UN ESCAP, CCOP/SOPAC Tech. Bull. 3 : 77-83

A SEDIMENTARY STRUCTURE SOUTHWEST OF VITI LEVU, FIJI: THE BARAVI BASIN

B M LARUE, J Y COLLOT, AND A MALAHOFF

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ABSTRACT

Geophysical data collected during the cruise EVA VI, jointly organized by ORSTOM and NOAA/NOS, identified a basin 2 to 2.5 km deep, oriented NNW–SSE, 20 km southwest of Viti Levu Island, Fiji. Its main features are: (1) Length 80 km; width 30 km (from a preliminary bathymetric map); (2) Sediment thickness equivalent to 2 s (two-way travel time) on a single-channel seismic-reflection profiler; (3) a −70 mgal gravity anomaly indicating a sedimentary section 3 km thick; (4) commencement of filling in Early Miocene times. The hypothesis that the basin was formerly connected with the Aoba Basin, New Hebrides, is discussed.

INTRODUCTION

During EVA VI cruise (organized by l'Office de la Recherche Scientifique et Technique Outre-Mer (ORSTOM) Noumea and the National Oceanic and Atmospheric Administration / National Ocean Survey (NOAA/NOS) Washington) in June 1978, on Research Vessel *Coriolis,* two profiles EVA 648 and 649 were made offshore to the southwest of Viti Levu Fiji (Fig. 1). The seismic reflection, gravity and magnetic data of EVA 648 show a sedimentary basin previously unknown. It was named Baravi Basin by the Fiji Government during the time of the Symposium.

The purposes of this paper are to describe this structure, to identify some of its essential characteristics (depth, sedimentary thickness, age, limits) and to try to fit it into the structural pattern of the southwest Pacific.

STRUCTURE AND AGE

The single-channel seismic reflection, of which an interpreted cross section is given in Fig. 3, suggests that there are two sedimentary basins defined by three ridges (A, B, C). However, the preliminary bathymetric map drawn by the Mineral Resources Department of Fiji (MRD 1979) and used as background to Fig. 1, shows that the central ridge B is simply an undersea advance heading out of Viti Levu Island and made visible by the proximity of the coast. The singleness of the basin is indicated by the long wavelength of the magnetic anomaly, probably produced by a volcanic basement only slightly perturbated by the central ridge B (Fig. 2a).

The sedimentary filling is thicker to the east of the Central Ridge (in the B-C area of Fig. 3) than to the west, probably owing to terrigenous drifts from Viti Levu. The acoustic penetration, slightly less than 2 stwtt (seconds of 2-way travel time) increases as the profile edges away from the coast, i.e. draws closer to the centre of the basin. The basement on which the sediments lie has not been reached. Three distinct sedimentary series can be described:

(1) The youngest, 0.9 stwtt thick, is strongly disturbed by terrigenous drift, coming most probably from the Singatoka River (Fig. 1). A bathymetric bulge and disorder in the sedimentation may be due to the presence of an undersea fan at the river mouth. On both sides of this fan, the layering is more regular.

(2) The second layer, very thin (0.2 stwtt) and comparatively well bedded, is transgressive on the deepest one.

(3) The third layer — base not reached — is not less than 0.6 stwtt thick.

Eastwards, the lowest layer laps and thins on to ridge C. Thus the ridge and the sedimentary layer are probably coeval, i.e. Plio-Pleistocene (Geological Survey of Fiji, 1965), confirmed as 4.6 m.y. by K-Ar dating of volcanics of Vatulele by Whelan and Gill (1979).

