INITIAL

CRUISE REPORT

USGS R/V S.P. LEE

Southwest Pacific

Hydrocarbon Resource Investigation

March-June 1982

By

H. G. Greene

USGS/SOPAC Cruise Coordinator

September 1982

CRUISE REPORT

Under the Australia, New Zealand and United States (ANZUS) tripartite treaty and in association with the Committee for the Coordination of Joint Prospecting for Mineral Resources in South Pacific Offshore Areas (CCOP/SOPAC), the U.S. Geological Survey (USGS) undertook a hydrocarbon resource investigation in the offshore areas of Tonga, Vanuatu, and the Solomon Islands (Fig. 1). The investigation was a part of a joint program of marine geoscientific research and mineral resource studies in the South Pacific region. The U.S. Department of State was instrumental in negotiating the treaty and establishing the framework for the cooperative research. Most of the funding for this investigation was made available to the USGS by the Office of Energy of the United States Agency for International Development (AID), and additional funds came from the Government of Australia. CCOP/SOPAC served a basic coordination role, and provided, along with CCOP/SOPAC member nations, Australia and New Zealand, some of the cruise scientific staff. The initial data collection phase of this investigation was concluded with the completion of the 3-leg, 60-day cruise of the R/V S.P. LEE. This report summarizes the cruise, gives tentative results, outlines the future work schedule and proposes significant work to be continued.

The LEE left its home port of Redwood City, California, USA, on March 1, 1982, (see attached Cruise schedule) and arrived at Honolulu, Hawaii, on March 15 to refuel and resupply. While in Hawaii, the LEE took on relief supplies to be delivered to the victims of Cyclone Issac that had hit Tonga on February, 1982. Over 20,000 lbs. of food and clothing were stuffed into every nook and cranny of the LEE. These supplies were collected from all over Hawaii and were loaded aboard by the Tongan Relief Committee which, previous to learning of the offer by the USGS to assist Tonga in their relief effort, was unable to make arrangements for the supplies to be shipped to Tonga. Heavily laden, the LEE left Honolulu on March 16, and stopped in Pago Pago, American Samoa, from March 26 to 28, 1982, to refuel, resupply, and take on the scientists for Leg 1 of the SOPAC cruise. On March 31, 1982, the LEE arrived in the port of Nuku'alofa, Tongatapu, Tonga, to the welcome of a brass band and cheering Tongans. The ship's entire complement was treated to a traditional Tongan feast while the relief supplies were being offloaded. The Captain of the LEE and Chief Scientists met with the King of Tonga, Taufa'ahau Toupou IV, KCMG, KBE, on the afternoon of March 31, 1982. In behalf of the United States, Australia and New Zealand, they presented a physiographic diagram of the sea bottom in the vicinity of the Kingdom of Tonga which was prepared by Tau Rho Alpha from bathymetric data assembled by Thomas E. Chase of the USGS. Copies of this diagram as well as others prepared for Vanuatu and the Solomon Islands were latter signed by President Ronald Reagan and distributed to the appropriate Heads of States of the three countries. Those attending the audience with the King are listed in Appendix A of this report.

In addition to the audience with King Toupou IV, the Crown Prince Tupou'Toa of Tonga hosted a reception for the ship's entire crew with invited dignitaries from Tongan and other government institutions; this reception was well attended by Ministers and their wives. On April 1, 1982, USGS and

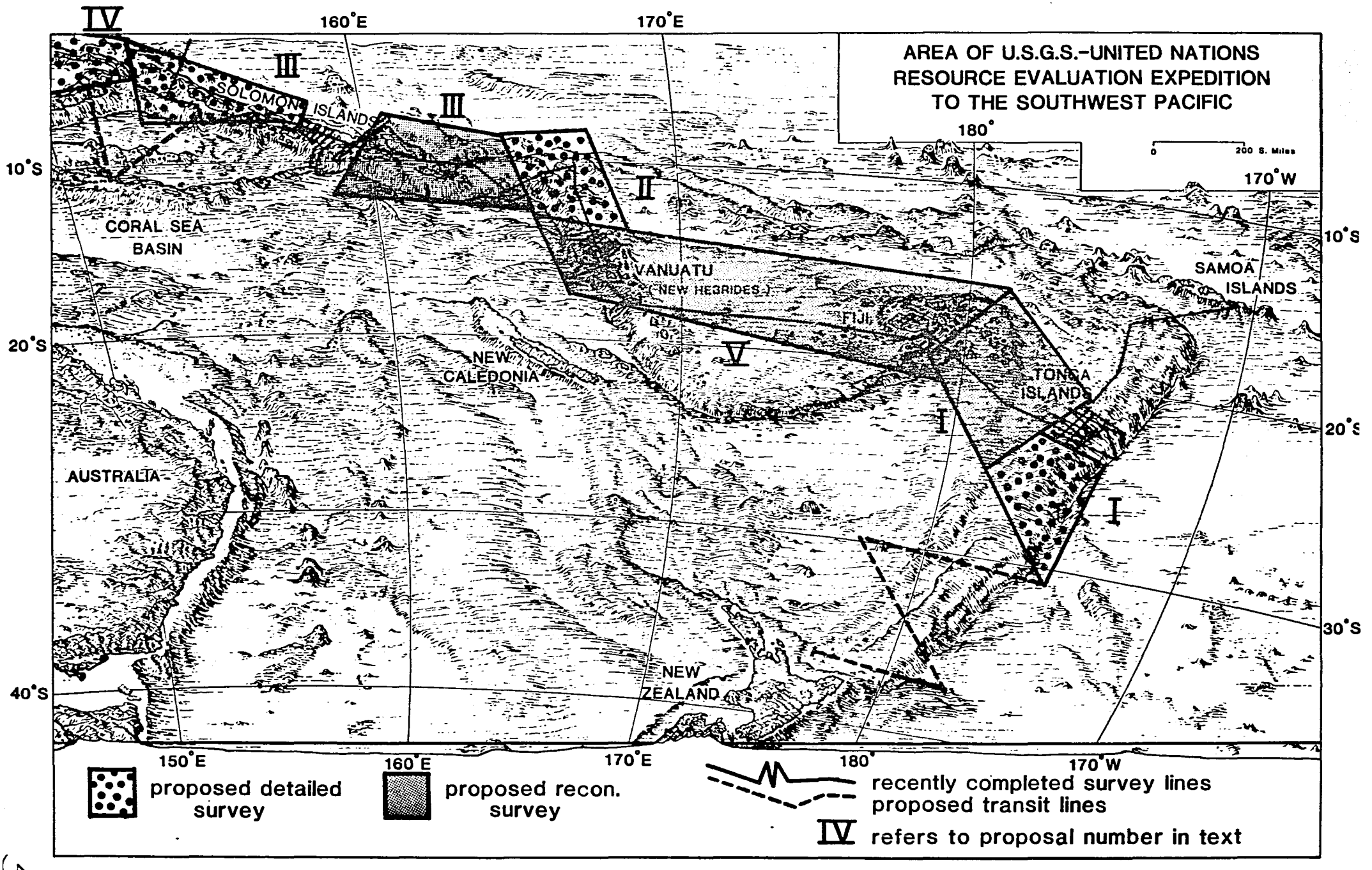

AREA OF U.S.G.S.-UNITED NATIONS
RESOURCE EVALUATION EXPEDITION
TO THE SOUTHWEST PACIFIC
0
200 S. Miles
160°E
170°E
180°
170°W
10°S
20°S
30°S
40°S
150°E
IV
III
II
I
V
SOLOMON ISLANDS
CORAL SEA
BASIN
VANUATU
(NEW HEBRIDES)
FIJI
SAMOA
ISLANDS
NEW
CALEDONIA
TONGA
ISLANDS
AUSTRALIA
NEW
ZEALAND
proposed detailed
survey
proposed recon.
survey
recently completed survey lines
proposed transit lines
IV refers to proposal number in text

Figure 1

Cruise Schedule

SOPAC Leg 1

16 MAR (Tue)	1100	Depart:	Honolulu, Hawaii	
LEG 5		Ops:	Transit only	
25 MAR (Fri)	1500	Arrive:	Pago Pago, American Samoa	
---				
28 MAR (Sun)	0000	Depart:	Pago Pago, Am. Samoa	Cruise Loc. L5-82-SP
LEG 6		Chief Sci.:	Scholl	
		Ops:	Transit	
31 MAR (Wed)	1230	Arrive:	Nuku'alofa, Tongatapu	
---				
2 APR (Fri)	1330	Depart:	Nuku'alofa, Tongatapu	Cruise Loc. L5-82-SP
LEG 7		Chief Sci.:	Scholl (USGS)/Muang (CCOP/SOPAC)	
		Ops:	SOPAC multichannel seismic - South Tonga Plateau	
20 APR (Tue)	0930	Arrive:	Suva, Fiji	
---				
23 APR (Fri)	1835	Depart:	Suva, Fiji	Cruise Loc. L5-82-SP
LEG 8		Chief Sci.:	Scholl (USGS)/Muang (CCOP/SOPAC)	
		Ops:	Transit after taking stores and fuel in Suva	
26 APR (Mon)	1200	Arrive:	Port Vila, Vanuatu	

SOPAC Leg 2

28 APR (Wed)	0600	Depart:	Port Vila, Vanuatu	Cruise Loc. L6-82-SP
LEG 9		Chief Sci.:	Greene (USGS)/Falvey (Australia)	
		Ops:	SOPAC multichannel seismic - Central Vanuatu Basin	
16 MAY (Sun)	1500	Arrive:	Honiara, Guadalcanal	

SOPAC Leg 3

19 MAY (Wed)	1700	Depart:	Honiara, Guadalcanal	Cruise Loc. L7-82-SP
LEG 10		Chief Sci.:	Vedder (USGS)/Tiffin (CCOP/SOPAC)	
		Ops:	SOPAC multichannel seismic - Central Solomon Trough	
11 JUN (Fri)	1330	Arrive:	Rabaul, New Britain	

51

CCOP/SOPAC scientists hosted a lunch aboard the LEE for dignitaries and officials of the Tongan government; this was followed by an Open House for the general public aboard the LEE during the afternoon.

Onshore during April, at the time the shipboard data collection was being done for Leg 1, H.G. Greene, the USGS LEE program co-ordinator and Co-Chief Scientist for Leg 2, spent 3 days at the CCOP/SOPAC office in Suva, Fiji. He worked with Cruz Matos, Project Manager, and Don Tiffin, Marine Geologist and Leg 3 CCOP/SOPAC Co-Chief Scientist, in planning the upcoming legs to Vanuatu and the Solomon Islands. Logistic planning and coordination of vendors for resupplying the LEE was also accomplished during this time. Greene not only briefed the CCOP/SOPAC Secretariat of the LEE expedition plans but informed the U.S. Embassy in Suva of the schedule of events, sought the Embassy's assistance in logistic support, and met with Ambassador Fred Eckart. From Suva, Greene traveled to Port Vila, Efate, Vanuatu where, on April 18, he briefed the Deputy Foreign Affairs Officer and the First Secretary of Lands and Natural Resources about the USGS/SOPAC LEE expedition. He also met with Mr. Michael Ovington, the Australian High Commissioner to Vanuatu. Greene worked with Mr. Alexander Macfarlane, Director of the Vanuatu Department of Geology, Mines, and Rural Water Supply, to finalize the Leg 2 survey schedule and arranged logistic support for the vessel.

Greene was joined by David Falvey, the CCOP/SOPAC Co-Chief Scientist to Leg 2, on April 10, and the two spent time together in the field examining and sampling rocks that would be useful in the interpretation of the shipboard data. Greene and Falvey visited the island of Malekula on April 11 and 12, and then flew on to Espiritu Santo Island to join Macfarlane aboard a small boat that was used as a floating base camp. From April 13 to 17, the three geologists examined and sampled rocks on the western part of the island and in the Big Bay-Jordan River area. Geological trainees of Vanuatu accompanied the geologists in the field, both to assist in sampling and to learn from the scientific discussions and arguments that occurred during this field trip.

On April 18, 1982, Greene and Falvey flew to Suva, and on April 19 met with the Australian High Commissioner to Fiji to discuss the methods and procedures of paying LEE expenses with the US$325,000 the Australians had put into a fund in Suva to cover 25 days ship-time for the ANZUS CCOP/SOPAC USGS hydrocarbon resource appraisal program. Greene met with Mr. Russell Jay Surber and Commander Dwayne Norris of the U.S. Embassy in Suva April 19 to further brief them and arrange for the arrival of the LEE.

After Leg 2, during the time the LEE was at sea in the Solomon Islands region, Gary Greene travelled to Papua-New Guinea to brief government geologists on the activities of the LEE and to arrange logistic support for the ship when it arrived in Rabaul. Greene arrived in Rabaul May 19, 1982, and spent the day with Peter Lowestein, Senior Government Volcanologist and Director of the Rabaul Volcanology Observatory, arranging logistic support for the LEE. The next day, Greene spent time with Peter Lowenstein, Chris McKee, and Patrice de Saint Ours planning the geophysical survey of Rabaul harbor. A request from the government of Papua-New Guinea had been made earlier to CCOP/SOPAC for a detailed bathymetric survey of Rabaul harbor by the LEE upon her arrival in Rabaul. This request was forwarded to Greene

who pointed out that the detail of work requested could not be undertaken by the LEE because she was too large of a ship and did not have aboard the precision navigational instruments needed for such a survey. However, he did state to Don Tiffin of CCOP/SOPAC that a general, reconnaissance type bathymetric survey could be made by the LEE as it entered and left the port of Rabaul. Upon Greene's arrival in Rabaul and subsequent discussion with the Observatory staff on the scientific objectives of such a survey, Greene suggested that Papua-New Guinea take advantage of the geophysical instruments aboard the LEE to make a more sophisticated investigation than previously proposed. Tracklines were laid out and geophysical procedures established and relayed to the ship. Greene departed Rabaul May 21. He stopped in Port Moresby to brief Ian Riapper of the Geophysical Observatory about the LEE program and then continued on to Sydney, Australia. After two days of working with David Falvey preparing a draft preliminary geologic report for Leg 2, Greene returned home on May 24.

LEG 1--TONGA RIDGE: PAGO PAGO, AMERICAN SAMOA, TO NUKU'ALOFA, TONGA, TO SUVA, FIJI, TO PORT VILA VANUATU

Scientific Staff

Participating scientists on Leg 1 were:

David W. Scholl ----------	USGS Co-Chief Scientist
Tun U M. Maung ----------	CCOP/SOPAC Co-Chief Scientist
Tracy L. Vallier ---------	USGS
Andrew J. Stevenson ------	USGS
Jon Childs ----------	USGS
Mark W. Sandstrom --------	Australia National University Canberra, Australia
Neville E. Exon ----------	Bureau of Mineral Resources, Canberra, Australia/CCOP/SOPAC
Richard Herzer ----------	New Zealand Geological Survey, Wellington, New Zealand
Sione Soakai ----------	Ministry of Lands, Surveys and Natural Resources, Nuku'alofa, Tonga.

Cruise Chronology

Leg 1 of the USGS/SOPAC cruise started when the LEE sailed from Pago Pago at midnight on March 28, 1982, as underway geophysical data were collected en route to Tonga from American Samoa. The LEE sailed from Nuku'alofa on the morning of April 2, 1982, and headed for its survey area on the southern Tonga Platform some 150 kms to the south to initiate the USGS's hydrocarbon resource investigation as stated in the ANZUS tripartite treaty. During the 23 days at sea, over 5700 km (3078 n.mi.) of 12 kHz, 3.5 kHz, gravity and magnetic profiles were collected. On the southern Tonga platform, 2421 km (1307 n.mi.) of 24-fold, CDP, seismic reflection profiles, and 54 sonobuoy wide-angle reflection/refraction profiles were obtained. In addition, the LEE occupied 13 sampling stations collecting 9 dredge hauls and 4 gravity cores. A brief (12 hour) sampling visit was made to Ata Island during the time surveying was being done nearby; this was done without interruption to the shipboard data collection.

Because of engine trouble, the LEE arrived in Suva on April 20, one day ahead of schedule. In spite of the engine trouble, which looked grim at the time, the 19 days of data collection in the Tonga region more than sufficiently covered all objectives proposed in the ANZUS tripartite treaty. On April 20, a luncheon prepared by the USGS aboard the LEE, and hosted by Russell Surber, Deputy Chief of Mission at the U.S. Embassy in Suva, was attended by various Fiji government dignitaries and international government representatives. On the afternoon of April 21, the LEE hosted a public Open House, including some students from the local schools. Educational literature consisting of USGS published brochures and booklets of various geological topics and disciplines was made available to all visitors of the LEE; over 5,000 publications were distributed during the entire USGS/SOPAC cruise. Also on April 21, the Russian oceanographic vessel CALLISTO tied up adjacent to the LEE, and during the next 24 hours scientists from both ships exchanged visits.

The LEE departed Suva April 23, 1982, one day behind the original scheduled departure date due to engine repairs; a complete main engine overhaul was accomplished within 4 days by the hardworking personnel of the ship's engineering department who worked 24-hour days. Immediately after clearing the harbor of Suva, geophysical gear was deployed and several hours of data collection offshore of the western shelf margins of the island of Viti Lavu, over Baravi Basin, were done at the request of the Fiji Mineral Resources Department. Geophysical data was also gathered along the LEE's track from Suva to Port Vila. The LEE arrived at Port Vila, Efate, Vanuatu on April 26, 1982, ending Leg 1 of the USGS/SOPAC cruise.

General Results

Preliminary analysis of shipboard geophysical data indicates the existence of a sedimentary section thickening and dipping to the west. This section, underlying the central platform, is cut by numerous high-angle faults that strike both transverse and parallel to the NE-SW trend of the platform. These faults appear to be extensional in origin, and broad folds or draped structures are commonly associated with them. A comprehensive evaluation of the petroleum potential of this platform section must await the results of laboratory analysis of rocks dredged from the seafloor and sampled on land, and the interpretation of the fully processed multifold reflection profiles. A more detailed discussion of the Leg 1 cruise results, including a trackline chart, has been prepared and is included in Appendix B. Also included is a draft press-release for Leg 1 prepared by the Co-Chief Scientists of that Leg shortly after their arrival home.

LEG 2--THE CENTRAL BASIN OF VANUATU - PORT VILA, EFATE, VANUATU TO HONIARA, GUADALCANAL, THE SOLOMON ISLANDS

Scientific Staff

Participating scientists on Leg 2 were:

H. Gary Greene ----------	USGS Co-Chief Scientist
David Falvey ----------	CCOP/SOPAC Co-Chief Scientist Sydney Unversity, Sydney, Australia
Michael Fisher ----------	USGS
Alexander Macfarlane -----	Dept. Geology, Mines, & Rural Water Supplies, Vanuatu
Jacque Daniel ----------	ORSTOM, Noumea, New Caledonia
Rudolf Katz ----------	New Zealand Geological Survey, Lower Hutt, New Zealand
David Johnson ----------	James Cook Univ., Townsville, Australia
Mark Holmes ----------	USGS

Cruise Chronology

While in port in Port Vila, the LEE was open to the public, and private tours of the ship for dignataries and officials of the Vanuatu government were arranged. The Captain and Chief Engineer of the LEE, Co-Chief Scientists of both Legs 1 and 2 of the USGS/SOPAC cruises and principal Australian, New Zealand, and CCOP/SOPAC scientists visited with His Excellency President Ati George Sokomanu, President of the Republic of Vanuatu, in his Port Vila residence the morning of April 27, to discuss the plans and hopes of the USGS/SOPAC program; those in attendence are listed in Appendix A. During this visit the President was presented with a physiographic diagram of the sea bottom in the vicinity of the Republic of Vanuatu prepared by the USGS. The diagram was given to His Excellency as a symbol of friendship and respect by the scientists of Australia, New Zealand, America and CCOP/SOPAC. A physiographic diagram of the sea bottom of the entire USGS/SOPAC program area was presented to the Honorable Father Walter Lini, Prime Minister of the Republic of Vanuatu during a tour of the LEE which was organized for Ministers and officials of the Vanuatu government and hosted by Mr. Michael Ovington, the Australian High Commissioner to Vanuatu. Following this event the government of Vanuatu held a reception and luncheon for the Captain, Chief Engineer, and principal scientists of the LEE; the event was hosted by the Honorable Father Walter Lini, Prime Minister of Vanuatu. Lists of attendees to the formal affair in Vanuatu are included in Appendix A.

The LEE sailed from Port Vila April 28, 1982, for the Central Basin of Vanuatu, initiating the start of Leg 2. During Leg 2, 2520 km (1361 n.mi.) of 24-fold, CDP multi-channel seismic-reflection profiles were collected. In addition, 622 km (336 n. mi.) of high-resolution Uniboom seismic-reflection profiles and nearly 4500 km (2430 n. mi.) of 3.5 kHz very high-resolution seismic reflection, 12kHz bathymetric, magnetic, and gravity profiles were collected. Thirty-three Sonobuoy wide-angle reflection/refraction profiles were also obtained. Seven sampling stations, 4 dredge and 3 gravity core

stations, were occupied by the LEE, but unfortunately due to a malfunctioning tensiometer, sample recovery was limited to 2 small, cobble size, calcarinite rocks recovered in one dredge haul and to two short cores (104 and 110 cm long) obtained out of the three coring attempts. Approximately 3500 m of wire and 3 chain-bag dredges were lost in the sampling attempts and after 24 hours of struggling to obtain samples, efforts were abandoned and the LEE headed north for the Solomons. Geophysical trackline spacing in the Central Basin of Vanuatu was generally 5 to 10 km (2.7 to 5.4 n. mi.) apart and in some localities spacing was a close as 1 km (0.5 n. mi.) apart. A draft report including a trackline map and draft press-release is given in Appendix C. Leg 2 of the USGS/SOPAC cruise ended with the arrival of the LEE in Honiara, Guadalcanal, the Solomon Islands on May 16, 1982.

General Results

Preliminary onboard data reduction and interpetation resulted in: (a) the delineation of three small shelf sedimentary basins east of Malekula and Espiritu Santo; (b) estimation of minimum sedimentary thickness in the intra-arc Central Basin; and (c) the discovery of the northward continuation of the southern New Hebrides Trench. Tentative interpretation of the single-channel seismic-reflection data indicates that regionally the islands are deformed by a complex structural pattern. These structures may be related to the complex tectonic evolution of the arc that involves perpendicular subduction, oblique subduction, and arc reversal through middle and late Miocene times.

The three shelf or shelf-edge sedimentary basins mapped all lie in water depths of less than 1000 meters and have sediment thicknesses greater than two kilometers. In all basins, structures, particularly faults, capable of trapping oil or other liquids are present. Sedimentary rocks identified within these smaller shelf edge basins appear locally to be connected with the deeper intra-arc basin (e.g., the Central Basin) that contains over 4 km of sediment, thereby forming potential pathways for petroleum migration from thick sedimentary sections in deep-water marine source beds to shallow-water reservoir beds and traps.

A comprehensive evaluation of the resource potential for the Central Basin region of Vanuatu cannot be made at this time. Only after completion of the processing and interpretation of the multichannel seismic reflection and other geophysical data can an attempt be made to evaluate the resource potential. In addition, onshore source-rock analysis must be made to complete a resource assessment. However, preliminary results of the onboard interpretation of the single-channel seismic-reflection data can be used to suggest the most promising sites for hydrocarbon accumulations, and speculation of oil and gas potential is based here on these results.

The three insular basins identified in the survey are considered promising sites for further potential hydrocarbon investigation. They are equal in size, geometric dimension, and sediment thickness to some of the smaller hydrocarbon producing basins found elsewhere in the world (e.g., western coast of the United States). Traps resulting from faulting may exist, and the water depths overlying all of these basins are shallow enough for drilling with the current technology. Stratigraphic and structural

connections forming migration paths may exist between the insular basins and the deep-water intra-arc basin where past open-marine conditions may have resulted in deposition and burial of organic-rich sediment and subsequent generation of hydrocarbons.

LEG #3, CENTRAL SOLOMONS TROUGH - HONIARA, GUADALCANAL, SOLOMON ISLANDS TO RABAUL, NEW BRITAIN, PAPUA-NEW GUINEA

Scientific Staff

Participating scientists on Leg 3 were as follows:

Jack Vedder	USGS, Co-Chief Scientist
Don Tiffin	CCOP/SOPAC, Co-Chief Scientist
Larry Beyer	USGS
Terry Bruns	USGS
Alan Cooper	USGS
Michael Marlow	USGS
Loren Kroenke	CCOP/SOPAC, Hawaii
Raymond Wood	New Zealand Geological Survey, Lower Hutt, New Zealand
Jim Colwell	Bureau of Mineral Resources, Canberra, Australia
Frank Coulson	Solomon Islands Geological Survey, Honiara, Guadalcanal

Cruise Chronology

Because the LEE had to anchor out it was not possible to hold an Open House for the public at Honiara, although one was planned. However, a formal reception was held aboard the ship May 18 for Solomon Island dignitaries and government officials, and a lunch was hosted by the New Zealand High Commissioner, Mary Chamberlon. On the evening of May 17, both the New Zealand and Australian High Commissioners hosted a reception ashore for the Captain, crew and scientists of the LEE, which was attended by Ministers, officials, and dignitaries of the government of the Solomon Islands. In addition, geological and war relic field trips were arranged and conducted for the crew and scientists of the LEE by Frank Coulson of the Solomon Islands Ministry of Lands, Energy and Natural Resources.

The third and final leg of the LEE cruise in the South Pacific started May 19, 1982, with the sailing of the ship from Honiara. During Leg 3 approximately 3700 km (1998 n. mi.) 24-fold, CDP high-resolution "Uniboom" seismic-reflection profiles were collected in the Central Solomons Trough - The Slot - and in Indispensible Strait. For the entire leg, including transit lines, about 5500 km (2970 n. mi.) of high-resolution, seismic reflection, magnetic, gravity and 12 kHz bathymetric profiles were collected. In addition 36 wide-angle seismic reflection/refraction sonobouy profiles were obtained. Nine dredge hauls were made, and two gravity cores were taken. On June 11, a short survey using high-resolution equipment and one Sonobouy run was made in the Rabaul harbor of New Britain, Papua-New Guinea, at the request of the Director of the Rabaul Volcanological Institute. Trackline spacing is generally between 5 and 10 km (2.7 to 5.4 n. mi.). A draft report and press-release is given in Appendix D.

In addition to the agreed upon hydrocarbon resource survey specified in the tripartite treaty, the USGS undertook a courtesy survey in Rabaul harbor at the request of CCOP/SOPAC and the Rabaul Volcanological Institute. The

LEE arrived in Rabaul the morning of June 11, and took aboard Peter Lowenstein, Senior Government Volcanologist, P. Hill of the Geological Survey of Papua-New Guinea, Patrice de Saint Ours and Benjamin Talai, volcanologists at the Rabaul Volcanology Observatory.

Reconnaissance bathymetric data was acquired and the Rabaul seismic network was tested using the airgun system aboard the LEE. Also, a sonobouy-refraction profile was recorded and intermediate penetration and high-resolution "Uniboom" seismic-reflection profiles were collected. The purpose of the survey was to 1) determine if local uplift is taking place in the harbor, 2) test the sensitivity of the Rabaul seismographic network with controlled, artificially generated, seismic waves, and 3) to obtain refraction velocities of the rocks in the harbor area that can be used to calibrate the network. A draft report on this survey is given in Appendix E.

After about 10 hours of surveying in Rabaul harbor, the LEE tied up and thus ended Leg 3 of the USGS-CCOP/SOPAC survey. This ship's complement was well received in Rabaul, and Patrice de Saint Ours led a geologic field trip to active volcanoes in the area for many of the LEE's scientific participants. The LEE sailed north enroute to the Aleutian Islands June 14, 1982, ending the initial phase of the USGS-CCOP/SOPAC tripartite hydrocarbon-resources expedition.

General Results

Preliminary results of the Leg 3 survey in the Central Solomons Trough indicate that sediments up to 6 km of thickness rest between the volcanic basement exposed on the islands on each side of the Slot. Although much of the sediment is likely to be derived from volcanics, limestone and other carbonate rocks also may be present. Buried reefs, although not well defined in this survey, may also occur in the stratigraphic column. The area surveyed can be divided into several different geomorphic features and, based on the onboard preliminary interpretations of the geophysical data, several sedimentary basins have been defined and named in the region. Starting from the southeast, offshore northern Guadalcanal, the basin previously identified in Iron Bottom Sound (newly named Iron Bottom Basin) is bounded by Savo Island to the northwest, Guadalcanal to the south and the Florida Island platform to the northeast. Another sedimentary basin lies in Indispensable Strait (newly named the Indispensable Basin) and is separated from Iron Bottom Basin by the Florida Island platform; it is bounded to the northeast by Malaita and the Malaita anticlinorium. The largest basin in the survey area lies in New Georgia Sound where the newly named Russel Basin extends from Savo Island northwest to the small mid-basin horst between Choisel and the New Georgia Group north of Kolombangara Island. Another basin, the Shortland Basin, is located in the western end of New Georgia Sound, extending from the mid-basin horst to the Shortland Islands.

In order to fully comprehend the hydrocarbon potential of the seafloor areas of the Solomon Islands, additional multichannel tracklines are needed, particularly in the Indispensable Strait-San Cristobal area and in the western part of the Shortland Basin. Seafloor sampling needs to be done, based on the recently collected geophysical data, to correlate acoustic stratigraphy with lithologies of the thick sedimentary bodies.

OVERALL CRUISE RESULTS

Field examination and initial processing of all data collected by the USGS in the Southwest Pacific indicate that the data quality ranges from good to excellent. Although it is too soon to fully evaluate the scientific results ~~of~~ the cruise, a high degree of confidence can be expressed in the delineation of promising hydrocarbon targets. It is important to note that all USGS cruise objectives, as stated in the tripartite treaty, were accomplished. In addition, data distribution, post-cruise meetings, and preparations of reports, are presently underway. Initial data distribution has been done for Tonga and should be accomplished by October 1982 for Vanuatu and November 1982 for the Solomon Islands; this meets the dates set forth in the tentative General Program Schedule of the USGS proposal. Major post-cruise meetings for all three USGS-SOPAC LEE cruise legs were held in Honolulu, Hawaii, August 19 and 20, 1982. The first public presentation of data from each leg of the cruise was made at the August 1982 Third Circum-Pacific Energy and Mineral Resources Conference and will be submitted for publication in the Proceedings volume; copies of those publications are included in Appendices B, C, and D. A brief description and a list of participants to the LEE post-cruise meetings are included in Appendix F.

Above and beyond those objectives stated in the tripartite treaty, the LEE transported relief supplies to Tonga and undertook non-scheduled surveys in Baravi Basin of Fiji for CCOP/SOPAC and the Mineral Resources Department of Fiji, and in Rabaul harbor of New Britain, Papua-New Guinea, for CCOP/SOPAC and the Rabaul Volcanological Observatory. Considerably more kilometers of multi-channel profiles were acquired than originally suggested in the USGS proposal; approximately 8000 kms (4320 n. mi.) were acquired compared to the 3240 (1749 n. mi.) initially proposed.

Immediate Benefits to Participating Nations

It will be approximately one year before all the data collected on the three LEE legs can be fully interpreted and reported upon, and not until that time can a comprehensive energy and mineral resources evaluation be made. However, initial results will alert the nations to potential target areas that appear most promising for resource exploration and that may need further study. Immediate direct benefits to Tonga were realized with the delivery of relief supplies by the LEE and to Papua-New Guinea with the calibration of the earthquake seismograph network in Rabaul.

Limited training in shipboard procedures and field methodology were realized by a few nationals from Tonga and Vanuatu. It would be very valuable if training in handling, interpreting and general use of marine geologic and geophysical data could occur within the next year, but no specific training program or budget has been proposed.

Scientific participants of the treaty nations of Australia and New Zealand, as well as scientists from CCOP/SOPAC, gained invaluable knowledge of marine geophysical and geological methodologies presently being used in

61

the U.S. In addition, the rapport and comradeship developed by the participating scientists has established viable and effective teams of international geoscientists that now can expeditiously tackle difficult and significant geological problems elsewhere in the region.

Data Distribution

The USGS is in the process of reducing, and reproducing cruise data for initial distribution to scientific participants from CCOP/SOPAC, member and treaty countries. Computer plots and printouts of all navigational data have been transferred to mylar stable bases and photo reproduction of all geophysical data is presently being processed for distribution to CCOP/SOPAC, Fiji, Tonga, Vanuatu, Solomon Islands, New Zealand and Australia. To date, over 65 separate sheets (average dimension of each sheet is 40 in by 60 in) of reproducable data has been distributed, primarily to the Leg 1 cruise scientists. In addition, 4 separate sets of duplicate microfilm of the geophysical data have been distributed.

The data packages being sent out at this time generally consist of the following:

- Computer printouts of cruise index data
- Stable base trackline charts at 4 inches/degree and 16 inches/degree
- Revised bathymetric maps at 4 inches/degree and 16 inches/degree
- Single-channel seismic-reflection profiles - reduced to 6 inch mylar strips
- Sonobuoy wide-angle reflection/refraction profiles - reduced to 6 inch mylar strips
- Gravity profiles from computer printouts - reduced to 6 inch mylar strips
- Magnetic profile from computer printouts - reduced to 6 inch mylar strips

Once the multichannel seismic-reflection data is processed, it will also be photographed, put on microfilm and sent out on reduced 9 inch mylar strips. Eventually microfilms of all data will be distributed.

Acknowledgements

The cruise operations were successful because of the assistance so generously given to the USGS by a variety of people. In an operation as large and complex as the LEE expedition, it requires a multitude of individuals to make things run smoothly. It is not possible to mention everyone who made this program possible, but I would like to give special thanks in chronologic order to a few of the people who significantly helped us during the field operations. First Scott Hardmen, Peace Corp Country Representative in Tonga unselfishly gave his time and assistance to the crew and scientists of the

LEE while it was in Nuku'alofa. In addition, he managed the air-shipping of a generator, much needed for our repairs, from Tonga to Fiji. Sione Tongalava gave invaluable assistance to the USGS while the LEE was in Tonga waters. This was particularly commendable since Tonga had just been devastated by a cyclone. In Fiji, Cruz Matos and the CCOP/Secretariat staff gave us great help in solving logistic problems for the LEE; Don Tiffin, in particular, devoted many long hours to arranging for repairs and resupply of the vessel as well as unravelling a multitude of logistic problems. Generous assistance was given to the USGS by the United States Embassy in Suva; specifically Russel Jay Surber, Deputy Chief of Mission, and Dwayne Orange Norris, Commander, United States Navy, who helped in most aspects of the preparation for the LEE's arrival.

A special sincere thanks goes to Mr. Michael Ovington, the Australian High Commissioner in Vanuatu, for his professional devotion to seeing that every aspect of the LEE operation in Vanuatu was looked after; because of such attention by Mike, the Leg 2 cruise ran particularly smooth and was successfully completed without a hitch. Alexander Macfarlane of Vanatu is also to be commended for his sincere interest in expediting the LEE cruise for Vanuatu; his attention to all sorts of minute details guaranteed the success of Leg 2.

In the Solomon Island, Frank Coulson worked hard to assure smooth operations for Leg 3; his efforts in personally leading geological field excursions for the scientists of the LEE was much appreciated by all aboard the LEE. In Rabaul, Peter Lowenstein, Senior Government Volcanologist for Papau-New Guinea, unselfishly arranged logistic support for the LEE, and Petrice de Saint Ours of the Rabaul Volcanology Observatory cheerfully lead a geological field trip for scientists of the LEE. Finally, special commendation must go to Captain Vern Pilgram and the crew of the LEE for their pleasant and helpful assistance. Chief Engineer Aaron Dunwald's special efforts to keep all equipment aboard ship working, and his long hours of toil in port, is specially appreciated. Also, the outstanding meals of Chief Cook John Williams were much appreciated by the crew and all guests to the LEE and this extra work by John should be specially noted.

RECOMMENDATIONS FOR FUTURE ENERGY AND MINERAL RESOURCES ASSESSMENTS IN THE CCOP/SOPAC REGION

Introduction

The initial phase of the U.S. Geological Survey (USGS)/SOPAC hydrocarbons resources investigation of the South Pacific was successfully concluded with the completion of the third leg of the cruise of the R/V S.P. LEE at Rabaul, New Britain, Papua New Guinea (PNG) on June 11, 1982. This investigation, which was part of a program of Marine Geoscientific Research and Mineral Resources Study, was carried out in accordance with a Tripartite Treaty signed by Australia, New Zealand, and the United States (ANZUS). The United Nations Committee for Coordination of Joint Prospecting for Mineral Resources in the South Pacific Offshore Areas (CCOP/SOPAC) coordinated the joint efforts and contributed along with CCOP/SOPAC member nations, Australia, and New Zealnd, some of the cruise scientific staff.

The U.S. Department of State was instrumental in negotiating the treaty and establishing the administrative framework for the cooperative research. Most of the funding (U.S. $1 million) was made available to the USGS by the Office of Energy of the U.S. Agency for International Development (AID). Additional funds (U.S. $325,000.00) came from the Government of Australia.

Data were collected primarily in the offshore areas of Tonga, Vanuatu, and The Solomon Islands (Fig. 1) during the 3 legs of the 60-day cruise of the R/V S.P. LEE (see Cruise Report, 1982 USGS R/V S.P. LEE, Southwest Pacific Hydrocarbons Resource Investigation, 1982; USGS Administrative Report). Based on shipboard and initial post-cruise laboratory analysis of the data, general recommendations for further work can be proposed. During the USGS/SOPAC LEE post-cruise meeting held in Honolulu, Hawaii, August 19 and 20, 1982 initial

scientific results, status of data processing and distribution, scientific commitments and coordination, and future work were discussed. At this meeting CCOP/SOPAC, Australian, New Zealand, and U.S. cruise participants demonstrated that future investigations in the SOPAC region recently surveyed by the R/V S.P. LEE would be required to fully assess the resource potential. Rationales and proposals for continued investigations in the SOPAC region were then generated. These proposals are fundamentally a logical extension of the work initiated by the LEE and are intended to fill significant data voids as well as to assure a more comprehensive hydrocarbons assessment of frontier SOPAC regions. It must be realized, however, that it is difficult at this time to propose detailed supplementary investigations because the body of the recently collected seismic, geopotential, and geologic data has not been processed and interpreted. Nevertheless, there is sufficient knowledge and understanding to suggest regions and topics of study that would be beneficial in completing comprehensive energy and mineral resources investigations.

In order to assist the CCOP/SOPAC countries in continuing their evaluation of energy and mineral resources, this report sets forth recommendations for future geoscientific studies in the CCOP/SOPAC region recently explored by the R/V S.P. LEE (see Fig. 1). Specifics of these proposals will be added approximately 6 to 9 months hence when the existing data are further reduced and interpreted. The proposals included herein are for planning purposes so that the ANZUS Tripartite Treaty governments, CCOP/SOPAC, and their country representatives can plan and budget for future geoscientific investigations in the SOPAC region. The recommended work is intended to focus on resource assessments of offshore frontier or little-known areas.

65

Proposals

I. Tonga Platform-Lau Ridge: Continuation of program begun on LEE Leg 1.

Additional multichannel seismic-reflection work may be recommended over the southern Tonga platform after completion of a full study of those profiles acquired during the USGS/SOPAC LEE cruise L5-82-SP (Fig. 1). However, reflection seismology is critically needed over the far southern region of the Tonga platform (south of 23.5°S to about 27°S), which remains virtually unstudied, and the closely adjacent Lau Ridge. To judge from the narrow width of the separating Lau Basin, the rifting event that affected the far southern Tonga platform may have been less severe (rapid) and possibly occurred later than the event to the north; these circumstances can be viewed as increasing the petroleum potential of the ridge's far southern platform section. But, equally significant, the early and mid-Tertiary history of the Tonga and Lau Ridges can be jointly studied and their resource potential mutually evaluated.

In the southern Tonga platform, sampling of additional submerged outcrops is urgently needed. With guidance provided chiefly by shipboard seismic-reflection records, the sampling program carried out during the LEE's 1982 cruise proved so valuable that it is evident that a follow-up dredging program can be designed to far more adequately sample the platform's exposed sedimentary sequence. In the absence of an effective sampling program, questions regarding the ridge's geologic evolution cannot be resolved or even factually approached. The sampling program, although necessarily centering along the crestal area of the ridge, must involve the flanks of the ridge, which may contain a record of substantial middle and late Cenozoic subsidence. Resolution of the ridge's history of vertical tectonism is crucial to assessing its petroleum resource potential, which is likely housed

in porous reefal masses of early and middle Tertiary age.

A follow-up or continuation program in the general Tonga area should, therefore, consist of two principal elements. First, a sampling program of rock dredging (possibly including gravity coring) over the southern Tonga platform (60%), and, second, multichannel seismic-reflection profiling over the far southern platform and adjoining Lau Ridge. Sampling of submerged outcrops along the Lau Ridge should be an essential part of the program.

If the regional operational plans for the supporting research vessel involves a New Zealand Port-o-call, then the Tonga-region continuation program should budget sufficient time to run one or more E-W multichannel lines from the South Fiji Basin across the Colville Ridge, Harve Trough and Pacific floor (Fig. 1).

II. Vanuatu and Eastern Solomons Basins: Continuation of program begun on LEE Leg 2.

Data collected during Leg 2 (Fig. 1) of the USGS/SOPAC LEE cruise L6-82-SP delineated four sedimentary basins on the western margin of the Central Basin of Vanuatu that may have hydrocarbon resource potential. It is certain that before a comprehensive analysis of the energy and mineral resources potential, and assessment of the geological hazards can be made in the Vanuatu region, several different studies need to be completed. These include rock-sampling and heatflow measurements to determine source rock potential, past sedimentary depositional environments, and petroleum maturation history for the region. In addition, existing reconnaissance seismic-reflection data north of the Banks Islands indicate the existence of other sedimentary basins. These basins probably are Miocene to Pleistocene in age and therefore are possibly of some resource interest. It would be appropriate to extend the

1982 multichannel seismic-reflection grid to the relatively shallow shelf region that lies between the Torres Islands and the Santa Cruz Island group, E.S.P. (Fig. 1). A 20-day cruise leg devoted to approximately 10 days of seafloor sampling and heatflow measurements within the LEE's 1982 survey area and 10 days of multichannel seismic-reflection surveying in the northern Torres-Santa Cruz region is recommended. In addition, detailed seismic-reflection surveying is needed along the western Central Basin to further advance resource play concepts and assess associated geologic hazards.

Preliminary interpretations of the 1982 LEE data have shown two other areas in Vanuatu that should be studied in more detail, preferably with seismic-reflection and rock-sampling techniques: (1) the relatively shallow shelf area south of Malekula and Efate Islands, where sedimentary basins have been identified, and (2) along the flanks of Maewo and Pentecost Islands, where promising structures for trapping hydrocarbons may exist.

Studies of the deep tectonic framework of the island arc in Vanuatu and the eastern Solomons Province may be possible using two-ship operations. Should it be possible to coordinate two ships in the region, it is recommended that an arc transect involving expanding seismic spreads parallel to the arc plus constant offset spreads across the arc be completed.

It would be extremely desirable to coordinate the SOPAC program and correlate the USGS/SOPAC LEE survey data with any wide-beam sidescan sonar survey data that could be collected in the Vanuatu region. Ideally, this type of survey should be made prior to the work recommended here in order to be of assistance to the final planning process for the proposed LEE follow-up work.

III. Solomon Islands and Bougainville (PNG) Basins: Continuation of program begun on LEE Leg 3.

Additional geophysical work, in particular multichannel seismic -reflection surveying, as well as sea floor sampling are needed to adequately evaluate the resource potential in the West Melanesian Arc. Although more information is desirable to determine the nature of the tectonic framework, the recommendations here are confined to those relating more directly to analysis of resources potential.

A multichannel seismic survey of the southeastern part of Indispensable Strait and the basin areas north and east of San Cristobal Island are required to complete the work done on Leg 3 of the LEE in 1982; cruise L7-82-SP (Fig. 1). This work should have first priority and should be extended eastward to tie with work done by the LEE in Vanuatu and the New Hebrides Arc (Fig. 1). Several tracklines toward Santa Cruz Islands from the vicinity of San Cristobal would be sufficient to accomplish a reconnaissance survey.

Bottom sampling is necessary to determine the age, nature and stratigraphic relationship of rocks beneath the arc, particularly in the Central Solomons Trough, but also in other areas of the arc including Indispensable Strait and the region east of Bougainville and north of Choiseul. Inasmuch as the offshore basins in this region represent much greater areas than the islands, and may reflect much different histories, sampling should be helpful in revealing the evolution and resource potential of the arc.

The Shortland Basin in the vicinity of the Shortland Islands requires supplemental multichannel seismic lines to adequately appraise the resource potential of that basin (Fig. 1). Seafloor sampling should also be associated with any geophysical work in this region.

It is estimated that approximately 30 days of ship time is needed to accomplish the work recommended for the Solomons. This time could be divided into three ten-day phases with the ratio of geophysical work to seafloor sampling being about 50/50.

The above proposals (I-III) represent a logical extension of work initiated with the 1982 USGS/SOPAC LEE cruises. In addition, new work can be proposed for adjoining areas where regional geological and geophysical information and scientific study can significantly advance resource assessment. Representatives attending the LEE post-cruise meeting in Honolulu in August, 1982 recommended the following work be initiated under the same scientific guidelines as those followed for the 1982 Tripartite investigations supported by the R/V S.P. LEE.

IV. New Ireland Basin (PNG)

The New Ireland Basin is a continuation of the Vanuatu, Solomons and Bougainville Basins associated with the Melanesian Arc. It extends for about 900 km from eastern New Ireland to western Manus Island, and lies mostly offshore, south of the islands. It averages 160 km in width and locally contains more than 5 km of sedimentary section. Water depths range from zero to 3000 m. The basin is truncated on the southwest by a system of transform faults, and much of the sedimentary and carbonate sequence pinches out against the Northeast Ridge, which was the outer arc of the West Melanesian Trough during Oligocene time.

Neville Exon and Donald Tiffin of CCOP/SOPAC have made considerable progress in reviewing the petroleum prospects of the New Ireland Basin, in which seismic-reflection surveys have been carried out by CCOP/SOPAC, Gulf Oil, Austradec and the Australian Bureau of Human Resources. Only the Gulf

28

Oil data are of first-class multichannel standard.

Land geology and interpretation of offshore seismic-reflection data indicate that a thick Oligocene volcaniclastic sequence is overlain by as much as 2 km of Miocene platform and reefal carbonate beds, and a similar thickness of younger volcaniclastics and biogenic sediment. Should the offshore Miocene sequence indeed prove to consist largely of carbonates, the New Ireland Basin would have considerable petroleum potential.

To further evaluate the basin, which has not been drilled, and from which few bottom samples have been recovered, it is suggested that a three-week research program be carried out, consisting of approximately 40% multichannel seismic-relfection surveying, and 60% station work. The seismic surveying should concentrate on the eastern and western areas where no multichannel data exist (Fig. 1).

The station work should consist largely of dredging and, if possible, heatflow work to help assess the present-day thermal gradient in the basin. The dredging would be designed to sample the older sequences identified seismically, and especially the "carbonate" sequence. Steep slopes, on which dredgable outcrops should occur are present along the faulted southwest margin of the basin, around the uplifted Tabar-Feni islands in the northeast, and possibly in the West Melanesian Trench.

The New Ireland research program would not only greatly increase scientific and economic knowledge of the basin's petroleum potential, but also would help in the overall geological understanding of this highly complex region, which tectonically involves at least four crustal plates.

V. North Fiji Basin

A reconnaissance geophysical survey and sampling program within the North

Fiji Basin (Fig. 1), especially in its southernmost areas that geologically tie Fiji with Vanuatu, is highly desirable. It has been shown by many investigators that the Fiji Islands and the New Hebrides Arc regions were once closely adjoining structures and that they were separated beginning in late Oligocene to early Miocene time to form the North Fiji Basin. This hypothesis suggests that the sedimentary basins located in Bligh Waters of Fiji, which have been explored for oil and gas, may have evolved collaterally and contemporaneously with the Central Basin of Vanuatu.

To confirm or discount this speculation and thereby more completely assess the resource potential of both regions it is proposed that multichannel seismic-reflection profiles and other geophysical data be collected along the north and western margins of Fiji and that several long multichannel lines be run across the central and southern part of the North Fiji Basin (Fig. 1). In addition, seafloor sampling should be done along the north and west margins of Fiji and on selected sites along the tying traverses. Approximately, 20 to 30 days of ship time would be required for this investigation.

Recommendation for Research Vessel and Instrumentation

For the proposals listed below the supporting research vessel identified for data collection should be scientifically staffed to efficiently conduct both high-resolution and multichannel seismic-reflection and sampling programs. The shipboard personnel must, therefore, necessarily include paleontologists, geologists, geophysicists, and their technical assistants. Shipboard equipment must include at least the following geophysical instrumentation:

1) Integrated satellite-based and sonar doppler navigation system.

2) Gravimeter and magnetometer.

3) Single-channel seismic-reflection system (200-500 in^3 airgun source or equivalent) with output display at low (2-4) vertical exaggeration.

4) Multichannel seismic-reflection system with hydrophone cable length of at least 2400 m and acoustic source equivalent to 1500-2000 in^3 air guns at 1800-2000 psi.

5) Standard 12 and 3.5 kHz non-cross-talking acoustic sounding systems and Uniboom or equivalent high-resolution seismic-reflection system.

6) Sonobuoy recording system for both commercial and military sonobuoys.

7) Digitizing tables and appropriate ADP equipment for the onboard reduction of geophysical data.

8) Physical property measuring equipment (i.e., velocity, porosity, permeability, etc.).

Shipboard equipment must also include the following for geologic sampling:

1) Deep-sea winch with 10,000 m of 3 x 19 or equivalent wire, 0.5 in. or larger diameter.

2) Gravity corers and dart corers.

3) Bottom grab-samplers.

4) Rock-preparation laboratories for production of thin-sections and separation of fossils and perhaps certain minerals.

5) Rock saws and smear-slide preparation equipment.

6) Petrographic and binocular microscopes and related accessories.

7) Chain-bag dredges, time-depth recorders, and wire-mounted pingers for depth control.

8) Word processor and attached printers for the preparation and editing of onboard reports including the production of tables and graphics.

9) Onboard organic geochemistry instruments for determining types of hydrocarbon fractions that may be present in sediment samples.

In addition the selected research vessel should have the ability to put parties ashore in support of geological field studies for onshore-offshore stratigraphic correlation and the placement of navigation transponders or aids. The dispatch and recovery of the field parties should take place in conjunction with continuous shipboard data collection. It may be necessary in some localities to employ precision navigation controls. This type of equipment should be available aboard ship.

Products and Data Distribution

In order to conform with the products arising from the initial USGS/SOPAC LEE program, similar products ought to be generated by the proposed work described herein. Recommended products should include:

1. Microfilmed and reduced reproducible copies of all seismic reflection, refraction, magnetic, gravity and bathymetric profiles.
2. Maps

    Updated bathymetric base maps

    General geologic maps

    Structure and hazards maps

    Sedimentary isopach maps

    Maps showing location of possible sedimentary and structural hydrocarbon traps

All maps, including those for any other pertinent parameter pertaining to sources, should be at a scale of 1:500,000 or larger.

3. Cross sections

    Photographs and line-drawings of pertinent seismic-relfection profiles.

Idealized structural cross-sections extending onshore to include island geology where possible.

4. Lab studies of rock samples

Tabular summary of porosity, permeability and petrologic, geochemical and organic-matter data.

Tabular summary of economic mineral types.

Tabular summary of species lists and zonation from paleontologic samples.

5. Reports

Draft papers and summary reports describing initial results of survey work for each area will be submitted to the funding agencies and participating SOPAC nations within one year of the field work.

Final reports describing scientific results and overall petroleum potential for each investigated area (USGS, Open-File Reports); co-authored (jointly authored with cooperating SOPAC and academic scientists) scientific papers will be published in scientific journals.

To maintain a standardized display of data developed for the USGS/SOPAC LEE program, it is recommended that all shipboard geophysical data collected in these proposed investigations should be microfilmed and copied and that 6 or 9 in. reproducible mylar strips be made. Copies of shipboard records and data sets should be distributed within 6 months of the completion of the survey. Processed multichannel data should be similarly microfilmed and copied on reproducible mylar or sepia strips, and dispersed to CCOP/SOPAC, their member countries involved in the work, and scientists responsible for preparing all required reports.

An index of cruise data, reproducible mylar or sepia copies of finalized

navigation tracks, and a listing of navigation and station-keeping data should also be sent to all CCOP/SOPAC personnel shortly after the completion of any cruise. It is preferable to have these data presented in the data sheet format that has been established for the recently generated data from the 1982 LEE cruise.

Conclusions

Even though the data recently collected during the USGS/SOPAC LEE cruises (Fig. 1) in 1982 have not been fully processed and therefore interpreted, it is evident from the results gleaned from the incompletely reduced data that a continuation of these geoscientific studies would significantly advance the energy and mineral resources assessment of the frontier CCOP/SOPAC region. Accordingly, the principal SOPAC LEE cruise participants have presented in this document their considered recommendations for follow-on investigations in the same region (Fig. 1).

