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Passive obduction and gravity-driven emplacement of large ophiolitic sheets: The New Caledonia ophiolite (SW Pacific) as a case study?

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Passive obduction and gravity-driven emplacement

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of large ophiolitic sheets :

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The New Caledonia ophiolite (SW Pacific) as a case study?

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Obduction passive et mise en place gravitaire des grandes nappes

9

ophiolitiques : les ophiolites de Nouvelle-Calédonie (SW Pacifique)

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sont-elles un cas d'école ?

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by, par

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29

Abstract

The 300 km long allochthonous sheet of oceanic mantle forming the New Caledonia ophiolite displays three specific characters : 1. the ophiolite pile lacks concordant sheeted dykes and pillow basalt layers ; 2. the ophiolite, referred to as the Peridotite Nappe, is thrust over the basaltic formations of the Poya terrane which are classically thought to originate from a different oceanic environment; 3. The basal contact of the ultramafic sheet is remarkably flat all along New-Caledonia and the Peridotite Nappe has not been thickened during obduction, rather it experienced significant extension. This suggests that the peridotites have not been emplaced by a tectonic force applied to the rear. New petrological and geochemical results obtained from mantle rocks finally show that the Poya terrane may originate from the same oceanic basin as the peridotites. In this article, we consider such possible cogenetic links and we propose a simple model for the obduction of the New Caledonia ophiolite in which the Poya basalts represent the original cover of the Peridotite Nappe. We infer that continuous uplift of the subducted units buried beneath the oceanic lithosphere in the northern part of New Caledonia drove passive uplift of the ophiolite and led to erosion and to initiation of sliding of the basaltic layer. During the Priabonian (Latest Eocene), products of the erosion of the basaltic layer were deposited together with sediments derived from the Norfolk passive oceanic margin. These sediments are involved as tectonic slices into an accretionary wedge formed in response to plate convergence. The volcanoclastic sedimentation ends up with the emplacement of large slided blocks of basalts and rafted mafic units that progressively filled up the basin. Obduction process ended with the gravity sliding of the oceanic mantle sheet, previously scalped from its mafic cover. This process is contemporaneous with the exhumation of the HP-LT units of Pouébo and Diahot. Gravity sliding was facilitated by the occurrence of a continuous serpentine sole resulting from metasomatic hydration of mantle rocks which developed during the uplift of the Norfolk basement and overlying Diahot and Pouébo units. Progressive emersion of the obducted lithosphere allowed subsequent weathering under subaerial, tropical conditions

56

Key words : New Caledonia, Peridotite nappe, Poya terrane, HP-LT units exhumation, gravity sliding, passive obduction.

59

Résumé

61 *La nappe de manteau de Nouvelle-Calédonie, s'étendant sur 300 km de long montre trois*
62 *caractéristiques importantes : (1) La succession ophiolitique ne contient ni dykes, ni basaltes*
63 *en coussin, (2) l'ophiolite est charriée sur des formations basaltiques (nappe de Poya) que*
64 *l'on considère classiquement comme originaires d'un bassin océanique différent de celui d'où*
65 *est issu le manteau, et (3) le contact basal de la nappe ultrabasique est remarquablement*
66 *plat tout le long de l'île et celle-ci n'a pas été épaissie durant l'obduction. Cela suggère que*
67 *les péridotites n'ont pas été mises en place en réponse à une poussée tectonique arrière. De*
68 *nouveaux résultats pétrologiques et géochimiques obtenus sur l'ophiolite montrent en réalité*
69 *que les basaltes de Poya peuvent être extraits de la fusion du manteau de l'ophiolite. Nous*
70 *proposons donc un nouveau modèle pour l'obduction, dans lequel les basaltes de Poya*
71 *forment la couverture initiale primitive du manteau de la nappe des Péridotites. La surrection*
72 *progressive des unités profondes enfouies lors de la subduction de la lithosphère du bassin*
73 *sud-Loyauté à l'Eocène, a permis le soulèvement passif de l'ophiolite et l'érosion puis le*
74 *glissement des unités basaltiques. Durant le Priabonien, l'accumulation des produits de*
75 *l'érosion de la couche des basaltes et de la marge passive de Norfolk ont formé les séquences*
76 *de flysch comprenant localement des débris basaltiques grossiers. Ces sédiments font partie*
77 *d'un prisme d'accrétion tectonique construit en réponse à la convergence au front de la*
78 *subduction. La sédimentation détritique se termine par la mise en place de grandes unités*
79 *basaltiques glissées qui comblent le bassin. Le processus de l'obduction se termine par le*
80 *glissement gravitaire de l'écaille de manteau océanique sur les basaltes. Cet événement est*
81 *contemporain de l'exhumation des unités HP-BT de Pouébo et du Diahot. Le glissement*
82 *gravitaire a été facilité par la présence sous l'ophiolite, d'une semelle continue de serpentines*
83 *résultant de l'interaction du manteau avec des fluides métasomatiques remontant durant*
84 *l'exhumation des unités enfouies pendant la subduction continentale. L'émersion progressive*
85 *de la lithosphère obduite a placé le manteau dans des conditions d'altération supergène*
86 *tropicale-*

87

88 **Mots clés :** *Nouvelle-Calédonie, nappe des Péridotites, Nappe de Poya, exhumation, unités*
89 *HP-BT, glissement gravitaire, obduction passive.*

90

91

92

92 **1. Introduction**

93

94 New-Caledonia consists of a 300 km long allochthonous sheet of oceanic mantle, the
95 Peridotite Nappe, lying in tectonic contact over the Norfolk-New Caledonia continental block
96 (Avias, 1967; Paris, 1981 and references herein). Obduction is thought to have followed
97 subduction and subsequent closure of back-arc and forearc oceanic domains during the Late
98 Eocene (Cluzel et al. 2001; Crawford et al. 2003; Schellart et al. 2006; Wattham et al. 2008).
99 Constraints for the timing of the exhumation of subducted terranes are provided by studies
100 of the northern regions of New Caledonia where Eocene HP-LT units of oceanic and
101 continental origin are exposed. For this reason, New Caledonia is a key region for studying
102 the processes of obduction and related subduction-exhumation of arc and back-arc basins
103 fragments.

104

105 However, despite numerous recent investigations, the successive stages of the obduction
106 process of the Peridotite Nappe are still a matter of debate and various models have been
107 proposed successively in the last 10 years (Cluzel et al. 2001; Crawford et al. 2003; Schellart
108 et al. 2006; Wattham et al. 2008; Ulrich et al. 2010; Titus et al. 2011; Cluzel et al. 2012). One
109 cause of such uncertainties is that the New Caledonia ophiolite pile lacks concordant
110 sheeted dykes and pillow basalt layers. In addition, the ultramafic sheet is thrust over
111 basaltic formations of the Poya Terrane which are classically thought to originate from a
112 different oceanic environment. New petrological and geochemical results obtained by Ulrich
113 et al. (2010) allow re-considering the possible cogenetic links between the Poya Terrane and
114 the mantle rocks of New Caledonia. In this article, we examine how these new results modify
115 our understanding of the geodynamics of this region. In particular, we propose a simple
116 model for the obduction of the New Caledonia ophiolite in which the Poya basalts represent
117 the original cover of the Ultramafic Nappe. This model highlights the role played by regional-
118 scale gravity sliding of large mafic and ultramafic sheets as a response to the exhumation
119 and rapid uplift of subducted units.