Westwards the lowest layer abuts ridge B. A comparison with land geology (see Fig. 1,

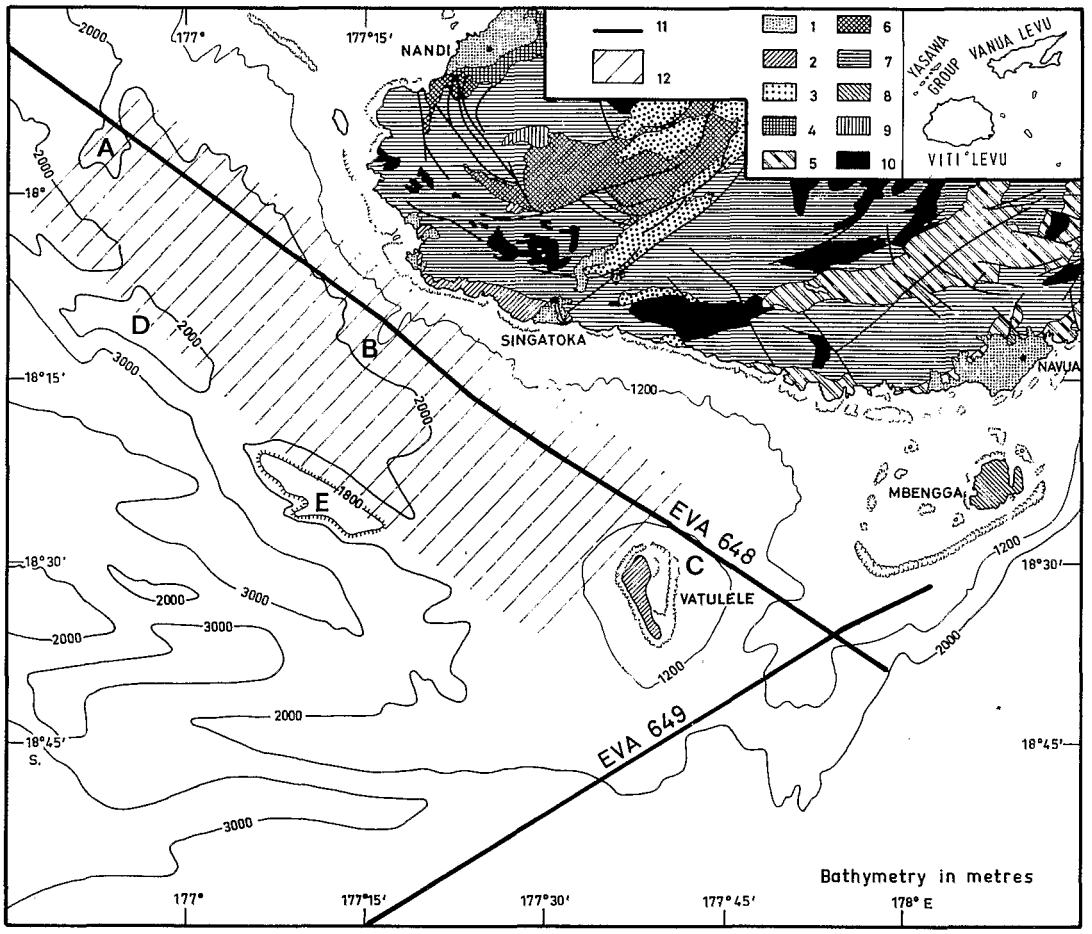


Figure 1. Baravi Basin: location and ship tracks; bathymetry (after MRD 1979); geology (after Rodda 1967).

