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BURMA

Technical report 1

Geology and mineralization of the Shangalon copper prospect and surroundings

Prepared for the Government of the Socialist Republic of the Union of Burma by the United Nations, acting as executing agency for the United Nations Development Programme

UNITED NATIONS
New York, 1978

NOTES

Abbreviations used:

DGSE	-	Department of Geological Survey and Mineral Exploration
m.y.	-	million years
DDH	-	diamond drill hole
ppm	-	parts per million
amp	-	ampere
cps	-	cycles per second
I.P.	-	induced polarization
S.P.	-	self-potential
AAS	-	atomic absorption spectrophotometry
ml	-	millilitre
Å	-	Ångstrom
MIBK	-	Methyl-isobutyl-ketone
N	-	normal

As of 1 June 1978, the rate of exchange was 7.10 kyats (K) to the US dollar.

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CONTENTS

Page

PREFACE vi

ABSTRACT vi

Part One. Shangalon

INTRODUCTION 1

I. SUMMARY 2

II. GENERAL REMARKS 3

Location, map coverage, aerial photography and access 3
Physical environment 3
Previous mining activities 3
Project activities 3

III. REGIONAL GEOLOGIC SETTING 7

IV. GEOLOGY OF THE SHANGALON PROSPECT 8

Field work and mapping methods 8
Weathering and erosion 8
Leached capping 8
Lithology 8
Alteration 10
Structure and mineralization 12
Conclusions 14

V. GEOPHYSICS 16

Methods and coverage 16
Interpretation of geophysical data 17
Conclusions 19

VI. GEOCHEMISTRY 20

General 20
Stream sediments 20
Soil sampling 20
Presentation of results 22
Conclusions 24

VII. DIAMOND DRILLING 25

Equipment 25
Objectives 25
Selection of sites 25

		Page
VIII.	ANALYTICAL CHEMISTRY	27
	Sample preparation	27
	Analytical methods	27
	Check analyses	27
IX.	GENERAL CONCLUSIONS AND RECOMMENDATIONS	30
X.	ACKNOWLEDGEMENT	30
	Part Two. Surroundings	
	INTRODUCTION	31
	Preceding work	31
	Present work	31
	Presentation and summary of results	31
I.	GEOLOGY	33
	Methods	33
	Sedimentary and eruptive rocks	33
	Intrusive rocks	34
	Structure	35
II.	GEOCHEMISTRY	36
III.	GEOPHYSICS	38
	Methods	38
	Interpretation	38
IV.	CONCLUSIONS AND RECOMMENDATIONS	40
	Annexes	
1.	Shangalon Prospect: List of maps not included in the report	41
2.	National personnel at Shangalon	41
3.	Project personnel	42
4.	Project reports	44
5.	National personnel in Shangalon Surroundings	45

Figures

Part One

General:	1	Location of project field areas	4
	2	Simplified geologic map Pinlebu-Banmauk area	5
Geologic:	3	Lithology	Opposite 8
	4	Lithology (with cross-section)	Pocket
	5	Alteration	Pocket
	6	Mineralization and structure	Pocket

CONTENTS (continued)

			Page
Geophysical:	7	Magnetic isolines	Opposite 18
	8	Magnetic isolines	Pocket
	9	Geophysical interpretation	Opposite 18
	10	Geophysical interpretation	Pocket
	11	Turam anomalies	Opposite 18
	12	Radiometric interpretation	Opposite 18
Geochemical:	13	Pinlebu-Banmauk area stream sediments	21
	14	Soil map	Pocket
	15	Soil sampling, statistical treatment	23
	16	Copper contours in soil	Opposite 24
	17	Copper contours in soil	Pocket
	18	Molybdenum contours in soil	Pocket
	19	Comparison of Cu values between DGSE Laboratory and Barringer Research Laboratory	29
Combined:	20	Profile L3500	Opposite 30
	21	Map	Opposite 30

Part Two

22	Geology of Shangalon Surroundings	Pocket
23	Stream sediment sample locations and copper-molybdenum distribution	Pocket
24	Induced polarization results	Opposite 38
25	Electrical resistivity results	39
26	Magnetic and radiometric profiles	Opposite 40

PREFACE

This report, "Geology and Mineralization of the Shangalon Copper Prospect and Surroundings", covers the work of the following international experts: F. Baumann and P. Carrel, geologic mapping; A. Mitchell, regional geologic setting; F. Sumi, geophysical studies; and B. Zitek, geochemical studies; in co-operation with numerous Burmese experts (see annex 2).

ABSTRACT

Field mapping, diamond drilling and laboratory study were included in the exploration of the Shangalon porphyry copper prospect in northern Burma. The work involved geologic mapping, combined geoelectric, magnetic and radiometric surveys and geochemical soil sampling. Further geologic mapping, sediment sampling over 254 km^2 surrounding Shangalon and electric, magnetic and radioactive survey extending 15 km southward from it were also carried out.

Diamond drilling, which started in early 1975, was terminated in May 1977, when 33 holes totalling some 8,785 feet were completed. Only about 9 millions tons of potential ore containing 0.23 per cent copper, traces of molybdenum and 0.17 grams per ton of gold exist at Shangalon. The prospect is not economic at the present time, and no indications of other mineable mineralization were found.

Part One. Shangalon

INTRODUCTION

The Geological Survey and Exploration Project (BUR-72-002), for which the United Nations was the executing agency, became operational in January 1974. The Government co-operating agency was the Department of Geological Survey and Mineral Exploration (DGSE) of the Ministry of Mines.

The total United Nations Development Programme (UNDP) contribution, according to the revised budget, is estimated at $US 1,882,752, and the Government contribution at kyats (K) 5,120,600, partly in cash and partly in kind. The latest (as of October 1977) project revision extended the project through June 1978.

The main objective of the project was to carry out systematic regional geochemical exploration and geologic mapping of selected areas, followed by detailed investigations in areas of special interest. Between 1974 and late 1977 approximately 15,525 square miles were surveyed by the project. One of the major results of these operations was the discovery in late 1974 that the Shangalon area - where minor mineralization was previously known - was in fact a porphyry copper-molybdenum prospect. This report summarizes the results of integrated geologic, geophysical and geochemical studies and diamond drilling at Shangalon, which were in progress from January 1975 until May 1977.

Frank Baumann was responsible for detailed geologic mapping; Andrew Mitchell, for regional geologic setting; Franc Sumi, for geophysical studies; and Bohus Zitex, for geochemical studies. Early geologic mapping was done by Pierre Carrel. The national professional staff is listed in annex 2.

I. SUMMARY

This report describes the detailed exploration done on the Shangalon porphyry copper prospect in northern Burma. It is based on extensive field work as well as on results of diamond drilling and laboratory studies. The work involved geologic mapping, combined geoelectric, magnetic and radiometric surveys and geochemical soil sampling carried out along 100 m grid lines which covered an area of over 20 km^2 (Part One of this report). Further geologic mapping, sediment sampling over 254 km^2 surrounding Shangalon and electric, magnetic and radioactive survey extending 15 km southward from it were also carried out to check if other mineralization was present in the vicinity (Part Two of this report).

Diamond drilling, which started in early 1975, was terminated on 4 May 1977, when 33 holes totalling some 8,785 feet were completed. The geologic mapping, supported by geophysical and geochemical data, delineated seven mayor zones of alteration or mineralization. The most promising of these zones were drilled and found to contain only a subeconomic grade of copper. Smaller higher grade vein-type showings were also tested for possible low-tonnage reserves, but the results were not encouraging. Estimations based on drilling results indicate that a maximum possible 9 million tons containing 0.23 per cent copper, a trace of molybdenum and approximately 0.17 grams per ton of gold exist at Shangalon. The short high-grade sections intersected in several drill holes do not show any continuity and are economically insignificant.

This report concludes that at present the Shangalon prospect is not economic and that there is no indication of any other mineable mineralization worth further investigation in the surrounding area studied on a 1:25,000 scale.

II. GENERAL REMARKS

Location, map coverage, aerial photography and access

The Shangalon prospect lies within Kawlin township in the Northern Sagaing Division and is located 16 miles southwest from the Kawlin station, which is on the Mandalay-Myitkyina railway line (figure 1). There is no road connection between Kawlin (figure 2) and Mandalay.

The approximate centre of the prospect is located at grid co-ordinates 147 352 on the 84 M/10 topographic map (scale 1 inch to 1 mile, or 1:63,360) of Burma series; the corresponding latitude is 23°42'30" E and longitude 95°31'00" N. The area is covered by aerial photographs at approximately 1:20,000 scale flown on 17 December 1957, the centre picture being on flight line 423 number 26.

The Shangalon area can best be reached from Rangoon by plane to Mandalay (2 hours); by train from Mandalay to Kawlin (8 to 12 hours); and by 4-wheel drive vehicle (dry season only) from Kawlin to Shangalon (1 hour 45 minutes). The area is accessible only by bullock-carts and on foot during the monsoon season (June to December).

Physical environment

The main topographic features in the Shangalon area (see figure 4) are the alluvial plains within the Kalon stream drainage basin (elevation around 625 feet) and fairly gently rolling hills, with the highest peak (1,250 feet) at Chigyindaung (Pagoda Hill). The exceptionally rapid erosion has resulted in numerous deep gulleys in the area.

The climate is characterized by a dry season (November-May) and by a humid and rainy monsoon season (June-October). The average minimum daily temperature for November-February is 65°F, and the annual rainfall averages 75 inches.

The hilly parts of the prospect are covered by open and easily penetrated bamboo and deciduous forest. The alluvial plains and lower eluvial areas are almost exclusively occupied by paddy fields. The two major villages in the prospect area are Shangalon (about 150 huts) and Pudaw (about 60 huts). Rice cultivation, cattle breeding and timber cutting are the main occupations of the local population.

Previous mining activities

Reports of old exploration or mining activities in Shangalon are scarce and incomplete. According to the known records, an Indian leaseholder carried out prospecting and some test mining from 1918 to 1920 which included shallow shafts, adits, trenches and test pits in areas of visible copper showings (mainly copper sulfates, malachite and azurite). It is not known if any ore treatment took place, but it is possible that some hand-picked ore was leached.

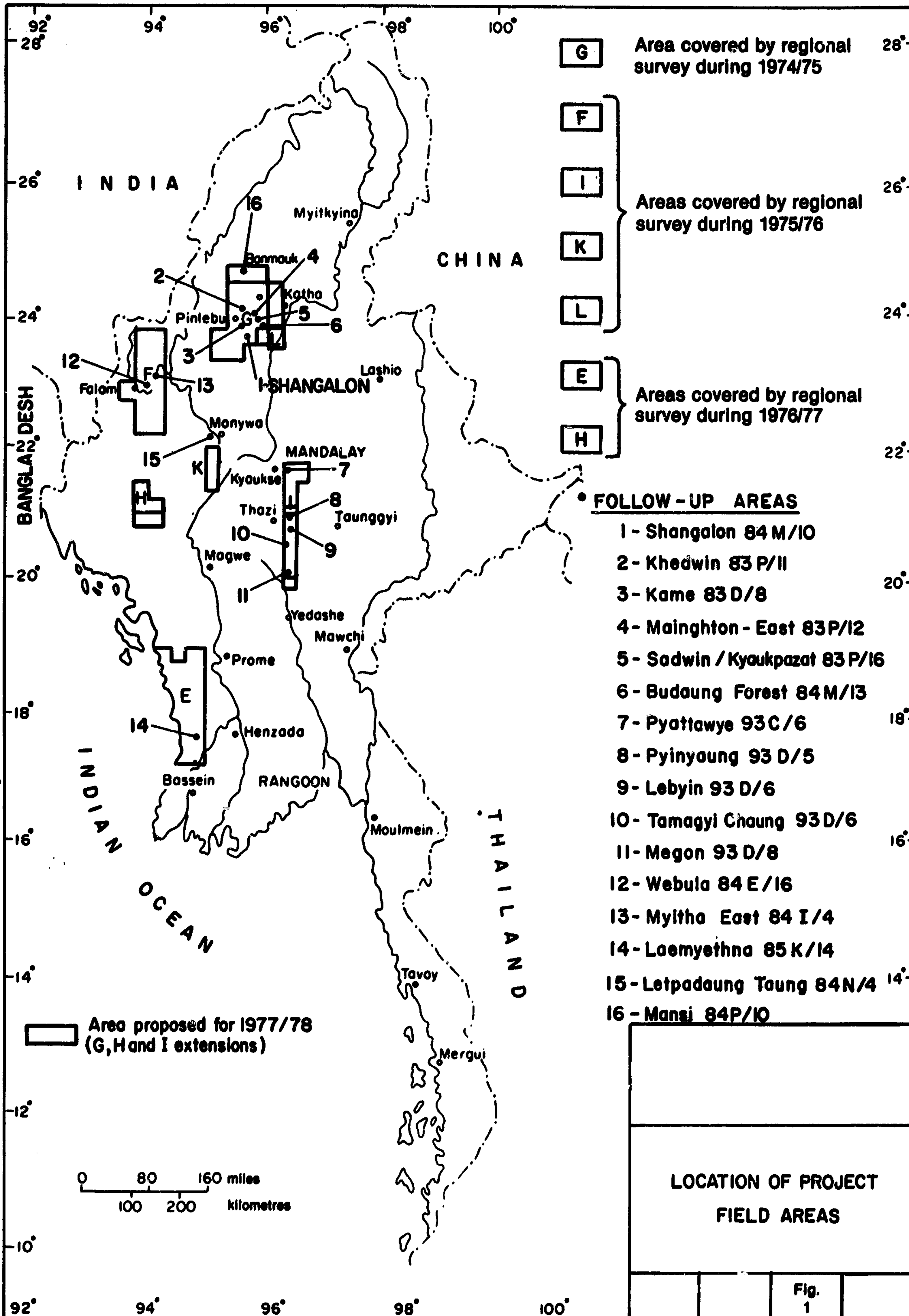
During 1954-1955, a Chinese leaseholder proceeded with similar activities, and during this period the area was briefly studied by the Burma Geological Department assisted by two Yugoslav experts. Unfortunately, their work was interrupted owing to lack of security, and only a few field days were spent in the area.

Small and low-grade gold placers in the streams which drain the prospect area are panned on a small scale by local inhabitants. Most of the gold is fine-grained and yields only moderate additional income for co-operative family labour. Panning is carried out in selected places after heavy rains because new pay gravel and coarse sand are transported in quantity owing to the rapid erosion.

Project activities

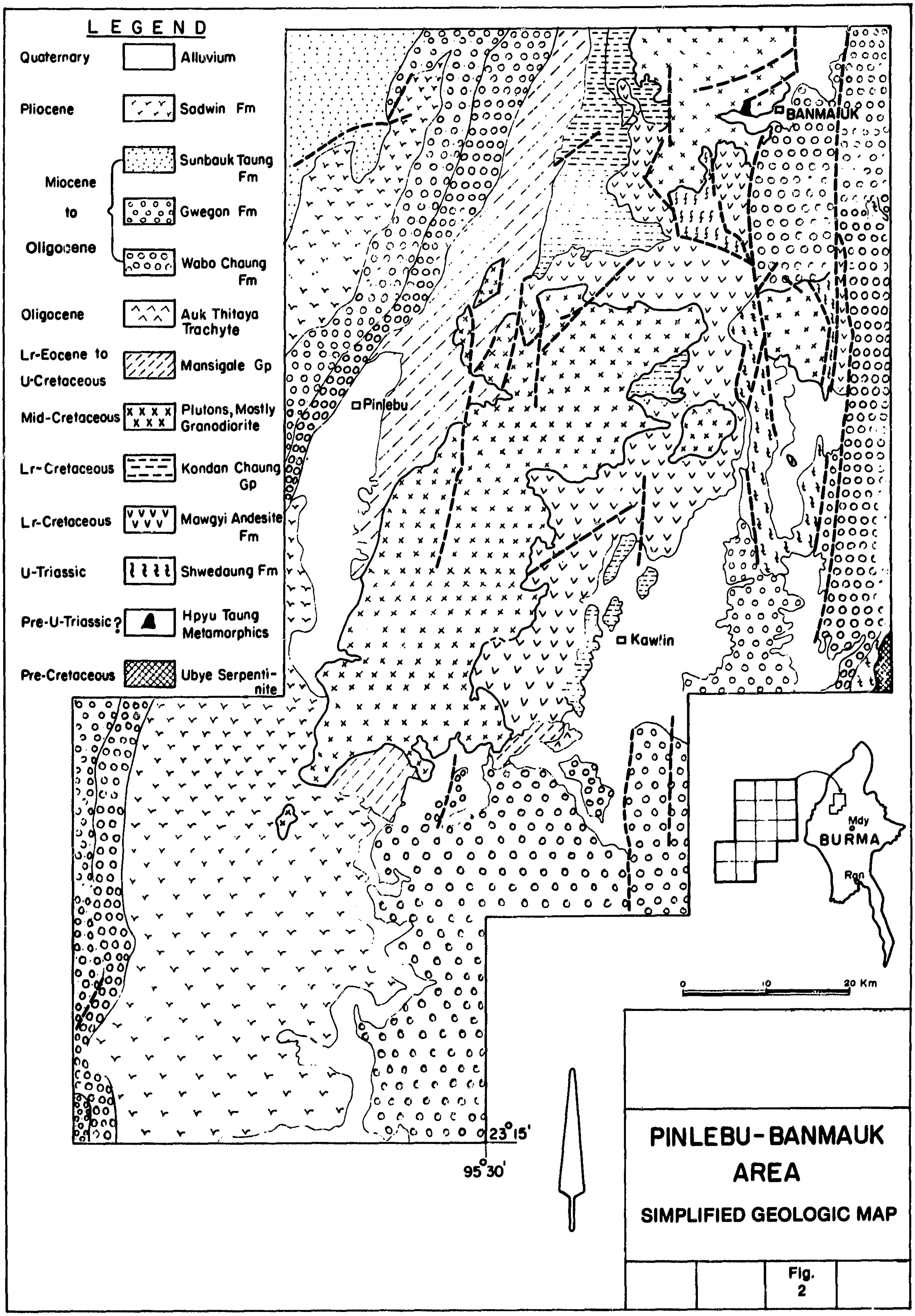
The Shangalon area was covered by the project's systematic regional geochemical reconnaissance and geologic mapping of the Banmauk-Kawlin G-area in late 1974. During the course of this survey malachite/copper sulphate straining was observed in the road cutting close to Shangalon village, and a few sediments from streams draining what is now known as Shangalon prospect gave anomalous values of around 200 ppm/Cu against the regional background of 23 ppm.

The regional survey was followed by more detailed sediment sampling, which revealed a large anomalous zone with values up to 3,070 ppm/Cu and 20 ppm/Mo. Meanwhile, brief geologic orientation work indicated that the Shangalon area mineralization might be of the porphyry



LOCATION OF PROJECT FIELD AREAS

Fig. 1


LEGEND
Quaternary
Alluvium
Pliocene
Sadwin Fm
Miocene to Oligocene
Sunbauk Taung Fm
Gwegon Fm
Wabo Chaung Fm
Oligocene
Auk Thitaya Trachyte
Lr-Eocene to U-Cretaceous
Mansigale Gp
Mid-Cretaceous
Plutons, Mostly Granodiorite
Lr-Cretaceous
Kondan Chaung Gp
Lr-Cretaceous
Mawgyi Andesite Fm
U-Triassic
Shwedaung Fm
Pre-U-Triassic ?
Hpyu Taung Metamorphics
Pre-Cretaceous
Ubye Serpentinite
BANMAUK
Pinlebu
Kawlin
23°15'
95°30'
Mdy
BURMA
Rgn
0
10
20 Km
PINLEBU-BANMAUK AREA
SIMPLIFIED GEOLOGIC MAP
Fig. 2

copper type. Consequently, a complete programme of integrated geologic, geophysical and geochemical work, which was followed by diamond drilling, was initiated in early 1975.

The work started by opening a grid line system which covers an area of more than 20 km^2 around the Shangalon prospect; the lines were cut 200 m apart, with fill-in lines in the areas of special interest. The grid formed the base for topographic and geologic mapping, induced polarization, resistivity, self-potential, magnetic and radiometric surveys, and geochemical soil and rock sampling.

The work is summarized as follows:

Duration of field work:	14 months (drilling 28 months)
Area covered by geologic mapping:	20.07 km^2
Lines cut and topographic surveys:	215.4 km
Geochemical samples collected:	3,071
Geoelectric measurements:	15,109 points
Magnetic measurements:	6,190 points
Radiometric measurements:	6,190 points
Number of analytical determinations:	16,710
Diamond drilling:	
BBS-15 (12 holes):	6,195 feet
Winkie (21 holes):	2,589 feet 8 inches

III. REGIONAL GEOLOGIC SETTING

Shangalon lies within the Burma Volcanic Arc comprising igneous rocks of pre-middle Cretaceous to Quaternary age, which extends for 600 km northwards from Mt. Popa through Monywa into northern Burma and forms the northern continuation of the Sunda Mountain Arc of Sumatra.

Results of geologic mapping by the project of about 3,500 square miles north of and around Shangalon (Technical Report No. 2) are shown in simplified form in figure 2. The Volcanic Arc here consists of late Triassic marine sediments overlain by extensive andesitic flow breccias and local pillow lavas which pass up into volcanogenic sediments and a turbiditic limestone. This succession is intruded by plutonic rocks forming a NNE-trending batholith and satellite plutons, mostly of mid-Cretaceous age; they consist largely of hornblende-biotite granodiorite with minor diorite and adamellite, and muscovite granite in the north near Banmauk. The batholith and its folded host rocks is overlain by coal-bearing sediments and conglomerate, mudstones, dacite and tuff with interbedded andesitic sills. At Shangalon this succession of probable late Cretaceous to early Eocene age is intruded by Oligocene tonalite porphyry dykes, which also intrude an Oligocene granodiorite stock. A diorite body adjacent to the mineralization pre-dates granodiorite. The mineralization and hydrothermal alteration affects the lower part of the late Cretaceous to early Eocene succession and an older quartz diorite, and is related to the tonalite porphyry dykes. Local trachytes of Oligocene age are also present at Shangalon.

At thick succession of non-marine conglomerate, sandstone and siltstone of late Oligocene to Miocene overlies older rock and is overlain by Pliocene sediments. Quaternary volcanoes occur within the Volcanic Arc at Mt. Popa in the south, north of Monywa, and 120 km north of Shangalon.

The post-batholith sediments thicken westwards into the Chindwin Basin, a broad syncline of late Cretaceous to Quaternary sediments more than 12 km thick. West of the Chindwin Basin and 150 Km west of Shangalon, the Chin Hills form part of the Indoburman Ranges, an arcuate mountain range comprising an eastern belt of highly deformed flysch-type sediments of late Triassic age with metamorphic and minor ophiolitic rocks, and a western belt of late Cretaceous to early Tertiary flysch (Technical Report No. 4).

East of Shangalon a major dextral transcurrent fault, the Sagaing Fault, separates the volcanic arc and surrounding Tertiary sediments from a narrow belt of schist and gneiss to the east, and extends southwards to the west of the Shan Plateau. The western part of the Plateau includes a thick and locally metamorphosed Precambrian and Palaeozoic succession, Mesozoic sediments and volcanis and tin-bearing granite plutons, some of which are of late Cretaceous to early Eocene age.

In plate tectonic terms, the Burma Volcanic Arc can be broadly related to eastward subduction of ocean floor beneath the western part of the Indoburman Ranges outer arc; the Chindwin Basin thus occupies the tectonic setting of an outer arc trough. The stratigraphy of the area north of Shangalon, south of Monywa and in the Shan Scarps suggests that subduction was intermittent, with major episodes in the early Cretaceous and late Cretaceous to early Eocene and an Oligocene episode. Since the early Miocene, oblique convergence of the Indian and Asian plates has been taken up partly by dextral strike-slip faulting along the Sagaing Fault, which has resulted in displacement of more than 300 km, and partly by intermittent minor subduction beneath the Indoburman Ranges. Burma west of the Sagaing Fault thus forms a small plate between the Indian and Asian plates, although plate interactions are complicated by a small spreading centre in the Andaman Sea and northward overthrusting of the Western Burma plate in northernmost Burma.

The Quaternary volcanism in the Volcanic Arc, the copper mineralization at Monywa and the mineralization at Shangalon are presumably related to episodic subduction during the Cenozoic. The oldest exposed rocks in the Volcanic Arc are schist, gneiss and amphibolite, which north of Shangalon occur as xenoliths and roof pendants in plutons and crop out south of Monywa. There is some evidence that these rocks are related to a major late-Triassic orogeny, and that the Volcanic Arc developed across this older orogenic belt on the continental margin of Asia.

IV. GEOLOGY OF THE SHANGALON PROSPECT

Field work and mapping methods

A total of 33 days were spent mapping the Shangalon area between March and May 1976. Using grid lines as a control, individual outcrops were systematically plotted and then studied to determine the rock types, alteration and indicated mineralization. Since the major control of mineralization is fractures, the density and orientation of veinlet sets were carefully measured where possible and plotted. Drill core was studied at Shangalon and Rangoon, lithology, alteration mineralogy, fracture density and mineralization being noted on specially designed log forms.

In the main area of interest, centred at L3400/3300, outcrop is excellent as many creeks have cut through the bedrock. In the flatter northern areas, however, outcrop is generally poor, and geologic interpretations were often based on studies of float boulders, soil type and interpretations of magnetic, radiometric and induced polarization results.

Weathering and erosion

Weathering is extremely rapid at Shangalon; several centimetres of soil can easily be removed during one rainy season. This is clearly shown by boulders perched on mounds of compact dirt, whereas surrounding soil is washed away. On the flanks of hills, new outcrops are often exposed by heavy rainshowers, which cause small wash-outs to occur.

Because most float and soil in areas of low relief are residual rather than transported, good correlation was found between float or soil and underlying rock type. Soils over granodiorite, for example, are quartz-rich, coarse-grained and light-coloured; those overlying diorite usually retain fine biotite fragments and are a darker colour. Siliceous rock is commonly better preserved, with the result that quartz float gives a deceptively large impression of the underlying bedrock source.

Leached capping

Erosion at Shangalon has proceeded almost as rapidly as leaching, with the result that no enrichment blanket was formed and only minor chalcocite is seen in a few drill holes at Shangalon. In outcrop however, hypogene sulphide is only rarely seen since leaching is usually several metres ahead of erosion.

Limonite was only partially used as a guide to hypogene sulphide identification since little comparative data was available and pyrite: chalcopyrite ratios are generally high. Nevertheless, more yellow jarositic limonite was in a general sense linked to more pyrite-rich rock, and ochre-orange-red hematitic limonite to more chalcopyrite-enriched areas. Usually, the latter areas also displayed some malachite or neotocite, indicating the presence of copper.

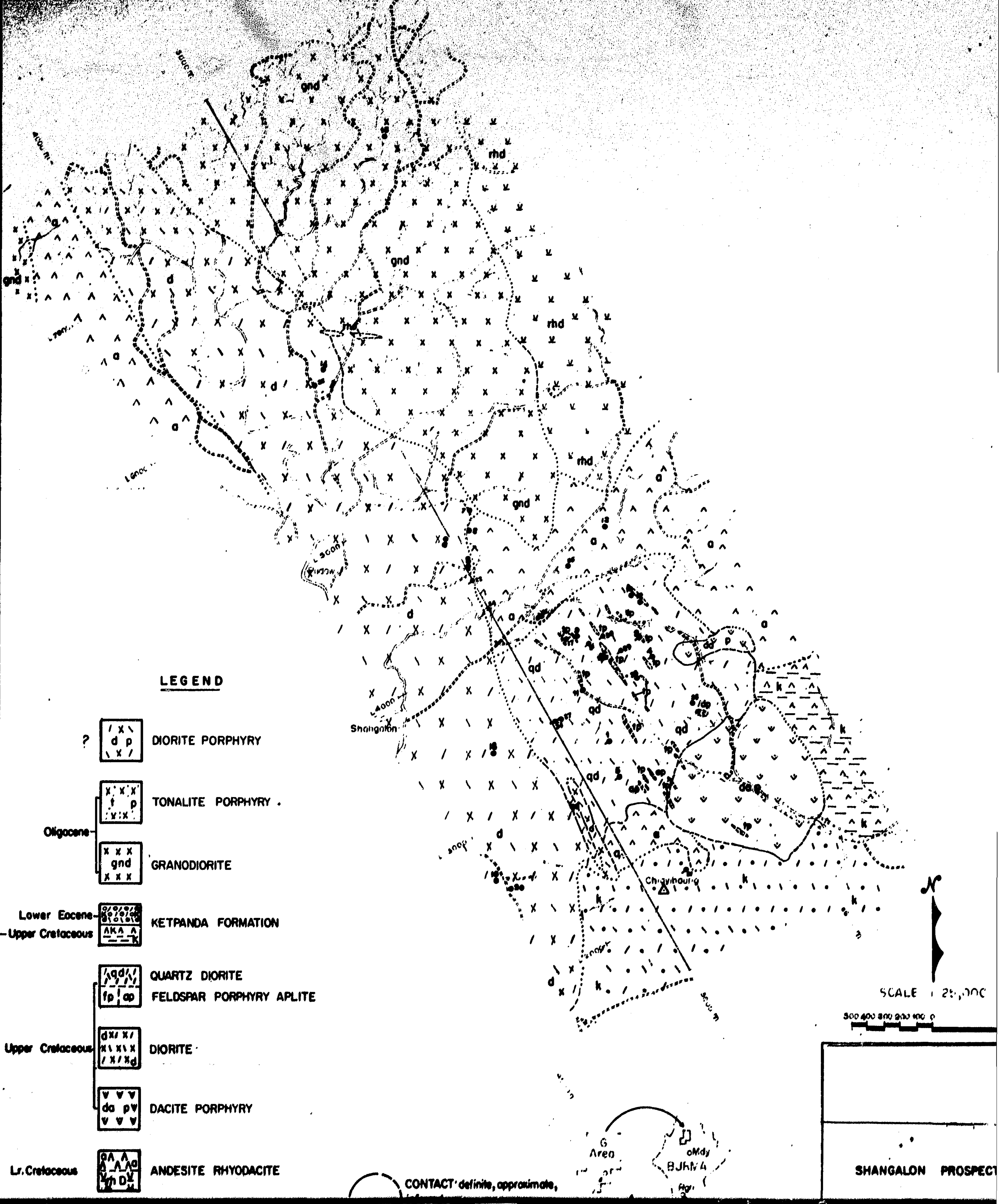
Lithology

Five major intrusive, three volcanic and one sedimentary unit were identified in the Shangalon area (figures 3 & 4). Petrologic descriptions are based on studies of thin sections, stained blocks are obtained from outcrop or drill core, and modal percentages are derived from point counts. Rocks were classified according to the textbook Petrography (Williams, Turner and Gilbert, 1954). Units are described in order of age, andesite and rhyodacite being oldest.

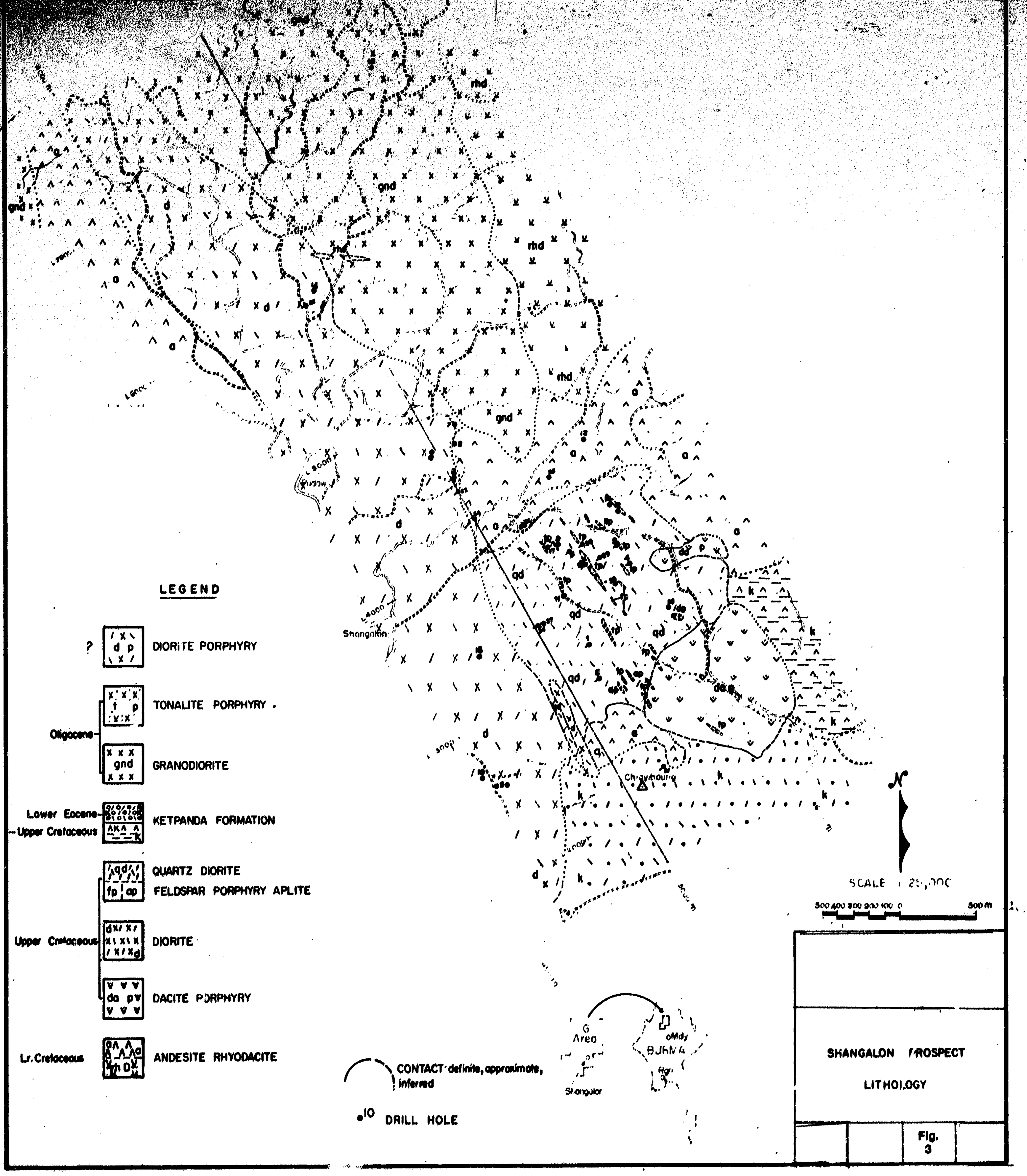
Andesite (Mawgyi Andesite)

The Mawgyi Andesite is believed to be the oldest unit in the Shangalon area. Similar andesitic flows and flow breccias of the Mawgyi Andesite about 9 miles to the north are intruded by plutons, which have yielded potassium-argon ages on biotite of 93.7 ∓ 3.4 and 97.8 ∓ 3.6 m.y (Early Upper Cretaceous). This suggests that the andesites are at least as old as Early Cretaceous.

In hand specimen, the andesite is typically a dark green porphyritic rock where not affected by alteration. Commonly however, it is silicified, chloritized and biotized to a green-grey or even black well-indurated aphanitic rock. Magnetite is generally present, not exceeding 3 per cent. Pyrite and lesser chalcopyrite is ubiquitous, usually either disseminated or in microveinlets.



LEGEND
? DIORITE PORPHYRY
TONALITE PORPHYRY
Oligocene
GRANODIORITE
Lower Eocene - Upper Cretaceous
KETPANDA FORMATION
QUARTZ DIORITE
FELDSPAR PORPHYRY APLITE
Upper Cretaceous
DIORITE
DACITE PORPHYRY
Lr. Cretaceous
ANDESITE RHYODACITE
CONTACT definite, approximate,
Shangalon
SHANGALON PROSPECT



LEGEND
? DIORITE PORPHYRY
Oligocene
TONALITE PORPHYRY
GRANODIORITE
Lower Eocene-Upper Cretaceous
KETPANDA FORMATION
QUARTZ DIORITE
FELDSPAR PORPHYRY APLITE
Upper Cretaceous
DIORITE
DACITE PORPHYRY
Lr. Cretaceous
ANDESITE RHYODACITE
CONTACT definite, approximate, inferred
10 DRILL HOLE
Shangalon
Chayvhoung
SCALE
SHANGALON PROSPECT
LITHOLOGY
Fig. 3

Rhyodacite

This is a little-studied silicic volcanic rock forming small irregular bodies within andesite in the northeastern part of the prospect. It was possibly emplaced as minor intrusions associated with eruption of the Maingthon Dacite described below. In hand specimen, it is a grey-buff massive, silicic rock with few discernible phenocrysts.

Dacite porphyry (Maingthon Dacite)

The Maingthon Dacite, a volcanic rock, is recognized by its bleached white appearance and porphyritic texture. Fresher samples, rarely seen, have a darker grey-green appearance. In thin section, the bleaching is due to pervasive weak sericitization of phenocryst and groundmass plagioclase. Fine disseminated pyrite is usually present, but fracture-contained sulphide and quartz are only apparent close to the main area of mineralization/alteration. This suggests that the hydrothermal alteration may in fact be superimposed on a weak deuteric alteration phase.

Contacts between dacite and quartz diorite are difficult to interpret. The dacite is considered to be equivalent to the Maingthon Dacite to the north and to overlie the andesite.

Diorite

Diorite is a poorly exposed unit, which occurs throughout the western half of the Shangalon area. In hand specimen, it is a dark-green rock with a conspicuous black, cloudy mass of hornblende and/or biotite crystals. In weathered outcrops it is sometimes difficult to identify, although biotite (or its bleached, weathered equivalent) is usually distinctive. Local fresh exposures show highly variable grain size and proportion of hornblende, with some areas of coarse mela-diorite adjacent to porphyritic andesite or microdiorite. In places the compositional variations suggest layering.

Normally, the diorite is only weakly chloritized and very poorly mineralized, although close to granodiorite (see below) it often contains large, poorly exposed quartz veins with chalcopyrite and molybdenite. Some quartz-tourmaline veins are also found in the southerly portions of the diorite, but these are probably not related to mineralization.

Quartz diorite

The quartz diorite unit intrudes andesite and probably dacite and is the major host rock for the mineralization/alteration seen at Shangalon. Nowhere in the prospect area is an unaltered outcrop of this rock exposed. The least altered specimens show complete destruction of original mafic minerals and weak sericitization of plagioclase.

Since a complete gradation from weakly to strongly altered rock exists, sericitized specimens, although their original texture is destroyed, can be readily identified as intrusive rock by their field relationships or by thin-section examination.

In hand specimen, the quartz diorit is typically a fine- to coarse-grained, somewhat leucocratic rock, with conspicuous quartz and fine sericite partially replacing plagioclase laths. Less altered specimens are more even-textured and slightly green in colour, whereas highly sericitized varieties display a strongly porphyritic texture with quartz phenocrysts set in a bleached, sericitic groundmass. Quartz-sulphide veinlets are always present, increasing in density in more altered rock.

In thin section, subhedral to euhedral plagioclase crystals, normally zoned, are pervasively altered to saussurite or sericite, but only rarely has sericitization completely destroyed original feldspars. Quartz, in anhedral crystals of variable size, occurs in greater quantity in more altered rocks as a result of silicification and as a by-product of sericitization.

Sericite, with minor feldspar separated from a hydrothermally altered part of the pluton, yielded a K/Ar age of 52.9 ∓ 2.3 m.y. This is interpreted as a probable maximum age for hydrothermal alteration in the area.

Aplite and feldspar porphyry dykes are found in the quartz diorite and presumably represent a late magmatic event. They are everywhere altered and mineralized, but owing to their compact nature, usually less so than the main phase of quartz diorite porphyry.

Ketpanda Formation

The predominantly sedimentary Ketpanda Formation occupies the southern and southeastern parts of the prospect area. It lies unconformably on the Mawgyi Andesite, and geologic mapping to the east of the prospect indicates that its contact with quartz diorite plutons is also unconformable with local basal boulder beds. The unit consists of coloured shales, cross-bedded sandstones, grits and conglomerates, and local dacite flows and tuffs with hornblende andesite sills or flows near the base. A prominent conglomerate with abundant quartz pebbles strikes NE through the Chigyindaung Pagoda Hill, where the sediments are hydrothermally altered and tourmalinized and locally brecciated. A tonalite porphyry dyke intrudes the base of the formation. A hornblende andesite sill near the base of the unit yielded a whole-rock potassium-argon age of 50.1 ∓ 2.5 m.y., or Lower Eocene. Stratigraphic evidence suggests that the formation is of Upper Cretaceous to Lower Eocene age.

Granodiorite

The granodiorite is a fairly well-exposed unit found northwest of the main area of interest, and its emplacement is considered to be closely associated with mineralization. It is readily identifiable by its coarse-grained texture and large biotite "books", which are visible even in weathered outcrops.

The unit is weakly silicified and poorly mineralized over a wide area near L5600/5200 where widely spaced, thin quartz-K-sparchalcopyrite veinlets and occasional chalcopyrite specks usually enveloped in phenocrysts of biotite are found in a number of outcrops. In DDH-14B, granodiorite is clearly seen to intrude diorite. Furthermore, mineralized quartz veins in diorite close to the contact are probably related to the intrusion of the granodiorite. A sample of the granodiorite yielded a K/Ar age on biotite of 33.2 ∓ 1.3 m.y., or mid-Oligocene.

Tonalite porphyry (T-rock)

This rock occurs in lenticular dykes usually oriented along a 150° trend and intrudes granodiorite, quartz diorite, Maingthon Dacite and the base of the Ketpanda Formation. In hand specimen, it is identified by its dark colour and porphyritic texture, the most conspicuous phenocryst being biotite. During initial field work it was believed to be a tonalite; hence its field name, T-rock.

In thin section and in stained blocks, fresh samples are seen to be compositionally similar to granodiorite, suggesting that this rock may be a phaneritic derivative of the granodiorite. Furthermore, its predominance in rocks close to the southward trending extension of, and its possible stratigraphic position above, the main granodiorite stock further suggests a possible genetic relationship between these rock types.

Most of the hydrothermal alteration and mineralization appear to be about the same age as the tonalite porphyry. This is well seen in a dyke near DDH-2W, where most of the quartz-sulphide veinlets in altered quartz diorite porphyry are cut by the tonalite porphyry, but some of them transect both quartz diorite and tonalite porphyry. Furthermore, although the porphyry is usually weakly chloritized and sericitized, it is always less altered than the rock it intrudes in the main area of interest.

A K/Ar age of 37.9 ∓ 1.4 m.y. was obtained on biotite from the tonalite porphyry. Allowing for the experimental error, this is slightly older than the granodiorite (33.2 m.y.) which it intrudes. However, the apparent younger age of the granodiorite could be explained if the K/Ar age reflects the cooling age of the pluton.

Post-granodiorite andesite dykes

Dark plagioclase porphyry andesite dykes are present at a few localities within the granodiorite. They probably post-date the mineralization.

Diorite porphyry

Two small outcrops of fine- to medium-grained diorite with plagioclase phenocrysts occur in the quartz diorite. These are of uncertain age, but show some similarities to hornblende andesite and microdiorite within the Ketpanda Formation.

Alteration

A large zone of hydrothermal alteration has been superimposed on virtually all rocks in the Shangalon area (figure 5). The intensity and type of alteration is dependent on two major factors: the type of rock affected and the degree of structural preparation (fracturing) of the host rocks. Lateral zoning is well displayed at Shangalon and is best seen in areas where the hydrothermal alteration has not crossed lithologic boundaries. The quartz diorite, traversed from point 4500 to 5600 along L2800, affords an excellent example of such zoning: propylitized intrusive becomes increasingly sericitized and pyritized eastwards; phyllic alteration then increases to its maximum near point 5200, then decreases in intensity, until propylitic assemblages are once again encountered near point 5600.

Alteration changes are gradational, but usually accomplished over fairly short distances; on L2800 the change from propylitic to phyllic occurs over less than 100 m. This is mainly due to the strong structural control of the mineralization and alteration at Shangalon.

In drill holes, alteration decreases with depth, but this is more probably due to alteration zoning across a given structural zone rather than only vertical zoning. Regionally however, some vertical zoning is indicated since zones of strongest phyllic alteration are found in southerly exposures (e.g. near DDH-5B), K-spar veinlets exist in the granodiorite pluton to the north and moderate to strong phyllic alteration is between these two types. Southeasterly tilting and subsequent erosion of the hydrothermal cupola would explain the present configuration of alteration zones.

Propylitic alteration

Diagnostic minerals: Epidote, chlorite, calcite, and saussurite with minor sericite, magnetite and pyrite.

This assemblage is most pronounced in the quartz diorite, but andesite is also affected. It is usually peripheral to areas of strong fracturing and mineralization, although near L2600/5600 several propylitized outcrops of quartz diorite have more than one per cent pyrite. In hand specimen, propylitized rock is usually poorly fractured and has a distinct greenish tinge. Epidote is particularly diagnostic, although not always seen. In thin section, propylitization is seen to affect mainly mafic minerals, although plagioclase is also partially altered to saussurite and sericite. As alteration increases, epidote disappears, but chlorite persists and sericitization increases.

Sericitic alteration

Diagnostic minerals: Weak sericite, chlorite and quartz; minor pyrite.

Sericitic alteration, distinct from the phyllic assemblage described below, is a weak, pervasive, partial replacement of plagioclase by sericite. It is seen in dacite porphyry and in sediments on the flanks of the Chigyindaung Pagoda Hill.

In the dacite porphyry, its presence in sulphide-deficient rock and its occurrence in areas far removed from the major zone of mineralization suggests that it is partially a product of deuteric alteration of the volcanic rock. In the sediments, however, it appears to be a manifestation of weak hydrothermal potash metasomatism on mafic-poor rock and is normally associated with weak pervasive sulphide.

Weak phyllic alteration

Diagnostic minerals: Weak sericite, quartz and pyrite; minor chlorite.

Owing to the abrupt nature of alteration changes between propylitic and phyllic assemblages, argillic alteration was never clearly defined at Shangalon. Instead, the term "weak phyllic" was adopted to describe rock alteration which affects quartz diorite porphyry, dacite porphyry and arkosic sediment and is mid way between propylitic or sericitic and strong phyllic in intensity.

In hand specimen, it is characterized by a virtual lack of chlorite and epidote and less than 15 per cent sericite content, the latter occuring mainly in alteration envelopes surrounding quartz-sulphide veinlets. Although plagioclase laths farther away from quartz-sulphide veinlets are saussuritized and sericitized, thin section studies show that they always retain their original twinned, subhedral appearance.

Strong development of clay minerals, mainly kaolin, was seen in large outcrops along L3800/5200-5800. Subsequent drilling (DDH-17B and 10B) clearly established that these clays are of supergene origin and disappear within 30 m as the zone of weathering is passed.

Weak phyllic alteration also manifests itself in the sediments of the Chigyindaung Pagoda Hill. The hypogene origin of this alteration is shown by its association with tourmaline and by the presence of quartz-sulphide veinlets. In thin section the rock is seen to be strongly sericitized an silicified, but a low sulphide content precludes its inclusion in the more advanced phyllic assemblage.

Phyllic alteration

Diagnostic minerals: Quartz, sericite, pyrite.

A typical hand specimen of phyllically altered rock is grey to chalk white, plagioclase laths being especially bleached. Quartz phenocrysts are obvious, and fine-grained felted sericite is visible as tiny reflecting flakes in strong sunlight.

The hydrothermal cupola was probably unusually dry, preventing complete sericitization of plagioclase, except near sulphide veinlets. Some outcrops, such as near L3300/4950, L3200/5700 and at L2700/5100 do, however, show complete sericitization of plagioclase in rock that was originally quartz diorite porphyry.

The sediments on the Chigyindaung Pagoda Hill (especially quartz pebble conglomerate near L2300/5300) are particularly well sericitized. This may be due to their mafic (and therefore iron) deficiency, which would make the plagioclase susceptible to attack by hydrothermal fluids. Associated tourmaline, silica and quartz-sulphide veins again attest to the hydrothermal origin of the alteration in this rock.

Phyllic alteration is most closely associated with areas of highest sulphide content. The sulphide is mainly pyrite, with less chalcopyrite and molybdenite, and is most commonly contained in quartz-sulphide veinlets or healed micro-veinlets; true dissemination is rare.

Hornfelsic alteration

Diagnostic minerals: Quartz, secondary biotite, chlorite, pyrite, magnetite and sericite.

This hornfelsic alteration is only seen in andesitic volcanic rock within the zone of alteration and mineralization. It varies in intensity, depending on how much potash and silica metasomatism has occurred, and produces a grey to dark-green or black, aphanitic siliceous rock with pervasive finely disseminated magnetite, biotite and chlorite, with sericite of possible supergene origin. Pyrite and lesser chalcopyrite are always present in disseminations and microveinlets, usually enveloped in a fine, felted mass of secondary biotite and/or chlorite.

At Shangalon, the spatial distribution of hornfels suggests that it does not represent a true potassic zone in the sense of a potash-rich core surrounded by phyllic alteration. It is more likely a result of hydrothermal fluids encountering iron and magnesium-rich andesitic rock and forming biotite and chlorite in addition to sericite.

Silicification

Silicification is widespread at Shangalon, quartz having been introduced along fractures and also produced as a by-product of potassic alteration. Besides quartz veining, the silicification manifests itself as silica envelopes surrounding the veinlets (especially in dacite porphyry) and in the pervasive silicification of andesite.

Potassic alteration

As previously mentioned, a true potassic zone - in the sense of a discrete core of potassium-feldspar and secondary biotite surrounded by phyllic alteration - was not identified at Shangalon, although the quartz-potassium-feldspar-sulphide veinlets of limited extent which are found in the granodiorite may in fact represent a deep potassic zone if the granodiorite is the intrusive source of the hydrothermal fluid.

Other alteration

Tourmalinization is generally weak but widespread at Shangalon. It appears to be concentrated in the envelopes surrounding larger quartz veins in southern exposures of the diorite and also in veinlets and disseminations in altered sediment. However, all altered rock was found to have some tourmaline associated with it.

Calcite veining is also common. It appears to be slightly younger than hydrothermal quartz, but it is often associated with quartz and sulphide in veinlets. Although it is usually peripheral to outcrops of strongest alteration, it can still occur in areas of high copper values.

A pink soft mineral, believed to be alunite, was found in some strongly altered rock. Since it is restricted to the zone of weathering, its origin appears to be due to supergene rather than hypogene alteration.

Structure and mineralization

Regional structure

The primary structural control in the Shangalon area is a 150° (northwest)-oriented tectonic system, which has determined both the orientation of the granodiorite and tonalite porphyry and the attitude of the minor mineral-bearing structures (figure 6). On a regional scale, this tectonic system pre-dates north-trending splay faults of post-Oligocene age associated with dextral strike-slip faulting along the major fault east of the Volcanic Arc.

At Shangalon, discrete faults are of lesser importance, the major manifestation of the 150°-oriented tectonic system being crudely lenticular zones where rock has been intensely fractured and subsequently mineralized. However, several faults were noted in the Shangalon area, and large quartz veins and dyke-like bodies presumably follow old fault fissures. In several major creeks, strong fracturing that crosses the 150° regional strike was noted. These indicate that cross-faulting does exist, but no evidence of large-scale movement was found. Emplacement of the plutons was apparently passive, as they lack intrusion-related shearing.

Vein-type structures and their mineralization

Larger quartz-sulphide veins have been poorly studied because they are usually found in areas of heavy overburden. Four places containing vein-type mineralization were found: i) within the quartz diorite; ii) in diorite near L2800/4200 and 4700; iii) in the diorite close to the granodiorite contact from L4300/5000 to L7600/4500; and iv) in diorite close to volcanic rock near L5600/4100. In the quartz diorite, true veins of sizable width are rare, but mineralized zones, where copper grades dramatically increase over several metres, were found in DDH-4B, 9W, 16B and 17B.

In the drill cores, these high-grade segments occur in zones either where quartz-sulphide veining locally increases or, as in DDH-9W, where unusual amounts of chalcopyrite occur disseminated in a granodiorite porphyry dyke. The drill core indicates that these occurrences have only limited strike length.

Quartz veins in diorite have the most potential for vein-type mineralization. Where visible in the south, they are less than one metre thick, with up to 30 m silicified and tourmalinized alteration envelopes. Pyrite and minor chalcopyrite is visible, although most sulphides have been leached out. However, according to the drilling results also these veins have only limited extension and no obvious grade.

Along the diorite-granodiorite contact, between L4300 and L5000, molybdenite and chalcopyrite-bearing quartz veins are indicated in float and poor outcrop. Four holes (DDH-3W, 6W, 7W and 8W) have been drilled in this area, but only DDH-6W intersected a quartz-chalcopyrite vein, which grades 1.13 per cent and 120 ppm Mo over one foot. However, DDH-7W and 8W, may have significant although sub-economic copper and gold values. A summary of these results is given below:

Table 1. Optimum copper, molybdenum and gold intervals in four drill holes

DDH	Depth	Best Cu interval	Best Mo interval	Best Au interval
3W	133'	3 m of 1,240 ppm	3 m of 840 ppm	6.1 m of 0.25 ppm and 3 m of 0.32 ppm
6W	125'	0.3 m of 11,300 ppm	0.3 m of 120 ppm	0.3 m of 1.36 ppm
7W	143'	6.1 m of 720 ppm	3 m of 240 ppm	30.7 m of 0.81 ppm
8W	150'	15 m of 3,606 ppm	3 m of 70 ppm	12.2 m of 0.17 ppm

Another area of quartz-sulphide veining that has been partially tested is located near L6000/4800. East and west of here, pyrite chalcopyrite and molybdenite in quartz veins up to two metres in width are found. However, DDH-14B, drilled at L6000/4800, intersected only sporadic patches of weakly mineralized rock, the best interval being 3,156 ppm Cu over 9.2 m.

Other areas where vein-type occurrences of mineralization have been found are summarized below:

Location	Mineralization indicated	Comments
L5600/4150	Chalcopyrite and molybdenite in quartz veins	Minimal size and grade indicated
L6400/4500 and 4700	Chalcopyrite in quartz veins	Minimal size and grade indicated
L5100/4750	Chalcopyrite in quartz veins	Minimal size and grade indicated
L7080/5850	Chalcopyrite in K-spare-quartz veinlets	Tested by DDH-15W; best interval was 0.3 m of 1,139 ppm Cu

Minor structure and mineralization

The majority of the mineralization occurs in quartz-sulphide-filled fractures less than 1 mm in width, densities in areas of more than 2 per cent sulphide being greater than 25 veinlets per foot. With increasing distance from zones of strong fracturing, first fracture thickness and then fracture density decreases, the net result being an over-all decrease in amount of sulphide and, in a more general sense, a decrease in intensity of alteration. Although every rock type can be fractured, quartz diorite porphyry appears to have been particularly susceptible to fracturing and contains the bulk of the mineralization and alteration.

Disseminated mineralization

Pyrite dissemination is widely spread at Shangalon, but the bulk of the pyrite occurs in quarz-sulphide-filled fractures and fracture zones. Dissemination of chalcopyrite is scattered and mainly fine-grained, and has no significant effect on the ore grade. It has been observed mainly in the vicinity of chalcopyrite-bearing structures, but also associated with large biotite books in granodiorite, in the northwest corner of the prospect. Rare disseminated molybdenite has been found only in strongly silicified zones of quartz diorite in the centre part of the main mineralization.

Metal distribution

Copper. Copper is mainly contained in chalcopyrite, although copper analyses suggest that some of it may be present in pyrite. Trace amounts of secondary chalcocite are also present, but erosion has generally proceeded as rapidly as leaching, preventing development of a chalcocite blanket. Copper carbonate, mainly malachite, is widespread and especially visible in old workings where it was presumably recovered in the past. Neotocite, covellite and bornite were also noted, but only in very minor quantities.

Molybdenum. Molybdenum was mostly observed as molybdenite, mainly in large milky quartz veins near L4600/4900. It is sometimes found disseminated in small quartz-sulphide veinlets in the main area of interest, but nowhere does it occur in a true quartz-molybdenite stockwork setting. Minor ferrimolybdite was also noted.

Gold. Placer gold is found in virtually all large creeks east of the Kalon River and probably originates in quartz-sulphide veins related to the hydrothermal system. Although most core analyses showed only low values, gold may be valuable as a by-product if recovery of other metals should prove feasible.

Other metals. Trace amounts of lead and zinc mineralization were found in float near Pudaw. In drill holes, average lead and zinc values were consistently less than 25 ppm, while the highest values were only 58 ppm lead and 119 ppm zinc.

Silver values were also low, averaging consistently less than 1 ppm, with the highest recorded value of 17 ppm over a one foot quartz vein in DDH-6W.

Sulphide distribution

The dominant sulphide at Shangalon is pyrite veins and disseminations, the 1 to 2 per cent pyrite halo being almost 2 km^2 in size. Within this pyrite halo, sulphide is concentrate (greater than 2 per cent) in 7 major zones, which are shown on the 1:10,000 scale Mineralization and Structure map (figure 6).

Mineral zoning

Mineral zoning is only partially understood at Shangalon. Generally, pyrite tends to be peripheral and is much more abundant in southern outcrops in the main area of interest. This is well shown in DDH-5B, which had good alteration and high sulphide content, but averaged only 360 ppm copper; DDH-4B had comparable alteration and sulphide, but average copper was 982 ppm. This difference may be due to uplift of the more northwesterly portions of the mineralized rock, resulting after erosion in exposure of the pyrite-rich upper cupola of the alteration shell. The zone of best copper anomalies would then lie within the pyrite zone, stratigraphically lower than rock in the area of DDH-5B.

Conclusions

Volcanic activity within the Burma Volcanic Arc had started by the early Cretaceous, with the widespread eruption of andesitic volcanics and emplacement of a granodiorite batholith. At Shangalon intrusion of a quartz diorite was followed by uplift and erosion and late Cretaceous to early Eocene sedimentation and minor volcanism which was widespread in the region. The major diorite body at Shangalon was probably emplaced in or before the early Eocene and pre-dated mineralization.

The final major intrusive event was the emplacement of a NNW-trending granodiorite stock and porphyritic dykes in all previously formed rock. This stock with its hydrothermal cupola was the major source of the mineralization and alteration seen at Shangalon. Hydrothermal minerals, including chalcopyrite and molybdenite, were emplaced along thin fractures that had been formed as a result of the north-north-east-oriented regional tectonism. Fracturing was not uniform in density, but occurred more strongly in crude lenticular zones that mimic the regional structure. Since these zones were more structurally prepared, the degree of hydrothermal alteration and mineralization in them was more intense, and they constitute the major bulk tonnage exploration targets at Shangalon.

Alteration and mineralization in these targets is typical of porphyry copper deposits. Where hydrothermal fluid was best able to permeate the intruded rock, phyllic or strong hornfelsic alteration and highest sulphide content is found. Conversely, as fracture density decreases, propylitic-chloritic, weak hornfelsic or sericitic alteration with lower sulphide content predominates. Although a true potassic zone, centered with phyllic alteration was not found, biotization of iron-rich andesite occurred while quartz-feldspar veinlets in granodiorite may be deep remnants of such alteration.

Alteration assemblages are not strongly imprinted on the affected rock, suggesting that the hydrothermal phase was fairly dry at Shangalon; complete alteration of feldspars, for example, is only rarely seen. Since the hydrothermal event affected virtually all rock types, alteration assemblages vary greatly according to the lithology.

Vertical alteration zoning is apparent in drill holes, but this appears to be primarily structure-controlled rather than a product of the depth of emplacement of the affected rock within the hydrothermal cupola. Also, mineralization tends to be more pyrite-rich in peripheral areas and near the apparent stratigraphic top of the hydrothermal system, while copper is more centrally located, and molybdenum is sporadic, but tends to follow stronger copper anomalies.

Larger vein-type mineral showings are found, throughout the Shangalon area, primarily in diorite close to contacts. A few of the most promising ones were drilled and were found to have only limited width, strike length and weak mineralization, suggesting that they have even less potential than the bulk tonnage targets.

The final events at Shangalon were minor post-mineral intrusion and uplift, which apparently tilted the upper part of the mineralization and alteration system to the southeast. Subsequent erosion has partially exposed a diagonal slice of this system where pyrite is best preserved in more southerly exposures. Minor chalcopyrite in feldspar veinlets is found in northern exposures, and the best bulk tonnage pyrite-chalcopyrite targets are in between.

V. GEOPHYSICS

Methods and coverage

Choice of methods

The main objective of the geophysical surveys in Shangalon was to locate and delineate disseminated or massive sulphide mineralization and to support geologic mapping.

The electrical self-potential method was used to carry out a general reconnaissance for possible sulphide mineralization and as a prelude to an induced polarization survey. Electrical induced polarization was used to detect sulphide mineralization. This method has much better resolving power in the case of deeper-level mineralized bodies than does the self-potential method. Simultaneously, resistivity measurements were made to determine concealed geologic contacts, possible large conducting ore masses, large masses of altered rocks (e.g. alunitization, sericitization, silicification) and the thickness of residual soil cover.

Electromagnetic Turam measurements were made to detect highly conductive vein-type massive sulphide zones. The experimental radiometric method was utilized to complete the geologic exploration map and to find out possible anomalous zones due to potassic alteration. The magnetic method was used to determine hidden geologic boundaries, to differentiate rocks of different magnetic susceptibilities and remanent magnetism, and to detect tectonic lines.

Description of methods and technical data

A 1:5,000-scale topographic sketch map based on grid lines at 100 m or 50 m spacing was prepared and used as the basis for presentation of all field data. Electric self-potential was measured by a transistorized D.C. voltmeter (Elektrisk Malmletning and the S.P. Geonics Ltd.). Non-polarizing Cu/$CuSO_4$ electrodes in porous pots were used. Measurements were carried out along all lines every 25 m and reduced to the same arbitrarily selected zero level. Results were plotted in the form of profiles (figure 20) and presented in the form of anomaly axes (figures 9 and 10) on the geoelectric interpretation map.

Electrical resistivity and the induced polarization were measured simultaneously. A Scintrex time domain and the Geoscience frequency domain instruments were utilized. Copper plates 30 by 40 cm or bronze screen wire mesh electrodes were used in the transmitting circuit, and non-polarizing electrodes were used as receiving electrodes. A dipole-dipole configuration of electrodes formed the standard, with length of dipole a = 50 m and separation between two dipoles ranging from a = 50 m to n x a = 300 m or 200 m increasing in steps of 50 m, with n ranging from 1 to 6 to 4. The results were plotted in the usual form of pseudo-sections along lines (figure 20). Pseudo-sections conveniently present the apparent resistivity and induced polarization data, but differ from the actual distribution of the true values on the vertical profile. Terrain corrections of resistivity values were calculated for line L3100, but as the correction terms proved insignificant, they were not calculated for other lines.

The time domain method was used with alternating pulse duration and interruptions of 4 seconds each. Polarization was interpreted in the interval between 0.45 and 1.75 seconds after the end of the pulse. Four cycles were recorded at each station, and the mean value was calculated. The primary current was mostly about 1 amp.

The frequency domain method was used with frequencies of 10 and 0.3 cps. At least two observations were taken in each point and the mean value was calculated. Corrections for transmitter and receiver drift were applied. The primary current was mostly about 4 amp. Since the results of time domain measurements south of the line L4000 and frequency domain measurements north of that line are shown on the same map, approximate conversion factors from frequency to time domain methods were calculated statistically from the data measured along profile L4000 using both methods.

Electromagnetic measurements in selected areas were made with an ABEM Turam instrument, using frequencies 220 and 660 cps. Coil distance was kept constant at 20 m. Some lines were measured twice, with the energizing cable first at one end and then at the other end of the profiles. The topographic effect was neglected. Ratio and phase difference values, for a 220 cps frequency only, were plotted along profiles and positions of underground conductors indicated (figure 12).

The radiometric survey was carried out using a 4-channel Scintrex gamma analyser. Total radiation was measured along the lines every 25 m. Where isolated strong total value anomalies were recorded, differential measurements were done separately for potassium, thorium and uranium. Results are represented in the form of profiles (figure 20) and a map of isolines (figure 11).

The vertical component of the earth's magnetic field was measured by a Jalander fluxgate magnetometer. Measurements were carried out along grid lines at 25 m spacing and reduced to the same arbitrarily selected zero level. Diurnal variations were calculated and eliminated using periodic observations at the base point. Results are presented as profiles (figure 20) and as magnetic isolines (figures 7 and 8).

Interpretation of geophysical data

Electrical self-potential survey

Ground electrochemical conditions in the mineralized zones at Shangalon area permit creation of the electrical self-potential phenomenon because sufficient natural moisture is present for development of oxidation and reduction zones. The surrounding rocks have an adequate, but not too high electrical conductivity, permitting a measurable electric field. Mineralization is near enough to the surface, and there is only a thin soil cover. The only disadvantage for self-potential measurements is the locally dense vegetation (forest and jungle), which sometimes produces spurious potential differences and masks the values caused by mineralization. Basically the self-potential anomalies over oxidized sulphide zones are negative. However, if the electrochemical reaction is of the Redox type (as it could be in the case of magnetite and some sulphides), anomalies may be positive.

Pilot profiles L3800 and L3600 were measured first because they cross old workings with known mineralization. As expected, the near-surface parts of known mineralization caused negative self-potential anomalies, which are not very high but sufficiently clear for interpretation. The method was therefore used for general reconnaissance over a large area to delineate the known mineralized zones and to find new ones.

