F.** DW4757-A sample, (a.) *Planorbulinella solida.* **G.** DW4770 sample, (a.) *Truncorotalia truncatulinoides* (d'Orbigny) (b.) *Truncorotalia tosaensis* (Takayanagi and Saito).

Figure 13: **A.** Schematic cross-sections showing the geometry and evolution of shallow water post-obduction systems on the eastern margin of Grande Terre in the vicinity of Poindimié (1), north of Pines Ridges along Banc de la Torche (2), south of Pines Ridge (3), and over Crypthelia (4) and (5)Munida seamounts. (location in Fig. 13C). **B.** Paleogeographical reconstruction and spatial distribution of Mio-Pliocene carbonate banks. **C.** Paleogeographical reconstruction and spatial distribution of Quaternary barrier reef of Grande Terre and submerged isolated platforms along Pines Ridges and seamounts.

Table 1: Characteristics of the seismic acquisition devices.

Table 2: List of carbonate rock samples analysed in this study

Table 3: Table summarizing microfacies description and interpretation of depositional environment, age of *in-situ* components and age of reworked components (identified in red in Table 4)

Table 4: List of the component occurrence with identification of reworked elements (red cross).

Figure 1

Click here to access/download;Figure;FIG-01.tif

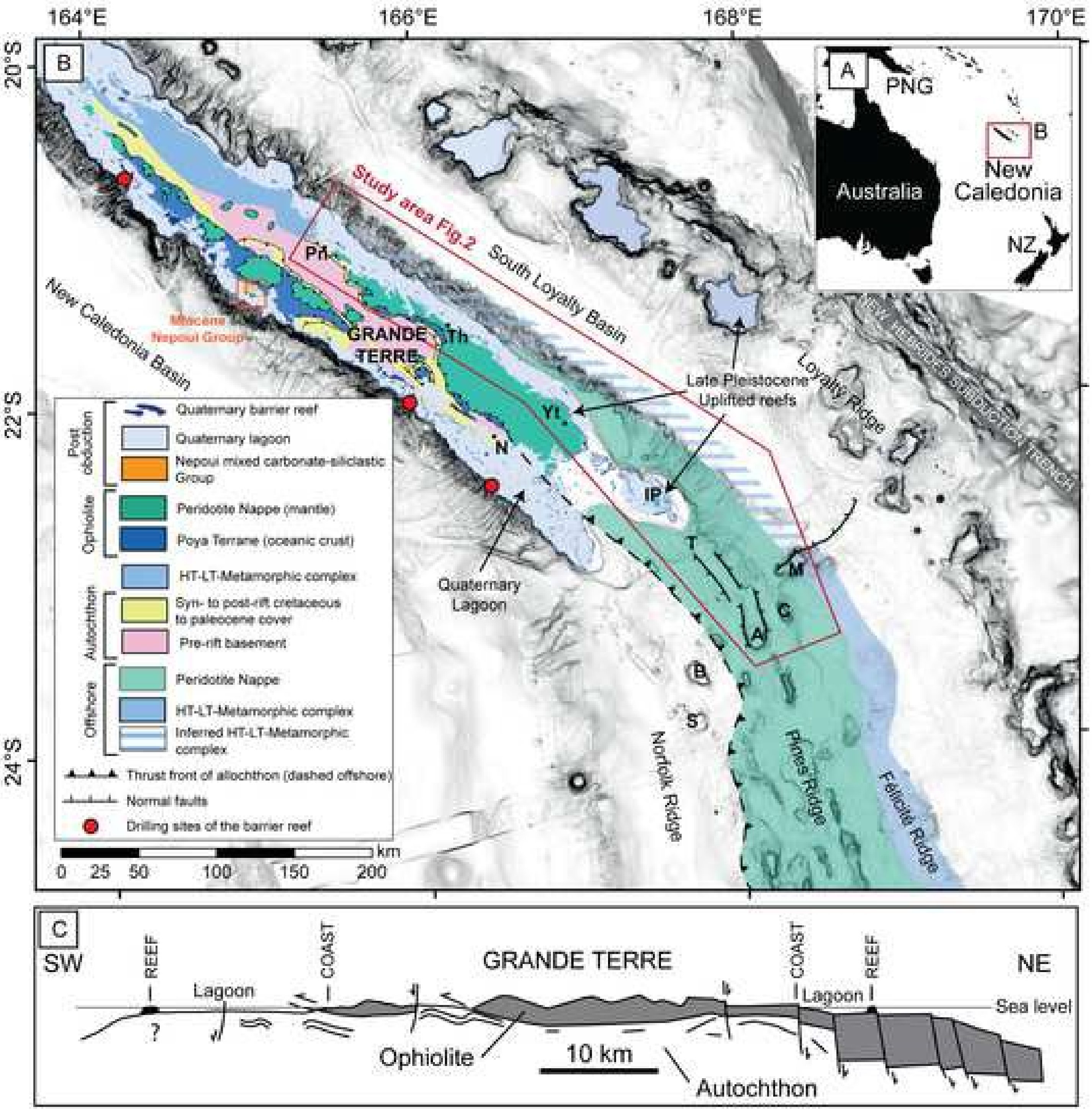

Figure 2

Click here to access/download;Figure;FIG-02.tif

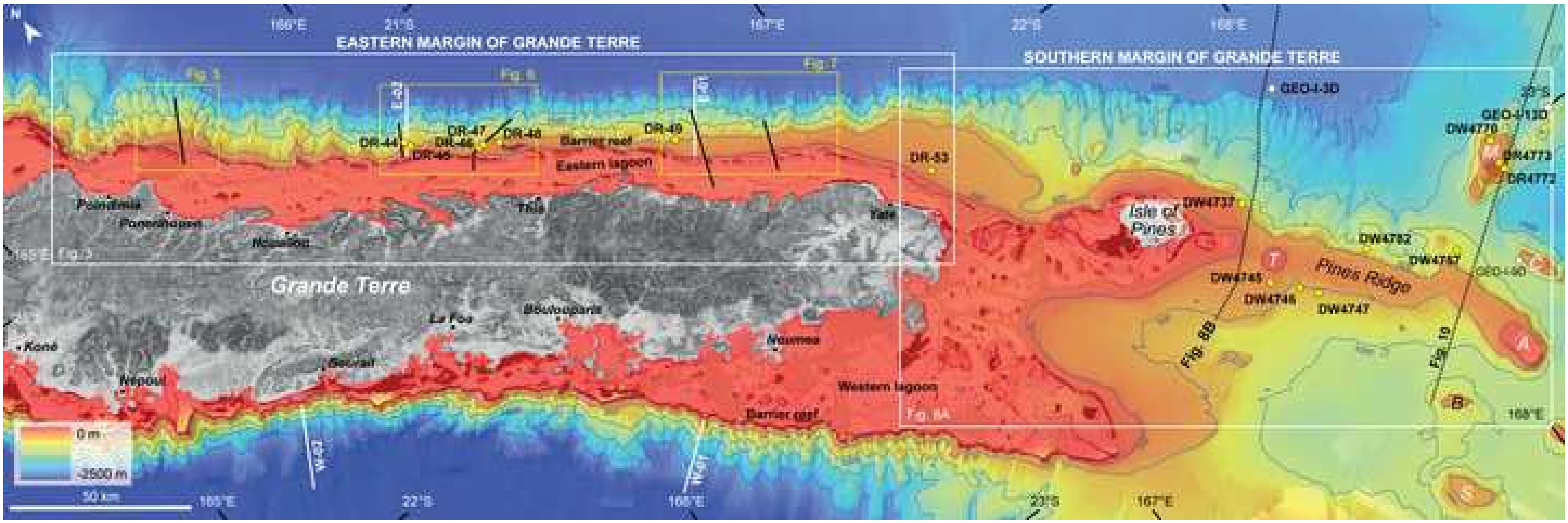

Figure 3

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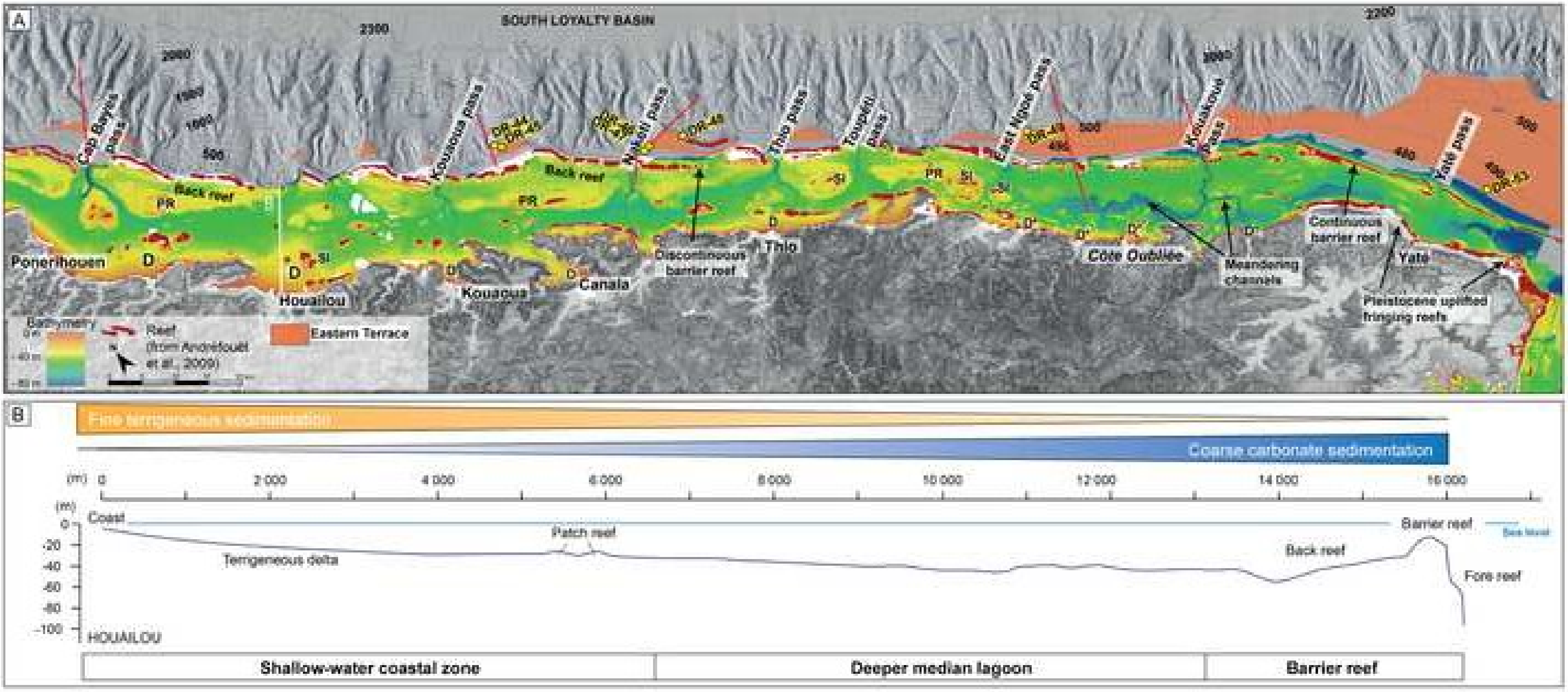