In 1981 the USGS submitted to the U.S. Department of State a proposed 5-year marine geologic program for the SOPAC region that would aid the CCOP/SOPAC member countries in understanding the energy and mineral resources of their offshore territories (see Addendum A). Funding for the first 18 months of the program was provided by the U.S. Department of State, and the corresponding field work has been accomplished. Funding for the remaining 3.5 years of the program needs to be identified. The proposal submitted herein essentially describes work that was to be proposed for year 4 of the 5-year program. However, it now appears that progress resulting from the preliminary analyses of the first year's data (1982) can be used to stimulate and maintain program momentum and productivity if it is initiated earlier in 1984. Also, the level of commitments of the USGS to national offshore development

activities was recently reduced, thus allowing the availability of the USGS's R/V S.P. LEE for potential scientific and resource-related work in the SOPAC region in 1984.

It is here recommended that some form of the 5-year program included in this report be followed. It is desirable, for continuity's sake, to retain a sizable core of the original principal scientific participants to the LEE 1982 cruise for involvement in any ongoing program. In addition, more academic scientists and CCOP/SOPAC country geological trainees should become involved in any ongoing work.

It is also recommended that a modest training program be undertaken in association with any cruises that take place in the SOPAC region. This training should primarily be aimed at educating CCOP/SOPAC member country nationals in the elementary methods and procedures of collecting and interpreting offshore geologic data. The training aspects should be oriented toward the educational background and experience of the trainees. A suggested training program is given in Addendum B.

Addendum A

Proposed 5-Year Marine Geologic Program Outline

for the CCOP/SOPAC Rgion

prepared by USGS - May 4, 1981

This is a five-year program proposed by the U.S. Geological Survey and submitted to the U.S. Department of State. The intent of this program is to maximize the marine scientific expertise and equipment available via the State Department for marine geologic sutdies in the SOPAC region. Consideration of critical funding and future program commitments of the USGS have played a major role in this formulation. Nevertheless, the significant scientific

capability of U.S. universities to work in the region has also been incorporated.

Most of the university studies have been conducted for general marine scientific research. The USGS feels that these projects and other regional studies provide an adequate foundation to support regional and topic-specific, resource-oriented investigations including a combination of onshore and offshore work. Also, the preliminary marine geophysical work done by oil companies attests to the fact that multichannel-seismic resource studies can be carried out effectively in the region. As stated in the USGS proposal, a review of existing university and publicly available industry data will be completed prior to the first cruise. American oil industries are supportive of this USGS proposal and have shown a willingness to share their data with the USGS. Also, continuation of university studies is an important portion of any comprehensive program in the SOPAC region.

With these considerations in view, we have designed the following outline for a 5-year marine geologic program in the SOPAC regime.

YEAR 1

Resource-oriented marine and land studies should be undertaken per the USGS proposal, modified to incorporate any concerns of the SOPAC countries and the U.S. Department of State. University scientists should be encouraged to participate as co-principal investigators in the first year studies.

This is the ideal time for the USGS to contribute to the SOPAC resource appraisal study, as the Research Vessel S.P. LEE and USGS marine geophysical equipment are available for work in the winter of 1982. Funding (approx. $800,000), scientists, and equipment may not be available for work in the SOPAC region in the future because of forthcoming accelerated offshore oil and

gas leasing. Without this initial (1982) work, the SOPAC countries will be unable to evaluate their potential energy resources and their needs for future studies of this kind.

YEAR 2

The USGS investigators with cooperating SOPAC scientists would work full time to complete a summary resource report for the areas surveyed. The report would include a regional geology section, a petroleum resource appraisal and a summary of geological hazards -- to oil exploration and development. The universities would be involved in the major scientific field effort. University studies that could directly assist in refining this resource investigation should be given top priority. Proposals, such as those put forth by the Hawaiian Institution of Geophysics should be considered, as well as those from other U.S. institutions such as Cornell University, Lamont-Doherty Geological Observatory, Scripps Institution of Oceanography and the University of Texas.

University resource-related work should be undertaken at this time with oceanographic fieldwork aboard ship(s) being operated in target regions identified by year 1 studies. This work should be specifically oriented to fill data voids identified through a joint USGS-university-SOPAC scientific coordinating committee as proposed in the USGS proposal.

Where applicable, USGS scientists should participate with university scientists in the field work. Funding for this year's program should be approximately $1 million with the majority of funding going to the universities.

YEAR 3

Year 3 resources-oriented work should follow those proposed here for Year 2 work. Universities again should play a major role in data collection with cooperation from the USGS scientists. The scientific coordinating committee established in Year 1 should review and recommend the studies to be done based on evaluation of the previous year's work. Again, approximately $1 million should be budgeted for this year's work with about 2/3 going to the universities and 1/3 to the USGS for advanced seismic data processing and hydrocarbon geochemical analysis.

YEAR 4

This is probably a good time for the USGS to again make resource appraisal surveys in secondary areas identified from the results of previous work and recommended by the scientific coordinating committee. University and SOPAC scientists would again participate with the USGS in doing very detailed, site-specific resource appraisal field studies aboard a USGS research vessel. Approximately $2 million would be needed for this year's work as it may require the presence of both a USGS and university vessel in the SOPAC region. Various types of dual ship geophysical work (i.e. long distance-deep crustal penetration, seismic refraction shooting) may be desirable at this time.

YEAR 5

This is the year most difficult to determine. The type of work and the amount of funding necessary to complete the 5-year program should be recommended by the scientific coordinating committee as the results of the previous years' work are analyzed.

Appendum B

Training

A concerted effort should be made to train SOPAC geoscientists selected by CCOP/SOPAC to participate in the cruise. This training should be organized into three phases (1) a pre-cruise phase (2) the cruise phase and (3) a post-cruise phase and will be tailored to the educational level of the participants.

(1) Pre-Cruise Phase

Participating trainees should receive a 5- to 10-day pre-investigation course on elementary marine geophysical theory and geological sampling techniques. The course should be designed to cover the scope of experiments and shipboard data collection methods. It should emphasize modern methodologies used in offshore resource assessment and geological hazards appraisal.

(2) Cruise Phase

SOPAC scientific participants will gain onboard experience in marine geophysical and geological data collection. They will participate in the operation of the onboard geophysical instruments and positioning equipment, and in collection and the processing of geological samples. Their shipboard education will be directly overseen by the Co-chief Scientists.

(3) Post-Cruise Phase

The SOPAC scientific participants should be instructed in data reduction and interpretation. A short course could be given on theory and techniques of interpretation of marine geophysical data where the trainees could actually play an integral part in the interpretive process.

APPENDICES

A. Lists of attendees to formal receptions

B. Leg 1 draft report and press-release

C. Leg 2 draft report and press-release

D. Leg 3 draft report and press-release

E. Draft report on Rabaul survey

F. LEE post-cruise meeting

G. Publicity given to LEE - press release, articles, etc.

Appendix A

List of Attendees to Formal Receptions

List of Attendees to

Official Function

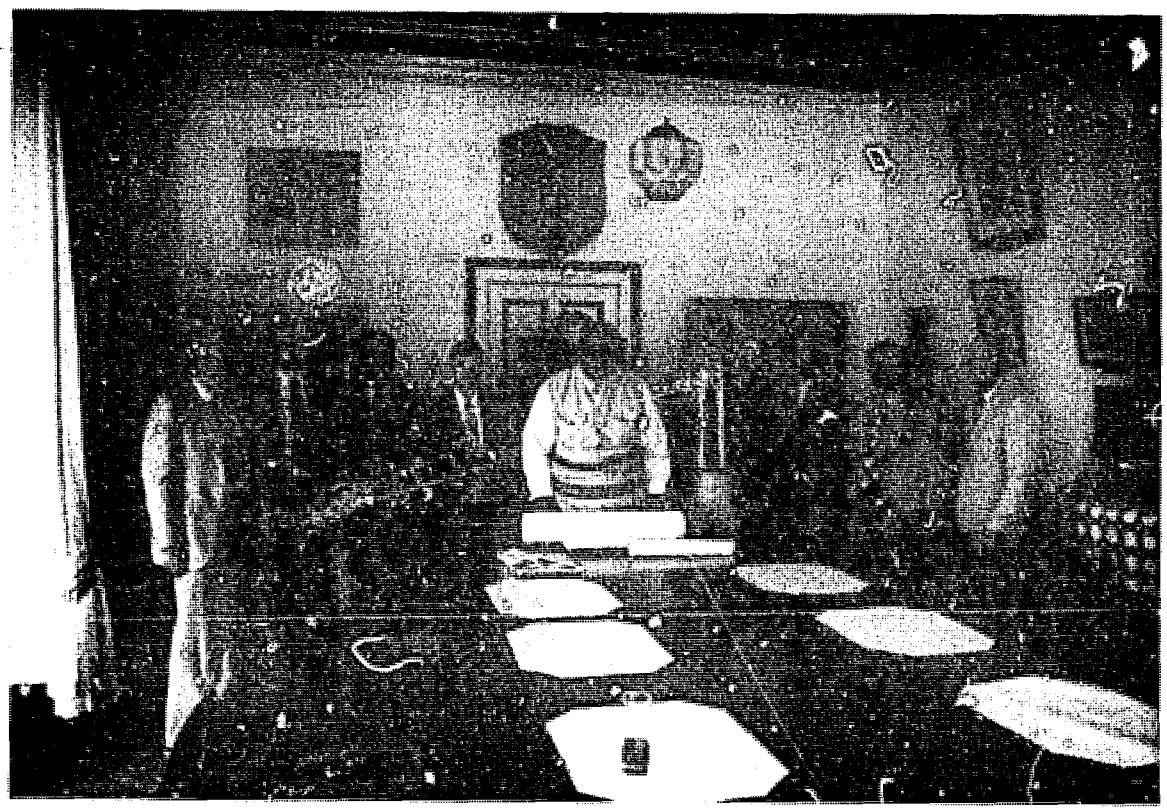
in

Tonga

List of Attendees that visited with
The King of Tonga - Tanfa'ahau Tupou IV
Nuka'alofa, Tongatapu, Tonga
Thursday, April 1, 1982

Robert Rowland, USGS
Mark Sandstrom, Australia
Tun Muang, CCOP/SOPAC
David Scholl, USGS

H. Gary Greene, USGS
Rick Herzer, New Zealand
Tracy Vallier, USGS
Neville Exon, Australia



85

List of Attendees to

Official Functions

in

Suva, Fiji

Luncheon on R/V S.P. LEE, Suva Wharf, 1200 noon
Tuesday 20 April 1982 by Governments of Australia,
New Zealand and the United States of America and
CCOP/SOPAC

The Hon. Mr. W. Clark, Minister of State for Energy
The Hon. Mr. Sakeasi Waqanivavalagi, Minister of State for Lands and Mineral Resources
H.E. Mr. Michael Powles, New Zealand High Commissioner
Mr. Ken Brazel, Acting Australian High Commissioner
Mr. Russell J. Surber, Charge d'Affaires, a.i. American Embassy
Mr. Satya Nandan, Permanent Secretary for Foreign Affairs
Mr. Arthur Holcombe, UNDP Representative
Mr. Cruz Matos, Project Manager, CCOP/SOPAC
Captain J. H. F. Vollmer, Ports Manager, Ports Authority of Fiji
Mr. R. H. Bechan, Acting Comptroller of Customs
Mr. Howard Plummer, Director of Mineral Development

Regrets:
Ratu Sir Penaia Ganilau, Deputy Prime Minister
Dr. Uday Raj, Institute of Marine Resources, USP

List of Attendees to

Official Functions

in

Vanuatu

Official Guest List: CCOP/SOPAC Reception
R.V. SAMUEL P. LEE
Tuesday 27 April at 11 A.M.
Hosted by Michael Ovington, Australia High Commissioner to Vanuatu

His Excellency President Ati George Sokomanu, President of the Republic of Vanuatu
The Hon. Father W. Lini, Prime Minister
The Hon. Pastor F. K. Timakata, Deputy Prime Minister and Minister of Home Affairs
The Hon. Kalpokor Kalsakau, Minister of Finance
The Hon. Donald Kalpokas, Minister of Education
The Hon. Pastor W. Korisa, Minister of Health
The Hon. Pastor S. Regenvanu, Minister of Land and Natural Resources
The Hon. John Naupa, Minister of Communications and Public Works
The Hon. Maxime Carlot, Speaker of Parliament
His Lordship F. G. Cook, Chief Justice
The Hon. V. Boulekone, Leader of the Opposition
Mr. P. Taurakoto, First Secretary, Prime Minister's Office
Mrs. Grace Molisa, Second Secretary, Prime Minister's Office
His Excellency Mr. B. T. Sope, Roving Ambassador and Secretary of Foreign Affairs, Prime Minister's Office
Mr. Nike Nike Vurobaravu, Department of Foreign Affairs
Mr. J. A. Natuman, Department of Foreign Affairs
Mr. M. Tamata, First Secretary, Ministry of Land and Natural Resources
Mr. S. Leodoro, Second Secretary, Ministry of Land and Natural Resources
Dr. H. S. Kim, Chief Planning Officer, Central Planning Office
Mr. A. Garae, Central Planning Office
Dr. K. Calvert, Central Planning Office
Mr. G. Pakoa, First Secretary, Ministry of Communications and Public Works
Captain M. Ligo, Commanding Officer, MALA
Mr. W. J. Horman, Police Commissioner, Vila Police Headquarters
Mr. I. Cook, VMF Commander, VMF Barracks
Mr. J. Carlo, Director, Government Information Service, Radio Vanuatu
Mr. J. Tavoa, Tam Tam, Government Information Service
Mr. L. Garae, Tam Tam, Government Information Service
Mr. K. Huffman, Curator, Vanuatu Cultural Centre

Reception Onboard SAMUEL P. LEE
Tuesday 27 April 1982

DEPARTMENT OF GEOLOGY, MINES AND RURAL WATER SUPPLY

Mr. A. Macfarlane
Mr. Kalman Kiri
Mr. Willie Harrison
Mr. Ken Gosschalk

DEPARTMENT OF SURVEY (T.O.P.O.)

Mr. Mike Wright
Mr. Bruno Chenier
Mr. Jonathan Maynard
Mr. Remy Delaveuve

DEPARTMENT OF FISHERIES, MINISTRY OF LAND AND NATURAL RESOURCES

Mr. Jim Crossland
Mr. Maurice Theriault
Mr. Xavier Revier

O.R.S.T.O.M.

Mr. Pierre Caballion (C/- Agriculture - Acting Head of Mission)
Mr. Roger Foy (C/- Geology)
Mr. Rene Grandperrin (C/- Fisheries)
Mr. Francis Bandoux (C/- Geology)

Guest List for Luncheon: Tuesday 27 April 1982

CCOP/SOPAC: C/- R.V. SAMUEL P. LEE

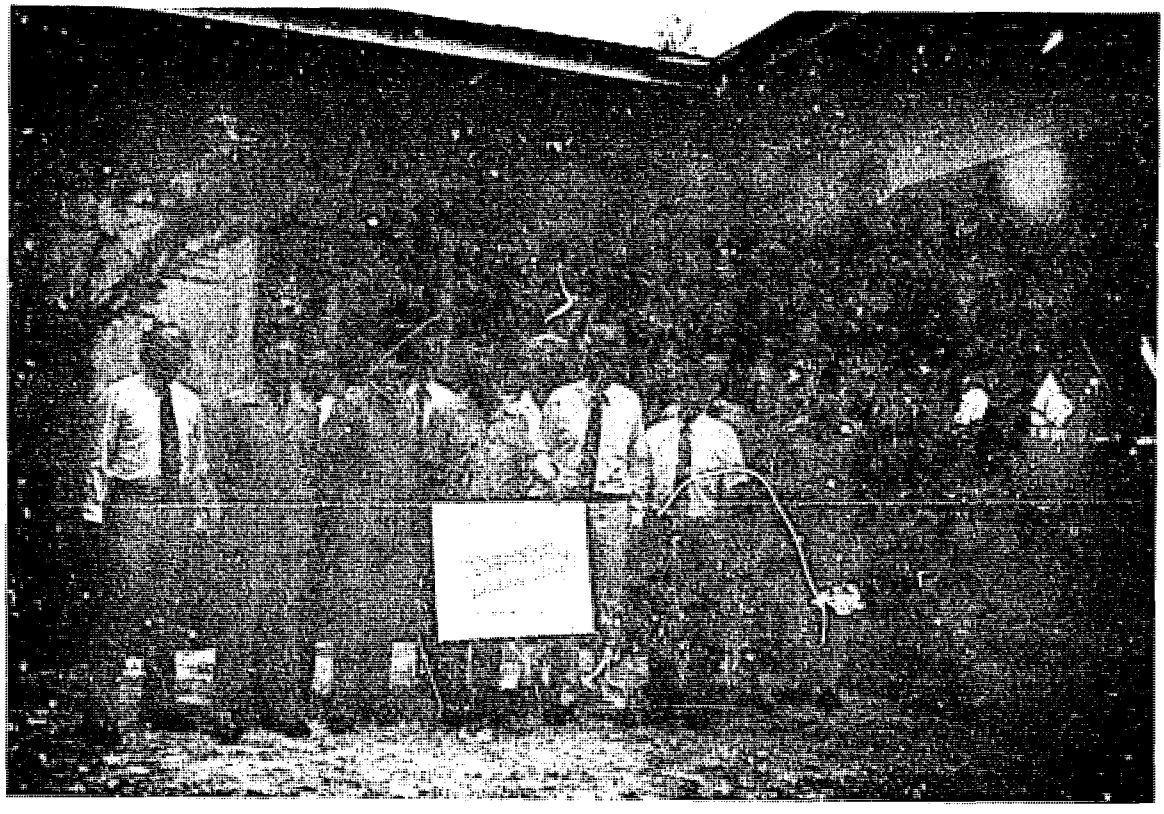
Dr. H. G. Greene (USA)
Dr. D. Falvey (AUST)
Dr. H. R. Katz (NZ)
Dr. J. Daniel (ORSTOM-FRANCE)
Dr. D. Scholl (Chief Scientist - Tonga Sector)
Dr. Johnson (AUST)
The Captain, R.V. SAMUEL P. LEE
Mr. A. Macfarlane (Vanuatu & Chairman CCOP/SOPAC)
Dr. R. Rowland (USA)

VANUATU GOVERNMENT LIST

(Approx. 10 guests including Australian High Commissioner, Michael Ovington.)

List of Attendees Meeting with the President
of Vanuatu - Ati George Sokomanu

Alexander Macfarlane	-	Vanuatu
David Falvey	-	CCOP/SOPAC Co-Chief Scientist
H. Gary Greene	-	U.S. Co-Chief Scientist
Robert Rowland	-	U.S.G.S. Pacific-Arctic Marine Geology Branch Chief
Rudy Katz	-	New Zealand
David Johnson	-	Australia
Capt. Vern Pilgrim	-	Captain, S.P. LEE
Chief Aaron Dunwall	-	Chief Engineer, S.P. LEE
David Scholl	-	Co-Chief Scientist, Tonga Leg
Michael Ovington	-	Australian High Commissioner
Jacques Daniel	-	ORSTOM



92

List of Attendees to

Official Functions

in

The Solomon Islands

Reception aboard R/V S.P. LEE
Guest List
Honiara, Guadalcanal, Solomon Islands
Tuesday, May 18, 1982

The Hon. K. Teke, Deputy Prime Minister
The Hon. F. Daly, Chief Justice
Mr. D. Kausimae, Chairman S.I. Ports Authority
The Hon. B. Ulufa'alu, Minister for Finance
The Rt. Hon. Sir Peter Kenilorea, Leader of Opposition
Mr. Matthew Kubebatu, Deputy Commissioner, R.S.I.P.
Mr. B. Lundy, General Manager SOLTEL
Mr. S. MacFarlane, Chairman, CCOP
Mr. F. Coulson, Ministry of Lands
CPOSR Slade, Hydrographic Unit, Marine Division
Mr. S. Danitofea, Chief Geologist, Ministry of Lands, Energy & Natural Resources
H.E. Miss M. Chamberlain, N.Z.H.C.
H.E. Mr. T. Sofield, A.H.C.
Mr. F.J. Saemala, Atg. Permanent Sec., Ministry of Foreign Affairs
The Hon. M. Evo, Atg. Minister for Foreign Affairs & International Trade
Mr. M. Sibisopere, Permanent Sec., Min. Transport, Communications & G.U.
Mr. L. Maenu'u, Permanent Sec., Ministry Lands, Energy & Natural Resources
Hon. P. Salaka, Ministry Land Energy & Natural Resources
Mr. S. Surimalefo, Senior Immigration Officer
Mr. G. Hiele, Controller of Customs & Excise
Mr. Vitali Tegnisi, Senior Marine Officer (Hydrography)

Appendix B

Leg 1 - Tonga Draft Press-Release,

Scientific Abstract and Initial Cruise Report

SUGGESTED PRESS RELEASE - DRAFT

CCOP/SOPAC AND THE U.S. GEOLOGICAL SURVEY BEGIN STUDIES OF THE TONGA OFFSHORE REGIONS TO ASSESS PETROLEUM POTENTIAL

The offshore regions of the Tonga Islands were studied during a recent cruise of the U.S. Geological Survey research vessel S.P. LEE which carries a full complement of geophysical equipment, including a deep-penetration multi-channel seismic reflection system. Scientists from United Nations Committee for the Coordination of Joint Prospecting for Mineral Resources in the South Pacific (CCOP/SOPAC) and the U.S. Geological Survey designed the March and April, 1982 cruise in order to provide data for a preliminary assessment of the petroleum potential. Funds for the research were provided through a tripartite treaty among Australia, New Zealand, and the United States governments to aid southwest Pacific island nations in their search for petroleum.

The cruise departed from Pago Pago, American Samoa and arrived in Port Vila, Vanuatu. About 19 of the 23 cruise days were spent in Tonga waters, particularly over the southern Platform. More than 5700 km of tracklines were run during the cruise which included the collection of 2400 km of deep-penetration seismic reflection data. In addition, gravity, magnetic, precise bathymetry, and single-channel seismic reflection data were collected and submarine samples were taken from eight successful dredge hauls. Fifty-three sonobuoys were launched at 42 stations. Ata, Eua, and Tongatapu islands were sampled to assist in the interpretations of offshore data.

A large amount of work is required before a viable resource report can be written. Evaluations of some data will be completed by October, 1983, but studies will continue in order to choose the most promising areas for additional studies. Preliminary interpretations of shipboard and sonobuoy data suggest that: 1) the sediment cover that overlies volcanic basement on the southern Tonga Platform is probably no greater than 3 km thick; 2) a thicker sediment section in the relatively deep Tofua Trough north of Tongatapu may have a thick layer of volcaniclastic sediments overlying older rocks with source rock potential; 3) Lau Ridge and the Tonga Platform probably are parts of the same old island arc that bifurcated during the formation of the Lau Basin; and 4) subaerial erosion of the Tonga Platform may have occurred in the Late Eocene-Early Miocene interval. Principal investigators discussed preliminary results during a symposium at the Circum-Pacific Energy and Mineral Resources Conference in Honolulu, Hawaii, August 22-28. Preliminary results from surveys in Vanuatu, the Solomon Islands, North Fiji Basin, and the Melanesian borderland also were presented.

ABSTRACT FORMAT

uthor's name, professional affiliation, ddress. (If there are multiple authors, ndicate speaker with an asterisk.)

*Scholl, D.W., U.S. Geological Survey, Menlo Park, Ca.; Mauang, T.U., CCOP/SOPA, U.N. Offshore Mineral Prospecting, Suva, Fiji; Vallier, T.V., U.S. Geological Survey, Menlo Park, Ca., and Scientific Party Cruise 1 CCOP/SOPAC, R/V S.P. LEE[1]

uthor's telephone number (415) 856-7089

est time to call: 8:00 AM - 5:00 PM Monday-Friday

aper Title: Preliminary Results of Geophysical and Geological Studies to Assess the Resource Potential and Geologic Evolution of the Central Tonga Ridge and Summit Platform (21-24° latitude)

ubmitted for ___ Poster Session X Oral Presentation

think most appropriate for session: Hydrocarbons
(use title from list on first page)

bstract: *(Typewritten, double spaced, 250 words or less)*

In April, 1982, the R/V S. P. LEE, operated by the USGS, supported geological and eophysical studies over the central area of the Tonga Ridge immediately south of ongatapu. The cruise plan calls for the collection of approximately 2000 km of ultichannel (24) seismic reflection data and several dredge stations to sample ubmarine outcrops. The bulk (70 percent) of this work will be concentrated over the ummit platform of the ridge in water depths less than about 1500 m. One or more seismic ines will be extended eastward to and slightly seaward of, the Tonga Trench, and estward of the ridge's present volcanic axis toward the Lau Basin in order to resolve he regional rock and structural framework of the ridge. A number of multichannel lines ill cross the forearc basin that lies between the summit platform and the trench. onobuoy refraction and wide-angle reflection data will be gathered routinely as well as ravity and magnetic data and high-resolution subbottom seismic records (3.5 kHz and

Author's Address U.S. Geological Survey, MS 99
345 Middlefield Road
Menlo Park, CA

Speaker's Address, if different [1]Childs, J., and Stevenson, A.J., USGS, Menlo Park, Ca.; Exon, N.F., Bureau of Mineral Resources, Canberra, A.C.T., Australia; Herzer, R.H., New Zealand Geol. Survey, Lower Hutt, New Zealand; Sandstrom, M.W., Australian Nat. Univ., Canberra, A.C.T., Australia; Soaki, S., Ministry of Lands, Survey of Natural Resources, Nuku'alofa, Tongatapu, Tonga

multiplate Uniboom sources). Navigation will be controlled by satellite fixes and computer-generated dead-reckoning positions based on ship's heading and speed, and doppler-sonar inputs.

The results of the shipboard examination of dredged samples, seismic monitor records, and possibly several hundred km of brute-stacked processed multichannel records will be presented at the CPEMRC III. The implications of this sketchy and roughly assembled data base relative to the mineral and petroleum resource potential of the sedimentary sections underlying the ridge's summit platform and the adjacent forearc basin will be discussed. Comments on the geologic and tectonic history of the Tonga Ridge implied by the incompletely analyzed field data will be offered for discussion and consideration.

PRINT OF PAPER SUBMITTED TO THE TRANSACTIONS,
CIMPACIFIC ENERGY AND MINERAL RESOURCES CONFERENCE,
DLLLR, HAWAII, 1982.

INITIAL CRUISE REPORT, SOPAC LEG 1 (CRUISE L5-82).

SOUTHERN TONGA PLATFORM

by

David W. Scholl

and

Tracy L. Vallier

United States Geological Survey, Menlo Park

California 94025

and

Tun U. Maung

U.N. Mineral Prospecting, C/O Mineral Resources Dept.

Private Mail Bag, GPO, Suva, Fiji

Shipboard Scientific Party*

General Narrative

In 1979 and 1980 single-channel geophysical studies over the southern region of the Tonga platform most completely identified a section of sedimentary rocks that could contain petroleum deposits of economic importance. This work was sponsored by the CCOP/SOPAC (Committee for the Coordination of Joint Prospecting for Mineral Resources in the South Pacific) office of UNDP, Suva, Fiji. Scientific and resource studies were continued in April, 1982, when the research vessel S.P. LEE, U.S. Geological Survey,

---

* Neville F. Exon, Bureau of Mineral Resources, Canberra, Australia; Richard Herzer, New Zealand Geological Survey, Lower Hutt; Mark W. Sandstrom, Australia National University, Canberra; Andrew J. Stevenson, and Dennis M. Mann, USGS, Menlo Park, California; and Jon Childs, USGS, Reston, Virginia.

examined the southern Tonga platform with multichannel (24) seismic reflection technology. The continuation of the program was funded by a tripartite agreement between the governments of Australia, New Zealand, and the United States.

Leg 1 (cruise no. L5-82) of the LEE's three SOPAC cruises (1 = Tonga, 2 = Vanuatu, and 3 = Solomon Islands) departed from Pago Pago, America Samoa, on March 28. The vessel proceeded to Nuku'alofa, Tonga, and after a brief stop (March 31-April 2), conducted an 18-day geophysical and geological study over the southern Tonga platform (21-23.5 deg S). Geomorphically the platform is the summit plateau or crestal area of the Tonga Ridge, a massive, NE-SW-trending and mostly submerged mountain range that lies between the Tonga Trench to the east and Lau Basin to the west (Fig. 1). Water depth over the surface of the platform typically range from about 200 to 1000m; the regional bathymetric slope is westward from the Pacific toward the Lau Basin side of the platform. Cruise L5-82 terminated at Port Vila, Vanuatu, on April 26, after a short visit to Suva, Fiji, for reprovisioning (April 20-23).

Information Gathered

Geological and geophysical data were gathered during approximately 23 at-sea days. Single channel seismic reflection records (using airgun acoustic sources), 12 and 3.5 khz reflection profiles, and underway gravity and magnetic data were collected during most of the cruise. Navigation was controlled by satellite fixes augmented by dead-reckoning positions computed onboard by entering speed and heading data assisted by sonardoppler and, rarely, Omega navigation information. The cumulative or line-distance of geophysical data sets are each approximately 5700 km (3070 n.miles). Multichannel (24 fold) reflection profiles (using a 1311 in^3 tuned airgun array) were gathered along 2421 km (1307 n.miles) of trackline located solely

over the southern Tonga platform and immediately flanking areas. Refraction velocity profiles using military and commercial sonobuoys were recorded at 53 stations, nearly all of which were located along the Tonga platform. Forty-eight of these sonobuoys provided good to excellent data.

Bottom sampling was attempted at 13 stations, 9 of these were dredge hauls, the remaining 4 were gravity cores. All of the dredge hauls, including one (the last) at a depth of about 8000 m along the inner wall of the Tonga Trench near Eua Island, were successful. A surface layer of pumice or coarse carbonate rubble limited the subsurface penetration of the gravity corer to a few cm. A brief sampling visit was made to Ata Island, a late Quaternary or Holocene volcanic center along the Tofua arc, by small launch. The LEE remained underway, collecting geophysical data, during the island sampling. Tertiary rocks on Eua Island were also sampled for comparisons with the dredged rocks; and key stratigraphic relations exposed on the island were examined to aid in the interpretation of the acoustic stratigraphy of the offshore extension of the platform section.

General Results

Geophysical data attest to a westward-thickening and dipping sedimentary section -- the platform section -- underlying the southern Tonga platform (Fig. 2). The general structure and certain stratigraphic characteristics of the platform section, which is defined here as the sequence of acoustically layered or coherently reflecting deposits underlying the platform, had been outlined most completely by the single-channel reflection work of the R/V MACHIAS (CCOP/SOPAC) in 1979 and 1980 (Maung et. al., 1981). The existence and significance of the section had previously been noted by Katz (1974; 1976) and Dupont (1978; in press). Monitor records and initial-stage processed multichannel reflection profiles (Fig. 2) imply that the platform section is

composed of at least two sequences or packets of eastward thinning sedimentary deposits (Fig. 2).[1] The upper packet, the thinner (0-1.5 km) of the two, is (acoustically) prominently layered and evidently wedges out eastward over structurally ascending beds of the lower unit, which is exposed over the eastern or Pacific side of the platform. The lower sequence includes laterally discontinuous horizons and certain mound-like bodies. An erosional unconformity (?) appears to separate the two sequences; other unconformities are indicated by structural divergencies deeper within the lower sequence.

The platform section is only broadly deformed and probably not thicker than about 3 km. It is characterized by relatively elevated acoustic velocities that are as high as 2-2.5 km/sec near the sea floor and average about 3.5-4.0 km/sec near the base of the section (Fig. 2). Preliminary laboratory studies indicate that the velocities of upper Cenozoic rocks dredged from the platform's upper section range from 1.7-3.5 km/sec. Velocities typical of the underlying acoustic "basement"[2], presumably firmly lithified volcanic rubble and associated igneous rocks, are greater than 4.5-5.0 km/sec. Eastward across the crest of the ridge the surface of the basement ascends structurally to shallowly underlie the platform's Pacific side. Beneath this structural crest, and farther east beneath the descending

1) On Eua Island, the exposed platform section consists of a basal unit of Eocene limestone unconformably overlain by a mostly Miocene volcaniclastic sequence and younger reefal masses (Kroenke and Tongilava 1975).
2) The expression "acoustic basement" or "basement" refers to the arc massif or bedrock framework of the Tonga Ridge. Although the bulk of this framework was formed prior to late Eocene time (probably by 40 ma), it is still forming along the active Tofua magmatic front. Thus acoustic identification of basement rock does not carry an age connotation.

landward slope of the adjacent Tonga Trench, basement rocks acoustically exhibit little if any internal structure or lateral reflection coherency (Fig. 2).

In some areas the eastward thinning sedimentary section passes over the platform's Pacific structural crest and wedges out against the trenchward descending surface of the underlying basement. In general, the lower sequence of the platform section is broadly domed over the crest of the Pacific basement high (Fig. 2). The platform section is broken by numerous high-angle faults that strike both generally transverse and parallel to the NE-SW trend of the platform. Virtually all of the faults are of extensional origin; the dips of many of them are antithetic to the regional, westward dip of the platform section. Faults are most prominent over the broad warp associated with the eastern structural high, and along the western side of the platform where the section is thickest adjacent to the Tofua magmatic arc (Fig. 2). Extensional faulting along the western side is dominantly down-to-basin, and evidently related (at least in part) to the rifting event that formed the Lau Basin. No evidence that the platform section extends westward beneath this basin was found.

Regional information and preliminary cruise results imply that the platform section is mostly of post-middle Eocene age, and that the bulk was deposited in Miocene and earliest Pliocene time. Dredging along the eastern edge of the platform failed to recover rocks of the basement sequence, but, judging from geopotential data (Fig. 3) and the section exposed on Eua Island, they possibly include volcanic units of early Tertiary age (Kroenke and Tongilava, 1975; Maung, et. al., 1981). Near the base of the landward slope of the adjacent Tonga Trench, fragments of serpentinite, volcanic breccia, and volcanic sandstone and siltstone were recovered (Fig. 1, dredge station 9).

Dredging results attest that much of the upper part of the platform section consists of volcaniclastic siltstone, sandstone, and breccia interbedded with fossiliferous limestone. Initial paleontologic age calls indicated that much of the platform's upper sequence is of late Miocene through early Pleistocene age. The relatively high velocity structure of the stratified platform section implies that consolidated and relatively dense sedimentary rocks comprises much of its mass.

The platform section is gravimetrically distinct, appearing as a relative low between ridges of prominent gravity highs that are associated with the volcanic line of the Tofua front to the west, and the basement high that underlies the Pacific edge of the platform to the east (Fig. 3). In general, magnetic anomalies over the platform section are more weakly expressed than those associated with the Tofua front and the basement highs of the platform's Pacific edge. The implications of the distribution of magnetic and gravity anomalies is that a magmatic arc may have formed along the present eastern (Pacific) edge of the summit platform in early or mid Tertiary time.

Petroleum Geology

A meaningful evaluation of the petroleum potential of the sedimentary section of the southern Tonga platform must await the results of laboratory study of rocks dredged from the ridge, and the examination of fully processed multifold reflection profiles. A number of geologic problems must be solved or significantly clarified if the ridge's geologic history, a key to assessing its resource potential, is to be deduced. These problems, which can be addressed with the new data provided by cruise L5-82, include the following:

General Geology

1) What is the lithology and age of the acoustic basement rock of

the southern Tonga platform -- is the igneous arc basement rock exposed on Eua Island equivalent to the acoustic basement of the southern platform?

2) Where was the mid- and late Tertiary source terrane for the volcaniclastic sandstone and breccia that evidently make up much of the platform section -- Lau Ridge, or the present Tonga platform or forearc areas?

3) What are the ages of the youngest and oldest beds of the platform's volcaniclastic section?

4) What are the ages of the volcanic clasts in the platform's volcaniclastic section -- do they support a mid-Tertiary episode of arc volcanism, or were they eroded from an Eocene or older volcanic landmass?

5) Does the volcaniclastic section unconformably overlie older platform beds of massive foraminiferal limestone and volcanic conglomerate of Eocene age (which is the circumstance on Eua Island)?

6) Do the higher velocity (3.5-4.5 km/sec) beds at the base of the platform section represent the Eocene (or younger) limestone sequence and underlying basal conglomerate, or the intrusive, extrusive and volcaniclastic rocks of the so-called arc basement?

7) What is the depositional environment of the limestone beds that are interbedded with the volcaniclastic units -- do the carbonate deposits attest to general subsidence, stability, or uplift of the ridge crest?

8) Is there evidence in the dredged rocks, or on Eua Island, for that matter, for reefal limestone masses of early and mid-Teritiary age?

9) What do the eastward-onlapping depositional sequences of the upper and lower platform sequences eustatically or tectonically imply?

10) What is the origin of the canyon-like bathymetric relief cut into the lower platform sequence along the Pacific side of the platform?

General Tectonic

1) What is the origin of the regional westward tilt and westward thickening of the platform section -- and what was the tectono-depositional setting (i.e., forearc, backarc, arc-slope, summit basin) of this sedimentary mass?

2) Where is the missing downslope or westward-thickening extension of the volcaniclastic and carbonate section of the Tonga platform -- has it been rifted away to the west side of the Lau Ridge?

3) When was the platform section rifted along its western side, and when did the Tofua volcanic arc first form?

4) Is the prominent normal faulting of the platform section coeval with the rifting episode?

5) Did a Miocene volcanic arc form along the southern Tonga platform -- what was its polarity?

6) Does the downslope and trenchward wedging out of the platform section imply that the landward slope of the Tonga trench was once a highland that subsided (e.g., the Pacific margin east of Honshu, Japan) during mid and late Cenozoic time?

Hydrocarbon Generation and Entrapment

1) Was the missing western extension of the platform section thick enough (presume normal heat-flow circumstances) to have generated petroleum hydrocarbons -- prior to rifting, could they have migrated updip into the section presently beneath the southern Tonga platform?

2) Was the platform section sufficiently heated by the igneous events (e.g., spreading in Lau Basin, emplacement of the Tofua magmatic bodies) associated with rifting to have generated petroleum accumulations in the section remaining along the Tonga Ridge?

3) Is the Oligocene section missing, or mostly so, on Eua Island -- is there a related early Tertiary karst topography etched into the Eocene foraminiferal limestone that could serve as petroleum reservoir?

4) Do the volcaniclastic and limestone beds of the southern platform section in fact overlie an early Tertiary karst surface etched into basal units of Eocene limestone?

5) Are the mound-like bodies detected acoustically within the western or thicker parts of the platform sections in fact mid Tertiary reefs -- could they be volcanic or intrusive masses related to arc volcanism?

6) Is there any organic geochemical evidence (provided by laboratory studies of the the dredged rocks) that the platform section has generated or been the habitat for petroleum hydrocarbon products?

Future Work Needed

Additional multichannel seismic reflection work may be recommended over the southern Tonga platform after the completion of a study of those profiles acquired during cruise L5-82. Reflection seismology is certainly needed over the far southern region of the Tonga platform (south of 23.5 to about 27 deg S), which remains virtually unstudied. Interestingly, to judge from the width of the Lau Basin and Harve Trough, the rifting event that affected the far southern platform may have been less severe (rapid) and possibly occurred later than to the north; these circumstances can be viewed as increasing the petroleum potential of the ridge's far southern platform section.

In the southern Tonga platform, even at this early stage of study, it is clear that sampling of additional submerged outcrops is critically needed. With guidance provided chiefly by newly collected shipboard reflection records, the trial sampling program carried out during the LEE's 1982 cruise prove so valuable that a subsequent dredging program should be designed to

more adequately sample the platform's entire sedimentary sequence. In the absence of an effective sampling program, questions regarding the ridge's geologic evolution cannot be resolved or even factually approached. The sampling program, although necessarily centering along the crestal area of the ridge, must involve the flanks of the ridge, which may contain a record of substantial mid and late Cenozoic subsidence. Resolution of the ridge's history of vertical tectonism is crucial to assessing its resource potential.

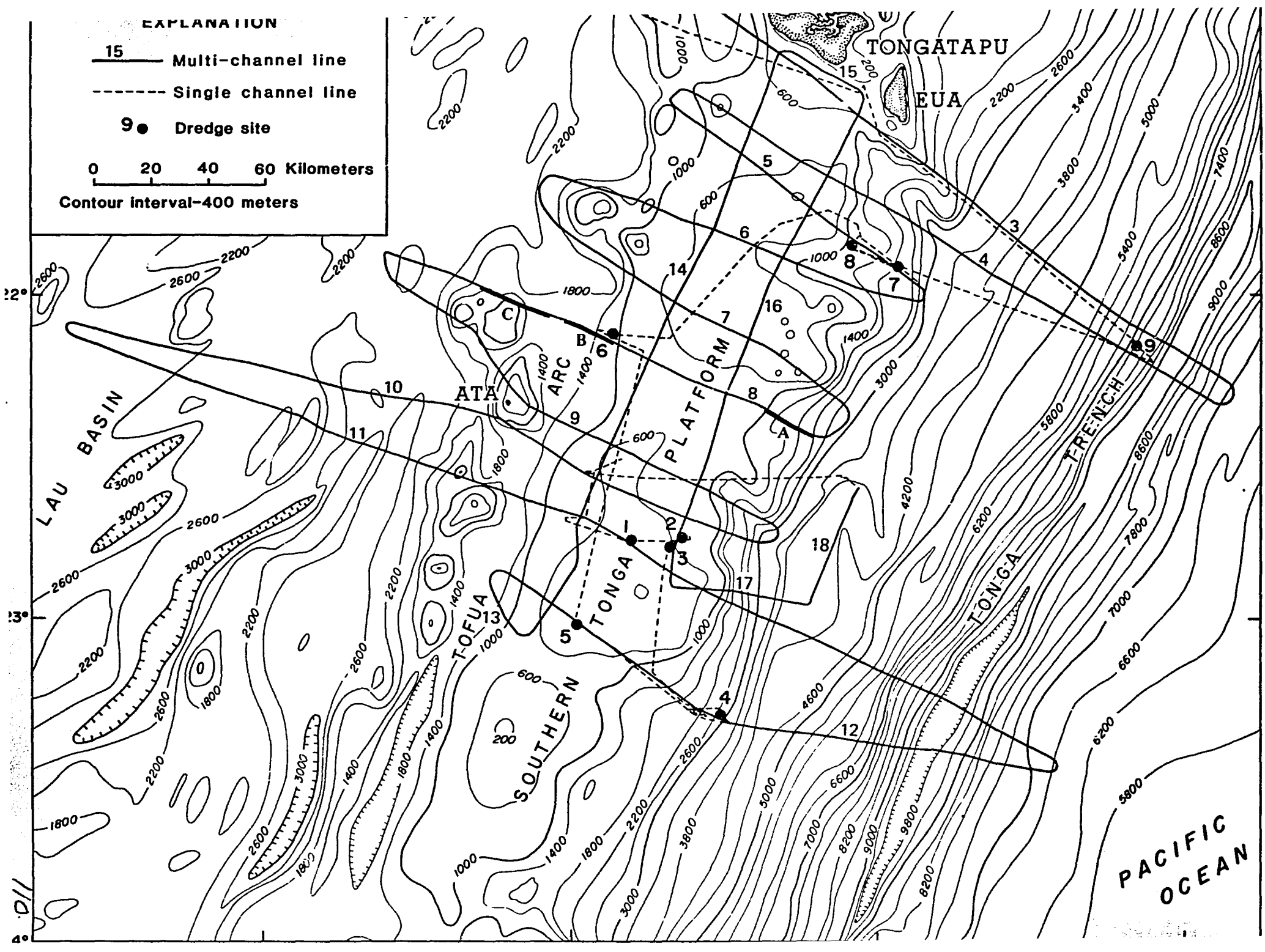
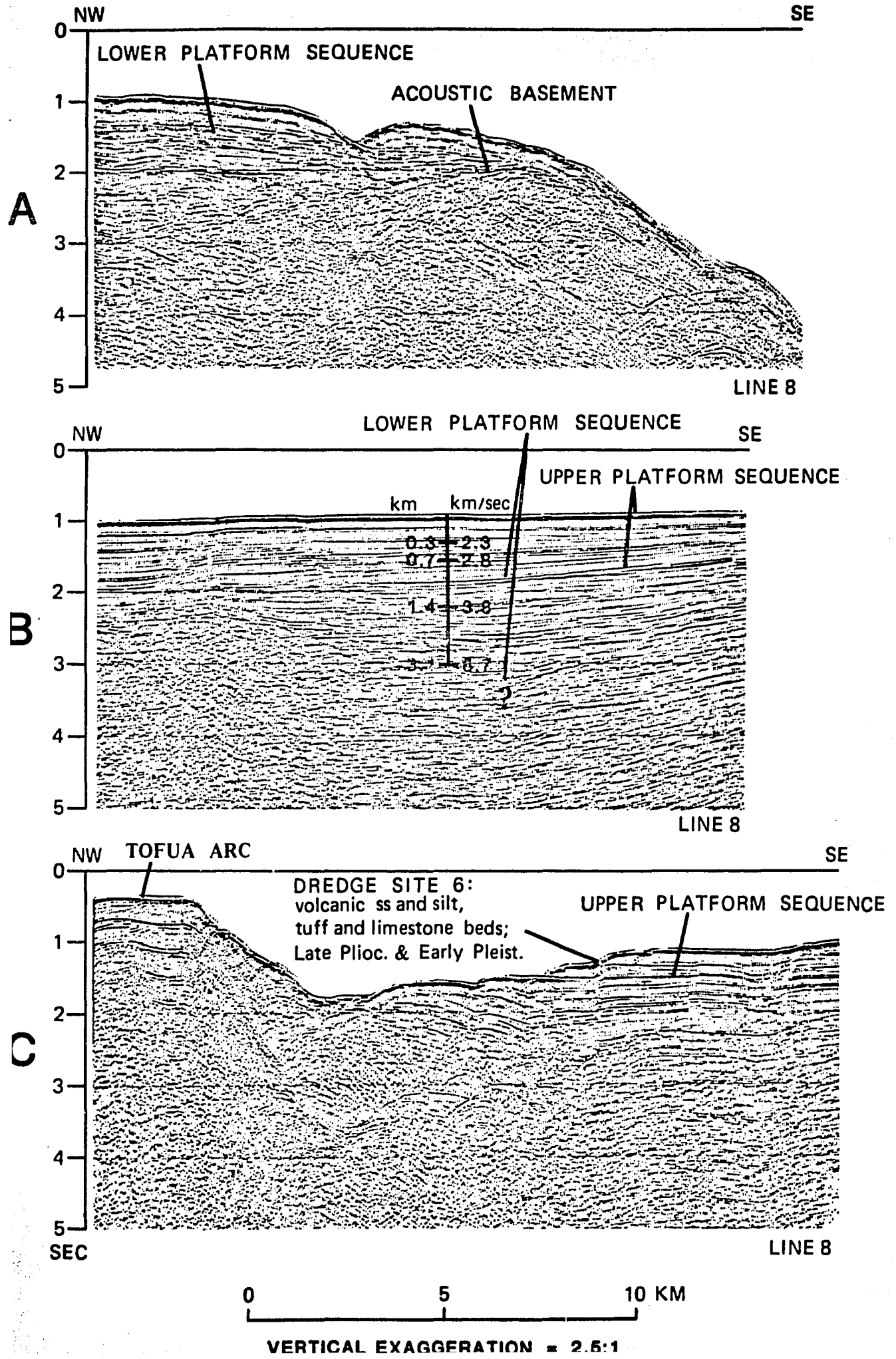

EXPLANATION
15 Multi-channel line
Single channel line
9 Dredge site
0 20 40 60 Kilometers
Contour interval-400 meters
TONGATAPU
EUA
ATA
LAU BASIN
TONGA PLATFORM
TOFUA
SOUTHERN TONGA ARC
TONGA TRENCH
PACIFIC OCEAN

FIG. 1

FIG. 2


A
NW
SE
LOWER PLATFORM SEQUENCE
ACOUSTIC BASEMENT
LINE 8
B
NW
SE
LOWER PLATFORM SEQUENCE
UPPER PLATFORM SEQUENCE
km
km/sec
0.3 — 2.3
0.7 — 2.8
1.4 — 3.8
3.1 — 6.7
?
LINE 8
C
NW
TOFUA ARC
SE
DREDGE SITE 6:
volcanic ss and silt,
tuff and limestone beds;
Late Plioc. & Early Pleist.
UPPER PLATFORM SEQUENCE
SEC
LINE 8
0
5
10 KM
VERTICAL EXAGGERATION = 2.5:1

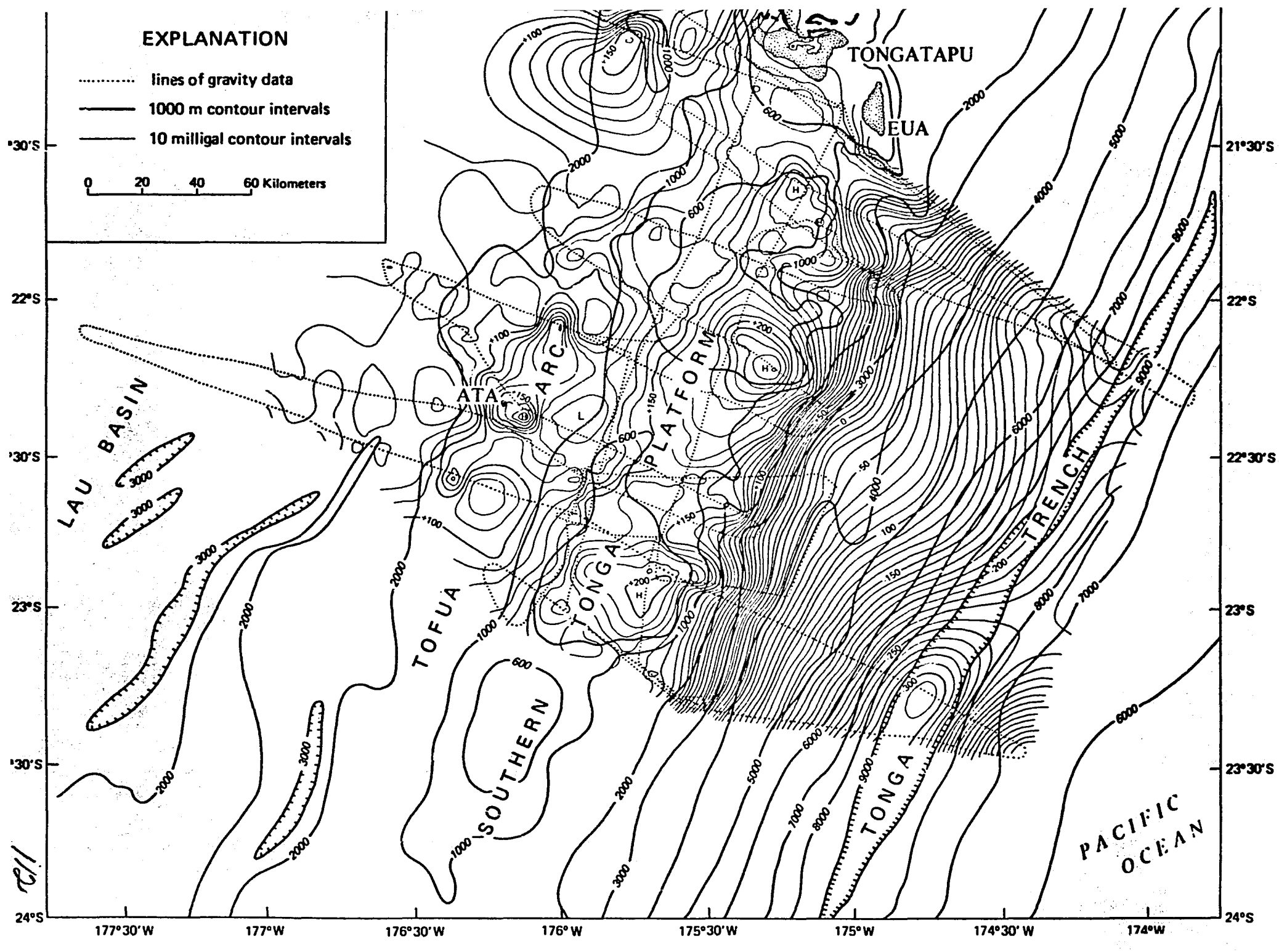

EXPLANATION
lines of gravity data
1000 m contour intervals
10 milligal contour intervals
0 20 40 60 Kilometers
TONGATAPU
EUA
ATA
LAU BASIN
TOFUA
SOUTHERN
TONGA ARC
TONGA PLATFORM
TONGA TRENCH
PACIFIC OCEAN
21°30'S
22°S
22°30'S
23°S
23°30'S
24°S
177°30'W
177°W
176°30'W
176°W
175°30'W
175°W
174°30'W
174°W

FIG. 3

REFERENCES CITED

Dupont, J., 1978, Rapport preliminaire sur la mission EVA III- 1977 royaume des Tonga: Office de la Recherche Scientifique et Technique outre Mer (OSTROM), Noumea, New Caledonie.

