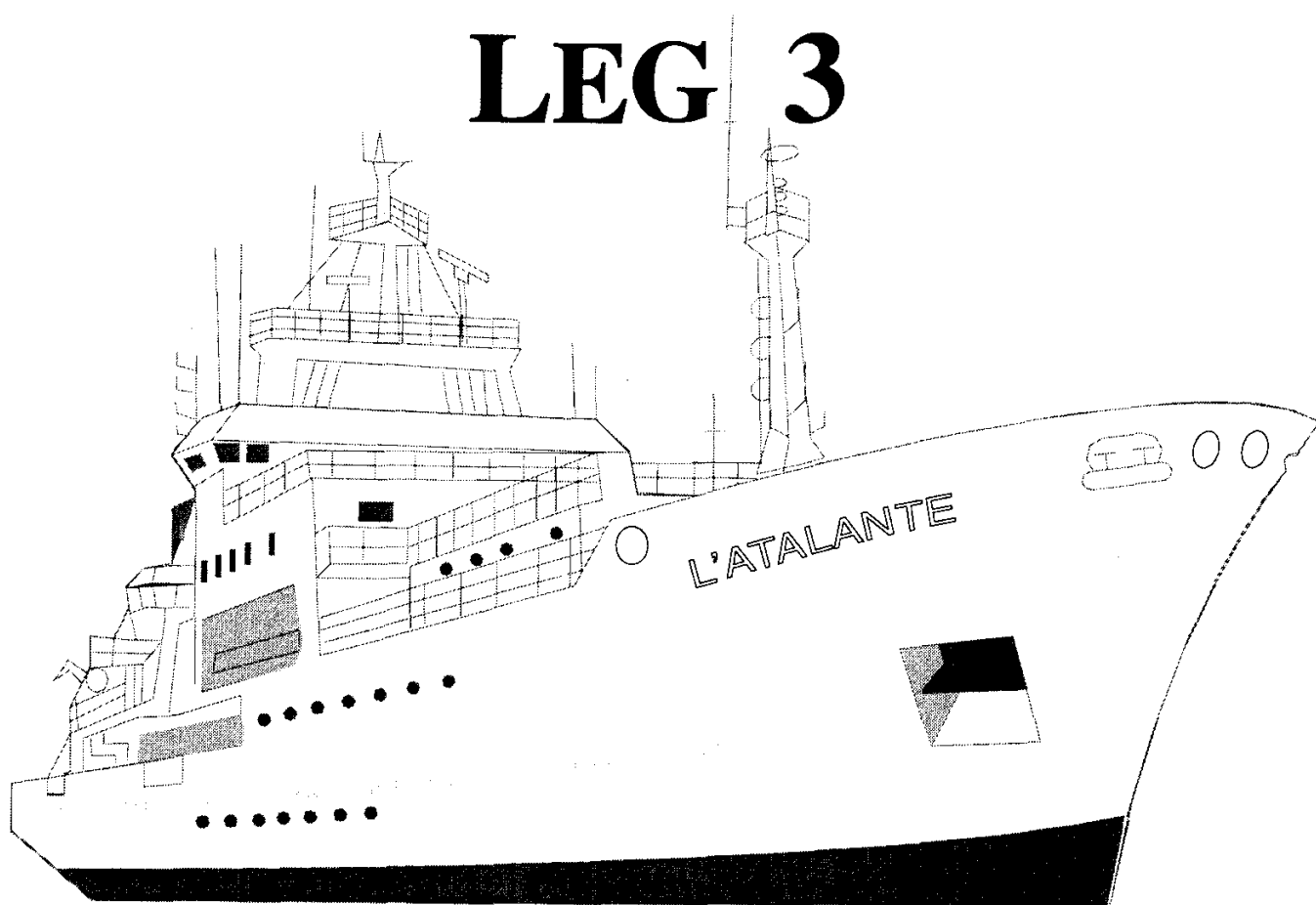


# SOPACMAPS PROJECT

## PRELIMINARY REPORT

### LEG 3



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<p style="text-align: center;"><b>CHAPTER 1</b></p> <p style="text-align: center;"><b>SOPACMAPS PROJECT PRESENTATION</b></p>
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A contract for the SOPAC (SOuth Pacific Applied geosciences Commission) swath mapping project funded by the EEC (Lome III - European Development Fund n° 6) known as SOPACMAPS, has been awarded to IFREMER (Institut Français de Recherche pour l'Exploitation de la MER), the French government research organization that operates the new high-tech oceanographical research vessel : *L'Atalante*.

The tender process saw six bids received for the work. Of these, three bids stood out. EEC procedures rules one of these ineligible narrowing the final selection down to two. IFREMER's bid was found to be the most technically competent and was recommended by SOPAC and accepted by the EEC.

The 85-meter R/V "*L'Atalante*," launched in 1990, was built specifically for swath mapping surveys and carries a dual Simrad EM12 multibeam bathymetric system.

The dual EM12 system produces 160 cross-track beams of 1° angle which radiate from hull mounted transducers. These provide depths over a swath of up to 5 times the water depth. The ship surveys at a speed of 10 knots, more under the right conditions. An associated acoustic side-scan imagery is obtained in the same time.

The final purpose of the SOPAC seabed swath mapping project is to gain an accurate and reliable assessment of the potential living and non-living resources of selected areas of the ocean floor within the E.E.Z.'s of Fiji, Solomon Islands, Tuvalu and Vanuatu.

In order to produce the complete scientific study with interpretative maps and geological reports, acoustic side scan imagery and multi-beam bathymetric profiles of the seafloor are needed, along with high resolution 3.5 khz sub-bottom profiles, single channel seismic reflection, gravity and magnetic data. These data and images had to be fully processed and co-registered on mosaics.

The schedule of the cruises is :

- \* **Leg 1** - 19 July in Noumea (New Caledonia) to 15 August 1993 in Honiara (Solomon Islands),
- \* **Leg 2** - 19 August in Honiara (Solomon Islands) to 16 September 1993 in Suva (Fiji),
- \* **Leg 3** - 22 September in Suva (Fiji) to 20 October 1993 in Noumea (New Caledonia) (Fig. 1).

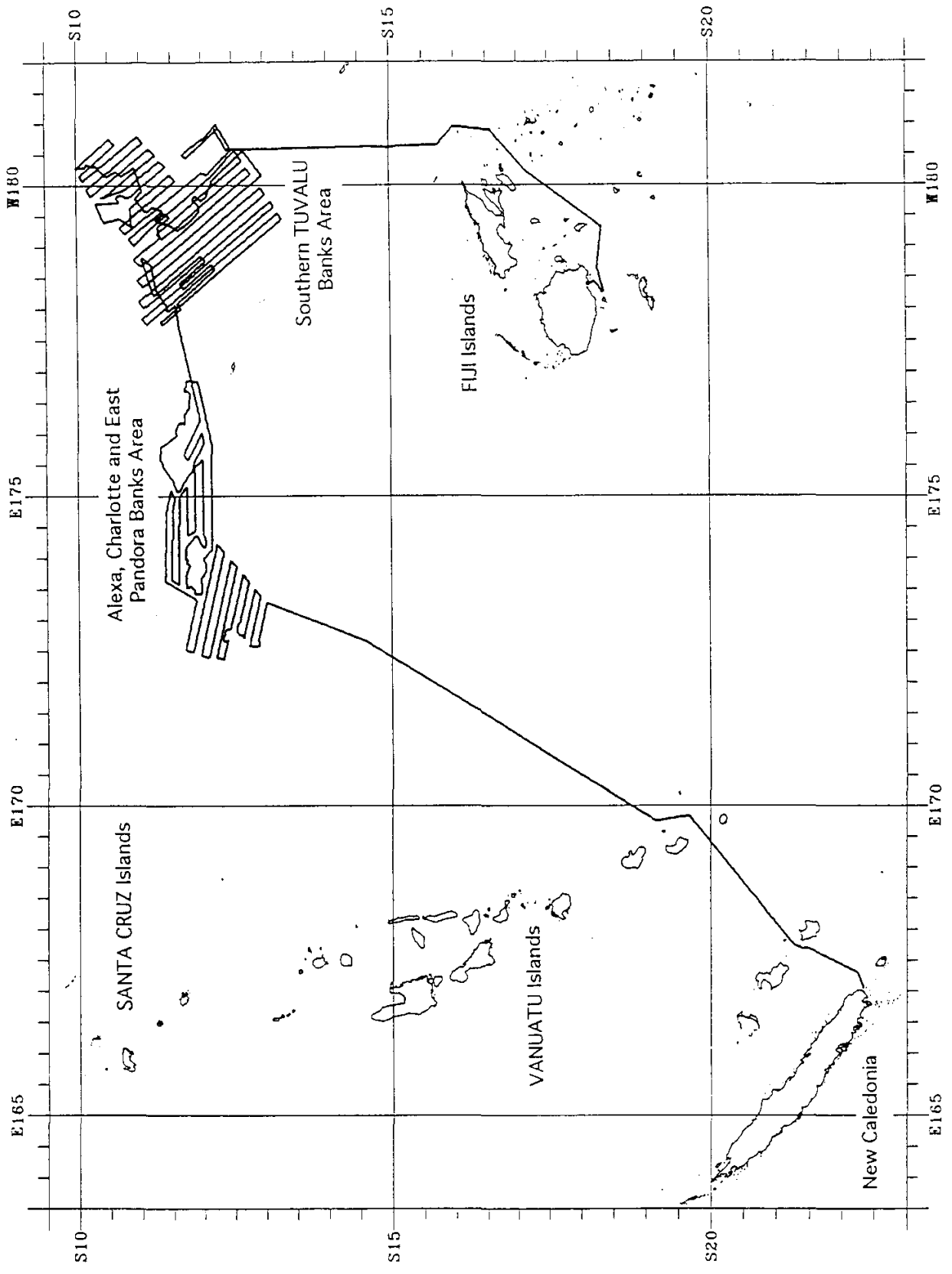


Fig. 1 - General navigation map of SOPACMAPS - Leg 3

# CRUISE CHRONOLOGY

<p style="text-align: center;"><b>CHAPTER 2</b></p> <p style="text-align: center;"><b>CRUISE CHRONOLOGY</b></p>
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**21 September 1993**

Departure from Suva at 21:00 UT. Start of profiling (EM12, gravimetry and magnetism) off Suva Harbour, in order to complete the map obtained at the end of Leg 2.

Profiles PR193 and PR194.

Very good sea conditions.

**22 September**

The ship stops between 00:00 and 01:55 UT due to engine problems. End of profiling of Suva Harbour (profile PR195) and beginning of transit toward the Tuvalu Bank.

Profiles T6 to T9 between the Fiji Islands.

Very good sea conditions.

**23 September**

Continuing the transit. Profiles T10 and T11. Beginning of seismic profiling at 14:50 UT on profile T11. Beginning of mapping the Southern Tuvalu Banks area around Hera Bank at 19:20.

Profiles PR196 and PR197.

Moderate sea conditions.

**24 September**

Continuing the mapping of Southern Tuvalu Banks area : PR197 to PR202 around Bayonnaise Bank. The peaks with water depths of 31 m located west of Bayonnaise Bank and reported on the hydrographic chart have not been found.

Moderate sea conditions.

**25 September**

Mapping around Kosciusko-Niulakita-Martha Banks : profiles PR203 to PR210. The bank of 24 m reported in 1880, south of Rose Bank, has not been found. In contrast a shallow bank, east of Martha Bank, was found.

Good sea conditions.

**26 September**

Mapping the area east and southeast of Kosciusko-Niulakita-Martha Banks. The banks at 25 m (1889), 18 m (1963) and 20 m (1977), east of the Martha Bank, have not been found.  
Profiles PR210 to PR215.  
Good sea conditions.

**27 September**

Continuing the profiles in the northeastern area of the Southern Tuvalu Banks. High bank is located near 10°13'S - 179°42'W.  
Profiles PR215 to PR219.

**28 September**

Stop of seismic reflexion acquisition from 02:30 to 17:00 UT and beginning of profiling in order to map the gaps between previous tracks, especially on the eastern banks and south of Rose Bank. End of mapping of the northeastern sector of the Southern Tuvalu box and beginning of mapping the part west of Bayonnaise Bank.  
Profiles PR219 to PR231.  
Good sea conditions in the morning beginning moderate in the afternoon.

**29 September**

Continuing of profiling west of the Bayonnaise Bank. The banks at 26 m, 40 m and 22 m reported on the hydrographic map, west of the Bayonnaise Bank, have not been found.  
Profiles PR231 - PR232.  
Bad sea conditions. Trade winds more than 30 knots.

**30 September**

Continuing profiles west of the Hera-Bayonnaise Bank.  
Profiles PR232 to PR234.  
Bad sea conditions, wind 30 knots and abundant rain.

**1 October**

Continuing mapping the volcanic edifices west of Hera Bank. Interprofiles in order to cover the gaps between previous profiles.  
Profiles PR234 to PR248.  
Bad sea conditions continuing, wind 30 knots and abundant rain.

**2 October**

Profiling west of Hera-Bayonnaise Bank.  
Profiles PR 249 to PR252.  
Bad sea conditions. wind 25-30 knots and rain.

**3 October**

Continuation of the Southern Tuvalu Banks survey, west of Bayonnaise Bank in the area of Alcarity and Eaglestone Ridges.  
Profiles PR2  
Moderate sea conditions

**4 October**

Continuation of the Southern Tuvalu Banks survey, in the area Eaglestone Ridge.  
Profiles PR255 - PR256.  
Moderate sea condition beginning bad at the end of the day.

**5 October**

Profiling on Eaglestone Ridge.  
Profiles PR256 - PR257.  
Bad sea conditions, wind 25-30 knots.

**6 October**

Continuation of survey around Eaglestone Ridge.  
Profiles PR258 - PR259.  
Sea conditions around wind 20-25 knots.

**7 October**

Profiling on Eaglestone Ridge to fill the gap between the previous profiles.  
Profiles PR259 to PR265.  
Moderate sea conditions.

**8 October**

Finishing the Southern Tuvalu Banks area.  
Transit to Alexa Bank.

**9 October**

Delimiting and mapping the flank of Alexa Bank. Beginning of Alexa Bank box at 02:00.  
Seismic and magnetic records stop at 03:00 UT.  
Profiles PR269 to PR273.  
Good sea conditions.

**10 October**

Finishing to delimit Alexa Bank. Seismic and magnetic records start at 13:00 UT.  
Profiles PR273 to PR278.  
Good sea conditions.

**11 October**

Transit to Charlotte Bank and delimiting and mapping the contour of Charlotte Bank.  
Seismic and magnetic records stop between 05:00 and 22:00 UT.  
Profiles PR278 to PR280.  
Good sea conditions.

**12 October**

Mapping the area between Charlotte and Alexa Banks.  
Profiles PR280 to PR284.  
Good sea conditions.

**13 October**

Mapping the area North of Charlotte Bank.  
Profiles PR284 to PR287.  
Moderate sea conditions at the beginning. Wind increases at the end of the day.

**14 October**

Finishing to map the area west of Charlotte Bank and mapping the area south of Charlotte Bank.  
Profiles PR287 to PR290.  
Rough sea conditions, wind 25 knots.

**15 October**

Mapping the area east of Pandora Bank.  
Profiles PR290 to PR292.  
Moderate sea conditions, wind 25 knots.

**16 October**

Continuing to map the area east of Pandora Bank.  
Profiles PR292 to PR295

**17 October**

Finishing the area east of Pandora Bank and beginning at 12:00 UT the transit to Noumea.  
Profiles PR295 to PR297 and T12

**18 to 20 October**

Transit to Noumea trough the North Fiji Basin and the New Hebrides Trench.  
Profiles T13 to T16.  
Arrival in Noumea at 21:00 local time.

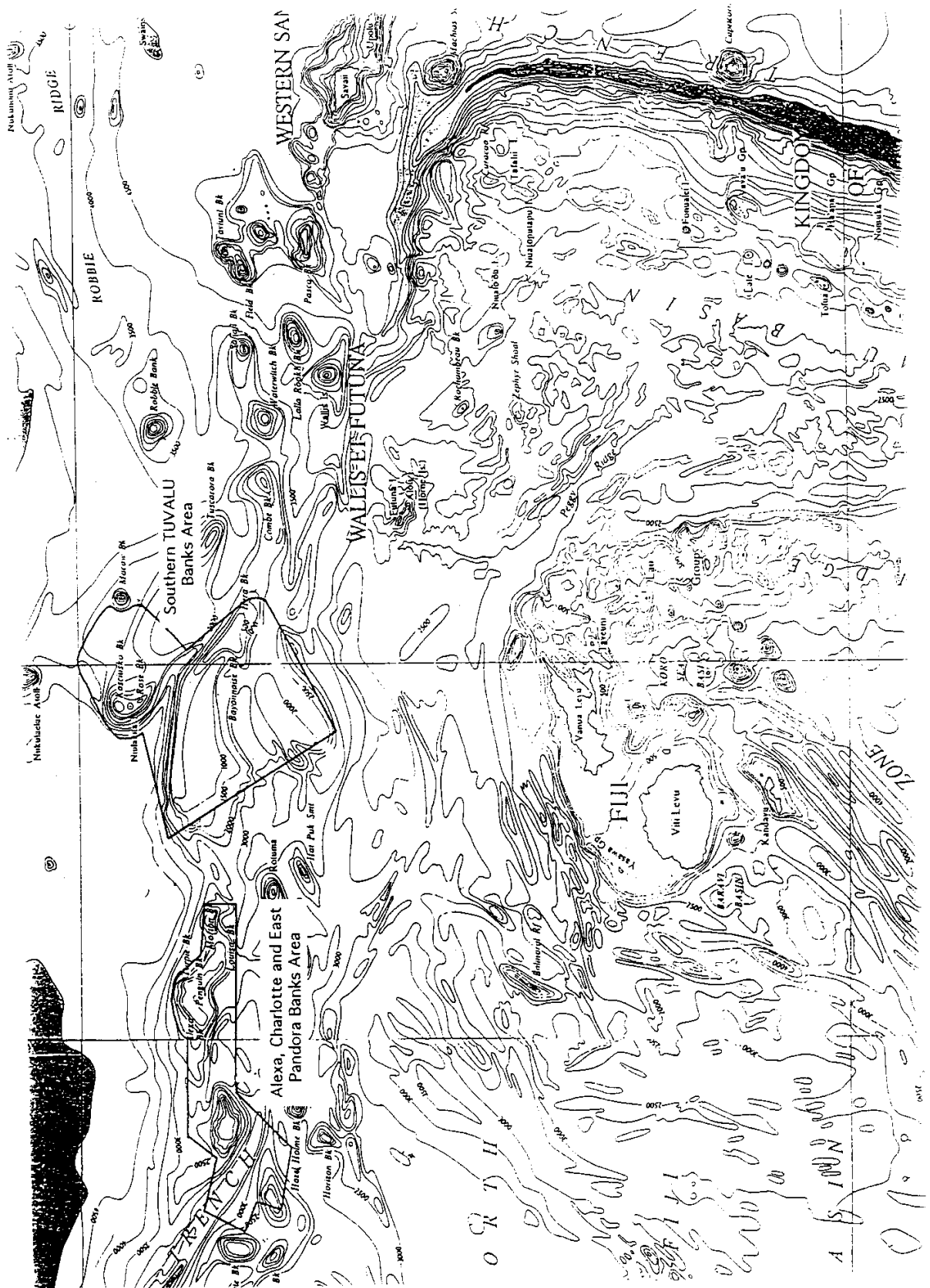


Fig. 2 - Location of the studied areas

# **GEOLOGICAL FRAMEWORK**

## CHAPTER 3

### GEOLOGICAL FRAMEWORK

#### 3.1 - TECTONIC SETTING OF THE SOUTHWEST PACIFIC

In the southwest Pacific, the part of the Pacific-Australian Plate Boundary is marked by a broad and complex zone of interplate deformation (Fig. 3). Plate convergence occurs along two subduction zones with opposite polarity, the Tonga Trench in the east where the Pacific Plate is subducting westward beneath the Tonga Arc and the New Hebrides Trench in the west where the Australian Plate is consumed below the New Hebrides Arc. Between these two subduction zones, back-arc extension, spreading and transform motions take place in the Lau and North Fiji Basin which are marked by high heat flow, thin and recent oceanic crust, low seismic velocities, high seismic attenuation, diffuse seismic activity, and complicated series of spreading centres and transform faults. Between these two active back-arc basins lie the Fiji Platform and the Lau Ridge (Fig. 4) which are both remanant arc active from the upper Eocene to the Pliocene. Outward migration of the Tonga and New Hebrides Arc was accompanied by opening of the North Fiji and Lau Basins. The two subduction zones are now connected by large transform faults: the Fiji Fracture Zone, which runs north of the Fiji Platform from the northern tip of the Tonga Trench to the central spreading segment of the North Fiji Basin; and a fracture zone between the southern part of the central spreading centre of the North Fiji Basin and the southern New Hebrides Trench. The Vityaz Trench Lineament, north of the North Fiji and Lau Basins, marks the boundary between the young cenozoique lithosphere in the south and the older Cretaceous Pacific crust in the north. North of the Vityaz Trench lies the Melanesian Border Plateau, a volcanic belt of seamounts, ridges and islands that extends toward the WNW over more 1,500 km from the Samoan Islands. This cruise is devoted to the study of western part of the Melanesian Border Plateau.

#### 3.2 - THE NORTH FIJI BASIN

The North Fiji Basin (NFB) is a deep triangular basin comprised between the New Hebrides Arc to the west, the Fiji Platform to the east, the Vityaz Fossil Subduction Zone to the north and the Matthew-Hunter arcuated zone to the south. Different models of opening of the NFB have been proposed (Chase, 1971; Gill and Gorton, 1973; Falvey, 1975; Dubois *et al.*, 1977; Malahoff *et al.*, 1982a; Auzende *et al.*, 1988a; Pelletier *et al.*, 1993; Auzende *et al.*, submitted). Although these models vary, especially on the location of active spreading centres, they all consider that the opening of the basin is related to the rotation of the New Hebrides Arc and the Fiji Platform.

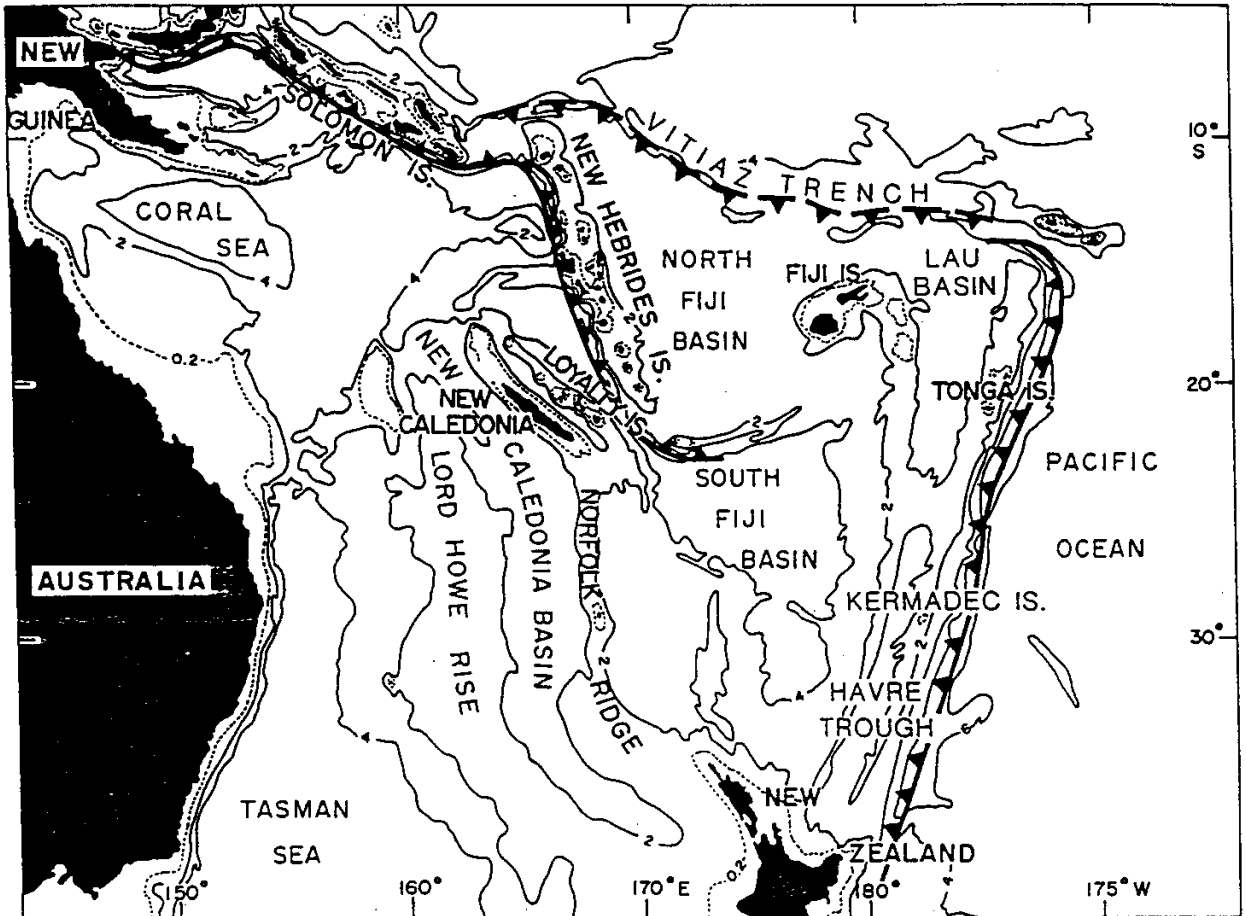


Fig. 3 - General tectonic setting of the Southwest Pacific  
(Bathymetric contour in km).