Figure 4

Click here to access/download;Figure;FIG-04.tif

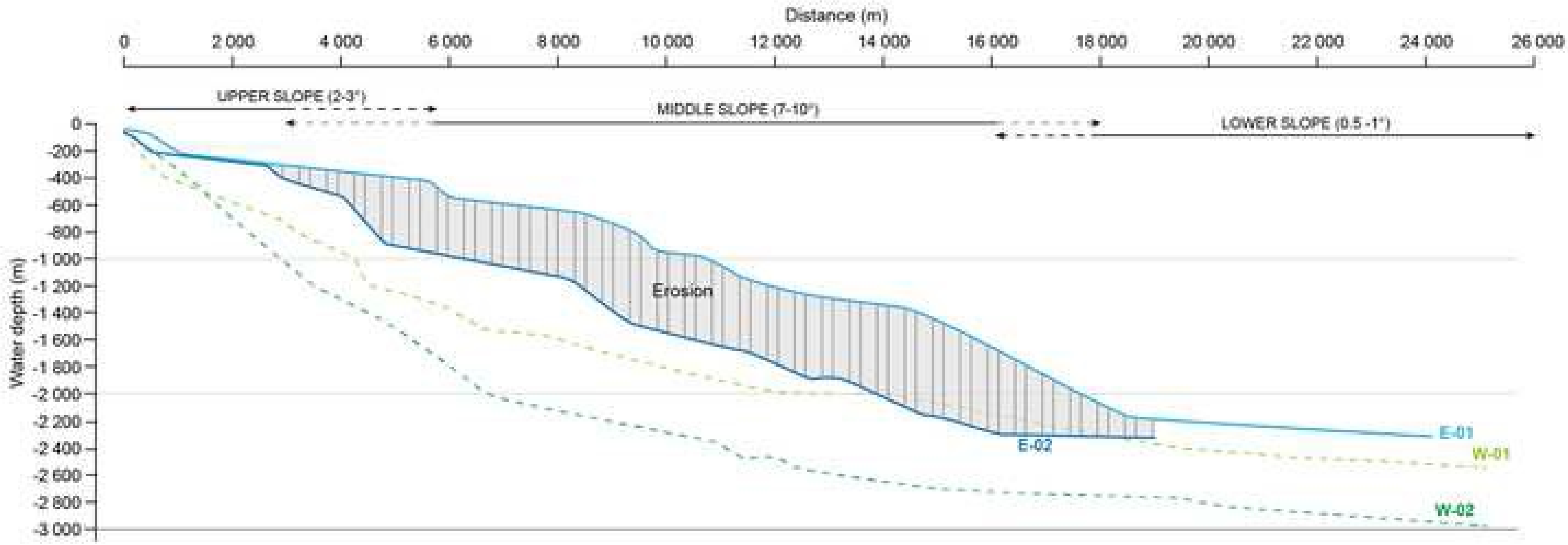

Figure 5

Click here to access/download;Figure;FIG-05.tif

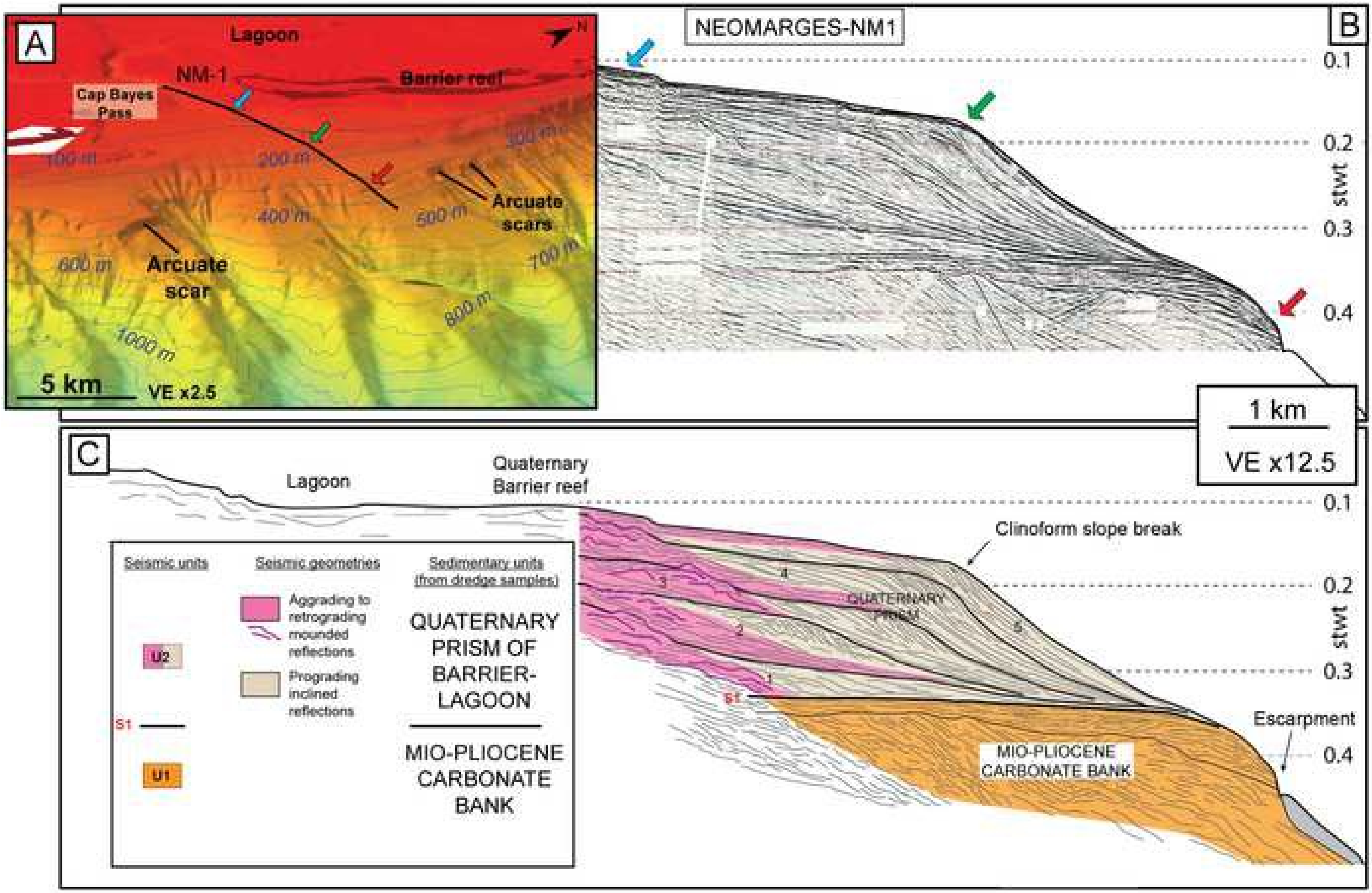

Figure 6

Click here to access/download;Figure;FIG-06.tif

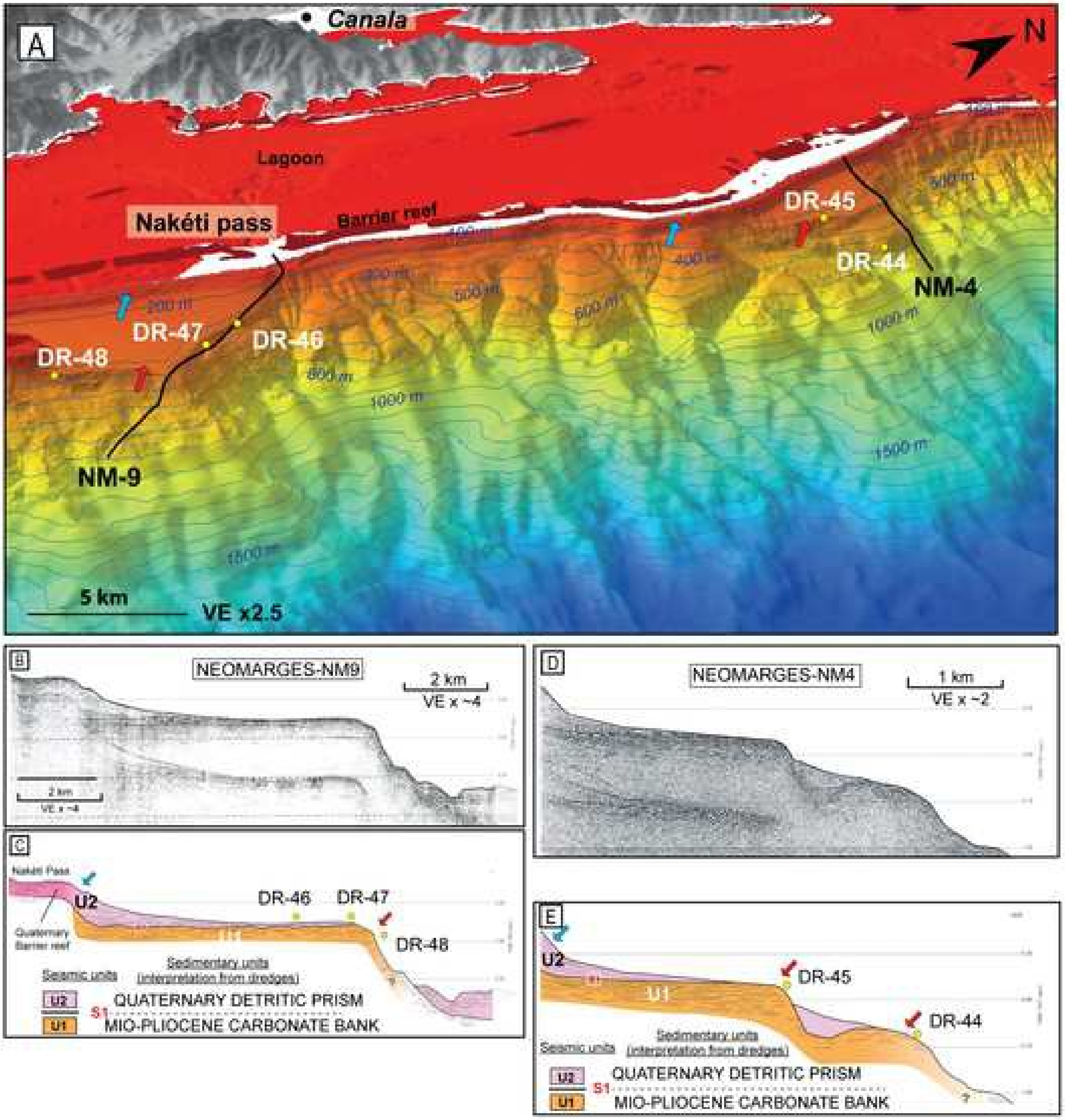

Figure 7

Click here to access/download;Figure;FIG-07.tif

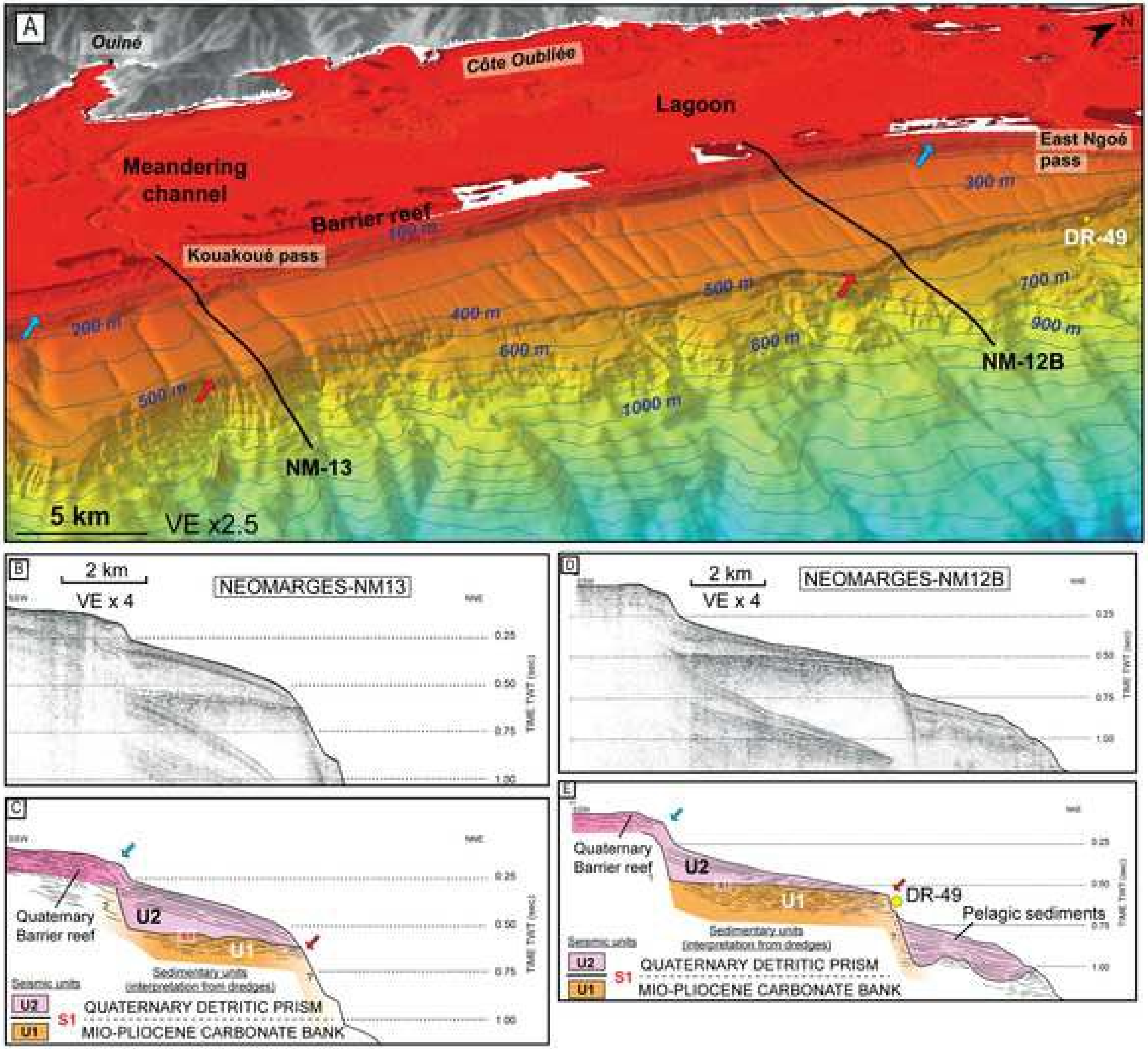

Figure 8

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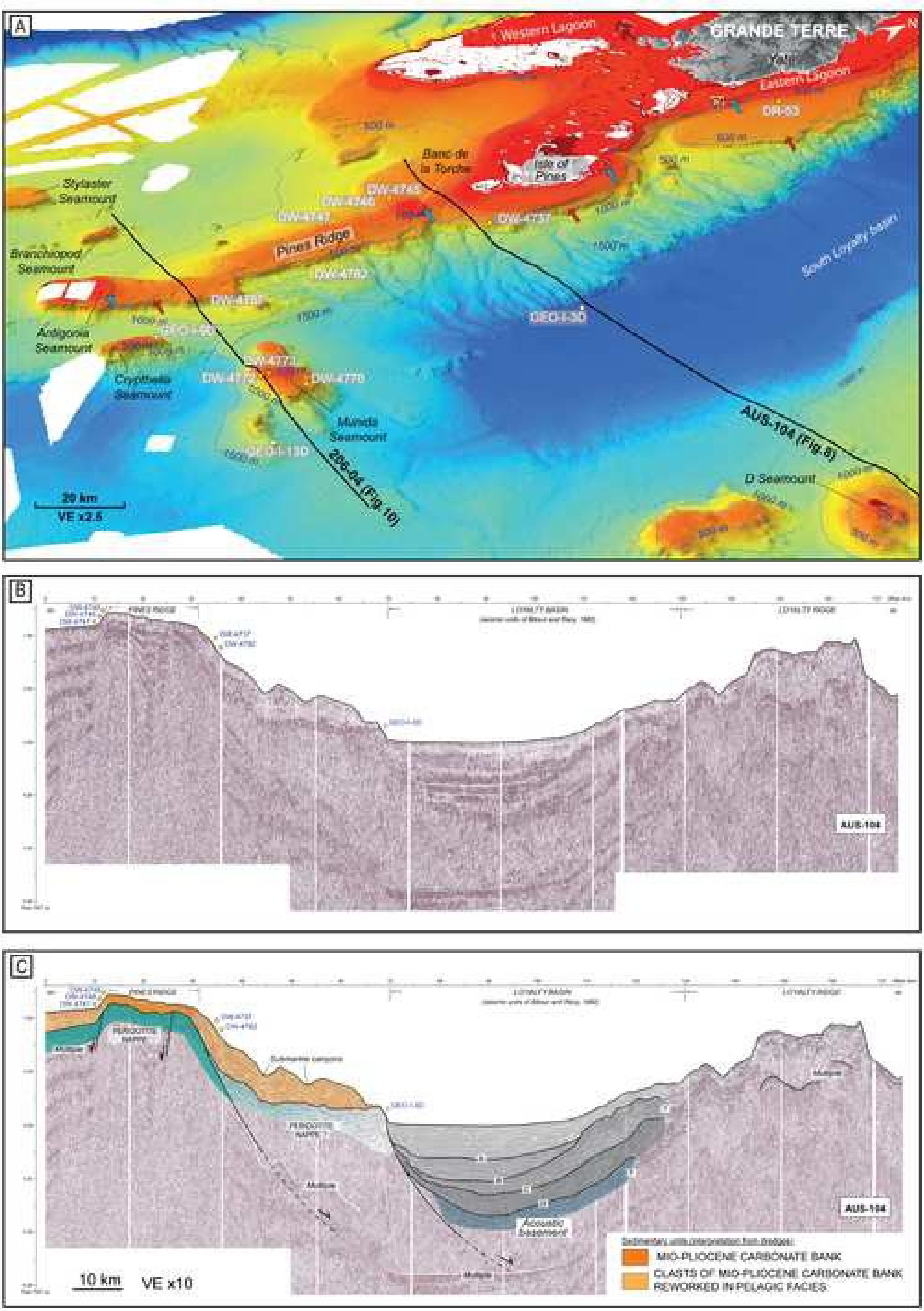

