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PHILIPPINE MARINE SEISMIC SURVEY PROJECT

CRUISE PROPOSAL

by

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Division of Marine Geosciences & Petroleum Geology

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CRUISE PROPOSAL

Project 123.03
(Survey 108)

Co-Chief Scientists

Chao-Shing Lee & Doug Ramsay

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SUMMARY

This document describes a cooperative project to assist the Government of the Republic of the Philippines in undertaking technical and geoscientific programs to promote exploration for petroleum in offshore Philippine basins. It has the following main objectives:

- to upgrade the knowledge of petroleum prospectivity of selected areas in the Philippines and thus promote potential opportunities for future Philippines-Australia joint venture exploration; and

- to assist the Philippine Government in acquiring the skills to plan, obtain and interpret seismic data and other petroleum resource related information and use these to focus future petroleum exploration in Philippine waters.

The project involves the collection of 2500 km of modern multichannel seismic reflection data, plus hydrocarbon-detection geochemistry data and other underway geophysical data, over two selected offshore areas in Philippine waters. Survey Area I consists of the Northeast Palawan Shelf and the Cuyo Platform, and Survey Area II consists of Tayabas Bay and Ragay Gulf. These data will be processed in Australia, integrated with existing exploration data from previous industry sources, interpreted and analysed for petroleum potential. The final analysis, together with the basic data, will then be presented to the exploration industry, initially in the Philippines and Australia, and later internationally, in order to promote further exploration.

The project will provide the Government of the Republic of the Philippines with independent assessments of petroleum resource potential and information necessary for the designing, awarding and management of exploration permits. The project will also provide the Philippine Office of Energy Affairs (OEA) with an Australia-designed computer-based mapping system (i.e. Petrosys System) to assist OEA's on-going seismic mapping and database capability for the Philippine sedimentary basins. Training of Philippine geoscientists will be undertaken throughout the life of the project, so they will be able to more effectively manage Philippine petroleum exploration.

The project will involve staff of the OEA, some representatives from petroleum exploration companies in the Philippines, and the Australian Bureau of Mineral Resources, Geology and Geophysics (BMR). The data acquisition will be carried out from the BMR's geoscientific research vessel, *Rig Seismic*. Data processing will be carried out in BMR laboratories and computer centres in Canberra.

1. INTRODUCTION

The Philippine Offshore Seismic Project is designed to achieve the following objectives:

- to upgrade the knowledge of petroleum prospectivity of selected areas in the Philippines and thus promote potential opportunities for future Philippines-Australia joint venture exploration; and

- to assist the Philippine Government in acquiring the skills to plan, obtain and interpret seismic data and other petroleum resource related information and use these to focus future petroleum exploration in Philippine waters.

These objectives will be achieved by the acquisition of relevant seismic data from selected offshore areas, by the analysis of these and existing data and by the public release of results to the petroleum industry in the Philippines, in Australia and internationally. Geoscientific personnel from the Philippine OEA will assist in these activities and will receive necessary training. Equipment to support this capability will also be provided.

This document provides a brief description of the scientific background, a progress report of cruise planning activities, and proposed ship track and cruise itinerary.

2. REGIONAL GEOLOGY AND TECTONICS

The Philippine Archipelago lies in an area of complex regional geology and tectonics (Fig. 1). It is located near the junction of three major tectonic plates: the Southeast Asia plate to the west, the Philippine Sea plate to the east and the Indo-Australia plate to the south. The Philippine Sea plate consists of Eocene oceanic crust, while the two other plates consist of units of oceanic crusts, continental blocks, and magmatic arcs with associated basins and collisional melange.

The active archipelago zone is undergoing overall oblique compressive deformation between the Philippine Sea and Southeast Asia plates. In the central Philippines, the major shear component is taken up by the sinistral Philippine Fault system which dominates regional structures.

The convergence that has taken place between the Philippine Sea and Southeast Asia plates since early Cenozoic is substantial. This convergence resulted in the collision of several terranes - each with a unique stratigraphy and geologic history - which have been amalgamated into the main north-south archipelago. These terranes include a rifted continental block, metamorphic blocks, magmatic arcs, accretionary wedges and oceanic crusts.

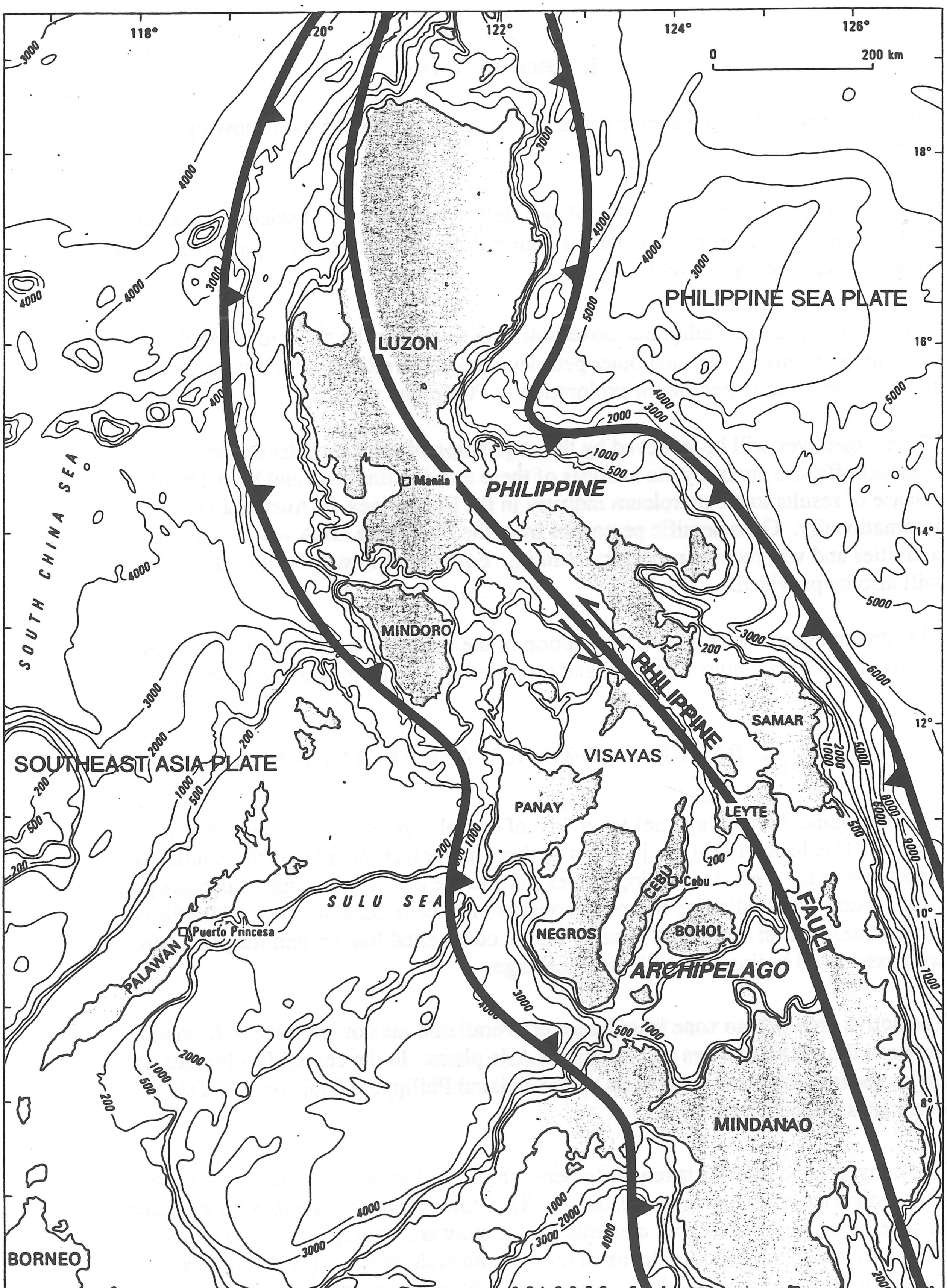


FIG. 1. Philippine Archipelago regional tectonic setting

Regional tectonics and the resultant structure have controlled the evolution of the Philippine sedimentary basins (Hamilton, 1979; Petroconsultants Report, 1991). Two distinct sedimentary domains have been identified: the Philippine Island Arc System, which hosts 11 major sedimentary basins, and the continental Kalayaan-Calamian Microplate, which hosts 2 sedimentary basins. Sedimentation in the Philippine Island Arc system began in the Cenozoic and is characterised by an abundance of sediments deposited in mostly forearc and backarc settings. In the Kalayaan-Calamian Microplate, a continental margin style of sedimentation commenced in the Mesozoic.

3. RANKING OF INDIVIDUAL BASINS

The 13 major Tertiary sedimentary basins have varying oil and/or gas potential, expected hydrocarbon types and exploration maturity (OEA-World Bank Report, 1986). These can be categorized into 6 classes based on relative prospectivity (Fig. 2).

Class I basins are considered to have very good hydrocarbon potential. The Northwest Palawan Shelf alone qualifies under this category. It is regarded as a marginally explored basin which offers very good possibilities for future hydrocarbon finds.

Class II basins are rated as having fair to good potential for predominantly oil plays. The Southeast Luzon Basin, the Visayan Basin and the Sandakan Sub-basin belong to this class. Southeast Luzon Basin and the Visayan Basin are given higher rankings due to their potential gas accumulations as well as oil. Southeast Luzon Basin, moreover, is frontier with virtually no wells to test numerous play concepts.

