CHAPTER 3 CONCLUSIONS AND RECOMMENDATION

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3–1 Conclusions

In the area of 300 km^2 in Acupan–Itogon region in Benguet Province, the Philippines, where several geothermal manifestations are seen, geological, geochemical, gravity, resistivity and magnetic explorations were conducted to select the promissing and high potential area for geothermal resources exploration.

As the conclusion, further detailed explorations in the zone of vent breccias relating to gold deposits are considered to be highly worthwhile conducting in the future.

1) Balatoc plugs which are vent breccias (dacitic), indicating as 0.8 to 1.0 Ma. (Million year ago) by age determinations, are considered to be related with geothermal activity in this region.

2) According to the results of geological and geophysical explorations, there are no large scale basin or graben structures to preserve geothermal fluid to be found; however, this fissure system relating to the formation of the plugs is assumed to be the favorable geothermal fluid pass successive to the depth.

3) Hot water found around plugs are classified as NaCl type and the assumed temperature of the reservoir calculated as chemical thermometer is over 200°C. And the results of isotope analysis also support that this is the manifestation of deep geothermal fluid.

In view of the above-mentioned conclusions, it is considered as geothermal fluid ascending along the faults and fissures in and around the plugs is the promissing high-temperature geothermal resource for the future geothermal electric power generation.

In order to confirm the movement of the geothermal fluid and the area of interest in this region, it is necessary to dig several thermal gradient bore-holes for the following points;

1. About 350 m northwest from a bridge across the Ambalanga River, east side of the road to Balatoc, with an elevation of 760 m (Around the gravity station No. 27),
2. The road-end toward southwest from Batuang, with an elevation of 890 m (350 m northeast of the gravity station No. 174),
3. Southeast of the plane of Virac, with an elevation of 970 m (400 m southeast of the gravity station No. 33),
4. The creek, 500 m south from the Acupan mine office (The gravity station No. 165),
5. 450 m north of Itogon with an elevation of 730 m (Around the gravity station No. 29),
6. 650 m north-northwest of Itogon, south end of the road, with an elevation of 920 m (500 m east of the gravity station No. 28),

7. 300 m east of the entry of the Itogon–Suyoc mine with an elevation of 800 m (Gravity station No. 193).

3–2 Recommendations

According to the results of the first phase survey, it is recommended to pay attention to the following points in order to carry out further detailed geothermal exploration definitely.

1) Since geothermal reservoir of this area is considered as fracture type reservoir structure accompanies with the formation of vent breccia (dacitic), it is necessary to conduct detailed survey for fissure system and structural control to estimate the scale of geothermal reservoir.

2) About the one-meter-depth measurement, temperature, mercury, and radon gas concentration are supposed to be measured. It is favorable if surveying points can be planned to locate as close as possible by grid. Accompanying for this, alteration survey should be undertaken.

3) Since geothermal manifestation zone is under the operation as gold mines, any geophysical surveys such as resistivity sounding can not be conducted: however, geothermal fluid movement along faults and fractures causes the occurrence of microearthquake in many cases. Hence, in order to estimate the active range of geothermal fluid at depth, adoption of microearthquake monitoring is considered to be reasonable.

Ground water level for this area is artificially disturbed since here is an active gold deposit zone. In order to confirm the deep thermal gradient without disturbance, the drilling depths must be deep enough, at least the maximum depth of present active excavation depth of 550 m A.S.L..

The above-mentioned locations have been selected because of the following reasons:

* Since the heat source is considered to be present under the Quaternary vent breccia, gradient holes are selected in and around the vent.

* Since vein fissures of this area must be the favorable pass for geothermal fluid, the drilling sites are separated and located within the distribution area (12 km^2) of vein fissures and their host rocks.

