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SONNE 68 - OLGA II RESEARCH CRUISE
April 29 to June 25, 1990
PRELIMINARY CRUISE REPORT

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Prepared for: South Pacific Applied Geoscience Commission (SOPAC)
Offshore Programme

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SONNE 68 - OLGA II

RESEARCH CRUISE

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PRELIMINARY CRUISE REPORT

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September 1990

The research cruise "SONNE 68 - OLGA II" (Ozeanische Lagerstatten: Geologisch-Mineralogische Analyse = Oceanic Deposits: Geological-Mineralogical Analysis) of the University of Marburg, under the direction of Prof. Dr. Werner Tufar, was the first to conduct a detailed economic-geological mapping of coherent deposits of recent hydrothermal mineralizations ("smokers") in a back-arc basin with detailed statistical sampling.

At the beginning and the end of the research cruise a considerable number of geophysical traverses could be established on the transit routes. Starting in Suva (Fiji) the ocean floor was continuously mapped by SeaBeam across the North Fiji Basin, along the northern Vanuatu Arc, the San Cristobal Trench off the Solomon Islands, finally traversing the Solomon-New Britain Trench to Rabaul (New Britain, Papua New Guinea). Apart from bathymetric profiles, a major aim was to prove the true nature of two suspected volcanic seamounts, the Kana Keoki and the Coleman southwest of Rendova, central Solomon Islands. At least for the Kana Keoki seamount there is good evidence for a central crater (caldera) indicating its volcanic origin, while the exact topography of the Coleman seamount remains unclear.

In accordance with the high priority for study by the Papua New Guinea Government the newly found submarine Tavui Caldera just north of Rabaul was mapped at their request in detail by SeaBeam (Fig. 1). This mapping took place in close cooperation with SOPAC (Dr. Don Tiffin) and the Department of Minerals and Energy, Geological Survey of Papua New Guinea. Besides the exact morphology of the Tavui Caldera the presence of numerous previously unknown eruptive vents could be shown. Samples recovered by dredging exemplify the dominance of various types of pumice in the sediment on the caldera floor, while minor dense volcanics also occur.

The main aim of the OLGA II Research Cruise was an economic-geological investigation of the northeast Manus Spreading Center, which was mapped in detail from 3' 42' S, 149" 37' E through 3" 0' S, 150' 34' E (Figs. 2 - 3) by SeaBeam profiling and OFOS (Ocean Floor Observation System) surveys, as well as by TV Grab, revealing a number of active hydrothermal areas associated with recent hydrothermal mineralizations. The presence of these recent active hydrothermal areas and mineralizations could be substantiated and localized within the central graben of the Manus Spreading Center from the northeastern to the southwestern end of the area investigated. Fundamental to all subsequent work is the detailed bathymetric mapping, which clearly demonstrates the presence of a linear spreading ridge. Readily detected is the variable morphology of the ridge along strike. While east of 150' 12' E a distinct

central graben is discernible, it gradually disappears west of this point to eventually result in no more than a plateau. Changes in morphology are invariably linked to changes in the lava types and in the chemistry of the volcanics and the spreading rate: while fast spreading and variable chemistry typify the southwest part, more homogeneous volcanics and slow spreading are characteristic of the northeast part. However, distinct indications of hydrothermal activity (e. g. temperature anomalies, occurrence of characteristic fauna, hydrothermal precipitates) were recorded all along the ridge. Furthermore, water samples often showed methane anomalies.

In the northeast part extremely widespread and typical is the presence of homogeneous, dense, massive, mostly glassy pillow lavas in the central graben. Minor lobate, sheet, pahoehoe, and aa lava flows occur and may mostly be attributed to a less moderate morphology. Coating with manganese hydroxides and other hydrothermal precipitates (e. g. smectite) is frequently encountered around lava cavities. In proximity to hydrothermal vents, volcanics often display a thick cover of hydrothermal sediment (e. g. manganese hydroxides, nontronite) and in places considerable hydrothermal alteration. There, gradual transitions from altered to mineralized country rocks and sulfide precipitates are observed, together with stockwork mineralizations in the fissured and brecciated volcanics. Stockwork mineralizations pass directly over into sulfide chimneys. Moreover, peripheral grading of sulfide precipitates into oxides and hydroxides, respectively (hydrothermal sediment), is apparent.

Most strikingly, hydrothermal activity is documented by - even active - massive sulfide chimneys ("smokers", "black smokers") emanating colorless, milky and black "smoke" in Field 1: "Wienerwald" (Vienna Woods) centered at 3" 9.86' S, 150" 16.78' E and extending for about 1000 meters in diameter. Commonly, outlets of the hot springs are seen to branch off from central feeder channels, thereby causing lateral buildup of the chimneys. In places, repetition of this process resulted in huge sulfide chimneys and columns which can reach more than 20 meters in height. Several of these complex massive sulfide chimneys are encountered about the center of each hydrothermal vent, while the height and volume of the smokers are substantially reduced in places towards the periphery and show transition to crusts and/or low sulfide mounds. Very characteristic for the active chimneys is a dense coating consisting of gastropods, crustaceans, polychaetes, barnacles, etc. Besides sulfide chimneys and smokers, white smokers could also be found, consisting of anhydrite and opaline silica.

Smaller in size and more or less inactive, but otherwise comparable with Field 1 Wienerwald was Field 2, centered at 3" 9.47'S, 150' 17.04' E and extending for about

500 meters in diameter. By contrast, sulfide chimneys in Field 2 strike NE - SW from 3" 6.95' S, 150' 21.25' E to 3' 6.45' S, 150' 22.15' E, revealing a predominantly areal extent.

Hydrothermal activity connected with formation of sulfide chimneys was recorded for example on the plateau of the spreading ridge far to the southeast at 3'22.18'S, 150' 2.24' E. Just as in the other areas temperature anomalies are also obvious for this hydrothermal field.

The complex massive sulfide mineralizations are invariably restricted to the central graben. They occur in different spatial associations. Clusters of chimneys are commonly juxtaposed to or surrounded by partly fresh pillows. They display circular to elliptical outlines and strong hydrothermal sediment coating of the intervening ocean floor. The linear distribution of hydrotherms may be attributed to fissures paralleling the spreading axis.

Particularly apparent is the content of base metals in the sulfide chimneys recovered from the Manus Back-Arc Spreading Center. All samples are dominated by zinc sulfides, often amounting to an average of 30% - 40%. Iron sulfides contribute 20% - 30%, while copper sulfides were frequently present in considerable amounts (up to 5%, average of 2% or less). Locally, significant lead contents were analyzed (up to 2.5%). Major ore minerals are sphalerite, wurtzite, schalenblende, pyrite, marcasite, melnikovite-pyrite and in places chalcopyrite. Galena can be observed in places as an accessory ore mineral and in places as minor mineral constituent. This complex massive sulfide paragenesis is supplemented by variable amounts of gangue material (e. g. opaline silica, anhydrite, barite, native sulfur). In places the zinc sulfides contain relatively high concentrations of silver. The recovered portions of active sulfide chimneys often demonstrated the odor of hydrogen sulfide, even after being brought on board the research vessel. In conclusion, the materials recovered provide good evidence for recent hydrothermal activity and extensive ore deposition at depths of between 2000 and 2500 meters below sea level with high concentrations of base metals (notably zinc and copper).

A further characteristic for the recent hydrothermal activity is an abundant and astonishingly diverse fauna connected and associated with the recent metallogenesis. This fauna, newly discovered by the OLGA II Research Cruise, consists of polychaetes, actinians, gastropods, barnacles, crustaceans, octopods, fish etc., including previously unknown, new species. Very typical is the dense coating of the active chimneys by gas-

trpods, crustaceans, polychaetes, barnacles etc. In contrast to the fauna of the active hydrothermal fields in the northeastern part of the hydrothermal fields and areas, the southwestern part of the investigated portion of the Manus Spreading Center is characterized by tube worms (e. g. Ridgea) and pink actinians. Chemosynthetic thermophilic archaeobacteria represent the beginning of the nutritional sequence necessary for the fantastically abundant fauna associated with the hydrotherms and smokers. Consequently, the nutrient supply and hence the type and diversity of the ecosystem is determined and restricted by the degree of hydrothermal activity. Active smokers ("black smokers", as well as smokers emanating milky or colorless "smoke") are typified by a dense biological coating of polychaetes, gastropods, crustaceans, barnacles etc. Declining activity is characterized by a rapid decrease in these associated organisms, finally showing only a few barnacles. An even further decrease in hydrothermal discharge is documented by a gradual appearance of coral-like growth forms, mostly along fissures associated in places with huge actinians. The subsequent extinction of all fauna and commencing oxidation (e. g. halmyrolysis) of the complex massive sulfide chimneys indicate the lack of reducing conditions and hence terminated hydrothermal activity.