Class III basins are rated as having fair to good potential for predominantly gas plays. The Mindoro-Cuyo region of North Palawan-Mindoro Basin and the South Palawan Basin fall under this group. The Mindoro-Cuyo region consisting of the East Mindoro Depression and Cuyo Platform is frontier, while the South Palawan Basin has been only marginally explored by drilling.

Class IV basins include those assessed with poor to fair oil potential. These consist of three frontier basins, namely: Agusan-Davao and Cotabato Basins, and Balabac Sub-basin. The Agusan-Davao Basin has gas potential while the Cotabato Basin has oil potential.

Class V basins are rated as having poor to fair potential for predominantly gas plays. Cagayan Basin, Central Luzon Basin and Ilocos Trough comprise this group. Cagayan Basin has minor oil potential in addition to its known gas finds. Central Luzon Basin has better parameters for petroleum accumulation, particularly gas.

Class VI basins are regarded as having poor potential for gas play. These include West Luzon Platform, Iloilo Basin/West Masbate Shelf, Bicol Shelf/Lamon Bay and Bancauan Sub-basin. The West Luzon Platform is more promising because of one

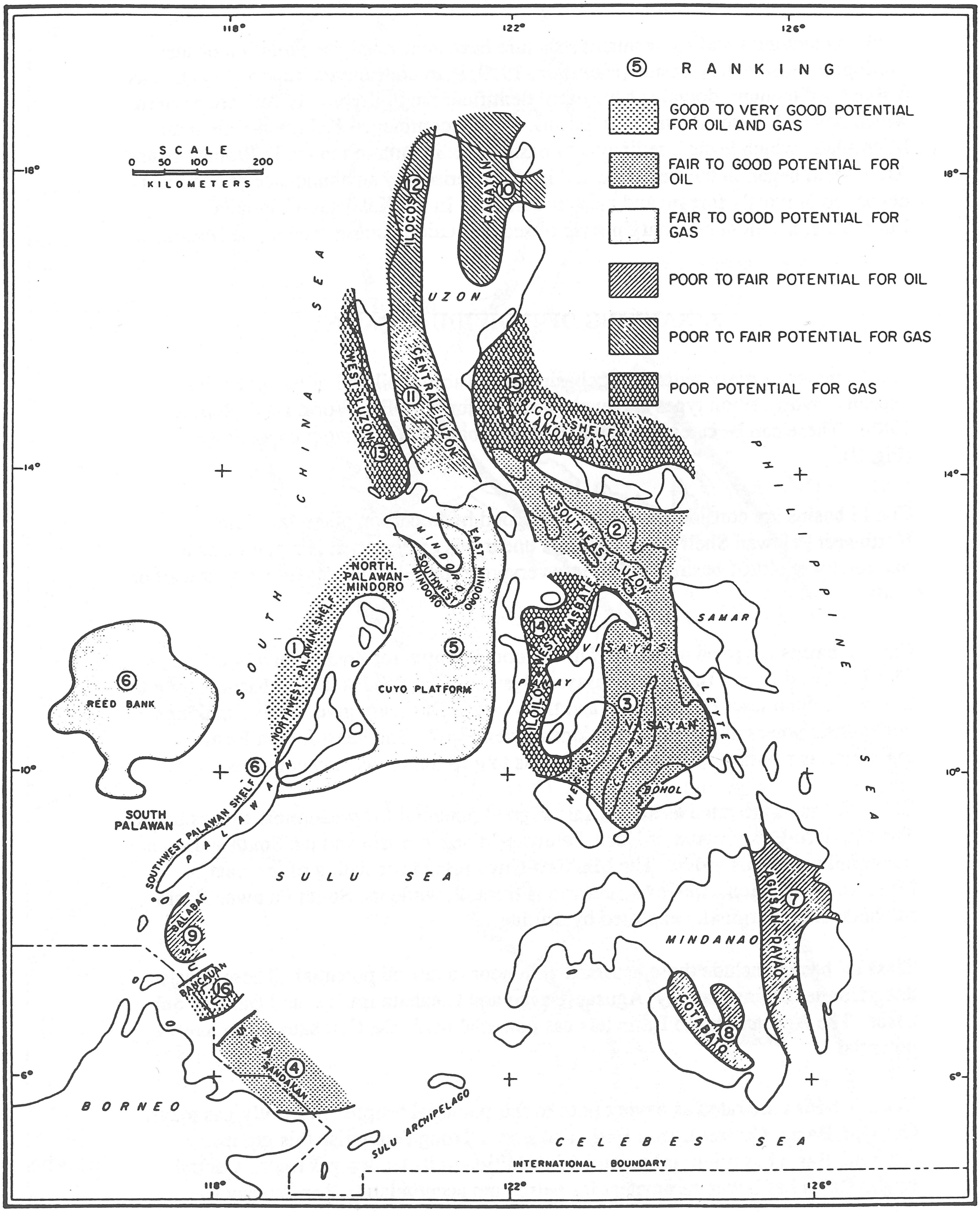


FIG. 2. Philippine sedimentary basins appraisal map

deep sub-basin whose sedimentary provenance may have been the continental terrane of the Kalayaan-Calamian Microplate. Iloilo Basin/West Masbate Shelf have at least two deep depocentres which offer a number of drilling targets. The potential of Bicol Shelf/Lamon Bay area seems to hinge on the Paleogene plays only. The Bancauan Sub-basin is the least prospective because of its thin sedimentary fill (low thermal maturity).

4. HISTORY OF PETROLEUM EXPLORATION AND PRODUCTION

4.1. EXPLORATION

Petroleum exploration in the Philippines dates back to 1896 when the first well was drilled in Cebu, central Philippines. From the 1950s to 1970s, there was widespread exploration activity with 301 onshore wells and 4 offshore wells being drilled. Of these, 68% were drilled on the basis of surface mapping and/or oil seeps and the remainder based on some surface gravity and magnetic surveys or seismic surveys. 74% of the wells drilled were less than 1000m deep and most in fact were virtually shallow stratigraphic test holes. The results, however, produced only sub-commercial quantities in two basins: gas in the Cagayan Basin, and oil and gas in Cebu and the Visayan Basin.

From 1949 to 1972 the legislation regulating petroleum exploration and development was the Republic Act No 387, known as the "Petroleum Act of 1949". This act granted petroleum concessions to qualified parties. In return the Philippine government was due a royalty payment of 12.5% of the proceeds should there be commercial oil production.

The service contract system took effect in 1973 with the enactment of Presidential Decree No 87. This resulted in a big increase in offshore drilling. The majority of the wells drilled were located using seismic data and drilling depths increased (OEA Report, 1987).

The shift of exploration interest to the offshore areas in the 1970s paved the way to several oil discoveries in offshore Northwest Palawan. The first oil discovery, the Nido-1 well, was drilled in 1976 by a consortium led by Philippine Cities Service Inc. (PCSI) on a Lower Miocene reefal build-up. This turned out later to be non-commercial although it proved to be the impetus for renewed drilling activities in the country.

Subsequent drilling by PCSI along the same Lower Miocene reefal trend led to the discovery of the South and West Nido oilfields which were later jointly developed as the Nido Oil Complex. Amoco Philippines Inc. also made a commercial discovery in Northwest Palawan when it drilled the Cadlao-1 well in 1977. It tested oil from a similar Lower Miocene carbonate build-up and started production in 1979.

From 1978 to 1980, PCSI drilled additional wells in the Matinloc Complex in offshore Northwest Palawan. The Complex proved to be commercially viable and started production in 1981. It consists of the Matinloc, Pandan and Libro fields.

In the Reed Bank area, Sampaguita-1 well, drilled by a Swedish consortium, yielded gas from Paleocene-Eocene sands. Significant oil and gas discoveries have also been found in deep water areas off Palawan. The Galoc-1 well, drilled by PCSI in 1981, flowed 35° API oil from Lower Miocene turbidite sands. The San Martin A-1X well, drilled by Phillips Petroleum, yielded substantial gas from a Lower Miocene reefal carbonate.

From 1983 to 1986, a major catalyst was the World Bank-financed Petroleum Exploration Promotion Project which produced a comprehensive 12-volume report on the petroleum potential of the country's 13 sedimentary basins (OEA-World Bank Report, 1986). Included in the package are updated atlas-sized plates, figures, tables, a synopsis, and numerous enclosures. Figures and tables within the text show a variety of petroleum geological features including petrophysical characteristics, engineering data, lists and appraisals of all the wells drilled, diagrammatic cross-sections and detailed stratigraphic columns. Basins were individually assessed and ranked according to petroleum prospectivity.

Up to 1991, a total of 165 wells were drilled under the service contract system and more than 160,320 line-kms of seismic data were also acquired (OEA Report, 1991; Fig. 3).

4.2. PRODUCTION

In 1986, the Philippines had three oil fields producing from Lower Miocene reefal limestone reservoirs. There are now six declared fields. All are off NW Palawan.

The Nido Complex started production in 1979 from five wells in two fields. As of the end of 1986, cumulative production reached a total of 15.4 million barrels of 27° API crude. The Cadlao field was put on stream in 1981; the two producing wells have flowed 8.50 million barrels of 46° API oil as of the end of 1986. Production in the Matinloc Complex started in 1982 from five wells in three separate reefal build-ups. At the end of 1986, total cumulative production amounted to 7.89 million barrels of 44° API oil. Cumulative production from the above three offshore complexes as of the end of 1986 reached 31.8 million barrels.