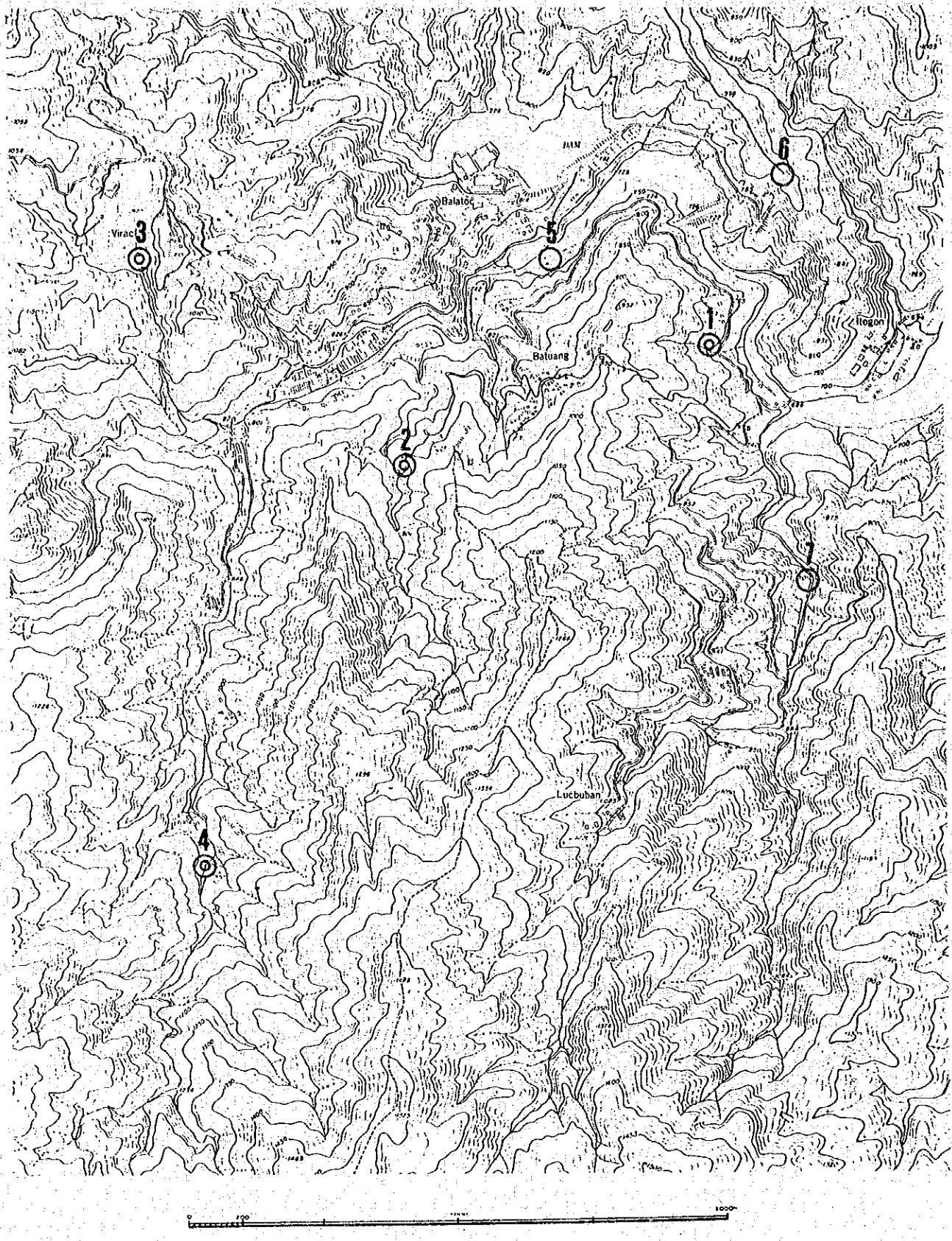

Fig. III–3–1 Proposed Sites of Gradient Holes

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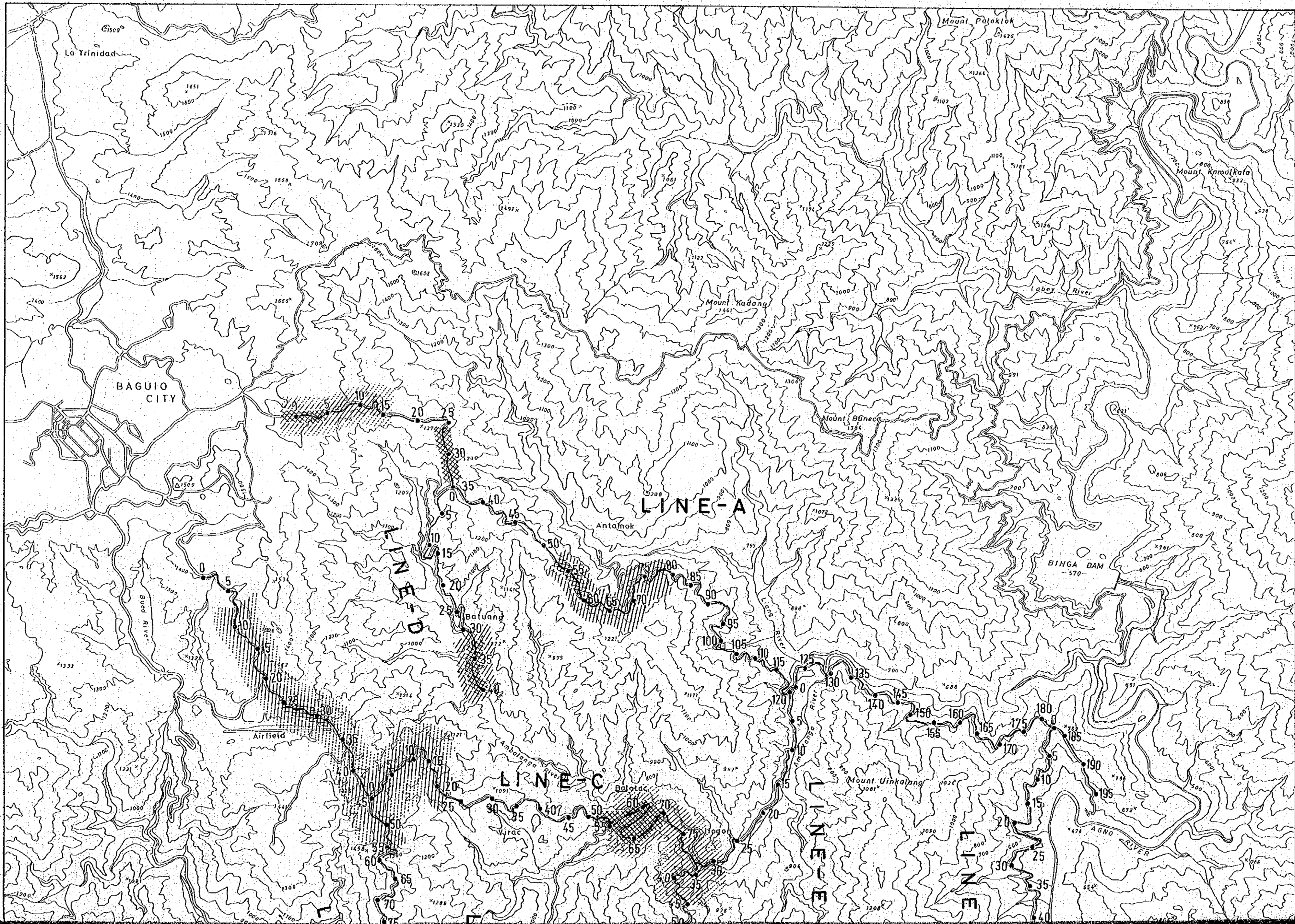
La Trinidad
BAGUIO CITY
Mount Kadang
Mount Bineng
Mount Palaktak
Mount Kamalkala
Labey River
BINGA DAM
LINE-A
LINE-C
LINE-D
LINE-E
Antamok
Batuang
Airfield
Ambalanga River
Balatac
Virac
Liang River
Mount Uinkalang
AGNO RIVER
Bued River

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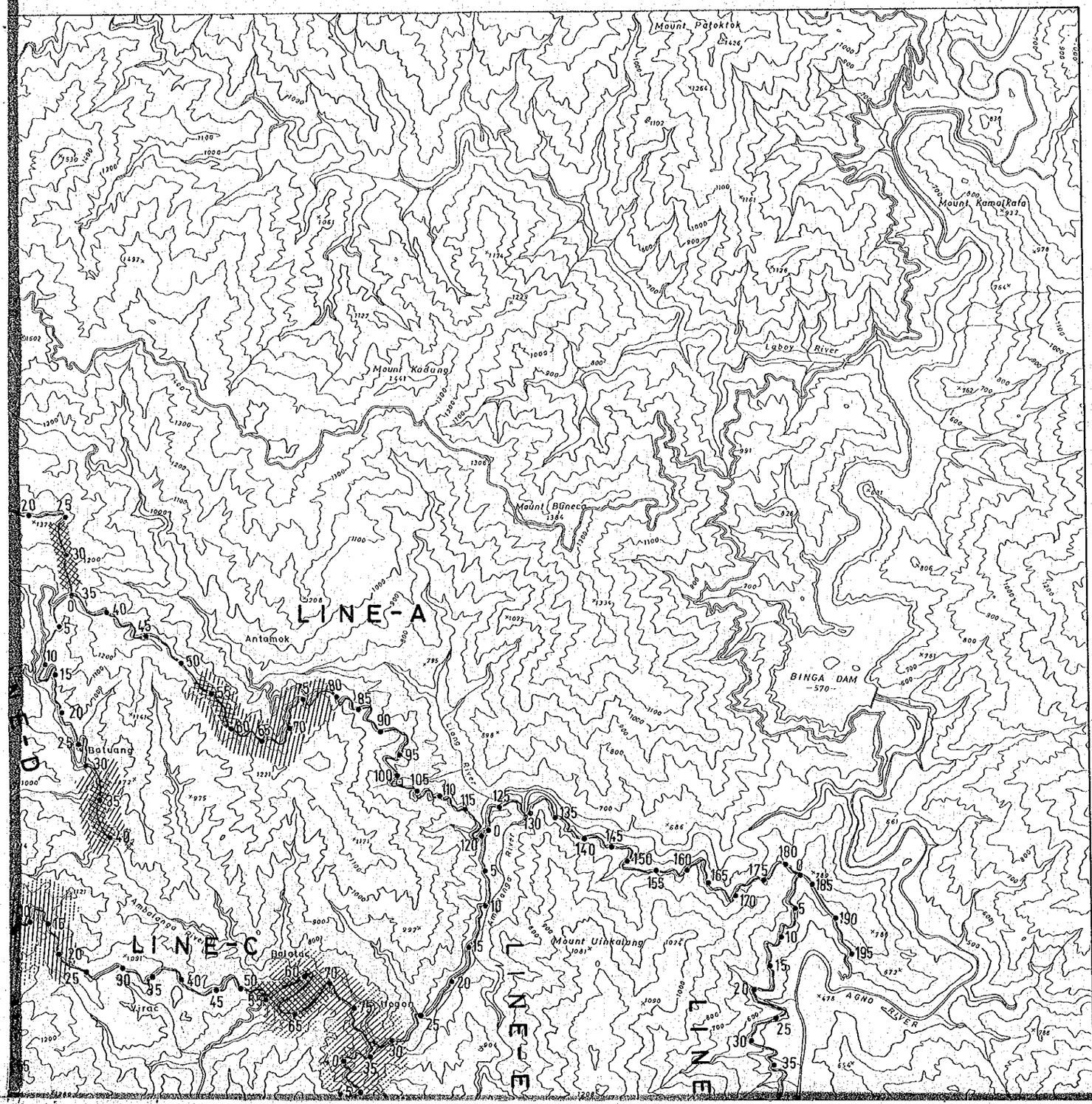
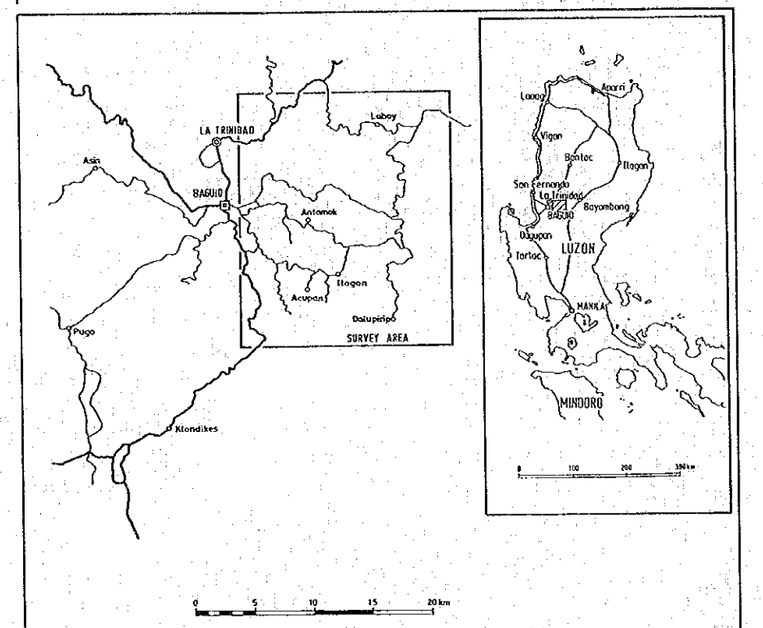
Fig.II-4-10 Plan Map of Resistivity





