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COMMENTS ON THE SEABEAM MAP OF THE NORTH FIJI BASIN RIDGE BETWEEN 16°10'S AND 21°40'S

J.M. Auzende*, **E. Honza****, **J.-P. Maze*** and the **Starmer Group*****.

* *Marine Geosciences Department, IFREMER Centre de Brest, Plouzané France.*

** *Geological Survey of Japan, Higashi, Tsukuba, Ibaraki 305, Japan.*

*** *STARMER Group:* France: *V. Bendel, J.P. Eissen, E. Gracia-Mont, P. Huchon, Y. Lafoy, Y. Lagabrielle, E. Ruellan.* Japan: *Y. Iwabuchi, M. Joshima, K. Kisimoto, T. Matsumoto, K. Mitsuzawa, H. Momma, T. Naganuma, J. Naka, Y. Nojiri, K. Otsuka, M. Tanahashi, T. Tanaka, T. Urabe.*

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ABSTRACT

Since 1985, the North Fiji Basin ridge has been intensively studied either in the frame of the French SEAPSO project or in the frame of the French-Japanese STARMER project. Four surface ships cruises and one diving cruise allowed to draw a complete coverage Seabeam bathymetric map of the North Fiji Basin ridge between 16°10'S and 21°40'S(1). This map shows that the North Fiji Basin ridge can be divided into four major segments characterized by a spreading ridge morphologically very close to the East Pacific type ridge. Due to the peculiar geodynamical position of the North Fiji Basin comprised between two opposite subduction zones, the whole basin and especially the ridge axis are affected by numerous deformation features. Among them, the 16°40'S triple junction accomodates the functioning of the North Fiji Fracture Zone and the change in trend of the previously NS spreading ridge.

RESUME

Depuis 1985, le Bassin Nord-Fidjien a été intensément étudié, que ce soit dans le cadre du projet français SEAPSO ou dans le cadre du projet franco-japonais STARMER. Quatre campagnes de surface et une campagne de plongée nous ont permis d'élaborer une carte bathymétrique en couverture "Seabeam" continue de la dorsale du Bassin Nord-Fidjien, entre 16°10'S et 21°40'S.

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(1) This map (1/200,000 scale, 6 colored sheets) is freely distributed by IFREMER-DRO/GM, BP 70, 29280 Plouzané Cedex, France.

