No. 55

REPORT
ON
THE MINERAL EXPLORATION

MINERAL DEPOSITS AND TECTONICS OF TWO CONTRASTING GEOLOGIC ENVIRONMENTS IN THE REPUBLIC OF THE PHILIPPINES

TERMINAL REPORT

FEBRUARY 1990

JAPAN INTERNATIONAL COOPERATION AGENCY

METAL MINING AGENCY OF JAPAN

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PREFACE

In response to the request of the Government of the Philippines, the Government of Japan has decided to conduct a survey on the potential of mineral resources in the eastern Luzon, Visayas and the Palawan. The survey was entrusted to the Japan International Cooperation Agency (JICA) and the Metal Mining Agency of Japan (MMAJ).

The survey was conducted since 1984 and completed in 1989. It is a great pleasure to present, at the conclusion of the project, this Terminal Report which incorporates the comprehensive assessment and an overall perspective of the results of the project. These results had been reported during the progress of the project in ten separate volumes.

We wish to express our deepest appreciation to the officials of the Government of the Philippines and the Ministries of Foreign Affairs and International Trade and Industry of Japan and the officials of the Embassy of Japan for their close cooperation for the survey.

February, 1990

Kensuke Yanagiya

President

Japan International Cooperation Agency

Gen-ichi Fukuhara

President

Metal Mining Agency of Japan

SUMMARY

Implementing Arrangement regarding the project "The mineral exploration-mineral deposits and tectonics of two contrasting geologic environments in the Republic of Philippines" was concluded by the Governments of Japan and the Republic of Philippines on September 26, 1984. The project was carried out during the period 1984 ~ 1989.

The project was designed to obtain basic knowledge and information regarding geology, particularly mineralization of the less explored regions of the Philippine Islands, thereby provide a basis for future exploration and development of mineral resources.

Six regions were selected for investigation. These regions are, in the Philippine mobile belt; Northern Sierra Madre, Southern Sierra Madre - Polillo, Masbate - Central/East Panay - Southwest Negros, Cebu - Bohol - Siquijor - Southwest Leyte, Samar - Leyte - Dinagat, and in stable belt; Palawan - Romblon - Antique Range. A total of 66,000 km^2 of the above regions were surveyed.

In these regions, key areas were surveyed geologically, the known important mineral showings investigated and a total of 43,459 stream sediment samples were collected and analysed for Cu, Pb, Zn, Ag, As, Mn, Ni, Co, Mo, Hg, and where warranted Cr, Sb, Sn, W were analysed additionally. Also a total of 2,367 samples were panned for heavy minerals and the concentrates were analysed for Au, Ag, Ga. These data were processed statistically, anomalies extracted and promising areas were delineated after geological evaluation.

The anomalous areas extracted and considered amounted to 70 of which 25 were recognized to be clearly related to mineralization and were designated as promising areas. These areas were prioritized in the order of prospectivity within each region.

Of the above promising areas, six areas which are considered to possess particularly high mineral potential are extracted from the whole project area. They are classified as "promising areas, rank A" and are recommended to be considered for future exploration. These areas and the targets for future exploration are, from north to south:

(1) Dimakawal area, Northern Sierra Madre.

Hydrothermal base metal sulfide mineralization, porphyry copper and/or veins are expected.

(2) Middle reaches of Umiray River, Southern Sierra Madre.

Hydrothermal gold-bearing base metal mineralization, veins and/or porphyry-type are expected.

(3) Area joining Mt. Uac and Aroroy, Masbate.

A wide area where gold and base metal showings occur, gold-silver, base metal hydrothermal mineralization, veins and/or porphyry-type are expected.

(4) Area joining Pilar and Concepcion, East Panay.

A follow-up survey has been conducted in Concepcion area and hydrothermal base metal and gold mineralization has been found. Gold and base metal veins are expected.

(5) Area joining Panaon and Sogod, Southern Leyte.

Gold mineralization exemplified by the St. Bernard Mine is expected in the vicinity of northern Panaon and base metal mineralization near Sogod. This area sits along the Philippine Fault.

(6) Area joining Long Point-Narra-Pulute Range, Southern Palawan.

Orthomagmatic chromite mineralization, Ni laterite concentration are expected from this ophilolite area. Massive sulfide mineralization is possible in the western part. Follow-up survey has been carried out in the eastern part and chromite mineralization has been confirmed.

THE MINERAL EXPLORATION - MINERAL DEPOSITS
AND TECTONICS
OF TWO CONTRASTING GEOLOGIC ENVIRONMENTS
IN THE REPUBLIC OF THE PHILIPPINES

TERMINAL REPORT

CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ATTACHED PLATES

CHAPTER 1 INTRODUCTION

1.1 Background and Objectives

In accordance with the Implementing Arrangement concluded between the Government of Japan represented by the Japan International Cooperation Agency (JICA) · Metal Mining Agency of Japan (MMAJ) and the Government of the Republic of Philippines represented by the Mines and Geo-sciences Bureau (MGB) of the Department of Environment and Natural Resources (DENR) on September 26, 1984, the project "The mineral exploration, mineral deposits and tectonics of two contrasting geologic environments in the Republic of Philippines" was carried out during the period 1984 - 1989.

The objective of this project was to delineate areas of high prospectivity through geological and geochemical investigation of regions which had not been systematically explored previously.

With the progress of the survey, seven volumes of Annual Reports and three volumes of Consolidated Reports (JICA-MMAJ, 1985 - 1990) have been issued. This Terminal Report was prepared in order to provide an overall perspective of the results of the project which have been reported in separate volumes and also to achieve a comprehensive evaluation at the conclusion of the project.

1.2 Contents of the Project

The Philippine Archipelago was studied geoscientifically through existing material, and regions for survey were selected. The basis for the selection of these regions was that the knowledge of the mineral potential of these regions was less clear because of the lack of systematic exploration. They are, in the mobile belt; Northern Sierra Madre, Southern Sierra Madre - Polillo, Masbate - Central/East Panay - Southwest Negros, Cebu - Bohol - Siquijor - Southwest Leyte, Samar - Leyte - Dinagat, and in the stable belt; Palawan - Romblon - Antique Range (Fig. 1).

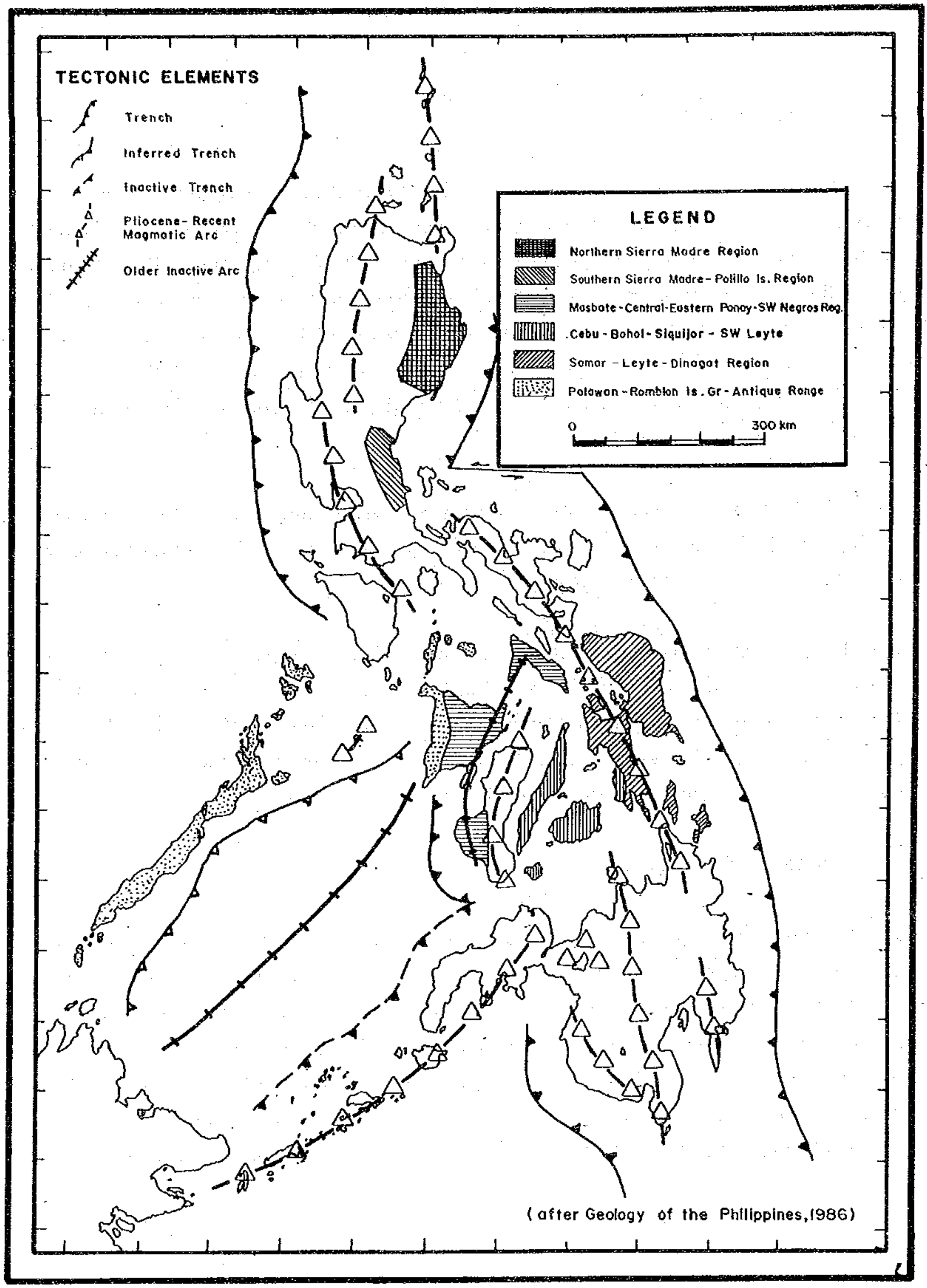


Figure 1 Regional Divisions of the Project Area

The total area of the above regions is approximately 130,000 km^2 accounting for about one third of the land area of the Philippines. The area covered by field survey, however, was approximately 66,000 km^2 because the environment of some parts of the regions were not conducive for field work.

In the above regions, key areas were surveyed geologically, the known important mineral showings investigated and a total of 43,459 stream sediment samples were collected and analysed for Cu, Pb, Zn, Ag, As, Mn, Ni, Co, Mo, Hg, and where warranted, Cr, Sb, Sn, W were analysed additionally. Also a total of 2,367 samples were panned for heavy minerals and the concentrates were analysed for Au, Ag, Ga. These data were processed statistically, anomalies extracted and promising areas were delineated after geological evaluation (Fig. 18).

In this Terminal Report, the results of the past work are examined in total and six areas which are believed to have particularly high prospectivity are delineated and designated as "Promising areas of rank-A" (Fig. 18). It is recommended that detailed exploration be carried out in these areas.

1.3 Members of the Survey Team and Schedule

(1) Planning and negotiation

Planning and negotiation were conducted at the start of the project and at the beginning of each fiscal year by;

Officials of JICA · MMAJ for Japan	Officials of DENR for the Philippines

(2) Field work

Field work was carried out each year as a collaborative effort of the Japanese and Philippine geoscientists. Field survey for each region was of the scale of approximately 50 days by several parties.

(3) Chemical analysis

Eighty percent of the samples were analysed at the PETROLAB, MGB, Philippines and the remainder at a commercial laboratory.

(4) Data processing, interpretation and annual and consolidated reports

Statistical processing of geochemical data was carried out in Japan, geologic interpretation made jointly and the reports were prepared in Japan with collaboration of the Philippine geologists.

(5) Terminal report

After discussion on the contents, chapters 2, 3 and 4 were drafted by MGB geologists. The report was finalized in Japan with discussions and contributions from both sides.

Those concerned with the preparation of this report are:

Japan		Philippines	
Yoshikazu Okubo	Overseas Mineral Resources Development Co.	Romeo L. Almeda	MGB.
Yukio Uehara	"	Antonio N. Apostol Jr.	"
Yoshihiko Shimazaki	"	Noel V. Ferrer	"
		Rogel A. Santos	"
		Jose Claro Manipon Jr.	"
		Raymundo Villones Jr.	"
		Fernando Esquerra	"
		Joselito Velasques	"
		Arnulfo Cabantog	"
		Emmanuel Santos	"

CHAPTER 2 REGIONAL TECTONIC SETTING

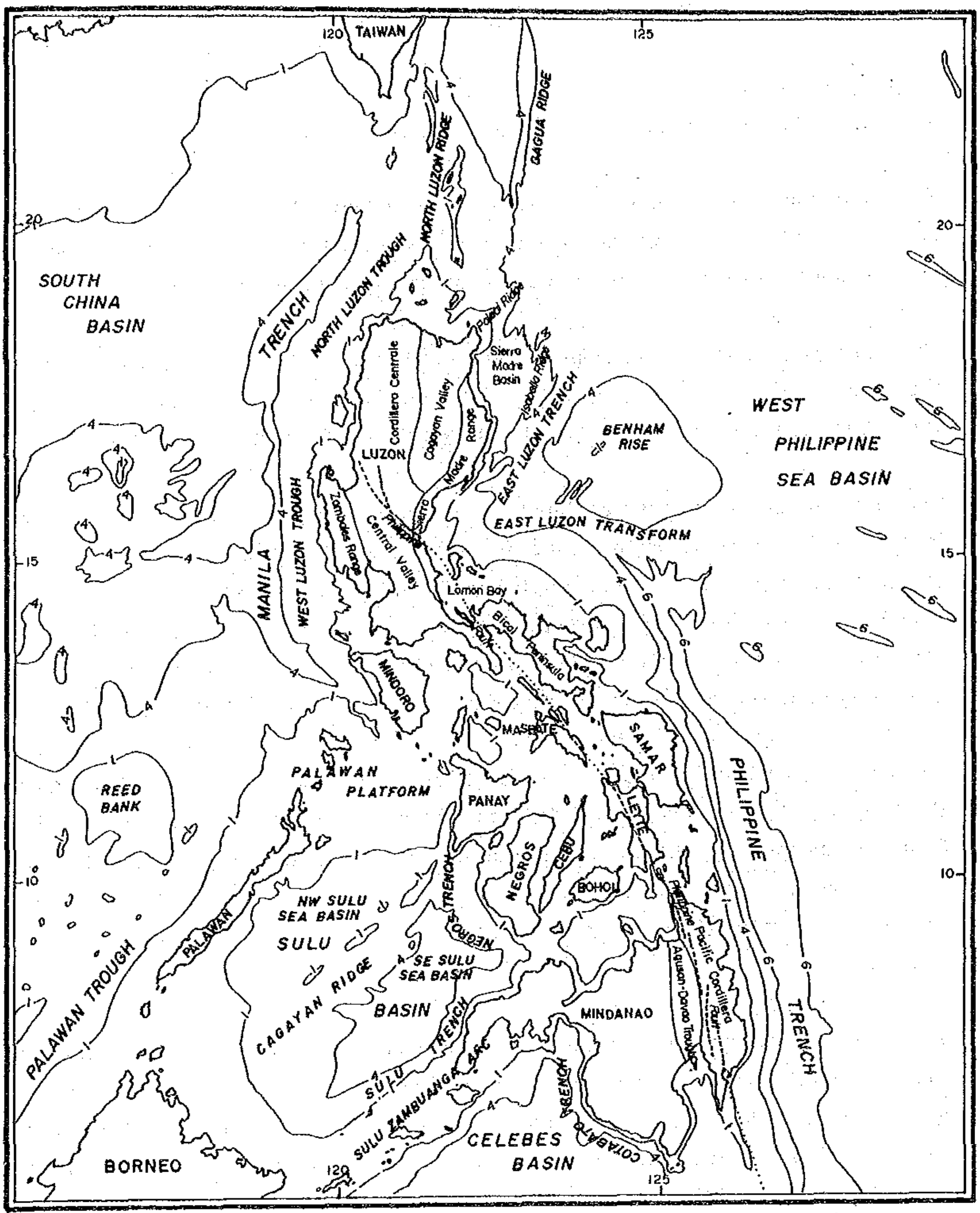
2.1 Tectonic Development of the Philippine Islands

The Philippine Archipelago is a complex assemblage of trench-arc systems and junctions of lithospheric plates and marginal basins characterized by the presence of high seismicity, overlapping arc volcanism and intense tectonism (Figs. 1, 2).

Convergence between the Philippine Plate and the Eurasian Plate is absorbed along the eastern and western margins of the Philippine Arc as well as within the arc itself through internal deformation and by the Philippine Fault which transects the arc.

The eastern margin of the Archipelago is marked by the East Luzon Trench-Philippine Trench which is the trace of an west-dipping active subduction wherein the southwestern margin of the Philippine Plate is being consumed. The western margin is defined by the Manila, Negros and Cotabato Trenches which are characterized by an eastward subduction and a general north-south trend. The continuity of these trenches is still speculative. The Manila and Negros Trenches are offsetted and healed along the Mindoro and Antique Range sutures in which the Palawan Platform, defined as a rifted continental margin, is impinged. Southward, the Cotabato Trench is separated from the Negros Trench by the recently inactive Sulu-Zamboanga Arc wherein the northern front is defined by the Sulu Trench. Considering the Palawan Trough as a trench is still a conjecture although a northeast trending depression defines the west-northwest margin of the Palawan chain of islands.

The geological development of the Philippine Archipelago commenced sometime in the Mesozoic. During the Permian to Cretaceous, carbonates, turbidites and cherts of the Palawan Platform were deposited within a forearc basin environment of Andean-type arc at the southern margin of the Middle Mesozoic (or older) mainland China (Holloway, 1981). The arc formation is attributed to the northwest dipping subduction zone adjacent to the margin, remnants of which are still observed in southeastern Vietnam and eastern China (Holloway, 1981; Taylor and Hayes, 1983) (Fig. 3).



(adapted from Lewis and Hayes, 1983)

Figure 2 Tectonic Features of the Philippines Archipelago

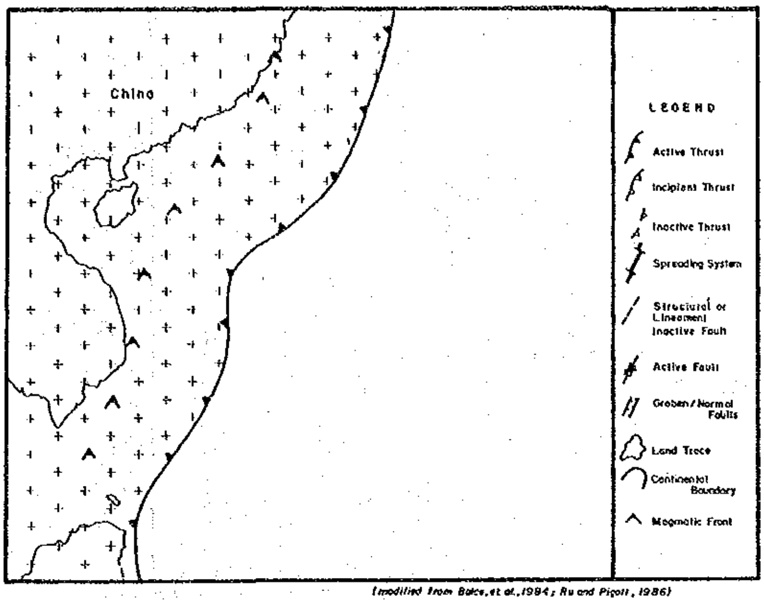


Figure 3 End of Early Cretaceous

Cessation of activity along this Andean-arc type margin of mainland China by the latest Cretaceous marks the inception of an east-southeast dipping subduction zone (Revilla and Malaca, 1987; Mitchell et al., 1986). This trench in which the Southern Sierra Madre and the Masbate-East Panay-Southwest Negros arc is the arc pair is inferred to lie immediately southeast of a postulated spreading system. Thus the proto-Sulu Sea and the proto-China Sea were being consumed along this trench-arc system (Mitchell et al., 1986; Balce et al., 1983).

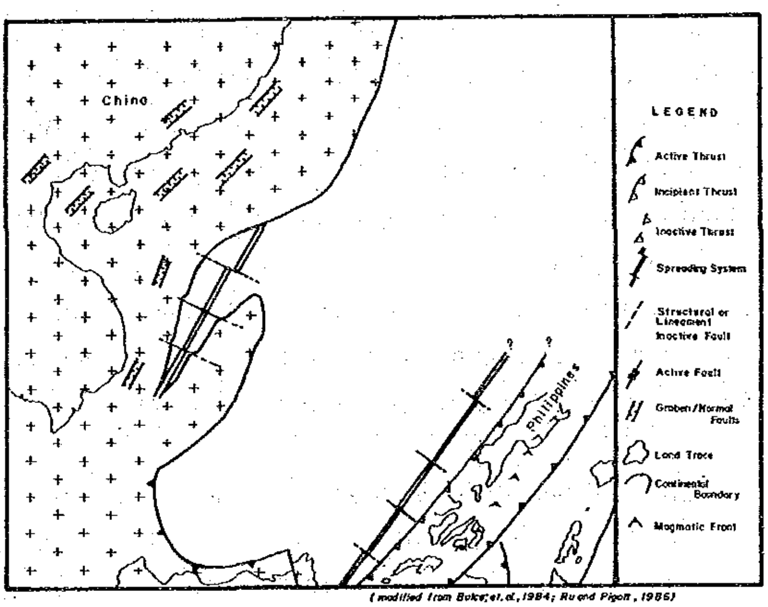
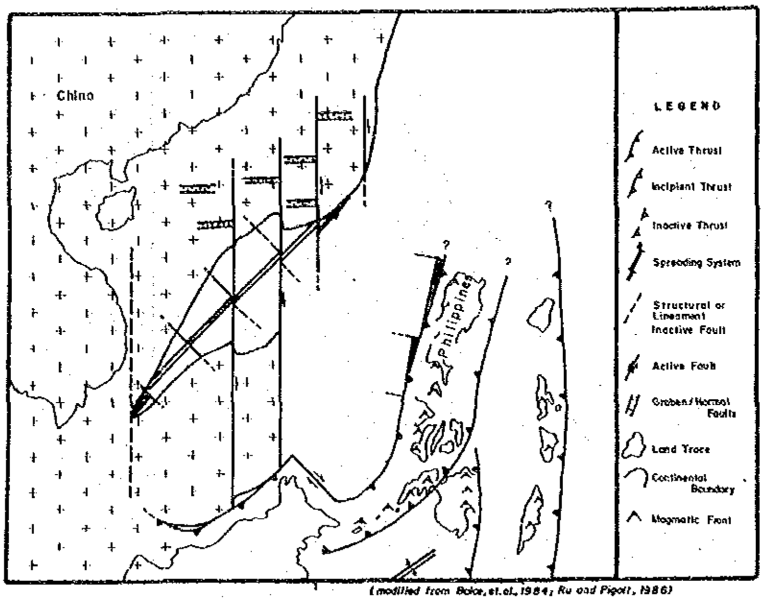


Figure 4 End of Paleocene



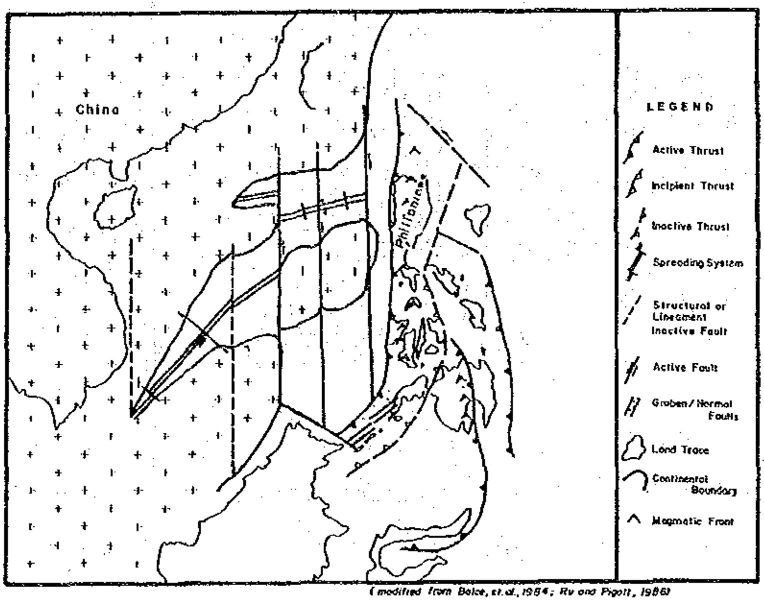
(modified from Bolce, et. al., 1984; Ru and Pigott, 1986)

Figure 5 End of Eocene

Detachment of the ophiolite upon the approach of a postulated spreading system along the east-dipping trench marked the Paleocene period. Ophiolite emplacement, opening of the South China Sea sub-basin, and the magmatic activities along the aforementioned trench arc systems remained continuous until the early part of the Oligocene (Figs. 4, 5).