According to the intensity and distribution of electrical self-potential anomalies, the area may be divided into three parts. The first part covers Chigyindaung Hill and its surroundings. Anomalies are strong, up to -140 millivolts, with steep gradients suggesting near surface mineralization, which could either be pyrite only or could include copper. The second part covers a zone of old workings (between lines L3000 and L4000 east of the base line and around a gallery and shaft near line L3100) and its surroundings. Anomalies have values up to -80 millivolts and suggest near-surface mineralized zones; these strike NW and dip NE east of the base line, while in the gallery-shaft zone they dip SW. The total self-potential anomaly zone is much larger than the zone of old mine workings. The third part covers the zone northwest of line L4000. Anomalies are weak (up to -40 millivolts), isolated and scattered over a large area. This zone may be interesting because it coincides with visible occurrences of copper and molybdenum minerals. The electrical self-potential method gave information about shallow parts of mineralized zones, which were explored more precisely and at greater depth by the induced polarization method.

Electrical induced polarization and resistivity surveys

As with the electrical self-potential survey, the pilot profiles L3800 and L3600 were measured first. It was found that the chargeability of barren rocks was between 5 and 15, mostly about 10 milliseconds (=background). The chargeability of the whole area of old workings and surroundings is 3 or more times the background. Within this area, there are zones with chargeability values of 8 or more times the background, which indicate higher sulphide concentration.

The whole area from line L1600 to line L7800 was systematically explored by the induced polarization method. The zones of 3 and 8 times background are marked on the profiles (figure 20) and on the interpretation map (figures 9 and 10).

The largest anomalous zone is located in the southern part of the area between line L1900 and L4200. It is more than 2 km long and nearly 1 km wide. This zone covers altered quartz diorite, located also by magnetic and radiometric surveys, as well as andesite on the northern slope, and sediments near the summit of Chigyindaung Hill. Zones of stronger induced polarization response inside the main anomaly are probably due to higher sulphidic concentrations. The depth of the polarized (mineralized) zone extends to at least 150 m.

North of line L4200 the main anomalous zone splits into two narrow bands. The eastern one crosses the recent fluvial sediments and reaches andesite. The western anomalous band follows the base line, narrows almost to zero, and occurs as a complex of a few medium- and small-size anomalies between lines L5000 and L4700. These anomalies probably reflect sulphide mineralization, but are not comparable in size and intensity to the main anomaly south of line L4000.

Results of the electrical resistivity measurements are presented as pseudo-sections together with the induced polarization method, but only one line combined with geologic and geochemical data is shown in figure 20.

The electrical resistivity of rocks in the surveyed area is fairly uniform, most values being between the 50 and 100 ohm-meter limits, with rare exceptions. Consequently granodiorite, andesite, tonalite porphyry and dacite porphyry could not be differentiated. The only exceptions were the high resistivity values on Chigyindaung Hill in clastic sediments, reaching 3,000 ohm-meters. This zone, shown schematically on the interpretation map (figures 9 and 10), coincides with a zone of strong negative self-potential anomalies, which could be caused either by sulphide mineralization or by electrofiltration in silicified rocks because of its location on the hilltop.

The relatively uniform and fairly low resistivity values over altered and unaltered rocks indicate that silicification and sericitization may be present, but not extensive clay alteration.

Turam method

Only the most interesting part of the Shangalon area was surveyed by the Turam method (figure 11). Ratio and phase difference anomalies are relatively weak, suggesting the absence of good conductors. Ratio values are almost equal for both frequencies, and ratio anomalies in general are smaller than phase difference anomalies, which also confirms the absence of good conductors. Positions of conductors are shown on figure 11. Interpretation is done not only on the basis of Turam profiles shown on the map, but also by using measurements with the energizing cable at the opposite end of profiles and by using infill lines.

Radiometric method

Most of the radiation in the Shangalon area is probably due to the presence of radioactive potassium in the igneous rocks. Comparing the radiometric data obtained on profiles over known geology, the following intensities of radiation can be attributed to different rocks of the area (figure 12):

	Radiation counts per second	Estimated relative magnetization
Andesite	40	4
Rhyodacite	40	2
Sediments around Chigyindaung Hill	60	1
Quartz diorite	60	1
Granodiorite	80	1
Dacite porphyry	80	1
Diorite	80	3
Tonalite porphyry	80	2?
Andesites north of Chigyindaung Hill	80	2

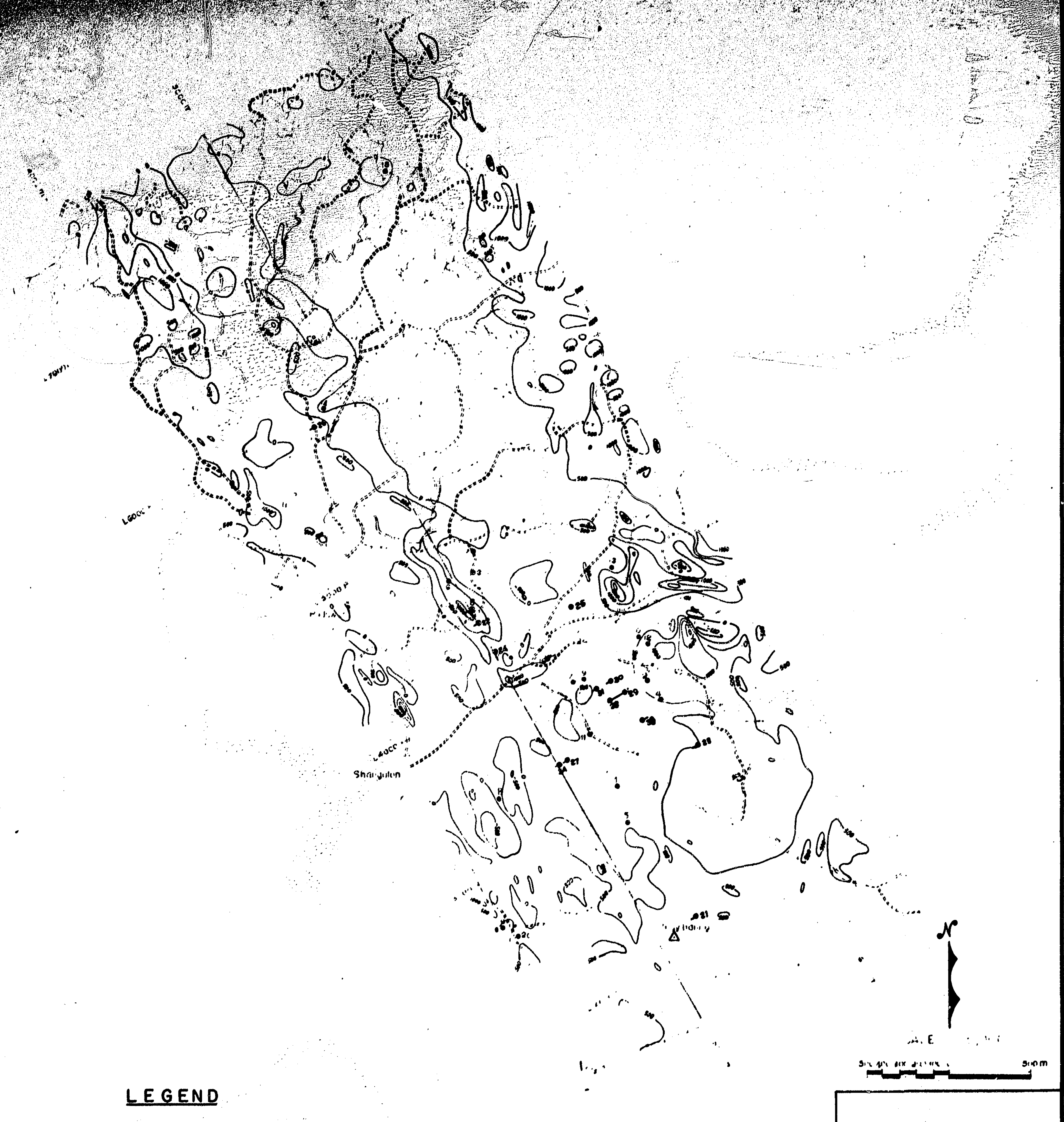
When radiation intensities are combined with estimated relative values of magnetic susceptibility for the various rock types, it is possible to differentiate between all rocks of the area, except for two pairs. These are the granodiorite in the northern area and dacite porphyry, both with 80 counts per second radiation and a relative susceptibility of one; and the quartz diorite in the southern area and sediments around Chigyindaung Hill, both with 60 counts per second radiation and a relative susceptibility of one.

The mineralized, altered quartz diorite of the southern area with a 60 counts per second response can be distinguished from the probably younger and less mineralized granodiorite in the northern area with a 80 counts per second response, both having similar magnetic properties.

Magnetic survey

The magnetic properties of the different rocks in the Shangalon area vary considerably within a wide range. The magnetic susceptibilities of rocks were not determined for lack of an appropriate instrument; however, these were estimated on the basis of magnetic field measurements along geologically known profiles, and are listed together with radiometric properties of rocks (see radiometric method).

The weakes magnetic susceptibility and the weakest remnant magnetization were observed over sediments in the south of the area, over quartz diorite in the central mineralized zone, over granodiorite in the north, and over the dacite porphyry in the southeast (figures 7 and 8). Rhyodacite in the northeast of the area has an intermediate magnetization, while diorite on the western and andesite on the eastern flank of the area are strongly magnetized. The andesite on the northern slope of Chigyindaung Hill is an exception, being only weakly magnetic. This suggests that the magnetite in it might have been destroyed; this could be explained by hydrothermal alteration and indicates a possible sulphide mineralization. There is apparently no



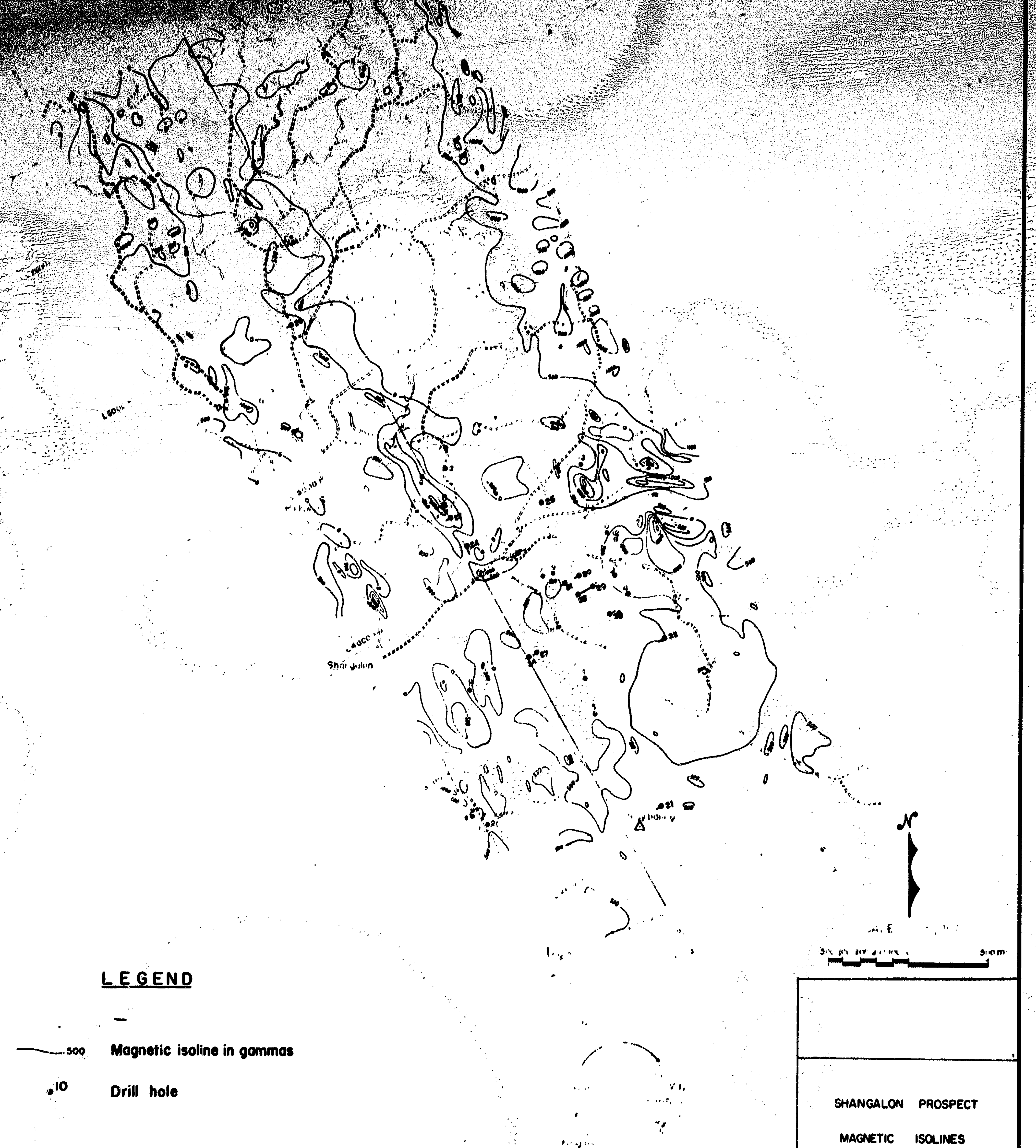
LEGEND

500 Magnetic isoline in gammas

•10 Drill hole

SHANGALON PROSPECT

MAGNETIC ISOLINES



LEGEND

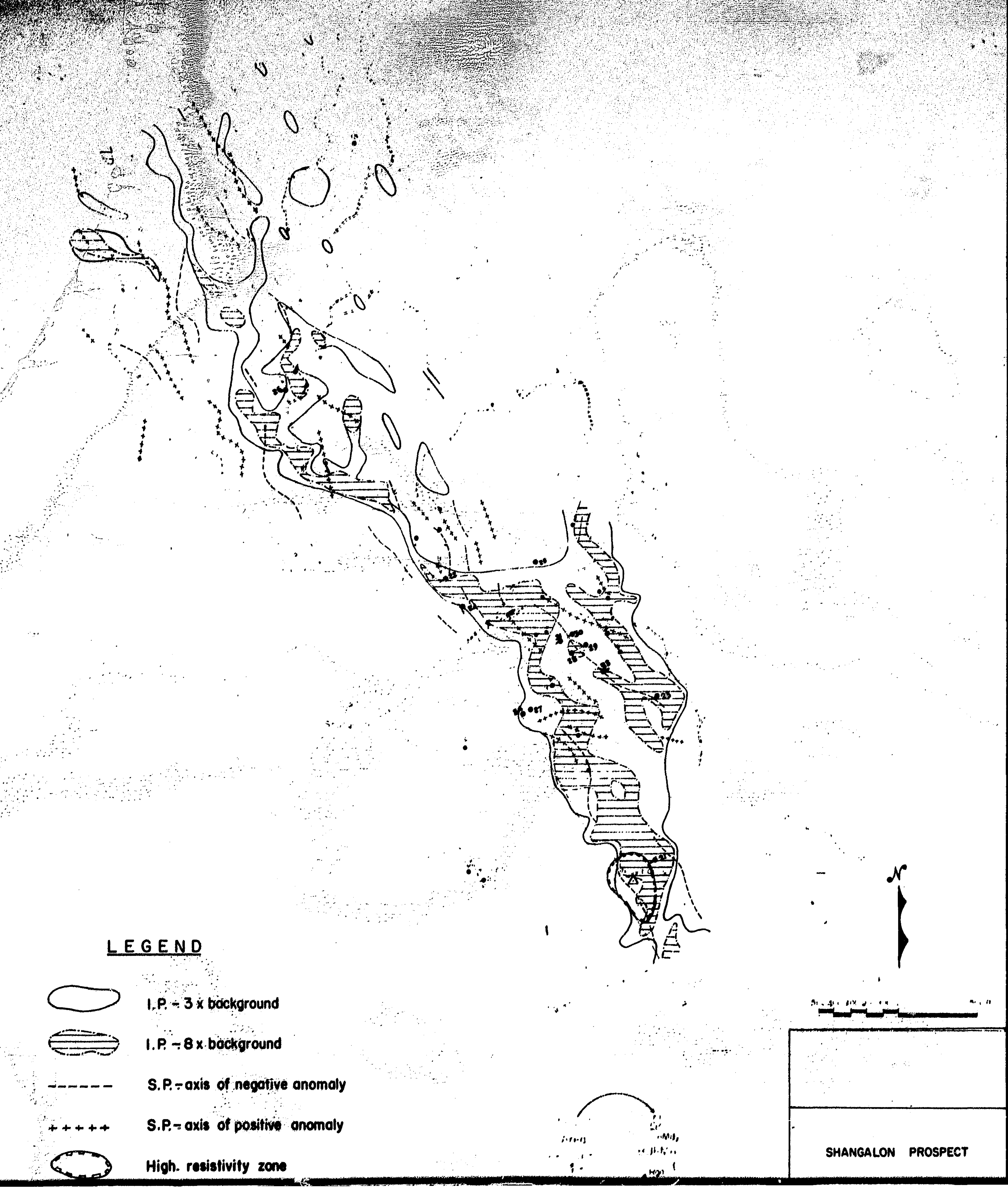
500 Magnetic isoline in gammas

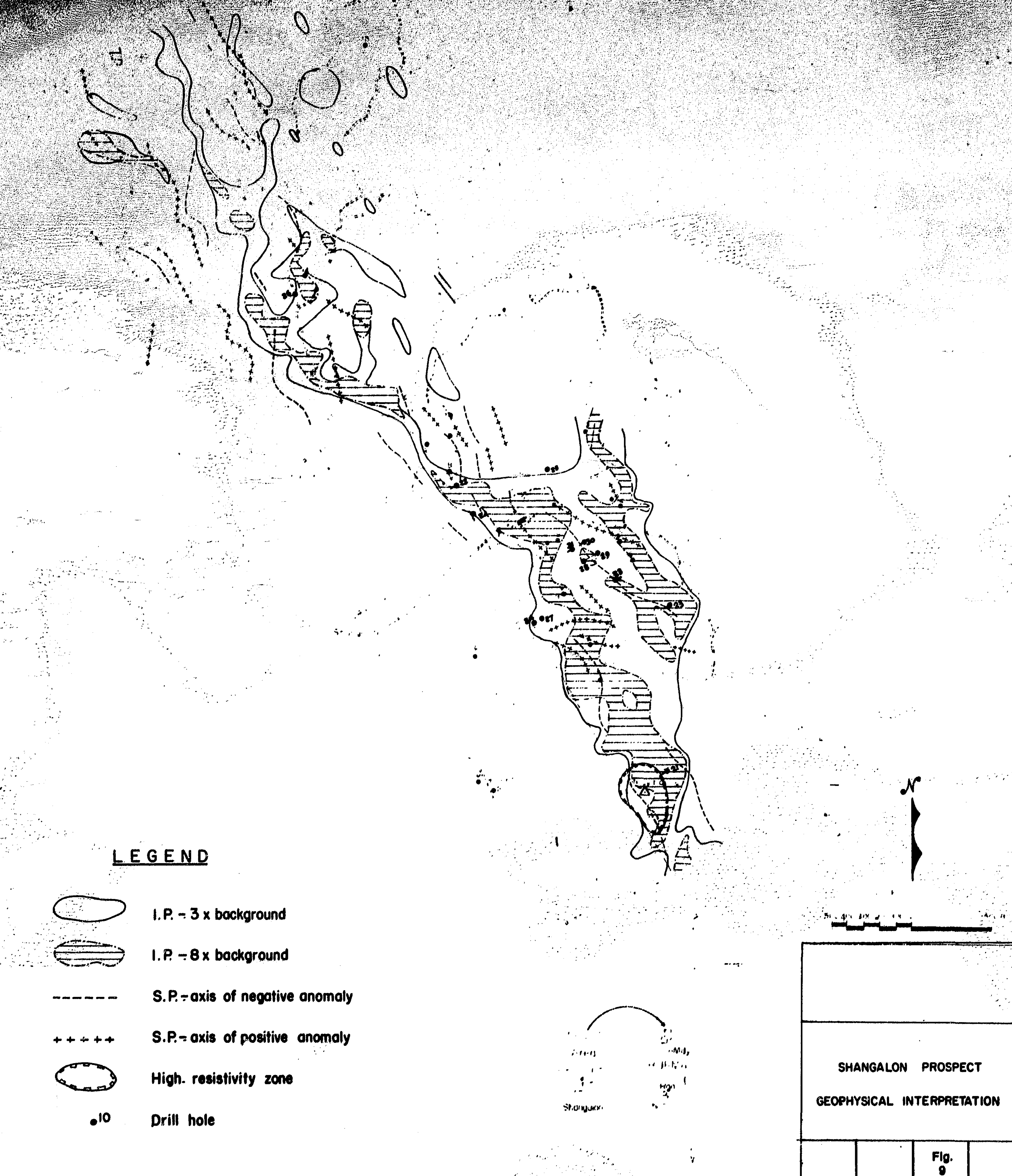
10 Drill hole

SHANGALON PROSPECT

MAGNETIC ISOLINES

Fig. 7

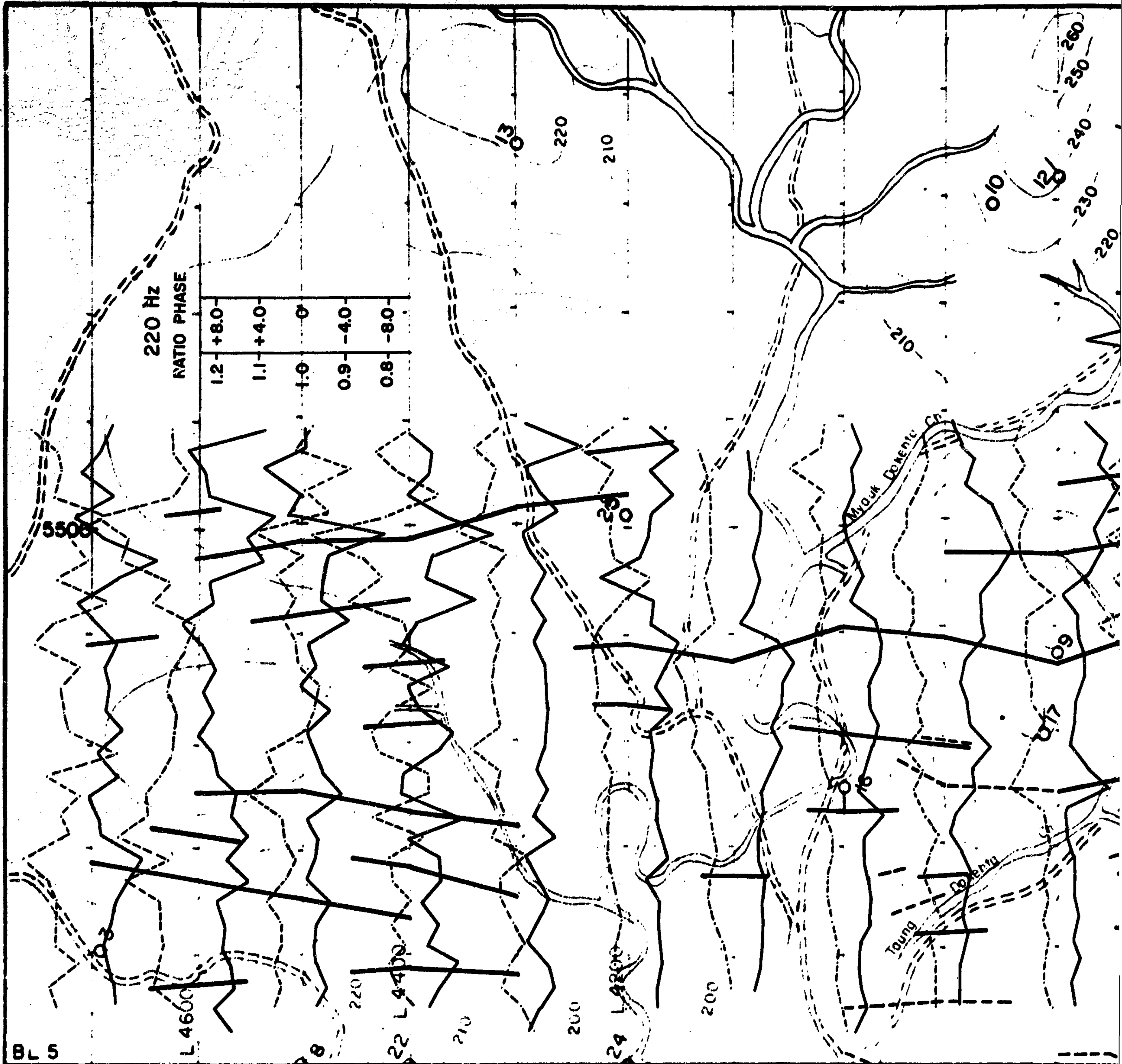

LEGEND
I.P. – 3 x background
I.P. – 8 x background
S.P. – axis of negative anomaly
S.P. – axis of positive anomaly
High. resistivity zone
SHANGALON PROSPECT



SHANGALON PROSPECT

GEOPHYSICAL INTERPRETATION

Fig. 9



LEGEND

Turam ratio

Phase difference

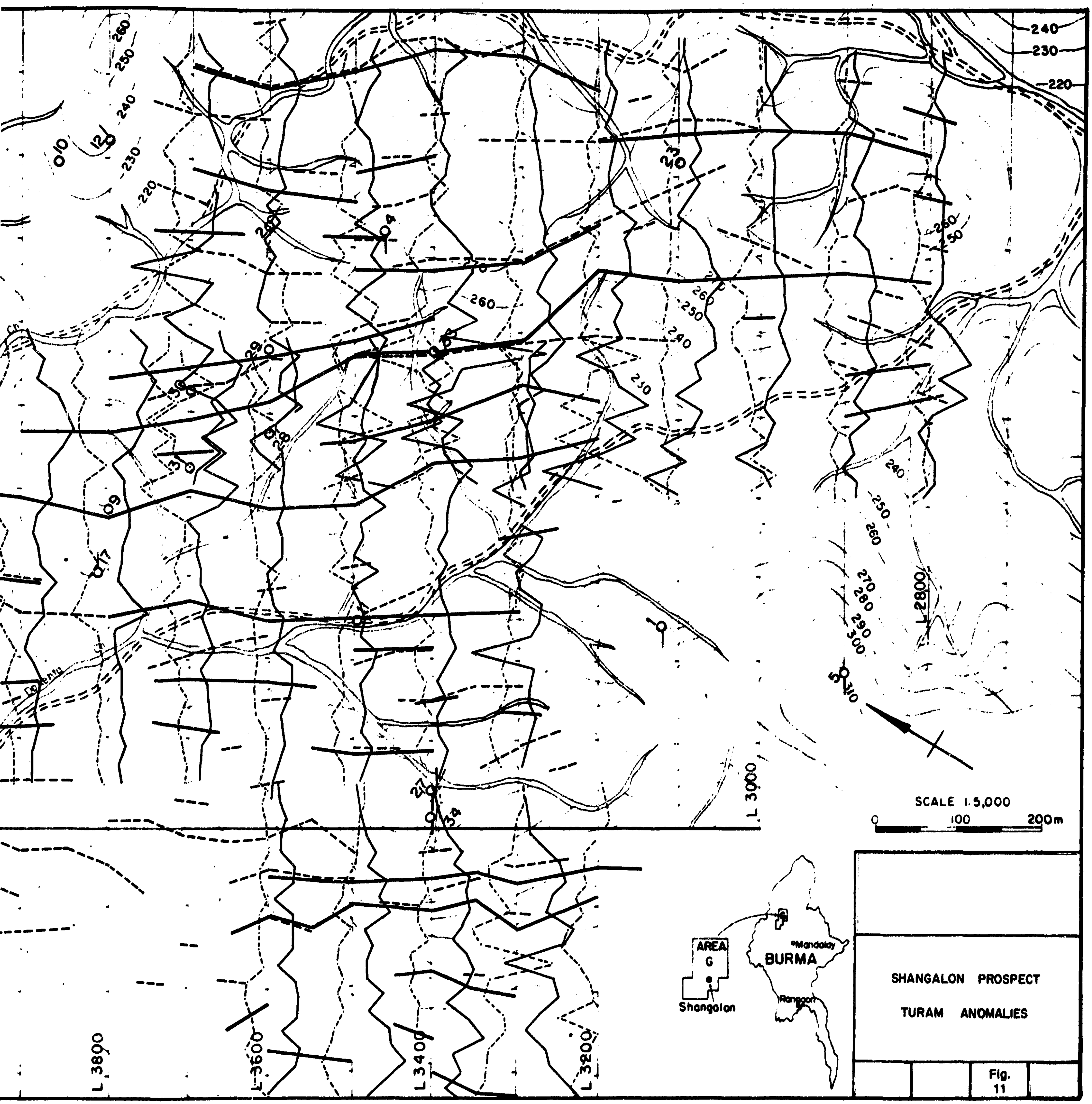
Location of conductors (Turam data on map)

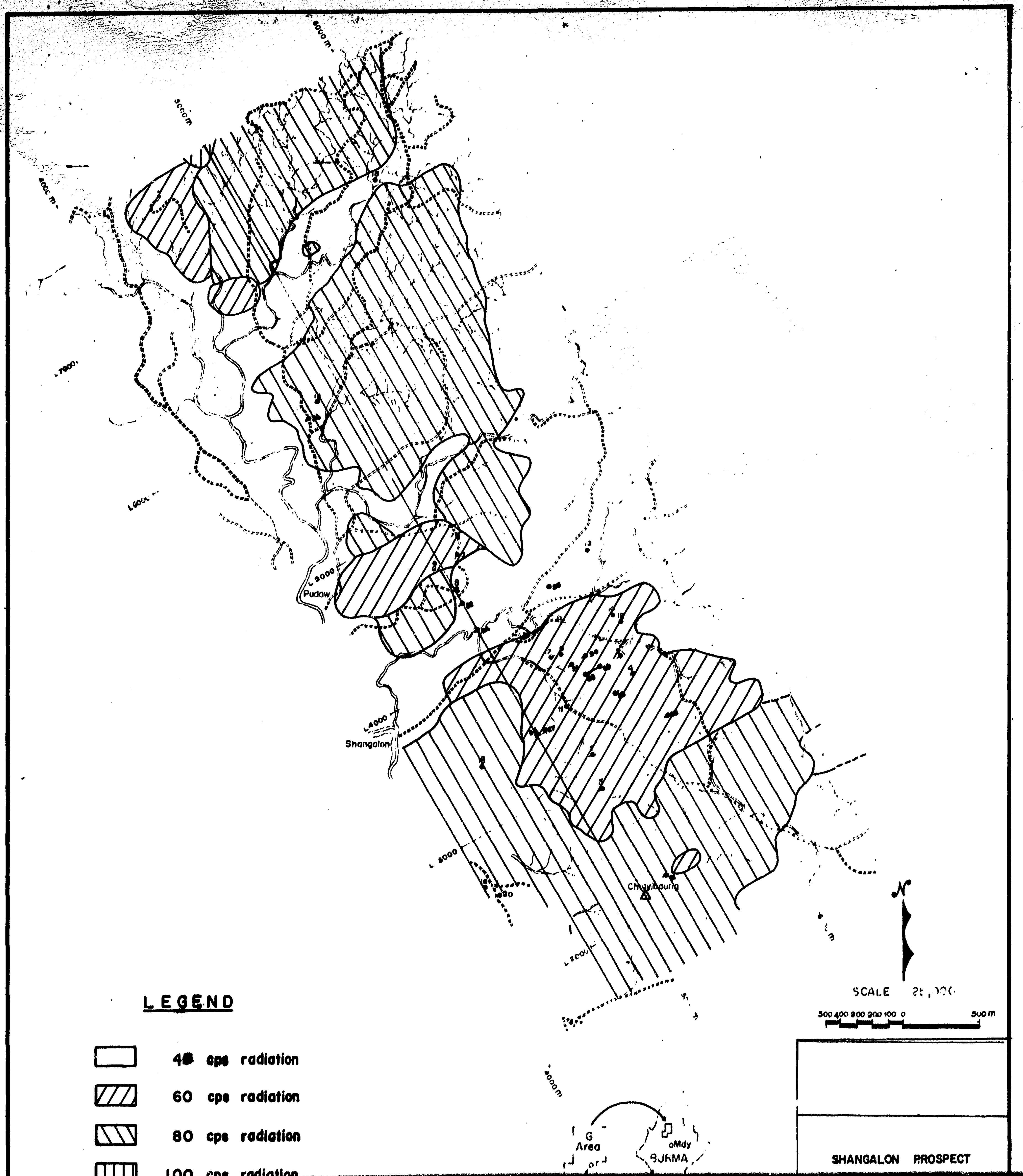
Location of conductors (energizing cable at opposite end of profiles , Turam data not shown)

Interpretation includes infill lines (not shown)

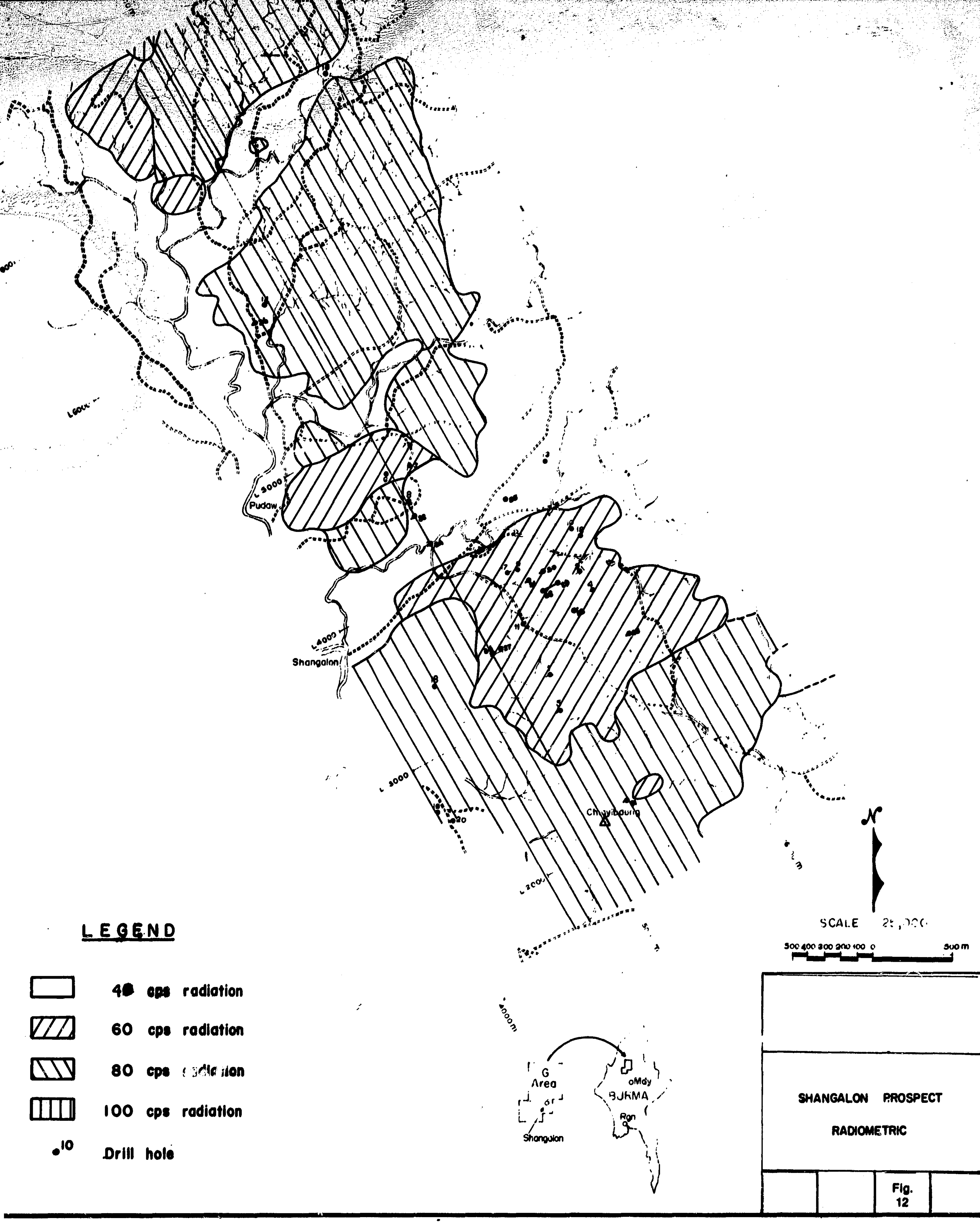
L 4000

L 3800


SCALE 1:5,000
0 100 200m
L 3800
L 3600
L 3400
L 3200
L 3000
L 2800
AREA G
Shangalon
BURMA
Mandalay
Rangoon
SHANGALON PROSPECT
TURAM ANOMALIES
Fig. 11



Pudaw
Shangalon
Chaungbauk
SCALE
LEGEND
40 cps radiation
60 cps radiation
80 cps radiation
100 cps radiation
SHANGALON PROSPECT
BURMA



LEGEND
40 cps radiation
60 cps radiation
80 cps radiation
100 cps radiation
Drill hole
Pudaw
Shangalon
L 3000
L 4000
L 2000
SCALE
500 400 300 200 100 0
500 m
G Area
Shangalon
oMdy
BURMA
Rgn
SHANGALON PROSPECT
RADIOMETRIC
Fig. 12

magnetic difference between altered and mineralized quartz diorite in the south and the almost unmineralized granodiorite in the north. The 2 km long, strongly negative magnetic anomaly along a base line between lines L4200 and L6200 is probably due to a quartz vein or system of quartz veins, which could form a host rock to possible mineralization.

Because of the very weak magnetization of the altered quartz diorite, no faults could be identified within it. In contrast, it is quite easy to recognize faults interrupting and displacing the negative quartz anomaly, as well as faults in the andesite. The magnetic map coincides well with the geologic map and was of use in its completion.

Conclusions

1. Electric self-potential, induced polarization, resistivity, Turam, radiometric and magnetic methods were used during the geophysical survey in Shangalon.

2. Electrical self-potential gave only vague information on mineralization.

3. The induced polarization method detected one large anomalous zone in the southern area and several smaller and less intense zones in the northern area.

4. Electrical resistivity detected very high values round Chigyindaung Hill, probably due to strong silicification. Elsewhere, resistivity is fairly uniform and suggests some alteration of rocks, but little or no clay alteration.

5. The Turam method revealed numerous anomalies, indicating the presence of conductors with characteristics not typical of massive sulphide deposits.

6. Magnetic and radiometric methods helped in geologic mapping, especially in the areas of concealed bedrock. The weak magnetic response of the andesite on the slope of Chigyindaung Hill is significant in indicating alteration and hence possible mineralization of the rock.

VI. GEOCHEMISTRY

General

The regional stream sediment survey of the Pinlebu-Banmauk area revealed significant copper anomalies in the Shangalon region. This led to more detailed sediment sampling, followed by a pilot study of various soil formations and different horizons to determine the best sampling depth for the systematic soil survey. All samples were analysed for copper, lead, zinc, silver and molybdenum and selected samples for gold. The semi-quantitative spectrographic method was used to scan for other elements.

Geochemical work carried out in the Shangalon area is shown in the following statistics:

	Number
Stream sediments (reconnaissance and detailed)	365 and 133
Rock samples	49
Soil samples	2,973
Soil samples from pits	98
Soil samples, total	3,071
Copper, lead, zinc and silver - AAS determinations	3,071
Molybdenum - colorimetric method	3,071
Gold - AAS determinations	146
Semi-quantitative spectrographic method	1,159
Control samples - DGSE	43
Control samples - (abroad)	264

Stream sediments

Regional geochemical sampling density in the Banmauk-Kawlin area varied between 1.5 - 2.5 samples per square mile. At and around the Shangalon prospect the density was later increased to 10 samples per square mile. The sediment sampling in the Shangalon surroundings, which was done in the 1976/1977 field season, is not included here but is described in Part Two of this report.

The validity of the sediment survey results was checked by detailed sediment sampling of the Dokehta-Shan Chaung*, which crossed the mineralized zone at Shangalon. Here the copper values were above threshold for a distance of 2 km downstream from the mineralized zone, and above the regional background for more than 8 km downstream. It is therefore unlikely that any similar mineralization in the Pinlebu-Banmauk area has been overlooked, with the sampling density of two samples per square mile.

The regional background for copper in the Pinlebu-Banmauk area in igneous environment is low: 23 ppm/Cu. The threshold value set in this area at 90 ppm/Cu was exceeded by 39 stream samples in the Shangalon region (figure 13). Two other Cu anomalies in the Pinlebu-Banmauk area (Kame and Maingthon East), which are shown in figure 13, have some similarities in geologic setting to the Shangalon prospect but are less important.

Soil sampling

The soil conditions in the Shangalon area (figure 14) are fairly complicated owing to relief, heterogeneous parent material, modified drainage system and varied vegetation cover. Essentially, three main soil types are present; these are:

(a) Immature azonal soils, developed on ridges and steep slopes, which consist of a high proportion of fresh and imperfectly weathered rock fragments, e.g., at both Dokehta ridges (around L38/5900) and the hilly area around Pudaw;

(b) Mature zonal soils, found in the gently sloping terrain, which have developed classical soil horizons; and

(c) Transported soils, without any developed soil horizons and comparatively homogeneous, which occur in alluvium and paddy fields.

In addition, transitional types or sub-types also exist (figure 14).

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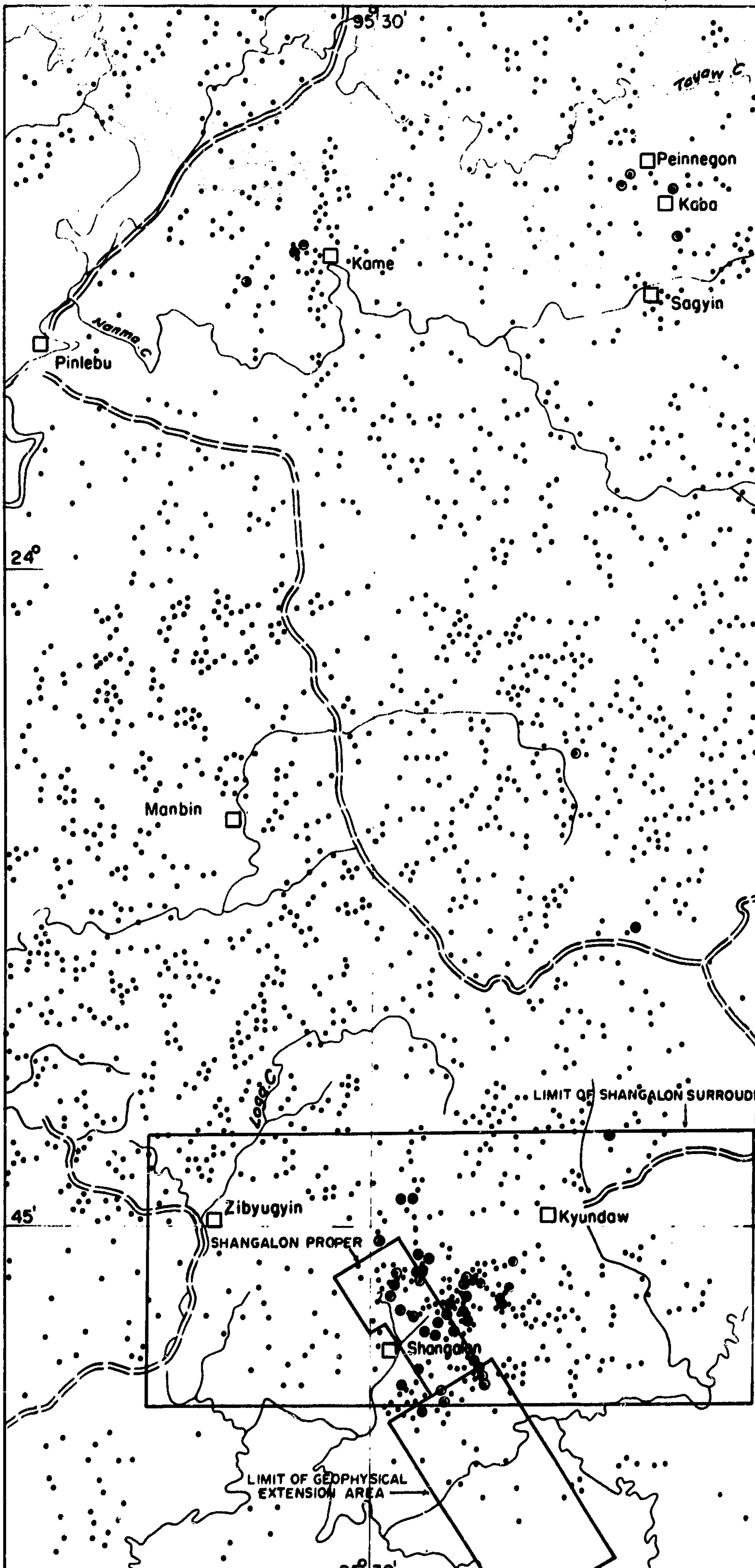
* Chaung = stream.



PINLEBU - BANMAUK AREA
STREAM SEDIMENTS
COPPER

Fig. 13

Nine pits (figure 14) were dug in different soil types and systematically sampled to determine the vertical distribution of anomalies and the most suitable soil layer for detailed sampling. Analytical results and petrologic observations led to the following conclusions, which were used in the geochemical interpretation:

(a) The trace element values in immature azonal soils are close to the trace element values in the parent material;

(b) The transported alluvial soils in alluvium and in paddy fields also have an immature character, depending on their state of development; some contain higher trace-element values apparently unrelated to the underlying parent rocks;

(c) The mature soil types, with developed soil horizons, contain slightly increased values of trace elements, such as Cu, Mo, Pb and Zn in the reddish B_2 horizon usually found at a depth of 0.60-1.80 m; however, this minor increase did not affect the selection of sampling depth;

(d) In some pits the Cu values decreased with increasing depth; this may be due to lateral movement of material or solutions from a mineralized zone to a barren area.

On the basis of this information, and to avoid possible surface contamination, a soil sampling depth of 25 cm was chosen. This lies between the upper enrichment zone with organic debris and the underlying B_2 horizon. Samples were taken every 50 m along the 100-m grid lines. One pilot line (L3600), which crosses the main anomalous zone, was sampled every 25 m, but the results showed that 50 m sample spacing is sufficient because of the larger area and magnitude of the anomalies.

Presentation of results

The data were treated graphically by plotting the cumulative frequency percentage on probability paper. The purpose of this was: (a) to identify anomalous populations; and (b) to assist in choosing contour intervals. Anomalous values of Cu and Mo were obvious from the data, and statistical treatment was not necessary to identify the main anomalies. However, a quick simplified graphical treatment is presented here.

Six elements (Cu, Pb, Zn, Mo, Ag, Au) were analyzed, but only Cu, Pb and Zn values were systematic enough for statistical treatment. The anomalous values of especially Mo, but also Ag and Au, were scattered and commonly isolated.

Copper: As shown on cumulative frequency curve (figure 15), 20 per cent of soil copper values were greater than 300 ppm (the highest value being 14,160 ppm), 80 per cent being between 2 and 300 ppm. Because of this large range, most of the copper soil anomalies were easily outlined.

Three methods of grouping the data were tried, to determine both the most suitable contour intervals and a realistic threshold value; the results were plotted on probability paper: (a) values between 5 and 500 ppm, with a 5 ppm class interval; (b) values between 25 and 4,000 ppm, with a 25 ppm class interval; and (c) values between 10 and 4,000 ppm, with a 0.1 log class interval.

Graph (b) proved to be the most satisfactory for this purpose and is included in this report. The threshold value supported by geologic evidence was taken as 245 ppm. Selection of higher anomaly levels above threshold was based on practical considerations. The second level was chosen at the value 399 ppm (the next inflection point on cumulative frequency curve); other levels were selected at 999 ppm and 1,999 ppm. A graph with a 5 ppm class interval, not included in this report, suggests the presence of many populations below 500 ppm copper; these probably represent different rock and/or soil types. The copper anomalies are shown generally in figure 16 and compared with molybdenum in detail in figure 17.

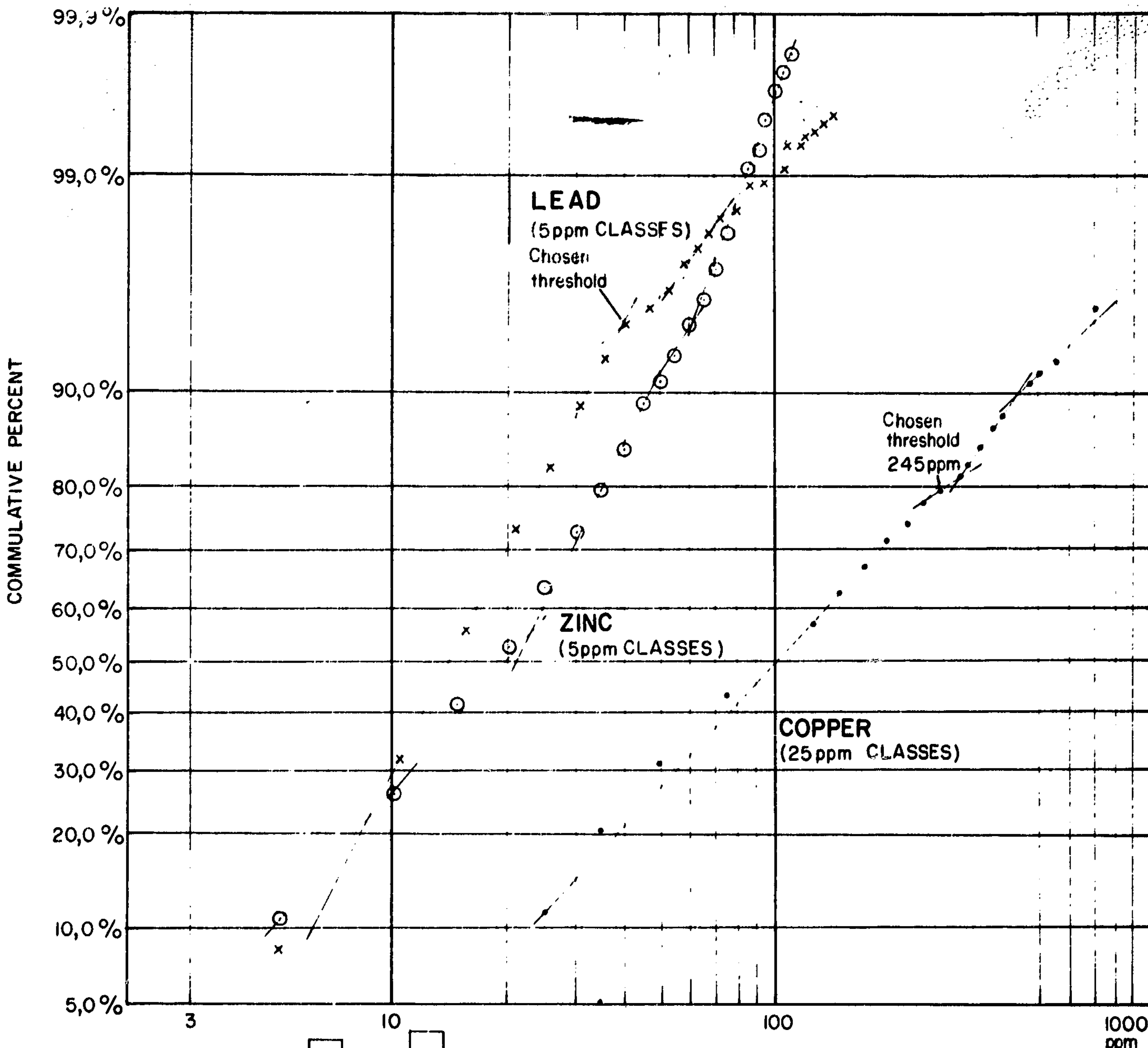
Lead: More than 90 per cent of the soil values contained less than 40 ppm. Two inflection points were identified on the cumulative frequency curve, at 35 and 70 ppm; these were taken as contour intervals. There is a low positive correlation between high copper, molybdenum and lead (correlation coefficient is +0.35 between copper and molybdenum, +0.66 between copper and lead, and +0.48 between molybdenum and lead).

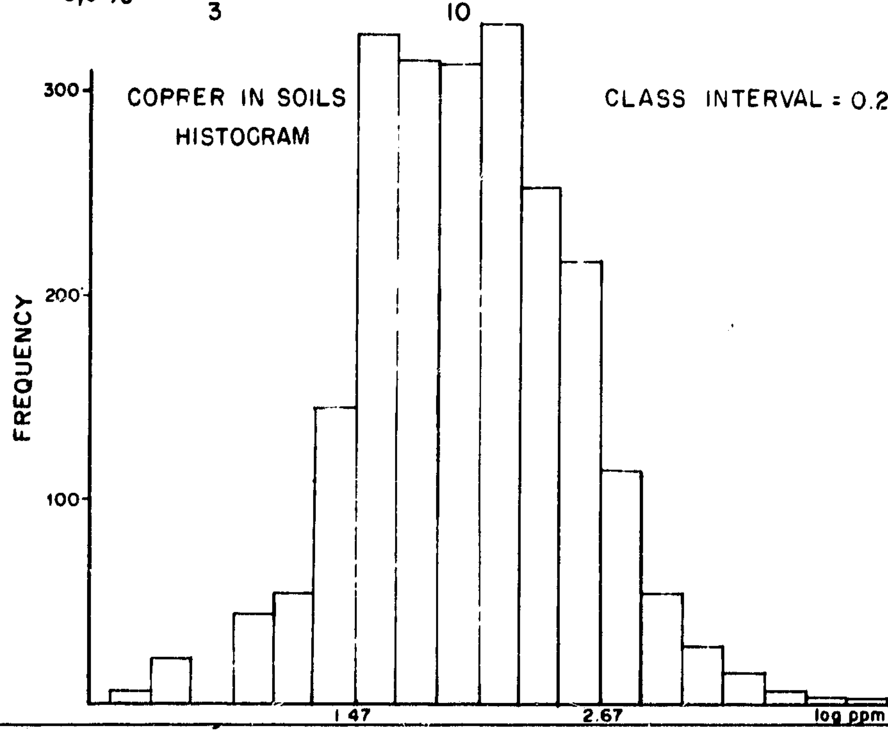
Zinc: Over 90 per cent of the soil zinc values were less than 50 ppm. The two inflection points at 20 and 55 ppm were taken as contour intervals in working map. There is no apparent correlation between zinc and the other elements analysed.

Molybdenum: The molybdenum results were erratic and often too low for the detection limit to be treated statistically; when plotted, they show a good over-all positive correlation with high copper values, although frequently peak molybdenum and copper values do not coincide (figure 18).

The results of the statistical treatment of the geochemical soil data enabled a north-west-trending elongated zone to be defined, within which 9 anomalous areas were specified (figure 16). The anomalous zone is approximately 5,500 m long and 200-1,000 m wide. East-west discontinuities occur in the zone approximately along Shan Chaung

COMMULATIVE FREQUENCY DISTRIBUTIONS FOR COPPER, LEAD AND ZINC IN SOILS





SHANGALON PROSPECT

SOIL SAMPLES

STATISTICAL TREATMENT

Fig. 15

(L4200), Shwedone Chaung (L5100) and Kyagyi Chaung (L6900). These might be due to leaching, to masking by sediments transported from the east or to tectonics affecting the mineralization. The trend of the discontinuities as well as that of the anomalous zone are parallel to the two main tectonic features.

Anomalies north-west of the Shan Chaung are generally better defined than those in the south-eastern area, possibly due to the uplift in the latter and consequent erosion. The south-east anomalies are larger than in the north-west area, and high copper values are widespread, for example near the Seik Twin pit (L3100/5250). Some lower copper values in the mineralized zones may be due to leaching processes. Copper could be leached from the oxidized zone because pyrite is present in sufficient quantities to maintain a surplus of sulphuric acid throughout the oxidation process.

The soil anomalies in the Shangalon area are summarized as follows (figure 17):

I. The westernmost anomaly in the Pudaw area associated with granodiorite; it is not significant.

II. An anomalous zone coverying 140,000 m^2, with overlapping Cu, Pb and Mo anomalies; the anomaly source might be elongated and possibly inclined eastwards. The lead may be significant, as lead anomalies are commonly found in upper peripheral zones of porphyry systems. Old workings are present in this zone.

III. An anomalous area with some higher Pb values, with traces of old mining activities and having slight erosion. A mineralization might occur at depth.

IV. A small anomaly of no apparent significance.

V. A very narrow and short anomaly on a small hill, in an old working area around L5100/4700, where anomalous Cu and Mo values overlap. The mineralized zone may be at the contact of two rock types. Perhaps it connects at depth with anomaly No. VI and possibly with anomaly No. IV.

VI. A large anomaly (192,500 m^2) between L4300 and L4800. The overlap of the Mo and Cu anomalies is less marked than in the previous zone (No. V). Scattered molybdenite-bearing quartz float is common. Minor mineralization has been intersected by a few drill holes and in a test pit close to DDH-3W. The anomalous zone covers both volcanic and intrusive rocks.

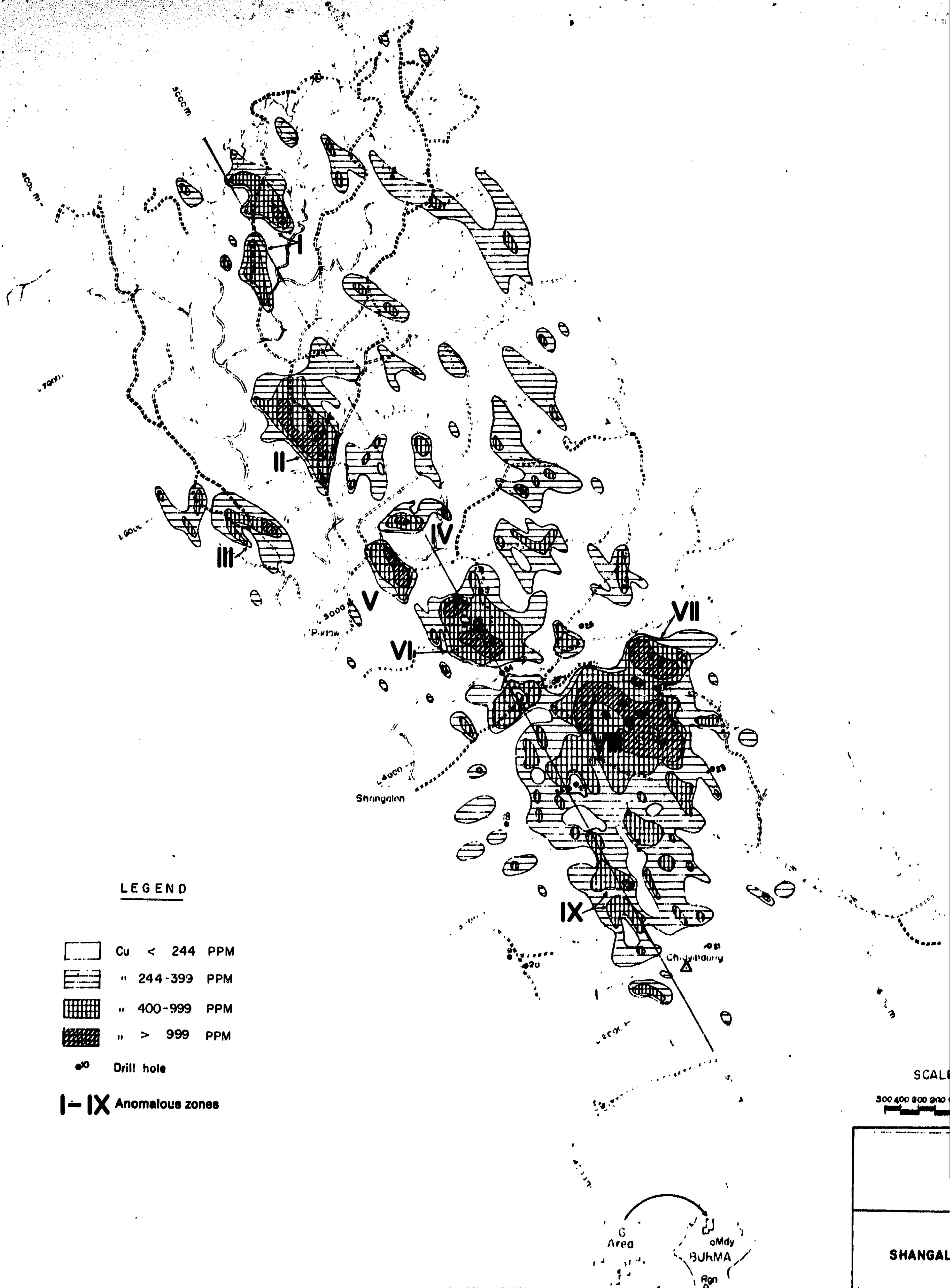
VII. An anomaly outlining an old working area; mineralization is visible in quarz-diorite outcrops. Molybdenite is also present.

VIII. The largest copper anomaly in the Shangalon prospect area (800 m by 300 m = 240,000 m^2); it includes several old mine workings. Pyrite, chalcopyrite, minor chalcocite and some molybdenite were observed in the old dumps and in the drill holes. The large anomalous area here might be due to surface spread of material from both the mineralized zone and the old mine dumps.

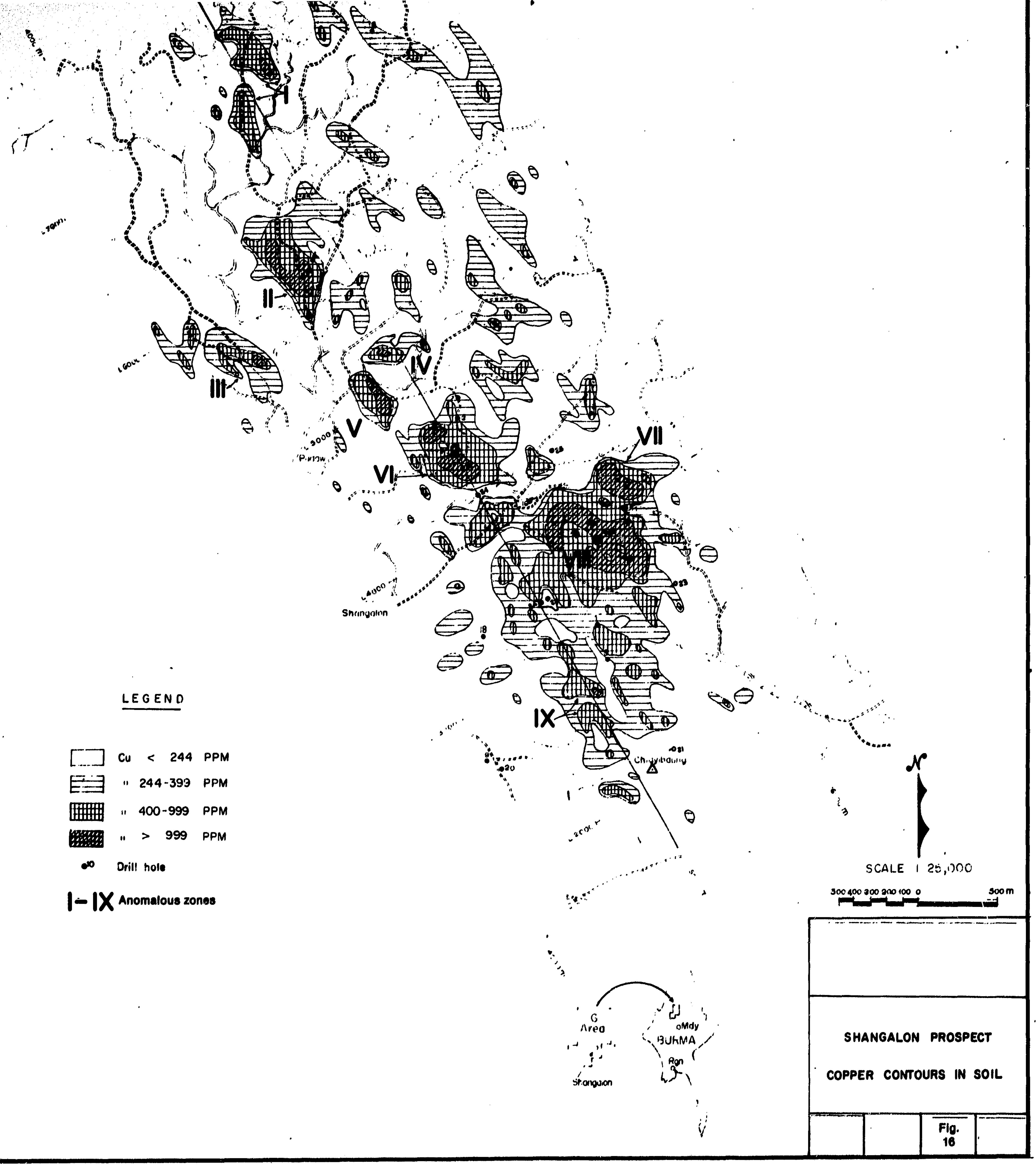
IX. A scattered anomalous zone in the south-eastern part of the area. Lower values in soils are perhaps due to leaching, but the possibility of mineralization at depth should not be excluded.

Conclusion

Geochemical follow-up work in the Shangalon prospect consisted of detailed soil sampling and soil mapping. The values obtained from the soil samples indicate nine anomalous zones in some detail. The element selected for routine determinations provided a satisfactory coverage for location of mineralization. Spectrographic analyses on a number of representative lines showed no significant anomalous concentrations of other elements. Generally, diamond drilling results are in agreement with the geochemical soil anomalies. The methods and procedures used in the geochemical follow-up in the Shangalon prospect as well as in the geochemical reconnaissance survey in the G-area are considered essentially valid.