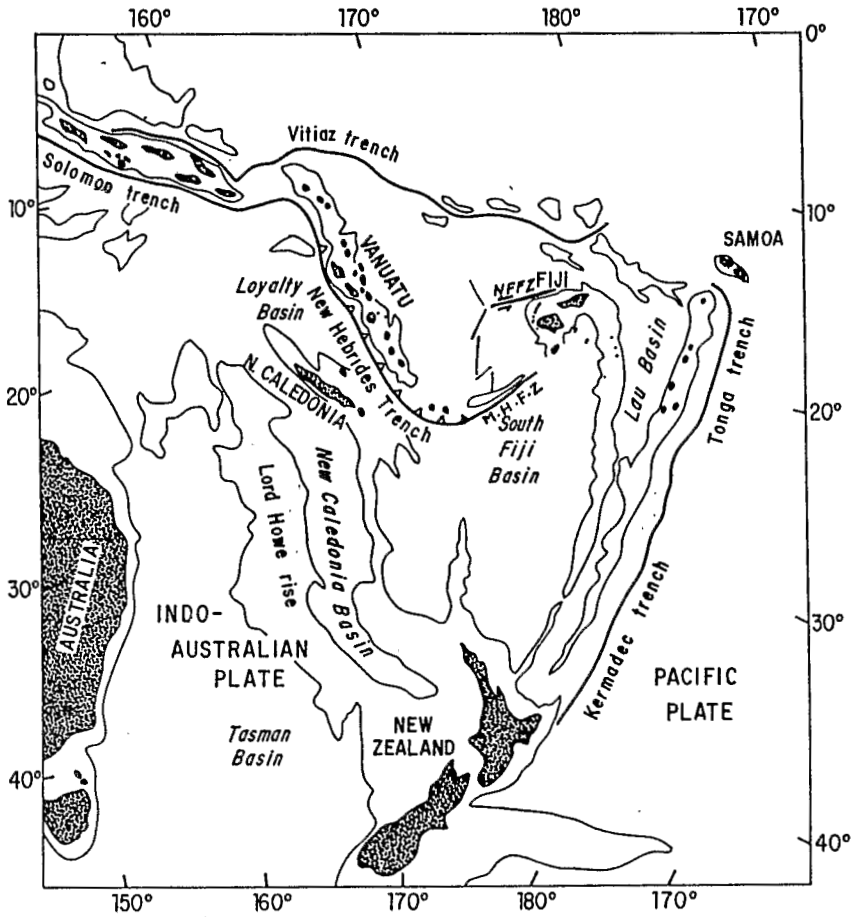
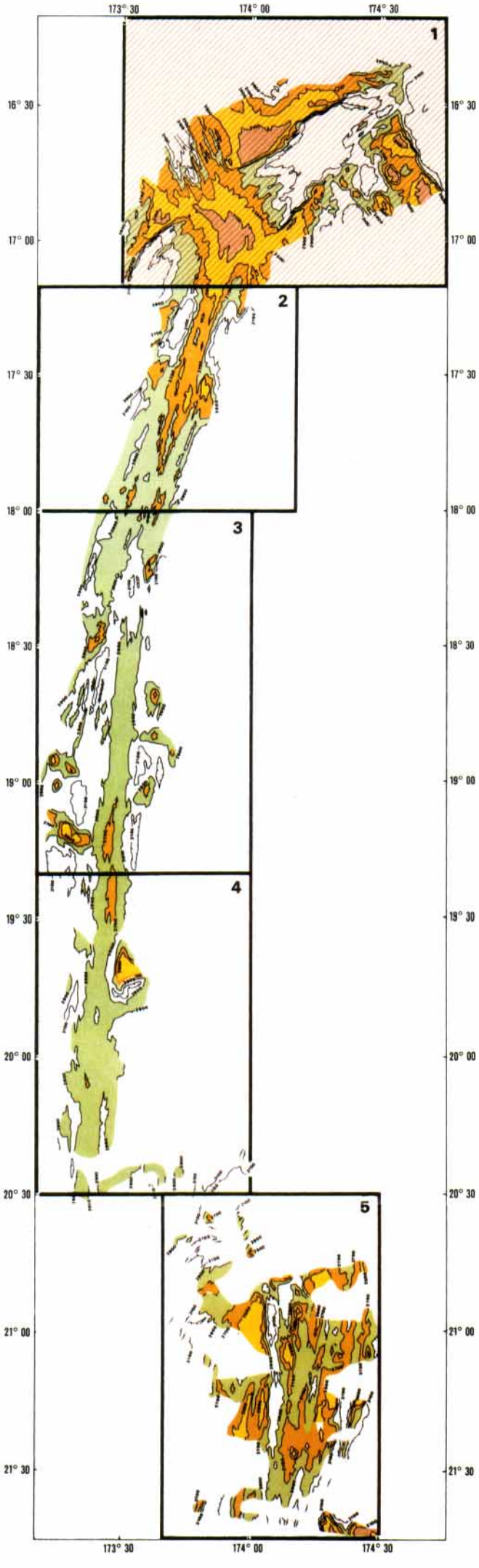


Fig. 1 – Geodynamical setting of the North Fiji Basin in the South-West Pacific.
The NFB ridge axis is indicated. NFFZ: North Fiji Fracture Zone. MHFZ: Matthew Hunter (subduction) Fracture Zone.