KEY TO LEGEND

Plio-Pleistocene and Recent
1 Alluvium
2 Thuvu Sedimentary Group and Vatulele

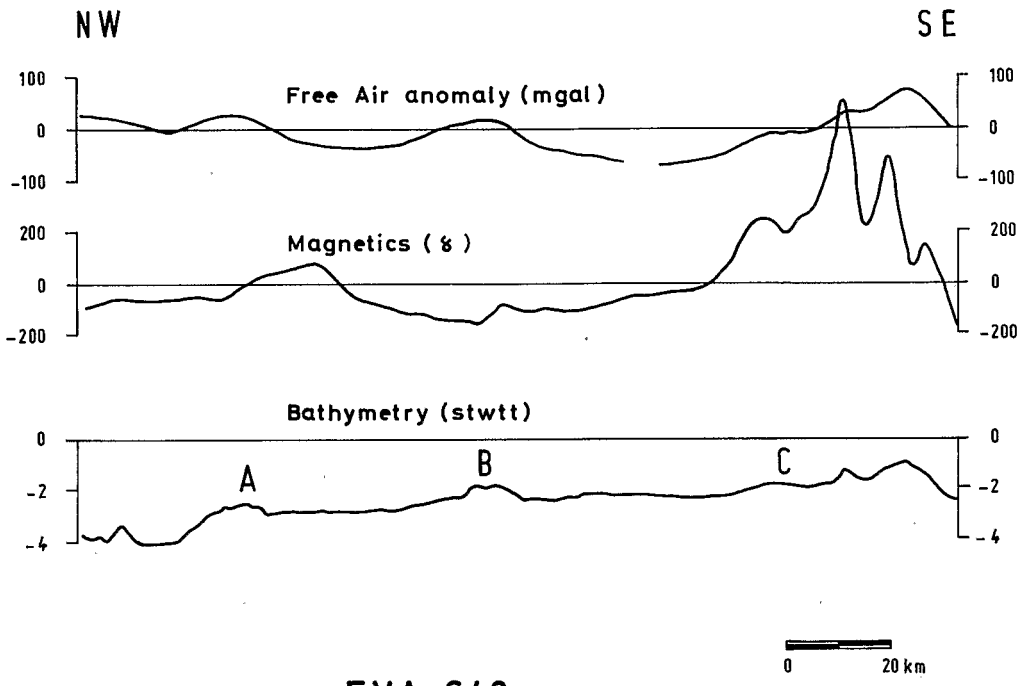
Mio-Pliocene
3 Navosa Sedimentary Group
4 Nadi Sedimentary Group
5 Mendrausuthu Andesitic Group

Eocene Miocene
6 Singatoka Sedimentary Group
7 Wainimala Group
8 Undifferentiated Cainozoic volcanics

Intrusives
9 Upper Tertiary
10 Lower Tertiary

11 Ship track
12 Baravi Basin

based on Rodda 1967, Rodda *et al.*, 1967, and Geological Survey of Fiji, 1965, who assign Vatulele to the Thuvau sedimentary group) leads us to identify ridge B with the Wainimala group, aged Eocene–Miocene. Thus we see the same structure on land as at sea: Eocene–Upper Miocene basement, ridge B, and Wainimala group, on which lie sediments, at least as old as Pliocene, covered by recent terrigenous drifts and alluvium. To the west of the central ridge (section AB of Figs. 1, 2 and 3) only two separable sedimentary layers are seen. An irregular sedimentation is peculiar to the first one (1′), the thickness of which can reach 1 stwtt. A network of relatively shallow normal faults indicates tensional movements, parallel to the shore. Layer 1′ is discordant on a strongly tectonized layer 2′ + 3′, which is thought to be the equivalent of layers 2 and 3 of section B-C. Northwestwards, away from



