REPUBLIC OF PERU

REPORT ON MINERAL EXPLORATION

OF

ISCAYCRUZ (OYON) AREA

PHASE Ⅲ

SEPTEMBER 1985

JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN

PREFACE

The Government of Japan, in response to the request of the Government of the Republic of Peru, decided to conduct the mineral exploration composed of drilling and tunnelling surveys in the Iscaycruz (Oyon) Area in cooperation with Instituto Geologico, Minero, y Metalurgico (INGEMMET), and entrusted its execution to Japan International Cooperation Agency (JICA) and Metal Mining Agency of Japan (MMAJ).

Metal Mining Agency of Japan dispatched a survey team headed by Mr. Jinichi Nakamura to conduct the Phase III of the project. The survey had been started on 7 May, 1984 following the Phase II survey and accomplished on 1 June, 1985 under close cooperation with the Government of the Republic of Peru and its various authorities.

This report is a compilation of the survey of the Phase III and after the completion of the project the consolidated report will be submitted to the Government of the Republic of Peru.

We wish to express our appreciation to all of the organizations and members who bore the responsibility for the project, the Government of the Republic of Peru, Instituto Geologico, Minero y Metalurgico, and other authorities and the Embassy of Japan in Peru.

August, 1985

Keisuke Arita
President
Japan International Cooperation Agency

Masayuki Nishiie
President
Metal Mining Agency of Japan

On the Revision of Tunnelling Survey Map
in the Report of Mineral Exploration in the Iscaycruz Area
Republic of Peru Phase I and Phase II.

In the Tunnelling Survey Map of Adit-N attached to the previous reports, an error was detected in its direction as a result of the check survey carried out in Phase III. Consequently, the plan of the Adit-N has been corrected in the Phase III and Consolidated Reports.

Please use, hereafter, the attached Maps of Phase III and Consolidated Reports.

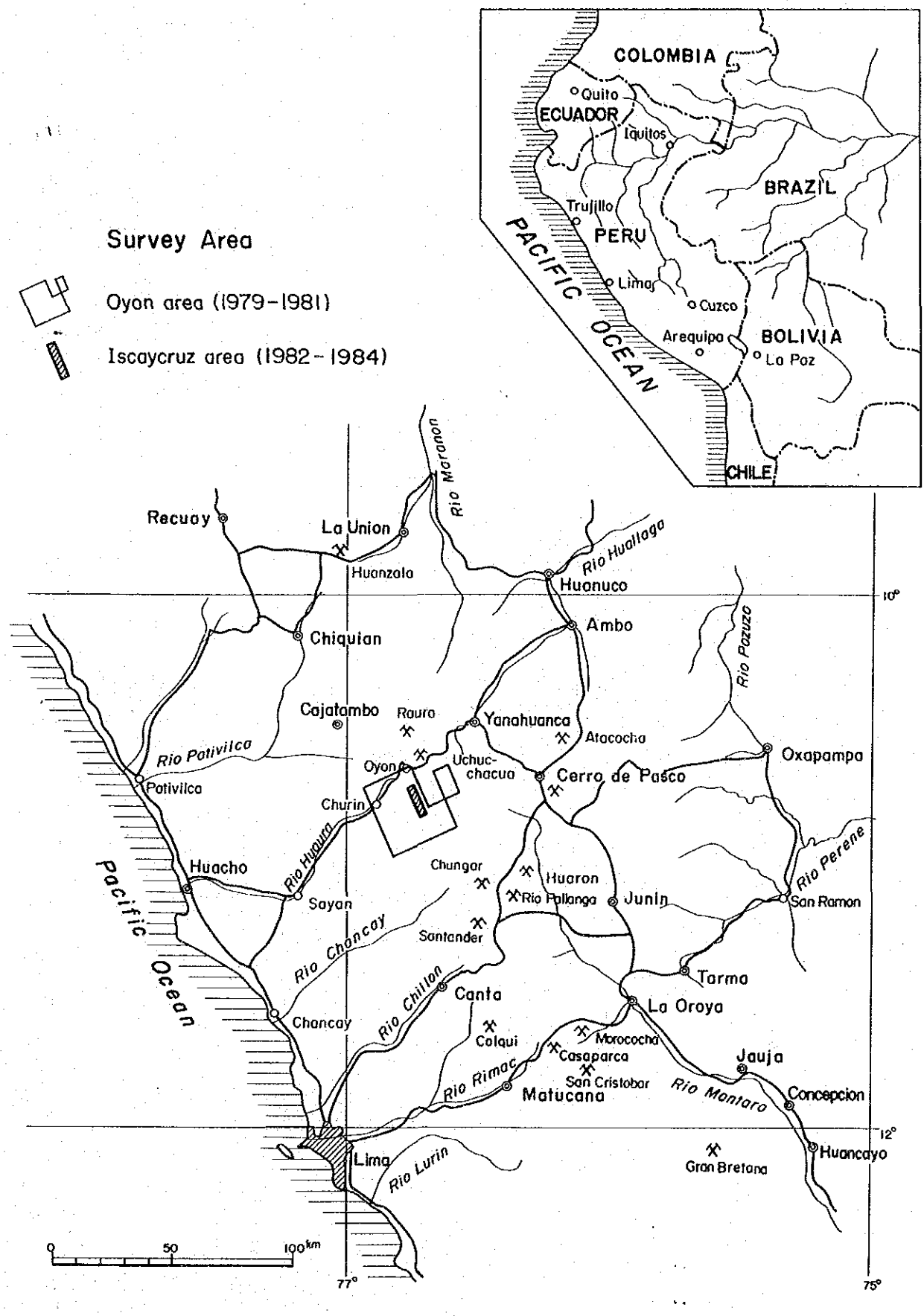

Fig. 1 Index Map

ABSTRACT

This report summarizes results of the third year's work of the Mineral Exploration by means of drilling and tunnelling explorations carried out in the Iscaycruz Area (40 km^2), the Republic of Peru.

The purpose of this project is to examine relationship between geological structure and mineralization, and to confirm lateral and vertical continuity of the mineralized zone, by means of drilling exploration and tunnelling exploration in this area.

The Iscaycurz Area had been extracted as a favorable area where economic ore deposits would be expected to be emplaced, by the results of the Mineral Exploration in the Oyon Area (860 km^2), which was carried out during the period of three years from 1979 to 1981.

The Iscaycruz Area is located about 150 km north of Lima, in the backbone range of the Western Andes. Geologically, Mesozoic sedimentary rocks are widely distributed in this area, forming remarkable composit folded structure due to tight folding with the axes in the Andean direction, namely NNW-SSE.

The Iscaycruz mineralized zone is located approximately 7 km south-southeast of Oyon, in the high mountain at the altitude of 4,700 m above sea level. The mineralization occurs in the limestones of the Santa Formation, about 50 to 100 m in thickness, and continues about 12 km along the strike. In this mineralized zone, ore deposits are divided roughly into two categories; the one is contact metasomatic skarn type ore deposits represented by copper-zinc skarn orebodies and the other is hydrothermal replacement ore deposits represented by copper-lead-zinc massive sulphide orebodies as well as by disseminated orebodies of lead and zinc in the siderite beds.

The investigations in the present year, following the works in the last year, the tunnelling exploration (crosscut of Adit-N, main tunnel of Adit-S and two crosscuts of Adit-S) total length of which is 748 m, and the drilling (6 drill holes in the underground, 1 drill hole on the surface, total length 1,340 m) were carried out in the Limpe area, in addition to the drilling carried out in the Limpe-South area (3 drill holes on the surface, total length 560 m).

By the results of the drilling, high grade zinc orebodies associated silver, copper and lead minerals (the grade of Cu + Pb + Zn is up to 20%) was confirmed in the 4 holes; 3 holes in the Limpe area and 1 hole in the Limpe-South area. Considering the results of the drilling in this year with the data obtained in the past, the scale of the orebody in the Limpe area is estimated to be about 300 m in horizontal extension, more than 150 m in vertical extension and 10 to 30 m in

thickness. Also, it has been confirmed that there is a fair potentiality of the emplacement of high grade copper-zinc ore deposit in the Limpe-South area.

By the results of the tunnelling exploration, two portions of high grade lead-zinc mineralization have been confirmed in the crosscut of Adit-S. The sizes and the ore grade of these mineralized portions are presumed to be better than those estimated from the data obtained by the drilling.

The exploration works in the Limpe area during the period of these three years have brought about the full comprehension of the existence of fairly large scale of high grade lead-zinc ore deposits in this area and it is thought that the purpose of the investigation has been completed in the subject area.

As to the investigation of the next stage, it is recommended to carry out the survey for the planning of the developmentl including every item in necessary fields for the investment to the development of mineral resources.

GENERAL REMARKS

GENERAL REMARKS

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CHAPER 1 INTRODUCTION

1–1 Purpose of the Survey

The purpose of this survey is, in addition to the comprehension of the geological structure in relaton to the mineralization in the Iscaycruz Area, to confirm lateral and vertical continuity of the mineralized zone, by means of drilling and tunnelling explorations and the analysis of the related geology.

The survey works have been completed with the cooperation of the Instituto Geologico, Minero y Metalurgico (INGEMMET).

1–2 Scope of the Survey

The Mineral Exploration was carried out for three years from 1979 to 1981 in the Oyon Area (860 km^2). By the results of the investigations, it was confirmed that the high grade copper-lead-zinc sulphide ore deposits and skarn ore deposits were emplaced in the Iscaycruz Area (40 km^2) and also it was proved that high potentiality of the mineralization would be expected in this area for the development of mineral resources.

The Limpe area and Limpe-South area, where high grade lead-zinc ore deposits were expected, were selected for the next continuous Mineral Exploration in the Iscaycruz Area, and more detailed investigations by drilling and tunnelling explorations were carried out scheduled in three years program for 1982 to 1984. This year survey (1984) is the third year final plan.

1–3 Outline of the Survey

1) Drilling Exploration

Surface drilling of 4 holes and underground drilling of 6 holes in the Limpe area, totalling 10 holes, 1,900 m was carried out in this year.

	Phase I	Phase II	Phase III	Total
Limpe area; Surface	1300(5)	–	180(1)	1480(6)
Adit–N		440(2)	680(3)	1120(5)
Adit–S		470(2)	480(3)	950(5)
Limpe–S, Surface			560(3)	560(3)
Total	1300(5)	910(4)	1900(10)	4110(19)

(unit:m)

2) **Tunnelling Exploration**

The purpose of the tunnelling exploration is to confirm, along the tunnel wall passing through the orebodies, various factors as figures of orebodies, features and continuity of grade distribution and aspect of combinations of ore minerals, as well as to utilize the tunnel as the base for the underground drilling crosscutting the orebodies, which is the most effective for the confirmation of lateral and vertical continuity of the orebodies and the mineralized zone (refer to Fig. 5).

Main tunnels were excavated in the Chimu Formation and crosscut tunnels into the mineralized zones in the Santa Formation.

As the time for the investigation was limited, two starting points were established for the excavation of the tunnels with the approximate distance of 1,400 m, so that the two faces, that are Adit–N and Adit–S, could be worked at the same time. Excavation length in this year was 175 m in Adit–N and 573 m in Adit–S, totalling 748 m.

	Phase I	Phase II	Phase III	Total
Adit–N; Main Tunnel	310	200	–	510
Crosscut–1	–	150	–	150
Crosscut–2	–	–	175	175
Adit–S; Main Tunnel	270	330	346	946
Crosscut–1	–	–	141	141
Crosscut–2	–	–	86	86
Total	580	680	748	2,008

(unit: m)

1–4 Organization of the Survey Team

Japan Side Planning, Negotiation, and Supervision

Toru Miura	MMAJ*
Masao Tsuge	MMAJ
Makoto Ishida	MMAJ
Sumihiro Fure	MMAJ
Takashi Kamiki	MMAJ

Peru side Planning and Negotiation

Francisco Sotillo	INGEMMET**
Gregorio Flores	INGEMMET
Augusto Zelaya	INGEMMET

Japanese Survey Team

Jinichi Nakamura (Team Leader)	MINDECO***
Nobuhiko Yamamoto (Drilling)	MINDECO
Hisashi Shimizu	MINDECO
Tsutomu Aoyama	MINDECO
Tetsuo Yoshida	MINDECO
Kunihiko Tsukanaka (Tunnelling)	MINDECO
Seiichi Furuyado	MINDECO

Peruvian Survey Team

Gregorio Flores (Team Leader)	INGEMMET
Hector Zarate	INGEMMET
Emilio Rojas	INGEMMET
Luis Santalla	INGEMMET

* Metal Mining Agency of Japan

** Instituto Geologico, Minero y Metalurgico

*** Mitsui Mineral Development Engineering Co., Ltd.

CHAPTER 2 OUTLINE OF THE SURVEYED AREA

2–1 The Surveyed Area

The Iscaycruz Area is, on the administrative division, belonging to Provincia Cajatambo of Departamento Lima, and is located about 150 km north of Lima, the capital (see Fig. 1).

To reach the Area from Lima, it is necessary to come to Sayan through Chancay (137 km, about 3 hours by vehicle). From Sayan, running along a rough and bending road along the valley of the Rio Huaura, one can come to Oyon through Churin (93 km, about 3 hours). After passing through Pampahuay, an access road is available to pass over the range at the approximate altitude of 5,000 meters above sea level, to come to the Iscaycruz Area (approximately 30 km, about 2 hours, (see Fig. 2).

The surveyed area lies in the Cordillera Occidental, a main range of the Western Andes, and is situated in the source area of Rio Huaura which belongs to the drainage system of the Pacific coast, about 11 km west to the continental divide. The area forms steep mountaneous topographical feature. The elevation of the surveyed area is 4,600 ~ 4,700 meters above sea level.

The climate in this area belongs to what is called Andean highland climate. Daily variation of temperature is in fairly great range, and sometimes the temperature reaches over 20°C in daytime, while it goes down to less than 0°C in night time. To take annual variation of the climate, there are two seasons. The dry season is in the period from May to September, while the wet season is in the period from October to April. In the wet season, snowfall can be seen almost every day in the highland area at the altitude of more than 4,000 meters above sea level.

2–2 Outline of Geology

1) Regional Geological Setting

The Iscaycruz Area and the peripheral area belong stratigraphically to the zone of Cretaceous sedimentary basin (la Zona de la Cuenca Cretacea) by Cobbing (1973), and is structually situated in the folding-thrusting zone (la Zona de Pliegues y Sobreescurrimientos) by Wilson (1967).

Thick Cretaceous sedimentary rocks are widely distributed in this area. The lower part is composed mainly of clastic rocks such as siliceous sandstone and shale, and the upper part calcareous rocks associated with dolostone and shale, and the uppermost part red formation.

The clastic rocks of the lower part is divided into the Oyon, Chimu, Santa, Carhuaz and Farrat Formations, and the calcareous rocks of the upper part into the Pariahuanca, Chulec,

Pariatambo, Jumasha, Celendin and the uppermost red Casapalca Formations in ascending order. These formations are unconformably covered by the Calipuy volcanics in Tertiary and are intruded by tonalites, dacites, granite porphyry and others.

The Cretaceous sedimentary rocks suffered intensely a structural movement in consequency of the Andean Orogeny to form composite folds with NNW–SSE trend. Anticlines and synclines appear at intervals of 2 to 3 km, sometimes several tens meters, so that the same stratum is repeatedly exposed at the surface. At the central part in the orogenic zone thrust faults parallel to the fold axis are developed.

On the east of this area the Eastern Andes consisting mainly of Paleozoic sedimentary rocks and Pre-Cambrian metamorphosed rocks runs, while on the west Tertiary volcanic rocks are continuously distributed and the Andean batholith intrudes into this volcanic rocks (see Fig. 3).

2) Outline of Geology in the Iscaycruz Area

The Iscaycruz Area is about 6 km to 18 km south-south-east of Oyon. Canaypata is at the north end of the area and Antapampa is at the south end (see Fig. 2).

In the east of this area, an anticline is recognized with the axis running in NNW–SSE direction. The Oyon Formation, the lowest Cretaceous, composed mainly of sandstone and shale with coal measures and the overlying Chimu Formation, 600 to 700 meters thick, composed of quartzite or quartzose sandstone are distributed along the axis of the anticline. They look dark grey to dark brown in color and form irregular rough mountain land. In the west of this area, a syncline is recognized with the axis in NNW–SSE direction, along which is distributed the upper Cretaceous Jumasha Formation composed of massive limestone of the thickness of almost 1,400 meters. The limestone forms steep mountain land, brightly shining in grey color. Between the two mountain lands, topographically lower part has been formed in the area occupied by the Carhuaz Formation composed of the alternation of shale and sandstone, 500 to 700 meters thick.

In a narrow zone between the Chimu Formation and the Carhuaz Formation, the Santa Formation is distributed. The Santa Formation is as thick as 50 to 100 meters, composed of well-stratified bluish grey limestones. This formation constitutes the country rock of the mineralization in the Iscaycruz Area. Between the Carhuaz Formation and the Jumasha Formation, there are four other formations which are distributed zonally. They are Farrat Formation, about 100 meters in thickness, composed of quartzose sandstone and calcareous sandstone; Pariahuanca Formation, about 100 meters in thickness, composed of dark grey massive limestone; Chulec Formation, about 200 meters in thickness, composed mainly of light grey marlstone; and Pariatambo Formation, about 200 meters in thickness, composed of the alternation of thin layers of shale

and dark grey to dark-colored limestone.

The Santa Formation is situated on the wing of the fold structure. The dipping of the strata of this formation is almost vertical, as they constitute parts of the remarkable tight-folds. Overturned structures are observed to be developed in the Limpe area and Limpe-South area in the central part of this area.

As for igneous rocks, dacitic porphyry is recognized near the axis of the syncline in the west of Cumbre de Iscaycruz (Iscaycruz pass) and also acidic dyke complex is found to have been active around the anticline axis near Cumbre de Cunsha Punta, in the middle to southern part of this area (see Fig. 4).

2–3 Outline of Ore Deposits

1) Outline

According to Bellido et al (1972), the Iscaycruz Area is located geologically in the Sub-Provincia Polimetalica del Altiplano in the Provincia Metalogenica Andina Occidental. In the vicinity of the survey area, there are many silver-lead-zinc mines in operation, such as Raura mine (Pb · Zn), Uchucchacua mine (Ag), Atacocha mine (Pb · Zn · Ag), Cerro de Pasco mine (Pb · Zn · Ag), Huaron mine (Pb · Zn · Ag), and Santander mine (Cu · Zn).

2) Iscaycruz Mineralized Zone

The Iscaycruz mineralized zone is found in the limestone of the Santa Formation, and is distributed intermittently along the limestone in a distance of about 12 km from Canaypata, the northern end, to Antapama, the southern end. The indications of mineralization are found as dark-colored gossans bearing lead and zinc, massive pyrite orebodies associated with galena and sphalerite, skarn masses containing chalcopyrite and sphalerite, hematite masses disseminated with chalcopyrite and sphalerite, and disseminations in dolostones with galena and sphalerite (see Fig. 4).

Dark-colored gossans exposed widely on the surface are composed mainly of goethite, quartz and kaolinite, associated with manganese oxides and siderite. Most of the metal ingredients in the gossans are thought to be in the form of oxide or carbonate such as chalcophanite and smithsonite. It is inferred that the dark-colored gossans are the oxidation products of manganiferrous siderite.

Massive pyrite ore deposit, which is composed mainly of pyrite associated with pyrrhotite and marcasite, is occasionally enriched with galena and sphalerite. There occurs a lot of druses in pyrite orebody and hematite in the marginal places. In sphalerite, spotted small grains of chalcopyrite are contained.

Main ore minerals of skarn ore deposit are chalcopyrite, sphalerite, pyrite, and magnetite, and main skarn minerals are tremolite, garnet, epidote, and quartz.

Silicification, sericitization, argillization, sideritization, dolomitization, and brecciation are remarkable alterations in the host rock of the ore deposits. The acidic dykes, which intruded into the Oyon and Chimu Formations around Cumbre de Cunsha Punta, are thought to have been related to the mineralization.