Cette carte montre que la dorsale peut être subdivisée en quatre segments principaux caractérisés par une morphologie très proche de celle observée sur la dorsale Est-Pacifique. En raison de sa position géodynamique particulière, le Bassin Nord-Fidjien, compris entre deux zones de subduction de sens opposés, et sa dorsale sont affectés par de nombreuses déformations. Parmi elles, le point triple de 16°40'S accommode le fonctionnement de la Zone de Fracture Nord-Fidjienne et le changement de direction de l'ancien axe NS.

Fig. 2 – Simplified Seabeam map of the North Fiji Basin ridge between 16°10'S and 21°40'S.
Hachured area: location of Fig. 6. Brown: <2100; yellow: 2100–2500; orange: 2500–2700; green: 2700–2900.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INTRODUCTION

The North Fiji Basin is a back-arc basin located at the converging boundary between Indo-Australian and Pacific Plates (Fig. 1). It shows several unusual features:

- it is located between two opposite subduction zones (New Hebrides and Tonga-Kermadec zones).
- its opening results of two main phases. The first one, between 10 and 3 Ma, characterized by the clockwise rotation of the New Hebrides arc (Auzende et al., 1988a), the second one by the emplacement and functioning of a NS spreading ridge (Auzende et al., 1990a).

The aim of the Seapso 3 cruise of the R/V Jean Charcot (December 1985) was the localization and the characterization of the NS spreading axis (Auzende et al., 1988b). Before the Seapso 3 cruise, the existence of a spreading axis in the axial part of the North Fiji Basin was only supposed from paleomagnetic, kinematic, seismologic and magnetic data (Malahoff et al., 1979; Pascal et al., 1978; Taylor and Karner, 1983). Since this cruise, Japanese (Science and Technology Agency) and French (Ifremer) groups have decided to sign a joint project named Starmer for the study of the rift system of the North Fiji Basin. In the frame of this joint project, 4 surface ship cruises and one diving cruise with the Nautile have been carried out along the North Fiji Basin NS spreading axis (Kaiyo 87, 88 and 89, Yokosuka 90 and Starmer Nautile 89). The goal of these cruises was the geological, geophysical and geochemical mapping of the axial domain.

One of the most spectacular results of the Starmer project is the complete coverage Seabeam map of the axial ridge between 16°10'S and 21°40'S (Auzende et al., 1990b) (Fig. 2). The scale of the published maps is 1/200,000 at latitude 19°S, the average width of the Seabeam coverage is 20 miles (about 40 km), the contour interval is 20 m and the colour interval is 200 m. These maps are published in five sheets concerning the Seabeam survey and one sheet which is a processed 3D view of the whole area. Our purpose in this paper is to comment the main features evidenced by the maps.

DESCRIPTION OF THE MAPS

From the South to the North we distinguish 4 main areas or segments on the axial ridge:

1. Between 21°40'S and 20°40'S

In this area, the axial domain is morphologically very complicated and it is difficult to locate precisely the present-day spreading axis. The only evidence of the accretion activity is a very well defined axial magnetic anomaly centered on 174°05'E (Fig. 3). The whole area is occupied by an alternation of NS parallel ridges and grabens: the ridges culminating at less than 2500 m depth and the grabens reaching more than 3500 m depth. This spreading zone is very close to the Matthew-Hunter subduction zone and the main offset of this position is that the oceanic bottom is spotted by numerous