To date, only 6 fields are producing. A total of 40.7 million barrels of oil have been produced since 1979 up to 1991 from these fields (OEA Report, 1991; Fig. 4).

5. RESULTS OF CRUISE PLANNING ACTIVITIES

5.1. SELECTION, EVALUATION AND RECOMMENDATION OF SURVEY AREAS

5.1.1. Selection of Study Areas

Since July 1991, BMR and OEA project personnel have reviewed the sedimentary basins of the Philippines using OEA's World Bank Report (1986). As a result of this review, two areas were selected for the pre-survey study, the Southeast Luzon Basin and East Palawan Shelf.

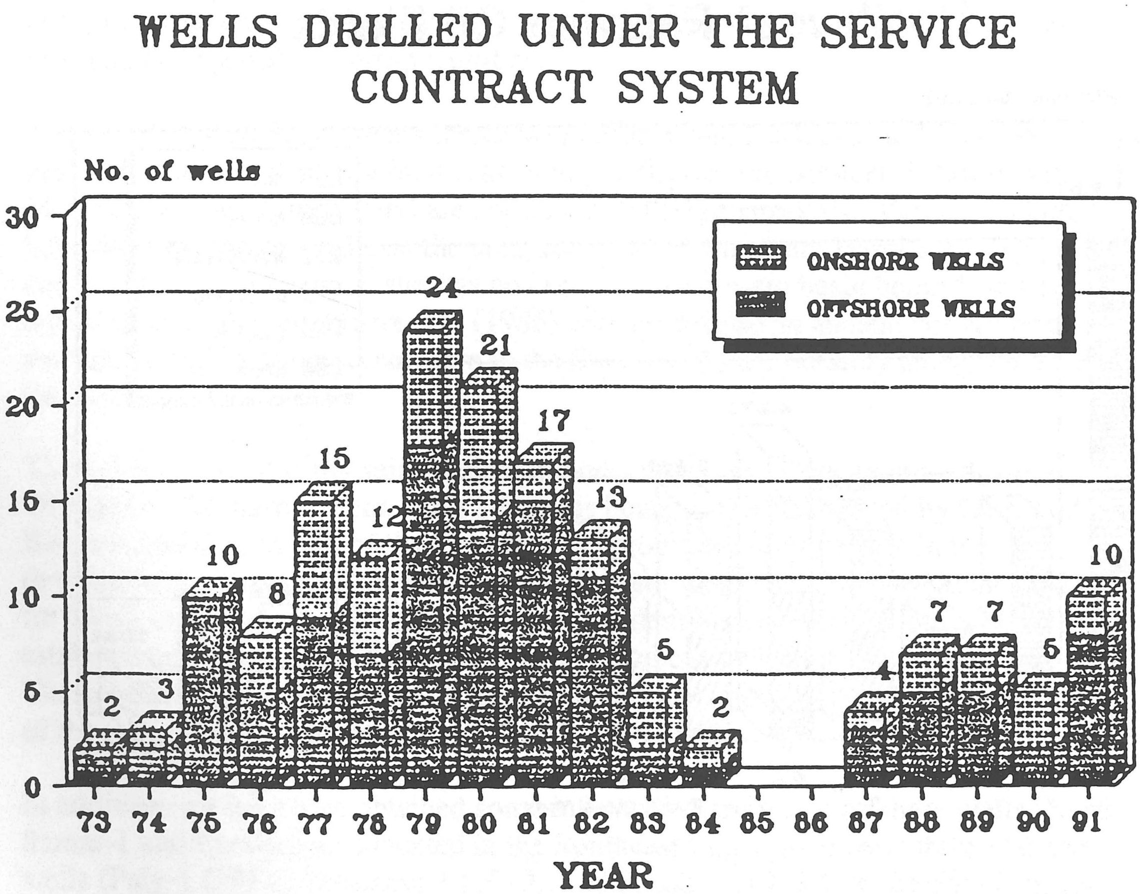


FIG. 3. Number of wells drilled under Service Contract System since 1973

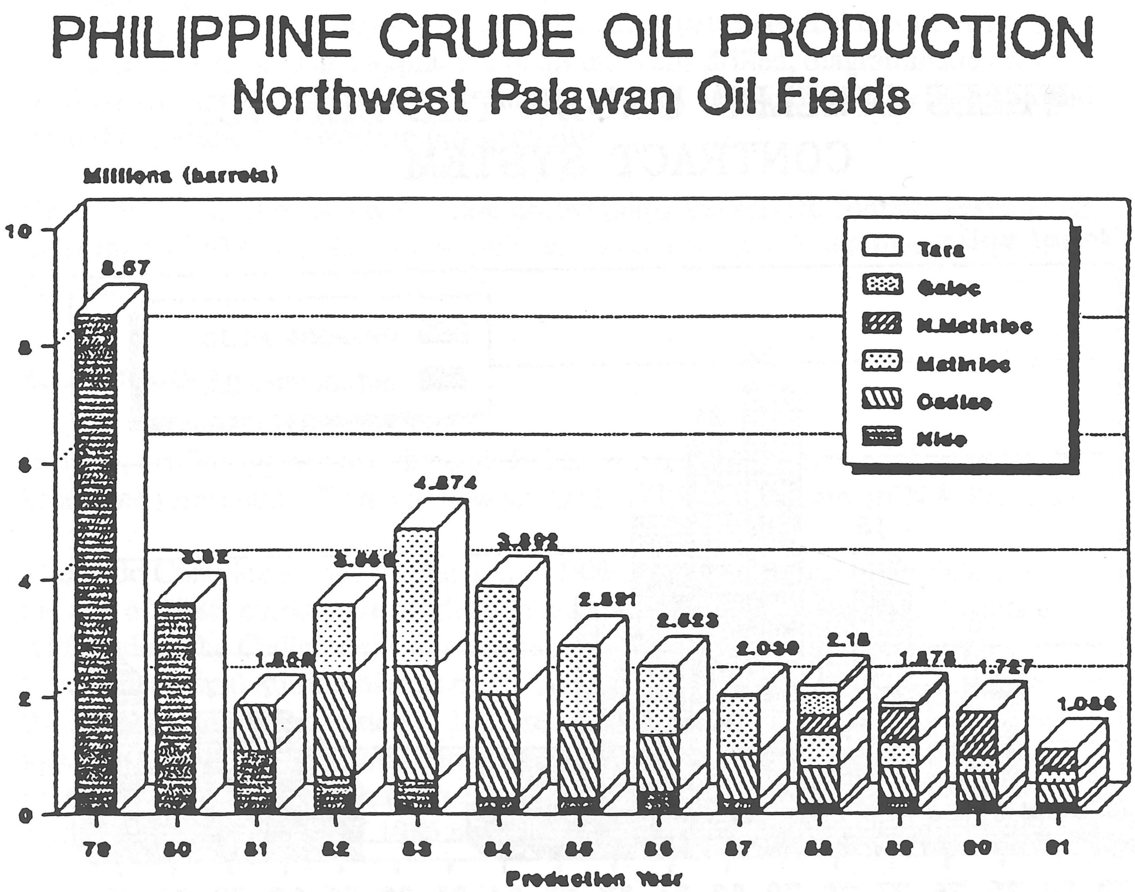


FIG. 4. Philippine crude oil production between 1979 and 1991

The Southeast Luzon Basin covers Tayabas Bay, Ragay Gulf, Burias-Ticao Pass, North and West Samar Sea, and Lagonoy Gulf. It has a total area of about 40,000 square-kms. Results of the studies made by OEA and Petro-Canada in 1986 have shown that the basin has a fair to good potential for oil and possible minor gas. Previous seismic coverage is from about 5 x 5 km-grid in the Ragay Gulf and part of the West Samar Sea to about 20 x 20 km-grid in the Lagonoy Gulf. It remains as a frontier exploration region. Up to date, only two offshore wells, North Samar-1 (1981) and Cataingan-1 (1979) have been drilled in this area.

The Southeast Luzon Basin is classified as a backarc basin modified by wrenching. It exhibits some of the characteristics of backarc basins of Indonesia and Malaysia, including moderate to high geothermal gradients and reworked volcanoclastic reservoirs. Reefal structures seen on some of the sections in the area indicate possible additional hydrocarbon reservoirs. Additional seismic data in this area are needed in order to locate other leads and further define those previously identified fields and evaluate their petroleum prospectivities.

The East Palawan Shelf covers the Cuyo Platform, and Northeast and Southeast Palawan continental shelf which is an elongate depocentre between Palawan and the Mid-Sulu Ridge. It has a total area of about 50,000 square-kms. Various authors have done extensive works on the area, foremost of which are Hamilton (1979) who considers the East Palawan shelf as an outer-arc or fore-arc basin behind the Palawan non-volcanic ridge, and Hinz et al (1986) who postulated an ancient convergent margin east of Palawan somewhere in the Sulu Sea Basin, possibly along the trace of the Mid-Sulu Sea Ridge.

The existing oil company seismic data in both study areas were examined using OEA's new database system. This system is being jointly developed by OEA and Kestrel Data Co., as part of the Canadian aid program. Because it is in the development stage, there are some problems regarding seismic profile identification for filing and retrieval. We have been able to identify and obtain about 90% of the total data set in the Southeast Luzon Basin and about 70% in the East Palawan Shelf. These data are now used by BMR and OEA staff for evaluation and recommendation of the survey areas.

