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1 **High-resolution stratigraphic forward modeling of a Quaternary**
2 **carbonate margin: controls and dynamic of the progradation**

3 **J. Busson^{1, 2, 3}, P. Joseph², T. Mulder¹, V. Teles², J. Borgomano⁴, D. Granjeon², C. Betzler⁵, E.**
4 **Poli³, M. Wunsch⁵**

5 1. Université de Bordeaux, CNRS UMR5805 EPOC, allée Geoffroy St Hilaire, CS 50023, 33615
6 Pessac

7 Cedex, France

8 2. Direction Géosciences R16, IFP Energies Nouvelles, 1-4 avenue de Bois Préau, 92852 Rueil-
9 Malmaison Cedex – France

10 3. Projet “Carbonates”, Exploration & Production SCR/RD, Total S.A., CSTJF, Avenue Larribau,
11 64000 Pau, France

12 4. Aix-Marseille Université, CNRS UMR7330 CEREGE, 3, Place Victor Hugo, 13331 Marseille
13 Cedex 3, France

14 5. Institut für Geologie, Universität Hamburg, Bundesstr. 55, 20146 Hamburg, Germany

15 **Corresponding author : Jean Busson ; jean.busson@u-bordeaux.fr**

16

17 **ABSTRACT**

18 The relationships between the margin sedimentary regime and the platform progradation are
19 studied using forward stratigraphic numerical simulations on the Leeward (Western)
20 prograding margin of the Great Bahama Bank (GBB) during the Quaternary (1.7 - 0 Ma). The
21 corresponding sedimentary regime in the slope and the platform is well known from the ODP
22 leg 166 and Bahamas Drilling Project wells located along the “Western line” seismic transect.
23 However the sedimentary regime on the margin is not well established: the coral reefal margin
24 observed before between 1.7 and 0.8 Ma in the well Clino is not active anymore at present-
25 day, and the Holocene sedimentary regime is geometrically unable to account alone for the
26 progradation. This study is based on three 2D high-resolution forward stratigraphic numerical

27 modeling experiments with the software DionisosFlow that include the platform, margin and
28 slope domains on the “Western Line Section” in the same sedimentary models. The results are
29 compared to the six sedimentary cores and to the present day bathymetry in order to identify
30 the more realistic scenario. The three experiments test different models of carbonate
31 sediment production and transport. Experiment 1 shows that the highstand shedding of the
32 fine-grained uncemented platform production is unable to reproduce the progradation and
33 the present-day profile. Experiment 2 and 3 incorporate cemented facies in the margin, with
34 the best results obtained with the cemented marginal wedges produced in Experiment 2
35 during platform emersion. From these results a high-resolution interpretation of the margin
36 seismic section is proposed. This study shows that the platform progradation can be decoupled
37 from the highstand shedding of the fine-grained platform production. It is dependent on the
38 accumulation in front of the steep margin of coarse or cemented material. Before 0.8 Ma this
39 corresponds to the coral reef identified in Clino. The transition after 0.45 Ma to 100-kyr large
40 eustatic cycles with total platform flooding created two distinct marginal regimes: (1) during
41 platform flooding aggrading accumulation of non-skeletal sands, and (2) during platform
42 emersion prograding cemented marginal wedges produced in-situ.

43 **KEYWORDS**

44 Bahamas; Forward Stratigraphic modeling; Carbonate slope; Platform Progradation; Lowstand
45 wedges; Cemented margin

46 **1 Introduction**

47 **1.1 High-resolution stratigraphic study of a progradational margin**

48 Carbonate sedimentary systems are a major component of the rock record of sedimentary
49 basins, and a major reservoir of geological resources (Schlager, 2005). The margin area is the
50 transition domain from the shallow marine carbonate factory to the slope where sediments
51 are re-sedimented (Mcllreath & James, 1978; Mullins & Cook, 1986; Schlager, 2005; Playton et

52 al., 2010; Reijmer et al., 2015). The sedimentary processes and physiography of the margin
53 controls the stratigraphic evolution of the shallow platform and the sediment export
54 mechanisms towards the slope (Eberli and Ginsburg, 1987; Playton et al., 2010). The evolution
55 of the margin is influenced both by external factors, such as hydrodynamic conditions and
56 tectonics, and internal ones, especially the variety of carbonate producers and the mechanical
57 properties of the accumulated production (Playton et al., 2010).

58

59 Forward stratigraphic models such as the DionisosFlow software (Granjeon and Joseph, 1999;
60 Granjeon, 2014) are a reliable tool to reconstruct the facies and geometry of a carbonate
61 sedimentary system through time (Warrlich et al., 2008; Montaggioni et al., 2015; Berra et al.,
62 2016; Lanteaume et al., 2018). This high-resolution stratigraphic model realizes a reliable
63 process-based interpolation of the available geological data. They are used to constrain the
64 geological parameters governing the modelled sedimentary processes (Aurell et al., 1998;
65 Seard et al., 2013; Montaggioni et al., 2015; Kolodka et al., 2016)

66 This study focuses on the “Western Line” transect of the Great Bahama Bank (GBB) for the
67 time interval 1.7 Ma to present day (Fig. 1A and 1B). Different scenarios defined by various
68 carbonate producers and sediment properties are tested under well-constrained external
69 controls. Different margin architectures are then generated and compared to the observations
70 for the most recent deposits (Wilber et al., 1990; Eberli et al., 2004) and to the core sections on
71 the slope and platform (Wilber et al., 1990; Eberli et al., 1997; Ginsburg et al., 2001; Eberli et
72 al., 2004). These results give 1) insights on the internal and external controls of the margin
73 geometry and evolution, and 2) their influences on the stratigraphic evolution of the whole
74 transect. These modeling results provide conceptual insights for the sequential evolution of a
75 leeward carbonate margin.

76 **1.2 Bahamas case study: State of the art**

77 The Bahamas Archipelago is one of the most studied present-day analogues for ancient
78 tropical carbonate systems (Fig. 1A). It has yielded major contributions on the understanding
79 of carbonate systems (Schlager and Ginsburg, 1981; Mullins and Cook, 1986; Grammer and
80 Ginsburg, 1992; Schlager et al., 1994; Eberli et al., 2004; Betzler et al., 2014; Reijmer et al.,
81 2015). The low-angle leeward western slope of the GBB shows a remarkable progradation of
82 ~15 km into the Strait of Florida during the late Miocene (Eberli and Ginsburg, 1987; Eberli et
83 al., 1997) (Fig. 1B, Fig. 2). The platform and slope architectures are well described on the 2D
84 section known as the “Western line” defined by a continuous seismic platform-to-basin profile
85 (Eberli and Ginsburg, 1987) (Fig. 1B). Six research wells were core-drilled on this transect
86 during the Bahamas Drilling Project (BDP) (Ginsburg, 2001) on the platform, and during the
87 ODP leg 166 (Eberli et al., 1997a) on the slope. The platform margin however has not been
88 drilled for the Quaternary deposits younger than 1.7 Ma. The recent sedimentary processes on
89 the slope and the platform have been well established (Mulder et al., 2012; Chabaud et al.,
90 2016; Principaud et al., 2016; Harris et al., 2015; Wunsch et al., 2017; Schnyder et al., 2018).
91 However, the margin sedimentary regime is described with good confidence only for the
92 Holocene deposits by Wilber et al. (1990).

93 **1.2.1 Quaternary evolution of the Western margin**

94 The post-Cretaceous evolution of the “Western Line” transect is well constrained by the
95 identification of 3rd order sequences named *a* to *r* from the more recent to the oldest one
96 (Betzler et al., 1999; Eberli et al., 2002; 2004; Principaud et al., 2016; Wunsch et al., 2018) (Fig.
97 2).

98 During sequence *d* (2.6-1.7 Ma) the non-skeletal grains become abundant on the platform
99 with coral reefs in well Unda (Budd and Manfrino, 2001). The platform margin progrades with

100 the deposition of a thick regressive package but it is of reduced thickness on the slope. (Eberli
101 et al., 1997b; Kenter et al., 2001; Principaud et al., 2016).

102 Sequence *c* (1.7 to 0.33 Ma) corresponds to another significant progradation pulse of the
103 platform along with a transition from a ramp-like profile to a steeper platform margin profile
104 (Eberli et al., 1997b; Betzler et al., 1999; Principaud et al., 2016). Coevally the carbonate
105 production along the transect becomes almost entirely non-skeletal and peloid-dominated
106 (Eberli, 2000; Kenter et al., 2001; Manfrino and Ginsburg, 2001). These evolutions can be
107 related to a regional pattern of coral reefs decline and extinction during the Pleistocene,
108 culminating between 1.0 Ma and 0.8 Ma (Reijmer et al., 2002).

109 The interval 1.7 to 0.8 Ma is expressed by an subaerial exposure hiatus in well Unda and the
110 progradation of a coral reefal margin in well Clino, with an evolution from reefal to reef crest
111 and platform environment. After 0.8 Ma, the deposits in BDP wells Unda and Clino indicates
112 mostly platform top and platform margin environments, respectively (Budd and Manfrino,
113 2001; Manfrino and Ginsburg, 2001) (Fig. 2, Fig. 4). On the slope, sequence *c* to *a* are
114 dominated by the accumulation of periplatform-ooze wedges exported from the platform
115 during the highstand flooding periods (Eberli et al., 1997a). These packages form periplatform
116 drift wedges (Betzler, et al., 2014) under the action of the Florida Current (Principaud et al.,
117 2016; Wunsch et al., 2018). They are separated by condensed cemented intervals related to
118 the platform emersion during glacial lowstands (Eberli et al., 1997a; Eberli, 2000; Rendle and
119 Reijmer, 2002) (Fig. 4).