As for the fracture system, shear faults of WNW–ESE and NNE–SSW directions, both of which are oblique to the folding axis, tension fracture of ENE–WSW which shows right angle to the folding axis, and thrust fault and bedding fracture parallel to the folding axis are observed to be developed in this area.

The mineralized zone in the Iscaycruz Area is in a narrow zone about 12 km in length. The exposures of the mineral indications are intermittent and the features of concentration of the ore minerals are variable. Viewing the whole area at a glance, the skarn ore deposits containing copper and zinc minerals are recognized in the Limpe-S area, nearest to the center of the activity of the acidic igneous rocks. It is thought these skarn ore deposits would occupy the area corresponding to the central portion of the mineralization in this area. Both in the Limpe area in the north of this central area, and the Cunsha Punta area in the south of it, massive sulphide ore deposits have been found, in places associated with lead and zinc minerals. In the outermost zone of the Cumbre de Iscaycruz area and the Antapampa area, dissemination type ore deposits of lead and zinc in the manganiferrous siderite layers are recognized. These ore deposits of various types are distributed in zonal arrangement, centered in the acidic igenous rocks, and they are thought to have been formed in a single mineralosphere by a series of mineralization as a whole.

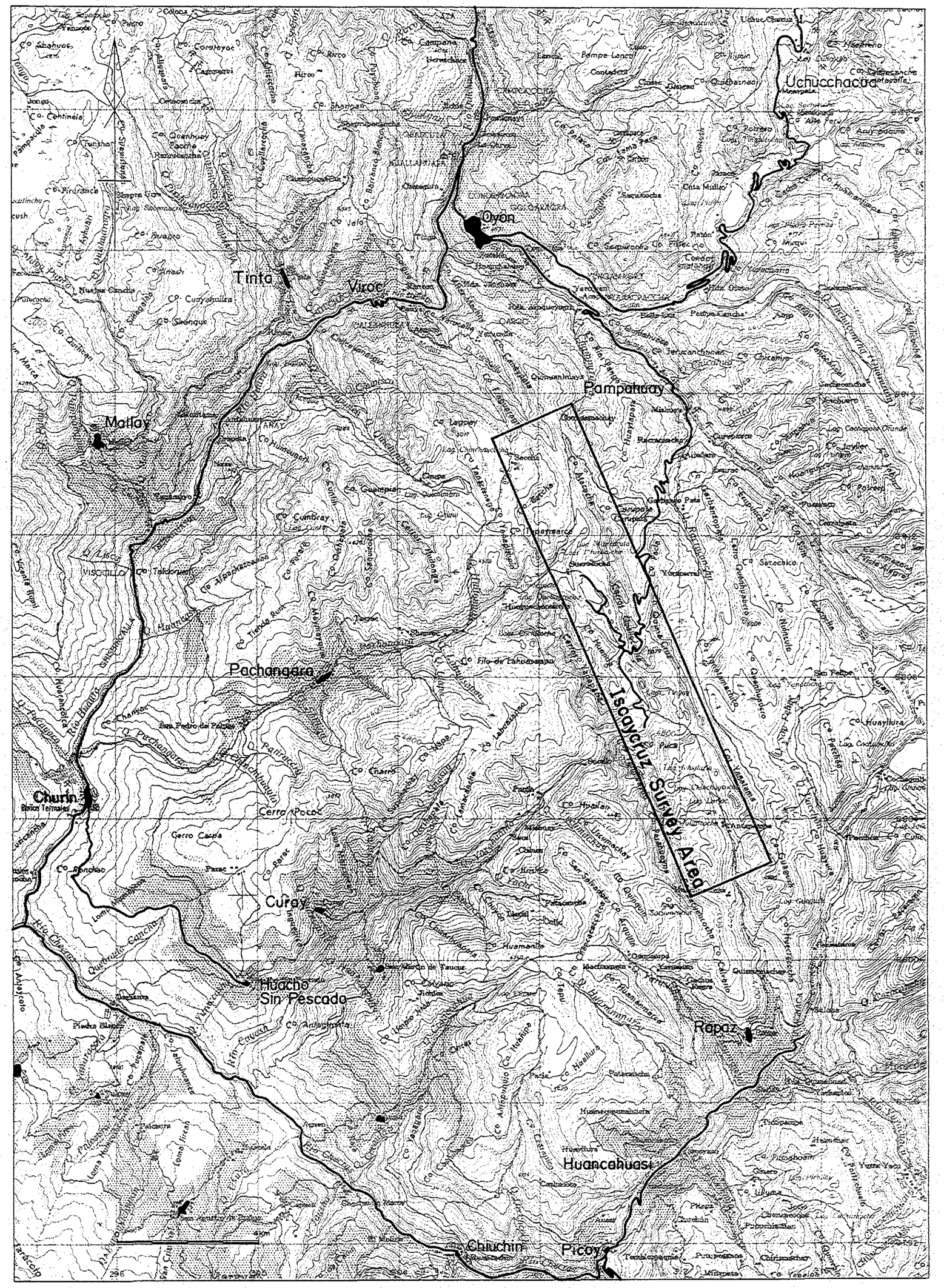
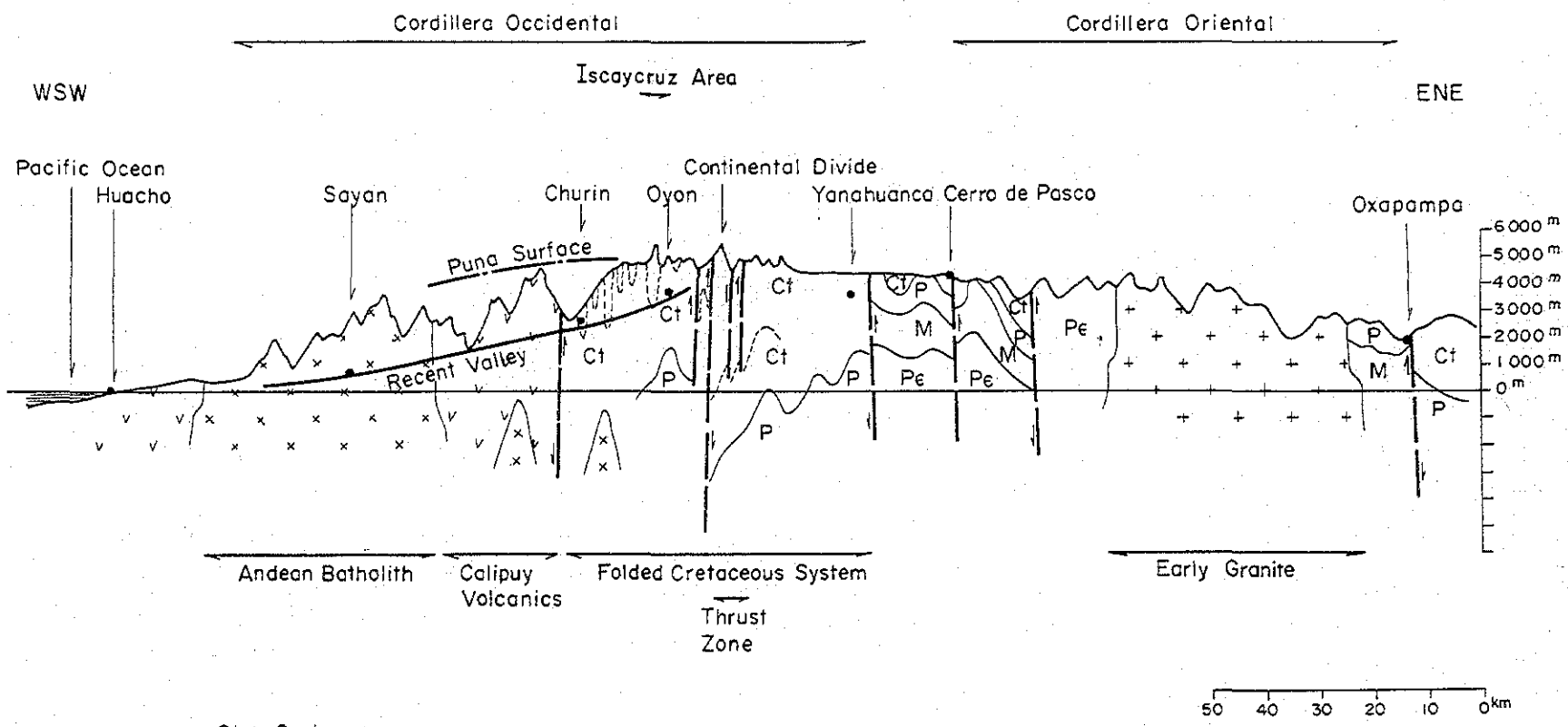


Fig. 2 Location and Access Map



Ct : Cretaceous
P : Jurassic & Triassic (Pucara Group)
M : Permian (Mitu Group)
Pε : Precambrian

Fig. 3. Schematic Profile of the Central Andes Area

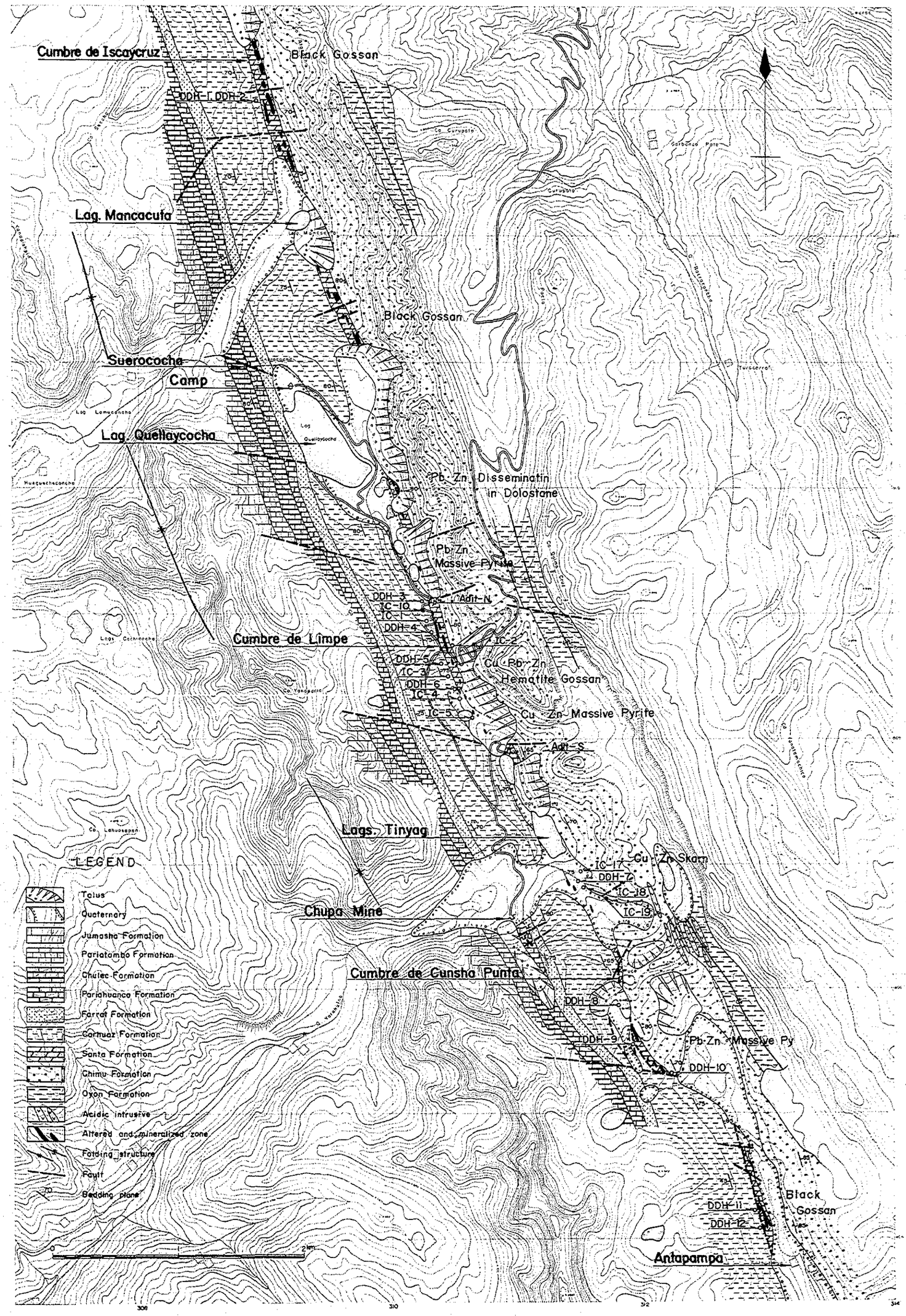


Fig.4 Geological Map of the Iscaycruz Area

CHAPTER 3 OUTLINE OF THE SURVEY RESULTS

3–1 Drilling Exploration

In the present year, under ground diamond drilling of 10 holes, whose total length was 1,900 meters, was carried out in 8 drill sites, 1 site on the surface at Limpe, 2 sites in the underground of Adit-N, 2 sites in the underground of Adit-S and 3 sites on the surface in the Limpe-South (Tinyag) area.

1) IC–10 (on the surface at Limpe)

At the immediate depth of the gate of the Adit-N, the drill hole caught only a weak indecation of lead-zinc-copper mineralization in dolostone, siderite, pyrite and hematite.

2) IC–11, IC–12 and IC–13 (in the underground of Adit-N)

Rich indications of mineralization were caught in the drill holes of IC–11 sited at the 310 m point in the Adit-N and IC–12 sited at the 410 m point in the Adit-N. The ore grade of high grade portion of the indication is as high as more than 40%. The assay results of the samples collected every one meter of the cores are shown in the following table.

Hole	Depth (m)	Length (m)	No. of Samples	Ag (g/t)	Cu (%)	Pb (%)	Zn (%)	Horizontal Width (m)
IC–11	107.2–115.4	8.2	5	39	0.05	4.44	7.97	
"	115.4–124.5	9.1	9	47	0.05	1.38	39.16	
"	124.5–133.9	9.4	5	25	0.04	3.94	19.00	
Average	107.2–133.9	26.7	19	38	0.04	3.16	22.69	20.5
IC–12	144.3–161.5	17.2	17	40	0.01	2.11	8.37	
"	161.5–175.5	14.0	14	153	0.48	3.23	44.80	
"	175.5–183.5	8.0	7	32	0.06	2.64	21.59	
Average	144.3–183.5	39.2	38	78	0.19	2.61	24.08	33.2

The levels of the location of the above two indications of mineralization are 4,610 m and 4,570 m respectively, and it is thought that these two indications would form one orebody with the indications formerly caught at 4,680 m level in the drill hole IC–2 and at 4,590 m level in the hole DDH-5. The scale of this orebody is estimated to be more than 250 meters in horizontal extension and over 150 m in vertical extension.

The southern extension of this orebody has been confirmed to be massive pyrite, which was caught in the drill hole IC–13.

3) **IC–14, IC–15 and IC–16 (in the underground of Adit-S)**

In the drill hole IC-14 sited in the underground at the 710 m point of the Adit-S, 4 layers of zinc mineralization has been confirmed around massive pyrite.

Hole	Depth (m)	Length (m)	No. of Samples	Ag (g/t)	Cu (%)	Pb (%)	Zn (%)
IC–14	100.7–102.4	1.7	1	30	0.43	0.02	17.50
IC–14	107.1–113.9	6.8	4	18	0.05	0.04	9.90
IC–14	113.9–123.7	9.8	9	42	0.27	0.19	21.56
IC–14	131.6–133.8	2.2	2	28	0.28	0.06	31.00

The average grade of 16.6 meters of the core between 101.7 m and 123.7 m is Ag 32 g/t, Cu 0.18%, Pb 0.13% and Zn 16.78%, and the horizontal width is estimated to be 13.2 meters. This indication is thought to be connected to the indication caught in the drill hole DDH-6. This fact suggests that the orebodies in the Limpe area has dipping to the south as a whole.

It is confirmed in the drill hole IC–15 located at the same site that the above mineralization is thinning out in the southern extention where the rocks of the Santa Formation have been remarkably pyritized. In the pyrite zone, local dissemination of copper minerals is recognized.

Also, in the drill hole IC–16 located in the underground at the 510 m point in the Adit-S, large scale of massive pyrite and hematite are confirmed, and copper minerals are recognized to be disseminated locally.

4) **IC–17, IC–18 and IC–19 (on the surface at Limpe-South)**

The mineralized and altered Santa Formation was recognized in the core of the length of over 60 meters in the drill hole IC–17, located about 100 meters north of the drill hole DDH-7, in which high grade mineralization was formerly confirmed. However, the mineralization is found not to be magnificent.

Hole	Depth (m)	Length (m)	No. of Samples	Ag (g/t)	Cu (%)	Pb (%)	Zn (%)
IC–17	94.8–99.5	4.7	3	11	1.25	0.00	0.09
IC–17	127.3–127.7	0.4	1	11	9.00	0.00	38.40
IC–17	140.0–141.0	1.0	1	8	0.42	0.00	22.00

In the drill hole IC–18 located about 110 meters southeast of the drill hole DDH-7, high grade mineralization has been confirmed associated with skarn minerals as tremolite in the Santa Formation which is recognized over 45 meters after passing through the fault fractured zone developed along the boundary of the Chimu Formation and the Santa Formation.

Hole	Depth (m)	Length (m)	No. of Samples	Ag (g/t)	Cu (%)	Pb (%)	Zn (%)	Horizontal Width (m)
IC–18	96.9–101.8	4.9	3	22	2.86	0.03	21.60	
IC–18	101.8–110.8	9.0	9	9	0.90	0.01	28.89	
IC–18	110.8–125.5	12.7	10	7	0.97	0.01	12.24	
Average	96.9–125.5	28.6	22	8	1.32	0.01	19.79	22.3

In the drill hole IC–19 located about 320 meters southeast of the drill hole DDH-7, skarnized and intensely pyritized rocks belonging to the Santa Formation are confirmed over 38 meters after passing through a large fault fractured zone. However, no other mineralization but local dissemination of zinc and copper minerals has been recognized.

3–2 Tunnelling Exploration

As the tunelling exploration in this year, total 748 meters of tunnel excavation was carried out:

Crosscut-2 of Adit-N	175 m
Adit-S (main tunnel)	346 m
Crosscut-1 of Adit-S	141 m
Crosscut-2 of Adit-S	86 m

The cummulative total length of the excavation of the Adit-N is 835 meters and that of the Adit-S is 1,173 meters.

1) Crosscut-2 of Adit-N

The starting point of this crosscut-2 is at the 460 m point of the Adit-N. The geology along this cross cut is as follows.

0 m – 49 m :	quartzite (Chimu Formation)
49 m – 92 m :	alternation of sandstone, marlstone, mudstone and dolostone (transitional zone of the Chimu Formation)
92 m – 126 m :	massive pyrite (Cu-Zn dissemination, Santa Formation)
126 m – 140 m :	dolostone, pyrite (Cu-Zn dissemination, Santa Formation)
140 m – 170 m :	limestone (Santa Formation)
170 m – 175 m :	shale (Carhuaz Formation)

A fault of NE series is confirmed at around the 57 m point. Faults parallel to the bedding planes are well developed along the boundary zone of the different rocks.

The high grade orebody in the lower horizon caught in the drill holes of IC–2 and IC–12 is

recognized to have varied to massive pyrite in the extension while the lead-zinc orebody in the upper horizon has been thinning out.

2) **Adit-S main tunnel**

The Adit-S main tunnel was excavated in the NNW direction, following the works in the last year, in the transitional zone of the Chimu Formation, which is composed of quartzite, marlstone, mudstone and dolostone. Faults parallel to the bedding planes are well developed along the border between the hard rock like quartzite and the soft rocks such as marlstone, and the excavation was fairly difficult. The main tunnel whose direction was changed to the left side at the 835 m point encountered the Santa Formation at the 32 m point and the excavation was carried out in the dolostone toward the proposed position of the opening point of the crosscut-2. At the 94 m point, there is a fault of WNW-ESE series dipping to the south. In the far side beyond this fault, there is a large druse. Dissemination of zinc minerals is recognized in the dolostone.