Dupont, J., in press, Morphologie et structures superficielles de l'arc insulaire des Tonga-Kermadec, in Contribution a l'etude geodynamique du sudouest Pacifique, Equipe de Geologie-Geopysique du Centre ORSTOM de Noumea.

Katz, H.R., 1974, Margins of the southwest Pacific, in Burk, C. A., and Drake, C.L., (eds.), The Geology of Continental Margins: Springer-Verlag, New York, p. 549-565.

Katz, H.R., 1976, Sediments and tectonic history of the Tonga Ridge, and the problem of the Lau Basin; in Glasby, G.P. and Katz, H.R., (eds.), Papers presented at the IDOE workshop, Suva, Fiji, 1-6 September, 1975: UN ESCAP CCOP/SOPAC Tech. Bull. No. 2, p. 153-165.

Kroenke, L., and Tongilava, S.L., 1975, A structural interpretation of two reflection profiles across the Tonga arc: South Pacific Marine Geological Notes, v. 1, n. 2, p. 90-15, UNDP ESCAP, CCOP/SOPAC, Suva, Fiji.

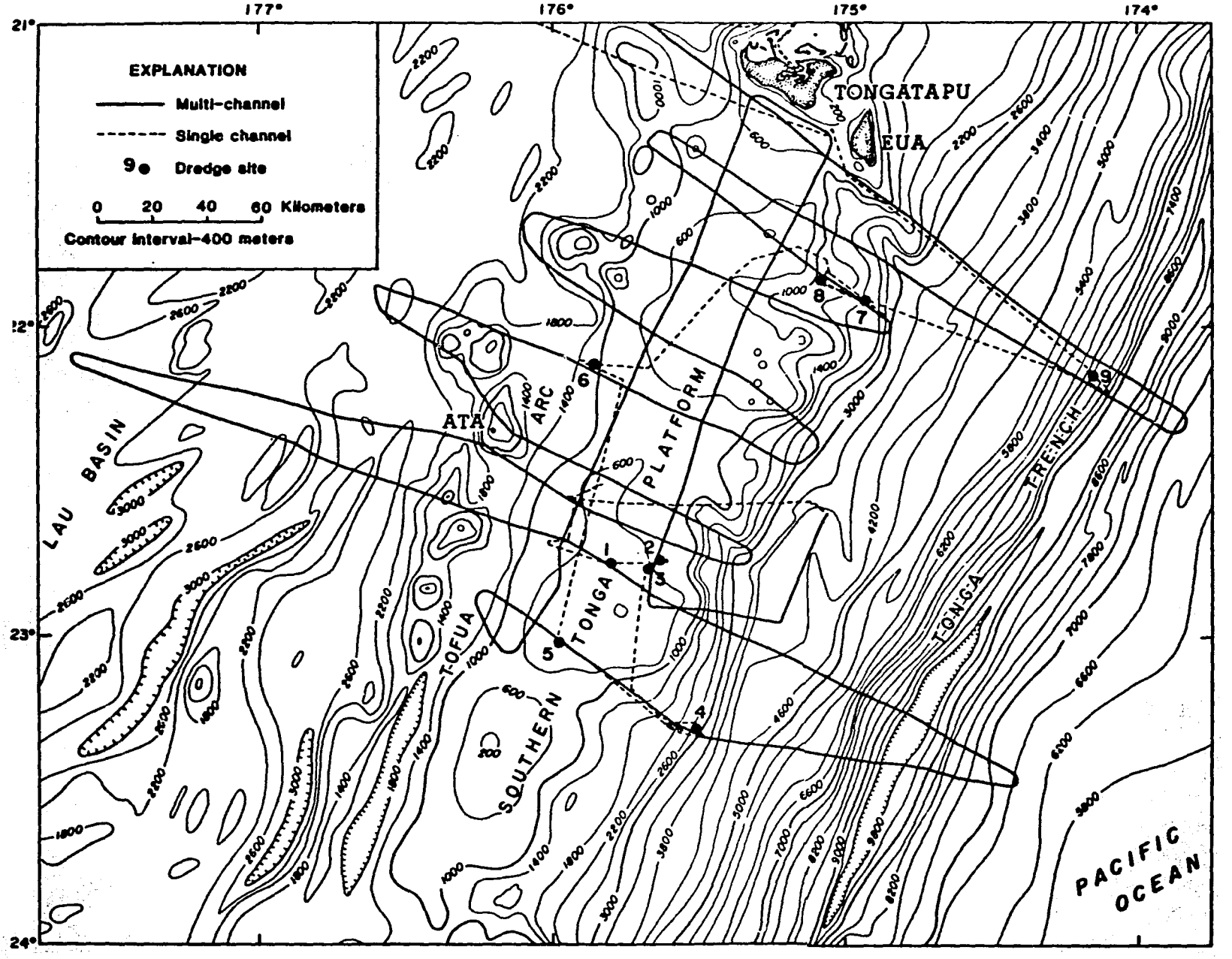
Maung, T.U., and Anscombe, K., and Tongilava, S.L., 1981, Assessment of petroleum potential of the southern and northern parts of the Tonga platform: United Nations Development Program, ESCAP technical report No. 18, CCOP/SOPAC project office, Suva, Fiji, 57 p.

FIGURE CAPTIONS

Figure 1. Bathymetric chart (in meters, based on velocity-corrected soundings) of the southern Tonga platform showing tracklines of single and multichannel seismic reflection profiles, locations of dredge stations, and the locations of the profile segments shown on Figure 2. Gravity and magnetic data were gathered along virtually all tracklines. Navigation was controlled by satellite fixes; dead-reckoning positions were computed by a mix of ship speed and heading information assisted by sonardroppler and, rarely, Omega navigation data.

Figure 2. Three segments, A, B, and C, of multichannel reflection line 8 (Fig. 1). Basement is presumably a complex of volcanic and volcaniclastic rocks of pre-late Eocene age. The overlying sedimentary section of the platform section includes at least two depositional sequences, a lower one chiefly of pre-late Miocene age, and an unconformably overlying upper sequence of late Miocene and Pleistocene age. Volcaniclastic and limestone beds occur in both sequences of the platform section. The velocity structure and thickness notation included on segment B is based on sonobuoy refraction data.

Figure 3. Preliminary, computer contoured free-air gravity map of the southern Tonga platform. The pattern of relative gravity highs along the western or Lau Basin side of the platform is associated with the Tofua volcanic arc of late Cenozoic age; the similar pattern of positive anomalies along the opposite or Pacific side of the platform falls along the axis of a structural high of basement rocks of probable pre-late Eocene age.


EXPLANATION
Multi-channel
Single channel
Dredge site
0 20 40 60 Kilometers
Contour interval-400 meters
177°
176°
175°
174°
21°
22°
23°
24°
TONGATAPU
EUA
ATA
LAU BASIN
SOUTHERN TONGA PLATFORM
TOFUA
ARC
TRENCH
TONGA
PACIFIC OCEAN

Appendix C

Leg 2 - Vanuatu Draft Press Release,

Scientific Abstract and Preliminary Cruise Report

Suggested Press Release Draft

Preliminary Results of a Recently Completed Marine Geophysical Cruise in the Waters of Vanuatu Show Possible Exploration Sites for Offshore Petroleum Resources

A recent marine geophysical survey in the region of the Central Basin of Vanuatu (formerly the New Hebrides) delineated several sedimentary basins that may contain gas and oil. This study is part of the CCOP/SOPAC*-coordinated hydrocarbon appraisal of the offshore areas of Tonga, Vanuatu, and the Solomon Islands. The survey by the U.S. Geological Survey's research vessel S. P. LEE, is funded by an Australian, New Zealand, and United States tripartite treaty designed to aid southwest Pacific island nations in evaluating their resource potential, especially the potential for hydrocarbons.

Although most basins had been identified previously, no detailed investigations had been made using state-of-the-art geophysical survey methods. The S. P. LEE has a full complement of geophysical equipment needed for a comprehensive resources assessment program - in particular, a system for collecting deep-penetration, 24-channel seimsic-reflection data. Nearly 2500 km of multichannel data were collected along tracklines spaced about 5 to 10 km apart. Also gravity, magnetic, single-channel seismic reflection and sonobuoy data were collected. Further processing and interpretation of these new data will considerably increase the understanding of the geology, tectonics and resource potential of this region.

*Committee for the Coordination of Joint Prospecting for Mineral Resources in South Pacific Offshore Areas - a United Nations sponsored organization.

Preliminary onboard data-reduction and interpretation resulted in: (a) the delineation of four small sedimentary basins on the insular shelf east of Malekula and Espiritu Santo; (b) estimates of minimum thickness of sedimentary rocks in the deep inter-arc Central Basin; and (c) the discovery of the northward extension of a trench-like feature.

The four shelf or shelf-edge sedimentary basins mapped in this investigation all lie in water depths of less than 1000 meters and have sediment thicknesses greater than 2 kilometers. In all basins, significant structures, such as faults and folds, capable of trapping oil or gas are present. Sedimentary rocks in these basins appear to be locally connected with the deeper inter-arc basins (e.g., the Central Basin) that contain more than 4 kilometers of sedimentary rocks. The connections form potential pathways for petroleum migration from the thick sections of rock under deep water that may contain source beds for petroleum. If accumulation of organic-rich sediment has occurred in the Central Basin region then a source for hydrocarbons would exist. In addition, in the Big Bay-Jordan River area, the shelf basin contains more than 2 km of sedimentary rocks and is the seaward extension of an onshore basin mapped on Espiritu Santo.

Much faulting has taken place in the region. Two primary sets of fault lineaments or fracture zones appear to exist. One major fault lineament is oriented E-W along rifts through the active volcano of Ambrym, and the zone extends westward from Ambrym and possibly across Malekula where it may offset the northern third of the island. Another major lineament extends westward from the recently active volcano of Mere Lava along the southern flanks of Gaua, where extrusions appear to rise above the seafloor, and the lineament continues across the northern shelf of Espiritu Santo to the trench. A third

lineament includes the active rifts on Ambae (Aoba). From Ambae it may extend eastward across the southern third of Maewo and westward between Espiritu Santo and Malekula.

Much additional work needs to be done to determine the probability of the source, migration, and pooling of hydrocarbons in these basins. Evaluation of data collected in the survey of Vanuatu will continue for the next 18 months, at which time the most promising areas identified as potential resource targets will be chosen for further study. Both island and sea floor geologic sampling must be done before a comprehensive evaluation is completed.

ABSTRACT FORMAT

ıthor's name, professional affiliation, ldress. (If there are multiple authors, dicate speaker with an asterisk.)

*Greene, H. G., U.S. Geological Survey, Menlo Park, Calif.
Falvey, D., University of Sydney, Sydney, Australia
Macfarlane, A., Vanuatu Geological Survey, GPO Port Vila, Vanuatu and
Scientific Party of SOPAC Cruise, R/V S. P. LEE[1]

ıthor's telephone number (415) 856-7047

st time to call: 9:00 AM - 5:00 PM Monday-Friday

per Title: Preliminary Results of Leg 2 of Research Vessel S. P. LEE Cruise in the Central Basin of Vanuatu to Assess the Hydrocarbon Potential and Geologic Evolution of New Hebrides Arc Basins, Southwest Pacific

omitted for ____ Poster Session X Oral Presentation

ıink most appropriate for session: Hydrocarbons
(use title from list on first page)

stract: *(Typewritten, double spaced, 250 words or less)*

We report on a CCOP/SOPAC coordinated cruise, funded by Australia, New Zealand, the United States (ANZUS), that surveyed the central basin of Vanuatu (formerly New Hebrides) in May 1982 to examine the hydrocarbon potential of the region. work was concentrated primarily in the Big Bay-Jorden River graben area and along east flanks of the Espiratu Santo and Malekula Islands, where we examined uctural and stratigraphic characteristics in detail. The collection of continuous tichannel seismic, single-channel intermediate-penetration, and high-resolution smic, magnetic, and gravimetric profiles provided significant new data for the luation of oil and gas traps and geologic hazards. The region is an active canic arc that overlies an east-dipping seismic (Benioff) zone. The geologic tory of the region is complex because subduction directions shifted from east to t during post-middle Miocene time. Subsequent tectonism resulted in block lting of upper Tertiary sedimentary and volcanic rocks to form islands with narrow lves and intervening deep-water basins.

hor's Address U.S. Geological Survey, 345 Middlefield Road, MS 99, Menlo Park, Calif. 94025

[1] Cochrane, G., USGS, Menlo Park, Calif.; Daniel, J., ORSTROM, Noumea, New Caledonia; Fisher, M. A., USGS, Menlo Park, Calif.; Holmes, M. L., USGS, Seattle, Wash.; Katz, H. R., New Zealand Geol. Survey, Lower Hutt, N. Z.; Smith, G. L., USGS, Menlo Park, Calif.

PRELIMINARY REPORT ON THE GEOLOGY, STRUCTURE, AND RESOURCES POTENTIAL OF THE CENTRAL BASIN OF VANUATU

H. G. Greene[1], D. A. Falvey[2], A. Macfarlane[3], and

Scientific Party[4]:

Leg 2 CCOP/SOPAC S. P. LEE Cruise

1982

[1] U.S. Geological Survey, Menlo Park, California

[2] University of Sydney, Sydney, N.S.W., and CCOP/SOPAC, Suva

[3] Department of Geology, Mines, and Rural Water Supply, Port Vila, Vanuatu

[4] Cochrane, G., U.S.G.S., Menlo Park, CA.; Daniel, J. O.R.S.T.O.M., Noumea, Caledonia; Fisher, M. A., U.S.G.S., Menlo Park, CA.; Holmes, M. L., U.S.G.S. Seattle, WA.; Johnson, D., James Cook University, Townsville, Australia; Katz, H. R., New Zealand Geological Survey, Lower Hutt, New Zealand; and Smith, G. L., U.S.G.S., Menlo Park, CA.

Introduction

A recent marine geophysical survey in the region of the Central Basin of Vanuatu has led to the delineation of several sedimentary basins. They, in part, document the geologic history of the island arc and they may also contain potential petroleum exploration targets. The geophysical survey was part of the CCOP/SOPAC* coordinated hydrocarbon appraisal program of the offshore areas of Tonga, Vanuatu, and the Solomon Islands. This investigation by the U.S. Geological Survey's Research Vessel S. P. LEE in southwest Pacific waters is funded by an Australia, New Zealand and United States (ANZUS) tripartite treaty designed to aid South Pacific island nations in a general evaluation of their resources, specifically hydrocarbons, potential.

Although most basins had been identified previously, no detailed geophysical investigation of these basins had been made. The S. P. LEE operates a full complement of geophysical equipment needed for a comprehensive resource assessment program - the main component of this equipment is a deep penetration, 24-channel seismic-reflection system. In addition, 12 and 3.5 kHz, Uniboom, intermediate-penetration-single-channel seimsic reflection, wide-angle reflection and refraction sonobuoy, magnetic and gravity data were collected during both multichannel and routine underway operations. Nearly 2500 km of multichannel data were collected along tracklines generally spaced 5 to 10 km apart; locally spacing approached 1 km (Fig. 1). An additional 700 km of other geophysical data were also collected.

*Committee for the Coordination of Joint Prospecting for Mineral Resources in South Pacific Offshore Areas - a United Nations sponsored organization.

Preliminary onboard single-channel seismic-reflection and sonobuoy refraction data reduction and interpretation resulted in: (a) the delineation of four small shelf sedimentary basins east of Malekula and Espiritu Santo; (b) estimation of minimum sedimentary thickness and acoustic stratigraphy of the major intra-arc Central Basin; and (c) the discovery of a northward extension of the a trench like features. Tentative interpretations indicate that regionally the New Hebrides island arc is complexly deformed and exhibits a structural pattern of primary and conjugate faults and folds. These structures may be related to the complex tectonic history of the arc that involves perpendicular or normal subduction, oblique subduction and arc reversal initiated in middle to late Miocene times.

Shelf Basins

Four shelf or shelf-edge sedimentary basins are located on the eastern side of the islands of Malekula and Espiritu Santo (Fig. 2). The most southerly basin is located directly offshore from northeastern Malekula Island beneath a relatively flat sea floor in water depths of 200 to 1200 m, and is nearly 55 km long and 20 km wide. The basin trends southeast, parallel to the island's coastline, and may also extend onshore to include middle Miocene rocks exposed near the coast. The basin is bounded on the east by a faulted ridge made up at least in part of older (Tertiary?) sedimentary rock. The basin fill appears to consist of sediment derived and transported from the area presently occupied by Malekula; these sediments are ponded in the structural trough shoreward of the faulted ridge (Fig. 3). Two major acoustic stratigraphic units, separated by an angular unconformity, have been identified on the seismic profiles. The lower unit is well layered whereas the upper one is poorly layered to non-layered. Acoustic basement was not

identified on the single channel reflection profiles. However at least 2.8 km of sediment or sedimentary rock can be seen filling this basin.

The second sedimentary basin lies immediately offshore from central and southern Espiritu Santo in water depths generally less than 1000 m (Fig. 2). The basin trends almost due south, is 110 km long and over 20 km wide. Like the basin near Malekula, this basin is also bounded on its seaward side by a faulted ridge that is composed of sedimentary rocks older than the sedimentary fill (Fig. 4). The ridge appears to have trapped sediment that was transported eastward from the area now occupied by Espiritu Santo. Over 2 km of sediment has accumulated in the basin, and the fill may be divided into at least two major acoustic stratigraphic units. The upper unit is well layered to intermittently layered and unconformably overlies the lower poorly layered to acoustically transparent unit. On the eastern side of the faulted ridge a considerable thickness (up to 0.5 km) of sediment or sedimentary rocks dip eastward and extend beneath the northern Central Basin. The sedimentary fill of the basin is either juxtaposed against the faulted ridge to form a buttress unconformity or is folded into the ridge.

The third basin lies offshore to the north-east of Espiritu Santo and appears to be the northward extension of the Cape Queiros Peninsula (Fig. 2). This basin trends southeast, is 90 km long and less than 25 km wide, and lies beneath a flat sea floor at water depths less than 1000 m. It is separated from the basin of Big Bay and from the shelf basin to the south by a faulted ridge of uplifted sedimentary rocks, and from the deeper, northern Central Basin by a series of normal faults. The basin has a complex structure in that it is severely faulted and has been elevated along southeast trending faults to form a horst, which is identified with the offshore extension of the

rocks that form the Cape Queiras Peninsula. Over 2.5 km of sediments are known to form a series of alternating very well layered to acoustically transparent units (Fig. 5). Several unconformities have been identified and appear to represent reworking and deposition of sediments during the elevation and faulting of the region.

The fourth basin lies in Big Bay and is a physiographic and structural sedimentary basin presently being eroded by an active submarine canyon system. The basin has a general northerly trend, is 120 km long, 20 km wide, and lies beneath water depths of less than 1000 m (Fig. 2). It appears to be a general northward (seaward) extension of the basin mapped in Jordan River-Big Bay region of central Espiritu Santo. The sediment fill is more than 2.5 km thick. Stratigraphy and structure are complicated by the juxtaposition of many different stratigraphic units along numerous faults (Fig. 5). As many as four acoustic stratigraphic units have been identified and all are separated by angular unconformities. The lowest unit appears to consist of older (Tertiary?) sedimentary rocks that in most places are overlain by an inconsistently to irregularly layered unit. The latter unit, in turn, is overlain by a well layered unit. Locally, however, apparent inversion of the upper two units occurs. The fourth unit does not appear everywhere and is primarly a submarine slump deposit. A possible southern extension of the Big Bay basin exist in the offshore region between Malekula and Espiritu Santo.

Deeper Inter-arc Basins

Adjoining these shelf and marginal basins to the east is the deep water, intra-arc Central Basin of Vanuatu (Fig. 2). It is a physiographic and structural sedimentary basin separated into a northern and southern portion by the now dormant volcano of Ambae (Aoba). Katz (this vol.) has separated these

two basins on their differing structure and evolution and has named them north and south Aoba basins. Although sediment and sedimentary rock thickness in both basins is about the same (4.5 km thick in the north Aoba Basin and 4.2 km thick in the south Aoba Basin), the acoustical stratigraphies and water depths are different.

In the northern basin the water depth is over 3000 m and the seafloor is flat. Several separate acoustic stratigraphic units have been identified in this basin and all are separated by angular unconformities or disconformities (Fig. 4). Acoustic basement in the deeper parts of the basin cannot be detected in the single-channel seismic-reflection profiles. Thus, other stratigraphic units may exist and may be identified in the multichannel data. The eastern margins of the Central Basin appear to be volcanic and sedimentary rocks that underlie, or are faulted against, the basinal sediments. Along the western margin of the Central Basin the well layered sedimentary sequence laps onto, or is juxtaposed against, the faulted sedimentary ridge of the central Espiritu Santo shelf basin (Fig. 4). A thin layer of irregularly bedded (probably detrital) sediments locally overlie the well layered unit. Overlying and buttressed against these three units are the more recently deposited basinal units. The oldest is a thick, discontinuously layered unit. This is overlain by a very well layered unit that is in turn overlain by a thin, similarly well layered unit of probable Holocene age.

The floor of the south Aoba Basin of Katz (this vol.) is shallower and more irregular than the northern basin. The water depth is nearly 2400 m compared to 3000 m in the north Aoba basin of Katz (this vol.). This difference could be the result of active filling of the basin from ash and volcaniclastic sediment derived from the active volcano of Ambrym along with

debris eroded from the exposed arc. Acoustic stratigraphy is considerably more complex in the southern basin than in the northern basin. Two poorly defined basinal units have been identified and consist of a lower folded, well layered unit unconformably overlain by a discontinuously layered unit (Fig. 3). Sonobuoy refraction data in the southern basin give low seismic velocity of 1.65 km/sec for the upper unit of about 1 km thickness suggesting that the upper layer may be primarily non-consolidated, porous ash. Older sedimentary rocks and volcanics border, underlie and are faulted against the sedimentary fill of both basins.

Structure

Preliminary results show new locations for trench-like features in the vicinity of the New Hebrides Trench. Several tracklines cross the trench offshore from northern Malekula and southern Espiritu Santo, and seismic-reflection and bathymetric data show that a trench-like feature extends northward to at least the central part of Espiritu Santo. Our data along other tracklines that cross the trench just north of Espiritu Santo show that the trench extends southward to at least the northern part of the Cumberland Peninsula.

Much faulting has taken place in the central basin region and conjugate fault patterns have been tentatively outlined. Two primary sets of fault lineament or fracture zones appear to exist (Fig. 2). A general westerly trend has been identified for fracture zones at the southern and northern ends of the Central Basin. The southern lineament incorporates along the rift of the active volcano of Ambrym and extends westward from Ambrym and possibly across Malekula where it may offset the northern third of the island. The northern lineament extends westward from the recently extinct volcano of Mere

Lava along the southern flanks of Gaua, where sea floor extrusions appear to exist, across the northern shelf of Espiritu Santo to the trench.

The other trend dominant in the region is oriented generally southwest and is primarily exemplified by a major fracture zone that separates the north Aoba basin of Katz (this vol.) from the south Aoba basin of Katz (this vol.). This zone includes the active rift of Aoba. From Aoba the zone appears to extend eastward across the southern third of Maewo, and westward between Espiritu Santo and Malekula. The zone is apparently continuous across the western slope of the western belt and intersects the Ambrym fracture zone at the trench.

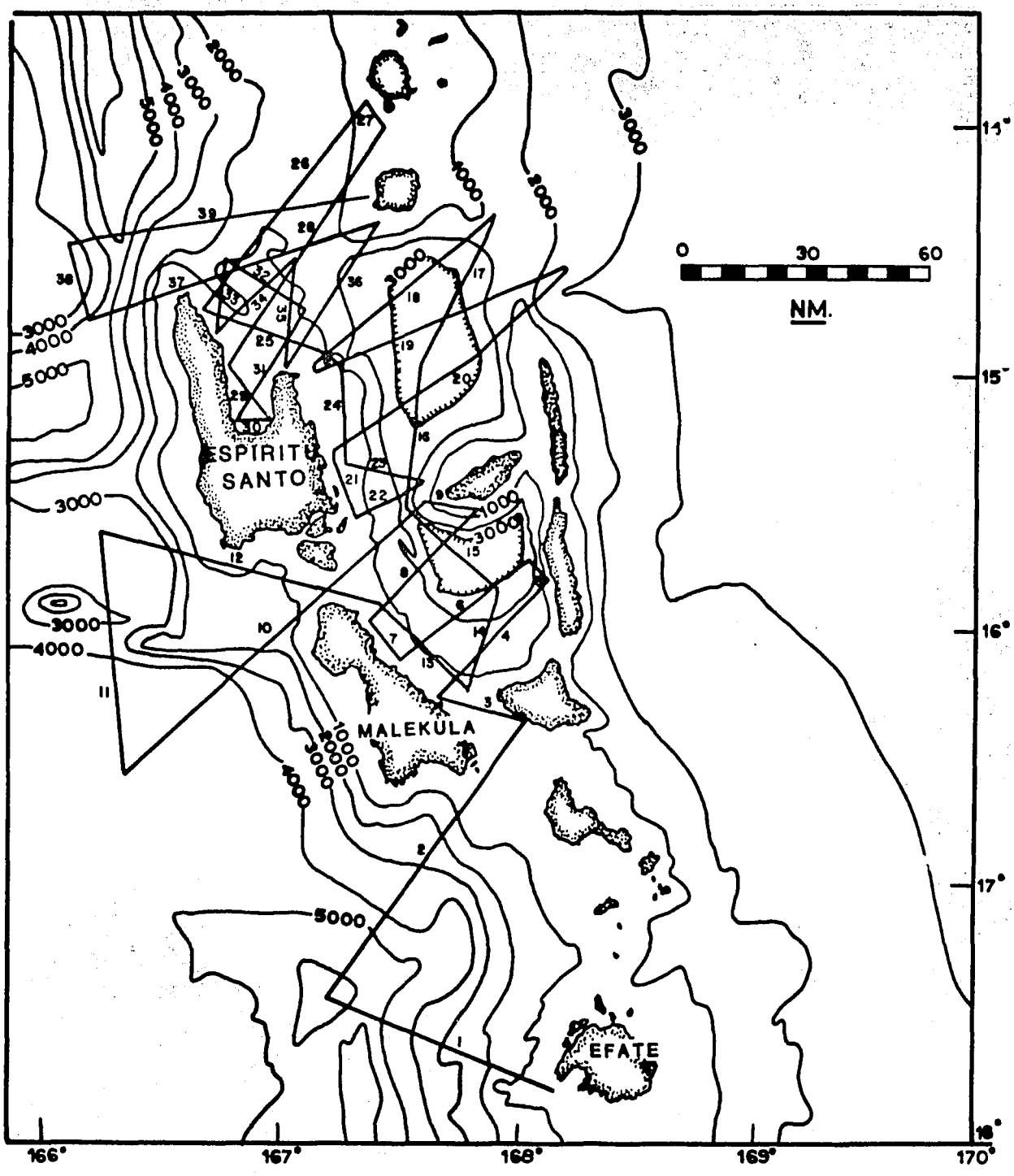
Resources Potential

A comprehensive evaluation of the resource potential for the Central Basin region of Vanuatu cannot be made at this time. Only after completion of the processing and interpretation of the multichannel seismic-reflection and other geophysical data can an attempt be made to intelligently evaluate the resource potential. In addition, onshore source rock analyses must be made to complete a resource assessment.

However, preliminary results of the onboard interpretation of the single-channel seismic-reflection data can be used to suggest the most promising sites for hydrocarbon accumulations, and speculation of oil and gas potential is based here on these results.

The four insular basins identified in the survey are considered promising sites for further potential hydrocarbon investigation. They are structurally similar to the small hydrocarbon producing basins found along the western coast of the contiguous United States. Traps resulting from faulting and folding may exist and the water depths overlying all of these basins are

shallow enough for drilling at the present day technology. Stratigraphic and structural connections forming migration paths may exist between the shallow shelf basins and the deep water intra-arc basin where open-marine conditions of the past may have resulted in deposition and burial of organic-rich sediment and subsequent generation of hydrocarbons.


ESPIRITU SANTO
MALEKULA
EFATE
0 30 60
NM.
166°
167°
168°
169°
170°
14°
15°
16°
17°
18°
1000
2000
3000
4000
5000

Appendix D

Leg 3 - Draft Press Release,

Scientific Abstract and Cruise Narrative

SUGGESTED PRESS RELEASE - DRAFT

The U.S. Geological Survey ship, the S. P. LEE, recently completed a geophysical survey in the Solomon Islands as part of a program sponsored by the United States, Australia, New Zealand, and the United Nations Committee for the Coordination of Joint Prospecting for Mineral Resources in the South Pacific (CCOP/SOPAC), to assess the hydrocarbon potential in several regions of the Southwest Pacific. The S. P. LEE carries sophisticated electronic and geophysical survey equipment. The survey, mainly concentrated in waters of the "Slot" and "Indispensible Strait", obtained a total of 3450 km of multi-channel seismic reflection profiles, 40 sonobuoy refraction profiles, 10 dredge hauls of ocean floor rocks, two gravity cores, and high resolution seismic profiles of the near surface sedimentary structure under the sea bottom. In addition, echo soundings, gravity, and magnetic data were collected.

Preliminary results indicate that sediments up to 6 km thick rest between the volcanic basement exposed on islands on each side of the "Slot". Although much of the sediment is likely to be derived from volcanics, limestone and carbonate rocks also may be present. Reefs may also exist in the sedimentary column and these reefs often provide targets for petroleum exploration. The "Slot" is an area familiar to many World War II servicemen where major battles were fought between Japanese and American warships during the Guadalcanal campaign.

ABSTRACT FORMAT

Author's name, professional affiliation, address. (If there are multiple authors, indicate speaker with an asterisk.)

*Vedder, J. G., U.S. Geological Survey, Menlo Park, Calif.; Tiffin, D. L., CCOP/SOPAC, U.N. Offshore Mineral Prospecting, Suva, Fiji; Coulson, F.I.E., Geological Survey of the Solomon Islands, Honiara, Solomon Islands; and the scientific party[1]

Author's telephone number (415) 856-7025

Best time to call: 8:00 AM - 5:00 PM Monday-Friday

Paper Title: Preliminary Results of Leg 3 of the Research Vessel S. P. Lee Cruise--Basin Development and Resource Potential of the Central Solomons Trough

Submitted for ____ Poster Session X Oral Presentation

I think most appropriate for session: Hydrocarbons
(use title from list on first page)

Abstract: *(Typewritten, double spaced, 250 words or less)*

A CCOP/SOPAC cruise, funded by Australia, New Zealand, and the United States, surveyed parts of the Solomon Islands region in May and June 1982 to assess the potential for petroleum accumulations and to identify geologic hazards. Work was concentrated in the central Solomons trough (the Slot) between Guadalcanal, Santa Isabel, New Georgia, and Choiseul, where continuous multichannel, single-channel, and high-resolution seismic records were acquired together with magnetic and gravity profiles. The Slot is underlain by a composite depositional basin that contains as much as 4.5 km of Cenozoic sedimentary deposits. Despite its complex island-arc setting, submarine volcanoes, and 800- to 1,800-m-water depths, the basin includes structural, stratigraphic, and, possibly, thermal elements that favor generation and entrapment of hydrocarbons.

Author's Address U.S. Geological Survey, 345 Middlefield Road, MS 99, Menlo Park, CA 94025

[1]Beyer, L. A., Bruns, T. R., USGS, Menlo Park, Calif.; Colwell, J., Bureau of Mineral Resources, Canberra, A.C.T., Australia; Cooper, A. K.; USGS, Menlo Park, Calif.; Kroenke, L., Hawaii Inst. of Geophysics, Honolulu, Hawaii; Marlow, M., USGS, Menlo Park, Calif. and Wood, R. A., New Zealand Geological Survey, Lower Hutt, New Zealand

Cruise Narrative
CCOP/SOPAC Leg 3
Solomon Islands

Jack Vedder, Don Tiffin, and Loren Kroenke

Introduction

A geophysical and sampling cruise in the central and western Solomon Islands was done aboard the R/V S.P. LEE during the period 19 May and 11 June, 1982. This cruise was the third of thee legs undertaken jointly by CCOP/SOPAC, Australia, New Zealand, and the United States as part of a program to evaluate the hydrocarbon potential of the Central Solomons Trough (The "Slot"). Scientists on board included representatives from CCOP/SOPAC Technical Secretariat, Solomon Islands, Australia, New Zealand, and the United States. A special survey was made in Rabaul harbor, Papua-New Guinea, at the conclusion of the operation.

Between 19 May and 6 June, 1982, 52 multichannel seismic lines totaling approximately 2000 nautical miles (3700 km), 40 sonobuoy refraction lines, high resolution reflection profiles, and gravity and magnetics measurements were completed. Nine dredge hauls were made, and two gravity cores were taken. On June 11, a short survey using high resolution equipment and one sonobuoy was made in the Rabaul harbor area of Papua-New Guinea at the request of the Director of the Rabaul Volcanological Observatory.

The multichannel seismic reflection system used on the S.P. LEE consisted of a tuned array of 5 Bolt airguns with a combined capacity of 21.7 liters (1,326 cu.in.), a 2,400m, 24-group SEI streamer, and GUS 4300 digital recording instruments. Navigation was by means of Magnavox MX702A dual channel satellite navigation system supplemented by Radar ranges and visual bearings, High resolution reflection profiling data, using a 1200J EG&G Uniboom system, and 12 and 3.5kHz bathymetric data, both using Raytheon CESP III systems, were acquired concurrently. Six Raytheon Line Scan Recorders, two of which were used as single-channel air gun monitors, continuously recorded these data. Gravity and magnetic data also were obtained simultaneously, using a LaCoste-Romberg gravimeter and a Geometrics proton-precession magnetometer, respectively.

Chain bag dredges were used for bedrock sampling, and a 3-m gravity corer was used for sampling Holocene sediment beneath New Georgia Sound.

Summary of Multichannel Survey

Four multichannel lines (1, 14, 15 and the beginning of 16) traversed Iron Bottom Sound. The Sound approximately outlines a sedimentary basin, Iron Bottom Basin (new name), which is bounded by Savo Island to the northwest, Guadalcanal to the south and the Florida Island platform to the northeast. This subsidiary basin connects with the Central Solomons Trough by way of a narrow depression north of Savo Island.

Ten lines (2-8, 32, 33 and 37) traversed Indispensable Strait. The strait nearly coincides with Indispensable Basin (new name), which extends from the Florida Island platform northeast to the Island of Malaita and includes the deeply buried, tightly folded southwestern flank of the Malaita anticlinorium. The northwestern end of the basin abuts Santa Isabel; the southeastern end is not as well defined and possibly terminates south of Small Malaita (north of San Cristobal, west of Uki Island).

North of Indispensable Basin, six lines (33-37) extended northward across the Malaita anticlinorium and onto the south flank of the Roncador homocline (the outer slope of the North Solomon Trench). South of Indispensable Basin, four lines (2, 9, 32 and 37) crossed the Florida Islands platform: line 2 through the Sealark Channel south of Nughu Island; lines 9, 32 and 37 northwest of Vatilau in the Florida Group. Five lines (11-13, 26, and 27) extended across the frontal arc horst, southwestward over the inner trench wall, and onto the floor of Woodlark Basin. Lines 26 and 27 traversed Pocklington Ridge and Trough, grazing the flank of the Louisiade Rise.

Twenty-three lines (part of 11, part of 13, most of 16, 17-25, parts of 26 and 27, 29-31, part of 32, 38, and 40-42) were located in the southeastern end of New Georgia Sound between Santa Isabel and the frontal arc horst, which culminates in the New Georgia and Russell Islands. The deep subsidiary basin in this part of the Central Solomons Trough is here called the Russell Basin. This basin extends from Savo Island northwest to the small midbasin horst between Choiseul and the New Georgia Group north of Kolombangara Island. Structural deformation including faults and low-amplitude folds is evident on lines in the northeastern part of Russell Basin. Some of these structures disrupt the seafloor. Nine lines (44-52) traversed the northwestern end of New Georgia Sound, in the Shortland Basin (new name), which extends from the mid-basin horst to the Shortland Islands.

Summary of Sonobuoy Refraction Data

Seismic refraction arrivals, routinely recorded to a range of 37-45 km, provided maximum layer depth estimates of 10-12 km beneath the island arc and adjacent ocean basins. Within the Central Solomons Trough, the crustal depression contains 1-5 km of sedimentary section. Velocities of the crustal rocks beneath the sedimentary section range from 4.8-7.5 km/sec. The acoustic basement, in part metamorphosed, has velocities of 4.8-5.8 km/sec; a deeper layer, which has a velocity of 6.4-7.5 km/sec, is 3-5 km below the acoustic basement. These higher velocity rocks may include deeper crustal igneous rocks similar to those exposed on some of the islands.

Summary of Sampling

Station 1 (gravity core) was taken in a water depth of 1809m in the central part of New Georgia Sound northwest of Russell Islands and recovered 192cm of laminated mud. Station 2 (dredge) on the southwestern edge of the Russell Basin, west of Mborukua Island between the Russells and the New Georgia Group in 1109m of water recovered recemented reef detritus together with minor amounts of consolidated tuffaceous sediment. Station 3 (dredge)

southwest of the Russell Islands, at the base of a 300cm fault scarp fronting a tilted block of stratified sediment in water depths between 1250 and 984m; recovered ashy siltstone. Station 4a (dredge) in water depths between 750 and 400m at the southern edge of the Russell Islands platform on a prominent submarine scarp recovered reef limestone detritus. Station 5 (dredge) northeast of the Russell Islands in water depths between 1100 and 900m along the stratified base of the Island platform recovered a trace of volcaniclastic (?) mud on the dredge frame. Station 6 (dredge) on the north insular slope of the Russell Islands in 600 to 300m of water recovered recrystallized, Mn-coated reef limestone. Station 7 (dredge) on the southwest insular slope of Santa Isabel Island in 900 to 300m of water recovered coralline debris. Station 8 (gravity core) on the lower insular slope south of San Jorge Island in 1279m of water recovered 262cm of bioturbated, foram-rich mud. Station 9 (dredge) on a low submarine ridge north of New Georgia recovered Mn-coated, foram-rich, fine-grained silty volcaniclastic sandstone. Station 10 (dredge) in water depths between 825 and 685m along the base of a submarine ridge, which apparently overthrusts the crest of the frontal arc horst west of Vella Lavella recovered foram-rich, volcaniclastic sandstone together with sandy calcilutite and lapilli tuff. Station 11 (dredge) in water depths between 700 and 600m along the stratigraphically higher upper slope of the same ridge dredged at station 10 recovered Mn-coated fine-grained calcarenite together with foram-rich, sandy, volcaniclastic mudstone.

Calcareous nannofossils from selected samples from each of the dredge stations indicate Quaternary ages, largely in the range 0.2 to 1.6 ma.

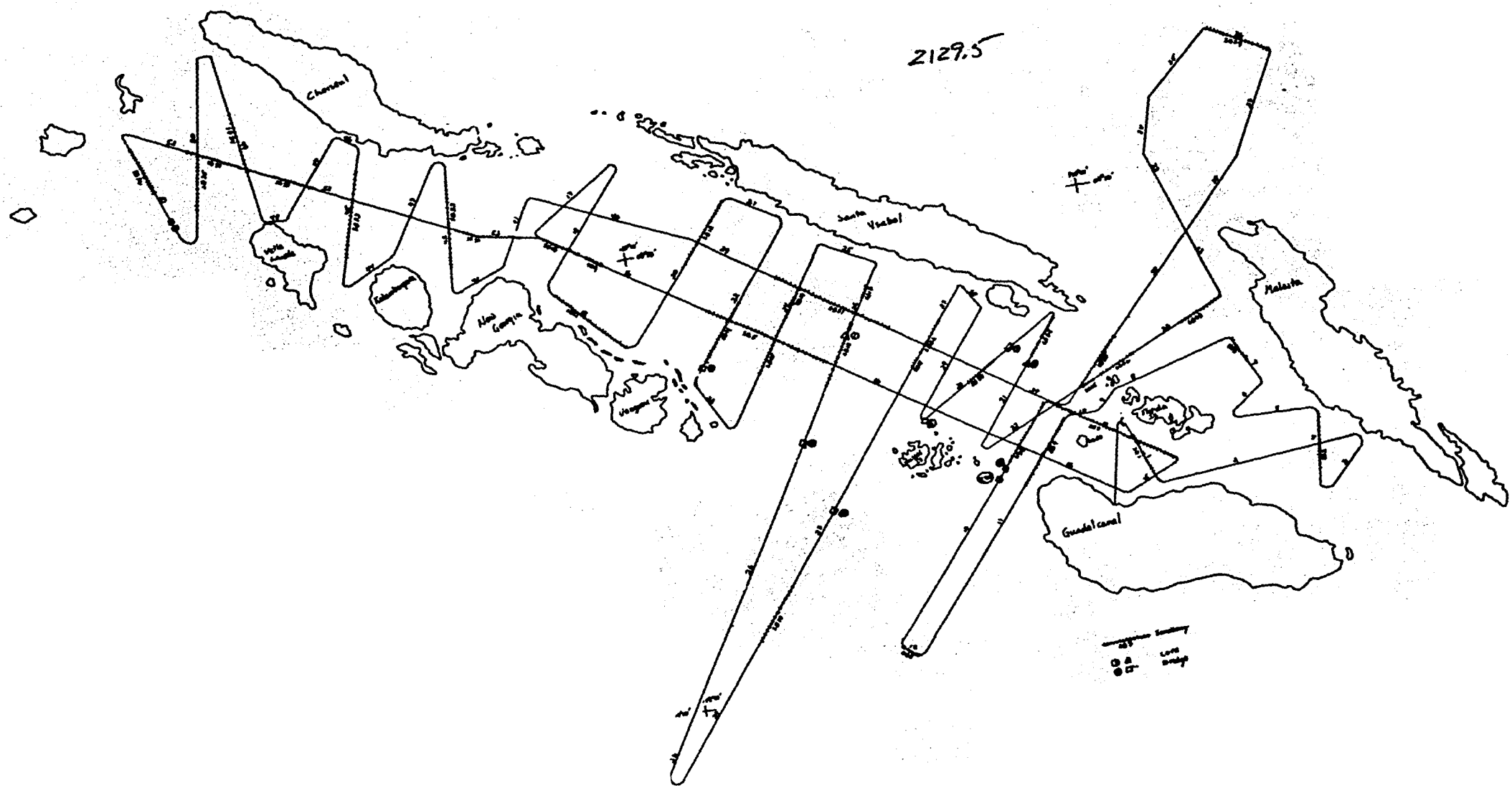
Rabaul Harbor Survey

Reconnaissance bathymetric data were acquired, and the Rabaul seismic network was tested using the airgun system. In addition, a sonobuoy refraction profile was recorded. The purpose of this work was three fold: 1) to determine if local uplift is taking place, 2) to test the response of the Rabaul seismic network to artificial sources and the accuracy of its location plots, and 3) to obtain refraction velocities in the area north of Gazelle Peninsula. None of these data have been reduced and interpreted to date.

Recommendations

In order to complete a thorough evaluation of the hydrocarbon potential of seafloor areas of the Solomon Islands, at least 400 n.mi. of additional multichannel tracklines are needed, particularly in the Indispensable Strait - San Cristobal area and in the western part of the Shortland basin. At present, subsea samples of bedrock are inadequate for stratigraphic analysis. Targets for dart cores and dredge hauls, which have been identified on the seismic profiles, would require at least six days to sample. Emphasis should be placed on sampling if ship time becomes available.

The Rabaul harbor survey is incomplete. A detailed operation is needed to furnish accurate positioning and bathymetry. Assistance by the government of Papua-New Guinea would be required to support shore-based navigation, vertical (tidal) control, and small boat operations.


2129.5
Choiseul
Malaita
Guadalcanal

Appendix E

Cruise Report: Papua-New Guinea Survey

Rabaul Harbor Cruise Report

PAPUA-NEW GUINEA SURVEY IN RABAUL HARBOUR
Cruise Report No. of PE/PN. 4

by

D. L. Tiffin (CCOP/SOPAC) and J. G. Vedder (U.S. Geological Survey)

INTRODUCTION

This work was undertaken as part of the CCOP/SOPAC Work Programme CCSP/PN.4 (onshore and nearshore surveys related to harbour development and coastal management).

The city of Rabaul, Papua New Guinea, is situated in a huge ancient caldera on the north coast of New Britain. The caldera is open to the sea on one side, forming an excellent sheltered harbour. Several smaller active volcanoes are now situated around the rim of the ancient caldera, and eruptions from these have been recorded in historical time. During one eruption in 1937, 500 lives were lost. The city of Rabaul now has a population of close to 25,000 people, five times the population of 1937. A new eruption of any of the surrounding volcanoes could prove to be a major disaster for Rabaul and its people. The Rabaul Volcanological Observatory (RVO) overlooks the harbour of Rabaul and monitors seismicity and related volcanological events around Rabaul and elsewhere to determine if volcanic activity is reaching the

point where action is needed to protect the lives and property of the citizens.

Over the past few years the frequency of seismic events noted on the Rabaul seismic network has increased several fold. At the same time, an area of gentle uplift has been noted and measured by optical leveling, tilt-meters, and gravity surveys. The uplift is almost 1 meter on the southeast end of Matupet Island, but the centre of the steadily rising area has been identified to be southwest of Matupet Island under Blanche Bay. The maximum local seismic activity is in the same area.

The Director of the Rabaul Volcanological Institute requested, through his government, that, if possible, CCOP/SOPAC, using the U.S. Geological Survey's research vessel the S. P. LEE, conduct bathymetric and other surveys during an extended four-day port stop in Rabaul.

CRUISE OBJECTIVES

Originally, a detailed bathymetric survey was requested which was anticipated to outline any submarine uplift in the area southwest of Matupet Island. However, the S.P. LEE was not properly equipped to perform this type

of detailed work and is too large a vessel (1300 tons) to maneuver in the tight quarters proposed or to go into shallow water. The survey was therefore scaled down to a collection of reconnaissance bathymetric data along with a thorough testing of the Rabaul seismic network using the airgun seismic sources of the survey ship. In addition, a sonobuoy refraction profile was desirable to obtain refraction velocities in the upper crust of the marine areas.

The three basic objectives were therefore (1) to obtain bathymetric and geological data to assist in determining the marine geological structure, and to determine, if possible, where uplift is taking place under the bay; (2) to test the response of the Rabaul seismic network to artificially derived seismic waves from various locations in the harbour and to check the accuracy of the locations provided by the network; and (3) to obtain seismic refraction velocities in the area north of Gazelle Peninsula.

EQUIPMENT AND FACILITIES

The geological research vessel S.P. LEE is an American flag survey ship 208 ft in overall length and 1300 registered tons with a crew of 22 and a

scientific complement of 18. The main capability of the ship is in multi-channel seismic-reflection surveys, for which it is equipped with a 48-channel, 2.4-km-long seismic hydrophone streamer and a tunable air gum array composed of five large air guns totalling 1300 in^3 capacity. The ship is capable of performing bottom-sampling operations, such as coring and dredging, and bottom photography.

The ship is also equipped with a 13 kHz echo sounder, a 3.5 kHz high-resolution subbottom profiler, and a powerful Uniboom subbottom profiling array capable of considerable subbottom penetration. A single-channel air gun seismic system can also be deployed, and sonobuoys are routinely used for collection of velocity data. Navigational facilities include two relative motion radars, Omega, Satellite Navigation receivers, Loran, Doppler speed logs, and Gyro-compass heading inforamtion; all input to an online computer navigational system which updates the trackline continuously and displays navigation information on monitors throughout the ship.

For the Rabaul Harbour survey, for a number of reasons only selected equipment was operated. Bathymetric information was a requirement so the 12 kHz echo sounding system was used. In addition, the Uniboom system was

deployed to obtain subbottom information. The sonobuoy recording system was used and one air gun of the largest capacity was towed. Because of the shallow water, dangers to navigation and the small area as well as the large number of turns required, the usual navigation procedures were not employed and all navigational functions were placed on the bridge. A navigational officer manned each radar while a third officer plotted positions on the chart at 5 minute intervals. The captain conned the ship from the bridge. The tight quarters for a ship of this size precluded towing equipment over the side which would hamper her manueverability or prevent her from going astern if need be. The only over-the-side equipment was therefore limited to the one air gun off the stern and two short hydrophone arrays for the Uniboom towed off the starboard side well forward of the propellors.

A smoked cylinder recorder and a SSB radio were brought from RVO to record seismic shot-times and to communicate directly from the ship to observatory staff manning the seismic monitor network at RVO.

METHOD

Correspondence to initiate this survey had taken place between RVO and CCOP/SOPAC after the S. P. LEE had begun its South Pacific survey program. There was, therefore, no opportunity to include this work in the ship's schedule nor was there time to plan a more thorough survey with equipment other than what was already onboard. Since Dr. Gary Greene, USGS cruise co-ordinator, was already scheduled to visit Rabaul a few weeks before the arrival of the S. P. LEE, he was requested to discuss the proposed survey with RVO in view of the capabilities and drawbacks of the S. P. LEE for this type of work. During his visit, reconnaissance tracklines were proposed in Blanche Bay and Great (or Matupe) Harbour adjacent to Matupit Island to fulfill, in part, the objectives of the original request. Co-ordinates for these proposed lines were radioed to the ship in the Solomon Islands, where they were plotted on U.S. navigational chart 82192 "Blanche Bay and Approaches." Arrangements for the survey were also completed by radio, and a rendezvous with a PNG harbour craft was scheduled for 0600 hours June 11 to transfer personnel and equipment from RVO to the S. P. LEE.

At the appointed hour on June 11, four scientific personnel, three from

RVO and one from the Geological Survey of PNG, Port Moresby, joined the S. P. LEE off Cape Gazelle, after which the survey equipment (one air gun and Uniboom hydrophone streamers) were deployed over the side and the survey was started. At the end of the survey, a "bar check" was made on the depth using a measured wire lowered to the bottom in about 16 fathoms of water.

PRELIMINARY RESULTS

The tracklines covered, and five-minute position fixes by simultaneous radar readings, are shown in figures 1 and 2. The location of the sonobuoy refraction profile is indicated on Figure 2. Table 1 is a listing of the five-minute positions as taken from the chart (82192).

With respect to survey objective 1, good quality bathymetric and high-resolution seismic data was obtained over the whole survey. The high-resolution data was photographed by polaroid land camera and the photographs were left with RVO. The seismic results show large areas of thick sediments underlying parts of the area, particularly under Great Harbour and southern Karavia Bay. The sediments under Karavia Bay extend unto the southern shore-line where they are overlain by possible pyroclase or ash deposits which have

little or no stratification. Several factors mitigate againsty determining an uplift area from the echo soundings. These factors were outlined to RVO in a letter prior to the survey (NR/SOPAC/TECH-SEC-345, 8 April, 1982) which pointed out that comparing two surveys to determine small changes in water depth necessitates great care in ensuring accuracy in navigation and depth corrections in both surveys. Since much of the bottom over the area covered by theis survey is irregular, a small error (± 20 m) in navigation could result in an error in dpeth of ± 2 m or more. The radar navigation employued could easily have errors of this magnitude, and on the chart used for plotting (at a scale of 1:25,000) 20 m is less than 0.8 mm long, hardly larger than a pencile mark. Nevertheless, it is worthwhile to check as carefully as possible with previous data in the event that large changes in depth (± 10 m) may have occurred which could be documented with some reliability. For this purpose, arrangements were made with RVO to obtain tidal records from Rabaul Harbour so that tidal corrections could be applied to this survey data. The comparison of this data to previous surveys is best done in Rabaul where access to older surveys is available. RVO have opted to do this follow-up work.

The response of the seismometers employed in the Rabaul seismic network was shown to be adequate for most of the locations. Even the weak signals (compared to seismic earth tremors) generated by the air gun, which has a higher frequency output than naturally generated seismic waves and therefore is not centered in the response bank of the seismometers, were picked up by those seismometers sited on bedrock. However, two seismometer stations did not receive the air gun impulse at all, even though the ship passed within 1000 yards of one of these sites. These stations are situated upon the sedimentary units noted on the high-resolution profiles to underlie the southern shore of Karavia Bay. Evidently the sediments attenuate the seismic signal to such an extent that they are lost.

A calibration of the epicenter location program of RVO using the ship's position at different areas within the seismic network will be made by RVO using their computer program. It should be noted that the seismic source is about 60 m astern of the navigation points determined from the bridge radars, and approximately 10 m below the water surface.

It is perhaps worth noting that the seismic network response increased markedly when the ship was in Matupi Harbour. This was apparently not only

due to the proximity to the seismometer sites in this area, but possibly also due to increased coupling of the seismic pulse to the underlying seafloor and to the greater reverberation usually generated in shallow water.

The final objective of the work was accomplished with a sonobuoy profile of about 15 km in length north of Gazelle Peninsula.

