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MORPHOSTRUCTURE AND MAGNETIC FABRIC OF THE NORTHWESTERN NORTH FIJI BASIN

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Abstract. Four successive spreading phases are distinguished in the northwestern part of the North Fiji Basin. After an initial NE-SW opening, a N-S spreading phase took place, up to the northwesternmost tip of the basin, along the South Pandora, Tikopia and 9°30 Ridges. The N-S spreading phase in the northern North Fiji Basin was followed by an E-W opening phase along the central North Fiji Basin axis. A triple junction was probably active during an intermediate stage between the two phases. E-W spreading underwent a reorganisation that induced the functioning of the 16°40'S triple junction and the development of the E-W trending Hazel Holme Extensional Zone from the active central spreading axis to the southern tip of the New Hebrides Back-Arc Troughs. Active extension also occurs along the E-W Santa Cruz Trough which crosscuts the arc platform at the northern end of the N-S trending Back-Arc Troughs. The existence of the Back-Arc Troughs is mainly due to the construction of the 400 km-long volcanic Duff Ridge which trapped a piece of the old North Fiji Basin oceanic crust.

Introduction

The North Fiji Basin (NFB) is a triangular-shaped active marginal basin created by the convergence of the Pacific and Australian plates. The northwestern part of the basin, bounded in the north by the fossil Vitiaz Trench (VT) and in the west by the New Hebrides Arc (NHA), has been interpreted as the result of a first opening stage along a NW-SE spreading axis behind the NHA during the clockwise rotation of this arc (Falvey, 1975; Malahoff et al., 1982; Auzende et al., 1988). This interpretation, however, is speculative as previously no detailed marine data had been available in the area.

Figures 1 and 2 are morphostructural and magnetic anomaly lineations maps of the northwestern NFB established from: i) recent data acquired through the northwesternmost part of the NFB during Eva XIV (Aug. 1987) and Santa Cruz (Nov-Dec. 1991) ORSTOM cruises conducted respectively onboard the R/V Coriolis and R/V Le Noroit (Pelletier et al., 1988 and 1993); ii) data collected during previous cruises through the NFB and the NHA (IFP-ORSTOM-CNEXO cruises: Austradec I, III, IV; ORSTOM cruises: Eva X, XI, XIII, Georstom I, II, Multipso; ORSTOM-CCOP SOPAC cruises: Geovan I and II; IFREMER-ORSTOM cruises: Seapso I, II, III; Woods Hole Oceanographic Institution cruise: Chain 100; Hawaii Institute of Geophysics cruises: Kana Keoki 1972 and Kana Keoki Tripartite; United States Geological Survey cruise: Lee Tripartite I).

Morphostructure and magnetic fabric

Six main morphological units can be distinguished in the northwestern NFB (Figure 1).

The Back-Arc Troughs (BAT) domain, previously described south of 12°S only (Charvis and Pelletier, 1989; Récy et al., 1990), is located east of the NHA Platform and is separated from the NFB by the Duff Ridge (DR). It is constituted by N-S trending volcanic ridges and depressions (3000 to 3500 m deep), and is intruded by large volcanic complexes at 12°S and 10°30'S. It is 60 km wide south of 12°S and widens northward to 100 km at 10°45'S. North of 12°S, the western edge of the BAT domain is delineated by NNW-SSE and E-W fault scarps. At 10°30'S, the western flank of the BAT domain abuts on the N95 trending Santa Cruz Trough which cuts the arc platform. This trough is underlined by intense shallow seismicity (Louat and Pelletier, 1989) and is located east of the Tinakula Volcano, the only active aerial volcano in this part of the arc. A submerged active volcanic line may exist as suggested by numerous seamounts lying along the western edge of the BAT domain. North of 10°30'S, a NW-SE depression bounding to the southwest the Duff Islands may represent the northern extension of the eastern part of the BAT domain. The Duff Islands, composed of basaltic dykes and andesitic tuffs, breccias and flows (Hughes et al., 1981), lie at the northernmost tip of the DR which is a continuous 400 km-long ridge from 13°30'S to 9°45'S. The DR is constituted by a series of aligned volcanic highs. The ridge strikes N-S and rises to around 1500 m south of 10°45'S, when it trends NW-SE and shallows to 20 m north of 10°45'S.

Most of the magnetic anomalies overlying the BAT domain and the DR are dipolar. However, N140 trending magnetic lineations exist in the eastern part of the BAT domain, north of 11°S from the eastern edge of the NHA Platform to the DR, and south of 13°S across the BAT domain and the DR.