3) **Crosscut-1 of Adit-S**

Geology of the crosscut-1 is as shown below (the opening of the crosscut-1 is at the 700 m point of Adit-S).

0 m – 46 m :	alternation of sandstone, marlstone, mudstone and dolostone (transitional zone of the Chimu Formation)
46 m – 100 m :	massive pyrite (Santa Formation)
100 m – 120 m :	limestone and dolostone (Santa Formation)
120 m – 130 m :	pyrite (Santa Formation)
130 m – 141 m :	limestone (Santa Formation)

In the far side of the 46 m point along this tunnel, there were several localities where remarkable acidic spring water (pH=1) came out, and the excavation was awfully difficult and had to be stopped. Although a large scaled pyritic orebody was confirmed in this tunnel, no more mineralization than local dissemination of zinc minerals at around the 129 m point has been recognized.

4) **Crosscut-2 of Adit-S**

Two remarkable mineralization zones have been confirmed in the sections between 3 m and 19 m points and between 60 m and 67 m points along this tunnel. The assay results of the samples collected along every 1 meter of the channels on both of the walls are given as below.

	Depth (m)	Length (m)	No. of Samples	Ag (g/t)	Cu (%)	Pb (%)	Zn (%)
D7 North wall	3–21	18	18	161	0.16	4.25	29.80
South wall	5–19	13	13	210	0.16	3.28	30.54
Average		15	31	182	0.16	3.84	30.11
U6 North wall	60–67	7	7	15	0.06	2.84	8.64
South wall	61–66	5	5	33	0.10	2.47	13.97
Average		6	12	26	0.08	2.63	11.75

The above U7 orebody was caught in the drill hole DDH-5 at the almost same locality. According to the data of the hole DDH-5, the horizontal width of this orebody is 11.9 m and the ore grade is Ag 163 g/t, Cu 0.14%, Pb 2.92% and Zn 27.15%. The result of the confirmation of this orebody in the tunnel is better than the result obtained in the drill hole in the viewpoint either of scale or of grade.

(PHASE Ⅲ) GEOLOGICAL SURVEY OF THE ISCAYCRUZ AREA, PERU PL. 1

EXPLORATION PROGRAM OF THE LIMPE AREA

EXPLORATION MAP OF THE LIMPE AREA (PERSPECTIVE PLANE)

0 100 200m

METAL MINING AGENCY OF JAPAN
JAPAN INTERNATIONAL COOPERATION AGENCY

JULY 1985

Prepared by MINDECO

310,500 311,000

LEGEND

Geology

- Talus
- Sandstone
- Shale
- Ls Limestone
- Do Dolostone
- Quartzite
- Brecciated rock
- Altered and Mineralized outcrop
- 70 Bedding
- Fault
- Santa Formation (surface)

Exploration

- Survey point and elevation
- Access road
- Drilling site and direction
- Gate of adit
- Exploration adit

- High-grade Pb-Zn ore
- Cu ore
- Pyrite or Hematite ore

Fig. 5 Exploration Map of the Limpe Area

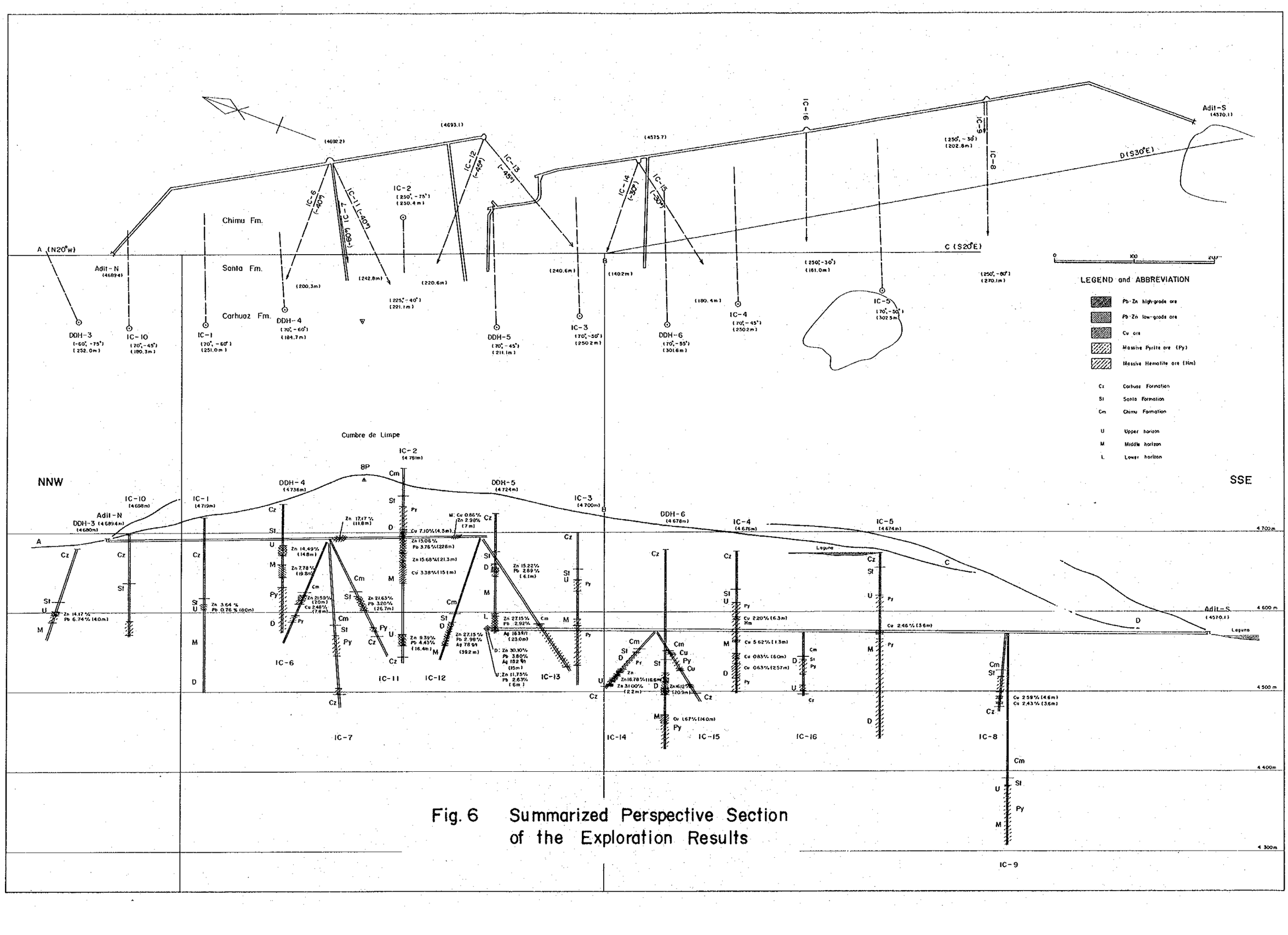


Fig. 6 Summarized Perspective Section of the Exploration Results

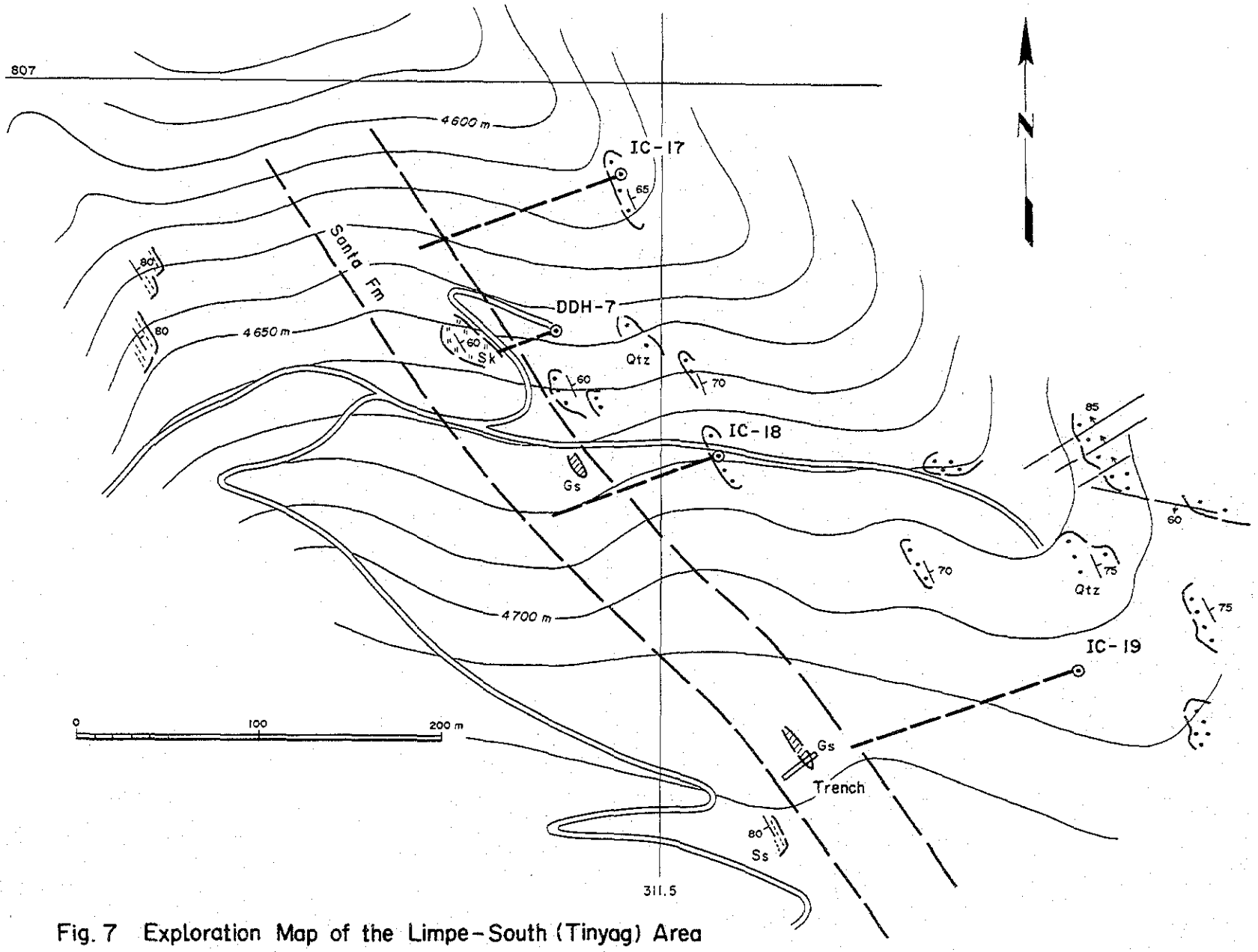


Fig. 7 Exploration Map of the Limpe-South (Tinyag) Area

CHAPTER 4 ORE RESERVE ESTIMATION (TENTATIVE CALCULATION)

4–1 *Methods of Calculation*

The mineralization in the Limpe area, which is the main object of the surveys, is represented by irregular massive ore deposits formed by the replacement of limestones. Viewing from the survey results, it seems that the shapes and the sizes of the orebodies might have variation to a considerable extent and that the distribution of ore grades might be inhomogeneous. For such undeterminable orebodies, it is impossible to insist that the exploration works carried out by this stage would have been enough in amount for the delineation of precise properties of the orebodies by this stage, because only four crosscut tunnels have been excavated within such a distance of 1,400 meters and the drilling exploration has been done merely with the spacing of every 100 meters. It is not appropriate to say that now is the right stage when ore reserve estimation by any means expecting certain accuracy could be possible.

By the tunnelling and drilling explorations, more than ten indications of high grade mineralization have been confirmed. It is thought that they are related intimately to the pyritization and to the brecciation, and it is estimated that they have continuity to some extent, being controlled by the structure of the limestone. Therefore, it would be possible only on such basis to execute tentative ore reserve estimation for rough assumption of the ore reserve and the ore grade.

As to the method of calculation Polygon Method was employed, which is thought to be the most simple and objective way of ore reserve estimation.

4–2 Process and Basis of Calculation

(1) The indications involved in the estimation are those having thickness of more than 2 meters and having grade of more than 10 % of Pb+Zn. In case of copper ore, indications having grade of more than 2 % of Cu are employed. However, any indications which are composed of only one sample satisfying the above conditions have been excluded.

(2) Center points of each of the indications caught are projected on a perspective section, which is established parallel to the extension of the mineralization zone (N20°W–S20°E).

(3) After real thickness of each of the indications is obtained based on the angle between the direction of the drill hole and the boundary plane of the wall rocks and the ore deposit or the plane structure of the ore deposit, its width on the horizontal plane is calculated according to the inclination of the ore deposit or the wall rocks (see Table 1).

(4) The area of the calculation in both strike and vertical directions is taken not to exceed five times of the horizontal width of the indications and is limited to be less than 50 meters at the maximum.

(5) The area down to the depth of 30 meters below surface is not included in the ore reserve estimation due to the possibilities of oxidized and/or leached zone.

(6) In case the distance between any two center points of the indications is within 5 times of the total of the two horizontal width of the indications, and the continuity of the mineralization is expected geologically, they are regarded to be within one single orebody.

(7) In case there are more than two points of the indications within a single orebody, polygons are established with each of the points of the indications to be the centers. Boundaries of the polygons are taken so that any neighbouring two points could have equal distance to the boundary between them. Unmineralized points in the mineralized horizon are also considered to decrease ore reserve tonnage. Tetragon is drawn with such orebody with only one point.

(8) After area and volume of each of the polygons are obtained, the ore reserves and the ore grade are calculated. Specific gravity is decided to be 3.4, considering the amount of 12 % of the porosity of the orebodies over 3.83, the measured value of the specific gravity.

(9) It is the known tendency of the polygon method that the ore reserve would be estimated excessively especially along the margin of each polygon when the density of the survey elements is rough or when the variation of thickness and shapes of the orebody is fairly big. Considering such characteristics of the polygon method, in addition to the fact that the figures of the horizontal widths of the orebodies are obtained only as the estimated values, it may be safer to infer actual ore tonnage, if an assesment factor of around 90 % to 75 % was adopted.

(10) As for ore grade calculation, a safety factor of 95 % is adopted.

4–3 Sampling and Analysis

1) Sampling Methods of the Drill Cores

(1) High grade ore

Sampling interval is 1 meter as a rule. Core is cut squally into two half pieces along the axis by diamond cutter and the half of the core is further cut into two equal pieces in the same way. Thus, one fourth of the core is employed as a sample.

(2) Moderate grade ore

Sampling interval is 2 meters as a rule. With core splitter core is split into two pieces to employ half of the core as a sample. On necessity, cores are broken in site and are reduced to make one sample by sample reducer.

(3) Low grade ore

Sampling interval is free up to 10 meters in maximum. With hammer, one sample is prepared by collecting small pieces continuously.

2) **Sampling Methods in the Tunnels**

(1) High grade ore

Continuous channel sampling on both walls with the interval of every 1 meter at a level of 1 meter above the bottom of the tunnel.

(2) Moderate grade ore

Channel sampling of the length of 1 meter with the interval of every 2 meters either in zig-zag way on both walls or along a wall on one side.

(3) Low grade ore

Channel sampling of the length of 1 meter with the interval of 4 meters on a wall.

3) **Analysis**

(1) Analysis of Ore Samples

The analysis of ore samples were carried out at the laboratory of INGEMMET as a rule, but some of the samples were sent to the Plenge Laboratory for the analysis. The ingredients for the analysis are Ag, Cu, Pb and Zn.

The laboratory of INGEMMET employs the Atomic Absorption Spectrochemical Analysis. In the third year, some samples show very high grade more than 40% up to 50% in zinc. The Wet Chemical Analysis is more suitable method to such high grade ore samples. Therefore, all samples of high grade ore more than 30% of zinc content were sent to the Plenge Laboratory and re-analysed by the Wet Chemical Analysis, and the assay values of the Plenge Laboratory were adopted for the ore reserves calculation (refer to Fig. 9 and A. III–1).

(2) Analysis of Composit Samples

Three composit samples were analysed for the contents of minor elements, and the results of the analysis are shown as follows.

	Length (m)	Depth (m)	Cu (%)	Pb (%)	Zn (%)	Bi (%)	Cd (g/t)	Sn (%)	W (%)
IC–11	26.7	107.2–133.9	0.05	2.92	18.17	0.10	270	0.32	Nd
IC–12	29.1	151.4–180.5	0.51	1.82	20.39	0.23	15	0.35	Nd
IC–14	9.8	113.9–123.7	0.19	0.02	17.90	0.13	54	0.38	Nd

	Sb (%)	Hg (%)	Fe (%)	As (%)	S (%)	Au (g/t)	Ag (g/t)
IC–11	0.09	0.01	21.30	0.43	27.46	Nd	32
IC–12	0.09	0.14	24.62	0.10	28.36	Nd	58
IC–14	0.09	0.03	29.16	0.11	34.72	Tr	52

4) Measurement of Specific Gravity

Apparent specific gravity was measured with 37 samples, collected in the main mineralized parts of the drill cores. The samples for the measurement of specific gravity had been dried in the temperature of 60°C in 24 hours before measurement and the surface of the samples were coated with paraffine. The results of the measurement are shown in Table 2. The average value of the specific gravity measured with 26 samples of pyritized ore in the Limpe area is 3.83, while the average value measured with 7 samples of skarnized ore in the Limpe-South area is 3.61. As druses or other hollow parts are developed in the actual orebodies in situ, it is necessary to give consideration on the porosity of ore for the specific gravity in situ. Assuming the value of such porosity to be 12% with the pyritized ore and to be 6% with the skarnized ore, the apparent specific gravity in situ common to both types of ore is calculated to be 3.4.

4–4 Calculation Result

1) Limpe Area

The perspective sections for ore reserve estimation are shown in the Fig. 8 and the calculation table is shown in the Table 3. The result of the ore reserve calculation by the polygon method in the mineralization zone in the Limpe area is as follows.

Type of Ore	Ore Reserve (1,000 ts)	Grade of Ore			
		Ag (g/t)	Cu (%)	Pb (%)	Zn (%)
Pb-Zn ore	3,250	48	0.13	1.95	18.99
Cu ore	100	32	2.84	0.03	0.39

2) Limpe-South Area

The exploration is at the preliminary stage where mineralization has been confirmed in only two drill holes spaced about 100 m each other. If the horizontal width of the orebody is taken to be 19.1 m, horizontal extension to be 200 m, vertical extention to be 150 m, specific gravity to be 3.4 and the index of existence of the orebodies to be 75%, total 1,460 thousand tons of ore reserves are expected according to the following calculation.

19.1 m x 200 m x 150 m x 3.4 x 0.75 = 1,461,150 t

The weighted average of the ore grade of the orebodies confirmed in the two drill holes is Ag 10 g/t, Cu 1.85%, Pb 0.01% and Zn 19.59%.