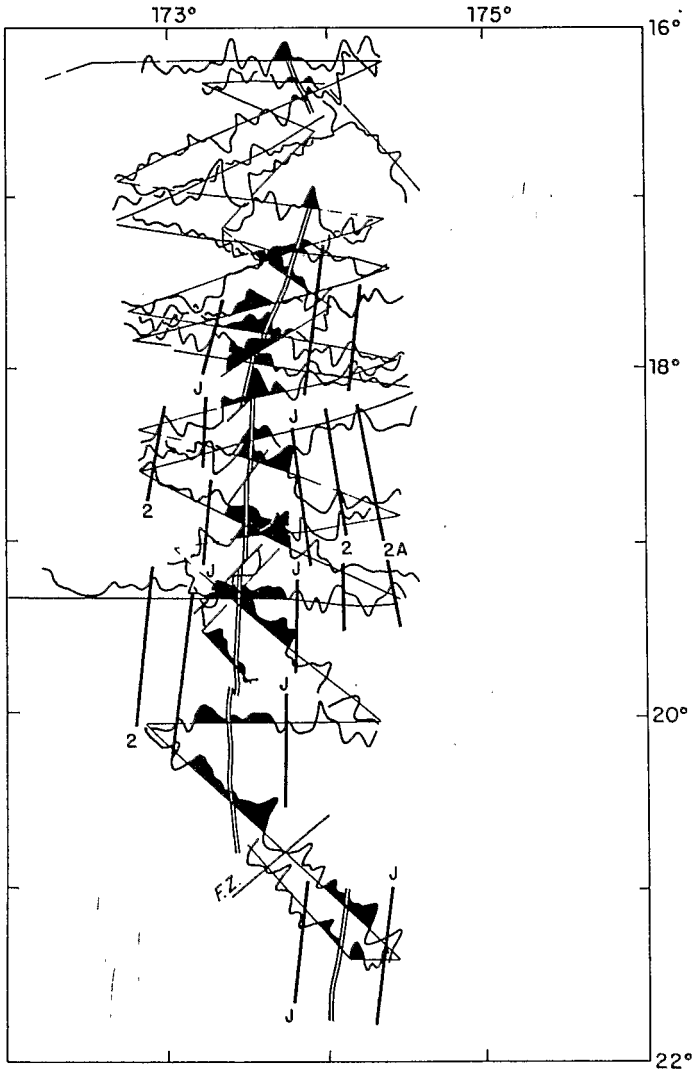

Fig. 3 – Magnetic map of the North Fiji Basin (after Auzende et al., 1988a). In black: axial anomaly; J, 2 and 2A: identified magnetic lineations.

isolated volcanoes probably related to the subduction. To the North, this axial domain abuts against a N45 transverse feature, previously interpreted as a fracture zone and named Jean Charcot Fracture Zone (Ruellan et al., 1989). The new data acquired during the last Kaiyo 89 cruise allow us to give a new interpretation of this transverse feature: it is probably a pseudo-fault due to the northward propagation of this ridge combined with the southward propagation of the next northern segment of the North Fiji ridge

