Table-5 Correlation Coefficient between Each Element

All Data

	Cu	Pb	Zn	Ag	Co	Ni	Mn	Mo	As	Hg	Cr
Cu	1.000										
Pb	0.185	1.000									
Zn	0.537	0.276	1.000								
Ag	0.055	0.330	0.071	1.000							
Co	0.317	-0.060	0.244	-0.020	1.000						
Ni	0.146	-0.023	0.050	0.026	0.795	1.000					
Mn	0.408	0.236	0.638	0.136	0.478	0.231	1.000				
Mo	-0.010	0.077	-0.038	-0.004	-0.035	-0.049	-0.139	1.000			
As	0.232	0.208	0.196	0.080	-0.026	-0.002	0.187	0.135	1.000		
Hg	0.124	0.353	0.126	0.219	0.175	0.190	0.229	0.022	0.128	1.000	
Cr	-0.155	-0.082	-0.251	-	0.755	0.917	0.092	-0.129	-0.034	0.127	1.000

4-2-2 Analysis for Heavy Mineral Samples

1) Analytical method

A total of 370 heavy mineral samples were collected by panning in the Northern Sierra Madre Area. Statistical analysis was carried out on microchemical analysis results.

These samples were taken from the down side of junction of streams. They were reduced from 3 kgs to 20 grams by panning in each places. On these samples, microchemical analysis for Au, Ag and Ga were carried out by atomic absorption method at PETROLAB.

The results of this are shown in Appendix-8.

On these microchemical analysis results, logarithmic normal dispersion, mean value and standard deviation were calculated similar to the stream sediment samples analysis. A threshold value of 1.5 has been classified from the data.

The statistical values are shown in Table- 6.

Table-6 Statistical Value on the Geochemical Analysis of Heavy Mineral Samples in the Northern Sierra Madre Area

	$\bar{x}$ value	1 σ value	1.5 σ value	2 σ value	Maximum value	Minimum value
Au (ppb)	30.5	282.0	856.9	2,603.6	4,600	-20
Ag (ppb)	75.3	183.6	286.8	447.8	650	-100
Ga (ppm)	12.2	18.2	22.3	27.2	32.6	-2

2) Identification of constituent minerals of heavy mineral samples

Constituent minerals were identified by binocular microscope on random 40 specimens (each 10 specimens picked up from the Northern Sierra Madre I - IV Areas). Magnetite is recognized as main constituent mineral and other constituent minerals are in the order of chromite, ilmenite and hematite.

Details are shown in Table- 7.

Table-7 Constituent Minerals of Heavy Mineral Samples in the Northern Sierra Madre Area

Cauayan Area

Order	1	2	3	4	5	6	7	8	9	10
Mineral Name	Magnetite	Chromite	Ilmenite	Olivine	Pyroxene	Hornblende	Hematite	Quartz	Zircon	Iron Oxide
Range	70 - 10%	30 - 5%	15 - 2%	15 - 2%	30 - 2%	23 - 1%	5 - 2%	5 - 1%	2 - Tr%	1 - 0%
Mean	48	19	8	7.5	7	4.5	3	2	0.6	0.5

Ilagan Area

Order	1	2	3	4	5	6	7	8	9	10
Mineral Name	Magnetite	Pyroxene	Plagioclase	Chromite	Olivine	Hornblende	Hematite	Quartz	Ilmenite	Zircon
Range	90 - 3%	22 - 3%	25 - 2%	20 - 2%	16 - 2%	15 - 2%	15 - 1%	10 - 1%	10 - 2%	1 - Tr%
Mean	46	10	9	8	7	6	5	4	3	0.3

Palanan Area

Order	1	2	3	4	5	6	7	8	9
Mineral Name	Magnetite	Chromite	Pyroxene	Hematite	Plagioclase	Limonite	Ilmenite	Hornblende	Quartz
Range	72 - 15%	78 - 2%	25 - 1%	8 - 2%	8 - Tr%	5 - 1%	5 - Tr%	3 - Tr%	2 - Tr%
Mean	44	37	6	5	3.5	3	1	1	0.5

Tuguegarao Area

Order	1	2	3	4	5	6	7	8	9
Mineral Name	Magnetite	Pyroxene	Chromite	Hornblende	Plagioclase	Hematite	Ilmenite	Limonite	Quartz
Range	82 - 50%	20 - 2%	12 - 3%	20 - 3%	10 - 2%	4 - 2%	3 - 1%	2 - 1%	4 - Tr%
Mean	66	7	7	6	6	3	1.9	1.6	1.6

4-2-3 Local Distribution of Anomalous Values

1) Univariate analysis for stream sediment samples

Anomalous values in each lithological code are classified in the following range limit.

These classified anomalous values were plotted in 1 : 250,000 scale sample locality map with symbols ●, ▲ and ■.

Local features of anomalous value in each elements are shown in the map on the distribution of anomalous values. (attached map 3-1·2)

Analytical Value (Z)	Symbol
1σ value $\leqq Z < 1.5\sigma$ value	●
1.5σ value $\leqq Z < 2\sigma$ value	▲
2σ value $\leqq Z$	■

Cu; Accumulation zones of high anomalous values (2σ value $\leqq$ Z) are observed at Miocene sediments at the east side of Minuri, Oligocene sediments at 14 kms ENE of Ilagan, Palaeocene sediments and pre-Tertiary basalt in the southern part of Palanan Area (III), pre-Tertiary ophiolite, basalt and chert at 20 kms N of Palanan, at the contact zone between Palaeocene sediments and dioritic intrusive rock at the west side of Baguio Cove in the most northern part of Palanan Area (III), Paleocene sediments in upstream of Paret River at 35 kms NE of Tuguegarao Area (IV) and Paleocene sediments at 20 kms E of Gattaran in the northernmost part of survey area.

Pb; Accumulation zones of high anomalous values (2σ value $\leqq$ Z) are observed at Palaeocene sediments and pre-Tertiary basalt and diorite in contact with the above mentioned rocks at the east side in the southern part of the survey area (overlaped zone with Cu anomaly), in the Palaeocene sediments around Mt. Dos Cuernos at 30 kms ESE of Tuguegarao and contact zone between Miocene limestone and Pliocene sediments 25 kms NE of Tuguegarao.