120 **1.2.2 Recent margin evolution and sedimentary processes**

121 For the Holocene highstand, at the top of the Western Line section the edge of the bank is
122 gently sloping with a 3-10° slope towards a slope break at 55-60 m of water depth (Wilber et
123 al., 1990; Ginsburg et al., 2001). The platform edge shows a 10 – 30 m thick accumulation of
124 Holocene fine to medium non-skeletal sands (Fig. 3A). A lithified marginal escarpment marks
125 an abrupt increase in slope reaching more than 30° down to a depth of 140-180 m. Direct

126 sampling of lithified samples a few meters inside the “escarpment wall” have also yielded
127 Holocene ages (G. Eberli, pers. comm.). At the bottom of the escarpment, a plunge-pool and
128 related slope-break deposits result from the hydraulic jump of density cascading currents
129 (Wilson and Roberts, 1992; Wilber et al., 1990; Wunsch et al., 2016; Schnyder et al., 2018).
130 Downslope the Holocene deposits form a 10 –to 60 m thick wedge of muddy periplatform
131 ooze. In the profiles of Wilber et al. (1990) the Holocene wedge clearly onlaps on Pleistocene
132 surface of the plunge pool (Fig. 3A). The Holocene platform edge and thin wall deposits also
133 appear to downlap this same surface in the lower part of the wall. Holocene sediment
134 accretion in front of the escarpment seems severely limited by the strong activity of the
135 downslope currents. Laterally along the GBB Western margin this profile vary with a more or
136 less developed slope wedge (Wilber et al., 1990; Principaud et al., 2016).
137 If one takes a conceptual look at the architecture resulting from the repetitive stacking
138 Highstand sediments accumulation at the margin identical to the observed Holocene package
139 (Fig. 3A), it shows an aggrading trend for the platform margin (Fig. 3B). The construction of any
140 prograding trend would have required additional sedimentary accumulation in front of and at
141 the toe of the wall (Fig. 3C). So when considering the margin progradation from 0.8 Ma to the
142 Holocene, other types of margin geometries than the observed Holocene geometry would
143 have to come into play at some points. The well-established “highstand shedding” regime of
144 the Western line transect (Schlager et al., 1994; Eberli, 2000; Eberli et al., 2004) is not
145 associated with a progradational geometry for the Holocene highstand on this section.

146 **1.3 Objectives of the paper**

147 We present here a stratigraphic forward numerical investigation of the evolution of the
148 Western GBB margin during the 1.7 – 0 Ma interval (Fig. 2). During this interval, the
149 sedimentation on the margin is only known by the 1.7-0.8 Ma coral reef found in Clino (Fig. 4),
150 and the present-day regime of the Holocene margin (Fig. 3A). Our objective is to investigate

151 the stratigraphic architecture in the uncertain domain between these two records with the
152 following questions in mind:

- 153 1) How has the margin evolved between 1.7 and 0 Ma?
- 154 2) What is the relationship between the margin geometries and the depositional model?
155 Which external and internal controls can be identified?
- 156 3) How does the architecture of the margin influence the progradation of the platform?

157 To apply a process-based modelling approach, it is necessary to use a unequivocal and
158 consistent stratigraphic framework with time-lines that will be considered as stratigraphic
159 markers across the whole well transect. Numerous chronostratigraphic studies have been
160 published on this transect (Eberli et al., 1997b, McNeill et al., 2001; Eberli et al., 2002; Rendle
161 and Reijmer, 2002; Principaud et al., 2016; Wunsch et al., 2018; see Table 1). They present
162 some discrepancies and uncertainties: Eberli et al. (2002) estimate an average error of 0.38
163 Myr in their estimation of sequence *c*, *b* and *a* in the ODP wells, and on the platform wells only
164 the 1.7 Ma and 0.8 Ma magnetostratigraphic markers can be considered as certain (McNeill et
165 al., 2001). Choices and hypotheses made in this paper are not a new chronostratigraphic
166 model for the “Western line” transect, but only a consistent synthesis of the published data.
167 The results of the numerical experiments are used in the discussion to propose a high-
168 resolution interpretation of the seismic record at the platform margin ((Eberli and Ginsburg,
169 1987; Principaud et al., 2016; Wunsch et al., 2018).

170 **2 Data and Methods**

171 **2.1 Well Data**

172 The ODP leg 166 wells 1005, 1004, 1003 and 1007 were drilled on the slope. They were logged
173 with a full set of wireline tools and a checkshot survey was realized for wells 1003, 1005 and
174 1007 (Eberli et al., 1997a).

175 The two wells Clino and Undawere drilled on the platform as part of the Bahamas Drilling
176 Project (BDP) campaign (Ginsburg, 2001). Both are located on a very shallow platform (about 7
177 m water depth), the well Unda is located 8.5 km inward of the well Clino along the « Western
178 Line » profile (Fig. 1A and Fig. 2. Both holes were logged with a standard suite of wireline tools
179 and a continuous vertical seismic profile (VSP) was shot (Ginsburg et al., 2001).

180 **2.1.1 Well Chronostratigraphy**

181 The chronostratigraphy on the ODP leg 166 slope wells is first based on the planktonic
182 foraminifer and nannofossil biostratigraphic framework built for the Leg 166 initial report
183 (Eberli et al., 1997a). Another dating approach was conducted by Rendle and Reijmer (2002)
184 on the wells 1007, 1003 and 1005, based primarily on $\delta^{18}\text{O}$ isotopes, grain size and X-Ray
185 Diffraction (XRD) analyses, U/Th dating and nannofossils bio-events to establish a high-
186 resolution stratigraphy of the Quaternary deposits (Rendle et al., 2000). Wunsch et al. (2018)
187 proposed another high-resolution stratigraphy based on the distal ODP 166 sites 1008 and
188 1006. They are not located in our zone of interest and record a different sedimentary regime
189 dominated by the Florida current (Rendle and Reijmer, 2002). As these are globally
190 undisturbed sections, compared to the slope wells these records present higher confidence
191 for the local stratigraphy, but higher uncertainty in the correlation with sections on the slope.
192 For the BDP wells an age model has been established as well using foraminifera, nannofossils,
193 strontium isotope stratigraphy and magnetostratigraphy (Mc Neill et al., 2001).

194 The chronostratigraphic correlation of the platform (BDP) and the slope (ODP 166 wells) has
195 not been established and published yet. A synthesis of the available literature led us to
196 establish a consistent age/depth correlation for all the wells, based only on geological
197 reasoning in case of contradictory results (Table 1). We did not endeavour to re-date the cored
198 sections. This work was guided by the premise that exposure surfaces on the platform form
199 time-lines corresponding to condensed and lithified layers on the slope (Eberli and Ginsburg,
200 1987; Eberli et al., 2002; Wunsch et al., 2016). For the slope wells we considered the

201 correlation of early lithified layers and peaks of High Magnesium Calcite (HMC) (Eberli et al.,
202 1997a; Rendle and Reijmer, 2002).

203

204 In this synthesis we identify and correlate the seismic sequence boundaries (SSB) A, B and C
205 defined by Eberli et al. (1997a, 1997b and 2002) (Table 1, Fig. 4).

206 With an age of 1.7 Ma SSB C was correlated with the Top Olduvai datum in the BDP Well Unda
207 and Clino (Manfrino and Ginsburg, 2001). This choice is consistent with the interpretation of
208 SSB C as a major downward shift of the regressive margin (Eberli et al.,1997b; ; Manfrino and
209 Ginsburg, 2001; Principaud et al., 2016).

210 SSB B was identified on the slope wells by Rendle and Reijmer (2002) with the condensed
211 surface of MIS (Marine Isotope Stage) 10 at 0.37 Ma (Lisiecki and Raymo, 2005).On the
212 platform SSB B was identified as an exposure surface at the top of a thick transgressive reefal
213 unit in BDP well Clino (40 – 28 mbsf) and the corresponding deep lagoonal unit in well Unda
214 (38 - 27 mbsf) (Manfrino and Ginsburg, 2001). We assume it to be the backstepping record of
215 the highly transgressive MIS 11 highstand (Lisiecki and Raymo, 2005; Miller et al., 2011).

216 SSB A is defined in the ODP slope wells as the base of the Holocene deposits (Eberli et al.,
217 1997a, 2002; Rendle and Reijmer, 2002;).. The corresponding exposure surface has not been
218 recovered in Clino and Unda, but has been identified with the bottom of the Holocene
219 unconsolidated sediments (Manfrino and Ginsburg, 2001; McNeill et al., 2001).

220

221 Three additional stratigraphic markers have been tentatively identified in the 1.7 - 0 Ma
222 interval in order to increase the stratigraphic constrains for the comparison of simulations with
223 well sections.

224 Marker *t20*, corresponds to the top of MIS 20 (0.79 Ma) (Lisiecki and Raymo, 2005). It is
225 identified in well 1003 by Rendle and Reijmer (2002) and is coeval with the
226 Brunhes/Matuyama magnetostratigraphic transition,identified in Clino and Unda by Manfrino

227 and Ginsburg, (2001). This surface was correlated in the ODP slope wells with the first notable
228 peak of HMC composition and a remarkable positive Vp anomaly (Table 1, Fig.4).

229 The second stratigraphic marker, *t12*, corresponds to the top of MIS 12 (0.42 Ma), identified in
230 ODP well 1005 and 1003 (Rendle and Reijmer, 2002). It can be correlated in wells 1004 with an
231 abrupt decrease in Low Magnesium Calcite (LMC) concentration (Fig. 4). In the BDP wells it was
232 correlated with the base of the transgressive reef/lagoon unit (Manfrino and Ginsburg, 2001)
233 interpreted to correspond to MIS 11 (Table 1, Fig. 4).

234 The third stratigraphic marker *t6* corresponds to the top of MIS 6 (0.13 Ma)(Lisiecki and
235 Raymo, 2005). It is identified in ODP wells 1005 and 1004 as the top of the penultimate
236 condensed level (Fig. 4), in good agreement with ODP 166 U/Th dating (Henderson et al.,
237 2000). It is absent in well 1003 that exhibits a major hiatus between *t10* and the Holocene
238 (Rendle and Reijmer, 2002). In BDP wells Clino and Unda, it was identified as the first
239 transgressive lag cored (Manfrino and Ginsburg, 2001) (Table1, Fig.4).