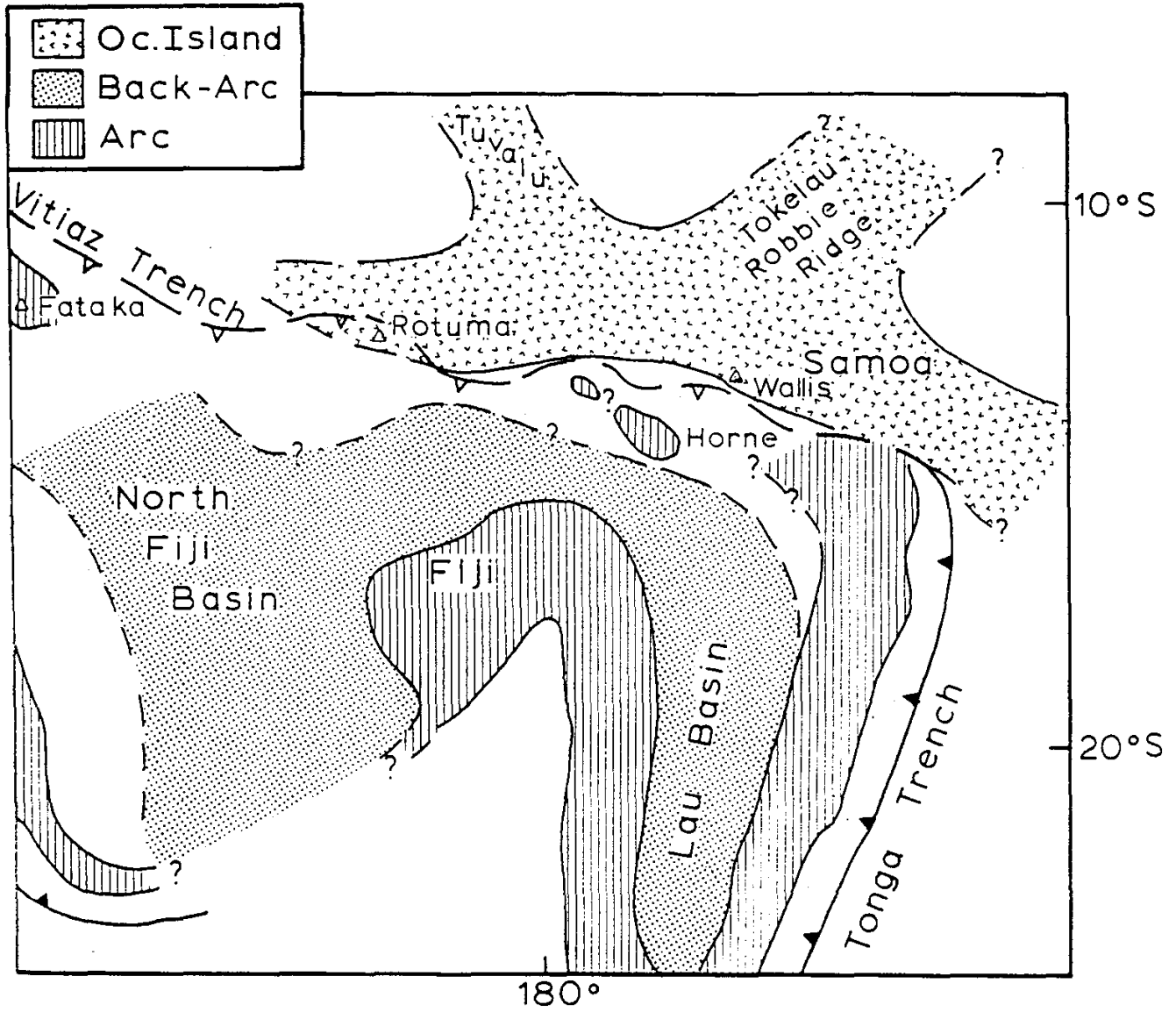


Fig. 5 - Map of the Vityaz Trench area with the petrologic provinces

Paleomagnetic results from Vanuatu and Viti Levu indicate a clockwise rotation of about 28° since 6 My of the New Hebrides Arc (Falvey, 1978) and a counterclockwise rotation of 21° since 4 My (James and Falvey, 1978) and of 90° since 7 my (Malahoff *et al.*, 1982b) of the Fiji Platform. Recent new paleomagnetic results indicate a total absolute rotation of the New Hebrides Arc of 50° ± 13° since the late Pliocene which is in better agreement with the opening geometry of the North Fiji Basin (Musgrave, submitted).

The southern and central part of the North Fiji Basin was intensively surveyed and are the best known part of the basin. Two active spreading ridges are functioning simultaneously on the southern part of the basin (Auzende *et al.*, 1993 and in press; Huchon *et al.*, in press). The main central axis, firstly evidenced by Chase (1971), Larue *et al.* (1982), Malahoff *et al.* (1982a) and Maillet *et al.* (1986), is now fully mapped by multibeam equipment from 22°S to 14°30'S (Auzende *et al.*, 1986 and 1990). Located around 173°30'-174°E, it includes four segments that trends 15°-10°E and is interpreted as a southward propagating rift (Auzende *et al.*, 1993). This axis, firstly postulated by Sclater and Menard (1967), Chase (1971), Brocher and Holmes (1985) and Louat and Pelletier (1989), trends 5°N-10°E and is interpreted as a southward propagating rift (Auzende *et al.*, 1993). This axis is bounded to the north by the western part of the Fiji Fracture Zone which connects the main spreading axis in the 16°50'S triple junction (Lafay *et al.*, 1987 and 1990).

Toward the north, the N160°E trending segment of the main spreading axis is connected with the sub E-W trending Hazel Holme Ridge (Pelletier *et al.*, 1993) and the south Pandora Ridge interpreted as a slow spreading centre (Price and Kroenke, 1991; Kroenke, 1991). A possible triple junction occurs at the northern end the main axis (Auzende *et al.*, in press).

The northwestern part of the basin, located north of 14°S has been recently surveyed and is interpreted to be the result of accretion along two fossil successive spreading centres trending first NW-SE then E-W (Pelletier *et al.*, 1998 and 1993a and b).

The overall structure of the northeastern part of the North Fiji Basin, east of 174°E and north of the Fiji Fracture Zone, is largely unknown. On the basis of an aeromagnetic survey over the whole area, Cherkis (1980) reported E-W trending magnetic lineations and proposed an active spreading centre located near 14°-14°30'S. The only area explored by surface ship is located north of Viti Levu Island and comprised between 176°30'E and 178°E and 13°30'S and 16°40'S (Halunen, 1979; Brocher, 1985; von Stackelberg *et al.*, 1985; von Stackelberg and von Rad, 1990). On the basis of sedimentary thickness and WNW-ESE magnetic lineations and bathymetric trends, these authors proposed a WNW-ESE inactive spreading centre at 14°30'S and 14°S.

The opening of the NBF can be divided into three major stages (Pelletier *et al.*, 1993; Auzende *et al.*, submitted):

- \* an opening in a NE-SW direction from 12 to 7 My,
- \* an opening in a NS direction from 7 to 3 My and,
- \* an opening in an EW direction from 3 My to the present day.

The triangular shape of the basin results from these three successive spreading phases. Since the beginning of the creation of the NFB, the location of the successive spreading centres migrates southward to accompany the migration of the New Hebrides Arc.

### 3.3 - THE FIJI PLATFORM, THE FIJI FRACTURE ZONE AND THE NORTHERN PART OF THE LAU BASIN

The Fiji Platform (Fig. 6) which supports the Fiji Islands corresponds to the northern end of the Lau Ridge. The crustal thickness in Fiji is about 15-20 km which is typical of island arcs (Hamburger *et al.*, 1990). The Fiji Islands are primarily composed of arc-related volcanic and intrusives rocks indicating a complex evolution into three periods (Rodda, 1967 and 1976; Gill, 1976 and 1984; Gill *et al.*, 1984; Rodda and Kroenke, 1984; Whellan *et al.*, 1985):

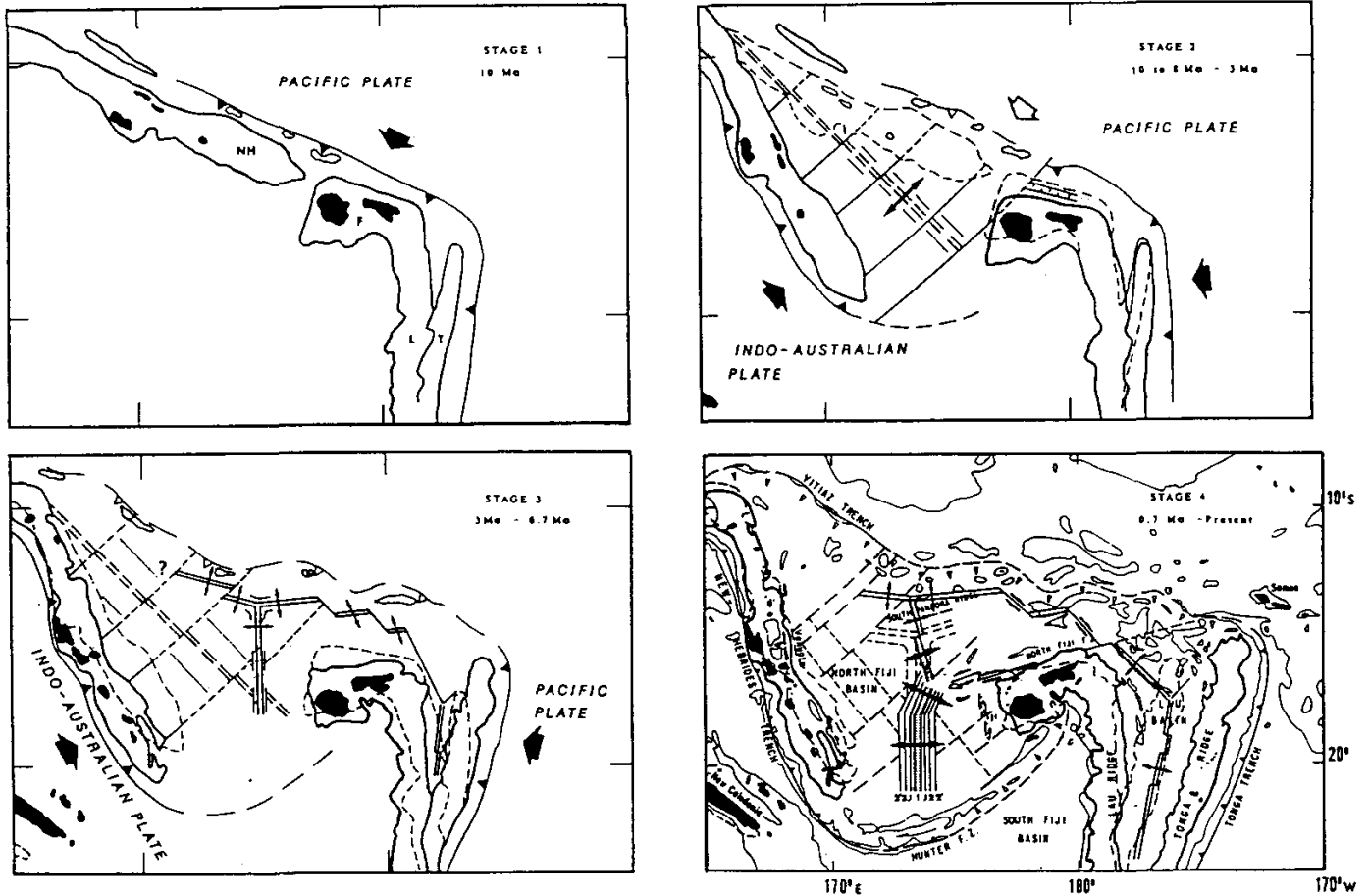
- \* a period of intra-oceanic island arc in the late Eocene to middle Miocene,
- \* a period of arc fragmentation in the late Miocene to middle Pliocene, and
- \* a period of back-arc deformation since the late Pliocene.

The first period is marked by upper Eocene-lower Oligocene dacite tuffs and Island arc tholeiites intruded by lower Oligocene tonalite. This Island arc tholeiite volcanism, which may extend in the early Miocene, is considered to be part of the Vityaz Arc that included the previously coalescent Lau-Tonga Arc, the Fiji Platform and the proto New Hebrides Arc before the late Miocene onset of opening of the north Fiji Basin and the Pliocene onset of opening of the Lau Basin. Island-arc tholeiitic eruptives and intrusives were emplaced in the middle-late Miocene from 13 My to 7 My (Whellan *et al.*, 1985) and were followed by calc-alkaline to shoshonitic series from 6 to 3 My. Late Pliocene-Pleistocene volcanism on Fiji was of two types and occurred in different tectonic settings. Shoshonitic and high-K calc-alkaline volcanism ranging in age from 3 to 1 My was erupted on the southern part of Fiji, on the Kandavu Ridge and is related to the subduction of the south Fiji Basin along the Hunter Fracture Zone. Alkalic volcanism in northern and eastern Fiji resulted from tensional rifting. This ocean island type of volcanism replaced at 3 My the subduction related volcanism (Gill *et al.*, 1984; Cole *et al.*, 1985).

The topography of the northern flank of the Fiji Platform is controlled by strike-slip and extensional deformation along the so-called Fiji Fracture Zone. This fault zone is underlined by an E-W trending broad seismic belt that extends westward from the northern end of the Tonga Trench to the central triple junction of the North Fiji Basin. Numerous strike-slip focal mechanisms along the entire length of the fault indicates E-W trending left-lateral strike-slip motion (Isacks *et al.*, 1969; Sykes *et al.*, 1969; Eguchi, 1984; Hamburger and Isacks, 1988; Hamburger *et al.*, 1988; Pelletier and Louat, 1989; Louat *et al.*, 1989; Hamburger *et al.*, 1990).

The northern flank of the Fiji Platform and the northern part of the Lau Basin have been recently imaged by GLORIA during a SOPAC Survey in 1989 (Tiffin, 1989; Clarke *et al.*, 1991; Parson and Tiffin, 1992; Jarvis *et al.*, in press). Two opposing senses strike-slip plate boundaries have been identified.

The left-lateral Fiji Fracture Zone bounds the northwest flank of the platform. It mainly exhibits E-W structural trends and is offset by at least two N-S to N45°E extensional relay zones. These pull-apart basins occurs at 177°25'E and 178°40'E. In the former previously reported by von Stackelberg *et al.* (1985), fresh MORB and BABB lavas with hydrothermal sulfide mineralizations have been recovered (von Stakelberg and von Rad, 1990; Johnson and Sinton, 1990).



**Fig. 6 - Sketch of evolution of North Fiji basin (see text for explanation).**

- Stage 1:** New Hebrides (NH), Vityaz, Fiji (F), Lau (L) and Tonga (T) ridges constitute arc above subducting Pacific plate.
- Stage 2:** Reversing of polarity of subduction under New Hebrides, clockwise rotation of New Hebrides arc, and first counterclockwise rotation of Fiji Islands.  
Large heavy black arrows indicate active subduction. White arrow indicates fossil subduction. Thin black arrows indicate active spreading.
- Stage 3:** End of New Hebrides and Fiji rotations. Beginning of north-south spreading in central north Fiji Basin and functioning of triple junction in northern part.
- Stage 4:** Recent rearrangements of axial spreading zone.  
Large dashed lines = flow lines of New Hebrides rotation. Thin dashed lines = magnetic lineations.  
1, J, 2 and 2' = identified magnetic anomalies. F. Z. = fracture zone.

The bathymetric highs located in the North Fiji Basin, north of the Fiji Fracture Zone, like the Braemar Ridge and the Balmoral Ridge and Reef further west, are interpreted by Jarvis *et al.* (in press) to be pieces of the Fiji Platform rifted away by successive spreading segments (pull-apart basins) during changes in the location of the North Fiji Fracture Zone.

One or possibly two dextral fracture zones bound the northeastern flank of the Fiji Platform. One is the NW-SE trending Peggy Ridge in the northwestern part of the Lau Basin. The Peggy Ridge is seismically very active and was interpreted either as active NW-SE spreading centre (Chase, 1971; Sclater, 1972; Auzende *et al.*, 1988), or as a NW-SE right-lateral strike-slip fault (Sclater *et al.*, 1972; Weissel, 1977; Eguchi, 1984), or as a transtensional feature (NW-SE dextral strike-slip motion and E-W extension: Louat and Pelletier, 1989; Parson, 1990) inducing a leaking aspect. Another dextral strike-slip fault zone runs west of the Peggy Ridge along the flank of the platform close to the Cikobia Island. The relationship between this faults zone and the Fiji Fracture Zone is unclear. A recent volcanic zone with NNW-SSE to NNE-WSW trending series of trough and ridge has been identified in the junction area, north of the Cikobia Island (Clarke *et al.*, 1991). However the Fiji Fracture Zone have to be traced north of this structure and south of the Futuna Island.

### 3.4 - THE VITYAZ TRENCH LINEAMENT

The Vityaz Trench Lineament bounds northward the North Fiji Basin and the northern end of the Lau Basin and separates them from the Pacific oceanic crust which is Jurassic to Cretaceous in age. The lineament consists of the Vityaz Trench and three discontinuous and elongated troughs, the Alexa, Rotuma and Horne Troughs, which connects the Vityaz Trench to the northern termination of the Tonga Trench (Brocher, 1985). The exact location of this lineament in its eastern part is still unclear. The Vityaz Trench Lineament is believed to be the site of former subduction of the Pacific Plate below the Australian Plate from the Eocene to late Miocene. At that time, the Vityaz Arc was a single continuous east-facing arc from Tonga to Solomon (Gill and Gorton, 1973; Falvey, 1975 and 1978; Coleman and Packham, 1976; Gill *et al.*, 1984). The cessation of the North Solomon and the Vityaz Subduction Zone is explained by the arrival at the trench of the Ontong Java Plateau and the Melanesian Border Plateau which induced a reversal of arc polarity and the inception south of the arc of the south Solomon and New Hebrides Trenches (Kroenke, 1972; Packham, 1973; Falvey, 1975). Although most of the authors agree with this model, the details of this arc reversal history is still unclear. Another explanation for the origin of the Vityaz Trench Lineament is to propose that this lineament was the site of transform motion between the Pacific and the Australian Plate (Fairbridge, 1961). The western (Vityaz Trench) and eastern (Alexa, Rotuma and Horne Troughs) parts of the Vityaz Trench Lineament have been partly surveyed by Pelletier *et al.* (1988 and 1993) and Brocher (1985) respectively.

The Vityaz Trench is a more than 600 km long well-marked depression from 8°30' at the northern tip of the North Fiji Basin to 12°S, north of Pandora Bank. The depth, which is mainly more than 4,500 m, reaches a maximum of 5,600 m. The trench is composed of NW-SE segments left laterally offset by E-W features. The trench floor is flat and is underlain by 0.2-0.3 s. thick sediments. The shape of the trench is almost symmetric and the water depths on each side of the

trench are quite similar. Between 167°E and 168°E the trench like morphology disappears and a volcanic edifice obstructs the trench. The northern wall of the trench is characterized by sedimentary cover, by southwest facing scarps which strike parallel to the trench, and by a rise elongated NW-SE rising to 3,200 m. The southern flank of the trench is in general steeper than the northern one. A narrow and discontinuous ridge parallels the different segments of the trench to the south. However, no large structure, which could be interpreted as a volcanic arc, lies along its southern flank especially north of 11°S. south of 11°S, large volcanic edifices adjacent to the trench can be regarded as piece of the fragmented Vityaz Arc.

Structure of Alexa, Rotuma and Horne Troughs lying along the eastern part of the Vityaz Trench Lineament which extends from 174°E to 176°W were mainly addressed by Brocher (1985). Alexa Trough (4,000 m deep) strikes WSW-ENE and lies south and west of the Alexa Bank and north of the Rotuma Island and Ridge. Rotuma Trough is a curved trough, composed of two parts. In its western part, it is narrow, 4,000 m deep and strikes NW-SE between Rotuma Island and Hat Puk Seamount to the west and the Alacrity and Eaglestone Ridges to the east. In the eastern part, the trough is deeper (4,800 m deep), more asymmetric and trends NE-SW between the Alacrity and Hera Banks to the north and the high in the south called the Haut-fond Rotumah and Mont Arabis on the hydrographic map and Manatu Seamount by Brocher (1985). The Horne Troughs (4,600 m deep) trends E-W and extends west of Wallis Islands and north of Horne Islands (Futuna and Alofi). On the basis of different evidences, Brocher (1985) proposed that the Vityaz Trench Lineament was first an active site of subduction of the Pacific Plate and then subjected to post-subduction translational deformation due to collision of seamounts of the western Samoan Chain. Where the segments of the trench lineament are less deformed and not narrowed or eliminated by collision with seamounts, the former subduction zone morphology and structure are preserved: the outer (northern) wall is sedimented and shows normal faulting, the inner (southern) wall is steeper and is generally flanked to the south by a structural high. However the eastern part of the trench lineament is, as the Vityaz Trough, characterized by lack of well defined forearc and magmatic arc south of it. Brocher (1985) proposed a progressive reversal of Vityaz subduction from west to east since the late Miocene and a cessation of the subduction around 3 My. This interpretation is based on oblique convergence between the Pacific and the northern tip of Tonga Trench, westwards thickening of post-collisional sequences filling the troughs, and post-Miocene island arc volcanism south of the lineament.

However, geochemical affinity and age of volcanism lying immediately south of the Vityaz Lineament are still not well known.

\* Quaternary alkalic volcanism is present on Rotuma Island (Sinton *et al.*, 1985; Woodhall, 1986;) and is correlated with active extension along the South Pandora Ridge on the North Fiji Basin (Sinton *et al.*, 1985) or local extension along the Vityaz Suture Zone during recent plate reorganization (Sinton *et al.*, 1985).

\* Volcanics of possible island arc-affinity (Sinton *et al.*, 1985) have been recovered from the Manatu Seamount and dated of latest Pliocene (1.8 My: Duncan, 1985).

\* Early Pliocene (5.4 My : Duncan, 1985) tholeiites with island arc affinity (Sinton *et al.*, 1985) have been recovered from the northern flank of the Horne Islands and are interpreted as the reflect of subduction along the Lau-Vityaz Trench (Sinton *et al.*, 1985). A petrological and

geological study of the Horne Islands (Grzesczyk *et al.*, 1987 and 1991) reported two Pliocene volcanic series capped by Quaternary reef limestones. The first volcanism corresponds to submarine tholeiite having an affinity close to that of the Lau Basin and of the orogenic volcanics from Fiji, Lau and Tonga Islands. This volcanism is dated as early Pliocene by micropaleontologic dating of the sediments associated with the lavas. The second volcanism overlying the tholeiitic lavas is composed of alkali-enriched tholeiites and transitional basalts of late Pliocene in age. This change in volcanism type in Horne Islands coincides with the change at 3 My in Fiji and Lau volcanism from subduction island arc tholeiites to alkali basalts reported by Gill *et al.* (1984) and Cole *et al.* (1985), and is correlated with a main plate reorganization in the termination of the north Tonga Trench from convergence (Vityaz - Tonga Subduction) to transform motion (North Fiji Fracture Zone) (Grzesczyk *et al.*, 1991).

### 3.5 - THE MELANESIAN BORDER PLATEAU

The Melanesian Border Plateau (Fairbridge and Stewart, 1960), also called the New Hebrides-Samoan Lineament (Hawkins, 1976) is a series of volcanic seamounts, ridges, banks and islands on the Pacific oceanic crust, which parallels northwards the Vityaz Trench Lineament from 173°30'E to the Samoan Islands (172°W). The absence of magnetic anomalies lineations on the Pacific crust north of the Vityaz Lineament and the presence further north of magnetic lineations identified as lower Cretaceous anomalies M1 (115 My) to M14 (130 My) suggest that the seafloor around the Melanesian Border Plateau was formed during the upper Cretaceous magnetic quiet zone (110 to 80 My: Schneibner *et al.*, 1991). Abundant altered tholeiitic basalt and gabbro, as well as in minor proportion alkalic basalt and hyaloclastites have been recovered on a fault scarp, northeast of Niulakita Island in deep water (3,400 - 4,000 m) (Sinton *et al.*, 1985). The tholeiitic basalt yields a Ar/Ar age of 82 My which is in agreement with the inferred age of the oceanic crust in the region (Duncan, 1985).