Zn; Accumulation zones of high anomalous values (2σ value $\leqq$ Z) are observed at Pliocene limestone in the middle part of Cauayan Area (I), Paleocene sediments and pre-Tertiary basalt at the east side in the southern part of the survey area, in the ophiolite to Palaeocene sediments at its east side 20 kms N of Palanan, upstream of Dikatayan River 12 kms SW of Bolos Cove in the east coast and Paleocene sediments at 20 kms ENE of Gattaran in the northernmost part of survey area (overlapped zone with Cu anomaly).

Co; Accumulation zones of high anomalous values (2σ value $\leqq$ Z) are observed at pre-Tertiary ophiolite in the northern and southwestern part of Digollorin Point of the east coast, pre-Tertiary ophiolite in the southern part of Divilican Bay of the east coast and Paleocene sediments in the western part of Maconacon Cove of the east coast.

Ni; Accumulation zones of high anomalous values (2σ value $\leqq$ Z) are observed around pre-Tertiary ophiolite in the northern and southwestern part of Digollorin Point in the east coast (overlapped zone with Co anomaly partly), along the fault at the contact zone between pre-Tertiary ophiolite and Palaeocene sediments in the southern part of Divilican Bay, in Palaeocene

sediments at the west side of Maconacon Cove (overlapped zone with Co anomaly), Miocene limestone at 15 kms E of Tuguegarao and Pliocene sediments at 15 kms E of Dabbas.

Mn; Accumulation zones of high anomalous values (2σ value $\leq$ Z) are observed at Palaeocene sediments and pre-Tertiary basalt at the eastern slope in the southernmost part of the survey area (overlapped zone with Cu, Pb and Zn anomalies), at contact zone between Paleocene sediments and Miocene - Pliocene sediments in the eastern part of San Mariano, ophiolite in the southern part of Divilican Bay, its neighboring Paleocene sediments (overlapped zone with Co and Ni anomalies partly) and at contact zone between Pliocene and Pleistocene sediments 10 kms N of Tuguegarao.

As; Accumulation zones of high anomalous values (2σ value $\leq$ Z) are observed at Palaeocene sediments and pre-Tertiary basalt at the eastern slope in the southernmost part of the survey area (overlapped zone with Cu, Pb, Zn and Mn anomalies), in the northern part of Digollorin Point in the east coast (overlaped zone with Co and Ni anomalies), at contact zone between Palaeocene sediments and dioritic intrusive rock west of Maconacon Cove and contact zone between Paleocene sediments and dioritic intrusive rock 20 kms E of Tuguegarao.

Hg; Accumulation zones of high anomalous values (2σ value $\leq$ Z) are observed at Palaeocene sediments and pre-Tertiary basalt at the eastern slope in the southernmost part of the survey area (overlapped zone with Cu, Pb, Zn, Mn and As anomalies), Miocene sediments the east side of Minuri in the southwestern part of Cauayan Area, younger limestone in the northern part of Digollorin Point in the east coast, pre-Tertiary ophiolite in the southern part of Divilican Bay in east coast and Pleistocene sediments at the north side of Nagbalayan 25 kms SSE of Ilagan.

Mo; Many Mo analytical values are under detection limit.
Accumulation zones of high anomalous values (2σ value $\leq$ Z) are observed at contact zone between Paleocene sediments and dioritic intrusive rock 20 kms SSE of San Mariano, contact zone between dioritic intrusive rock which extend to a NW direction 6 kms W of Maconacon Cove in the east coast and Palaeocene sediments and Pliocene sediments at 12 kms E of Dabbao in the northern part of the survey area.

Cr; Accumulation zones of high anomalous values (2σ value $\leq$ Z) are observed at the zone extending over 20 kms NS, which are associated with the fault along the boundary between the pre-Tertiary ophiolite in the southern part of Divilican Bay in the east coast and its western neighbouring Paleocene sediments.
Cr analysis was carried out only Palanan Area in the east coast. Therefore the Cr anomaly on the inland areas along the Cagayan River is not clear.

Ag; Almost all Ag analytical values are under detection limit.
Accumulation zone of high anomalous values is observed at dioritic intrusive rocks at the western slope of the Northern Sierra Madre.
Ag analysis was not carried out for the Palanan Area. Therefore the Ag anomaly on the east coast area is not clear.

2) Univariate analysis heavy mineral samples

Extracted anomalous values from statistical procedure are classified below. These classified anomalous values are plotted with symbol ● , ▲ and ■ on 1 : 250,000 scale sample location map distributed. Features of anomalous value in each elements are shown in the map on distribution of anomalous values. (attached map-4).

Au; Extracted anomalous values are 2 high anomalous values (2σ value $\leq$ Z) and 2 low anomalous values (1σ value $\leq$ Z $<$ 1.5σ value). These are seen at Cauayan Area in the southern part of the survey area. One high anomalous value is observed near the boundary zone between Palaeogene Abuan River Formation and the dioritic intrusive body at the western slope of the Northern Sierra Madre. It overlap with Cu, Co and Ni anomalous zones based on stream sediment samples. The other high anomalous value is observed in the Pliocene Cabagan Formation at 40 kms SSE of Cauayan. It overlap with As, Zn and Cu anomalous zones.

Ag; Extracted values are 7 high anomalous values, 5 middle anomalous values and 6 low anomalous values. The two high anomalous values overlap with the Au anomalous zone in the southern part of Cauayan Area. The other high anomalous values overlaps with Cu, Zn and As anomalous zones. One is recognized at the eastern slope of the southern range, two of these are at the Bicobian Area in the southern part of Divilican Bay east coast and the other two are in the diorites at the upstream of Dikatayan River in the east coast of the northern part.

Ga; Number of extracted anomalous values are over 50. The high and middle anomalous values are observed near the contact zone between the Callao limestone and Lubuagan Formation 37 kms SE of Cauayan, near contact zone between the Dipadian Formation and the Abuan River Formation 30 kms SSW of Palanan and in the Abuan River Formation in the southwestern part of Divilian Bay in the east coast. These overlap with Cu and Zn (partly Co and Mn) anomalous zones of the stream sediment samples.