Activity along the northwest dipping subduction (Northern Sierra Madre-Cebu-Zamboanga Trench) gradually declined during the middle part of Oligocene. Simultaneous to this event is the gradual approach of the north-south transform which is a part of a series of transform faults inherent to the drifting of a fraction of the southern margin of mainland China -the Palawan Platform- towards the counter-clockwise moving proto-Philippine arc (Fig. 6). During this period the easternmost portion of the South China Sea basin began to open. From the latter part of the Oligocene through the Miocene, these events continued persistently and have led into the amalgamation/suturing of the East Luzon-Samar-Mindanao arc and the emplacement of the West Philippine ophiolite series which includes the ophiolite suites of Zambales, Mindoro, Panay and probably of Zamboanga.

Recent works on the Sulu Sea Basin yielded a late Early Miocene to early Middle Miocene age for the time of opening of the basin coinciding with the cessation of volcanism of the Cagayan Ridge (Rangin, 1987; ODP Leg 124, 1989). McCabe regarded the Cagayan Ridge as an arc terrane which was formed as a consequence of pre-late Neogene subduction either along the Palawan Trench (?) (Hamilton, 1979) or along a northwest dipping subduction south of the Sulu-Zamboanga arc wherein the Celebes Basin could have been subducted (Rangin, 1987; Mitchell et al., 1986). The latter magmatic arc could be the southwest continuity of the Northern Sierra Madre-Cebu-Zamboanga (?) trench-arc system (Fig. 6).



(modified from Bolce, et.al., 1984; Rv and Pigott, 1986)

Figure 6 End of Oligocene

Sometime during the late Early Miocene to early Middle Miocene, the Philippine Fault could have been formed (Karig, 1983) and it is thought that crustal plate convergence is the major factor for its formation. Fitch (1972) attributes the vertical transcurrent fault formation on the mechanical decoupling of the crust due to the oblique convergence between the Philippine Sea Plate and the Eurasian Plate. Another contention relates the Philippine Fault formation as a response to stresses generated due to plate convergence that are not accomodated by underthrusting in the Philippine Trench. Hamilton (1979) regarded the fault as a result of internal shearing deformation whereas Cardwell (et al., 1980) considers the fault as a result of a combination of the aforementioned models.

By Late Miocene, the Philippine Archipelago has almost assumed its present configuration. Both the Cotabato and the Philippine Trenches began its activity. The development of Cotabato Trench prior to Late Miocene is still uncertain. The tectonic activity along this zone during the latter part of the Miocene could probably be contemporaneous with the trench-arc "migration" of the Negros and the Manila Trenches. To date, oceanic crust consumption proceeds along these trenches; the Celebes Basin along Cotabato Trench, the South China Sea Basin along Manila

Trench, the southeast Sulu Sea Basin along the Negros Trench and the Eocene West Philippine Sea Basin along the East Luzon and Philippine Trenches (Fig. 7).

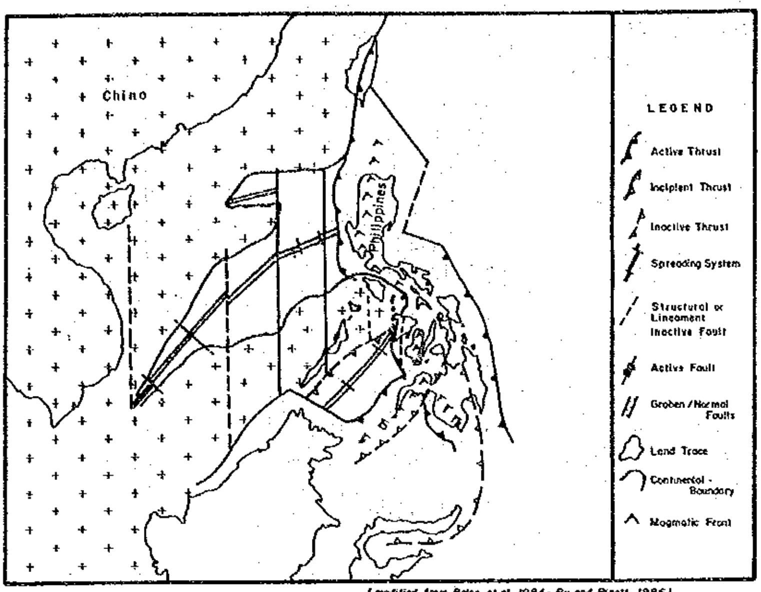


Figure 7 End of Miocene

2.2 Tectonic Features of the Philippine Islands

2.2.1 East Luzon Trench-Arc System

The East Luzon trench-arc system is believed to represent an old trench-arc system which is being reactivated and propagating northward. It consists of a trench, a well-developed accretionary prism, the Isabela Ridge, and a forearc basin, the Sierra Madre Basin. Present-day convergence accommodates the west-northwest subduction of Eocene oceanic crust of the West Philippine Sea Basin (West Philippine Basin) beneath Luzon (Fig. 2).

That an old arc existed is suggested by an early Tertiary magmatic arc in the Northern Sierra Madre and a turbidite-filled (undeformed) trench, which together with the Isabela Ridge and Sierra Madre Basin, are buried beneath a late Oligocene unconformity. The age for this gap is based on the geology of Northern Sierra Madre and DSDP 292.

The trench has then been reactivated. This has been based on a shallow and poorly-defined Wadati-Benioff zone, seismicity and deformation of trench fill confined to 15°N to 17 °N, and the absence of a Quarternary volcanic arc. The free air gravity anomaly map, the confinement of seismic events to these latitudes, and the northward decrease in deformation of the trench fill suggests subduction to be propagating northward.

An east-west trending trench-trench transform, the 15 °N Transform, connects the East Luzon Trough with the Philippine Trench. Focal mechanism solutions indicate a left-lateral strike slip sense of displacement. This supports the motion implied by the westward underthrusting of the Philippine Plate beneath the archipelago. The transform as defined by seismicity does not coincide with a bathymetric trough connecting both trenches. Seismic reflection profiles across the transform show a fault zone dipping northward with cumulative offsets of 1 km.

2.2.2 Philippine Trench-Arc System (Fig. 2)

The Philippine trench extends from the transform fault east of Luzon to Halmahera. An associated volcanic arc extends from southeastern Luzon to Leyte. No belt of Quarternary volcanoes associated with the trench is present in eastern Mindanao.

A Wadati-Benioff zone dips gently westward beneath the archipelago to a depth of less than 200 km. Focal mechanism solutions clearly show that Eocene oceanic crust of the West Philippine Sea Basin is being underthrust beneath the archipelago on a fault plane which dips $24° \pm 10°$ to the west.

The Philippine Trench is a relatively young tectonic feature and this is supported by several lines of evidence. These include its morphological sharpness and absence of trench fill deposits; absence of a well-developed accretionary prism; absence of associated arc volcanism in eastern Mindanao; and the presence of a shallow Wadati-Benioff zone especially towards the southern sector. The presence of a thick pile of undeformed sediments east of the trench over the ocean floor of the Philippine Sea further supports the argument in favor of a young age. These sediments are believed to have been derived from eastern Mindanao and Talaud prior to the formation of the Philippine Trench. The Palau-Kyushu Ridge has been ruled out as an alternate source for the sediments (Karig, 1975).

2.2.3 Manila Trench-Arc System

The Manila Trench-Arc System is a west-facing island arc system where oceanic crust of the South China Basin is being subducted eastwards beneath Luzon. It consists of the Manila Trench, a well developed accretionary prism and forearc basins, the West Luzon Trough and the North Luzon Trough, and a Quaternary volcanic arc. It is marked by continent-arc collisions at both its terminations in the Taiwan and Mindoro areas.

The chain of Quaternary volcanoes extends from Maestro de Campos Island in the Tablas Strait through Mindoro and Luzon, to the Babuyan and Batan groups of islands. Although Taal and other volcanoes in Southern Luzon appear to be associated with the subduction zone, it is also possible that they lie along a fracture zone which trends normal to the arc.

2.2.4 Negros Trench-Arc System

The Negros Arc consisting of an active trench, accretionary prism, forearc basin, and Quarternary volcanic arc, is a west-facing trench-arc system wherein oceanic crust of the Sulu Sea Basin is being subducted beneath Negros. Seismic reflection profiles show active underthrusting. No Wadati-Benioff zone is clearly defined but earthquakes at mantle depths are recorded. Shallow earthquake activity is fairly continuous between the Manila and Negros trenches. The Negros Trench might once have been connected with the Manila Trench but was interrupted with the collision of the Palawan Ridge with the Central Philippine Arc.

2.2.5 Cotabato Trench-Arc System

The Cotabato Trench extends from the western side of the Sangihe Ridge and extends along the southwest side of Mindanao. It is separated from the Negros Trench by the recently inactive Sulu Arc which continues onshore as the Zamboanga peninsula. A shallow Wadati-Benioff zone and the absence of associated active volcanism shows that the Cotabato Trench was initiated only recently. Seismic profiles and focal mechanism solutions show that Eocene oceanic crust of the Celebes Sea Basin is being subducted eastwards beneath Mindanao. The morphology of the trench as well as its seismicity decreases southwards. No trench exists west of Sangihe Ridge between the southern extent of the Cotabato Trench and the North Sulawesi Trench.

2.2.6 Sulu Trench-Arc System

The Sulu Trench-Arc System consists of the Sulu Trench, a well developed accretionary prism, forearc basin, and a belt of Quarternary volcanoes. The absence of associated seismic events and the presence of still active volcanism suggests that this system, wherein Middle Miocene oceanic crust of the Sulu Sea Basin was once being subducted southwards beneath the Sulu-Zamboanga Ridge, has been deactivated only recently. Seismic reflection profiles, however, show deformation of trench deposits.

2.2.7 The Philippine Fault

Convergence between the Philippine Plate and the Eurasian Plate is absorbed by the Manila-Negros-Cotabato Trenches in the east and the East Luzon Trench-Philippine Trench in the west. Convergence is further absorbed by internal deformation within the Philippine mobile belt especially along the Philippine Fault. The Philippine Fault is a major left lateral strike slip which extends for 1,200 km. The fault is active and focal mechanism solutions to earthquakes related with the fault show left-lateral strike slip motion. Aside from its seismic activity, the interpretation of seismic profiles, morphology, cutting of recent deposits, and actual ground breakage further attests to its activity.

2.2.8 Sulu Sea Basin

The Sulu Sea is a small basin enclosed by Palawan to the north, Sulu Archipelago and Zamboanga to the south, Borneo to the west, and Panay and Negros to the east. A east-northeast trending volcanic ridge, the Cagayan Ridge, with a smooth northwest slope and a steep southeast slope marked by normal faults bisects the Sulu Sea into a northwest or outer sub-basin and a southeast or inner sub-basin (Fig. 8). Samples dredged from the Cagayan Ridge yielded a date of 14.7 ±0.6 Ma.

Seismic refraction studies show that the northwest basin has a thick crust with two layers showing velocities typical of island arc roots and an upper layer which may represent either volcanic basement or metasediments.

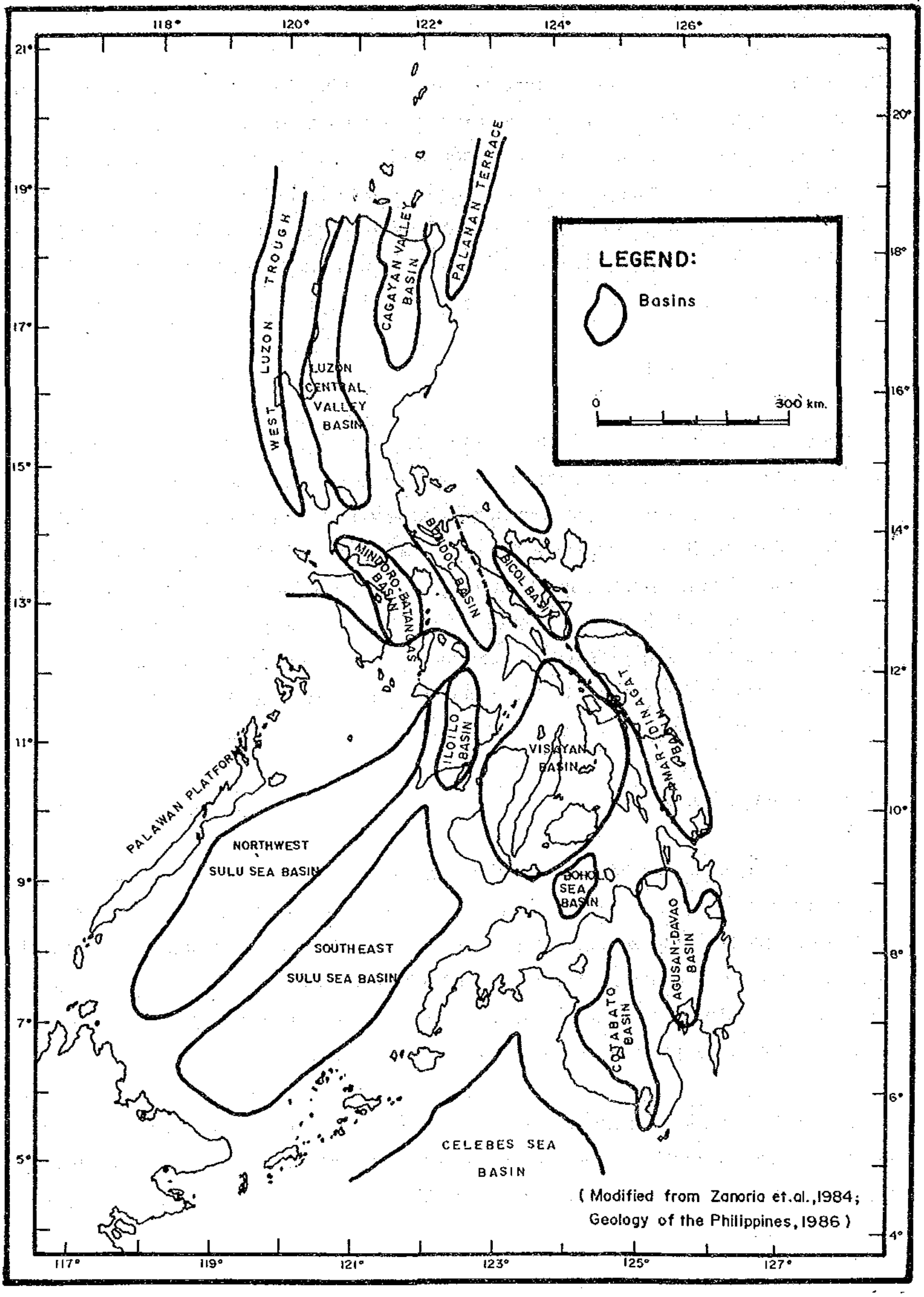


Figure 8 Major Sedimentary Basins of the Philippines

The southeast basin, on the other hand, is deeper. It has an abyssal plain with depths of 3,000-4,500 m, overlain in the shallower southwestern portion by thick turbidites derived from Borneo. Seismic refraction data shows that the basement of the southeast basin is oceanic in nature. Relatively high heat flow values and water depths suggest a mid-Tertiary time of formation for the basin.

The origin of the basin is not yet completely solved, the most probable model is, however, that the Southeast Sulu Basin opened as a backarc in Middle Miocene time either through southward subduction of proto-South China Sea crust at the Palawan Trough or through northward subduction of Celebes Sea crust beneath Sulu.

2.2.9 Celebes Sea Basin

The Celebes Sea Basin is enclosed, from the north clockwise, by the Sulu-Zamboanga Ridge, Southwest Mindanao, Sangihe Ridge, the north arm of Sulawesi, and Borneo. Depths to the abyssal plain are 5,000 to 5,500 m with sediments supplied by Borneo and Sangihe. To the northeast and south are the relatively young Cotabato and North Sulawesi Trenches, respectively. Seismic refraction shows the crust to be oceanic in nature. One-limbed magnetic anomalies 18 to 20 (42-47my) in the southwest portion of the basin trend roughly parallel to the Sulu Ridge. The Eocene age provided by the magnetic lineations conform with those suggested by basin depths and heat flow. It is generally accepted that Celebes Sea crust represents trapped oceanic crust isolated by the formation of the Sulawesi Ridge.

2.2.10 West Philippine Sea Basin

The West Philippine Sea Basin, occupying the western half of the Philippine Plate, is bounded on the east by the Oki-Daito, Palau-Kyushu and Tobi Ridges and on the west by the active Philippine Trench, the East Luzon Trench, the Gagua Ridge, and the active Ryukyu Trench. Prominent morphological features within the basin are the Benham Rise, Urdaneta Plateau and the Central Basin Fault. Based on regional bathymetry, structural and magnetic fabric, the West Philippine Sea Basin was subdivided by Mrozowski et al., (1982) into the main basin, northwest sub-basin and southern sub-basin.

The main basin is characterized by a west-northwest trending structural and magnetic fabric roughly parallel and symmetrical to the Central Basin Fault. The magnetic lineaments were identified as anomalies 21 to 17 (49 to 39 my) showing that sea floor spreading occurred in an east-northeast direction (present geographic position) during Eocene time. The magnetically-determined Eocene age is in good agreement with paleontologic and radiometric dates on DSDP samples.

The apparent symmetry of the anomalies about the Central Basin Fault as well as its ridge-rift morphology led previous workers to conclude that the feature is an extinct spreading center. However, detailed studies show that the Central Basin Fault cuts both structural and magnetic lineaments at an angle. This, as well as microseismicity, heat flow and radiometric data, suggest that the Central Basin Fault is a post-spreading tectonic feature and that the axis of spreading lies within its zone of rough topography.

Profiles across the boundary of the main and southern sub-basins show a pronounced topographic step with the latter being shallower. In addition, it has a smoother acoustic basement and thick sedimentary cover. No magnetic anomalies were identified.

The northwest sub-basin lies northwest of the Benham Rise and Urdaneta Plateau. The basement of the basin is dominated by a series of north-northeast trending ridges buried beneath a thick sedimentary pile which records the uplift of Luzon. This fabric truncates at a normal angle the WNW-ESE morphological and magnetic trends of the main basin including the Central Basin Fault. Karig and Wageman (1975) believe that this north-northeast trend is maintained by individual trends of an echelon ridges and troughs within the Central Basin Fault although its apparent trend is WNW-ESE. It has been suggested that the northwest sub-basin originated as part of the main basin but underwent a deformation not experienced by the latter. Magnetic lineaments might have continued into this sub-basin but were degraded by this deformation.

Two basic models account for the formulation of the West Philippine Sea Basin; the entrapment and inter-arc spreading models. In the first, pre-existing oceanic crust is trapped with the formation of the Palau-Kyushu Ridge following the transformation of an old transform into a subduction zone. The second model has the basin forming through island arc splitting and back arc spreading either behind the Palau-Kyushu Ridge, the Oki-Daito Ridge.

2.2.11 South China Basin

The deeper portion of the South China Sea consisting of an abyssal plain represents an inactive marginal sea basin of Middle Oligocene to Early Miocene age (Taylor and Hayes, 1980, 1983). It is bounded on the north by the passive margin of mainland Asia; on the west by the inactive Vietnam transform; on the south by the rifted continental margin of Palawan; and on the east by the actively subducting Manila Trench.

The surrounding shallow areas are marked by plateaus, ridges and seamounts. These include the Paracel Islands, Macclesfield Bank, Reed Bank, Spratley Islands and Dangerous Grounds. That these areas are underlain by continental crust has been suggested by seismic refraction (Ludwig et al., 1979) and other geophysical data and has been confirmed by drilling.

Rising above the sea floor of the abyssal plain is a chain of Seamounts, the Seaborough Seamounts, which traverses in a roughly east-west trend, the axis of the basin.

The South China Basin has been subdivided into three sub-basins; main, northwest and southwest sub-basins. The main is characterized by east-west trending linear magnetic anomalies parallel and symmetrical to the Seaborough Seamounts which contains an extinct spreading center. The magnetic lineations have been recognized and identified as anomalies 11 to 50 (32 to 17my). This indicates that sea floor spreading took place in a north-south direction from Late Oligocene through Early Miocene time.

The northwest sub-basin has a structural fabric also in the east-west direction. This sub-basin is not dated and does not contain recognizable anomalies. The southwest basin has both magnetic (although unidentified) and structural trends which differ markedly as they are in a northeast-southwest direction. The age of this sub-basin is likewise unknown. Although the relative spreading histories of the sub-basins are not known, whatever models arise should take into account certain geometrical difficulties concerning the boundary of the southwest and main sub-basins.

The synchrony of prominent pre-Neogene regional unconformities in both northern and southern margins of the South China Sea and the facies relationships of the unconformity-bounded rock packages suggest the sharing of a common pre-Neogene history. An unconformity at the Cretaceous-Paleogene boundary records the initial rifting of the proto-margin of mainland Asia. A Middle to Upper Oligocene unconformity marks the cessation of rifting and the onset of sea-floor spreading. A mid-Miocene unconformity in Palawan suggests that the collision of Reed Bank with Palawan, end of sea floor spreading and uplift of Palawan occurred at this time (Holloway,1981).

2.2.12 Rifted Continental Terrane

The Palawan Group of islands, the Buruanga Island Group, the Reed Bank, the Buruanga Peninsula in Northwest Panay, the Tablas Island Group and Southwest Mindoro have been collectively termed as the North Palawan Block by Holloway (1981), as the Calamian Microcontinent by Taylor and Hayes (1980), and as the North Palawan Continental Terrane by McCabe et al. (1985). Geological surveys covered by this report and some recent studies in this terrane (Rangin, 1987; Marchadier, 1988; ODP Leg 124, 1989) consider the perimeter of the latter to extend as far north as the southern margin of South China Sea Basin to the Luconia Shoals in the west; offshore west of Masbate and south of Marinduque Island in the east; and offshore southeast of Palawan roughly paralleling the trend of the island.

This terrane has been known to contain the oldest lithological assemblage in the Philippine Archipelago. Throughout the terrane, the metamorphic units (the Romblon Metamorphics, the Buruanga Metamorphic Complex, the Caramay Schist, the Concepcion Phyllites and the Halcon Metamorphics) have been regarded as the basement lithologies and are pressumed to be Paleozoic or older in age. These metamorphic suites are composed essentially of quartz-mica schist, graphite schist, some quartzites and greenschist. Although the greater fraction of the metamorphic assemblage are of sedimentary derivation, the rocks are apparently barren of fossils. The degree of metamorphism throughout the terrane is not uniform despite its widespread effect and there is a predominance of low-grade metamorphism (Fontaine et al., 1983).

Late Paleozoic to Mesozoic chert, limestone and clastic units also abound within the terrane. Characteristic of the chert and the clastic units which are mostly turbidites is its highly disturbed features - intensely folded and fractured. The limestone formations, although in limited occurrences, are sporadically distributed within the terrane. Late Paleozoic to Mesozoic carbonates have been delineated in Carabao

Island of the Romblon Island Group, in Northern Mindoro, and offshore northwest Palawan.

Early to middle Tertiary period is highlighted by the ophiolite emplacement (the ophiolitic units of Palawan and probably the serpentinites within Ambil Island (Rangin et al., 1985) and along the Mindoro suture zone delineated by Karig et al. (1986), the deposition of the series of turbidite fans of continental origin, and the intrusion of quartz-rich plutons. It is curious to note that the latter units are hosted solely by the aforementioned metamorphic assemblage and studies on such units particularly those delineated in northern Palawan (the Kapoas Intrusives) yielded an anatectic origin of sedimentary derivation.

Impingement of the North Palawan Terrane against the proto-Philippine arc by Late Tertiary could have induced the emplacement of the Lumintao Mafic Complex (Karig et al., 1986) of Mindoro (Rangin et al., 1985) and the Antique Ophiolite, the entrapment of the northern extreme of the Cagayan de Sulu arc and the deformation and metamorphism in part of both the old and the latter lithologies within the terrane.

The North Palawan Terrane has been interpreted to be a drifted fragment of the southeastern margin of the mainland China (Halloway, 1981; Taylor and Hayes, 1980 and 1983; Wind and Schloter, 1983; Ru and Pigott, 1986). The terrane is highly disturbed and in some areas the lithological assemblage is chaotic. Such assemblages are best exhibited by the intensely folded and fractured chert and turbidite units. Early Tertiary crustal attenuation and strike-slip movements inherent to the drifting, ophiolite obduction during the Eocene, and the subsequent impingement of the terrane with the proto-Philippine Arc during the Miocene have been considered as the major activities in which the Terrane deformation and disturbance could be attributed. Isozaki et al., (1988) based on their studies in Palawan, regarded the structure of the chert to be inherent of an accretionary wedge wherein its continuity parallels the trend of the Mesozoic convergent margin of the mainland Asia. This margin is in turn draped by series of Early to Middle Tertiary turbidite fans of quartzofeldspathic composition.

Although several theories have been proposed regarding the emplacement history of the North Palawan Terrane, the southward migration of the terrane from the southern flank of mainland China is generally attributed to the mid-Tertiary opening of the South China Sea (Taylor and Hayes, 1980).