CONCLUSIONS AND RECOMMENDATIONS

In order to provide the necessary information to delineate the offshore area of uplift, a more detailed survey will be necessary with carefully controlled positioning and bathymetry using shore-based navigation. This work will require the assistance of the government of Papua New Guinea in providing a suitable small vessel, personnel to assist in the survey, properly prepared shore sites, and other facilities to ensure that the accuracy required in vertical and horizontal control is attained. In the meantime, it is recommended that RVO assess the bathymetric results obtained in this survey by comparing with previous data to determine if any area shows anomalous changes in depth not accountable to survey inaccuracies. If further surveys of this nature are desirable, they should be requested of CCOP/SOPAC by Papua New Guinea.

The siting of seismometer stations of the Rabaul network showing low or no response to low level seismic impulses should be changed, if possible, to sites done to, or preferably, upon bedrock.

It should be possible to improve epicentral location of events within the Rabaul seismic network by incorporating refraction velocities for the marine refraction layers into the computer program used to calculate these epicenters.

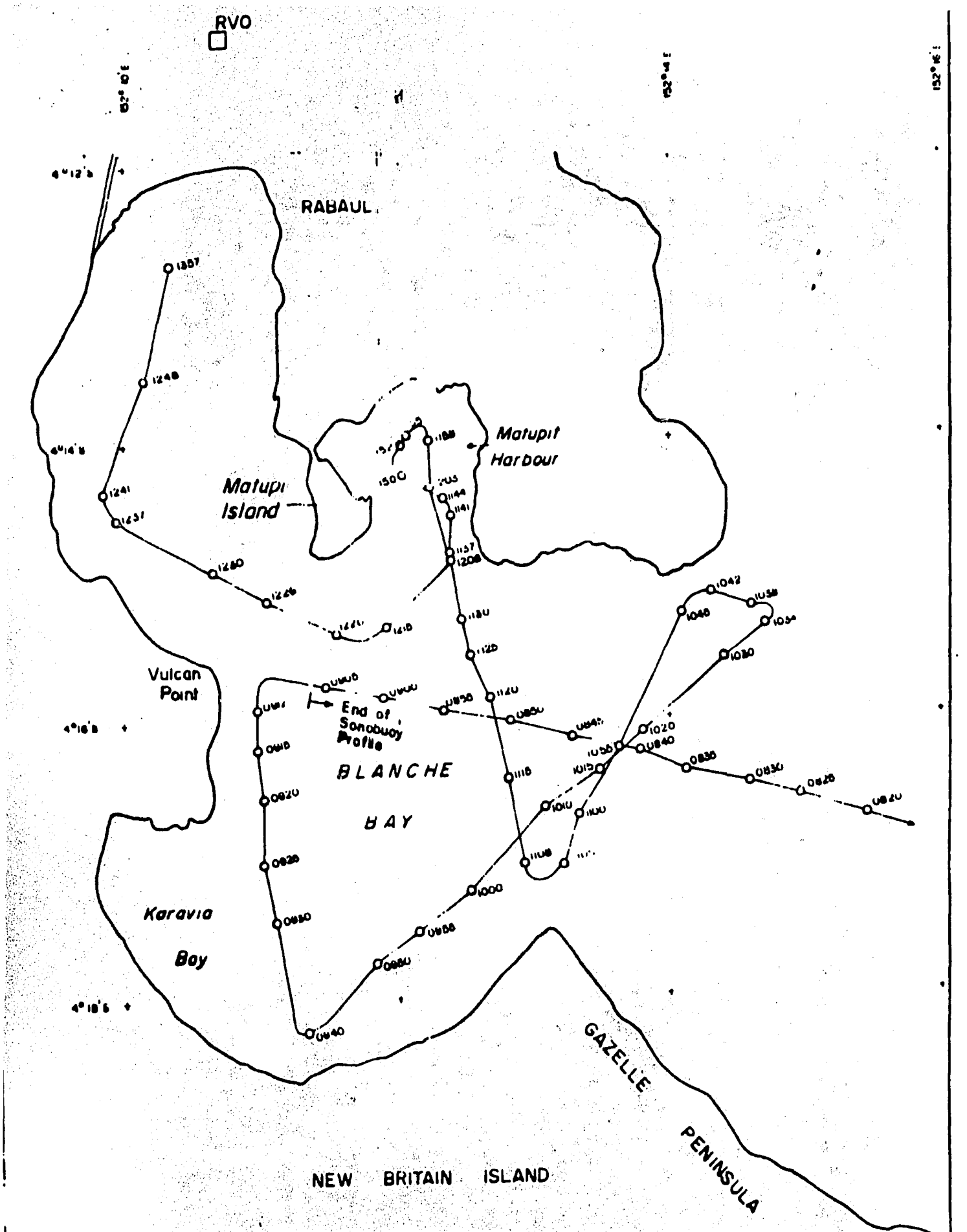

RVO
RABAUL
Matupit Island
Matupit Harbour
Vulcan Point
End of Sonobuoy Profile
BLANCHE BAY
Karavia Bay
GAZELLE PENINSULA
NEW BRITAIN ISLAND

FIGURE 1.

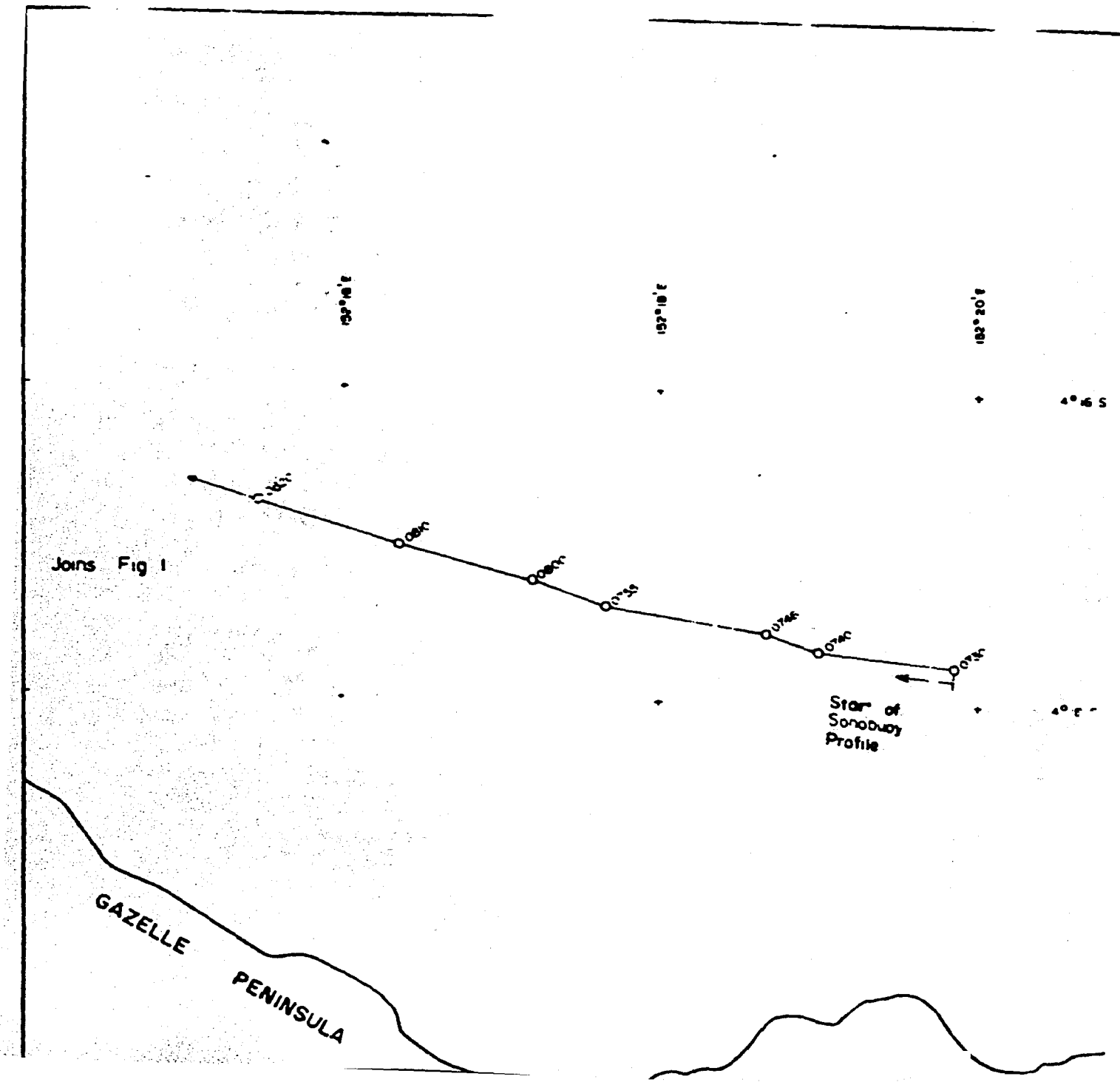


FIGURE 2.

Rabaul Survey - Personnel Participating

Scientific Personnel:

D. L. Tiffin, CCOP/SOPAC, Co-Chief Scientist
J. G. Vedder, U.S.G.S., Co-Chief Scientist
F. Coulson, Solomon Islands Geological Survey
L. Kroenke, Hawaii Institute of Geophysics
J. Colwell, BMR, Australia
R. Wood, New Zealand Geological Survey
M. Marlow, U.S.G.S., Sonobuoy Refraction
A. Cooper, U.S.G.S., Sonobuoy Refraction
T. Burns, U.S.G.S.
L. Beyer, U.S.G.S., Navigation
G. Lewis, U.S.G.S.
G. Cochrane, U.S.G.S.
K. Kinoshita, U.S.G.S., Navigation
D. Blackman, U.S.G.S., Navigation
D. Hogg, U.S.G.S., Electronics
L. Kooker, U.S.G.S., Electronics
K. O'Toole, U.S.G.S., Marine equipment
P. Wenbarg, U.S.G.S., Marine equipment
P. Lowenstein, Senior Government Volcanologist, RVO
P. Hill, Geological Survey of PNG, Port Moresby
D. de Saint Ours, Volcanologist, RVO
Benjamin Talai, Volcanologist, RVO

Ships Master:

Capt. Verne Pilgrim and crew, R/V S.P. LEE

Rabaul Volcanological Observatory:

Chris McKee manned the Observatory monitors and SSB radio during the survey.

Appendix F

LEE Post Cruise Meeting Summary and Relevant Circum-Pacific Abstracts

USGS/SOPAC LEE Post-Cruise Meeting

On Thursday and Friday, August 19 and 20, 1982 principal scientific participants (see attached list of attendees) of the USGS/SOPAC LEE Cruise met in the Empire Room of the Hilton Hawaiian Village Hotel in Honolulu, Hawaii to discuss the status of the science resulting from the Cruise. This was a formal post-cruise meeting in accordance with agreements within the ANZUS triparty treaty. All participants were initially informed of the progress of work and the status of data reduction, reproduction, and distribution for each of the three legs. Potential problems and scientific responsibilites were discussed and resolved. No impending problems were brought to light that would significantly impact the program in the near future.

Three small working groups, representing each of the cruise legs, met to refine the first publishable scientific papers that are to be included in the Third Circum-Pacific Energy and Mineral Resources Conference volume and to finalize press releases that can be used by the signators to the treaty for reporting on the initial scientific results of the cruise. Methods and procedures for reporting on the preliminary results of the cruise at the Circum-Pacific Conference were also discussed and agreed upon; see attached copies of the abstracts submitted and program of conferences.

This post-cruise meeting was completed with a lengthy discussion of future work. Scientific studies that would be a natural extension of the USGS/SOPAC LEE Cruise were written up and will be submitted to the U.S. State Department in the near future. Donald Tiffin, of the CCOP/SOPAC Secretariat Office in Suva, Fiji, Neville Exon, of the Australian BMR, and Brian Taylor, from Hawaii Institute of Geophysics, all took copies of the recommendations produced from this meeting and will submit them to their respective agencies for comment. It is understood that these recommendations will be tabled and discussed at the upcoming CCOP/SOPAC meeting to take place in Wellington, New Zealand, 9-17 November, 1982.

List of Attendees to USGS/SOPAC LEE Post-Cruise Meeting
Honolulu, Hawaii - August 19 and 20, 1982

Name	Affiliation
H. Gary Greene	USGS, Menlo Park
Loren Kroenke	Hawaii Institute of Geophysics
Jacques Daniel	ORSTOM, New Caledonia
Rick Herzer	New Zealand Geological Survey
Mark Sandstrom	Australia - BMR
George Chaproniere	Visitor
Tun U. Maung	CCOP/SOPAC
Neville Exon	CCOP/SOPAC - Australia, BMR
Frank Wang	USGS, Menlo Park
Mike Marlow	USGS, Menlo Park
Terry Bruns	USGS, Menlo Park
Alan Cooper	USGS, Menlo Park
Rudi Katz	New Zealand Geological Survey
Mike Fisher	USGS, Menlo Park
Dave Falvey	CCOP/SOPAC, Australia
Rick Terman	USGS, Reston
Gary Hill	USGS, Menlo Park
Brian Taylor	Hawaii Institute of Geophysics
Don Tiffin	CCOP/SOPAC
Jack Vedder	USGS, Menlo Park
Dave Scholl	USGS, Menlo Park
Mark L. Holmes	USGS, Seattle

AGENDA
USGS-SOPAC LEE CRUISE POST-CRUISE MEETING
Honolulu, Hawaii
August 19 and 20, 1982

Thursday, August 19

0900 - Introduction - Gary Greene

0930 - Leg 1 Summary - David Scholl and Tun Muang

1000 - Coffee Break

1030 - Leg 2 Summary - Gary Greene and David Falvey

1100 - Leg 3 Summary - Jack Vedder and Don Tiffin

1130 - Rabaul Survey Summary - Don Tiffin

1200 - 1330 Lunch

1330 - 1600 Working sessions for individual legs

Friday, August 20

0900 - Direction of the day - Gary Greene

0930 - Proposed future work and schedule for Leg 1 - Scholl

1000 - Coffee Break

1030 - Proposed future work and schedule for Leg 2 - Greene

1100 - Proposed future work and schedule for Leg 3 - Vedder and Tiffin

1130 - Future plans - Macfarlane and Greene

1200 - 1330 Lunch

1330 - 1600 Continue work on individual leg business if necessary. Review of talks to be given at Circum-Pacific Conference.

CIRCUM-PACIFIC ENERGY AND MINERAL RESOURCES CONFERENCE
HONOLULU, HAWAII
August 22-28, 1982

Convention Headquarters: Mid-Pacific Conference Center, Hilton Hawaiian Village

Sponsored Jointly by
The American Association of Petroleum Geologists
The Committee for Coordination of Joint Prospecting for Mineral Resources in Asian Offshore Areas
The Committee for Coordination of Joint Prospecting for Mineral Resources in South Pacific Offshore Areas
East-West Center, Hawaii
International Union of Geological Sciences
Pacific Science Association
University of Hawaii
in cooperation with

American Geophysical Union
American Society of Photogrammetry
Arab Organization for Mineral Resources
Australian Academy of Technological Sciences
Australian Institute of Energy
Association of Earth Science Editors
Association of Engineering Geologists
Australasian Institute of Mining and Metallurgy
Australian Petroleum Exploration Association, Ltd.
Australian Society of Exploration Geophysicists
Canadian Society of Petroleum Geologists
Geological Association of Canada
Geological Society of America
Geological Society of Australia
Geological Society of Bolivia
Geological Society of Japan
Geological Society of Korea
Geological Society of London
Geological Society of Malaysia
Geological Society of Philippines
Geological Society of Thailand
Geothermal Resources Council
Indonesian Petroleum Association
Korean Institute of Energy & Resources
Korean Federation of Scientific & Technological Societies
Mineralogical Association of Canada
National Research Council
Norwegian Petroleum Society
Pan American Institute of Geography and History
Petroleum Exploration Society of Australia
Royal Geological and Mining Society of the Netherlands
Seismological Society of America
Sociedad Geologica de Mexicana
Society of Economic Paleontologists and Mineralogists
Society of Exploration Geophysicists
Southeast Asia Petroleum Exploration Society
Union Geofisica Mexicana
Unione Francise des Geologues
United States Geological Survey

157

A. A. MEYERHOFF, Meyerhoff & Cox, Tulsa, OK; CHIN CHEN, W. Connecticut State College, Danbury; and J.-O. WILLUMS, Oildeco, Sandvika, Norway: Economic Geology and Mineral Resources Base of People's Republic of China

MAURICE J. TERMAN, USGS, Reston, VA: The Last 200 Million Years in Eastern Asia: Yanshanian Subduction and Post-Yanshanian Extension

HELIOS S. GNIBIDENKO, Sakhalin Complex Scientific Research Inst., USSR, and IGOR I. KHVEDCHUK, Pacific Expedition Soyuzmorgeo, Sakhalin, USSR: Cenozoic Sedimentary Basins of Okhotsk Sea

LIU HEFU, Wuhan College Geology, Beijing, China: Structural Styles of Mesozoic-Cenozoic Petroliferous Basins of China

STANLEY S. L. CHANG, P. T. HSIAO, JENNWEI YUAN, and WEN-RONG CHI, Chinese Petroleum Corp., Republic of China: The Neogene Series, Tectonic Evolution, and Petroleum Potentialities of Southwestern Taiwan

DENNIS E. HAYES and STEPHEN D. LEWIS, Lamont-Doherty Geol. Observatory, Palisades, NY: Marine Geophysical Studies of the Western Margins of Luzon, Philippines

A. SALDIVAR-SALI, Philippines, and H. G. OESTERLE and D. N. BROWNLEE, Philippines-Cities Service, Manila: Geology and Production History of Offshore Northwest Palawan, Philippines

KARL W. STAUFFER, Chevron, San Francisco, CA: Rio Zulia Field, Colombia

THURSDAY, AUGUST 26

SPECIAL SOPAC CRUISE REPORTING SESSION
Kai Ballroom IV
Presiding: **H. GARY GREENE, N. EXON**

10:00 D. W. SCHOLL, USGS, Menlo Park, CA; T. U. MAUNG, CCOP/SOPAC, Suva, Fiji; T. V. VALLIER, USGS, Menlo Park, CA; and Scientific Party: Preliminary Results of Geophysical and Geological Studies to Assess Resource Potential and Geologic Evolution of Central Tonga Ridge and Summit Platform (21-24° Latitude)

H. G. GREENE, USGS, Menlo Park, CA; D. FALVEY, Univ. Sydney, Australia; A. MACFARLANE, Vanuatu Geol. Survey, Port Vila; and Scientific Party: Preliminary Results of Leg 2 *Lee* Cruise in the Central Basin of Vanuatu to Assess Hydrocarbon Potential and Geologic Evolution of New Hebrides Arc Basins, S. W. Pacific

J. G. VEDDER, USGS, Menlo Park, CA; D. L. TIFFIN, CCOP/SOPAC, Suva, Fiji; F. I. E. COULSON, Geol. Survey Solomon Islands, Honiara; and Scientific Party: Preliminary Results of Leg 3 *Lee* Cruise—Basin Development and Resource Potential of Central Solomons Trough

T. M. BROCHER, Hawaii Inst. Geophysics, Honolulu, and R. HOLMES, CCOP/SOPAC, Suva, Fiji: Tectonic Framework of Melanesian Borderland

L. W. KROENKE, Hawaii Inst. Geophysics, Honolulu, and J. V. EADE, New Zealand Oceanographic Inst., Wellington: Geomorphology, Structure, and Geochemistry of North Fiji Basin Triple Junction

11:00 B. TAYLOR, Hawaii Inst. Geophysics, Honolulu, and N. F. EXON, Bur. Min. Resources, Canberra, Australia: Subduction of Woodlark Spreading System at Solomon Island Arc

CIRCUM-PACIFIC MAP PROJECT:

11:30 JOHN A. REINEMUND and PHILLIP W. GUILD, USGS, Reston, VA, and WARREN O. ADDICOTT, USGS, Menlo Park, CA: Circum-Pacific Map Project: Framework for International Resources Assessment

NATURAL RESOURCES EXPLORATION

12:00 FRED B. HENDERSON III: Satellite Remote Sensing Systems for Circum-Pacific Energy and Mineral Resources

12:30 ALLEN M. SHINN, JR., Office of Scientific Drilling, Natl. Science Foundation, Washington, D.C.: Future of Scientific Ocean Drilling

THURSDAY, AUGUST 26

POSTER SESSION II - Authors present 10:00 a.m.-Noon
Exhibit Pavilion

Booth 13 • J. P. PARIS and A. COLLEAU, BRGM, and M. ESTERLE, SLN, Noumea, New Caledonia: Preliminary Metallogenic Map of New Caledonia—First Part: Mineral Deposits Associated with the Overthrusted Ophiolite

14 • P. MAURIZOT and J. M. EBERLE, BRGM, Noumea New Caledonia: Preliminary Metallogenic Map of New Caledonia—Second Part: Mineral Deposits Nonassociated with Ultrabasic Rocks

15 • M. P. KENNEDY, Scripps, La Jolla, CA; H. G. GREENE and S. H. CLARKE, JR., USGS, Menlo Park, CA; and M. R. LEGG, Univ. of Calif., Santa Barbara, CA: Marine Geologic Map Series of California

16 • MARK R. LEGG, Univ. California, Santa Barbara, CA, and VICTOR WONG O., Centros de Investigacion Cientifica y Educacion Superior de Ensenada, San Ysidro, CA: Seismicity, Faulting, and Tectonics of Inner Continental Borderland Offshore Northern Baja California, Mexico

17 • H. R. KATZ, New Zealand Geol. Survey, Lower Hutt: Mineral Resources and Maps of New Zealand, The New Hebrides and the Solomons

18 • FRANCES M. DELANY, Sec. Gen., CGGMW: International Mapping Activities of the Commission for the Geological Maps of the World

19 • PHILLIP W. GUILD, USGS, Reston, VA: Preliminary Metallogenic Map of North America, Scale 1:5 million

20 • M. J. BERGIN, USGS, Reston, VA, and E. R. LANDIS, USGS, Denver, CO: Role of the U.S. Geological Survey in the Assessment of Conventional Energy Resources in Countries Other Than the U.S.A.

21 • B. G. FISK and J. W. FARTHING, Energy Res. of Australia, Sydney: Development of Ranger Mine

22 • GEORGE L. CHAN, Commonwealth Northern Mariana Islands, Saipan: Integrated Farm-

trongest uranium mineralization in oceanward tectonic es was associated with cratonization of oceanic rocks.

.BERT, JOHN T. E., Adjunct—New Zealand

y Environmental Planning for Offshore Oil and Gas Ex- ation and Production

) abstract)

.ES, DAVID L., and CARL E. NELSON, Cimarron Ex- ration Inc., Lakewood, Colorado

ncipal Features of Epithermal Lode Gold Deposits of cum-Pacific

'roduction from epithermal primary lode gold deposits along Circum-Pacific rim exceeds one million ounces annually, n around 20 countries. Distribution of this important osit type coincides with, and is genetically related to, con- gent plate boundaries and the chain of associated volcanic- onic activity framing the ocean basin. Deposits are emplaced s clusters along two subparallel belts: the ocean margin transi- on zone and the zone within the continental framework oundary. Ocean margin deposits are associated with island arc- ype intemediate to mafic igneous activity, active geothermal henomena, and subduction-related regional fracture systems. eposits inside the continental margin are associated with in- rmediate to felsic volcanic-plutonic belts and exhibit block ulting or volcano-tectonic fracture control. They feature rong Pb-Zn-Ag and local S-W metal associations. Within both elts, a continuum exists between near surface hot spring eposits, local disseminated replacement (Carlin-type) deposits, nd deeper bonanza systems. Hot spring and replacement eposits feature relatively high Au:Ag ratios, contain micron- zed gold particles, are enriched in Hg-As-Sb-Ba, and are osted by hydrofracted quartz-pyrite stockworks or fine-grained rbonaceous limestones. Bonanza deposits are characterized by olymetallic veins and stockworks. Economic concentrations re- uire initial high gold solubility, unrestricted recharge of eteoric water into a region of steady high heat flow, fracture- ntrolled fluid focusing, and either host-rock reactivity or isodic self-sealing, with explosive pressure release in the zone f deposition. Boiling, temperature decrease, solution oxidation nd local ground-water mixing are the primary processes of ore eposition. Modern-day analogs of such ore forming systems ist in New Zealand, Japan, western USA, Indonesia, and the hilippines, among others.

IBIDENKO, HELIOS S., Sakhalin Complex Scientific earch Inst., Novoalexandrovsk, Sakhalin, USSR

in Features of Kuril-Kamchatka Deep-Sea Trench Tectonics Geologic Development

he upper crust structure of the Kuril-Kamchatka deep-sea ch and continental slope is a system of horst-anticlinorial fts of the acoustic basement and separating them partially compensated graben-synclinorial troughs stretching in the heastern direction according to the trench general trend. rom dredging data the acoustic basement rock associations he horst-anticlinorial uplifts of the trench continental slope are pre-Neogene (Late Cretaceous and older) complexes of the deformed geosynclinal volcanogenic and sedimentary deposits broken by gabbroids, granodiorites, and granitoids. Graben-synclinal troughs are filled with sedimentary deposits mainly of the Neogene-Quaternary ages, the thickness of which in some basins exceeds 1.8 mi (3 km).

The oceanic slope of the trench is composed of the sedimentary layer with thickness of about 300 to 990 ft (100 to 300 m), lying on the second layer of the oceanic crust. According to the dredging, the acoustic basement roof on the marginal oceanic swell (Hokkaido Rise) is mainly composed of metamorphosed basalts and it seems to include the sedimentary rock intercalation. From the whole rock K-Ar data, the period of intensive basaltic volcanism on the Hokkaido Rise is from Cretaceous to Paleogene.

Crustal faults along the Kuril-Kamchatka and Aleutian trenches can be characterized as a "normal faults," especially for the oceanic side, which points out their development in crustal tension conditions.

The faults transversal to the trenches are mainly established from magnetic data. The anomalous magnetic field is subdivided generally in two regions in which the trend of anomalies varies from the subparallel (in the southern part of trench) to the subtransversal to the trench (in the northern part). A vast region next to the oceanic plate adjacent to the crustal and northeast parts of the Kuril-Kamchatka trench is characterized by the absence of linear magnetic anomalies which can be associated with the structure and movement of the subducted plate.

GNIBIDENKO, HELIOS S., Sakhalin Complex Scientific Research Inst., Novoalexandrovsk, Sakhalin, USSR, and IGOR I. KHVEDCHUK, Pacific Expedition Soyuzmorgeo, Yuzhno-Sakhalinsk, Sakhalin, USSR

Cenozoic Sedimentary Basins of Okhotsk Sea

The northern and central parts of the Okhotsk Sea is the epi-Mesozoic platform. The hetero-aged acoustic basement is represented by the deformed geosynclinal rocks from Cretaceous to Paleozoic and, probably, Precambrian. The slightly deformed sedimentary cover leveled the uneven surface of the acoustic basement, and this upper Paleogene-Neogene cover filled the system of the structural basins. The general northwest to southeast and east-to-west trending taphrogenic horsts and grabens of the acoustic basement were formed due to extending and subsiding of the earth's crust during late Paleogene-Neogene time.

GRAY, J. K., Canadian Hunter Exploration

Developing Canada's Energy Resources in the 1980s

Abstract on page 51.

GREENE, H. G., U.S. Geol. Survey, Menlo Park, California, D. FALVEY, Univ. Sydney, Sydney, Australia, A. MACFARLANE, Vanuatu Geol. Survey, Port Vila, Vanuatu, and Scientific Party of SOPAC Cruise, R/V *S. P. Lee:* G. COCHRANE, USGS, Menlo Park, California; D. J. ORSTOM, Noumea, New Caledonia; M. A. FISHER, USGS, Menlo Park, California; M. L. HOLMES, USGS, Seattle, Washington; H. R. KATZ, New Zealand Geol. Survey, Lower Hutt, New Zealand; G. L. SMITH, USGS, Menlo Park California, J. PRAGNELL, Univ. Sydney, Sydney, Australia

State of Oaxaca, where reserves of crystalline graphite, estimated at more than 2 MMt, assay at 4.25% and are processed by a 600 t/d plant.

The total reserves of in-situ metallics amount to 124 MMt, with a value of US$8,680 MM. They include Au, Ag, Cu, Pb, Zn, As, Bi, W, Fe, etc. The total volume of in-situ nonmetallics is 78 MMt, valued at US$3,600 MM. The most important of these are barite, borates, gypsum, marble, anthracite, and magnesite. Geologic and geophysical maps show the locations of outstanding deposits.

SALDIVAR-SALI, A., Philippines, and H. G. OESTERLE and D. N. BROWNLEE, Philippines-Cities Service, Manila, Philippines

Geology and Production History of Offshore Northwest Palawan, Philippines

The area of study is the continental shelf and rise off northwest Palawan and part of the southeastern margin of the South China Sea spreading center. A pre-Tertiary continental basement complex is separated from the accreted oceanic crust, outcropping on southern Palawan, by the Ulugan Bay fault, which is one of several north-south-trending strike-slip fault zones recognized in the area.

A geologic section consisting, in the lower part, of limestones, volcanics and fine-grained clastics, ranging in age from pre-Tertiary to lower Oligocene, is encountered off northwest Palawan. This is unconformably overlain by the Nido Limestone and deep-marine shales of the Pagasa Formation (upper Oligocene to middle Miocene). The contact with the coarse clastic Matinloc Formation is an unconformity recognized on a regional scale and related to collision of the drifting margin with the remainder of the Philippine archipelago. The sequence is topped by the Carcar Limestone, described from many areas in the Philippines.

A total of 30 wells have been drilled so far: 12 were dry, 10 were discoveries, 7 of which have been declared commercial, and 7 were delineation wells. Occurrence of hydrocarbons had been restricted to reef-related reservoirs of the Nido Limestone, until the recent discovery of oil in sandstone reservoirs in Galoc 1 heralded a new chapter in the Philippines search for hydrocarbons.

Evaluation of the production performance from these reefs and analysis of the behavior of fractured limestones as reservoirs serves as a guide for future operations in the area. The future prospects of the northwest Palaway shelf and rise can be assessed from the current discovery success ratio in the exploration for reefs and from initial discoveries in turbidites.

SCHEIBNER, ERWIN, Dept. Mineral Resources, Australia

Tectonic Map of Circum-Pacific Southwest Quadrant—A Draft Presentation

(No abstract)

SCHOLL, D. W., U.S. Geol. Survey, Menlo Park, California, T. U. MAUNG, CCOP/SOPAC, U.N. Offshore Mineral Prospecting, Suva, Fiji, T. V. VALLIER, U.S. Geol. Survey, Menlo Park, California, and Scientific Party Cruise, CCOP/SOPAC, R/V *S. P. Lee* (J. CHILDS and A. J. STEVENSON, U.S. Geol. Survey, Menlo Park, California; N. F. EXON, Bur. Mineral Resources, Canberra, A.C.T., Australia; R. H. HERZER, New Zealand Geol. Survey, Lower Hutt; M. W. SANDSTROM, Australian Natl. Univ., Canberra, A.C.T.; S. SOAKI, Ministry of Lands, Nuku'alofa, Tongatapu, Tonga)

Preliminary Results of Geophysical and Geological Studies to Assess Resource Potential and Geologic Evolution of Central Tonga Ridge and Summit Platform (21-24° Latitude)

In April 1982, the R/V *S. P. Lee*, operated by the USGS supported geological and geophysical studies over the central area of the Tonga Ridge immediately south of Tongatapu. The cruise plan calls for the collection of approximately 1,250 mi (2,000 km) of multichannel (24) seismic reflection data and several dredge stations to sample submarine outcrops. The bulk (70%) of this work will be concentrated over the summit platform of the ridge, in water depths less than about 5,000 ft (1,500 m). One or more seismic lines will be extended eastward to and slightly seaward of the Tonga Trench, and westward of the ridge's present volcanic axis toward the Lau Basin, in order to resolve the regional rock and structural framework of the ridge. Several multichannel lines will cross the fore-arc basin that lies between the summit platform and the trench. Sonobuoy refraction and wide-angle reflection data will be gathered routinely as well as gravity and magnetic data and high-resolution subbottom seismic records (3.5 kHz and multiplate Uniboom sources). Navigation will be controlled by satellite fixes and computer-generated dead-reckoning positions, based on ship's heading and speed, and doppler-sonar inputs.

The results of the shipboard examination of dredged samples, seismic monitor records, and possibly several hundred km of brute-stacked processed multichannel records will be presented at the CPEMRC III. The implications of this sketchy and roughly assembled data base relative to the mineral and petroleum resource potential of the sedimentary sections underlying the ridge's summit platform and the adjacent fore-arc basin will be discussed. Comments on the geologic and tectonic history of the Tonga Ridge implied by the incompletely analyzed field data will be offered for discussion and consideration.

SHUPE, JOHN W., and D. RICHARD NEILL, Hawaii Natural Energy Inst., Univ. Hawaii, Honolulu, Hawaii

Wind Applications in Pacific

Hawaii shares with many other isolated areas and island communities of the Pacific a near-total dependence for energy on imported oil—a supply source which during the past decade has become increasingly expensive and less secure. Hawaii also shares with many of these areas which are deficient in conventional energy supplies, a variety of renewable energy resources which can serve as substitutes, or alternatives to seaborne petroleum. A case study showing what has been accomplished in Hawaii in moving one of these resources—wind energy—closer to commercialization is based on the limited amount of known information on the potential of wind energy in the Pacific region and studies which are underway to expand the knowledge on the extent of the wind resource throughout this region.

The Hawaii Natural Energy Institute (HNEI) and the Department of Meteorology of the University of Hawaii have developed over the past 6 years an inventory of the wind resource in Hawaii. This effort involved an extensive system of 18 long-term wind data stations located on the five major islands, supplemented by a series of mobile, short-term stations and a loan program of wind measurement devices for specific site measurements. The Hawaii Wind Data Bank provides infor-

160

TAYLOR, BRIAN, Hawaii Inst. Geophysics, Univ. Hawaii, Honolulu, Hawaii, and N. F. EXON, Bur. Mineral Resources, Canberra, A.C.T., Australia

Subduction of Woodlark Spreading System at Solomon Island Arc

The initial results of a marine program sponsored by Australia, New Zealand, the United States, and CCOP/SOPAC to investigate the subduction of the Woodlark spreading system beneath the Solomon island arc can be reported. This unusual tectonic situation provides (a) a controlled experiment in which the roles of subducted oceanic crust and sediments in island arc petrogenesis can be assessed, and (b) an opportunity for determining the relation between the thermal structure of the subducted oceanic lithosphere and the thermal regime of the island arc/back arc. Station work during the 24-day cruise included dredging, coring, and digital heat flow measurements.

TERMAN, MAURICE J., U.S. Geol. Survey, Reston, Virginia

The Last 200 Million Years in Eastern Asia: Yanshanian Subduction and Post-Yanshanian Extension

The pre-Yanshanian (pre-200 m.y.B.P.) geology of Asia can be interpreted as an unique record of numerous small plates, some of which were separate rifted blocks as early as 1,500 m.y.B.P. The north-south agglomeration of these blocks to form the bulk of modern Asia began in the west during the Carboniferous (Hercynian events) and climaxed in the east during the Late Triassic (Indosinian events). In the eastern part of the continent, four major east-trending sutures (Red River, Qin Ling, Yan Shan, and Mongol-Okhotsk) bound three major blocks (respectively, South China, North China-Korea, and Manchuria-Bureya).

The Yanshanian geology in eastern Asia, particularly the widespread belts of calc-alkaline igneous rocks, can be interpreted as resulting from magmatism superposed above major peripheral subduction zones that dipped northwestward under South China and westward under North China-Korea and Central Mongolia from 200 to 100 m.y.B.P., and westward under North China-Korea (fronted by Southwest Honshu) and Manchuria-Bureya from 100 to 50 m.y.B.P. Some subduction also took place from 200 to 100 m.y.B.P., parallel to the Qin Ling, Yan Shan, and Mongol-Okhotsk sutures, as all finally closed. Hydrocarbon-rich basins formed as the result of major epeirogenic subsidence on western margins of the oldest continental nuclei, farthest from the eastern subduction zones. Rates of subsidence and subduction appear correlative; areas of magmatic arcs and volumes of sedimentary basins reflect subduction rates; both reach a maximum in the Late Jurassic and Early Cretaceous.

The post-Yanshanian (since 50 m.y.) geology in eastern Asia can be interpreted as resulting from northeast-southwest crustal extension in the region between the Siberian craton and the continental margin from Primorye to Taiwan, contemporaneously with collisions between Asia and the Okhotsk block in the northeast, the India block in the southwest, and the Philippine arc in the southeast. The extension is evidenced by hydrocarbon-rich Tertiary grabens, by voluminous Late Tertiary alkalic basalt volcanism localized along former plate sutures, and by historically recorded, scattered, intraplate, shallow seismicity.

THOMPSON, THOMAS L., Tulsa, Oklahoma

Tectonic Guidelines for Oil and Gas in the Circum-Pacific

(No abstract)

U MAUNG, TUN CCOP/SOPAC Technical Secretariat, Suva, Fiji, and KAREN ANSCOMBE and SIONE L. TONGILAVA, Ministry of Lands, Survey and Natural Resources, Nuku'alofa, Tonga

Petroleum Potential of Southern Part of Tonga Platform

The Tonga platform is roughly outlined by the 2,000-m isobath with an average width of about 60 to 75 mi (100 to 120 km) surrounding the Tongan Islands of Vava'u, Ha'apal, and Tongatapu. Single-channel seismic profiles across the platform were acquired between 1977 and 1979 by scientific expeditions sponsored by CCOP/SOPAC (Committee for Cooperation of Joint Prospecting for Mineral Resources in South Pacific Offshore Areas) and ORSTOM (Office de la Recherche Scientific et Technique Outre Mer). This survey and a five-well drilling program on Tongatapu were inspired by the discovery of seeps of weathered crude oil from vuggy coralline limestone. Reef buildups and normal fault structures are interpreted from seismic data, and the wells penetrated Miocene and Eocene limestones, volcanogenic clastics, and some reached volcanic basement. Few oil and gas fields are found in fore-arc basins, of which the Tonga platform is typical, but the reefs offer prospects and the seeps suggest that the requirements of source rock and maturation may be satisfied.

VEDDER, J. G., U.S. Geol. Survey, Menlo Park, California, D. L. TIFFIN, CCOP/SOPAC, U.N. Offshore Mineral Prospecting, Suva, Fiji, F. I. E. COULSON, Geol. Survey Solomon Islands, Honiara, and Scientific Party (L. A. BEYER and T. R. BRUNS, USGS, Menlo Park, California, J. COLWELL, Bur. Mineral Resources, Canberra, A.C.T., Australia, A. K. COOPER, USGS, Menlo Park, California, L. KROENKE, Hawaii Inst. Geophysics, Honolulu, M. MARLOW, USGS, Menlo Park, California, and R. A. WOOD, New Zealand Geol. Survey, Lower Hutt)

Preliminary Results of Leg 3 *Lee* Cruise—Basin Development and Resource Potential of Central Solomons Trough

A CCOP/SOPAC cruise funded by Australia, New Zealand, and the United States surveyed parts of the Solomon Islands region in May and June 1982, in order to assess the potential for petroleum accumulations and to identify geologic hazards. Work was concentrated in the central Solomons trough (the Slot) between the islands of Guadalcanal, Santa Ysabel, New Georgia, and Choiseul, where continuous multichannel, single channel, and high resolution seismic records were acquired together with magnetic and gravity profiles.

The Slot is underlain by a composite depositional basin that contains as much as 2.8 mi (4.5 km) of Cenozoic sediments. Despite its complex island-arc setting, submarine volcanoes, and 2,625 to 5,900 ft (800 to 1,800 m) water depths, the basin includes structural, stratigraphic, and possibly thermal elements that favor generation and entrapment of hydrocarbons.

WALLHIG, MICHAEL, Univ. California, Berkeley

A Review of United States Active/Passive Solar Cooling Program for Building

Abstract on page 53.

WALTHIER, THOMAS N., and JUAN A. PROANO, St. Joe Minerals Corp., New York, New York, and RAMON ARANEDA and JACK CRAWFORD, Compania Minera El Indio, El Indio, Chile

New Gold-Silver-Copper Orebody at El Indio, Chile

In June 1975, a St. Joe Minerals Corp. geologist, Dave Thomson, visited a remote prospect called El Indio, 300 mi (500 km) north of Santiago, close to the Argentine frontier at 13,000 ft (4,000 m) elevation. He recognized the great potential and St. Joe moved promptly. However, an agreement to purchase 80% of the property was not signed until June 30, 1976. Intensive exploration and development followed. It took another year to negotiate a foreign investment agreement with the government of Chile.

On December 2, 1981, the El Indio mine-mill complex was dedicated. The total investment approximates U.S.$200 million and the facility will process 1,380 tons (1,250 MT) ore per day. Mill-feed ore reserves at the time of dedication were calculated at 3.1 million tons averaging 12 g gold, 144 g silver, and 3.5% copper. In addition, direct shipping high-grade ore reserves are estimated at 70,000 tons averaging 11 oz (345 g) of gold per ton. Similar material has been mined and shipped since 1979, containing in excess of 345,000 oz (10,750 kg) of gold. Our geological assessment is that continued exploration at El Indio will discover considerably more ore of both types.

The ore is found in a complex vein system within volcanic andesites, dacites, and quartz dacites within, but near the border of, a caldera. The regional structural pattern is north-south faulting. Northeast cross faults forming sigmoid loops are very important ore controls.

Massive enargite-pyrite veins are up to 33 ft (10 m) wide. Propylitic, argillic, quartz-sericite, and siliceous alteration are widespread, with precious metal content favoring the highly siliceous areas. Gold is rarely visible as average grain size of the native metal is 5 microns.

WOODS, ALAN J., Dept. National Development and Energy, Australia

Australian Energy Development and Policies for the 80s

Australia has substantial reserves of energy resources and energy-related minerals, and therefore has the potential for major increases in the production of such resources and the processing of minerals for export. Realization of this potential in the 80s will depend largely on the state of world markets.

Australia's resource base and its energy position have been described, and evaluated in the context of the development of Australia's energy resources as a contribution to the national and global transition away from oil. The economic growth that will flow from energy resources development and related activity is noted and possible constraints on development are considered.

The role of the Commonwealth government is addressed, proceeding from the key energy policy goal of ensuring adequate supplies of liquid fuels for Australian industry, especially the transport sector, and private consumers. Specific objectives and achievements in energy conservation, fuel substitution, oil exploration and production, and the development of synthetic fuels are discussed. The preparations made by the Commonwealth and State governments and the private sector to deal with severe disruptions to imported oil supplies are outlined. Energy research and development policies and programs are described briefly.

The Commonwealth government's policies are also examined in the context of setting the scene for resource development in the 80s. The importance of appropriate macro-economic and other supporting policies is emphasized.

Major individual resource projects are described, and Australia's potential contribution to the Pacific region, both in direct energy trade and in technological cooperation, is considered.

It is concluded that Australia has developed a flexible policy framework which will facilitate the development of its natural resources in the 80s.

XIANG-GAN, WU, College of Rural Machinery of Zhen-jiang, Beijing, China

Impact of Renewables on China's Energy Supplies

The People's Republic of China has abundant conventional as well as renewable energy resources. During the 33 years since liberation, the energy production has increased some 25 times and the country is now self-sufficient for all the 800 million tce (ton coal equivalent) energy demands, including the biomass consumed as fuel in the vast rural region. However, due to the enormous population, the energy consumption per capita is rather low, around some 0.8 tce/capita including the noncommercial energy sources. The PRC is now making great efforts to increase the energy supplies to meet the tremendous energy demands in the course of "Four Modernizations."

The renewables constitute a considerable portion of China's energy supply. The potential hydraulic resources amount to 680 Gw, of which about 430 Gw is exploitable. Mini-hydro stations constitute the main supply for the electrification in rural regions. Agriculture waste provides about 33% of the rural energy supply, 28% comes from firewood, and 10% from coal from local small mines. Due to the shortage of domestic fuel in some regions, excessive burning of agriculture wastes and deforestation results, threatening the future of agriculture production. Therefore, policies are being adopted to develop biogas as well as other renewables in order to improve the ecological equilibrium in rural regions.

YOUNGBLOOD, STANLEY B., Acurex Corp.

Operating Experience of Johnson & Johnson Solar Industrial Process Steam Facility

Abstract on page 54.

YU, SHUI-BEIH, and YI-BEN TSAI, Inst. Earth Sciences, Academia Sinica, Taipei, Taiwan, Republic of China

Study of Microearthquake Activity in Four Geothermal Areas of Taiwan

Detailed microearthquake surveys were conducted in four geothermal areas of Taiwan, namely, Tatun volcanic region, Chingshui-Tuchang geothermal area, Lushan hot spring area,

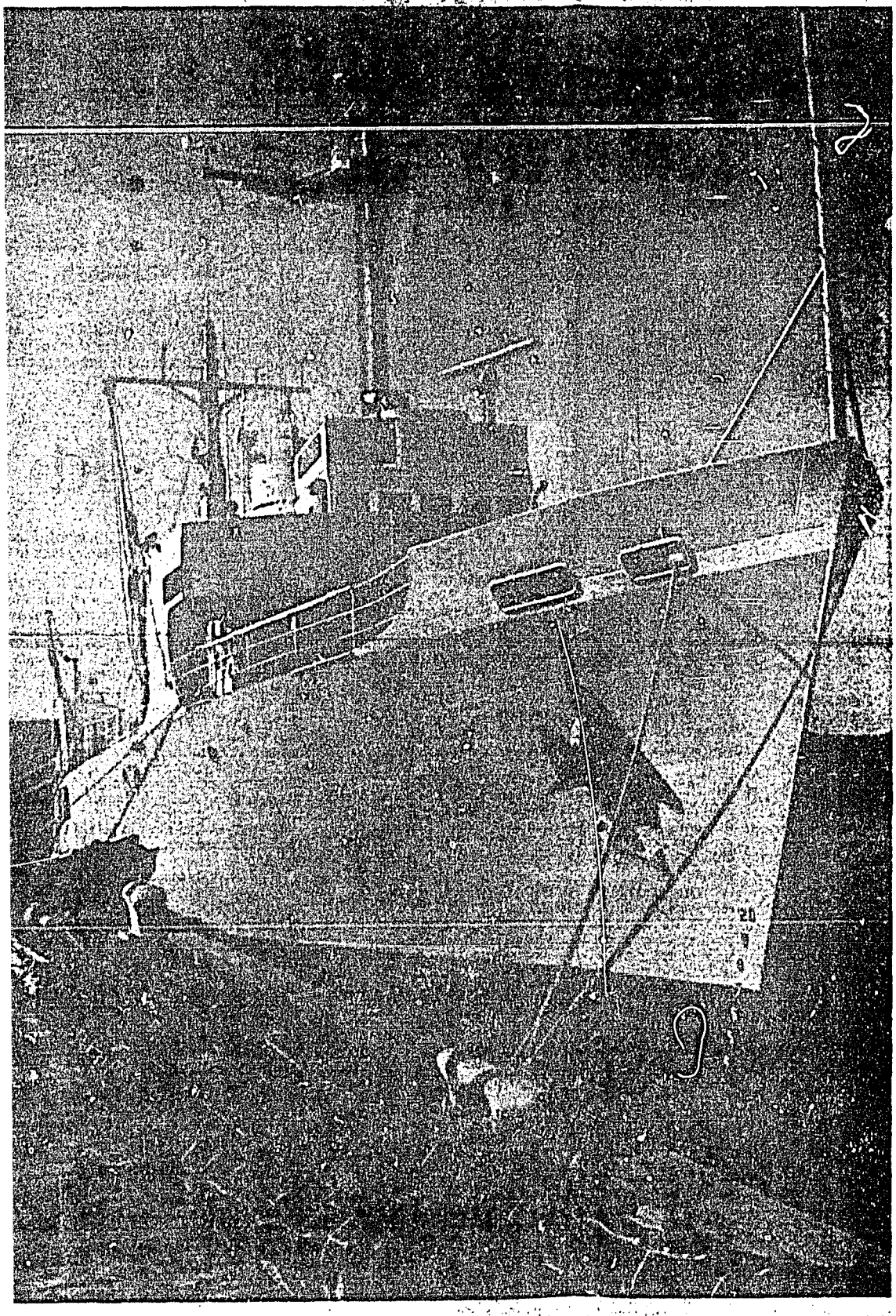
162

Appendix G

Publicity

WEEKEND

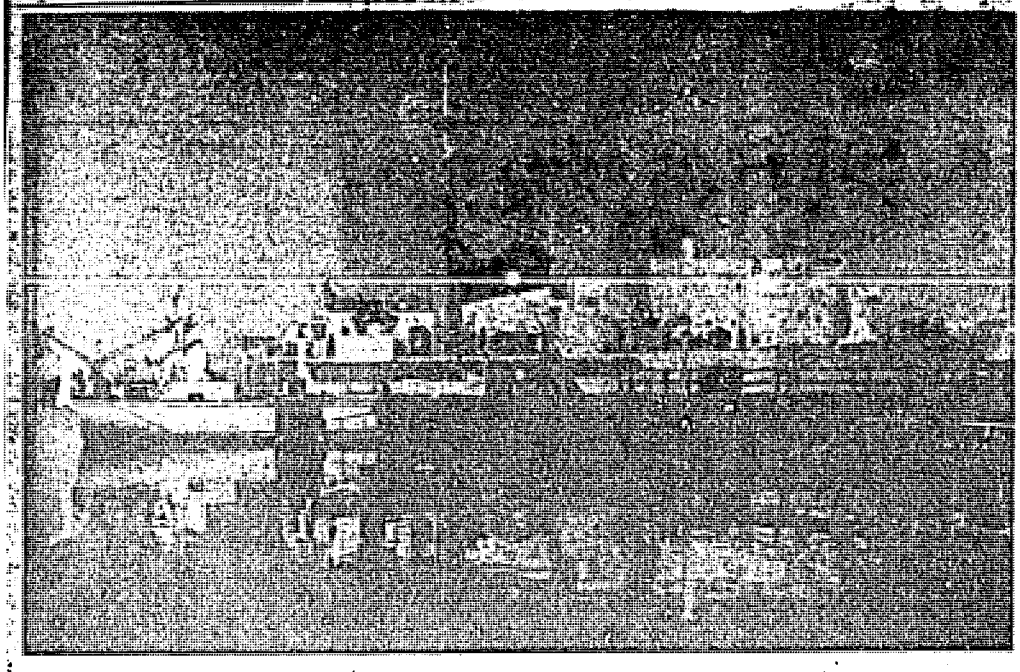
The Times
February 20, 1982

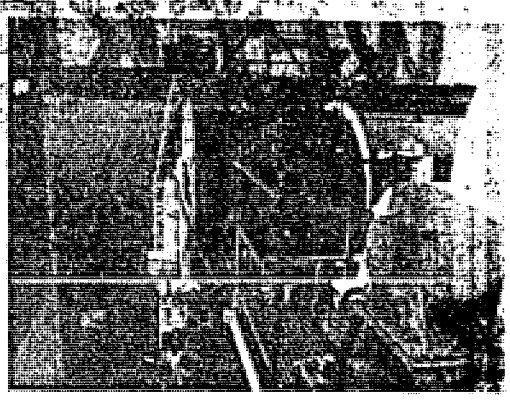


This troller's hooks are set for oil

. . . Page 2

ALSO INSIDE: TV Times • Theaters • Travel • Homes





(Times photos by Ray Zirke)

SHIP OF SCIENCE

Just before sailing, the U.S. Geological Survey's refitted exploration vessel S.P. Lee is docked at Redwood City. Above, a closeup of the multichannel "streamer" that can stretch nearly 2 miles behind the ship and provide topographical data from deep below the ocean floor.

Underseas search for black gold

By CHRISTINE DELSOL
Times Staff Writer

The South Pacific is known for many things — flagrant sunsets, lazy beaches, tropical fruit, exotic people. It is not known for its oil and gas resources. But the U.S. Geological Survey's research vessel *S.P. Lee* left its Redwood City berth Feb. 5 for the first leg of a nine-month expedition aimed at changing that.

As important, perhaps, as the energy potential, this pioneering research project renews the United States' friendship with developing nations of the South Pacific and strengthens its ties with Australia, a long undervalued ally. And the mission may lead to a similar expedition to the Indian Ocean.

Nor is it insignificant that the United States' technological capability has edged the Soviet Union out of an area of increasing scientific — and political — interest.

"It's the first time the United States has gone into such a venture since World War II," says Gary Greene, the USGS marine geologist who initiated the joint venture with New Zealand and Australia in 1980.

"And it's the biggest expedition we've undertaken. This ship has the most sophisticated geological equipment available. It's the only government ship outfitted for purely geological and geophysical research."

Other research ships divide their efforts among biology, physical oceanography and meteorology as well as geology. Oil industry ships with comparable equipment stick to applied research, to meet their specific needs, while the *Lee* integrates applied with basic research aimed at advancing scientific understanding.

"That makes this ship unique in the world," Greene says. He might have added that it makes it indispensable in offshore exploration, a field in which current knowledge is roughly comparable to what was known of the Wild West in the mid 1800s.

It was on a similar ship that another USGS scientist, David Scholl, discovered the bountiful Bering Sea basin off Alaska's shores in 1967. Scholl also will join the South Pacific expedition.

