PART I GEOLOGICAL SURVEY

Chapter 1 Geology

1–1 General Geology

The Philippine archipelago is divisible into two structural units according to Gervasio (1966); namely the mobile belt and the stable region. The former, extending longitudinally through Luzon, Visayas and Mindoro, is characterized by a concentration of earthquake epicentres, numerous active and recently inactive volcanos, prevalence of Mesozoic to Tertiary igneous rocks, distribution of porphyry copper deposits and greater degree of deformation and metamorphism of the rocks. While the latter, being the western side of the boundary and including southwestern parts of Mindoro Island, Palawan Island, Sulu archipelago and so on, is aseismic in nature and shows virtual absence of Tertiary igneous activity.

Mindoro Island belongs to the western physiographic province of four major physiographic provinces which are proposed by Balce et al. (1981). The province constitutes the belt of mountain ranges in the western side of the mobile belt. The ophiolite belts of both Ilocos-Mindoro ophiolite belt and Antique ophiolite belt are passing in the western province together with pared Magmatic belt of both Luzon Central Cordillera-Marinduque magmatic belt and Negros-Zamboanga magmatic belt respectively. Balce et al. (1981) inferred also that the basement considered to be Carboniferous to Early Jurassic in Mindoro is continental crust as well as other areas surrounding the Sulu Sea. Holloway (1981) and other authors suggested that the crustal material comprising the North Palawan block which consists of Mindoro Island, and the Reed Bank area, once formed a part of the mainland of Asia and attached to southern China.

In Mindoro, Paleozoic and Mesozoic rocks are distributed in the central part in the direction of NW–SE, which are overlain by Cenozoic rocks dipping northeast and southwest. It shows a huge anticlinal structure.

The stratigraphy of Mindoro is divided from the oldest into the Halcon metamorphics; the Baco group, which comprises the Mansalay formation and the Lumintao formation; the Mamburao group; the Sablayan group; the Bongabong group; the Socorro group and the Alluvial deposits. Intrusive rocks consist of big Ultramafic complex, small body of acidic to intermediate rocks such as granodiorite, quartz diorite, diorite and diorite porphyry, and small-scale basic rocks of dolerite and gabbro.

The above division was proposed in Phase I, and it proved suitable in this phase. This time, the stratigraphic relationship between the Halcon metamorphics and the Baco group came into problem, and the geology of Lumintao formation was clarified. Concerning the Ultramafic