5. SYNTHESIS

5. Synthesis

5-1 Summary

dipping

5-1-1 Geology and Structure

The Northern Sierra Madre Area which is the survey area is located at the northeast side of Luzon Island.

The N-S trending Northern Sierra Madre range divides the survey area into an easternen and western.

At the east tectonic region, the Paleocene Abuan River Formation and Dipadian River Formation are distributed with N-S striking intrafolial faults with dips as steep as 40°. At the east side of these faults, the basement consists of an ophiolite suite (Isabela Ultramafic Complex) and the Mesozoic consists of Bicobian basalt and Dikinaraman chert distributed along the east coast of the southern part of Divilican Bay. Their Mesozoic are covered by Pliocene and Pleistocene Formations unconformably in the central portion of east coast. At the west tectonic region, the Lowest Paleocene Abuan River Formation which underlic mountain range is intruded by Eocene quartz diorite at its eastern side. This quartzdiorite is distributed widely an area extent of 140 kms NS and 12 kms EW in the southern part of survey area with many cupolas. The Abuan River formation dips to west side with an averaged 20°, exhibiting gentle dipping fold which is in contrast with those formations of the east tectonic region. The Oligocene Dibuluan Formation, Miocene Lubuagan Formation, Pliocene Cabagan Formation and Pleistocene Ilagan Formation are distributed with N-S strikes in this order at the west tectonic region.

At the Dabbao basin in the northern part of Survey Area, the NS wavy fold curves to the NE and the Tertiary formations accompanied with EW basin structures are seen around the basin.

5-1-2 Mineralization

The mineralization corresponds well with the above mentioned rock formations. Orthomagmatic chromite deposits are related to the ophiolite, Mesozoic bedded cupriferous sulphide deposit and bedded manganese deposits are seen at the east tectonic region. At the west tectonic region, epithermal and disseminated deposits are seen mainly around quartzdioritic intrusive bodies.

5-1-3 Relationship between Geochemical Survey and Mineralization

1) Univariate analysis of stream sediment samples

In this survey, a total of 4,997 stream sediment samples were collected and analyzed by atomic absorption method (AAS) for Cu, Pb, Ag (except for the Palanan Area (III)), Zn, As, Hg, Ni, Co, Mn, Mo and Cr (only for the Palanan Area (III)). The results of these analysis were treated by statistical univariate analytical procedures. This study has shown intimate relationship between geology and mineralization. For instance, the accumulation of many anomalous values were observed around Mesozoic bedded deposits and orthomagmatic chromite deposits, and accumulation of Cu, Zn and As anomalous values were recognized around quartzdioritic intrusive bodies.

The anomalous zones which are assumed to exhibit intimate relationship mineralization are as follows;

1 Polymetallic anomalous zones of Cu, Pb, Zn, As, Hg and Mn in Paleocene sediments, pre-Tertiary basalt and around intrusive quartzdiorite at the east side of the range in the southernmost part of the survey area.

2 District of pre-Tertiary ophiolite, basalt and chert 20 kms N of Palanan.

3 Ni, Cr anomalous zones along the fault that passed between the pre-Tertiary ophiolite and Paleocene sediments in the southern part of Divilican Bay.

4 Cu, Zn, As and Hg anomalous zones in Pliocene sediments 7 kms NE of Minuri in the southwestern part of the survey area.

5 Cu, Pb, Zn, As and Mo anomalous zones associated with the quartzdiorite intrusive body 10 kms W of Bolos Cove in the northeast coast of the survey area.

2) Univariate analysis for heavy mineral samples

In this survey, a total of 370 heavy mineral samples were collected and analyzed by atomic absorption method (AAS) for Au (ppb), Ag (ppb) and Ga (ppm). The results of this analysis were treated by statistical univariate analytical procedures.

High anomalous zones (2σ value $\leqq$ Z) of Au and Ag show fair concordant relationship to the above mentioned anomalous zones 1 and 4 of the stream sediment samples. High and middle anomalous zones of Ga are noted to accumulate near the contact between the Miocene limestone and sediments and has intimate relationship with the Cu and Zn anomalous zones of the stream sediment samples.

5-1-4 Conclusions

In Northern Sierra Madre Area, orthomagmatic Ni and Cr maineralization, stratabound cupriferous pyritic deposit and manganese deposit in Cretaceous basalt and chart and hydrothermal deposits associated with Tertiary diorite are known. These mineralizations are superior at the eastern side of the Northern Sierra Madre Range in which Cas Chrome and Bicobian etc., operated mines are known. However in the west side no operated mine is known. Mineralization in the westside is almost concentrated around the Tertiary diorite intrusive bodies.

This Tertiary diorite has many rock facies from quartz diorite to granodiorite, all of which include magnetite and are expected relation to metallic mineralizations. The promissing areas which were selected on the basis of related mineralizations and extracted anomalies are as follows.

1) Around Dimakawal mineral showing located at the southern most part of the Northern Sierra Madre Range.

   This anomalous zone consists of poly-metalic anomalies: Cu, Pb, Zn, As Hg and Mn. Country rocks are pre-Tertiary basalt intruded by diorite. Dimakawal (East) and Palig Creek (West) mineral showings are known, Ag anomary of heavy mineral samples was encountered also at the Palig Creek.

2) Around Bicobian mineral showing which located 20 km north of Palanan in the east coast

   This anomalous zone consists of Cu, Zn and Mn anomalies associated with late Cretaceous to Paleocene basalt and chert. The Bicobian mineral showing is known as a stratabound cupriferous pyritic deposit.

3) Cr, Ni and Co anomalous zone associated with the fault zone between the Paleocene series and Pre-Tertiary system.

   Mineral showings are unknown in this zone, but many high and middle grade of anomalies distribute along the fault were noted.

4) Anomaly zone in the Pliocene series 7 km NE of Minuri located at the southwestern part of survey area

   This anomalous zone overlaps Cu, Zn, As and Hg anomalies, Miocene limestone and diorite exposes noted near the site, therefore hydrothermal and contact metamorphic mineralization are expected.

5) Anomalous zone associated with the quartzdiorite 10 km west of Bolos Cove in east coast.