CHAPTER 3 GEOLOGIC ENVIRONMENT AND MINERALIZATION

3.1 The Philippine Arc

3.1.1 Northern Sierra Madre Region

3.1.1.1 Regional geologic setting

Lying on the extreme northeastern part of Luzon, the Northern Sierra Madre (NSM) Region is characterized by a basin-ridge-basin system (Figs. 1, 9). On its western portion is a homoclinal belt of Miocene to Pleistocene sedimentary rocks aproning a core of older volcano-plutonic rocks. On its eastern part is a structurally bounded occurrence of ultramafic rocks with a trough-like basin overlain by relatively young sedimentary rocks.

The region has been divided (Aurelio and Billedo, 1987) into two parts based on tectono-stratigraphic relationships of the underlying rock units. The boundary between the two portions is the Divilacan Thrust which extends from Divilacan Bay in the north to Dinapiqui Point in the south. The area west of the Divilacan Thrust has been called the Central Tectonic Terrane (CTT) while the area to the east is termed as the Eastern Tectonic Terrane (ETT).

Lying to the east of the NSM range is an inactive subduction complex known as the Isabela Ridge. Immediately west of this ridge is the westward dipping East Luzon Trench. The subduction event that preceded this trench during the geologic past was the main driving force in the shaping of the tectonic character of the area.

3.1.1.2 Lithology and stratigraphy

The oldest rocks in the region are grouped under the Cretaceous Isabela Ultramafic Complex which forms the basement complex of the ETT. It is composed of serpentinized peridotite with dunite lenses and massive and layered gabbro. Probably in thrust contact with these rocks are units of the Bicobian Basalt and the Dikinamaran Chert. The Bicobian consists essentially of pyroxene basalts. Overlying this unit is the Dikinamaran Chert. This was dated as Early Cretaceous on the basis of the radiolarian assemblage found therein (Table 1).

Table 1 Columnar Section of Northern Sierra Madre Region

GEOLOGIC TIME					NORTHERN SIERRA MADRE			
MILLION YEARS	ERA	PERIOD	EPOCH	AGE	CENTRAL TECTONIC TERRANE	IGNEOUS ACTIVITY	EASTERN TECTONIC TERRANE	IGNEOUS ACTIVITY
	CENOZOIC	QUATERNARY	HOLOCENE		ALLUVIUM		KANAIPANG Ls.	
			PLEISTOCENE	LATE	ILAGAN Fm.			
				EARLY				
		TERTIARY	PLIOCENE	LATE				
				MIDDLE				
				EARLY	CABAGAN Fm.			
			MIOCENE	LATE			PALANAN Fm.	
				MIDDLE	CALLAO Ls.			
				EARLY	LUBUAGAN Fm. BULAO Ls.	BASALT FLOW	DIERCO Fm.	
			OLIGOCENE	LATE	DIBULUAN Fm.			
				MIDDLE				
				EARLY	MASIPI GREEN TUFF / DIPADIAN Fm.	DACITE FLOW NORTHERN SIERRA MADRE BATHOLITH		
			EOCENE	LATE	MT. CRESTA Fm. ABUAN Fm. / DIPADIAN Fm.	ANDESITE, BASALT FLOW		
				MIDDLE				
				EARLY				
			PALEOCENE	LATE				
				MIDDLE				
				EARLY				
							DIKINAMARAN CHERT	BASALT FLOW
							BICOBIAN BASALT	
							ISABELA ULTRAMAFIC COMPLEX	

The development of the magmatic arc during the Oligocene resulted in the generation of the volcano-plutonic assemblages and related sedimentary units of the CTT. Making up the assemblages are the Abuan Formation, Mt. Cresta Formation and the Masipi Green Tuff. Stated in the order of decreasing age; the Abuan formation consists of andesitic flows, flow breccias and volcanic derived sediments; the Mt. Cresta Formation on the other hand, is made up of dacitic lava flows, pyroclastics and clastic rocks; while the Masipi Green Tuff is essentially pyroclastic rocks. Synchronous to the deposition of the three rock units above is the deposition of the Dipadian Formation. This formation consists of volcanic derived wackes, conglomerates and volcanic rocks found immediately west of the Divilacan Thrust. It is inferred to be a facies change from a magmatic arc of the CTT into a forearc of the ETT. Intruding these older units is the NSM Batholith, an enormous pluton of tonalitic to granodioritic composition, occurring in the central part of the region.

Representing the waning stage of arc magmatism in the region are the deposition of basalt flows and pyroclastic rocks of the Late Oligocene Dibuluan Formation. Cessation of subduction activity followed closely the deposition of the Dibuluan Formation and this was marked by the formation of the Early to Middle Miocene Ibulao Limestone, a gray creamy limestone in the CTT.

Shortly following thereafter is the deposition of the Lubuagan Formation (CTT) and by Dierico Formation in the ETT. The Lubuagan Formation is composed of sandstones, shales, conglomerates and coal beds. It has been inferred that the bottom part of the formation has a flysch-type sequence, the middle part as having a proximal turbidite depositional environment, and the topmost portion as having been derived from a reefal source. The Dierico Formation covers the juxtaposed CTT and ETT above the Divilacan Thrust. It is composed mainly of conglomerate whose clasts include limestones from the Dipadian Formation and serpentinites from the Isabela Ultramafic Complex.

Intertonguing with the calcareous members of the Lubuagan Formation is the Callao Limestone in the CTT. The lower portion of this limestone is massive and resistant to weathering while the upper part is porous and less dense. Paleontological evidences suggest that the Callao Limestone has been deposited in a neritic to littoral environment during Middle Miocene.

Another intertonguing relationship exist between the upper portion of Callao Limestone and the lower members of the overlying Cabagan Formation. Dated to be

Late Miocene to Early Pliocene, the latter consist of interbedded sandstone, shale, siltstone and conglomerate with some limestone lenses. Meanwhile in the ETT, the Palanan Sediments (sandstone and calcareous mudstone) were laid down in a deep trough as renewed subduction from a postulated former spreading center began its activity.

Late Pliocene to Pliestocene time was marked by the deposition of the Ilagan Formation in the CTT and of the Kanaipang Limestone in the ETT. The Ilagan Formation consists of poorly compacted calcarenites at the bottom with sandstones and conglomerates at the top. The sequence suggests an environment of deposition from shallow marine to fluviatile environment. The Kanaipang Limestone is a reefal limestone whose lower portion intertongues with the Palanan Sediments. This would indicate the start of sea regression during the Late Pliocene and it continued up to the time of deposition of the upper layer of the Kanaipang Limestone.

Since the time of sea regression, the subduction east of the region has continued to this day and has come to be known as the East Luzon Trench. This event has built up a presently inactive subduction complex immediately offshore of the region, known as the Isabela Ridge. Meanwhile, erosion of exposed rock units in the region supplied the alluvium that covers the flat lying areas in both terranes.

3.1.1.3 Geologic structure

Construction of a strike rosette diagram from the delineated structural elements in the region reveals that the primary stress which acted upon it was directed on a nearly east-west trend with a minor north-south component (Fig. 9).

Thrust faults and imbricate structures abound in the ETT and they have been largely responsible for the spatial distribution of the rock units in the said terrane. Where direct field observation fail to delineate such structures, stratigraphical contact relationships strongly suggest the presence of these thrust faults. The Divilacan Thrust which runs for about 90 kms from Divilacan Bay to Dinapiqui Point, for example, has been inferred to be the contact between the CTT and the ETT based on the context of trench-island arc model. Thrust relationships can also be inferred from the small occurrences of the Dipadian Formation east of the Divilacan Thrust (interpreted by Aurelio and Billedo as klippen) and from the apparent overlying position of the Dikinamaran Chert with the peridotites of the Isabela Ultramafic Complex.

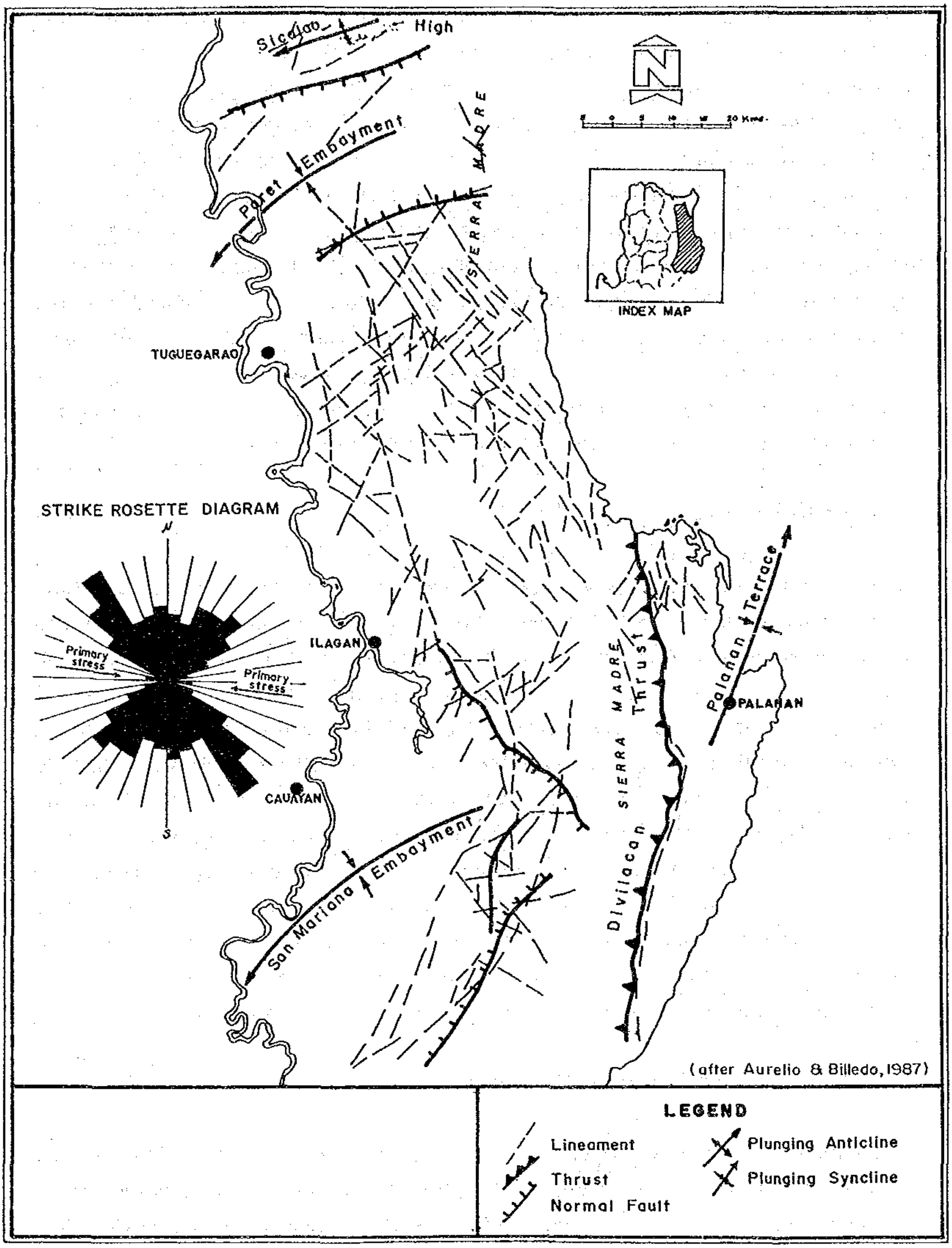


Figure 9 Structural and Lineament Map of Northern Sierra Madre Region

Aside from the homoclinal attitude of the sedimentary rock formations of the CTT, at least four fold structures have been delineated in the region. In the ETT, the sedimentary units concentrated along the Palanan Valley and presently assume a major plunging synclinal position termed as the Palanan Terrace. In the northwestern edge of the CTT, rocks of the Abuan Formation unconformably overlain by the Callao Limestone are deformed and has assumed a plunging anticlinal form (Sicalao-Cataggayan High) with a southwest trending plunge. Parallel to the Sicalao-Cataggayan High and immediately south of it, is the Paret Embayment, a plunging syncline that affects the Ilagan and Cabagan Formations. Another major fold in the region is represented by the San Mariano Embayment found at the southernmost part of the region. It is a southwest trending plunging syncline affecting a large chunk of the Ilagan and Cabagan Formations. Large high-angle tension faults and strong lineaments with variable trends are observed throughout the region.

3.1.1.4 Mineralization

In the context of metallogenic provinces and epochs, mineralization in the NSM region could be divided into two basic types: (1) ETT mineralization which was formed in an oceanic crust during the Cretaceous and (2) CTT mineralization which was formed in a volcano-plutonic arc during the Tertiary. The types of mineralization in the ETT are the orthomagmatic type chromite deposits, cyprus-type massive sulfide deposits and residual manganese deposits which was originally formed from submarine exhalative processes in the oceanic crust (Table 2). In the CTT, the types of mineralization are porphyry copper-type deposits, vein-type Cu-Au-Ag deposits, manto-type manganese deposit and sedimentary-type iron deposits (Table 3). Mineralization in the ETT is hosted by the Isabela Ultramafic Complex, Dikinamaran Chert and by the Bicobian Basalt. In the CTT, the bulk of metallic mineralization is found in the volcano-plutonic arc represented by the NSM Batholith, Abuan Formation, Dipadian Formation and Mt. Cresta Formation.

3.1.1.4a Orthomagmatic-type chromite deposits

The chromite deposits are found in Wasayan, Dikapisan, Dibenelang, Disukad and Dilacnadinom (Fig. 10). In these areas, the chromite occurs as disseminations, lenses and/or as massive bodies in serpentinized dunite of the Isabela Ultramafic Complex. Cr2O3 values in Cas Chrome Wasayan II and in Dibenelang are 53.39 % and 46.35 %, respectively. The ores are generally low in silica (0.04 % in Wasayan II and 6.79 % in Dibenelang) and in alumina (14.95 % in Wasayan II and 10.91 % in Dibenelang).

Table 2: Major Mineral Deposits and Prospects in the Eastern Tectonic Terrane, Northern Siera Madre Region

Mineral Deposit/ Prospect	Location	Commodity & Mineralization	Age	Tectonic Province
1) Cas Chrome Wasayan I @	122°17' E 16°35' N	Cr Ortho-magmatic	Cretaceous	Oceanic
2) Cas Chrome Wasayan II @	122°18' E 16°35' N	Cr Ortho-magmatic	Cretaceous	Oceanic
3) Dikapisan **	122°27' E 16°53' N	Cr Ortho-magmatic	Cretaceous	Oceanic
4) Dibenelang *	122°20'-24' E 17°17'-42' N	Cr Ortho-magmatic	Cretaceous	Oceanic
5) Disukad *	122°23'-06' E 17°11'-15' N	Cr Ortho-magmatic	Cretaceous	Oceanic
6) Dilacnadinom *	122°19'-40' E 17°11'-05' N	Cr Ortho-magmatic	Cretaceous	Oceanic
7) Lacson @@	122°23'-06' E 17°14'-33' N	Cu Cyprus-type massive sul	Cretaceous	Oceanic
8) Bicobian @@	122°24' E 17°15' N	Cu Cyprus-type massive sul	Cretaceous	Oceanic
9) Dikadiaoan *	122°27' E 17°00' N	Mn stratabound	Cretaceous	Oceanic
10) Disawit *	122°29' E 16°59' N	Mn stratabound	Cretaceous	Oceanic
11) Kanaipang Hill *	122 °27' E 16°58' N	Mn stratabound	Cretaceous	Oceanic

Note: * - Prospect; ** - Explored, undeveloped;
@ - Operating mine; @@ - Stopped operation

Table 3: Major Mineral Deposits and Prospects in the Central Tectonic Terrane, Northern Sierra Madre Region

Mineral Prospect	Location	Commodity and Mineralization	Age	Tectonic Province
12) Casablangan	122°00' E 17°37' N	Porphyry Cu	Oligocene-Miocene	Volcano-plutonic arc
13) Dinacdacan	122°02' E 17°34' N	Porphyry Cu	Oligocene-Miocene	Volcano-plutonic arc
14) Dinapiqui	122°13' E 16°36' N	Cu-Ag-Au? Vein	Oligocene-Miocene	Volcano-plutonic arc
15) Dina Creek	122°13' E 16°49' N	Cu-Ag-Au? Vein	Oligocene-Miocene	Volcano-plutonic arc
16) Diwagao	122°12' E 16°41' N	Cu-Ag-Au Vein?	Oligocene-Miocene	Volcano-plutonic arc
17) Dimakawal @@	122°12' E 16°35' N	Mn Manto-type Cu-Ag Dissem.	Oligocene-Miocene	Volcano-plutonic arc
18) Capisayan west	121°54' E 18°03' N	Fe Sedimentary	Pliocene	Back-arc basin
19) Capisayan east	121°55' E 18°03' N	Fe Sedimentary	Pliocene	Back-arc basin

Note: @@ - Stopped operation
All the other prospects are still undeveloped.

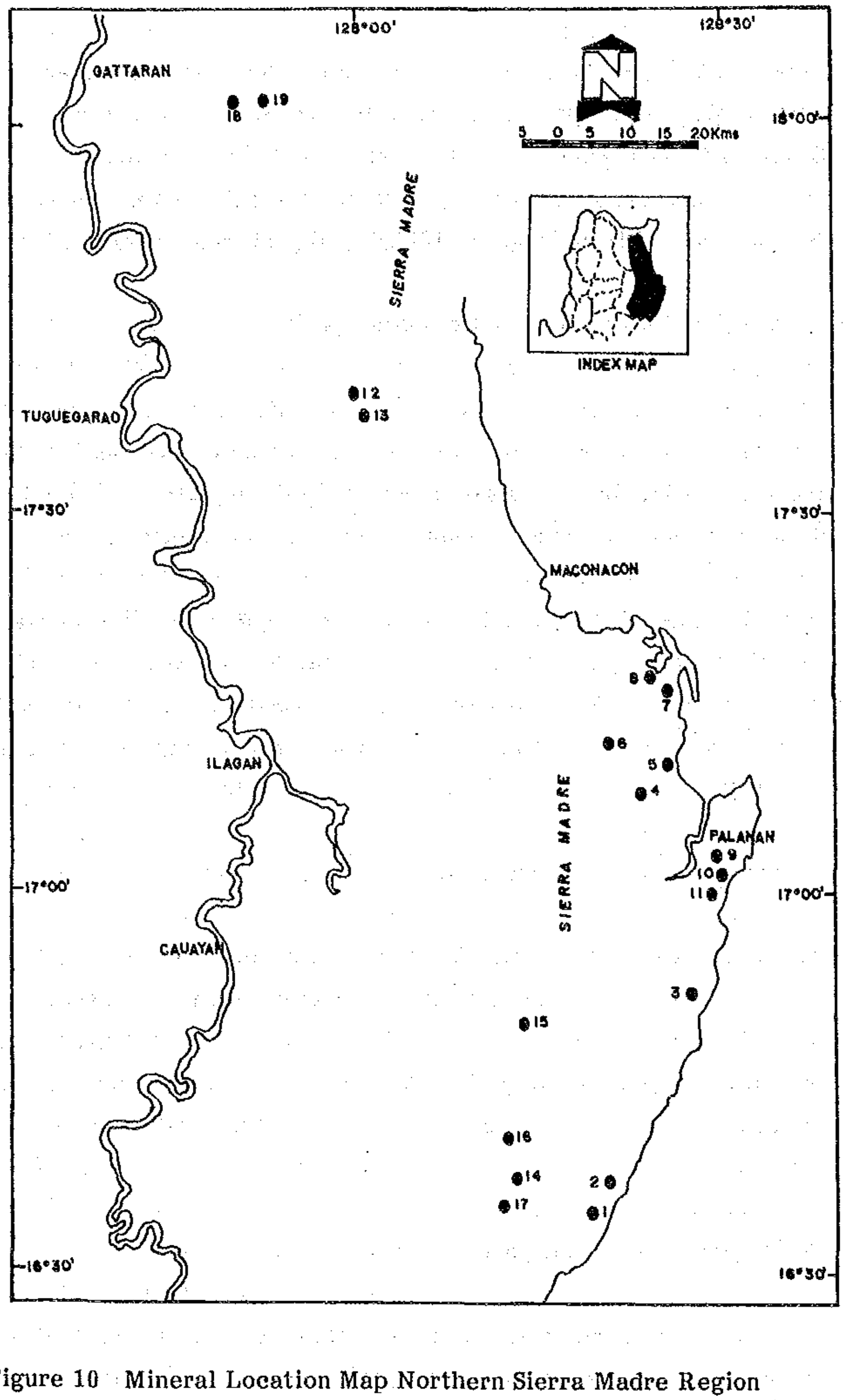


Figure 10 Mineral Location Map Northern Sierra Madre Region
(Numbers correspond to tabulated description of Tables 2, 3.)

3.1.1.4b Cyprus-type massive sulfide deposits

The cyprus-type massive sulfide deposits found in Bicobian and Lacson are hosted by the Bicobian Basalt. The ore bodies are actually found near the contact of the Bicobian Basalt and the Dikinamaran Chert with a mineral assemblage consisting of pyrite, chalcopyrite, chalcocite, bornite, covellite and sphalerite. Cu values range from 7.4 % to 54.4 %; Ag from 12 g/t to 168 g/t and gold from 0.5 g/t to 5.5 g/t.

3.1.1.4c Residual and manto-type manganese deposits

Residual manganese deposits occur as wads in chert and tuffaceous sediments of the Dikinamaran Chert. They are distributed in a narrow belt southeast of Palanan in three locations - Dikadiaoan, Disawit and Kanaipang Hill. These residual concentrations were derived from the manto-type deposits described below.

Manganese in Dimakawal in the CTT is hosted by the Dipadian Formation. It overlies the Cu mineralization (reference is made to 3.1.1.4e) and occurs as beds and lenses in tuffaceous sedimentary rocks. Cross cutting Mn veins and disseminations are also found in some parts of the mineralized zones which suggest an epigenetic hydrothermal origin.

3.1.1.4d Porphyry copper-type deposits

Occurrences of porphyry-type Cu mineralization in the CTT are found in Casablangan and Dinacdacan. Mineralization in these areas are hosted by dacite flows of the Mt. Cresta Formation near its contact with the NSM Batholith. Although samples from these sites yield very low Cu tenors, Ag values are relatively significant and the same samples are characterized by disseminations of chalcopyrite.

3.1.1.4e Vein-type Cu-Ag-Au deposits

Vein-type Cu-Ag-Au mineralization is exemplified by occurrences in Dinapiqui, Diwago and Dina Creek. In these sites, pyrite-chalcopyrite and sulfide bearing quartz veins are hosted by the volcanic flows of the Abuan and Dipadian Formations. Copper values range from 0.03 % to 3.07 %; Au values from 0.1 to 2.5 g/t; and Ag values from 0.07 to 9.0 g/t.

Vein-type Cu mineralization is also exhibited by the Dimakawal Cu-Mn deposit in Isabela but the main form of mineralization appears to be as Cu disseminations in silicified andesitic rocks of the Dipadian Formation. Copper values reach as high as 15 % in the form of massive sulfides but these are actually highly enriched zones in the host rock (Cabantog, 1974).

3.1.1.4f Sedimentary-type iron deposits

Iron deposits are found in the CTT as layered bodies or as nodules in sandstone and shale members of the Ilagan Formation. Although the formation has a wide distribution, the sedimentary iron deposits are so far found only in two sites in Capisayan. Magnetite grains dominate the iron-rich layers and these layers contain 26 g/t Ag, 0.017 % Cu and 13.26 % Fe.

Scattered throughout the volcano-plutonic arc of the CTT are occurrences of hydrothermally altered rocks. Although samples collected from these occurrences yield low base metal values, the possibility of deeply seated and/or hidden mineralization is not discounted.

3.1.2 Southern Sierra Madre and Polillo Island Region

3.1.2.1 Regional geologic setting

The Southern Sierra Madre (SSM) and Polillo Island region lies on the eastern flank of central Luzon (Figs. 1, 11). The region is bounded on the west by the Luzon Central Plain and on the east by the Philippine Sea. The Philippine Fault, after traversing the Bicol Region, runs in between the SSM mountain range and Polillo Island along Polillo Strait. The Laur-Dingalan Valley at the southwestern side of the Caraballo Mountain Range marks the passage of the Philippine Fault, and forms the northern boundary of the region. The southward extension the SSM mountain range could be projected along an east-west line from the southern shores of Laguna de Bay on the east to Lamon Bay on the west. However, one may still consider the Quaternary Mt. Banahaw further south to be the terminus of the SSM mountain range. Occurring directly northeast of Polillo Island is an east-northeast trending transform fault called the "East Luzon Transform" which left-laterally displace the "East Luzon Trench" from its southward extension, the "Philippine Trench".

