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Propagating rift west of the Fiji Archipelago (North Fiji Basin, SW Pacific)

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Abstract. A Sea Beam survey of an area located west of the Fiji Islands in the North Fiji Basin, between 17°10'S and 18°S and 175°40'E and 176°40'E, shows a complex structure characterized by two deep grabens bounding a central plateau. In previous papers, we interpreted this area as an intraoceanic strike-slip deformation zone, rejecting the possibility of oceanic spreading in the area. By comparison with the structures observed in the Galapagos 95.5° W area, we now reinterpret the area as a southward propagating spreading system. The analysis of structural and magnetic data and earthquake focal mechanisms confirms this new interpretation. The full spreading rate for the North Fiji Basin ridge, deduced from magnetic lineations, varies from 50 to 80 mm/yr. For the West Fiji spreading ridge, the magnetic anomaly analysis gives a spreading rate of about 50 mm/yr for the northern segment and slightly slower (40 mm/yr) for the southeastern segment. Using a 50 mm/yr spreading rate, the angles between the pseudofaults allow us to calculate the propagation velocity. For an angle of 75° north of 17°35'S, the propagation velocity is 33 mm/yr. The tip of the propagator is characterized by a 20° angle between the pseudofaults, which implies a recent increase of propagation velocity to 141 mm/yr. The initiation of this propagation could be related to the emplacement of the North Fiji fracture zone 1 to 1.5 m.y. ago, resulting in the formation of the 16°50'S triple junction. The main kinematic implication of the existence of a propagating rift west of the Fiji Islands is that in the North Fiji Basin the present-day accretion is distributed on two parallel active spreading ridges, one in the central part of the basin, the other one in its southeastern quadrant. Such a phenomenon, unusual on mid-oceanic ridges, except for microplates such as Galapagos, Easter and Juan Fernandez, may be more common in marginal basins because of their peculiar geodynamic setting.

Introduction

The recent evolution of the North Fiji Basin (NFB, Figure 1) is characterized by roughly east-west opening since 3 to 3.5 Ma along a north-south spreading ridge centered on 173°30'E (Figure 2). The details of the structure, segmentation, and deformation of this ridge are now well known and have been described in different articles [*Auzende et al.*, 1986a, 1988a, 1990, 1995; *Huchon et al.*, 1994; *Tanahashi et al.*, 1994]. The spreading rate along this central ridge varies along strike from 82 mm/yr at 19°S to 47 mm/yr near 16°S [*Auzende et al.*, 1990; *Huchon et al.*, 1994].

For a long time the existence of another active spreading axis located immediately west of the Fiji archipelago has been proposed based on parameters such as magnetism [*Chase*, 1971; *Malahoff et al.*, 1995], plate reconstructions [*Brocher and Holmes*, 1985; *Kroenke et al.*, 1995] and seismicity [*Louat and Pelletier*, 1989]. In contrast, *Auzende et al.* [1986b] used structural arguments to deny the existence of an active spreading ridge and proposed instead, the hypothesis of grabens under tectonic extension in a right-lateral strike-slip deformation zone (Figure 3).

Louat and Pelletier [1989] presented evidence of a well-defined N15E trending seismic belt centered on 176°E between 17°S and 20°S characterized by normal fault and strike-slip fault focal mechanism solutions. Using seismotectonic and plate tectonic considerations, they calculated a 30 mm/yr spreading rate along this extensional plate boundary.

Lafoy [1989] using the magnetic profiles acquired by the R/V *Jean Charcot* (Seapso III cruise, 1985) in an area between 17°10'S and 18°S and 175°40'E and 176°40'E (Figure 4), demonstrated the existence of roughly N-S magnetic lineations associated with extensional features (mainly deep grabens).

Using all of the data in the area, and the conclusions relative to the North Fiji Basin central spreading ridge intensively covered during the Starmer French-Japanese joint project [*Auzende et al.*, 1990, 1992, 1994; *de Alteris et al.*, 1993], we now reinterpret the West Fiji area in terms of a propagating spreading zone.

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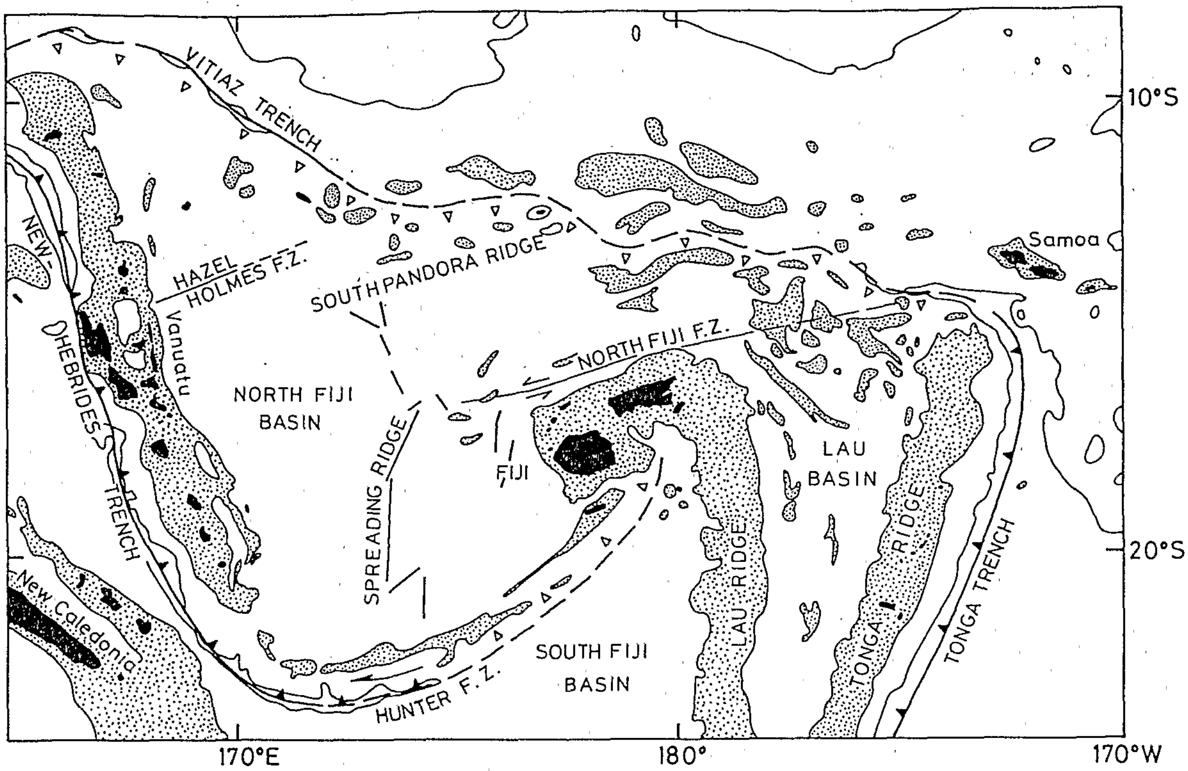

Figure 1. Geodynamic setting of the North Fiji Basin.

Data Acquisition and Processing

The bathymetric map of Figure 5 shows results from the compilation of the 60% coverage Sea Beam survey carried out during the Seapso III cruise. The map was drawn at a scale of 1:50,000 with a contour interval of 50 m. The bathymetric data combined with geophysical data were used to draw the structural interpretation (Figure 6a).

Simultaneously with the 10 knot (18.5 km/h) Sea Beam survey, geophysical coverage was obtained with single channel seismic, gravimeter and proton magnetometer measurements. The direction of profiles is E-W and the distance between each profile is about 3 mi (≈5 km) (Figure 4). The seismic profiles have been shot with a Sodera S 80 water gun. One representative seismic profile is shown in Figure 7.

The value of the reference magnetic field (IGRF 80) was removed from the measured total field, and the magnetic anomalies obtained were projected along the E-W trending tracks (Figure 8). The magnetic data were contaminated with short wavelength noise. In order to smooth the noisy data, filtering (5-to 200-km band-pass filter) was necessary. The vertical derivative method [*Galdéano*, 1974] was used to obtain a splitting of the anomalies. Its main effect is to split the "polluted" anomalies into small size, short wavelength anomalies. The magnetic anomalies are shown in Figure 9.

