Mid-Tertiary magmatic events in New Caledonia : K-Ar dating of boninitic volcanism and granitoid(MEMORIAL VOLUME TO THE LATE PROFESSOR TERUHIKO SAMESHIMA) intrusives

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Mid-Tertiary magmatic events in New Caledonia: K-Ar dating of boninitic volcanism and granitoid intrusives

Philippa M. BLACK[1], Tetsumaru ITAYA[2], Takashi OHIRA[2], Ian E. M. SMITH[1] & Miki TAKAGI[2]

Abstract The Cenozoic geological record of New Caledonia contains two autochthonous magmatic associations, the Early Eocene Formation of Basalts and the Late Oligocene-Early Miocene granitoid suite of the Koum and St Louis areas. New K-Ar dates show that the boninites in the Nēpoui region, hitherto thought to be Early Eocene, are Late Oligocene. Allochthonous ultramafic rocks of the New Caledonia Ophiolite were emplaced in the Late Eocene or Early Oligocene. The similar age of the Nēpoui boninites and the Koum-St Louis granitoids suggests that they were linked to a short lived subduction event which took place after ophiolite emplacement.

Key words: boninite, clinoenstatite, ultramafics, granodiorites, New Caledonia

INTRODUCTION

The geology of New Caledonia can be represented in terms of four dominant tectonostratigraphic units (Fig. 1): a core of Late Paleozoic and Mesozoic clastic rocks, variably deformed and metamorphosed, which includes the Central Chain complex and all other rocks of the same age range; Late Cretaceous and Early Tertiary sedimentary successions deposited in basins on the margin of the Central Chain complex; ocean floor basalts and minor oceanic sediments (Formation of Basalts); and an obducted ultramafic sheet. The island is unusual among Pacific Rim countries in that it has apparently been tectonically stable since the Early Miocene when the north-east dipping Pacific-Australian convergent plate boundary shifted to the east of New Caledonia and no longer influenced the tectonics of the island (Kroenke 1984; Falvey & Greene 1988). New Caledonia therefore lacks the voluminous Late Cenozoic arc-type volcanism which characterises most other countries in the region.

The record of Cenozoic magmatism in New Caledonia is fragmentory. Basalts in the Formation of Basalts have been K-Ar dated as 42-59 Ma, ages which are compatable with the faunal ages of associated sediments (Guillon & Gonord 1972). Spatially associated with the Formation of Basalts is the Nēpoui boninite suite which, although of uncertain age was believed also to be Early Tertiary by Cameron (1989). The only record of autochthonous magmatic activity is the occurrence of several small granodiorite intrusives intruding the ultramafic sheet in the St Louis area east of Nouméa and at Koum (Fig. 1), (Guillon 1975; Rodgers 1976); biotites from these rocks have been K-Ar dated as 32 Ma (Guillon 1975) and 25 Ma (Paris 1981). The allochthonous rocks of the ultramafic complex are believed to have been obducted onto the New Caledonian microplate in the late Eocene (Paris 1981) or Early Oligocene (Guillon 1975).

In this paper we use K-Ar dating to elucidate the relationship between the Formation of Basalts, ophiolite, Nēpoui boninite suite and the granitoids that intrude the ultramafic sheet.

THE NĒPOUI BONINITE SUITE

After moving to New Zealand in 1973 Professor Teruhiko Sameshima made many trips back to Japan. On one of these he made a stop over in New Caledonia to see the geology of that country. While driving across the Plaine des Gaïacs, north of Nēpoui, on the West Coast (Fig. 1) he stopped by an unusual concentration of boulders in the savannah-type vegetation. He recognised the abundant phenocrysts weathered out on their surface

[1]Department of Geology, University of Auckland, Private Bag 92019, Auckland, New Zealand.
[2]Hiruzen Research Institute, Okayama University of Science, 1-1 Ridai-cho, Okayama, 700 Japan.

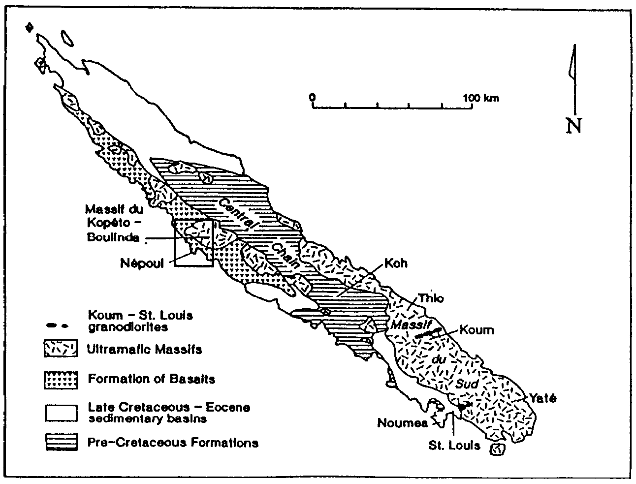

Fig. 1 Simplified geological map of New Caledonia in terms of the main tectonostratigraphic units showing the localities of boninites and the Koum and St Louis granitoids. Area outlined shows position of Fig. 2.

