

FRANKLIN

National Facility
Oceanographic Research Vessel

**Search for Submarine Hydrothermal Activity, Manus and
Woodlark Basins, Papua New Guinea**

PACMANUS III

CRUISE SUMMARY

ORV FRANKLIN

FR 10/96

Depart Darwin
Arrive Cairns

Saturday 23 November 1996
Tuesday 17 December 1996

Principal Investigator

Dr R.A. Binns
CSIRO Division of Exploration and Mining

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Basins, Papua New Guinea**

PACMANUS III

**RV FRANKLIN
CRUISE FR 10/96**

Depart Darwin	1000 hours	Saturday 23 November 1996
Return Cairns	1000 hours	Tuesday 17 December 1996

CHIEF INVESTIGATORS

Dr R.A. Binns
CSIRO Division of Exploration Geoscience

Prof SD Scott
University of Toronto, Canada

Itinerary

Departed Darwin 1000h CST, Saturday 23rd November 1996

Transit to Bismarck Sea via Clarence Strait, Torres Strait, China Strait, Goschen Strait, Ward Hunt Strait, Star Reef Passage, Vitiaz Strait. Return via St Georges Channel, Jomard Entrance and Grafton Passage

Arrived Cairns 0700 EST, Tuesday 17th December 1996

Scientific Program

Title: Search for submarine hydrothermal activity, Manus and Woodlark Basins, PNG

General Objective: Study seafloor hydrothermal ore-forming activity in order to develop improved methods of exploring for ancient mineral deposits on land that originally formed by similar processes.

Specific Objectives:

- Locate and sample the source of a hydrothermal plume detected on the final day of FR 05/93 at Tumai Ridge, eastern Manus Basin
- Conduct further operations at and near the PACMANUS site discovered on FR 09/91
- *En route*, examine the following locations for possible hydrothermal activity
 - a basement fault zone in Goodenough Bay
 - a neovolcanic zone south of the Willaumez transform fault ("East Sherburne Volcanic zone", called "Caldera Zone" in cruise proposal)
 - a recently-discovered cluster of off-axis seamounts east of Misima in the Woodlark Basin.

Principal Investigators

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Results

Cruise 10/96 was an outstanding success, with all major objectives achieved. To allow more time at the new Susu Knolls discovery, the seamount site near Misima was not visited during the return passage. However three other areas not originally planned for examination were tested for hydrothermal activity with negative results: the Willaumez extensional transform zone, Bugave Ridge, and Tavui Caldera near Rabaul.

Factors critical to this success included accurate navigation with satellite communication of differential GPS corrections, and the excellent station holding achieved by ship's officers with the aid of a new *trackPlot* display. *Franklin* has again demonstrated her suitability for this kind of geoscientific research. With very little time lost through breakdowns or bad weather, an even higher productivity was achieved than during previous PACMANUS cruises. In 12 days 6 hours on station we conducted 39 dredges, 10 grabs, 19 sediment cores, 21 hydrocasts and tow-yos, 16 camera-video tows, and 13 echo-sounder traverses. A total of 236 km of cable was hauled.

Key outcomes of the cruise include the following:

- Discovery of a substantial new hydrothermal field, *Susu Knolls*, at the source of the 1993 Tumai Ridge plume. This is hosted by porphyritic dacite which is extensively altered. The active chimneys sampled are exceptionally rich in copper (and as subsequently found, in gold).
- Recovery of large hauls of massive sulfide chimneys at four active sites in the PACMANUS hydrothermal field.
- Clarification of enigmatic geological relationships between sediment and altered dacite at the Snowcap diffuse hydrothermal site, PACMANUS
- First recoveries of basement lithologies in the vicinity of PACMANUS and Susu Knolls.
- Petrological identification of 4 previously unexplored volcanic edifices in the eastern Manus Basin and of 3 minor volcanic features near PACMANUS: enlargement of the distribution of picritic basalts at Marmin Knolls.
- Discovery of a definite outcrop of pumiceous rhyolite near 2000m deep on an extensional fault scarp (doubling the previously known depth range for this lithology once considered exclusively subaerial).

- Characterisation of the previously unexplored East Sherburne Neovolcanic zone as back-arc ferrobaltic in character and thus related to the central Manus spreading zone rather than New Britain arc volcanism.
- No indications were found of hydrothermal activity at 3 previously untested and two part-tested localities (Goodenough Bay basement fault zone, East Sherburne Neovolcanic Zone, Willaumez extensional transform zone, Bugave Ridge, Tavui Caldera)
- Bathymetric delineation of major fault zones in St Georges Channel and its approaches, which link Manus Basin back-arc tectonics to flexing of the New Britain-Solomons subduction zone.
- Further photographic surveying and marking of sites proposed for ODP holes, and for PROD drilling during cruise FR09/97.

Cruise Narrative

Scientists joined Franklin at Fort Hill Wharf, Darwin from noon on Friday November 22. Loading of equipment was delayed by slow disembarkation of the previous party. This was through no fault of that party, RV Franklin or CSIRO. From 16:30 to 18:30 a function and tour of the ship was arranged for about 40 colleagues from CSIRO-TERC and Darwin geoscientists.

Day 1 - Saturday, 23rd November 1996

Cast off at 10:00h (GMT+9:30). Transiting via Clarence Strait, passed Howard Passage light at 14:25h. Preparation of equipment and laboratories commenced.

Day 2 - Sunday, 24th November 1996

Entered Arafura Sea at 04:30h. Preparation of equipment and laboratories continued. To provide overlap, 4-hour science watches were set to commence 1 hour before those of the Ship's officers and crew. Facility staff worked 12-hour watches commencing 1 hour after Ship's crew. Clocks were changed to Eastern Standard Time (GMT+10) at midnight for the remainder of the cruise.

Day 3 - Monday, 25th November 1996

Crossing the Gulf of Carpentaria.

Day 4 - Tuesday, 26th November 1996

Entered Prince of Wales Passage of Torres Strait at 0700, and Vigilant Channel abeam Sue Islet at 11:30h. Dummy operations were performed to become familiar with the "trackPlot" computer plotting routine. Entered the Gulf of Papua at 19:30h, with rising seas.

Day 5 - Wednesday, 27th November 1996

Differential GPS commenced operation. Transit continued across the Coral Sea, skirting the southern coast of Papua. More dummy operations with Bridge participation, to develop trackPlot protocols.

Day 6 - Thursday, 28th November 1996

Continued transit along the southern coast of Papua. Scientific watches stood to at 07:00h. Turned north at 09:00h, and negotiated China Strait at 11:30h. Continued across the Milne Bay graben, then negotiated Raven Passage into Goschen Strait at 14:00h. Traversed to our first area of operations, in Goodenough Bay, where the aim was to test for hydrothermal activity associated with faults in the sedimentary sequence covering rifted and tilted basement blocks.