The gravity data were recovered using a Bodenseewerk KSS30 gravimeter. Standard Eötvos corrections were made to the raw gravity data to obtain free-air gravity anomalies. The free-air anomaly map (Figure 10) was constructed by interpolating the data along the ship tracks onto a grid spaced at 1 km, and filling the gaps with data extrapolated according to the inverse of the square distance criterion. Mantle Bouguer anomalies (Figure 11) were generated by subtracting from the free-air anomaly the attraction of seafloor topography and the effect of the crust-mantle interface assuming a uniform 6 km thick crust. Densities of 1.03, 2.7, and 3.3 Mg/m^3 were used for seawater, crust, and mantle, respectively.

The distribution of epicenters of shallow earthquakes (0-to 70-km depth) located by worldwide seismological stations during the period 1963-1992 is shown in Figure 12. The published focal mechanisms of earthquakes with magnitude equal to or greater than 5.5 have been added. Focal mechanism solutions are taken from two types of data sets. One solution is a first-motion plane solution given by *Johnson and Molnar* [1972]. The other solutions are moment tensor solutions obtained with the Centroid tensor method [*Dziewonski and Woodhouse*, 1983].

Structure of the West Fiji Area

The structural map interpretation of the West Fiji area (Figure 6a) is based on bathymetry and single-channel seismic profiles. Three main zones can be identified in the survey box differentiated by their depths and structural trends.

Western domain. The most representative feature is a N15E graben, 10 km wide, 4000 m deep characterized by a steep western flank and a series of steps constituting the eastern wall (PR in Figure 6a). This graben disappears to the south near 17°40'S, 175°57'E. It is bounded westward by a ridge culminating at less than 2800 m deep and to the east by a succession of ridges and depressions at a depth of 2500 m. The axis of the western ridge is cut by a graben which is a few hundred meters wide and few tens of meters deep. The western ridge is itself flanked by a N155E trending graben, 4 km wide and 3000 m-deep converging with the main graben around 17°42'S. This system could be the southern extremity of a spreading system joining the surveyed area with the North Fiji fracture zone.

At the southern tip of the N-S ridge, the convergence zone of the ridges and grabens is a relatively flat, 3500-m deep area (TP in Figure 6a) curved toward the east and flanked by steep

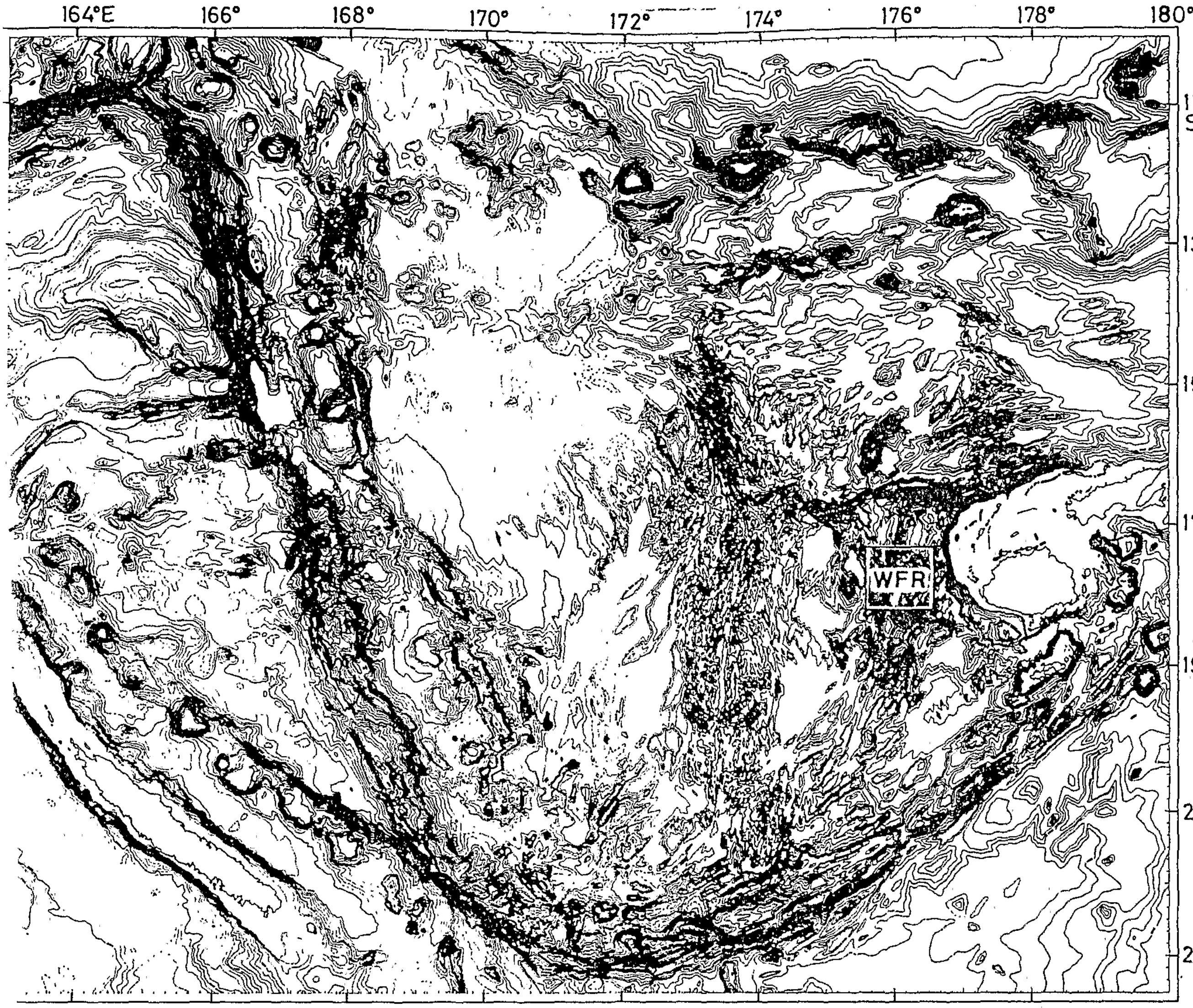

Figure 2. General bathymetry of the North Fiji Basin (map compiled by J.P. Mazé, IFREMER). Contour interval 100 m. The square indicates the location of the Sea Beam survey of Figure 5.

lls about 500 m high (OPF and IPF in Figure 6a). South of s graben-ridge system the oceanic bottom is characterized roughly N-S trending undulations at about 2800-m depth.

Eastern domain. East of 176°15'E it can be divided in ı parts. The southern part, south of a southwest-dipping rp (SC in Figure 6a), is characterized by an axial graben (SR Figure 6a), 10 to 12 km wide and 3200 m deep trending)E and abutting the N150E steep scarp. This graben, tered on 176°17'E, is flanked on both sides by alternating ıllel ridges and depressions in a 25-km-wide area. East of area the seafloor fabric is dominated by N-S to N05E ıgated ridges at a depth of 2500 m. North of the N150E ·p there is no graben and the seafloor is characterized by :essive N-S highs and lows.

:entral domain. It shows a more complicated structural ern. In the north between 17°20'S and 17°40'S, a fan-ıed succession of ridges and depressions converges to the hwest. The middle of the fan is occupied by a 3000-m-ı, 10-km-wide, N45E trending graben. South of 17°40'S ırea between the western and the eastern domains exhibits ed features separated by an E-W ridge linking both domains. South of this peculiar area, the N-S grain of the oceanic crust appears again at 17°53'S.

Throughout the whole survey area the sedimentary cover is thin or absent, as shown on the seismic profile of Figure 7. The only evidence of a very thin (few hundredths of milliseconds) sedimentary cover are located in the fan-shaped zone in the central domain. In the two main eastern and western grabens the oceanic crust outcrops as confirmed by the fresh basaltic rocks dredged during the Seapso cruise on the eastern wall of the western graben at 17°29'S [*Lafoy*, 1989]. These pillow basalts are slightly porphyric and coated with 1- to 2-cm-thick manganese crust, and their chemical and mineralogical compositions are very close to the mid-ocean ridge basalt (MORB) type lavas sampled all along the North Fiji Basin central spreading ridge [*Eissen et al.*, 1994].