   This anomalous zone overlaps Cu, Pb, Zn, As and Mo anomalies in south Blos River where small diorite stocks and in north Capisayan where mineralized dacite dykes are also known. High grade Mo anomalies are especially associated with the diorite. Porphyry copper type mineralization is expected.

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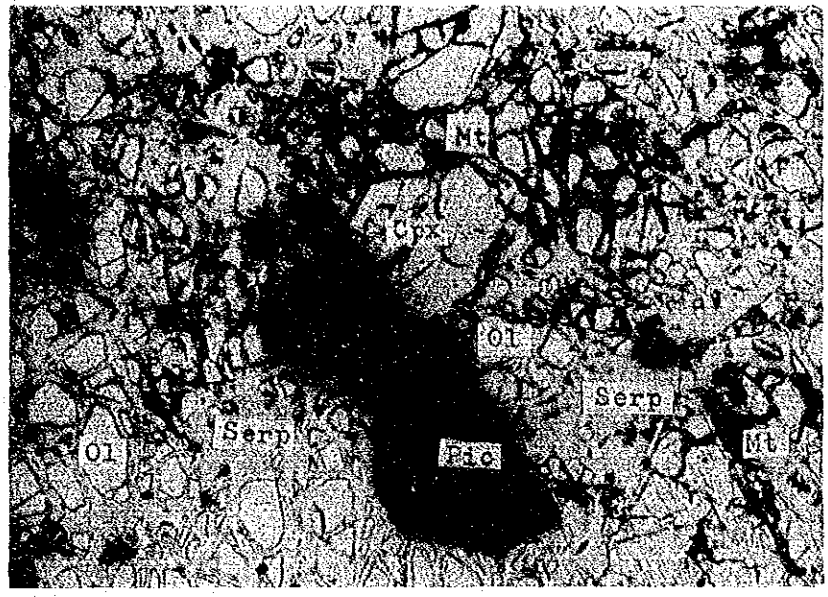
APPENDICS

Appendix 1 Microphotograph (Thin Section)

Palanan Area
(Thin Section Micro-photograph)

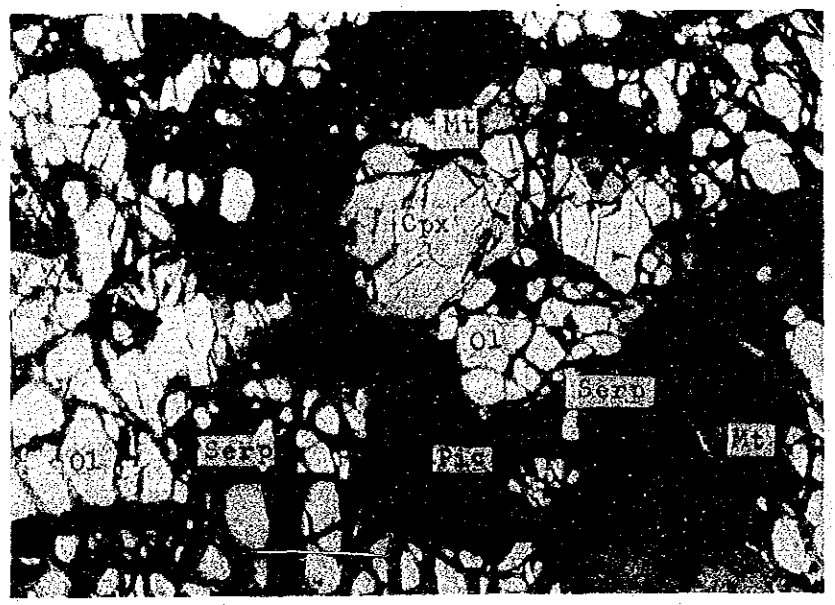


Mt ; Magnetite
Pic ; Picotite
Cpx ; Clinopyroxene
Ol ; Olivine
Sep : Serpentine

Parallel Nicol

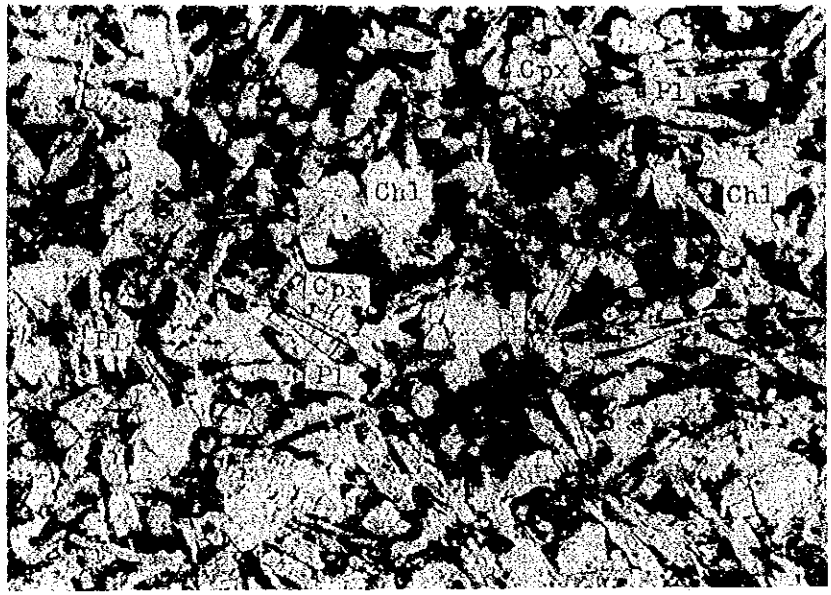
0.5 mm

Lherzolite, (Sample No. CA006) in Isabela Ultramafic Complex
Locality ; East Coast Dinatadmo Point SW 4 Km
Main mineral ; Magnetite, Picotite, Clinopyroxene, Olivine, Serpentine