Echosounder traverse ES-49A was run northeasterly along Mutter's seismic track 32 to locate its three scarps. Echosounder traverse ES-49B was then run in the opposite direction displaced about 800m to the northwest, establishing that the northeastern and central scarps trend close to northwesterly.

Hydrocast H-34 was a single cast conducted over the central graben on ES-49A. No transmissometer anomaly was observed. A uniform-temperature (13.3°C)-salinity, well mixed water mass was observed below 550m. A reference water sample was collected on the upcast 150m above bottom, and two salinity standards were collected nearer surface.

Sediment Core S-55 was taken at the same site, yielding 1.20 m of olive mud with a thin (~2 cm) brown surface layer and no obvious hydrothermal component.

Day 7 - Friday, 29th November 1996

Echosounder traverse ES-49C resumed the southwesterly track of ES-49B to relocate the southwestern scarp and determine its strike.

Hydrocast H-35 was conducted over the position of this scarp on ES-49A. This single cast detected no transmissometer anomaly. A reference water sample was taken 100m above bottom.

Grab G-2 at the same site retrieved a full load of olive mud with a thin brown surface layer disturbed by motion, from which several syringe mini-cores and a bulk sample were taken.

These initial operations of the cruise were technically successful, but provided no indications of hydrothermal activity at the Goodenough Bay site. At 04:10h the transit north to the Manus Basin was resumed. Ward Hunt Strait was passed at 07:00h, and Star Reef Passage was negotiated at 14:00h. At 22:30h the ship halted over the extension of the Markham submarine canyon (~6000m) for a successful pressure test of the video and strobe housings of the camera-video system to 1000m depth, while taking soundings with the ship drifting, for later assessment of channel topography. However the sounder was recording poorly, and many digital readings were erroneous.

Day 8 - Saturday, 30th November 1996

After entering Vitiaz Strait, a small eruption plume was observed at 06:06h over Langila Volcano, western New Britain. Further eruptions occurred during the day. Crossed between Umboe and Talakiwa Islands from the Solomon Sea into the Bismarck Sea at 12:30h. Preparation and maintenance of dredges, camera system and other equipment continued.

Echosounder traverses MES-10A and orthogonal MES-10B initiated operations in the previously unexplored East Sherburne Neovolcanic Zone, the aim being to locate a small seamount indicated in the Pacific Seafloor Atlas to possess a summit caldera. The presence of a 110 m deep summit caldera was confirmed.

Day 9 - Sunday, 1st December 1996

Hydrocast MH-30 was a tow-yo of 4 casts crossing this seamount, including one into the caldera. No plume anomaly was seen.

Echosounder traverse MES-10C was set to again cross the caldera and correct a small error in its previously-determined position.

Dredge MD-46 was deployed into the summit caldera, and returned a 1/3 load of brown and olive ooze with several cm-sized cinder-like delicate fragments of brown basaltic glass. No indications of hydrothermal deposit or alteration were found.

Echosounder traverse MES-11A was a northwesterly traverse across the dominant feature of this area (Giant Seamount) to test whether a caldera existed on its northwestern side. The apparent crest was at 604m, and the presumed calderas were more like ledges. Hydrocast MH-31 was a single dip northeast of Giant Seamount, which found no transmissometer anomaly.

Dredge MD-47 was hauled up the higher southeastern slope of Giant Seamount, becoming anchored following major bites soon after hauling commenced. The dredge returned upside down with the first weak link broken, and a 75kg load of ooze-covered basaltic fragments retained in the bag.

Hydrocast MH-32 was a single cast over the ledges on the NW side of Giant Seamount, which again failed to find any plume signal. Consequently we moved from this western area to the central section of the East Sherburne Neovolcanic Zone.

Hydrocast MH-33 was conducted over a flat area of high acoustic reflectivity with several small volcanic cones. No anomalies were found.

Dredge MD-48 was deployed onto this flat lava field and hauled some distance with many large bites. The dredge returned upside down again with main weak link sheared, and with the chain bag very tangled. Ooze was recovered from the sediment traps, and about 500g of glassy basalt chips and abraded pumice fragments were extracted from the bottom of the fishnet liner. Apparently the weak link parted early in the tow, and the dredge was then pulled some distance by its ring, causing the tangling and emptying most of the load. Maximum bite tension during the haul was only 1.8 tonnes, less than the nominal weak link strength of 2.7 tonnes.

The transit to the eastern sector of the East Sherburne Neovolcanic Zone crossed a volcanic cone with a 25m-deep summit caldera at $3^{\circ}45.4' 149^{\circ}09.8'$.

Echosounder traverses MES-12A and MES 12B were conducted orthogonally to locate the summit of a small volcanic cone with lava flow to its south, which appeared very reflective and apparently very young on the sidescan image (Pacific Seafloor Atlas). The cone proved to be only 30m high.

Hydrocast MH-34 was a single dip over the crest of this cone, which yielded no transmissometer anomaly.

Dredge MD-49 was deployed on the southern lava flow, but may not have climbed the cone as intended.

Maximum bite tension was only 0.8 tonnes, nevertheless the dredge returned with its main weak link broken. About 1kg of glassy basalt plates and some abraded pumice were recovered.

This completed our operations in the east Sherburne Zone, where we successfully characterised 4 volcanic edifices as basaltic, but found no evidence of hydrothermal activity.

Day 10 - Monday, 2nd December 1996

Following a 3 hour transit Hydrocast MH-35 was a 2-dip cast to check for hydrothermal activity over the thickest portion of the Willaumez Extensional Transform Neovolcanic Zone, never before tested. Only a very slight transmissometer anomaly at 2000 m was noted, possibly a water mass effect rather than hydrothermal plume.

After a further 9-hour transit towards PACMANUS, Dredge MD-50 was deployed, with calm conditions and a slight southeasterly wind astern, onto a scarp at the northwestern end of the "SE Manus Rifts" of Taylor et al, where Moana Wave seismic (MW8517, Line 10, 0225h) indicated a deformed basement below flatter rift sediments. The dredge was driven onto the scarp exactly on target. A 1.1 tonne bite occurred soon after hitting bottom. It returned again with the weak link broken. A number of large blocks of interbedded mudstone and fine semiconsolidated sandstone (basaltic ash) were recovered, and also many large blocks and smaller fragments of white pumice almost certainly derived from an outcrop. At last we have sampled basement, albeit at some distance from PACMANUS.

Dredge MD-51 was deployed with strengthening southeasterly winds onto the northwest flank of Dartboard Seamount, a conical volcano on the transform-parallel magnetic lineament passing through PACMANUS, near where harmonic tremor was recorded in 1982 and earlier by Rabaul Volcano Observatory. The dredge returned

upside down once again, with the main weak link broken. About 20kg of scoriaceous andesite blocks, some abraded pumice, and one tube of mud were recovered. Dartboard Seamount is hence not exceptionally young. Sediment Core MS-22 was taken on a flat sedimented floor of the rift immediately west of Kumul Trough, to fill a gap in our sediment collection. A good core of 101 cm was recovered, showing two turbidite beds with oxidised hemipelagic mud tops overlying the similar top of a third bed.