Magnetic Data

The magnetic maps (Figures 8 and 9) established from the compilation of the 21 east-west profiles collected during the

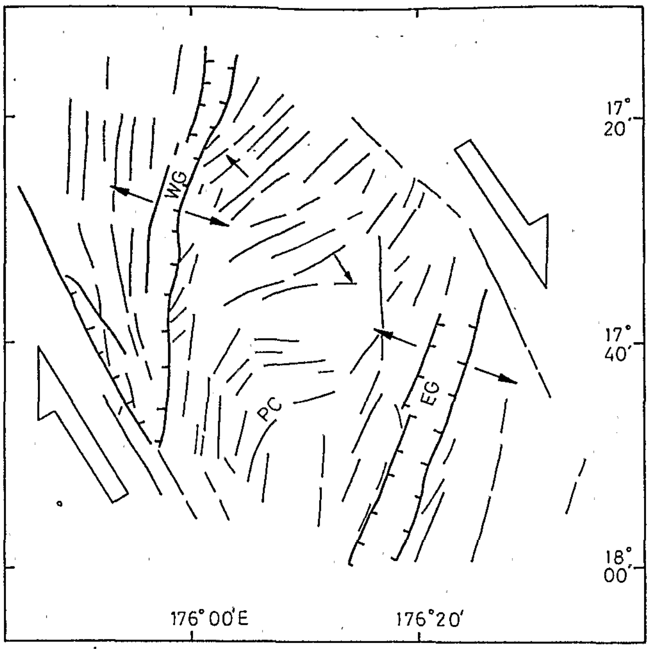

Figure 3. Structural sketch of the West Fiji Zone after *Auzende et al.* [1986a]. Black arrows indicate the extension, and white arrows strike-slip motion. WG, western graben; EG, eastern graben; PC, central plateau.

Jean Charcot Seapso cruise (Figure 4) allow us to distinguish three main magnetic provinces in the area.

The northwestern province, north of 17°40'S, is characterized by a high-amplitude (500 nT) N-S trending anomaly, with a width of about 40 km in the northern part of the survey area and narrowing to the south. It is interpreted as the Brunhes anomaly over the present-day spreading ridge (Figure 6a). This anomaly is slightly asymmetric, with the eastern limb more developed, and showing a fan-shaped pattern. The western flank of the Brunhes anomaly trends N-S. On the eastern side, the Brunhes anomaly is flanked by an oblique, curved high-amplitude anomaly converging with the western anomalies at the axial anomaly tip. These anomalies probably represent the Jaramillo event (0.98 Ma [*Cande and Kent*, 1992; *Huchon et al.*, 1994]). The total width of these anomalies out to the Jaramillo event is about 50 km in the northern part of the survey area at 17°10'S. The measured spreading rate is close to 50 mm/yr which fits very well with the computed anomaly pattern shown on Figure 8.

The southeastern province shows a magnetic pattern (Figures 8 and 9) with an Brunhes anomaly 32 km wide clearly defined up to 17°40'S centered on 176°20'E with a N05-N10E trend. This anomaly is flanked symmetrically by parallel lineations interpreted as the Jaramillo event. The spreading rate in this area is 40 mm/yr, slightly slower than in the previous domain (Figure 8). To the north the whole system is offset toward the east by about 15 km and it is not possible to distinguish the Jaramillo anomaly from the positive anomaly occupying the area. Another notable magnetic lineation is the linear N160E trending anomaly located east of the large N-S anomaly centered on 176°35'E.

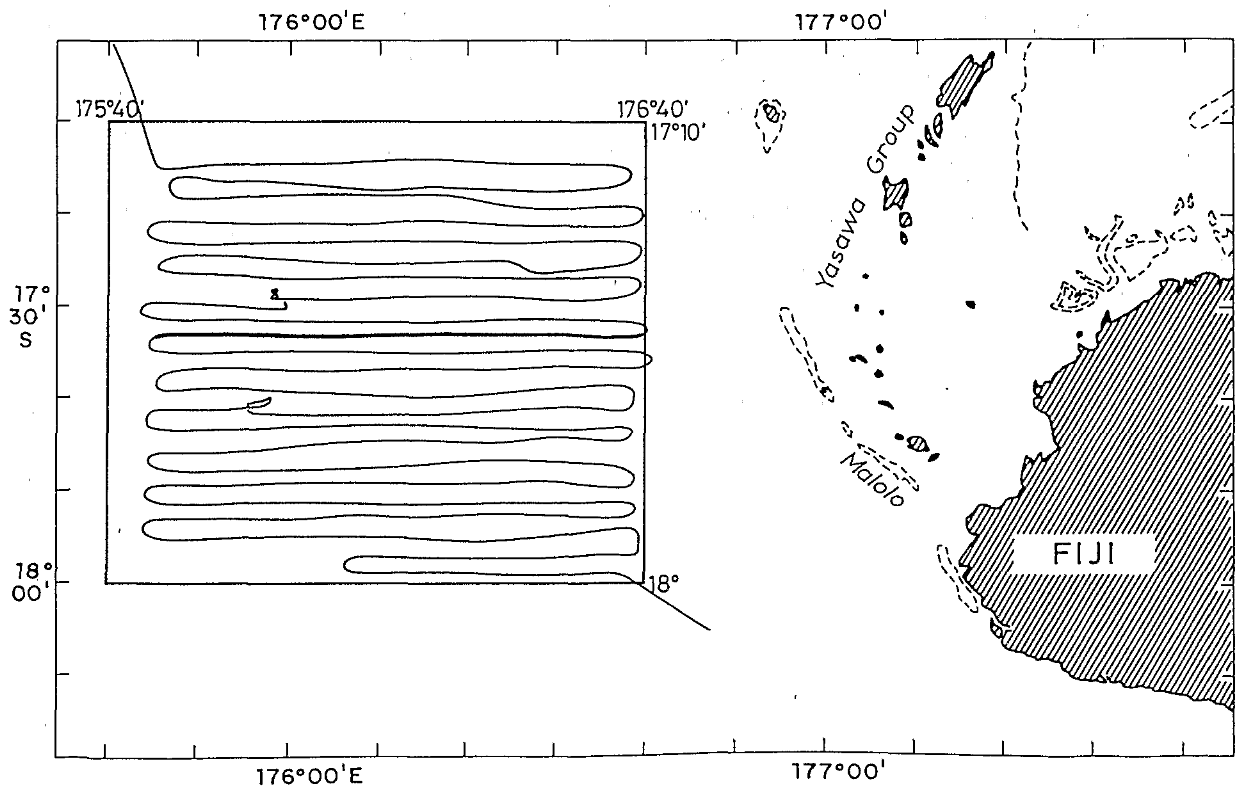

Figure 4. Location map of the Sea Beam and geophysical survey (gravity, single-channel seismic, and magnetism) carried out on the West Fiji Ridge, during the Seapso III cruise of the R/V *Jean Charcot* (December 1985). The Sea Beam coverage is about 60%. The heavy line is the seismic profile shown on Figure 7. The box is the area represented on Figures 5, 6a, 8, 9, 10, and 11.