120

121 **2. Geodynamical setting of New Caledonia**

122

123 New Caledonia is located at the junction between two ocean basins displaying contrasting
124 ages and origins: the New Caledonia basin to the west and the Loyalty basin to the east (fig.
125 1). The New Caledonia basin basement is made up of thinned continental crust to the north
126 and of oceanic crust of Cretaceous age to the south (Lafoy et al. 2005; Collot et al., 2008).
127 The Loyalty basin is a remnant of a wider oceanic domain, the north-eastern part of which
128 disappeared in the west-dipping Vanuatu subduction initiated 12 My ago (Auzende et al.,
129 1995; Ruellan and Lagabrielle, 2005). It is separated by the N140 trending Loyalty Ridge into
130 two basins, the North Loyalty basin and the South Loyalty basin. The Loyalty Ridge is a
131 discontinuous bathymetric high formed by evenly-spaced seamounts, the shallowest
132 forming the Loyalty Islands (fig. 1). Its origin remains unclear due to the lack of age
133 constraints. The root of the Loyalty Ridge has been interpreted as the remnant of an extinct
134 arc often referred to as the Loyalty arc in the literature (Cluzel et al. 2001 and references
135 herein). It likely relates to the northeast-dipping subduction of oceanic crust which initiated
136 east of the Norfolk ridge during the Late Cretaceous-Paleocene and lasted until the
137 obduction of the New Caledonia ophiolites during the Priabonian (37-34 Ma) (Aitchison et al.
138 1995; Eissen et al. 1998; Cluzel et al., 2001) (fig. 3). The oceanic basement of the North
139 Loyalty basin is considered to have spread along a N100 trending spreading center, at the
140 rear of the Loyalty arc. This back-arc basin opened from 43 to 35 Ma (Middle-Late Eocene),
141 that is during the emplacement of the New Caledonia ophiolites and the exhumation of the
142 HP-LT northern units of the main island (fig. 3). At the southern tip of the Loyalty ridge, the
143 South Loyalty basin connects to the South Fiji Basin which opened from 35 to 15 Ma (Herzer
144 et al. 2011).

145
146 To the north of New Caledonia, the Norfolk Ridge has an arch-shape and links up with the E-
147 W trending d'Entrecasteaux Ridge colliding itself with the current Vanuatu or New Hebrides
148 subduction zone (fig. 1). Based on dating of dredged basaltic samples, Maillet et al. (1983)
149 suggested that the d'Entrecasteaux Zone might represent the northern arcuate extension of
150 the Loyalty Eocene subduction/obduction zone. The easternmost basement of the
151 d'Entrecasteaux Ridge was drilled at ODP Sites 831 and 828 (Bougainville Guyot). It was
152 shown to consist of 37 Ma old andesitic breccias derived from a submarine arc volcano
153 (Baker et al., 1994) and of primitive arc tholeiitic appropriate for a forearc setting (Coltorti et
154 al. 1994). These results suggest that the d'Entrecasteaux Ridge contains relicts of an island

155 arc/forearc system that may belong to the northern portion of the extinct Late Eocene
156 Loyalty arc. In addition, Middle to Late Eocene andesitic volcano-clastic turbidites from a
157 submarine fan were recovered from the North Loyalty Basin, south of the d'Entrecasteaux
158 Ridge, at DSDP Site 286 (Andrews et al., 1975). These data are consistent with the hypothesis
159 that the Loyalty Ridge developed in response to the Eocene Loyalty subduction (fig. 1). This
160 subduction resumed with the obduction of the New Caledonia ophiolite.

161

162 **3. The New Caledonia ophiolite and the obduction-related units**

163

164 a. The Peridotite Nappe, the pre-obduction dikes and the amphibolites

165

166 To the north of New Caledonia, peridotites are found as a series of klippen aligned in the
167 N140 direction, along the western coast of the main island (fig. 2) (Guillon and Routhier,
168 1971). By contrast, mantle rocks exposed in the Massif du Sud represent almost 100% of the
169 surface of southern New Caledonia. Rare gabbros representing basal sections of crustal
170 magma chamber are exposed in the Massif du Sud. The peridotites might have been covered
171 initially by a more complete crustal sequence. We further discuss the possible reasons why
172 most of the mafic terms are lacking.

173 The basal layer of the Peridotite Nappe is formed of a porphyroclastic serpentine mylonite,
174 the serpentine sole, 20 to 100 m thick. Large scale normal faulting is frequently observed in
175 the serpentine sole as well as in the bulk ultramafic sheet (Lagabrielle and Chauvet, 2008).
176 Shear sense criteria from the sole locally indicate southwest directed shearing, a direction
177 consistent with the kinematics inferred for the obduction (Cluzel et al., 2012).

178

179 According to Ulrich et al. (2010), a large proportion of the ophiolite mantle of New Caledonia
180 is composed of highly depleted harzburgites (\pm dunites) with characteristic U-shaped bulk-
181 rock rare-earth element (REE) patterns, as shown by analyses performed in Koniambo and
182 Thiébagi massifs and in Massif du Sud. In contrast, lherzolites in the northernmost klippen,
183 such as Poum Peninsula, display spoon-shaped REE patterns. The major whole rock and
184 isolated mineral element and REE content of these lherzolites are indicative of abyssal
185 environments; in particular, their significant LREE enrichment is best explained by partial
186 melting in a spreading ridge, followed by near in-situ refertilization from deeper mantle

187 melts. These new data led Ulrich et al. (2010) to consider that the lherzolites likely represent
188 the equilibrium residue of the undepleted MORB terrane formed during the opening of the
189 South Loyalty basin, from Late Cretaceous to Paleocene. This MORB province might
190 represent a possible source for the basalts of the Poya terrane. In contrast, spinel data of the
191 most depleted harzburgites of New Caledonia, highlights strong forearc affinities. Their
192 compositions are best modeled by hydrous melting of a source that had previously
193 experienced depletion in a spreading ridge. Accordingly, the two melting events in the New
194 Caledonia ophiolite recorded the rapid transition from oceanic accretion to convergence in
195 the South Loyalty basin during the Late Paleocene, with initiation of a new subduction zone
196 at, or near the ridge axis during the Earliest Eocene (Ulrich et al. 2010; Cluzel et al. 2012; fig.
197 3).

198
199 The degree of serpentinization affecting the whole peridotite nappe increases from top to
200 bottom from less than 50% up to 100% within the serpentinite sole (Orloff, 1968). Locally, at
201 the hectometre scale, the uppermost part of the peridotite nappe is devoid of serpentine
202 minerals (Ulrich, 2010). According to Raman spectrometry, the serpentine minerals are
203 dominated by lizardite (up to 90%) while the HP polymorph, antigorite, only crystallized in
204 veins within the serpentinite sole. Ulrich et al. (2011) relate this contrasted bottom to top
205 serpentinization to an upward hydration of the Peridotite Nappe by metasomatic fluids
206 released from the downgoing slab during the Eocene convergence. The rare occurrence of
207 antigorite within the sole is interpreted as related to hotter fluid circulation ($T > 400^{\circ}\text{C}$)
208 when the HP-LT Diahot units were rising up beneath the ophiolite. As further discussed, this
209 result accounts for the creation of a major rheological discontinuity forming the entire basal
210 sole of the ultramafic sheet.

211
212 Felsic dikes cutting through the Massif du Sud peridotites have been dated at 53 Ma by
213 Cluzel et al. (2006). The dikes include four main rock types : granitoids, boninite-like
214 andesitic shallow intrusive rocks, high-Mg microgabbro/tonalites, and dolerite of island arc
215 tholeiitic affinities. They are interpreted as slab melts and supra-subduction zone magmatic
216 products. This strongly constrains the timing of incipient convergence at the Eocene Loyalty
217 subduction zone and is consistent with the hypothesis that subduction-related magmatism
218 began during the Early Eocene, probably at a spreading center (Ulrich et al. 2011 ; Cluzel et

219 al. 2012).

220

221 Amphibolite lenses locally crop out beneath the serpentinite sole, at the base of the
222 Peridotite Nappe. They recrystallised in the high-temperature amphibolite facies and display
223 the geochemical features of MORB with a slight Nb depletion (Cluzel et al. 2012).
224 Thermochronological data from hornblende, zircon and sphene reveal that these mafic rocks
225 recrystallised at ~56 Ma with peak conditions of ca 0.5 GPa at ca 800-950°C. These mafic
226 units are regarded as tectonic slices from the South Loyalty basin oceanic crust, thus
227 belonging to the lower plate of the subduction/obduction system. They recrystallised when
228 they subducted below young and hot oceanic lithosphere (Cluzel et al. 2012). Finally, the
229 presence of these amphibolite lenses and the occurrence of slab melts at ~53 Ma collectively
230 suggest that subduction inception occurred at, or near to the spreading ridge of the South
231 Loyalty Basin at ~56 Ma.