In addition, we have also obtained some information from two offshore wells (North Samar-1 and Cataingan-1) located in the Southeast Luzon Basin and three offshore wells (Paly-1 (1981), Dumaran-1 (1979), and Roxas-1 (1979)) on the East Palawan Shelf. We have obtained the well completion report and some well log information from three wells, but other information is missing. OEA staff will continue to search for the data. In future, we will request information from adjacent regions in order to establish the regional well cross sections for both study areas.

5.1.2 Evaluation and Recommendation of Survey Areas

After an assessment of available seismic and well data in the two study areas, the Southeast Luzon Basin and the East Palawan Shelf, we proposed a set of work programs that will be implemented in four sub-basins (Fig. 5). These include:

(1) a prospective area (Ragay Gulf-Burias Pass);

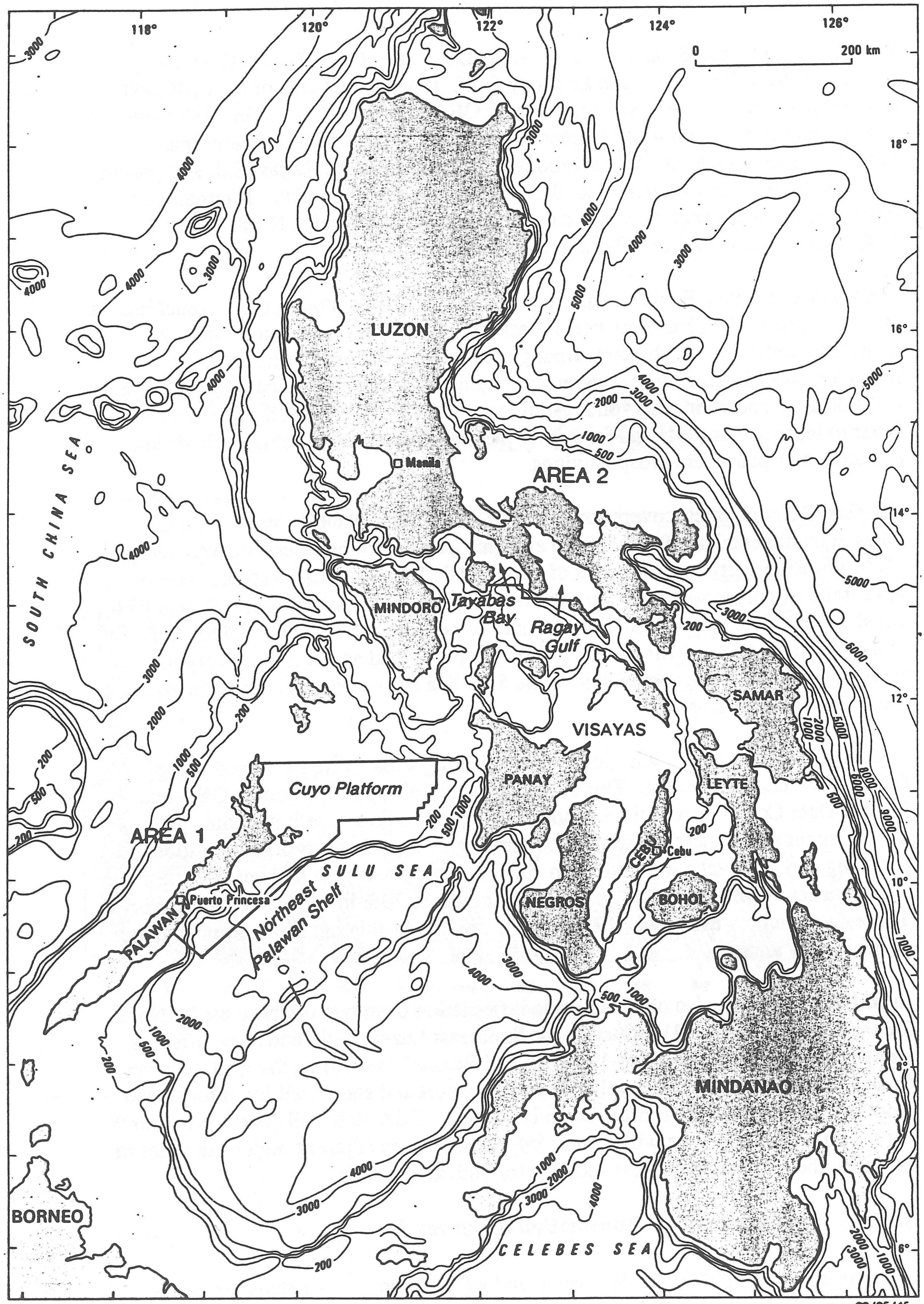


FIG. 5. Project proposed Survey Areas I and II

(2) an area which has the potential to become prospective (Cuyo Platform-NE Palawan Sub-basin); and
(3 & 4) two frontier areas (Tayabas Bay and SE Palawan Sub-basin).

In the work program, we recommend reprocessing an estimated 500 kilometres of existing seismic data, plus the acquisition of 2500 km of new seismic and sniffer geochemical data.

5.2. ESTABLISHMENT OF A PROJECT GUIDELINE AND MORATORIUM OF SURVEY AREAS

The establishment of opportunities for Filipino and Australian oil companies to apply for geophysical survey and service contracts over the project survey area is mentioned in the Memorandum of Understanding and the Design Document. BMR places high priority in ensuring that some specific actions are undertaken by the project in this regard. A meeting with the Philippine Petroleum Association was conducted on 1 October 1991, and further discussions with OEA on 9 and 11 October were held specifically to discuss the project and the objective of trying to establish some form of moratorium to benefit Filipino/Australian oil companies.

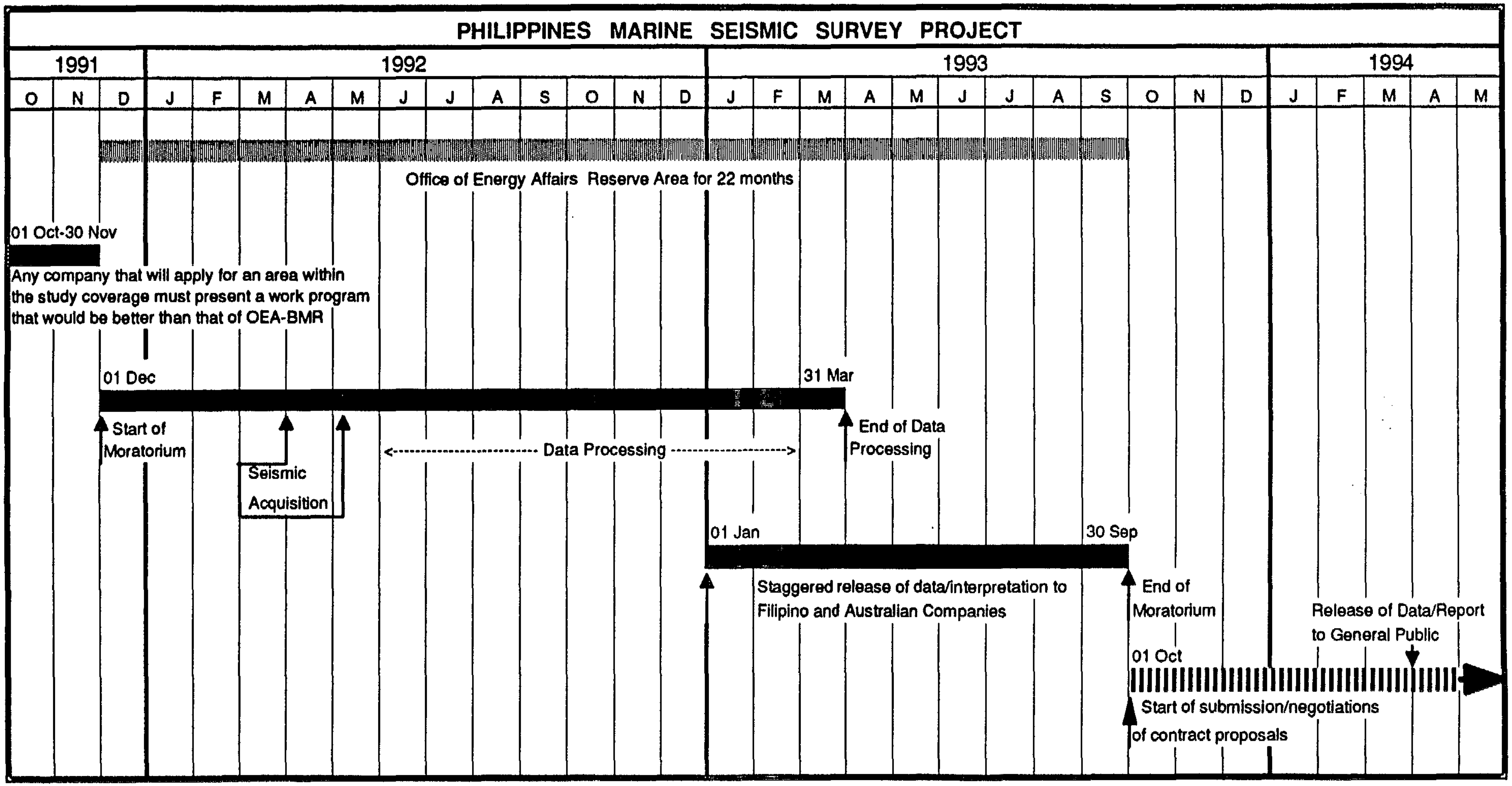
Following the assessment and recommendation, OEA has declared a moratorium over the survey areas effective 1 December 1991 (Fig. 6). The moratorium schedule has been slightly revised as follows to allow shorter reservation periods for the more prospective areas. We have grouped the Cuyo and Palawan areas as Survey Area I and the Tayabas Bay and Ragay Gulf as Survey Area II.