The origin of the volcanic highs along the Melanesian Border Plateau, still not well understood, is likely not unique and could be related to various plate tectonic processes. These highs can be divided into different groups which are aligned in different directions and may correspond to different magmatic provinces:

- 1 - The Samoan volcanic chain in the east,
- 2 - The Wallis Islands,
- 3 - The Tuvalu Chain in the northwest,
- 4 - The Robbie Ridge in the northeast,
- 5 - The Alexa-Charlotte Banks in the west.

These groups converge immediately north of the Vityaz Trench Lineament in the Southern Tuvalu Banks area on which this cruise is mainly focused.

The Samoan Volcanic Chain extends WNW-ESE and includes from west to east of the Samoan Islands, Field Bank, Lalla Rookh Bank and Combe Bank. Samoan Islands are composed of late Quaternary to historic post-erosional nephelinitic lavas which cover Pleistocene shield-building alkalic basalts and tholeiitic basalts (Stearns, 1944; Mac Donald, 1944; Hawkins and Natland, 1975; Natland, 1980; Natland and Turner, 1985). Rocks dredged from Field Bank, dated of 5.4 My by K-Ar and 4.2 by Ar/Ar methods (Duncan, 1985) and are strongly undersaturated lavas similar to the Samoan post-erosional magmatism (Sinton *et al.*, 1985). Rocks from Lalla Rookh Bank are late Miocene (10 My: Duncan, 1985) alkalic basalts and ankaramites (Sinton *et al.*, 1985, Johnson *et al.*, 1986) and are related to the transition from shield-building to post-erosional Samoan volcanism. The dredged rocks from Combe Bank are tholeiitic and alkalic basalts similar to the Samoan shield-building lavas (Sinton *et al.*, 1985). A picritic tholeiite, dated at 14 My, possibly represents the early phase of the shield-building magmatism at Combe Bank (Duncan, 1985). The geochemical character of the Samoan Island volcanism appear to extend westward to Combe Banks. Increase of age of this volcanism along the chain with a rate of  $7.7 \pm 2.5$  cm per year supports the idea that the Samoan Volcanic Chain has generated by hotspot (Hawkins and Natland, 1975; Natland, 1980) which is now 100 km east of Samoan Islands (Duncan, 1985). However post-erosional undersaturated lavas on the Samoan Volcanic Chain are though to be derived from peculiar deformation along the hinge fault at the northern Tonga Trench (Hawkins and Natland, 1975; Natland, 1980).

Wallis Islands located on the western part of the Samoan Volcanic Chain are composed of Quaternary (less than 0.5 My) tholeiitic and alkalic basaltic flows and pyroclastics (Sinton *et al.*, 1985; Duncan, 1985; Price *et al.*, 1991). Although these basalts are similar to shield lavas of the Samoan Islands, they are too young to be related to the Samoan hotspot. This volcanism is related, like the post-erosional volcanism of Samoa, to deformation along the transform plate boundary at the northern Tonga subduction zone (Price *et al.*, 1991)

The central seamounts of the Melanesian Border Plateau (Tuscarora, Hera, Bayonnaise, Kosciusko and Mac Caw Banks), although aligned along the Samoan Volcanic Chain, are also located in the southern prolongation of the NNW-ESE trending Marshall-Gilbert-Tuvalu Volcanic Chain, which is interpreted as a Cretaceous hotspot chain on the basis of its parallel direction with the Cretaceous segments of the Hawaii-Emperor and Louisville chains. Consequently, these seamounts could be the southernmost extension of Cretaceous hotspot chain or the western extension of the Samoan hotspot chain.

The Robbie Ridge trends ENE-WSW and also joins the Melanesian Border Plateau in its central part. Origin of the Robbie Ridge is unknown. Only limestones have been recovered from the Robbie Bank (Sinton *et al.*, 1985). Because the Robbie Ridge parallels the lower Cretaceous magnetic anomalies M1 to M14 identified further north, and the flexural response of the Pacific crust induced by the Robby Bank requires a thin lithosphereis, Watt *et al.* (1980) proposed that the Robbie Ridge formed on or close a spreading centre in the Cretaceous (Watt *et al.*, 1980). However on the basis of a more recent study of the flexural response of the Pacific crust around this bank, Robbie Bank is considered to be post-Cretaceous and to be possibly part of the Salmoan Seamount Chain (Brocher, 1980).

The western part of the Melanesian Border Plateau is composed by the Alacrity and Eaglestone Ridges and the Alexa and Charlotte Banks. The origin of these highs are unknown. Watt *et al.* (1980) proposed that Eaglestone Ridge and Alexa Bank formed off-axis after the Cretaceous. Basalts dredged along the Alexa Bank have tholeiitic to transitional alkalic affinity and are broadly similar to shield lavas from the Samoan Islands (Sinton *et al.*, 1985). However the Ar/Ar age of 36.9 Ma of a basalt is too old to be related to the Samoan hotspot volcanism (Duncan, 1985). Alexa Bank may formed onto Cretaceous Pacific seafloor during an Eocene mid-plate volcanism.

# **DATA ANALYSIS**

## CHAPTER 4

### DATA ANALYSIS

#### 4.1 - DATA ACQUISITION AND PROCESSING

##### 4.1.1 - Bathymetry

The R/V "L'Atalante" is equipped with the SIMRAD EM12 Dual system. This system is a low frequency (13 khz) multibeam echo sounder and provides accurate swath mapping capability to full ocean depths (11,000 m). Its typical vertical resolution is 0.25 % of water depth or 60 cm (whichever is greater).

The coverage sector of the EM12D (Dual) version is 150° with 162 beams, covering a maximum swath width of 7.4 times the water depth (see table below). Compared to the EM12S (Single), this gives an increase in swath width of approximately 10 km in the 3,000 m to 6,000 m depth range. In fact, the background noise depends on the sea state (sea state 4 gives an approximately 45 db noise level). In addition to the bathymetric sounding, the EM12D provides a set of energy measurements (bottom reflectivity) with the same consistency as bathymetry. These data are displayed as "acoustic imagery".

The EM12D have five different sectors (all with 162 beams) : 150°, 140°, 128°, 114°, 98°. These will be used as shown in the table below. Note that the coverage will not be roll dependent but depth capability may vary with different bottom conditions.

Angular Sector	Maximum Coverage	Depth Range	Horizontal Spacing
150°	7.4 x Depth	50 m - 3,000 m	0.047 x Depth
140°	5.5 x Depth	2,500 m - 4,200 m	0.035 x Depth
128°	4.1 x Depth	3,500 m - 6,000 m	0.086 x Depth
114°	2.9 x Depth	5,000 m - 8,000 m	0.019 x Depth
98°	2.3 x Depth	7,000 m - 10,000 m	0.015 x Depth

In order to keep accurate control of the sound velocity in sea water, temperature probes are used. The probe (Sippican) transmits the temperature profile to the operator. After the measurements, the sound velocity profiles may be computed by TRISMUS software using the salinity database Levitus, and loaded into the operating unit.

The SIPPICAN probes have a 2,000 m depth capability. For deeper water, the variation in sound velocity with position and time of year is very small, and only the temperature and salinity database Levitus are used.

The real time quality assurance unit is mounted on the R/V L'Atalante. Data processed in real time is displayed in the high resolution colour graphic monitor and printed on a Benson printer for hard copy documentation.

The post-processing system used on board is the TRISMUS software. The multibeam data post-processing is done with the navigation files. The software consists in numerous main components :

- Visualisation of navigation and multibeam files.
- Creation and visualisation of (x, y) files : it consists of merging the navigation with the bathymetric files.
- Calculation of Digital Elevation Model (D.E.M.) with a 25 m to 500 m grid step.
- Filtering, spline smoothing, slope calculation and arithmetic operation (include NTM files combination) on the NTM.
- Visualisation and plotting of the computed grid (statistic, 2D contour map, 3D block-diagram).

#### **4.1.2 - Acoustic Imagery**

The Simrad dual echosounder provides the acoustic imagery simultaneously with the bathymetry.

The imagery data are consistent with bathymetry (geometry, swath path, number of beams, resolution ...) and are contained in the set of signals resulting from sounding. The imagery data output is based on the different signal levels (in term of reflectivity) provided by the various types of sea-bottom.

The acoustic imagery data are on one hand displayed in real time on a wide Dowty analogic recorder and on the other hand stored in the computers systems for further specific processing. The data displayed in real time are not corrected by the navigation; the navigation corrections are introduced during the navigation processing. Then, the final processing of the imagery (mosaïcking, interpolation) is made possible with the IMAGEM software developed by IFREMER.

#### 4.1.3 - Magnetism

The magnetic data were acquired at a 6 seconds sampling interval using a BARRINGER M 244 proton magnetometer, towed 280 meters astern the ship. The magnetic anomalies were computed by subtracting the IGRF 90 from the measured total field, but not corrected for diurnal variations. The accuracy of the instrument being equal to about 0.5 nT, cross-over errors (which are less than about 50 nT) are thus mainly due to diurnal variations which are about 40 nT at the latitude of the cruise.

The magnetic anomalies provided by the on-line processing system were automatically contoured (the contour interval is 50 or 100 nT) using the GMT public available software and the TRISMUS software developed by IFREMER.

#### 4.1.4 - Gravimetry

The gravity data are collected using the sea gravity meter BODENSEEWERK KSS30. This gravimeter consists of a GSS30 gravity sensor mounted on a KT30-two-axes gyro stabilized platform. The gravity sensor includes a non-astatized spring-mass assembly as basic gravity detector. In calm sea, the theoretical accuracy of the gravity sensor can be  $\pm 0.2$  mGal.

Using the on-line-processing system, real gravity is obtained on board the ship, approximately 120 s after the measurement. This system provides values of gravity, Eotvos corrections, Free Air and Bouguer anomalies in mGal. Bouguer anomalies were calculated with a density contrast between the earth crust and the sea water of  $1.64 \text{ g/cm}^3$ . Gravity data are automatically corrected for spring tension, cross coupling, Eotvos and for latitude, according to the IGSN (International Gravity Standardisation Net) 1971 ellipsoid.

The gravity value measured in Suva (Fiji) Kings Wharf station 814 at the beginning of the cruise is 978609.49 mgals. The ending base station at Noumea is 978,864.62 mgals.

The free-air gravity anomaly was automatically contoured (the contour interval is 10 mgals) using the GMT public available software and the TRISMUS software developed by IFREMER.

## 4.3 - THE SOUTHERN TUVALU BANKS AREA

### 4.3.1 - Location and previous data

The southernmost part of the EEZ of Tuvalu includes the Niulakita Island, large shallow-water banks and numerous isolated shallow-water peaks (the Navy's hydrographic chart at the scale of 1:1,500,000 - 1992 and chart of the Service Hydrographique de la Marine at the scale of 1:1,000,000 - 1992). The Tuscarora Bank (26 m deep) lies in the southeast. The Hera and Bayonnaise Bank extend in the south where numerous soundings indicate water depths from 18 to 50 m. One and three unnamed peaks with depths ranging from 22 to 40 m are reported northeast and west of Bayonnaise and Hera Bank. The Macaw Bank (18 m) lies in the northeast part of the area. The northern part includes the Niulakita Island and the Kosciusko Bank (18-22 m), Martha Bank (26 m) and Rose Bank (25 m). Four other isolated and unnamed peaks ranging in depth from 18 to 25 m are also reported between the Niulakita Islands - Martha Bank and the Macaw Bank. On the western part of the area extends a large plateau at the depth of 500 to 800 m which is sometimes referred as the Eaglestone Ridge. South of it, some highs around 1,000 m are reported and referred as the Alacrity Ridge.

Geologically speaking, the southern Tuvalu Banks area is located just north of the Vityaz Trench Lineament, at the junction of the WNW-ESE trending Samoan Volcanic Chain in the east, the ENE-WSW trending Robbie Ridge in east, the NNW-SSE Tuvalu Chain in the north and the western massifs of the Melanesian Border Plateau in the west. Although the bathymetry of this region is in general poorly known, some selected parts especially the southeastern zone has been previously recognized. A Chinese survey in 1977 was devoted to the study of the Tuscarora Banks. A general survey on board the R/V Kana Keoki was conducted in 1982 along the Northern Melanesian Borderland during the Australia-New Zealand and United States Tripartite program (Brocher and Holmes, 1985). A detailed survey was conducted in 1988 by Japan and was focused, in our studied area, on the Bayonnaise Bank from 11°30'S to 12°S, on the northwestward extension of the Tuscarora Bank and on Macaw Bank (Japan International Cooperation Agency, 1989). The objective of this last survey was to assess the resources potential of manganese nodules and cobalt rich crust in the waters of Tuvalu. The following is the main geological results of these surveys.

The Tuscarora Bank trends almost E-W and has a shallow morphology of a drowned atoll (Fairbridge and Stewart, 1961). On the basis of the depth of its flat top below sea level, Brocher (1985) proposed that this guyot subsided at least 585 m since its formation. Hyaloclastics breccia and bioclastic shallow water limestones have been dredged on the eastern flank of the bank (Sinton

*et al.*, 1985; Brocher *et al.*, 1985). On the northern flank of the Tuscarora Bank, a piston core (89 cm recovered at 1,060 m) penetrated into a lithified Pliocene shallow water limestone overlain by unconsolidated Pleistocene to Holocene sand with reworked late Miocene faunas, suggesting that part of the bank subsided about 1,000 m since the early Pliocene (Chaproniere, 1985). Seismic reflexion indicates that the terrace developed at 100 m is underlain by at least 0.2 - of sediments on top of volcanic basement (Brocher, 1985). The Tuscarora Bank extends toward the north and forms a 120 km long ridge with a terrace. The northwestern portion is composed of E-W connected two guyots (near 11°20'S, 178°50' to 179°20'W) with large flat summit at 1,000 m, around which limestone including foraminifera and coral and foraminiferal sandy mud have been recovered (Japan International Cooperation Agency, 1989).

The Bayonnaise Bank recognized from 11°30'S to 12°S trends NW-SE and is a 3,500 m high. Its 15 km wide summit is flat and very shallow at about 40 m. Several knolls around 700-800 m lie in the northwestern extension of the summit. The eastern flank is steeper than the western slope. Limestone with coral and foraminifera have been recovered as well as vitrous and fresh basalt on the northeastern and northwestern slope. The basalt is a plagioclase-clinopyroxene aphyric basalt with an alkalic affinity. It has been dated of 0.2 My by the K/Ar method, but this very young age have to be taken with care due to the high content of stable Ar (Japan International Cooperation Agency, 1989). Sedimentary thickness is estimated as 0.2 s.t.w.t. thick on Hera Bank (Brocher, 1985).

The Macaw Bank (10°40'S - 179°10'W) is a 3,500 m high cone-shaped guyot with a 9 km wide square-shaped flat top at around 20 m. Only limestone with foraminifera and coral covered by foraminifera sand and mud have been recovered on this guyot (Japan International Cooperation Agency, 1989).

Eaglestone Ridge appears as a plateau in the western part of studied area. Seismic refraction profile indicates immediately east of the Eaglestone Ridge a minimum sedimentary thickness of 667 m (Brocher *et al.*, 1985). In contrast, the sediment isopach map shows less than 200 m of sediments on the ridge.

#### 4.3.2 - Sopacmaps cruise data

Taking into account the previous data, especially those obtained during previous cruises in the southeasternmost part of the Southern Tuvalu Banks Area, the Sopacmaps cruise was focused on the northeastern and western parts. The profiles have been chosen in order to define the contour of the main banks of the area (Hera-Bayonnaise and Kosciusko-Martha Banks, Eaglestone Plateau). The first and main profiles have been traced NNW-SSE parallelly to the main structural direction inferred from previous scarce data. The spacing between these profiles (8 to 6 miles) was calculated to obtain the best coverage for water depths greater or equal to 2,500 m and was adjusted during the cruise (Fig. 10).

In a second time, intermediate and crosscutting profiles were realized in each zone of shallower depths and seamounts, in order to obtain an almost complete coverage in depth greater than 800-1,000 m. Although the very shallow water large banks have not been mapped (due to timing and for a better use of the EM12 system), the banks have been well delimited and shallow

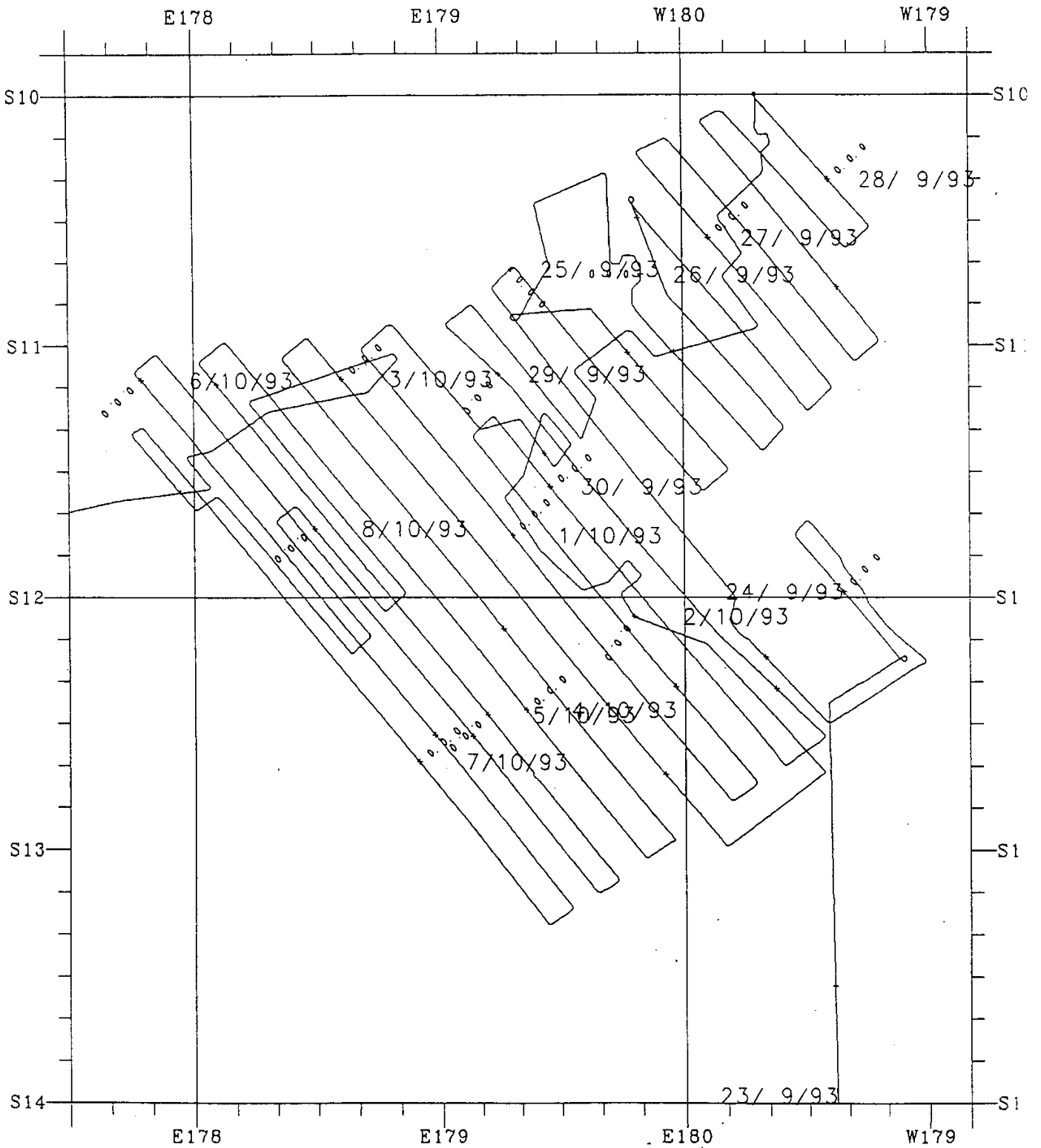


Fig. 10 - Navigation chart on Southern Tuvalu Banks Area

depths have often been recorded. EM12 bathymetry and imagery, seismic reflexion, magnetism and gravimetry data have been recorded along all profiles.

### 4.3.3 - Bathymetry

The bathymetric chart (Fig. 11) of the entire studied area allows identification of a large number of morphostructural units: the Hera-Bayonnaise Bank, the Kosciusko-Martha Bank, the Luao Seamount Chain, the Northern Seamount Chain, the Central Seamount Chain, the Eaglestone Plateau, different Basins labelled A through E between the banks, the Vityaz Trench Lineament and its associated northern wall, and a special zone of deformation between Hera-Bayonnaise Bank and Kosciusko-Martha Bank.

#### 4.3.3.1 - The Hera-Bayonnaise Bank (HBB)

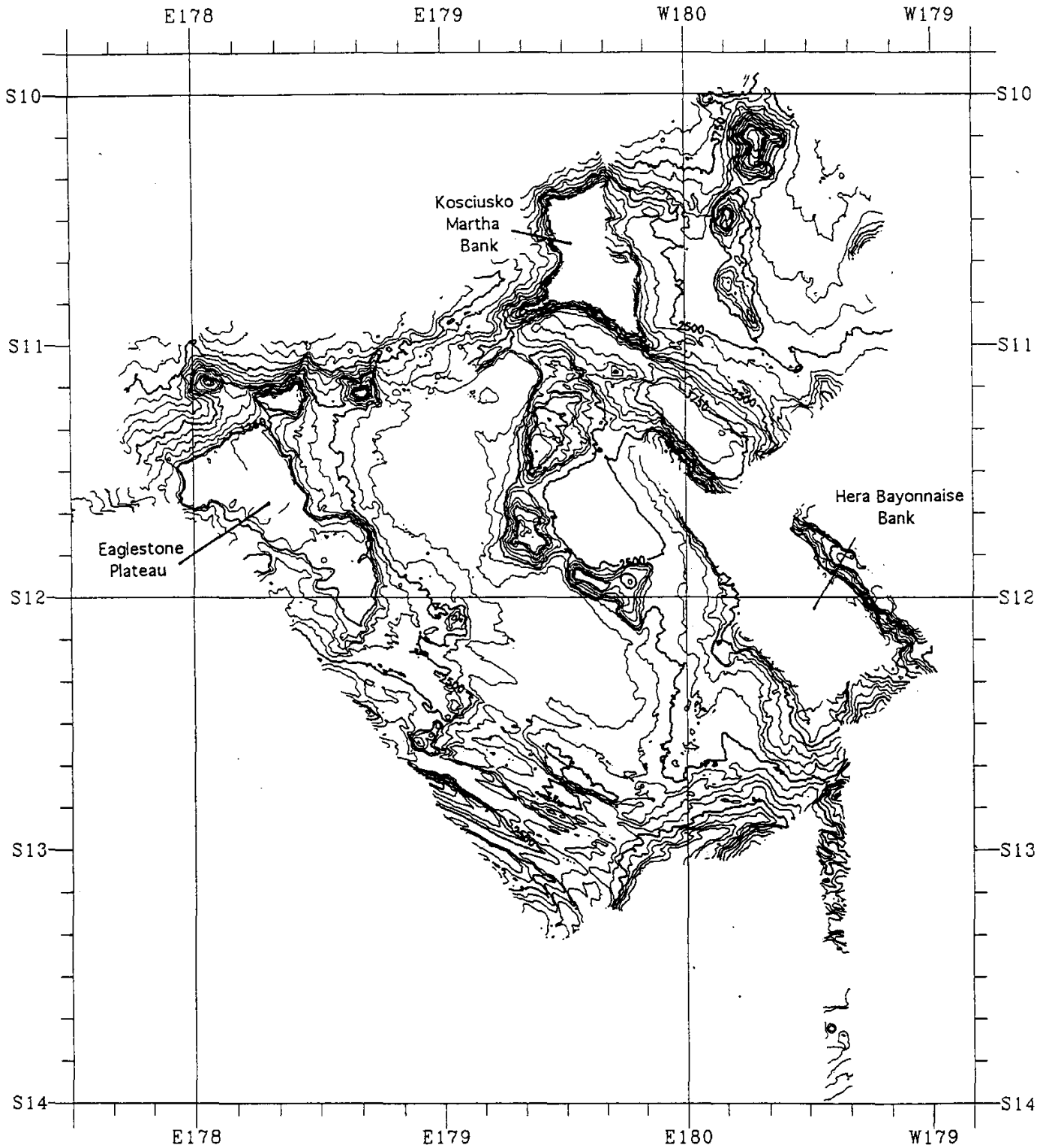
The Hera-Bayonnaise Bank is a flat topped guyot of 3,500-4,000 m high. It is centered at 179°35'W - 12°S and strikes N135°E. It extends from 12°20'S to 11°20'S and is about 120 km long. The southern part of the bank, south of 11°45'S, is wider and reaches a maximum width of 45 km. The northern part located in the extension of the southern part is 13 km wide. No Sopacmaps profiles cross over the bank, but hydrographic chart and previous data indicate that it is a flat bank at 40 m of depth with peaks at 18 m. The Sopacmaps profiles enclose the banks and depths of 300-400 m have been recorded in the southwest, south and southeast of the bank.

