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[redacted] geodynamic implications

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Filtered SEASAT data have been interpreted in an area covering the Cook-Austral archipelagoes (South Central Pacific) in order to detect or confirm the existence of structural directions. SEABEAM data recorded by N/O "Jean Charcot" were also interpreted. Additionally to the Austral fracture zone and Cook-Austral archipelagoes trends, the SEASAT data reveal the existence of two directions, the azimuths of which are N150° and N95° respectively. The first, which intersects the Austral archipelago close to the island of Maria corresponds to a long linear topographic bump. It is interpreted as evidence for the existence of an ancient hot spot with a trace copolar to the Emperor chain. This result explains the very important thermal rejuvenation found previously in that area by several authors. It also explains the very disturbed ages and morphologies of volcanic structures recorded in the Austral archipelago. The second direction, located south of the Cook archipelago is underlined by geoid signatures of fracture zone type. These postulated linear features are probably of similar origin to the ones detected previously farther east. They are interpreted as a possible consequence of some recent intraplate deformation.

1. Introduction

In spite of the effort of many oceanographical institutions during the past decades, the seafloor topography is still very poorly known in many oceanic areas. Due to the lack of data, only very tentative geodynamic models of evolution of some oceanic areas have been proposed. Such a situation holds for the South Central Pacific [1]. The recent knowledge of the marine geoid obtained with satellite altimeter data provides a large amount of information in vast areas previously unexplored. The high degree of correlation between the seafloor topography and the short-wavelength geoid anomalies has been used in numerous studies in order to detect uncharted features [2–7]. Maps of geoid [8–10] can be studied as well in order to analyse structural trends. In a recent study, Baudry et al. [7] presented the results of an investigation of unsurveyed seamounts and their precise location in the western part of the Austral archipelago, using SEASAT data. They detected ten previously unknown seamounts and located eight with a precision of 15 km. They also gave an estimation of the height of each seamount and of their morphological regularity. They confirmed too the result of Lambeck and Coleman [2] who postulated that no bathymetric features were present on the charted position of Fabert Bank (Fig. 1). During the SEAPSO Leg V cruise onboard the N/O "Jean Charcot" (ORSTOM/IFREMER cruise, January 1986), SEABEAM surveys were achieved over the Austral archipelago on the charted location of Fabert Bank and on the locations of the detected seamounts S6, S5 and S2. The SEABEAM survey confirmed the predictions of Baudry et al. [7]. The maximum deviation between the predicted locations and the observed ones appeared to be of the order of 12 km [11,12]. Similar results were recently (February 1987) obtained over the seamounts S3 and S7 (see Fig. 1) during a cruise of the R/V "Sonne" (U. Von Stackelberg, personal communication). The seamounts detected in the Austral archipelago (S1 to S10) lie on two well defined trends. Some are located on a northwest extension of the southern

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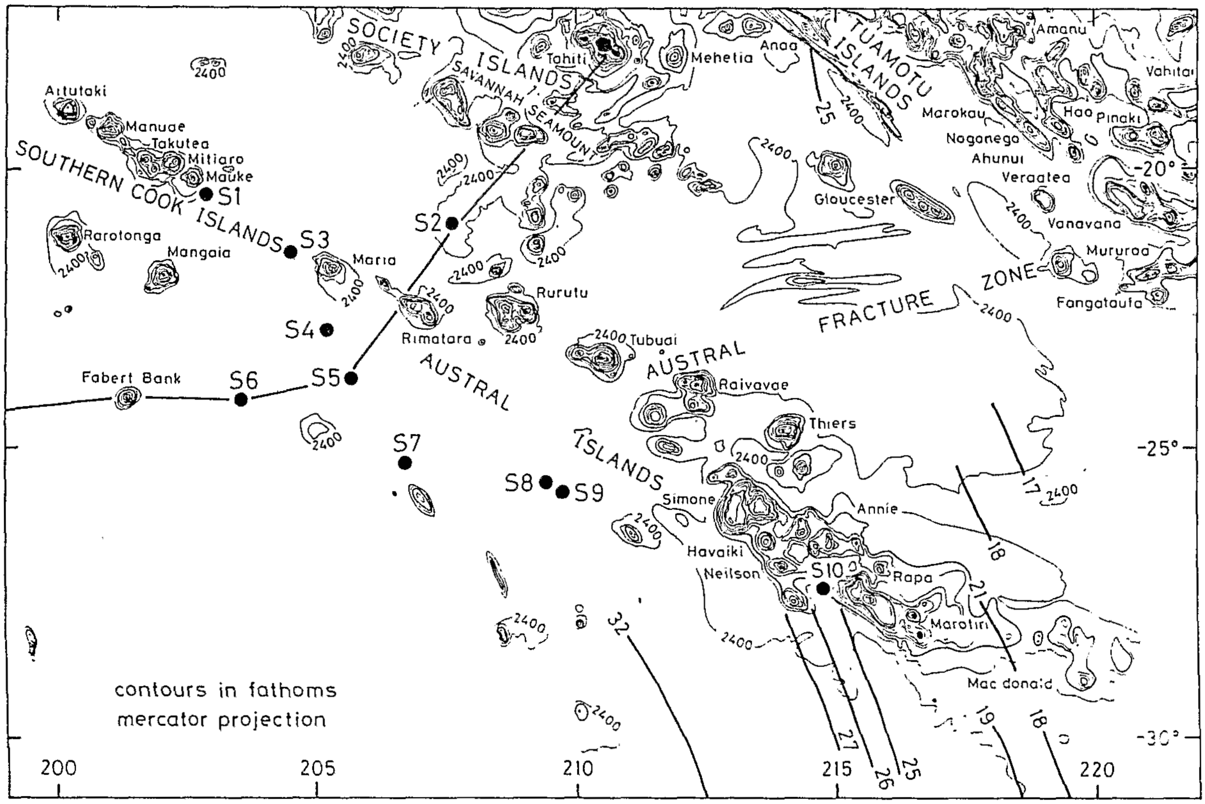

Fig. 1. Bathymetry of the area under study after Mammerickx et al. [1]. *S1* to *S10* are the 10 seamounts detected and located by Baudry et al. [7] using SEASAT data. The route of N/O "Jean Charcot" during the SEAPSO Leg V transit is also represented. Magnetic anomalies are also shown [14].