Area	Moratorium Period
Survey Area I:	
Cuyo Platform - NE Palawan	22 months (may be shortened depending on project progress)
SE Palawan	22 months
Survey Area II:	
Tayabas Bay	22 months
Ragay Gulf - Burias Pass	16 months

5.3. PROGRESS REPORT FROM SELECTED SEISMIC DATA REPROCESSING

The reprocessing of Philippine seismic data has reached a point where we are ready to commence production processing. We have conducted extensive testing of the data, and come to the conclusion that a significant improvement in the interpretability of the data can be achieved by use of the following processes:

FIG. 6. Project Moratorium chart



1. Use of Predictive Deconvolution to reduce short period multiples. On the original data, a proprietary package called DESIG was used to compress the source signature.

2. Use of Shot domain FK filtering to reduce the source generated coherent noise. This kind of noise is very evident on the data and partly contributes to the steeply dipping coherent noise on the stack sections.

3. Use of Common Receiver Domain FK filtering to reduce coherent noise attributed to scattering of seismic energy from near surface discontinuities. This is a second contributor to serious remnant coherent noise on the stack section.

4. Use of horizon based velocity analysis to improve the stack response.

5. Use of careful muting to eliminate remnant refraction energy.

The results are that there is a significant amount of apparently primary seismic energy which can be more readily interpreted from the section. The Data Processing staff will now proceed to put all the data through this sequence.

At this time, there are about 150 km of seismic data already reprocessed. Due to some original tape problems, a group of seismic data (the World Bank seismic data in the Ragay Gulf) cannot be successfully read. A considerable time has already been spent to recover the data but to no avail. The suspicion is that it is probably due to the sealing and storage of these tapes.

5.4. PROGRESS REPORT FROM LANDSAT TM AND SEASAT IMAGE PROCESSING

5.4.1. Background

The Information Systems Branch of BMR was contracted by the Marine Program to process Landsat TM imagery for shallow water mapping over the proposed survey areas in the Philippines. The purpose of this is to aid ship navigation.

The aim of the image processing was to produce easy to interpret images that highlighted areas of shallow water. Landsat TM imagery has a spatial resolution of 30 metres and a spectral bandwidth, from the visible to thermal infrared region, that is covered by 7 channels or bands.

The penetration of light through water is greatest in the visible blue wavelength and decreases at longer and shorter wavelengths. Thus depth can be inferred from the amount of reflectance measured by the sensor at different wavelengths. However, factors that will influence the signal received by the sensor include: sediment within the water, water surface conditions, variations in the material on the sea floor, and atmospheric conditions.

5.4.2. Landsat Data Acquisition

A list of Landsat TM scenes covering the proposed survey areas was prepared at the beginning of the project. The procedure for purchasing satisfactory scenes required the following criteria:

1. Imagery had to be as cloud free as possible over water;
2. High sun angle for maximum penetration;
3. Minimum turbidity and water surface disturbance.

The first 2 criteria were achieved by firstly viewing microfiche for imagery over the area held by the Thailand Remote Sensing Centre in Bangkok. The Centre has been archiving imagery from late 1980s to the present. The Landsat satellite makes repeated passes over a particular area every 16 days. However imagery is not recorded for each scene on each pass, therefore lowering the number of available images.

A visit was made to the centre in Bangkok in September 1991 to provide a list of suitable scenes and as a result 4 scenes were purchased. In October we purchased 3 microfiche of specific dates covering the proposed survey areas, and from these a further 5 quarter scenes and 1 full scene were ordered in December 1991. These final tapes were received in early January 1992.

5.4.3. Landsat Image Processing Strategy

Processing began in mid-November 1991 on one of the scenes from the first shipment. The first phase of processing involved checking the integrity of the data and testing and refining the algorithms and processing steps required to produce an acceptable final product. This phase was completed in the first week of January 1992 with the delivery of geometrically corrected and scaled imagery for one of the scenes. The second phase was to routinely process imagery over the specific survey areas and produce scaled colour prints. This work commenced at the beginning of January 1992 with a deadline for processing and printing all depth and turbidity images by the end of January. At this stage these products will be printed at 1:200,000 scale but will not be geometrically rectified. The third phase will consist of geometric rectification, annotation and printing of processed imagery. The deadline for all processing is set at the middle of March 1992.

5.4.4. Landsat Image Processing Procedures

Initial investigations of the imagery showed cloud and shadow patches over the sea in most images, as well as variations in water quality mainly in the form of turbidity. While the cloud patches could be easily identified, the turbidity effects were more widespread and would have a deleterious effect on depth estimations. Therefore a processing procedure was needed to highlight these variations in the data so that proper interpretations could be made. It was decided that at least 2 images per scene would be needed: a pseudocoloured depth image and a black-and-white turbidity image. The substrate images were given lower priority. This was because substrate types that are relevant to this project and can be well defined in shallow water zones become more difficult to resolve in deeper water zones. The following points highlight the steps required to generate the required processed imagery.

- read in data from tapes, make back-up copy and check data quality;
- process for sea depth and sea bottom types using algorithms developed by the Environmental Geoscience group;
- destripe processed imagery to suppress line-oriented noise;
- produce single band turbidity image;
- manipulate original imagery to add back cloud and land to the sea-processed imagery;
- pick control points from imagery using existing maps and then geometrically rectify imagery to relevant map projections;
- digitise bathymetry contours from existing maps onto the processed imagery to aid interpretation;
- produce scaled prints on the colour laser printer.

5.4.5. Results to Date

The two enclosed figures are examples of the processing to date (Figs. 7 and 8). Figure 7 is a geometrically rectified pseudocoloured depth image. The image covers the designated Survey Area II in the Mopog Pass and Ragay Gulf region. In this image shallow to deep water ranges from reds through greens to blues. The 20 metre depth range is marked by cyan and is the depth limit before deep water defined by the dark blue areas. The areas defined by cyan are also influenced by turbidity effects and residual banding effects in the data.

The variation in turbidity is shown in Figure 8, with light grey areas indicating sediment and thus turbidity. The areas of turbidity can then be used to re-evaluate the depth image. Comparisons of cyan in the depth image and light greys in the turbidity image show areas of correlation for some areas and no correlation in other areas, therefore indicating true depth estimates. A greyscale bar and appropriate annotations will be prepared for the final print production.

5.4.6. Seasat Image Processing

Bathymetric features such as mid-ocean ridges, trenches, fracture zones, plateaus and sea mounts produce corresponding sea surface fluctuations that can be measured by satellite altimetry. Seasat was a multisensor oceanographic satellite that included a radar altimeter that measured the topography of the sea surface at 5 minute intervals with decimetre accuracy.

The gridded data were filtered to highlight high frequency effects then added back to the original data. The resulting image was registered to the accompanying map and pseudocoloured for display (see Fig. 9). Data over the major islands was masked to remove spurious altimeter effects produced over land. The resulting image depicts bathymetric highs as magenta to red and deep regions as greens to blues. The major trench along the eastern margin of the Philippines appears offset to the northeast when compared to the contours on the accompanying map. The northeast trending ridge in the Sulu Sea, however, coincides with contour trends on the map.

5.5. PRELIMINARY REPORT OF SHIP PREPARATION

Approaching the end of January, preparations for the AIDAB-funded project in the Philippines are advancing steadily. Purchasing of the multitudinous consumables and minor spares is continuing. We are now gearing up for the trials off Fremantle from mid-February to mid-March which includes a significant component of testing equipment to be used on the Philippines survey.

Our main activities have been:

(1) Spares for the seismic cable, compressors and airguns have been ordered and only minor purchases should now be left. Materials to construct a spare gun bundle should be on their way from the USA shortly.
(2) We are obtaining inserts to reduce the volume of the airguns. This will allow us to achieve the 10-second shooting rate needed using the full array while staying within the capacity of the compressors.
(3) The navigational support required is presently being finalised after discussions with Racal Surveys, from whom we are leasing the SKYFIX differential GPS navigation system.
(4) Further compass birds are being obtained so that we can better define the location of the long seismic streamer behind the ship.

Preparations are in hand for the trials off Fremantle. Practically all the main systems to be used in the Philippines will be tested out under operational conditions. This should give us considerable confidence that our scientific crew can join the ship in Puerto Princesa and find the ship in a good state of readiness. Some of the things we will be doing are:

(a) Testing the outputs of the modified airguns to ensure we are getting an adequate signal and frequency response. Checking source and depth sensors.
(b) Checking the compressor performance to ensure that we can deliver enough air to the arrays. Look at temperatures in the compressor room as these have a significant effect upon air capacity.
(c) Stream the long seismic cable and check for noisy or leaking sections. Verify the operation of the new compass birds and the depth controllers. Check the cable noise levels against towing speed and depth.
(d) Verify the latest modifications to the dGPS system. Calibrate and adjust the back-up dead reckoning navigation system.
(e) Test out the hydrocarbon sniffer system. Check the new cable fairings and terminations. Make sure that the A-frame used to deploy it is in good working order.
(f) Check the performance of the echo sounders. Modify and test the EPC recorders used to display the depth data.

6. PROPOSED SHIP TRACK

The proposed ship track maps for Survey Areas I and II are shown in Enclosures 1 and 2.

