NEW CALEDONIA
Geological Map

Scale : 1/500 000

First edition

1cm = 5 000 m

Peridotite units

brgm

december 2009

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NEW CALEDONIA
Geological Map

Scale : 1/500 000

0 5 10 20 km

Bibliographic reference :

- **Map :** Maurizot P., Vendé-Leclerc M., 2009 – New Caledonia geological map, scale 1/500 000, Direction de l'Industrie, des Mines et de l'Energie - Service de la Géologie de Nouvelle-Calédonie, Bureau de Recherches Géologiques et Minières. Explanatory note by Maurizot P. and Collot J., 2009.

- **Note :** Maurizot P., Collot J., 2009 – Explanatory note of the geological map of New Caledonia, scale 1/500 000, Direction de l'Industrie, des Mines et de l'Energie - Service de la Géologie de Nouvelle-Calédonie, Bureau de Recherches Géologiques et Minières. Map by Maurizot P., Vendé-Leclerc M., 2009.

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Overview

The archipelago of New Caledonia is part of a complex zone consisting of oceanic and thinned continental crust basins, largely submerged continental strips, and volcanic ridges or arcs located between the Australian continent to the west and the broad Pacific Ocean to the east (Kroenke, 1984; Schellart et al., 2006). Most basins opened since mid Cretaceous time in the upper plate of a west-dipping subduction zone which retreated towards the east, resulting in the fragmentation of the eastern Gondwana margin. From west to east the following are distinguished (Figure 4):

- The Tasman Sea is a deep oceanic basin which opened by seafloor spreading from Late Cretaceous to Late Paleocene, leading to anti-clockwise rotation and isolation of all the structures located to the east (Gaina et al., 1998; Hayes and Ringis, 1973).

- The Lord Howe Rise is a mainly continental submerged feature (Klingelhoefer et al., 2007). Two DSDP drill holes have intersected Cretaceous to Paleocene sediments similar to those found in New Caledonia and New Zealand (Burns et al., 1973a, b). The Rise is intersected by several lines of NS intraplate volcanoes (including the Chesterfield chain) that resulted from hot spot activity since the Late Eocene (Missègue and Collot, 1987). To the west of the Rise lies the Middleton Basin, a thinned continental crust basin and the Dampier Ridge of continental origin (Jongsma and Mutter, 1978; McDougall et al., 1981).

- The Fairway Basin is a thinned continental crust basin that connects southwards with the Aotea Basin in New Zealand (Collot et al., 2009, Klingelhoefer et al., 2007).

- The Fairway Ridge is a continental ridge, buried in some places, which separates the Fairway Basin from the New Caledonia Basin and connects southward with the West-Norfolk Ridge (Exon et al., 2007, Collot et al., 2009).

- The New Caledonia Basin, off New Caledonia's west coast, has a thinned intermediate-crust (Klingelhoefer et al., 2007), and presents an east-dipping foreland-basin with a sedimentary cover reaching 6 km of thickness. This local tilting of the basin is interpreted as being the result of deformation linked to the Eocene New Caledonia obduction event (Collot et al., 2008). Further south, the basin has an oceanic-like crust (Klingelhoefer et al., 2007) and the sedimentary cover thins out (Lafoy et al., 2005).

- The Norfolk Ridge, which bears the Grande Terre of New Caledonia to the north and connects southwards to the landmass of New Zealand, is a continental strip (Klingelhoefer et al., 2007), mostly submerged.

- The South Loyalty Basin has a thick sedimentary cover (up to 8 km thick) overlying an oceanic crust that rises towards and outcrops in New Caledonia. The root of the basin is exposed in New Caledonia in the ophiolitic nappe (Collot et al., 1987). The age of formation of the basin is thought to be synchronous with that of the Tasman Sea (Cluzel et al., 2001).

- The Loyalty Ridge extends northwards toward the d'Entrecasteaux zone and is connected southwards to the Three Kings Ridge through the Cook Fracture Zone (Kroenke and Eade, 1982). It consists of a line of seamounts capped by reef formations. The geology and origin of the ridge are poorly known. However, taking into account its possible link with the d'Entrecasteaux Ridge (in which Eocene andesites were drilled (Collot et al., 1992), and its relationship to the Three Kings Ridge to the south, where Eocene and Miocene volcanic shoshonites were dredged (Bernardel et al., 2003; Mortimer, 1998), the Loyalty Ridge is widely considered as an Eocene island arc.

- The North Loyalty and South Fiji basins are oceanic back-arc basins which, depending on authors, opened between Eocene and Miocene (Herzer et al., 2009; Maillet et al., 1983; Sdrolias et al., 2003; Mortimer et al. 2007)

- The arc-trench system of the New Hebrides (Vanuatu) represents one of the two current active convergent boundaries between the Pacific and Australian plates. The east-dipping subduction zone was established during the Miocene, in opposition to the overall west-dipping pattern of the western Pacific margin.

- The North Fiji Basin is an active 10 Ma old back-arc basin of the Vanuatu subduction zone (Malahoff et al., 1982; Pelletier et al., 1993). With more than 4,000 km of active divergent boundaries (star-like spreading centers and transform faults) in a triangle of only 1500 km on a side, it is one of the most active expansion zones of the world and one of the worlds' largest observed geoidal highs, which suggests the existence of a large thermal anomaly in the underlying mantle (Malahoff and Larue, 1979).

