REPORT
ON
THE MINERAL EXPLORATION
IN
THE OTAVI MOUNTAINLAND AREA
THE REPUBLIC OF NAMIBIA

PHASE III

MARCH [illegible]

JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN

REPORT
ON
THE MINERAL EXPLORATION
IN
THE OTAVI MOUNTAINLAND AREA
THE REPUBLIC OF NAMIBIA

PHASE III

MARCH, 1998

JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN

PREFACE

In response to the request of the Government of Namibia, the Japanese Government decided to conduct a Mineral Exploration Programme in the Otavi Mountainland Area Project and entrusted the survey to the Japan International Cooperation Agency (JICA) and the Metal Mining Agency of Japan (MMAJ).

JICA and MMAJ sent a survey team to Namibia headed by Mr. Tetsuo Hatasaki from 4 August to 29 November, 1997.

The team exchanged views with the officials of the Government of Namibia and conducted a field survey in the Otavi Mountainland area. When the team returned to Japan, further studies were made and this report has been prepared.

We trust that this report will serve the development of mineral deposits and contribute to the promotion of friendly relations between the two countries.

We wish to express our deep appreciation to the officials concerned of the Government of Namibia for their close cooperation extended to the team.

February 1998

Kimio FUJITA
President
Japan International Cooperation Agency

Hiroaki HIYAMA
President
Metal Mining Agency of Japan

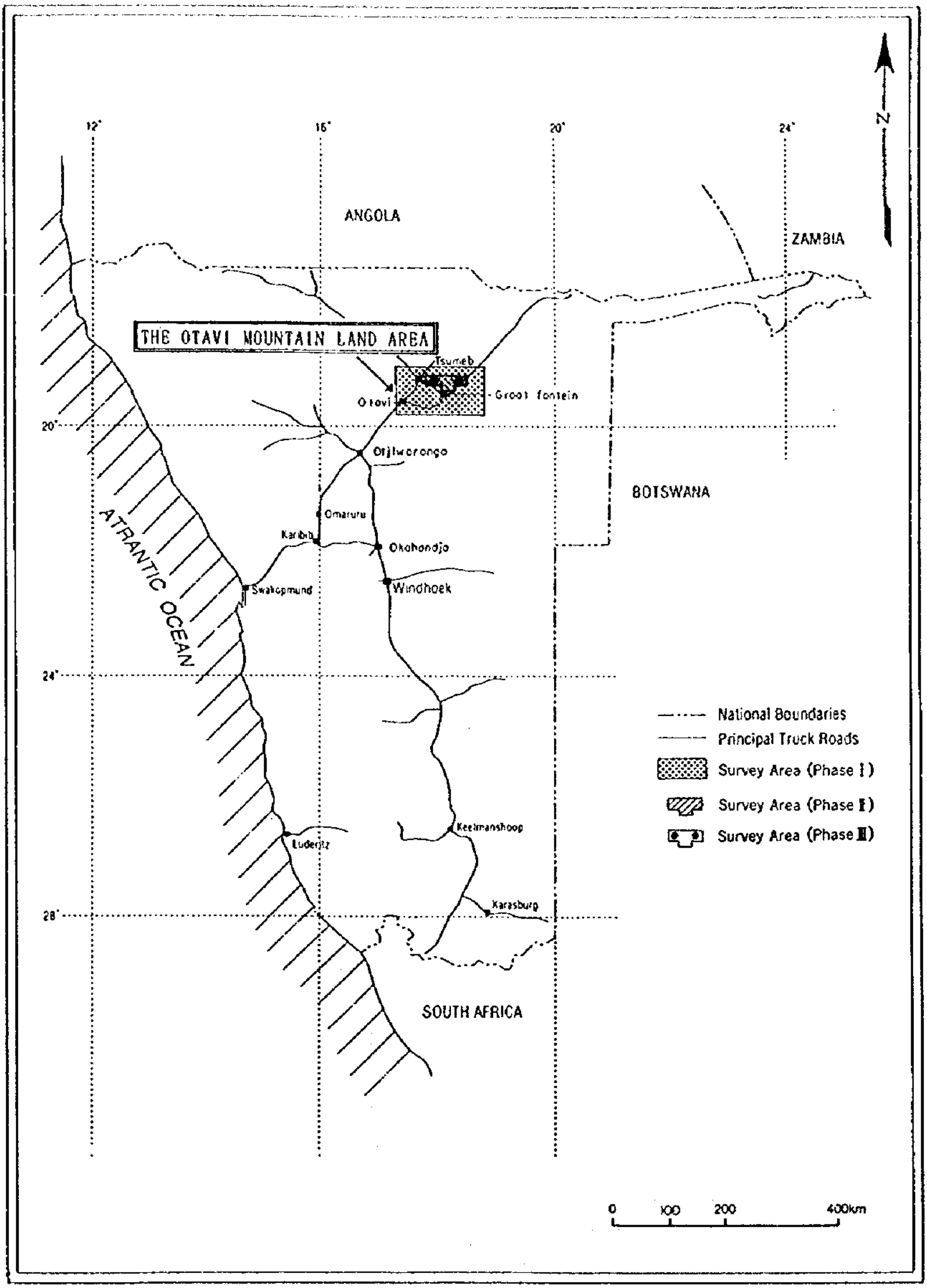

Fig. I - 1 - 1 Index map of the Otavi Mountain Land Area

Summary

The phase III exploration programme consisted of follow-up by drilling of eight airborne electromagnetic anomalies, which were delineated during the Phase II survey. The physical properties of the core were measured and the data was used for interpretation of the anomalies.

Low grade lead and zinc mineralisation was intersected by bore hole MJNM-9 in the east of the survey area. This hole is located 700 metre northwest of MJNM-1 which was drilled during Phase II and the mineralisation is deemed to an extension of that of MJNM-1. The mineralisation is stratigraphically controlled by T4 which is characterized by dolomite grainstone. The mineralisation assayed 0.83% Pb and 0.17% Zn over 0.75 metres, with an average grade of combined Pb-Zn of 0.129% over 5.24 meters, which is much weaker than MJNM-1.

In hole MJNM-11, drilled in the west of the survey area, some dots of chalcopyrite and galena were observed. These are associated with an intensely fractured zone within the upper Tsumeb subgroup. The chemical assays indicated a considerable concentration of Cu, Pb and Zn and it is suggested that the mineralisation is of Tsumeb · Kombat type based upon the metal ratio. This weak mineralisation could be associated with the ENE-WSW resistivity lineament which runs through the Tsumeb ore deposit and therefore it could be a tracer for an ore deposit of moderate size.

The interpretation of airborne electromagnetic anomalies with correlation to the result of drilling revealed that the Damara system and subsurface structure of the area extends throughout the survey area covered by the calcrete. The exploration rationale was that an ore deposit should be hosted in a Karst cavities and should be related to a deep-seated growth fault which should give a signal of low resistivity anomaly in a high resistivity terrain. However, practically the drilling suggested that the lineament and spots of low resistivity which traverse subsurface structure, were correlated to a swarm of dolerite dyke and their surrounding hydrothermal alteration zones. The observed resistivity values of core samples also supported this suggestion. No favourable structures for ore formation such as Karst and solution breccias were encountered in the holes.

The Mulden group sandstone was expected to occur extensively based on the previous maps and the current airborne geophysical survey of Phase I and II, however holes drilled in these areas intersected no sandstone of the Mulden group. This explains the incoherent resistivity of surface formations and that a detail interpretation of resistivity is thus inevitable for the interpretation of deeper structure of geology.

The planned depth of the drill holes proved to be adequate for subsurface exploration judging by the depth of each of the frequency resistivity profiles prepared in Phase II and the comparison to the observed geology.

The above results and interpretation led to the future recommendation starting from an airborne geophysical survey over the known ore deposits and coming to a proposal of new area.

CONTENTS

Figure page

Table		page

Part I General Remarks

Part I General Remarks

Chapter 1 Introduction

I-1-1. Background and Objective of the Survey

This survey is part of a three year-mineral exploration project which started in 1995. The survey was conducted in the Otavi Mountainland Area of Namibia, which is one of the most promising base metal provinces of the country. Two operating mines; Kombat and the new Khusib Springs and several dormant mines as well as many mineral deposits are situated in this area. The area has been in explored by several companies. Exploration mainly focused on the areas of outcrop where most of the deposits are located. However, exploration in areas overlain by calcrete and Kalahari sediments was minimal due to the difficulties in experienced in assessing the underlying geology. The depletion of ore reserves in the operating mines and the favorable geological setting of this area has necessitated the urgent appraisal of mineral potential and exploration in the eastern extension of the Otavi Mountain Land. The Government of Namibia, through the Ministry of Mines and Energy has thus requested the Japanese Government to conduct a proper exploration survey in this area by means of bilateral technical aid.

Initially the Japanese government embarked on the survey by conducting a high resolution geophysical survey as well as research and compilation of the previous exploration information. The second phase programme included an airborne electromagnetic survey and drilling. This phase was followed up by a more detailed drilling survey which aimed to locate potential mineralisation based on the results of the previous two-year's exploration.

I-1-2. Conclusion of Phase II and Recommendation for Phase III

I-1-2-1. Conclusion of Phase II

The Phase II survey included an airborne geophysical survey(airborne electromagnetic survey), a drilling programme as well as the measurement of geophysical properties of the drill core. The survey concluded as follows through discussion of the details.

1. Four drill holes were sunk targeting the aeromagnetic anomalies delineated during Phase I targeting massive sulphide ore pipes of Tsumeb/Kombat type.

One hole; MJNM-1, intersected low grade lead and zinc mineralisation in the form of dissemination and network.

2. The mineralisation showed average grade of 0.23% lead and 0.38% zinc over 9.16m.

Within 9.16 metre, the mineralised portions that showed more than 1 percent concentration, are as follows.

111.58m-111.69m(0.11m) Pb=1.45%

112.30m-112.62m(0.32m) Pb=4.52% Zn=1.58%

245.75m-246.25m(0.50m) Zn=1.76%

246.25m-246.65m(0.40m) Zn=2.28%

3. Microscopic occurrences and chemical assays indicate that the mineralisation formed in a similar way to Mississippi Valley Type ore deposits.

4. No specific relationship between the mineralisation and aeromagnetic anomalies were established.

5. Geophysical properties of the core suggested that the mineral occurrence of this type would give very poor resistivity response for electromagnetic signals.

6. The electromagnetic survey by frequency method produced three resistivity plan maps of depths corresponding to three frequencies. The maps indicate the lithological contrast and general trend of geology. Some local low resistivity anomaly zones within a high resistivity zone traversing the geological trend were believed to be important targets for mineral deposits of massive sulphide pipes in particular, when they overlap with aeromagnetic lineaments.

7. The favourable areas were thus delineated for further exploration programme of Phase Ⅲ. The area selected was situated to the west of MJNM-1 and extends 8 kilometres from east to west 5 kilometres north to south. This included parts of Guinab 277, Aris 283 and Vogelsang 284.

I-1-2-2. Recommendation for Phase Ⅲ programme

Based upon the result of the survey and subsequent discussion and interpretation of all the data available, the following exploration programme for Phase Ⅲ was proposed.

(1)Survey area

The area is illustrated in Fig. Ⅱ －4－1. It is located in eastern portion of the Phase Ⅱ survey area and extends within Guinab 277, Aris 283 and Vogelsang 284 encompassing 8 kilometres east to west and 5 kilometres north to south.

(2)Exploration method

The drilling survey proposed followed that of Phase Ⅱ survey, targeting the subsurface evaluation of airborne electromagnetic anomalies. The target depth of holes was estimated at 300 metres each, and as the calcrete underlying first 80 metres from the surface has no ore potential, percussion drilling was done.

(3)Amount of survey

The budgeted time and finances for Phase Ⅲ would allow 6 holes with total depth of 1800 metres.