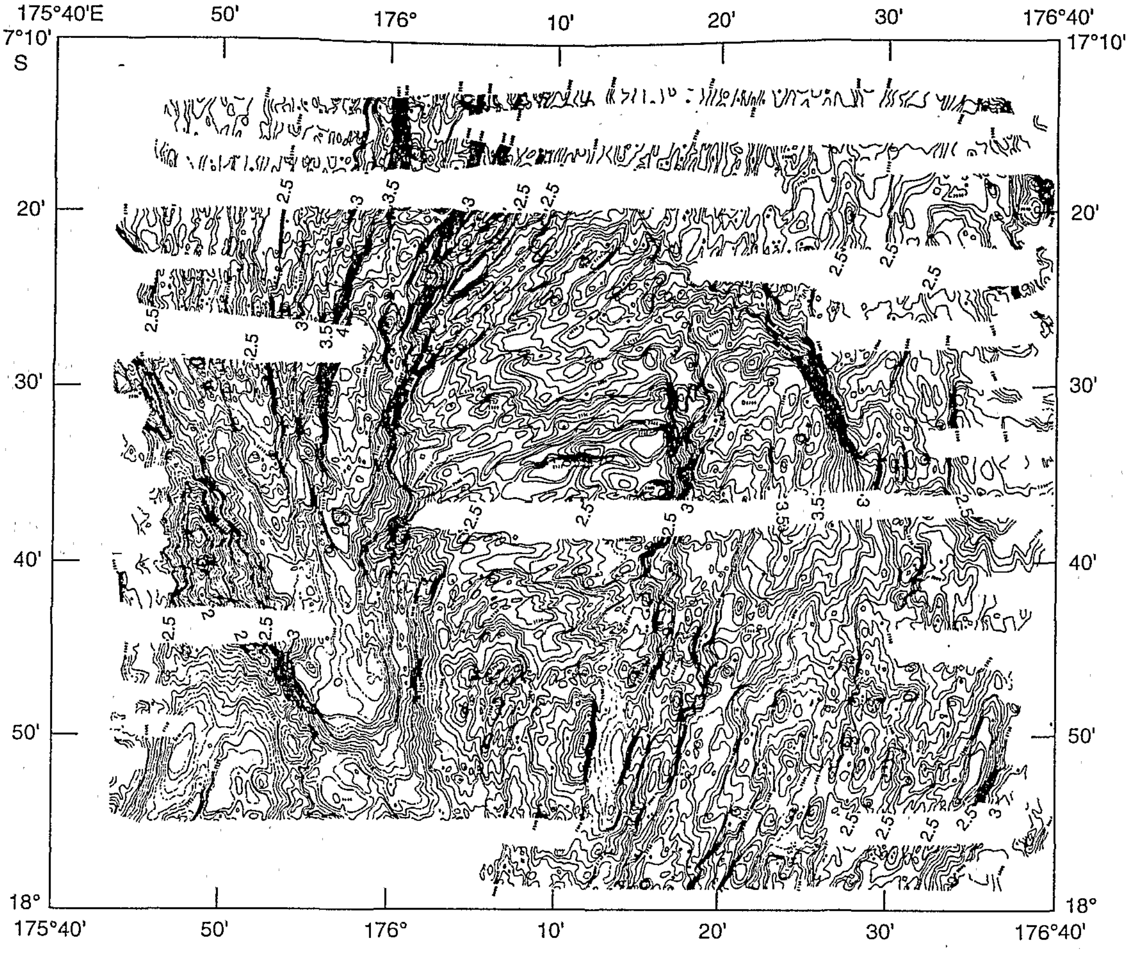

Figure 5. Sea Beam map of the West Fiji area established from the Seapso III, *Jean Charcot* survey [*Auzende et al.*, 1986b]. Contour interval: 50 m. The depths are indicated in kilometers.

'he central province is magnetically characterized by a :e E-W positive anomaly at latitude 17°35'S linking the emities of both previously described Brunhes anomalies ;ure 9).

avity Data

'he free-air gravity anomaly map contoured at a 10 mGal rval (Figure 10) is dominated by the seafloor topography, anomaly lows associated with the greater depths and tive anomalies over topographic highs.

n Figure 10 we can easily distinguish the deep western and ern grabens, both well expressed by negative (-10 mGal) -air gravity anomalies. The western graben is bounded by bathymetric highs characterized by positive anomalies, and 50 mGal from west to east. The eastern graben, ngly curved toward the west, shows the maximum negative ie (-20 mGal) at 17°30S. The central and elevated ngular zone separating the two grabens shows the largest tive anomalies, reaching values of 60 mGal.

n the other hand, the mantle Bouguer anomaly is related to subseafloor density structure. Thus, the mantle Bouguer naly map, contoured at 3-mGal intervals (Figure 11), cts the gravity field arising from density anomalies in the or mantle.

he most striking feature on this map is the significant V-ed positive mantle Bouguer anomalies associated with the propagating rift (Figure 11). These anomalies, ranging from 33 to 39 mGal, are roughly centered over the southern part of the western graben between 17°20'S and the V-tip at 17°40S. North of 17°20S, a relative gravity low corresponds to the northern part of the western graben. West of the V-shaped gravity high, relative negative mantle Bouguer anomalies are associated with a NW-SE trending ridge. Over the southeastern graben and centered at 17°50'S, a circular low mantle Bouguer anomaly (13 mGal) is observed. North of this feature and all along the graben, there is no significant anomaly.

The broad triangular positive Bouguer anomaly over the whole northwestern area, however, is roughly symmetric, consistent with the idea of a propagating rift structure. This well-expressed positive anomaly is interpreted as due to young and thin crust, created progressively while the spreading center propagates. On the Cocos-Nazca and Galapagos propagating rifts, which show structural features similar to those described in the West Fiji area, similar V-shaped mantle Bouguer anomalies have also been observed [*Lin and Phipps Morgan*, 1992].

The ridge located on the western edge of the propagating rift is interpreted as an older inactive structure with a thick isostatically compensated crust. Concerning the southeastern graben or southern rift, only a relative mantle Bouguer low is associated with it. This low can be associated with both hot and low-density mantle (melt) under the axis.

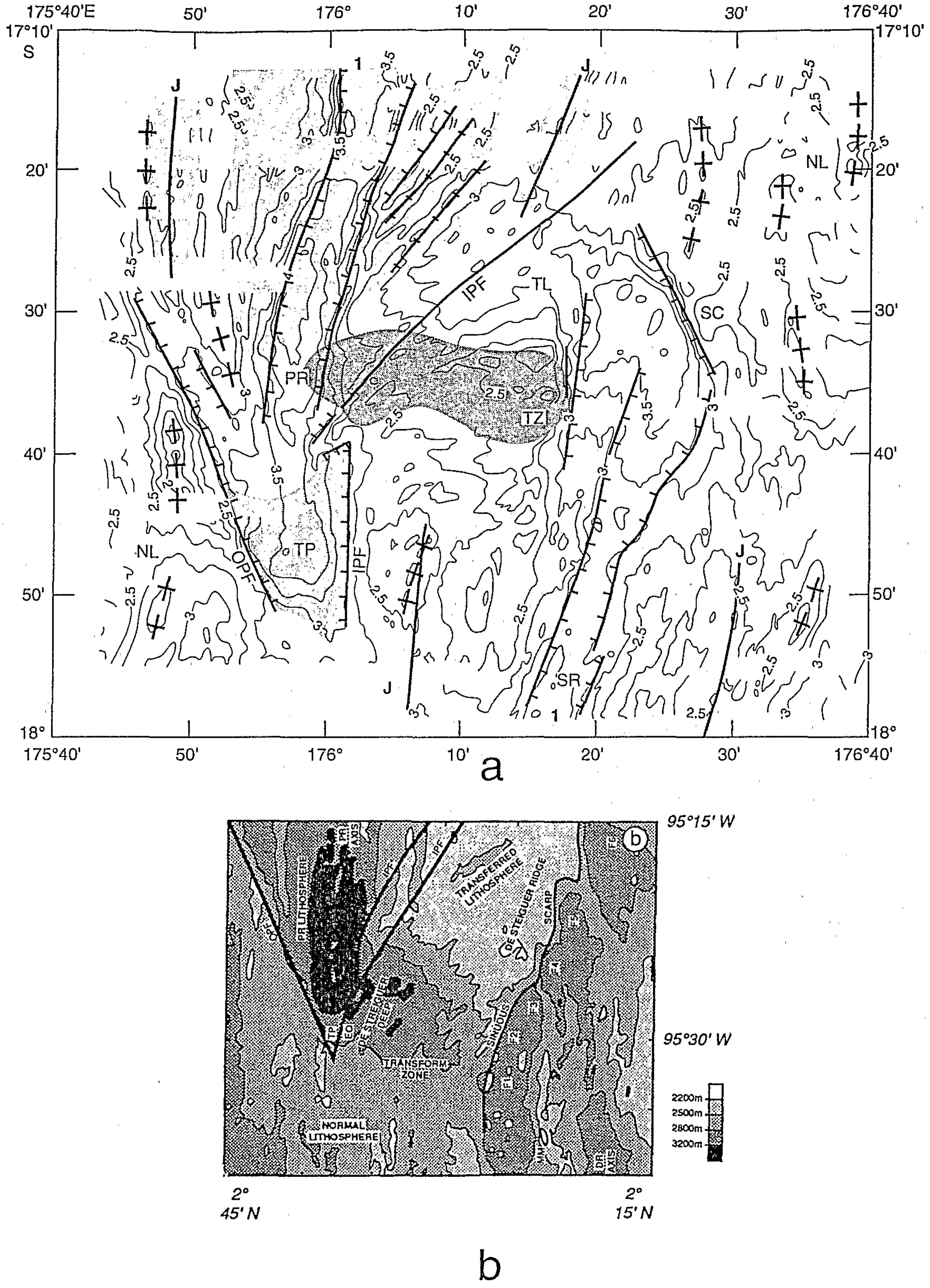

Figure 6. (a) Structural sketch of the West FIji Rift. PR, propagating rift; TP, tip of the propagating rift; OPF, outer pseudofault; IPF, inner pseudofault; SR, southern rift; NL, normal lithosphere; TL, transferred lithosphere; TZ, transform zone; SC, steep scarp. The crossed lines are structural ridges. Bathymetric depths are indicated in kilometers. The light gray areas represent the axial and J (Jaramillo) domains traced from the magnetic anomalies map of Figure 9. The dark gray area is the transform zone domain defined by a large negative magnetic anomaly (see Figure 9). The medium gray area is the propagating tip. (b) Structural sketch, at the same scale as Figure 6a, of the propagating rift near 95.5°W close to the Galapagos Islands [after *Hey et al.*, 1986].