Austral chain, and others along a lineation bearing N150° which intersects the archipelago (Fig. 1).

The purpose of the present paper is to carry out a more detailed investigation of these trends in order to discuss their possible origin from an analysis of SEASAT data complemented with the SEABEAM data gathered by N/O "Jean Charcot". Our results will then be interpreted in terms of geodynamic evolution of the South Central Pacific. The area under study extends 17°S to 31°S and 199°E to 222°E and therefore is larger than the one used for the detection of seamounts and covers part of the Society and Tuamotu Islands (see Fig. 1).

2. The Southern Cook and Austral chain area

Several linear bathymetric features are present in the area under study, such as the Cook-Austral chain, the southern part of the Society Islands, and the Austral fracture zone (Fig. 1). These features are emplaced on a wide bathymetric swell [13]. Identification of sea-floor spreading magnetic anomalies [14] shows that anomaly 18 is present close to the MacDonald seamount and anomaly 32 south of Raivavae (Fig. 1). Therefore the age of the lithosphere varies from about 42 m.y. close to MacDonald to about 70 m.y. close to Rurutu [15], this last age being obtained assuming that the recorded anomaly 32 can be extended to the north. More to the west, the age can be only guessed but the crust is probably older than 80 m.y. west of Maria island. Thus the ocean floor in this area was created at the East Pacific Rise before its 20 m.y. reorganisation [1,16]. The Austral fracture zone is the fossil part of a transform fault which offsets the East Pacific Rise before the jump of the accretionary center to its new position. The Cook-Austral chain and the Society Islands are recent volcanic structures [17,18] with an orientation of

N110° which has been interpreted as the traces of hot spots on the Pacific plate [18,19]. The morphology of the Austral archipelago consists of two parallel chains, but such a pattern does not seem to be an exception for mid-plate volcanic chains. Menard and McNutt [20] pointed out the existence of features with very variable morphology in the Austral archipelago; for example the President Thiers Bank is equally broad as Raivavae island but completely truncated (see Fig. 1). Therefore, from geomorphology, Menard and McNutt [20] proposed an older age for this bank. Indeed, the ages of islands and seamounts of the Austral and Southern Cook archipelagoes as deduced from K/Ar dating do not show a consistent age progression to the northwest as required by a single hot spot model [21]. Of the eleven Cook-Austral islands for which age determinations are presently available, at least four (Aitutaki, Rarotonga, Atiu and Mauke) have much younger volcanism that can be accounted for by a single hot spot presently located at McDonald seamount [21]. Some islands present two periods of volcanism separated by a very long period of quiescence [21,22]. For example, on Rurutu, volcanism took place about 12.5 m.y. ago and, more recently, about 1.9 to 0.6 m.y. ago. The existence of at least three hot spots in this area was then postulated [21] in order to explain this age pattern. The difficulty to account for the alignment of several hot spots along the absolute motion of the Pacific plate led Turner and Jarrard [21] to propose the existence of a "hot line", as previously proposed by Bonatti and Harrison [23] and Bonatti et al. [24] on the Nazca plate. This assumed hot line would extend from Tonga trench to the Peru-Chile trench, across the East Pacific Ridge. It would include 12 of the 19 known Quaternary volcanoes associated with linear volcanic chains in the Pacific basin [21]. Turner and Jarrard [21] proposed that the origin of this hot line could be small convection rolls similar to those described by Richter [25] and Richter and Parsons [26]. Many islands of the Cook-Austral chain present evidence for an important uplift. McNutt and Menard [27] showed that the uplift of Mangia, Atiu, Mitaro and Mauke coral reefs could be explained by the effect of the loading of the lithosphere due to the recent emplacement of Aitutaki, Manuae and Rarotonga. But as pointed out by Turner and Jarrard [21] the cause of the uplifts of Rimatara, Rurutu and Tubuai is unkown.

Analysis of the mechanical behaviour of the lithosphere supporting the Southern Cook and Austral islands and seamounts performed with various techniques [27–30], yields an abnormally thin equivalent elastic thickness for such old lithosphere on which recent loads have been emplaced. Indeed the various datations [17,18] of the studied seamounts and islands give an age ranging from 0 m.y. (McDonald seamount) to 18 m.y. (Mangaia). These values, when compared to the ages of the neighbouring lithospheres [16] yield equivalent elastic thicknesses ranging approximately from 29 km to 40 km. The observed ones [27–30] are comprised between 2.5 km to 15 km. Such a discrepancy cannot be explained assuming errors in datations, therefore several explanations were proposed in order to explain why the lithosphere supporting the features of the Cook-Austral archipelagoes present a much smaller rigidity than the theoretical one. These low values of the equivalent elastic thickness were interpreted by Lambeck [29] as evidence for a viscoelastic behaviour of the lithosphere. But this thin equivalent elastic thickness has been interpreted with more confidence by Menard and McNutt [20] and also by Calmant and Cazenave [30] as the effect of thermal rejuvenation proposed before by Detrick and Crough [31]. Yet it is surprising to notice that the thinning of the mechanical lithosphere is much higher for the Cook-Austral chain (almost 20 km) than for the Hawaiian-Emperor chain (6–10 km only) [20]. Various explanations have been proposed. Calmant and Cazenave [30] point out that the Cook-Austral chain is located over a broad geoid high. This high may be associated with the small convection pattern [32] giving rise to an upwelling convection flow which causes the important thinning of the mechanical lithosphere. Yet as shown by fig. 13 of Calmant and Cazenave [30] which displays the residual geoid (e.g. geoid anomalies filtered out of the wavelengths longer than 4000 km), the Hawaiian chain is also located over a geoid high. Moreover, as shown by Renkin and Sandwell [33], the interpretation of residual geoid in terms of evidence for mantle convection can be due to an artefact of data processing. Menard and McNutt [20] proposed that the Cook-Austral region has been subjected to several repeated thermal rejuvenations and therefore the effective elastic thickness should be very low as compared to other areas which underwent a single thermal rejuvenation as Hawaii is supposed to. Menard and McNutt [20] assumed that the McDonald hot spot was activated by the passage of early Tertiary lineations, but until now there is no field data which really supports the assumption concerning these repeated thermal events.