The eastern flank of the bank is steeper than the western flank. Its morphology varies along strike. South of 11°45'S, the eastern flank is marked by "en echelon" 125°N to 130°E trending scarps dividing the slope into four parts. From top to bottom, they are:

- a terrace near 800-1,000 m of depth on which some small circular edifices (average diameter: 2.5 km, high 250 m, depth 500-800 m);
- a first scarp of 4.5 km wide from 1,000 to 2,500-2,700 m;
- a bench (about 5.5 km wide, average depth, 2,750 m) deepening to the south (3,000 m) and bounded by a small ridge on the east;
- a second tight scarp (1.5 km wide) from 2,750 to 3,250-3,500 m. Due to the obliquity of the scarps these different parts of the slope are sometimes absent, and the slope is continuous from 400 to 3,500 m (12°05'S).

North of 11°35'S, the eastern flank of the bank is delineated by an unique NW-SE trending scarp from 800 to 4,000 m depth.

The western flank of the Hera-Bayonnaise Bank is less marked. However, a scarp exists in the uppermost part of the slope from 300 to 1,000 or 2,000 m depending of the area. The slope is cut by numerous little canyons. Two extensions of the bank are noted along the western slope. One lies at the southwest corner of the bank at 12°30'S - 179°30'W and shows terrace-like morphology at 800 m, 1,000 m and 1,500 m.



**Fig. 11 - General bathymetry of the Southern Tuvalu Banks Area  
(contour interval 250 m)**

E 178

E 179

W 180

W 179

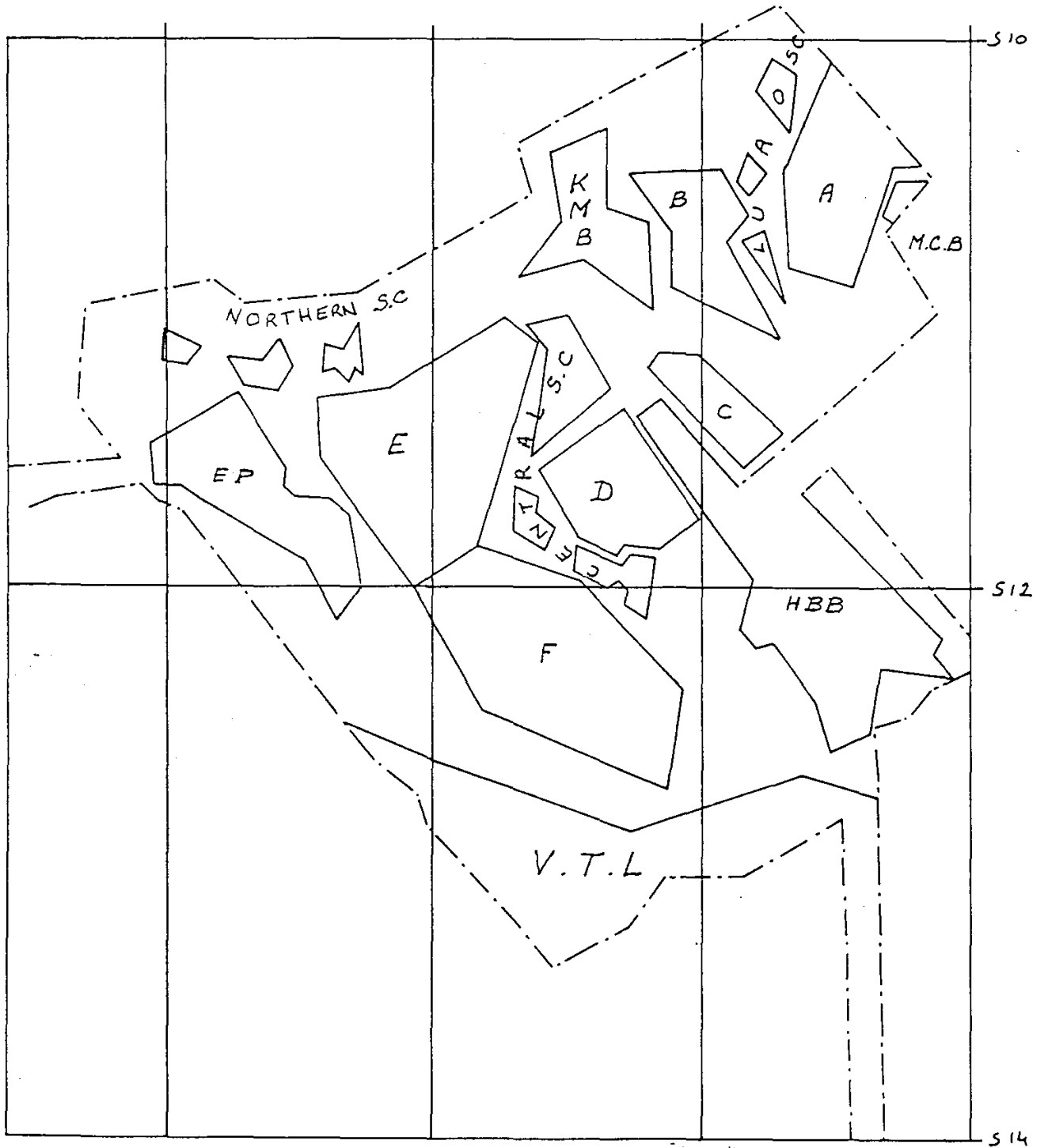


Fig. 12 - Morphological units in Southern Tuvalu Banks Area

The second extension is located at 12°10'S. It is 10km wide and is controlled by 20°N to N40°E trending scarps almost perpendicular to the bank. This extension is constituted by three imbricated terraces at 700, 1,000 and 1,400 m.

The southern flank of the bank shows a reentrant with small canyons at 12°20'S - 179°15'W between the southwestern extension and a N130°E ridge on the east on which volcanic edifice lies.

#### **4.3.3.2 - The Kosciusko-Martha Bank (KMB)**

This 3,000 to 3,500 high bank centered at 10°40'S - 179°40'E includes the Kosciusko Bank in the north, the Martha Bank in the center, and Niulakita Island in the west. The Sopacmaps profiles clearly define the contours of this bank which is likely a large and single bank. Shallow-waters shoals and banks (as the Rose Bank on the south and peaks in the west) reported on the hydrographic charts do not exist or are badly located highs which belong to Kosciusko-Martha Bank. Numerous depths ranging from 18 to 26 m are reported on this bank. No Sopacmaps profiles intercept the bank. However depths of 300 to 500 m have been recorded around the bank, and 30 m to 80 m soundings were recorded in the eastern part (10°41'S - 179°E'W) and the southernmost part respectively.

The bank extends over 65 km in a N150°E direction from 11°S to 10°20'S, and is 20 to 30 km wide. It is limited by two main structural directions: N60°E and N160°E. The northern part (Kosciusko Bank) appears as a rectangle trending NNW-SSE. The southern part is V-shaped. Two ENE-WSW trending knobs perpendicular to the bank exist around 10°45'S. Few little canyons incise the bank's slope. At 10°39'S - 179°44'E, a bench seems to indicate the presence of a terrace at 750 m of depth. North of ENE-WSW knobs, the bank is cut on its western flank by a large N60°E trending normal fault (10°35'S) and on its eastern flank by a N85-90°E oriented normal fault (10°30'S). Two main valleys are developed along these reentrants. The western one deepens to the WSW from 3,000 to 4,000 m. The eastern valley deepens to the east from 2,000 to 2,700 m before being shifted toward the north at 179°52'W by large volcanic edifices.

East of the Kosciusko Bank, between 10°30'S and 10°22'S, a E-W trending minor massif (1,650 m of depth and 750 m high) is linked to the main edifice by a N90°E structural direction. The northern edge of this massif is affected by two parallel scarps showing a "Z" contour (N60°E and N135°E). To the northeast, numerous small volcanoes exist and are aligned N60 or N135°E.

#### **4.3.3.3 - The Luao Seamount Chain (LUAO SC)**

This newly discovered chain is located in the northeasternmost part of the studied area. It is constituted by three large volcanic edifices aligned around 179°45'W and arranged "en echelon" along N150°E and NE-SW trending structural directions. The chain shallows from south to north, the summits of the seamounts being respectively at 1,500 m, 900 m and 18 m.

The southern seamount, centered at 10°45'S - 179°52'W, strikes N150°E and is 1,000-1,250 m high with a gentle slope. It includes numerous small 50 to 250 m high volcanoes which constitute 150N trending lineaments. The southern seamount is linked to the central edifice by a N150°E scarp suggesting a normal WSW dip fault.

The central seamount, centered at 10°30'S - 179°50'W, is 2,750 m high and is composed on its top of two N150°E oriented terraces around 750-800 m. The slopes are mainly controlled by NNE-SSW trending scarps. The western slope is steeper than the eastern one. The eastern flank is spotted by small 50 m to 250 m high volcanoes. This edifice is connected to the northern one by a saddle at a depth of 2,750 m.

The northern seamount at 10°10'S - 179°40'W is the biggest (more than 3,500 m high) and culminates at very shallow depth. This bank is not on the hydrographic map but was recently discovered by a fisherman from Tuvalu (personal communication). The top of the bank is composed of two parts separated by a pass at 1,000 m. The northern part is the largest and includes a well developed flat terrace at 750 m, a scarp from 700 to 50 m and a flat topped summit near 20 m. A sound between 15 and 20 m has been recorded on this northern part. This edifice is controlled by N120°E and N20°E directions. A N120°E-trending, 10 km wide graben cuts the eastern flank of the guyot. North of this bank, some small to medium size volcanoes (up to 750 m high) are aligned along a N150°E direction.

#### 4.3.3.4 - The Northern Seamount Chain (NSC)

This chain of seamounts, discovered during leg 3, trends E-W in the northern part of the studied area. It bounds a deep basin in the north (4,500 m) and is connected to the east with a N60°E trending ridge in the southwest extension of the Kosciusko-Martha Bank at the latitude of Niulakita Island.

This chain is constituted by three seamounts rising to 650 m and connected with NW-SE scarps. The western seamount located at 11°10'S - 178°05'E is 3,000 m high, 15 km wide, and shows a conical shape. The central seamount, located at 178°20'E immediately northeast of the Eaglestone Plateau, is a 3,500 m high guyot oriented WNW-ESE. Its flat summit at 650 m of depth extends over 18 km. A pronounced crest line along its northern flank strikes N20°E. The third seamount, at 178°40'E, is also a 3,000 m high guyot with a flat summit at 650 m. It shows a star shape with several crest lines. The main crest lines strike NNE-SSW and NW-SE.

#### 4.3.3.5 - The Central Seamount Chain (CSC)

This new seamount chain is located in the central part of the studied area, west and northwest of the Hera-Bayonnaise Bank. The chain is composed of three guyots following a croissant shape.

\* The southern guyot is 1,750 m high and is controlled by N110°E and N30°E conjugated structural trends. The northwestern summit of the guyot trends N110°E and is a 22 km long, 2.5 km wide ridge rising at 1,000 m. The northeastern summit is marked by a circular structure rising at 750 m. The southern part is delineated by a N-S trending ridge at 1,250 m. These three parts are delimited by two NE-SW trending faulted scarps which cut the western flank of the edifice.

\* The central guyot (10°45'S - 179°20'E) is 1,750 m high. Its summit corresponds to a 15 km long, 6 km wide platform at 750 m which strikes N140°E. ESE-WNW scarps in the northern part of the guyot separate platforms at 1,100 and 1,800 m.

\* The northern edifice is a large (55 km long, 33 km wide), guyot bounded in the south by a N60°E scarp and to the west by a N-S scarp. The guyot is cut by numerous ESE-WNW to E-W normal faults along which the summit platform is tilted and collapsed toward the north from 750 to 2,250 m.

#### 4.3.3.6 - The Eaglestone Plateau (EP)

The Eaglestone Plateau is a N125°E trending large plateau located in the northwestern part of the studied area from 11°20'S to 12°10'S. The maximum and minimum widths of the plateau are 50 and 18 km respectively. The plateau deepens toward the south and can be divided into three blocks. The northern part, bounded in the north by a N60°E linear scarp of few hundred meters high, is flat at about a depth of 750 m. Between 11°45'S and 11°55'S the central part corresponds to a terrace at 1,000 m. South of 11°55'S, the depth of the plateau is around 1,100 m. In the southernmost part the plateau deepens to 1,500 m. The different blocks are separated by regular slope, E-W to ENE-WSW scarps or canyons, suggesting the presence of faults. The southernmost part is cut by N120°E scarps. The contour of the plateau is marked by a steep slope in the upper part (higher on the eastern flank) and then a gentle slope below 1,500-2,000 m on which numerous small canyons are developed. Some circular edifices interpreted as volcanoes lie on the top of the plateau. East of the Eaglestone Plateau at 11°52'S, a small 9 km wide plateau is tilted toward the south.

#### 4.3.3.7 - The Basins between the Banks and Seamount Chains

Five basins (labelled here A to F) lying between the banks and seamount chains can be observed on the bathymetric map :

- \* **Basin A (A)** is located in the northeastern part of the studied area between the Macaw Bank to the east and the Luao Seamount Chain in the west. It strikes N-S to N25°E and is about 48 km wide and at least 80 km long. The basin deepens toward the northeast from 2,500 m to 3,500 m. Many small volcanoes of 50 to 400 m high are observed in the northeastern part of the basin.
- \* **Basin B (B)** is located between the Luao Seamount Chain and Kosciusko-Martha Bank and is bounded by ridges at 10°30 and 11°S. It is a small enclosed flat basin. This basin is 2,500 m deep.
- \* **Basin C (C)** is bounded in the west by the northern end of the Hera-Bayonnaise Bank and the northern guyot of the Central Seamount Chain, and in the east by the Kosciusko-Martha Bank and a ESE-WNW trending ridge. This basin is divided into two parts by E-W trending scarps and ridge around 11°10'S. The southern part is deeper and corresponds to a 4,000 m deep, 15 km wide flat basin trending N135°E. The northern part at the toe of the Kosciusko Bank gently deepens to the southeast from 3,200 to 3,400 m and joins the southern part.

- \* **Basin D (D)**, centered at 11°40'S - 179°40'E, is a square-shaped basin enclosed between the Hera-Bayonnaise Bank and the Central Seamount Chain. It is 38 km wide and 45 km long. The bottom of the basin is flat at 2,500 m.
  
- \* **Basin E (E)** is an enclosed basin bounded in the north by a ridge which connects the Northern Seamount Chain with the Kosciusko-Martha Bank, in the east by the Central Seamount Chain, and in the west by the slope of the eastern flank of the Eaglestone Plateau. The basin is the largest of the surveyed area and is composed of two parts :
  - the northern part, 22 km wide, trends NE-SW and reaches a depth of 3,250 m. Some E-W and ENE-WSW trending small scarps are present.
  - the southern part centered at 11°30'S - 179°E strikes NNE-SSW and is less deep (3,100 m). Its maximum width is about 55 km. On the west the slope is cut by numerous small valleys which reach the flat central area of the basin.
  
- \* **Basin F (F)**, centered at 12°10'S - 179°30'E, is separated from the Basin E to the north by a pass at 3,000 m. The axis of this basin trends NW-SE in the prolongation of the Basin E. The southwestern part of the Basin F shows N120°E trending scarps interpreted as the result of normal faulting associated with the Vityaz Trench Lineament.

#### 4.3.3.8 - The Vityaz Trench Lineament (VTL) and its northern wall

Part of the Vityaz Trench Lineament and its related structures have been mapped in southernmost part of the surveyed area. The morphology and structure of this area is complex and can be divided into three zones :

- \* From 179°45'E to 179°35'W, the main feature corresponds to a deep and narrow trough (4,900m deep) which trends NE-SW and shallows toward the northeast to less than 4,000 m. North of the trough, the northern wall of the trough is characterized by a succession of E-W trending oblique scarps to the trough. Further north, the northern wall shows N-S trending scarps. The southern wall of this trough is steeper than the faulted northern flank.
  
- \* East of 179°35'W, the trough shortens, shallows and is divided into two branches. One strikes NE-SW and runs, at a depth of 2,300 m, between the Hera-Bayonnaise Bank in the north and a massif rising to 1,200 m in the south. The second strikes NW-SE and runs south of the previously cited massif. The second branch is interpreted as the extension of the main trough because it is deeper (3,300 m) than the northern one and the southern part of the intermediate massif shows NW-SE trending fault scarps.
  
- \* West and northwest of the 4,900 m deep trough, the surveyed area is characterized by well developed N120°E trending structural fabric. Parallel and N120°E scarps extend over a 80 km wide zone. The amplitude of the scarps generally increases toward the south. Most of the large (500 to 1,700 m high) scarps face toward the north except one of 1,000 m high. Scarps separate elongated ridges and narrow flat basins restricted to the toe of the north facing scarps.

The depth of the three main basins, which slowly deepens to the southeast, decreases from north to south: 3,700, 3,100 and 2,900 m. North of 12°35'S, several volcanic massives are observed and are cut by the N120°E trending structures although the scarps are less developed. The structural fabric also cut the southernmost part of the Eaglestone Plateau. This fabric is interpreted as normal faulting related to the Vityaz Trench Lineament which lies immediately southwest of the survey area.

#### 4.3.4 - Acoustic imagery

Even if the acoustic energy generated by the sea bottom is still being experienced (IFREMER is working on a R&D program on the subject), it can be assumed that the acoustic and energy response of the bottom is mainly related to its nature: so, indurated rocks (volcanic or sedimentary) are characterized by a high level of energy (which correspond to the dark areas on the analogic record) while soft sediments appear with different levels of grey. These levels of grey are not yet very well documented, because of the numerous physical characteristics which must be considered in the signal interpretation: sediments grain size, surface texture, water content, etc. That is why the acoustic imagery interpretation presented in this report is generally conducted with the sub-bottom profiler data and in agreement with the rules of marine geology and more particularly sedimentology.

The different basins (Fig. 13 and 1/250 000 attached chart) are characterized by a light grey reflectivity corresponding to proximal and distal turbidite deposits and to pelagic sediments. As the water depth is less than CCD (which is assumed to range from 4,000 to 4,500 m in the study area), this "reflectivity facies" is probably related to carbonate deposits. From place to place Basin A, basement piercing structures are observed (dark spots). The northern limit of Basin E corresponds to a rocky slope (2,500 to 3,000 m) around 11°10'S.

Heavy contrast appears on the imagery map between the three volcanic structures of the Luao Bank and the adjacent Basins A and B. The volcanic structures are sediments free, except a few areas where small suspended basins are observed. Luao Bank shows evidence of gravity mass movements resulting from sediments instability.

Between Luao Bank and the northwestern limit of the studied area, a very limited sediment deposit is observed; it is characterized by an alternance of dark and light grey areas with a series of lineations orientated SE-NW. Those lineations can be interpreted as indicators of bottom currents circulation.

Between Basin B and C, meander-like features are observed. They may be due to local modifications in the texture of surface sediments or also related to normal faulting (see § Seismic descriptions).

The structural trends located along the northeastern flank of the Hera-Bayonnaise Bank and visible on the bathymetry charts, are evident on the imagery in dark facies indicating important slopes or basement outcrops (see the feature starting from 12°S - 179°22'W which propagates to NW and then to WNW). Noteworthy is that the acoustic imagery, because its high capability to identify sediments free areas, can underline some features which can be smoothed out by the

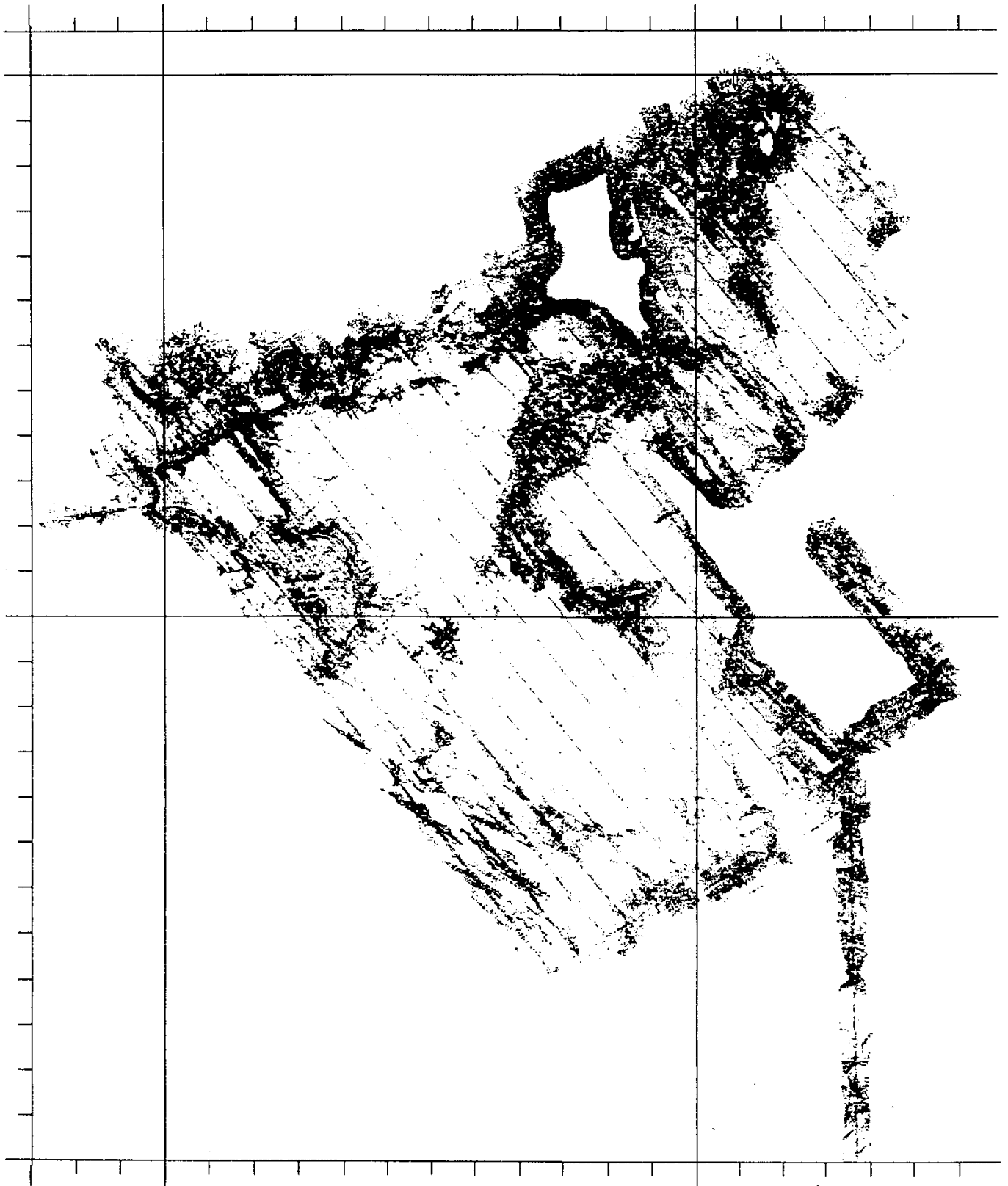


Fig. 13 - General acoustic imagery on Southern Tuvalu Banks Area

bathymetry DEM (Digital Elevation Model) processing. From a general point of view, the slopes of the Hera-Bayonnaise Bank provide a high energy signal corresponding to rock outcrops. From place to place one can note the evidence of a few sediments deposits when the slope is less steep. As a general rule, sediments are swept off on the slopes where turbidity currents occur. The "flat" terrace around 700-800 m along the eastern side and southwestern side of the bank is characterized by a continuous and mid grey reflectivity which probably corresponds to foraminiferal sand or ooze deposits (see for example at location 11°58'S - 179°23'W).

The Kosciusko-Martha Bank limit shows a pattern of reflectivities comparable to those observed at the Hera-Bayonnaise Bank boundaries. Steep slopes are characterized by high energy, with enforcement of the signal (mainly along the southern and western boundaries) where slope oversteep. As evidenced by the 3.5 khz records, the bank breakline can be interpreted as the outer part of a fossil and subsided reef barrier, but this interpretation cannot be really confirmed by the acoustic imagery (possible similar energy between the reef and the bioclastic surrounding sediments). Thalwegs along which sediments are drained are reported on the main slope in the northwestern and eastern regions. Those thalwegs are sediments free and appear as dark lineations. Between the thalwegs, on more or less flat or gently inclined areas, the sediments are stabilized (mid grey reflectivity). In the adjacent sedimentary basins, particular features (scattered heavy grey patches) are observed and may correspond to slight variations in the sediments texture.

The Northern and Central Seamount Chains displays a pattern of dark and light grey reflectivities and numerous indications of sediments movements on the slopes. The tops and flanks of the seamounts are characterized by many suspended basins evidenced by a mid grey and continuous reflectivity. As the top and the flanks of the structure are preserved from turbiditic deposits, it can be assumed that this reflectivity facies is characteristic of shallow carbonate deposits. The northern guyot of the Central Seamount Chain is characterized by dark E-W trending dark lineations which can be correlated to the faulted scarps crosscutting this guyot. Northeast of this guyot, special acoustic facies separates the two parts of the Basin C and can be interpreted as the results of volcanic activity.