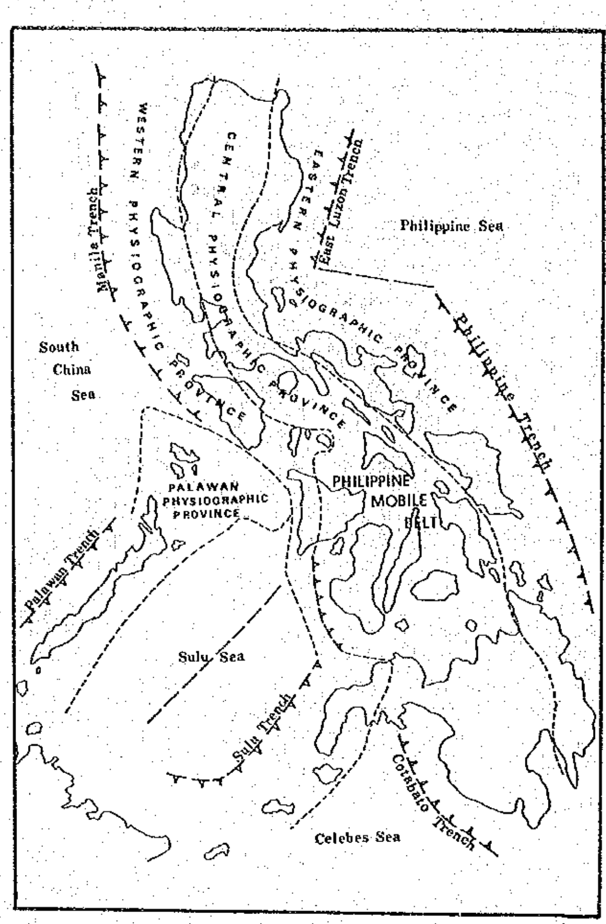

Fig. Ⅰ-1 Major Physiographic Elements in the Philippines

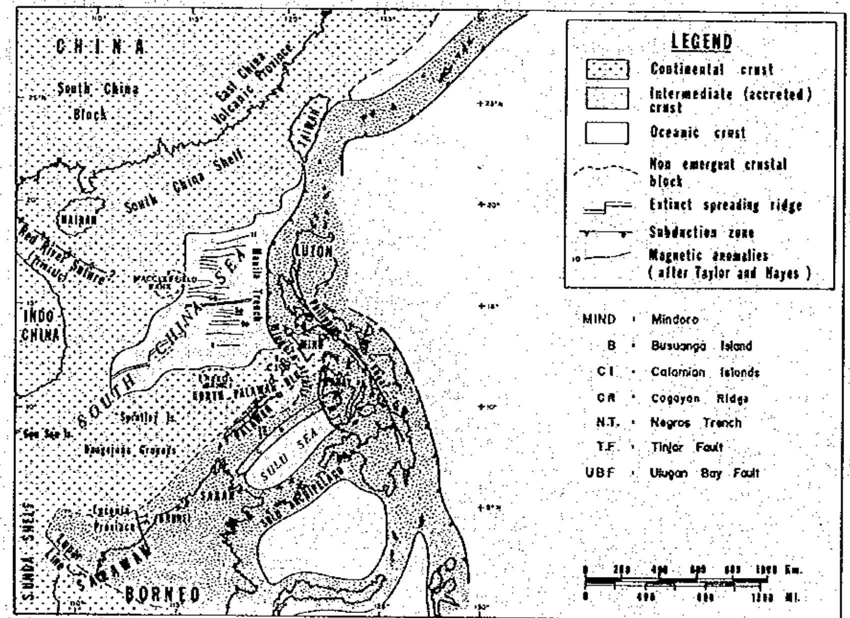

Fig. Ⅰ-2 South China Sea Area Geography and Tectonic Elements

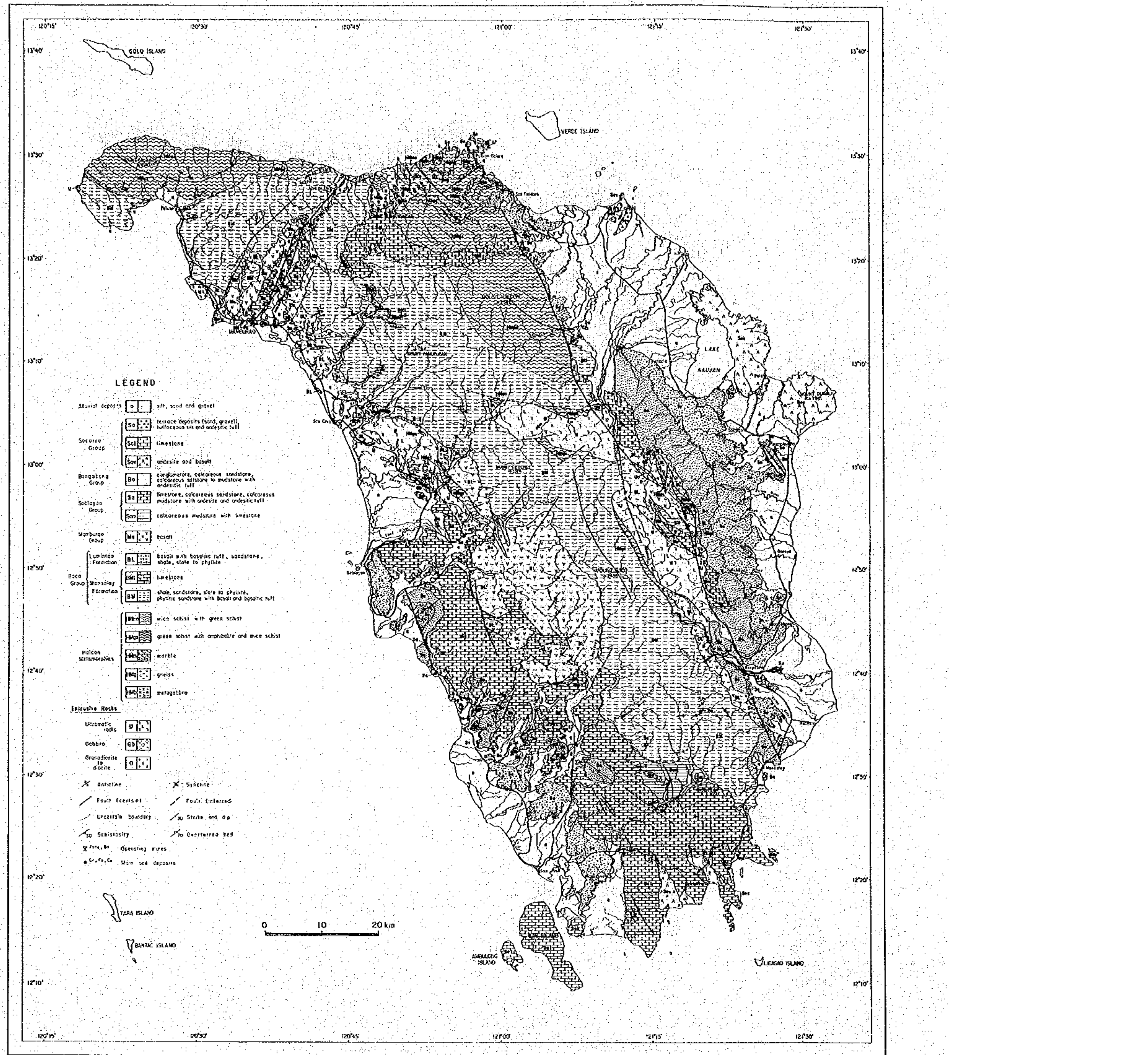

Fig. I-3 Geological Map of the Survey Area

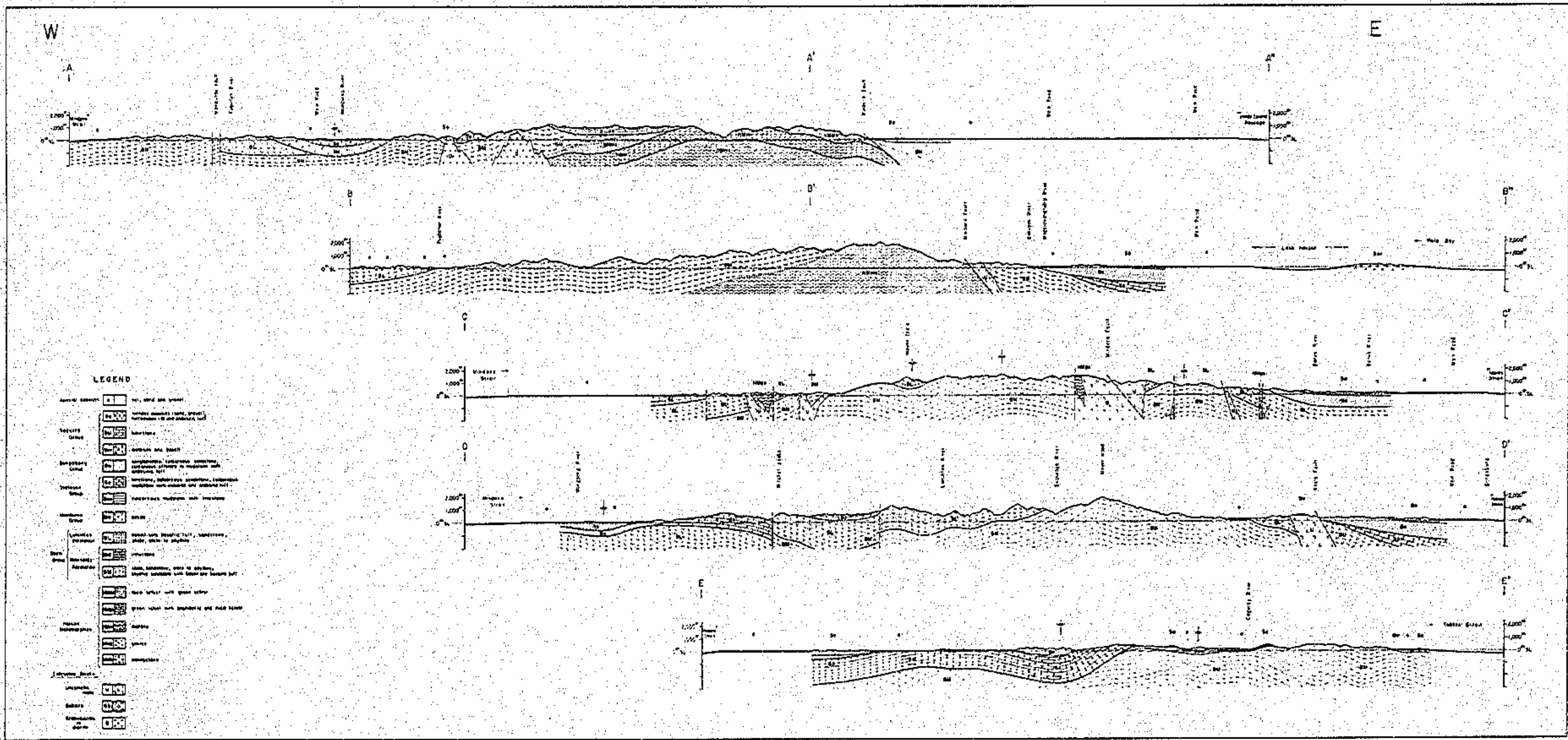

Fig. I-4 Geological Profile of the Survey Area

Table I-1 Generalized Stratigraphic Section of the Survey Area

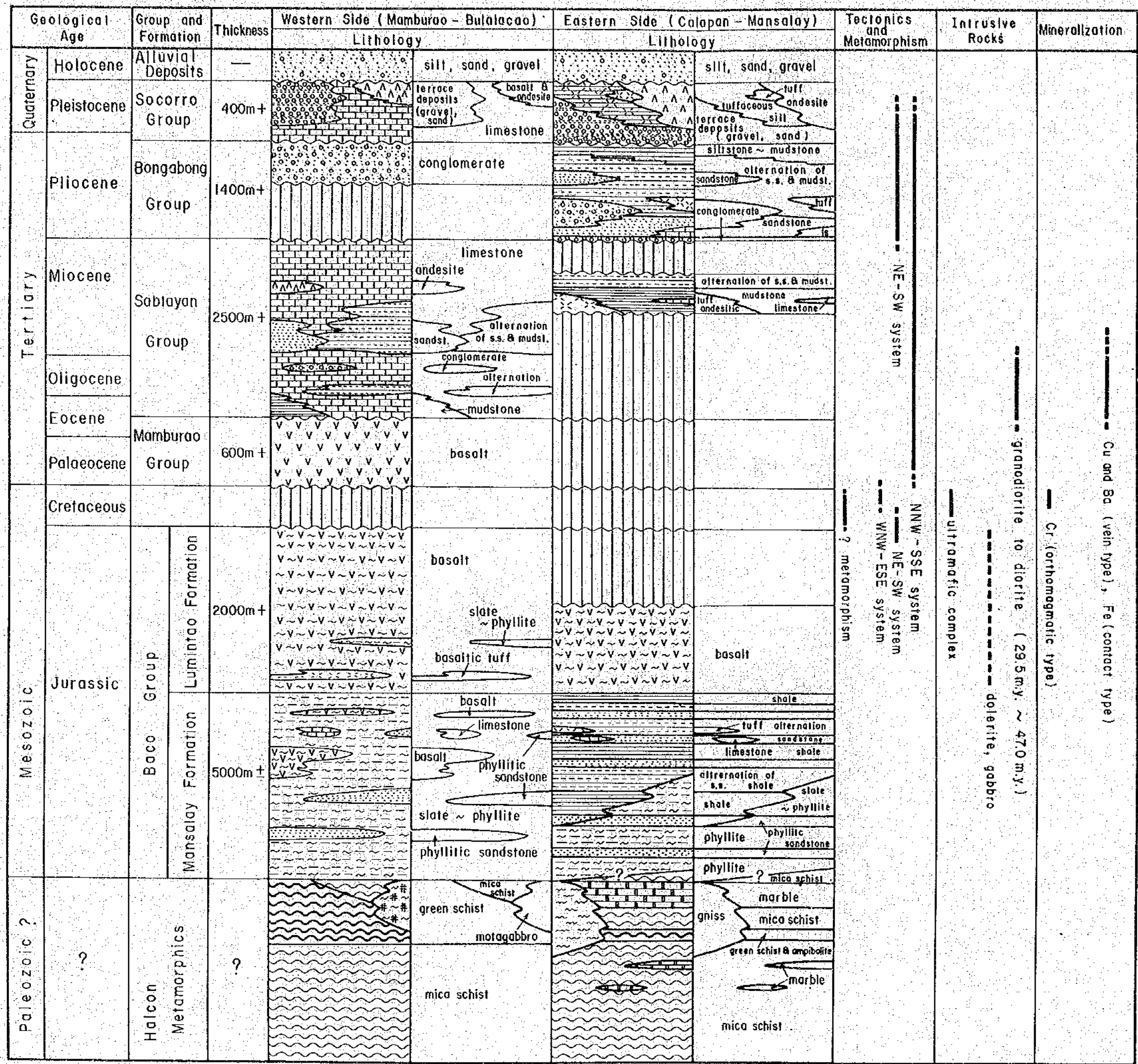

Table I -2 Stratigraphic Correlation

Era	Period	Epoch	Age	Teves (1953)	Weller & Vergara (1955)	Andal et al. (1968) Hanzawa & Hashimoto (1970)	Miranda (1980)	JICA MMAJ (1983)
Cenozoic	Quaternary	Holocene		Recent Deposits	Alluvium		Alluvium, San Jose Terrace Gravel and Eplog Volcanics	Alluvial Deposits
		Pleistocene	Late	Oreng Formation	Eplog Lava Flows and High-level Sand & Gravel	Sumagui Formation and Balanga Formation		Socorro Group
			Early					
	Tertiary	Pliocene	Late				Balanga Formation, Ambulong Limestone	
			Early	Balanga Formation		Famnoan Formation, Barubo Sandstone	Punso Conglomerate, San Teodoro Volcanics	Bongabong Group
		Miocene	Late	Famnoan Formation, Barubo Sandstone	Pocanil Formation	Pocanil Limestone	Pocanil Formation	Sablayan Group
			Middle	Pocanil Limestone	Mato-ang Limestone, Napisian Formation		Napisian Coal Measure Napisian Limestone	
			Early	Tangon Formation	Buialacao Limestone	Tangon Formation	Tangon Formation	
		Oligocene	Late	Camangui Sandstone		Bugtong Limestone and Camangui Sandstone	Bugtong Limestone	
			Early		Bandao Limestone			
		Eocene	Late	Mansiol Conglomerate		Eocene Formation	Agbahag Conglomerate	
			Early					Mamburao Group
		Paleocene						
Mesozoic	Cretaceous				Mesozoic Sandstone		Abra de Ilog Formation	
	Jurassic		Late	Mansalay Formation		Mansalay Formation	Mansalay Formation	Baco Group: Lumintao Formation
			Middle					Baco Group: Mansalay Formation ?
			Early					Halcon Metamorphics
	Triassic			Wasig Formation				
Paleozoic	Permian			Mindoro Metamorphics				
	Carboniferous						Mindoro Metamorphics	

complex, the distribution was almost completely revealed, furthermore, some of the lithological, petrological and structural characteristics were understood.

The generalized stratigraphic section of Mindoro Island and the stratigraphic correlation between the present survey and previous works are shown in Table I–1 and I–2.

1–2 Previous Works

A small number of reports were published on geology and ore deposits of Mindoro Island, moreover most of them were described mostly on the northern part, around Abra de Ilog and Calapan, and on the southern part, around Bongabong, Mansalay and Bulalacao. But many unpublished reports of the Bureau of Mines and Geo-Sciences described regional geology or mineralization are available to refer. All of these reports were used for compilation as references.