Therefore it seems that, as postulated by various authors [7,17,20], the Cook-Austral chain is anomalous and it appears that neither the isotopic dates nor the bathymetric information constrain a self-consistent geodynamic model of evolution of this area. The altimetric data can be tentatively interpreted in order to explain the following points: (1) the non-monotonic increase of age along the chain; (2) the very low elastic thickness of the lithosphere supporting the chain; (3) the disturbed morphology of the Cook-Austral archipelago.

3. Detection and interpretation of new lithospheric features

3.1. The N150° lineament

Baudry et al. [7] assumed that the detected seamounts S3, S4, S5 and S7 (Fig. 1) lie on the extension of some bathymetric features located farther south. According to the existing maps [14] obtained with limited ship tracks, these bathymetric features form a discontinuous lineament oriented N150°. A continuous linear feature is present on the illumination map of the interpolated geoid of Sandwell [9, fig. 10a] or on the geotectonic image of Haxby [10]. One can notice that, on these maps, the N150° direction seems to stop south of 33°, and that a N110° lineament seems to extend the N150° trend to the southeast. Such a pattern closely resembles the Hawaiian-Emperor chain morphology. Fig. 2 displays all the available SEASAT tracks in the studied area. Since the direction of the descending tracks is about 296°,

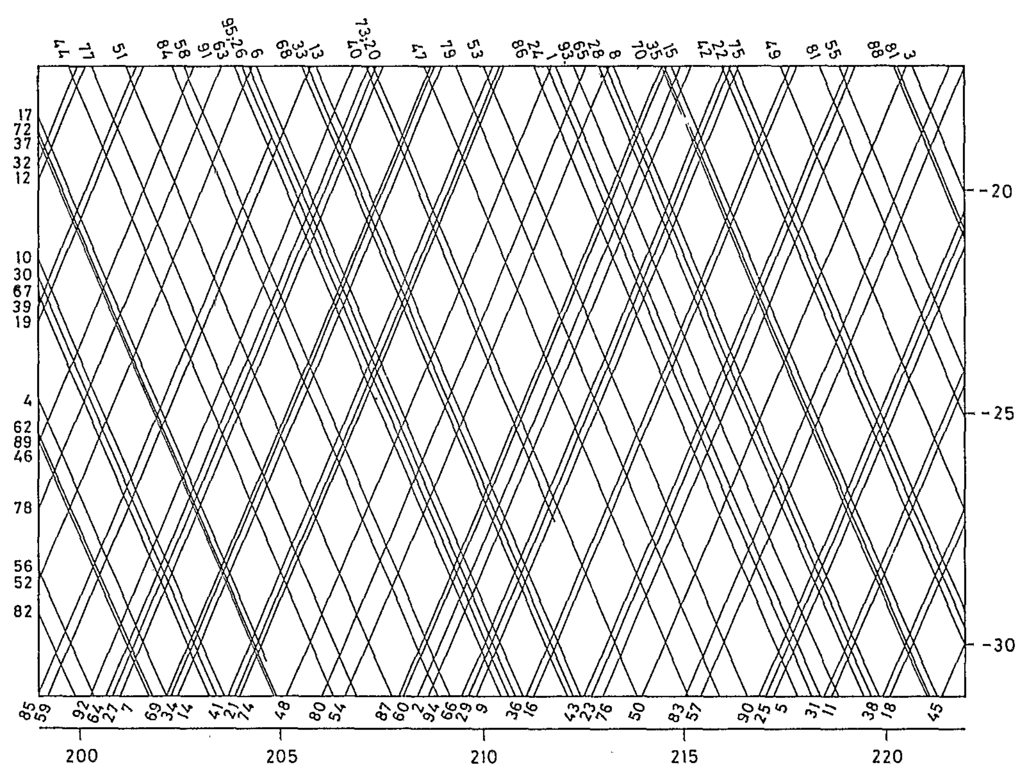

Fig. 2. Location of SEASAT-profiles available in the area under study.