LEGEND
Cu < 244 PPM
" 244-399 PPM
" 400-999 PPM
" > 999 PPM
Drill hole
I – IX Anomalous zones
I
II
III
IV
V
VI
VII
IX
Shangalon
SCALE
G Area
oMdy
BURMA
Rgn



SHANGALON PROSPECT

COPPER CONTOURS IN SOIL

Fig. 16

VII. DIAMOND DRILLING

Equipment

Diamond drilling in Shangalon was first undertaken with one light Winkie GW-15 drill (capacity 150 feet) because the Boyles BBS-15 rig (capacity 1,200 feet) which was ordered in January 1974 arrived in the field only in late July 1975. This was due to its late delivery in Rangoon and local transport difficulties in the peak of the monsoon season. A second BBS-15 rig was obtained on loan from the project "Post-Graduate Training in Mineral Exploration" (BUR-71-516), and was put into operation in February 1976. All BBS-15 holes were drilled using the wireline system (NWL down to AWL); Winkie holes were cored by BXT and AXT series of bits. No sludge was collected owing to the excellent core recovery, especially in deep holes drilled by the BBS-15 machines.

Objectives

The aim of the drilling was, first, to outline the area of mineralization by widely spaced drill holes, and then, to drill in more detail the areas of best mineral showings. Thick overburden in parts of the area and combined effects of deep weathering, leaching and alteration prevented good geologic surface observations. Diamond drilling was thus the most practical means of obtaining reliable information on mineralization and alteration, and supporting geologic mapping and interpretation of geophysical and geochemical data. The shallow Winkie holes were drilled mainly to determine the lateral extent of the near-surface mineralization and alteration, and to define geologic boundaries. The deep holes were drilled to gain information on the vertical extent or zoning of mineralization and alteration.

Selection of sites

Selection of drill sites was based on geologic observations and geophysical and geochemical anomalies. A few holes were drilled outside anomalies to check their spatial relationship to mineralization in underlying rock. The drill sites for the light Winkie machine had to be where overburden was thin or absent.

Spacing between the drill holes was selected so that an economic size of both porphyry and vein-type of mineralization would be intersected by at least one drill hole in the areas where either surface observations or integrated geophysical or geochemical anomalies indicated a possible sulphide system of significant grade in depth.

Most of the sulphide mineralization in Shangalon is related to fracture veins or veinlets with prevailing sub-vertical or high-angle dips. For this reason, 10 out of 12 deep holes drilled by BBS-15 rigs were inclined 50° to 60° from the horizontal and directed perpendicular to the general strike of approximately 150°. Table 2 gives selected drill hole data.

Table 2. Shangalon prospect, drill hole data
(Average core recovery W (Winkie), 90.7%)
(Average core recovery B (BBS-15), 96.4%)

Drill hole	Line/station (metres)	Inclination	Direction	Total depth (feet and inches)		Core recovery %
DDH 1W	L3125/5250	70°	240°	141	3	98
2W	3600/5750	60°	240°	141	6	98.5
3W	4700/5100	Vertical (90°)	-	133		64
4B	3465/5725	60°	240°	800	6	96
5B	2900/5200	50°	240°	900		100
6W	4700/4975	Vertical	-	124	10	81
7W	4800/5175	Vertical	-	142		88
8W	4500/5000	Vertical	-	150		93
9W	3800/5375	Vertical	-	155	3	80
10B	3865/5800	Vertical	-	335	6	100
11W	3500/5250	Vertical	-	148	4	100
12W	3800/5825	60°	30°	134	3	81
13W	4300/5850	Vertical	-	153		100
14B	6000/4800	Vertical	-	420	6	90.5
15W	7080/5850	Vertical	-	129	7	100
16B	4000/5225	60°	240°	456		95
17B	3820/5300	60°	60°	532	6	93
18W	3400/4575	Vertical	-	40		76
19W	2800/4200	Vertical	-	47		80
20W	2600/4260	Vertical	-	58	6	102
21B	2180/5300	60°	240°	541		93
22B	4400/5000	60°	240°	452		98
23W	3100/5800	60°	240°	152		98
24W	4200/5000	Vertical	-	33		100
25W	4205/5513	Vertical	-	106	10	82
26B	5900/4705	50°	240°	400		99
27W	3400/5050	60°	240°	149		98
28W	3600/5475	50°	60°	151	6	100
29B	3600/5575	50°	240°	429		93
30B	3700/5525	50°	240°	624	6	98
31W	3700/5440	50°	240°	149	7	76
33W	3400/5575	60°	60°	150	3	100
34B	3400/5020	50°	240°	302	6	100
			Total	8,784	8	

VIII. ANALYTICAL CHEMISTRY

Sample preparation

Damp soil samples as well as wet stream sediments of approximately 200-300 g were dried in the field, then gently crushed in a porcelain mortar and sieved on an 80-mesh nylon sieve. The minus 80-mesh material was transferred to 3-by-5-inch paper envelope and sent to the joint DGSE and project laboratory in Rangoon for analytical treatment. The plus 80-mesh fraction was returned to the original 4-by-8-inch paper envelope and reserved for future use.

The core was transported to Rangoon, where it was split, and half of it crushed and ground by a Denver laboratory jaw crusher which reduces the samples to pass a 1-cm screen. Using a Jones splitter, the samples were mixed and quartered to obtain 1/8 of the original weight. This portion (about 500 g) was pulverized and sent to the analytical laboratory.

Analytical methods

The samples were analysed as follows:

1. Copper, lead, zinc and silver (soils and stream sediments). Determination of these elements were carried out by atomic absorption methods from a sample solution prepared by treating 0.5 g of the sample with 2.5 ml of concentrated nitric acid and employing reflux boiling in a test tube placed in an aluminium block which holds 50 tubes. Boiling was conducted for 30 minutes. The solution was cooled, diluted to the 20 ml mark with deionized water to make a 10 per cent acid solution, mixed, left overnight, and the absorbance was measured (wavelength Cu = 3247.5 Å, Pb = 2170.0 Å, Zn = 2138.6 Å, Ag = 3280.7 Å).

2. Gold (core and soils). Determinations of gold were made by an atomic absorption procedure using cold acid treatment. 20 ml of hydrobromic acid-bromine solution was used to treat 10 g of sample. After shaking for 45 minutes, the mixture was centrifuged, and the clear solution was transferred to a separating funnel. Ten ml of MIBK was added and shaken for 2 minutes. Before adding 25 ml of 0.1N HBr, the layers were allowed to separate and the aqueous phase was drained off. The MIBK layer was separated and its absorbance was measured by AAS (wavelength 2428.0 Å).

3. Molybdenum (soils, stream sediments). Determinations of molybdenum were carried out by a dithiol colorimetric procedure after fusion with flux (Na_2CO_3, NaCl and KNO_3 in 5:4:1). The sample solution was treated with hydroxylamine hydrochloride, to reduce potassium nitrite formed by decomposition of potassium nitrate, which could oxidize the dithiol, and at the same time the solution was acidified. The green molybdenum complex was extracted into amyl acetate by shaking at frequent intervals by using a test-tube shaker.

4. Copper and zinc (core). For copper and zinc determinations in core samples, a special atomic absorption technique was used. The sample solution was prepared by treating 1.0 g sample with 15 ml of hydrochloric acid, 5 ml nitric acid and 2 to 3 drops of bromine on the hot plate. The solution was taken to fume with sulphuric acid. De-ionized water was added, and the solution was boiled to dissolve all the soluble salts, then filtered, cooled and diluted to 250 ml to measure the absorbance with AAS (wavelength Cu = 3247.5 Å, Zn = 2138.6 Å).

5. Lead and silver (core). Method (a) was used, with the difference that 1.0 g sample was brought to a 20 per cent nitric acid medium of 0.5 g sample to a 10 per cent nitric acid medium.

Check analyses

The reliability of the analytical results was checked by the DGSE laboratory and by an outside laboratory. One sample was selected randomly from each batch and analysed in duplicate as a check on the reproducibility of analytical work. The duplicate determination for each element was expressed as a percentage of the original value. These percentages were then averaged, and the standard deviation for each element was calculated. The results showed that the 43 duplicate determinations for Cu averaged 100.5 per cent of the original values, with a standard deviation of 5.30 ppm, for Zn, respectively, 99.3 per cent and 0.98 ppm; for lead, 101.3 per cent with a standard deviation of 1.75 ppm. All these checks showed that the results are sufficiently accurate, and the reproducibility of the analytical work is quite satisfactory for exploration purposes.

Statistical analyses of replicate determinations of soil samples by atomic absorption method (Youden)

Element	j	$\bar{x}$	SD	P
Cu	43	172	5.30	6.17%
Pb	43	20	1.75	17.70%
Zn	43	28	0.98	7.10%

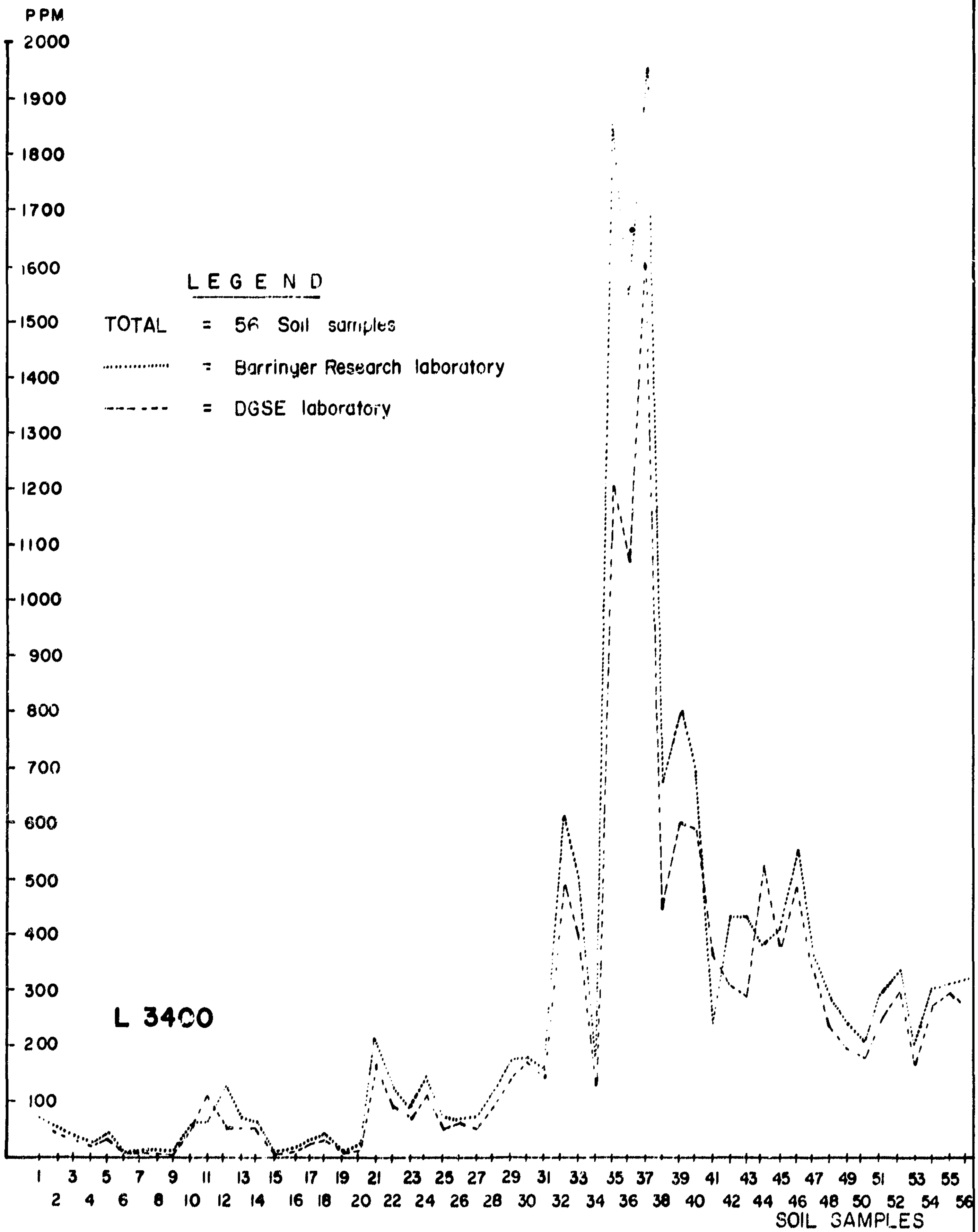
n = number of replicate determinations.

$\bar{x}$ = arithmetic mean.

SD = standard deviation.

P = precision at the 95 per cent confidence level.

The analyses by an outside laboratory (Barringer Research Laboratory) differed from the results of the DGSE laboratory because different analytical procedures were used, particularly in digestion. Comparison of these results indicates generally higher values for the outside laboratory, as shown in figure 19, where both results are plotted on one cross-section through Shangalon, including barren and mineralized zones. The Barringer Research Laboratory used for digestion procedures perchloric-nitric acid, while the DGSE laboratory applied nitric acid. Because of both these divergencies in procedure and the background correction for lead and silver determinations by the outside laboratory, it was not possible to evaluate the accuracy in the usual statistical way. A graphic comparison of results between the DGSE and outside laboratories (figure 19) demonstrates adequately that the DGSE values are acceptable for purposes of exploration.



SHANGALON - L 3400

COMPARISON OF COPPER VALUES BETWEEN DGSE LAB. AND BARRINGER RESEARCH LAB

Fig. 19

IX. GENERAL CONCLUSIONS AND RECOMMENDATIONS

An intensive exploration programme was carried out by the project team at Shangalon and in its vicinity. At Shangalon the existence of porphyry copper-type mineralization was confirmed by the presence of a large sulphide system, widespread hydrothermal alteration, a large copper geochemical anomaly and peripheral quartz-sulphide veining in an area with a complex history of volcanic and intrusive events. Porphyry-type mineralization is also indicated by extensive IP as well as molybdenum and lead anomalies. Figures 20 and 21 give interpretations of the findings of both the geochemical and geophysical surveys.

Both the Shangalon prospect and the Monywa porphyry copper deposits 160 km to the south lie within the same calc-alkalic Burma Volcanic Arc, which forms a geologically favourable belt for porphyry mineralization. Within the Pinlebu-Banmauk area the arc was investigated by regional exploration of about 3,500 square miles (9,100 km^2) north of and around Shangalon, and by a more detailed survey of 100 square miles (260 km^2) in the vicinity of Shangalon. The latter work, which included integrated geophysical measurements extending 15 miles (24 km) southward from the prospect, is described in Part Two of this report. In addition, a large number of conspicuous anomalies and mineral showings within the northern extension of the volcanic belt were followed up in detail.

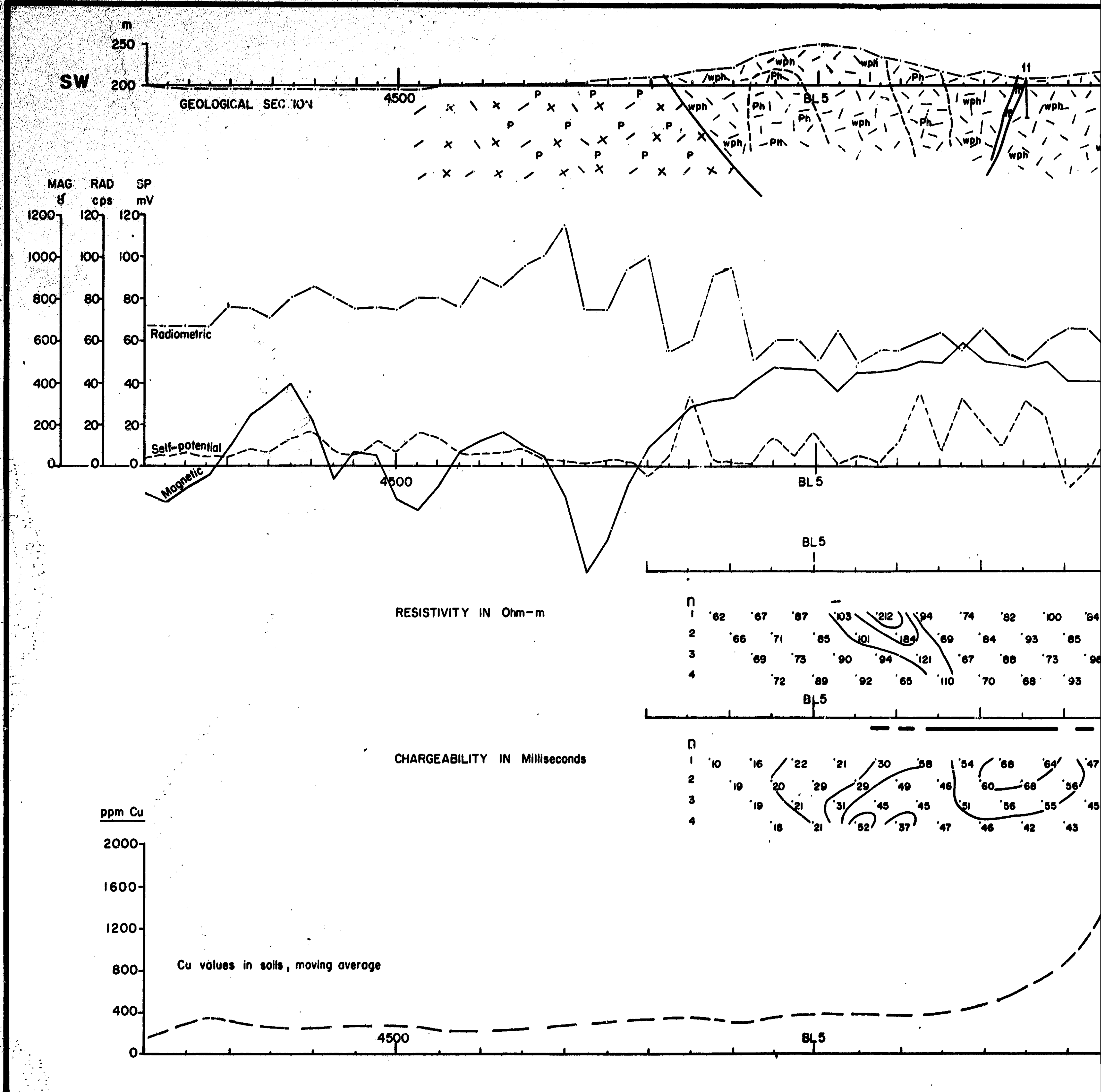
The results at Shangalon were discouraging: diamond drilling intersected mostly-non-economic grade of hypogene ore, and the few sporadically high copper values in zones of extensive fracturing represent only an insignificant tonnage of mineralization. No secondary enrichment zone is present owing to rapid erosion.

In the sulphide zone A (figure 6), which has the best mineral potential, the maximum possible reserves based on eight drill holes and surface indications of significant sulphide are calculated at 9 million tons of 0.23 per cent Cu and only insignificant credits of Mo. Gold values are incomplete, but about 0.17 ppm/Au is probable. The true mineable grade would probably be lower than that calculated owing to the barren zones and dilution factor of mining.

Neither the detailed geologic mapping, nor further geochemical sampling of the surrounding area, nor the geophysical survey of the southern extension produced any evidence of economic mineralization. Shangalon and the surrounding area are non-economic at present and even in the near future; no further groundwork is recommended.

X. ACKNOWLEDGEMENT

The successful completion of the Shangalon work is in large measure due to the high general ability and enthusiasm of the Burmese national staff, who did most of the systematic field work and much of the preliminary calculations and interpretations. The work was done by members of the geophysical, geologic, geochemical, drilling and chemical laboratory sections of the DGSE (annex 2).



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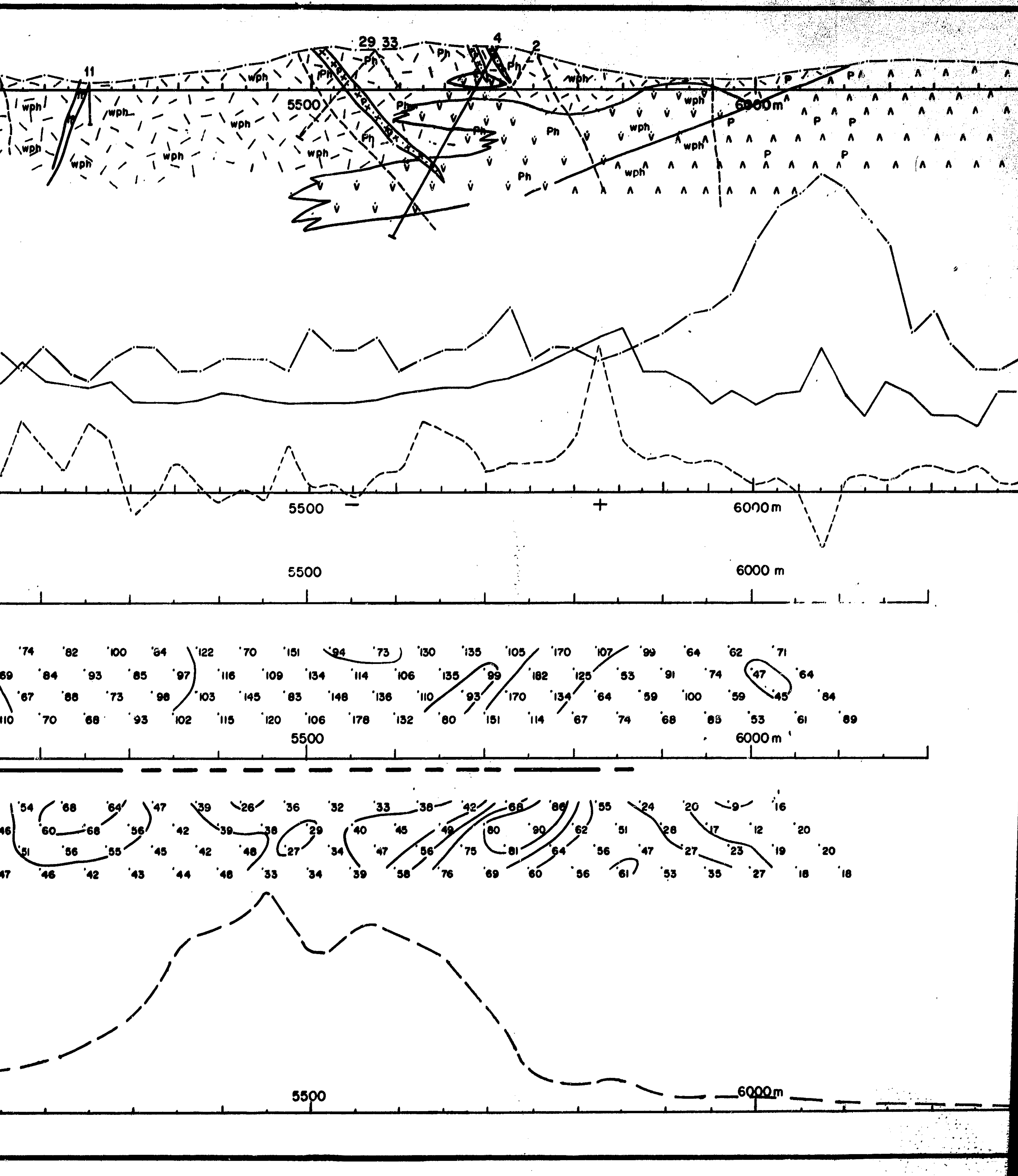
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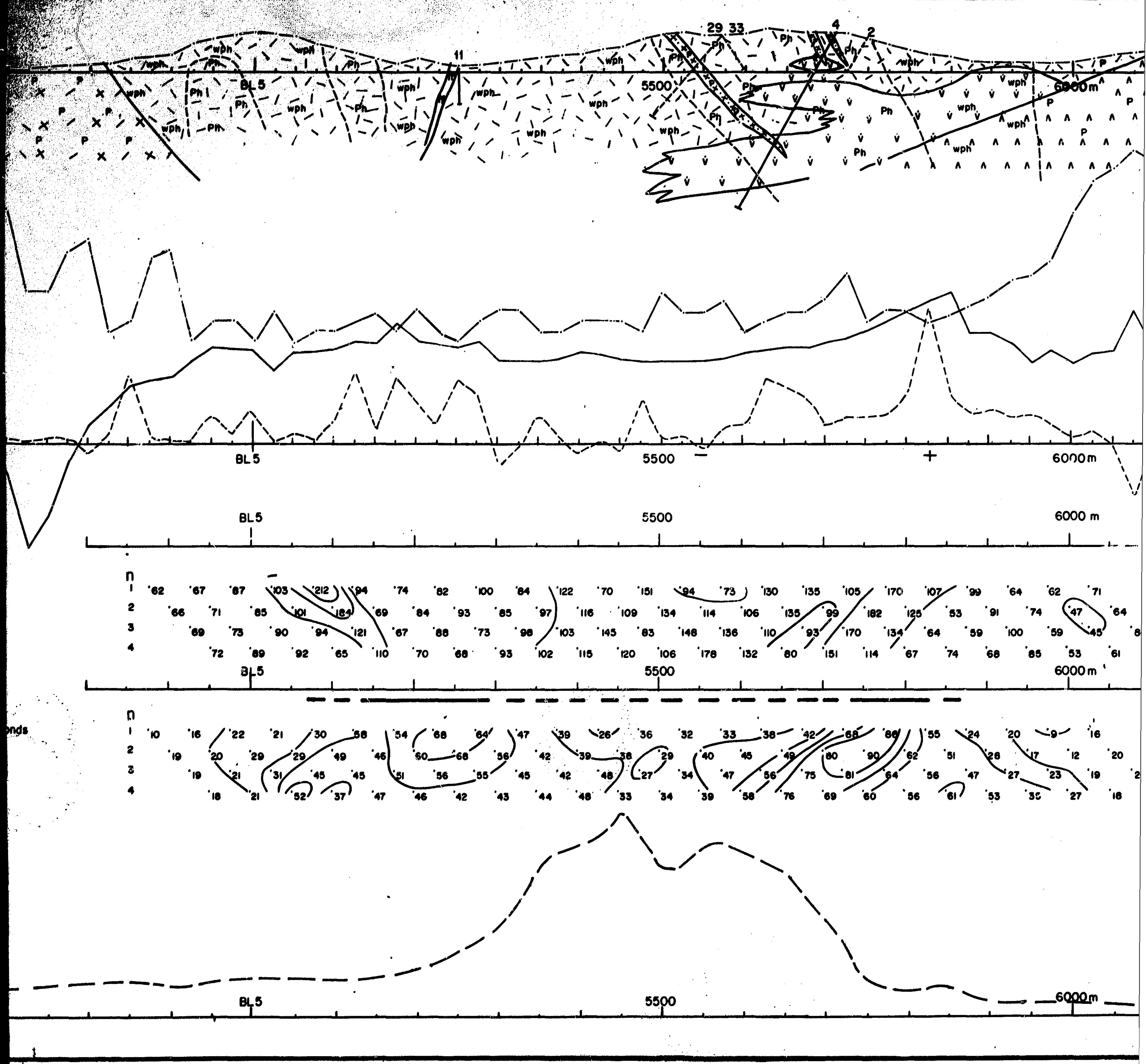
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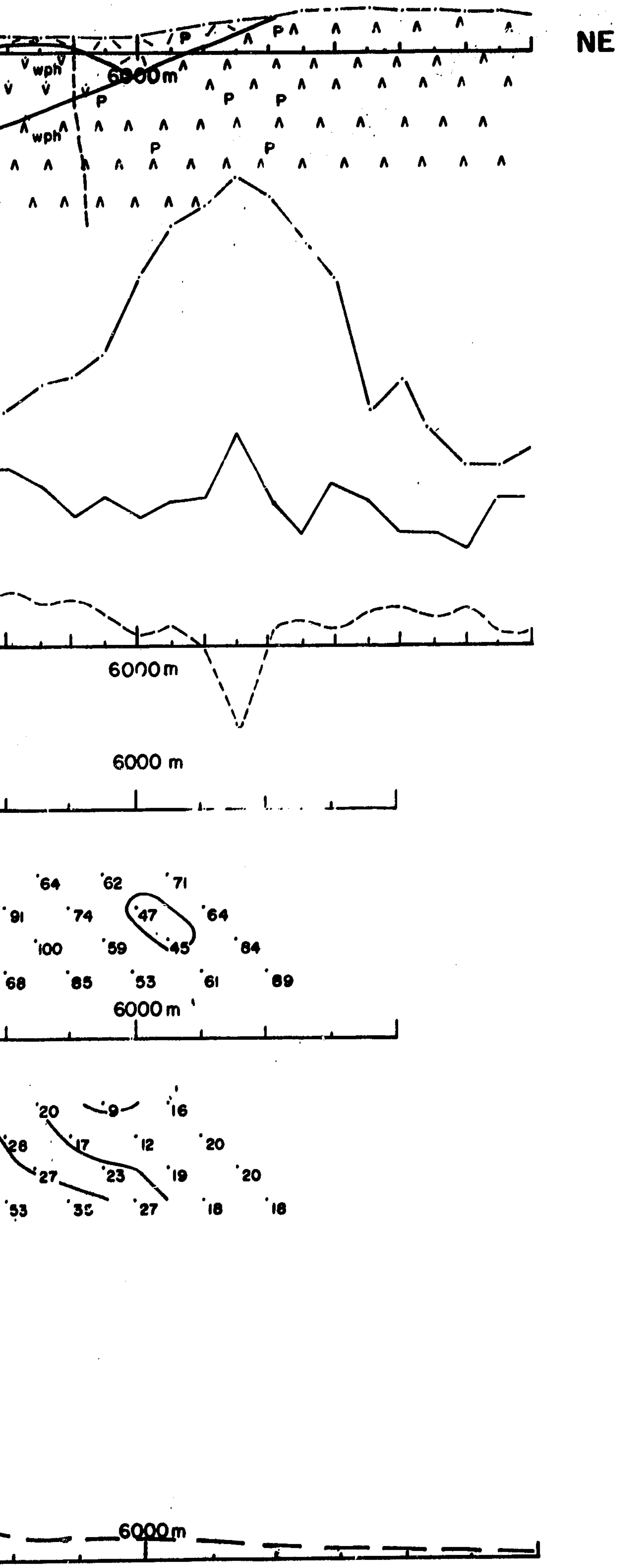


LEGEND

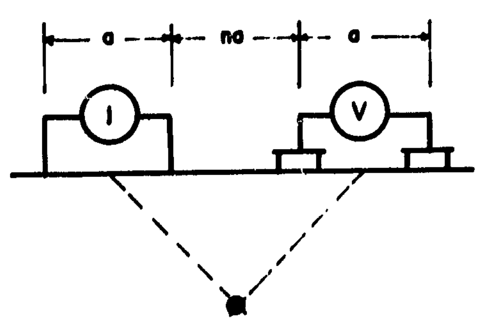
Lithological ——— Alteration - - - - - Boundaries

- Tonalite porphyry
- Diorite
- Quartz diorite and feldspar porphyry (fp)
- Dacite porphyry
- Andesite
- P — Propylitic, less than 1/2 % sulphide
- wph — Weak phyllic, 1/2 - 2 % sulphide
- Ph — Phyllic, more than 2 % Sulphide
- + Positive S.P. anomaly
- − Negative S.P. anomaly
- I.P. 3 x back ground (dashed)
- I.P. 8 x back ground (solid)
- Drill hole in profile
- Projected drill hole

Scale 1:5000

0 50 100 150 200m

ELECTRODE CONFIGURATION



PLOTTING POINT

a = 50 m

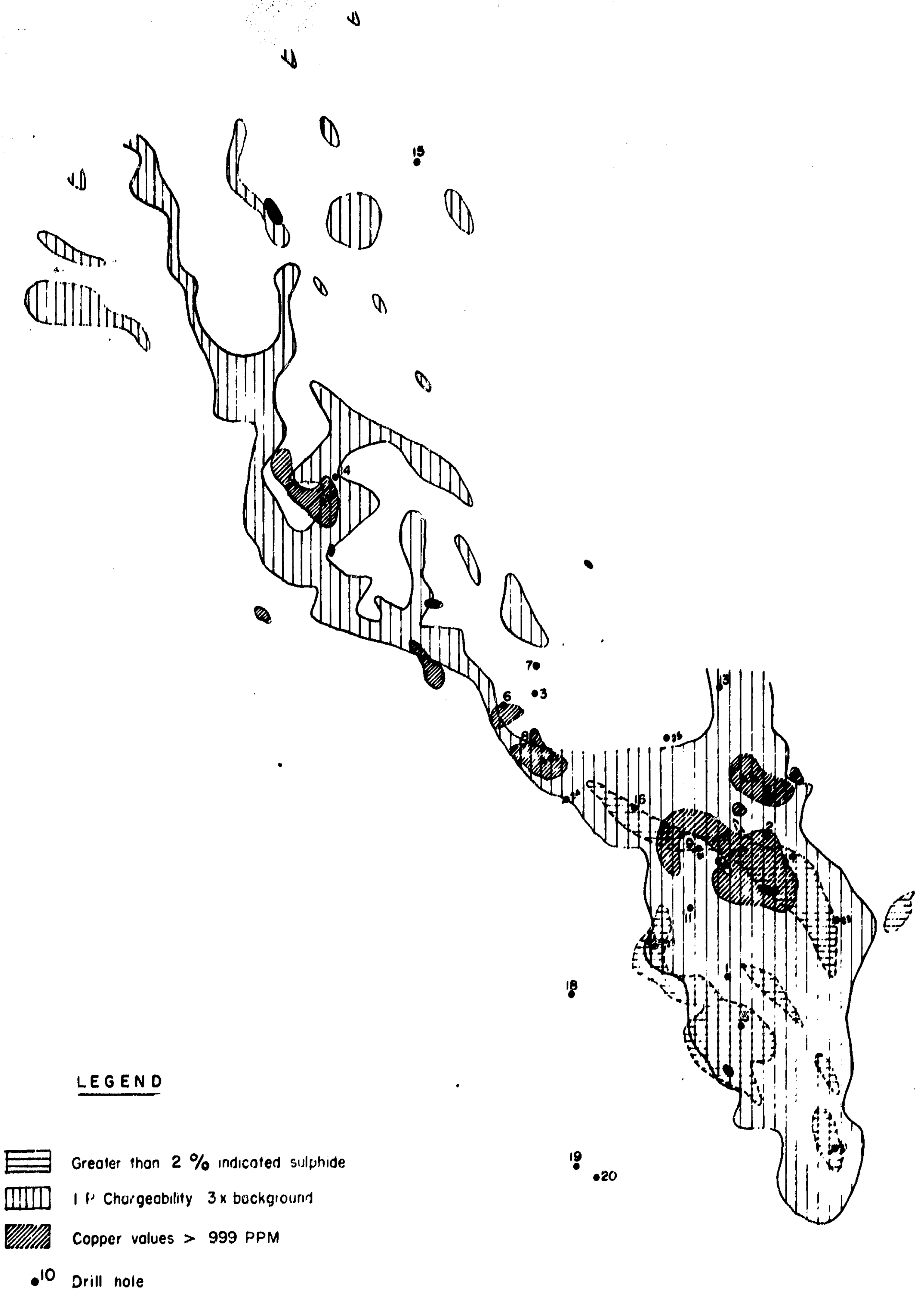
n = 1, 2, 3 and 4

SHANGALON PROSPECT

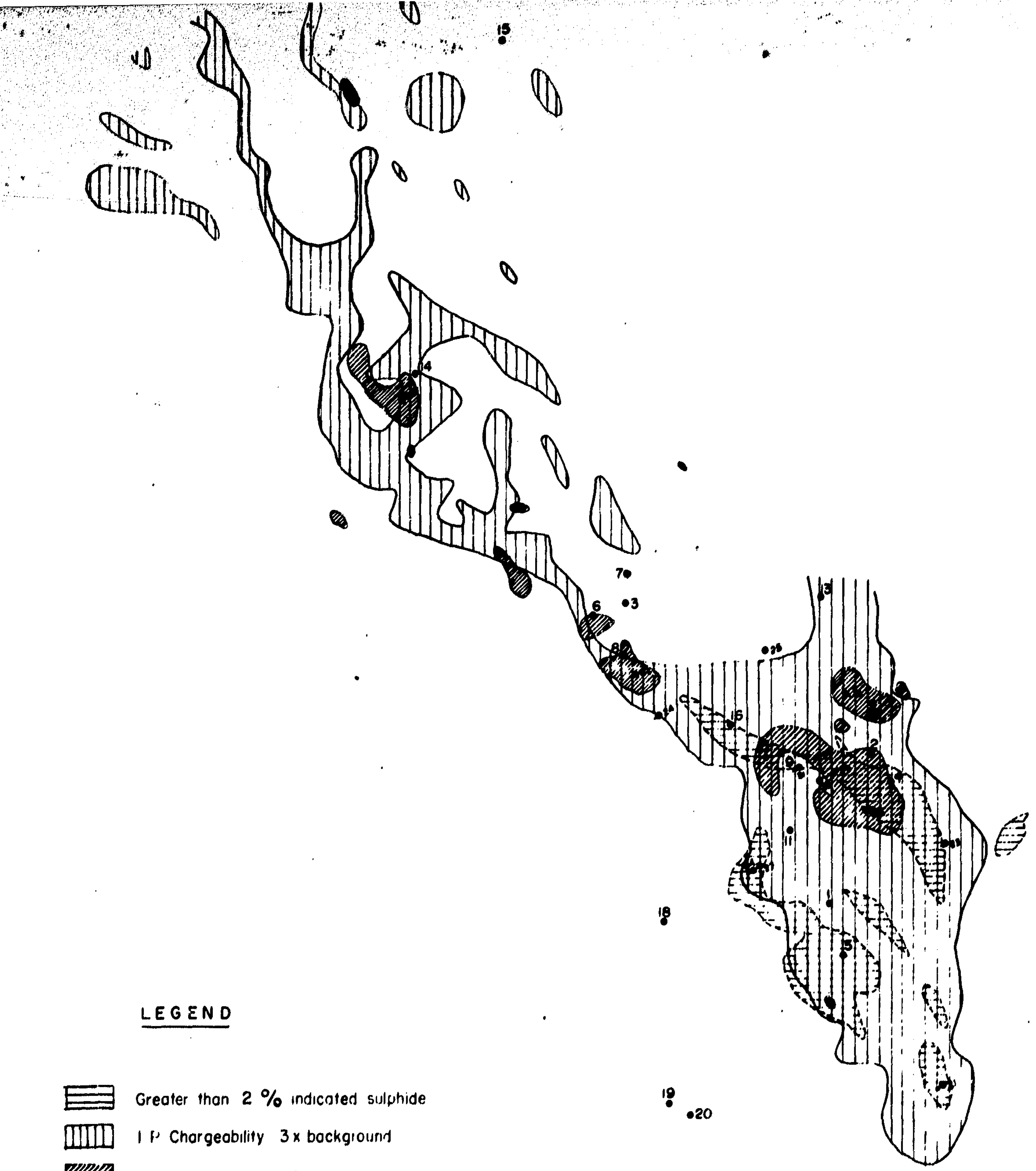
GENERAL CROSS SECTION

L 3500

Fig 20



SHANGALON PROSPECT



LEGEND

- Greater than 2 % indicated sulphide
- I P Chargeability 3 x background
- Copper values > 999 PPM
- •10 Drill hole

SHANGALON PROS

COMBINED MA

Fig. 21

Part Two. Surroundings

INTRODUCTION

Preceding work

The Shangalon area was included during the field season 1974-1975 in the project's regional geochemical survey and geological mapping of the Pinlebu-Banmauk area (Technical Report No. 1). This work was followed during the same season by additional stream sediment sampling and more accurate geological mapping of about 20 km^2 to cover the area of reconnaissance anomalies at Shangalon. The results were encouraging and led to the detailed investigations of the Shangalon copper prospect and adjacent areas covering 20 km^2, here referred to as the Shangalon grid, which are described in Part One of this report.

Present work

Significant copper anomalies in stream sediment samples were also discovered to the north of the Sangalon area, at Kame and Maingthon-East (Tecnical Report No. 6), within the north-trending Burma Volcanic Arc, in which both the Shangalon prospect and Monywa porphyry copper deposits are situated.

Because this belt is considered to be geologically favourable for porphyry copper deposits which elsewhere are commonly found in groups, it was decided to survey the Shangalon surroundings and especially its northern extension in detail to ensure that no "satellite" mineralization was left undiscovered.

Consequently an intensive exploration programme over about 275 km^2 surrounding Shangalon was carried out during the field season 1976-1977. It involved geological mapping on scale 2 inches to a mile (figure 22), stream sediment sampling (figure 23), and geophysical IP, resistivity and magnetic surveys (figures 24, 25 and 26).

The topography of the northern part of the Shangalon Surroundings is formed by gently rolling hills, where rock exposures are plentiful and drainage patterns well-defined; in contrast, the area to the south-east is occupied almost exclusively by Oligocene and younger sediments and alluvium which forms part of the Kyunhla-Kawlin plain (Technical Report No. 2). Therefore, it was decided to carry out combined geological mapping and detailed geochemical sediment sampling in the main part of the area (260 km^2), and a geophysical survey assisted only by random geological observations and widely spaced sediment sampling in the 15 km^2 of the south-eastern extension (Part One, figure 13).

The main mapping area es a rectangle bounded by latitude 23°41'24" and 23°47'12", and longitude 95°25'00" and 95°38'42" on the 1 inch to 1 mile topographic maps 84 M/5, 6, 9 and 10 of the Burma Series. The 1.5 km-wide belt which was surveyed mainly by geophysical methods extends 10 km south-east from the Shangalon copper prospect, reaching the latitude of 23°38'.

Presentation and summary of results

Part Two of Technical Report No. 1 should be read together with Part One, which contains details of geographic settings and physiographic features of the area not repeated here. The report is largely based on the results of geologic mapping, geophysical and geochemical surveys, photointerpretation, laboratory analysis, interpretation of field data and study of thin sections by the project's national personnel. The preliminary geological information was presented in a national internal report "Geology and Geochemistry of the Area Surrounding Shangalon" by Mg Mg Myint, Thein Han, Tin Than and Soe Kyi. All the basic data, including field maps and laboratory results related to the investigations, are filed with the DGSE.

Shangalon Surroundings comprise an area of 275 km^2 centred on the Shangalon copper prospect described in Parte One. Geological mapping, geochemical sampling and geophysical surveys were carried out between October 1976 and May 1977 in order to determine whether mineralization either related or similar to that at Shangalon prospect was present.

Geological mapping included observations on lithology, alteration and mineralization; combined with radiometric age determinations, this resulted in major refinements to the regional geological map of the area, showed that plutons of mid-Cretaceous, latest Eocene and possibly Jurassic age are present, and established the volcanic and sedimentary stratigraphy ranging from pre-Lower Cretaceous to Oligocene in age. During geochemical sampling 133 stream sediments were collected and analyzed for copper, lead, zinc, and in some cases molybdenum. Geophysical investigations were carried out in a narrow mostly alluvium-covered zone 15 km^2 in area, extending southeastward from Shangalon; they comprised induced polarization, electrical resistivity and magnetic and radiometric surveys.

No new mineralization was found during the geological mapping, and the geochemical survey revealed no significant anomalies. The geophysical results did not reveal any evidence of buried sulphide concentrations southeast of Shangalon. The results of the combined exploration methods therefore indicate that no economic mineralization is present in Shangalon Surroundings, and no further work is recommended.

I. GEOLOGY

Methods

Geological mapping combined with geochemical sampling extended from November 1976 to mid-March 1977, with 4 geologists and geochemists. The mapping was based on a photographic enlargement (twice original) of the 1-inch to one-mile-scale topographic map, and 1:20,000-scale air photographs were also used.

The approximate boundaries of the major lithological units in the area were known from the regional geological mapping carried out previously. In the more detailed mapping, emphasis was placed on delineation of boundaries and on determination of stratigraphic relationships in order to find the geological controls on any mineralization in the area. Weathered volcanic rocks were examined in some detail because of the difficulty in distinguishing hydrothermally altered from unaltered lavas in zones of deep weathering. Traverses in the extensive andesites in the north of the area were mainly confined to streams. Elsewhere stream sections, paths and ridges were traversed and lithological contacts were followed.

Sedimentary and eruptive rocks

Sedimentary rocks, lavas and pyroclastics occupy nearly two-thirds of the area and range in age from Lower Cretaceous or older to mid-Tertiary. Stratigraphic names are based largely on those used in adjacent areas in the regional mapping, but should be regarded as informal. The rock units are described below in probable order of decreasing age.

Shwedaung Formation

A small area of phyllites, phyllitic schists and cleaved mudstones is exposed over a few hundred square metres in the stream draining Mein-Mathat Taung (M/10 238 355). Numerous dykes or sills of andesite intrude the metasedimentary rocks. Boulder float of green clastic volcanic rock found in the stream and on the road nearby are possibly derived from the unit. The formation is provisionally correlated with the Shwedaung Formation of the eastern part of the Pinlebu-Banmauk area. Its age lies in the range Upper Triassic to Middle Cretaceous.

Mawgyi Andesite Formation

Nearly a third of the area is occupied by the Mawgyi Andesite, one of the most widespread rock-types in the region. It is mostly a dark grey to rarely greenish porphyritic rock, commonly occurring as flow breccias with angular lava blocks in an unsorted matrix of similar material, but massive lava flows or sills as well as dykes are common. In hand specimen phenocrysts of plagioclase and scattered mafic minerals, mostly hornblende, occur in an aphanitic groundmass. The Andesite is older than plutons north of the area which yielded earliest Upper Cretaceous K/Ar ages; it is probably therefore Lower Cretaceous in age.

Within the Andesite, particularly in the eastern part of the unit, are areas of bleached pale green to white rock, ranging from less than 1 m to 50 m in diameter. Pyrite is widespread in these rocks and thin sections of the most strongly altered samples show a quartz-sericite-pyrite schist. A trace of chalcopyrite is present in places. Field relationships suggest that the bleached areas are hydrothermally altered zones within the Andesite; they could be of similar age to the Andesite, but they are more probably related to intrusive rocks at depth.

Sagyindaung Dacite

Dacitic rocks occupy a discontinuous belt extending northeastwards from immediately east of Shangalon, and underlying Sagyindaung hill. The dacites range from dark grey or purple to cream in colour and mostly lack flow structures. Near Shangalon, the dacite is altered to a dense yellow to white rock and locally mineralized. Phenocrysts of quartz and plagioclase are set in an aphanitic groundmass with minor altered biotite visible in thin section. The position of the Dacite suggests that it overlies the Mawgyi Andesite, and in the Kyaukmore Chaung contacts with andesite are exposed. The Sagyindaung Dacite is probably equivalent to the Maingthon Dacite of probable Lower Cretaceous age described from elsewhere in the Pinlebu-Banmauk area.

Mawlin Formation

West of Shwethamindaung grey, black and

purple-coloured siltstones with minor sandstones and grits, steeply dipping to the east, are poorly exposed in the hillside. Conformable bodies of dacite and andesite, interpreted as sills, are present within the unit. The sedimentary rocks show similarities to the Mawlin Formation which occurs to the north, west of Wuntho, and which contains similar sills. On the basis of this correlation, the unit is considered to be of probable Lower Cretaceous age.

Ketpanda Formation

This unit forms a northeast-trending belt of mudstones, carbonaceous mudstones, siltstones, gritty sandstones and conglomerates with interbedded discontinuous dacites termed the Kawdaw Dacite. The formation is named from the similar succession east of Pinlebu, which is of probable Upper Cretaceous to Lower Eocene age. Conglomerates are mostly fine-grained, but a distinctive basal conglomerate is present which locally becomes a boulder bed. Clasts in the boulder bed are of vein quartz, mudstone, phyllite, quartz-diorite, dacite and andesite. Conformable andesite layers interpreted as sills are present in places and are widespread in the streams north of Gwedauktaw. The formation overlies the Mawgyi Andesite and Sagyindaung Dacite and probably overlies the Quartz Diorite. In the Chigyindaung area, the formation is hydrothermally altered and locally tourmalinized with minor mineralization.

The Kanwdaw Dacite occurs within the outcrop area of the Ketpanda Formation, with which it is interbedded. The Dacite is mostly white to yellow in colour and in places includes tuffs as well as probable flows, for example, near Auk Thitaya, where kaolinized laminated acidic tuffs are present. In some places coarse-grained pyroclastic rocks with angular fragments up to 5 cm across are present; north of Shwethamindaung they are cut by dacitic dykes. Locally, particularly on hill slopes, the dacite is kaolinized with an irregular surface layer of silicification. This alteration is considered to be the result of weathering, rather than hydrothermal in origin. The prominent pagoda-capped hill of Taungkamauk is considered to consist of Kawdaw Dacite, although here and in some other localities criteria for distinguishing between Sagyindaung and Kawdaw Dacite are not always present. The kaolinised tuffs near Auk Thitaya are quarried by hand to provide a source of kaolin, and boulders of coarse pyroclastic rocks west of Shwethamindaung are broken by hand and used for local road-metal.

Auk Thitaya Trachyte

Pale grey to purple strongly porphyritic rocks underlie two areas with scattered low hills in the southeastern part of the area. Some of the rocks show well-developed flow texture, and in places, for example near the road east of Mein-Mathataung, what are probably intrusive breccias include angular fragments of siltstone together with blocks of coarsely porphyritic trachyte. In hand specimen the rock is porphyritic with semi-translucent phenocrysts of euhedral sanidine, commonly more than a centimetre and locally up to 5 cm long, minor biotite and possibly quartz in an aphanitic groundmass. Thin sections show subequal amounts of sanidine and plagioclase (total 40 to 60 per cent) with biotite, minor augite and opaques. Field relationships indicate that the trachyte overlies the Ketpanda Formation. A previously reported K/Ar age determination on biotite from the trachyte near Auk Thitaya (M/10 263 373) yielded an age of 32.2 ∓ 1.3 m.y., or Lower Oligocene.

Intrusive rocks

Kanzachaung Batholith

The eastern part of the area is occupied largely by part of the Kanzachaung Batholith, a major northeast-trending plutonic body of predominantly granodioritic composition. Within the area the batholith consists largely of medium to coarse-grained hornblende and hornblende-biotite granodiorite, but areas of biotite adamellite and rarely of granite are present in places. The eastern margin of the granodiorite is in contact with hornblende diorite. Two K/Ar radiometric datings on granodiorite from beyond the area yielded mid-Cretaceous ages.

Hornblende Diorite

Mafic hornblende-bearing plutonic rock forms two NNW-trending bodies to the west of Shangalon, and a small body to the south. The rock is mostly dark coloured, consisting largely of hornblende and plagioclase. Hornblende commonly forms 30 to 50 per cent of the rock, and in places hornblendites with more than 90 per cent hornblende occur. In a few localities there is some evidence for compositional layering of lighter and darker rocks.

Field relationships suggest that the hornblende diorite intrudes granodiorite of the batholith and also the Mawgyi Andesite. However, K/Ar radiometric age determinations on hornblende from a sample of the western body of diorite (84 M/6 113 396) and from the small southern pluton (84 M/10 148 336.2) yielded ages of 144 ∓ 10 m.y. and 186 ∓ 18 m.y., respectively. These Jurassic ages are difficult to reconcile with the field evidence that the diorites intrude the granodiorite and Mawgyi Andesite.

Quartz Diorite

A NNW-trending pluton of quartz diorite

extends through Gwegyo, northwest of Shangalon, and five small and one larger body of similar rock occur near the contact between Mawgyi Angesite and Sagyindaung Diorite, southeast of Kyundaw. Largely altered quartz diorite also forms the main host to mineralization at Shangalon. The rock is mostly holocrystalline and clearly intrusive, rather than volcanic. It is commonly pale grey in colour, consisting of quartz, felspar and minor biotite; alkali felspar is scarce or absent. Alteration in the mineralized pluton near Shangalon has been described previously (Part One). The quartz diorite intrudes the Mawgyi Andesite and Sagyindaung Diorite. It is intruded by tonalite dykes and overlain unconformably by the Ketpanda Formation. A previously reported K/Ar age determination on secondary muscovite from the altered quartz diorite in a drill core yielded an age of 53 m.y. or Lower Eocene, indicating a probable minimum age for the hydrothermal alteration and hence for the mineralization.

Biotite diorite

A narrow northwest-trending pluton of biotite diorite lies west of the mineralized area at Shangalon. The diorite is mostly a dark greenish to black, mostly fine to medium but locally coarse-grained, rock with biotite and hornblende often forming a felty mass with interstitial felspar. In weathered outcrop, the rock can be distinguished from other plutons by the amount of biotite, although thin sections show that hornblende is commonly the most abundant mafic mineral. Other constituents visible in thin section are minor quartz, chlorite and opaques. The pluton intrudes the Mawgyi Andesite and quartz diorite and probably intrudes the Ketpanda Formation. It lacks mineralization and is probably younger than the alteration and sulphide mineralization at Shangalon.

Biotite granodiorite

A distinctive coarse-grained plutonic rock occupies a bomb-shaped area northwest of the mineralized area. It is easily distinguished in the field by the presence of larger flakes of biotite within quartz and felspar. Alteration, which is weak, and minor mineralization are restricted to the Shangalon grid area. A previously reported K/Ar radiometric determination on biotite yielded an age 33.2 ∓ 1.3 m.y., or Lower Oligocene.

Tonalite porphyry

Dykes of tonalite porphyry are restricted to the grid area and are not described here. A previously reported K/Ar radiometric age determination on one of the dykes yielded an age of 38 m.y. or latest Eocene, slightly older than the biotite granodiorite to the north.

Andesitic dykes and sills

Andesitic dykes intrude the biotite granodiorite, and sill-like bodies of andesite are present within the Ketpanda Formation. A previously reported K/Ar age determination from an andesite in the Ketpanda Formation gave an age of 50.1 ∓ 2.5 m.y., or Middle Eocene.

Aplitic dykes

Small dyke-like bodies of aplitic rock had been mapped within the grid area, but no new occurrences were found within Shangalon surroundings.

Structure

Within and northwest of the grid area, the major structural trend is 150°. Features with this trend comprise the plutons of hornblende diorite, biotite diorite, quartz diorite and granodiorite, the tonalite porphyry dykes in the mineralized area, and the mineralized fractures within the quartz diorite and biotite granodiorite at Shangalon. Fractures of this trend do not occur elsewhere in the Pinlebu-Banmauk area and there is no obvious explanation for their presence at Shangalon. Possibly they are related to splay faults associated with dextral movement on the major transcurrent fault to the east of the area.

In the southeastern part of the map, the structural trend is in marked contrast to that at Shangalon. The trend of stratigraphic units here is predominantly northeasterly, ranging from ENE in the south to northerly in the northeastern part of the map. Dips throughout this belt are mostly to the southeast. The sedimentary and volcanic rocks here evidently form the northwestern limb of a syncline, and have been eroded from the older Mawgyi Andesite in the north of the area. The folding which resulted in the NE-trending structure is very probably younger than the NW-trending fractures with which the mineralization is associated; the folds affect mid-Tertiary sediments south of the area and could be as young as Late Miocene.

II. GEOCHEMISTRY

The present work increased the regional geochemical sampling density of 0.7 to 1.9 samples per km^2 over the main extension area of 260 km^2 surrounding the Shangalon grid. To obtain comparable results with the earlier reconnaissance surveys, the same methods of sampling and analytical procedures were used throughout the work.

The drainage pattern is characterized by gently rolling relief and is very broadly radial. Perennial water was observed only in master streams (Kalon Chaung and Laga Chaung) while all tributaries are dry from January till May. Owing to the rapid erosion in monsoon seasons and different weathering processes, the detritus of streams draining plutonic rocks is predominantly coarse sand, while the streams of volcanic areas contain mostly boulders, gravel and mud. Consequently, as the drainage patterns are well-developed, the collected sediments represent adequately the upstream geology and geochemistry. It is believed that in this environment any mineralization of significance would have caused a significant geochemical anomaly, especially with the high sampling density used.

The geochemical data were treated applying Lepeltier's simplified graphical statistical treatment. Owing to the excess of high copper values near Shangalon, the results from Shangalon Surroundings were combined with the regional results of the Pinlebu-Banmauk area to provide more reliable statistical información and consequently a better interpretation. In the Pinlebu-Banmauk area, the geology was divided into two main lithological geochemical units for statistical treatment of stream sediment values: (i) areas of mostly igneous rocks and (ii) those of predominantly sedimentary rocks.

The table on page 38 shows the statistical parametres for copper, lead, zinc and molybdenum in these two environments within the Pinlebu-Banmauk area.

The Shangalon Surroundings were classified as an area with predominantly intrusive and volcanic rocks; therefore in the following geochemical interpretation, the igneous environment statistical parametres were used.

The copper threshold value set at 90 ppm is exceeded by 99 values, e.g. by 25 per cent of the stream sediment samples taken in the area. The anomalous copper values are clearly concentrated close to the known mineralized zones, as is seen on the geochemical map (figure 23). Most of the other anomalous values appear in the eastern tributaries of Kalon creek, north of Kyunhla village. These values of 100 to 200 ppm Cu apparently correspond to the weak sulphide mineralization of pyrite-chalcopyrite and scattered molybdenite which had been found during the detailed survey in the biotite granodiorite (Part One). Some higher isolated values situated north from the grid area and another group scattered southwest from Kyundaw village are due either to pyrite-rich lenses in the Mawgyi Andesite or to the sporadic quartz-felspar-sulphide veinlets in the biotite granodiorite.

No significant lead or zinc anomalies were found, but only a few isolated values distributed erratically over the prospect area. Nevertheless, some low lead anomalies (threshold 47 ppm/Pb) tend to group in the area between Shangalon village and Gwedauktaw, where the main mineralization occurs.

Molybdenum stream sediments values above the arbitrary chosen threshold (5ppm) coincide very well with the higher copper anomaly. Molybdenum values of about 10 ppm and higher were found only in the Shangalon grid area and were confirmed by molybdenite findings either in drill core or in residual quartz float.

Table. Statistical parametres for Cu, Pb, Zn, and Mo

	Igneous environment			Sedimentary environment		
	Number of samples	Median (ppm)	Threshold (ppm)	Number of samples	Median (ppm)	Threshold (ppm)
Copper	2574	23	90	2344	15	55
Lead	3062	16	47	2910	14	40
Zinc	3254	43	160	3304	29	72
Molybdenum	-	-	50[a/]	-	-	-

a/ Arbitrary value.

III. GEOPHYSICS

Methods

A 1:25,000-scale topographic sketch map of 15 km^2, based on grid lines at 1,000 m or 500 m spacing and completed by data from the 1-inch to 1-mile scale map, was prepared and used as a basis for presentation of all geophysical data of the southeastern extension area. Induced polarization was measured by a frequency domain instrument with frequencies of 10 and 0.3 cps. Dipole-dipole method was used, with a dipole length of 100 m and a distance between two dipoles of 100 m and 200 m. The results were plotted in the form of profiles (figure 1). The electrical resistivity soundings were made using the induced polarization equipment, with a separation ranging from 2 to 400 m between the two current electrodes. Sounding curves are presented on the usual bilogarithmic scale (figure 25 as an example). Magnetic (vertical component) and radiometric measurements were taken along lines every 25 m and reduced to the same reference level as in the Shangalon grid area. Results are presented as profiles on the 1:25,000 map (figure 26).

Interpretation

Electrical induced polarization (I.P.)

As expected, the high induced polarization of the Shangalon anomaly attenuates towards the southeast and attains background values approximately on line L1600N (figure 24). Measurements along the line L1000N did not reveal any I.P. anomaly. South of that line, a few relatively weak anomalies of limited size were discovered, for example the anomalies on line L0, point 4750, and on line L2000S, point 2750. Since the discovered anomalies were scattered and insignificant, it was decided to stop the survey.

Electrical resistivity soundings

Five resistivity soundings were done in the plain between the Chigyindaung Hill and the Daungyu River south of it (figure 1). All soundings are typical of a 3-layer case (e.g. figure 25). The uppermost layer has a very high resistivity, ranging from 200 to 15,000 ohmmeters and a thickness of between 0.9 and 2.5 metres only. The high resistivity is due to very fine-grained sand, which is dry in the upper part. The second layer has a low resistivity of only 5 to 13 ohmmeters and a thickness of 2.3 to 12 metres. The low resistivity is due to the clay component in the sediments. The third layer with a slightly higher resistivity of 15 to 30 ohmmeters represents the lowest part of the sediments overlying the basement and the upper part of the basement itself. It is not possible to determine the depth of the basement because of insufficient resistivity contrast between sediments and basement.

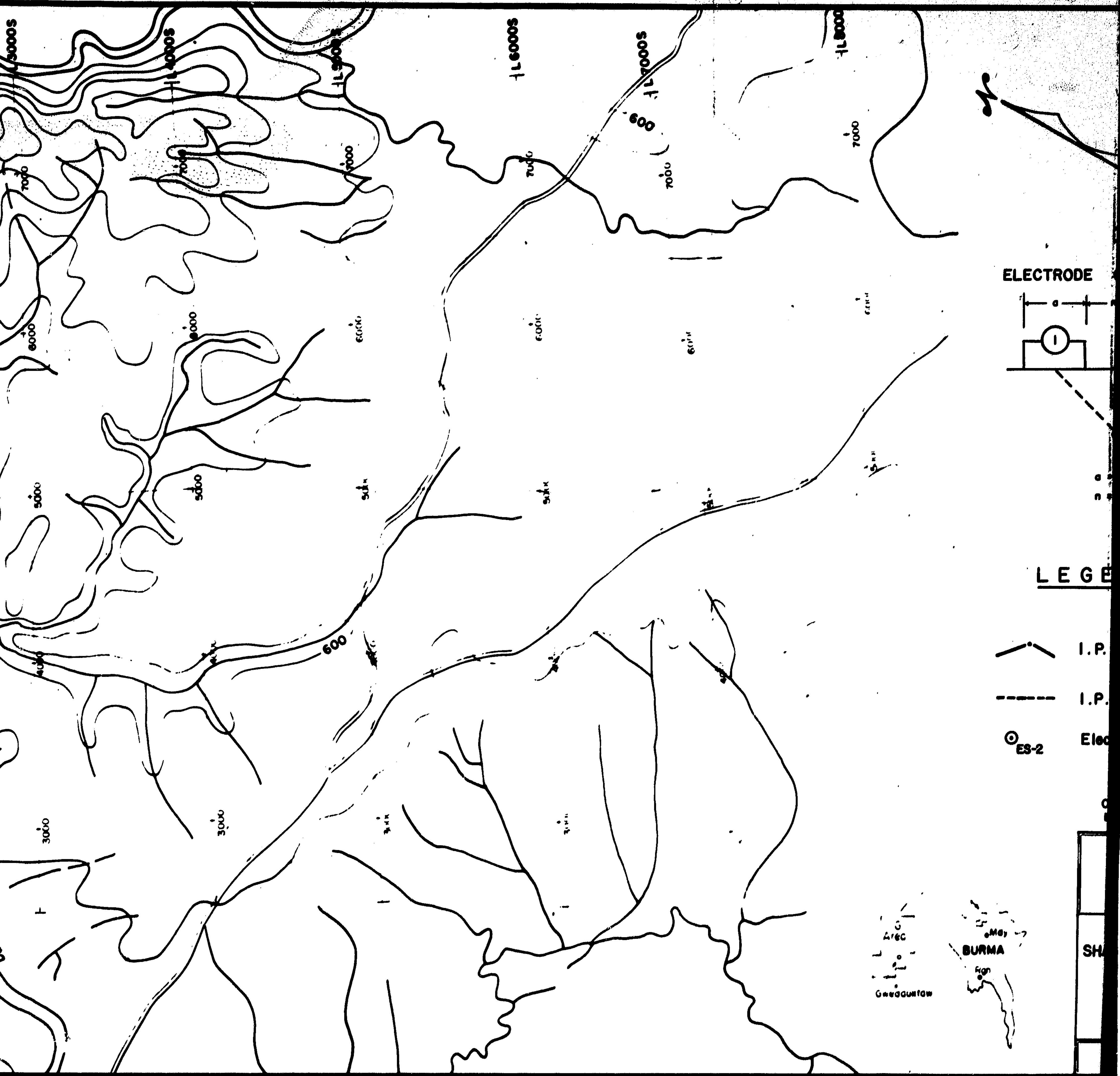
Magnetic reconnaissance

Results of magnetic measurements are shown on the map (figure 26). The vertical magnetic intensity is very regular along all lines. The only characteristics are a slight gradient in the northerly direction, which is caused by a very deep-seated structure, and local anomalies on the northeastern end of lines L0 and L1000N, most likely due to the near-surface igneous rocks covered by sediments. Since no magnetic anomaly has been found in the area down to the profile L8000S in the south, and since the sediment cover increases in thickness in that direction, the magnetic survey was stopped.