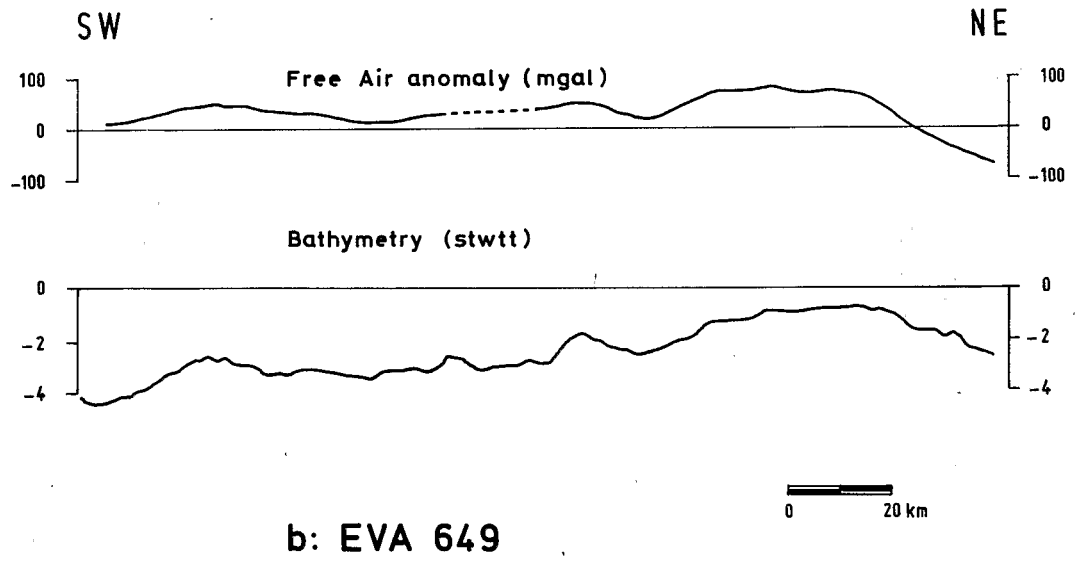


Figure 2. Profiles EVA 648 and 649 — bathymetry, magnetics, gravity.

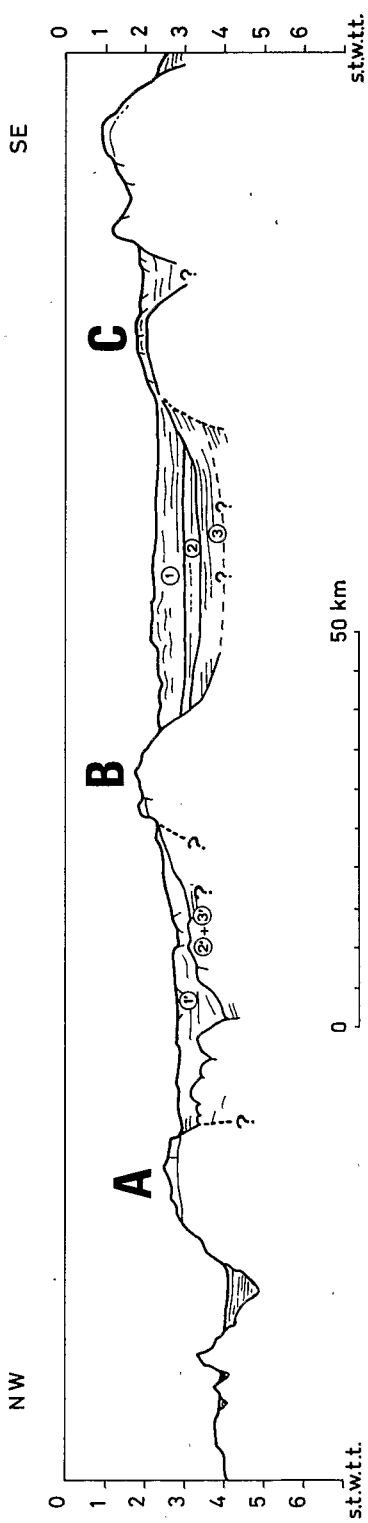


Figure 3. Interpreted seismic reflection EVA 648.

ridge A, deepening of the sea floor, thinning of the sedimentary blanket and fracturing of basement characterize the transition zone between the Fiji Platform and the North Fiji Basin.

