

FRANKLIN

National Facility
Oceanographic Research Vessel

Variability related to subduction style of submarine hydrothermal and volcanic activity in the Western Bismarck Island Arc, Papua New Guinea

CRUISE SUMMARY

RV FRANKLIN

FR 02/02

Depart Cairns 1040 hrs, Friday 1 March, 2002
Arrive Rabaul 0930 hrs, Monday 25 March, 2002

Principal Investigators

Dr Ramond A Binns (Chief Scientist)
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Dr Tim McConachy, CSIRO Exploration and Mining, Sydney

Professor Richard Arculus, Dept. of Geology, Australian National University

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Principal Investigators

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Scientific Objectives

General aims of our research program are to study modern 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. This approach avoids the problems of metamorphism and deformation that can confuse direct genetic investigations of ancient orebodies themselves. We are now at the stage where, following successes in the Eastern Manus Basin, we are extending our research to additional and different tectonic provinces in the Western Pacific so that results can be directly applied to a broader range of orebody settings.

A major hypothesis being examined in our overall research program is that magmatic sources of hydrothermal fluids and contained metals are vital for the development of "world-class" orebodies in the subvolcanic-epithermal-subhalative-exhalative spectrum. It is also important, for improved interpretation and exploration of ancient geological terrains, to improve our understandings of the links between tectonism and igneous characteristics in modern, undeformed terrains.

Cruise Objectives

Specific aims of Cruise FR02/2002 were to locate, study and sample submarine volcanoes with active hydrothermal systems in the Western Bismarck Island Arc of Papua New Guinea, in particular at sites having highly potassic characteristics and where summit calderas occur.

The cruise itself was not testing major hypotheses (apart from the presumption that an island chain of this character will possess active submarine hydrothermal centres). Rather, it represented expeditionary "field work" where, after hunting for and finding "natural laboratories", we intended to collect data and samples that become the subject of a range of laboratory investigations. These will help build up actualistic models of hydrothermal processes and products in relation to their overall geological environment.

As by-products of this research, we aimed to clarify the geochemical characteristics of the Western Bismarck Arc and to test the presence of systematic along-arc geochemical variations. The results will feed into improved understandings of the complex tectonics and geodynamics of this important segment of the Indo-Australian Plate margin.

Another subsidiary aim was to sample hydrothermal plumes in order to extend the understanding of hydrothermal components to the chemistry of the Bismarck Sea and environs. Expecting Rabaul to be the arrival port, our Cruise Plan also envisaged spending some time at the end of the cruise in the eastern Bismarck Sea conducting operations to answer questions raised during previous *Franklin* expeditions to the area.