The region is underlain by a basement of Early Cretaceous metamorphic rocks, over which, slabs of ophiolitic rocks had been emplaced. Late Cretaceous volcanism in the region is widespread and the older rocks were intruded by dioritic stocks during the Paleocene time. This event represents a long activity of magmatism from mid-Cretaceous (Santonian) to late Paleocene. Later, forearc/backarc basin sedimentation and magmatism deposited a variety of volcano-plutonic and sedimentary rock formations in the region. Revilla and Malaca (1987) suggested that this accretion of basinal sedimentary rocks as punctuated by magmatic events in SSM was related to a subduction event from the west. In Polillo, post-Paleocene sedimentation was related by Zepeda and Jagolino (1986) to a subduction event from the east.

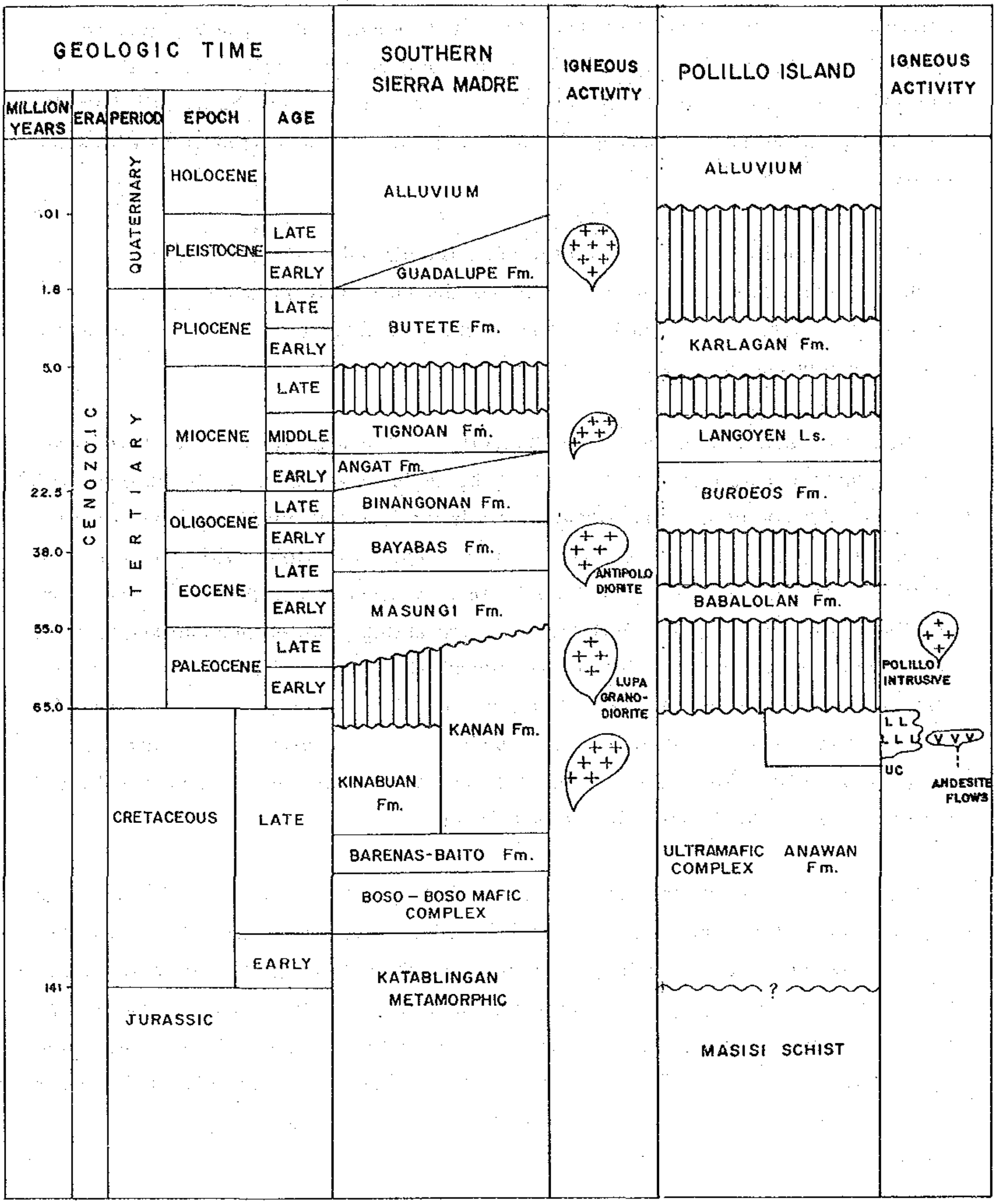
3.1.2.2 Lithology and stratigraphy

The basement rocks in the region are metamorphic rocks of sedimentary origin. These basement rocks are represented by the Early Cretaceous Katablingan Metamorphics in SSM and by the pre-Cretaceous Masisi Schists in Polillo Island (Table 4). Extensively exposed on the east side of Infanta Fault, the Katablingan Metamorphics are composed mainly of quartz-chlorite schists and gneisses. Phyllites are also present and some outcrops contain relict grains of sandstone.

In Polillo, the Masisi Schist occupies the western fringe of the Island. This formation is actually of the greenschist facies which constitute a mosaic of calcite veinlets, tremolite-actinolite aggregates, chlorite and quartz. Occurrences of phyllite and marble are also known in this unit.

Overlying the Katablingan Metamorphics in SSM is the early Cretaceous Boso-boso Mafic Complex with its associated pelagic sediments, the Barenas-Baito Formation. The Boso-boso Ophiolite is composed only of the upper units of a regular ophiolite sequence, starting from massive gabbro to the pillow basalt unit. Occuring along a north-south trending belt near the western fringe of the SSM, the Boso-boso Mafic Complex is believed to have been detached from the oceanic crust when the Katablingan Metamorphics collided with an active trench on the west. In Polillo, the mechanics of emplacement of the Polillo Ultramafic Complex (peridotite and gabbro) with respect to the Boso-boso Mafic Complex is unclear but the former is widely believed to have been emplaced during Late Cretaceous. Included as part of this complex is an amphibolite schist that is regarded as the metamorphic sole of the thrusted ophiolitic rocks.

Table 4 Columnar Section of Southern Sierra Madre and Polillo Island Region



After the collision and thrusting events, subduction presumably shifted directions and this initiated a long event of magmatism that was capped by simultaneous plutonic activities in SSM and in Polillo Island. In SSM, Paleocene plutonism was represented by the Lupa Granodiorite. Facies of this rock unit actually range from granodiorite to diorite. In Polillo, Paleocene plutonism was represented by the so-called Polillo Diorite but the actual facies range from granodiorite to quartz monzonite with some aplites.

Rock units deposited in SSM and Polillo after the plutonic events up to Pliocene time cannot be correlated to each other. In Polillo, post-early Paleocene rocks are all sedimentary rocks while in SSM, the rock sequence is an alternation of arc magmatic deposits and basinal sediments.

In SSM, post-early Paleocene active subduction on the west triggered at least three more igneous events punctuated regularly by sedimentation. First to be deposited after the intrusion of the Lupa Granodiorite is the Maybangain Formation, consisting predominantly of dense, steel gray to pitch black limestone with minor clastic interbeds. Dated to be Late Paleocene to Early Eocene, this formation is overlain by the Early Oligocene Bayabas Formation. Representing renewed magmatism, units of the Bayabas Formation are distributed almost along the entire length of the SSM mountain range. These consist predominantly of basalt and andesite flows with minor intercalations of coarse clastic beds. This formation is intruded by the Antipolo Diorite. Andesitic dikes and other hypabyssals are associated with the hornblende diorite and quartz diorite of this unit.

In SSM, particularly in the Laur-Dingalan Valley, a Quaternary debris avalanche deposit can be found and this may be inferred to have arisen from the subtle but constant movement of the Philippine Fault along the valley. At the southern part of SSM, renewed volcanism, presumably a late stage backarc activity of the subduction event from the Manila Trench caused the deposition of the Guadalupe Formation. Pyroclastic rocks with minor volcanic flows and fine tuffaceous clastic interbeds characterize this formation. Alluvium now covers most of the flat-lying areas of the region.

3.1.2.3 Geologic structure

The major geologic structure in the region is the sinistral Philippine Fault (Fig. 11). It cuts across the Polillo Strait in a northwesterly trend and sharply enters the Luzon

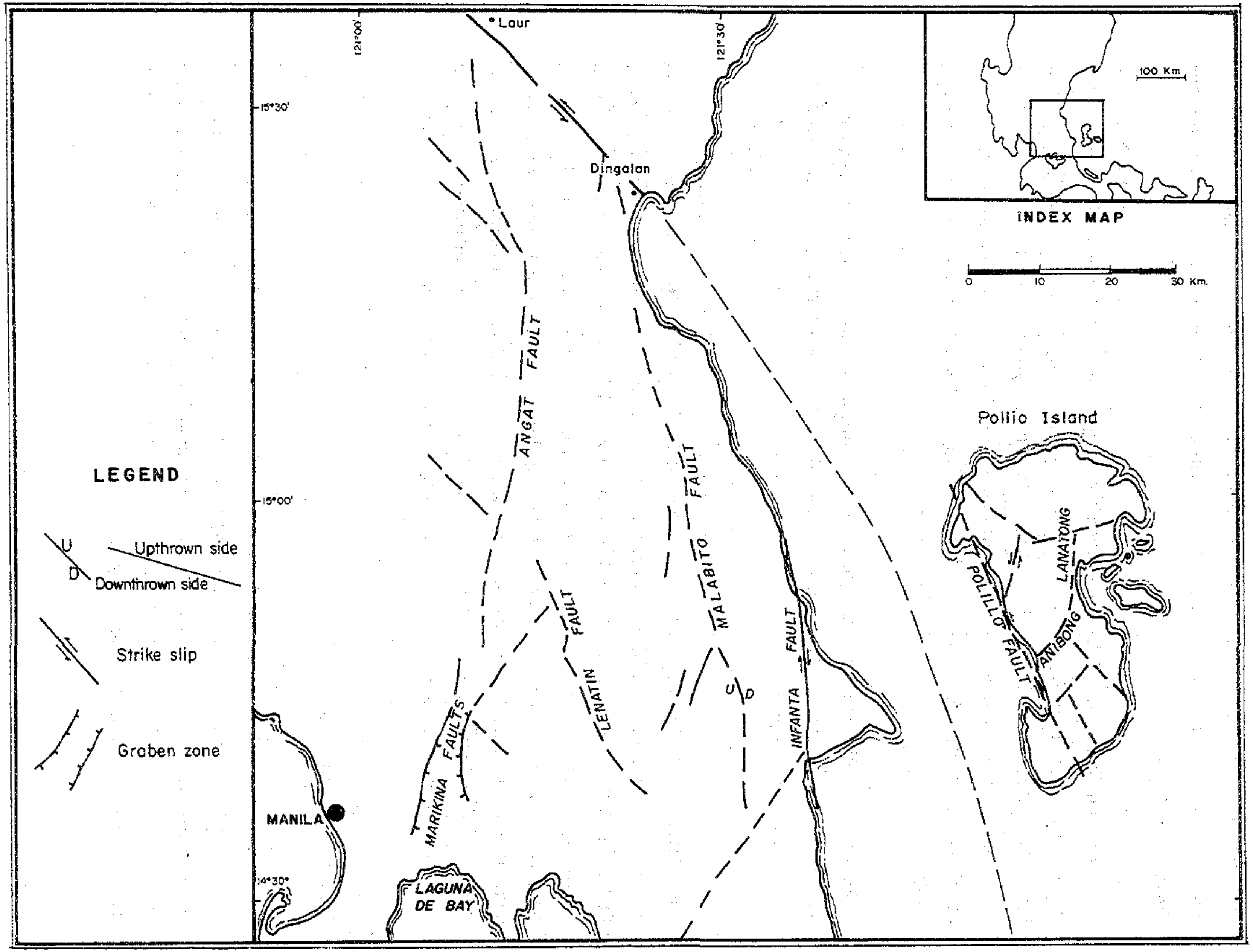


Figure 11 Map of Major Geologic Structures in the Southern Sierra Madre and Polillo Island Region

mainland through Dingalan. At this point, the fault bends and takes on a more northwesterly trend. Other structural features in the region mostly parallels the Philippine Fault.

Polillo Island is traversed by numerous high angle faults but the main faults found therein are the Polillo Fault, Anibong Fault and Lanatong Faults. The Polillo Fault is found at the western rim of the island. Closely paralleling the Philippine Fault, it also has a sinistral movement. The Anibong Fault cuts the midsection of the island at a northeasterly trend then gradually veers northward to become the Lanatong Fault.

Folds are well displayed in the Burdeous Formation and the fold axes trend nearly north-south. Imbricate structures and overthrusts characterize areas underlain by the ultramafic complex.

The attitudes of the structural lineations in SSM are not different from those in Polillo. The main faults in SSM are, from west to east, the Marikina Faults, Angat Fault, Lenatin Fault, Malabito Fault and Infanta Fault. All of these faults trend in a rough north-south manner while traversing almost the entire length of the SSM range. In contrast to the parallel and nearby Polillo Fault, the Infanta Fault has a dextral movement. This movement, in conjunction with the sinistral movement of the Philippine Fault, would have moved the Infanta Peninsula southward. The fold axial trends in SSM follow a north-south direction, almost similar to those found in Polillo.

3.1.2.4 Mineralization

There are four major types of mineralization in the region (Table 5 and Fig. 12). These are the contact metasomatic type, porphyry type, vein type and kuroko type massive sulfide mineralization. Many of the deposits discussed below are now being worked on or had been worked on as small scale mines. Only the Stata Ines Iron Deposit had been mined on a large-scale basis.

Table 5: Major Mineral Deposits and Prospects in the Southern Sierra Madre-Polillo Region

Mineral Deposit/ Prospect	Location	Commodity & Mineralization	Age	Tectonic Province
1) Camaching *	121°08' E 15°05' N	Fe Contact metasomatic	Oligocene?	magmatic arc
2) Angat *	121°08' E 14°59' N	Fe Contact metasomatic	Oligocene?	magmatic arc
3) Sta. Ines @@	121°19' E 14°44' N	Fe Contact metasomatic	Oligocene?	magmatic arc
4) Canicanian, Polillo **		Mo Porphyry type	Paleocene	magmatic arc
5) Sumacbao River *	121°12' E 15°17' N	Cu Porphyry type	Eocene-Oligocene	magmatic arc
6) Lumbay **	121°24' E 14°51' N	Cu Porhyry type	Eocene-Oligocene	magmatic arc
7) Puray @@	121°12' E 14°46' N	Cu Kuroko type massive sul	Eocene-Oligocene	magmatic arc
8) Ibuna *	121°22' E 15°18' N	Cu-Ag-Au Vein	Eocene-Oligocene	magmatic arc
9) Marcopper Matani **	121°21' E 14°52' N	Cu-Ag-Au Vein	Eocene-Oligocene	magmatic arc
10) Tignoan *	121°33' E 14°35' N	Cu-Ag-Au Vein	Eocene-Oligocene	magmatic arc

Note: * - Prospect; @@ - Stopped operation
** - Explored, undeveloped:

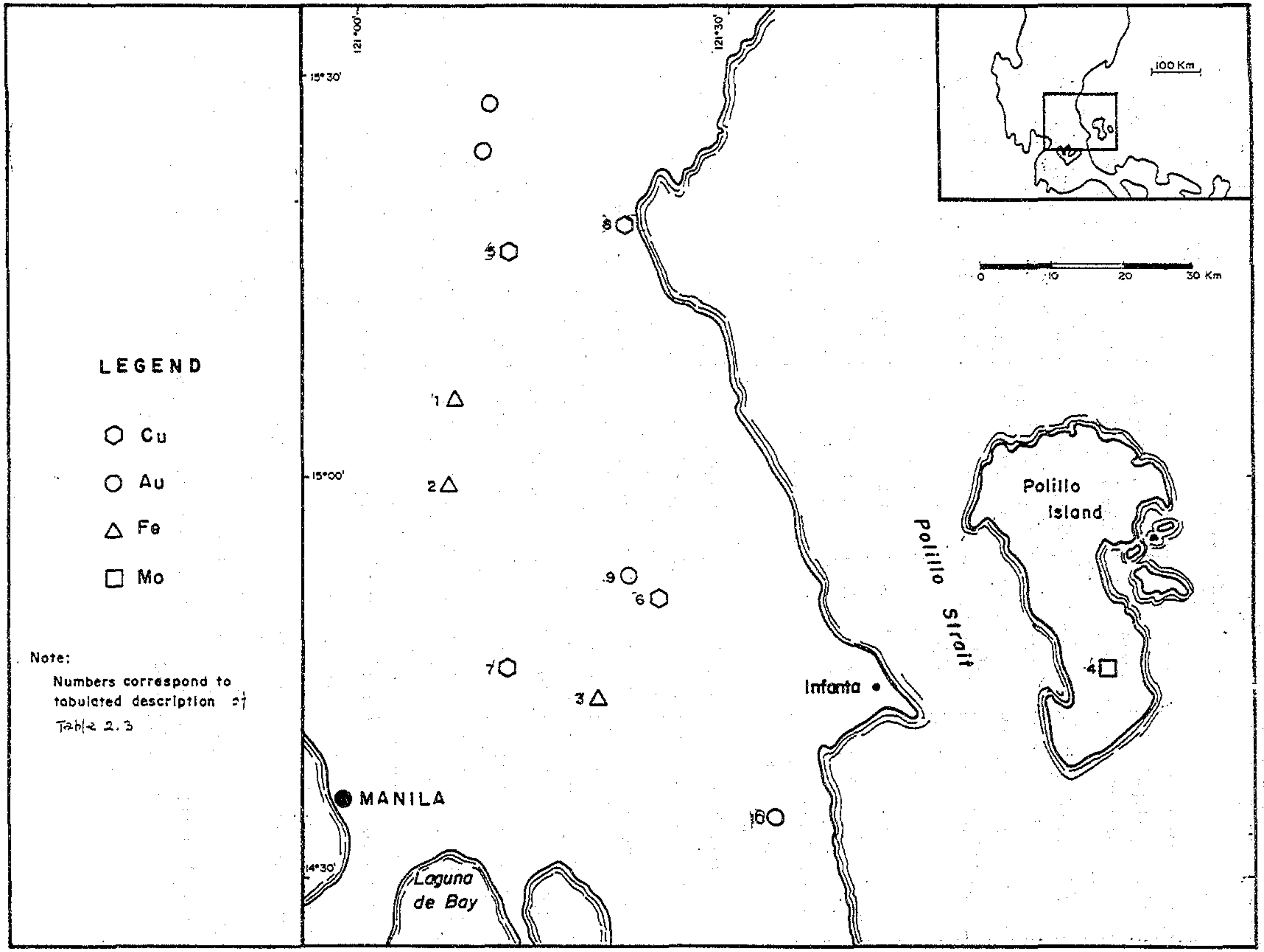


Figure 12 Location of Major Mineral Deposits and Prospects in the Southern Sierra Madre and Polillo Island Region

3.1.2.4a Iron contact metasomatic deposits

The most important type of mineralization in the region is the contact metasomatic type. All deposits from this type of mineralization has magnetite as the main ore mineral with copper, zinc and gold as associated elements. The iron contact metasomatic deposits are found in (1) Camaching, Umpacan Area, (2) in Angat, Norzagaray Area and in (3) Sta. Ines, Antipolo Area. The clastic and limestone members of the Binangonan and Angat Formations hosted mineralization as they were intruded by quartz diorite or diorite stocks from, probably, the last stages of magmatic activity of the Oligocene Antipolo Diorite.

3.1.2.4b Porphyry type deposits

There are three known porphyry-type deposits in the region and one of them is found in Polillo Island. This deposit is known as the Marcopper Polillo Prospect in Canicanian River. It is actually a porphyry molybdenum deposit related to the intrusion of the Polillo Diorite. In SSM, the porphyry-type mineralization have copper as its main constituent with minor gold content. The Antipolo Diorite as it intruded the Bayabas Formation, is responsible in the formation of this type of mineralization in Sumacbao River (Mount Balintingon Area) and in Lumbay, Umiray River Area.

3.1.2.4c Vein-type deposits

Vein-type mineralization occurs as sulfide bearing quartz veins and are related to andesitic rocks of the Eocene-Oligocene Bayabas and Miocene Tignoan Formations. The quartz veins contain significant amounts of silver and copper with moderate to strong gold tenors. The veins are widely distributed throughout the region. This wide distribution of gold-bearing vein systems could also account for the numerous placer gold occurrences in SSM. The Umiray, Angelo, Montalban, Papaya and Bosoboso Rivers are some of the drainage systems being panned for gold by small-scale miners.

3.1.2.4d Kuroko-type deposit

The last type of mineralization found in the region is the Kuroko-type ore deposit as exemplified by the Puray Prospect in Montalban. The ore deposit occur in basaltic tuff breccia and dacite members of the Bayabas Formation.

3.1.3 Masbate - Central/Eastern Panay - Guimaras Island - Southwest Negros Region

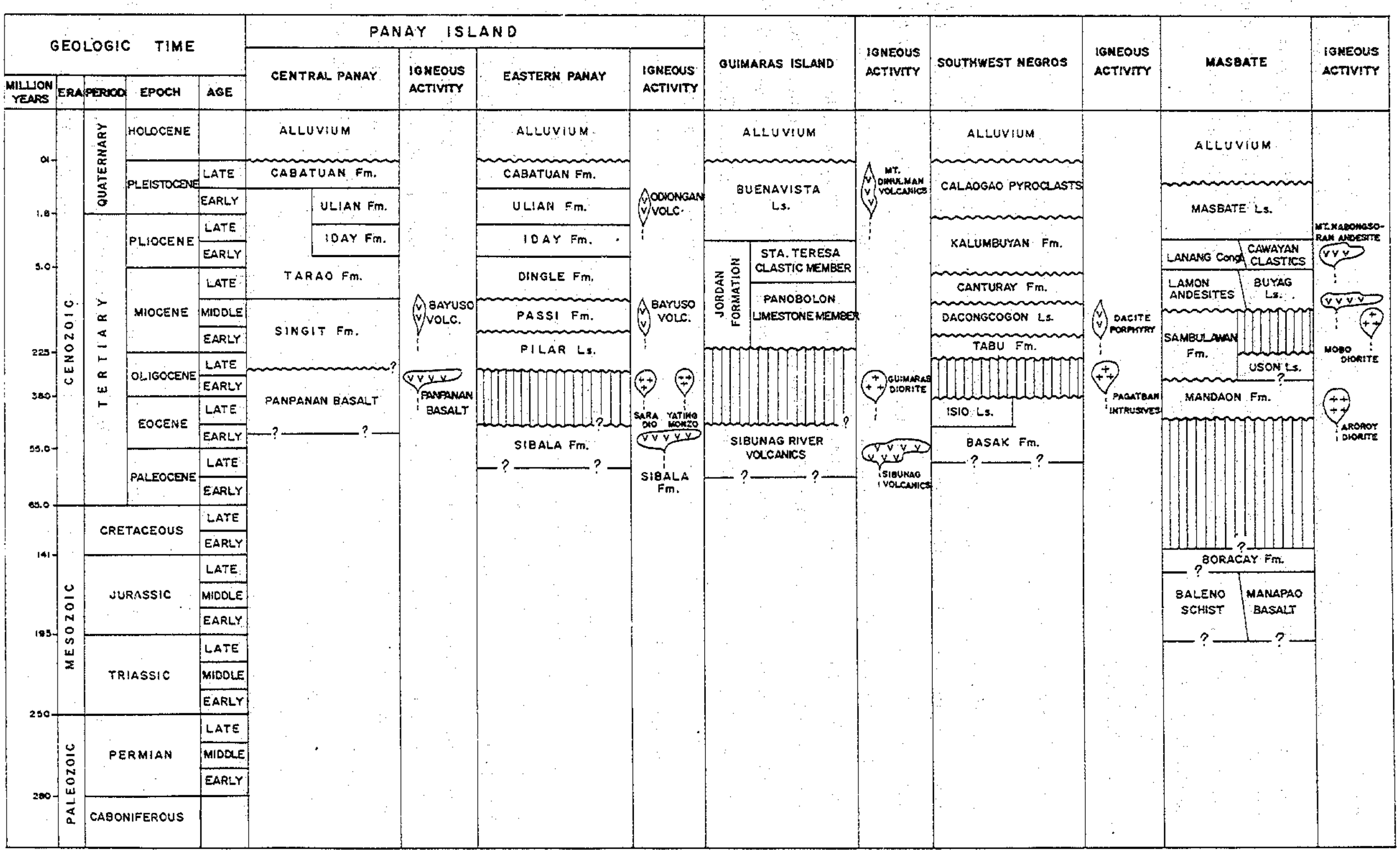
3.1.3.1 Regional geologic setting

The Masbate Island - Central and Eastern Panay - Guimaras Island - Southwest Negros Region is located in the central part of the Philippine Mobile Belt. And, is physiographically encompassed by the Tertiary Visayan Sea Basin along the southeast and the Iloilo Basin along the western flank of the region (Figs. 2, 13). A north-northeast trending Cretaceous to Paleogene volcano-plutonic ridge divides both basins.

