REPUBLIC OF PANAMA
Ministry of Commerce and Industries

ADMINISTRATION OF MINERAL RESOURCES

UNITED NATIONS
DEVELOPMENT PROGRAMME
MINERAL SURVEY
OF THE AZUERO AREA

PORPHYRY COPPER MINERALIZATION AT CERRO PETAQUILLA PROVINCE OF COLON PANAMA

JULY 1969

TECHNICAL REPORT
PREPARED FOR
THE GOVERNMENT OF THE REPUBLIC OF PANAMA
BY
THE UNITED NATIONS
ACTING AS PARTICIPATING AND EXECUTING AGENCY
FOR THE UNITED NATIONS DEVELOPMENT PROGRAMME

(Publication Nº 3)

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Spanish-English glossary[1]

a lo largo	-	along
aéreo(a)	-	aerial, aero-
aluviones	-	alluvial deposits
aproximadamente	-	approximately
arenisca	-	sandstone
brecha	-	breccia
cada	-	every, all
caliza	-	limestone
cámara	-	chamber
carretera	-	highway
cerro	-	hill
ciento	-	hundred
complejo	-	complex
contorno	-	contour
Cretácico	-	Cretaceous
cuarzo	-	quartz
curva	-	curve
división continental	-	continental divide
edad	-	age
escala	-	scale
esquemático	-	schematic
esquistos	-	schists
falla	-	fault
filo	-	ridge
geoquímica	-	geochemistry

1/ This glossary has been prepared to facilitate understanding of map references, which are presented in Spanish at the Government's request. Most of the terms with only minor differences in spelling between the two languages have been omitted.

golfo	- bay, gulf
grado	- degree
igual	- equal
indiferenciado	- undifferentiated
intermedio	- intermediate
límite	- boundary
línea	- line
lutita	- lutite
mayor	- greater than
mangerita	- mangerite, orthoclase-diorite
mar	- sea
medio(a)	- medium, middle
menor	- less than
mensura	- measurement
metro	- metre
mina	- mine
muestra	- sample, specimen
nivel	- level
perfil	- profile
perforación	- drill hole
poco(a)	- small
profundidad	- depth
proyecto	- project
quebrada	- stream
reciente	- recent
red	- network, grid
referencia	- legend
río	- river
roca	- rock
silicificada	- silicified
sobre	- above
suelo	- soil

superior - upper
Terciario - Tertiary
tobas - tuffs
ubicación - location
valor - value
zona - zone

SUMMARY

The main purpose of the project was to carry out a pre-investment survey of a selected area of 17,000 sq.kms. in central Panama to assess its mineral potential and to attract outside investment in the sector of mining exploration and development.

In the course of routine regional reconnaissance a promising target was indicated by a pattern of copper and molybdenum anomalies in stream sediments between the Cordillera and the Caribbean coast. Follow-up surveys established the presence of porphyry copper type mineralization in the area now known as Cerro Petaquilla.

Subsequent detailed surveys by the project staff were planned so as to provide sufficient factual information to encourage systematic economic evaluation of the area. This work involved cutting a grid of survey lines totalling 200 kilometres in length and covering an area of 28 square kilometres. A total of 9,150 soil samples was collected for geochemical analyses, 2,336 rock specimens were classified in the course of geological mapping, more than 10,000 magnetic measurements were made along the grid-lines, and a total of 2,794 metres was drilled at 37 sites.

Exploration methods employed by the project have proved eminently suitable and effective under the prevailing conditions. Numerous checks by the project and outside laboratories have shown that the numerical data presented in this report and in supporting material are essentially reliable.

Interpretation of the factual information in terms of possible economic potential was not an object of this

survey, but it is concluded that one or more of the mineralized zones within the area may be of economic size and grade, and therefore merit further exploration.

The geological investigations in the Cerro Petaquilla area have indicated that a volcanic complex of intermediate to basic composition has been intruded by a suite of granodioritic, quartz-monzonitic and gabbro-dioritic rocks. Rocks of dacitic type are common, but their true origin has not been definitely established. The age of one gabbro diorite specimen, as determined by the potassium-argon method, is about 33 million years, or late Oligocene.

Strong hydrothermal alteration typical of porphyry copper deposits affects some parts of the intrusive complex, and in places extends into the volcanics. In fact, the whole of the mapped dacitic unit may represent older volcanic rocks altered by hydrothermal activity.

The primary mineralization occurs at or near the surface mostly in intruding rocks, but in some places along the contacts copper minerals have penetrated into the surrounding volcanics.

Although minor amounts of gold and silver have been shown in a few of the assays, with erratic distribution, on present knowledge only copper and molybdenum are of possible economic importance. No direct evidence of significant supergene enrichment has been found.

PART ONE

INTRODUCTION

A. PROJECT HISTORY

The project, named Mineral Survey of the Azuero Area, was to asses the mineral potential within a selected area with a view to outlining a mining development plan and attracting investment. A parallel aim was to strengthen the Administración de Recursos Minerales by providing in-service training for its staff and establishing the necessary services.

The project has been carried out jointly by the United Nations acting as the executing agency for the United Nations Development Programme, and by the Government of Panama.

The total cost of the project amounts to U.S. $1,608,000, of which the Special Fund contributed $940,000 and the Government $668,000 partly in cash and partly in kind.

The selected area, covering 17,000 square kilometres, is shown on map 1. It covers the Azuero Peninsula on the Pacific side and extends northward across the Cordillera to the Caribbean coast. The area was declared a Mineral Reserve by Presidential Resolution Nº 24 dated 23 July 1964.

The project became operational in October 1965 with the arrival of the Project Manager appointed by United Nations. The other members of the United Nations team took up their posts between January and April 1966. The Panamanian counterpart professional staff consisted at that time of only one geologist, acting as Project

Co-ordinator, and one chemical engineer (petroleum refining), but the Government contracted two recently graduated Italian geologists to serve on the project. The full list of staff is presented in Annex I.

In the early stages an airborne geophysical survey, magnetic and radiometric, was carried out between February and April 1966 by Lockwood Survey Corp. under contract to United Nations. Concurrently, the international staff were largely engaged on compilation of what little was known about the geology and mineral occurrences within the project area. The following programme was adopted:

(1) Regional survey - collection and analysis of stream sediment samples and geological observations.

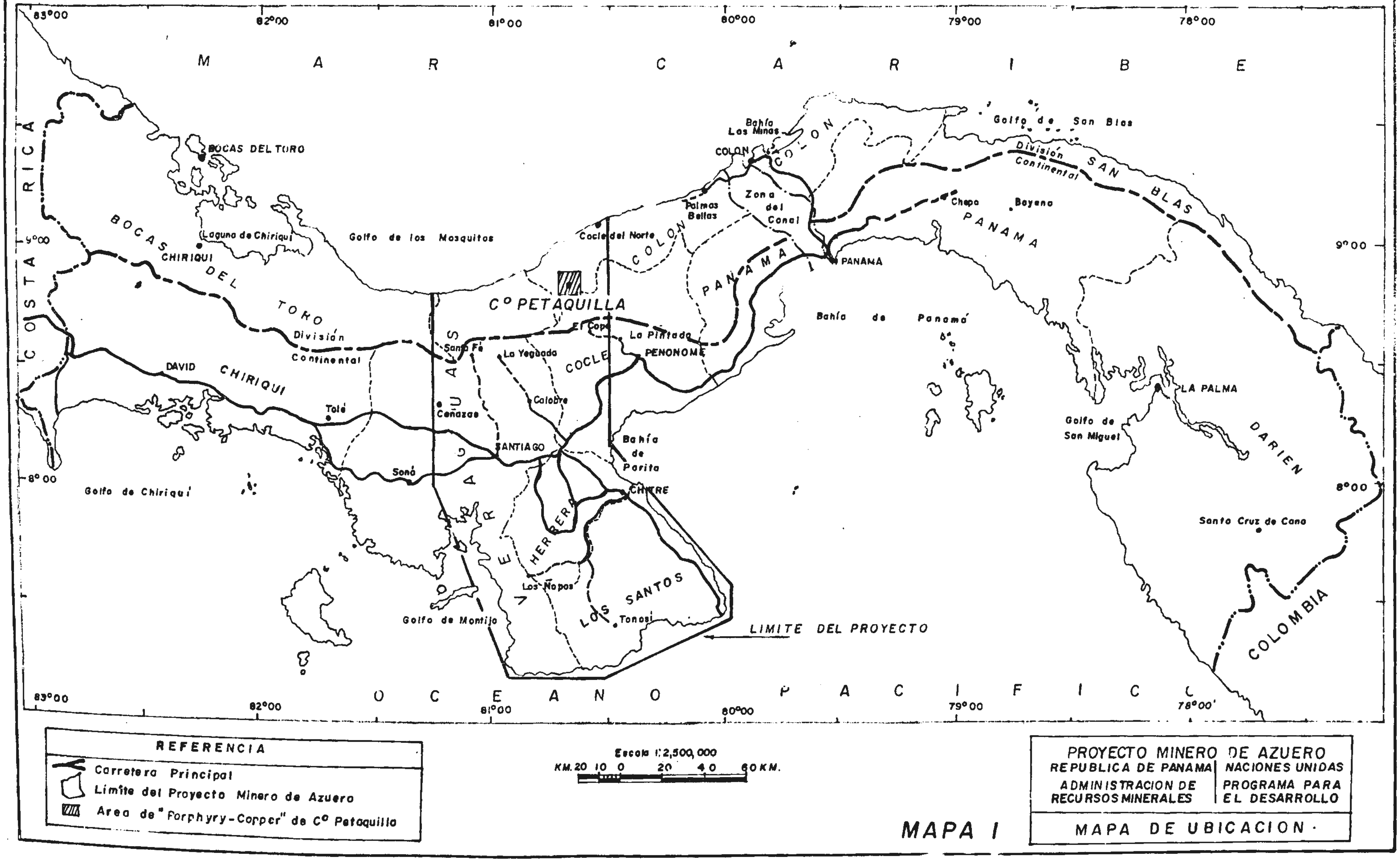
(2) Selection of target area, based on results of the regional survey and on available information about mineral occurrences.

(3) Detailed work in target areas: geology and outcrop sampling, geochemical analysis of soil samples, geophysical methods as applicable, and photogeological interpretation.

(4) Subsurface exploration (pitting, trenching, diamond drilling).

Field work started in April 1966, with emphasis on the regional survey. But work in the difficult and unmapped northern part of the area near the Caribbean Coast was postponed in the hope that the planned but long delayed aerophotographic survey might take place. In the meantime, the first of the target areas were being investigated in detail. Eventually, a reconnaissance survey of the northern part was made in January 1967. The results showed promising copper values in the sediments of

REPUBLICA DE PANAMA



PROYECTO MINERO DE AZUERO

REPUBLICA DE PANAMA	NACIONES UNIDAS
ADMINISTRACION DE RECURSOS MINERALES	PROGRAMA PARA EL DESARROLLO

MAPA DE UBICACION·

MAPA I

all major streams draining what was to become the Cerro Petaquilla prospect area, but follow-up work was postponed because of difficulties of working in this inaccessible and uninhabited rain forest without the aid of maps or air photographs.

When it seemed obvious that no photographs were likely to become available in the foreseeable future, and with only four months remaining for field work, a strong team equipped with a field laboratory and radio transcievers entered the area on 13 February 1968. Within days, strong indications of porphyry-copper type of mineralization were found in Río Botija, and soon afterwards in a tributary to Río Petaquilla. By a stroke of good luck the map problem was solved when the pilot of an Inter-American Geodetic Survey aeroplane, passing along the coast on a ferry flight, noticed one of the rare breaks in the cloud cover and decided, without any knowledge of the project's operations, to take some photographs. He only had time to cover one strip before the clouds closed in again, but that flight passed directly over the Cerro Petaquilla area. The photographs were immediately interpreted by the project photogeologist, and the resulting drainage maps, showing also form-lines and ridges, were received in the field in the first week of March.

A brief announcement of the discovery was released simultaneously in New York and in Panama on 30 April 1968. Up to that time, mineralization of this type had not been known, and hardly suspected, in the long gap between the North American belt of deposits terminating at Sonora in northern Mexico, and the deposits of Peru and their continuation into Chile and Argentina. As a result, a number of mining companies have already started prospecting activities in Panama and in other parts of Central America.

By the end of May 1968 enough detailed work had been done to produce an ad hoc report (listed in Annex III) which generated much interest among mining companies. At the same time the U.N.D.P. and the Government agreed to extend the project's life till the end of June 1969.

Field work was resumed in October 1968 after a 3-months' leave period, and completed in February 1969 except for scout drilling which continued until 24 June 1969.

The project's work can be illustrated by the following figures; these include the Cerro Petaquilla detailed survey.

Field work

Duration of field campaign	38 months
Rock specimens collected	7,036
Geochemical samples collected	25,771
Geophysics: magnetic measurements	18,245
electromagnetic profiles, line-kms	124
self-potential profiles, line-kms	45
Diamond drilling: metres	4,316

Laboratories

Number of determinations: (geochemical, chemical, fire assays and checks)	162,714
Number of petrographic thin sections	3,600
Number of polished sections	160

B. BACKGROUND INFORMATION

1. Physical environment

The main topographic feature is the range of Cordillera Central which runs in a general easterly direction across the northern part of the project area. Its highest parts reach 1,800 metres above sea level near the area's western boundary and 800 metres in the east. The southern part of the Azuero peninsula is also mountainous, with peaks reaching 1,600 metres above sea level. In between stretch the plains and the rolling country where much of the country's agriculture and stock breeding is concentrated. To the north of the Cordillera a tropical rain forest covers almost all of the foothills and of the coastal plain. In the Cerro Petaquilla area the terrain is rugged, but relief does not exceed 250 metres.

The climate is tropical, with temperatures averaging 80ºF (28ºC) in winter and 88ºF (32ºC) in summer. Rainfall is generally heavy, ranging from 1,500-2,000 mm/year in the savannah country of central and eastern Azuero to some 5000 mm/year north of the Cordillera. The dry season on the Pacific side of the Cordillera varies in duration from three to as much as six months, with an average of 4 1/2 months (December-April). On the Caribbean side the seasons are less well defined. During the project's work at Cerro Petaquilla heavy rains were frequent from mid-December to mid-March, with variable rainfall during the rest of the year.

2. Regional geology and mineralization

a) Geology. The following main rock divisions, shown in map 2, have been identified in the project area:

(i) Recent alluvial deposits
(ii) Tertiary dykes, intermediate to basic
(iii) late Tertiary to early Quaternary ignimbrites and basalts
(iv) mid Tertiary and late Tertiary intrusions
(v) Early Tertiary to Quaternary volcanic and some sedimentary rocks
(vi) Cretaceous dacites
(vii) pre-Tertiary, intermediate to basic intrusions (Cretaceous according to two potassium-argon age determinations)
(viii) (?) Mesozoic, ultrabasic complex of igneous rocks
(ix) (?) Mesozoic green schists

Lavas and their pyroclastic equivalents, mainly of the continental type, are dominant in the project area, but some sedimentary rocks have also been mapped.

The middle Tertiary (Oligocene) intrusions of granite, granodiorite, quartz monzonite, and some quartz diorite, diorite and gabbrodiorite occur north of the Cordillera. They intrude undifferentiated Tertiary volcanic rocks. Dacitic rocks have also been observed. The late Tertiary (Pliocene) intrusions have been observed mostly in the central Cordillera and its southern foothills; the intruded volcanic assemblage is upper Miocene.