Cruise Track

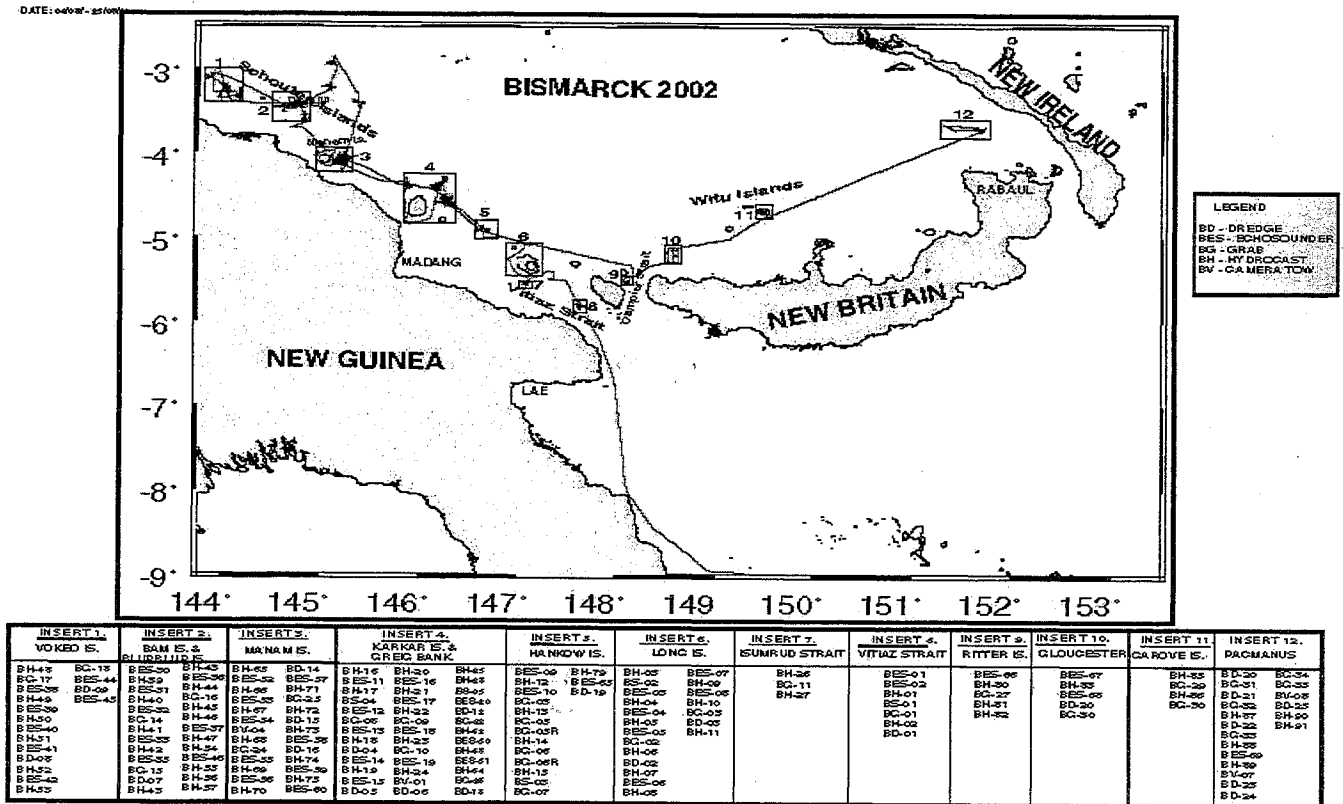


Figure 1 Cruise Track

From Cairns, we sailed via China Strait and Vitiaz Strait into the western Bismarck Sea, PNG. Operations commenced south of Umboi Island and extended west of Vokeo Island, then we returned east to Ritter Island north of Umboi (see Figure 1). Finally, after brief operations off the north coast of New Britain on the final transit to Rabaul, we spent 2 days following up outcomes of previous cruises in the eastern Manus Basin.

Results

While in the end we did not locate, photograph and sample any new hydrothermal sites on the floor of the western Bismarck Sea, we achieved important outcomes in relation to our principal objective concerning hydrothermal activity. In particular we found two especially exciting sites where multiple transmissivity anomalies (particulate-rich plumes in the seawater column) occur. The data collected suggest both of these represent potentially new styles of seafloor hydrothermal activity, associated with extensional faulting in a sediment basin and with a basement high respectively. Each site was examined in detail. If laboratory investigations of the plume particulates confirm a hydrothermal source, we will have achieved a major "first" for economic geology – the discovery of modern analogues for highly-important sediment-hosted hydrothermal orebodies. Both sites (East Manam, East Schouten Ridge) could become a major focus for future cruises, submersible and ROV dives, and seafloor drilling programs.

Altogether, we surveyed the flanks of 4 active volcanic islands, finding only minor hints of hydrothermal activity, and we examined no fewer than 23 submarine edifices, only four of which proved non-volcanic. Eight of these represent entirely new discoveries. The others were located using shoal features on nautical and soundings charts or previous *Franklin* bathymetry, and their identification as mostly volcanic seamounts or knolls also constitutes important new information. Eleven shoal features were found to be non-existent near their charted positions. Furthermore, we visited three reported sites of submarine volcanic eruptions, finding no features or phenomena that would warrant their continued inclusion on volcano catalogues.