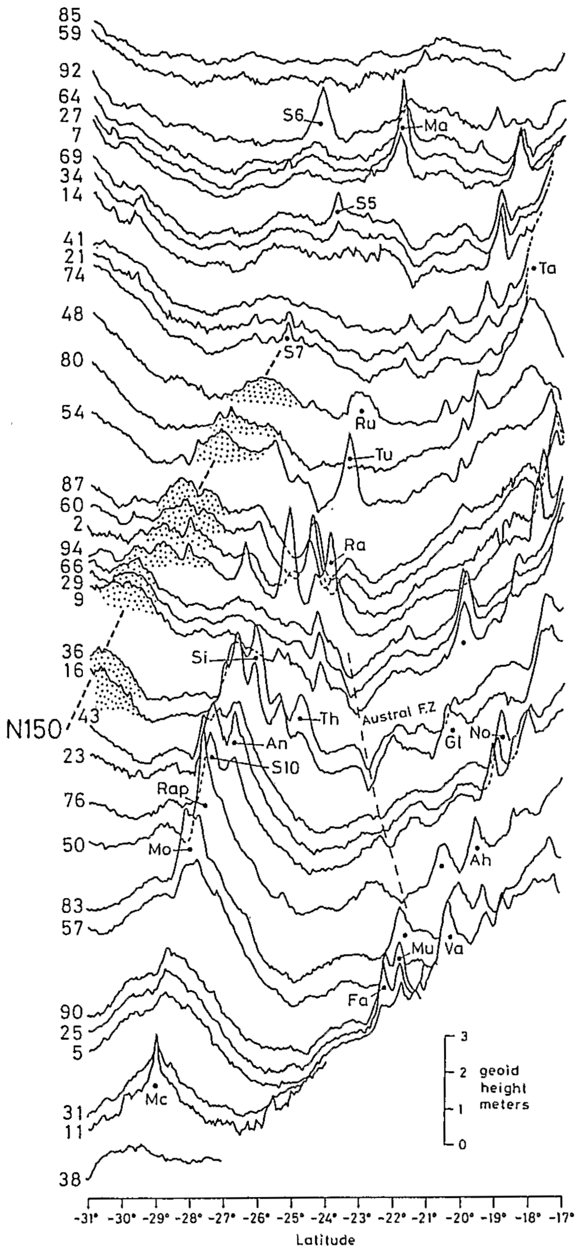

Fig. 3. Geoid heights along the descending SEASAT tracks. The long wavelengths as given by the first 12 harmonics of the GRIM 3B model being removed. *Ma* = Maria, *Ru* = Ruturu, *Tu* = Tubuai, *Ra* = Raivavae, *Th* = Thiers, *Si* = Simone, *An* = Annie, *Rap* = Rapa, *Mo* = Marotiri, *Gl* = Gloucester, *No* = Nogonego, *Ah* = Ahunni, *Va* = Vanavana, *Mu* = Mururoa, *Fa* = Fangataufa, *Ta* = Tahiti.

the signature of the N150° trend should be detectable. This is indeed the case (Fig. 3). The long-wavelength geoid has been filtered out by removing the regional field given by the first 12 harmonics of the GRIM 3B model [34] and the linear residual trend. The seamounts and islands of the volcanic chains give rise to significant geoid anomalies which are easily correlated with the bathymetric map (Fig. 1). The signature of the Austral fracture zone appears clearly northeast of the Austral chain. Southwest, the prolongation of the Austral fracture zone corresponds to a minimum which flattens west (see tracks 14–59). The N150° direction is clearly marked by a small bump which correlates on profiles 16–48. This is an evidence for the existence of a continuous feature. The amplitude and width of this anomaly are of about 1 m and 250 km, respectively. Northwest of profile 48 the signature softens and seems to diseappear after crossing the southern Austral chain. One can notice that, on the maps of Sandwell [9] or Haxby [10], the linear anomaly also disappears north of the southern Austral chain. Therefore, from the examination of SEASAT data, we can conclude that a feature giving rise to a continuous linear geoid anomaly exists south of the southern Austral chain. We interpret this linear geoid anomaly as the gravitational effect of a linear topographic bumping oriented N150°. Baudry et al. [7] also noticed that the seamounts and islands S10, Neilson, Havaiki, Simone, and Raivavae (see Fig. 1) form a lineation oriented N150°.

Two possible mechanisms can be advocated in order to explain the origin of these features. First, considering that the N150° direction is roughly parallel to the direction of identified magnetic anomalies (Fig. 1), we can assume that the N150° ridge is due to an abnormal functioning or a jump of the East Pacific Ridge. Such a mechanism has been proposed in order to explain the formation of some linear seamount chains in the Indian Ocean [35] or of the Line Islands chain [36]. But, for the Line Islands chain, this postulated mechanism was rejected by Schlanger et al. [37] on the basis of paleomagnetic and petrographic data.

If a ridge jump had occurred, the Austral fracture zone would show some reorientation which is not seen. In the pattern of magnetic anomalies there is no evidence (Fig. 1) that any sea floor was created at that ridge since the magnetic anomalies show a regular increase to the west. Yet, as previously noted, identification of magnetic anomalies