"Industry had ignored the Bering Sea because they thought it was just hard bedrock. But Scholl ran a line and discovered a thick sedimentary basin. Since then, the oil companies have found some of the largest basins in the United States up there," Greene recalls.

THE SOUTH PACIFIC region, too, may have remained unexplored had Tonga not discovered an unexplained oil seep. "If it wasn't for that oil leak," Greene says, "they'd still be saying there's no oil in the South Pacific."

As a member of the United Nations technical advisory group with the appellation "Committee for Coordination of Joint Prospecting for Mineral Resources in South Pacific Offshore Areas" (CCOP/SOPAC), Greene attended a session in the Gilbert Islands in 1980. Tonga reported its oil seep, and other developing nations were juggling myriad industrial offers for drilling and other rights, having no idea what they'd be giving away.

The South Pacific nations made it clear that the best aid the United States could offer them was with resource assessment.

"I went to inquire at USGS," Greene recounts. "Funding had been a problem, so the ship was tied up here anyway. Also, our field season (in the South Pacific) is our winter, so the ship wasn't able to work here then."

The State Department became interested, and its U.S. Aid arm ultimately provided most of this country's share of project funding for what became known as the SOPAC cruise. Australia, an oil-importing nation just now beginning to look into its offshore potential, joined in.

"They have a vast continental shelf," Greene explains. "Now they want to really get in the game. They want their scientists involved so they can get training, and they are going to process our computer data."

New Zealand, with a history of scientific and other aid to the South Pacific, was interested for similar reasons.

THE PROJECT'S POLITICAL history is as significant as its scientific background. Since World War II, the United States has paid scant attention to the tiny island territories once under British or French rule. They have since gained independence, becoming small Third World nations with great respect for the United States, Greene says, "but they're a little miffed because they haven't gotten much help from us. Australia and New Zealand have helped them the most, and Japan.

"The reason the United States is getting in now is that the Russians have a tremendous interest in the South Pacific. They have offered some pretty interesting scientific packages to them. . . . The Russians desperately want to get in there, but they can't supply them with the technology we have to offer, and remarkably inexpensively. I'd be surprised if the tab comes to $2 million for the whole project."

A paltry figure to a nation faced with a projected budget deficit of nearly $100 billion, this is more aid than the South Pacific receives in a year, according to Greene.

Even better, he says, "This type of aid isn't corruptible. It goes directly to the people of the region. With grain and flour, it goes one way and another. My feeling is that with this type of aid, every penny goes where it should go."

He also considers the educational aspect of the mission a superior form of foreign aid. "There are not many geologists in the South Pacific, but they are in the process of training their natives in geology. I'll be presenting workshops in coastal mapping techniques to young natives."

IT WILL BE A TRULY international expedition journeying to Hawaii, Samoa, Tonga, Fiji, Vanuatu (formerly New Hebrides), the Solomons, Papua New Guinea and Wake Island before heading back to familiar Arctic regions.

David Scholl, chief scientist on the Tonga leg of the trip, will be aided by U.N. scientist Tun Muang of Burma. Greene, joining the expedition in American Samoa late in March to lead the Vanuatu leg, will have David Falvey of Australia as co-chief. Another USGS scientist, Jack Vedder, will head the Solomon Islands portion with co-chief Don Tiffon, a Canadian U.N. scientist. French and British scientists also will be on board.

In addition, Greene says Japan "is watching the program very closely. They have in the past given a great deal of assistance to these nations, especially with their fisheries. And they have very nice ships. They are really ahead of the game in oceanography."

Also watching closely, but not so openly, will be the Soviet Union.

The South Pacific trip will be a morale booster for the *Lee's* crew, which has worked primarily in icy Arctic climes for some seven years, says Greene. "This kind of thing keeps scientists tuned into research — a new place and exciting geology."

THE PACIFIC-ARCTIC Branch of Marine Geology is part of the USGS' Geologic Division, one of four major operating units of the Survey's western region headquartered in Menlo Park. Its aim is assessing undersea mineral and energy resource potential and environmental characteristics, and predicting and minimizing certain hazards.

To that end, marine geologists study the shape of the ocean floors, distribution and character of sediments, composition of underlying rocks, and geologic processes that have been at work since the beginning of time — aided by research vessels berthed in Redwood City.

Most of the tools and methods of marine geology

Continued on Page 4A

INSIDE WEEKEND

FLIGHT LOG 5
TRAVEL 6-7
BOOKS 8
TELEVISION LOGS 9-16
THEATERS 17-19
RECORDS, SWITCHING ON 20
OUR LIVELY LANGUAGE 21
HOMES, REAL ESTATE 22-24

Editor, JANE BARBER
With Times writers, AP, UPI, Copley News Service

A voyage of international import

Continued From Page 2A

have been developed within the last half century, and the greatest strides have been taken within the past 20 years.

Before 1965, the branch was limited to small boat work. In 1966, the USGS acquired the 97-foot yacht *Polaris* from the University of California and outfitted it for limited studies along the West Coast. But many offshore investigations still required an expensive and time-consuming search for a larger vessel, then outfitting it for the mission and "de-outfitting" it later. Cooperative programs often were undertaken with such agencies as the U.S. Navy or the U.S. Coast and Geodetic Survey.

In 1974, the Pacific-Arctic Branch acquired long-term use of the *Samuel P. Lee* (named after a navy admiral who pioneered in the field of hydrography) from the navy and equipped the 208-foot, 1,300-ton ship, built in 1967 for Naval Oceanographic Office research, with the latest marine geological equipment.

The *Polaris* now is used mostly for studying water quality in the San Francisco Bay. The branch has since added several small 40-footers, and a *Polaris II* is on the way.

"THE PRIMARY PURPOSE of this ship is assessing hydrocarbon (oil and gas) resources in the continental shelves of the United States," Greene says of the *Lee*.

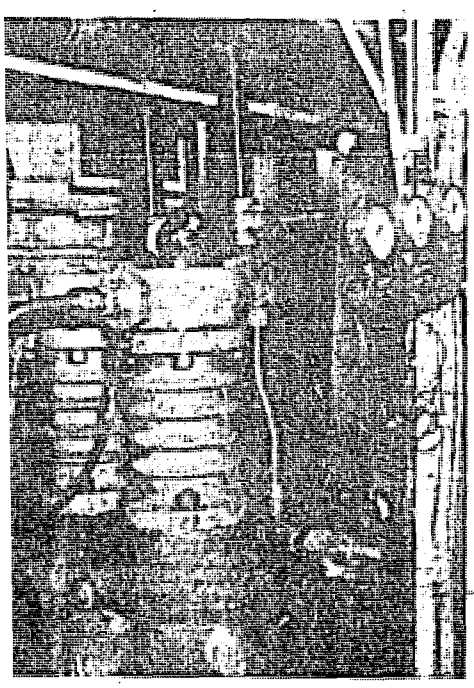
That means looking for the same three characteristics sought on land: deep sedimentary basins of porous sedimentary rock where oil can accumulate (university research has established the presence of basins in the South Pacific); zones that can trap the oil as it migrates upward through osmosis (including faults and stratographic overlaps); and, most difficult of all, a source of oil formation — an area where accumulated organic material can break down into oil under the right pressure and temperature conditions.

As onshore wells become exhausted, the search turns increasingly to offshore areas despite the expense of tapping such sources.

"But the type of research this ship has been doing is pioneering," Greene says. "Regardless of the policies of this administration, the scientists feel dedicated in the sense of reporting exactly what is there. They feel obligated to point out any environmental hazards that may exist. We produce maps that show oil basins as well as active faults, slumps, oil or gas seeps — any hazards that may have an effect during drilling or after.

"Most of us are research scientists; our real love is research. We want to try to understand the history of the earth, its geologies and tectonics. And we want to understand the processes that produce geological features."

That drive for understanding can make the difference between success and failure in frontier areas like offshore Alaska and the West Coast, where relatively little data and control are available. Because initial resource evaluations depend on scientific insight, the Pacific-Arctic Branch's most experienced scientists are assigned to resource assessment programs.



ep belowdecks are air compressors for the vital ultichannel sounding system.

Greene joined the USGS in 1966, beginning with a heavy metals project exploring for placer gold deposits off Alaska's shores and attending Scholl's Bering Sea cruise.

He's also explored the submarine canyons of Monterey Bay and the Oxnard Plain off Ventura in search of groundwater basins, and he spent time in Spain training scientists in geology and oceanography while evaluating that country's offshore areas. He's studied the "sea mounts" (usually volcanic underwater mountains) between the Aleutian Islands and Midway which figure into the "hot spot" theory of volcanic chains, and he's still project chief of a study of the geological hazards of offshore oil exploration off the Southern California coast.

THE *LEE'S* SELLING POINT for the SOPAC cruise was its multichannel acoustic system, designed especially for the ship, which can "see" as far as 10 kilometers below the sea floor. Its multiple channels also eliminate false echoes, providing more accurate computer enhanced images than were previously available.

"This equipment is the primary reason we're going down there," Greene says. "This is the capability these nations want."

Ten to 12 air guns mounted on the sides of the ship, each under 2,000 pounds of pressure, are dropped over and discharged at once, performing the function dynamite once served. Nearly 2 miles of "streamer" (a clear plastic cable containing 24 hydrophones packed in oil) picks up reflected sound waves that delineate the sea floor's topography and the thickness, folding and faulting of sediment-covered rocks.

"It's just as if you'd taken a knife and cut through the earth's crust," says Greene.

The streamer disappears over the curve of the earth, its end marked by a buoy. Bullet-shaped "birds" can drop the cable to safety if another ship ventures too close.

"We've had Russian ships deliberately try to cut our cable," Greene says. "I remember once, despite all our radio warning signals and the buoy, this Russian ship just kept on coming. We had to dive the streamer."

While the multichannel system is at work, the *Lee* moves no faster than 5 knots (about 5 mph), making turns at a maximum of 3 degrees, to keep the cable straight. Otherwise, top speed is 9 or 10 knots (about 10 mph). Either way, it's a long trip, and expeditions are broken into legs of 20 to 21 days.

CRUCIAL AS IT IS, the multichannel system is but one of the ship's research tools. A single-channel acoustic system can use the same air guns and penetrate up to 2 kilometers into the earth's crust. Scientists also read the sea bottom with "sonobuoys," initially developed to search for submarines, which record underwater sound refraction.

"There are all kinds of beeps and booms," Greene says. "It's a very noisy ship."

The ship also has precision sonar, miniranger and radio beacon, radar and satellite navigation equipment. Along with records of the earth's gravity and magnetic field, the shipboard computer integrates this data on tape to produce video displays throughout the ship.

"We steer by that," Greene says. "When you are way out there, you have no idea what anything is or where. It's like flying through space."

Even with all the sophisticated technology, shipboard scientists need the confirmation of "ground truth." Metal tubes, or corers, draw samples from within the bottom sediment, and a massive winch dredges the bottom to for samples of bedrock from outcroppings.

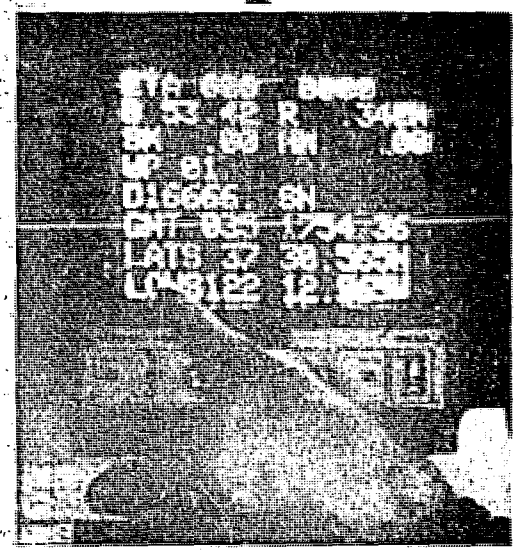
"It's like being on top of a two-story building, and you're standing there with a needle on a long thread, trying to scrape off a bit of mud from the sidewalk — but you're doing it in the dark," Greene says.

"It's very archaic, but it's interesting that with all this sophisticated equipment, we still need the ground truth. The other equipment all requires a great deal of interpretation. That's what separates geology from other sciences — they are very mathematical."

Re-outfitting the ship for its tropic expedition, where the water averages 85 degrees, after years in the Arctic where 50 degrees is high, was a three-month undertaking. The cable was ballasted with oil of a different viscosity, the air conditioning system was revamped, and the ship's black hull was repainted light beige.

The *Lee* carries a crew of about 30 — usually 15 scientists and 15 maritime crew members under Captain Terry Ruff. The SOPAC cruise is weighted toward scientific staff, which includes electronic technicians.

Even broken up into three-week legs, it can be an arduous journey with little diversion and virtually a 24-hour work day.



ON LOCATION

Video display screens spotted throughout the S.P. Lee tell exact location of the ship and indicate magnetic fields, gravity and other pertinent geophysical data.

"Good technicians are very hard to find," Greene says. "The scientists are working all the time, but the technicians' job can get tedious. The adventure wears off in a hurry. The young and adventurous ones who haven't gotten weary of ship life don't have the experience with the gear we need."

DESPITE THE MISSION'S pioneering nature and the expected benefits to emerging Third World nations, Greene says he is repeatedly asked, "But what good will it do us?" And he has an answer — in fact, he has three.

First, he points out, any foreign aid makes the world feel better toward America.

"I felt really warmly received in that area (the South Pacific). And the Australians really are our best allies, and we've pretty much ignored them." To illustrate Australian regard for U.S. ingenuity, Greene tells about a day-long train ride he took across the Great Victorian Desert. His seatmates were two old Aussies who were scowling at the expanse of desert rolling by.

"One of them leaned over toward the other and said, 'You know, if it was the Yanks, they'd be growing things all over here,' " Greene recounts. "They have tremendous respect for the 'Yanks.' "

Second, the project will advance the United States' evaluation of world oil supplies and increase our ability to predict shortages. "We need to actively comprehend the world oil picture, and by being involved in this type of project, we can," Greene says.

Finally, this kind of research advances scientific understanding of oil origins and formation. "The tectonics and deep sedimentary basins of the area are very like California's. There are volcanoes spewing along the way. It probably represents the Southern California borderland 30 million years ago. If we find traps for oil, we can come back and look for similar traps in the U.S. I'd say that probably is of the most value to the American citizen and taxpayer."

FEDERAL CUTBACKS already have hit the Survey hard — the Pacific-Arctic Branch has lost a major research ship and numerous personnel — and projects like the SOPAC cruise may become, if not rarer, less effective.

"What's really frustrating to the scientists is that we've been on the forefront of the oil search, and now we're rapidly falling behind because of lack of funding to maintain and replace equipment. We want to keep equipment up to the state of the art," Greene says. The multichannel system installed seven years ago, for example, is quite old by electronic standards.

USGS work has been applied basically to resource crises. It was gold when Greene came on board; now it is petroleum, and in the future, he predicts it will be water. Reagan's interest in oil independence probably is a major reason the SOPAC cruise was funded, he says.

"In the future, our research into water resources is going to help. But it is really getting harder and harder to do our job the way we want to do it."

166

Scientists, sailors staff the S.P. Lee

In top-level conference, Bob Rowland, chief of the USGS Pacific-Arctic Branch (left), and the Lee's skipper, Captain Terry Ruff.

Marine Geologist Gary Greene, who initiated the oil exploration project, explains part of the sophisticated navigation system.

Jack Vedder makes a final equipment check. He'll rejoin the staff as USGS scientist in charge of the Solomon Island leg of the cruise.

SOFA UPHOLSTERY Special

INCLUDES!
LABOR, MATERIAL,
Pick-up and Delivery

MOST SOFAS UPHOLSTERED...
$360

CHOOSE FROM OUR
FABULOUS FABRICS!
LARGEST STOCK OF UPHOLSTERY FABRICS ON THE PENINSULA! VELVETS, PRINTS, HERCULONS, BROCADES, ETC., ALL HALF NORMAL RETAIL PRICE! OUR BEST STOCK EVER!

EXAMPLE: HIDE-A-BED OR SOFA.....LABOR.....$250.
WITH 11 YDS. AT HALF NORMAL.....FABRIC.....$110.
RETAIL PRICE... $360

PLUS YOUR CHOICE OF THESE SLOW SEASON INCENTIVES!

FREE SCOTCHGUARD
ON YOUR SOFA
OR TWO CANS OF SCOTCHGUARD!

FREE EXTRA ARM COVERS
OR
THROW PILLOWS

Dan's Upholstery 591-8993
551 TAYLOR NO. 2
BELMONT, CALIFORNIA

TIME FINANCING

NORTH
SOUTH

161

Tonga-relief ship to be loaded Monday

3/19/82

Fifty thousand pounds of Hawaiian relief supplies for storm-stricken Tonga will create cramped quarters for the crew of the U.S. Geological Survey Ship S.P. Lee arriving here tomorrow.

"They said they will take the supplies if they have to put them in their staterooms and showers," said Harry Soukop who, with his Tongan wife, kicked off the relief effort in Hawaii last week.

As a result, Soukop called off an emergency plea for sheets of plastic and canvas tarpaulins to cover the supplies on deck.

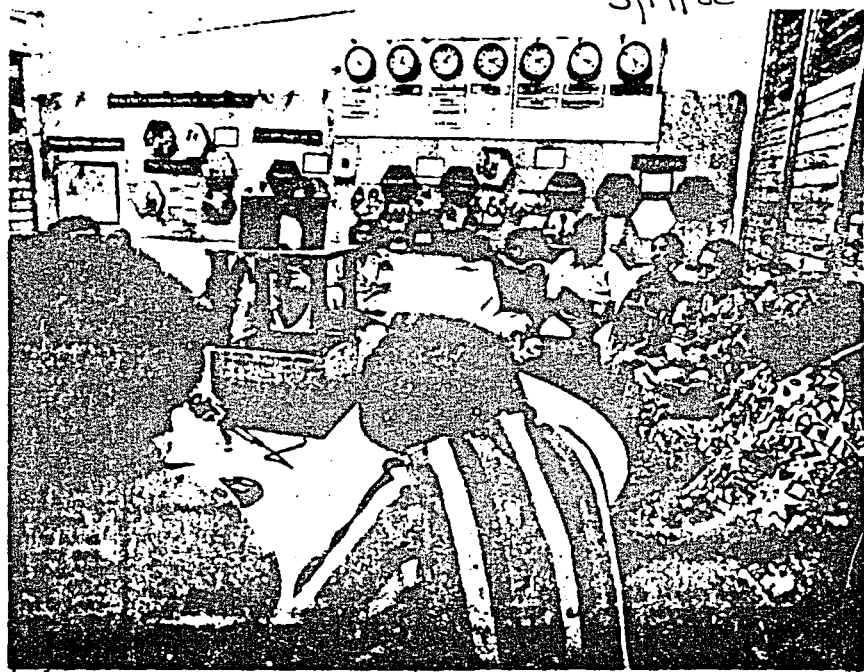
"A lot of my wife's Tongan relatives (she is Kalo Mataele, entertainer and producer) will load the ship on Monday," he said. "We have 1,781 boxes of supplies on hand."

The ship sails on Tuesday and will pick up more than a dozen scientists in Pago Pago, American Samoa, before proceeding to Tonga, making her more crowded than ever.

Soukop said South Pacific Airlines had taken about 10,000 pounds of Hawaii-donated food and clothing to Tonga. Canadian Pacific Airlines hauled a cargo of medical supplies.

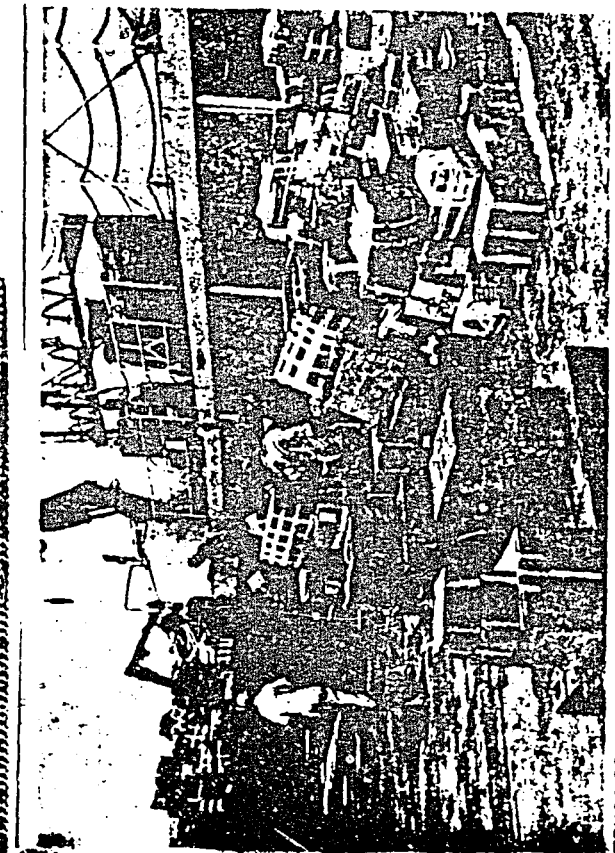
He said he would fly to Tonga on Wednesday to set up the receiving end before the ship arrives. Soukop said he would work with Crown Prince Tupouto'a who heads the Tonga National Disaster Relief Organization.

There will be a Tonga fund-raising benefit at the Hawaiian Hut within a few weeks, Soukop said. Owner Spencer Weaver will donate drinks and pupus and local entertainers will donate talent.



Advertiser photo by Gregory Yamamoto

A group of Hawaii residents listens for the voices of loved ones in recently cyclone-torn Tonga yesterday during a PEACESAT satellite hookup which connected Tongans in New Zealand, Western and American Samoa, the Mainland and here with officials and relatives in Tonga.



TONGA BOUND—Most of the 26 tons of food and clothing donated by Hawaii residents for the cyclone victims of Tonga was loaded aboard the U.S. Geological Survey ship S.P. Lee at Pier 43 yesterday. The crew of the ship offered to stow the 1,700 boxes in all available space, including crew quarters, to get it to Tonga by April. Another 10,000 pounds collected in the relief drive was transported by South Pacific Island Airways. —Star-Bulletin Photo by Terry Luke.

Helping Tonga to Recover

On behalf of the Tongan community in Hawaii, I would like to thank each person who made the effort to donate to our Tongan Relief Drop-off on March 5 and 6 at 711 Keeaumoku St. The press did a commendable job of covering our project and assisting in promoting the collection of supplies. As a result, the response by the community was overwhelming and heart-warming.

In just two days, we collected over 1,500 boxes of food and clothes, totaling in excess of 30 tons of relief supplies. We know, having been in frequent contact with our families in Tonga, just how desperately these supplies are needed. Words of thanks already have arrived from Tonga, thanks to South Pacific Island Airways, which responded quickly with free cargo space to Tonga.

Our families back home tell us that while everyone seems to be managing, we would barely recognize the towns and villages which we grew up in. It is hard to imagine, but we are told that what was once dense brush is now barren land, and our flat islands are covered with pools of contaminated water.

In some villages, only a handful of houses and the churches are left standing, and now provide the housing for the dozens of Tongans who will be left homeless for months to come.

It took more than a week for relief efforts to reach the villages on the less populated and rural islands and portions of the main island, after Cyclone Isaak destroyed their once-secure lifestyle. It looks now, as though, it will take years for Tonga to recover.

Hawaii's contribution to Tonga is not over, but would not have been possible without the initiative and assistance of a few people.

Sen. Andy Anderson was one of the first to soothe our fears by immediately offering whatever assistance he could, including his centrally located, clean, office space at 711 Keeaumoku for the local collection of food and clothes. His office worked to pull together the necessary assistance from the community, and proceeded to follow our efforts with sincere concern all the way through to assuring the transport of everything by ship by the U.S. Geological Survey.

As soon as the Friendly Isles of Tonga are beautiful again, I hope you take the opportunity to visit, and allow the Tongans to repay what you have done for them. I think you will then understand why so many have done so much to help.

Onelua Mataele Wendt

Local Problems

We have been reading a lot about the difficult days ahead for the sugar industry.

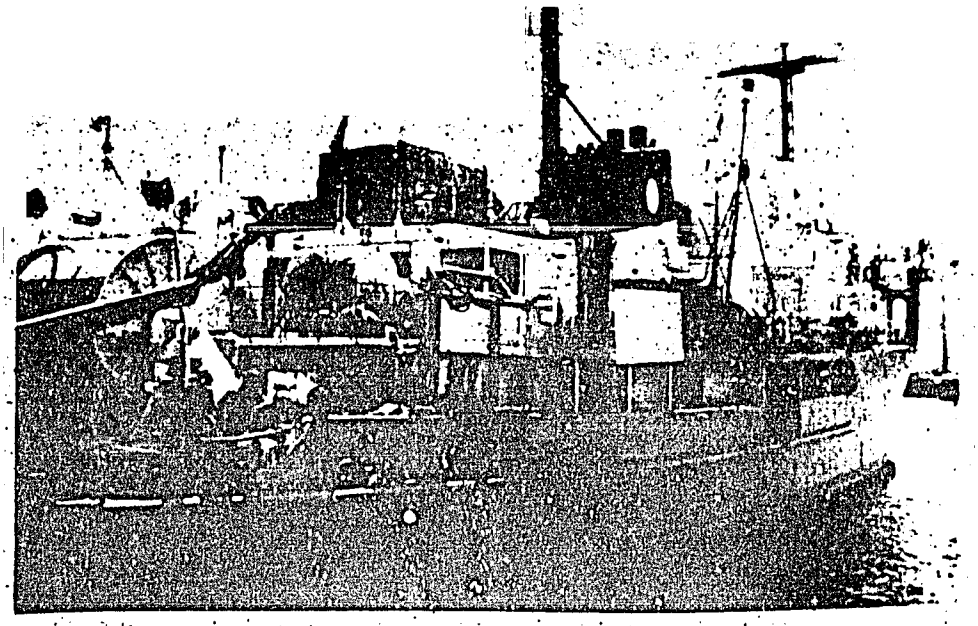
The question is what will the lawmakers do to alleviate the conditions for any industry if difficult days are evident?

Can Hawaii survive without sugar, pineapple, tourism, coffee, etc?

We should find the solutions to these problems. We cannot rely on the federal government. These are local problems.

Lary M. Kamada

169



S.P. Lee departs for Tonga with 35 tonnes of food and clothing. Ko e mavahe mai mei Honolulu 'a e SP Lee mo e uta tokoni afaa toni 'e 35 mei 'Amelika.

GIFT FOR NEEDY

About 35 tonnes of relief supplies for Tonga, on board the Geological Survey Ship, 'S. P. Lee', are due to arrive at Nuku'alofa from Honolulu next month.

Although the ship is not a freighter, Captain Terry Ruff and his 21 crew members have agreed to ship over the relief supplies.

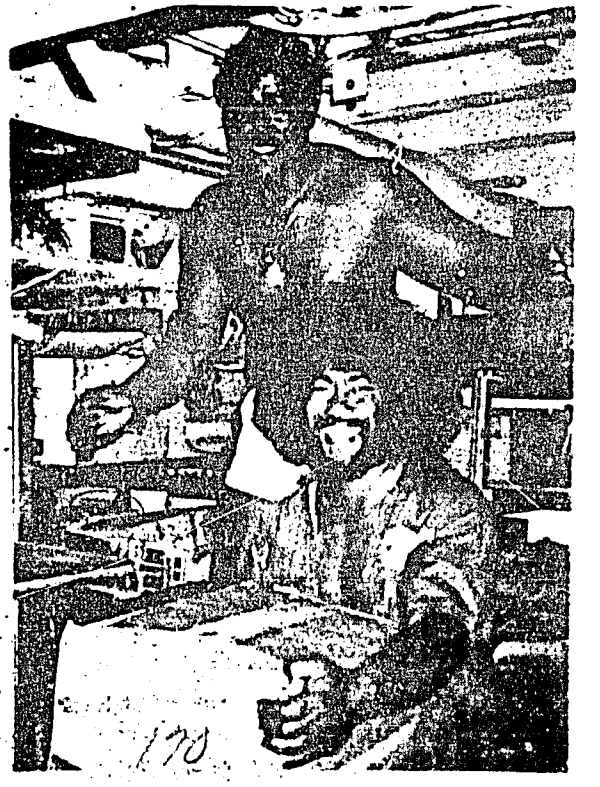
According to Mr Harry Soukop who organised the ship to transport the supplies, the crew is greatly inconvenienced by voluntarily carrying the supplies. "They sacrificed their saloon and some crew members donated their cabin space so that the supplies could get on to Tonga," he said.

"S. P. Lee" is due at Pago Pago next week to pick up 15 scientists to conduct a geological survey in Tongan and Fijian waters for potential off shore mineral exploration.

The Tongan Community in Hawaii donated 90 per cent of the relief supplies which consist of 65 per cent food and 35 per cent clothing. Ten per cent of the supplies were donated by Hawaiian citizens.

Mr Soukop said the Polynesian community in Hawaii is going to stage a fund raising concert for Tonga in Honolulu on April 4.

Part of the Tongan community helped to pass up pack aft pack to be stacked in the SP Lee saloon and also inside t engine room (shown below). Ko e konga eni 'o e kakai Ton 'i he'enau tokoni ke fakaheka nima pe 'a e uta tokoni af 'toni 'e 35.



WCC To Help Tonga

Tonga National Council of Churches, on Tuesday, March 23, officially sent a request for $US500,000 to the World Council of Churches office in Geneva, towards the cost of the following reconstruction programme, according to the Tonga National Council of Churches Secretary, Rev. John Connan,

- seed, spray and insecticide $50,000
- community housing (private dwellings) ...

the Church of Tonga, all the other member churches have outside connections and they can arrange for bilateral funding.

The TNCC, since cyclone Isaac, has had discussions as to what action they should take following the devastation caused by the cyclone.

World Council of Churches had previously telexed $20,000 and Fiji Council of Churches also donated $10,000. From

Council of Churches is buying and despatching seeds which are expected in the Kingdom soon.

Mr Connan said the TNCC is organising a national thanksgiving service to be held on Sunday evening at the Centenary church Nuku'alofa to praise and thank God and also express our thanks to various governments which have generously assisted Tonga since

2 April 1982

Offshore Potential of South Pacific Islands

Dry land is only a fraction, approximately four per cent, of the 12,630,000 square kilometres comprising the total area of eight island countries in the South Pacific. But the surrounding waters and seabeds contain potential marine and mineral resources waiting to be exploited and developed.

The minerals and other resources in the offshore areas of Cook Islands, Fiji, Kiribati, Papua New Guinea, Samoa, Solomon Islands, Tonga and Vanuatu include petroleum, manganese nodules, metalliferous sediments, phosphorites, bauxite, gold and precious corals.

The eight nations, together with New Zealand, form the Committee for Co-ordination of Joint Prospecting for Mineral Resources in the South Pacific Offshore Areas (CCOP/SOPAC).

Established in 1972 by the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), the inter-governmental body helps members in the exploration of their mineral potential. The CCOP/SOPAC Technical Secretariat was established in 1974 at Suva Fiji.

Member countries support the Technical Secretariat, especially in undertaking surveys, by providing personnel, facilities (including ships), equipment and supplies.

Assistance from donor countries, like Australia, France, Japan and United States, comes in the form of funding, shipboard training, ship time, non-reimbursable consultants, gifts and loans of equipment.

The United Nations Development Programme (UNDP) supports COOP/SOPAC activities, which will be reviewed at the thirty-eighth session of ESCAP in Bangkok from March 23 to April 3, 1982.

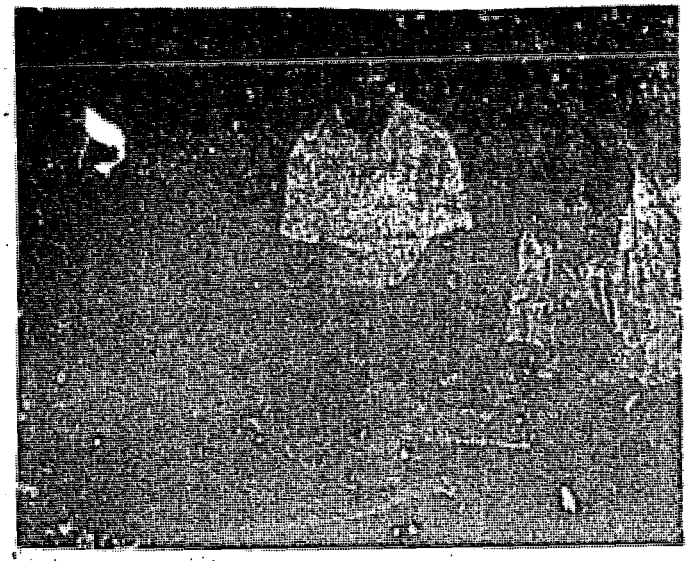
In January 1979, UNDP established a US$2.5 million project, officially known as "Investigation of Mineral Potential of the South Pacific." ESCAP is the executing agency for this project, which a UNDP review mission has recommended for extension for another three years.

Additional financial support in the amount of US$2.3 million will be provided by UNDP.

CCOP/SOPAC began its survey work in 1975. Vessels have been chartered for offshore surveys every year since 1977. Offshore work focused on prospecting for petroleum, manganese nodules, metalliferous sediments, submarine phosphate and precious corals, and, to a lesser extent, on search for offshore gold and submerged bauxite.

A nearshore programme seeking construction materials was launched in 1979 and inshore environmental studies were started in 1980.

Training of member country personnel has been carried out aboard ship, at the Technical Secretariat and at special courses sponsored by the United Nations system. It has also sponsored workshops dealing with offshore and nearshore mineral resources and regional tectonics.



Taniela Tufui, Secretary to Government signing the doc transferred the Telecommunications Training Centre and Vaololoa from the International Telecommunicatio Government. From left to right: Neil Nottage, Technical M ment; 'Anau Falekakala, Head of Training Centre a Representative.

Ko hono fakamo'oni'i eni 'e he Sekelitali 'a e Pule'anga k momoi mai 'o e Senita Ako Fetu'utaki Fakamakoni mo e t naunau 'oku 'i Vaololoa 'nei he International Telecommunic 'anga 'o Tonga. Mei to'ohema Nottage, pule tekinikale 'o e Telefoni, 'Anau Falekakala, 'ulu 'o e Senita mo Ron Linds ITU.

In Tonga, there have been two seismic surveys for petroleum, two for manganese nodules, one for metalliferous sediments, one for phosphorite and four for precious corals. Additional work was clearly justified in the search for petroleum.

The discovery of hydrothermal manganese in deep water south of Tonga, and of manganese on a volcanic island in the North provided encouragement for further work.

A few specimens of precious corals have been found but some potential areas remained unsurveyed.

The search for construction materials has led to three surveys off Tongatapu and the discovery of fine grained sand deposits which, however, needed further evaluation.

Work on land has shown that beach sands should no longer be used for construction material, as they were not being replenished at an adequate rate to meet local demand.

'Pass the
Margarin
please'

TAILULU PROJECT

The Tonga Chronicle

Where Time Begins

Nuku'alofa, TONGA. Friday April 8, 1982. Volume XVIII No. 45 10 seniti.

Tokoni Lahi 'a e Pule'anga

Kuo tali 'e he Fakataha Kapineti 'a 'Ene 'Afio ha ngaahi tokoni fakapule'anga 'i he tafa'aki fakangoue, naunau langa, toutai mo e ako tupu mei he maumau lahi kuo fai 'e he saikolone ko 'Aisake.

Ko e tafa'aki ki he ngoue kuo tu'utu'uni ai 'o pehe:

- ko e kau ngoue fakame'atokoni 'e palau mo tisi ta'eotongi 'a e 'uluaki 'eka 'e taha pea ko e 'eka hono ua mo lahi hake 'e totongi vaeua pe.
- ko e kau ngoue fakapisinisi -- 'e totongi vaeua 'a e 'eka 'e taha 'o a'u ki he 'eka 'e 8¼.
- Ko e tenga'i'akau mo e ngaahi pulopula ke tufa ta'e totongi 'i he mahina 'e ono ka hoko mai.
- pea ki he ngaahi feitu'u 'oku 'ikai ha misini tulekitoa palau mo tisi 'o hange ko e fanga ki'i motu iiki 'i Tongatapu, Ha'apai mo Vava'u ke tufaki ta'e totongi ai 'a e ngaahi huo lafalafa, huo sipeiti, huo langa mo e helepelu.

(Vakai ki hono fakaikiiki 'i he peesi 8)

NAUNAU LANGA

- 'E ta'etotongi 'a e naunau langa 'o a'u hono mahu'inga ki he 'api kolo pe 'api lisi ki ha monomono pe ko e toe langa fo'ou 'o ha fale maumau.
- Kuopau foki ke vakai'i eni mo tokanga'i 'e he 'Ofisi Langa mo Tokoni Afaa 'o fakafou he Potungaue 'o e Ngaahi Ngaue 'o e ngaue 'aki 'a e naunau langa pea kuopau foki ke fakapapau'i 'oku fefeka 'a e sino'i fale 'e he Potungaue 'o e Ngaahi Ngaue.

KO E AKO

- 'E 'ikai ha totongi ako ki he fanau ako mei Vava'u, Ha'apai, Tongatapu mo 'Eua 'i he ngaahi ako'anga 'a e Pule'anga 'i he konga ta'u fakaako hono ua mo e tolu 'o e 1982.

Promising Signs For Oil Survey

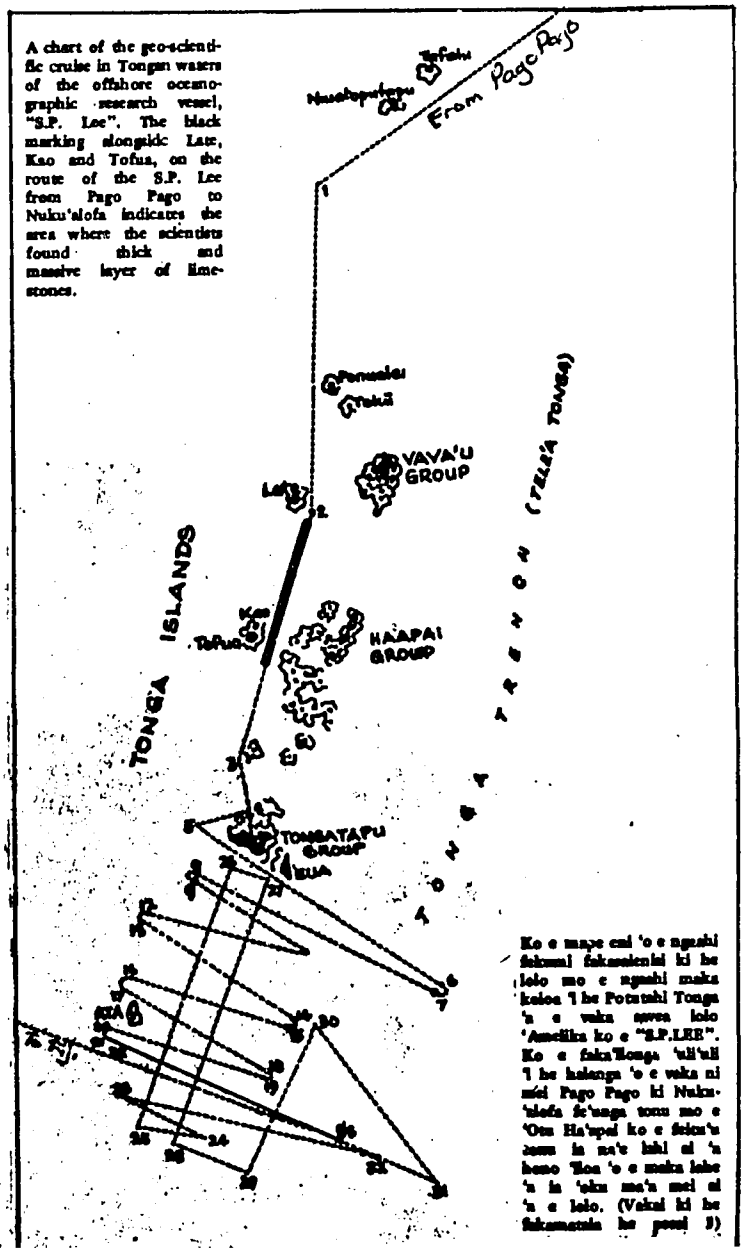
The 18-day offshore geo-scientific survey for mineral resources in Tongan waters has so far shown a promising potential site for mineral exploration at Ha'apai.

The leading scientists from the American Oceanographic reserch vessel "S.P. LEE" have told His Majesty King Taufa'ahau Tupou IV during their audience that they have found a potential site for oil, gas or mineral exploration at Ha'apai.

The vessel, on her way from Pago Pago to Nuku'alofa, cruised over and monitored data from a trench lying north to south between the Tongan volcanic islands which included Late, Kao and Tofua and the coral islands to the east of Ha'apai group which included Mo'unga'one, Fotuha'a and also Ha'ano, Foa, Lifuka and 'Uiha. The data shows that the limestone layer in this area is deeper and thicker, thus indicating possibilities of a resourceful mineral potential offshore area.

Meanwhile the SP LEE is currently cruising in the southern part of Tongatapu. This is the second time that a similiar survey has been conducted offshore in the kingdom. The first was undertaken by a commercial research vessel "Western Islander" hired by Webb Tonga to survey between Tongatapu and 'Eua in September and October 1979.

The offshore exploration for oil in Tonga is not to start until next year because of unavailability of a drilling vessel.



A chart of the geo-scientific cruise in Tongan waters of the offshore oceanographic research vessel, "S.P. Lee". The black marking alongside Late, Kao and Tofua, on the route of the S.P. Lee from Pago Pago to Nuku'alofa indicates the area where the scientists found thick and massive layer of limestones.

Ko e mape eni 'o e ngaahi fakamatala fakasaienisi ki he loto mo e ngaahi maka kaloa 'i he Potutahi Tonga 'a e vaka sovea loto 'Amerika ko e "S.P.LEE". Ko e faka'ilonga 'uli'uli 'i he halanga 'o e vaka ni mei Pago Pago ki Nuku'alofa fe'unga tonu mo e 'Otu Ha'apai ko e feitu'u tonu ia na'e kahi ai 'a hono 'Eua 'o e maka lahe 'a ia 'oku ma'a mei ai 'a e loto. (Vakai ki he fakamatala he peesi 8)

$750,000 From NZI

New Zealand insurance company has paid out T$750,000 for claims against cyclone Isaac damage from about 700 clients in Tonga.

According to the NZI s'gent in Tonga, Mr Keiepi Tupou, the funds were paid to their clients through either the Bank of Tonga or Tonga Development Bank.

The company officials and assessors from New Zealand and Fiji branches are busy making final assessment of the damage caused by the cyclone to their clients' properties in Tongatapu, 'Eua, Ha'apai and Vava'u. They have toured the stricken areas and visited each of their clients in Tonga to receive first-hand reports of the cyclone damage.

The company manager, Mr Graham Wooley, who is based in Suva, is currently in Tonga to make final assessments and payments to their clients.

170

OFFSHORE POTENTIAL MONITORED

TONGA CHRONICLE. April 8, 1982.

Searching for clues which may yield future oil or minerals, an internationally staffed and funded research ship is cruising near the Tonga Trench.

Rising up from the Tonga Trench, the Southern Platform will be extensively surveyed by the American geological ship S.P. Lee, Lying north to south, the Southern Platform will be crisscrossed east to west by the research vessel as it carries out a number of sophisticated tests.

Travelling at about five knots, the boat carries twenty scientist who rotate watch assignments. Their job is to monitor data collected from highly technological equipment. After the information is analyzed, experts can better determine the nature of the rock underneath the ocean and whether oil could be trapped inside.

Included on the research team is Sione Soakai of the Geological Survey, Ministry of Lands and Surveys and Natural Resources in Tonga. His 8.00 a.m. to 4.00 p.m. watch will monitor gravity and magnetic field data. Mr Soakai is a veteran of similar research cruises conducted by New Zealand and France. He said that the assignment of monitoring geophysical data will be new to him.

An international crew including Americans, Australians and New Zealanders will be rotated in the three different legs of the mission. After completing their eighteen day exploration of the Tonga platform, the Lee will head to Fiji for a brief stopover before continuing to Vanuatu and the Solomons for the second and third legs of the mission.

Programme director and marine geologist, Gary Greene, emphasized that the primary goal of the mission was to look for resource potential off Tonga's shores.

"We are not in the business of exploiting those resources, "Mr Greene said. "This is purely a research vessel. If there is potential oil or minerals, it's up to the government and the interested companies to agree on what to do next."

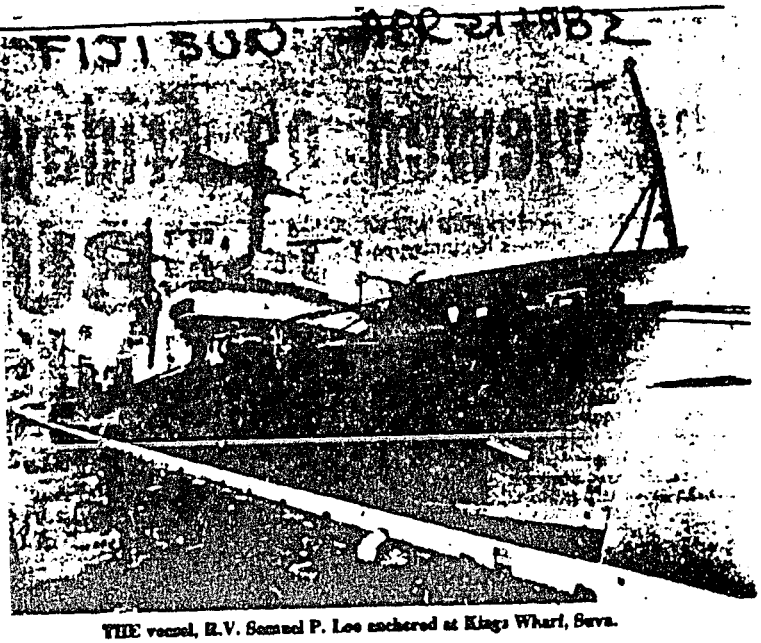
It will take a month before preliminary findings are known. A more thorough report will be presented in August at a geological convention in Hawaii with a final written report available in eighteen months.

Sponsored by the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), the research mission is being funded by the United States, Australia and New Zealand. It is working through the Committee for Co-ordination of Joint prospecting for Mineral Resources in the South Pacific Offshore Areas (CCOP/SOPAC).

Operating cost for the vessel is $10,000 a day. Electronic gear alone is worth an estimated three to four million dollars. It has had extensive cruises along the oil-rich Alaskan coastline along with conducting tests off Oregon and California.

Along with measuring the earth's magnetic field and gravity, the Lee will gather seismic information and collect soil samples from the Tonga Platform. Other tests will be able to determine what kinds of rock lie 2.5 miles below the ocean bed.

173



THE vessel, R.V. Samuel P. Lee anchored at Kings Wharf, Suva.

Largest U.S. oil hunting team surveys S. Pacific

WO United States vessels, R.V. Samuel P. ee and R.V. KanaKeoki involved in a major arch for oil, gas and minerals in the South acific are visiting Suva.

The geo-scientific survey ich involves more than scientists from South ific island countries the ted States, Australia New Zealand began y this month in Tongan ers and is expected to in Papua New Guinea ers in June after ling through Fiji, uatu, and the Solomon nds.

he work is part of a six ne programme involthe two American ela, aimed at better rstanding the mineral petroleum potential of Southwest Pacific.

e work is being finanby Australia, New and and the U.S. and is carried out under the ices of CCOP/SOPAC United Nations supd body based in Suva. e function of CCOP/ AC is to search for ore minerals in the Pacific.

rticipating scientists d the Samuel P. Lee r David Scholl from S Geological Survey r Tun Maung from /SOPAC in Suva.

S.P. Lee is a well ped research vessel 500 tonnes which ly works off the ican west coast, but spend nearly three s in this region g the present ign.

On the recent cruise she concentrated on geophysical work on the southern Tonga Platform, an area of relatively shallow water south of Tongatapu and flanked by the Tonga Trench to the east.

The aim of that cruise was to assess the petroleum potential of the platform, which lies just south of an area under petroleum lease.

A sophisticated seismic system revealed details of the strata as far as 8km below the seabed but a great deal of computer processing is needed before final results will be available.

Complementary information was obtained by dredging the rocks which underlie the platform where they crop on its flanks.

Altogether, high quality seismic data was obtained.

FIRST

The early results of the cruise show that the southern Tonga Platform is a possible petroleum province but the scientists on board have to study and refine their results before making any more definite statements on petroleum potential.

Their report will be presented to the Kingdom of Tonga and subsequently published in a comprehensive CCOP/SOPAC report

• TURN TO PAGE 13

• FROM PAGE 12

within two years of the cruise.

The Marine Biologist with the U.S. Geological Survey team, Dr Gary Greene said this is the first time that the U.S. has gone into such a venture since World War II.

"It's the biggest expedition we've undertaken," he said.

"The Lee is the only government ship outfitted for purely geological and geophysical research.

"Other ships divide their time and efforts among biology, physical oceanography and meteorology as well as geology.

UNIQUE

"Oil industry ships with comparable equipment stick to applied research to meet with specific needs which the Lee integrates applied with basic research aimed at advancing scientific understanding.

"She is a unique ship, and indispensable in off shore exploration.

"It was on a similar ship that USGS scientist, David Scholl discovered the Bearing Sea basin off Alaska shores in 1967.

"Industry had ignored the Bearing Sea because they thought it was just hard bedrock. But Scholl ran a line and discovered a thick sedimentary basin.

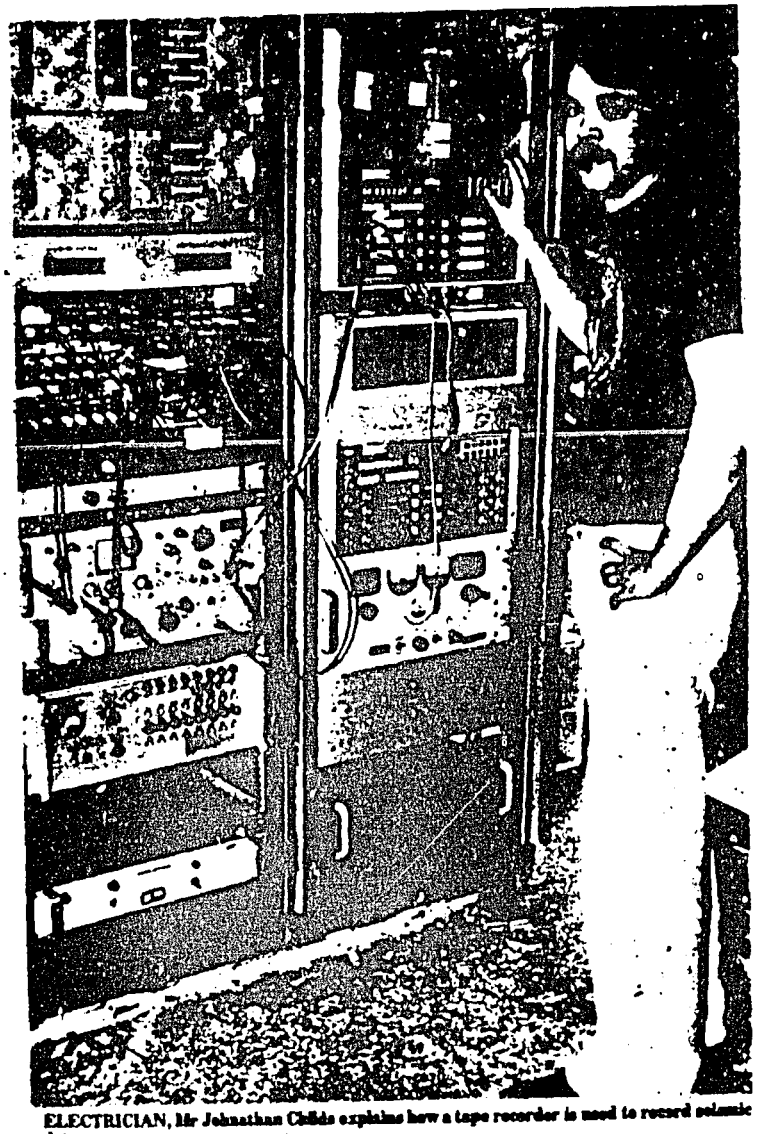
"Since then oil companies have found some of the largest oil deposits in the U.S.

"The South Pacific may have remained unexplored had Tonga not discovered an unexpected oil seep. If it was not for that oil leak, they would still be saying there's no oil in the South Pacific.

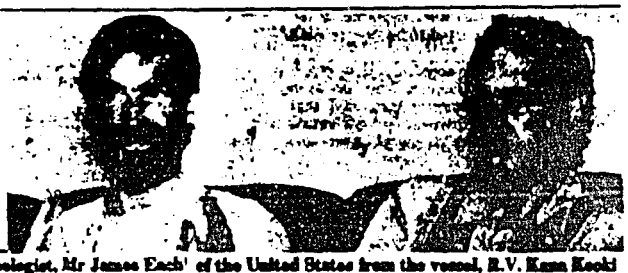
"The Lee carries a crew of about 30 — usually 15 scientists and 15 maritime crew members. The SOPAC cruise is weighted toward scientific staff, which includes electronic technicians."