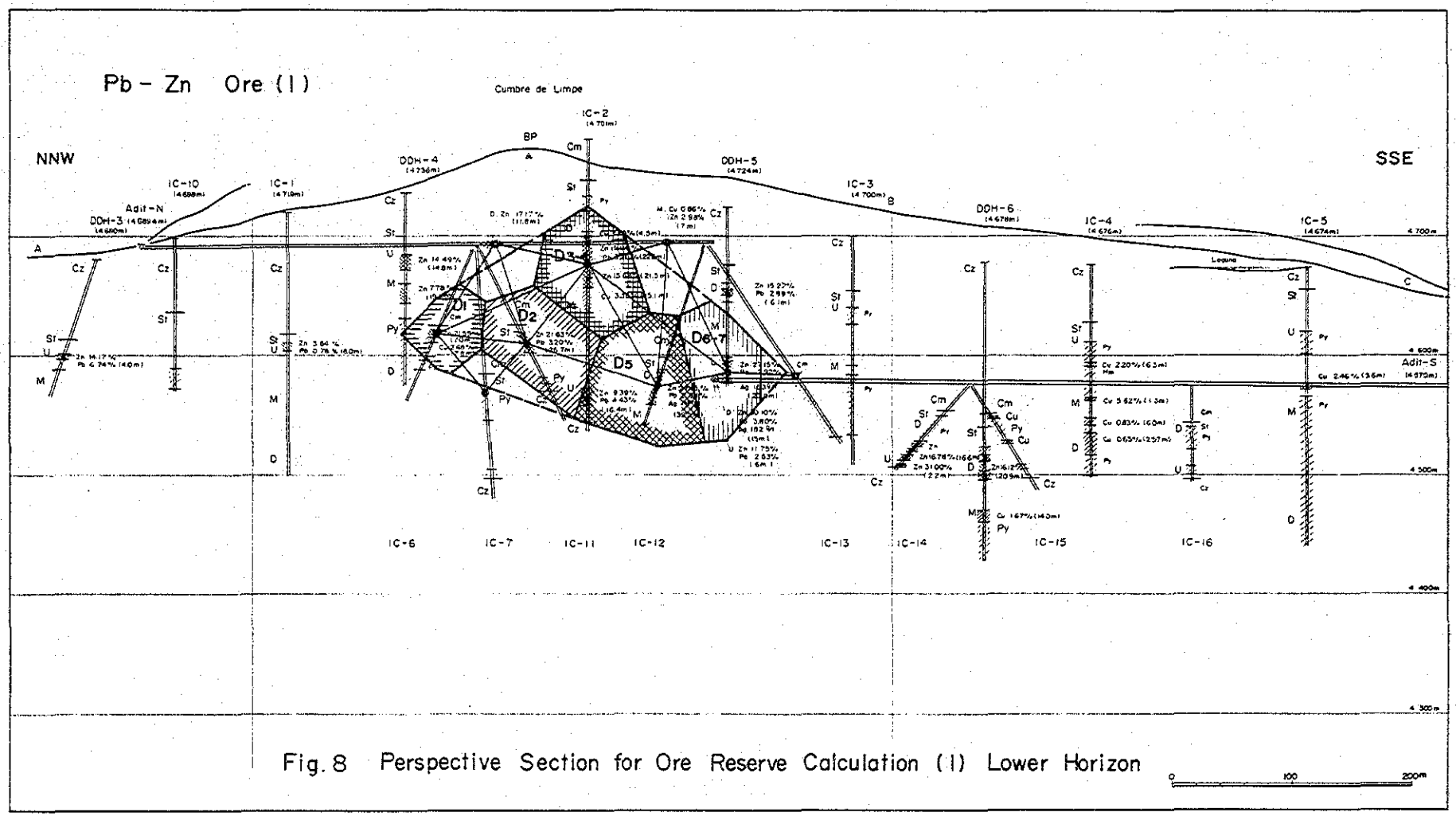


Fig. 8 Perspective Section for Ore Reserve Calculation (I) Lower Horizon

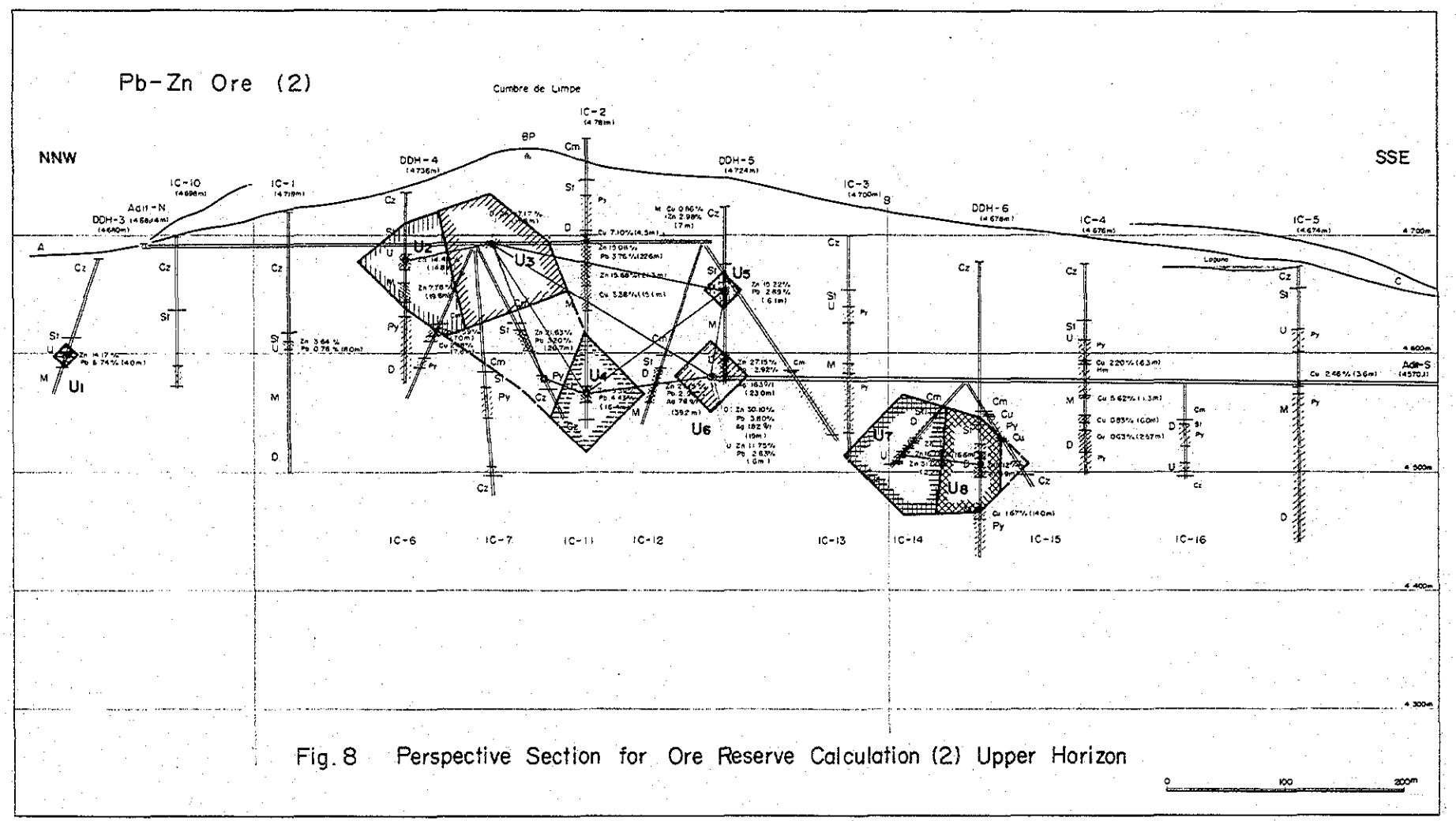


Fig. 8 Perspective Section for Ore Reserve Calculation (2) Upper Horizon

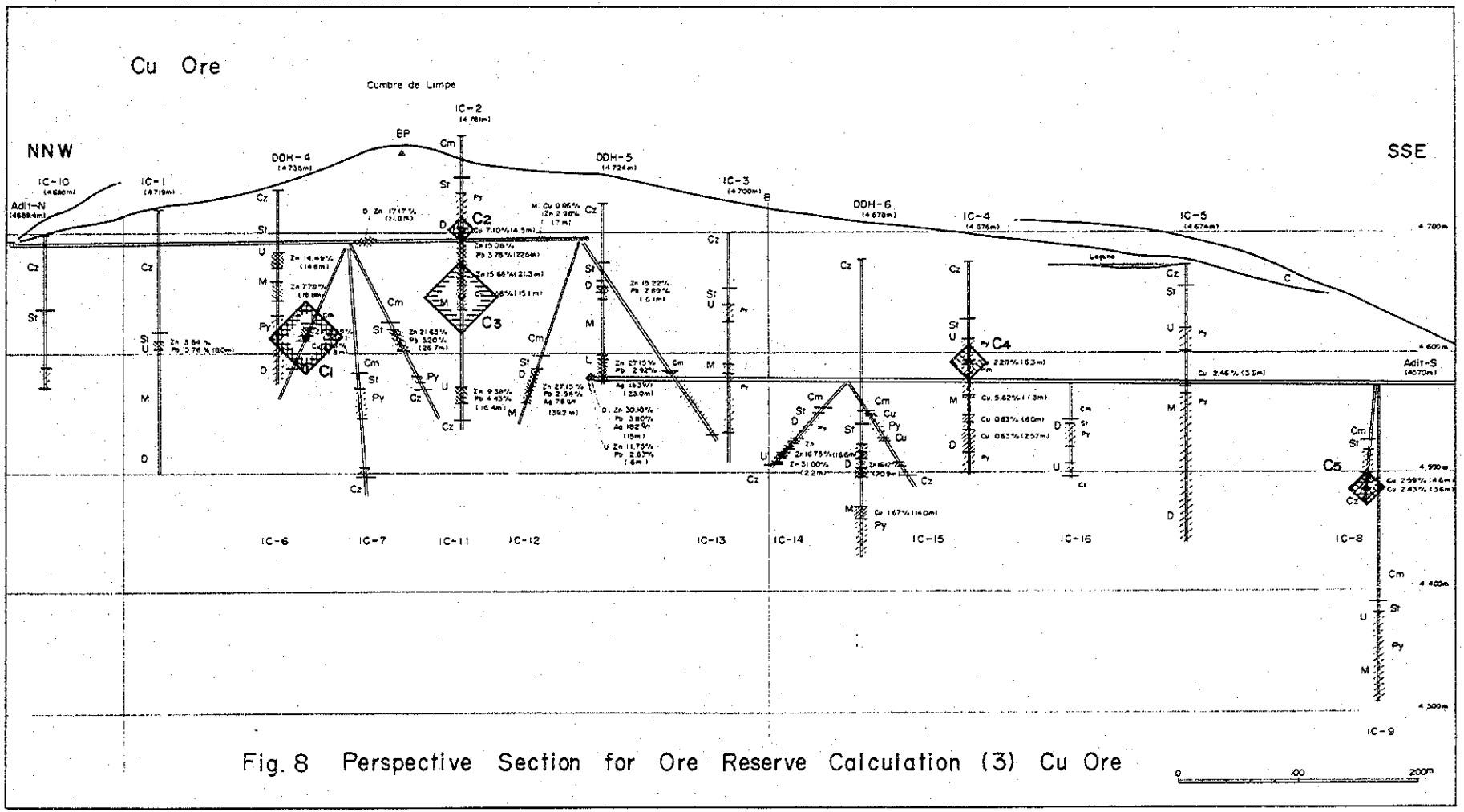
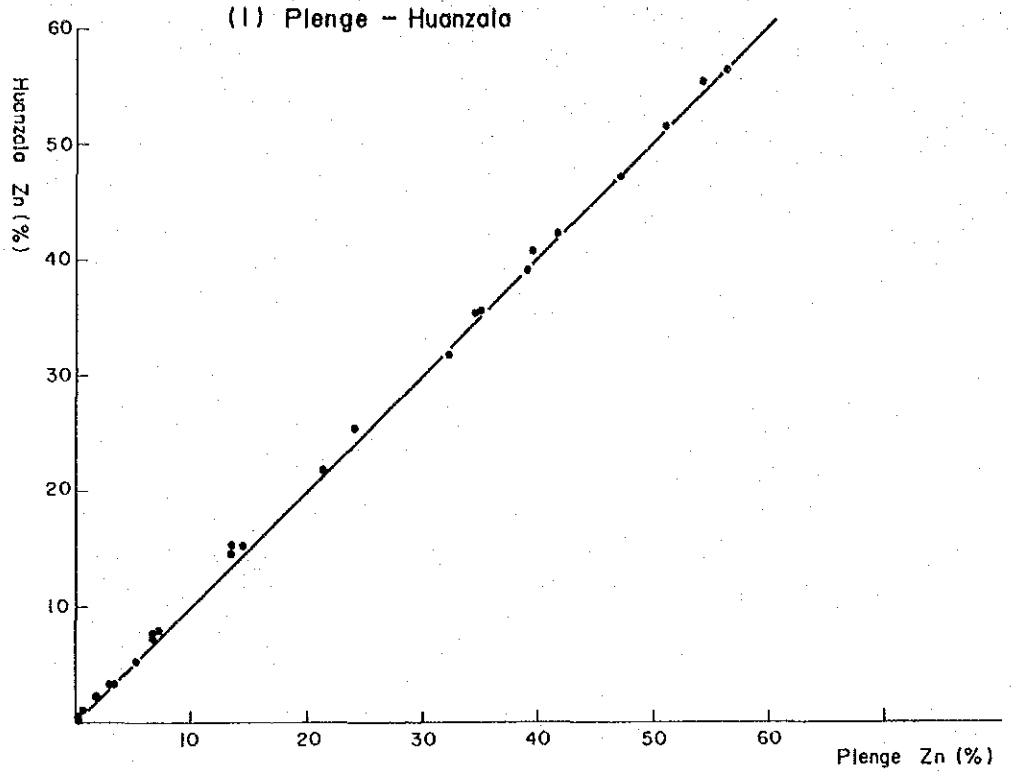


Fig. 8 Perspective Section for Ore Reserve Calculation (3) Cu Ore



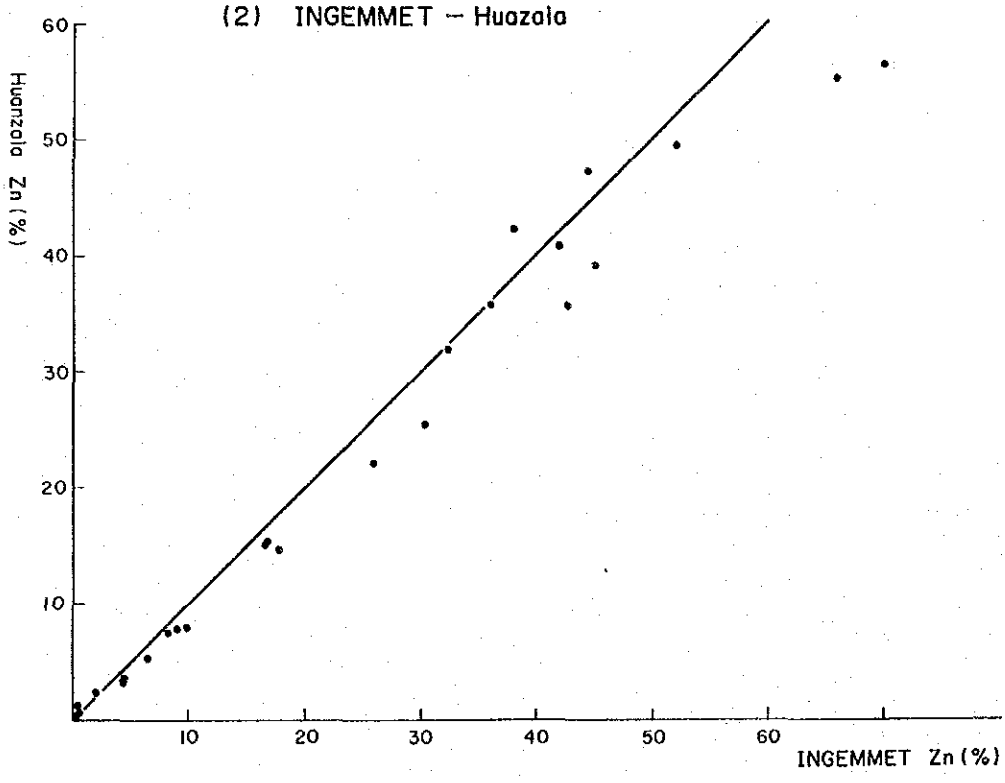


Fig. 9 Correlation Diagram of Check Assays

Table 1 List of the Confirmed High Grade Mineralized Parts

Area	DDH	Depth m	Interval m	No. of Sample	Ag g/t	Cu %	Pb %	Zn %	Angle (Comp.)	Inc.	Real Thick m	Horiz. Width m	Orebody
Limpe	DDH-3	104.6-108.6	4.0	4	89	0.03	6.74	14.17	55°	90°	2.29	2.3	U_1
	DDH-3	108.6-118.9	10.3	10	32	0.03	1.26	4.56	55°	90°			
	IC-10												
	IC-1	121.0-129.0	8.0	4	4	0.07	0.76	3.64	40°	90°			
	DDH-4	61.3- 76.1	14.8	15	13	0.07	0.04	14.49	50°	90°	9.51	9.5	U_2
	DDH-4	84.9-104.7	19.8	16	10	0.10	0.30	7.78	55°	90°			
	IC-6	96.8-101.0	4.2	4	4	0.03	0.85	5.27	40°	85°			
	IC-6	108.0-115.0	7.0	5	15	0.32	0.02	21.59	30°	85°	6.06	6.1	D_1
	IC-6	115.0-122.8	7.8	4	23	2.48	0.02	0.46	30°	85°	6.75	6.8	C_1
	IC-7												
	NX-1		6.0	6	17	1.42	0.04	0.30	10°				
	NX-1		12.0	24	8	0.10	0.07	17.13	10°			11.8	U_3
	IC-11	107.2-133.9	26.7	19	38	0.04	3.16	22.69	40°	85°	20.45	20.5	D_2
	IC-2	77.6- 82.1	4.5	2	5	7.10	0.22	0.48	50°	80°	2.89	2.9	C_2
	IC-2	82.1-104.7	22.6	19	34	0.08	3.75	15.06	60°	75°	11.30	11.7	D_3
	IC-2	104.7-126.0	21.3	4	4	0.14	0.16	15.68	60°	75°	10.65	11.0	D_4
	IC-2	126.0-146.3	15.3+	5	46	3.43	0.03	0.43	60°	80°	7.65	7.8	C_3
	IC-2	211.0-227.4	16.4	8	25	0.06	4.53	9.39	45°	80°	11.60	11.8	U_4
	NX-2		7	8	32	0.86	0.31	2.98	10°				
	IC-12	144.3-183.5	39.2	38	78	0.19	2.61	24.08	35°	75°	32.11	33.2	D_5
	DDH-5	95.6-101.7	6.1	5	35	1.10	2.89	15.22	55°	80°	3.50	3.6	U_5
	DDH-5	181.0-204.0	23.0	23	163	0.14	2.92	27.15	60°	75°	11.50	11.9	D_6
	SX-2		15.0	31	182	0.16	3.80	30.10	0°			15.0	D_7
	SX-2		6.0	12	26	0.08	2.63	11.75	0°			6.0	U_6
	IC-13												
	IC-3												
	IC-14	107.1-123.7	16.6	13	32	0.18	0.13	16.78	40°	75°	12.72	13.2	U_7
	IC-14	131.6-133.8	2.2	2	28	0.28	0.06	31.00	45°	75°	1.56	1.6	
	SX-1												
	DDH-6	194.4-215.3	20.9	18	22	0.18	0.20	16.04	65°	85°	8.83	8.9	U_8
	DDH-6	248.2-262.2	14.0	7	13	1.67	0.03	0.10	60°	85°			
	IC-4	114.0-120.5	6.3	3	32	2.20	0.02	0.29	60°	80°	3.15	3.2	C_4
	IC-16												
	IC-5												
	IC-8	174.5-178.1	3.6	3	23	2.43	0.11	0.11	10°	65°	3.55	3.9	C_5
Tinyag	DDH-7	56.0- 63.0	7.0	5	5	0.21	0.01	19.71	60°	65°	3.50	3.9	T_1
	DDH-7	81.0- 99.0	18.0	18	4	0.11	0.05	5.34	60°	65°			
	DDH-7	116.0-135.0	19.0	15	9	3.18	-	19.53	55°	65°	10.90	12.0	T_2
	IC-18	96.9-125.5	28.6	22	8	1.32	0.01	19.79	45°	65°	20.22	22.3	T_3

* In principle, listed up ore parts above 5% in Pb+Zn and above 1.5% in Cu averaging more than 2 samples.