- The Vitiaz Lineament (Pelletier and Auzende, 1996) represents the remnants of a Late Cretaceous – Paleogene, south-dipping arc-trench system, which probably gave birth to some of the oldest marginal back-arc basins of the SW Pacific. This system was blocked by the collision of the Ontong Java oceanic plateau, and plate convergence was then relayed to the new New Hebrides arc-trench system of opposite vergence.

With the exception of the Chestefield Islands, which are atolls built on intra-oceanic volcanoes, and of the Mathew and Hunter Islands, which are volcanoes located on the southern tip of the Vanuatu island arc, the territory of New Caledonia rises along two parallel ridges : **the Norfolk Ridge and the Loyalty Ridge**.

The Loyalty Islands are uplifted atolls built on a line of volcanic seamounts. Middle Oligocene to Middle Miocene volcanic and sedimentary rocks have been dredged and sampled from submersible dives on the flanks of the ridge (Monzier et al., 1989; Monzier, 1993; Pelletier, 2006). Two small Upper Miocene volcanic basalt exposures are known on the island of Maré, which present alkalic hotspot signatures (9-11 Ma, Baubron et al., 1976). The oldest known reef or rhodolite limestones are Middle Miocene (14 to 15 Ma; Maurizot & Lafoy, 2003) and are contemporaneous with the known volcanism. The construction of the atolls lasted until the Holocene. Currently, two hypotheses exist regarding the origin of the ridge:

1) The ridge corresponds to an ancient Eocene intra-oceanic island arc that was, contemporaneous with the subduction and the convergence zone observed on the Grande-Terre, reactivated by younger hot spot volcanism (Maillet et al., 1983, Cluzel et al. 2001; Schellart et al., 2006).

2) The ridge results from anorogenic magmatic activity in an extensional context (Rigolot et al., 1988).

The Grande Terre which rises on the northern end of the **Norfolk Ridge** is composed of:

1) composite terranes assembled during a period of convergence from Late Carboniferous to Early Cretaceous (the Late Cretaceous cycle, 300 - 100 Ma).

2) units emplaced after the Late Cretaceous and before the Miocene (the New Caledonian cycle, 100 - 24 Ma) in which are distinguished:
- a sedimentary cover deposited in a Late Cretaceous to Paleocene rift or extensive environment, followed in the Eocene by a change to a convergent depositional environment.
- ophiolitic units obducted at the end of the Late Eocene.

3) marine and continental post-obduction units (the Miocene to present cycle).

Pre-Late Cretaceous basement

Four contiguous terranes are recognised within basement rocks that underlie the Cretaceous unconformity, each one bearing its own lithological, structural and metamorphic signature. They are all of intra-oceanic origin.

Téremba Terrane (Aitchison et al., 1995), extends along the west coast from the Baie de Saint-Vincent to the Baie de Téremba (Campbell et al., 1985). It is composed of eruptive volcanic products and erosional deposits of a calc-alkaline volcanic arc that was located further to the west. The oldest sedimentary rocks are of Late Permian age and the youngest are Middle Jurassic. The various sedimentary units are organized into sequences of several hundred meters thick, unevenly distributed, separated by unconformities (erosional surfaces and hiatuses) and suggestive of relatively stable tectonic settings. The lower part is characterised by proximal Permian to Early Triassic volcanism (flows, domes, dikes, sills, coarse pyroclastics) and differs from the

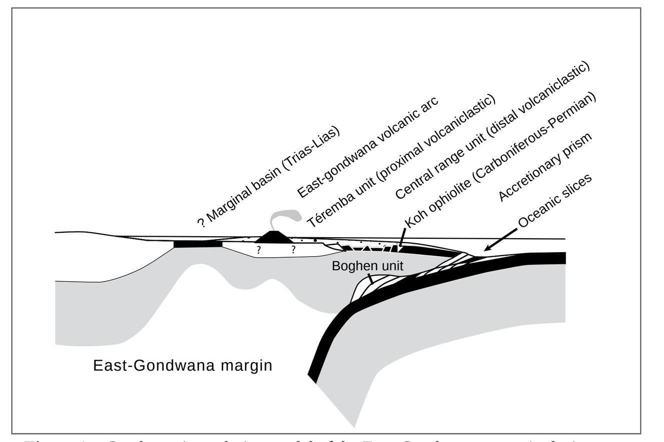

Figure 1 – Geodynamic evolution model of the East-Gondwanan margin during Mesozoic (from Cluzel and Meffre, 2002).

upper part which is predominantly comprised of epiclastic sedimentary rocks (volcaniclastic greywackes, minor tuffs), often fossiliferous, deposited in a context of external platform or slope. The paleofauna and flora are remarkably similar to those of New Zealand. The Gondwanan affinities during the Permian disappear and are replaced by Triassic and Jurassic fossil biota with marked endemism and low biodiversity (Maorian Province; Grant-Mackie et al., 2000).

Sediment provenance studies reveal only minor evidence of continental affinity. The average content of quartz in the greywackes never exceeds 5%. Zircons are rare and sub-contemporaneous with the volcanism. The geochemistry of volcanic products is calc-alkaline. The values of Sm and Nd are characteristic of an immature intra-oceanic volcanic island arc with little or no continental crustal contamination (Meffre, 1995). The Permian part of the Téremba Terranes is comparable to the Brook Street Terrane of New Zealand (Spandler et al., 2005), while the Mesozoic sedimentary part is comparable to the Murihiku Terrane (Campbell et al., 1985).