While in Suva the Lee will be open to public inspection today from 2pm to 4pm.

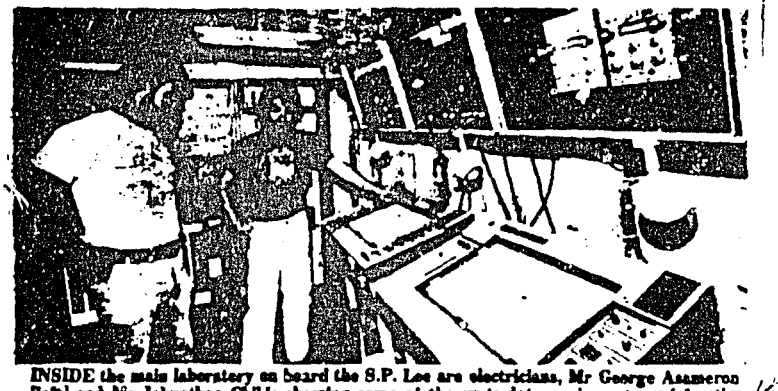
The Kana Keoki is visiting Suva until Friday and the Lee will leave tomorrow.



ELECTRICIAN, Mr Johnathan Childs explains how a tape recorder is used to record seismic data.



MARINE geologist, Mr James Each' of the United States from the vessel, R.V. Kana Keoki talks about the survey while Micropaleontologist from Australia, Dr Alan Carte listens to him on board the vessel yesterday.



INSIDE the main laboratory on board the S.P. Lee are electricians, Mr George Asameron (left) and Mr Johnathan Childs showing some of the up-to-date equipment used for the survey.

174

SOPAC

United States
Department of the Interior
Geological Survey, Western Region
Menlo Park, California 94025

Public Affairs Office — Edna King (415) 323-8111, Ext. 2953

Gail Wendt (703) 860-7444

For release: UPON RECEIPT (Mailed May 7, 1982)

USGS RESEARCH SHIP CRUISES PACIFIC OCEAN FOR ENERGY, MINERAL RESOURCES

The U.S. Geological Survey research ship S. P. Lee is currently on a nine-month cruise in the Pacific Ocean gathering geologic information that may lead to discoveries of new oil and gas resources deep beneath the ocean's surface.

The USGS research vessel, home-based in Redwood City, Calif., is presently (early May 1982) surveying offshore areas around the Republic of Vanuatu (formerly New Hebrides Islands), gathering seismic, gravity and magnetic data. Such data will help USGS scientists evaluate the regional geology and tectonic framework to assess the potential for the occurrence of oil and gas resources, and to assess geologic hazards that could affect exploration and development. The Lee has already surveyed an area around the Kingdom of Tonga.

The S.P. Lee voyage is providing technical support in conventional energy resource identification to Pacific Island governments under the sponsorship of the Agency for International Development, and is conducted under an agreement among the governments of Australia, New Zealand and the United States.

Some of the preliminary results from the current voyage will be given at the quadrennial meeting of the Circum-Pacific Council for Energy and Mineral Resources, August 22-28, 1982, in Honolulu, Hawaii. Some 1,000 international representatives are expected to attend the Hawaii meeting and to exchange information on the many ambitious studies that the various countries are conducting as part of the Circum-Pacific Project.

USGS scientists and others will meet for a briefing Monday, May 10, 1982, at 10:00 a.m. in the Lecture Room of the National Academy of Sciences (2101 Constitution Ave., NW, Washington, D.C.) as part of a four-day working session on the Circum-Pacific Map Project.

The Map Project -- probably the largest undertaking of its kind -- will map the ocean floor and the continental margins of the Pacific basin, which covers more than half of the Earth's surface. Results of this ambitious mapping effort will aid in the search for critically needed mineral and energy resources and will increase our understanding of the resources, and of earthquake and volcanic hazards in this geologically volatile area of the world.

As an example of new mineral deposits that can occur in the Pacific Ocean, a team aboard the S. P. Lee last fall found rich metal deposits of zinc, copper, silver and other critical minerals 7,000 feet below the ocean surface on the Juan de Fuca ridge 250 miles off the Pacific Northwest coast. The discovery was hailed as one of "the most exciting events for U.S. marine geologists in recent years."

The South Pacific leg of the cruise will end about June 11 in Rabaul (formerly New Britain). The S. P. Lee will then head to the Bering and the Beaufort seas to conduct additional geologic investigations on the U.S. Outer Continental Shelf.

# # # #

Photo no. 81-240 — Photo credit: U.S. GEOLOGICAL SURVEY

175

the Broadsword and the Brilliant -- in the battle group. They have the much more modern Sea Wolf antimissile missile systems featuring highly sophisticated Marconi Ltd. radars.

Sea Wolf is comparable to the U.S. Navy's Aegis battle-management air-defense radar system which first went to sea last year aboard the CG-47 class cruiser Ticonderoga. The Aegis system, incorporating General Dynamics Standard ER (extended range) and Standard MR (medium range) missiles will be deployed on all such cruisers, two of which are requested, at $1.1 billion, in the FY83 defense budget. Moreover, the Navy also is starting to deploy the General Dynamics Phalanx system -- radar-controlled rapid fire cannon -- for point defense against any missiles which slip through the F-14s and the medium-range and short-range missiles.

But as of now, the air-defense systems on most Navy ships are very old ones, based on radar and missile technologies dating back to the 1960s. "We'd be in very tough shape against a massed missile attack," asserts one Navy source, contrary to the official claims of the brass for public consumption. Adds a very high-ranking Defense Dept. civilian official: "The Navy has done a great job in antisubmarine warfare but it's 'way behind the curve in its ability to defend surface combatants against missiles."

Many analysts agree that the harshest fact for the U.S. Navy -- and all navies -- to face, amid the arguments and counter-arguments over defensive measures, is this: missiles and torpedoes will continue to improve in accuracy, range and explosive power, while surface combatants get bigger and easier to find and hit, if not necessarily to sink.

But a carrier need not be sunk. All an attacking missile force need do is put its flight deck out of commission, leaving its interceptors and attack aircraft unable to take off or land. "As if it needed proving," says one Pentagon official, "the Exocet incident demonstrated that all navies are up against the new age of missiles." And by the year 2000, he and others predict, there will be "no way of sustaining surface fleets without bankrupting the defense budget to pay for their defense."

USGS RESEARCH SHIP S. P. LEE IS ON A NINE-MONTH CRUISE IN THE PACIFIC. Currently the vessel is in the New Hebrides (now identified as the Republic of Vanuatu); the ship has already covered the area around the Kingdom of Tonga. Preliminary results of the voyage will be presented at the 22-28Aug82 meeting of the Circum-Pacific Council for Energy & Mineral Resources in Honolulu. The Lee is looking for oil.

Meanwhile, earth scientists from 25 nations are working on the Circum-Pacific Map Project, an eight-year-old venture which, says the U.S. Geologic Survey, should produce a "better understanding of the potential resources locked deep beneath the ocean's surface and help in mitigating the earthquake and volcanic hazards in this geologically volatile area of the world." Map project scientists recently met in Washington DC.

NAMES IN THE NEWS: PROF. JOHN E. (JACK) FLIPSE WAS ELECTED to the Natl. Academy of Engineering. Flipse is at Texas A&M Univ., College Station.... L. Donelson Wright of The Univ. of Sydney, Australia, has been appointed professor of marine science and chairman of the Dept. of Marine Geology at the Virginia Institute of Marine Science, Gloucester Point.... Fritz Huntsinger Sr. received the 1982 Offshore Technology Conference Award for Individuals. He is the founder and chairman of Vetco Inc., Ventura CA, and was honored for his "50 years of technological achievements and for his contribution to the development of subsea wellheads, blowout prevention equipment, control systems, and marine conductors for offshore drilling and production operations".... The tenth Rosenstiel Award in Oceanographic Science went to Prof. Anthony B. Watts, Lamont-Doherty Geological Observatory, Columbia Univ., New York.... Lt. Cmdr. Wayne L. Perryman has been named commanding officer of the NOAA ship Chapman, the newest vessel in the fleet of the Natl. Oceanic & Atmospheric Administration. She is a 127-ft. fisheries research vessel.

OCEAN SCIENCE NEWS is published weekly by Nautilus Press Inc., Washington DC @ $235 per yr. Edward W. Scripps II, Publisher & Board Chairman; John R. Botzum, President; Jerald G. Clemans, Vice President-Marketing; Frank Capra Jr., Vice President; John J. Mullane Jr., Secretary-Treasurer. OSN editorial staff: Editor: John R. Botzum; Associate Editors: Martha

Iran's War Successes Threaten Neighbors

By DeVan L. Shumway

AN UNEXPECTED side effect of the Iran-Iraq war, entering a critical new stage, involves Saudi Arabia, and whether this stalwart U.S. ally in the Middle East faces a new threat to its political stability.

In the past, discussions of threats to Saudi Arabian stability have centered on two primary theories:

- That the kingdom eventually was going to be torn apart in an Iranian-type revolution that would take it from friendship to enmity toward the U.S. in much the same pattern as Iran, which not long ago was a U.S. ally in the Middle East. That scenario generally is not accepted as valid by persons who have closely examined the history and culture of Saudi Arabia and know the strength of the royal family.
- That ultimately the Soviet Union would tighten its ring of influence around the Arabian Gulf — a program that seems to be succeeding — and find a way to subvert the Saudis. The Soviets have extended their influence in the region through Afghanistan and Iraq, but the communist giant hasn't made perceptable headway in Saudi Arabia.

The alleged new threat to Saudi Arabia comes from the fact that the tide has turned in the Iran-Iraq war toward the Iranians, who say they'll continue marching into Baghdad and install their type of fundamentalist Islamic regime in Iraq. That is seen as a threat to the Gulf's more conservative states, most particularly and importantly Saudi Arabia.

Repeatedly, Iran has warned members of the Gulf Cooperation Council, such as Saudi Arabia, Qatar, the United Arab Emirates, Bahrain, Kuwait and Oman, that it will spread the war to their territory if they continue aiding Iraq. The GCC is trying to form and initiate a unified Arab stand toward the Iran-Iraq war.

Finally, the Reagan administration is becoming concerned about the effect of the war in the strategically important Persian Gulf. It was that concern which led Secretary of State Alexander M. Haig Jr. to say in a speech at the Chicago Council on Foreign Relations that the U.S. intends to assume a more active role in trying to find a road to peace.

Is there danger that the Khomeini government, if it succeeds in winning the war that Iraq began, will decide now is the time to spread its fundamentalist sectarian religion to other nations of the gulf through force of arms? Certainly there is such a danger, but such acts — either through military or political subversion means — certainly would result in the threat of a direct counter-response from the U.S.

However, it may be a recognition of such a potential threat that's awakening the Reagan administration to the new status of the Iran-Iraq war. Or perhaps it was a statement by Ayatollah Khomeini warning the Gulf nations to stop what he sees as obedience to the United States. "You must realize that the superpowers will not support you as much as they helped the criminal Saddam (Iraqi President Saddam Hussein)," he said. "They will sacrifice you for their own interests. I have a piece of brotherly advice for you — do not do anything which will oblige us, under the tenets of the Koran, to treat you according to divine law."

Ship's Pacific Research Will Be Topic at Conference

By Marvin Murphy
Oil Daily Staff Writer

SCIENTISTS reporting on the voyage of the research ship S.F. Lee at a 32-nation Pacific energy conference in August will have more to talk about than their primary mission, the hunt for signs of oil, gas and minerals.

The Lee has been harassed by a Soviet trawler off Alaska's Kodiak Island, took emergency supplies to storm-swept Tonga Island and found strange sea creatures swimming through boiling water off the Oregon coast.

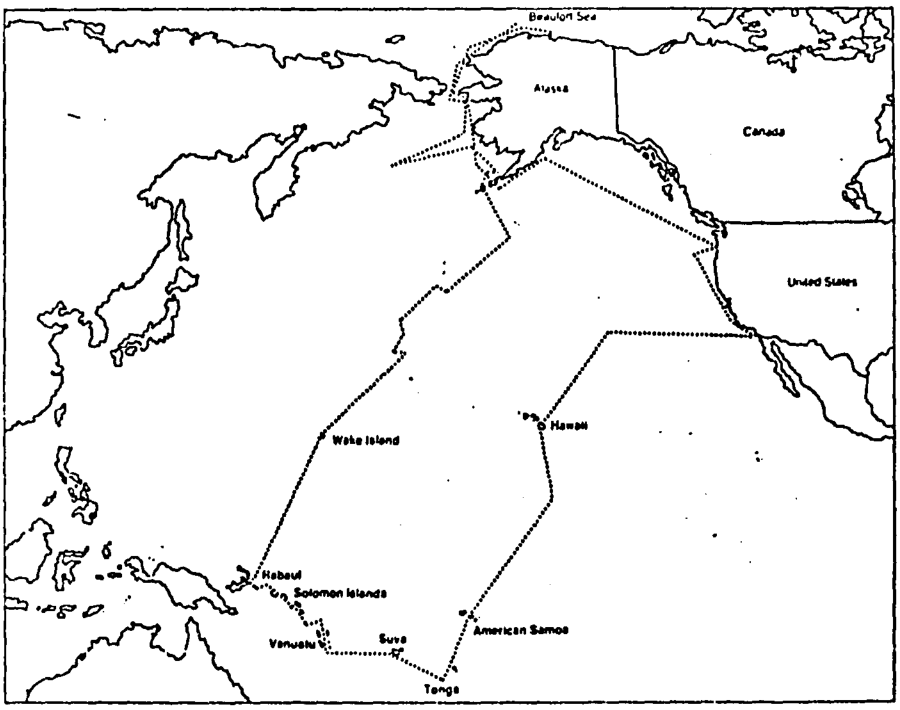
Gary Greene, marine geologist with the U.S. Geological Survey, will head a team of scientists reporting on the Pacific leg of the S.F. Lee's nine-month cruise. They will discuss the trip to about 1,000 people expected to attend the Circum-Pacific Council for Energy and Mineral Resources conference in Honolulu Aug. 22-28.

Greene, deputy chairman of the conference and one of 20 scientists aboard the ship, recently came home to prepare his Aug. 26 report to the conference.

The survey is being conducted under the auspices of the United Nations, with help of agencies in the United States, Australia and New Zealand.

While trailing a two-mile-long drag line equipped with seismic sensing hydrophones, the Lee narrowly averted a collision with a Soviet trawler during a cruise several years ago off Alaska. Ship Capt. Terrence Ruff said the Soviet vessel veered at the last minute.

Ruff said the Lee kept coming despite repeated warnings that it had been trailed one whole day and had been photographed repeatedly. During operations in the Alaskan area, the ship found oil-bearing rock in the Bering Sea and hydrocarbon potential in the Navarin Basin.



HUGE AREAS OF THE PACIFIC are indicated in a map showing the route of the research vessel S.F. Lee as it studies the oil, gas and mineral potential of the Pacific. The voyage's findings will be discussed at the Circum Pacific Council for Energy and Mineral Resources conference in Honolulu Aug. 22-28.

Last March, the ship began what the USGS hailed as the first extensive survey of the Pacific Ocean south of Hawaii — a voyage that would last nine months, taking it to Hawaii, Tonga, the Solomons, Fijis, American Samoa, and Vanuatu (formerly New Hebrides Islands).

After the South Pacific portion of its mission, ending about June 11 in Rabaul (formerly New Britain), the Lee will head for the Bering and Beaufort Sea, off Alaska, for further seismic work — returning to its home base in Redwood City, Calif., in October.

Shortly after leaving California, it received an emergency call for help in transporting food and clothing donated by Hawaiians after the kingdom of Tonga, near Fiji, was struck by Cyclone Isaac, leaving thousands homeless.

After delivering its cargo, scientists and the crew were invited to meet the king. Fortunately for the men, normally dressed in shorts and T-shirts, there were a few nicely pressed Merchant Marine uniforms aboard for the official ceremonies.

Undersea Springs

While operating 280 miles off the Oregon coast last year, it discovered a volcanic hot springs with crab like and worm-like creatures in near 400-degree Celsius temperatures. The area, believed to contain rich deposits of zinc, copper, silver and other critical metals, has an "incredible resource potential," said Ruff.

The Pacific conference is sponsored by the American Association of Petroleum Geologists, six other related organizations, and is supported by 42 scientific groups in countries along the Pacific.

China will send a representative to the conference for the first time. Other major speakers at the meeting — held every four years during the past 12 years — will come from the U.S., the Soviet Union, Indonesia, Australia, Chile, and Canada.

More than 175 reports will be given at the conference, said J. Erick Mack Jr. of Union Oil Co., general chairman. Mike Halbouty, Houston geologist, is chairman of the council and honorary chairman of the conference.

During the meeting, details of a 10-year mapping project involving 190 geoscientists from 27 Pacific countries will be released. Data obtained during the mapping, containing detailed information on the sea floor contour, shore lines, energy and minerals, geothermal and volcanic activity, and other technical matter is being put on a USGS computer.

THE
OIL DAILY
The Daily Energy Newspaper
Founded 1951
Published Every Business Day
By The OIL DAILY INC.

KEITH J. FANSHIER
President and Founder
59 E. Van Buren St.
Chicago, Ill. 60605
312 922 7654

DeVAN L. SHUMWAY
Editor & Publisher
1301 Pennsylvania Ave. N.W.
Suite 1010
Washington, D.C. 20004
202 638 5150

PETER J. GAFFNEY
General Manager

JOHN A. MOORE
Associate Editor

NICK SNOW
Managing Editor

EDITORIAL OFFICES
WASHINGTON, D.C. John A. Moore, Associate Editor, Nick Snow, Managing Editor, Vince Reichart, Assistant Managing Editor, Sharon Penny, Assistant Editor Special Issues, Marvin Murphy, Senior Correspondent, S. Lawrence Paulson, Bureau Chief, Marcy Gordon, Staff Writer, Susan L. Hahn, Staff Writer, Donna Smith, Staff Writer, Anita Jenkins, Editorial Assistant, 1301 Pennsylvania Ave. N.W., Suite 1010 20004, 202-638 0812. Telex 89-4.2 HOUSTON Gene Wilburn, Bureau Chief, Jim Drummond, Special Correspondent, 1230 Americana Building, 77002, 713 652 3870. LOS ANGELES Jane F. De Lorenze, 325 N. Jackson, 6, Glendale, Calif. 91206, (213) 243 4600. NEW YORK Bruce Fraser, Bureau Chief, 850 Third Ave., 10022, 212 759-1629. CALGARY Tom Kennedy, Correspondent, 403 262 2777. The Oil Daily also maintains correspondents in significant foreign and domestic cities.

PRODUCTION COORDINATOR
Richard Styles
P.O. Box 1926, Des Plaines, Ill. 60018
312-296-7311

ADVERTISING SALES
DONALD F. O'BRIEN, District Manager, 850 Third Ave., New York, N.Y. 10022, 212 750 1626. DAVID NEIMAN, Suite 215, 10400 West Higgins Rd., Rosemont, Ill. 60018, 312-298-6495. DON STRONG and ROBERT L. LINSMIER, District Sales Managers, 1230 Americana Building, Houston, Texas, 713 652 3870. DICK FAUST, Sales Representative, 2600 Madison Street, Suite 100, Torrance, Calif. 90503, 213 373 9641. TADASHI MORI, Sales Representative, Media Sales Japan Inc., Tamiracho Bldg., 3 3 14 Shimbashi, Minato-Ku, Tokyo 105, Japan. KEN McKINLEY, Marketing Consultant, New York City. LAURA STEPHAN, Advertising Production, Washington. INGEBORG SCHMIDT, Classified Advertising Manager, New York City, 212 750 1027

EDITORIAL ADVISORY BOARD
FRANK IKARD
Chairman
(Former President, the American Petroleum Institute)

THEODORE R. ECK, chief economist, Standard Oil of Indiana, Chicago, Ill.; D. TRUITT DAVIS, CPI Oil and Refining Inc., Abilene, Texas; MICHEL T. HALBOUTY, Halbouty Associates, Houston, Texas; JOHN H. LICHTBLAU, executive director, Petroleum Industry Research Foundation Inc., New York; SHIGERU MASUDA, president, S. Masuda Inc., New York; JOHN J. McKETTA, Department of Chemical Engineering, University of Texas at Austin; C. JOHN MILLER, president, Independent Petroleum Association of America, and president, Miller Brothers Oil Corp., Allegan, Mich.; DONALD C. O'HARA, president, National Petroleum Refiners Association, Washington, D.C.; W. H. QUORTRUP, president, National Oil Jobbers Council and president, Quortrup Petroleum Products Inc., Carrollton, Texas.

Member
Audit Bureau of Circulation
© 1982 The Oil Daily Inc.
All Rights Reserved

The Oil Daily Inc.
is a subsidiary of
WHITNEY COMMUNICATIONS CORPORATION

JOHN HAY WHITNEY
(1904-1982)
Chairman

WALTER N. THAYER
Chairman

CHARLES H.G. REES
President

JOHN S. PRESCOTT
President
Magazine Division

SUBSCRIPTIONS: $277 per year. Foreign rates on request. Send orders and address changes to Circulation Dept., The Oil Daily, 850 Third Ave., New York, N.Y. 10022 or phone 212 541 2100 or 800 223 6033

177

New Pacific Basin Map Could Aid Resource Search

By Edward Ladica
Special to The Asian Wall Street Journal

WASHINGTON – International scientists have nearly completed a geological profile of the Pacific Basin that could aid in the search for "critically needed" energy and mineral resources, U.S. Geologic Survey officials have announced.

"It's probably the biggest map-making project in history," asserts Dallas Peck, the federal agency's director. "We've assembled several hundred earth scientists from 25 different countries to chart an area that covers more than half the Earth's surface."

The results so far are "amazing," Mr. Peck says. The Pacific map, eventually will be published in a total of 43 separate formats and detailed segments. The map compiles earlier discoveries of seabed minerals and subterranean oil and gas and also indicates the probable location of other such troves through the interpretation of geological data.

Besides its potential commercial value, the project's analysis of fault lines, seismic zones and other crustal features will help the Pacific countries "minimize the hazards of natural disasters like earthquakes and volcanic eruptions," by enabling agencies to provide better advance warnings, Mr. Peck says.

Some of the project's findings will be reported to a conference of the Circum-Pacific Council for Energy and Mineral Resources, an international body that organized the project. The meeting will be held Aug. 22 to 28 in Honolulu.

The council is supported by the U.S. Geological Survey, several major international oil companies and geological societies from the several countries.

Related Research

Eighteen of the 43 charts are already available to scientists and exploration companies through the American Association of Petroleum geologists, a Tulsa, Oklahoma, professional body that's assisting the council.

The Pacific project, started in 1973 at the initiative of U.S. scientists and oil companies, has spun off a number of related research activities.

For instance, it has encouraged the U.S. government and United Nations agencies to support the first detailed study of hydrocarbons in areas off Tonga, the Solomon Islands and Vanuatu, formerly the New Hebrides Islands. These South Pacific islands lie on the same geological-plate boundary where productive Indonesian oilfields are situated.

A U.S. Geological Survey vessel, the S.P. Lee, has completed soundings off Tonga and is accumulating seismic data off Vanuatu and the Solomons. The Redwood City, California-based research ship is the same one that recently found rich deposits of zinc, copper, silver and other minerals 400 kilometers off the U.S. Pacific Northwest at depths of 2,100 meters.

The results of the South Pacific survey will be reported at the Honolulu conference. If the data indicate possible hydrocarbon deposits, oil companies could be induced to apply for exploration rights, the council's spokesmen say.

Cooperative Effort

The cooperative effort has also led to the signing of three U.S.-Chinese scientific agreements that will involve 31 joint-research projects and the exchange of more than one hundred scientists between the two countries. Among other things, the two nations will work together on earthquake-prediction methods, coal-basin exploration and drought and flood studies.

"We're newcomers to earth sciences compared to the Chinese," a U.S. Geological Survey spokesman says. "They've been working in this field for thousands of years."

By pinpointing the likeliest mineral locations, the map-making project could significantly reduce the cost of future exploration, the council says.

"Three conditions have to be met before an area can be judged to be worth prospecting," explains Donovan Kelley, a Geological Survey official. "It has to have the right kind of rocks, a history of temperature and pressure needed to cook the raw materials for fossil fuels and geological structures in which those fuels could be trapped."

Union Oil Signs Pact to Develop Thai Gas Fields

Special to The Asian Wall Street Journal

BANGKOK – Union Oil Co. of California and two Japanese partners signed a contract with the Thai government that will result in a $1.6 billion investment to bring new natural-gas fields into production.

The 25-year sales contract marks a major step forward in Thailand's bid to slash 30% to 40% off its costly oil-import bills. By the end of 1986, Union Oil and its partners expect to provide between 550 million and 650 million cubic feet of gas a day, up from about 140 million now being supplied under a 1978 agreement. Thai industry is expected to use the gas, which will be taken from the Gulf of Thailand.

Union Oil said it and the two Japanese partners will invest $1.4 billion in bringing the new fields into production. The Petroleum Authority of Thailand, the government agency that will buy the gas, said it will invest $200 million for a 42-kilometer pipeline to connect the fields with an already-operating 425-kilometer pipeline that transports gas from other fields to shore.

The contract covers gas from four blocks in the Gulf of Thailand concession held by Union Oil and its partners.

Union Oil has an 80% interest in each of two of the four blocks, while South East Asia Petroleum Exploration Co. of Japan holds 20%. The U.S. company holds 60% of each of the other two blocks and Mitsui Oil Exploration Co. of Japan holds 40%.

In 1978, Union Oil and Thailand signed a 25-year contract covering one field. Production at that field, Erawan, began last September but has been below contract levels because of technical problems. Petroleum authority officials said Union Oil currently is supplying between 140 million and 150 million cubic feet of gas a day instead of the contracted 200 million. Production is expected to reach 200 million cubic feet by September and 250 million cubic feet by the end of the year, they said.

Under the new contract, Union Oil and its partners will supply an additional 150 million cubic feet a day beginning in 1985 and more later. The price at which Thailand is buying gas under the second contract hasn't been disclosed, but sources said it is about $2.25 per 1,000 cubic feet during the first year of production. The petroleum authority is buying Erawan gas at $2.20 per 1,000 cubic feet for the first year of that field's production.

Italian Auto Makers Want BL's Car Labeled as Japanese, Not British

Special to The Asian Wall Street Journal

ROME – The Italian auto industry is contesting the nationality of a car, and the dispute may affect future Japanese ventures in Europe.

The car is the Triumph Acclaim, which is made in the United Kingdom by BL PLC of Britain under license from Honda Motor Co. of Japan. The model uses some Japanese parts.

BL says its Triumph Acclaim is British, but the Italian auto industry association claims it is Japanese. The question of nationality is important because Italy limits imports of Japanese automobiles to 2,500 a year. BL plans to sell 4,500 Acclaim models in Italy over the next 12 months.

Italy's Foreign Trade Ministry says it is examining the car's origins and may use the information it garners as a basis of a protest to the European Community's executive commission.

Italy apparently would have a hard time making its case because the pertinent EC regulation states that a product's origin is the country where the final and most important production process takes place. Not only is the Acclaim assembled in Britain, by BL says 70% of its parts are British.

But 70% apparently isn't enough for some Italian auto makers. "We are opposed to this car's entry into the Italian market because its contents don't reflect what we consider to be the proper level of European participation," says Cesare Romiti, managing director of Fiat S.p.A., Italy's largest auto maker. He says a car should be 80% European.

Other Italian auto industry leaders have disputed BL's 70% figure and say the car is only 60% British and that that isn't enough.

One Italian auto industry insider says that Italy isn't really interested in winning its case against the Acclaim but is more concerned about "the entire issue of Japanese products coming into Europe under cover of joint ventures such as these."

A top auto industry association official agrees. "I think we have the general support of other Common Market members in rethinking what constitutes a European product in these situations," the official says.

Friction over the Acclaim heated up in April when shipments were held up in North-

178

USGS Research Vessel To Explore Pacific

by Tony Hatch

REDWOOD CITY, Calif. — Hot streams of water, a lode of valuable metals, eerie sea creatures and even some harassment from foreign ships may all be part of a voyage of the Samuel P. Lee.

The Lee is a 210-foot research vessel operated by the USGS based here. The converted Navy ship sailing with 20 scientists and a crew of 22 on a nine-month cruise encompassing Hawaii, the Solomons, the Fiji Islands, American Somoa, Vanuatu and finally north to the Beaufort Sea before returning to California in October.

According to USGS marine geologist Gary Greene, this is the first time the Survey has extended an exploratory mission south of the Hawaiian Islands.

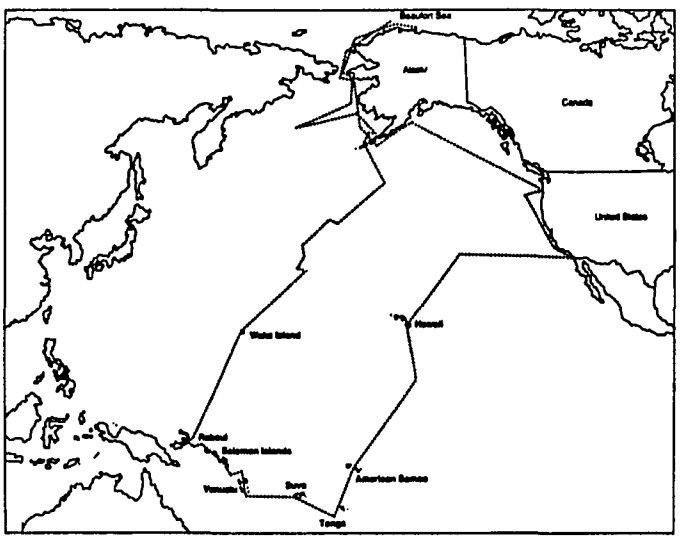
Greene, deputy general chairman of the Circum-Pacific Energy and Mineral Resources Conference, to be held Aug. 22-28, said that findings made on the Lee's voyage will be made public at this summer's conference in Honolulu. International earth scientists representing nations having an interest in the vast Pacific Basin are expected to attend.

The Lee, said Greene, will search for oil, gas and mineral deposits in the Pacific.

Seismic surveying will be done by using a compressed air sound source to produce echos from rock layers beneath the sea floor. The echo effects are monitored by hydrophones towed by cable near the surface two miles astern of the Lee. The data is processed by on-board computers as the vessel zigzags on its course across the Pacific.

The Lee's captain, Terrance Ruff, a 25-year veteran, recalled a 1977 cruise in waters south of Kodiak Island, Alaska, when Russian trawlers headed straight for his ship, only to veer away at the last minute. Ruff explained that the Lee has little maneuvering room while the seismic towing apparatus is deployed behind his vessel. The Lee, he said, has — in addition to customary international flag and light signals — specially recorded radio messages in foreign languages to warn other shipping away from his vessel.

Members of the crew also recall other times when they've been shadowed by foreign submarines and naval photo ships. On one occasion, said Ruff, a photo vessel spent nearly a whole day shooting pictures "up one side of the Lee and down the other."



The scheduled nine-month voyage of the Samuel P. Lee.

The results of the research vessel Samuel P. Lee's findings will be made public at the Circum-Pacific Energy and Mineral Resources Conference, Aug. 22-28, in Honolulu.

Minerals And Strange Sea Creatures

As part of this year's assignment, the Lee will also explore an area of the Pacific for manganese nodules — which could lead to potential mining of that strategic mineral — and others.

On a voyage last year, scientists on the ship discovered a volcanic "vent" which they believe could reveal a lode of silver, zinc and copper. The volcanic hot springs, apparently sustaining an assortment of strange-looking sea creatures, was discovered approximately 280 miles off the Oregon coast in a section of the rugged mid-ocean ridge system called the Juan de Fuca rise. The sea creatures living near the 400 degree (Celcius) spring included crab-like and worm-like animals.

According to one of the Lee's scientists, the oceans have "an incredible resource potential — resources we didn't even know we had 10 years ago."

The energy and mineral potential of the Pacific will be the prime subject among one thousand or more scientists and authorities who will meet in Honolulu. Among the nations represented will be the United States, the Soviet Union, Mexico, the Philippines, Australia, Japan and — for the first time — China.

At least 42 scientific organizations in North and South America, Asia and Europe will take part.

Rifle Is Employed For Seismic Shots

LAWRENCE, Kan. — Use of a .22-caliber rifle has helped produce seismic records to find shallow water, according to the Kansas Geological Survey here.

Don Steeples and Ralph Knapp, both with KGS, have been able to detect water-bearing formations as shallow as 25 feet underground. The rifle, mounted on a holder, is shot directly into the ground, producing clearer seismic records than other sources of vibrations, the geologists said. Conventional seismic shots usually do not detect formations within 100 feet of the surface they said.

As well as aiding shallow water prospecters, the method could be used to indicate the nature of shallow rock formations intended to provide foundations for buildings and dams, according to Steeples and Knapp.

Study Reviews Mineral Usage

In 1980, nearly 9,000,000 tons of industrial minerals worth well over $750 million were used in oilwell drilling and completion operations, according to a recent study by Gorham International, a contract research and development firm based near Portland, Maine.

In 1981, as a result of the increase in world drilling activity, mineral demand has surpassed all expectations, and growth is forecast to continue at an average annual rate of 13 percent through 1985. By 1990, the market is estimated to be nearly triple the present size and be worth almost $2 billion in constant 1980 dollars.

Barite and bentonite continue to dominate the list of over 20 minerals required by drilling and well service companies. However, as cost pressures fuel the search for more effective drilling fluid components, minerals such as hematite, ilmenite, calcium carbonate, mica, salt and silica, among others, are showing excellent potential for specialized end uses.

The just-completed Gorham study warns of possible bottlenecks, delves into probable changes in the state-of-the-art, and suggests strategies to tap the volatility and rapid growth of the world drilling market. The report also provides a detailed mineral-by-mineral analysis and a long range market and technical forecast, as well as covering the status of the competitive situation and distribution problems.

For more information on "Industrial Minerals for Drilling Mud and Well Completion Markets," contact: Dr.

RMAG Elects New Executive Officers

DENVER — The Rocky Mountain Association of Geologists has announced 1982 Executive Board elections.

Joining president Joseph Hull (LF '53), Ensource Inc., are David B. Mackenzie (AC '57), Marathon Oil Co., president-elect; James D. Lowell (AC '56), consultant, first vice president; Edward D. Dolly (AC '65), consultant, second vice president; and Nancy Darnell (JR '74), Nova Petroleum, secretary.

Peter F. Coffin (AC '67), Merit

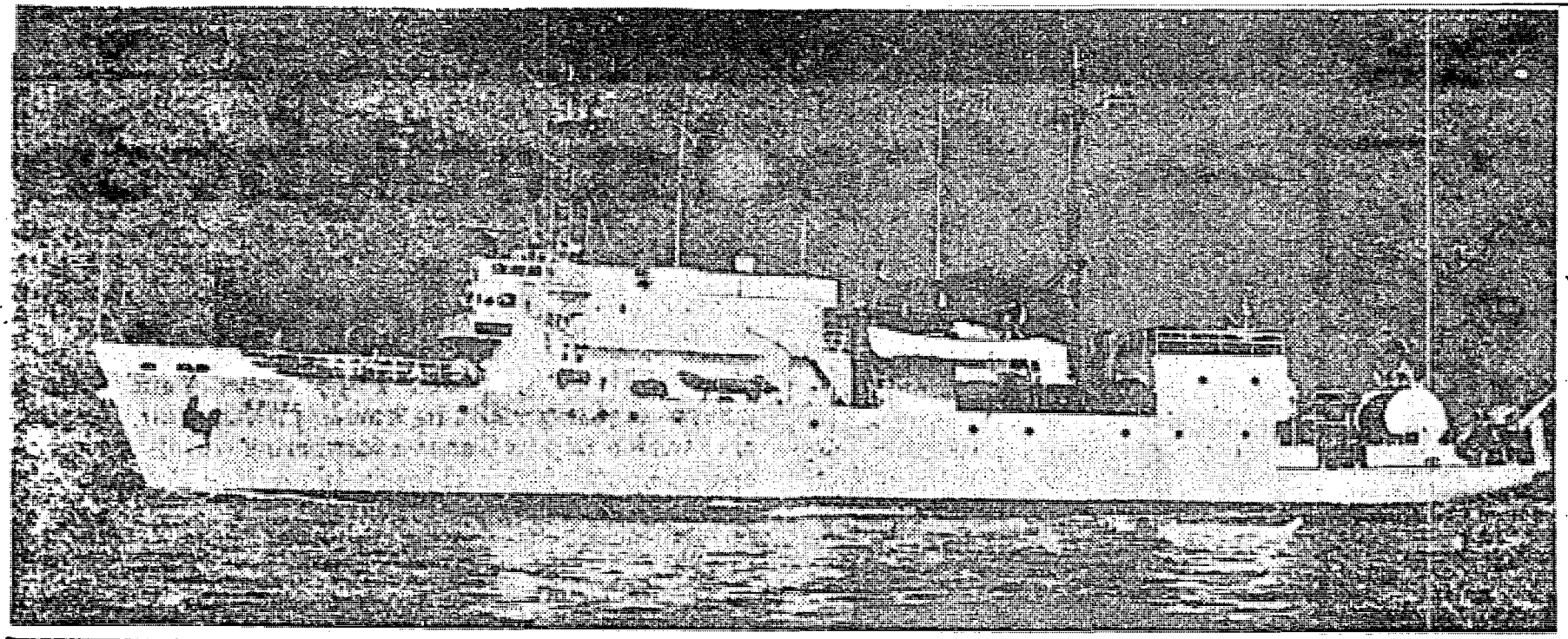
Saudi Arabia Lets Aramco Lower Crude Oil Production

HOUSTON — Saudi Arabia apparently plans to allow Aramco production to drop as much as 2 million barrels of oil per day to defend its $34 price tag on Arabian light crude, according to *Petroleum Information International*.

The Feb. 15 issue reports that current production has dropped to a little more than 8 million barrels per day and the Saudis are prepared to drop production even further under

Although the Saudi government has not officially set policy to deal with the current unusually weak market for its crude, the production cutback has received the strong support from neighboring producers and Aramco offtakers.

According to PI, the Saudis have not previously dropped production significantly due to customary caution in changing production levels and a desire for new OPEC prices to reduce



Research boat Samuel P. Lee . . . floating laboratory for scientists studying Rabaul volcano.

Study on volcano

A group of international scientists is conducting studies on Rabaul volcano.

They are searching for valuable information on the subsurface structure and submarine topography of the volcano.

Chief government geologist Mr Kerry Doble said the seismic refraction and bathmetric studies in the harbor might enable volcanologists to make better predictions on future volcanic activity.

The scientists, who arrived aboard an American geological survey research boat, the Samuel P. Lee, are expected to complete their studies today.

Mr Doble said the boat was working under the auspices of the committee for coordination of joint prospecting for mineral resources in South Pacific offshore areas.

Mr Doble said a similar marine survey had just been completed in the Solomon sea region, west of Woodlark Island.

The surveys have been funded by the United States, Australia and New Zealand governments.

PAPUA NEW GUINEA
Post-Courier
Incorporating South Pacific Post and New Guinea Times Courier
P.O. Box 85, Port Moresby.
24 Pages TUESDAY, JUNE 15, 1982 15 toea
Phone Port Moresby 21 2577
Goroka 72 1251
Lae 42 1168
Madang 82 2703
Rabaul 92 1344
Wewak 86 2384

E DISCOUNT
E OUR
AND QUALITY
E (15t per print.)

281

Pacific Expedition Finishes Search for Oil Sources

By Susan Manuel
Star-Bulletin Writer

Scientists know more about the nergy-yielding potential of the outhwest Pacific Ocean floor nd about the chance of finding il in ocean and island reefs as he result of a nine-month cruise inished this year.

The U.S. Geologic Survey expe- ition hinted that a huge oil asin could run from the Solo- on Islands to Tonga, but the searchers still don't know if ommercial amounts of oil exist ywhere south and west of Ha- aii.

Under the auspices of the nited Nations and funded by e United States, Australia and ew Zealand, the research ship P. Lee dragged a two-mile line gging seismic sensing hydro- ones around Hawaii, Tonga, the lomons, Fiji, American Samoa d Vanuatu.

A. Macfarlane, director of the epartment of Geology, Mines d Rural Water Supplies in nuatu, said the cruise was "ex- emely successful," but "whether not there's any oil or gas isn't own." Results won't be out for months.

H. GARY Greene, a U.S. Geo- gic Survey marine geologist, id the basins observed during e cruise had a similar structure oil-bearing regions elsewhere the world.

Greene and Macfarlane joined out 1,000 other scientists for e week-long Circum-Pacific nergy and Mineral Resources onference at the Hilton Hawai- n Village this week.

Besides exchanging mineral nd energy research from around e world, scientists were intro- uced to a huge Pacific Basin eologic map, assembled by hun- reds of earth scientists from 25 untries.

As a spinoff from the mapping oject, begun in 1973, the United ations began studying hydrocar- ons and minerals around the uth Pacific Islands. Tun U aung, a U.N. petroleum geolo- st, said yesterday that he's opti- istic oil will be found on or ar some of the island nations.

MAUNG SAID data from Tonga looks particularly promising. In the early 1970s, oil companies converged on Tonga to investigate five oil seepages for commercial potential.

Although the seepage yielded genuine crude oil, three of the companies pulled out, unable to find the source of the oil. Samuel Gary Oil Producers Inc. remain and share Maung's theory that the "source rock," once found, will be the once-organic material that evolves into oil-bearing minerals.

Maung said Fiji, Vanuatu and the Solomon Islands also have good prospects for yielding oil. But the process of finding it is slow and expensive. And if the oil sits more than 600 feet under water, the technology to extract it has not been developed.

"We need perserverance, money, time and ideas," he said.

The U.N. also is helping the island nations explore other forms of energy, primarily hydroelectric. In Tonga that means harnessing blow holes and tidal waves, and in Fiji, damming a river.

181

Pacific Basin oil a big energy forum topic

By Barbara Hastings
Advertiser Science Writer

The oil industry is focusing its attention on the Pacific Basin, and with good reason, according to papers presented this week at the Circum Pacific Energy and Mineral Resources Conference in Waikiki.

More than 120 papers were presented to about 700 delegates, and about a third of the papers related to oil and natural gas development in the Pacific.

Indeed, Michael Halbouty, chairman of the Circum Pacific Council and an independent Houston oilman, told the conference there's as much oil and natural gas still to be discovered in the world as already has been found. The Pacific Basin will be the source of a great deal of that, he said.

John M. Parker, president of the American Association of Petroleum Geologists, estimated there are between 300 billion and 1,500 billion barrels of oil or natural gas equivalent in the basin.

And William F. Kieschnick, president of Atlantic Richfield Co., predicted the Circum Pacific region "could be one of the leading economic growth regions in the world over the next 20 years." His company is part of a just-announced agreement with the China National Offshore Oil Corp. to explore in the South China Sea.

Predictions at the conference were that China will become one of the major oil exporters of the world.

Much of this potentially good news about oil comes from recent geological sources. A flurry of activity, from satellite mapping to dredging and seismic studies, is going on in the Pacific Basin to determine where the likely spots are for hydrocarbon deposits.

The resulting picture is a colorful one: There are basins and pockets all over the Pacific region that have the kind of sediments that could mean petroleum. They could be dry holes, too, but that's left up to actual exploration to discover.

But local energy demand isn't going to be supplied by local petroleum finds. "Hawaii doesn't have any promise for oil," said Gary Greene of the U.S. Geological Survey. Greene was discussing the Sopac cruise — a United Nations coordinated project to evaluate the resource potential of the waters of underdeveloped nations of the South Pacific.

The Sopac cruise was accomplished by a special treaty between the United States, New Zealand and Australia, and paid for (about $3 million) by the three.

What was found throughout the area were "fairly thick sedimetary bodies that could trap hydrocarbons," said Greene, "if the source exists."

On his own leg of the cruise, promising pockets were found off Vanuatu, Tonga and the Solomon Islands. Tonga might be the most promising, because there are oil seeps there — a pointer to potential oil below. In fact, Greene said, a small oil company already has started to drill on land in Tonga.

Up to now, these areas have been ignored, because if there is any oil, it's in small basins, Greene said. Now, however, due to the world oil market, small basins are looking more and more economical for drilling.

Another project that will help pinpoint potential energy supplies is the massive Circum Pacific map project. This $100 million program is an ambitious attempt to delineate the geologic features, the earth's plates, the energy and mineral resources of the Pacific in a series of eight sets of maps.

But if the oil industry is looking to the Pacific for oil, the nations of the Pacific are looking beyond oil for their energy needs. Certainly they are interested in potential oil finds, but it's clear these nations don't want to continue the days of everything in a single energy basket.

For example, take Indonesia, which has a great deal of petroleum. In fact, much of the oil that fuels Hawaii comes from there.

Yet Indonesia is actively investigating its geothermal potential. Joedo Sumbono, president director of Pertamina, Indonesia's oil company, told the conference Indonesia hopes to generate electric power from geothermal energy on the island of Bali, reducing domestic oil use so that exports, which bring in foreign dollars, can continue at existing levels.

Union Oil Co.'s geothermal division is exploring the Indonesian geothermal potential.

Union also has developed geothermal fields in the Philippines. Carel Otte, president of Union Geothermal, told the conference that 550 megawatts of electricity are on line on the main island of Luzon and 110 more are under construction.

Otte sees the entire Pacific Basin as ripe for geothermal exploration.

The timeliness of geothermal development was apparent at the conference. Two full sessions were devoted to this energy source.

Alternatives, from biomass to wind to solar collectors to hydropower, played a prominent role at the conference, especially when compared to the 1978 conference (the Circum Pacific group meets every four years), when alternatives were step-sisters in the sessions.

Preliminary Results of Leg 2 *Lee* Cruise in Central Basin of Vanuatu to Assess Hydrocarbon Potential and Geologic Evolution of New Hebrides Arc Basins, Southwest Pacific

We report on a CCOP/SOPAC coordinated cruise, funded by Australia, New Zealand, and the United States (ANZUS), that surveyed the Central basin of Vanuatu (former New Hebrides) in May 1982, to examine the hydrocarbon potential of the region. Our work was concentrated primarily in the Big Bay–Jorden River graben area and along the eastern flanks of Espiratu Santo and Malekula Islands, where we examined structural and stratigraphic characteristics in detail. The collection of continuous multichannel seismic, single-channel intermediate penetration and high-resolution seismic, magnetic, and gravimetric profiles provided significant new data for the evaluation of oil and gas traps and geologic hazards.

The region is an active volcanic arc that overlies an east-dipping seismic (Benioff) zone. Geologic history of the region is complex because subduction directions shifted from east to west in post middle Miocene time. Subsequent tectonism resulted in block faulting of upper Tertiary sedimentary and volcanic rocks, forming islands with narrow shelves and intervening deep-water basins.

GREENWOOD, P., and P. ROBINSON, Papua New Guinea Univ. Technology, Lae, Papua New Guinea

Small Scale Hydropower in Papua New Guinea

Papua New Guinea has an area of 178,364 mi^2 (461,961 km^2) and is large compared to the other island nations of the western Pacific. It lies between 2 and 10° south of the equator, has one of the highest average rainfalls anywhere in the world, and has a mountainous geography. These factors give the country a vast potential for hydropower. To date, with one or two notable exceptions, this potential has not received significant attention. Public Utility schemes form the mainstay of the electricity development plan, but smaller scale applications are proving difficult to initiate in significant numbers. During the last 20 years, many small hydropower schemes fell into disuse, mainly through lack of skilled maintenance. Some were even replaced by diesel generation despite the disparity in total cost.

Recently there have been moves in several areas of the country to implement modest Rural Electrification Programmes. Papua New Guinea has only a few transmission lines, linking a handful of centers. A national electricity grid system has yet to evolve. Small towns and rural centers are supplied independently, usually by diesel generators.

Rural Electrification research and development work has been proceeding at the University of Technology in Lae for nearly 10 years. Over the last few years, development has concentrated on small (1-50 kW), village scale, self-help hydrosystems which are inexpensive, easy to operate and, above all, reliable. This has led to developments in these areas: (1) electronic load controllers and protection devices; (2) turbine design suitable for local manufacture; (3) inexpensive transmission lines; (4) induction generators; and (5) reticulation and wiring for bush material houses.

At the same time, the university has become involved in site surveys and project evaluation on behalf of local governments. It also assists with planning and submissions for funding. While the details of these developments will be of interest in other Pacific Islands, perhaps the most important aspect is the coordination between local governments and users to implement and maintain these projects.

GREGORY, ARTHUR, III, Exxon USA, New Orleans, Louisiana, and LOREN W. KROENKE, Hawaii Inst. Geophysics, Honolulu

Reflection Profiling Studies of 500-Meter Shelf South of Oahu: Reef Development on a Mid-Oceanic Island

Abstract on p. 51.

GUILD, P. W., and M. P. LEE, U.S. Geol. Survey, Reston, Virginia

Circum-Pacific Minerals Maps

Maps portraying the mineral resources are being compiled as one of the series depicting the geology, tectonics, energy resources, and other features of the Circum-Pacific region at 1:10,000,000 on a quadrant-by-quadrant basis. The Minerals Map of the Northeast Quadrant is the first to be completed and will serve as the prototype for those to follow.

Land-based deposits are plotted over a simplified geologic/tectonic background that emphasizes the provenance of sedimentary rocks (oceanic, miogeoclinal, or continental) and the intrusive or extrusive nature of igneous rocks. Symbol shapes, colors, sizes, and ornamentation denote the metal/mineral content, relative importance, geologic class, and, for some, age of mineralization of the deposits. No distinction is made between active, exhausted, or unmined deposits.

The prevalence and transition-metal content of the ocean-floor manganese nodules are shown in relation to water depth and surficial-sediment character, the latter simplified from the Geologic map series. The rift and fracture-zone pattern reproduced from the Plate-Tectonic map serves to locate the sulfide deposits discovered by submersibles and deep drilling to the spreading centers where they are generated. Phosphate and other seabed resources are included.

When completed, the maps will provide an overview of the mineral resources of a region encompassing more than half the globe that should be useful not only for planning purposes, but also as stimuli for creative analysis of the relation of ores to major earth features and processes such as subduction, hot spots, and accreted terranes.

HALBOUTY, MICHEL T., Consulting Geologist and Petroleum Engineer, Independent Producer and Operator, Houston, Texas

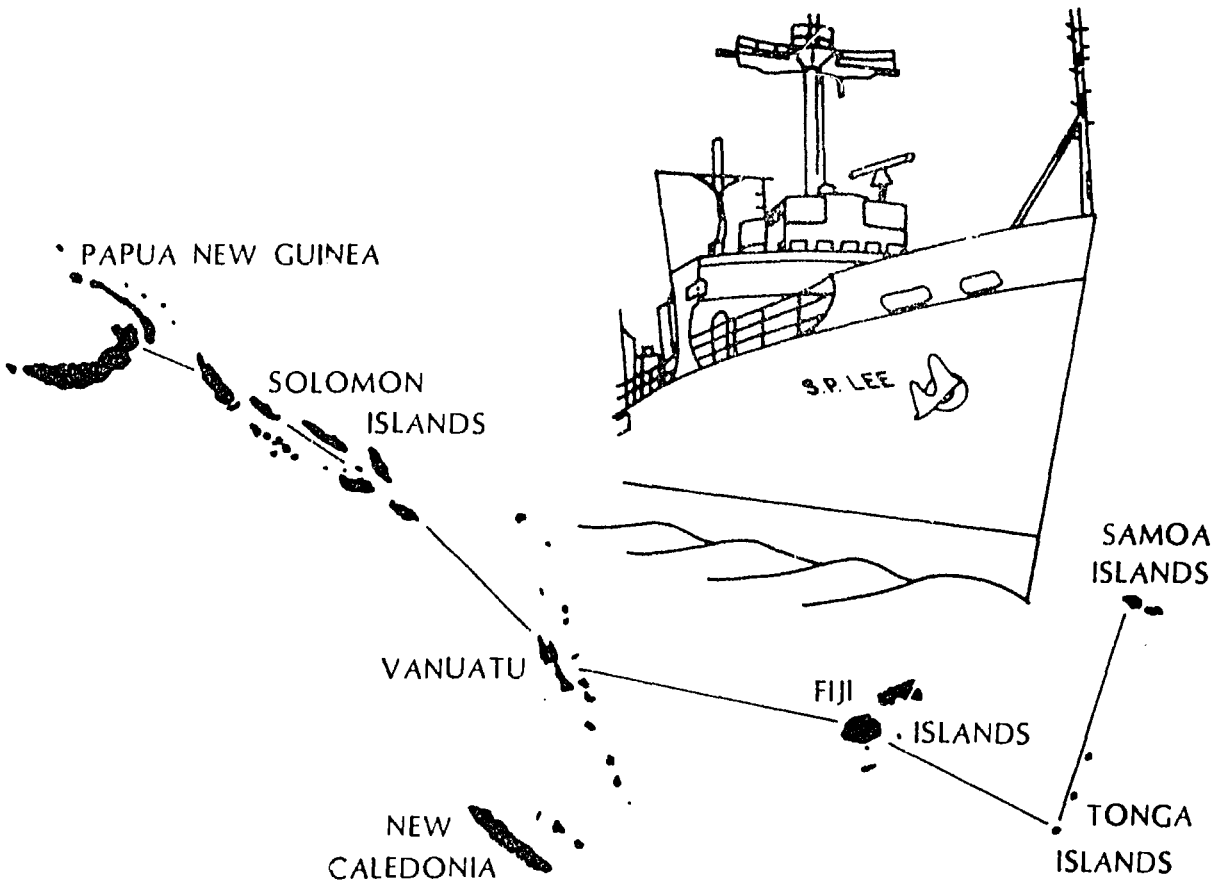
Basins of the World and New Frontiers

Petroleum exploration in the coming decades must be concentrated toward discovering commercial supplies—large and small—of the oil and gas which lie untapped in both the known petroleum producing areas of the world and in the frontier regions. These frontier areas—the deserts, ice-covered lands, deep waters, and remote continental interiors—are estimated to hold vast hydrocarbon accumulations. It is in these sectors

file SoPac

Hydrocarbon Resource Studies in the Southwest Pacific, 1982

GEOLOGICAL SURVEY OPEN–FILE REPORT 83-293



Prepared in cooperation with the governments of Australia and New Zealand, the United Nations Committee for the Coordination of Joint Prospecting for Mineral Resources in South Pacific Offshore Areas, and the Circum-Pacific Council for Energy and Mineral Resources

184

Hydrocarbon Resource Studies in the Southwest Pacific, 1982

By H. Gary Greene, Florence L. Wong, and the scientific staff of the 1982 CCOP/SOPAC cruise

GEOLOGICAL SURVEY OPEN-FILE REPORT 83-293

Prepared in cooperation with the governments of Australia and New Zealand, the United Nations Committee for the Coordination of Joint Prospecting for Mineral Resources in South Pacific Offshore Areas, and the Circum-Pacific Council for Energy and Mineral Resources

Second printing

1983

PREFACE

This report summarizes the investigation conducted aboard the U.S. Geological Survey's Research Vessel *S.P. Lee* in 1982 under the terms of an agreement between Australia, New Zealand, and the United States (ANZUS Tripartite Agreement) in association with the United Nations Committee for the Coordination of Joint Prospecting for Mineral Resources in South Pacific Offshore Areas. Data collected on the cruise were first presented at the *S.P. Lee* postcruise meeting in Honolulu, Hawaii on August 19 and 20, 1982, and further discussed at a meeting cosponsored by the U.S. Geological Survey and the Circum-Pacific Council for Energy and Mineral Resources, a section of the American Association of Petroleum Geologists, in Menlo Park, California, on April 5, 1983.