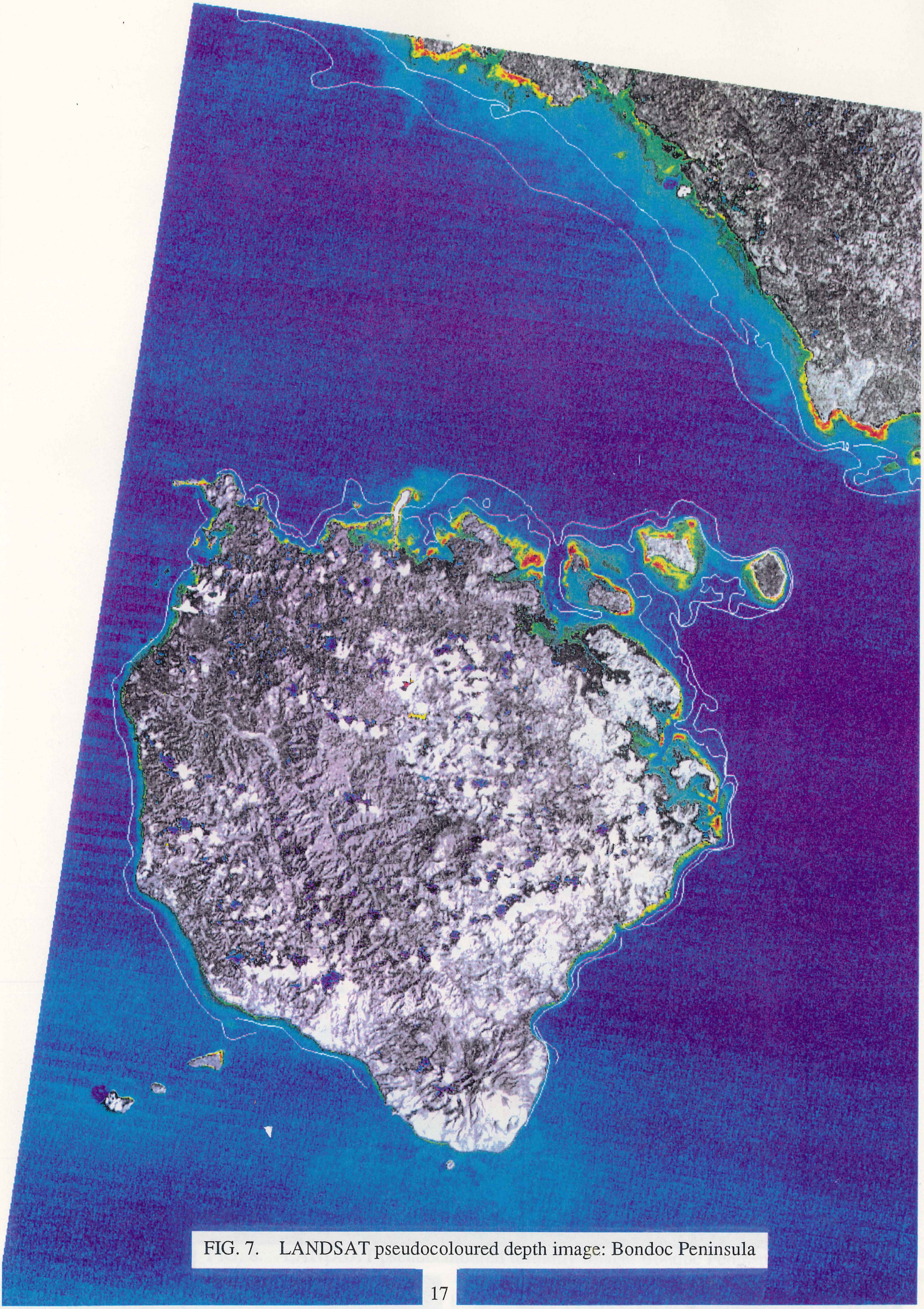


FIG. 7. LANDSAT pseudocoloured depth image: Bondoc Peninsula

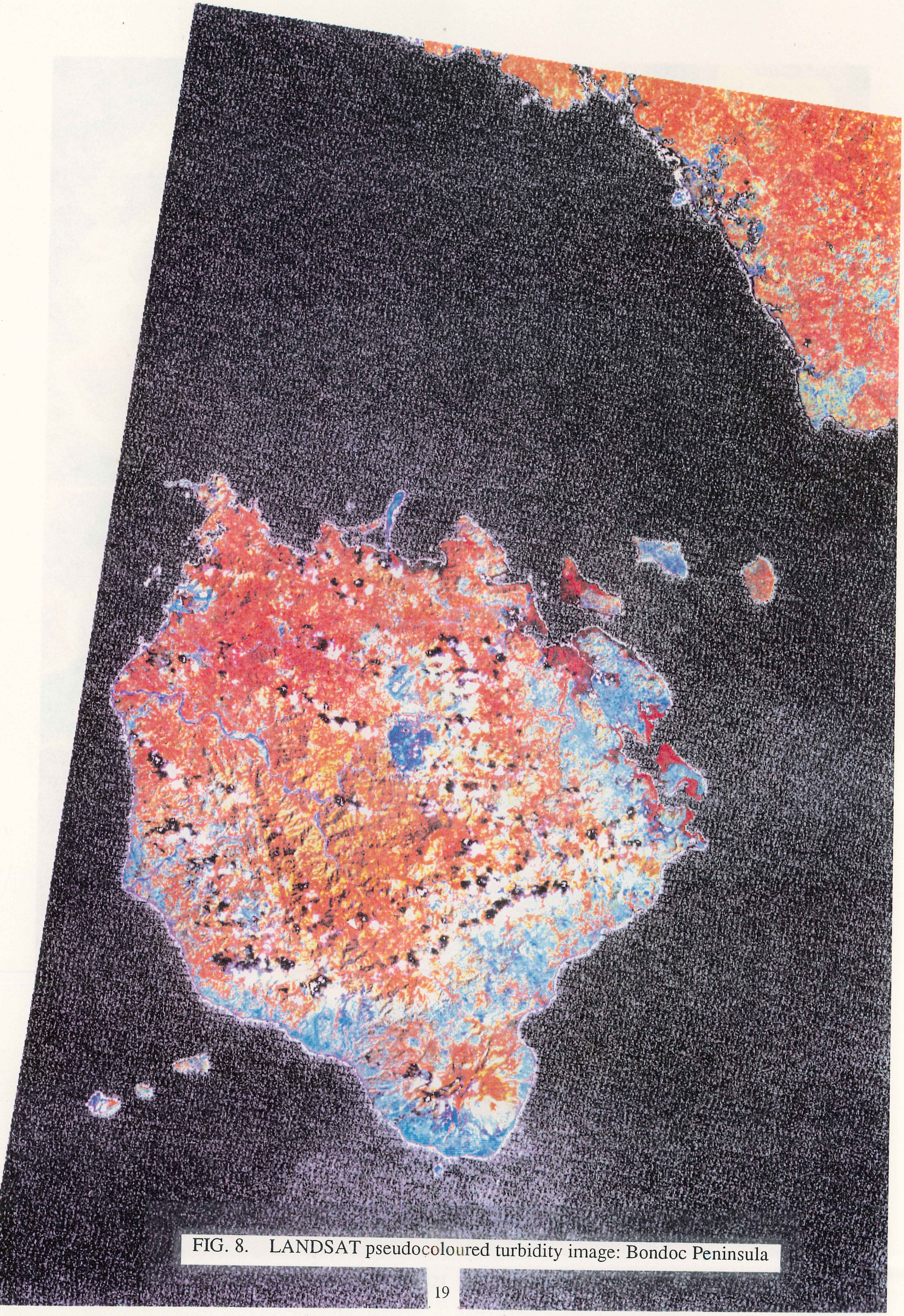


FIG. 8. LANDSAT pseudocoloured turbidity image: Bondoc Peninsula

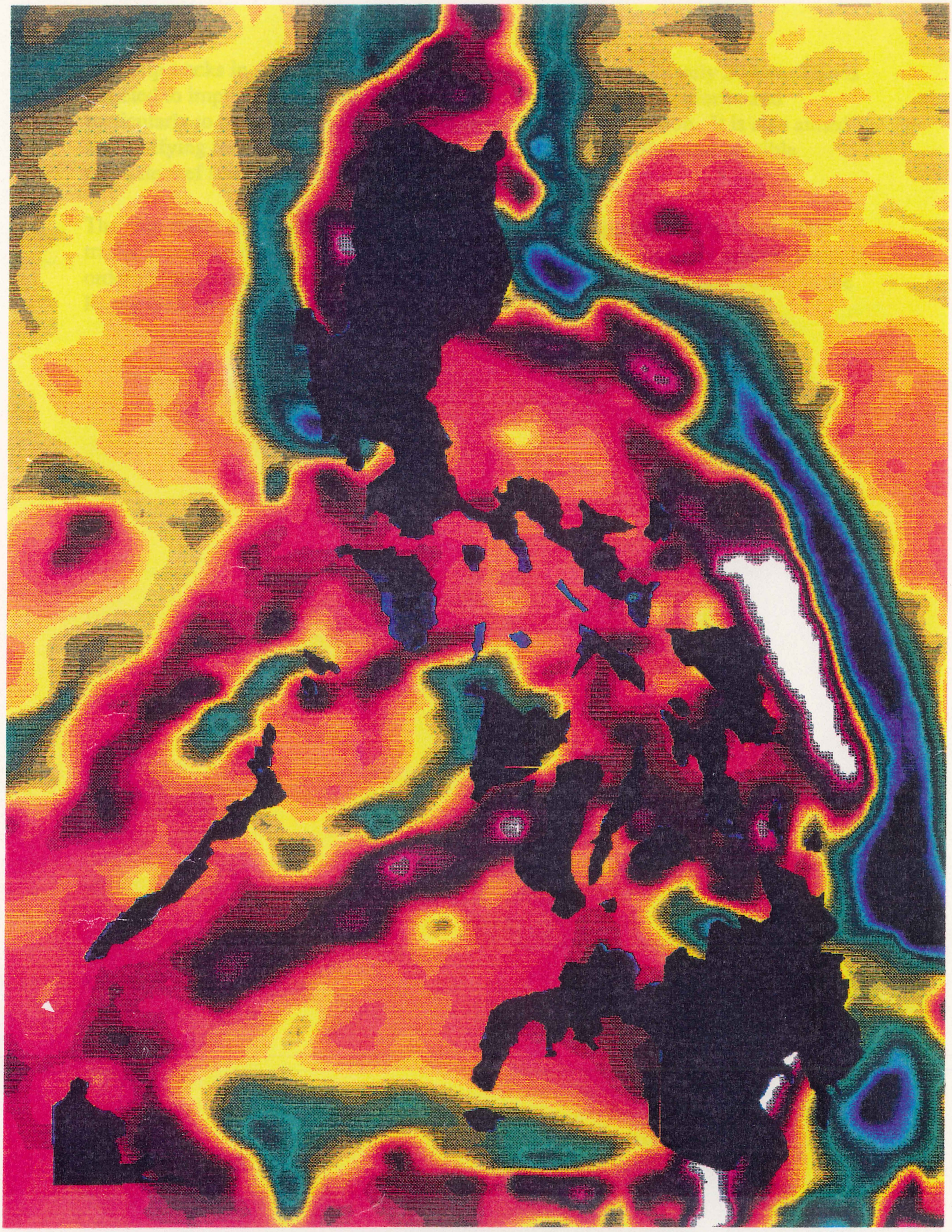


FIG. 9. SEASAT image: Philippine offshore basins

The ship tracks in Area I form a grid with a spacing of approximately 20 km. This is targeted to improve the quality of seismic records on the Cuyo Platform, and particularly to penetrate the deep Palaeogene and Mesozoic section. It is also aimed at identifying the sediment depocentres, the thick mature sections and possible pinnacle reef structueres on the NE Palawan Shelf.

The ship tracks in Area II form a grid with a spacing of approximately 5 km. The tracks are oriented about 45° to the direction of previous oil company seismic lines, in order to image the tectonics and the shape of the transform sedimentary basins in the Ragay Gulf and Tayabas Bay.

7. PROPOSED CRUISE ITINERARY

Following is a tentative *Rig Seismic* cruise itinerary for this project:

Date	Day	Work Plan	Time	Comments
12-Mar		In Fremantle to load equipment & stores		
14-Mar		Departure from Fremantle		
24-Mar		Arrival at Puerto Princesa		
25-Mar		Inward clearance & vessel bunkers BMR & AMSA staff join Rig Seismic Ship crew change		
26-Mar	D	Australian Ambassador & Project PMC on board Departure for Survey Area I Meet with chase boat, African Queen Deploy cable and test	2 days	
29-Mar	D + 3	Shooting at Survey Area I (1239 kms; NE Palawan & Cuyo)	12 days	at production rate 100 km/day
10-Apr	D + 15	Retrieve cable	1 day	
11-Apr	D + 16	Transit to Survey Area II African Queen refuels at Batangas City	1 day	
12-Apr	D + 17	Deploy cable and test	2 days	
14-Apr	D + 19	Shooting at Survey Area II (1298 kms; Tayabas Bay & Ragay Gulf)	22 days	at production rate 60 km/day
6-May	D + 41	Retrieve cable	1 day	
7-May	D + 42	Transit	1 day	
8-May	D + 43	Vessel anchors off Batangas City for outward clearance from the Philippines Departure for Australia		

8. PARTICIPATION LIST

Following are two lists of cruise participants, both scientific and ship personnel, along with their duties:

Scientific Personnel for *Rig Seismic* Cruise 108.

NAME	TITLE	DUTY	WORK AREA
Chao-Shing Lee	SRS	Chief Scientist	Interpretation & Instrument Room
Doug Ramsay	SPOB	Co-Chief Scientist	"
AIDAB representative*		Observer	"
Filipino Scientist 1**		Trainee	"
Heather Miller	PO2	Systems Expert	Instrument Room & Systems
Leo Kalinisan	PO2	Systems Expert	"
Jim Bedford	TO3	Science Technical Officer	Instrument Room & Seismic Cable
Fenji Stradwick	TO1	"	"
Tony Hunter	TO3	"	"
Tieman McNamara	TO3	"	"
Lachlan Hatch	TO2	"	"
Filipino Scientist 2**		Trainee	"
Jeremy Bishop	PO2	Geochemistry Supervisor	Geochemistry Lab & Sniffer Cable
Collin Tindall	TO3	Geochemistry Officer	"
Filipino Scientist 3**		Trainee	"
Filipino Scientist 4**		Trainee	"
David Holdway	TO3	Electronics & Safety Officer	Electronic Room & Seismic Cable
Claude Saroch	TO3	Electronics Officer	"
Jeremy Vickery	TO2	Mechanical Officer	Gun Mechanic & Compressor Room
Markus James	TO2	"	"
Brian Dickinson	TO2	"	"
Alan Radley	TO2	"	"
Craig Dyke	TO2	"	"

*AIDAB representative:
(to be provided)

**Filipino Scientists:
J. Raymund L. Apostol
Edmundo B. Guazon
Dennis Panganiban
Neil Trinidad

Ship Personnel (AMSA staff) for *Rig Seismic* Cruise 108.

NAME	DUTY
A. R. Codrington	Master
R. T. Walters	1st Mate
M. J. Gusterson	2nd Mate
C. A. Hellier	3rd Mate
G. N. Pretsel	Seaman