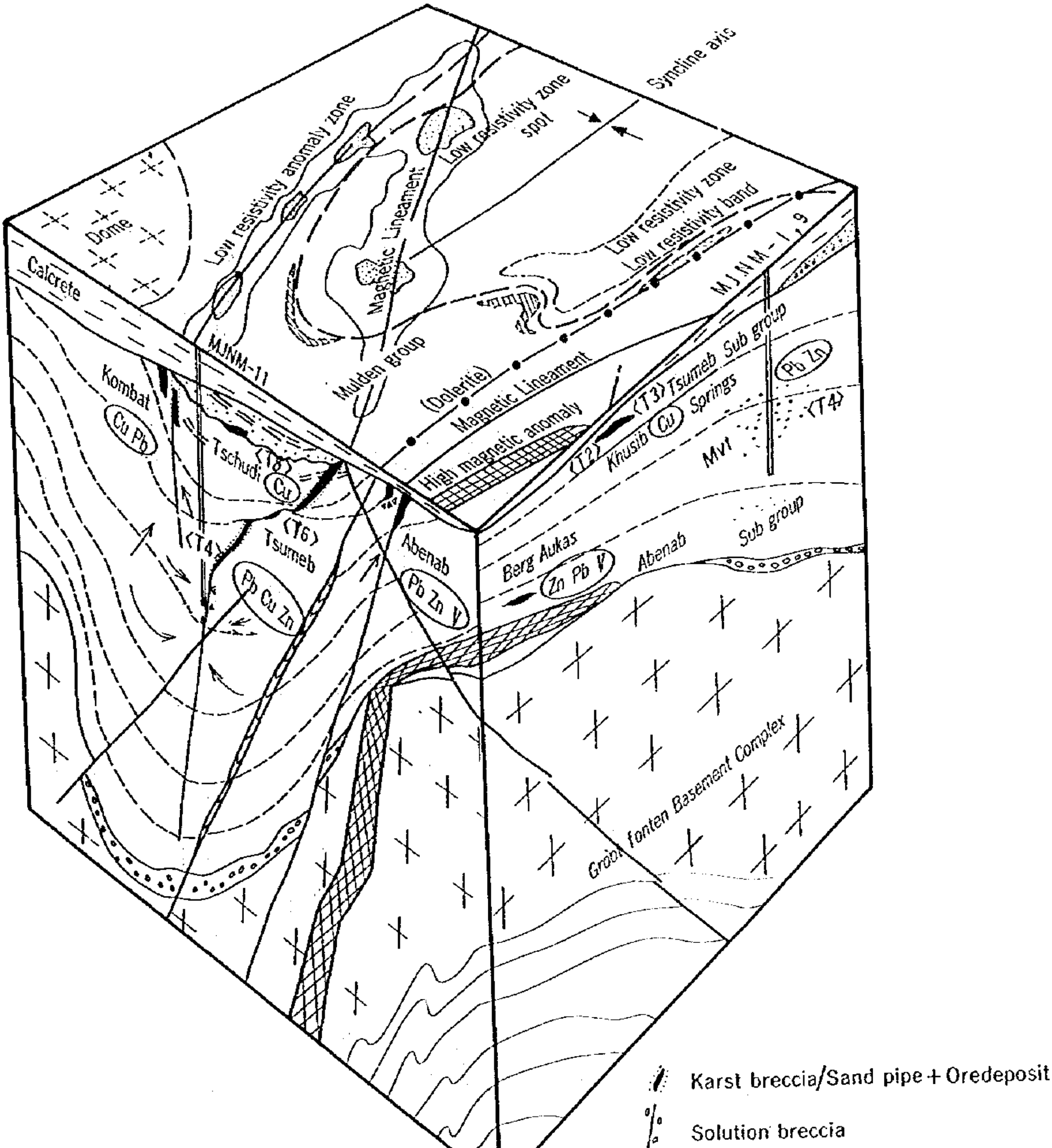

Fig. I — 1 — 2 Exploration model based upon Phase II survey

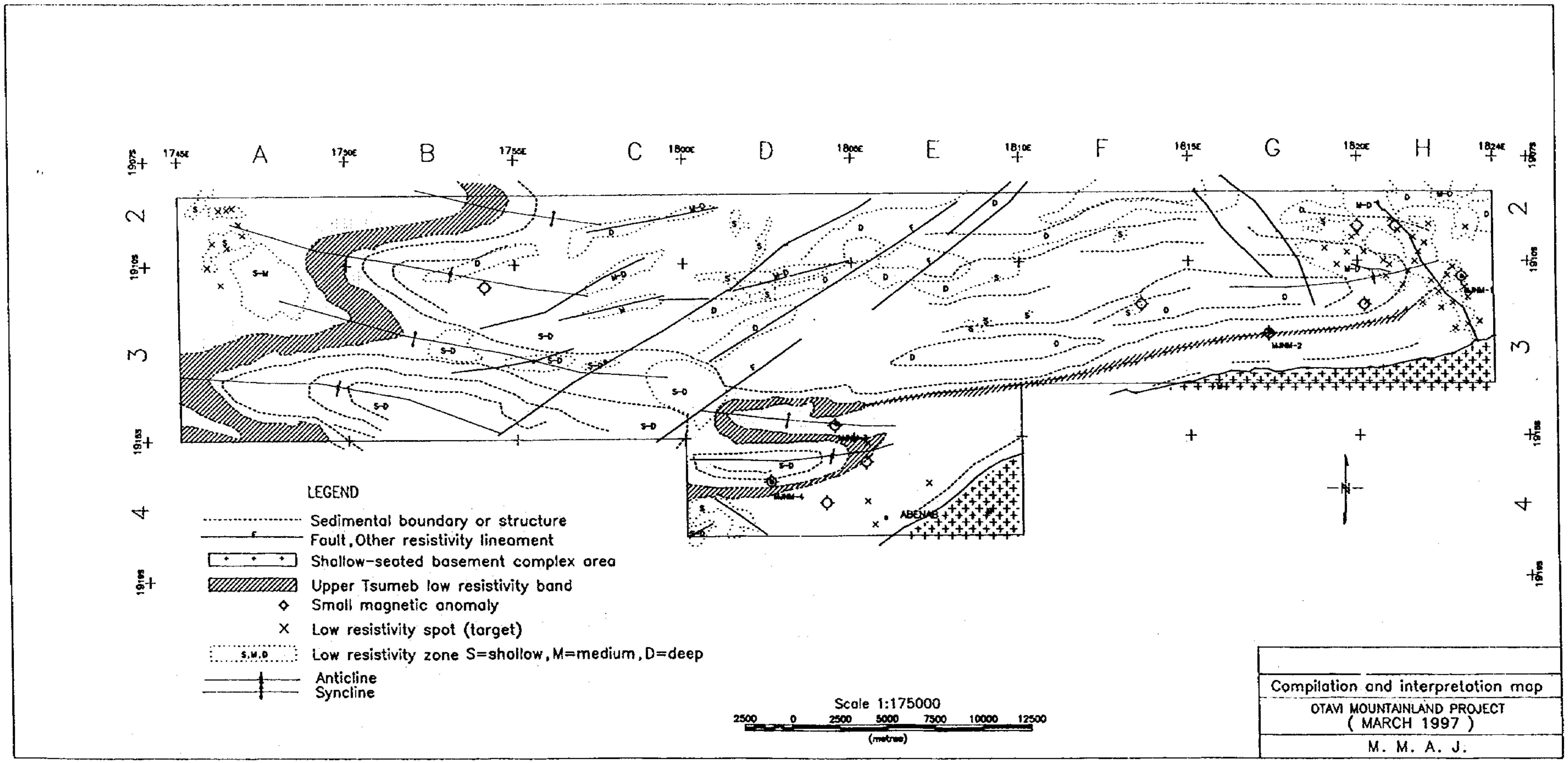

Fig. I −1−3 Compilation and interpretation map of the Phase III survey

Flow Chart of Selecting Resistivity Anomalies for Drilling Survey

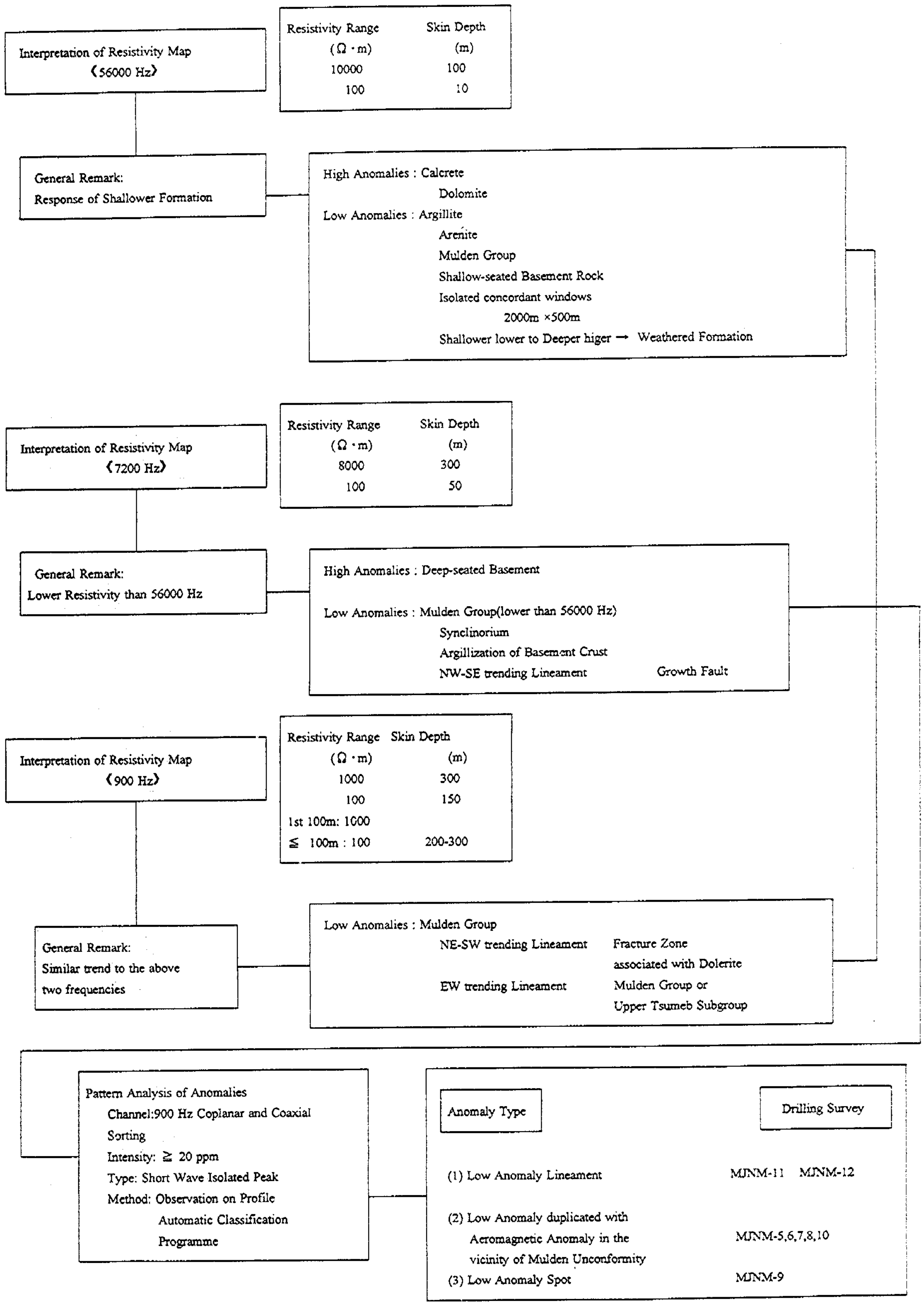

Fig. I −1−4 Flow chart of selecting resistivity anomalies for drilling survey of Phase III

I-1-3. Summary of the Phase III

I-1-3-1 Survey area

The survey area is illustrated in Fig.I-1-1.

I-1-3-2 Objective of the survey

The objectives of the survey of Phase III was to evaluate the ore potential by means of drilling of sites which were regarded to be favourable for ore formation based on the Phase II survey in the area with calcrete cover. Coinciding with the drilling programme the survey included an airborne electro magnetic survey over the selected aeromagnetic area of Phase I. The survey defined some low resistivity zones which may host sulphide mineralisation.

I-1-3-3 Survey methods

An exploration model as was constructed through compilation of the results of Phase I and II is illustrated in Fig.I-1-2. This was used for exploration rationale of Phase III. The compilation and interpretation map of Phase II is shown in Fig.I-1-3. Criteria and procedure of site-selection for drilling survey of PhaseIII are shown in Fig.I-1-4 and flow chart of the Phase II is shown in Fig.I-1-5.

(1)Drilling survey

The Phase II report recommended drilling survey based on the result of the airborne electromagnetic survey of Phase III, and the anomaly pattern analysis preceded the drilling survey. Eventually eight holes were located aiming intersecting potential mineralisation and checking the source of the airborne electromagnetic anomalies.

The analysis covered isolated peaks of short wave length and filtered potential anomalies from those resulting from artificial noise. No potential source of significantly low resistivity was filtered out other than formational or artificial responses. Eight potential sites were selected within low resistivity terrain with favourable conditions.

The drilling was contracted to Drillcon Africa Pty Limited; South Africa-based contractor who conducted diamond and percussion drilling.

The details of the surveys are illustrated in Table I-1-1.

The Specifications of the Survey is shown in Table I-1-1.