240 **2.1.2 Core lithofacies analysis**

241 A synthetic lithofacies model with five facies was elaborated from the published core
242 descriptions (Eberli et al., 1997a; Kenter et al., 2001; Manfrino and Ginsburg, 2001; Rendle and
243 Reijmer, 2002). The lithofacies are designated by the Well Facies code (WF) A to G (Table 2).
244 They are identified by a depositional environment, range of Dunham sedimentary fabric and
245 dominant cementation state and mineralogical composition.

246 The highstand carbonate sedimentation on the platform is dominantly aragonitic with a fine-
247 grained (Silt and Clay size) and peloidal assemblage (Eberli et al., 1997a; Chabaud et al., 2016;
248 Harris et al., 2015). It originates mostly from aragonitic green algae and seagrass production,
249 especially *Halimeda* sp. and *Thalassia* sp., and whiting events (Eberli et al., 1997a; Manfrino
250 and Ginsburg, 2001; Chabaud et al., 2015; Harris et al., 2015;).

251 WF A is the periplatform ooze slope facies corresponding to the off-bank export of the
252 highstand platform production (Wilson and Roberts, 1992; Schlager et al., 1994; Eberli, 2000;;
253 Wunsch et al., 2018).

254 WF B corresponds to the condensed deposits associated with glacial sea-level lowstands
255 (Eberli et al., 1997 a; Eberli, 2000; Chabaud et al., 2016; Wunsch et al., 2017).. WF B is
256 aragonite-poor due to 1) the dissolution of aragonite followed by the precipitation of an High-
257 Magnesium Calcitic micro-sparitic cement (Schlager and James, 1978; Mullins et al., 1980;
258 Mullins et al., 1985;; Munnecke et al., 1997; Eberli, 2000; Rendle et al., 2000; Melim et al.,
259 2002;) and 2) a higher relative input of calcitic pelagic tests during lowstands (Eberli et al.,
260 1997a; Eberli, 2000; Chabaud et al., 2016). WF B is clearly identifiable with 1) the marked
261 decrease in aragonite composition in the XRD mineralogical log and 2) P-positive Wave velocity
262 anomaly in relation with 3) early lithification state (Eberli et al., 1997a).

263 Several lower slope sub-facies are incorporated into WF A for synthetic considerations(Eberli
264 et al., 1997a).

265 WF C corresponds to a variety of coral reef facies (Kenter et al., 2001; Manfrino and Ginsburg,
266 2001). WF D is interpreted by Manfrino and Ginsburg, (2001) as high-energy sandy deposits of
267 inner platform beach and shoals. It as the last member of shallowing upward sequences (Aurell
268 et al., 1995)

269 **2.2 Seismic data**

270 The seismic interpretation has been performed on a dataset composed of three different
271 acquisitions on the “Western Line” transect (Fig. 2).

272 1-The original “Western Line” profile acquired in the 1980’s. Resolution in this seismic data is
273 around 30 m in the upper part studied here It is presented in the original undersampled
274 publication format with one trace out of seven (Eberli and Ginsburg, 1987).

275 2- Wunsch et al. (2018) (Fig. 9 A) have published the reprocessed version of this seismic,
276 presented also in Eberli et al. (2004) (Fig. 16, from the platform edge and margin between well

277 1005 and well Clino for 0 to 700 ms TWTT). . As is clearly visible in Eberli et al. (2004) due to
278 the very high impedance contrasts on the shallow platform, the seismic data have been cut at
279 ~ 0.08 ms TWTT. It gives the outer platform a flat top appearance, whereas it is indeed sloping
280 from 7.6 m water depth in Clino (Manfrino and Ginsburg, 2001) to 60 m at the platform edge
281 (Wilber et al., 1990)(Fig. 11A).

282 3- Slope seismic data collected during the seismic survey of Leg 1 of the Carambar cruise
283 (Mulder et al., 2012). have a vertical resolution of 2 m and are relevant down to
284 approximately 1s TWTT (Principaud et al., 2016). A small displayed section in Figure 11 is part
285 of the ODP 166 high-resolution dataset studied by Anselmetti et al. (2000).

286 **2.2.1 Well tie**

287 Well-tie data were published for the ODP well sites (Eberli et al., 1997a; Anselmetti et al.,
288 2000; Eberli et al., 2002; Wunsch et al., 2018) providing with time-depth points for the SSB A, B
289 and C (Fig. 2B). The preservation of reflector continuity for SSB B on the slope gave us a
290 slightly shallower value at well 1005 of 80 ms TWTT versus 100 ms. Eberli et al. (2001)
291 published also well tie data for the platform wells with the reprocessed seismic. We use these
292 values, though for SSB A they fall above the cut at 0.08 s. The time geometry of SSB A and the
293 seafloor was reconstructed based on these points, the reflectors visible at the platform edge
294 and similar to the geometry of Wilber et al., 1990, and the knowledge of the sea-floor depth at
295 the platform edge (55-60 m, Wilber et al., 1990) and at Clino and Unda (7.6 and 6.7 m
296 respectively, Manfrino and Ginsburg, 2001) (Fig. 11B).

297 **2.3 Stratigraphic forward modeling**

298 **2.3.1 Model outlines and strategy**

299 The numerical forward stratigraphic DionisosFlow model (Granjeon and Joseph, 1999) was
300 designed to investigate the 3D development of siliciclastic and carbonate sedimentary systems
301 at the basin scale. It has been used for smaller scale clastic or carbonate systems (Rabineau et

302 al., 2005; Csato et al., 2014; Montaggioni et al., 2015) allowing reconstruction of sedimentary
303 architectures below the fifth order time-scale resolution. The model offers the possibility to
304 test the impact of a conceptual depositional model on the internal stacking pattern and
305 stratigraphic evolution of the resulting sedimentary accumulation (Warrlich et al., 2008;
306 Montaggioni et al., 2015; Lanteaume et al., 2018). In this study the choice of the processes and
307 the values of the parameters are based on the available geological constraints and fitted
308 through a trial and error process. The quality of experiment is determined by the fit of the
309 simulated stratigraphic markers position against their core interpretation and the valid
310 geometry of the reconstructed present-day margin profile.

311 Three modelling experiments are tested on DionisosFlow (Fig. 5).

- 312 • Experiment 1 looks at the margin geometry associated with a progradation driven
313 entirely by the highstand shedding of the inner platform production.
- 314 • Experiment 2 investigates the influence of bio-constructed and early cemented
315 carbonate production at the margin.
- 316 • Experiment 3 tries to reproduce the platform evolution after 0.8 Ma under the
317 sedimentary regime described in the Holocene (1.2.2).

318 The three simulations aim at evaluating the relations between highstand production and
319 shedding and the platform progradation, and the impact of carbonate producers changes
320 under a given eustatic history.

321

322 We used here a 42 km long 2D model, with a grid resolution of 50 m. Time is discretized into
323 340 time-steps of 5 kyr from 1.7 to 0 Ma BP. This pseudo 2D section represents the “Western
324 line” transect projected in a direction orthogonal to the slope (Fig. 1B). It comprises 12 km of
325 platform domain, and 30 km of slope domain. Due to the limited modeling of the contour
326 current activity in a 2D section, the displayed zone of interest is limited to the slope domain
327 and stops downward of well 1007 (Fig. 1B), with 12 km of platform domain and 9 km of slope

328 (21 km in total). The ODP and BDP wells were also projected under a cylindricity hypothesis on
329 this modelled section (Betzler et al., 1999).

330

331 In DionisosFlow carbonate production is defined through time by the definition of a source
332 function. It describes CaCO_3 production rate according to water depth. In this study it is tied to
333 a type of carbonate sediment material that can be more or less easily traced back to a mix of
334 biogenic sources. Depending on the simulated sediment, this sediment source function can
335 integrate already a certain range of mixing, degradation and transport processes in the
336 simulated « production » process. In that case it is would be more aptly described as an
337 “accumulation” rate. The production rates are defined in order to fit, insofar as possible, the
338 observed architecture. They are heavily dependent on the geometry and transport efficiency
339 of the simulation.

340

341 The transport processes are modelled in DionisosFlow by a non-linear diffusion law
342 approximation (Granjeon, 2014). Several diffusion coefficients are attributed to each sediment
343 class in order to model the slope-driven transport and the wave-driven transport. The slope-
344 driven transport expresses the sediment flux $Q_s=K*S$ where S is the local slope, and K the
345 diffusion coefficient in km^2/kyr . In the western GBB sedimentary system the major part of the
346 transport of the fine-grained production on the platform towards the slope is due to an
347 advection process: density-cascading of sediment-laden water from the platform (Wilson and
348 Roberts, 1992; Eberli, 2000; Wunsch et al., 2016). This remobilization of sediment on the
349 platform was simulated in DionisosFlow using a 1D wave model defined with a wave base
350 action depth at 20 m (fair-weather waves). The bathymetry-dependent wave energy function
351 allows the remobilization of the sediment according to the local wave energy. Sediment
352 transport on the platform is actually driven by the wind and the shallow tidal currents (Harris
353 et al., 2015). This wave-driven diffusion function is used as a diffusion boost to account for

354 these complex shallow transport processes on the flat platform. The reworked sediment is
355 then transported according to the local slope under the rules of gravity-driven diffusion.