Day 11 - Tuesday, 3rd December 1996

Dredge MD-52 was deployed on the scarp directly southeast of Kumul Trough with the aim of sampling basement, using Dredge A and the second depressor weight for the first time this cruise. The dredge was placed accurately on the eastern scarp, recording several bites reaching only 1.0 tonnes maximum. The dredge was lost when the main weak link parted and the safety chain snapped ahead of the 2nd weak link. The remaining dredge was refitted with stronger safety chain and shackles at the 2nd and 3rd attachments, and much discussion was held regarding weak links. Small chips of basaltic glass and some mud were recovered from fresh scours on the 0.5 tonne lead weight, so the operation was not a total loss.

Following this operation the ship was moved to the Snowcap site at PACMANUS for attempts at precision sampling of altered dacite and associated materials.

Sediment Core MS-23 was deployed with 10-12 kt southeasterly wind which caused difficulty holding position. The corer recovered a broken mussel and its soft parts, which had clogged the core-catcher and prevented collection of a sediment core. Some small particles of glassy and altered dacite were filtered from cloudy water drained from the liner into a plastic bag as the corer was brought on deck.

Grab MG-14 was deployed after one aborted attempt on the same Snowcap target, but again drifted during deployment and hit well southeast of the target. On impact the grab jaws closed over a 20cm lump of platy, unaltered dacite. Because of the difficulty experienced in holding station, further sampling operations were suspended.

Hydrocast MH-36 was conducted at right angles to previous tow-yo's to provide an orthogonal profile of the PACMANUS and any subsidiary plumes. Its northeasterly traverse for 4 miles along the axis of Pual Ridge extended from near Roman Ruins to cross an anomaly detected by MH-16 in 1993. A progressively declining, thickening plume was recorded. The anomaly over andesites noted by MH-16 was not repeated. Two reference seawater samples were taken at 1750m and 1450m on the final upcast. At the end of this operation, a successful test was carried out of holding station in TAC mode, while recording the pinger signal from the CTD on the aft-facing broadband echosounder transducer. This indicated that precision camera tows in TAC mode could be planned.

Camera-Video Tow MCV-24 was the first attempt to hold station during camera deployment and for a period on bottom when two Ocean Drilling Program (ODP) markers (A and C, carried on the tailfin of the cage) were released acoustically onto the proposed ODP site EMB-1H, at the crest of the northeastern knoll of Pual Ridge. After deployment of markers, a short northeasterly track (~150m) was surveyed. The cage returned without the markers, but their deployment was not recorded by video. During this operation it was noted that the tensiometer recording showed accidental bottomings of the camera system. An apparent temperature anomaly recorded by the Yeokal SDL, coinciding with a 5-minute bottoming, was believed due to trapping of heat from the floodlamps buried in ooze.

Dredge MD-53 was successfully conducted as a high-precision deployment despite gusty winds, onto the northwestern foot and flank of Sonne Pimple, a small 30m high feature revealed by Parasound during Sonne cruise SO-94. The dredge returned a 2/3 load with ropy andesite at the top (identifying the pimple) and dacite with much mud at the bottom (older Pual Ridge). An ophiuroid and a small tubeworm were also present. Sediment Core MS-24, intended as a grab but changed because 15 kt winds prevented holding station while using the hydrowire, was another attempt to sample mat, sediment and altered dacite at the Snowcap Knoll hydrothermal site. No core was obtained, but fragments of glassy and altered dacite were caught in the nosecone.

Because continued gusty winds were expected to prevent precision operations of the kind now required at PACMANUS, it was decided to transit towards the Tumai site.

Sediment Core MS-25 was taken at proposed ODP drill site EMB-5A. An 84 cm core of two turbidite beds overlying mud with an ash layer was recovered.

Day 12 - Wednesday, 4th December 1996

Hydrocast MH-37 was a 4-mile tow-yo conducted in a southeasterly direction to overlap and extend MH-29 which in 1993 detected a plume in the Tumai Ridge area. Although changeable wind forced the track further east than intended, an increasingly intense two-layer plume was detected. Eight water samples were taken from the plume on several upcasts.

Hydrocast MH-38 was conducted on the reciprocal track displaced to the west. Passing over a pair of high-standing peaks given the name Susu Knolls, the upper level anomaly increased dramatically.

Hydrocasts MH-39 and MH-40 were placed to the south and southeast, confirming that the plume was centred on Susu Knolls. Echosounding during these hydrocasts were used to place later cross-lines intended to locate the exact crests and heights of North Su and South Su.

Dredge MD-54 was aimed to sample the western slope of North Su at about 1500m depth, and after several small bites returned with about 20kg of dark, feldspar-phyric volcanic rock, whose microlite-rich glassy groundmass was characterised as dacite. No ooze was contained in the chainbag or sediment traps. Camera-Video Tow MCV-25 was designed as an initial survey of the crests of both South Su and North Su, and of Cleavage Col between them. Because of the steep slopes, three "hovers" with raisings inbetween were conducted. ODP Marker F was released acoustically on South Su at about 1329m, but its deployment was not confirmed since no video was taken during the operation due to a non-damaging leak in the pressure housing. A second marker was deliberately brought back to confirm that the release system was robust. The attempted climb from Cleavage Col to the crest of North Su was not completed. Difficult flying was experienced because the echosounder had not been switched to broadband. Distinct temperature anomalies (0.2°C) were recorded several times by the data logger on South Su, in Cleavage Col, and on the slope to North Su.

Day 13 - Thursday, 5th December 1996

As MCV-25 was being brought aboard at 01:40h, a potentially disastrous failure of the main power supply cancelled the TAC control, causing the ship to surge ahead out of control, with the A-frame extended and the camera-video system still overboard. No further operations requiring TAC control were permitted until the problems were examined in daylight.

Echosounder Traverse MES-13 was set normal to the track of MH-40 to locate the exact crest of North Su, whose elevation was confirmed (as crossed on MH-40) at 1160 metres.

Sediment Core MS-26 was attempted twice from a small enclosed deep just east of the intersection between Bugave Ridge and Tumai Ridge. The first effort recovered a little fine sediment settled from the twisted and broken liner. The second recovered a quantity of sandy sediment in the nosecone, which included grains of feldspar and glassy material similar to the groundmasses of dacite from North Su.

Circuit boards of the TAC system were removed and cleaned prior to the next operation.

Dredge MD-55 was deployed on the lower southwest slope of South Su, indicated from preliminary assessment of hydrocast results as a possible source of the deeper plume at Susu. The TAC controls failed again during this operation. After several large bites, the dredge returned one-third full of ooze, which included a pale grey sandy layer of dacite mineral and groundmass fragments. Pieces of glassy andesite, and of exotic pumice, were washed from the ooze.