232

233 A major feature of the Peridotite Nappe is that it exhibits a very simple structure and lies
234 undeformed above a remarkably flat, sub-horizontal fault. This simple geometry sharply
235 contrasts with the complex structure of the underlying Poya terrane characterized by
236 imbricated folds and thrusts, demonstrating significant shortening during tectonic
237 emplacement. By contrast, the Peridotite Nappe does not show any major internal thrusts
238 and therefore did not experience thickening during its tectonic emplacement. The lack of
239 contractional deformation affecting the Peridotite Nappe is confirmed by the structure of
240 the pre-obduction, 53 Ma old dikes, which lie remarkably undeformed except in the
241 serpentine sole (Cluzel et al. 2012).

242

243

244 b. The Poya Terrane and the Tertiary flysch units

245

246 A tectonic unit made up of basalts with an oceanic affinity, named the Poya nappe or Poya
247 terrane (Cluzel et al., 2001), systematically underlies the Peridotite Nappe. This basalt unit is
248 well developed beneath the peridotite klippen of the western coast and forms a thin, almost
249 continuous level beneath the mantle rocks of southern New Caledonia. The Poya terrane is
250 composed of pillow basalts and dolerites with minor abyssal argillites that contain

251 Campanian to Late Paleocene or Early Eocene radiolarians (Cluzel et al. 1994 ; Aitchison et al.
252 1995 ; Cluzel et al. 1997; Eissen et al. 1998; Cluzel et al. 2001). MORB-type tholeiites
253 dominate (ca. 90%) but minor back-arc basin basalts (BABB, ca. 5%), and ocean island basalts
254 (OIB) are also present. The back-arc and ocean island basalts probably represent small
255 seamounts erupted on older (Campanian–Early Eocene) MORB crust (Ulrich et al., 2010).
256 Fresh dikes and glassy pillow lavas of boninitic composition are found in rare outcrops of the
257 Poya terrane. Isotopic data demonstrate that these rocks are petrogenetically and
258 tectonically unrelated to the rest of the magmatic terrane (Cameron, 1989). The New
259 Caledonian boninites probably have formed rapidly after the inception of the subduction
260 zone since partial melting for boninitic magmas requires high temperatures (Arndt, 2003).

261
262 The Poya nappe has been tectonically emplaced over a composite flysch formation of Late
263 Eocene age. In northern New Caledonia, the Lutetian flysch deposits have recorded the
264 increase in turbidite supply from a terrigenous source. Flysch sections from Koumac and
265 Gomen are characterized by an input of iron and aluminium, a feature interpreted as an
266 echo of weathering and erosion of a continental province (Maurizot, 2011). In southern New
267 Caledonia, the base of the sequence consists of Late Bartonian – Early Priabonian (ca. 40 Ma)
268 pebbly shallow water limestones lying unconformably upon eroded pre-Cretaceous to mid-
269 Eocene terranes. These lowermost levels underlie marls and calcareous sandy marls which
270 accumulated into a rapidly subsiding basin (Cluzel et al., 2001). These deposits, forming the
271 “lower flysch”, progressively change into alternating sandy marls or calcarenite and marls
272 and are overlain by the “upper flysch”. The “upper flysch” is an upward coarsening
273 sequence topped by an olistostrome that reworks all the components of the sedimentary
274 cover of the Norfolk basement, including clasts of the Late Eocene bioclastic limestone and
275 the flysch itself (Cluzel et al., 2001). In southernmost New Caledonia, the Eocene flysch
276 includes the Nouméa-Bourail flysch of Late Bartonian to Late Priabonian age (37-34 Ma;
277 Paris, 1981). This upper flysch, well exposed around Nouméa (fig. 1), is 1500 to 3000 m thick.
278 It ends up with fine-grained calcareous turbidites showing basaltic volcanoclastic
279 intercalations and coarsening upward into an olistostrome containing dominant basalt
280 blocks (Cluzel et al., 2001 and references herein). This clastic formation is remarkably devoid
281 of any ultramafic debris, implying that the ultramafic rocks were not in a position to feed the
282 flysch basin and were not widely exposed to the surface at this stage of the orogenic

283 evolution.

284 A flysch formation partially fed by an ultramafic source has been mapped along the east
285 coast of New Caledonia near Nepoui (fig. 1) (Coudray, 1975; Paris et al., 1979). The Nepoui
286 flysch, 300-500 m thick, stratigraphically overlies the Poya terrane and in turn tectonically
287 underlies the Peridotite Nappe (Cluzel et al., 2001). This geometry is consistent with an
288 interpretation as a piggy-back basin transported by the Poya Nappe during obduction
289 (Cluzel, 1998). The Népoui flysch includes dominant mafic and carbonate clasts. Ultramafic
290 clasts are rare except in two levels at the base and at the summit of the formation. They are
291 mixed with detrital chromite grains from proximal sources and derive from a strongly
292 weathered peridotite. Therefore, these clasts may represent debris transported from the
293 advancing Peridotite Nappe. However, since serpentine slices are also present within the
294 Poya basalts, a single derivation from the Poya terrane cannot be ruled out (Cluzel et al.,
295 2001). The exact age of the Nepoui flysch is not certain, but a post-Late Bartonian age is
296 assigned to the upper levels of the flysch based on the occurrence of carbonate olistolith
297 containing Late Bartonian faunas (Cluzel et al., 2001 and references herein).

298

299 The volcanic rocks reworked in the Nouméa-Bourail flysch display undepleted and depleted
300 MORB signatures and are obviously reworked from the Poya Terrane (Cluzel et al., 1997).
301 Therefore, the progressive increasing supply of mafic detritus in the upper flysch is the
302 record of the approach of the mafic Poya Terrane allochthon towards the foreland basin of
303 the Late Eocene orogeny. It must be noticed that the arrival of the basaltic allochthon sheet
304 occurred during the final stages of the post-collision exhumation of the metamorphic
305 terranes exposed in northern New Caledonia, as reported in the following section.

306

307 c. The Northern High Pressure - Low Temperature units

308

309 A complex of mafic, high pressure-low temperature (HP-LT) metamorphic units is exposed in
310 northern New Caledonia (fig. 2) (Yokoyama et al., 1986; Black et al., 1993; Clarke et al., 1997,
311 Aitchison et al., 1995; Cluzel et al., 2001; Rawling and Lister, 2002; Fitzherbert et al., 2004,
312 2005; Spandler et al., 2004, 2005; Potel et al., 2006). It forms an elongated foliation
313 anticlinorium, a geometry displaying some similarities with the structure of metamorphic
314 core complexes. This high pressure complex includes two major terranes of oceanic origin.

315 The exact geometry of these two terranes and their structural relationships are not
316 completely established yet.

317 (1) The highly disrupted Pouébo terrane is represented by dominant metabasite eclogites
318 and glaucophanites and minor serpentine slices. Metabasalts and eclogitized sediments
319 experienced peak metamorphism conditions close to $T = 590^{\circ}\text{C}$ and $P = 1.9\text{--}2.3\text{ GPa}$ (Clarke
320 et al., 1997; Carson et al., 2000; Spandler et al., 2004). Most of the metabasalts have E-
321 MORB affinities and might have been erupted in a back-arc ocean basin, possibly the South
322 Loyalty basin (Cluzel et al., 2001). A link between the Poya Terrane and the mafic rocks of
323 the Pouébo Terrane has been made based on geological and geochemical data (Aitchison et
324 al., 1995; Cluzel et al., 2001, Spandler et al., 2004), and a direct correlation of the terranes is
325 supported by zircon U–Pb dating of high-P rocks at 85–55 Ma which fall within the age of the
326 Poya Terrane (Spandler et al. 2005). Therefore, both terranes are suggested to be slices
327 originating from the same oceanic basin, the South Loyalty basin, but the Pouébo terrane
328 reached important depth due to oceanic subduction during the Eocene convergence, whilst
329 the Poya terrane never experienced significant burial.

330 (2) The Diahot blueschist terrane consists of Cretaceous to Eocene metasediments and
331 minor volcanics which initially formed the sedimentary cover of the eastern continental
332 margin of the Norfolk block. They experienced lower peak metamorphism conditions,
333 around $T = 550^{\circ}\text{C}$ and $P = 1.2\text{ GPa}$. The Diahot terrane includes sedimentary component
334 related to the erosion of an island-arc (Cluzel et al., 2001).