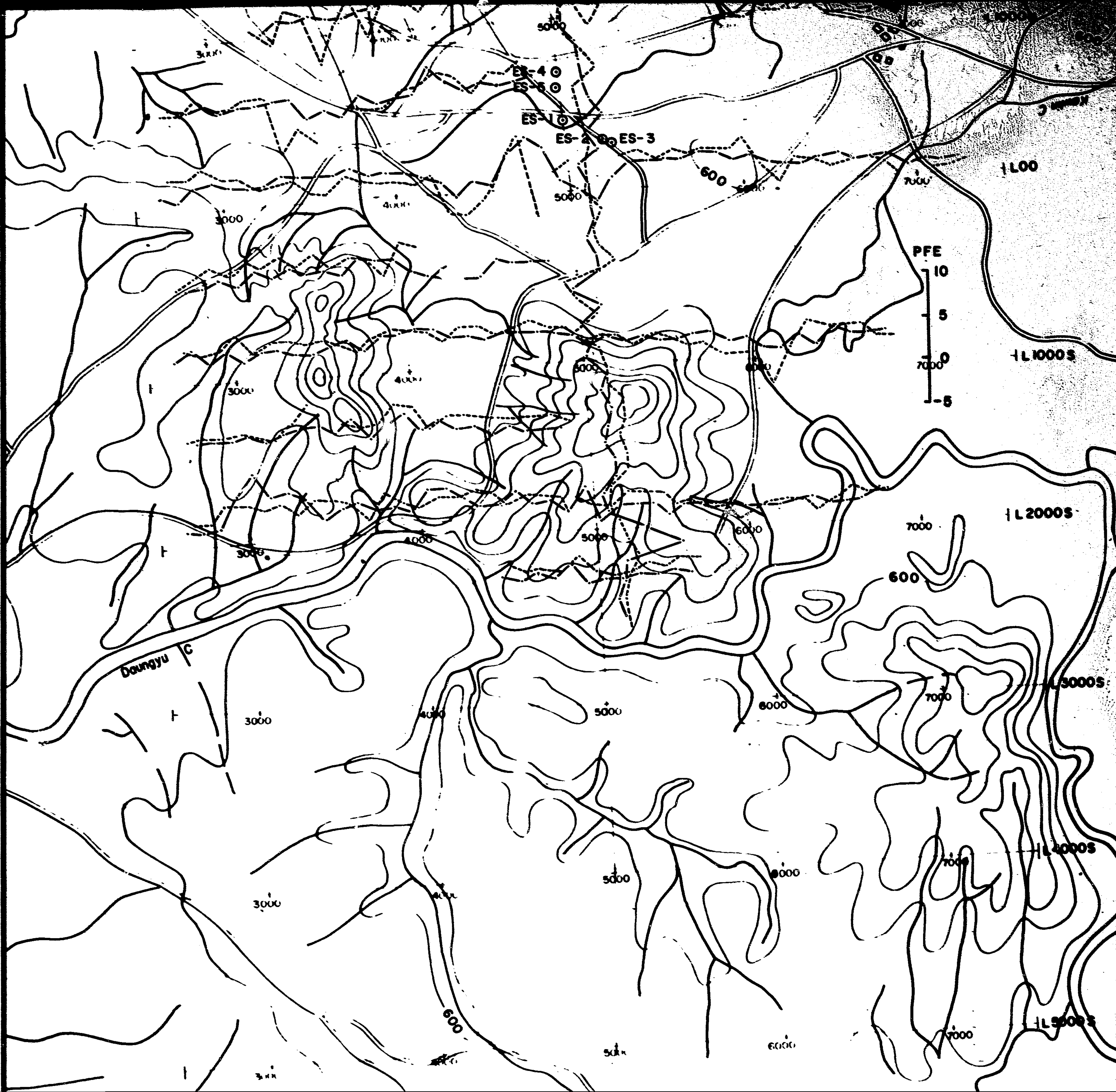
Radiometric reconnaissance

The radiation measured on sediments south of the Shangalon area is fairly uniform and ranges from 40 to 50 cps. Occasional peaks of up to 100 cps coincide with small dry streams and are probably due to a concentration of potassium-rich sediments. No anomalous radiation which could be attributed to igneous rocks was detected.

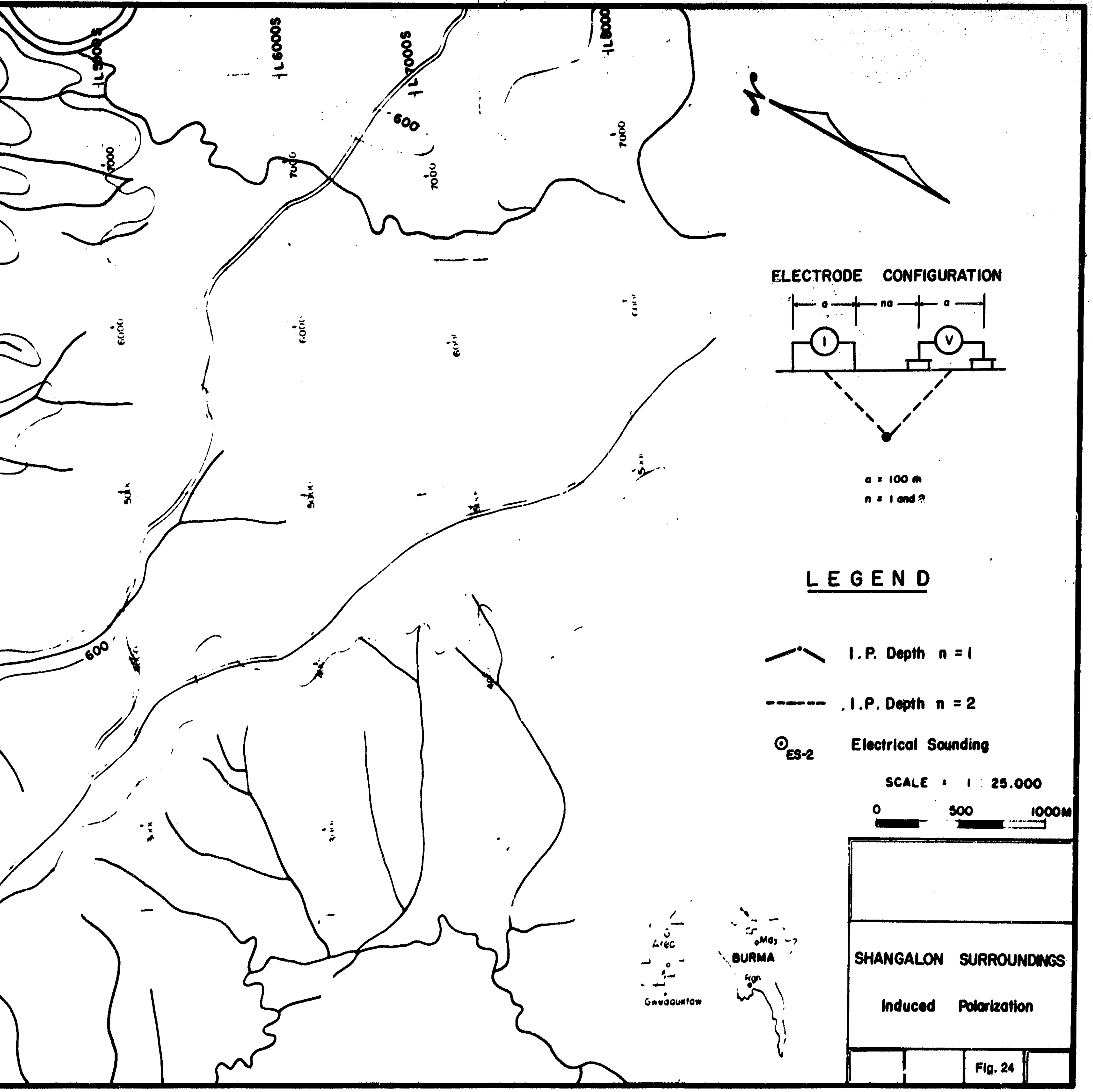

Chigyindaung
750
Gwedauktang
L1000N
600
Kemin C
L00
ES-4
ES-5
ES-1
ES-2
ES-3
600
PFE
10
5
0
-5
L1000S
L2000S
L3000S
600
Daungyu C
3000
4000
5000
6000
7000



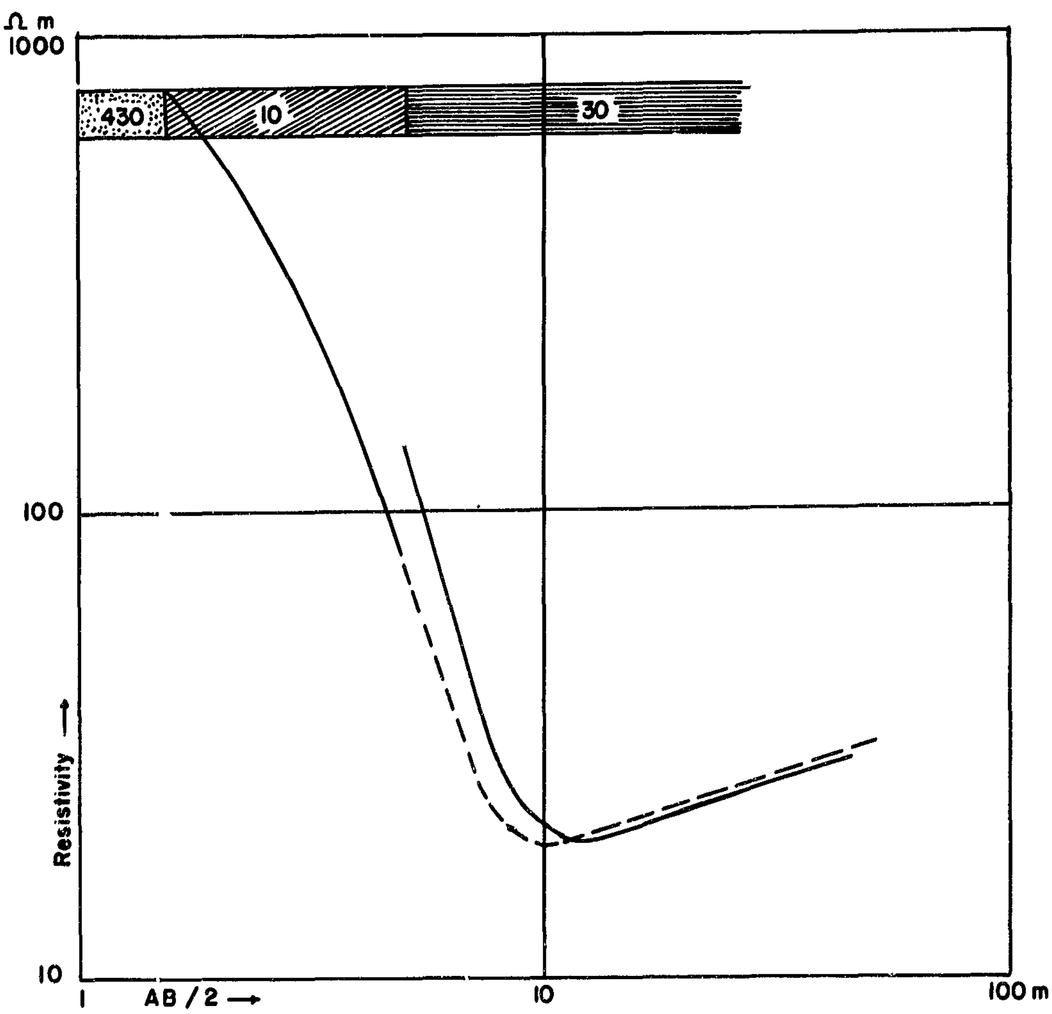
L5000S
L4000S
L6000S
L7000S
600
7000
6000
5000
3000
ELECTRODE
LEGE
I.P.
I.P.
ES-2
Elec
BURMA
SHA



PFE
10
5
0
-5
L00
L1000S
L2000S
L3000S
L4000S
L5000S
ES-1
ES-2
ES-3
ES-4
ES-5
600
Daungyu
C
3000
4000
5000
6000
7000


L6000S
L7000S
L8000
600
7000
6000
ELECTRODE CONFIGURATION
a
na
a
I
V
a = 100 m
n = 1 and 2
LEGEND
I.P. Depth n = 1
I.P. Depth n = 2
ES-2
Electrical Sounding
SCALE : 1 : 25.000
0
500
1000M
BURMA
SHANGALON SURROUNDINGS
Induced Polarization
Fig. 24

Sounding I



SHANGALON SURROUNDINGS

Electrical Sounding

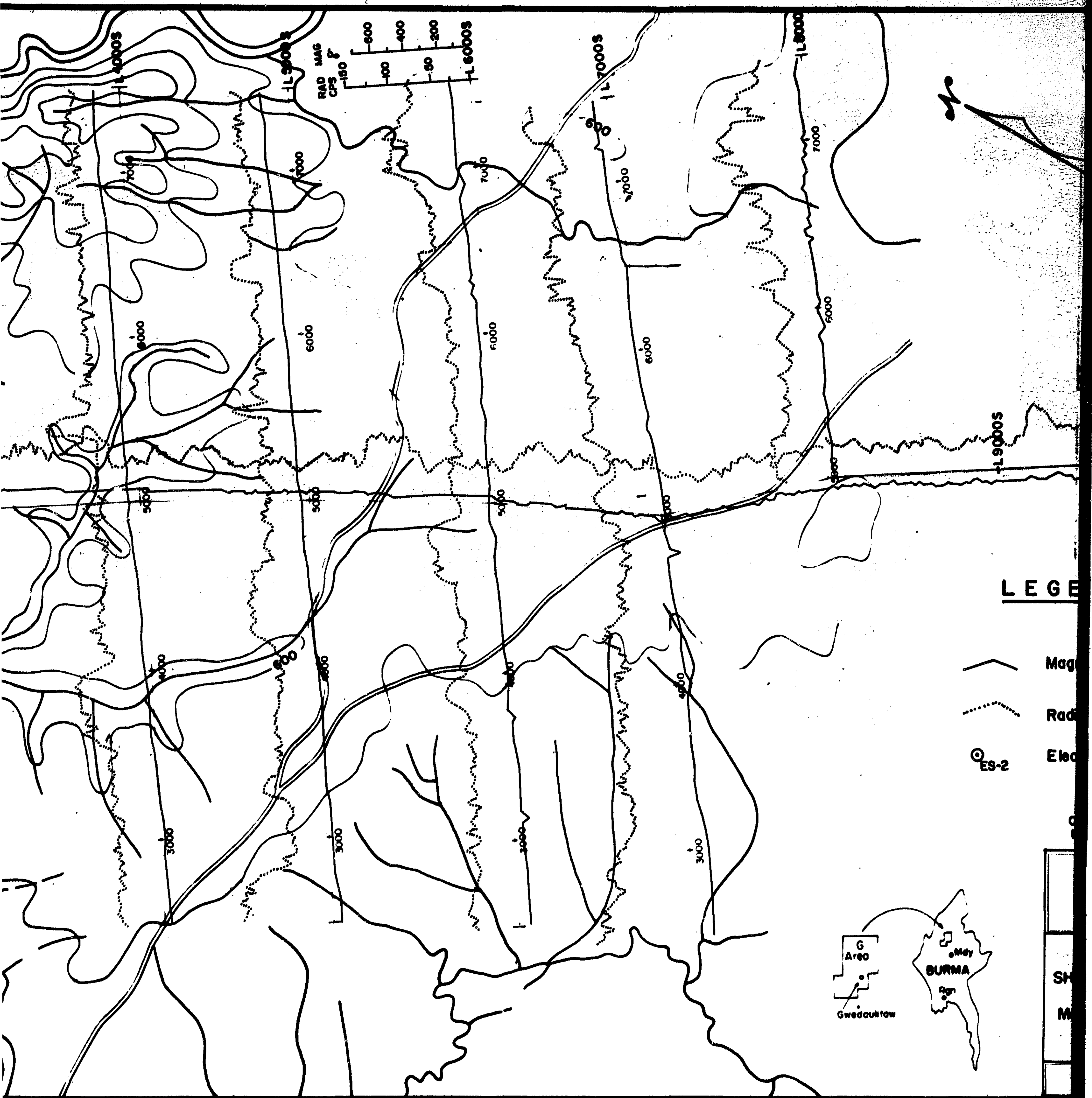
Fig. 25

IV. CONCLUSIONS AND RECOMMENDATIONS

In the main area of 260 km^2 the physiographical conditions are excellent for a reliable geochemical sediment survey, and the area is reasonably well exposed for detailed geological surface mapping. In the southeastern extension area, the geological and topographical conditions are such that any sizable sulphide bodies should have given clearly detectable geophysical I.P. anomalies. It is therefore concluded that the results of combined explorations methods are essentially reliable and valid.

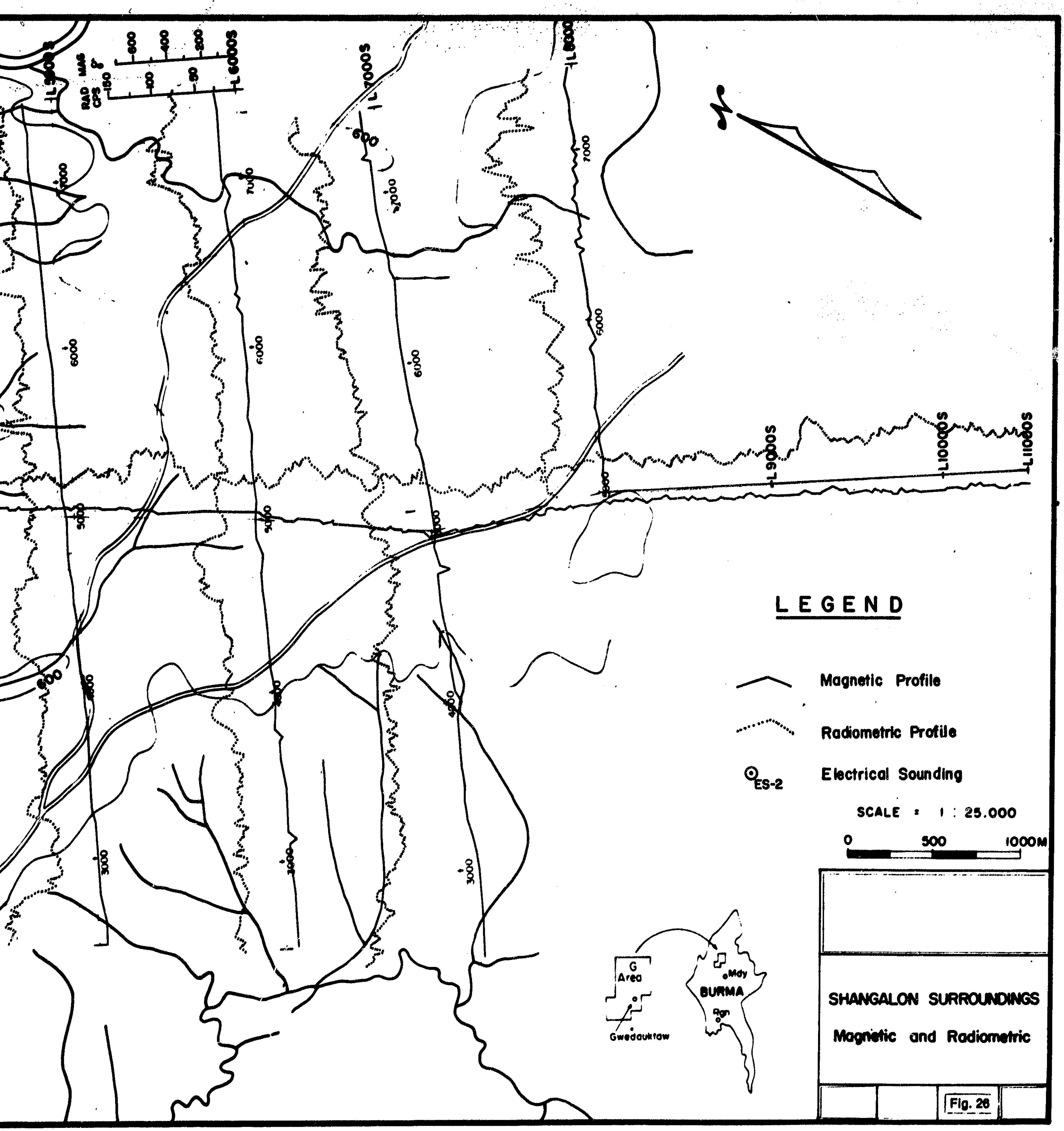
The geological mapping, which included lithological, alteration and mineralization observations, discovered no indications of prominent mineralization in the study area. Nor did the results of very detailed stream sediment survey detect any significant anomalies outside the grid area. Finally, the geophysical survey of the alluvium-covered part of the southeastern extension found no evidence of sulphide concentration. Part One of this report concluded that the Shangalon prospect is not economic at present. The results described in Part Two indicated that no economic mineralization is present in Shangalon Surroundings, and no further exploration work is recommended.

L00
L1000S
L2000S
L3000S
L4000S
7000
6000
5000
4000
3000
600
750
Chigyindaung
Daungyu C
ES-3
ES-4



RAD CPS
MAG δ
150
100
50
600
400
200
L 4000S
L 5000S
L 6000S
L 7000S
L 8000S
L 9000S
600
7000
6000
5000
4000
3000
LEGE
Mag
Rad
Elec
ES-2
G Area
Gwedauktaw
BURMA
Mdy
Rgn
SH
M

L 00
L 1000S
L 2000S
L 3000S
L 4000S
L 5000S
ES-1
ES-3
ES-4
Daungyu
600
3000
4000
5000
6000
7000
RAD CPS
MAG γ
150
100
600
400



SHANGALON SURROUNDINGS
Magnetic and Radiometric

Fig. 26

ANNEXES

Annex 1

SHANGALON PROSPECT

List of maps prepared by the project team which are not included in the report.

	Map	Scale
1)	Topographic map of Shangalon area	1:25,000
2)	Topographic map of Shangalon area	1:10,000
3)	Topographic map of Shangalon area	1:5,000
4)	Geophysical profile L3800	1:5,000
5)	Magnetic isolines	1:5,000
6)	Geoelectric interpretation	1:5,000
7)	Turam profiles BL 1, 3	1:5,000
8)	Turam profiles BL 2, 4	1:5,000
9)	Self-potential isolines	1:5,000
10)	I.P. and resistivity pseudosections L1600 - L1900	1:5,000
11)	I.P. and resistivity pseudosections L1900 - L2600	1:5,000
12)	I.P. and resistivity pseudosections L2700 - L3300	1:5,000
13)	I.P. and resistivity pseudosections L3400 - L4000	1:5,000
14)	I.P. and resistivity pseudosections L4100 - L5000	1:5,000
15)	I.P. and resistivity pseudosections L5100 - L5700	1:5,000
16)	I.P. and resistivity pseudosections L5800 - L6400	1:5,000
17)	I.P. and resistivity pseudosections L6500 - L7100	1:5,000
18)	I.P. and resistivity pseudosections L7200 - L7800	1:5,000
19)	Copper contours in soil	1:5,000
20)	Molybdenum contours in soil	1:5,000
21)	Lithology	1:5,000
22)	Mineralization and structure	1:5,000

Annex 2

NATIONAL PERSONNEL AT SHANGALON

Geologists and geochemists

Soe Kyi, Thein Han, Tin Swe, Myint Swe, Saw Naung, Kyaw Win, Tet Sein, Tin Maung Win, Tin Than and Maung Maung Myint.

Geophysicists

Tin Myint Oo, Win Myint, Nyunt Sein, Mya Thaung, Khin Maung Htay, Thein Htun, Than Swe, Kyaw Soe, Nyunt Lwin and Tauk Tut.

Drillers

Ba Soe, Ba Su, Tin Win, Kaing Shwe, Win Myint, San Nyunt and Soe Thein.

Analytical chemists

Shwe Gaung Lay, Kyaw Soe, Myint Thein, Cho Cho Myint, Khin Khin Myint, Yan Aung, Khin Khin Lay, San San Yee, Khin Swe Swe, Myint Myint Than, Saw Shalama and Khin Moe Hnin.

Annex 3

PROJECT PERSONNEL

International staff	Nationality	Arrival date	Departure date	Total man-months served
		Internal personnel		
J. V. Huhta Project Manager	Finland	Jan. 1974	-	-
A.H.G. Mitchell Chief Geologist	United Kingdom	Jan. 1974	-	-
P. Carrel Economic Geologist	France	Dec. 1974	Oct. 1976	24
F. Sumi Geophysicist	Yugoslavia	Oct. 1974	-	-
B. Zitek Chief Geochemist	Czechoslovakia	Feb. 1975	-	-
T. Davenport Field Geochemist	United Kingdom	April 1975	Feb. 1976	12
F. Baumann Consultant	Canada	March 1976	Jul. 1976	4

Government personnel

U Kyi Soe — Project Co-Director

Geologists

U Zaw Pe
U Danny Sein
U Khin Maung Aye (1)
U Tin Hlaing (2)
U Tin Maung Thein
U Tin Swe
U Kyi Tun
U Soe Thi Ha
U Nyunt Htay
U Myint Swe (2)
U Myint Swe (3)
U Khin Maung Aye (2)
U S Lwin Than
U Ko Ko (1)
U Aye San
U Kyaw Sein
U Tet Sein
U Sein Tun (2)
U Tint Naung
U Kyaing Sein
U Saw Andrew Htwe

Geologists (continued)

U Ohn Maung (2)
U Ye Maung Tin
U Than Aung
U Htein Win (1)
U Htein Lynn
U Tin Than
U Soe Kyi
U Aung Gyi (3)
U Tin Hlaing (3)
U Tin Maung Win (2)
U Shyam
U Sein Aung Win
U Richard Shwe
U Kyaw Win (5)
U Tint
U Myo Myint Swe
U Saw Naung
U Htay Win (2)
U Thein Han
U Ko Ko (5)
U Ba Kyi

Government personnel (continued)

Geochemists

U Shwe Gaung Lay

U Kyaw Soe

Daw Khin Khin Win

Daw Thit Thit Hla

Daw Myat Myat Sein

Geophysicists

U Tin Myint Oo

U Win Myint

U Nyunt Sein

U Tauk Tut

U Thein Htun

Geophysicists (continued)

U Mya Thaung

U Khin Maung Htay

U Kyaw Soe

Drilling Engineer

U Ba Soe

Draftsmen

U Tun Aye

U Tun Shin

U Khin Pyone

U Tin Wan

U Khin Sein

Annex 4

PROJECT REPORTS

Technical Report 1: Geology and Mineralization of the Shangalon Copper Prospect and Surroundings (Part One: Shangalon; Part Two: Surroundings). (This report)

Technical Report 2: Geology and Exploration Geochemistry of the Pinlebu-Banmauk Area, Sagaing Division, Northern Burma. (In preparation)

Technical Report 3: Geology and Exploration Geochemistry of the Shan Scarps Area, East of Kyaukse, Thazi and Tatkon, Central Burma. (In preparation)

Technical Report 4: Geology and Exploration Geochemistry of Part of the Northern and Southern Chin Hills and Arakan Yoma, Western Burma. (In preparation)

Technical Report 5: Geology and Exploration Geochemistry of the Salingyi-Shinmataung Area, Central Burma. (In preparation)

Technical Report 6: Mineral Exploration in Selected Areas. (In preparation)

Technical Report 7: Geological Mapping and Geochemical Exploration in Mansi-Manhton, Indaw-Tigyaing, Kyindwe-Longyi, Patchaung-Yane, and Yezin Areas, Burma. (In preparation)

Letpadaung Taung Copper Prospect. (Memorandum)

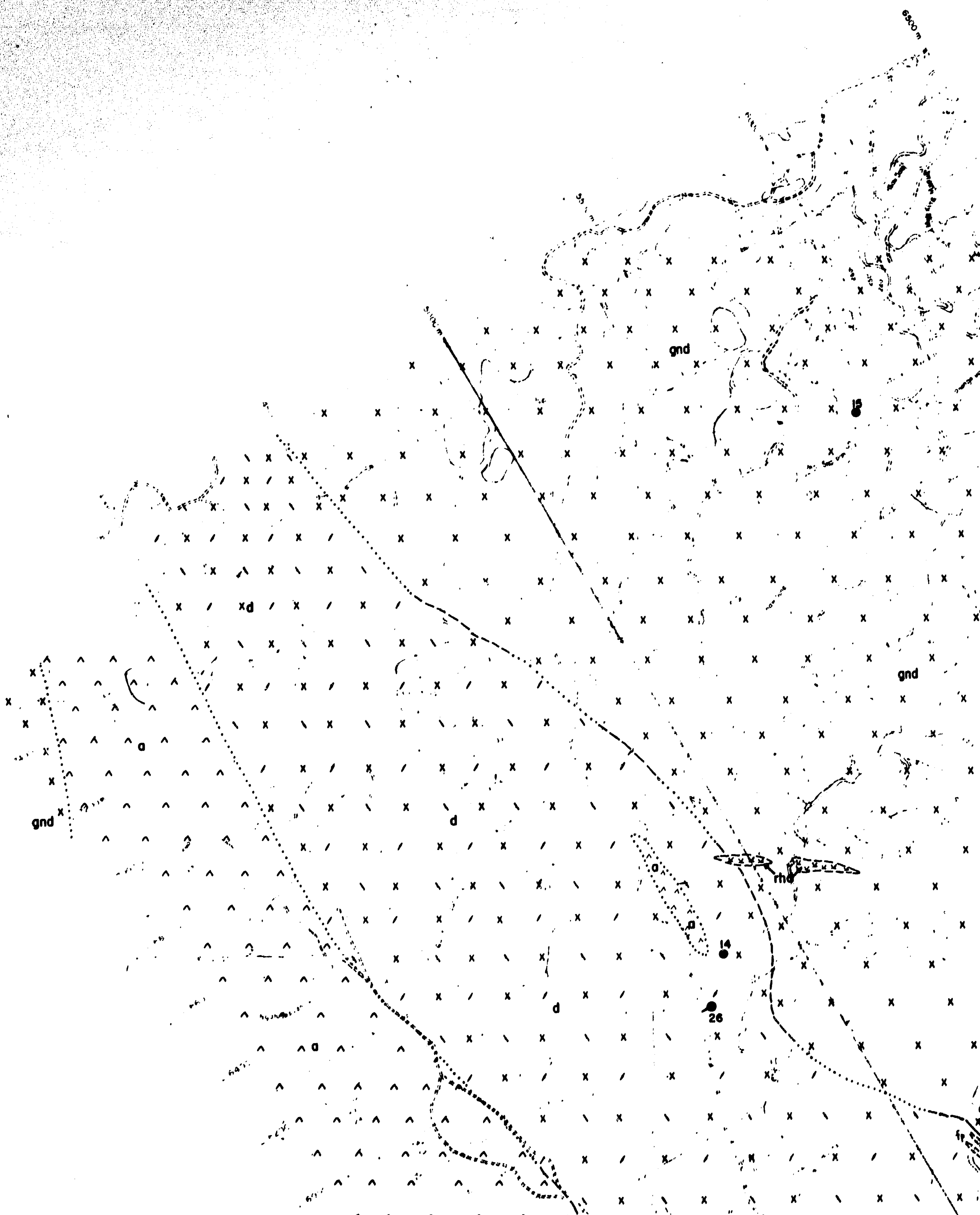
A Graphical Method for the Treatment of Geochemical Data (by T.G. Davenport). (Internal report)

Geological Mapping and Exploration Instructions for Field Personnel.

Annex 5

NATIONAL PERSONNEL IN SHANGALON SURROUNDINGS

Sr. No.	Name	Designation	Remarks
		Geophysical field party	
1.	U Tin Myint Oo	Geophysicist III	Team Leader
2.	U Win Myint	Geophysicist III	Deputy Team Leader
3.	U Nyunt Sein	Geophysicist IV	
4.	U Tauk Htut	Geophysicist IV	
5.	U Mya Thaung	Geophysicist V	
6.	U Thein Htun	Geophysicist V	
7.	U Khin Maung Htay	Geophysicist V	
8.	U Kyaw Soe	Geophysical Assistant III	Surveyor
		Geological/geochemical field party	
1.	U Soe Kyi	Geologist IV	Team Leader
2.	U Thein Han	Geologist V	Mapping Geologist
3.	U Tin Than	Geologist V	Geochemist
4.	U Mg Mg Myint	Geologist V	Geologist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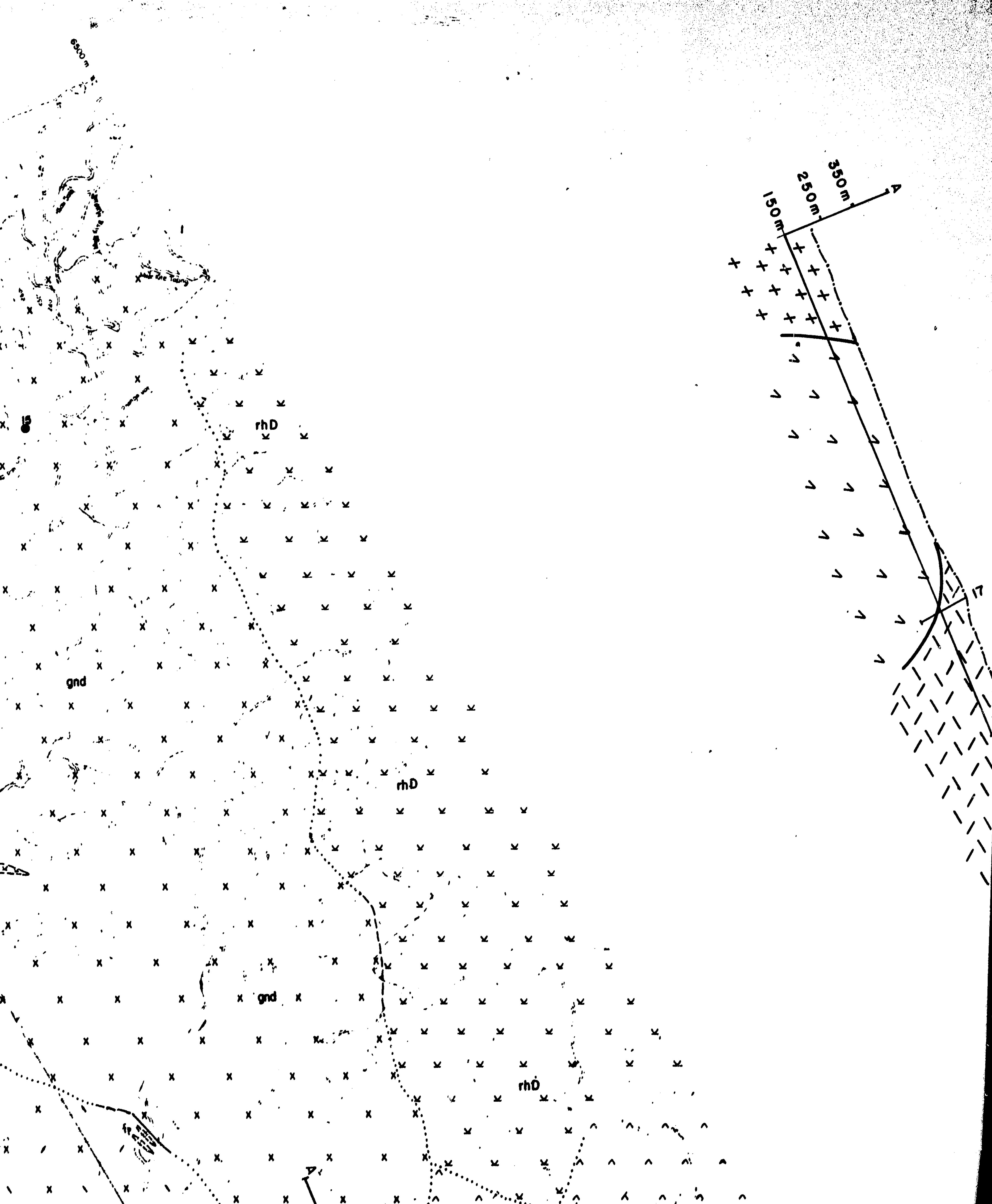
gnd
15
d
a
gnd
gnd
d
a
rhd
a
14
d
26
a



6500 m
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250 m
350 m
A
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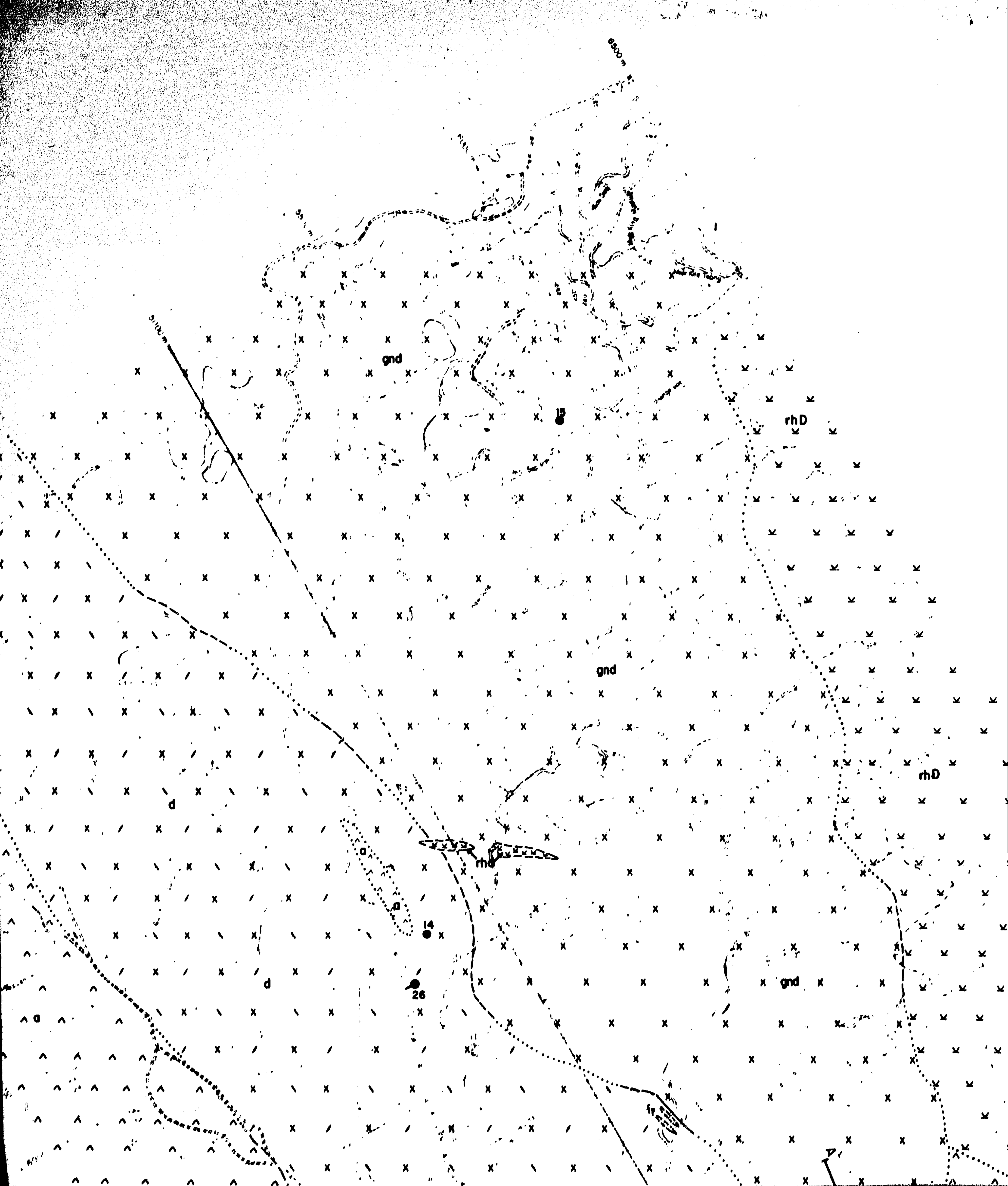
rhD
rhD
gnd
gnd
15
17


gnd
rhD
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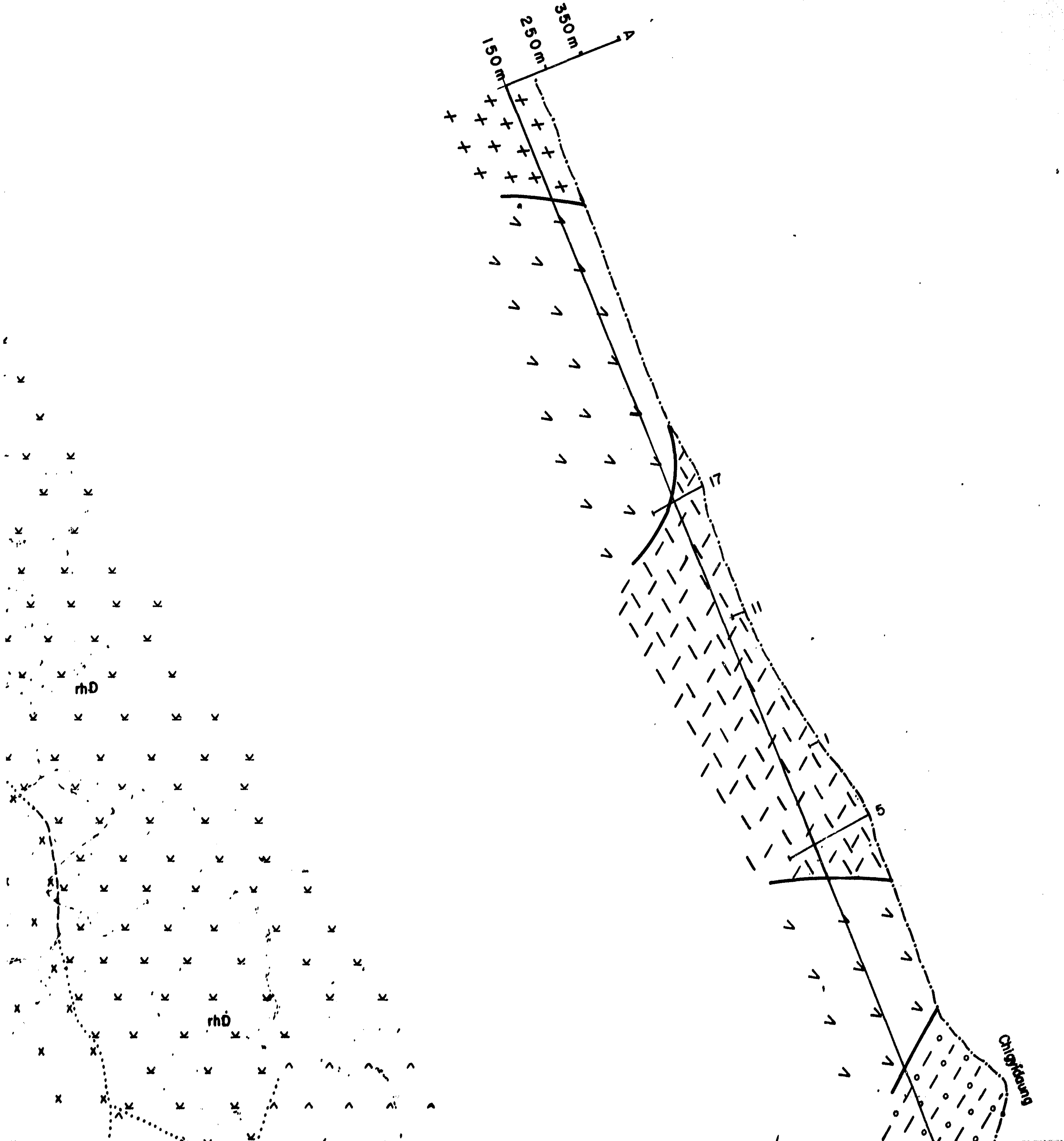
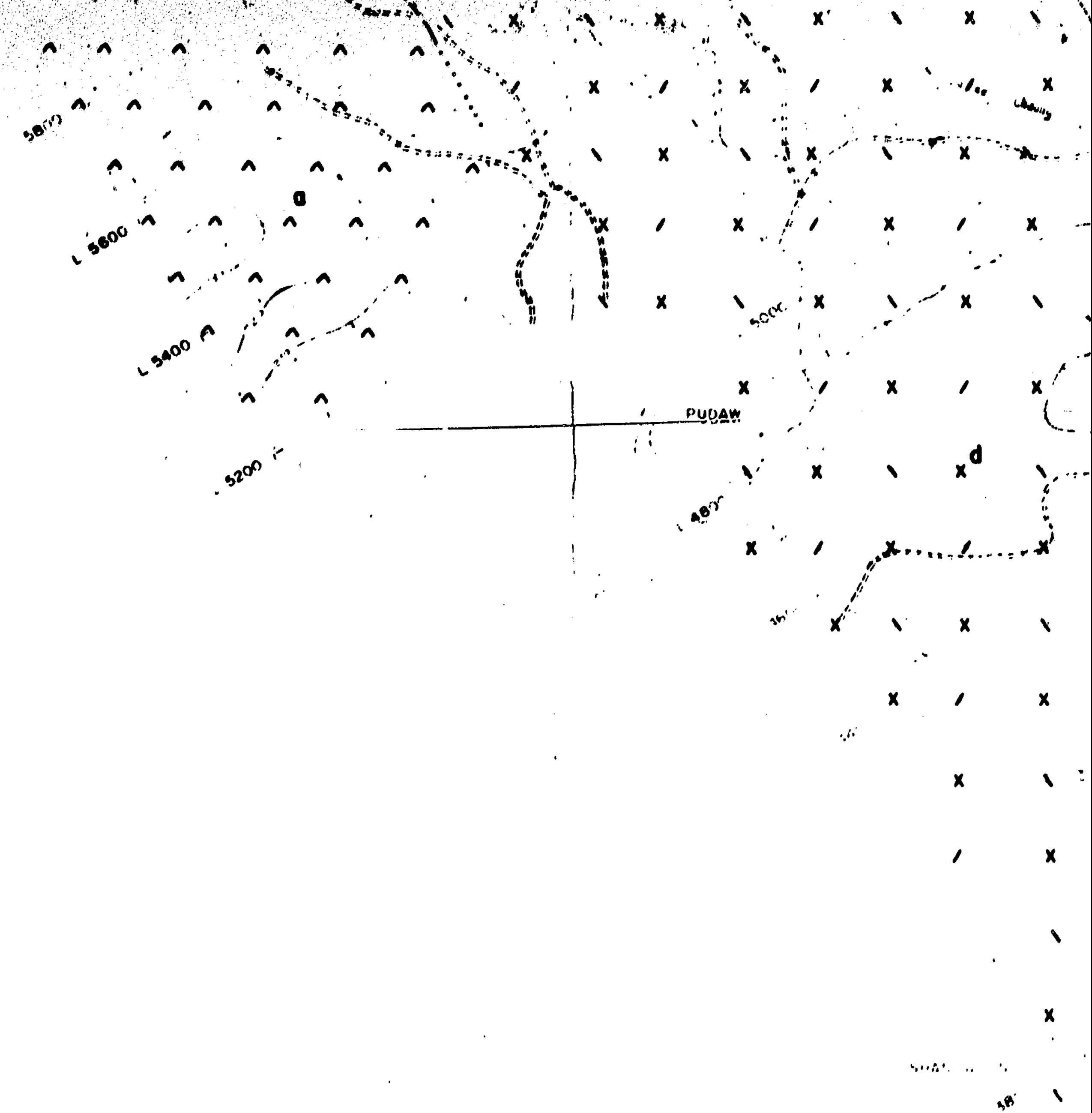
gnd
rhD
d
a
rh
a
14
d
26
gnd
a


350 m
250 m
150 m
A
17
11
5
rhD
rhD



LEGEND

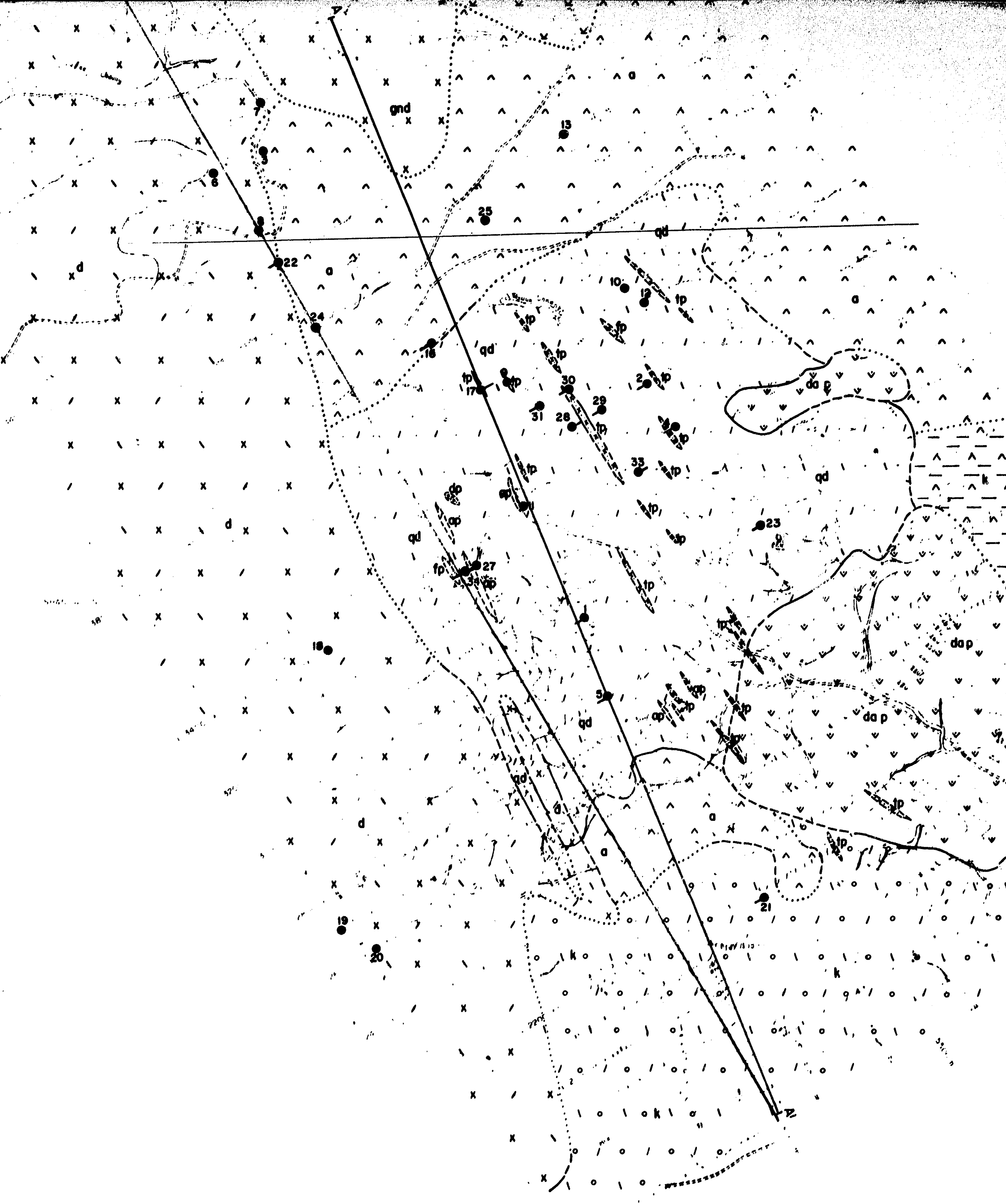
Oligocene –

- DIORITE PORPHYRY: medium-grained with large plagioclase phenocrysts
- TONALITE PORPHYRY: (T-Rock) fine to medium grained dike-like bodies with biotite, plagioclase and quartz phenocrysts.
- GRANODIORITE: coarse-grained biotite granodiorite.

Lr. Eocene to Up. Cretaceous – KETPANDA FORMATION mostly quartz-pebble conglomerate, arkosic sandstone, grit, mudstone, tuff. mostly coarse grit, mudstone, sandstone, andesite flows or sills, tuff.

QUARTZ DIORITE fine to coarse grained rock with quartz

APLITE FELDSPAR PORPHYRY phenocrysts pervasively altered


gnd
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qd
fp
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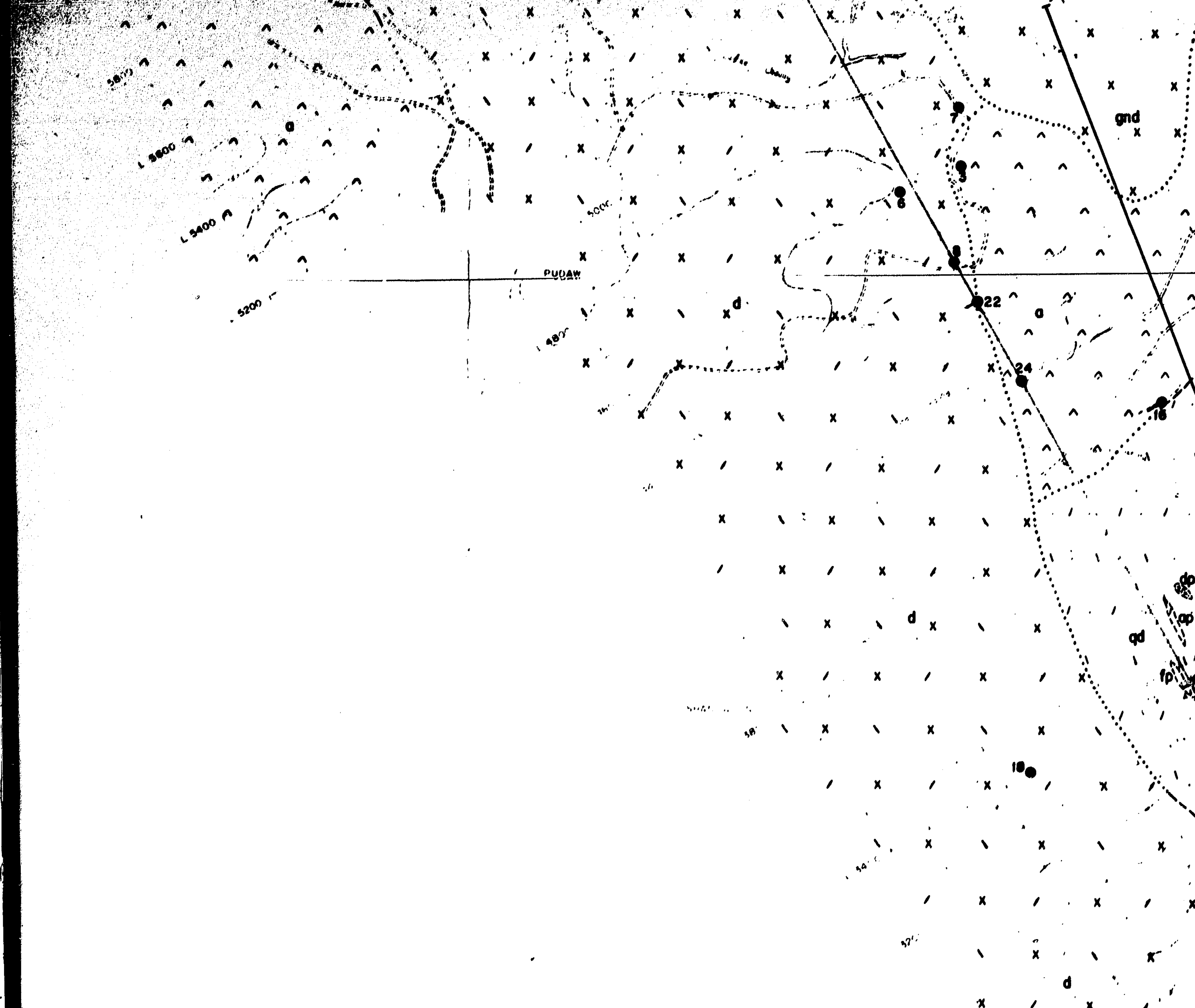


N D

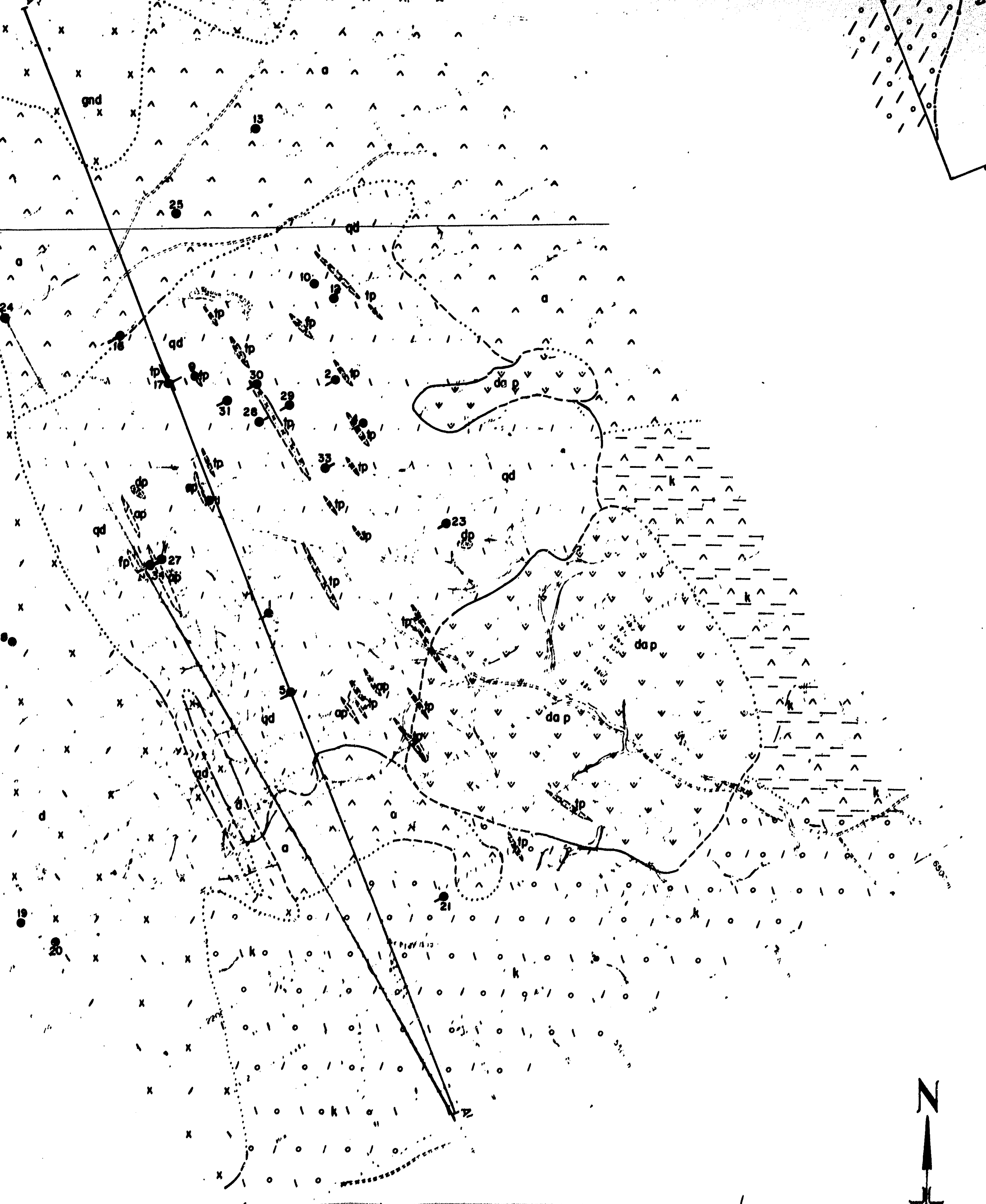
RY: medium grained with large plagioclase phenocrysts

HYRY: fine to medium grained dike-like bodies with biotite, plagioclase and quartz phenocrysts.

arse-grained biotite granodiorite.

ION: mostly quartz-pebble conglomerate, arkosic sandstone, grit, mudstone, tuff.
mostly coarse grit, mudstone, sandstone, andesite flows or sills, tuff.

ine to coarse grained rock with quartz
PORPHYRY phenocrysts pervasively altered.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da p
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N

Oligocene

DIORITE PORPHYRY: medium-grained with large plagioclase phenocrysts

TONALITE PORPHYRY: (T-Rock) fine to medium grained dike-like bodies with biotite, plagioclase and quartz phenocrysts.

GRANODIORITE: coarse-grained biotite granodiorite.

Lr. Eocene to Up. Cretaceous

KETPANDA FORMATION mostly quartz-pebble conglomerate, arkosic sandstone, grit, mudstone, tuff. mostly coarse grit, mudstone, sandstone, andesite flows or sills, tuff.

Upper Cretaceous

QUARTZ DIORITE fine to coarse grained rock with quartz

APLITE, FELDSPAR PORPHYRY phenocrysts pervasively altered.

DIORITE: fine to medium grained biotite diorite.

DACITE PORPHYRY: massive feldspar-quartz porphyry usually bleached by weak, pervasive sericite.

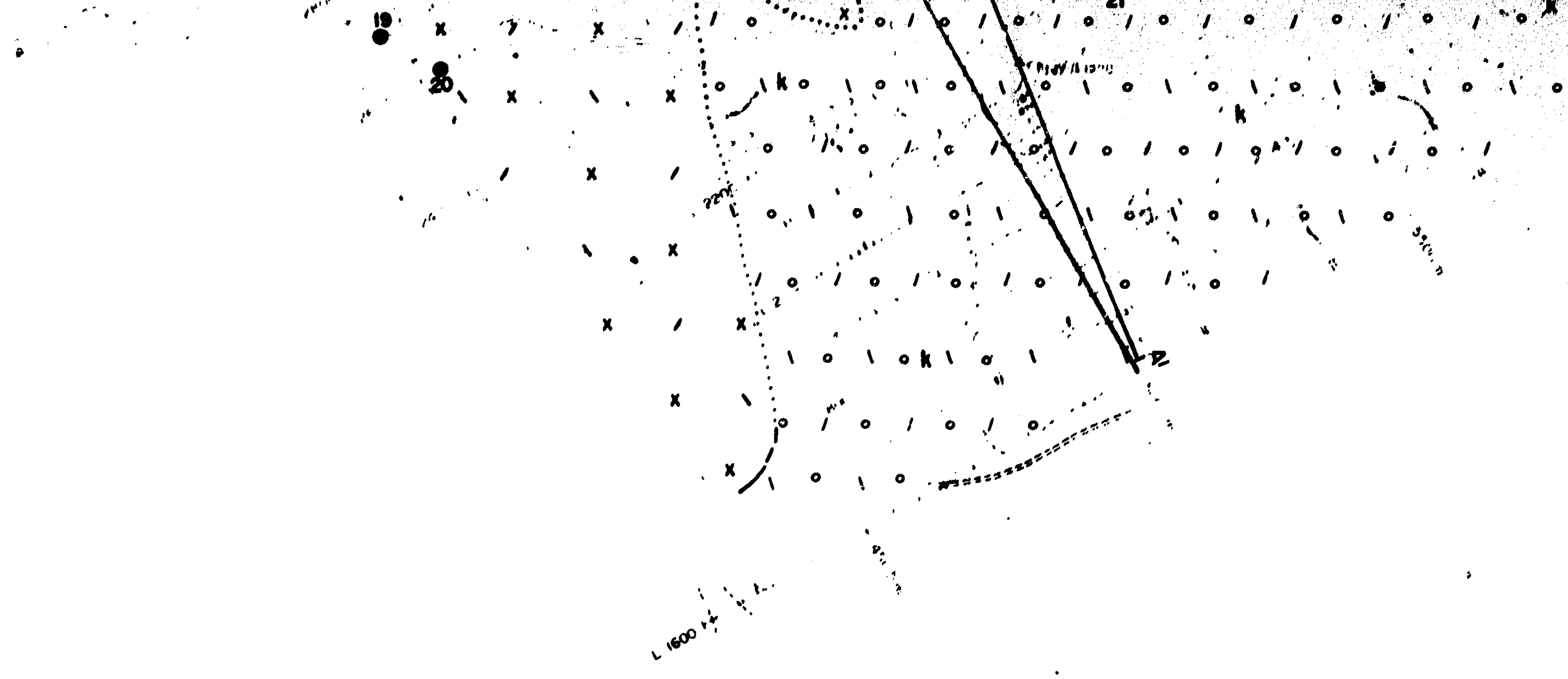
? Lower -Cretaceous

ANDESITE, RHYODACITE: massive feldspar porphyry, commonly hornfelsic rhyodacite more siliceous with few phenocrysts.

CONTACT: definite, approximate, inferred

10

DRILL HOLE: showing direction of inclined hole.



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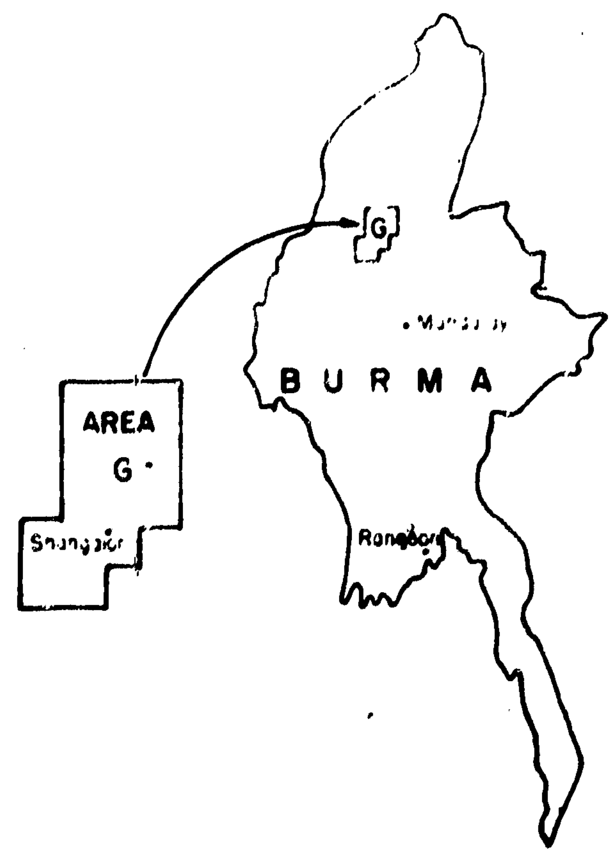

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PHYRY: medium-grained with large plagioclase phenocrysts

ORPHYRY: fine to medium grained dike-like bodies with biotite, plagioclase and quartz phenocrysts.

coarse-grained biotite granodiorite.