Koh Terrane is comprised of fragments of oceanic crust and includes Cantaloupai, Tarouimba-Sphynx, Pocquereux, Koh, Kouah and Nassirah ophiolite units. The lower parts of these sequences (gabbro cumulate, dolerite, plagiogranite) are in faulted contact with the Boghen Terrane. The upper parts (dyke complex, pillow basalt, radiolarian chert) are overlain by Mesozoic volcaniclastic sedimentary rocks that appear to be in primary depositional contact. These rocks are mapped as Central Range unit. None of these units show a preserved basal-mantle sequence. The Koh unit is dated as Carboniferous (302 Ma) and the Kouah unit is Early Permian (290 Ma; U/Pb on zircon; Aitchison et al., 1998). In the Koh unit, an episode of boninite composition (Cameron et al., 1983; Meffre et al., 1996) is intercalated within a series of predominantly tholeiitic (IAT[2] and BABB[3]) basalts. These ophiolitic units can be interpreted as remains of marginal basins or intra-oceanic fore-arc structures, formed in a supra-subduction zone and unrelated to the volcanism of the Téremba Terrane or that of the Permian-Mesozoic Central Range unit.

Central Range unit (part of the Koh Terrane) is comprised of several thousand meters of sparsely fossiliferous volcaniclastic sedimentary rocks that lie in apparent primary depositional contact upon Koh Terrane ophiolite units. The rocks are mainly volcaniclastic turbidite (greywacke) associated with bathyal chert, vitric tuff and black shale. Rare occurrences of basalt (IAT) are known. The succession of several cycles with alternating periods of volcanic activity (coarse epiclastic sediments) and quiescence (black shale with high organic content) suggests the existence of several successive volcanic arcs. Deformation and metamorphism are weak.

The composition of the clinopyroxenes clasts of the greywackes is typical of basic to intermediate calc-alkaline arc volcanism (Meffre, 1995). Fossils are comparable to that of the Téremba Terrane but are much less common. They indicate Late Permian to Early Cretaceous ages (Adams et al., 2009). Ages pro parte, lithology, geochemistry and biota are thus comparable to those of the Téremba Terrane. The Permian-Mesozoic Central Range unit represents accumulation of distal erosion products of several volcanic arcs, active between the Permian and the Early Cretaceous. They probably correspond to several terranes deposited in separate areas to the east of the Téremba Terrane and amalgamated later on.

Boghen Terrane (Aitchison et al., 1995) bears the imprint of a polyphase complex deformation and metamorphism with a P-T-t path oscillating between green and blue schist facies. This terrane is always in fault with adjacent pre-Late Cretaceous units. Boghen Terrane can be subdivided in two parts:

- A lower ophiolitic part (Cluzel, 1996), which probably corresponds to an oceanic seafloor, with E-MORB[4], rarely BABB and OIB[1] basalts, that originates from different magmatic sources, and is completely lacking input from terrigenous continental sources or subduction related fluids.

- A monotonous upper sedimentary part with a volcaniclastic component (tuff and hematite - sphene quartzite) and an organo-terrigenous component (black silty argillite and sandstone).

The fine grain size and laminar bedding indicate deposition distal from source. These rocks can be locally intra-brecciated.

Boghen Terrane rocks display polyphase deformation with isoclinal folds, transposition of S0 and pervasive crenulation. The HP - LT metamorphism is usually of low-grade (pumpellyite) but locally reaches the garnet-glaucophane ± lawsonite paragenesis. Provenance studies have yielded Carboniferous to Liassic (190 - 305 Ma, Cluzel & Meffre, 2002) and Cretaceous (Cluzel, unpublished) ages for zircons indicating that the metasediments are largely contemporaneous with those of the Central Range unit. The dating of the «blue schist metamorphic event» at 150 Ma (K/Ar on glaucophane; Blake et al., 1977) is inconsistent with the new detrital zircon age data and is therefore incorrect.

Boghen Terrane is interpreted as an accretionary sedimentary prism that accumulated offshore of a Permo-Mesozoic East Gondwanan volcanic arc that was subducted (to produce «blue schist»), incorporating slices of oceanic crust and then exhumed (as «green schist»).

These **pre-Late Cretaceous amalgamated terranes** can be interpreted in a geodynamic framework (Cluzel & Meffre, 2002) as part of a Permian to late Mesozoic East-Gondwanan active margin (Figure 2). In this scenario, the Boghen Terrane represents an accretionary complex and the Central Range unit and Téremba Terrane represent respectively the distal and proximal products of related but distinct volcanic arcs. These arcs were possibly located either at the current location of the Lord Howe Rise or on the East Australian margin. Although the activity of such arcs could last more than 100 million years, the products of erosion of their deep plutonic components remain still unfound. The Koh Terrane ophiolites could represent fragments of basins trapped in a forearc position. The accretionary complex of the Boghen Terrane was first subject to high-pressure metamorphism and was subsequently emplaced by exhumation.