In the middle of the OLGA II Research Cruise, i. e. at the end of May and beginning of June, 1990, the USSR Academy of Sciences "Akademik Mstislav Keldysh" 21st Research Cruise, under the direction of Prof. Dr. Lisitzin, came to the Manus Spreading Center to conduct investigations. The OLGA II Cruise provided detailed SeaBeam bathymetric maps and results of OFOS (Ocean Floor Observation System) and TV Grab studies including the exact coordinates of the hydrothermal mineralized areas and active smoker fields and its associated - in part completely previously unknown - fauna together with samples to the "Akademik Mstislav Keldysh" 21st Research Cruise as a basis for the diving program with their two submersibles. These data significantly enhanced the effectiveness of the Russian submersible dives. The materials obtained by the OLGA II Cruise was impressively confirmed by the "Akademik Mstislav Keldysh" 21st Cruise. The work accomplished to date serves as an excellent example of international scientific cooperation and should form a sound basis for integrated joint future research and close cooperation.

At the end of the OLGA II Research Cruise, investigations were carried out near Lihir Island. A bathymetric map was produced of the formerly unknown area between Lihir Island and the Emirau-Feni Ridge. A distinct upwarp of the ridge was recorded. Dredging yielded Tertiary limestone. OFOS and TV Grab studies near Luke Harbour (Lihir Island) revealed a uniform dipping ocean floor of sediment which was morphologically featureless apart from occasional massive, scattered blocks of limestone. Very slight

temperature anomalies were also recorded. One small inactive chimney could be observed. Sampling yielded calcareous sediment, while hard rock was not present.

Finally, during transit, a section paralleling New Ireland, across the Solomon Plate and through the western Woodlark Basin on the way from the Manus Basin past Lihir Island to Port Moresby was mapped by SeaBeam.

It is planned to continue the already successful investigations in the Manus Basin and in the Tabar-Feni-Lihir-Bougainville chain by one of the next OLGA Research Cruises in the corning years, as soon as the R/V "Sonne" returns to this region. For the moment it is not possible to say, if this will already be in the fall of 1991, because of a longer stay of the R/V "Sonne" in a shipyard. SOPAC will be informed as soon as the respective dates for the new OLGA Research Cruise to Papua New Guinea are scheduled.

On behalf of the OLGA II Research Cruise I wish to express my sincere thanks to SOPAC and to the Government of Papua New Guinea, the Department of Minerals and Energy, Geological Survey, for their professional support, which contributed substantially to the success of the OLGA II Research Cruise, as well as to the Federal German Minister for Research and Technology (BMFT) for funding of the OLGA Research Project. My particular thanks are due to the German Ambassador in Papua New Guinea, Mr. Kamps, for his valuable assistance.

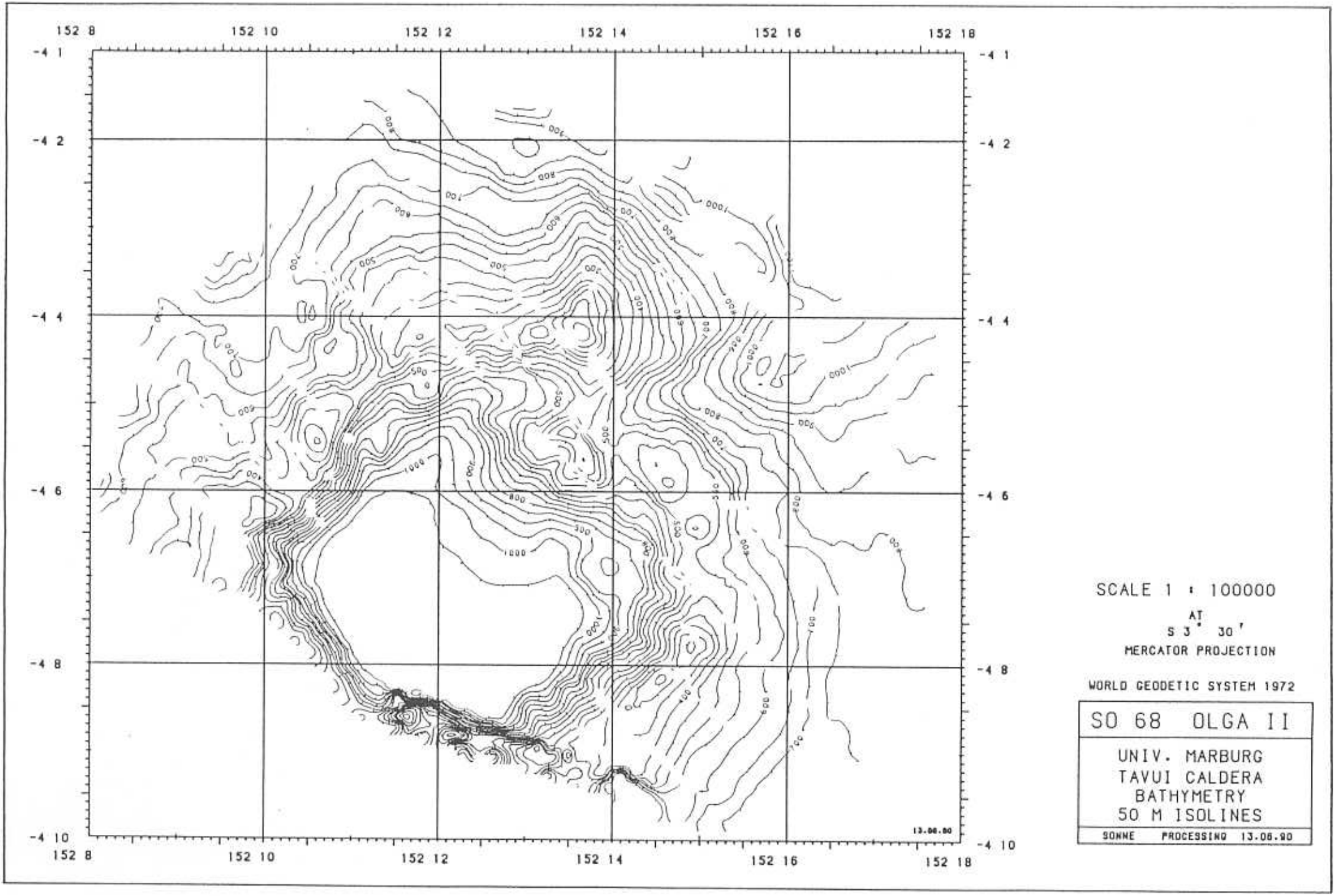
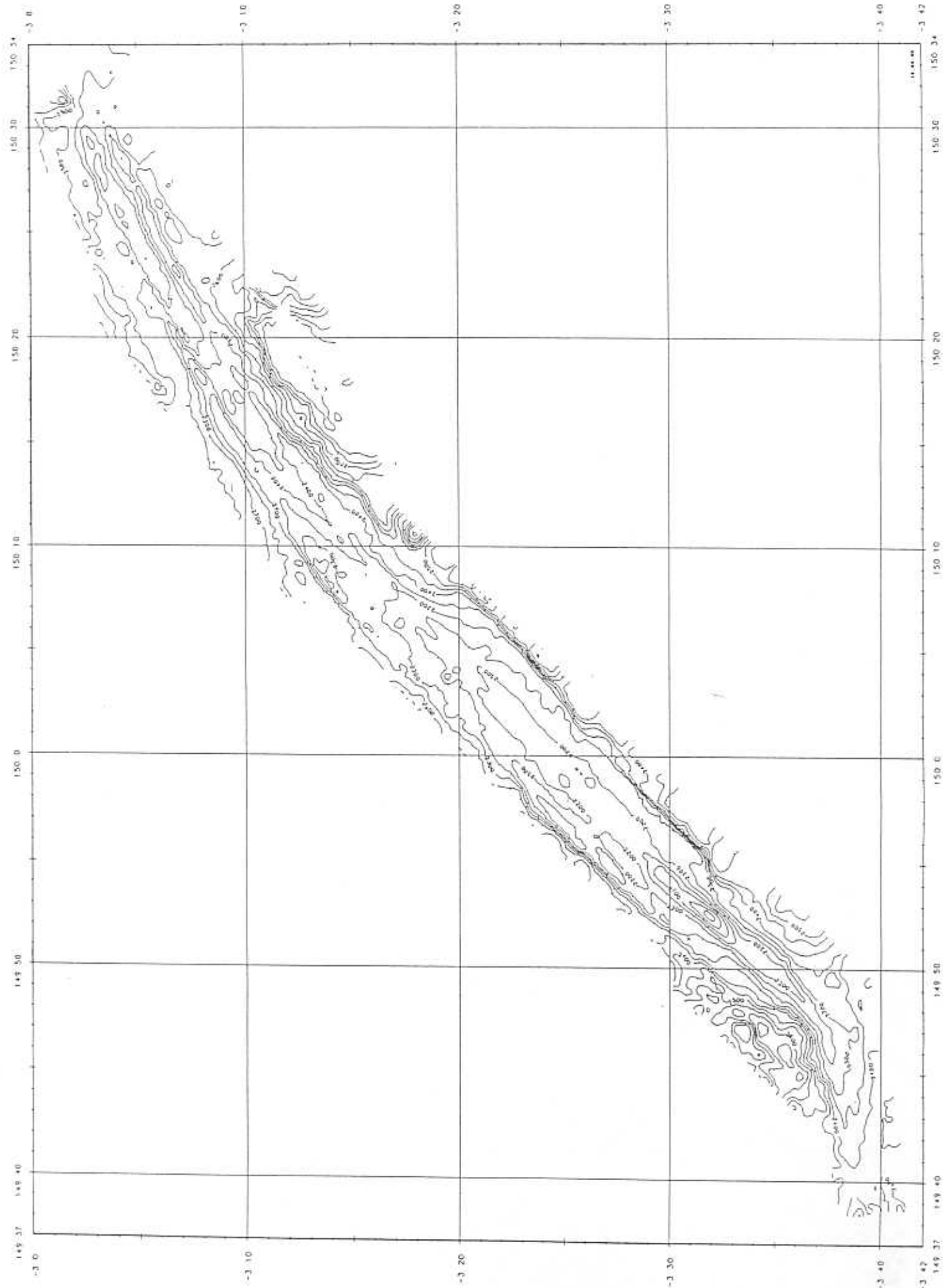