Figure 9

Click here to access/download;Figure;FIG-09.tif

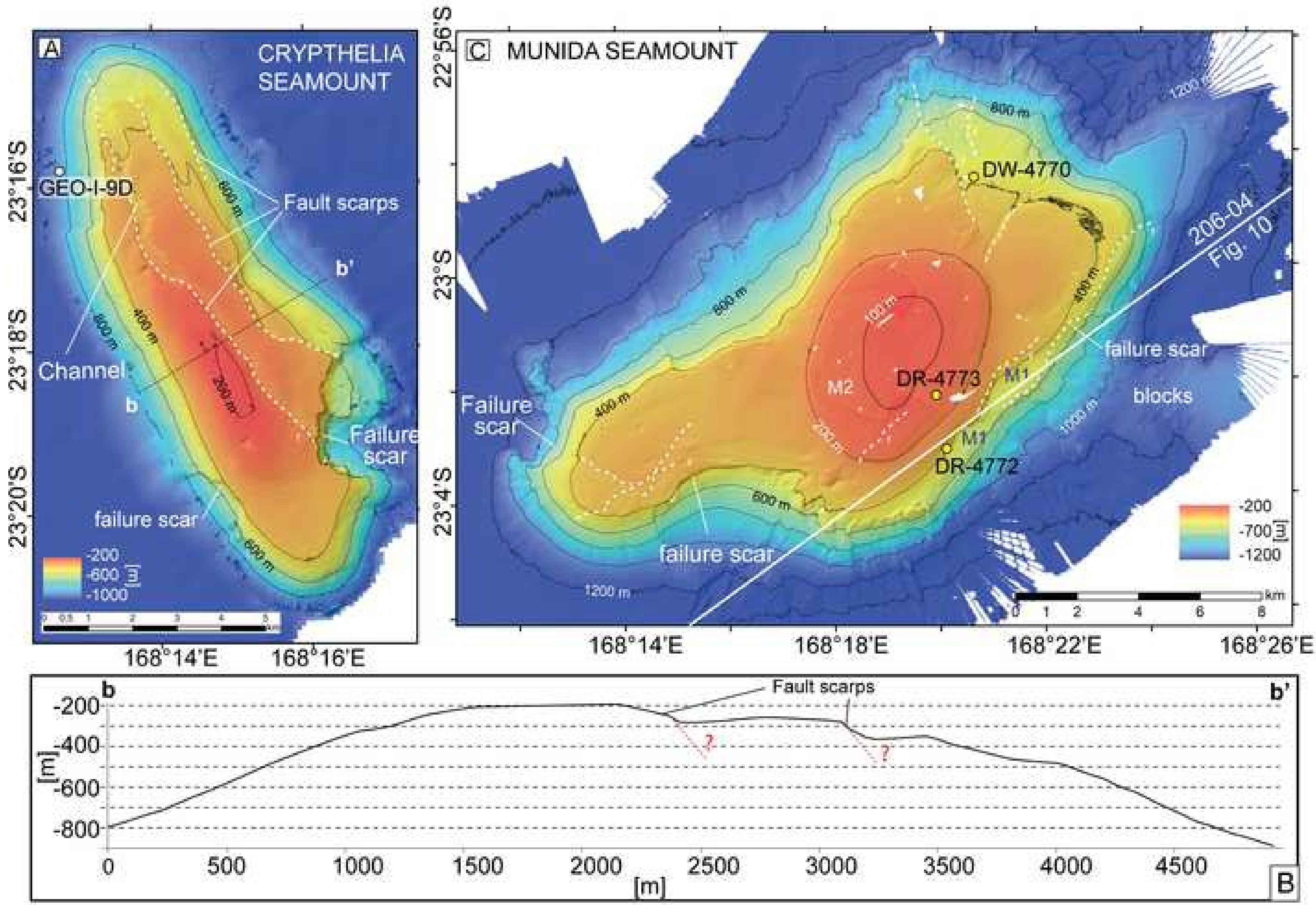

Figure 10 Click here to access/download;Figure;FIG-10.tif

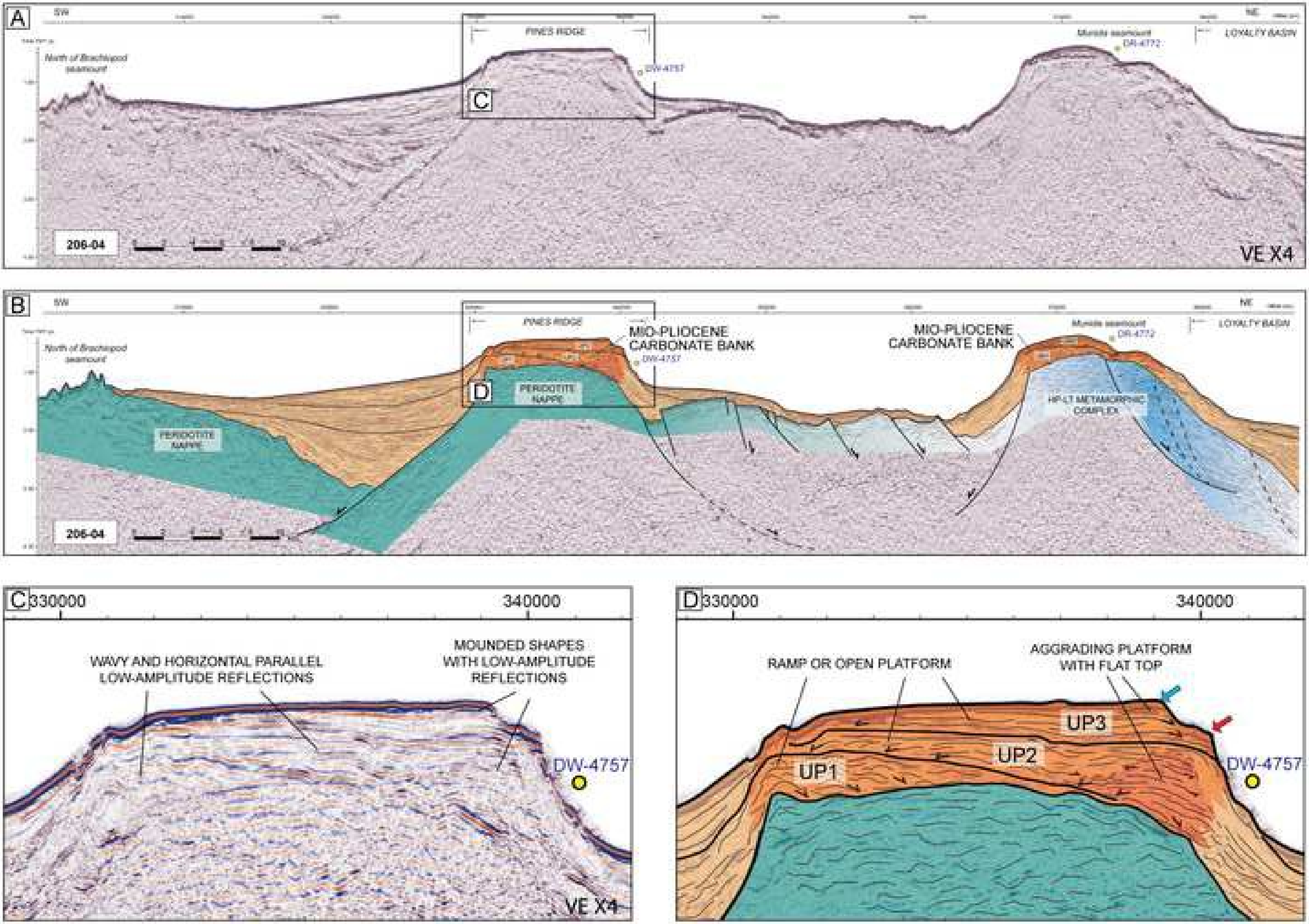

Figure 11

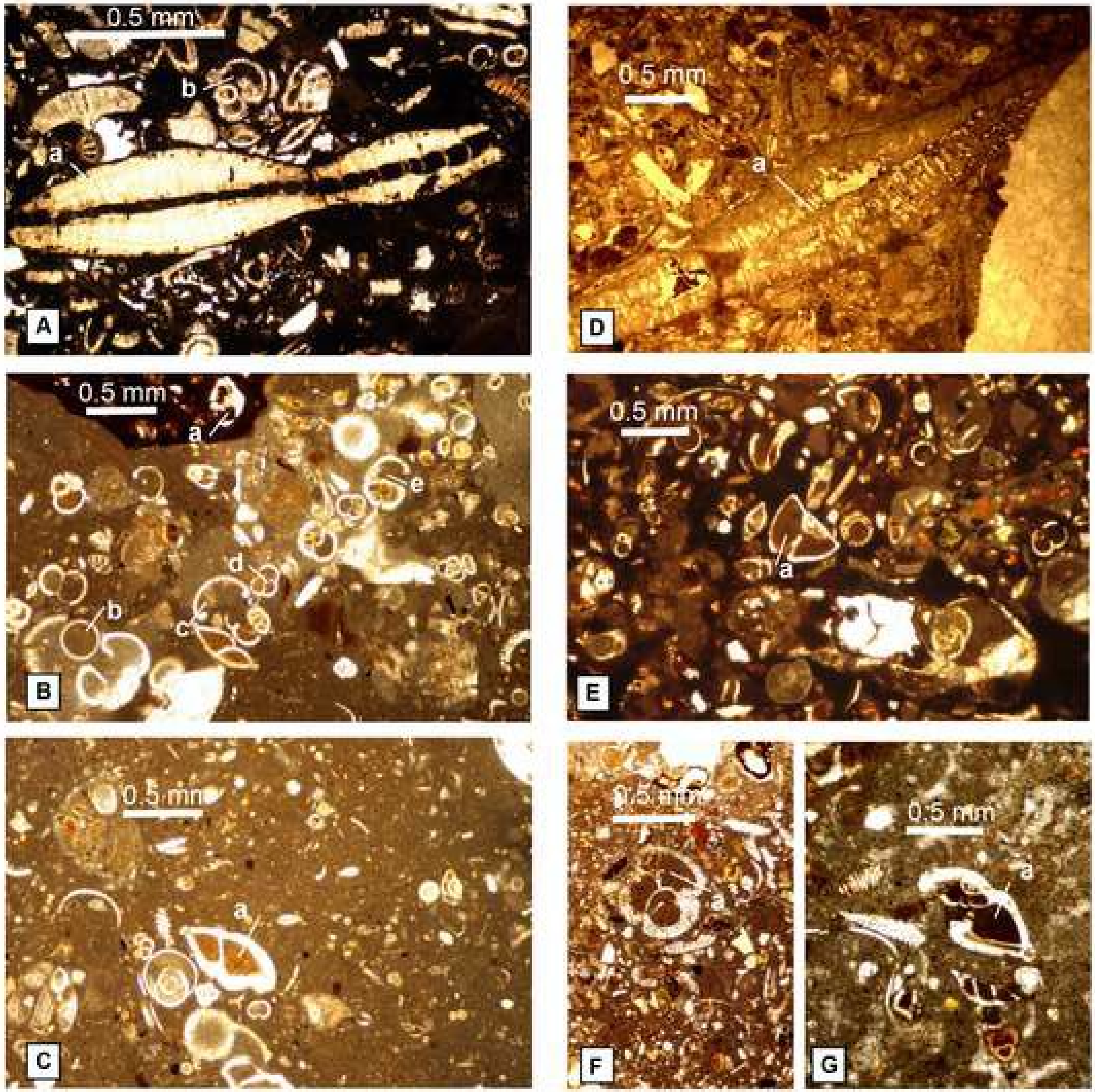

Figure 12

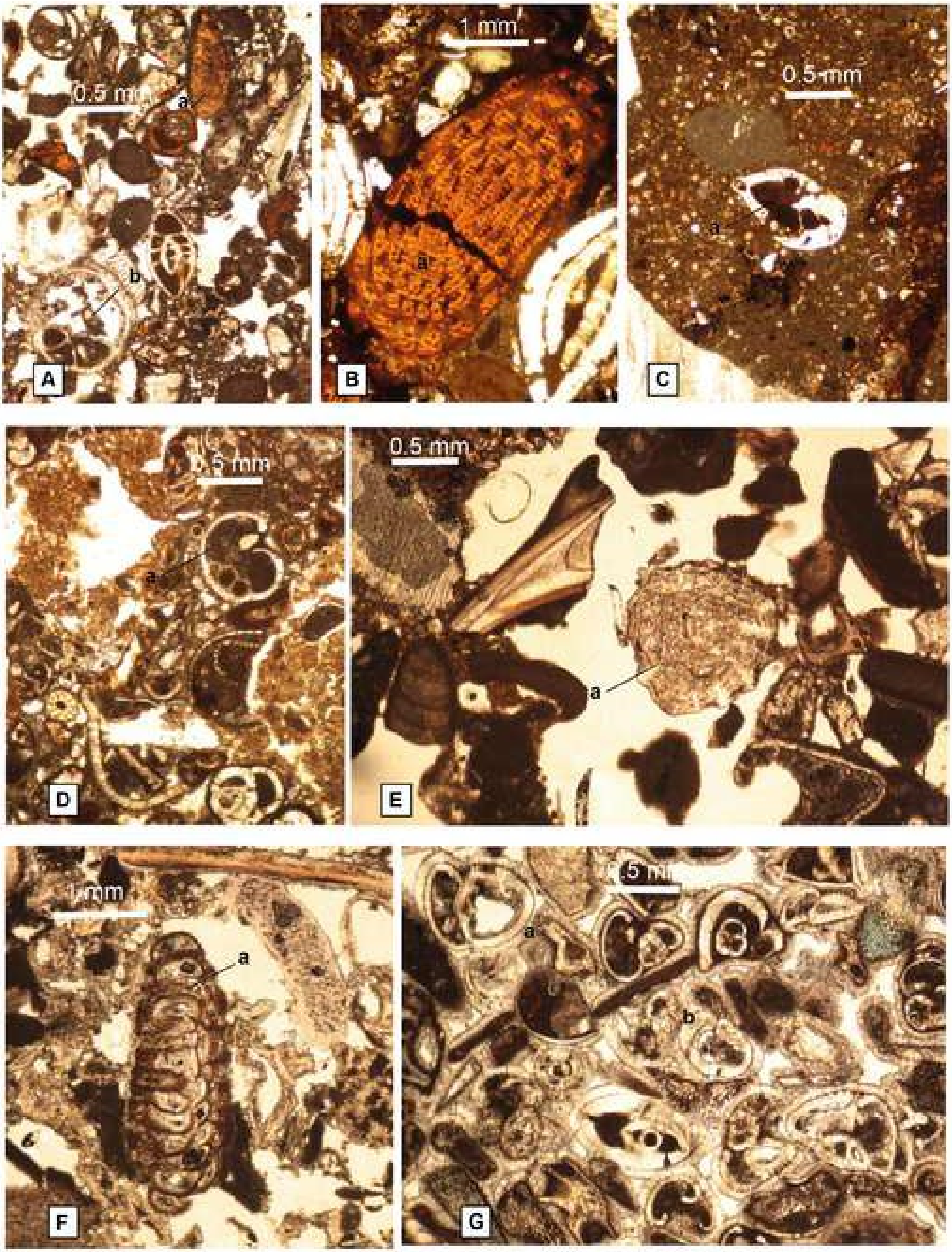

Figure 13

Click here to access/download;Figure;FIG-13.tif

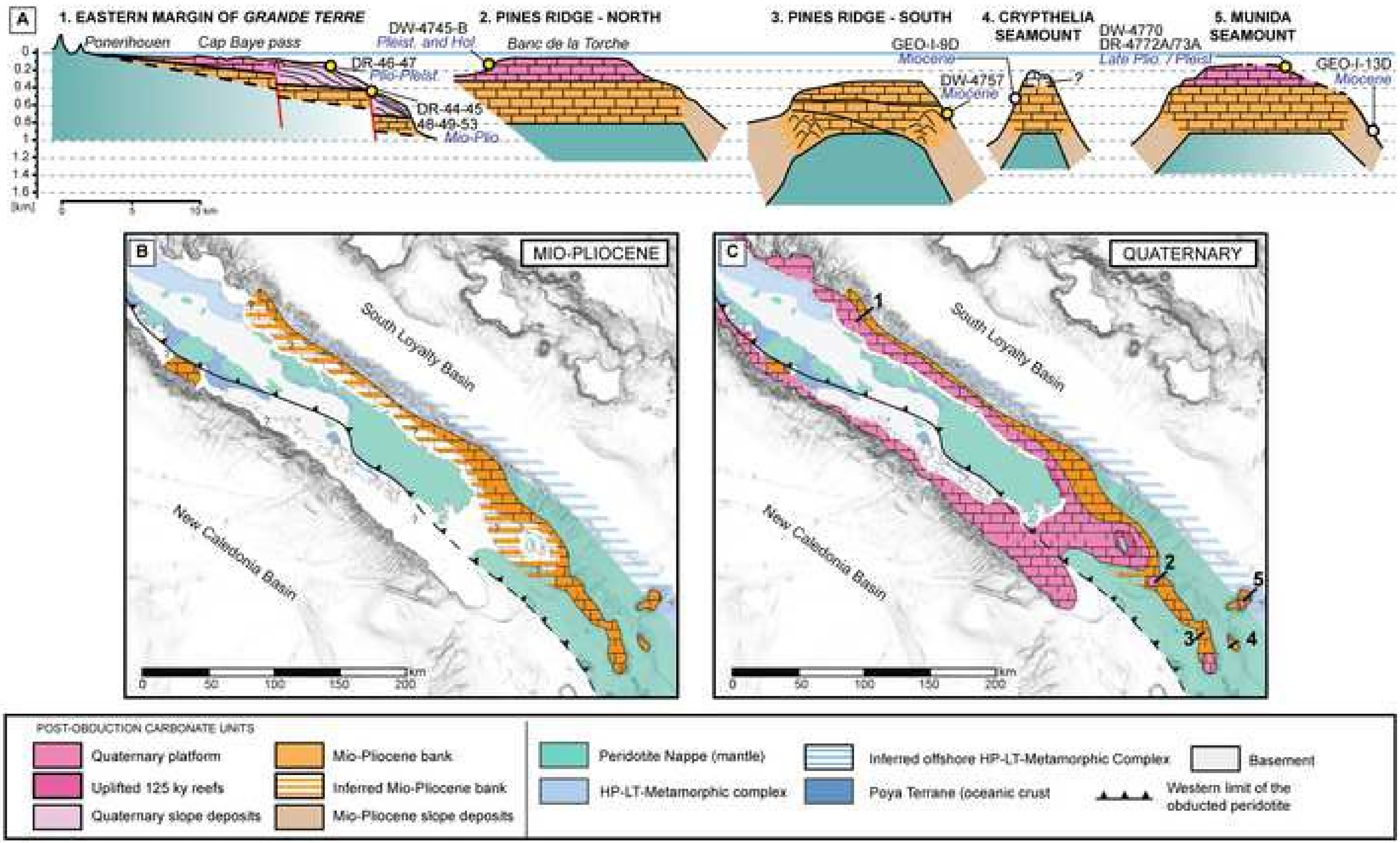

Table01 Click here to access/download;Table;Table1.xls

SEISMIC PROFILE	*Figure in this study*	CRUISE	STREAMER LENGHT (KM)	NUMBER OF CHANNELS	SOURCE TYPE	SOURCE VOLUME (CU)	SOURCE BAND WIDTH (Hz)	SHOT INTERVAL (m)
NM-1	Fig. 5	NEOMARGES, 2006	0.072	24	Airgun Bolt 600BT	20	50 to 500	5,5 to 8
NM-4	Fig. 6B							
NM-9	Fig. 6C							
NM-12B	Fig. 7B							
NM-13	Fig. 7C							
AUS-104	Fig. 8B	AUSTRADEC-1, 1972	_	12 or 24	Flexichoc source	–	–	–
206-04	Fig. 10	FAUST-1, 1998	3.3	264	Systems HG Sleeve guns	3000	50-60	50