Units of the New Caledonian cycle

These units were deposited unconformably, or overthrust over the previous relative-basement during a Late Cretaceous to Oligocene cycle (100 - 24 Ma). From the Cretaceous to the Paleocene several marginal basins opened on the eastern Gondwana margin above a west dipping subduction zone (Figure 2A) which propagated toward the Pacific via trench rollback process; from the Australian continent to the Pacific Ocean: the Tasman Sea, the Fairway-Aotea Basin, the New Caledonia Basin and the South Loyalty Basin. This period of rifting and expansion was disturbed during the Paleocene by the initiation of a new subduction (Figure 2B) with opposite vergence (dipping to the NE). In this new convergence zone the South Loyalty Basin followed by the Norfolk ridge were gradually subducted (Figure 2C).

The Late Cretaceous to Paleogene sedimentary cover of the Grande Terre successively reflects these two main deformational phases, consisting of a continuous passive margin megasequence, with coarse detrital peri-continental sediments at the base (syn-rift) and marine transgressive deposits towards the top (post-rift). A basal conglomerate unconformably overlies the earlier Late Cretaceous amalgamated units and grades into terrigenous circa-littoral deposits with coal measures (the «Formation à charbon»). In the quartz sandstones, the zircons provenance is either from the Mesozoic substrate or from the Archean (Aronson et al., 1970). Interbedded volcanics occur in both the Nouméa and Diahot regions. In the Noumea region, they are represented by pyroclastic deposits, flows and sills. The compositions are basaltic, andesitic, trachytic, and rhyolitic (ignimbrite). The geochemistry is calc-alkaline to alkaline with continental signatures which were most likely generated through a mixture of metasomatized upper mantle and lower continental crust (Black, 1995). In the Diahot region, arc tholeiites (IAT) and rhyodacites are found. These lavas are geochemically very similar to those from Nouméa. They are associated with polymetallic massive sulfide deposits bearing base metals and gold.

Terrigenous sediments fine upward and grade into a succession of black siltstones and shales with organic components, sulfides and fossiliferous nodules (the «Mamelons Rouges» level, Tissot & Noesmoen, 1958). These levels are Coniacian to Campanian in age according to the macro faunas of ammonites and Inocerams (Paris, 1981). They grade into black cherts, rich in organic components and sulfides (former «phtanites» of P. Routhier, 1953), of Maastrichtian to Early Paleocene age. These sediments were deposited in a hemipelagic to pelagic context and anoxic environment resulting from the post-rift thermal subsidence. In the North, the top part of the black cherts gradually evolve into pelagic Paleocene micrites with planktonic micro fauna.

These sedimentary formations have their equivalents in New Zealand: the «Coal measures» for the «Formation à charbon», the «Whangai formation» for the «black cherts» (Moore, 1988) and the «Amuri limestone» for the «Paleocene micrites» (Hollis et al., 2005).

The deposits of the **Eocene flysch** (Gonord, 1977) reflect and record the gradual progression of the Norfolk Ridge into the convergence zone. These deposits, which present a strong turbiditic character as they get higher in the sequence, lie in continuity with the underlying flysch in the north and are unconformable over the foreland bulge in the south. They correspond to an increasingly coarser mega-sequence tending towards a sommital olistostrome and preceding the obducted allochtonous units. They present a dual source characteristic: from the subducting plate (Norfolk Ridge) and from the forearc accretionary complex (Poya Terrane or South Loyalty Basin). The vertical evolution of the flysch deposits (successively carbonated, then volcaniclastic and finally wild flysch) reflects the overall horizontal motion of the overridden plate toward the collision zone, from the bulge down into to the subduction trench and at last into the subduction zone (Cluzel et al., 1998).

During Eocene, the Norfolk Ridge moves to the north obliquely into the subduction zone (Figure 2B, C) and as the collision occurs the flysch deposits propagate toward the south along the ridge. A certain proportion of the early-flysch was probably dragged into the subduction zone and incorporated in the HP - LT North New Caledonian metamorphic protolith which is no longer recognizable. The earliest known turbidites (calciturbidites) lie conformably upon the Paleocene micrites in the northern part of the island. In contrast, unconformably, overlying the Téremba Terrane, which is the last unit to be involved in the collision zone before blocking of the subduction, the base of the flysch is made of reefal to peri-reefal limestones (Uitoé limestone) of the terminal Eocene - basal Oligocene, overlain by continental sandstones and conglomerates. Between these two extremes, the flysch can locally reach 4000 m in thickness (Bourail anticline), this depocentre reflects the establishment of a flexural foreland basin in the south (Bourail to Nouméa). The lower part of the flysch was fed by clasts of the carbonate platform established on the foreland bulge. The upper part of the flysch was fed by clasts whose geochemistry is characteristic of the Poya Terrane (currently accreted in the fore arc). The earliest flysch to the north and its substrate (calciturbidites, Late Cretaceous to Paleogene cover and Mesozoic strips) are overturned on the top of the youngest flysch in the south, first as olistolithes in the sediments of the olistostrome, then tectonically to form the «Montagnes blanches» nappe, a unit which is systematically inserted between the higher terms of the flysch and the ophiolitic allochtonous units (Figure 3).

Locally (Népoui, Koumac) monogenic basaltic turbidites are deposited in restricted piggy back basins perched on the Poya Terrane during its accretion in the fore arc (Cluzel, 1998).

The overall flysch sediments are remarkably devoid of any clasts of the peridotite nappe or of an Eocene volcanic arc contemporaneous with the subduction. The flysch is in turn topped by the ophiolitic allochthonous units namely the Poya Terrane and the peridotites nappe.