SEDIMENT THICKNESS

The total thickness of the sedimentary filling can be estimated by gravity. The free-air anomaly indicates a −0.4 mgal/km regional gradient in contrast to the bottom slope, which reaches −0.9 mgal/km after reduction of the water influence. This is due to the deepening of the Moho, whose depth reaches 24 km under Viti Levu as calculated by Robertson (1967) from the −30 mgal Bouguer anomaly. Two negative anomalies, respectively −70 and −90 mgal, correlated with the sedimentary filling, are superimposed on this gradient. The model has been calculated in two dimensions, made necessary by the disposition of the single gravity profile. In this case, in consequence of the basin configuration (Fig. 1) the sediment thickness is underestimated. Estimations of densities are needed to evaluate thickness. Nettleton's (1940) method gave a value of 2.6 for the ridges, which is close to that found by Robertson (1967) for the rocks of the Wainimala group, namely 2.6 ± 0.13 for the 'intermediate and acidic igneous rocks' and 2.76 ± 0.1 for the 'basic igneous rocks'. A density of 2.7 has been adopted for the base of the basin. As far as the sediments are concerned, a comparison with other sedimentary basins (Collot and Missegue 1977, Pontoise *et al.* 1980) leads us to estimate the density of layers 1 and 1′ at 2.0 and that of layers 2, 2′ and 3 at 2.2. These figures, introduced with a geometrical feature compatible with the seismic reflection in a 2-D programme (Talwani *et al.* 1959) adapted for a HP 9845 computer (Missegue 1979), produced the model shown in Fig. 4. It should be noted that a higher density, 2.9, must be attributed to Mbengga in order to match the observed anomaly: the volcanic character and strong magnetism of Mbengga seem to justify this. The maximum thickness of sediments is 3 km close to ridge B.

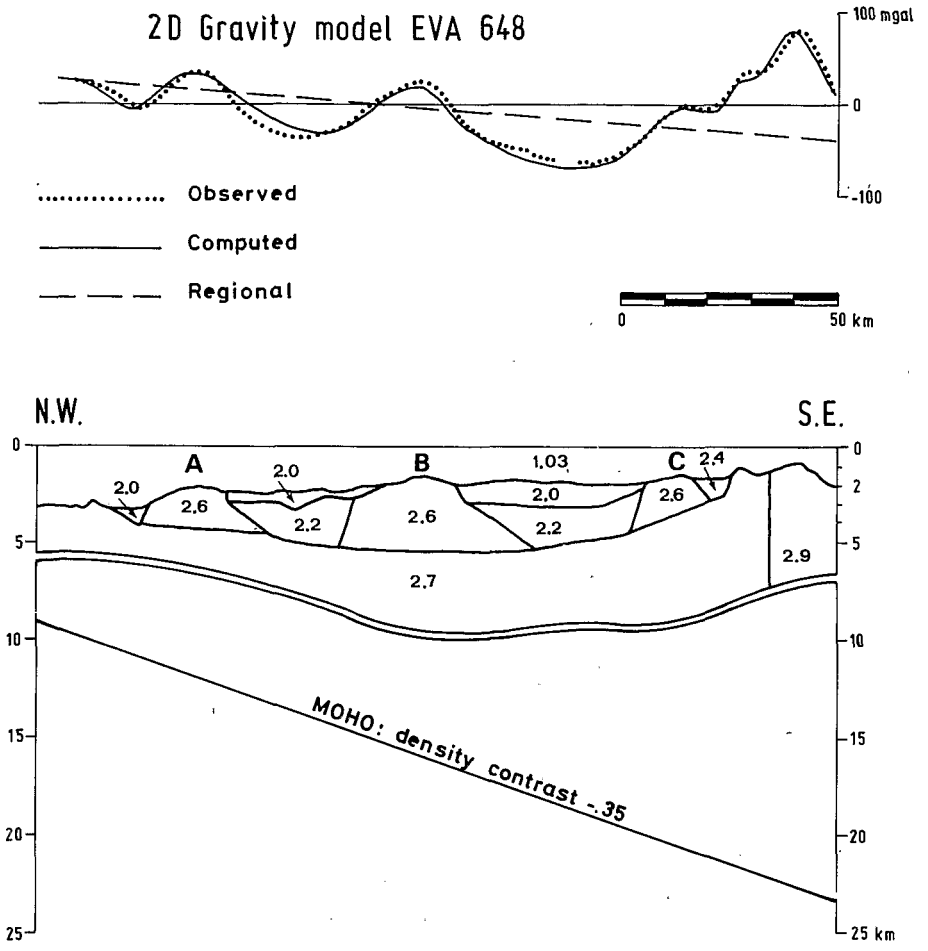


Figure 4. 2 D gravity model, EVA 648.