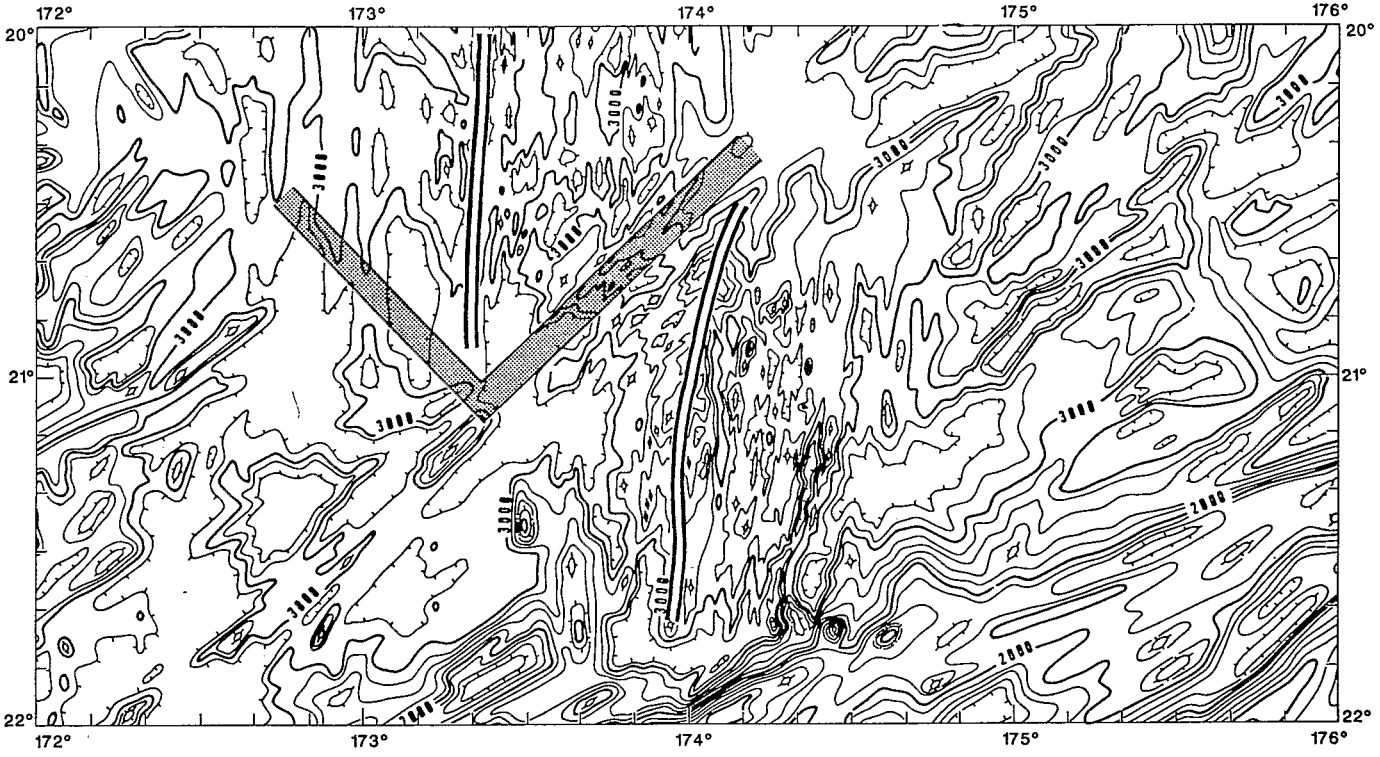

Fig. 4 – Southern part of the North Fiji Basin Ridge.
In heavy double line: ridge axes. The V-shape pseudo-faults system is underlined.

(Fig. 4).

2. Between 20°40'S and 18°20'S

The pseudo-fault in the area surveyed by Seabeam profiling is constituted by elongated N45 ridges (about 2500 m deep) and depressions (3000 m deep) extending across a 60 km wide area. West of this area, the following segment of the North Fiji Basin ridge is offset from the previous one by about 80 km to the West. This segment between 20°40'S and 18°30'S shows a typical fast spreading ridge morphology very similar to the East Pacific Rise one. It is constituted by a 8 km wide, 200 m high ridge. The average depth of the top of the ridge is 2800 m. In more detail, the flat top of the ridge is cut in some places by a 200 m wide, 40 m deep axial graben which is probably the location of the present-day accretion. In this area, the only peculiar feature observed is constituted by two volcanic obliquous lines symmetrical on both sides of the axis. The first one crosses the axis at 19°10'S. On the western limb, its direction is N120 while on the eastern one it is trending N40. The second volcanic line crosses the axis around 19°S and shows the same trends. These volcanic lines must be compared with the ones described on the EPR (Batiza, 1989; Sinton et al., in press) and interpreted as reflecting the direction of absolute plate motion. Another interpretation could be that these volcanic lines are emplaced on tectonic deformation zones cutting the older oceanic bottom. In the case of the North Fiji Basin ridge, these volcanic lines could also reflect an oblique spreading trending around N60-N80. To the North, between 18°30'S and 18°20'S, the axial ridge deepens and is limited by a sharp V shape pseudo-fault system suggesting that this axis has also been propagating very recently toward the North (Fig. 5).

3. Between 18°20'S and the 16°40'S triple junction

This segment corresponds to a change in the direction of the ridge from NS to N15. This change of trend is due to the recent (less than 1 Ma ago) migration toward the East of the 16°40'S triple junction (Lafoy et al., 1990).