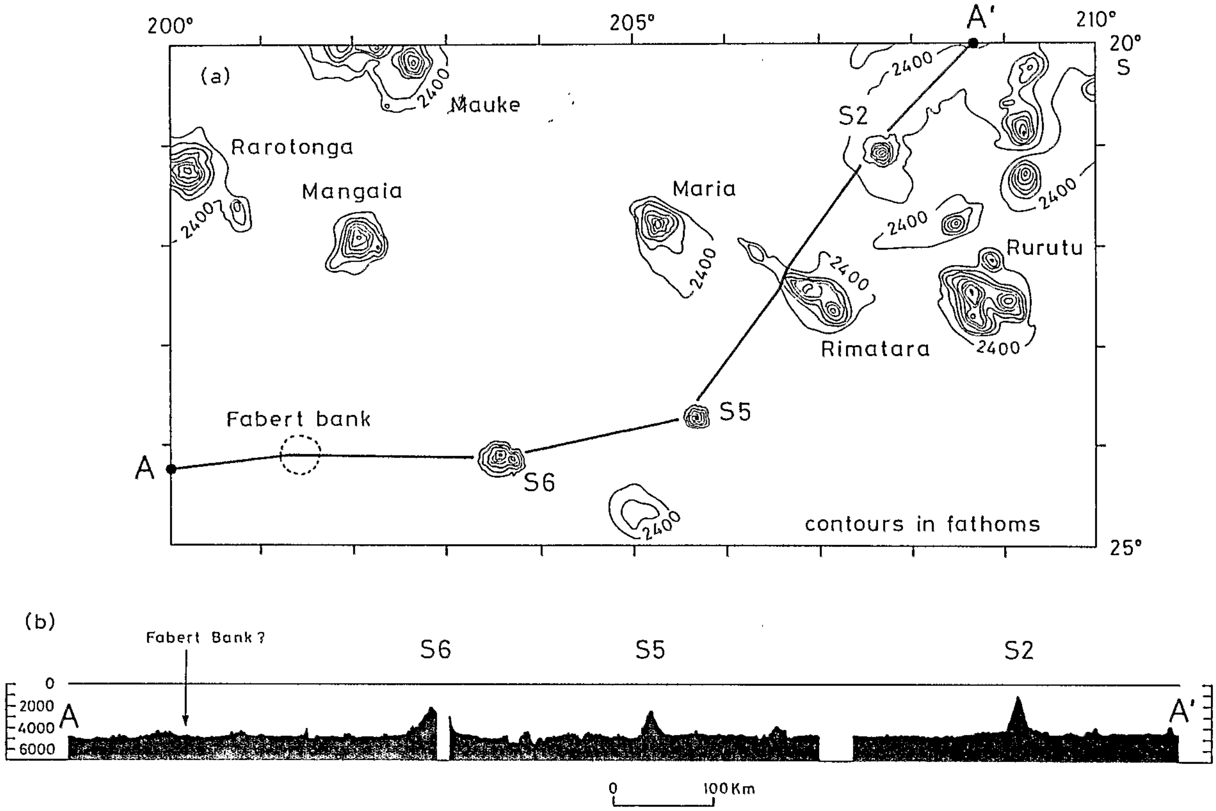

Fig. 4. (a) Route of the N/O "Jean Charcot" in the Austral archipelago. The real morphology of seamounts S6, S5 and S2 has been added to Mammerickx's chart. (b) Bathymetry obtained from the central beam of SEABEAM.

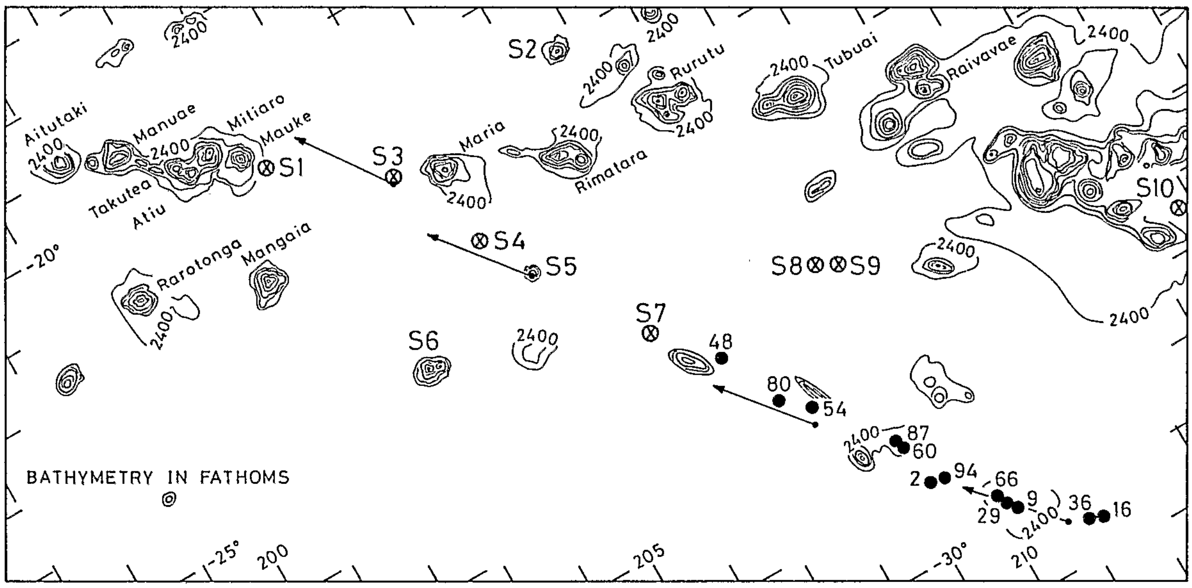

Fig. 5. Location of the N150° anomaly as observed on SEASAT data. Arrows correspond to the direction of the displacement of the Pacific plate over the hot spot reference frame as deduced from Clague and Jarrard's pole [39]. For the southern part there is a good agreement between the N150° ridge and the computed azimuth of the plate motion.

is poor in the area. The SEABEAM data gathered during the SEAPSO (Leg V) cruise of January 1986 [11,38] revealed the existence of several intriguing features in that region. Fig. 4a displays "Jean Charcot"'s route. The exact morphology of S6, S5 and S2 as deduced from the data gathered then has been added to Mammerickx's chart. As shown in Fig. 4b the sea-floor morphology given by the vertical beam is generally smooth except in the part between S6 and S5 where some grabens are present. SEABEAM data on this specific part reveal structural directions oriented from N155° to N170° i.e. parallel to the magnetic anomalies. The morphology of these structural lineaments consists of important normal faults bordering grabens. The sea floor is displaced vertically by more than 500 m. A very low gravity anomaly is observed over these features, due to the fact that short wavelengths of gravity anomalies are filtered out due to the depth of the ocean floor. We interpret these scarps as normal faults which were created during the accretion. Since there is no apparent connection between these scarps and the N150° anomaly, we suggest that the N150° ridge is not the result of a ridge jump.

