

Quaternary Stratigraphy and sediment routing of the modern mixed platform of the Grande Terre of New Caledonia.

Field approach and stratigraphic modelling

SYMCA project (New Caledonia Mixed System project)

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General context :

The SYMCA thesis project aims to characterise the Quaternary evolution and stratigraphy of the New Caledonian platform. In particular, the goal is to better constrain recent and current sedimentary transfer processes across the platform, which is a remarkable modern example of a mixed carbonate and silico-clastic sedimentary system developed in a tropical context. This type of complex sedimentary system, installed on carbonate platforms attached to continental landforms and fed by terrigenous flows, appears to be particularly sensitive to sea level variations as well as to climatic and anthropogenic fluctuations during the Late Quaternary (Cabiocch et al., 2008; Duprey, 2012)

Previous studies of such systems along the Australian Great Barrier Reef (Webster et al., 2012; Harper et al., 2015), in the Gulf of Papua New Guinea (Jorry et al., 2008) or in Belize (Gischler et al., 2010; Droxler and Jorry, 2013) led to discuss and evolve the 'reciprocal sedimentation' model for which carbonate sediment deposition alternates during transgressions and high sea levels and silico-clastic deposition during regressions and low sea levels (Schlager et al., 1994). In some environments, periods of low sea level are also accompanied by a reduction in overall carbonate and clastic flux. The export of these sediments upslope is thought to be greatest during post-glacial platform reflooding (Harper et al. 2015). In addition, the development of incised palaeo valleys connected to the outer passes and partly connected to the mainland to the fluvial valleys takes place during the low level period but also during the episodes of platform re-flooding. These incisions seal an inherited topographic lthat plays an important role in reef growth (Droxler and Jorry, 2013) and in the sediment transfer processes towards the slope and basin, thus contributing to maintaining a sedimentary balance within the lagoon (Le Roy et al. 2019). Furthermore, the stratigraphic record of this sedimentation in lagoon domains show that, in most cases, lagoon filling is limited to two 4th order Pleistocene-Holocene sequences (e.g. Zinke et al., 2001; D'Agostini et al., 2015; Le Roy et al., 2019).

The responses of mixed carbonate/silico-clastic systems to forcing factors are therefore highly variable and the sedimentation of the lagoonal domains of such systems, which are poorly documented, remain to be better understood at the scale of fourth (100-20 ka) and fifth order (<20 ka) sequences. Beyond these time scales, it is also necessary to better characterise the sensitivity of reef carbonate systems to variations in terrigenous inputs and sea level, such as modifications linked to current climate change and anthropogenic activities (e.g. intensification of watershed erosion).

The New Caledonian shelf, which has the second largest lagoon complex in the world after the Australian Great Barrier Reef, provides the ideal context for addressing these issues.

The New Caledonia platform and previous work

Previous work on the platform has focused on reef systems about 150 m thick, which resulted in part from the development of the barrier reef since about 400 ka (Montagionni et al., 2011). The clastic system of the platform is largely fed by the alteration and dismantling of the ultrabasic units of the Peridotite Nappe, which are widely exposed in the south of the island (Avias and Coudray, 1967). Nevertheless, the whole platform and in particular the filling of the New Caledonian lagoon remain poorly studied. In order to fill this gap, a series of sea campaigns were initiated by IUEM and Ifremer (UMR Geo-Ocean team) in collaboration with the Geological Survey of New Caledonia and IRD: CALGON (2004), CALICO (2013), MARGEST (2022). These campaigns have acquired a large dataset combining multibeam bathymetry, reflectivity, Sparker seismic-reflection, Kullenberg cores (>60 sites), grab samples acquired across the South-Western lagoon (the largest) and the Eastern lagoon (southern half). A complementary onshore coring campaign (SEDICAL, 2018, 18 sites) allowed the recognition and sampling of the sedimentary formations across the coastal plain.