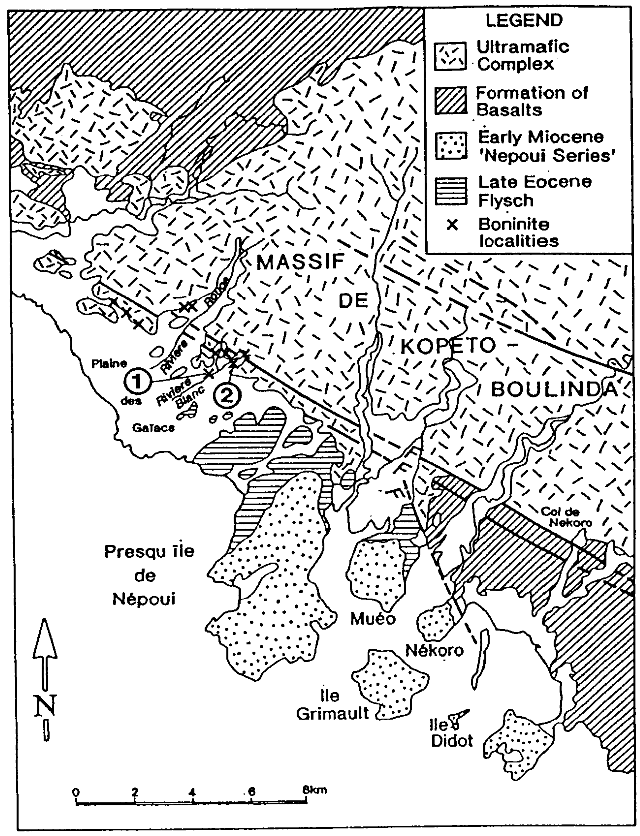

Fig. 2 Simplified geological map of the Népoui area showing the localities of the boninites after Paris (1981) and Cameron (1989).

as clinoenstatite and identified the rock as a boninite; this was the first record of boninites in New Caledonia. Later, he and coworkers from New Zealand and New Caledonia, collaborated to provide a description of the locality together with mineralogical and geochemical data for the Népoui boninite (Sameshima *et al.* 1983).

Clinoenstatite-bearing boninites (low-Ca boninites in the terminology of Crawford *et al.* 1989) are rare rocks and the Népoui occurrence has attracted the interest of several other petrologists. Additional boninite-type lithologies were described from the same locality by Campiglio *et al.* (1986) and Cameron (1989). A survey of New Caledonian basalt localities has identified a second stratigraphic horizon of boninites in the Permian or Triassic ophiolite complex of the Massif de Koh; however the Koh boninites are much older than the Népoui boninite suite, which although of uncertain age, is believed to be Early Tertiary (Cameron 1989).

The Népoui boninites are closely associated spatially with the two ophiolite units which dominate the Geology of New Caledonia (Fig. 2) – the Late Cretaceous to Eocene Formation of Basalts and the ultramafic sheet (Paris 1981) – but the temporal relationship between the three units is enigmatic. The boninites occur as dykes (Shiraki *et al.* 1984), pillow lavas and flows and residual blocks which overlie the Formation of Basalts but outcrop close to the thrust contact of the Kopéto-Boulinda ultramafic massif (Cameron 1989). The petrology of the Népoui boninites has been described by Sameshima *et al.* (1983), Campiglio *et al.* (1986) and Cameron (1989) all of whom noted that they contained fresh glass, and were unaltered and undeformed. The Népoui boninites, therefore, lack evidence of hydrothermal alteration or metasomatism or shearing that might be expected from their close proximitry to an extensively serpentinised ultramafic sheet. Cameron (1989) also noted that the Népoui boninites had chemical compositions which indicated that they were unlikely to be either petrogenetically or tectonically related to the weakly metamorphosed, locally very deformed, Formation of Basalts. The Népoui area also contains Late Eocene sediments and exposures of Miocene littoral marine sediments (Népoui Series) the latter containing ultramafic debris and coral reef horizons (Paris 1981) but there is no contact between them and the boninites and boninite debris has not been recorded in the Népoui Series. In the absence of any dates for the Népoui boninites it is impossible to place them in a stratigraphic or tectonic setting.