This ridge segment can be divided into a southern and a northern part:

- the southern part (South of 18°S) is characterized by a very diffuse accretion zone. In this area, it is impossible to individualize a ridge axis. The whole oceanic bottom is spotted by numerous volcanoes in an area structured by N15, N10, NS fractures. This segment of the North Fiji Basin ridge has been interpreted (Gente, 1987; Auzende et al., 1988b) as a propagating rift within the western limb of the southern NS ridge. The southern tip of this segment is also characterized by a peculiar feature which is an Overlapping Spreading Centre (Fig. 5). This Overlapping Spreading Centre was probably active at the beginning of the migration of the 16°40'S triple junction, 1 Ma ago, and seems to be abandoned today and replaced by the northward propagation of the NS ridge. It is interesting to notice that the two branches of the Overlapping Spreading Centre are on the western side of the present-day ridge. Usually, the ridge propagation occurs in the middle part of the Overlapping Spreading Centre letting one branch on each side of the new active axis (Mac

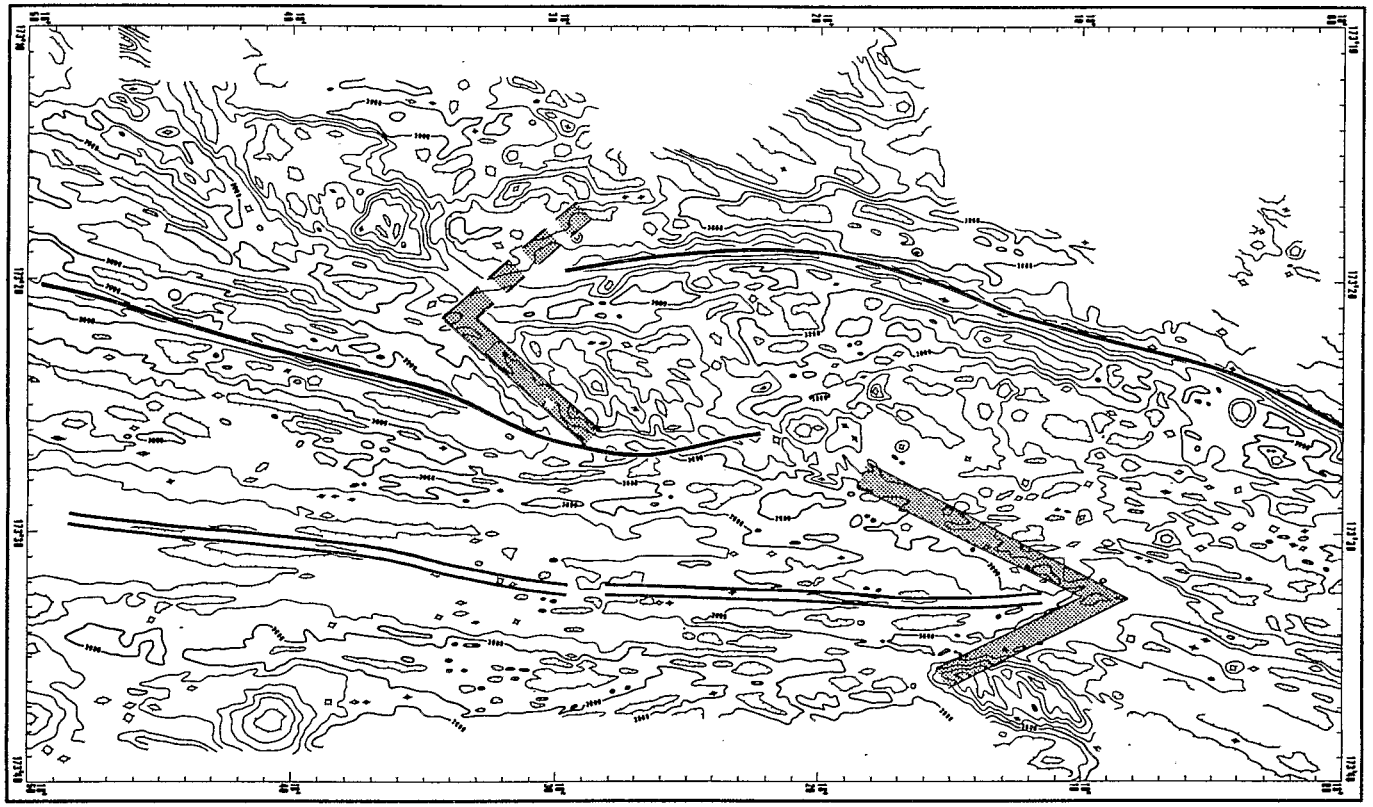

Fig. 5 – Detail of the propagation of the NS segment to the North and the possible propagation of the N15 segment to the SW. The pseudo-faults are underlined. Double line: present-day ridge axis; single line: top of the overlapping spreading centre segments.