Undifferentiated Tertiary lavas and tuffs form many of the highlands in the Azuero peninsula, and are the prevailing volcanic assemblage north of the ignimbrite zone of the central Cordillera. Early to middle Tertiary extrusive rocks (tuffs) and sediments (fossiliferous limestone, shale, sandstone) occur mainly along the southern coast of the peninsula and along the southern margin of the central lowlands. Middle to upper Tertiary extrusive rocks (tuffs and agglomerates) and sediments (sandstones, conglomerates) underlie the central lowlands; local exposures also occur along the Caribbean coast. Late Tertiary and Quaternary ignimbrites and basalts are found almost exclusively on the high ground of the Cordillera, but remnants of volcanic cones and flows occur in the central lowlands, in the central Cordillera and to the north of it.

Cretaceous dacites are found on the borders of the somewhat older Cretaceous intrusions in the southwestern part of the project area.

The oldest intrusions are the ultrabasic complex (picrites, olivine gabbros, and picritic lavas) and the late Cretaceous diorites and gabbros in the southwestern and south-central parts of Azuero peninsula.

Green schists (chloritic-actinolitic) occur in a few exposures in the southwestern part of the Azuero peninsula. The schists are thought to be metamorphosed portions of the (?) Mesozoic ultrabasic complex.

b) Structure. The Azuero peninsula is crossed by pronounced faults trending easterly and southeasterly.

Strikes and dips in the project area are variable, but northerly dips prevail in the region south of the Cordillera.

In the area between the Cordillera and the Caribbean coast, which includes Cerro Petaquilla, the prevailing structures are northerly trending faults. Strikes and dips have not been definitely established. Where observed, the dips are northerly.

There is no direct evidence of geosynclinal development.

A schematic geological section is shown in figure 1.

c) <u>Mineralization</u>. The project area contains local occurrences of lode and placer gold, manganese, iron, barite, copper, lead and zinc.

The lode and placer gold showings are mainly in the northwestern part of the area on each side of the Central Cordillera.

Small manganese outcrops are centred around the village of Las Minas in the central western part of the project area.

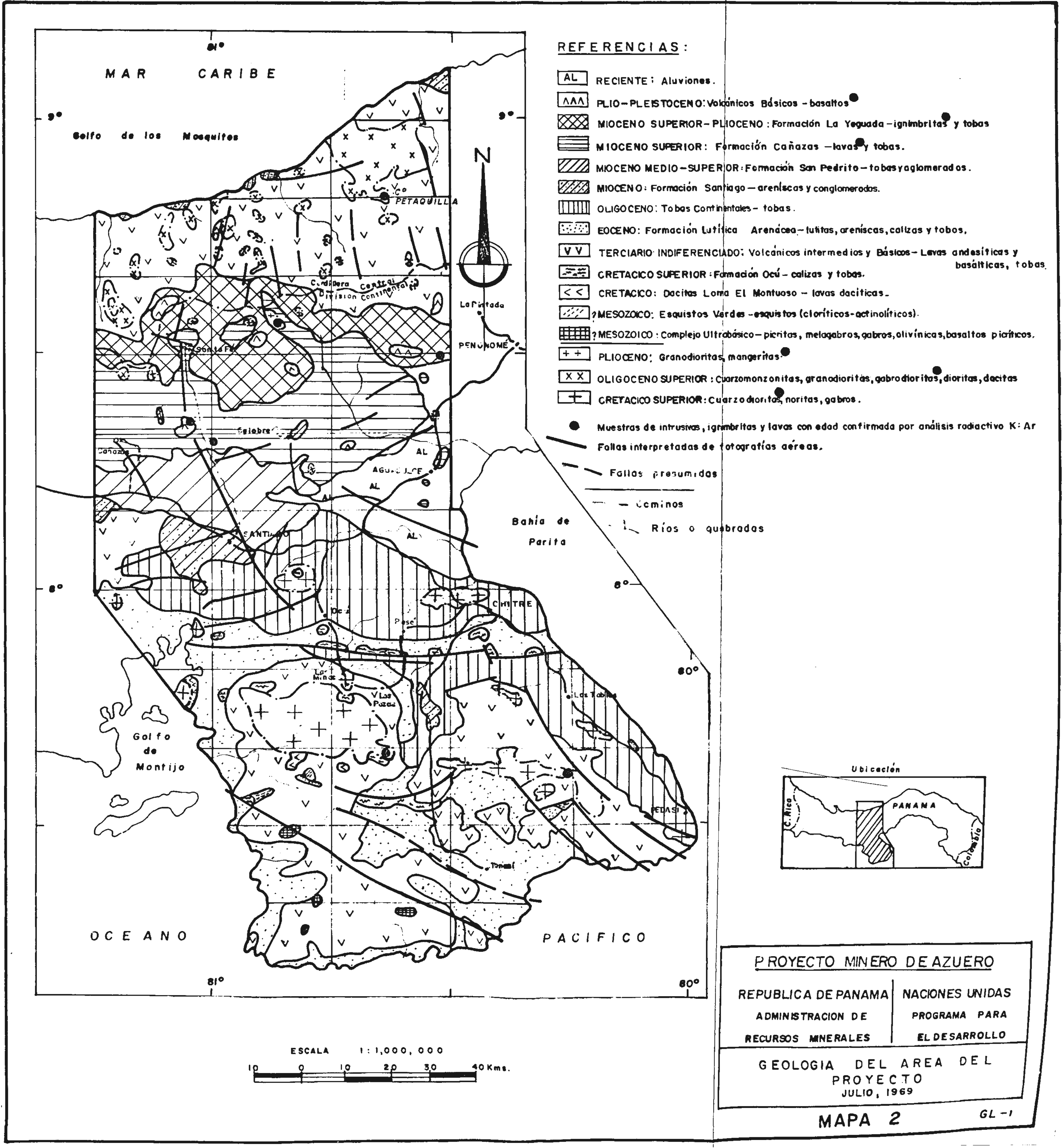
Iron (magnetite and hematite) occurs as local segregations in basic intrusions near the village of Las Minas. Lateritic iron was found in the central part of the project area at La Mesa.

Base metals, associated with barite in places, have been seen mainly in the central, southern and southwestern parts of project area. Some of these showings have been explored in the past, but they are all small and of doubtful economic value. Two copper prospects (Iguana and Barro) discovered by geochemical stream sediment sampling during the project investigations contain mostly marginal grade copper, but further investigations are recommended.

A number of base metals anomalies in stream sediment values were indicated in other parts of the project area. The geochemical background values are generally high, but vary somewhat in certain zones (map 3).

3. Previous mining activity

Records of past activities are extremely scarce. Gold mining has been carried out, sporadically, since the



PROYECTO MINERO DE AZUERO

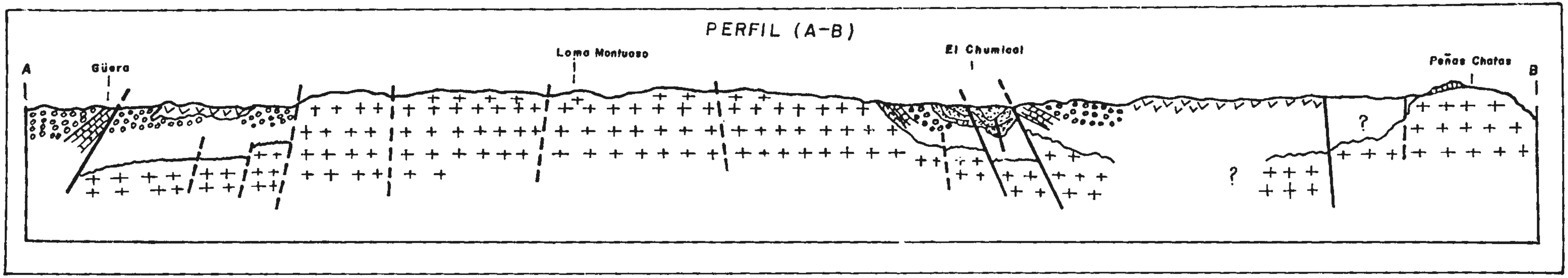
REPUBLICA DE PANAMA	NACIONES UNIDAS
ADMINISTRACION DE RECURSOS MINERALES	PROGRAMA PARA EL DESARROLLO

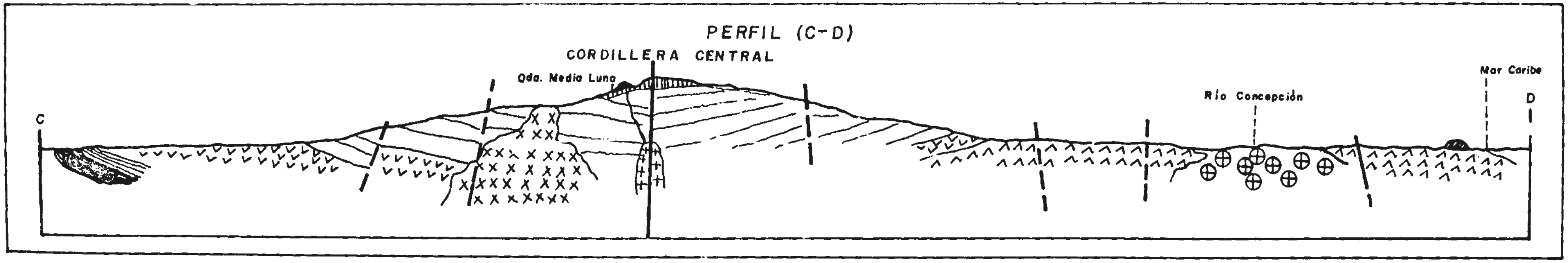
GEOLOGIA DEL AREA DEL PROYECTO
JULIO, 1969

MAPA 2

GL-1

PERFILES GEOLOGICOS ESQUEMATICOS


PERFIL (A-B)


PERFIL (C-D)

PERFIL (A-B)

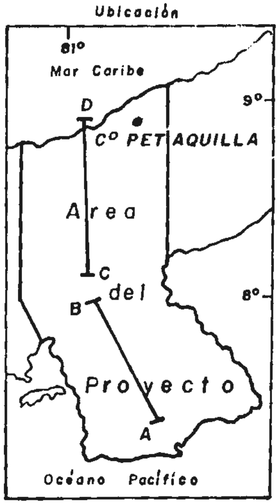
LEYENDA

- ▨ Tobas continentales oligocénicas.
- ⌄⌄⌄ Volcánico terciario
- ∘∘∘ Formación Lutitico—Arenácea
- ▦ Formación Ocú
- ^^^ Dacitas cretácicas
- +++ Intrusivo cretacico

PERFIL (C-D)

LEYENDA

- ▥ Basalto post-ignimbrítico
- ☰ Formación La Yeguada
- ⌄⌄⌄ Formación Cañazas
- ☰ Formación San Pedrito
- ■ Formación Santiago
- ^^^ Lavas oligocénicas
- +++ Cámara magmática volcanismo pleistocénico
- ××× Intrusivo pliocénico
- ⊕⊕⊕ Intrusivo oligocénico


Ubicación

ESCALA HORIZONTAL APROXIMADA
1:250,000
(EXAGERACION VERTICAL 2:1, APROX.)

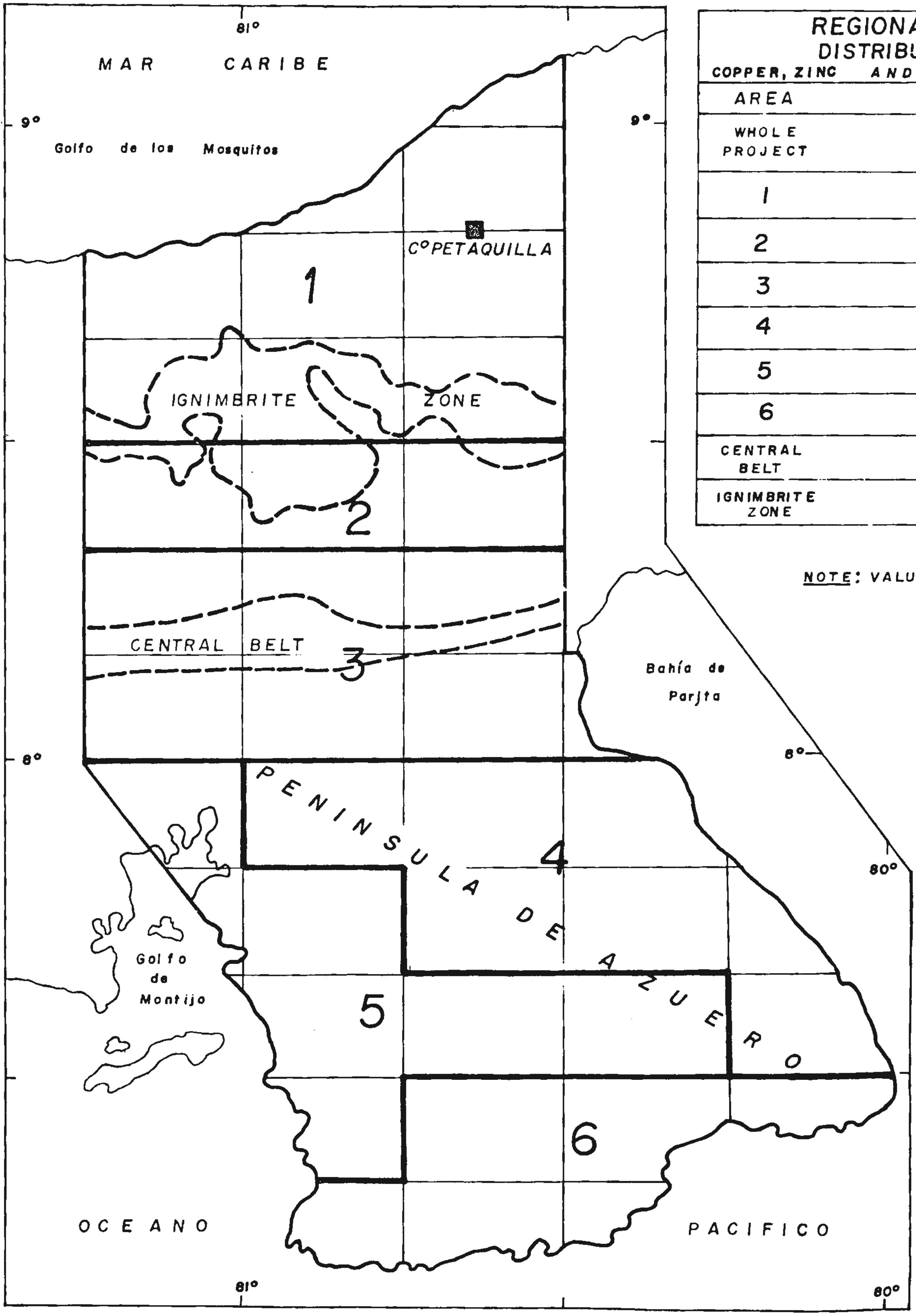
FIGURA I

PROYECTO MINERO DE AZUERO

REPUBLICA DE PANAMA	NACIONES UNIDAS
ADMINISTRACION DE RECURSOS MINERALES	PROGRAMA PARA EL DESARROLLO

PERFILES GEOLOGICOS ESQUEMATICOS
Junio de 1969

GL 3



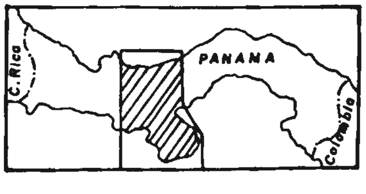
REGIONAL GEOCHEMICAL SURVEY
DISTRIBUTION OF MEDIAN VALUES

COPPER, ZINC AND COLD EXTRACTABLE HEAVY METALS (cx HM)

AREA	ELEMENT	MEDIAN VALUE, p.p.m.
WHOLE PROJECT	Cu Zn cx HM	100 90 4
1	Cu Zn	95 95
2	Cu Zn	90 85
3	Cu Zn	100 100
4	Cu Zn	80 90
5	Cu Zn	110 100
6	Cu Zn	110 100
CENTRAL BELT	Cu cx HM	125 6
IGNIMBRITE ZONE	Cu cx HM	80 3

NOTE: VALUES ARE FOR STREAM SEDIMENTS.