The Poya terrane, which is always located in-between the autochthonous units of the Norfolk Ridge and the peridotite nappe (Cluzel et al., 2001) corresponds to a pile of overlapping scraped-off slices of oceanic crust (pillow lava basalts, dolerites, and subordinate intercalations of abyssal sediments: ferro-manganiferous jaspers, radiolarian cherts and argillites, exhalative hydrothermal sediments, and sulphide deposits with Mn, Ba, Cu and Au). This crustal ophiolitic unit, devoid of any mantle or cumulate sequences, is affected by static low grade sub-seafloor metamorphism.

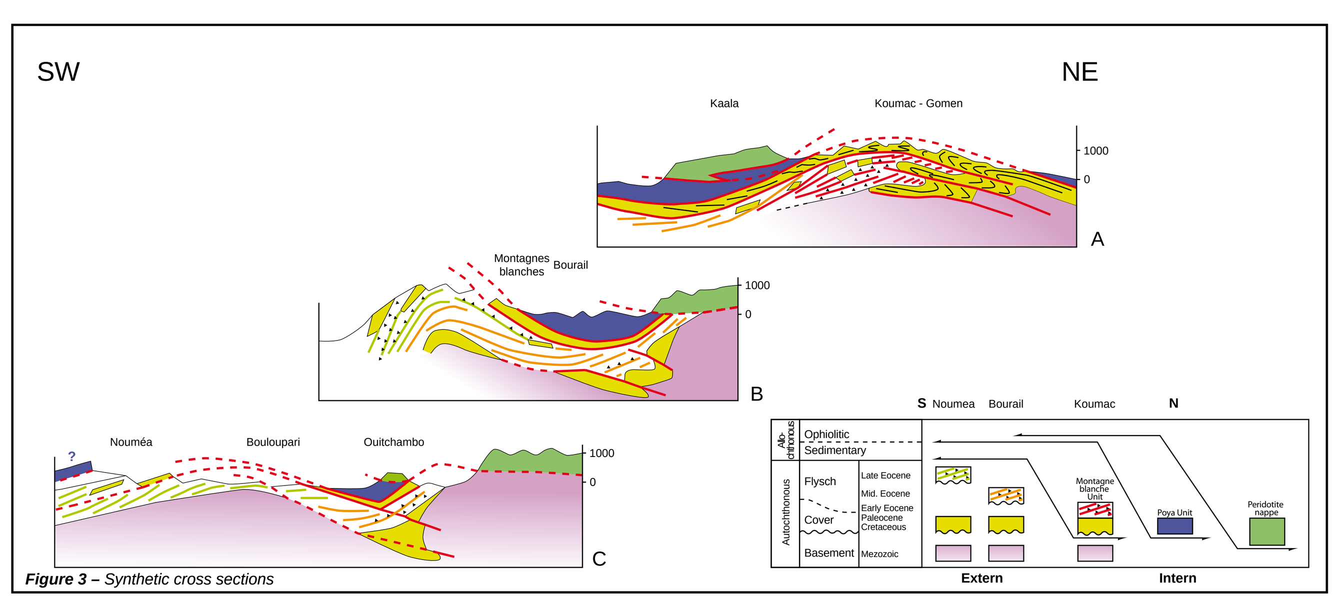

Figure 3 – Synthetic cross sections

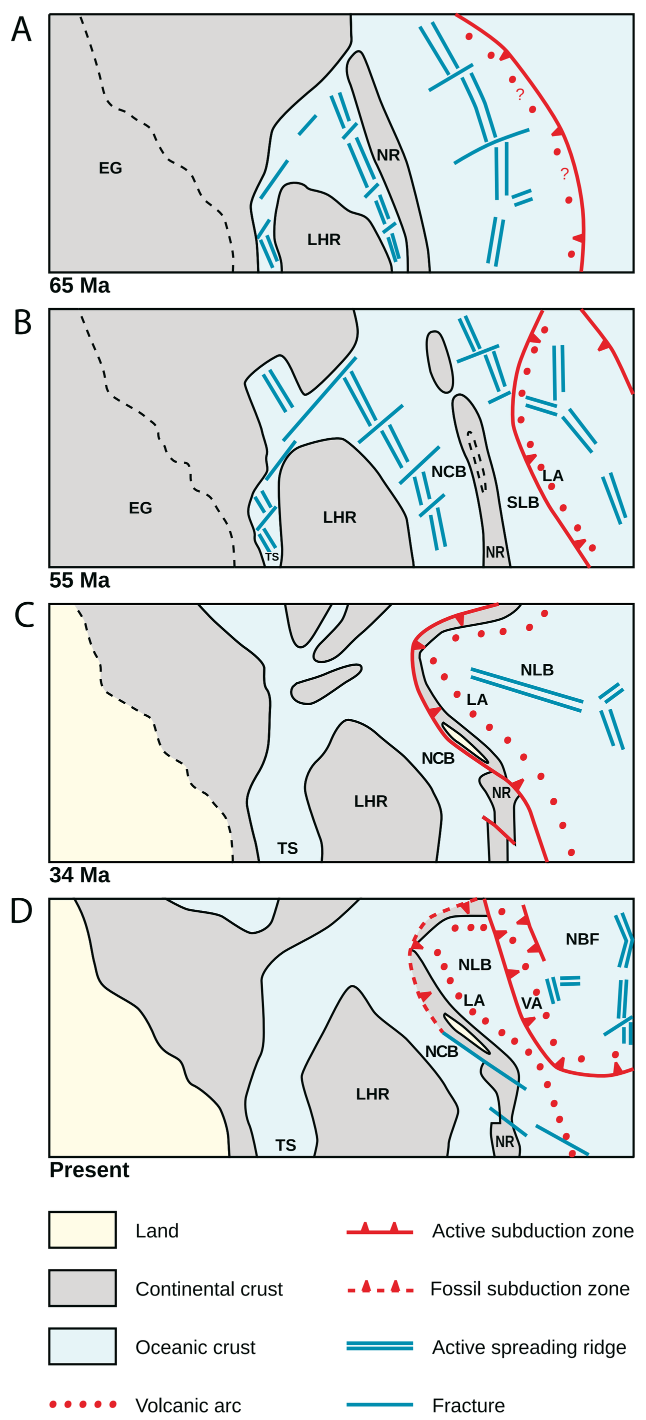

Figure 2 – Geodynamic evolution model for New Caledonia from 65 Ma (EG : East Gondwana, LHR : Lord Howe Rise, NR : Norfolk Ridge, LA : LoyaltyArc, NLB : North Loyalty Basin; VA : Vanuatu Arc, NLB : North Loyalty Basin).

E-MORB tholeiites are preponderant over IAT, BABB and depleted N-MORB[5] tholeiites. The geochemical continuum of the composition suggests a mixture of materials from a supra-subduction depleted slab source and from an enriched deeper source coming from a mantle plume. The macrofauna and radiolarians indicate a Late Cretaceous (Campanian) to Paleocene age (Cluzel et al., 2001). The paleomagnetic data enable us to locate the emission centre at about 300 to 500 km north of the unit's current position (Ali & Aitchison, 2000).

Locally, at Pinjen, specific hydroclastic tuffs and pillow lavas, alkaline in composition (OIB), are interbedded with micrite containing Late Paleocene planktonic microfaunas. These occurrences are interpreted as being remnants of intraplate seamounts, independently generated by hot spot volcanic activity.

At the base of the unit on the west coast, the basalts are interbedded with argillites, cherts and vitric tuffs, bearing Late Cretaceous Inocerams (Routhier, 1953). These hemipelagic sediments predominate in some places over the basalts. They could represent a distinct terrane, formerly located close to the northern margin of the Norfolk Ridge.

In its northern part, the Poya Terrane incorporates many serpentinite slivers, sometimes in connection with the sole thrust of the peridotite nappe, which are slices of mantle torn down from the overriding plate in the subduction zone.