Cross Nicol

0.5 mm



Cpx ; Clinopyroxene
Pl ; Plagioclase
Chl ; Chlorite

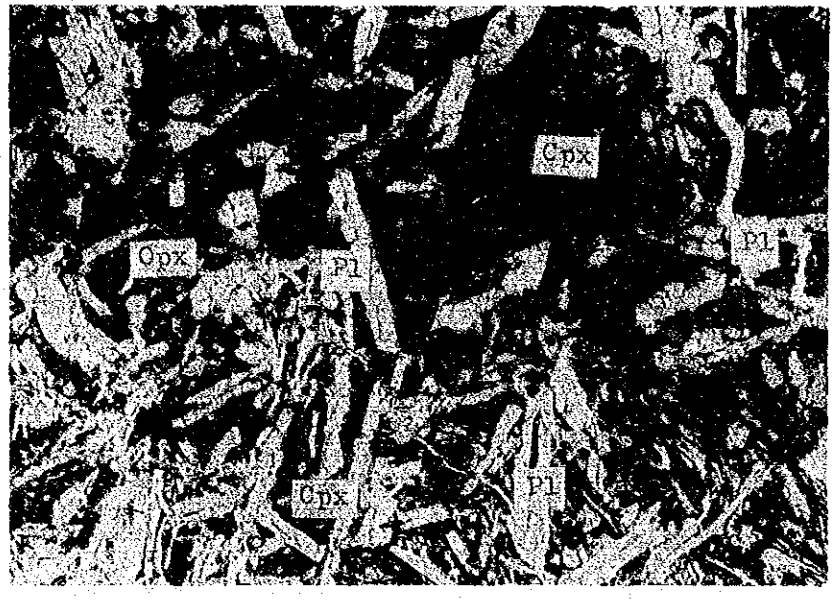
Parallel Nicol

0.5 mm

Basalt, (Sample No. CA009) in Bicobian Basalt
Locality ; East Coast Dinapiqui NW 10 Km
Main mineral ; Clinopyroxene, Plagioclase, Chlorite

Cross Nicol

0.5 mm

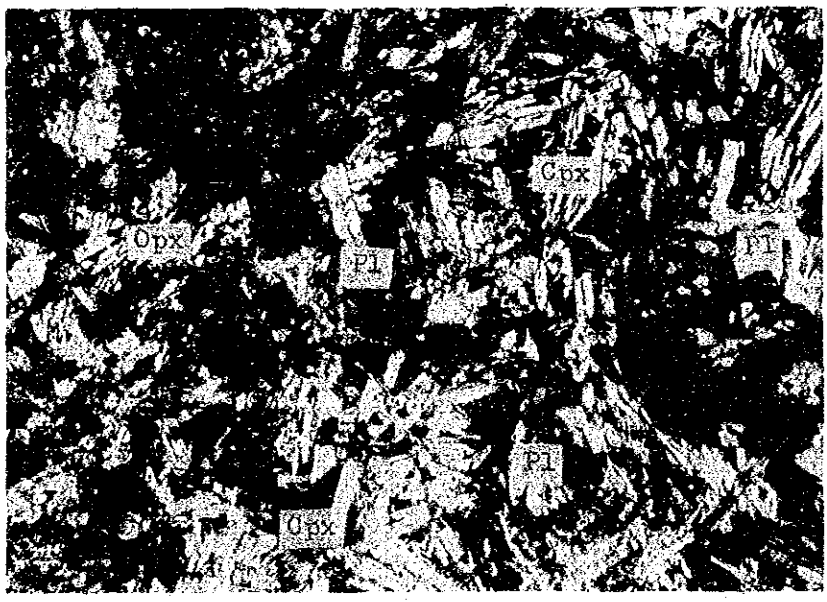


Opx ; Orthopyroxene
Cpx ; Clinopyroxene
Pl ; Plagioclase

Parallel Nicol

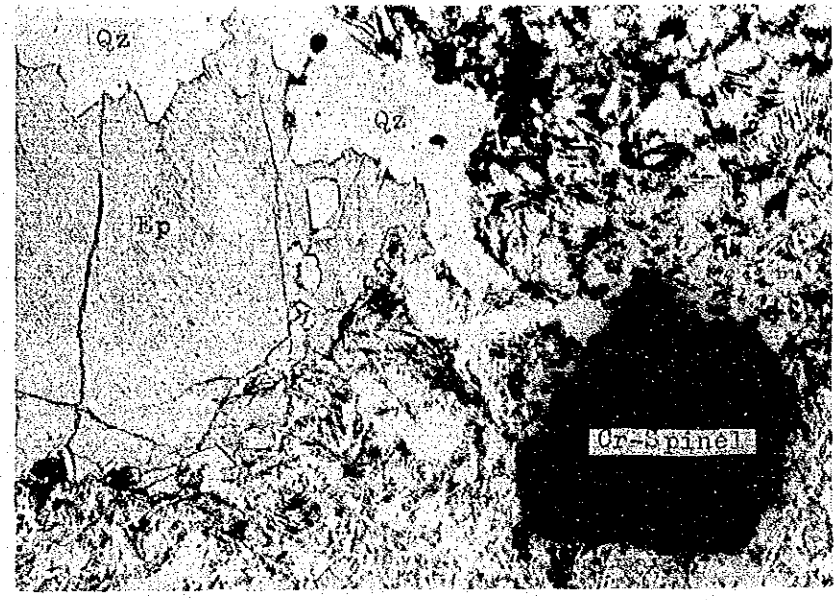
0.5 mm

Dolerite, (Sample No. BIC4) in Dikinaraman River Chert
Locality ; East Coast Palanan N 20 Km
Main mineral ; Orthopyroxene, Clinopyroxene, Plagioclase