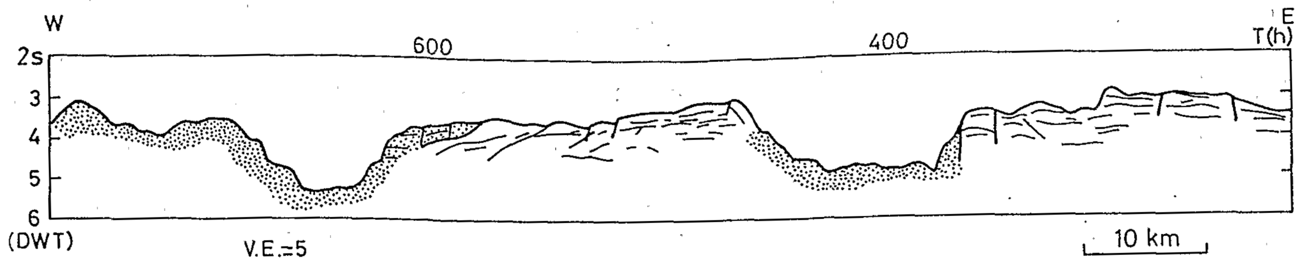

Figure 7. Seismic profile (see location on Figure 4) across the West Fiji domain at latitude 17°32'S. Vertical exaggeration is 5. Shading shows the area without sedimentary cover.

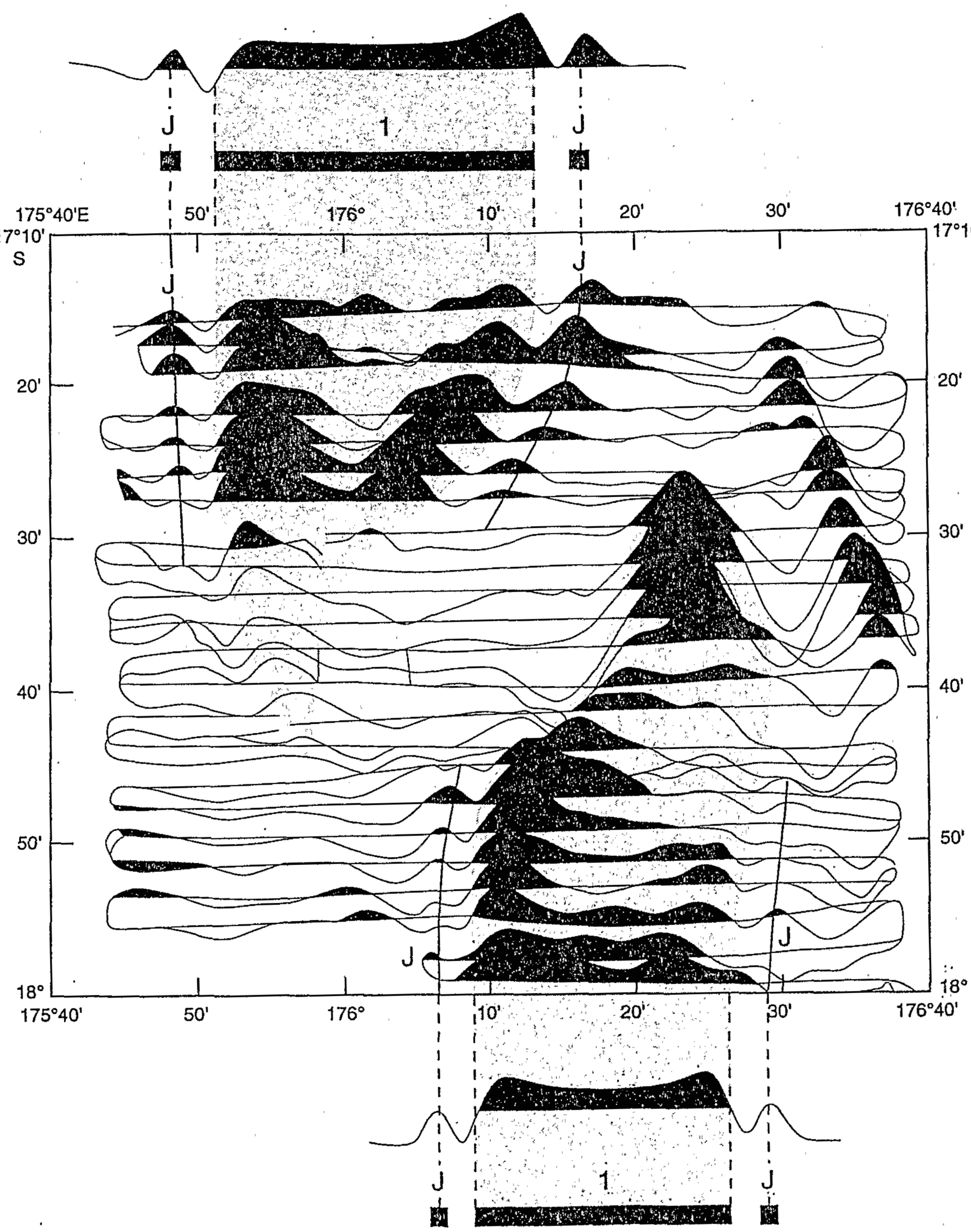

Figure 8. Magnetic anomalies plotted along the *Jean Charcot* tracks (Seapso III cruise). The vertical amplitude of the anomalies is 1 cm for 400 nT; 1, axial anomaly; J, Jaramillo event (0.98 Ma [after *Cande and Kent,* 1992]). Above the survey box we have represented the computed anomaly with the following parameters: present magnetic latitude -18, remnant magnetic latitude -18, lineation azimuth 10E, depth to magnetic layer 2.8 km, thickness of magnetic layer 0.5 km, full spreading rate 50 mm. Below the box is the computed anomaly with the following parameters: present magnetic latitude -17, remnant magnetic latitude -17, lineation azimuth 0, depth to magnetic layer 2.8 km, thickness of magnetic layer 0.5 km, full spreading rate 40 mm.