356 **2.4 Simulations parameters**

357 **2.4.1 External controls**

358 A constant and uniform subsidence rate of 34.1 m/Myr was assumed as there is no evidence of
359 vertical relative sediment displacement along the transect (Eberli and Ginsburg, 1987; Eberli et
360 al., 2004; Principaud et al., 2016; Wunsch et al., 2018). This value is calibrated by the
361 reconstitution of the correct present-day position for SSB C line and the 56 m thick
362 accumulation observed at well Unda. The eustasy parameter was derived from the curve of
363 Miller et al. (2011) resampled at 5 kyr resolution. In order to better constrain the real
364 accommodation space and sedimentation rate, we also simulated the mechanical compaction.
365 The definition of the initial basement topography is a key assumption for the whole simulation
366 (Montaggioni et al., 2015; Lanteaume et al., 2018). We considered the depth of the SSB C in
367 the six wells of the section to draw a 1.7 Ma topographic profile consistent with the seismic
368 interpretation. The initial sea-level position at 1.7 Ma was derived from the location of the first
369 onlap in the seismic interpretation. The platform level is thus set at 40 m above sea-level at 1.7
370 Ma.

371 The Santaren Current is considered as a major external control, limiting sediment
372 accumulation at the toe-of-slope (Betzler et al., 1999; Rendle and Reijmer, 2002; Betzler et al.,
373 2014; Principaud et al., 2016; Wunsch et al., 2018). It was integrated in the pseudo-2D
374 DionisosFlow with an open boundary condition on the basin section westward of well 1007. A
375 constant northward discharge of 0.01 km³/Myr of fine-grained sediment is applied. It prevents
376 deposition in the basin fixes the toe of the progradation at ~10 km from the platform break.
377 In the model the contour current effect was activated after 0.8 Ma, though it has likely been
378 active since the Pliocene (Rendle and Reijmer, 2002; Principaud et al., 2016; Wunsch et al.,

379 2018). This is consistent with the sedimentary profile of the ODP well 1007, with 25 m of
380 deposits between 1.7 Ma and 0.8 Ma, and only 12 m after.

381 **2.4.2 Definition of carbonate producers**

382 Three different carbonate producers are considered in our experiments for the Quaternary
383 interval (1.7 - 0 Ma). They are simulated by different bathymetry-dependent source functions
384 (Fig. 6), and different high-diffusion or low-diffusion gravity driven transport laws, determining
385 respectively low or high slope angle of accumulation (Granjeon, 2014). Following the analysis
386 of Kenter (1990) the slope of accumulation of the carbonate production is directly related to
387 its dominant sediment fabric.

388 As explained in section 4.1 the value of the wave transport coefficients for the same facies can
389 vary between different experiments in order to keep a comparable off-bank sediment flux
390 (Table 3). The contrast in wave-driven diffusion coefficients expresses the easy mobilization of
391 fine-grain uncemented sediment in respect to the cemented material accumulated *in situ*.

392 The contrast between the high-diffusion and low-diffusion facies is always preserved. Low
393 slope-driven diffusion coefficients (Table 3) expresses the ability of cemented,
394 bioconstructed/binded or coarse grained facies to build stable accumulations with steep slopes
395 (Kenter, 1990; Playton et al., 2010).

396

397 The first producer, designed as “aragonite ooze”, corresponds to the fine-grained aragonite
398 ooze produced on the platform. It has a very high gravity diffusion coefficient, constrained by
399 the very low slope angle of periplatform ooze accumulation (Kenter, 1990; Playton et al., 2010)
400 (Table 3). The ooze deposits cannot form any relief on the platform nor accumulate on the
401 steep margin (Fig. 5). It is easily remobilized by the hydrodynamic currents on the platform and
402 exported to the slope (Fig. 5). It is simulated with a high value of wave driven-diffusion
403 coefficient (Table 3).

404

405

406 Two other producers were defined to account for the marginal production and accumulation.

407 Both are cemented low-diffusion sediment accumulating in steep marginal configurations

408 (Kenter, 1990; Grammer and Ginsburg, 2012; Betzler et al., 2016). The low diffusion value

409 limits also their transport in the low-angle slope domains. They have a low wave-driven

410 coefficient as they accumulate *in-situ*.

411 The first one is named as “reef & cemented talus” (RCT). It aims at simulating the lowstand

412 coarse cemented wedge described by Grammer and Ginsburg (1992), supplied in particular by

413 a fringing reef development.

414 The second one is named as “coarse & cemented platform edge” (CCPE). It aims at simulating

415 the sandy and cemented accumulation described at the platform edge by Wilber et al. (1990).

416 They are transported by shallow platform currents to this outer and deeper platform edge

417 depocenter at water depth extending from 10 to 60 m (Wilber et al., 1990). As explained in

418 section 4.1 the crudel model of hydrodynamism on the platform in these simulations is unable

419 to simulate consistently this transport toward the platform edge where the sediment is

420 accumulated and cemented. As a consequence the CCPE material is directly simulated as a

421 cemented low-diffusion sediment, and its source function is actually an accumulation curve in

422 the platform edge depocenter. Since it is composed of non-skeletal grains (ooids, pelletoids

423 and grapestone) produced on the inner platform (Wilber et al., 1990; Harris et al., 2015) the

424 CCPE producer is active in the simulation during platform flooding only.

425

426 A mechanical compaction curve was associated to each producer. For the « aragonite ooze » it

427 was designed from experimental results of five oedometers tests on periplatform ooze

428 samples from sediment cores of the Little Bahama Bank (LBB) northern slope, and three

429 oedometer tests on periplatform ooze of the same slope published in Lavoie et al. (1988). The

430 proposed curve is consistent with the porosity trend of the four ODP Leg 166 wells on the

431 slope. For the RCM and CCPE material, the “coarse” compaction curve of Caspard et al (2004)
432 calibrated for the platform margin of the “Western Line” section was used.

433 **2.4.3 Production laws**

434 The production of the “aragonite ooze” facies occurs during whittings event and with the
435 degradation of green algae and seagrasses (*Halimeda* sp., *Thalassia* sp.) on the shallow
436 platform (0-10 m water depth) (Schlager and Ginsburg, 1981; Manfrino and Ginsburg, 2001;
437 Harris et al., 2015). It decreases progressively with the light intensity and stops at 50 m water
438 depth corresponding to the base of the present-day photic zone in Bahamas (Schlager et al.,
439 2005) (Fig. 6).

440 The production function for the RCT facies is defined with maximum production at 10 m water
441 depth as observed for corals (Pomar and Hacq, 2016) (Fig. 6). This production is also restricted
442 to the high wave energy domain above 80W/m^2 in order to prevent it reaching in the shallow
443 platform interior. The sustained production rate between 30 and 50 m allows to account for an
444 oligotrophic component (Betzler et al., 2016) and the gravity driven accumulation of erosional
445 lithoclasts (Grammer and Ginsburg, 1992).

446 The production of the CCPE facies is defined with a similar shape but it creates slightly deeper
447 accumulation down to the mesophotic zone (Wilber, et al., 1990) (Fig. 6).

448 The values of the production rate vary during the simulation (Fig. 6). These variations come
449 mostly from the trial-and-errors calibration of the best fit for all the three experiments. They
450 also account for the general warming that followed the end of the Mid-Pleistocene Transition
451 and the Mid-Bruhnes event (~ 0.45 Ma) (Reijmer et al., 2002; Wunsch et al., 2018). The
452 increasing trend for the “aragonite ooze” and “CCPE” facies production corresponds to the
453 increase in the flooded surface of the platform during the highstands (Kievmann, 1998). The
454 very high values of the “aragonite ooze” production for Experiment 2 are explained in section
455 4.4.

456 **2.4.4 Definition of resulting lithofacies**

457 The definition of five simulated lithofacies, based on the sediment composition and
458 sedimentation rate, allows to highlight and understand the interplay between the muddy
459 aragonitic highstand sediments in the platform and slope and the coarser or more cemented
460 margin sediments (Table 4).

461 The two slope facies (below 150 m) “Periplatform ooze” and “cemented ooze” are
462 distinguished only by a sedimentation rate threshold of 1000 m/Myr. The diagenetic signal of
463 early cementation is simulated here (Fig. 7, Fig. 8) using the sedimentation rate as a proxy.

464 **3 Results**

465

466 **3.1 Experiment 1: fine-grained uncemented margin**

467 Experiment 1 is constructed with reefal production between 1.7 and 0.8 Ma only, leaving only
468 the inner platform aragonite ooze production between 0.8 and the present (Fig. 6). The result
469 shows a remarkable contrast between these two. During 1.7-1.4 Myr interval, the
470 accumulation of mostly reefal production on the upper margin profile creates a lowstand
471 wedge, both prograding downslope and onlapping upslope. It finally covers the whole platform
472 domain during the 1.5-1.4 Ma transgression (Fig. 7A). During this period there is bypass on the
473 steep margin and reduced deposition in the slope. During the following 1.4-0.8 Ma interval the
474 prograding/aggrading evolution of the margin evolves towards a more forced prograding
475 pattern. Vertical accretion on the platform is much reduced, but becomes dominated by
476 aragonite ooze production (Fig. 9A). Accumulation of reefal production at the front of the
477 margin ensures the profile progradation as the slope accumulation is much reduced.

478 Overall during this period the platform margin has prograded and steepened. It has created an
479 accretionary slope profile with a constant gradient and a flat-top platform (Fig. 7A).

480 The profile geometry is considerably modified after 0.8 Ma until 0.42 Ma. There is almost no
481 deposition in the system and no effective progradation of the platform (Fig. 7C). This general
482 modification is due to both the end of low-diffusion reefal production and the change of
483 eustatic regime with lower maximum values and two marked falls at 0.6 and 0.42 Ma (MIS 16
484 and 12) that reduce the available accommodation space.

485 With the major transgression of MIS 11 (0.42 – 0.37 Ma) the platform is flooded again allowing
486 accumulation of aragonite mud on the platform and export downslope of a very large
487 onlapping highstand wedge (in red on Fig.7A). The successive flooding of MIS 9 (0.34 – 0.30
488 Ma) and 5 (0.13 – 0.07 Ma) leaves no large accumulation on the platform, but two slope
489 wedges that onlap progressively above the platform edge (Fig.7). This succession creates an
490 accretionary prograding margin and a smooth slope profile with a very open platform margin
491 (Fig.7 C). Consequently the Holocene leaves a continuous prograding tract of mud, without the
492 onlap of a distinct slope wedge (Fig.7 A).