335
336 Radiometric dating of prograde and retrograde metamorphic assemblages from the
337 northern HP-LT complex cluster around 44 Ma and 34 Ma respectively (Aitchison et al.,
338 1995; Baldwin et al., 1999; Spandler et al., 2005; Baldwin et al., 2007). This indicates that
339 subduction started at least before 44 Ma and that uplift and unroofing of the metamorphic
340 terranes occurred 10 Ma later, possibly in response to the break of the South Loyalty basin
341 slab (Cluzel et al. 2001). Exhumation of eclogites was almost completed at 34 Ma as shown
342 by apatite fission tracks data (Baldwin et al., 2007). Fluid inclusions data show that unroofing
343 occurred isothermally (Potel et al., 2006). A striking feature is that uplift and exhumation of
344 the HP-LT units occurred in the same time interval as basalts of the Poya nappe, followed by
345 the mantle of the Peridotite Nappe, were emplaced over the Late Eocene flysch sequences
346 in more external domains. This points to a possible relationship between uplift of deep

347 crustal levels in northern New Caledonia and late motions of the ophiolite sheet in southern
348 New Caledonia and along the west coast due to gravitational forces along an increasing
349 westward dipping slope. This point is discussed in section 5 below.

350

351 **4. New Caledonia Obduction : facts and models**

352

353 Among the numerous plate reconstructions of the southwest Pacific and tectonic models of
354 the New Caledonia orogen, most suggest that the South Loyalty Basin was subducted
355 beneath the Loyalty arc during the Eocene (Eissen et al., 1998; Cluzel et al., 2001; Crawford
356 et al., 2003; Spandler et al., 2005 ; Whattam et al., 2008 ; Whattam, 2008). As discussed
357 above, a minimum age of ~53 Ma for the formation of this so-called Loyalty Eocene
358 subduction is provided by geochemical and geochronological studies of the pre-obduction
359 dikes that intrude the mantle section of New Caledonia (Cluzel et al., 2006). Additional
360 informations from the amphibolite lenses associated with the serpentine sole confirm that
361 subduction at the newly formed Loyalty trench initiated at the dying Loyalty basin spreading
362 center around 56 Ma (Cluzel et al., 2012). Obduction was preceded by the shortening of the
363 continental margin of the Norfolk block and by the tectonic emplacement of sedimentary
364 units to form an accretionary wedge at the front of the Loyalty subduction, as shown in the
365 evolutionary model of fig. 4. The Eocene sedimentary formations of New Caledonia have
366 recorded a marked change from a quiet pelagic environment to a tectonically active
367 environment characterized by calciturdites and proximal breccia deposits (Maurizot, 2011).
368 Syntectonic sedimentation into a foreland basin led to the formation of thick Late Eocene
369 flysch sequences mostly fed by the subaqueous or subaerial erosion of the active tectonic
370 wedge. Stratigraphical data constrain the onset of contraction in the continental margin
371 domain to have occurred around 50 Ma (Ypresian). Thrusting of large units of Eocene
372 sediments occurred during the sedimentation of the youngest flysch sequences, before the
373 tectonic emplacement of the Poya terrane over the Late Eocene flysch (Montagne Blanches
374 subunits, Maurizot, 2011). The final phase of obduction of the New Caledonia ophiolite is
375 constrained to occur between 34 Ma and 27 Ma, due to the presence of Uppermost Eocene,
376 pre-obduction sediments beneath the ophiolitic nappe (Formation de la Cathédrale, Cluzel
377 et al. 1998), and to the occurrence of post-obduction, Late Oligocene granitoids cross-
378 cutting the peridotites of the Massif du Sud (Cluzel et al. 2005).

379
380 Reconstructions of the Late Cretaceous to Cenozoic geodynamics of the SW Pacific region
381 (Cluzel et al., 2001; Crawford et al., 2003 ; Schellart et al., 2006; Whattam et al., 2008) point
382 out the role played by a west-dipping subduction zone active in the region between 82 to 52
383 Ma that accommodated opening of the South Loyalty basin (fig. 3). This was accompanied
384 for authors by fast slab roll-back of the Pacific plate. Assuming continuous spreading
385 between 70 and 50 Ma at a rate of 5 cm/yr along the South Loyalty basin spreading center,
386 which is the average rate for the opening of ocean basins in this region, the maximum size of
387 the South Loyalty basin could be about 1000 km. This is large enough to provide a 500 km
388 long-slab, thereby making the Eocene Loyalty subduction possible. These parameters have
389 been used to construct the evolutionary model in fig. 4.

390
391 Although based on similar time constraints, the various published models propose different
392 plate tectonic processes at the onset of the Eocene subduction. For Cluzel et al. (2001) the
393 locus for inception of the Loyalty subduction is not really clarified. For Crawford et al. (2003)
394 and Whattam et al. (2008) the NE-dipping Loyalty subduction may have nucleated at 55 Ma
395 at the recently extinct spreading center of the South Loyalty Basin (fig. 3). Eissen et al. (1998)
396 also suggested that inception of NE- dipping subduction in the South Loyalty Basin occurred
397 via reactivation of a recently extinct spreading ridge. For Ulrich (2010) and Ulrich et al.
398 (2010), opening of the South Loyalty Basin during the Campanian to Paleocene was
399 associated with the slab withdrawal east to the Gondwana margin. The formation of
400 undepleted MORB of the South Loyalty basin crust with equilibrium residue in the mantle
401 relates to this event; it was followed by near in-situ refertilization of the peridotites from
402 deeper mantle melts. This led to the formation of the impregnated lherzolites, i.e. the future
403 northern klippen of the New Caledonia ophiolite. A new NE-dipping subduction nucleated at
404 (or near) the spreading ridge center, initiating the closure of the South Loyalty Basin which
405 lasted from Late Paleocene to Early Eocene. The dehydration of the slab is responsible for
406 the second stage of partial melting of the forearc peridotites, probably forming boninitic
407 melts. This allowed the formation of the residual harzburgites, i.e. the future bulk New
408 Caledonia ophiolite. In this model, the future Poya terrane corresponds to the accretionary
409 prism linked to the NE-dipping subduction, it is composed of tectonic slices of basaltic crust

410 detached from the descending South Loyalty Basin oceanic plate, that is from the lower
411 plate of the subduction system. This point is discussed in the following section.

412

413 **5. Our proposition : a simple model for the emplacement of the New Caledonia mafic and**
414 **ultramafic ophiolitic units**

415

416 The first comprehensive model for the New Caledonia obduction was proposed by Cluzel et
417 al., (2001). The most striking points raised by this model are as follows : (i) the Poya nappe
418 basalts (Poya Terrane) and the Peridotite nappe did not originate from the same oceanic
419 basin ; (ii) the Poya nappe basalts have been scrapped off from an oceanic domain located
420 on the descending plate ; (iii) the present-day Loyalty Ridge basement represents the
421 remnant island arc of the Eocene subduction (Loyalty arc) ; (iv) the Peridotite nappe is the
422 obducted edge of the fore-arc domain of the Loyalty arc. This model contains most of the
423 main elements which compose all published models, especially when considering the
424 evolution of the Loyalty subduction. However, despite its own self-consistency, it cannot
425 solve two remaining questions: (1) Why only rare upper gabbros but no basalts nor sheeted
426 dikes are preserved over the peridotites, and (2) why only the Poya nappe basalts have been
427 captured from the advancing plate and nothing from the rest of this plate?

428

429 It has long been considered that the Poya terrane cannot represent the detached cover of
430 the overlying ultramafic terrane (Eissen et al., 1998). This led most authors to build
431 obduction models in which the Poya basalts originated from various settings such as
432 seamounts scrapped from the downgoing oceanic plate during the east-dipping Eocene
433 subduction (Cluzel et al., 2001). However, using equilibrium melting equations, Ulrich et al.
434 (2010) show that melts extracted from the lherzolites of the Northern Peridotite klippen are
435 compositionally similar to the MORB of the Poya terrane. This is used by these authors to
436 infer that the ultramafic nappe and the mafic Poya terrane represent oceanic lithosphere of
437 a single marginal basin that formed during the late Cretaceous.

