SURVEY REPORT
ON
THE PROMOTION OF IRON AND STEEL INDUSTRY IN NEPAL

JULY 1966

GOVERNMENT OF JAPAN

PREFACE

The Japanese Government, by request of the Nepalese Government, decided to dispatch an investigation group to that country with a view to cooperation in her iron manufacturing project, and requested us Overseas Technical Cooperation Agency, an executive organization belonging to the government, to enforce the decision.

The Agency thus composed an investigation group consisting of five specialists in that line, who made fundamental examinations in Nepal to draft an iron making project during a period of 45 days starting close to November 1965.

This report has been prepared as the result of the actual investigations thus made.

It will be our great pleasure for economical cooperation and friendship between the two nations if this report helps the iron making and resultantly industrial development in Nepal.

We deeply acknowledge favours of the Nepal Government and the people concerned who have given their hearty assistance and cooperation for execution of the investigations.

July 1966

Shinichi Shibusawa
Director General
Overseas Technical Cooperation Agency

CONTENTS

List of Drawings

I Introduction

1.1 Purpose of the survey

This survey has been carried out to answer the request of the Government of Nepal as a part of the industrial development plan of the country. Thus the survey deals with the development of such natural resources of the country as iron ore, limestone and woods as well as the plan itself of the establishment of the iron and steel works. Research has been made to give the Government recommendations about the facility of the proposed establishment plan of the iron and steel works, its scale, process of operation and the kinds of the product through investigation of:

1. Possibility and method of exploitation of the iron ore and limestone resources
2. Possibility and method of charcoal production using woods resources
3. Steel demands and the availability of proposed plant site

1.2 Outline of the survey including the schedule

The period and the area of the survey are as follows:

(a) Period

Iron-making group	30 days
Mining group	45 days

(b) Area

Iron deposits.	Phulchoki and Labdi deposits
Limestone deposits:	Bhainse and Chobhar deposits
Forest:	Birganji and Chitwan districts
Plant sites:	Hetaura and Amlekhganj districts
Markets:	Kathmandu Valley, Hetaura, Amlekhganj and Pokhara districts

(c) Works and Plants inspected for reference

Himal Iron & Steel Company
Timber Cooperation of Nepal
Hetaura Diesel Power Station
National Sugar Mill
Hetaura-Kathmandu Rope-Way Station

(d) Visiting Government Offices for collecting materials

Department of Industry, Industry & Commerce Ministry
Department of Commerce, Central Bureau of Statistics, Economic Planning Ministry

Department of Forest, Forest & Agriculture Ministry

Department of Electricity, Irrigation & Power Ministry

Department of Customs & Excise, Finance Ministry

Bureau of Mines

(e) Organization of the survey party

Leader, Iron-making group,		Mr. Y. Matsubayashi
Member,	do.	Mr. T. Yasumoto
do.	do.	Mr. Y. Furukawa
do.	Mining group	Mr. T. Kikuchi
do.	do.	Mr. S. Hamabe
do.	do.	Mr. H. Matsushita

(f) Schedule

Date		Mining Group	Iron-making Group
Nov.	22 Mon.	Leave Tokyo -- Arrive Calcutta	
	23 Tues.	Visit J.C.I. and Inst. of Geological Survey Calcutta -- NewDelhi	Leave Tokyo--Arrive in NewDelhi
	24 Wed.	Visit Japanese Embassy and Nepalese Embassy	
	25 Thur.	Leave NewDelhi Arrive in Kathmandu	
	26 Fri.	Visit Bureau of Mines. Investigation of the shedule and necessary materials	
	27 Sat.	Collection of data and references Arrangement of the equipments and materials regard to investigation	Visit the Department of Forest, the Department of Import & Export, and the Department of Industry
	28 Sun.	Preparation for the survey of Phulchoki deposit and Chobhar limestone deposit	Visit the Department of Forest and the Department of Electricty
	29 Mon.	ditto	
	30 Tues.	Move from Kathmandu to Phulchoki. Camp on hill side	Visit Forest Adminstration
Dec.	1 Wed.	Survey of Phulchoki Mine	Go from Kathmandu to Parawanipur via Tribhawan Rajpath
	2 Thur.	ditto	Inspection of Himal Iron & Steel, Birganj Sugar Mill, Birganj Forest District
	3 Fri.	ditto	Inspection of Timber Corp. of Nepal and Birganj Forest
	4 Sat.	ditto	Inspection of Hetaura Diesel Electric Power Station and Chitwan Forest District
	5 Sun.	ditto	Inspection of Hetaura Rope Way Terminal. drop in Hetaura and came back to Kathmandu
	6 Mon.	Discussion with Iron-making group	Inspection of Phulchoki Mine

Date		Mining Group	Iron-making Group
Dec.	7 Tues.	Survey of Mine	Discussion with Nepalese Bureau of Mines about Collected data of the survey
	8 Wed.	ditto	ditto
	9 Thur.	Close the Camp and go back to Kathmandu	Discussion with Mining group in the evening
	10 Fri.	Adjustment of Samples and data, Examination of further schedule with the Bureau of Mines	A member, Mr. Yasumoto returns to Japan Examination of the materials
	11 Sat.	Preparation for the survey of Bhainse and Labdi Mines	Meeting with the Bureau of mines in the afternoon
	12 Sun.	Leave Kathmandu to Bhainse	Examination of the materials
	13 Mon.	Survey of Bhainse Mine	From Kathmandu to Pokhara Survey of Pokhara district
	14 Tues.	ditto	Survey of RopeWay Kathmandu Station
	15 Wed.	ditto	Discussion with the Bureau of Mines regard to steel-making process
	16 Thur.	ditto	Mr. Matsubayashi, the leader of the party leaves the country. Consultation with a related person of the Bureau of Mines (Dr. M. N. Rana)
	17 Fri.	ditto	ditto (Dr. M. N. Rana)
	18 Sat.	ditto	ditto (Dr. M. N. Rana)
	19 Sun.	Leave Bhainse for Labdi and stay overnight in Jugedi	ditto (Dr. M. N. Rana)
	20 Mon	Leave Jugedi and stay overnight in Ghainhat	Mr. Furukawa leaves Kathmandu and stay overnight in Delhi
	21 Tues.	Leave Ghainhat and stay overnight in Labdi	Visit J. C. I
	22 Wed.	Survey of Labdi Mine	Mr. Furukawa leaves Delhi arrives in Tokyo
	23 Thur.	ditto	
	24 Fri.	ditto	
	25 Sat.	Leave Labdi and stay overnight in Ghainhat	
	26 Sun.	Leave Ghainhat and stay overnight in Bhainse	
	27 Mon.	Leave Bhainse and stay overnight in Kathmandu	
	28 Tues.	Classification of the survey materials and samples Consultation with the Bureau of Mines	
	29 Wed.	Classification of collected materials and preparation for leaving for Chobhar	
	30 Thur.	Survey of Chobhar	
	31 Fri.	ditto	

Date		Mining Group	Iron-making Group
Jan.	1 Sat.	Preparation for sending back of the survey equipments and the materials	
	2 Sun.	Preparation for going back home Greeting the president of the Bureau of Mines and the vice president of the Bureau of Commerce & Industry in the afternoon	
	3 Mon.	Leave Kathmandu, Arrive in NewDelhi	
	4 Tues.	Greeting Japanese Embassy in India	
	5 Wed.	Leave NewDelhi, Arrive in Tokyo	

II Conclusions and Recommendations

2.1 Introduction

In reference to the basic data supplied by the Government of Royal Nepal, the survey party has made investigations of the raw materials for the proposed project of iron and steel industry in Nepal in view of:

Iron ore resources (Phulchoki & Labdi deposits),
Limestone resources (Bhainse & Chobhar deposits) and
Forest resources (Hetaura district).

The investigation was made also about the conditions of transportation, demands for product, availability of electric power, water and other utilities. The facility of the establishment of the iron and steel works, justifiable production scale and operating process of the iron-making has been examined to reduce following conclusions and recommendations.

2.2 Development of the iron ore and limestone resources

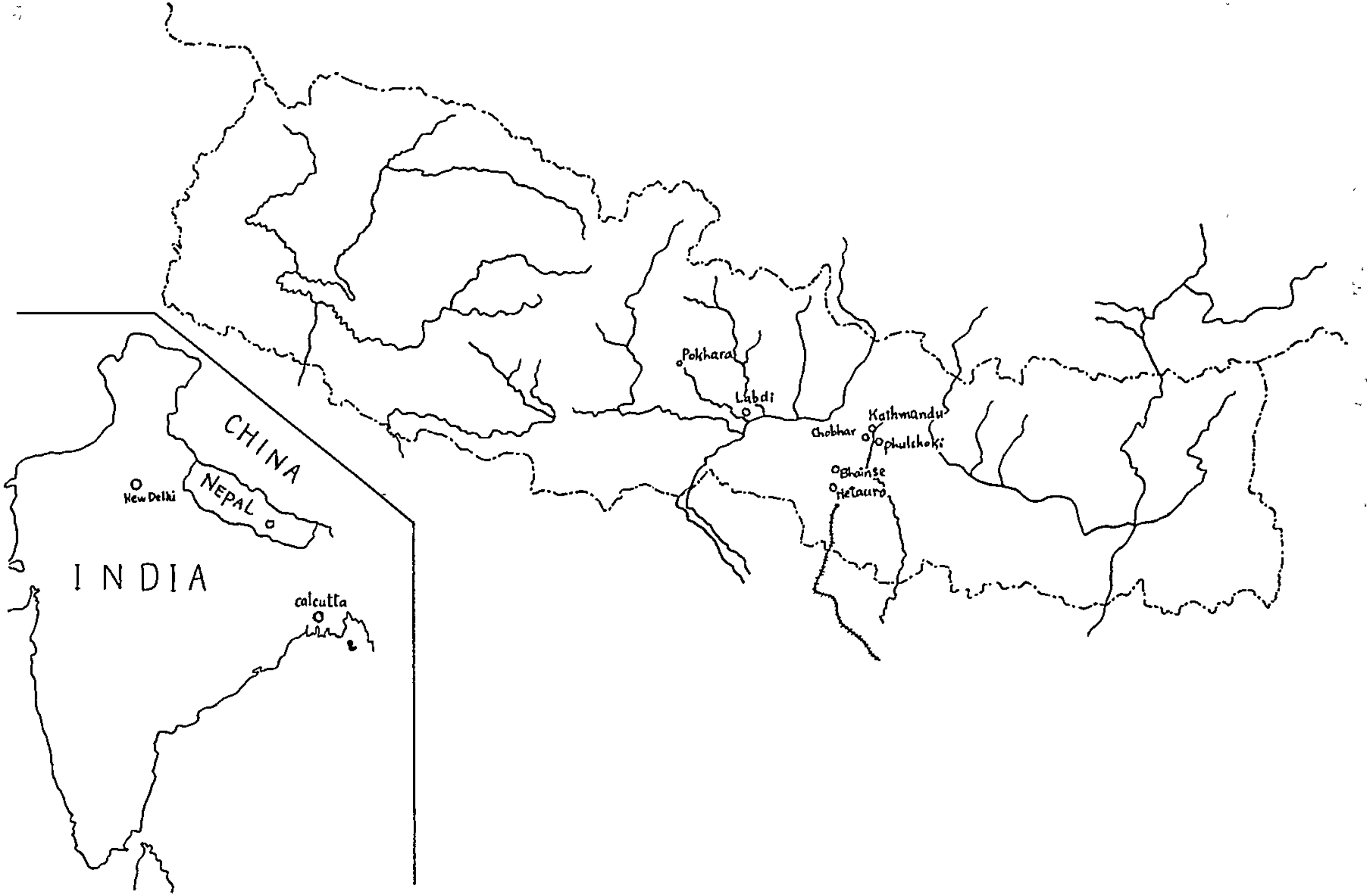
Our survey program was restricted to Phuluchoki and Labdi deposits because of the limited schedule and the lack of adequate transport facilities. It was informed that other deposits including Thosay were confirmed and some of them were developed in a small scale to supply for the local demands. These other deposits seem to deserve further investigation, however, considering the present conditions.

To compare the two iron deposits investigated, Labdi ore is sensitive to degradation, requiring, as a result, pelletizing. This makes it inadequate for the simple preparation plant to be operated in a small scale of production as presently conceived. Labdi deposit was excluded from the present planning because of, in addition to the shortcoming pointed above, (1) the lack of proof for the total reserves, (2) the low grade of ore and (3) the lack of transportation facilities. Further inquiry will be needed in future to cope with the increase in demands for steel in the country.

Concerning the Phulchoki ore deposit, whose depth is not yet confirmed sufficiently, the probable ore reserves can be estimated at about two million tons to permit 50, 000 to 60, 000 tons of production per year. As the difficulties in this case can be said: (1) inconvenience for transportation (2) inconsistent availability of water and the place for waste disposal. Although these difficulties are fatal for the location of a mine, they must be overcome at the inevitable expense of high production cost. Urgently required for this deposit, too, is the prospecting to the depth of the ore body.

As for limestone, the investigation was made on Bhainse and Chobhar deposits. The former is large in scale but is banded by gangue minerals such as

Location Map of Survey Sites.



phyllite separating thin layers of limestone. Furthermore the limestone itself is low in CaO content and high in sulphur, and it is not suitable for the flux of ferrous metallurgy. To consider the use of upper part of Chobhar deposit, CaO content is as low as 36.5% because of the heavy intervention of slate layers. This will result in such a drawback that larger amount 0.8t of limestone is required per ton of pig iron. If the lower part of the deposit is worked, on the other hand, the limestone ratio in iron-making operation will decrease, while 2-3 m^3 of overburden will have to be removed per ton of limestone and, at the same time, the elongation of the gallery will necessarily increase. The resultant needs for engineering machines for stripping and drainage will not be justified by the small scale production under consideration.

Taking into consideration, too, that the transportation will cost about Rs. 50/ton, it seems advantageous to import limestone from India, as in Birgenj sugar mill, supposing that the iron smelter is built at Hetaura.

2.3 Establishment of the iron and steel works

First, we have to consider about supply conditions of iron ore, limestone and reductant as the principal materials for iron-making. Let us suppose that iron ore is supplied from Phulchoki deposit and limestone is imported from India instead of developing Bhainse or Chobhar, the former because of its inferior quality and the latter because of high mining and transportation costs. Charcoal producted in Birganj Forest District are to be used for reductant.

Although steel scrap is useful for steel-making, we assume that it is not available in the country and the import from India also was abandoned.

It was confirmed that both iron ore and charcoal resources are sufficient to supplying for the charcoal-blast furnace of up to 50 tons per day at the maximum.

Survey of iron and steel market indicates, however, that the demands for steel (steel rods of middle or small size of which domestic production is possible) is 15,000 t/year, while the demands for cast iron is trivial. On this basis it may well be considered to establish a 50 t/day blast furnace and correspondingly a steel-making shop for crude steel of 18,000 t/year. But, taking into account that scrap steel is not available in the country, application of the L.D. converter process can be used on economic base if the daily capacity exceed 150 tons. As a small scale steel-making process of about 50 t/day nothing can be probable but the electric furnace process with de-siliconization by oxygen. Considering the high installation cost, and additionally the high production cost, of this process as well as the technical difficulties involved, it seems infeasible to establish steel-making shop and the rolling works which follows.

If the scrap steel constituting 70% of the steel-making materials (35 t/day of scrap steel in the case of 50 t/day production) can be obtained at the international market price, refining operation by electric arc furnace will be much easier. It must be calculated further that even the steel-making furnace of 20 t/day necessitates 3, 500 KVA of electric power, too heavy for the capacity of Hetaura Diesel Power Station (4, 500KW).

Production of cast iron made from foundry iron was investigated, too. Demands for foundry products is far below the level of 5, 760 t/year (16 t/day) which is the production rate (by foundry iron) of the smallest size of charcoal-blast furnace. Therefore, the establishment of blast furnace neither 50 t/day nor 20 t/day capacity is not adequate under present conditions.

The demands for charcoal pig, however, is expected to increase in future together with the industrial development, since it is useful as the raw matearial of high quality cast iron for vehicle industry, stripping rolls and cast iron products such as ingot mould as well as for producing special steel. As no charcoal pig is produced in India, there can also be expected of export to India. If Himal Iron and Steel Co. constructs an electric furnace, it will require 2, 000 ton of pig iron per year as the part of its raw material.

The reserves of iron ore should be investigated further by means of more detailed exploration by boring and drifting to confirm the supplying capacity of 300 tons of iron ore per day and, at the same time, the demands for bars of small and medium size exceed the level of 50, 000 t/year in future, it may be possible to produce steel domestically at a reasonable production cost even without steel scrap, depending on a blast furnace of 150 t/day combined with 6 t/day L. D. converters.

Demands for cast iron will be increased, if efforts are made to promote agricultural development for which agricultural machines and tools are required together with pumps and pipes for irrigation. An additional pig iron demand of 2, 000 t per year by Himal Iron and Steel Company will be expected on the assumption that production of rolled steel is increased up to 15, 000 t/year by installation of electric furnace of 8, 000 t/year in it's works whose present production is 7, 000 t/year. The prerequisite for this extention plan, however, is the research on collection of steel scrap.

To make the matter more difficult, the electric furnace larger than 5 t/charge cannot be operated, unless support of electricity supply is made by Trisuli hydroelectric station. In these circumstances, it seems to be wise to proceed by steps: in the first step, a charcoal-blast furnace (16 t/d) may be constructed when the demands for cast iron attains to 6, 000 t/year, and in the meanwhile development of iron-ore deposit is promoted and increased supply capacity ensured by intensive exploration, and finally, when appreciable ore reserves is confirmed, decision would be made for establishment of 150 t/day steel making shop.

Details are given in the text about the production of charcoal, smelting equipments, etc. in consideration of the 16 t/day blast furnace, of which outline is presented below:

Outline of production plan for 16 t pig iron per day

Item	Capacity	Investment Rs.	Number of labourers
Production of charcoal	16 t/day	1, 048, 500	150
Charcoal-blast furnace	16 t/day	6, 680, 000	130

Estimated production cost per ton

Item	Cost (Rs. /t
Phulchoki iron ore	228
Birganj charcoal	160
Pig iron	917

As indicated above, the production cost of pig iron is considerably high, because the costs of iron ore and limestone including freightage are expensive. Import from India will greatly lower the cost, if the loss of foreign currency can be neglected. According to the suggested plan, 75% of the production cost (917 Rs./ ton of pig iron) can be paid by national currency. Thus steel can be obtained at a trivial loss of foreign currency, and therefore, we regard the project worth considering as a national enterprise.

III Survey of iron and limestone deposits

3.1 Outline of General Geological Structure

Nepal, a narrow and long territory, is located along Himalaya Mountains, the roof of the glove. Only rough investigation of geology of this country has been made by a few persons on account of its adverse geographic condition; and no geologic map of the entire territory has been published. Among the investigators, Dr. T. Hagen who conducted his survey for several years gives us the most comprehensive picture of the geology of this country. According to Dr. Hagen, geology of Nepal, i. e. geology of Himalaya, is characterized by numerous nappe structures on a gigantic scale, than can well be correlated with the Alpine ones. The nappe moved southward along the thrust fault planes. The nappe itself is divided into base, back (the part relatively flat), and end (violently folded and faulted).

Such geological division can be correlated to topographical division of Nepal. This country can be divided into the following six zones.

(1) The Tibetan Plateau (a mountainous desert area with elevation of 3000 to 5000 meters above sea level) -- stable land block with gently dipping Paleozoic and Mesozoic sedimentary rocks.

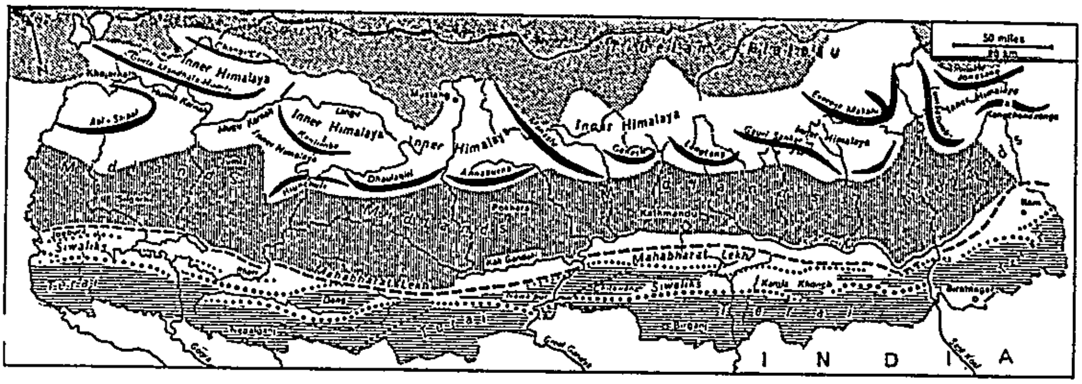
(2) The Himalayan Range (the elevation of 8000 meters or more above sea level, sectioned by the frontier in the eastern Nepal) --- the base of the nappe consisting of Paleozoic and Mesozoic rocks.

(3) The midlands (the area in between the Himalayan Range and Mahabarat Range with gentle slope; elevation 600 to 2000 meters above sea level; this area includes Kathmandu Valley) --- back of the nappe consisting of mostly Paleozoic and Mesozoic rocks.

(4) The Mahabarat Range (a mountain range with an elevation of approximately 3000 meters above sea level) --- the end of the nappe forming synclinal structure, consisting of Paleozoic and Mesozoic rocks.

(5) The Sinaliks (Rises up from the Ganges Plain, with approximate elevation of 1500 meters above sea level) --- located on the south of the nappe, adjoined by the thrust; the rocks consist of Tertiary sandstones and conglomerates.

(6) The Terai Belt (Ganges Plain of India, approximately 200 meters above sea level) --- covered by alluvial sediments.



Himalayas
Mahabharat Lekh
Siwaliks
Midlands
Terai

The above figure is selected from "Tonie Hagen et al., Nepal, Königreich am Himalaya (1960)"

3.2 Iron ore deposits

Among the several iron ore deposits of Nepal known to date the following three deposits are the major ones:

Phulchoki Iron Ore Deposit
Labdi Iron Ore Deposit
Thosay Iron Ore Deposit

As there is no truck road connection between Thosay iron deposit and Kathmandu which is located about 110 Km west of the deposit, it was excluded from the object of the present survey; and the survey was confined to the other two deposits.

3.2.1 Phulchoki Deposit

a) Ore mineral: hematite

b) Location and access

The deposit is located at the western slope of Mt. Phulchoki (2765 m above seal level) which is at the southeastern corner of Kathmandu Valley. Access to the deposit from Kathmandu Ropeway Station is as follows:

Kathmandu Ropeway Station —4Km / Paved road→

Patan (1310 m above sea level) —13Km / Passable for truck→

Godavari (1530 m above sea level) —approx. 4Km / Mine road→ Camp site

—approx. 4Km / Mine road→ The deposit. (2300 m above sea level)

Location of the deposit

latitude	27°36'35"N
longitude	85°23'30'E

c) History

around 1850: Operated in a small scale by the local people who produced pig iron at the site.

Nov., 1953: Outcrop survey of the deposit was conducted by R. N. Suwal.

1954: The scale of the deposit was surveyed by trenching and pitting, and partially by prospect-tunnelling.

1959: Mine road was constructed connecting Godavari and the upper part of the deposit.
Boring was conducted by the Bureau of Mines of the government in order to determine the thickness of the ore bed, but it was stopped at the depth of 20 meters below the surface. A test for making pig iron from the iron ore by the low shaft furnace was conducted in India, attaining a good result.

Present: The mine is currently out of operation after a scheduled prospecting work. A small scale impregnation of zinc ore in veinlets is observed in the dolomite bed which is thrust over the iron deposit; and a large scale prospecting work is on the way by the Indian Company.

d) Mining right: Owned by the government.

e) Topography and climate

The iron ore deposit is located at the western slope of Mt. Phulchoki which is at the southeastern corner of Kathmandu Valley. Topography in the vicinity of the deposit is extremely steep, and the area is cut by numerous major and minor valleys through which waters flow down to Godavari. Topography of the area where the deposit is covered by a dolomite bed is much steeper mostly forming cliffs. The dolomite bed crops out at the south of the deposit and partly overlies the deposit by overthrusting. The outcrop of the deposit tends to extend to the direction of the topographic slope, and dips 30 to 40 degrees. The surface area surrounding the deposit is a forest composed mainly of oaks, maples which are intermingled by shrubs. Average thickness of the surface soil is approximately 2 meters and the rocks are fairly weathered.

No suitable open space for mining facilities is available in the vicinity of the deposit on account of the steep topography; and as the valleys are dried up during the dry season, water for mine operation cannot be expected. In Godavari, however, flat lots of land and plenty of water are available.
Climate in the vivinity of the ore deposit is much similar to that of Kathmandu The following table shows temperature, humidity and rainfall of Kathmandu in 1963.

Month of 1963	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual average
Monthly average temperature (°C)	9.4	12.5	15.0	18.6	21.7	24.7	25.0	24.4	23.9	20.0	14.7	12.0	18.5
Averag humidity (%)	63.4	51.3	53.3	49.3	54.9	67.8	79.3	81.2	74.5	68.3	68.1	60.4	56.1
Rainfall (mm)	11.9	2.0	86.4	46.5	53.3	159.5	334.0	327.2	193.5	37.3	18.3	4.8	106

f) Geology

According to Dr. T. Hagen the region is covered by Ordovician and Silurian sedimentary rocks which are overthrust by the "Kathmandu Nappe IV". Although the rocks are intensely disturbed by folding, they generally strike N70° - 80° W steeply dipping toward either north or south. The stratigraphic sequence from south toword north is roughly as follows:

200 - 300 m	limestone	(Medium to coarsely crystalline; white to bluish grey; massive; non-fossiliferous.)
30 - 60 m	quartzite	(Fine grained; hard; arenaceous; locally micaceous.)
200 - 300 m	slate, sandstone altern.	(Ore-bearing bed)
200 - 300 m	limestone	

The iron ore deposit is localized in the ferruginous bed sand-wiched by the above-mentioned interbedded slate and sandstone; and it strikes N70° W dipping toward north. The following is a schematic cross-section of the stratigraphy in the vicinity of the deposit. All the beds are conformable.

N						S
	Slate / sandstone } altern.	Iron formation 4 - 25 m	Slate 1 - 40 m	Quartzite 30 - 60 m	dolomite	

Not much is known about faults around the ore deposit on account of poor exposure of the outcrops. Large scale faults don't seem to be abundant except for the one overthrusting the dolomite. Such small scale faults as observed at the underground opening of Bench No. 6, however, may be expected elsewhere.

Following is a summary description of the respective stratigraphic units:

(i) *Dolomite: It is widely distributed to the south of the ore deposit, and is cut by an overthrust at* the eastern margin of the extension of the ore deposit. The thrust plane dips approximately 45 degress, and the rock is somewhat brecciated nearby the thrust plane. The rock is white to bluish grey in color, and is coarsely crystalline. Hydrothermal vein-like impregnation of zinc associated with bornite is sometimes recognized at the vicinity of the contact between dolomite and the iron deposit. Microscopic observation reveals that quartz is associated with sphalerite in veinlets, and that the country rock is a mosaic aggregate of dolomite crystals with the diameters ranging as large as 2 millimeters

Specimen No. Phnl 52.

Thin Section
Open Nicol
At - *sphalerite*
veinlet in dolomite

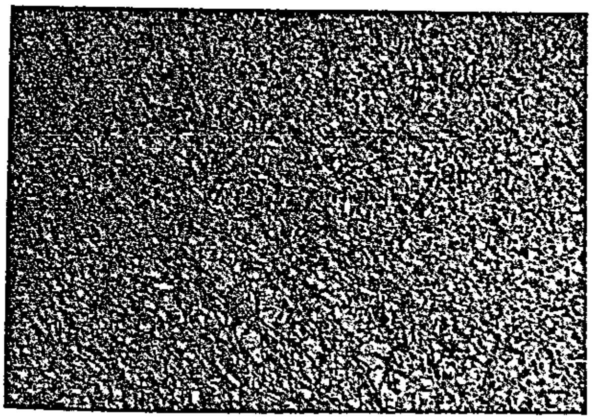
0 X67 0.5mm

(ii) Quartzite: The quartzite is a white, massive rock overlain by 1 to 3 meters' thick slate which corresponds to the footwall of the ore deposit on the eastern extension of the deposit. Microscopic *observation reveals that the rock consists of 70 to 80 per cent of equigranular quartz with the* diameters ranging 0.3 to 0.8 mm, and 20 to 30 per cent of orthoclose and microcline. Accessory minerals are sericite, zircon and limonite replacing pyrite.

(iii) Slate: The rock is light brown to bluish grey with greenish tinge in color, with well-developed bedding plane.

The rock may well be called biotite-sericite metaschist under microscope. Quartz grains of the matrix are about 0.1 mm in diameters, and the grains are elongated to the direction of the bedding.

Specimen No. Phul. 16



Thin Section
Open Nicol

0 X67 0.5mm

(iv) Iron Formation: Thickness of the iron formation is 4 to 25 meters, and recognized extension to the direction of the strike is 940 meters. It is conformable with clay slate, the wall rock, and is interbedded with numerous thin clay slate beds.

g) Ore Deposit

The ore deposit is considered to be syngenetic in origin from the following criteria:

1. The ore bed is in conformity with the country rocks.

2. A thin iron ore bed, 5 to 20 cm in thickness, which is found at approximately 1 meter to the hanging wall direction, fairly will extends to the direction of the strike for about 150 meters between Bench No. 6 and Bench No. 7.

3. The ore is crypto-crystalline, and is intimately interbedded with jasperoid rocks.

At present only one ore bed is known to exist.

Nineteen trenches and more than ten pits reveal that the ore bed extends for 940 meters horizontally, the difference between highest and lowest part, being 450 meters, with its thickness ranging from 4 to 25 meters. The eastern end of the ore bed is cut by overthrust dolomite, however, it may extend farther west. The ore bed pinches out at the western end. The ore bed extending for 940 meters to the direction of the strike may be divided into four (4) sections as follows:

Bench No. 1 - No. 10:	High-grade ore with thick bedding. Continuity of the ore bed is confirmed.
Bench No. 10 - No. 12:	Low-grade ore. Continuity of the ore bed is confirmed.

Bench No. 12 - No. 13: Continuity of the ore bed is confirmed by a few pits.

Bench No. 13 - No. 19: Medium-to-low grade ore; thin bedded. Continuity of the bed is confirmed.

(i) Bench No. 1 - No. 10: Extension of the ore bed to the strike direction is 350 meters, with average thickness of 20 meters. The orebody contains 5 per cent in average of the interbedded slate. The ore is compact and massive, and its underground extension as deep as 30 meters is recognized by two drifts driven along the hanging wall and footwall of the Bench No. 6. The ore bed dips steeply north.

(ii) Bench No. 10 - No. 12: Extension of the ore bed to the strike direction is 70 meters, with average thickness of 8 meters. The average ore grade is 23% Fe, and the ore is interbedded with thin beds of slate. The ore bed dips steeply north.

(iii) Bench No. 12 - No. 13: Extension of the ore bed to the strike direction in 290 meters, with average thickness of 17 meters. The ore is recognized by only a few pits throughout this section, and it seams that the ore bed contains considerable quantity of interbedded slate. The ore bed dips 50° to 55° north.

(iv) Bench No. 13 - No. 19: Extension of the ore bed to the strike direction is 230 meters, with average thickness of 10 meters. The ore consists of thinly interbedded high-grade hematite and jasperoid rock, and contains approximately 15 percent of slate. Although the ore grade is fairly consistent throughout the section, it is medium-to-low grade ore. The ore bed dips 55° to 70° north.

Among the four sections described above, the ore grade in highest in the section between Bench No. 1 - No. 10, followed by the ore between Bench No. 13 - No. 19. The high-grade ore near the surface is relatively hard and massive. The ore of deep underground which has not been influenced by secondary enrichment, however, is expected to be lower in grade, and to increase in powdered ore. Average thickness of the overburden is 2 meters. Between Bench No. 1 and No. 10, it consists of fragments of high-grade ore.

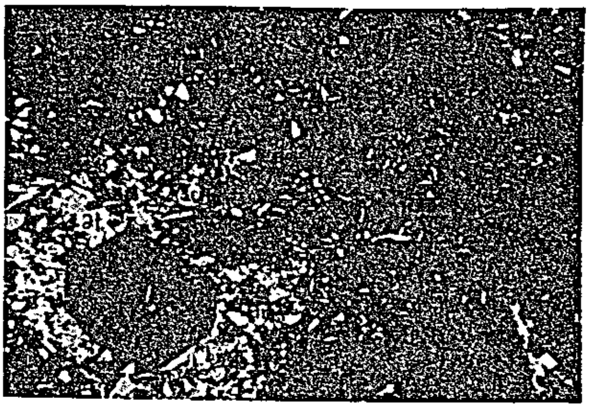
h) Ore grade

The ore of this mine is classified roughly into three kinds as follows:

(i) Compact massive ore: The ore is predominant in the section between Bench No. 1 and No. 9, and it seems to have been secondarily enriched. No cleavage planes are clearly recognized in this kind of ore, which is not the case in the other part of the ore deposit; and the ore is relatively massive.

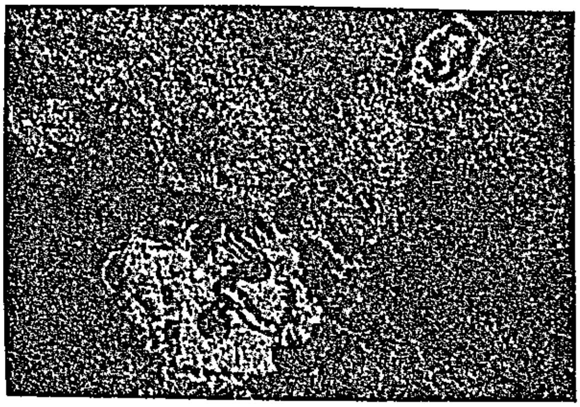
Microscopic Examination Example 1. Phul - 11

Hematite is dark red under the transmitted light, and is cryptocrystalline interlocking with quartz and sericite. Colloform texture of hematite with diameter of 0.06 mm is sometimes observed. Average diameter of the quartz grains is 0.05 mm, and it is scattered all over the ore in angular particles. Sericite occurs in short laths as large as 0.01 mm x 0.1 mm. Presence of limonite probably replacing pyrite suggests increase in sulfur content of the deep ore.



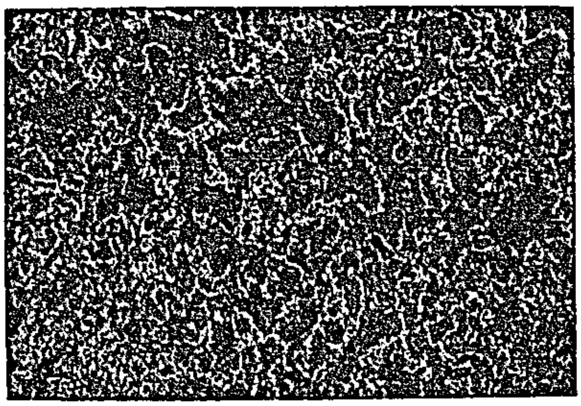
0 X67 0.5mm

Thin Section Open Nicol
Qt: Quartz
Ser: Sericite
Hmt: hematite
Lmt: limonite
Photomicrograph showing the relation between high-grade hematite and quartz and sericite inclusions; and the limonite replacing pyrite.



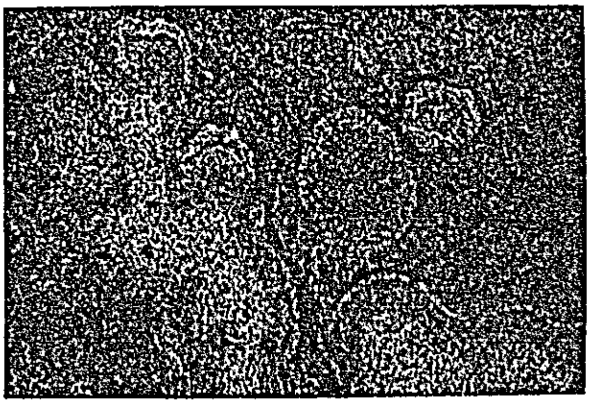
0 X105 0.5mm

Polished Section, Open Nicol. Photomicrograph showing the relation between hematite and gangue minerals, and limonite replacing pyrite.



Polished Section
Open Nicol
Dark Part - gangue minerals
Bright Part - hematite

0 X105 0.5mm

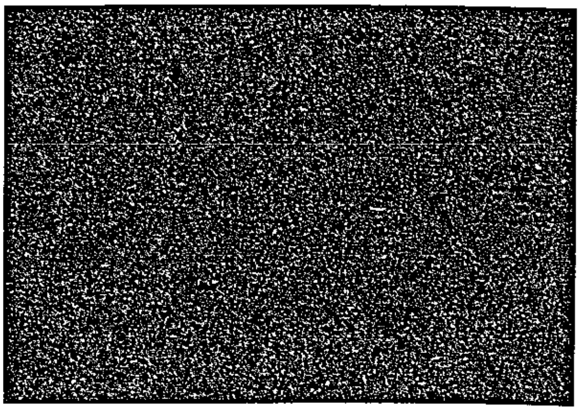


Polished Section
Open Nicol
Colloform texture of hematite.

0 X105 0.5mm

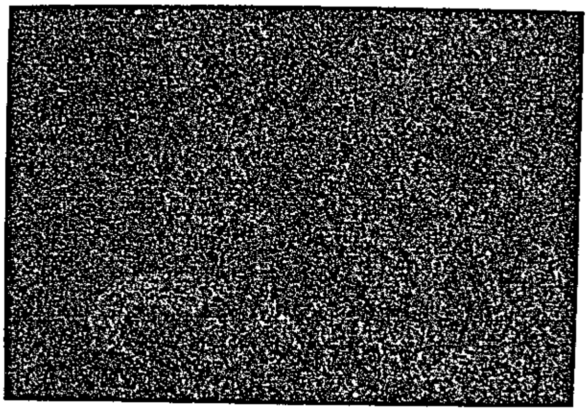
Microscopic Examination Example 2. Phul-12.

It is apparent that hematite is cementing sand grains in the sandstone. Cleavage planes are more or less clearly observed. Quartz grains have maximum diameter of 0.4 mm, averaging 0.03 mm, and ore angular in shape. Although there is no regular pattern in the distribution of the minerals, the fraction of the one richer in angular quartz and one richer in hematite are irregularly interbedded. Sericite laths are oriented parallel to the bedding where quartz is predominant. Colloform texture of hematite is sometimes observed.



0 X67 0.5mm

Thin Section, Open Nicol
Black Part: hematite.



0 X105 0.5mm

Polished Section Open Nicol
Colloform texture of
hematite.

(ii) Soft ore: The ore found at Bench No. 11 is fissile and generally soft. Although the ore grade is high, it is small in quantity.

(iii) Low-grade ore. (Interbedding of high-grade ore and gangue): Most of the ore in the section between Bench No. 13 and No. 19 belongs to this type, and it consists of interbedded thin hematite and red jasperoid rock, the thickness of the respective beds ranging from 0.5cm to 1cm. The ore is fissile and friable along fine fractures, and the grade is low.

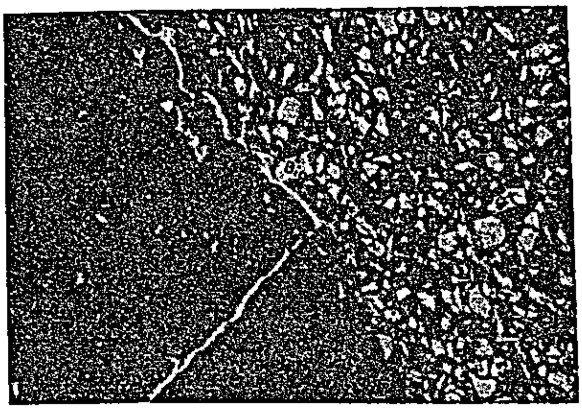
Microscopic Examination Example 3. Phul-79.

Interbedded ore with 5mm of high-grade, 4mm of low-grade and 4mm of medium-grade parts in respective thickness.

High-grade part: Includes 15 to 20% of quartz grains, 0.02 mm in diameter, in the hematite.

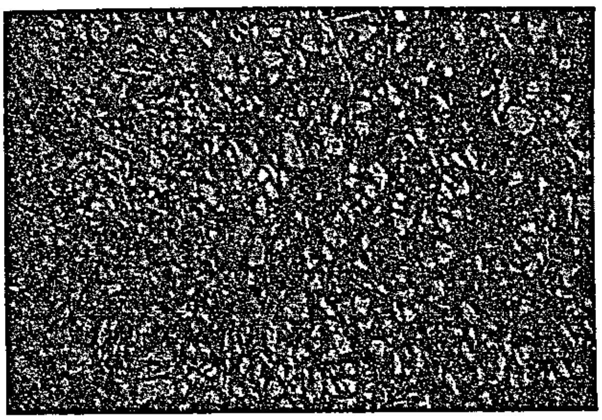
Low-grade part: Consists of 60 to 70% of quartz grains, 0.02 to 0.04mm in diameter, with the interstices filled by biotite, sericite and chlorite.

Medium-grade part: Quartz graines are about the same as the low-grade part in quantity and size, with about half of the matrix being occupied by hematite, and the other half by biotite and sericite.



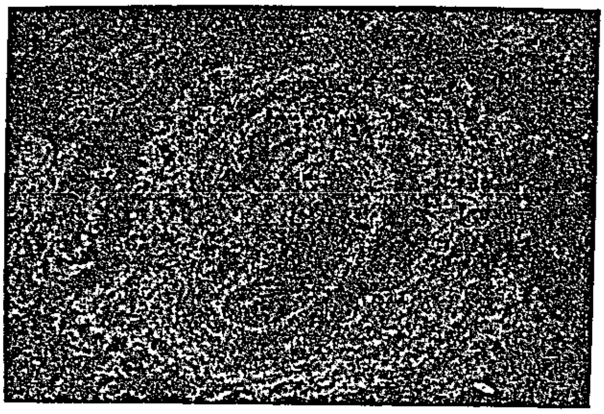
Thin Section Open Nicol
Left half - high-grade part
Right half - medium-grade part.

0 X67 0.5mm



Thin Section Open Nicol
Left half-medium-grade part
Right half-low-grade part.
(Slate-silty part)

0 X67 0.5mm



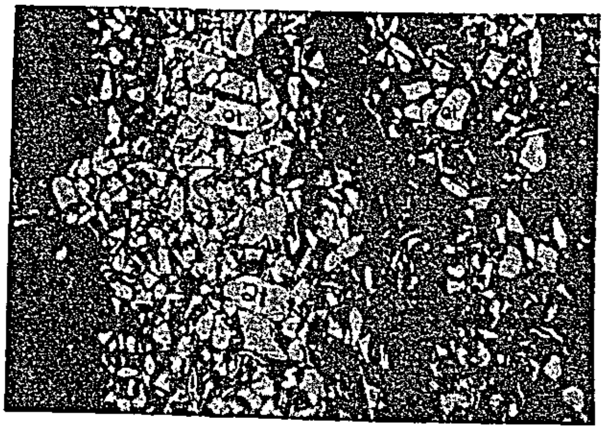
Polished Section Open Nicol
Colloform texture of hematite
Bright part-hematite
Dark part-gangue minerals

0 1 2mm
X22

Microscopic Examination Example - 4. Phul-90.

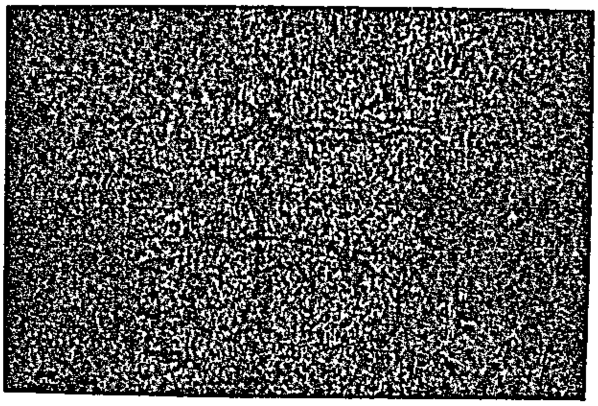
Thin interbedding of hematite and aggregate of angular quartz grains with 0.06mm in diameters.

The boundary of the interbedding is not clear.



Thin Section Open Nicol
Bonds of hematite and
quartz rich part.

0 X67 0.5mm



Polished Section Open Nicol
The same as above specimen
Bright part-hematite
Dark part-gangue minerals

0 X105 0.5mm

Ore Grade: Chemical analyses of the samples taken from various parts of the ore deposit are summarized in the table.

Ore grade of every bench, distribution of ore grade on the cross-sections and calculated grade of mineable crude ore are discussed in the chapter "Development Plan".

The wastes that are expected to mingle with the ore in the course of mining are almost exclusively slate. Chemical composition of the slate is as shown below:

SiO_2	Al_2O_3	CaO
64.3%	16.6%	1.9%

Comparison of surface and underground ore grade at Bench No. 6 and Bench No. 10 is tabled below. No change in the ore grade from the surface has been recognized underground as far as 20 meters below the surface. Farther downward, however, where there has been no secondary enrichment, some lowering of the grade and increase in sulfur content may be expected. Increase of small grain ore when operation comes down deeper.

Sample No.	TFe%	SiO_2%	Al_2O_3%	CaO%	Remarks
Phul - 1	56.28	9.02	3.03	0.99	Bench No.6, outcrop
41	61.88	5.60	2.30	0.12	Bench No.6, S adit, corresponds to Phul-1. ca. 10m underground
Phul - 2	55.32	10.76	3.99	0.11	Bench No.6, outcrop
42	58.38	7.98	3.08	0.25	Bench No.6, S adit, corresponds to Phul-2. ca. 10m underground
Phul - 9	55.91	13.56	2.87	0.14	Bench No.6, outcrop
43	56.89	11.82	2.91	0.11	Bench No.6, N adit, corresponds to Phul-9. ca. 20m underground
Phul - 32	43.79	23.54	5.86	0.33	Bench No.10, outcrop
64	45.88	22.44	5.20	0.23	Bench No.10, Adit, corresponds to Phul-32. ca. 15m underground

i) Ore Reserves

Cross-sections of the ore bed are drawn for every 60 to 75 meters interval from the trenching data, and the ore reserves are calculated.

Sections	Ore Reserves						
	Proved	Probable	Total	Grade (%)			
				T.Fe	SiO_2	Al_2O_3	CaO
1 - 6	928,000	728,000	1,656,000	57.98	10.54	2.87	0.14
6 - 9		238,000	238,000	53.69	14.50	3.86	0.12
10 - 13	154,000	107,000	261,000	50.25	19.18	4.12	0.09
Total	1,082,000	1,073,000	2,155,000	56.26	12.28	3.21	0.13

The block of ore twice as deep as the thickness of the ore bed around the surface is considered as proved ore in the calculation of the ore reserves; and farther downward, again, to the depth of twice as much as the extent of the proved ore reserves is considered as probable. Specific gravities of the ore used in the calculation are ones related to T. Fe% as shown in Supplement-3.

j) Prospecting Work

Prospecting work conducted up to date has been limitted to the surface, and no information at all is available about the deeper part of the ore body. Extension of the ore bed between Bench No. 12 and No. 13 is barely recognized by a few pits.

Although there are three prospect tunnels in between Bench No. 6 and No. 10, respective length of which ranging from 20 to 30 meters, all of them are drifts following the boundaries of ore and slate; and no crosscut has been excavated. Therefore, following exploration work is recommended for effective planning of the future mining operation.

By excavating drifts at 2194.5 meters' level and 2315.5 meters' level toward the central part of the ore body, and by driving crosscuts toward the center of 1-2 and 2-3 ore blocks, confirm the thickness of the ore bed, distribution of the ore grade and ratio of the powdered ore.

At the elevation of 2075 meters on the Section No. 8 line, drive a crosscut toward north. It is expected to hit the ore at about 65 meters' position, and the ore body may continue for approximately 35 meters along the crosscut tunnel.

Supplement - 1

Phulchoki Mine

Sample No.	Sampling Locality	Remarks	Analyses (%)												S.G.	Sort of Sampling	
			TFe	FeO	Fe_2O_3	SiO_2	Al_2O_3	CaO	Mn	P	S	Ti	Cu	C.W		Width (cm)	Spot
Phul. - 1	Bench No.6	Mixed with Red power	56.28			9.02	3.03	0.99							4.14	45	
Phul. - 2	"	Hmt. port in Hmt-Sl. alternation	55.32			10.76	3.99	0.11							4.24	12	
Phul. - 3	"	Massive Hmt.	50.03			13.97	5.48	0.18							3.98	30	
Phul. - 4	"	Brecciated Hmt.	62.52			5.64	1.50	0.05							4.70	130	
Phul. - 5	"	Hard Massive Hmt.	61.56	0.88	87.06	7.53	1.92	0.13	0.03	0.020	0.005	0.09	0.005	0.90	4.59	220	
Phul. - 6	"	"	61.27			8.42	2.22	0.07							4.57	290	
Phul. - 7	"	"	60.05			8.40	2.60	0.10							4.55	760	
Phul. - 8	"	"	58.81			10.30	2.32	0.07							4.36	315	
Phul. - 9	"	"	55.91	1.08	78.75	13.56	2.87	0.14	0.04	0.015	0.002	0.16	0.004	1.42	4.28	380	
Phul. - 10	"	Hard Massive H.G.Hmt.															o
Phul. - 11	"	"															o
Phul. - 12	"	"															o
Phul. - 13	Bench No.7	"	54.21			16.24	3.09	0.08							3 87	20	
Phul. - 14	"	Massive Hard Hmt. Purplishred Friable Hmt. mixture	55.04			14.56	3.89	0.08							4.00	125	
Phul. - 15	"	Hard Friable Hmt.	58.53			11.12	2.48	0.07							4.16	165	
Phul. - 16	"	Massive Hmt	59.35			9.94	2.60	0.07							4.35	360	
Phul. - 17	"		59.85			9.60	2.71	0.10							4.47	455	
Phul. - 18	"	Sl. mixed Hmt. (Friable in parts)	51.00			15.86	4.96	0.54							3.33	130	
Phul. - 19	"	Massive Hmt.	59.63			10.00	3.12	0.16							3.77	80	
Phul. - 20	"	Sl. mixed Hmt. (Friable in parts)	57.03	0.88	80.58	10.84	3.43	0.14	0.01	0.058	0.005	0.17	0.005	2.05	3.49	340	
Phul. - 21	"	Massive Hmt.	58.57			9.14	2.86	0.40							4.06	50	
Phul. - 22	"	"	59.46			8.99	2.81	0.08							4.16	50	
Phul. - 23	"	Float ore on the Ore Deposit														Th. 100	
Phul. - 24	Bench No.8	M - H.G. Hmt.														260	
Phul. - 25	"	"															
Phul. - 26	Bench No.9	Sl. mixed L - M.G.Hmt.	44.80			21.20	6.56	0.14							3.56	130	
Phul. - 27	"	"	48.78			18.01	5.15	0.22							3.58	205	
Phul. - 28	"	Float ore														130	
Phul. - 29	Bench No.6 S Adit	Quartzite (White Sandstone)															o
Phul. - 30	"	Slate															o
Phul. - 31	Bench No.10	M.G.Hmt.	43.79			23.54	5.86	0.33							3.38	75	
Phul. - 32	"	Sl. Hmt. fine alternation	48.27	0.93	68.00	19.13	5.33	0.16	0.01	0.060	0.005	0.28	0.003	2.90		220	
Phul. - 33	"	Massive H.G. Hmt.	59.49			10.01	2.26	0.08							4.30	280	
Phul. - 34	"	Hmt. (Massive H.G. in parts)	51.40			15.72	4.39	0.14							4.03	240	
Phul. - 35	"	Sl. Hmt. alternation	45.48			20.56	6.10	0.15							3.55	105	
Phul. - 36	Bench No.11	H.G - M.G.Hmt. Friable	57.84			11.16	2.85	0.08							4.29	370	
Phul. - 37	"	Friable Sity Hmt. (Specular Hmt. veinlet in parts)	55.37			13.30	3.67	0.08								110	
Phul. - 38		Red Clay	49.73			14.16	5.82	0.14							3.25	10	
Phul. - 39	Bench No.6 SAdit	Clayey Hmt. Friable	61.88			5.60	2.30	0.12							3.72	35	
Phul. - 40	Bench No.6 S Adit	Massive Hmt.	58.38			7.98	3.08	0.25							3.44	20	
Phul. - 41	Bench No.6 N Adit	Friable Hmt.	56.89			11.82	2.91	0.11							4 12	70	
Phul. - 42	Bench No.5 (Road Cutting)	Massive Hmt. (intercalate Sl. seams)														226	
Phul. - 43	"	Hmt. Sl. fine alternation (1cm order)														60	

Sample No.	Sampling Locality	Remarks	Analyses (%) TFe	FeO	Fe_2O_3	SiO_2	Al_2O_3	CaO	Mn	P	S	Ti	Cu	C.W.	S.G.	Sort of Sampling Width (cm)	Spot
Phul. - 44	Bench No. 5 (Road Cutting)	Hmt. Sl. alternation (Ca 2:1)														191	
Phul. - 45	"	Massive Hmt.														300	
Phul. - 46	" No. 4	"														150	
Phyl. - 47	"	"														235	
Phyl. - 48	"	"														150	
Phul. - 49	"	"														140	
Phul. - 50	Bench No. 2 Southern Spot from	Dolomite with Zn. network															o
Phul. - 51	Pit No. 9	H.G. Massive Hmt.															o
Phul. - 52	Bench No. 3	Siderite (?)														30	
Phul. - 53	Bench No. 3	Massive Hard H.G. Hmt.	58.80			7.18	1.83	0.32								510	
Phul. - 54	"	"	58.24			8.24	2.26	0.19							4.16	365	
Phul. - 55	"	"	61.87	1.00	87.36	7.05	1.84	0.13	0.00	0.013	0.016	0.10	0.003	1.12		1080	
Phul. - 56	Bench No. 2	"															o
Phul. - 57	Around Bench No. 4	Barite (Float Ore)															o
Phul. - 58	Bench No. 1	Brecciated Hmt.														550	
Phul. - 59	Pit No. 1	Red Clayey L.G. Hmt.														15	
Phul. - 60	Bench No. 6	Float Ore on the Ore Deposit														Th. 200	
Phul. - 61	Bench No. 9	H.G. Hmt.	60.33			9.40	2.43	0.08							4.51	690	
Phul. - 62	Bench No. 10 Adit	Hmt. (intercalating Sl. seams)	45.88			22.44	5.20	0.23							3.78	65	
Phul. - 63	Pit No. 3	H.G. Hmt.														95	
Phul. - 64	"	L.G. Hmt.														120	
Phul. - 65	Pit No. 2	"														45	
Phul. - 66	Pit No. 4	H.G. Hmt.														50	
Phul. - 67	Pit No. 5	Sl. intercalated in M.G. Hmt.														40	
Phul. - 68	"	" L - M.G. Hmt.														150	
Phul. - 69	"	L.G. Hmt.														120	
Phul. - 70	Pit No. 7	H.G. Hmt.														150	
Phul. - 71	"	"														30	
Phul. - 72	Bench No. 13	Friable M - H.G. Hmt.	54.35			14.02	3.78	0.06							4.03	310	
Phul. - 73	"	H.G. Hmt.	47.73			21.72	4.70	0.08							3.91	500	
Phul. - 74	Pit No. 6	"														20	
Phul. - 75	Pit No. 8	Sl. Hmt. alternation														70	
Phul. - 76	"	Friable Hard H.G Hmt.														235	
Phul. - 77	"	Typical Hmt. Sl. alternation															o
Phul. - 78	Bench No. 14	M.G. Hmt.	50.61			18.56	4.05	0.06							3.99	490	
Phul. - 79	Bench No. 15	" (Jasperic in parts)	52.13			17.66	3.76	0.06								410	
Phul. - 80	"	" (")	53.13			16.72	3.66	0.15							3.80	240	
Phul. - 81	Bench No. 16	H.G. Hmt.														100	
Phul. - 82	Bench No. 17	"	45.45			23.76	4.84	0.10							3.97	420	
Phul. - 83	"	Sl. Hmt. fine alternation	39.27			31.24	5.82	0.11							3.67	110	
Phul. - 84	Bench No. 18	Jasperic-Hmt. alternation	49.33			20.34	3.91	0.10							3.99	600	
Phul. - 85	"	Friable Hmt.														110	
Phul. - 86	Bench No. 19	Friable M.G. Hmt.														174	
Phul. - 87	"	"	47.16	1.16	66.15	22.82	4.33	0.16	0.01	0.023	0.004	0.31	0.003	1.50		206	
Phul. - 88	"	Typical Sample of Jasperic rock and Hmt. alternation															o
Phul. - 89	Bench No. 12	Sl. Hmt. alternation L.G	47.27			19.36	6.09	0.10							3.79	245	
Phul. - 90	"	H.G. Hmt.														35	

Supplement - 2

Phulchoki Mine
Calculation Table of Grade of Benches

Bench No.	Thickness of Ore body (m)	Thickness of Outcrop (m)	Total Thickness of Hmt. (m)	Total Thickness of Slate (m)	Thickness of Slate x 100 / Thickness of Out crop (%)	Sample Number	Sampling Thickness (m)	Grade (%) T.Fe	Grade (%) SiO_2	Grade (%) Al_2O_3	Grade (%) CaO	Grade (%) x Sampling Thickness (m) T.Fe	Grade (%) x Sampling Thickness (m) SiO_2	Grade (%) x Sampling Thickness (m) Al_2O_3	Grade (%) x Sampling Thickness (m) CaO
B - 1	4.50	100% 4.50	4.50	0	0										
B - 2	10.80	100% 10.80	10.80	0	0										
B - 3	22.20	94% 20.90	19.55	1.35	6.46	Phul.-55	5.10	58.80	7.18	1.83	0.32	299.880	36.618	9.333	1.6320
						56	3.65	58.24	8.24	2.26	0.19	212.576	30.076	8.249	0.6935
						57	10.80	61.87	7.05	1.84	0.13	668.196	76.140	19.872	1.4040
						Average	19.55	60.39	7.31	1.92	0.19	1,180.652	142.834	37.454	3.7295
B - 4	20.29	63% 12.79	11.66	1.13	8.84										
B - 5	20.80	14% 2.90	2.71	0.19	6.55										
B - 6	22.50	99% 22.22	21.82	0.40	1.80	Phul.- 1	0.45	56.28	9.02	3.03	0.99	25.3260	4.0590	1.3635	0.4455
						2	0.12	55.32	10.76	3.99	0.11	6.6384	1.2912	0.4788	0.0132
						3	0.30	50.03	13.97	5.48	0.18	15.0090	4.1910	1.6440	0.0540
						4	1.30	62.52	5.64	1.50	0.05	81.2760	7.3320	1.9500	0.0650
						5	2.20	61.56	7.53	1.92	0.13	135.4320	16.5660	4.2240	0.2860
						6	2.90	61.27	8.42	2.22	0.07	177.6830	24.4180	6.4380	0.2030
						7	7.60	60.05	8.40	2.60	0.10	456.3800	63.8400	19.7600	0.7600
						8	3.15	58.81	10.30	2.32	0.07	185.2515	32.4450	7.3080	0.2205
						9	3.80	55.91	13.56	2.87	0.14	212.4580	51.5280	10.9060	0.5320
						Average	21.82	59.37	9.43	2.48	0.12	1295.4539	205.6702	54.0723	2.5792
B - 7	24.80	73% 18.22	17.60	0.62	3.40	Phul.14	1.25	55.04	14.56	3.89	0.08	68.8000	18.2000	4.8625	0.1000
						15	1.65	58.53	11.12	2.48	0.07	96.5745	18.3480	4.0920	0.1155
						16	3.60	59.35	9.94	2.60	0.07	213.6600	35.7840	9.3600	0.2520
						17	4.55	59.85	9.60	2.71	0.10	272.3175	43.6800	12.3305	0.4550
						18	1.30	51.00	15.86	4.96	0.54	66.3000	20.6180	6.4480	0.7020
						19	0.80	59.63	10.00	3.12	0.16	47.7040	8.0000	2.4960	0.1280
						20	3.40	57.03	10.84	3.43	0.14	193.9020	36.8560	11.6620	0.4760
						21	0.50	58.57	9.14	2.86	0.40	29.2850	4.5700	1.4300	0.2000
						22	0.50	59.46	8.99	2.81	0.08	29.7300	4.4950	1.4050	0.0400
						Average	17.55	58.02	10.86	3.08	0.14	1018.2730	190.5510	54.0860	2.4685
B - 9	27.30	40% 10.90	10.25	0.65	5.96	Phul.-26	1.30	44.80	21.20	6.56	0.14	58.2400	27.5600	8.5280	0.1820
						27	2.05	48.78	18.01	5.15	0.22	99.9990	36.9205	10.5575	0.4510
						63	6.90	60.33	9.40	2.43	0.08	416.2770	64.8600	16.7670	0.5520
						Average	10.25	56.05	12.62	3.50	0.12	574.5160	129.3405	35.8525	1.1850
B - 10	11.80	87% 10.23	9.20	1.03	10.07	Phul.-32	0.75	43.79	23.54	5.86	0.33	32.8425	17.6550	4.3950	0.2475
						33	2.20	48.27	19.13	5.33	0.16	106.1940	42.0860	11.7260	0.3520
						34	2.80	59.49	10.01	2.26	0.08	166.5720	28.0280	6.3280	0.2240
						35	2.40	51.40	15.72	4.39	0.14	123.3600	37.7280	10.5360	0.3360
						36	1.05	45.48	20.56	6.10	0.15	47.7540	21.5880	6.4050	0.1575
						Average	9.20	51.82	15.99	4.28	0.14	476.7225	147.0850	39.3900	1.3170
B - 11	7.20	72% 5.15	4.80	0.35	6.80	Phul.-37	3.70	57.84	11.16	2.85	0.08	214.0080	41.2920	10.5450	0.2960
						38	1.10	55.37	13.30	3.67	0.08	60.9070	14.6300	4.0370	0.0880
						Average	4.80	57.27	11.65	3.04	0.08	274.9150	55.9220	14.5820	0.3840
B - 13	8.65	100% 8.65	8.10	0.55	6.36	Phul.-74	3.10	54.35	14.02	3.78	0.06	168.4850	43.4620	11.7180	0.1860
						75	5.00	47.73	21.72	4.70	0.08	238.6500	108.6000	23.5000	0.4000
						Average	8.10	50.26	18.77	4.35	0.07	407.1350	152.0620	35.2180	0.5860