MATION mostly quartz-pebble conglomerate, arkosic sandstone, grit, mudstone, tuff.
mostly coarse grit, mudstone, sandstone, andesite flows or sills, tuff.

E fine to coarse grained rock with quartz

PAR PORPHYRY phenocrysts pervasively altered.

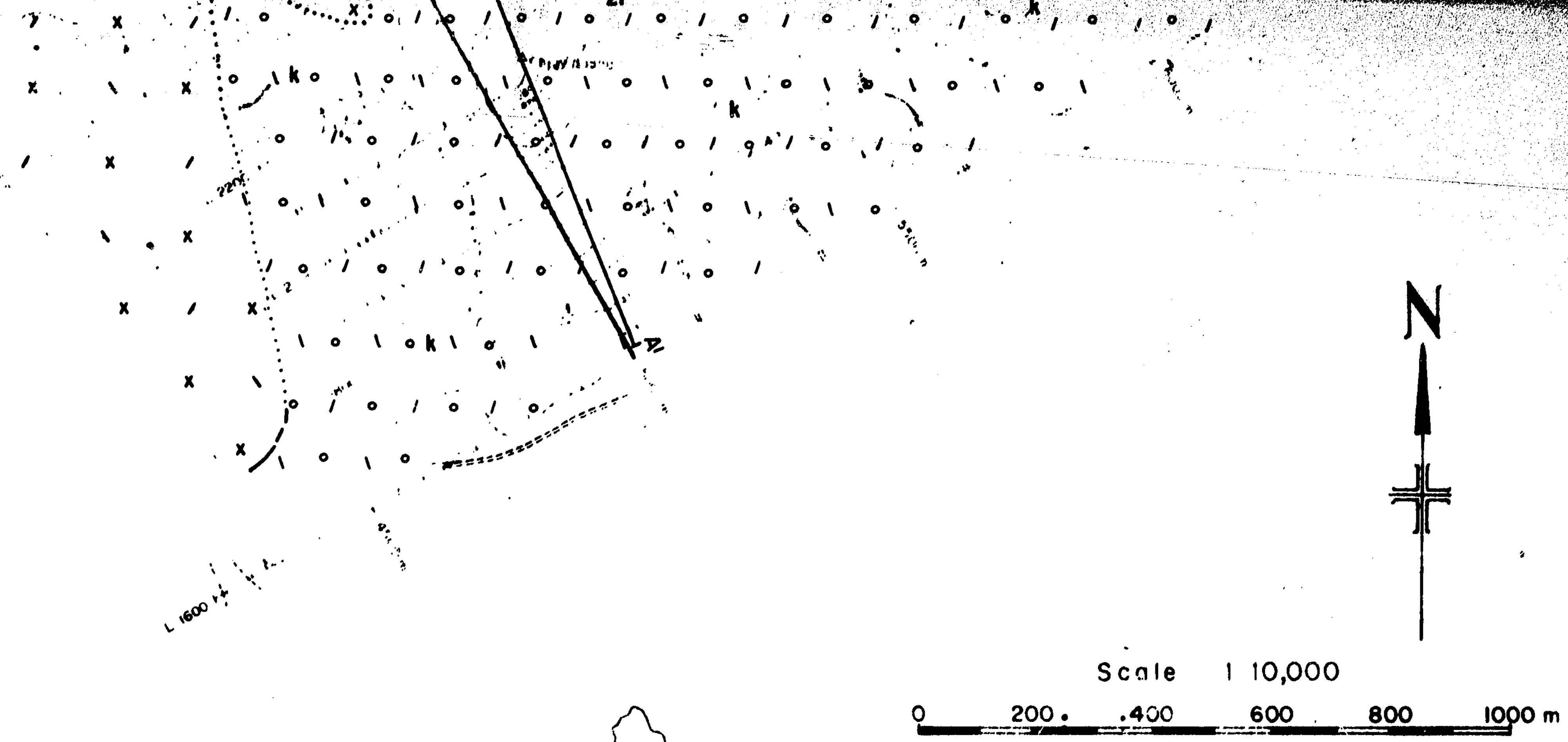
medium grained biotite diorite.

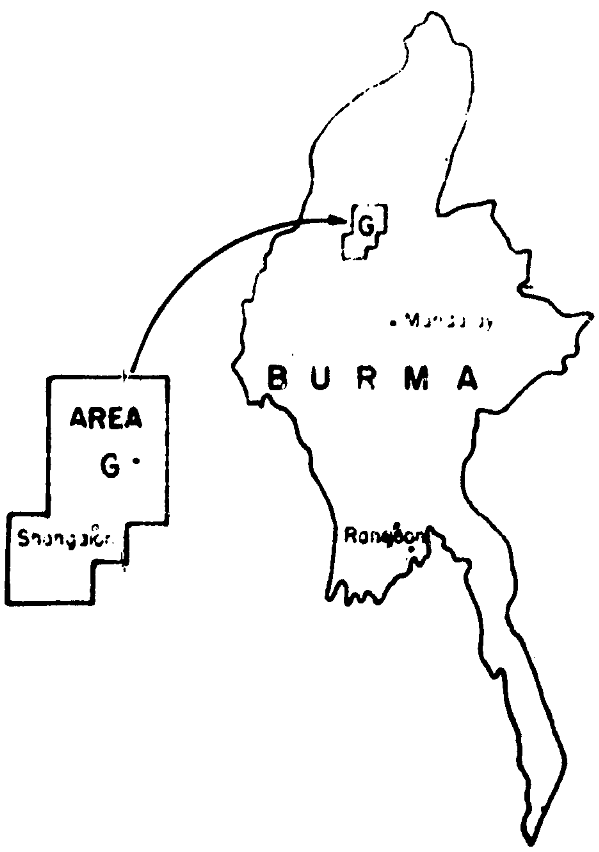
RY: massive feldspar-quartz porphyry usually bleached by weak, pervasive sericite.

DACITE: massive feldspar porphyry, commonly hornfelsic
rhyodacite more siliceous with few phenocrysts.

ite, approximate, inferred

showing direction of inclined hole.





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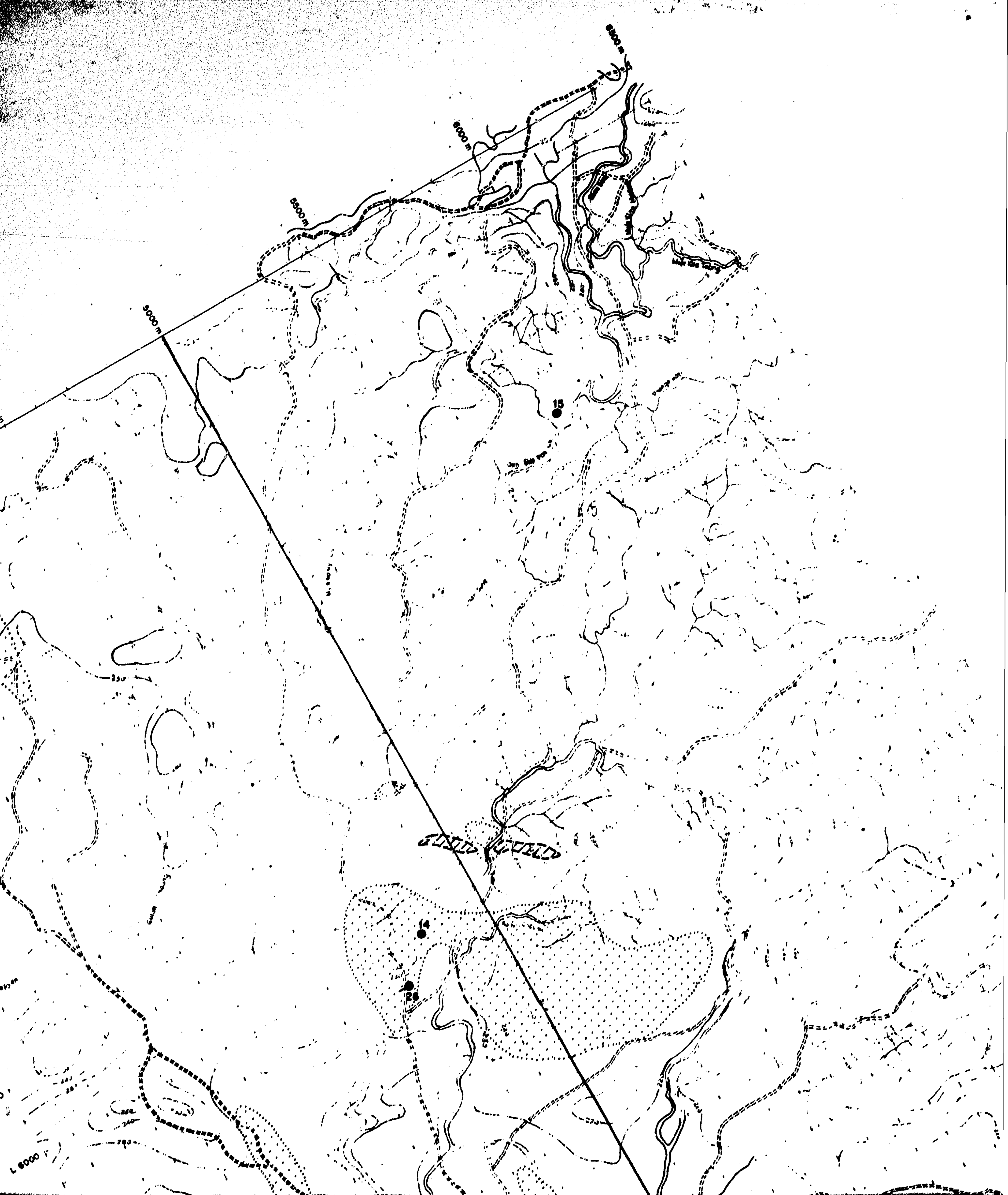
UNITED NATIONS
Bur/72/002 Geological Survey and Exploration Project

SHANGALON PROSPECT

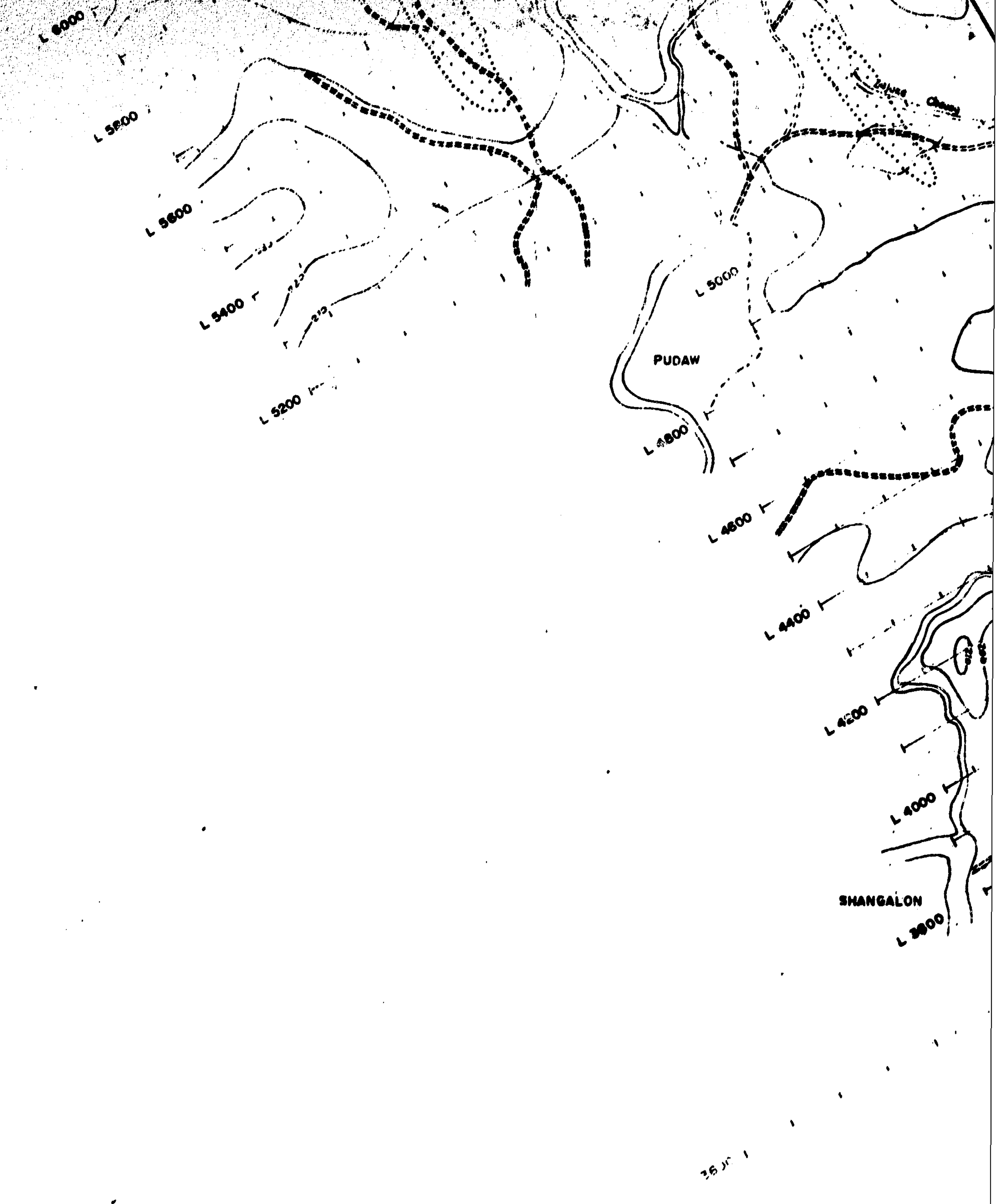
LITHOLOGY

		Fig. 4	


4000 m
4500 m
5000 m
5500 m
6000 m
6500 m
15
14
26
L 7200
L 6800
L 6600
L 6400
L 6200
L 6000
230
240
280



6500 m
6000 m
5500 m
3000 m
15
14
26



LEGEND

Unaltered

Weakly Altered — PROPYLITIC – CHLORITIC: chlorite, epidote, calcite, pyrite minor sericite, tourmaline, magnetite and quartz. Minor K-spar in north.

SERICITIC: (Dacite and sediments) — weak, pervasive sericite and quartz very minor pyrite and chlorite.

WEAK HORNFELSIC: (Andesite) — weak, pervasive silica, chlorite and biotite minor pyrite and magnetite

SHANGALON
L 4400
L 4200
L 4000
L 3800
L 3400
L 3200
Shan Chaung
18
19
20
21
22
23
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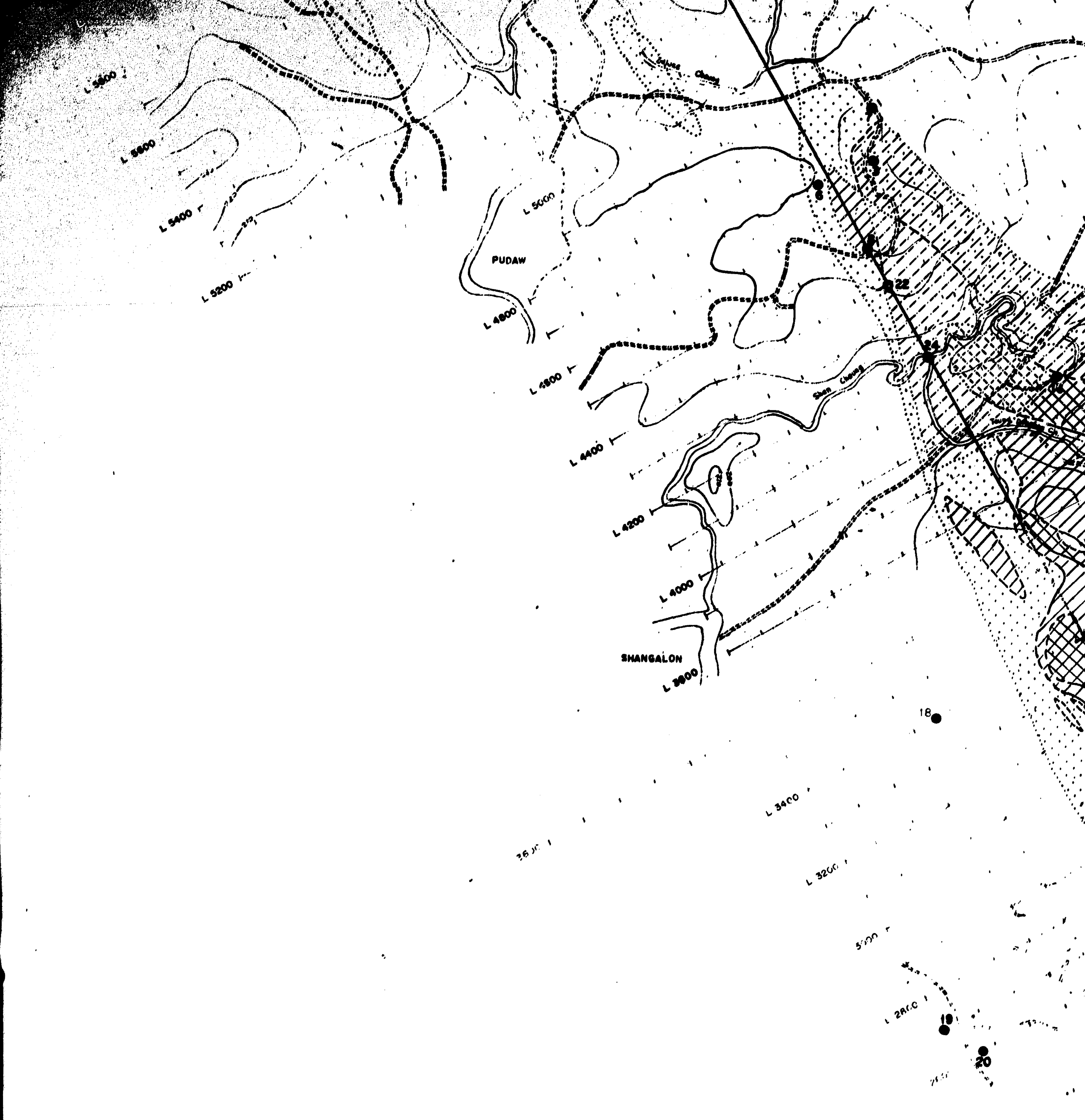
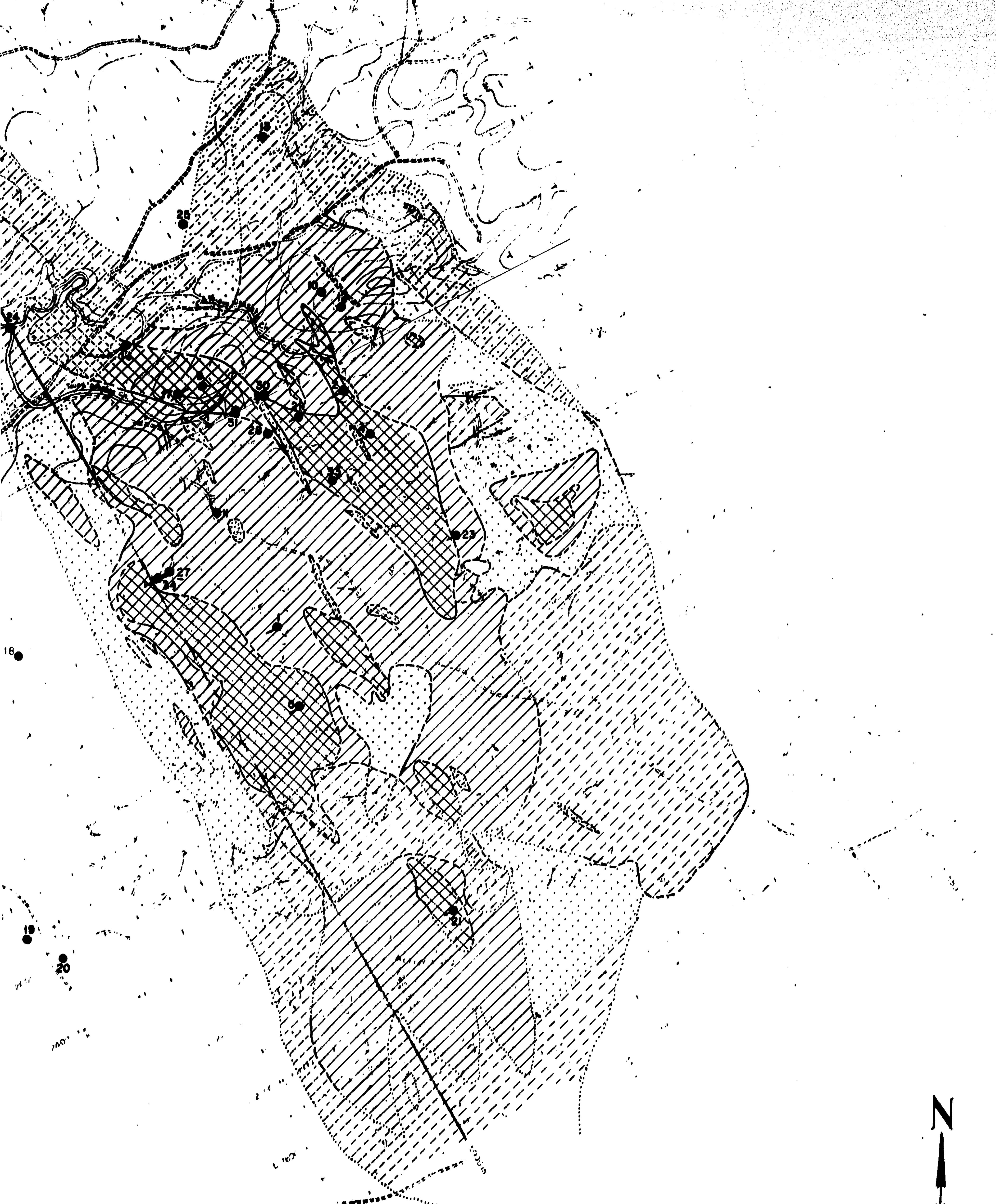
30
31



TIC: chlorite, epidote, calcite, pyrite minor sericite, tourmaline, magnetite and quartz. Minor K-spar in north.

weak, pervasive sericite and quartz-
very minor pyrite and chlorite.

eak, pervasive silica, chlorite and biotite
inor pyrite and magnetite



15
25
10
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18
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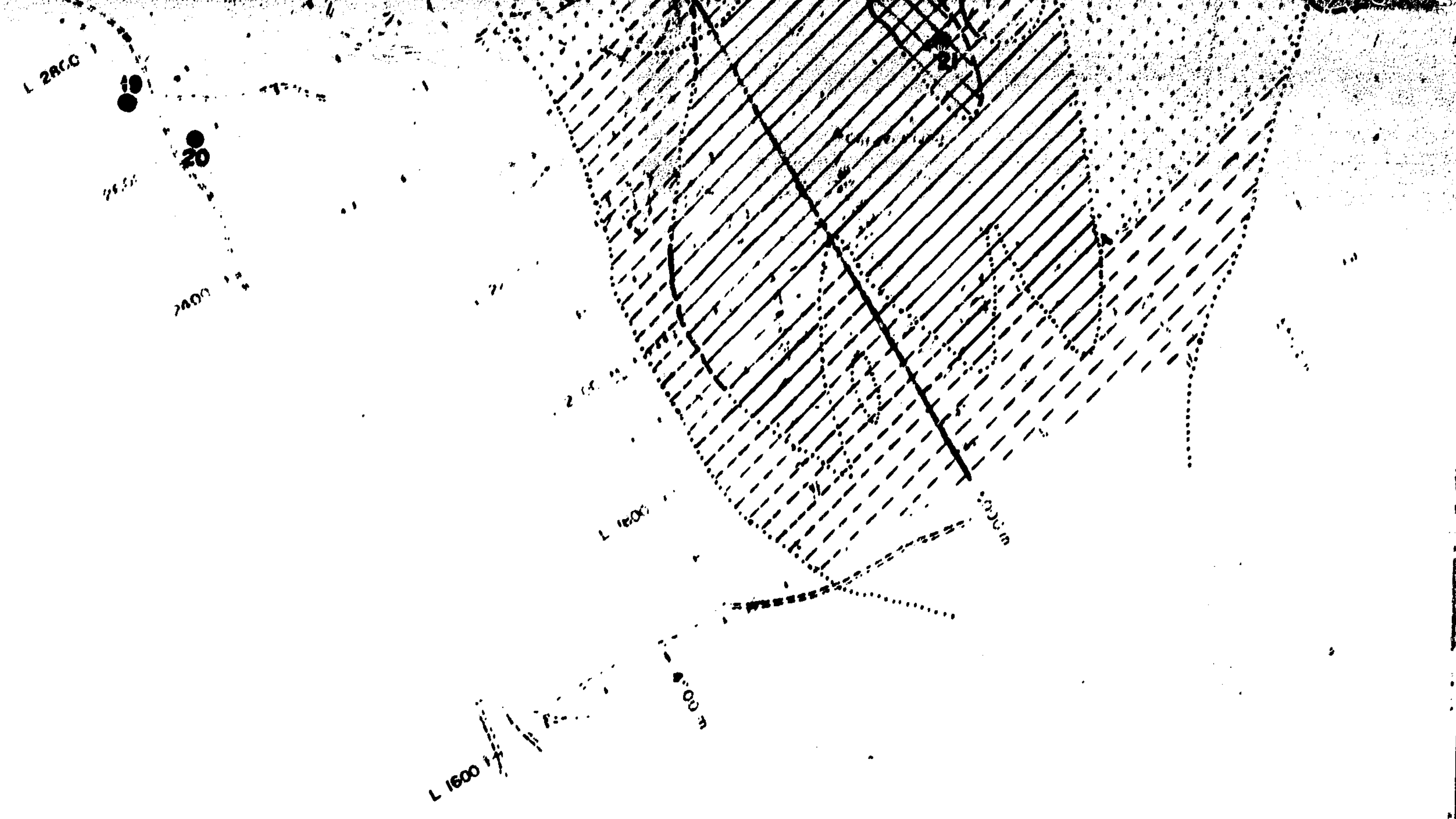
20
21
N

LEGEND

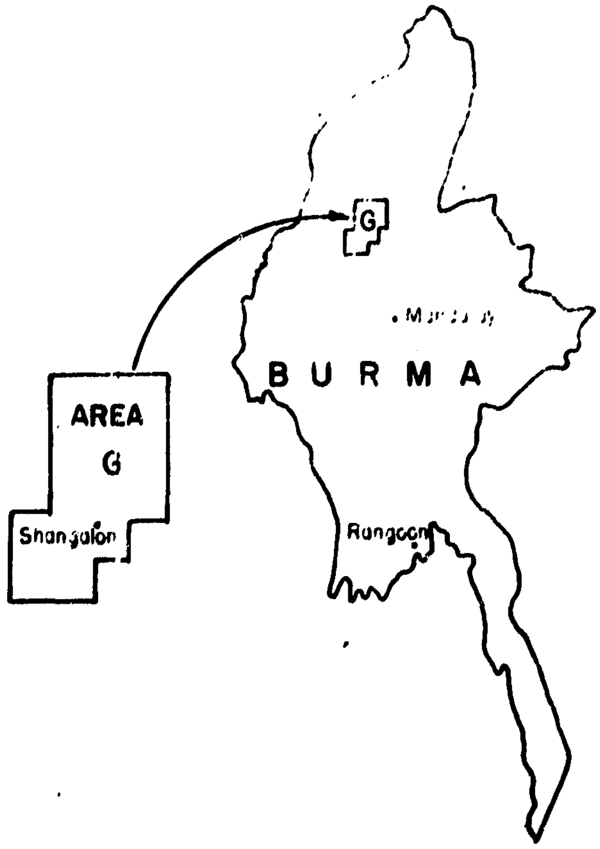
Unaltered	f	
Weakly Altered	p — PROPYLITIC – CHLORITIC:	chlorite, epidote, calcite, pyrite minor sericite, tourmaline, magnetite and quartz. Minor K-spar in north.
	s — SERICITIC: (Dacite and sediments)	weak, pervasive sericite and quartz very minor pyrite and chlorite.
	wh — WEAK HORNFELSIC: (Andesite)	weak, pervasive silica, chlorite and biotite minor pyrite and magnetite
Moderately Altered	wph — WEAK PHYLLIC:	weak to moderate quartz - sericite - pyrite, minor chlorite, chalcopyrite and tourmaline
	mh — MODERATE HORNFELSIC: (Andesite)	moderate, pervasive quartz, biotite, pyrite minor chlorite, chalcopyrite and tourmaline
Strongly Altered	ph — PHYLLIC:	moderate to strong quartz - sericite - pyrite - chalcopyrite minor molybdenite and tourmaline
	H — HORNFELSIC: (Andesite)	moderate to strong quartz, biotite, pyrite and chalcopyrite. Minor tourmaline

CONTACT: definite, approximate, inferred

10 DRILL HOLES: showing direction of inclined holes.



0 20



Directorate

Bur/72/002

SH

ITIC: chlorite, epidote, calcite, pyrite minor sericite, tourmaline, magnetite and quartz. Minor K-spar in north.

weak, pervasive sericite and quartz very minor pyrite and chlorite.

weak, pervasive silica, chlorite and biotite minor pyrite and magnetite

to moderate quartz - sericite - pyrite, r chlorite, chalcopyrite and tourmaline

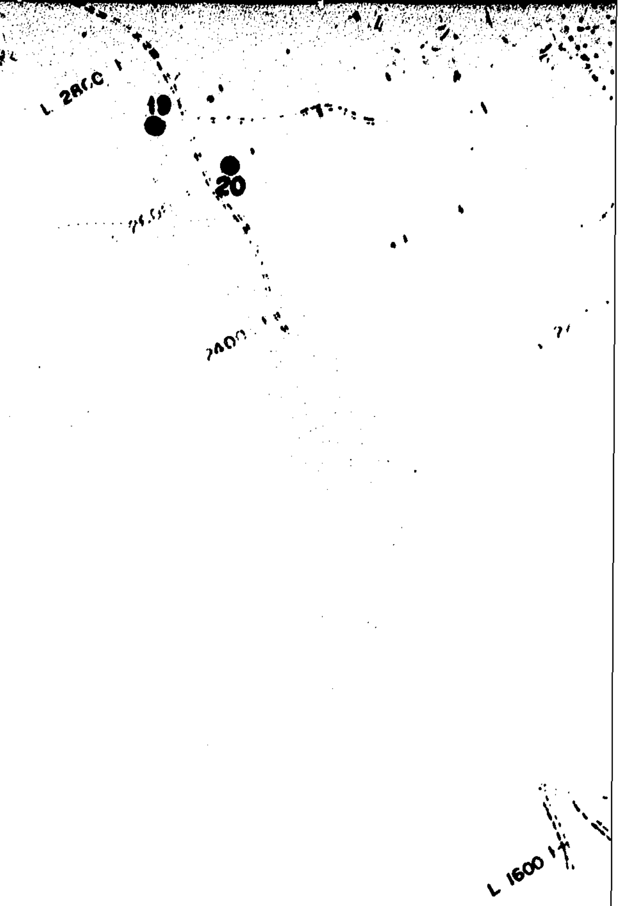
LSIC: moderate, pervasive quartz, biotite, pyrite minor chlorite, chalcopyrite and tourmaline

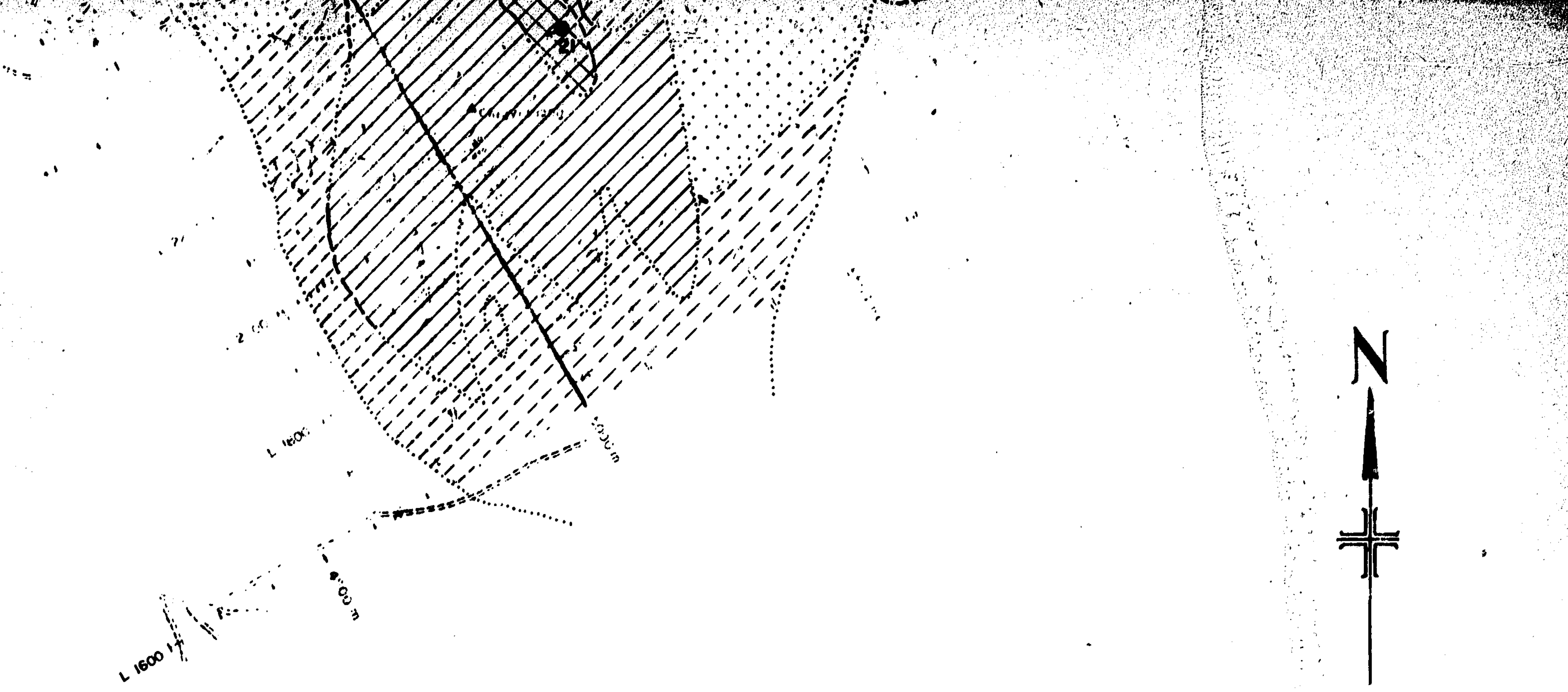
o strong quartz - sericite - pyrite - chalcopyrite ybdenite and tourmaline

ts to strong quartz, biotite, pyrite and chalcopyrite. ourmaline

pproximate, inferred

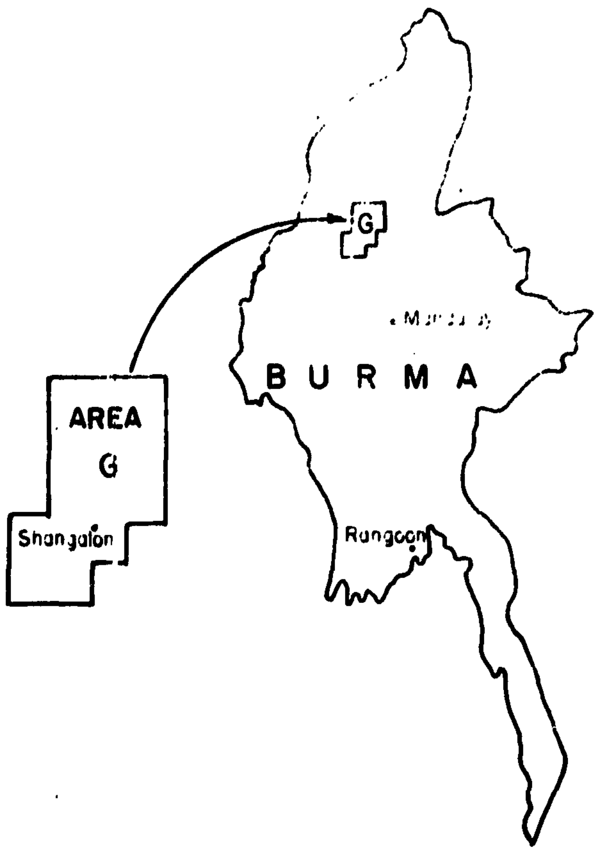
ng direction of inclined holes.





Scale 1 10,000

0 200 400 600 800 1000 m



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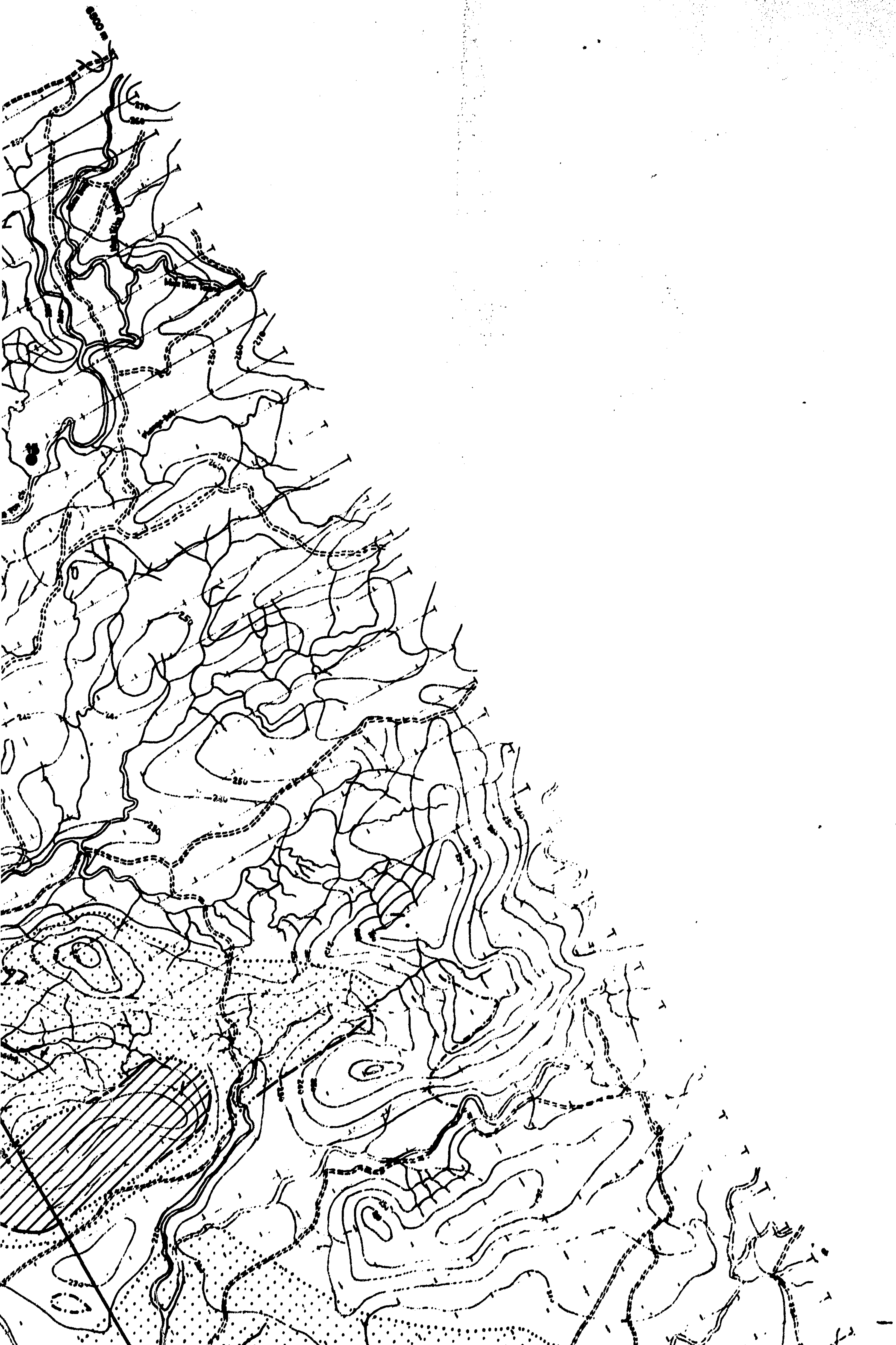
SHANGALON PROSPECT

ALTERATION

		Fig. 5	

L 7800
L 7600
L 7400
L 7200
L 7000
L 6800
L 6600
L 6400
L 6200
L 6000
4000 m
5000 m
240
230
Galam Chaung




250
240
L 6000

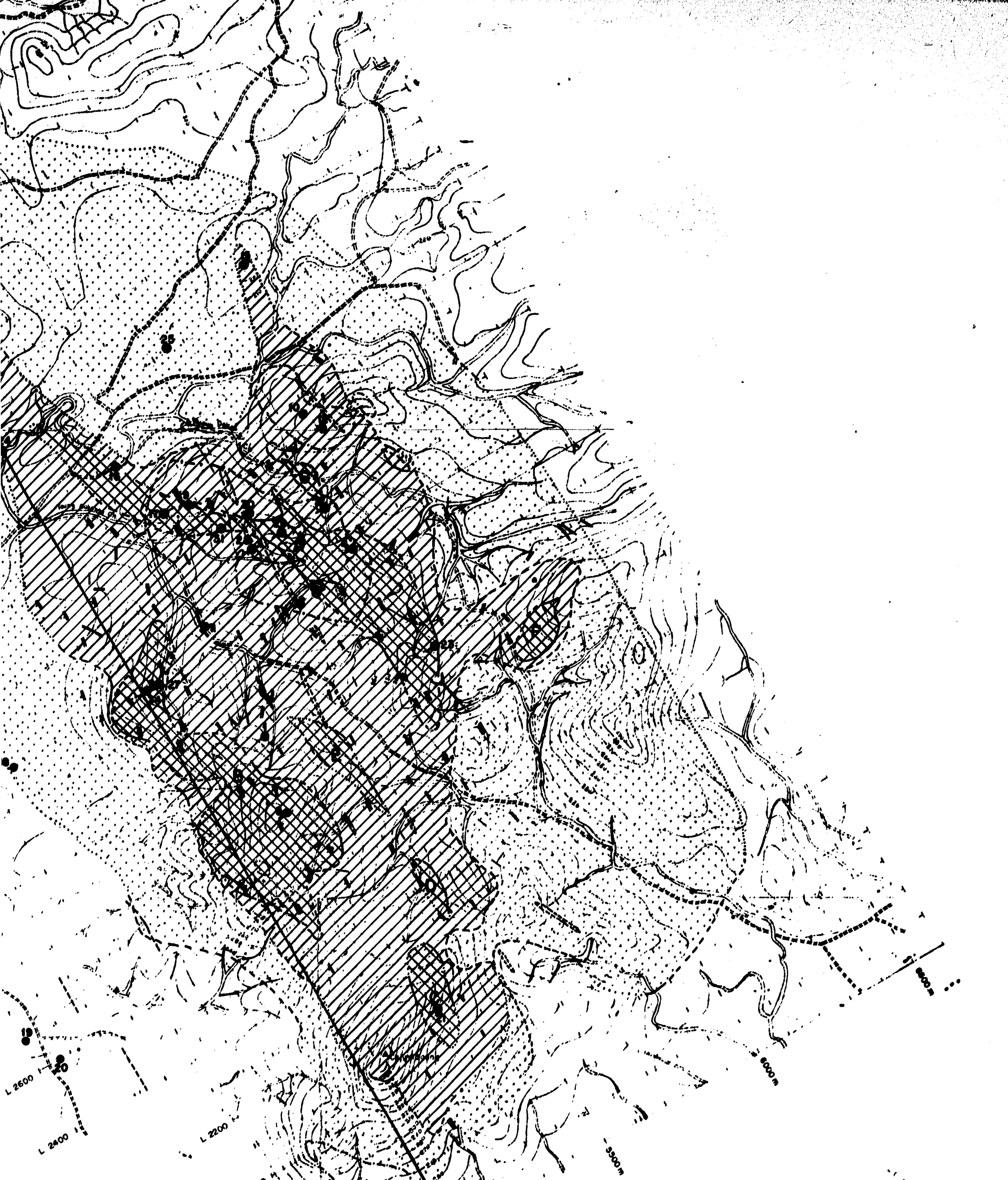
LEGEND

Greater than 2% indicated sulphide

Greater than 1/2% but less than 2% sulphide


SHANGALON
L 4400
L 4200
L 4000
L 3800
L 3400
L 3200
L 3000
L 2800
L 2600
L 2400
L 2200


L 5800
L 5600
L 5400
L 5200
L 5000
PUDAW
L 4800
L 4600
L 4400
L 4200
L 4000
SHANGALON
L 3800
L 3600
L 3400
L 3200
L 3000
L 2800
19
20
L 2600
L 2400



L 2600
L 2400
L 2200
3300 m
6000 m
6600 m

LEGEND

Greater than 2% indicated sulphide

Greater than 1/2% but less than 2% sulphide

Less than 1/2% sulphide

Unmineralized Rock

Contact: definite, approximate, inferred

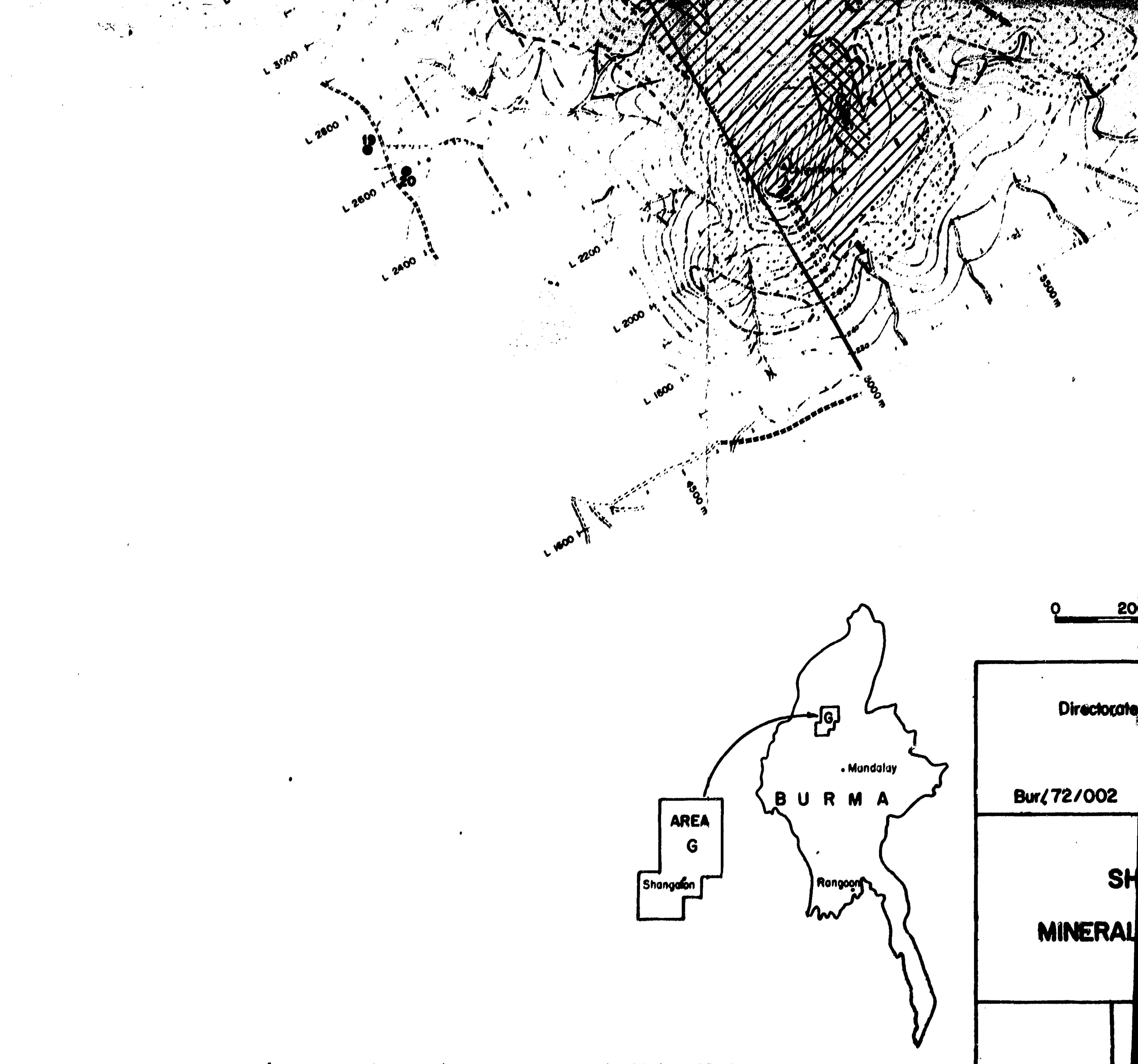
Limit of greater than 1000 ppm Cu soil geochem anomaly

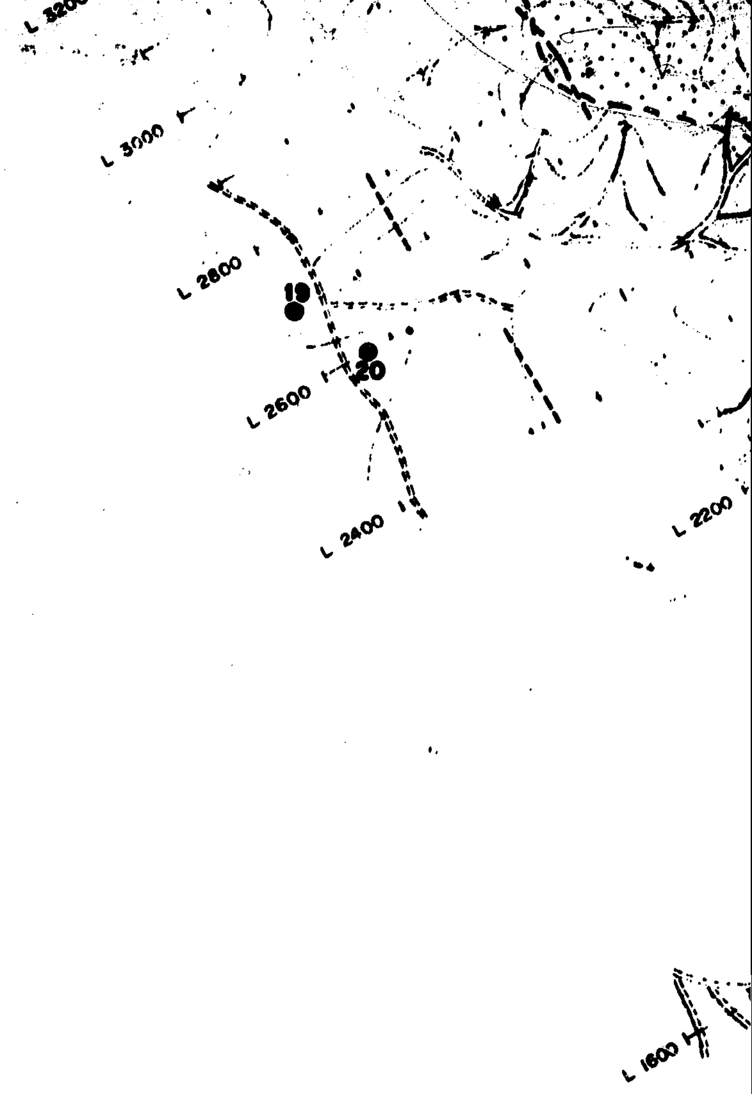
less than 5 veinlets per foot	Attitude and Number of Quartz-Sulphide Veinlets per Foot.
between 5 and 15 veinlets per foot	
between 16 and 25 veinlets per foot	
greater than 25 veinlets per foot	

Quartz-sulphide veins, definite, inferred

A Identification of major sulphide zones

DRILL HOLE


L 3000
L 2800
L 2600
L 2400
L 2200
L 2000
L 1800
L 1600
19
20
3300 m
3000 m
4300 m
AREA
G
Shangalon
G
Mandalay
B U R M A
Rangoon
Directorate
Bur/72/002
SH
MINERAL



2% sulphide

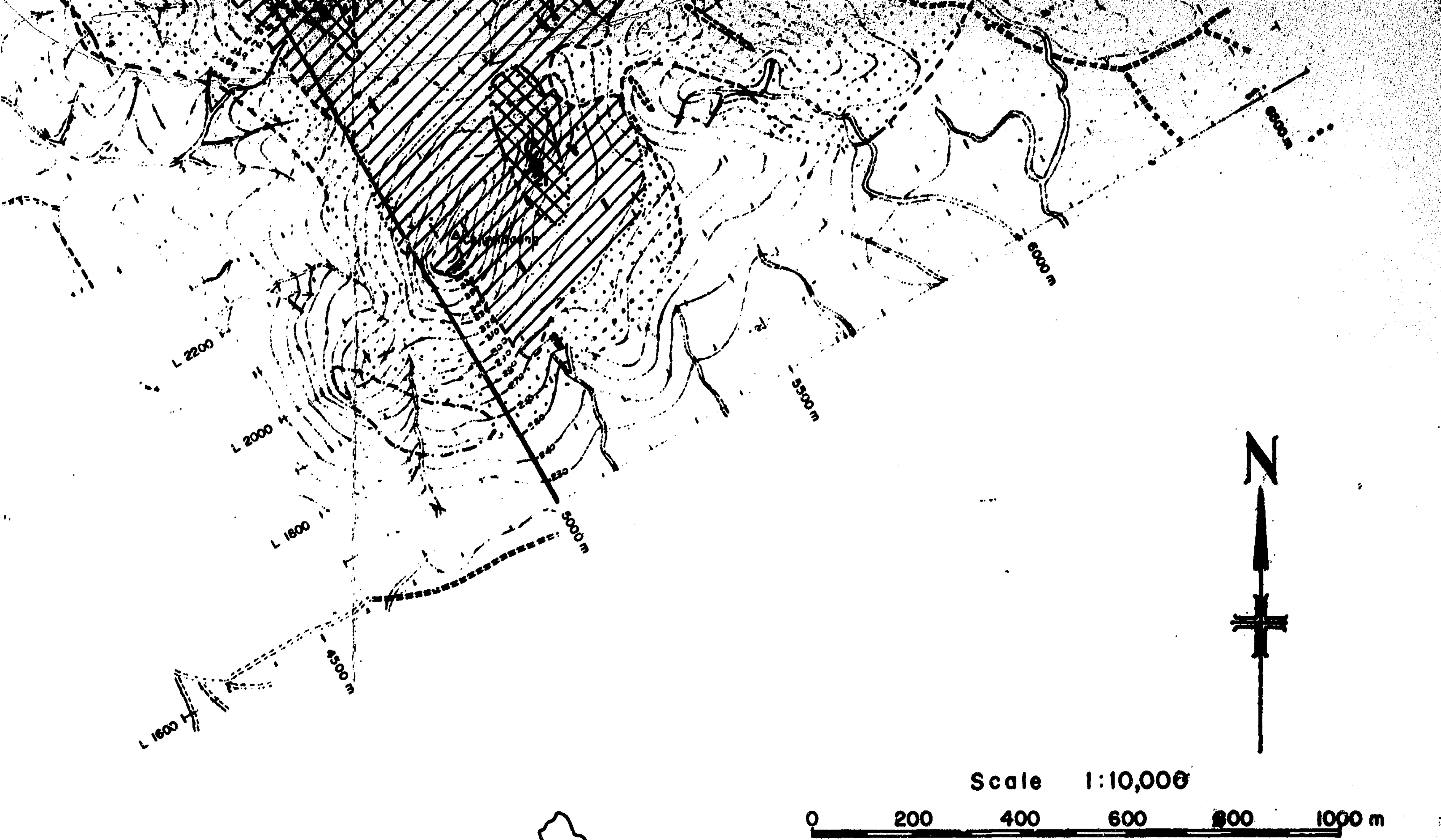
rred

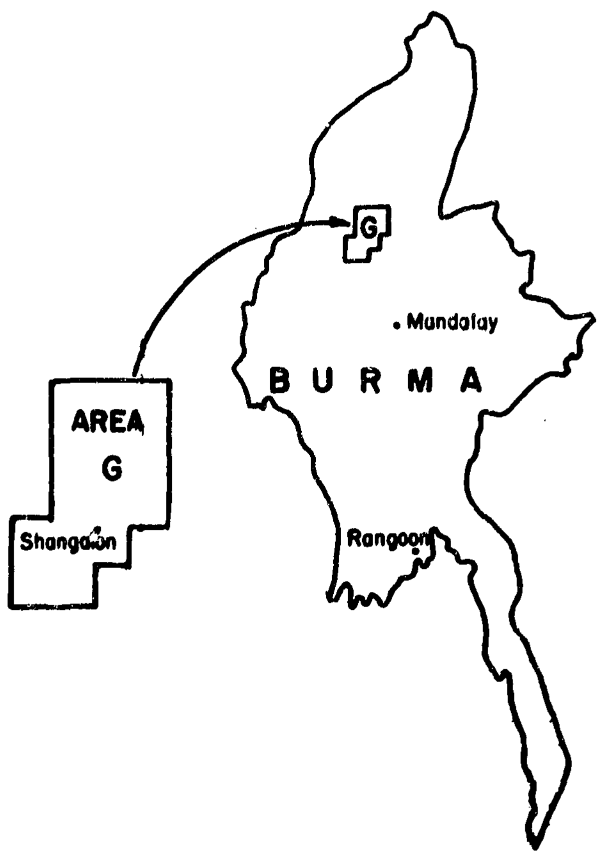
Cu soil geochem anomaly

Attitude and Number of Quartz-Sulphide
Veinlets per Foot.

rred

nes





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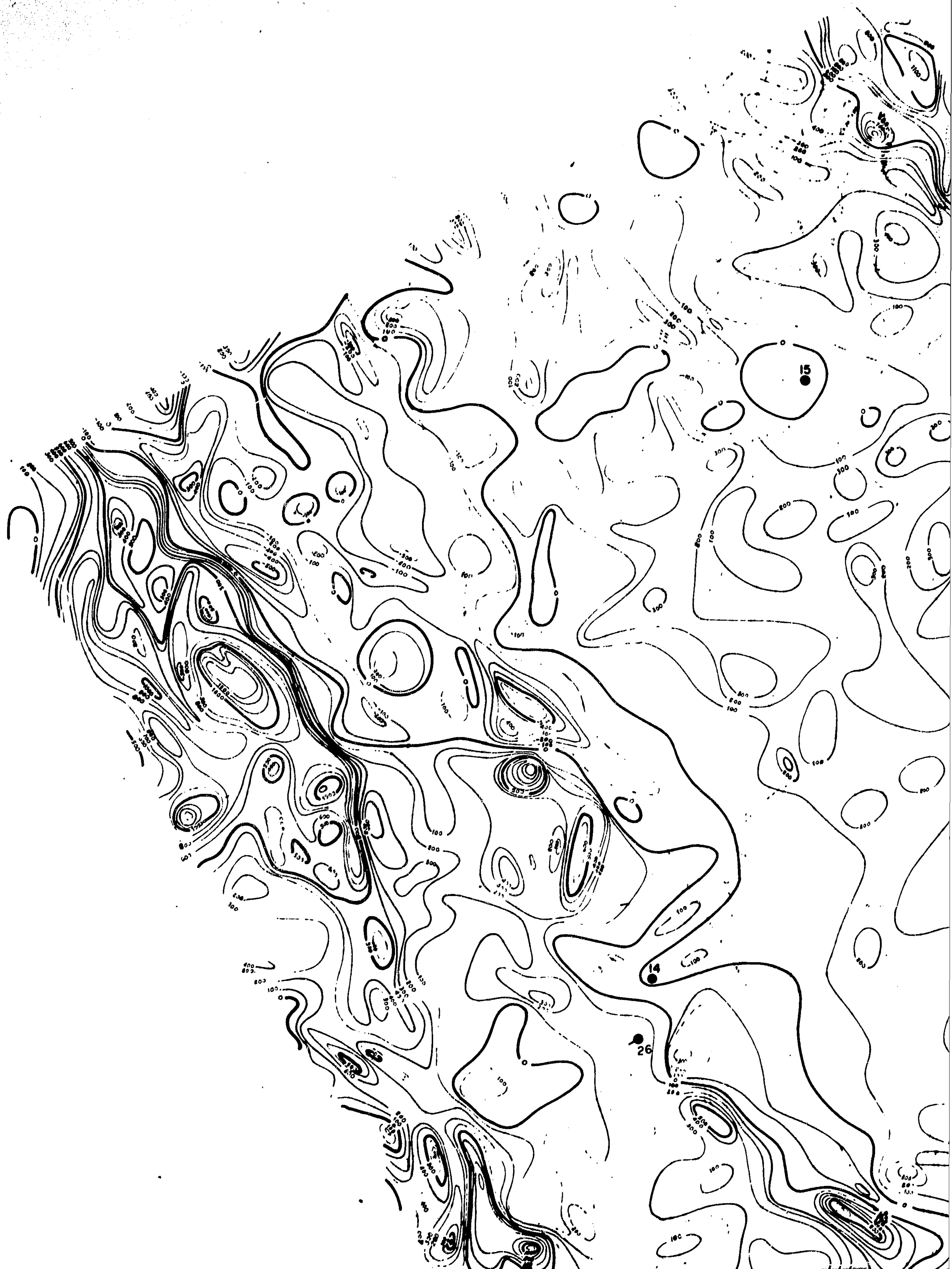
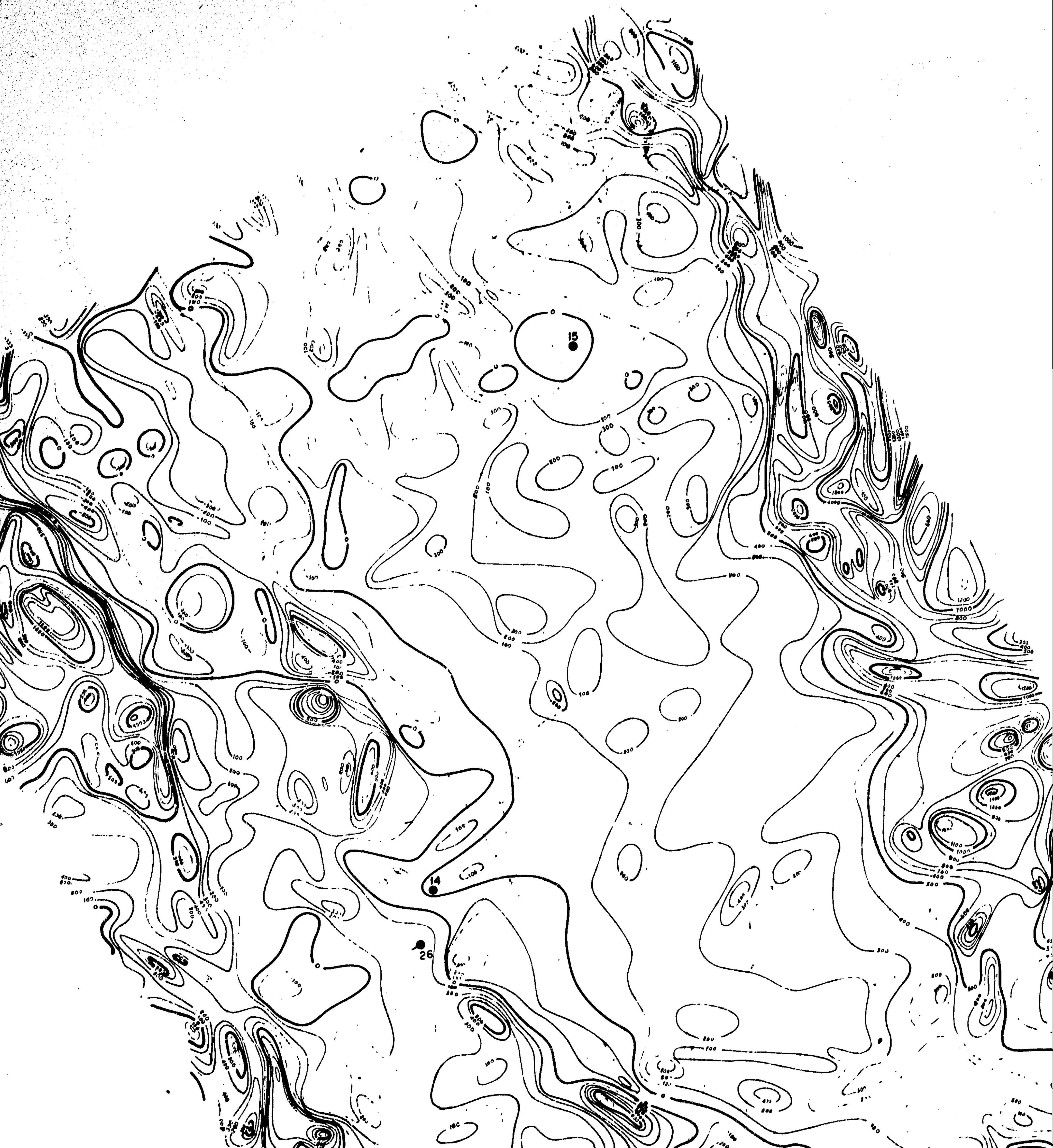
SHANGALON PROSPECT