438

439 Following Ulrich et al., (2010) we may now consider that basaltic formations similar to the
440 Poya MORB-type lavas once formed the stratigraphical cover of the New Caledonia
441 peridotites. Moreover, geochemical data of Marchesi et al. (2009) show that the highly

442 depleted harzburgites of the Massif du Sud are residues after high degrees (20–30%) of
443 partial melting, generating liquids with a geochemical signature transitional between those
444 of island-arc tholeiites and boninites. This suggests that the rare boninites erupted over the
445 Poya basalts could derive from the melting of mantle source similar to the Massif du Sud
446 peridotites. Moreover, it must be noticed that hydrous remelting of the oceanic mantle only
447 occurs in the mantle wedge of the upper plate of any subduction zone. This constraints the
448 boninitic lavas of the west coast of New Caledonia to originate from the upper plate of the
449 Loyalty subduction complex. Since the MORB basalts and the boninitic dike and lavas are
450 closely associated within the Poya Terrane, we may therefore conclude that both the mantle
451 rocks and the mafic units forming the New Caledonia ophiolite originated from the upper
452 plate of the Loyalty subduction, that is from the eastern flank of the South Loyalty spreading
453 center (Fig. 3).

454

455 As reported above, a crucial feature of the New Caledonia tectonic pile is that the basalt
456 formations are found beneath the mantle rocks sheet. Taking into account the « unique
457 origin » for the complete mafic-ultramafic pile of New Caledonia as proposed here, the only
458 scenario able to account for such a geometry is that the original oceanic lithosphere
459 belonging to the upper plate has experienced a diverticulation process during its final
460 emplacement over the Norfolk continental basement. Diverticulation within a tectonized
461 sequence, a term defined by Maurice Lugeon, allows upper tectonic units to be overthrust
462 by lower units, as well observed in the Swiss Alps (Badoux, 1972 and references herein). This
463 classically happens in gravity-driven tectonics when the uppermost units of a wedge are
464 detached as large gravitational bodies which may slide far from their source before being in
465 turn tectonically buried under former deeper units. Similar mechanism may explain the
466 emplacement of the Montagne Blanches subunits within the upper flysch formations
467 (Maurizot, 2011).

468

469 As shown in model of figure 4, we infer that in a first step, the Poya basalts have been
470 detached from the underlying ophiolite and have experienced gravity-driven sliding along a
471 detachment surface allowing the exhumation of deeper levels of the ophiolite. In a second
472 step, the Poya basalts were overthrust by the rest of the ophiolitic pile, also experiencing
473 gravity-driven sliding over its serpentine sole (fig. 4). During the advance of the Peridotite

474 Nappe, compressional deformation may have affected the underlying units, resulting in a
475 complex geometry of superimposed structures (fig. 4).

476

477 As reported by Cluzel et al. (2001), a striking features of the upper Eocene flysch is the
478 progressively increasing amount of mafic ophiolitic detritus recording the approach of the
479 Poya basalts mafic allochthon. Angular mafic clasts (i.e. basalt, dolerite and fine-grained
480 gabbro) are widespread in breccias and their abundance and size increase upwards. These
481 first records of the erosion of the basalts and dolerites are followed by large olistoliths which
482 have been detached from the frontal regions of the advancing nappes during the Priabonian.
483 The occurrence of fine-grained gabbros reflects the erosion of relatively deep levels of the
484 mafic sequence (Cluzel et al., 2001). We assume that in the very final stage of this clastic
485 sedimentation, the large basaltic sheets forming the basalt nappes of the Poya terrane have
486 entirely filled up the foreland basin (fig. 4). The presence of the ultramafic-bearing Népoui
487 flysch overlying the basalts of the Poya terrane might indicate that detrital material from the
488 advancing Peridotite nappe has been deposited following the sedimentation of the basalt-
489 bearing clastic sequences. This transition from mafic to ultramafic sources is consistent with
490 our hypothesis (fig. 4).

491

492 We assume that the detachment and subsequent sliding of the ultramafic sheet has been
493 facilitated by the occurrence of a continuous serpentinite layer which developed from
494 bottom to top, in relation with the migration of metasomatic fluids during the uplift of the
495 metamorphic units (Ulrich et al., 2011) (fig. 4). In fact serpentinites have notoriously a soft
496 rheology and they are classically interpreted as lubricant during tectonic processes (Moore
497 et al., 1997; Guillot et al., 2001). The nature of the decollement level which allowed the
498 detachment of the mafic sheet remains questionable. Assuming first an original complete
499 mafic sequence, such as those emplaced at fast-spreading ridges, the decollement level has
500 to be found within the lava pile itself or at the boundary between the sheeted dike complex
501 and the lava sequence where a rheological contrast can be expected. Alternatively, the
502 original mafic layer of the obducted oceanic lithosphere may have been formed at a slow- or
503 intermediate-spreading center. In such a case, the dike complex may be reduced or lacking
504 and the lavas may have been erupted directly over mantle rocks or over eroded gabbros
505 exposed at the axial seafloor of the spreading center, as reported from investigations in

506 modern oceans or in ophiolites from the Alpine belt (Lagabrielle and Lemoine, 1997;
507 Lagabrielle 2009 with references). In this case, the decollement level might correspond to
508 the sharp unconformity separating the lavas from the underlying oceanic basement covered
509 with sediments.

510
511 Our model refers to a mechanism of nappe emplacement which has been the subject of
512 considerable discussions since more than 100 years. In his synthesis about the theories and
513 observations of nappe emplacements, O. Merle (1998) recalls that the main progresses in
514 our understanding of the kinematics of nappes and thrust sheets have been made when
515 scientists realized that a nappe is not a volume of rigid material displaced along an inclined
516 surface under frictional conditions of solids. Rather, a nappe is a volume of viscous material
517 in which any rheological analysis has to integrate the factor of time, so fundamental in
518 geology. By integrating a plastic rheology for the bulk volume of the nappe and a layer of
519 weak material at its base, J. Goguel (1948) showed that a nappe of three kilometers
520 thickness can slide under its own weight on a slope of three degrees. In addition, basal
521 detachments of some major accretionary wedges have been shown to be exceedingly weak
522 with very low effective coefficient of friction (Suppe, 2007). The rheological parameters
523 evoked here fall in the range of what can be expected in the case of New Caledonia.
524 According to Guillon and Routhier (1971), the minimal thickness of the Peridotite Nappe
525 reached indeed 2.5 km. In addition, three degrees appears to be a possible value for the
526 overall slope of a dome formed by the exhumed units during their ascent to the surface.
527 Orogenic wedge average surface slopes calculated for two major orogens, the Himalaya and
528 the Taiwan range, are of the order of 4° and 3° respectively (Hilley and Strecker, 2004).

529
530 Diverticulation of the ophiolitic nappes occurred in a context of overall convergence. It
531 marks the last stages of a compressional regime and follows a long period of subduction and
532 contraction of the Norflok continental margin. Tectonic shortening resulted in early folding
533 of both the pre-Eocene continental basement and its Mesozoic cover as well as the Eocene
534 flysch deposited in the foreland basin. However, the Peridotite Nappe did not record any
535 thickening and its basal fault contact remains almost undeformed. Therefore, the peridotites
536 have not been tectonically emplaced by a force applied to the rear. On the contrary, in the
537 specific case of New Caledonia, we infer that the obduction occurred under a gravity-driven

538 regime in response to the rapid uplift of the subduction-obduction complex linked to the
539 exhumation of the eclogite-blueschist units of the northern region of the island.

540

541 The large impact of extensional tectonics in the overriding oceanic lithosphere through large
542 scale normal faulting has been already reported by several authors (Rawling and Lister,
543 2002; Lagabrielle et al., 2005, with references; Chardon and Chevillotte, 2006; Lagabrielle
544 and Chauvet, 2008; Ulrich, 2010). Detachment faults have been initiated in the peridotites
545 during the initiation of the gravity sliding, and we assume that very large masses of
546 peridotites representing the northern massifs klippen were detached from the main nappe
547 and have slid on the roof of the basalts down to their present-day position. Initial sliding
548 may have occurred entirely below sea level or within subaerial conditions. Tectonic
549 fracturing allowing important water circulation is thought to trigger rapid weathering of the
550 peridotites under both marine or continental environments. Continuous uplift during the
551 Oligocene and the Miocene led to complete emersion of the obducted lithosphere in New
552 Caledonia and its active weathering under subaerial, tropical environment as revealed by
553 recent chronological data (Sévin et al., 2011).