Ubicacion



MAPA 3

PROYECTO MINERO DE AZUERO

REPUBLICA DE PANAMA	NACIONES UNIDAS
ADMINISTRACION DE RECURSOS MINERALES	PROGRAMA PARA EL DESARROLLO

REGIONAL GEOCHEMICAL SURVEY
DISTRIBUTION OF MEDIAN VALUES
Junio 1969

GC-1

colonial times. In fact, Columbus learnt during his fourth voyage, in 1502 and 1503, that natives had been winning gold from river gravels near the Caribbean coast in the present district of Santa Fé in the province of Veraguas. The main deposits were found by the Spaniards in Río Concepción where some 9 tons of gold were produced by slave labour in the second half of the 16th century. Minor deposits of gold were later exploited by the Spaniards on the west coast of Azuero (Calvo, 1967).

Other gold mines were worked in pre-Columbian times and in the 16th century on the southern slopes of Cordillera Central de Veraguas, at and around Los Hatillos. Numerous scars left by open pit workings can still be seen. Minor mining and exploration activities were resumed in this area for some months in 1931.

Some copper showings in the Herrera Province (central Azuero) have been explored in the past. A small deposit of rich copper ore was mined out in the 1950's at El Guásimo near Pesé.

Outside the project area, the richest gold mines were in operation at Santa Cruz de Caná in the eastern part of Darién. Started in 1680, the mines were abandoned in 1727 because of frequent raids by buccaneers. They were re-discovered and worked for 9 years until 1907, producing about 4 tons of gold in that time.

At present only some quarries are in operation (road metal, sand, limestone, gravel, clay), employing in all about 90 persons in the whole of the country.

4. Economic background

The total population of Panama in 1968 has been estimated at 1,400,000, with an annual increase of about 3%.

Unemployment was estimated at 7.3% of the "economically active" population of 418,000. The Caribbean side of the project area is almost uninhabited, except for a few small settlements, mainly at the mouths of bigger rivers.

Panama is predominantly an agricultural country, though only 12 per cent of the total area is under cultivation. Out of the total exports worth $109 million in 1968, bananas accounted for 55 per cent, shrimps for 8.5 per cent and sugar for 4 per cent.

The deficit in external balance of payments amounted to $153 million in 1968. However, goods and services to the Canal Zone (including the United States Armed Forces) provided a net surplus of nearly $120 million, leaving an overall deficit of only $33 million.

This dependence on outside factors influences the Government's economic policies. The main objectives have been formulated in following terms in the "Informe Económico 1968" prepared by the Dirección General de Planificación y Administración, Presidency of the Republic:

(1) Parity between Balboa and U.S. Dollar.

(2) Free movement of local and international funds, within and outside the bank system.

(3) Freedom of action, within the law, for every national or foreigner engaged in economic activities.

(4) Expropriation or nationalization of enterprises will not be considered.

(5) The economy will be protected from artificial controls that may adversely affect individual initiative.

(6) A sharp increase in public investment is planned to achieve a quick economic recovery.

(7) The Government reaffirms its commitment to the principle of free private enterprise.

Among other possible areas of future development, mineral resources are specifically mentioned in this document.

Panama is an important communications centre with daily connections by air and sea to most parts of the world. At present between 40 and 50 ships transit the canal daily.

Within the country, local companies provide scheduled and charter flights to several towns and to numerous landing strips in all parts of the country. A public rail service is operated by the Panama Canal Company between Colón and Panamá, and two short, local rail lines exist in the province of Chiriquí. Otherwise, public transport is restricted to private bus services. An adequate network of roads, many of them all-weather, exists in the Azuero Peninsula, with several spurs towards the southern slopes of the Cordillera. The main artery is, of course, the Interamerican Highway running from Panama City to Central American countries and beyond. There are, however, no roads and only very few footpaths in the part of the project area to the north of the Cordillera, where Cerro Petaquilla is located.

The hydroelectric plant of 6,000 kw at La Yeguada in Veraguas Province provides power for a part of the project area, but has not the capacity to support a large industrial operation. A new hydroelectric plant of 150,000 kw is due for completion in 1974 at Bayano, Panama Province, and a thermoelectric plant of 80,000 kw at

Bahía Las Minas, Colón Province in 1971; the first stage of the latter (40,000 kw) has been completed. A hydroelectric project at La Fortuna (Chiriquí) is under study; the proposed capacity is 150,000 kw or more. Another project, on Río Coclé del Norte flowing into the Caribbean close to the project area's eastern boundary, is being considered. The intention is to link all these plants into a national grid.

C. PRESENTATION OF RESULTS

The present report is an account of results obtained in the Cerro Petaquilla porphyry copper prospects. Separate technical reports are being issued on other aspects of the project's work; these are listed in Annex III.

Each report is supported by a large volume of data in the form of tables, maps and interim reports. For the Cerro Petaquilla survey this includes two series of maps, both on 1:5,000 scale. The first series shows all the basic data such as location and index numbers of all geochemical samples and rock specimens, results of analytical, and petrological determinations, magnetometer readings etc. The second series presents the project's interpretation of these data in the form of geological contacts, geochemical and magnetic anomalies, alteration patterns, topographic contours etc. All this material is on open file and may be inspected in the Administración de Recursos Minerales in Panama City. Copies may also be obtained on application. All the supporting data for Cerro Petaquilla survey are listed in Annex II.

D. ACKNOWLEDGEMENTS

Much of the success of this project is owed to the active help and assistance, hereby gratefully acknowledged, that has been received from many and various sources too numerous to name individually.

The constant interest and co-operation of the Director of the Administración de Recursos Minerales and his staff has been much appreciated.

In the office, field and laboratory, the Panamanian counterpart staff have shown a capacity for work, often under very adverse conditions, and general ability that has contributed in large measure to the success of the project.

Many government departments, both civic and military, showed considerable interest in the work done by the project and gave assistance in a number of ways. Instituto Geográfico Nacional "Tommy Guardia", Catastro Rural and the University of Panama deserve special thanks.

Some valuable scientific work beyond the resources of the project has been contributed by the Institute of Geological Sciences, London (age determinations), and by the University of Rome (palaeontological studies).

Useful discussions were held with many of the representatives of mining companies who visited the Cerro Petaquilla area. Mention must be made of the valuable help given by the Duval Corporation in providing check chemical analyses and by the Phelps Dodge International for carrying out some petrographic work.

PART TWO

METHODS AND PROCEDURES

The character of the Cerro Petaquilla prospect area, heavily wooded and dissected by steep valleys, remote and uninhabited, has imposed certain limitations and special requirements on the planning and execution of detailed investigations.

Although the area can be reached by walking, mostly in river beds and usually in fairly deep water, either from the points that can be reached from the coast by canoes or from La Pintada on the southern slopes of the Cordillera, pack animals cannot be used and it was found impracticable to do this work without continuous helicopter support, both for communication with the outside world and for movement of equipment and personnel within the area. This necessitated an average of 30 hours flying time per month, and the clearing of eleven landing pads within the survey area; their locations can be found on map T/65-2 (on open file). One important advantage of the helicopter support was that geochemical samples, rock specimens, drill core, and all other field data could be regularly sent to headquarters in Panama City as soon as they became available. After processing the data, the results were relayed by two-way radio to the field team who used them for planning further work in the most economical way.

The various methods and procedures used in the survey are described below.

A. MAP COVERAGE AND AEROPHOTOGRAPHY

Prior to the project's field activities no reliable maps of the region were available. The census map of the Donoso District, Colón Province, prepared in 1959 by the Dirección de Estadística y Censo de la República de Panamá at scale 1:50,000 is not sufficiently accurate. Aerial photographs existed only along the coast and in a few parts of the region. The nearest north-south flight line (photographs 3,212-3,226, line 41) passed just to the east of the Cerro Petaquilla grid system.

In February 1968 the Inter American Geodetic Survey succeeded in taking a north-south strip of 1:60,000 scale photographs (flight line L 119 A, photographs 620-635)[1/] which extended south from the Caribbean Coast, over the Cerro Petaquilla area, and across the continental divide of the Cordillera.

A drainage base map covering the area at 1:30,000 scale was prepared by the project photogeologist from exposures 628, 629 and 630 of this new photography, and exposures 3,220 and 3,221 of the old flight line 41.

For the recording of detailed survey data a series of topographic grid line maps was prepared at 1:5,000 scale from field topographic and grid line measurements, with partial control by photo interpretation. These maps were later reduced photographically to scale 1:15,000 for compilation and interpretation of results.

[1/] Photographs 627-635 of flight line L 119 A were provisionally designated by the numbers 1 to 9 of flight line L 56 in the *ad hoc* interim report published in May 1968.

Regional survey data have been plotted on a series of 1:50,000 scale drainage maps, prepared by the project staff from the new and old photography. These maps were reduced photographically to 1:250,000 scale; they depict the drainage pattern more accurately than is shown on the published 1:250,000 maps available from the National Geographic Institute of Panama, and form the basis for map 4 accompanying this report.

In June and July 1969 a "side looking" radar survey was carried out over the region of Cerro Petaquilla, but the results have not yet been published. A photographic record at approximately 1:160,000 scale is being prepared from the survey data. This new surveying technique now makes it possible to obtain clear images of the ground even through a fairly heavy cloud cover. Preliminary results were made available to the project and used in photogeological interpretation of structure in the region, (map 4).

B. GEOCHEMISTRY

1. Regional geochemical/geological survey

The original survey which led to the discovery of Area 65-Cerro Petaquilla, was made in January 1967. Sediment samples from rivers draining the area (Botija, Canoa, Cuatro Callitos, Caimito and Petaquilla) gave clear, if not very strong, anomalies in copper, molybdenum and in cold-extractable heavy metals.

The second survey in April 1967 and the first part of the third in February 1968, were still regional in character, but the spacing between sample sites was reduced to 1 km or less, and more detailed geological observations were made in places of potential interest. Sample-site determinations of cold-extractable copper were widely used to help in the day to day planning of field work.

2. Detailed surveys

Immediately after the discovery of the Botija and Petaquilla mineralization a detailed follow-up geochemical sampling of all the nearby drainage was started, and a simple field laboratory to analyse copper and zinc was established.

In the next stage, soil samples were systematically collected at 20-metre intervals along a system of survey lines spaced at 50 to 200 metres intervals, totalling 200 kilometres in length, and covering an area of 28 square kilometres. The material was collected from a depth of about 15 cm., immediately below the poorly developed humus layer. This work revealed an additional mineralized zone at Río Medio, and several other zones which merit further detailed study (Río Medio, Botija West, Botija North, Botija Abajo and Quebrada Vega in the Río Petaquilla sector). With the exception of Río Palmilla, all the known zones of mineralization are contained within the present grid system.

3. Presentation of results

The geochemical data are presented for sediments, soils and rock specimens in table 1. The various sets of data were processed for interpretation by statistical treatment, and the median values and the anomalous variations were calculated from frequency distributions.

The median value of any given set of data is regarded as the background value. The threshold value represents, with few exceptions, the 20 per cent step of the cumulative frequency distribution. In other words, 20 per cent of the collected samples show values equal to, or higher than, the threshold value. If the 20 per cent step value is more than 2.5 times the background value, the threshold is normally selected at this level of 2.5 times the background (e.g. sector Río Petaquilla, molybdenum distribution).

The anomaly levels have been selected as the 2 per cent and 5 per cent steps. The "low" level of a set of samples represents the 80 per cent step of the frequency distribution. The tabulated ratios are calculated with reference to background values.

The major geochemical anomalies in soils are outlined in maps 6, 7 and 8 attached to this report. Maps containing detailed information on sample locations, individual values and distribution of anomalies in stream sediments, soils and rock outcrops are held on open file (see Annex II for a complete list of maps). For convenience in presentation, the whole area named Cerro Petaquilla from the dominant topographic feature, has been divided into four main sectors: Río Botija, Río Petaquilla, Río Medio and Río Botija Abajo, as indicated on the location sketch on map 8.

C. GEOPHYSICS

1. Physical environment

a) Terrain. As already stated, the Cerro Petaquilla area is deeply incised, with a total relief of some 250 metres and terrain gradients reaching 40 degrees, and more in many places along river banks. The rocks are heavily weathered to variable depths, from 10 to over 40 metres on higher ground, and the weathered zone, clayey in many parts, has a high electrical conductivity.

This type of terrain militates against effective use of all geophysical methods, though with varying severity depending on the method.

The survey was conducted over volcanic rocks of andesitic to basaltic composition, intruded by granodiorite, quartz-monzonite and gabbrodiorite. Parts of the intrusion are fractured, altered and mineralized. Metallic minerals are mostly disseminated sulphides. The term "disseminated" is used loosely; in fact, the sulphides usually occur as fillings in fractures and in thin veinlets. This is typical for porphyry copper deposits. However, true dissemination, with little fracture filling, has also been observed, e.g. at Botija.

b) <u>The ambient magnetic field</u>. In the Cerro Petaquilla area, the following parameters have been interpolated from magnetic charts (U.S. Naval Oceanographic Office, 1966), and adjusted to the end of 1968.

Declination : 3º East
Inclination : 36º20' North
Total field : 37,815 gamma
Vertical component : 22,215 gamma
Horizontal component: 30,215 gamma

2. Applicability of methods

a) <u>Gravimetric method</u> has not been considered.

Although one could expect a lowering of rock density in the mineralized parts of the intrusion by some 10 to 20 per cent due to fracturing and alteration, it would be extremely difficult and expensive to determine the terrain and elevation corrections with sufficient accuracy.

b) Electrical resistivity methods were also discarded. Again, the relevant physical parameter, resistivity, can be expected to be significantly lowered, perhaps by a factor of ten or more, as a result of the combined effects of alteration and continuity of sulphide veinlets, but the very high conductivity of the weathered overburden and its variable thickness would make it almost impossible to interpret the results with any degree of confidence.

c) Induced polarization was decided against, not without some reluctance. It is, par excellence, a method for disseminated sulphides and its efficacy has been proved in many parts of the world. However, in addition to the adverse effect of thick, conductive overburden, two other factors had to be taken into consideration.

(i) If the limit of detectability is accepted as 2 to 2.5 per cent of sulphidic material, then even with 0.7 per cent copper content (equivalent to about 2 per cent chalcopyrite) mineralization would hardly be detected by the I.P. method. In many cases economic mineralization can be so detected, because the accompanying pyrite may raise the total sulphide content well above the limit of detectability, but no such consistent relationship has been observed in the Cerro Petaquilla area. Pyrite, often abundant, has been seen in many places unaccompanied by chalcopyrite, and the latter is known to occur (e.g. in the Botija sector) with only little pyrite.

(ii) In the presence of numerous mineralized outcrops in stream beds, and of well defined copper and molybdenum anomalies in the residual soils, selection of drill hole sites never caused serious problems.

d) Electromagnetic methods, in common with all the other methods utilizing electrical fields of force, are handicapped by the type of conductive overburden present at Petaquilla. In addition, the rough topography makes it difficult to compute with sufficient accuracy the elevation and distance variations needed for correcting the in-phase component measurements. In spite of this, and although disseminated mineralization does not, per se, produce any significant E.M. anomalies, pilot surveys were run at Botija and later at Medio, using a vertical coil arrangement for measurement of the in-phase and out-of-phase components at two frequencies. The objects were to check whether more massive mineralization was present, in particular base metals veins so often found in the peripheral zones of porphyry copper deposits, and also whether a significant response could be obtained from a shear zone which appears to be controlling mineralization in the Río Medio sector.