The region is structurally bounded on the east by the sinistral Philippine Fault System which skirts Masbate Island, and on the west by a Late Miocene tectonic collision zone as exposed in the Antique Range of western Panay. This collision zone serves as the present on-shore terrane boundary between the Paleozoic-Mesozoic North Palawan Continental Block and the Cretaceous-Paleogene Eastern Panay-Masbate Arc with its corresponding forearc basin - the Iloilo Basin, which occurs in Central Panay. The Southwest Negros area, which is the southern extension of the Cretaceous-Paleogene Eastern Panay-Masbate Arc, is presently trapped between the Neogene Negros Trench to the west and its coeval Quaternary volcanic arc to the east.

The pre-Cretaceous basement rocks (Table 6) of the Cretaceous-Paleogene arc in the region mainly consist of metamorphosed (greenshchist facies) ophiolitic sequences, as represented by the Mt. Manapao Basalt and the associated Boracay Formation, in northeastern Masbate Island. The Baleno Schist, which also occurs in Masbate, is presently considered as part of the pre-Cretaceous basement of the region, probably representing an imbricate thrust sole of the said ophiolitic suite or a much older remnant arc material. The basement rocks of the Iloilo Basin in central-eastern Panay, on the other hand, consist of relatively younger Cretaceous-Paleogene oceanic crust material - the Panpanan Basalt - believed to have originated from the primitive Southeast Sulu Sea Basin (Balce, unpublished BMG Rpt., 1983).

Table 6 Columnar Section of Masbate - Central/East Panay - Guimaras - Southwest Negros Region



Built-up over these basement rocks in the region are Tertiary to Quaternary volcano-sedimentary island arc formations related to the development of the Visayan Sea Basin and the Iloilo Basin, with attendant magmatism associated with subduction along the Negros Trench. The stratigraphy and lithology of the region are herein discussed with respect to the Masbate-East Panay-Guimaras Island-Southwest Negros segment and the Iloilo Basin in Central-East Panay.

3.1.3.2 Lithology and stratigraphy

3.1.3.2a Basement rocks

The oldest basement rocks in the Masbate-Eastern Panay-Guimaras-Southwest Negros region are represented by the pre-Cretaceous Baleno Schist (chlorite schist), exposed in the northeastern coast of Masbate Island, and the Mt. Manapao Basalt (massive aphyric pillow basalt), which is exposed in the southwesternmost leg of the island. The latter occurs as isolated windows, probably representing the upper portion of an underlying ophiolite slab. This unit is conformably overlain by the pre-Cretaceous Boracay Formation which is composed of cherty sediments, basaltic flow breccia, conglomerate, wacke sandstone, siltstone, mudstone, semi-schist and tuff. This formation is believed to be the ophiolitic pelagic material associated with the Mt. Manapao Basalt.

Cretaceous to Eocene rock units that also serve as basement in other areas of the region are represented by the Sibala Formation (basaltic andesite lava flows, pyroclastics, tuffs and lithic sandstone) in East Panay; the Sibunag Pyroclastics/Volcanics in Guimaras Island, which is designated as Paleocene to Eocene in age, and; the Basak Formation (andesitic to basaltic volcanic lava; flow breccia, tuff and volcaniclastic material) in Southwest Negros. The Panpanan Basalt (amygdaloidal basalt flows, volcanic breccia, volcanic sandstone-mudstone-shale and calcirudite) in Central Panay may also be partly correlated to the Cretaceous-Paleogene arc formations in Masbate, East Panay, Guimaras and Southwest Negros.

3.1.3.2b Tertiary Geology of Masbate-East Panay-Guimaras Island-Southwest Negros

Magmatic activity in the region, related to subduction along the Negros Trench during Oligocene time, is represented by the Pagatban Intrusive (quartz diorite and gabbroic facies) in southwest Negros; the Late Oligocene Aroroy Diorite (granodiorite, quartz diorite, tonalite and gabbroic facies) in Masbate; the Early Oligocene Sara Diorite (diorite and quartz diorite) and Yating Monzonite (monzonite porphyry) in East Panay, and; the Guimaras Diorite in Guimaras Island. Correlating the ages of the intrusive bodies based on K-Ar datings (25.1 - 28.0 Ma) and their similar mineralogical compositions initially suggest that they were part of one continuous Oligocene magmatic arc which probably traversed from western Masbate through East Panay, Guimaras Island. Southwest Negros, and even extending further down to northwestern Mindanao (Fig. 6).

Intruding the Oligocene-Middle Miocene volcaniclastic units in this segment of the region are the Mobo Diorite (hornblende-biotite diorite and tonalite) of Lower to early Middle Miocene age (K-Ar 18.3 Ma) occurring in Central Masbate, and the unnamed dacite porphyry stocks in southwest Negros with K-Ar dates of 14.4 and 13.2 Ma based on hydrothermal sericite.

Middle to Late Miocene deposition and volcanism in the eastern half of the region is represented by the unconformably overlying Lamon Andesite (plagiophyric hornblende andesite and augite andesite porphyry) with a K-Ar dating of 12.2 Ma, with the associated fringing Buyag Limestone (coralline limestone) in Central Masbate; the Canturay Formation (carbonaceous to calcareous sediments) in Southwest Negros, and; the Panebolon Limestone Member of the Jordan Formation in Guimaras Island.

Late Pliocene volcanism in the region is reflected by the Mt. Nabongsoran Andesite in Masbate Island. It is possible that such activity, related to pulsational subduction along the Negros Trench, is also responsible for the Odiongan Volcanics (silicified porphyritic andesite flows) in East Panay and the Mt. Dinulman Volcanics (dacite flows) in Guimaras Island.

3.1.3.2c Tertiary Geology of Central-East Panay (Iloilo Basin)

The western half of the region is represented by the Iloilo Basin, encompassing Central Panay and a portion of East Panay. This segment evolved as a forearc basin of the Negros Trench - Antique Range collision zone from Late Oligocene to Pleistocene time.

The geologic basement in Central Panay consists of the Paleogene (Eocene to Late Oligocene?) Panpanan Basalt (see section 1.2.1) which is predominantly exposed on the western flank of the Iloilo Basin. This formation probably represents the northern extension of the proto-Southeast Sulu Sea Basin prior to its spreading during the Late Oligocene. This basement unit is now thrusted over the Middle Miocene Antique Range collision/suture zone (see section on Palawan-Western Panay-Romblon-Tablas Region). The basement unit of the Iloilo Basin in East Panay is the Cretaceous-Paleogene Sibala Formation (see section 1.2.2).

3.1.3.3 Geologic structure

The structural grain in Masbate Island and Southwest Negros shows a north-northwest trend. In Masbate, the structures are notably influenced by the Philippine Fault which runs parallel along the eastern coastline of Masbate Island. In Central-East Panay and Guimaras Island, the structural trend is generally north-northeast, perpendicular to the Antique Range collision zone in western Panay.

In Masbate Island, northwest-southeast trending thrust faults control the emplacement of ophiolitic slivers represented by the Mt. Manapao Basalt and the Boracay Formation over the Mandaon Formation of Late Eocene age. North-northwest trending faults and lineaments, as well as northwest trending folds in the island, are attributed to movements along the Philippine Fault Zone. In western Masbate, such fold axes include the Dimasalang, and Santa Cruz Anticlines, and the P.V. Cruz and Guium Synclines. A northeast trending fold, the Cabancalan Syncline, also occurs.

The geologic structure in Southwest Negros is dominated by a series of long and generally rectilinear north-northwest striking fault systems. Northeast-trending complimentary faults of smaller magnitude displace some rock units. These north-northwest trending faults are thought to have exerted a strong control on the intrusion and emplacement of the Pagatban Batholith and its late-stage differentiates into the older Bask Formation basement. Fault contacts between the diorite bodies of the batholith and the Dacongcogon Limestone and the Canturay Formation are well-defined in several localities. A major north-northwest trending fault projects from the vicinities of CDCP Mining in Basay and terminates at the Calatong Mountains.

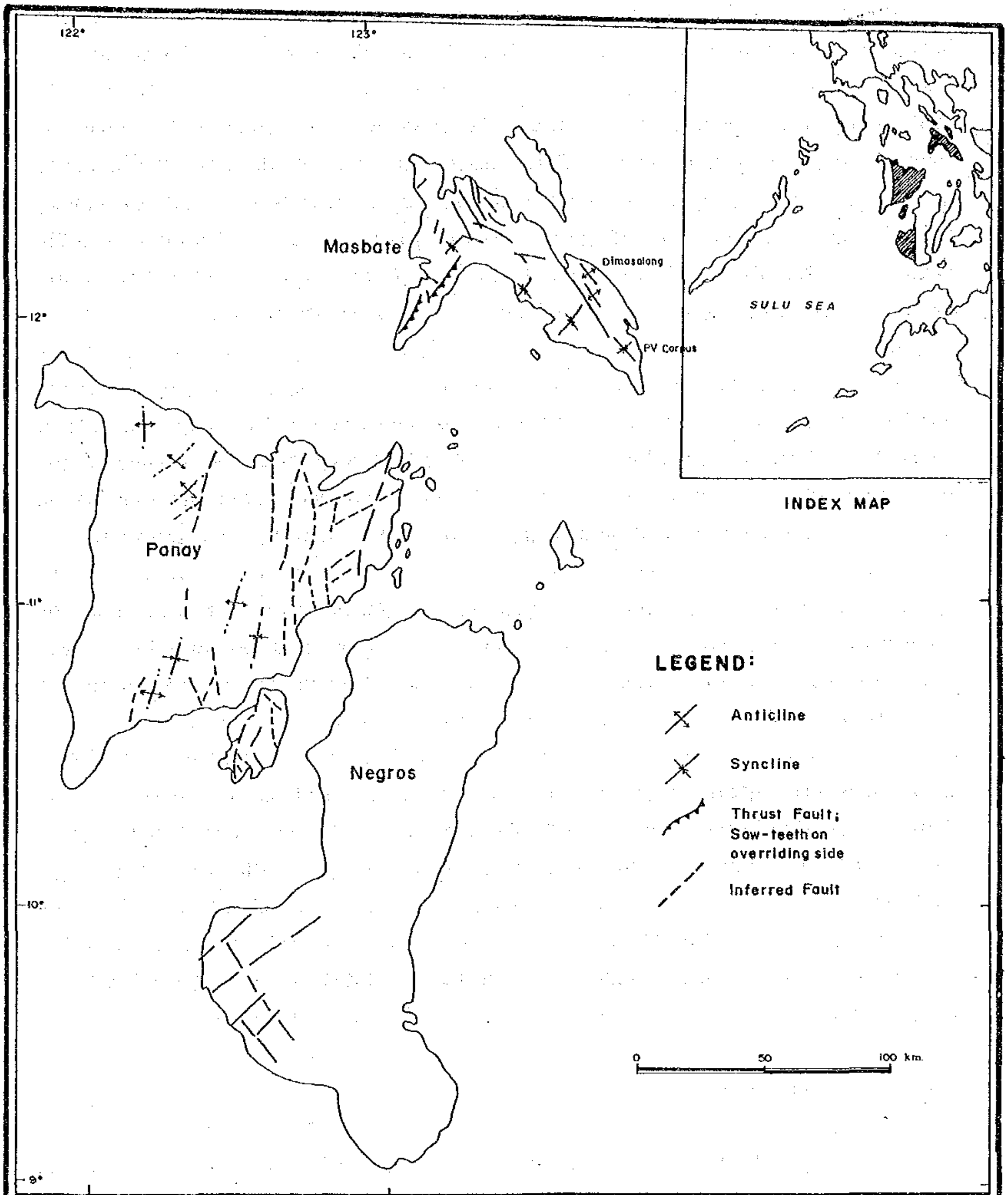


Figure 13 Map of Major Geologic Structures in the Masbate - Central/East Panay - Guimaras - SW Negros Region

(After: David, 1988; Santos, E., and Velasquez L., 1988; Baybayan and Matos, 1986; Morales & Jagolino, 1987)

Northwest trending folds within Southwest Negros are also generally well-developed in the older sedimentary units, specifically in the Lower Miocene Tabu Formation.

In Panay Island, a major thrust structure, the Panpanan Thrust, occur at the base of the ophiolitic Panpanan Basalt. This thrust zone defines the terrane boundary between the Antique Range collision lithologies and the Iloilo Basin in Central Panay, wherein the basalt unit is found overthrusted on foliated gabbros at a 40 degree-dip angle. This thrust extends up to Northwest Panay wherein sediments of the Iloilo Basin are inferred to be thrusted over Middle Miocene volcanic rocks.

In Central Panay, the sedimentary rocks of the Iloilo Basin are folded, exhibiting northeast to northwest-trending fold axes. The succession of the Singit Formation, Tarao Formation and the Ulian Formation occurring along the western edge of the basin generally dip southeast, whereas on the eastern edge, the succession of the Pilar Limestone, Passi Formation and Dingle Formation generally dip southwest.

In East Panay, the Cretaceous-Paleogene Sibala Formation is cut by numerous transcurrent faults and fractures, trending northeast and northwest. These structures controlled hydrothermal base metal quartz vein mineralization in the area, as well as the emplacement of the Sara Diorite.

In Guimaras Island, the structural grain shows a general north-northeast trend. The Guimaras Diorite in the island is confined along a prominent northeast trending fault system with complimentary northwest faults occurring perpendicular to the major fault structures. The prominent northeast fault system which characterizes the Guimaras Diorite and the Sibunag Pyroclastics rock units in the island are possibly related with the structural trends that controlled the intrusion of the Sara Diorite in East Panay.

3.1.3.4 Mineralization

Porphyry copper deposits and vein-type gold deposits dominate the few types of mineralization in the region (Table 7). In fact, the region is noted for these types of mineralization as it produces much of the country's gold, copper and molybdenum ores. Manganese and iron are also found in the region as sedimentary, residual, mechanical and contact metasomatic deposits.

3.1.3.4a Porphyry copper

Oligocene-Miocene magmatic arc activity in Southwest Negros, Eastern Panay, Masbate and Guimaras Island brought about several porphyry copper-type mineralization in the region (Table 7). In Southwest Negros, the biggest known porphyry copper deposits in the district is Maricalum Mining Company's Sipalay Mine (0.41-0.05 % Cu) and the (CDCP Mining) Muhong Copper Deposit (0.40 % Cu) in Basay. In between these two deposits and within its peripheries are several other porphyry-type copper deposits and prospects such as Aya-aya, Saguibon, Inayauan, Manlucahoc, New Manila, Asia and Hinobaan. The last was also prospected for vein-type gold deposit within its vicinities.

Sulfide mineralization in these deposits generally occur both within the metavolcanics/metasediments and the diorite intrusive host rocks as disseminations, veinlets, stringers and fracture fillings with close association to quartz veins/veinlets. Primary ore minerals are mainly chalcopyrite, bornite, chalcocite, molybdenite, covellite, secondary azurite, malachite and chrysocolla. Other associated minerals include galena, sphalerite, pyrite, magnetite and tennantite. Supergene enrichment is well develloped in Muhong Copper Deposit in Basay which has yielded 5.5 million metric tons of 0.64 % Cu. Alteration includes silicification, biotization, argillization, propylitization and pyritization that generally overlap each other. Mineralization in Southwest Negros is quite different from other porphyry copper-type deposits of the country due to the high molybdenum content of the deposits (generally 0.10 % Mo) with correspondingly low gold content.

In Guimaras Island, porphyry copper-type mineralization is exemplified by the Salvacion Copper Deposits which are confined within the Sibunag Volcanics and pyroclastics and the Guimaras Diorite. The deposits are also associated with vein-type copper mineralization.

Copper deposits in Masbate (Baleno, Mt. Uac, Dogosangan, Matanglad), Panay (Azure Mining in Loay, Pilar and Mt. Pari Pilar, Del Filar in Barotack Viejo) and Guimaras Island (Salvacion, Nueva Valencia and San Antonio) are considered to be vein-type deposits. In Loay, the vein systems follow a N75°E to N45°E, along fracture zone, while in Pari the veins trend N80 °W and N75 °E. The deposits are generally surrounded by phyllic, argillic and propylitic alteration zones. Stockworks/stringers (associated with quartz, gypsum/anhydrite veins) and disseminations of sulfide minerals could be observed at the adjacent wall rocks. Ore minerals present are chalcopyrite, chalcocite, bornite, malachite, azurite and pyrite. Ore grades range from 0.44 to 2.28 % Cu.

3.1.3.4b Vein-type gold

Gold mineralization in Masbate is generally confined in wide sheeted epithermal quartz-calcite veins and veinlets developed mainly within andesite metavolcanics and partly on the diorite intrusive. Sulfide minerals in the veins are barely discernable except for some minute specks of pyrite and chalcopyrite. Native gold and tellurides occur as disseminations, intergranular fillings, intergrowths and replacements. The Masbate Gold Operations of Atlas Mining best exemplifies the vein-type gold mineralization in the area. Other deposits have also been discovered and some are presently being mined by small-scale miners in Goldfields, Tinaojo, Capsay, Lanonoy, Colorado, IXL, Royal Paracale and other adjacent areas. Epithermal gold veins are also found in Bo, Matanglad, Manahoc, Masbate. Ore grades range from 1.4 to 2.7 g/t Au, although gold bonanza horizons also exist.

In Southwest Negros, epithermal gold veins include deposits at Vista alegre, Bulawan, Hinobaan, Sanke and Paling Gamay where panning activities are presently going on. In Eastern Panay, gold veins occur in Laoy and Pilar, Capiz, in Barotac Viejo and Nipa, Concepcion, Iloilo where pre-war mining activities took place.

3.1.3.4c Sedimentary manganese deposits

Manganese deposits in Masbate are found in Nabangig, Ayat, Taysan, Calumpang and Balud which are associated with conglomerate, chert, siltstone, shale, mudstone and basaltic lava flows. The manganese ore bodies occur as lenticular bodies within a definite and/or in several horizons. Secondary residual ores in boulder, cobble and pebble size are recognized along river banks and within the mineralized zone, manganese deposits in Masbate are generally low grade (47-70 % Mn). In Ayat, the high grade portions (72 % Mn) of the deposit which are confined within chert and shale host rocks are nearly mined-out.

In Southwest Negros, manganese occurrences are generally confined within the Tabu Formation (along Salong River) and the sinkholes and potholes of Dacongcogon Limestone. Pre-war mining activity was carried out on the manganese deposits in Tapol, Kabankalan, Southwest Negros. In Eastern Panay, the manganese deposit in Anilao, Capiz occurs as lenses and layers associated with andesitic rocks.

Table 7: Major Mineral Deposits and Prospects of the Masbate - Central/East Panay - Guimaras - SW Negros Region

Deposit/ Prospect	Type of Mineralization	Location	Remarks
1) Sipalay @	Porphyry Cu	9°49'04" 122°26'36"	0.50% Cu; 368,026,229 t res.
2) Baclao-Sipalay @@	Porphyry Cu	9°49'22" 122°25'31"	0.41% Cu; 56,229,000 t res.
3) Sipalay-Cauayan **	Porphyry Cu	9°48'33" 122°59'13"	0.42% Cu; 13,608,000 t res.
4) New Manila Ilog & Asia **	Porphyry Cu	9°35'39" 122°43'01"	0.35% Cu; 27,000,000 t res.
5) Hinobaan **	Porphyry Cu	9°32'39" 122°33'49"	0.45% Cu; 94,657,000 t res., development stopped
6) Inayauan **	Porphyry Cu	9°50'12" 122°29'14"	0.42% Cu; 13,707,930 t res.
7) CDCP Basay @@	Porphyry Cu	9°28'35" 122°40'32"	0.40% Cu;
8) Malinao, Basay @@	Porphyry Cu	9°28'39" 122°40'09"	0.40% Cu, 1.59% Ag;
9) Salvacion N. Valencia *	Porphyry Cu	10°32'06" 122°31'10"	For exploration
10) Aroray Bold (ACMDC) @	Porphyry Cu	12°29'04" 123°23'46"	2.47 g/t Au;
11) Capsay Masbate @	Vein type Au	12°29'04" 123°27'44"	9.26 g/t Au, 24.51 g/t Ag;
12) Loay Pilar (Azura Mines) @@	Vein type Au	11°29'04" 123°01'10"	1.40 g/t Au, 98.70 g/t Ag; 2.23% Cu
13) Mt. Pari (Pari, Pilar) @@	Vein type Au	11°28'40" 122°59'38"	0.44% Cu.
14) Guimaras Island **	Vein type Au	10°29'56" 122°33'50"	2.28% Cu.

Note: @ - Operating mine; @@ - Stopped operation; * - Prospect; ** - Explored, undeveloped

Table 7 (cont'd)

Deposit/ Prospect	Type of Mineralization	Location	Remarks
15) Nabangig (Masbate) **	Layered/lenses Manganese	12°07'05" 123°56'43"	47.3% Mn.
16) Ayat (Masbate) **	Layered/lenses Manganese	12°06'35" 123°01'10"	72.2% Mn.
17) Calumpang (Masbate) **	Layered/lenses Manganese	11°56'32" 123°10'22"	67.9% Mn.
18) Tapol Kabangkalan @@	Layered and residual Mn.	9°56'02" 122°45'01"	
19) Anilao Iloilo, Panay @@	Lentricular lenses Mn.	10°38'35" 122°44'59"	
20) Mandaon Masbate **	Layered/lenses Manganese	12°11'42" 123°08'12"	51.0% Mn; evaluated 1948 108,385 t reserve
21) Guimaras Iron Prospect **	Lenses/contact metasomatic	10°35'00' 122°40'10"	51.75% Fe 1,800 t reserve

3.1.3.4d Contact metasomatic and mechanical concentration of iron deposits

Several iron prospects and deposits (Leningwan, Pencian, Bantayan and Arbol) occur in Guimaras Island. The iron ores are localized along almost east-west trending structures with northerly dips. The iron ores average about 52 % Fe and are chiefly hematite and magnetite and are confined mainly on the metavolcanics (Sibunag Volcanics) and near the contact with the Guimaras Diorite body. The iron ore generally occur as lenses and irregular masses. In Southwest Negros, iron deposits are found at New Manila, Kabankalan which are also of the contact metasomatic-type. In Panay (Ivisan, Capiz) and in Southwest Negros (Basay and Bayawan), magnetite sand deposits of economic quantity are generally concentrated near the shore as beach and alluvial sands.

3.1.4 Cebu-Bohol-Siquijor-Southwest Leyte Region

3.1.4.1 Regional geologic setting

The Cebu-Bohol-Siquijor Islands - Southwest Leyte Region in the Central Philippines is physiographically encompassed by the Visayan Sea Basin and is presently tectonically bounded partly on the east by the sinistral Philippine Fault System and on the west by a west-facing Quaternary volcano-plutonic arc related to the Negros Trench (Figs. 2, 14).

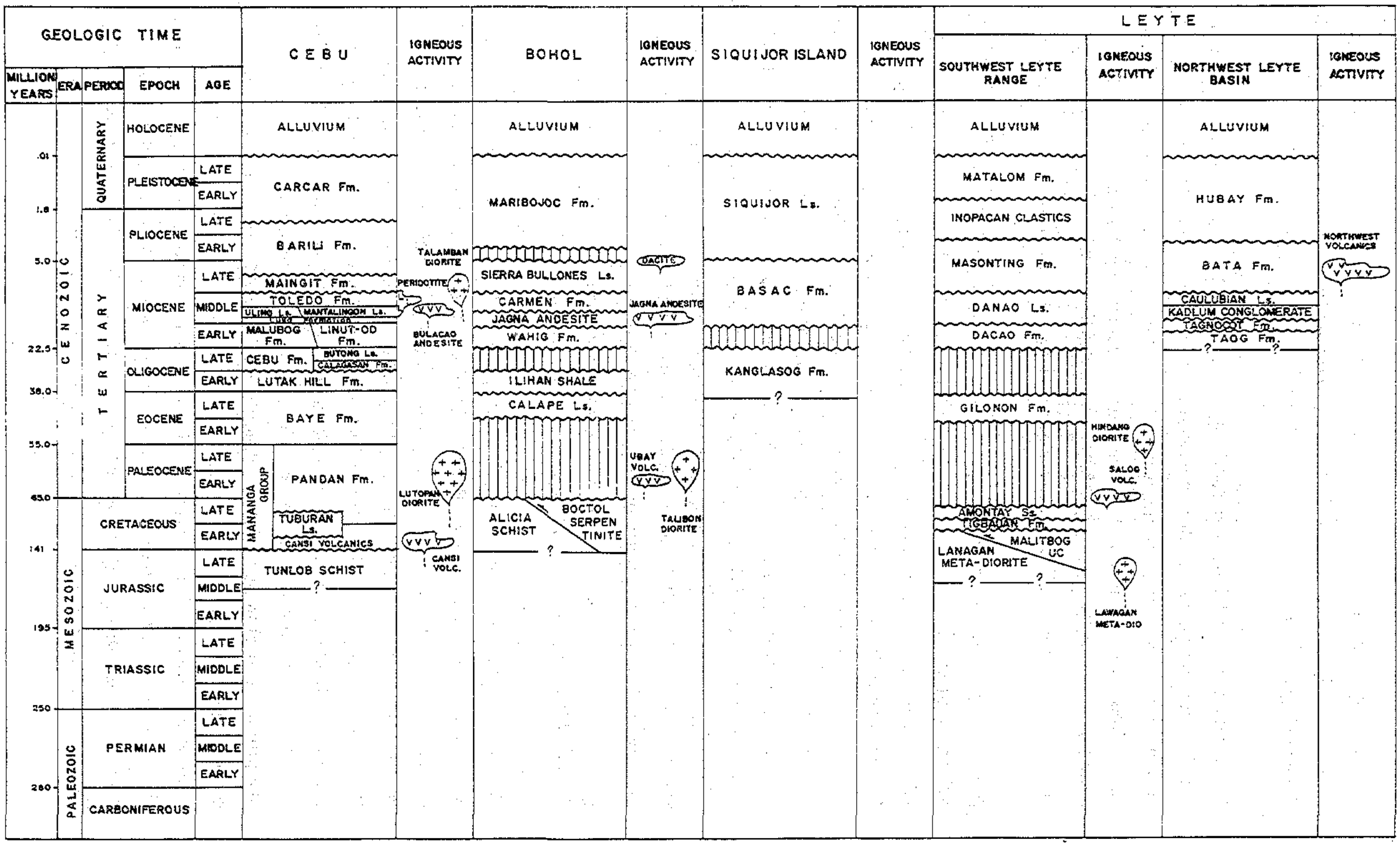
Cebu Island, Bohol Island and Southwest Leyte are basically underlain by a core of pre-Cretaceous metamorphic basement rocks that probably represent trapped remnants of primitive plutonic arcs. Thrusted over this metamorphic basement are imbricated and dismembered Cretaceous (Turonian) ophiolitic units with associated amphibolite occurring as thrust soles, as exposed in Bohol Island. In Cebu Island, fault-bounded slivers of serpentinite are associated with deformed basement rocks.