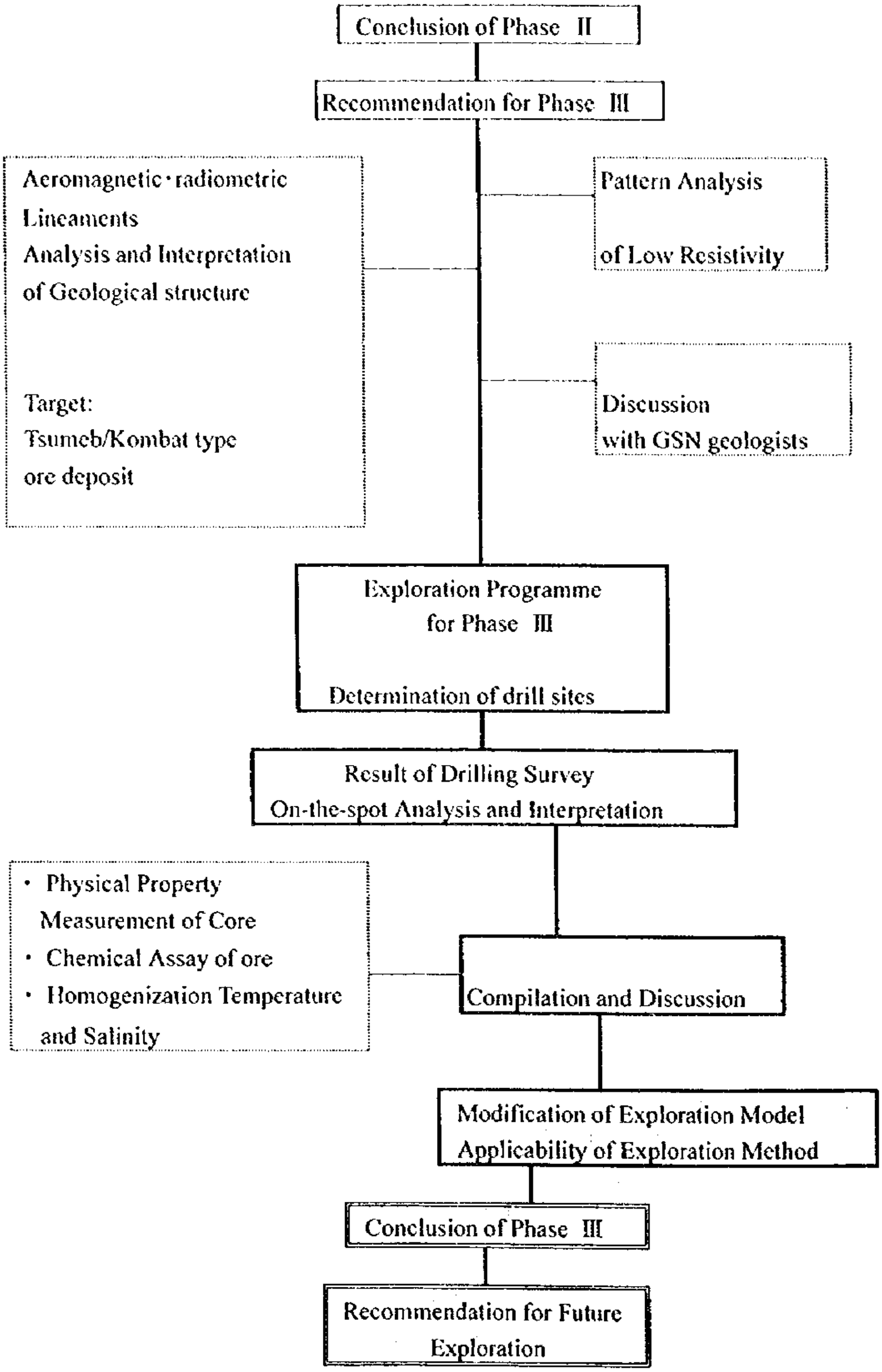

Fig. I −1−5 Flow chart of the Phase III survey

Table I −1−1 Specifications of the Survey (1)

Items	Detailed Specifications and Amount			
Drilling Survey	Hole No.	Depth	Inclination	Direction
	MJNM-5	220 m	-90°	-
	MJNM-6	300 m	-90°	-
	MJNM-7	300 m	-90°	-
	MJNM-8	300 m	-90°	-
	MJNM-9	300 m	-90°	-
	MJNM-10	300 m	-90°	-
	MJNM-11	300 m	-90°	-
	MJNM-12	300 m	-90°	-
	Total depth 2,320 m			

Table I −1−1 Specifications of the Survey (2)

Items of Laboratory Test	Number
(1) Microscopic Identification of Thin Section	20 samples
(2) Microscopic Identification of Polished Section	10 samples
(3) X-ray Diffractometry	10 samples
(4) Chemical Assay of Ore (Au,Ag,Cu,Pb,Zn,Cd,Ga,V)	20 samples
(5) Homogenization Temperature and Salinity of Fluid Inclusion	10 samples
(6) Measurement of Geophysical Property (Magnetic Susceptibility, Resistivity, and Chargeability)	50 samples

I-1-3-4. Members of the Survey

The following members were organized for the survey team, planning of the project and negotiations between the two countries.

Planing and Negotiation

Japanese Representative	Namibian Representative
Mr.Tadashi Ito (Metal Mining Agency of Japan) Mr.Hiroshi Shibazaki (Metal Mining Agency of Japan) Mr.Yoshiyuki Kita (Metal Mining Agency of Japan)	Dr.Gabriele I.C. Schneider (Director: Geological Survey of Namibia) Mr. Volker Petzel (Deputy Director: Geological Survey of Namibia) Mr. Herbert Roesener (Chief Geologist Geological Survey of Namibia)

Survey:

Japanese Member	Namibian Member
Mr.Tetsuo Hatasaki Chief of the mission Organization of Drilling Survey (Dowa Engineering Co.,Ltd.)	Mr. Volker Petzel (Deputy Director: Geological Survey of Namibia) Mr. Herbert Roesener (Chief Geologist Geological Survey of Namibia)

Field Supervisor:

Mr. Hiroshi Shibazaki (Metal Mining Agency of Japan)

Mr.Yoshiyuki Kita (Metal Mining Agency of Japan)

I-1-3-5. Terms of the Survey

The survey was conducted as the following programme.

Total Period Overseas: From 4 August to 29 November 1997

Drilling Survey: From 11 August to 18 November 1997

Chapter 2 Physical Features

I-2-1. Location and Access

The survey area is located in the northeast of the republic of Namibia centered by Tsumeb and Grootfontein extending from 19° 08'00" to 19° 15'00"south latitude and from 17° 55'00"to 18° 24'00"east longitude.

The area is situated about 500 km north of Windhoek and is accessible by road (B1) from Windhoek via Otjiwarongo to Tsumeb. Air Namibia's is also flying from the Eros airport in Windhoek to Tsumeb.

I-2-2. Topography and Drainage System

Namibia covers 820,000 square kilometers, more than twice the size of Japan. It is bordered by Angola, Zambia, South Africa, Botswana and the Atlantic Ocean.

The land is geographically divided into three zones; the forest zone in the northern part, the savanna zone of inland plateau, and the desert zone along the Atlantic Ocean. While the forest zone and the desert zone are of flat relief, the inland plateau is of high relief and mountainous.

The Otavi Mountainland is situated in the savanna zone. The geomorphology of the survey area is controlled by the underlying geology. The area underlain by the basement complex show gentle relief, whilst the terrain consisting of the overlying Damara carbonate rocks show considerably rigid topography particularly at the axial cores of anticlinorium. The eastern part of the survey area is flat and covered by calcrete and recent sediments. The flat areas range in height between 1,200 metres and 1,600 metres. The highest peak in the mountainland is 2,155 metres above the sea level. The southwest corner of the survey area is the highest and flattens to the north and east. No well developed fluvial systems are present in the survey area.

I-2-3. Climate and Vegetation

The climate of the Namibia is between semi-arid and subtropical. The highest mean temperature for Windhoek are 23 degrees centigrade in November and the lowest mean temperature is 17 degrees centigrade in July. The annual average rainfall is 600 millimetres in the northern forest zone, 20 millimetres in the desert zone, and 350 millimetres in the inland plateau. The wet season is in summer (October to April) with rare winter rains occurring in the extreme south of the country. The temperatures at Tsumeb are 2 to 3 degrees centigrade higher than in Windhoek while the annual average rainfall for Tsumeb is 572 millimetres.

The vegetation in Namibia is also variable. The forest zone is covered with broad-leaved trees. The inland plateau is spotted with stunted acacias while the desert zone is covered by scattered shrub and lichen.

Chapter 3 General Geology

Regional geology of the vicinity of the survey area is illustrated in Fig.I-3-1.

Regional stratigraphy is presented by Geological Survey of Namibia(1982) and the Geological Society of South Africa(1983). There were five main periods of lithogenic activity and these are as follows.

Tertiary to Recent (<65 Ma)

Carboniferous to lower Cretaceous (345 to 120 Ma)

Namibian (1,000 to 570 Ma)

upper Mokolian (1,800 to 1,000 Ma)

Vaalian to lower Mokolian (2,100 to 1,800 Ma)

The oldest rocks occur within metamorphic complexes of Vaalian (2620 to 2070 million years) to early Mokolian age (Mokolian: 2070 to 1080 million years). These form a basement to younger sedimentary and volcanic successions, the oldest of which are of mid-Mokolian age and of limited regional extent. The next major phase of activity involved the formation of the Rehoboth-Sinclair magmatic arc and the Namaqua Metamorphic Complex during the late Mokolian. The Damaran orogenic phase is the third main event; it started with intracontinental rifting and sedimentation about 900 million years ago and lasted approximately 450 million years. Extensive peneplanation precede the fourth phase which was the deposition of the Karoo Sequence between the Carboniferous and early Cretaceous. Cretaceous to Recent deposits cover many of the older stratigraphic units. Lower cretaceous to tertiary sediments and minor volcanics which are probably underlain by Karoo Sequence rocks form a thick offshore succession.

The distribution of pre-Tertiary rocks divides the country roughly into three regions. the Damara Sequence covers most of the northern half of the country. The southern half is divided along an approximate north-south line into a western third, underlain by rocks older than about 600 million years, and an eastern two-thirds underlain largely by the Nama Group and Karoo Sequence: older rocks are exposed in the far south of the latter portion. Tertiary deposits of the Kalahari Sequence cover large areas in the eastern and northern parts of the country. Much of the coastal region is covered by sand seas, deflation lag deposits and fluviatile sediments of the Namib Desert.

The Stratigraphical sequence is shown in TableI-3-1.

The Damara system is divided into eight units with special emphasis of host rock for mineralisation within Tsumeb subgroup. The Chuos formation is the lowest unit called T1 of the subgroup being characterized by glacier sediment including diamictite, tillite and banded iron formation. This unit represents a period of regression. The subsequent transgression introduced the deposition of Maieberg formation. Lower half of the formation consists of argillaceous limestone is assigned to T2 which

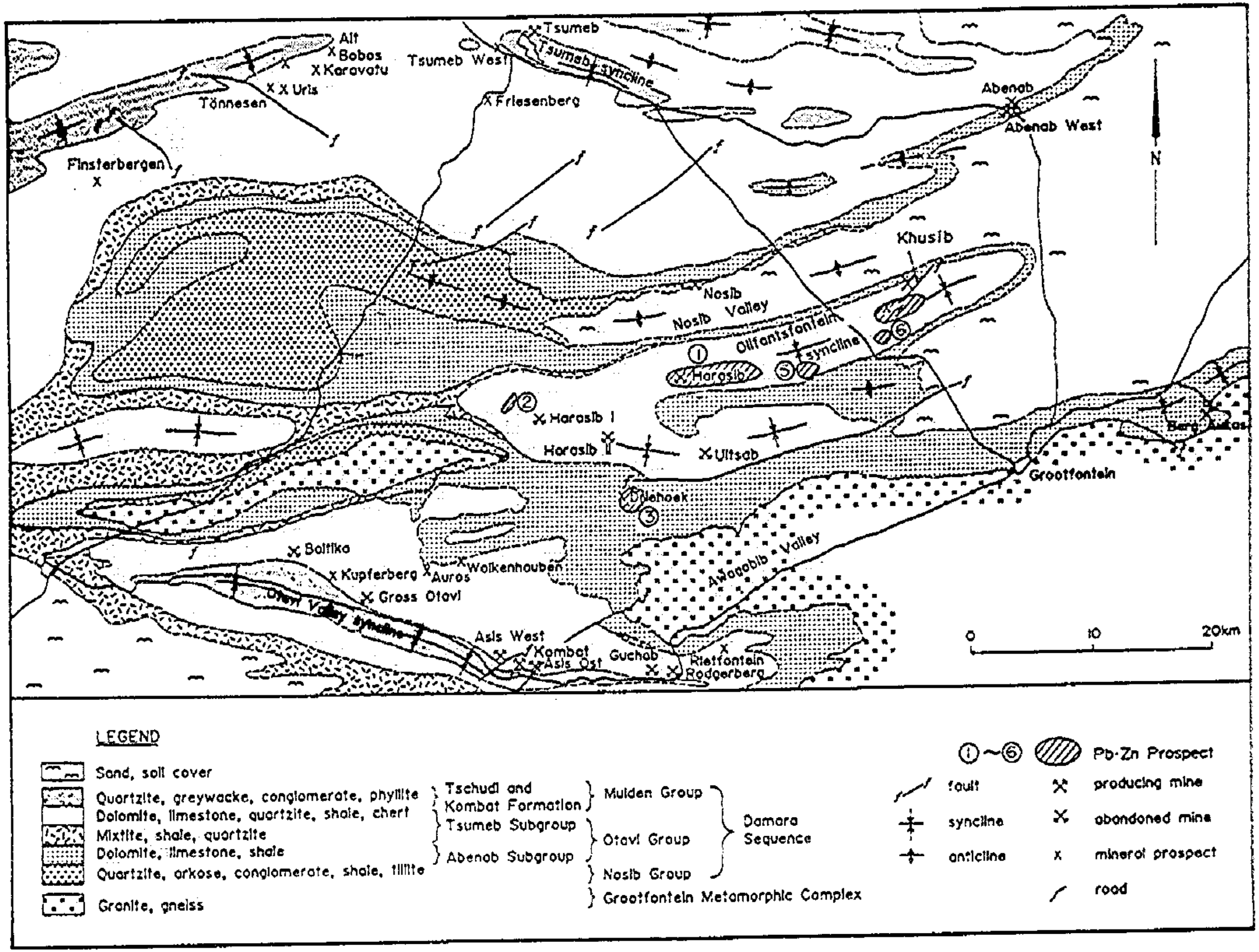

Fig. I—3—1 Regional geologic map of the Otavi Mountain Land area deposited under deep sea environment. The next regression occurred at the end of T2 and the upper half of the formation mainly composed of quartz cluster dolomite(T3) deposited. T4 is the lower part of Elandshoek formation in which grainstone predominates and is pervasively fractured. The breccias were filled with quartz and sparry carbonate associated with calcitization. Fine to coarse grained sandy dolomite and oolite are characteristics of the sediment from T3 to T4. T5 is a lagoonal sediment of the upper Elandshoek formation which consists of dolomitic shale, mudstone and sandstone.