Fig. 1: Bathymetric map of the Tavui Caldera

Fig. 2: Bathymetric Map of the Manus Spreading Center from 3° 42' S, 149° 37' E to 3° 0' S, 150° 34' E



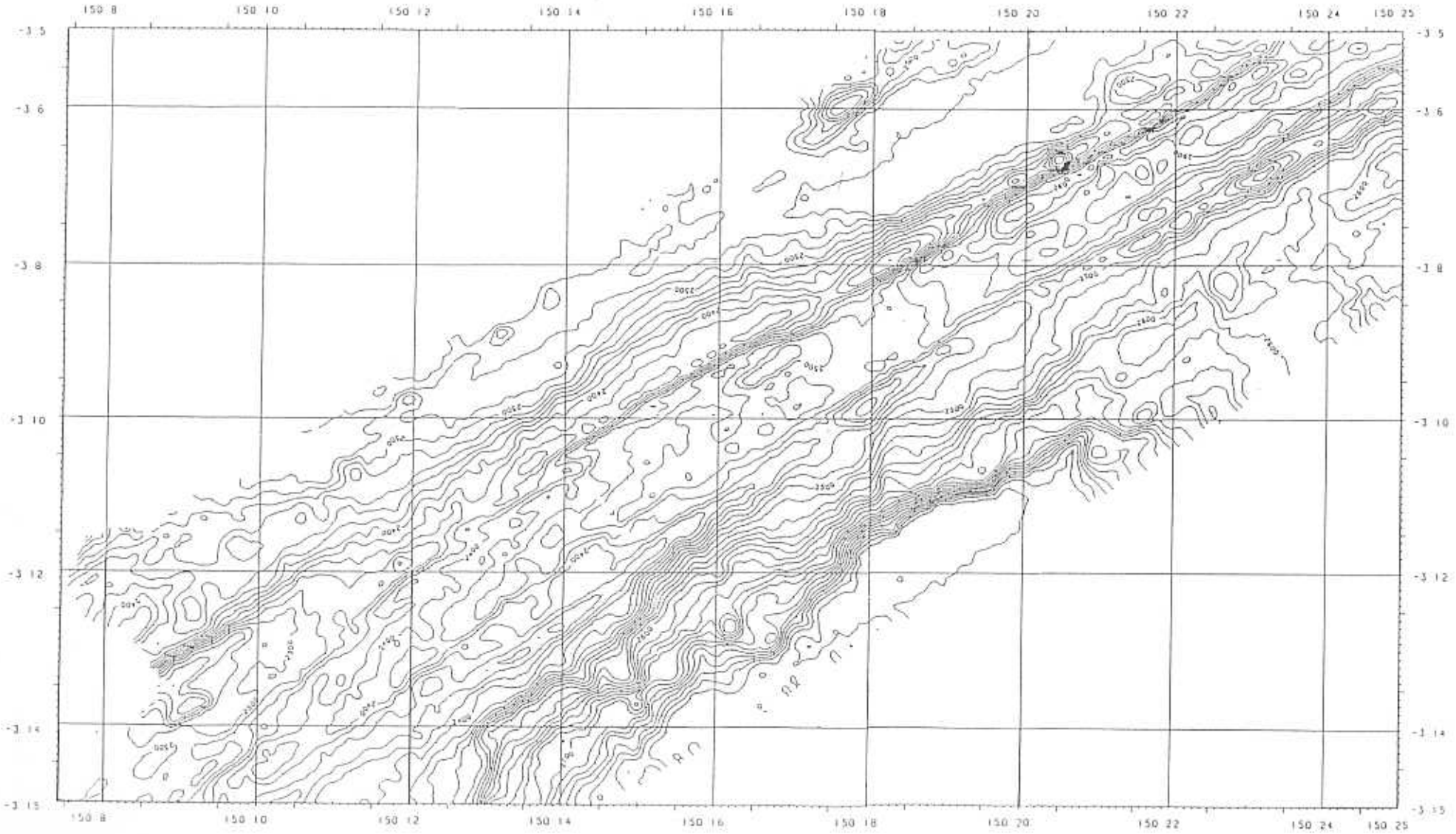


Fig. 3: Detailed bathymetric map of the Manus Spreading Center from
3° 15' S, 150° 8' E to 3° 5' S, 150° 25' E

APPENDIX 1

SONNE 68 - OLGA II RESEARCH CRUISE
REPORT ON LEG 1
April 29 to June 1, 1990

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SONNE 68 - OLGA II RESEARCH CRUISE
RV "SONNE"
MANUS BASIN, PNG
LEG 1, 29th April to 1st June, 1990

Transit from Suva, Fiji, to Rabaul, Papua New Guinea

For the eight-day transit to Rabaul, Seabeam seafloor topographic mapping was operating continuously. The route crossed the North Fiji Basin and the northern end of the Vanuatu arc, then entered the San Cristobal Trench south of San Cristobal, Solomon Islands. The track then remained northwesterly, following the Solomon-New Britain Trench as closely as possible. Southwest of Rendova, in the central Solomon Islands, the summits of a pair of seamount volcanoes, Kana Keoki and Coleman (Crook and Taylor, in prep.), were traversed. The trench axis is not easily defined in this area, but appears to lie northeast of the seamounts, implying that they rest on oceanic crust of the eastern Woodlark Basin. The summit morphology of the seamounts is complex, especially for Kana Keoki, and may comprise nested craters.

Survey of Tavui Caldera, Papua New Guinea

Previous mapping by B Taylor (pers. comm.) discovered a submerged caldera offshore from the nottheastern coast line of the Gazelle Peninsula in eastern New Britain. Transponders installed on Watom Island and the summit of Kombui (Mother) provided accurate navigation for a detailed Seabeam survey of Tavui Caldera. The caldera has a rectangular shape (rim dimensions 10km by 8km) and the floor is relatively flat and topographically featureless. Several small cones, presumably eruptive vents, occur on the inner wall or on the rim of the caldera. The caldera floor lies at about 600m below the rim, at a depth of 1000m. The southwestern wall is very steep and linear. One OFOS (Ocean Floor Observation System, comprising deep sea towed video and still cameras, with continuous temperature and depth monitoring, plus capacity for water sampling) profile revealed rugged topography over the caldera rim and inner wall. The caldera floor is largely covered with pumice and sediment.