Bench No.	Thickness of Ore body (m)	Thickness of Outcrop (m)	Total Thickness of Hmt. (m)	Total Thickness of Slate (m)	Thickness of Slate x 100 Thickness of Out crop (%)	Sample Number	Sampling Thickness (m)	Grade (%)				Grade (%) x Sampling Thickness (m)			
								T.Fe	SiO_2	Al_2O_3	CaO	T.Fe	CiO_2	Al_2O_3	CaO
B - 14	5.90	100% 5.90	4.90	1.00	16.95	Phul.-80	4.90	50.61	18.56	4.05	0.06				
B - 15	7.30	100% 7.30	6.50	0.80	10.96	Phul.-81	4.10	52.13	17.66	3.76	0.06	213.7330	72.4060	15.4160	0.2460
						82	2.40	53.13	16.72	3.66	0.15	127.5120	40.1280	8.7840	0.3600
						Average	6.50	52.50	17.31	3.72	0.09	341.2450	112.5340	24.2000	0.6060
B - 16	5.00	20% 1.00	1.00	0.00	0										
B - 17	5.40	100% 5.40	5.30	0.10	1.85	Phul.-84	4.20	45.45	23.76	4.84	0.10	190.8900	99.7920	20.3280	0.4200
						85	1.10	39.27	31.24	5.82	0.11	43.1970	34.3640	6.4020	0.1210
						Average	5.30	44.17	25.31	5.04	0.10	234.0870	134.1560	26.7300	0.5410
B - 18	8.08	100% 8.08	7.28	0.80	9.90										
B - 19	4.00	100% 4.00	3.80	0.20	5.00	Phul.-88	1.74	49.33	20.34	3.91	0.10	85.8342	35.3915	6.8034	0.1740
						89	2.06	47.16	22.82	4.33	0.16	97.1496	47.0092	8.9198	0.3296
						Average	3.80	48.15	21.68	4.14	0.13	182.9838	82.4007	15.7232	0.5036

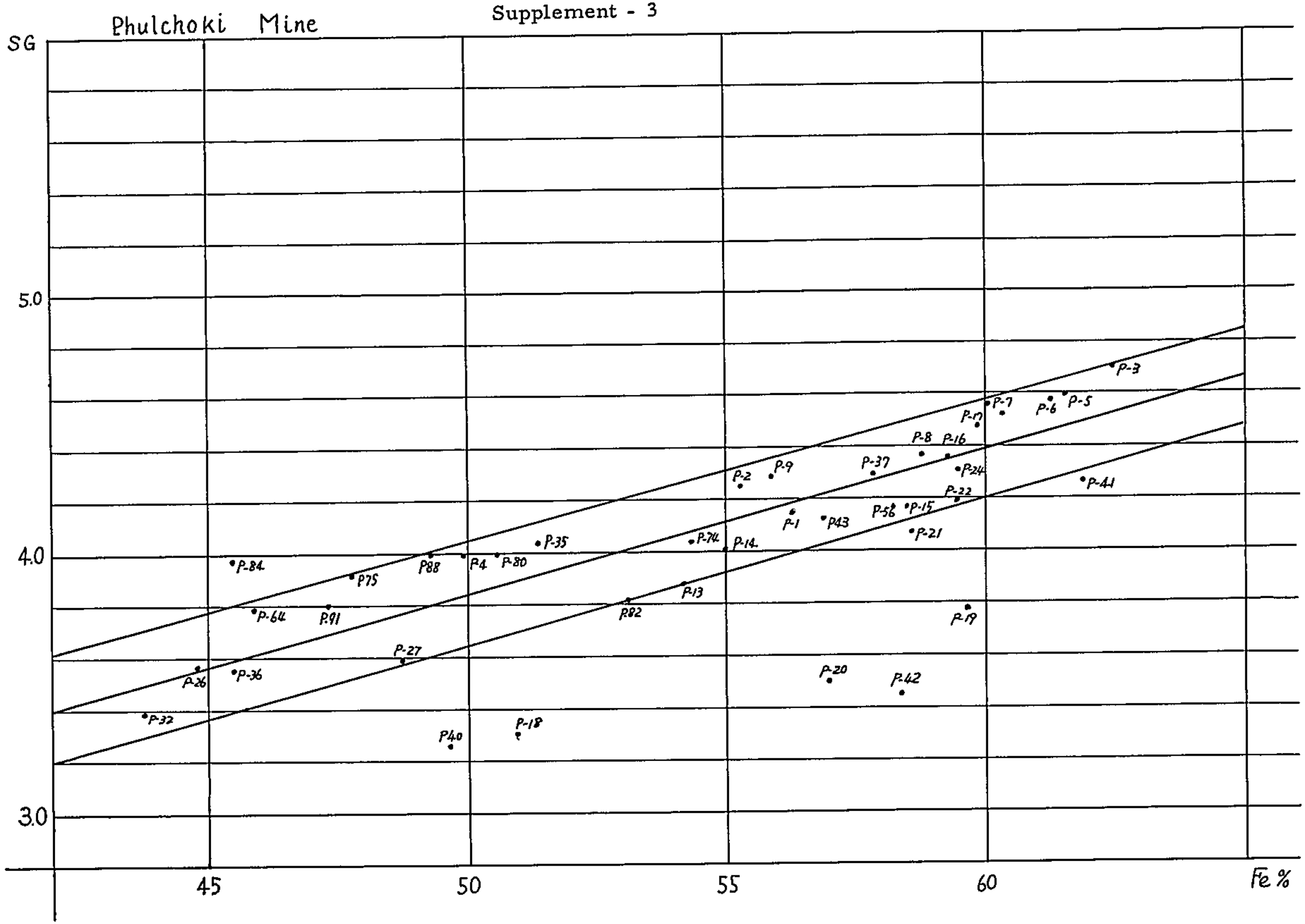
Phulchoki Mine
Grade Calculation between Sections

Sections	Bench No.	Thickness of Ore Dep. (m)	Grade (%)				Content			
			T.Fe	SiO_2	Al_2O_3	CaO	T.Fe	SiO_2	Al_2O_3	CaO
1 - 2	B - 3	19.55	60.39	7.31	1.92	0.19	1180.6520	142.8340	37.4540	3.7295
	B - 6	21.82	59.37	9.43	2.48	0.12	1295.4539	205.6720	54.0723	2.5792
	Average	41.37	59.85	8.42	2.21	0.15	2476.1059	348.5060	91.5263	6.3087
2 - 3	B - 6		59.37	9.43	2.48	0.12				
3 - 4	B - 7		58.02	10.86	3.08	0.14				
4 - 5	B - 7	17.60	58.02	10.86	3.08	0.14	1018.2730	190.5510	54.0860	2.4685
	B - 9	10.25	56.05	12.62	3.50	0.12	574.5160	129.3405	35.8525	1.1850
	Average	27.85	57.19	11.49	3.23	0.13	1592.7890	319.8915	89.9385	3.6535
5 - 6	B - 9	10.25	56.05	12.62	3.50	0.12	574.5160	129.3405	35.8525	1.1850
	B - 10	9.20	51.82	15.99	4.28	0.14	476.7225	147.0850	39.3900	1.3170
	Average	19.45	54.05	14.21	3.87	0.13	1051.2385	276.4255	75.2425	2.5020
6 - 7	B - 10 B - 11		53.69	14.50	3.86	0.12				
10 - 11	B - 13	8.10	50.26	18.77	4.35	0.07	407.1350	152.0620	35.2180	0.5860
	B - 14	4.90	50.61	18.56	4.05	0.06	247.9890	90.9440	19.8450	0.2940
	Average	13.00	50.39	18.69	4.24	0.07	655.1240	243.0060	55.0630	0.8800
11 - 12	B - 14	4.90	50.61	18.56	4.05	0.06	247.9890	90.9440	19.8450	0.2940
	B - 15	6.50	52.50	17.31	3.72	0.09	341.2450	112.5340	24.2000	0.6060
	Average	11.40	51.69	17.85	3.86	0.08	589.2340	203.4780	44.0450	0.9000
12 - 13	B - 15	6.50	52.50	17.31	3.72	0.09	341.2450	112.5340	24.2000	0.6060
	B - 17	5.30	44.17	25.31	5.04	0.10	234.0870	134.1560	26.7300	0.5410
	B - 19	3.80	48.15	21.68	4.14	0.13	182.9838	82.4007	15.7232	0.5036
	Average	15.60	48.60	21.10	4.27	0.11	758.3158	329.0907	66.6532	1.6506

Phulchoki Mine
Calculation of Workable Ore Grade

		T.Fe	SiO_2	Al_2O_3	CaO	T.Fe	SiO_2	Al_2O_3	CaO
	80	60.39	7.31	1.92	0.19	4,831.2	584.8	153.6	15.2
1	20	0	64.30	16.60	1.90	0	1286.0	332.0	38.0
	100	48.31	18.71	4.87	0.53	4,831.2	1870.8	486.6	53.2
	85	59.85	8.42	2.21	0.15	5,087.25	715.70	187.85	12.75
1 - 2	15	0	64.30	16.60	1.90	0	964.50	249.00	28.50
	100	50.87	16.80	4.37	0.41	5,087.25	1680.20	436.85	41.25
	85	59.37	9.43	2.48	0.21	5,046.45	801.55	210.80	17.85
2 - 3	15	0	64.30	16.60	1.90	0	964.50	249.00	28.50
	100	50.46	17.66	4.60	0.46	5,046.45	1766.05	459.80	46.35
	85	58.02	10.86	3.08	0.14	4,931.70	923.10	261.80	11.90
3 - 4	15	0	64.30	16.60	1.90	0	964.50	249.00	28.50
	100	49.32	18.88	5.11	0.40	4,931.70	1887.60	510.80	40.40
	85	57.19	11.49	3.23	0.13	4,861.15	976.65	274.55	11.05
4 - 5	15	0	64.30	16.60	1.90	0	964.50	249.00	28.50
	100	48.61	19.41	5.24	0.40	4,861.15	1941.15	523.55	39.55
	80	54.05	14.21	3.87	0.13	4,324.0	1136.8	309.6	10.40
5 - 6	20	0	64.30	16.60	1.90	0	1286.0	332.0	38.0
	100	43.24	24.23	6.42	0.48	4,324.0	2422.8	641.6	48.40
	75	50.39	18.69	4.24	0.07	3,779.25	1401.75	318.00	5.25
10 - 11	25	0	64.30	16.60	1.90	0	1607.50	415.00	47.50
	100	37.79	30.09	7.33	0.53	3,779.25	3009.25	733.00	52.75
	75	51.69	17.85	3.86	0.08	3,876.75	1338.75	289.50	6.00
11 - 12	25	0	64.30	16.60	1.90	0	1607.50	415.00	47.50
	100	38.77	29.46	7.04	0.54	3,876.75	2946.25	704.50	53.50
	80	48.60	21.10	4.27	0.11	3,888.00	1688.0	341.60	8.80
12 - 13	20	0	64.30	16.60	1.90	0	1286.0	332.00	38.00
	100	38.88	29.74	6.74	0.47	3,888.00	2974.0	673.60	46.80
	85	48.15	21.68	4.14	0.13	4,092.75	1842.80	351.90	11.05
13 -	15	0	64.30	16.60	1.90	0	964.50	523.55	39.55
	100	40.93	28.07	8.75	0.50	4,092.75	2807.30	875.45	50.60
	80	53.69	14.50	3.86	0.12	4,295.20	1160.0	308.8	9.60
6 - 7	20	0	64.30	16.60	1.90	0	1286.0	332.0	38.0
	100	42.95	24.46	6.41	0.48	4,295.20	2446.0	640.8	47.60

Supplement - 3



Supplement - 4

Phulchoki Mine Ore Reserves (Prove

Sectional Line	Section (m^2)	Average Section (m^2)	Intervals of Section (m)	Volume (m^3)	Safety factor (%)	S.G.	Ore Reserves (t)	Grade (%) T.Fe	Grade (%) SiO_2	Grade (%) Al_2O_3	Grade (%) CaO	Contents (t) T.Fe	Contents (t) SiO_2	Contents (t) Al_2O_3	CaO
		312	30	9,350	90	3.9	32,819	60.39	7.31	1.92	0.19	19,819	2,399	603	62
1 - 1'	935														
		948.5	75	71,138	90	3.9	249,694	59.85	8.42	2.21	0.15	149,442	21,024	5,518	375
2 - 2'	962														
		688	60	41,280	90	3.9	144,893	59.37	9.43	2.48	0.12	86,023	13,663	3,593	174
3 - 3'	414														
		665.5	60	39,930	90	3.8	136,561	58.02	10.86	3.08	0.14	79,233	14,831	4,206	191
4 - 4'	917														
		1,046	60	62,760	90	3.8	214,639	57.19	11.49	3.23	0.13	122,752	24,662	6,933	279
5 - 5'	1,175														
		729	65	47,385	85	3.7	149,026	54.05	14.21	3.87	0.13	80,549	21,177	5,767	194
6 - 6'	283														
Sub-Total			350				927,632	57.98	10.54	2.87	0.14	537,818	97,756	26,621	1,274

Sectional Line	Section (m^2)	Average Section (m^2)	Intervals of Section (m)	Volume (m^3)	Safety factor (%)	S.G.	Ore Reserves (t)	Grade (%) T.Fe	Grade (%) SiO_2	Grade (%) Al_2O_3	Grade (%) CaO	Contents (t) T.Fe	Contents (t) SiO_2	Contents (t) Al_2O_3	CaO
10 - 10'	267														
		278	60	16,680	90	3.6	54,043	50.39	18.69	4.24	0.07	27,232	10,101	2,291	38
11 - 11'	289														
		244.5	65	15,893	90	3.6	51,493	51.69	17.85	3.86	0.08	26,617	9,192	1,988	41
12 - 12'	200														
		164	90	14,760	90	3.5	46,494	48.60	21.10	4.27	0.11	22,596	9,810	1,985	51
13 - 13'	128														
		43	15	645	90	3.4	1,973	48.15	21.68	4.14	0.13	950	428	82	3
Sub-Total			230				154,003	50.25	19.18	4.12	0.09	77,395	29,530	6,346	133
Total			580				1,081,635	56.88	11.77	3.05	0.13	615,213	127,286	32,967	1,407

		323	30	9,690	65	3.9	24,564								
1 - 1'	968														
		1,006	75	75,450	65	3.9	191,266								
2 - 2'	1,044														
		744	60	44,640	65	3.9	113,162								
3 - 3'	444														
		706	60	42,360	65	3.8	104,629								
4 - 4'	968														
		1,134	60	68,040	65	3.8	168,059								
5 - 5'	1,300														
		832.5	65	54,113	65	3.7	126,624								
6 - 6'	365														
Sub-Total			350		65		728,304	57.98	10.54	2.87	0.14	422,270.7	76,763.2	20,902.3	1,019.62
6 - 6'	365														
		309	70	21,630	50	3.5	37,853								
7 - 7'	253														
		910.5	75	68,288	50	3.5	119,504								
8 - 8'	1,568														
		916.5	50	45,825	50	3.5	80,194								
9 - 9'	265														
Sub-Total			195		50		237,551	53.69	14.50	3.86	0.12	127,541.1	34,444.9	9,169.5	285.06
10 - 10'	288														
		254	60	15,240	65	3.6	35,662								
11 - 11'	220														
		220	65	14,300	65	3.6	33,462								
12 - 12'	220														
		182	90	16,380	65	3.5	36,374								
13 - 13'	144														
		48	15	720	65	3.4	1,591								
Sub-Total			230		65		107,089	50.25	19.18	4.12	0.09	53,812.2	20,539.7	4,412.1	96.38
Total			775				1,072,944	56.26	12.28	3.21	0.13	603,624.0	131,747.8	34,483.9	1,401.06

3.2.2 The Labdi Iron Deposit

a) Ore mineral: Hematite

b) Location and areas: Labdi Khola, Bandipur State

This deposit is located at a mountain area 14 Km north of the Chitwan Basin (its maximum width is 20 Km), which is separated from the Indian Plain by the Silwalilik mountains. Access to the deposit from Kathmandu is as follows:

Kathmandu $\frac{\text{136 Km}}{\text{paved road}}$ Hetaura $\frac{\text{93 Km}}{\text{truck road}}$ Narayanghar

$\frac{\text{8 Km}}{\text{passable for jeep}}$ $\frac{\text{2 Km (on foot)}}{\text{mountain path}}$ Jugedi $\frac{\text{8 Km}}{\text{narrow path}}$ $\frac{\text{0.1 Km}}{\text{ferryboat}}$

Gaighat $\frac{\text{6 Km (on foot)}}{\text{narrow path}}$ Amdanda $\frac{\text{0.1 Km}}{\text{ferryboat}}$ Mouth of Labdi Khola River

$\frac{\text{1.5 Km}}{\text{narrow path}}$ Camp Site.

This deposit is located at lat. 20° 50' 05" - 28° 50' 30" N, and long. 84° 27' 30" - 84° 28' 30" E.

c) History

1958: The first report on this deposit was presented by J.E. O'Rourk.

1960: R. N. Sawal prospected the highest-grade part of this deposit by excavating tunnels.

1961: B. M. Pradhan surveyed the deposit by pits and trenches.

Present situation: Survey by the tunnels and pits that were excavated by B. M. Pradhan but have been let alone has been rendered impossible as they have fallen in and are clogged up. The deposit has not been developed yet.

d) Mining right: Owned by the government

e) Topography and climate

The deposit area is connected with Chitwan province by the Trisulganga River up to Gaighat, and next by its branch, the Seti River, to the Labdi Khola mouth. These rivers gently flow down with low stream velocity, which enable people to travel by small boats. There are a number of flat grounds near the crests of the mountains. River banks, however, form cliffs, and thus topographically rejuvemated mature stage is revealed.

The ore deposit ourcrops on a narrow ridge and on its steep slope which Seti River and Labdi Khola Valley. The average inclination of the lower part of the slope is 50°. The highest point in this area is the triangulation point

977m above the sea level, located in between Labdi Khola and Majuwa village and higher by 780m than Labdi Khola.

The area is covered mostly by only copses on account of its steep topography, and there are cultivated fields on relatively flat grounds in the vicinities of mountain ridges. There is little flat ground near the ore-deposit. In the vicinity of mouth of Labdi Khola River, however, there is sufficient land required for mining operation and water is abundant.

The climate is subtropical; annual rainfall is presumed to amount 1270 mm.

f) Gegology and ore deposit

A thrust fault lies near by halfway between Jugedi and Gaighat to the south of this area. To the south of it there are sandstone and conglomerate belonging to the Tertiary Siwalik Group, and to the north as far as the vicinity of the ore deposit alternations of phyllite, quartzite, dolomite and a small quantity of green schist of Paleozoic age are distributed. Two phyllitic iron formations are sandwiched between these alternations near Labdi Khola. The general strike of this phyllite and surrounding rocks are N 60° - 80° W, and 50 - 80°S, and it changes to N 40 - 50°W and 45 - 60°SW, respectively in the western part.

Phyllite is calcareons, slightly varied to schist, and is intruded by a network of barren quartz veins.

Although we found, besides the main deposit, localities of outcrops and floats with similar kind of ore, they appear poor in scale and not promising in extension.

The Labdi ore deposit lies mainly within phyllite beds in conformity with them, and consists of two layers. The upper layer extends horizontally for 460 m, and its maximum thickness is about 10 m. The lower layer extends horizontally for about 700 m, and its maximum thickness is about 10 m. There is a phyllite layer of 1 to 10 m in thickness between the two layers. To the west of these two layers, there is a deposit, which extends for about 200 m with minimum thickness of 6 m, near the ridge; no correlation of these two deposits has been ascertained on account of the lack of outcrop for the distance of 300 m between them.

The ore minerals are finely crystallized hematite and a small amount of magnetite. The gaugue minerals are quartz, calcite, sericite and so on; and the ore is mostly low grade. The ore body often grades into the country rock.

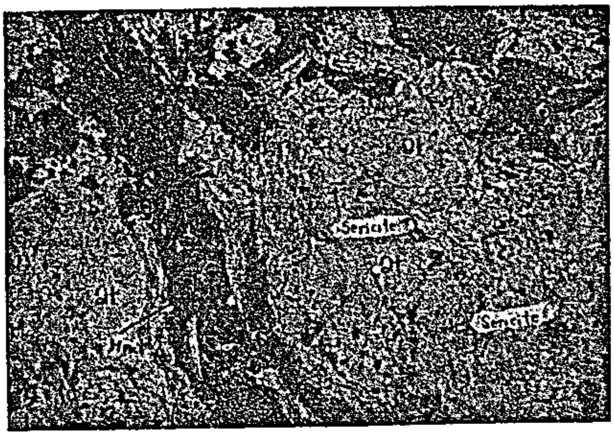
g) Ore grade

The high-grade iron ore occupies very small fraction of the ores of this deposit; and most of them are low grade, and some of them may adequately be called "ferruginous phyllite."

The low grade ore is alternation of ore minerals and phyllite beds in microscopic to megascopic scale; and it is phyllitic and soft in nature. The ore minerals are hematite and a small amount of magnetite, and the gangue minerals are quartz, calcite and a small amount of sericite. The ratio of the amount of hematite to other gangue minerals is very irregular and changeable.

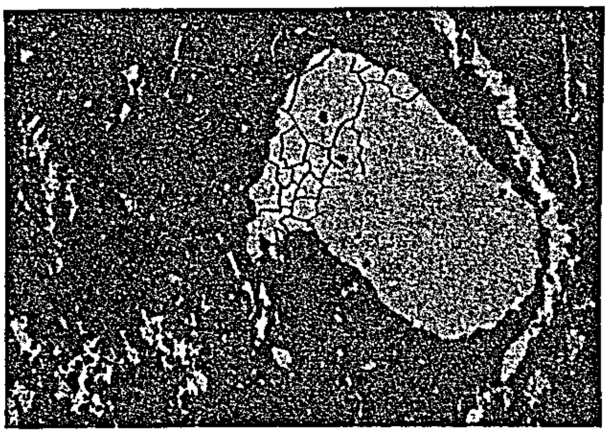
Microscopic Examination 1. Lab-2.

This sample contains (zircon), tourmaline, sericite, quartz and hematite. Tourmaline is fragmental, 0.1 mm ± in diameter, and scattered passably. Granular quartz (0.03 mm ± in diameter) (ca. 10%) and mosaic quarts less than 0.03 mm in diameter (ca. 40%), filling the interstices of the former quartz with sericite. Sericit - complicatedly admixed with quartz, in laths, 0.02 x 0.08 mm in size, and is oriented parallel to the schistosity (ca. 30%). Hematite is similar to sericite in occurrence.



Thin Section
Open Nicol

0 X67 0.5mm



Thin Section Open Nicol
Quartz mosaic and Laminae convexed along the big crystals.

Polished Section
Magnetite grain in
Hematite

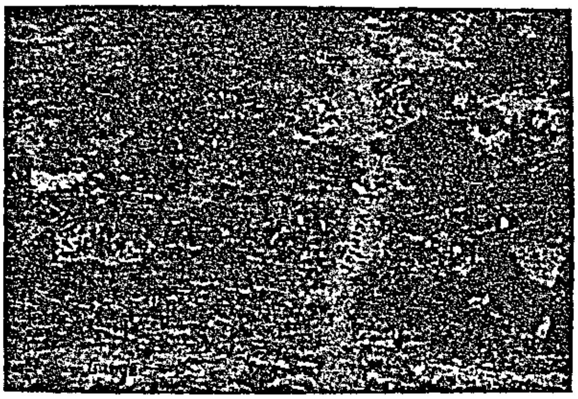
0 0.1 0.2mm
X 175

Microscopic Examination 2. Lab-10 (cut parallel to the bedding plane.)

Phyllitic ore: Includes a small amount of biotite and sericite; generally calcareous. A small amount of granular magnetite 0.03 x 0.01 mm in size, with the long direction oriented parallel to the bedding plane. Calcite: 40 - 50%; quartz: 10 - 20%; hematite: ca 10%; and others ca 10%.

Thin Section
Open Nicol

0 X 67 0.5mm

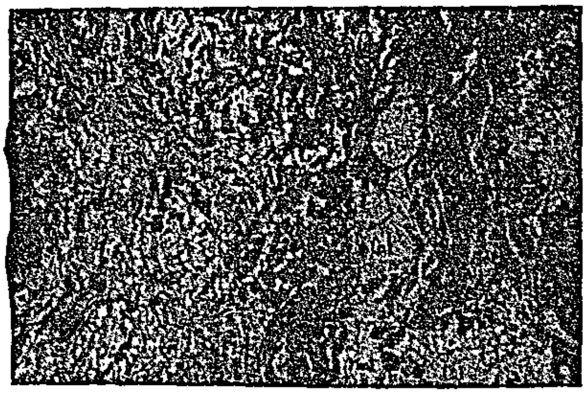


Polished Section
Open Nicol

0 X 105 0.5mm

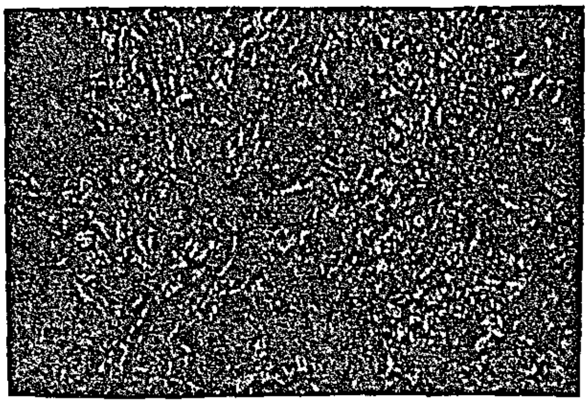
Microscopic Examination 3. Lab-12 (normal to the bedding plane)

Calcite-hematite ore with a small amount of sericite and quartz; little magnetite.



Thin Section
Open Nicol

0 X 67 0.5mm



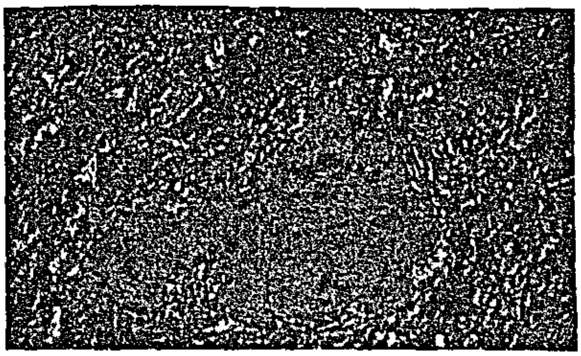
Polished Section
Open Nicol

0 X 105 0.5mm

Only four among 32 analyzed samples of the ore from this deposit contained 50% T.Fe or more, and their distribution appears to be irregular. (See Table 1). The best grade ore, Lab-1, is taken from an old pit; and it is flaky, micaceous and soft in nature.

Microscopic Examination 4. Lab-1.

The gangue minerals are mostly quartz and a small amount of sericite. Mosaic of quartz, 0.6mm in diameter, is scattered. A small amount of magnetite adheres to gangue forming middling, with maximum grain size of 0.1 x 0.2 mm.

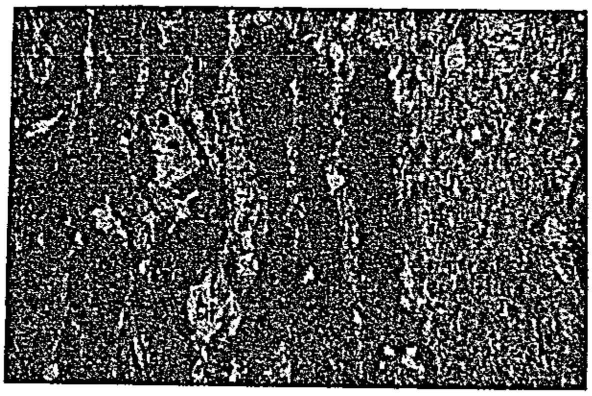


Polished Section
Open Nicol
Hematite crystals are arranged along Quartz aggregate spot.

0 X 105 0.5mm

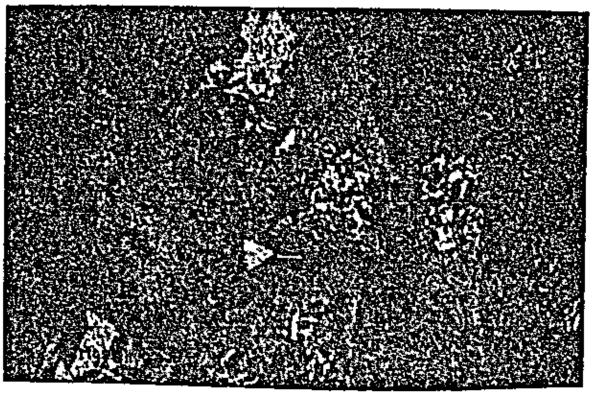
Microscopic Examination 5. Lab-24.

A very thin interbedding of hematite and sericite rich phyllite. Granular magnetite (0.5 mm in maximum diameter, averaging 0.1 mm ±), is contained in a considerably large amount, and other minerals curve around it. Pyrite is euhedral and is scattered passably.



Thin Section
Open Nicol
Black part – Hematite
Light part – Sericite, Quartz

0 X 67 0.5mm

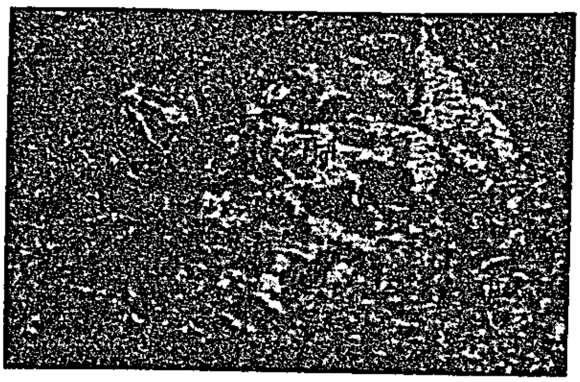


Polished Section
Open Nicol

0 X 105 0.5mm

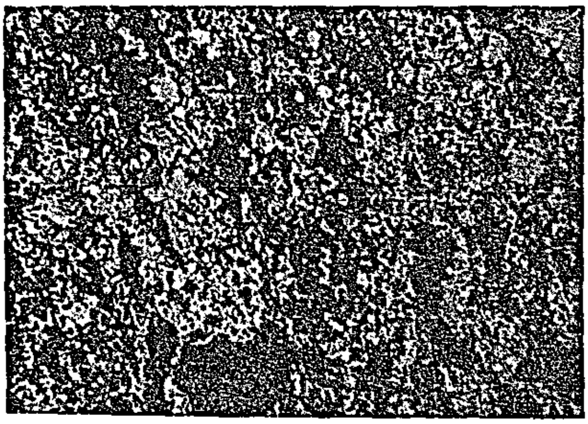
Microscopic Examination 6. Lab-35 (normal to the bedding plane)

This sample is assemblage of mosaic fine quartz and lath-like crystalline hematite, containing a small amount of carbonate. Granular magnetite (0.4 mm in maximum diameter, averaging 0.05 mm) is scattered all over the specimen.



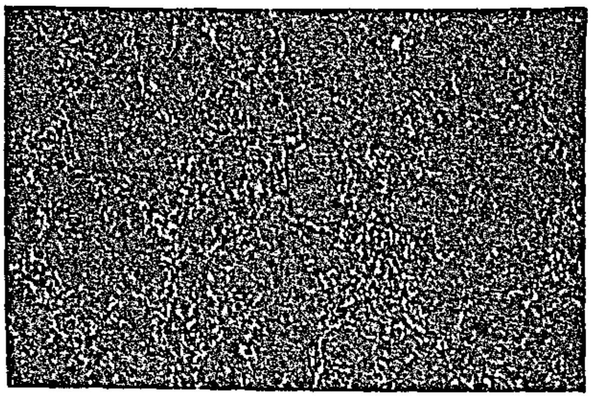
Polished Section
Laminae along the
Magnetite crystal

0 0.1 0.2mm
X 175



Thin Section
Open Nicol
Black part — Hematite
Light part — Quartz

0 X 67 0.5mm



Polished Section
Open Nicol
Bright part — Hematite
Gray part — Gangue minerals

0 X 105 0.5mm

The ore of this deposit is generally soft and is not equi-granular, and very little ore is fit for direct use in furnace. This conclusion can be drawn also from the point of view of its ore grade.

h) Ore reserves

On account of its location in steep topography, thick over-burden and short period of our investigation, no information enough for ore reserves calculation has been available for us, except the data obtained from a few trenches. Probable ore reserves, however, are calculated by taking the depth as twice the thickness of the ore bed, as shown in the table below.

	Ore Reserves (t)	Grade		
		T.Fe	FeO	Fe_2O_3
No.1 OB	736,000	41.10	1.37	57.59
No.2 OB	309,000	32.37	2.42	43.86
No.3 OB	36,000	34.97	0.99	47.36
Total	1,081,000	38.40	1.68	53.33

i) Recommendation for exploration

Just the initial step of the prospecting for this deposit has been taken, and further prospecting work is indispensable to determine its economic feasibility of its development. Therefore, following prospecting works are recommended:

(1) To trace distribution of every ore deposit on the surface.

(2) To examine continuity of the deposit and the change of the grade by excavating a tunnel from outcrop toward west.

(3) To examine the thickness and the grade of the ore body by reopening the old tunnels.

(4) To make trenches around the outcrops that were not examined in our survey, in order to ascertain the distribution of ore bodies around the outcrops.

Supplement - 1

Sample Number	Sampling Locality	Remarks	Analyses (%)						S.G.	Sort of Sampling	
			TFe	FeO	Fe_2O_3	SiO_2	Al_2O_3	CaO		Width (cm)	Spot
Lab - 1	Adit No.2	Flaky, H.G. Micaceous Hmt.	55.28	1.00	78.41	14.86	3.48	0.05		270	
Lab - 2	Bench. No.6	Typical Hmt, Phyllite fine altern.									o
Lab - 3	Bench No.1'	Ferrugeneous Phyllite	13.82	1.14	18.61					80	
Lab - 4	"	Qt. network in Micaceous Hmt.								10	
Lab - 5	"	Ferrugeneous Phyllite	28.12	0.77	39.59					30	
Lab - 6	"	Green rock (f.w. of Ore deposit)									o
Lab - 7	"	Ferrugeneous Phyllite	27.08	1.07	37.77					130	
Lab - 8	Bench No.1	M.G. Hmt.	34.60	0.93	48.74					50	
Lab - 9	"	Ferrugeneous Phyllite	19.56	0.71	27.35					95	
Lab - 10	Bench No.3	Phyllitic Hmt. with Qt. network	31.28	1.14	43.73	34.94	4.18	4.65		240	
Lab - 11	"	Phyllitic Hmt. Phyllite a alternation	40.10	0.85	39.44					100	
Lab - 12	"	"	33.94	1.07	47.63	32.82	3.74	3.26		250	
Lab - 13	Bench No.2	"	36.74	0.78	51.98					610	
Lab - 14	Bench No.4	"	32.47	1.14	45.43					470	
Lab - 15	Bench No.4'	Massive Hmt. with Qt. network	36.39	0.57	51.78					360	
Lab - 16	Bench No.6	Soft Phylitic Hmt.	41.23	1.21	57.96	31.68	4.72	0.17		410	
Lab - 17	"	"	42.92	1.57	59.99					660	
Lab - 18	Between Bench No.6-No.7	Soft Phyllitic Hmt.	46.61	0.93	65.95	20.24	3.97	0.13			
Lab - 19	"	"	51.25	1.07	72.54						
Lab - 20	"	Soft Phylitic seam in Phyllite	39.42	0.85	55.77						o
Lab - 21	"	Soft Phyllitic Hmt.	33.73	1.14	47.25					450	
Lab -22	"	"	37.51	1.15	52.68						
Lab - 23	"	Ferrugeneous Phyllite	19.69	1.08	27.12						
Lab - 24	Bench No.7	Phyllitic Hmt.	51.82	1.06	73.37					550	
Lab - 25	Between Bench No.7-No.8.	Ferrugeneous Phyllite	27.09	0.71	37.18						
Lab - 26	"	"									
Lab - 27	Bench No.8	Phyllitic Hmt.								106	
Lab - 28	"	Ferrugeneous Phyllite	21.99	1.42	30.06	37.32	4.94	2.53		680	
Lab - 29	"	"	32.97	5.39	41.40	38.92	7.96	1.92		1000	
Lab - 30	Bench No.5	Soft Phyllitic Hmt.	54.34	1.27	76.75						
Lab - 31	Around Bench No.5	Float ore									
Lab - 32	Bench No.9	Phyllitic Hmt.	30.16	0.92	42.36	37.32	5.76	0.05		130	
Lab - 33	"	"	40.15	3.69	53.64	32.20	4.88	0.27		50	
Lab - 34	"	"	27.99	3.12	36.77	40.44	4.54	2.31		230	
Lab - 35	"	"	49.02	1.56	68.78	22.42	4.22	0.16		600	
Lab - 36	Bench No.10	"	31.51	2.27	42.80					115	
Lab - 37	"	Ferrugeneous Phyllite	28.33	1.28	39.33					30	
Lab - 38	"	"	25.58	4.31	31.98					560	

Supplement - 2

Labdi Iron Deposit
Calculation of Ore Grade

	Sample No.	(%) T.Fe	(%) FeO	(%) Fe_2O_3	(cm) Thickness	T.Fe x Th.	FeO x Th.	Fe_2O_3 x Th.
	Lab. - 10	31.28	1.14	43.73	240	75.072	2.736	104.952
	11	40.10	0.85	39.44	100	40.100	0.850	39.440
	12	33.94	1.07	47.63	250	84.850	2.675	119.075
	Total	33.90	1.06	44.66	590	200.022	6.261	263.465
	Lab. - 16	41.23	1.21	57.96	410	169.043	4.961	237.636
	17	42.92	1.57	59.99	660	283.272	10.362	395.934
	Total	42.27	1.43	59.21	1070	452.315	15.323	633.570
	Lab. - 1	55.28	1.00	78.41	270	150.256	2.700	211.707
	18	46.61	0.93	65.95	2400	1118.640	22.320	1582.800
	19	51.25	1.07	72.54	2000	1025.000	21.420	1450.800
	Total	49.21	0.99	69.49	4670	2293.896	46.420	3245.307
	Lab. - 21	33.73	1.14	47.25	450	151.785	5.130	212.625
	23	19.69	1.08	27.12	1300	255.970	14.040	352.560
	Total	23.30	1.10	32.30	1750	407.755	19.170	565.185
	Lab. - 32	30.16	0.92	42.36	130	39.208	1.196	55.068
	33	40.15	3.69	53.64	50	20.075	1.845	26.820
	34	27.99	3.12	36.77	230	64.377	7.176	84.571
	35	49.02	1.56	68.78	600	294.120	9.360	412.680
	Total	41.36	1.94	57.34	1010	417.780	19.577	579.139
	Lab. - 36	31.51	2.27	42.80	115	36.237	2.611	49.220
	37	28.33	1.28	39.33	30	8.499	0.384	11.799
	38	25.58	4.31	31.98	560	143.248	24.136	179.088
	Total	26.66	3.85	34.06	705	187.984	27.131	240.107
No.1.O.B.	Lab. - 16.17	42.27	1.43	59.21				
	1.18.19	49.21	0.99	69.49				
	22	37.51	1.15	52.68				
	28	21.99	1.42	30.06				
	30	54.34	1.27	76.75				
	32.33.34.35	41.36	1.94	57.34				
	Average	41.11	1.37	57.59				
No.2.O.B.	Lab. - 21.23	23.30	1.10	32.30				
	24	51.82	1.06	73.37				
	25	27.09	0.71	38.18				
	29	32.97	5.39	41.40				
	36.37.38	26.66	3.85	34.06				
	Average	32.37	2.42	40.39				
No.3.O.B.	Lab. -10.11.12	33.90	1.06	44.66				
	13	36.74	0.78	51.98				
	14	32.47	1.14	45.43				
	Average	34.37	0.99	47.36				

Supplement - 3

Labdi Iron Deposit Ore Reserves

	Sectional Line	Sectional Area (m^2)	Average of Sectional Area (m^2)	Intervals of Sectional Line (m)	Volume (m^3)	S.G. in Situ	Safety ratio (%)	Ore Reserves (t)	Grade (%)			Work-able ratio (%)	Ratio of Dilution (%)	Workable ore Reserves (t)	Grade (%)
									TFe	FeO	Fe_2O_3				
No.1 O.B.			108	70	7,560										
	1 - 1'	108													
			392	100	39,200										
	2 - 2'	675													
			425	100	42,500										
	3 - 3'	176													
			159	100	15,900										
	4 - 4'	141													
			108	100	10,800										
	5 - 5'	75													
			699	100	69,900										
	6 - 6'	323													
			811	100	81,100										
	7 - 7'	300													
			100	35	3,500										
	Sub-total			705	270,460	3.4	80	735,651	41.10	1.37	57.59	50	20	441,390	34.25
No.2 O.B.			300	110	33,000										
	1 - 1'	300													
			412	100	41,200										
	2 - 2'	523													
			299	100	29,900										
	3 - 3'	75													
			133	100	13,300										
	4 - 4'	192													
			64	50	3,200										
	Sub-total			460	120,600	3.2	80	308,736	32.37	2.49	43.86	50	20	185,242	26.98
No.3 O.B.			23	10	230										
	8 - 8'	68													
			76	100	7,600										
	9 - 9'	83													
			57	100	5,700										
	10 - 10'	42													
			14	10	140										
	Sub-total				13,670	3.3	80	36,089	34.97	0.99	47.36	50	20	21,653	29.14
Total								1,080,476	38.40	1.68	53.33			648,285	32.00

3.3 Limestone Deposits

Limestone is considered to be one of the most abundant mineral resources in Nepal.

Our investigation of Bhainse Limestone Deposit which had been expected to be earmarked for the iron manufacturing plan suggested that it might involve difficulty with regard to its quality. Therefore, Chobhar limestone deposit at the suburb of Kathmandu, which is of good quality, was also investigated.

3.3.1 Bhainse Limestone Deposit

a) Location and access

This deposit is located by the main road connecting Kathmandu and Hetaura, so traffic to the site is very convenient.

Kathmandu $\frac{\text{20 Km}}{\text{paved road}}$ Bhainse Dobhan $\frac{\text{12 Km}}{\text{paved road}}$ Hetaura

Location: Latitude 27° 30'N
Longitude 85° 03'E

b) History

The deposit has not been operated. Prospecting works by the Bureau of Mines of the Government was under way during the present survey.

c) Mining right: Owned by the Government

d) Topography and climate

The area is located at the mountain region about 10 km north of the plain around Hetaura area along the Rapti River. Both banks of Rapti River form cliffs as high as 200 meters.

The deposit forms a big ridge stretching NWW-SEE and the maximum elevation difference of the ridge from Rapti River is as much as 500 meters.

Generally upper half of the slope is flat land, turned into cultivated field. The lower half of the slope is steep and covered by shrubs. The deposit is revealed by favorable outcrops exposing nearly entire bed along the Rapti River but no fine outcrops on the slope.

On this slope about 200 m above the Rapti River level, there are two ropeway towers at a distance of about 330 m from each; the ropeway connects Kathmandu and Hetaura. Therefore, mining operation around these towers will raise difficulties.

The site for mine facilities is not confined and water for mine use is abundant. The climate is thought to be subtropical.

e) Geology and deposit

The limestone bed forming a ridge extending NWW-SEE has a thickness of approximately 600 m, and presumably extends for over 20 km. The bed forms a klippe structure overlying schists. To the south, it is bordered by an overthrust, and Paleozoic phyllite is distributed to the south of the overthrust. Northern boundary associates considerable fractured zone, and schist and quartzite are distributed to farther north.

The limestone bed generally strikes N70° W and dips 70 - 80° N. To the north, however, it gently dips 30° N, and it is reversed at the north of the ropeway tower level, gently dipping south. To the south it is again reversed steeply dipping north.

Generally the limestone is thinly interbedded with sandstone, phyllite, etc., and the maximum thickness of single limestone bed is about 30 m, averaging 5 to 10 meters. The limestone itself is siliceous and partly dolomitic. Cross lamination is clearly observed in some parts of the rock.

The limestone bed is divided into eight layers which have limestone with thickness over 14 m and under 15% of partings of waste.

Ore is white to grey, coarsely crystalline and interbedded in millimeters to meters of thickness; and weathered surface is similar to that of weathered sandstone.

f) Ore grade

The limestone of this deposit is white to grey coarsely crystalline and siliceous; and small amount of pyrite is impregnated.

As to the quality, there is no ore of over 50% CaO, but the ore below 40% CaO is predominant. Therefore, it may be classified as low grade ore (See Supplement I). Dividing this limestone bed into the layers which have over 14 meters' thickness and under 14% of partings of waste. Ore grade is calculated as follows:

Chemical Components

Sample Number	CaO%	MgO%	SiO_2 %	Ig loss%	Fe_2O_3%	Al_2O_3%	S %	Thickness (m)
Bha - 7 8	39.23	3.34	16.36	34.40				7.10
9	26.44	2.76	37.60	22.88				3.30
10	42.93	3.95	9.46	38.56				7.00
12	49.30	0.56	6.75	39.20				1.50
13	49.66	1.31	5.36	40.47	1.27	0.87	0.11	6.50
14	43.89	0.89	13.42	35.28				2.00
15	39.80	1.55	18.72	31.80				1.40
16	42.65	2.42	14.32	34.28				3.70
17	42.93	2.71	13.98	35.10				4.40
18	35.12	1.14	26.08	28.40	1.57	5.95	0.41	Spot
29	33.95	3.63	24.08	30.20				9.20
30	28.75	4.20	32.56	25.28				4.60
31	24.97	7.36	29.90	27.05	1.43	7.03	0.08	9.50
32	34.40	5.91	17.60	33.20				6.30
33	25.69	7.44	29.86	26.60				15.40
34	38.47	1.80	19.82	32.60				4.00
39	28.99	1.06	32.80	26.44				6.10
40	40.58	1.22	18.70	32.20	1.55	4.51	0.16	9.90
41	44.05	1.90	12.40	25.20				7.40
42	40.14	2.34	17.73	32.56				11.50
43	42.04	2.12	14.74	34.60	1.11	3.87	0.06	15.60
44	41.26	1.44	16.92	33.20				3.60
45 46	38.91	3.75	17.10	33.32	1.19	4.81	0.04	22.00
47	41.82	4.06	12.53	35.80				7.60
48	39.63	5.75	13.88	34.83				2.50
49	40.98	1.61	17.98	32.60				3.50
55	36.06	7.71	12.50	37.60				10.60
Average	38.25	3.11	18.63	32.36	1.35	4.51	0.14	

As a sequent to the above, the following is induced.

	CaO %	MgO %	SiO_2 %	Ig loss %	Total Thickness (m)	Total Thickness of Limestone (m)	Total Thickness of Phyllite (m)	*Expected CaO% of Ore mixed with waste
1	38.29	3.48	17.61	33.89	18.00	17.40	0.60	37.0
2	45.54	1.75	10.90	36.83	22.60	19.50	3.10	39.3
3	32.22	3.80	26.91	28.56	14.60	13.80	0.80	30.5
4	28.73	6.78	25.00	29.50	17.60	15.80	1.80	25.8
5	28.33	6.28	27.79	27.84	22.15	19.40	2.75	24.8
6	36.16	1.16	24.08	30.00	17.10	16.00	1.00	33.8
7	41.78	2.08	15.39	32.03	40.80	38.10	2.70	39.0
8	39.79	3.75	15.98	33.88	35.60	35.60	0	39.8

* Expected content of CaO in quarrying operation on the presumption that $CaCO_3$ in phyllite is 0%.

g) Ore reserves

As the limestone of this deposit is low in grade as described above and not suitable for the purpose of iron manufacturing, calculation of ore reserves is omitted.

The ore reserves of about 40% CaO can be said to be almost inexhaustible.

Supplement - 1

Bhainse

	Total Thickness m	Total Thickness of Limestone m	Total Thickness of Phyllite m	Ratio of Phyllite %	Sample Number	Thickness	Grade (%)				Grade (%) x Thickness (Sampling)			
							CaO	MgO	SiO_2	Ig. loss	CaO	MgO	SiO_2	Ig. Loss
1	18.00	17.40	0.60	3.4	Bha.-7.8	7.10	39.23	3.34	16.36	34.40	278.533	23.714	116.156	244.240
					9	3.30	26.44	2.76	37.60	22.88	87.252	9.108	124.080	75.504
					10	7.00	42.93	3.95	9.46	38.56	300.510	27.650	66.220	269.920
					Average	17.40	38.29	3.48	17.61	33.89	666.295	60.472	306.456	589.664
2	22.60	19.50	3.10	15.9	Bha.-12	1.50	49.30	0.56	6.75	39.20	73.950	0.840	10.125	58.800
					13	6.50	49.66	1.31	5.36	40.47	322.790	8.515	34.840	263.055
					14	2.00	43.89	0.89	13.42	35.28	87.780	1.780	26.840	70.560
					15	1.40	39.80	1.55	18.72	31.80	55.720	2.170	26.208	44.520
					16	3.70	42.65	2.42	14.32	34.28	158.841	8.954	52.984	126.836
					17	4.40	42.93	2.71	13.98	35.10	188.892	11.924	61.512	154.440
					Total	19.50	45.54	1.75	10.90	36.83	887.973	34.183	212.509	718.211
3	14.60	13.80	0.80	5.8	Bha.-29	9.20	33.95	3.63	24.08	30.20	312.340	33.396	221.536	277.840
					30	4.60	28.75	4.20	32.56	25.28	132.250	19.320	149.776	116.288
					Total	13.80	32.22	3.80	26.91	28.56	444.590	52.716	371.312	394.128
4.	17.60	15.80	1.80	11.4	Bha.-31	9.50	24.97	7.36	29.90	27.05	237.215	69.920	284.050	256.975
					32	6.30	34.40	5.91	17.60	33.20	216.720	37.233	110.880	209.160
					Total	15.80	28.73	6.78	25.00	29.50	453.935	107.153	394.930	466.135
5	22.15	19.40	2.75	14.2	Bha.-33	15.40	25.69	7.44	29.86	26.60	395.626	114.576	459.844	409.640
					34	4.00	38.47	1.80	19.82	32.60	153.880	7.200	79.280	130.400
					Total	19.40	28.33	6.28	27.79	27.84	549.506	121.776	539.124	540.040
6	17.10	16.00	1.10	6.9	Bha.-39	6.10	28.99	1.06	32.80	26.44	176.839	6.466	200.080	161.284
					40	9.90	40.58	1.22	18.70	32.20	401.742	12.078	185.130	318.780
					Total	16.00	36.16	1.16	24.08	30.00	578.581	18.544	385.210	480.064
7	40.80	38.10	2.70	7.1	Bha.-41	7.40	44.05	1.90	12.40	25.20	325.970	14.060	91.760	186.480
					42	11.50	40.14	2.34	17.73	32.56	461.610	26.910	203.895	374.440
					43	15.60	42.04	2.12	14.74	34.60	655.824	33.072	229.944	539.760
					44	3.60	41.26	1.44	16.92	33.20	148.536	5.184	60.912	119.520
					Total	38.10	41.78	2.08	15.39	32.03	1.591.940	79.226	586.511	1.220.200
8	35.60	35.60	0	0	Bha.-45 46	22.00	38.91	3.75	17.10	33.32	856.020	82.500	376.200	733.040
					47	7.60	41.82	4.06	12.53	35.80	317.832	30.856	95.228	272.080
					48	2.50	39.63	5.75	13.83	34.83	99.075	14.375	34.575	87.075
					49	3.50	40.98	1.61	17.93	32.60	143.430	5.635	62.755	114.100
					Total	35.60	39.79	3.75	15.98	33.88	1.416.357	133.366	568.758	1.206.295

3.3.2 Chobhar Limestone Deposit

a) Location and access

Chobhar limestone deposit is located forming a hill, at the southwestern part of the Kathmandu valley. The place is very conveniently accessible by going down 6 km south on a paved road from Kathmandu Ropeway Station.

Location:	Latitude	20°40'N
	Longitude	85°17'E

b) History

The deposit is said to be quarried by the local people for road macadum and for burning lime for motor. It is, however, nearly untapped.

c) Mining right: Owned by the Government
(it is said that quarrying is partly permitted.)

d) Topography and climate

The vicinity of the ore deposit is a broad plain, located at the southwestern margin of Kathmandu Valley.

The deposit is in a hilly elevation with gentle slope stretching NW-SE, which is not higher than 150 m from the surrounding aluvial plain. The surrounding plain is extensive and cultivated as paddy fields or farms, and slopes and flat grounds of the hill are used for residential area and farms. This area is covered mainly by lawn.

It is said that mining on the western bank of Bagmati River will not be permitted to protect the road passing through the bank.

Sufficient land and water are available for mining.

Climate of the area is similar to that of Kathmandu.

e) Gegology and deposit

This deposit consists of interbedded limestone and slate which is in the western extention of the interbedded limestone, quartzite and slate in the vicinity of the Phulchoki Mine.

The general strike of the bed is N 70° W, dipping 30° to the south. The ore bed is well exposed on the banks of Bagmati River which crosses the deposit forming a deep valley. The limestone bed roughly is divided into two layers.

The upper layer is about 28 m in thickness and contains about 30% of a slate intercalator and a dolomitic layer which is 0.2 - 1.1 m thick. The entire layer is observed along the Bagmati River, but at the sides, it is erroded out and distribution is narrow.

The lower layer, interlaying a slate bed as thick as 26 meters is distributed to the north of the upper layer.

The thickness of the layer is about 30 m, and interlaying matter is little except the one which occupies about 3% of the layer. Thus the layer is of high quality. The slate, forming wall rock, is weakly schistosed.

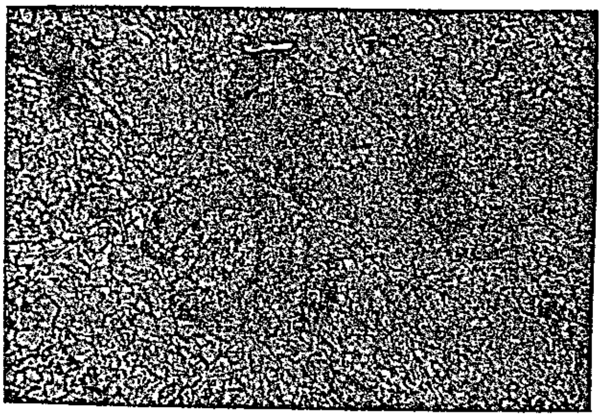
On the place about 200 m northwest along the Bagmati River from the lower layer is a outcrop of shattered slate impregnated by copper minerals such as chalcopyrite, bornite.

f) Ore grade

The limestone of this deposit is white to grey, massive and very finely crystalline. Interbedded waste is all slate except the crystalline dolomite layer of 0. 2 - 1. 1 m in thickness.

Microscopic Ex. 1. Cho.7.

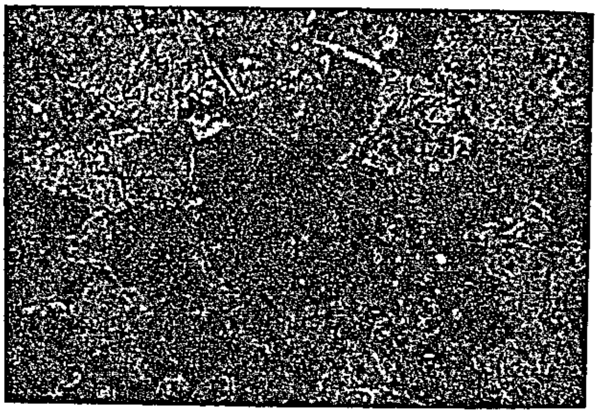
Diameter	0.08 mm ±	mosaic aggregate of calcite
Diameter	0.03 mm ±	Rounded to pipe like texture abundant, may be fossils (?)



Thin Section
Open Nicol
Calcite mosaic with fossils (?)

0 X 67 0.5mm

Microscopic Ex. 2. Cho-22.



Thin Section
Crossed Nicol
Quartz grain (0.06 x 0.18mm) in calcite

0 X 310 0.1mm

The analytical data of Chobar Limestone is as shown in the table below. Average grade of the upper and lower layers respectively is as follows:

	CaO %	MgO %	SiO_2 %	Ig loss %	Thickness
Upper layer	47.8	2.3	4.1	41.1	21.05
Lower layer	49.1	0.7	7.7	39.2	29.60

Average grade of the upper layer shown above is the ore excluding interbedded slate. Including the 8 meter thick slate, however, the average ore grade drops from 47.8% CaO to 35% ± CaO.

g) Ore reserves

As the upper layer is relatively thin, and approximately 30% of the layer consists of slate, only lower layer of the eastern bank of Bagmati River is taken into account in the calculation of the ore reserves. The specific gravity used in the calculation is 2.6.

Chobhar Limestone Analyses

Sample No.	CaO	MgO	SiO_2	Ig loss	Total	Remarks	Thickness
Cho - 4	47.7	1.8	6.2	40.2	95.9	G10	4.00
5	50.1	0.4	5.3	40.5	96.3	G11 - 12	13.00
6	48.4	1.5	4.0	40.7	94.6	G13 - 14	
7	49.7	1.1	3.2	41.5	95.5	G14 - 15	
8	51.3	0.8	1.3	41.7	95.1	G16 - 17	5.00
9	49.2	2.8	3.1	42.9	98.0	G17 - 18	2.60
10	34.6	13.0	0.6	43.7	91.9	Dolomite (0.2 - 1.1m)	1.00
11	47.6	3.3	1.4	42.3	94.6	G18 - 19 Ls fw brecciated	4.50
12	50.4	1.0	4.0	41.0	96.4	G20 fw side	3.55
13	41.8	1.5	14.8	35.7	93.8	G21 fw side	3.00
14	48.4	1.2	5.2	39.7	94.5		1.70
15	51.0	1.0	4.9	40.8	97.7	G23 - 24 H.G.Ls	10.10
16	49.4	0.4	7.6	39.2	96.6	G24 - 25 H.G.Ls	9.70
17	39.9	0.4	22.7	31.6	94.6	G27 - 28 H.G.Ls: Sl =7:3	3.00
18	49.7	1.0	5.5	40.4	96.6	G28 - 29 H.G.Ls	6.00
21	51.0	1.0	3.7	41.5	97.2	outcrop along the road	
22	48.7	1.4	5.6	40.4	96.1	"	
24	50.1	1.4	3.2	41.2	95.9	G36 - 37	

Chobhar Limestone Deposit

Sample No.	CaO	MgO	SiO_2	Ig loss	Thickness	CaO X Th	MgO X Th	SiO_2 X Th	Ig loss X Th	Remarks
Cho - 8	51.3	0.8	1.3	41.7	5.00	256.50	4.00	6.50	208.50	
Cho - 9	49.2	2.8	3.1	42.9	2.60	127.92	7.28	8.06	115.40	
Cho - 11	47.6	3.3	1.4	42.3	4.50	214.20	14.85	6.30	190.35	
Cho - 12	50.4	1.0	4.0	41.0	3.55	178.92	3.55	14.20	145.55	
Cho - 13	41.8	1.5	14.8	35.7	3.00	125.40	4.50	44.40	107.10	
Cho - 14	48.4	1.2	5.2	39.7	1.40	67.76	1.68	7.28	55.58	
Cho - 10	34.6	13.0	0.6	43.7	1.00	34.60	13.00	0.60	43.70	
Average 1	49.7	1.9	2.2	42.2	15.65	777.54	29.68	35.06	659.80	Cho.8,9,11,12
2	48.4	1.8	4.3	41.0	20.05	970.70	35.86	86.74	822.48	Cho.8,9,11,12,13,14
3	47.8	2.3	4.1	41.1	21.05	1,005.30	48.86	87.34	866.18	Cho.8,9,11,12,13,14,10
Cho - 15	51.0	1.0	4.9	40.8	10.10	515.10	10.10	49.49	412.08	
Cho - 16	49.4	0.4	7.6	39.2	9.70	479.18	3.88	73.72	380.24	
Cho - 18	49.7	1.0	5.5	40.4	6.80	337.96	6.80	37.40	274.72	
Cho - 17	39.9	0.4	22.7	31.6	3.00	119.70	1.20	68.10	94.80	
Average 4	50.1	0.8	6.0	40.1	26.60	1,332.24	20.78	160.61	1,067.04	Cho.15,16,18
5	49.1	0.7	7.7	39.2	29.60	1,451.94	21.98	228.71	1,161.84	Cho.15,16,17,18

* Ore reserves 829,000 t

Ore Reserves

Sectional Line	Sectional Area (m^2)	Average of Sectional Area (m^2)	Intervals of Section (m)	Volume (m^3)	Safety factor + Workable ratio (%)	S. G. in Situ	Workable Ore Reserves (t)
3 - 3'	1,330	650	15	9,750	90	2.6	22,815
4 - 4'	2,836	2,083	40	83,320	90	2.6	194,969
5 - 5'	2,025	2,430	40	97,200	80	2.6	202,176
6 - 6'	2,860	2,442	40	97,680	80	2.6	203,174
7 - 7'	2,808	2,834	40	113,360	70	2.6	206,315
Total				400,950	80	2.6	829,449

* Calculated in 7-7' section over 1,265 ml.

h) Recommendation for exploration

Although the outcrop of the deposit fairly continuous along Bagmati River, nearly none is exposed elsewhere. Therefore, it is recommended to trench the deposits on the eastern bank where outcrop is expected at intervals of 50 to 100 meters; this will be valuable for development planning.