PARTICIPATING SCIENTISTS

Leg 1 (L5-82-SP)*, April 2 to April 20, 1982

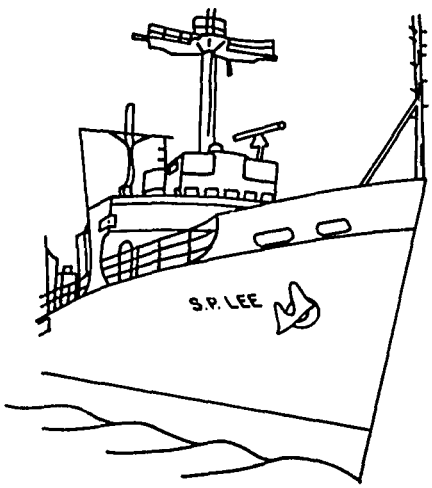
Jon Childs	USGS
Neville Exon	Bureau of Mineral Resources Canberra, Australia, CCOP/SOPAC
Chris Gutmacher	USGS
Richard Herzer	New Zealand Geological Survey, Wellington, New Zealand
Kay Kinoshita	USGS
Dennis Mann	USGS
†Tun U. Maung	CCOP/SOPAC
Graig McHendrie	USGS
Robert Rowland	USGS
Mark Sandstrom	Australia National University, Canberra, Australia
†David W. Scholl	USGS
Barbara Seekins	USGS
Sione Soakai	Ministry of Lands, Surveys and Natural Resources, Nuku'alofa, Tonga
Andrew J. Stevenson	USGS
Tracy L. Vallier	USGS

Leg 2 (L6-82-SP)*: April 28 to May 16, 1982

Donna Blackman	USGS
Guy Cochrane	USGS
Jacque Daniel	Office de la Recherche Scientifique et Technique OutreMer, Noumea, New Caledonia
†David Falvey	CCOP/SOPAC, Sydney University, Sydney, Australia
Michael Fisher	USGS
†H. Gary Greene	USGS
Carol Hirozawa	USGS
Mark Holmes	USGS
David Johnson	James Cook University, Townsville, Australia
H.R. Katz	New Zealand Geological Survey, Lower Hutt,New Zealand
Kay Kinoshita	USGS
Greg Lewis	USGS
Alexander Macfarlane	Dept. of Geology, Mines and Rural Water Supplies, Port Vila, Vanuatu
Greg Smith	USGS

Leg 3 (L7-82-SP)*: May 19 to June 11, 1982

Larry Beyer	USGS
Donna Blackman	USGS
Terry Bruns	USGS
Guy Cochrane	USGS
Jim Colwell	Bureau of Mineral Resources, Canberra, Australia
Alan Cooper	USGS
Frank Coulson	Solomon Islands Geological Survey, Honiara, Solomon Islands
Kay Kinoshita	USGS
Greg Lewis	USGS
Loren Kroenke	CCOP/SOPAC
Michael Marlow	USGS
†Donald Tiffin	CCOP/SOPAC
†Jack Vedder	USGS
Raymond Wood	New Zealand Geological Survey, Lower Hutt, New Zealand



* cruise locating code
† cochief scientist

186

CONTENTS

	Page
Preface	II
Introduction	1
Acknowledgments	1
Leg 1—Tonga Ridge	2
Leg 2—Central Basin of Vanuatu	2
Leg 3—Central Solomons Trough	11
Recommendations	15
I. Tonga Platform-Lau Ridge	20
II. Vanuatu and Eastern Solomons Basins	20
III. Solomon Islands and Bougainville, Papua New Guinea	22
IV. New Ireland Basin, Papua New Guinea	22
V. North Fiji Basin	23
References	23

ILLUSTRATIONS

		Page
FIGURE	1. Index map of study area	1
	2. Physiographic diagram of southwest Pacific with tracklines	3
	3. Leg 1: Detailed tracklines and bathymetry of Tonga platform	4
	4. Leg 1: Multichannel seismic line 8 across Tonga platform	5
	5. Leg 1: Multichannel seismic line 11 across Tonga platform	6
	6. Leg 1: Isopach map of the Tonga platform	7
	7. Leg 2: Detailed tracklines and bathymetry of the Central Basin of Vanuatu	8
	8. Leg 2: Structure and shelf sedimentary basins of the Central Basin of Vanuatu	10
	9. Leg 2: Multichannel seismic line 10 across the New Hebrides Trench	11
	10. Leg 2: Isopach map of the Central Basin of Vanuatu	12
	11. Leg 2: Single-channel seismic line 25 offshore of Espiritu Santo, Vanuatu	13
	12. Leg 2: Single-channel seismic line 20A offshore of Espiritu Santo, Vanuatu	14
	13. Leg 3: Detailed tracklines and bathymetry of the central Solomons Trough	16
	14. Leg 3: Isopach map of the central Solomons Trough	18
	15. Leg 3: Multichannel seismic line 30 between Santa Isabel and the Russell Islands	19
	16. Leg 3: Rabaul harbor bathymetry and tracklines	19
	17. Recommended tracklines for future work in southwest Pacific	21

187

Hydrocarbon Resource Studies in the Southwest Pacific, 1982

By H. Gary Greene, Florence L. Wong, and the scientific staff of the 1982 CCOP/SOPAC cruise

INTRODUCTION

From April 2 to June 11, 1982, the USGS (U.S. Geological Survey) conducted a hydrocarbon resource investigation in the offshore areas of Tonga, Vanuatu, and the Solomon Islands (fig.1). The work was arranged under the ANZUS (Australia, New Zealand, and United States) Tripartite Agreement in association with CCOP/SOPAC (United Nations Committee for the Coordination of Joint Prospecting for Mineral Resources in South Pacific Offshore Areas), as part of a program of marine geoscientific research and mineral resource studies in the South Pacific region.

The U.S. Department of State was instrumental in negotiating the agreement and establishing the framework for the cooperative research. The USGS provided instruments and scientific and technical personnel. The Office of Energy of the United States Agency for International Development (AID) provided funding for the implementation and operation of the investigation. Funds were also provided by the government of Australia. CCOP/SOPAC in Fiji served as the basic coordinator and provided, along with Australia, New Zealand, and CCOP/SOPAC member nations, some of the scientific staff.

The data collection phase of the joint program was a three-leg, 60-day resources survey by the Research Vessel *S.P. Lee*. This report summarizes that investigation, gives tentative results, outlines the future work schedule, and proposes significant work to be continued.

ACKNOWLEDGMENTS

This report required the devotion and labor of many to meet the publication deadline. We are grateful to Tom Chase for his efforts in supplying us with bathymetric and navigation charts, and to Phyllis Swenson who spent many hours drafting the illustrations for this report. David Scholl and

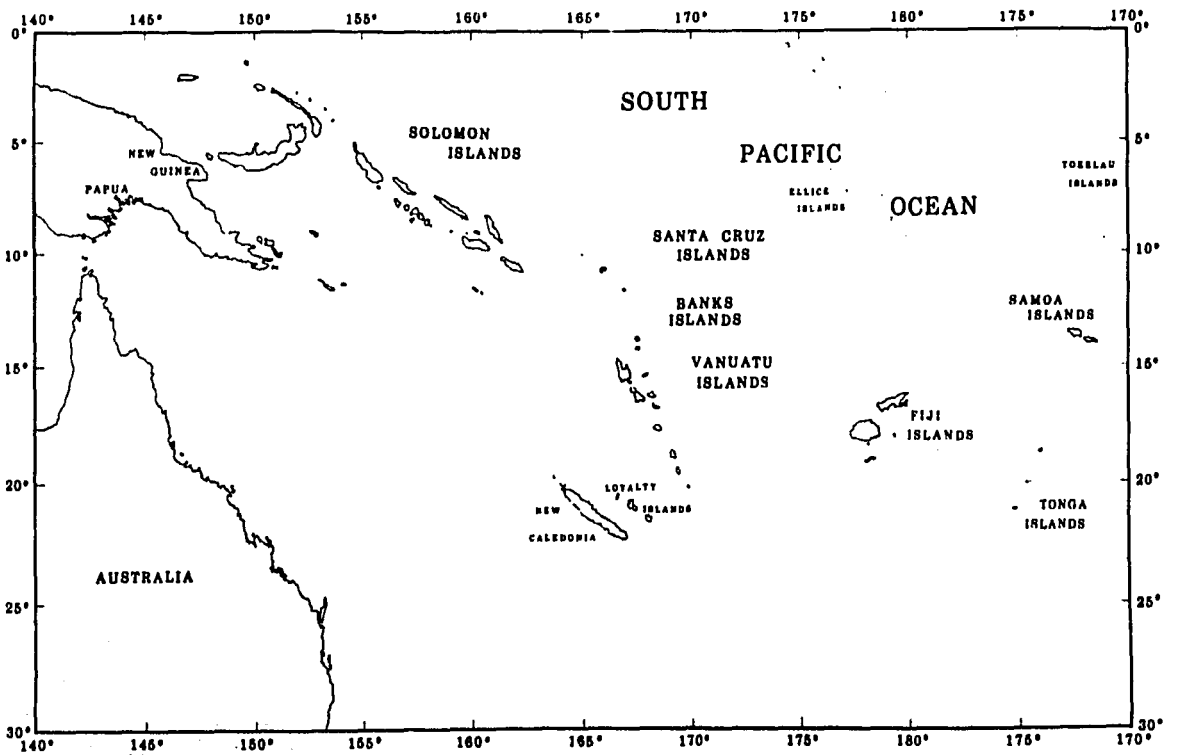


FIGURE 1.—Location map of the South Pacific study area.

188x

Jack Vedder reviewed the manuscript and contributed significantly to the improvement of the text. We also appreciate the encouragement and support from the ANZUS Tripartite and CCOP/SOPAC scientific participants. The studies were funded by the U.S. Agency for International Development, the government of Australia, and the U.S. Geological Survey and were conducted in cooperation with the governments of Australia, New Zealand, and the United States.

LEG 1, TONGA RIDGE

Departed Pago Pago, American Samoa, March 28
Arrived Nuku'alofa, Tonga, March 31; departed, April 2
Arrived Suva, Fiji, April 20; departed, April 23
Arrived Port Vila, Efate, Vanuatu, April 26

METHODS

Leg 1, conducted mainly on the southern Tonga platform up to 250 km south of Tongatapu, Tonga, included over 5,700 km (3,078 n. mi.) of 12 kHz, 3.5 kHz, gravity, and magnetic profiles (fig. 2). In the area, 2,421 km (1,307 n. mi.) of 24-fold, CDP seismic-reflection profiles, and 54 sonobuoy wide-angle reflection-refraction profiles were obtained (fig. 3). Also, at 13 sampling stations 9 dredge hauls and 4 gravity cores were taken. A brief (12-hr) sampling visit was included at Ata Island during data collection in the platform area (Scholl and others, 1982).

Geophysical data were also gathered offshore of the western margin of the island of Viti Levu, Fiji and over Baravi Basin at the request of the Fiji Mineral Resources Department, and along the *Lee's* virtual due-west track from Suva to Port Vila (fig.2).

GENERAL RESULTS

Initial results include the following data taken from Maung and others (1982) and Scholl and others (1983): (1) acoustical resolution of a westward-thickening, extensionally deformed platform section (<4.5 km/s; 2-3 km thick) of chiefly Neogene and younger volcaniclastic and limestone beds overlying a basement of arc-type igneous rocks (>5 km/s) (figs. 4, 6); (2) identification of a regional unconformity of late Miocene age in the upper part of the platform section that possibly reflects thermal uplift of the ridge just prior to the opening of the Lau Basin; (3) identification of large, moundlike buildups in the lower part of the platform section that may be reefal or possibly igneous masses (fig. 4); (4) recognition of evidence that the forearc area, most of which is deeply submerged, may have been a source terrane for some of the volcaniclastic deposits of the platform section; (5) southwestward tracing (at least 250 km) of an axis of early Tertiary volcanism that is situated along the Pacific side of the platform and passes beneath or close to Eua Island; (6) acoustical tracking of the subducted surface of the Pacific plate 25-30 km landward of the inner trench wall (fig. 5); this slope is not underlain by offscraped, low-velocity oceanic pelagic deposits; and (7) the probable detection of a magma chamber 3-4 km below a spreading axis in Lau Basin (fig. 5).

A comprehensive evaluation of the petroleum potential of the Tonga platform area must await the results of laboratory analysis of rocks dredged from the sea floor and sampled on land, and the interpretation of the fully processed multifold reflection profiles.

LEG 2, CENTRAL BASIN OF VANUATU

Departed Port Vila, Efate, Vanuatu, April 28
Arrived Honiara, Guadalcanal, Solomon Islands, May 16

METHODS

Leg 2, conducted in the Central Basin of Vanuatu, included 2,520 km (1,361 n. mi.) of 24-fold, CDP multi-channel seismic-reflection profiles (fig. 7). In addition, 622 km (336 n. mi.) of high-resolution Uniboom seismic-reflection profiles and nearly 4,500 km (2,430 n. mi.) of 3.5 kHz very high resolution seismic-reflection, 12 kHz bathymetric, magnetic, and gravity profiles were collected, and 33 sonobuoy wide-angle reflection refraction profiles were obtained (Greene and others, 1982, 1983; fig. 2). Three sampling stations comprised one dredge station and two gravity core stations. Geophysical trackline spacing was generally 5-10 km (2.7-5.4 n. mi.) apart, and in some localities spacing was as close as 1 km (0.5 n. mi.) apart (fig. 7).

GENERAL RESULTS

Preliminary onboard data reduction and interpretation resulted in (1) the delineation of three small shelf sedimentary basins east of Malekula and Espiritu Santo; (2) estimation of minimum sedimentary thickness in the intra-arc Central Basin; and (3) the discovery of the northward continuation of the southern New Hebrides

189

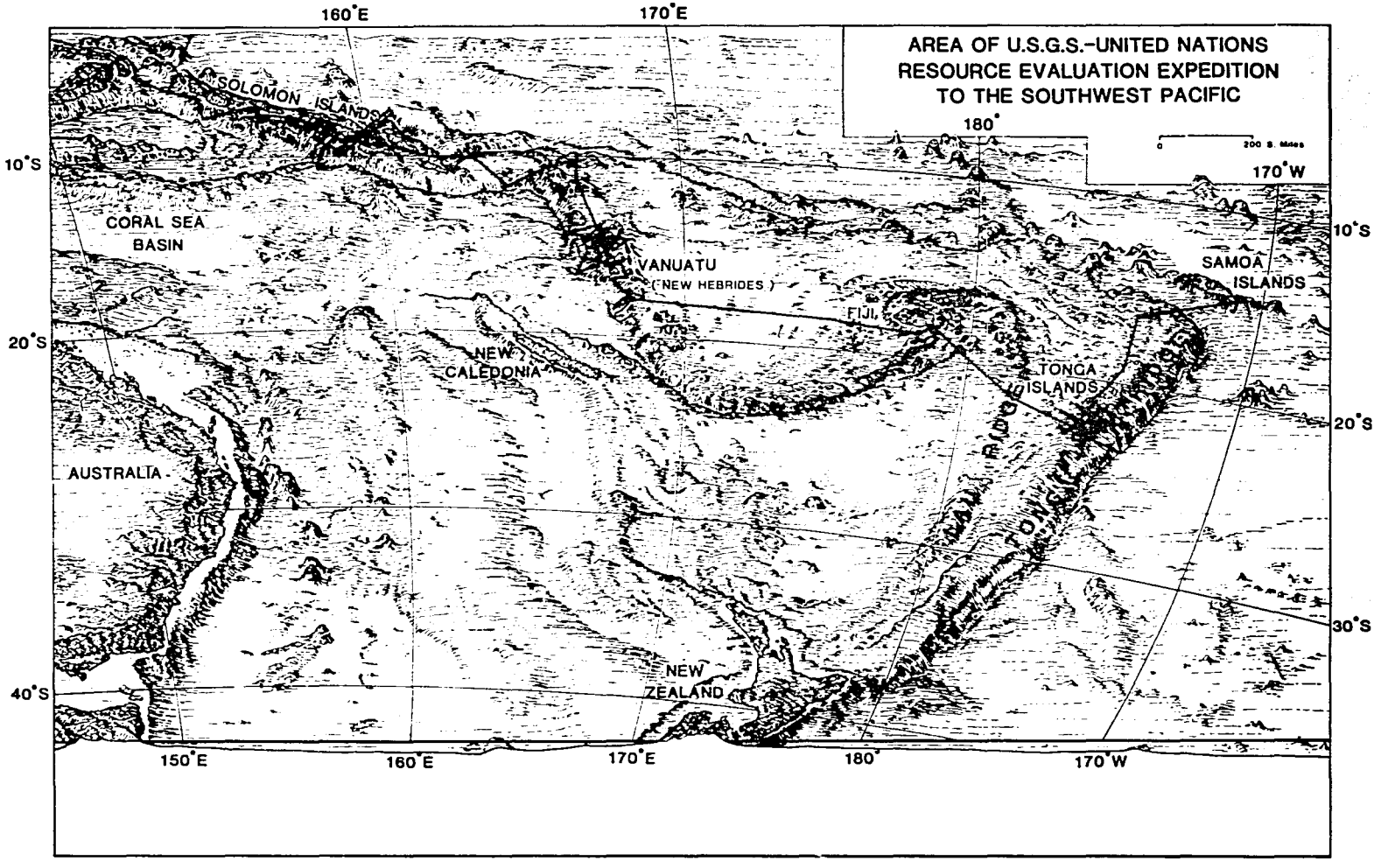


FIGURE 2.—Physiographic map with tracklines covered by Research Vessel *S.P.Lee* during the 1982 South Pacific surveys. Physiography by Tau R. Alpha.

190x

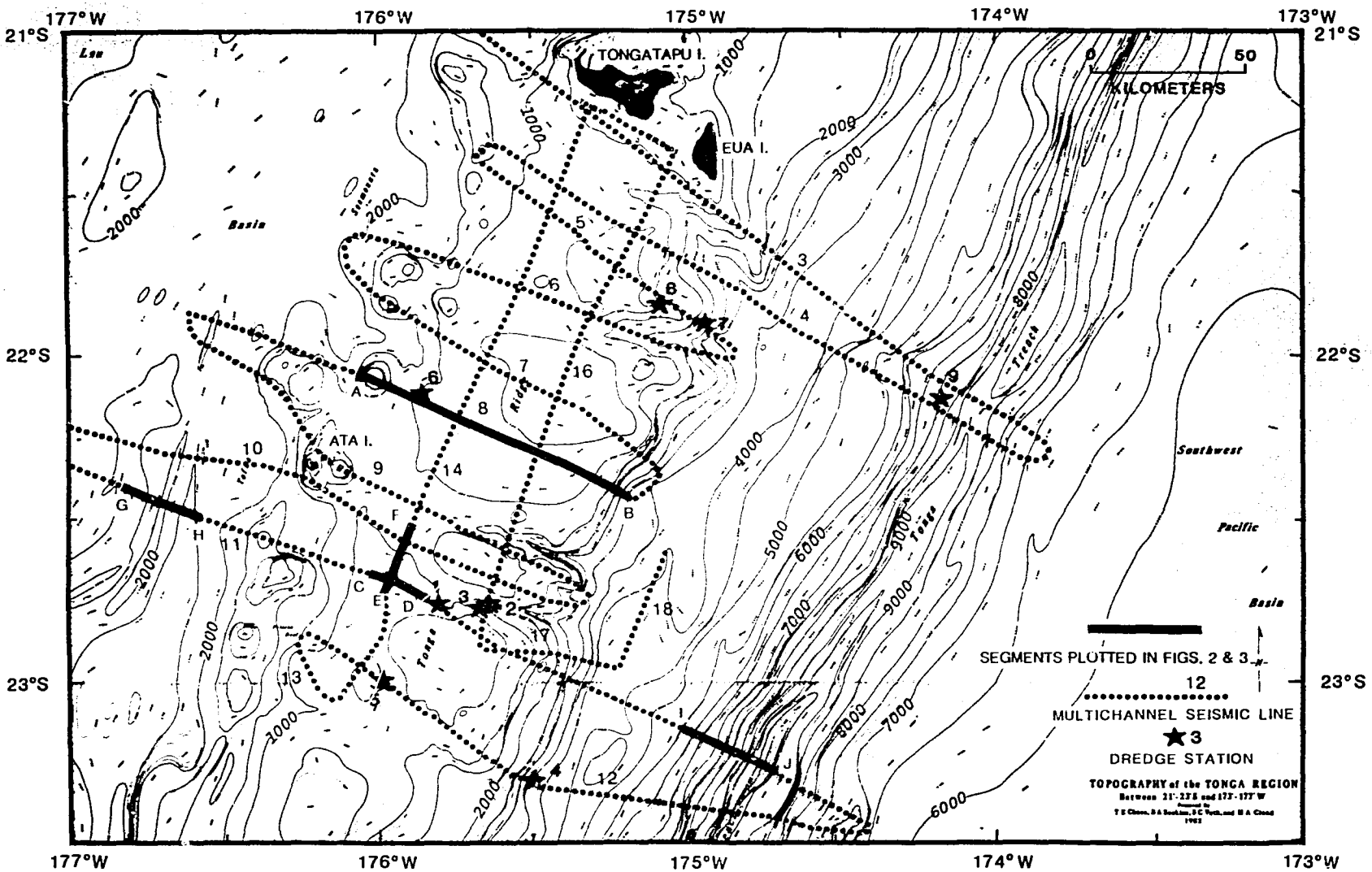


FIGURE 3.—Index map of southern Tonga platform showing tracklines of 24-fold multichannel data, locations of profile segments (that is, A-B through I-J) displayed on figures 4 and 5, positions of dredge stations where submarine outcrops were sampled, and depth contours in meters (based on velocity-corrected soundings).

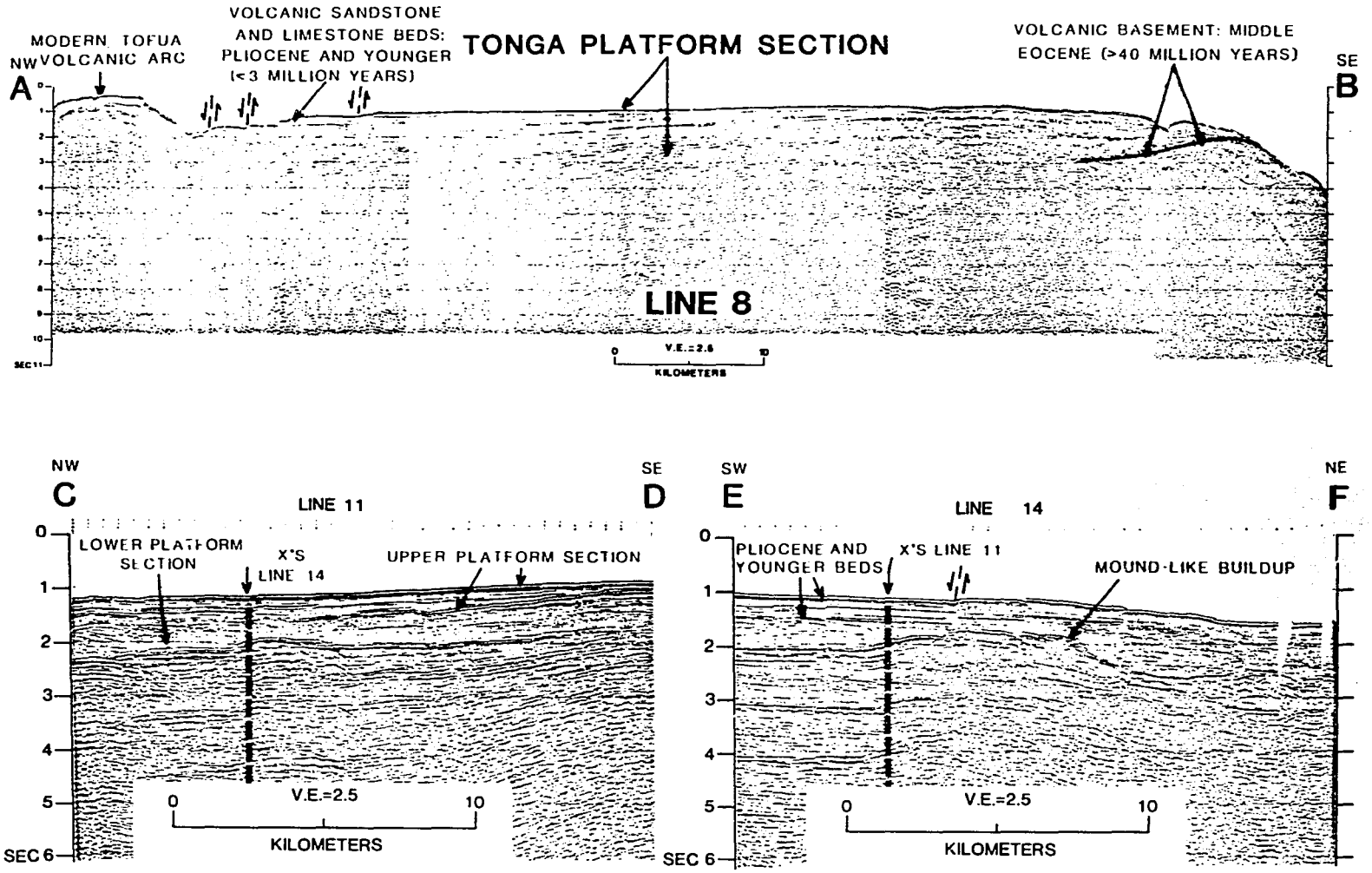


FIGURE 4.—Annotated segment of multichannel line 8 (A-B), which traverses the crestal platform of the Tonga Ridge, and mutually crossing segments of lines 11 and 14, which reveal a subsurface moundlike structure of possible igneous or reefal origin (see figure 3 for locations). The platform section noted along line 8 is constructed of volcaniclastic and limestone beds of post-Eocene age that, in general, are characterized by acoustic velocities less than about 4.5 km/s. The section's underlying acoustic basement is presumably arc-type volcanic and intrusive rocks of Eocene and older age. The upper, more coherently layered strata of the platform section is composed of Pliocene and younger beds; the underlying moundlike buildup within the lower platform section is probably associated with Tertiary beds of Miocene age.

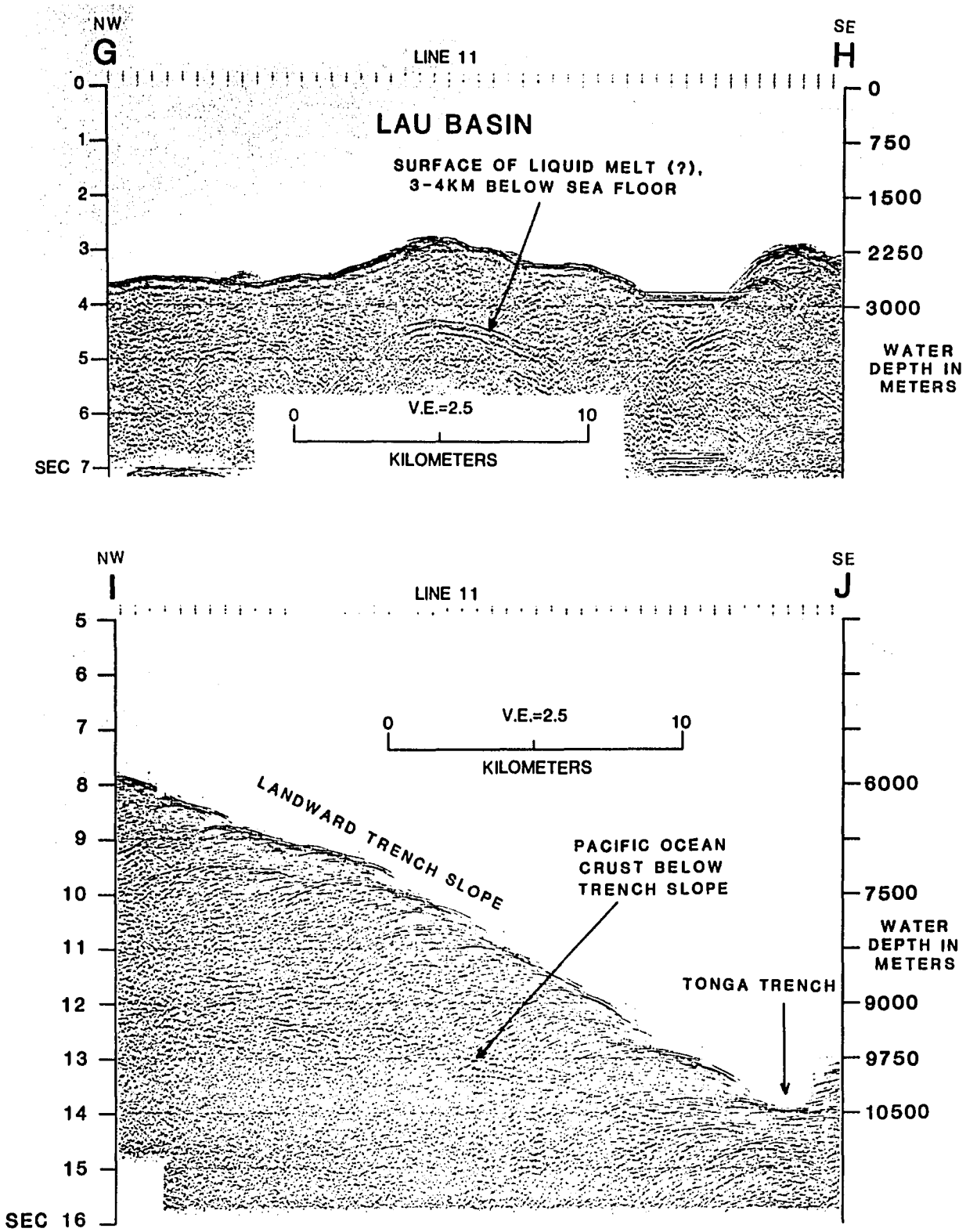


FIGURE 5.—Annotated segments of multichannel line 11. Segment G-H reveals a subsurface upper crustal reflection horizon near the eastern side of Lau Basin that may be the top of a magma chamber underlying a spreading center. Segment I-J, recorded over the lower part of the landward slope of the Tonga Trench, reveals a deep, subsurface reflection horizon that is presumed to be the top of subducted Pacific oceanic crust. On a true-depth section, the horizon actual dips downward beneath the Tonga Ridge, but a prominent velocity pull-up effect induced by high-velocity rocks underlying the lower slope causes the horizon to ascend to the west on this reflection-time section.

Trench (fig. 8). Tentative interpretation of the single-channel seismic-reflection data indicates that regionally the islands are deformed in a complex structural pattern. These structures may be related to the complex tectonic evolution of the arc that involves orthogonal subduction, oblique subduction, and arc reversal through middle and late Miocene times.

Multichannel seismic data from this investigation indicate that the trench near the central part of this arc is nearly devoid of sediment and that the accretionary wedge is covered by only a veneer of sediment (Fisher and others, 1982; fig. 9). Rocks within this wedge have high acoustic velocities (4-5 km/s), and these rocks cause faint reflections that dip arcward. Oceanic crust can be traced beneath this wedge for 30 km.

The three shelf or shelf-edge sedimentary basins that were mapped all lie in water depths of less than 1,000 m and have sediment thicknesses

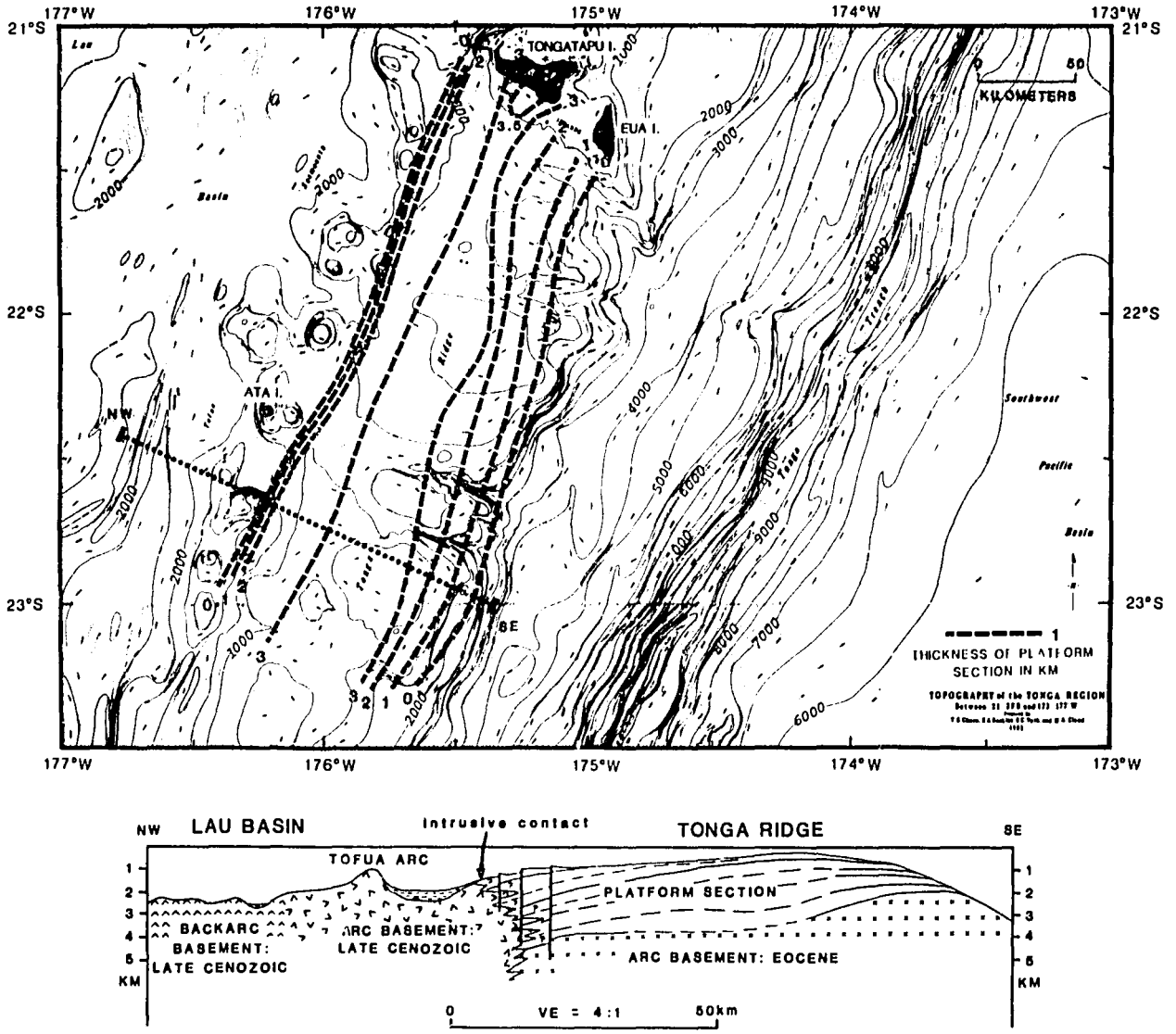
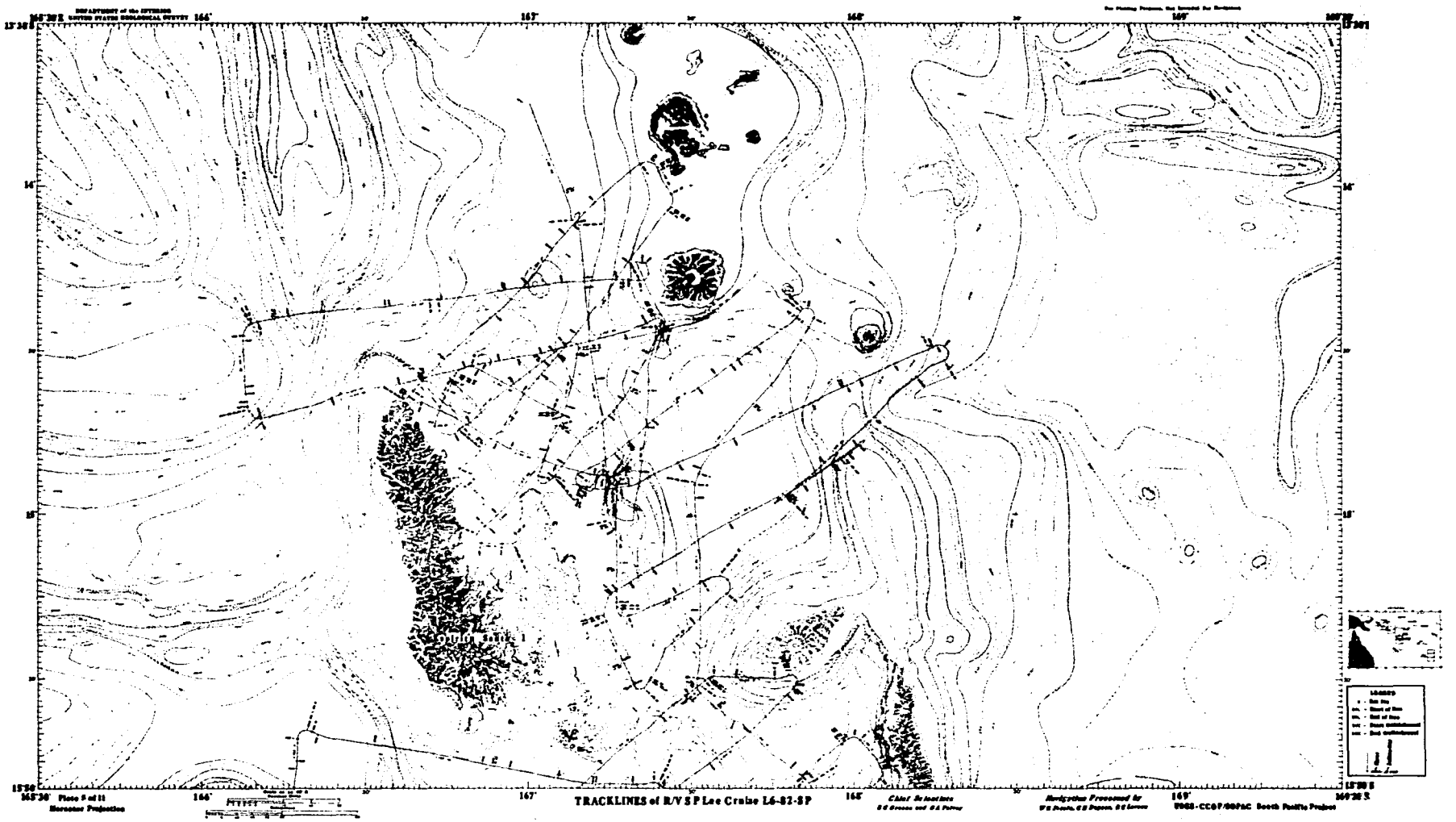


FIGURE 6.—Diagrammatic representation of isopach contours, based on multichannel and sonobuoy refraction velocities and depth calculations, showing the thickness of the platform section in kilometers. Lower cross-section, from Lau Basin to the eastern edge of the southern Tonga platform, is a cartoon or schematic drawing illustrating presumed structural and stratigraphic relations of regional importance (based on sonobuoy refraction data and multichannel reflection profile 11; see figure 3). Platform section has presumably been truncated by extensional rifting along western side of ridge. Young arc basement is shown intruding the truncated edge of the section. The missing or western part of the section presumably underlies Lau Ridge, approximately 300 km to the west.

194


DEPARTMENT of the INTERIOR
UNITED STATES GEOLOGICAL SURVEY
Plate 5 of 11
Mercator Projection
TRACKLINES of R/V S P Lee Cruise L6-82-SP
Chief Scientists
Navigation Processed by
USGS-CCOP/SOPAC South Pacific Project

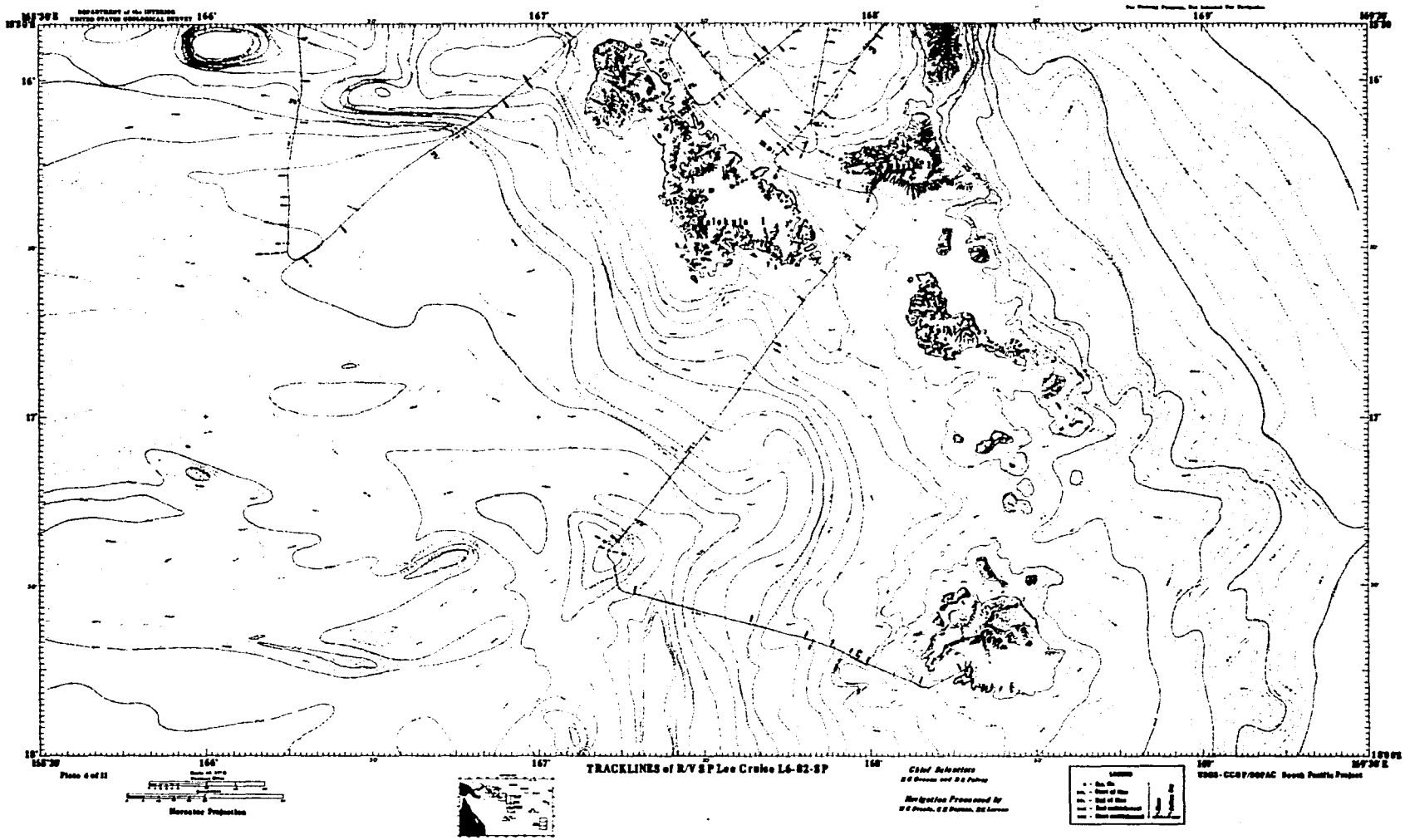


FIGURE 7.—Trackline map and bathymetry, Leg 2, Vanuatu

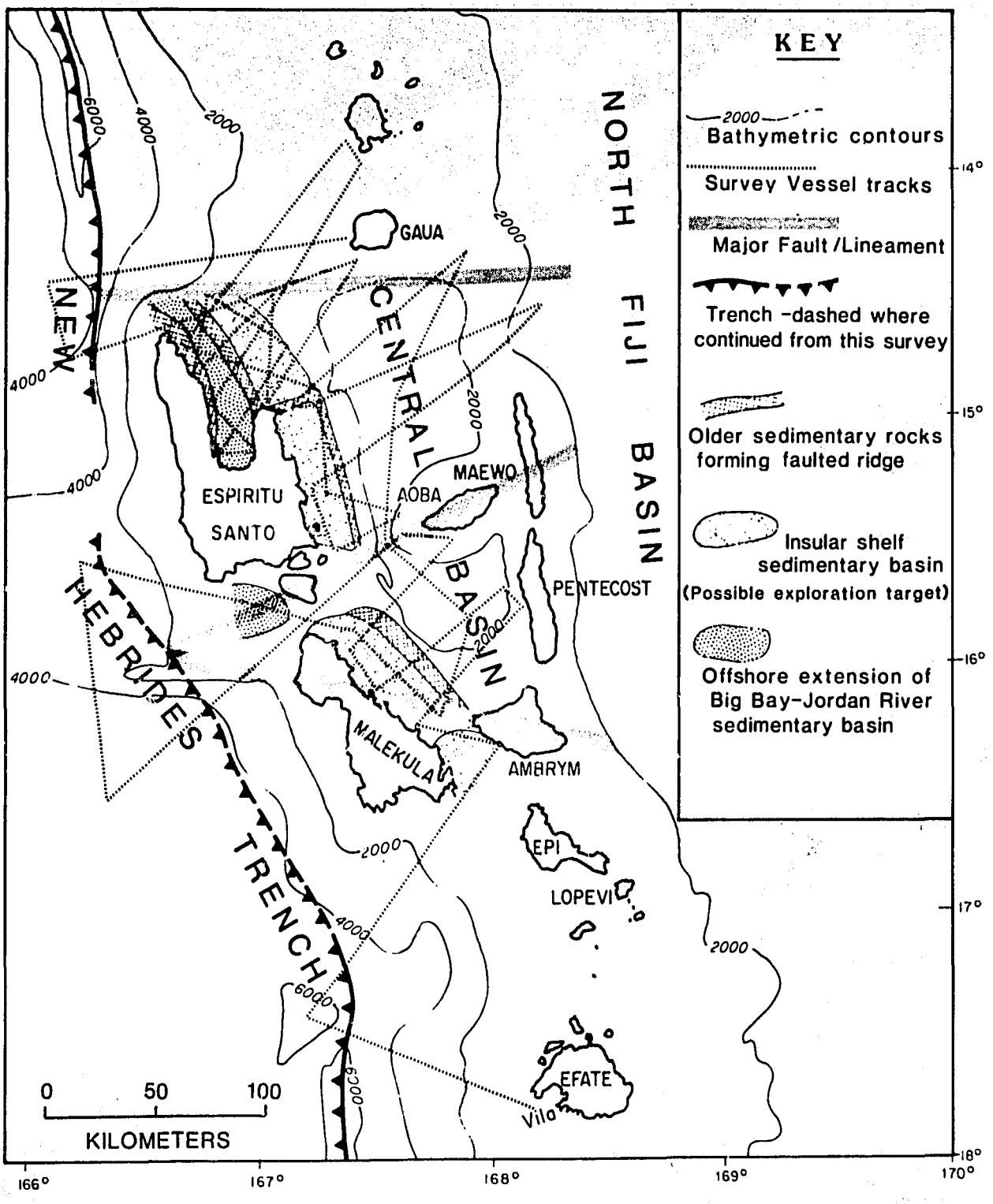


FIGURE 8.—Generalized outline of shelf or shelf-edge sedimentary basins and primary structural features delineated during Leg 2. Bathymetry in meters.

197

greater than 2 km (fig. 10). Structures capable of trapping oil and gas are present in all three basins. Sedimentary rocks identified within these smaller shelf-edge basins appear to be locally connected with the deeper intra-arc basin (that is, the Central Basin), thereby forming potential pathways for petroleum migration from thick sedimentary sections in deep-water marine source beds to shallow-water reservoir beds and traps (fig. 11).

The main part of Central Basin contains about 5 km of rocks that have velocities less than 5 km/s (fig. 10). Preliminarily processed multichannel seismic data indicate that three main seismic-stratigraphic units compose the basin fill, all separated by unconformities. They consist from oldest to youngest of an older, poorly bedded sedimentary unit resting on acoustic basement along the margins of the basin and everywhere overlain by a well-layered sedimentary unit that is in turn overlain by a thin layer of well-bedded unconsolidated sediments (fig. 12). Several large structures deform the youngest units of this fill; these structures do not appear to have igneous rocks at their core.

The three shelf-edge basins identified in the survey are considered promising sites for further investigations of hydrocarbon potential. They are equal in size and sediment thickness to some of the smaller hydrocarbon producing basins found elsewhere in the world (for example, western coast of the United States). The water depths overlying all of these shelf-edge basins are shallow enough for drilling with current technology.

LEG 3, CENTRAL SOLOMONS TROUGH

Departed Honiara, Guadalcanal, Solomon Islands, May 19
Arrived Rabaul, New Britain, Papua New Guinea, June 11

METHODS

Leg 3, conducted in the Solomon Islands trough area, included approximately 3,700 km (1,998 n. mi.) of 24-fold, CDP multichannel and about 3,200 km (1,728 n. mi.) of high-resolution Uniboom seismic-reflection profiles in the central and western Solomon Islands area (fig. 13). For the entire leg, including transit lines, about 5,500 km (2,970 n. mi.) of 3.5 kHz high-resolution, seismic-reflection, magnetic, gravity, and 12 kHz bathymetric profiles were collected. In addition 36 wide-angle seismic reflection-refraction sonobuoy profiles were obtained. Nine dredge hauls were made, and two gravity cores were taken. Dredge hauls ranged in water depths from approximately 1,200 m to 300 m. Trackline spacing was generally between 5 and 10 km (2.7 and 5.4 n. mi.).

In addition to the resource survey specified in the ANZUS Tripartite Agreement, the USGS made an 8-hour survey in Rabaul harbor, New Britain, on June 11 at the request of CCOP/SOPAC and the Rabaul Volcanological Institute (fig. 14). Reconnaissance bathymetric data were acquired, and the Rabaul seismograph network was tested using the airgun system aboard the *Lee* as an artificial seismic source. Also, a sonobuoy refraction profile was recorded, and intermediate penetration and high-resolution Uniboom seismic-reflection profiles were collected.