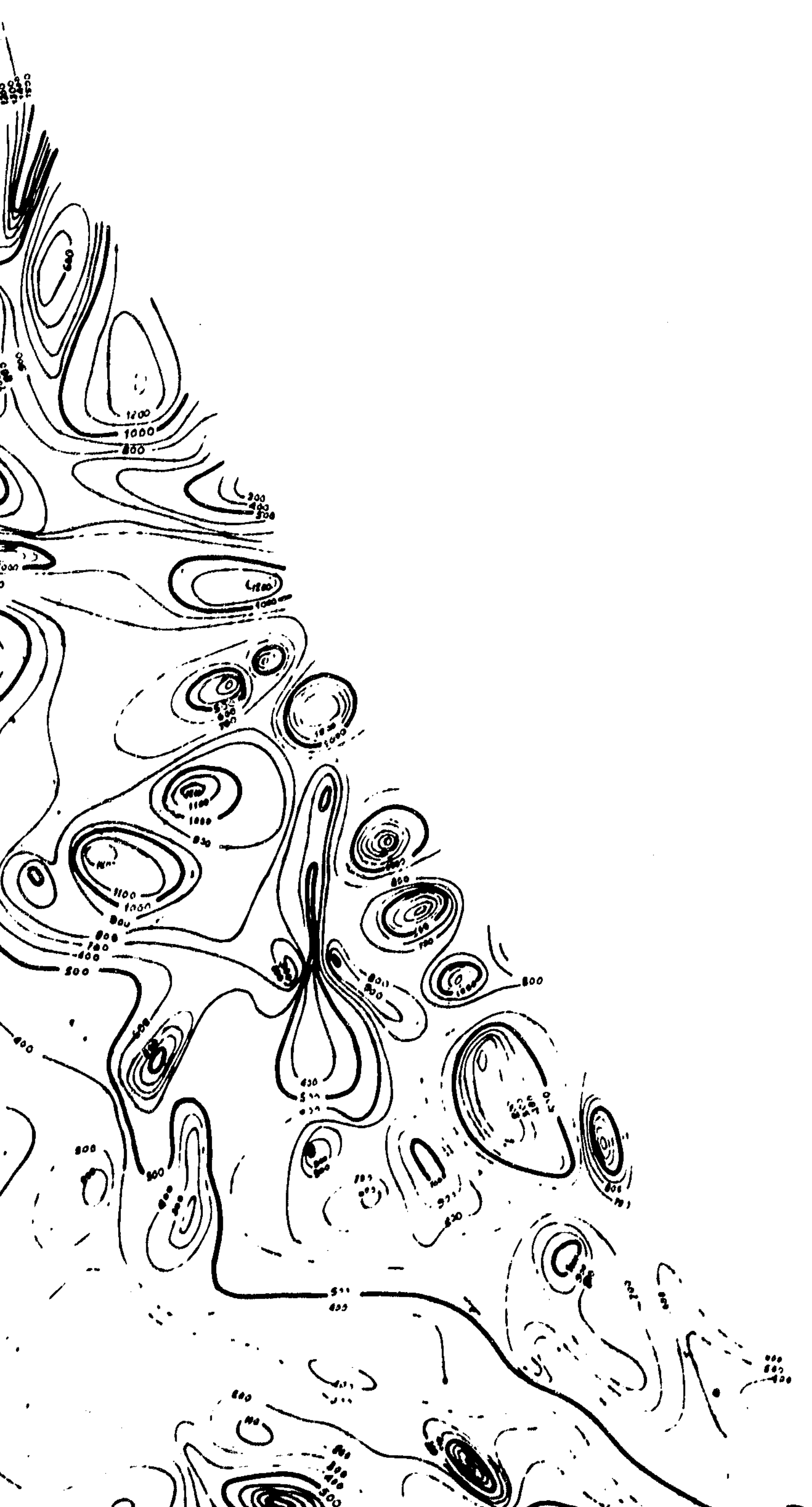
MINERALIZATION AND STRUCTURE

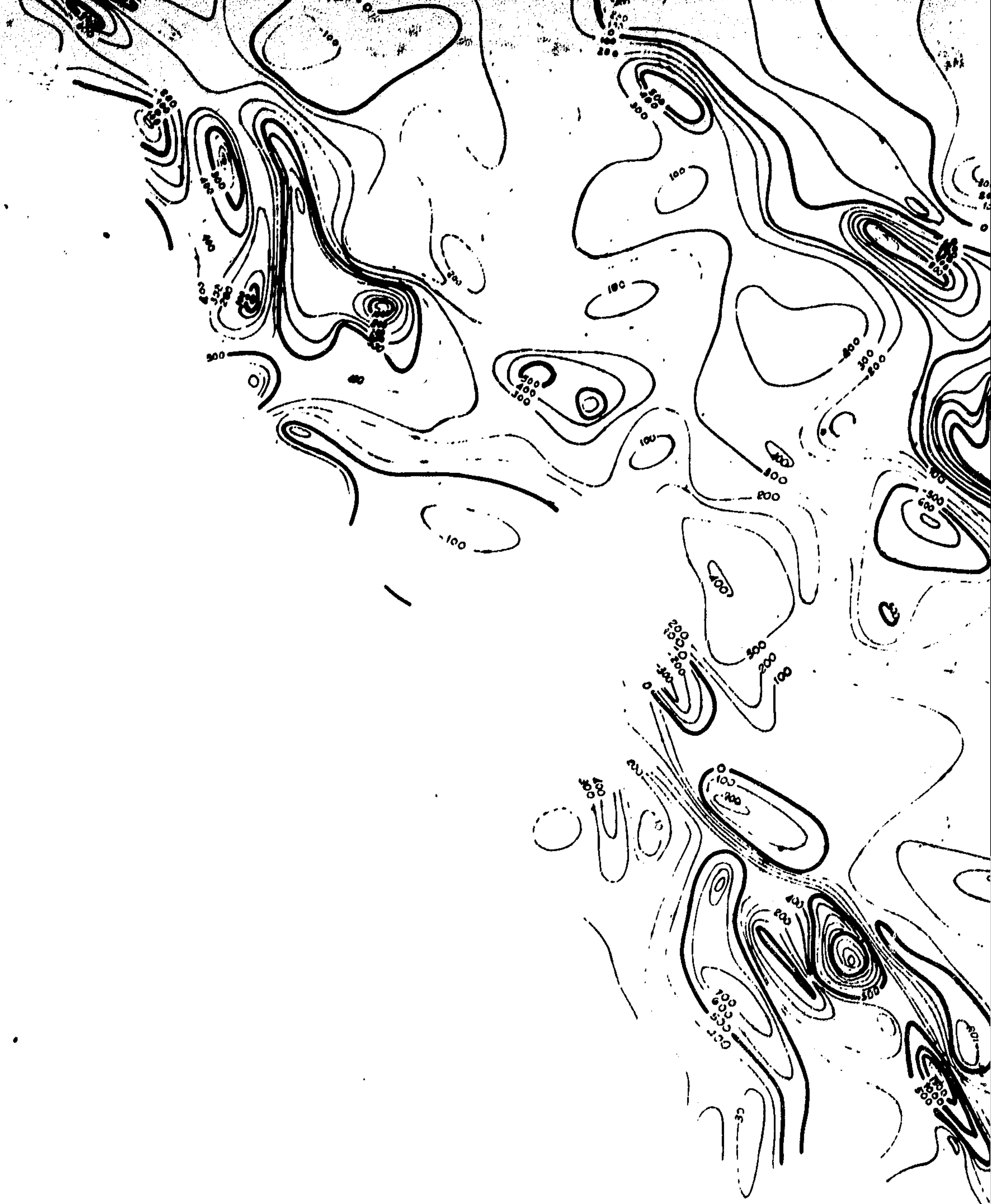
Fig. 6

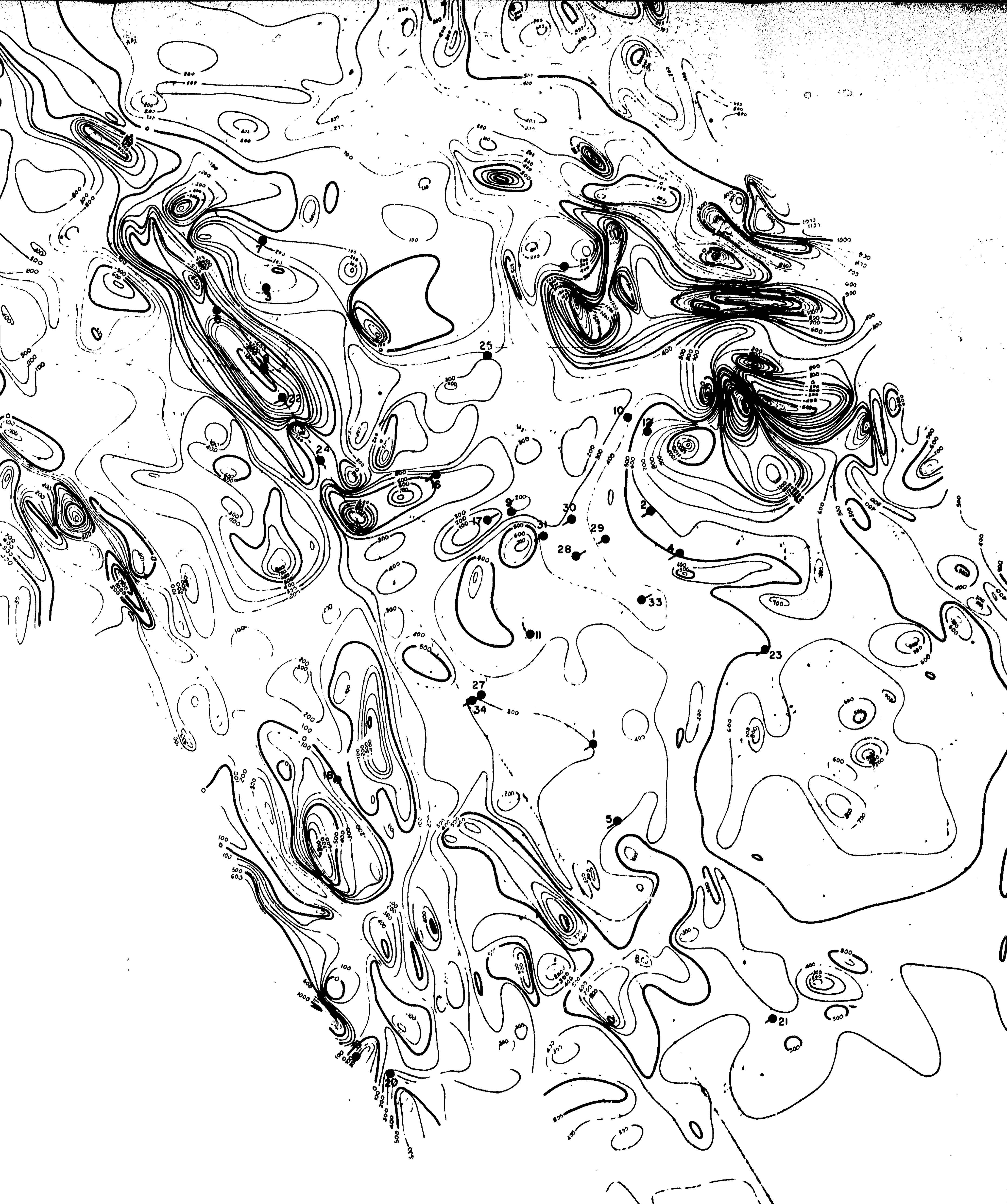

15
14
26

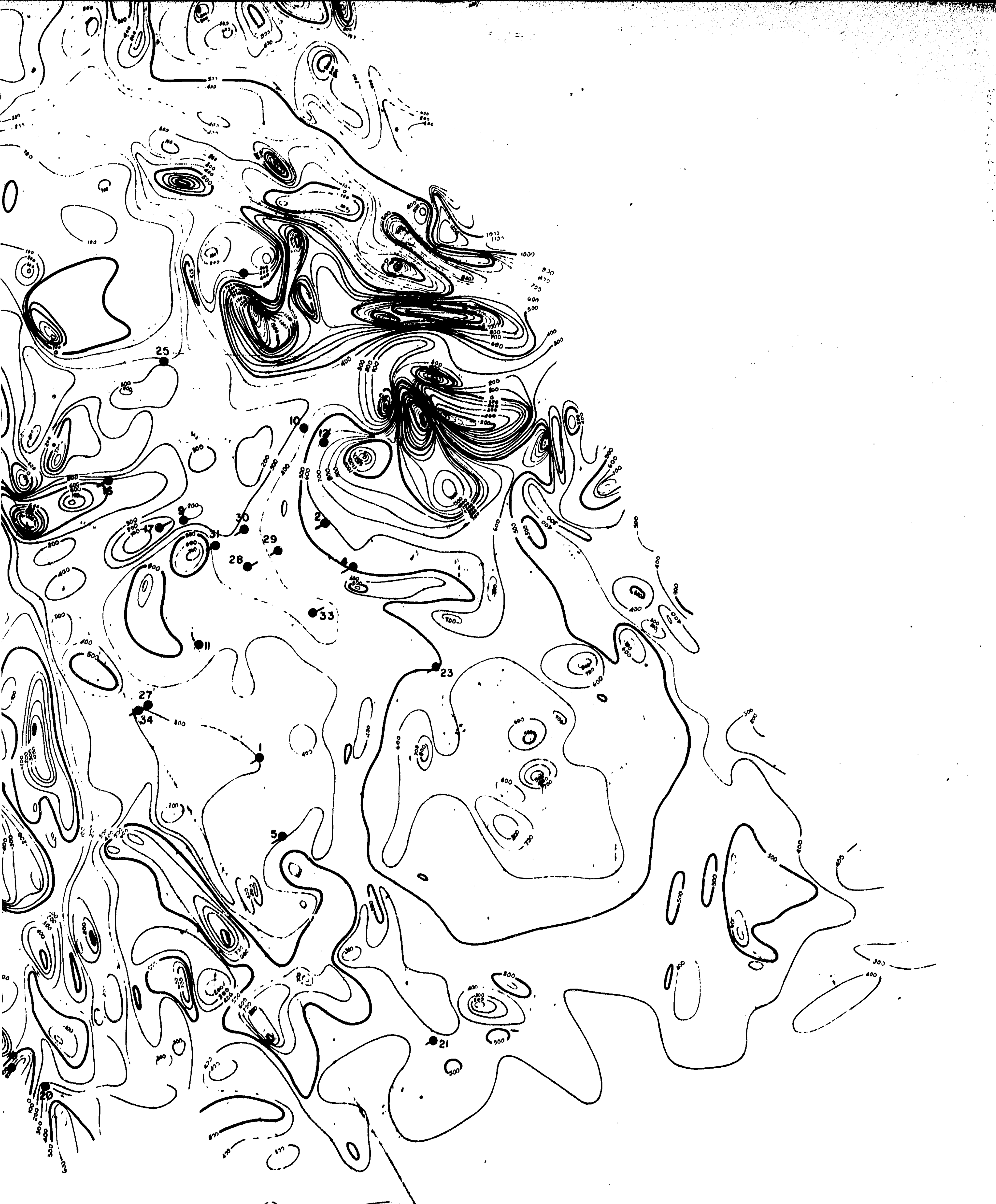

15


15
14
26



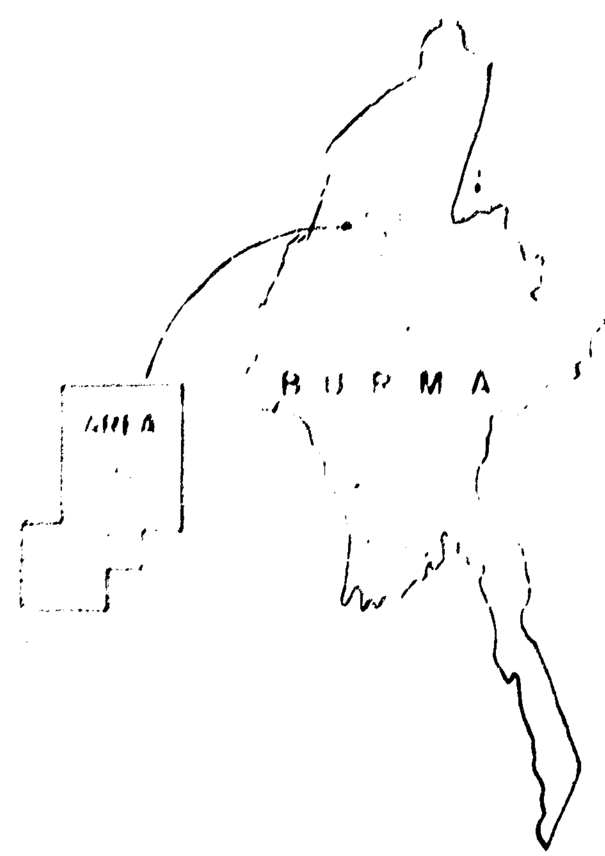



25
22
24
10
12
9
17
30
31
29
28
33
11
23
27
34
1
5
21
20


25
10
12
2
4
9
17
30
31
29
28
33
11
23
27
34
1
5
21
20

LEGEND

400	Magnetic isoline in gammas
10	Drill Hole



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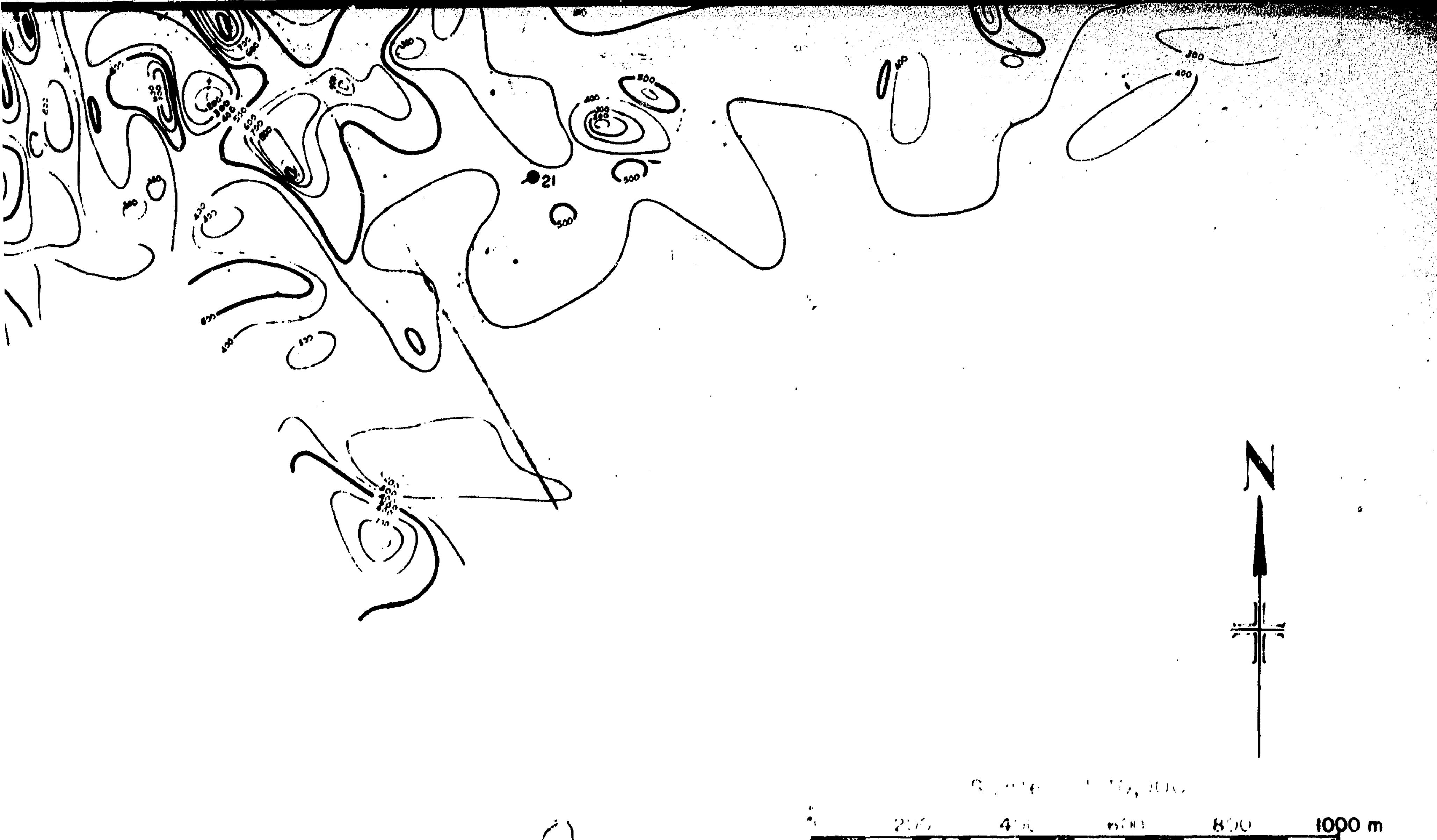
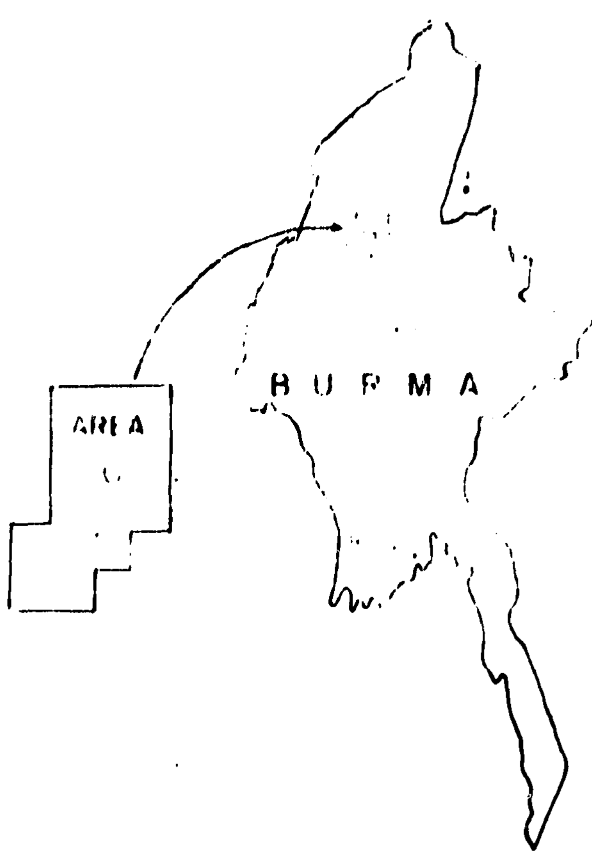
SI

END

tic isoline in gammas

late





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SHANGALON PROSPECT

MAGNETIC ISOLINES

		Fig. 8	


15

LEGEND

I.P. – 3x background

I.P. – 8x background

L 4000
4200
13
24
27
34
18
19
20
23

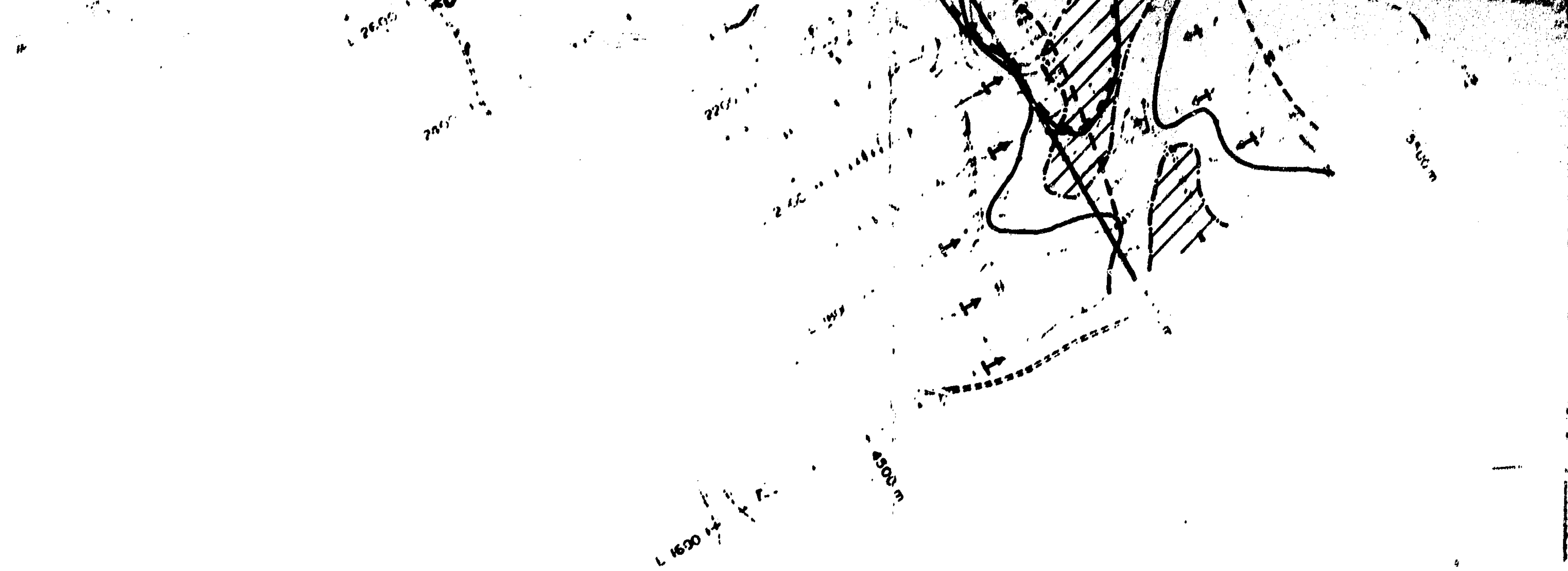

L 5800
L 5600
L 5400
L 5200
L 5000
PUDAW
L 4800
L 4600
L 4400
4200
4000
SHANGAL
3200
3000
22
24
27
16
19
20

ound

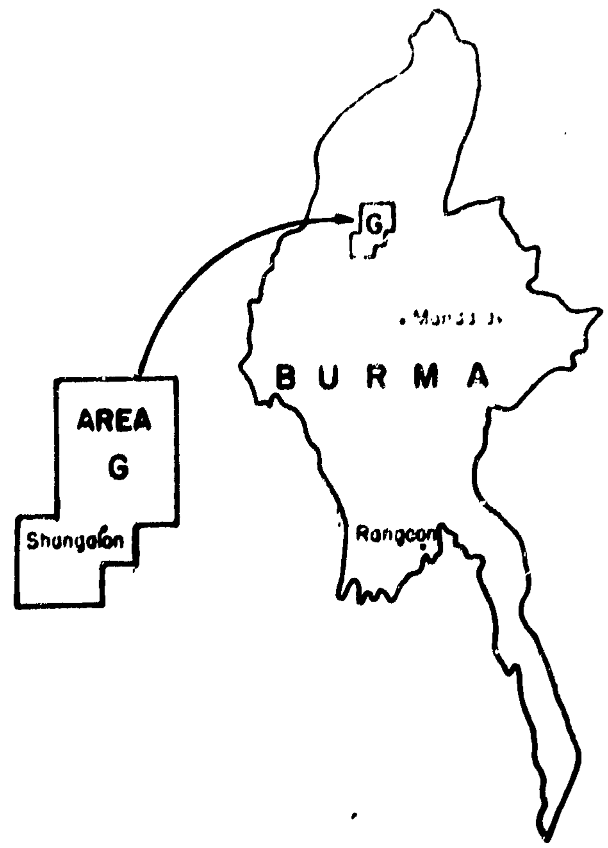
13
25
18
23
27
27
34
33
21
19
20
N

LEGEND

(solid outline)	I.P. – 3x background
(hatched outline)	I.P. – 8x background
├→ ←┤	Limits of I.P. measurements
-------	S.P. – axis of negative anomaly
++++++	S.P. – axis of positive anomaly
(outline with ticks)	High-resistivity zone
10	Drill hole



0 200



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SH

GEOPHYS

ackground

ackground

.P. measurements

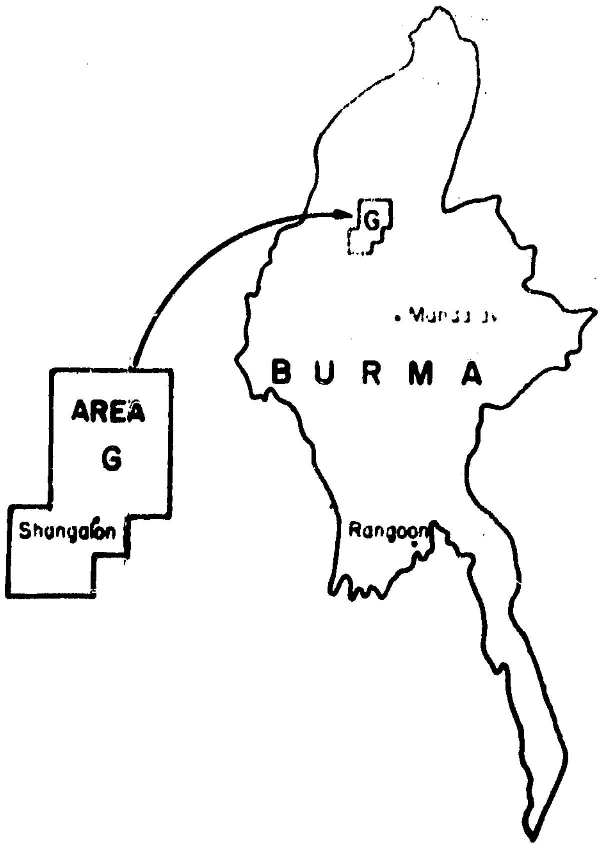
of negative anomaly

of positive anomaly

tivity zone

Scale 1:10,000

0 200 400 600 800 1000 m



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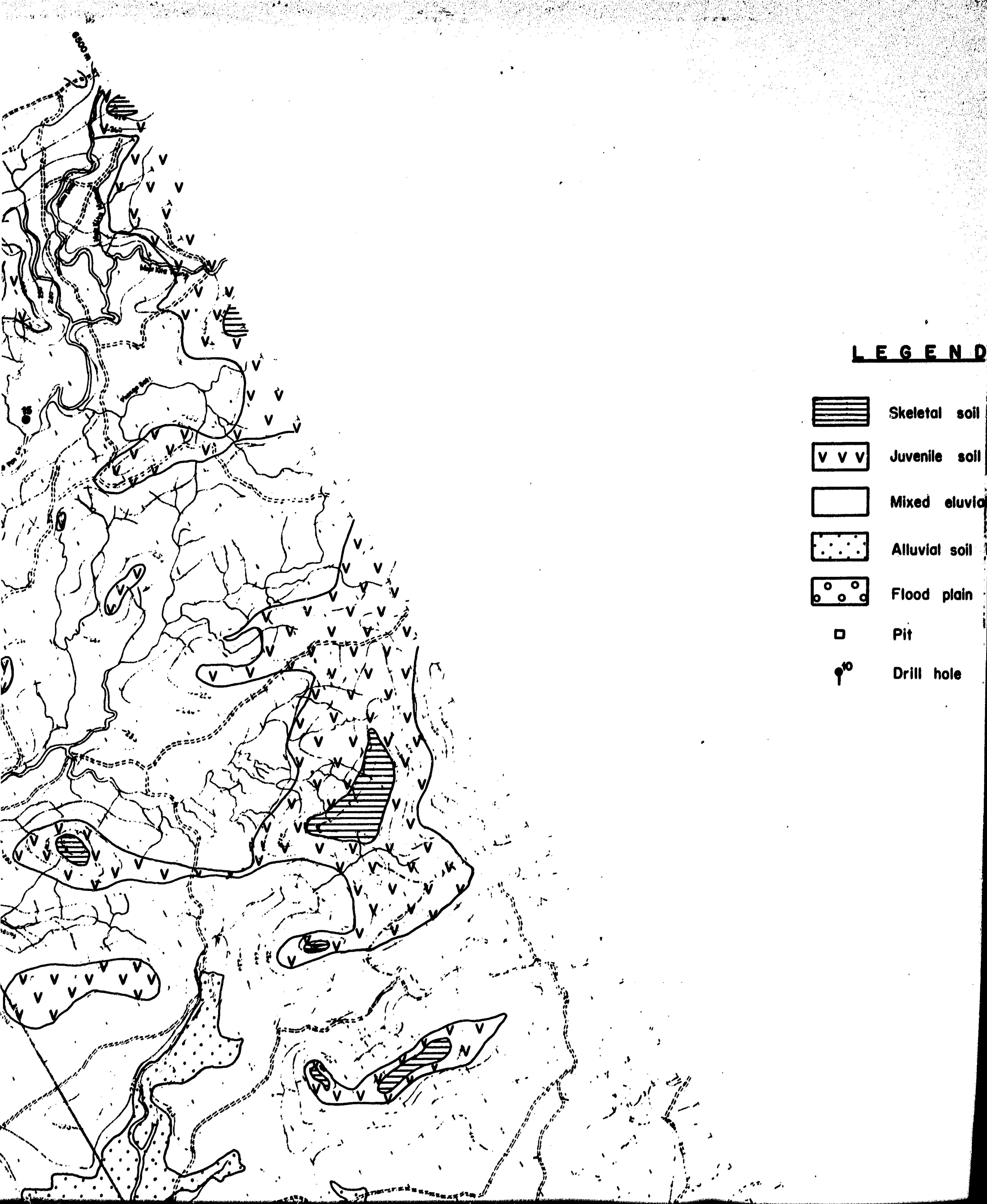
SHANGALON PROSPECT

GEOPHYSICAL INTERPRETATION MAP

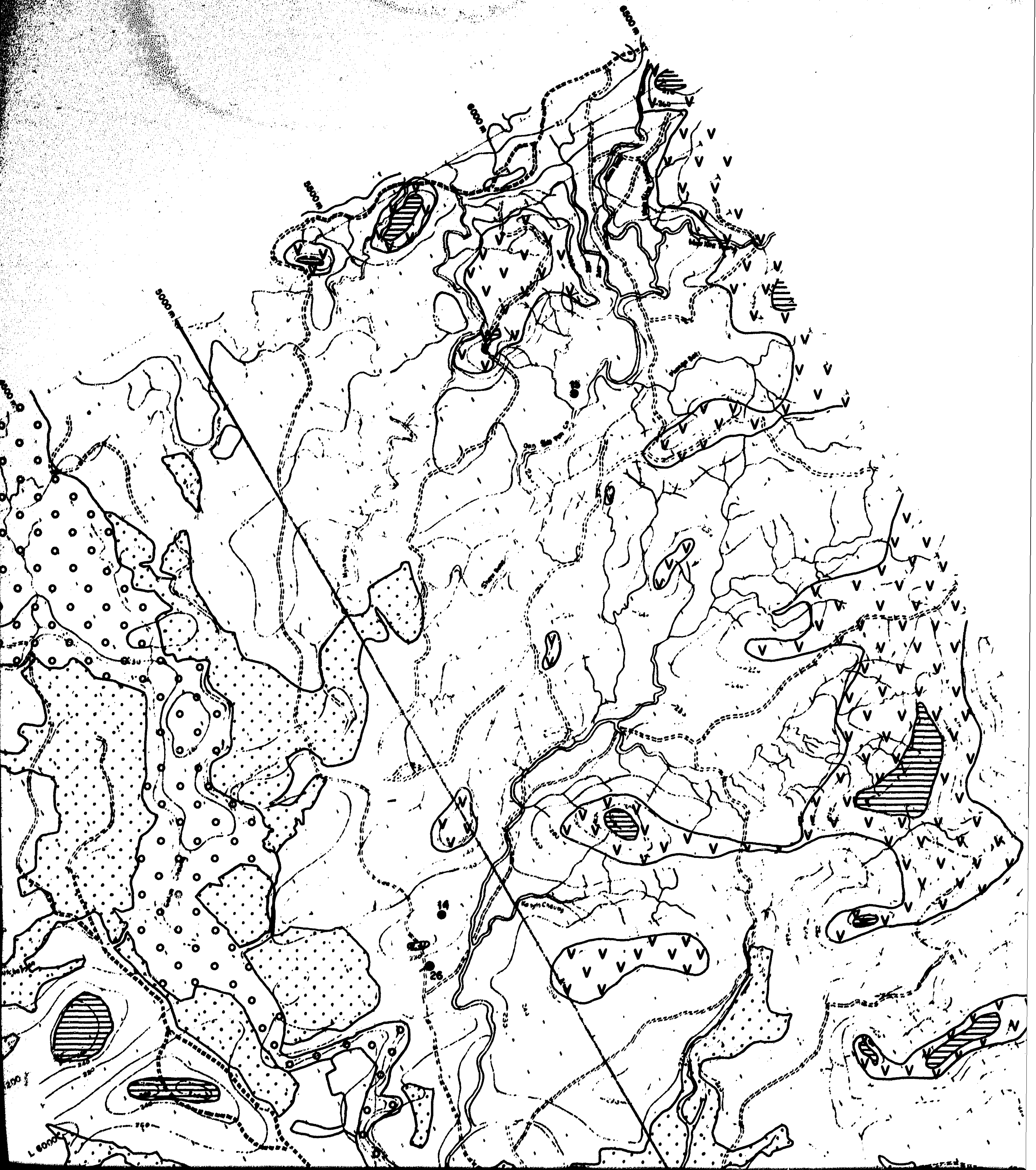
		Fig 10	

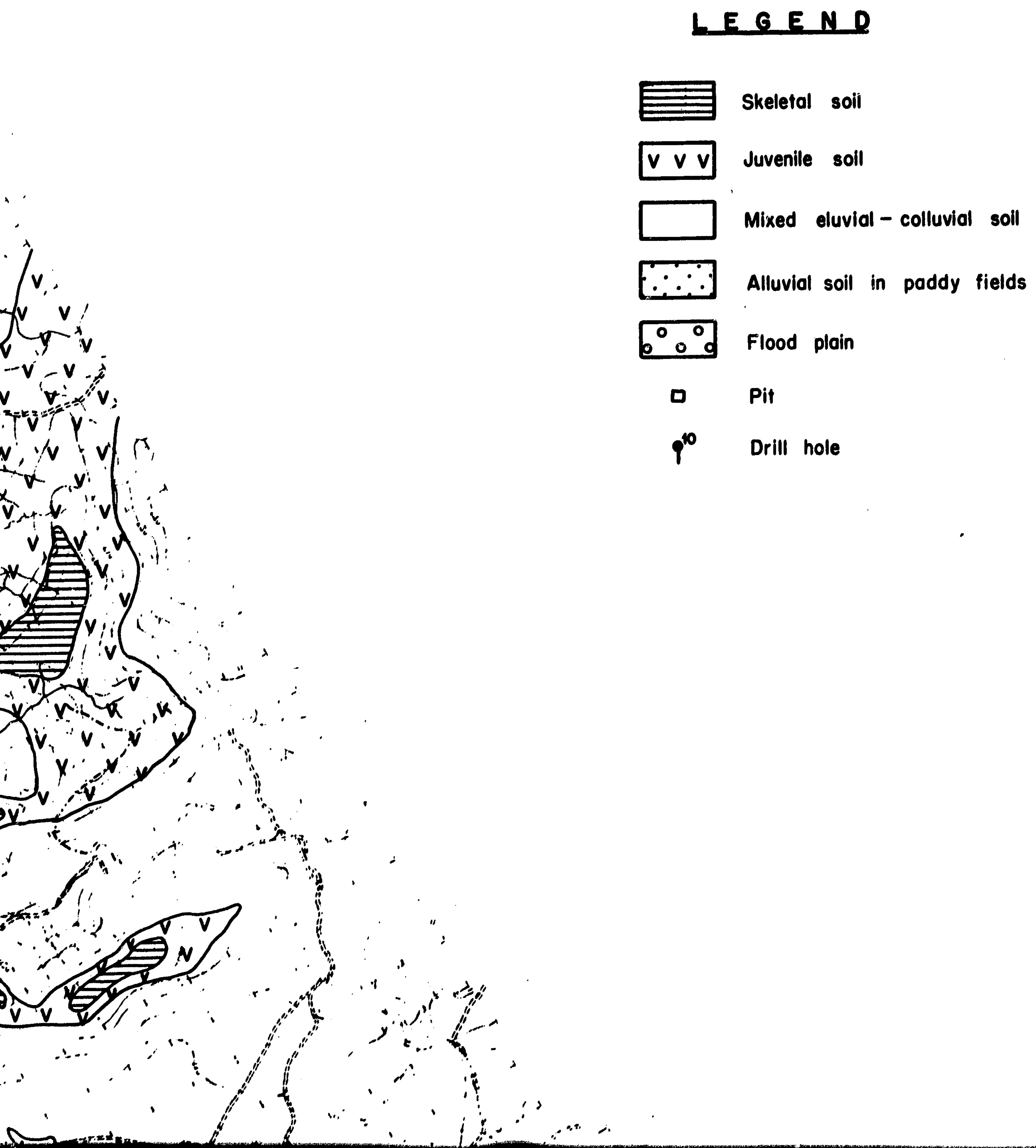
START 4

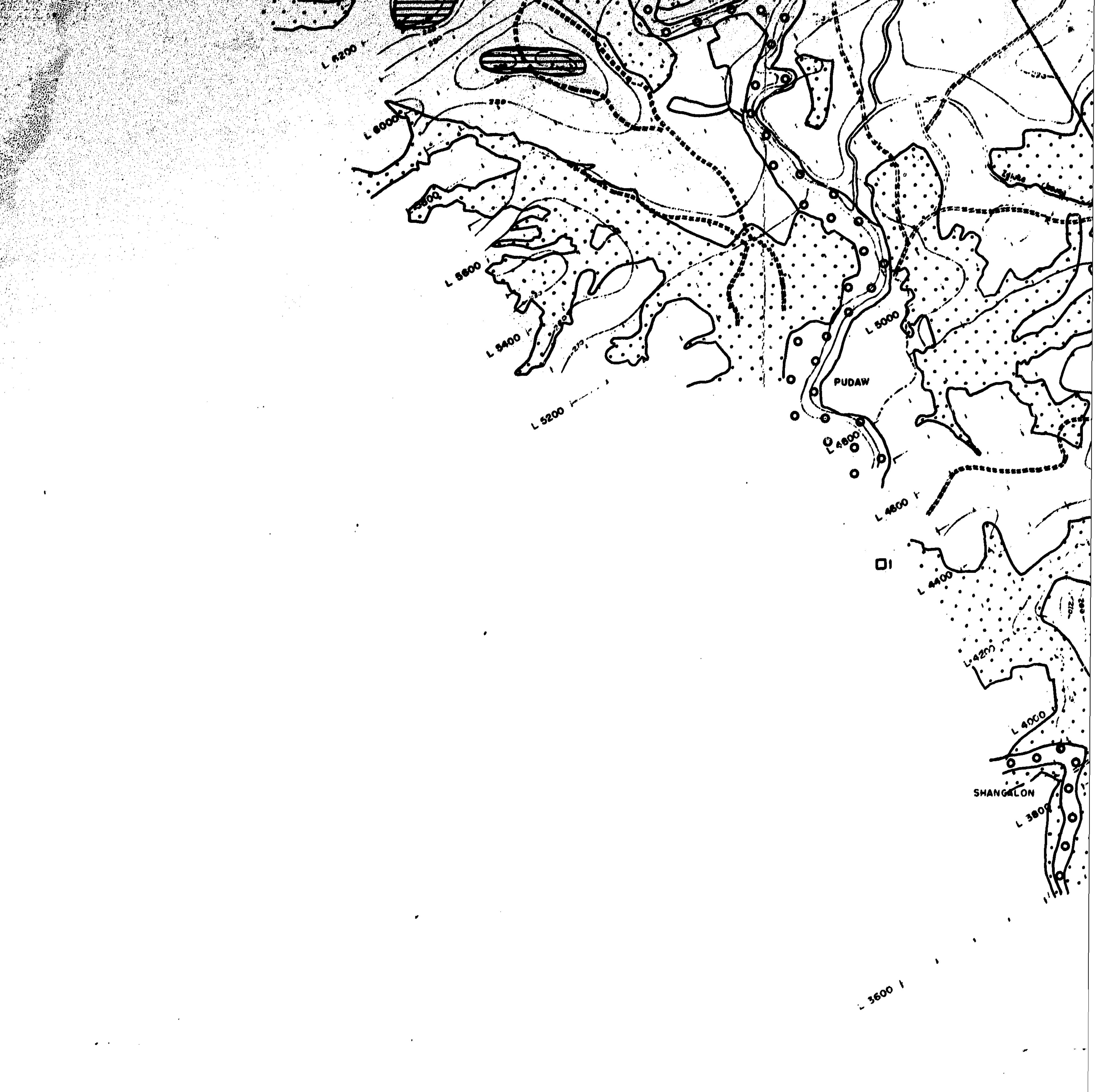

6000 m
6000 m
5500 m
5000 m
4500 m
4000 m
14
26
L 6000

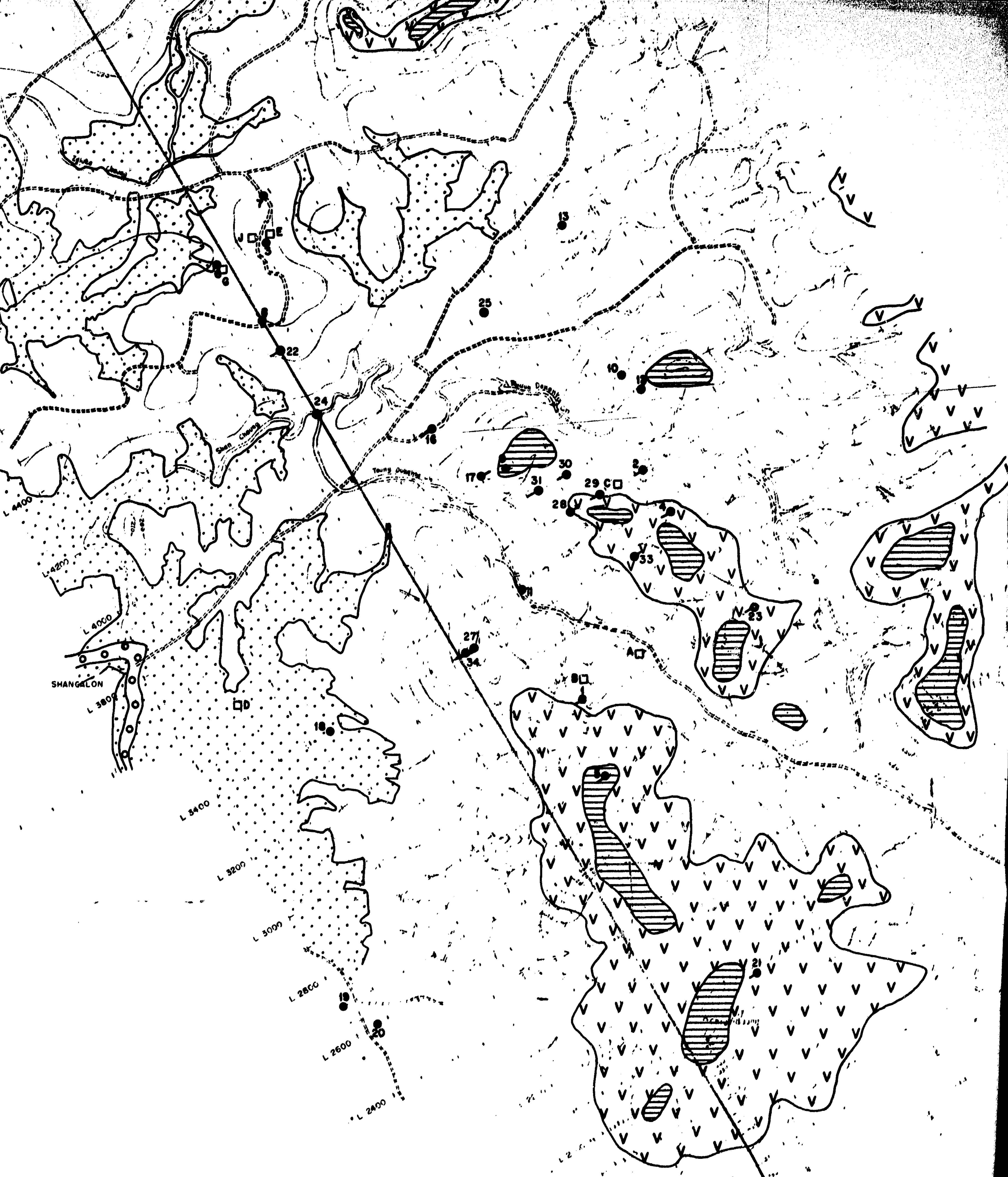


LEGEND
Skeletal soil
V V V
Juvenile soil
Mixed eluvia
Alluvial soil
Flood plain
Pit
Drill hole




LEGEND
Skeletal soil
Juvenile soil
Mixed eluvial – colluvial soil
Alluvial soil in paddy fields
Flood plain
Pit
Drill hole

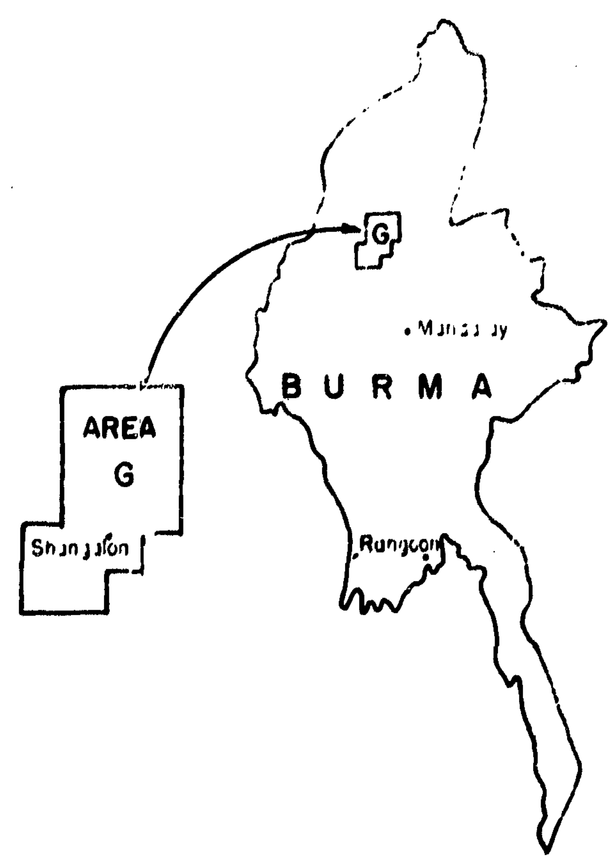

L 6200
L 6000
L 5400
L 5200
L 5000
PUDAW
L 4400
L 4200
L 4000
SHANGALON
L 3600



J
E
3
6
13
25
22
24
16
10
30
31
17
29
C
28
4
33
2
11
23
27
34
A
B
D
18
19
20
21
Shan Chaung
SHANGALON
L 4400
L 4200
L 4000
L 3800
L 3400
L 3200
L 3000
L 2800
L 2600
L 2400

L 6000
L 5800
L 5600
L 5400
L 5200
L 5000
L 4800
L 4600
L 4400
L 4200
L 4000
L 3800
L 3600
L 3400
L 3200
L 3000
L 2800
L 2600
L 2400
PUDAW
SHANGALON
J
E
6
22
24
16
1
D
18
19
20

13
25
10
16
30
31
29 C
28
33
23
A
B
27
34
21
19
20
2600
2400
N



0 20

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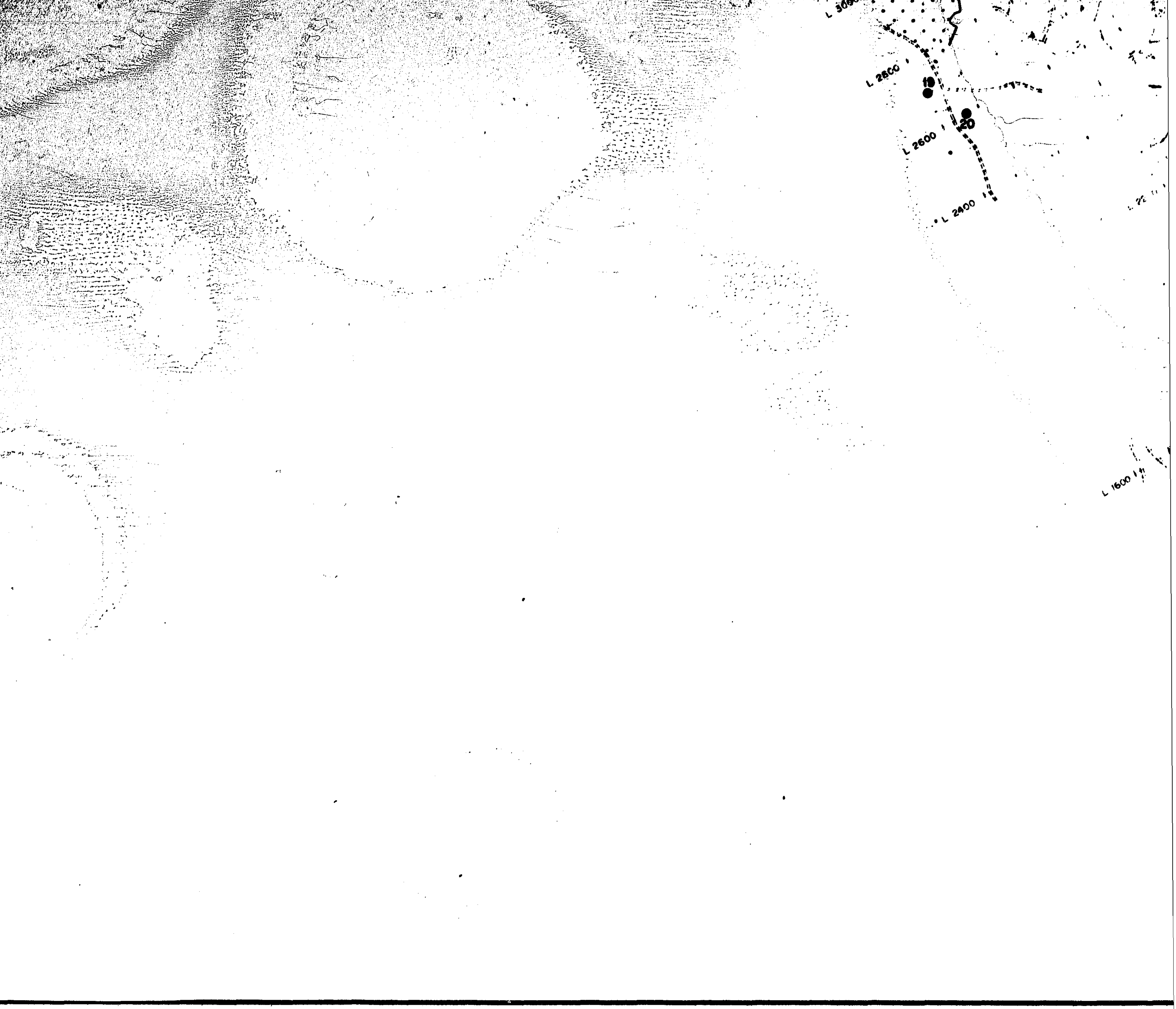
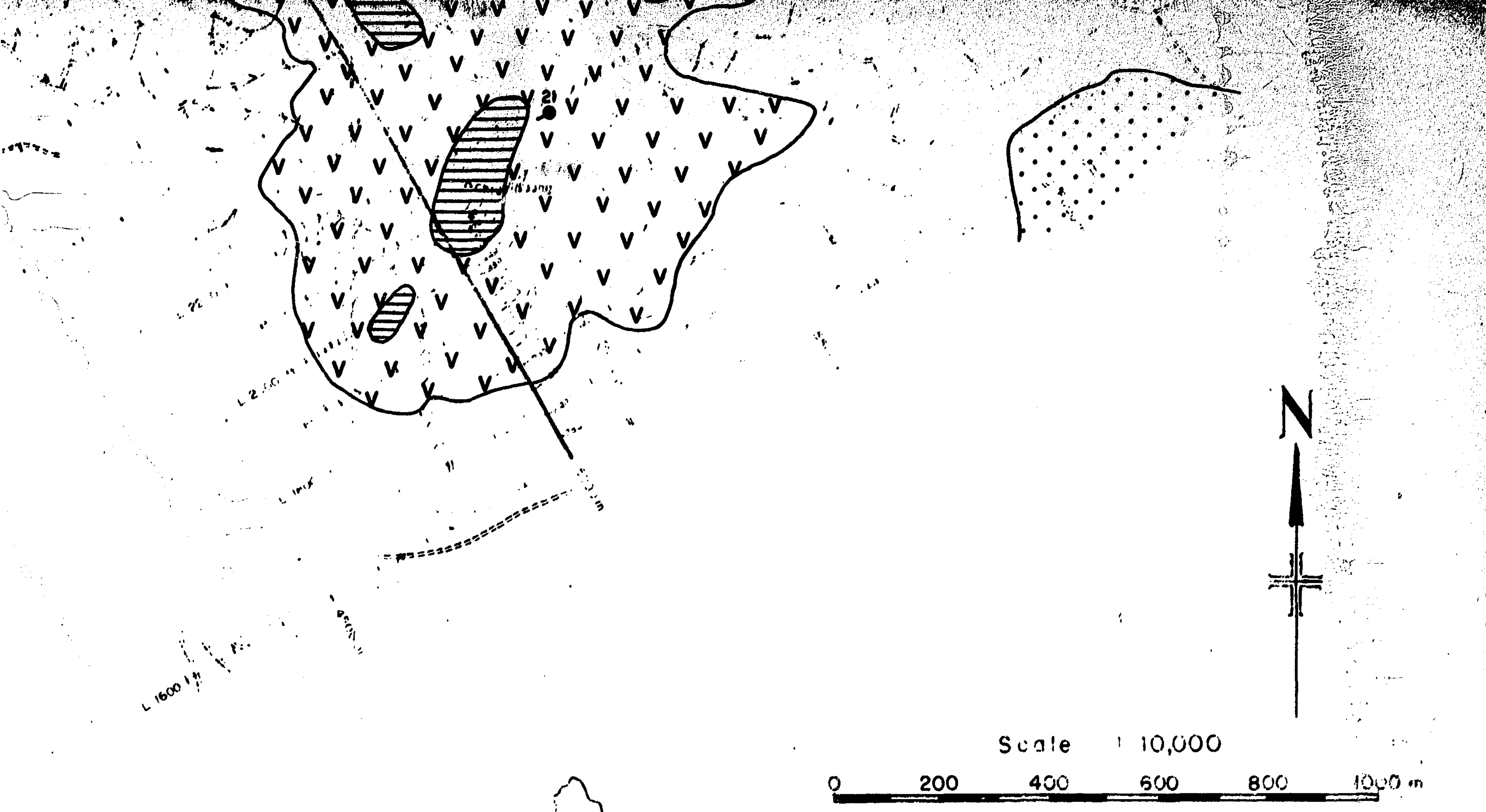
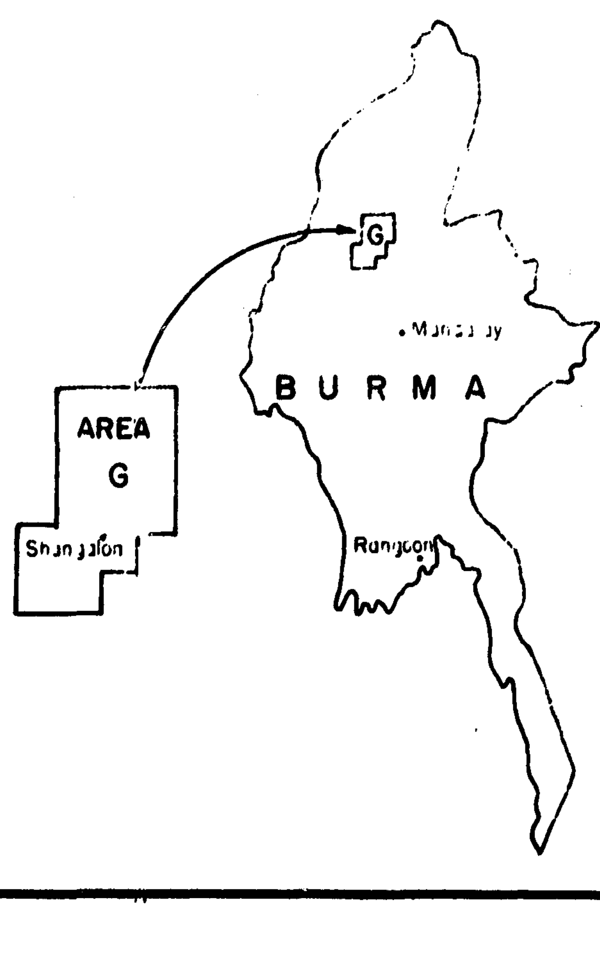
SH


L 2800
19
20
L 2600
L 2400
L 1600





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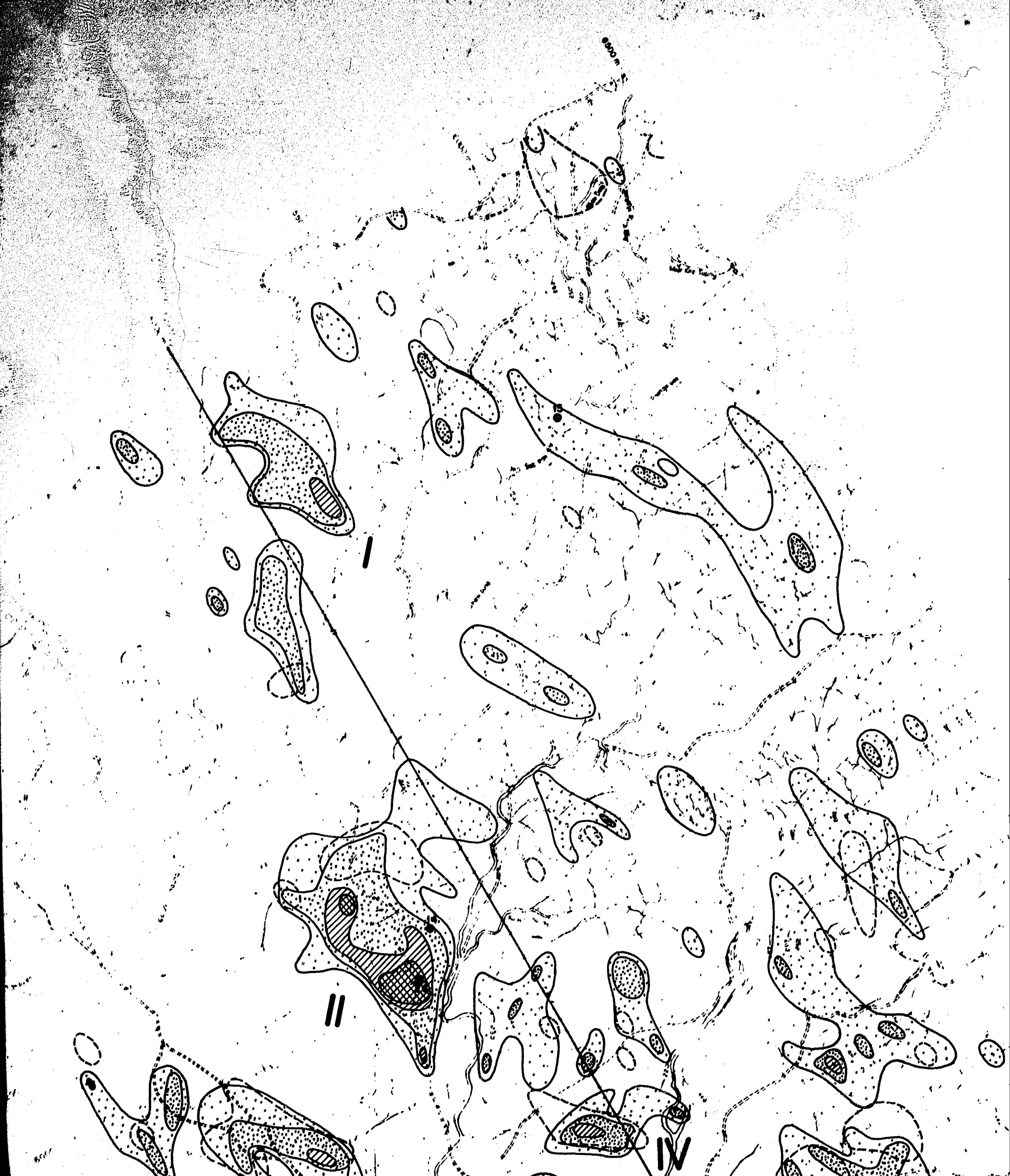
SHANGALON PROSPECT