Accreted onto these metamorphic basement and ophiolitic units are a series of volcano-plutonic and sedimentary rock formations that have evolved from periodic island arc magmatism and forearc/backarc basin sediment deposition from Cretaceous to Pliocene time. The geologic build-up and amalgamation of said series of arc material and marine sedimentary deposits in the Cebu-Bohol-Siquijor-Southwest Leyte region can probably be related to active subduction along a postulated west-dipping Sulu-Zamboanga-Masbate Trench and arc system (Mitchell, 1987; Balce et al., 1987) during Cretaceous to Pliocene time and to the development of the Visayan Sea Basin from Eocene to Pleistocene time. Capping the islands in the region are Plio-Pleistocene shallow marine sedimentary units reflecting recent emergence towards the south of Visayan Sea Basin.

3.1.4.2 Lithology and stratigraphy

Pre-Cretaceous basement rocks in the Cebu-Bohol-Siquijor-Southwest Leyte region are represented by the Tunlob Schist (chlorite orthoschist, micaceous paraschist and amphibolite) in Cebu Island; the Alicia Schist (chlorite-epidote-albite-actinolite-mica schists, quartz-feldspathic schists and amphibolite) in Bohol Island, and; the Lawagan Meta-Diorite (meta-diorite, meta-gabbro and cataclastic schists) in Southwest Leyte (Table 8). Cretaceous ophiolitic rock suites in thrust contact with these basement schists in the region include the imbricated Boctol Serpentinite (harzburgite, gabbro and pillow basalts) in Bohol Island: the dismembered Malitbog Ophiolite (harzburgite, gabbro, diabase dike complex, pillow basalts and the pelagic sediments of the Tigbawan Formation) in Southwest Leyte, and; possibly the remnant serpentinite slivers associated with basement rocks in Cebu Island in Southwest Leyte, deformed and partly metamorphosed sedimentary units of the Early Paleocene Amontay Sandstone unconformably overlies the metamorphic basement.

Table 8 Columnar Sections of Cebu - Bohol - Siquijor - Leyte Region



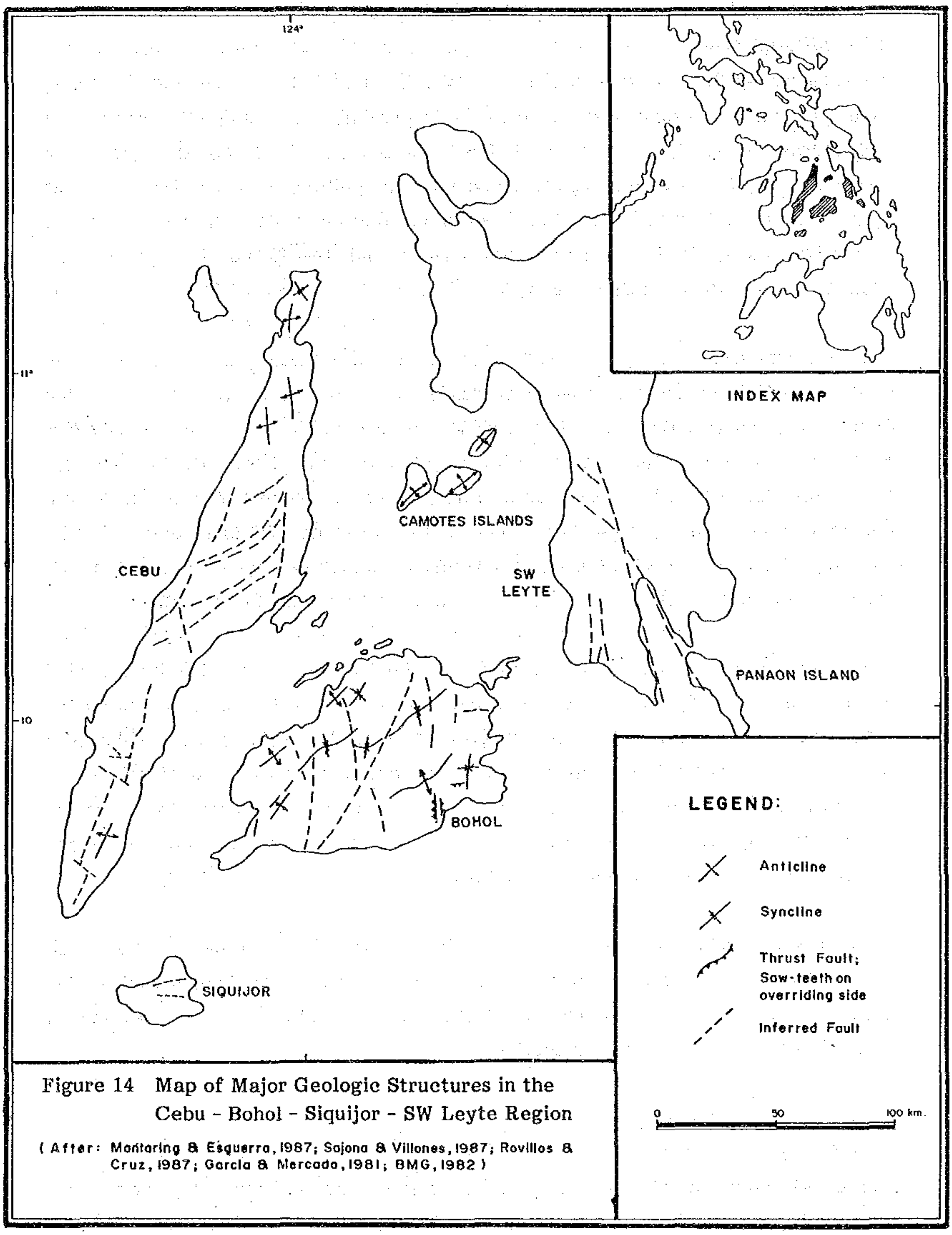


Figure 14 Map of Major Geologic Structures in the Cebu - Bohol - Siquijor - SW Leyte Region

(After: Montoring & Esquerra, 1987; Sajona & Villones, 1987; Rovillos & Cruz, 1987; Garcia & Mercado, 1981; BMG, 1982)

Cretaceous to Paleocene island arc magmatism possibly related to the initiation of the Sulu-Zamboanga-Masbate arc-trench system in the region is represented by the Mananga Group in Cebu Island, the Ubay volcanics in Bohol Island and the Salug River Volcanics in Southwest Leyte. The pre-Miocene Kanglasog Formation (volcanic pyroclastics, tuffs and minor flows) in Siquijor Island may also have been formed during this volcanic episode. Coeval acid plutonism during this stage of magmatism in the region include the intrusion of stocks of diorite and quartz diorite, as represented by the Lutopan Diorite in Cebu Island, the Talibon Diorite in Bohol Island and the Hindang Diorite in Southwest Leyte.

The Mananga Group in Cebu Island is composed of intertonguing units of Early Cretaceous Cansi Volcanics (massive flows, breccia and pillow lavas), the overlying Tuburan Limestone and the Late Cretaceous to Paleocene Pandan Formation (shallow marine sediments and limestone with intercalated volcanic flows). The Cretaceous age of the Cansi Volcanics and Tuburan Limestone is based on *Orbitulina* while the Paleocene age of the Pandan Formation on the presence of *Globotruncana*. The corresponding magmatic pluton of this volcano-sedimentary group is the Lutopan Diorite with the K-Ar datings of Late Cretaceous to Paleocene (59-108 Ma).

Correlated with the Mananga Group of Cebu Island is the Ubay Volcanics in Bohol Island, consisting of undifferentiated basalt to andesite volcanic flows, breccias, hypabbysal porphyries, pyroclastics and tuff members. The coeval intrusive pluton of this volcanic suite is the Talibon Diorite. In Southwest Leyte, the Salug River Volcanics, composed of weakly metamorphosed andesite and basalt flows, and the coeval Hindang Diorite are considered equivalent to the Cretaceous-Paleocene volcano-plutonic rocks in Cebu and Bohol Islands.

A resurgence of island arc volcanism in the region during Middle Miocene is indicated by the extrusion of the Bulacao Andesite in Cebu Island and the Jagna Andesite in Bohol Island. In Cebu Island, magmatism extended up to Late Miocene as evidenced by the intrusion of the Talamban Diorite.

3.1.4.3 Geologic structure

The Cebu-Bohol-Siquijor-Southwest Leyte region has a pronounced northeast-southwest structural lineament grain, parallel to the postulated northeast-southwest trending Sulu-Zamboanga-Masbate arc-trench system of Cretaceous to Pliocene age.

Cebu Island is structurally divided into three areas by the Cabagdalan Fault and the Lutac-Jaclupan Fault, with several other minor but important fault structures that generally trend northeast. These faults dominantly had vertical movements between Cretaceous to Tertiary, but later exhibited left-lateral strike-slip displacement during the Pliocene. In the central highland area of Cebu, rotational movement of a rhombic fault block consisting of basement rock units has been reported. The intrusion of the Lutapan Diorite, the emplacement of serpentinite slivers and introduction of mineralization in the island were also controlled by faulting and rifting activities in the geologic past. Folding of Plio-Pleistocene sediments in the island also generally follow northeast trending fold axes.

The major structures in Bohol Island also trend northeast-southwest. Several low-angle thrusts that define contacts between the Alicia Schist and the Boctol Serpentinite and imbrication of the latter's ophiolitic members are aligned in northeast-southwest direction. Northeast-trending fold axes of Tertiary to Quaternary sedimentary formations in the island include the Colonia-Mahayag-Buenavista Syncline, Catigbian-Sagbayan Syncline, Guindulman Syncline, Inabanga Syncline-Anticline, Sierra Bullone Anticline, Balilihan Anticline, Candijay Anticline and the Tubigon Anticline. Samll-scale strike-slip faults transect the sedimentary units in the island.

In Siquijor Island, low-dipping anticlinal folds locally characterize the Quaternary sediments while high-angle normal faults transect the other units occurring to the east of the island.

3.1.4.4 Mineralization

Mineralization in the Cebu-Bohol-Siquijor-Southwest Leyte Region is represented by four types of deposits, namely; (1) porphyry copper, (2) vein-type (3) residual/lateritic and (4) orthomagmatic deposits (Table 9).

3.1.4.4a Porphyry copper

Porphyry copper type mineralization in the region is well exemplified by the Atlas Consolidated Mining and Development Corporation (ACMDC) property in Lutopan, Toledo, Cebu Island. The deposits of this mine was formed associated with the activities of the Lutopan Dirorite which intruded into the area during Paleocene-Eocene and occur as dissemination and veins within the diorite and also in the metavolcanic in the vicinity. The reserves amount to over a billion tons of minable ore and constitute the largest base metal mine in the Philippines.

Other porphyry copper prospects in the region are found in Kanapnapan, Cebu and in Bonakan, Talibon, Bohol (Table 9). In these areas, mineralization is generally confined within and near the contacts between older meta-volcanics, meta-sediments and the intrusive diorite bodies. Ore minerals are chalcopyrite, bornite, chalcocite, covellite and cuprite occurring as veinlets, stringers, disseminations and specks. Secondary minerals such as chrysocolla, azurite and malachite are also present, and associated gold occurs as minute disseminations.

3.1.4.4b Vein-type deposits

In Bohol Island, vein-type gold deposits are found in Cangmundo, Boyog and Kauswagan, Trinidad prospects located in the northern and central portions of the island. The veins are confined within andesite flows and diorite bodies, with an ore sample in the Kauswagan Prospect having a grade of 78 g/t Au, 36 g/t Ag and 0.56 % Cu.

In Cebu, hydrothermal veins are confined in Cretaceous andesitic and pyroclastic rocks, characterized by pyrite, sphalerite, chalcopyrite and gold minerals occuring as specks, stringers and impregnations within and along quartz-clay (sericite) vein structures and immediate wallrocks. In the Sigpit-Lutopan Prospect, gold-bearing quartz veins occur in the Cansi Volcanics, with ore sample reporting a grade of 20 g/t Au. Small scale panning activities are now carried out in the area.

In Southwest Leyte, vein-type mineralization such as those found in Mt. Bagacay, Punpunan and Sogod occurs in sheared and argillized andesite and basalt units. Sulfide minerals (chalcopyrite, pyrite and bornite) are present within the quartz-clay vein structures. In Panaon Island, vein-type mineralization is present in Anilao and Pinut-an Prospects. The Pinut-an deposit is now being mined for gold (10 g/t Au ave.) by Benguet Exploration.

Similar to the vein-type nickel deposit in Antipolo, Tacloban, Leyte (3.1.5.4e) is the nickel deposit found in Bohol. Nickel mineralization here is generally associated with magnesite veins/veinlets (5-10 cm thick) hosted by serpentinized peridotite. Previous analysis of samples from Boctol, Jagna and from Nagasgas Hill in Alicia indicates a low grade of 0.58 % Ni.

3.1.4.4c Residual manganese deposits

Residual-type manganese deposits are found in the Hudson Mine (43 % Mn), Anda Peninsula, Bohol. Mineralization occurs as fine sands and pisolites in brown soil, and as accumulations concentrated on the erosion surface and within other cavities, fissures and sinkholes in limestone beds. Other deposits include prospects in Buenavista, Carmen in central Bohol.

In Southwest Leyte, assay in the manganese prospect in Pasangan, Baybay show 57 % Mn. Here, manganese occurs as nodules and as beds or layered bodies. In contrast, the deposits found in Siquijor Island occur as accumulations in fissures, sinkholes and cracks in limestone bodies and as layers on top of shale beds. The deposits in the island are found in Nangka, Conmasque, and Zamba. A sample taken from one of these deposits assayed 37 % Mn.

3.1.4.4d Nickeliferous laterite

Nickeliferous laterite deposits are found in the Maasin Nickel Prospect in Southwest Leyte. Remnant rocks found in lateritic soils are mainly serpentinized peridotite with minor fragments of gabbroic rocks. Laterite beds are thought to exceed 30 cm in thickness.

3.1.4.4e Orthomagmatic chromite deposits

Orthomagmatic podiform chromite mineralization in Bohol occurs in the Bangwalog Prospect, Duero in the southeastern part of the island. Chromite ore occurs as pods or lenses hosted by serpentinized peridotite with a low grade of 0.33 % Cr_2O_3 and 33 % MgO.

Table 9: Major Mineral Deposits and Prospects of the Cebu - Bohol - Siquijor - SW Leyte Region

Deposit/ Prospect	Type of Mineralization	Location	Remarks
1) Lutopan, Toledo, Cebu @	Porphyry Cu	124°43' E 10°20' N	0.44% Cu 0.26 g/mt Au
2) Kanapnapan Toledo, Cebu **	Porphyry Cu	124°43' E 10°23' N	0.50% Cu
3) Bonakan, Talibon, Bohol **	Porphyry Cu (possibly also vein-type Au)	124°11' E 10°07' N	4.18 g/mt Au+ 2.40 g/mt Ag+ 1.02% Cu+
4) Cangmundo, Boyog, Bohol **	Vein-type Au	124°13' E 10°07' N	
5) Kauswagan, Trinidad, Bohol **	Vein-type Au	128°16' E 10°30' N	77.6% g/mt Au+ 35.7 g/mt Ag+ 0.56% Cu+
6) Sigpit, Lutopan, Cebu **	Vein-type Au	128°42' E 10°23' N	20 g/mt Au+
7) Pinutan, Panaon Is. SW Leyte @@	Vein-type Au	125°16' E 10°01' N	9.75 g/mt Au 12.81 g/mt Ag
8) Larena, Maria, Siquijor @@	Sedimentary manganese	123°38' E 9°13' N	33.61% Mn+
9) Pasangan, Baybay, Leyte *	Residual manganese	124°48' E 10°37' N	57.28% Mn+
10) Hudson Mine, Anda Boho @@	Residual manganese	124°33' E 9°46' N	42.37% Mn+
11) Bohol *	Vein-type Ni	124°24' E 9°33' N	0.58% Ni
12) Maasin Leyte *	Ni laterite	124°49' E 10°11' N	

Note: + - Indicates grande of one sample only and not the average grade
* - Prospect status @ - Operating mine
** - Explored/undeveloped @@ - Stopped operation

3.1.5 Samar-Leyte-Dinagat Region

3.1.5.1 Regional geologic setting

This section covers the islands of Samar and Dinagat and the north, northeastern and central highland portions of Leyte (Figs. 2, 15). These islands are located at the eastern side of the Visayas in the central-western part of the Philippine Mobile Belt. Bounding these islands on the east is the Philippine Trench where the Philippine Plate is currently being underthrusted. West of Samar and Dinagat, and traversing the whole island of Leyte is the left-transcurrent Philippine Fault which, in itself, splays into several conjugate faults. Recent seismicity and volcanism in Leyte are attributed to the presently active Philippine Fault Zone and the subduction along the Philippine Trench.

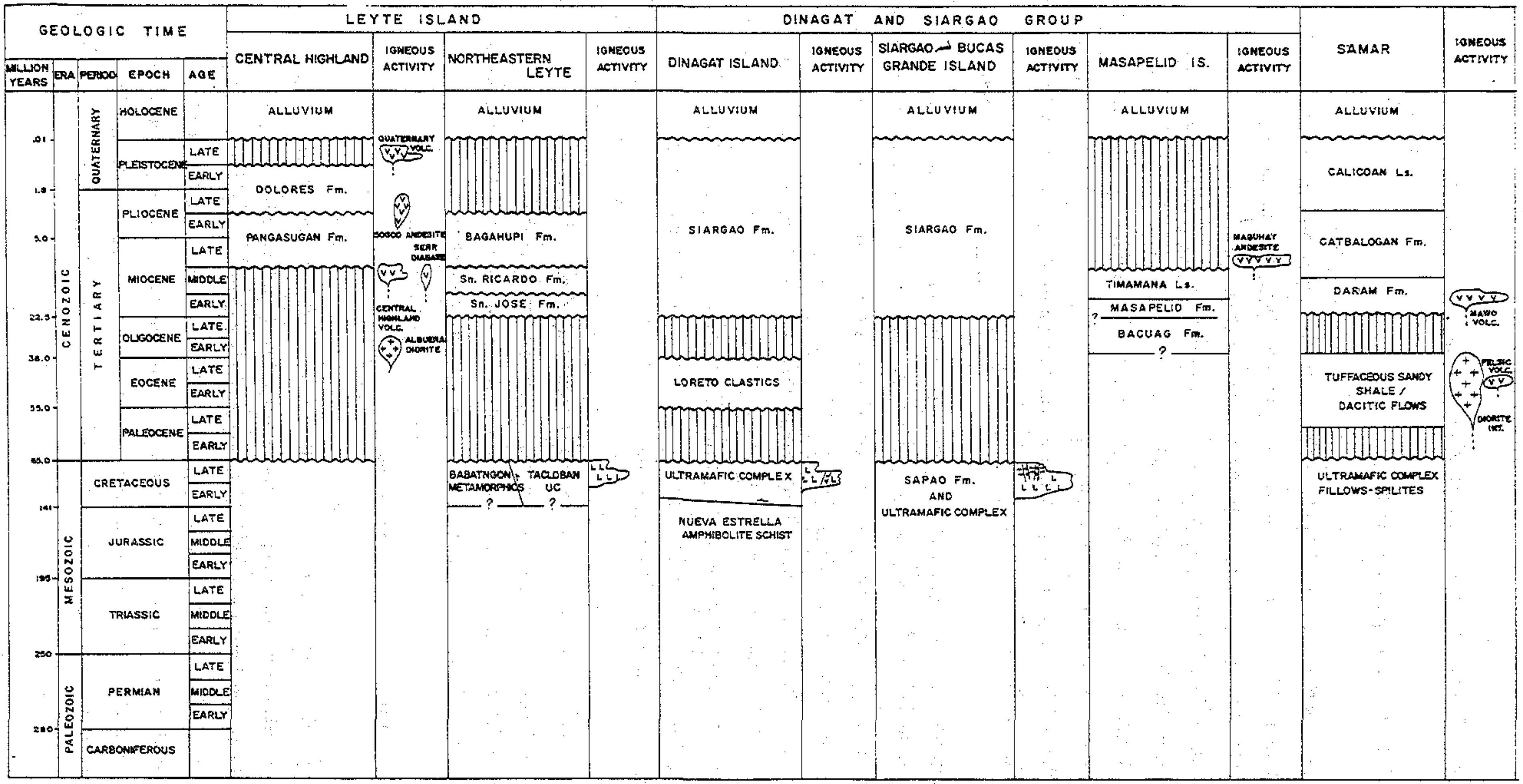
Occurring as basement rocks in the region are suites of metamorphic rocks exposed in northeastern Leyte and Dinagat (Table 10). These rocks probably represent the remnants of a primitive (pre-Tertiary) arc which collided with the proto-Philippine arc sometime in the Oligocene to Miocene time (Lewis, et al., 1981; Uyeda and McCabe, 1981). Overthrusting the basement are ultramafic/ophiolitic rocks which are likewise assigned to a pre-Tertiary (Cretaceous or older) age. Differentiated from the ultramafic rocks of oceanic derivation are serpentinized ultramafic diapirs along the trace of the Philippine Fault in Leyte, believed to have been emplaced as solid intrusions during Miocene time.

The presence of pre-Tertiary to Paleogene dioritic and basic to intermediate volcanic rocks also attest to an old westward subduction east of the region. The arc-arc collision was followed by periods of erosion, sedimentation and periodic volcanism throughout the Upper Tertiary to Recent time.

3.1.5.2 Lithology and stratigraphy

Basement metamorphic rocks of the Samar-Leyte-Dinagat Region are represented by the Cretaceous Babatngon Metamorphics (epidote-albite-actinolite schist) in northeastern Leyte and the Cretaceous Nueva Estrella Amphibolite Schist in Dinagat (Sunga and Palaganas,1986). Garcia, et al., (1981) noted the close folding and crenulation of schistosity planes in the Babatngon, features which they considered as products of a strong compressive force in an east-west direction. The Nueva Estrella Amphibolite occurs as a tectonic window beneath the Dinagat Ophiolite and is

Table 10 Columnar Sections of Leyte - Dinagat - Siargao



considered younger than the latter by not more than ten million years (Sunga and Palaganas, 1986).

Overriding the metamorphic basement are bodies of ophiolitic material observed in southeastern Samar, Dinagat and the vicinity of Tacloban in Leyte. In Samar, the ultramafic complex (serpentinized peridotite and dunite and limited gabbro bodies) are discontinuously distributed along north-south thrust faults where they are juxtaposed over spilitic and pillow basalts and associated cherty sediments.

As was mentioned earlier, a westward subduction active from pre-Tertiary to Paleogene time produced arc volcanism and plutonism. Resultant to this activity are the Albuera Diorite in the Leyte Central Highland; Cretaceous intercalated basaltic lavas, volcanic breccias and pyroclastics in Borongan, Giporlos and San Jose de Buan in Samar; and Paleogene interlayered dacitic lavas, volcanic breccias and lapilli tuffs in Central Samar. The dacitic rocks in Central Samar are of particular interest due to their associated massive sulfide deposits found in Lonoy, Bagacay and Lawaan. Evidence of this magmatic activity is absent in Dinagat.