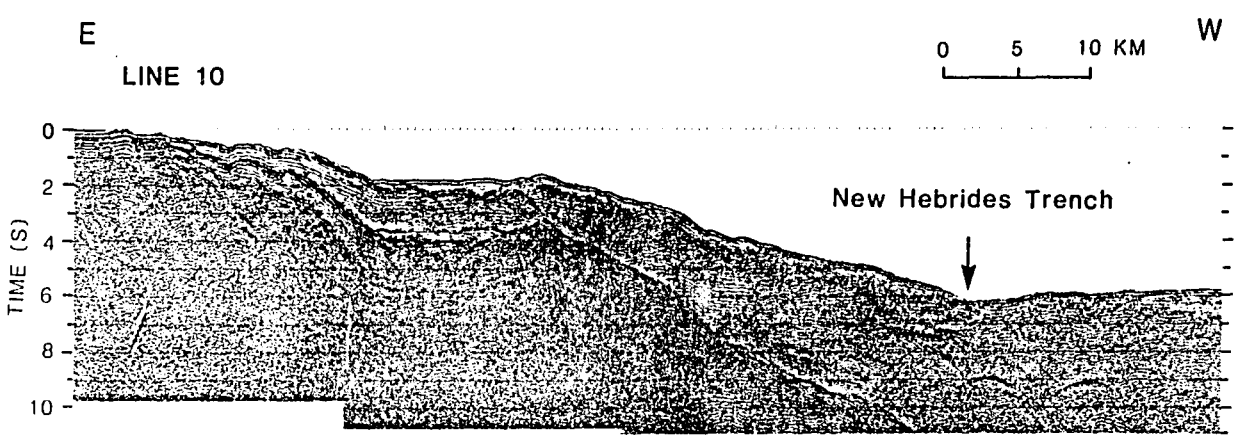


FIGURE 9.—Uninterpreted multichannel record of line 10, Leg 2, across the New Hebrides Trench.

198x

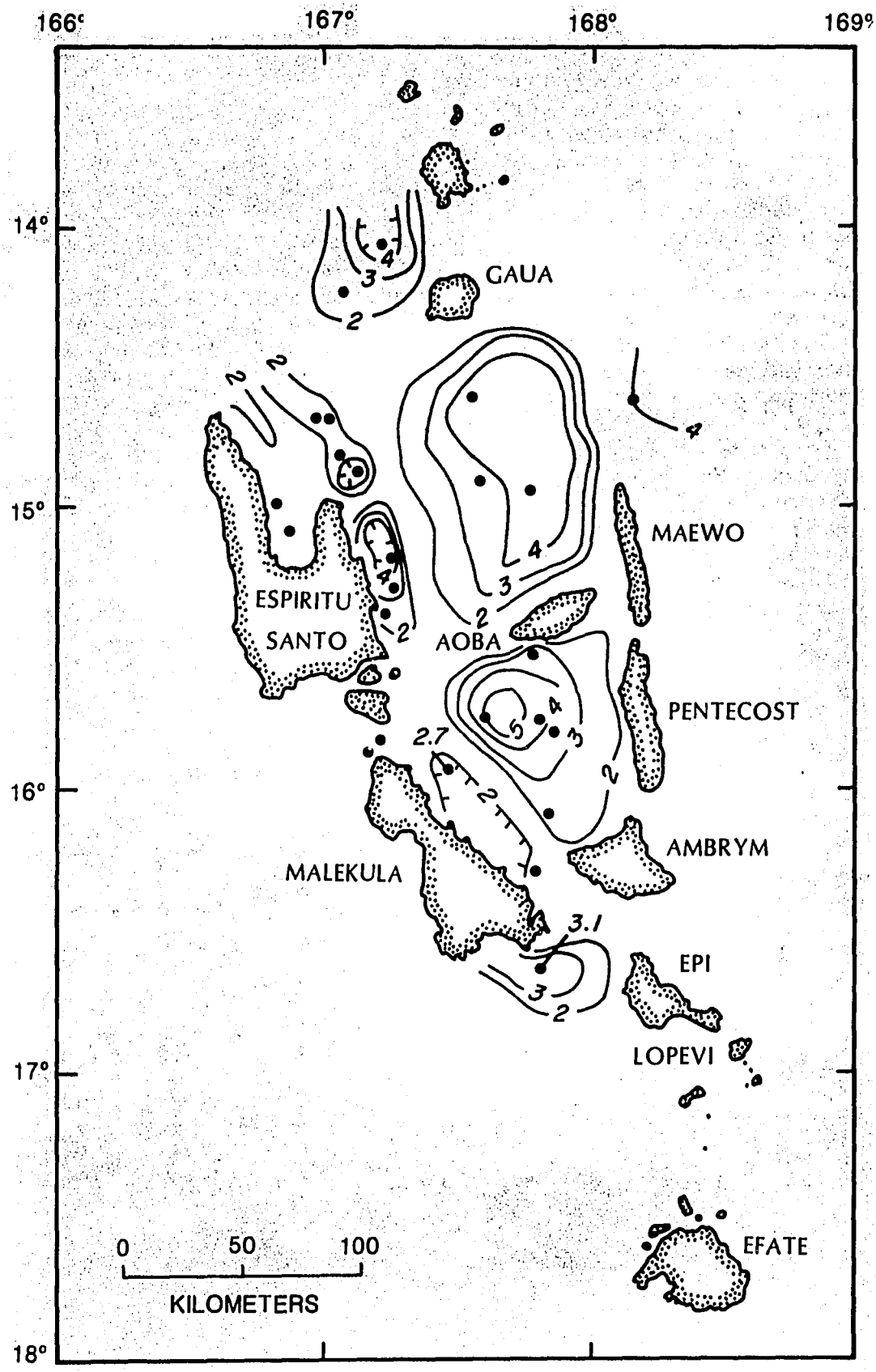


FIGURE 10.—Preliminary isopach map of sediments overlying acoustic basement rocks of 5 km/s seismic velocity in the Central Basin of Vanuatu. Dots are approximate sonobuoy locations where basement reflectors were recorded. Contours are sediment thickness in kilometers; numbered dots indicate deepest recorded sediment thickness.

199

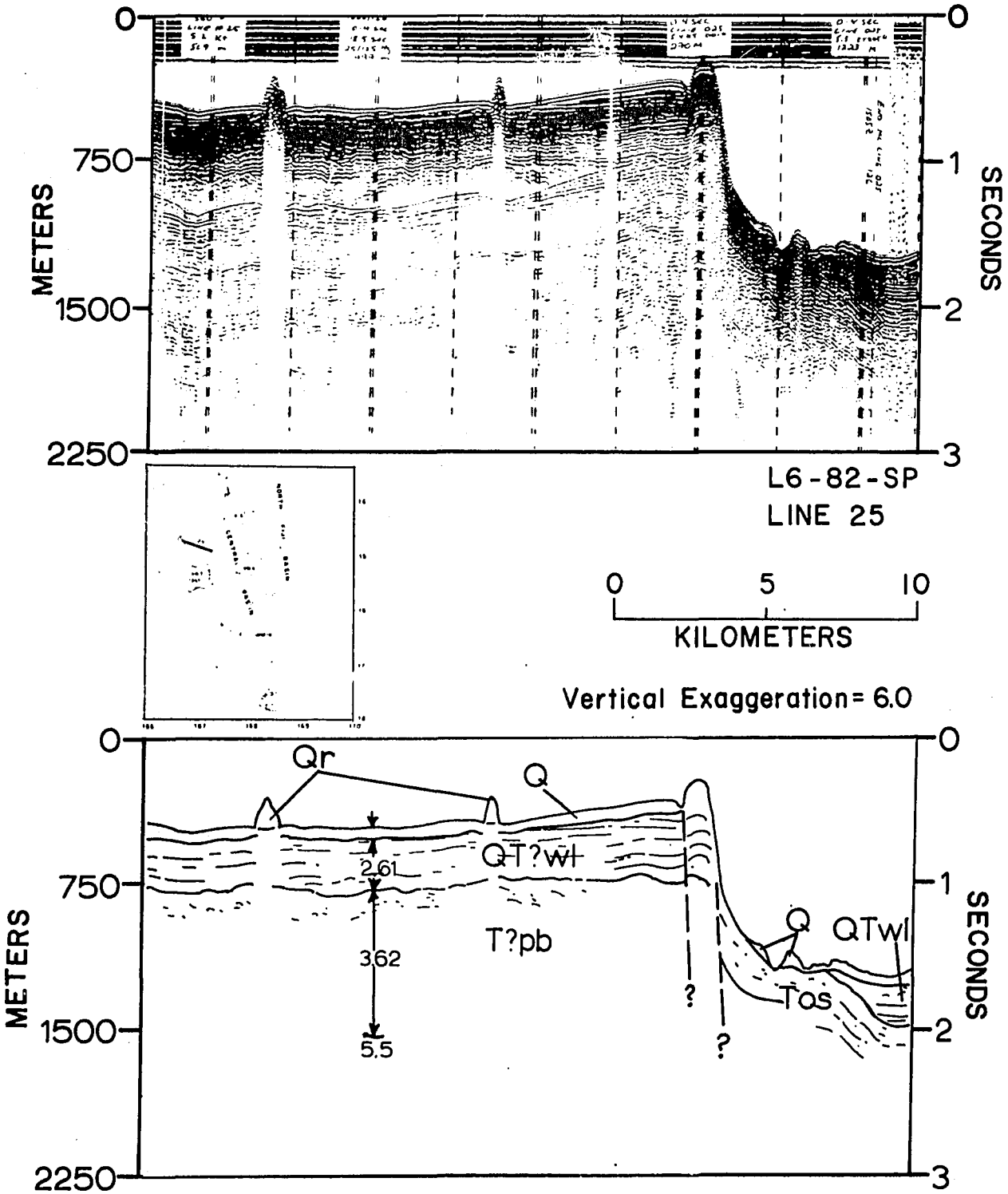


FIGURE 11.—Single-channel record and line drawing of line 25, Leg 2, which crosses the shelf basin off northern Espiritu Santo. Symbols: Q, Quaternary; Qr, reef deposits; T?pb, poorly bedded Tertiary strata, age uncertain; QTwl, well-bedded Tertiary strata, ?, age uncertain; Tos, older sediment.

200x

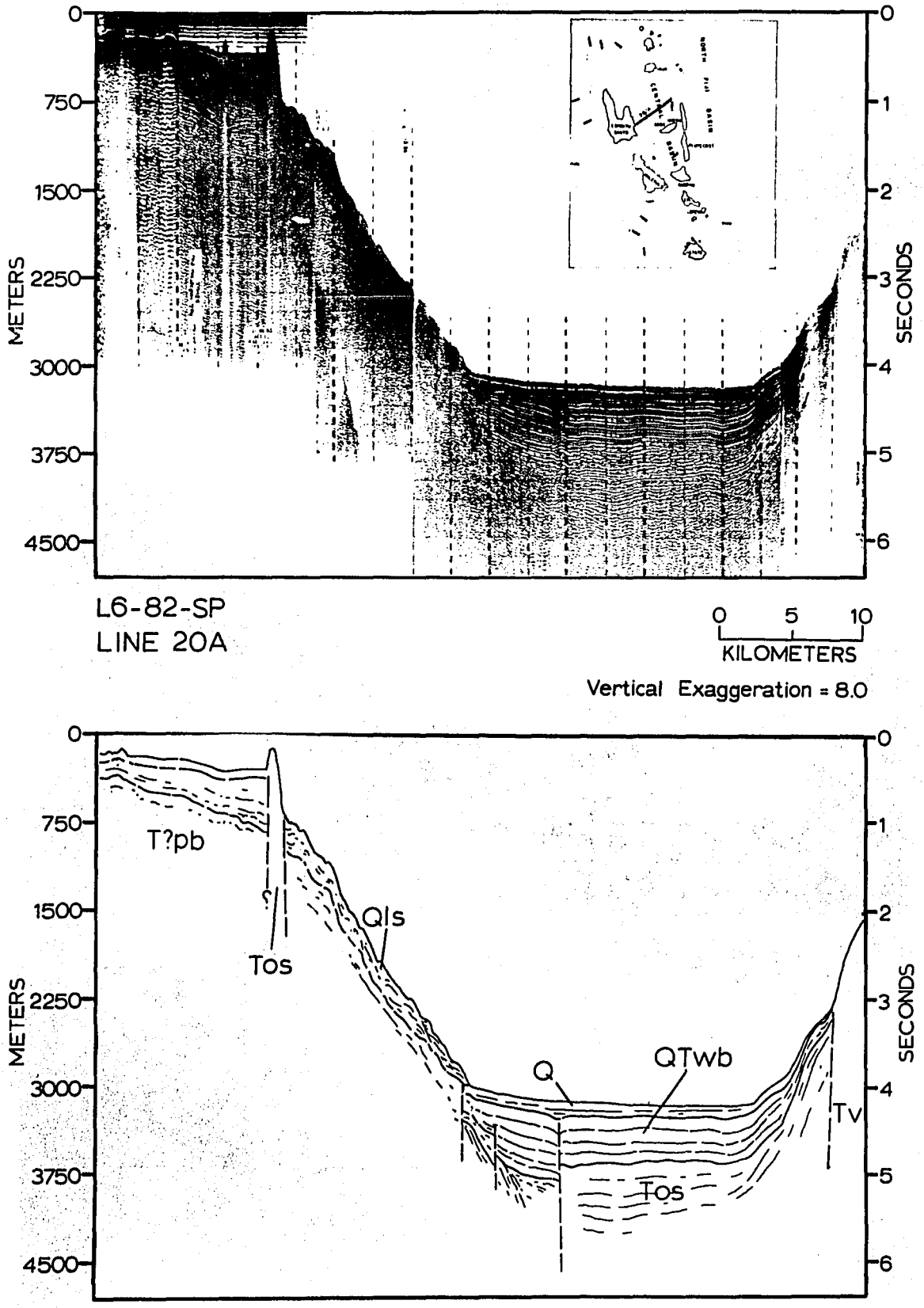


FIGURE 12.—Single-channel record and line drawing of line 20A, Leg 2, across the northern Central Basin of Vanuatu. Profile shows ponded sediment behind a faulted ridge of older sedimentary rocks located on the eastern shelf of Espiritu Santo. Symbols: Qls, landslide deposits; QTwb, well-bedded Tertiary strata; Tv, Tertiary volcanic rocks; others as in figure 11.

201

The purpose of the harbor survey was to (1) determine if local uplift is taking place in the harbor, (2) test the sensitivity of the Rabaul seismograph network, and (3) obtain refraction velocities of the rocks in the harbor area to calibrate the seismograph network. Upon completion of the harbor survey, the *Lee* docked at Rabaul and thus ended the USGS-CCOP/SOPAC survey.

GENERAL RESULTS

The Solomon Islands region encompasses three geologic provinces (Coleman, 1976): the Pacific province, which is underlain by obducted portions of the Ontong-Java Plateau on the northeast flank; the Central province, which is largely underlain by early Tertiary volcanic and volcaniclastic rocks; and the Volcanic province, which includes the late Cenozoic volcanic island arc on the southwest flank. The structure of the Solomon Island region is believed to consist of a volcanic ridge underlain by shallow, high-velocity rocks and incised by a deep intra-arc basin known as the central Solomons Trough (Katz, 1980; fig. 15). The ridge is flanked by oceanic crustal rocks of the Woodlark Basin on the southwest and thickened transitional crustal rocks of the Ontong-Java Plateau on the northeast. The deep-water (800-1,800 m), intra-arc sedimentary basin lies between the Volcanic and Central provinces and may contain more than 5 km of sedimentary section at places (fig. 15).

Both wide-angle sonobuoy reflection and refraction data were recorded, and velocity profiles for the sedimentary section and crustal layers were computed from these data. Seismic refraction arrivals, routinely recorded to a range of 37-45 km, provided maximum sedimentary layer depth estimates of 10-12 km beneath the island arc and adjacent ocean basins (Cooper and others, 1982; fig. 16).

Two subsidiary basins separated by a horst-like feature constitute the central Solomons Trough. These newly named structural basins are the Shortland Basin and the Russell Basin (fig. 15). The late Cenozoic Russell Basin is an elongate (60 × 250 km) asymmetrical crustal depression that contains a 1-5 km sedimentary section (fig. 15). Velocities of the crustal rocks beneath the sedimentary section range from 4.8-7.5 km/s. The acoustic basement, thought to be volcanic and volcaniclastic rocks that are partly metamorphosed, has velocities of 4.8-5.8 km/s; a deeper layer, which has a velocity of 6.4-7.5 km/s, is 3-5 km below the acoustic basement. These higher velocity rocks may include deeper crustal igneous rocks similar to those observed in island outcrops in the Central province.

In addition to the Russell and Shortland Basins, two other sedimentary basins have been defined and named in the region (fig. 15). Offshore from northern Guadalcanal, the basin previously identified in Iron Bottom Sound (newly named Iron Bottom Basin) is bounded by Savo Island to the northwest, Guadalcanal to the south, and the Nggela Sule Island platform to the northeast. Another sedimentary basin (newly named the Indispensable Basin) lies in Indispensable Strait and is separated from Iron Bottom Basin by the Nggela Sule Island platform; it is bounded to the northeast by Malaita and the Malaita anticlinorium.

The samples dredged from the perimeter of the Russell and Shortland Basins consist principally of volcaniclastic rocks and reef-detritus limestone (Vedder and others, 1983). In general, the volcaniclastic rocks include poorly sorted foraminiferal sandstone, sandy calcilutite, lapilli tuff, and ashy mudstone that range from indurated to friable. The limestone is largely recemented and partly recrystallized coralline and algal reef detritus that suggests downslope transport as well as submergence since deposition. Both the volcaniclastic rocks and the limestones have low porosity. Calcareous nannofossils in selected samples from each of the dredge stations indicate Quaternary ages, chiefly in the range 0.2 to 1.6 million years before present (David Bukry, written commun., 1982). Radiocarbon ages on two limestone samples are >31,000 years before present (J. B. Colwell, written commun., 1982).

The two gravity cores from water depths of 1,810 and 1,279 m in the central Russell Basin recovered 192 and 262 cm, respectively, of Holocene laminated to bioturbated foraminifer-rich mud. Thin layers of ashy material occur at intervals in both cores.

RECOMMENDATIONS

To assist CCOP/SOPAC in further evaluation of hydrocarbon, as well as mineral, resources, future studies in the region of this recent survey are recommended (fig. 17). These recommendations

202x

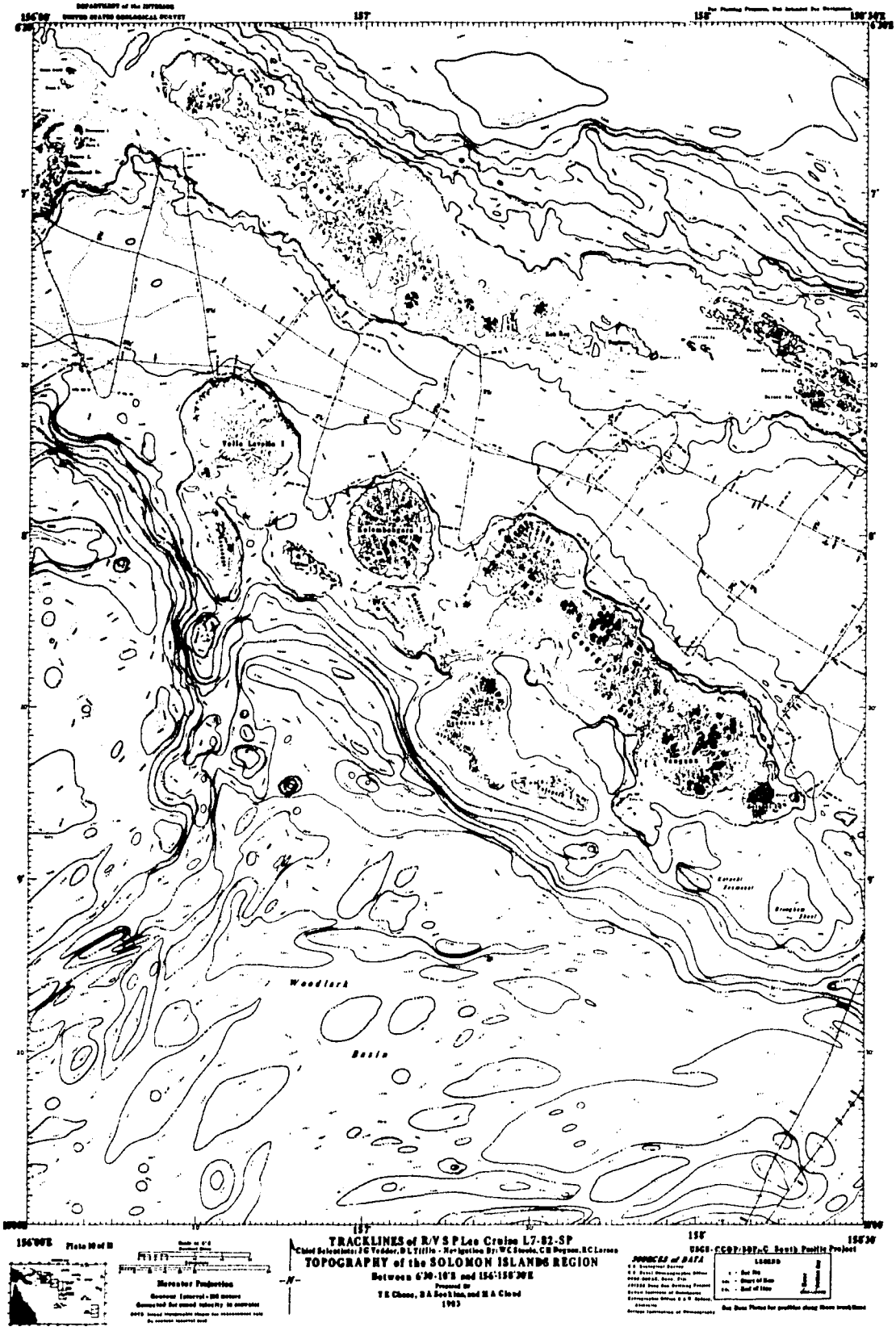


FIGURE 13.—Trackline map and bathymetry for Leg 3, Solomon Islands.

303

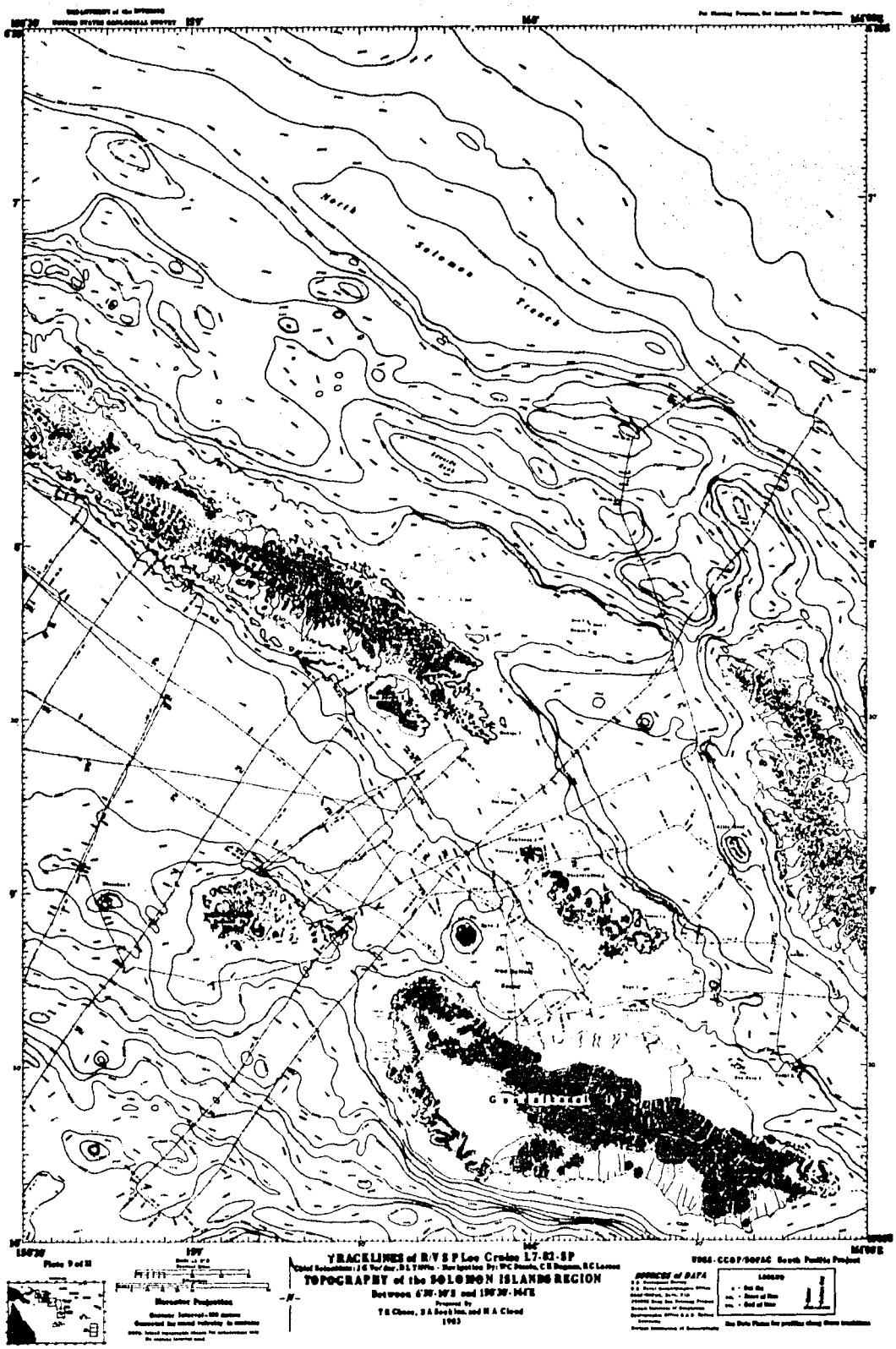


FIGURE 13.—Continued.

204x

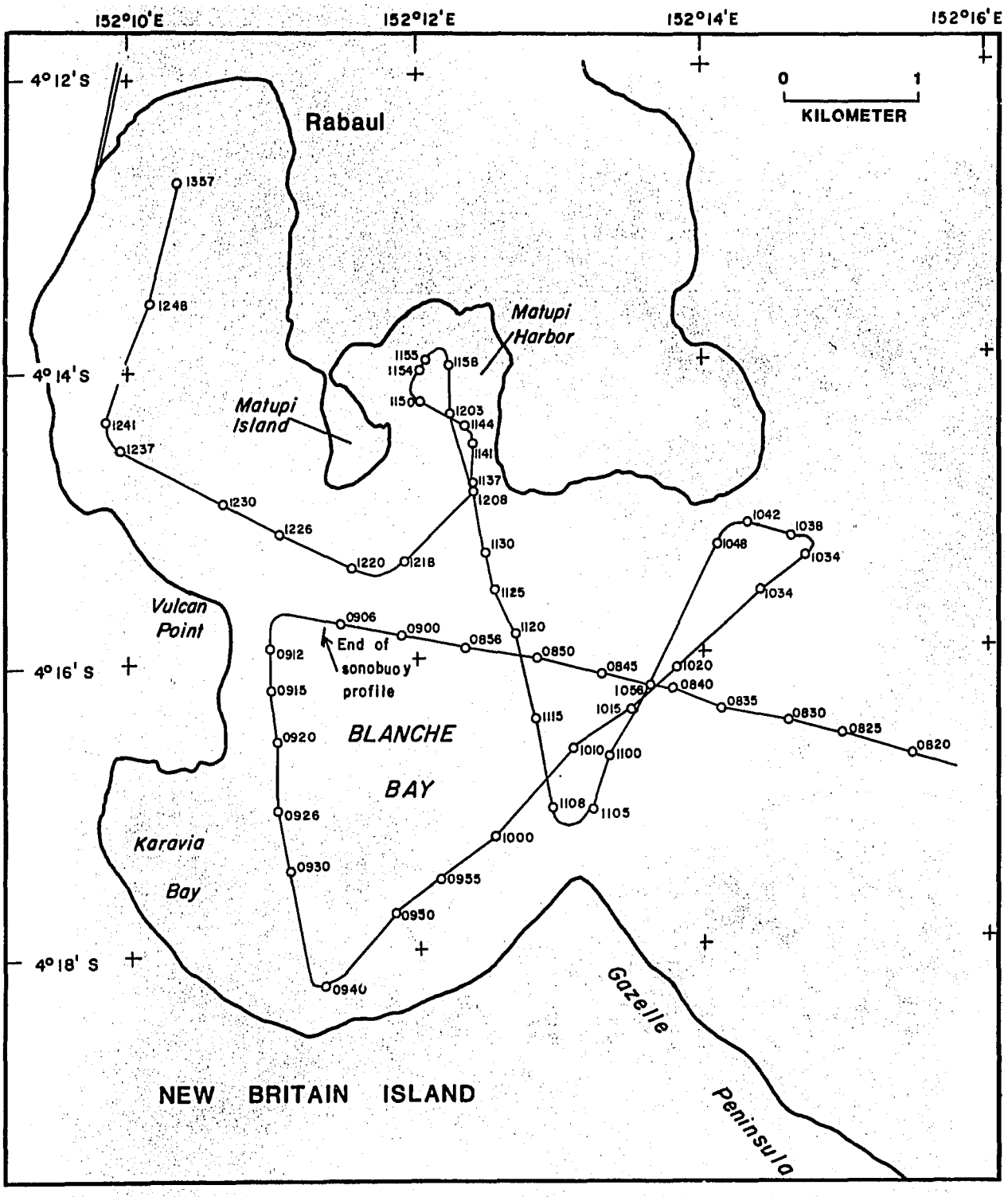


FIGURE 14.—Trackline map, Leg 3, Rabaul harbor area, New Britain, Papua New Guinea.

205

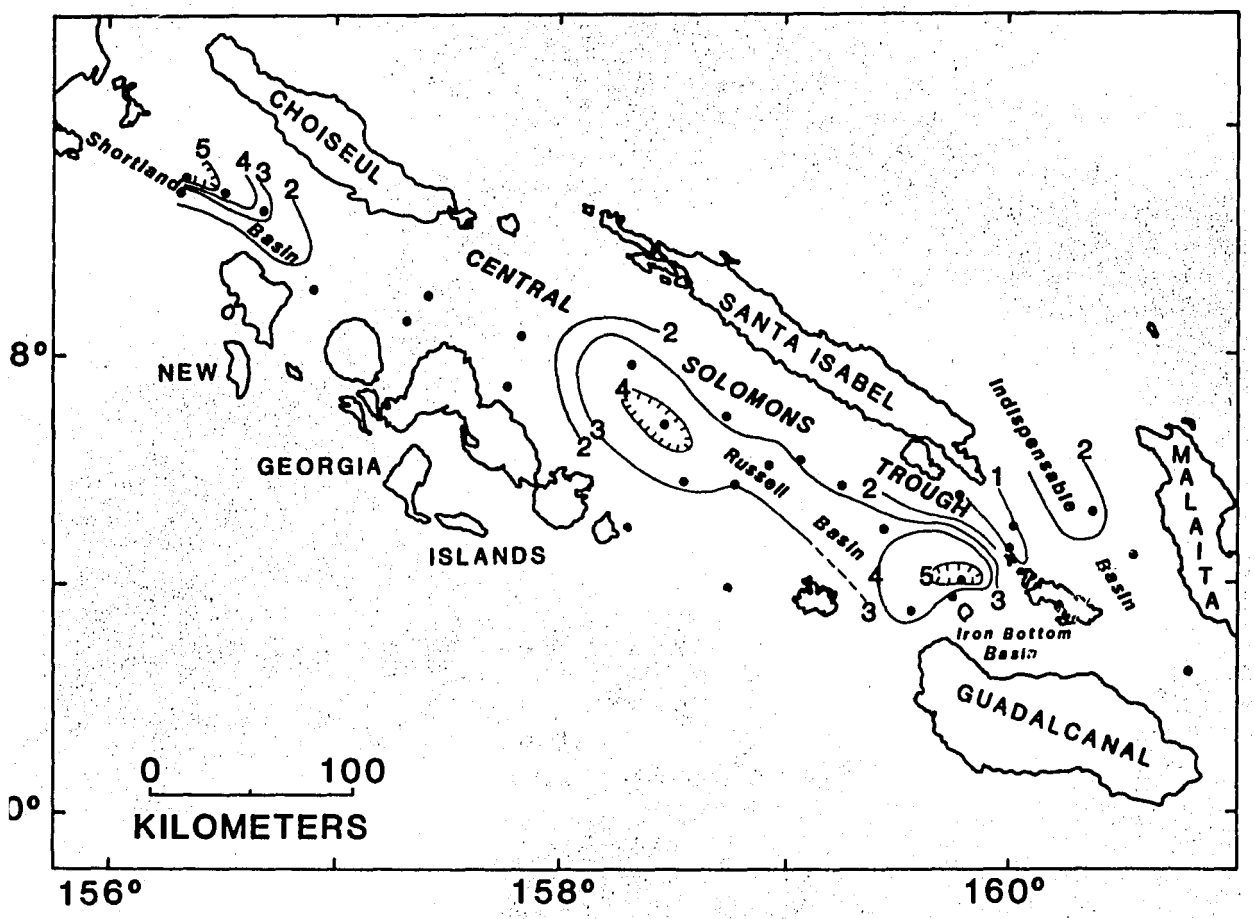


FIGURE 15.—Structural basins and preliminary isopach map of sediment overlying basement rock in the Solomon Islands. Dots are sonobuoy locations at which basement refractors were recorded. Contours are sediment thickness in kilometers.

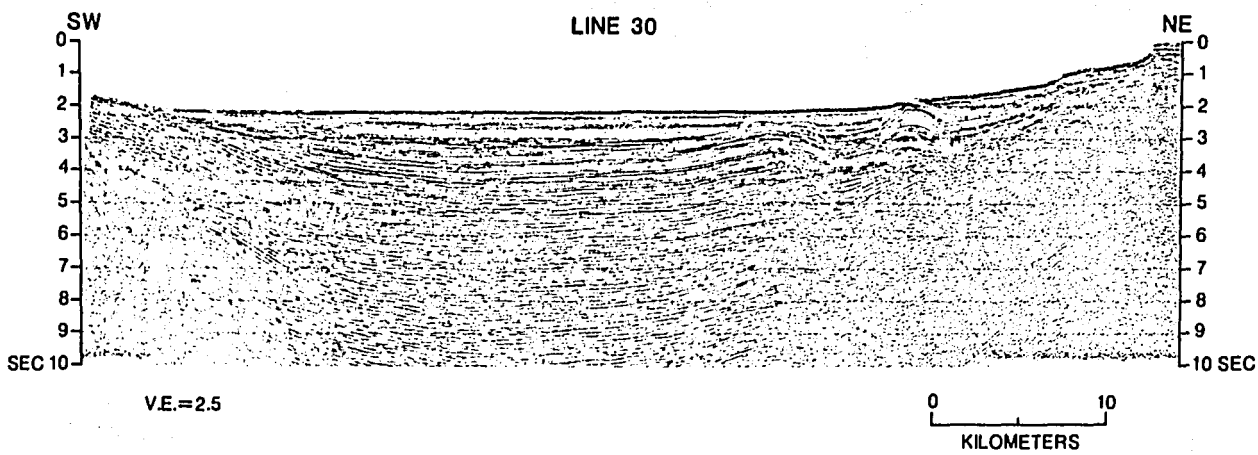


FIGURE 16.—Uninterpreted multichannel profile, Leg 3, line 30 between Russell Islands and the southeast end of Santa Isabel. See figure 13 for location.

206x

were developed at a postcruise meeting held in Honolulu, Hawaii, August 19-20, 1982, in conjunction with the Third Circum-Pacific Energy and Mineral Resources Conference. At this meeting, many of the cruise participants as well as other interested scientists discussed the initial scientific results, the status of data processing and distribution, the scientific commitments and coordination, and future work and concluded that future investigations would be required to more fully assess the resource potential of the 1982 study area and adjacent areas. Their conclusions, which were fundamentally logical extensions of the 1982 work, formed the basis for the following recommendations, presented first at the Eleventh CCOP/SOPAC Session held at Wellington, New Zealand, in November 1982.

I. Tonga Platform-Lau Ridge (continuation of Leg 1)

Multichannel seismic-reflection work to supplement that of Leg 1 is recommended in the southern Tonga platform area and over the adjacent Lau Ridge, which is underlain by a coeval if not syngenetic section (figs. 2, 17). Reflection seismology is especially needed over the far southern region of the Tonga platform (south of 23.5 S. to about 27 S.), which still is nearly unstudied, and the closely adjacent Lau Ridge. The closeness of the ridges separated by Lau Basin in this area indicates the rifting event that split them may have been less severe (rapid) and possibly occurred later than the event that rifted the southern Tonga platform area to the north. These circumstances may enhance the hydrocarbon potential of the ridge's far southern platform section. Valuable resource information can also be extracted by extending the collection of geophysical data farther northward along the Lau Ridge. Further investigation in the Tonga-Lau region would in general be aimed at clarifying the early and mid-Tertiary history of this area, which would significantly advance the evaluation of its overall resource potential.

Additional sampling is also needed in the southern Tonga platform area, as well as along the adjacent Lau Ridge. The sampling program carried out during the present investigation was assembled from shipboard analysis of seismic-reflection records. By studying these records in greater detail, sites for another dredging program can be selected to sample more comprehensively the platform's exposed sedimentary sequence; without this program, questions regarding the ridge's geologic history and resource potential cannot be resolved. The sampling program should include the flanks, which may comprise outcrops revealing substantial middle and late Cenozoic subsidence, and crestal areas of both Tonga and Lau Ridges. Resolution of the history of vertical tectonism of these two geanticlinal ridges is particularly significant in assessing their hydrocarbon potential, which, if present at all, is likely contained in porous reefal masses of early and middle Tertiary age.

Investigation of the possibility that polymetal sulfides may be forming above the magma chambers (?) identified in Lau Basin immediately west of the Tonga platform is also needed. This reconnaissance exploration will involve the collection of close-line bathymetric data, bottom photographs, water samples for helium-isotope anomalies, and samples of young lava.

II. Vanuatu and Eastern Solomon Islands Basins (continuation of Leg 2)

Data collected during Leg 2 (fig. 17) delineated three sedimentary basins on the western margin of the Central Basin of Vanuatu that may have hydrocarbon and mineral potential. Before their potential can be defined and assessment of the area's geological hazards made, additional studies are needed. These include rock-sampling and heatflow measurements to determine source-rock potential, past sedimentary depositional environments, and hydrocarbon maturation history.

Previously gathered seismic-reflection data north of the Banks Islands indicate the presence there of other sedimentary basins (Katz, 1980). These basins probably are Miocene to Pleistocene in age and therefore possibly have resource potential. It would be particularly useful to extend the 1982 multichannel seismic-reflection grid to the relatively shallow shelf region that lies between the Torres Islands and the Santa Cruz Island group to determine the presence of sedimentary basins (fig. 17).

A 20-day survey is recommended: 10 days of seafloor sampling and heatflow measurements within the 1982 survey area and 10 days of multichannel seismic-reflection surveying in the northern Torres-Santa Cruz region. In addition, detailed seismic-reflection surveying is needed along the western Central Basin to further define potential struc-

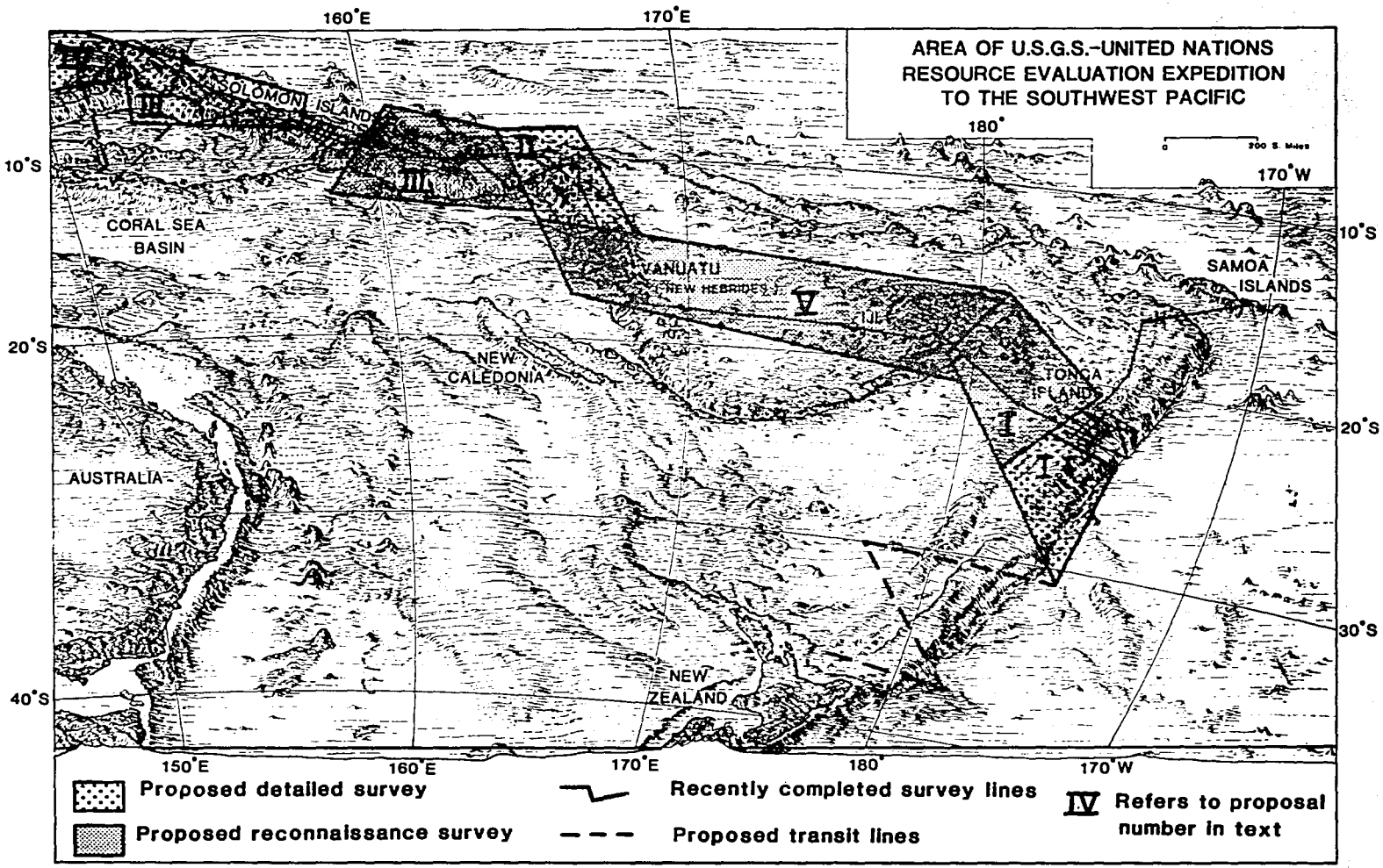


FIGURE 17.—Recommended survey areas of the USGS in the South Pacific.

tural and stratigraphic traps and to assess possible geologic hazards.

Preliminary interpretation of the 1982 *Lee* data have shown two other areas in Vanuatu that should be studied in more detail, preferably with seismic-reflection and rock-sampling techniques: (1) the relatively shallow shelf area south of Malekula and Efate Islands, where sedimentary basins have been identified, and (2) along the flanks of Maewo and Pentecost Islands, where structures indicating hydrocarbon traps may exist.

Studies of the deep structure in the Vanuatu and eastern Solomon island arc province may be possible using a two-ship operation. Should it be possible to coordinate two ships in the region, it is recommended that an arc transect involving expanding seismic spreads parallel to the arc plus constant offset spreads across the arc be undertaken. It would also be desirable to collect wide-beam sidescan sonar survey data in the Vanuatu region to better define the bedrock sea-floor exposures.

III. Solomon Islands and Bougainville, Papua New Guinea, Basins (continuation of Leg 3)

Additional geophysical work, in particular multichannel seismic-reflection surveying, and sea-floor sampling are needed to adequately evaluate the resource potential in the West Melanesian arc. Although more information to determine the nature of the tectonic framework would also be desirable, the recommendations here are confined to those relating directly to resource potential.

A multichannel seismic survey of the southeastern part of Indispensable Strait and the basin areas north and east of San Cristobal Island are required to complete the present work. This work should have first priority and should be extended eastward to correlate with the present investigation in Vanuatu and the New Hebrides arc (fig. 17). Several tracklines toward Santa Cruz Islands from the vicinity of San Cristobal would be sufficient to accomplish a reconnaissance survey.

Bottom sampling is necessary to determine the age, nature, and stratigraphic relation of rocks beneath the arc, particularly in the central Solomons Trough, but also in other areas of the arc including Indispensable Strait and the region east of Bougainville and north of Choiseul. Inasmuch as the offshore basins in this region represent much greater areas than the islands, and may reflect much different histories, sampling should be useful in revealing resource potential as well as the evolution of the arc.

Before the hydrocarbon potential of the sea-floor areas of the Solomon Islands can be fully evaluated, additional multichannel tracklines are required, particularly in the Indispensable Strait-San Cristobal area and in the western part of the Shortland Basin. Sea-floor sampling needs to be done, based on the recently collected geophysical data, to correlate acoustic stratigraphy with rock types that make up the thick sedimentary bodies.

It is estimated that approximately 30 days of ship time are needed to accomplish the work recommended for the Solomons area. This time could be divided into three 10-day phases, with the time devoted to geophysical work and sea-floor sampling being divided equally.

Recommendations IV and V represent adjoining areas where regional geological and geophysical study can significantly increase resource assessment data; scientists attending the *Lee* post-survey meeting in Honolulu in August 1982 recommended this work be initiated under the same Tripartite Agreement and scientific guidelines as for the present study.

IV. New Ireland Basin, Papua New Guinea

The New Ireland Basin is a continuation of the Vanuatu, Solomon Islands, and Bougainville Basins associated with the Melanesian arc. It extends for about 900 km from eastern New Ireland to western Manus Island and lies mostly offshore, south of the islands. It averages 160 km in width and has a sedimentary section that is locally thicker than 5 km. Water depths range from 0 to 3,000 m. The basin is truncated on the southwest by a system of transform faults, and much of the sedimentary and carbonate sequence pinches out against the Northeast Ridge, which was the outer arc of the West Melanesian Trough during Oligocene time.

Neville Exon of the Australian Bureau of Mineral Resources and Donald Tiffin of CCOP/SOPAC made considerable progress in assessing the hydrocarbon potential of the New Ireland Basin from seismic-reflection surveys carried out by CCOP/SOPAC, Gulf Oil, ORSTROM, (Office de la Recherche Scientifique et Technique Outre-Mer) and the Australian Bureau of Mineral Resources.

Land geology and interpretation of present offshore seismic-reflection data (Exon and Tiffin, 1983) indicate that the basin comprises a thick Oligocene volcaniclastic sequence overlain by as

much as 2 km of Miocene platform and reefal carbonate beds, and a similar thickness of younger volcaniclastics and biogenic sediment. Should the offshore Miocene sequence prove to consist largely of carbonates, the New Ireland Basin would be considered to have good hydrocarbon potential.

To further evaluate the basin, which has not been drilled and from which few bottom samples have been recovered, it is suggested that a three-week research program be carried out, consisting of approximately 40 percent multichannel seismic-reflection surveying and 60 percent sampling. The seismic surveying should concentrate on the eastern and western areas where no multichannel data exist (fig. 17). The sampling should consist largely of dredging and, if possible, heatflow work to assess the present day thermal gradient in the basin. The dredging would be designed to sample the older sequences identified seismically, and especially the carbonate sequence. Dredging should also be carried out, if possible, on steep slopes along the faulted southwest margin of the basin, around the uplifted Tabar-Feni Islands in the northeast, and possibly in the West Melanesian Trench.

The proposed New Ireland Basin study would not only greatly increase knowledge of the geology, geophysics, and resource potential of the basin, but also would aid in the understanding of the tectonic framework in this highly complex region, which involves at least four crustal plates.

V. North Fiji Basin

A reconnaissance geophysical survey and sampling program within the North Fiji Basin (fig. 17), especially in its southernmost area that geologically connects Fiji with Vanuatu, is highly desirable. It has been shown (Falvey, 1978) that the Fiji Islands and the New Hebrides arc regions were once adjoining structures and that they were separated beginning in late Oligocene to early Miocene time to form the North Fiji Basin. This hypothesis suggests that the sedimentary basins located in Bligh Waters of Fiji, which have been explored for oil and gas, may have evolved adjacent to and contemporaneously with the Central Basin of Vanuatu. To confirm or discount this hypothesis and thereby more completely assess the resource potential of both regions, it is proposed that multichannel seismic reflection profiles and other geophysical data be collected along the north and western margins of Fiji and that several long multichannel lines be taken across the central and southern part of the North Fiji Basin (fig. 17). In addition, sea-floor sampling should be done along the north and west margins of Fiji and on selected sites along the tying traverses. Approximately, 20-30 days of ship time would be required for this investigation.

REFERENCES

Coleman, P. J., 1976, A re-evaluation of the Solomon Islands as an arc system: United Nations Committee for the Coordination of Joint Prospecting for Mineral Resources in South Pacific Offshore Areas, Technical Bulletin 2, p. 132-140 (IDOE Workshop, Suva, 1975).

Cooper, A. K., Wood, R. A., Bruns. T. R., and Marlow, M. S., 1982, Crustal structure of the Solomon Islands arc from sonobuoy refraction data [abs.]: EOS, Transactions of the American Geophysical Union, v. 63, p. 1121

Exon, N. F. and Tiffin, D. L., 1983, Geology of offshore New Ireland Basin in northern Papua New Guinea, and its petroleum prospects: Transactions, Third Circum-Pacific Conference for Energy and Minerals, August 1982, Honolulu, Hawaii [in press].

Falvey, D. A., 1978, Analysis of palaeomagnetic data from the New Hebrides: Bulletin of the Australian Society of Exploration Geophysicists, v. 9, p. 117-123.

Fisher, M. A., Falvey, D. A., and Greene, H. G., 1982, Investigation of the central New Hebrides arc, using multichannel seismic data [abs.]: EOS, Transactions of the American Geophysical Union, v. 63, p. 1120.

Greene, H. G., Falvey, D. A., Macfarlane, A., Cochrane, G., Daniel, J., Fisher, M. A., Holmes, M. L., Katz, H. R., Smith, G. L., and Pragnell, J., 1982, Preliminary results of Leg 2 *Lee* cruise in Central Basin of Vanuatu to assess hydrocarbon potential and geologic evolution of New Hebrides Arc basins, southwest Pacific [abs.]: American Association of Petroleum Geologists Bulletin, v. 66, p. 969.

Greene, H. G., Falvey, D. A., Macfarlane, A., Cochrane, G., Daniel, J., Fisher, M. A., Holmes, M. L., Johnson, D., Katz, H. R., and Smith, G. L., 1983, Preliminary report on the geology, structure, and resource potential of the Central Basin of Vanuatu: Transactions, Third Circum-Pacific Energy and Minerals Conference, August 1982, Honolulu, Hawaii [in press].

Katz, H. R., 1980, Basin development in the Solomon Islands and their petroleum potential: United Nations Committee for the Coordination of Joint Prospecting for Mineral Resources in South Pacific Offshore Areas, Symposium on Petroleum Potential in Island Arcs, Small Ocean Basins, Submerged Margins and Related Areas, Technical Bulletin No. 3, p. 59-75.

Maung, T. U., Exon, N. F., Sandstrom, M. W., Herzer, R. H., Vallier, T. L., Stevenson, A. J., Childs, J., and Scholl, D. W., 1982, Tonga Ridge, initial results of new geological and geophysical studies [abs.]: EOS, Transactions of the American Geophysical Union, v. 63, p. 1121.

Scholl, D. W., Maung, T. U, Vallier, T. L., Childs, J., Stevenson, A. J., Exon, N. F., Herzer, R. H., Sandstrom, M. W., and Soakai, S., 1982, Preliminary results of geophysical and geological studies to assess resource potential and

210x

geologic evolution of central Tonga Ridge and summit platform (21-24° latitude) [abs.]: American Association of Petroleum Geologists Bulletin, v. 66, p. 983.

Scholl, D. W., Vallier, T. L., Maung, T. U., Exon, N. F., Herzer, R. H., Sandstrom, M. W., Stevenson, A. J., Mann, D. M. and Childs, J., 1983, Initial cruise report, SOPAC Leg 1 (cruise L5-82) southern Tonga platform: Transactions, Third Circum-Pacific Energy and Mineral Resources Conference, August 1982, Honolulu, Hawaii [in press].

Vedder, J. G., Tiffin, D. L., Coulson, F. I. E., Beyer, L. A., Bruns, T. R., Colwell, J. B., Cooper, A. K., Kroenke, L., Marlow, M. S., and Wood, R. A., 1982, Preliminary results of Leg 3 *Lee* cruise—basin development and resource potential of central Solomons Trough [abs.]: American Association of Petroleum Geologists Bulletin, v.66, p.986.

Vedder, J. G., Tiffin, D. L., Kroenke, L., Colwell, J. B., Cooper, A. K., Beyer, L. A., Bruns, T. R., Coulson, F. I. E., Marlow, M. S., and Wood, R. A., 1983, Preliminary results of Leg 3 *Lee* cruise, Solomon Islands: Transactions, Third Circum-Pacific Energy and Minerals Conference, August 1982, Honolulu, Hawaii [in press].

GPO 687-040/23

211