SAMPLE NAME	CRUISE	SITE	WATER DEPTH (m)	LATITUDE	LONGITUDE
DR44	2005-NC-DR	Eastern margin of *Grande Terre*	550 to 680	-21.276	166.020
DR45	2005-NC-DR	Eastern margin of *Grande Terre*	300 to 410	-21.295	166.023
DR46	2005-NC-DR	Eastern margin of *Grande Terre*	295 to 380	-21.404	166.170
DR47	2005-NC-DR	Eastern margin of *Grande Terre*	295 to 380	-21.405	166.183
DR48	2005-NC-DR	Eastern margin of *Grande Terre*	290 to 400	-21.426	166.220
DR49	2005-NC-DR	Eastern margin of *Grande Terre*	400 to 500	-21.701	166.598
DR53	2005-NC-DR	Eastern margin of *Grande Terre*	280	-22.168	167.092
DW4737-B	KANACONO	Southern margin of Isle of Pines	387 to 456	-22.716	167.709
DW4746-B	KANACONO	Southern margin of Isle of Pines	494 to 508	-22.975	167.693
DW4745-B	KANACONO	Southern margin of Isle of Pines	310 to 403	-22.918	167.636
DW4747-B1	KANACONO	Southern margin of Isle of Pines	550 to 590	-23.015	167.722
DW4747-X	KANACONO	Southern margin of Isle of Pines	550 to 590	-23.015	167.722
DW4757-A	KANACONO	Southern margin of Isle of Pines	800 to 850	-23.142	168.096
DW4782-A	KANACONO	Southern margin of Isle of Pines	845 to 856	-23.000	167.903
DW4770	KANACONO	Munida seamount	455 to 470	-22.975	168.350
DR4772-A	KANACONO	Munida seamount	230 to 795	-23.051	168.336
DR4773-A	KANACONO	Munida seamount	230 to 400	-23.035	168.334

SAMPLES	SITE	DEPTH	CRUISE	MICROFACIES	DEPOSITIONAL ENVIRONNEMENT	ZONE and AGE	ZONE and AGE of reworked components (in red Table.4)
DR44	Eastern Margin, in front of Canala (Fig.6)	550 to 680 m	2005-NC-DR	Micritic pelagic packstone with reworked micritic patches of planktonic foraminifera, recrystallised algae and larger benthic foraminifera	Forereef environment LBF reworked into inner to outer neritic environment	N19-N20a (5.3 Ma to 3.6 Ma) Early Pliocene	N12 (13.82 Ma to 12.00 Ma) Serravallian
DR45	Eastern Margin, in front of Canala (Fig.6)	300 to 410 m	2005-NC-DR	Micritic pelagic packstone with reworked micritic patches of planktonic foraminifera, recrystallised algae and larger benthic foraminifera	Forereef environment LBF reworked into inner to outer neritic environment	N19-N20a (5.33 Ma to 3.6 Ma) Early Pliocene	N12-N13 (13.82 Ma to 11.63 Ma) Serravallian
DR46	Eastern Margin, in front of Nakéti Pass (Fig.6)	295 to 380 m	2005-NC-DR	Micritic packstone of planktonic foraminifera with reworked patches of reworked pelagic micrite	Inner to outer neritic	N22a (1.8 Ma to 1.00 Ma) Pleistocene	N4-N17a (23.03-7.2Ma) Miocene
DR47	Eastern Margin, in front of Nakéti Pass (Fig.6)	295 to 380 m	2005-NC-DR	Micritic wackestone of recrystallised algae with reworked patches of reworked pelagic micrite	Inner to outer neritic	N20a (3.8 Ma-3.6 Ma) Late Pliocene	N4-N17a (23.03-7.2Ma) Miocene
DR48	Eastern Margin, in front of Nakéti Pass (Fig.6)	290 to 400 m	2005-NC-DR	Micritic packstone of algae with reworked patches of reworked pelagic micrite	Forereef environment LBF reworked into inner to outer neritic environment	N22 (1.8 Ma to 0.12 Ma) Pleistocene	N12-N13 (13.82 Ma to 11.63 Ma) Serravallian
DR49	Eastern Margin, in front of Ngoé Pass (Fig.7)	400 to 500 m	2005-NC-DR	Micritic packstone of algae and larger benthic foraminifera reworked into pelagic micrite	Forereef environment LBF reworked into inner to outer neritic environment	N19 (5.3 Ma to 3.8 Ma) Early Pliocene	N12-N13 (13.82 Ma to 11.63 Ma) Serravallian
DR53	Eastern Margin, in front of Yaté (Fig.8)	280 m	2005-NC-DR	Micritic packstone of planktonic foraminifera	Inner to outer neritic	N18-N21a (5.8 Ma to 2.5 Ma) Late Miocene (Messinian) to Early Pliocene (Zanclean))	Serravallian to Pliocene, N12-N21
DW4737-B	SE Isle of Pines (Fig.8)	387 to 456 m	KANACONO	Micritic wackestone of foraminifera and fragments of algae	Inner to outer neritic	N20b-N21 (3.6 Ma to 2.5 Ma) Pliocene	
DW4745-B	West of Pines Ridge (Fig.8)	310 to 403 m	KANACONO	Micritic packsotne of foraminifera and algae	Inner to outer neritic	N22-Recent (1.8 Ma to Recent) Pleistocene - Holocene	
DW4746-B	West of Pines Ridge (Fig.8)	494 to 508 m	KANACONO	Grainstone cemented by sparite of planktonic foraminifera with reworked micritic patches	Inner to outer neritic	N22 (1.8 Ma to 0.12 Ma) Pleistocene	N19-N21 (5.33 Ma to 1.8 Ma) Pliocene
DW4747-B1	West of Pines Ridge (Fig.8)	550 to 590 m	KANACONO	Micritic packsotne of foraminifera and algae	Inner to outer neritic	N19-N22 (5.33 Ma to 0.12 Ma) Pliocene - Pleistocene	
DW4747-X	West of Pines Ridge (Fig.8)	550 to 590 m	KANACONO	Micritic wackestone of foraminifera	Inner to outer neritic	N21-N22 (2.5 Ma to 0.12 Ma) Late Pliocene - Pleistocene	
DW4757-A	East of Pines Ridges (Fig.8)	800 to 850 m	KANACONO	Micritic wackestone of foraminifera	Forereef environment	N4-N12 (23.03 Ma to 12 Ma) Early Miocene	
DW4782-A	East of Pines Ridges (Fig.8)	845 to 856 m	KANACONO	Micritic wackestone of foraminifera	Inner to outer neritic	N17-N20 (8.6 Ma to 3.4 Ma) Late Miocene - Early Pliocene	
DW4770	Munida seamount (Fig.8 and Fig.9)	455 to 470 m	KANACONO	Micritic/sparitic packstone of foraminifera and algae	Inner to outer neritic	N22 (1.8 Ma to 0.12 Ma) Pleistocene	
DR4772-A	Munida seamount (Fig.8 and Fig.9)	320 to 795 m	KANACONO	Grainstone cemented by sparite of planktonic foraminifera with reworked micritic patches	Inner to outer neritic	N21-N22 (3.4 Ma to 0.12 Ma) Late Pliocene - Pleistocene	N4-N17a Miocene
DR4773-A	Munida seamount (Fig.8 and Fig.9)	230 to 400 m	KANACONO	Grainstone cemented by sparite of planktonic foraminifera with reworked micritic patches	Inner to outer neritic	N21-N22 (3.4 Ma to 0.2 Ma) Late Pliocene - Pleistocene	N4-N17a (23.03-7.2Ma) Miocene

Table04

	Planktonic foram																					
	Beella sp.	Catapsydrax cf. dissimilis	Catapsydrax sp.	Dentoglogigerina altispira	Globoquadrina dediscens	Globoquadrina sp.	Globorotalia plesiotumida	Globorotalia tumida	Globorotalia menardii	Globorotalia inflata	Globorotalia scitula	Globorotalia miocenica	Globorotalia ungulata	Globorotalia sp.	Globigerina bulloides	Globigerina praebulloides	Globigerina spp	Globigerinoides quadrilobatus	Globigerinoides conglobatus	Globigerinoides ruber	Globigerinoides trilobus	Globigerinoides obliquus
DR44				X	X	X	X	X	X	X								X	X	X		
DR45					X			X									X	X				
DR46		X						X	X	X						X		X				
DR47					X			X		X	X					X	X	X		X	X	
DR48																		X			X	
DR49								X	X	X				X				X			X	
DR53								X	X	X					X			X				X
DW4737-B												X								X		
DW4745-B													X					X				
DW4746-B	X				X		X	X		X								X			X	
DW4747-B1														X				X			X	
DW4747-X																						
DW4757-A																						
DW4782-A			X															X				
DW4770						X												X				
DR4772-A										X						X					X	
DR4773-A										X						X	X					

iniferra

Globigerinoides spp.	Neogloboquadrina pachyderma	Neogloboquadrina humerosa	Neogloboquadrina dutertrei	Neogloboquadrina acostaensis	Neogloboguadrina spp.	Orbulina universa	Prosphaeroidinella parkerae	Pulleniatina obliquiloculata	Pulleniatina primalis	Pulleniatina praecursor	Pulleniatina sp.	Sphaeroidinella dehiscens	Sphaeroidinellopsis subdehiscens	Sphaeroidinellopsis paenedehiscens	Sphaeroidinellopsis seminulina	Truncorotalia crassaformis	Truncorotalia truncatulinoides	Truncorotalia crassula	Truncorotalia tosaensis		Acervulina sp.	Alanlordia sp.,	Alveolinella praequoyi	Alveolinella sp.
X						X						X		X		X					X			
					X										X								X	X
	X	X	X			X	X									X	X							
X	X				X	X		X			X													
X	X		X		X	X		X	X			X									X		X	
X													X										X	
	X			X		X	X		X	X						X					X	X		
X			X															X				X		
X								X			X						X							
X	X							X		X		X					X		X					
						X				X														
																			X					
X		X				X							X		X									
X			X					X									X		X					
																			X					
X		X						X				X	X						X					

												x					Amphistegina tuberculata	Benthic Foraminifera
				x							x						Amphistegina lessonii	
x					x			x	x	x			x	x	x	x	Amphistegina spp	
										x							Baculogypsina sp.	
			x							x		x	x	x		x	Bolivina sp.	
															x		Brizalina sp.	
					x	x						x		x			Carpenteria sp.	
																x	Cycloclypeus spp.	
						x						x					Dasyclad spp.	
x											x					x	Elphidium sp	
											x, x						Gypsina sp.	
x																	Homotrema sp	
																x	Katacycloclypeus martini	
							x		x								Quasirotalia guamensis	
				x							x				x	x	Lepidocyclina sp.	
		x				x						x	x	x			Lenticulina sp.	
x							x		x			x					Marginopora sp.	
x										x	x	x	x	x			Small miliolids	
												x	x				Nodosaria sp.	
x			x			x								x	x		Operculina spp.	
											x						Operculinoides spp.	
	x																Paragloborotalia kugleri	
											x	x		x			Planorbulinella larvata	
				x													Planorbulinella solida	
						x									x		Planorbulina sp.	

X						X				X						X	Sphaerogypsina sp.	
X												X	X				Textularia sp.	
													X			X	Radiolaria sp.,	***Other component***
X						X			X	X	X	X	X	X	X	X	Gastropod spp.	
	X	X		X		X	X	X	X	X	X	X	X		X	X	Rodophyte spp.	
												X					Halimeda sp.	
X	X	X		X	X	X	X	X	X	X	X	X	X	X	X		Echinoid spp.	
						X										X	Bryozoa spp.	
														X			Ostracod sp.	
				X	X	X			X			X	X			X	Coral spp.	

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Seismic data

Bathymetric Data

Click here to download Research Data https://georep.nc/plate-forme-de-telechargement

Neogene to Quaternary evolution of carbonate and mixed carbonate-siliciclastic systems along New Caledonia's eastern margin (SW Pacific)

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ABSTRACT

Neogene and Quaternary shallow-water carbonate records surrounding New Caledonia main island, Grande Terre, provide a good example for understanding the stratigraphic architecture of tropical mixed carbonate-siliciclastic systems. Due to a southeastern tilt of the eastern margin, the eastern shelf of Grande Terre has been better preserved from erosion than the western part, favouring the development and preservation of shallow-water carbonates. Based on the integration of bathymetric and seismic data, along with paleoenvironmental and biostratigraphic constraints derived from dredged carbonate rocks, a comprehensive geomorphological and architectural characterization of the offshore eastern margin of Grande Terre has been ~~performed. We show that during~~made. During the Mio-Pliocene, a wide, up to 750 m-thick carbonate build-up developed and extended over at least 350 km from north to south. This Mio-Pliocene build-up, currently lying at 300 to 600 m water depths, is overlain by a Pleistocene-Holocene barrier reef-lagoon complex and associated slope deposits. The switch from aggrading Neogene carbonate banks to backstepping Quaternary platforms likely reflects an increase in accommodation due to a high subsidence rate or to ~~flooding events~~relative sea-level rise, and/or results from a switch in carbonate producers associated with global environmental changes. The internal architecture of the Quaternary barrier reef-lagoon complex is highlighted, especially the development of lowstand siliciclastic prisms alternating with transgressive shallow-water carbonate sequences. This pattern agrees with the reciprocal sedimentation model typically invoked for mixed sedimentary systems. This stratigraphic pattern is well developed in front of the Cap Bayes inlet in the north of our study area, yet it is not observed southward along the eastern margin. This difference suggests that other factors than relative sea-level variations directed the architecture of the margin, such as low terrigenous inputs, lagoon paleo-drainage networks or sediment by-pass towards deep basins.

Keywords: mixed carbonate-siliciclastic system, reciprocal sedimentation, tropical carbonates, terrigenous inputs, New Caledonia, SW Pacific.

1. INTRODUCTION

Mixed carbonate-siliciclastic depositional systems are characterized by a high variability in facies and architectures resulting from ~~a combination of~~ several factors, such as relative sea-level change, tectonic motions, carbonate production, terrigenous inputs, sediment transfer and hydrodynamic conditions, complicating the sequence stratigraphy interpretation (Droxler and Jorry, 2013; Zeller et al., 2015). According to the classical "reciprocal sedimentation" model (Wilson, 1967), mixed systems in the tropical realm have been commonly subdivided into alternating temporal phases where siliciclastic deposits would prevail during low sea-level periods whereas carbonates would dominate during transgressions and highstands. This reciprocal concept is yet relevant for several ancient and some modern cases studies (~~*e.g.*~~ Kerans & Tinker, 1999; Toomey et al., 2016), but has been shown to be inadequate in describing several others examples. This model appears not applicable for some mixed cool-water carbonate platforms, where sandstones can be deposited when wave abrasion depth ~~rise~~rises above the seafloor during transgressions, whereas ~~shellbeds~~shell-beds formed during lowstands (Brachert et al., 2003). Another ~~counter~~ example is the Great Barrier Reef, where siliciclastic deposits are released to the slope and basin during late transgression, possibly due to the reworking of significant amounts of fine-grained terrigenous sediment stored on the shelf during lowstand (Wallace et al., 2002; Dunbar and Dickens, 2003; Mitchell et al., 2007; Harper et al., 2015). In addition, wave and/or current energy might prevent the infill of the lagoon during highstands, during which carbonate production is thought to be maximal, inducing, thus, an "empty bucket" pattern (Schlager, 1989; Purdy and Gischler, 2005; Zinke et al., 2001; Weij et al., 2019). This variability in the ~~stratigraphic~~sedimentological response of mixed systems to relative sea-level changes demonstrates that other ~~control~~controlling parameters should also be considered in order to improve the prediction of their complex depositional architectures.