Hydrocast MH-41 was a north-easterly tow-yo normal to previous traverses, designed to close-off the plume and better define the "eyes" of upper and lower portions. Re-interpretation of all transmissometer anomalies taking into account CTD lag behind the ship indicated the higher plume was centred on the crest of South Su, and the lower portion on its lower southern flank.

To provide time for further examination of TAC controls, and with calmer conditions prevailing, a transit back to PACMANUS was commenced. During this, 3 each of the nominal 2.7 and 3.7 tonne weak links for dredging were tested to destruction by fixing to a deck bollard and hauling with the main winch. They sheared at close to their nominal values. Since maximum tensions much less than this were recorded during dredge hauls where the weak link broke, it appears short-term impact forces exerted at the dredge are not transmitted to the main sheave where tension is measured. This means a stronger weak link can be tolerated provided winch operators ensure the maximum allowable tension is not exceeded by paying cable when required.

Sediment Core MS-27 was taken at the proposed ODP EMB-5C drill site, in rift-fill above a possible concealed intrusion. A 57 cm core with similar stratigraphy to MS-25 (5 km north) was obtained. This lacked any indication of hydrothermal alteration.

Hydrocast MH-42 was a single dip at this site to check for a hydrothermal plume, with negative results. Two reference samples were taken on the upcast. A one-hour delay ensued for further checks of TAC control and gyrocompass.

Dredge MD-56 restarted operations at PACMANUS, with an attempted high precision sampling of the Roman Ruins site based on ManusFlux positions and taking account of distance from DGPS aerial to outstretched A-frame. The recovery included about 400 kg of dacite, with "pumiceous" rinds and iron oxide staining of fractures, three small Cu-rich chimney fragments, and pieces of fragile orange-brown oxide deposit.

Camera-Video Tow MCV-26 commenced at proposed ODP site EMB-1G by deploying (and photographing) ODP markers F and V, then traversed northwest to and north from a hover point at the known ManusFlux position of the "Roman Ruins North" hydrothermal field, re-named Rogers Ruins during this cruise. A temperature anomaly was observed when the video recorded shimmering chimneys. Video lights failed while traversing the latter.

Discussions with the Chief Engineer indicated more time would be needed next day to progressively replace circuit boards of the TAC system, and thereby define the problem with it.

Day 14 - Friday, 6th December 1996

Sediment Core MS-28 was yet another attempt to obtain a section through bacterial mat and sediment into altered dacite at Snowcap Knoll, but recovery was nil.

Grab MG-15 conducted under very calm conditions at the same site had the same objective. It returned a two-thirds load with a surface of brown mud, platelets of Fe oxide, black volcanic chips, a mussel, and a radiating tubular organism. No white bacterial mat was observed. The deeper part of the grab consisted of brown to grey

sediment with abundant tiny rock chips. Later petrographic study indicated an unusual range of rock compositions, from andesite to rhyodacite.

Grab MG-16 repeated this operation closely and provided another good section. The upper surface, 1 to 2 cm thick, consisted of dark grey mud with chips to 1 cm of volcanic rocks, galatheids, mussels, and soft worms. Below, the sample consisted mainly of fresh and altered rock fragments to 4 cm size, with little mud. Soft worms and mussels were immersed in this zone.

Dredge MD-57 was aimed to sample chimneys known from previous camera tows and ManusFlux dives to occur at the southwestern side of Snowcap. After a large bite or anchoring, it returned with a distorted weak link and a half bag of dacite fragments with pumiceous rinds and large vesicles, some 10 fragments probably of the same sphalerite-rich chimney at the top of the dredge bag, numerous small chimneys and chimney fragments immersed lower in the haul, and fragments of Fe oxide crust.

Grab MG-17 was deployed onto the Roman Ruins hydrothermal site, and collected the top of a small Cu-rich chimney top in its jaws, plus sulfide-rich sludge with many small chimney fragments in the scoops.

A side trip was then made to 3°43.0' 151°40.0' where surplus volcanic rocks were disposed of in 1900m of water.

Dredge MD-58 was placed with precision in the centre of the Roman Ruins hydrothermal field as defined by ManusFlux dives, and returned with about 300 kg of chimneys including one 0.8x0.3x0.5m entire sample, together with small pieces of glassy dacite, two live snails, a brachyrian blind crab, and shrimp.

Camera-Video Tow MCV-27, using the "move and hover" technique, surveyed and placed ODP Markers X and T at the col on Yuam Ridge where the start of MCV-19 in 1993 photographed a few glimpses of possible hydrothermal mound. Only scattered, heavily sedimented lava exposures were seen, and there was no temperature anomaly, so the occurrence of hydrothermal deposits on Yuam Ridge was not confirmed.

Dredge MD-59 was precision-deployed onto the Rogers Ruins hydrothermal site as defined by a ManusFlux dive. After many good bites, about 200 kg was recovered of hydrothermal deposit, partly to thoroughly oxidised with red-brown Fe oxides and green atacamite. This included one very large ~50kg block. A large block of Fe-stained, Mn-coated vesicular dacite with coke-like surface was also recovered.

Grab MG-18 was yet another attempt to sample sediment and altered dacite at Snowcap Knoll. It returned part filled with disturbed mud and chips of "woody pumice" and a spicular shard.

Another side trip was then made to 3°43.0' 151°38.0' where two lengths of damaged cable and excess rocks were dumped at the site used for this purpose in 1993. The re-terminated cable was stretched and rewound en route.

Dredge MD-60 was a second precision operation to sample the Rogers Ruins field. It recovered a stratified half bag load of oxidised chimney fragments, some with atacamite, overlying glassy dacite. Some Mn oxide fragments and Mn-coated volcanics were also present. Ooze with rock chips and oxide fragments was present in the sediment tubes. This result is virtually identical with MD-59.

Day 15 - Saturday, 7th December 1996

Camera-Video Tow MCV-28 commenced by deploying and photographing ODP Markers L and E just west of the Roman Ruins hydrothermal field, then traversed north across the Rogers Ruins field. Scattered hydrothermal crusts and yellow deposits were recorded along with volcanic outcrops between Roman Ruins and Rogers Ruins. Video lights failed after heading north from the previously known position of Rogers Ruins. No 35mm film was taken. Two diffuse but minor temperature anomalies corresponded to the separate fields. Several rock chips were recovered in the tailfin.

Dredge MD-61 was another precision operation aimed at collecting further samples from the Roman Ruins field. It recovered around 300 kg of massive sulfide fragments, including fresh and part-oxidised fragments of large chimneys, mostly rich in chalcopyrite, and numerous small parasitic chimneylets. Cataloguing this large haul continued almost to the end of the cruise. Many snails and a small galatheid were also recovered.

Sediment Core MS-29 was yet another attempt to obtain a profile through mat and sediments on the Snowcap Knoll. Only three small chips of rhyodacite were recovered from a sock used as an extra trap.