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Scale 1:50,000

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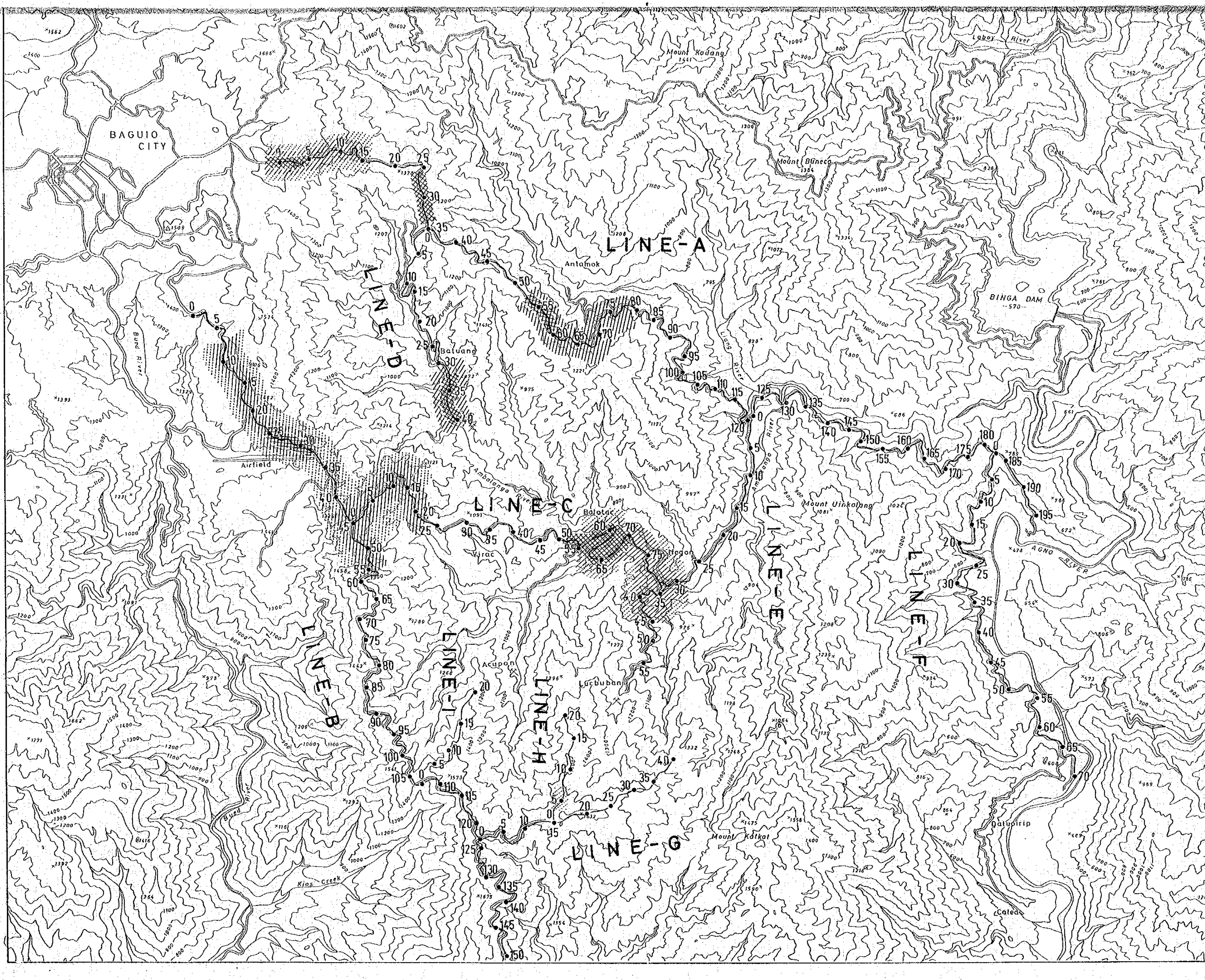
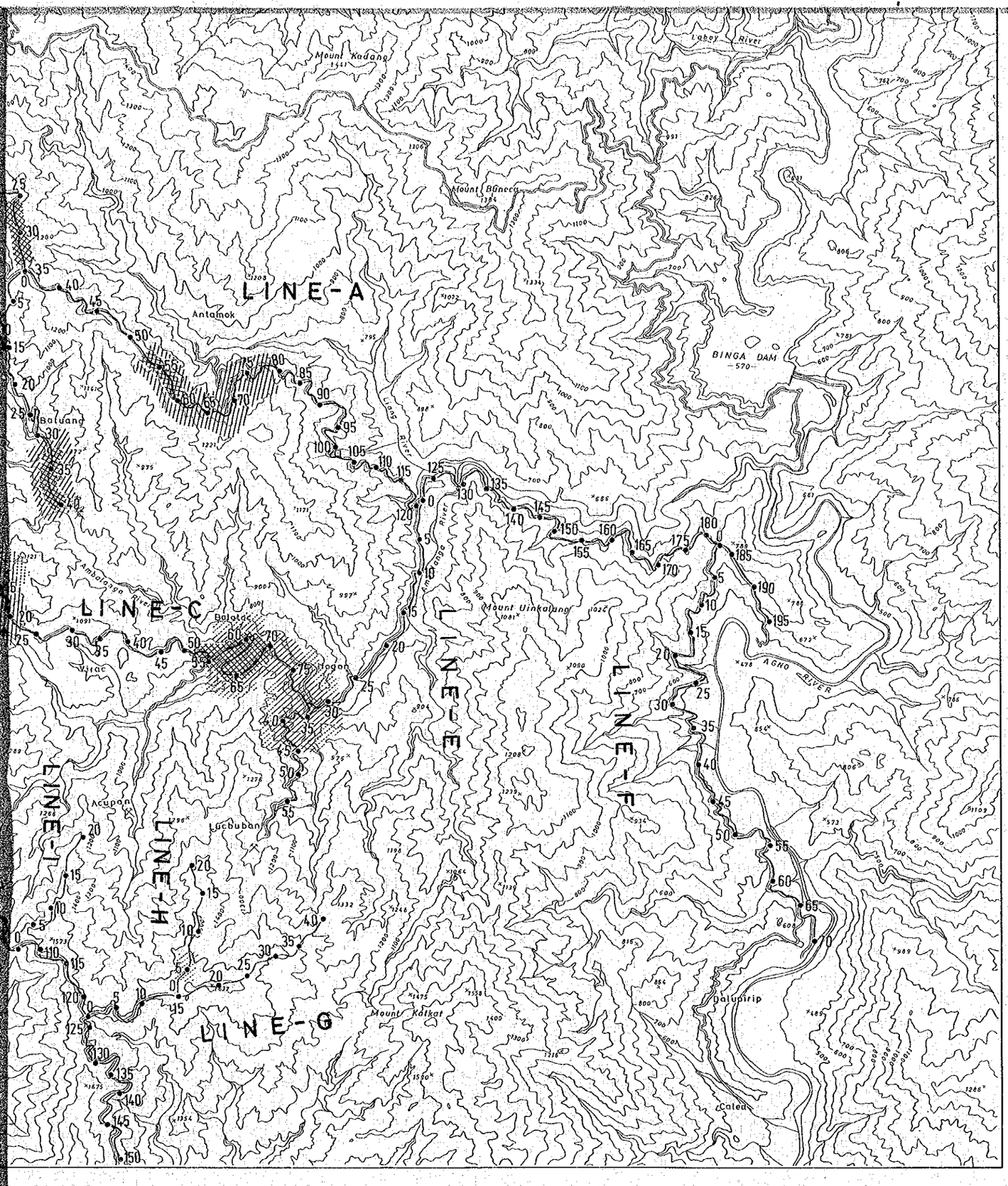
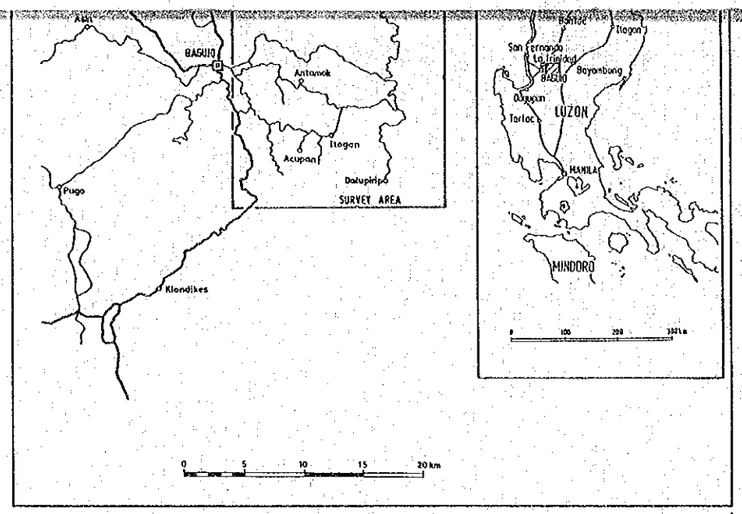
LEGEND