Much of the Miocene up to the Pliocene saw the vigorous deposition of volcanic derived clastics and carbonate rocks which is accompanied by the extrusion of intermediate to basic lavas and pyroclastics. A large portion of the Samar-Leyte-Dinagat area gradually subsided and, for the most part of the Miocene up to the Pliocene time, was submerged.

The initiation of the Philippine Fault activity in the Middle to Late Miocene brought about the injection of ultramafic rocks as solid diapiric intrusions along the trace of the fault in Leyte. These harzburgitic to lherzolitic bodies were observed as isolated lensoid masses mostly within the Central Highland Volcanics.

Quaternary volcanism associated with the activity of the Philippine Fault Zone and the reactivation of the westward subduction in the now so-called Philippine Trench is presently manifested in Leyte as volcanic chains with accompanying geothermal activity.

3.1.5.3 Geologic structures

The Samar-Leyte-Dinagat region comprise a part of a generally east-facing arc which extends from the Bicol region down to the Pujada Peninsula. Regional structural grain and lineament is in a north-northwest disposition.

Splays of the Philippine Fault and smaller tensional faults occur in Samar (Pilac, et al., 1965). The compressive force brought about by the persistent subduction east of the island generated thrust faulting in southeastern Samar, with the ultramafic basement overriding the Cretaceous sedimentary and volcanic units in that area. Folding of the ultramafic basement developed several northwest trending fractures along which dioritic intrusions were emplaced. Cutting through the felsic lavas are minor and discontinuous though mineralized east-northeast trending fractures. Extreme deformation (tight folding) and, in places, overturning has affected the younger sedimetary sequences along the western coastline of Samar, particularly within the vicinity of the Catbalogan Fault.

The island of Leyte lies along a trace of the Philippine Fault which is a zone of major strike-slip dislocation. The general motion along the fault is left-lateral, though dextral movement in the course of its history is not discounted. Rifting along the fault has caused several other faults and fractures with varying trends and dips, as well as highly deformed and cataclastic zones. Thrust faulting is evident in the northeastern portion of the island, as the metamorphic basement is juxtaposed under the ultramafic/ophiolitic rocks. A broad synclinal structure runs through the whole of Ormoc Valley and extends up to the Leyte area (Garcia, et al., 1981).

Lying between two major structural features in the Philippines, the Philippine Fault and the Philippine Trench, is the Dinagat Island Group. The several compressive as well as tensional forces within the area has rendered the structural features in this region rather complex. A major feature, however, is the prominent thrust which serves as tectonic contact between the ophiolitic complex of the island and the underthrusted amphibolitic schists. Several northwest trending faults which reflect the structural distribution of the different lithologies are themselves cut by complimentary northeast trending faults. Intense brecciation and thick gougy material attest to dislocation along these structures. Syncline and syncline-anticline structures are imposed along the Loreto-Malinao Valley and the central portion of Siargao Island (del Carmen-Libertad and Esperanza), respectively (Sunga and Palaganas, 1986).

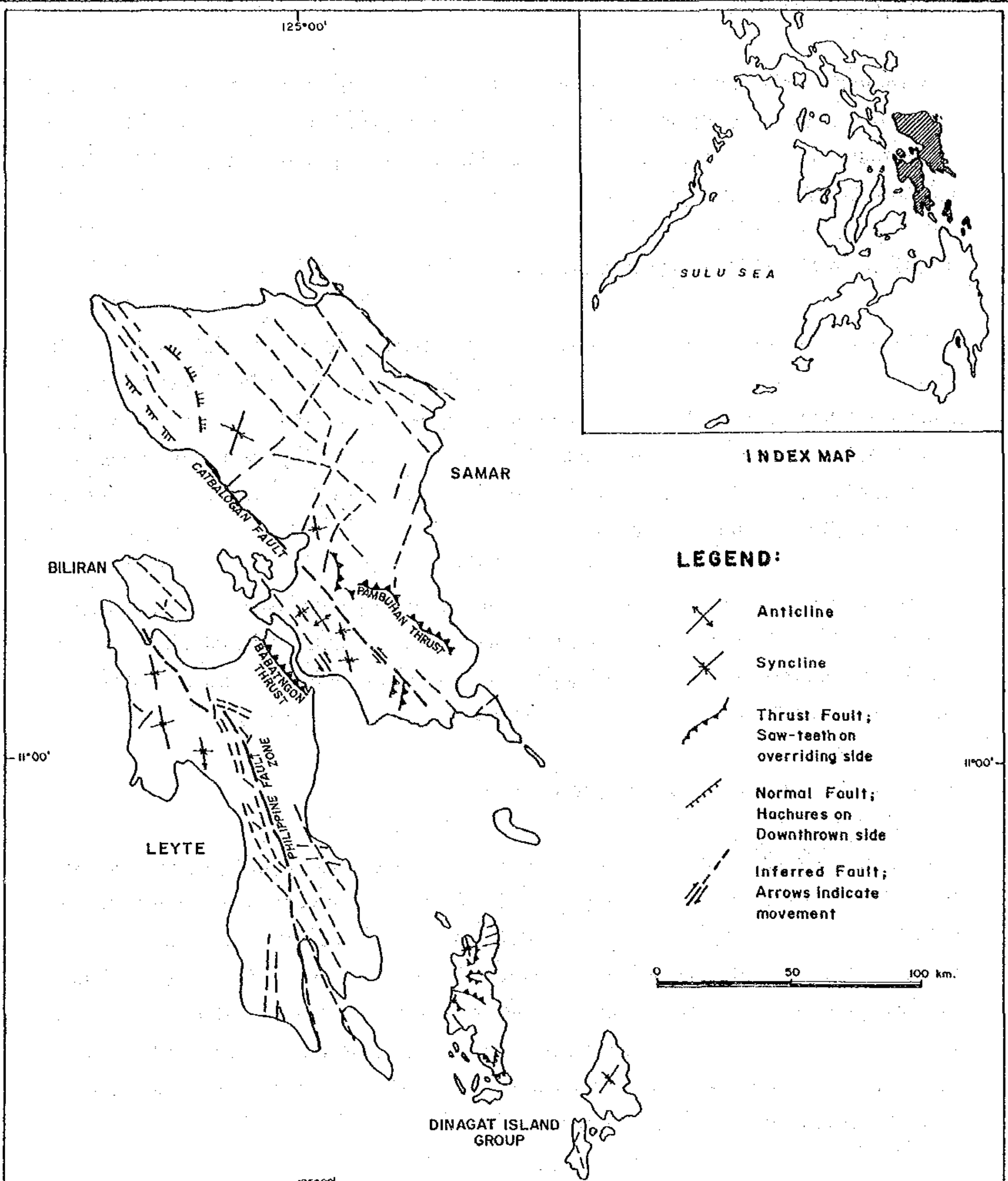


Figure 15 Map of Major Geologic Structures in the Samar - Leyte - Dinagat Region

(After: Garcia & Mercado, 1981; Sunga & Palaganas, 1986)

3.1.5.4 Mineralization

The region is endowed with rich mineral resources and is considered to possess high potential for future development (Table 11). The major metallic minerals which have been found in the region are gold and the platinum group metals (PGM), iron, chromite, nickel, manganese, copper and bauxite.

3.1.5.4a Epithermal vein-type deposits

Epithermal vein-type deposits in the region, yields gold and nickel as the main products, each with its characteristic geologic setting. Gold vein deposits occur in Abuyog-Mahaplag area, Layog and Aldecoa, Leyte (BMG, 1986). In these areas, the gold-bearing quartz veins are hosted by the Central Highland volcanics. In Cangmundo, Masapelid Island, gold-bearing quartz-pyrite veins (0.01-10.8 g/t Au) are found in argillized andesitic rocks.

In one of two main occurrences of nickel in the region, a deposit found in Antipolo, Tacloban, Leyte occurs as secondary veins in serpentinized peridotite. Previous investigators classified this nickel deposit as epithermal vein. The nickel content of the deposit averages 0.23 % with about 3.03 million tons of reserve.

3.1.5.4b Copper massive sulfide deposits

The major copper deposits found in the region are stratabound massive sulfide deposits. Kuroko-type copper deposits are found in Eastern Samar (Bagacay and Sulat) with copper values ranging from 0.61 % to 2.4 % Cu with significant Pb and Zn tenors. The deposits are hosted by volcanic flows and associated clastic rocks. Cyprus-type massive sulfide deposits characterize the copper mineralization in Leyte. The deposits/prospects are found in Curajo, Caibaan, Tigbao and Suhi all in Tacloban. Cu values range from 0.02 % to 10.7 % Cu. The mineralization is hosted by basalt lavas and pelagic sediments.

3.1.5.4c Orthomagmatic chromite

Dinagat Island hosts the largest orthomagmatic podiform and layered chromite deposits in the region. The deposits in the island are found in Talisay, Masdang, Mt. Redondo, Velor, Avelina and Tagbaboy. All of these deposits are hosted within dunite bodies. Sunga and Palaganas (1886) notes that the deposits found in the northern part are typically layered while those found in the central and southern part of the island are podiform in shape. The chromite ores occur as massive, sparsely to densely disseminated and nodular. Most of the prospects are highly promising as they yield chromite values ranging from 29.82 % to 50.09 % Cr_2O_3.

Samar Island is potentially rich in podiform chromite deposits judging from the numerous and rich occurrences of chromite in laterite. The peridotites and dunites of the detached ophiolites of Samar are targets for exploration for podiform chromite deposits in the island.

3.1.5.4d Residual/mechanical concentration deposits

Due to the dynamic geomorphic history of the region, most especially of Samar Island, several important minerals were deposited through the processes of residual and mechanical concentration. Among the minerals deposited in this way are ore minerals of manganese, bauxite and iron.

The manganese prospect is located in San Jose, Borongan, Eastern Samar. The manganese occurs as veins in Oligocene to Miocene limestone (Daram Formation). X-ray diffraction analysis revealed large amounts of quartz and minor todorokite, pyrolusite, hematite and geothite.

Bucas Grande Island of the Dinagat Island Group contain residual ferruginous bauxite deposit. The deposits are found in soils overlying mafic/ultramafic rocks as concretions (BMG, 1986). In Samar, bauxite is hosted by limestone bodies in its depressions and sinkholes. They are found in Batag Island (seven million tons of reserve at 31-53 % Al_2O_3), in Concord, Hinabangan, Western Samar (20 million tons of 43 % Al_2O_3) and in Mercedes, Guian (87 million tons of 20-45 % Al_2O_3) (BMG, 1986).

In Leyte, the coastal areas of Abuyog, Tolosa, MacArthur and Tacloban are characterized accumulations of magnetite brought about by mechanical concentration. In the past, these areas were mined extensively but due to environmental reasons, mining operations were stopped. Only the magnetite beach sands in Tacloban remains to be exploited.

3.1.5.4e Laterite deposits

In this region, laterite deposits are important sources of many mineral commodities such as chromite, nickel and iron.

Viable chromite deposits in Samar come from laterites in the towns of llorente, Hernani and MacArthur. Total ore reserves from these areas were estimated at 2.8 million tons of 45 % Cr_2O_3. Larger primary chromite reserves could be expected as the island is characterized by sporadic occurrences of detached ophiolitic rocks.

Nonoc Island, immediately south of Dinagat possesses one of the largest nickel deposit in the Philippines. The deposit occurs in laterite with a positive reserve of about 60 million metric tons and assaying 1.23 % Ni, 0.1 % Co and 38.8 % Fe (BMG, 1986).

Iron laterite deposit in the region is found only in Awasan, Dinagat Island. Here, iron minerals are found as nodules or concretions in the top 10 m of the laterite profile. Iron content averages 45 % total Fe (BMG, 1986).

3.1.5.4f Placer gold and PGM

Placer gold deposits with some PGM tenors are presently being panned by small scale miners in Guinipundan. Giporlos and Lorente, Samar. These areas are underlain by chromite-rich ultramafic rocks and diorite bodies. In Dinagat Island, placer gold is also found in river systems draining chromite mining areas.

Table 11: Major Mineral Deposits and Prospects of the Samar - Leyte - Dinagat Region

Deposit/ Prospect	Type of Mineralization	Location	Remarks
Cangmundo, Masapelio Island *	Epithermal Au vein-type	9°42'00" N 124°38'00" E	0.01-10.8 g/t Au
Abuyog-Manaplag Area, Leyte *	- do -	10°40'00" N 124°59'00" E	
Layog, Leyte *	- do -		
Aldecoa, Leyte *	- do -		
Antipolo, Tacloban Leyte @@	- do -	11°15'30" N 124°58'00" E	Hosted by serpentinite veins
Bagacay, Samar @	Kuroka-type massive sulfide	11°52'00" N 125°19'00" E	0.61-2.4% Cu
Sulat, Samar @	- do -	11°41'00" N 125°07'00" E	0.61-2.4% Cu
Curajo, Palo Leyte *	Cyprus-type massive sulfide	11°10'32" N 124°58'08" E	0.02-10.7% Cu
Caibaan, Tigbao & Suhi, Tacloban *	- do -	11°11'55" N 124°56'38 E	0.02-10.7% Cu
Northern & Central Dinagat Island @	Orthomagmatic Cr	10°00'00" N 125°35'00" E	29.82%-50.09% Cr_2O_3
San Jose, Borongan Samar *	Vein-type Mn in Karstic limestone	12°02'45" N 124°01'25" E	very limited reserve
Bucas Grande Island Dinagat **	Resiudal ferruginous bauxite deposit	9°40'00" N 125°57'00" E	
Batag Island, Samar **	- do -	12°37'30" N 125°03'45" E	7 million t reserve at 43% Al_2O_3
Mercedes, Samar **	- do -	11°12'30" N 125°28'45" E	47.8 million t 20-45% Al_2O_3

Note: @ : Operating, @@ : Stopped operation,
* : Prospect, ** : Explored

Table 11 (cont'd)

Deposit/ Prospect	Type of Mineralization	Location	Remarks
Guian, Samar **	- do -	11°01'30" N 125°44'00" E	25.6 million t
Concord, Hinabanga, Samar	- do -	11°45'00" N 125°12'00" E	53.7 million t 53.45% Al_2O_3
Abuyog, Leyte @@	Fe mechanical concentration	10°46'00" N 125°00'30" E	Beach deposit
Tolosa, Leyte @@	- do -	11°03'00" N 125°10'15" E	- do -
MacArthur, Leyte @@	- do -	11°50'00" N 125°00'00" E	- do -
Tacloban Leyte *	- do -	11°14'45" N 125°00'15" E	- do -
Llorente, Samar @	Cr laterite deposit	11°21'00" N 125°23'00" E	45% Cr_2O_3
Hernani, Samar @	- do -	11°20'00" N 125°34'30" E	- do -
MacArthur, Samar *	- do -	11°17'50" N 125°32'45" E	- do -
Nonoc Island, Dinagat **	Ni laterite	9°51'00" N 125°37'00" E	60 million t 1.23% Ni
Awasan, Dinagat **	Fe laterite		45% Fe
Guinipundan, Giparlos, Llorente, Samar @	Placer Gold, PGE	Major drainage system located in each municipality	Small scale mining

3.2 Rifted Continental Terrane
Palawan-Romblon Island Group-Buruanga Peninsula-Antique Range

3.2.1 Regional Geological Setting

As mentioned in section 2.2.12, the region comprising Palawan, major part of Mindoro, western Panay constitutes the stable region of the Philippines (Figs. 1, 2, 16, 17). It is considered to be a rifted continental margin and is known to contain the oldest rock assemblage of the Philippine Archipelago. During the course of this project, the Palawan-Romblon Island Group-Buruanga Peninsula-Antique Range area within this rifted continental block was surveyed.

The Palawan Island is geologically divided into the northern and the southern Palawan by the Sabang Thrust which is a sinuous, low angle thrust intersecting the central part of the main island.

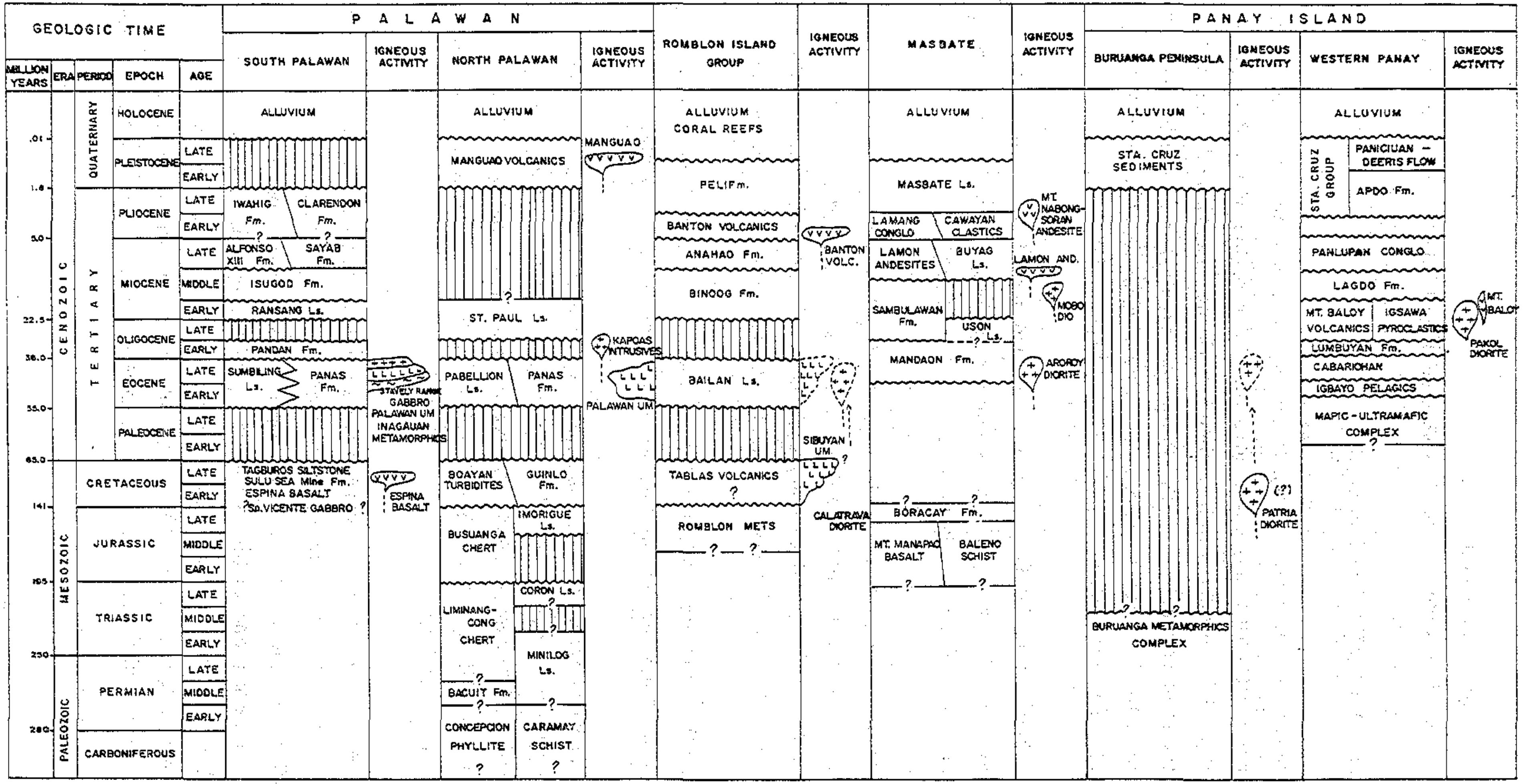
Carboniferous to Permian metamorphic units of quartz sericite schist, some graphite schist and greenschist facies and Cretaceous to Eocene quartzofeldspathic sandstones, shale, and carbonaceous mudstone of turbiditic affinity underlies the northern fraction of Palawan, Romblon Island Group and Buruanga Peninsula.

In South and Central Palawan, the Cretaceous chert-spillite formation serves as the basal lithology for the turbidite aprons and the ophiolite nappes.

These basal formations are interpreted to be the eastern protruding portion of a drifted marginal fragment of the proto-mainland China. This fragment is inferred to underly the Luconia Shoal, the Reed Bank, the Northwest Sulu Sea Basin, the Southwest Mindoro Island the offshore south of Marinduque, and the northwestern part of Panay (Fig. 2).

The extreme deformation and the metamorphism in part of this continental fragment have been attributed to the series of rifting and thermal activities prior to its drifting, to the Middle-Late Miocene collision-accretion event against the proto-Philippine arc and to the overthrusting of the ophiolite suites. Consequent to the collision-accretion event is the impingement of an active volcanic arc, the Cagayan de Sulu Ridge, and an oceanic fragment against the proto-Philippine arc thus forming a series of imbricate thrust slices which constitute the present Antique Range.

Table 12 Columnar Sections of Palawan - Romblon - Masbate - Panay



The basal metamorphic units which are of probable Late Paleozoic to Mesozoic in age hosted the intrusion of Eocene-Oligocene intermediate to acid plutons and the fissure flowage of Pliocene-Pleistocene basalts.

3.2.2 Lithology and Stratigraphy

A chaotic assemblage of chert, limestone, turbidites, and metamorphic rocks constitutes the greater fraction of the Palawan-Buruanga Peninsula-Romblon Island Group Region (Table 12). Faure (1987) and Isozaki (et al, 1988) consider such an assemblage as an olistrostomal unit wherein the chert (Late Permian to Triassic Liminangcong chert; Jurassic Busuanga Chert), the limestone bodies (Middle Permian to Early Triassic Minilog Limestone), some blocks of schists (Concepcion Phyllites; Caramay Schist) and quartzites are confined within pelitic to quartzofeldspathic sandstone (probably part of the Late Permian Bacuit Formation). Cretaceous (Guinlo Formation; Boayan Turbidites) and Eocene (Panas Formation) turbidites of quartzofeldspathic composition covers in part these Permian to Jurassic assemblage.

The basement lithologies of the region are represented by the Caramay Schist in North Palawan; the Buruanga Metamorphic Complex in Northwest Panay; The Romblon Metamorphics in Romblon Island Group; and the Cretaceous Espina Basalts in Central and Southern Palawan. The metamorphic suites are primarily composed of quartz-feldspar-mica schist with minor quartzites and carbonate lenses. Phyllites, cherts and greenschist are inferred to occur as minute lenses in the upper horizon of the complex or as remnant units at the top of the metamorphic complex. The age of the complex is probably pre-Cretaceous (presumed Carboniferous to Permian in North Palawan, Jurassic in Romblon Island Group, and Triassic in Buruanga Peninsula). Although K-Ar age determinations on several samples of the schist in Palawan yielded ages ranging from 10.5 Ma. (UNDP, 1985) to 13.6 Ma. (RP-JAPAN, 1989), the ages could be suggestive of a metamorphic rejuvination sometime in the Late Miocene which is consequent with the collision of the region to the proto-Philippine arc.

The Espina Basalt is inferred to be the leading edge of the drifted continental fragment over which the quartzofeldspathic turbidites of Cretaceous (Boayan Turbidites) and Eocene (Panas Formation) ages are deposited.

Several interpretations have been made regarding the age and the continuity of the Palawan Ophiolite. Rammlmair (unpublished MGB Rpt., 1985) and UNDP (unpublished, 1985) have considered an Eocene age for this ophiolite based on correlation with the presumed age of the Zambales Ophiolite which they consider as belonging to the same ophiolite belt as the Palawan Ophiolite. In the RP-JAPAN Consolidated Report (1989), the Espina Basalt, the San Vicente Gabbro and the Sultan Peak Gabbro are regarded as parts of a Cretaceous ophiolite suite different from the Eocene Mt. Beaufort Ultramafics and Stavely Range Gabbro which were considered as the main components of the Palawan Ophiolite.

In the recent follow-up survey (JICA•MMAJ, 1989) in Palawan, several field evidences suggest the continuity of the Sultan Peak Gabbro to the Mt. Beaufort Ultramafics. Thus inferring that lithologies of ophiolitic affinity are confined within a single ophiolite suite.

A Cretaceous age is the assigned to the Espina Basalt on the basis of documented dating. Similar age considerations have been provided to the Sibuyan and Antique Ophiolite suites although the age could extend up to the Eocene based on the age of the overlying pelagic unit, the Igbayo Pelagic Complex. These ophiolite bodies occur as overthrusted nappes throughout the region.

The emplacement of the ophiolites through thrusting which occurred sometime during the Eocene have brought about the metamorphism in part of the underlying turbidites (Panas Formation, Boayan Turbidites) and the juxtaposition of the latter with the the metamorphic sole (amphibolite and greenschist) of the ultramafic complex.

Associated with the Panas Formation as interbeds or as lenses particularly in the upper horizon of the formation and at times as capping are the Eocene limestone bodies. The distribution is extensive throughout the region. It is represented by the Sumbiling Limestone in South Palawan, the Pabellion Limestone in North Palawan, the Bailan Limestone in Tablas Island, and the Cabarriohan Limestone in Antique Range. Characteristic of their foraminifers assemblage is the presence of nummulites, distichoplax biserialis, pellatispira, and discocyclina.