Cross Nicol

0.5 mm



Ep ; Epidote
Qu ; Quartz

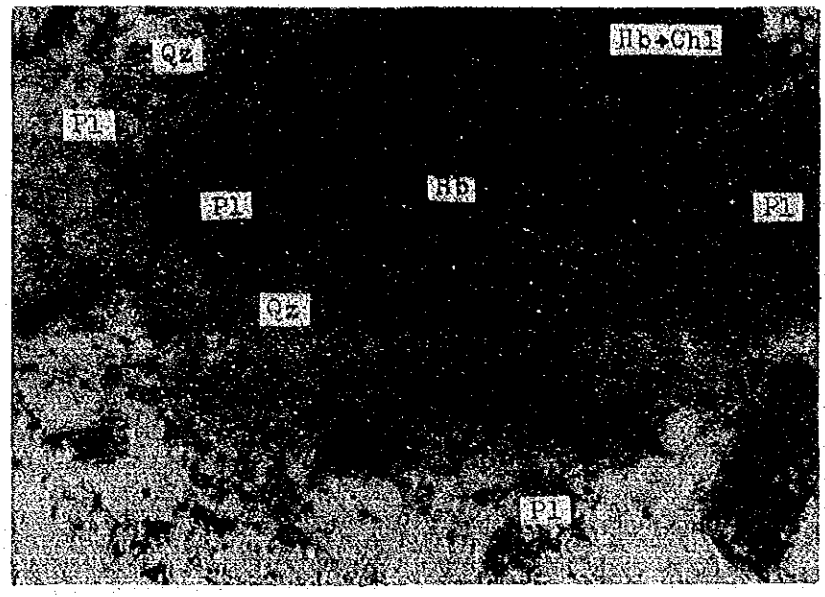
Parallel Nicol

0.5 mm

Altered Basalt, (Sample No. CK647) in Abuan River Formation
Locality ; East Coast Maconacon Cove NW 12 Km
Main mineral ; Cr-Spinel, Epidote, Quartz

Cross Nicol

0.5 mm



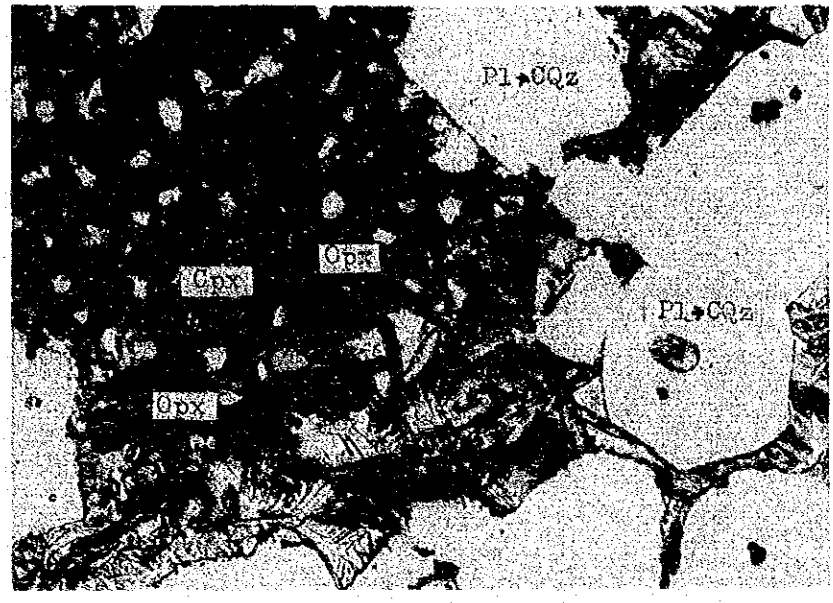
Hb ; Hornblende
Chl ; Chlorite
Qz ; Quartz
Pl ; Plagioclase

Parallel Nicol 0.5 mm

Quartz diorite, (Sample No. CJ05) in Bolos River Diorite
Locality ; East Coast Maconacon Cove W 12 Km
Main mineral ; Hornblende, Quartz, Plagioclase, Chlorite

Cross Nicol 0.5 mm

Cauayan Area



Opx ; Orthopyroxene
Cpx ; Clinopyroxene
Pl→CQz ; Plagioclase changed to Chalcedonic quartz

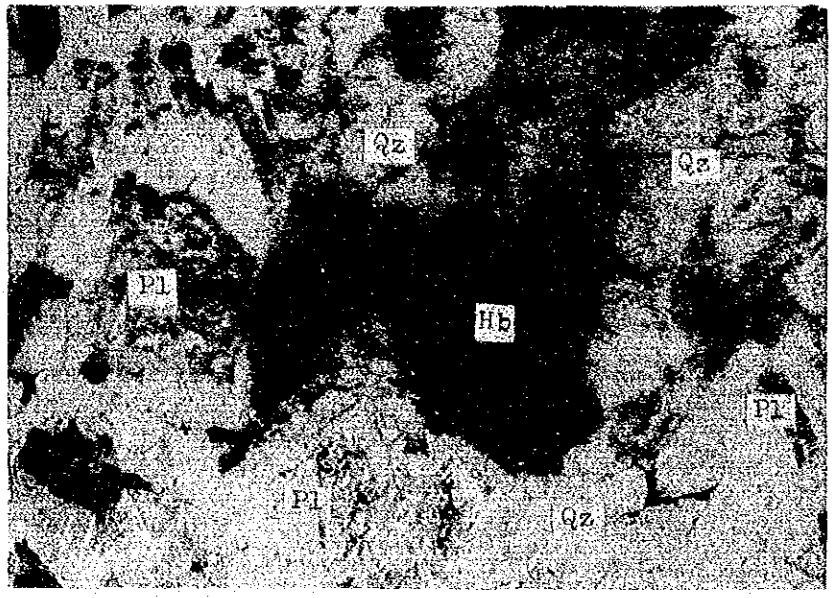
Parallel Nicol

0.2 mm

Basalt, (Sample No. AL002R) in Abuan River Formation (Rapid Cooling Facies)
Locality ; 30 Km SE San Mariano, East Side of Northern Sierra Madre Range
Main mineral ; Orthopyroxene, Clinopyroxene, Plagioclase (changed to Chalcedonic quartz