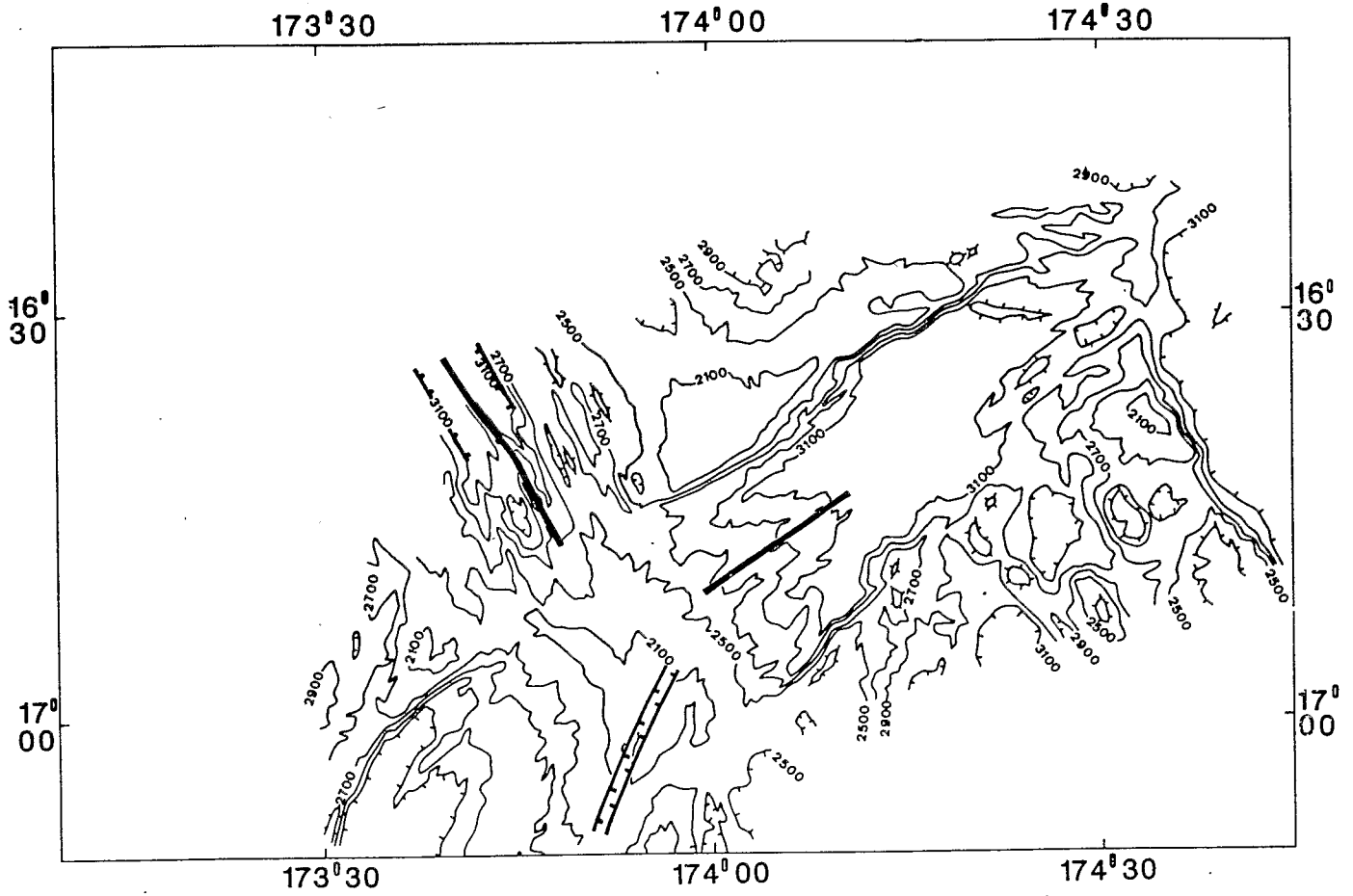

Fig. 6 – Simplified map of the 16°40'S triple junction. In heavy line: neovolcanic ridge. : axial graben.

Donald et al., 1988).
- North of 18°S, the N15 ridge is characterized by the uplifting of the axial zone from 2800 m deep until less than 1900 m at the triple junction. This uplifting is related to a very active magmatic stage illustrated by the existence of very high volcanic massives culminating at 1600 m depth all around the triple junction zone. This volcanic accumulation occurred just before the beginning of the functioning of the 16°40'S triple junction and was dismembered by the recent phase of evolution of the triple junction. The main manifestation of this last phase on the N15 segment is the creation of a 2103 km wide and 200 m deep axial graben. The Starmer 89 diving cruise carried out in this graben at the northern tip of the N15 ridge has shown that the graben was tectonically active (fissuration, fracturation) and also hydrothermally active (Auzende et al., 1989, in press).

4. The 16°40'S triple junction

It is constituted by the N15 segment of the ridge previously described, by a N160 branch of the ridge and by the western end of the North Fiji Fracture zone represented by a triangular deep graben (Lafoy et al., 1990) (Fig. 6).

- **The N160 spreading ridge.** Our survey concerns only the southern part of this ridge which has also been surveyed by Seamarc II (Kroenke et al., 1987; Jarvis et al., 1987).
  In this area, the spreading axis is located in a deep graben 8 km wide reaching 4000 m depth, flanked by steep walls 1000 m high. This graben is cut in its axial part by a neovolcanic zone trending N160 to NS. This axial graben crosscuts a wide and high triangular volcanic massive constituting one part of the volcanic accumulation emplaced before the functioning of the triple junction.