Around the main island of New Caledonia, "Grande Terre", Neogene to Quaternary shallow-water carbonate systems ~~are~~occur coeval with high terrigenous fluxes derived from the erosion of rugged mountain ranges located all across the island and primarily composed of obduction-related thrust sheets. The oldest known Neogene shallow-water carbonates on Grande Terre are ~~the~~ lower Miocene mixed carbonate-~~siliclastic~~siliciclastic series cropping out in the ~~restricted~~ Népoui area, on the western part of the island, close to the present day coastline (Fig. 1). These outcrops were interpreted as reflecting sediment deposition ~~of~~on Aquitanian and Burdigalian ramps where seagrass-related and scleractinian carbonate production occurred simultaneously to strong fluvio-deltaic terrigenous inputs (Maurizot et al., 2016; Tournadour et al., 2020). However, the offshore extent of this Miocene mixed system remains unknown.

At the present day, Grande Terre is surrounded by one of the largest modern barrier reef in the world. This barrier reef has been drilled on the western margin and past studies (Coudray, 1975; Cabioch et al., 2008b ; Montaggioni et al., 2011) showed that it initiated ~~from~~at 400 cal kyr B.P. or Marine Isotope Stage 11 (MIS 11), over non-reefal shallow water carbonates that were deposited ~~from~~as of *ca.* 1.2 Ma ago on a carbonate ramp or ~~an~~ non-rimmed platform (Montaggioni et al., 2011). The inner lagoon, in turn, started its infill only since 200 cal kyr, B.P. or Marine Isotope Stage 7 (MIS7) (Le Roy et al., 2008). This points to the fact that the southwestern shelf of New Caledonia does not follow a classic reciprocal sedimentation pattern but constitutes a unique mixed carbonate-siliciclastic tropical system with a strong temporal and spatial partitioning between the outer coral plateau and the inner lagoon depression where terrigenous clastic sediments prevail (Le Roy et al., 2019).

In contrast, the Neogene to Quaternary shallow-water mixed systems of the eastern margin of Grande Terre are much less documented than ~~in the west~~their western counterparts, largely because of a lack of boreholes, rare outcrops onshore and few acoustic data offshore. However, this margin is thought to have a very different tectonic history than the western margin, ~~most likely~~probably a ~~greater~~higher subsidence that ~~most likely~~would have resulted in a better preservation of shallow-water systems on the shelf, thus allowing to improve our understanding of the onset of Neogene carbonate systems and the transition to ~~quaternary~~Quaternary barrier reef lagoon in the regional tectonic context. In addition, those sedimentary records allow to discuss the potential controlling factors ~~on~~determining the stratigraphic architectures along the margin, such as terrigenous inputs or paleo-drainage networks. With that aim, we have compiled both existing and newly acquired geophysical data and dredged carbonate rock samples from Ponérihouen to Antigonia seamount (Fig. 1) to perform a comprehensive analysis of slope morphologies ~~as well as a reconstruction of~~and to reconstruct the depositional environments and ages of the main terraces and seismic units observed along the eastern margin.

2. GENERAL SETTINGS

2.1. Geography

New Caledonia is a remote archipelago located in the South West Pacific (Fig.1). Its main island, Grande Terre, is a 50 to 80 km wide and approximatively 400 km long land stripe oriented in a N140° direction. Highest summits are *ca.* 1600 m high. Because of dominant southeastward trade winds (N110-120°) its eastern margin is positioned on the windward side, whereas the western margin is the leeward side. Its eastern part is typified by steep reliefs, deeply incised valleys and short coastal plains, whereas the western part has more extended valleys, wider alluvial lowlands and large coastal plains. This landform dissymmetry impacts the spatial distribution of rainfall, with the eastern windward coast receiving twice as much precipitation than the western leeward coast. Such differences induce a one-and-a-half-time higher river discharge along the eastern coast compared to the western coast (Terry & Wolting, 2011).

2.2. Tectonics

Grande Terre marks the northeastern tip of Zealandia (Mortimer et al., 2017), a mostly submerged fragment of continental crust isolated from Gondwana during the Late Cretaceous to Paleocene due to regional rifting followed by seafloor spreading in the Tasman Sea (Hayes & Ringis, 1973; Gaina et al., 1998). During the Eocene Grande Terre underwent a convergence phase that led to the NE-SW emplacement of several tectonic nappes and finally, in the late Eocene-early Oligocene, to the obduction of a prominent kilometres-thick ophiolite mostly constituted of serpentinized peridotites (Paris, 1981; Maurizot et al., 2020). Once obduction terminated, extensional tectonics prevailed all over Grande Terre (Lagabrielle et al., 2005; Chardon & Chevillotte, 2006; Lagabrielle & Chauvet, 2008). During this post-obduction extensional phase, that may still be active today, widespread normal faulting affected both island margins of the island. The assymetric morphology of Grande Terre is likely the result of these obduction and post-obduction tectonics. Drivers of the extension are either attributed to a plate tectonic divergent phase (i.e. far-field stresses related to initiation of east-verging subduction of the Australian plate beneath the Pacific Plate, Chardon & Chevilotte, 2006) and/or to post-orogenic collapse, dismantling and combined isostasic rebound (Lagabrielle et al. 2005, Lagabrielle & Chauvet, 2008; Moretti & Turcotte 1985; Collot et al., 2017). In this second hypothesis, unroofing the ridge of dense allochthonous mantle material and loading the adjacent basins resulted in subsidence of the basins and uplift of the ridge. The latter uplift is thus interpreted as being at the origin of the steepening of both the western and eastern margins of Grande Terre. The deep structure of the eastern margin has not been imaged by seismic data but is interpreted to be structured by a series of normal faults (see simplified geological cross-section of Fig. 1 and Collot et al. (1987)). Timing and amplitudes of these extensional events and vertical motions over the post-obduction period are not constrained as no continuous Oligocene to present day geological records exist. The Neogene to Quaternary carbonates that are the focus of this paper have developed on these structures. Offshore, towards the south, major listric normal faults bordering the obducted mantle sheets are imaged by seismic data along Pines Ridge (Chardon & Chevillotte, 2006; Flamand, 2006; Chardon et al., 2008; Patriat et al., 2018) (Fig.1). Apart from post-obduction extension, since the late Miocene, the southern part of Grande Terre and the Loyalty Islands are the foreland area of the Vanuatu Subduction Zone where the Australian Plate subducts beneath the Pacific Plate. A lithospheric flexure associated to this process is observed and results in the uplifts of the Loyalty Islands, the southern tip of Grande

Terre and the Isles of Pines. As a result, Quaternary 125 ka fringing reefs around Yaté and Isle of Pines are uplifted ~~between~~and now are positioned 10 to 20 m ~~high~~above present-day sea level (Cabioch et al., 1996).

2.3. Miocene mixed carbonate siliciclastic systems

~~Onland~~On land, the post-obduction geology is characterized by an Oligocene sedimentary hiatus and the oldest known marine sediments that overlie allochthonous units are Miocene mixed carbonate-siliciclastic sedimentary rocks only cropping out in a restricted nearshore area located west of Grande Terre, in the region of Népoui (Coudray, 1975; Maurizot et al., 2016; Tournadour et al., 2020). These successions have been interpreted to reflect deposition of an Aquitanian carbonate ramp dominated by seagrass-related carbonate production, overlain by Burdigalian fan delta deposits that laterally evolve towards a carbonate ramp dominated by seagrass meadows and small-sized coral bioconstructions (Tournadour et al., 2020).

Offshore, despite a lack of drill core data, a few dredged carbonate samples were recovered from the outer slope of the eastern margin of Grande Terre (Chardon et al., 2008; Yamano et al., 2015) and close to *Munida* and *Crypthelia* seamounts (Daniel et al., 1976; Bitoun and Recy, 1982) (Fig. 2). These samples, collected between 400 m and 800 m water depths, are the only evidences of Miocene shallow-water carbonate deposits along the eastern margin of Grande Terre and Pines Ridge. Based on the interpretation of seismic profiles along Grande Terre's southeastern margin, Chardon et al. (2008) identified several normal faults that they interpret as being related to Late Miocene extensional tectonics. These authors also interpreted two planar surfaces as post-obduction erosional lateritic land surfaces resulting from weathering processes overlain by shallow-water carbonate deposits.

2.4. Quaternary carbonate systems

Our knowledge on the nature, structure and chronology of the New Caledonian ~~quaternary~~Quaternary carbonate systems primarily comes from coring investigations carried out through the western parts of the New Caledonian barrier system (Coudray, 1976, Cabioch et al., 2008b; Montaggioni et al., 2011). Four cores, ~~ranging from~~ 120 to ~~226m~~226 m-long, reached the upper Cretaceous and Eocene bedrock and allowed to characterize the Quaternary development history of the western carbonate shelf margin. The recovered carbonate sequences result from stacking of about ten sedimentary carbonate units that ~~have~~were deposited during successive transgressive and high sea-level stands corresponding to interglacial periods (Cabioch et al., 2008b). These units are separated from each other by unconformities formed during sea~~ ~~-level drops in glacial periods. The succession of depositional events was reconstructed using lithostratigraphy, magnetostratigraphy, uranium-series dating and nannofossil stratigraphy (Cabioch et al., 2008b; Montaggioni et al., 2011). Carbonate ~~initiation~~sediment production was initiated prior to 1.2 Ma ~~from~~within an open shallow-water shelf margin, ~~believed to have~~which acted as a carbonate ramp system until 0.48 Ma. Corresponding deposits forming the lower units recovered in ~~borehole~~boreholes (red dots on Fig. 1) include grainstone, packstone and wackstone rich in corals, coralline algae, encrusting foraminifera with locally thick rodoliths accumulations (Montaggioni et al., 2011). The ramp system is assumed to have evolved into a rimmed, reef platform ~~from~~as of 0.40 Ma. The initiation of ~~typical~~ coral reef tracts and the associated reef-rimmed platform are thus considered to have begun after MIS 11 (Montaggioni et al., 2011), i.e. the Mid-Brunhes Event. Corresponding sedimentary units are made up of stacked *poritid*-rich framework beds correlated to reef-flat environments with moderate to lower-water energy, and coralgal frameworks partly including arborescent acroporids suggesting deposition ~~at~~in a protected reef-flat setting (Montagggioni et al., 2011). Complementary studies of the Quaternary evolution of the ~~SW NC~~south-west lagoon ~~were performed by~~obtained seismic, bathymetric and coring data (Le Roy et al., 2008; Le Roy et al., 2019). Results ~~have shown~~showed that infill is composed of two or three 100 ka sedimentary sequences with a first significant flooding of the lagoon assumed to have started during MIS7, at 220 cal kyr B.P. The disparate ages of the lagoon and reefs can be reconciled with the fact that the first reefs were probably initially fringing

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structures without a significant lagoon that has expanded later in response to subsidence of the margin and reef growth (Le Roy et al., 2018). Offshore, the outer barrier reef slopes of Grande Terre are marked by five marine terraces located between ca. 20 and ca. 120 m water depths that Flamand (2006) tentatively correlated to the five reefal lithological sequences cored on the western barrier reef and interpreted as the morphological expressions of Quaternary interglacials. However, a younger, last deglacial origin for these terraces located above 120 m water depth cannot be ruled out. Note that these ~~quaternary~~Quaternary marine terraces are located in the area indicated by the blue arrow on bathymetrical and seismic data. (Figs. 5 to 8).

2.5. Quaternary subsidence rates

Based on cores of the ~~quaternary~~Quaternary barrier reef of the western margin of Grande Terre, subsidence rates are estimated to range between 0.03 to 0.20 mm.yr^{-1} since the last 400 ka (Coudray, 1975; Cabioch et al., 1996; Flamand, 2006; Frank et al., 2006) and ~~to have~~display mean rates of ≤0.08 mm.yr^{-1} over the past 1 Ma (Montaggioni et al., 2011). Such values ~~are believed to~~possibly reflect a long-term subsidence of the western margin of Grande Terre suggesting that post-obduction extensional tectonics are still active and allowing sufficient accommodation space to record most Quaternary sea-level highstands. Unfortunately, the lack of core data on the eastern margin does not allow reconstructing any Neogene to Quaternary vertical motions.

3. DATA AND METHODS

Our morphological and stratigraphic analyses are based on the integration of existing and newly acquired bathymetrical and 2D seismic reflection data supplemented by dredged rock samples (Fig. 2). Existing bathymetrical data are derived from four datasets. The former covers the lagoon of Grande Terre and was essentially acquired during hydrographic surveys of the French Navy (SHOM), compiled by the New Caledonia Government within a 25 m resolution grid. The second dataset corresponds to data acquired between 2002 and 2006 onboard RV *Alis*

(EM1002 multibeam echosounder) along all the outer slopes of Grande Terre and Loyalty islands, as well as on seamounts of the Pines Ridges (down to *ca.* 1000 m of water depth), in the framework of the ZoNéCo program (*ege.g*. Pelletier et al., 2002, 2004, 2012; Perrier et al., 2004a, 2004b, 2004c, 2005) and IRD research projects (*ege.g*. Cabioch et al., 2002a, 2002b). The third dataset corresponds toconsists of data acquired in the 90's and 2000's in deeper waters (>1000 m of water depth), such as in the South Loyalty Basin, onboard RV *L'Atalante* (EM12D multibeam echosounder), again through ZoNéCo (*eg.* ZoNéCo-1, Pautot et al., 1993; ZoNéCo-2, Lafoy et al., 1994; and ZoNéCo-3; Missègue et al., 1996). These two multibeam datasets were compiled in 2009 in 25 m (EM1002) and 100 m (EM12D) resolution grids by New Caledonia Government (Juffroy, 2009) and included in the 2012 atlas of New Caledonia (Pelletier et al., 2012). The fourth dataset is the global seafloor topography derived from satellite altimetry and ship depth soundings (Smith and Sandwell, 1997). Newly acquired bathymetrical data corresponds to those gathered by the KANACONO cruise onboard R/V *Alis* (Puillandre & Samadi, 2016).

The seismic dataset mainly consists of published multichannel seismic reflection profiles located on the upper slope of the eastern margin of Grande Terre, acquired onboard R/V *Alis* during the NEOMARGES cruise (Chardon et al., 2007), using a 24 channel streamer and a 20 cubic-inch air gun source. The high-resolution images have a maximum penetration of 0.25 s two way time (twt) (Table 1) and were reinterpreted in this study through detailed line drawings. Seismic profiles 206-04 (Lafoy et al. 1998) and AUS-104 (Bitoun & Recy et al. 1982), which are publicly available in the *Tasman Frontier seismic database* (Sutherland et al., 2012), were also interpreted. These profiles were acquired using lower frequency seismic devices (see Table 1) and hence have a lower resolution but a higher penetration, reaching 3 s twt in the offshore basins. Seismic stratigraphic analysis was performed on these profiles including identification of seismic facies, unconformities and sequences following Mitchum et al. (1977). To estimate the thickness of the carbonate units on the Pines Ridge, we assumed that they are composed of shallow--water carbonates with a low-porosity, affected by early compaction and dissolution, for which we attributed a mean velocity of 3000 $m.s^{-1}$ (Anselmetti & Eberli, 2001).

Sedimentary facies determinations were made on 17 carbonate rock samples dredged during the DR-2005-NC and KANACONO cruises onboard R/V *Alis* (Pelletier et al., 2006; Puillandre & Samadi, 2016; respectively) in water depths between 250 and 900 m (Table 2). Samples were described from large thin sections in order to identify textures and main components and ultimately reconstruct depositional environments. Biostratigraphic datings and paleoenvironmental reconstructions were based on the interpretation of foraminiferal assemblages (larger benthic and planktonic foraminifera). In our definitions of stratigraphic ranges, the planktonic foraminiferal zonal scheme of BouDagher-Fadel (2015, 2018a) is used. This scheme is tied to the time scale of Gradstein et al. (2012) and the revision by Cohen et al. (2017).