The results were negative and the method was dropped.

e) Spontaneous polarization method was also tested on a limited scale in the Río Botija sector, as a check whether more massive mineralization was present. No significant anomalies were recorded.

f) Magnetic method would not be expected to respond directly to economic mineralization of the "porphyry" type, as pyrrhotite does not normally occur in the mineral assemblage. Indirectly, however, useful information can be obtained for one or more of the following reasons:

(i) Alteration processes may destroy the constituent magnetite, thus lowering the magnetic intensity over mineralized zones.

(ii) magnetite may be introduced hydrothermally in some places; such magnetite is usually accompanied by economic minerals.

(iii) a pattern of magnetic anomalies may indicate faults or shear zones, thus contributing to geological interpretation of an area.

3. Field work

Measurements of the vertical component of magnetic field were systematically taken along all the survey gridlines at 20 metre intervals, and at closer spacing in areas of high magnetic gradients. The magnetic anomalies, contoured at 600 gamma intervals, are shown on map 9 accompanying this report. The indifidual values and more detailed contours of the magnetic field may be found in maps at 1:5,000 scale listed in Annex II and held on open file.

D. PETROGRAPHY

Classification of rocks was based principally on thin section studies. Many of the collected rock specimens were cut for optical examination; the others were classified macroscopically on the basis of analogies with optical classification. The total number of thin sections examined was 1,302, including 436 used for determination and classification of alteration.

Two microscopes were employed: a Bausch & Lomb, Model LR (monocular) and a Leitz Ortholuz (binocular). The optical identification of minerals was done by routine methods: observations with polarized parallel light (one Nicol) or under crossed Nicols with parallel or convergent light. Mineral study was performed both on thin sections and, rarely, on extracted grains. The tables used were those of Kerr (1959) and Larsen and Berman (1934).

Quantitative evaluation of the mineral content in rock samples, in the absence of an integrating stage, was attempted on the basis of a calculation of the area occupied by minerals present in the thin section, using the micrometer ocular. Confirmation of the project's results was received from Phelps Dodge Corporation. Their analyses were made on forty-two drill core and surface rock specimens using an integrating stage.

For a study of metallic minerals and paragenesis, twenty-eight polished sections were prepared. The Leitz Ortholuz microscope was used for the study of opaque minerals.

E. DRILLING

1. Objectives

It was agreed at the start of the detailed survey of the Petaquilla area that only an orientation scout drilling programme was to be carried out, since any attempt at evaluating the prospects was far beyond the scope, or indeed the terms of reference, of the project.

Due to very strong weathering in the Petaquilla area, few fresh outcrops can be found, mainly in deep river valleys. The combined effects of alteration, weathering and leaching cause additional difficulties in field observations. Diamond drilling was thus the chief means of obtaining reliable information, not only about the nature of mineralization and its approximate grade, but also to support the geological interpretation of surface mapping.

2. Selection of sites

Drill sites were selected on the basis of geochemical anomalies and geological surface observations. The deep holes were drilled to gain information on the vertical extent of mineralization. The shallow holes were to help mainly in determining the possible lateral extent of mineralized areas. The locations of drill sites are shown on maps 5, 5A, 6, 7 and 8.

A few shallow holes were drilled outside of the geochemical anomalies to check the spatial relationship between anomalies and mineralization in underlying rocks. To some extent, however, the actual location of sites had to depend, partly at least, on the topography, distance to water etc. In view of the limited resources and short time available, no very laborious preparations could be made, apart from the unavoidable clearing of helicopter landing pads for each of the deep holes. The deep holes were therefore placed on the flat, top parts of ridges or hills to avoid the need for much levelling on the generally steep slopes, and the pump capacities further limited the choice to sites within a certain distance from the nearest water supply. The shallow holes drilled with the

Winkie lightweight rig had to be placed in stream valley beds where overburden was thin or absent.

It cannot, therefore, be claimed that the drill sites are in all cases the most suitable for obtaining significant information.

3. Equipment and operations

A Boyle's BBS-1 rig was used to drill the deep holes and proved most suitable and reliable. The engine of the Winkie lightweight machine gave a lot of trouble at first; this was overcome finally by doubling the oil-gasoline ratio, by limiting the depth of holes to 30 metres as a rule, and to 60 metres as an absolute maximum, and by avoiding sites with more than a few metres of overburden.

Between October 1968 and June 1969 a total of 1,960 metres (6,430 feet) was drilled by the BBS-1 at 10 sites, and 834 metres (2,740 feet) at 27 sites by the Winkie rig.

The overall core recovery of 70.5 per cent is not fully satisfactory. The main reason may have been the usually strong fracturing and the frequent clayey shearings of the rocks drilled; the fact that the drilling was largely done by trainee drillers with very little previous experience is certainly one of the reasons; finally, only small core sizes (BQ, AQ, IAX, IEX) were used, to speed up the progress.

Sludge samples were systematically collected when possible from each drill hole, to give some idea of the presence or absence of copper and molybdenum mineralization in those cases where core recovery should be poor. As drilling progressed, the sludge material was collected in a one-metre long core-storage box, the sludge entering at the slightly raised end and the overflow passing out at the other end of the box. After each 3.1 to 4.6 metres of drilling, a grab sample was collected from the deposit of material in the box into a plastic bag, and the sludge box was washed in readiness for the next sludge sampling cycle.

4. Costs

The costs of drilling at Cerro Petaquilla were inflated by the helicopter charter and by the larger than usual labour force needed to clear sites for camps, drill sites and landing pads.

The operational costs, including depreciation, diamond products, fuel, written off barrels, casing and rods, and all personal emoluments, amounted to $29.10 a metre ($8.87 a foot). The additional cost of the helicopter services was $14.86 a metre ($4.53 a foot).

F. ANALYTICAL CHEMISTRY

Virtually no facilities for analytical chemistry existed prior to completion of the new building of the Administración de Recursos Minerales in October, 1966. Subsequently, over the duration of this project the laboratories were equipped and staff trained to handle most types of analytical work expected from a small national organisation of this type. Methods were introduced for the geochemical determinations of a wide range of elements; ore analysis for copper, zinc, lead, molybdenum, gold, silver, manganese, iron and the like; technical analysis of limestones; and complete analysis of silicate rocks by rapid methods. A counterpart chemist spent one year in the U.S.A. on a United Nations Fellowship in analytical chemistry.

Brief descriptions of the methods employed and results obtained on Cerro Petaquilla samples are presented below and in Annex IV. For control of analytical work, reference standards were usually included in each batch of analytical samples, and statistics calculated from these replicate determinations are given in Annex IV, A and B. The project laboratory is equipped with a Perkin Elmer Model 303 atomic absorption spectrophotometer which has been used extensively for both geochemical and ore analysis, and all photometric determinations were carried out with a Beckman Model B spectrophotometer. Further details of methods and procedures may be found in the technical-report entitled "Laboratory Services, Analytical Chemistry".

1. Sample preparation

a) Geochemical samples. All geochemical stream sediment and soil samples were dried at 80º to 90ºC overnight in an electric oven, and then gently crushed in a porcelain mortar and sieved on an 80-mesh non-metallic sieve. The minus 80-mesh material is well mixed, transferred to a 5 in x 3 in kraft paper envelope, and used for all analytical determinations. The plus 80-mesh fraction is returned to the original sample envelope and reserved.

b) Drill core and rock samples. All "as received" drill core and rock samples are first broken down in a Denver 2 1/4 in x 3 1/2 in laboratory jaw crusher, and then passed through a McCool Model 6 1/2F disc-type grinder to pass, depending on the size of the original sample, 4-mesh, 10-mesh or 28-mesh Tyler screens. Most drill core samples are crushed first to pass 10-mesh. The screened product is mixed and split once. One half is reserved and the other crushed to pass 28-mesh when, after mixing, a half or a quarter is cut to analytical sample size. This minus 28-mesh material is crushed in a Tema Model T100 vibratory disc mill to pass 10-mesh, and is then mixed thoroughly.

Accuracy of sampling is systematically checked by preparing a fresh analytical sample from the reserved half of the first sample split. Approximately 1 in 12 drill core samples have been so prepared, and results for copper, zinc and molybdenum on both original and duplicate samples have shown very good agreement, usually to within 2 per cent of the copper content, with a maximum difference of 6.7 per cent. Results for zinc and molybdenum gave similar agreement.

Sludge samples "as received" are contained in plastic bags. These samples are first transferred to aluminium pans and dried at 80º to 90ºC for 8 hours in an electric oven, before crushing in the McCool grinder to pass 28-mesh. The mixed minus 28-mesh material is then sampled and finally crushed to minus 100-mesh on the Tema vibratory disc mill.

Small, chip specimens for geochemical analysis are broken down using the Denver jaw crusher, and ground to pass 28-mesh before sampling, if necessary, and final crushing on the Tema mill.

2. Methods of analysis

a) Geochemical samples

(i) Soils and stream sediments. Apart from a few sediment samples collected during the early reconnaissance geochemical survey, all determinations of copper, lead, zinc and molybdenum have been carried out on aliquots of the same sample solution prepared following an initial attack with hot (1:1) hydrochloric acid. Copper, lead and zinc are determined by atomic absorption spectrophotometry, and molybdenum by a dithiol colorimetric method. The values so obtained are, therefore, hot acid extractable contents.

To check on the efficiency of this attack, approximately 1 in 40 soil samples were analysed for both copper and molybdenum following fusion with potassium pyrosulphate. Results are reported in Annex IV, A, table 3, together with brief details of the hydrochloric acid method. Using the values determined after pyrosulphate fusion as "total" contents, the average extraction by the hydrochloric acid attack was found to be 67 per cent for copper and 85 per cent for molybdenum. Samples which contained 500 p.p.m. of copper and above, as determined by the pyrosulphate method, gave 66 per cent extraction and those below 500 p.p.m. 71 per cent. The reverse was true for molybdenum which on the 251 soils analysed showed 89 per cent extraction at the 50 p.p.m. level and above, and 71 per cent in samples containing less than 50 p.p.m. A quarter of these check soil samples were also analysed for copper by an atomic absorption method after an aqua regia attack, and this procedure gave 80 per cent extraction against 67 per cent on the same samples by the hydrochloric acid method.

Stream sediments generally showed higher percentage extraction for copper. Thus, 232 samples from the Cerro Petaquilla region gave an overall extraction of 78 per cent by the hydrochloric acid method when compared with colorimetric diquinolyl values determined after pyrosulphate fusion. Some 25 of these samples were also analysed by the aqua regia method, and these values gave 94 per cent extraction, against 85 per cent by the hydrochloric acid procedure on the same samples. Molybdenum was also determined on the 25 samples by the dithiol pyrosulphate attack procedure, and an extraction of 83 per cent by the hydrochloric acid method was obtained.

A field laboratory was used in Botija at an early stage of the follow up survey, mainly for the determination of hot acid soluble copper in soils and stream sediments by a standard diquinolyl colorimetric method. Results so obtained, all of which were later checked in the central laboratory, greatly facilitated rapid delineation of anomalies in the Cerro Petaquilla Area.

(ii) <u>Rock samples</u>. All rock specimens, and grab and drill sludge samples were analysed for copper, lead and zinc by atomic absorption techniques in a sample solution prepared by treating with hydrochloric and nitric acids and, after evaporating to dryness, taking up the residue in 0.5M hydrochloric acid. This solution was also used for the determination of molybdenum by a geochemical thiocyanate method in drill core sludges and some rock samples, but most rocks were analysed by a dithiol procedure on a separate sample weight after fusion with potassium pyrosulphate. Cross checks for molybdenum by the two methods usually showed good comparison. It was found, however, that a few samples containing small amounts of molybdenum gave lower results by the aqua regia method, which was attributed to lock up of molybdenum in the insoluble residue. For this reason, and owing to the better sensitivity of the method (detection limit of 2 p.p.m.) and generally very much lower molybdenum contents in these samples, the pyrosulphate fusion has been preferred for rock samples. Brief details of the methods used are given in Annex IV, A 2.

Results for copper and molybdenum on reference samples and on numerous determinations in rocks and drill core by other methods show that for these samples the aqua regia attack for copper, and the pyrosulphate fusion for molybdenum are both satisfactory, and results by these procedures can be regarded as "total" contents. Thus, for example, 102 rock samples gave arithmetic means of 958 p.p.m. and 960 p.p.m. of copper respectively by the aqua regia-atomic absorption method and by the diquinolyl colorimetric-pyrosulphate fusion procedure. Similarly, 231 drill core samples gave an average of 52.7 p.p.m. of molybdenum by the dithiol pyrosulphate fusion method against 54.0 p.p.m. by the photometric procedures used for drill core analysis, and in a further check geochemical aqua regia-thiocyanate and pyrosulphate-dithiol values showed arithmetic means of 82 p.p.m. and 76 p.p.m., respectively, on 177 sludge samples.

b) Drill core samples

(i) Copper and zinc. All results reported for copper and zinc in drill core from Cerro Petaquilla were determined by atomic absorption methods. The sample (1 g) is dissolved by treatment with hydrochloric and nitric acids, followed by the addition of a few drops of bromine, and finally evaporated to fumes with sulphuric acid. The cold residue is taken up in water, boiled to dissolve soluble salts, filtered and after allowing to cool, diluted to 250 ml. This solution is used for the determination of copper and zinc by atomic absorption techniques, and also for molybdenum by photometric methods. Brief details of the procedures used are presented in Annex IV, B 1 and B 2, together with statistics calculated from replicate determinations on reference samples. Good reproducibility is shown by these statistics, and adequate coefficients of variation were obtained for all three elements.

Approximately 1 in 7 drill core samples were analysed in duplicate and, of 104 drill core samples checked, 90 showed copper values agreeing to within 0.02 per cent copper, with a maximum difference of 0.10 per cent obtained on one sample which originally gave 1.18 per cent and on repeat determinations 1.08 and 1.07 per cent of copper. Similar results were obtained for zinc and molybdenum.

Systematic check determinations for copper were carried out by a conventional electrolytic method after solution of the sample as described above but with the omission of the few drops of bromine. One in 12 samples were thus analysed, and results obtained showed good comparison, usually to within 5 per cent of the values determined by atomic absorption, but with the electrolytic method giving slightly higher results. This positive bias is shown by the arithmetic means for all checked samples of 1.11 per cent and 1.09 per cent copper, respectively, by the electrolytic and atomic absorption procedures, and also by the maximum difference of 0.07 per cent copper found on one sample which gave 2.93 and 2.86 per cent copper by the respective methods.

(ii) Molybdenum. Three methods have been used: thiocyanate and dithiol photometric procedures and an atomic absorption technique. The thiocyanate method has been in routine use since early 1969, with check determinations carried out by the dithiol procedure and, with samples containing more than 50 p.p.m. of molybdenum, by atomic absorption. All samples containing less than 50 p.p.m. of molybdenum are also analysed by a geochemical dithiol method after fusion of the sample with potassium pyrosulphate and these values are included when averaging results. The pyrosulphate fusion has been shown to be an efficient attack for molybdenum in Cerro Petaquilla samples.

Both thiocyanate and dithiol photometric procedures are carried out on aliquots of the solution prepared for copper and zinc determinations. For atomic absorption analysis, a separate sample weight is taken, and determinations by this technique serve as a check by a completely independent method on results obtained by the photometric procedures. Owing to the relatively poor sensitivity for molybdenum by atomic absorption methods (about 1 p.p.m. for 1 per cent absorption) large sample weights, usually 5 g, are taken for analysis, thus reducing any errors that may arise from inhomogeneity of sample.

Results obtained by the three methods, each of which gave good reproducibility on replicate determinations in standard samples, generally showed satisfactory agreement, but with thiocyanate values usually reporting slightly higher than those determined by the other methods. Thus, 23 samples analysed by each procedure gave arithmetic means of 234, 226 and 221 p.p.m. of molybdenum respectively by the thiocyanate, dithiol and atomic absorption methods. The trend towards somewhat lower results by the atomic absorption method is also reflected in the arithmetic means of determinations on 186 samples which gave 195 p.p.m. of molybdenum by the photometric methods and 186 p.p.m. by atomic absorption. This negative bias was not, however, shown by atomic absorption results determined on reference samples, which suggests that some molybdenum may be retained by the insoluble residue in the samples of drill core analysed.