Cross Nicol

0.2 mm

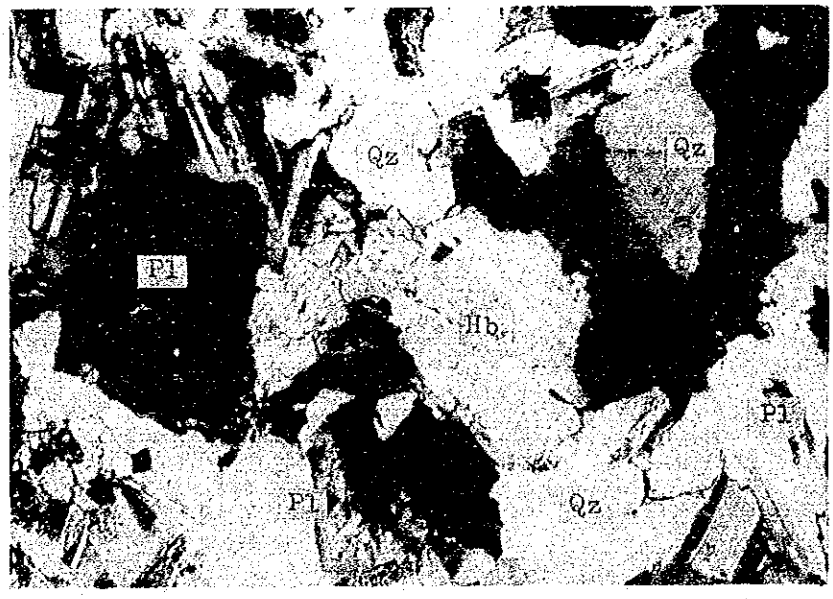


Hb ; Hornblende
Qz ; Quartz
Pl ; Plagioclase

Parallel Nicol

0.5 mm

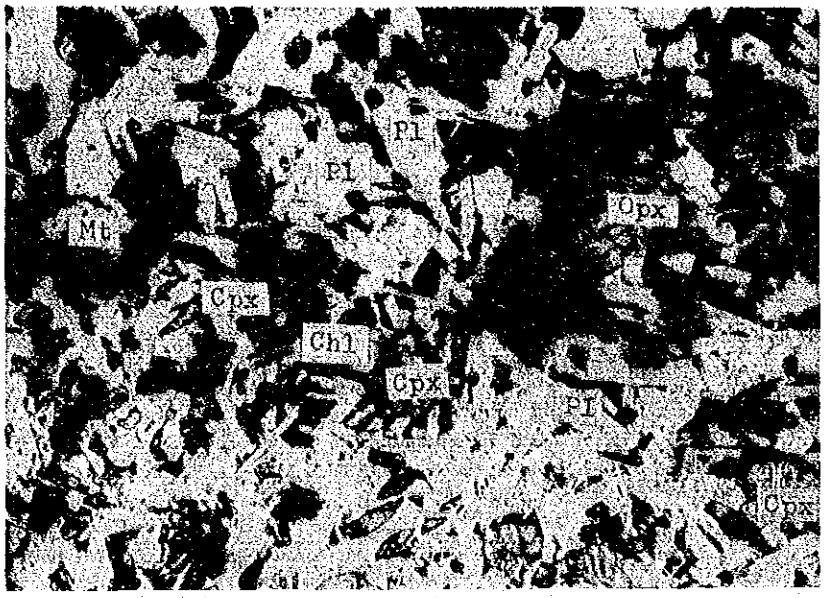
Tonalite, (Sample No. AM054R) in Siagot Diorite
Locality ; 38 Km ESE of Cauayan, East Side of Northern Sierra Madre Range
Main Mineral ; Hornblende, Quartz, Plagioclase



Cross Nicol

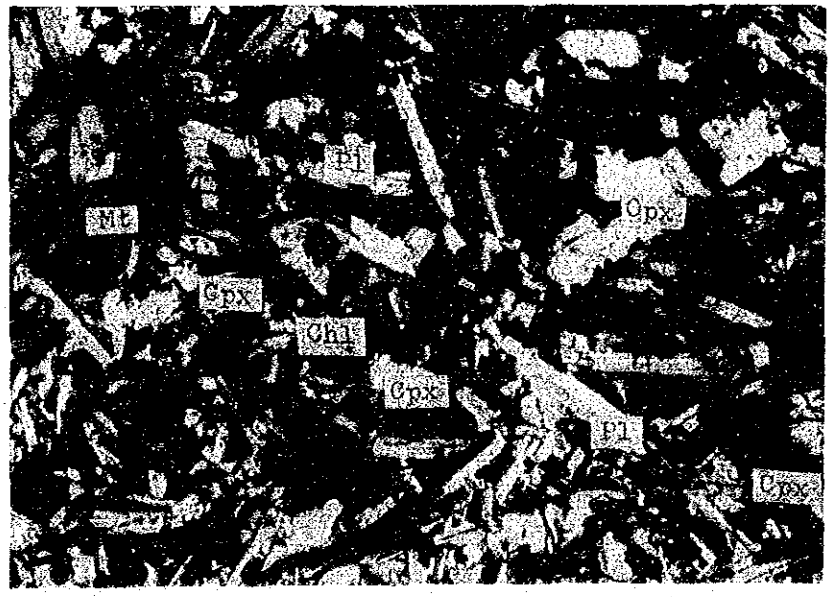
0.5 mm

Ilagan Area

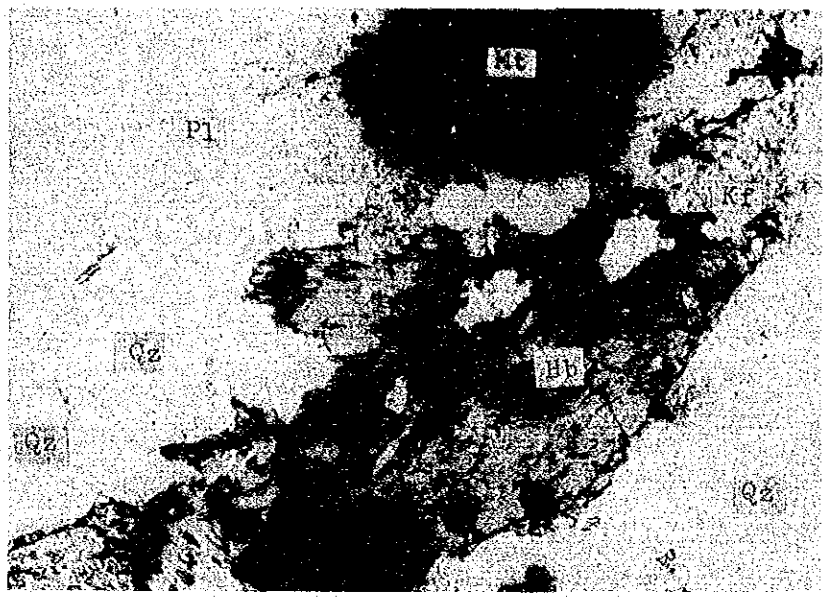


Parallel Nicol 0.5 mm

Dolerite, (Sample No. BB058) in Abuan River Formation
Locality ; 7 Km SSE of Mt. Cresta
Main mineral ;