Most of the interpretation achieved to date have been done from data acquired in the south-western part of the area (Le Roy et al., 2008, Michel, 2014, Gautier, 2017, Jorry et al., 2017, 2018, Le Roy et al., 2019, Delanoë, 2019). The results suggest that the establishment of the barrier reef in the Middle Pleistocene and the subsequent flexure of the platform allows the lagoonal sedimentary infilling, which does not appear to be significant before 200ka. The aggrading geometries of the 4th order sequences appear to be controlled by the palaeomorphology of the platform bedrock and its very steep external slope limiting the lateral migration of the reef system. The shallow depth of the platform also leads to much longer exondation phases than for most clastic systems and leads to a strong morphological and low level sedimentary imprint across the lagoon with a strong spatial contrast. Clastic sedimentation remains dominant in the proximal part of the lagoon delimiting a depression parallel to the coast where low level assemblages are preserved. The median and outer parts of the platform, on the other hand, show a carbonate nature associated with transgressive and high level intervals. The incised valleys leading to the passes constitute a major morphological feature allowing the export of intra-lagoon material, thus limiting the filling of the platform.

The eastern platform remains to be characterised. Nevertheless, a preliminary morphological comparison of the eastern and western margins highlights different developments. Whereas in the west, the outcropping barrier at the edge of the platform is almost uninterrupted except for the passes and is bordered by a steep structural slope, in the east, the discontinuous barrier is often submerged and bordered by a stepped slope delimiting a large Quaternary sedimentary prism. This is essentially underlain by the roof of an ancient Mio-Pliocene carbonate platform interpreted as a ramp system (Tounadour et al., 2021). Moreover, the first observations from the MARGEST campaign suggest that the eastern lagoon of Grande Terre is still deeper than in the west, with an average bathymetry of over 40 m and reaching values of over 80 m towards the south at a position very close to the coast. The eastern platform has, as in the west, a mixed terrigenous-carbonate character, but with a terrigenous component which appears to be dominant in general. This detrital character was recognised by coring revealing lateritic relics sometimes very close to the surface.

Finally, the post-obduction tectonic context of the Oligo-Miocene isostatic rebound seems to control the structuring of the system (Lagabrielle et al., 2005; Chardon et al., Collot et al., 2017, 2020; Tournadour et al., 2021). The vertical movements associated with this evolution seem to differ between the eastern and western margins (greater subsidence along the eastern margin?) but need to be better characterised. Analysis of the sedimentary records of the eastern and western lagoons will also help to better constrain the post-obduction tectonic phase.

Work to be carried out:

1/ Interpretation of the whole data set available for the eastern platform.

Work to be carried is based on data from the MARGEST campaign (bathymetric integration, seismic interpretation and analysis of sediment cores) and data from the SEDICAL campaign (exploitation of cores on land). The work will be carried out at the Brest site, which has all the tools and resources required to interpret the sedimentological and geophysical data.

2/ Synthesis of comparison of the two south-western and eastern margins. The aim is to provide 1) a detailed and synthetic analysis of the stratigraphic architecture of the eastern platform and its evolution in relation to sea level variations, 2) a characterisation of present and past sedimentary transfers across the platform and understanding of sedimentary partitioning in the lagoon, 3) an evaluation of vertical movements in order to understand the potential control of Neogene tectonics on Quaternary sedimentation.

3/ To model the stratigraphic evolution of the lagoon fill using the Dionisos software. The work to be carried out here aims to identify and quantify the forcing factors of sedimentary transfers on the mixed platform of the two margins for which the data are most numerous. The interpretation and synthesis of the data will be used to build a geological model (qualitative and quantitative) that will be tested and refined using the stratigraphic model. After a preliminary study of the model's sensitivity, the objective of the forward modelling will be to restore the variability of the geometries observed along large 2D cross-shore transects in a coherent chrono-stratigraphic framework by integrating their various control factors. Following the example of the modelling work carried out on the Australian mixed platform (Thran et al., 2020), the aim is to gain a better understanding of the sedimentary processes controlling the sedimentary and geomorphological evolution of the platform (and its spatio-temporal variability) from the interaction of key factors, such as the initial topography, variations in sea level, sedimentary inputs, vertical movements and hydrodynamics

Location of the work :

Most of the work will be carried out in the Geo-Ocean laboratory, which brings together geologists from Ifremer and UBO-IUEM and offers a level of equipment that allows most of the analyses to be carried out on site. A few weeks' travel to New Caledonia is to be expected in the context of the thesis and in collaboration with the Geological Service of New Caledonia.

Candidate profile required:

geology degree or engineering degree and knowledge of sedimentology/stratigraphy, including the study of sedimentary cores, who is comfortable using digital tools. Knowledge of seismic interpretation software Kingdom Suite, ease of use of GIS.

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