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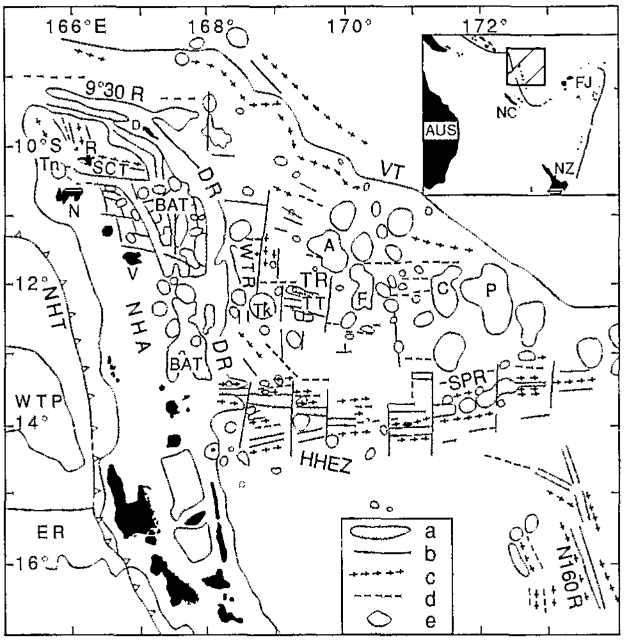

Fig. 1. Structural map of the northwestern NFB. The studied area is shown in insert. a, troughs and depressions; b, structural trend and fractures; c, structural highs; d, structural lows; e, volcanic highs. AUS, Australia; NC, Nouvelle-Calédonie; FJ, Fiji; NZ, New Zealand; NHT, New Hebrides Trench; NHA, New Hebrides Arc; VT, Vitiaz Trench; BAT, Back-Arc Troughs domain; 9°30 R, 9°30'S Ridge; DR, Duff Ridge; WTR, West Tikopia Ridge; TR, Tikopia Ridge; HHEZ, Hazel Holme Extensional Zone; SPR, South Pandora Ridge; N160R, N160 Ridge of the central NFB; TT, Tikopia Trough; SCT, Santa Cruz Trough; WTP, West Torres Plateau; ER, d'Entrecasteaux Ridge. Islands and reefs are in black: D, Duff Islands; R, Reef Islands; Tn, Tinakula Island; N, Ndende Island; V, Vanikoro Island; Tk, Tikopia Island; A, Anuta Island; F, Fatutaka Island; C, Charlotte Bank; P, Pandora Bank.

The Hazel Holme Extensional Zone (HHEZ), which is the western part of the Hazel Holme Fracture Zone of Chase (1971), is located west of 171°20'E and has been recently interpreted as an active extensional zone (Pelletier et al, 1988; Charvis and Pelletier, 1989; Louat and Pelletier, 1989). The HHEZ is seismically active and intersects the NHA at 13°30'S where the BAT are disrupted and the morphology of the NHA undergoes a dramatic change. The HHEZ shows a general WNW-ESE trend, but is composed in detail of N80-90 trending ridges, troughs and scarps, extending over a zone up to 120 km wide. The HHEZ comprises several parallel narrow troughs more than 3500 m deep. The deepest trough (4500 m deep around 169°E) in the axial part of the HHEZ appears to be right-laterally offset. West of 168°30'E, the width of the ridge decreases, the lateral troughs disappear and a 2500-3500 m deep E-W trough is bounded by symmetrical ridges rising up to 1700 m. This trough ends at 168°10'E, at the southern tip of the N-S trending BAT domain.

E-W magnetic fabric is possibly associated with the HHEZ. East of 169°40'E, E-W and N120 magnetic lineations exist north and south of HHEZ respectively. In the western part, the ridge is superimposed on NW-SE trending magnetic lineations. However, E-W magnetic lineations could be restricted to the axial trough.

The South Pandora Ridge (SPR) represents the eastern part of the Hazel Holme Fracture Zone of Chase (1971). It is located east of 171°20'E and has been recently interpreted as an active slow spreading ridge (Price and Kroenke, 1991; Kroenke et al., in press). The SPR shows a general ENE-WSW trend and is 110 km wide. The ridge is cut alongstrike by a central trough intruded in some places by volcanic highs. The central trough is 10 to 20 km wide, 3500 to 4000 m deep, and is flanked by 1000 to 2000 m-high scarps. In detail, the ridge is constituted by a series of 90 km-long E-W segments displaced by 25 km-long offsets along N-S faults at 171°20'E, 172°10'E and 173°E.

N80-90 magnetic lineations, offset by N-S faults, can be identified up to 60 km from the axial trough of the SPR. N100 to N120 magnetic lineations exist south of 14°30'S.