554

555 **6. Conclusions.**

556

557 A striking feature of the New Caledonia obducted lithosphere is that the ophiolite pile lacks
558 concordant sheeted dykes and pillow basalt layers. Moreover, the ophiolite is thrust over
559 basaltic formations of the Poya Terrane which were classically thought to originate from a
560 different oceanic environment. This led most authors to propose scenarii for the tectonic
561 evolution of this Southwest Pacific region in which the basaltic and plutonic formations
562 originated from different oceanic basins. Based on the new petrological and geochemical
563 results obtained from the mantle sequence of New Caledonia by Ulrich et al. (2010), we
564 propose a simple model for the obduction of the New Caledonia ophiolite in which the Poya
565 basalts represent the original cover of the Peridotite Nappe. Our simple model highlights the
566 role played by slope tectonics. We assume that continuous uplift of the HP-BT units in the
567 northern part of New Caledonia following continental subduction and possible slab break-
568 off, drove passive uplift of the ophiolite, and led to onset of sliding of the basaltic layer

569 followed by the mantle sheet previously scalped from its mafic cover. This caused the
570 inversion of the initial sequence in a process known as diverticulation.

571

572 The three main points which strengthen this model are as follows :

573

574 1. As early emphasized by various authors, exhumation of the HP units of northern New
575 Caledonia occurred coevally with the obduction of the Peridotite Nappe around 37-34
576 Ma. This temporal coincidence allows to envision and to discuss a cause and effect
577 link between these two processes.

578 2. Boninitic dikes which intrude the Poya terrane make this unit a portion of the upper
579 plate of the Loyalty subduction system. Therefore, the Poya basalts do not belong to
580 the lower plate as postulated by Cluzel et al. (2001, 2012). The Poya basalts were
581 overlying the mantle rocks of the Peridotite Nappe which also host slab melts dikes.

582 3. The basal contact of the ultramafic sheet is remarkably flat all along New-Caledonia.
583 Moreover, the Peridotite Nappe has not been thickened during obduction, rather it
584 experienced significant extension. This implies that the peridotites have not been
585 emplaced by a force applied to the rear but that they experienced sliding under the
586 force of gravity. This gravity-driven emplacement was facilitated by the development
587 of a 100% serpentine sole during exhumation of the continental units.

588

589 Finally, the simple model presented in this article makes New Caledonia a case-study for
590 purely passive, gravity-driven obduction processes following the subduction and contraction
591 of a continental margin beneath a marginal basin. The oceanic lithosphere is not thrust
592 toward the continent by rear push. Rather, the continental margin is underthrust beneath
593 the ocean and subsequently uplifted beneath it. Additional investigations in various very
594 large ophiolites worldwide should help establishing whether such a « passive obduction
595 model » may fully apply to other obduction scenarii. The importance of passive uplift of
596 ophiolitic units in response to the exhumation of HP units has been already highlighted by
597 studies in the Oman mountains. Numerous steps in the development of this subduction
598 orogen share clear similarities with the mechanism of passive uplift and sliding of oceanic
599 lithosphere reported here from New Caledonia (Lippard, 1986 ; Robertson, 1987 ; Goffé et
600 al., 1988; Robertson and Searle, 1990; Michard et al., 1994; Searle et al., 2004; Breton et al.,

601 2004 ; Saddaqui et al., 2006; Agard et al., 2007 ; Yamato et al., 2007 ; Agard et al., 2010). In
602 particular, for numerous authors, tectonic processes involved in some stages of the
603 evolution of the Oman orogen refer to normal faulting and possible related gravity-driven
604 sliding. Three most representative cartoons extracted from such published models are
605 shown in figure 5. This gravity-driven processes are the consequences of the uplift of the
606 internal units of the Arabian platform. Therefore, we assume that gravity may play a
607 fundamental role during the last stages of the emplacement of the largest ophiolitic sheets.
608 This role has not been completely deciphered yet in all the ophiolitic provinces around the
609 world.

610

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612

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620

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- 836
- 837

837 **Figure captions**

838

839 Figure 1. Topography of the Southwest Pacific region with location of the main features
840 described in text. Topography is after the application *GeoMapApp* by Lamont-Doherty Earth
841 Observatory, Columbia University and NSF.

842

843 Figure 2. Simplified geological map of New Caledonia and two typical cross-sections of the
844 southern and northern part of the main island (A and B) (modified after Cluzel et al., 2001).

845

846 Figure 3. A simple three stages model for the development of the Loyalty subduction zone in
847 the SW Pacific. This figure points to the chronology of opening of the South and North
848 Loyalty basins

849

850 Figure 4. A simple model for the obduction of the New Caledonia ophiolite.

851 - Steps 1 and 2. Initiation of the Loyalty subduction at the dying Loyalty spreading center.

852 Emplacement of the pre-obduction slab melts in the upper plate (boninites and granitoids)
853 and metamorphic evolution of basaltic units underplated from the lower plate (future
854 amphibolite lenses). Chronological and petrological data are from Cluzel et al. (2006, 2012).

855 - Step 3. Inversion of the passive margin and continental subduction (red arrow).

856 Construction of a tectonic wedge by accretion of sediments from the Norfolk margin.
857 Deposition of the Lutetian flysch, mainly calciturbidites, in the foreland basin. Rate of
858 subduction can be estimated at 6 cm/yr assuming that 500 km of oceanic and 100 km of
859 continental lithosphere have to be subducted between 55 and 45 Ma.

860 - Step 4. Maximum depth of burial reached by the future Pouébo and Diahot Terranes.

861 - Step 5. Syntectonic sedimentation in the «lower» flysch basin and tectonic emplacement of

862 Montagnes Blanches-type subunits (MB). Erosion of the basalt layer : deposition of the
863 «upper» flysch (volcaniclastic Bourail flysch with an important mafic contribution).

864 Serpentinization of the future sole of the Peridotite Nappe assisted by fluids extracted from
865 the exhumed continental units. Uprising of the Pouébo terrane following a path allowing its

866 future structural position beneath the less metamorphosed Diahot terrane. Similar paths are
867 reported by Yamato et al., (2007), in the Oman mountains., for the highest HP grade unit of

868 As Sifha underlying the less metamorphosed units of Hulw and Ruwi-Quryat.

869 - Step 6. Gravity sliding of the Poya basalts (PB) and unroofing of the mantle rocks.
870 Deposition of the Nepoui flysch which includes ultramafic clasts (NF).

871 - Step 7. Overall uplift of the internal New Caledonia orogen. Unroofing of the HP units dome
872 and gravity sliding of the Peridotite Nappe (PN); subsequent deformation of the underlying
873 units (Poya basalts and flysch units). Possible weathering under subaerial conditions in the
874 region of maximum uplift, including the peridotites. Normal faulting in the advancing mantle
875 unit and locally in the continental basement.

876

877 Figure 5. Selected cartoons from three different models of the evolution of the Oman
878 mountains. These cartoons highlight the role played by extensional tectonics and possible
879 related gravity-driven phenomena during crucial stages of the emplacement of the oceanic
880 lithosphere sheet forming the current Semail Nappe. These sketches share clear similarities
881 with drawings of steps 5 to 7, in fig. 4.