IV Development plan of Phulchoki iron deposites

4.1 Ore reserves to be mined

The lowest limit of the part of the ore body to be mined is set at 2,194.5 meters level above sea for the reasons as follows:

a) As mentioned in 3.2.1, continuity of the deposit towards the lower part can be proved by the present survey as well as the result of investigation by Bureau of Mines of Nepalese government so far conducted.

b) On the other hand, lowering of ore grade and increase of ratio of fine ore can be expected as mining comes down to the lower part of the deposit.

c) Required ore production concluded from the inquiry of demand in the present survey was taken into consideration.

In considering mining method, we took into consideration the following points:

a. Steep topography

b. The width of the deposit is limited and its vertical extension is large.

The above factors will render the mine road lengthy in opencast mining, the amount of overburden to be stripped excessively large, and the adjustment of progress of mining to that of working face preparation difficult.

Such consideration as above has led us to adopt underground mining by sublevel stoping method, in which stope width is 50 meters and permanent pillar is 20 meters wide; tunnels connecting slots are used for slits; for blasting fan-shaped long-hole drilling is adopted.

In such mining, extracting the ore from each block of the ore deposit, the upper limit of which being the surface, the ore reserves as the objective of mining and mineable ore reserves are tabled as under:

Block	Proved or Probable	Ore reserved as mining objective		Mineable ore reserves	
		quantity	Fe content	quantity	Fe content
1 - 1	Proved	99,693 ton	57.3 %	98,696 ton	51.5 %
	Probable	4,451	47.9	4,406	43.1
	Sub total	104,144	56.9	103,102	51.2
1 - 2	Proved	45,885	57.3	45,426	51.5
	Probable	27,269	47.9	18,266	43.7
	Sub total	73,154	53.8	63,692	49.3
Pillar between 1 and 2	Proved	47,090	57.4	-	-
	Probable	26,144	43.7	-	-
	Sub total	73,234	52.5	-	-
2 - 1	Proved	-	-	-	-
	Probable	32,010	49.5	26,044	44.5
	Sub total	32,010	49.5	26,044	44.5
2 - 2	Proved	152,820	57.6	151,291	52.7
	Probable	33,684	49.1	31,678	44.4
	Sub total	186,504	56.1	182,969	50.8
Millar between 2 and 3	Proved	42,246	57.4	-	-
	Probable	28,409	48.6	-	-
	Sub total	70,655	53.9	-	-
3 - 1	Proved	37,710	55.5	37,333	50.9
	Probable	101,833	49.1	77,890	44.2
	Sub total	139,543	50.9	115,223	46.4
3 - 2	Proved	26,092	57.5	25,831	51.2
	Probable	-	-	-	-
	Sub total	26,092	57.5	25,831	51.2
GRAND TOTAL	Proved	451,536	57.0	358,577	51.7
	Probable	253,800	48.4	158,284	44.2
	TOTAL	705,336	54.1	516,861	49.4

Note 1: In the column of mineable ore reserves, the ratio of waste mingled in the course of stoping is set at 10%.

Note 2: Upper part of block 4-2, though mineable, is excluded from the above calculation.

Note 3: Regarding classification between "proved" and "probable" ore reserves, see

4.2 Outline of development plan

4.2.1 Underground structure

At the present situations of geological survey the part of the deposit that can be the objective of mining is the ore above bench 10. As to the site where tunnel mouth facilities related to mining operation and a crushing plant are installed, no place other above bench 9 is available. Further, required amount of iron ore for the proposed iron foundry for the period of 20 years can be covered by the ore reserves existing above bench 9 on the conditions that the ratio of concentrate to crude ore is 60% as explained in 4.1; so the level of main haulage tunnel is set at bench 9. (2,194.5 meter level above sea).

As for mining method sub-level stoping method is adopted judging from the shape and conditions of the deposit. The vertical difference of stopes induces preparation of subsidiary haulage levels at the levels of 2,247.5 meters above sea; in order to minimize capital expenditures and shorten development period, development works are set about on the part above this 2,247.5 meters level.

From the 2,275 m.l. raises are excavated up to the surface, and these are used for paths to stopes and for transports of ore and waste during the initial period of development. The intervals between sublevels which are to be driven from the raises are shown in "model plan of mining system".

The stope width is 50 meters and permanent pillar width is 20 meters. Leaving the secondarily enriched zone of the ore deposit near the surface as pillars will result in the unfavorable result of lowering crude ore grade, so that the deposit is to be mined up to the surface. As a precaution against heavy rains in rainy seasons, mining of the part near the surface during rains is suspended and instead deeper part will be mined. For this reason, by the time of exhaustion of stope No. 1, excavation of a raise between 2,194.5 m.l. and 2,247.5 m.l. for the purpose of drainage will be finished in addition to preparation of stope No. 2 on 2,194.5 m.l. haulage. The expenses for the above works are disposed of as the ores for preparation of stopes under the running expenses from the third year onward.

Loading the ore into mine wagon is done by chute; manual labor is used for both loading and transport.

Importance is attached to the practical considerations that excessive mechanization relative to production scale will cause higher cost and that the country's ecomic situation require new openings, as large as possible, for the employment of the local people; and use of manual labor for every part of operation in stead of machines is considered.

4.2.2 Crushing plant

Installing ore-dressing plant near the tunnel mouth, without any adequate source of water, will be under various adverse restrictions as to be selecting operation.

Having the plant, instead, at Godavari where abundant water is available will complicate the difficulties that no site for dumping waste is found and a great deal of cost is needed for post-selection treatment discharge of waste into near-by streams should be avoided because the water of such streams is for home use of the local people.

Taking into consideration cost as well as the above circumstances, we have come to adopt dry process plant which is situated at mine site.

Raising ore grade by flotation and strong-magnetic separation is not considered impossible, but involves a large amount of capital expenditures for equipment, which is not recommendable for a small production mine; for ore-dressing plant only crushing and screening equipment is advisable.

4.2.3 Transport of concentrate

Construction of a new facilities for concentrate transport between minesite and Godavari such as a ropeway brings about a high rate of depreciation which such a small size mine can hardly bear; for a better alternative improvement of the existing road, though operation cost is increased, is recommended. On this road 3 ton truck is considered passable.

Near the Bureau of Mine's warehouse of machines and tools is established a stock pile site, where concentrate carried down on 3 ton trucks is stored for a time; then the concentrate is transported on trucks between Godavari and Kathmandu Ropeway Station and further between Hetaura Ropeway Station and the iron foundry; the distance between Kathmandu and Hetaura is covered by the ropeway. The transportation is to be operated by Nepal Transport Corporation. So the capital and operation cost for loading and unloading at the ropeway stations is included in the cost of ropeway transportation, and excluded from the present development plan.

4.2.4 Power

One can contemplate utilization of surplus electric power from the projected power plants when such plants and power-transmission lines are completed.

However raising up of capacity of transmission between Kathmandu and Godavari and also installation of a new transmission line between Godavari and mine site cannot bring out depreciation bearable by such a small size production. Therefore, though operation cost is increased, an engine-driven generating station of minimum size is to be provided at the mine.

4.2.5 Other surface facilities

4.2.5.1 Equipment for handling crude ore and waste

From 2, 247. 5 meters level haulage and No. 4 sub-level of stope No. 4 (the latter comes out to the surface in order to shorten the development work), the ore from the underground is carried on 3 ton trucks down to the bin at the crushing plant or to the Godvari stock pile. For this purpose, a wooden ore-pocket and a truck for dumping waste in the glen on the south are provided respectively at the mouths of the levels.

4.2.5.2 Road connecting tunnel-mouths and illuminating equipment

A road connecting tunnel-mouths is constructed along the dip of the deposit. The mine is operated on two shifts excluding surface transport section, so that illuminating fixtures are put on this road for the convenience of the workers who take the road in the night.

4.2.5.3 Other ancillary facilities near tunnel-mouths

An air-compressor room, a powder magazine and a drill-repairing shop are installed near the mouth of 2, 247. 5 m. l. tunnel, and a power generator room, an office, a rest house and a warehouse near the mouth of 2, 194. 5 m. l. tunnel.

4.2.5.4 Kathmandu Office and employees' houses

People accomodated at the mine site are restricted to on-the-job superintendents and some staff members in charge of personnel business and warehouse keeping; the head office is established at Kathmandu; houses for the employees working at the mine site are built at Godavari and for those who live around Kathmandu houses are provided near Kathmandu.

As for maintenance shop, the existing repairing shops under other departments of the Government are to be utilized, not installing a shop for this mine.

No hospital is to be built at mine site or Godavari; hospitals of Kathmandu are relied on.

4.3 Financial aspect

Two years will be required for construction of the proposed iron foundry, which will have half a year, i. e. the first half year of the third year, for trial operation period, during which consumption of rain materials will be increased gradually; and the latter half of the third year will be dedicated to the start of a full operation. The development schedule of the mine is geared with the above program.

As the schedule of stope preparation works explains, the preparation of stope No. 1 will be completed three and a half years after from the start of development works, and mining works will follow.

This plan does not preclude the programmed ore consumption at the iron foundry, because iron ore requirement at the trial operation period is well satisfied by the stored ore produced by stope preparation since the start of development works and also by the newly produced ore from the stope being prepared.

Capital expenditures for the 1st year

item	cost	remarks
Machinery & equipment for mining	Rs. 39,900	air-compressor (discharge capacity: 4.8m^3/min.) ...... 1 unit leg-drill .... 3 units
Machinery & equipment ancillary to the above	6,500	welding machine (alternating current; arc type) " " (oxyacetylene) chain block list grinder etc.
Tunnel excavation	48,830	total length 112.5m
Works incidental to the above	53,610	excavation of tunnel mouths of 2,294.5m.l. and 2,247.5m.l. ore-loading equipment at 2,247.5m.l. loading chute .... 1 track laying .... 100 m. road construction .... 150 m. road to stopes, illuminating fixtures, repair of road
Surface facilities related to mining operation	12,000	powder magazine air-compressor room drill-repairing shop
Transport facilities	73,200	3 ton dump truck .... 1 jeep 2
Surface facilities (including generator)	109,820	power generator .... 1 power station, office, warehouse, quarters, garage
Utensils & fittings	10,000	surveying instrument, calculator etc.
Construction of crushing plant	100,000	
Purchase of land	70,000	mine site .... 50 acres Kathmandu .... 2 acres
Royalties for mining right	870	
Administration expenses	168,100	
Overhead	62,560	operation of air-compressor, and power station transport of stored ore
Sundries	37,270	
Sub-total	792,660	
Technical guidance expenses	680,000	engineers' team for detailed designing (mining, mechanical, electrical engineers and survey-technician.) resident mining technicians (for guidance) .... 2 persons
Freight & import duties	16,070	
Total	1,563,170	

Capital expenditures for the 2nd year

item	cost	remarks
Machinery & equipment for mining	Rs 32,280	air-compressor (discharge capacity: $32m^3$/min.) .... 1 unit air hoist .... 1 unit stoper .... 2 units leg-drill .... 1 unit
Tunnel excavation	132,240	347.8m.
Works incidental to the above	27,690	equipment for dumping waste from sub-level No.4, stope No.1 laying 4" pipe for compressed air
Transport facilities	158,550	3 ton dump truck .... 3 jeep .... 1 dozer-shovel 1
Power facilities	36,750	
Crushing plant	300,000	
Purchase of land	70,000	mine site .... 50 acres Kathmandu .... 2 acres
Building employees' houses	600,000	
Royalties for mining right	870	
Administration expenses	172,200	
Overhead	169,500	
Sundries	87,000	
Sub-total	1,787,080	
Technical guidance expenses	550,000	mining engineer 1 person ore-dressing engineer 1 " mechanical engineer 1 " survey-technician 1 " ore-dressing technician 1 " mining technicians 2 persons
Freight & import duties	18,120	
Interest	144,720	
Total	2,499,920	
Grand total of capital expenditures	4,063,090	

The first half of the first year is spent for construction of surface facilities; construction of the crushing plant is commenced in the second half of the first year and is finished at the end of the second year; houses and quarters are built in accordance to the required personnel program, but these are not to be appropriated excluding for a part of personnel, for the great number of laborers who are employed for the works in the first half the first year when the works rely on mainly manual labor.

Only the funds required in the first and second year are to be brought under the capital expenditures, which becomes the objectives of depreciation; and all the expenditures from the third ýear on will be disbursed from operation cost, except the fund for obtaining tangible assets.

The year-to-year program of expenditures for the development is in the attached table.

The interest rate is set at 7.5 per cent. The interest for one year on the required annual funds is added. The comparatively high proportion of technical guidance expenses in the total expenditures is explained by the factor of expenses for dispatch of engineers' team engaging in detailed design and also by the consideration that not a few personnel from Japan for technical guidance will be needed for the establishment a new kind of industry of which Nepal has no experience.

Schedule of Stope Preparation Works

	1st year						2nd year												3rd year					
	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
Haulage tunnel	12.5^{M}	12.5^{M}	$12\ 5^{M}$	25.0^{M}	25.0^{M}	25.0^{M}	25.0^{M}	0.5^{M}																
Roof cutting of loading point, Chute No.1											2.5^{M}													
Cutting draw hole of the above											3.6^{M}													
Raising from the above											2.7^{M}	6.3^{M}												
Excavation of undercutting level tunnel												0.6^{M}	10.0^{M}						1.5^{M}	4.9^{M}				
Excavation of man way for sub-level No.1																	13.5^{M}	11.0^{M}						
Excavation of tunnel for drilling for same part																		28.0^{M}	23.5^{M}					
Excavation of man way connecting slots for same part																			23.5^{M}					
Excavation of man way for sub-level No.2														11.0^{M}	14.5^{M}									
Excavation of tunnel for drilling for the same part															7.5^{M}	50.0^{M}	2.5^{M}							
Excavation of man way connecting slots for same part																	20.5^{M}							
Excavation of man way for sub-level No.3																				22.7^{M}	2.8^{M}			
Excavation of tunnel for drilling for the same part																					22.2^{M}	25.0^{M}	19.8^{M}	
Excavation of man way connecting slots for the same part																							5.2^{M}	22.8^{M}
Excavation of tunnel for drilling for sub-level No.4								7.1^{M}	7.3^{M}	7.3^{M}				7.3^{M}	2.0^{M}		15.9^{M}	18.3^{M}	1.9^{M}	2.9^{M}				
Raising slot																					22.7^{M}	25.0^{M}	6.3^{M}	
Raising man way								7.5^{M}	7.5^{M}	7.5^{M}	15.0^{M}	15.0^{M}	15.0^{M}	5.5^{M}										
Undercutting & wallcutting																				362^{M^3}	38^{M^3}			
Stope No.2																							18.7^{M}	25.0^{M}
Total	12.5^{M}	12.5^{M}	12.5^{M}	25.0^{M}	25.0^{M}	25.0^{M}	25.0^{M}	15.1^{M}	14.8^{M}	14.8^{M}	23.7^{M}	21.9^{M}	25.0^{M}	23.8^{M}	24.0^{M}	50.0^{M}	52.4^{M}	57.3^{M}	50.4^{M}	40.5^{M}	47.7^{M}	50.0^{M}	50.0^{M}	47.8^{M}

4.4 Estimate of cost for the first five years from start of production

Estimated production cost for the first five years from commencement of is seen from the attached table.

With regard to the years from the 8th year on, one can expect such cost-raising factors as inevitable rise of labor cost (in this estimate the annual rising rate is set at 2.5 per cent) and increase of cost of maintenance and replacement of equipment and machinery owing to their deterioration, while decrease of undepreciated amount accompanied by lessening burden of interest will reduce the cost. So the cost is expected to go on between the levels of Rs. 170 to 180 per ton, unless any extraordinary change of prices related to mine operation arises. (in our estimate no rise of prices is taken into consideration.)

One cannot disregard the causes bringing about higher cost than the same kind of foreign enterprises, such as the conditions of ore deposit, production scale, traffic and other conditions peculiar to this country and necessity for importing most of required materials to be transported through the large area of India.

We estimated the cost on the following conditions:

i) For depreciation, we took equal depreciation for the period of 10 years, which commences from the latter half of the third year.

ii) On the amount undepreciated at the beginning of each fiscal year, the annual interest of 7.5 per cent is summed up.

In the third year, interest is calculated for one full year on the operation cost for half a year.

iii) Regarding royalties for mining right, rate on mineral product and import duties, we calculated the respective amount, making reference to the pertaining parts of the Bureau of Mine's reply to our questionair. But municipal property tax and business are excluded.

iv) Prices of materials and land, as long as available in Nepal, are summed up from the source of the Bureau of Mine's reply mentioned in the above. Those materials unavailable in Nepal are presupposed to be imported from Japan, these prices being ± o.b. prices plus freight and import duties.

v) Labor cost factors are put as follows, as a result of making reference to data obtained in Nepal.

Manager	Rs. 1,500/month
Middle Manager	Rs. 1,000 to 1,200/month
Superintendent	Rs. 300 to 500/month

Underground laborer	drilling loading transport timbering	Rs. 10/day
Other underground laborer	except the above and the under	Rs. 7 to 8.5/day
Machine operator mechanic		Rs. 8/day
Surface sundry services worker		Rs. 5/day

vi) The higher cost for the third year in spite of commencing depreciation from the latter half of the acme is explained by the following reasons:

a) The first half of the same year is taken as the trial operation period and the consumption of the iron foundry is estimated lower than ordinary period.

b) As mentioned in the preceding, interest on the half year's operation cost was calculated for one full year.

c) As there is no stock yard for the ore produced in the 1st and 2nd years, it is stored at Godavari for a time and, on completion of the crushing plant, is carried back to the mine site to be treated at the plant.

Estimated Cost for the initial 5 years from start of production

		3rd year		4th year		5th year		6th year		7th year	
Crude ore fed to plant		ton 17,615	Fe % 49	ton 20,000	Fe % 49	ton 20,000	Fe % 49	ton 20,000	Fe % 49	ton 20,000	Fe % 49
Concentrate		ton 10,565	Fe % 49	ton 12,000	Fe % 49	ton 12,000	Fe % 49	ton 12,000	Fe % 49	ton 12,000	Fe % 49
Total length of excavated tunnel		277.6 M	15.8 M	267.8 M	13.4 M	150.0 M	7.5 M	150.0 M	7.5 M	146.5 M	7.3 M
Personnel	staff	18		18		18		18		18	
	laborer	44		44		44		44		43	
	sub-total	62		62		62		62		61	
Efficiency		crude ore/ head ton 0.95		crude ore/ head ton 1.08		crude ore/ head ton 1.08		crude ore/ head ton 1.08		crude ore/ head ton 1.09	
Cost Components		cost amount	per ton	cost amount	per ton	cost amount	per ton	cost amount	per ton	cost amount	per ton
Mining sect		RS 189,180	17.9	200,830	16.7	132,570	11.0	119,690	10.0	119,560	9.9
Transport sect		147,250	14.0	138,960	11.6	139,320	11.6	139,680	11.6	140,040	11.7
Ore dressing sect		30,220	2.9	32,680	2.7	34,220	2.9	35,120	2.9	35,600	3.0
Overhead		154,540	14.6	176,940	14.7	166,570	13.9	167,200	13.9	167,830	14.0
Administration		176,410	16.7	180,720	15.1	185,140	15.4	189,670	15.8	194,320	16.2
Depreciation		203,150	19.2	411,530	34.3	411,530	34.3	411,530	34.3	411,530	34.3
Interest		355,300	33.6	275,770	23.0	246,760	20.6	217,740	18.1	202,520	16.9
Contract work		34,880	3.3	36,510	3.0	32,890	2.7	32,570	2.7	32,870	2.7
Royalties for mining right		770	0.1	770	0.1	770	0.1	770	0.1	770	0.1
Rate on mineral product		55,990	5.3	63,600	5.3	63,600	5.3	63,600	5.3	63,600	5.3
Technical guidance expenses		480,000	45.4	231,000	19.3	81,000	6.8	81,000	6.8	81,000	6.8
Concentrate transport		581,080	55.0	660,000	55.0	660,000	55.0	660,000	55.0	660,000	55.0
Total		2,408,770	228.0	2,409,310	200.8	2,154,370	179.6	2,118,570	176.5	2,109,640	175.8
Investment		52,180		—		—		—		—	
Undepreciated amount of the year end		3,912,120		3,500,590		3,084,960		2,872,830		2,461,300	

Number of face preparation against planned ore quantity

	Section	1-1	1-2	2-1	2-2	3-1	3-2	Total
Transport level	2.5^Mx2.1^M	188.0^M (53.0^M)	-	241.5^M (90.0^M)	-	-	-	429.5^M (143.0^M)
Change transport level	2.5^Mx2.1^M	-	-	100.0^M (70.0^M)	-	100.0^M (70.0^M)	-	200.0^M (140.0^M)
Roof falling of loading mouth of No.1 chute	2.5^Mx3.0^M	2.5^M (0.0^M)	-	2.5^M (1.5^M)	-	2.5^M (0.0^M)	-	7.5^M (1.5^M
Raise beginning of draw hole of the above	3.0^Mx2.0^M	3.5^M (0.0^M)	-	3.5^M (2.0^M)	-	3.5^M (0.0^M)	-	10.5^M (2.0^M)
Raise of the above	1.8^Mx3.0^M	9.0^M (0.0^M)	-	9.0^M (3.0^M)	-	9.0^M (0.0^M)	-	27.0^M (3.0^M)
Roof falling of loading mouth of No.2 chute	2.5^Mx3.0^M	-	-	2.5^M (2.5^M)	-	2.5^M (0.0^M)	-	5.0^M (2.5^M)
Raise beginning of draw hole of the above	3.0^Mx2.0^M	-	-	3.5^M (3.5^M)	-	3.5^M (0.0^M)	-	7.0^M (3.5^M)
Raise of the above	1.8^Mx1.5^M	-	-	9.0^M (3.0^M)	-	9.0^M (0.0^M)	-	18.0^M (3.0^M)
Roof falling of leading mouth of No.3 chute	2.5^Mx3.0^M	-	-	-	-	2.5^M (0.0^M)	-	2.5^M (0.0^M)
Raise beginning of draw hole of the above	3.0^Mx2.0^M	-	-	-	-	3.5^M (0.0^M)	-	3.5^M (0.0^M)
Raise of the above	1.8^Mx1.5^M	-	-	-	-	9.0^M (0.0^M)	-	9.0^M (0.0^M)
Under cut level	2.0^Mx2.0^M	17.0^M (0.0^M)	-	53.5^M (10.0^M)	-	53.0^M (0.0^M)	-	123.5^M (10.0^M)
Connecting man way of No.1 sub-level	2.0^Mx2.0^M	24.5^M (0.0^M)	-	29.0^M (0.0^M)	-	11.5^M (0.0^M)	-	65.0^M (0.0^M)
Boring Gallery of the above	2.5^Mx2.5^M	51.5^M (25.5^M)	-	107.5^M (53.0^M)	-	101.5^M (50.0^M)	-	260.5^M (128.5^M)
Slot connecting man way of the above	2.5^Mx2.5^M	23.5^M (11.5^M)	-	8.0^M (0.0^M)	-	11.5^M (0.0^M)	-	43.0^M (11.5^M)
Connecting man way of No.2 sub-level	2.0^Mx2.0^M	25.5^M (0.0^M)	-	$29.^M$) (0.0^M)	-	-	11.5^M (0.0^M)	66.0^M (0.0^M)
Boring Gallery of the above	2.5^Mx2.5^M	60.0^M (30.0^M)	-	104.0^M (52.0^M)	-	-	101.0^M (50.0^M)	265.0^M (132.0^M)
Slot connecting man way of the above	2.5^Mx2.5^M	20.5^M (10.0^M)	-	22.0^M (0.0^M)	-	-	11.5^M (0.0^M)	54.0^M (10.0^M)
Connecting man way of No.3 sub-level	2.0^Mx2.0^M	-	25.5^M (0.0^M)	-	32.5^M (0.0^M)	-	-	58.0^M (0.0^M)

Number of face preparation against planned ore quantity (contn.)

	Section	1-1	1-2	2-1	2-2	3-1	3-2	Total
Boring Gallery of the above	2.5^{M}x2.5^M	-	67.0^M (33.0^M)	-	103.0^M (51.0^M)	-	-	170.0^M (84.0^M)
Slot connecting man way of the above	2.5^{M}x2.5^M	-	28.0^M (14.0^M)	-	22.0^M (0.0^M)	-	-	50.0^M (14.0^M)
Boring Gallery of No.4 sub-level	2.5^{M}x2.5^M	-	78.0^M (39.0^M)	-	98.5^M (38.0^M)	-	-	176.5^M (77.0^M)
Slot raise	1.8^{M}x1.5^M	54.0^M (27.0^M)	35.0^M (17.0^M)	28.0^M (11.5^M)	54.5^M (0.0^M)	24.0^M (0.0^M)	-	195.5^M (55.5^M)
Man way raise	2.7^{M}x1.5^M	73.0^M (0.0^M)	-	71.0^M (2.0^M)	-	-	-	144.0^M (2.0^M)
Drainage raise	2.7^{M}x1.5^M	54.5^M (36.5^M)	-	-	-	-	-	54.5^M (36.5^M)
Total length of drifting	-	607.0^M (193.5^M)	233.5^M (103.0^M)	823.5^M (304.0^M)	310.5^M (89.0^M)	346.5^M (120.0^M)	124.0^M (50.0^M)	2,445.0^M (859.5^M)
Undercutting for No.1 draw hole	-	400M^3 (100M^3)	-	400M^3 (200M^3)	-	400M^3 (0M^3)	-	1,200M^3 (300M^3)
Undercutting for No.2 draw hole	-	-	-	400M^3 (0M^3)	-	400M^3 (0M^3)	-	800M^3 (0M^3)
Undercutting for No.3 draw hole	-	-	-	-	-	400M^3 (0M^3)	-	400M^3 (0M^3)
Total of undercutting	-	400M^3 (100M^3)	-	800M^3 (200M^3)	-	1,200M^3 (0M^3)	-	2,400M^3 (300M^3)

Number in parenthese is quantity of excavated rock.

V Survey of the demands for iron and steel

5.1 Demands for iron and steel

According to the survey of annual demands for iron and steel by the Department of Commerce of the Nepalese Government, the country's consumption of these materials is estimated as in the following table:

Table 1 Estimation of iron and steel demands in Nepal for 1965/66

Product	Quantity * (metric tons)
Structural including bars and rods	8, 000
Corrugated galvanized sheets	2, 000
Scrap steel for agricultured purpose	4, 000
Household appliance	6, 000
Billets for re-rolling	8, 000
Hoop iron	200
Total	28, 200
Pig iron	10, 000

* The figures refer to the orders has been placed in 1965/66

The five-year plan of economical development estimates the demand for steel during the whole period at 70, 000 metric tons, which represents the steel structurals imported as equipment parts.

5.2 Demands of steel products by kind

As indicated in Table 1 8, 000 metric tons of iron are required for bars and rods and the same quantity of billets: the total of these billets is re-rolled by Himal Iron and Steel Company into about 7, 000 metric tons of bars. Accordingly the estimated demand for bar totals 15, 000 metric tons.

Construction of schools, hospitals and other buildings by aid from abroad requires a lot of steel products, but they are too large in size to be rolled by the shop of Himal and it is not for general industrial uses: therefore, it cannot be regarded as a steady demand for them.

5.3 Demands for cast iron products

Although the demand for pig iron is estimated at 10, 000 metric tons per year, as shown in Table 1, the figure is far beyond probable for today. Nepal is predominantly an agricultural country, and for the welfare of the nation it is of prime necessity to promote the increase in food production and the improvement of cask-crop. In the third five-year plan of economical development, the Government lays the strongest emphasis on the development of agriculture. The improvement of productivity of agriculture in this country requires many pumps and pipes for irrigation and farm machines and implements. But farmers can afford to buy only agricultural machines and implements which require only small elements made of foundry iron ammounting to a trivial weight.

5.4 Peculiarity of charcoal pig iron

Pig iron produced with charcoal as reductant contains little sulphur and other impurities, and therefore is highly evaluated as quality materials for superior cast iron for vehicles, for rolls and for ingot mould, it is effective for the improvement of the quality of casts. Since chacoal iron is not produced now in India, most probably she will want to import it to lengthen the life of ingot moulds. Besides, it is highly valued as a raw material of quality steel because of its low sulphur content and virginity. Welding rods and wire cables will deserve consideration for production in Nepal.

VI Raw materials and other utilities

In planning iron work, it is necessary to investigate supply conditions of main raw materials, that is, iron ore, limestone and reductant. In addition to them, availability of manganese ore, deoxidizer and refractories, electric power, industrial water, etc. must be examined, too.

6.1 Iron ore

Regard to the conditions of iron ore has been discussed already in Chapters III and IV, it will be noted here briefly.

(a) The iron ore deposits in Nepal

Although in Nepal the three deposits, namely, Phulchoki, Labdy and Thosay are recognized, only Phulchoki is workable.

(b) Dependability of Phulchoki deposit

According to Chapter IV, the supply capacity of Phulchoki deposit and the chemical composition and the production cost of Phulchoki ore are estimated as follows.

(i) Supply capacity .... 900, 000 t

(ii) Average composition (%) of ore may be supplied

Fe,	SiO_2,	Al_2O_3,	CaO
49.4,	17.5,	4.3,	0.3

(iii) Production cost (including freightage)

Year;	3rd,	4th,	5th,	6th,	after 11th
Rs/t	228,	200,	179,	176,	118

The low Fe content and high transportation cost of the ore make the iron industry in Nepal very difficult both technically and economically.

6.2 Limestone

Although two domestic limestone deposits can be named, one located at Bhainse near Hitaura and the other at Chobhar to the south of Kathmandu, it is assumed to import limestone from India, for, according to the investigation of this time, the limestone from Bhainse is of low grade and that from Chobhar makes its transportation cost very high in spite of its high grade.

Composition of Indian limestone (assumed)

CaO	SiO_2
50	5

Purchasing price at the iron works in Nepal (assumed) ...... Rs 40/t

6.3 Reductant

(a) Choice of Reductant

As a reductant of iron ore coke and charcoal can be used. If coke is imported from India, its price at the iron works in Nepal is assumed to be Rs. 154/t. As calculated in chapter XII, the price of charcoal from Birganj forest is Rs 160/t, a little more expensive than that of imported coke. Considering the basic idea that the main raw materials should self-supplied, domestic charcoal is to be preferable. In Birganj forest trees are small on the whole in diameter, so that the amount of the trees which can be used as timbers is estimated to be less than 20% of the all. It was observed that Birganj forest was abundant in trees with moderate size for charcoal making.

(b) Dependability of Birganj forest as a source of charcoal.

(i) Specific wood yield of Birganj forest is estimated to be $50m^3/ha$ on the average.

(ii) Specific gravity of the timber is estimated to be 0.59.

(iii) The quantity of charcoal obtained from 1 ton of the timbers is estimated to be 0.17t.

(iv) It is calculated from (ii) and (iii) that 10 m^3 of timbers are needed to produce 1 ton of charcoal.

(v) The quantity of charcoal required per ton of hot metal is estimated to be 900 kg.

(vi) Therefore the yearly consumption of charcoal can be calculated as follows;

$$900kg \times 5.760 = 5184 \fallingdotseq 5,200t$$

(vii) On the other hand, the quantity of timbers required annually is;

$$10m^3 \times 5200 = 52,000m^3$$

(viii) Total quantity of timbers obtained from Birganji forest, the area of which is 400 sq. mile, is calculated as follows;

$$50m^3 \times (259 \times 400) = 5,180,000m^3$$

That is, in terms of charcoal .... 518,000 tons

(ix) The life of Birganji forest is;

In the case of the operation with 16 t blast furnace,

$$(5,180,000 \times 0.8 \div 10) \div (5,200 \div 0.9) = 71 \text{ years}$$

(x) In the above calculation, the factor "0.8" means that 20% of the all trees can be supplied to Timber Corporation of Nepal, while "0.9" means that 10% of charcoal will be reduced to powders which cannot be fed to the blast furnace.

6.4 Electric power

Three diesel generators are equipped in Hitaura Diesel Electric Power Station, each of which is bestowed, with a capacity of 1400 KVA, so that the total capacity of the station amounts to 4410 KW.

Electric power generated in this station is scheduled to be transmitted to the southern district, Birganj through the 11KV line in the near future.

In addition, Trisuli Hydroelectric Power Station (18, 000, kVA), the construction of which will be completed soon, to the north of Kathmandu, is planned to supply mainly to Kathmandu. The latter is also planned to transmit its power to Terai district over the mountain pass in the future.

On the other hand, though the Kulikhani Hydroelectric project is only in planning yet, and we cannot foresee exactly the starting of its construction, its proposed output of 26, 000 kVA will contribute very much to the development of the industry in Hitaura district.

As described above, Central Terai district is expected to become center of the power transmission grids.

It is informed that the unit cost of electric power for industrial use is Rs 0.3/ kwh.

6.5 Industrial water

The Karra Khola River, which running at the south of Hitaura village from the east to the west, joins the Rapti River, is small in scale, but never dries up throughout the year. Its flow rate is, however, small. Therefore, for combined operation of both pig iron smelting and steel refining, reuse of industrial water should be necessary.

Anyway, exact investigation of the flow rate is required.

6.6 Steel scrap

Steel scrap is required for refining steel as a part of the raw materials. In most cases the price of steel scrap approximately equals 80% of that of pig iron.

It cannot be expected to acquire it in the country. In the northeast India it is hardly available, too. Therefore, import of steel scrap was assumed to be hopeless.

6.7 Refractory bricks, deoxidizers etc.

Since the consumption of refractory bricks is estimated to be small, they were assumed to be imported instead of being self-supplied.

Deoxidizers, oil and grease and other consuming goods must be imported, too.

VII Economic feasibility of establishment of the iron and steel works

According to the investigation on the demand for steel, it was estimated that the demand for steel amounts to 28, 000 t/year, while that for cast iron is very small.

Out of the total demands for steel, 28, 000 t, the products which can be manufactured by small scale works are limited to bars and shapes of medium to small size, which amount to 8, 000 t, according to Table I. Therefore, the sum of this and the 7, 000 t of bars produced by Himal works from 8, 000 t of billet, i. e. 15, 000 tons can be reckoned as the total demands, for which 18, 000 t/year of ingot are required. The capacity of the blast furnace suitable for this production rate is 50 t/day.

In the districts where steel scrap is hardly available, while more than 50, 000 tons of crude steel is to be produced, the L. D. converter process is applicable to refining steel. On the other hand, if the scale of production is smaller than this, for example, 18, 000 t/year as in the case mentioned above, the only applicable method seems to be the electric arc furnace process with desiliconizing by use of oxygen. However, the production cost of this process is almost inhibitory because of the high installation cost. Therefore, it can be concluded that the construction of a 50 t/day blast furnace in accordance with the production scale of steel ingot of 18, 000 t/year is not reasonable. In the refining operation of steel by the electric furnace using only hot metal, the hearth of the furnace is badly eroded by silicon, so that the operating hours are greatly shortened by repairing time for the damaged hearth. In Japan the process is operated in only two works which can cancel out these demerits by the cheap by-product oxygen gas supplied by neighboring chemical plants, with conducting pretreatment of the desiliconizing process in ladles with basic lining, and by producing special steels with high additional values.

Thus, investigation of the possibility of production of foundry pig iron for cast iron indicates that the demand for cast iron in Nepal today is far below the minimum capacity (16 t/day) of a charcoal furnace, that is, 6, 000 t/year.

So, endeavor should be made to expand demands for foundry pig iron, until the construction of a blast furnace with the capacity of 16 tons per day can be started when the demands attain to 6, 000 t/year.

To sum up, we do not recommend to build a blast furnace with a capacity of 50 tons because its capacity is too large to meet the present demands for cast iron, while the steel production cost will be too high although in this case the steel production capacity is adequate.

Construction of a blast furnace with the capacity of 16 tons per day, which is the smallest possible capacity of the charcoal furnace, is not justifiable, too, because the cost of steel ingot will be even higher due to smaller size of steel making capacity, if it is directed to steel making, while the yearly demand for foundry pig iron is too small, if it is considered to produce foundry iron.

If the Government begins to promote construction of the factory for agricultural machinery and irrigating equipments in view of agricultural development and mass production of pumps and pipes were started, demands for cast iron will increase rapidly, even though the present demands are trivial. Moreover, if the investigation of the cast iron market in India shows that export to India is promising, it will also be possible to prospect a demand of more than 7, 000 tons per year.

Some day in the future when the demand exceeds 6, 000 tons per year, taking all into account the charging material for the electric furnace of Himal Steel, production of agricultural machinery and export to India, it will be reasonable enough to construct, as the initial installation, a charcoal blast furnace with a capacity of 16 tons per day.

Consequently, this report deals only with the operation of 16 tons per day charcoal blast furnace in further details.

For the sake of reference, brief description is made of steel-making operation, too.

VIII Selection of operation process

8.1 Selection of iron making process

(a) Condition of reductant

There are two types of iron making processes, namely, blast furnace iron smelting process and electric iron smelting process.

In a blast furnace, pig iron is produced by reaction between iron ore and coke or charcoal. In this case, coke or charcoal is used not only as reductant but also as fuel.

In an electric furnace, charcoal or anthracite is charged together with iron ore and the charged material are heated by means of electricity. Thus, the only role of coke or the like is to reduce the ore.

Therefore, in this case, the consumption of reductant is only 50% of that required in the former case, while the electric power of 2, 400 kwh is required per ton of pig iron.

(b) Choice of reductant

At first it should be examined, which is suitable, coke imported from India or indigenous charcoal.

(i) Indigenous charcoal

Central Terai District is the large forest zone consisting of Birganji and Chitwan, of which area is 400 square mile each. The climate of this district is characterized by high temperature and high humidity, and Malaria fever is ready to prevail. As a result the agriculture in this district has not been developed yet.

Birganji forest is a gigantic jungle extending to 90 km from the east to the west and 20 km from the north to the south, covered mainly with Sal trees and inhabited by wild beasts and animals.

If charcoal is produced taking advantage of this wood source of Birganji forest, more than 518, 000 t of charcoal will be available at the cost of Rs 160/t, as already mentioned in the section 3 of Chapter VI. It is calculated that the life of this source would be 71 years, if a 16 t/day blast furnace is operated. Considering the possibility of reforestation, it is reliable enough as the source of charcoal. The production cost of charcoal is reasonable compared with the international standard.

(ii) Coke imported

The ex-factory price of Durgapur coke, India, is Rs. 97/t. Being transported a long distance via. the border, Raxoul, to Hitaura, its price rises up to Rs. 154/t, much the same to that of domestic charcoal.

In case the main materials are supplied from foreign countries, any accident may happen in transportation by which the supply is interrupted. Also because the foreign currency should be saved, it is concluded that coke should not be imported.

In addition, the coke which India is willing to export is of nut size, too small to be charged to the blast furnaces in India. According to the forecast of the iron industry in India in the future, swelling demands for iron ore will necessarily require introduction of sintering process for beneficiation of fine ores, as a result of which the demand for nut coke will grow so rapidly that export will be impossible any more.

As it is not reasonable to ask for materials with little dependability, it was concluded that domestic charcoal should be used as reductant.

(c) Comparison between blast furnace and electric furnace, both fired by charcoal.

By use of an electric furnace, charcoal can be saved, while power consumption is very large. The latter is estimated at 3000kwh/per ton of pig iron in this case because of the low grade of the iron ore.

The capacity of the transformer attached to the electric furnace must be 3500kVA, which is almost impossible for the present power supply conditions in this district. Even if the power were available, the power cost per ton of pig iron is calculated as;

$$0.3 \times 3000 = \text{Rs. } 900/t$$

On the other hand, the cost saved by cutting off 500 kg of charcoal is;

$$160 \times 0.500 = \text{Rs.} 80/t$$

In comparison between those two values, it is clear that the production cost of the electric furnace is much higher than that of the blast furnace. Moreover, in case of the electric furnace the cost for electrode paste must be calculated.

Thus, it can be concluded that preference should be given to the blast furnace process.

By the way, the installation cost of the electric furnace approximately equals 70% of that of the blast furnace.

8.2 Selection of steel-making process

Although it was concluded in Chapter VI that steel-making plant would not be constructed, a trial planning has been made of the steel-making plant with a proposed capacity of 50t/day, of which brief description is made below.

Steel can be produced by various methods as presented in Table 2. Proper choice should be made case by case according to the characteristics of raw materials mainly scrap charging percentage, the scale of the plant and the quality of the product.

Table 2: Various methods of steel making and their characteristics

Type of furnace	Ratio of steel scrap (%)	Production capacity per day	
Open hearth furance	40 - 75	100t	Minimum
Electric arc furnace	70 - 90	20t	"
L. D. converter	0 - 25	150t	"
L. D. /A. C.	0 - 20	150t	"
Kaldo converter	0 - 30	400t	"
Acidic Bessemer	0	100t	"
Thomas converter	0	100t	"
Side blown converter	0	20t	"

The figues in the above table are not absolute. Especialy some of the figure showing productivity may be too reserved in the light of the actual performances.

(a) Decision of steel making process

As described in the first two sections of Chapter V, the demand for steel amounts to 15, 000 t/year. This means that 18, 000 tons of steel ingot are required per annul. Even though steel scrap is not available, this scale of steel-making makes it essential to depend on the electric furnace process. If hot metal is charged directly into the electric furnace, the hearth is exposed to heavy erosion by the silicon contained in the hot metal and the operation must be often interrupted. To avoid this, desiliconizing process is introduced in order to reduce the silicon content of the hot metal.

The desiliconizing process can be done in a ladle lined with basic refractories almost free from erosion.

Although iron ore can be used for refining, mainly decarburizing, of hot metal in the electric furnace, bessemerizing by oxygen gas is even more preferable.

For accelerating the refining process through bessemerizing by oxygen gas, the electric power required can be reduced by a half. The unit cost of oxygen gas, however, will be extremely high as shown below because of the small scale of generation and high unit cost of electric power.

The unit cost of oxygen gas can be estimated at Rs. 1.2/m^3.

Lime and dolomite are required as the flux and the hearth fettling material, while facilities for calcination of clinkers are also needed.

The amount of lime required 5t/day

The amount of dolomite required 1.5t/day

On account of the small scale of the calcinizing furnace, it is assumed so that the unit cost of fuel and the like would be twice that in usual cases.

Further, it is not preferable to transport them from distant places, because long-term stock is not possible.

It may be inevitable to depend on import for some materials such as bricks, deoxidizers, etc.

Side blown converter process seems to meet for a small scale steel-making process of which main material to be charged is hot-metal only, however, we decide not to adopt this system since the difficulty of continuous operation.

IX Selection of the plant site of the iron and steel works

In selecting the place of establishment of the iron and steel works, it is necessary to examine carefully the following conditions. In difference from the choise of the process or the arrangements of machines, the selection of the plant site cannot be altered afterwards. Miscalculation of the selection of the site does permanent harm to the economy of the project.

The following points can be named as the prerequisites for the choise of the site.

9.1 Prereguisites

(1) Minimum cost of transportation of major raw materials such as iron ore, linestone and reducing agents.

(2) Availability and dependability of transportation facilities for supply of raw materials.

(3) Small distance to the market.

(4) Possibility to occupy large enough plant site to meet future extention.

(5) Sufficient soil strength and ensure low ground levelling cost.

(6) Availability of electric power with small additional investment.

(7) Assurance for both industnal and drinkable water in all seasons.

(8) Easy access to the town ship, especially residencess, schools and hospitals.

(9) Presence of repair shops for machines and equipments.

(10) Transportation facilities for carrying part of raw materials or other supplies from abroad, if any.

(11) Ease or difficulty in collecting labourers.

It is important to investigate most considerately the geographical relationship to the supply source of raw materials, which influences most seriously the cost of production among others.

9.2 Comparison of the proposed sites, between Hitaura and Patan

(1) Iron ore is mined near to the south of the City of Kathmandu, charcoal is produced in Terai district, and limestone is imported from India.

(2) The east side of Patan can be proposed which is near the source of supply of iron ore and it seems to meet approximately other conditions.

(3) Hitaura can be named in Terai district, since it is near the charcoal-producing center.

The following is comparative examination of both proposed sites.

(4) The weight and the volume of raw materials per ton of pig iron in a 16-tpd blast furnace are estimated at:

	Weight (metric tons)	Volume (cubic meters)
Iron ore	2. 0	0. 8
Limestone	0. 3	0. 3
Charcoal	0. 9	4. 5

The fare of the rope way: -

for Kathmandu Rs 81. 1/t

for Hitaura Rs 40. 1/t

Comparison of the fare of the rope way per metric ton of pig iron production: -

Plant site	Iron ore Limestone	charcoal		total
		by weight	by volume	
Hitaura site	80	0	0	80
Patan site	24	73	365	97 - 389

Charcoal is a material of low bulk density of 200 - 250 kg/m^3. If the rope way fare is charged by the weight of charcoal, the total fare to Patan will be Rs. 97 per metric ton of pig iron, Rs. 17 higher than the fare to Hitaura, Rs. 80/t. This shows the superiority of Hitaura over Patan. But for light materials such as charcoal, the fare is usually reckoned by volume. In this way of calculation, the fare to Patan is Rs. 389/t, 5 times as high as the transportation cost of the ore to Hitaura. This figures indicates decisive superiority of Hitaura over Patan as the place of establishment of the iron works.

The substantial object of the rope way is to transport supplies from the south to Kathmandu. Transport of charcoal to Kathmandu Valley by rope way requires as many as 300 carriers of 0. 3 m^3 each, which may disturb orderly operation of time-shared transport program with other supplies.

especially in the rainy season it will involve troublesome works for protecting charcoal from wetting.

As indicated above, the comparison of the transportation cost for raw materials depends on whether the fare on charcoal is charged by weight or by volume so largely as to determined to which place of proposal the preference is given.

(5) Since Patan is handicapped by the following points besides greater transportation cost of raw materials, Hitaura was selected as the place to build the iron-works.

(a) High construction cost due to increased transportation cost of equipments and machines and higher price of cement.

(b) Increased transportation cost for imported subsidiary materials.

(c) Additional transportation cost for the products to Birganj and Biratnagar where 60% the total products will be consumed.

Two prospective sites for the iron works in Hitaura were submitted to comparison: .one proposed site is abutting on the south side of the rope way station and the other is on the left bank of the Karra Kohla, 1.5 km south of the rope way station along the highway. As a result of comperative investigation, the latter was adopted. Since the ground along the River of Karra Kohla, abutting on the highway, covers an immensely large area of thin forest, a sufficiently large space is available. This place is appointed as a center of the industrial development by the Government with the support of the United States, and it is expected that various industries will arise there in future. It is advantageous to be located near the plants of related industries. It becomes, however, necessary to transport ores and other materials from Hitaura rope way station. On the contrary, the place adjacent to the south side of the rope way station is convenient for the handling of ores, but it is now used as farms and rather small in space. As a result of the comparative examination of both areas, it can be said the land on the east of the highway and the left side of the Karra Kohla is more adequate.

In the following section a brief discussion will be made to inquire whether or not this place satisfies the preceding prerequisits.

9.3 Prerequisites related to the condition of Hetaura site

(1) Omitted

(2) The capacity of the rope way is large enough to transport the ores. This place is convenient for transportation by trucks along Tribhuan Rajpath

to Kathmandu, Birganj and India. Also, Amlekhganj is provide with access to the railway lines. Futhermore the completion of East - West Highway, which is now under construction, will bring about convenience for access to Biratnagar, an industrial district near the east boundary.

Hetaura is located at the important position of these traffic networks.

(3) Kathmandu, Hetaura-Birganj and Biratnagar are three major markets for iron products and Hetaura is in the center of them.

(4) This building site is on a slightly rugged plateau adjoining to Birganj Forest Division, and a large space is available.

(5) Although the soil strength is not fully proved yet, it is observed that ground is not soft nor damp, and expectedly requires little expense for levelling.

(6) Electric power receiving is easily assured, as the main transmission line (11KV) from Hetaura Diesel Power Station (4, 500 kw) extends to the south along the highway. Electric supply from Trisuli Station can also be expected in future.

(7) Karra Kohla is a brook as implied by name, but does not dry up in all seasons. A large river, Rapti runs to the south close to the west side of Hetaura Town.

(8) Hetaura is a small community now, but is provided with various public facilities such as schools and hospitals and suitable for inhabitation.

(9) There is a small machine shop in Hetaura and Birganj Sugar Mill is equipped with a cupola.

(10) This place is convenient for transport of brick, cement, etc. from India. The same can be said of the transportation of construction materials and various equipments and machines.

(11) Expectedly labourers can be collected easily.

Thus, Hetaura can be recommended as a favourable place for building the iron works.

X Outline of the equipments and the operation of the project

10.1 Equipments of the iron-making plant

The project concerns with the construction of one unit of blast furnace producing 16 tons of foundry pig iron per day approx, 6,000 t/year. In case of hot metal production for steel shop the capacity of furnace is increase to 20 ton per day.

(a) Meterial stockyard and handling facilities

(i) Iron ore

At rope way station in Hetaura, iron ore coming from Phulchoki is sent to a receiving hopper by the mono-rail transportor, then fed to a ore bin with belt conveyor. Capacity of the bin is 32 t which corresponds to the throughput of the charcoal blast furnace per day.

The ore in the bin is discharged onto a truck through a discharge gate at the bottom of the bin, and sent to the ore stockyard in the plant site.

The stockyard has a capacity of 320t, equal to the charge quantity of 10 days.

From the stockyard the iron ore is transferred to a bin near the blast furnace by belt conveyors, and then discharged into a weigher car through a gate set at the bottom of the bin. Then the ore is fed into a charging bucket which is waiting in the pit beneath the lifting tower near the furnance.

(ii) Limestone

Limestone is sent to the plant from Raxoul by trucks, and is handled in the entirely same way as the iron ore.

(iii) Charcoal

Charcoal is transported from Birganj carbonization center to the plant by the 4t special trucks, and then sent to a charcoal bin by a belt conveyor at the plant site.

The charcoal bin, being roofed against rains, has a holding capacity corresponding to 5 days' operation. The belt conveyor is also protected from wetting by rains.

Handling and charging procedure of charcoal is the same as that of iron ore.

(b) 16t blast furnace and auxiliary equipments

(i) Dimensions of the furnace

The furnace, whose sectional probile is shown in Fig. 2, has following dimensions.

Hearth diameter	1,300 mm
Total height	9,050 mm
Total volume	16.4 m^3
Effective volume	15.1 m^3

(ii) Charging equipments

Each material discharged from the bin is sent to the lifting tower by a weigher car, and dumped into the charging bucket ready in place at the foot of the tower.

The charging bucket goes up vertically at first, and then travels horizontally to the furnace top. When the bucket setts down on the furnace top, the bell at bottom of the bucket falls to discharge the material into the double bell hopper of the furnace.

(iii) Hot blast stove: Cowper type, 3 sets

(iv) Dust collection and gas cleaning equipment: Theisen washer

(v) Air blower and blast pipe

(vi) Pig casting machine

(vii) Ladles, etc.

2 Operation of the iron-making plant

(a) Proposed quality of foundry iron produced

The content of carbon and silicion in the foundry pig iron produced is assumed to be 3.5% and over 2% respectively.

(b) Charge calculation

Using Phulchoki iron ore, whose chemical composition is presented below, Indian limestone, and Birganj charcoal, the charge ratios can be calculated as follows.

(i) Content weight per ton of iron ore

Fe	494 kg
SiO_2	175 kg
CaO	3 kg
MgO	-
Al_2O_3	43 kg

(ii) Content weight per ton of hot metal

Fe	938 kg
C	40 kg
Si	20 kg

To produce 1 ton of hot metal, 950 kg of Fe is needed in total: 938 kg of Fe for hot metal and 12 kg of Fe as the slag loss.

(iii) Required amount of iron ore for making 1 ton of hot metal

For producing 950 kg of Fe 1, 920 kg, or about 2, 000 kg, of iron ore is required.

$$950 \text{ kg} \div 0.494 = 1,920 = 2,000 \text{ kg}$$

The main ingredients contained in 1, 920 kg of iron ore are as follows:

SiO_2	17. 5% x 1, 920 kg =	334 kg
CaO	0. 3% x 1, 920 kg =	6 kg
Al_2O_3	4. 3% x 1, 920 kg =	82 kg

In iron making operation 43 kg of SiO_2, out of 334 kg, is reduced to 20 kg of Si which is retained in hot metal; the rest of SiO_2 (291 kg) goes into slag.

(iv) Slag basicity

When foundry pig iron is produced from the high siliceous iron ore described above, acidic slag operation is more economical than basic.

The definition of basic operation or acidic operation depends upon the ratio $\frac{\text{CaO (kg) in materials charged}}{SiO_2 \text{ (kg) in materials charged}}$.

If the ratio is over 1. 2, the operation is called "basic", if it is less than 1. 2, it is called "acidic".

In this project the slag basicity of the iron making operation is assumed should be 0. 7.

(v) Amount of limestone required per ton of pig iron.

At the slag basicity of 0. 7, the amount of Indian limestone required per ton of pig iron is calculated from following formula.

L .... Amount of limestone required per ton of pig iron in ton.

$$\frac{\text{CaO kg in limestone}}{SiO_2 \text{ kg from iron ore and limestone}} = 0.7$$

Assuming that the limestone imported from India has the composition, CaO: 50%, SiO_2: 5%, we obtain:

$$\frac{500 \times L}{219 + 50 L} = 0.7$$

L = 0.330 t

(vi) *Content amount of CaO and SiO_2 in 330 kg of limestone*

CaO 50% x 330 kg = 165 kg

SiO_2 5% x 330 kg = 16 kg

(vii) Amount of slag produced per ton of pig iron.

The amount of slag is calculated as 576 kg from the following table. But the actual quantity of the slag may increase to about 850 kg, since Al_2O_3, MgO, *the ash from charcoal and additions of micellaneous* ores are assumed to add to the total slag formation.

Calculation table of slag quantity

(unit: Kg)

	Slag formation		Total quantity
	From ore	From limestone	
FeO	16	-	16
SiO_2	291	16	307
CaO	6	165	171
MgO	-	-	-
Al_2O_3	82	-	82
Total	395	181	576

(viii) Required quantity of raw materials per ton of pig iron

Phulchoki iron ore	2, 000 Kg
Indian limestone	330 Kg
Birganj charcoal	900 Kg

(c) Number of worker required

Staffs	30
Labourers	100
Total	130

10.3 Charcoal carbonization plant

The volume of the kiln of the type, showed in Fig. 3, was assumed to be 40 m^3 (4t of charcoal produced per charge). If suitable clay is available, it is feasible to build simple charcoal carbonizing oven of small size in stead of the kiln.

(a) Annual production capacity of the kiln

The kilns are operated with one cycle of 10 days between charging of raw wood and discharging charcoal produced. Within one cycle of the operation, 40 m^3 of raw wood is carbonized to 4 t of charcoal.

It is calculated that each kiln has the annual production capacity of 144t.

4t per 10 days x (360 days per year ÷ 10 days per cycle)

= 144 t per year/kiln

(b) Number of kiln needed

As the projected iron making plant 6, 000 t/year consumes 5, 400 t of charcoal per year, it is necessary to build 42 kilns for producing the required quantity of charcoal.

5, 400 x 1. 1 t per one year ÷ 144 t per year per kiln

= 42 kilns

In this calculation, the annual consumption of charcoal is estimated at 5, 940 t, assuming the handling loss of the charcoal is 10% in weight.

Addition of a spare capacity of 15% to the calculated number of units results in the total number of kilns in 50 units.

(c) Number of worker required

About 16t of charcoal, including dust loss, is required per day. It means that 160 m^3 of raw wood in total should be treated daily in the charcoal carbonization plant.

Considering the actual performance is Japan, it is estimated that 0. 15t of charcoal is produced per one man-day at the average working efficiency including falling down and transportation of raw woods and the operation of the charcoal kiln.

Calculating from the efficiency of 0. 15 t per man-day, 117 workers should be required for the operation.

16t x 1. 1 per day — 0. 15t per man-shift

= 117 workers

Adding to this 13 staffs, 6 workers for transportation of charcoal and 10% spare member, the total number comes up to 150.

(d) Kiln center

The total 50 kilns including the stand-by are grouped into 5 of 10 units, and for each group a kiln center is established.

The grouping is done from consideration of the distance of transportation of raw woods.

(e) Forest area coverd by each kiln center

The area of the forest which should be coverd by each kiln center is examined as follow;

Each kiln center with 9 units of working kilns (another kiln will be under repairs) produces 4t of charcoal daily on the average.

It is assumed that each center displaces its position every five years. Thus the amount of raw woods to be cut down during the period and its forest area should be as follows:

$$1,152 \times 1.2 \times 10 \times 5 \div 50 = 1,400 \text{ hectare}$$

1,152 ...... Charcoal production tounage per kiln per year.

1.2 .... 20% wood may be used for timber.

10 ...... Wood volume (m^3) per ton of charcoal.

5 ...... 5 years.

50 ...... Wood volume (m^3) yield per hectare.

The area of 1,400 hectare is equal to about 3.8 km squre. Therefore, suppose the kiln center is positioned in the center of the field of 4 km squre, the distance of transportation of raw woods will be about 1 km on the average for 5 years.

(f) Construction cost of kilns

The materials needed for the construction of one kiln are as follows:

Steel structurals	2 t
Brick and mortar	23 t
Sand and gravel	5 m^3
Cement	60 Kg
Total construction cost	12,700 Rs.

(g) Transportation of charcoal

Two special freight trucks of 20 m^3 (4 t) will transport 16 t of charcoal to the plant by 4 round trips per day. In addition, two station wagons will be provided.

(h) Reforestation

Operating a blast furnace with a capacity of 16 t per day, no reforestation will be needed after cutting down the trees, because the forest is large enough. In this way, agricultural land of 1,440 hectare may be obtained every year.

Along the forest roads in Birganj Forest water springs are found in some places, indicating that the forest area is good for cultivation as well as for reforestation.

10.4 Equipment of steel-making plant

Consideration was made for the steel making plant corresponding to a blast furnace of 16t or 50t of pig iron per day, or annual capacity of 6,000 t or 18,000 t of steel respectively. The conclusion was, however, that neither plan was practicable.

For the sake of reference only, description is made of the steel making plant with an annual capacity of 18,000 t of crude steel.

(a) Steel making plant (producing 18,000 t of crude steel per year)

5 t electric arc furnace	2 units
Electric transformer	2,000 KVA
10 t hot metal crane	1 unit
De-siliconizing ladle	5 units
Hot metal mixer (20 t)	1 unit

(b) Equipments for moulding yard

Teeming pit and ingot mould	
Ladle and 10 t ladle crane	2 units

(c) Oxygen gas generator

Capacity 60 m^3/h

Oxygen gas compressor

Oxygen gas receiver (100 m^3)

(d) Calcination kilns for limestone and dolomite

Capacity of limestone kiln	5 t/day
Capacity of dolomite kiln	1.5 t/day

10.5 Operation of steel-making plant

Hot metal is tapped from 50 t blast furnace, transferred to the ladle lined with basic refractory, and then submitted to deoxidizing process.

On the assumption that the steel making plant is constructed the role of the blast furnace is to produce pig iron for steel making. In this case silicon content of the hot metal should be less than 1%.

Desiliconized hot metal is charged into the electric arc furnace, in which oxygen gas is blown in for decarburization i. e. bessemerizing.

100 kg of lime is required per ton of steel.

After refining is over, the liquid steel is tapped into a ladle and then teemed into the ingot molds prepared at the teeming pit of moulding yard. Thus the billet size ingot of 80 kg each are produced. The bottom teeming method should be applied, since the ingot size is very small.

It is not practical to produce ingots smaller than 80 kg in view of the security of quality and the ease of operation.

Because the size of the 80 kg ingot is 85 x 85 mm in cross section, it can not be worked by the existing rolling mill at the Himal Iron and Steel Co., due to insufficient size of the roll diameter. The maximum ingot size which can be handled by the Himal's mill is 65 x 65 mm.

In order to roll the ingot of 80kg, it is necessary to arrange another roughing mill prior to the existing rolls to reduce preparatorily the sectional area of the ingot.

XI Estimation cost of construction

11.1 Iron-making plant

Material stockyard and handling equipment	860
Blast furnace and ancillaries	1,370
Auxiliary plant and equipments	1,400
Foundation and other civil works	810
Buildings and laboratory	1,180
Engineerings and contingency	1,060
Total (unit: 1,000 Rs.)	6,680

Expenses for the purchase of the plant site, the clearing of the ground, the residence of workers and welfare facilities are not included.

Besides the expenses for construction, over 1,400,000 rupees are required for as working capital.

11.2 Carbonization plant

Construction of 50 kilns, purchase of portable conveyors for loading charcoal onto the trucks, and the transportation facilities of charcoal and raw wood, and the tools for falling down of trees required following capital:

4 t kilns 50 units	630,000 rupee
Saws, belt conveyors, etc.	170,000
Trucks 4	280,000
Total	1,080,000

11.3 Steel-making plant

The steel making plant producing 18,000 t of ingot annually will require about Rs. 8200,000 for the equipments as described in chapter X.

In the case of the plant having annual production capacity of 18,000 t ingot, the construction cost per ton of ingot will be Rs. 455, much higher than that of large scale production plant.

XII Estimation of production cost

12.1 Production cost of pig iron per ton: (the 3rd year after the beginning of operation)

	Material required (kg/t)	Material unit price (Rs/t)	cost (Rs)
Material Cost			
Iron Ore	2,000	228	456
Manganese Ore	20	213	4
Lime Stone	330	40	13
Charcoal	900	160	144
Total:	3,250		617
Operation Cost			
Subsidiary material			28
Maintenance & repair			21
Labor cost			30
Total:			79
General administrations			26
Depreciation & interest			195
Grand Total:			917

Remarks: The depreciation is supposed to be paid by yearly installments spread over ten years with the interest of 7.5%, and the labor cost to be Rs. 5 per day on the average.

As the price of iron ore when it arrives at the works is Rs. 201 per ton in the fourth year after the beginning of operation, the production cost of pig iron becomes Rs. 863 per ton.