Low Resistivity Zone



BAGUIO CITY
LINE-A
LINE-B
LINE-C
LINE-D
LINE-E
LINE-F
LINE-G
LINE-H
LINE-I
Mount Kadang
Mount Buneco
Antamok
BINGA DAM
570
Batuang
Airfield
Bued River
Balatoc
Itogon
Acupan
Lucbuban
Mount Uinkolang
AGNO RIVER
Mount Kalkot
Dalupirip
Kias Creek





Japan International Cooperation Agency

Scale 1 : 50,000

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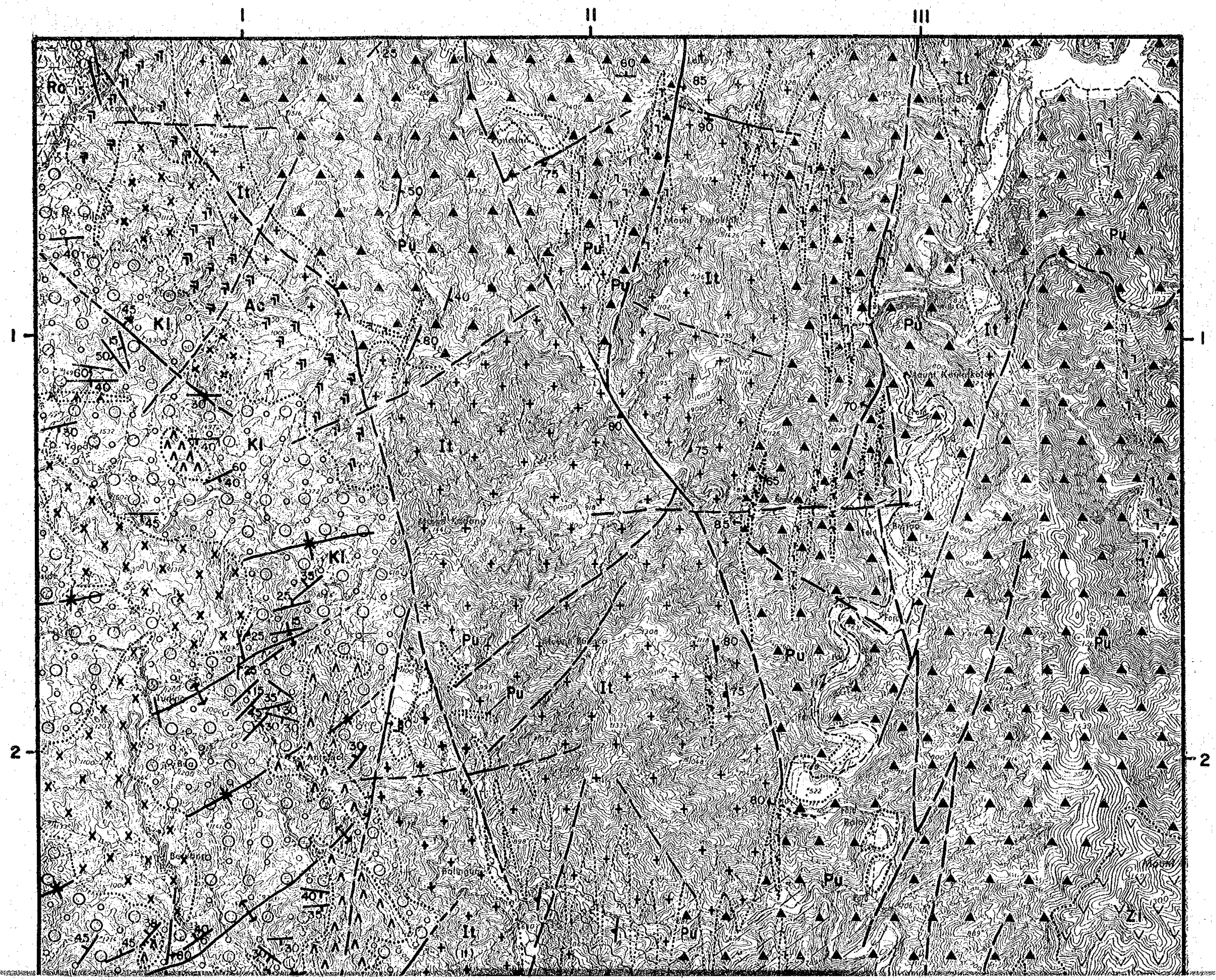
LEGEND

Low Resistivity Zone

100m depth (50Ω-m les)

200m depth (100Ω-m les)

300m depth (100Ω-m les)