There have always been difficulties in correlating the Népoui boninites. There is no evidence in the stratigraphic record of the Main Island of any Tertiary volcanism younger than that contained in the Late Cretaceous to Eocene Formation of Basalts (Paris 1981). Apart from the Formation of

Basalts the only known magmatic events in the Tertiary are those related to the ultramafic sheet and the occurrence of the granitoid intrusives in the St Louis area and at Koum.

THE GRANITOID SUITE

Granitoids form stocks and dykes in the Koum area and a small pluton with associated dykes in the St Louis area (Guillon 1975; Rodgers 1976). Rock types range from porphyritic microdiorites to granodiorites and adamellites. They show a clear intrusive relationship to the obducted ultramafic sheet.

Geochemical data for the granitoid suite in the St Louis area shows a close comparison with plutonic rocks associated with arc-type volcanic suites in northern New Zealand and in southeastern Papua New Guinea (Smith & Clark 1992). In Papua New Guinea the granitoids show a similar intrusive relationship to an obducted ultramafic sheet (Smith & Davies 1976). On the basis of this comparison the New Caledonian granitoids are interpreted as representing a subduction related magmatic event.

DATING METHODOLOGY

Whole-rock samples of the boninites were ground and groundmass-rich and clinoenstatite-rich separates of 60-80 mesh size were used for the Ar analysis, and a portion of each of the separates was also ground in an agate mortar for the K analysis. The 60-80 mesh size of biotites and hornblende separated from the granodiorites were used for Ar analysis and a portion then ground for K analysis.

Analyses of K and Ar, and calculation of ages and errors, were carried out according to the method described by Nagao *et al.* (1984) and Itaya *et al.* (1991). K was analysed by flame photometry using a 2000 ppm Ce buffer. Ar analyses were carried out on a 15 cm radius, sector-type mass spectrometer with a single collector system at Okayama University of Science. HIRU (Itaya *et al.* 1991) by an isotopic dilution method using an ^{38}Ar spike. The errors of age shown have 2σ confidence levels (Itaya *et al.* 1991). The decay constants used in the age calculations are from Steiger and Jäger (1977) and are 0.581×10^{-10} /year and 4.962×10^{-10}/year for ^{40}K to ^{40}Ar and ^{40}Ca, respectively, and 0.0001167 for ^{40}K content in potassium.

RESULTS

Our results are presented in Table 1. Both sets of data for the boninites indicate a Late Oligocene age while the minerals separated from the granitoids gave slightly younger ages (Late Oligocene to Early Miocene). Our results for the St Louis granitoid confirms the Early Miocene age recorded by Paris (1981).

The crystalline clinenstatite-rich concentrates consistently gave a younger age and had larger errors than the glassy matrix. Clinenstatite is a low temperature phase formed as the result of polymorphic inversion of metastable high temperature protoenstatite (Dallwitz *et al.* 1966); such polymorphic transformations are usually sluggish and would be expected to lead to large errors. The date obtained would be that of the polymorphic inversion which would certainly be after the boninite had been extruded and quenched and may also be a considerable time after the boninite had cooled.

The K-Ar dates indicate that the close spatial relationship between the Nêpoui boninites and the only known Miocene sediments exposed on the main island was not fortuitous.

DISCUSSION

Boninitic rocks are now known to be a minor but important component of magmatic activity in several tectonic settings including ophiolite complexes, forearc regions of intra-oceanic arcs and continental margin convergent plate boundaries (Crawford *et al.* 1989). While the boninites of the Koh massif are clearly associated with tholeiitic basalts in an ophiolite complex (Cameron 1989), this is not the case for the Nêpoui boninites.

The dating of the Nêpoui boninites as Late Oligocene provides the first indication of Mid Tertiary volcanism in New Caledonia. The very isolated occurrence of boninites without associated andesites or tholeiitic basalts is unusual. A very wide geochemical range of basalt types (alkaline, tholeiitic and calcalkaline) have been recorded in the Formation of Basalts (Paris 1981) and while the age relations of the basalt types remain unknown the possibility exists that other Mid Tertiary volcanics may be discovered.

The genesis of boninite magmas requires high temperatures at low pressures and a source of hydrous fluids (Crawford *et al.* 1989). Cameron (1989) observed that the geochemistry of the Nêpoui boninites is unusual in that they are severely depleted in CaO, Ti, V, Sc, Nb and P and have the lowest CaO contents and the highest alkali contents recorded for any boninites. They also have high Zr contents, are LREE-enriched and have Sr and Nd isotopic compositions which suggest that they have originated from a depleted refractory harzburgite source (Cameron 1989) and hydrous fluids derived from a young sediment-free

Table 1 K-Ar dates for boninites and granitoids intruding the ultramafic sheet, New Caledonia.