SOIL MAP

Fig. 14


I
II


LE
VI
IV
15



I
II
IV

LEGEND

Cu < 244 PPM

" 244-399 PPM

" 400-999 PPM

" 1000-1999 PPM

" > 1999 PPM

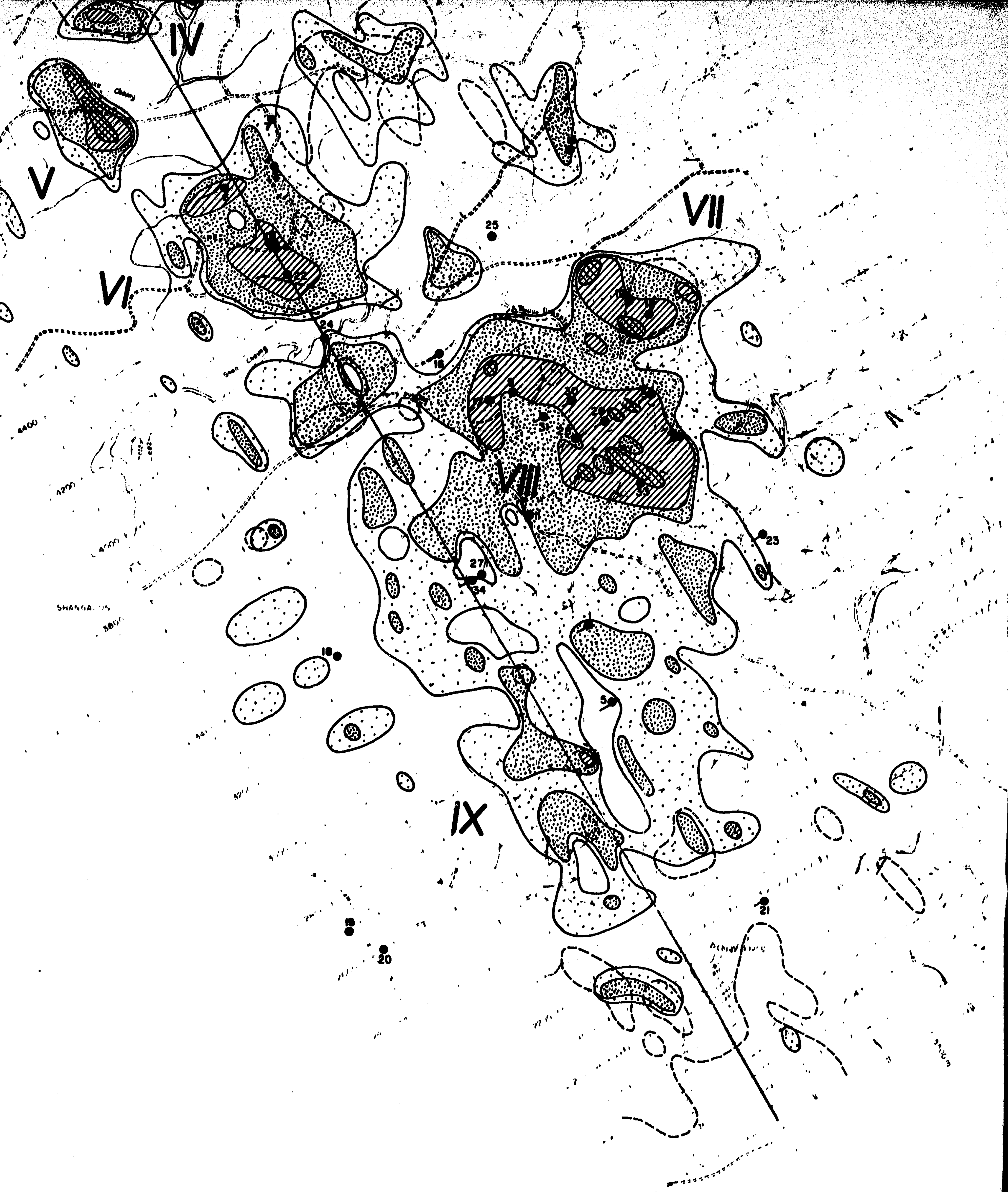
Pb < 35 PPM

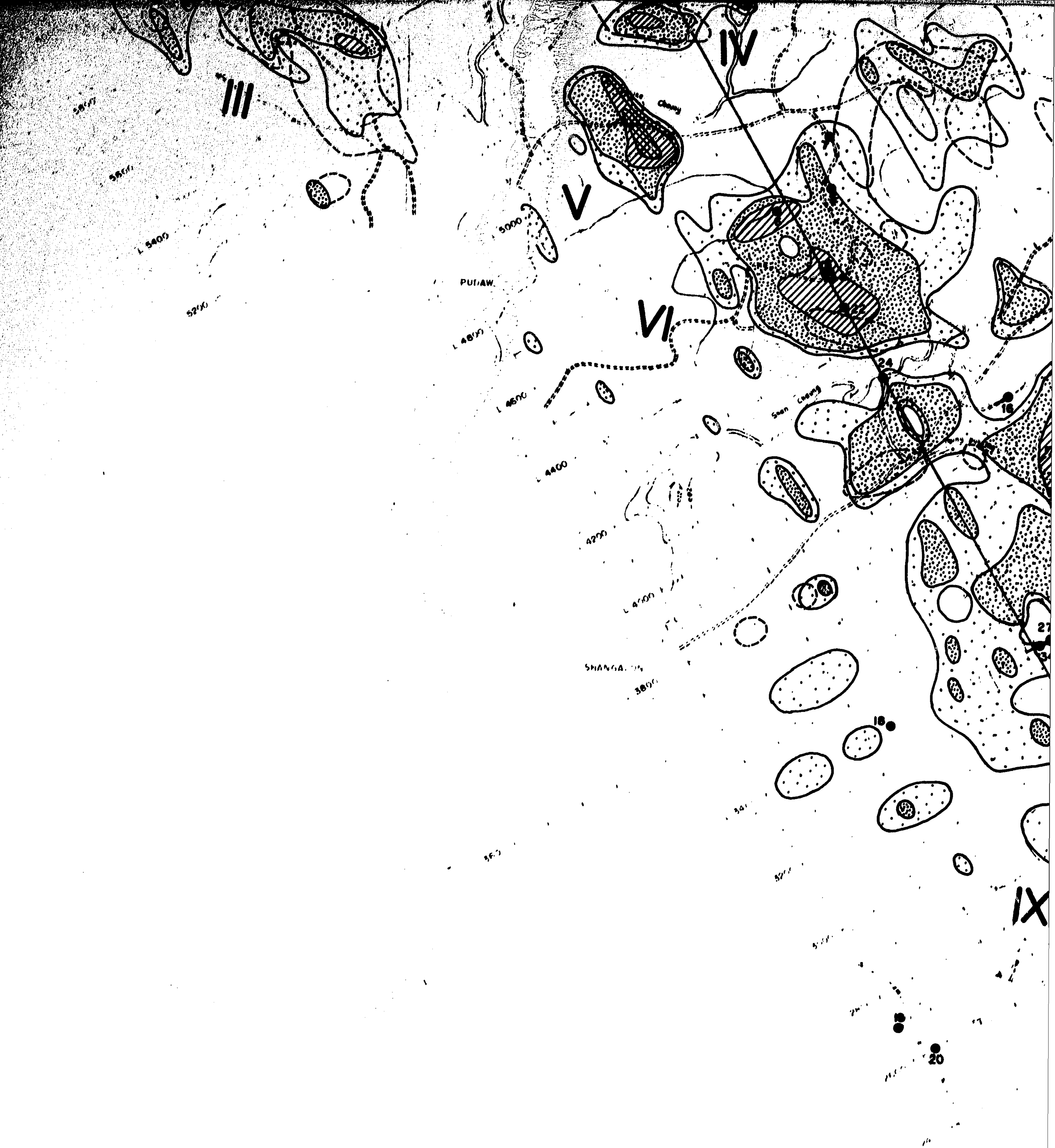
" > 35 PPM

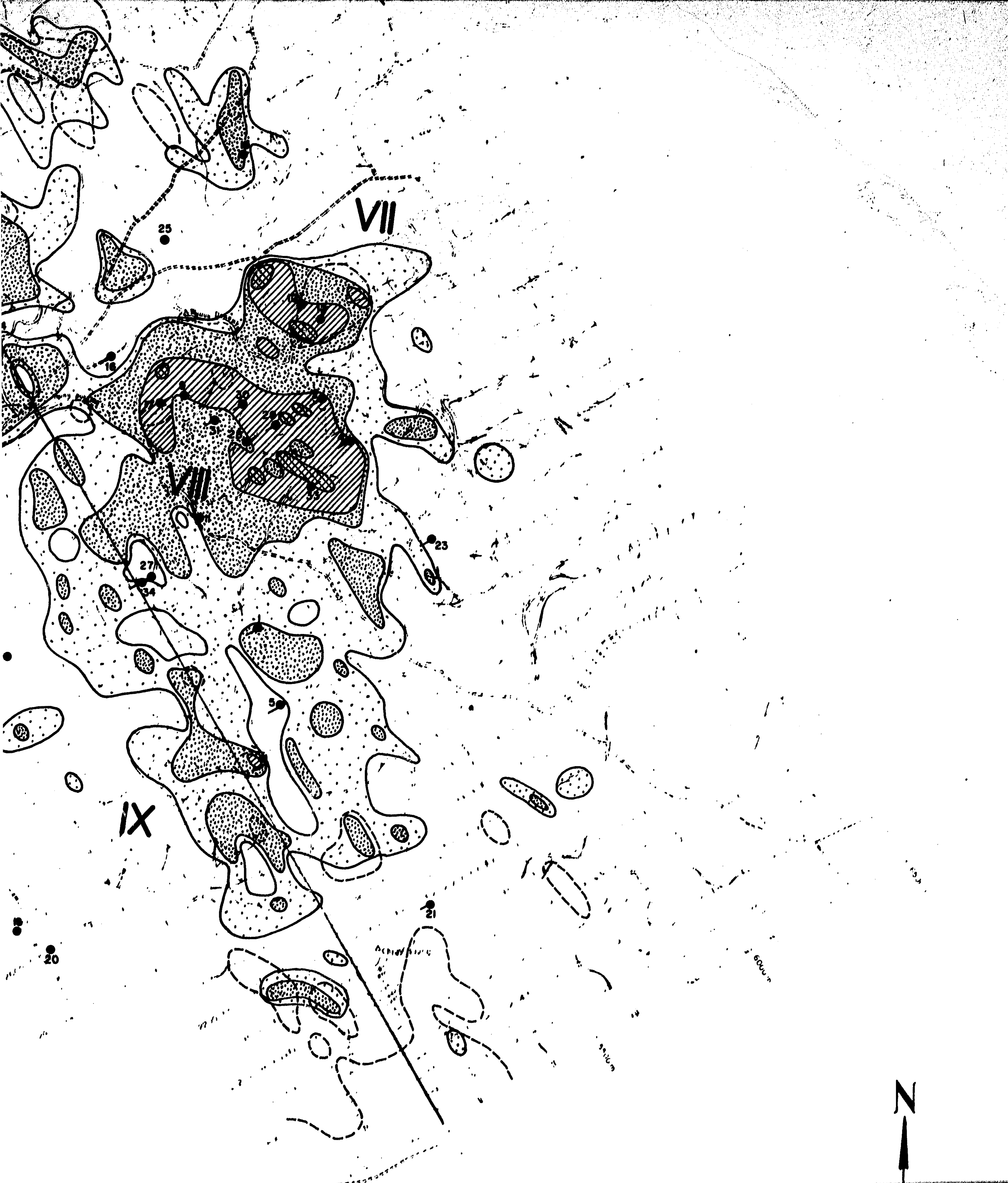
VI Number of anomaly

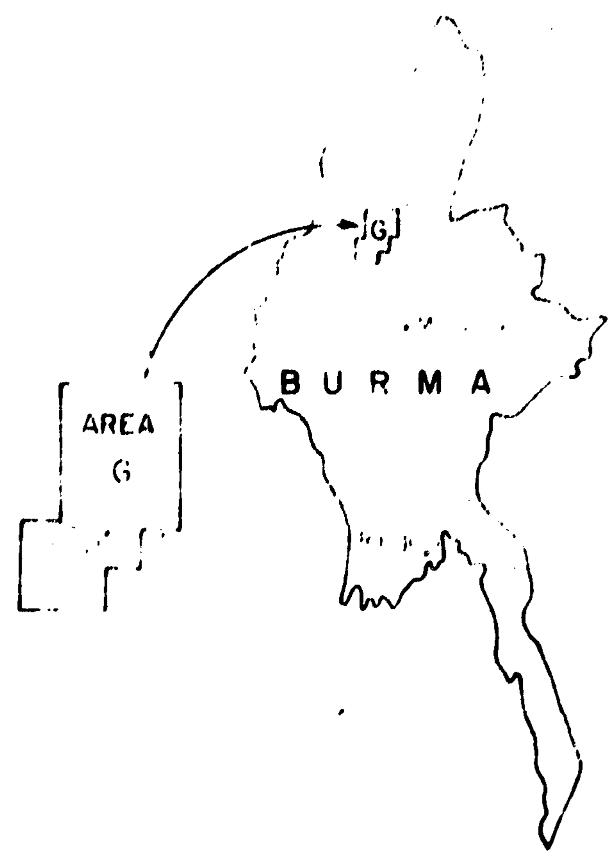
10 Drill Hole


III
V
VI
PUDAW
5600
5400
5200
5000
4800
4600
4400
4200
4000


IV
V
VI
VII
VIII
IX
25
24
16
23
27
34
18
5
19
20
21
4400
4200
3800


III
IV
V
VI
IX
PUDAW
5000
L 4800
L 4600
4400
4200
L 4000
24
18
20


VII
VIII
IX
25
16
23
27
34
21
20
N



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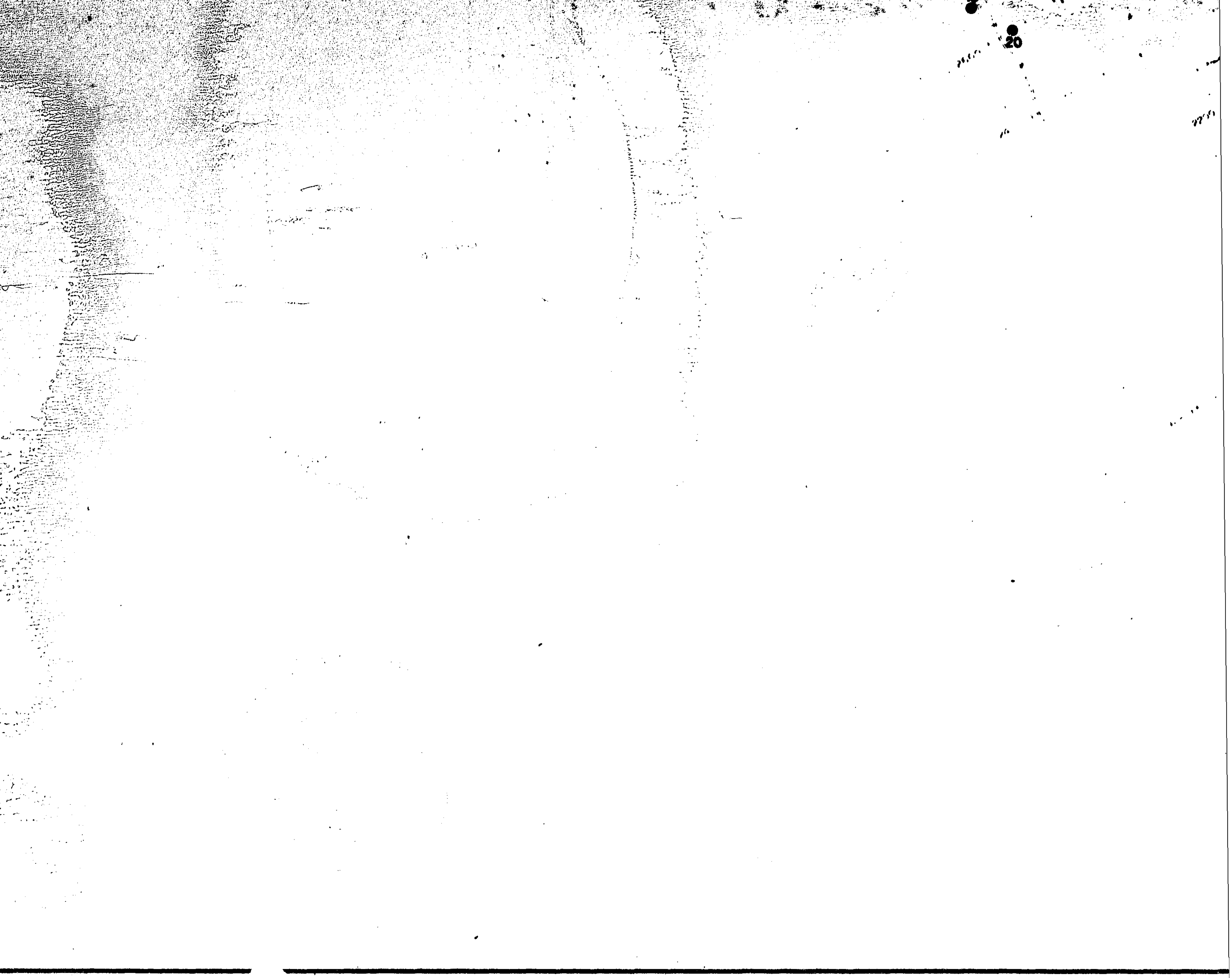
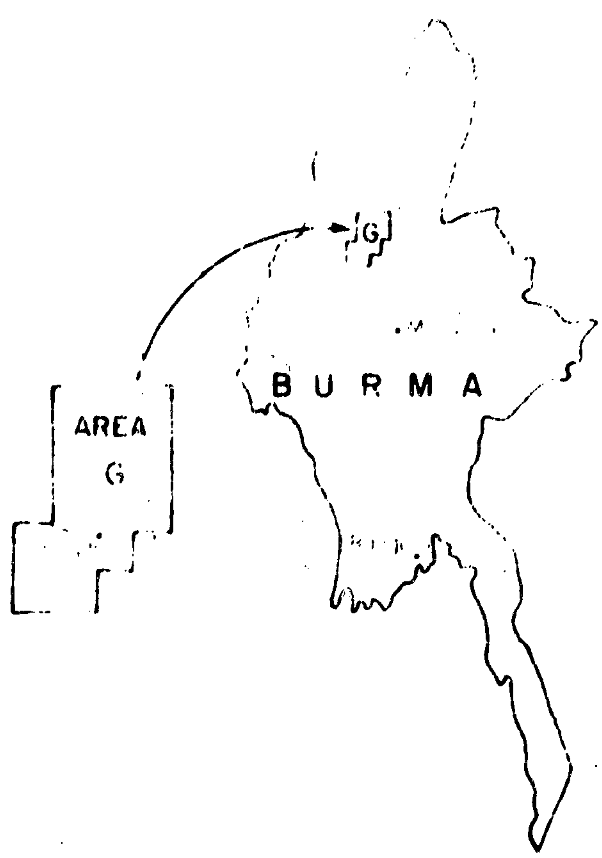
S

COP


20



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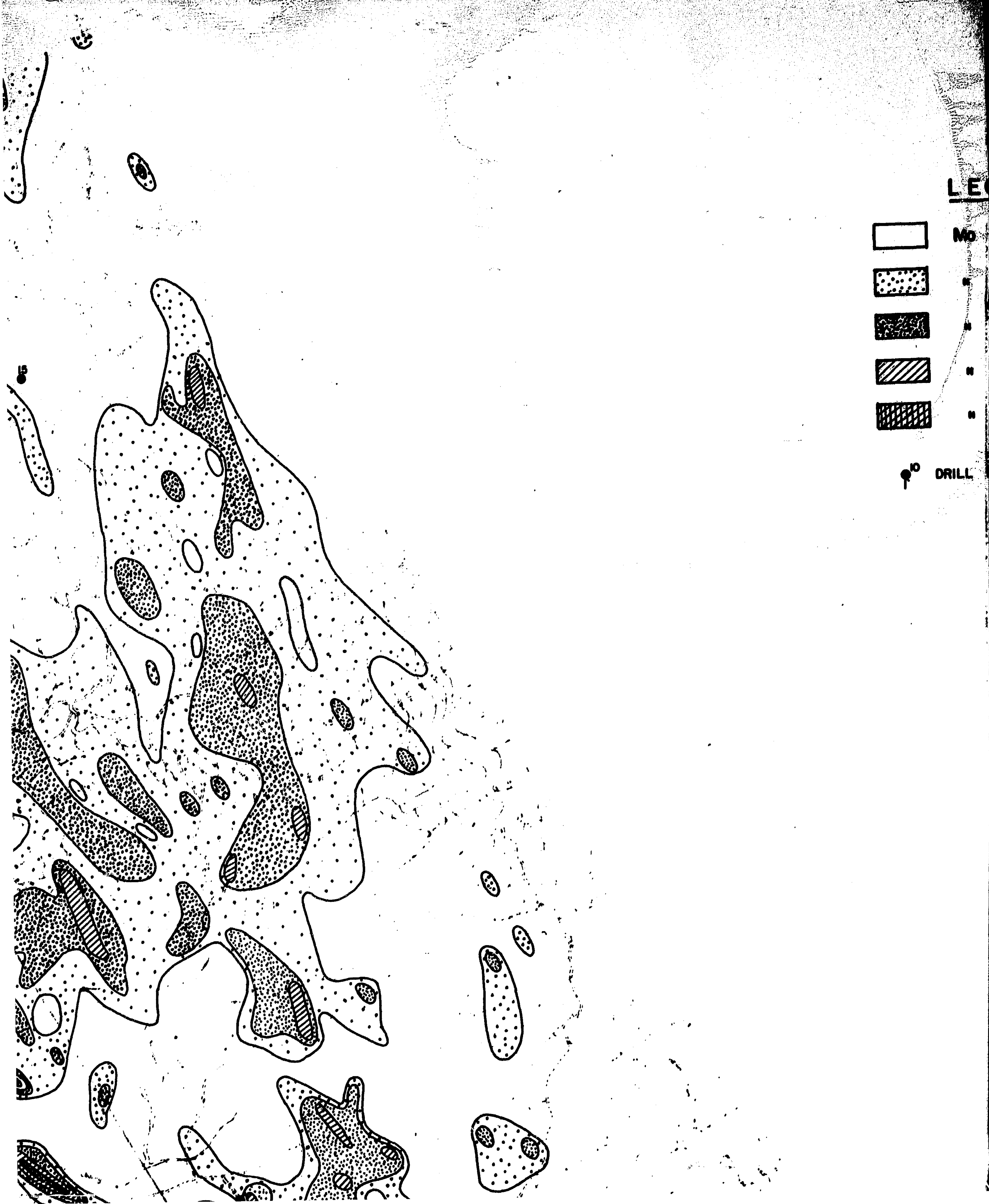
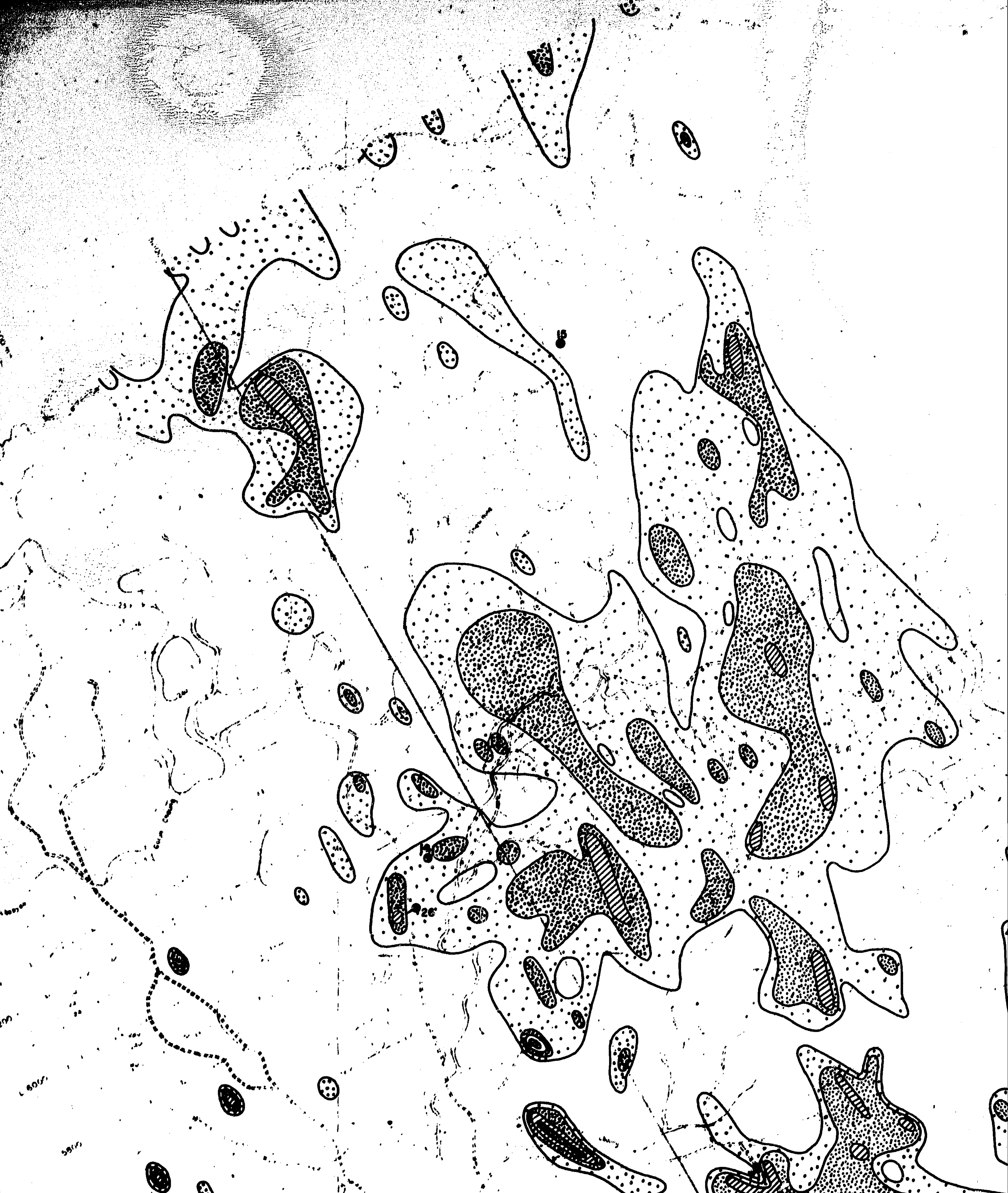
SHANGALON PROSPECT

COPPER CONTOURS IN SOIL

Fig. 17

L 7400
L 7200
L 7000
L 6800
L 6600
L 6400
L 6200
L 6000
15
26

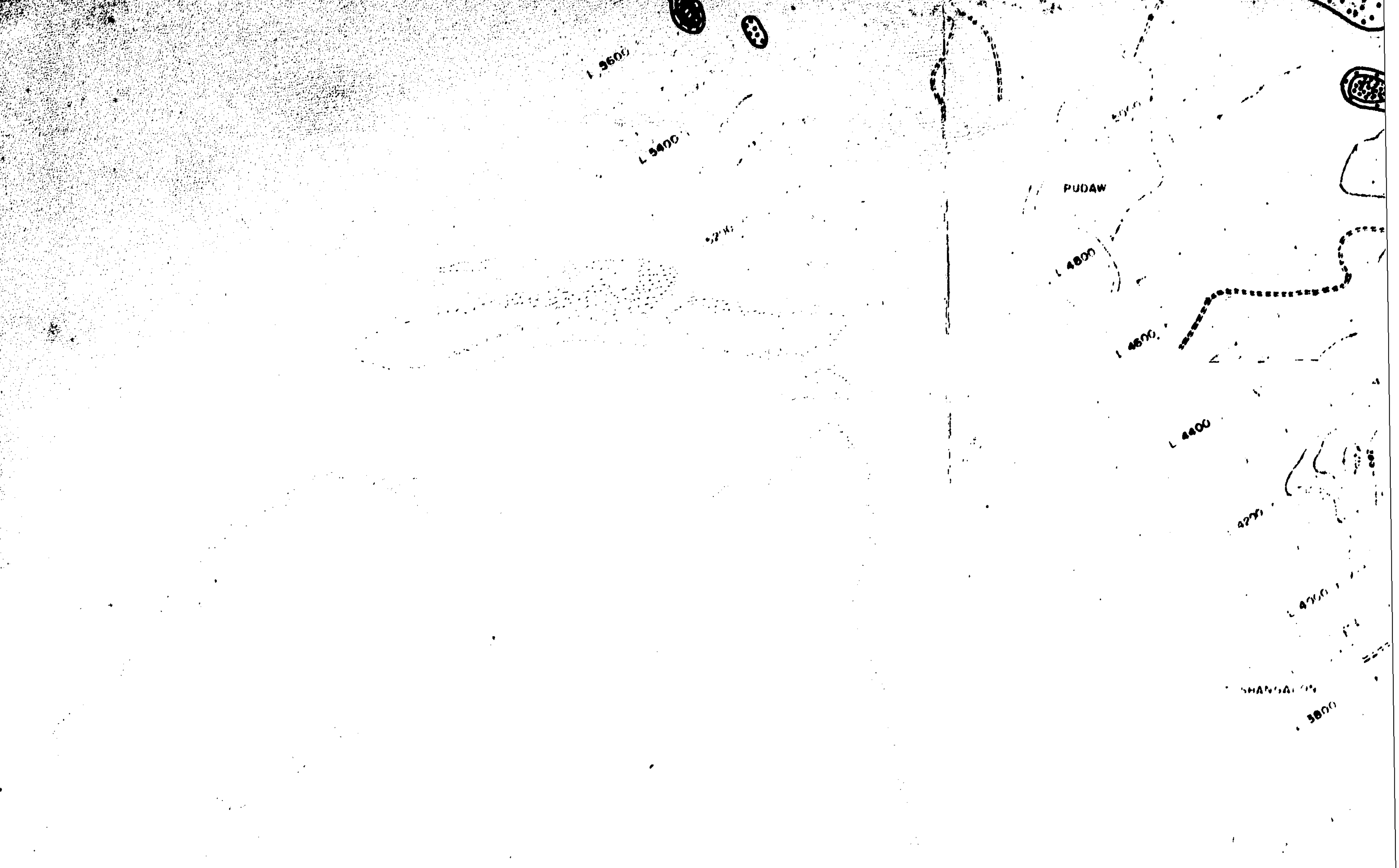

15
LE
Mo
10
DRILL



LEGEND

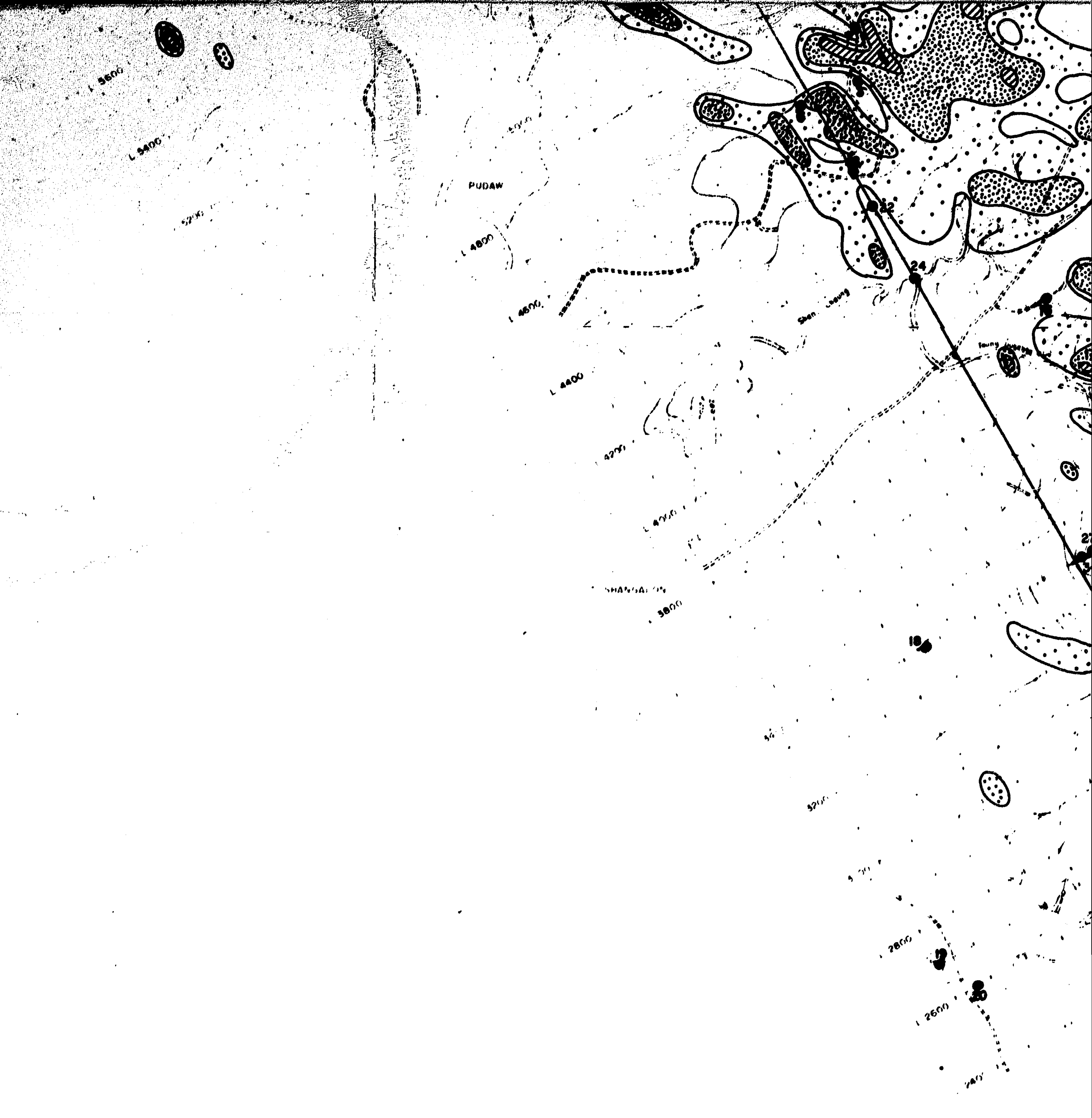
(blank)	Mo > 4	PPM
(dotted)	" 4 – 8	PPM
(dense stipple)	" 9 – 27	PPM
(diagonal hatch)	" 28 – 54	PPM
(cross hatch)	" > 54	PPM

o[10] DRILL HOLE



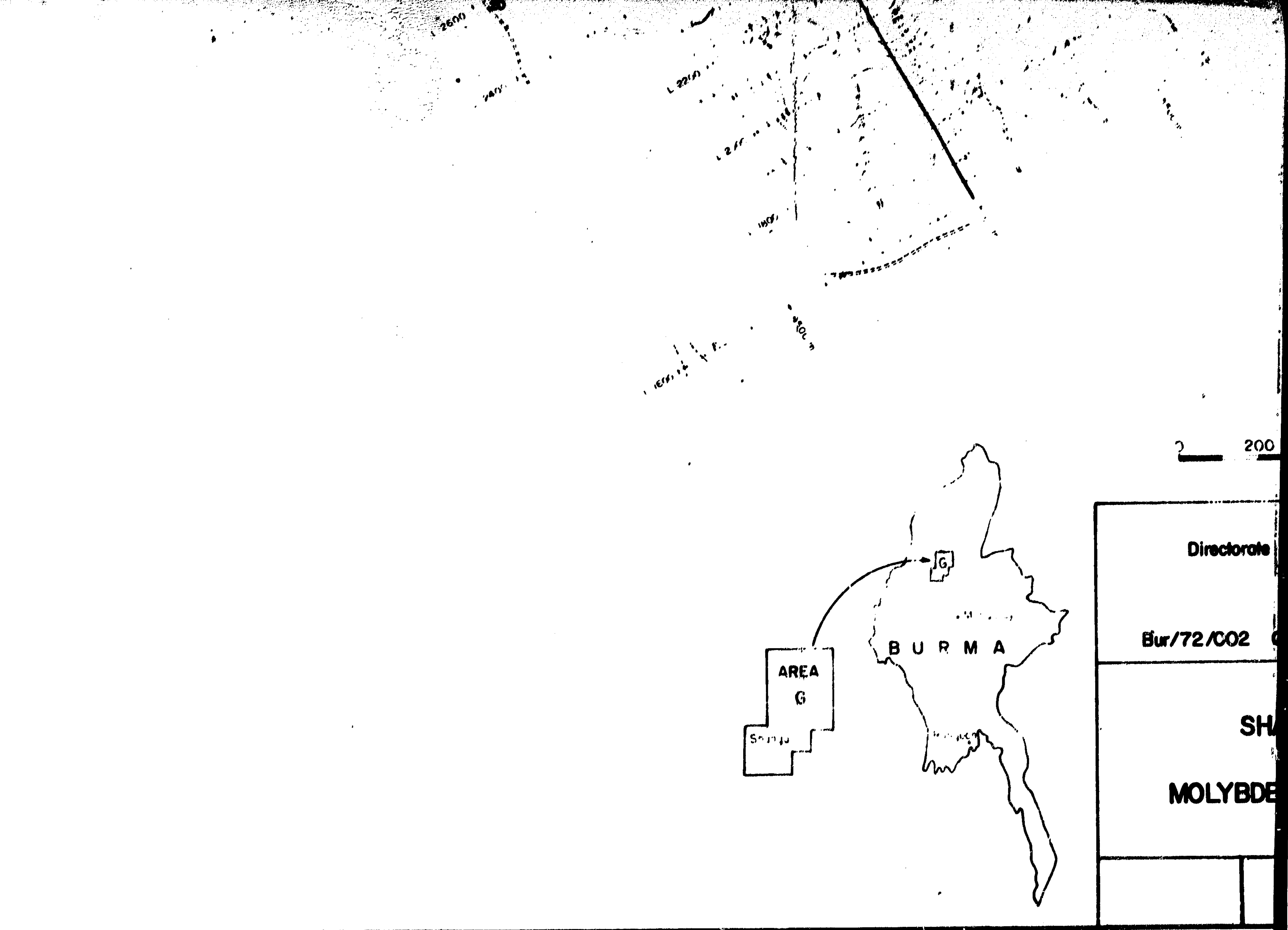
5600
5400
PUDAW
4800
4600
4400
4200
3800

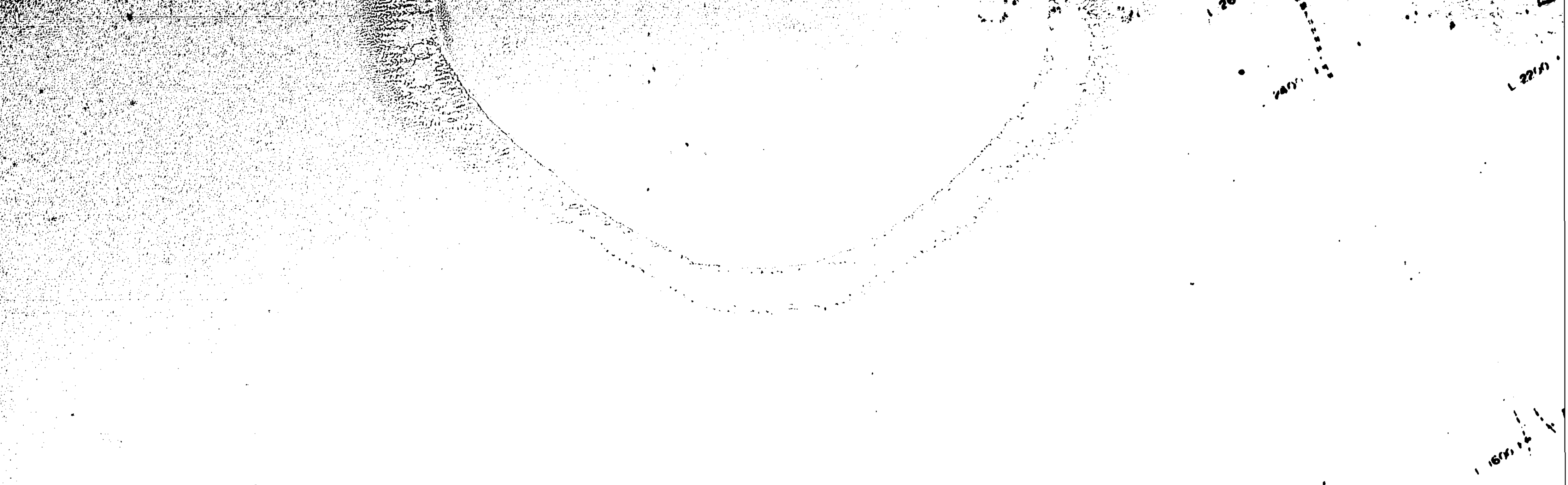
22
24
25
27
34
23
33
21

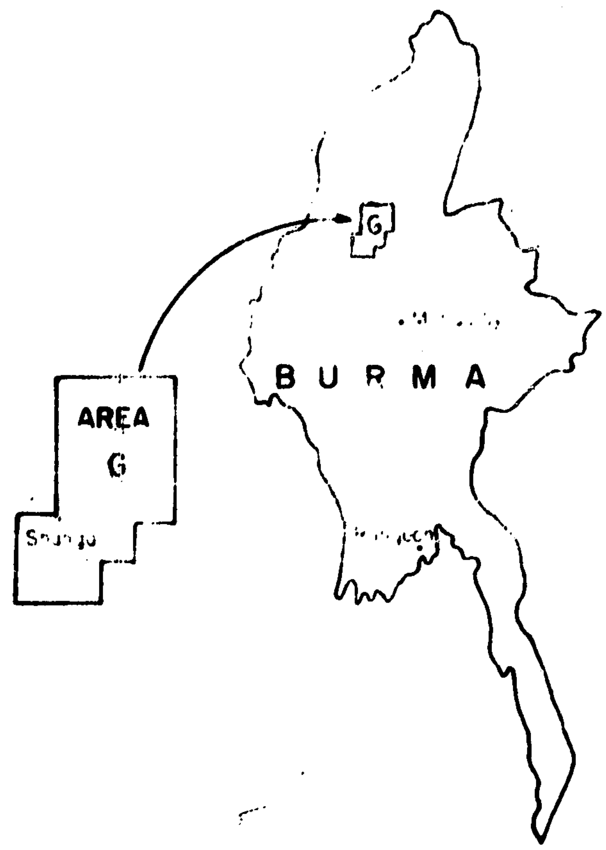


PUDAW
L 5600
L 5400
L 4800
L 4600
L 4400
4200
L 4000
3800
2800
L 2600
22
24

N


2600
2200
200
AREA
G
G
B U R M A
Directorate
Bur/72/CO2
SH
MOLYBDE





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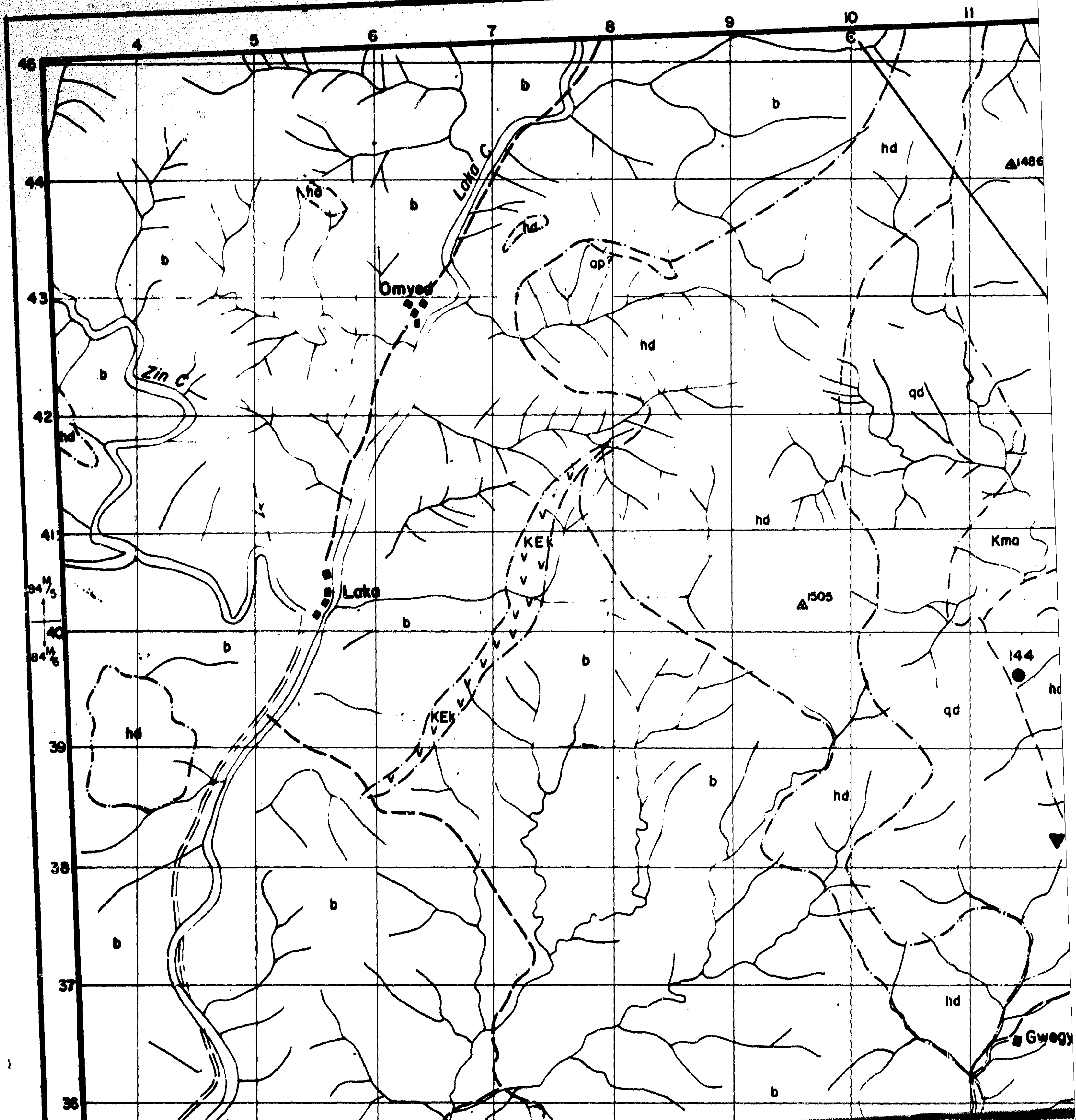
SHANGALON PROSPECT

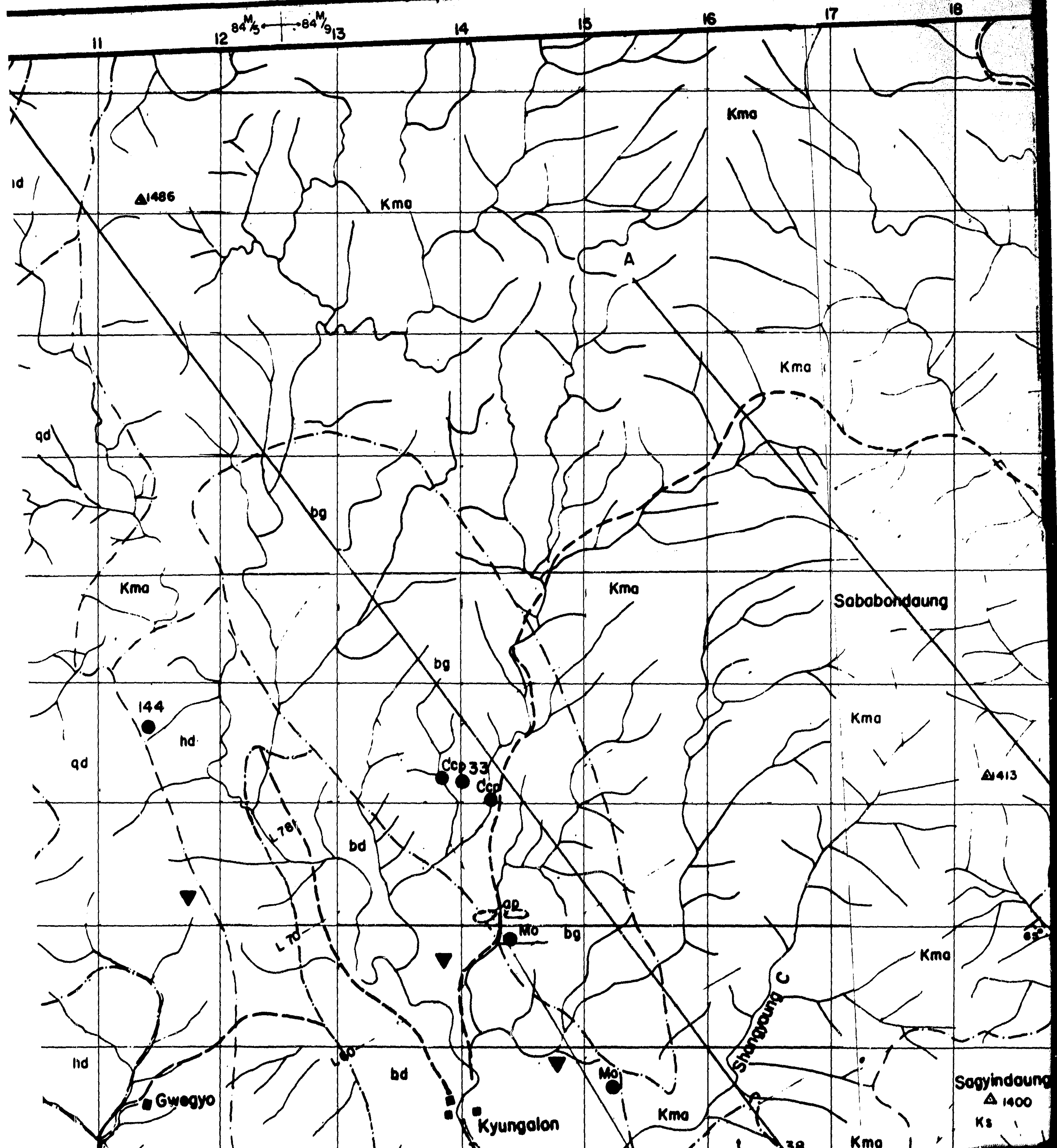
MOLYBDENUM CONTOURS IN SOIL

Fig.
18

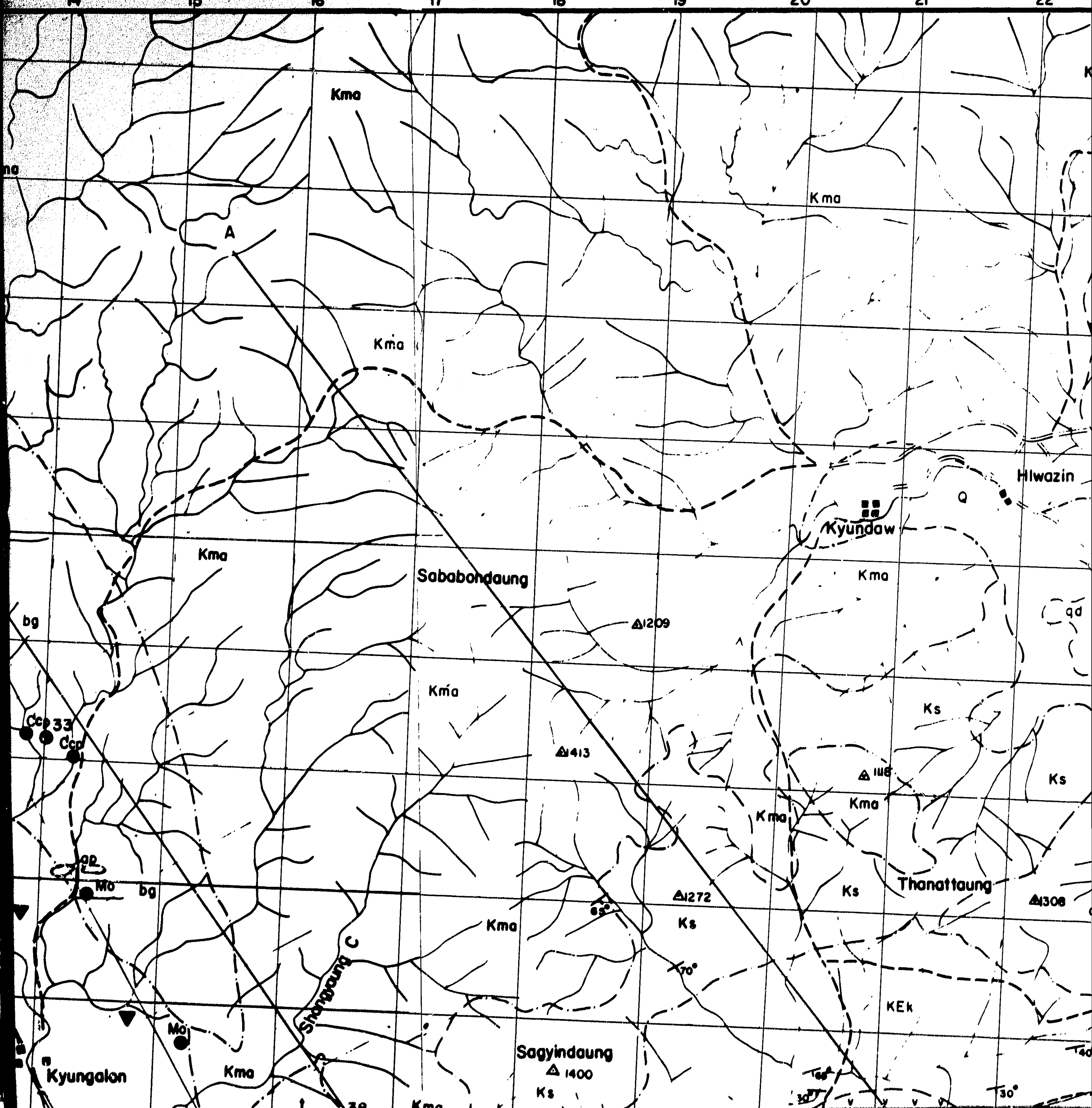
GEOLOGY OF THE ARE



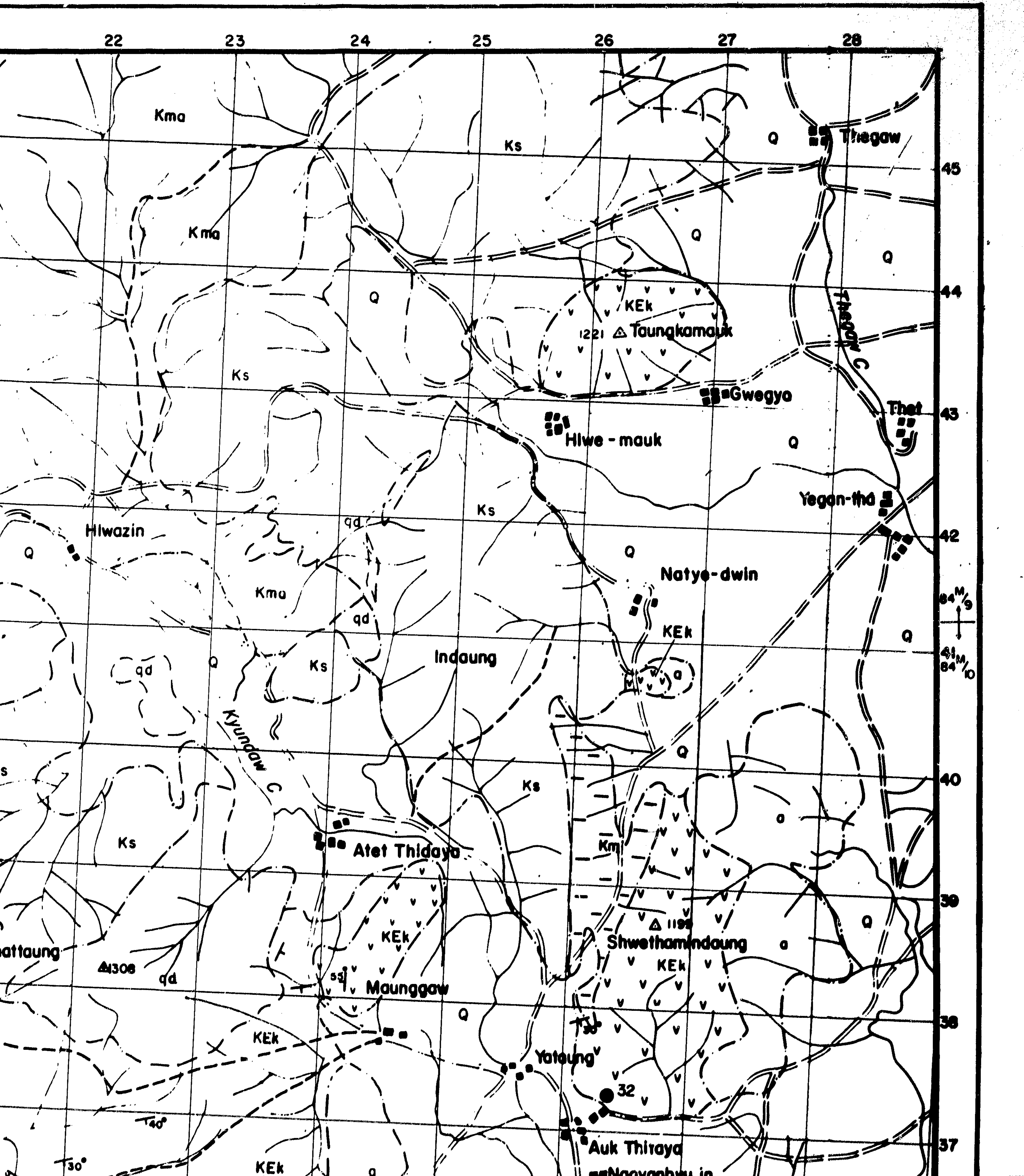
HE AREA AROUND SHANGALON, KAWLIN

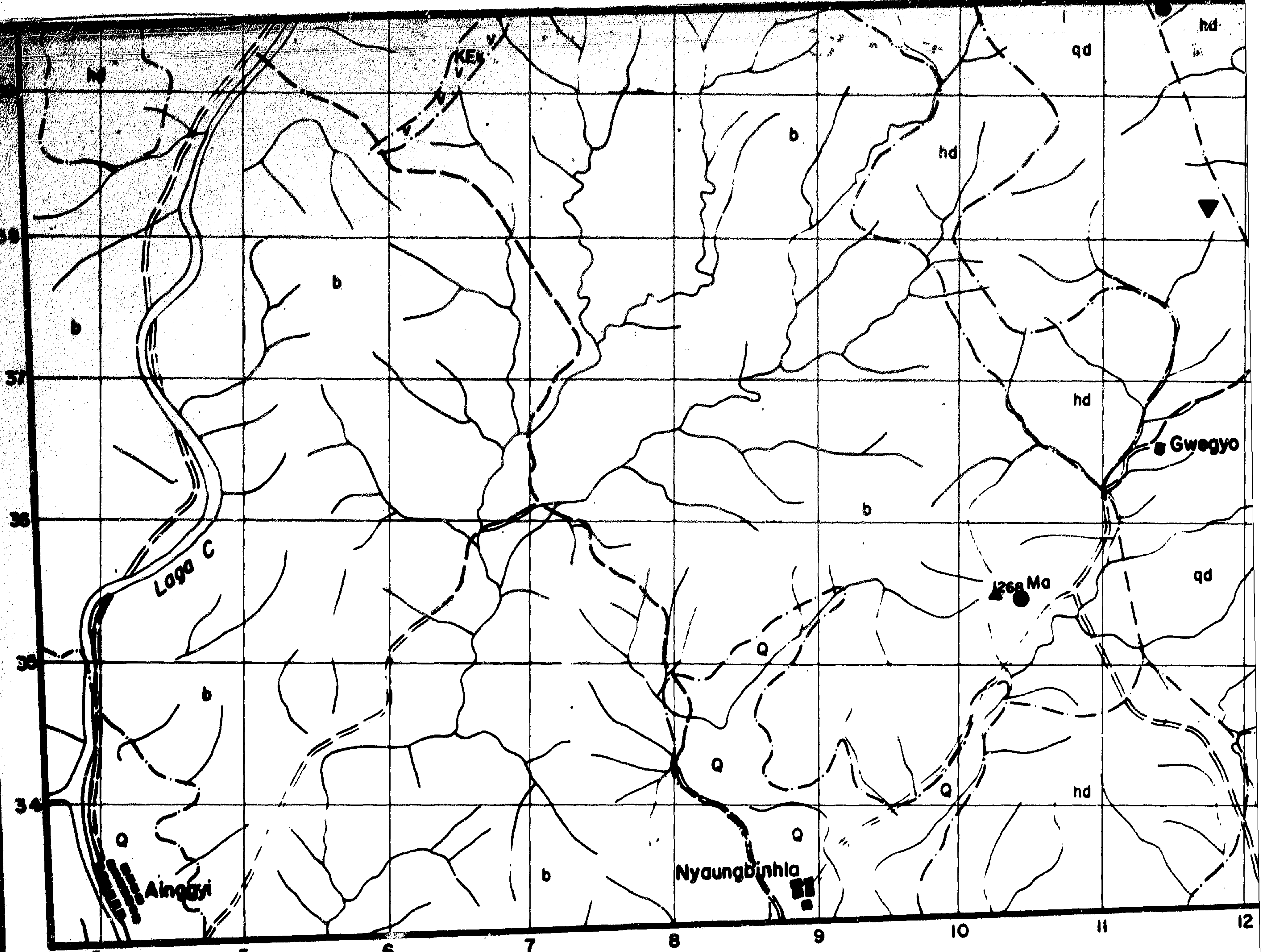


ND SHANGALON, KAWLIN TOWNSHIP, NORTHER



ORTHERN BURMA.