4. PHYSIOGRAPHY, STRUCTURE AND STRATIGRAPHY OF THE EASTERN MARGIN

4.1. Lagoon

The eastern lagoon, extending from the shoreline to the external barrier reef, is 10-15 km wide between Poindimié and Yaté with an average water depth of 40 m, whereas the western lagoon does not exceed a width of 5-10 km ~~wide~~ with an average water depth of 20 m, except in its southern part where it is deeper and wider (Le Roy et al., 2008, 2019). Another difference with the western lagoon, which is bounded by continuous barrier reefs, is that the eastern lagoon is typified by a discontinuous external barrier reef with drowned segments in its southern part, off Yaté (Cabioch et al., 1996; Andrefouet et al., 2009) (Fig. 2). The eastern lagoon can be divided into three morphological domains: (1) the shallow-water coastal zone, (2) the median lagoon and (3) the external barrier reef (Fig. 3B).

The shallow-water coastal zone is particularly well-developed between Ponérihouen to Thio, where coastal bays are shallow and have gentle slopes, due to terrigenous deltas located at river and estuarine mouths (Fig.3). The ~~latter are~~deltaic deposits extend for 2.5 to 7 km ~~long~~ and can reach the central part of the lagoon. Between Côte Oubliée and Yaté, deltas are very restricted and do not exceed 2 km in length (Fig.3A). Previous studies on unconsolidated seafloor sediments revealed that these deltas are mainly composed of terrigenous sediments (Chevillon, 1997).

The deeper median lagoon, is relatively flat in its central part and contains isolated patch reefs as well as sandy islets aligned parallel to the coastline (Fig.3A). Southeast of the East Ngoé Pass, the median lagoon deepens (with an average water depth of 60-70 m) and contains a meandering channel that runs parallel to the coastline (Fig. 3A). This channel extends over 30 km, incises the lagoon up to 40 m deep and is connected to the Kouakoué Pass, where it runs perpendicular to the coastline thanks to a *ca.* 90° bend (Fig.3A).

The barrier reef domain comprises the reef crest, close to sea- level, as well as a back-reef and reef flats within a 5 km-wide shallow-water area (20 to 40 m water depths). The latter is dominated by carbonate sediments of heterogeneous grain size, ranging from fine-grained sands to gravels (Chevillon, 1997). The barrier reef domain is interrupted by numerous passes (ie. inlets) connected to lagoonal channels that cross-cut the back-reef domain and ~~that~~ are oriented roughly perpendicular to the coastline and the reef crest (Fig.3).

4.2. Outer slope

4.2.1 Overall slope profile

The outer slope morphologies of Grande Terre were previously described by Bitoun and Récy (1982), Rigolot (1989), Flamand (2006) and Pelletier et al. (2012). The outer slope of the western margin is very steep with values up to 20° between 0 to 2000 m water depths. This margin is very abrupt as the upper part of the slope is also very steep (see W-01 and W-02 profiles Fig.4). In comparison, the outer slope of the eastern margin, from Poindimié to Yaté, is smoother and extends over 15 to 20 km from the platform edge to the toe of slope at a water depth of approximately 2200 m (Fig. 4). It is composed of 3 domains: (1) the upper slope, characterized by a slope gradient lower than 3°, between 100 to approximately 500 m water depths and extending up to 20 km in areas preserved from the erosion (*e.g.* offshore Côte Oubliée and Yaté, see E-01 profile Fig.4). On the contrary, some areas are devoid of an upper slope domain and canyon heads are ~~there~~ in ~~close~~direct contact with the external barrier reef (e.g. offshore Houaïlou, see E-02 profile Fig.4); (2) the middle slope shows a slope gradient of up to 10° between 400-500 m to approximately 2200 m water ~~depths~~depth; (3) the lower slope and toe-of-slope domain shows a gentle slope gradient ranging from 0.5 ~~to1~~to 1°. This slope section starts approximately at 2200 m water depth, which corresponds ~~to~~with the transition to the Loyalty Basin floor. The slope section contains numerous erosional by-pass features such as submarine canyons that incise the slope up to a depth of 200 m. Backscatter imagery reveals depositional lobes at canyon mouths, offshore Thio and Yaté, as previously reported by Cotillon et al. (1989, 1990). The cut off angles are intended to characterize the morphology of the slope and have no universal value. Even in the case of a Gaussian slope angle evolution (*sensu* Adams and Kenter, 2013) angle values may vary between different carbonate systems.

4.2.2 Physiography of the upper slope

The upper slope is delimited by a major scarp located at 300-400 m water depth close to the Cap Bayes Pass (Fig. 5A) and the Nakéti Pass (Fig. 6A), at 400-500 m water ~~depths~~depth in front of Côte Oubliée (Fig. 7A) and at 500-600 m water depths close to the Yaté Pass. The low-angle upper slope is only 3 to 4 km wide close to Nakéti Pass and widens southward to reach a width of 20 km in the vicinity of Yaté (Fig. 3A). Arcuate scars occur along the scarp, suggesting slope failure processes along the upper slope (Fig.5A and 6A). In front of Côte Oubliée, the 5-6 km wide upper slope is incised by low sinuosity, U-shaped, 40 to 80 m deep gullies (Fig.7A). Gullies are of variable extension along the upper slope, some start at 150 m water depth close to the outer reef slope, whereas others, shorter, gullies start at 300 m water depth, 3-4 km away from the shelf edge. The majority of gullies are located in front of Kouakoué Pass through which they are connected to the meandering lagoonal channel (Fig.3A).

4.2.3 Stratigraphy of the upper slope

Seismic profiles covering the platform edge to the upper slope region reveal two main seismic units, U1 and U2 separated by unconformity S1 (Fig. 5, 6 and 7). These profiles also show that U1 is exposed on the seafloor along a major scarp (see red arrows on maps and profiles of Fig. 5, 6 and 7). U1 comprises wavy reflections and is delimited at its top by erosional truncations and toplap terminations ~~on~~at bounding surface S1. The latter is overlain by unit 2 (U2) which shows well-layered reflections downlapping onto S1 (Figs. 5, 6 and 7). The maximal thickness of U2 varies between 0.1 to 0.25 s twt. In front of Côte Oubliée, on profile NM-13, at the mouth of the Kouakoué Pass, U2 is twice ~~thicker~~as thick than on profile NM-12b located 20 km further north at distance from any pass (Fig. 7).

Seismic profile NM1 at the mouth of the Cap Bayes Pass displays a well-developed unit U2 which forms a 0.2-0.25 s twt thick sedimentary prism (Fig. 5) composed of five stratigraphic sequences each composed of retrogradational sets (in pink on Fig. 5) overlain by progradational clinoform foresets (in beige on Fig. 5), noted 1 to 5. The slope break of the youngest (5th) clinoform foreset (annotated “Clinoform slope break” on Fig. 5) is located at 150 m water depth. Retrogradational sets contain low-amplitude, mound-shaped seismic reflections that are only observed in topsets. Progradational sets show high-amplitude sigmoidal oblique reflections that downlap onto the underlying unit and are mainly located in the distal part of the sedimentary prism.

4.3. Pines Ridge

The Pines Ridge corresponds to the structural extension of the eastern margin of Grande Terre towards the South (Fig. 2). It is a NNW-SSE trending structure extending from the Isle of Pines to the Cook Fracture Zone.

4.3.1 Basement structure and first-order seismic stratigraphy of the Pines Ridge

The Pines Ridge is a horst of peridotite bounded by normal faults (Bitoun & Recy, 1982; Patriat et al., 2018) and is the southern offshore extension of the Peridotite Nappe cropping out onland (Patriat et al., 2018). In this paper, we have studied the area comprised between the Isle of Pines and Antigonia seamount, where Pines Ridge is the shallowest (Fig. 8A). Seismic profile AUS-104 (Fig. 8B) reveals that the Pines Ridge comprises at its top high-amplitude subparallel reflections between 0.7 and 0.9 s twt, which contrast with the transparent seismic character of the underlying acoustic basement. Along the eastern flank of the Pines Ridge, the acoustic basement crops out on the seafloor at 2000 m water depth and was sampled by dredge GEO-I-3D (Daniel et al., 1976; Bitoun & Recy, 1982) (Fig. 8). The samples comprised altered basalt pebbles within a carbonate mud matrix containing planktonic foraminifera from the late Oligocene – earliest Miocene (Daniel et al., 1976). At that location, the acoustic basement forms a slightly tilted plateau located between 2.5 and 2.7 s twt, interpreted as an erosional weathering surface on top of peridotites by Bitoun and Recy (1982). This peridotite platform constitutes the western edge of the South Loyalty Basin (Figs. 8B and 8C). The peridotite basement is covered by a seismic unit composed of discontinuous low-amplitude subparallel reflections that is about 0.2 s twt thick at the crest of the ridge and up to 0.6 s twt-thick on its eastern flank. This unit is interpreted as a post-obduction sedimentary sequence (Bitoun & Recy, 1982 ; Patriat et al., 2018). The unit is incised by several submarine canyons along the eastern slope that extend from the Pines Ridge to the South Loyalty Basin (Fig. 8).

4.3.2 Physiography of the Pines Ridge

Along the northern part of the Pines Ridge, on the upper slope, the terrace identified on the eastern outer slopes of Grande Terre is continuously present between 300 to 600 m water depths (red arrows on Fig. 8A). East of the Isle of Pines, this terrace is affected by arcuate scarps most likely corresponding to submarine gravity collapses. Towards the Antigonia seamount, the top of the Pines Ridge is capped by this terrace (Fig. 2). Indeed, between the Banc de la Torche and Antigonia seamounts, the ridge's top remains positioned at 400-500 m water depth and its eastern slope is again characterized by a steep gradient and collapse features (red arrows on Fig. 8A). In turn, the Banc de la Torche and Antigonia display flat tops in 30 m to 60 m water depths (blue arrows on Fig. 8A). These two submerged isolated banks are surrounded by two terraces at 80-90 m and 120 m water depth.

The isolated Crypthelia and Munida seamounts are delimited by a main scarp at 400-500 m water depths (Figs.2 and 8). Their tops are located at 194 m and 93 m water depths, respectively. The Crypthelia seamount is 3 km wide and 12 km long elongated in a N160° direction (Fig. 9A and 9B). Three fault scarps located approximatively in 250, 350 and 500 m water ~~depths~~depth affect the seamount across its entire length~~ with~~. Fault scarp heights are comprised between 30 m and 100 m (see map and cross section of Fig. 9B). In the northern part, the eastern fault scarp is associated with a channel probably formed by ~~the action of~~ bottom currents circulating along the footwall of the fault (Fig. 9A and 9B). The southern edge of the seamount is marked by two 2-3 km wide failure scars, evidenced by arcuate headscarps located between 350 to 600 m water ~~depths~~depth. The Munida seamount, located further to the northeast, extends over 8 km wide and 18 km long with a N60° direction (Fig. 9C). Its edges are bordered by N60° and N160° oriented fractures. On its southern flank, a terrace (M1) bordered by fault scarps is identified between 400 m and 600 m water depth. Above 200 m water depth, the top of the seamount (M2) is relatively flat (Fig. 9C) but still shows terraces at 100 m and 120-130 m water depth.

4.3.3 Stratigraphy of the Pines Ridge

The internal architecture of the post-obduction sedimentary sequence overlying basement of Pines Ridge and Munida seamount are imaged by seismic profile 206-04 (Fig.10). Over the Pines Ridge, the capping sedimentary unit reaches up to 0.5 s twt thick, i.e. approximately 750 m thick considering a velocity of 3000 $m.s^{-1}$ for a 30% porosity limestones according to Geldart (2004). In details, this interval is composed of 3 units, UP1 to UP3 (Fig.10C and 10D). Unit UP1 mainly developed on the SW edge of the ridge and is composed of low-amplitude reflections northeastwardly downlapping on basement. Unit UP2 downlaps basement on the eastern edge of the ridge with very low-amplitude reflections that form mounded morphologies. To the west, the seismic character of UP2 laterally evolves into low-amplitude, wavy to horizontal parallel reflections onlapping onto UP1 towards the southwest. Unit UP3 is typified by low-amplitude, sub-parallel and nearly horizontal reflections with low relief, mounded morphologies on the eastern edge of the ridge. Because seismic line 206-04 runs along the south-eastern slope of Munida Seamount (Fig. 9C), seismic imaging is poor due to 3D lateral effects. However, the profile intersects a part of the seamount with less slope that reveals that the sedimentary sequence has a minimum thickness of 0.4 s twt, i.e. approximately 600 m-thick (Fig.10A and 10B). It is composed of two distinct seismic units, UM1 and UM2 (Fig.10). Unit UM1 overlies the basement and comprises low-amplitude subparallel mounded reflections with downlapping and onlapping terminations. Unit UM2 overlies UM1 and comprises high-amplitude subparallel reflections with downlapping terminations.

4.4. Lithologies and biostratigraphic ages

4.4.1 Eastern margin of Grande Terre

Seven carbonate rock samples have been collected along the upper slope of the eastern margin (Table 3, see location on Fig. 2). DR44 and DR45 were recovered on scarps located at 400 m and 600 m water depths, at the seafloor exposure of seismic unit U1 (see location on Figs. 6A and 6B). DR44 is a micritic packstone with recrystallised algae, large benthic foraminifera (LBF) of Serravallian age (PZ N12, Tf2, 13.82 Ma to 12.00 Ma) (see BouDagher-Fadel, 2018b) and corals. These elements are reworked within a pelagic mud dominated by plancktonic foraminifera (Table 4) that comprise *Globigerinoides quadrilobatus* (Fig.11A, b.), *Dentoglobigerina altispira* (Fig.11B, b.), *Globorotalia menardii* (Fig.11B, c.), *Globigerinoides conglobatus* (Fig.11B, d.), *Globigerinoides ruber* (Fig.11B, e.), *Truncorotalia crassaformis*, *Orbulina* *universa, Globorotalia plesiotumida* (Fig.11C, a), *Sphaeroidinella dehiscens* of Early Pliocene age (N19-N20a, 5.3 Ma to 3.6 Ma). DR45 comprises ultramafic pebbles and gravels encrusted by algae incorporated in a micritic packstone similar to that of DR44 and also includes *Lepidocyclina* sp. (Fig. 11D) and *Alveolinella praequoyi*, with the same Serravallian age. DR46, DR47 and DR48 were collected on the edge of the terrace located between 200 to 400 m water depths near the Nakéti Pass (Figs. 6A and 6C). These three samples consist of micritic wackestone/packstones with patches of reworked pelagic micritic facies. DR46 assemblages are dominated by planktonic foraminifera such as *Truncorotalia crassaformis* (Fig, 11E, a.) *T. truncatulinoides*, *Globorotalia inflata, Globorotalia menardii* and *Orbulina univesa* of Pleistocene age (N22, 1.8 Ma to 0.12 Ma). DR47 sample shows numerous terrigenous grains (quartz, altered serpentine and undifferentiated clasts). Planktonic foraminifera are common and include *Globoquadrina dehiscens* (Fig. 11F, a.), *Globigerinoides quadrilobatus, Globigerinoides trilobus, Globigerinoides ruber, Globorotalia tumida, Globigerinoides spp.*, and *Pulleniatina obliquiloculata* of Late Pliocene age (N20a, 3.8 Ma to 3.6 Ma). DR48 contains numerous recrystallized algae and reworked LBF, such as *Alveolinella praequoyi* (Fig. 12A, a.) of Serravallian age (see Adams, 1984; BouDagher-Fadel and Banner, 1999; BouDagher-Fadel, 2018b), planktonic foraminifera of Pleistocene in age (N22, 1.8 Ma to 0.12 Ma) such as *Pulleniatina obliquiloculata* (Fig. 12A, b.), *P. primalis* and *Neogloboquadrina dutertrei*. DR49 sample was collected along the scarp at 500 m water depth, near the East Ngoé pass. The lower part of this scarp corresponds to the top of seismic unit U1 (Table 3, see location Figs.7A and 7B). Recovered samples comprise a micritic packstone ~~composed of~~with algae and LBF of Serravallian age, such as *Alveolinella praequoyi* (Fig. 12B, a.) and planktonic foraminifera such as, *Globorotalia tumida* (Fig12C, a.), *Sphaeroidinellopsis subdehiscens*, *Globorotalia menardii* and *Globorotalia inflata* of Early Pliocene age (N19b, 4.2 Ma to 3.8 Ma) after BouDagher-Fadel (2018a). DR53 is located further south, in front of the Yaté Pass, in ca. 280 m water depth, and is a micritic packstone containing planktonic foraminifera such as *Pulleniatina primalis* (Fig.12D, a.), *Prosphaeroidinella parkerae,* *Pulleniatina praecursor, Globigerinoides obliquus* and *Truncorotalia crassaformis* of Late Miocene to Early Pliocene age (Table 3, see location Fig.2).