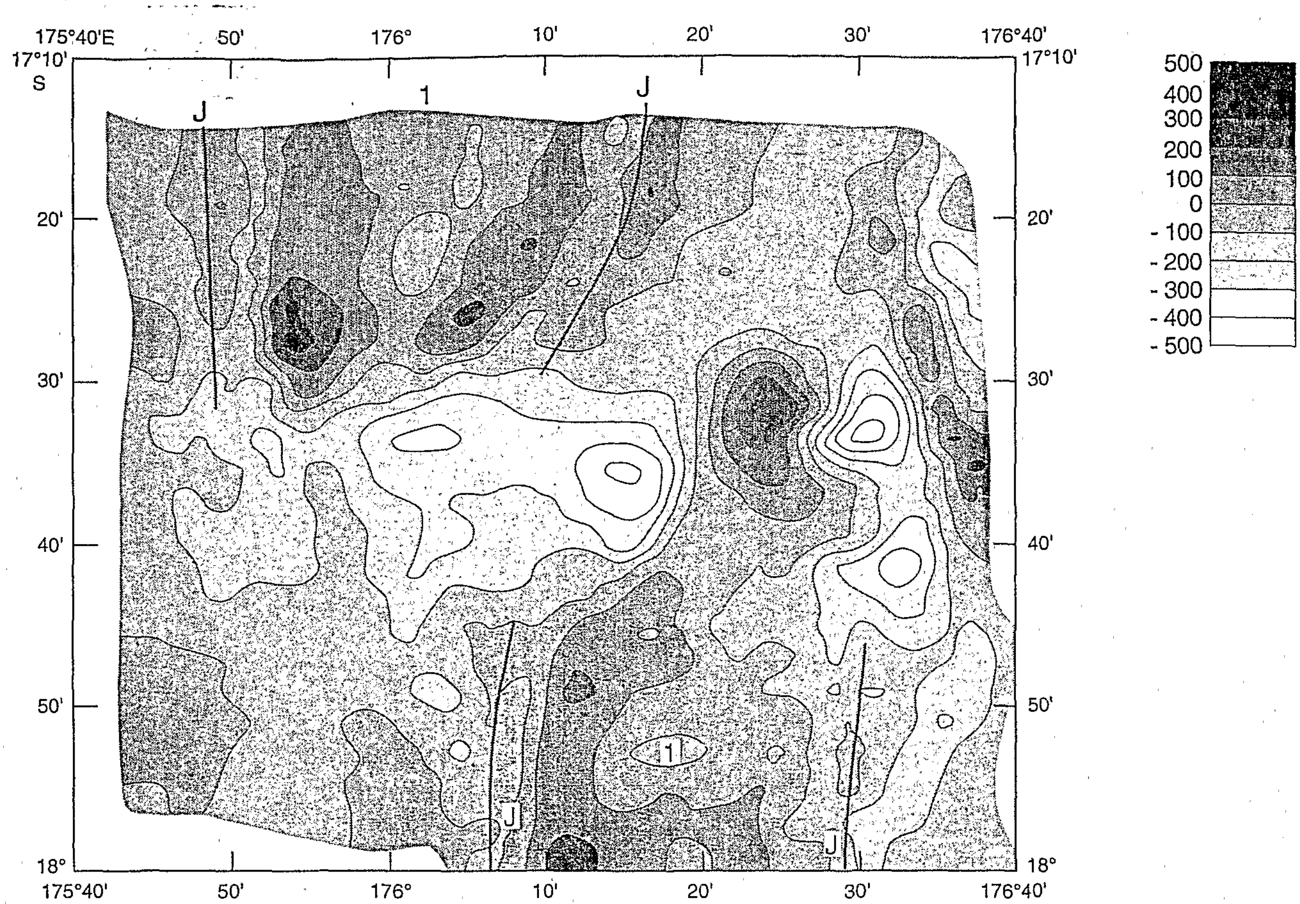

Figure 9. Magnetic map: latitude of origin 17°S; ellipsoid GRS80; projection Mercator WGS84, contour interval 100 nT. See Figure 8 for the interpretation of magnetic lineations; 1, axial anomaly; J. Jaramillo event (0.98 Ma [after *Cande and Kent,* 1992]).

Seismicity

The level of seismic activity in the western part of the Fiji Islands is very low compared to that observed in the surrounding areas. We have plotted on Figure 12 the shallow events which have been located during the past 30 years in this region which are listed in U.S. Geological Survey and a National Earthquake Information Service annual reports from 1963 to 1992. Thirteen earthquakes have a magnitude greater or equal to 5.5 and only one has a magnitude greater than 6.0 (October 12th, 1984, M=6.1). Due to the scarcity of seismological stations in these regions, the depths of the earthquakes are generally not well constrained. More than 50% of the events have no depth estimate. Nevertheless, the depths of well-determined hypocenters indicate generally very shallow seismic activity. However, some earthquakes 100 km deep occurred along the North Fiji fracture zone, and two events having a depth close to 550 km are clearly related to the Tonga Benioff Zone.

In the northern part of the area the location of epicenters roughly delimits the North Fiji fracture zone, which is characterized in this area by a N80E general trend. In detail, this trend consists of a "zig-zag" pattern containing N85E, N60E, N-S and N140E directions. In the West Fiji Propagator area (Figure 12) most of the recorded earthquakes are located on the transform zone and the transferred lithosphere between the two active ridges. To the south, outside the Sea Beam box, the earthquakes are aligned along a N15-20E trend representative of the southern active rift.

The focal mechanisms of nine events are shown on Figure 12. *Hamburger and Isacks* [1988] reported one strike-slip fault solution for one of the registered earthquakes in this area, but *Dziewonski et al.* [1988], recomputing the parameters of the same earthquake, argued for a normal fault solution. The T-axis of the normal fault solution is perpendicular (N108E) to the strike of the propagating rift.

Interpretation

The structural, magnetic, gravimetric and seismic data suggest this area should be interpreted in terms of rift propagation such as defined during the last 20 years in different parts of the world ocean [*Herron*, 1972; *Bowin*, 1974; *Shih and Molnar*, 1975; *Hey*, 1977; *Courtillot et al.*, 1980; *Hey et al.*, 1980, 1986; *Naar et al.*, 1991; *de Alteris et al.*, 1993]. Figure 6b is the structural map of the 95.5°W Galapagos propagating rift published by *Hey et al.* [1986]. The striking similarity in size and shape of the different morphological and geological features in the Galapagos and NFB areas helped us to reinterpret the West Fiji Ridge in terms of propagation.

The graben observed in the northwestern domain of the West Fiji Ridge is considered to be the present-day active ridge axis propagating southward. Its southern tip curves east toward the offset southern ridge axis. Such curvature is a very common phenomenon of propagating rifts and ridge-transform intersections [*Macdonald*, 1983; *Fox and Gallo*,

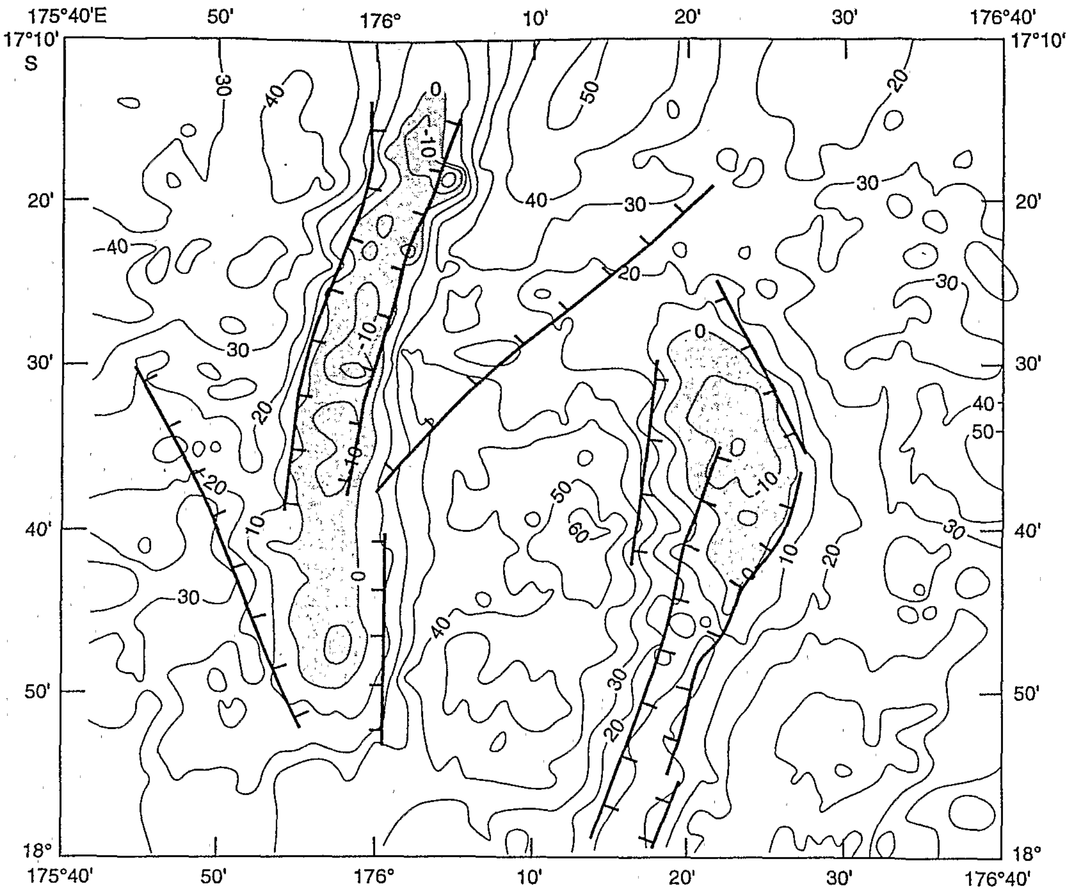

Figure 10. Gravity anomaly map: origin of latitude 17°S, projection is Mercator WGS84, ellipsoid GRS80, contour interval 10 mGals. Gray area shows negative anomaly. The main structural features of Figure 6a are indicated.