Dredge MD-62 was precision-deployed at the centre of the Satanic Mills site as defined by ManusFlux dives. It recovered one-third of a bag of massive sulfide chimney fragments, including one 40cm long by 30-35cm across with separate chalcopyrite and sphalerite orifices, together with some fragments of Fe-stained fresh dacite and some of possible altered dacite.

Two buckets of surplus rock were dumped at 3°39' 151°39' en route to the next operation.

Dredge MD-63 sampled a low scarp north of Marmin Knolls, where Leg 1 of seismic traverse SCS-07 (RV Sonne, 1994) indicated outcrops of possible basement. About 30kg of lithified sediment was recovered, comparable with Rataman Formation (New Ireland).

Dredge MD-64 then sampled a previously unexplored ridge in the northwestern part of the Marmin Knolls region, recovering an almost full bag of mud with a layer of rocks near the centre. The rocks included small pieces of pumice, and picritic basalt similar to other Marmin edifices. All sediment tubes were full with brown ooze. Grey ash layers occurred in the "top" half of ooze in the dredge.

Camera-Video Tow MCV-29 was a traverse along the northeastern arm of Pual Ridge where rhyodacites had been dredged previously, seeking any hydrothermal deposits and recording the morphological characteristics of these very siliceous lavas. Chips of rhyodacite were embedded in the camera tailfin. ODP Marker S was

deployed at the start of the traverse, but an incorrectly installed second marker failed to release. A slight temperature anomaly was recorded by SDL during the initial hover.

Dredge MD-65 was precision-deployed on the chimney field at the southwestern end of Snowcap Knoll. An almost full load of fresh dacite was recovered, together with a 40x23x15 cm chimney and numerous fragments probably off the same structure, which were at the top of the dredge bag. The chimney displays a fragmental structure and contains significant chalcopyrite. The sediment tubes contained dacite chips and a little greenish ooze. Spaghetti tube worms, snail fragments, galatheids and mussels were present in the haul.

Dredge MD-66 sampled a small volcanic knoll on the eastern flank of Pual Ridge near PACMANUS, recovering a quarter bag of fresh dacite. Some samples show Fe-staining, Mn coatings, and bluish blooms suggesting there may be some hydrothermal activity in the vicinity.

Surplus volcanic rocks from MD-65 and MD-66 were dumped near 3°42.7' 151°37.0' during transit to the next operation.

Day 16 - Sunday, 8th December 1996

Dredge MD-67 aimed to sample basement from the steep scarp at the inner nodal deep west of Kumul Trough where it meets the Djuai Fault. It was placed accurately on bottom just above the foot of the scarp and hauled upslope with many bites for 25 minutes before anchoring. The haul direction was reversed to release the dredge. About 1 tonne of varied basement lithologies provisionally identified as metabasalts, jointed sandstone and consolidated mudstone was recovered, plus some glassy basaltic pillows and lobes. One sediment trap contained ooze.

Dredge MD-68 returned to PACMANUS, attempting a repeat of the MD-62 sampling at Satanic Mills.

Although deployed within 30m of the latter, it recovered a quarter load of fresh dacite but no sulfides. Some dacites showed Fe staining or Mn coating. There was no mud in the dredge or the sediment traps.

Dredge MD-69 sampled the lower of two scarps east of Yuam Ridge, interpreted from Moana Wave and Sonne seismic to expose basement but not successfully sampled in 1993. A one-third load of mud with some fragments to 40cm of dacite and possible andesite were recovered. These resemble previous samples from the volcanic edifices of Yuam Ridge, and the scarp is no longer considered basement. A small jellyfish was also recovered.

A further length of damaged cable and surplus hydrothermal fines from MD-60 were dumped on the valley floor between Yuam and Pual Ridges, at 3° 45.5' 151°41.8'.

Dredge MD-70 sampled a small volcanic edifice on the valley floor south of PACMANUS, recovering about 500kg of scoriaceous cinders and large blocks of vesicular basaltic andesite, some with ropy surfaces. Brown ooze was present in the sediment traps and towards the top of the dredge bag. Fauna comprised one octopus tentacle.

Camera-Video Tow MCV-30 was a "move and hover" operation which commenced on the moderately-sedimented jagged dacite crest of Pual Ridge close to Sonne Pimple, where ODP Markers Y and Z were placed, then climbed the Pimple. Video lighting failures during crashes late in the tow prevented immediate observations of andesite lava structures, but these may be on the 35mm film although the SDL pressure recordings indicate the crest might not have been achieved. Mottled sediments with possible Mn nodules were noted early in the tow. No temperature anomalies were recorded by SDL.

After a 2-hour delay caused by stormy weather, Dredge MD-71 was the first attempt this cruise to use the dredge for sampling altered dacite on Snowcap Knoll. Although station was held well despite gusty winds, the dredge returned with about 100 kg of mostly fresh dacite fragments with glassy and pumiceous rinds. There was no mud in the bag or sediment tubes. Some rocks had red Fe-stained fractures or sooty Mn coatings. Many white echinoid attachment scars on the rocks also indicate proximity to hydrothermal activity. A few samples show possible surficial alteration.

This operation concluded activities at PACMANUS, and a looping transit to Tumai Ridge was commenced with three sediment cores near the fringe of the PACMANUS plume, in the basin northeast along strike from Pual Ridge.

Sediment Core MS-30 recovered 85cm of turbidite sediment with two ash layers. Twisting of the core liner due to excessive length occurred, and remaining liners were shortened 5mm.

Sediment Core MS-31 recovered 140 cm from a single turbidite unit without ash layers.

Day 17 - Monday, 9th December 1996

Sediment Core MS-32 recovered a 113cm core, mostly one turbidite unit overlying the top of an oxidised hemipelagite, again without ash layers.

During the transit to Tumai, surplus samples were cast overboard passing 3°45' 152°00'.

Camera-Video Tow MCV-31 was flown easterly along a contour on the lower southern flank of South Su, covering a possible source of the Susu plume as assessed from earlier hydrocasts. The traverse was heavily sedimented, with only occasional rocky outcrops and fauna. Some rock chips were embedded in the tailfin. A possible temperature anomaly occurred during the initial hover.

Hydrocast MH-43, sailed northwesterly for 5 miles, linked up with previous tow-yos to extend the Tumai plume survey further south. Exceptionally intense transmission anomalies were noted at 1000-1100m while abeam of South Su, while anomalies at 1400m and 1600m had maxima further to the northwest. Several intervals of acoustic noise were experienced

Dredge MD-72 was aimed at Cleavage Col between North Su and South Su. No real tensiometer bites were experienced during two brief placements on bottom, nevertheless a good haul was obtained of fresh black porphyritic lava as well as partially altered equivalents with stockwork-like pale zones creating a brecciated appearance. No ooze was recovered.