882

882 Légendes des figures

883

884 *Figure 1 . Topographie de Sud-Ouest Pacifique et localisation des principales structures*
885 *décrites dans le texte. Carte dressée grâce à l'application GeoMapApp du Lamont-Doherty*
886 *Earth Observatory, Columbia University et de la NSF.*

887

888 *Figure 2. Carte simplifiée de la Nouvelle-Calédonie et deux coupes représentatives au nord et*
889 *au sud de l'île (A et B) (modifié d'après Cluzel et al., 2001).*

890

891 *Figure 3. Modèle en trois étapes de l'établissement de la subduction des Loyauté. Cette figure*
892 *montre la chronologie de l'ouverture des bassins Sud- et Nord-Loyauté.*

893

894 *Figure 4. Un modèle simple de l'obduction en Nouvelle-Calédonie.*

895 *- Etapes 1 et 2. Début de la subduction des Loyauté au niveau du centre d'accrétion inactif du*
896 *bassin Sud-Loyauté. Mise en place des magmas pré-obduction issus de la fusion du slab et*
897 *métamorphisme d'une partie de la plaque plongeante pour donner les futures amphibolites.*
898 *Les données pétrologiques et géochronologiques sont de Cluzel et al., (2006, 2012).*

899 *- Etape 3. Inversion de la marge passive du bloc de Norfolk et subduction continentale (flèche*
900 *rouge). Construction d'un prisme tectonique par accrétion des sédiments de la marge de*
901 *Norfolk. Dépôt du flysch lutétien dans la bassin d'avant-chaîne. On peut envisager un taux de*
902 *subduction de 6 cm/an en admettant que 500 km de lithosphère océanique et 100 km de*
903 *lithosphère continentale ont été subduits entre 55 et 45 Ma.*

904 *- Etape 4. Stade pour lequel les futures unités de Pouébo et du Diahot ont atteint leurs*
905 *profondeurs maximales d'enfouissement.*

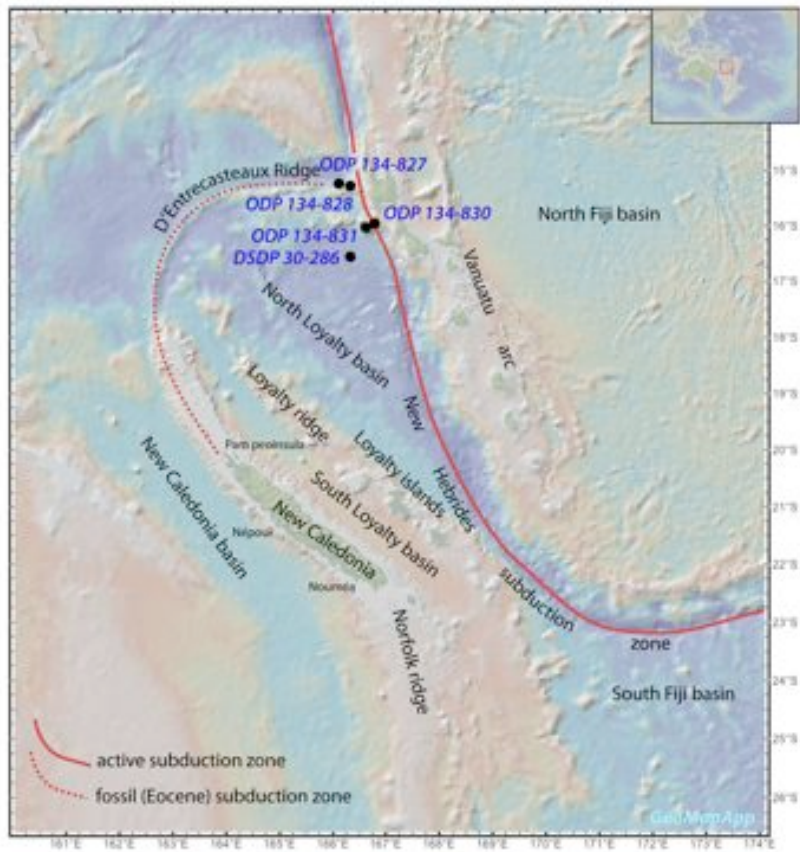
906 *- Etape 5. Sédimentation syntectonique dans le bassin du flysch "inférieur" et mise en place*
907 *tectonique des unités de type "Montagnes Blanches" (MB). Erosion de la couche basaltique*
908 *de l'ophiolite et dépôt de l'ensemble du flysch "supérieur" (flysch volcanoclastique de Bourail*
909 *caractérisé par une forte contribution mafique). Serpentinisation de la future semelle de la*
910 *Nappe des Péridotites assistée par des fluides s'échappant des unités continentales sous-*
911 *jaçantes en cours d'exhumation. Remontée des unités de Pouébo selon un trajet permettant*
912 *leur future position structurale sous les terrains moins métamorphiques du Diahot. Des*
913 *trajets semblables sont décrits par Yamato et al., (2007) en Oman pour les unités de As Sifha,*

914 *situées sous les unités moins métamorphiques de Hulw et Ruwi-Quryat.*
915 *-Etape 6. Glissement gravitaire de l'unité des basaltes de Poya (PB) et décoiffement des*
916 *péridotites. Dépôt du flysch de Népoui (NP) qui remanie localement du matériel ultrabasique.*
917 *- Etape 7. Surrection d'ensemble de l'orogène néo-calédonien interne. Décoiffement du dôme*
918 *d'unités de haute pression et glissement gravitaire de la nappe des péridotites (PN).*
919 *Déformation induite des unités sous-jacentes (nappe de Poya et flysch). Altération possible*
920 *en condition sub-aérienne de la région de soulèvement maximal, y compris des péridotites.*
921 *Tectonique extensive en failles normales possible dans la nappe en cours d'avancée et dans*
922 *le soubassement continental.*

923

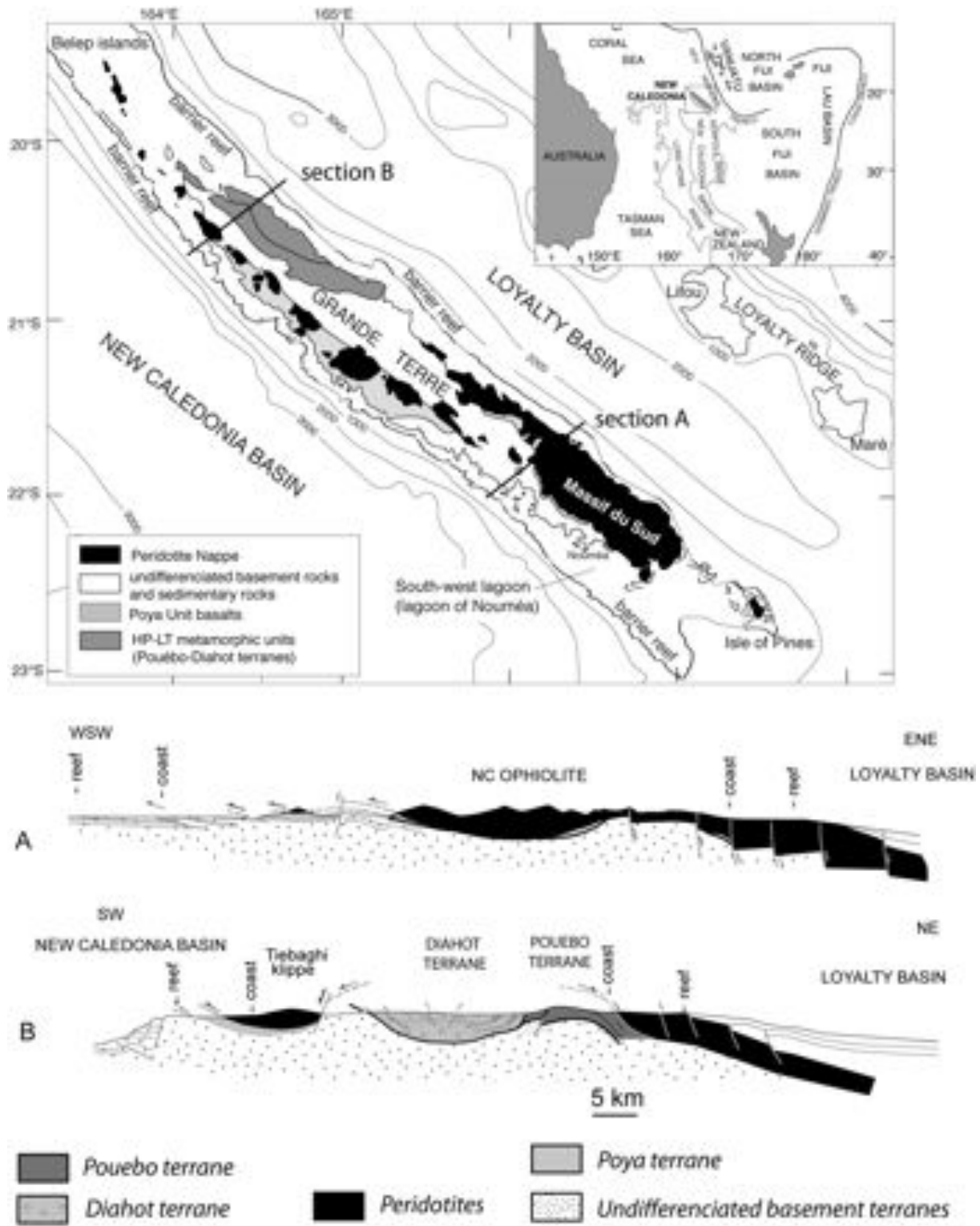
924 *Figure 5. Schémas tirés de trois modèles d'évolution des montagnes d'Oman. Ces dessins*
925 *illustrent le rôle joué par la tectonique extensive et les phénomènes tectoniques gravitaires*
926 *durant des stades importants de la mise en place de la lithosphère océanique formant*
927 *aujourd'hui la nappe de Semail. Ces figures montrent de nettes ressemblances avec les*
928 *dessins des étapes 5 à 7 de la figure 4.*