The age and settings of the Poya Terrane are similar to those of the Tangihua Complex (Northland Allochthon) and the Matakaoa Complex (East Cape allochthon), units obducted to the SW during the Miocene (Ballance & Spörli, 1979) in the north of New Zealand. However, there is no analogy in their geochemical compositions (Nicholson et al., 2000). The opening of these oceanic basins was thus synchronous, but their origins are distinct and their obductions are diachronous.

The high pressure - low temperature (HP - LT) metamorphic complex found in the North of New Caledonia is one of the largest and best preserved in the world. It was formed in the Paleogene by subduction of the plate which carries the Norfolk Ridge and the South Loyalty basin. The metamorphic protolith includes:

- **The Diahot - Panié unit** (Cluzel et al., 1995), which is the NE lateral equivalent of the unmetamorphosed Late Cretaceous - Paleogene sedimentary cover. It consists mainly of blueschist facies lawsonite and glaucophane-bearing mica schist and gneiss. In the Poindimié area, parts of the pre-Late Cretaceous formations are also affected by this metamorphism.

- **The Pouébo unit** is a chaotic mixture of boulders within a metasedimentary or serpentinite matrix (Maurizot et al., 1989) metamorphosed to eclogite facies then retrograded through blueschist to greenschist facies. The Pouébo unit is a metamorphic equivalent of the Poya Terrane with which it shares both geochemical composition (Cluzel et al., 2002) and age of formation (85 Ma, based on zircons; Spandler et al., 2005).

These two units may have undergone a distinct evolution before being amalgamated in the subduction zone. Their P-T-t paths follow a clockwise prograde then retrograde evolution. In the Diahot unit the maximum P-T conditions are estimated to be 1.7 GPa and 600 °C (Fitzherbert et al., 2005). In the Pouébo unit, the peak conditions are estimated to be 2.4 GPa and 650 °C (Clarke et al., 1997), implying a 70 km depth of burial. The peak metamorphic age of the Pouébo unit is 44 - 45 Ma (Early to Middle Eocene) based on U/Pb dating of neoformed rims of zircons (Spandler et al., 2005). The retrograde stage corresponds to the exhumation of the Pouébo unit across the unroofed Diahot unit, in an extensional context (Cluzel, 1995). The blueschist and greenschist facies stages are controlled by extensional tectonics and fluids. Their cooling ages are well constrained between 40 and 34 Ma (Middle to Late Eocene) by numerous radiometric ages: K/Ar, Ar/Ar on late phengite (450 ± 50 ° C; Ghent et al. 1994; Rawling, 1998) and by apatite fission tracks (80 ° C; Baldwin et al, 2007).