(iii) Gold and silver. All determinations for gold and silver in Cerro Petaquilla drill core samples have been carried out by atomic absorption methods, details of which are given in Annex IV, B 3.

3. Check analyses by outside laboratories

Eleven samples of drill core which had been analysed for copper and molybdenum were sent to a contracting laboratory for check determinations. Seven of these samples were also assayed by the contracting laboratory for gold and silver. As a check on the accuracy of sampling, duplicate samples were prepared from the reserved first sample split of the eleven samples and analysed for copper, molybdenum, gold and silver both at the project laboratory and at the Esperanza Mine laboratory of Duval Corporation.

Results of these check analyses are reported in Annex IV, table 3. Good general agreement is shown for copper, both in the original and duplicate samples, by all three reporting laboratories.

Results for molybdenum in the duplicate samples as determined by the project and Duval Corporation laboratories agree very well with each other, and also with those obtained in the original samples by this project.

The contracting laboratory, however, reported higher values in these original samples, on which at first numerical results were given for only three samples containing appreciable molybdenum. When requested, the contracting laboratory re-analysed the remaining eight samples, presumably by a different method, and all results reported by them are given in Annex IV, table 3.

At the low levels of gold and silver in the samples analysed, comparison of results for these elements by all three laboratories show greater variation, particularly for gold. The contracting laboratory reported values of 2.0 p.p.m. of gold in two samples, which on the duplicate samples were found to contain less than 0.3 p.p.m. by both the project laboratory and Duval Corporation.

Check analyses for copper, lead, zinc and molybdenum in geochemical stream sediment and soil samples were carried out by F. Berndt, Chemist-Analyst, U.N. Mineral Survey, Guatemala City. Both laboratories determined copper, lead, zinc and molybdenum following a hot hydrochloric acid extraction, and also for copper and zinc after aqua regia attack. Results, which are reported in Annex IV, table 4, show good general agreement, particularly for molybdenum, but with this laboratory reporting somewhat higher values for copper.

4. Composite drill core samples

Two composite samples, representing between them the whole of the core recovered, were prepared from each deep drill hole, and analysed for copper, zinc and molybdenum. Results so obtained are reported in Annex IV, table 5, together with the arithmetic mean of the contents in the corresponding individual samples. Generally, good comparison between these values is shown for all composites, with 14 out of the 19 samples agreeing to within 0.01 per cent for copper, and with a maximum difference of 0.04 per cent in one composite which was found to contain 0.61 per cent copper against the 0.65 per cent arithmetic mean. Similar agreement is shown for molybdenum and zinc.

5. Spectrographic analysis

Nine samples, consisting of six composites from deep drill holes, and three individual samples of drill core, were sent to a contracting laboratory for semi-quantitative spectrographic analysis. Most of the elements looked for were below the limit of detection by the method used, and apart from the major economic elements, values for which have been reported by the project laboratory, the analyses show no significantly high concentrations of other elements. Barium and strontium are in the 0.05 to 0.1 per cent range for all eight samples, 0.01 per cent lead was found in one sample, and 0.005 per cent of cobalt and 0.001 per cent of nickel in the sample from Río Petaquilla sector.

The elements looked for but not detected are antimony, arsenic, beryllium, bismuth, boron, cadmium, cerium, chromium, columbium (niobium), germanium, hafnium, indium, iridium, lanthanum, lithium, mercury, neodymium, palladium, phosphorus, platinum, rhodium, ruthenium, tantalum, tellurium, thallium, thorium, tin, uranium and zinc. Results for elements that were detected are included in Annex IV, table 6.

PART THREE

GEOLOGY AND MINERALIZATION IN THE CERRO PETAQUILLA AREA

A. GENERAL STATEMENT

1. Geology

The region lying between the northern foothills of the Cordillera Central and the Caribbean coast contains numerous outcrops of igneous rocks (map 4), but dense tropical vegetation obscures many surface exposures, and deep residual weathering hinders definite identification of rocks and types of alteration.

The overburden in the Cerro Petaquilla area is mainly residual with only small local alluvial deposits along the larger rivers. The area is underlain by a Tertiary volcanic complex which has been intruded by a large pluton (map 5), but because of heavy weathering rock exposures occupy only a very small part of the total area. In its deeper, central parts the intrusive mass is composed of quartz monzonite, which grades outward into granodiorite, porphyritic granodiorite, porphyritic dacite, and dacite. The latter two types may represent the marginal parts of the intrusive mass, or they may be an alteration product of the intruded volcanics. Sharp contacts between granodiorite and volcanics have been observed, with the granodiorite in places containing volcanic xenoliths.

Local exposures of diorites, gabbrodiorites, gabbros and intermediate to basic dykes have been observed within the intrusion. The gabbrodioritic rocks may be a differentiate of the quartz monzonite-granodiorite mass and therefore contemporaneous, or they may be older on the basis of locally observed contact metamorphic features. The age of a sample of gabbrodiorite from the Río Botija sector has been determined as 32.6 ± 2 million years by the radioactive potassium-argon method.

The volcanic complex consists mainly of lavas of andesitic and basaltic composition. Tuffaceous rocks are found only locally, in small patches.

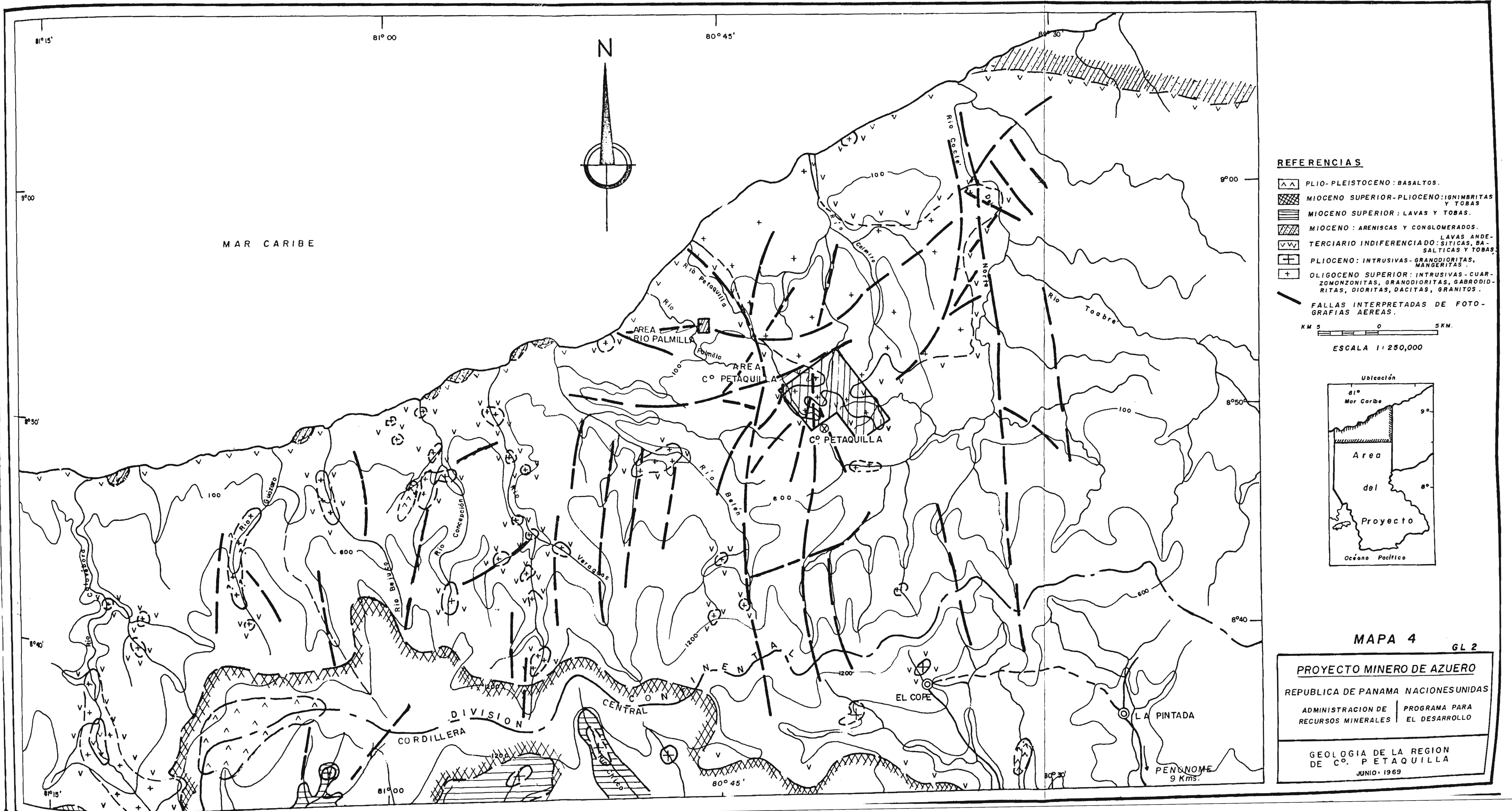
Very limited amount of field information has been obtained on structures. The volcanics are not known to be folded, but faulting on a local and regional scale is evident in aerial photos, with some confirmation from magnetic data.

2. Alteration

Throughout the area contact metamorphic and hydrothermal alteration features are common, the former being confined to the volcanic rocks and the latter occurring mainly in the intrusive bodies, and partly in the adjacent volcanic rocks. It is not always easy to determine the types and degrees of alteration in outcrops because of the effects of heavy weathering. However, some fresh outcrops permit identification.

Contact metamorphism is represented by amphibolization (the development of amphibolite and epidote after pyroxene) and by magnetite development from iron bearing minerals.

Hydrothermal alteration is indicated by the development of chlorite, epidote, calcite, anhydrite, kaolin, quartz, sericite, potassium bearing feldspars and pyrite, predominantly in the intrusive rocks and to a minor extent



MAPA 4

GL 2

PROYECTO MINERO DE AZUERO

REPUBLICA DE PANAMA NACIONES UNIDAS

ADMINISTRACION DE RECURSOS MINERALES | PROGRAMA PARA EL DESARROLLO

GEOLOGIA DE LA REGION
DE Cº. PETAQUILLA
JUNIO, 1969

in the volcanics.

Following the customary classification of alteration types, four subdivisions have been adopted: propylitic, argillic, phyllic, and potassic. The propylitic type is identified by a dominance of chlorite, epidote and carbonates; the argillic by a dominance mainly of kaolin, quartz and sericite; the phyllic by quartz, and sericite, possibly pyrite, and minor kaolin and potassic feldspar; the potassic by quartz, plus at least two of the potassic feldspars, biotite, sericite, anhydrite and calcic minerals. These alteration types occur throughout the area, and although the available data are insufficient to outline exactly their limits, some generalizations can be made, as shown in map 5-A. Alteration is very irregular and does not extend throughout the various types of intrusive.

Propylitic alteration is common and confined mainly to the contact zones between the volcanic rocks and the relatively unmineralized parts of the intrusives.

Argillic alteration is also common, overlapping partly the propylitic type in the volcanic rocks and in poorly mineralized intrusive rocks, and the phyllic type in the better mineralized sections of the intrusion.

The phyllic type appears to show no preference for any particular rock unit and occurs in many places in volcanic and various intrusive rocks, but normally it is prevalent where higher grades of mineralization exist.

The potassic type is not common, and has only been observed in the granodioritic rocks, where it overlaps in places the phyllic alteration.

Silicification accompanies all types of alteration.

It has affected mainly the lavas, tuffs, breccias and the dacitic porphyries. In places silicification is very intense.

Skarn type of alteration have not been observed in the area.

Some evidence of lateral and vertical zoning of alteration has been found, particularly in drill cores (especially those from the Río Botija sector).

3. Mineralization

For the most part the porphyry type copper and molybdenum mineralization in the Cerro Petaquilla area is found in the intruding rock, but it extends in places along fractures into the volcanics, especially in the Río Petaquilla sector. Relatively rich copper mineralization has been found locally in the contact zones.

Mineralization coincides normally with more intensive alteration, but some fresh and only weakly fractured granodiorite rocks contain copper mineralization of possible economic grade, e.g. in the Río Botija sector. In places, less fractured and poorly mineralized rock has been found within zones of mineralization.

Mineralization is almost entirely hypogene with very little secondary enrichment, except for the possible remnants of a chalcocite "blanket" in some outcrops in Río Botija, and in Río Petaquilla close to its junction with Quebrada Piedras Coloradas. Some development of present day copper enrichment, mainly in the form of chalcocite, occurs on the surface in the mineralized zone of the Río Medio sector, and in Quebrada Vega in the Río Petaquilla sector.

The principal copper mineral is chalcopyrite, with minor amounts of chalcocite, bornite, covellite and rare malachite and chrysocolla. Molybdenite accompanies copper almost invariably. Pyrite occurs in all parts of the area and its ratio to chalcopyrite is variable, but generally low where higher grade copper is present. In some places magnetite is abundant and closely related to copper mineralization. No significant lead and zinc concentrations have been found in the area.

B. DETAILED RESULTS

1. Geology, alteration and mineralization

a) Río Botija. The sector is underlain mainly by granodioritic and volcanic rocks (map 5). The granodiorite occurs in the southern half of the area, as the central part of a large body which extends into the Río Botija Abajo and Río Medio sectors. The northern part of the Río Botija sector is covered by volcanic rocks. Dacitic rocks are exposed only in the central part of the sector along the margins of a volcanic enclave. Northerly trending, steep, westerly dipping basic dykes, and one exposure of gabbrodiorite, have been observed within the granodiorite.

Strong phyllic alteration prevails in the mineralized zones in the Río Botija sector, though potassic and argillic alterations are also present. Silicification, with occasional potassic alteration in the central parts of the mineralized zone, is well developed; sericite, commonly present, can normally be seen only under the microscope. Surface observations carried out by the project are not sufficient to outline exactly the various alteration zones; however, some sections of drill core show lateral and vertical changes from phyllic-argillic alteration to propylitic alteration in the relatively fresh granodiorite. The contact zones of the invaded volcanics have been locally amphibolized as a result of contact metamorphism.

The known mineralization is confined to granodioritic rocks. It occurs predominantly as even grained dissemination of chalcopyrite in the parts of the host rock that are fractured and altered. A few exceptions, where fairly fresh granodiorite is well mineralized, have been observed.

The overall ratio of pyrite to chalcopyrite is surprisingly low in this sector, and within the mineralized zone the chalcopyrite is actually dominant.

In the northern part of the sector a thin volcanic layer is presumed to overlie granodioritic rock. The only evidence of mineralization, apart from a few outcrops seen in deep stream beds, in a strong copper anomaly in soils accompanied, however, by molybdenum anomalies of only small surface extent.

Mineralization in the western zone of the sector, as indicated by soil anomalies and seen in a few outcrops, is confined to a strongly silicified contact zone between intrusive and volcanic rocks. Its economic potential is unknown.

Further details of the Río Botija sector mineralization will be found in the composite drill logs (Annex V, charts 1 and 2) and in the supporting 1:5,000 scale maps listed in Annex II.

b) <u>Río Petaquilla</u>. The sector is underlain mainly by dacitic and volcanic rocks, the dacite possibly representing a product of hydrothermal activity in the volcanic rocks (map 5). Some exposures have been observed of granodiorite, gabbrodiorite and post-mineralization dykes of basic composition. In the northeast part of the area, along Quebrada Huhta, silicified breccias of undetermined origin have been found.

Numerous faults cross the area; some of them are of regional extent and probably post mineralization. The major faults have a northerly trend.