\+ Excluded of non-core part.

NX and SX marks show Tunnels.

Real Thickness (m) = Interval (m) x sin (90° - Angle)

$$\text{Horiz. Width (m)} = \text{Real Thickness (m)} \times \frac{1}{\cos (90° - \text{Inc.})}$$

Table 2 Measurement Results of Specific Gravity

Sample No.	Type of Ore	Wa (g)	Wp (g)	Ww (g)	D
BC-03-107	Gl-Sp-Py ore	70.40	71.70	53.25	4.13
BC-04-064	Sp-Py ore	182.15	185.45	138.90	4.24
BC-04-068	Sp-Py ore	115.90	117.50	88.15	4.19
BC-04-076	Sp-Py ore	141.50	143.50	107.30	4.16
BC-04-087	Sp-Py ore	124.95	126.90	96.00	4.34
BC-04-104	Sp-Py ore	79.30	80.60	59.80	4.08
BC-05-099	Gl-Sp-Py ore	65.45	66.50	48.60	3.90
BC-05-183	Sp-Py ore	62.40	63.70	47.40	4.19
BC-05-190	Sp-Py ore	61.05	62.30	45.30	3.90
BC-05-192	Sp-Py ore	64.25	65.45	47.00	3.74
BC-05-195	Sp-py ore	75.50	77.00	56.35	3.97
BC-05-199	Gl-Sp-Py ore	71.05	72.90	52.90	3.95
IC-02-083	Sp-Py ore	131.0	133.2	96.5	3.81
IC-02-089	Sp diss ore	67.6	69.2	44.9	2.99
IC-02-099	Gl-Sp-Py ore	133.6	136.3	98.6	3.84
IC-02-103	Sp-Py ore	145.5	148.2	108.3	3.93
IC-02-118	Sp diss ore	100.6	102.7	64.2	2.77
IC-02-225	Sp-Py ore	75.6	77.2	55.1	3.71
IC-11-119	Sp-Py ore	87.2	89.5	64.3	3.84
IC-11-123	Sp ore	112.6	114.7	83.3	3.86
IC-12-164	Gl-Sp ore	114.4	116.7	82.6	3.62
IC-12-172	Sp ore	159.8	163.0	122.5	4.32
IC-12-175	Sp ore	98.2	100.3	72.6	3.86
IC-12-183	Sp ore	72.0	73.8	45.5	2.73
IC-14-117	Sp-Py ore	124.7	127.2	91.3	3.76
IC-14-133	Sp-Py ore	114.8	117.1	82.9	3.62
Av. of Massive Sp-Py ore					3.83
BC-07-085(A)	Sk ore	152.35	154.30	107.90	3.43
BC-07-085(B)	Sk ore	108.50	110.30	73.35	3.10
BC-07-123	Sp Sk ore	104.50	105.85	78.65	4.05
BC-07-126	Sp Sk ore	104.60	106.40	70.50	3.08
BC-07-127	Sp-Mt Sk ore	80.30	81.50	59.70	3.91
IC-18-121	Sp Sk ore	58.7	59.9	41.0	3.33
IC-18-125	Sp-Py ore	128.4	130.7	98.9	4.38
Av. of Skarn ore					3.61

$$D = \frac{Wa \times Dw}{Wp-Ww-(Wp-Wa)/Dp}$$

D : Apparent specific gravity
Wa: Weight of dried sample in the air
Wp: Weight of paraffin coated sample in the air
Ww: Weight of paraffin coated sample in the water
Dp: Specific gravity of paraffin (≈0.9)
Dw: Specific gravity of water (≈0.997)

Table 3 Table for Ore Reserves Calculation

Zone	Body	Area (m^2)	Wid. (m)	Volume (m^3)	Tonnage* (t)	Grade Ag g/t	Grade Cu %	Grade Pb %	Grade Zn %	Metal Value Ag kg	Metal Value Cu t	Metal Value Pb t	Metal Value Zn t
D	D_1	3,200	6.1	19,520	66,300	15	0.32	0.02	21.59	994	212	13	14314
	D_2	6,500	20.5	133,250	453,000	38	0.04	3.16	22.69	17214	181	14314	102785
	D_{3-4}	6,600	22.7	149,820	509,300	20	0.11	2.01	15.36	10186	560	10236	78228
	D_5	8,400	33.2	278,880	948,100	78	0.19	2.61	24.08	73951	1801	24745	228302
	D_{6-7}	5,500	13.4	73,700	250,500	172	0.15	3.36	28.62	43086	375	8416	71693
	Subtotal				2,227,200	65	0.14	2.59	22.24	145431	3129	57724	495322
U	U_1	200	2.3	460	1,500	89	0.03	6.74	14.17	133	0	101	212
	U_2	5,000	9.5	47,500	161,500	13	0.07	0.04	14.49	2099	113	64	23401
	U_3	7,600	11.8	89,680	304,900	8	0.10	0.07	17.13	2439	304	213	52229
	U_4	3,900	11.8	46,020	156,400	25	0.06	4.53	9.39	3910	93	7084	14685
	U_5	450	3.6	1,620	5,500	35	1.10	2.89	15.22	192	60	158	837
	U_6	1,800	6.0	10,800	36,700	26	0.08	2.63	11.75	954	29	965	4312
	U_7	5,600	13.2	73,920	251,300	32	0.18	0.13	16.78	8041	452	326	42168
	U_8	3,700	8.9	32,930	111,900	22	0.18	0.20	16.04	2461	201	223	17948
	Subtotal				1,029,700	19	0.12	0.89	15.15	20229	1252	9134	156036
	Zn-Pb Ore Total				3,256,900	51	0.13	2.05	19.99	165660	4381	66858	651114
	Adjusted Total**				3,256,900	48	0.13	1.95	18.99	157377	4161	63515	618558
Cu	C_1	1,800	6.8	12,240	41,600	23	2.48	0.02	0.46	956	1031	8	191
	C_2	200	2.9	580	1,900	5	7.10	0.22	0.48	9	134	4	9
	C_3	1,800	7.8	14,040	47,700	46	3.43	0.03	0.43	2194	1636	14	205
	C_4	450	3.2	1,440	4,800	32	2.20	0.02	0.29	153	105	0	13
	C_5	450	3.9	1,755	5,900	23	2.43	0.11	0.11	135	143	6	6
	Cu Ore Total				101,900	34	2.99	0.03	0.42	3447	3049	32	424
	Adjusted Total**				101,900	32	2.84	0.03	0.39	3274	2896	30	402

* Specific gravity in situ : 3.4

** Safety factor of ore grade : 0.95

CHAPTER 5 CONCLUSION AND RECOMMENDATION

5–1 Conclusion

1) The Results of the Survey in the Third Year (1984)

The investigation works carried out in the present year were those in the final phase of the three years' program of the Mineral Exploration by means of drilling and tunnelling explorations in the Iscaycruz Area.

Following the last year's investigation, the diamond drilling of the 10 holes was carried out, totalling 1900 m, and the tunnelling exploration of the Adit-N and the Adit-S was carried out, the total length of which is 748 m.

As for the drilling, all the holes excavated in this year caught indications of mineralization. Among those indications, high grade lead zinc orebodies are confirmed in four drill holes; IC–11 and IC–17 located in the underground in Adit-N, and IC–14 located in the underground in Adit-S in the Limpe area, and IC–18 located on the surface in the Limpe-South (Tinyag) area. The scale and the ore grade of the indications of high grade mineralization caught in the survey are given in the following table.

Hole No.	Depth (m)	Length (m)	No. of Samples	Ag (g/t)	Cu (%)	Pb (%)	Zn (%)	True Width (m)	Horizontal Width (m)
IC–11	107.2–133.9	26.7	19	38	0.04	3.16	22.69	20.5	20.5
IC–12	144.3–185.5	39.2	38	78	0.19	2.61	24.08	32.1	33.2
IC–14	107.1–123.7	16.6	13	32	0.18	0.13	16.78	12.7	13.2
IC–18	96.9–125.5	28.6	22	8	1.32	0.01	19.79	20.22	22.3

As for the tunnelling exploration, two layers of lead zinc orebodies have been confirmed in the crosscut-2 of Adit-S. The scale and the ore grade of the indications of mineralization thus caught are given in the following table.

Tunnel	Orebody	Depth (m)	Length (m)	No. of Samples	Ag (g/t)	Cu (%)	Pb (%)	Zn (%)	Horizontal Width (m)
XS-2	D_7	3– 21	15	31	182	0.16	3.84	30.11	15
XS-2	U_5	60– 67	6	12	26	0.08	2.63	11.75	6
(DDH-5)	D_6	181–204	23	23	163	0.14	2.92	27.15	11.9

The above D_7 orebody has been caught at almost same locality in the drill hole of DDH-5 carried out on the surface (D_6 as is listed in the above table). The scale and the ore grade confirmed in the underground are better than those estimated from the results of the drilling.

2) Mineralization Zone in the Limpe Area

The amount of the drilling survey carried out in the Limpe area in the Iscaycruz Area by this year is 4,390 m of total length in 20 holes; 10 holes on the surface and another 10 holes in the underground. The amount of the tunnelling exploration is 2,008 m of the total length of Adit-N and Adit-S.

By the drilling, high grade lead zinc orebodies have been confirmed in 9 holes, while high grade orebodies are recognized at 3 localities in the tunnel exploration.

Through these exploration works, the following points have been clarified as to the mineralization in the Limpe area.

(1) The ore deposit is massive sulphide ore deposit formed by the replacement of limestone of the Santa Formation. The ore minerals are mainly sphalerite and pyrite associated with galena and chalcopyrite.

(2) Remarkable mineralization is found stratigraphically in the horizons situated in the lower portion and in the upper portion of the Santa Formation.

(3) The mineralization is intimately related to the brecciation and the fractuation of the wall rocks.

(4) The copper-lead-zinc mineralization is closely related to the pyritization, and the ore deposits are located around massive pyrite zone and in such portions as remarkably brecciated in pyrite zone.

(5) Scale of the main orebodies is about 300 m in horizontal extension, more than 150 m in vertical extension (lower extension has not been confirmed) and the thickness is 10 to 30 m.

3) Mineralization Zone in the Limpe-South Area

In the Limpe-South area, the drilling of the total length of 770 m of 4 holes including 3 holes completed in this year was carried out on the surface. High grade copper zinc mineralization has been caught in two of the drill holes. In this mineralization zone, there have been confirmed such ore deposits composed mainly of chalcopyrite, sphalerite, magnetite and pyrite associated with skarn minerals. The high grade zone shows 1% to 3% of Cu and about 19% of Zn, and the horizontal width is estimated to be 10 m – 20 m. The ore reserve more than one million tons is expected in the Limpe-South area.

4) Tentative Estimation of the Ore Reserves

Based on the survey results, the ore reserves are estimated tentatively by the polygon method as to the grade and the amount of the ore which is estimated to be emplaced in the mineralization zone in the Limpe area. The result of the ore reserve estimation is as follows.

Type of Ore	Ore Reserve (1,000 ts)	Grade of Ore			
		Ag (g/t)	Cu (%)	Pb (%)	Zn (%)
Pb–Zn ore	3,250	48	0.13	1.95	18.99
Cu ore	100	32	2.84	0.03	0.39

It is noted that there is possibility for the above-estimated ore reserves to be increased through further detailed exploration works and especially through the investigation at the depth of the orebodies.

As the figures and the grade distribution of the orebodies are fairly complicated, it would be necessary to conduct further detailed exploration works such as drifting exploration at the main levels, shafting exploration partly serving for ventilation, short hole drilling in the underground, as well as to carry out investigation for possible extension at the depth of the ore deposits by long hole drilling.

5–2 Recommendation

For the potentiality of the emplacement of mineral ore deposits in the Iscaycruz Area, there has been carried out stage by stage various investigations such as geological survey, geochemical exploration, geophysical prospecting, surface drilling, tunnelling exploration and underground drilling, for these six years.

In the Limpe area, extracted as the most favorable area for the investigation of mineral resources, tunnelling exploration and drilling exploration either on the surface or in the underground were conducted, and the existence of high grade lead zinc orebodies have been confirmed. In the Limpe-South area, surface drilling was carried out and the emplacement of high grade copper zinc ore mineralization has been clarified. It is noted that there are other potential area warranting further investigation for mineral resources as Limpe-North area and Kunsha Punta area.

It is recommended as the investigation of the next stage to carry out the survey for the planning of the development including every item in necessary fields for the investment to the development of mineral resources.

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PARTICULARS
PART I
DRILLING EXPLORATION

PART 1 DRILLING EXPLORATION

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CHAPTER 1 DRILLING EXPLORATION

1–1 Outline of the Exploration

1) Drilling Exploration

The drilling exploration in the present year was carried out in the underground and on the surface. The total length of the drill holes was 1,908.50 m, of 10 holes.

Site	Hole	Bearing	Inclin.	Depth(m)	Core length(m)	Recovery(%)
Surface	IC–10	70°	–45°	180.30	146.45	81.2
Adit–N	IC–11	225°	–40°	221.10	178.80	80.9
Adit–N	IC–12	280°	–45°	220.60	215.80	97.8
Adit–N	IC–13	210°	–45°	240.60	213.10	88.6
Adit–S	IC–14	270°	–30°	140.20	126.20	90.0
Adit–S	IC–15	210°	–30°	180.40	168.30	93.3
Adit–S	IC–16	250°	–30°	161.00	139.90	86.9
Surface	IC–17	250°	–45°	160.20	147.50	92.0
Surface	IC–18	250°	–60°	200.50	162.90	81.2
Surface	IC–19	250°	–50°	203.60	152.40	74.9
TOTAL				1,908.50	1,651.35	86.5

This drilling exploration in the underground and on the surface was performed in the period of 242 days from June 6, 1984 to February 3, 1985.

The drill machine employed was TGM–3C (drilling capacity: NQ 510 m, BQ 660 m) and TGM–5A (drilling capacity: NQ 400 m, BQ 550 m).

Location (grid coordinate) and altitude of each drill hole are as follows.

Site	Hole	Longitude	Latitude	Elevation(m)
Surface	IC–10	310,280E	809,020N	4,698
Adit–N	IC–11	310,550E	808,860N	4,692
Adit–N	IC–12	310,650E	808,690N	4,693
Adit–N	IC–13	310,650E	808,690N	4,693
Adit–S	IC–14	310,690E	808,500N	4,576
Adit–S	IC–15	310,690E	808,500N	4,576
Adit–S	IC–16	310,800E	808,320N	4,574
Surface	IC–17	311,480E	806,960N	4,620
Surface	IC–18	311,500E	806,800N	4,680
Surface	IC–19	311,630E	806,740N	4,700

2) **Core logging and analysis works**

All the cores of the drill holes were logged with regard to lithology and mineralization. The results of the logging were described in the geological logs of the scale of 1 to 200.

As for the mineralized parts of the cores, half-split pieces or quarterly-split pieces were collected to prepare samples for chemical analysis for such elements as silver, copper, lead and zinc.

Also, as to the parts of the cores where mineralization and indications of mineralization were recognized polished sections were prepared for microscopic observation. Some of the samples were provided for the identification of minerals by X–ray diffraction analysis.

The main content and number analyses are given as follows.

(1) Chemical analysis of the mineralized parts of the cores (Ag, Cu, Pb, Zn) --------210 samples

(2) Microscopic observation of the polished sections or ore -------- 10 pieces

(3) X–ray diffraction analysis ------- 5 samples

1–2 Works of Preparation

1) **Transportation of materials and equipments**

After the customs clearance at the Callao port, the materials and the equipments were transported on the 11 t trucks to the Pampahuay on July 22, 1984, through Churin and Oyon. On the way from Pampahuay to Iscarcruz, the transportation was done by two 1 t pick up trucks.

2) **Preparation of Drill Sites**

Four drill sites were prepared on the surface. In the underground, two drill chambers each along the Adit–N and along the Adit–S, that is, total 4 underground drill chambers, were prepared by excavating walls of the tunnels.

3) **Water Supply for Drilling**

For the drill holes of IC–10, IC–11, IC–12, and IC–13, approximate 800 meters of pipeline was established and the necessary water was supplied by pumping, from the lake located north of the Cumbre de Limpe.

For the drill holes of IC–14, IC–15, and IC–16, approximate 1000 meters of pipe-line was established and the necessary water was supplied by natural flowing from the lake located south of the Cumbre de Limpe.

For the drill holes of IC–17, IC–18, and IC–19, approximate 1100 meters of pipe-line was established and the necessary water was supplied by natural flowing from the lake located at the Cumbre de Cunsha Punta.

4) **Preparation Period**

Total 46 days were needed for the preparation works including transportation of materials

and equipment, construction of electric cable and establishment of pipe-line.

1–3 Drilling Operations

HQ wire line method was employed for the drilling. Casing pipes were sunk on necessity so that the final diameter of the hole should be BQ–size. Usually, bentonite mud water was used all the time.

1) IC–10

Hole length	:	180.30 m
Core length	:	146.45 m
Core recovery	:	81.2 %
Date commenced	:	June 6, 1984
Date completed	:	June 15, 1984

* 0 m – 6.00 m : By 116 mm metal crown, using bentonite mud water, the hole was excavated in the talus sediments down to the depth of 6.00 m. As the wall was recognized to be stable there, HW casing pipes were sunk to the depth of 6.00 m.

* 6.00 m – 101.00 m : By HQ wire-line diamond bits, using bentonite mud water, the hole was excavated in quartzite, sandstone, shale and dolostone to the depth of 101.00 m. As the wall was recognized to be stable there, NW casing pipes were sunk to the depth of 101.00 m. At the depth between 86.80 m and 88.00 m, zinc mineralization was confirmed.

* 101.00 m – 180.30 m : By NQ wire-line diamond bits, using bentonite mud water, the hole was excavated in dolostone, clay fracture zone, limestone, sandy sulphide zone, and shale, to the depth of 180.30 m, where the excavation was stopped as the purpose of the hole was thought to have been completed.

2) IC–11

Hole length	:	221.10 m
Core length	:	178.80 m
Core recovery	:	80.9 %
Date commenced	:	August 15, 1984
Date completed	:	August 31, 1984

* 0 m – 1.50 m : By 101 mm diamond bit, the hole was excavated in quartzite and HW casing pipes were sunk to the depth of 1.50 m.

* 1.50 m – 111.40 m : By HQ wire-line diamond bits, the hole was excavated in quartzite, sandstone, shale, marlstone, and dolostone, and NW casing pipes were sunk to the depth of 111.40 m.

* 111.40 m – 194.80 m : By NQ wire-line diamond bits, the hole was excavated in dolostone, zinc-mineralized zone, clay fracture zone of shale, sulphide ore zone and shale zone to the depth of 194.80 m. As the wall was recognized to be stable there, BW casing-pipes were sunk to the depth of 194.80 m. In the portion of the depth between 107.20 m and 133.90 m as well as between 164.80 m and 167.70 m, were recognized and confirmed zinc-lead mineralized zones.

* 194.80 m – 221.10 m : By BQ wire-line diamond bits, the hole was excavated in shale and in sandstone to the depth of 221.10 m, where the excavation was stopped as the purpose of the hole was thought to have been completed.

3) **IC–12**

Hole length	:	220.60 m
Core length	:	215.80 m
Core recovery	:	97.8 %
Date commenced	:	September 30, 1984
Date completed	:	October 9, 1984

* 0 m – 2.50 m ; By 116 mm bit, the hole was excavated in quartzite and HW casing-pipes were sunk to the depth of 2.50 m.

* 2.50 m – 60.50 m : By HQ wire-line bits, quartzite and shale were drilled and NW casing pipes were set to the depth of 60.50 m.

* 60.50 m – 220.60 m : By NQ bits, shale, quartzite, marlstone, dolostone, zinc mineralized zone, pyrite zone, and limestone were drilled to the depth of 220.60 m, and the drilling was completed after hight grade zinc mineralized zone was confirmed between 145.50 m and 183.50 m.