The Tikopia (TR), West Tikopia (WTR) and 9°30'S (9°30R) Ridges constitute, north of the HHEZ, a succession of orthogonal ridges within the northwestern part of the basin. The TR is a 50 km-wide elongated dome striking N90-100. A 10 km-wide, 65 km-long trough (4200 m deep) bounded by 1000 to 1500 m-high scarps lies on the crest of the dome. To the west, the TR ends with the large Tikopia volcano (3500 m high, 35 km wide at its base) on which is located the Tikopia Island. West of the Tikopia volcano, the N-S trending WTR is composed of seamounts rising up to 800 m, aligned along 168°30'E from 12°20'S to 10°45'S. North of the WTR, a volcanic massif shoaling up to 10 m and centered at 168°E, 10°S, represents the eastern extension of the N100 trending 9°30R. The 9°30R is composed of aligned volcanoes from 165°45'E to 168°15'E, north of the DR and

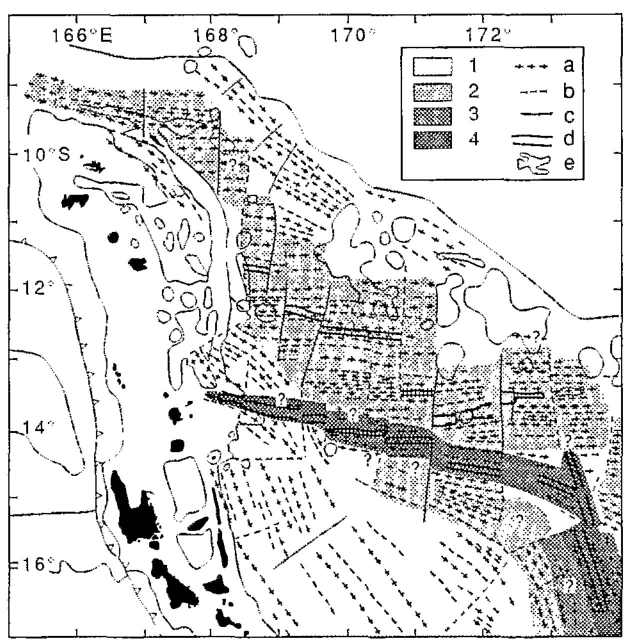

Fig. 2. Map of magnetic anomaly lineations in the northwestern NFB. a and b positive and negative magnetic anomaly lineation respectively; c, fault zone; d, contour of the axial part of the spreading ridges; e, contour of the main morphostructural features taken from Figure 1. The four phases of spreading are shown by different grey scales.

the NHA platform. The 9°30R appears to be right-laterally offset at 168°E by a N-S fault parallel to the WTR.

N90-95 trending magnetic fabric associated with the TR and the 9°30R can be identified from 14°30'S to 9°S in the central northwestern part of the basin. East of the WTR, magnetic lineations are distributed over a 220 km wide zone, the Tikopia trough lying in the central part of the zone. The lineations are disrupted by N-S faults and abut on the WTR. West of the WTR, the N90-95 trending lineations define a zone centered close to the 9°30R, which decreases in width to the west from 110 km to 40 km.

Numerous volcanic highs, including the Anuta and Fatutaka Islands and the Charlotte and Pandora Banks, lie south of the VT, between 10°30'S to 13°S and 169°E to 174°E. Anuta and Fatutaka Islands consist of basaltic lavas and andesitic breccias (Hughes et al., 1981). These volcanic highs, previously interpreted as a part of the inactive Vitiaz Arc, do not constitute a continuous chain but are isolated and located as far as 240 km from the VT. They constitute a series of massifs aligned on N-S faults. North of 10°30'S, a narrow and discontinuous swell (3200-3400 m deep) parallels the VT (4500 to 6000 m deep) which shows a succession of NW-SE and E-W scarps along its western flank.

In spite of perturbations due to the volcanic highs, E-W trending magnetic lineations are discernible between Fatutaka Island and Charlotte Bank. NW-SE magnetic lineations may exist along the southern edge of the Vitiaz trench, between 170°E and 173°E, at the southeastern extension of the N120-140 trending lineations which define, northwest of Anuta Island from 11°S to 8°30'S, a 100 km-wide zone narrowing to the north.

The N160 Ridge (N160R), located in the southeastern part of the studied area, represents the northern arm of the NFB 16°40'S triple junction (Lafoy et al, 1987 and 1990; Auzende et al., 1988; Price and Kroenke, 1991; Kroenke et al., in press). The axial part of the N160R, mapped by multibeam echosounder from 16°50'S to 14°50'S, is characterised by a succession of 4000 to 4500 m deep "en échelon" grabens flanked by 1000 m-high steep walls (Auzende et al., 1991). At 14°50'S, the N160R ends on a possible triple junction characterised by the convergence of a N160 southern graben, a N120 trending western graben and a N140 northern ridge (Auzende et al., in press).