;4; *de Alteris et al.*, 1993]. It is interpreted as the result of rotation of the principal axis of tension from an entation parallel to the spreading direction to an entation at 45° from it [*Hey et al.*, 1986]. On both sides, propagating rift is bounded by steep faults converging thward and representing the pseudofaults created during the pagation. In the northern part the eastern fault or inner udofault (IPF) is located immediately to the east of the tern ridge and trends N50E. On the western side the limit ween the propagating rift seafloor and the adjacent seafloor ery sharp and is marked by a linear outer pseudofault (OPF) nding N155E from north to south. The angle between the and OPF is 75°.

The tip of the propagating rift is located between 17°40'S 17°50'S and is characterized by a deep flat basin bounded the converging N155E and N175E OPF and IPF (the angle ween both faults is 20°). The seafloor topography in this a suggests recent volcanic flows infilling the basin like a ge lava lake as proposed by *Hey et al.* [1986] for the lapagos propagator or an amagmatic stretching resulting in cropping of deep levels of the oceanic crust.

The axial magnetic anomaly (Figures 8 and 9) corresponds ctly with the graben, whereas the area corresponding to the nhes period covers the lateral ridges. The interpreted amillo anomalies show a fan-shaped pattern. The fit of served and computed magnetic profiles indicates the rage spreading rate for the last million years is close to 50 n/yr. This value is higher than the 30 mm/yr rate proposed m seismicity and kinematic data by *Louat and Pelletier* 989].

The southeastern domain represents the offset southern active ridge axis. The previously described 3000-m-deep graben is considered as the active accretion center bounded by symmetrical ridges and lows. The magnetic anomaly pattern fits well with this interpretation (Figures 8 and 9). A typical axial anomaly is centered on the axis of the graben from the southernmost part of our survey up to 17°50'S. On both sides of the Brunhes anomaly, the Jaramillo anomaly is clearly identified up to 17°45'S and disappears northward. This suggests that the present-day ridge tip is located at 17°40'S. The measured spreading rate is 40 mm/yr, which is in good agreement with the computed profile of Figure 8.

To the north, in an overlapping position relative to the southward propagating ridge, a strong positive anomaly, at 17°31'S, 176°25'E, prolongates, with a slight offset, the axial anomaly. This fact lead *Huchon et al.* [1994] to hypothesize that the whole system could be considered as a giant overlapping spreading center and that the southern ridge represents the main propagating ridge. This hypothesis can be rejected if magnetic and structural data are considered together. The southeastern rift graben does not show the typical features usually related to propagating rifts such as pseudofaults, propagating tip, etc. If we compare the size of the West Fiji Ridge system with OSC's described in mid-oceanic ridges [*Macdonald and Fox*, 1983], we can see that the distance between both spreading ridges in the West Fiji Ridge system is about 45 km, which is 2 or 3 times larger than the OSC's typical of mid-oceanic ridges. The strong positive magnetic anomaly, located north of the southern rift, might be (1) related to short episodes of northward propagation of

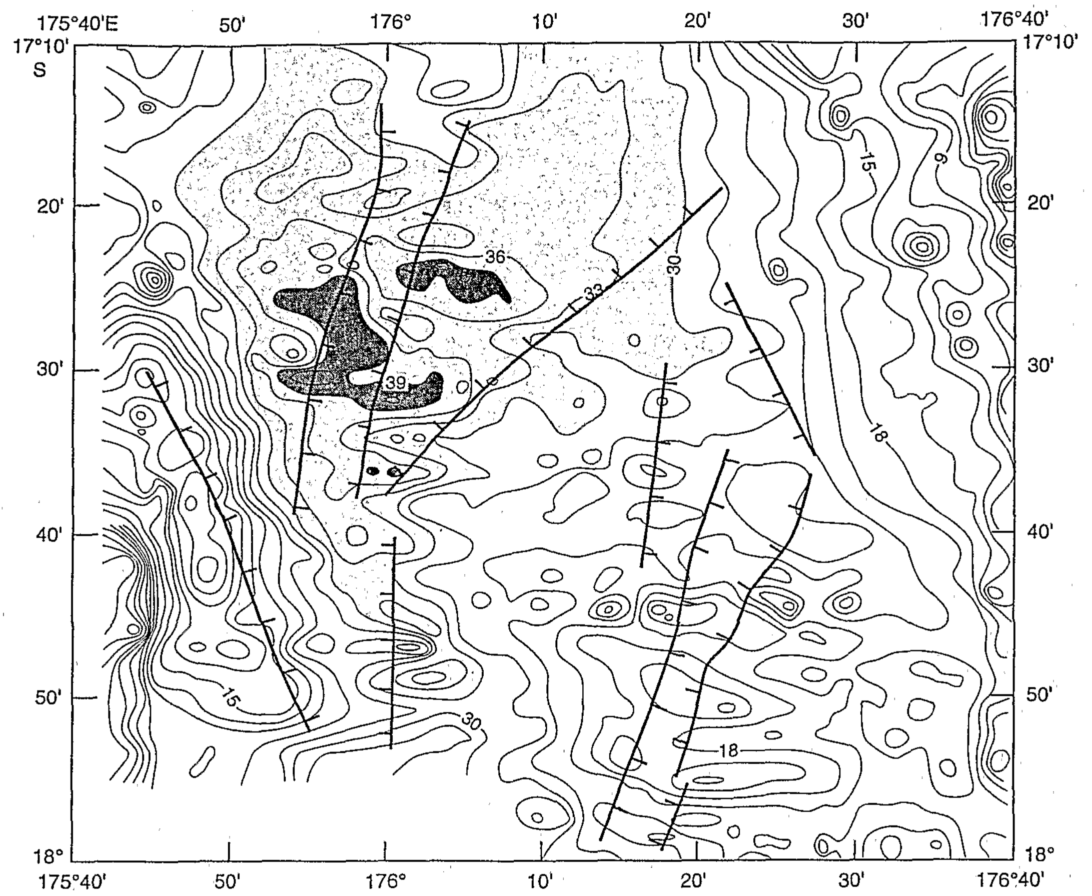

Figure 11. Mantle Bouguer anomaly map: contour interval 3 mGals. Gray area shows high values related to the propagating rift. The main structural features of Figure 6a are indicated.

the southern rift, (2) interpreted as a part of the failed rift-doomed rift system abandoned during the southward propagation of the western ridge, or (3) linked to off-axis volcanic events (D.F. Naar, personal communication, 1994).

If we extrapolate the present day spreading rate measured along the propagating rift, the time necessary for the creation of the crust located between the Fiji platform and the present-day axis (about 70 km) would be about 3 Ma. If there is a link between the emplacement of the North Fiji fracture zone, 1.5 m.y. [*Lafoy et al.*, 1990; *Auzende et al.*, 1993], and the beginning of the accretion along the West Fiji Ridge, only one half of the crust has been created during this last phase. The other portion of the existing crust was emplaced during a previous phase of opening of the North Fiji Basin.

The area between both ridges reflects the kinematic deformations due to the propagation. The zone located between 17°45'S and 17°25'S, characterized by fan-shaped features, results from the rotation of the lithosphere created by the eastern rift and transferred to the western one during the propagation. The transferred lithosphere is similar to that observed in other propagating rift systems and, at a larger scale, to the Easter [*Naar et al.*, 1991] and the Juan Fernandez [*Larson et al.*, 1992; *Searle et al.*, 1993] microplates.

South of the transferred lithosphere area (near 17°35'S) the structural map (Figure 6a) shows a series of short elongated ridges and no clear transverse feature related to transform motion between the two spreading ridges. On the contrary on the magnetic map (Figures 8 and 9), a very clear E-W negative magnetic anomaly aligned on 17°35'S and more than 20 km wide, forms the junction between both ridges. The width of this E-W anomaly suggests that the West Fiji propagating rift corresponds to the Figure 2c case of *Hey et al.* [1986] in which the increase of the spreading rate of the propagating ridge from zero to the full rate and the decrease of the spreading rate of the failing rift takes a relatively long time. In this case the transform motion will be accommodated within a broad zone named the transform zone.

Conclusions

The reinterpretation of the structure, seismological, magnetic and gravity data gives strong evidence for the existence of a propagating spreading rift West of the Fiji Archipelago and modifies the previous hypothesis of an extensional zone in a strike-slip environment as proposed by *Auzende et al.* [1986b].