4) **IC–13**

Hole length	:	240.60 m
Core length	:	213.10 m
Core recovery	:	88.6 %
Date commenced	:	September 9, 1984
Date completed	:	September 22, 1984

* 0 m – 1.50 m : By 116 mm bit, quartzite was drilled and HW casing pipes were sunk.

* 1.50 m – 30.00 m : By HQ bit, quartzite was drilled and NW casing pipes were set to the depth of 30.00 m.

* 30.00 m – 81.50 m : By NQ bit, quartzite and marlstone were excavated. Since the wall condition was poor in the fracture zone in quartzite, the hole was reaming by NW casing shoe bit and NW casing pipes were sunk down to the depth of 81.50 m.

* 81.50 m – 240.60 m : By NQ bit, marlstone, dolostone, and pyrite ore was drilled to the

depth of 240.60 m, and the work was terminated.

5) IC–14

Hole length	:	140.20 m
Core length	:	126.20 m
Core recovery	:	90.0 %
Date commenced	:	November 12, 1984
Date completed	:	November 17, 1984

* 0 m – 1.50 m : HW casing pipes was set down to 1.50 m.

* 1.50 m – 69.00 m : Marlstone, sandstone, dolostone, and pyrite ore were excavated by HQ bit and NW casing pipes were sunk to the depth of 69.00 m.

* 69.00 m – 140.20 m : By NQ bit, pyrite ore, shale, marlstone, and zinc ore were drilled down to the depth of 140.20 m and the work was completed attaining the object. From 116.40 m to 124.80 m, and from 131.60 m to 133.80 m, zinc ores were confirmed.

6) IC–15

Hole length	:	180.40 m
Core length	:	168.30 m
Core recovery	:	93.3 %
Date commenced	:	November 22, 1984
Date completed	:	December 10, 1984

* 0 m – 2.00 m : HW casing pipes were set down to 2.00 m.

* 2.00 m – 87.50 m : By HQ bit, marlstone, sandstone, dolostone, and fracture zone in pyrite ore were excavated to the depth of 87.50 m. In the fracture zone, where acid water (300 ℓ/min, pH=1) flew out, jamming state hoppened. By reaming the hole with NW shoe bit, NW casing pipes were sunk to the depth of 87.50 m.

* 87.50 m – 123.00 m : Sand-like pyrite ore and limestone were drilled using NQ bit and BW casing pipe were sunk down to the dpeth of 123.00 m.

* 123.00 m – 180.40 m : By BQ bit, limestone, dolostone, sulfide ore, and shale was drilled, and the work was completed at the depth of 180.40 m.

7) IC–16

Hole length	:	161.00 m
Core length	:	139.90 m
Core recovery	:	86.9 %
Date commenced	:	October 20, 1984
Date completed	:	November 4, 1984

* 0 m – 2.00 m : Quartzite was drilled using 116 mm bit and HW casing pipes were set down to 2.00 m.

* 2.00 m – 30.00 m : Quartzite and marlstone were drilled by HQ bit and NW casing pipes were sunk down to 30.00 m.

* 30.00 m – 109.20 m : By NQ bit, marlstone, sandstone, quartzite, and pyrite ore were excavated and BW casing pipes were sunk down to the 109.20 m depth.

* 109.20 m – 161.00 m : Limestone, pyrite ore, shale, and marlstone were excavated using BQ bit down to the depth of 161.00 m, and the hole was terminated since the purpose was completed.

8) **IC–17**

Hole length	:	160.20 m
Core length	:	147.50 m
Core recovery	:	92.0 %
Date commenced	:	June 26, 1984
Date completed	:	July 4, 1984

* 0 m – 1.70 m : Quartzite was drilled using 116 mm bit and HW casing pipes were set down to 1.70 m.

* 1.70 m – 30.00 m : Quartzite was drilled using HQ bit and NW casing pipes were set down to 30.00 m.

* 30.00 m – 160.20 m : Quartzite, sandstone, marlstone, sulfide ore, and shale were excavated by NQ bit. The hole was terminated at the depth of 160.20 m since the purpose was completed after zinc ore was confirmed between 140.00 m and 141.00 m.

9) **IC–18**

Hole length	:	200.50 m
Core length	:	162.90 m
Core recovery	:	81.2 %
Date commenced	:	July 10, 1984
Date completed	:	August 11, 1984

* 0 m – 1.50 m : By HQ bits, using bentonite mud water, the hole was excavated in quartzite to the depth of 1.50 m. Reaming the hole with HW casing shoe bits, HW casing-pipes were sunk to the depth of 1.50 m.

* 1.50 m – 164.90 m : By NQ bits, using bentonite mud water, the hole was excavated to the depth of 164.90 m in quartzite, marlstone, fracture zone, sulphide ore zone, zinc mineralized zone, skarn zone, and shale zone.

At the depth between 62.80 m and 86.40 m, the wall condition was extremely poor owing to the wall swelling, due to the weathered fracture zone, and the NQ wire-line lod was destroyed at the depth of 164.90 m. It took 6 days to recover from the trouble.

Zinc mineralization was recognized and confirmed at the depth between 96.90 m and 99.90 m, between 102.80 m and 110.80 m, and between 118.00 m and 122.20 m.

* 164.90 m – 200.50 m : By BQ bits, the hole was excavated in shale and sandstone to the depth of 200.50 m, where the excavation was stopped as the purpose of the hole was thought to have been completed.

10) IC–19

Hole length	:	203.60 m
Core length	:	152.40 m
Core recovery	:	74.9 %
Date commenced	:	November 26, 1984
Date completed	:	February 3, 1985

* 0 m – 103.65 m : By HQ bits, using bentonite mud water, the hole was excavated to the depth of 103.65 m in quartzite, dolostone, and weathered clay fractured zone. Because of the weathered clay fractured zone at the depth between 102.15 m and 103.65 m, jamming happened at the depth of 103.65 m. It took 9 days to recover from the jamming accident. After the recovery, NW casing pipes were sunk to the depth of 103.65 m.

* 103.65 m – 121.50 m : By NQ bits, the hole was excavated in quartzite to the depth of 121.50 m. As the wall was recognized to be stable at this depth, NW casing pipes were sunk to the depth of 121.50 m, after reaming the hole with NW casing diamond shoe bit.

* 121.50 m – 145.00 m : By NQ bits, using bentonite mud water, the hole was excavated in quartzite. In the portion at the depth between 125.50 m and 144.00 m, the hole hit a druse in the quartzite where the wall condition was poor, and BW casing pipes were sunk to the depth of 145.00 m.

* 145.00 m – 203.60 m : By BQ bits, the hole was excataed in quartzite, sulphide ore zone, and shale to the depth of 203.60 m, where the excavation was stopped as the purpose of the hole was thought to have been completed.

I–4 Mobilization and Removal

1) Mobilization

The number of days used for mobilization is given as follows.

IC–17 : 7 days
IC–18 : 3.5 days
IC–11 : 13 days
IC–13 : 6 days
IC–12 : 6 days
IC–16 : 8 days
IC–14 : 5 days
IC–15 : 3.5 days
IC–19 : 8 days

2) **Removal**

As the climate was unfavorable and the condition of the roads for transportation was poor while removal of the equipment from the drill site of IC–19, it was necessary to repair the roads and to transport the equipment and the materials by 8 workers. They were adjusted and stored at the camp after the transportation of 17 km distance. Total 28 days were used for removal.

1–5 Performance of the drilling

1) **Drilling efficiency**

As shown in A.I–11, with regard to drill holes totalling 1908.5 meters, the drill length per shift was 2.54 m/shift, and that of real drill works was 4.17 m/shift.

The drilling pace and the number of bit rotation are given as follows.

	Drilling pace	Number of bit rotation
Hard rocks	1.0 ~ 1.5 cm/min	450 ~ 650 r.p.m.
Moderate rocks	1.5 ~ 2.0 cm/min	350 ~ 450 r.p.m.
Soft rocks	2.0 ~ 2.5 cm/min	250 ~ 350 r.p.m.

2) **Core recovery**

As shown in A. I–11, 1651.35 meters of cores were recovered against 1908.50 meters of the total length of the drill holes.

The average core recovery was 86.5 %.