Camera-Video Tow MCV-32 was intended to cover the crest of North Su and then descend its northwestern ridge, but it became severely anchored soon after moving along bottom. Releasing by reversing the haul direction took 96 minutes. The cage returned with 25 kg of large and small blocks of porphyritic volcanic rock, some with surfaces having a weathered appearance. Minor damage was caused to the forward shield of the cage. A short interval of heavily sedimented volcanic outcrop was recorded prior to the anchoring, with much particulate material in the water column near the seabed. A 0.4°C temperature anomaly occurred at the start of the tow. Others during the anchoring period were possibly due to lamp heating of sediment during burials. Several intervals of acoustic noise were recorded on both the 12 kHz scientific and 25 kHz bridge echosounders, just prior to anchoring and during the recovery manouvers.

Hydrocast MH-44 was a 4-mile tow-yo sailed northeast, orthogonal to previous traverses, across the apparent "eye" of the Tumai plume and confirming its position. Acoustic noise was again experienced crossing South Su.

Day 18 - Tuesday, 10th December 1996

Camera-Video Tow MCV-33 commenced near the crest of South Su and then descended its higher southern flank. Flying was made difficult by a poorly reflecting bottom and at one stage an interval of intense acoustic noise. Most of the track was flown too high, and within a "snowstorm" of particulate material. Occasional glimpses of sedimented bottom, of volcanic outcrops, and of a possible chimney structure were recorded. Small rock chips were recovered in the tailfin. Some small, possibly spurious temperature anomalies were recorded by SDL.

Dredge MD-73 sampled the lower western flank of The Pyramid, a tetrahedral peak (1060m crest) 5 miles east of Susu Knolls. After only minor bites, a load of brown ooze with a number of "porphyritic dacite" blocks resembling those at Susu was recovered.

Dredge MD-74 was deployed higher than anticipated from the Aquarius SeaBeam chart on the scarp south of the inner nodal deep at the intersection between Bugave Ridge and the Weitin transform fault zone, expecting to sample basement. The dredge became anchored and was freed by pulling sideways. Despite cable tension rising to 4.0 tonnes the weak link suffered only minor distortion. A one-third load of mud returned, from which was extracted 5 small fragments of igneous rock, several of consolidated sediment, and some exotic pumice. The igneous rocks included diabase, and a "porphyritic dacite" similar to those from The Pyramid and Susu Knolls. Possibly both upper and lower basement sequences, and a volcanic edifice surmounting the scarp, were sampled from sediment-covered talus near the base of the scarp. Sediment traps were filled with brown ooze.

Sediment Core MS-33 was attempted from a small basin southeast of Bugave Ridge to obtain a profile of volcanic and hydrothermal activity in this area. Through an error in calculating its waypoint, the corer descended on the side of this depression and recovered only 13 cm of fine sandy sediment of local volcanic derivation.

Camera-Video Tow MCV-34 was a hover-and-move operation deployed initially on the col between North Su and a smaller knoll to its northwest (Suzette), before raising and redeployment near the crest of Suzette. Although flown at good height, the hover over the initial col did not record bottom because of intense hydrothermal particulate "snow". Glimpses of sediment-covered surface through the snowstorm occurred during a climb to the 1510m crest of Suzette, then chimneys and fauna were recorded at the crest, this being the first confirmation of hydrothermal deposits at Susu Knolls.

Grab MG-19 on the crest of South Su collected several fragments of variably altered fragmental volcanic, some with disseminated sulfides constituting the second confirmation of the hydrothermal activity indicated by the plume surveys.

Dredge MD-75 was deployed on the upper western slope of Suzette, recovering a quarter bag of gritty mud containing andesite fragments with glass rinds, a single fragment of sphalerite-barite chimney, small pieces of ferruginous oxide crust, and sediment cemented by oxide material - the third confirmation of hydrothermal activity in a few hours.

Hydrocast MH-45 was a single dip at the "eye" of the Tumai plume, specifically to collect on upcast a sequence of samples for geochemical studies and filtering of particulates, at depths from 1668m to 1000m spanning a trifurcate lower and bifurcated upper transmissometer plume profile.

Camera-Video Tow MCV-35 was a short hovering traverse across the crest of South Su, deliberately dropped to bottom (lowered tensiometer reading) on occasions to ensure seeing through the hydrothermal "snowstorm". Flying was very difficult because of acoustic noise. The video did not operate, so 35mm processing must be awaited. Topography along the track was severe, making it difficult to assess whether temperature anomalies were recorded by SDL. Some rock chips were recovered from the tailfin.

A malfunction in the main block tensiometer and wire-out meter developed in this operation, preventing further use of the main winch until repairs could be carried out in daylight.

Day 19 - Wednesday, 11th December 1996

Grab MG-20 was aimed at the chimneys photographed by MCV-34 on the crest of Suzette, but recovered only dark green sandy silt.

Grab MG-21 was similarly aimed at the crest of North Su. The first attempt yielded no sample. A repeat attempt yielded a small quantity of dark greenish sand. In both cases wire-out exceeded depth by 100m, so apparently the grab did not descend vertically.

Hydrocast MH-46 was intended as a 4-mile tow-yo along Bugave Ridge linking Susu with the area studied during the Aquarius Cruise in 1990. It was terminated early as the Tumai plume anomaly dropped in intensity towards the northeast. A reference water sample was taken at 1400m on the final upcast, and several salinity standards were collected at other depths.

The Main Block was repaired after dawn, during MH-46. After completion of the latter, trial runs were conducted of the ship's new rescue boat, affording opportunities for photography.

Dredge MD-76, like grab MG-20, was precision-deployed on the crest of Suzette and hauled northwest a short distance to sample the chimney zone photographed by MCV-34. After strong bites, it returned a large haul, 2/3 of a bag, of massive sulfide chimneys immersed in a black sulfidic mud. Many larger chimney fragments are rich in chalcopyrite, and some have bornite and covellite as well. Some samples of sphalerite-barite chimney wall, and some composite samples were also present, many with thin outer brown surfaces. In addition there were a number of small chimneys, again cupriferous. Some exotic fragments of pumice were washed from the mud. Fauna included 2 live snails and several shells, a galatheid, and tubeworms.

Camera-Video Tow MCV-36, using the hover-and-move method to oscillate between two waypoints, followed a 200m track over a 60m-high plug on the crest of North Su, then returned to become anchored, apparently on this plug, for 15 minutes at the end of the tow. It was particularly well flown, with deliberate groundings to ensure sighting bottom through the hydrothermal "snowstorm". Several intervals of acoustic noise were recorded. The cage returned with many fragments to fist-size of dark grey altered porphyritic volcanic with globules of native sulfur, covering the battery cases. The videotape showed both jagged and sheet-like volcanic outcrops, sedimented zones, and a variety of hydrothermal crusts, mounds, dark sediments, and unusual ribbed deposits and rippled sediments. Much particulate matter was suspended in the water column, and in places bottom was obscured by billowing bacterial mat. Marked temperature anomalies of 2 to 3°C recorded by SDL at the early and later stages of the tow correspond to shimmering fluid observed on video, while a brief 11.5°C peak mid-way corresponds to a "hole" in the billowing bacterial mat.