4.4.2 Pines Ridge

Seven carbonate rocks were sampled along the Pines Ridge (Table 3, see location Fig. 2 and Fig.8A). These samples are mainly micritic wackestones/packstones with planktonic foraminifera and algae. Samples DW4737-B, DW4745-B, DW4746-B, DW4747-B1 and DW4747-X have ages ranging from Pliocene to Late Pleistocene (N19 to N22, 5.33 Ma to 0.12 Ma). Planktonic foraminifera assemblages of these samples include *Neogloboquadrina pachyderma, Sphaeroidinella dehiscens, Truncorotalia truncatulinoides, Truncorotalia tosaensis,* and *Pulleniatina obliquiloculata* and LBF, such as *Alanlordia* sp. (Fig.12E, a.), are found reworked together with Pliocene planktonic foraminifera into the younger assemblages. Further south, samples DW4757-A and DW4782-A were collected along the eastern slope of Pines Ridge (Table 3, see location Fig.8A and Fig.10). DW4757-A includes Oligocene to earliest middle Miocene LBF such as *Lepidocyclina* sp. and *Planorbulinella solida* (Fig.12F, a.), while DW4782-A comprises late Miocene to Pleistocene (N17-N20, 8.6 Ma to 3.4 Ma) planktonic foraminifera such as *Neogloboquadrina humerosa, Sphaeroidinellopsis seminulina, Sphaeroidinellopsis subdehiscens*.

4.4.3 Munida seamount

Three carbonate rock samples have been collected along the edges of *Munida* (Table 3, see location on Fig. 8A and Fig. 9C). Samples from DW4770, located on the northeast flank of the seamount, comprise micritic and sparitic packstones composed of algae and planktonic foraminifera, such as *Truncorotalia truncatulinoides* (Fig.12F, a) and *Truncorotalia tosaensis* (Fig.12F, b) of Pleistocene age (N22, 1.8 Ma to 0.12 Ma). DR4772-A and DR4773-A samples, located on the southern flank, are grainstones cemented by sparite, with planktonic foraminiferal assemblages including *Sphaeroidinellopsis subdehiscens*, *Sphaeroidinella dehiscens, Truncorotalia tosaensis* and *Pulleniatina obliquiloculata* of Pliocene to Pleistocene age (N21-N22, 3.4 Ma to 0.12 Ma). These samples also reveal many reworked Miocene and Pliocene planktonic foraminifera.

4.5. Paleoenvironmental interpretations

The assemblages of DR44 and DR45 are dominated by Early Pliocene planktonic foraminiferal assemblages (e.g. *Sphaeroidinellopsis paenedehiscens, Globoquadrina dediscens, Orbulina universa, Globorotalia plesiotumida, G. tumida* and *Dentoglogigerina altispira*). These mixed, globular and heavily keeled planktonic foraminifera are indicative of inner to outer neritic environments (BouDagher-Fadel, 2015). Miocene larger benthic foraminifera (e.g. *Lepidocyclina* sp., *Katacycloclypeus martini*, *Cycloclypeus* sp.) and fragments of corals and rodophyte species are also frequently reworked within the deeper Early Pliocene platform. These larger benthic foraminifera are flat in shape and are associated with symbiont-bearing diatoms (Leutenegger 1984; Romero et al. 2002). They are common in forereef environment where they adapted to light attenuation with increasing habitat depth (Hottinger, 1983; Hallock and Schlager, 1986; Hohenegger, 1995; 2005; Yordanova & Hohenegger, 2002; 2007; BouDagher-Fadel, 2018b).

The Late Pliocene to Pleistocene deposits of DR46, DR47 and DR48 contain mainly planktonic foraminifera of mixed assemblages of globular forms (e.g. *Globigerinoides quadrilobatus, Orbulina universa*) and keeled globorotalids (e.g. *Truncorotalia truncatulinoides, Globorotolia tumida).* These assemblages are indicative of an inner to outer neritic environment (see BouDagher-Fadel, 2015). Micritic patches of older Miocene deposits with mainly globular small globigerinids (e.g. *Catapsydrax cf. dissimilis, Globigerina praebulloides*) are also present indicating the reworking of an inner neritic Miocene platform within the deeper deposits of the Pliocene.

DR 49 is interpreted as being deposited in an Early Pliocene inner to outer neritic platform. It contains planktonic foraminifera assemblages dominated by globular forms (e.g. *Globorotalia menardii, G. inflata, Globigerinoides trilobus, Gldes quadrilobatus)* with occasional occurrences of keeled forms (e.g., *Globorotalia tumida, G. menardii*) and thickly coated forms in a thick, smooth cortex of calcite, *Sphaeroidinerlla dehiscens.* The latter is an extant thermocline dweller found rarely in subsurface, tropical, and subtropical waters (Chaisson and Ravelo, 1997; BouDagher-Fadel, 2018b). Reworked reefal Miocene larger benthic foraminifera (e.g., *Alveolinella praequoyi, Lepidocyclina sp., Planorbulina larvata, Amphistegina lessonii, Operculinoides spp., Gypsina sp.*) are also present. The presence of the large fusiform miliolid, *A. praequoyi* indicates the reworking of ~~quiet~~ shallow reefal facies into the deeper Early Pliocene neritic environments.

The assemblages of DR53 are dominated by Late Miocene to Early Pliocene globular planktonic foraminifera species (e.g., *Neogloboquadrina pachyderma, N. acostaensis, Orbulina universa, Prosphaeroidinella parkerae, Pulleniatina praecursor, P. primalis, Globigerinoides obliquus*). Occasional keeled forms (e.g., *Truncorotalia crassaformis, Globorotalia menardii, Globorotalia tumida*) are also present. Larger benthic foraminifera such as *Amphistegina spp.* and *Sphaerogypsina spp.* are also found. The extant *Amphistegina* has adapted to high energy conditions, however, it is also found in mud free sands in areas of sea grass or coralline algae and in reefal areas down to depths of 35m (McKee et al, 1959), while *Sphaerogypsina* is generally common in shallow-water reefal environments (Nebelsick et al. 2001). These assemblages are interpreted as being deposited in an inner to outer neritic platform.

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All samples from Pines Ridge point to inner to outer neritic settings, except DW4757-A which is typified by a forereef environment because of the occurrence of larger benthic foraminifera, such as *Amphistegina lessonii, Lepidocyclina sp., and Planorbulinella solida.* All samples from Munida seamount contain mixed assemblages of globular and keeled planktonic foraminifera (e.g., *Sphaeroidinellopsis subdehiscens, Sphaeroidinella dehiscens, Truncorotalia tosaensis, Pulleniatina obliquiloculata, Globorotalia inflata*) and are thought to reflect inner to outer neritic settings.

5. CARBONATE SYSTEM EVOLUTION ON THE EASTERN MARGIN OF NEW CALEDONIA

5.1 Mio-Pliocene carbonate banks

Carbonate rocks sampled on the upper slope scarp along the eastern margin contain algae, benthic foraminifera and coral fragments evidencing shallow-water carbonate production as early as the middle Miocene (Serravalian) and up to the Pliocene (Table 3, Fig. 13). This scarp corresponds to the top of seismic unit U1, which is bounded by the gently downslope dipping surface S1 (Figs. 5, 6 and 7). Because of its planar character, Chardon et al., (2008) interpreted this surface, topping a clastic continental wedge, as a lateritic land surface formed by weathering during emersion. Because none of the dredges that sampled this scarp (and thus U1) contained any traces of lateritic deposits, we propose an alternative interpretation where seismic unit U1 corresponds to a Mio-Pliocene carbonate bank, presently located at 300-600 m water depth. This important ~~drowning~~subsidence cannot be explained only by eustatism and we suggest that the post-obduction normal faulting that affected the Peridotite Nappe is likely the main driver of the ~~drowning~~subsidence. Surface S1 is interpreted as the top of the carbonate bank characterized by low-inclination features (Fig. 13A and B). The numerous ultrabasic pebbles/gravels and quartz grains within the carbonate matrix of samples DR45 and DR47 suggest coeval siliciclastic inputsinput with the carbonate buildup development. A similar mixed carbonate-siliciclastic system also occurs along the coastal domain of the western margin of Grande Terre in the well-constrained Burdigalian Népoui system (Tournadour et al., 2020) (Fig.13B). The onset of these mixed systems indicates that both margins of Grande Terre were inexperienced shallow marine conditions during the Miocene. However, their current positions, up to 20 m above present day sea-level for the Lower Miocene NepouiNépoui outcrops of the western margin and up to 500 m water depth for the middle Miocene samples of the eastern margin, suggest a contrasted tectonic evolution of the margins.

Our results suggest that the Mio-Pliocene carbonate platform (Table 3, Fig.13) extended southward along the Pines Ridge, over peridotite horsts, which were at that time located in shallow-water (Fig.13A and B). Within this sedimentary succession, unit UP1 is interpreted as an attached carbonate platform developing on the western edge of the ridge.. The eastward thickening of unit UP2, which unconformably overlies unit UP1 (Fig.10D), suggests a deposition simultaneous or subsequent to the eastward tectonic tilting of Pines Ridge. The aggrading mounded reflections of the lower part of UP2 on the eastern edge of the ridge, may be interpreted as shallow-water, reefal bioconstructions (e.g. Miocene from the Browse basin, Australia: Belde et al., 2017), or as an oligo-mesophotic bank with dominant algal and foraminiferal production (e.g. Lower Miocene from Myanmar: Teillet et al., 2020a and 2020b). However, in the upper part of UP2, the upward change from mounded to flat-topped morphologies on the eastern margin strongly suggests the development of reef-flat environments aggrading up to sea-level. Finally, subunit UP3 is also characterized by a slight overgrowth along the eastern edge as evidenced by low-relief mounded reflectors (Fig.10). Such an asymmetric feature could be explained by the continuation of an eastward tectonic tilt or could be related to eastward winds driving carbonate growth (Fig.10).

Based on seismic interpretation, two stages of carbonate growth are identified on the Munida seamount (seismic units UM1 and UM2). A carbonate sample, collected 15 km away from the seamount (GEO-I-13D, located,; location on Fig.2), contains benthic foraminifera indicative of shallow-water environment, that can be dated Early Miocene (Daniel et al., 1976; Bitoun and Recy, 1982). This sample suggests a first stage of carbonate growth (UM1) of Miocene age coeval ~~to~~with carbonate platforms from Pines Ridge (UP1 and/or UP2) (Fig.13A and B). A Miocene carbonate platform also likely developed on the Crypthelia seamount as suggested by a Middle to Late Miocene carbonate sample exhibiting forereef facies (GEO-I-9D, see location Fig.2 and Fig.9A) (Daniel et al., 1976; Bitoun and Recy, 1982).

Based on ~~these~~aforementioned observations, we propose ~~a~~the following palaeogeographical reconstruction of the distribution of Mio-Pliocene shallow-water carbonate systems along the margin of New Caledonia (Fig. 13B). The Mio-Pliocene carbonate systems extend for about 350 km, along the southeastern margin to Antigonia Seamount. On the western margin, the Quaternary carbonate reef-lagoon system directly overlies Eocene allochthonous units (see Fig.1). At that location, the absence of Miocene shallow-water deposits could be explained by a non-deposition or by erosion in relation to the uplift of the western margin. The thickness of the Miocene ramp is a least 200 m on the Nepoui area (Maurizot et al., 2016; Tournadour et al., 2020), but remains unknown along the eastern margin~~, but~~. However, it can be estimated to be around 750 m on the Pines Ridge (Fig.10B). Similar Miocene carbonate ~~growths~~growth rates have been reported ~~in~~for the southwestern Pacific suggesting that, in addition to local tectonic control (subsidence) allowing significant volumes of sediments to accumulate, larger-scale oceanographic or global factors favoured a sufficiently high carbonate production to fill the created accommodation~~ space~~. For example, the 600 m-thick Marion Plateau platforms, northeast of Australia, result from ~~a~~ robust carbonate growth through early and middle Miocene up to its terminal demise in the late Miocene (Ehrenberg et al., 2008). Along the northwestern shelf of Australia, seismic profiles reveal a giant middle Miocene prograding barrier reef that backstepped in the late Miocene (McCaffrey et al., 2020). Finally, the Gulf of Papua is also structured by large-scale isolated long-lived carbonate platforms during the late Oligocene-early Miocene and which demised during late Miocene-early Pliocene (Tcherepanov et al., ~~2008~~2008b). In our study, the prolific Mio-Pliocene carbonate accumulation is favoured by the subsidence of the shelves of New Caledonia and Pines Ridge, most likely in relation to post-obduction extensional tectonics (Lagabrielle and Chauvet, 2008; Patriat et al., 2018).

5.2 Transition from Mio-Pliocene to Quaternary platforms

Along the eastern margin of Grande Terre, the Quaternary rimmed platform is thought to have backstepped onto a Mio-Pliocene carbonate bank (Fig. 13A and 13C). Southward, along the Pines Ridge and associated seamounts, the Mio-Pliocene carbonate banks are drowned but several Quaternary flat-topped isolated platforms survived and aggraded.

In the vicinity of the study area, the carbonate platform of Maré, on the Loyalty Ridge, records a significant change in the nature of carbonate production which is rhodalgal-dominated during the late Miocene, and coralgal-dominated during the Pliocene (McNeill and Pisera, 2010; Maurizot et al., 2020). These authors explain the switch of carbonate production by the trend of decreased coralline red algae species richness (Aguirre et al., 2000) combined ~~to~~with the global-scale Zanclean Flood Event (McKenzie et al., 1999). The exposure of these carbonate records would result from the local tectonic uplift of the Loyalty Ridge related to Pliocene-Pleistocene lithospheric flexure associated with the New Hebrides subduction (Dubois et al., 1974 and 1975).

Along the western margin of Grande Terre, the coral reef flourished from 400 ky (MIS-11) considered as a period of luxuriant reef expansion in the southwest Pacific (Cabioch et al., 2008b). Nevertheless, during the Quaternary, non-reefal carbonates were identified prior to MIS-11 as early as 1.4 Ma, overlapping the Eocene allochtonous units and could form the foundation of the Quaternary rimmed platform (Cabioch et al., 2008b; Montaggioni et al., 2011).

Along the eastern margin, the occurrence of a Mio-Pliocene platform below the eastern barrier reef-lagoon suggests that an older carbonate platform developed similarly to what is observed in Maré Island. The common occurrence of normal faults suggests that the eastern margin and Pines Ridge were dominated by tectonic subsidence that would have promoted accommodation for Neogene carbonate deposition and preservation, by opposition to the western margin where the Quaternary carbonates are found on top of ~~eocene~~Eocene peridotites. However, high subsidence rates could also explain the demise of the Mio-Pliocene carbonate systems along the Pines Ridge and the backstepping of Quaternary platforms. After 125 ky, the southeastern margin is slightly uplifted in the Yaté area and the Isle of Pines (Launay, 1985; Cabioch et al., 1996). This uplift could be due to the isostatic rebound of the central part of Grande Terre (Cabioch et al., 1996; Lagabrielle and Chauvet, 2008) or alternatively, could be associated with the lithospheric bulge of the New Hebrides subduction which is known to have a regional impact from the Loyalty Islands to the Isle of Pines (Dubois et al., 1974 and 1975; Cabioch et al., 1996). ~~In any cases~~Hence, both margins of New Caledonia seem to have been affected by long ~~-~~term subsidence during the Quaternary which, together with high-amplitude eustatic sea-level variations, allowed the aggradation and preservation of the reef-lagoon successions.