Three dredge stations recovered samples comprising 95% pumice and the remainder being dense lava. Streaky and banded, dacitic?, tube pumice predominated, accompanied by lesser amounts of white, rhyolitic? and dark grey, andesitic? pumice. Two lava varieties were sampled: dense, black, aphyric lava, and dark blue-grey, porphyritic lava. The pumice probably includes Tavui eruption products, as well as substantial pumice from historic eruptions of Rabaul Caldera (eg Vulcan Island, 1878) and other centres in the region. However, the lava samples must be local to Tavui. The age of the caldera is as yet poorly constrained, but can reasonably be expected to predate the last major eruption of Rabaul Caldera (1400y BP plinian fall and ignimbrite). Identification of the Tavui caldera-forming eruption products amongst the tephra stratigraphy preserved around Rabaul remains a major challenge, with implications for assessing its current level of activity and potential hazards, and for the eruptive history of Rabaul Caldera.

Manus Basin, Papua New Guinea

The principal objective of the cruise was to produce a detailed and comprehensive assessment of the size, shape, geological setting, mineralogy and composition of recent, hydrothermal, massive sulphide deposits in a back arc basin. The approach is similar to that required for economic evaluation of ore deposits or prospects on land. The initial target was in an area surveyed by the Moana Wave with SeaMARC II, bottom sampling and seafloor photography (Tiffin et al 1986) during which hydrothermal deposits were discovered (Both et al 1986) on the northeastern end of a segment of the northeast-trending spreading axis of the Manus Basin at 3'09.7'S, 150'16.8'E. Photographs taken by the Moana Wave cruise showed several chimneys and abundant fauna in the central graben of the spreading axis of the basin.

The SeaMARC II data showed significant variation in character of the spreading axis from southwest to northeast (B. Taylor, pers. comm.): the southwest is marked by an axial high, a relatively fast spreading rate and a wide range of lava compositions (Fe MORB; BAB basalt, basaltic andesite and andesite; 'X'BAB); the northeast has a slower spreading rate and a well-defined graben morphology, from which only Fe MORB lavas were sampled. The southwest resembles the East Pacific Rise, whereas the northeast resembles the Mid Atlantic Ridge, both of which harbour numerous sites of active and recent hydrothermal, massive sulphide mineralisation (Rona1988).

Regional survey, northeastern Manus Basin spreading axis

The setting of the target area was established by Seabeam profiles (Figure 2) along the length of the northeastern spreading axis and by OFOS surveys (stations 2 to 7). Two dredge hauls recovered pillow basalt. Together these surveys suggested three areas of interest:

1. The site discovered by Both et al (1986);
2. The axial high at the southwest end of the spreading axis segment;
3. The plateau area between the axial high to the southwest and the graben to the northeast.

The Seabeam profiles provided data for 10m topographic mapping of the northeastern segment of the spreading axis. The axial high (at 1942m depth) in the southwest is separated from the deepest part in the northeastern graben (about 2600m depth) by a narrow (<100m wide) rift that traverses a central plateau (about 2200m depth). Fresh lava is more abundant on the southwest axial high but occurs locally in pillow lava cones and deep clefts on the floor of the northeastern graben. Pillow lava dominates although a wide variety of other flow types is present (lobate, sheet, pahoehoe, aa). Sediment cover is very thick in places, mainly within the graben and on the flanks of the narrow rift in the central plateau. Deep fissures and stepped faults cut the sediment covered lavas of the graben.

OFOS stations alternated with GTV stations (video-directed grabs or 'TV' grabs). Two of these (3 and 5) were successful in retrieving fragments of sulphide chimneys from Area 1. Samples of basalt (GTVA 7) and of sediment (GTVA 9) were also recovered. The OFOS data was used to define the most prospective area for detailed mapping and sampling, where transponder navigation would be required. These were identified by sighting chimneys or other indications of

hydrothermal deposits, and by temperature anomalies which were typically accompanied by abundant fauna.

Detailed survey of Area 1

Five transponders were emplaced and accurately positioned using GPS on May 17th, in preparation for detailed mapping and sampling of the most prospective sites of Area 1. This transponder array enclosed an area of approximately 3km x 3km that covered sulphide chimney locations found by the regional OFOS surveys.

During the ensuing ten days, systematic OFOS surveys (OFOS stations 8 to 15) were run at about 250m spacing perpendicular to the graben axis. In addition to the 14 across-axis tracks, detailed examination of selected sites and an along-axis traverse (OFOS 16) were completed. Each OFOS station identified targets for the following GTV station. Of these 25 GTV stations, 20 successfully recovered massive sulphide chimneys; two samples of basalt pillow lava and one of sediment from the chimney locations were also retrieved. Dredge stations obtained basalt pillow lava (D7 and D9) and massive sulphide chimney fragments (D8). Multisonde stations (M3 and M4) were conducted in order to investigate one of the higher temperature anomalies near a chimney site.

The chimney samples came from two chimney fields. Field A in the south (near 3'09.87'S, 150'16.78'E; Figures 2, 3) includes the locality found by Both et al (1986). Field B in the north (near 3'09.46'S, 150'17.04'E; Figures 2, 3) is a new chimney locality. Field A chimneys are accompanied by temperature anomalies and an abundant and diverse fauna (three gastropod species, barnacles, limpits, worms, sponges, stalked corals?). They are not actively depositing sulphides but in a waning phase. Chimneys of Field B are inactive and may be older than the Field A examples, lacking temperature anomalies and the attendant fauna. In other respects, chimneys of both fields are similar. They range in size up to atleast 12m high and 1 to 2m across. They have numerous channels and cavities but are coherent and not significantly weatherd. The sulphide mineralogy is dominated by zinc-rich phases (sphalerite, wurtzite, schalenblende). Pyrite is minor in most and chalcopyrite only occurs (visibly) in one sample. Relative proportions of the different sulphide minerals appear to be variable within single samples and in the entire sample suite as well. The sulphides are accompanied by very small amounts of silica, anhydrite and barite. The chimneys from Field B are completely coated with manganese oxides. A vast range in textures and grainsize is displayed by the collection and by individual samples.

Basalt pillow lava from the chimney fields shows the effects of hydrothermal alteration being distinctly green (rather than dark blue grey). Fine grained alteration minerals are especially concentrated along radial joint surfaces. The sediment sample comprises green and orange mud and silt that may be in part of hydrothermal origin.

The chimney fields are constructed on sediment ponds adjacent to pillow lava highs and close to fissures. Although centrally located in the graben, they are not in the deepest parts. The two chimney fields, other less extensive hydrothermal sulphide deposits, and sites of significant temperature anomalies are clearly aligned northeast-southwest, parallel to the spreading axis. Sites of interest occur sporadically along this trend and are separated by apparently barren intervals.

After completion of profiles in the first transponder array, OFOS stations further northeast along the spreading axis defined a second prospective area. On the 26th of May three transponders were positioned close to the northeastern limit of the Seabeam regional mapping. Four OFOS stations identified several sites of hydrothermal activity and deposits. Most are located at the margins of a relatively fresh pillow lava cone (Field C, around 3'06.67'S, 150'21.75'E; Figures 2, 3) and are associated with high temperature anomalies and abundant fauna. The hydrothermal deposits appear to be quite different from those of the first transponder array area. Only squat low chimneys and low mounds were observed by the OFOS stations. They are coated with yellow deposits (nontronite and/or smectite?) and with black manganese oxides. Four attempts to date at sampling these chimneys with GTV have not been successful. However, the area is promosing and one of the GTV stations discovered a very large chimney (about 10m high) that had been missed by OFOS. These northern sites may be younger than those in the first transponder area because they are closely associated with fresh lava and higher than normal temperatures. Further GTV sampling attempts are planned and will no doubt prove successful eventually.

Exploration in Area 3

The final OFOS station (21) of Leg 1 explored the central plateau of the spreading axis (Figure 2), focussing on the deep central cleft. The cleft is characterised by large collapse features, deep chasms, and talus. Pillow, lobate and sheet flows with partial sediment cover occur on the flanking highs. The highest temperature anomalies yet recorded were found at three sites, one in the cleft and two on either side of it. Abundant fauna coincided with the temperature anomalies but no hydrothermal deposits were recognised. This area may include active chimneys.