The Eaglestone Plateau is remarkable from different points of view:

- \* the quasi continuous outer dark line which corresponds either to the upper part of the slope, or to the outer limit of the coral reef built before the plateau subsidence;
- \* a more or less continuous line corresponding to a terrace lower in the slope;
- \* a series of thalwegs, some of which highly ramificated and connected with the adjacent basin. Such features can be observed along the major slopes surrounding the basin. They probably bring an important contribution for the (turbiditic) sedimentation in the depression;
- \* the top of the plateau shows a mid grey and continuous reflectivity comparable to that observed on the terrace bounding the Hera-Bayonnaise Bank and at the tops of the Luao Bank and the flat guyots of the Northern and Central Seamount Chains. The study of the 3.5 khz records clearly indicates the presence of coarse soft deposits (probably foram sand and bioclastic associated deposits). From place to place, small round shaped

structures are reported on the summit of the Eaglestone Plateau and correspond either to late volcanic activity or very limited coral edifices;

- \* the southward tilting of the south termination of the plateau (see Seismics description) is operated around  $11^{\circ}50'N$  and may correspond to the observed sediments-free features orientated EW.

In the southern part of the surveyed area, a series of sub-parallel and elongated structures are clearly related to the crust breakage and block tilting along the no more active Vityaz Trench Lineament (see Bathymetry and Seismics descriptions). North facing normal faults have been created and no sediments (or very few) have been deposited along these slopes. The fault fronts are underlined by the imagery dark facies. Toward the east, E-W and N-S trending features are related to the virgation of the Vityaz Trench Lineament.

#### 4.3.5 - Seismic reflection

The seismic reflection profiles allow to obtain information concerning the sedimentary thickness in the different basins and on some parts of the banks and guyots, and about the structure of the area. Interpretation of seismic reflexion profiles are reported on separate figures. The main results are reported below.

Sedimentary thickness reported in secondes (two way travel times) varies in the different basins from 0.3 to 1.4 s.t.w.t. The enclosed basins have the thickest sedimentary section. Total sedimentary thickness are respectively 0.5, 0.6, 1.4, 1.2, 1, and 0.6 s.t.w.t. in Basins A, B, C, D, E and F respectively.

Three units have been identified in the different basins:

- \* The first one is characterized by low frequency, high amplitude and continuous reflectors.
- \* The second shows intermediate amplitude, high frequency and discontinuous reflectors.
- \* The third presents high amplitude, discontinuous to continuous and low frequency reflections.

The three sequences are in general separated by unconformity although in some parts the units are conformable.

Above the first unconformity, the first unit is 0.1 to 0.3 s.t.w.t. thick. The unconformity is especially well marked in the Basins E and B and C. It is associated with a tilting of the underlying sequences. The unit 1 is mainly restricted in the central part of the basins and results from deposits supplied by the neighbouring canyons that cut the basin's slopes.

The second unconformity between units 2 and 3 is clearly discernible in the Basin D and appears 0.5 to 0.6 s.t.w.t. below the basin's floor. The unit 2 is posterior to the formation of the Central Seamount Chain and likely results from deposits deriving from the erosion of these volcanic edifices.

Basement highs have been observed at several places: in the southern part of the Basin D, in the northeast prolongation of the southern edifices of the Central Seamount Chain, in the Basin E, north of the central guyot of the Central Seamount Chain, and in the central part of the Basin F. These basement highs are interpreted as volcanic constructs associated with the banks and seamount chains.

Banks and guyots are overlain by sedimentary cover a 0.6 s.t.w.t. thickness has been observed in the southwestern extension of the Hera-Bayonnaise Bank. The central and northern guyots of the Central Seamount Chain shows about 0.4 s.t.w.t. of sedimentary cover. The Eaglestone Plateau is overlain by a 0.2 to 0.5 s.t.w.t. thick sedimentary cover. The northern part of the plateau shows below the upper flat reflectors, a section of steep reflectors (apparent dip toward the SSE) of unknown origin. Such reflectors are not visible in the southern part of the plateau.

Small volcanic intrusions which apparently crosscut sedimentary sections have been observed on different seismic lines in the northern part of the Basin A and on the top of the Eaglestone Plateau. Volcanoes seems associated with normal faulting.

Three zones of intense normal faulting have been recognized :

- \* The first area is located between 11°S and 11°20'S between Hera-Bayonnaise Bank and Kosciusko-Martha Bank. The ridge lying northeast of the Basin C is affected by a series of N120°E trending normal faults. This zone of deformation extends also in the Basin C which is divided into two parts by an E-W south facing scarps and follows westward across the northern guyot of the Central Volcanic Chain. This guyot is cut by numerous normal faults trending N120°E to E-W. Its northern part appears collapsed from 1,000 m to 1,500-2,000 m. Several normal faults trending sub-EW occurs in the northeastern part of the Basin E and cut all the sedimentary section.
- \* The second zone of deformation is documented by the tilting and normal faulting of the Eaglestone Plateau. At 10°45'S the plateau is cut by a normal fault along which the plateau is tilted southward. Further south, at 10°55'S, ENE-WSW to E-W trending normal faults cut the plateau in a 200-300 m deep graben.
- \* The third zone of normal faulting lies in the southwestern part of the studied area. This area is characterized by a series of tilted blocks along N120°E trending large normal faults. Most of the faults faces NNW. Two sequences can be clearly identified in seismic lines. The underlying 0.4 s.t.w.t. thick sequence is tilted SSW. It formed the SSW slopes of the structural highs and is unconformably overlain by a 0.25 s.t.w.t. thick (maximum) horizontal sequence deposited in the narrow valleys at the toe of the normal faulted scarps.

This disposition suggests that the normal faulting was rapid and is now inactive. The normal faults are developed across the volcanic edifices and are observed in the southern termination of the Eaglestone Plateau. The normal faulting is interpreted as the results of the functioning of the Vityaz Trench.

#### 4.3.6 - Magnetism

Magnetic anomaly values in the Southern Tuvalu Banks Area (Fig. 14) range between -800 nT and +650 nT. The cross-over errors do not exceed 40 nT. These errors are likely generated by the diurnal-solar variations which are about the same range (around 40 nT at this latitude). Except in the NW region and part of the NE region where cross-over are numerous, isogams are interpolated from measurements on 8 miles spaced profiles. Low anomalies values range between -50 nT and +50 nT do not have to be considered as significant.

At the general view, the computer contoured magnetic anomalies chart is characterized by low values between -100 nT and +50 nT in most of the part of the surveyed area (especially south of 11°40'S, north of the Vityaz Zone and over the different basins) and by strong dipolar anomalies associated with the edifices of the different volcanic chains. Strong dipoles with positive values of 300 to 600 nT and negative anomaly from 400 to 700 nT appear on the Luoa, Northern and Central Volcanic Chain. Strong dipole is also located over the volcanic edifices in the southwestern part of the surveyed area, south of the Eaglestone Plateau. The gradients between these dipoles mainly strike NW-SE and ENE-WSW. These two directions are especially evident on and around the Eaglestone Plateau where the profiles are less spaced and then the accuracy of the contouring is better. East of the plateau at 11°30'S, a pair of positive and negative magnetic lineations oriented ENE-WSW is well discernible.

The two directions of magnetic gradients observed in the magnetic map are also identified on the bathymetric map and likely correspond to the main structural directions along which the volcanic edifices have been emplaced.

#### 4.3.7 - Gravimetry

Generally, positive and negative gravity anomalies are associated to high banks and deep basins respectively. In Southern Tuvalu Banks Area (Fig. 15), the volcanic chains are characterized by anomaly values which range from 10 to 170 mgals, these values coincide to a few 10 m and 2,500 m while the values reported in deep basins vary from -10 to -125 mgals corresponding to 2,500-4,900 m. Some exceptions still exist in area of high or low axis where anomalies are positive for important depth (2,500-3,000 m). To compare the different banks, in preliminary study, it is necessary to find the extremum anomaly values, to calculate the gravity gradients and observe the anomaly isogal shapes.

##### 4.3.7.1 - Luao-Northern and Central Seamount Chains

If we are interested in the highest gravity anomalies and in gravity gradients associated to seamounts of Northern, Luao and Central Seamount Chains (the extreme anomaly values are respectively about 170, 160 and 140 mgals corresponding to a few hundred meters depth and their gradients are about 10.8, 8.7 and 4.3 mgals/km), we note that the Central Seamount Chain is wider with a moderate slope while northern and Luao Seamount Chains characteristic drops are steeper. The other seamounts of these chains seem to follow the evolution in a lower amplitude (the highest the anomalies are, the strongest the gradient; for instance, the range of 40-90 mgals can be referred

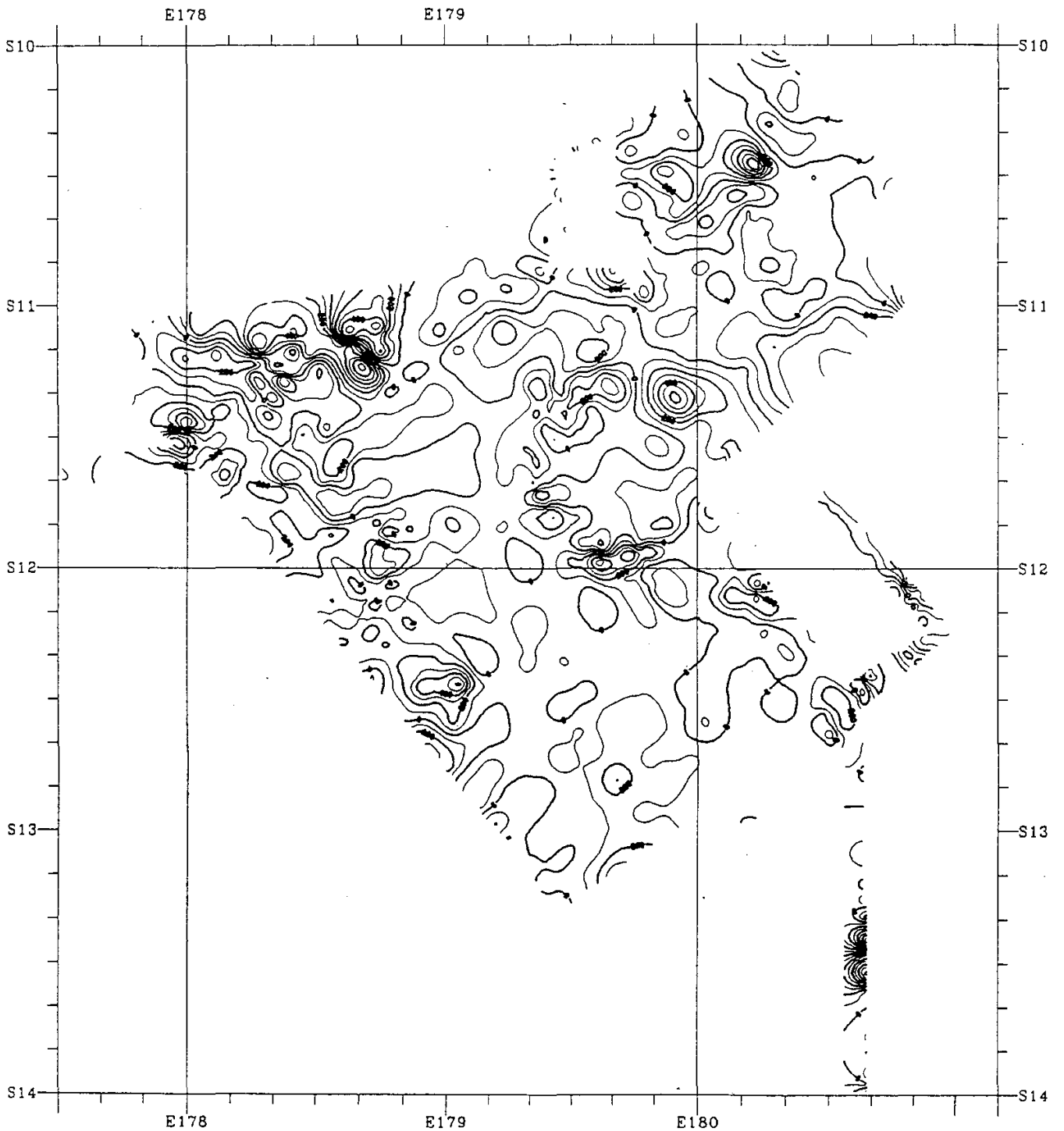


Fig. 14 - Magnetic anomalies contouring in Southern Tuvalu Banks Area

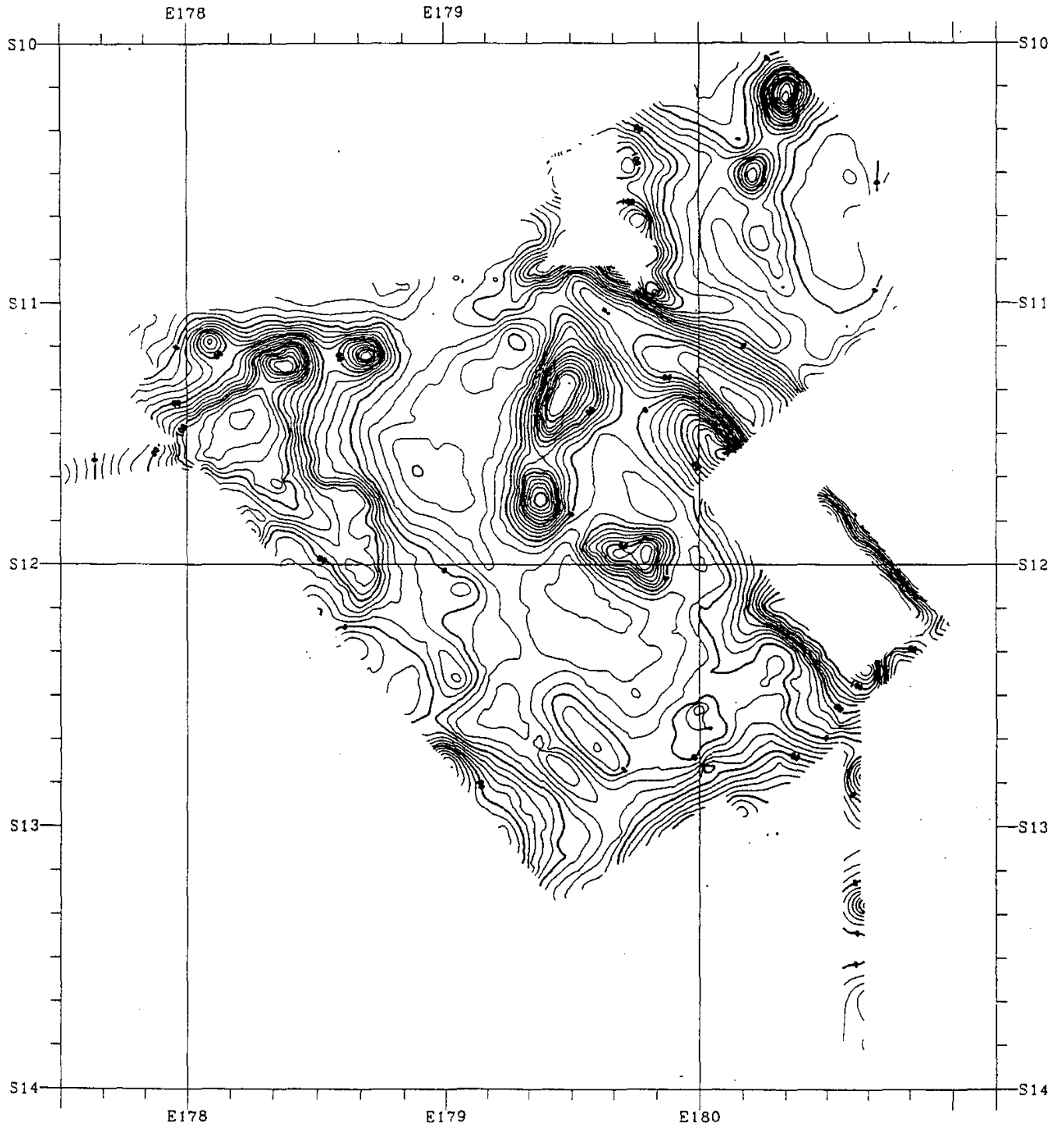


Fig. 15 - Gravity anomaly contouring in Southern Tuvalu Banks Area

to 2.3-6.3 mgals/km). Some of the seamounts present a main and secondary orientations: the northern guyot of the Central Seamount has three orientation axis: the privileged one is in SW-NE, the second in S-N and the last one in W-E.

When we look at each whole bank, the anomaly isogal plottings show a rough virgation for the Central Chain where southern seamounts are oriented E-W and the northern ones follow N-S and SW-NE axis. Luao Chain is globally oriented N-S while we have a W-E lineation for Northern Seamount Chain.

#### **4.3.7.2 - Hera-Bayonnaise Bank**

Surrounding the rectangular block of Hera-Bayonnaise Bank, strong gravity gradients are observed: they exceed 12 mgals/km. This corresponds to sharpened slopes, particularly at the eastern part and suggests the presence of high plateau.

#### **4.3.7.3 - Eaglestone Plateau**

The anomaly isogal plotting clearly indicates a main NW-SE axis that is pertubated by a breaking line located between 11°40'S and 11°50'S. North of the breaking line, the higher gravity anomalies (100-150 mgals) slowly decrease all around the maximum (the gradient value is about 1.2 mgals/km). Especially at the eastern side, the transition to Basin E is characterized by a weak gravity gradient (3.5 mgals/km). In the southern part of the plateau, the variation is still weak with a gradient of 2.5 mgals/km. To the east, the gradient at the plateau-basin E transition is more accentuated than the northern one. The low anomaly variations, showing a gentle southward gradient, are consistent with the deepening of Eaglestone Plateau toward the south.

#### **4.3.7.4 - Kosciusko-Martha Bank**

The anomaly isogal plottings describe three main orientations NE-SW, NW-SE and W-E that respectively correspond to the western elongated extremity, the eastern one and the eastern part located at 10°20'S; these parts are all characterized by low gravity gradients (2,5 and 2.5 mgals/km). The maximum values are about 150 mgals located in the eastern extremity, at 10°20'S - 179°43'E and 10°40'S - 179°46'E. We note that gravity gradients are variable surrounding the bank: one of the higher, situated in 10°40'S, is about 8 mgals/km; the transition with the Basin C is stronger (13 mgals/km).

#### **4.3.7.5 - The Basins**

To study basins area, for a general point of view, it is interesting to locate at sedimentary concentration zones (according to seismic interpretation) and look at the associated gravity anomalies. In the basins , the gravity anomalies vary from +40 to -100 mgals and the depth range is 2,500-4,000 m. The anomaly isogal plottings show the same main structure orientations in comparison to those of the volcanic chains (N-S, NW-SE and NE-SW directions). Higher sedimentary concentrations are situated in narrow basins (Basin D and south of Basin C) characterized by extremum negative anomaly values (-10 and -100 mgals) where depth range is

2,500-4,000 m and at north of Basin E where anomalies and depth reach are respectively -50 mgals and 3,000 m. Mean sedimentary concentrations are found at Basins A, B and F associated to intermediate gravity anomalies (-20 to -50 mgals) excepted Basin B where anomaly values are positive (+10 to +40 mgals) and depth is about 2,500-3,000 m. There is a noticeable high gravity gradient (12 mgals/km) between the elongated part of Hera-Bayonnaise Bank and south of Basin C corresponding to a brutal changing level (1,500 to 4,000 m). There is a lot of dynamic constrains surrounding this area and it would be interesting to insist on the anomaly variations.

#### **4.3.7.6 - The Vityaz area**

This area shows the minimum gravity anomalies of the whole studied southern Tuvalu Banks, that reach 125 mgals corresponding to 4,900 m depth. The anomaly isogal plotting clearly indicates a NE-SW orientation toward 12°50'S - 179°30'W and from this point an obvious combined N-S and W-E virgation. At south of Eaglestone Plateau, from west to east, we observe an alternation of positive and negative gravity anomalies respectively referred to a seamount part with high anomalies (100 mgals), a narrow basin and a high axis. Their anomaly isogal plottings clearly describe a SE-NW directions.

#### **4.3.7.7 - Conclusion**

Free-air anomaly gradients on the Seamount Chains are quasi-constant around each isolated structure while those of Hera-Bayonnaise and Kosciusko-Martha Bank are variable, for the same anomaly range. Eaglestone Plateau is characterized by weak gradient all over the structure. The qualitative results coming from free-air anomaly data interpretation relative to basins do not allow us to assume common relationship between gravity anomalies, topography and sedimentary concentrations. To go furthermore in our investigations, it is necessary to apply corrections and process to signal data filtering (separation of short, intermediate and long waves).

#### 4.4 - ALEXA, CHARLOTTE AND EAST PANDORA BANKS AREA

##### 4.4.1 - Location and previous data

This area surveyed during the second part of the SOPACMAPS 3 cruise is located (Fig. 3) in the northernmost part of the EEZ of Fiji (Alexa and Charlotte Banks) and is the westernmost part of the EEZ of Solomon Islands (East Pandora Banks).

The bathymetry of the area is almost unknown. The only available marine navigation chart is the hydrographic chart of the Navy (Solomon Islands to Tuvalu, Chart Series, Pacific Ocean, chart n° 2901, scale 1:1,658,000, 1978 with corrections to 1993). In the northeastern part of the studied area, a series of shallow waters banks, referenced as the Alexa Bank, includes from east to west Morton Bank, Louisa Bank, Turpie Bank, Penguin Bank and Alexa Bank. This bank seems to be the best known of the area; waters depth ranging from 13 to 50 m are reported on the different banks.

The Charlotte Bank found in 1788 lies west of the Alexa Bank in the central part of the surveyed area. It is composed of numerous shoals (18 to 40 m of water depth) which are aligned in an E-W direction and have been mainly reported in 1945. A reef has been reported in 1992 in the northeast of the previously cited shoals. The location and the shape of the Charlotte Bank area appears poorly constrained on the hydrographic map. The southwestern part of the studied area includes numerous isolated unnamed shoals lying southwest of the Pandora Bank area and ranging from 11 to 29 m depth below sea level. East of the surveyed area lies the Hazel Bank shoaling to 22 m.

From a geological point of view, Alexa and Charlotte Banks belongs to the Melanesian Border Plateau and lie on the old Pacific oceanic crust, immediately north of the Vityaz Trough and Alexa Trough which constitutes a portion of the Vityaz Trench Lineament (see Brocher, 1985). In contrast, the shoals southeast of the Pandora Bank lie on the North Fiji Basin lithosphere directly south of the Vityaz Trough.

The only previously surveyed bank is the Alexa Bank which has a shallow morphology of a drowned atoll and is considered to have been an atoll in Pleistocene time (Fairbridge and Stewart, 1960). Seismic refraction data, collected during the 1953 Capricorn Expedition by the SCRIPPS I.O. indicate at least 0.8 to 1.6 km of carbonate sedimentary cover or reef growth on Alexa Bank (Raitt, 1983 in Brocher, 1985), suggesting a large subsidence since the formation of the edifice. Alkalic basalt dated of 35 My (Duncan, 1985) have been dredged on the steep southern flank of the bank, as well as argillites, black laminated shales and siltsones

#### 4.4.2 - Bathymetry

The surveyed area (Fig. 16 and 17) can be divided into three morphostructural provinces:

- \* The Alexa and Charlotte Banks province in the north,
- \* The Vityaz Trough,
- \* The East Pandora Bank province (labelled here the following Simone and Robert Banks Area) in the southwest.

##### 4.4.2.1 - The Alexa and Charlotte Banks Area

This large area, which corresponds to the major part of the survey, is characterized by a very rough topography mainly due to volcanic constructions. This area is marked by a pervasive structural direction trending N130 to N100. The major topographic highs are the Alexa Bank in the east and the Charlotte Bank in the west.

The Alexa Bank extends over 180 km from 175°07'E to 176°50'E and from 11°20'S to 11°52'S. Its width decreases toward the east (65 km in its northwestern part and less than 10 km in its easternmost part).

The Alexa Bank overall shape is controlled by two main directions trending N120° and N60°, the former being the dominant. The southern flank of the bank shows from 176°E to 175°35'E a N120-trending large reentrant. A large flat terrace at 750 m of water depth has been identified on the eastern part of the bank. The northern flank, less higher than the southern one, is characterized by numerous thalwegs. The Alexa Bank is bounded in the south by a 3,200 m deep flat basin.

The Charlotte Bank is a 4,000 m high bank extending from 174°20'E to 173°30'E. It is smaller than Alexa Bank; its size does not exceed 80 km x 20 km. Its general orientation is N100°. However the northern and southern flank is accidented by scarps orientated N30°.

The whole domain located between Alexa and Charlotte Banks and north and south of the Charlotte Bank can be described as several series of "en echelon" volcanic ridges orientated N120° to N100° and separated by 4,000 m deep flat bottom sedimentary basins. A secondary structural direction is N30.

At the northernmost part of the surveyed area, a 17 km wide volcano rise to less than 700 m and is associated with six minor edifices (diameter: 1.8 km).