The production cost of foundry iron, Rs. 917 per ton seems to be too expensive compared with the international price Rs. 520, but out of this production cost Rs. 917 only about Rs. 243 of maintenance and repair cost, administrations and subsidiary material cost, etc. must be paid by foreign currency, while 75% of it can be covered by domestic one. Therefore foreign currency can be greatly cut down.

12.2 Production cost of charcoal:

The production cost of charcoal per ton is as follows.

Royalty	Rs. 125 per 500 ft^3	Rs.	88
Consumption goods			6
Labor cost			30
Depreciation & interest			12
Total:			136

The transportation to Hetaura Works is made by the trucks of exclusive use for charcoal, and this distance is 24 miles (38 km) on the average. Therefore, the transportation cost will be Rs. 24 per ton.

Accordingly the price of charcoal when it arrives at the works is Rs. 160 per ton.

12.3 Production cost of blister steel ingot per ton: In case of annual production amount of steel-ingot is 18,000 tons.)

Items	consumption (kg/t)	unit price (Rs/t)	cost (Rs)
Hot metal	1,000	917	917
Return scrap	150	-	-
Burnt lime	100	250	25
Iron ore	30	228	7
Ferro-alloy	8	2,400	19
Electric Power	300 kwh	0.3/kwh	90
Electrode	10	4,000	24
Oxygen gas	40 m^3	1.2/m^3	48
Refractories & others			80
Labor cost and administrations			40
Maintenance & repair			50
Depreciation & interest			68
Grand Total:			1,368

Because of the high prices of hot metal, oxygen gas, electric power and the depreciation amount to be born, the production cost of steel-ingot becomes very high; it is twice as large as the international price of steel products, Rs. 720 per ton.

In case steel bars are produced from this ingot of high price by rolling suppose the yield is 82%, the price of ingot per ton of finished steel becomes Rs. 1,640 per ton, and if rolling expense is added to this, the cost becomes Rs. 1,910 per ton, which is well over the current price of the imported steel materials Rs. 1, 670 per ton.

As explained above this project may be rather unprofitable and have to take a rather special process, which seems quite risky, so we decided to give up planning for the establishment of the steel shop.

XIII Influence of this project on national economy

1. If this plan is realized, Nepal can self-supply various products for industrial use and agricultural machinery and implements, and as a result the income and productivity of the nation will be increased.

2. If the steel making shop is established, they will be able to purchase domestic steel materials at a stabilized price and with certainty, so the gradual development of many kinds of steel-based industries can be expected. It may still be premature, however, to realize this project.

3. This facility can give employment for about 342 persons in all; about 62 for mining, 150 for charcoal production and 130 for steel production.

4. The forest region of 1, 440 hectare can be offered to farmers every year as farm lands after the felling of material wood.

5. The annual total amount of labor cost:
   In case Rs. 5 per day per capita is paid on the average,

   5 x 342 x 365 = Rs. 625, 000/year

   Rs. 612, 000 can annually be paid out as the salary of employees.

6. Income from ropeway:
   In order to transport the iron ore necessary for the blast furnace producing 16 tons per day, the transportation facility to Hetaura, which has scarcely been used up to this time, will be utilized, and the expected income from this ropeway is as follows:

   Iron ore Rs. 40. 55 x 2 x 6, 000 = Rs. 486, 000

7. Royalty for material wood:
   The royalty of the Government for material wood is Rs. 125 per 500 cubic feet which equal to Rs. 8. 8 per cubic meters. Since 10 cubic meters of material wood is required for a ton of charcoal, the annual royalty becomes:

   Rs. 88 x 6, 000 = Rs. 528, 000 year

8. The rate of national income to the production cost of pig iron:

Labor cost	Rs.	625, 000
Ropeway charges	"	486, 000
Royalty for material wood	"	528, 000
Total:	Rs.	1, 639, 000

The total amount is Rs. 1, 639, 000 per year, which corresponds to Rs. 273 per ton of pig iron, so the rate of national income is 30% of the whole production cost of pig iron.

XIV Problems requiring further considerations

1. Iron manufacturing industry is a basic industry of small profit. Especially in the case of such a small enterprise as this projects, it cannot stand itself without any governmental counterplan of protection such as tax exemption and protective tariff, because the equipment cost and the running cost are too large.

2. The annual productive capacity of the rolling mill in Himal Iron and Steel Co. is 20, 000 tons, but the import of billet from India is limited to only 8, 000 tons per year. Considering the steel manufacturing affairs of India, the increase of the import over this amount cannot be expected. Because of this fact it can be recommended provide the billet size ingot by himself. However, since it is not easy to get scrap iron, it is necessary to confirm the availability of the scrap iron before the establishment of electric furnace can be started.

3. In order to establish the blast furnace, productive capacity of which is 16 tons per day, it is the most important point to confirm the demand for pig iron. For this purpose it is necessary to do the best of the development of the demand for pig iron, such as the export for India and the demand as a part of material for electric furnace in Himal works.

4. If 50% discounts of the rope-way charges and the royalty for material wood are possible, the production cost of pig iron will be reduced to Rs. 837 per ton.

5. It is recommended that the iron works should be established after the domestic supply of cement becomes possible in order to cut down the construction cost and saving of foreign currency.

6. As to the iron ore deposits it is important to extend exploration to the deeper parts of the ore bodies by means of boring test, etc. in order to increase the confirmed reverves of iron ores.

PLATE 10

CHOBHAR LIMESTONE DEPOSIT

CROSS SECTIONS OF DEPOSIT

SCALE 1 1.500

0 10 20 30 40 50m

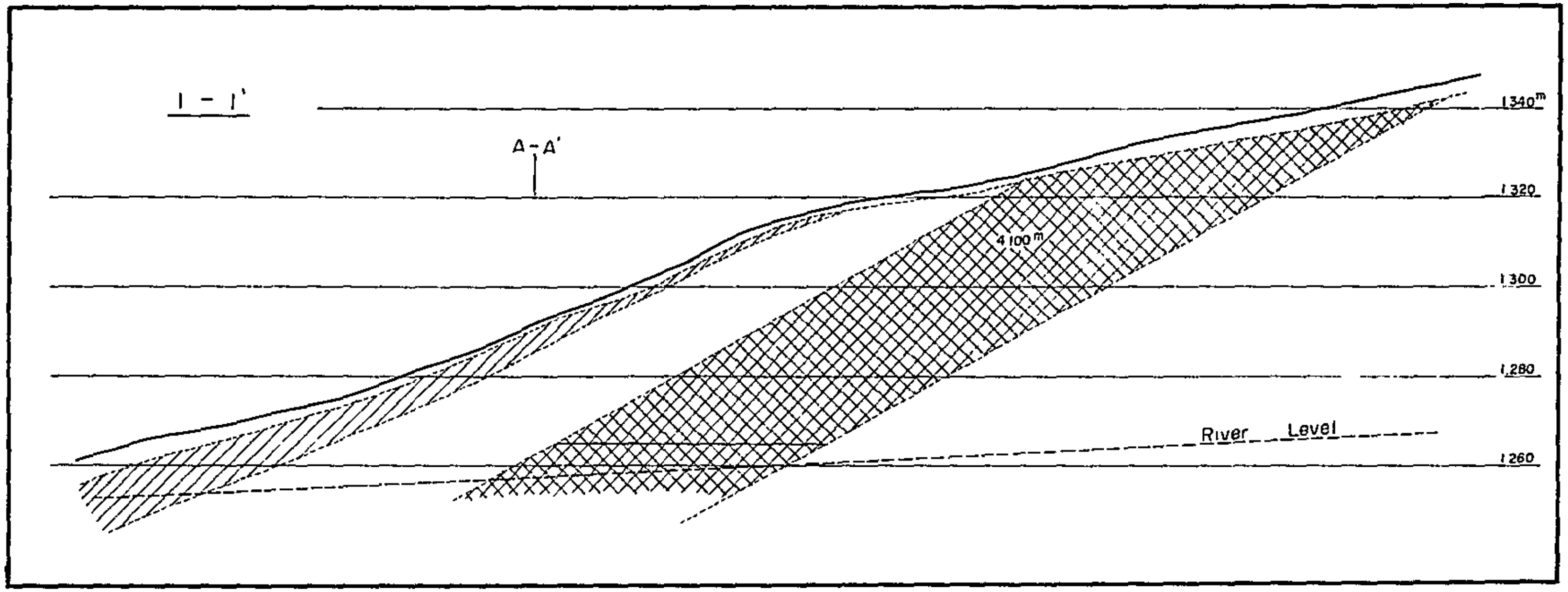
LEGEND

UPPER LIMESTONE FORMATION

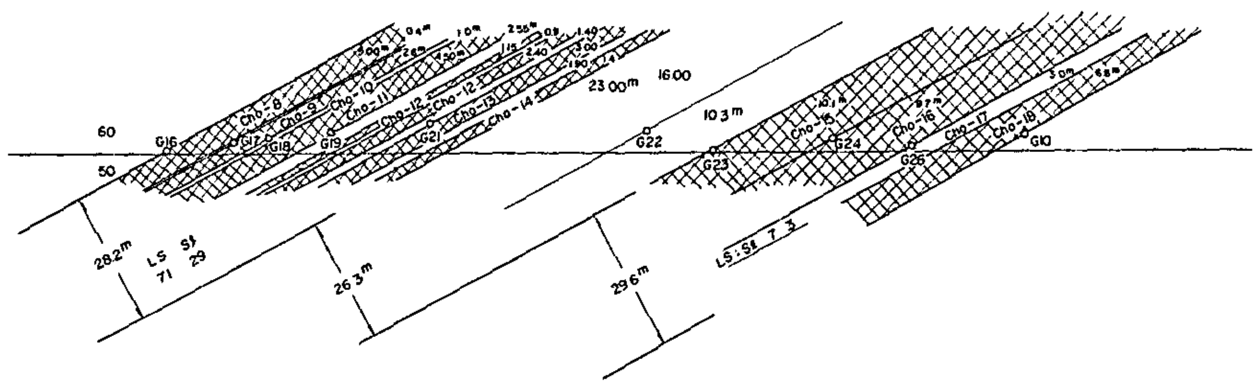
LOWER LIMESTONE FORMATION

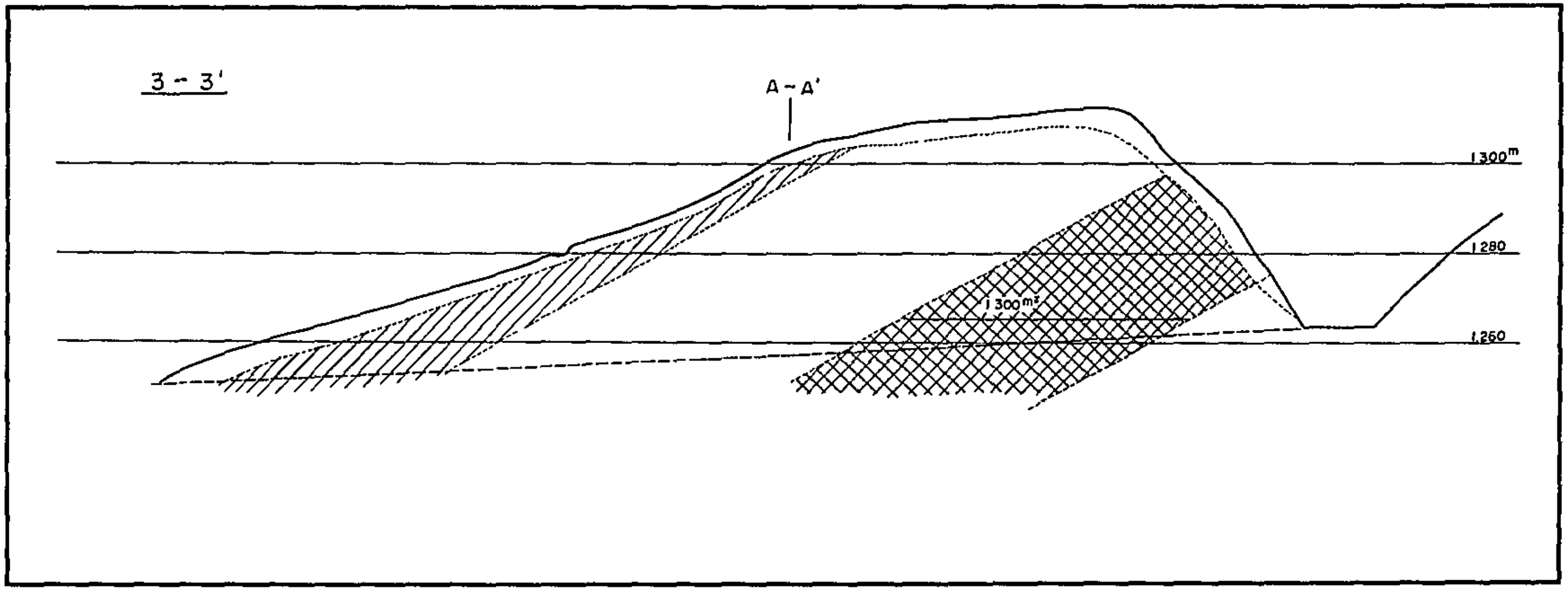
SLATE

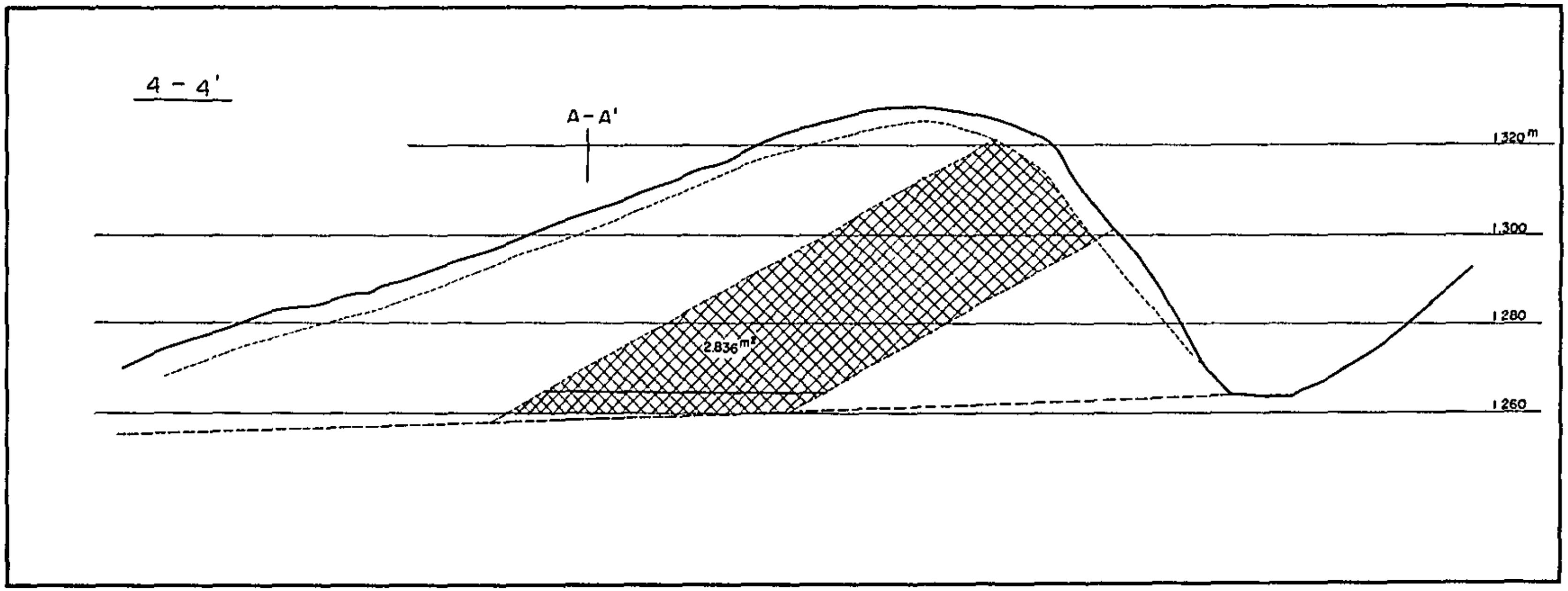
AREA OF ORE RESERVES CALCULATION


I - I'
A - A'
1340m
1320
1300
1280
1260
4100m
River Level

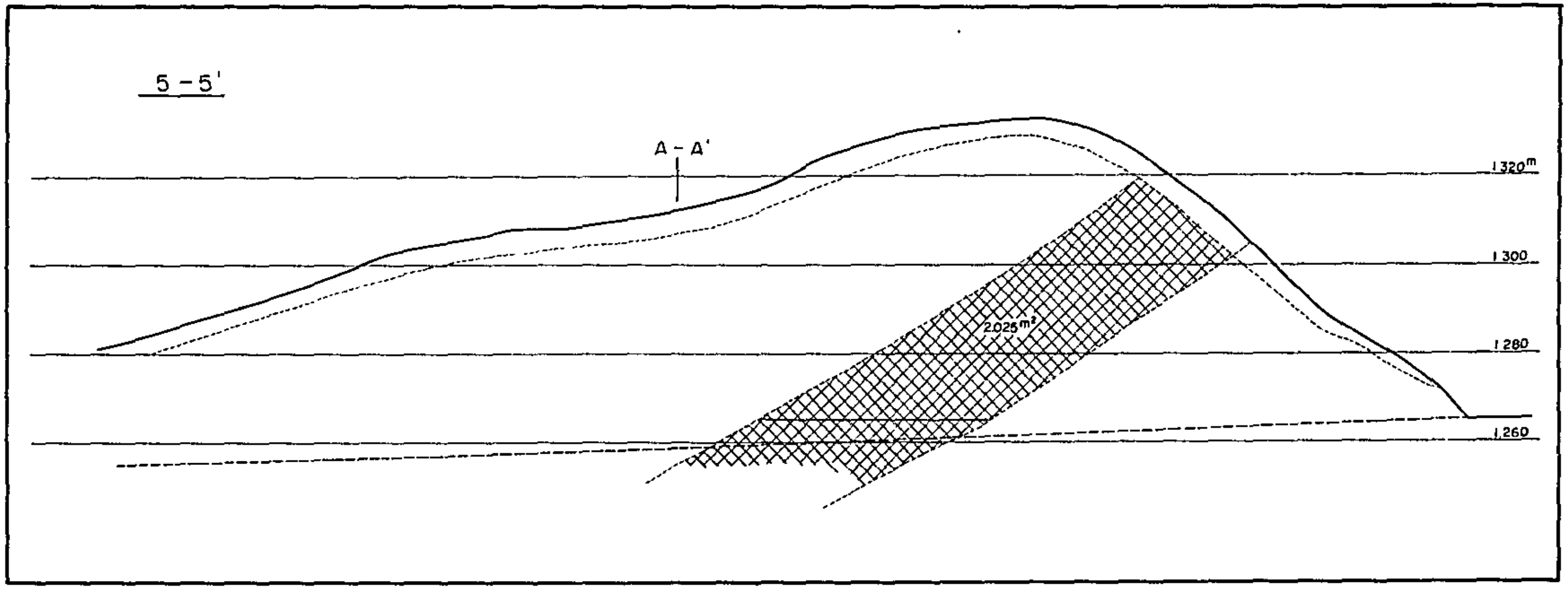
IDEALIZED SECTION ALONG THE RIVER

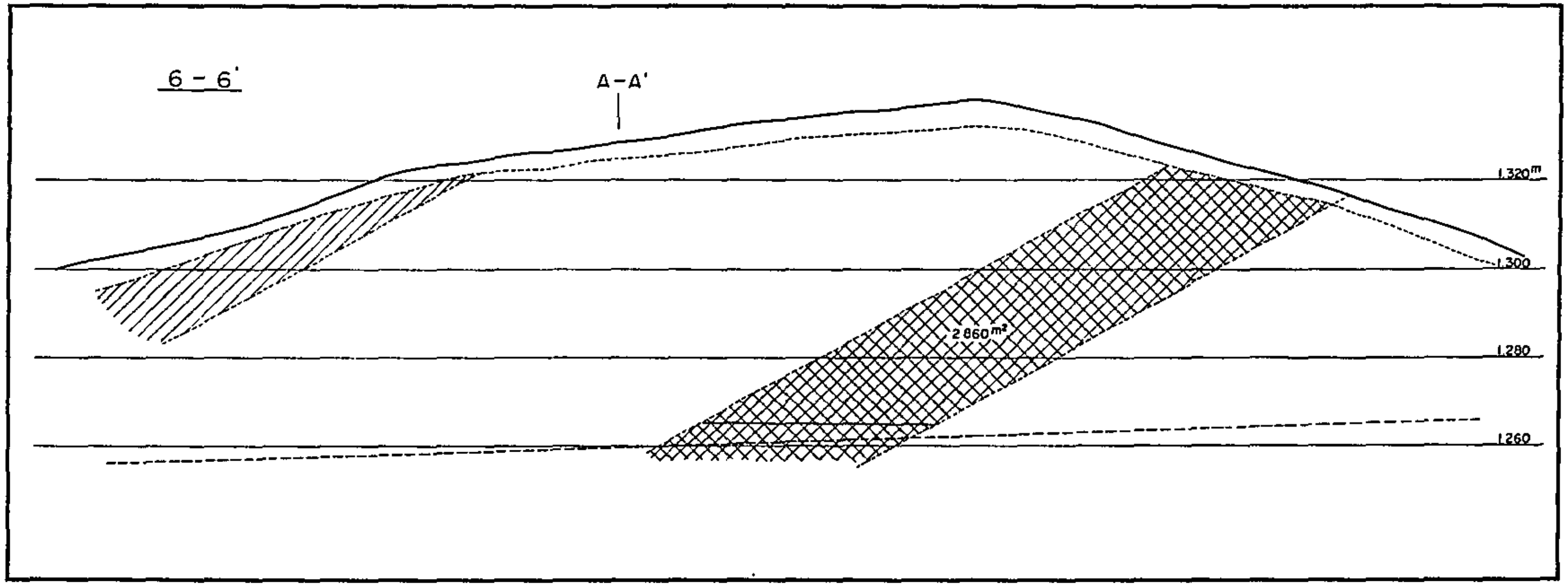


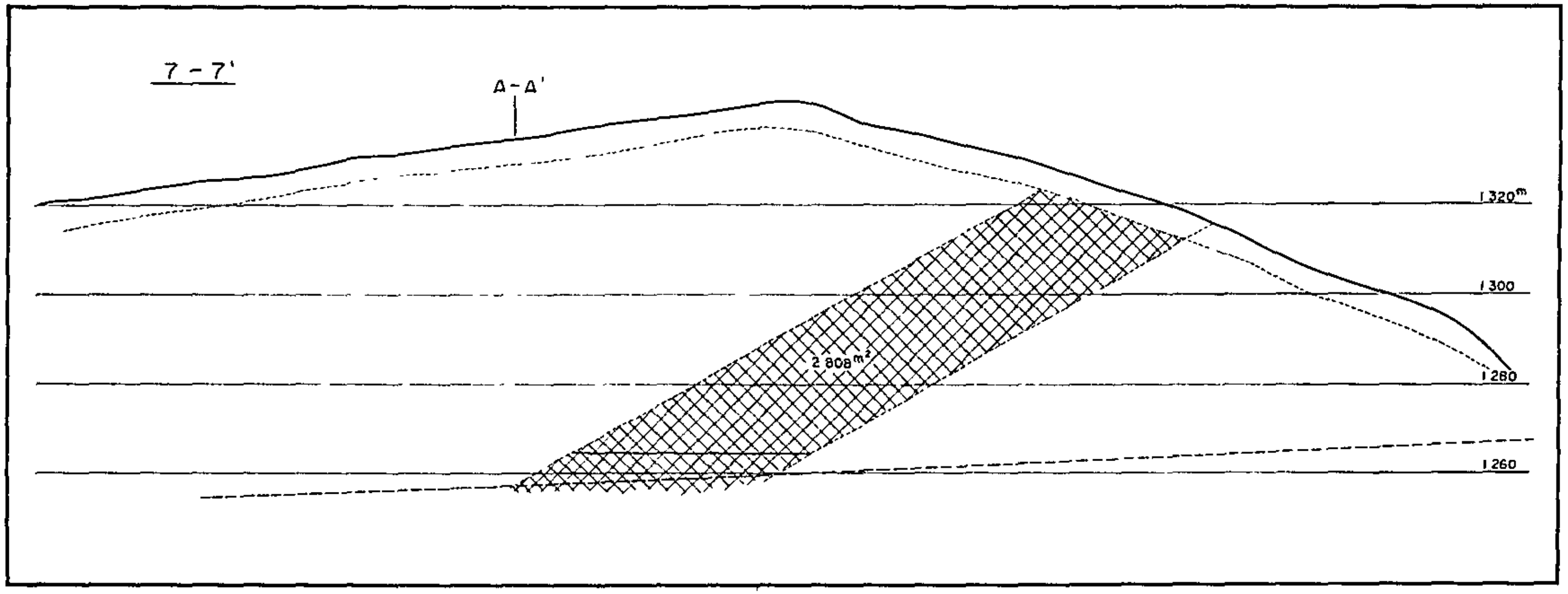

3 - 3'
A - A'
1300m
1280
1260
1300m²



4 - 4'
A - A'
1,320m
1,300
1,280
1,260
2,836m²

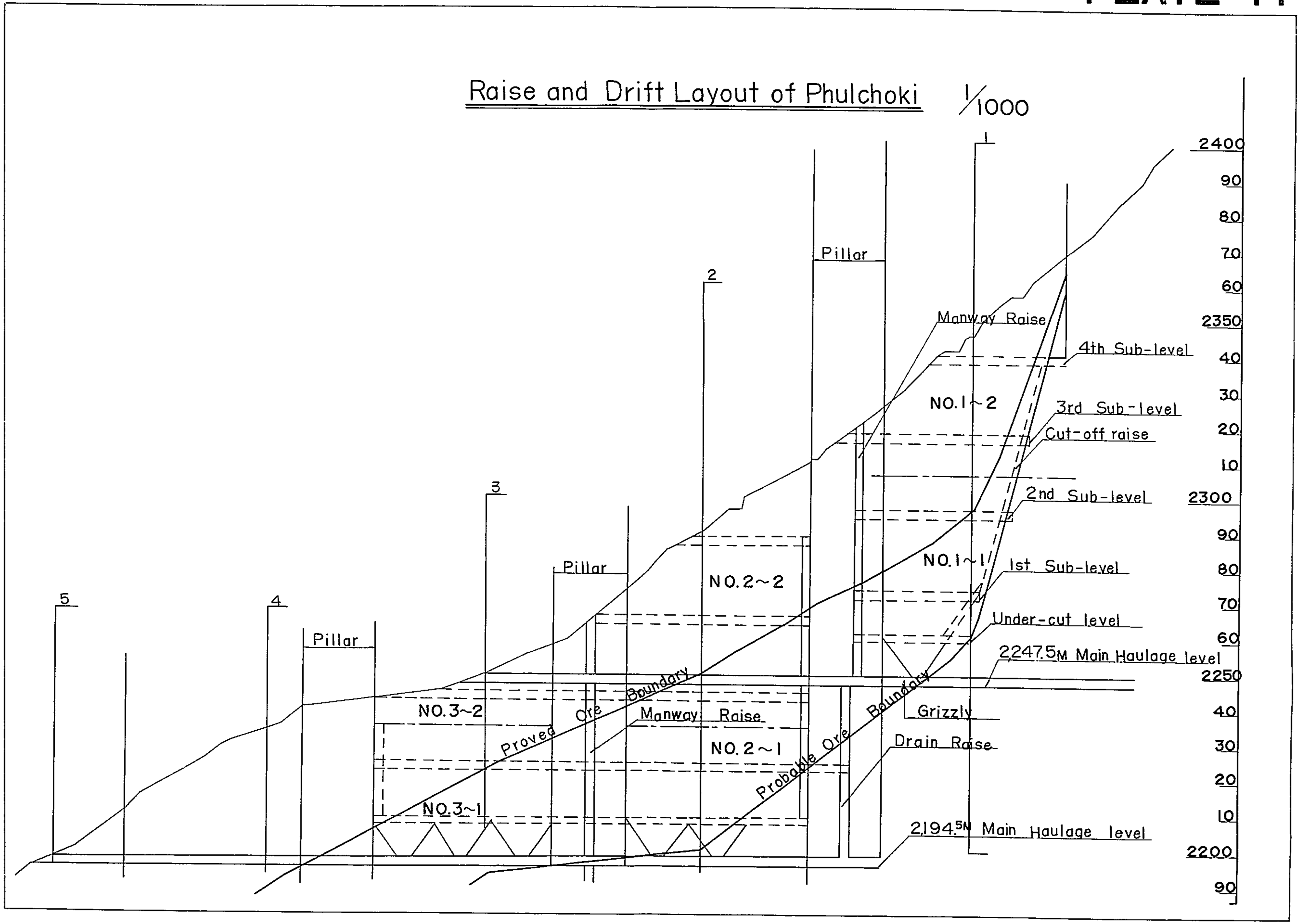

5 - 5'
A - A'
1.320m
1.300
1.280
1.260
2.025 m²


6 - 6'
A-A'
1,320m
1,300
1,280
1,260
2,860m²



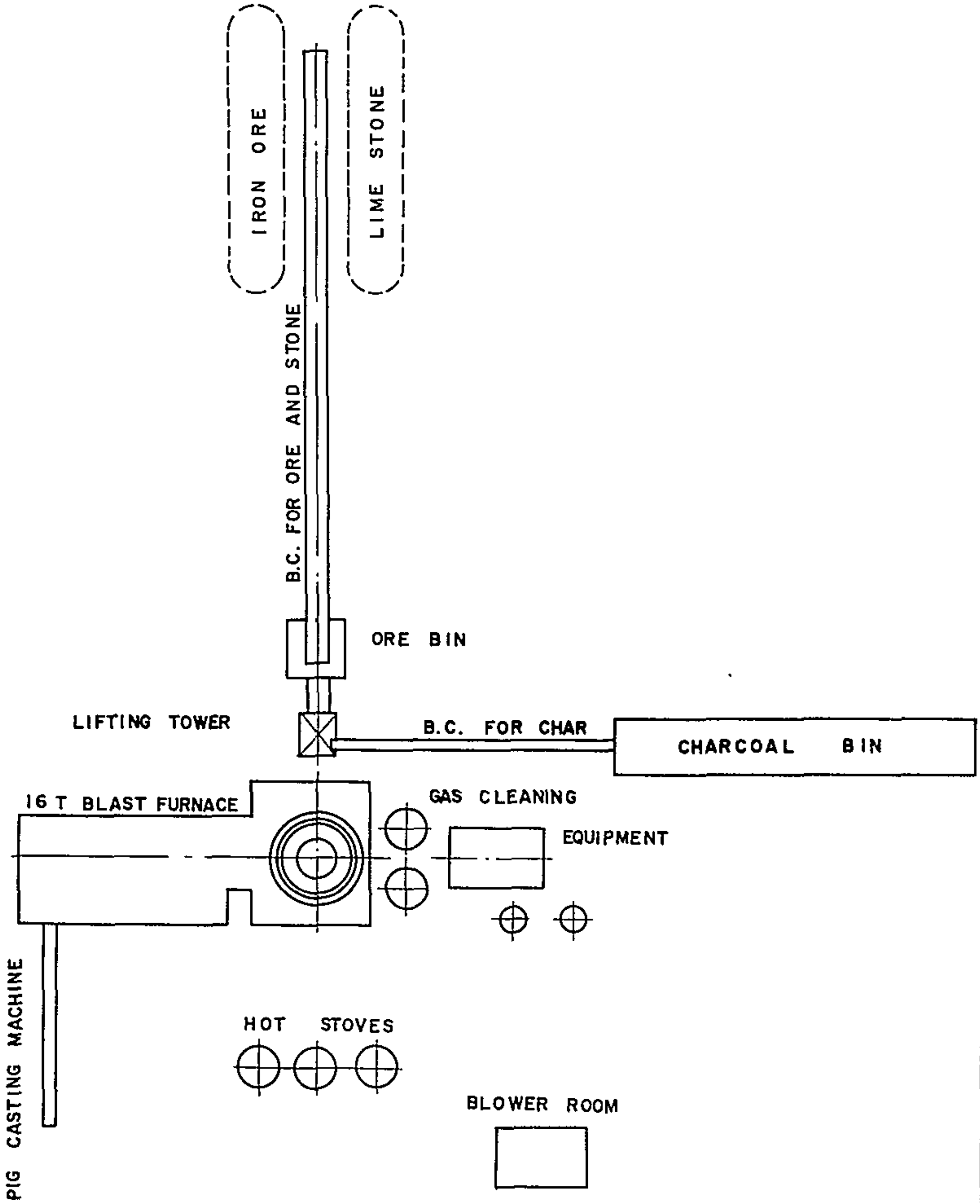
7 - 7'
A - A'
1 320m
1 300
1 280
1 260
2 808m²

PLATE 11



Raise and Drift Layout of Phulchoki
1/1000
1
2
3
4
5
Pillar
Pillar
Pillar
Manway Raise
4th Sub-level
NO.1~2
3rd Sub-level
Cut-off raise
2nd Sub-level
NO.1~1
1st Sub-level
NO.2~2
Under-cut level
2247.5M Main Haulage level
NO.3~2
Proved Ore Boundary
Manway Raise
Boundary
Grizzly
NO.2~1
Probable Ore
Drain Raise
NO.3~1
2194.5M Main Haulage level
2400
90
80
70
60
2350
40
30
20
10
2300
90
80
70
60
2250
40
30
20
10
2200
90

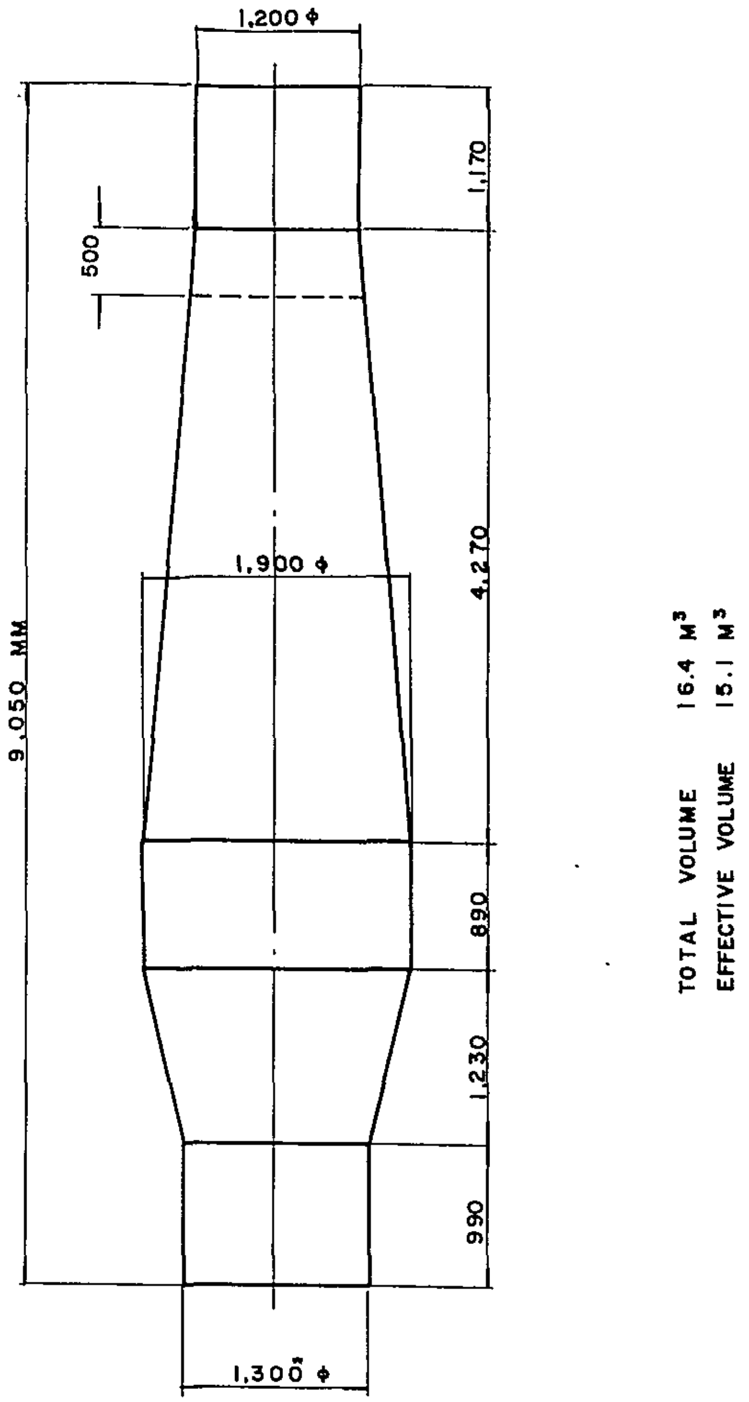
PLATE 12



LAYOUT OF 16 T/D IRON - MAKING PLANT

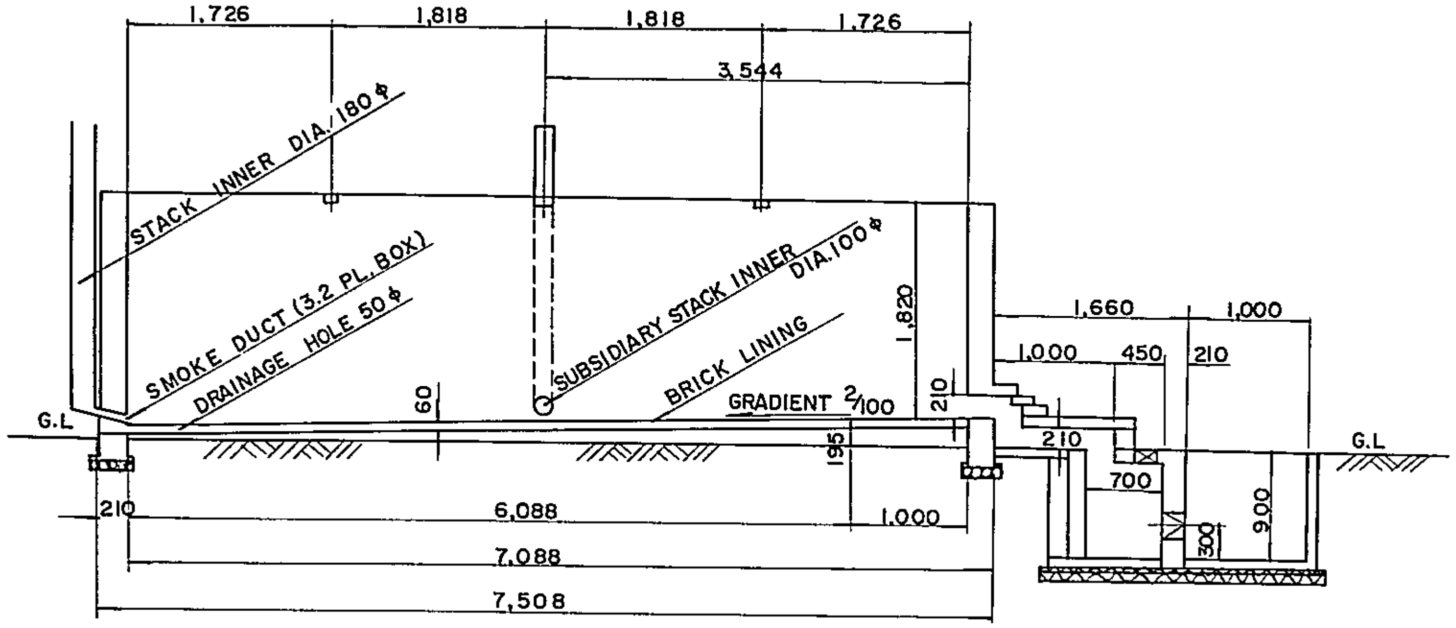
SCALE 1 : 600

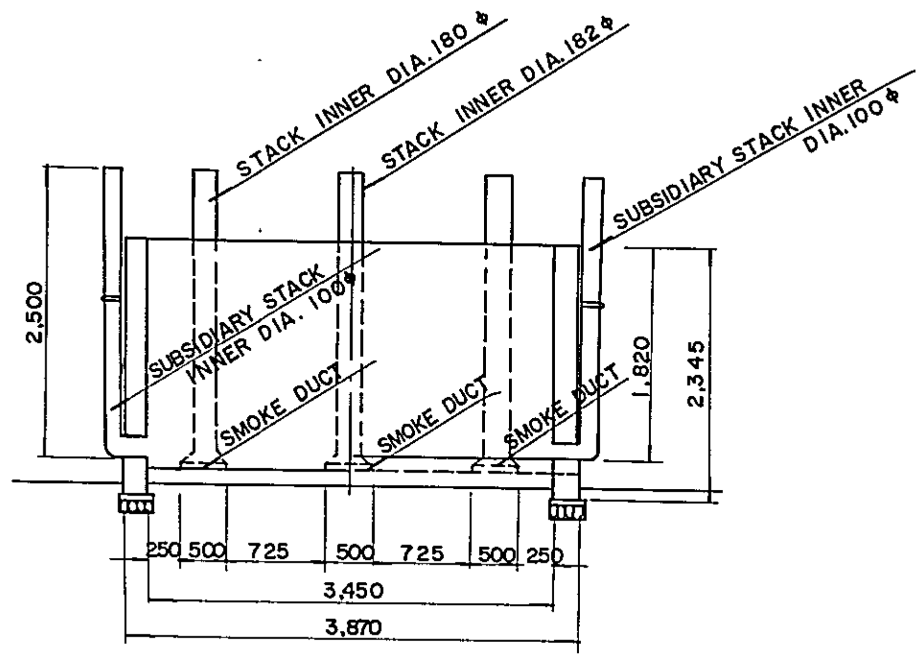
PLATE 13

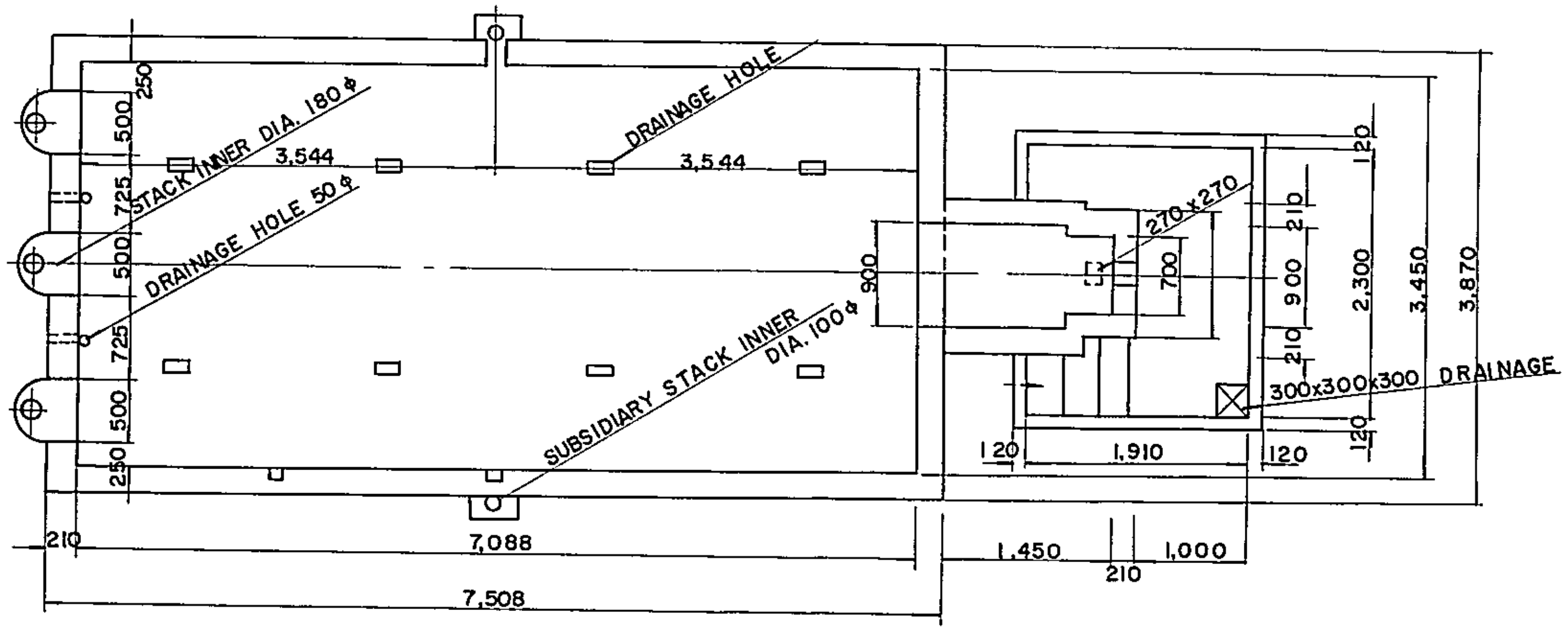


16 T BLAST FURNACE PROFILE

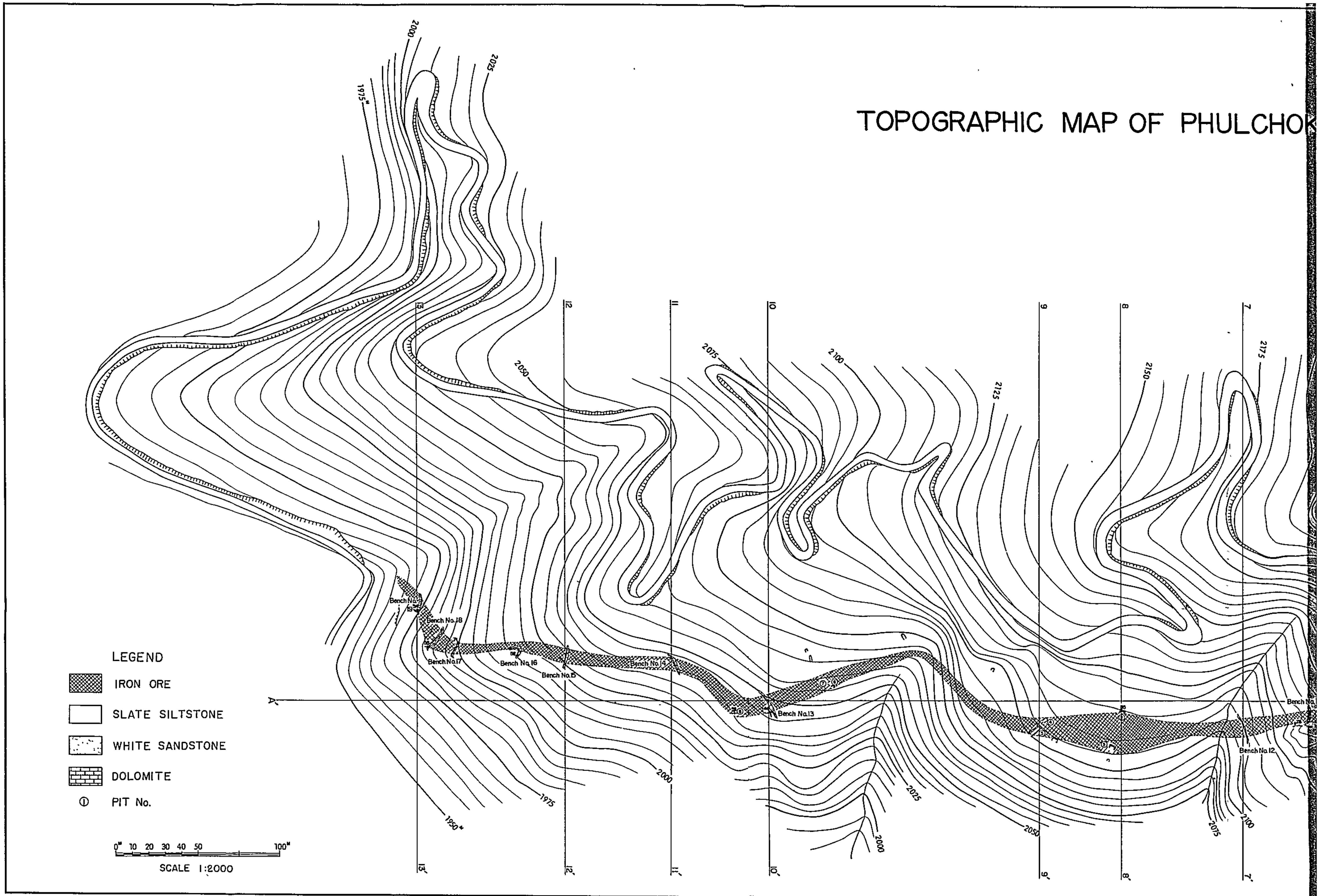
PLATE 14





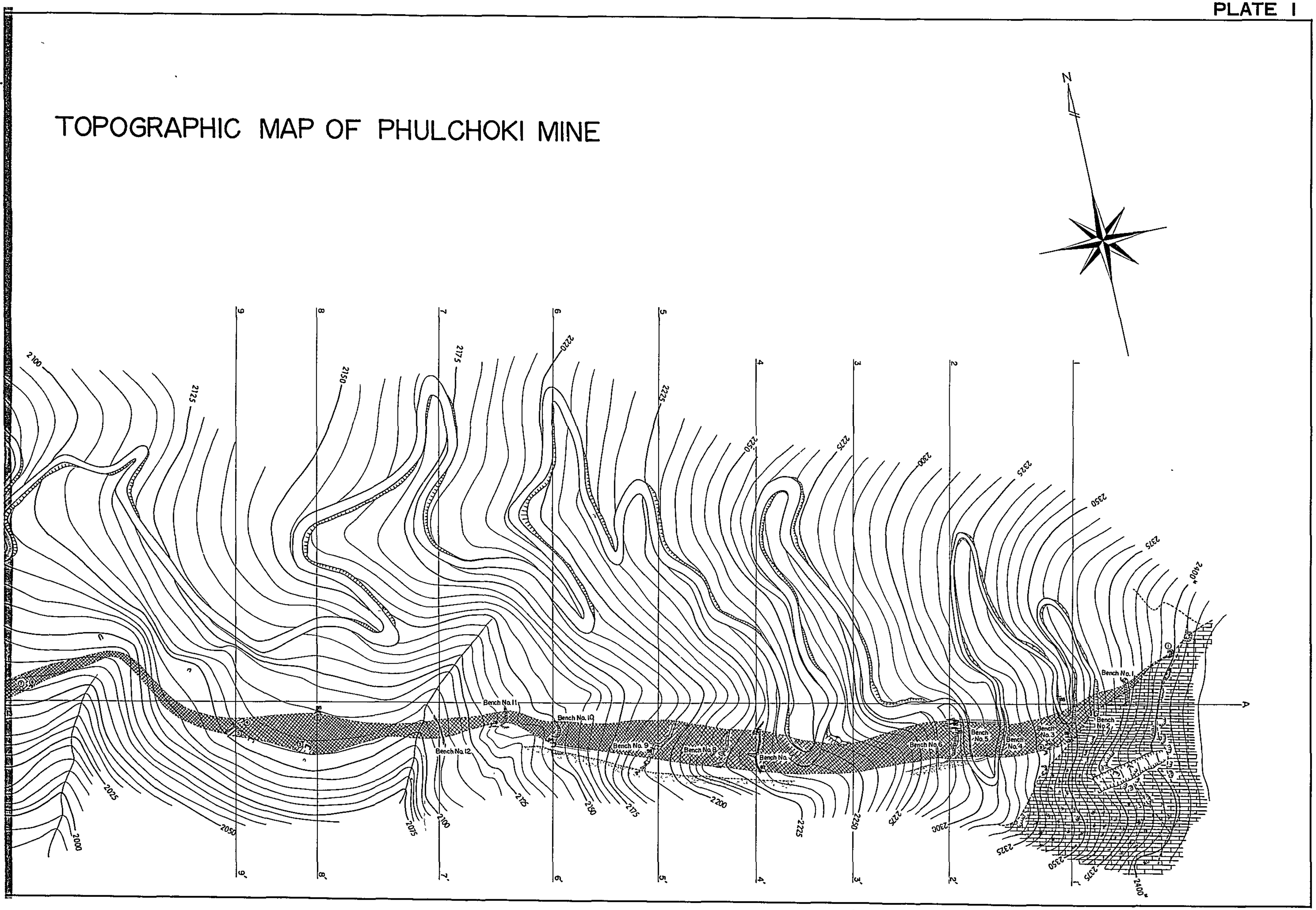


4 T CHARCOAL KILN



TOPOGRAPHIC MAP OF PHULCHOK
LEGEND
IRON ORE
SLATE SILTSTONE
WHITE SANDSTONE
DOLOMITE
① PIT No.
0M 10 20 30 40 50 100M
SCALE 1:2000
Bench No.13
Bench No.14
Bench No.15
Bench No.16
Bench No.17
Bench No.18
Bench No.12
1975M
2000
2025
2050
2075
2100
2125
2150
2175
1950M

TOPOGRAPHIC MAP OF PHULCHOKI MINE



Phulchoki Iron Deposit

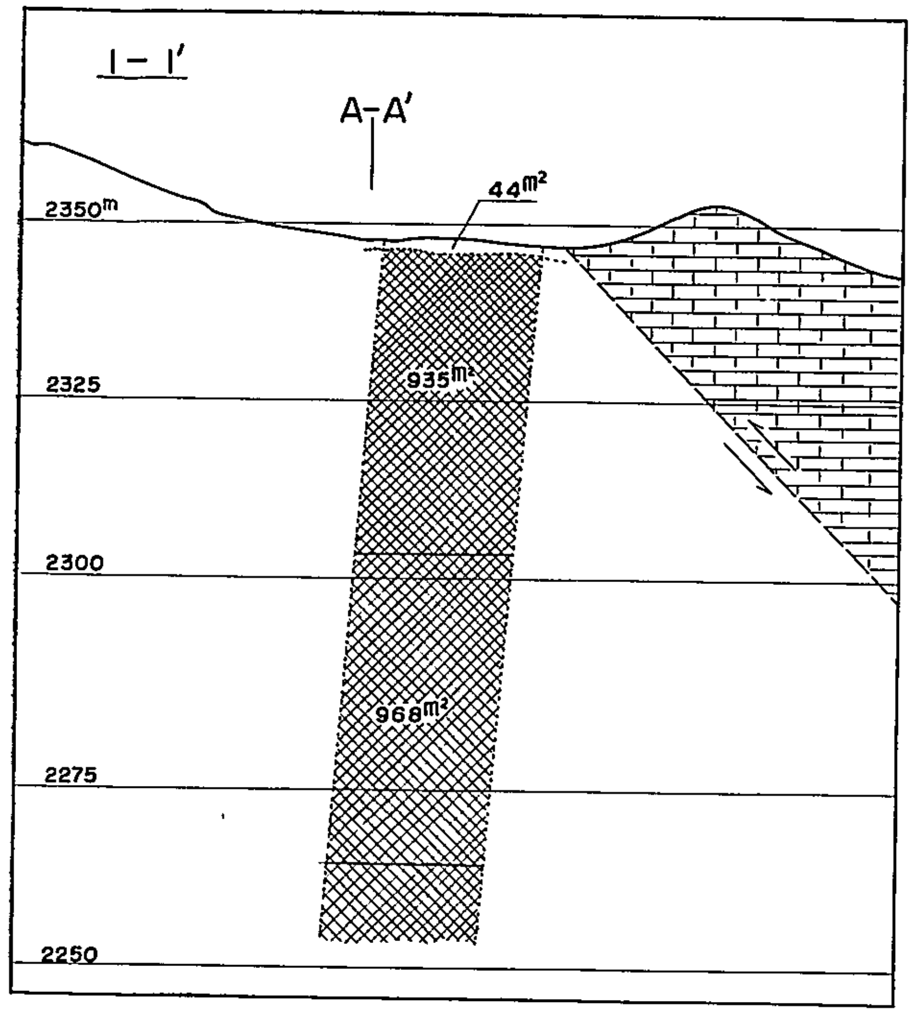
CROSS SECTIONS OF ORE DEPOSIT

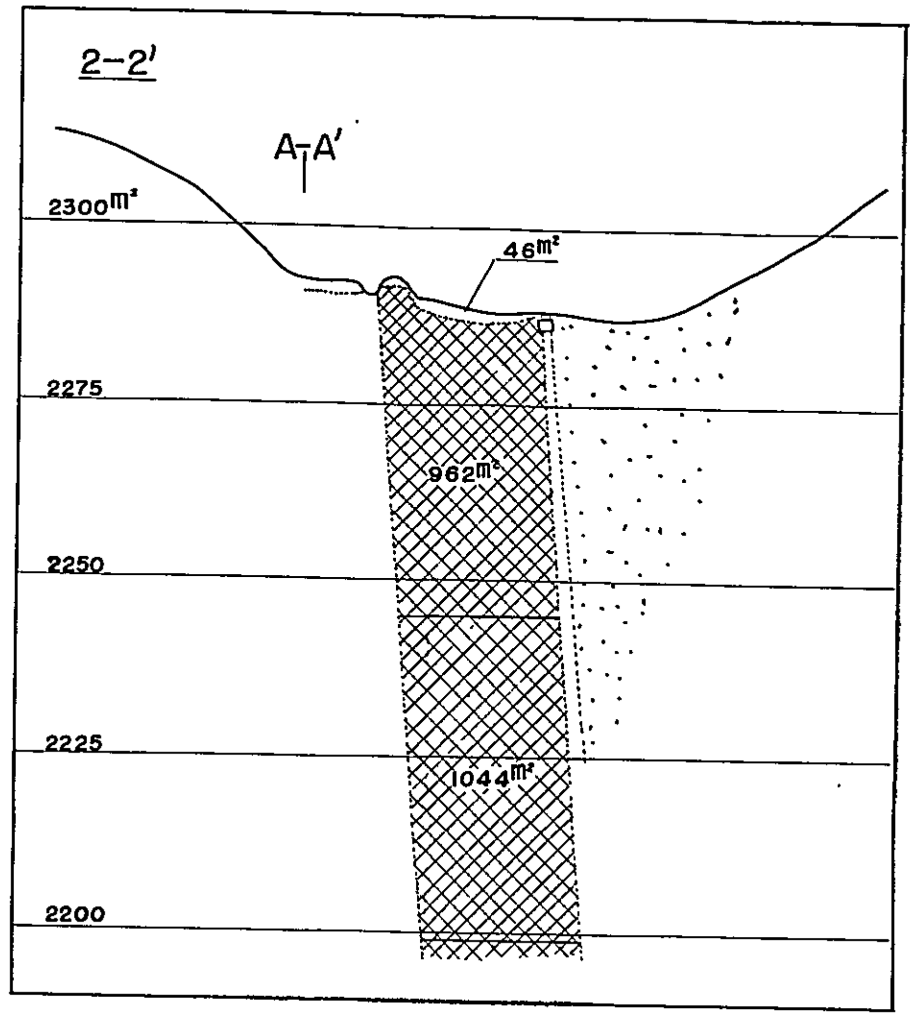
1/1,000

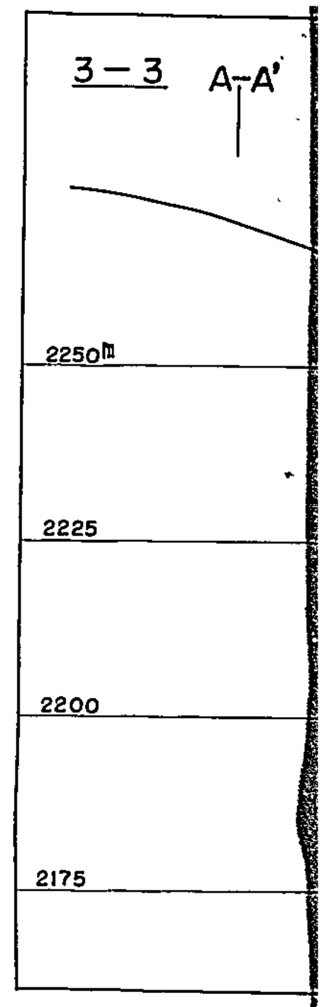
0 10 20 30 40 50

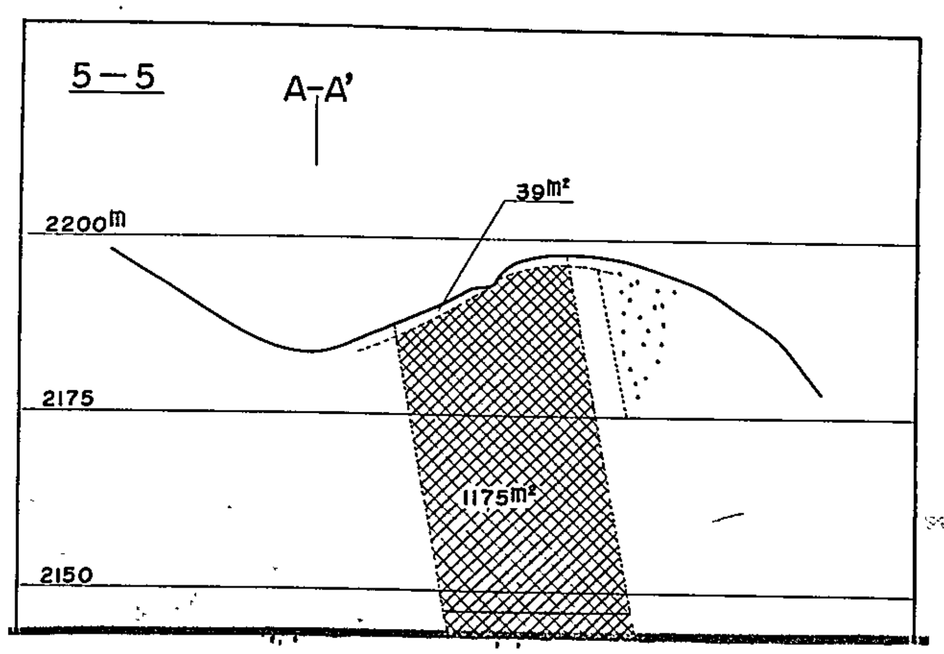
LEGEND

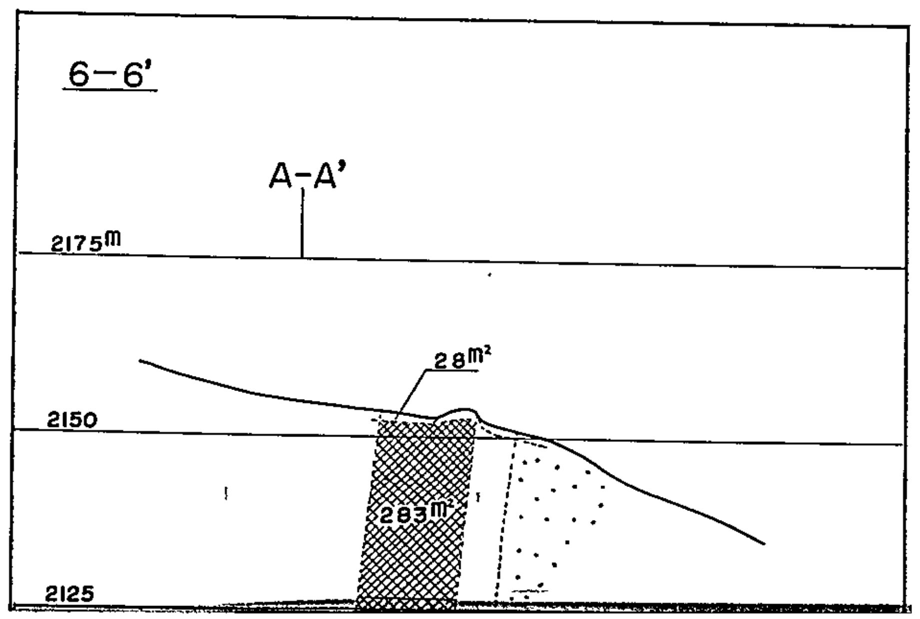
- ORE DEPOSIT
- SLATE
- DOLOMITE
- QUARTZITE