Sample	K (wt%)	Rad.argon^{40} (10^{-8}ccSTP/g)	Non Rad. Argon (%)	Age (Ma)
Népoui Boninites				
1 GMR	0.541 ±0.011	63.41 ±0.83	22.6	30.0 ±0.7
CER	0.187 ±0.009	19.25 ±0.43	47.1	26.4 ±1.4
2 GMR	0.541 ±0.011	57.79 ±0.83	27.5	27.3 ±0.7
CER	0.300 ±0.015	28.55 ±0.77	55.1	24.2 ±1.4
St Louis Intrusives				
3 Ho	1.474 ±0.029	118.5 ±1.5	20.2	20.6 ±0.5
3 Bi	7.329 ±0.147	725.7 ±8.1	14.5	25.3 ±0.6
4 Bi	7.431 ±0.149	716.0 ±8.0	14.3	24.7 ±0.6

1 Boninite (clinoenstatite lava) described by Sameshima *et al.*, 1983 (sample AU 37211).

2 Boninite boulders from roadside between Riviere Blanche and Rouge (sample AU 45529).

GMR = groundmass-rich concentrate; CER = clinoenstatite-rich concentrate.

3 and 4 hornblende and biotite separated from two St Louis granitoids intruding the ultramafic nappe (sample 3 = AU 45608; sample 4 = AU 45609).

Bi = biotite; Ho = hornblende.

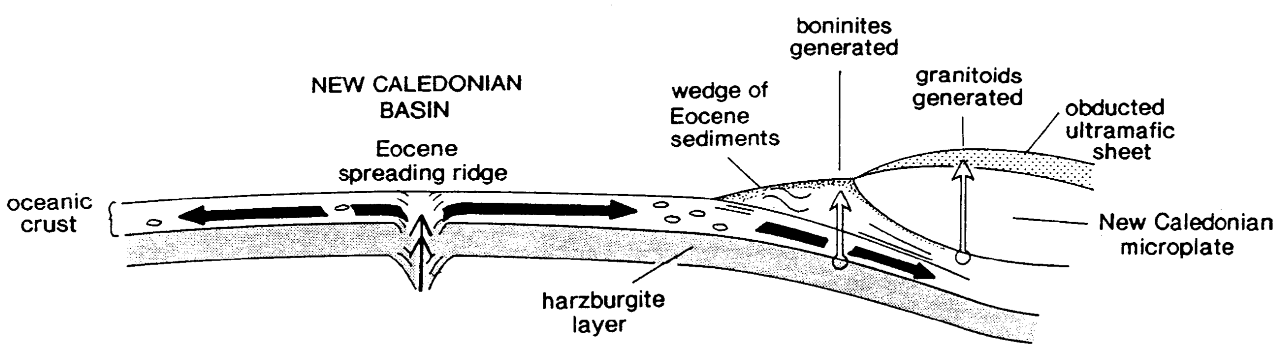

Fig. 3 Cartoon illustrating the tectonic setting and mechanism of generating boninites and granitoids in the New Caledonian area in the Mid Tertiary.

crust (Crawford *et al.* 1989). This poses problems as far as generating a model to explain the Mid Tertiary magmatism is concerned since there was no spreading known in the immediate area during that time. The last spreading event west of New Caledonia is associated with the opening of the New Caledonia Basin and is believed to have ceased by the end of the Eocene (Kroenke 1984; Eade 1988).

The data presented in this paper provide evidence for two magmatic events which postdate the obduction of the ultramafic sheet. The Early

Miocene granitoid suite shows an arc-type geochemical signature which is lacking in the slightly older Népoui boninites so it is unlikely that they are genetically related. Nonetheless their close temporal relationship suggests that they belong to the same tectonic event. Seismic profiles have shown a wedge of early Tertiary sediments dipping from the west under New Caledonia and this has been interpreted as an Eocene subduction zone (Dubois *et al.* 1974). Kroenke (1984) has postulated that a brief reactivation of this Eocene subduction zone in the Early Miocene resulted in the generation of granodioritic magma which then rose to intrude the ultramafic sheet. We propose that the young hot oceanic crust generated by Eocene spreading was also subducted beneath the New Caledonian lithospheric micro-plate (as represented by the Central Chain Complex) during a very short tectonic event in the Late Oligocene to Early Miocene producing a small pulse of boninite magma erupted through Tertiary sediments on the west of the Central Chain while downdip to the east and beneath the Central Chain granitoids were generated by crustal melting and intruded through the ultramafic sheet (Fig. 3).

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