493

494 Experiment 1 results partially reproduce the platform accumulation in wells Clino and Unda.
495 On the slope it captures the general increase of sedimentation rates after 0.8 Ma and the
496 alternation of thick interglacial highstand packages with condensed lowstand surfaces.

497 However it overestimates the sediment thickness in the slope wells after 0.42 Ma, and
498 underestimates it before 0.8 Ma (Fig. 9A). There is construction of a progradational margin but
499 the progradation is not developed enough (Fig. 7C).

500 Most importantly, the steepening trend and the present-day profile are not reproduced (Fig.
501 7A). A constant smooth slope is instead realized as only one diffusive material is accumulated.

502 Any increase in production and export would lead to larger progradation but also greater
503 overestimation of the slope accumulation. A decrease would result in loss of progradation or
504 even no margin deposition after 0.8 Ma, though the thickness at the slope well would be more

505 correct. The constant slope depositional profile is unable to reproduce the steep margin and
506 low angle slope transect evolution.

507 This experiment of highstand progradation of uncemented fine-grained sediment tracts is not
508 consistent with the progradation of the observed section. Another depositional model must be
509 considered for the Quaternary leeward slope.

510 **3.2 Experiment 2: Cemented margin**

511 For the 1.7-0.8 Ma period, experiments 1 and 2 are fairly identical, except for the thickness of
512 the downslope aragonite mud deposits (Fig. 9B). This might be a consequence of the increased
513 wave diffusion coefficient (export efficiency) in experiment 2 (Table 3).

514 However, after 0.8 Ma, the depositional architecture is quite different: during the 0.8-0.4 Myr
515 interval, deposition of cemented facies occur on the margin, maintaining the steepening trend
516 under a forced regression regime (Fig. 7A and B). Export of aragonite mud on the slope also
517 occurs (Fig. 9B). Similarly, the MIS 11 flooding after 0.42 Ma leads to aragonite mud
518 accumulation on the platform and the slope (Fig. 8). However the onlapping slope wedge is in
519 a lower position and of smaller volume than in experiment 1. There is aggradation of RCT
520 material in the margin, maintaining the steep profile. RCT material also backsteps on the
521 platform (Fig. 7B). This can be related to the reefal accumulation observed in well Clino
522 between 48 and 35 mbsl (Fig. 9B) and interpreted by Manfrino and Ginsburg (2001) as a reefal
523 backstep. Accumulation is relatively reduced during MIS 9 (0.34 – 0.3 Ma) on the platform and
524 the onlapping slope wedge. The MIS 8-6 (0.3 - 0.13 Ma) interval shows only accumulation of
525 cemented material on the margin, forming a lowstand prograding wedge onlapping up to the
526 platform edge and dowlapping down to the top of the slope (Fig. 7C). MIS 5 (0.13 – 0.07 Ma)
527 repeats the depositional pattern of MIS 11 (0.42 – 0.37 Ma) with a reduced thickness and no
528 backstepping of the marginal cemented accumulation. The sea-level fall during MIS 2-4 (0.07-
529 0.01 Ma) leads to the deposition of another lowstand marginal wedge of cemented material. It

530 evolves into an aggrading margin with the Holocene transgression and the deposition of the
531 platform and onlapping slope highstand deposits (Fig. 7C).

532 This experiment reconstructs fairly well the steepening trend and the present-day geometry of
533 the profile (Fig. 7A). The well succession on the slope and platform is well reproduced,
534 especially in terms of the different sedimentary packages and the total thickness (Fig. 9B).

535 However the thicknesses of the highstand packages after 0.33 Ma are always moderately
536 underestimated (Fig. 9B). The repartition of the two simulated facies is in good agreement
537 with the information from the wells. The highstand shedding pattern of off-bank mud export
538 into onlapping slope wedges is well reproduced in this experiment. The « Aragonite mud » is
539 accumulated on the inner platform and on the slope, in onlapping highstand wedges separated
540 by aragonite poor glacial layers. The cemented facies accumulates in the margin in two
541 positions. It creates lowstand marginal wedges during the platform emersion periods,
542 especially during the MIS 16 (0.68 – 0.62 Ma) (, MIS 12 (0.48 – 0.42 Ma), MIS 8-6 (0.3 – 0.13
543 Ma) and MIS 4-2 (0.07-0.01 Ma) intervals. Its ability to accumulate at steep slopes allows to fill
544 part of the accommodation space available on the margin during these periods. The cemented
545 facies also aggrades at the platform edge during flooding periods, maintaining a steep margin
546 profile. However this affects the exact restitution of the platform depositional profile. Very
547 flat-top platform morphology are created, as early as 1.5 Ma, whereas the present-day profile
548 show a sloping geometry seaward of Clino and a more open margin (Fig. 7C). The RCT
549 accumulation at the margin creates an inconsistently steep and shallow geometry.

550 The accumulation of cemented facies in lowstand marginal wedges allows for steepening of
551 the profile . The and the progradation of the platform (Fig. 7C). The architecture obtained is
552 that of a composite prograding margin. This experiment 2 proposes a satisfying forward
553 reconstruction, but the exact nature and existence of the prograding cemented lowstand
554 wedges need to be assessed.

555 **3.3 Experiment 3: Cemented margin during highstand only**

556 The results of experiment 3 stand in-between those of Experiment 1 and 2. Indeed it
557 comprises a cemented facies, as Experiment 2, but the production after 0.8 Ma is nevertheless
558 limited to the highstand periods (Fig. 8). Before 0.8 Ma the results are very similar to
559 Experiment 1, with the same deficit of export to the slope, probably related to the relatively
560 low value of the wave-diffusion coefficient (Fig. 9C and Table3). During the critical period
561 between 0.8 and 0.42 Ma the production is limited to the margin area with the CCPE in a
562 forced regression configuration (Fig. 7A and B). The reality of non-skeletal carbonate
563 production for the CCPE accumulation during this period of very limited platform flooding is
564 debatable. This is why reduced production values were attributed to this facies during this
565 period (Fig. 6). After 0.42 Ma the results for the slope domain are similar to the Experiment 1,
566 with very high sedimentation rates (Fig.8). The margin profile is however similar to Experiment
567 2, but with less progradation (Fig. 7C). In the absence of lowstand production the cemented
568 margin is simply aggrading, as proposed in Figure 3B.

569

570 In this last experiment, the general architecture is well reconstructed, except in the slope
571 (excess of sediment) and in the reduced platform progradation. In contrast with experiment 1,
572 the simulated section in Clino is fairly correct (Fig. 9C). Indeed the platform profile is well-
573 reproduced in this scenario, with a steep margin escarpment but still a relatively convex and
574 open platform to margin transition (Fig. 7A). This is a good validation of the reproduction of
575 the Holocene platform edge depocenter described by Wilber et al. (1990). The accumulation of
576 cemented material during highstand flooding periods allows building a steep leeward margin
577 profile, but the major drawback of this simulation is the absence of progradation even with
578 very high rates of export and sedimentation on the slope. In a transect dominated by leeward
579 offbank transport and highstand shedding, the presence of the lowstand marginal wedges of
580 experiment 2 still appear critical for the progradation of the platform.

581 **3.4 Platform-to-basin Stratigraphic evolution**

582 The DionisosFlow simulations defines two major periods for the Quaternary interval. They are
583 separated by a transition interval between 0.8 and 0.4 Ma that corresponds to the transition
584 from 41-kyr eustatic cycles to the 100-kyr eustatic cycles (Fig. 7D).

585 After the sea-level fall at 1.7 Ma, a well-developped coral reef progrades in the upper margin
586 (Budd and Manfrino, 2001). The progradation of the reef and lagoon unit is clearly reproduced
587 in all the Dionisosflow experiments. It is illustrated in well Clino by the vertical succession of
588 coral framestone, coral floatstone and lagoonal mud until 70 mbsf (Manfrino and Ginsburg,
589 2001) (Fig. 4 and Fig. 10). The Dionisos experiments correlate this growth episode with the
590 1.7–1.4 Ma time interval which corresponds to a general sea-level rise (Fig. 7D). Deposition in
591 the slope is limited and seems to start after the more widespread flooding of the platform
592 landward of well Unda after 1.5 Ma (Fig. 8).

593 After the initial build-up of this aggrading/prograding reefal wedge at the margin, the
594 simulated stratigraphy evolves towards a regressive pattern. Important changes take place
595 during the normal to forced regressive interval (0.8 - 0.42 Ma) (Fig. 6) with very little
596 accumulation on the platform (Fig. 7A). In Clino, a 10-m-thick lagoonal mud interval may
597 indicate a significant flooding possibly related to the relative sea-level highstand of MIS 17
598 (0.71 – 0.68 Ma) or MIS 19 (0.79 – 0.76 Ma). Otherwise the lithologic records in wells Clino and
599 Unda for this period show reduced accumulation, with four emersion surfaces in 20 m of
600 stacked platform deposits (WF D and E) (Fig. 4). This corresponds to the globally low sea-level
601 values of the eustatic curve.

602 . This eustatic evolution between 0.8 and 0.42 Ma ensures that the sediment accumulation is
603 limited to the margin domain (Fig. 8). The lower accumulation rates on the slope combined
604 with the margin progradation lead a steepening of the profile.(Fig. 7A).