DIMENSIONS AND EXTENT

The Baravi Basin is estimated to be 80 km long and 30 km wide. As shown by Fig. 2, no structures similar to those seen on EVA 648 are visible on profile 649. From this observation and the bathymetric chart, the southeastern limit of the basin is undoubtedly the Vatulele and Mbengga headings. On the northwest, the bathymetric bulge characteristic of a ridge (Fig. 1) is aligned with the Yasawa Group, which forms the ultimate limit of the Fiji Platform.

Crosswise, only bathymetric information is available: two rises are present — D and E (Fig. 1) — a few hundreds of metres high and about 5 km wide. They must have acted as a trap in the sedimentary process, in which the importance of terrigenous drift has been previously noted.

The Baravi Basin is the most southerly structure trending parallel to the edge of the Fiji Platform. (Fig. 1).

STRUCTURAL CONTEXT

Geodynamic reconstructions of the Southwest Pacific based on petrology (Carney and Macfarlane 1978), paleomagnetics (Falvey 1978), or magnetic anomalies (Malahoff *et al.*, 1979) suggest that the New Hebrides and Fiji were linked in a single island arc in Miocene times. In such reconstructions one can note the alignment of the Baravi Basin and the North and South Aoba basin (excluding Aoba, Ambrym, other recent islands and the southern part of the arc).

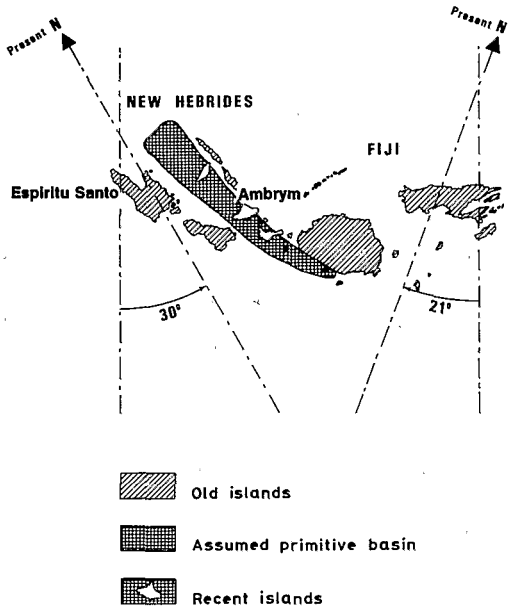


Figure 5. Reconstruction of the Melanesian Island Arc in Miocene times.

The similarities between the two basins are not limited to their tectonic position, but extend to their crosswise dimensions (Luyendyk *et al.* 1974, Ravenne *et al.* 1977), the sedimentary fill (Ravenne *et al.* 1977, Dugas *et al.* 1977), gravity anomaly (Luyendyk *et al.* 1974) and even the date of commencement of sedimentary infilling (Coleman 1969, Carney and Macfarlane 1980).

It should be noted that they predate the opening of the North Fiji basin (Chase 1971; Falvey 1978; Malahoff *et al.* 1979; Halunen 1979). Thus a continuous structure (Fig. 5) could have been split by expansion of the marginal basin. Since, according to Wood (1980), the Yasawa Group marks the transform fault which gives evidence of the early opening of the North Fiji Basin, the existence of, and similarities between, the two basins impose contraints to the Melenasian arc reconstruction (Fig. 5) and lead to a consideration of the southern islands of the New Hebrides as postdating the opening of the North Fiji Basin, which is in accordance with their age.

CONCLUSION

Though the discovery of fairly deep basins does not provide any short-term interest in terms of petroleum potential, it is essential to make a systematic inventory of such sedimentary structures. This paper indicates that a number of them might still be discovered in the Southwest Pacific.

ACKNOWLEDGEMENTS

We extend our thanks to the Mineral Resources Division, Fiji for permission to publish extracts from their preliminary bathymetric map, and to C. Jouannic, CCOP/SOPAC, for his valuable help.