The lower Huttenburg formation which is classified into T6 is a shallow seated sediment and is characterized by stromatolites and algael mats. The middle part of the formation is T7 where laminated dark dolomite associated with black shale and is believed to have deposited under lagoonal reducing environment.

At the end of T7 the transgression took place with coarser-grained sediment. T8 is the upper Huttenburg formation which is composed of bedded dark grey dolomite and chert. The upper most facies include three beds of oolite and pisolite-bearing sandstone.

Mineralisation in the survey area includes two broad types: the Tsumeb-type and the Berg-Aukas type. The Tsumeb type is characterised by complex sulphide ores containing copper, lead, zinc, silver, arsenic, germanium, cadmium and gallium. The ore minerals occur in several loci: pipes, solution breccias, shear zones, dilation fractures etc.. These ore bodies are not stratabound and are generally confined to the upper Tsumeb Subgroup and appear to be related to the disconformity between the Tsumeb Subgroup and the Mulden Group.

The Berg Aukas type is similar to the lead Pb-rich Mississippi Valley-type deposits. The sulphide ore contains lead, zinc and vanadium with little or no copper. Enrichment of silver, germanium, gallium and cadmium is less than those in the Tsumeb type ore deposits. The Berg Aukas type deposits are generally confined to the Abenab Subgroup and the middle-lower part of the Tsumeb Subgroup. The mineralisation occurs in breccia bodies and may be stratabound or discordant. Brecciation and karst structures are important in the localisation of the ore bodies.

Table I −3−1 Stratigraphic Succession in the Otavi Mountain Land Area

Sequence	Group	Subgroup	Formation	Informal Lithozone	Lithology	Average thickness (m)
Damara	Mulden		Kombat and Tschudi		Kombat Formation: slate; sub-arkose and pebbly sandstone near base Tschudi Formation: feldspathic sandstone, sub-greywacke; argillite and conglomerate interbeds in basal portion	> 700
			Disconformity			
	Otavi	Tsumeb	Hüttenberg	T8	Dolomite, bedded light to medium grey; oolitic chert and stromatolite layers near top	240
				T7	Dolomite, bedded dark grey; limestone, shale and chert interbeds	300
				T6	Dolomite, bedded light grey; abundant chert; stromatolite interbeds in lower part	300
			Elandshoek	T5	Dolomite, bedded and massive light grey	1 200
			Maieberg	T4	Dolomite, massive light grey	
				T3	Dolomite, thinly bedded light and dark grey	180
				T2	Limestone, bedded light and dark grey	700
			Chuos	T1	Tillite, quartzite, shale, minor dolomite and limestone	200
			Disconformity			
		Abenab	Auros		Dolomite, bedded and massive light to medium grey; limestone, marl, shale, oolite and stromatolite interbeds	350
			Gauss		Dolomite, massive light to dark grey; local oolite and stromatolite interbeds	750
			Berg Aukas		Dolomite, laminated and massive light and dark grey; black limestone, shale	550
			Disconformity			
	Nosib		Varianto		Quartzite, conglomerate, arkosic mixtite, dolomite, ferruginous shale	
			Askevold		Phyllitic agglomerate, tuff; epidosite	750
			Nabis		Feldspathic quartzite, arkose, conglomerate	
			Unconformity			
Grootfontein Basement Complex					Granite, gneiss, mafic schist	

Chapter 4 Interpretation and Discussion

I -4-1 Characteristics and Structural Control of Mineralisation

Eight holes totaling 2,320 metres were drilled using the exploration model prepared on the basis of the results of Phase I and Phase II survey which consisted of compilation of the previous exploration, airborne geophysical survey and wide spaced drilling.

The hole of MJNM-9 intersected an extension of the medium to weak lead and zinc mineralisation of so called Mississippi Valley Type which was encountered in MJNM-1 of Phase II. The average grade of Pb combined with Zn over 5.24m of cumulative length of mineralised section was 0.129 % and lower in comparison with MJNM-1. The mineralisation is hosted within grainstone as with MJNM-1. The stratigraphic control of T4 is suggested.(Fig. II -2-1(1))

Intense pyrite mineralisation was intersected by both holes of MJNM-11 and MJNM-12 which occur within the sandstone of Mulden group. Chemical assays indicate that the pyrite was not associated with copper concentration. The occurrence of pyrite is of syndepositional origin under a reducing environment.

MJNM-11 targeted the intersection of the ENE-WSW trending low resistivity lineament and the NNE-SSW trending lineament, and encountered copper-lead-vanadium mineralisation associated with dolospar and calcite veinlets hosted by T8 dolomite. This mineralisation could be grouped into Tsumeb type ore rather than Mississippi Valley Type as the metal ratios indicated a high concentration of copper compared to lead and zinc. This weak mineralisation is believed to occur at the fringes of an intensely fractured zone. A potential ore deposit could be expected along the extension of the fracture zone which could develop into karst breccias and therefore further exploration is recommended in in this area in the future.(Fig. II -2-1(2))

No mineralisation was encountered in the low resistivity lineaments or in spot anomalies traversing the Mulden group unconformity which was accounted for the original exploration rationale. The drilling revealed that the low resistivity lineaments might coincide with NW-SE trending dolerite dykes and associated with hydrothermal alteration including talc argillization. No low resistivity spot anomalies so far drilled coincided with any karst breccias and solution breccias.

I-4-2 Relationship between Airborne Electromagnetic Anomalies, Geological Structure and Mineralisation

The Mulden sandstone was expected to underlie extensively the areas in the east of the survey area. This was based on the interpretation of resistivity map combined with aeromagnetic anomaly map however, drilling intersected no sandstone in these areas. The ore potential under the Mulden unconformity were thus not tested sufficiently. For a more detailed exploration of potential karst structure in the Mulden group terrain, a ground geophysical survey as TDEM would be needed with narrower-spaced survey lines prior to further drilling.

In the west of the survey area, the sandstone of Mulden group was intersected over more than 100m where it was not expected on the basis of image interpretation and airborne geophysical data.(Fig. II -2-1(2)). This explains potentially limited interpretation of the underlying formation using the resistivity data. In the east of the survey area, the Kalahari sand could be a source of low resistivity at a shallow depth, which possibly mask the low resistivity anomalies which might originate from a potential ore deposit.(Fig. II -2-1(2))

There could thus be various sources for low resistivity anomaly including aquifer and clay minerals formed during weathering process at a shallower depth which may mask on the deeper structure of resistivity. In other words, practically the lower frequency may receive the signals of a shallower depth and that may make the deep exploration less effective.

I-4-3 Ore Potential

Phase III drilling survey confirmed that lead and zinc mineralisation of Mississippi Valley Type occurs within the survey area. However this study combined with the previous exploration work led to the conclusion that this type of mineralisation so far is not economic because of low ore grade in this region.

A massive sulphide ore pipe was not intersected by the drill holes, however, this might not necessarily indicate low potential of Tsumeb type ore deposit. There still remains high potential of high grade ore deposit like Khusib Springs, which is hosted between T2 and T3 in addition to ore potential in the upper formations. The mineralisation encountered in the fractured dolomite of MJNM-11 could be the fringes this type of ore deposit.

An airborne geophysical survey was the most effective method of collecting subsurface information over the non exposed areas or the area covered by recent sediments. High resolution analysis are possible when an aeromagnetic survey is combined with an airborne electromagnetic survey. This area is still worthy of further exploration based upon the exploration rationale which should be combined with-up to-date information.

Chapter 5 Conclusion and Recommendation

1-5-1. Conclusion

Phase III survey includes drilling survey associated with laboratory tests as well as measurement of geophysical properties using drill cores. The survey concluded as follows through discussion of the details.

1. Eight drill holes were sunk targeting on the airborne electromagnetic anomalies of Phase II for massive sulphide ore pipes of Tsumeb/Kombat type.

One hole of which; MJNM-9 intersected low grade lead and zinc mineralisation in the form of dissemination and veinlet. The hole is located 700 metres northwest of MJNM-1 of Phase II. The mineral occurrence and host stratigraphic horizon may suggest that the mineralisation is an extension of that of MJNM-1 and is subject to stratigraphic control.

Within 5.24 metre, the mineralised portions showing more than 0.1 percent concentration, are as follows.

234.10m-234.50m(0.40m)		Zn=0.58%
242.60m-243.35m(0.75m)	Pb=0.17%	Zn=0.83%
248.10m-248.64m(0.54m)		Zn=0.31%

2. In the hole of MJNM-11, some dots of chalcopyrite and galena were recognized being associated with intensely fractured zone within upper Tsumeb subgroup. Chemical assays revealed a considerable concentration of Cu, Pb and Zn.

The mineralised portions showing more than 0.1 percent concentration, are as follows.

270.70m-270.75m(0.05m)	Pb=0.18% (Cu=0.028% Zn=0.026%)
272.30m-272.50m(0.20m)	Pb=0.10% (Cu=0.026% Zn=0.08%)

The metal ratios of Cu, Pb and Zn show the mineralisation is of Tsumeb/Kombat type. This minute mineral occurrence could be derived from an potential ore deposit of moderate size and therefore should be explored in the future.

3. Pyrite mineralisation is commonly hosted in the sandstone of Mulden group but almost no copper content was assayed in the mineralisation. The copper content and syndepositional occurrence may explain that the pyrite was biogenic and was precipitated under reducing environment. The pyrite mineralisation is believed to be a potential source of the low resistivity at every frequency.

4. The interpretation of airborne electromagnetic anomalies with correlation to the result of drilling indicated that the Damara system and its subsurface structure are extended as far as the survey area covered by calcrete. But the drilling result showed inconsistency with exploration rationale. The low resistivity lineaments traversing the geological trend were correlated to a swarm of dolerite dyke and the surrounding hydrothermal alteration zones. The observed resistivity values of core samples also

supported the discussion. No spot anomaly coincided with any Karst or solution breccias.

5. No sandstone of Mulden group was practically intersected in the area where it had been widely expected from the previous maps and the current geophysical survey and vice versa. The detail estimate of resistivity of surface formation is thus inevitable for the interpretation of the deeper structure of geology.

6. The programmed depth of 300 meter of holes were believed to be adequate from the result of drilling correlated to the key depth of resistivity profile.

I-5-2. Recommendation for the future

Based upon the result of the survey and subsequent discussion and interpretation of all the data available, the following recommendation for the future was made.

1. Airborne geophysical survey over the known ore deposits

The exploration rationale used in this project had been based upon the premise that pipe like formed massive sulphide ore deposit should give a signal of low resistivity anomaly and therefore should be target of the drilling. Nevertheless, there seems to be an opposite example that ground electromagnetic survey showed inconsistency of the ore deposit with low resistivity anomaly at Khusib. Therefore it is needed to restudy the geophysical response of the ore itself and ore controls. It is thus important to fly over the known ore deposit to collect the signals of ore control.

2. Restudy of exploration rationale

The exploration rationale used in this project should be thereby modified on the basis of the geophysical interpretation.

3. Ground geophysical survey and subsequent drilling

With the revised exploration rationale the detailed ground electromagnetic survey is recommended within the extracted area. The core samples of this project are available for interpretation of anomaly maps, particularly the cores may provide more information of geophysical properties of surface formation.

4. Follow-up exploration for MJNM-11 mineral showing

The minute mineralisation is recommended to be assessed using new exploration rationale and the result of ground geophysical survey and thereafter be drilled.