Quaternary
Pleis
Plio

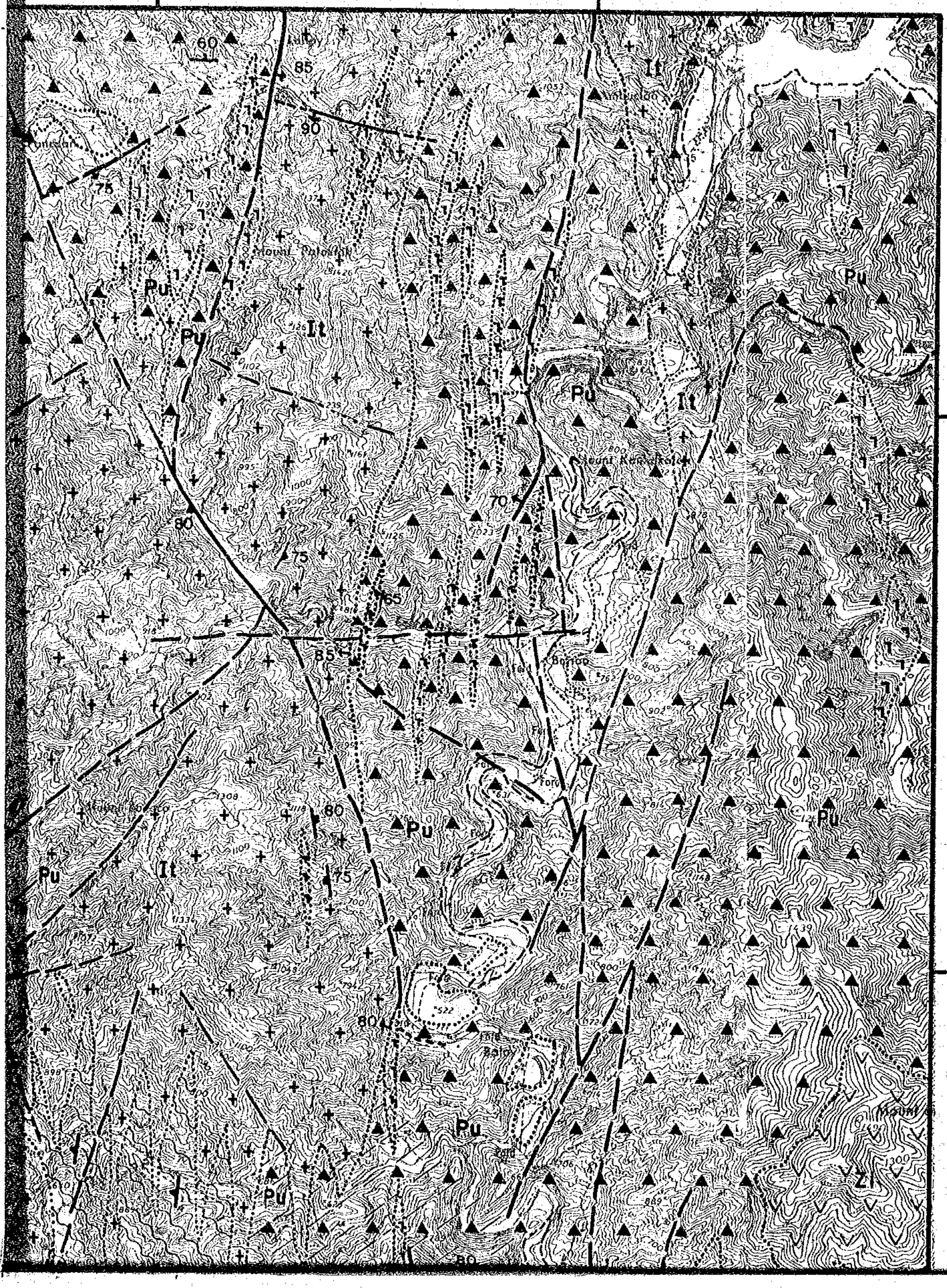


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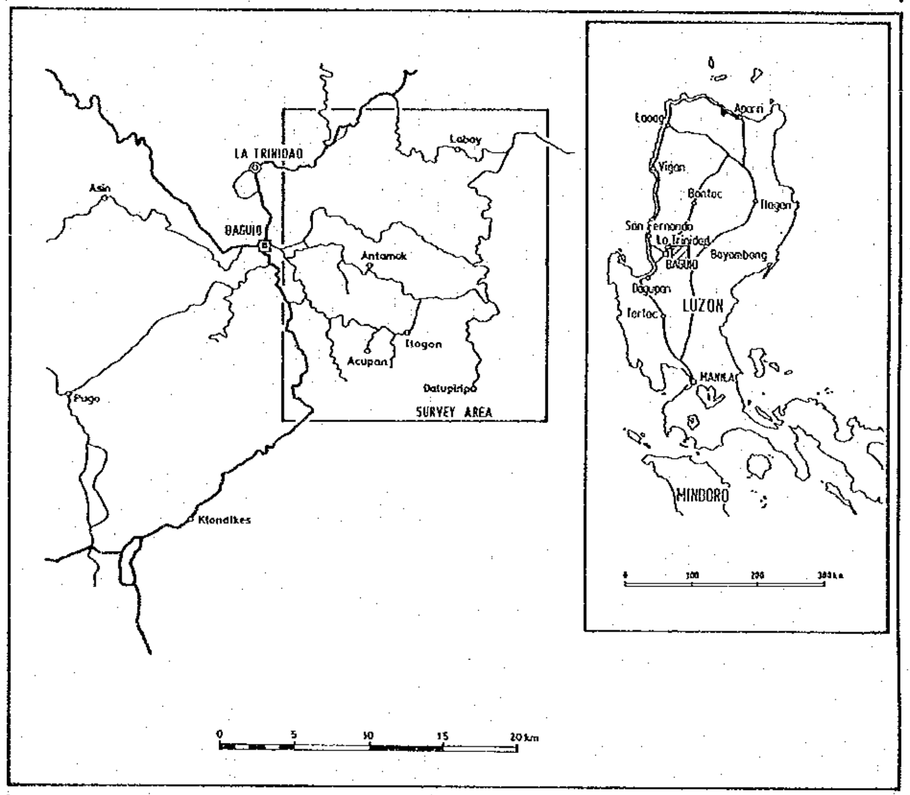
Fig. II-1-3 Geological Map



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Scale 1:50,000

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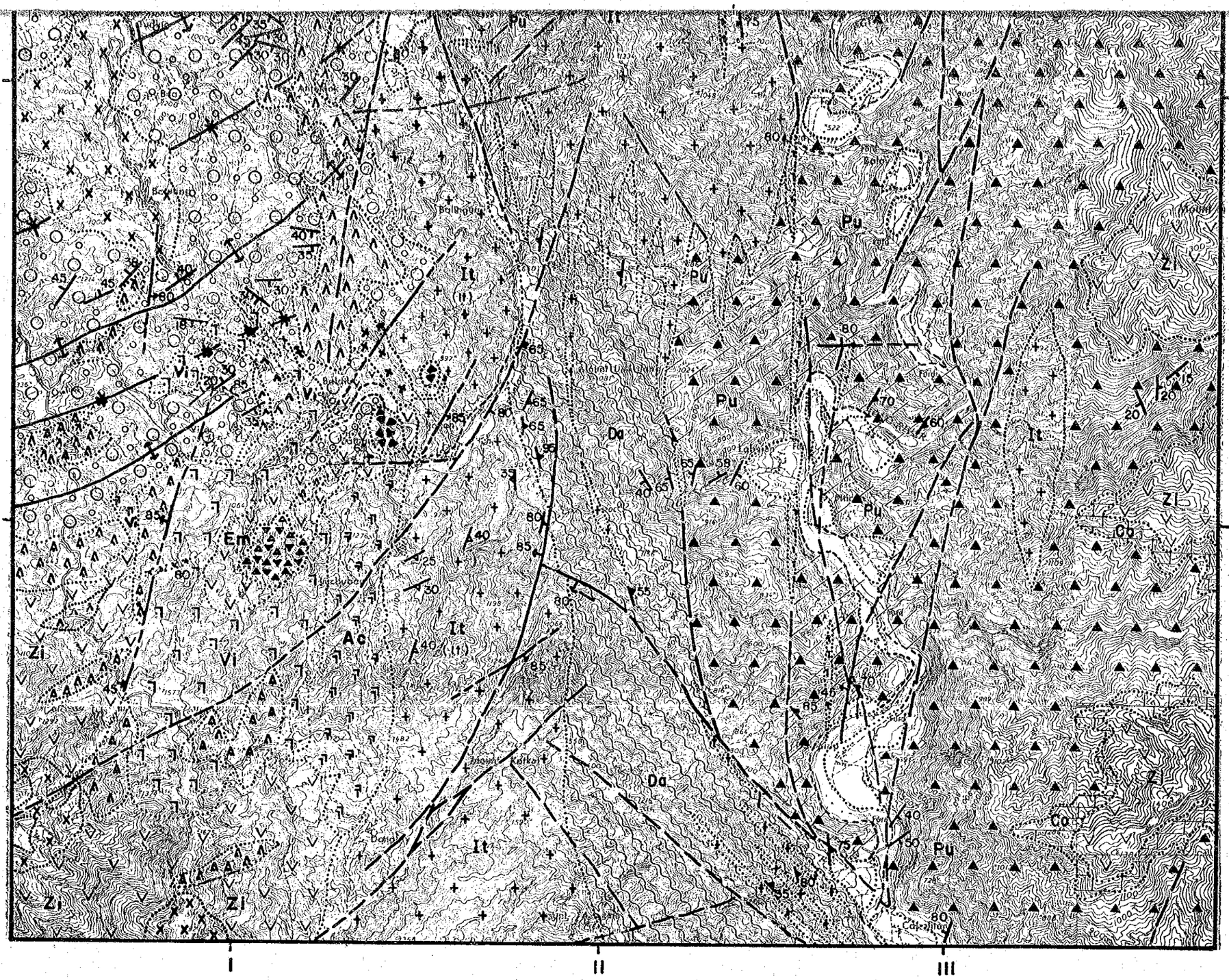
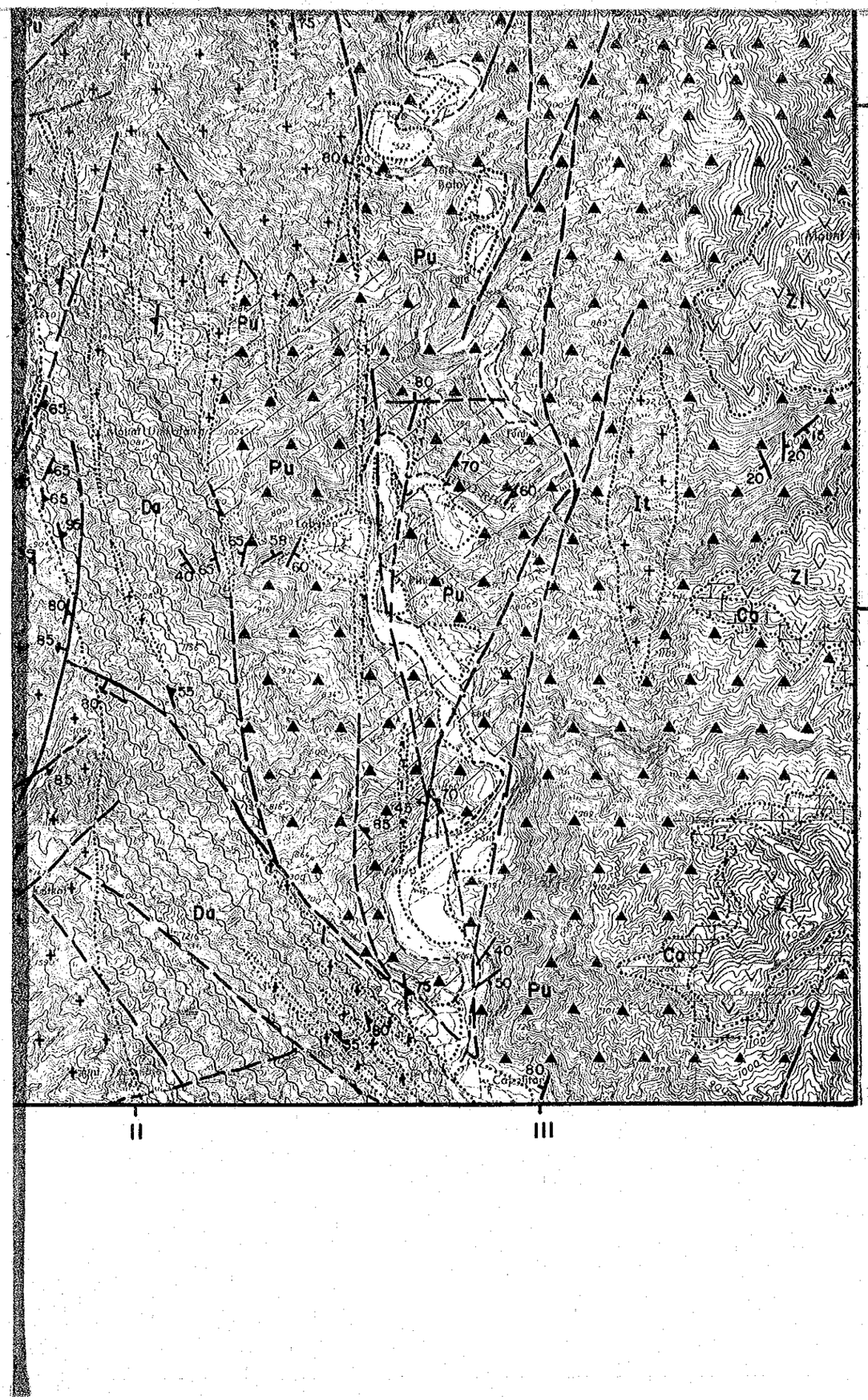
LEGEND