On the northern part, Caagusan (1966) studied the petrography of the metamorphic rocks and Hashimoto & Sato (1968a) confirmed Eocene formation by Paleontological work and conducted a structural analysis.

On the southern part, there are relatively many published reports on paleontology and stratigraphy. Teves (1953) had investigated around the area of Mansalay and Bongabong, and tried to establish the stratigraphy of Mesozoic and Cenozoic rocks. Andal et al. (1968) established the stratigraphy of Mesozoic rocks, the Mansalay formation, which crops out to the west of Mansalay, and determined its age as from Middle Callovian to Oxfordian (upper Middle to lower Upper Jurassic). Hashimoto and Sato (1968b) had conducted a paleontological work and a structural analysis on the region to the west and northwest of Mansalay, and proposed the distribution of Eocene formation. Hashimoto and Sato (1969) discussed the stratigraphy of Cenozoic rocks proposed by Teves (1953), conducting paleontological work. Weller and Vergara (1955) had carried out a detailed regional mapping on the Bulalacao coal field.

Besides, in 1974 Bureau of Mines (presently Bureau of Mines and Geo-Sciences) published the report on geology and mineral resources of Mindoro Island which compiled the internal reports.

1–3 Stratigraphy

1–3–1 Paleozoic and Mesozoic

Paleozoic and Mesozoic rocks composed of the Halcon metamorphics and the Baco group are widely distributed in the area, which form the mountain range trending northwest to southeast.

(1) Halcon metamorphics

The Halcon metamorphics is the tentative name given in Phase I to the metamorphic rocks, which form the basement of the surveyed area. As mentioned later, a problem on the age of original rocks was brought up in this phase from the data on the lithology, structure and stratigraphic relationship. In this report, the name of Halcon metamorphics was used to the metamorphic rocks showing a green schist to amphibolite facies. It is included in the Mindoro metamorphics reported by Teves (1953) and the Basement Complex of the Bureau of Mines (1974).

Distribution: The rocks crop out around the northwestern coast and the area from Puerto Galera to Mt. Halcon. Also, small exposure can be observed around the Ultramafic complex.

Rock facies: The Halcon metamorphics are composed of mica schist, green schist, epidote amphibolite, amphibolite, gneiss, metagabbro and marble. Granulite were also found in the limited place.

Mica schist is distributed along the northwestern coast and around the Mt. Halcon. It is light grey to black in color and shows a banded structure and clear schistosity. It consists mainly of muscovite and quartz. Segregated quartz vein is accompanied in some places. Under the microscopic observation, the mica schist is composed of muscovite-chlorite bands and quartz-plagioclase bands, and it shows a fibroblastic texture or a nematoblastic texture. The fact that the mica schist exposed in the Dulangan River on the east foot of Mt. Halcon contains many garnet crystals, 2–3 mm in size, suggest that this mica schist was formed by the metamorphism of higher temperature than others. Moreover, the coexistence of biotite, muscovite and chlorite supports the idea that the metamorphism is the high-pressure type such as the Sanbagawa belt in Japan.

Green schist crops out around Paluan, to the south of Puerto Galera and near the Ultramafic complex located in the central part. The rock is light green to green in color and shows clear schistosity. Under the microscopic observation, it shows a nematoblastic texture and the constituent minerals are generally composed of epidote, chlorite, actinolite and plagioclase. It often contains a small quantity of calcite.

Epidote amphibolite and amphibolite are mainly exposed around the Ultramafic complex, and small outcrops are also found in gneiss and metagabbro bodies. Most of these exhibit a schistosity and some are massive. Under the microscopic observation, the epidote amphibolite consists mainly of epidote, hornblende and plagioclase with sphene, muscovite and quartz. The amphibolite generally has the same constituent minerals as the epidote amphibolite except for epidote. But some contain a small quantity of epidote. Garnet of 1 – 2 mm in size is observable in the amphibolite exposed in the upper reaches of the Ogos River. Those texture are lepido-

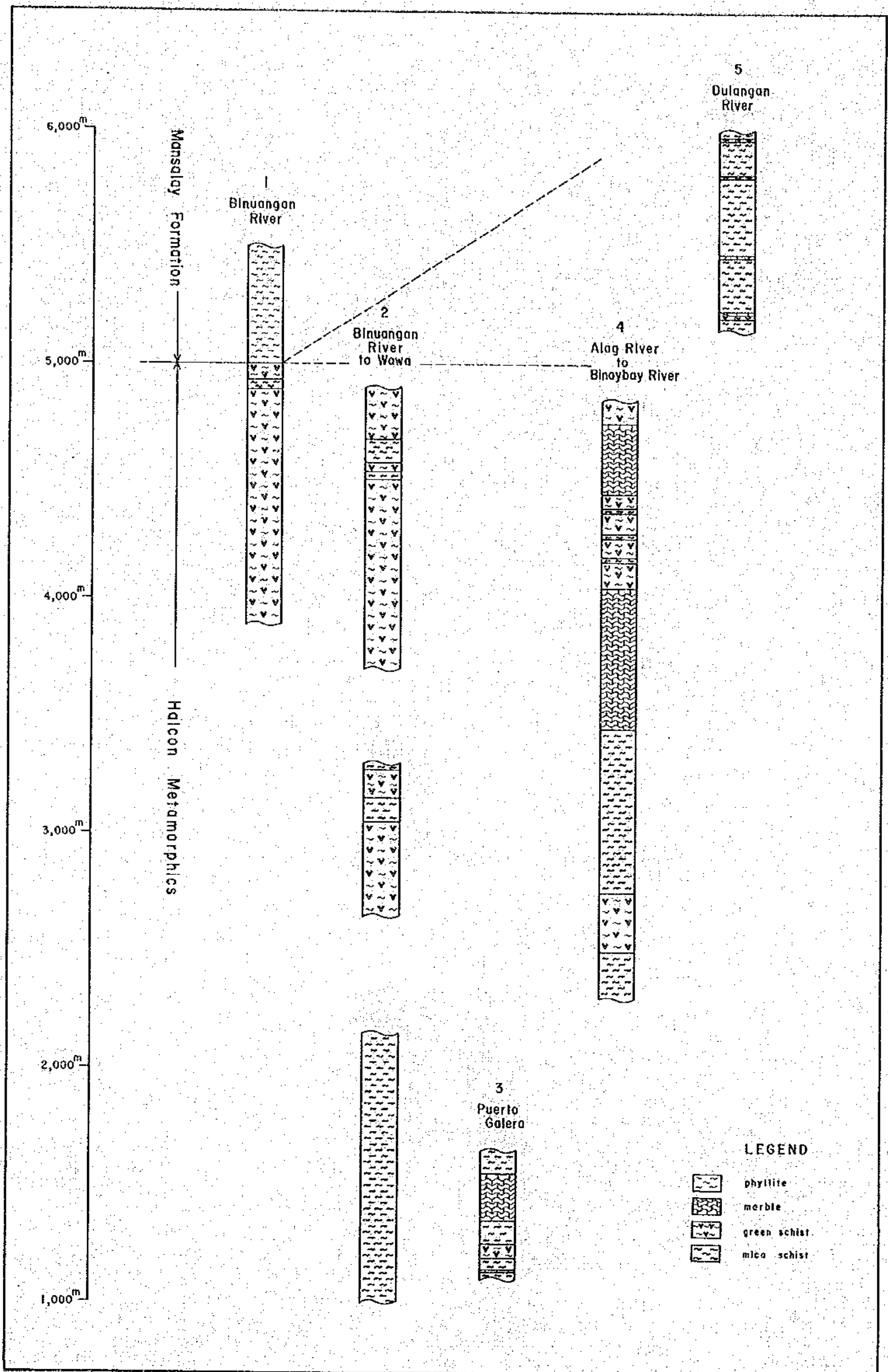

Fig. I-5 Geological Columnar Section of Halcon Metamorphics blastic or granoblastic.

Gneiss is found around the Camarong River and is composed of very coarse-grained crystals of quartz, muscovite, plagioclase and potash-feldspar. The parallel alignment of the forming minerals, especially mica, makes a gneissose texture noticeably. Considering from the fact that the boundary between the gneiss and the crystalline schist is oblique to their schistosity and gneissosity in the Matobang River and to the southwest of Puerto Galera, the source rock of the gneiss is presumed to be acidic igneous rock.

Metagabbro crops out in the northern slope of Mt. Buruburungan. It appears dark green in color, and shows a coarse-grained texture made of hornblende and plagioclase.

Marble is distributed to the south of Puerto Galera and the north of Mt. Halcon. To the south of Puerto Galera, it alternates with crystalline schist or shows a lenticular form in crystalline schist. On the contrary, it forms a thick bed of over 1,000 m thick to the north of Mt. Halcon. These are generally white to light pink in color, though alternating parts often appear black to dark grey in color.

Besides, a small outcrop of granulite is found in the upper reaches of the Banus River, which contacts with the Ultramafic complex.

<u>Geological structure</u>: Field evidence indicates that the schistosity of Halcon metamorphics is correspond closely to the bedding. The following structure is recognizable, considering from general trend of schistosity and distribution of green schist and marble. Around Puerto Galera there is an anticline with an axis trending N–S and plunging SW. In the vicinity of Mt. Halcon, it strikes N45 – 60°W beside the Mindoro fault and changes from E–W to NNE–SSW toward the west. In the northwestern part, the strike changes from NW–SE to NE–SW and then to E–W toward the east from the western part.

<u>The relationship with the Mansalay formation</u>: The stratigraphic relationship between the Halcon metamorphics and Mansalay formation was inferred in Phase I to be unconformable for the reason why the grade of both metamorphism is different and why the conglomerate of the Mansalay formation contains gravels of metamorphic rocks. In this phase, it was confirmed that the relationship between the Mansalay formation and the metamorphic rocks which are composed mainly of epidote amphibolite and amphibolite and are associated with the Ultramafic complex, is of a tectonic contact, and it was also confirmed that the relationship between the green schist and the phyllite of the Mansalay formation is conformable in the northwestern part. In addition, the boundary between mica schist and phyllite to the west of Mt. Halcon seems to be oblique to the structure of the Mansalay formation.