Most of the submarine features examined in the western Bismarck sector show evidence of sufficient antiquity as to be hydrothermally quite inactive (several are foundered atolls) and, apart from one, none of the others showed pronounced signs of present or past hydrothermal activity. The exception, near Greig Bank, has manganiferous crusts at its crest but the lack of particulate plumes suggests these are old.

Returning to Rabaul we visited the submerged caldera of Garove Island, collecting bottom sediment and finding major near-bottom transmissivity anomalies to be tested in the laboratory as indications of hydrothermal activity. We also defined here a second, previously unknown explosion crater responsible for flooding of the caldera. In the eastern Manus Basin, we built on foregoing cruises and found a new hydrothermal site, evidently large and with active chimneys and live vent fauna, which is a prime candidate as the source of a major but previously enigmatic hydrothermal plume in the northern part of Pual Ridge. Also we confirmed the certain presence of major hydrothermal activity near a site (East Umbo Basin) that previously has received little attention, while at SuSu Knolls we found evidence either that hydrothermal activity has ceased or that a major shift has occurred in deep current directions. More samples of massive sulfide chimneys were dredged from the PACMANUS site, for engineering studies related to possible future undersea mining and for collection of hyperthermophilic microbes to be used in CSIRO's "Biomining Initiative".

In addressing our subsidiary objectives, the cruise was also highly successful. Numerous water samples from plume and background positions were collected for future investigations relating

to ocean chemistry and hydrothermal inputs. We also collected rock samples from many of the submarine edifices encountered, dominated by andesite and basaltic andesite but ranging from olivine-bearing basalt to rhyolite. Following shore-based geochemical analysis, these will add considerably to petrogenetic understandings of the West Bismarck volcanic arc, which occupies an unusual tectonic setting unrelated for the most part to subduction processes. One of the newly-discovered submarine volcanoes is a 1500 m high steep rhyolite plug, possibly the first submarine representative known anywhere and certainly the first in the Bismarck Sea. Several edifices have summit craters or caldera-like structures. None of these was hydrothermally active, and several were clearly nearer sea level when originally formed. One appears to be a foundered atoll now 800-900 m deep. In the central Bismarck Sea, well north of both the west Bismarck Arc and also of the zone of shallow seismicity which marks the boundary between the Indo-Australian and Pacific Plates in this vicinity, we found a 2000 m high basaltic andesite seamount (Betano Seamount) whose geochemistry will be particularly interesting in the light of its unexpected tectonic setting. Near Manam Island we collected a 112 cm sediment core with at least 8 horizons of volcanic debris that will clarify the history of catastrophic eruptions from Manam over approximately the past 4000-5000 years.

Our characterisation of East Schouten Ridge (north of Bam Island) as a basement structure (steep-dipping, early Tertiary volcanics and volcanoclastics?) on or north of the present plate boundary, and of several probably equivalent ridges further north, will have major implications concerning the tectonic nature and evolution for this segment of the Australian Plate margin. The new bathymetric data acquired, when combined with previous accurately-navigated *Franklin* soundings, will add to this tectonic knowledge. In particular, there would seem to be no single structure (previously called the "Bismarck Fault") corresponding to the linear zone of shallow seismicity along this boundary. In the eastern Manus Basin, we examined a part of the Djuai Fault at the request of Rabaul Volcano Observatory which has been recording numerous earthquakes recently in the vicinity, finding signs of a major turbidite flow probably induced by this seismicity. These latter data will constitute a baseline for follow-up by future cruises.

During the cruise we observed numerous significant ash eruptions from the south crater of Manam Volcano. No eruptions were seen from sea at Langila, Long, Karkar, Bam and Ritter volcanoes, all of which are classed as active. Fumerolic activity only was observed passing Tavurvur Volcano, Rabaul.