605 After the warming phase corresponding to the Mid-Brunhes Event at ~0.45 Ma (Reijmer et al.,
606 2002; Montaggioni et al. 2015; Wunsch et al., 2018), the very large transgression of MIS 11

607 (0.42 – 0.37 Ma) is the first flooding of the whole GBB platform (Aurell et al., 1995; Kievmann
608 et al., 1998). It is well expressed in the three simulations as well as in the platform wells (Fig.
609 9). On the platform, a retrograding transgressive package compound of interlayered coral
610 floestone and lagoonal mud correlates in experiment 2 with a major increase of “Aragonite
611 ooze” sediment (Fig. 7A and Fig. 9). The coeval sediment bypass in the marginal escarpement
612 and the thick onlapping deposit in the slope (53 m in well 1005) are well apparent in the three
613 experiments (Fig. 7A). Flooding of the platform occurs during MIS 9 (0.34 – 0.3 Ma) and 5 (0.13
614 – 0.07 Ma) (Aurell et al., 1995; Kievmann, 1998; Rendle and Reijmer, 2002) (Fig. 9). MIS 7 sea-
615 level peak is distinctively lower (Lisiecki and Raymo, 2005; Miller et al., 2011) and might not
616 have flooded the whole platform (Fig. 7D). Concerning the platform and margin, the detailed
617 identification in wells and seismic record of the highstand packages between SSB B and A is
618 relatively difficult (Eberli et al., 2013). Deposition during MIS 10-6 (0.37 – 0.13 Ma) appears
619 very limited in Clino and Unda, with mixed skeletal/non skeletal accumulation in the former
620 (Fig. 9). MIS 5 (0.13 – 0.07 Ma) highstand is instead well-associated with platform deposits in
621 both Unda and Clino.

622 A remarkable result of the Dionisos simulation is the simulation of the actual sedimentation
623 rates on the section (Fig. 8). They can reach up to 8 m/kyr during the MIS 11 (0.42 – 0.37 Ma)
624 transgression. Such high-values are driven by the very short duration of effective
625 sedimentation period and are similar to those of Wilber et al. (1990) for the Holocene. For
626 instance the Holocene slope wedge with sedimentation rates above 5 m/kyr is mostly
627 deposited after 5 kyr B.P., when the platform flooding is effective, and not since the beginning
628 of MIS 1 (14 kyr BP) (Lisiecki and Raymo, 2005; Montaggioni et al., 2015; Chabaud et al., 2016).

629 **4 Discussion**

630 **4.1 Numerical experiments limitations**

631 Several limitations exist in the DionisosFlow numerical simulations, affecting the validity of the
632 detailed simulated architectures. They do not suppress however the consequences of the initial
633 design of the three numerical experiments on the obtained architecture, and the subsequent
634 conclusions.

635 Sub-aerial erosion is mostly limited to carbonate dissolution in Present-day systems (Schlager
636 et al., 2015). Values of 100 m/Myr or 250 m/Myr were inferred by Kolodka et al. (2016) and
637 Montaggioni et al. (2015). Considering an emersion period of 0.1 Myr this would lead to a
638 destruction of 10 to 25 m of platform material, which is up to half of the record for the
639 simulated period on the platform. This is also not in agreement with the remarkable
640 preservation of MIS 5 deposits all around the Bahamas archipelago (Aurell et al., 1995). As a
641 consequence a no-erosion approximation was used in our simulations. This hypothesis
642 provides a very tight control of the subsidence rate parameter.

643 A more accurate integration of erosion would bring valuable refinements to the problem.
644 Gravity, karstic and wave erosion probably occur at the steep margin wall during subaerial
645 exposure (Grammer and Ginsburg, 1992; Rankey and Doolittle, 2012; Fauquembergue et al.,
646 2018). The interpreted seismic surfaces also show convex upward geometries at the platform
647 edge that might suggest sub-aerial or wave erosion (Fig. 11B). These geometries are not very
648 well reproduced, showing instead flatter architecture in the experiments (Fig. 11D).
649 Improvement on the use of sub-aerial and shallow water transport model in further
650 experiments could yield better results.

651 The high-resolution production and export balance on the platform is modelled without a
652 specific model of the shallow hydrodynamic regime and transport. As a consequence, the
653 values of the wave diffusion coefficient and the production function for the mud are not

654 independent. They have to be set together to achieve the amount of export required for the
655 slope section in response to a given wave energy configuration at the platform edge. The
656 simulated wave-energy field depends on the margin geometry as it is depth controlled. As the
657 resulting wave energy pattern becomes more favorable, the diffusion coefficient needed for a
658 given flux of sediment decreases. The volume of accommodation space is also positively
659 affected by the off-bank export increase. As a result, both the production law and the diffusion
660 coefficient must be jointly decreased in order to maintain the balance between platform
661 accumulation and off-bank export. This is particularly notable for experiment 2, with the
662 existence of a reefal shallow margin that strongly decreases the wave energy at the platform
663 edge. The « aragonite ooze » facies is also produced on a very large platform area, more than
664 100 km in W-E length (Harris et al., 2015), but here only a small section of 12 km is considered.
665 The production values must be artificially raised to account for the actual amount of mud
666 produced on a much larger surface.

667 As a consequence of the no-erosion hypothesis and the very high platform production values,
668 the accommodation space on the platform is filled very quickly. This differs from the present-
669 day GBB platform that appears partially underfilled (Harris et al., 2015). The total produced
670 volume simulated is directly controlled by the total accommodation space created during a
671 flooding phase. This leads to an overestimation of the sediment accumulation on the platform
672 during a marked transgression like MIS 11. Then the available accommodation space for the
673 following flooding phase like MIS 9 or 5 is artificially reduced. The discrete sampling of the
674 eustasy curve contributes to this result by missing out the maximum peaks, especially for MIS
675 5.

676 Here, the influence of contour currents is limited to an open lateral boundary condition. It
677 controls the position of the lower slope periplatform drift in the experiments. The control of
678 the morphology of the periplatform drift by the current action (Betzler et al., 2014; Wunsch et
679 al., 2016) or by gravitational failures (Rendle and Reijmer, 2002; Principaud et al., 2015;

680 Principaud et al., 2016; Schnyder et al., 2016) are integrated into the diffusion approximation
681 by the value of the diffusion coefficient for the “aragonite ooze”.

682 **4.2 Mechanisms and controls of the margin progradation**

683 **4.2.1 Importance of cemented facies at the margin**

684 All the three modeling experiments show a progradation of the platform for the interval 1.7-
685 0.8 Ma through the construction of a reefal margin (Fig. 7B). After 0.8 Ma, only the
686 experiments 2 and 3 show a progradation with an acceptable final profile geometry (Fig. 7C).
687 The accumulation of early cemented material at the margin is essential in these two
688 experiments to obtain these results. However they simulate two different marginal
689 architectures originating from two different sedimentary systems. Experiment 2 is based on
690 the development of marginal fringing reefs and an associated debris talus during platform
691 emersion. This model is able to fill the accommodation space in front of the margin by
692 accumulating material in this zone of steep topography during emersion periods. The resulting
693 general architecture corresponds to a dominantly reefal margin with a filled lagoon.
694 Experiment 3 model is based on the accumulation during highstand periods exclusively of
695 coarse and cemented platform production at the platform edge and on the margin. The
696 resulting general architecture is that of an open platform margin with a deeper prograding
697 escarpment. These are two conceptual hypotheses that can be compared to available
698 observations in the section and other margin depositional models.

699 **4.2.2 Lithological and stratigraphic characteristics of the prograding** 700 **margin**

701 In the model of Grammer and Ginsburg (1992) for the slopes of Tongue of The Ocean, MIS 2-4
702 lowstand carbonate production is realized by fringing reefs feeding a steep (35-45°) cemented
703 sand and debris talus. In their study on the LBB margin, Hine and Neumann (1977) observed

704 reefal growth on the leeward margin during the Holocene transgression. After the platform
705 flooding they are buried however by the leeward export of platform sands. Coral floatstone
706 intervals are observed until MIS 6 (0.19 – 0.13 Ma) in well Clino (Manfrino and Ginsburg, 2001)
707 as well as several rare occurrences of coral debris in the OPD leg 166 cores for the Quaternary
708 (Eberli et al., 1997a) (Fig. 4). All these observations indicate simply the persistence of coral
709 production in fringing reefs (Hine and Neumann, 1977; Grammer and Ginsburg, 1992) after the
710 regional peak of coral extinction described by Reijmer et al. (2002). This does not support the
711 scenario of experiment 2 of a coral reefal margin constantly accumulating during flooding and
712 emersion of the platform.

713 Indeed the role of coral production in the margin after 0.8 Ma appears much reduced
714 compared to its extent in experiment 2. The margin is on the contrary dominated by the non-
715 skeletal sand accumulation described by Hine and Neumann (1977) and Wilber et al. (1990) as
716 modelled in experiment 3.

717 Interestingly the opposite trend is observed in the Pacific, with an increase in coral reef
718 developpments after MIS 11 (0.42 – 0.37 Ma) (Montaggioni et al., 2015). Contrasting regional
719 environmental changes might be at play, but most probably the first cause of the relative
720 disparition of coral reefs lies in the onset of large muddy production on the flooded platform
721 (Hine and Neumann, 1977). However during emersion phases this inhibition is absent and
722 coral production can be maintained in fringing reefs as proposed by Grammer and Ginsburg
723 (1992).

724 Lowstand prograding marginal bodies have been described, by Grammer and Ginsburg (1992)
725 as sandy talus sourced by a fringing reef factory. Mulder et al. (2017) identified possible coarse
726 lowstand shelf-edge tidal deltas or gravity collapse deposits on the northern slope of the LBB .
727 Betzler et al. (2016) also described MIS 2-1 coarse lowstand wedges on the slope of the
728 Maldives atolls. They are dominated by rodoliths and large benthic foraminifers produced in
729 situ. A relevant ancient analogue for lowstand wedges could be found in the Messinian

730 marginal reefal clinofolds described by Reolid et al. (2014) in the Cariatiz carbonate platform
731 (Spain). Clinofolds are 80 m high and 200 m long bodies, prograding by redistribution of the
732 coral and Halimeda marginal production and through episodes of mass-failure redeposition of
733 very coarse debris during sea level falls. The very steep (30 -60 °) upper slope is preserved by
734 early lithification of the corals by microbialith crusts.