All the usual types of hydrothermal alteration are present, but any possible zoning is difficult to recognize. The intensity of alteration is variable. In a few holes drilled into the volcanics close to their intrusive contacts, mainly propylitic alteration with pronounced epidotization has been noted. In the contact zones, numerous fractures are filled by zeolites and calcite, and the strong argillic alteration is also related to fractures. Phyllic alteration prevails in the mineralized parts of the granodiorite and dacite porphyries in this sector, with strongly variable intensities. The breccias seen in the sector are silicified throughout.

Mineralization occurs in the granodiorite/dacite porphyry complex and in volcanic rocks close to their contacts with the intruding rocks. Copper minerals are found either disseminated or, more commonly, as fracture filling in zones of strong fracturing.

Here, as in the Río Medio sector, the grade of "contact mineralization" in some places reaches a level permitting consideration of underground mining. In the Río Petaquilla sector three holes, one in Quebrada Piedras Coloradas and two in Quebrada Huhta, have intersected this type of mineralization; it is apparently related to almost compact magnetite/pyrite mineralization of hydrothermal origin. Further details of mineralization will be found in composite drill logs (Annex V, charts 3, 4 and 5).

c) Río Medio. This sector is underlain by quartz monzonite, granodiorite, dacite, and by volcanics rocks; the quartz monzonites occupy most of the northern half of the sector and extend beyond it to the west and north (maps 5 and 8). The granodiorite is the western portion of a larger mass which continues to Río Botija and Río Botija Abajo. The dacitic rocks predominate in the main mineralized zone of the sector and may have a similar origin as the dacites in the other sectors. Breccias of undetermined origin also occur in the main mineralized zone where strong shearing is present; there is little evidence of faulting. Disseminated magnetite, mainly in strongly amphibolized basalts, is frequently seen in outcrops and the related magnetic anomalies help in locating these contacts.

The intensities and types of hydrothermal alteration are very variable. In the drill core and in the outcrops alteration can change over a few metres from strong potassic to poorly developed argillic or propylitic types.

The outcrops of the main mineralization in a deep stream valley have the highest copper contents in the whole Cerro Petaquilla area. Strong shearing and the associated breccia may control the mineralization. One small outcrop of aplitic rock was found to contain a high content of molybdenum, approaching one per cent in some specimens.

Present day copper enrichment is seen in many places as thin surface coatings of chalcocite on pyrite, but it is of no economic significance. As in the Río Petaquilla sector, magnetite/pyrite bearing veins have been seen close to the contacts between the intrusive and volcanic rocks.

Details of drilling results are shown in Annex V, Chart 6.

d) Botija Abajo. This sector is underlain mainly by granodioritic and dacitic rocks. The granodiorite is a part of a larger mass of similar composition (map 5).

Extremely strong silicification, pyritization and strong leaching in the central part of the local grid are thought to be closely related to the low pH values (4.0 - 5.0) observed in the creeks draining this area. A few boulders containing copper minerals, mainly chalcocite and malachite, were found in these creeks.

2. Geochemical results

Statistical analysis has been made of results for copper, molybdenum, lead and zinc in all soil and stream sediment samples, but only for copper and molybdenum in rock specimens systematically collected from outcrops and from residual, often partly weathered, float on a higher slopes. The methods used in statistical treatment are briefly described in Part Two, B.

The anomalous distributions in the whole area and for each sector are shown in table 1.

Table 1

Geochemical distributions in the Cerro Petaquilla area

Location	Element and type of sample	Values in p.p.m. at distribution steps[1] and their ratios to the median (50% step) values				
		2%	5%	20%	50%	80%[2]
Cerro Petaquilla Area	Cu/ sediments	1600	1200	400	150	80
		10.6	8.0	2.7	1.0	0.5
	Mo/ sediments	88	70	17	3	-2
		29.3	23.3	5.7	1.0	
	Cu/soils	900	700	400	200	90
		4.5	3.5	2.0	1.0	0.5
	Mo/soils	150	80	25	4	-2
		37.5	20	6.3	1.0	
	Pb/soils	140	80	30	15	-5
		9.3	5.4	2.0	1.0	
	Zn/soils	170	120	50	20	10
		8.5	6.0	2.5	1.0	0.5
	Cu/rock samples	4200	2300	900	340	100
		12.4	6.8	2.6	1.0	0.3
	Mo/rock samples	180	80	15	2	-2
		90.0	40.0	7.5	1.0	
Sector Río Botija	Cu/soils	1200	830	460	240	120
		5.0	3.5	1.9	1.0	0.5
	Mo/soils	250	150	31	6	-2
		41.6	25.0	5.2	1.0	
	Pb/soils	95	40	15	10	-10
		9.5	4.0	1.5	1.0	
	Zn/soils	130	90	45	15	10
		8.7	6.0	3.0	1.0	0.7
	Cu/rock samples	5100	2700	1100	425	140
		12.0	6.4	2.6	1.0	0.3
	Mo/rock samples	200	94	24	6	-2
		33.3	15.7	4.0	1.0	

1/ A "distribution step of 2%" signifies that 2 per cent of all samples contain the stated amount, or more, of the particular element.

2/ Minus sign denotes less than.

(Table 1, cont'd.)

1	2	3				
		2%	5%	20%	50%	90%
Sector Río Botija Abajo	Cu/soils	480 6.0	400 5.0	230 2.9	80 1.0	15 0.2
	Mo/soils	70 23.3	50 16.7	14 4.7	3 1.0	-2
	Pb/soils	260 26	100 10	35 3.5	10 1.0	-5
	Zn/soils	110 11.0	75 7.5	35 3.5	10 1.0	5 0.5
Sector Río Petaquilla	Cu/soils	720 3.3	600 2.7	390 1.8	220 1.0	110 0.5
	Mo/soils	200 25.0	110 13.8	40 5.0	8 1.0	2 0.25
	Pb/soils	180 9.0	100 5.0	45 2.3	20 1.0	10 0.5
	Zn/soils	200 13.4	130 8.7	55 3.7	15 1.0	5 0.3
	Cu/rock samples	5000 16.2	2600 8.4	860 2.8	310 1.0	95 0.3
	Mo/rock samples	210	75	15	-5	-5
Sector Río Medio	Cu/soils	940 4.7	720 3.6	390 1.95	200 1.0	85 0.4
	Mo/soils	62 31.0	34 17.0	11 5.5	2 1.0	-2
	Pb/soils	75 5.0	55 3.7	25 1.7	15 1.0	-10
	Zn/soils	190 6.3	130 4.3	65 2.2	30 1.0	15 0.5
	Cu/rock samples	2900 9.4	2100 6.8	790 2.5	310 1.0	90 0.3
	Mo/rock samples	75	33	8	-5	-5

In the regional survey, the anomalous values of copper in stream sediments amounted to about 200-225 p.p.m. at distances up to 15 kilometres downstream from Cerro Petaquilla, against the regional background of 95 p.p.m. The local background in the Cerro Petaquilla general area is taken as 150 p.p.m. of copper and 3 p.p.m. of molybdenum. The extent and strength of major stream sediment anomalies within the prospect area are by far the largest encountered in the project's work. Their maximum values are about 2,000 p.p.m. of copper and 125 p.p.m. of molybdenum.

Copper-mineralized outcrops were first found in February, 1968, during an intensive follow-up work in Río Botija and its tributaries, and soon afterwards in the eastern tributaries of Río Petaquilla, about 4 to 5 kilometres farther west. The Río Medio mineralization was found much later, in November 1968.

At least two types of geochemical soil anomalies can be identified, the first mechanical, caused by micrograins of the original minerals in transported material or in residual soils, and the other, perhaps more common, where the elements have gone first into solution and were then transported by surface or ground water and finally precipitated because of a change in pH values or by evaporation and change of the water table level.

The copper anomalies in the Cerro Petaquilla area have a tendency to creep down the slopes because of the fairly high mobility of copper. Molybdenum, on the other hand, is less mobile and the anomalies are more closely related to their sources. Little is known about lead-zinc mineralization in the area, but the soil anomalies in these elements form recognizable haloes around the known centres of copper-molybdenum mineralization.

The irregularity of the copper and molybdenum content in rock specimens collected within the zones of mineralization may be due to varying degrees of leaching, but this does not rule out the possibility that mineralization itself is mainly concentrated close to the well altered major fracture zones, while the areas between such zones may be only poorly mineralized.

a) Río Botija. The intensity of the copper and molybdenum soil anomalies in the Botija sector is greater than in other parts of the general area (table 1 and map 7).

The main zone of mineralization is correlated with a strong and pronounced molybdenum anomaly; the corresponding copper anomalies are relatively weaker and less consistent. The reason might be that the disseminated chalcopyrite mineralization is more limited spatially than the "fracture filling" type of the molybdenum mineralization.

The Botija North anomaly is of a different character. The surface rocks are mainly volcanic, presumably representing an andesitic capping overlying granodioritic intrusion. Strong copper anomalies are extensive, but only few isolated molybdenum anomalies have been recorded in this part of the sector.

The anomalous zone of Botija West is not very significant, although the copper and molybdenum anomalies overlap in the area where some mineralized outcrops have been observed.

b) Río Petaquilla. The detailed geochemical soil survey in Río Petaquilla sector revealed three significant copper-molybdenum anomalies and several smaller ones of doubtful importance (map 6).

The greater extent of molybdenum anomalies in this sector may be due to the fact that molybdenum mineralization is more widespread, especially in fracture fillings, than copper mineralization.

c) Río Medio.[1] Unlike those in the Río Petaquilla sector, copper anomalies are more extensive in this sector than the molybdenum anomalies, and "slope creep" of copper in soils is assumed to have taken place. The main copper anomaly is a good example (map 8).

d) Río Botija Abajo. Strong silicification and leaching have resulted in a "negative" copper anomaly in overlaying soils (less than 20 p.p.m. Cu, and at many sites less than 5 p.p.m., against the local background of 80 p.p.m. Cu). A remarkable feature is that this "negative" anomaly is surrounded by molybdenum, lead and zinc anomalies, in addition to copper anomalies; the molybdenum anomalies extend into the "negative" copper anomaly near the western margin of the area.

The possibility that copper has been leached out near the surface and then precipitated at depth might be considered.

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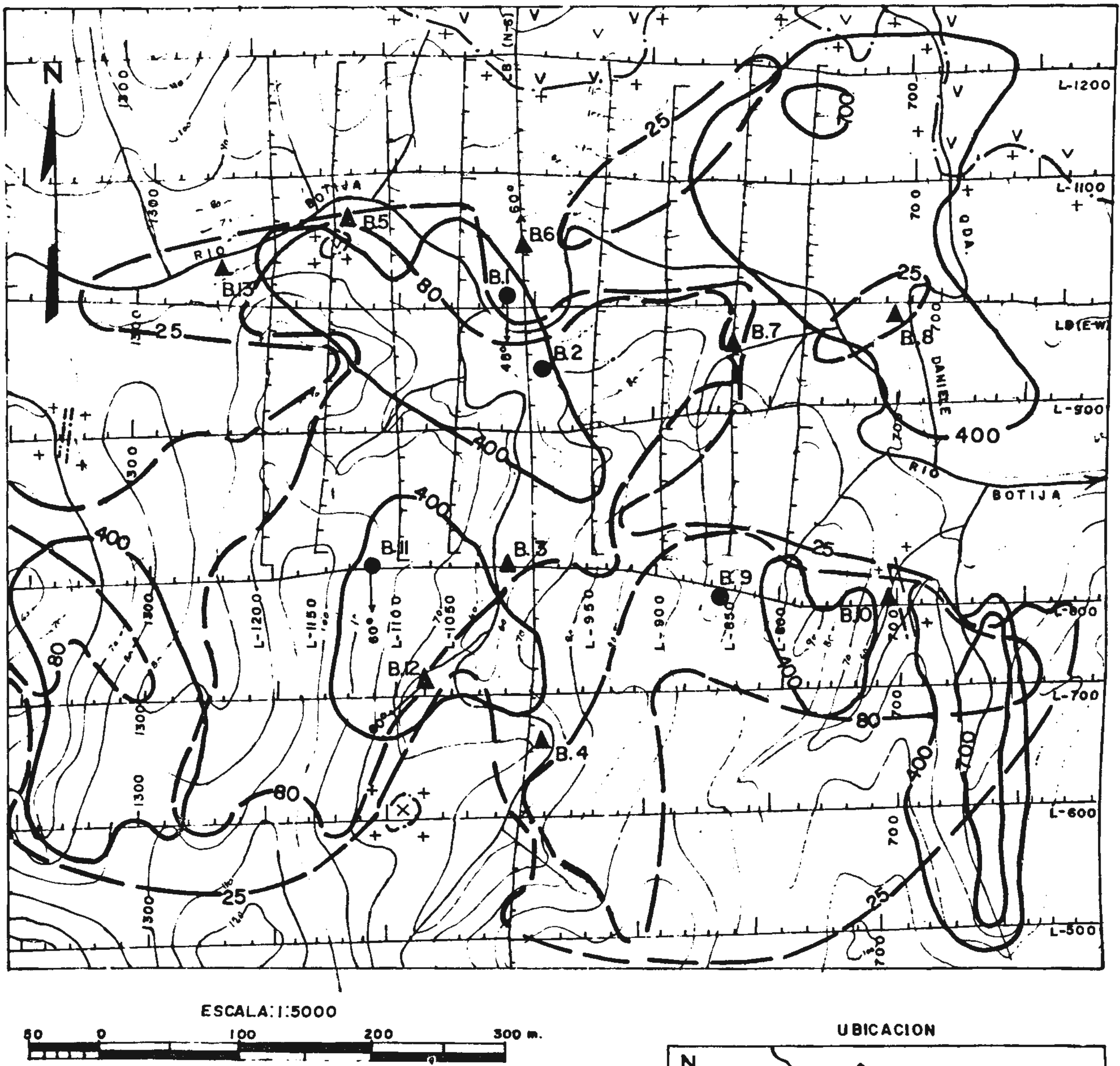
[1] The stream sediment results in this sector, at sample locations 20,038 to 20,043 shown on the 1:30,000 scale map attached to the ad hoc report on Cerro Petaquilla, published in May 1968, were erronously plotted. The correct values of stream sediments at these six sample sites average 1,150 p.p.m. for copper and 26 p.p.m. for molybdenum.