Concluding remarks

The first leg of the cruise has been thoroughly successful in achieving its aims. One known and one new chimney field have been mapped and sampled in detail, and the stage is set for mapping another new field (in the second transponder array). Other areas promising of active chimneys have also been located. A large amount of high quality geological data has been collected, with potential implications for the tectonics, petrogenesis and mineral resources of the region.

References

Both R, Crook K, Taylor B, Brogan S, Chappel B, Frankel E, Liu L, Sinton J and Tiffin D 1986 Hydrothermal chimneys and associated fauna in the Manus Back-Arc Basin, Papua New Guinea. EOS67:489-490.

Rona P A 1988 Hydrothermal mineralisation at oceanic ridges. Canadian Mineralogist 26: 431-465

STATION SUMMARY : SONNE 68 - OLGA II, LEG 1

Date	Station	Locality	Result
29.4.90 -6.5.90	Seabeam	TRANSIT: Suva Fiji to Rabaul, PNG	Seafloor topographic map along transit track
7.5.90 -9.5.90		TAVUI CALDERA Gazelle Peninsula, eastern New Britain, PNG	
	Seabeam		Topographic map of caldera
	OFOS 1		Survey of caldera rim, wall and floor
	Dredges 1-4		Samples of pumice and lava
	Multisonde 1,2		Water column samples and measurements
		MANUS BACK-ARC BASIN Bismarck Sea, PNG	
10.5.90	Seabeam	Spreading axis, northeastern graben	Topographic map of Area 1
	OFOS 2	Spreading axis, north-eastern graben	Survey of northeastern graben in Area 1
	Dredge 5	Area 1	Basalt pillow lava samples
11.5.90	Seabeam	Spreading axis, central plateau and southwestern axial high	Topographic map of Areas 2 and 3
	GTVA 2	Area 1 (A)	- no sample
	Dredge 6	Area 1	Basalt lava samples
12.5.90	Seabeam	Spreading axis, north-eastern tip	Topographic map of spreading segment tip
	GVTA 3	Area 1 (A)	Massive sulphide chimney sample
13.5.90	OFOS 3	Spreading axis, north-eastern graben	Survey of Area 1 continued
	GTVA 4	Area 1 (A)	- no sample
14.5.90	Seabeam	Spreading axis, north-eastern tip	Topographic map of spreading segment tip
	OFOS 4	Spreading axis, north-eastern graben	Survey of Area 1 continued
14.5.90	GTVA 5	Area 1 (A)	Massive sulphide chimney sample
	GTVA 6	Area 1 (A)	- no sample
15.5.90	OFOS 5	Spreading axis, north-eastern graben	Survey of Area 1 continued
	GTVA 7	Area 1 (C)	Pillow basalt and sediment sample
	GTVA 8	Area 1 (C)	- no sample
16.5.90	OFOS 6	Spreading axis, south-western axial high	Survey of Area 2
	GTVA 9	Area 1 (A)	Sediment sample
17.5.90	OFOS 7	Spreading axis, north-eastern graben	Survey of Area 1 continued
		Area 1, Fields A and B	Transponders installed and positioned
	GTVA 10	Area 1 (B)	- no sample?
	GTVA 11	Area 1 (B)	Basalt pillow lava samples
18.5.90	OFOS 8	Area 1, transponder array 1	Profiles 1, 2, 3 perpendicular to graben axis
	GTVA 12	Area 1 (B)	Massive sulphide chimney sample
	GTVA 13	Area 1 (B)	Massive sulphide chimney sample
19.5.90	OFOS 9	Area 1, transponder array 1	Profiles 3, 4, 5 perpendicular to graben axis; detail around Field A
	GTVA 14	Area 1 (A)	Basalt pillow lava and sediment samples
	GTVA 15	Area 1 (A)	Massive sulphide chimney sample

	GTVA 16	Area 1 (A)	Massive sulphide chimney sample
20.5.90	OFOS 10, 11	Area 1, transponder array 1	Profiles 6, 7, 8 perpendicular to graben axis, detail around Field A
	GTVA 17	Area 1 (A)	Massive sulphide chimney sample
	GTVA 18	Area 1 (A)	Massive sulphide chimney sample
	GTVA 19	Area 1 (A)	Massive sulphide chimney sample
21.5.90	OFOS 12	Area 1, transponder array 1	Profiles 9, 10, 11 perpendicular to graben axis; detail around Fields A and B
	GTVA 20	Area 1 (A)	Massive sulphide chimney sample
(21.5.90)	GTVA 21	Area 1 (A)	- no sammple
	GTVA 22	Area 1	- no sample
22.5.90	OFOS 13	Area 1, transponder array 1	Profile 12 perpendicular to graben axis
	Dredge 7	Area 1, Field A to Field B	Basalt lava samples
	Dredge 8	Area 1, Field B to Field A	Massive sulphide chimney samples
	GTVD 22	Area 1 (A)	Massive sulphide chimney sample
	GTVD 23	Area 1 (A?)	Massive sulphide chimney and sediment samples
	GTVA 24	Area 1 (A?)	Massive sulphide chimney sample
23.5.90	OFOS 14	Area 1 transponder array 1	Profile 13 perpendicular to graben axis
	Dredge 9	Area 1, central graben	Basalt pillow lava samples
	Multisonde 3	Area 1, Field A temperature anomaly	Water samples and measurements
	GTVA 25	Area 1 (A?)	Sulphide chimney sample
	Multisonde 4	Area 1, Field A temperature anomaly	Water samples and measurements
24.5.90	Seabeam	Spreading axis, central plateau and south-western axial high	Additional tracks to widen and extend topographic map of Areas 2 and 3
	GTVA 26	Area 1 (A)	Massive sulphide chimney sample
	GTVA 27	Area 1 (B)	Massive sulphide chimney sample
25.5.90	OFOS 15	Area 1, transponder array 1	Profiles 13, 14, detail around Fields A and B
	GTVA 28	Area 1 (B)	Massive sulphide chimney sample
	GTVD 29	Area 1 (B)	- no sample
	GTVA 30	Area 1 (B)	Massive sulphide chimney sample
26.5.90	OFOS 16	Area 1, transponder array 1	Detail around Field B
		Area 1, Field C	Transponders installed and positioned
	GTVA 31	Area 1 (C)	Basalt pillow lava sample
	GTVA 32	Area 1 (B)	Massive sulphide chimney sample
27.5.90	OFOS 17	Area 1, transponder array 2	Surveys along and across graben
	GTVA 33	Area 1 (B)	Massive sulphide chimney sample
(27.5.90)	GTVA 34	Area 1 (B)	Massive sulplhide chimney sample
	GTVA 35	Area 1 (A)	Massive sulphide chimney sample
28.5.90	OFOS 18	Area 1, transponder array 2	Surveys along and across graben, detail around Field C
	GTVA 36	Area 1 (C)	- no sample
	GTVA 37	Area 1 (C)	Sediment sample
29.5.90	OFOS 19	Area 1, transponder array 2	Surveys along and across graben, detail around Field C
	Dredge 10	Area 1, transponder array 2	Basalt pillow lava samples
	GTVA 38	Area 1 (C)	- no sample
30.5.90	OFOS 20	Area 1, transponder array 2	Surveys along and across graben, detail around Field C

(Meeting with scientists from Russian research ship "Akademic Keldysh")

31.5.90	OFOS 21	Spreading axis, central plateau	Survey of Area 3 narrow axial rift

(Meeting with scientists from "Akademic Keldysh")

1.6.90	Seabeam	Area 1 to Kavieng, New Ireland	Seafloor topographic map along transit track

END OF LEG 1, KAVIENG, PNG

FIGURE 1. Sketch map of Leg 1, Sonne 68-Olga II transit from Suva, Fiji to the Manus Basin, PNG.