929

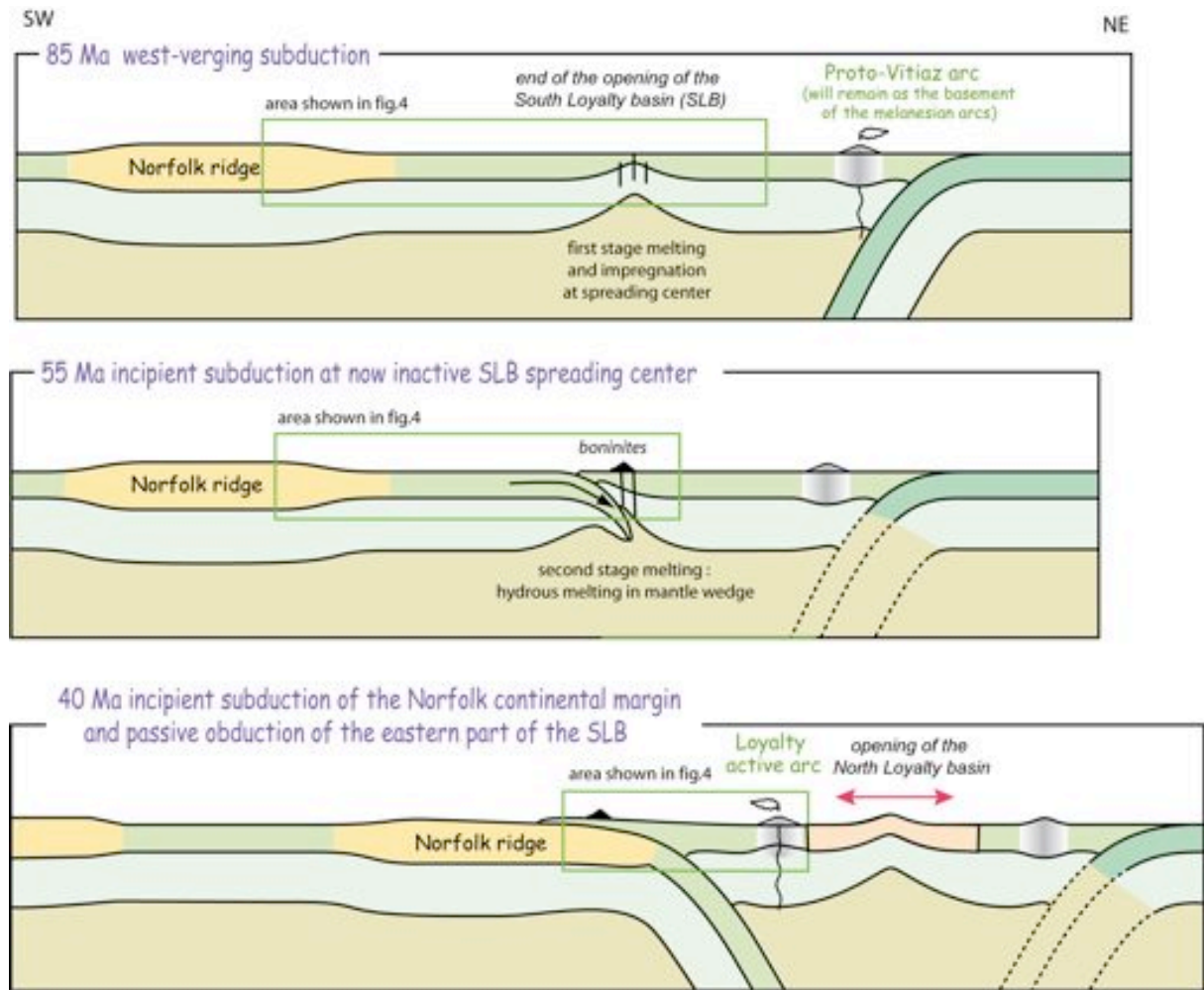


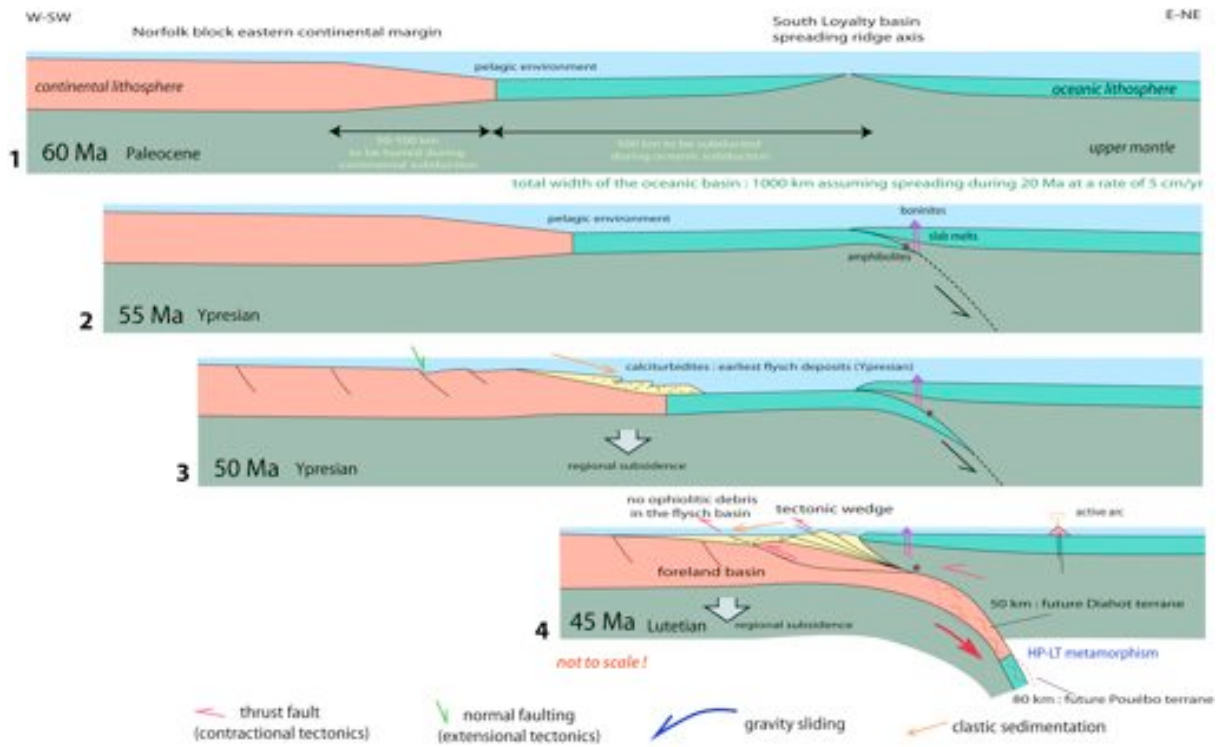
929

Lagabrielle et al., fig. 1



section A and B modified from Cluzel et al. (2001)





Lagabrielle et al., fig.4 part A

40 Ma MAJOR CHANGE : SHIFT FROM CONVERGENCE AND HORIZONTAL CONTRACTION TO DOMINANT VERTICAL MOTIONS AND EXHUMATION OF BURIED UNITS