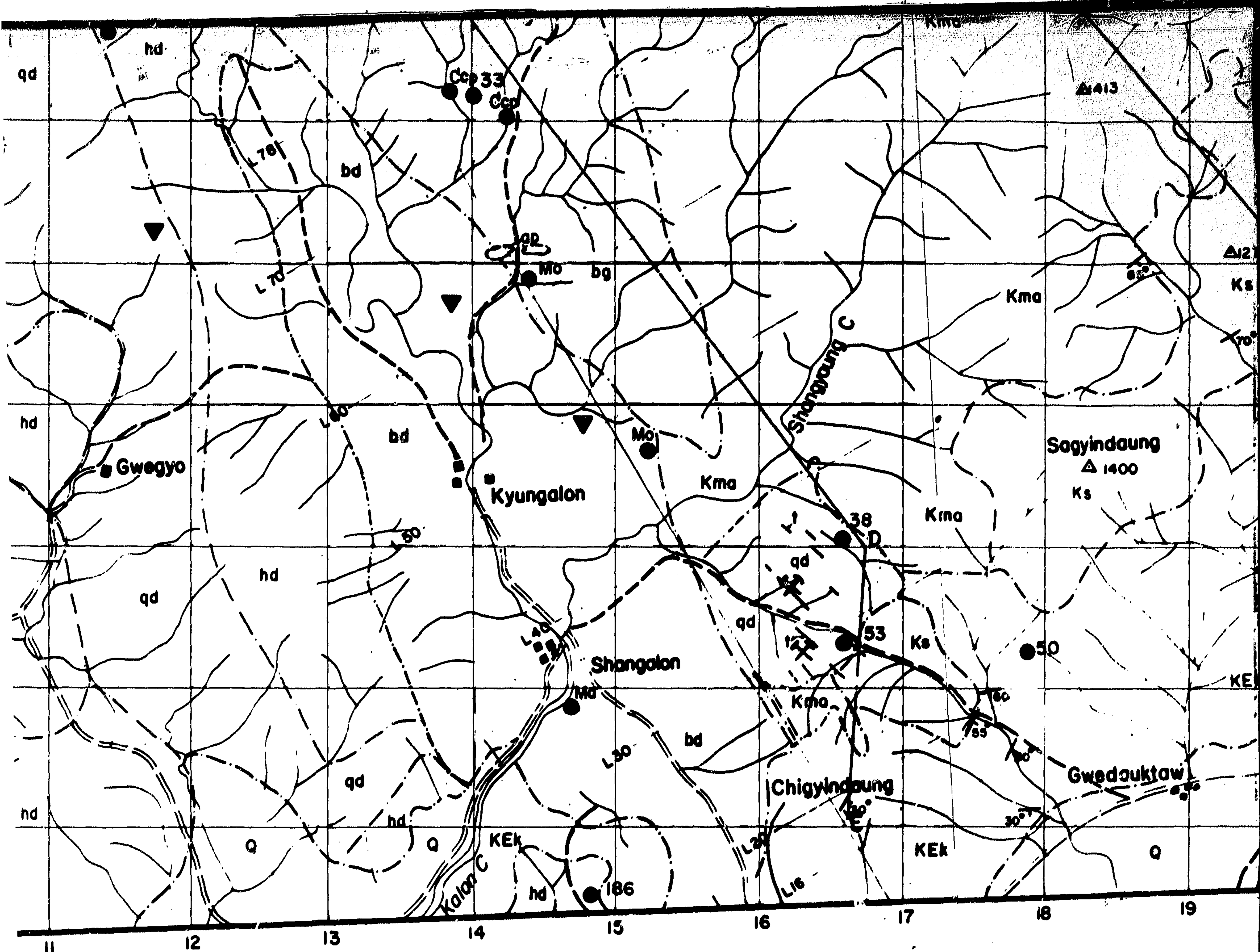




CROSS SECTIONS = AB and CDE

SCALE - HORIZONTAL = 1:31680

VERTICAL EXAGGERATION X 2

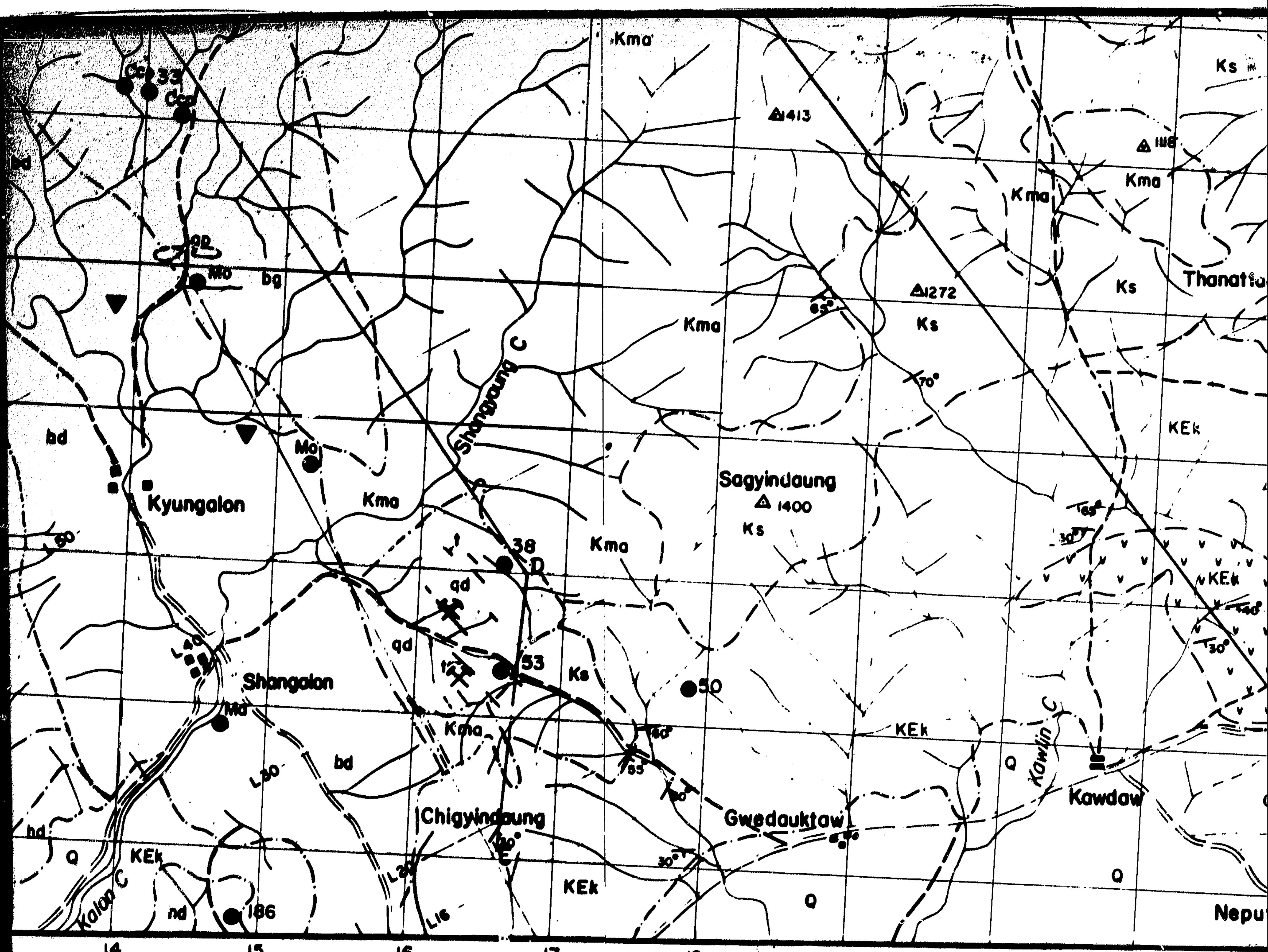


CDE

QUATERNARY	Q	ALLUVIUM
UPPER OLIGOCENE	a	AUKTHITAY
LOWER OLIGOCENE	t/	TONALITE
EOCENE TO LOWER OLIGOCENE	bd	BIOTITE
B LOWER OLIGOCENE	bg	BIOTITE
? LOWER EOCENE TO PALEOCENE	KEk	KETPAND (Kawdaw
UPPER CRETACEOUS	qd	QUARTZ
? UPPER CRETACEOUS	hd	HORNBL
? UPPER CRETACEOUS	ap	APLITIC

)

RATION X 2 APPROX



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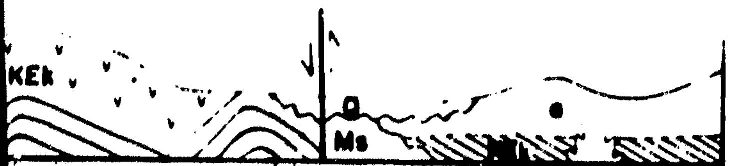


B

QUATERNARY	Q	ALLUVIUM
UPPER OLIGOCENE	a	AUKTHITAYA TRACHYTE
LOWER OLIGOCENE	t/	TONALITE PORPHYRY
EOCENE TO LOWER OLIGOCENE	bd	BIOTITE DIORITE
LOWER OLIGOCENE	bg	BIOTITE GRANODIORITE
? LOWER EOCENE TO PALEOCENE	KEk	KETPANDA Fm (Kawdaw Dacite)
UPPER CRETACEOUS	qd	QUARTZ DIORITE
? UPPER CRETACEOUS	hd	HORNBLENDE DIORITE

● MINERAL

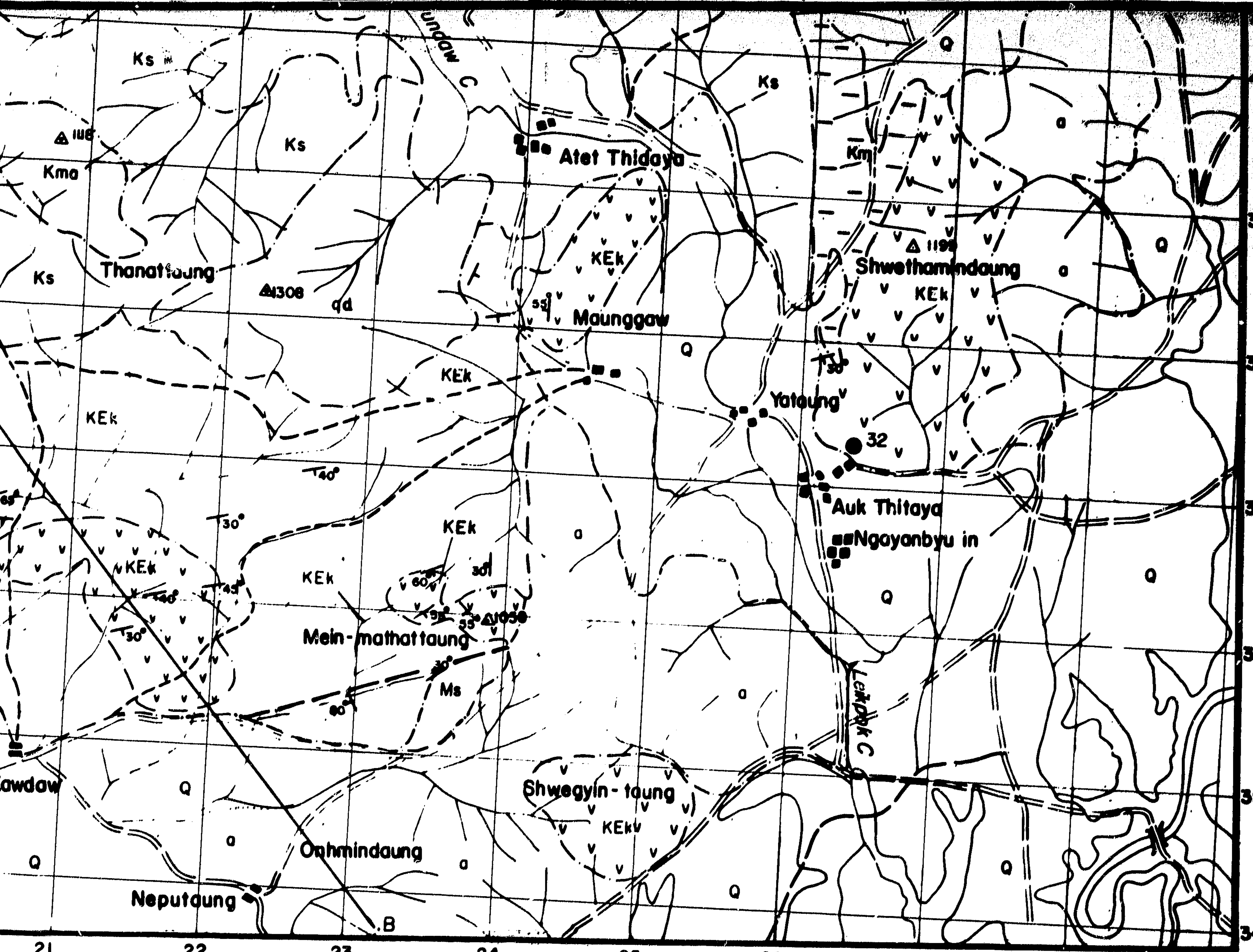
▼ OLD PITS

Ccp CHALC

Mo MOLYB

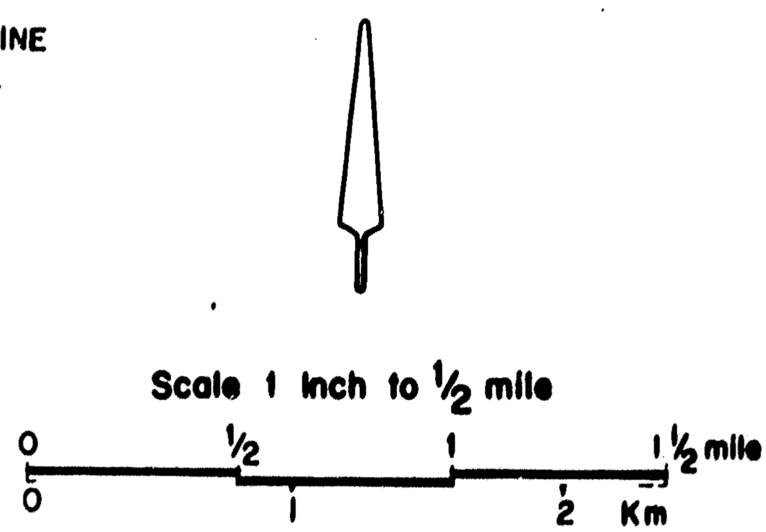
Ma MALAC

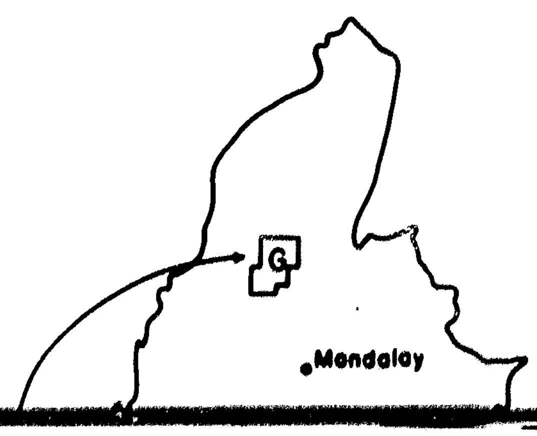
⚒ · SHANG



- ● MINERAL SHOWING
- ▼ OLD PITS AT COPPER SHOWING
- Ccp CHALCOPYRITE
- Mo MOLYBDENITE
- Ma MALACHITE
- ⚒ SHANGALON COPPER PROSPECT
- LITHOLOGICAL BOUNDARY
- DIP AND STRIKE OF BEDDING
- SHANGALON GRID LINE
- Δ ELEVATION IN FEET
- FOOTPATH
- MOTOR ROAD
- ■ VILLAGE

Scale 1 inch to 1/2 mile



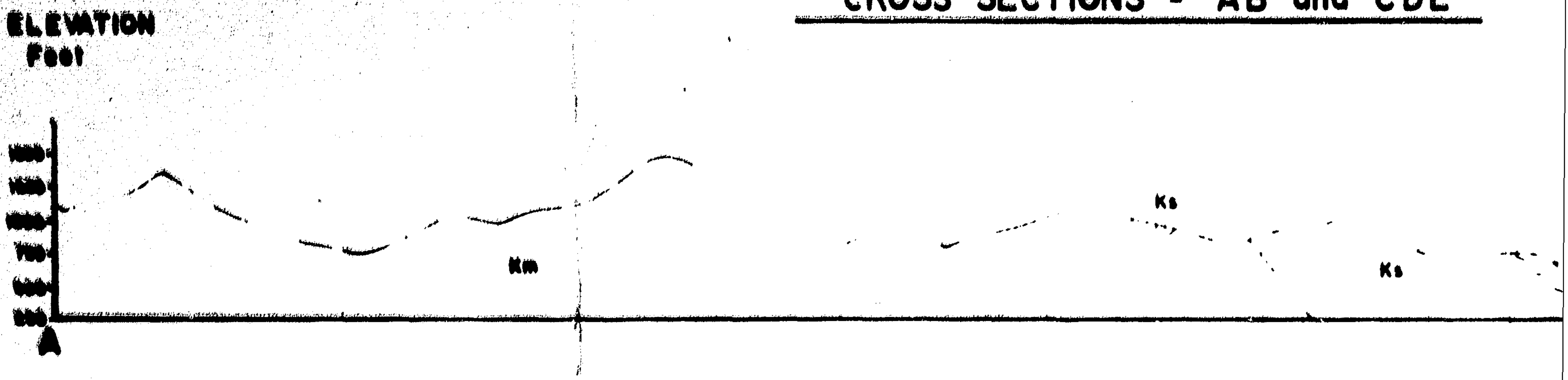


BURMA

Department of Geological Survey and Exploration

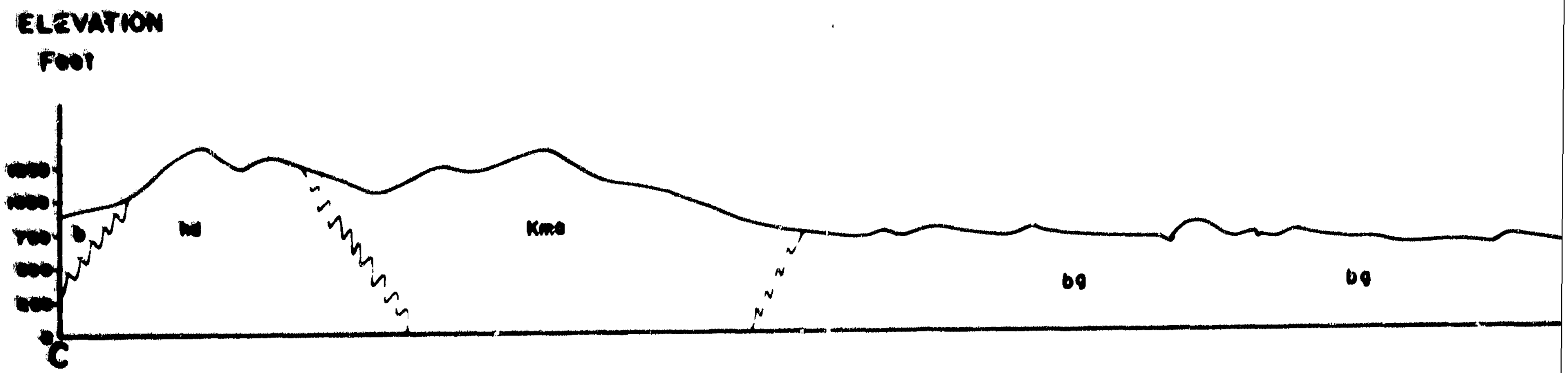
UNITED NATIONS

CROSS SECTIONS = AB and CDE



SCALE - HORIZONTAL = 1:31680

VERTICAL EXAGGERATION X



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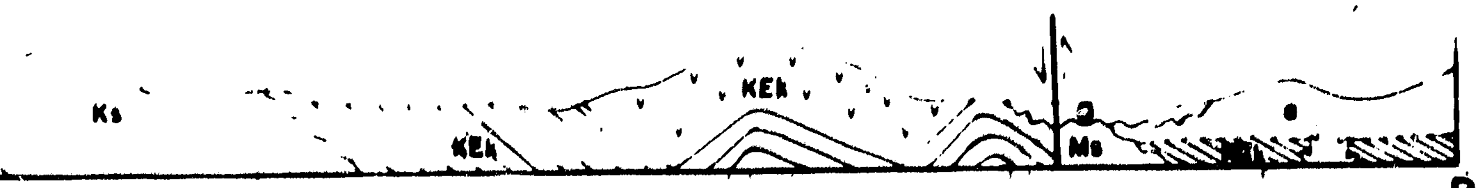
nd CDE



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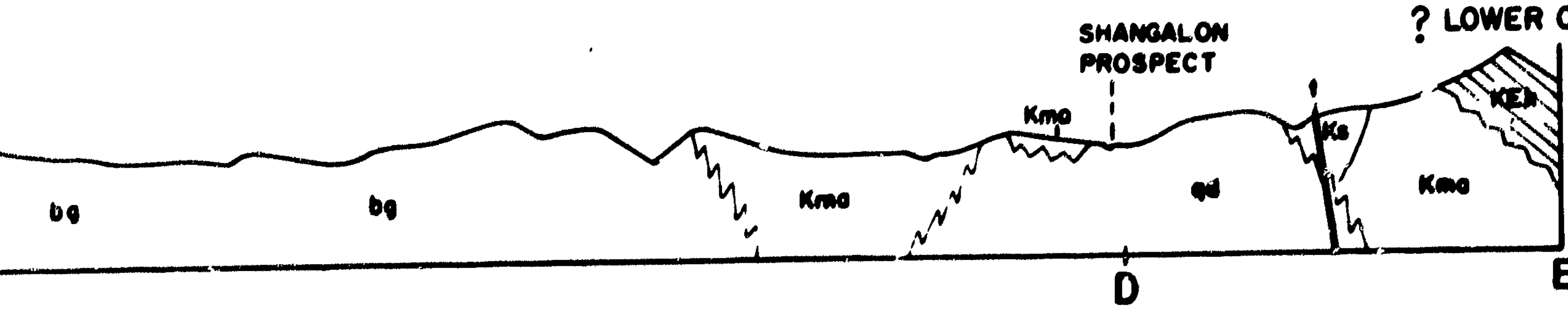
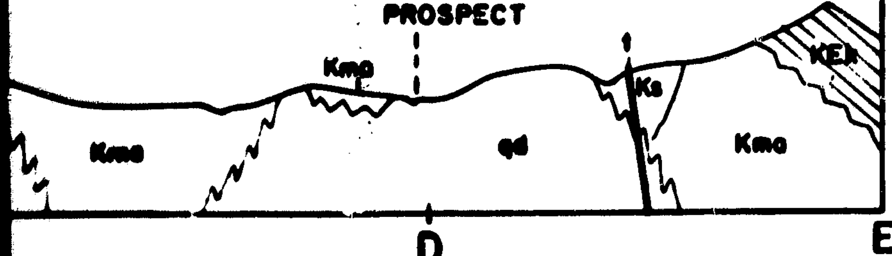
GGERATION X 2 APPROX



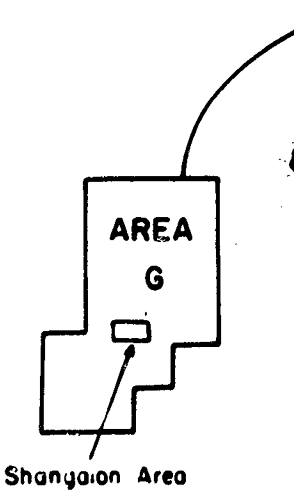
QUATERNARY	Q	ALLUVIUM
UPPER OLIGOCENE	a	AUKTHITAYA
LOWER OLIGOCENE	t/	TONALITE P
EOCENE TO LOWER OLIGOCENE	bd	BIOTITE DIO
LOWER OLIGOCENE	bg	BIOTITE GR
? LOWER EOCENE TO PALEOCENE	KEk	KETPANDA (Kowdaw Dac
UPPER CRETACEOUS	qd	QUARTZ DIO
? UPPER CRETACEOUS	hd	HORNBLEND
? UPPER CRETACEOUS	ap	APLITIC DY
EARLY UPPER CRETACEOUS	b	KANZA CHA
? LOWER CRETACEOUS	Km	MAWLIN Fm
? LOWER CRETACEOUS	Ks	SAGYINDAU
? LOWER CRETACEOUS	Kma	MAWGYI AN
MESOZOIC	Ms	SHWEDAUN

15 16 17 18 19 20 21 22

QUATERNARY	Q	ALLUVIUM
UPPER OLIGOCENE	a	AUKTHITAYA TRACHYTE
LOWER OLIGOCENE	t/	TONALITE PORPHYRY
EOCENE TO LOWER OLIGOCENE	bd	BIOTITE DIORITE
LOWER OLIGOCENE	bg	BIOTITE GRANODIORITE
? LOWER EOCENE TO PALEOCENE	KEk	KETPANDA Fm (Kawdaw Dacite)
UPPER CRETACEOUS	qd	QUARTZ DIORITE
? UPPER CRETACEOUS	hd	HORNBLENDE DIORITE
? UPPER CRETACEOUS	ap	APLITIC DYKE
EARLY UPPER CRETACEOUS	b	KANZA CHAUNG BATHOLITH
? LOWER CRETACEOUS	Km	MAWLIN Fm
? LOWER CRETACEOUS	Ks	SAGYINDAUNG DACITE
? LOWER CRETACEOUS	Kma	MAWGYI ANDESITE Fm
MESOZOIC	Ms	SHWEDAUNG Fm



- ● MINERAL SHOWING
- ▼ OLD PITS AT COPPE
- Ccp CHALCOPYRITE
- Mo MOLYBDENITE
- Ma MALACHITE
- ⚒ SHANGALON COPP



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MINERAL SHOWING

OLD PITS AT COPPER SHOWING

CHALCOPYRITE

MOLYBDENITE

MALACHITE

SHANGALON COPPER PROSPECT

LITHOLOGICAL BOUNDARY

DIP AND STRIKE OF BEDDING

SHANGALON GRID LINE

ELEVATION IN FEET

FOOTPATH

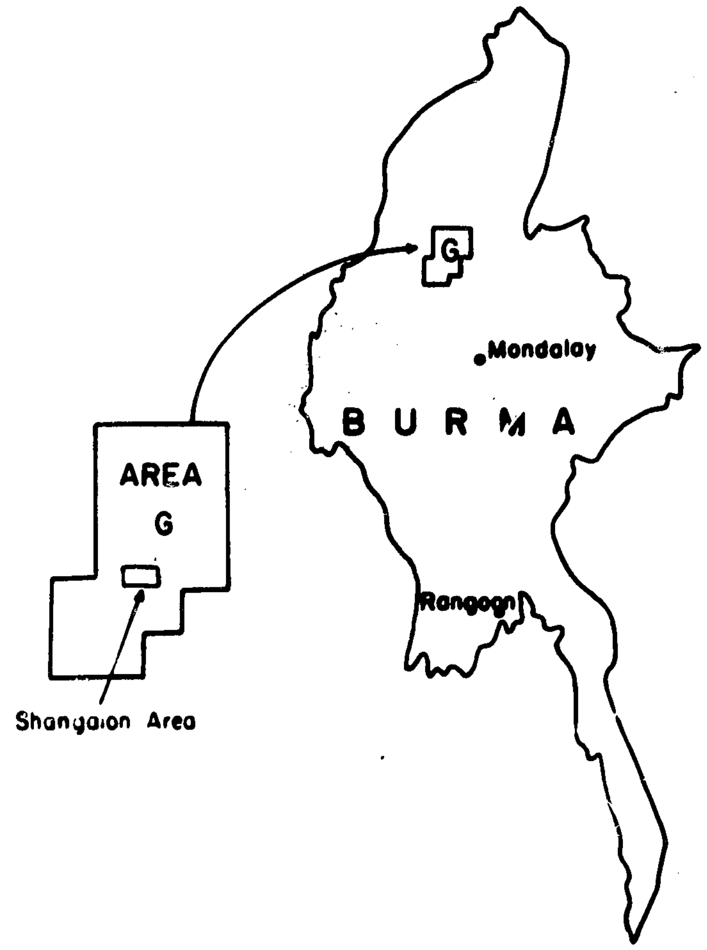
MOTOR ROAD

VILLAGE

Scale 1 inch to ½ mile

0 ½ 1 1½ mile

0 1 2 Km



BURMA

Department of Geological Survey and Exploration

UNITED NATIONS

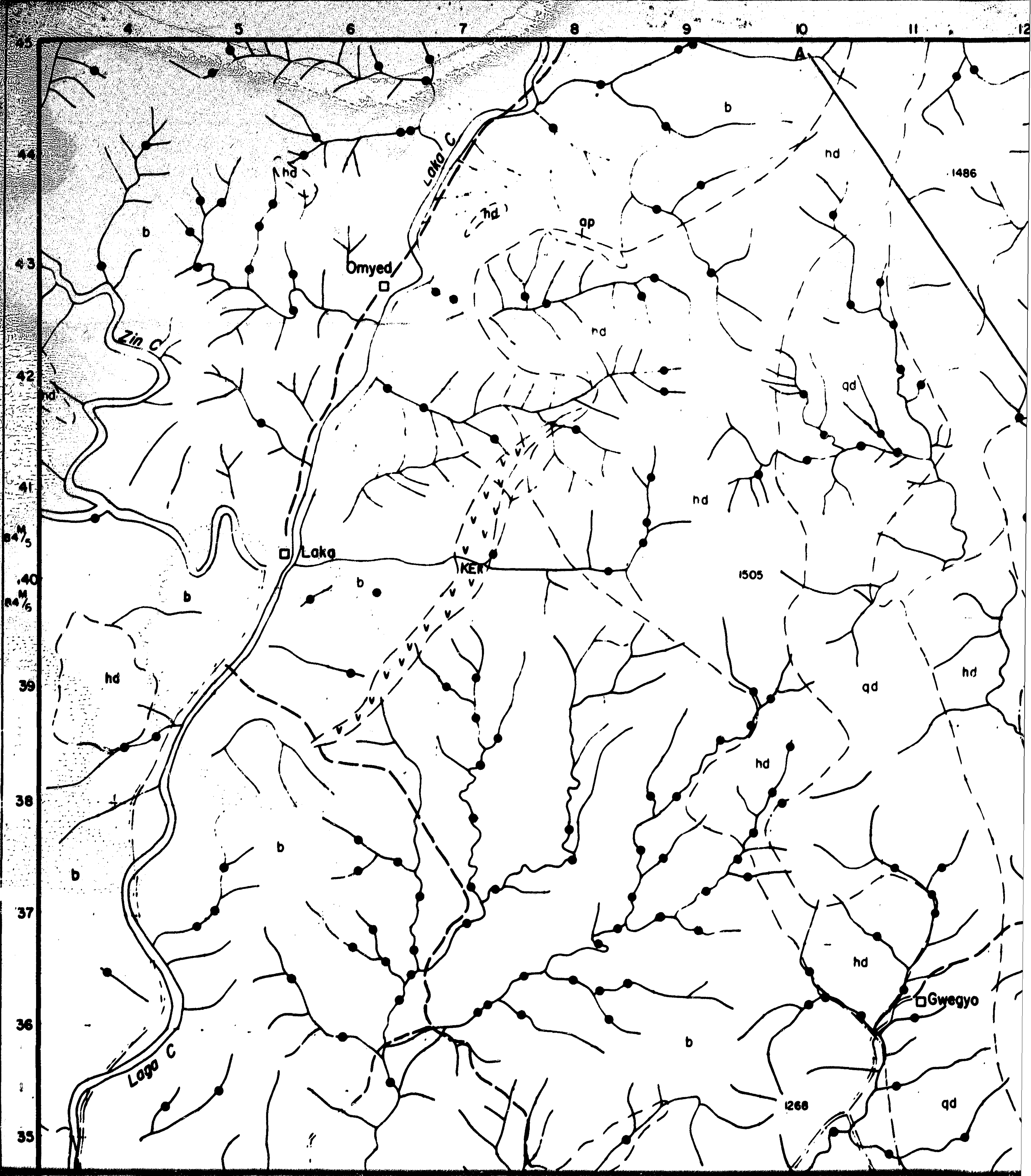
Bur/72/002 Geological Survey and Exploration Project

Geology of the area around Shangalon, Kawlin Township, Northern Burma.

Figure 22

Traced by Tin Wan

START 5



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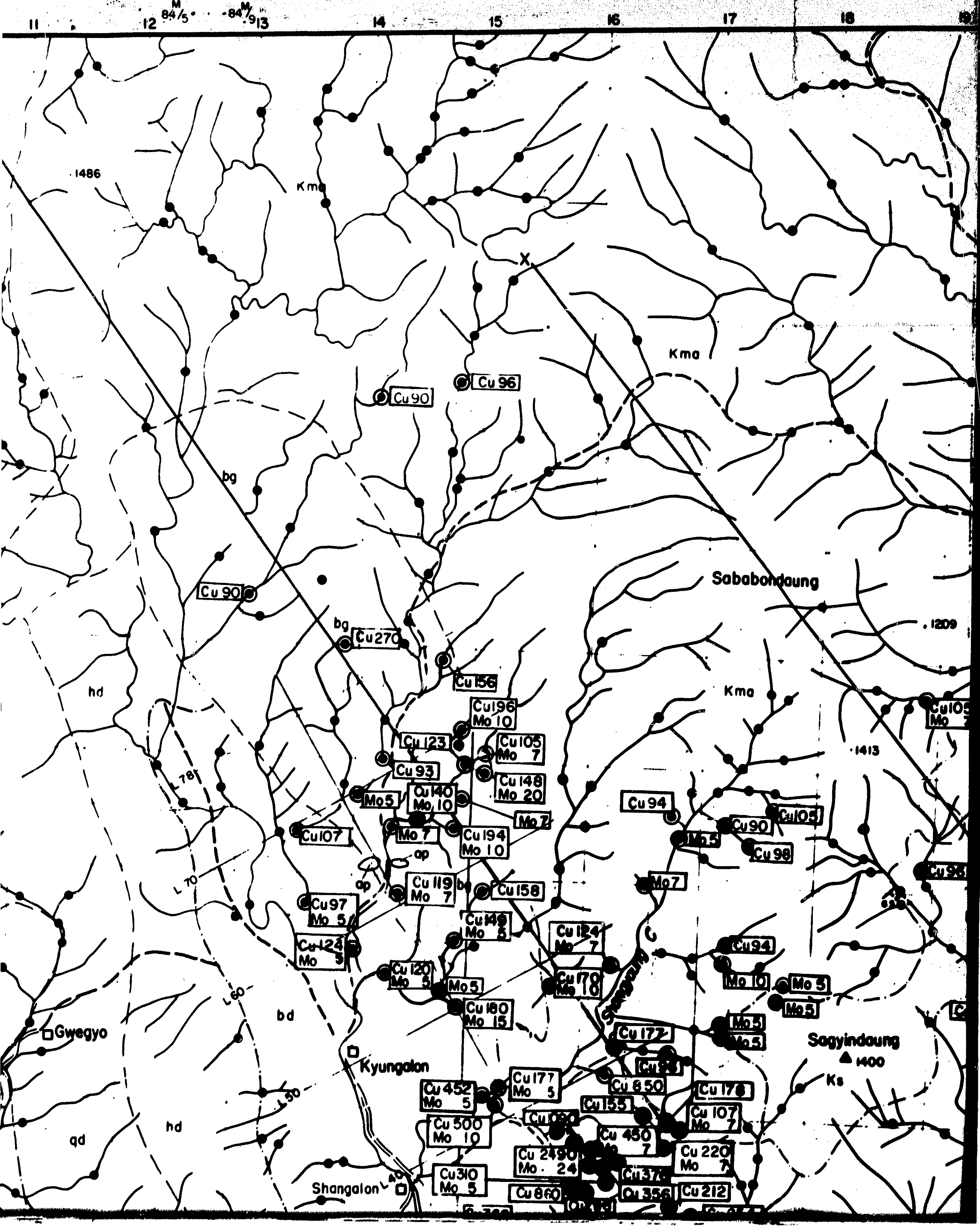

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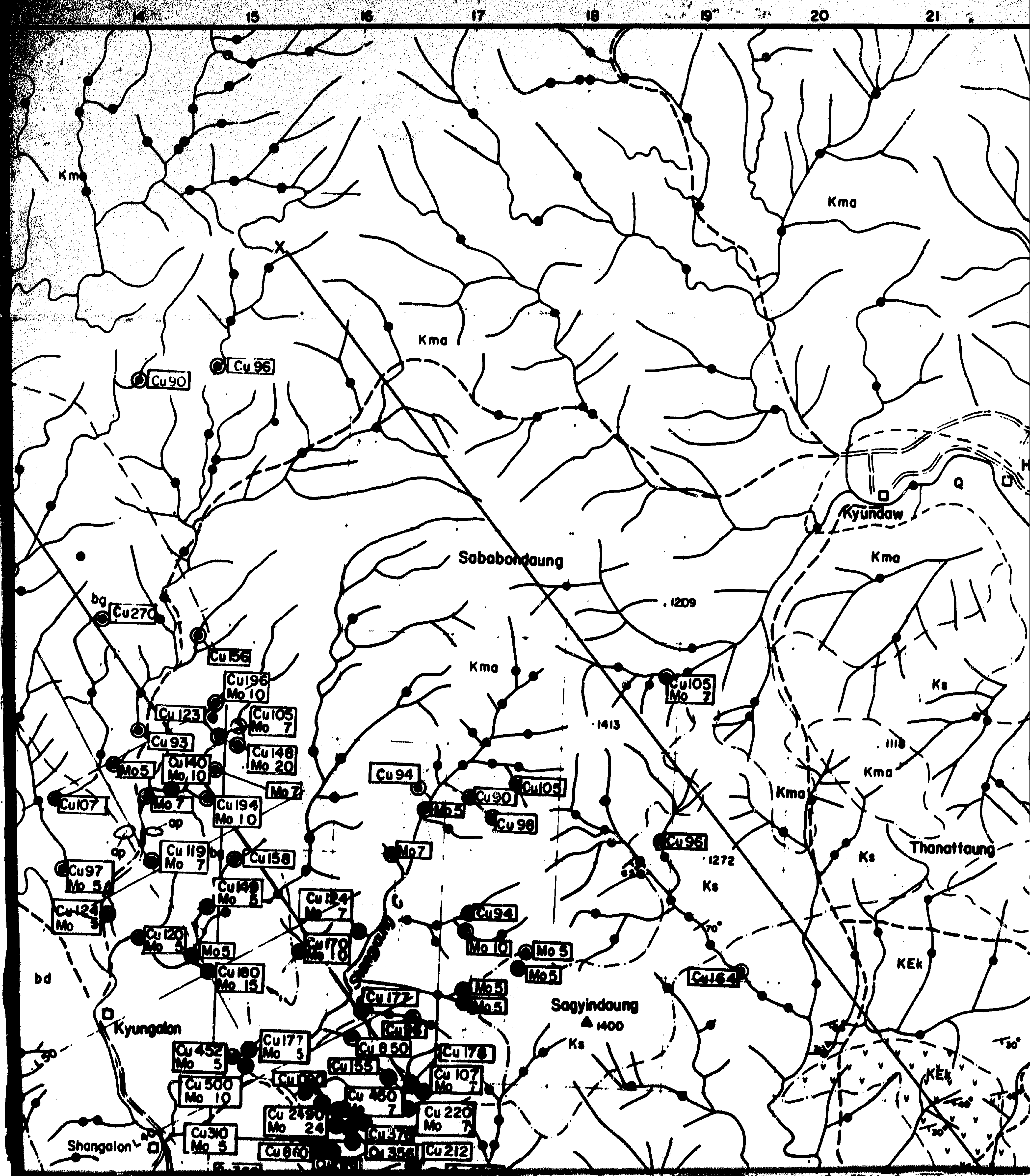

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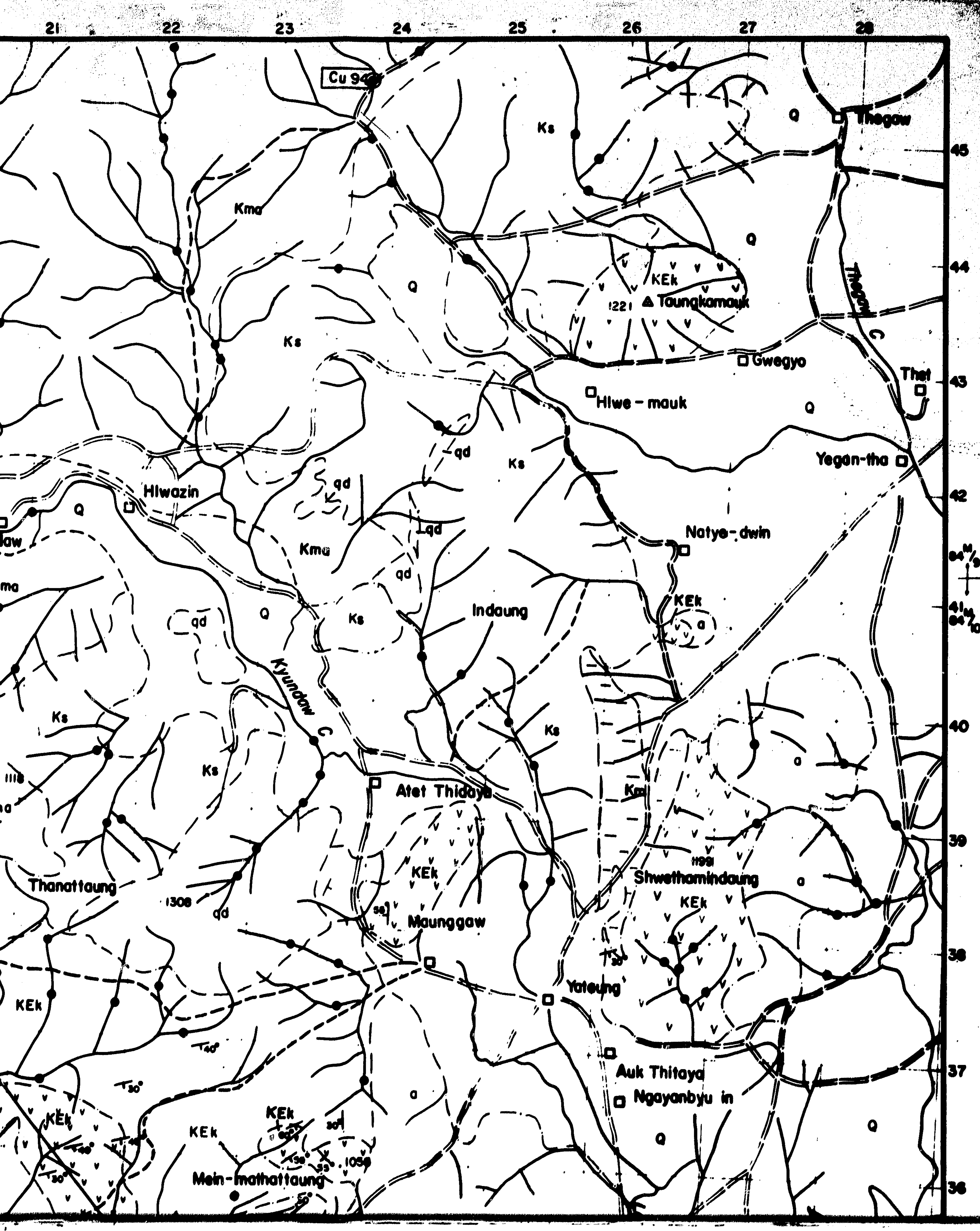

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Maunggaw
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Mein-mathattaung
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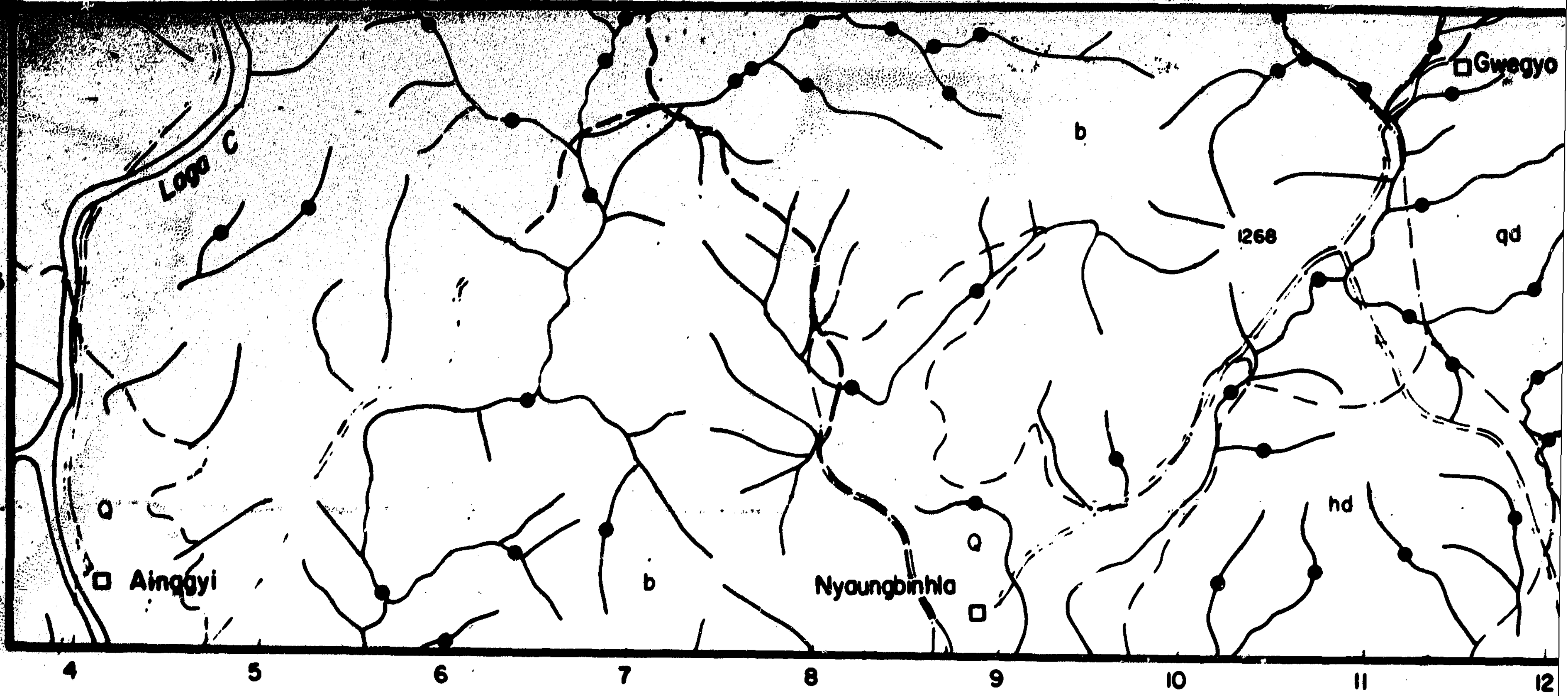
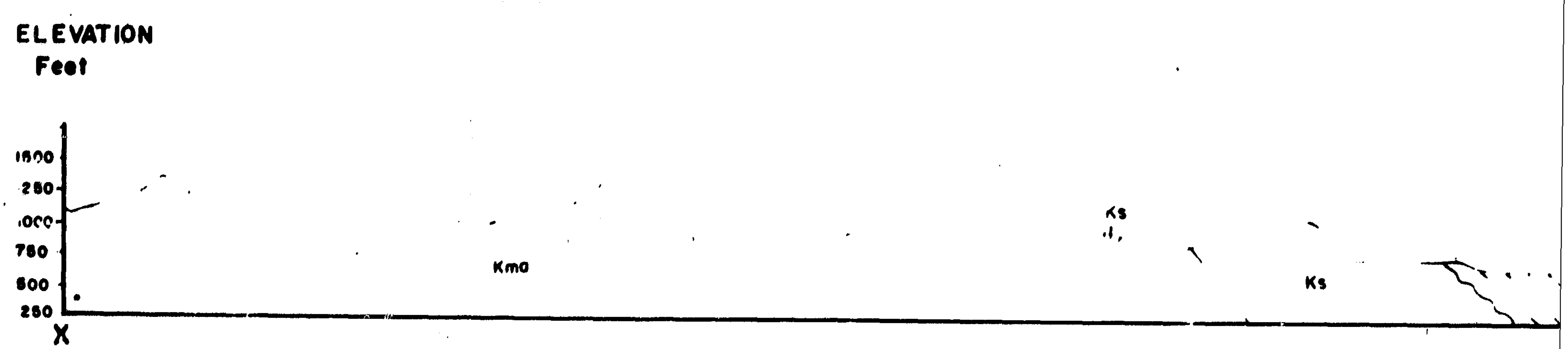
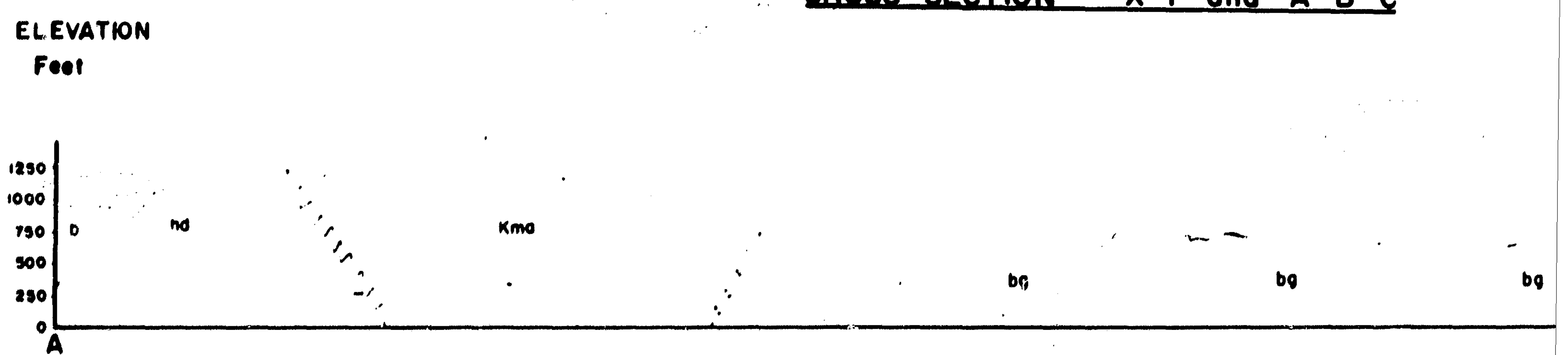


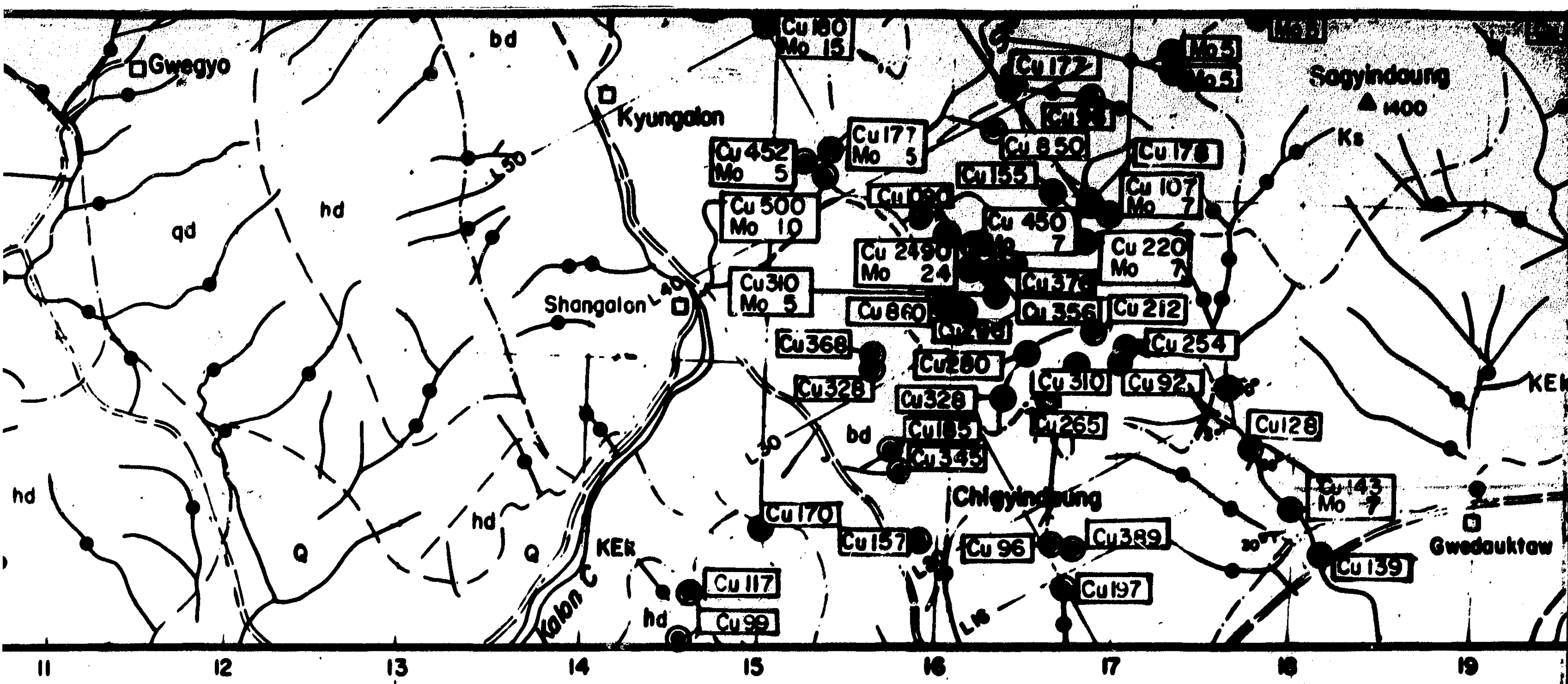


SCALE - HORIZONTAL = 1:31680

VERTICAL EXAGGERATION X 2

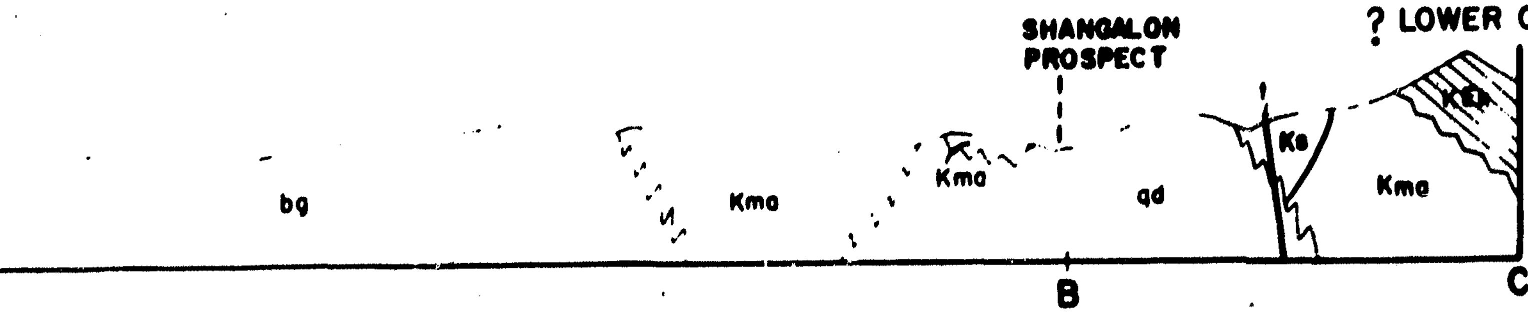
<u>CROSS SECTION = X Y and A B C</u>



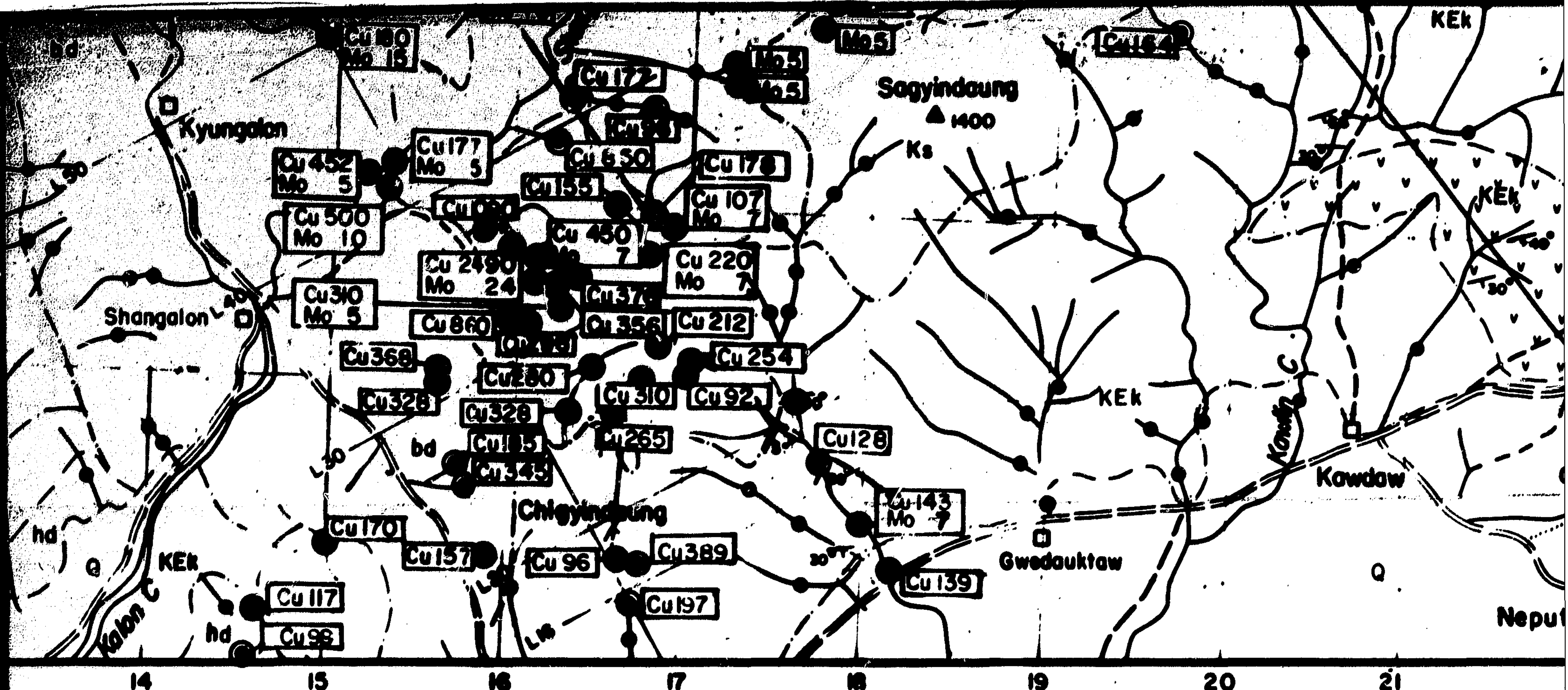


ATION X 2 APPROX

B C



QUATERNARY	Q	ALLUVIUM
UPPER OLIGOCENE	a	AUKTHITAYA
? OLIGOCENE	/	ANDESITIC
LOWER OLIGOCENE	t /	TONALITE
EOCENE TO LOWER OLIGOCENE	bd	BIOTITE DI
LOWER OLIGOCENE	bg	BIOTITE GR
? LOWER EOCENE TO PALEOCENE	KEk	KETPANDA (Kawdow Do
UPPER CRETACEOUS	qd	QUARTZ DIO
? UPPER CRETACEOUS	hd	HORNBLEND
? UPPER CRETACEOUS	ap	APLITIC DY
EARLY UPPER CRETACEOUS	b	KANZA CHA
? LOWER CRETACEOUS	Km	MAWLI... F
? LOWER CRETACEOUS	Ks	SAGYINDA
? LOWER CRETACEOUS	Kma	MAWGYI A
MESOZOIC	Ms	SHWEDAU



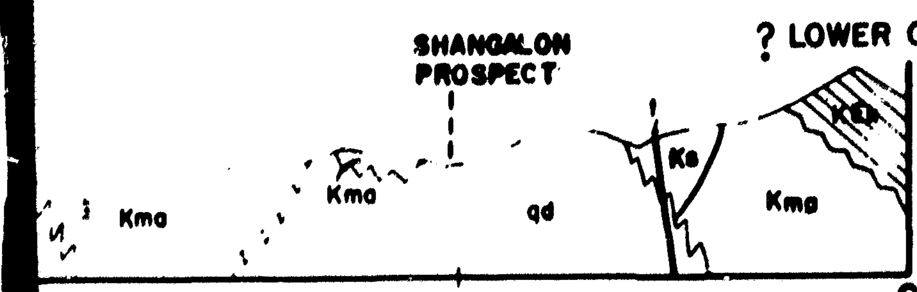
M/10

QUATERNARY	Q	ALLUVIUM
UPPER OLIGOCENE	a	AUKTHITAYA TRACHYTE
? OLIGOCENE	/	ANDESITIC DYKES AND SILLS
LOWER OLIGOCENE	t /	TONALITE PORPHYRY
EOCENE TO LOWER OLIGOCENE	bd	BIOTITE DIORITE
LOWER OLIGOCENE	bg	BIOTITE GRANODIORITE
? LOWER EOCENE TO PALEOCENE	KEk	KETPANDA Fm (Kawdaw Dacite)
UPPER CRETACEOUS	qd	QUARTZ DIORITE
? UPPER CRETACEOUS	hd	HORNBLENDE DIORITE
? UPPER CRETACEOUS	ap	APLITIC DYKE
EARLY UPPER CRETACEOUS	b	KANZA CHAUNG BATHOLITH
? LOWER CRETACEOUS	Km	MAWLIN Fm
? LOWER CRETACEOUS	Ks	SAGYINDAUNG DACITE
? LOWER CRETACEOUS	Kma	MAWGYI ANDESITE Fm
MESOZOIC	Ms	SHWEDAUNG Fm

• STREAM SED

Cu 389 ● COPPER VAL

Mo7 ● MOLYBDENUM



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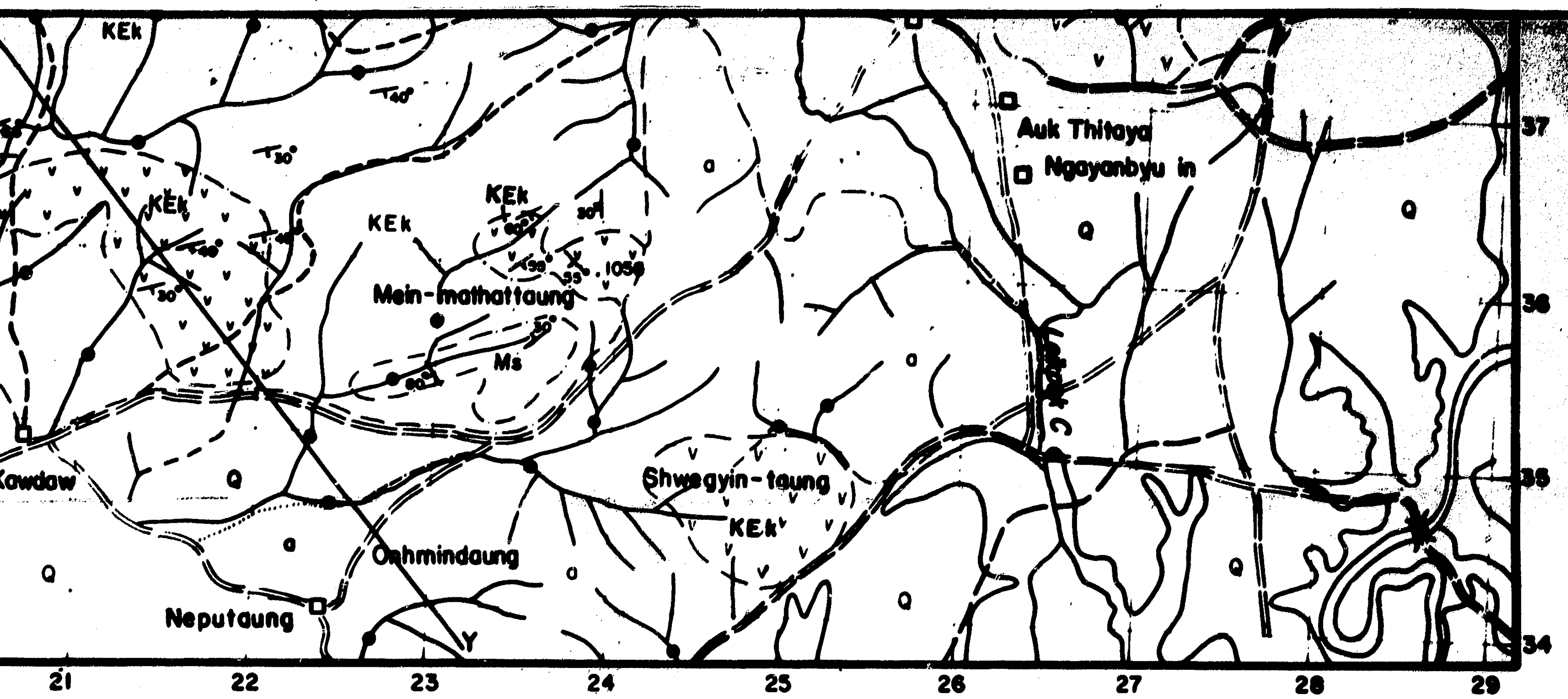


● STREAM SED. SAMPLING SITE

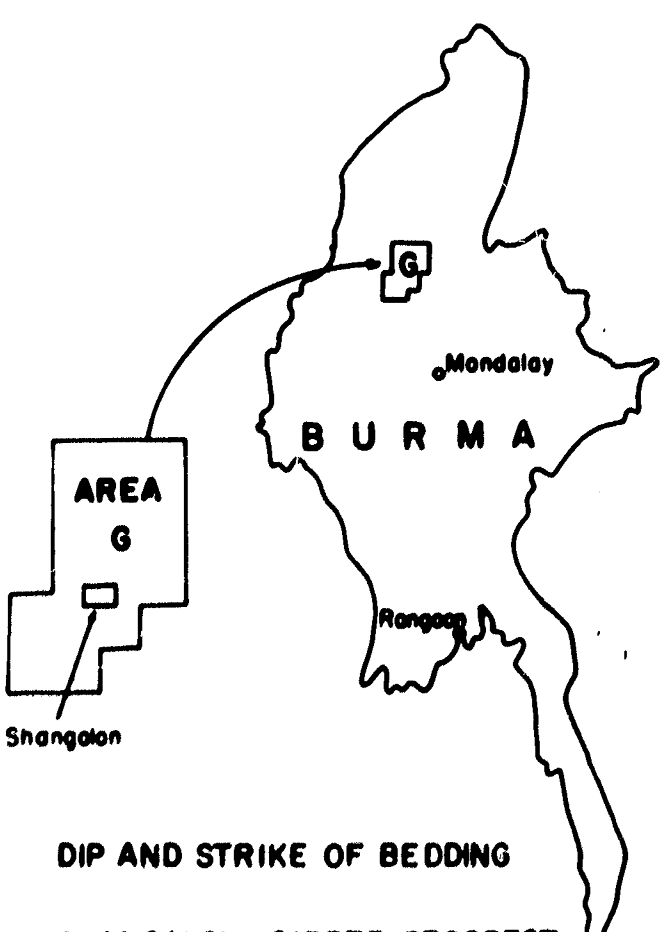
389 ● COPPER VALUES ≧ REGIONAL THRESHOLD (90 PPM)

Mo7 ● MOLYBDENUM ≧ 5 ppm (arbitrary value)

Scale 1 inch to ½ mile

0 ½ 1 1½ mile

0 1 2 Km



DIP AND STRIKE OF BEDDING

SHANGALON COPPER PROSPECT

GRID LINE FOR DETAILED WORK

BURMA Department of Geological Survey and Mineral Exploration UNITED NATIONS Bur/72/002 Geological Survey and Exploration Project			
SHANGALON SURROUNDINGS STREAM SEDIMENTS COPPER / MOLYBDENUM			
	TIN WAN	Figure 23	

UNITED NATIONS NATIONS UNIES

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REFERENCE: EC 132/226/2 BURMA (12)

I have the honour to refer to the project "Geological Survey and Exploration (BUR-72-002)" undertaken in Burma with the assistance of the United Nations Development Programme, for which the United Nations served as executing agency, and to transmit a technical report (No. 2) of the United Nations entitled "Geology and Exploration Geochemistry of the Pinlebu-Banmauk Area, Sagaing Division, Northern Burma" (DP/UN/BUR-72-002/11).

The report covers the geologic mapping and reconnaissance geochemical work carried out by the United Nations and the Burmese personnel during the period October 1974 to May 1975 in the Pinlebu-Banmauk Area, comprising 9,670 sq km.

The stratigraphy and structure of the area together with the provisional ages of a batholith and plutons were determined; three geologic map sheets were also prepared.

Geochemical reconnaissance involved the taking of 7,082 stream-sediment samples, on which 37,024 element determinations were performed. The anomalous zones disclosed were the subject of further investigations, the results of which have been presented in Technical Reports Nos. 1 and 6. It is recommended that limited further investigation be made of a quartz-magnetite occurrence west of Banmauk.

We should appreciate your informing us, through the Office of the Resident Representative of the United Nations Development Programme, of your Government's comments on the report.

This report represents technical contributions prepared with the co-operation of the United Nations Development Programme. In conformity with the agreement governing such co-operation, the report should be available for utilization by all interested parties. We should therefore appreciate your Government's agreement to the derestriction of the report so that it may be placed on open file and made available to all interested parties. Yous Government's concurrence to derestriction will be assumed, unless you inform us, within six months of the date of this letter, that you wish the report to remain restricted.

Accept, Sir, the assurances of my highest consideration.

Findley Burns, Jr.
Director of Operations
Department of Technical Co-operation
for Development