Another hypothesis can be invoked in order to explain the origin of the N150° direction: the N150° ridge is the trace of a hot spot which may have been active during Late Cretaceous to Eocene. The ridge should be then copolar with the linear chains emplaced at the same time: the Emperor seamount chain, the Tuamotu archipelago and the Louisville ridge [17]. Using data on these three chains, Clague and Jarrard [39] computed a rotation pole of the Pacific plate which holds from 42–44 to 67–70 m.y. and is located 17° N, 107° W. Using this pole, we computed the amplitude and azimuth of the displacement rate for various points of the N150° anomaly. Results are summarized in Fig. 5 where black dots correspond to the maximum of the anomaly as detected on SEASAT tracks. For the southern points, there is a perfect agreement between the computed azimuth and the detected anomaly. Only at the northern point, there is a discrepancy of about 10°. Thus, it appears that the agreement between the computed azimuth and the N150° direction is good. From this result, combined with the various evidence against the ridge jump origin for the N150° direction, we deduce a hot spot origin for the detected ridge. The total length of the ridge as detected on SEASAT tracks and the value of the computed displacement rate yield an emplacement time of about 15 m.y.

It is also noteworthy that the N150° lineament is very close to the trace of the Pacific-Farallon-Aluk triple junction as given by Cande et al. [40] although being located slightly northeast to the trace of the triple junction. Such a coincidence is probably not fortuitous but we do not believe that the N150° ridge corresponds to the triple junction trace. Indeed the width of the bathymetric signature of a triple junction trace were known, as for example in the Indian Ocean, is always more narrow than the one of the N150° lineament (see Fig. 3) (J. Ségoufin, personal communication). Moreover, as previously mentioned, careful examination of geoid and geotectonics maps [9,10] shows that the N150° lineament stops south of 33° but that another lineament oriented N110° seems to extend to the southeast. Obvously, in order to study the possible interaction between the N150° lineament and the triple junction trace, it will be necessary to record other marine geophysical data.

3.2. Geodynamic implications

The main criticism against the hot spot interpretation is the apparent lack of superficial volcanic activity giving rise to seamounts or islands, at least south of S7. The question whether the seamounts located on the N150° trend (S7, S5, S4 and S3) were emplaced by our postulated hot spot or contemporarily with the Austral chain is still open. Again, more data are required to answer this question. In case these seamounts were created due to the activity of the "present" Austral hot spot, then no superficial volcanic activity apparently accompanies the N150° trend. This explanation was proposed by Thiessen et al. [41] who argued that non-volcanic continental topographic domes may represent hot spots whose magma has not reached the surface. Duncan and Clague [42] also postulated that many lineaments whose existence is due to Late Cretaceous to Early Tertiary volcanic activity are still unsurveyed in many oceanic areas. Menard and McNutt [20] have also suggested that the N150° lineation going through President Thiers Bank is the superficial expression of a hot spot active at the same time as the Emperor hot spot.

Our hypothesis explains the unusual observations in the Austral archipelago mentioned in section 2. Indeed it appears that the Austral archipelago has been emplaced during late Eocene by a hot spot presently located under MacDonald volcano, on a lithosphere previously affected by a major late Cretaceous thermal event as postulated by Menard and McNutt [20]. The lithosphere was abnormally thinned and probably fractured when it passed over the hot spot. Therefore. Eocene volcanoes could have been emplaced in a broad area and not on a single line as it is required in the framework of the hot spot model [19].

As concerns the low elastic thickness found for the lithosphere beneath the Cook-Austral archipelago, we can now confirm that this thinning is mainly due to the reheating of the lithosphere by the Createaceous hot spot. Therefore, this is a different mechanism from that observed over Hawaii [43,44] where the reheating of the lithosphere appears to be only due to an effect of the hot spot creating the chain .

This geodynamic evolution of the Cook-Austral archipelago can be compared to the one of the Line Islands archipelago. The Line Islands consist of a main linear chain oriented NNE-SSE, copolar to the Emperor and Louisville chains. Some linear trends intersect the chain, such as the Cross Line seamount chain. These linear trends which are visible on the geotectonic map of Haxby [10] have been interpreted by Schlanger et al. [37] as traces of hot spots intersecting the main chain. Similarly to the Cook-Austral chain area, slightly low equivalent elastic thickness was found in the Line Islands chain [45]. Therefore, the geodynamic evolution of the Line Islands area can be modelled identically to the Cook-Austral one, except that the chronology is reversed. The Line Islands were emplaced during Cretaceous on a young lithosphere, later on the main chain was crossed by the traces of several hot spots copolar with the Hawaiian and Cook-Austral chains. This explains satisfactorily the very disturbed distribution of volcanism along the chain [37].

3.3. Other trends

Examination of geoid and geotectonic maps in the area [9,10] reveals the probable existence of other lineament trends. In order to investigate these possible trends we analysed the SEASAT data in the southwestern part of the studied area, i.e. in the area where a priori the signature of the Austral archipelago would not dominate the geoid and thus makes any interpretation difficult. It appears that some ascending and descending SEASAT tracks located in that area show some steplike geoid anomalies. These anomalies are shown on the profiles with arrows (Fig. 6). One can notice that on the other tracks of the area