Cross Nicol 0.5 mm

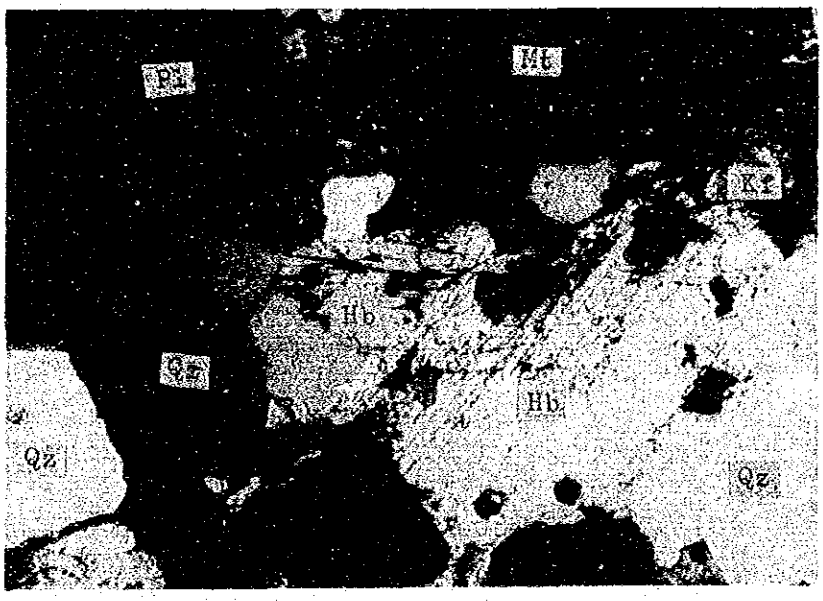


Mt ; Magnetite
Kf ; Potash Feldspar
Pl ; Plagioclase
Hb ; Hornblende
Qu ; Quartz

ParaLlel Nicol

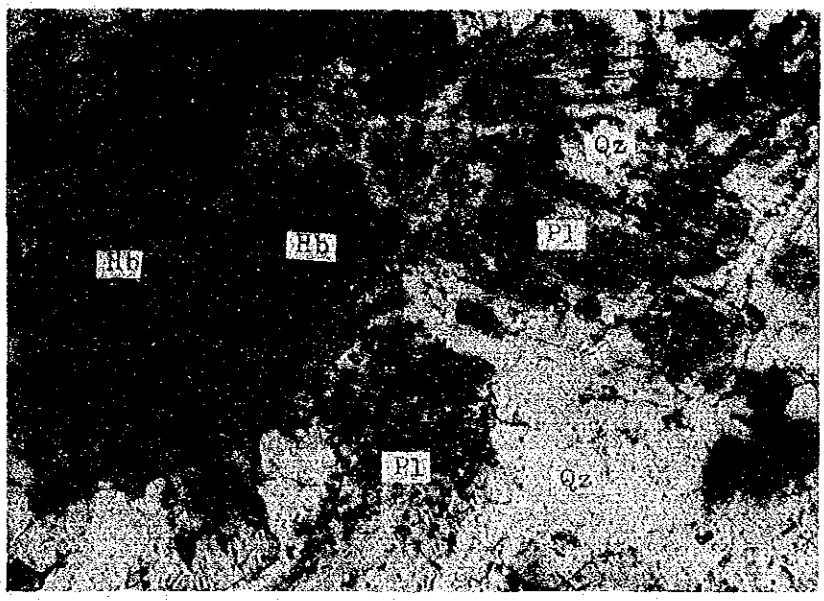
0.5 mm

Granodiorite, (Sample No. BJ052) in Siagot Diorite
Locality ; 22 Km ESE Ilagan
Main mineral ; Magnetite, Potash Feldspar, Plagioclase, Hornblende, Quartz



Cross Nicol

0.5 mm

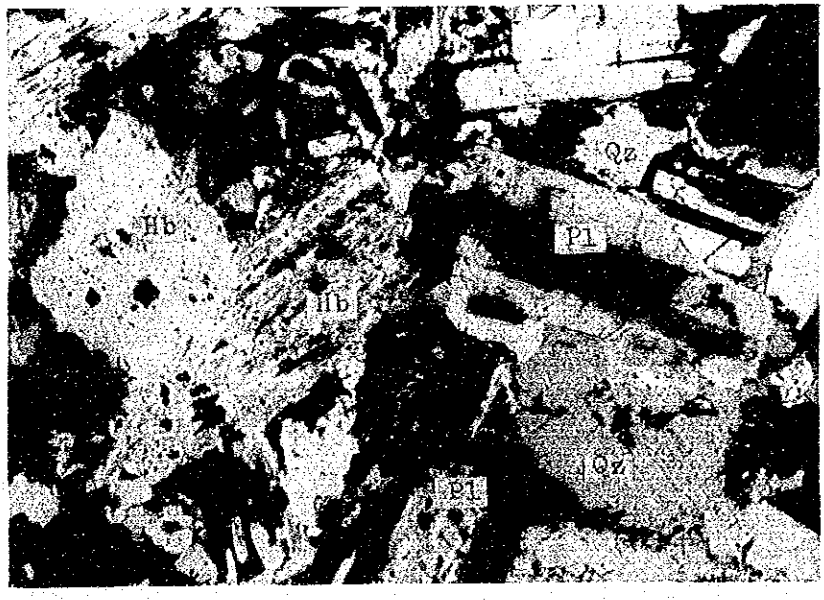


Hb ; Hornblende
Pl ; Plagioclase
Qu ; Quartz

Parallel Nicol

0.5 mm

Quartz diorite, (Sample No. DH-057) in Siagot Diorite
Locality ; 23 Km E of Tuguegarao
Main mineral ; Hornblende, Plagioclase, Quartz



Cross Nicol

0.5 mm