These facts suggest the possibility that the initial rocks of the Halcon metamorphics and the

Mansalay formation are the sediments of the same age and the different lithofacies are caused by the metamorphism.

Age: The Rb–Sr dating was conducted this time but the results are not match to other stratigraphic data on the age of metamorphism.

Concerning the age of the source rock, it is estimated to be pre-Permian because of the discovery of fusulinid-bearing limestone pebbles in a conglomerate cropping out at Agbahag Point, Mindoro (Koike et al., 1967). As mentioned above, however, it would be Jurassic age when the Mansalay formation was deposited.

If the source rock is Jurassic, the age of metamorphism could be late Jurassic to Cretaceous which is the same age of the crystalline schist of the Sanbagawa metamorphic belt in Japan.

(2) Baco Group

The Baco group is the tentative name given in Phase I to the volcanic and clastic rocks undergone slight or none metamorphism, and it is followed in this report. These rocks are divided into two formations; the lower which is the Mansalay formation, comprised predominantly of clastic rocks, and the upper which is the Lumintao formation, composed mostly of volcanic rocks.

(2)–1 Mansalay formation

The Mansalay formation is named to the formation from which fossils of Jurassic age are discovered, and is exposed in the western part of Mansalay. Before, this Jurassic formation was thought to crop out only in the western and northwestern parts of Mansalay. According to the results of the investigation in Phase I and II, however, the beds formed primarily of slate and phyllite, which are found from the north to the central area, are quite similar to the rock facies of the Jurassic formation exposed in the southeastern part, and the facies changes gradually to the order, moreover both are continuous in structure. Consequently, it was inferred that the beds composed mostly of slate and phyllite are originally equivalent to the Mansalay formation.

Distribution: The formation is distributed in a long belt with a northwest-southeast direction, from Mamburao to Mansalay.

Thickness: At the Amnay River and Rayusan River the formation is approximately 5,000 m thick.

Rock facies: The Mansalay formation is formed principally of pelitic and psammitic rocks, and includes basic lava and tuff locally. Because these rock facies are different according to metamorphic grade, they will be discussed by area.

① Rock facies of the southeastern sections

It mainly consist of sandstone and shale which are accompanied by the alternating beds of sandstone and shale, conglomerate and basic tuff.

Sandstone is mainly a white to greyish-white arkose sandstone, which is coarse-grained and rich in quartz crystals. A greyish-white to grey colored greywacke can sometimes be found. These are generally massive and poorly bedded. They form a thick bed and reached over 750 m thick in the Sinolili River of the upper stream of the Caguray River. The sandstone is partially interbedded with shale and limestone, and the thin layer of interstratified shale with the lenticular coal below 1 cm in thickness is encountered in the Sinolili River.

Shale is grey to black in color and generally massive but locally well bedded. It forms a thick bed and reaches over 900 m thick in the Sinolili River. Calcareous nodule is often found in shale which contain fossils. Pelecypoda and gastropoda fossils are obtained from the shale which crops out in the upper reaches of the Caguray River and the tributary of the Balangan River. An ammonite fossil is also discovered in the Naigan River to the northwest of Mansalay.

The alternating beds of sandstone and shale are well exposed in the upper stream and the tributary of the Balagan River, where the thickness of bed varies from 10 cm to 50 cm. The beds reaches 650 m in the upper reaches of the Balangan River.

Conglomerate forms thin layers which are accompanied with sandstone. The gravels consist of quartz and grey or red chert, and their size ranges from granule to pebble.

Basic tuff shows green or red in color, most of which is fine-grained and thinly layered. The basic tuff exposed in the Taytay River, a tributary of the Caguray River, is however, thick, light green in color and coarse-grained. The thickness is over 300 m.

Andal et al. (1968) carried out a geological survey along the Mansalay River, the Amaga River and the Cagancan River and divided the Mansalay formation into several members. According to this division, the thick sandstone bed between the Amaga River horizon and the Parucpoc Hill horizon could be traced toward north in this survey. Although an ammonite outcrop was found only in the Naigan River this time, floats of ammonite were observed in the upper stream and the tributary of the Balangan River, indicating that the horizon of ammonites extends to the Balangan River.

② Rock facies of the northern to central sections

As in the southeastern sections, they are mainly pelitic and psammitic and are subjected to a low grade metamorphism with a range of slate to phyllite or indurated sandstone to phyllitic sandstone. These rocks intercalate basalt lava, basaltic tuff, limestone and conglomerate.

Phyllite and slate is generally calcareous and black to dark grey in color. The schistosity or cleavage is well developed and is very fissile. Those are often accompanied by segregated quartz veins of usually few cm to rarely 1 m in thickness. They form thick beds and exceed 1,000 m in the vicinity of the Amnay River.

Indurated sandstone and phyllitic sandstone are greyish white to grey in color, arkosic, medium to coarse-grained and predominant in quartz. The indurated sandstone is massive, but the phyllitic sandstone often shows the schistosity by the alignment of minerals and flattened rock fragment. Those rocks are 10 – 200 m in thickness and intercalated in slate or phyllite.

The alternating beds of pelitic rocks and psammitic rocks are also encountered in some places, and a bed is mostly below 10 cm thick and the psammitic rocks are fine-grained. But, locally, the thickness of a bed ranges from 1 to 5 m and the psammitic rocks are coarse-grained. The thickness of the alternating beds is 100 to 300 m.

Basalt lava is dark green in color, and shows a clear pillow structure. It exists in slate or phyllite, and the thickness is generally 20 – 50 m.

Basaltic tuff shows light green to green or reddish brown in color, and is locally distributed as a bed below 100 m thick. In northern part it is phyllitic.

Limestone crops out in the Pagbahan River as a thick bed of 400 m and in the upper reaches of the Abra de Ilog as a thin bed. These are massive rocks appearing grey to light grey in color, and are recrystallized.

Thin conglomerate beds are intercalated in slate and are found in two localities. The gravels are composed of greyish white chert and quartz, and their size is granule.

Geological structure: The Mansalay formation exhibits a slightly different structure depending on the area.

In the northern part the bed generally strikes E–W and dips south except the area from Mamburao to Abra de Ilog where the bed strikes NE–SE. The foldings with a wave length of 1 km are well developed around the Amnay River and Pagbahan River, and their axis are trending mostly E–W.

In the central part, the formation forms a NNW–SSE trending anticline around Mt. Baco. The anticline is plunging toward inside, and thus the distribution of the Mansalay formation is narrow in the vicinity of Mt. Baco and wide to the north and south. Besides, it forms NW–SE trending anticline and syncline along the Rayusan River, which plunges southeast.

In the southern part, the beds strike NW–SE around Mansalay and along the boundary with Lumintao formation, but they tend to strike E–W toward the west. The foldings with a wave length of a few km are developed, and their axes are trending E–W, NW–SE or NE–SW.

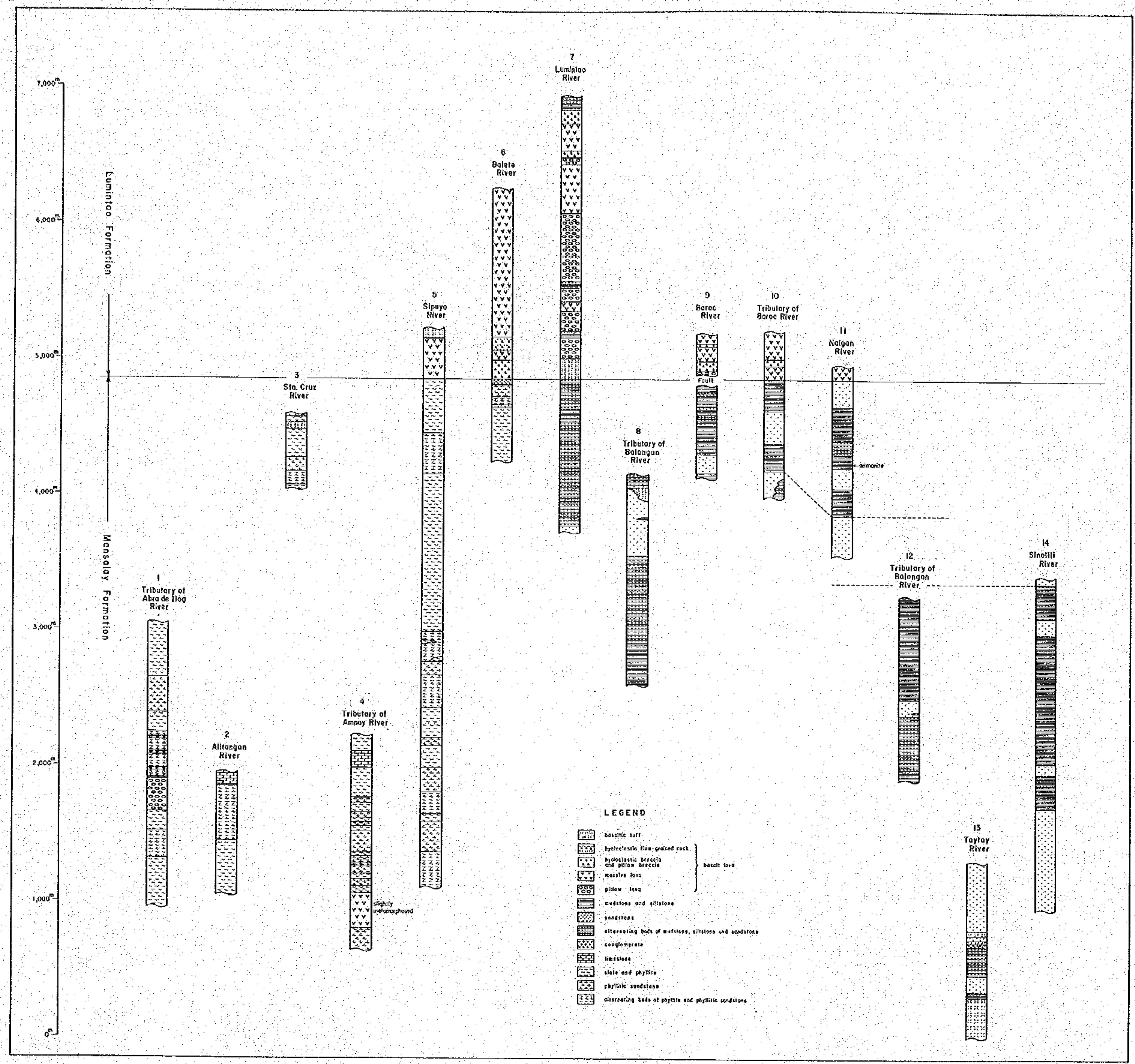

Fig. I-6 Geological Columnar Section of Baco Group

Stratigraphic relationship: As described already in the part of the Halcon metamorphics, although it has been thought that the Jurassic formation unconformably overlies the metamorphosed basement rocks of Paleozoic age, the lithological and structural data collected in Phase I and II suggests that the basement rocks of Mindoro Island would be the Jurassic formation, namely the Mansalay formation.