Dredge MD-77 was deployed in a southwesterly direction across the crest of South Su. It became seriously anchored soon after bites commenced on hauling and was released after 25 minutes by carefully moving the ship back across the deployment point. The dredge returned undamaged with a good haul including one very large rock and many smaller pieces of altered and unaltered porphyritic volcanic, dark sulfide-rich breccias with clayey or siliceous fragments, and a quantity of mud with three distinct layers, grey overlying black overlying brown. Two sediment tubes contained ooze. Fauna included a tubeworm and several galatheids.

Camera-Video Tow MCV-37 followed a 300m southwesterly track on the crest of South Su, and was flown well although affected by intervals of intense acoustic noise. Although the ship was returned to its initial waypoint, the camera probably only started its intended return trip after crossing a 25m high spine. The video recorded dense plume particulates and thick bacterial mats, with occasional volcanic outcrops and rilled sediment. Possible small chimneys with rising vent fluid near the start of the tow correspond with a noisy temperature pattern (0.1°C amplitude) recorded by SDL. A large 30x27x15cm block of altered volcanic with pervasive pyrite, and a number of small fragments of similar material, were returned with the camera frame.

Dredge MD-78 was hauled northwest along the col between North Su and Suzette. After only one minor bite it returned with a quarter load, of two big blocks and many smaller pieces of fresh porphyritic lava. The sediment tubes were full. Dark sandy material elutriated from mud adhering to the rocks consisted of mineral grains equivalent to the phenocryst assemblage.

To provide breaks during transit for the heavily worked winch drivers, several operations followed in the basin north of Tumai Ridge.

Sediment Core MS-34 was taken from the centre of this basin, but recovered only 25cm of dark greyish brown mud. A stiff layer in the nosecone probably prevented better penetration.

Day 20 - Thursday, 12th December 1996

Echo-Sounder Traverse MES-14A was a south to north profile across Lunar Cone, a small 320m-high volcano with a lava flow extending to its south, very prominent and youthful in appearance on the Moana Wave sidescan sonar mosaic. During the lead-up, a small 100m-high feature (not evident on sonar or previous bathymetry) on the lava flow was crossed. MES-14B recrossed Lunar Cone from west to east, locating the true crest (1787m) at 3°39.72' 152°02.80'.

Dredge MD-79 was then hauled up the western slope of Lunar Cone, starting close to its base and climbing to about 2000m before lift-off. A half-full bag was returned, of brown and greenish mud with numerous porphyritic volcanic rocks, again with dacitic groundmass. Most rocks had an older-looking, faintly weathered exterior. Sediment tubes contained green and brown mud. These results indicate Lunar Cone is not a mafic cinder cone, nor is it exceptionally youthful. A brittle star and soft worm were also collected.

Camera-Video Tow MCV-38, returning to Susu Knolls, overlapped and extended the track of MCV-34 down the ridge trending northwest from the crest of Suzette. Actively smoking chimneys with abundant fauna (snails,

crabs, worms) were recorded just before and when the 1510m crest was passed, probably the same location photographed by MCV-34. Hummocky sediments (plume fallout?) and much suspended particulate matter with only rare volcanic outcrops were encountered on the northwestern flank and ridge. A 2°C temperature anomaly was recorded by SDL when passing a smoker at the crest, and smaller anomalies occurred in the vicinity. A large flange-like portion of chimney with chalcopyrite rich centre and sphaleritic exterior, and many smaller fragments mostly rich in chalcopyrite, were collected by the camera during a crash.

Dredge MD-80 was hauled northwest up the southwestern end of Bugave Ridge, near its intersection with Tumai Ridge. A 1/3 bag of green, brown and black mud, and blocks of andesite lava was recovered after a large bite and 6-minute anchoring.

Camera-Video Tow MCV-39 extended the track of MCV-32 down the southern flank of South Su, towards the "eye" of the deeper plume, descending to 1710m and then turning back under the eye. At the end of the tow the system was raised while still photographing for some 450m through the plume. Unfortunately the video camera failed on this occasion: geology and plume studies must await processing of the 35mm film. Chips of altered volcanic rocks were recovered from the tailfin. No temperature anomalies were recorded by the SDL.

Dredge MD-81 was deployed with precision on the chimney field photographed by MCV-38. Using SDL depths and wire-out, the lagged track of the camera was estimated, and in lowering the dredge account was taken of the distance between GPS aerial and A-frame. Haul was to the southeast. After several bites and a brief anchoring (probably breaking a chimney), a quarter bag of dark mud below and massive sulfide chimney fragments near the top was recovered. The sulfidic mud was finely stratified on a millimetre scale, with some red-brown oxide bands, constituting a most important discovery. The chimney are chalcopyrite-rich, and some contain bluish bornite or covellite. Sphalerite-barite outer zones occurred on some samples. One showed a small chimneylet growing from a part-oxidised older structure. Flakes of Fe oxide separated from some chimney exteriors were also collected. The sediment traps of the dredge contained dark grey mud.

Grab MG-22 was taken on the southwestern flank of South Su, to collect fallout under the "eye" of the Tumai plume. A full load of stratified sediment was obtained, with approximately 0.5cm of surface black ooze (sulfidic?) overlying a 3-4 cm pale grey layer, which in turn overlies normal brown pelagic ooze. No fauna was present.

Dredge MD-82 was hauled up the higher southern flank of South Su, commencing about 100m below the crest. It became severely anchored soon after moving, and returned with broken weak link after a 4 tonne rise in tension. A quarter-bag haul was nevertheless returned, containing blocks of fresh and altered volcanic rock, some dark grey mud, and a lot of fauna including snails, mussels and a crab. Many volcanic fragments contain native sulfur, and some have disseminated pyrite. A distinct H₂S smell was reported but not confirmed. Rising wind at this stage prevented precision operations, and battery malfunction prevented a planned camera-video tow. A series of sediment cores was commenced, during which further problems with tension and wire-out meter were experienced.

Sediment Core MS-35 was taken below the southwestern fringe of the Tumai plume, but the O-ring of the corer closure was lost and except for a little sandy sediment in the core-catcher sock the sample washed out before the corer came on deck.

Sediment Core MS-36 was taken at the site where MD-81 had been deployed on Suzette, and recovered 75 cm of diffusely layered sandy sediment, ranging from black and dark grey to local olive grey and brownish. About 7cm of dark sediment redeposited during retrieval overlay the core. The upper 38cm of core appears detrital and the lower section hydrothermal, with several hyaloclastite layers of local derivation plus blebs of grey rhyolitic pumice ash.

Day 21 - Friday, 13th December 1996

Hydrocast MH-47 was a single dip with CTD and transmissometer placed over the bathymetric culmination of Bugave Ridge. No significant anomaly was detected. With MH-46 and the results of Aquarius Cruise hydrocasts, this confirmed that Bugave Ridge is not hydrothermally active.