D. A. Kane	Seaman
A. Dale	Seaman
R. W. Thomas	Chief Engineer
I. J. McCarthy	2nd Engineer
W. W. Hanson	Electrical Engineer
P. Hutchinson	AB/Engine Room Asst.
B. Fowler	Chief Cook
G. R. Conley	Cook
M. E. Cumner	Steward
M. J. Perrett	Steward

9. SPECIFICATIONS OF SCIENTIFIC EQUIPMENT

9.1. GENERAL

Raytheon echo sounders: 3.5 kHz (2 kW) and 12 kHz (2 kW)
Geometrics G801/803 magnetometer
Bodenseewerk Geosystem KSS-31 marine gravity meter

Navigation

Trimble/RACAL satellite link (SKYFIX) differential GPS System
Magnavox T-set Global Positioning System
Magnavox MX1107RS and MX1142 transit satellite receivers
Magnavox MX610D and Raytheon DSN450 dual axis sonar dopplers
Arma Brown and Sperry gyro-compasses; plus Ben paddle log

Seismic streamer

Fjord Instruments, transformerless coupling
Maximum of 288 seismic channels, 12 auxiliary channels
10 Teledyne T-1 hydrophones per 6.25 metre group
Nominal sensitivity 20 Volts/Bar for standard group
6.25, 12.5, (18.75), and 25.0 metre groups available
Maximum towable length 6000 metres

Recording instrumentation & recording options

Low noise charge-coupled preamplifiers
Preamplifier gain from 1 to 128 in 6 dB steps
Maximum of 320 channels including seismic and auxiliaries
LC filters : 8, 12, 24 and 48 Hertz at 18 dB/octave
HC filters : 64, 128, 256 and 512 Hertz at 72 dB/octave
Sampling rates : 0.5, 1, 2, and 4 millisecs
Record lengths : 2 secs to 20 secs
SEG -Y recording format
IFP operating at 200 kHz with special floating point format
Data recorded as 4-bit binary exponent and 12-bit mantissa

9.2. WATER-COLUMN GEOCHEMICAL EQUIPMENT

The Direct Hydrocarbon Detection (DHD) method continuously analyzes C_1-C_8 hydrocarbons within seawater. Thermogenic hydrocarbons migrating up faults from source rocks and/or hydrocarbon reservoirs debouch into the seawater at the seafloor, producing higher concentrations of light hydrocarbons within the water column. These seep gases have molecular compositions that are distinctively different from that of the biogenically-produced hydrocarbons which are mainly produced by *in situ* processes in seawater. If the hydrocarbons are present in sufficient amounts, the molecular composition of the thermogenic hydrocarbons may be used to infer whether the primary source of the seep was oil, condensate or dry gas.

The method used on the RV *Rig Seismic* is as follows. Seawater is continuously delivered into the geochemical laboratory onboard the ship via a submersible fish (which is towed approximately 10 m above the seafloor). The seawater is degassed in a vacuum chamber and the resulting headspace gas is injected into three gas chromatographs which sequentially sample the flowing gas stream and measure a variety of light hydrocarbons. Total hydrocarbons (THC) are measured every thirty seconds, light hydrocarbons (C_1-C_4) are measured every two minutes, and C_5-C_8 are measured every 8 minutes. These data, as well as fish altitude (above the seafloor), the depth of the fish, hydrographic (temperature and salinity) and navigation data are recorded on computer. All these data are recorded and displayed continuously so that any hydrocarbon anomalies in the water column can be quickly recognised and additional measurements can be made when appropriate. Detection sensitivity is approximately 10 parts per billion in the stripped headspace sample. At a ship speed of 4 knots, the measurement of THC is made every 70 m, of C_1-C_4 every 250 m, and of C_5-C_8 every 1400 m.