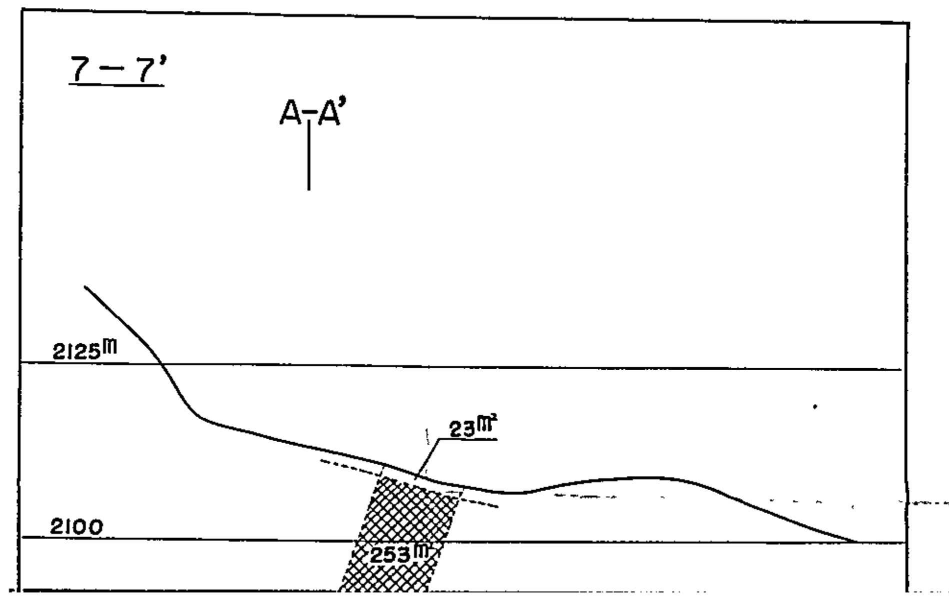












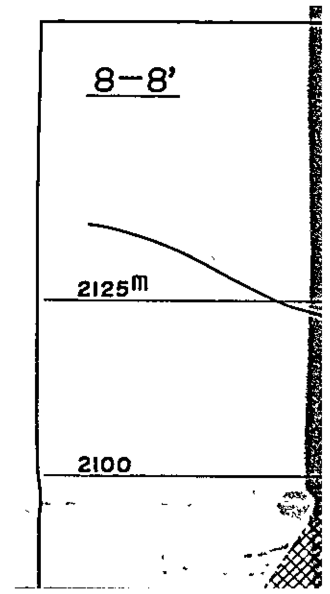
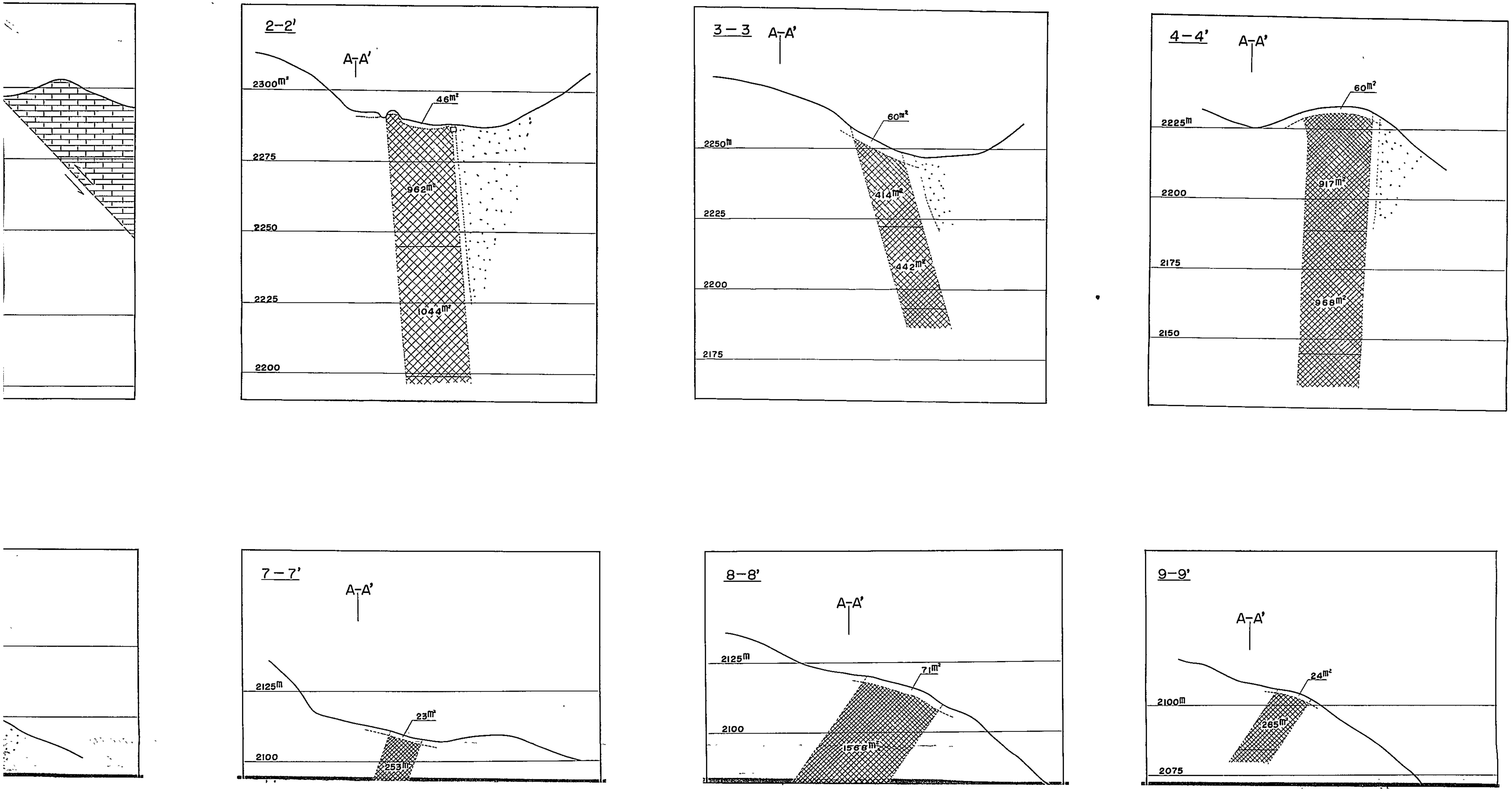
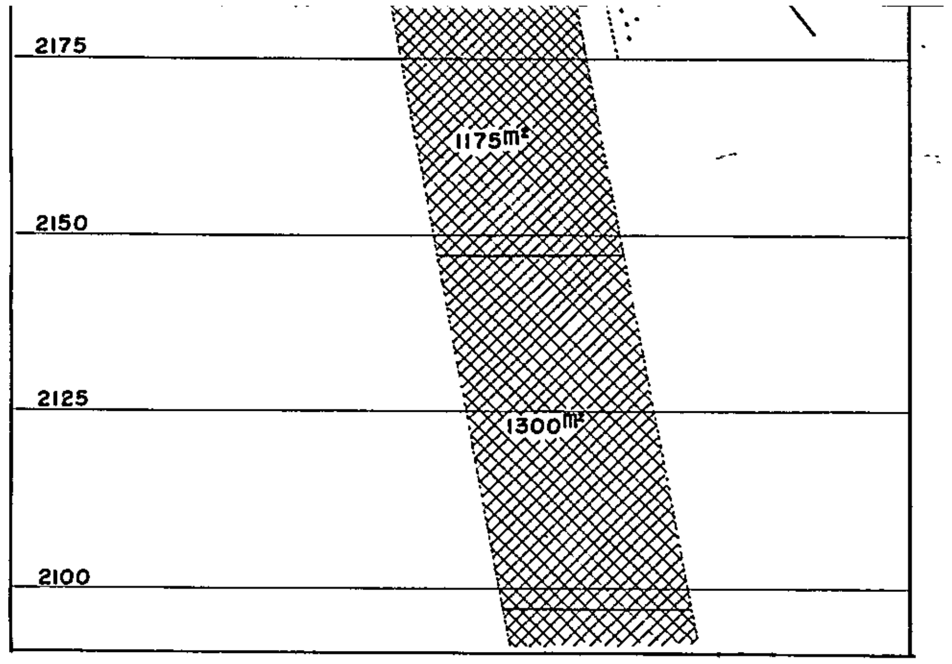
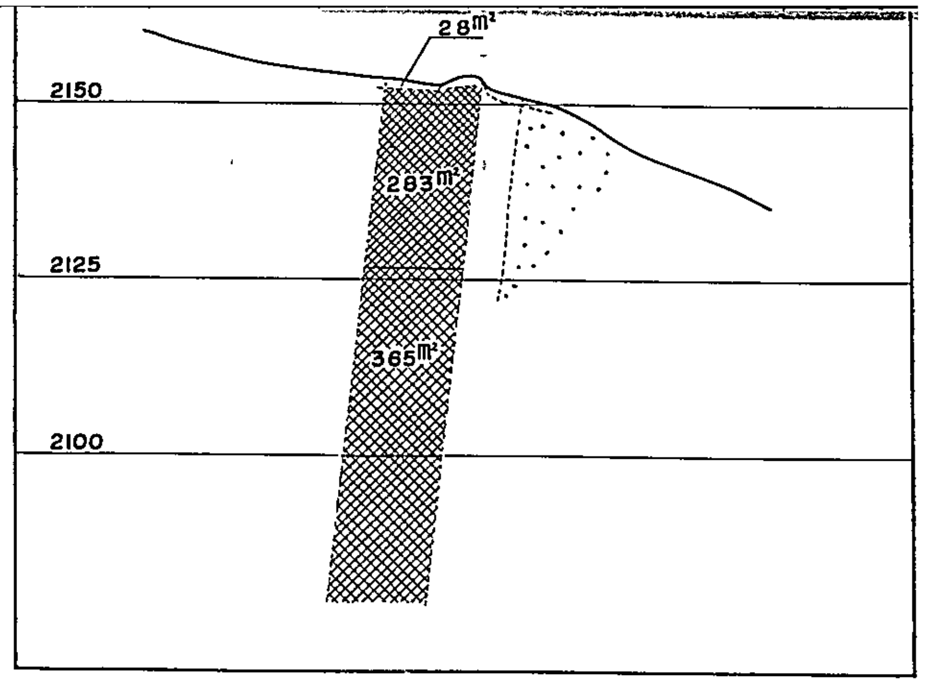


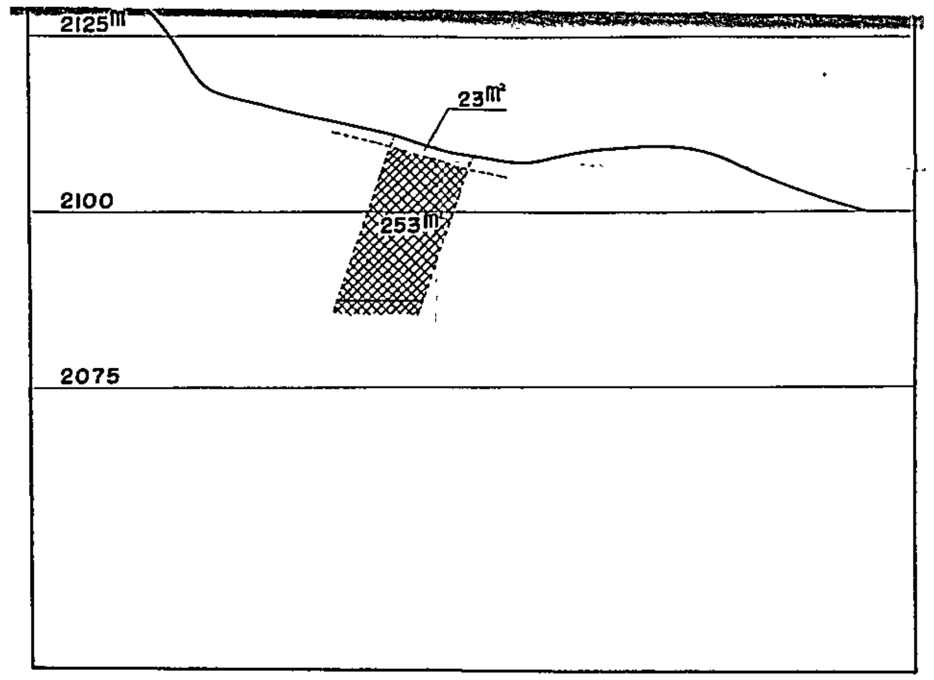
PLATE 3

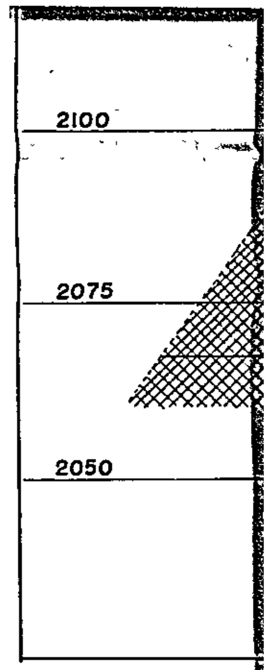


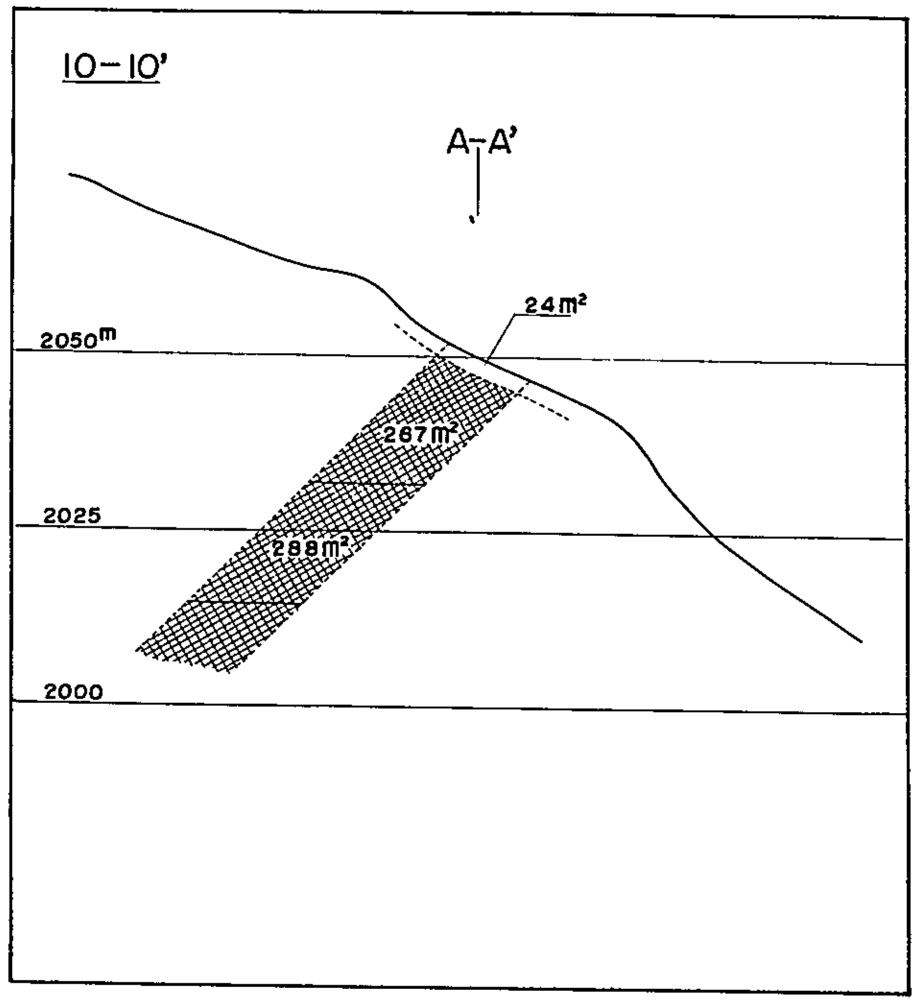
2-2'
A-A'
2300m²
46m²
2275
962m²
2250
2225
1044m²
2200
3-3
A-A'
60m²
2250m
414m²
2225
442m²
2200
2175
4-4'
A-A'
60m²
2225m
917m²
2200
2175
968m²
2150
7-7'
A-A'
2125m
23m²
2100
253m²
8-8'
A-A'
2125m
71m²
2100
1566m²
9-9'
A-A'
24m²
2100m
265m²
2075

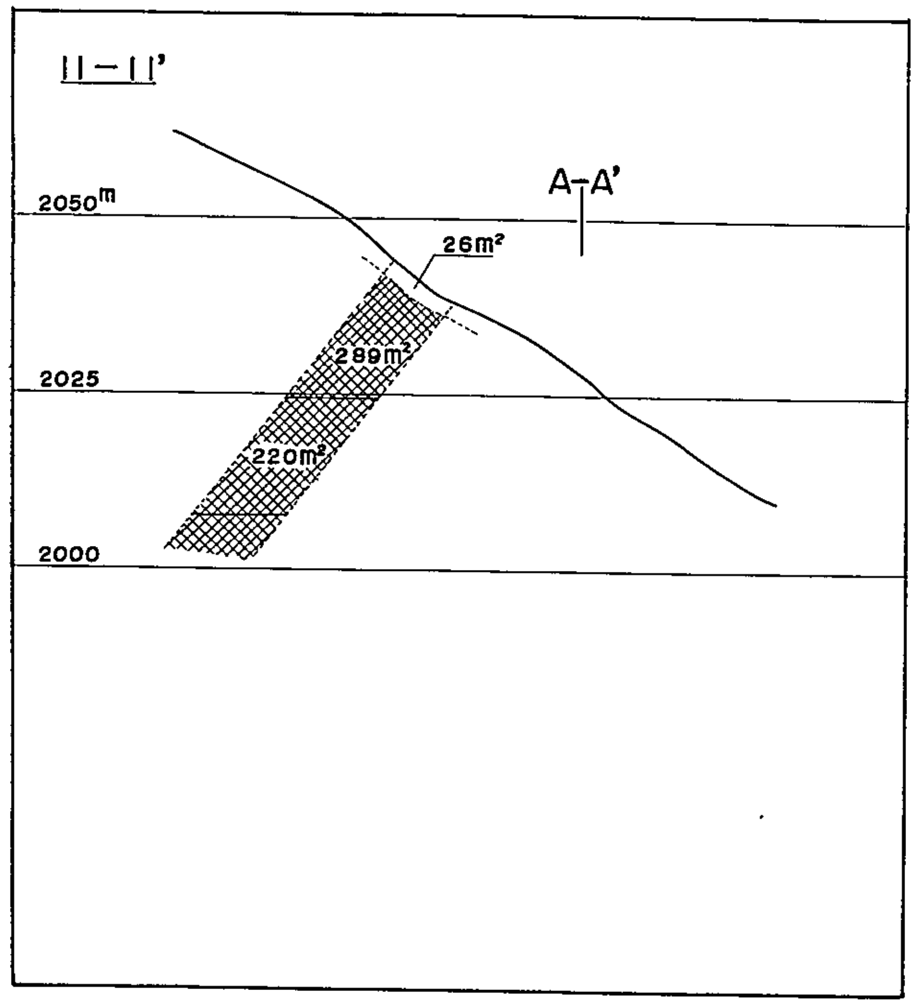

2175
1175m²
2150
2125
1300m²
2100

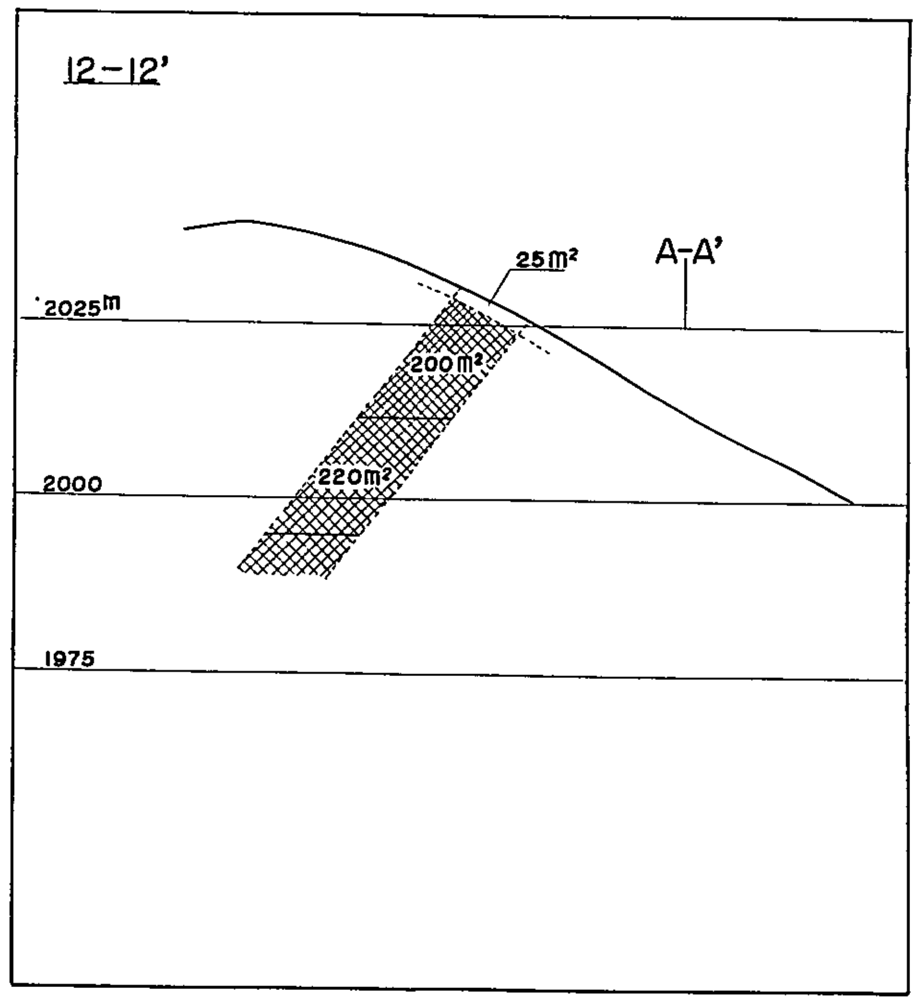

28m²
2150
283m²
2125
365m²
2100

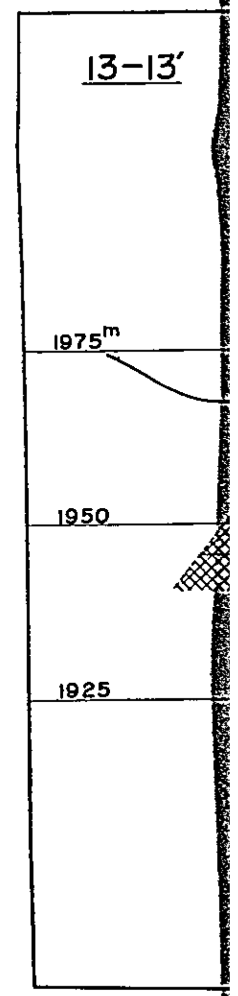

2125m
23m²
2100
253m²
2075

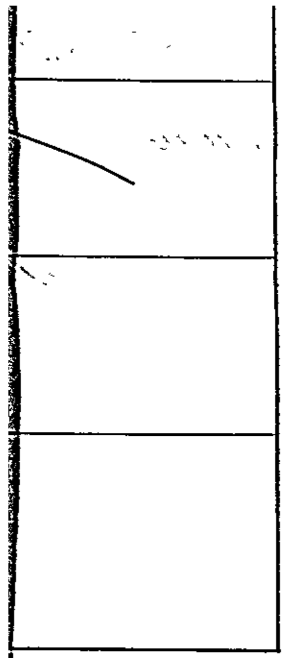

2100
2075
2050

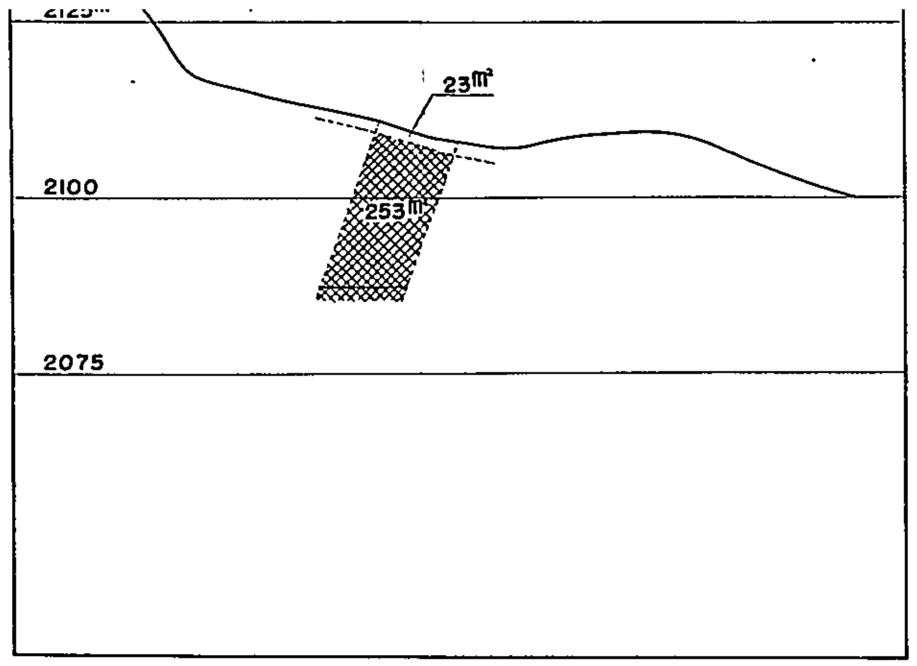

10-10'
A-A'
24m²
2050m
267m²
2025
288m²
2000


11-11'
2050m
A-A'
26m²
289m²
2025
220m²
2000

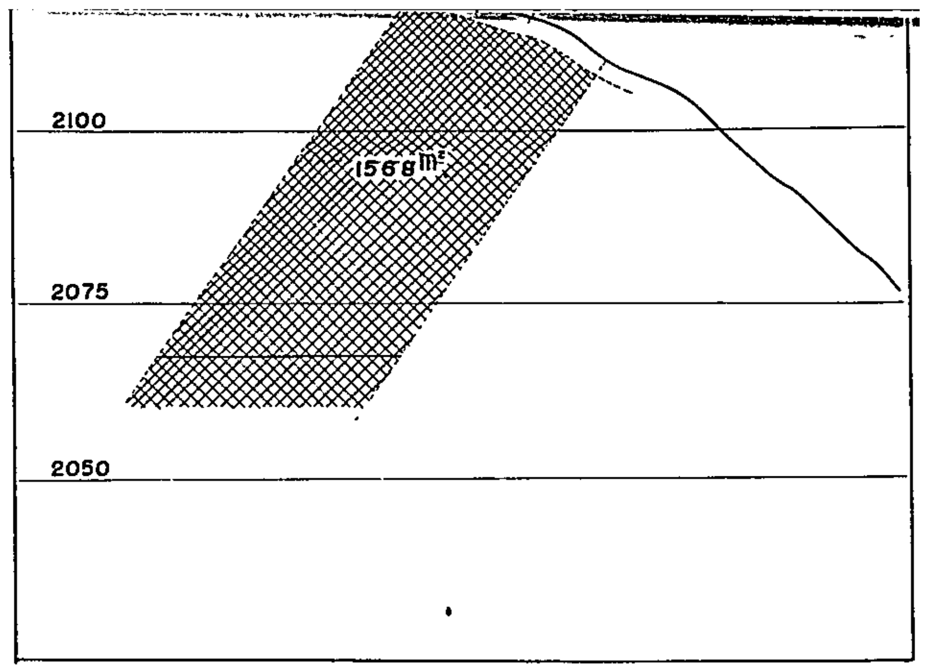

12-12'
25m²
A-A'
2025m
200m²
2000
220m²
1975


13-13'
1975m
1950
1925

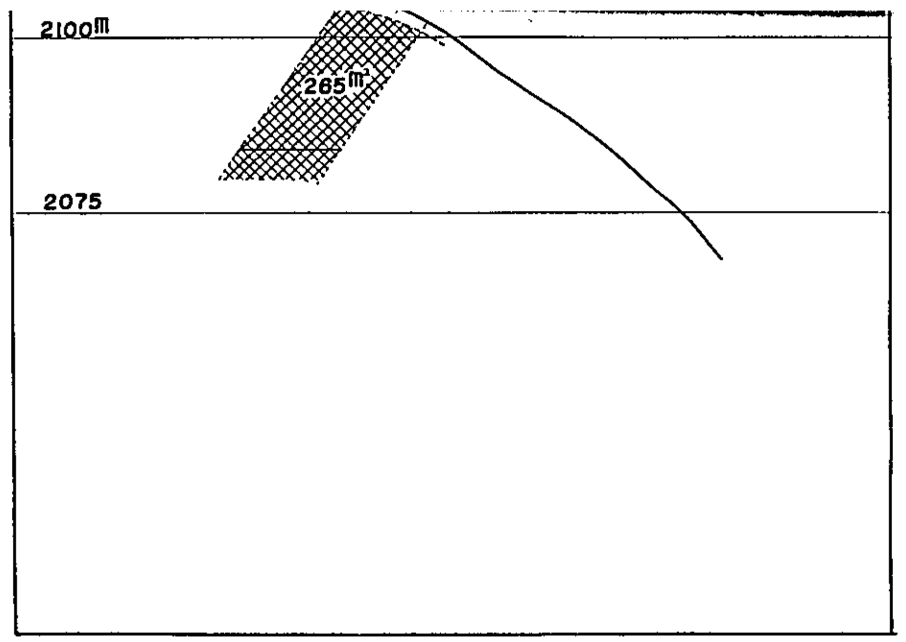




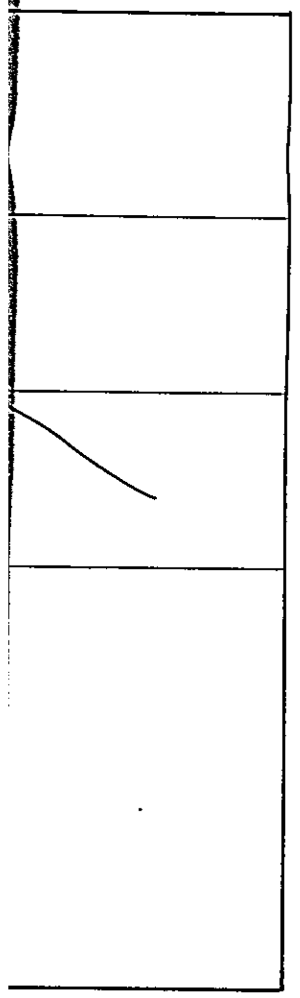
2125m
23m²
2100
253m²
2075

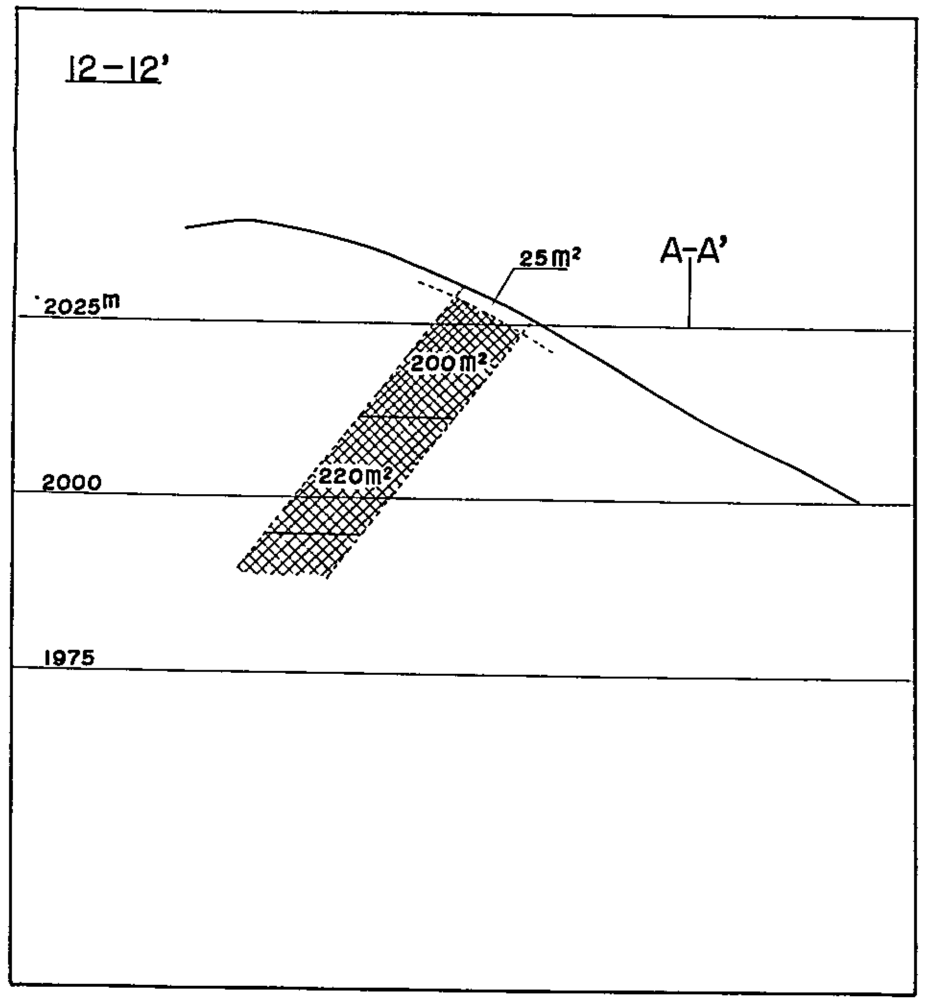


2100
1568m²
2075
2050

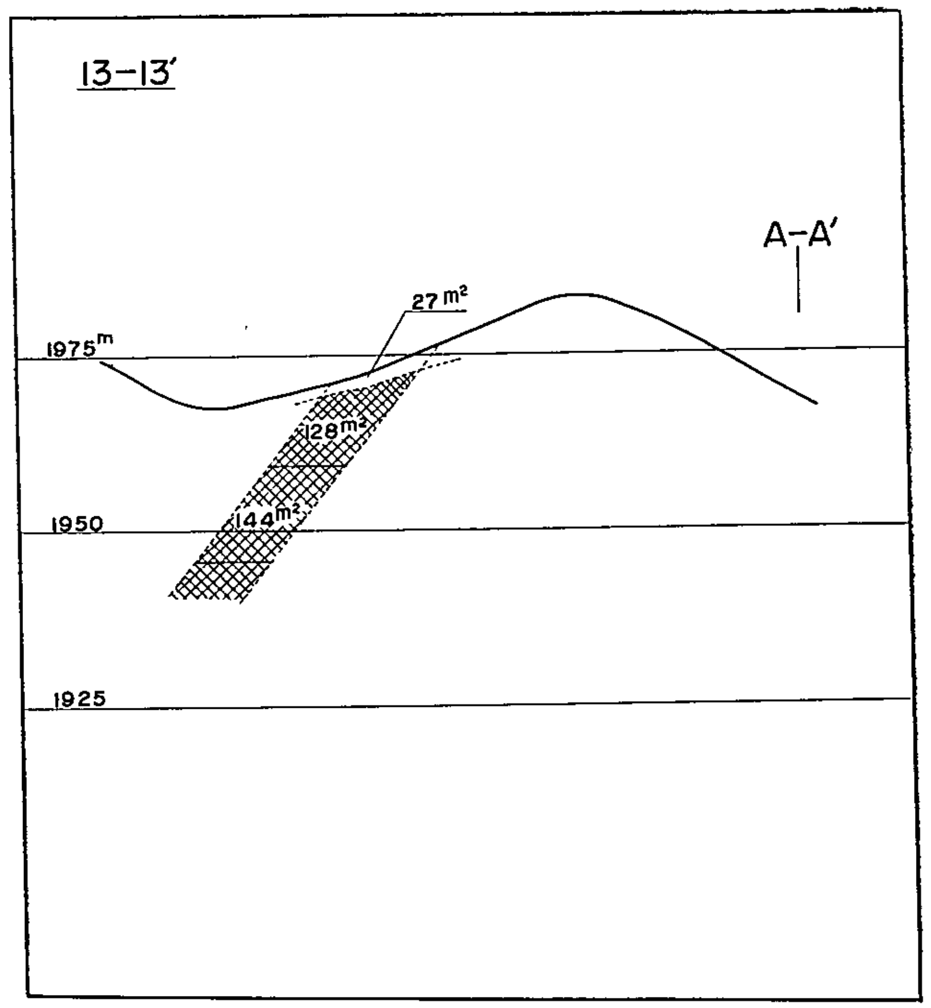


2100m
265m²
2075





12-12'
25m²
A-A'
2025m
200m²
2000
220m²
1975



13-13'
A-A'
27m²
1975m
128m²
1950
144m²
1925

TOPOGRAPHIC SKETCH MAP OF LABDI IRON D

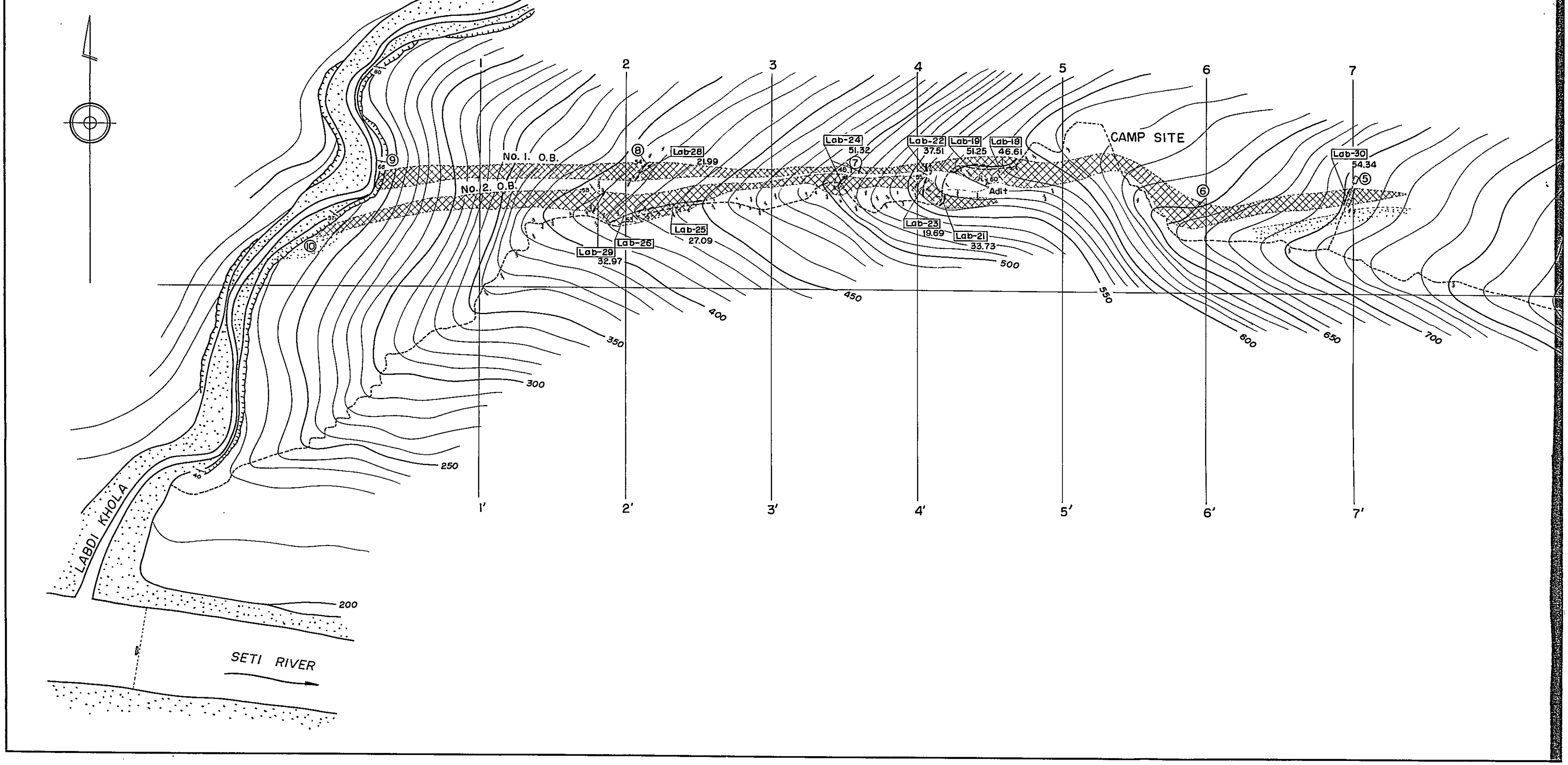
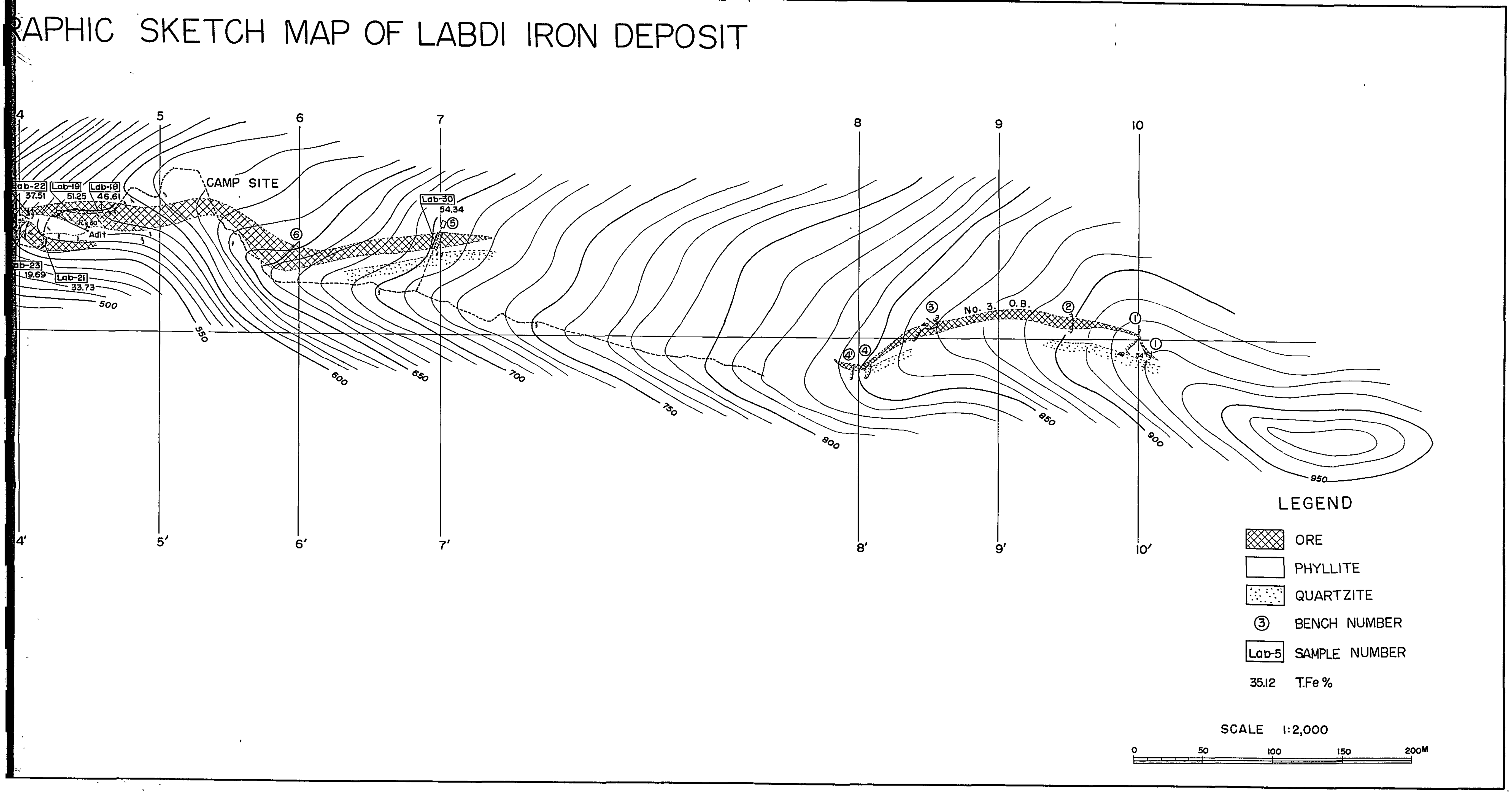
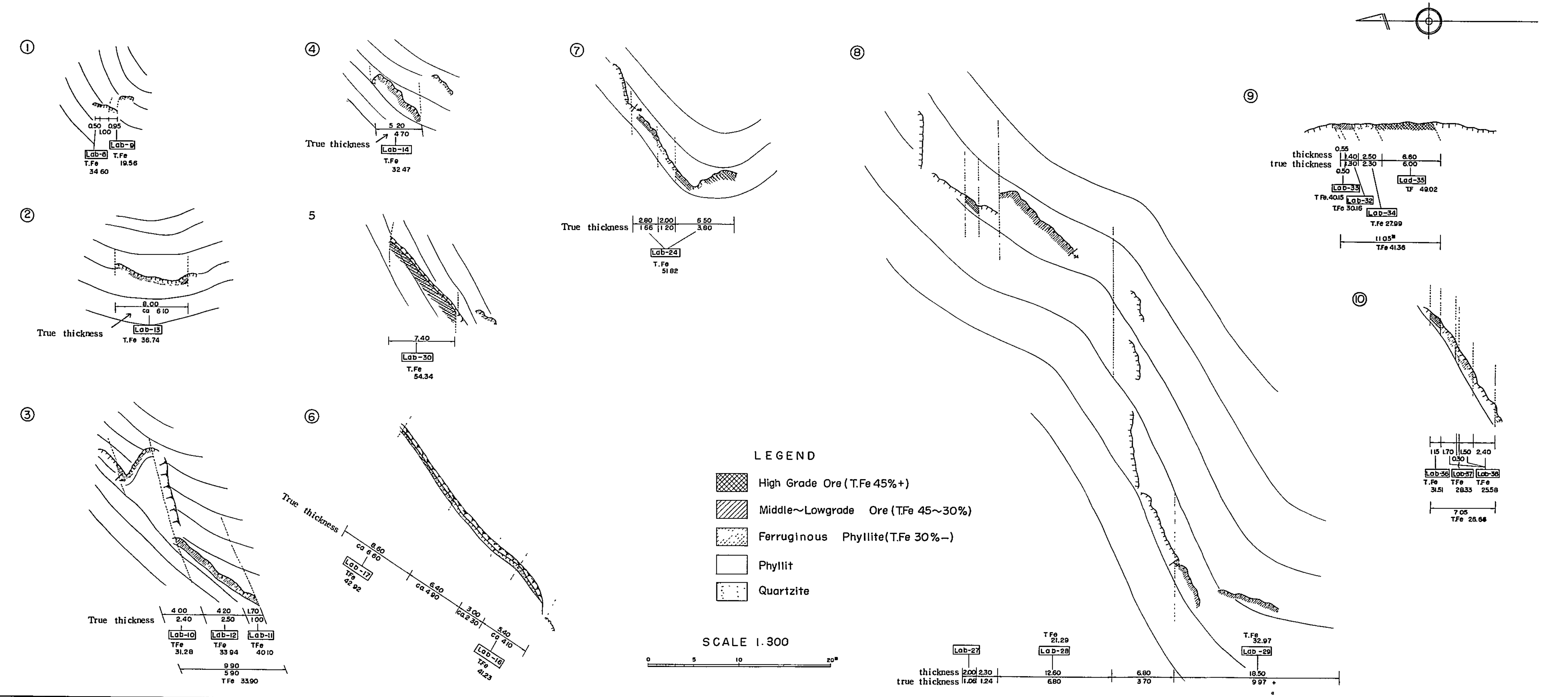


PLATE 4



RAPHIC SKETCH MAP OF LABDI IRON DEPOSIT
4
5
6
7
8
9
10
CAMP SITE
Lab-22
37.51
Lab-19
51.25
Lab-18
46.61
Adit
Lab-23
19.69
Lab-21
33.73
Lab-30
54.34
No. 3 O.B.
500
550
600
650
700
750
800
850
900
950
4'
5'
6'
7'
8'
9'
10'
LEGEND
ORE
PHYLLITE
QUARTZITE
③ BENCH NUMBER
Lab-5 SAMPLE NUMBER
35.12 T.Fe %
SCALE 1:2,000
0
50
100
150
200M