In Phase I, the relation between the Halcon metamorphics and the Mansalay formation followed the previous idea of unconformity based on the field evidence that the conglomerate exposed in the creak to the east of Abra de Ilog contains gravels of crystalline schist, however, it needs to review the conglomerate.

Age; It is reported by many researchers that the formation yields abundant Jurassic fossils in Mansalay, such as, Hayasaka, 1943; De Villa, 1944; Kobayashi and Mori, 1955; Kobayashi, 1957; Teves, 1953; Sato, 1961; Andal et al., 1968.

A detailed study of Ammonites was conducted by Andal et al. in 1968, and the age of the formation in Mansalay area was considered as late Callovian to Oxfordian, which is a period from the late Middle Jurassic to the early Late Jurassic. The representative species of Ammonites identified are as follows.

1. Amaga River horizon
   Perisphinctes (Kranaosphinctes) cf. bullingdonensis Arkell
   Euaspidoceras cf. hypselum (Oppel)
   Taramelliceras cf. trachinotum (Oppel)
2. Parucpoc Hill horizon
   Parawedekindia arduennensis (d'Orbigny)
   Perisphinetes (Kranaosphinctes) cf. bullingdenensis Arkell
   Camphylites sp.
3. Caromata Hill Horizon
   Hecticoceras (Zieteniceras) sp.

(2)–2 Lumintao formation

The Lumintao formation was tentatively named in Phase I to the beds composed mainly of basic volcanic rocks overlying the Mansalay formation. As the survey was conducted along the Lumintao River and detailed data were obtained in this phase, the Lumintao formation is proposed to be defined as the beds whose type locality is at the Lumintao River.

Distribution: In the west side the formation crops out the area from Lumintao River to Mamburao, and in the east side it is exposed in the upper stream of the Casiligan River and Balete River to the west of Pinamalayan, and in the area from the middle stream of the

Bangabong River to the places to the west of Roxas.

Thickness: It is more than 2,000 m in the Lumintao River.

Rock facies: The Mansalay formation consists mostly of basalt lava which partially intercalates basic tuff, pelitic rock and psammitic rock.

Basalt lava is classified into five units on the field survey of the Lumintao River as follows.

① Massive lava; it is massive and does not show a pillow structure. At the margin of this unit the flow structure is sometimes observable, and it grades into pillow breccia. The massive lava is greenish dark grey to dark green in color, and relatively hard in spite of much fracture. It is generally fine-grained or glassy, but a coarse-grained part is sometimes recognizable. It is altered intensely and veinlets, networks and boxworks of albite, calcite, chlorite-epidote and zeolite occure. This is one of characteristics of the Lumintao formation.

② Autobrecciated lava; it crops out in the fringe of lava flows, and is composed of breccias of basalt which are a few cm to over 10 cm in size. It is a greyish green to greenish brown in color and has a small amount of homogeneous matrix. The volume of this unit is smaller than other units.

③ Pillow lava; it is alternating with the massive lava, and the volume is the next beggest to the massive lava. The size of pillow structure is relatively small (40 – 100 cm in diameter). The each size is almost same, consequently it is inferred that the lava was supplied continuously. The pillow lava generally shows dark green in color, but locally reddish brown to light greenish red at a certain horizon. Abundant calcite occured in the matrix. The lava portion is predominant at the lower part of Lumintao formation, and is intercalated with shale and the thin alternating beds of shale and sandstone near the bottom.

④ Pillow breccia and hyaloclastic breccia; these are exposed around the pillow lava and massive lava. They are generally light greensih grey to dark green in color, but reddish brown to light greenish red in the vicinity of the reddish pillow lava. The volume of this unit is smaller than other units.

⑤ Hyaloclastic fine-grained rock; this is the hyaloclastite whose grains are 2 mm or less in size, and the hyaloclastite whose grains are more than 2 mm is included in the hyaloclastic breccia. It is light yellowish green to greyish green in color, and shows a clear lamination with intervals of 1 mm to 10 cm. It forms thin beds of 10 cm to a few m thick, and is interbedded in the pillow lava as well as in the massive lava. Most of the cases, it has been deformed by slumping.

Besides the basalt lava mentioned above, the Lumintao formation contains thinly interbedded layers of less than 50 m thick mostly at the lower portion, which consist of basic tuff, pelitic and psammitic rocks. The basic tuff is fine-grained and reddish brown to greyish green in color, and has often been crushed flaky. Around Sablayan and Mamburao, it is hard because of metamorphism. The pelitic and psammitic rocks are non-metamorphosed in the southern area, but slightly metamorphosed in the central and northern areas and change to be slaty or phyllitic. In addition to these rocks, the alternating beds of basic tuff and sandstone, and those of shale and sandstone are exposed in the Lumintao River.

The microscopic observation of basalt lava is as follows.

Basalt (KR2–014)

Texture: Intersertal texture.

Constituent minerals: Phenocrysts are made up of euhedral and subhedral plagioclase laths, and euhedral and subhedral augite of 0.2 – 1 mm and 0.2 – 0.8 mm in size respectively. Groundmass consists of microlite composed of needles of plagioclase, granular clinopyroxene, opaque minerals and glass. As for secondary minerals, quartz and chlorite altered from groundmass, sericite from some parts of plagioclase and veinlets of albite, quartz and calcite are observed.

Geological structure: The formation is distributed on the flank of anticline whose axial part is formed of the Mansalay formation, and it generally strikes NW–SE and dips NE and SW in the east and west sides respectively. It is clarified from the structure shown in pillow lava and hyaloclastite that the formation forms the NE–SW trending anticline and syncline and the beds are exposed repeatedly in the Lumintao River. NE–SW trending faults are developed to the west of Pinamalayan.

Stratigraphic relationship: The Lumintao formation conformably overlies the Mansalay formation by reason that the transitional part is observed around at the boundary, which is concordant with the structure of the Mansalay formation.

Age: Because this formation is conformable with the Mansalay formtion, the age is supposed to be late Jurassic.

1–3–2 Cenozoic

The Cenozoic rocks are widely distributed in the area as if they encompass the Halcon metamorphics and the Baco group. They are divided into the Mamburao group, the Sablayan group, the Bongabong group, and the Alluvial deposits in the ascending order.

(1) **Mamburao group**

This group was tentatively named in Phase I to the basic volcanic rocks thought to be mostly Paleocene, and this definition is followed in this report. Among the areas where the group is considered to be exposed in Phase I, however, the basic volcanic rocks cropping out at Sta. Cruz is considered to belong to the Lumintao formation, and in the upper reaches of the Caguray River the beds composed mainly of mudstone changed to belong to the Sablayan group because the Eocene fossils were obtained from these beds.

Distribution: The Mamburao group is distributed along the lowland from Mamburao to Abra de Ilog.

Thickness: It is more than 600 m in the upper stream of the Mamburao River.

Rock facies: The group consists of basalt which shows greyish green to brown in color and a pillow structure. The basalt is generally fine-grained or glassy, but the phenocryst of plagioclase and pyroxene are rarely observed in part.

Geological structure: It is difficult to clarify the structure of the group, because it is comprised of basalt lava. However, the distribution suggests that it forms a NE–SW trending syncline.

Stratigraphic relationship: In the upper stream of the Mamburao River it was confirmed that this group unconformably overlies the Mansalay formation.

Age: This group covers the Baco group with angular unconformity and is overlain by the Sablayan group with slightly angular unconformity as explained below. Accordingly, the age of this group is supposed to be Paleocene to early Eocene.

(2) **Sablayan group**

The Sablayan group was given as the tentative name in Phase I for the beds which predominantly includes the limestone of the late Eocene to late Miocene age, and it is followed in this report. As shown in Table I–2, the beds such as Mansiol conglomerate, Camangui sandstone and Pocanil limestone reported by Teves (1953), and Bandao limestone, Bulalacao limestone, Napician formation, Mato-ang limestone and Pocanil limestone reported by Weller and Vergara (1955) belongs to this group.

Distribution: Besides the extensive distribution of this group from Sablayan to Bulalacao, it is also exposed in the upper stream and lower stream of the Mamburao River, and in the upper stream of the Magasawangtubig River, Banus River, Sumagui River and Tangon River.

Thickness: It is more than 2,500 m.

Rock facies: This group is primarily composed of limestone, which is accompanied by mudstone, sandstone, alternating beds of sandstone and mudstone, conglomerate, andesite lava and andesitic to basaltic tuff.

Limestone is predominant from Sablayan to Bulalacao. It shows light grey, light brown, and white in color. Some portions are massive, and others are well bedded ranging from 10 to 50 cm in thickness of each bed. It is fossiliferous, and yields larger foraminiferas, coral and so on. The limestone exposed in the upper stream of the Mamburao River is recrystallized because of the influence of intrusive rocks such as diorite and quartz diorite.

Mudstone is calcareous and grey to black in color. It is massive, and forms thick beds. There are two types of mudstones of different age, the one is late Eocene beds being exposed in the upper stream of the Caguray River and the other is Miocene beds cropping out in Siay to the northwest of Bulalacao and the upper reaches of the Banus River. The former unconformably overlies the Mansalay formation, and intercalates limestone beds which are well bedded and yeild abundant larger foraminiferas. This mudstone is restricted in distribution, and at the place where it is thining out, the Mansalay formation is unconformably overlain by the thick limestone which contains fossils of late Eocene age. Consequently, the mudstone changes laterally in lithofacies into the limestone. As for the latter, the mudstone exposed in the Banus River intercalates relatively many sandstone beds accompanied by the alternating beds of sandstone and mudstone, and fossiliferous limestone yielding a larger foraminifera. While, the mudstone cropping out in Siay interbeds thin layers of mudstone, limestone, sandstone, besides four coal seams of 0.2 – 1 m thick.