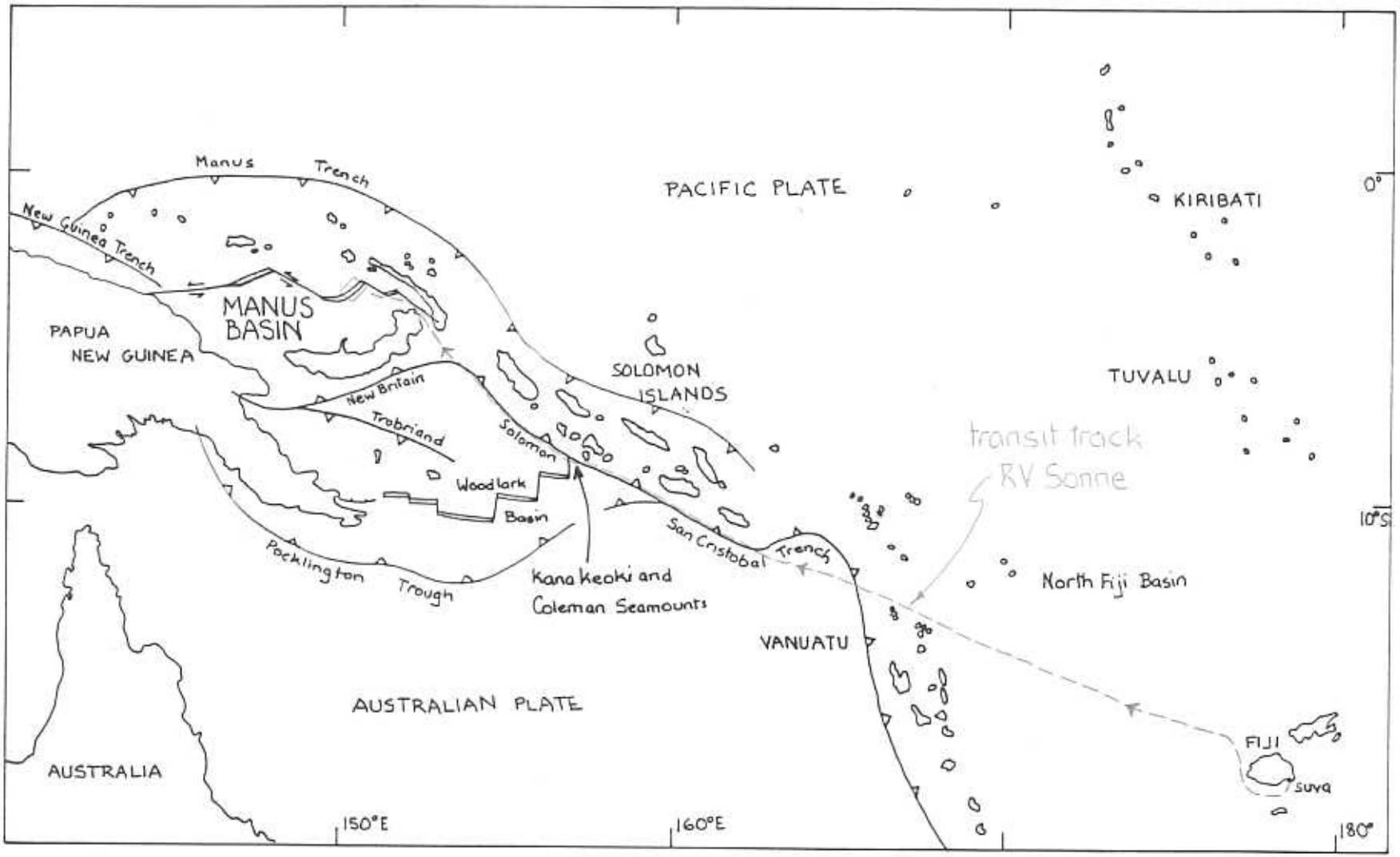


FIGURE 2. Ship track for Seabeam survey of the Manus Basin spreading axis, study areas and chimney fields for Leg 1, Sonne 68 - Olga II research cruise, RV Sonne

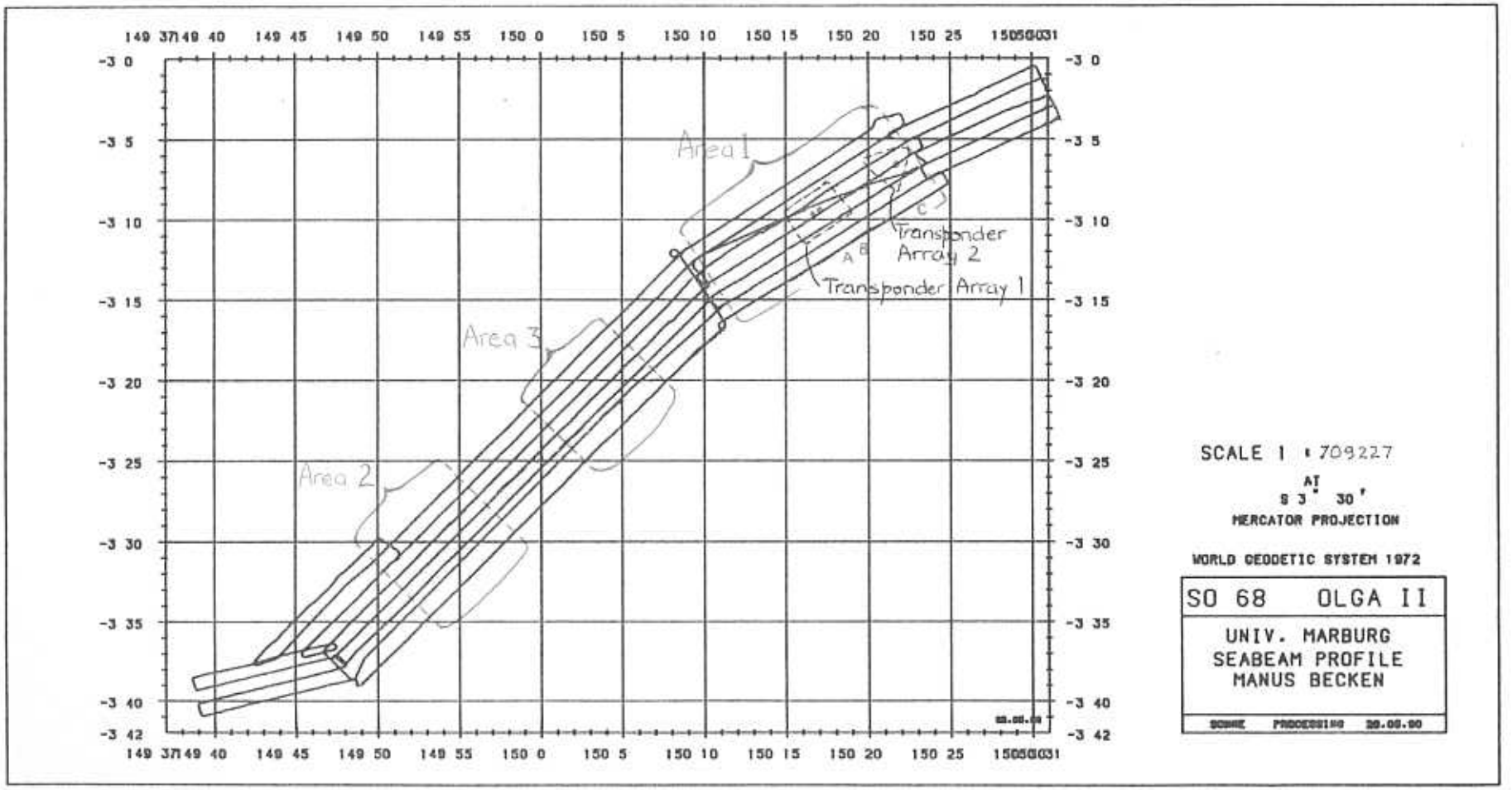
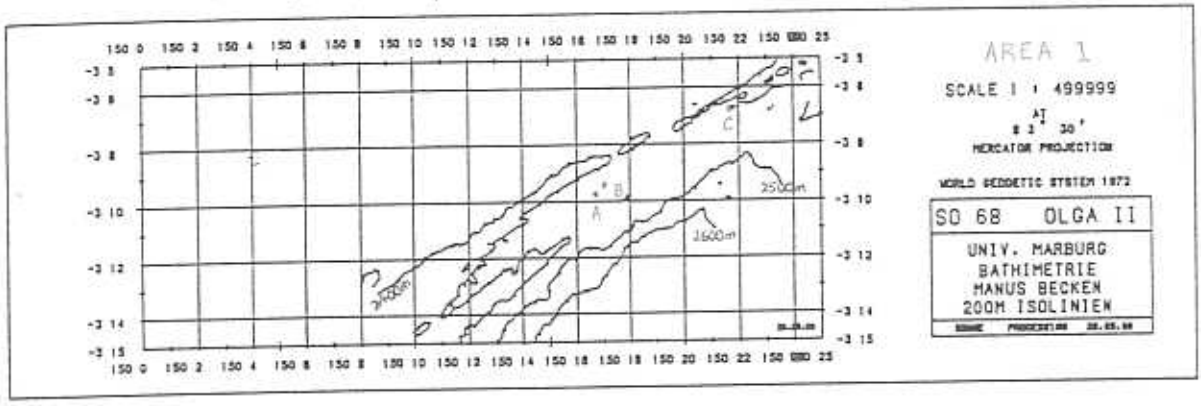