SECTOR RIO BOTIJA
ZONA DE MINERALIZACION



REFERENCIAS

GEOLOGIA:

- CONTACTO GEOLOGICO
- V ROCAS VOLCANICAS
- X ROCAS DACITICAS
- + ROCAS GRANODIORITICAS
- + ROCAS CUARZOMONZONITICAS
- Λ ROCAS GABRODIORITICAS
- S ROCAS SILICIFICADAS

GEOQUIMICA:

- 400 LIMITE DE ANOMALIA - 400 p.p.m. Cu EN SUELOS
- 700 LIMITE DE ANOMALIA - 700 p.p.m. Cu " "
- 25 LIMITE DE ANOMALIA - 25 p.p.m. Mo " "
- 80 LIMITE DE ANOMALIA - 80 p.p.m. Mo " "

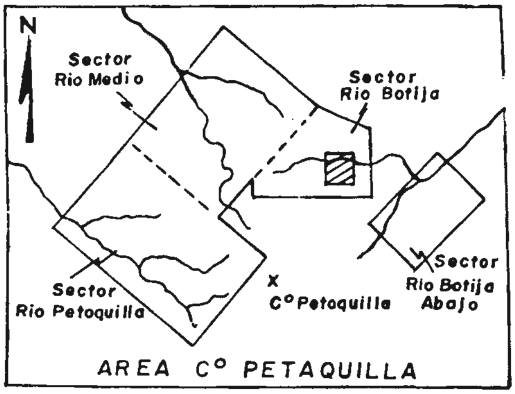
PERFORACIONES:

- B.5 ▲ POCA PROFUNDIDAD
- B.9 ● MEDIA PROFUNDIDAD
- LINEAS DE LEVANTAMIENTO
- 90 CURVAS DE NIVEL EN METROS, APROX. SOBRE EL NIVEL DEL MAR
- RIOS O QUEBRADAS

MAPA 7

GL 65/I-53

UBICACION

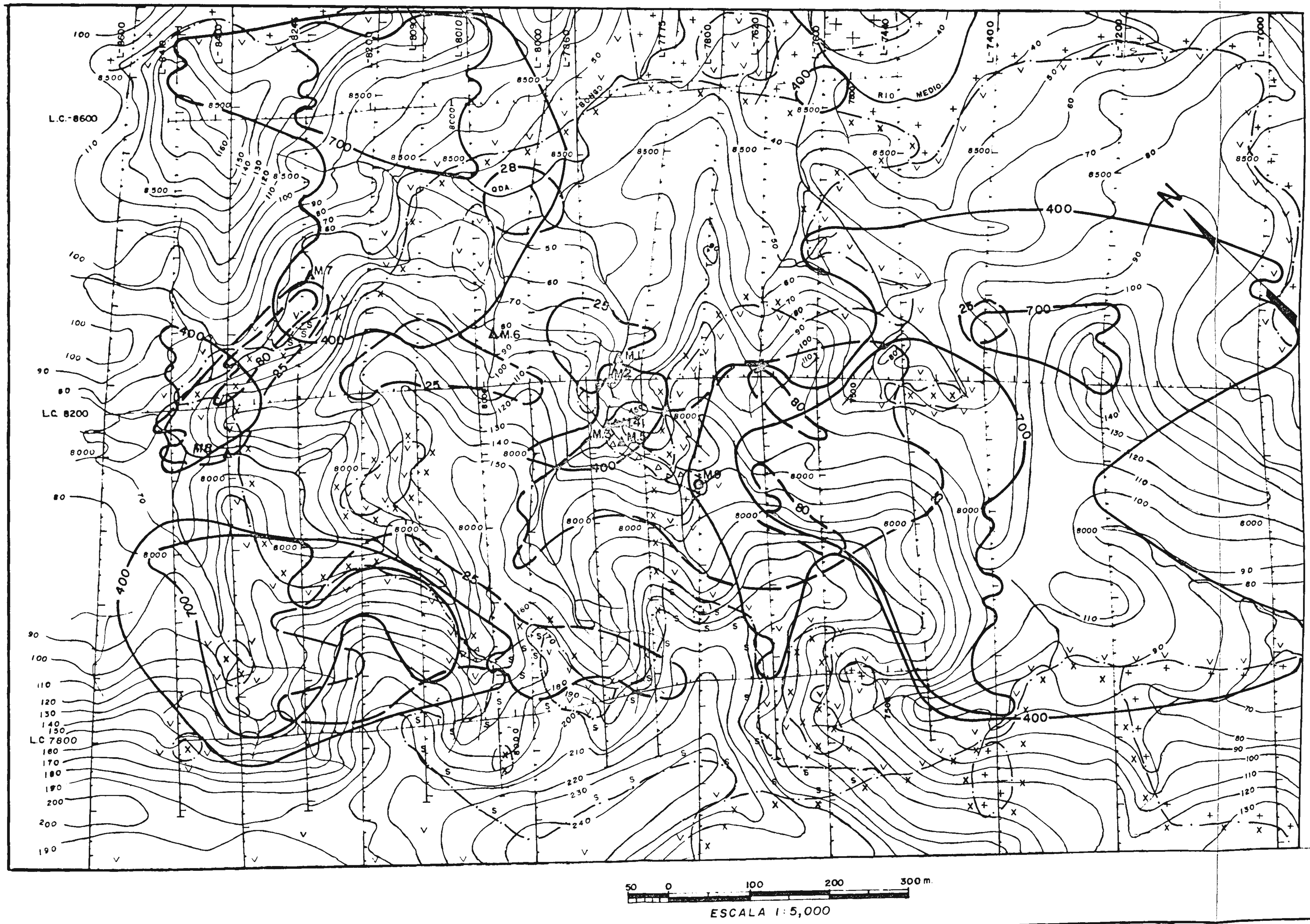


PROYECTO MINERO DE AZUERO

REPUBLICA DE PANAMA	NACIONES UNIDAS
ADMINISTRACION DE RECURSOS MINERALES	PROGRAMA PARA EL DESARROLLO

AREA Cº PETAQUILLA
(SECTOR RIO BOTIJA)
ZONA DE MINERALIZACION
JUNIO, 1969

ZONA DE MINERALIZACION
(SECTOR DE RIO MEDIO)



REFERENCIAS

GEOLOGIA

—·— CONTACTO GEOLOGICO
V ROCAS VOLCANICAS
X ROCAS DACITICAS
+ ROCAS GRANODIORITICAS
+ ROCAS CUARZOMONZONITICAS
Λ ROCAS GABRODIORITICAS
S ROCAS SILICIFICADAS
◁ BRECHAS

GEOQUIMICA

—400— LIMITE DE ANOMALIA - 400 p.p.m. Cu EN SUELO
—700— " " " , - 700 p.p.m. Cu " "
—25— — " " " - 25 p.p.m. Cu " "
—80— — " " " - 80 p.p.m. Cu " "

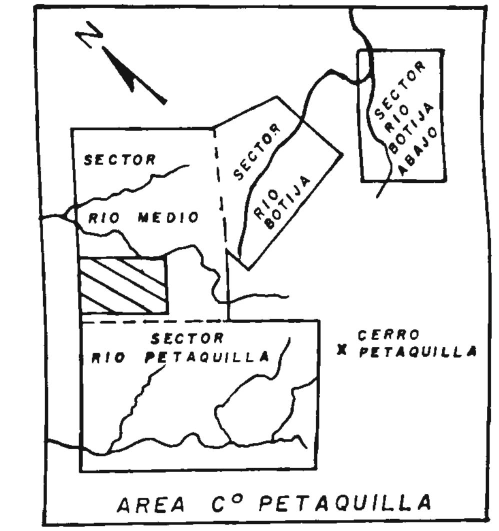
PERFORACIONES

▲ POCA PROFUNDIDAD ● MEDIA PROFUNDIDAD

TOPOGRAFIA

LINEAS DE LEVANTAMIENTO
—50— CURVAS DE NIVEL EN METROS, APROXIMADAMENTE, SOBRE EL NIVEL DEL MAR
RIOS O QUEBRADAS

UBICACION



PROYECTO MINERO DE AZUERO	
REPUBLICA DE PANAMA	NACIONES UNIDAS
ADMINISTRACION DE RECURSOS MINERALES	PROGRAMA PARA EL DESARROLLO

AREA Cº PETAQUILLA
(SECTOR RIO MEDIO)
ZONA DE MINERALIZACION
JUNIO 1969

MAPA 8

GC 65/3-54

3. Geophysical results

The aeromagnetic survey made in 1966 was very severely handicapped in the northern part of the project area by bad weather. This limited the coverage to a zone 20 by 30 kilometres, which happened to include the present Cerro Petaquilla Area. In the absence of reliable maps, the positioning of flight lines had to rely almost entirely on the Doppler data and a few landmarks on the coast. When air photographs became available in March 1968, the airborne survey's 35 mm positioning films were used to replot the flight lines. Few landmarks within the area were positively identified, but it is believed that the new plot is fairly accurate. It shows seven flight lines crossing the grid-line system, but their spacing varies from 700 metres to as much as 3 kilometres. Since, in addition, topographic relief within the area made it impossible to maintain a reasonably constant ground clearance, no reliable interpretation can be made of the airborne data. They do, however, indicate the presence of shearing or faulting, trending northerly and northwesterly across the area.

As already mentioned in Part Two, section C, geophysical surveys on the ground were limited to measurements of the vertical magnetic intensity. The results have been compiled on a series of maps on the scale 1:5,000 (listed in Annex II); only the main features of the magnetic field are presented in this report (map 9). All values are referred to an arbitrary datum.

a) Río Botija. The magnetic intensities recorded over volcanic rocks in the northern part of the sector are more disturbed and, in general, some 300 to 1000 gamma higher than the average intensity over the granodiorite in the southern and western parts. The more subdued magnetic field over the granodiorite reaches its highest values along a belt in the southermost part of the sector where no significant copper/molybdenum geochemical anomalies have been recorded.

b) Río Petaquilla. As at Río Botija, the general level of the magnetic field is more varied and higher, by 300 gamma or more, over the volcanic rocks than in the central part underlain by dacitic porphyry. The lowest intensities were recorded over the zone of mineralization and heavy alteration in Quebrada Piedras Coloradas in the northwestern corner of the sector.

The most striking magnetic feature in the Río Petaquilla sector is a long, narrow anomaly, trending northwesterly for more than three kilometres and defined by the 5,500 gamma contour line. This contour represents values higher by some 500 gamma than the average for dacitic porphyry, and by about 300 gamma than the average for volcanics. Within this anomalous belt still higher values are recorded, up to a maximum of 7,600 gamma near the southeastern end and up to 16,500 gamma in the northwest. The anomalous belt follows the boundary between dacitic and volcanic rocks, a little to the north of the mapped contact, except for a section between lines 6,400 and 6,600 where it cuts across the base of a volcanic "tongue" jutting out into the dacite. The high intensity sections of this belt are offset in several places by about 200 metres in each case; the offsets may indicate dextral shearing or faulting.

One of these sections, close to ~~the~~ intersection of line 7,800 with the control line 6,500 and trending easterly for a distance of some 250 metres, coincides at its western end with an outcrop of magnetite hydrothermally introduced into the contact zone. In the shallow drill hole P-9 this magnetite was shown to be associated with fairly rich copper and pyrite mineralization (2.12 per cent copper, on the average).

At the eastern end of the belt, another strong anomaly trends easterly for about 400 metres. The shallow drill hole P-12 was placed on an outcrop of similar "hydrothermal" magnetite, some 30 metres to the south of the axis of the anomaly, and produced an average copper content of 1.53 per cent. Two other drill holes were put down in this vicinity: P-13, 40 to 50 metres south of the anomaly axis, gave an average of 0.53 per cent copper, and P-14, some 60 to 70 metres from the axis, averaged 0.14 per cent copper. The locations of these three drill holes were largely dictated by the topography. The Winkie drill could not be used on the very steep slopes, with deep weathering, near the axis of the magnetic anomaly.

More work is needed here, as the relationship between the "hydrothermal" magnetite and the strong magnetic anomaly cannot be fully established on available data. The magnetic anomaly may, in part at least, be caused by the disseminated magnetite observed both in the basalt and in gabbroic rocks mapped in the neighbourhood.

Other strong anomalies were recorded in the middle section of this magnetic belt. The steep slopes, deep weathering, absence of suitable stream beds and the short time available ruled out the possibility of subsurface exploration. Further investigations in this area are recommended.

c) Río Medio. The magnetic field in Río Medio sector is similar to those in other parts of the general area.

Magnetic intensities are generally higher and more variable over the volcanic rocks, and some of the lowest values were recorded over the mineralized parts of the dacite.

A very strong magnetic anomaly (3,150 gamma total amplitude) was recorded close to a volcanic/intrusive contact. This was traced to magnetite-rich basalt but no signs of copper or pyrite mineralization were observed.

d) Botija Abajo. The pattern of magnetic anomalies shows again a disturbed field with intensities generally reaching 5,800 or 6,000 gamma over volcanic rocks, and a smooth field, averaging 5,200 gamma, over the silicified and leached dacite. Along the northwestern contact, a narrow anomaly 1000 metres long and defined by the 5,500 gamma contour line may well have a significance similar to the longer and stronger contact zone anomaly at Río Petaquilla, described above.

4. Drilling results

The drilling results indicate that economically important secondary enrichment zones are not to be expected in the Cerro Petaquilla area, and that the large tonnage protore may have a fairly low average copper content. Some centres of mineralization were proved to carry copper contents higher than average, and a few holes intersected copper mineralization of underground mining grade.

Complete assay results of core and sludge samples for each drill hole are presented in composite logs, together with core recovery data, geological logs and notes on alteration (Annex V).

a) Río Botija. Three deep and ten shallow holes have been drilled in the Río Botija sector. Their locations are shown in maps 5 and 8.

The rock is almost entirely granodiorite. Some variations of quartz monzonites and tonalites were observed under the microscope. Only very few steeply dipping, post mineralization dykes were encountered in bore holes.

According to results from the three deep holes, the mineralization of economic grade does not exceed a depth of about 120 metres from the surface. In general, the better grades of mineralization are associated with alteration of the granodiorite, and the intensity of both decreases at depth. However, some fairly fresh parts of the granodiorite nearer the surface are surprisingly well mineralised.

Drilling in the Río Botija sector did not indicate any strong surface leaching; in fact, many holes have their richest parts close to the surface.

b) Río Petaquilla. Six deep and nine shallow holes were drilled in Río Petaquilla sector (map 5).

Very little of true granodiorite has been seen in the drill core; the prevailing rock is dacite porphyry, with gradual transitions either to granodiorite or andesite. Many post-mineralization, almost vertically dipping dykes were intersected, especially at the western end of the Petaquilla Abajo anomaly (e.g. in drill hole P-2). The drilling results do not support the view that the volcanic rocks covering some hill tops and ridges form only shallow cappings.

Strong leaching and a development of jarosite were observed in the top parts of a few holes, especially in the Quebrada Vega geochemical anomaly.

Apart from the contact zone type of copper mineralization, seen in a few holes (particularly in P-9 and P-12), the hypogene mineralization in the Río Petaquilla sector seems to be of fairly low grade, but reaches greater depths than the Río Botija mineralization.

c) Río Medio. One deep and eight shallow holes were drilled in the Río Medio sector (maps 5 and 9).

Four shallow holes closely spaced along the outcropping rich copper mineralization proved it to be at least 30 metres in depth and to reach about 25 metres horizontally from the controlling shear/fault zone. The related breccia was found in drill hole M-5 to be only irregularly mineralized.

The only deep hole in this sector, M-9, penetrated similar breccia and andesite, poorly mineralized throughout. It was completed on 24 June 1969 and it was not possible to drill on another site.

A few shallow holes were sited outside of the copper or molybdenum anomalies; their core assays show only negligible amounts of these elements.

PART FOUR

SUMMARY OF CONCLUSIONS

A complex of andesitic and basaltic lavas was intruded in the Oligocene by a large pluton of intermediate composition. Hydrothermal activity later introduced copper and molybdenum minerals into parts of the intrusive rocks and some of the contact zones. It is possible that one or more of the mineralized zones may be of economic grade and size under present conditions, but much work is required to evaluate these prospects. The overburden is almost entirely limited to a thin soil cover. The mineralized rocks are weathered to variable degrees and depths, but this zone still contains significant grades of copper and molybdenum in many places.

Geochemical prospecting methods played an important part in finding the Cerro Petaquilla mineralization. The anomalous sediment patterns are well extended along the drainage systems and thus easy to interpret. The residual overburden gives well defined soil anomalies, and no contamination of any kind is present in the area.

In general, the magnetic field reflects, roughly, the two main rock divisions. Although some of the lowest values were recorded over the altered and mineralized zones, the magnetic results are not diagnostic enough to be used as a guide in locating such zones, except possibly where copper has been deposited in association with magnetite in contact zones.

The chemical determinations have been found fully reliable by numerous checks with alternative methods and an adequate amount of duplicate analyses by outside laboratories.

REFERENCES

Calvo, A. Castillero, (1967). "Estructuras Sociales y Económicas de Veragua desde sus origenes históricos, Siglos XVI y XVII". Editora Panamá, 1967.

Huffman, Jr., C., Mensik, J. D. and Riley, L. B. (1967). "Determination of Gold in Geologic Materials by Solvent Extraction and Atomic-Absorption Spectrometry", U. S. Geol. Surv., Circular 544, U.S. Govt. Printing Office, Washington D.C.