5. Exploration of a new area

For a new area to be explored, the broad area extending north of Tschudi ore deposit through northwest of Tsumeb mine is recommended. The area is non exposed with thin calcrete less than 100 metre in thickness.

Part II Details of the Survey

Part II Details of the Survey

Chapter 1 Drilling Survey

II-1-1. Outline of the Survey

Locations of the drilling survey are illustrated in Fig.II-1-1 and Fig.II-1-2. The drilling was assigned to the local contractor based at the Republic of South Africa. Geological logging was recorded onto logging sheets at a scale of 1:200. The mineralised portions of the drill cores were taken at where necessary for chemical assays. The thin sections and polished sections of typical rock facies and mineralisation were prepared for microscopic test. The altered or argillaceous parts were collected for X-ray diffractometry. Some of the mineralised portion with lead and zinc were analyzed for lead isotopes. All the cores were marked showing orientation direction and packed in steel-made core boxes and recorded on the colour photos. The core boxes were housed in the core depository of GSN. The coordinates of drill holes are shown in Table II −1−1.

Table II −1−1 Coordinates of the Drill Holes

	HOLE No.	FARM LAND	LATITUDE Deg.	LATITUDE Min.	LATITUDE Sec.	LONGITUDE Deg.	LONGITUDE Min.	LONGITUDE Sec.
1	MJNM-5	Vogelsang 284	18	21	42.01 E	19	10	00.86 S
2	MJNM-6	Guinab 277	18	22	48.53 E	19	11	11.57 S
3	MJNM-7	Aris 283	18	22	10.57 E	19	10	34.20 S
4	MJNM-8	Vogelsang 284	18	19	59.08 E	19	09	12.91 S
5	MJNM-9	Guinab 277	18	22	47.86 E	19	10	10.46 S
6	MJNM-10	Vogelsang 284	18	19	41.04 E	19	09	38.75 S
7	MJNM-11	Birkenhead 699	17	55	58.79 E	19	12	42.35 S
8	MJNM-12	Bombay 670	17	57	28.12 E	19	12	51.38 S

II-1-2. Method and Equipment

The equipments and the consumables necessary for drilling were provided by DRILLCON AFRICA PTY LTD. The drill hole MJNM-1 of Phase II suggested the thickness of calcrete in the east of the survey area. Therefore percussion method was applied for the first 80 metres with Drill Master from the surface and thereafter the wire line method with L-44 rigs were used. Cementing and installation of the casing pipes were needed where the rock condition was not favourable. The important equipments and the consumables are listed in Table II-1-2 and Table II-1-4.

II-1-3. Drilling Work

(1) Transportation and Access Road

Farm roads were used for transportation to the nearest point to drilling sites and thereafter, the bush was slashed for a new road to the site.