735 In regards of these observations the hypothesis in Experiment 2 of coarse lowstand talus, with
736 a fraction of coral component, appears conceivable. These wedges are critical in the
737 experiments for the filling of the accommodation space in front of the margin (Cemented
738 Lowstand Talus in Figure 10). However they do not have the development of the reefal margin
739 observed before 0.8 Ma, during a different regime of eustatic oscillations (Manfrino and
740 Ginsburg, 2001; Miller et al., 2011).

741

742 According to experiment 3, the escarpment is the site of accumulation of sandy platform
743 material. This is compatible with the present-day observations on the GBB leeward margin
744 (Wilber et al., 1990). The accumulation at the steep margin by cementation of the platform
745 production would be comparable in geometry to the deep boundstone factory described by
746 Playton et al. (2010). However in this case the progradation of the planar clinofolds of the
747 margin is realized by the accumulation of debris apron resulting from frequent autogenic
748 collapse. Such wedges of marginal progradation are lacking in experiment 3. As this non-
749 skeletal sands observed in the Holocene corresponds only to flooding periods, we propose a
750 conceptual model combining lowstand talus during emersion periods and aggrading platform
751 edge sand bodies during flooding periods (Fig. 10).

752

753 As a conclusion the sedimentary accumulation at the margin has changed between 1.7 Ma and
754 the Present-day. It has evolved from a reef-dominated margin to the Present-day cemented
755 sand accumulation. The progradation of the platform before 0.8 Ma has been mostly realized

756 by a coral reef barrier. After 0.8 Ma the geometry obtained with experiment 2 is the more
757 consistent with the observed Present-day geometry. It supports a conceptual model of
758 lowstand cemented talus wedges alimeted by an undefined carbonate source, possibly reefal
759 in part. It is distinct from the cemented non-skeletal sand accumulation deposited only during
760 platform flooding periods in an aggrading pattern. The progradation of the margin after 0.8 Ma
761 is realized by the succession of these two sandy and early cemented accumulations during
762 emersion and flooding phases (Fig. 10).

763 **4.2.3 Extrinsic and intrinsic controls**

764 From the simulations results the interaction between extrinsic and intrinsic factors and the
765 evolution of the margin architecture can be discussed.

766 The situation before 0.8 Ma of a partial flooding of the platform (Kievmann, 1998) appears
767 more favorable to the progradation than later when the platform is completely flooded during
768 every highstands. The change in the eustatic regime between 0.8 and 0.42 Ma with a net
769 increase of accommodation space is influential in this change of sedimentary regime with the
770 increase of non-skeletal production. After a regressive phase of accumulation on the margin,
771 the sediment deposition is now concentrated on the platform and slope. The second period
772 (0.42-0 Ma) corresponds to an overall increase in accommodation space, with higher
773 amplitude sea-level rises and falls than during the first period and the abrupt transition from a
774 sloping reefal margin to a steep cemented margin. The resulting comprehensive flooding of
775 the GBB platform inhibits coral growth at the margin, and leads instead to the aggrading
776 accumulation of non-skeletal sands at the margin (Fig. 10). This promotes a steepening of the
777 margin profile, accentuating in turn the contrast between total emersion phases, with the
778 development of a steep cemented talus *in front* of the margin, and the aggradation *on* the
779 margin during flooding of the whole platform.

780 The very pronounced series of sea-level falls starting at 0.6 Myr also enhance the
781 development of a steep marginal escarpment (Wilber et al., 1990; Eberli et al., 2004; Rankey
782 and Doolittle, 2012; Mulder et al., 2017) (Fig. 7).

783 Chabaud et al. (2016) observed a similar major change in sedimentary regime at MIS 11 (0.43 –
784 0.37 Ma) for the northern slope of the LBB, corresponding to the flooding of the whole bank.

785 Remarkably the higher sea-level has led to increased production and export of sediment to the
786 slope (highstand shedding), but only to minor platform progradation (Fig. 6 and Fig. 7A). This
787 modification of the sedimentary regime corresponds to the change of the margin geometry. In
788 turns, it seems to be controlled by the type and mechanical properties of the carbonate
789 production as well as by the eustatic regime. The progradation regime is not controlled
790 primarily by the ratio of production rate and accommodation rate, but by the properties of the
791 carbonate production. As the dominant muddy production cannot accumulate on the steep
792 slopes inherited from the reefal progradation, it is built by early cementation of the coarse
793 accumulations. The reduced volume and the geometry of this sandy platform edge depocenter
794 favour an aggradational stacking pattern as observed in experiment 3 (Fig. 7C).

795

796 The activity of the Santaren Current is undoubtedly a major control parameter of the sediment
797 accumulation on the slope and basin, especially of the geometry of slope wedges (Rendle and
798 Reijmer, 2002; Betzler et al., 2014; Principaud et al., 2016; Wunsch et al., 2017; Wunsch et al.,
799 2018). By preventing the sediment accumulation at the toe of slope, it enhances the
800 steepening of the transect indifferently of the progradation or aggradation of the platform
801 edge. It seems actually to have no direct influence on the margin geometry: in Wilber et al.
802 (1990) the geometry of the platform-edge depocenter is very stable for all the transect,
803 whereas the varying slope geometry further down is indeed related to spatial variations in the
804 current activity. The active off-bank density currents (Wilson and Roberts, 1992; Betzler et al.,
805 2014; Wunsch et al., 2016; Schnyder et al., 2018) are probably one of the main controls of the

806 aggrading geometry of the platform-edge depocenter. They create erosive plunge-pools at the
807 base of the margin wall (Wilber et al., 1990; Schnyder et al., 2018), and probably limit
808 sedimentary accumulation along the steep wall.

809 **4.3 Interpretation of the stratigraphic architecture in the seismic**

810 The high-resolution geometries and stacking patterns simulated with DionisosFlow offer a
811 consistent template of the margin evolution (Fig. 7). The interpretation of the seismic
812 geometries at the margin *per se* is difficult, as the cored wells do not really constrain the
813 physiography of the margin domain. Moreover the reflectors can be difficult to pick in this area
814 of high-frequency impedance contrasts and variations (Eberli et al., 2004). It is however
815 possible to propose an interpretation of different genetic bodies using the results of the
816 forward stratigraphic modeling (Fig. 11).

817 The seismic section of the margin was analyzed in terms of reflectors terminations: downlap,
818 toplap and onlap distinguishing between coastal onlap due to deposition at the base-level on
819 the platform or the margin and marine onlap due to deposition in the slope underwater.
820 Reflectors with good amplitude and continuity and significant terminations relationships were
821 highlighted. The variations in amplitude of the reflectors in the margin were also used by
822 interpreting the very bright reflectors as indicative of early cementation.

823 SSB C is downlapped by a well-organized prograding unit on the flatter upper margin, with
824 moderate amplitude and low continuity reflectors (Fig. 11B). Deposition is further reduced
825 below 270 ms TWTT, on the steepest part of SSB C profile, down to a lower slope marine onlap
826 at 400 ms TWTT.

827 More continuous but lower amplitude reflectors underline a forced regressive architecture,
828 carrying the platform edge down to a remarkable downlapping/onlapping suspended body at
829 200 ms TWTT. Accumulation is still reduced on the lower margin and the slope (Fig. 11B). As a
830 consequence the steepening of the margin profile increases. This phase seems to end with a
831 general retrogradation of the system highlighted by the development of a cemented surface at

832 the very edge of the platform. Deposition occurs then on the slope, with new marine onlap,
833 and is also backstepping on the relatively flat platform up to the very bright reflector identified
834 as SSB B (Fig. 11B).

835 This evolution is very consistent with the results of the numerical experiments. The forced
836 regressive evolution between 0.8 and 0.42 Ma (Fig. 6) as well as the final retrogradation during
837 MIS 11 (0.42 – 0.37 Ma) are well observed in all the experiments. The new profile of SSB B is
838 more similar to the present-day profile than SSB C (Fig. 11C). .

839

840 Above 180 ms TWTT the geometries appear quite different on the margin (Fig. 11B). Platform-
841 edge bodies, delimited by bright sub-horizontal reflectors and with internal downlaps can be
842 identified with the platform edge depocenters described in Wilber et al. (1990) (Fig. 10). They
843 are onlapped by steep margin wedges with very bright reflectors indicating probably cemented
844 material. In the slope bodies with moderate amplitude and very continuous reflections are
845 onlapping the steep margin (Fig. 11C). Downlapping cemented marginal wedges are observed
846 in the seismic (Fig. 11B) similar to the cemented marginal wedges of experiment 2 (Fig. 7C).
847 Coastal onlaps that indicate an accumulation during platform emersion especially MIS 6-8 and
848 MIS 2-4 (Fig. 11B).

849 The interpretation of the margin stacking pattern in the seismic yields an architecture
850 consistent with the numerical results. The early geometries show the progradation of a reefal
851 margin. The progradation/aggradation after 0.42 Ma appears to involve platform edge bodies
852 and prograding marginal cemented wedges. The observed geometry of the present-day
853 Holocene mud wedge stands out from the earlier MIS 5 or 11 slope periplatform wedge, but it
854 might not correspond to the preserved highstand geometry (Fig. 11C).

855 **5 Conclusions**

856 The use of numerical forward stratigraphic modelling allowed us to investigate the high-
857 resolution evolution of the Quaternary leeward margin of the GBB. Maximum information has
858 been extracted from the quality data of the platform and slope wells, as well as the
859 reprocessed seismic of Wunsch et al. (2018) by comparison with the results of several
860 conceptual models.

861 This study has shown that the evolution of the margin during the Quaternary interval of
862 interest (1.7 – 0 Ma) can be divided in two different phases, with a transition period between
863 0.8 and 0.42 Ma. The first period (1.7–0.8 Ma) corresponds to a period of partial flooding of
864 the platform and progradation of dominantly coral reef and lagoon system. The second period
865 (0.8-0.42 Ma) corresponds to a period of short and discrete flooding episodes of the whole
866 platform triggering massive muddy offbank transport, and lowstand periods of margin
867 accumulation and progradation.