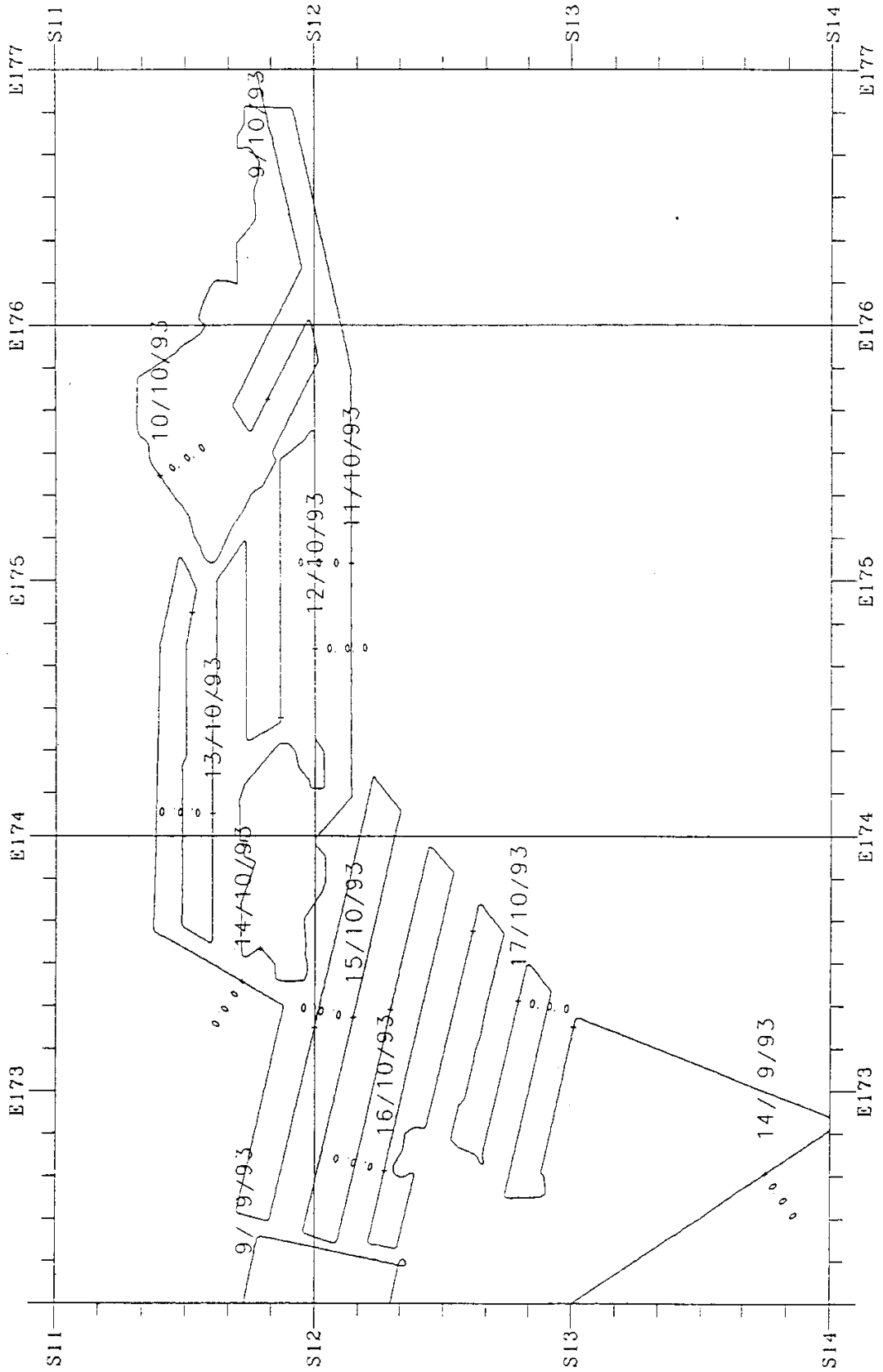


Fig. 16 - Navigation chart on Alexa, Charlotte and East Pandora Banks Area

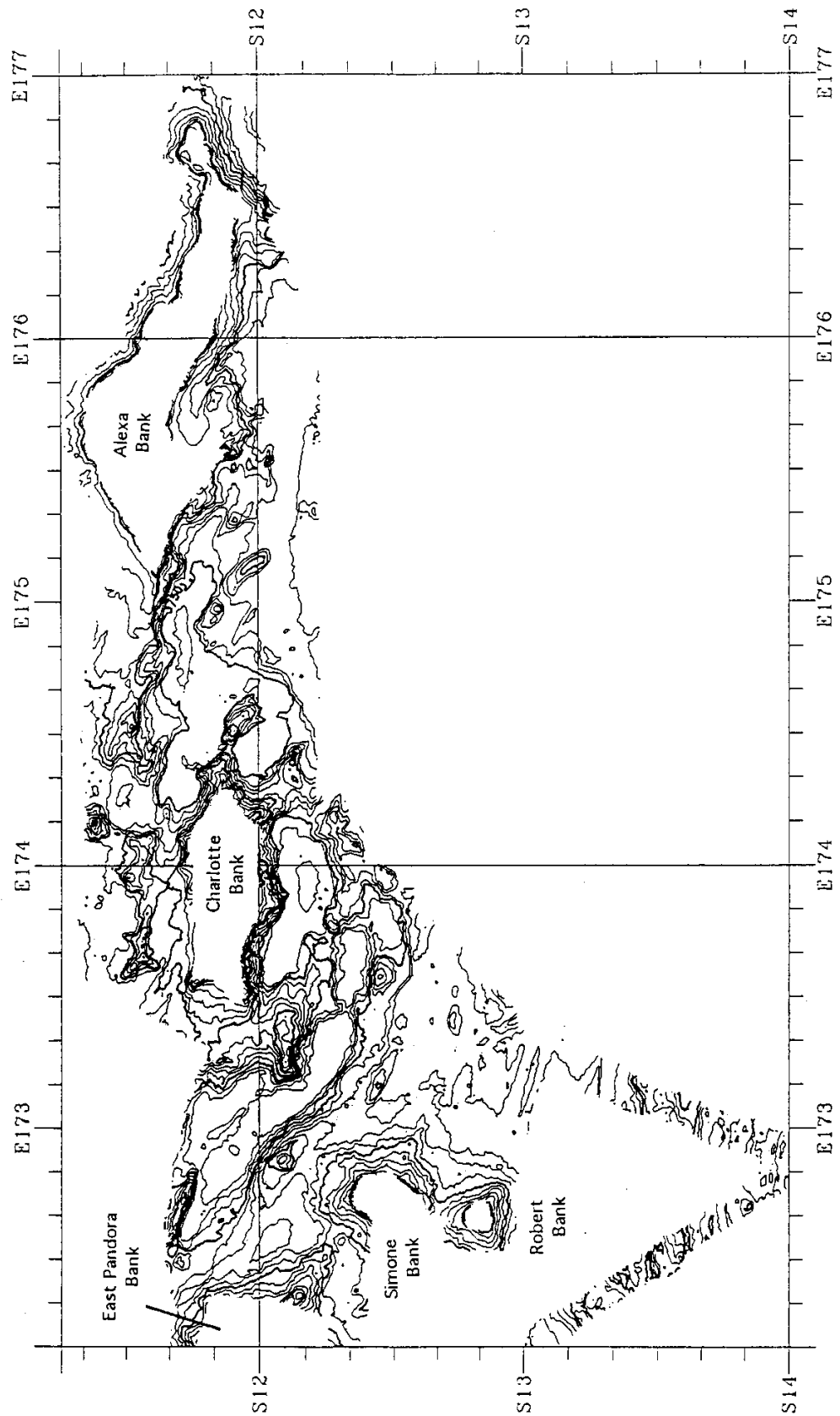


Fig. 17 - General bathymetry of Alexa, Charlotte and East Pandora Banks Area

#### 4.4.2.2 - The Vityaz Trough

This trough is one of the major features in the survey area. It runs NW-SE from 173°45'E - 12°20'S to 172°30'E - 11°40'S, southwest of the Charlotte Bank. It is 145 km long and 4,500-4,600 m deep and 11 to 16 km wide and is composed of a series of N100° to N120° trending small basins. It is reduced in width and sometimes clogged in front of successive N120° trending volcanic ridge of the Charlotte Bank province.

It is bounded toward the south by a continuous scarp showing N100 and N120 direction. A banana shaped structure extends along the southern flank of the trough between 173°E to 172°40'S. East of 173°20'E, a second scarp (500 m high) and an elongated ridge runs south and parallelly to the southern flank of the trough.

East of 173°45'E, the trough disappears and abuts against on volcanic edifice, and is bounded southward by a 4,000 m deep flat basin. The prolongation of the Vityaz Trough, east of 173°45'E, is unclear.

#### 4.4.2.3 - The East Pandora Bank area: Simone and Robert Bank area

This area corresponds to the southwestern part of our survey, and is located immediately east of the Pandora Bank which was surveyed during the SOPACMAPS 2 cruise. The major features of this area is two large volcanic edifices called herein Simone and Robert Bank.

- \* **Simone Bank**, centered on 12°30'S - 172°43'E, is a 18 km wide, 30 km long and 2,500 m high volcano. Its minimal identified depth is 500 m (as far as it has been mapped).
- \* **Robert Seamount**, located south of the Simone Bank and centered on 172°40'E - 12°50'S, is a 12 km in diameter circular volcano. Its minimal depth during our survey is 500 m, but its shape suggest that shallow water depths likely exist.

Around these two volcanic edifices, especially on their eastern sides, rough topography suggests lava flows and associated adventive small volcanoes.

A third noticeable but smaller volcano lies NNE at 12°05'S - 172°53'E. These three edifices are aligned and seem to constitute a N10° volcanic line.

The adjacent zone to these edifices is 3,200 m deep and shows some N100° trending scarps, grabens and elongated small volcanic ridges. This direction, perpendicular with the previously cited volcanic line, seems to be related with the development of lavas flows and adventive craters of the main volcanic centers.

The southern part of the surveyed area is characterized by a strongly developed N110° to N90° structural fabric.

#### 4.4.3 - Acoustic imagery

This study area shows four main bathymetric highs (see § Bathymetry description): Alexa, Charlotte, Simone and Robert Banks.

The contour of these highs is underlined by a high reflectivity directly related to the slopes and the nature of the bottom. As a general rule, and as shown by the numerous dark lineations, the slopes are concerned by erosional turbidity currents circulating along the thalwegs. As a consequence, the adjacent basins are more or less fed by the turbidites deposits, which, mixed with the vertical deposited sediments, bring to different reflectivity levels.

A part of the eastern top of Alexa Bank (flat terrace around 750 m) has been investigated on a very short section (around 11°52'S - 176°30'E). The mid grey and continuous response of the bottom is assumed to be related to shallow soft carbonate deposits (see for comparison the acoustic response observed on the highs in the Southern Tuvalu Banks Area). On the other banks contour, as the survey has been conducted more closely to the upper slope, the acoustic response of the bottom is consequently darker and correspond to rocky slopes.

The sedimentary basins display a pattern of grey probably related to the general conditions of sedimentation, and at least to the variations in the very surficial layer of sediments. As already indicated previously, the acoustic response of the sediments (in term of imagery) is not yet well documented, but several observations can be reported:

- \* The basin situated directly south of Alexa Bank is characterized by a light grey reflectivity which, confronted with the 3.5 khz data, can be assumed as a mixture of turbidites and pelagic deposits. The pelagic sedimentation probably consist of carbonates (3,250 m of water depth for a CCD between 4,000 and 4,500 m).
- \* South of Charlotte Bank, a series of basins (delineating the Vityaz Trough around 4,500-4,600 m) present a quasi uniform level of reflectivity. This characteristic (continuous mid grey) has never been reported before in any deep basin. It may be related to specific conditions of dissolution at the limit or beneath the CCD and to a particular surface texture of the sediments.

South of the Vityaz Trough and around the toes of Simone and Robert seamounts, the imagery is characterized by numerous mottled features with high to moderate backscattering. These features are interpreted as lavas flows emitted from edifice centers.

#### 4.4.4 - Seismic reflection

Not available for the preliminary report, will be provided with the final report.



Fig. 18 - General acoustic imagery on Alexa, Charlotte and East Pandora Banks Area

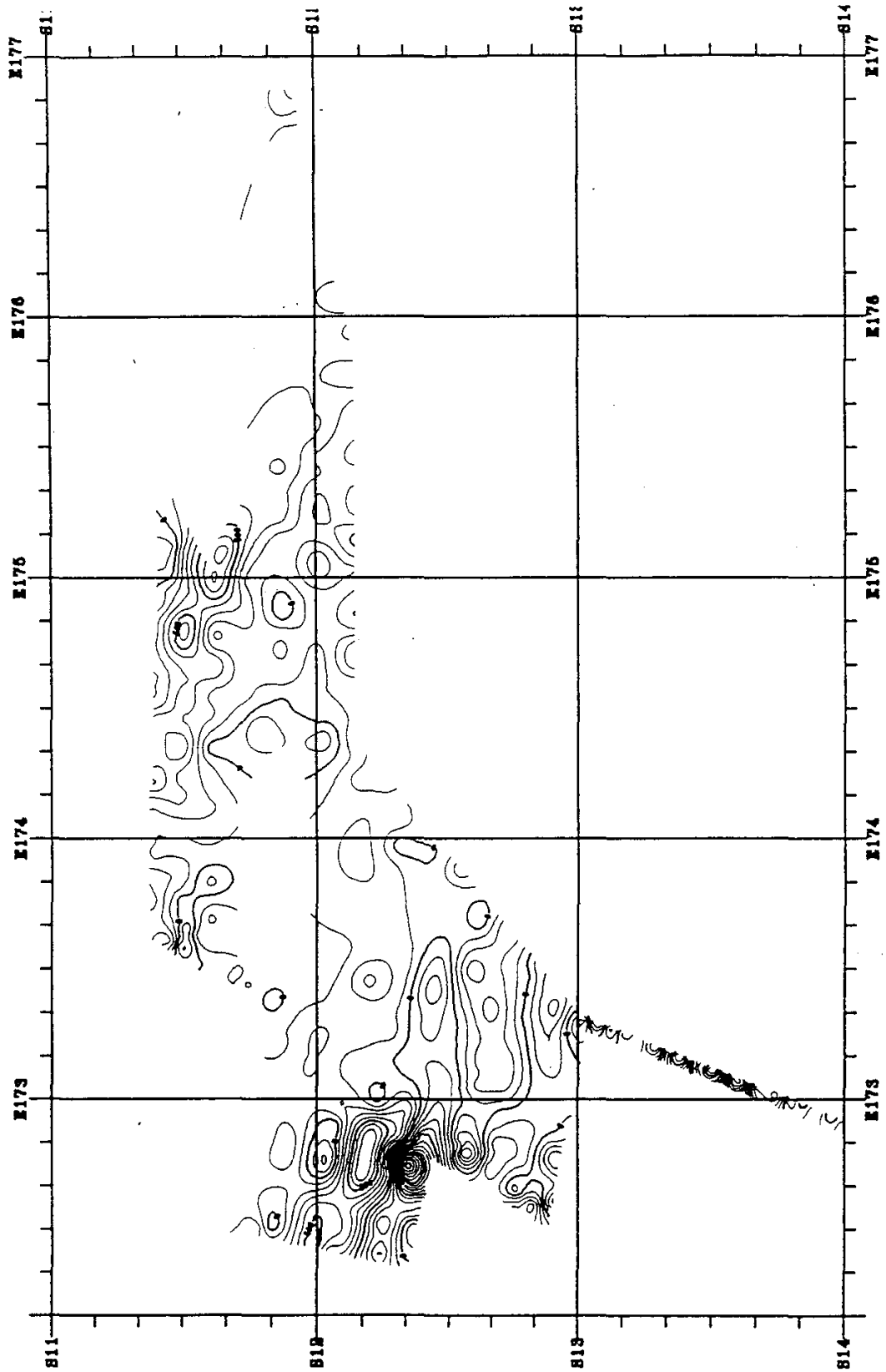


Fig. 19 - Magnetic anomalies contouring in Alexa, Charlotte and East Pandora Banks Area

#### 4.4.5 - Magnetism

Alexa and Charlotte Banks were not surveyed with magnetometer due to the possible presence of reefs. Most part of the area between these two banks has negative values (-100 nT to -300 nT) with a minimum -750 nT at west of Alexa Bank.

The magnetic map shows two main regions :

\* The area south of the Vityaz Trough is characterized by dipolar and sub E-W trending magnetic anomaly lineations. Two dipolar anomalies are observed above the volcanic Simone and Robert Banks (+1550 nT, -450 nT and +350 nT, -350 nT respectively). Those anomalies strike N90°. North of Simone Bank, an other strong N120°-trending dipolar anomaly (+200 nT, -750 nT) can be linked with the presence of lava flows observed on seismic profiles.

\* East of 173°E, the magnetic map clearly shows an E-W trending pattern. The lineations appear to be offsetted at 173°00'E. These lineations correlate with the trend of the structural fabric observed further south during the transit.

The separation of these two different magnetic areas confirms the seismic profiles interpretation which shows a faulted thin sedimentary cover in the perturbed magnetic zone, in opposition with thick sedimented area in quiet magnetic part north.

#### 4.4.6 - Gravimetry

In the Alexa, Charlotte and East Pandora Banks area, the free-air gravity anomaly plottings are very qualitative, particularly in the northern part of Alexa and Charlotte Banks. Some of volcanoes, that occur on bathymetric map, are implicit in our analysis. This is due to mean profile coverage (only one profile exists north of Alexa Bank). Anyway, we can guess structural shapes and present some interesting results on anomaly variations.

The deep basins are associated to anomaly values in range of +45 to -95 mgals corresponding to 2,500-4,600 m depth, while those of the volcanic chains vary from 10 to 120 mgals referring to a depth range of a few hundred meters to 2,500 m.

##### \* Alexa and Charlotte Banks

These banks are the two main features of the studied area. Looking at the anomaly isogal plottings, one will notice a NE-SW and NW-SE orientations respectively at eastern and western parts of Alexa Bank. The maximal plotted value is about 120 mgals and is associated to 700 m depth. We note negative anomalies (about -30 mgals) located in south of Alexa Bank, between 175°48'E and 176°07'E; the anomaly isogal shape indicates two NW-SE and E-W directions related to a reentrant of 2,250-2,500 m depth.

Charlotte Bank is characterized by a E-W orientation and the maximal plotted value (116 mgals) is associated to 700 m depth. Surrounding Charlotte Bank, the seamounts that are well-spotted on bathymetric map have a very weak gravitational signature excepted the northernmost one referred to a maximal value of 70 mgals.

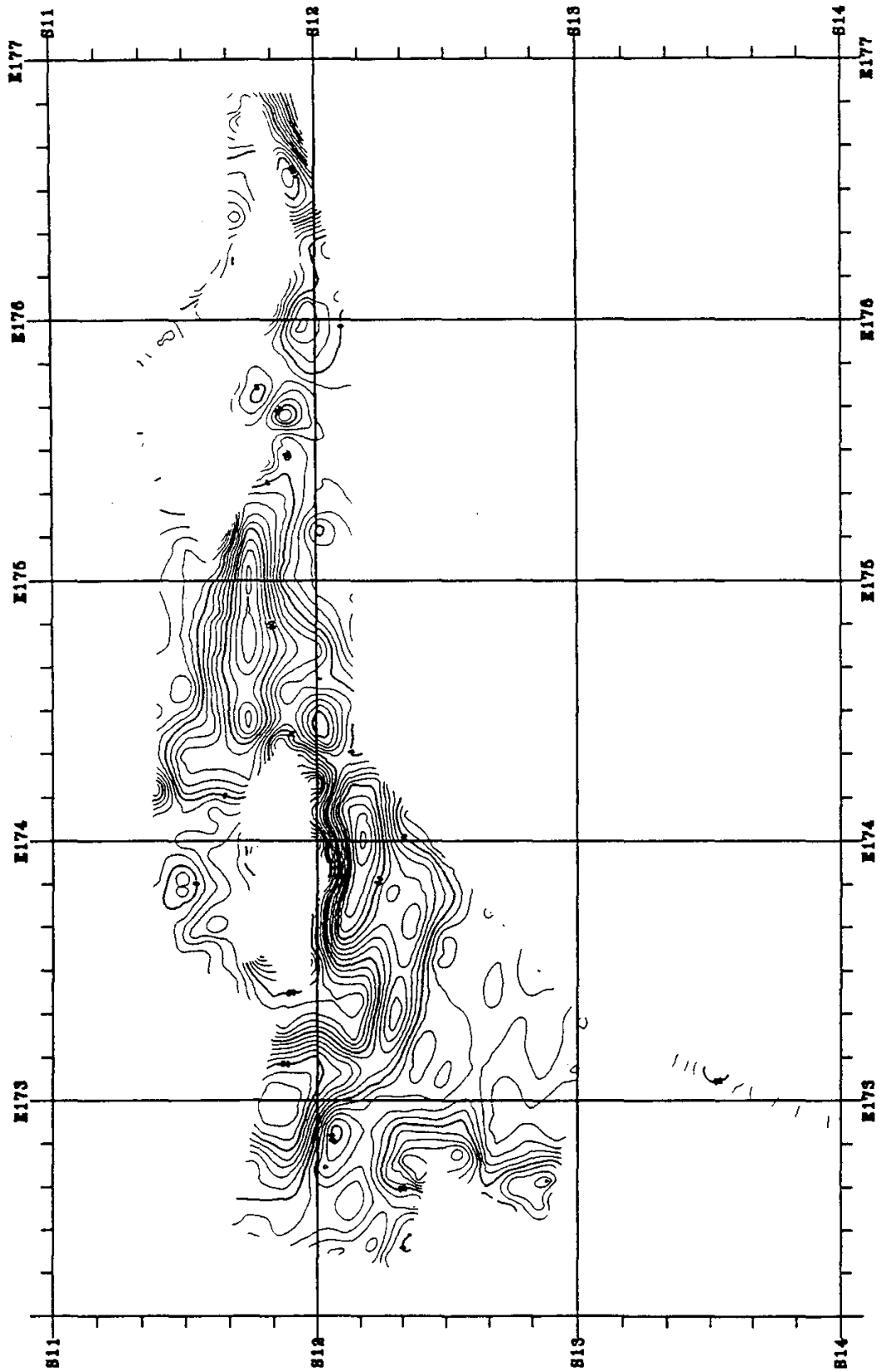


Fig. 20 - Gravity anomalies contouring in Alexa, Charlotte and East Pandora Banks Area

**\* East Pandora Bank area : Simone and Robert Banks**

The anomaly isogal plottings clearly describe two large seamounts: Simone and Robert Banks where high anomalies and low gravity gradients are found (the maximal anomaly values are respectively 100 and 90 mgals and the slopes are about 3 or 4.5 mgals/km). At north of the bank, we clearly see a smaller volcano which is aligned with Simone and Robert Banks in N-S direction.

**\* Basins in the Alexa and Charlotte Banks area**

We find higher sedimentary concentrations in deep basins located between Alexa and Charlotte Banks, at north and south of Charlotte Bank. These basins are characterized by a minimal anomaly range of -95 to -20 mgals where depth varies from 2,500 to 4,400 m. The basin between Alexa and Charlotte Banks shows a V-shape where low gravity gradients (of about 2.5 and 4.5 mgals/km) are found excepted in the transition related to southwest of Alexa Bank and northeast of Charlotte Bank. We also notice a NW-SE influence at southeast of the basin, corresponding to ridges. The northeastern anomaly isogal plotting indicates a clear N-S direction. At south of Charlotte Bank, an arc-shape runs along the bank with a E-W orientation. This zone, bounded by ridges, is characterized by a strong gravity gradient of 11 mgals/km corresponding to a brutal changing level (1,500-4,000 m). At southwest of the basin, from east to west, the anomaly isogal contours describe a serie of NW-SE, E-W, N-S directions (in U-shape) that corresponds to a volcanic ridge of Charlotte Bank, corresponding to an interval of positive and negative anomalies.

The basin extending from 174°30'E to 175°20'E has a relatively important depth of 3,250 m although the anomalies are positive (the maximum reaches 45 mgals).

Mean sedimentary concentrations are situated in Vityaz Trough referred to intermediate gravity anomalies (-50 mgals), respectively corresponding to 4,600 and 4,000 m depth. For Vityaz Trough, the anomaly isogal shape describes, from east to west, a E-W and NW-SE directions. South of the northern part, there is a rough gravity gradient between the northern volcano of east Pandora Bank and Vityaz Trough associated to the existing ridge.

Southeast of Vityaz Trough, the anomaly values are low and the maximal anomaly is about 35 mgals although the depths are around 3,000 m.

## CONCLUSION

If we compare the Southern Tuvalu Banks area with Alexa-Charlotte and East Pandora Banks, we will find an obvious difference in the gravity anomaly coverage. As a matter of fact, a mean anomaly profile data coverage does not allow us to define exactly the whole area characteristics: the anomaly isogal contours have a roughly quality. Particularly, there are few volcanoes that are well-spotted on bathymetric map while they are not taken into account in gravity anomaly plottings. However, we have found the main structures associated to correct anomaly values.