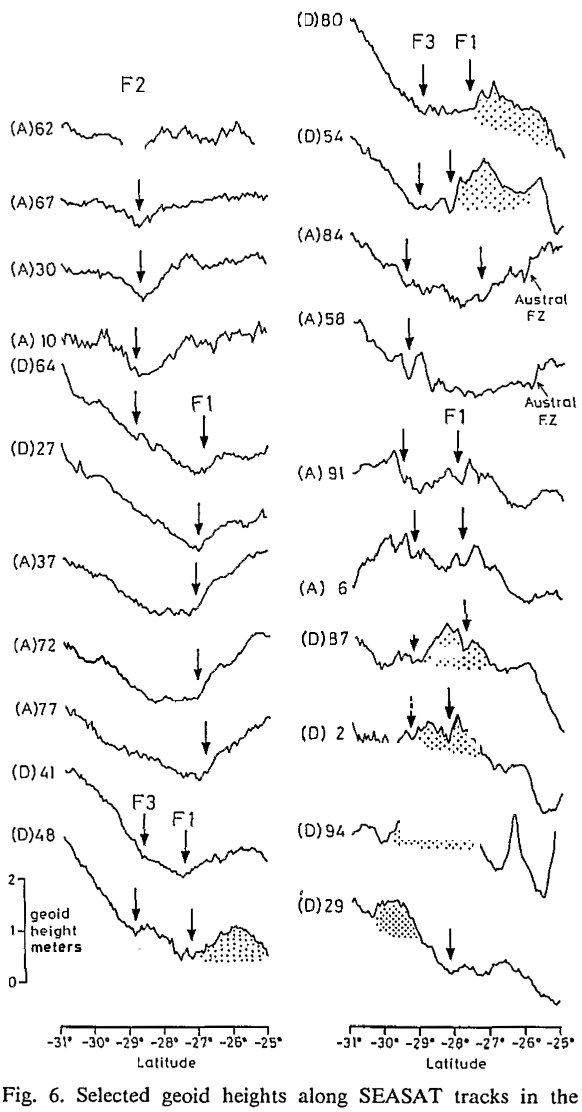

Fig. 6. Selected geoid heights along SEASAT tracks in the southwestern part of the studied area. Arrows show the location of fracture like anomalies detected. Dots correspond to the N150° ridge.

(Fig. 2) no anomaly was detected. From these profiles, only the longest wavelengths given by the first 10 harmonics of the GRIM 3B model [35] and the residual linear trend were removed. Therefore all short and intermediate wavelength information, i.e. shorter than about 4000 km, are shown. The anomalies generally correlate from one profile to another and therefore form more or less continuous features hereafter referred to as F1, F2 and F3. Dots on the descending profiles correspond to the N150° ridge. The geoidal signature of the Austral fracture zone is visible on profiles 58 and 84. F1 and F2 are clearly fracture zone-type signatures. Except on profile 58, F3 gives rise to a more tiny signature, yet of fracture zone type also. The locations of these features are also shown in Fig. 7.

Fig. 7 shows that the detected anomalies form a lineament pattern with an N95° orientation. Such a pattern closely resembles a transform fault geometry which generally consists in many stepping fractures rather than a continuous uninterrupted feature. On profiles 27–77, the amplitude of the jump of the geoid anomaly across F1 is of about 0.8 m. If the contrasting thermal structure of the lithosphere from each side of the fracture is caused by a time offset, such a jump corresponds to an offset of about 5 m.y. The existence of some fracture zones trending N95° has been revealed earlier by Sailor and Okal [4] and Okal and Cazenave [6] in a zone located east of the present study area. They found two parallel fracture zones: FZ1 and FZ2, located between 130°W and 120°W respectively at 22°S and 25°S. These fracture zones extend for about 400 km and 500 km respectively, therefore on a smaller length than

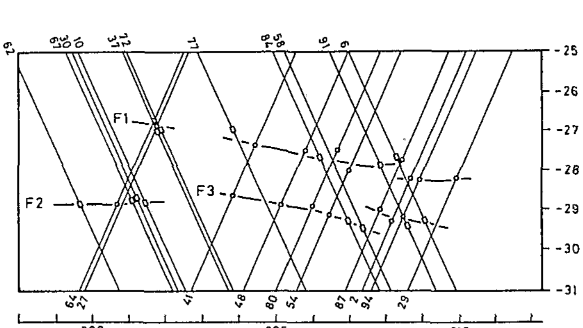

Fig. 7. Location of profiles shown in Fig. 6. The anomalies are represented on each track by circles (descending tracks) and squares (ascending tracks).

F1 or F3 do, and are apart from each other by about 400 km. The fracture zone FZ1 is located just south of an abnormal seismic zone [46]. Our result indicates that other lineaments, which can be also interpreted as faults similarly oriented, exist in the southwest. These structures extend linearly over a length longer than 1000 km.

3.4. Geodynamic implications

Since the azimuth of the linear features discovered by Okal and Cazenave [6] lies between the directions of the Austral fracture zone, absent in their studied area, and of major seamount lineaments oriented N110° (see [6, fig. 1, p. 100]); they assumed that this proves an intermediate regime during the 20 m.y. old reorientation of the East Pacific Rise. From the length of the discovered features interpreted as fracture zones, they also proposed that this regime lasted about 8 m.y. Our results demonstrate that the 95° direction revealed by Okal and Cazenave [6] is present on a much wider area of the South Central Pacific. Therefore another explanation must be proposed.

In the framework of plate tectonics, it is impossible to have at the same place two directions of fossil transform fault cutting each other. This is indeed the case in our studied area where the Austral fracture zone and the N95° oriented linear features are present. Therefore, we propose that the N95° direction must be interpreted as a fault trace whose origin is not a transform fault. Some intraplate deformation might be supposed in order to explain the origin of these faults.

A discrepancy between paleomagnetic pole position computed using data from seamounts and DSDP cores in the North Pacific and from Chatham Islands in the southern part of the Pacific plate has been interpreted by Suarez and Molnar [47] and Gordon and Cox [48] as an indication of some differential movement between the northern and southern parts of the Pacific plate since the Cretaceous. These authors suggest that the Pacific plate was composed of two or more plates between about 80 and 40 m.y. ago and that relative motion has taken place between the postulated North and South Pacific plates along a boundary located along or parallel the Eltanin fracture zone system [47] or along the Louisville Ridge or older portions of the Udintsev fracture zone [48]. More recently, Stock and Molnar [49] preferred to assume that some deformation took place between Late Cretaceous and Late Eocene time in the Antarctic plate rather than in the Pacific plate. However, since the linear features interpreted as faults and oriented N95° also affect a much younger lithosphere [6], one can grant that these linear features are a consequence of a recent differential movement between the north and the south parts of the Pacific plate.