FIGURE 3. Bathymetric map of Area 1, Manus Basin spreading axis, based on Seabeam surveys. Contour interval 100m. A,B,C - chimney fields



SCALE

APPENDIX 2

SONNE 68 - OLGA II RESEARCH CRUISE
REPORT ON LEG 2
June 1 to June 25, 1990

David Wallace
Minerals and Land Use Division
Bureau of Mineral Resources, Geology and Geophysics
Canberra, Australia

SONNE 68 - OLGA II RESEARCH CRUISE
RV "SONNE"
MANUS BASIN, PNG
LEG 2. 1 June to 25 June 1990

The primary objective of the Sonne 68 - OLGA II research cruise was to identify hydrothermally mineralized areas within the Manus Back-Arc Basin spreading centre and to conduct a detailed investigation of these areas. As well as mapping the hydrothermal areas the investigation was designed to systematically sample their massive-sulfide chimneys, particularly those chimneys which were still active as "black smokers". An important adjunct to the investigation was to sample the diverse fauna associated with the hydrothermal chimneys, together with the volcanic rocks and sediments of the spreading centre.

As detailed in the earlier report by Dr Jocelyn McPhie, the setting of the target area, along the length of the northeast spreading centre, was established by Seabeam profiling and OFOS surveys on the 1st Leg of the cruise . Three chimney fields, Fields A, B and C, were located in the target area and accurately positioned by transponder arrays. The geological character of these fields, together with descriptions of the sulfide chimneys, biological phenomena, volcanic rocks and sediments, observed and recovered from these areas, are fully documented in Dr. McPhie's report.

In light of the importance of the exciting discoveries made during the 1st Leg, it was decided that work of the 2nd Leg should concentrate principally on consolidating these discoveries. Priorities during the 2nd Leg were accordingly given to (a) accurately defining the extent of Fields A, B and c, (b) further sampling of sulfide chimneys and associated fauna, particularly those still actively depositing sulfides in these fields, (c) continuing the search for further hydrothermal fields by means of OFOS surveys, (d) carrying out Multisonde water sampling profiles throughout the northeast spreading centre in general and also in close proximity to the known hydrothermal fields. The proposed investigation of the Tabar-Feni Islands area was given a low priority.

Results

The area of operations in the Manus Basin and Tabar-Feni Islands are shown in Fig.1, together with the ships tracks.

13 OFOS surveys were carried out in the target area at depths of about 2.5kms, extending along the middle of the spreading centre from 3.22'S, 150.02'E to 3.05'S, 150.24'E and 6 Multisonde surveys were carried out at intervals along the spreading centre

axis from 3.30'S, 149.52'E to 3.05'S, 150.23'E. The locations of the OFOS and Multisonde surveys and the hydrothermal areas are identified in Fig.2. As hydrothermal Fields A and B are so closely adjacent they are shown as one field on Fig.2.

The OFOS surveys found no major sulfide chimney concentrations other than Fields A, B and C established during Leg 1, although isolated inactive chimneys were found elsewhere. Compared to the relatively sparse outcrop of chimneys, including broken chimneys, in Fields B and C, which appeared to be inactive, Field A (centred on 3.9,34'S, 150.16,81'E) contained abundant sulfide chimneys. The presence of abundant and diverse fauna, temperature anomalies and more rarely, visual sighting through TV monitors of "black smoke" emanations, all testified that the Field A hydrothermal area was still active. Owing to its numerous quantity of chimneys which resembled a forest extending over 1km across, Field A was named the "Wienerwald" (Vienna Woods) by the expedition leader, Dr.Tufar. Chimneys of up to 10 meters high were not uncommon and some of the largest examples were estimated as approaching 20 meters in height. Preliminary chemical analyses of the sulfide chimneys by XRF, gave average compositions of 10-20% Fe; 20-30% Zn; 1% Cu, which occurred mainly as sphalerite, wurzite, and minor pyrite, pyrrhotite and chalcopyrite.

From 25 TV-grab attempts on the Manus Basin segment of the 2nd Leg 12000 kg of chimney samples were recovered (25 tonnes overall), together with over 100kg of basalt (2 tonnes overall), mostly pillow lavas, and a large quantity of sedimentary material.

As noted by Dr. McPhie in her 1st Leg report, abundant and diverse fauna live on, or closely adjacent to actively depositing smokers. The ecosystem associated with the Manus Spreading Centre black smokers consists of about 20 different types of macroorganism. Organisms identified include several species of gastropods, barnacles, sea anemones, sponges, crabs, worms and simply branched coralline-like growths. Some species variants sampled are thought to be hitherto unknown, but these samples will require evaluation by suitably qualified biologists.

On board analysis of water profiles, sampled by means of the Multisonde facility, suggested qualitatively that the best indicators of thermal areas were C1 to C4 hydrocarbons, followed by parameters such as Redox and pH. The C1 to C4 hydrocarbons were analysed on board by gas chromatography, using a specially adapted method developed by the University of Hamburg, which is capable of determining concentrations down to 1 part in 10-13. Results indicate that, because of dilution effects and tidal influences, these determinations are valid only within the water column directly overlying the thermal areas and within no less than 50 m

from the surface. The light isotope of helium, Helium 3, widely regarded as the best indicator of hydrothermal activity, will be determined on aliquots of the water samples on return to Germany.

The last part of the 2nd Leg of the cruise, from 18-21 June, was devoted to investigations near Lihir Island in the Tabar-Feni island chain, east of New Ireland. During this part of the cruise Seabeam profiling was carried out over a 120 km area extending northwards from Lihir Island to the Emirau-Feni ridge (Fig.2) and OFOS and TV-grab surveys were carried out in Luise Harbour. Due to uncertainties about the accuracy of bathymetric data on the uncharted Luise Harbour and restrictions on the ships manoeuverability close inshore, these surveys were carried out at a distance of about 2kms from shore. The Luke Harbour surveys revealed a uniformly even, steeply-dipping floor of sediment, which was featureless apart from occasional massive, scattered, erratic blocks of limestone, presumably derived from the upraised Miocene reefal formation exposed on shore. A TV-grab survey was carried out along a short stretch of the Emirau-Feni Ridge at a depth of ca 400 meters. The ridge consisted of monotonously southward-dipping, flat-surfaced carbonate rock, a sample of which was recovered by TV-grab.

Seabeam profiling was carried out en route from Lihir Island to Port Moresby along the track shown in Fig.1.

Comments

The research cruise successfully fulfilled its aims in identifying , mapping and sampling three hydrothermal fields containing "black smokers" in the Manus Basin. The high quality and quantity of geological and biological data collected reflect the professional thoroughness with which the project was carried out. When all data are fully evaluated the results of the investigation will contribute significantly to the pool of scientific knowledge on this unique type of geological environment.