The peridotite nappe (Avias, 1967), which occupies one third of the surface of the island of Grande-Terre, is a fundamental element in the landscape, geology and economy of New Caledonia. Its obduction is a consequence of the blocking of subduction by the continental Norfolk Ridge, entering the convergence zone during the Eocene. The blocking led to the exhumation of the deeply buried metamorphic complex in the north and the rise of the ridge through the supra-subduction mantle. On the east coast, the peridotite nappe is rooted in the Loyalty Basin of which it represents the substrate (Collot et al., 1987). On the west coast the alignment of ultrabasic klippen could represent the remains of a once single unit detached from the front of the nappe.

The mantle sequence is of harzburgite-dunite type. Lherzolites are known in the north, in the Thiébaghi, Poum and Bélep klippen (Sécher, 1981; Moutte, 1982). Elsewhere are found depleted peridotites, with a high rate of partial melting (not cogenetic with the Poya Terrane). In the south of Grande Terre, several bodies of cumulate gabbros are distinguished within transition dunites. There is neither a sheeted dyke complex nor crustal basalts (initial lack, post obduction denudation, late erosion?).

The peridotites bear the typical mantle fabric resulting from asthenospheric flow and high temperature ductile deformation, and exhibit planar foliation, mineral segregation and stretching lineations (affecting olivines, orthopyroxenes and spinels). The overall indicators of the deformation (stretching N 160°) are homogeneous across the territory (Prinzhofer et al., 1980) with only some local fluctuations, implying that the now separated units and klippen were originally a single set, the initial expansion area being orthogonally oriented, thus EW.

The peridotites are crosscut by a set of ultrabasic, basic, boninitic, felsic, granitoids dykes, which are never present (with the exception of the latest granodiorite) in the autochthonous substrate or in the Poya Terrane and are therefore pre obduction. Some facies are pegmatoids, indicative of the important role of a fluid phase. Other veins have rodingitic parageneses characterizing the hydration of the mantle of the overriding plate by the crust of the overridden plate. Some of the dykes show ductile deformation (amphibolite). The average age for the dykes of acidic composition in the Massif du Sud (U/Pb zircon, Cluzel et al., 2006) is 53 Ma. These dykes, whose intrusion took place in a supra-subduction context, indicate a minimum age for the beginning of the convergence that is consistent with the age of the earliest flysch.

Two more important calc-alkaline granites (Saint Louis and Koum, at 32-27 Ma and 27-24 Ma; U/Pb on zircon, Cluzel et al., 2005) intrude both the peridotite nappe and the substrate during the Oligocene. Their geochemical and isotopic compositions are consistent with a mantle origin in a volcanic arc, uncontaminated by continental crust, and related to a short revival period of subduction on the western margin of the Norfolk Ridge (Cluzel et al., 2005).

In Papua New Guinea, ophioloitic units comparable to those of New Caledonia are obducted to the SW over the Australian continent (Papuan Ophiolitic Province). The Papuan Ultrabasic Belt includes the typical elements of an ophiolite with a mantle sequence, isotropic and cumulate gabbros, a dyke complex and pillow basalts. These ophiolites contain interbedded sediments of Late Cretaceous to Late Paleocene age. Dykes of various compositions (felsic, boninitic) are dated from the Paleocene-Eocene transition. These units are thrust to the SW over a HP-LT metamorphic complex (Owen Stanley Metamorphics) of which the protolith is Cretaceous to Paleocene in age (Whattam et al., 2008).

The Miocene to Quaternary post-obduction history was marked by a northeast migration of the plate boundary to Vanuatu, leaving the Norfolk Ridge and New Caledonia in an intra-plate setting. The Loyalty ridge, which was volcanically active until Miocene time, subsided and was gradually covered by carbonate reefs that evolved into atolls.

On the Grande-Terre, the post-obduction period was characterized, by extensional fault movements (Lagabrielle et al., 2005; Chardon et al., 2008) that led to collapse of ridge margins and variable deformation and faulting along the topographic axis. At least eight post-obduction formations (Chevillotte et al., 2006) are defined on the basis of weathering profiles and sediment type.

Tropical continental weathering of peridotites was extensive, especially within endoreic basins, some of which remain internally active at the southern tip of the Massif du Sud. Numerous perched paleosurfaces covered with lateritic weathering profiles and iron cap at their top are remnants of former basins that have since been uplifted. The bases of these weathering profiles contain economic supergene mineral deposits of nickel and cobalt. The distribution of laterite, and the high nickel concentrations that are associated with it, are controlled by long-term eustatic and climatic changes, by brittle faulting of the peridotite substrate, by large scale tectonic uplift (Chevillotte et al., 2006), and by local karstic phenomena that accompany weathering (Genna et al., 2005).

Sedimentary formations consist of fluvial and deltaic aggradation deposits (Chardon & Chevillotte, 2006): 1) the Goa N'Doro formation on the east coast (Gonord & Orloff, 1968) is possibly Late Oligocene; 2) the Népoui formation on the west coast contains deltaic to peri-reefal Middle Miocene sediments (Coudray, 1976); 3) the Fluvio-lacustrine formation in the Massif du Sud has unknown age. These sediments have reworked the products of continental weathering of peridotites: iron caps, garnierite, silica, laterites. On the NE margin of the Grande Terre, the Miocene sedimentary detrital prism is cross-cut by extensional faults (Chardon et al., 2007).