REFERENCES

Carney J N, Macfarlane A 1978: Lower to Middle Miocene sediments on Maewo, New Hebrides and their relevance to the development of the outer Melanesian arc system. *Bull. Aust. Soc. Explor. Geophys. 9*: 123–30.

Carney J N, Macfarlane A 1980: A sedimentary basin in the Central New Hebrides. (This volume.)

Chase C G 1971: Tectonic history of the Fiji Platform. *Geol. Soc. Am. Bull. 82*: 3087–110.

Coleman P J 1969: Derived Eocene large Foraminifera on Maewo Eastern New Hebrides and their South West Pacific implications. *Annu. Rep. Geol. Surv. New Hebrides for 1967:* 36–37.

Collot J Y, Missegue F 1977: Crustal structure between New Caledonia and New Hebrides. Pp. 137–44 in 'International Symposium on Geodynamics in the South West Pacific', Editions Technip, Paris.

Dugas F, Dubois J, Lapouille A, Louat R, Ravenne C 1977: Structural characteristics and tectonics of an active island arc, the New Hebrides. Pp. 79–80 in 'International Symposium on Geodynamics in the South West Pacific', Editions Technip, Paris.

Falvey D 1978: Analysis of paleomagnetic data from the New Hebrides. *Bull. Aust. Soc. Explor. Geophys. 9*: 117–23.

Geological Survey of Fiji 1965: Geological map of Fiji.

Halunen A J, Jr, 1979: Tectonic history of the Fiji Plateau. *Ph.D. Thesis Hawaii Inst. Geophys., Univ. Hawaii.* (Unpubl.)

Luyendyk B D, Bryan W B, Jezek P A 1974: Shallow Structure of the New Hebrides Island Arc. *Geol. Soc. Am. Bull. 85*: 1287–300.

Malahoff A, Feden R, Fleming H (in press): Magnetic anomalies and tectonic fabric of marginal basins north

of New Zealand. *J. Geophys. Res.*
Mineral Resources Division, Fiji 1979: Preliminary bathymetric map of the Southwest continental slope of Viti Levu. (Unpublished.)
Missegue F 1979: Programme Gravl 2, type conversationnel. Calcul de l'anomalie gravimétrique créée par un modèle à 2 dimensions. *Rapp. ORSTOM* 29 pp.
Nettleton L L 1949: Geophysical Prospecting for Oil, MacGraw Hill New York, 444 pp.
Pontoise B, Latham G, Daniel J, Dupont J 1980: Seismic refraction studies in New Hebrides and Tonga. (This volume.)
Ravenne C, Pascal G, Dubois J, Dugas F, Montadert L 1977: Model of a young intraoceanic arc: the New Hebrides island arc. Pp. 63–78 in 'International Symposium on Geodynamics in the South West Pacific', Editions Technip, Paris.
Robertson E I 1967. Bouguer anomaly map of Viti Levu. *N.Z. J. Geol. Geophys. 10*: 1309–13.
Rodda P 1967: Outline of the geology of Viti Levu. *N.Z. J. Geol. Geophys. 10*: 1260–73.
Rodda P, Snelling N J, Rex D D 1967: Radiometric age data on rocks from Viti Levu. *N.Z. J. Geol. Geophys. 10*: 1248–59.
Talwani M, Worzel J L, Landisman M 1959: Rapid gravity computation for two dimensional bodies with application to the Mendocino submarine fracture zone. *J. Geophys. Res. 64*: 49–59.
Whelan P M, Gill J B 1979: Post Miocene basaltic volcanism in Fiji. Patterns in space, time and composition. IGCP 110, Evolution of the India Pacific Plate Boundaries. Abstract, Third Southwest Pacific Workshop Symposium 17-19 December 1979, Sydney.
Wood B L 1980: The structure of the Yasawa Islands and its plate tectonic significance. (This volume.)

B M Larue, J Y Collot
ORSTOM
Centre de Nouméa
B.P. A5
Nouméa, Nouvelle-Calédonie

A Malahoff
NOAA/NOS
6601 Executive Bvd
Rockville, Md 20852, U.S.A.