Sandstone is less than 100 m in thickness and is intercalated in limestone or mudstone. It is light grey or light greyish green in color, mostly medium to fine-grained, and includes abundant rock fragments with calcareous matrix. The sandstone, distributed in Aritaytayan to the northeast of San Jose, is intercalated with coal seams of over 1.5 m thick.

The alternating beds of sandstone and mudstone crop out in Napician and the upper reaches of the Banus River on the east side, and in the Batangan River and Mongpong River on the west side. The thickness of each bed is 1 – 2 m, and the sandstone is predominant in general. In the Napician area, the alternating layers are more than 200 m in thickness with intercalation of coal seams. This layers and overlying sandstone beds has been designated as the Napician formation by Weller & Vergara (1954).

Conglomerate is exposed in the Lumintao River and to the west of the river. It is dark grey to greyish brown in color, massive and relatively well consolidated. The gravels are mostly 5 – 20 cm in size, rounded to subrounded, and consist of chert, green schist, phyllite, basalt, limestone, sandstone and shale. The matrix is a calcareous, coarse sandstone.

Andesite lava crops out in the lower stream of the Rayusan River, the east of Sablayan, and shows a dark green to greyish green color because of the alteration. It is accompanied by hyaloclastite.

Andesitic to basaltic tuff is exposed in the lower reaches of the Lumintao River and in the upper reaches of the Tangon River. It is light green to greyish green in color because of the alteration, mostly fine-grained, and rarely accompanied by tuff breccia.

Geological structure: The Sablayan group shows a rather complicated structure with minor foldings. In particular, the beds cropping out from Sablayan to Bulalacao, exhibit irregular structures with variation of strike and dip. As a whole, nevertheless, it tends to strike NW–SE and gently dip SW. In the west of the Lumintao River, several systems of faults draw the boundary between the Lumintao formation and the Sablayan group, and these indicate the tectonic depression. While in the eastern portion, the group has a normal structure, striking NW–SE to N–S and dipping 40 – 60° NE to E in the upper reaches of the Magasawangtubig River, and tending to strike NW–SE and dip 40°NE in the Sumagui River and the Tangon River, though a NW–SE trending anticline is present along the Tangon River. But, in the Banus River the beds strike E–W to NW–SE and dip 30 – 55° S to SW, and contact with the Baco group by the faults of NNW–SSE and NW–SE systems.

Stratigraphic relationship: This group shows a prominently angular unconformity with the Halcon metamorphics and the Baco group, and a gently angular unconformity with the Mamburao group.

Age: As stated above, the limestone of the group yields abundant larger foraminiferas, and the types as shown in Table A–1–1 were indentified this time. Among those, Halkyardia minima (Liebus) and Biplanispira mirabiris (Umbgrove) are of Eocene age and Nummulites fichteri (Michelotti) is of Oligocene age. Also, the assemblege of Miocene age was confirmed.

Based on the survey results of Phase I and Phase II, together with the studies of Hashimoto & Sato (1969), Hanzawa & Hashimoto (1970), the sedimentary age of this group is concluded as late Eocene to Miocene.

(3) Bongabong group

The Bongabong group was the tentative name given in Phase I to those beds composed mostly of Pleistocene conglomerate, tuffaceous sandstone and mudstone to siltstone. It is followed in this report. As shown in Table I–2, the Famnoan formation and the Barubo sandstone of Teves (1953) and Hanzawa & Hashimoto (1970), and the Punso conglomerate of Miranda (1980) are included in this group.

Distribution: This group is distributed continuously from Villacervesa to Mansalay in the eastern side, and is also scattered in Pasugui and to the north of San Jose.

Thickness: It is more than 1,400 m in the Pula River located in the east side.

Rock facies: There are some differences in rock facies in this group between in the western area and in the eastern area. In the west, conglomerate are well exposed, while in the east, sandstone and alternating layers of sandstone and mudstone predominate.

In the western part, this group is composed mainly of conglomerate, which is represented by the conglomerate formation called Punso conglomerate in Pitogo to the northeast of San Jose. The conglomerate includes many kinds of gravels such as sandstone, mudstone, limestone, andesite, crystalline schist, and small amounts of quartz diorite. These range in size from pebble to cobble, rarely with a boulder size. The matrix is a reddish brown, coarse-grained sandstone. The total thickness is over 700 m at Pasugui.

In the eastern part, this group begins with a basal conglomerate. The lower to the middle portion are made up of sandstone, conglomerate, and alternating layers of sandstone and mudstone to siltstone, with intercalations of tuff and limestone. In the upper portion, this group is formed of mudstone to siltstone and alternating beds with sandstone. Abundant smaller foraminiferas are mostly found in the mudstone to siltstone.

The basal and lower conglomerate and generally massive, grey to brown in color, and include many kinds of gravels as observed in the western parts. These are subrounded to subangular, and range in size from granule to pebble. The matrix is either tuffaceous or calcareous. The basal conglomerate is about 10 – 20 m thick in areas except the Casiligan River where the thickness reaches more than 100 m. But the lower conglomerate is over 300 m thick at the Banus River and the Balete River.

Sandstone is grey to light grey in color, fine to medium-grained, tuffaceous and calcareous, and is well bedded. It is generally 100 – 250 m thick, however it forms the bed over 400 m thick in the Sumagui River.

The alternating layers of sandstone and mudstone to siltstone are well exposed around the Pula River, with the thickness of each bed ranging from 20 – 100 cm. The sandstone and mudstone are of a tuffsceous and calcareous nature.

Mudstone to siltstone is grey in color, calcareous and fossiliferous, and is well bedded. This is well cropping out in the Sumagui River, where the thickness is more than 400 m.

Tuff is encountered at the tributary of the Pula River. It is light grey in color and fine-grained. It is an andesitic tuff, and the crystals of plagioclase, hornblende and pyroxene are observed on the outcrops.

Limestone lying above the basal conglomerate in the middle stream of the Bongabong River is a light brown in color, and grades upward into calcareous conglomerate or sandstone.

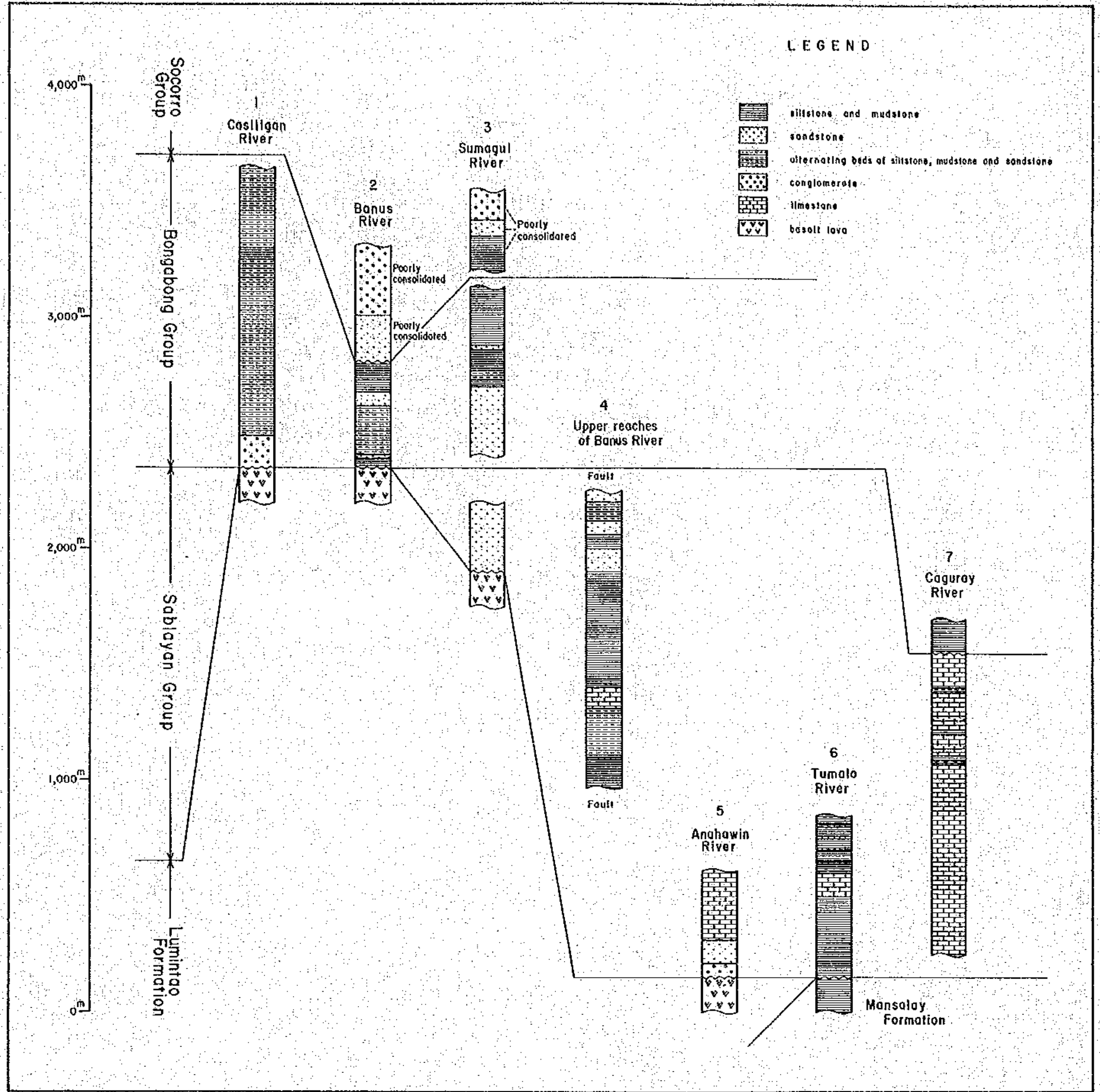

Fig. I-7 Geological Columnar Section of Cenozoic Rocks

Geological structure: In the eastern portion, this group exhibits a normal structure with a slight unduration by minor foldings, and it strikes NNW–SSE and dips 10 – 30° E. In the western portion, although the gentle syncline is formed to the southeast of Sablayan and to the north of San Jose, the beds is considered to be horizontal as a whole estimating from the distribution of outcrops.