Both the topographic ridges of the Grande Terre and the Loyalty Islands have doubly-plunging crestlines: their NW and SE extremities plunge gradually beneath sea level. This morphology results from a broad lithospheric bulge in front of the Vanuatu convergence zone, where the Australian plate is subducted (Dubois et al., 1974). The history of this bulge, combined with local fault movements and eustatic sea level changes are recorded by the fringing or barrier reefs that surround the archipelago. Uplifted reefs (Loyalty, Ile des Pins, Yaté) have a range of ages from Middle Miocene to Quaternary (Cabioch et al., 1999). The oldest carbonate formation known on the margin of the Grande Terre formed at 1.4 Ma (Cabioch et al., 2008), but the present barrier reef and lagoon geography did not develop until 0.4 Ma (Frank et al., 2006). The remoteness of the barrier reef from the shoreline and the development of the lagoon are caused by the subsidence of the margin of the Grande Terre, in a similar fashion to the formation of atolls on subsiding volcanic islands. During Quaternary sea-level lowstands (glacial periods at high latitudes), the lagoon was drained and rivers cut valleys through emergent reefs. The paths of these rivers are now flooded beneath the lagoon. The passes through the barrier reef represent their former outlets into the Pacific Ocean. (Chevillote et al., 2005).

1 Oceanic Island Basalts
2 Island Arc Tholeiites
3 Back-Arc Basin Basalts
4 Enriched Mid Oceanic Ridge Basalts
5 Normal Mid Oceanic Ridge Basalts

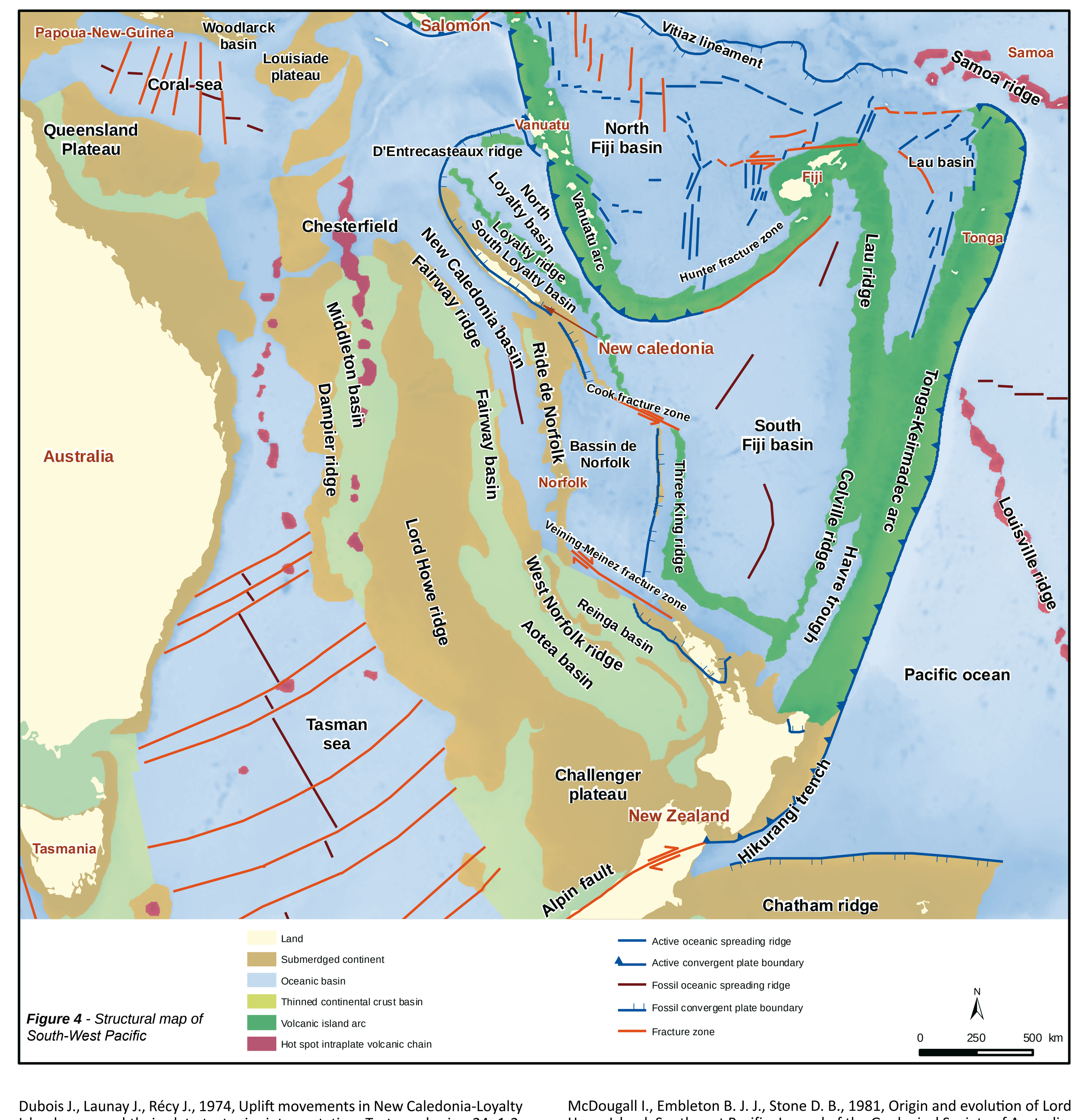

Figure 4 - Structural map of South-West Pacific

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