868 The evolution of the transect architecture during this period cannot be explained only by the
869 offbank transport of the fine-grained platform production. The Present-day sedimentary
870 architecture and profile is actually only indicative of the recent Holocene platform-flooding
871 highstand conditions. It has been shown that different sedimentary regimes have probably
872 existed during the Quaternary not only before MIS 11 transgression (0.42-0.37 Ma) but also
873 after during the long-duration emersion periods.

874 The numerical investigation shed some light on the controls of the margin architecture and the
875 progradation of the platform. The margin profile as interpreted in the seismic and observed at
876 present day seems always due to the marginal accumulation of a cemented or bio-constructed
877 material, different from the fine-grained inner platform-production exported off-bank. This
878 marginal material is well known before 0.8 Myr as a coral reef drilled in Clino. The numerical
879 experiments do not give an unequivocal identification of the undrilled material after this date.

880 It shows nevertheless that the Present-day platform edge accumulation of platform sands is
881 not sufficient to explain the architecture of the observed Present-day margin.

882 The experiments demonstrated the role of lowstand marginal accumulation in the
883 progradation of a leeward carbonate margin. A carbonate factory has to be producing and
884 accumulating at the steep margin area during platform emersion. Its characteristics differ from
885 the fine-grained Present-day platform production to be able to accumulate there, meaning
886 coarser grain sizes, cementation or bio-construction. Such a lowstand component is not visible
887 in studies of the slope area, as shown in our experiments, and can be overlooked in the model
888 based primarily on geophysical and sedimentary data from the slope (Principaud et al., 2016b;
889 Wunsch et al., 2016; Wunsch et al., 2018). However coarse and cemented lowstands prisms
890 have been described in recent systems, notably in the Maldives by Betzler et al. (2016) and in
891 the Bahamas by Grammer and Ginsburg (1992). In that latter case the carbonate source
892 proposed was lowstand fringing coral reefs, but other carbonate sources like red algae or large
893 benthic foraminifera could be considered as well (Betzler et al., 2016).

894 The evolution of the architecture of the platform-to basin transect during the Quaternary
895 appeared controlled by the eustasy as well as the characteristics of the carbon production.
896 Eustasy produces a strong control on the timing of the evolution but the geometry is
897 controlled by the carbonate production. The diffusive DionisosFlow model highlights the
898 critical role of the stability domain of carbonate grains and early cementation (Kenter, 1990;
899 Playton, 2010) to build the steep margin/low angle slope accretionary profile of the GBB
900 leeward slope.

901 The change in carbonate production after 0.42 cannot be disconnected from the evolution of
902 the eustatic regime toward high transgression of 100-kyr cycles. The resulting comprehensive
903 flooding of the platform and large leeward off-bank transport of sediments was probably an
904 important factor in the demise of large coral reefs. The diminishing importance of the coral
905 production is coeval with a reduction of the progradation rate of the system.

906 This high-resolution forward modeling approach could be implemented in on a wider extent on
907 the well mapped Leeward GBB Bahamas slope (Principaud et al., 2016; Wunsch et al., 2018), or
908 other slopes. A 3D approach could fully integrate the effect of the contour currents. This
909 approach could be conducted further for “source-to-sink” estimations of production, transport
910 and deposition balances of sediments in the whole carbonate system. The inputs of the data
911 from the Bahamas Drilling Project wells Clino and Unda (Ginsburg et al., 2001) were invaluable
912 in this study. New subsurface drilling investigations of present-day carbonate margin can bring
913 major insights in the dynamic and controls of carbonate platforms.

914

915

916

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924

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926

927

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1145 **TABLE CAPTIONS**

1146 Table 1: Age, Depth and time position of this study stratigraphic markers in the six wells,
1147 compared with the previous publications on this transect.

1148 Table 2: The five lithofacies identified in the six wells of the study, with their lithology,
1149 depositional environment and, mineralogic and diagenetic fabric.

1150 Table 3: Values of transport coefficients for the DionisosFlow simulation.

1151 Table 4 : Definition of the simulated lithofacies from the output of the DionisosFlow
1152 simulations.

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1157 **FIGURE CAPTIONS**

1158 Figure 1. A: General location of the Great Bahama Bank (GBB) and the leeward western slope.

1159 In orange, the area surveyed by the Carambar Leg 1 mission (Mulder et al., 2012), with, in red,

1160 the interpreted transect. B: Multibeam bathymetry of the western GBB slope (Principaud et al.,
1161 2016) with the position of the “Western line” Seismic transect (Eberli and Ginsburg, 1987), the
1162 ODP 166 Wells (Eberli et al., 1997a) and the BDP Platform wells (Ginsburg et al., 2001).

1163 Figure 2. « Western Line » platform to basin seismic transect and the six reference wells. A:
1164 Original seismic data. B: Sedimentary sequences interpreted on the Western line, following
1165 Eberli et al., 1997a nomenclature. The six post-Miocene seismic sequences interpreted by
1166 Eberli et al., 1997b are displayed. The “Quaternary” (1.7 – 0 Myr) refers here to the specific
1167 interval studied here. The seismic data come, from left to right, from the Carambar 1 HR data
1168 published in Principaud et al., 2016; in the box, the reprocessing of the “Western line” original
1169 acquisition published by Wunsch et al., 2018, superimposed on the original “ Western Line ”
1170 data as published by Eberli and Ginsburg, 1987.

1171 Figure 3. Present-day geometry of the leeward GBB margin, after Wilber et al. (1990), and
1172 geometrical implications for the stacking pattern. A: Observed Schematic section of the
1173 depositional geometry for the Holocene and the previous interglacial stage, after the drawing
1174 of Eberli et al. (2004; Figure 17 C) and the section of Wilber et al. (1990; Fig. 3). B: Conceptual
1175 scheme of the aggrading stacking pattern resulting from the accumulation of the Holocene
1176 deposits of A) minimizing the supplementary material needed. C: Conceptual prograding
1177 stacking pattern resulting from the accumulation of the Holocene deposits of A) plus
1178 supplementary material in the marginal zone.

1179 Fig. 4. Well correlation for the ODP wells 1003 to 1005 and the two BDP wells Clino and Unda
1180 showing the lithofacies interpretation corresponding to table see Table 2) and the identified
1181 stratigraphic markers (described in section 2.1). Left-top corner: Wells positions in the
1182 “Western Line” (see Fig. 1B and Fig. 2).

1183 For the BDP wells Clino and Unda, from left to right, we present the interpreted lithofacies and
1184 the detailed lithological description of Manfrino and Ginsburg (2001). For the ODP 166 wells,
1185 from left to right, the interpreted lithofacies and the lithological description of Eberli et al.

1186 (1997), for well 1005 the ODP Vp seismic velocity (core (red) and log (black) data of Eberli et al.
1187 (1997a)), and the XRD mineralogical composition modified from Eberli et al. (1997a). In the
1188 middle the time evolution of the accommodation on platform calculated from the eustatic
1189 curve of Miller et al. (2011) with our hypothesis of constant subsidence rate of 34.1 m/Myr.

1190 Figure 5. Schematic of the three experimental designs for the DionisosFlows simulations after
1191 0.8 Myr. Before this date they are all similar to Experiment 2.

1192 Figure 6. DionisosFlow production laws. Left: the normalized production profiles for the three
1193 producers. Right: time evolution of the maximum production value for the three producers,
1194 with the difference between Exp.2 and Exp 1&3 for the aragonite ooze production. The
1195 production of the CCPE facies (in Exp. 3) is discontinuous with time.

1196 Figure 7. Simulated sections at 0 Myr. A: Age results for the three experiments, following the
1197 color chart presented in D). B: Lithofacies results for the three experiments, according to table
1198 3. The black line indicates the observed present-day profile. C: Detail view of the age results of
1199 the experiments for the margin and slope. D: Eustatic Sea-level variations for the simulated
1200 interval, after Miller et al. (2011) in black line, and selected data points for the DionisosFlow
1201 simulation (in red). The color indicates different time periods, corresponding after 0.8 Myr to
1202 MIS 19 to 1.

1203 Figure 8. Wheeler diagram for the three experiments results, expressing the sedimentation
1204 rate. The position of the wells is indicated. On the right the eustatic sea-level variations for the
1205 simulated interval, after Miller et al. (2011) in black line, and selected data points for the
1206 DionisosFlow simulation (in red). The color indicates different time periods, corresponding
1207 after 0.8 Myr to MIS 19 to 1.

1208 Figure 9. Basin to platform well correlation showing side by side the interpreted well and
1209 modelled deposits at the well location (right and left, respectively). The interpreted lithofacies
1210 log is represented on the right. On the left the simulated lithofacies column is shown, with the

1211 « aragonite ooze » facies composition log (solid line) in opposition to the sedimentation rate
1212 log (in dashed black line).

1213 Figure 10. Conceptual model of margin and slope architecture for the GBB leeward slope
1214 during the 100-kyr large sea-level oscillation period (0.45 - 0 Myr)

1215 Figure 11. High-resolution seismic interpretation for the GBB leeward margin on the data from
1216 Wunsch et al. (2018) and Eberli and Ginsburg (1987). From top to bottom: A) original seismic
1217 data, B) High-resolution interpretation, with the downlap (red), toplap (blue), marine onlap
1218 (light blue) and coastal onlap (light green). The colored line corresponds to the seismic surfaces
1219 identified by Eberli et al. (1997a), the black line to the additional time-line reflectors identified
1220 in this study. C) The interpreted margin section, with the stratigraphic stages colored as in
1221 Fig.7. D) Simulated margin section from Experiment 2, with the same time-color code from fig.
1222 7. This section is a projection of the seismic line orthogonal to the slope, therefor the
1223 bathymetric profile is steeper and the horizontal scales are not matched.

1224 TABLES & FIGURES