Fig. I – 1 PROGRESSIVE RECORD OF DIAMOND DRILLING. IC-10

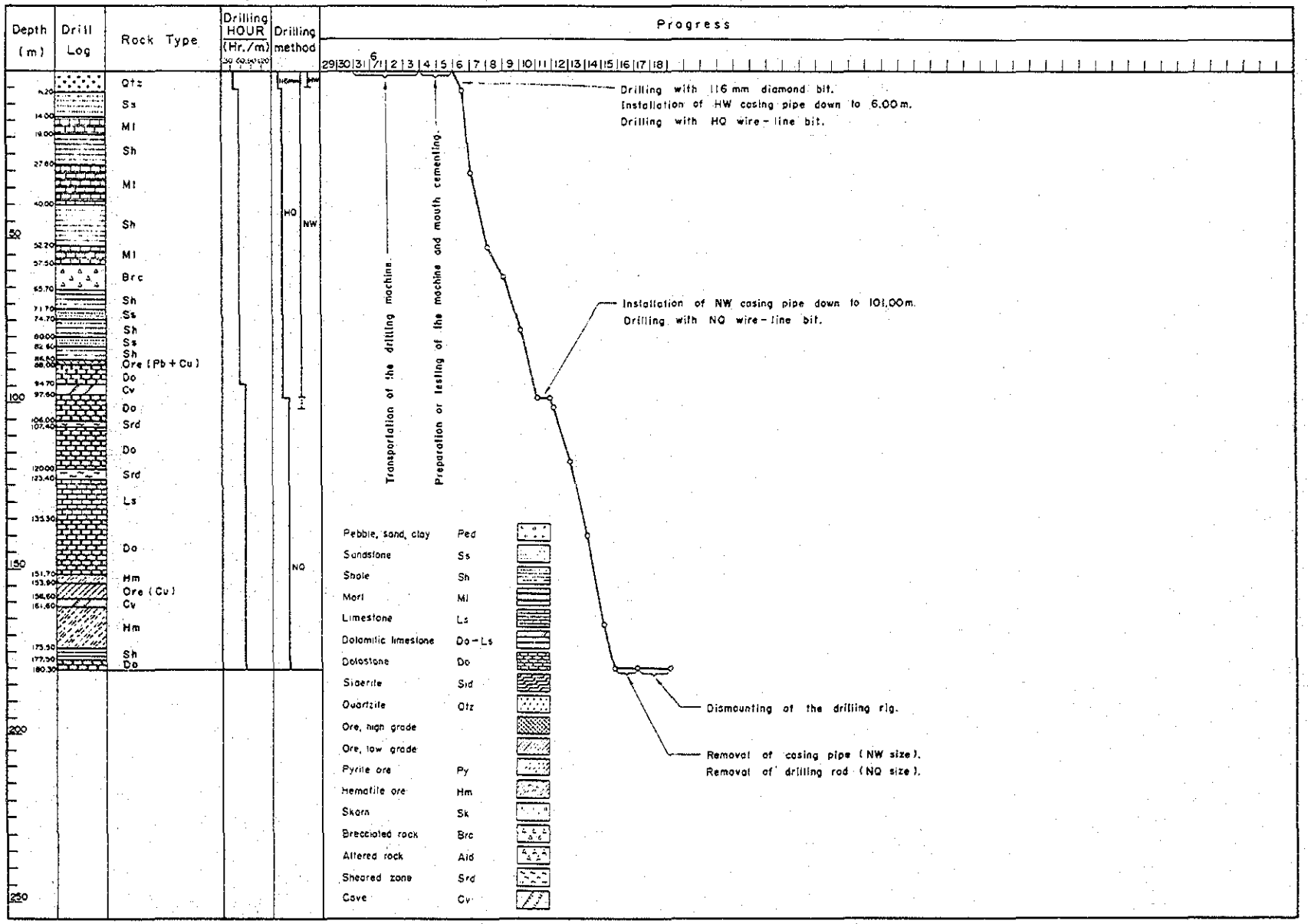


Fig. I - 2 PROGRESSIVE RECORD OF DIAMOND DRILLING. IC-11

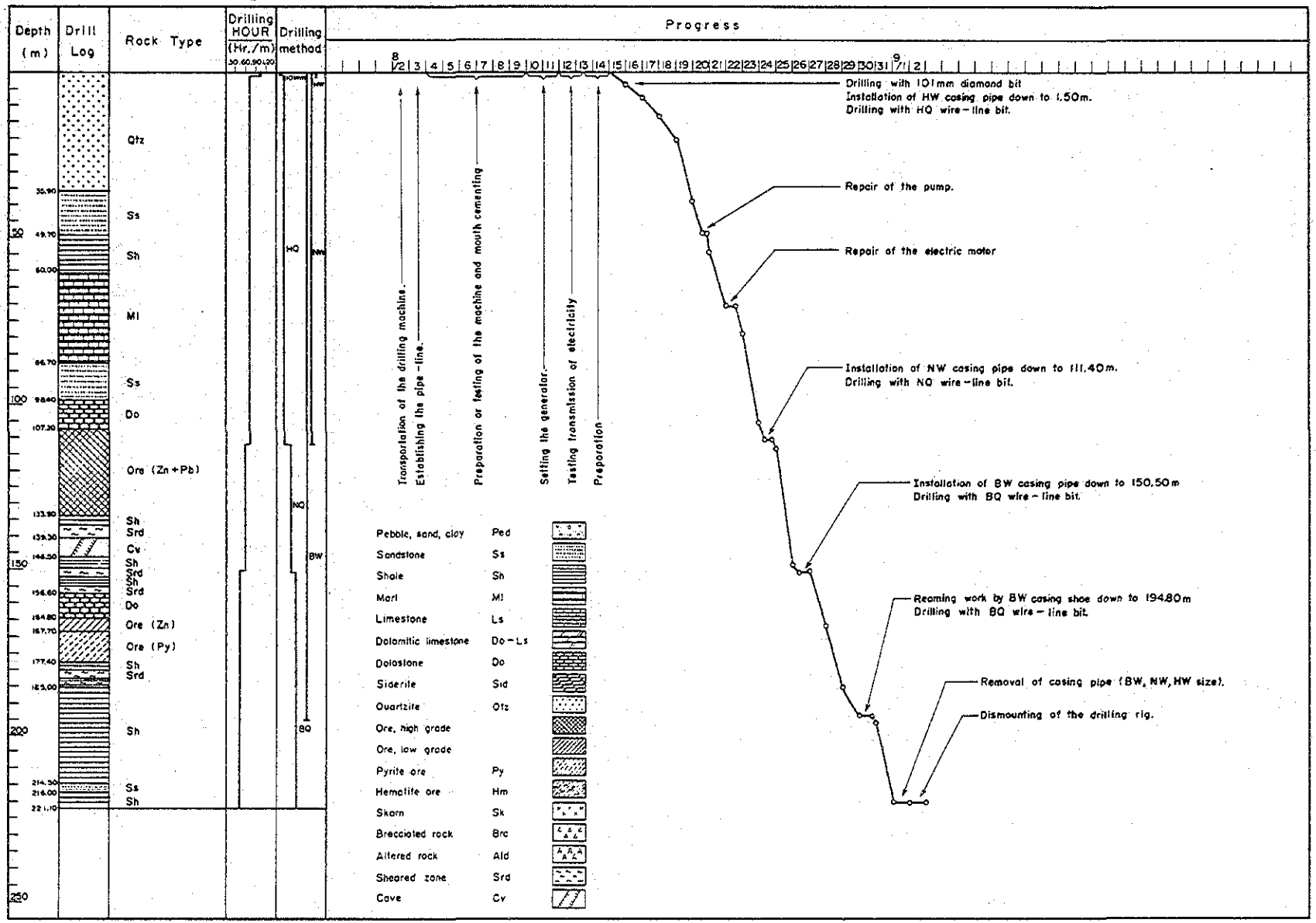


Fig. I - 3 PROGRESSIVE RECORD OF DIAMOND DRILLING. IC-12

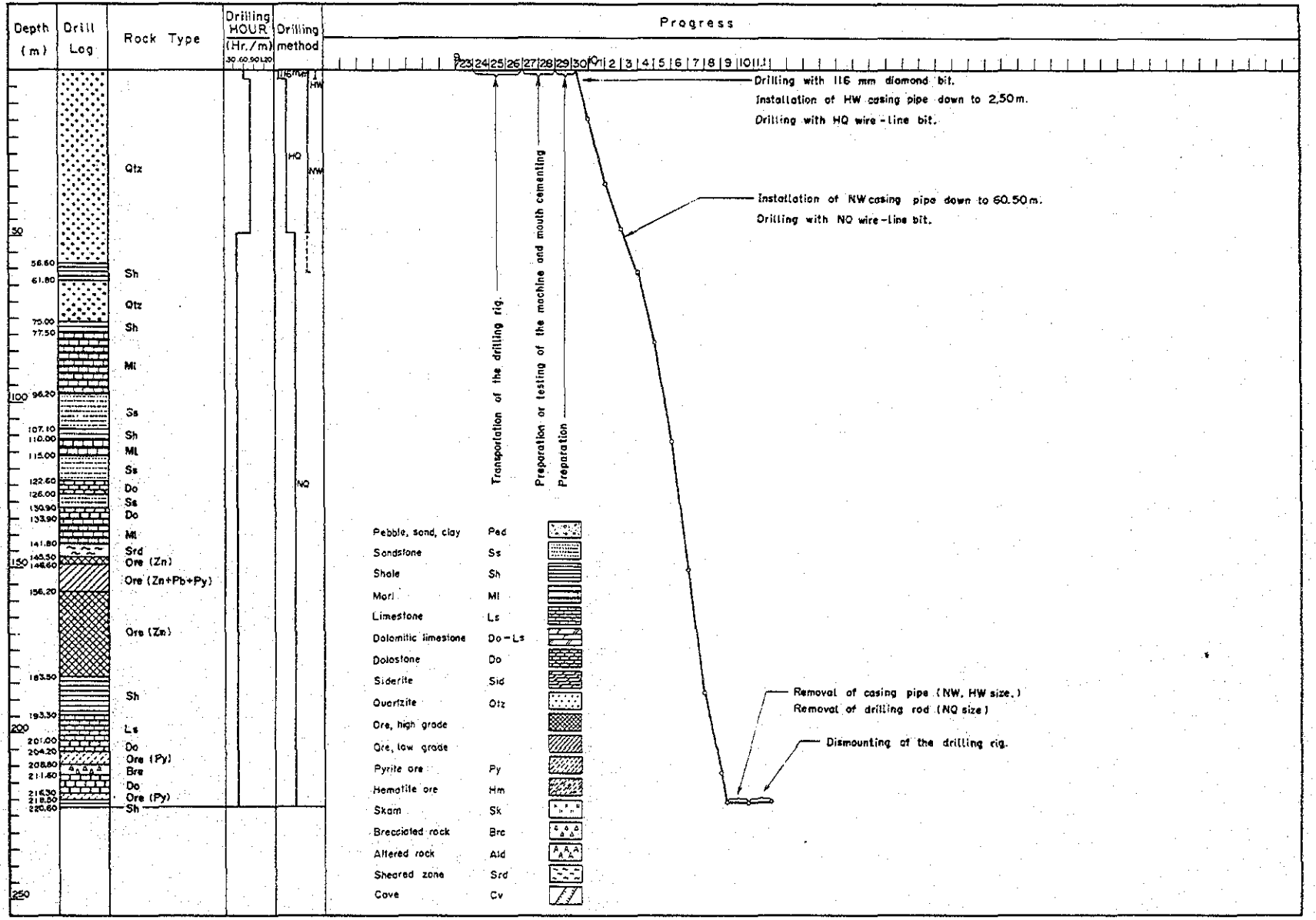


Fig. I-4 PROGRESSIVE RECORD OF DIAMOND DRILLING. IC-13

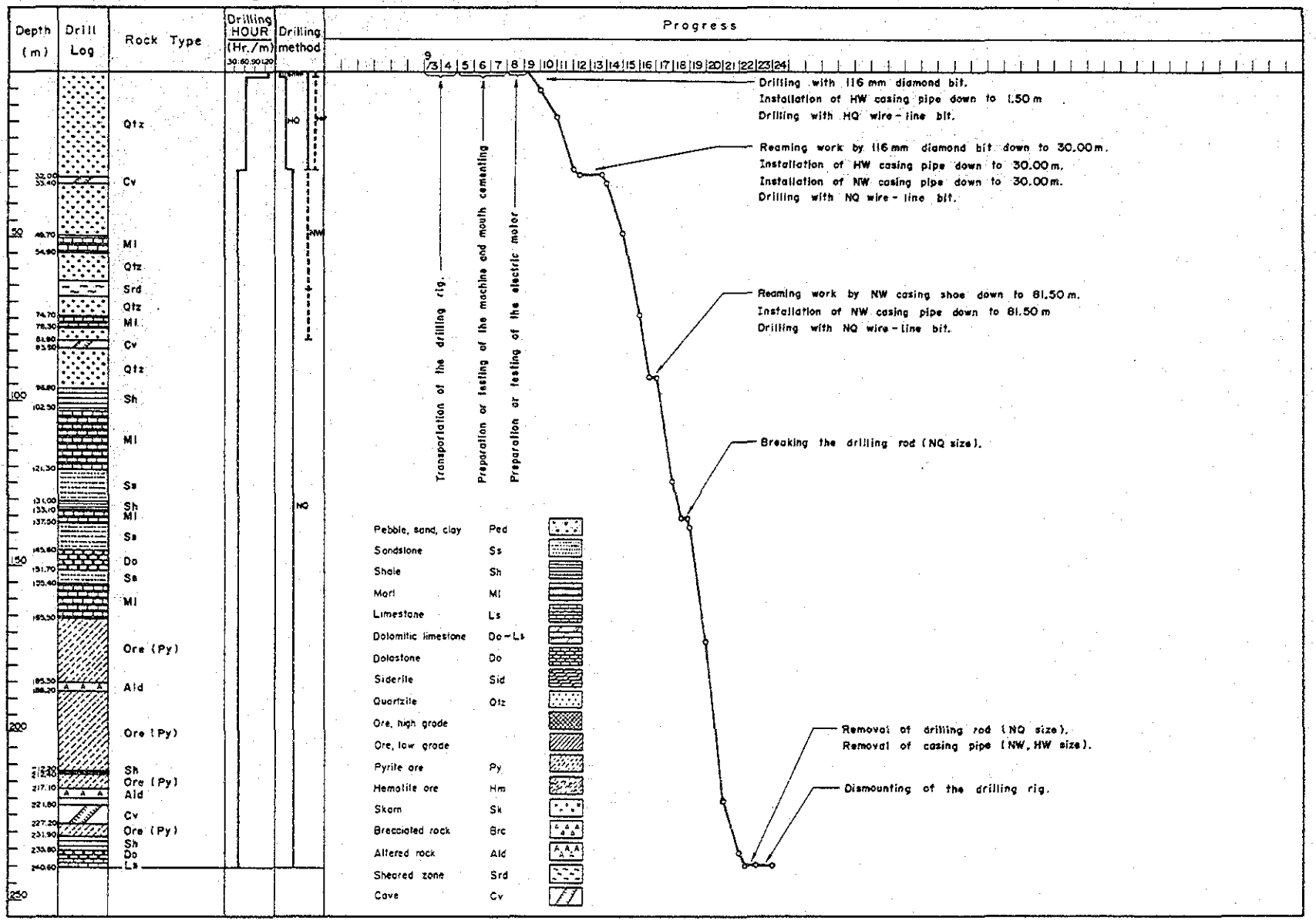


Fig. I – 5 PROGRESSIVE RECORD OF DIAMOND DRILLING. IC-14

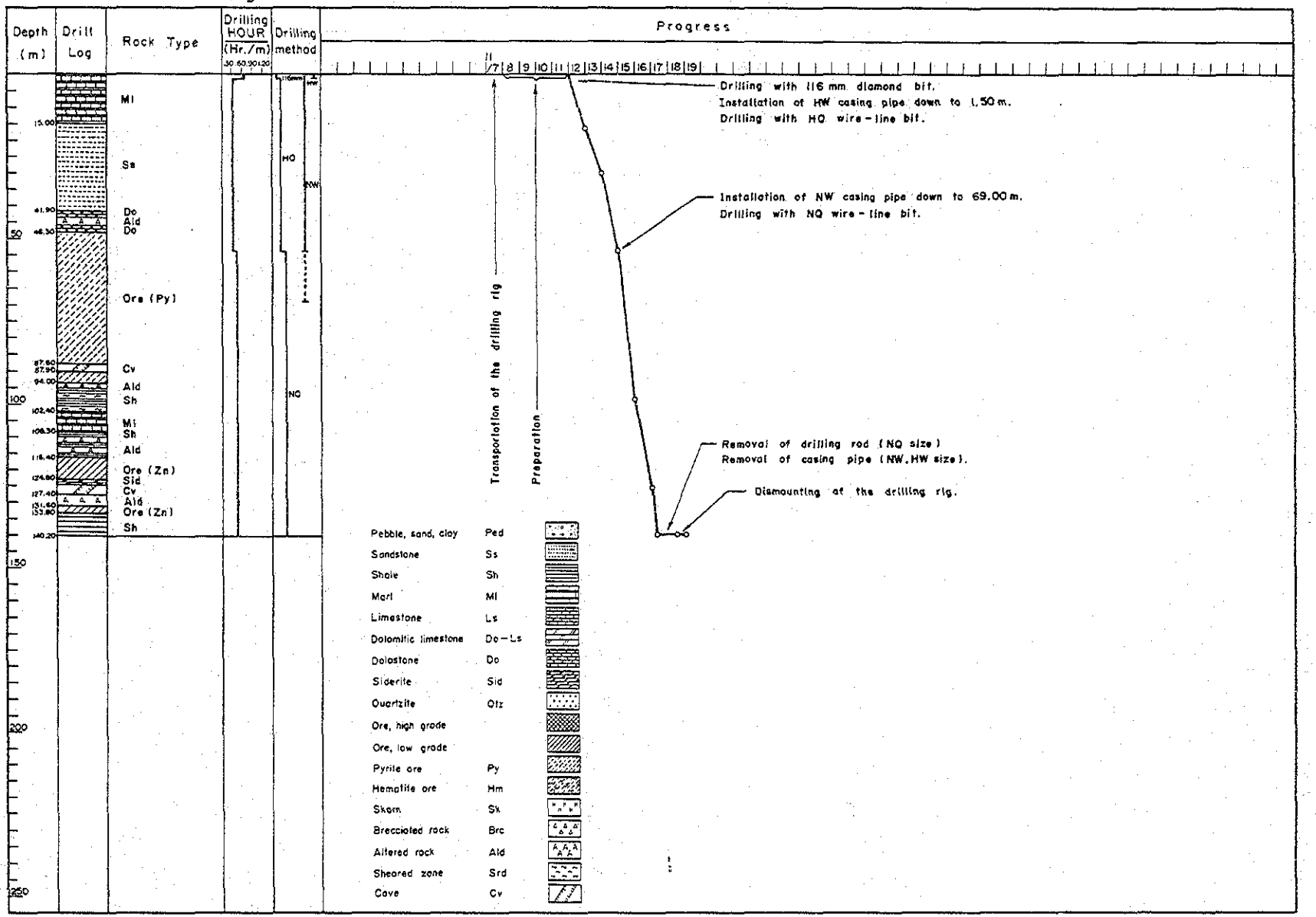


Fig. I-6 PROGRESSIVE RECORD OF DIAMOND DRILLING. IC-15

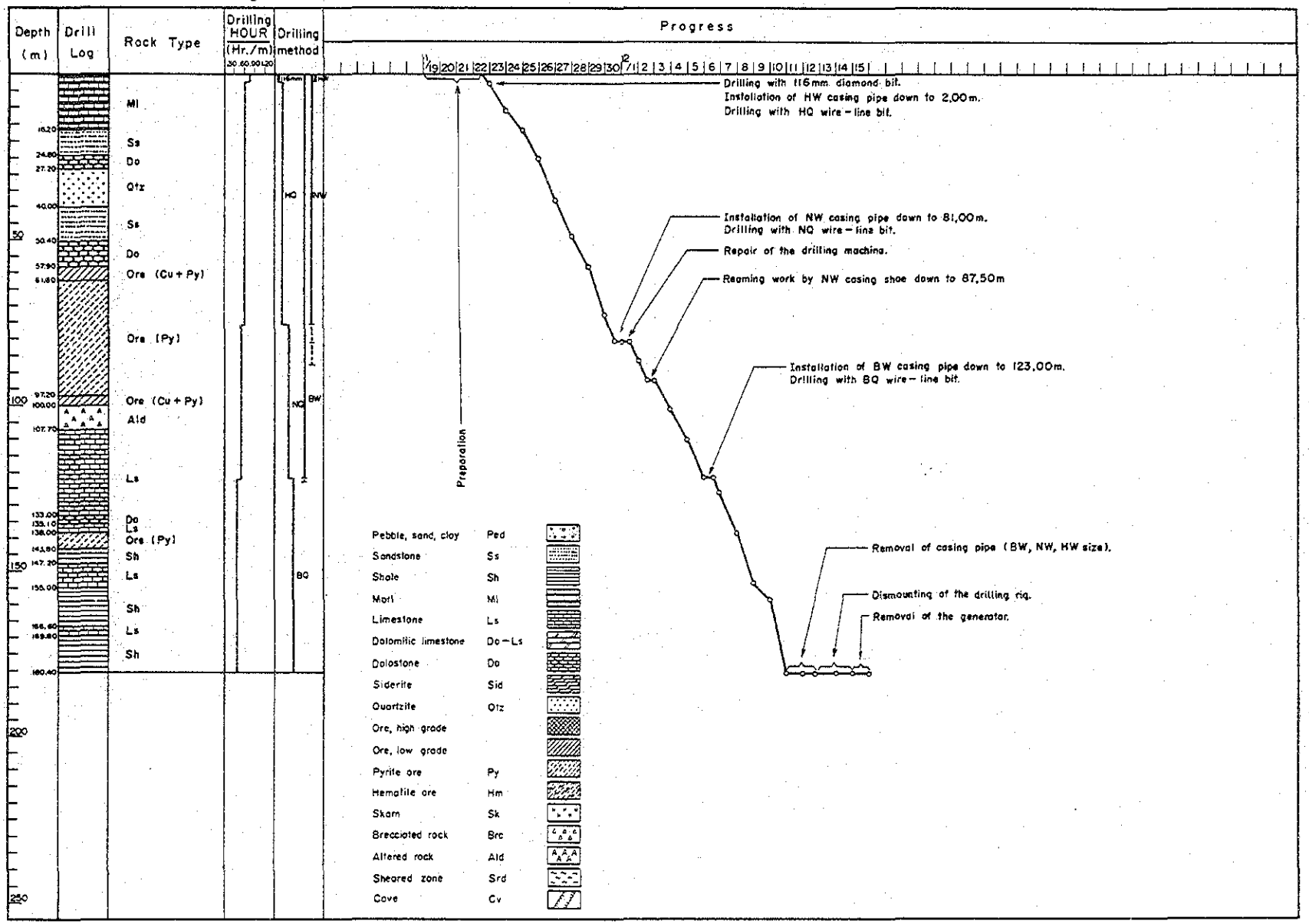


Fig. I – 7 PROGRESSIVE RECORD OF DIAMOND DRILLING. IC-16

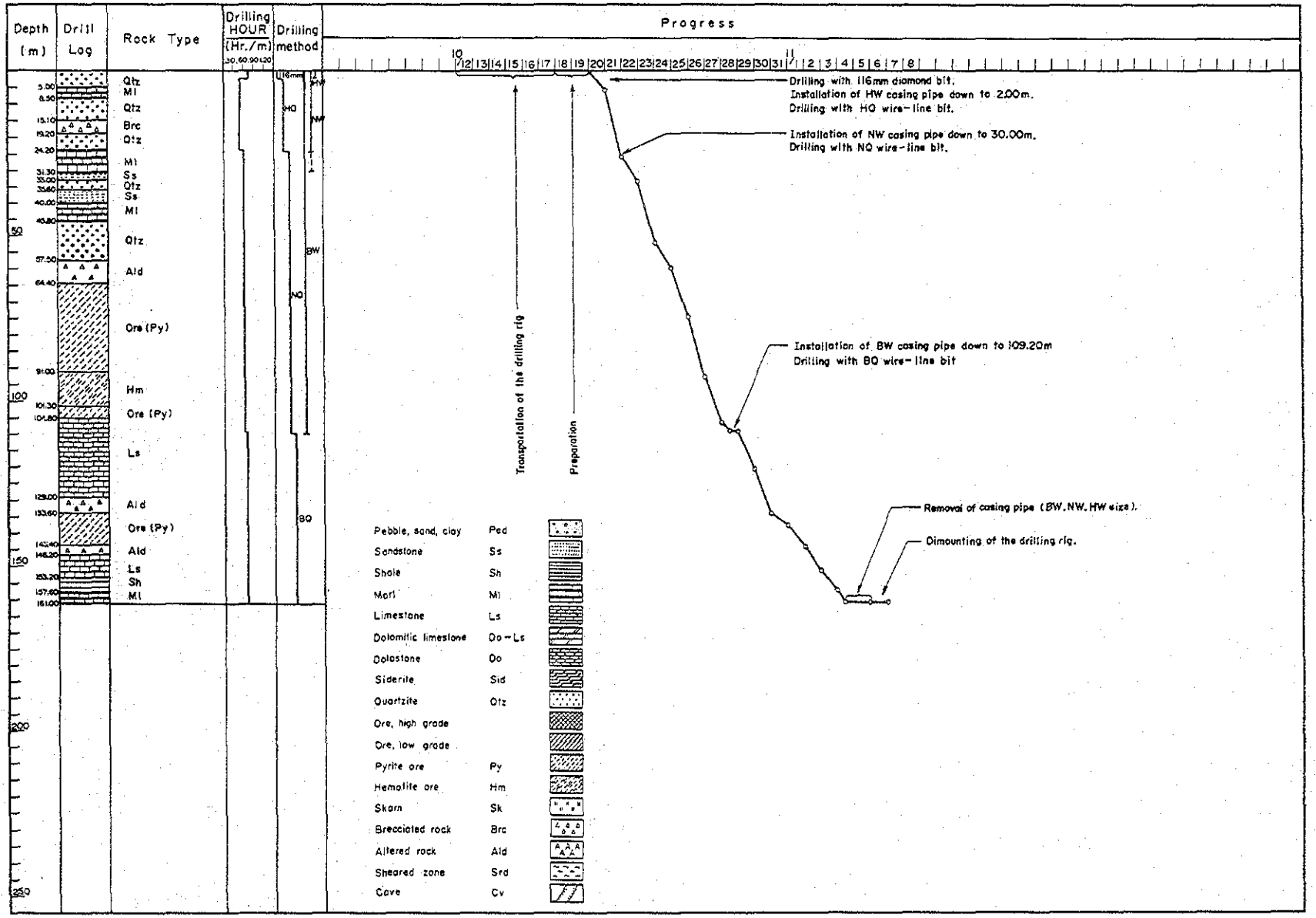


Fig. I – 8 PROGRESSIVE RECORD OF DIAMOND DRILLING. IC-17

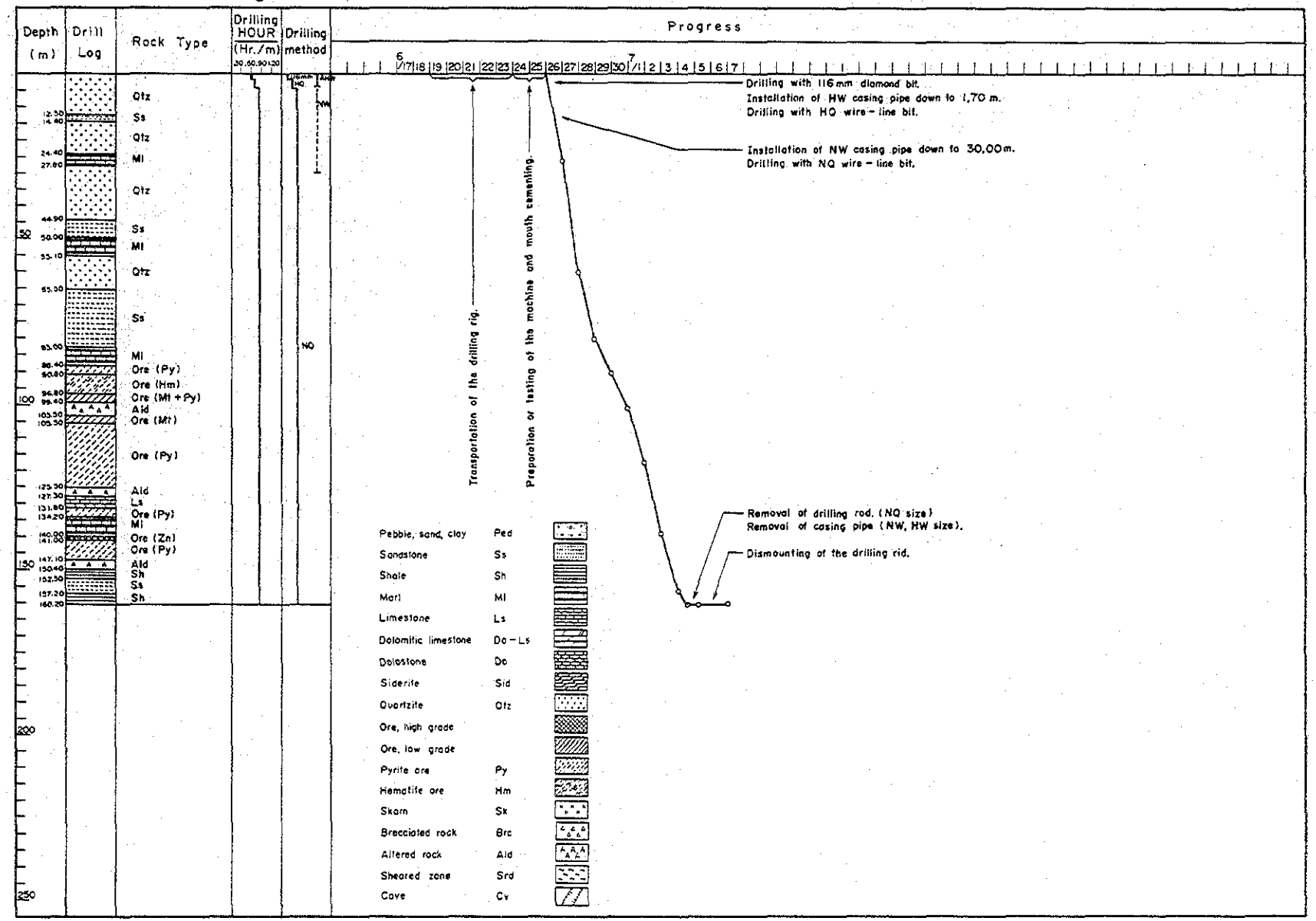


Fig. I-9 PROGRESSIVE RECORD OF DIAMOND DRILLING. IC-18

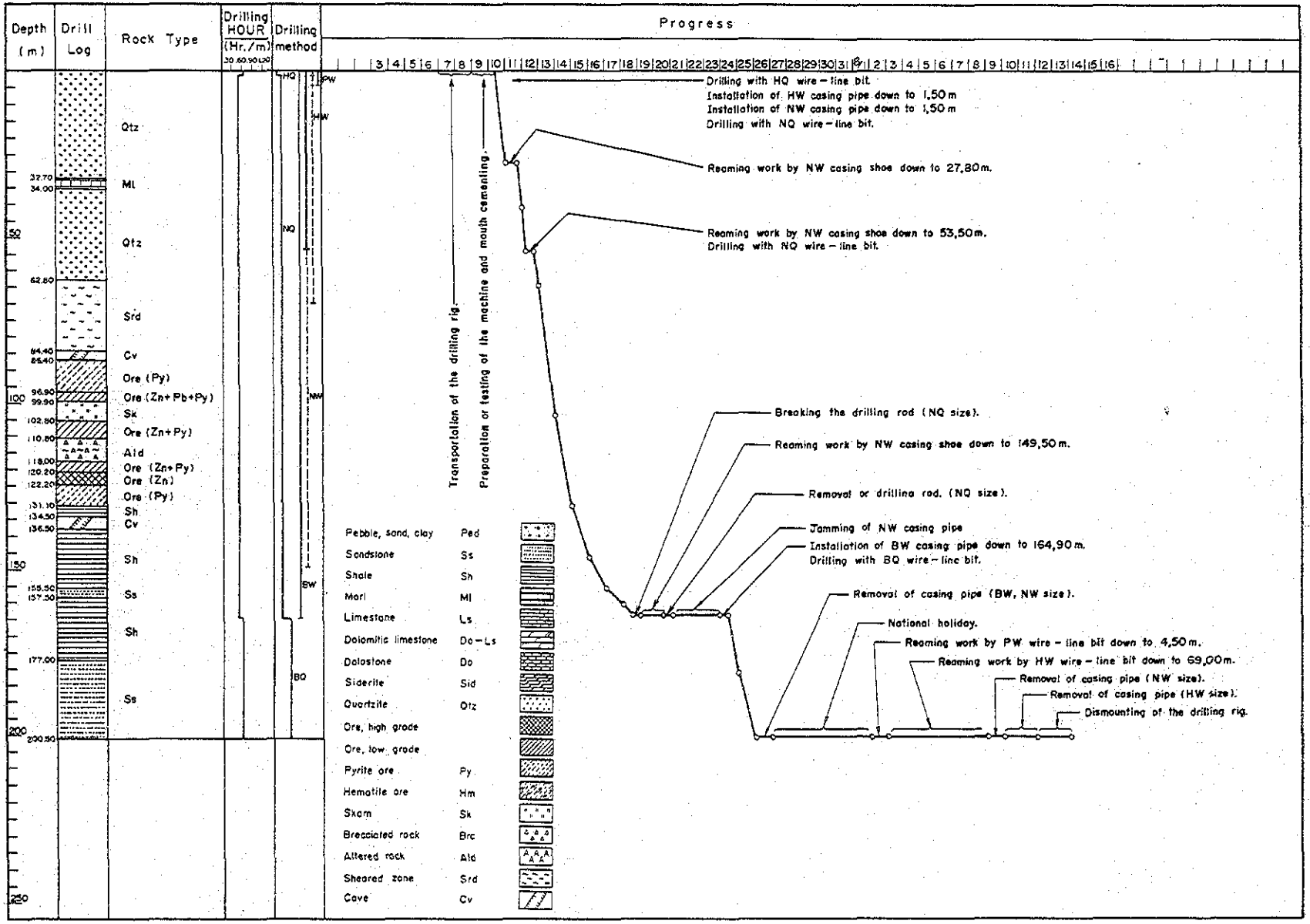
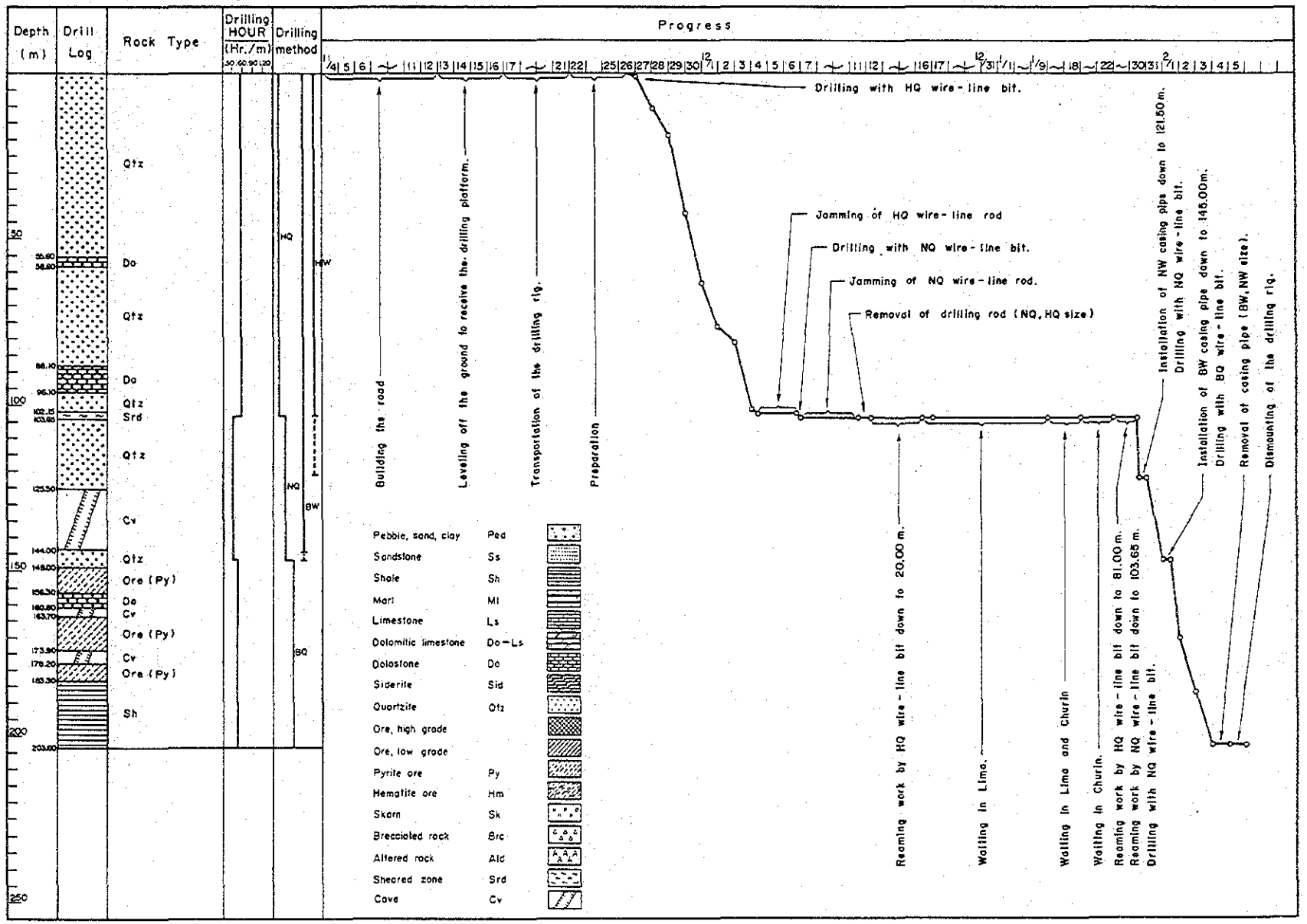


Fig. I – 10 PROGRESSIVE RECORD OF DIAMOND DRILLING. IC-19



CHAPTER 2 GEOLOGY AND MINERALIZATION IN THE DRILL HOLES

2–1 IC–10

(1) Purpose : The purpose of the excavation of this hole was to explore geology and mineralization in the midway area of the two drill holes, DDH–3 and IC–1.

(2) Location : At the point on the surface about 100 meters southwest of the gate of the Adit-N (at the altitude of 4,698 m above sea level). The bearing of the hole was 70°, and the inclination was –45°. The depth of the hole was 180.3 m (Fig. 4 and Fig. 5).

(3) Lithology : Base rock appeared at the depth of 6.2 m. Down to the hole depth of 86.8 m, the rocks were of the Carhuaz Formation which was composed of the alternation of shale, marlstone and sandstone. Santa Formation appeared at the depth of 86.8 m. To the hole depth of 151.7 m, alternation of dolostone and limestone was recognized with some thin insertions of shale. At the hole depth between 151.7 m and 174.5 m, the core was composed of hematite and pyrite with the dissemination of copper minerals.

Below the depth of 174.5 m, shale was recognized and dolostone appeared the bottom of the hole (Fig. I–11 and PL. I–10).

(4) Mineralization and grade : Dissemination of lead and zinc minerals was confirmed in the dolostone and in the siderite, and the dissemination of copper minerals was found in the hematite. However, as they were recognized to be only slightly disseminated, it can be said that no notable mineralization was confirmed in this hole.

2–2 IC–11

(1) Purpose : The purpose of the excavation of this hole was to explore the depth of the pyrite orebody found in the crosscut No.1 tunnel of the Adit-N as well as the northern extention of the enriched portion of the lead-zinc-copper mineralization caught in the drill hole IC–2.

(2) Location : Underground drilling at the point 310 m deep from the gate of the Adit-N. The bearing of the hole was 225°, and the inclination was –40°. The depth of the hole was 221.1 m.

(3) Lithology : Down to the depth of 75.0 m, the rocks were of the Chimu Formation, which was composed mainly of quartzite. To the depth of 98.4 m, transitional zone of the Chimu Formation was recognized, comprising sandstone, shale and marlstone. Down below the depth of 98.4 m, the Santa Formation appeared. To the depth of 107.2 m, dolostone was found and in the portion of the depth between 107.2 m and 133.9 m, high grade lead-zinc orebody was confirmed in the core of the length of 26.7 m. To the depth of 164.8 m, altered rocks and dolostone was

found, and in the portion of the depth between 164.8 m and 177.4 m, pyrite with zinc dissemination was confirmed. Down below the depth of 185.2 m, was found the Carhuaz Formation composed mainly of shale (Fig. I–12 and PL. I–11).

(4) Mineralization and grade : The analysis results of the ore samples collected from the parts of the high grade mineralization are given as follows.

Depth (m)	Length (m)	No. of Samples	Ag (g/t)	Cu (%)	Pb (%)	Zn (%)
107.2–115.4	8.2	5	39	0.05	4.44	7.97
115.4–124.5	9.1	9	47	0.05	1.38	39.16
124.5–133.9	9.4	5	25	0.04	3.94	19.00
Average	26.7	19	38	0.04	3.16	22.69

(5) Discussion : The above orebody was composed of a large amount of sphalerite including dots and aggregates or in some cases dendric aggregates of disseminated pyrite. Under microscope, small amount of galena, marcasite and pyrrhotite were recognized in addition to the above stated.

As the angle of the drill hole against the structure of the orebody was about 50° (the complement of 40°), the true thickness of this mineralized portion is estimated to be as follows;

$$26.7 \text{ m} \times \sin 50^\circ = 20.45 \text{ m}$$

2–3 IC–12

(1) Purpose : The purpose of this hole was to explore mineralization along the lower extension of the pyrite orebody caught in the No.2 crosscut of the Adit-N, and to investigate the area in the midst of the indications of lead-zinc-copper enriched mineralization found in the drill holes of IC–2 and DDH–5.

(2) Location : Underground drilling at the working face (410 m from the gate) of the Adit-N. The bearing of the hole was 270° and the inclination was –43°. The depth of the hole was 220.6 m.

(3) Lithology : Down to the hole depth of 75.0 m, the rocks were of the Chimu Formation which was composed mainly of quartzite with the inserted layers of shale and marlstone.

To the hole depth of 130.9 m, transitional zone of the Chimu Formation was recognized, comprising the alternation of sandstone, marlstone and dolostone.

The Santa Formation appeared below the depth of 130.9 m. The Formation was composed of brecciated rocks of dolostone, limestone, marlstone and altered rocks. In the portion of the

depth between 144.3 m and 183.5 m, was confirmed a high grade lead-zinc orebody in the core of the length of 39.5 m. The portion of the depth between 204.2 m and 208.8 m was composed mainly of pyrrhotite and the portion of the depth between 216.3 m and 128.5 m was composed of pyrite. Phyllitic shale was found at the bottom of the hole (Fig. I–13 and PL. I–12).

(4) Mineralization and grade : Below is given the analysis results of the ore samples collected continuously from every one meter of the core of the length of 39.5 m, where lead-zinc mineralization was confirmed.

Depth (m)	Length (m)	No. of Samples	Ag (g/t)	Cu (%)	Pb (%)	Zn (%)
144.3–161.5	17.2	17	40	0.01	2.11	8.37
161.5–175.5	14.0	14	153	0.48	3.23	44.80
175.5–183.5	8.0	7	32	0.06	2.64	21.59
Average	39.2	38	78	0.19	2.61	24.08

(5) Microscopic Observation

*IC–12–162 : Composed mainly of a large amount of sphalerite. Pyrite grains are found scattered in sphalerite. Seams of sphalerite, galena and pyrite are recognized to develop cutting the above sphalerite. The ore is composed megascopically of two kinds of sphalerite, dark brown sphalerite and yellow ~ pale brown one. The latter is found to occur in fine seams in the former.

*IC–12–163 : Composed mainly of a large amount of sphalerite. Fine grained galena and euhedral pyrite crystals are found in sphalerite. Lattice-like exsolution structure of pyrrhotite is observed in the sphalerite.