Quaternary	Pleistocene	Terrace dep.	gravel
		Balotoc plug (Ba)	dacitic pyroclastic r. <0.85±0.12 m.a.>
Pliocene		Rosario F. (Ro)	s.s. & pumice tf.
Upper			



Quaternary
Pleistocene
Tertiary
Pliocene
Miocene
Upper
Middle
Lower
Oligocene
Eocene
Paleocene
Up Cretaceous
<Intrusi



Scale 1:50,000

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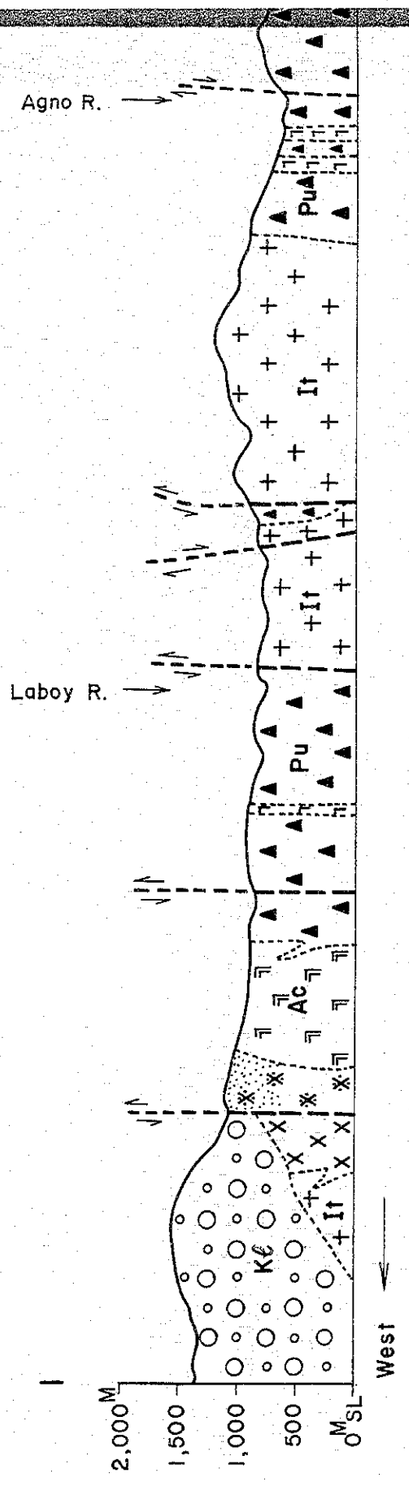
LEGEND

Quaternary	Pleistocene	Terrace dep.	gravel
		Batotoc plug	dacitic pyroclastic r. <0.85±0.12 m.a.>
Tertiary	Pliocene Upper	Rosario F.	s.s. & pumice tf.
	Miocene Middle	Klondyke F.	conglomerate, pyroclastic r, tf, s.s. & m.s.
	Miocene Lower	Zigzag F.	andesitic pyroclastic r. and andesite
	Oligocene	Columbus F.	lime stone
	Eocene Paleocene	Pugo F.	metavolcanic r. & metasedimentary r.
Up Cretaceous		Dalupirip sch	sch.

<Intrusive rocks>

	hb mega crstal bearing and porphyry <5.76±0.23 m.a.>
	intermediate volc-plutonic complex (and, and. porphyry and micro diorite bearing hb.)
	px. and porphyry
	acidic to intermediate volc-plutonic complex (compozed of mainly qtz dio. por, a minor amount of dacite porphyry, and qtz diorite, andesite, and. porphyry)
Agno batholith	bio-hb qtz diorte ~ granodiorite (so called virac granodia.) (medium grained to fine) <5.20±0.33 m.a.>
Agno batholith	hb diorite, hb gabbroic diorite (cos. grained)
Agno batholith	melanocratic to luecocratic hb qtz diorite <17.0~22.7 m.a.> (cos. grained to madium grained, main body of Agno batholith)
	transition zone (alternative semisch. and meta-vdcanics and/or meta-sediment

45	bedding
80	schistosity
60	foliation
60	joint
60	fault
	lineament
	operating mine and closed mine
	hot spring
	anticline, syncline


Agno R.
Pu
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Laboy R.
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Ac
Ke
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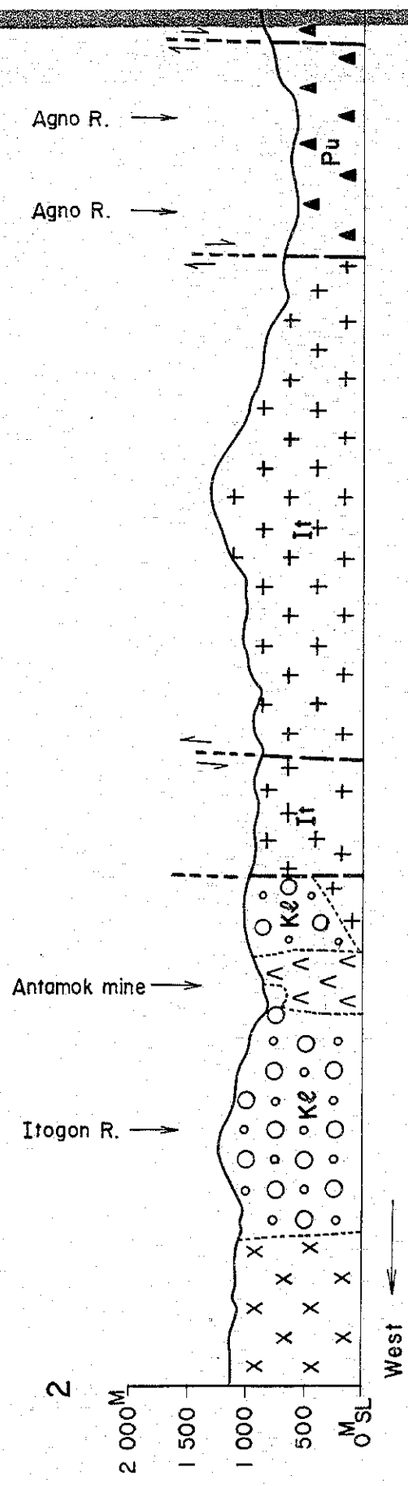
2,000 M
1,500
1,000
500
0 M SL
West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Agno R.
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Antamok mine
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Itogon R.
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1 000
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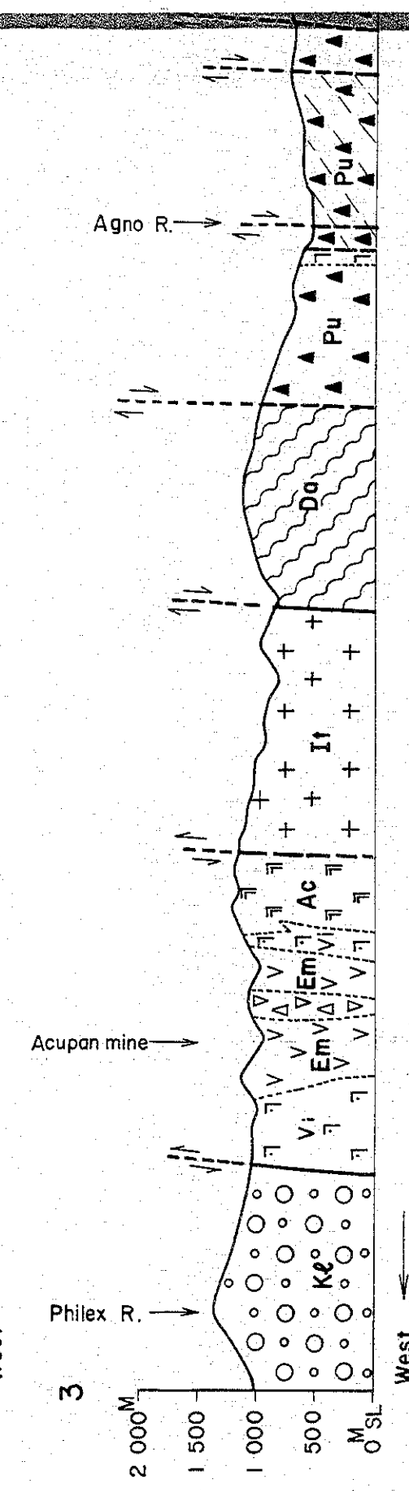
West