5.3 Quaternary carbonate platform

5.3.1 Late Quaternary mixed carbonate siliciclastic systems along the eastern margin

At the mouth of the Cap Bayes Pass, seismic unit U2 forms a 200 m-thick prism comprising five stratigraphic sequences (Fig. 5). In detail, the internal geometries of these parasequences are characterized by successive sets of aggrading to retrograding mounded reflections and progradational inclined reflections. We interpret these parasequences as mixed carbonate-siliciclastic prims that developed at the mouth of the pass, with aggrading ~~to~~and retrograding shallow ~~-~~water carbonate ~~transgressive~~ sequences that developed during a transgression (pink colour on Fig. 5C), deposited during the last glacial-interglacial Quaternary cycles. This interpretation is consistent with core data collected on the western barrier reef (see location of Fig. 1), which revealed that the barrier reef itself ~~is constituted by~~consist of four to five lithological sequences deposited during successive transgressions and highstands in sea level since the Mid-Brunhes, each transgressive reefal units being separated by subaerial unconformities (subaerial exposures) (Cabioch et al., 2008b; Montaggioni et al., 2011). The prograding seismic patterns (yellow colour on Fig.5C) ~~are~~ thus can be interpreted as lowstand siliciclastic ~~wedge~~wedges that formed during Late Quaternary glacial lowstands.

Siliciclastics might have ~~thus~~ developed contemporaneously with the Quaternary barrier reef bordering the eastern lagoon (Figs. 5, 6B and 7). This observation is consistent with the reciprocal sedimentation concept traditionally developed for carbonate-siliciclastic mixed systems (see review by Chiarella et al., 2017). According to this concept, siliciclastic deposits prevailed on the upper slope during ~~low~~ sea-level ~~periods~~lowstands and at the beginning of the ~~platform~~shelf reflooding, whereas carbonate facies dominate during transgressions and highstand periods. This configuration is currently observed on the platform edge of Quaternary mixed carbonate-siliciclastic systems such as the Australia and Papua New Guinea Reef (Tcherepanov et al., 2008a; 2008b; 2010; Harper et al., 2015; Mallarino et al., 2021) or the Belize Barrier Reef (Esker et al., 1998; Ferro et al., 1999; Gischler et al., 2010; Droxler and Jorry, 2013).

However, the reciprocal pattern is not expressed everywhere along the upper slope of the eastern margin. Near the Côte Oubliée, seismic unit U2 is not characterized by sedimentary prograding ~~clinoform~~clinoforms but rather by a downlapping aggrading wedge with a maximum thickness of 200 m in front of the Kouakoué Pass (Fig.7). The lack of prograding features associated with the lowstand clastic wedge could be explained by low terrigenous sedimentation rates as suggested by small deltas restricted to the coastal domain (Fig. 3A). Moreover, the southeastern part of the lagoon is characterized by a meandering channel network parallel to the coast and to the barrier reef, suggesting an alongshore transport which can partly intercept outgoing sedimentary flux from lagoon (Fig. 3A). In addition, the numerous gullies cutting the upper slope suggest ~~a~~ high off-bank sediment transport toward the deep basin and thus the accumulation of sediments along the upper slope (Fig. 7A). This off-bank sediment transport could result from density cascading processes driven by seasonal meteorological conditions (Wilson and Roberts, 1992, 1995). The alongslope heterogeneity of the eastern margin upper slope deposits clearly shows that the behaviour of a mixed carbonate-siliciclastic margin is difficult to predict and is not only dependent of relative sea-level changes, as mentioned previously (Chiarella et al., 2017; O'Connell et al., 2020).

5.3.2 Quaternary isolated flat-topped banks of Pines Ridge and seamounts

Along the Pines Ridge, dredged carbonate rock samples show that shallow-water carbonate deposition occurred on the Banc de la Torche and Antigonia seamounts during the Quaternary (Fig.13A and C). The two marine terraces at 80-90 m and 120 m water depth might evidence reef backstepping during the last deglacial sea-level rise, as reported around the Great Barrier Reef (Webster et al., 2018), the Gulf of Mexico (Khanna et al. 2017), the Maldives (Fürstenau et al., 2010; Rovere et al., 2018), the SW Indian Ocean (Jorry et al., 2016), the Marquesas Island (Cabioch et al., 2008a) and in Tahiti (Camoin et al., 2012). Carbonate rock samples dated at the youngest from the Pleistocene and collected on the flat-top of the Munida seamount that is currently submerged in 93 m water depth, are thought to be representative of seismic unit UM-2 which would correspond to the last stage of the carbonate platform's growth. Similarly to the Banc de la Torche and Antigonia, the flat-top of the eastern part of the Munida seamount is currently located in the photic zone which suggests ~~a~~ continuous carbonate aggradation from the Miocene to the Quaternary. Such a continuous deposition was possibly favoured by a slower subsidence at that location compared to other seamounts (Fig.13). The Crypthelia seamount that is submerged at 194 m water depth is affected by three N160°E normal faults scarps, leading to an overall eastward deepening of the seamount topography along several stepped terraces at ca 200 m, 300 m and 350 m water depths (Fig.9A). The lack of samples on these stepped terraces does not allow us to determine if the carbonate factory was active during the Quaternary and when the isolated carbonate platform was drowned (Fig.13A).

6. CONCLUSIONS

The eastern margin of Grande Terre records the evolution of a shallow-water mixed carbonate-siliciclastic system, with the successive development an aggrading Mio-Pliocene carbonate bank and a backstepping Quaternary barrier reef.

- ~~a~~A Mio-Pliocene shallow-water carbonate platform, presently drowned at 300 to 600 m water depth, extends about 350 km from Ponerihouen to Antigonia seamount and can be up to 750 m thick along the Pines Ridge.

- ~~in~~In front of Grande Terre, the Mio-Pliocene carbonate sediments are mixed with quartz grains and ultrabasic pebbles, which ~~attests of~~document terrigenous inputs resulting from high relief of the island topography dismantling coeval with carbonate production as early as the Serravalian.

- The transition between the aggrading Mio-Pliocene carbonate bank and the backstepping Quaternary carbonate platforms along the eastern margin could be explained by the regional subsidence context driven by an extensional tectonic regime or by global climate change associated with Late Quaternary high-amplitude sea-level variations and/or changes of carbonate producers through time.

- The stratigraphic architectures of mixed carbonate-siliciclastic systems, represented by the Quaternary reef-lagoon complex along the upper slope, vary widely from north to south. In front of the Cap Bayes Pass, this contribution evidences for the first time in New Caledonia the presence of a lowstand terrigenous prism alternating with transgressive shallow-water carbonate sequence, typical to reciprocal sedimentation models. ~~Nerveless~~Nevertheless, this configuration is not observed southward, probably because other control parameters prevailed such as low terrigenous inputs, the particular morphology of the paleo-drainage network, which appears parallel to the coastline, or the high by-pass sediment transport toward the deep basin.

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FIGURE AND TABLE CAPTIONS

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Figure 1: A. Regional location map of the study area. **B.** Simplified geological map of Grande Terre, New Caledonia (modified after Maurizot and Vendé-Leclerc, 2009) and shaded bathymetric map of surrounding offshore areas with the southern extensions of the Peridotite Nappe and metamorphic belt (Pines and Félicité ridges, respectively; after Patriat et al., 2018). Drill sites of the Quaternary barrier reef (Coudray, 1975; Cabioch et al., 2008; Montaggioni et al., 2011) and outcrops of the Lower Miocene mixed carbonate siliciclastic systems of Népoui are also indicated (Maurizot et al., 2016 ; Tournadour et al., 2020). **C.** Simplified SW to NE oriented geological cross-section of Grande Terre (modified after Lagabrielle et al., 2005 and Collot et al., 1987). N: Nouméa ; Pn: Ponérihouen ; Th: Thio ; Yt: Yaté ; IP: Isle of Pines ; T : Banc de la Torche ; S : Stylaster seamount ; B : Brachiopod seamount ; A : Antigonia seamount ; C : Crypthelia seamount ; M : Munida seamount.

Figure 2: Bathymetric map of the eastern margin of Grande Terre, from Poindimié to the Pines Ridge with location of the dataset used in this study including seismic profiles AUS-104 (Bitoun & Recy, 1982), 206-04 (dashed black lines), NEOMARGES (Chardon, 2006; Chardon et al. 2008, black lines), and dredged carbonate samples (yellow circles). T : Banc de la Torche ; S : Stylaster seamount ; B : Brachiopod seamount ; A : Antigonia seamount ; C : Crypthelia seamount ; M : Munida seamount.

Figure 3: A. Bathymetric map of the eastern lagoon of Grande Terre from Ponérihouen to Yaté. On the outer slope, note the terrace mapped in orange between 300 to 600 m water depths. **B.** Bathymetrical profile across the lagoon from the coast of Houailou to the outer barrier reef (see location on Figure A) showing three main morphobathymetric zones: 1) a shallow-water coastal zone dominated by fine-grained terrigenous sediments; 2) a deeper median lagoon with aligned islands and a coast-parallel channel network in front of Cote Oubliée; 3) a barrier reef domain cross-cut by passes, dominated by coarse-grained carbonate sedimentation. D: ~~Terrigenous~~

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~~deltas~~Deltas; D*: Restricted ~~terrigenous~~ deltas; SI: Sandy Islets; PR: Patch Reefs. Red lines are positions of seismic profiles. Yellow circles are positions of dredged carbonate samples.

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Figure 4: Typical bathymetric profiles of the outer slopes of Grande Terre (location on Fig.2) highlighting the very steep character of the western margin (dashed green lines; W-01 and W-02) contrasting with the more gently inclined eastern margin (solid blue lines; E-01 and E-02). The latter illustrate the main morpho-bathymetric domains of the eastern margin slope, which can be divided into a low gradient (2-3°) upper slope mostly preserved from erosion, a middle slope affected by numerous submarine canyons and a lower slope to to-of-slope region. ~~Along~~The hatched area shows the elevation difference between the southern and central parts of the eastern margin (~~profile~~ E-01~~)~~, and E-02, respectively), highlighting that the slope is better preserved from retrogressive erosion by slope canyons processes towards the south.

Figure 5: A. 3D bathymetrical map of the outer slope in front of Cap Bayes Pass with location of dip-oriented seismic profile NM-1. **B.** Seismic profile NM-1 profile with location of quaternary terraces (blue arrow, see details in Flamand, 2006), clinoform slope break of U2 prism (green arrow) and the bathymetrical scarp associated with the top of U1 seismic unit (red arrow). **C.** Interpretation of seismic profile NM-1 highlighting five sub-units inside U2, interpreted as parasequences (numbered from 1 to 5). Each parasequence is typified by an alternation of lowstand forced regressive wedges (in beige) and aggrading to retrograding shallow-water carbonate transgressive sequences (in pink), consistent with the pattern of reciprocal sedimentation model.

Figure 6: A. 3D bathymetrical map of the outer slope in front of Canala with location of seismic profiles NM-4 and NM-9 and dredged carbonate rocks (see Table 3). **B.** Uninterpreted seismic profile NM-4. **C**. Interpreted seismic profile NM-4. **D.** Uninterpreted seismic profile NM-9. **E.** Interpretation of seismic profile NM-9. Both profiles show U1 seismic unit overlain by downlapping U2 seismic unit interpreted as external slope deposits derived from the quaternary barrier reef.

Figure 7: A. 3D bathymetrical map of the outer slope in front of Côte Oubliée with location of seismic profiles NM-12B and NM-13 and dredged carbonate rock DR-49 (see Table 3). **B.** Uninterpreted seismic profile NM-12B. **C.** Interpretation of seismic profile NM-12B. **D.** Uninterpreted seismic profile NM-13. **E**. Interpretation of seismic profile NM-13. The upper slope is characterized by a thick downlapping U1 sedimentary unit incised by numerous gullies suggesting significant off-bank transport from the lagoon towards the basin.

Figure 8: A. 3D bathymetrical map of the southeastern slope of Grande Terre and Pines Ridge with location of AUS-104 and 206-04 seismic profiles. T : Banc de la Torche ; S : Stylaster seamount ; B : Brachiopod seamount ; A : Antigonia seamount ; C : Crypthelia seamount ; M : Munida seamount. **B.** Seismic profile AUS-14 across the Loyalty Basin bordered by the Loyalty and Pines ridges. **C.** Line drawing interpretation of profile AUS-14 showing spectacular normal faults affecting the peridotite nappe overlain by post-obduction sedimentary units. This study focuses on shallow-water carbonates that cover peridotite horsts of the Pines Ridge and which are currently at 300-400 m water depths.

Figure 9: Bathymetric map (**A**) and profile (**B**) of Crypthelia seamount located from 200 to 800 m water depth and marked by N160° oriented faults (f) associated with a channel (Ch) and large collapses on its southern edge. Bathymetric map of Munida seamount (**C**) marked by a southern terrace noted M1, located between 400 to 600 m water depth, and by a relatively flat top above 200 m water depth, noted M2.

Figure 10: A. Seismic profile 206-04 through the Pines Ridge and Munida seamount (see location on Fig.8A and 10C). **B.** Interpretation of profile 206-04 showing the normally faulted geometry the Peridotite Nappe and HP-LT Metamorphic complex resulting from post-obduction extensional tectonics (Patriat et al., 2018). Associated flat-topped horsts are capped by a shallow water carbonate ramp interpreted as being of Mio-Pliocene age based on biostratigraphic analysis of DW-4757 and DW-4782-A dredged samples (see Table 3). **C**. Close-up view on seismic profile 206-04 on the Pines Ridge. **D**. Detailed line drawing interpretation of C. showing

3 subunits UP1 to UP3 and an overall asymmetric configuration suggesting a tilt of Pines Ridge before and during deposition of the Mio-Pliocene carbonate ramp. The eastern part of UP2 subunit is characterized by buid-up geometries that could be interpreted as aggrading platform.

Figure 11: A. DR44 sample, (a.) *Katacycloclypeus martini*, (b.) *Globigerinoides quadrilobatus*. **B.** DR44 sample, (a.) *small rotaliid* in reworked micrite, (b.) *Dentoglobigerina altispira*, (c.) *Globorotalia menardii*, (d.) *Globigerinoides conglobatus*, (e.) *Globigerinoides ruber*. **C.** DR44 sample, (a.) *Globorotalia plesiotumida*. **D.** DR45 sample, (a.) *Lepidocyclina sp.*. **E.** DR46 sample, (a.) *Truncorotalia crassaformis.* **F.** DR47 sample, (a.) *Globoquadrina dehiscens.* G. DR47 sample, (a.) *Globorotalia tumida.*

Figure 12: A. DR48 sample, (a.) *Alveolinella praequoyi* (b.) *Pulleniatina obliquiloculata.* **B.** DR49 sample, (a.) *Alveolinella praequoyi*. **C.** DR49 sample, (a.) *Globorotalia tumida* **D.** DR53 sample, (a.) *Pulleniatina primalis* **E.** DW4737-B sample, (a.) *Alanlordia sp.* **F.** DW4757-A sample, (a.) *Planorbulinella solida.* **G.** DW4770 sample, (a.) *Truncorotalia truncatulinoides* (d'Orbigny) (b.) *Truncorotalia tosaensis* (Takayanagi and Saito).

Figure 13: A. Schematic cross-sections showing the geometry and evolution of shallow water post-obduction systems on the eastern margin of Grande Terre in the vicinity of Poindimié (1), north of Pines Ridges along Banc de la Torche (2), south of Pines Ridge (3), and over Crypthelia (4) and (5)Munida seamounts. (location in Fig. 13C). **B.** Paleogeographical reconstruction and spatial distribution of Mio-Pliocene carbonate banks. **C.** Paleogeographical reconstruction and spatial distribution of Quaternary barrier reef of Grande Terre and submerged isolated platforms along Pines Ridges and seamounts.

Table 1: Characteristics of the seismic acquisition devices.

Table 2: List of carbonate rock samples analysed in this study

Table 3: Table summarizing microfacies description and interpretation of depositional environment, age of *in-situ* components and age of reworked components (identified in red in Table 4)

Table 4: List of the component occurrence with identification of reworked elements (red cross).