D.A. Wallace
MLUP division
Bureau of Mineral Resources
20 July 1990

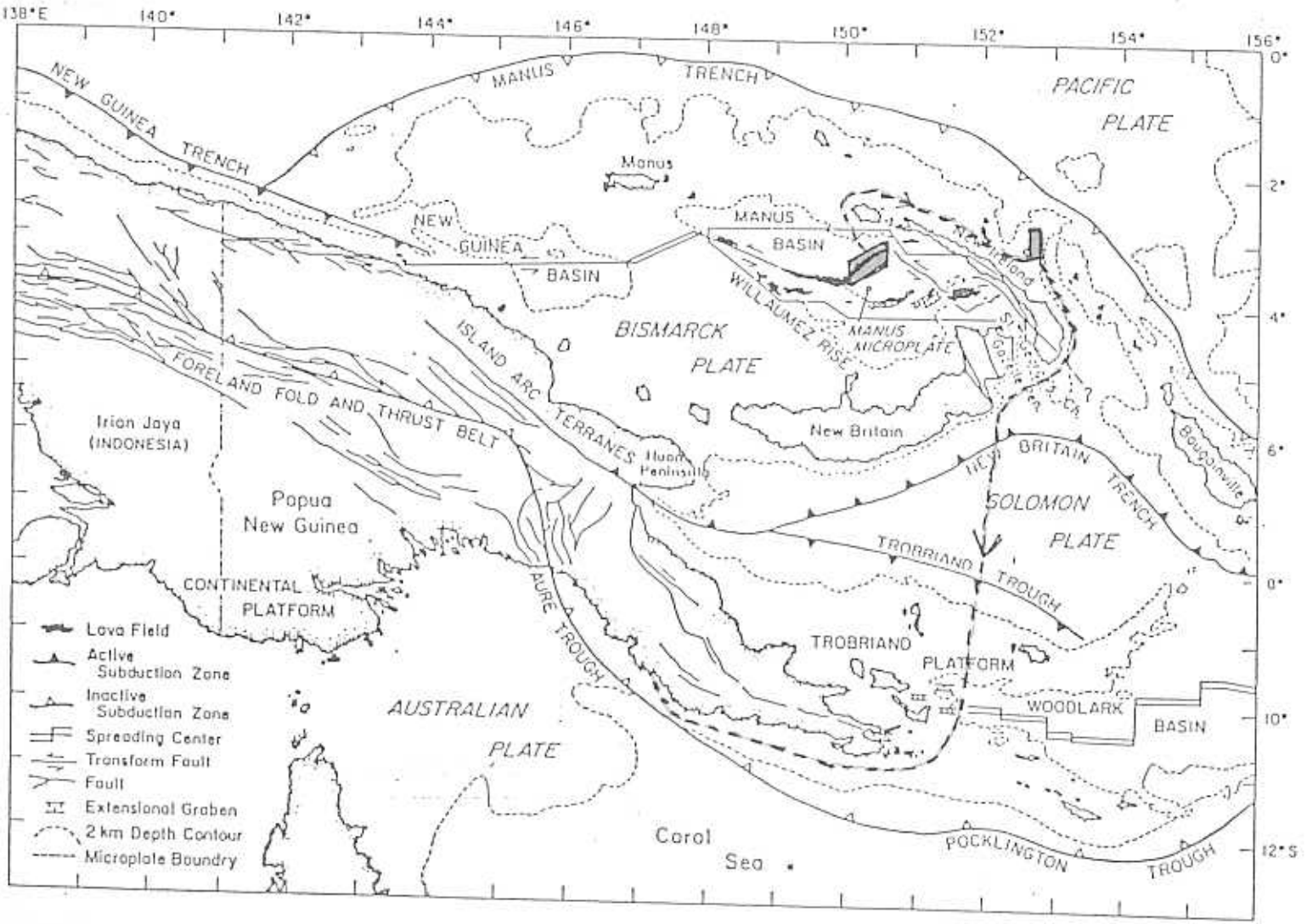
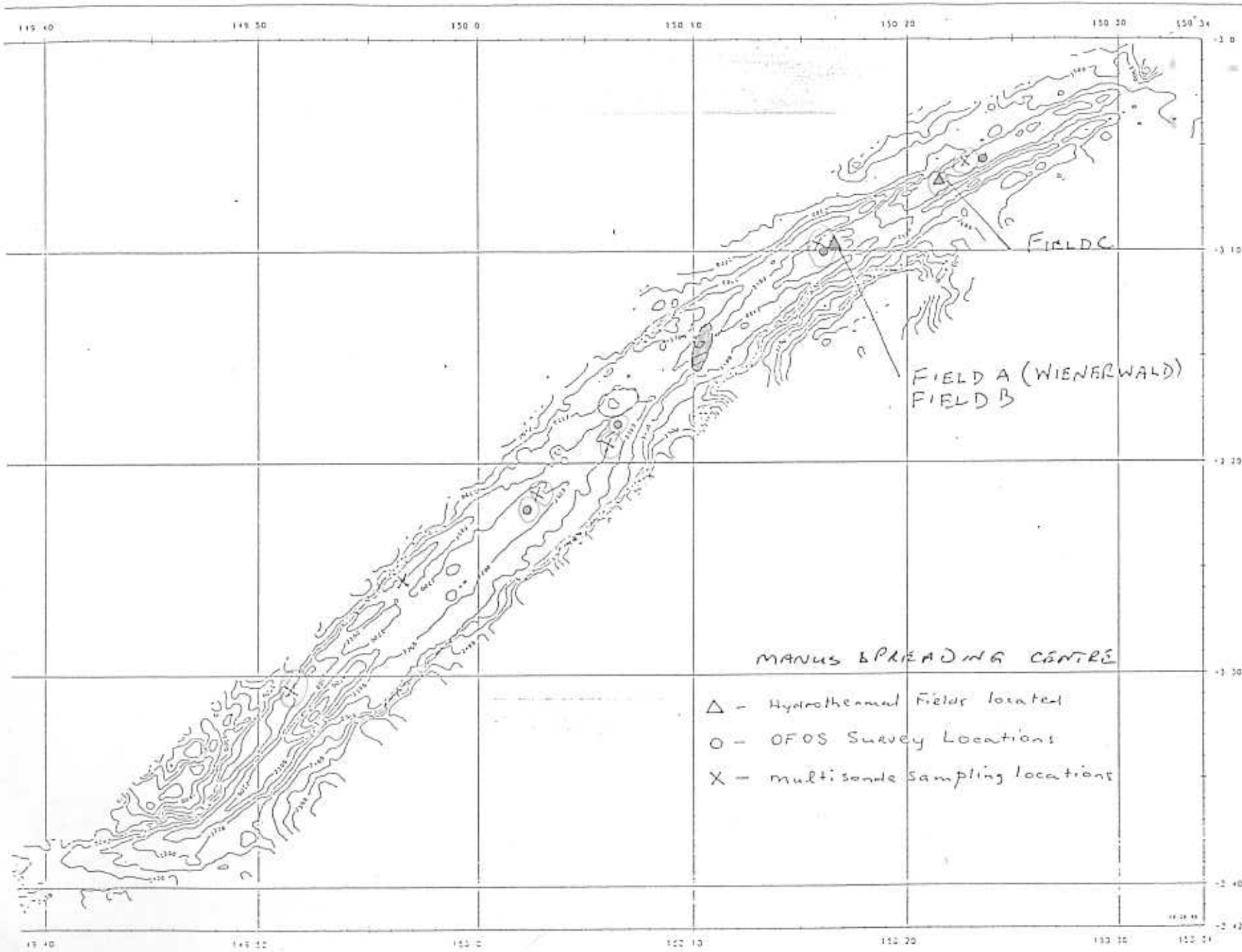

138°E
140°
142°
144°
146°
148°
150°
152°
154°
156°
0°
2°
4°
6°
8°
10°
12°S
NEW GUINEA TRENCH
MANUS TRENCH
PACIFIC PLATE
Manus
NEW GUINEA BASIN
MANUS BASIN
New Ireland
WILLAUMEZ RISE
MANUS MICROPLATE
Gogol
BISMARCK PLATE
FORELAND FOLD AND THRUST BELT
ISLAND ARC TERRANES
Huon Peninsula
Irian Jaya (INDONESIA)
New Britain
NEW BRITAIN TRENCH
Bougainville
Papua New Guinea
SOLOMON PLATE
TROBRIAND TROUGH
CONTINENTAL PLATFORM
AURE TROUGH
TROBRIAND PLATFORM
WOODLARK BASIN
AUSTRALIAN PLATE
Coral Sea
POCKLINGTON TROUGH
Lava Field
Active Subduction Zone
Inactive Subduction Zone
Spreading Center
Transform Fault
Fault
Extensional Graben
2 km Depth Contour
Microplate Boundry

Fig. 1.

Fig. 1.

MANUS BASIN
SONNE 68 – OLGA II RESEARCH CRUISE
2nd Leg - 1 – 25 JUNE 1990



SCALE 1 : 300000
MERCATOR PROJECTION
WORLD GEODETIC SYSTEM 1972
SO 68 OLGA II
UNIV. HAMBURG
MANUS BECKEN
BATHYMETRIE
50 M TIEFENLINIEN

FIG. 3.