Stratigraphic relationship: This group unconformably overlies the Sablayan group and other lower groups. It also unconformably covers the intrusive rocks of Ultramafic complex and quartz diorite.

Age: As states above, this group yields abundant fossils of smaller foraminifera. This time, planktonic foraminiferas of late Pliocene to early Pleistocene ages were obtained from the mudstone in the middle stream of the Caguray River, as shown in Table A–1-2. Hashimoto & Sato (1969) reported that planktonic foraminiferas of Pliocene age were obtained from the Famnoan formation at Balahid located in the middle reaches of the Bongabong River. Data of fossils and stratigraphic relationship indicate that the Bongabong group belongs to Pliocene age.

(4) Socorro group

The name of this group was tentatively given in Phase I to the layers composed of volcanic rocks and sedimentary rocks of the late Pliocene to Pleistocene ages, and it is followed in this report. The group includes the Oreng formation and the Balanga formation of Teves (1953), as well as formations proposed by Weller & Vergara (1955), which are the high level sand & gravel and the Eplog lava flows.

Distribution: This group is exposed extensively from Puerto Galera to Roxas through the area of Socorro, in the eastern sections. Besides, it also covers the area around San Jose, Sablayan and Mamburao.

Thickness: Approximately 400 m.

Rock facies: This group consists of several types of beds such as terrace deposits, tuff, tuffaceous mudstone, reef limestone, andesite lava and basalt lava.

Terrace deposits crop out well in San Jose, Sablayan, Bongabong, and in the middle stream of the Bansud River. It is primarily composed of unconsolidated gravel beds with intercalations of sand beds locally. The gravels consist of several kinds of rounded to subrounded rocks, and are poorly sorted. Rarely, these beds are poorly bedded.

Tuffaceous mudstone is distributed in San Teodoro and Socorro. It is grey to dark green in color, poorly consolidated, and poorly bedded. Smaller foraminiferas are rarely in it.

Tuff is encountered in San Teodoro. It is light grey in color, porous, vitritic and andesitic, and includes volcanic glass and pumice. It rarely shows a clear bedding.

Reef limestone is exposed on the west and south of San Jose, and also in Ilin and Ambulong Islands. It is well bedded and yields abundant larger foraminiferas.

Lava flows crops out at Calapan, the eastern shore of Lake Naujan, Mt. Dumali, Eplog hill and Mauhao. These consist of biotite-hornblende andesite at Calapan and Mt. Naujan, pyroxene andesite bearing extremely small amounts of biotite and hornblende at the eastern shore of Lake Naujan and the Mt. Dumali, hornblende andesite at Eplog Hill, and of pyroxene andesite and basalt at Mauhao.

Geological structure: The Socorro group generally shows a very gentle structure except the NW–SE trending foldings formed in limestone to the east of San Jose. The group strikes NNW–SSE and dips 5 – 10° E in the eastern part, and is almost horizontal in the western part.

Stratigraphic relationship: This group covers the older beds with an angular unconformity in the northern and southern parts, and in the eastern parts either gentle angular or parallel unconformity.

Age: In Phase I, the larger foraminifera of Pleistocene age was reported from the calcareous matrix of conglomerate in this group. The Sumagui formation proposed by Hashimoto & Sato (1969) is reported as Pliocene to Pleistocene age, and it is included in the Socorro group. These facts and the stratigraphic relationship indicate that the age of this group is late Pliocene to Pleistocene.

(5) Alluvial deposits

These are distributed along shores of the eastern and western sections, and are widely exposed from Calapan to Victoria. It is composed of gravels and sand in areas along the main rivers, but in other areas it is of muddy materials.

1–4 Intrusive Rocks

1–4–1 Ultramafic Complex

The Ultramafic complex widely crops out in Mindoro Island and is mostly distributed in the areas covered by Baco group, particularly Lumintao formation.

Mindoro Island lies within the Ilocos-Mindoro ophiolite belt. It is reported that the most complete ophiolite sequence in the Philippines is observed in Zambales where is situated in this ophiolite belt (Balce et al., 1981). Moreover, it is stated in Bureau of Mines (1974) report that the Ultramafic complex of Mindoro are generally thrusted or upfaulted.

By the investigation of last and this phase, the following field evidence was collected on the Ultramafic complex; it shows a discordant structural relationship with the Mansalay formation and Lumintao formation, the small bodies of the complex are distinctly intruded into those formations, no evidence is observed to suggest thrust fault along the complex and as well on the both sides of extension, and the huge blocks of metamorphic rocks are in and around the complex. These field evidences support the idea that the Ultramafic complex has intruded as the shape of solid emplacement.

Distribution and scale: This complex is distributed in the east side and the west side separately. As shown in Fig. I–3, the complex of the east side consists of Ogos body, Bongabong body and Balete bodies, while the west side is composed of Pintin body, Liwliw body, Igsoso body, San Vicente body and Paluan bodies. As for the scale of these bodies, the Bongabong body is the biggest, 34 km in length and 8 km in width. Others are shown in Table I–3.

Rock facies: The main consituent rocks are comprised of harzburgite, dunite and lherzolite.

Dunite is black to dark green in color for fresh part, and is dark green to dark greyish green in color for altered or weathered part because of serprentinization. It has a smooth surface which sometimes shows brown in color. Containing very few quantity of pyroxene, it is easily discriminated from other types in the field as far as it has not been strongly affected by serpentinization. Under the microscopic observation, some of dunite show a cataclastic texture and contain brownish crystals of spinel group, probably picotite. Consequently, most of the dunite in the area are a cumulate type, and some are a tectonic type.

Harzburgite is dark green, light greenish brown and black in color, and most of them are subjected to serpentinization. It is easy to differentiate it from dunite depending on the quantity of pyroxene, but difficult to do it from lherzolite. Under the microscopic observation, most of orthopyroxene altered to bastite bearing a bastite texture, moreover, phenocrysts mainly exhibit a cataclastic texture. Some harzburgites contain both chromite and orthopyroxene which show an exsolution texture. Hence it is inferred that those are a cumulate type although most of the harzburgite are a tectonite type in this area.

Lherzolite has less volume than the above two kinds of rocks in the area. It is dark grey in color for fresh part, and dark green in color for altered part. All samples of lherzolite collected in this phase contain orthopyroxene with exsolution lamellaes and do not show a cataclastic texture. It is presumed according to the above evidence that those are a cumulate type.

Besides the above rocks, the complex includes following rocks; orthopyroxinite and hornblendite as ultramafic rocks, gabbro, diorite porphyry and trondhjemite. Several kinds of gabbro can be distinguished under the microscope as follows: augite gabbro, augite-hypersthene gabbro, hornblende-hypersthene gabbro, hornblende-augite-hypersthene gabbro and hornblende gabbro. These are in a small scale and a few m to several hundred m in width.