LABDI IRON DEPOSIT BENCH MAP



LABDI IRON DEPOSIT

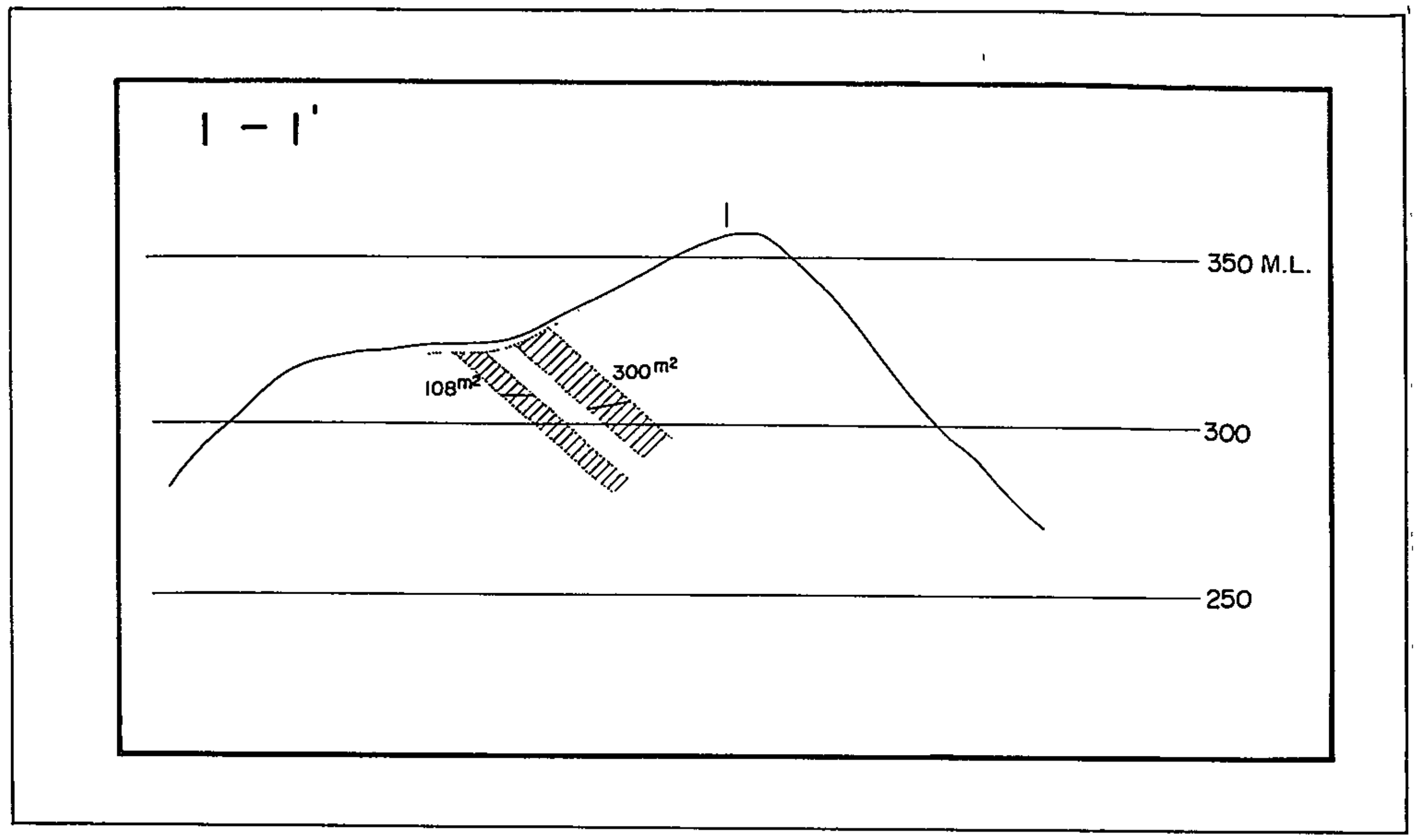
CROSS SECTIONS OF ORE DEPOSITS

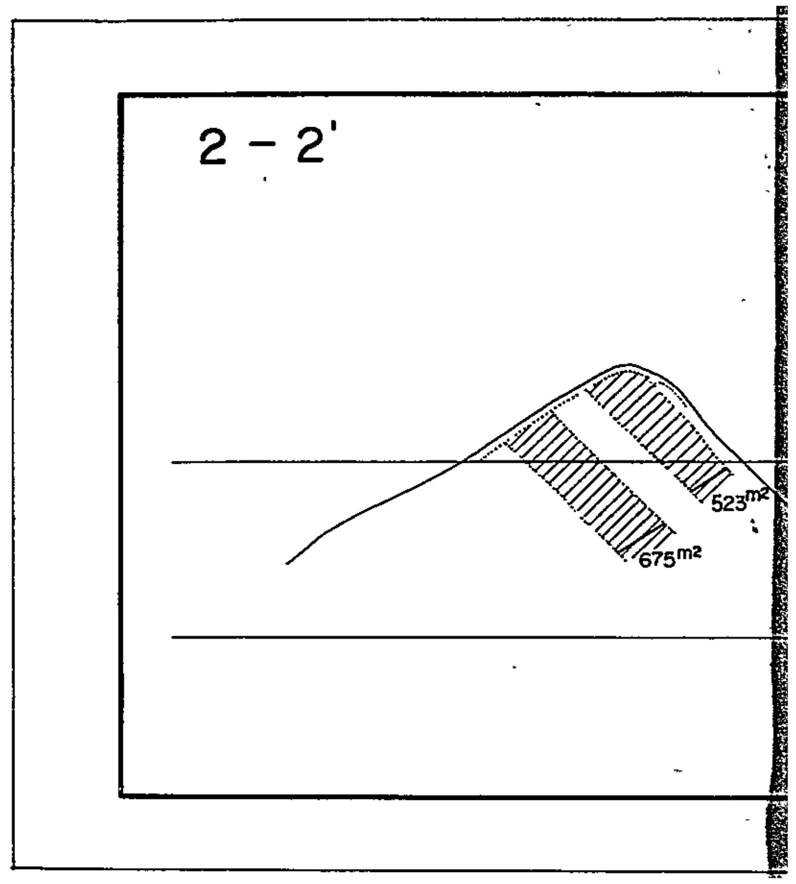
LEGEND

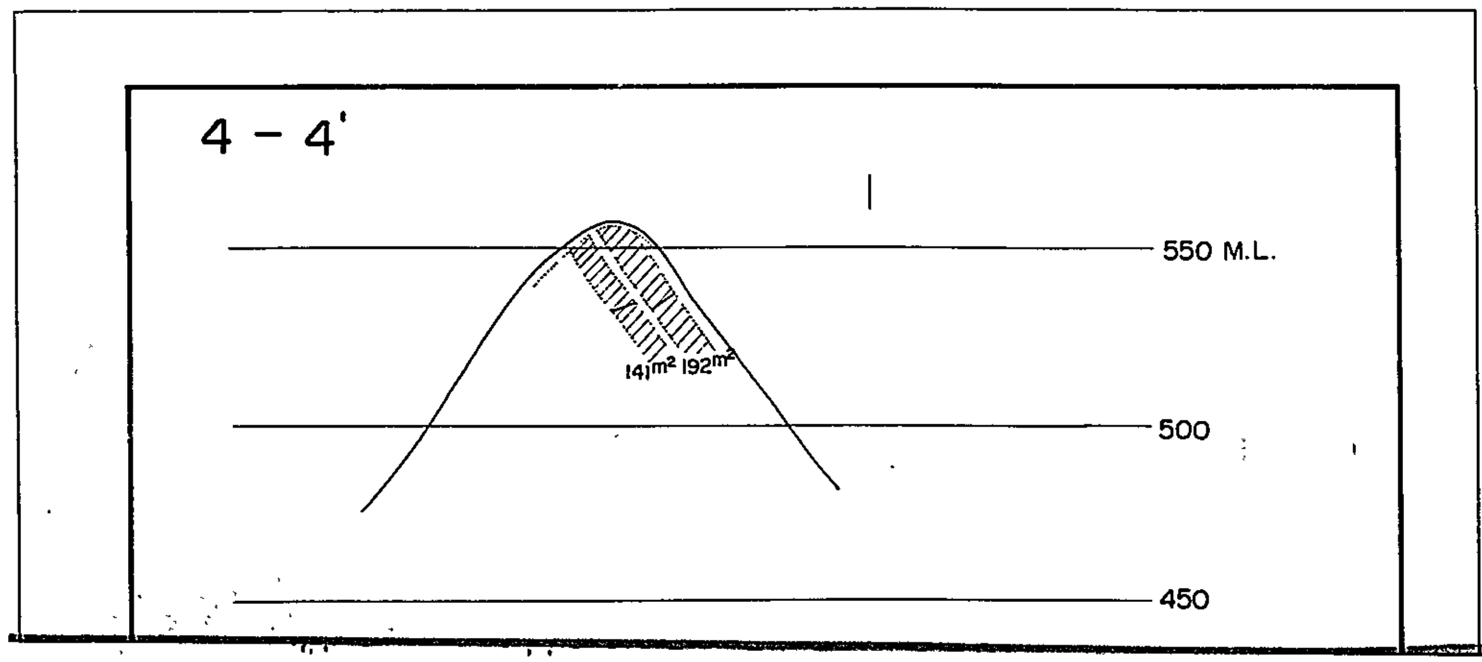
SCALE 1 : 2.000

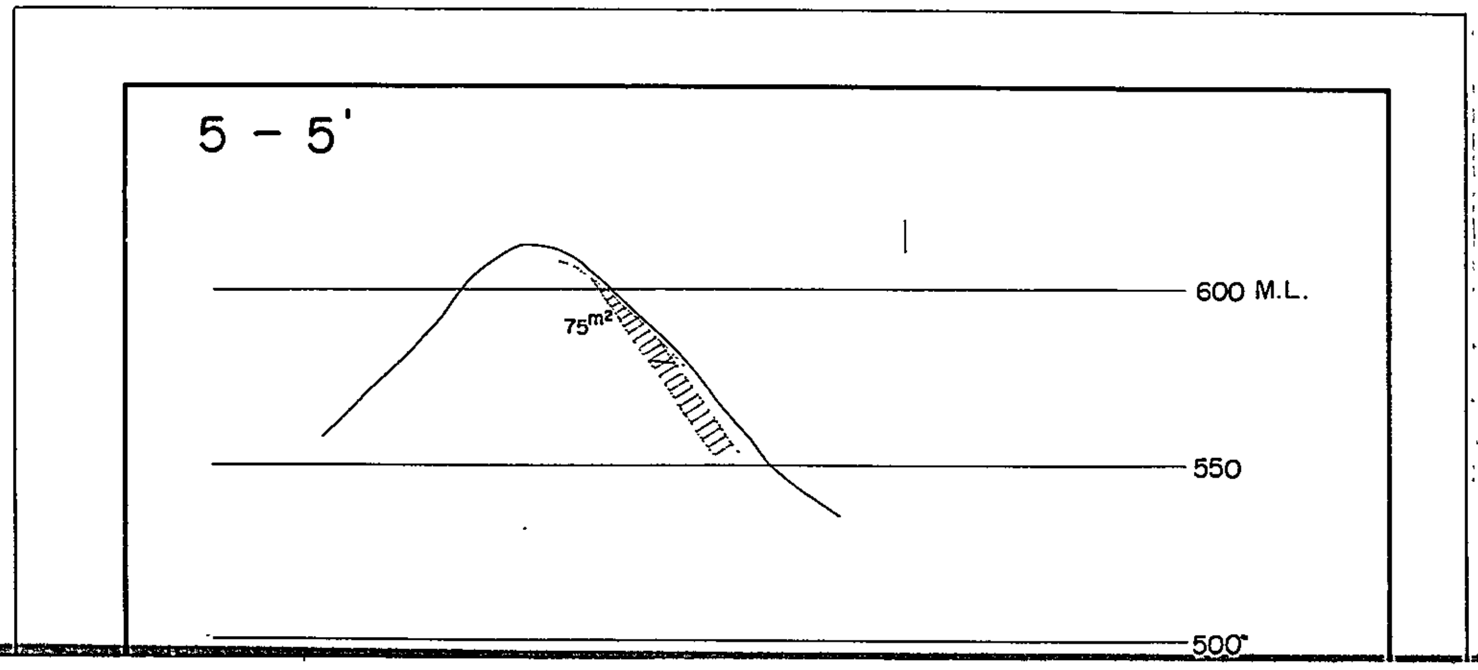
0 50 100m

ORE BODY









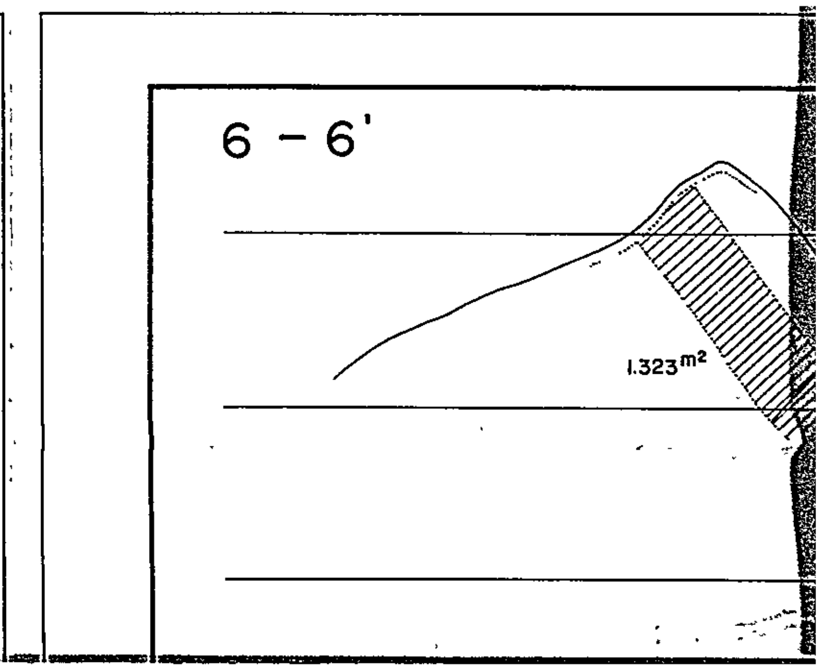
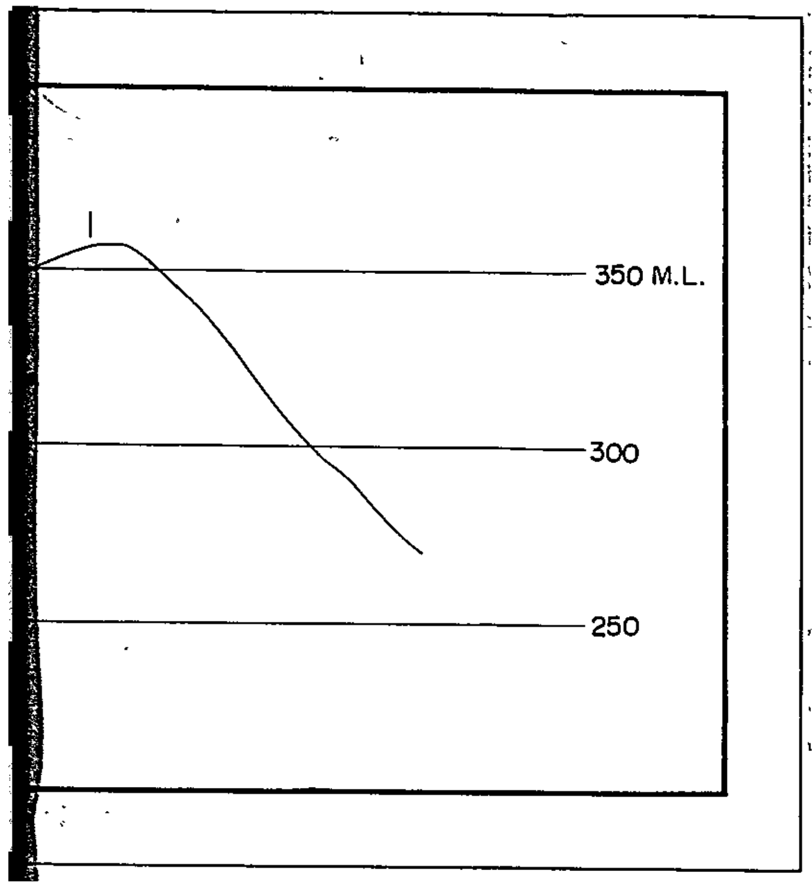
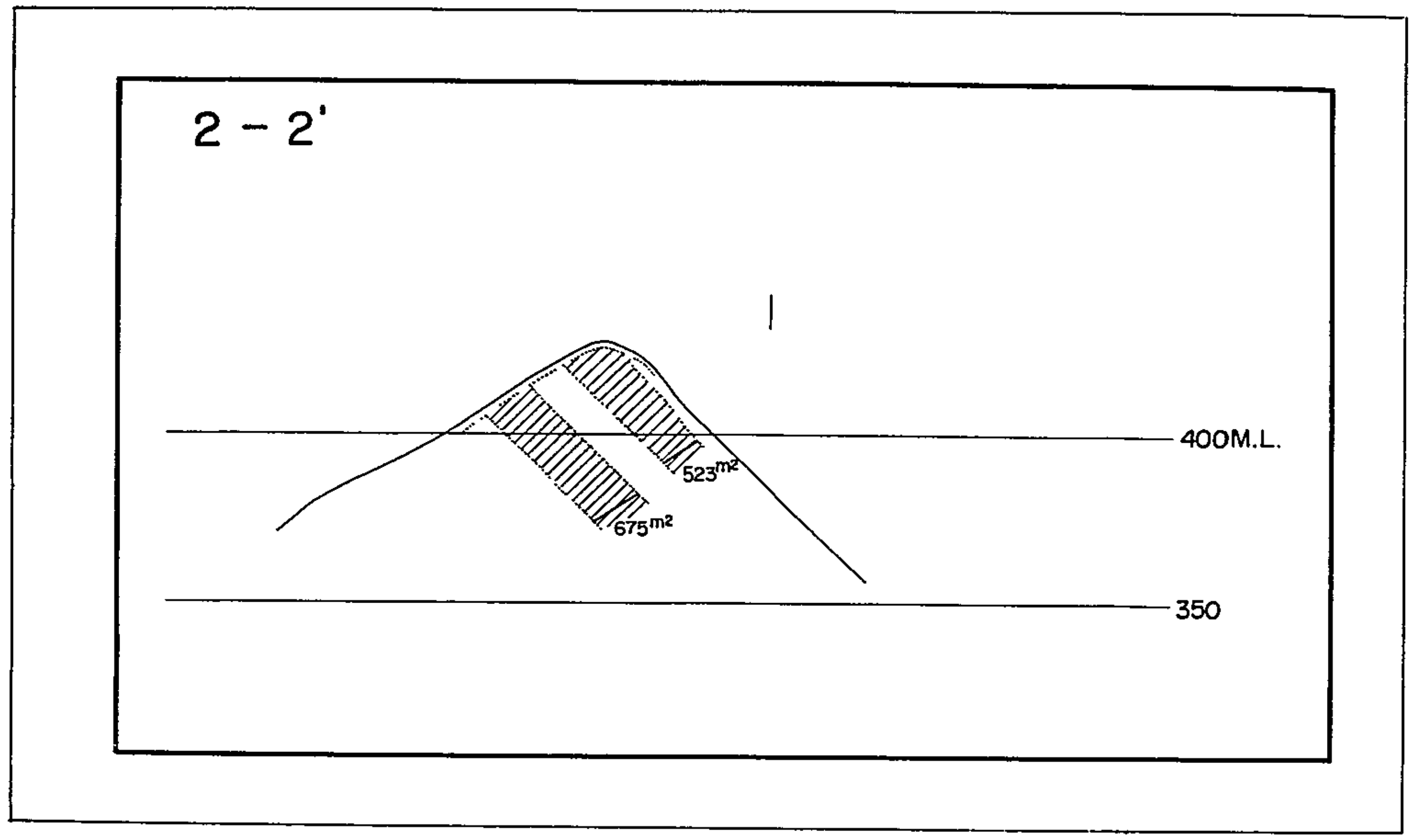
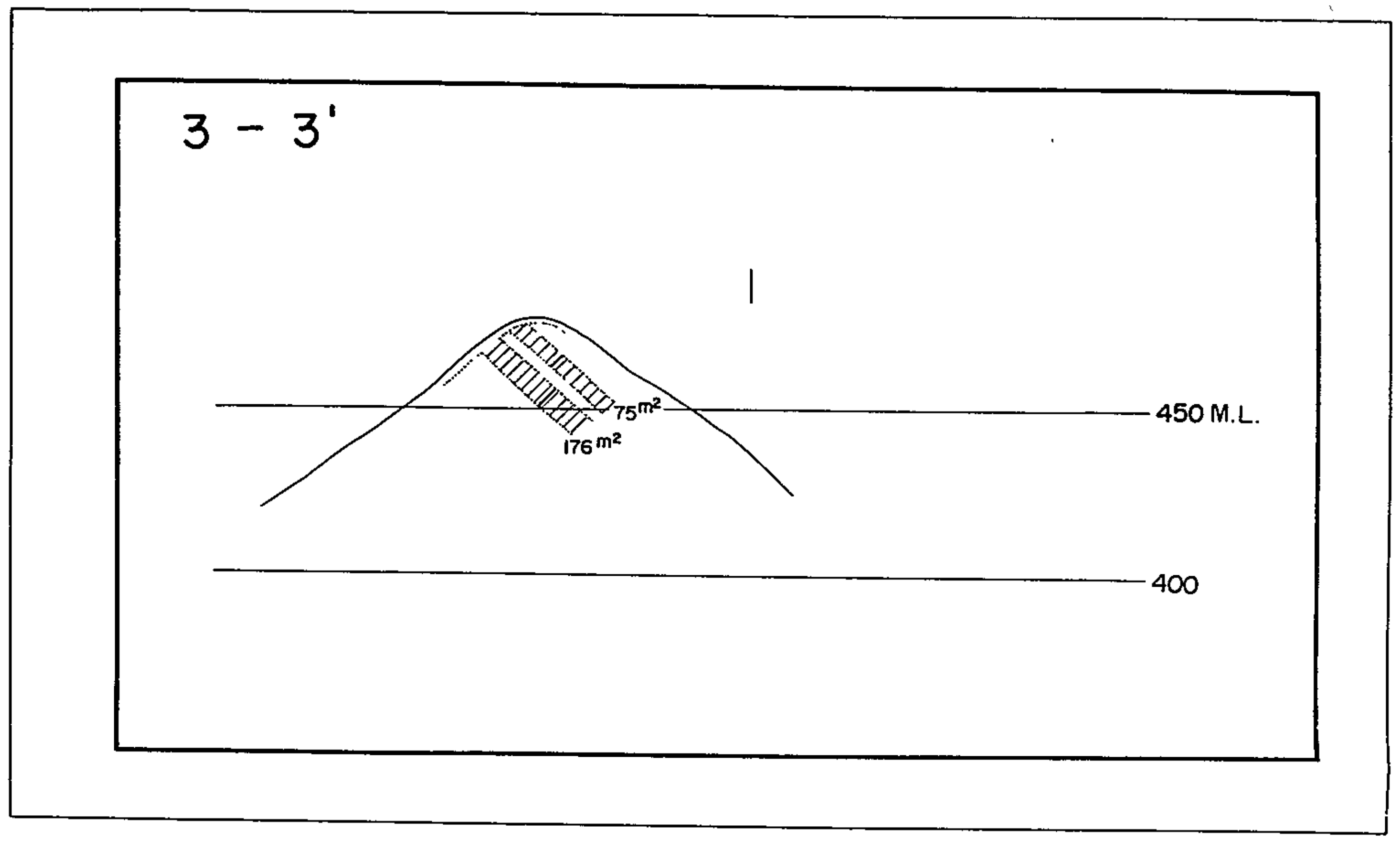
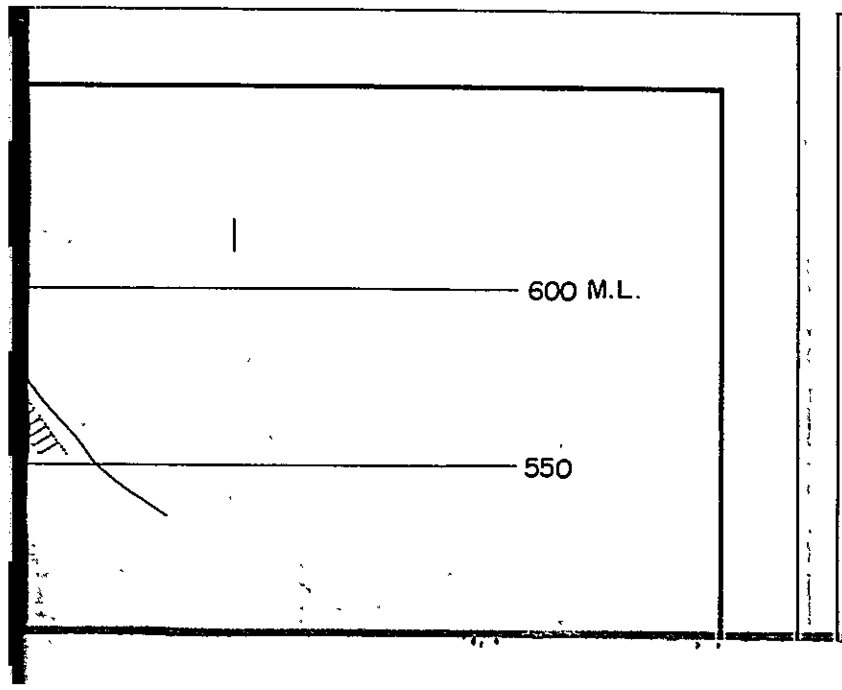


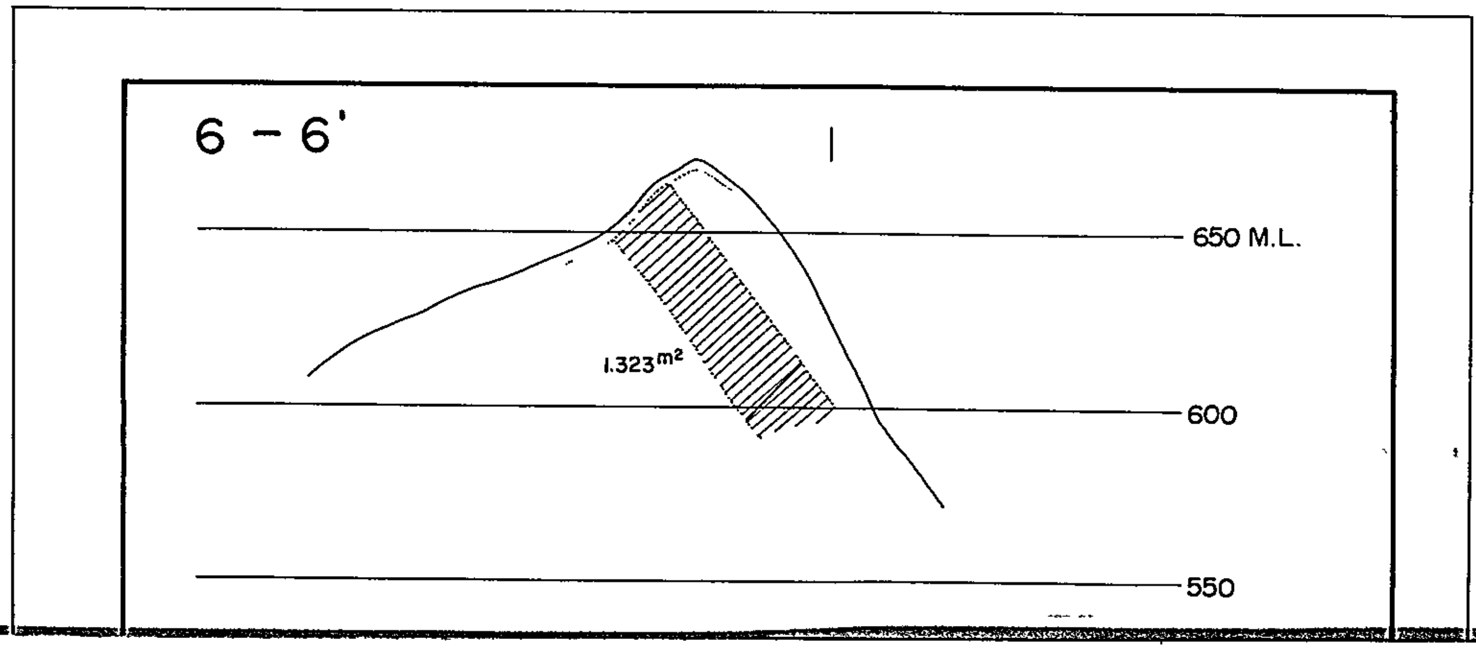
PLATE 6

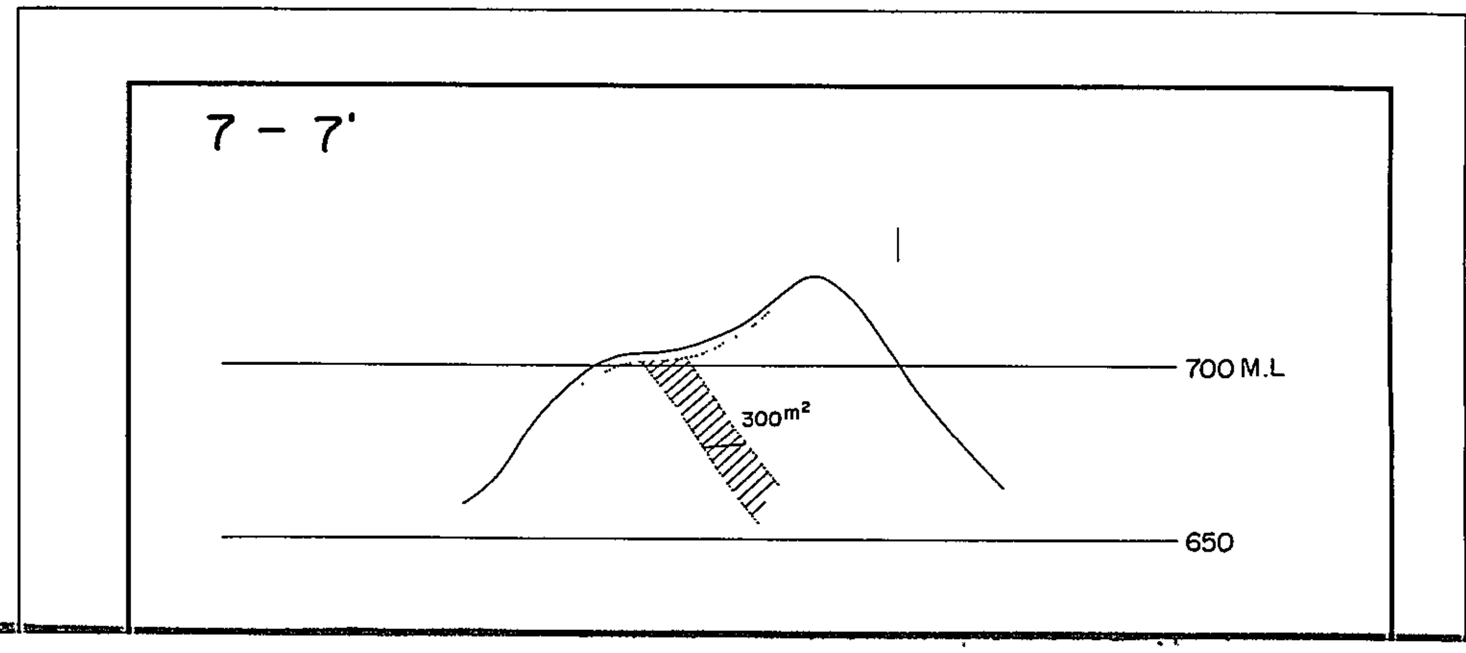

350 M.L.
300
250

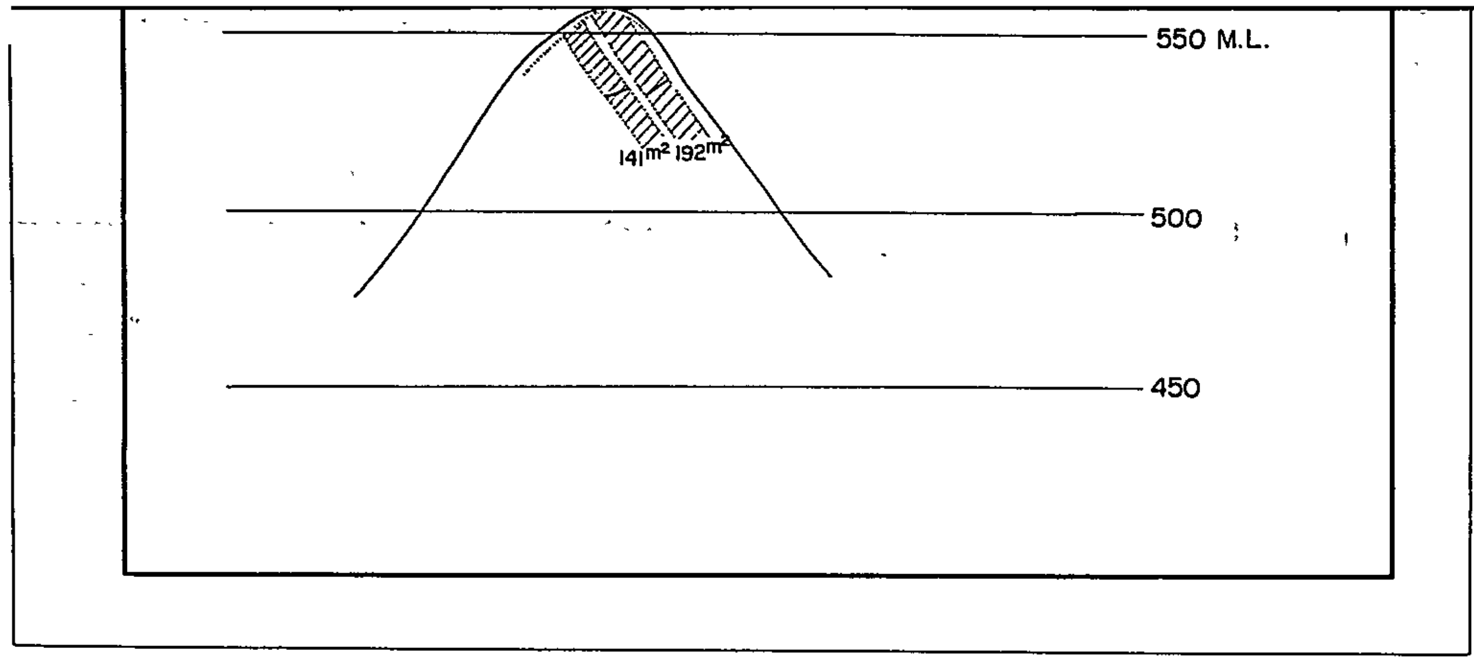

2 – 2'
400M.L.
350
$523 m^2$
$675 m^2$

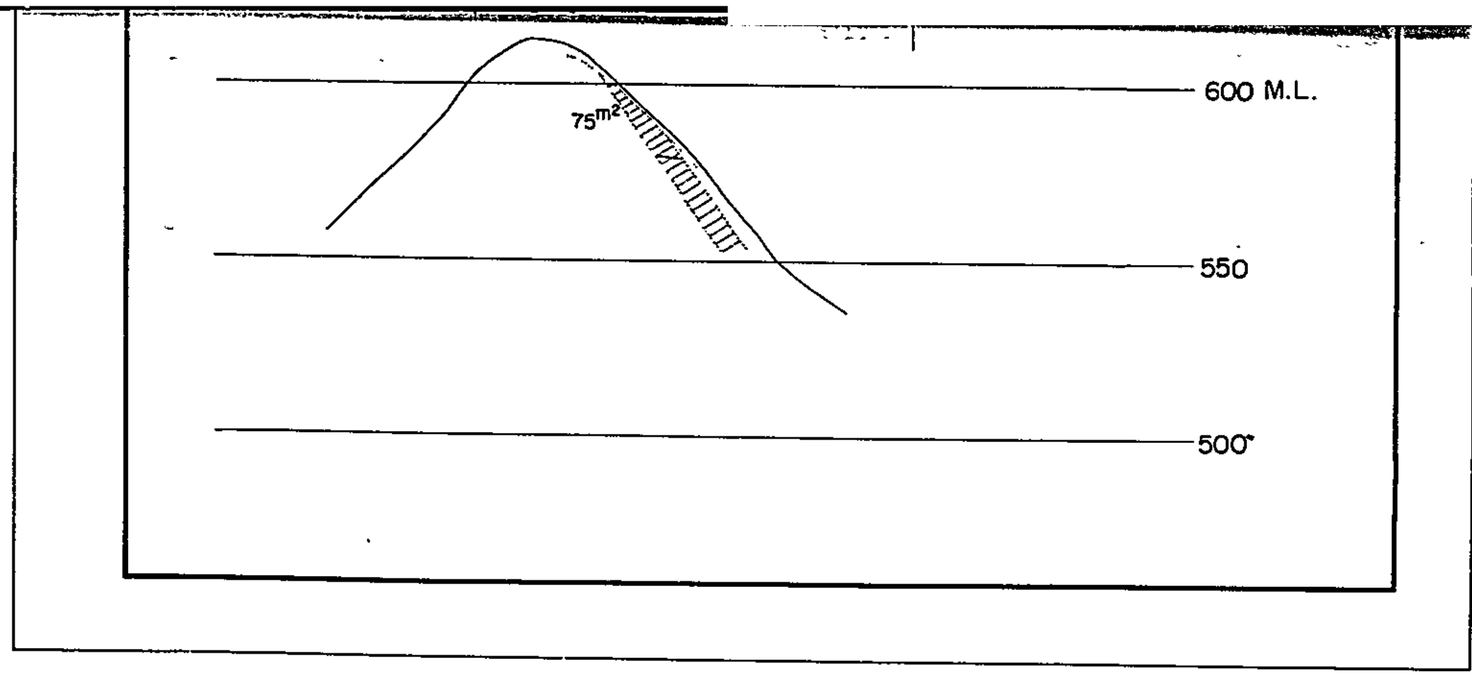

3 – 3'
450 M.L.
400
$75 m^2$
$176 m^2$

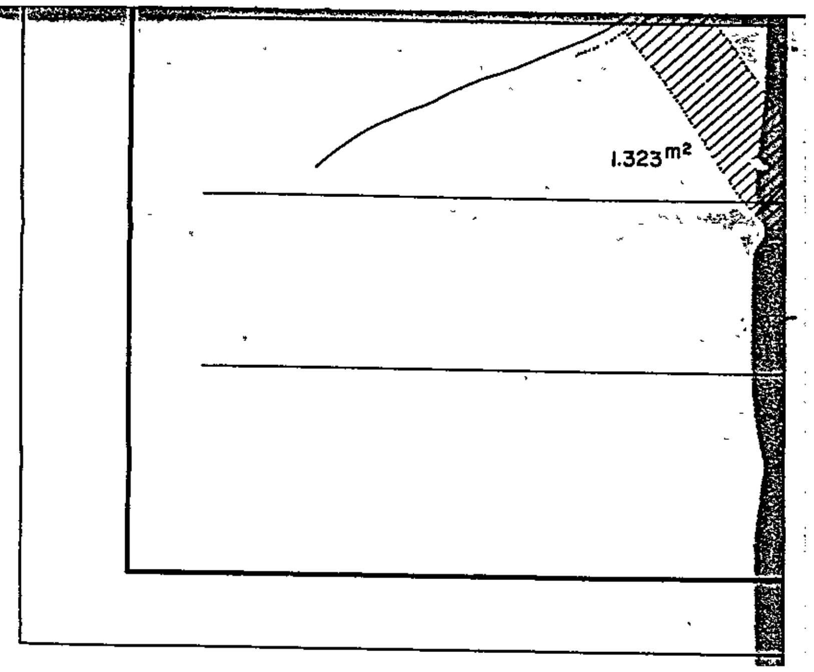

600 M.L.
550

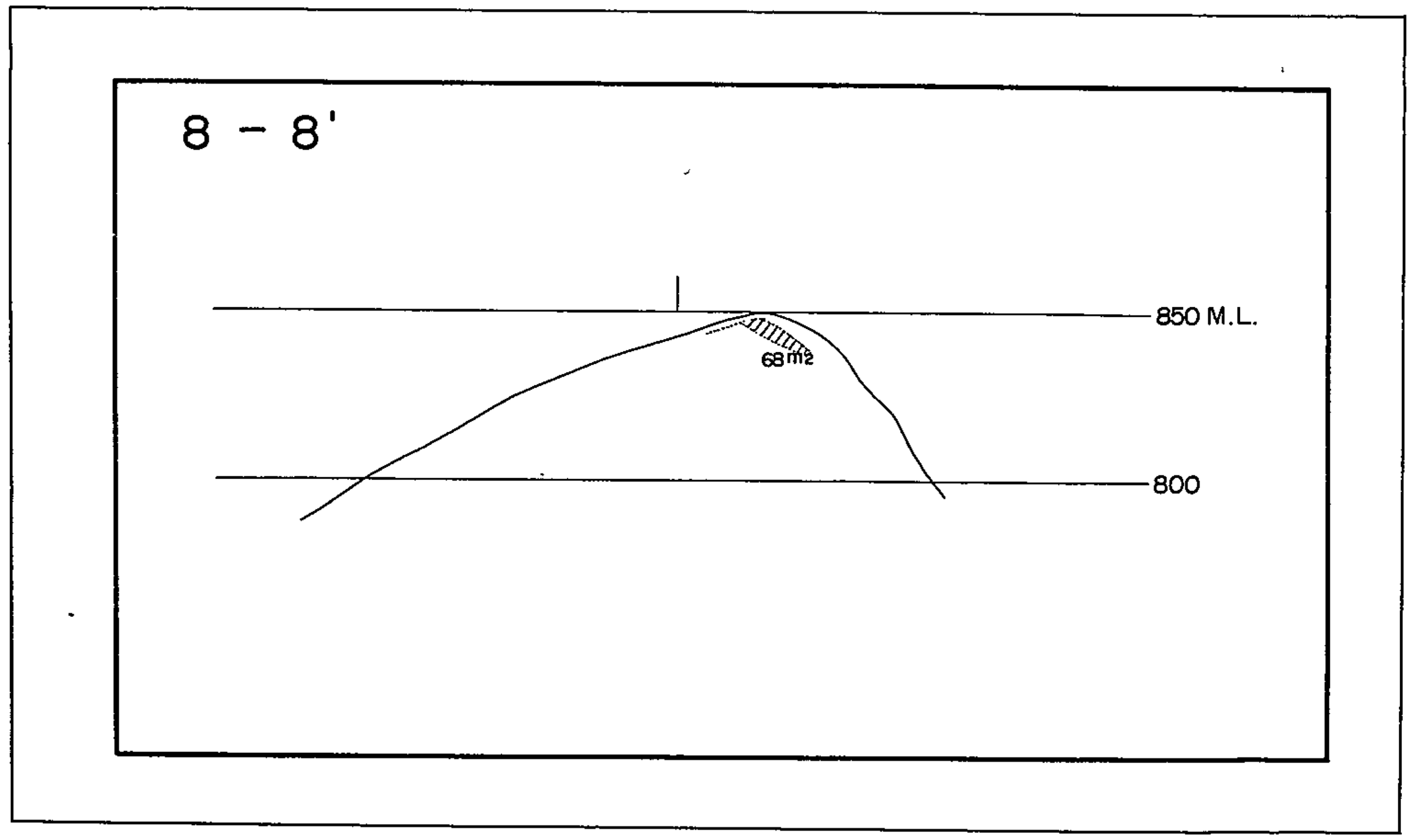

6 – 6'
650 M.L.
600
550
$1.323 m^2$

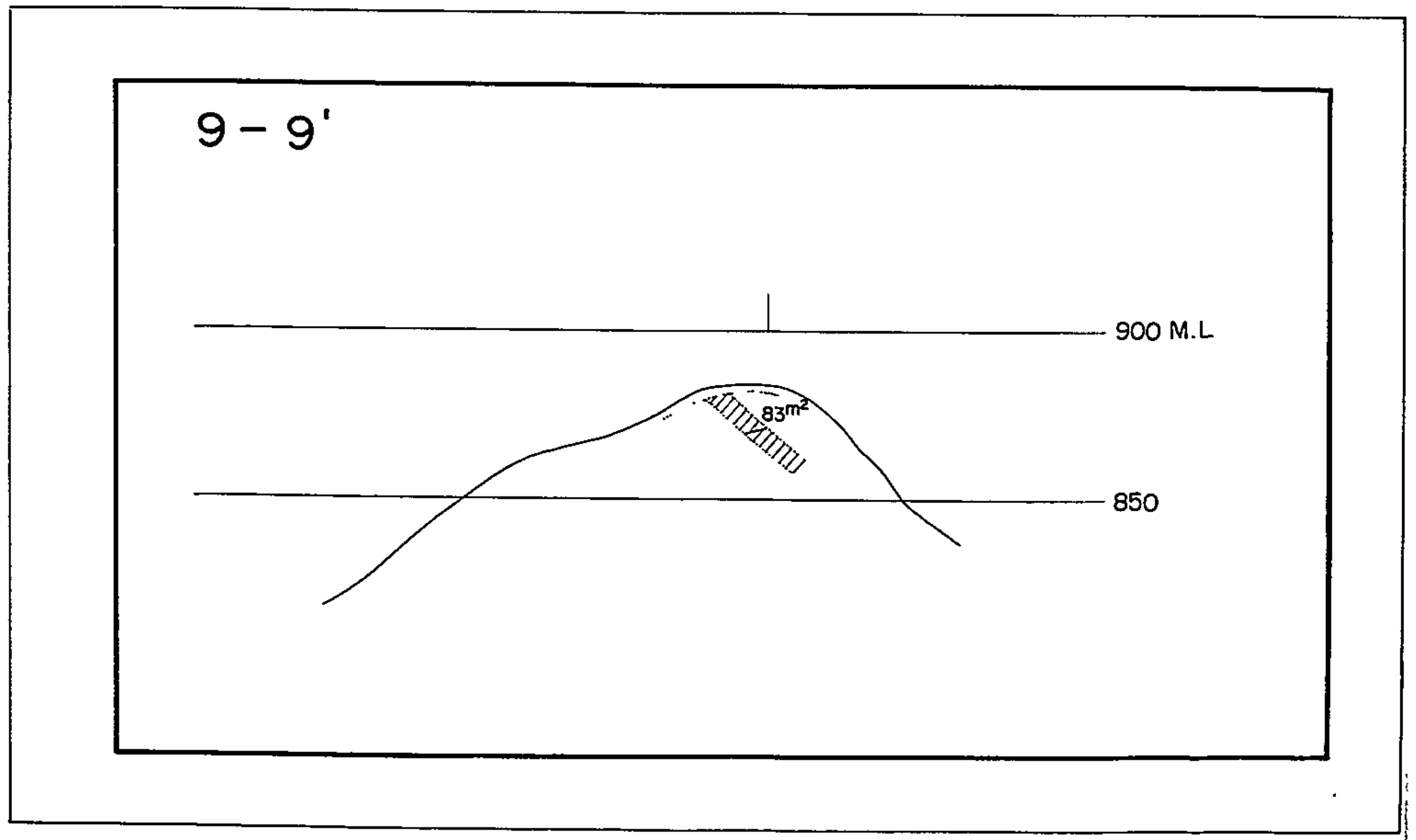

7 – 7'
700 M.L
650
$300 m^2$

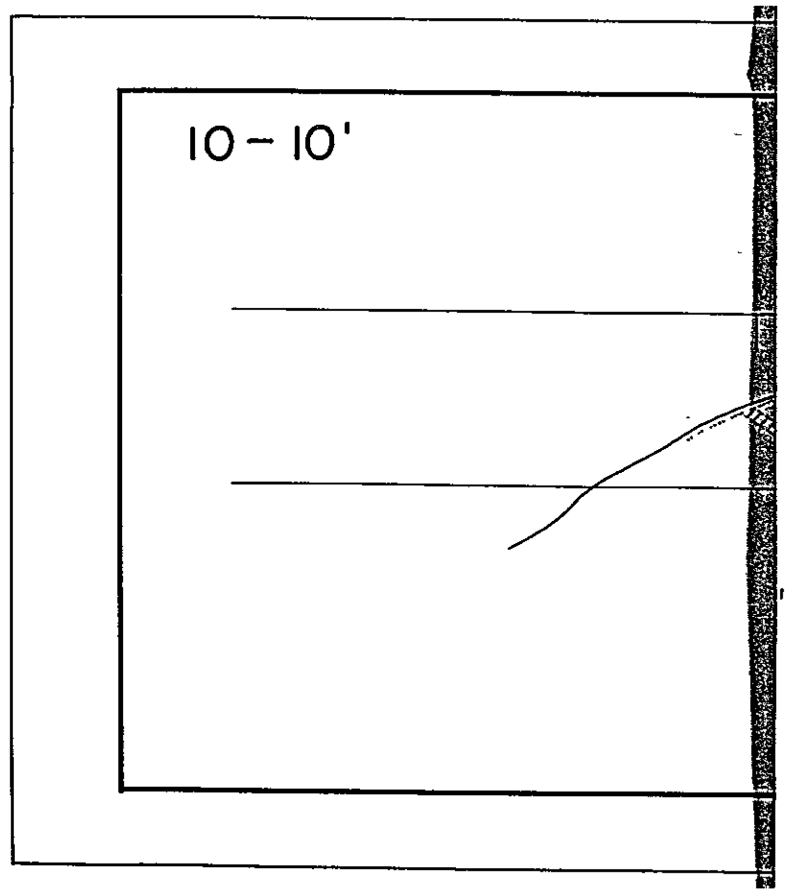

550 M.L.
500
450
141m²
192m²

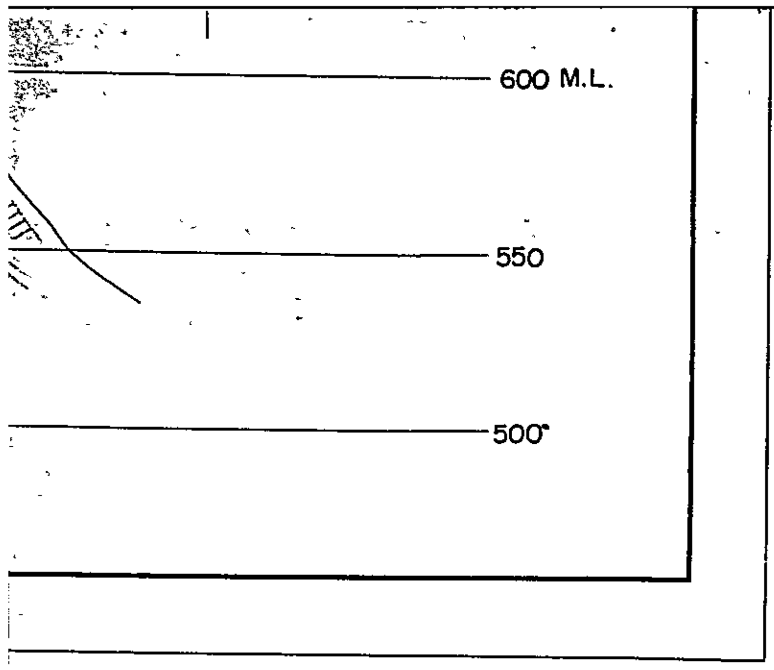

600 M.L.
550
500
75m²

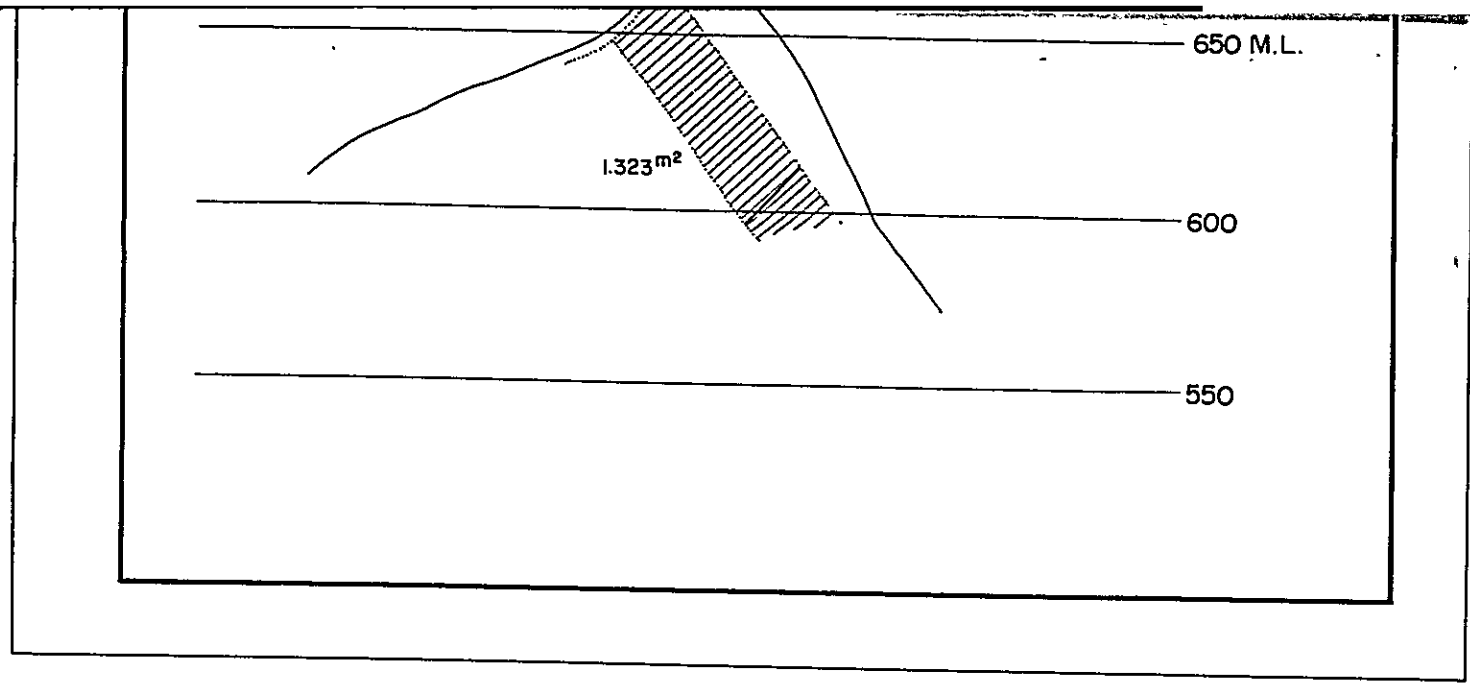

1.323m²

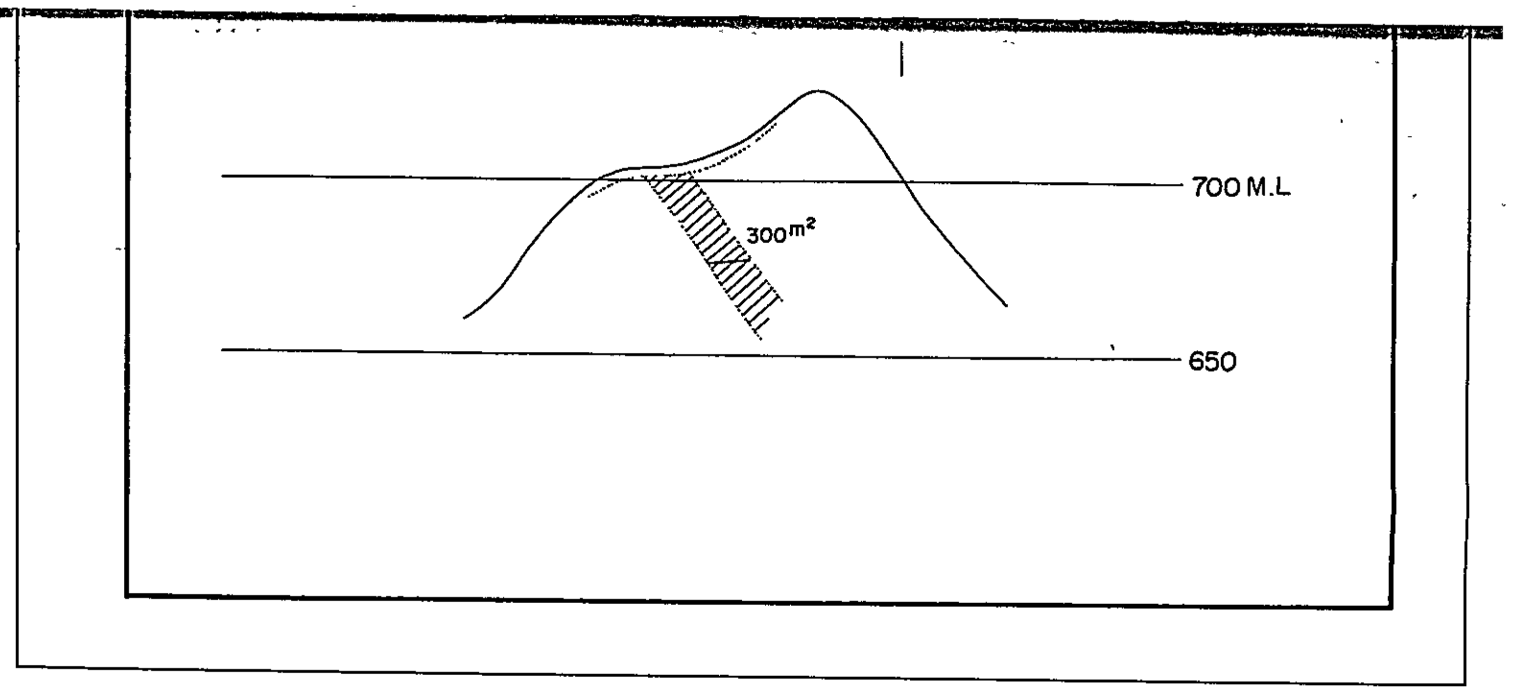

8 - 8'
850 M.L.
800
68m²

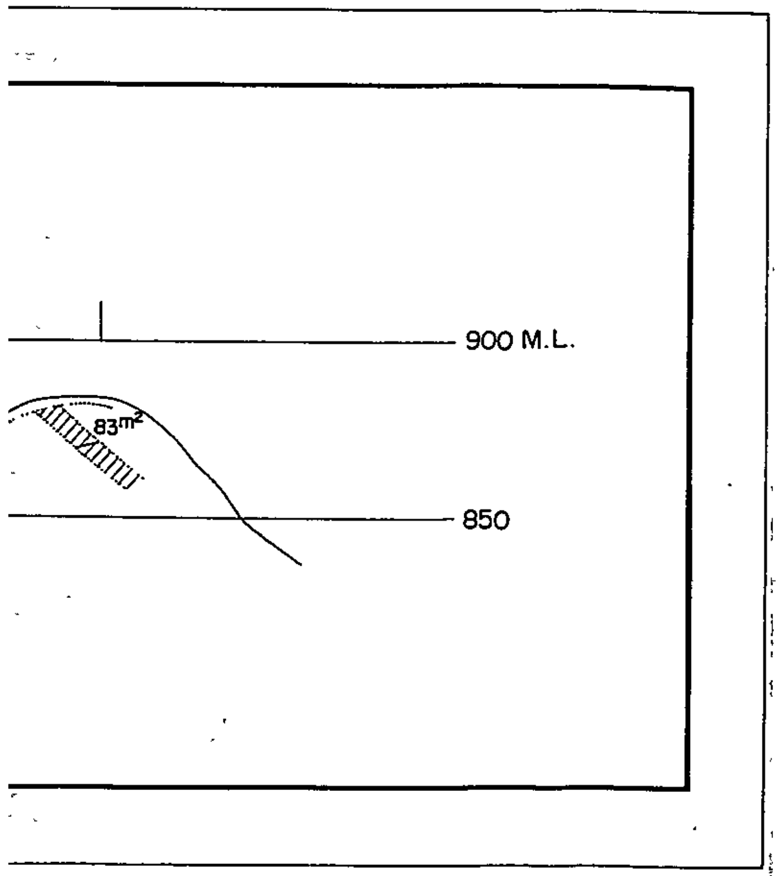

9 - 9'
900 M.L.
850
83m²


10 - 10'


600 M.L.
550
500


650 M.L.
1.323m²
600
550


700 M.L
300m²
650


900 M.L.
83m²
850

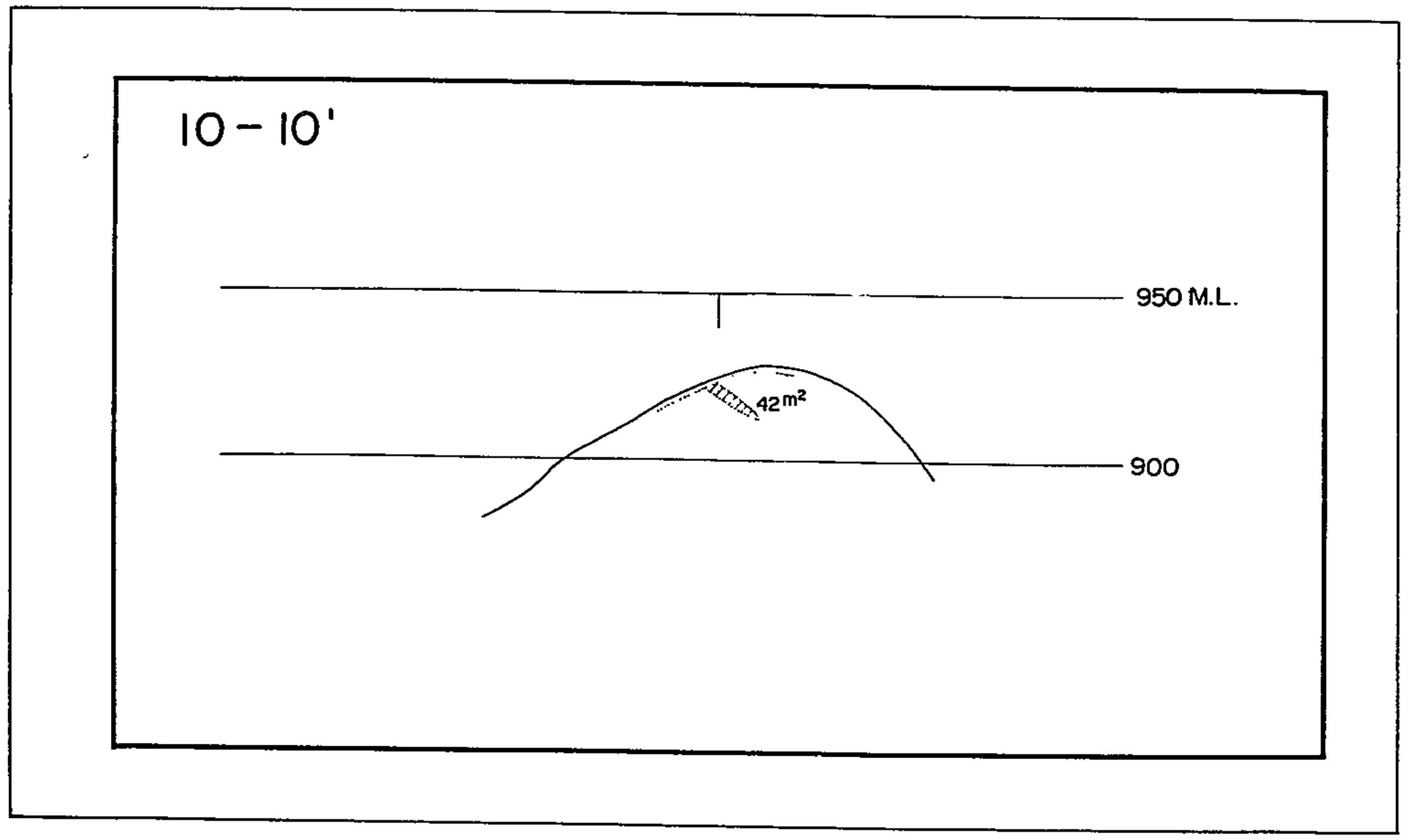
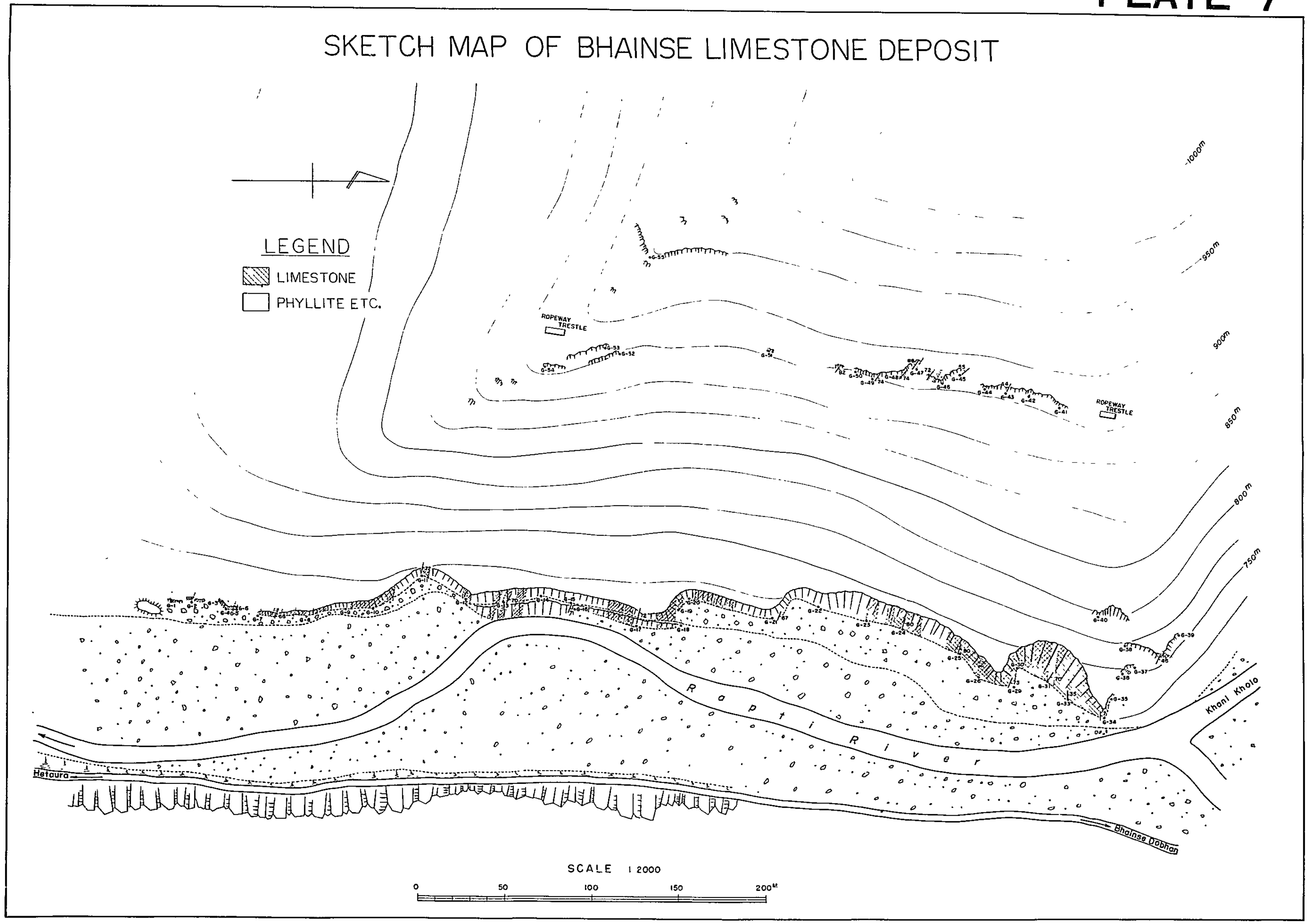

10 - 10'
950 M.L.
42m²
900

PLATE 7


SKETCH MAP OF BHAINSE LIMESTONE DEPOSIT
LEGEND
LIMESTONE
PHYLLITE ETC.
ROPEWAY TRESTLE
ROPEWAY TRESTLE
1000m
950m
900m
850m
800m
750m
Rapti River
Khani Khola
Hetaura
Bhainse Dobhan
SCALE 1 2000
0
50
100
150
200M

Bhainse Limestone Deposit

Vertical Sketch Map Of The Outcrop

Along Rapti River

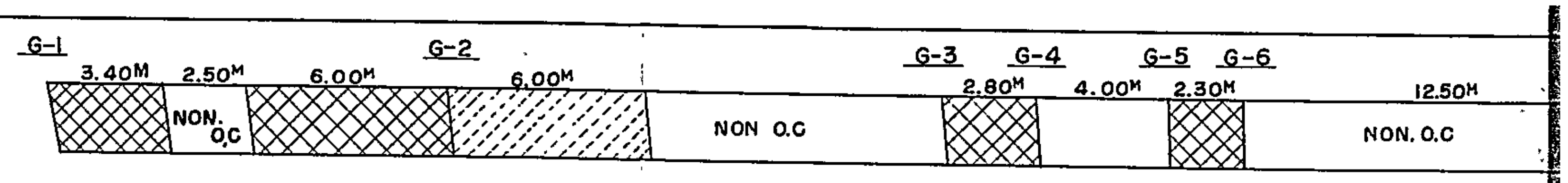
Scale 1/200

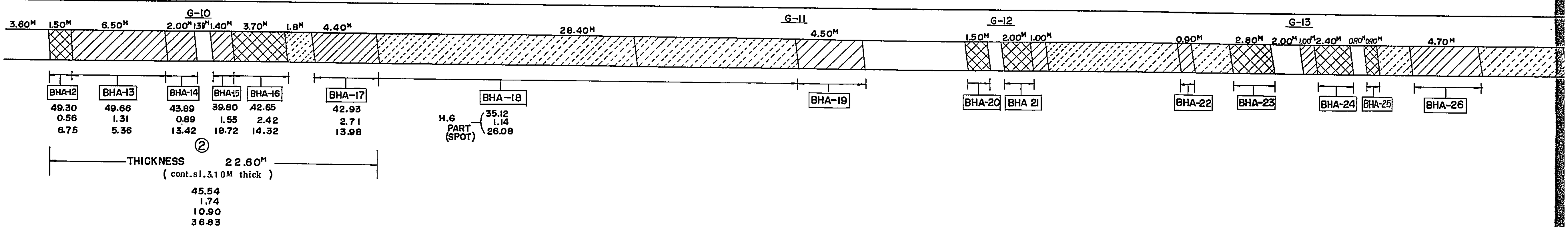
0 5 10m

LEGEND

- HIGH GRADE LS(LS:Sl 2:1)
- LS: SL = 1:1～2:1
- LS:Sl 1:1
- CALCAREOUS Sl. SD AND/OR PHYLLITE
- SD. SL AND/OR PHYLLITE

35.12	CaO %
1.14	MgO %
26.08	SiO_2 %
28.40	Ig. loss %





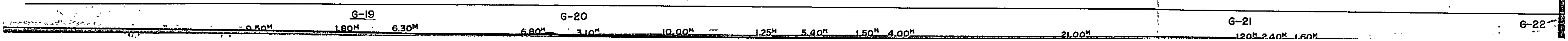
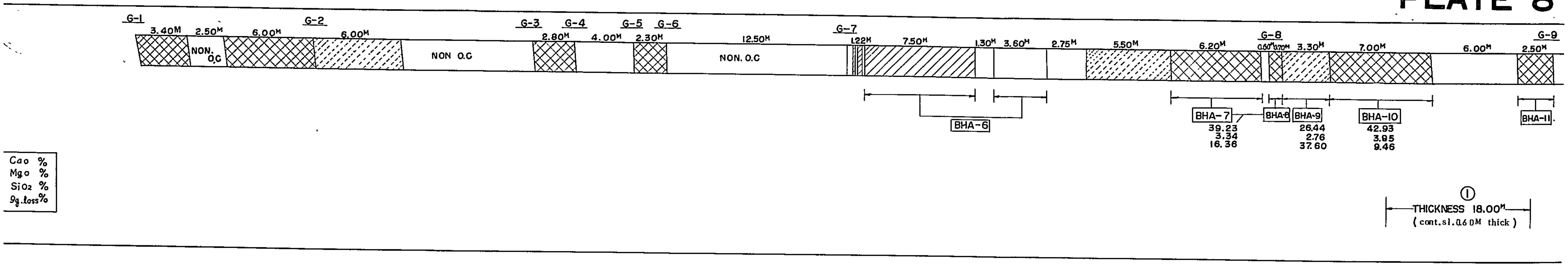
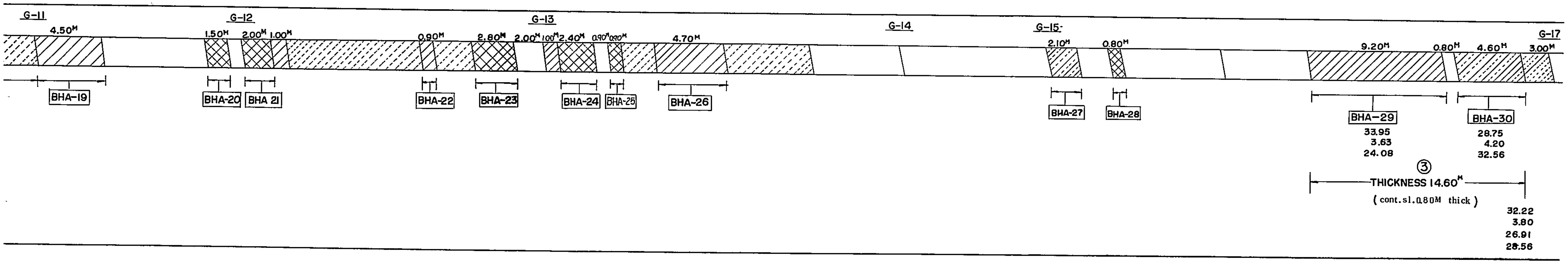
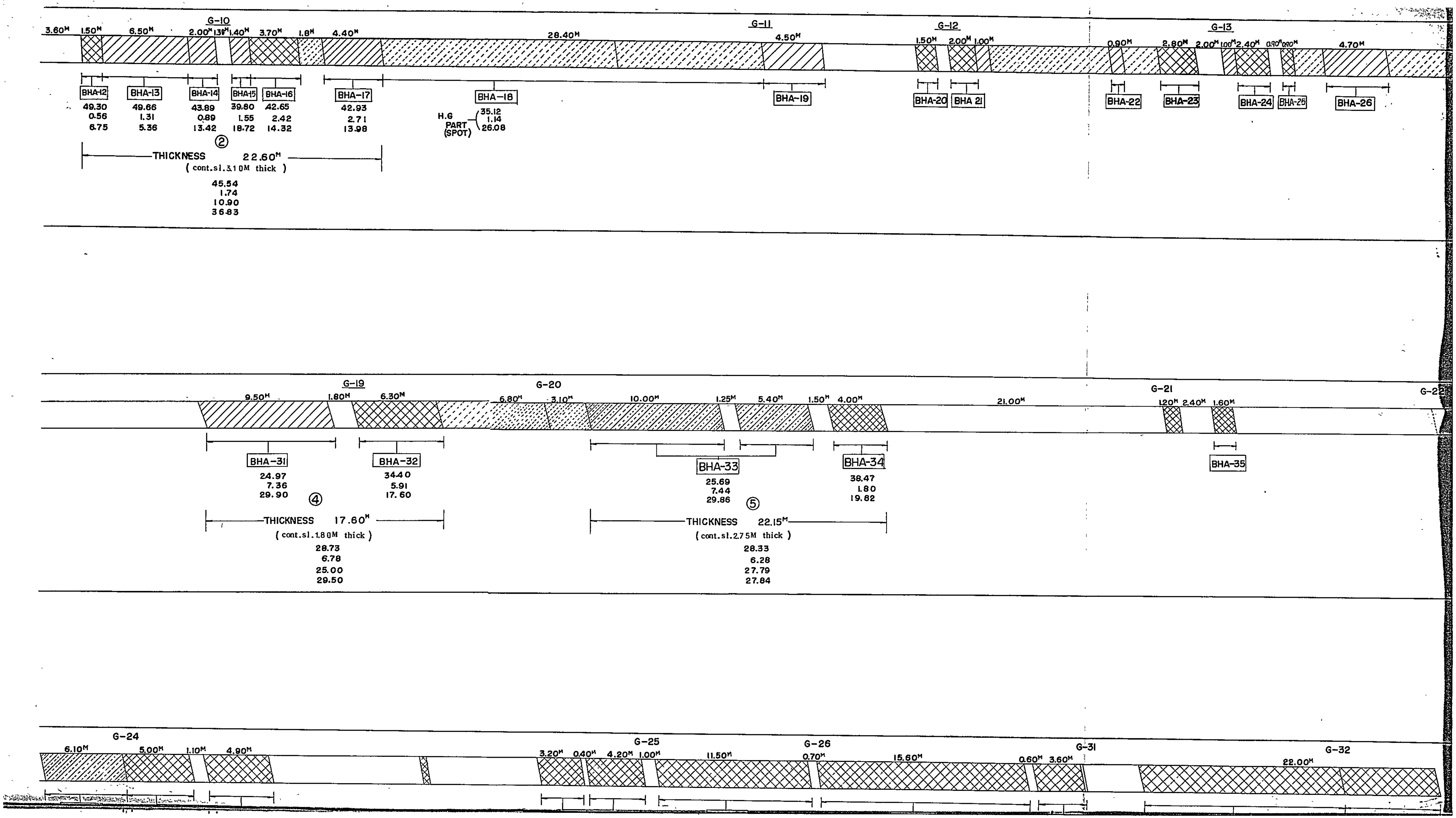