9.3. SEISMIC RECORDING PARAMETERS

The following geometry and recording parameters will be used for the Philippines offshore seismic survey:

Streamer geometry

Fjord Instruments transformerless: 2400 m active length
192 seismic channels plus 5 WBs plus 7 DTs plus 3 compass units
Group interval 12.5 m
Nominal depth 10 m
Near offset about 180 m
Far offset about 2568 m

Energy Source

16 x 110/130 cu.in. HGS sleeve gun per array; 2 arrays of 10 guns each in 4, 3, 2, 1 groups used
Pressure 2000 psi
Gun depths 10 m nominal

Recording parameters

8 Hz - 128 Hz passband
2 ms demultiplexed
7 sec record length
48 fold at a nominal 5 knots (shot rate = 9.7 sec = 25 m)
Seismic data recorded in SEG -Y format, special floating point format: 4 bit binary exponent, 12 bit mantissa

10. REFERENCES

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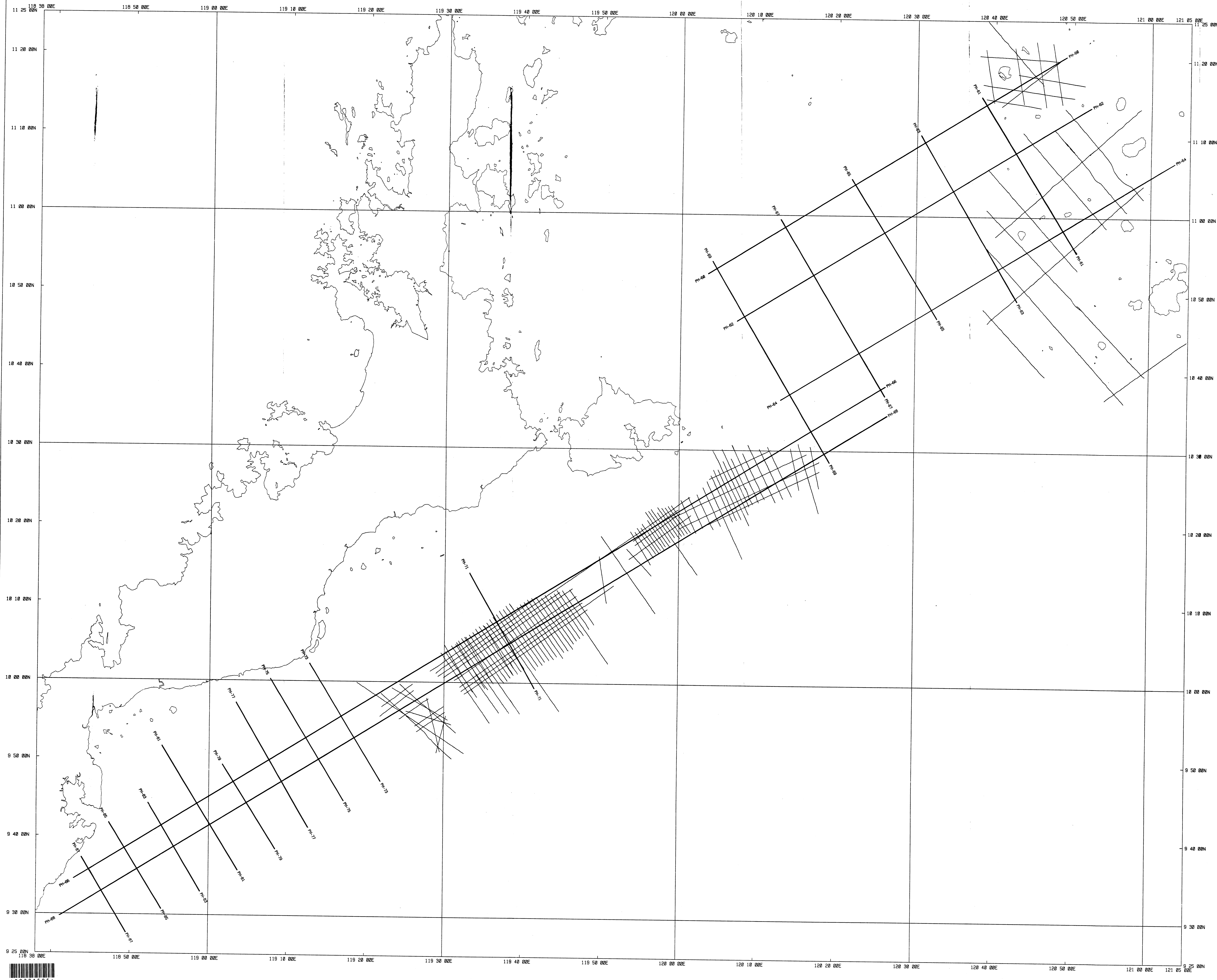

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0 6 12 18 24 30

KILOMETRES

0 2 4 6 8 10

MILES

MERCATOR PROJECTION

CLARKE 1866 SPHEROID

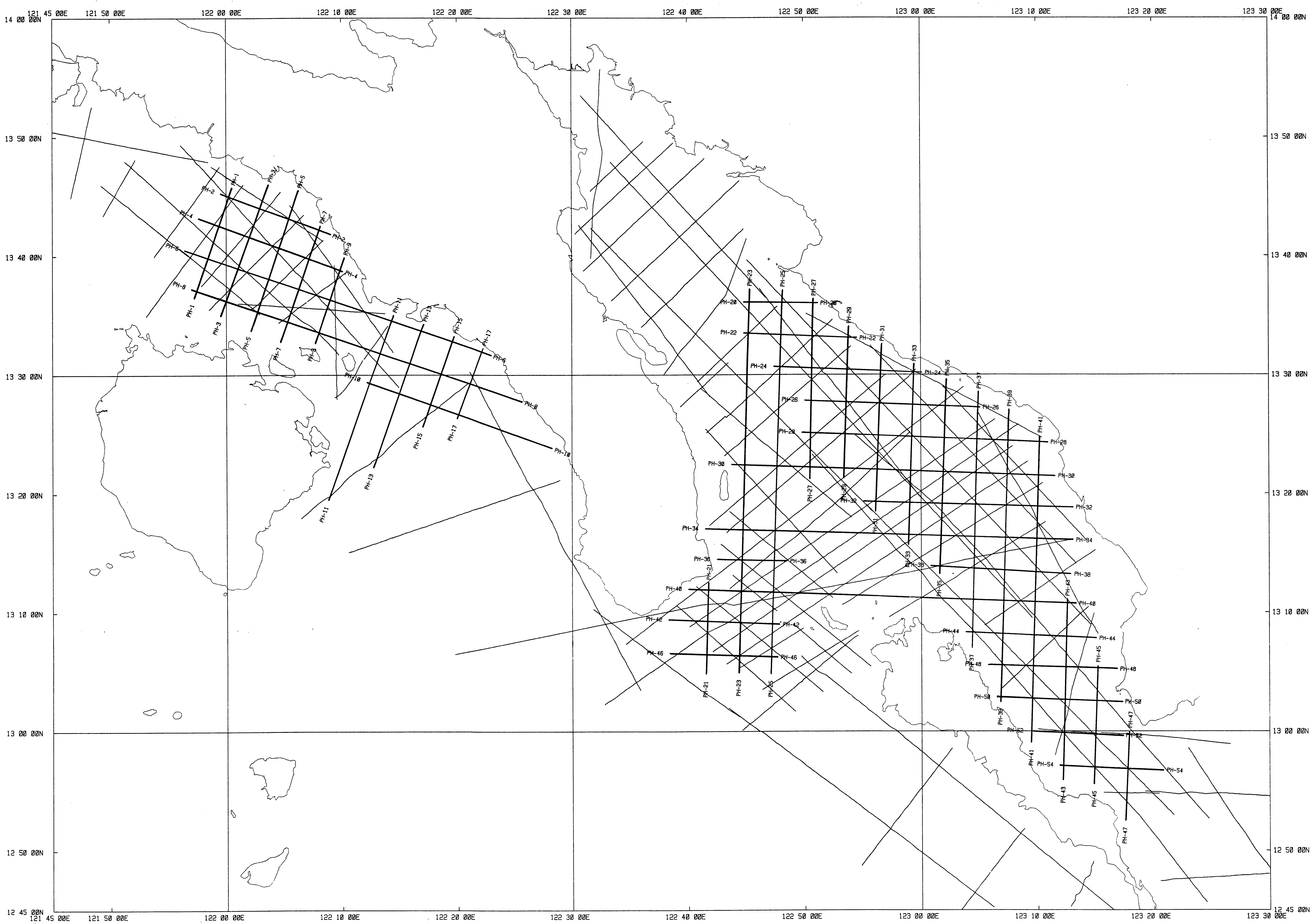
EQUATORIAL ORIGIN OF TRUE SCALE. CENTRAL MERIDIAN 117 00 00E

PHILIPPINES MARINE SEISMIC PROJECT

SURVEY AREA 1

- NORTHEAST PALAWAN SHELF

- CUYO PLATFORM



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KILOMETRES

0 2 4 6 8 10

MILES

MERCATOR PROJECTION
CLARKE 1866 SPHEROID
EQUATORIAL ORIGIN OF TRUE SCALE. CENTRAL MERIDIAN 123 00 00E

PHILIPPINES MARINE SEISMIC PROJECT

SURVEY AREA 2
- RAGAY GULF
- TAYABAS BAY

R9201504