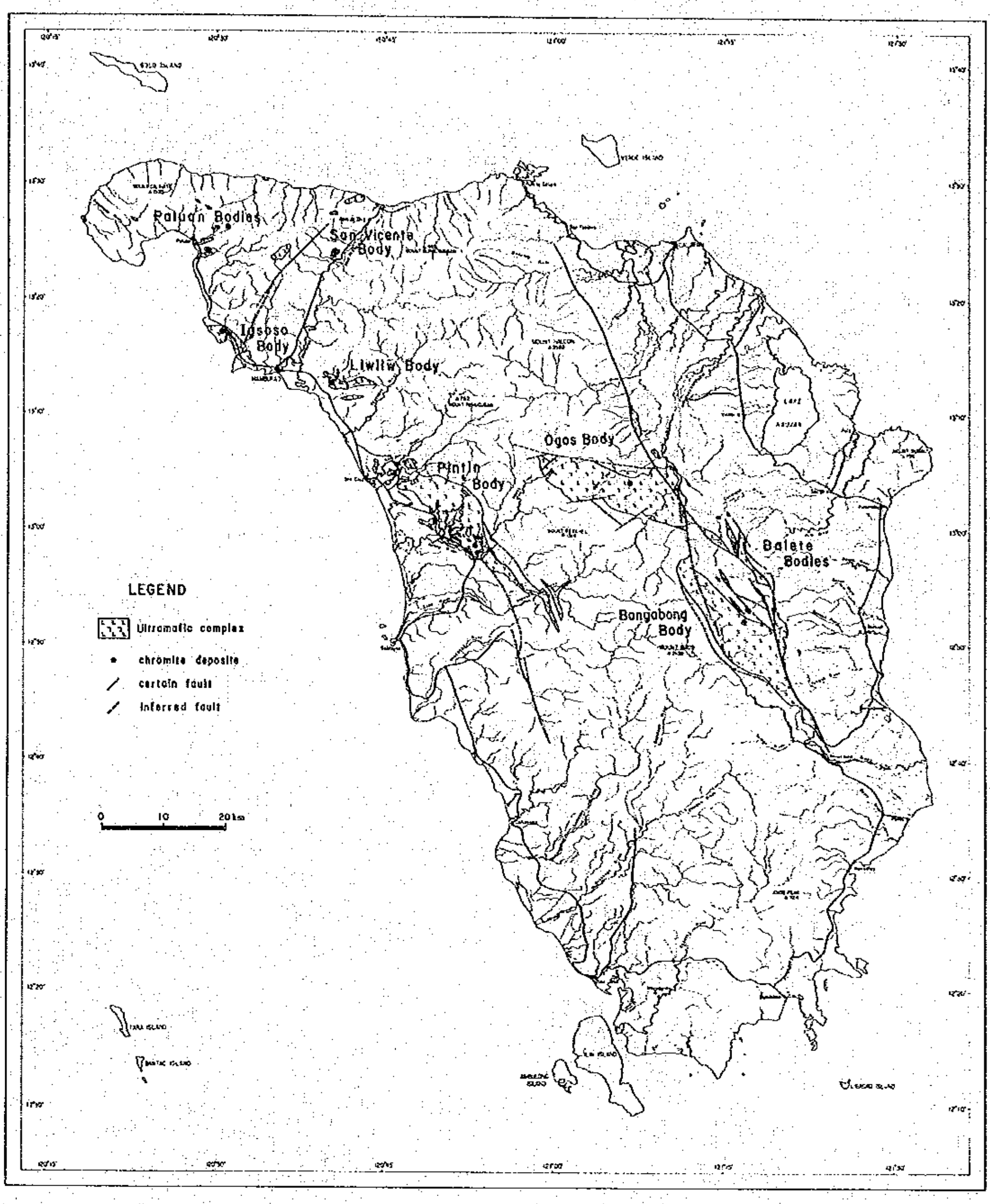

Fig. I-8 Location Map of Ultramafic Complex

Table I-3 Characteristics of Ultramafic Complex

Name of body or bodies	Scale (km)	Main constituent rocks	Accompanied rocks	Chemical composition*	Serpentinization	Chromite deposit
Ogos	22x10	dunite > harzburgite · lherzolite		84 ~ 86	weak	present (w: 5m)
Bongabong	34x8	harzburgite > dunite · lherzolite	orthopyroxinite, hb gabbro au gabbro au · hy gabbro	86 ~ 90	moderate to weak	present (w: 0.5m+)
Balete	max. 7x1	harzburgite > dunite	au gabbro hb gabbro	86	strong	?
Pintin	40x9	harzburgite > dunite · lherzolite	orthopyroxinite, au·hy gabbro hornblendite, hb·au·hy gabbro au gabbro	82 ~ 86	strong	present (w: ?)
Liwliw	8x3	harzburgite · lherzolite > dunite	hornblendite au·hy gabbro hb·hy gabbro	84	strong	present (w: 0.4m+)
Igsoso	10x3	dunite > harzburgite	au·hy gabbro, au gabbro au·hb gabbro, trondhjemite	86	moderate to strong	present (w: 0.4m+)
San Vicente	1.5x1	harzburgite	au·hy gabbro trondhjemite	84	strong	present (w: 2.0m+)
Paluan	max. 2x1	dunite > harzburgite	diorite porphyry	84	strong	present (w: 0.7m)

hb: hornblende, au: augite, hy: hyperthene
* : 100 x MgO/(MgO + Total FeO) on Ultramafic rocks

As shown in Table I–3, all of the body have almost same assemblages of constituent rocks except the Ogos body. But the accompanied rocks will be found in the Ogos body in future survey. Comparing the ratios of constituent rocks of complex bodies, dunite is predominant in the Ogos body, Igsoso body and Paluan bodies, while harzburgite is predominant in the Bongabong body, Pintin body, Liwliw body, San Vicente body and Balete bodies. The chromite deposit was founded in all of these bodies except in Balete bodies.

The discriptions of the microscopic observation for representative samples are as follows:

Dunite (KR2–100)

Texture: Holocrystalline, equigranular.

Constituent minerals: These are composed mostly of olivine which has been subjected to serpentinization along fracture developed like networks. Besides this, a small amount of euhedral chromite 0.1 – 0.5 mm in size is observed.

Harzburgite (KR2–094)

Texture: Holocrystalline, equigranular.

Constituent minerals: Primary minerals consist mainly of olivine,which is accompanied by enstatite. Olivine is completely altered to serpentine with a small quantity of fine-grained opaque minerals. Enstatite of 1 – 3 mm in size is observable sporadically, and it is almost completely altered to serpentine showing a bastite texture. In addition, enstatite has lamellaes of augite.

Besides these minerals, picotite of 1.5 mm in size is present.

Lherzolite (KR2–095)

Texture: Holocrystalline, equigranular.

Constituent minerals: In order of amounts, primary minerals are as follows; olivine, enstatite, and augite. Olivine is altered to a network of serpentine with some amounts of opaque minerals. Enstatite is 1 – 3 mm in size and contains lamellaes of augite, and is significantly altered to serpentine and chlorite. Augite is 0.5 – 3 mm in size and partially changed to serpentine and chlorite. Besides these, small amounts of chromite of 1 – 3 mm in size and picotite 0.2 – 2 mm are observable.

Orthopyroxinite (KR2–026)

Texture: Holocrystalline, equigranular.

Constituent minerals: These are composed of enstatite with some amounts of picotite. Enstatite is 0.2 – 3 mm in size and subhedral to anhedral, and partly contains lamellaes of augite. It also shows a unduratory extinction. Picotite is subhedral and 0.2 – 0.5 mm in size.

Hornblendite (KR2-025)

Texture: Holocrystalline, equigranular.

Constituent minerals: Primary minerals are composed mainly of hornblende which is subhedral to anhedral and 1 – 5 mm in size. Hornblende is brown in color and bears distinct pleochroism. It is partly altered to chlorite, actinolite and sphene. These minerals are affected by crushing.

Augite-hypersthene gabbro (KR2–030)

Texture: Holocrystalline, equigranular.

Constituent minerals: Main constituent minerals are composed of plagioclase, augite and hypersthene, and the ratio of augite to hypersthene is almost equal. Plagioclase is subhedral to anhedral and 0.5 – 1.2 mm in size. Augite is 0.3 – 1 mm in size and partially shows a poikilitic texture. Moreover, it is partly replaced by epidote and chlorite, and some augites contain lamellaes of orthopyroxene. Hypersthene of 0.3 – 1.2 mm in size contains a small amount of lamellaes of clinopyroxene, and is partly altered to chlorite. Besides the above minerals, a little opaque minerals, apatite and sphene, are also observed.

Hornblende gabbro (KR2–063)

Texture: Holocrystalline, equigranular.

Constituent minerals: Main constituent minerals are composed of plagioclase and hornblende. Plagioclase is 0.5 – 3 mm in size, euhedral to subhedral, and is replaced by sericite in a vermicular form. Hornblende of 0.3 – 2 mm in size, shows distinct pleochroism of green color, and is partly altered to chlorite, sphene and actinolite. Accessory opaque minerals and apatite are also observed.

Geological structure: The alignment of the complex bodies shows two trends, namely NW–SE and N–W, and it is characterized by area. In the east both the Bongabong body and Balete bodies trend NW–SE, while in the central the Ogos body trend E–W. Moreover in the west the Pintin body trends NW–SE, while in the northwest both the Liwliw body and Paluan bodies trend E–W but the Igsoso body trends NW–SE.

The large-scale bodies are accompanied with the alternating layers composed mainly of dunite and harzburgite. Each layer is a few cm to less than 10 m in thickness. Considering the trend of this structure and the distribution of each type of rock, the structures in five bodies are presumed as follows.

Ogos body; The zonal structure in a semicircular form, which trends E–W in the central part, NW–SE in the eastern part and NE–SW in the western part.

Bongabong body; The zonal structure trending NW–SE.

Pintin body; In the central and southern part, the zonal structure trends NW–SE, but it tends to trend E–W in the northern part.

Liwliw body; The zonal structure trending WNW–ESE.

Igsoso body; In the northern part, the body shows the E–W to ENE–WSW trending zonal structure.

Detailed survey for strucres in Ultramafic complex should be done to identify the chromite horizon.

Age: The Ultramafic complex intrudes into the Baco group, and these are unconformably overlain by the Mamburao group. Hence the age of intrusion is assumed to be Cretaceous.

1–4–2 Basic Rocks

Dolerite and gabbro and exposed in the area. Of the gabbro, one which is accompanied by the Ultramafic complex, was already described.

Disbribution and rock facies: Dolerite and gabbro well crop out in the Lumintao River and Rayusan River. Most of these intrude into the Lumintao formation, and some into the Mansalay formation.

Dolerite is fine-grained and greyish green to dark green in color. It is mostly accompanied with marginal facies, but rarely the facies is vague. It forms dikes whose width are generally less than 10 m, and even at its largest do not exceed 100 m. The dikes in the Lumintao River trend mainly NE–SW and the dikes in the Rayusan River trend mostly N–S.

Gabbro is coarse-grained and greyish green to dark green in color. It intrudes into the beds near the boundary between the Lumintao formation and the Mansalay formation with a slightly discordant relation, and it is considered to be a small-scale phacolith. The width of outcrops is 100 – 150 m. The gabbro exposed in the Lumintao River is associated with several veins of gabbroic pegmatite with 10 – 30 cm wide.

These dolerite and gabbro are though to be intrusive rocks related to the volcanism of the Lumintao formation.

The results of microscopic observation are as follows.

Dolerite (KR2–011)

Texture: Subophitic texture.

Constituent minerals: These are mainly composed of euhedral to subhedral plagioclase lath of 0.3 – 1.5 mm in size and euhedral augite of 0.2 – 1 mm in size. Bisides accessory opaque minerals, chlorite and albite altered from mafic minerals are observable.

Gabbro (KR2–015)

Texture: Holocrystalline, equigranular.

Constituent minerals: The main constituent minerals, in order of abundance, are plagioclase, augite and hypersthene. Plagioclase is euhedral to subhedral and 0.5 – 3 mm in size, and it is partly replaced by sericite. Augite is subhedral to anhedral and 0.3 – 3 mm in size, and is altered to chlorite along fractures. A little anhedral hypersthene of 0.4 – 0.6 mm in size, opaque minerals and sphene are also present.

Age: These rocks were intruded at the stage of the Lumintao formation.

1–4–3 Acidic to Intermediate Rocks

These are granodiorite, quartz diorite, diorite and diorite porphyry, intruding into the Halcon metamorphics, the Baco group and the Sablayan group. Their scale is quite small, and the largest body is 4 km in length and 1.5 km in width.

Distribution: These rocks occur mostly in the northern area, except the distributions in Villacervesa, in the upper reaches of the Casiligan River and Bongabong River.

Rock facies: Granodiorite is coarse-grained and leucocratic, whose main constituent minerals are comprised of muscovite, quartz and plagioclase. Quartz diorite shows grey to dark grey in color, and the main minerals are hornblende, plagioclase and quartz. Diorite and diorite porphyry appear dark green to dark grey in color, and are fine to medium in grain size. These show a higher color index, and the constituent minerals consist chiefly of horblende and plagioclase.