(2) Setting

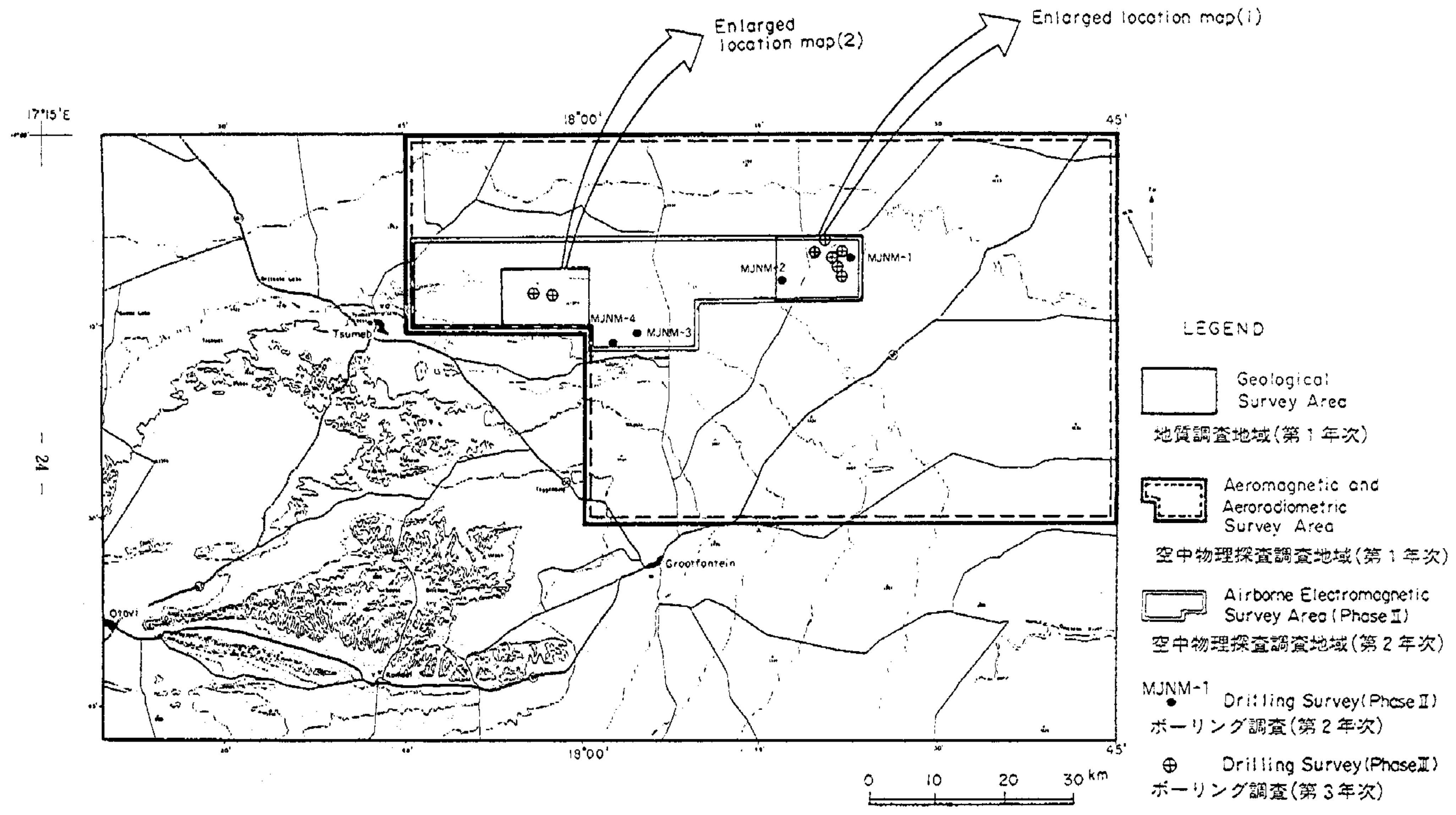

Fig. II－1－1　Location map of drilling survey

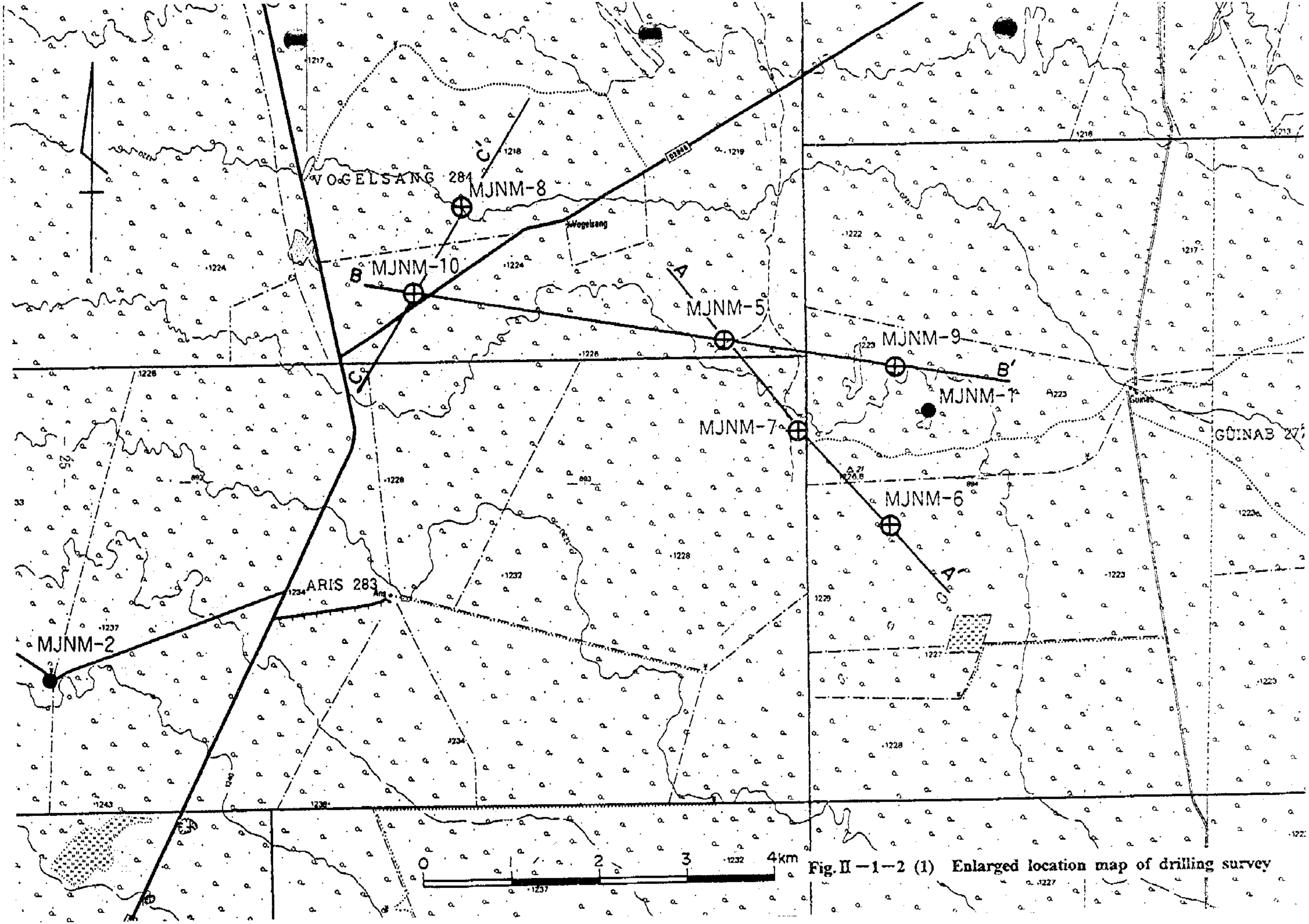

Fig. II −1−2 (1) Enlarged location map of drilling survey

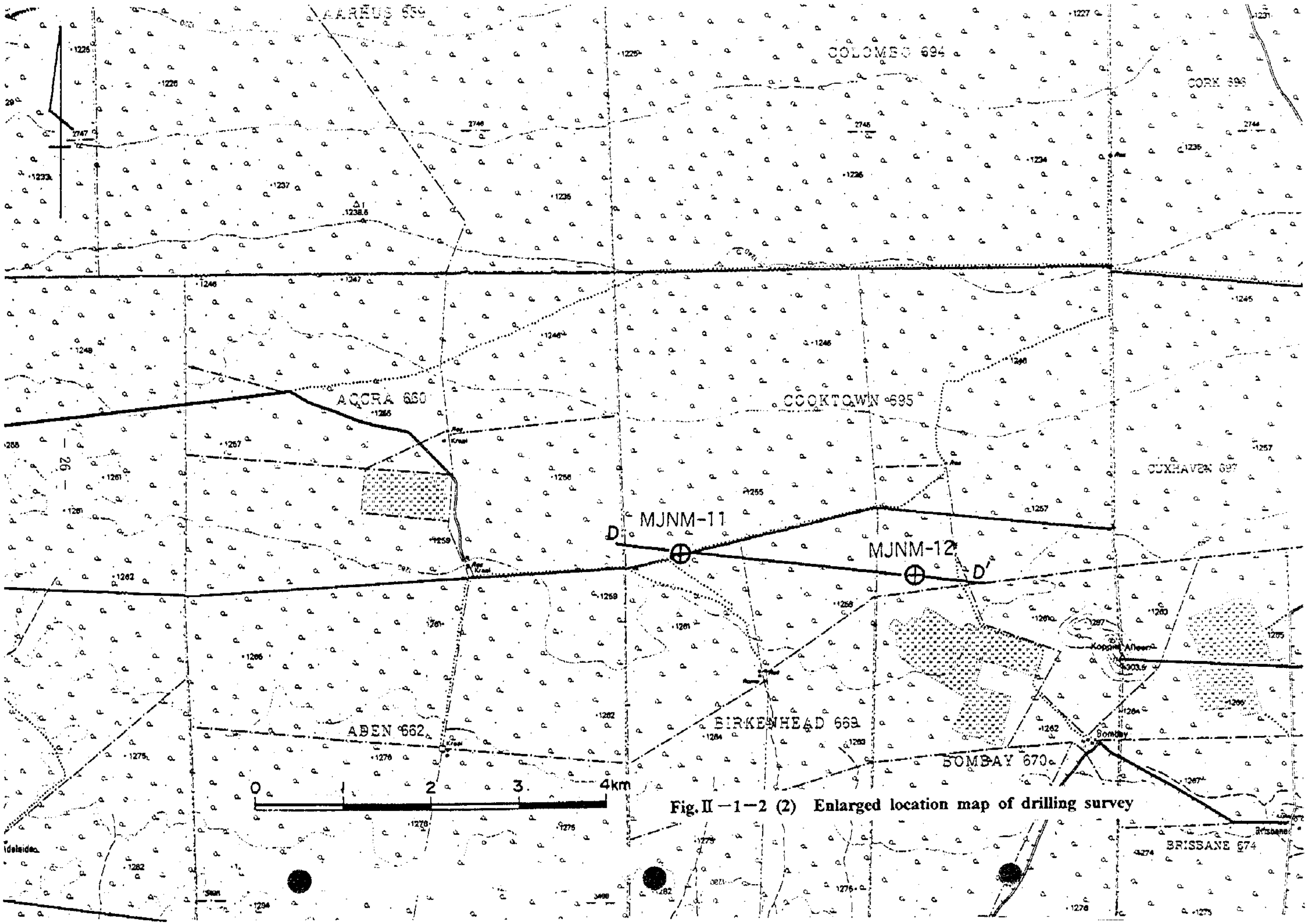

Fig. II −1−2 (2) Enlarged location map of drilling survey

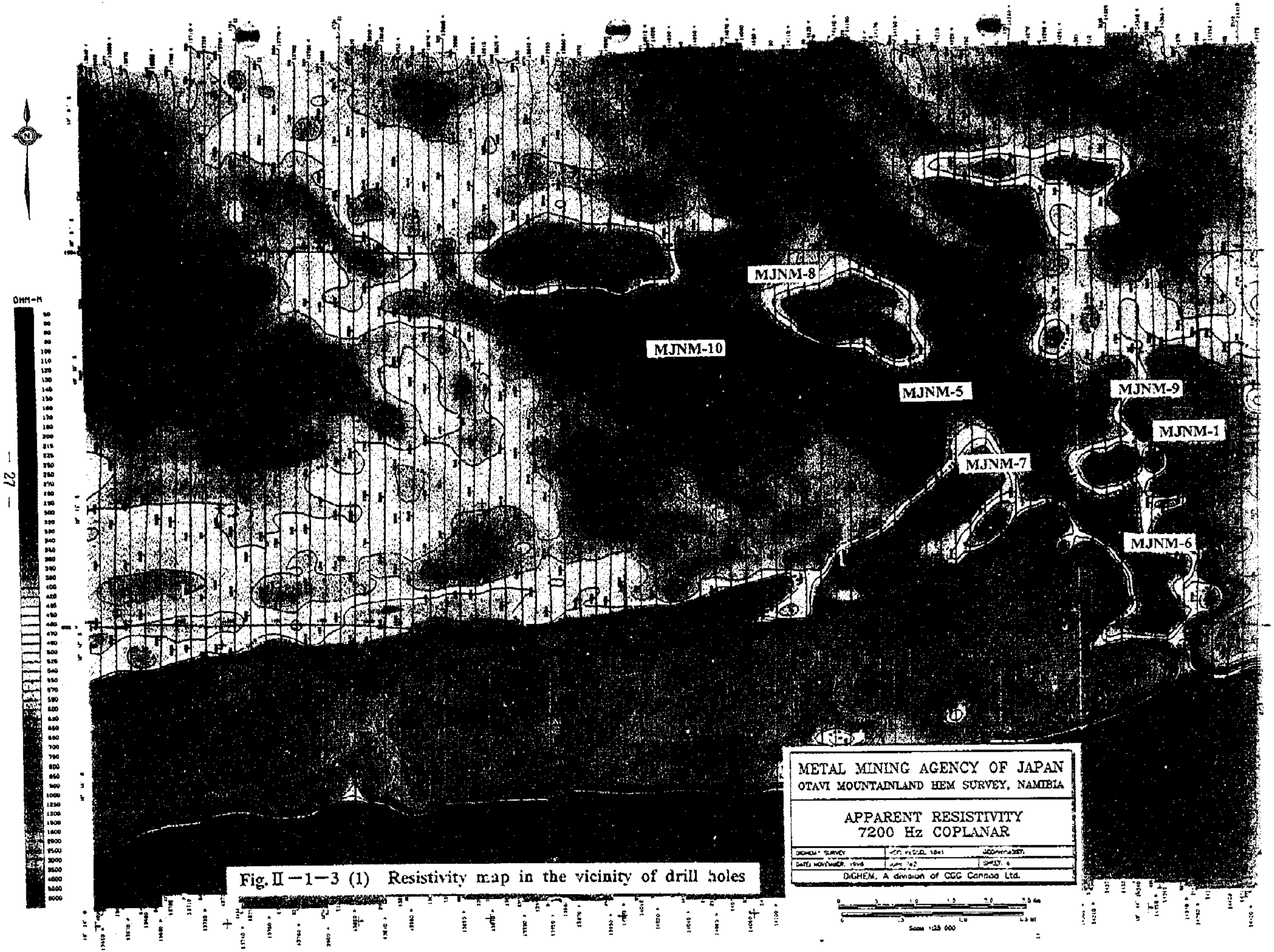

Fig. II −1−3 (1) Resistivity map in the vicinity of drill holes

Fig. II-1-3 (1) Resistivity map in the vicinity of drill holes

Fig. II－1－3 (2) Resistivity map in the vicinity of drill holes

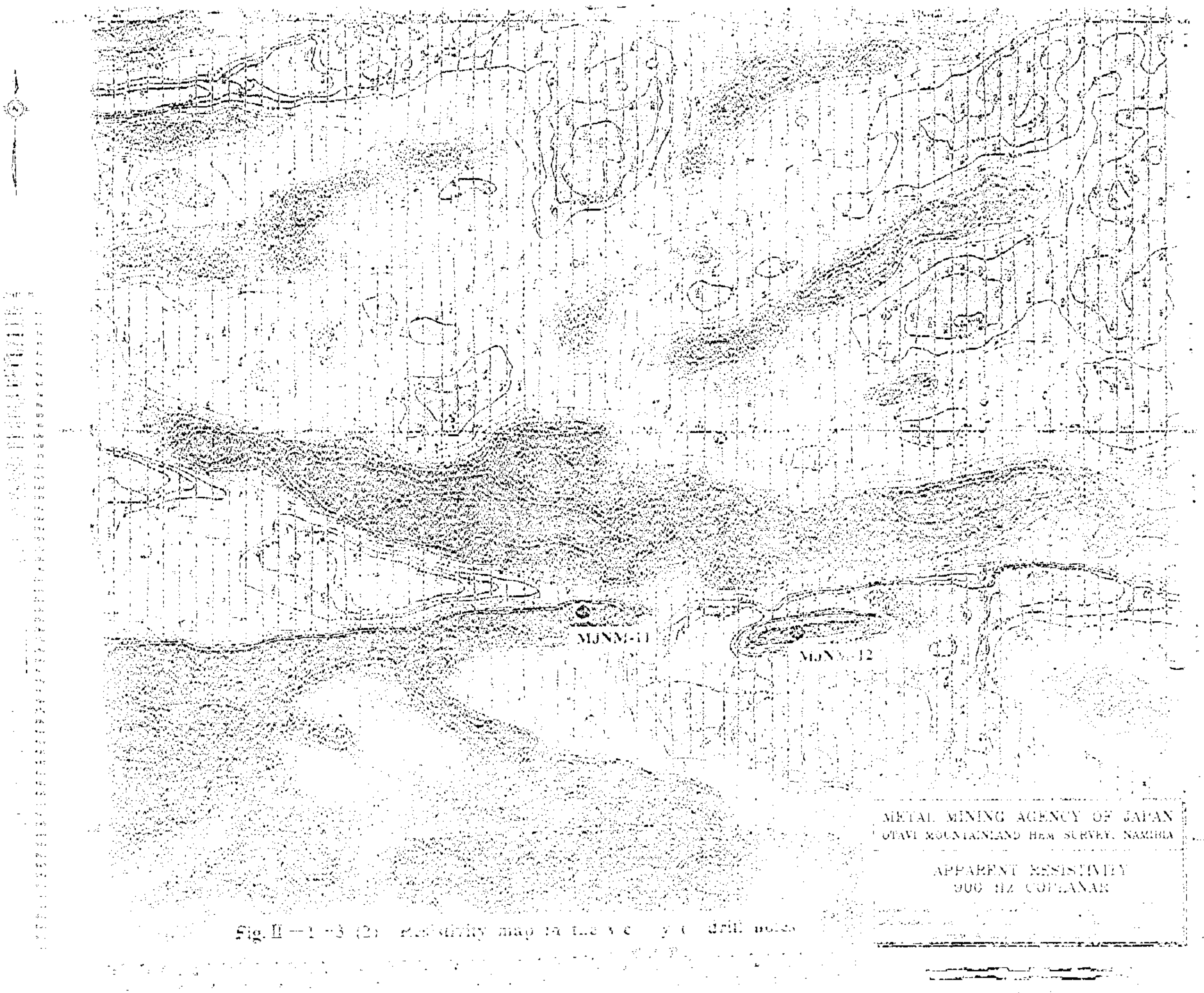

Fig. II—1—3 (2) Resistivity map in the vicinity of drill holes

Table II - 1 - 2　Specifications of Equipmentsf for Drilling

Item	Model	Specifications	Amount	Remarks
Percussion Drilling Rig	Drill Master Model 500	Compressor : 24 bar 900 cfm		
Wireline Drilling Rig	Longyear-44	Capacity : 600m Diesel Engine : Deutz 6 cylinder Engine Capacity : 87 kw 2300 R.P.M. Transmission : 4 speed	2	
Pump		Type : Bean R35B Hydro motor driven Max.Pressure : 50 kg/cm2 Max rate : 140 litres/min		
Rod	NQ	3.00m／70.00mm φ x60.3mm φ		
Casing	5 9/16	116 mm OD in percussion hole HQ rods use as casing below percussion holes		

Table II - 1 - 3　Amount of Used Daimond Bit and Reamer

Item	Type	Specifications	Amount								
			Hole No. MJNM -								Total
			5	6	7	8	9	10	11	12	
Diamond Bit	NQ INP	69.9mm φ x60.3mm φ	2	3	2	2	3	2	2	3	19
	NXC IMD	68.5mm φ x92.2mm φ		2			1		1		4

outer diametre x inner diameter

Table II －1－4　Amount of Consumables

ITEM	SPECIFICATIONS	UNIT	AMOUNT								
			HOLE NO. MJNM -								Total
			5	6	7	8	9	10	11	12	
Outer Tube(NQ)	73.0mm×60.3mm×3.0m	No	1	1							2
Inner Tube(NQ)	55.6mm×50.0mm×3.0m	No	2	2		1		1		1	7
Inner Tube Head	NQ	Set	1	1							2
Overshot	TC(Vertical)	No				1					1
Wire for Wireline	6mm φ ×320m	Role	1								1
Core Lifter	NQ	No	9	9	11	10	8	8	7	7	69
Core Lifter Case	NQ	No	2	2	2	2	2	2	2	2	16
Diesel Fuel		Litre	540	600	600	800	800	800	800	800	5,740
Petrol		Litre	20								20

One of the two rigs operating together for the beginning was transported from near the South African border and another from the Tschudi mine west of Tsumeb to the drilling site. The equipments for drilling and technical support were provided from Otjiwarongo. The crew camped near the site.

(3) Working shift

The drilling was undertaken on one shift during the period when the two rigs were operated and two shifts a day when only one rig operated. The working time per shift was ten to twelve hours. The crew was consisted of two to three drillers and an assistant under a driller. One driver for water transportation was used when necessary.

(4) Interhole Move and Demobilization

The trucks were used for interhole move and demobilization after completion of the whole work as the mobilisation. The percussion rig as well as wireline rigs were truck-mounted giving good mobility.

The ground damage was restored and the hole mouths were cemented.

(5) Drilling and Coring

The diametre of holes was 4 9/16 inches and the holes were cased with 110 m/m HQ size casing when necessary. The size of the first three metres was of 180 m/m diametre and was cased with 170 m/m casing. Chips from the hole were taken every metre for geological logging. From a depth of 80 m the wireline method was used with HQ or NQ core size. When the rock formation became unfavourable the hole was reamed to HQ and was installed with NQ casing.

The practical time schedule of drilling is shown in Table II-1-5 and the summary of drilling of each hole is shown in Table II-1-6(1) through Table II-1-6(8).

The progress of the holes was as follows.

MJNM-5

The drilling rate was slowered because of an important aquifer at the depth of around 60 metres. From 81 m, the wireline method was used. The water for drilling was transported by a 5 m^3 tanker lorry from a water hole which was sunk 50 metre east of MJNM-7 site. MJNM-5 encountered cavities at around 180 to 190 m which caused a great deal of water loss. No significant cavity development occurred deeper down. However during the drilling, at 222 metres, a rod was ruptured at a depth of 120 metre.