Sediment Core MS-37 was taken from the nodal basin between the Weitin Fault and Bugave Ridge. A 42cm core consisting of two turbidite beds was obtained, with the mud top of a third bed in the core catcher. No ash layers were present.

Sediment Core MS-38 returned under the southeastern fringe of the Tumai plume. Only 3cm of redeposited brown mud was recovered in the core liner, sock and Spanish fingers. Some brown water was pouring out on recovery, so the closure flap was disassembled and sanded.

Soon after dawn, the Main Block was removed and replaced. Dave Edwards measured the amount of wear on the old block, and calculated it caused overestimation of wire-out by a factor of 1.012 up to this stage of the cruise.

Dredge MD-83 was aimed at the fluted and shimmering hydrothermal deposits photographed on North Su by MCV-36, following application of lag corrections to the camera tow, but no adjustment for distance between A-frame and GPS aerial (expecting to haul this distance). Disappointingly, the 1/3 bag haul consisted of mostly fresh and some slightly altered porphyritic volcanic rock, a few with Fe-stained surfaces. Gritty mud and rock chips were collected by the sediment traps.

This operation terminated our activities in the Tumai-Susu area. With the Master's departure deadline approaching, the short transit to Tavui Caldera north of Rabaul was made for a short program to establish

conclusively whether or not it had been hydrothermally active, and to assess its igneous character (Tufar 1990 dredged the caldera on the OLGa expedition of RV Sonne and collected pumice). These operations supplemented MH-12 and MES-6 conducted in 1993 with RV Franklin.

Hydrocast MH-48 was a single dip within the caldera to provide comparison with 1993 data considering that the Tavuvur-Vulcan eruption of 1994 had intervened and its ash cloud passed overhead. No signs of a transmissometer anomaly ascribable to settling ash or renewed hydrothermal activity were found. A profile of water samples was taken from 10m above bottom to 600m depth, but these appeared exceptionally clear. Sediment Core MS-39 obtained about a 100cm section of sediment from the caldera floor, varying from mud to sand but with no ash layers from the 1994 or other eruptions. Unfortunately, the core was disturbed and disrupted during handling. A few millimetres of black sand with no clay fraction at the top of the core liner consisting of dacitic glass and lithic equivalents, with plagioclase and pyroxene grains, possibly derives from the 1994 eruption, but may have been artificially reworked.

Dredge MD-84 sampled the northwestern caldera wall, commencing about 150m above the caldera floor. Only small bites occurred during a brief haul. Mud was collected from one sediment trap, and from a small quantity of mud in the bag several small pieces of abraded pumice plus cm-sized chips of relatively mafic volcanic rock. A gastropod, shrimp, mussel and sea slug were also collected.

The return passage to Cairns commenced one minute late at 14:01h. A brief circuit was made of Blanche Bay near Rabaul to witness significant steam venting at Tavuvur Volcano, and the effects of the 1994 eruptions there and at Vulcan.

Echosounder Traverse MES-15 was conducted at full speed during the passage of St Georges Channel to the New Britain Trench. The track was placed 4 miles east of previous Franklin passages. Comparison with 1993 chart showed that performance of the SIMRAD 12 kHz echosounder has definitely deteriorated. Nevertheless, together with Hydrosweep swathes by Sonne closer to New Ireland, and soundings on the Naval chart, the results established that a major fault zone continues southeasterly from the southern shore of Wide Bay (east New Britain) to the inflection of the New Britain Trench, where it apparently displaces the trench. This fault zone is collinear with the Willaumez Transform of the central Manus Basin. Faults controlling two small pull-apart basins in St Georges Channel, floored respectively at 2100-2200m and 3500m respectively are now better defined.

Disassembly and packing of equipment commenced, and report writing became a major activity.

Day 22 - Saturday, 14th December 1996

Transit of Solomon Sea. Packing and report preparation continued. Curating a large backlog of samples, and petrological observations, were completed. Western side of Woodlark Island passed at close range at 16:30h.

Day 23 - Sunday, 15th December 1996

Jomard Entrance passed at 04:00h, and entered the Coral Sea. Packing and report preparation continued.

Day 24 - Monday, 16th December 1996

Continued crossing the Coral Sea with moderate seas and swell. Being some 5 hours ahead of schedule, the ship was slowed to 8.5 kts and a diversion to Bougainville Reef conducted. Report writing continued.

Day 25 - Tuesday, 17th December 1996

Passed Fitzroy Island at 04:00. Alongside the Container Wharf, Cairns, at 07:00h. Scientists and baggage were mostly disembarked by noon. During unloading a cargo net full of specimens for Canada, several bags were dropped into the harbour. Divers from nearby HMAS Cairns kindly recovered these promptly.

Summary

PACMANUS-III (FR 10/96) was a happy, exceptionally productive, and scientifically most successful cruise. We achieved more than our most optimistic expectations, in particular by not only tracking down the source of the Tumai hydrothermal plume, but by collecting a large quantity of samples of altered host rocks and massive sulfide deposits at the new site. As an example of accomplishments made possible by navigational improvements and changes to procedures relative to our previous cruises, we note that dredge MD-81 recovered an abundance of samples from a chimney field photographed by MCV-38 only 8 hours beforehand. Despite its small size relative to geoscientific research vessels operated overseas, *Franklin* is confirmed as a powerful platform for this kind of work.

Samples and data collected on FR 10/96 will provide more than a year's laboratory research for the research partnership. Even so, the Susu Knolls hydrothermal field is not yet fully delineated. It will be the subject of a further proposal for *Franklin* shiptime in 1999, and undoubtedly for manned submersible dives or ROV deployments using overseas facilities.

The Co-Chief Investigators wish specially to acknowledge the vital contributions of the ship's crew and ORV Facility staff to the success of PACMANUS-III, through precision handling of the ship, unflinching work at the

winch controls, assistance on the quarterdeck, maintenance or repair of ships equipment and scientific apparatus, and attention to personal comforts.

Personnel

Scientific Party

Bob Beattie	CSIRO Oceanography, Hobart
Ray Binns *	CSIRO Exploration and Mining, Sydney
Keith Crook	HURL, University of Hawaii, USA
Dave Edwards +	CSIRO Oceanography, Hobart
Bruce Gemmell #	CODES, University of Tasmania, Hobart
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Chris Taylor	CSIRO Exploration and Mining, Sydney
John Waters	CSIRO Exploration and Mining, Sydney

* Chief Scientist at Sea ** Co-Chief Scientist + Cruise Manager # Watch Captain

Ship's Crew

Dick Dougal	Master	Ray Issel	Able Seaman
Ian Menzies	Chief Officer	Wayne Browning	Able Seaman
Doug Henderson	Second Mate	Peter Genge	Able Seaman
Mike Culpeper	Chief Engineer	Phil French	Greaser
Dave Jonker	First Engineer	Gary Hall	Chief Cook
Don Roberts	Electrical Engineer	Peter Duy	Second Cook
Jannik Hansen	Bosun	John Tilley	Chief Steward