- **The third arm of the triple junction.** It is constituted by a triangular graben more than 3000 m deep flanked by steep walls structurated by N60 and N45 faults. The N60 trend is the general trend of the North Fiji Fracture Zone (Taylor and Karner, 1983; Auzende et al., 1988b). To the Southwest, the graben is limited by a N140 scarp which is probably the flow line of the opening of the graben.
  Inside of the graben from the West to the East, a 20 km long neovolcanic ridge has recently been propagating toward the North-East. The detail of the functioning of this Ridge-Ridge-Fracture-Zone triple junction is discussed in Lafoy et al. (1990).

CONCLUSIONS

This short analysis of the North Fiji Basin Ridge Seabeam map evidences the following points:
- since 3 Ma the North Fiji Basin accretionary system has been characterized

by a roughly NS Axial Spreading ridge. This idea which seems to be trivial today has been controversed for a long time. For example, in a recent paper, Hamburger et al. (1988) from seismicity arguments suggest that the accretion in the North Fiji Basin is diffuse and located on several centres scattered through the whole basin.

- The effects of the deformation due to the location of the North Fiji Basin between two converging major plates (Pacific and Indo-Australian plates) are represented by different features:
  . the first of them is oblique faulting or volcanism existing on one or both sides of the ridge axis;
  . the second one is represented by the changes of trend of the axis, sometimes marked by Overlapping Spreading Centres, offsets...;
  . the more spectacular deformation is the 16°40'S triple junction which accommodates the sinistral motion of the North Fiji Fracture Zone by the change of direction of the axis and the opening of a "pull apart" graben.

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