Laboy R.
Agno R.
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3
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Acupan mi

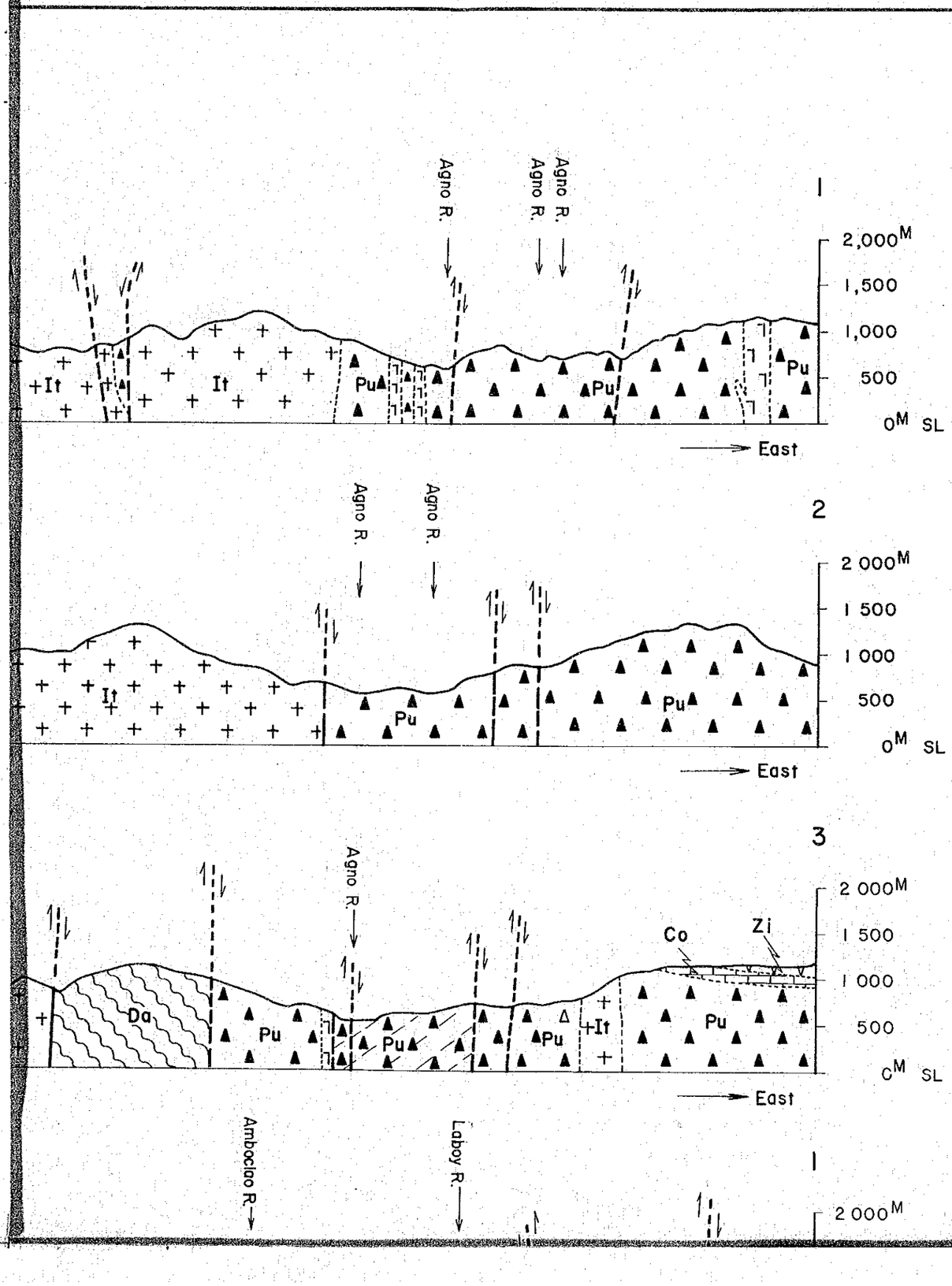

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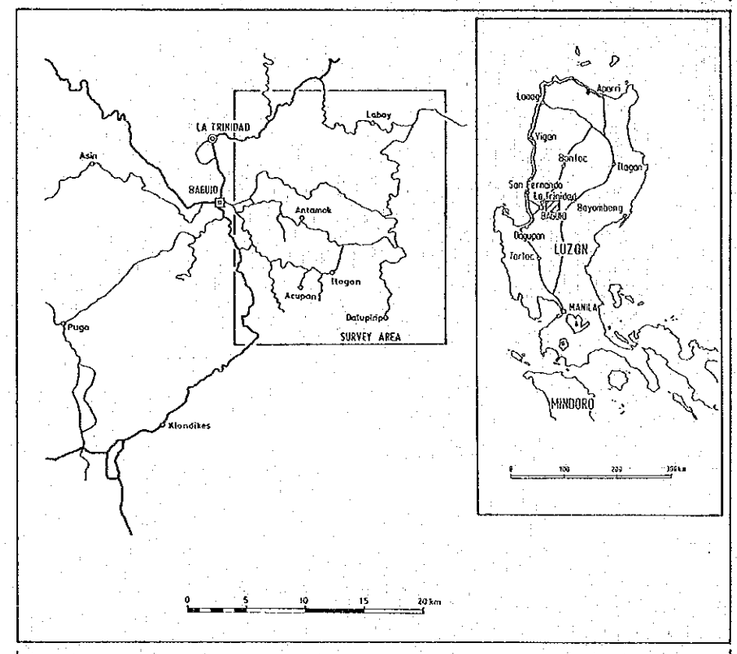
Fig. II-1-4 Geological Profile