*IC–12–167 : Composed mainly of sphalerite with minor amount of chalcopyrite and pyrite . Fine grains of gersdorffite are recognized. Numerous fine chalcopyrite grains are included in sphalerite, which shows remarkable exsolution structure. Chalcopyrite is observed in fine grains or in dots in sphalerite. It is also associated intimately with pyrite, as is recognized in cracks of pyrite and around pyrite grains. This ore is composed megascopically of two kinds of sphalerite, greenish dark grey sphalerite and pale brown sphalerite. The latter is found to occur in fine seams in the former sphalerite. It is inferred that the former is the one which has exsolution structure of chalcopyrite.

*IC–12–170 : Composed mainly of sphalerite. The sphalerite includes numerous fine chalcopyrite grains and has some zoning structure. Megascopically, it is characteristic that the sphalerite has greenish dark grey color.

*IC–12–174 : Composed mainly of a large amount of sphalerite with minor amount of galena and pyrite. Galena is found to occur in fine grains or in dots in sphalerite. Pyrite is observed to be in aggregates in sphalerite. Megascopically, it is characteristic that the ore has dots or aggregates of galena and pyrite in dark brownish sphalerite.

*IC–12–178 : Composed mainly of a large amount of sphalerite with minor amount of galena and pyrite.

*IC–12–183 : Composed mainly of sphalerite with minor amount of galena, pyrite, chalcopyrite and pyrrhotite. In parts of pyrite, is recognized concentric colloform-like ring structure or corrosion-like structure.

(6) Discussion : According to the X-ray diffraction analysis, the ore is composed mainly of sphalerite while the gangue minerals are mainly quartz associated with chlorite and siderite.

It is megascopically characteristic that the ore is brecciated remarkably. Sphalerite has replaced the brecciated wall rocks. Also, sphalerite of other quality is found to have precipitated in spaces in brecciated ore mass, associated with pyrite and galena.

Unmineralized breccias are included in some cases.

The following three qualities of sphalerite are recognized in the subject ore.

a) greenish dark grey sphalerite : Includes numerous very fine chalcopyrite and has exsolution structure. Composed almost solely of sphalerite and the ore grade reaches up to 40% or even to 50% of Zn.

b) dark brown sphalerite : Fe content is estimated to be highest in this type of sphalerite. The sphalerite is found to include dots and aggregates of pyrite and galena. The ore grade reaches up to 30% or 40% of Zn.

c) yellow ~ pale brown sphalerite : This type of sphalerite is usually pale and transparent in color, and is estimated to contain least Fe content. The sphalerite is recognized to occur in fine seams and disseminatedly in the above-stated two types of sphalerite. Usually, it is associated with euhedral pyrite and galina.

As for the pyrite found in the ore, the following differences are recognized with the occurrences.

a) The brecciated pyrite. Along the cracks sphalerite is found to have been precipitated or to have replaced the pyrite.

b) The pyrite found in dots or in aggregates in massive sphalerite. The pyrite is recognized to have been corroded and replaced by the sphalerite.

c) The pyrite found in dendric aggregates in massive sphalerite.

d) The pyrite found in veinlets, associated with galena, sphalerite, chalcopyrite etc. This type

of pyrite is euhedral in usual cases.

From the viewpoints of the above-stated particularities of the ore minerals and ore deposits, it is thought that the followings are the characteristics of the subject ore deposits.

1) Remarkable structural movement would have been there during the period of the mineralization.
2) There must have been at least two or three stages as to mineralization.
3) It is thought to be likely that the ore minerals would have precipitated rapidly in a comparatively short period under the condition of relatively low temperature.
4) Brecciation and fracturing are closely related to the mineralization.

(7) Scale of the ore deposit

The angle of the surface structure of this ore deposit against the direction of the drill hole is about 55° (the complement of 35°) and the true thickness of this ore deposit is estimated as shown below.

$$39.2 \text{ m} \times \sin 55^\circ = 32.11 \text{ m}$$

2–4 IC–13

(1) Purpose : The purpose of this drill hole was to explore the southern extension of the rich mineralization which had been caught by the drill hole DDH–5.

(2) Location : Underground drilling at the working face of the Adit-N. The bearing of the hole was 215° and the inclination was −43°. The depth of the hole was 240.6 m.

(3) Lithology : Down to the hole depth of 96.8 m, the rocks were of the Chimu Formation which was composed mainly of quartzite. To the hole depth of 155.4 m, transitional zone of the Chimu Formation was recognized, comprising the alternation of sandstone, marlstone, shale and dolostone.

The Santa Formation appeared below the depth of 155.4 m. The Formation was composed of limestone, dolostone and marlstone down to the depth of 165.5 m. In the portion of the depth between 165.5 m and 231.9 m, was confirmed massive pyrite orebody in the core of the length of 66.5 m. Below the depth of 231.9 m, alternation was found composed of shale, marlstone and limestone.

(4) Mineralization and grade : The rocks belonging to the Santa Formation were replaced by massive pyrite as a whole. However, no remarkable dissemination of zinc and copper was recognized in the core.

2–5 IC–14

(1) Purpose : The purpose of this drill hole was to explore the northern extension of the rich mineralization which had been caught by the drill hole DDH–6.

(2) Location : The drill hole was in the underground at the point 710 m deep from the gate of the Adit-S. The bearing of the hole was 270° and the inclination was –30°. The depth of the hole was 140.2 m.

(3) Lithology : Down to the hole depth of 43.8 m, the rocks were of the transitional zone of the Chimu Formation, which was composed of the alternation of sandstone and marlstone.

The Santa Formation appeared below the depth of 43.8 m. In the portion of the depth between 48.3 m and 94.0 m was confirmed massive pyrite orebody in the core of the length of 45.7 m. Five layers of zinc orebodies were recognized at the depth between 100.7 m and 133.8 m, the most remarkable of which was found to be the one at the depth between 113.9 m and 123.7 m in the core length of 9.8 m. Below the depth of 133.8 m, was recognized shale of the Carhuaz Formation.

(4) Mineralization and grade : Below is given the analysis results of the ore samples collected from the mineralized portion of the drill cores.

Depth (m)	Length (m)	No. of Samples	Ag (g/t)	Cu (%)	Pb (%)	Zn (%)
100.7–102.4	1.7	1	30	0.43	0.02	17.50
107.1–113.9	6.8	4	18	0.05	0.04	9.90
113.9–123.7	9.8	9	42	0.27	0.19	21.56
131.6–133.8	2.2	2	28	0.28	0.06	31.00

The average grade of the portion of the core of the length of of 16.6 m at the depth between 107.1 m and 123.7 m was Ag; 23 g/t, Cu; 0.18%, Pb; 0.13% and Zn; 16.78%.

(5) Discussion : According to the X-ray diffraction analysis (IC–14–15), the main alteration minerals were sericite, quartz and chlorite. By the microscopic observation of the polished section of the ore, sphalerite and magnetite are closely associated each other and sphalerite includes very fine grain chalcopyrite.

2–6 IC–15

(1) Purpose : The purpose of this drill hole was to explore the copper mineralization in the area midst of the drill holes of DDH–6 and IC–4.