It was proposed that a lot of clay filling the cavities was washed out and a cumulated at the hole bottom by the water during lost circulation and that this caused the jamming. HQ reaming was undertaken down to 126 metres immediately and the casing was installed. Subsequently, an attempt was made to recover the jammed rods with a specially-designed device but the bit of the lost rod could not successfully be detached from the tip of device. The attempt ended unsuccessfully abandoning 94 metre long rods, core barrel and a bit in the hole. The recovering effort lasted for seven days with unfavourable

Table II −1−5　Practical Time Schedule of Drilling

Hole No.	August (1 | 0, 2 | 0)	September (1 | 0, 2 | 0)	October (1 | 0, 2 | 0)	November (1 | 0, 2 | 0)	Remarks
MJNM-5	28 ◇	7 8 — 14, 17 ═ 20	17 ◇ 20, 22 ◇ 25 28		◇ :Percussion Drilling
MJNM-6	18 ◇, 24 ◇ 25, ◇ 27 —	— 6			~~ :Setting Tear down
MJNM-7	27 ◇ 29 —	— 4			— :Wireline Drilling
MJNM-8	29 ◇	8 — 14			═ :Restoration
MJNM-9			16 ◇ 17, 18 — 24		
MJNM-10	30 ◇	15 — 23			
MJNM-11				5 — 14	
MJNM-12			28, 29 —	— 4	

Table II - 1 - 6 (1) Summary of Drilling Work [MJNM-5]

Period of Drilling

Working Item	Period	Total Days	Working days	Off days	Number of Person-day
Set up	1997/08/28, 09/07	2	2	0	11
Drilling	1997/08/28, 09/08～09/20	14	7	0	34
Tear Down	1997/09/21	1	1	0	5
Total		17	10	0	50

Total Depth

Planned Depth	300.00 m	Soil	1.0 m
Additional depth	0.00 m	Core Length	122.80 m
Total Inspected Depth	220.00 m	Recovery Rate	55.8 %

Break Down of the Working Time

Net Drilling	68.0 h	39.5 %	36.8 %
Rod Raising and Insert	22.0 h	12.8 %	11.9 %
Inner Tube Operation	8.0 h	4.7 %	4.3 %
Accommpanying Work			
Recovering from Trouble	74.0 h	43.0 %	40.0 %
Others			
Subtotal	172.0 h	100.0 %	93.0 %
Interhole Moving			
Set up	7.0 h		3.8 %
Tear down	6.0 h		3.2 %
Grand total	185.0 h		100.0 %

Casing

Casing Diametre and Cased Length (m)		B/A×100 (%)	Recovered Casing (%)
HQ	126.0	57.3	100.0

Core Recovery Rate per 100 metres

Depth (m)	Core length	Recovery Rate	Cumulative Rate
0.00 ～ 81.00	0.00 m	0.00 %	0.00 %
81.00 ～ 180.00	83.83 m	84.68 %	46.57 %
180.00 ～ 222.50	38.97 m	91.69 %	55.19 %

Drilling Efficiency

Total Depth/Total Days	12.94	m/day
Total Depth/Working Days	22.00	m/day
Total Depth/Drilling Days	15.71	m/day
Total Depth/ Net Drilling Days	31.43	m/day
Total Depth/Total Person-day	4.40	m/P-day
Net Drilling Person-day/ Total Depth	0.15	P-day/m

Remarks
A:Total Depth
B:Cased Depth

result and the drilling of the remaining 80 metres from 220 to 300 m was abandoned. Stratigraphic correlation and evaluation of ore potential of the hole was done using the cores down to 220 m.

MJNM-6

Percussion drilling was interrupted soon after the start due to mechanical problems with the compressor, but the drilling resumed again five days later.

The potential aquifer was encountered at a depth of 60 metre. Drilling rate for calcrete was in the order of 8m/min. and one hole of 80 m needed an entire shift. The porous limestone was drilled at high drilling rate except for a fractured zone. The water was transported from the farmer's well nearby using a tank-lorry.

MJNM-7

The formation had cavities at a depth of 147 metre and consisted of intense talc argillization totally giving fissility, however the drilling rate reached to more than 60 m/shift. The water was pumped up from the water hole which was drilled 50 metre east of the hole and contained in a plastic tank from which the water was introduced to the rig directly through a pipe.

MJNM-8

The drilling rate was good except in the formation deeper than 240 metre because of some core clogging which resulted from pervasive talc argillization. The water was transported from a cistern 3.5 km to the west.

MJNM-9

The wear of the percussion hammer lowered the drilling rate and two days were needed for 80 metres, however the wireline method was on schedule. The formation of dolomite was subjected to silicification on the whole which eventually led to a drill rate of 20 to 30 m/shift). A two shifts per day system was adopted for two of seven days of net drilling days. The water was pumped up from the farmer's well and transported for 3 km by a tank lorry.

MJNM-10

This the hole encountered the Kalahari sand containing much clay from 90m, HQ reaming and casing installation were done to prevent jamming which could occur after cavities and the subsequent out of clay. Thereafter the drilling proceeded at a reasonable rate of 20 to 30m/shift. The water supply was the same as MJNM-8.

MJNM-11

Table II - 1 - 6 (2) Summary of Drilling Work [MJNM-6]

Period of Drilling

Working Item	Period	Total Days	Working days	Off days	Number of Person-day
Set up	1997/08/18, 08/25	2	2	0	15
Drilling	1997/08/18～08/25, 08/26～09/06	20	15	5	49
Tear Down	1996/09/06～09/07	2	2	0	6
Total		24	19	5	70

Total Depth

Planned Depth	300.00 m	Soil	1.0 m
Additional depth	0.00 m	Core length	216.80 m
Total Inspected Depth	300.00 m	Recovery Rate	72.3 %

Core Recovery Rate per 100 metres

Depth (m)	Core length	Recovery Rate	Cumulative Rate
0.00 ～ 81.40	0.00 m	0.00 %	0.00 %
81.40 ～ 195.30	112.20 m	98.51 %	57.45 %
195.30 ～ 300.00	103.63 m	98.98 %	71.94 %

Break Down of the Working Time

Net Drilling	108.0 h	67.9 %	61.0 %
Rod Raising and Insert	48.0 h	30.2 %	27.1 %
Inner Tube Operation	3.0 h	1.9 %	1.7 %
Accommpanying Work	0.0 h	0.0 %	0.0 %
Recovering from Trouble	0.0 h	0.0 %	0.0 %
Others	0.0 h	0.0 %	0.0 %
Subtotal	159.0 h	100.0 %	89.8 %
Transladation Interhole Moving			
Set up	12.0 h		6.8 %
Tear down	6.0 h		3.4 %
Grand total	177.0 h		100.0 %

Drilling Efficiency

Total Depth/Total Days	12.50	m/day
Total Depth/Working Days	15.79	m/day
Total Depth/Drilling Days	15.00	m/day
Total Depth/ Net Drilling Days	20.00	m/day
Total Depth/Total Person-day	4.29	m/P-day
Net Drilling Person-day/ Total Depth	0.16	P-day/m

Casing

Casing Diametre and Cased Length (m)		B/A×100 (%)	Recovered Casing (%)
HQ	108.0	36.0	100.0

Remarks
A:Total Depth
B:Cased Depth

Table II - 1 - 6 (3) Summary of Drilling Work [MJNM-7]

Period of Drilling

Working Item	Period	Total Days	Working days	Off days	Number of Person-day
Set up	1997/08/27,08/28～08/29	3	3	0	5
Drilling	1997/08/29～09/04	7	6	1	54
Tear Down	1996/09/06	1	1	0	4
Total		11	10	1	63

Total Depth

Planned Depth	300.00 m	Soil	1.0 m
Additional depth	0.00 m	Core length	215.70 m
Total Inspected Depth	301.95 m	Recovery Rate	71.4 %

Core Recovery Rate per 100 metres

Depth (m)	Core length	Recovery Rate	Cumulative Rate
0.00 ～ 80.50	0.00 m	0.00 %	0.00 %
80.50 ～ 197.00	111.70 m	95.88 %	56.70 %
197.00 ～ 301.95	104.00 m	99.09 %	

Break Down of the Working Time

Net Drilling	74.0 h	70.5 %	59.7 %
Rod Raising and Insert	19.0 h	18.1 %	15.3 %
Inner Tube Operation	2.0 h	1.9 %	1.6 %
Accommpanying Work	0.0 h	0.0 %	0.0 %
Recovering from Trouble	10.0 h	9.5 %	8.1 %
Others	0.0 h	0.0 %	0.0 %
Subtotal	105.0 h	100.0 %	84.7 %
Transladation Interhole Moving			
Set up	13.0 h		10.5 %
Tear down	6.0 h		4.8 %
Grand total	124.0 h		100.0 %

Drilling Efficiency

Total Depth/Total Days	27.45	m/day
Total Depth/Working Days	30.20	m/day
Total Depth/Drilling Days	43.14	m/day
Total Depth/ Net Drilling Days	50.33	m/day
Total Depth/Total Person-day	4.79	m/P-day
Net Drilling Person-day/ Total Depth	0.18	P-day/m

Casing

Casing Diametre and Cased Length (m)		B/A×100 (%)	Recovered Casing (%)
HQ	99.0	33.0	100.0

Remarks
A:Total Depth
B:Cased Depth

Table II - 1 - 6 (4)　Summary of Drilling Work [MJNM-8]

Period of Drilling

Working Item	Period	Total Days	Working days	Off days	Number of Person-day
Set up	1997/08/29, 09/07	2	2	0	2
Drilling	1997/08/29,09/08～09/14	8	8	0	32
Tear Down	1997/09/14	1	1	0	2
Total		11	11	0	36

Total Depth

Planned Depth	300.00 m	Soil	1.0 m
Additional depth	0.00 m	Core length	219.20 m
Total Inspected Depth	300.00 m	Recovery Rate	73.1 %

Core Recovery Rate per 100 metres

Depth (m)	Core length	Recovery Rate	Cumulative Rate
0.00 ～ 81.29	0.00 m	0.00 %	0.00 %
81.29 ～ 186.10	104.40 m	99.61 %	56.10 %
186.10 ～ 300.00	113.80 m	99.91 %	

Break Down of the Working Time

Net Drilling	75.0 h	65.8 %	61.0 %
Rod Raising and Insert	36.0 h	31.6 %	29.3 %
Inner Tube Operation	3.0 h	2.6 %	2.4 %
Accommpanying Work	0.0 h	0.0 %	0.0 %
Recovering from Trouble	0.0 h	0.0 %	0.0 %
Others	0.0 h	0.0 %	0.0 %
Subtotal	114.0 h	100.0 %	92.7 %
Transladation　Interhole Moving			
Set up	5.0 h		4.1 %
Tear down	4.0 h		3.3 %
Grand total	123.0 h		100.0 %

Drilling Efficiency

Total Depth/Total Days	27.27	m/day
Total Depth/Working Days	27.27	m/day
Total Depth/Drilling Days	37.50	m/day
Total Depth/ Net Drilling Days	37.50	m/day
Total Depth/Total Person-day	8.33	m/P-day
Net Drilling Person-day/ Total Depth	0.11	P-day/m

Casing

Casing Diametre and Cased Length (m)		B/A×100 (%)	Recovered Casing (%)
HQ	119.0	39.7	100.0

Remarks
A:Total Depth
B:Cased Depth

Table II - 1 - 6 (5) Summary of Drilling Work [MJNM-9]

Period of Drilling

Working Item	Period	Total Days	Working days	Off days	Number of Person-day
Set up	1997/10/15, 10/17	2	2	0	4
Drilling	1997/10/16～10/17, 10/18～24	9	9	0	44
Tear Down	1997/10/17, 10/24～10/25	3	2	0	4
Total		14	13	0	52

Total Depth

Planned Depth	300.00 m	Soil	1.0 m
Additional depth	m	Core length	220.52 m
Total Inspected Depth	300.00 m	Recovery Rate	73.5 %

Break Down of the Working Time

Net Drilling	96.0 h	84.2 %	78.0 %
Rod Raising and Insert	20.0 h	17.5 %	16.3 %
Inner Tube Operation	2.0 h	1.8 %	1.6 %
Accommpanying Work	h	0.0 %	0.0 %
Recovering from Trouble	0.0 h	0.0 %	0.0 %
Others	0.0 h	0.0 %	0.0 %
Subtotal	118.0 h	103.5 %	95.9 %
Transladation	Interhole Moving		
Set up	13.0 h		10.6 %
Tear down	6.0 h		4.9 %
Grand total	137.0 h		111.4 %

Casing

Casing Diametre and Cased Length (m)		B/A×100 (%)	Recovered Casing (%)
HQ	100.0	33.3	82.0

Core Recovery Rate per 100 metres

Depth (m)	Core length	Recovery Rate	Cumulative Rate
0.00 ～ 79.48	0.00 m	0.00 %	0.00 %
79.48 ～ 172.70	93.22 m	100.00 %	53.98 %
172.70 ～ 300.00	127.30 m	100.00 %	73.51 %

Drilling Efficiency

Total Depth/Total Days	21.43	m/day
Total Depth/Working Days	23.08	m/day
Total Depth/Drilling Days	33.33	m/day
Total Depth/ Net Drilling Days	33.33	m/day
Total Depth/Total Person-day	5.77	m/P-day
Net Drilling Person-day/ Total Depth	0.15	P-day/m

Remarks
A:Total Depth
B:Cased Depth

Table II - 1 - 6 (6) Summary of Drilling Work [MJNM-10]

Period of Drilling

Working Item	Period	Total Days	Working days	Off days	Number of Person-day
Set up	1997/08/30, 9/14	2	2	0	2
Drilling	1997/08/30, 09/15～09/23	10	10	0	40
Tear Down	1997/10/08	1	1	0	2
Total		13	13	0	44

(Total Days, Working days, Off days and Number of Person-day are grouped under "Details of the Period".)