PLATE 8

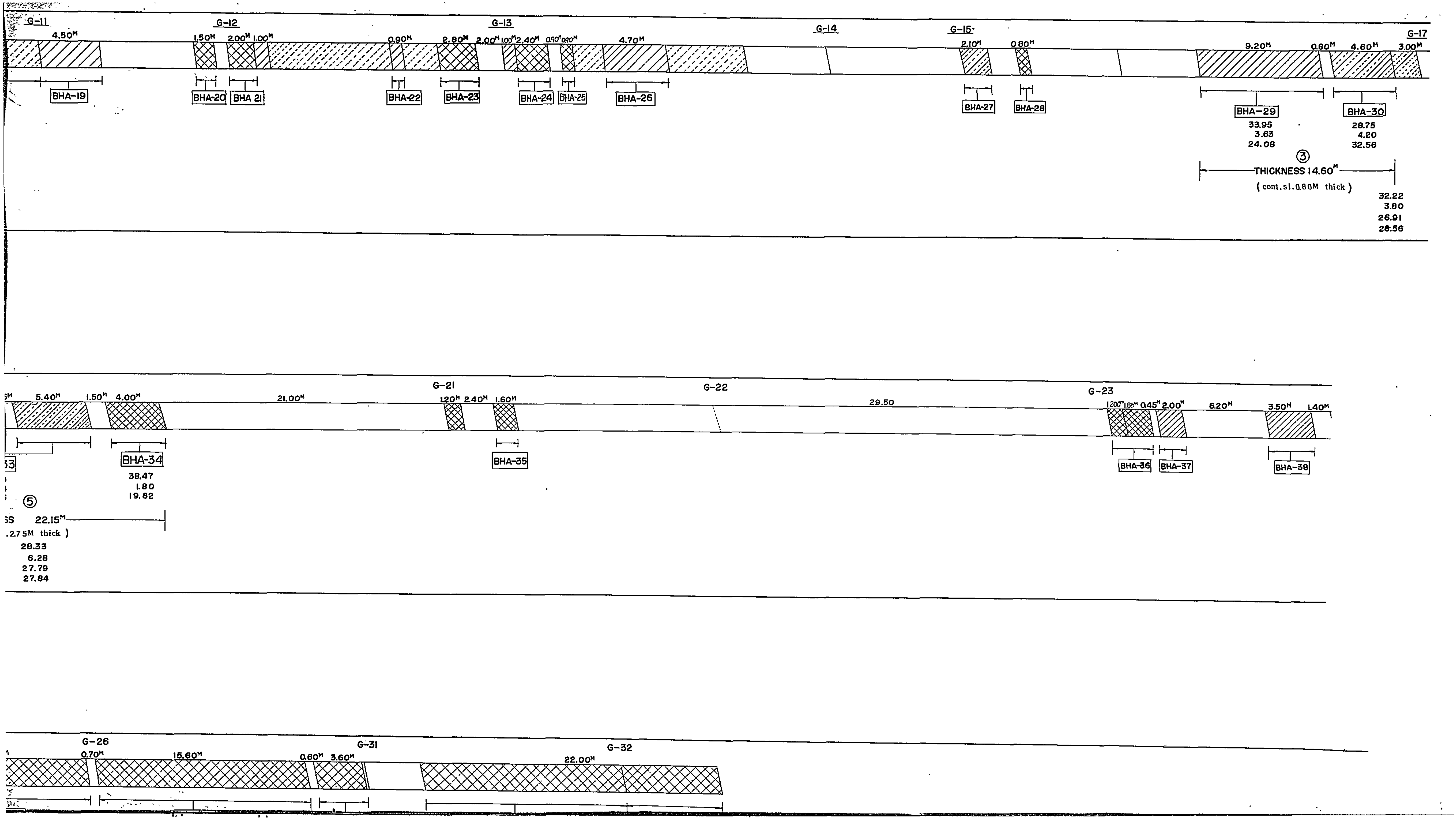

G-1
3.40M
2.50M
NON. O.C
6.00M
G-2
6.00M
NON O.C
G-3
G-4
2.80M
4.00M
G-5
G-6
2.30M
12.50M
NON. O.C
G-7
1.22M
7.50M
1.30M
3.60M
2.75M
5.50M
6.20M
G-8
3.30M
7.00M
6.00M
G-9
2.50M
BHA-6
BHA-7
39.23
3.34
16.36
BHA-8
BHA-9
26.44
2.76
37.60
BHA-10
42.93
3.95
9.46
BHA-11
Cao %
Mgo %
SiO2 %
Ig. loss %
①
THICKNESS 18.00M
(cont. sl. 0.60M thick)


G-11
4.50M
G-12
1.50M
2.00M
1.00M
G-13
0.90M
2.80M
2.00M
1.00M
2.40M
0.90M
0.90M
4.70M
G-14
G-15
2.10M
0.80M
9.20M
0.80M
4.60M
G-17
3.00M
BHA-19
BHA-20
BHA 21
BHA-22
BHA-23
BHA-24
BHA-25
BHA-26
BHA-27
BHA-28
BHA-29
33.95
3.63
24.08
BHA-30
28.75
4.20
32.56
③
THICKNESS 14.60M
(cont. sl. 0.80M thick)
32.22
3.80
26.91
28.56

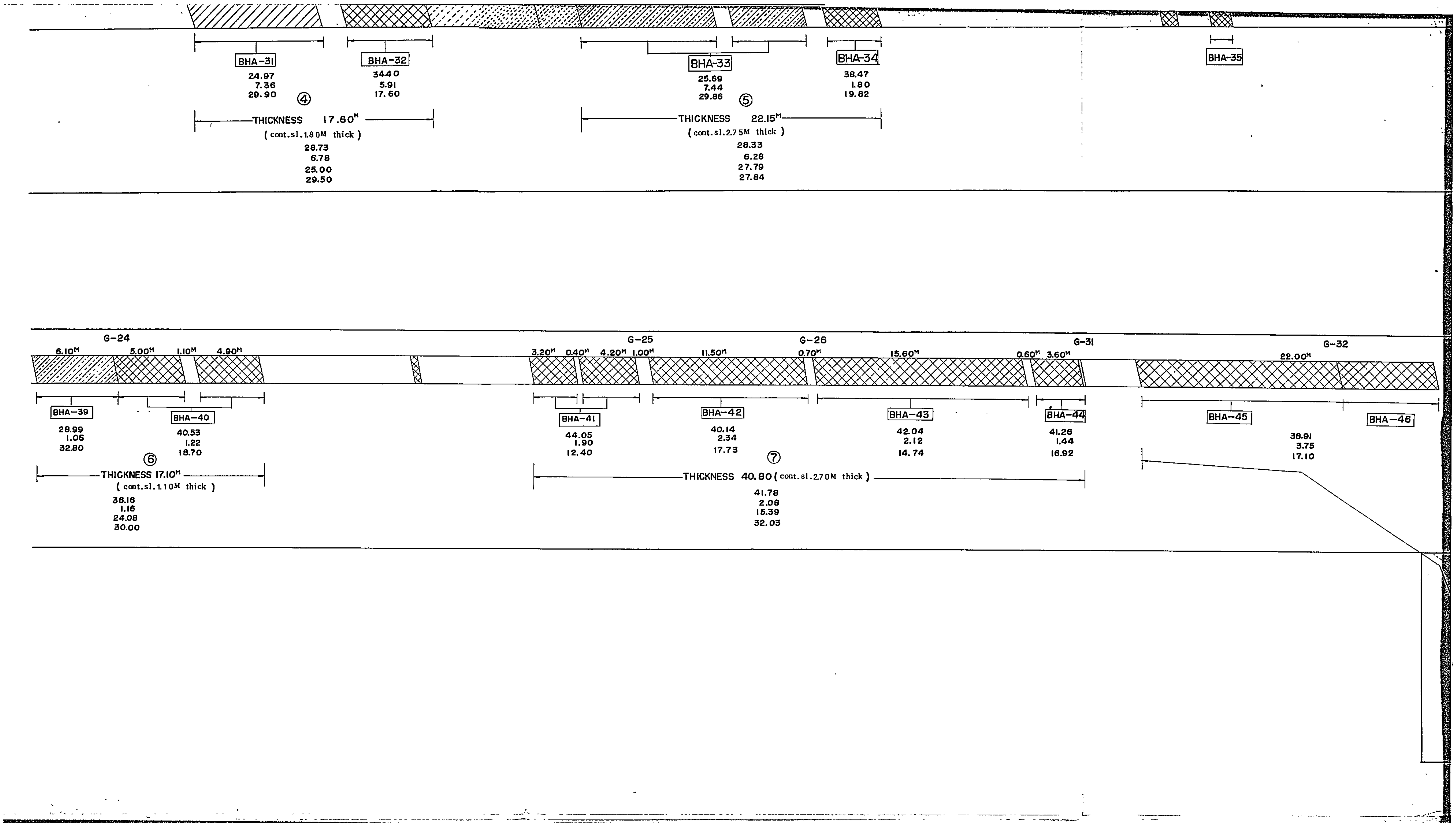

G-21
G-22
G-23



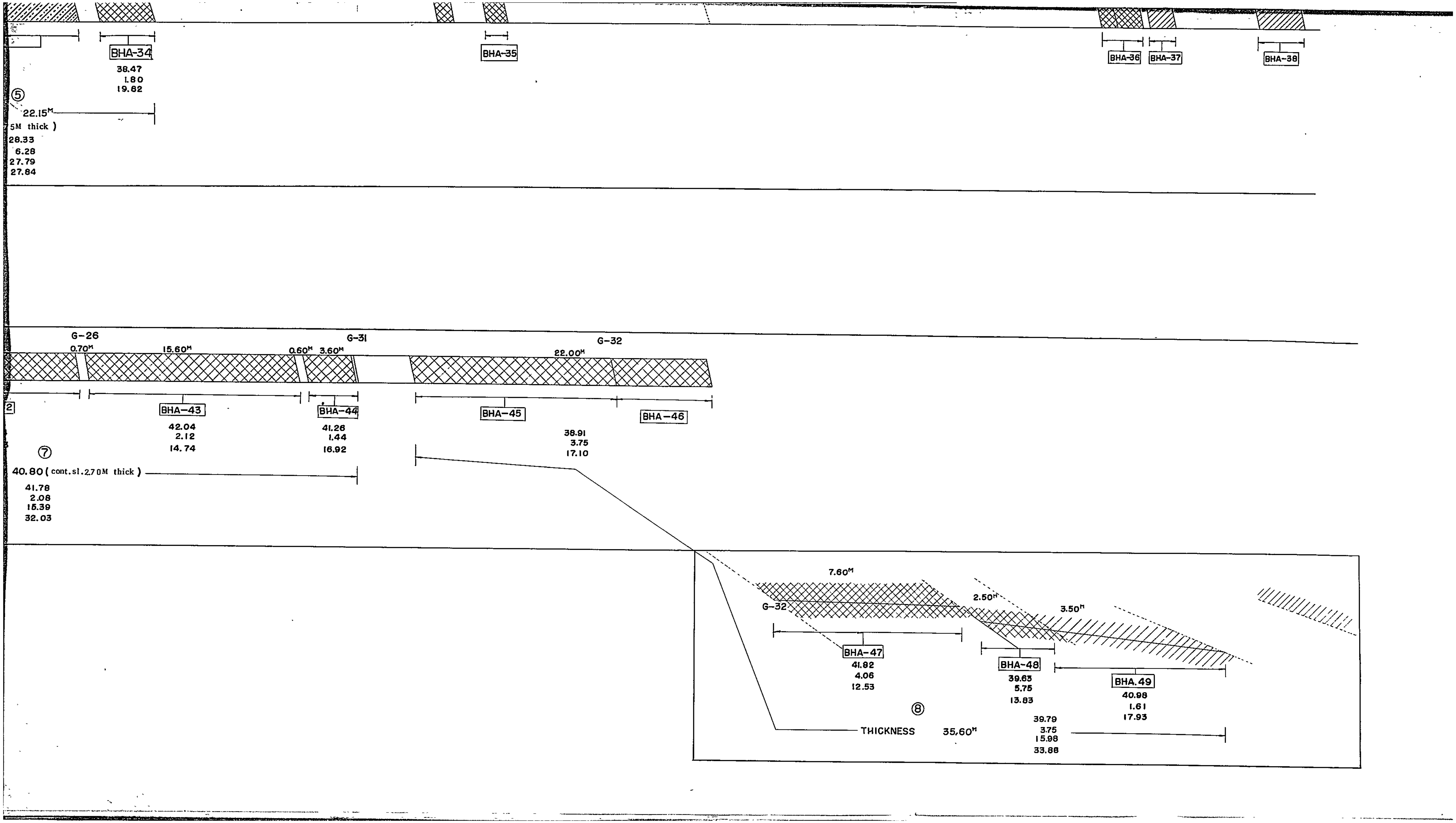
G-10
G-11
G-12
G-13
3.60M 1.50M 6.50M 2.00M 1.30M 1.40M 3.70M 1.8M 4.40M
28.40M
4.50M
1.50M 2.00M 1.00M
0.90M 2.80M 2.00M 1.00M 2.40M 0.90M 0.90M 4.70M
BHA-12 BHA-13 BHA-14 BHA-15 BHA-16 BHA-17 BHA-18 BHA-19 BHA-20 BHA 21 BHA-22 BHA-23 BHA-24 BHA-25 BHA-26
49.30 0.56 6.75
49.66 1.31 5.36
43.89 0.89 13.42
39.80 1.55 18.72
42.65 2.42 14.32
42.93 2.71 13.98
H.G PART (SPOT) 35.12 1.14 26.08
②
THICKNESS 22.60M
(cont.sl.3.10M thick)
45.54
1.74
10.90
36.83
G-19
G-20
G-21
G-22
9.50M 1.80M 6.30M 6.80M 3.10M 10.00M 1.25M 5.40M 1.50M 4.00M 21.00M 1.20M 2.40M 1.60M
BHA-31 BHA-32 BHA-33 BHA-34 BHA-35
24.97 7.36 29.90
34.40 5.91 17.60
25.69 7.44 29.86
38.47 1.80 19.82
④
THICKNESS 17.60M
(cont.sl.1.80M thick)
28.73
6.78
25.00
29.50
⑤
THICKNESS 22.15M
(cont.sl.2.75M thick)
28.33
6.28
27.79
27.84
G-24
G-25
G-26
G-31
G-32
6.10M 5.00M 1.10M 4.90M 3.20M 0.40M 4.20M 1.00M 11.50M 0.70M 15.60M 0.60M 3.60M 22.00M



G-11
4.50M
BHA-19
G-12
1.50M
2.00M
1.00M
BHA-20
BHA 21
0.90M
BHA-22
2.80M
BHA-23
G-13
2.00M
1.00M
2.40M
0.90M
0.90M
BHA-24
BHA-25
4.70M
BHA-26
G-14
G-15
2.10M
0.80M
BHA-27
BHA-28
9.20M
0.80M
4.60M
3.00M
G-17
BHA-29
33.95
3.63
24.08
BHA-30
28.75
4.20
32.56
③
THICKNESS 14.60M
(cont.sl.0.80M thick)
32.22
3.80
26.91
28.56
5.40M
1.50M
4.00M
21.00M
BHA-34
38.47
1.80
19.82
⑤
22.15M
.2.75M thick)
28.33
6.28
27.79
27.84
G-21
1.20M
2.40M
1.60M
BHA-35
G-22
29.50
G-23
1.20M
1.85M
0.45M
2.00M
6.20M
3.50M
1.40M
BHA-36
BHA-37
BHA-38
G-26
0.70M
15.60M
0.60M
3.60M
G-31
G-32
22.00M



BHA-31
24.97
7.36
29.90
BHA-32
34.40
5.91
17.60
④
THICKNESS 17.60M
(cont.sl.1.80M thick)
28.73
6.78
25.00
29.50
BHA-33
25.69
7.44
29.86
BHA-34
38.47
1.80
19.82
⑤
THICKNESS 22.15M
(cont.sl.2.75M thick)
28.33
6.28
27.79
27.84
BHA-35
G-24
6.10M
5.00M
1.10M
4.90M
BHA-39
28.99
1.06
32.80
BHA-40
40.53
1.22
18.70
⑥
THICKNESS 17.10M
(cont.sl.1.10M thick)
36.16
1.16
24.08
30.00
G-25
3.20M
0.40M
4.20M
1.00M
11.50M
G-26
0.70M
15.60M
G-31
0.60M
3.60M
G-32
22.00M
BHA-41
44.05
1.90
12.40
BHA-42
40.14
2.34
17.73
BHA-43
42.04
2.12
14.74
BHA-44
41.26
1.44
16.92
BHA-45
BHA-46
38.91
3.75
17.10
⑦
THICKNESS 40.80 (cont.sl.2.70M thick)
41.78
2.08
15.39
32.03



BHA-34
38.47
1.80
19.82
BHA-35
BHA-36
BHA-37
BHA-38
⑤
22.15M
5M thick)
28.33
6.28
27.79
27.84
G-26
0.70M
15.60M
0.60M
3.60M
G-31
G-32
22.00M
BHA-43
42.04
2.12
14.74
BHA-44
41.26
1.44
16.92
BHA-45
BHA-46
38.91
3.75
17.10
⑦
40.80 (cont.sl.2.70M thick)
41.78
2.08
15.39
32.03
7.60M
G-32
2.50M
3.50M
BHA-47
41.82
4.06
12.53
BHA-48
39.63
5.75
13.83
BHA.49
40.98
1.61
17.93
⑧
THICKNESS 35.60M
39.79
3.75
15.98
33.88

CHOBHAR LIMESTONE DEPOSIT

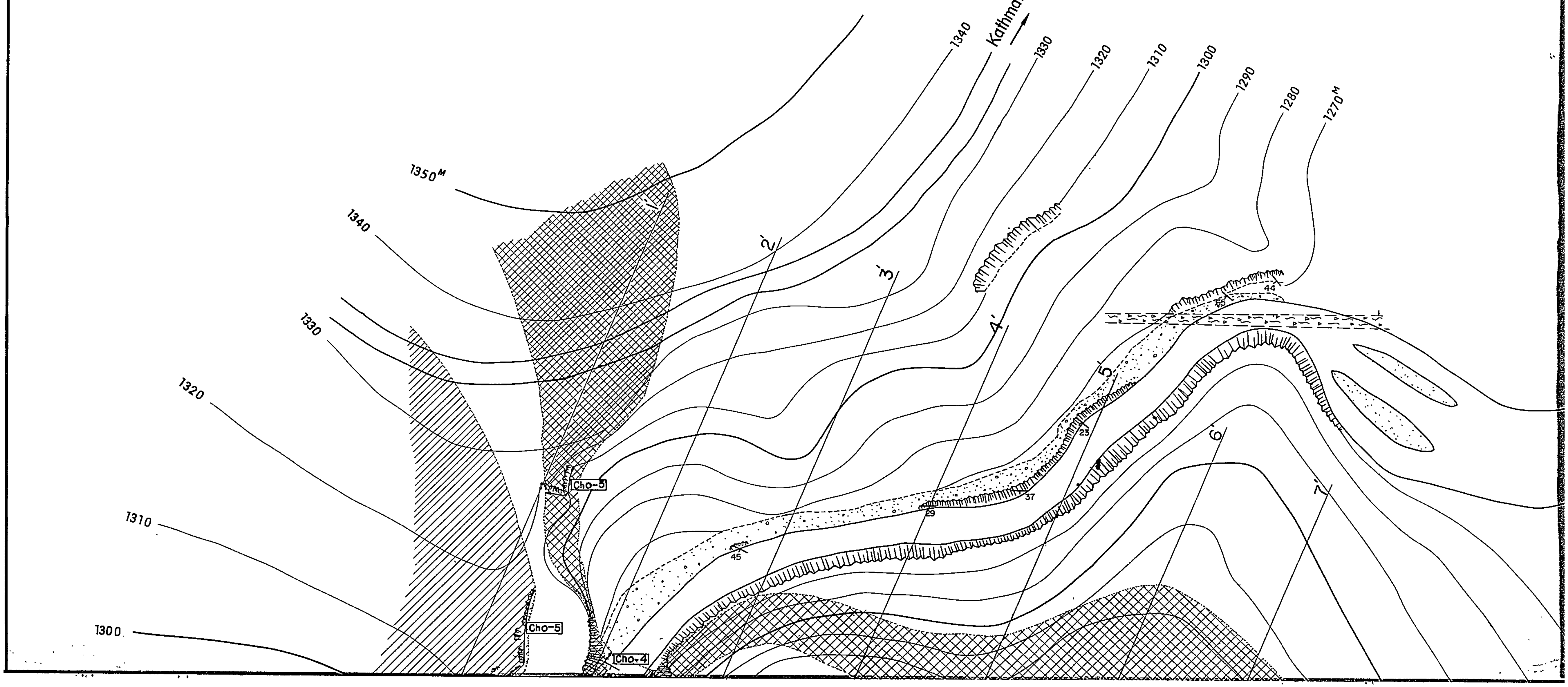
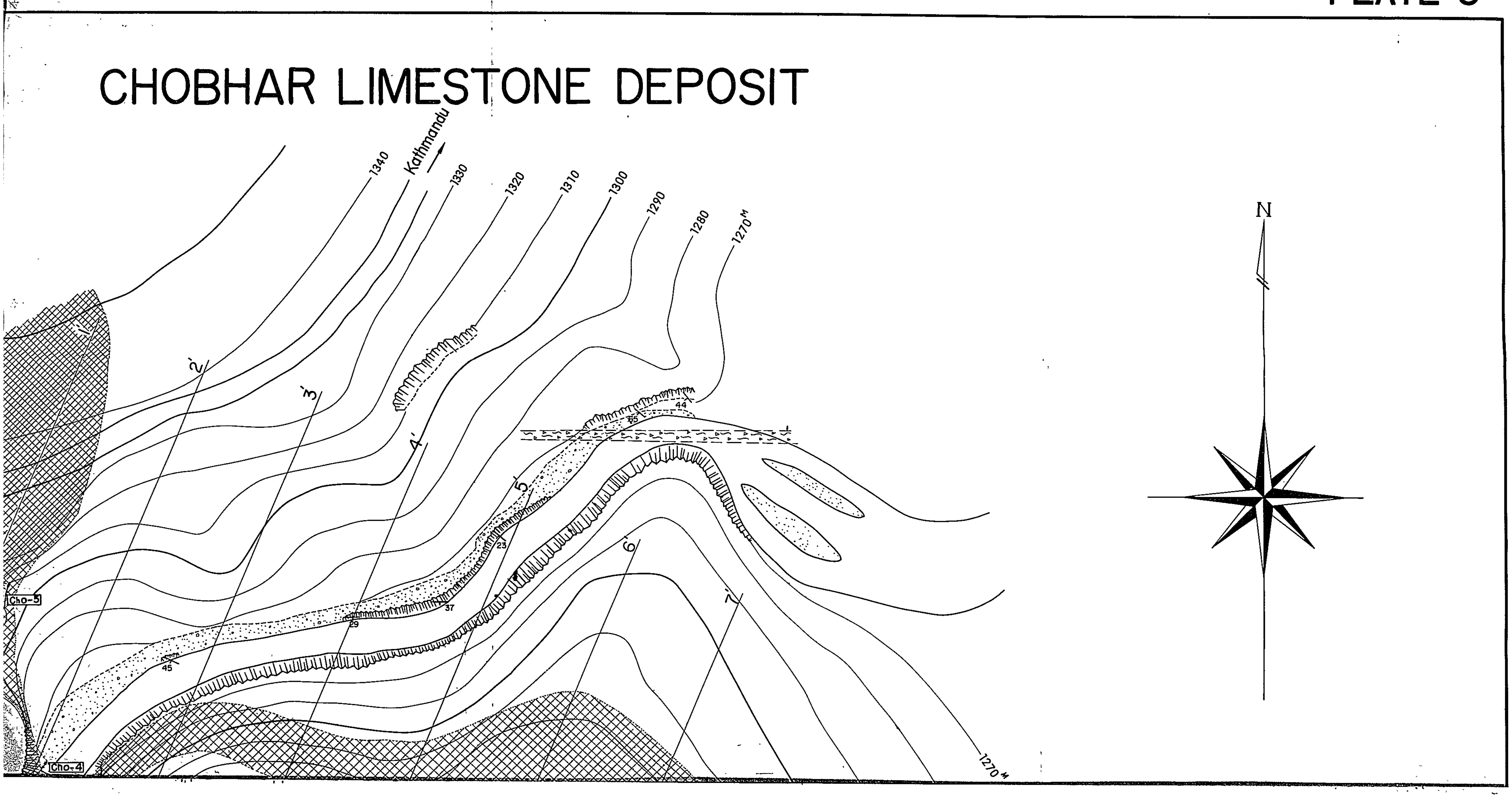
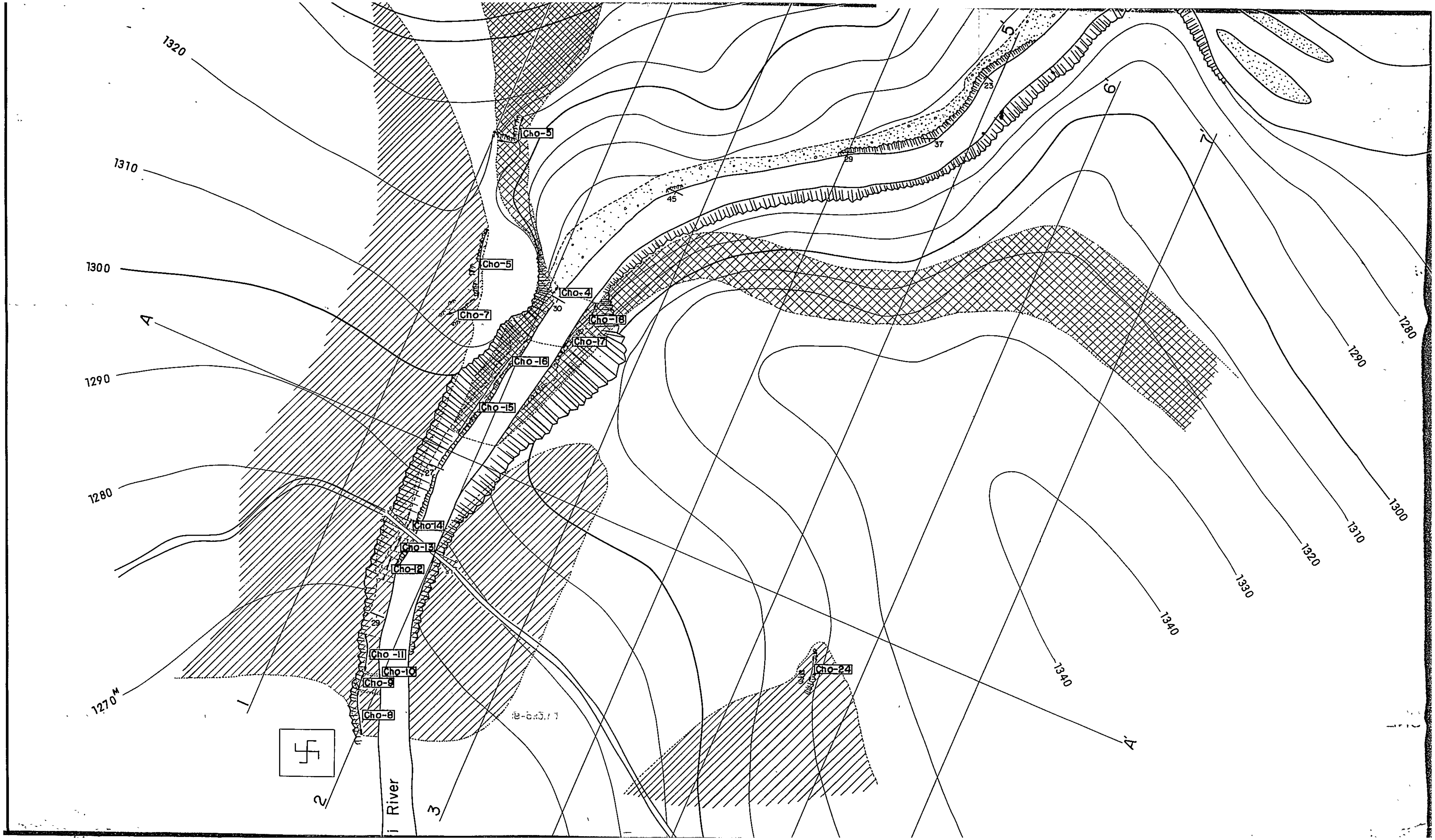
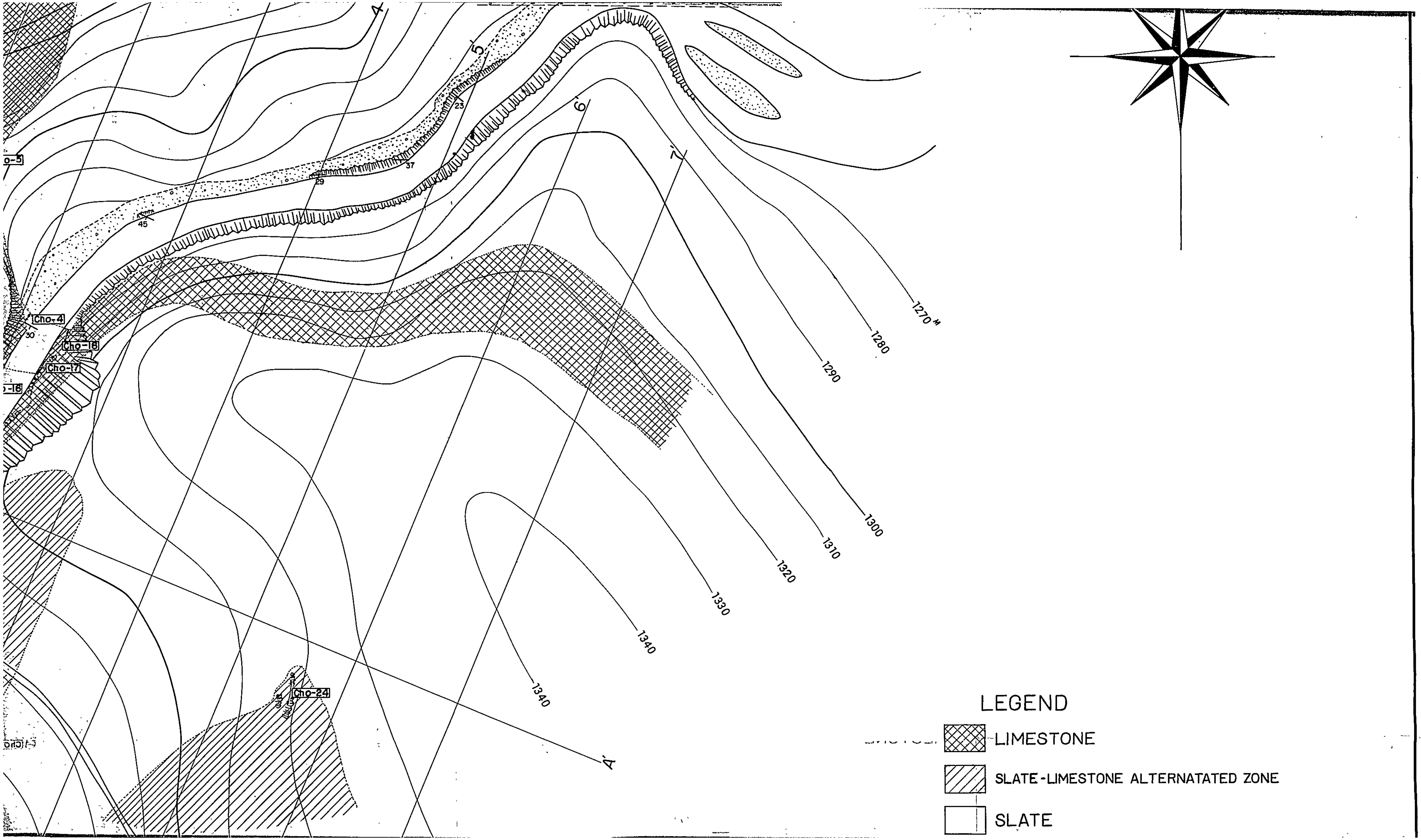


PLATE 9

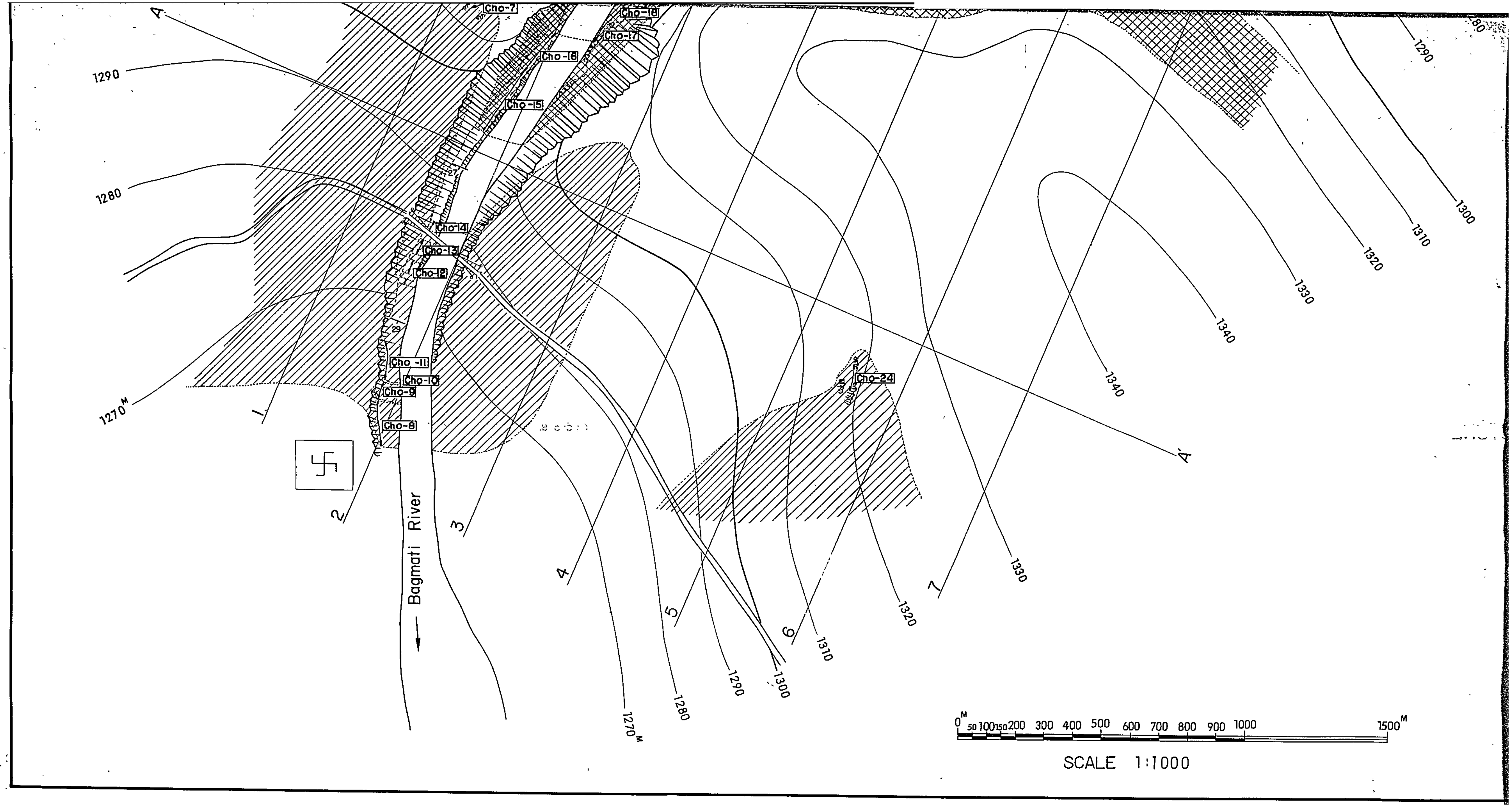

CHOBHAR LIMESTONE DEPOSIT
Kathmandu
1340
1330
1320
1310
1300
1290
1280
1270M
1270M
1'
2'
3'
4'
5'
6'
7'
44
55
23
37
29
45
Cho-5
Cho-4
N



1320
1310
1300
1290
1280
1270M
Cho-3
Cho-5
Cho-4
Cho-7
Cho-18
Cho-17
Cho-16
Cho-15
Cho-14
Cho-13
Cho-12
Cho-11
Cho-10
Cho-9
Cho-8
Cho-24
River
A
A'
1
2
3
5
6
7
1280
1290
1300
1310
1320
1330
1340
1340



1270 M
1280
1290
1300
1310
1320
1330
1340
1340
Cho-4
Cho-18
Cho-17
Cho-24
A
A'
5
6
7
LEGEND
LIMESTONE
SLATE-LIMESTONE ALTERNATATED ZONE
SLATE


A
A'
1290
1280
1270M
1270M
1280
1290
1300
1310
1320
1330
1340
1340
1330
1320
1310
1300
1290
Cho-7
Cho-18
Cho-17
Cho-16
Cho-15
Cho-14
Cho-13
Cho-12
Cho-11
Cho-10
Cho-9
Cho-8
Cho-24
1
2
3
4
5
6
7
Bagmati River
0M 50 100 150 200 300 400 500 600 700 800 900 1000 1500M
SCALE 1:1000

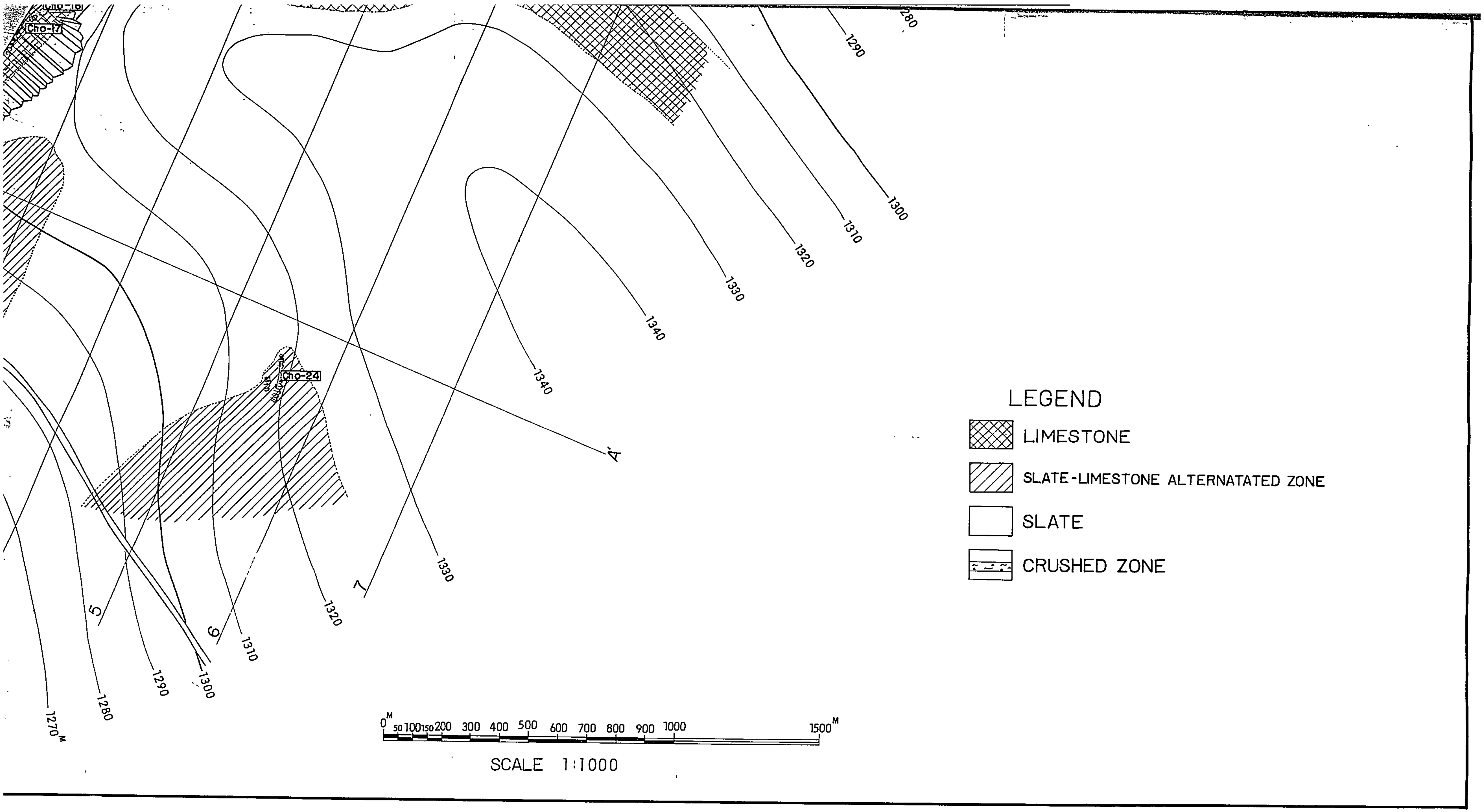
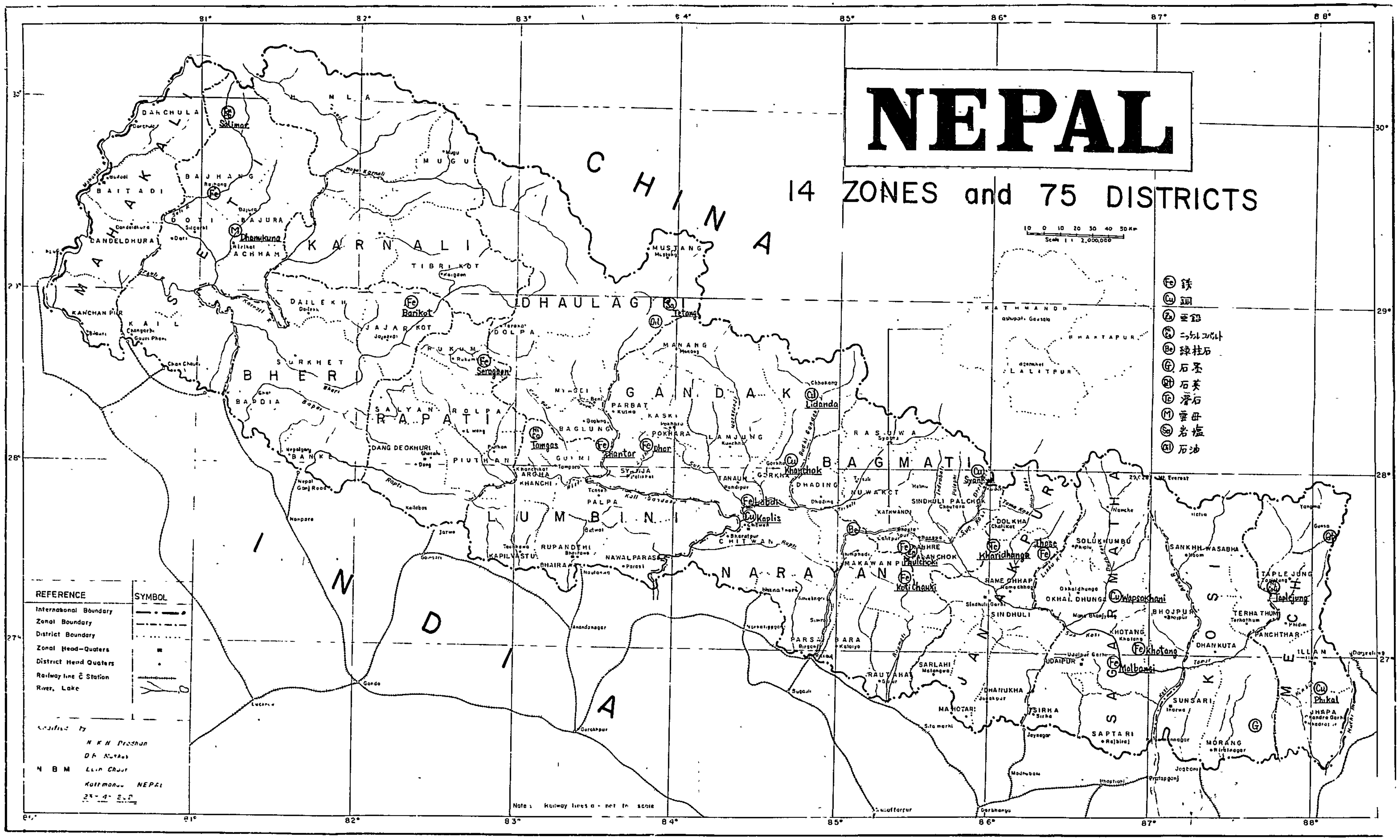
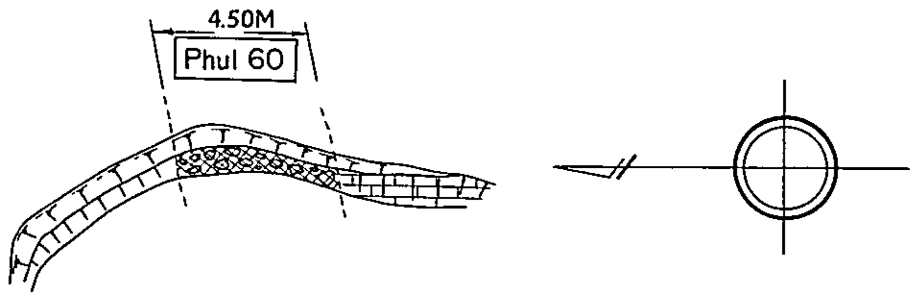

Cho-18
Cho-17
Cho-24
A'
5
6
7
1270M
1280
1290
1300
1310
1320
1330
1340
LEGEND
LIMESTONE
SLATE-LIMESTONE ALTERNATATED ZONE
SLATE
CRUSHED ZONE
0M 50 100 150 200 300 400 500 600 700 800 900 1000 1500M
SCALE 1:1000

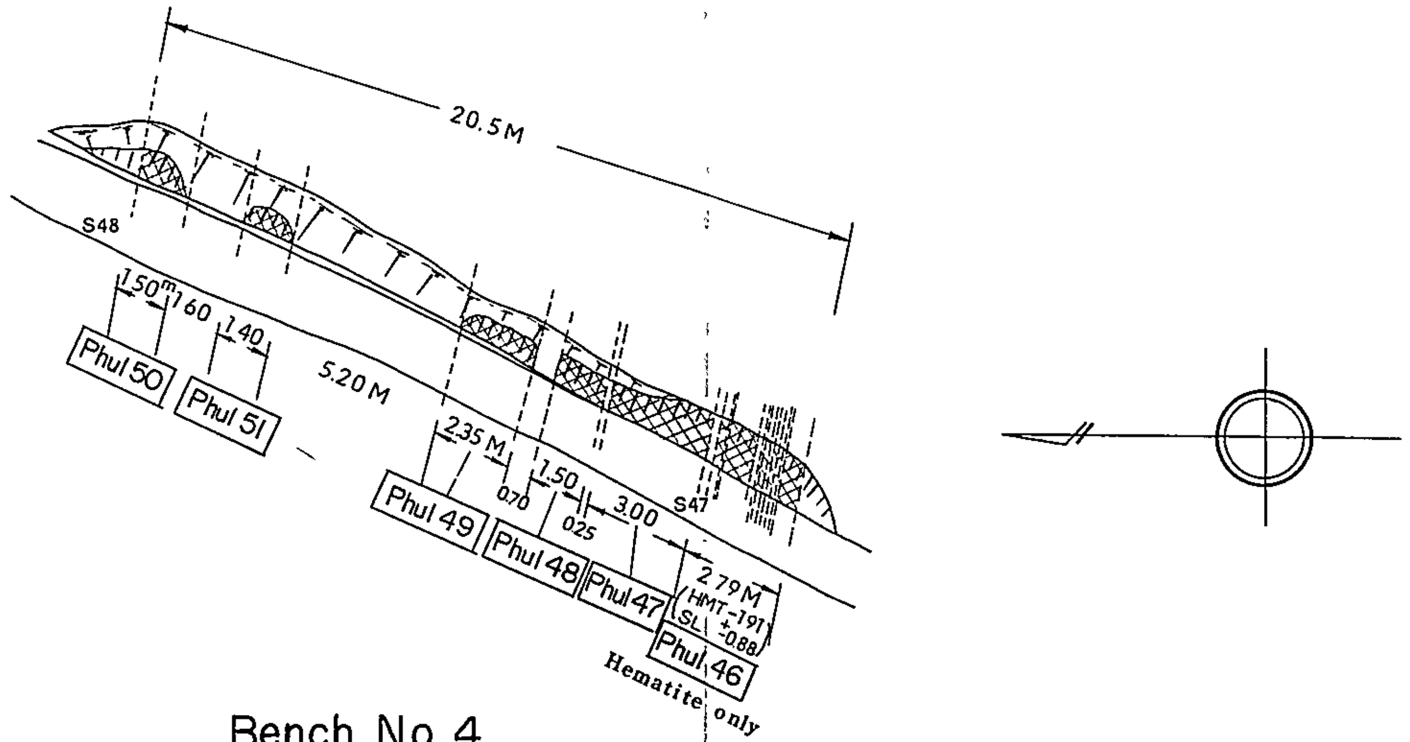
PLATE 15


NEPAL
14 ZONES and 75 DISTRICTS
Fe 鉄
Cu 銅
Zn 亜鉛
Ni Co ニッケル コバルト
Be 緑柱石
G 石墨
Qt 石英
Tc 滑石
M 雲母
Sa 岩塩
Oil 石油
CHINA
INDIA
MAHAKALI
SETI
KARNALI
BHERI
RAPATI
DHAULAGIRI
GANDAKI
LUMBINI
BAGMATI
NARAYANI
JANAKPUR
SAGARMATHA
KOSI
MECHI
REFERENCE
SYMBOL
International Boundary
Zonal Boundary
District Boundary
Zonal Head-Quaters
District Head Quaters
Railway line & Station
River, Lake
Mt. Everest

PHULCHOKI MINE
BENCH MAP I.



Bench No. 1



Bench No. 4

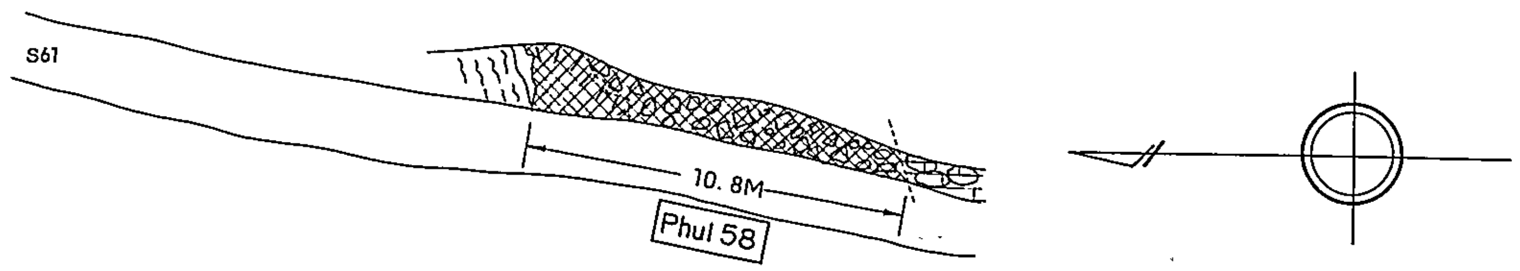
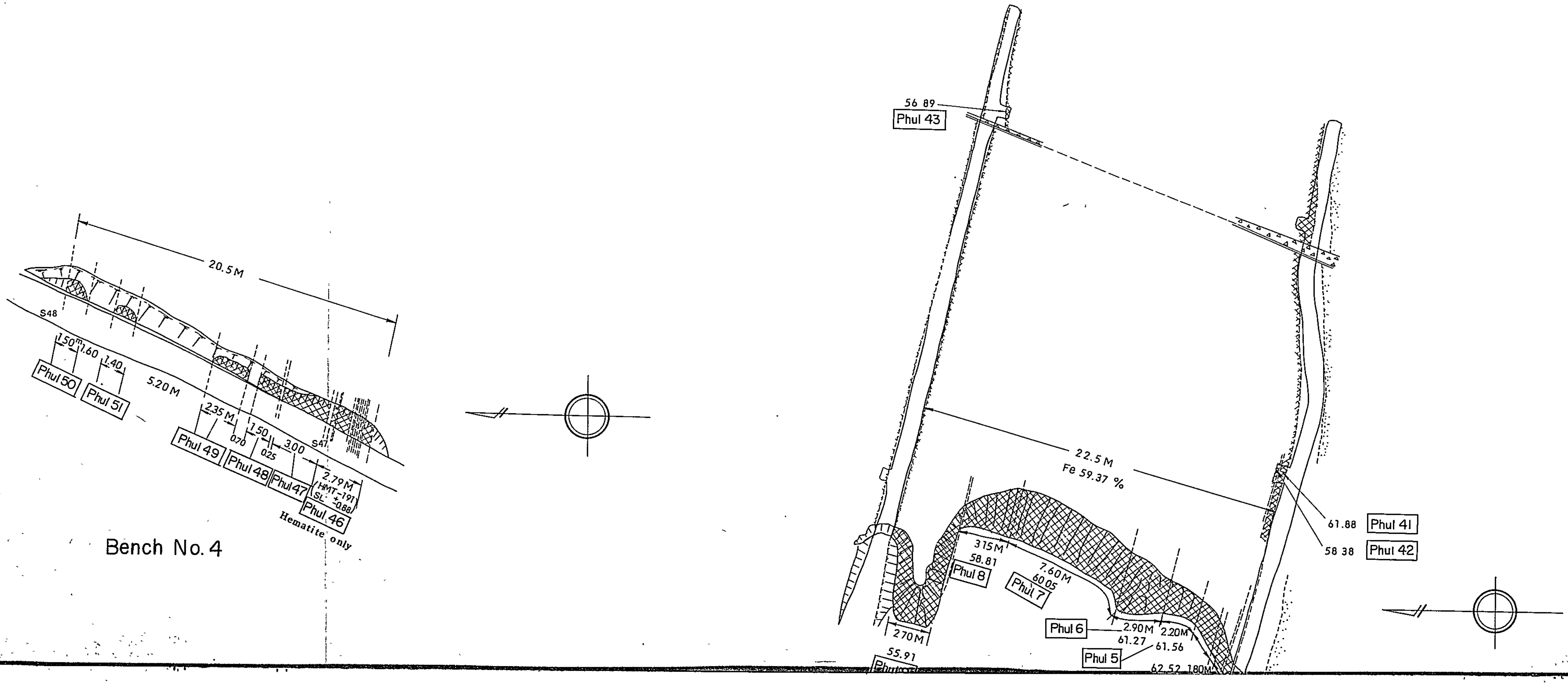


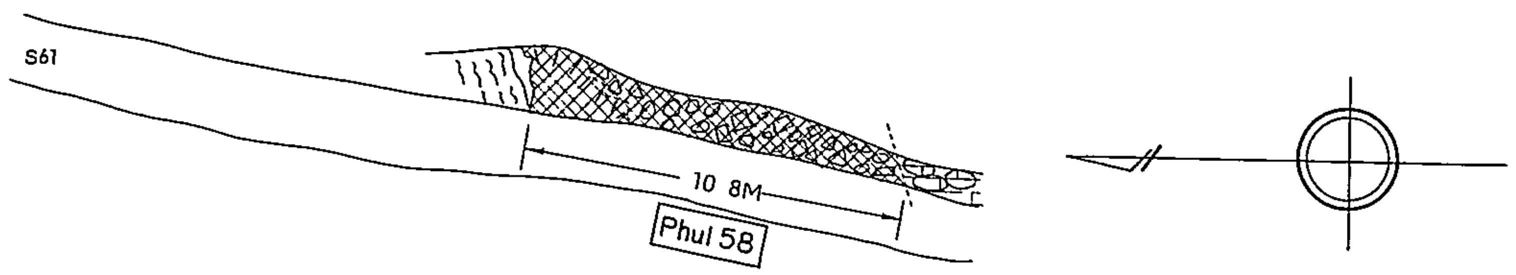
PLATE 2-1

PHULCHOKI MINE

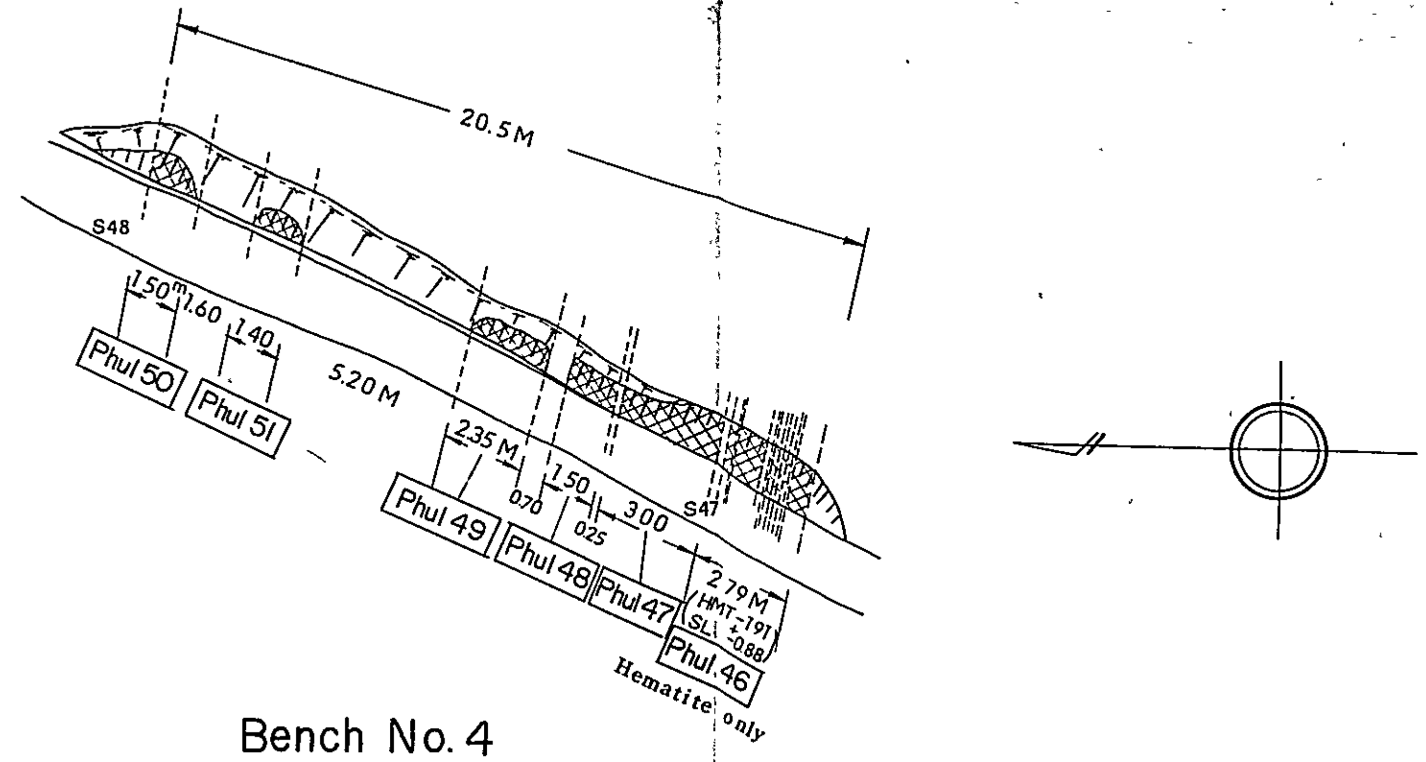
BENCH MAP 1.