Cruise Narrative

As indicated above, this cruise was exploratory in character. Consequently echosounding and hydrocasts with transmissometer occupied a larger than usual proportion of our time. Altogether, at the 51 features examined, we conducted 204 operations of which 136 involved over-the-side deployments of the CTD, dredge, grab, corer, and bottom-tow video system. Ninety operational plans were issued, with 470 waypoints.

Little time was lost through breakdowns. One delay of six hours was caused by failure of the controls for lowering the bow thruster, rectified within half a day following a sterling effort by the engineers. This caused the abandonment of a dredge attempt and resultant failure to adequately characterise one important ridge. Three other dredge attempts were aborted because the tensiometer and wire-out sensors failed, requiring many trips up the A-frame by the electronics technician. The wire-out readings for the tow cable were erroneous throughout the cruise, requiring a rather excessive empirical "fudge factor" of 1.035 to be kept in mind during operations. As it happens, this did not affect our results seriously but would have been a problem if we needed to conduct detailed surveys of a new hydrothermal site. The Smith-McIntyre grabs were frequently used as an alternative to dredging and provided some excellent hauls, though on many occasions they failed to

trigger probably because of unsuitable bottom characteristics. The computer systems worked well, with only a few brief crashes. The new EchoView display proved a boon when planning and evaluating operations.

A number of weak link failures were experienced when dredging. One of our dredges was lost on the first such operation, requiring us to avoid aggressive dredging with the second unit until it was clear the following cruise would be re-equipped for such work. The sediment corer was also lost when it inexplicably rolled overboard unobserved, and one of our cameras was destroyed when its pressure housing leaked during a tow, apparently after a collision with a shipwreck.

For the first two weeks in the western Bismarck Sea we experienced unusually strong northwesterly winds and moderate swells, requiring magnificent and almost always successful efforts by Bridge officers to maintain station. Even when the weather improved, conflicting winds and currents often caused similar problems, not helped by the inability of the bow thruster to deliver full power.

Despite these problems, the cruise overall could hardly have been more productive, nor more successful given the kind of geology encountered.

Summary

Cruise FR-02/2002 was highly successful even though the outcomes differed in many respects from those anticipated. It will generate a large amount of laboratory research relating to our overall objective, will be the topic for two Honours and one PhD thesis, and will influence the PhD research of 4 other participants relating to ore environments on land. We anticipate that many of the discoveries made on this cruise will be investigated further by *RV Onnuri* (Korean Ocean Research and Development Institute) later this year in a collaborative Australia-Korea program.

Personnel

Scientific Crew

Ray Binns	CSIRO Exploration and Mining	Chief Scientist
Pamela Brodie	CSIRO Marine Research	Cruise Manager, Computing
Russell Fulton	University of Tasmania	Economic geology
Brendan Mapham	Australian National University	Petrology
Sung-Hyun Park	Korean Ocean Research Development Institute	Petrology
Joanna Parr	CSIRO Exploration and Mining	Economic geology
Alvaro Pinto	University of Lisbon	Economic geology
Cameron Rees	University of New South Wales	Mining engineering
Andri Subandrio	Bandung Technical University	Petrology
Stephen Thomas	CSIRO Marine Research	Electronics, CTD
Jessie Wama	Geological Survey of Papua New Guinea	Geology
Rowland Whiting	Macquarie University	Geology

Ship's Crew

Neil Cheshire	Master
Arthur Stratton	First Mate
John Boyes	Second Mate
John Morton	Chief Engineer
Dave Jonker	First Engineer
Paul Dickson	Electrical Engineer
Dan Davies	Greaser
Mal McDougall	Bosun
Tony Hearne	IR
Lou Jacomas	IR
Graham McDougall	IR
Frank Souter	Chief Steward
Peter Williams	Chief Cook
Angie Zutt	Second Cook

Acknowledgements

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