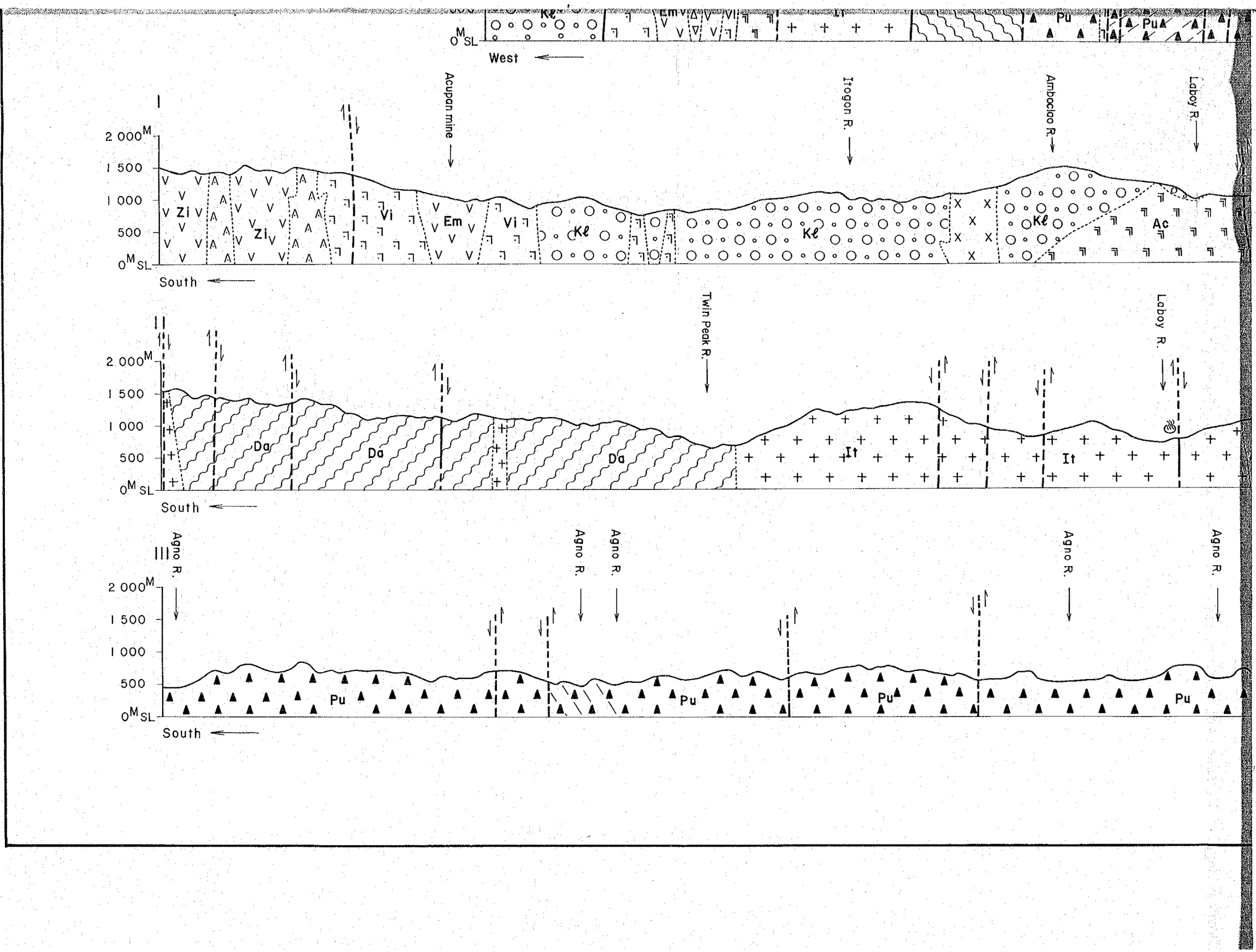
Japan International Cooperation Agency

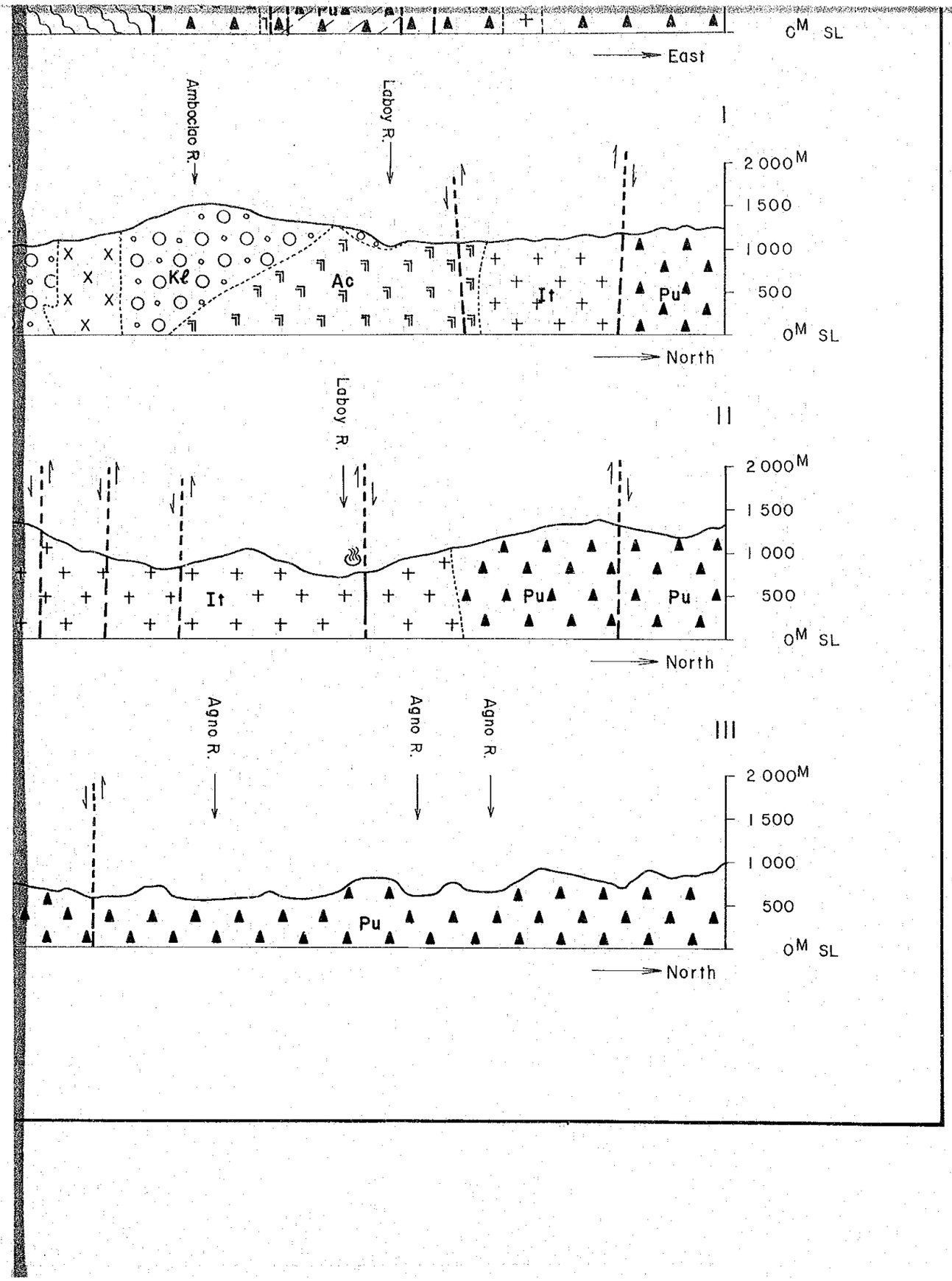
Scale 1:50,000

0 1.0 2.0 3.0 4.0 5.0km

LEGEND

Quaternary	Pleistocene	Terrace dep.	gravel
		Balotoc plug	dacitic pyroclastic r. <0.85±0.12 m.a.>
Tertiary	Pliocene	Rosario F.	s.s. & pumice tf.
	Upper Miocene	Middle Klondyke F.	conglomerate, pyroclastic r, tf, s.s. & m.s.


Kℓ
Em
Vi
Lt
Pu
Pu
0 M SL
West
I
2 000 M
1 500
1 000
500
0 M SL
Acupan mine
Itogon R.
Ambaclao R.
Laboy R.
Zi
Zi
Vi
Em
Vi
Kℓ
Kℓ
Kℓ
Ac
South
Twin Peak R.
Laboy R.
Da
Da
Da
It
It
South
Agno R.
Agno R.
Agno R.
Agno R.
Pu
Pu
Pu
Pu
South



Quaternary	Pleistocene	Terrace dep.	gravel
		Balotoc plug	dacitic pyroclastic r. <0.85±0.12 m.a.>
Tertiary	Pliocene	Rosario F.	s.s. & pumice tf.
	Miocene Upper		
	Miocene Middle	Klondyke F.	conglomerate, pyroclastic r, tf, s.s. & m.s.
	Miocene Lower	Zigzag F.	andesitic pyroclastic r. and andesite
	Oligocene	Columbus F.	lime stone
	Eocene	Pugo F.	metavolcanic r. & metasedimentary r.
	Paleocene		
Up Cretaceous		Dalupirip sch	sch.

<Intrusive rocks>

		hb mega crstal bearing and porphyry <5.76±0.23 m.a.>
		intermediate volc-plutonic complex (and, and. porphyry and micro diorite bearing hb.)
		px. and porphyry
		acidic to intermediate volc-plutonic complex (compozed of mainly qtz dio. por, a minor amount of dacite porphyry, and qtz diorite, andesite, and. porphyry)
Agno batholith	Vi	bio-hb qtz diorte~granodiorite(so called virac granodio.) (medium grained to fine) <5.20±0.33 m.a.>
Agno batholith	An	hb diorite, hb gabbroic diorite (cos. grained)
Agno batholith	It	melanocratic to luecocratic hb qtz diorite <17.0~22.7 m.a.> (cos. grained to madium grained, main body of Agno batholith)
		transition zone (alternative semisch, and meta-vdcanics and/or meta-sediment

- bedding
- schistosity
- foliation
- joint
- fault
- lineament
- operating mine and closed mine
- hot spring
- anticline, syncline