The spreading in this area started before the Jaramillo event (0.98 Ma) and is synchronous with the North Fiji fracture zone emplacement (1.5 Ma) north of the Fiji Islands, which connects the main spreading ridge of the North Fiji Basin [*Lafoy et al.*, 1990; *Auzende et al.*, 1994] with the Lau Basin spreading system [*Parson et al.*, 1990]. This phase follows a previous phase of opening starting at 3 to 3.5 Ma in the central North Fiji Basin [*Auzende et al.*, 1988b]. We have no

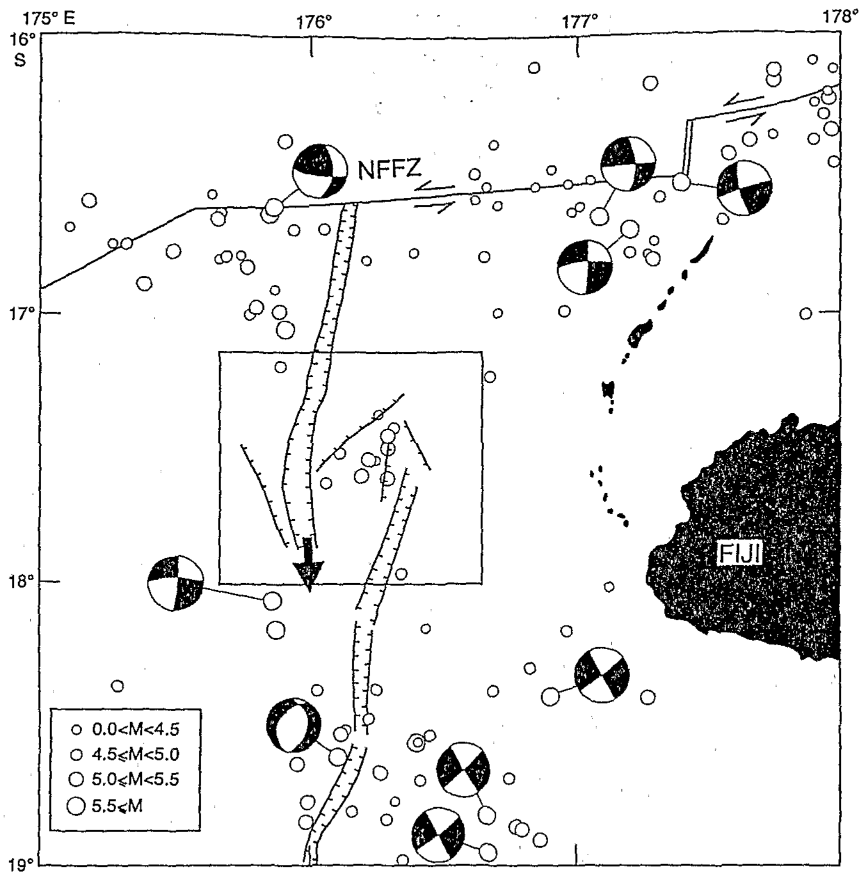

Figure 12. Spatial distribution of epicenters of shallow earthquakes (1963 to 1992) off western coast of Fiji Island. Open circles correspond to shallow and intermediate earthquakes. Focal mechanism solutions have been drawn for selected events with magnitudes greater than 5.5. The black arrow corresponds to the location of the West Fiji propagating rift. The major structural features along the West Fiji Ridge have been underlined. NFFZ, North Fiji fracture zone.

:ise information on the existence at this time of a ridge , immediately west of the Fiji Islands. The aeromagnetic ·cy of the U.S. Naval Research Office and NOAA published *Cherkis* [1980] is not precise enough to distinguish the ;ible N-S lineations associated with this former phase.

he kinematics of the left-lateral motion, which represents Australia-Pacific plate motion, along the North Fiji ure zone with a velocity close to 100 mm/yr [*Minster and lan*, 1978], the opening of the central North Fiji Basin : with a 50 mm/yr spreading rate, and the opening of the t Fiji Axis with a 40 to 50 mm/yr rate are in good :ment.

;ing the *Hey et al.* [1986] formula we have calculated the ıgation velocities along the West Fiji Axis. With an · of 75° between the OPF and IPF, the propagation ity is 33 mm/yr and for the more recent phase at the tip : propagator, with an angle of 20° between OPF and IPF, ›ropagation velocity increases to 141 mm/yr. These vely high velocities imply that the whole propagation West Fiji rift axis must have occurred since 1 to 1.5 Ma consider that the distance between the tip of the present-day propagating ridge and the intersection with the North Fiji fracture zone is 148 km. This gives an overall average propagation velocity of about 100 mm/yr, assuming that propagation was all in the same direction.

Another consequence of the existence of an active spreading ridge west of Fiji is that we have to consider that the accretion in the North Fiji Basin is distributed on two synchronously active ridges [*Auzende et al.*, 1994] (Figure 13). The Central Spreading Ridge and West Fiji Ridge are propagating in an opposite sense isolating an intermediate plate west of Fiji. This phenomenon can be compared with the Easter and Juan Fernandez microplates on the East Pacific Rise [*Francheteau et al.*, 1987; *Larson et al.*, 1992]. Such a case was until now not well documented in back arc basins, but other examples could exist in other marginal basins due to the peculiar geodynamic context of the accretion taking place in a large-scale shearing environment such as the North Fiji Basin [*Auzende et al.*, 1986b; *Hamburger and Isacks*, 1988]. The simultaneously active Peggy Ridge and the 176°30'W ridge in the Lau Basin [*Parson et al.*, 1990] are a good illustration of this kind of double ridge system.

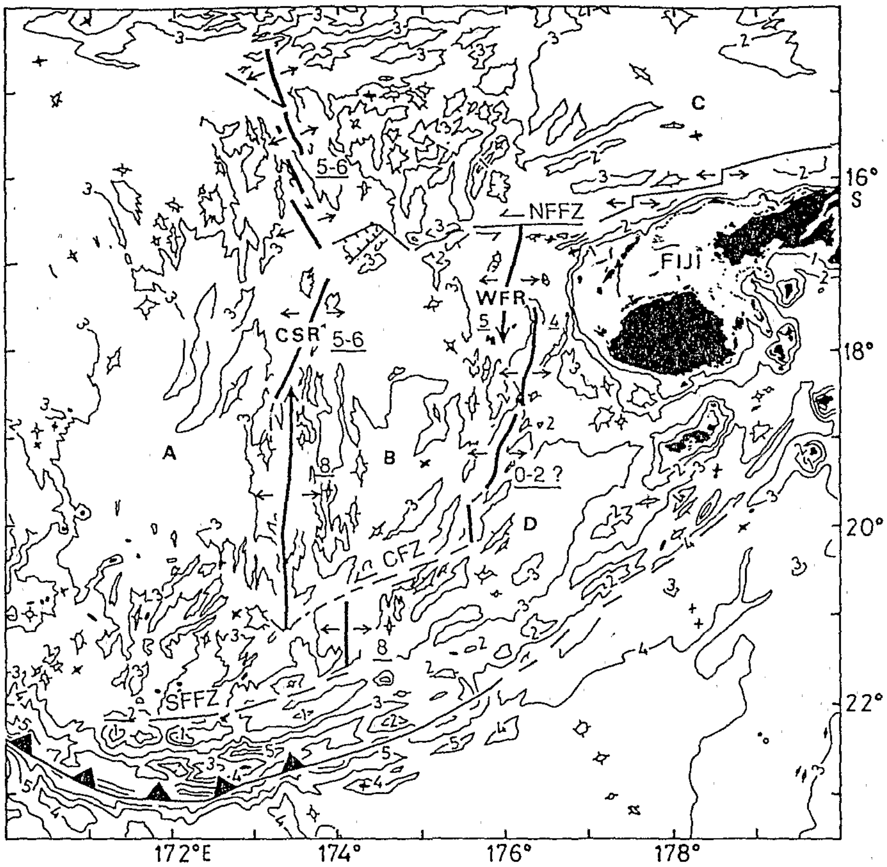

Figure 13. Kinematic sketch of the functioning of twin ridges in the North Fiji Basin (modified after *Auzende et al.,* [1994]). NFFZ, North Fiji fracture zone; CFZ, Central Fiji fracture zone; SFFZ, South Fiji fracture zone; CSR, central spreading ridge; WFR, West Fiji Rift; 5-6, spreading rate (in cm/yr) calculated from magnetic data; 0-2?, inferred spreading rate (in cm/yr). Arrows at tips of ridge segments indicate the direction of propagation. Contour interval, 1 km; A, western North Fiji Basin plate; B, intermediate microplate; C, North Fiji (Pacific?) plate; D, Southeast Fiji (Australian?) plate.

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