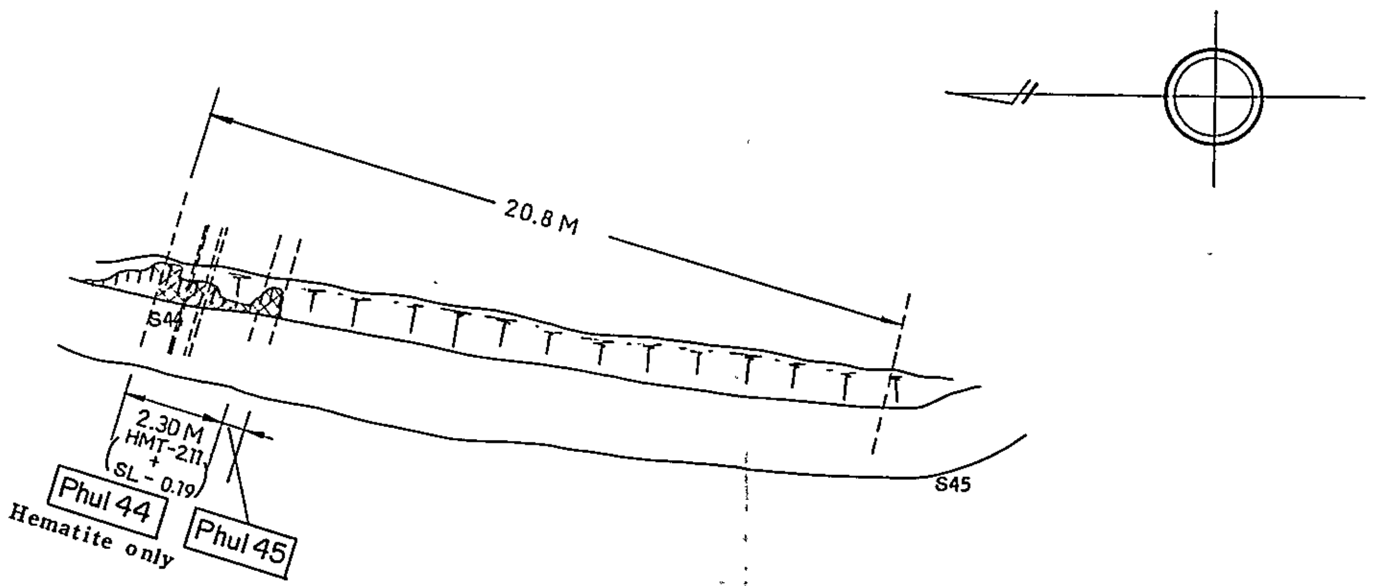
Bench No. 1

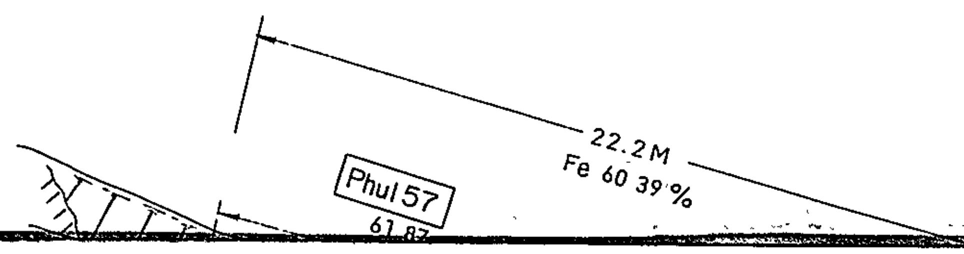


Bench No. 2

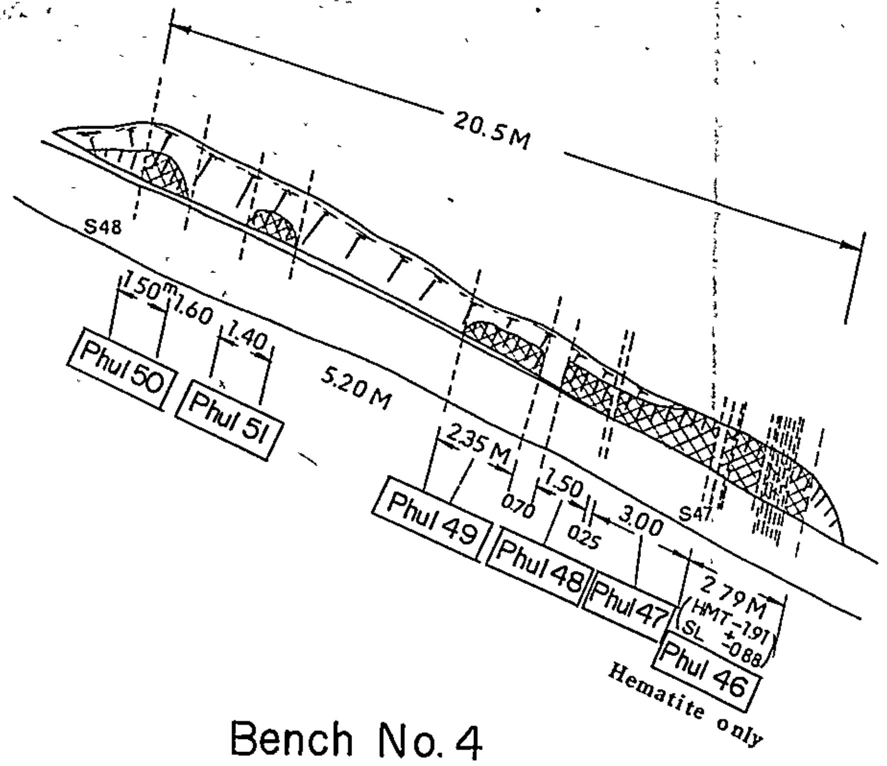


Bench No. 4

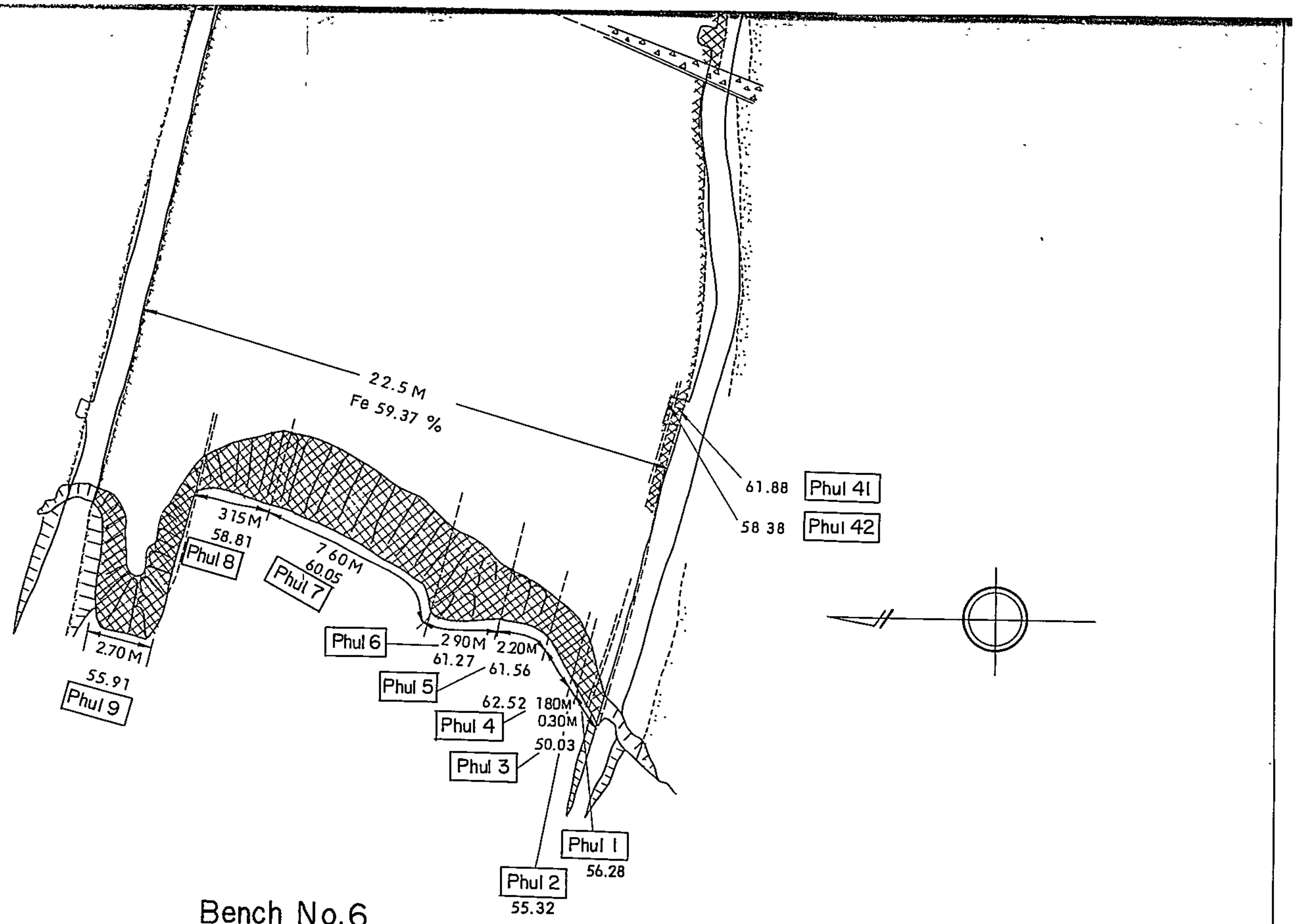




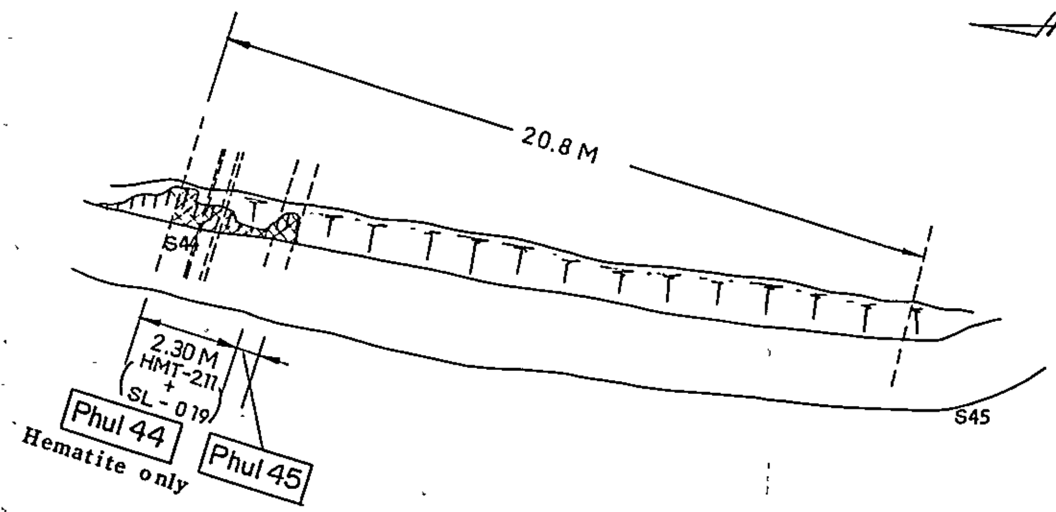
Bench No. 5



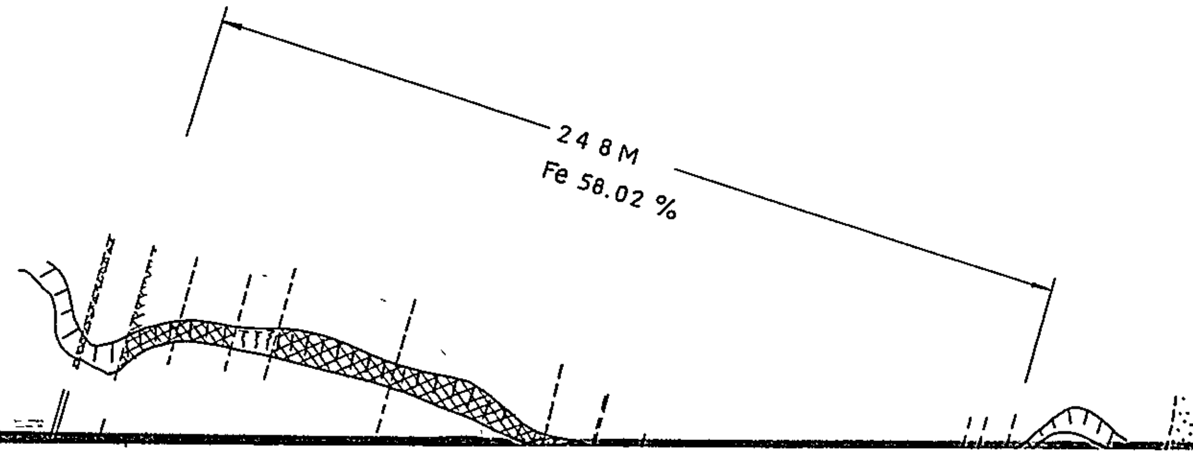
Bench No. 4



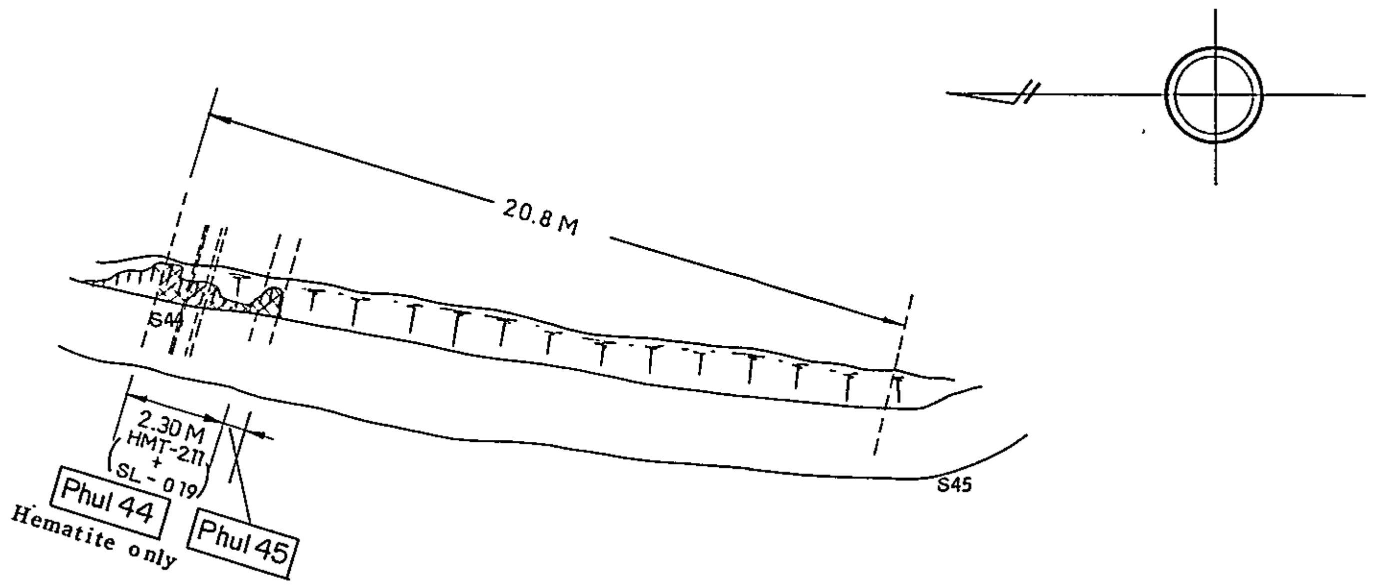
Bench No.6



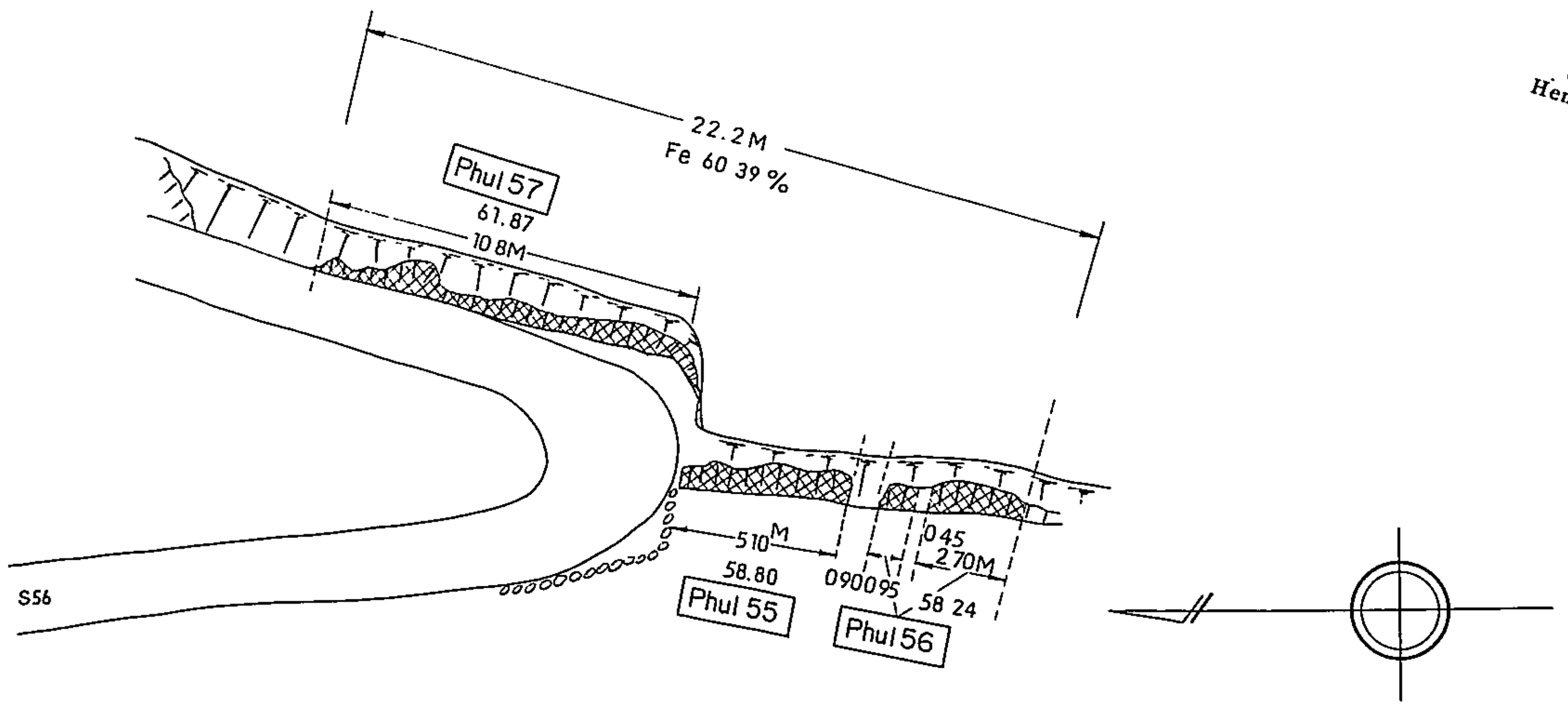
Bench No. 5



Bench No. 2

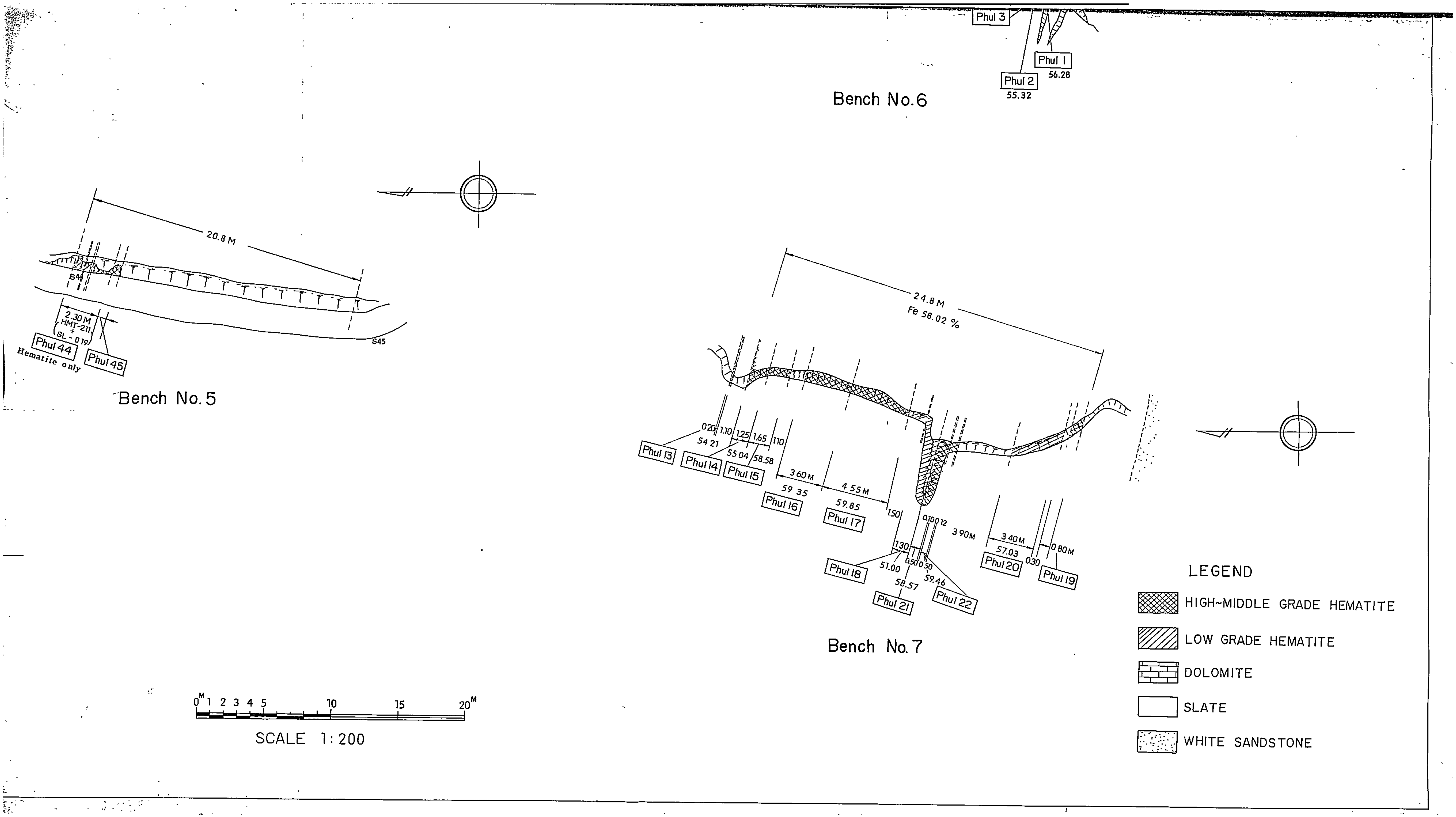


Bench No. 5



Bench No. 3

SCALE 1:200


Bench No.6
Phul 3
Phul 1
56.28
Phul 2
55.32
Bench No.5
20.8 M
2.30 M
HMT-2.11
+
SL - 0.19
Phul 44
Phul 45
Hematite only
S44
S45
Bench No.7
24.8 M
Fe 58.02 %
0.20
1.10
1.25
1.65
1.10
54.21
55.04
58.58
Phul 13
Phul 14
Phul 15
3.60 M
59.35
Phul 16
4.55 M
59.85
Phul 17
1.50
1.30
51.00
Phul 18
0.10
0.12
0.50
0.50
58.57
Phul 21
59.46
Phul 22
3.90 M
3.40 M
57.03
Phul 20
0.30
0.80 M
Phul 19
LEGEND
HIGH~MIDDLE GRADE HEMATITE
LOW GRADE HEMATITE
DOLOMITE
SLATE
WHITE SANDSTONE
0 M 1 2 3 4 5 10 15 20 M
SCALE 1:200

PHULCHOKI MINE

BENCH MAP 2.

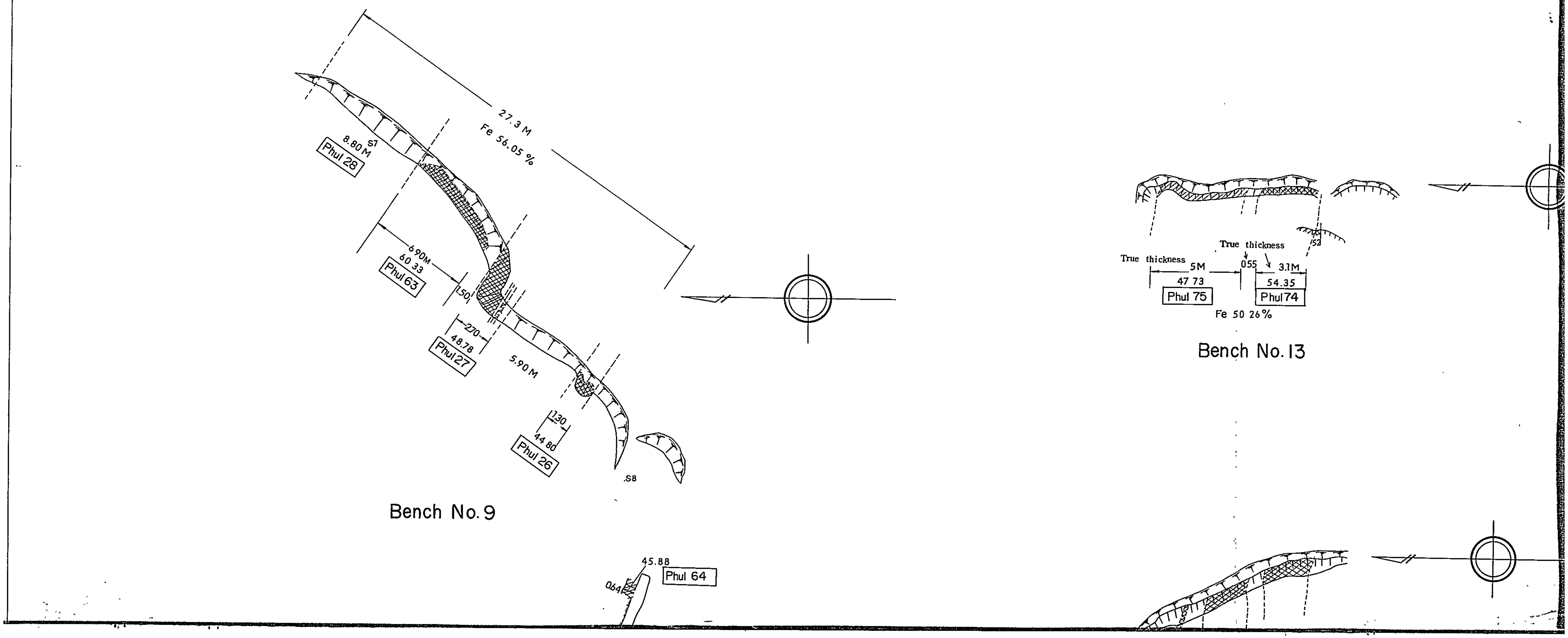
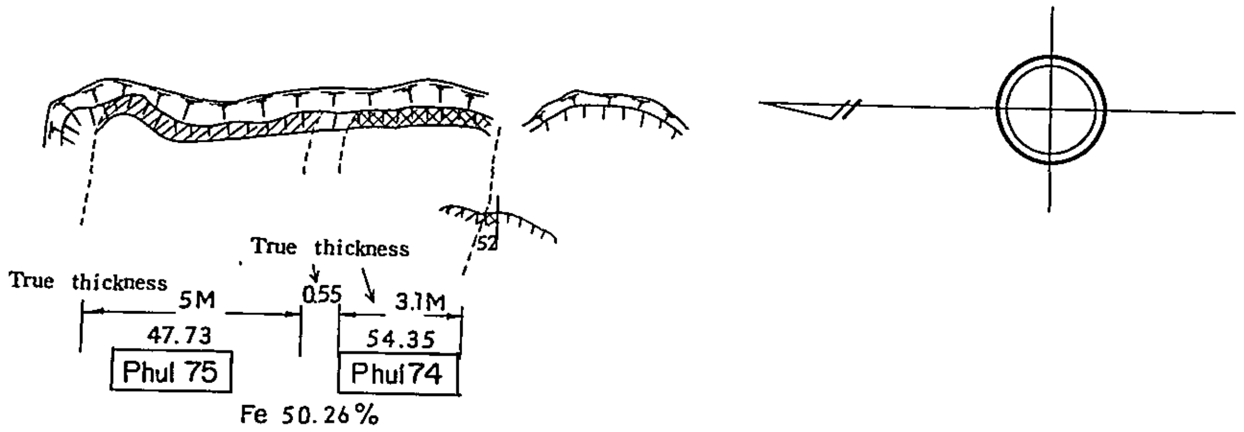


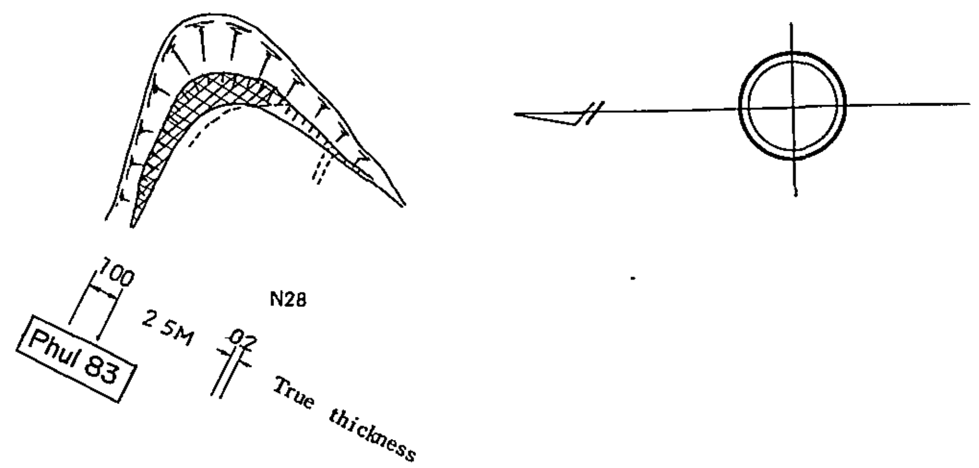
PLATE 2-2

PHULCHOKI MINE

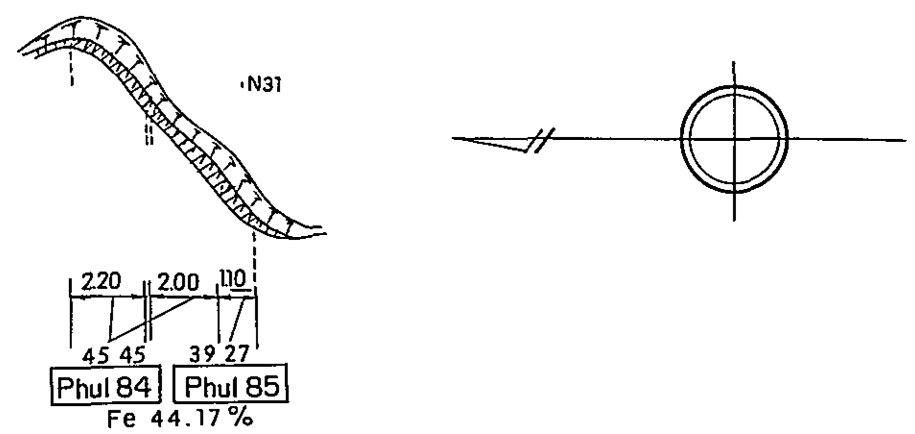
BENCH MAP 2.



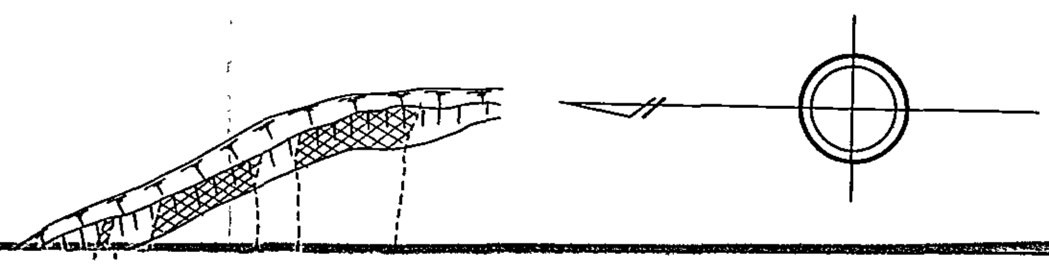
Bench No. 13

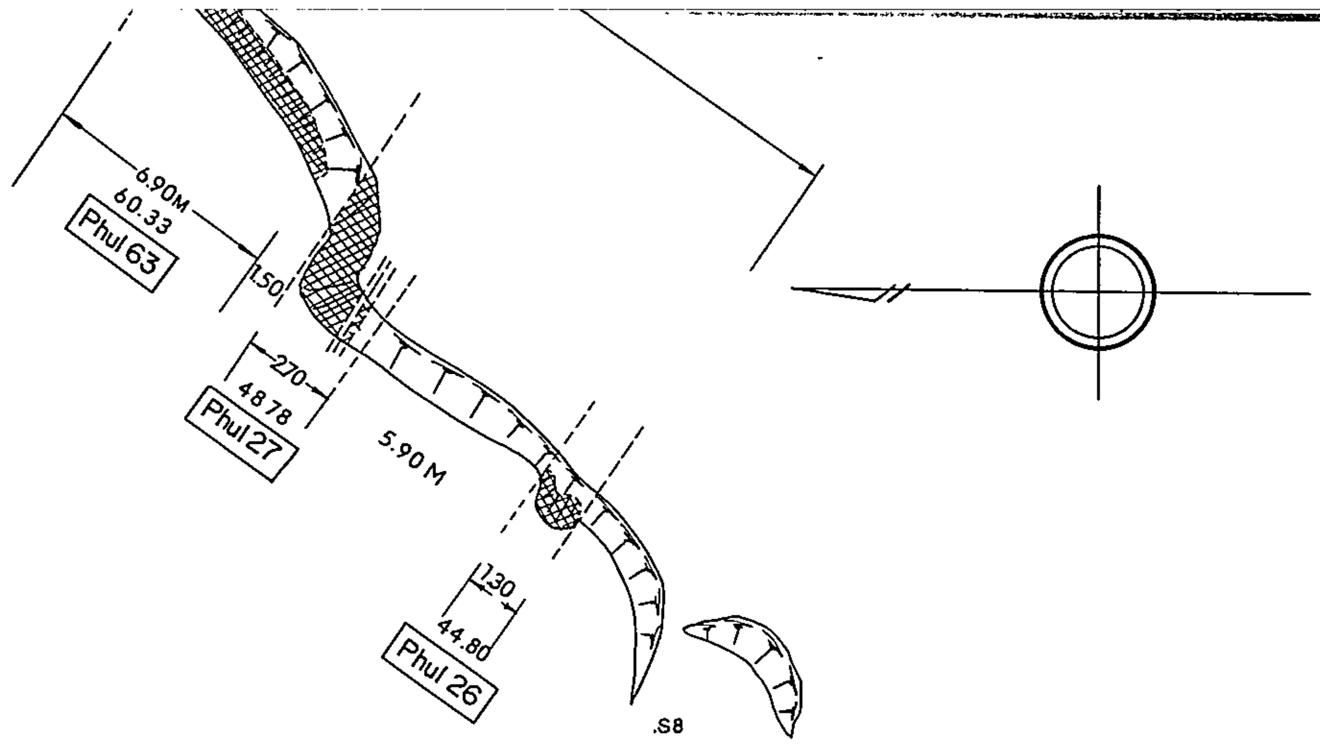


Bench No. 16

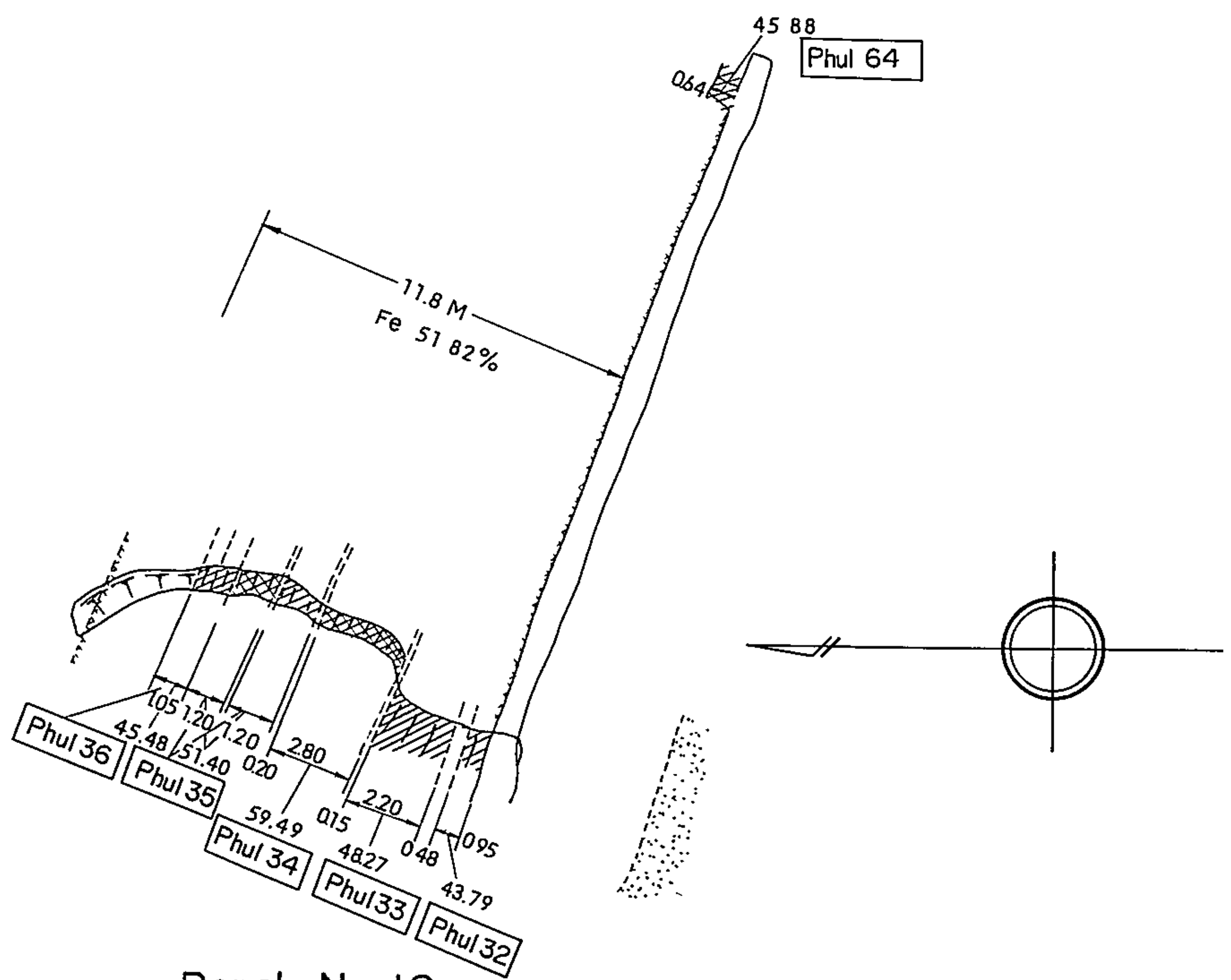


Bench No. 17





Bench No. 9



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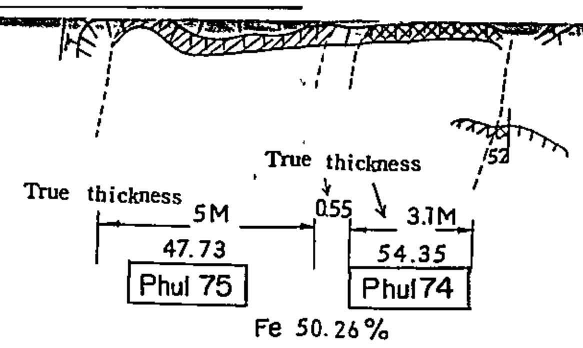

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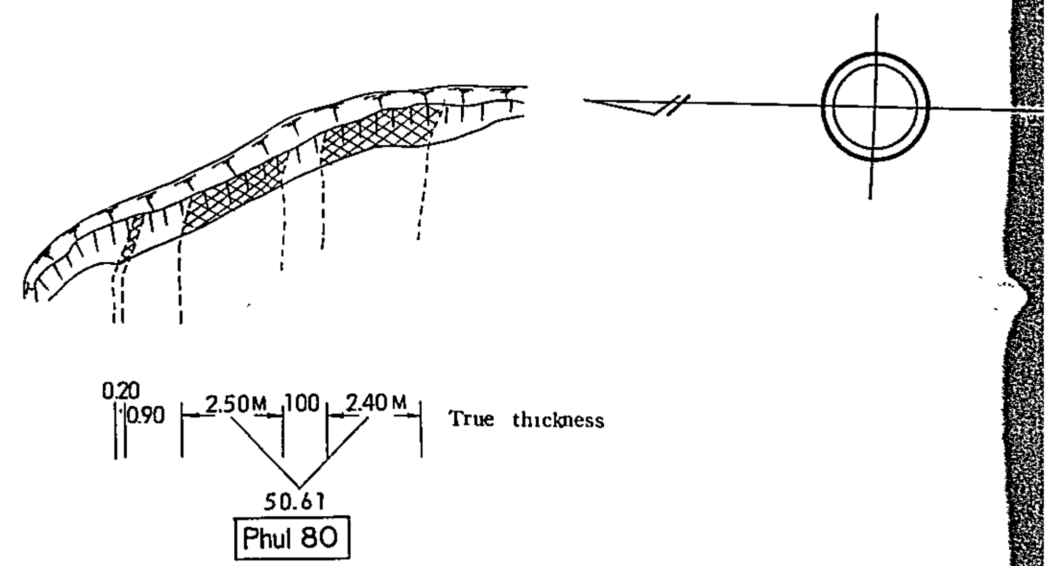

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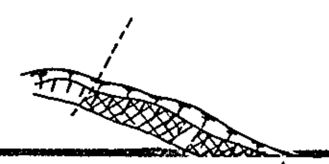

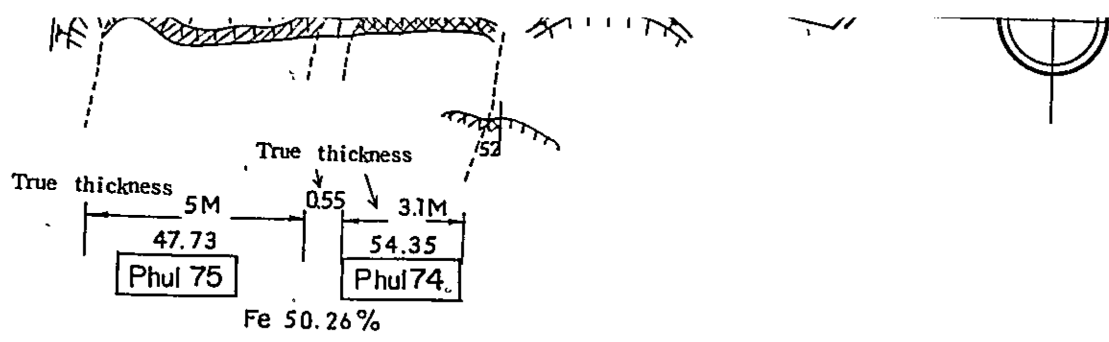

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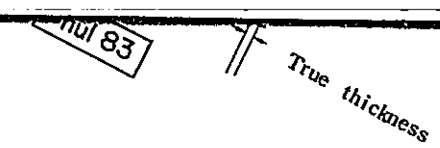

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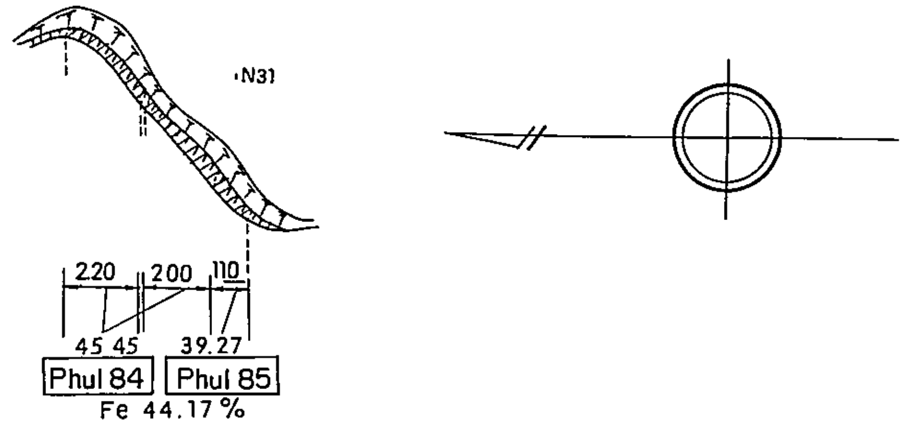

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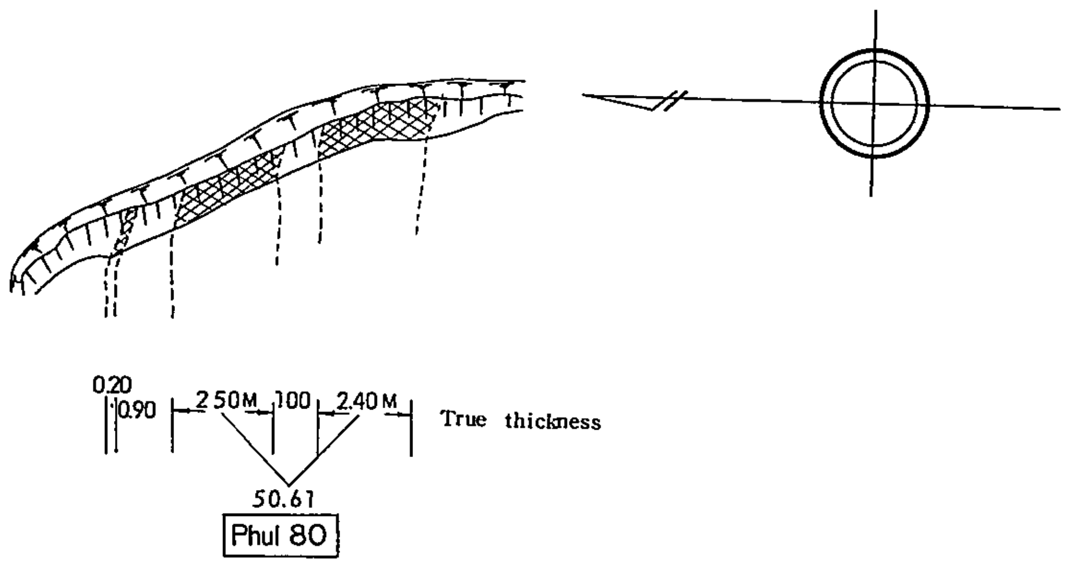

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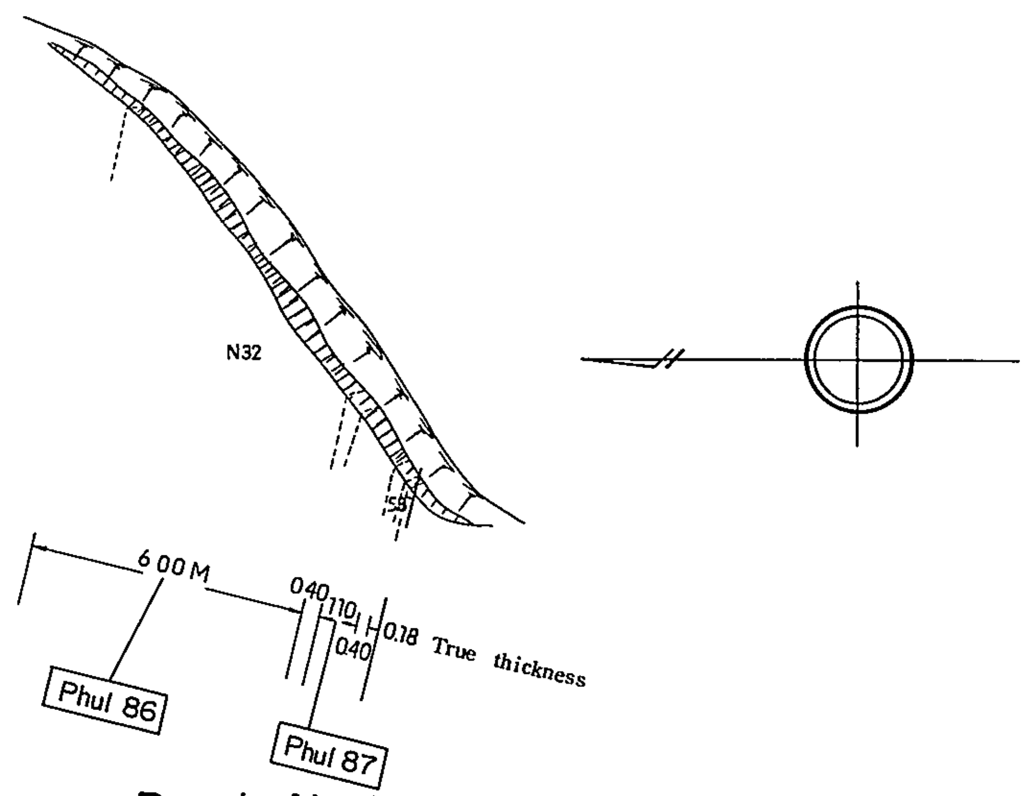
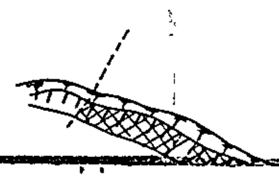
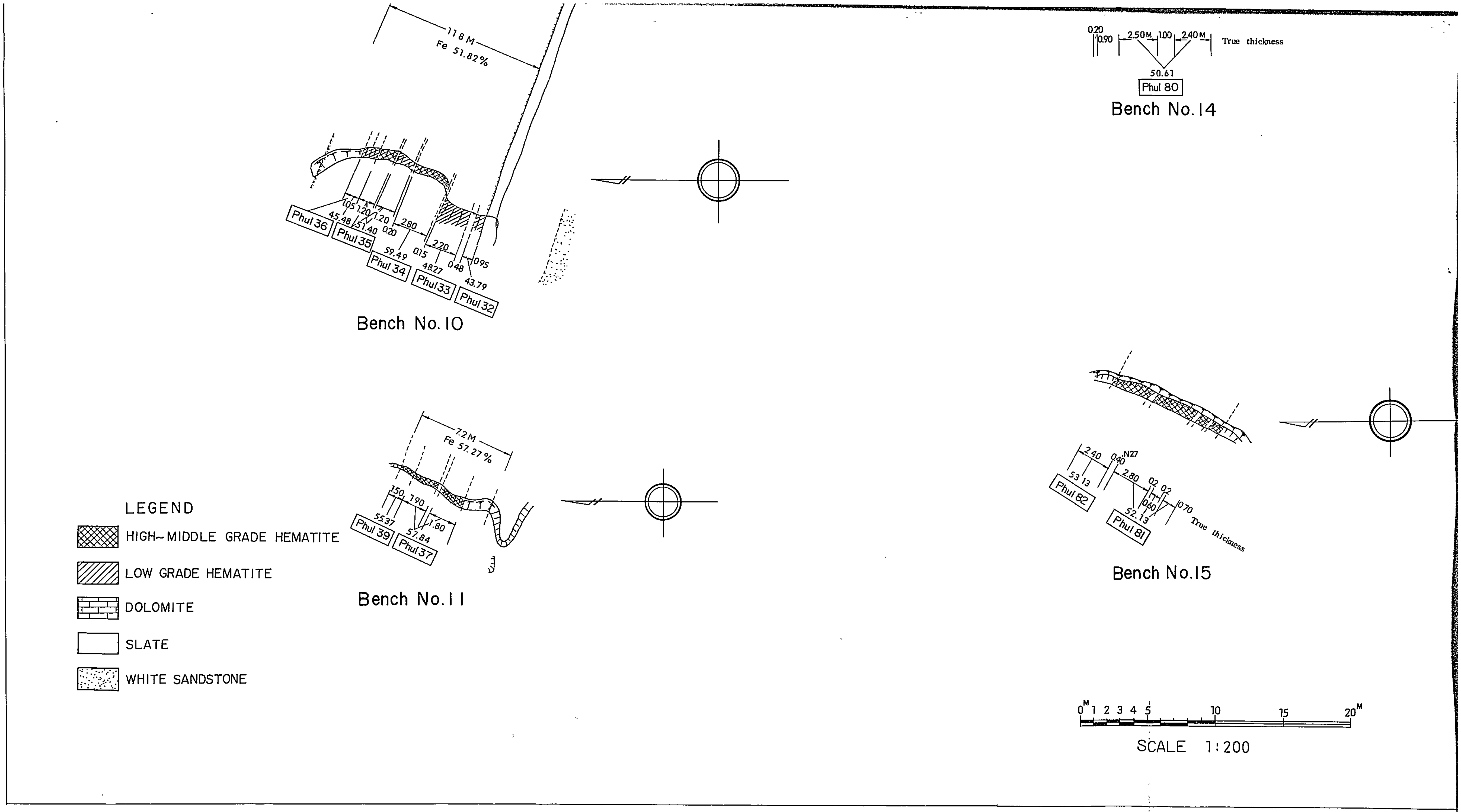
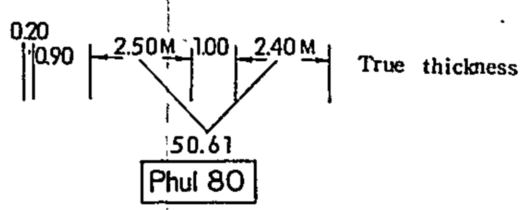


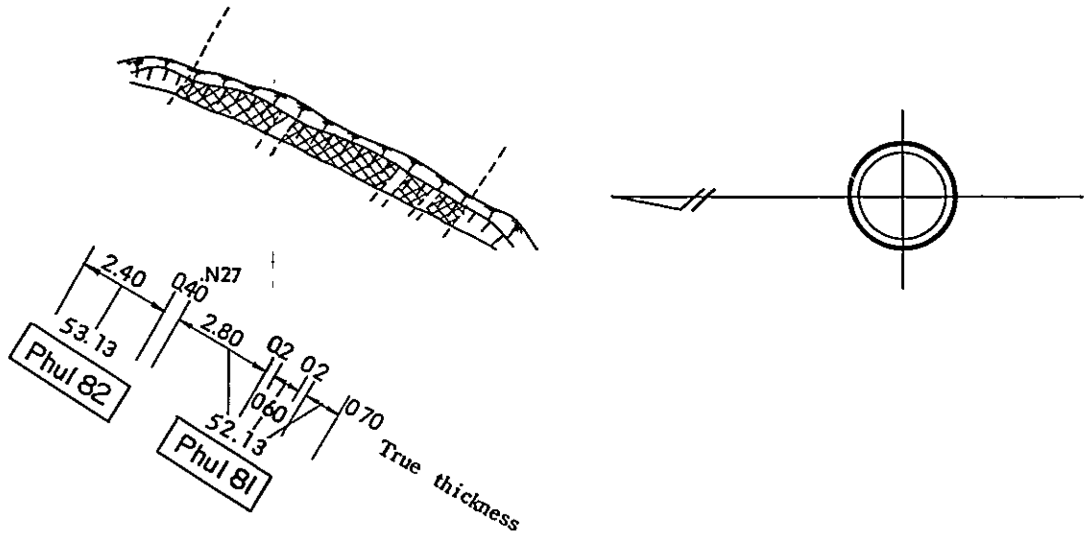
Bench No. 18



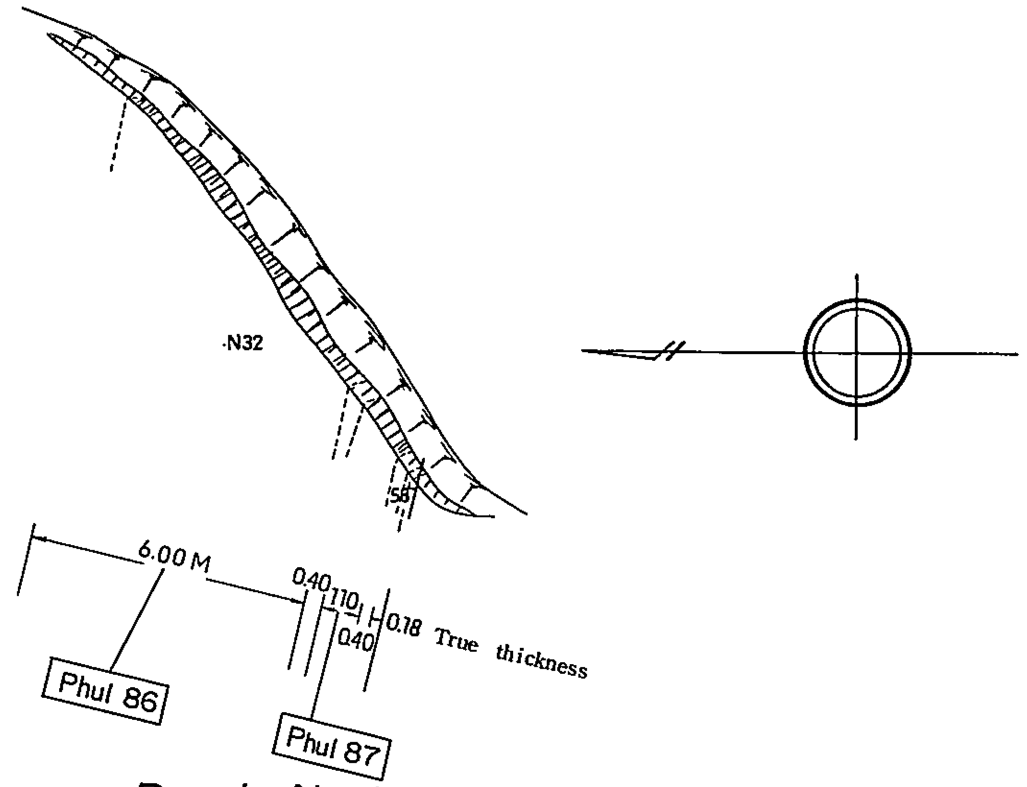

11.8 M
Fe 51.82%
1.05
1.20
1.20
0.20
2.80
2.20
0.15
0.48
0.95
45.48
51.40
59.49
48.27
43.79
Phul 36
Phul 35
Phul 34
Phul 33
Phul 32
Bench No. 10
0.20
0.90
2.50M
1.00
2.40M
True thickness
50.61
Phul 80
Bench No. 14
7.2M
Fe 57.27%
1.50
1.90
1.80
55.37
57.84
Phul 39
Phul 37
Bench No. 11
2.40
0.40
N27
2.80
0.2
0.2
0.60
0.70
53.13
52.13
Phul 82
Phul 81
True thickness
Bench No. 15
LEGEND
HIGH~MIDDLE GRADE HEMATITE
LOW GRADE HEMATITE
DOLOMITE
SLATE
WHITE SANDSTONE
0M 1 2 3 4 5 10 15 20M
SCALE 1:200



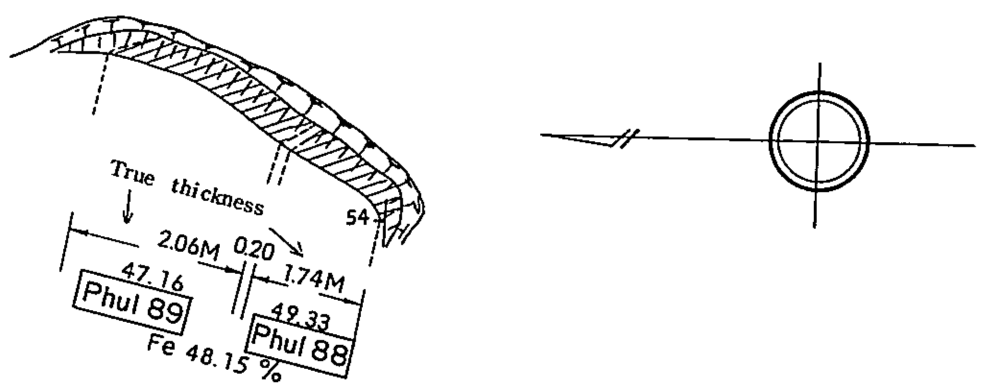
Bench No.14



Bench No.15



Bench No.18



Bench No.19

SCALE 1:200