# **PRELIMINARY GEOLOGICAL SYNTHESIS**

**CHAPTER 5**

**PRELIMINARY GEOLOGICAL SYNTHESIS**

The SOPACMAPS 3 cruise was mainly devoted to the study of highs and banks belonging to the Melanesian Border Plateau. This plateau, which lies on the Pacific oceanic crust north of the fossil Vityaz Trench Lineament is considered to be the location of the convergent plate boundary between the Pacific and the Australian Plates before the late Miocene time and the beginning of the opening of the North Fiji Basin. A part of the Vityaz Trench Lineament as well as part of the North Fiji Basin around the Pandora and associated banks was mapped at the end of the SOPACMAPS 3 cruise.

### **5.1 - SOUTHERN TUVALU BANKS AREA**

The banks, guyots and seamounts of the Southern Tuvalu Banks appear to be controlled by two conjugated structural orientations trending NW-SE and ENE-WSW, suggesting that the volcanism which created these highs is mainly fissural. Seismic reflection indicates that the guyots, banks and plateau are underlain by a sedimentary cover 0.2 to 0.6 s.t.w.t.. An unconformity in the basins enclosed by these edifices is interpreted as the result of the setting of the volcanic massives and is overlain by a 0.5 to 0.6 s.t.w.t. thick post sedimentary deposits. This suggests that these constructions are relatively old. A flat terrace at the depth of 700-800 m has been recognized on most of the edifices either at the top of the guyots or along the scarps of the banks. The existence of this terrace indicates that these guyots subsided at least 700-800 m since their formation. The area and especially the southern part has been then subjected to intense normal faulting that cut the crust into a series of tilted blocks, horsts and grabens trending NNW-ESE, and tilted and collapsed some large guyot and plateau. This normal faulting is interpreted as the result of the bending of the subducting Pacific Plate in front of the Vityaz Subduction Zone. Trend of normal fault set indicates the motion of convergence was WSW-ENE. The area appears to have been intruded by relatively recent volcanism which could be related to the the normal faulting and induced by the functioning of the Vityaz Trench Subduction Zone.

### **5.2 - ALEXA-CHARLOTTE BANKS**

Not available for the preliminary report, will be provided with the final report.

# **ENVIRONMENTAL CONDITIONS**

**CHAPTER 6**  
**ENVIRONMENTAL CONDITIONS**

## 6.1 - WEATHER OBSERVATIONS

Date	Wind* (Sector - Force)	Sea*	Swell*	Sky	Pressure (hPa)	Sea temp. (°C)	Air temp. (°C)
24/09/93	SE-5	3	0	5	1012.9	27.5	27.8
25/09/93	SE-5	3	3	8	1012.2	27.8	27.2
26/09/93	SE-2	1	1	5	1011.5	27.8	29.2
27/09/93	SE-3	0	1	4	1012.2	28.0	28.4
28/09/93	SE-3	1	1	1	1011.4	28.5	28.4
29/09/93	SE-4	1	1	5	1012.1	28.3	28.0
30/09/93	SSE-6	3	3	8	1012.2	27.8	27.3
01/09/93	SSE-5	2	3	8	1010.9	27.7	25.2
02/09/93	SEE-6	4	3	8	1011.2	27.3	23.8
03/10/93	SE-5	1	3	8	1011.9	27.4	23.2
04/10/93	ENE-4	2	3	8	1011.1	27.0	25.6
05/10/93	SE-7	4	3	8	1014.6	27.0	25.2
06/10/93	SE-6	3	3	4	1015.7	27.5	27.8
07/10/93	SE-6	4	3	3	1016.3	26.4	26.4
08/10/93	SE-6	3	3	2	1014.3	27.6	26.2
09/10/93	SE-4	2	1	7	1013.5	27.3	26.5
10/10/93	SE-5	1	1	2	1012.8	27.1	25.8
11/10/93	SE-5	2	0	4	1013.2	27.1	26.2
12/10/93	ESE-5	2	1	5	1011.9	27.2	26.8
13/10/93	SE-5	2	1	5	1011.1	27.3	26.8
14/10/93	SE-6	3	3	8	1013.6	27.0	27.2
15/10/93	SE-5	2	3	8	1014.7	26.7	27.3
16/10/93	SE-6	2	3	7	1015.2	26.7	26.5
17/10/93	SE-6	3	3	4	1013.8	26.6	26.2
18/10/93	SE-4	1	3	5	1015.0	26.2	26.0
19/10/93	SE-4	1	1	3	1017.2	24.1	23.8
20/10/93	E-3	0	1	2	1018.0	22.7	22.4

\* Weather codifications

SEA (Douglas Scale)	SWELL (Douglas Scale)	WIND (Beaufort Scale)
0 - calm	0 - no swell	0 - calm
1 - smooth	1 - low swell, short or average length	1 - light air
2 - slight	2 - low swell, long	2 - light breeze
3 - moderate	3 - moderate swell, short	3 - gentle breeze
4 - rough	4 - moderate swell, average length	4 - moderate breeze
5 - very rough	5 - moderate swell, long	5 - fresh breeze
6 - high	6 - heavy swell, short	6 - strong breeze
7 - very high	7 - heavy swell, average length	7 - near gale
8 - precipitous	8 - heavy swell, long	8 - gale
9 - confused	9 - confused swell	9 - strong gale
		10 - storm
		11 - violent storm
		12 - hurricane

## 6.2 - MARITIME TRAFFIC AND SURFACE CURRENTS

N.B.: No maritime traffic has been encountered during this cruise.

Date	Latitude	Longitude	Currents	Type of Ships / Remarks
	South	East/West	Force & Direction	
23/09/93	15°51.8	W 179°12.9	0.4 knot - 340	
24/09/93	11°58.6	W 179°21.2	0.1 knot - 230	
25/09/93	10°41.7	E 179°17.9	1.2 knot - 220	
26/09/93	10°43.0	E 179°50.1	0.6 knot - 310	
27/09/93	10°34.1	E 179°54.0	0.3 knot - 290	
28/09/93	10°20.2	W 179°24.8	0.4 knot - 180	
29/09/93	11°06.7	E 179°14.4	0.3 knot - 330	
30/09/93	11°33.5	E 179°26.7	1.2 knot - 230	
01/10/93	11°45.2	E 179°18.0	1.1 knot - 170	
02/10/93	12°04.5	E 179°48.2	2.0 knot - 310	
03/10/93	11°07.9	E 178°36.3	0.4 knot - 190	Sea bird (noddie) on board, 19:15
04/10/93	12°26.7	E 179°21.2	0.0 knot - 00	
05/10/93	12°28.0	E 179°11.4	2.0 knot - 300	Sea birds (noddies & boobies) fishing
06/10/93	11°08.5	E 177°47.9	0.8 knot - 310	
07/10/93	12°38.8	E 177°54.3	0.7 knot - 270	
08/10/93	11°43.0	E 178°29.7	1.3 knot - 280	
09/10/93	11°42.2	E 177°19.2	0.2 knot - 300	Dolphinfish (Coryphaena) fished, 20:00
10/10/93	11°24.0	E 175°24.7	0.1 knot - 260	
11/10/93	12°08.4	E 175°04.2	0.0 knot - 00	Sea birds (noddies & boobies) fishing
12/10/93	12°00.0	E 174°43.9	0.7 knot - 300	
13/10/93	11°36.0	E 174°05.2	0.3 knot - 220	
14/10/93	11°49.2	E 173°25.7	1.0 knot - 350	
15/10/93	12°08.9	E 173°17.2	0.4 knot - 100	
16/10/93	12°16.3	E 172°41.3	0.1 knot - 280	
17/10/93	12°47.4	E 173°21.2	1.5 knot - 280	
18/10/93	14°53.4	E 172°28.4	0.3 knot - 300	
19/10/93	18°26.2	E 170°13.0	0.3 knot - 340	
20/10/93	21°42.0	E 167°35.2	0.8 knot - 190	

# **POTENTIAL RESOURCES**

<p style="text-align: center;"><b>CHAPTER 7</b></p> <p style="text-align: center;"><b>POTENTIAL RESOURCES</b></p>
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## **7.1 - SOUTHERN TUVALU BANKS AREA**

### **7.1.1 - Fishing activities**

The area comprises large banks, seamounts and plateau. The morphology of these highs suggests that they are drowned atolls. Due to the volcanic nature of the substratum of these highs, and the associated soft sediments cover, the relatively low total sedimentary thickness in the enclosed and adjacent basins, and the present-day sedimentary deposit processes in the basins, the most obvious economic potentiality evidenced by our mapping survey is by the far the fishing activity.

The bathymetric data gained during our cruise allows to present a detailed and almost full coverage map of the area and to precisely locate and delimit zones of shallow water depth. All the isolated banks and shoals reported on the hydrographic charts west or southwest of the Hera-Bayonnaise Bank and east or south of the Kosciusko-Martha Bank have not been found during our survey and likely are wrongly located peaks belonging to the two previously cited banks. Three zones of very shallow water depths, which are the best candidates for fishing activity, exist in the surveyed area. They include the large Hera-Bayonnaise bank in the south (40 x 90 km), the large Kosciusko-Martha Bank in the north (60 x 20 km) where 30 and 80 m depths have been recorded, and the small Luao Bank in the northeast (8 x 2 km) where a 15-20 m depth has been recorded.

Another interesting area for the fishing activity is the 750 m deep large northern part of the Eaglestone Plateau in the western part of the studied area (40 x 40 km) and the 650 to 900 m deep flat topped guyots lying along newly discovered Seamount Chains, north of the Eaglestone Plateau, west and northwest of the Hera-Bayonnaise Bank and south of the Luao Bank. These guyots and plateau can constitute good sites for fishing deep species.

### 7.1.2 - Polymetallic nodules

As a general rule, polymetallic nodules are located in the deep basins where specific conditions of sedimentation occur. In these areas, generally located around 4500 to 5000 m of water depth, the youngest sediments are mainly constituted by siliceous ooze associated to detritic particles. The sedimentation rate is low (around 1m/My). Noteworthy is that polymetallic nodules are not reported in the equatorial belt (a high productivity zone) where the sedimentation rate is important.

As indicated before, the basins mapped during the survey on Southern Tuvalu Banks Area are assumed to be the place where carbonate sedimentation and turbidite activity (proximal and more or less distal) occur. These conditions of sedimentation are not favourable to the formation of polymetallic nodules and it can be assumed that these concretions, as they are classically known in the North Pacific, for example, will not be encountered in the study area.

### 7.1.3 - Cobalt rich crusts

Detailed studies conducted on these polymetallic concretions in the Pacific Ocean and more particularly in the E.E.Z. of French Polynesia (Le Suavé *et al*, 1989) show that the cobalt rich crusts are frequent on bathymetric highs (presently observed between 500 to 1200-1300 m of water depth) which have been preserved from important sedimentation by bottom currents activity. The various studies carried out on these concretions (bathymetry, seismic reflection, 3.5 kHz, side looking sonar data), and the in situ observations and sampling, clearly indicate that on geological structures such as drowned atolls, cobalt crusts are associated to neritic carbonates located on the external coral ring.

Even if in situ seafloor observations and sampling have not been operated in the Southern Tuvalu Banks Area, it can be assumed that in some places, regional conditions (subsidence) and local conditions (water depth, absence of sediments) may be favourable to the occurrence of such mineralizations. Nevertheless, it must be noted that the extension of these potential areas (such as the outer ring of Eaglestone Plateau and the shallowest slopes of the C.S.C northern seamount) should probably bring to a reduced potential economic interest.

## **7.2 - ALEXA, CHARLOTTE, SIMONE AND ROBERT BANKS AREA**

### **7.1.1 - Fishing activities**

As for the Southern Tuvalu Banks area, the most obvious economic potentiality evidenced by our mapping survey is by the far the fishing activity. The area is mainly characterized by four main high banks which represent the best candidates for fishing activities. Although our profiles do not cross the banks, their shape and extension are now well known. The Alexa Bank appears slightly larger than it was expected on the basis of the hydrographic chart. The contours of the Charlotte Bank are now well known. Most of the shoals and even one reef reported in 1992 have not been found at the location indicated on the hydrographic map. Size of the Charlotte massif is about 80 x 20 km. However the size of the shallow depth summit is not known. South of the Vityaz Trough and in the EEZ of Solomon Islands, two large volcanoes have been contoured. The largest one (18 x 30 km) named Simone Bank is located more or less close to the previously reported shoals. The second one (12 km in diameter and named Robert Bank) has been discovered during this cruise. The shape of these edifices suggest that they likely rise to very shallow water depths.

### **7.2.2 - Polymetallic nodules and cobalt rich crusts**

The sedimentation in the Alexa, Charlotte, Simone and Robert Banks Area has been through the different ages controlled by the same general processes than the Southern Tuvalu Banks Area: on the banks, carbonate deposits of neritic type in the early stages of the subsidence and deposition of carbonate ooze up to present times; in the basins, and depending on the vicinity of reliefs and possibility of turbidite inputs, deposition of a mixture of carbonate and turbiditic sediments. In this context, as for the previous study area, there is no favourable elements for the occurrence of polymetallic nodules.

Cobalt rich crusts may be found in a few places where a high energy reflectivity is observed. Those possible sites, considered with the necessary shallow water criteria, can be identified as the upper flank (and the top ?) of Simone and Robert Banks. On an other hand, Alexa and Charlotte Banks might be concerned with the subject, but as no investigation has been conducted on banks and their boundaries, the occurrence of polymetallic crusts must be considered as very hypothetical.

# **PRELIMINARY CONCLUSIONS**

<p style="text-align: center;"><b>CHAPTER 8</b></p> <p style="text-align: center;"><b>PRELIMINARY CONCLUSIONS</b></p>
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The SOPACMAPS 3 cruise was focused on the southern part of the EEZ of Tuvalu, the northern part of the EEZ of Fiji and the easternmost part of EEZ of Solomon Islands. Two large zones belonging to the Melanesian Border Plateau lying north and along the North Fiji Basin have been mapped and imaged during this cruise.

The first area of about 60,000 km<sup>2</sup> is located around the Hera-Bayonnaise Bank, Kosciusko-Martha Bank and Eaglestone Plateau. The second area of about 30,000 km<sup>2</sup> is located around the Alexa Bank, Charlotte Bank and Banks east of Pandora Bank. Seismic reflexion, magnetic and gravity data have been also collected in these both areas along about 8,200 km of profiles.

The almost full coverage bathymetric and imagery maps and the collected geophysical data largely increase our geological understanding of this almost unknown area. Moreover previously reported different banks have been precisely located and contoured, and new highs and chains of seamount have been found. These shallow water areas could represent good targets for fishing activities.

**ENCLOSURES**

**CHAPTER 9**

**ENCLOSURES**

Reminding of the codes used in the following tables:

Surveyed Areas		Documents	
Alexa Charlotte Banks Area	ACBA	Acoustic Imagery	ACI
South Suva Harbour Area	SSHA	Seismic Reflection Profiler	SRP
South Tuvalu Banks Area	STBA	Sippican Probe	SIP
		Sub-Bottom Profiler	SBP

**ENCLOSURE 1**  
**STAFF**

**R/V L'ATALANTE**  
(September, 22nd to October, 20th, 1993)

STAFF	NAME	COMPANY
Representatives	HANUAGI Tony PATALO Fanoanoagu CATAKI Viliame SICHOIX Lydie	S.I.Hydrographic Solomon Islands Lands & Survey Dpt, Tuvalu Fiji Hydrographic Service Pacific French University
Chief Scientist	<b>PELLETIER Bernard</b>	<b>ORSTOM Nouméa</b>
Watch: 0:00-4:00	SAGET Philippe LEAU Hélène LE ROY Pascal <i>PATALO Fanoanoagu</i>	IFREMER-DRO/GM UBO Brest UBO Brest
4:00-8:00	ASLANIAN Daniel FLEUTELOT Corinne <i>PATAKY Viliame</i> RIGAUT Frédéric	UBO Brest UBO Brest UBO Brest
8:00-12:00	LE SUAVE Raymond <i>HANUAGI Tony</i> <i>SICHOIX Lydie</i> TOUSSAINT Bertrand	IFREMER-DRO/GM ORSTOM Villefranche
EM12 multibeam <i>Acquisition</i>	JANNEZ Michel LE DOARE Jacques LOUSSOUARN Claude	GENAVIR GENAVIR GENAVIR
<i>Processing</i> Bathymetry Acoustic imagery	GUEGUEN Bernard LEBELLEGARD Pierre	GENAVIR ORSTOM Nouméa
Seismic reflexion <i>Acquisition</i>	LE PHILIPPE Jean-Luc QUEINNEC Yvon	GENAVIR GENAVIR
Cartography	PERRIER Julien	ORSTOM Nouméa
Secretary	CORNEC Jacques	IFREMER-DRO/GM

**ENCLOSURE 2**  
**LOGBOOK**

Date	Area	Profile number	Time			Beginning of profile		End of profile	
			Start	End	Total	Latitude	Longitude	Latitude	Longitude
21/09/93	SSHA	PR193	21:48	22:15	0 00:27	S 18° 10.30	E 178° 23.83	S 18° 13.33	E 178° 26.50
		PR194	22:19	23:32	0 01:13	S 18° 14.07	E 178° 26.31	S 18° 21.70	E 178° 16.83
22/09/93		PR195	02:18	04:16	0 01:58	S 18° 22.74	E 178° 17.86	S 18° 16.76	E 178° 40.68
22/09/93	Transit	TR6	04:17	07:35	0 03:18	S 18° 16.76	E 178° 40.68	S 18° 20.20	E 179° 18.67
		TR7	07:40	15:27	0 07:47	S 18° 20.00	E 179° 19.50	S 17° 09.90	W 179° 46.43
		TR8	15:27	19:51	0 04:24	S 17° 09.90	W 179° 45.61	S 16° 34.98	W 179° 06.65
		TR9	19:53	22:58	0 03:05	S 16° 34.98	W 179° 06.65	S 15° 59.85	W 179° 03.20
		TR10	23:00	00:47	0 01:47	S 15° 59.55	W 179° 03.61	S 15° 45.26	W 179° 20.70
23/09/93		TR11	00:47	19:15	0 18:28	S 15° 45.26	W 179° 20.70	S 12° 25.00	W 179° 25.00
23/09/93	STBA	PR196	19:17	21:27	0 02:10	S 12° 24.50	W 179° 24.27	S 12° 14.43	W 179° 06.85
		PR197	21:54	01:45	0 03:51	S 12° 14.39	W 179° 07.20	S 11° 45.52	W 179° 33.05
24/09/93		PR198	02:23	06:57	0 04:34	S 11° 42.12	W 179° 29.51	S 12° 14.33	W 179° 01.23
		PR199	07:07	09:49	0 02:42	S 12° 15.67	W 179° 01.31	S 12° 29.82	W 179° 24.75
		PR200	10:14	13:12	0 02:58	S 12° 27.00	W 179° 28.04	S 12° 05.78	W 179° 49.28
		PR201	13:16	13:47	0 00:31	S 12° 05.15	W 179° 49.36	S 12° 00.43	W 179° 48.11
		PR202	13:53	23:12	0 09:19	S 11° 59.58	W 179° 48.46	S 10° 46.91	E 179° 14.00
25/09/93		PR203	00:11	07:36	0 07:25	S 10° 41.90	E 179° 19.45	S 11° 34.35	W 179° 35.56
		PR204	08:33	13:24	0 04:51	S 11° 28.72	W 179° 50.13	S 10° 51.35	E 179° 36.73
		PR205	13:24	15:15	0 01:51	S 10° 51.35	E 179° 36.73	S 10° 52.64	E 179° 18.31
		PR206	15:39	17:04	0 01:25	S 10° 53.35	E 179° 19.94	S 10° 41.20	E 179° 27.54
		PR207	17:10	18:38	0 01:28	S 10° 40.22	E 179° 27.53	S 10° 28.54	E 179° 14.41
		PR208	18:45	20:35	0 01:50	S 10° 25.65	E 179° 24.56	S 10° 18.80	E 179° 41.31
		PR209	20:42	22:55	0 02:13	S 10° 19.43	E 179° 42.03	S 10° 40.51	E 179° 44.12
		PR210	23:00	00:54	0 01:54	S 10° 40.48	E 179° 44.74	S 10° 51.42	E 179° 48.82
26/09/93		PR211	00:54	05:13	0 04:19	S 10° 51.42	E 179° 48.82	S 11° 24.56	W 179° 41.92
		PR212	06:07	10:10	0 04:03	S 11° 18.92	W 179° 36.34	S 10° 48.17	E 179° 56.58
		PR213	10:12	12:16	0 02:04	S 10° 47.91	E 179° 56.41	S 10° 26.44	E 179° 48.37
		PR214	12:48	18:50	0 06:02	S 10° 26.25	E 179° 48.24	S 11° 15.16	W 179° 30.43
		PR215	19:41	02:20	0 06:39	S 11° 09.61	W 179° 24.21	S 10° 14.32	E 179° 49.42
27/01/00		PR216	03:06	09:41	0 06:35	S 10° 10.82	E 179° 56.83	S 11° 03.37	W 179° 18.72
		PR217	10:34	16:45	0 06:11	S 10° 58.07	W 179° 12.62	S 10° 06.99	W 179° 55.33
		PR218	17:24	21:44	0 04:20	S 10° 04.50	W 179° 55.33	S 10° 36.10	W 179° 20.88
		PR219	22:38	02:30	0 03:52	S 10° 30.74	W 179° 15.08	S 10° 03.39	W 179° 43.02
28/09/93		PR220	02:46	05:27	0 02:41	S 10° 10.15	W 179° 42.42	S 10° 18.13	W 179° 40.81
		PR221	05:38	06:53	0 01:15	S 10° 19.56	W 179° 41.94	S 10° 28.74	W 179° 51.59
		PR222	07:00	07:56	0 00:56	S 10° 29.83	W 179° 51.34	S 10° 37.82	W 179° 46.11
	PR223	07:56	08:37	0 00:41	S 10° 37.81	W 179° 46.11	S 10° 43.45	W 179° 50.63	
	PR224	08:39	10:01	0 01:22	S 10° 43.81	W 179° 50.55	S 10° 54.89	W 179° 42.59	
	PR225	10:07	12:24	0 02:17	S 10° 55.91	W 179° 42.77	S 11° 02.67	E 179° 53.69	
	PR226	12:27	13:16	0 00:49	S 11° 02.48	E 179° 53.24	S 10° 56.65	E 179° 46.48	
	PR227	13:17	14:47	0 01:30	S 10° 56.65	E 179° 46.48	S 11° 05.95	E 179° 34.07	
	PR228	14:52	15:37	0 00:45	S 11° 06.65	E 179° 34.10	S 11° 12.30	E 179° 38.89	
	PR229	15:42	16:46	0 01:04	S 11° 13.19	E 179° 38.96	S 11° 21.93	E 179° 35.65	
	PR230	17:06	21:21	0 04:15	S 11° 21.58	E 179° 34.82	S 10° 50.74	E 179° 08.43	
29/09/93	PR231	22:20	14:17	0 15:57	S 10° 55.66	E 179° 02.20	S 12° 32.74	W 179° 26.10	
30/09/93	PR232	15:39	02:00	0 10:21	S 12° 39.52	W 179° 36.52	S 11° 17.44	E 179° 13.92	
	PR233	02:53	15:12	0 12:19	S 11° 22.07	E 179° 08.37	S 12° 43.67	W 179° 43.23	
	PR234	16:00	05:12	0 13:12	S 12° 47.10	W 179° 49.45	S 11° 01.41	E 178° 41.39	