Several intrusive units ranging in composition from biotite granite to quartz monzonite and granodiorite were delineated throughout the region. These plutons are represented by the Kapoas Intrusives (Granite-granodiorite-quartz monzonite) in Palawan, by the Caltrava Intrusives (diorite-granodiorite) in Romblon Island Group, by the Patria Quartz Diorite (hornblende biotite quartz diorite) in Buruanga

Peninsula, and by the Pakol Diorite (hornblende-biotite diorite) in northern Antique Range.

Significant among the plutons, except for the Pakol Diorite which is arc related (Cagayan de Sulu Ridge), is their close association with the meta-sedimentary units and continental sediments which are widespread throughout the region and observed also in southwest Mindoro.

Instability of the region is reflected on the effects on sedimentation processes during the latter part of Middle Miocene. The disturbance is manifested through the admixture of coarse clastics to the carbonates (arkosic Middle Miocene Isugod Formation, Late Miocene Sayab Formation and marly Late Miocene Alfonso XIII Formation of Palawan; arkosic Anahao Formation of Tablas Island) and through the formation of conglomerates (Panlupan Conglomerate) proximal to the zone of collision.

3.2.3 Geologic Structure

Middle to Late Miocene collision of the Palawan Platform and the eventual opening of the Sulu Sea Basin have greatly influenced the structural configuration of the Palawan-Romblon-Buruanga Peninsula-Antique Range region.

East dipping thrust series divided the Antique Range into several slabs (Fig. 17). Prominent among the thrust structures are the Panpanan Thrust which marks the interface between the zone of suture and the basal lithology of the Iloilo Basin (see report on Iloilo), the Dalanas Thrust which defines the contact between the Lumbuyan Formation and the Mt. Baloy Volcanics, and the thrust delineating the sole of the Antique Ophiolite.

Low angle thrust structures define the contacts between the ultramafics of Tablas and Sibuyan Islands (Sibuyan Ultramafics) and the underlying metamorphic rocks. Similar features are exhibited by the Mt. Beaufort Ultramafics of the Palawan Ophiolite but the latter underlies quartzofeldspathic turbidites (Panas Formation; Boayan Turbidites). Collision and ophiolite overthrusting are the major causes of the extreme deformation of the turbidites and in part the metamorphic rocks (Concepcion Phyllites). Protrusion of the Caramay Schist is interpreted to be tectonic in origin and is an expression of a huge anticlinorium.

Numerous criss-crossing high angle faults transect the whole of Western Panay but the fault at the eastern margin of the Pakol Diorite and the inferred lineament from the western coast of Panay to eastern Tablas are the most pronounced. Both faults trend north to northwest.

Folds of north to northwesterly trends within the Mt. Baloy Volcanics and the Igsawa Pyroclastics were formed by stresses related to the Miocene collision within the region. Similar extent of folds are exhibited by the Late Tertiary formations at the western portion of the Tablas Island.

Tight recumbent folds and related faults forming imbricate structures of diverse orientation are notable among the cherts and associated clastics of North Palawan and Calamian Island Group and Buruanga Peninsula. Isozaki considered such structures as inherent to the accretion-wedging of the cherts and associated clastics prior to Miocene collision. Fold of Miocene sediments of Palawan Alfonso XIII Formation and Isugod Formation parallels the trend of the Island and is indicative *of post Miocene northwest-southeast compressive stresses.*

3.2.4 Mineralization

Mineralization in the Palawan-Romblon Island-Buruanga Peninsula-Antique Range Region is represented by the following four types of deposits, namely; (1) orthomagmatic, (2) hydrothermal vein-type, (3) bedded manganese deposits and (4) Cyprus-type massive sulfide deposits (Table 13).

3.2.4a Orthomagmatic chromite and associated deposits

Chromite deposits in the Philippines are exclusively associated with Alpine-type peridotite-dunite-gabbro complexes in ophiolite terranes. In this region, the probable Cretaceous to Eocene ultramafic complexes which are extensively distributed throughout Palawan, Antique and Romblon Island Group host the chromite and nickel deposits of varying grades and quantities.

The chromite deposits are typically of podiform type with shapes ranging from tabular, lensoid, to irregular. And the texture of the ores range from massive, nodular ("leopard type "), brecciated to disseminated. The ores consist primarily of chromite with varying amounts of magnetite and ilmenite and trace amounts of

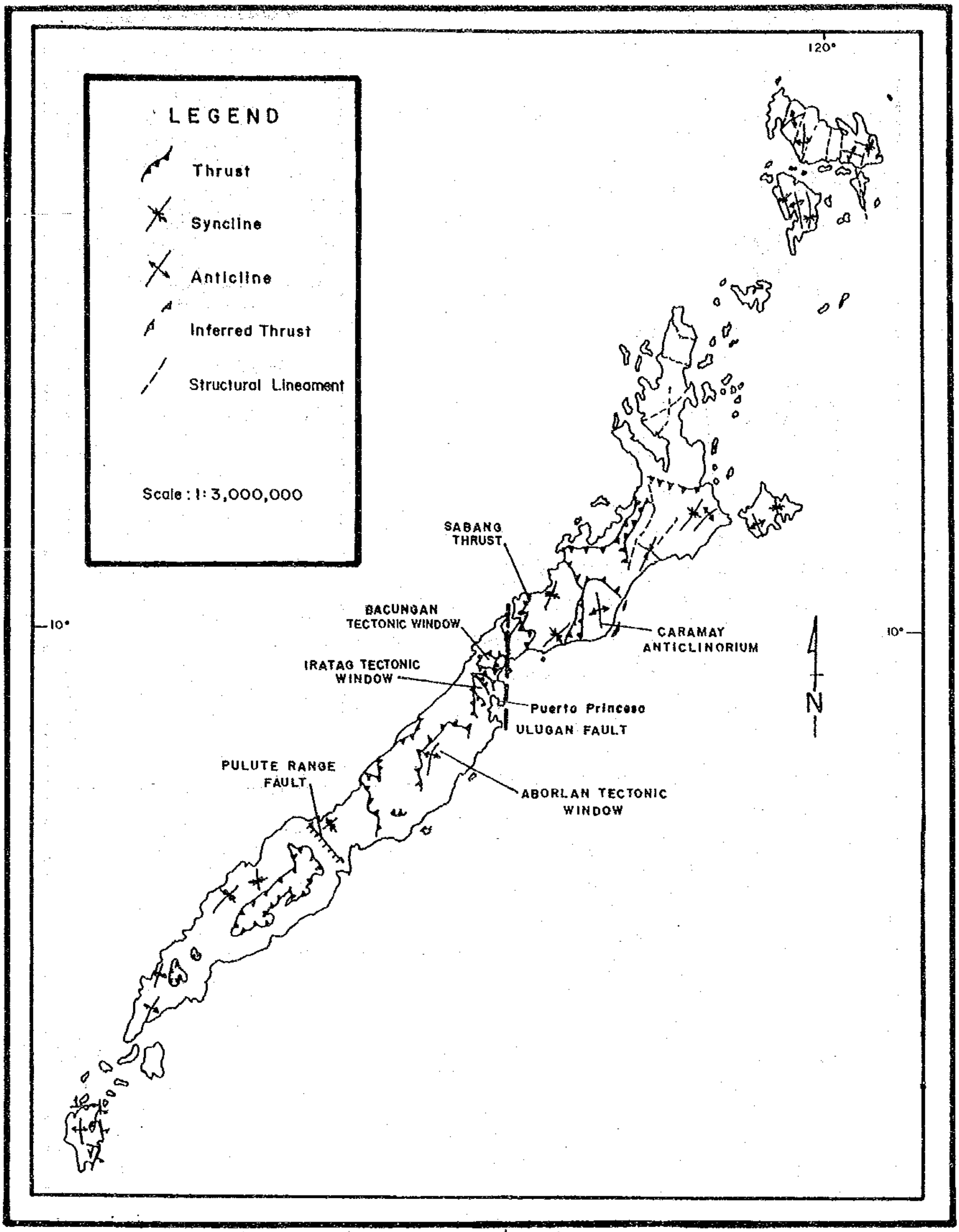


Figure 16 Map of Major Geologic Structures of Palawan (After: R.A. Santos, 1988)

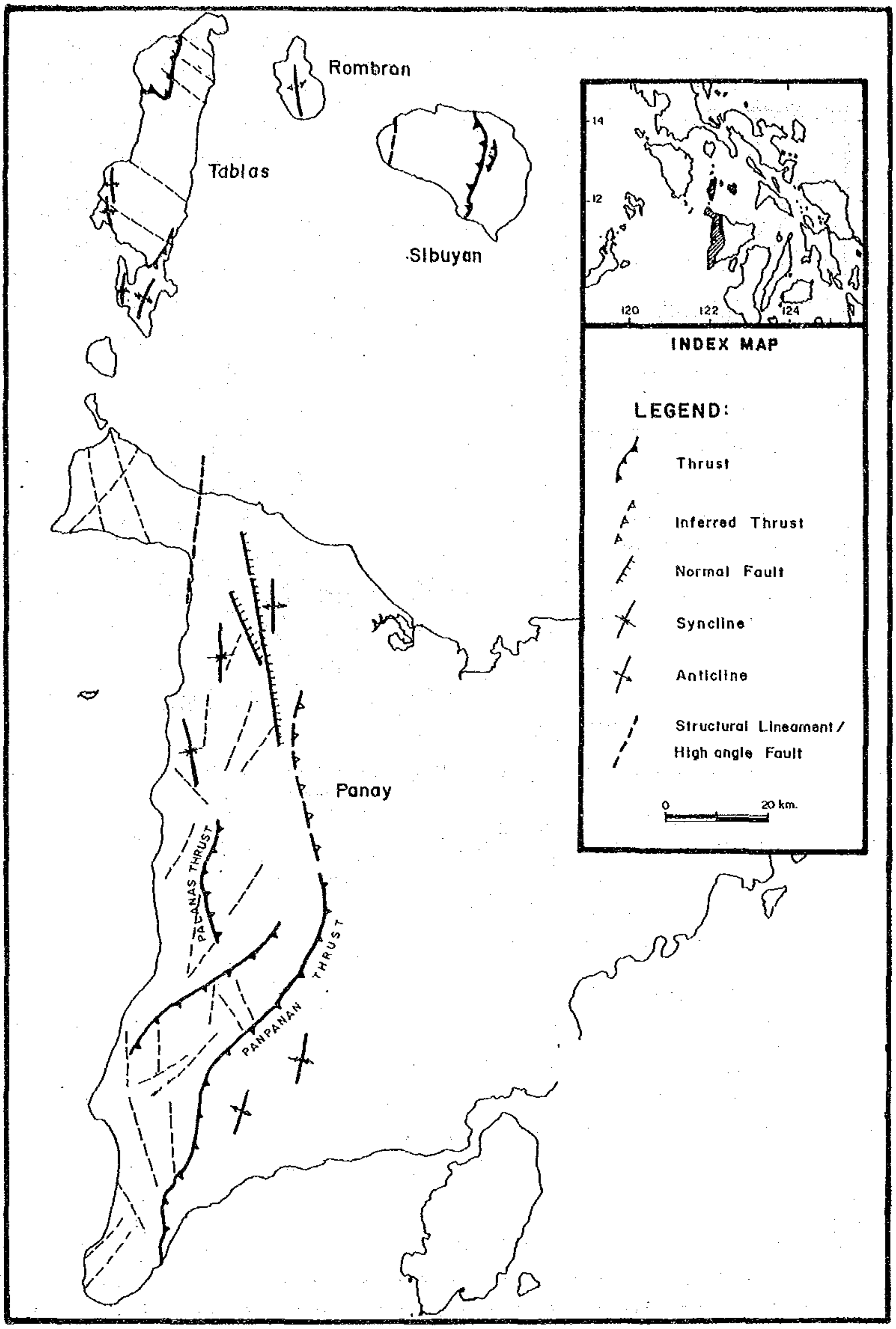


Figure 17 Map of Major Geologic Structures of Antique Range and Romblon Island Group
(After: S. David Jr., 1988; Zepeda and Caliboso, 1987; Y. Marchadier, 1988)

nickel sulfides, platinum and the palladium. There are also placer deposits derived by weathering of the host rocks and mechanical concentration.

Nickel, cobalt and vanadium are often associated with these chromite deposits. These deposits are known to occur in several localities in Palawan as in Puerto Princesa (Boyo Mine, Richman Mine and Benguet Mine), in Narra (Trident Mine, Olympic Mine and Romarao), in Quezon (Berong), in Brookes Point and in Bataraza. Similar occurrences could be observed within the ultramafic areas of the Antique Range as in Sibalom, mainly for chromite deposits. The presence of platinum group elements (PGE) in the Palawan Ophiolite together with the nickel and copper sulfides have been noted by Rammimair and Weiser (unpublished MGB Rpt., 1985) and were found to occur as inclusions in the chromite.

3.2.4b Hydrothermal vein deposits

Hydrothermal vein deposits in Central and Northern Palawan yield mercury and antimony as the main products. It is believed that the hydrothermal solutions responsible for the deposition of these deposits could have migrated upwards through the open post-collision tension fracture systems in the area during the Quaternary. In Antique, the hydrothermal gold vein deposits found are inferred to have been deposited after Middle Miocene and is related to magmatic activities.

Confined within the tectonic windows of Iratag and Bacungan in Central Palawan, mercury mineralization is one of the more recent deposits in the region and cinnabar (HgS) is the chief mercury mineral. It occurs essentially as fissure filling and replacement in ultramafics, basalts, schists, ferrugenous shale associated with basalts, gabbro and in the altered portions of the above rocks (Fernandez, 1968). In Bacungan (Palawan Quicksilver Mine area), the mercury ore was observed to be confined in steeply dipping zones of opaline silica distributed within a wide area of green clay of probable hydrothermal origin (UNDP, unpublished, 1985). The mercury grade throughout Central Palawan ranges from 0.15 lbs/t to 2.69 lbs/t at a total reserve of about 14,000,000 t (BMG, 1986).

Antimony mineralization of the region was delineated within the Lasgas, Iraan, Fabrica and Bolo-bolo areas in Palawan with the Caramay Schist as the host formation. The antimony sulfide (stibnite) is observed to occur in quartz veins associated with silicified rocks which trends northeast paralleling the foliation of the schist. In the recent geochemical survey of the RP-JAPAN Project (1989) in the aforementioned areas, the anomalous presence of As, Au and Hg were found overlapping with the antimony anomalies.

In Mt. Anoy and Limbato in Antique, the Igsawa Pyroclastics served as the host formation for the hydrothermal vein-type gold mineralization and is arc related (Cagayan de Sulu Arc). The mineralization is confined solely to the andesitic units of the formation (UNDP, unpublished, 1985).

3.2.4c Bedded manganese deposits

The manganese occurrence throughout the region is essentially stratigraphically controlled and associated with the pelagic chert units. The manganese are found interbedded and apparently syngenetic with chert, some basaltic breccias, and phyllitic mudstone deposits. Thus the manganese deposits ranges in age from Late Paleozoic to probably Eocene. In most of the deposits, the observable ore mineral assemblage is composed of pyrolusite and nodular psilomelane having calcite as the gangue mineral. Notable occurrences of manganese throughout the region are in Busuanga (San Nicolas and Coron) and Culion Islands (Kabol-kabol) of North Palawan; in Sulu Sea Mine in Puerto Princesa of Central Palawan; in Nabas, Buruanga Peninsula; and in Ibajay and Tangalan of north Antique Range.

In Palawan, the manganese deposits have an average grade of 46 % Mn and has a known positive reserve of 158,000 t.

3.2.4d Cyprus-type massive sulfide deposits

Massive sulfide deposits (cyprus-type) in Balabac Island and Brookes Point, South Palawan and in San Jose, SW Panay are the major base metal mineralization essentially of copper within the region. The ore is confined in both the spilitic lavas and the associated pelagic units. Thus, the Cretaceous Espina Basalts and the basalt unit of the Antique Ophiolite are the host formations for such deposits of the region. Pyrite is the dominant sulfide mineral. Chalcopyrite ranks next followed by subordinate amounts of sphalerite, hematite, bornite, chalcocite, covelite, and cuprite. The malachite-azurite-chrysocolla group are the usual secondary mineral assemblage of the deposit.

3.2.4e Laterite deposits

Laterite is one of the most important sources for nickel world-wide and, as mentioned in the sections regarding the Mobile Belt, it is also a very important mineral resource of the Philippines. In the stable belt which consists of rifted continental margin, ultramafic complexes thrusted over the continental crust are very extensively distributed. And upon weathering, they alter to laterite and nickel is often concentrated under favorable conditions.

There are several significant concentration of Ni of close to 1 % or higher in deposits, at Betlehem, Santa Monica, and Ibateng in Narra; Pulute Range in Quezon and Rio Tuba in Bataraza all in Palawan. In Romblon Island Group, similar deposits are known in Bato and Binayaan.

Table 13-1: Major Mineral Deposits and Prospects of Palawan

Deposit/ Prospects	Mineralization Commodity	Location	Remarks
1. Lanka Mn Mine (Coron Is.) **	Chert hosted lenticular Mn.	120°13' E 12°03' N	Mn grade: 13.2%-42.96% MnO; Mineral assemblage-psilomelane and pyrolusite
2. Dapdapan Mn Mine (Busuanga Island)	Chert hosted - bedded Mn	120°19' E 12°01' N	Mn grade: 22.06 % MnO Mineral assemblage-psilomelane and pyrolusite
3. Kabol-kabol Mn Deposit (Culion) *	Mn pods in chert transected by calcite veins	119°54' E 11°52' N	
4. Paly Is. *	Disseminated Cr	119°42' E 9°55' N	Sand size spinels
5. Bacungan @@	Mercury sulfide (cinnabar)	118°42' E 9°52' N	Known grade of Hg: 0.67 lbs./MT
6. Sta. Lourdes @@	Mercury as cinnabar	118°42' E 9°52' N	Known grade of Hg: 2.89 lbs./MT

Note: * - Prospect status; ** - Explored/undeveloped; @ - Operating mine; @@ - Stopped operation

Table 13-1 (cont'd)

Deposit/ Prospects	Mineralization Commodity	Location	Remarks
7. Tagburos @@	Mercury as cinnabar	118°43' E 9°50' N	Known grade of Hg: 0.15 lbs./MT
8. Atlas Mine @	Chromite in pods and dissemination	118°25' E 9°38' N	Operating mine
9. Benguet Mine @	Chromite pods and lenses	118°25' E 9°58' N	Cr grade ranges from 23.9%-59.0% Cr_2O_3
10. Richman Mine **	Chromite pods and lenses	118°28' E 9°37' N	Cr grade: 28.1%-48.8% Cr_2O_3
11. Boyo Mine @@	Chromite pods and lenses	118°29' E 9°42' N	Cr grade: 34.0%-50.0% Cr_2O_3
12. Berong @	Chromite pods and lenses	118°14' E 9°25' N	Cr grade: 42.6% Cr_2O_3 producing mine
13. Romarao **	Chromite pods in dunite: Cr dissemination in laterite	118°15' E 9°29' N	Chromite in soil: 41.08% Cr_2O_3; 11.24% FeO
14. Malatgao **	Nickel laterite	118°24' E 9°26' N	A sample yielded 1.09% NiO; 56.73% FeO
15. Ibateng **	Nickel laterite	118°22' E 9°25' N	A sample yielded 0.80% NiO; 66.51% FeO
16. Trident Mine @@	Chromite in various occurrences	118°21' E 9°19' N	A sample yielded 44.81% Cr_2O_3; 13.60% FeO ceased operation; estimated reserve of 199,000 MT as of 1986
17. Olympic Mine @	Chromite both in residual and in situ; Ni laterite	118°16' E 9°13' N	A chromite sample yielded 47.94% Cr_2O_3; 0.11% NiO
18. Betlehem Mine @	Nickel laterite	118°19' E 9°18' N	A sample yielded 1.66% NiO; 54.62% FeO
19. Sta. Monica *	Nickel laterite	118°14' E 9°13' N	A laterite sample yielded 1.64% NiO; 64.54% FeO

Table 13-1 (cont'd)

Deposit/ Prospects	Mineralization Commodity	Location	Remarks
20. Pulute Range Ni Prospect *	Nickel laterite	117°37' E 9°04' N	A laterite sample yielded 1.24% Ni; 2.91% Cr; 19.61% Fe2O3
21. Pulot Cu Prospect *	Copper bearing quartz in basalt	117°56' E 8°59' N	A vein sample yielded 1.42% Cu; 0.01% Zn; 6.5 g/MT Ag
22. Barong-Barong **	Copper - Cyprus type massive sulfide	117°49' E 8°46' N	A sample yielded 0.02%-6.52% Cu; 0.01%-0.23% Zn; 7 g/MT-52 g/Mt Ag; <0.07 g/MT-0.21 g/MT Au
23. Males *	opper - Cyprus type massive sulfide	117°43' E 8°59' N	A sample yielded 0.52% Cu; 0.19% Zn; 0.02% Pb; 13,3 g/MT Ag
24. Balabac Island @@	Copper - Cyprus type massive sulfide	117°04' E 7°59' N	A sample yielded 3.07% Cu; 0.01% Pb; 0.06% Zn; 11.8 g/MT Ag 0.69% g/MT Au; a known reserve of 80,000 MT
25. Rio Tuba @	Nickel laterite	117°25' E 8°34' N	Average grade: 3.3% Ni; 0.04% Co; reserve-9.6 Million T
26. Tagbita @	Silica sand	117°21' E 8°43' N	Produces 150,000 t/y of silica, 50% of which is high grade
27. Tinitian Antimonty Prospect **	Antimony in sulfide (stibnite) occurring in qtz vein hosted by schist	119°05' E 10°05' N	Ore samples yielded 36.17-49.0% Sb
28. St.Paul **	Bedded limestone	118°52' E 10°10' N	The St. Paul Peak has an estimated reserve of 566.9 million t of limestone

Table 13-2: Major Mineral Deposits and Prospects of Antique Range - Buruanga Peninsula

Deposit/ Prospects	Mineralization Commodity	Location	Remarks
1. Osman **	Hydrothermal gold vein	122°14' E 11°37' N	Auriferous pyrite-chalcopyrite assemblage within the vein and along the argillized zone of host rock.
2. Unidos *	Silica	121°58' E 11°54' N	Cherty blocks most probably associated with Buruanga Metamorphics.
3. San Roque *	Marble	121°58' E 11°47' N	Carbonate blocks most probably associated with Buruanga Metamorphics.
4. Libertad *	Copper	121°58' E 11°48' N	Probably associated with the diotite intrusives
5. Panak-takan Mine @@	Stratabound Mn	121°57' E 11°54' N	Rhodonite, rhodochrosite and Mn Oxide in chert; Samples yield 17.2-17.9% MnO.
6. Tacororoc Mine @@	Stratabound Mn	121°59' E 11°53' N	Interbedded Mn silicate and oxide in chert.
7. Ibanlac Mine @@	Stratabound Mn	121°57' E 11°55' N	Interbedded Mn silicate and oxide
8. Lomboyan, Barbaza **	Cu (hydrothermal base metal mineralization)	122°03' E 11°14' N	Contains silver and gold values; Explored prospect
9. Kalmar, Sibalom	Chromite	122°01' E 10°51' N	Chromite lenses in serpentinite
10. Carawi-san, San Remigio **	Cu (massive sulfide-basalt hosted)	122°03' E 10°51' N	Explored
11. Nagdayao Creek Sibalom **	Cu (massive sulfide-basalt and chert host)	122°02' E 10°47' N	Explored

Note: * - Prosepct Status
** - Explored/undeveloped
@ - Operating Mine
@@ - Stopped Operation

Table 13-3: Major Mineral Deposits and Prospects of Romblon Island Group

Deposit/ Prospects	Mineralization Commodity	Location	Remarks
1. Caloring *	Pophyry copper	122°03' E 12°18' N	Shows strong alternation; probably associated with the Calatrava Intrusives
2. Bato *	Nickel laterite	122°32' E 12°23' N	Derived from the weathering of Sibuyan Ultramafics
3. Binaya-on *	Nickel laterite	122°34' E 12°22' N	Derived from the weathering of Sibuyan Ultramafics
4. Dulangan **	Placer gold	122°29' E 12°26' N	Probably associated with a diorite intrusives (Caltrava ?)
5. Nailog *	Base Metal vein type deposit rich in gold and silver	122°28' E 12°26' N	Probably associated with a diorite intrusives; a sample yielded: 2.12 g/T Au, 172 g/T Ag, 0.93 % Cu; 3.63 % Pb; 6.62 % Zn
6. Cogon *	Porphyry Copper	122°03' E 12°11' N	Shows strong alteration and probably associated with the Calatrava Intrusives

Note: * - Prosepct Status　　@ - Operating Mine
** - Explored/undeveloped　　@@ - Stopped Operation