Total Depth

Planned Depth	300.00 m	Soil	1.0 m
Additional depth	0.00 m	Core length	219.00 m
Total Inspected Depth	300.00 m	Recovery Rate	73.0 %

Core Recovery Rate per 100 metres

Depth (m)	Core length	Recovery Rate	Cumulative Rate
0.00 ～ 81.00	0.00 m	0.00 %	0.00 %
81.00 ～ 191.40	110.40 m	100.00 %	57.68 %
191.40 ～ 300.00	108.60 m	100.00 %	73.00 %

Break Down of the Working Time

Net Drilling	106.0 h	61.6 %	57.3 %
Rod Raising and Insert	30.0 h	17.4 %	16.2 %
Inner Tube Operation	6.0 h	3.5 %	3.2 %
Accommpanying Work			
Recovering from Trouble	0.0 h	0.0 %	0.0 %
Others			
Subtotal	142.0 h	82.6 %	76.8 %
Interhole Moving			
Set up	5.0 h		2.7 %
Tear down	5.0 h		2.7 %
Grand total	152.0 h		82.2 %

Drilling Efficiency

Total Depth/Total Days	23.08	m/day
Total Depth/Working Days	23.08	m/day
Total Depth/Drilling Days	30.00	m/day
Total Depth/ Net Drilling Days	30.00	m/day
Total Depth/Total Person-day	6.82	m/P-day
Net Drilling Person-day/ Total Depth	0.13	P-day/m

Casing

Casing Diametre and Cased Length (m)		B/A×100 (%)	Recovered Casing (%)
HQ	120.0	40.0	87.0

Remarks
A:Total Depth
B:Cased Depth

Table II - 1 - 6 (7) Summary of Drilling Work [MJNM-11]

Period of Drilling

Working Item	Period	Total Days	Working days	Off days	Number of Person-day
Set up	1997/11/04	1	1	0	4
Drilling	1997/11/05~11/14	10	10	0	88
Tear Down	1997/11/14~15	1	1	0	4
Total		12	12	0	96

Total Depth

Planned Depth	300.00 m	Soil	1.0 m
Additional depth	0.00 m	Core length	296.90 m
Total Inspected Depth	300.00 m	Recovery Rate	99.0 %

Core Recovery Rate per 100 metres

Depth (m)	Core length	Recovery Rate	Cumulative Rate
0.00 ~ 110.83	107.73 m	97.20 %	97.20 %
110.83 ~ 196.56	85.73 m	100.00 %	98.42 %
196.56 ~ 300.00	103.44 m	100.00 %	98.97 %

Break Down of the Working Time

Net Drilling	180.0 h	104.7 %	97.3 %
Rod Raising and Insert	8.0 h	4.7 %	4.3 %
Inner Tube Operation	2.0 h	1.2 %	1.1 %
Accommpanying Work			
Recovering from Trouble	0.0 h	0.0 %	0.0 %
Others			
Subtotal	190.0 h	110.5 %	102.7 %
Transladation Interhole Moving			
Set up	12.0 h		6.5 %
Tear down	12.0 h		6.5 %
Grand total	214.0 h		115.7 %

Drilling Efficiency

Total Depth/Total Days	25.00	m/day
Total Depth/Working Days	25.00	m/day
Total Depth/Drilling Days	30.00	m/day
Total Depth/ Net Drilling Days	30.00	m/day
Total Depth/Total Person-day	3.13	m/P-day
Net Drilling Person-day/ Total Depth	0.29	P-day/m

Casing

Casing Diametre and Cased Length (m)		B/A×100 (%)	Recovered Casing (%)
HQ	48.0	16.0	12.0

Remarks
A:Total Depth
B:Cased Depth

Table II - 1 - 6 (8) Summary of Drilling Work [MJNM-12]

Period of Drilling

Working Item	Period	Total Days	Working days	Off days	Number of Person-day
			Details of the Period		
Set up	1997/10/28	1	1	0	4
Drilling	1997/10/29～11/04	7	7	0	48
Tear Down	1997/11/04	1	1	0	4
Total		9	9	0	56

Total Depth

Planned Depth	300.00 m	Soil	1.0 m
Additional depth	0.00 m	Core length	297.00 m
Total Inspected Depth	300.00 m	Recovery Rate	99.0 %

Break Down of the Working Time

Net Drilling	122.0 h	70.9 %	65.9 %
Rod Raising and Insert	14.0 h	8.1 %	7.6 %
Inner Tube Operation	2.0 h	1.2 %	1.1 %
Accommpanying Work			
Recovering from Trouble	0.0 h	0.0 %	0.0 %
Others			
Subtotal	138.0 h	80.2 %	74.6 %
Transladation	Interhole Moving		
Set up	12.0 h		6.5 %
Tear down	6.0 h		3.2 %
Grand total	156.0 h		84.3 %

Casing

Casing Diametre and Cased Length (m)		B/A×100 (%)	Recovered Casing (%)
HQ	57.0	19.0	100.0

Core Recovery Rate per 100 metres

Depth (m)		Core length	Recovery Rate	Cumulative Rate
0.00 ～	151.40	148.40 m	98.02 %	98.02 %
151.40 ～	221.61	70.21 m	100.00 %	98.65 %
221.61 ～	300.00	78.39 m	100.00 %	99.00 %

Drilling Efficiency

Total Depth/Total Days	33.33	m/day
Total Depth/Working Days	33.33	m/day
Total Depth/Drilling Days	42.86	m/day
Total Depth/ Net Drilling Days	42.86	m/day
Total Depth/Total Person-day	5.36	m/P-day
Net Drilling Person-day/ Total Depth	0.16	P-day/m

Remarks
A:Total Depth
B:Cased Depth

This hole and the following MJNM-12 were located in the west of the survey area. Previous information and the proximity from the hilly dolomite outcrops suggest that the calcrete is much thinner compared to the east of the survey area, and thus wireline drilling was used from the surface. The operating shift was two shift a day with 12 hours per shift. Since a formation of quartz rich sandstone followed calcrete reducing seriously the drilling rate, the drilling was continued seeing the adaptability of diamond bit to the formation.

And after breaking through the sandstone, the rate stayed under 20m/shift because of many thin lenses of chert and intense fracturings. The water transportation was increased particularly at a depth greater than 191m where total lost circulation had occurred.

MJNM-12

The sandstone which underlying calcrete was brittle for upper 40m due to weathering, and the hole was reamed and installed with casing. The sandstone was not so hard as that of MJNM-11 and the underlying dolomite formation were less fractured which resulted in 12 shifts in 6 days for completion. The water was transported using a tank lorry from water reservoir 0.8 km apart.

(6) Water supply

The drilling water was supplied from farmer's ground water or from a water hole drilled near the drill holes. Near MJNM-7 a water hole, 180 m/m in diameter and 56 metre deep was drilled by percussion method. The water pump was installed at a depth of 49 metres. The water level in a normal state was 3 to 6 m and pumping test revealed that the hole was capable of producing 2 m^3/h. The water was delivered to MJNM-7 and to MJNM-5.

Environment friendly type polymer was added to that water at the drill site before used and mud material was used when a lost circulation or ground collapse occurred.

II-1-4. Result of the Survey

The geological column sections are illustrated in Fig.II-1-2(1) through Fig.II-1-2(13), and the geological cross sections in Fig.II-1-4. The result of microscopic identification of thin sections, polished sections and X-ray diffractometry are shown in Table II-1-7 through Table II-1-9. The geological summary for each hole is as follows.

MJNM-5

- 0.00m- 83.00m Calcrete

This is a pale brown or greyish white pelagic calcareous sediment of concretion. The first aquifer was encountered at a depth of 6 metres and the aquifer 60 metre deep was the most important. In general the lower it goes, it shows mottled coloured and more pebbled. The upper part is unconsolidated sandstone with predominately quartz grains in red argillaceous matrix cut by steeply dipping white

Table II - 1 - 7 Microscopic Identification of Minerals in Thin Section

Sample No.	Hole No.	Depth (m)	Rock Name	Constituent Minerals						Accessory Minerals			Secondary Minerals				Remarks
				Qz	Cal	Dol	Cx	Pl	Bi	Hm	Mt	Ap	Ser	Qz	Dol	Cal	
T-01	MJNM-5	144.90	Oolite chert		△									◎			
T-02	MJNM-5	168.00	Dolomite			◎				△				△			
T-03	MJNM-5	219.30	Dolomite			◎								△	△		
T-04	MJNM-6	140.70	Dolomite			◎								○			
T-05	MJNM-6	250.70	Dolomite			◎										△	
T-06	MJNM-6	296.30	Dolomite			◎								△	△		
T-07	MJNM-7	133.50	Dolomite			◎											
T-08	MJNM-7	139.10	Calcareous chert	△		△				△		+		◎		○	
T-09	MJNM-7	163.90	Dolomitic shale	◎		◎						+	△		○		
T-10	MJNM-7	227.60	Dolerite				◎	△	△		○						
T-11	MJNM-8	140.00	Dolomite											△	◎		
T-12	MJNM-8	188.70	Limestone	○	◎	○										○	
T-13	MJNM-8	230.75	Chert/Dolomite	◎		◎									○		
T-14	MJNM-8	261.70	Dolomite			◎									○		
T-15	MJNM-9	132.00	Dolomitic shale	△		◎							△				
T-16	MJNM-9	188.30	Chert	◎											◎		
T-17	MJNM-9	243.40	Dolomite			◎								△			
T-18	MJNM-9	299.50	Dolomite			◎								△			
T-19	MJNM-10	83.80	Sandy calcrete			◎											
T-20	MJNM-10	131.45	Oolite chert			○								◎			
T-21	MJNM-11	110.60	Arenite	◎													

◎:abundant ○:common △:rare +:trace

Abbreviations

Qz:quartz Cal:calcite Dol:dolomite Cx:clinopyroxene plagioclase Bi:biotite

Hm:hematite Mt:magnetite Ap:apatite Ser:sericite/muscovite

Table II - 1 - 8 Microscopic Identification of Minerals in Polished Section

Sample No.	Hole No.	Depth(m)	Sulphide primary & oxide mineral					
			Gn	Sp	Cp	Py	Mt	Ds
P-01	MJNM-7	227.60					○	
P-02	MJNM-8	227.80				◎		
P-03	MJNM-9	232.07	+	△	+			
P-04	MJNM-9	241.87						△
P-05	MJNM-9	242.90	○	○	+			
P-06	MJNM-9	243.15	△	○	△	+		
P-07	MJNM-9	248.10	△	○	+			
P-08	MJNM-9	251.40						△
P-09	MJNM-10	269.10			+		△	
P-10	MJNM-11	270.70	+	+	+			

◎: abundant ○: common △: poor +:trace

abbreviations: Gn: Galena Sp: Sphalerite Cp: Chalcopyrite Py: Pyrite Ds: Descloizite

Table II - 1 - 9　Result of X-ray Diffractometry

Samples				Clay & Silicate Minerals								Carbonate Minerals		Other Minerals			Remarks
No.	Well No.	Depth	Rock Name	Smectite	Chlorite	Palygorskite	Talc	Quartz	Biotite	K-Feldspar	Albite	Calcite	Dolomite	Pyrite	Magnetite	Brucite	
X-1	MJMN-5	91.50 m	White argil			○		○									
X-2	MJMN-6	296.45 m	Calcareous dolomite										◎				
X-3	MJMN-7	157.00 m	Talc		△		◎	△									
X-4	MJMN-7	227.60 m	Dolerite		△				◎			○			△	○	+Chrysotile Lizardite
X-5	MJMN-7	262.70 m	Pink talc	△	△		◎						◎				
X-6	MJMN-8	230.75 m	Pyrite	△				○				○		○			
X-7	MJMN-9	113.30 m	Crackled dolomite		+			○				◎	◎				
X-8	MJMN-10	262.00 m	Dolerite	△	△							○		△			
X-9	MJMN-12	59.60 m	Mulden sandstone	△				◎		○	△						
X-10	MJMN-12	291.45 m	Pink talc				◎	○					+				

Abbreviation
◎:Abundant　○:Common　△:Poor　+:Trace