Date	Area	Profile number	Time			Beginning of profile		End of profile	
			Start	End	Total	Latitude	Longitude	Latitude	Longitude
01/10/93		PR235	06:15	09:42	0 03:27	S 11° 55.51	E 178° 48.05	S 11° 19.80	E 179° 09.84
		PR236	09:45	10:43	0 00:58	S 11° 19.89	E 179° 10.37	S 11° 17.59	E 179° 19.72
		PR237	10:48	12:26	0 01:38	S 11° 17.90	E 179° 20.27	S 11° 28.47	E 179° 28.36
		PR238	12:34	13:08	0 00:34	S 11° 28.26	E 179° 29.30	S 11° 24.03	E 179° 32.63
		PR239	13:11	14:00	0 00:49	S 11° 23.10	E 179° 32.59	S 11° 16.57	E 179° 26.94
		PR240	14:08	15:57	0 01:49	S 11° 16.76	E 179° 25.84	S 11° 31.07	E 179° 20.72
		PR241	15:57	16:44	0 00:47	S 11° 31.07	E 179° 20.72	S 11° 36.16	E 179° 16.08
		PR242	16:45	18:42	0 01:57	S 11° 36.16	E 179° 16.08	S 11° 48.61	E 179° 24.86
		PR243	18:42	20:35	0 01:53	S 11° 48.61	E 179° 24.86	S 11° 58.15	E 179° 35.38
		PR244	20:38	21:17	0 00:39	S 11° 58.19	E 179° 35.85	S 11° 56.44	E 179° 41.67
		PR245	21:19	21:57	0 00:38	S 11° 56.28	E 179° 41.93	S 11° 51.33	E 179° 46.31
		PR246	22:01	22:34	0 00:33	S 11° 51.52	E 179° 46.91	S 11° 54.67	E 179° 49.67
		PR247	22:38	23:13	0 00:35	S 11° 55.30	E 179° 49.52	S 11° 58.95	E 179° 45.01
		PR248	23:17	23:38	0 00:21	S 11° 59.62	E 179° 45.01	S 12° 04.50	E 179° 48.06
02/10/93		PR249	00:04	02:18	0 02:14	S 12° 04.86	E 179° 48.79	S 12° 11.20	W 179° 54.80
		PR250	02:08	07:03	0 04:55	S 12° 11.20	W 179° 11.20	S 12° 41.23	W 179° 26.24
		PR251	07:00	09:52	0 02:52	S 12° 41.23	W 179° 26.24	S 12° 58.97	W 179° 50.02
03/10/93		PR252	09:55	01:13	0 15:18	S 12° 58.92	W 179° 50.53	S 11° 58.45	E 178° 28.35
		PR253	02:07	19:03	0 16:56	S 11° 03.42	E 178° 22.00	S 12° 57.39	E 179° 57.42
04/10/93		PR254	19:05	19:44	0 00:39	S 12° 57.89	E 179° 57.03	S 13° 01.72	E 179° 57.42
		PR255	19:45	10:30	0 14:45	S 13° 01.69	E 179° 50.61	S 10° 59.35	E 178° 07.67
05/10/93		PR256	11:22	02:57	0 15:35	S 11° 04.80	E 179° 01.93	S 12° 42.87	E 179° 23.53
06/10/93		PR256B	02:43	06:46	0 04:03	S 12° 42.87	E 179° 23.53	S 13° 06.97	E 179° 44.00
		PR257	07:21	23:07	0 15:46	S 12° 09.97	E 179° 38.82	S 11° 02.43	E 177° 51.53
		PR258	23:48	18:43	0 18:55	S 11° 07.02	E 177° 46.66	S 13° 13.44	E 179° 32.68
07/10/93		PR259	19:27	09:35	0 14:08	S 11° 53.00	E 178° 15.91	S 11° 19.70	E 179° 48.04
		PR260	09:59	13:00	0 03:01	S 11° 22.08	E 177° 46.00	S 11° 39.12	E 178° 00.92
08/10/93		PR261	13:27	18:37	0 05:10	S 11° 36.75	E 178° 06.71	S 12° 13.20	E 178° 38.27
		PR262	18:42	19:12	0 00:30	S 12° 13.10	E 178° 39.02	S 12° 09.74	E 178° 38.27
		PR263	19:19	22:26	0 03:07	S 12° 08.67	E 178° 42.63	S 11° 42.36	E 178° 20.34
		PR264	23:18	02:34	0 03:16	S 11° 38.69	E 178° 25.52	S 12° 02.98	E 178° 46.08
		PR265	03:22	08:49	0 05:27	S 11° 58.46	E 178° 51.23	S 11° 13.94	E 178° 13.75
		PR266	08:55	12:46	0 03:51	S 11° 13.08	E 178° 14.05	S 11° 02.13	E 178° 46.36
		PR267	13:03	18:52	0 05:49	S 11° 03.85	E 178° 49.20	S 11° 26.38	E 177° 58.55
		PR268	18:57	19:51	0 00:54	S 11° 27.14	E 177° 58.59	S 11° 33.63	E 178° 04.01
08/10/93	ACBA	PR269	19:56	06:52	0 10:56	S 11° 34.17	E 178° 03.51	S 11° 57.13	E 176° 13.20
09/10/93		PR270	06:52	10:16	0 03:24	S 11° 57.13	E 176° 13.20	S 11° 40.90	E 175° 41.22
		PR271	11:06	14:14	0 03:08	S 11° 45.48	E 175° 35.50	S 11° 58.53	E 176° 01.10
		PR272	15:11	21:08	0 05:57	S 12° 00.95	E 175° 51.50	S 11° 38.88	E 175° 04.62
10/10/93		PR273	21:27	01:30	0 04:03	S 11° 34.34	E 175° 05.12	S 11° 18.80	E 175° 35.73
		PR274	01:30	02:43	0 01:13	S 11° 18.80	E 175° 35.73	S 11° 18.83	E 175° 47.39
		PR275	02:43	06:45	0 04:02	S 11° 18.83	E 175° 47.39	S 11° 42.00	E 176° 09.72
		PR276	06:45	11:41	0 04:56	S 11° 42.00	E 176° 09.72	S 11° 43.70	E 176° 51.11
		PR277	13:13	19:35	0 06:22	S 11° 55.19	E 176° 50.26	S 12° 08.41	E 175° 49.94
		PR278	19:35	05:05	0 09:30	S 12° 08.41	E 175° 49.94	S 12° 08.40	E 174° 11.82

Date	Area	Profile number	Time			Beginning of profile		End of profile	
			Start	End	Total	Latitude	Longitude	Latitude	Longitude
11/10/93		PR279	08:45	21:55	0 13:10	S 12° 08.58	E 174° 09.50	S 11° 59.99	E 174° 23.22
		PR280	21:55	05:30	0 07:35	S 11° 59.99	E 174° 23.22	S 12° 00.01	E 175° 34.80
12/10/93		PR281	05:38	06:27	0 00:49	S 11° 58.92	E 175° 34.78	S 11° 52.33	E 175° 28.61
		PR282	06:35	12:04	0 05:29	S 11° 52.00	E 175° 27.16	S 11° 51.99	E 174° 26.87
		PR283	13:02	17:50	0 04:48	S 11° 44.04	E 174° 23.18	S 11° 43.99	E 175° 09.07
		PR284	18:55	02:44	0 07:49	S 11° 36.98	E 174° 59.78	S 11° 33.98	E 173° 35.77
13/10/93		PR285	03:36	12:39	0 09:03	S 11° 29.02	E 173° 39.24	S 11° 32.24	E 174° 58.05
		PR286	13:39	21:40	0 08:01	S 11° 28.07	E 175° 04.88	S 11° 22.52	E 173° 37.88
		PR287	21:43	01:03	0 03:20	S 11° 22.79	E 173° 37.53	S 11° 52.50	E 173° 20.14
14/10/93		PR288	01:09	05:44	0 04:35	S 11° 52.69	E 173° 19.24	S 11° 41.92	E 172° 32.08
		PR289	06:49	18:25	0 11:36	S 11° 49.48	E 172° 29.66	S 12° 13.46	E 174° 13.82
		PR290	19:24	04:45	0 09:21	S 12° 20.00	E 172° 05.90	S 11° 57.45	E 172° 27.18
15/10/93		PR291	05:44	16:30	0 10:46	S 12° 05.52	E 172° 25.76	S 12° 26.25	E 173° 57.34
		PR292	17:16	01:32	0 08:16	S 12° 32.30	E 173° 51.39	S 12° 12.51	E 172° 24.58
16/10/93		PR293	02:21	12:37	0 10:16	S 12° 19.25	E 172° 23.59	S 12° 38.05	E 173° 43.46
		PR294	13:37	19:16	0 05:39	S 12° 43.92	E 173° 36.67	S 12° 38.32	E 172° 43.46
		PR295	19:37	01:02	0 05:25	S 12° 39.21	E 172° 44.91	S 12° 49.33	E 173° 29.40
17/10/93		PR296	01:57	06:20	0 04:23	S 12° 55.13	E 173° 23.14	S 12° 44.34	E 172° 35.56
		PR297	08:07	12:11	0 04:04	S 12° 52.93	E 172° 40.97	S 13° 00.89	E 173° 16.85
18/10/93	Transit	TR12	12:18	21:59	0 09:41	S 13° 01.87	E 173° 17.14	S 14° 35.28	E 172° 39.80
		TR13	21:59	04:45	1 06:46	S 14° 35.28	E 172° 39.80	S 19° 10.00	E 169° 45.50
19/10/93		TR14	05:19	07:49	0 02:30	S 19° 12.54	E 169° 45.20	S 19° 39.70	E 169° 49.98
		TR15	07:49	21:00	0 13:11	S 19° 39.70	E 169° 49.98	S 21° 12.90	E 167° 48.98
		TR16	21:24	04:30	0 07:06	S 21° 12.90	E 167° 48.98	S 22° 18.76	E 167° 07.86

**ENCLOSURE 3**  
**PROFILES TABLE**

*This table provides the list of survey profiles by roll (all kind of documents).*

Area	Profile nr.	ACI roll nr.	SBP 3,5 khz roll nr.	SEISMIC SRP	
				(narrow-4 sec) roll nr.	(wide-10 sec) roll nr.
SSHA	PR193	1	1	-	-
	PR194	1	1	-	-
	PR195	1	1	-	-
Transit	TR6	1	1	-	-
	TR7	1	1	-	-
	TR8	1	2	-	-
	TR9	1	2	-	-
	TR10	1	2	-	-
	TR11	1	2	-	1
STBA	PR196	1	2	-	1
	PR197	1	2	-	1
	PR198	1	2	1	2
	PR199	1	2	1	2
	PR200	1	2	1	2
	PR201	1	2	1	3
	PR202	1	2	1	3
	PR203	1	2	1	3
	PR204	1	2	1	3
	PR205	1	2	1	3
	PR206	1	2	1	3
	PR207	1	2	1	3
	PR208	1	2	1	3
	PR209	1	2	1	3
	PR210	1	2	1	3
	PR211	1	2	1	3
	PR212	1	2	1	4
	PR213	1	2	1	4
	PR214	1	2	1	4
	PR215	1	2	1	4
	PR216	1	2	1	4
	PR217	1	2	1	4
	PR218	1	2	1	4
	PR219	1	2	1	4
PR220	1	2	1	-	
PR221	1	2	1	-	
PR222	1	2	1	-	
PR223	1	2	1	-	
PR224	1	2	1	-	

Area	Profile nr.	ACI roll nr.	SBP 3,5 khz roll nr.	SEISMIC SRP	
				(narrow-4 sec) roll nr.	(wide-10 sec) roll nr.
	PR225	1	2	1	-
	PR226	1	2	1	-
	PR227	1	2	1	-
	PR228	1	2	1	-
	PR229	1	2	1	-
	PR230	1	2	1	5
	PR231	1	2	1	5 & 6
	PR232	1	2	2	6
	PR233	1	2	2	6
	PR234	1	2	2	7
	PR235	1	2	2	7
	PR236	1	2	2	7
	PR237	1	2	2	7
	PR238	1	2	2	7
	PR239	1	2	2	7
	PR240	1	2	2	7
	PR241	1	2	2	7
	PR242	1	2	2	7
	PR243	1	2	2	7
	PR244	1	2	2	7
	PR245	1	2	2	7
	PR246	1	2	2	7
	PR247	1	2	2	7
	PR248	1	2	2	7
	PR249	1	2	2	7
	PR250	1	3	2	7
	PR251	1	3	2	7
	PR252	1	3 & 4	2	8
	PR253	1	4	2	8
	PR254	1	4	2	8
	PR255	1	4	2	8
	PR256	1	4	2	8
	PR256B	1	4	2	8
	PR257	1	4	2	9
	PR258	1	4	2	9
	PR259	1	4	2	9
	PR260	1	4	2	9
	PR261	1	4	2	10
	PR262	1	4	2	10
	PR263	1	4	2	10

Area	Profile nr.	ACI roll nr.	SBP 3,5 khz roll nr.	SEISMIC SRP	
				(narrow-4 sec) roll nr.	(wide-10 sec) roll nr.
ACBA	PR264	1	4	2	10
	PR265	1	4	2	10
	PR266	1	4	2	10
	PR267	1	4	2	10
	PR268	1	4	2	10
	PR269	1	4	2	10
	PR270	1	4	2	-
	PR271	1	4	2	-
	PR272	1	4	2	-
	PR273	1	4	2	-
	PR274	1	4	2	-
	PR275	1	4	2	-
	PR276	1	4	2	-
	PR277	1	4	2	11
	PR278	1	4	2	11
	PR279	1	4	2	-
	PR280	1	4	2	11
	PR281	1	4	2	11
	PR282	1	4	2	11
	PR283	1	4	2	11
	PR284	1	4	3	11
	PR285	1	5	4	11
	PR286	1	5	4	12
	PR287	1	5	4	12
	PR288	1	5	4	12
	PR289	1	5	4	12
	PR290	1	5	4	12
	PR291	1	5	4	12
	PR292	1	5	4	12
	PR293	1	5	4	13
PR294	1	5	4	13	
PR295	1	5	4	13	
PR296	1	5	4	13	
PR297	1	5	4	13	
Transit	TR12	1	5	4	14
	TR13	1	5	4	14
	TR14	1	5	-	-
	TR15	1	5	-	-
	TR16	1	5	-	-

**ENCLOSURE 4**  
**DOCUMENTS TABLE**

*This table provides the list of roll numbers (all kind of documents) by profile.*

ROLLS Type & Number	BEGINNING		END		INCLUDED PROFILES
	Date	Hour	Date	Hour	
<b>SRP (wide record) 10 seconds</b>					
1	23/09/93	14:44	24/09/93	01:54	TR11 to PR197
2	24/09/93	02:47	24/09/93	13:14	PR198 to PR200
3	24/09/93	13:16	26/09/93	05:13	PR201 to PR211
4	26/09/93	06:55	28/09/93	02:31	PR212 to PR219
5	28/09/93	17:30	29/09/93	00:23	PR230 to PR231
6	29/09/93	00:37	30/09/93	15:12	PR231 to PR233
7	30/09/93	16:02	02/10/93	09:53	PR234 to PR251
8	02/10/93	09:56	05/10/93	06:44	PR252 to PR256B
9	05/10/93	07:21	07/10/93	12:44	PR257 to PR260
10	07/10/93	13:38	09/10/93	03:20	PR261 to PR269
11	10/10/93	13:14	13/10/93	12:39	PR277 to PR285
12	13/10/93	13:39	16/10/93	01:32	PR286 to PR292
13	16/10/93	02:33	17/10/93	12:11	PR293 to PR297
14	17/10/93	12:21	19/10/93	04:42	TR12 - TR13
<b>SRP(narrow rec.)</b>					
1	23/09/93	14:50	29/09/93	15:30	PR198 to PR231
2	29/09/93	15:49	12/10/93	17:50	PR232 to PR283
3	12/10/93	18:56	12/10/93	20:30	PR284
4	12/10/93	20:30	19/10/93	04:45	PR284 to TR13
<b>SBP 3.5 khz</b>					
1	21/09/93	21:40	22/09/93	15:04	PR193 to TR7
2	22/09/93	15:05	02/10/93	03:35	TR8 to PR249
3	02/10/93	03:40	02/10/93	18:00	PR250 to PR252
4	02/10/93	17:45	13/10/93	02:44	PR252 to PR284
5	13/10/93	03:00	20/10/93	04:33	PR285 to TR16
<b>ACI</b>					
1	21/09/93	21:40	20/10/93	04:45	PR193 to TR16

**ENCLOSURE 5**  
**SEISMIC PROFILES TAPES**

*This table provides the list of hexabyte tapes by seismic profile.*

Tape Number	Beginning		End		SEISMIC PROFILE NAME
	Date	Time	Date	Time	
198	23/09/93	14:46	23/09/93	19:13	TR11
199	23/09/93	19:17	24/09/93	01:46	PR196 - PR197
200	24/09/93	02:23	24/09/93	06:57	PR198
201	24/09/93	07:07	24/09/93	13:47	PR199 - PR200 - PR201
202	24/09/93	13:53	24/09/93	20:20	PR202
203	24/09/93	20:31	24/09/93	20:55	PR202
204	24/09/93	21:01	25/09/93	04:19	PR202 - PR203
205	25/09/93	04:26	25/09/93	07:39	PR203
206	25/09/93	08:33	25/09/93	12:23	PR204
207	25/09/93	12:29	25/09/93	18:39	PR204 - PR205 - PR206 - PR207
208	25/09/93	18:45	26/09/93	00:54	PR208 - PR209 - PR210
209	26/09/93	00:54	26/09/93	05:13	PR211
210	26/09/93	06:07	26/09/93	12:16	PR212 - PR213
211	26/09/93	12:48	26/09/93	18:51	PR214
212	26/09/93	19:41	27/09/93	02:12	PR215
213	27/09/93	03:06	27/09/93	09:35	PR216
214	27/09/93	10:35	27/09/93	16:45	PR217
215	27/09/93	17:24	27/09/93	21:00	PR218
216	27/09/93	21:02	27/09/93	02:30	PR218 - PR219
217	27/09/93	17:30	29/09/93	00:51	PR230 - PR231
218	29/09/93	00:59	29/09/93	07:14	PR231
219	29/09/93	07:26	29/09/93	13:46	PR231
220	29/09/93	13:53	29/09/93	20:30	PR231 - PR232
221	29/09/93	20:32	30/09/93	02:00	PR232
222	30/09/93	02:53	30/09/93	09:12	PR233
223	30/09/93	09:19	30/09/93	15:12	PR233
224	30/09/93	16:00	30/09/93	22:14	PR234
225	30/09/93	22:22	01/10/93	04:39	PR234
226	01/10/93	04:45	01/10/93	12:26	PR234 - PR235 - PR236 - PR237
227	01/10/93	12:42	01/10/93	18:42	PR238 - PR239 - PR240 - PR241 - PR242
228	01/10/93	18:49	02/10/92	02:05	PR243 to PR249
229	02/10/93	02:08	02/10/92	07:03	PR250
230	02/10/93	07:12	02/10/92	13:37	PR251 - PR252
231	02/10/93	13:43	02/10/92	19:47	PR252
232	02/10/93	19:53	03/10/93	01:13	PR252
233	03/10/93	02:07	03/10/93	08:34	PR253
234	03/10/93	08:34	03/10/93	14:53	PR253
235	03/10/93	15:00	03/10/93	21:30	PR253 - PR254 - PR255
236	03/10/93	21:37	04/10/93	03:56	PR255
237	04/10/93	04:02	04/10/93	07:10	PR255
238	04/10/93	07:25	04/10/93	13:48	PR255 - PR256
239	04/10/93	13:55	04/10/93	20:18	PR256
240	04/10/93	20:18	05/10/93	02:37	PR256
241	05/10/93	02:43	05/10/93	09:40	PR256B - PR257

Tape Number	Beginning		End		SEISMIC PROFILE NAME
	Date	Time	Date	Time	
242	05/10/93	09:47	05/10/93	16:05	PR257
243	05/10/93	16:02	05/10/93	22:32	PR257
244	05/10/93	22:38	06/10/93	05:00	PR257 - PR258
245	06/10/93	05:09	06/10/93	11:30	PR258
246	06/10/93	11:36	06/10/93	17:58	PR258
247	06/10/93	19:29	07/10/93	01:09	PR258 - PR259
248	07/10/93	01:15	07/10/93	07:31	PR259
249	07/10/93	13:27	07/10/93	14:07	PR259 - PR260 - PR261
250	07/10/93	14:17	07/10/93	20:47	PR261 - PR262 - PR263
251	07/10/93	20:51	08/10/93	02:34	PR263 - PR264
252	08/10/93	03:22	08/10/93	09:44	PR265 - PR266
253	08/10/93	09:50	08/10/93	16:28	PR266 - PR267
254	08/10/93	16:32	08/10/93	23:00	PR267 - PR268 - PR269
255	08/10/93	23:07	09/10/93	03:00	PR269
256	10/10/93	13:13	10/10/93	19:35	PR277
257	10/10/93	19:54	11/10/93	02:14	PR278
258	11/10/93	02:22	11/10/93	05:06	PR278
259	11/10/93	21:55	12/10/93	04:16	PR280
260	12/10/93	04:24	12/10/93	11:00	PR280 - PR281 - PR282
261	12/10/93	11:07	12/10/93	17:32	PR282 - PR283
262	12/10/93	17:44	13/10/93	01:11	PR283 - PR284
263	13/10/93	01:17	13/10/93	08:28	PR284 - PR285
264	13/10/93	08:34	13/10/93	15:52	PR285 - PR286
265	13/10/93	16:05	13/10/93	22:24	PR286 - PR287
266	13/10/93	22:36	14/10/93	05:03	PR287 - PR288
267	14/10/93	05:10	14/10/93	12:37	PR288 - PR289
268	14/10/93	12:44	14/10/93	18:24	PR289
269	14/10/93	19:24	15/10/93	01:50	PR290
270	15/10/93	01:55	15/10/93	09:12	PR290 - PR291
271	15/10/93	09:18	15/10/93	15:38	PR291
272	15/10/93	15:44	15/10/93	22:47	PR291 - PR292
273	15/10/93	23:00	16/10/93	06:10	PR292 - PR293
274	16/10/93	06:18	16/10/93	12:37	PR293
275	16/10/93	13:37	16/10/93	19:19	PR294
276	16/10/93	19:37	17/10/93	01:02	PR295
277	17/10/93	01:57	17/10/93	10:00	PR296 - PR297
278	17/10/93	10:06	17/10/93	16:32	PR297 - TR12
279	17/10/93	17:39	17/10/93	22:59	TR12
280	17/10/93	23:05	18/10/93	05:25	TR12
281	18/10/93	05:32	18/10/93	11:52	TR12 - TR13
282	18/10/93	11:58	18/10/93	18:18	TR13
283	18/10/93	18:27	19/10/93	00:46	TR13
284	19/10/93	00:53	19/10/93	04:45	TR13

**ENCLOSURE 6**  
**SIPPICAN STATIONS**

Area	SIPPICAN Number	Latitude South	Longitude East/West	Date	Time (GMT)
SSHA	PR195SIP1	18°22.599	E 178°18.406	22/09/93	02:24
Transit	TR7SIP2	17°55.557	E 179°38.910	22/09/93	10:24
	TR7SIP3	17°32.358	E 179°56.547	22/09/93	12:57
	TR9SIP4	16°22.834	W 179°05.280	22/09/93	20:57
	TR11SIP5	15°33.581	W 179°21.247	23/09/93	01:49
STBA	PR196SIP6	12°21.041	W 179°18.504	23/09/93	20:00
	PR198SIP7	11°45.631	W 179°26.263	24/09/93	02:55
	PR200SIP8	12°25.118	W 179°29.900	24/09/93	10:30
	PR203SIP9	10°43.053	E 179°20.417	25/09/93	00:22
	PR207SIP10	10°28.616	E 179°24.560	25/09/93	18:20
	PR212SIP11	11°19.920	W 179°44.230	26/09/93	07:17
	PR214SIP12	10°26.252	E 179°48.244	26/09/93	12:45
	PR215SIP13	11°05.333	W 179°27.771	26/09/93	20:16
	PR216SIP14	10°21.663	W 179°54.010	27/09/93	04:30
	PR218SIP15	10°28.573	W 179°27.853	27/09/93	20:42
	PR229SIP16	11°19.910	E 179°36.376	28/09/93	16:29
	PR231SIP17	11°42.320	E 179°45.320	29/09/93	04:49
	PR232SIP18	12°30.163	W 179°44.355	29/09/93	16:52
	PR233SIP19	11°22.640	E 179°08.699	30/09/93	03:00
	PR234SIP20	12°19.573	E 179°49.799	30/09/93	19:36
	PR252SIP21	11°49.317	E 179°11.287	02/10/93	18:40
	PR253SIP22	11°06.372	E 178°24.399	03/10/93	02:36
	PR253SIP23	11°32.338	E 178°46.105	03/10/93	06:37
	PR255SIP24	12°48.031	E 179°39.153	03/10/93	21:29
	PR256SIP25	11°53.231	E 178°42.232	04/10/93	18:25
	PR257SIP26	11°36.828	E 178°20.420	05/10/93	18:52
	PR258SIP27	12°03.941	E 178°34.251	06/10/93	07:41
	PR258SIP28	13°00.328	E 179°21.634	06/10/93	16:25
PR260SIP29	11°24.328	E 177°47.846	07/10/93	10:22	
ACBA	PR269SIP30	11°49.775	E 176°45.630	09/10/93	03:45
	PR272SIP31	11°38.981	E 175°08.940	09/10/93	20:37
	PR272SIP32	11°37.553	E 175°07.919	09/10/93	21:01
	PR276SIP33	11°42.416	E 176°44.760	10/10/93	10:53
	PR277SIP34	12°03.560	E 176°12.080	10/10/93	17:14
	PR277SIP35	12°06.136	E 176°00.315	10/10/93	18:48
	PR279SIP36	11°55.264	E 174°20.185	11/10/93	19:02
	PR285SIP37	11°29.000	E 173°49.119	13/10/93	05:19
	PR289SIP38	10°51.281	E 172°37.258	14/10/93	07:57
	PR289SIP39	12°12.000	E 174°04.000	14/10/93	17:17
	PR292SIP40	12°28.030	E 173°32.755	15/10/93	19:04
	PR293SIP41	12°42.000	E 173°40.000	16/10/93	12:47
	PR295SIP42	12°41.504	E 172°55.524	16/10/93	20:34

<b>Area</b>	<b>SIPPICAN Number</b>	<b>Latitude South</b>	<b>Longitude East/West</b>	<b>Date</b>	<b>Time (GMT)</b>
<b>Transit</b>	TR13SIP43	15°39.828	E 171°59.157	18/10/93	05:18
	TR13SIP44	18°14.055	E 170°20.963	18/10/93	22:35
	TR15SIP45	20°56.054	E 168°11.073	19/10/93	18:34

**ENCLOSURE 7**  
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