South of 15°30'S, N-S to N160 structural and magnetic fabrics can be identified up to 80 km from the axis. North of 15°30'S, magnetic lineations mainly strike N100-120.

Discussion and conclusion

The morphotectonics of the northwestern NFB coupled with the geometry of the magnetic lineations allow to distinguish four successive spreading phases. Respective ages for these spreading phases are proposed on the basis of provisional anomaly identifications (Pelletier and Lafoy, in prep).

Phase 1 corresponds to the initial opening of the basin in a NE-SW direction (anomalies 5A?-5 to 4: 12?-11 to 7 Ma). This phase is evidenced by NW-SE magnetic lineations which are present in the northernmost and southwestern parts of the studied area, along the southern edge of the VT and east of the NHA respectively. The lineations appear to be disrupted by NE-SW faults. The spreading axis, which functioned until the end of anomalie 4 at a rate of 5-6 cm/y, could be located, between 14°S and 17°S, in the central part of the large domain characterised by NW-SE lineations. Magnetic lineations of similar trend are present to the south, east of the NHA, up to 18°- 19°S, and southwest of the Fiji Platform (Larue et al, 1982; Auzende et al, 1988) and probably result from phase 1.

The water depth and the NW-SE magnetic fabric of the eastern part of the BAT domain suggest that it lies on the NFB oceanic crust, as previously proposed by Charvis and Pelletier (1989). The presence of troughs lying behind the NHA is mainly due to the construction of the continuous 400 km-long DR which trapped a piece of the NFB oceanic crust. The DR could be a fossil volcanic line related to the New Hebrides subduction.

Phase 2 corresponds to a N-S opening along the SPR, TR and 9°30 R (anomalies 3A to 2A: 7 to 2.5 Ma). This phase is evidenced by E-W magnetic lineations distributed over the entire central part of the northwestern NFB from 9°S to 15°S and flanked by NW-SE trending lineations. E-W lineations are disrupted by N-S transform faults. Magnetic lineations with similar E-W trend are also present north of the Fiji Platform (Cherkis, 1980; Larue et al, 1982; Auzende et al, 1988) and probably result from this second phase.

The N-S opening ended between anomalies 2A and 2. The spreading rate was about 5 cm/y along the SPR and the TR. The axial troughs of these ridges lie in the middle of the area characterised by E-W magnetic lineations, and are interpreted as the spreading axis. Magnetic lineations of the northern limb of the SPR and TR are obscured by intense volcanism (Anuta, Fatutaka, Charlotte and Pandora Islands and Banks) synchronous or posterior to phase 2. At 168°30'E, the spreading axis is offset northward by the N-S trending WTR interpreted as a transform fault. West of 168°E the spreading axis lies close to the 9°30 R.

Phase 3 corresponds to an E-W opening (anomalies 2 to J: 2.5 to 1.5-1 Ma) along the N-S central NFB axis from 21°S to 15°30'S (Auzende et al., 1988; Lafoy et al., 1990). From 17°S to 15°30'S, the magnetic lineations trend 160°-180°E. If we extrapolate the present day rate of spreading (5 to 6 cm/y: Auzende et al., 1991), the age of the crust created on the western limb (80 km) of the N-S axis north of 15°30'S should be at least 3 Ma (anomalie 2A). Besides, anomaly 2A is identified on the eastern limb of the N-S axis at 19°S (Auzende et al., 1988). This implies the functioning of a triple junction at anomaly 2A between the N-S axis and the SPR axis, as previously proposed by Auzende et al. (1988).

Phase 4 corresponds to the present-day opening and extension along the N160R and the HHEZ. This phase follows the functioning of the left-lateral strike-slip Fiji Fracture Zone which induced the 16°40'S triple junction and the reorientation of the axis from N-S to N15 and N160, south and north of the triple junction respectively (Auzende at al, 1988; Lafoy et al., 1990). Anomalies 1 and J along the N160 R indicate that the reorganisation occurred just before anomaly J (1.5-1 Ma). At the northern end of the N160R, the N120 trending western arm of the 14°50'S possible triple junction (Auzende et al., in press) probably represents the eastern continuation of the HHEZ.

East of 170°30'E, recent active spreading of the N120 axis into older crust may explain, within the southern limb of the SPR, both the overwidth of the magnetic fabric and the trend change of magnetic lineations from N80 to N120. Although

E-W trending magnetic lineations seem to be associated with the HHEZ, the anomalies are unidentifiable west of 170°30'E. Structural, magnetic and seismological data suggest that the HHEZ is an active extensional zone which crosscuts older oceanic crust and connects the N160R in the central NFB with the southern tip of the BAT. The northernmost manifestation of this active extensional tectonics occurs, at the northern end of the BAT, along the E-W trending Santa Cruz Trough which crosscuts the NHA platform.

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