Apart from the mentioned possible late Cretaceous differential movement between the North and South Pacific, evidence for a late Miocene-Pliocene change in the absolute motion of the Pacific plate was given by various authors ([50,51]; Vanpe, personal communication). Such a change in the direction of the absolute motion of the Pacific plate is very likely associated with internal deformation. But there is no evidence that such internal deformation would give rise to a long linear fault system.

Other remarks have to be made. First, as mentioned by Okal and Cazenave [6], fracture zones FZ1 and FZ2 are close to the Easter microplate and so there might be some relationship between the microplate and the fracture zone system. Also the existence of these long linear features could be associated with the proposed hot line [21,24] extending from the Tonga trench to the Peru-Chile trench across the Easter microplate. Then it can be also noticed that the Chile Ridge [52] has an orientation close to the one of the discovered linear features, such a coincidence might not be fortuitous.

Therefore it is difficult to correlate the existence of the N95° trend to any known tectonic event. Clearly, the SEASAT data have revealed here some intriguing intra-plate features but their origin cannot be really addressed using only these data. It would be indeed necessary to record more marine data on these features.

4. Summary and conclusions

The interpretation of SEASAT geoid anomalies in connection with SEABEAM data in a zone of the South Central Pacific (17–31°S, 199–222°E) has revealed or confirmed the existence of distinct structural trends (Fig. 8):

(1) The N110° direction corresponds to the present absolute motion of the Pacific plate and is formed by volcanic chains. The Cook-Austral archipelagoes appear to be formed of two distinct and parallel seamounts chains.

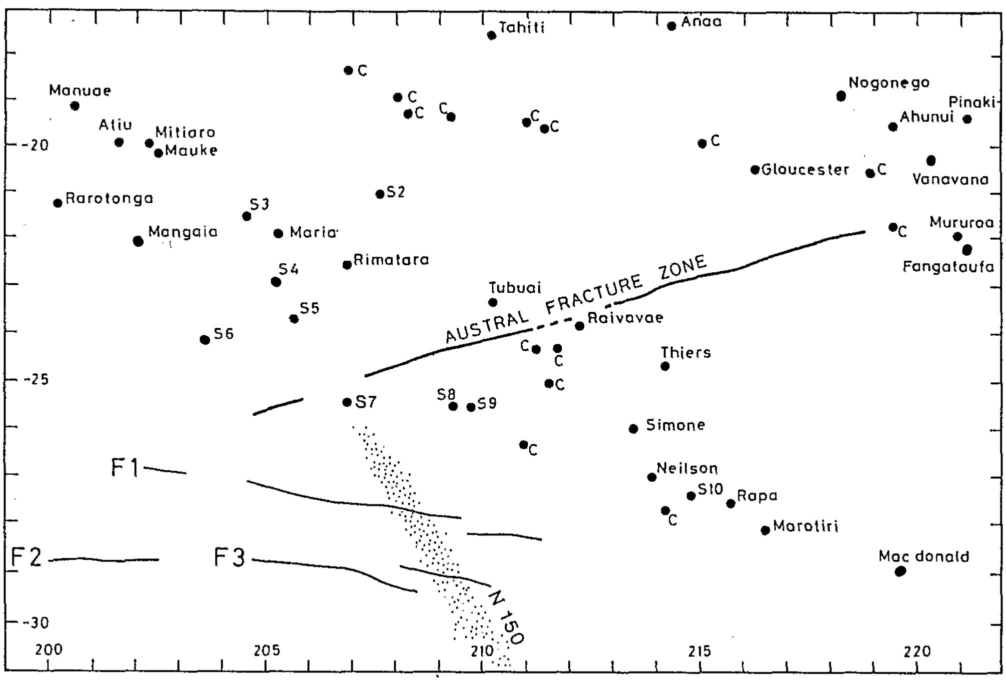

Fig. 8. Structural directions in the area as revealed from this study (see text). Dots represent seamounts and islands. *C* correspond to unnamed seamounts charted by various authors.

(2) The N70° direction, formed by the Austral fracture zone.

(3) A N150° direction, distinct from the N160°–N175° orientation of the magnetic anomalies, interpreted as the trace of a Late Cretaceous or Early Cenozoic hot spot.

(4) The SEASAT data reveal the existence of a N95° lineaments system, interpreted as faults. This shows that the linear features previously discovered by Sailor and Okal [4] and Okal and Cazenave [6] and interpreted as fracture zones extend farther west.

We have derived a scenario for the emplacement of the Autral archipelago which probably also holds for the Line Islands chain. The volcanoes belonging to the Austral archipelago were emplaced by a hot spot presently located at MacDonald; the lithosphere in that area was previously heated by a former hot spot. This hypothesis, put forward by Menard and McNutt [20], explains the various observations made in this area which are specific to the Austral archipelago and not to other volcanic chains presumably created by the action of a hot spot. It explains well the low equivalent elastic thickness found there and it is not necessary to invoke a viscoelastic relaxation of the lithosphere.

The existence of faults with a direction apparently incompatible with the plate movement has been interpreted as a possible consequence of a recent intraplate deformation, but there is no clear relationship between such a deformation and the detected features.

Finally, this study confirms that the short-wavelength geoid anomalies provided by satellite altimeter are a very powerful tool for geodynamic studies, and that they can be used in order to prepare future marine geophysical cruises.

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