Kerr, P. F. (1959). "Optical Mineralogy", McGraw Hill Book Company, New York.

Larsen E. S., Berman H. (1934). "Microscopic determination of the non-opaque minerals", U.S. Geol. Survey Bull. 848, U.S. Govt. Printing Office, Washington D.C.

Perkin Elmer (1964). "Analytical Methods for Atomic Absorption Spectrophotometry", Perkin Elmer Corp., Norwalk, Conn., U.S.A.

Sandell, E. B. (1965). "Colorimetric Determination of Traces of Metals", 3rd Edition, Interscience Publishers Inc., New York.

Stanton, R. E. and Hardwick, Mrs. A. J. (1967). "The Colorimetric Determination of Molybdenum in Soils and Sediments by Zinc Dithiol", Analyst, 92, p. 387.

Tindall, F. M. (1965). "Silver and Gold Assay by Atomic Absorption Spectrophotometry", Atomic Absorption Newsletter, 4 (Nº 9), p. 339. Perkin Elmer Corp., Norwalk, Conn., U.S.A., and personal communication.

U.S. Navy Oceanographic Office: "Charts of the Earth's magnetic field in c.g.s. units, Epoch 1965.0". Scale 1:12,233,000 at Equator.

ANNEX I

PROJECT PERSONNEL, CONSULTANTS AND CONTRACTORS

International Staff	Nationality	Arrival date	Departure date
D. A. Harkin Project Manager	United Kingdom	Oct. 65	June 67
L. Z. Makowiecki[1] Project Manager	United Kingdom	Jan. 66	-
J. V. Huhta Geochemist	Finland	Apr. 66	July 69
J. A. LaRocque Photogeologist	Canada	Mar. 67	-
W.K.L. Thomas Chemical Analyst	United Kingdom	Jan. 66	-
S. Wleklinski Field Geologist	Argentina	Mar. 66	-
D. del Giudice Field Geologist	Italy	Mar. 66	-
A. Ferencic Economic Geologist	Yugoslavia	Aug. 66	Aug. 68
K. Anzelius Geophysical Operator	Sweden	Jan. 66	-
E. Keen Drilling Supervisor	Canada	Apr. 68	-

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[1] Served as Project Geophysicist until June 1967.

Consultants

Arthur Blucher	United States	Consulting Mining Geologist
H. E. Hawkes	United States	Consulting Geochemist

Contractors

Lockwood Survey Corporation Ltd. Canada	Airborne Geophysical Survey
Helicopteros de Panama Panama	Air transport of personnel and cargo

Government counterpart personnel

Government Project Co-ordinator

F. Torre, from October 1965 to November 1966.

Jorge Luis Quirós P., Director, Administración de Recursos Minerales, after November 1966.

Field geologists

F. Torre
J. Roquebert
A. Metti
G. Recchi
J. Merida,
Asst. geologist

Chemists

R. Broce
A. de Cermelli
M. Pastor
I. Huhta

Field assistants

R. Carrizo
A. Espino
D. Luna
T. Palacios
R. Isaza
A. Rosas
J. Moreno

Drillers and assistants

F. Puzak
T. Vergara
B. Dominguez
M. Hooper
N. Vergara
M. Vega
V. Dominguez

Laboratory assistants

F. Márquez
R. Barroso
A. González
A. Monge

ANNEX II

SUPPORTING DATA

(held on open file and available on application to:
Director Ejecutivo, Administración de Recursos Minerales,
Apartado Postal 1631, Panama 1, Republica de Panama.)

A. MAPS

MAP DESIGNATIONS

T - topography
GL - geology
GC - geochemistry
GP - geophysics

65 - Cerro Petaquilla (whole area)
65/1 - Río Botija sector
65/2 - Río Petaquilla sector
65/3 - Río Medio sector
65/4 - Río Botija Abajo sector

		Scale
1)	Geology of the project area, GL-4	1:250,000
2)	Aeromagnetic series (Lockwood)	1:50,000
3)	Aeromagnetic contour map, Cerro Petaquilla region (re-plotted by project staff), GP-1	1:50,000
4)	Reconnaissance geological and geochemical data, (maps covering region between Cordillera and the Caribbean) GL-5 to 13, GC-2 to 10, and T-1 to 9	1:50,000
5)	Topography and grid of survey lines, T 65-1	1:15,000
6)	Location of drill holes, helicopter pads and camp sites, T 65-2	1:15,000
7)	Geochemical anomalies: copper in soils, GC 65-6	1:15,000

		Scale
8)	Geochemical anomalies: molybdenum in soils, GC 65-7	1:15,000
9)	Geochemical anomalies: lead and zinc in soils, GC 65-8	1:15,000
10)	Zones of anomalous values of copper and molybdenum in outcrop samples, GC 65-9	1:15,000
11)	Topography and grid of survey lines, T65/1-1, T65/2-2, T65/3-3 and T65/4-4	1:5,000
12)	Geological observations and rock samples locations, GL 65/1-5, GL 65/2-6, GL 65/3-7 and GL 65/4-8	1:5,000
13)	Geological maps: GL 65/1-9, GL 65/2-10, GL 65/3-11, GL 65/4-12	1:5,000
14)	Location of soil samples: GC 65/1-13, GC 65/2-14, GC 65/3-15, GC 65/4-16	1:5,000
15)	Copper contents in soil samples: GC 65/1-17, GC 65/2-18, GC 65/3-19, GC 65/4-20	1:5,000
16)	Molybdenum contents in soil samples: GC 65/1-21, GC 65/2-22, GC 65/3-23, GC 65/4-24	1:5,000
17)	Lead and zinc contents in soil samples: GC 65/1-25, GC 65/2-26, GC 65/3-27, GC 65/4-28	1:5,000
18)	Copper anomalies in soils: GC 65/1-29, GC 65/2-30, GC 65/3-31, GC 65/4-32	1:5,000

	Scale
19) Molybdenum anomalies in soils: GC 65/1-33, GC 65/2-34, GC 65/3-35, GC 65/4-36	1:5,000
20) Lead and zinc anomalies in soils: GC 65/1-37, GC 65/2-28, GC 65/3-39, GC 65/4-40	1:5,000
21) Copper and molybdenum contents in outcrops: GC 65/1-41, GC 65/2-42, GC 65/3-43, GC 65/4-44	1:5,000
22) Magnetic intensities, vertical component: GP 65/1-45, GP 65/2-46, GP 65/3-47, GP 65/4-48	1:5,000
23) Magnetic field, contour maps: GP 65/1-49, GP 65/2-50, GP 65/3-51, GP 65/4-52	1:5,000
24) Locations of soil samples GC 65/1-55	1:2,000
25) Geochemical values, copper and molybdenum in soils, GC 65/1-56	1:2,000

B. OTHER DATA

In addition to maps, other material held by the Administración de Recursos Minerales includes:

1. Files of edited field notes.
2. Files of petrographic descriptions.
3. Complete lists of geochemical values (copper, molybdenum, lead and zinc) in soil, sediment and rock samples, drill core and sludge.

(cont'd)

4. Thin sections and polished sections.
5. Rock specimens, the retained half of split drill core, retained part of each soil and sediment sample.

ANNEX III

PROJECT TECHNICAL REPORTS PREPARED FOR THE GOVERNMENT

1. "*Ad hoc* Report on Area 65-Cerro Petaquilla", Province of Colón, United Nations, May 1968, 10 pp, 3 maps. Publication Nº 2, Administration of Mineral Resources, Panama. (Mimeographed).
2. "Geología del área del Proyecto Minero de Azuero, parte central de la República de Panama".[1/] por D. del Giudice y G. Recchi.
3. "Results of detailed investigations in the Azuero Area"[1/]
4. "Gold deposits of Northern Veraguas"[1/] by S. Wleklinski
5. "Laboratory services, analytical chemistry"[1/] by W.K.L. Thomas
6. "Airborne Magnetometer-Scintillation Counter Survey of the Central Part of the Republic of Panama". Government of the Republic of Panama and U.N.D.P. Special Fund. Presented by Lockwood Survey Corporation Ltd., Toronto, Canada; in two parts, with maps.

[1/] In preparation, July 1969.

ANNEX IV

CHEMICAL METHODS AND RESULTS

A. METHODS FOR GEOCHEMICAL ANALYSIS

1. Soil and stream sediment samples

Weigh 1.0 g of the minus 80-mesh sample into a 16x150 mm test tube. Add 5 ml of (1:1) hydrochloric acid, and heat on the water bath at 95º to 100ºC for 60 minutes. Shake the test tube at frequent intervals. Dilute with 5 ml of water, mix and allow to stand overnight. This solution is used for the determination of copper, lead and zinc by atomic absorption methods (Perkin Elmer, 1964)[1/] and molybdenum by a dithiol colorimetric procedure (Stanton, and Mrs. Hardwick, 1967).

Determine lead directly on the sample solution by atomic absorption spectrophotometry using a x2 scale expansion and the Boling burner, and calibrating the instrument with standard solutions in (1:3) hydrochloric acid. The dilution factor is x10 and the range of the method is 10 to 200 p.p.m. of lead which may be increased to 400 p.p.m. by using x1 scale expansion, and to 4000 p.p.m. by diluting 1 ml aliquot to 10 ml with (1:3) hydrochloric acid.

Determine copper and zinc by atomic absorption spectrophotometry on a 2.0 ml aliquot of the sample solution diluted to 10 ml with water, and calibrating the instrument with standard solutions in (1:19) hydrochloric acid. The dilution factor is x50 for both copper and zinc, and the range of the method is 10 to 1000 p.p.m. of copper

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[1/] All references to literature in Annex IV are included in the list on p. 60.

and 5 to 150 p.p.m. of zinc in the sample. These ranges may be increased by diluting with (1:19) hydrochloric acid as required.

For molybdenum, pipette a 1.0 ml aliquot of the sample solution into a 16x150 mm test tube, add 4 ml of (3:2) hydrochloric acid, and complete the determination by the dithiol method described by Stanton and Mrs. Hardwich (1967), save that 1 ml of benzene is used in place of the 0.5 ml of petroleum spirit called for by the published method, and shaking vigorously for 2 minutes. The green colour of the solvent phase is compared visually against a standard series which is prepared in a similar way to the sample solutions, but with the addition of 2 ml of an iron solution containing approximately 1 mg of iron per ml in (1:1) hydrochloric acid before diluting to 5 ml with (1:1) hydrochloric acid. The range of the method is from 2 to 100 p.p.m. of molybdenum in the sample, which may be increased by taking an aliquot of 0.1 ml, adding 2 ml of the iron solution, and diluting to 5 ml with (1:1) hydrochloric acid before proceeding with the determination.

Reference samples are analysed along with each batch of analytical samples, and statistics calculated from replicate determinations so obtained gave precisions at the 95 per cent confidence level of from 9.2 to 15.4 per cent for copper and 7.9 to 14.0 per cent for zinc on 5 samples containing average determined contents of 100 to 390 p.p.m. of copper and 37 to 426 p.p.m. of zinc. Lead was also run on 2 of these samples, one of which reported less than the detection limit of 10 p.p.m. by the method used, and the other contained an arithmetic mean of 20 p.p.m. of lead with a precision of 42.0 per cent. Similarly, precisions of 7.7 to 29.3 per cent were obtained for molybdenum on 6 samples containing 23.7 to 255 p.p.m. of molybdenum.

All soils from Cerro Petaquilla were analysed by the hot (1:1) hydrochloric acid procedure, and to check on the efficiency of this method of attack 251 randomly selected soil samples were analysed after potassium pyrosulphate fusion, copper being determined by the diquinolyl and molybdenum by the dithiol colorimetric methods. Arithmetic means of results for all samples analysed are reported in table 2, together with the degree of extraction calculated as the percentage ratio of the hot (1:1) hydrochloric acid values to those obtained by the pyrosulphate fusion method, which are regarded in the geochemical sense as "total" contents.

Table 2

Extraction of copper and molybdenum in soils samples by the (1:1) hydrochloric acid attack

Sector	Nº of samples analysed	Cu			Mo		
		Arithmetic mean as ppm Cu		Extraction per cent[1]	Arithmetic mean as ppm Mo		Extraction per cent[1]
		$K_2S_2O_7$	HCl		$K_2S_2O_7$	HCl	
Río Botija[2]	93	383	251	65.7	59.8	52.3	87.5
Río Petaquilla	76	481	347	72.0	50.4	44.1	87.4
Río Medio	82	550	357	64.9	45.3	35.4	78.3
Whole area	251	467	315	67.4	52.2	44.3	84.9

1/ Expressed in terms of "total" contents as determined after fusion with $K_2S_2O_7$.

2/ Including sector Río Botija Abajo.

2. Rock and sludge samples

a) Copper, zinc and lead. Treat 2.5 g of sample with hydrochloric and nitric acids, heat and when the reaction has subsided, evaporate to dryness. Take up the residue in hot 0.5M hydrochloric acid, cool, dilute to 250 ml with 0.5M hydrochloric acid, mix and centrifugue a portion of the solution until the supernatant liquid is clear.

Determine copper, zinc and lead in this solution by atomic absorption spectrophotometry, calibrating the instrument with standard solutions in 0.5M hydrochloric acid and setting the instrument controls as recommended by the manufacturers (Perkin Elmer, 1964), except that for lead the Boling burner is used, with the wavelength at 2833A and scale expansion at x5.

The ranges covered are 50 to 2000 p.p.m. of copper, 10 to 300 p.p.m. of zinc and 50 to 1000 p.p.m. of lead in the sample. Prepare dilutions in 0.5M hydrochloric acid if the metal concentrations are outside the top standards, or for lead use scale expansions of x2 or x1 and, if still outside, prepare dilutions as required.

Statistics calculated from replicate determinations of copper in 4 reference samples showed precisions at the 95 per cent confidence level of 5.6, 6.6, 3.5 and 5.6 per cent in samples containing, as the arithmetic mean of all determinations, 4620, 4570, 4633 and 831 p.p.m. of copper. Zinc and lead were also determined in these samples. Arithmetic means of results so obtained reported in the range 64 to 137 p.p.m. of zinc and less than 50 to 57 p.p.m. of lead with precisions between 7.5 and 11.2 per cent for zinc, and 7.4, 15.6 and 16.4 per cent on the three samples containing detectable amounts of lead.

b) Molybdenum. For sludge samples, pipette a 5 ml aliquot of the sample solution prepared as outlined for the copper, zinc and lead determinations into a 16x150 mm test tube, and determine molybdenum by a modification of the thiocyanate method described by Sandell (1965) in which the molybdenum thiocyanate complex is extracted into 1 ml of a mixture of equal volumes of isoamyl alcohol and carbon tetrachloride, and the colour of the organic phase compared visually against a standard series. The range of the method is 5 to 200 p.p.m. of molybdenum in the sample, which may be extended by taking a smaller aliquot and diluting to 5 ml with 0.5M hydrochloric acid.

Statistics calculated from replicate determinations of molybdenum by this method in the 4 references samples, which were also used for control of copper, zinc and lead analyses, gave precisions of 7.4, 11.5, 12.3 and 4.9 per cent in the samples containing respectively arithmetic means of 270, 264, 264 and 78.8 p.p.m. of molybdenum.

For rock samples, weigh 0.25 g of the sample and fuse with 1 g of potassium pyrosulphate. Extract the fused melt with 5 ml of hot (1:1) hydrochloric acid, cool, add a further 5 ml of this acid and mix. Determine molybdenum on a 5 ml aliquot by the dithiol method as described for soil and stream sediment samples. The range is 2 to 80 p.p.m. of molybdenum in the sample which may be increased by taking a smaller aliquot. A sample containing 80 p.p.m. of molybdenum as reported by an outside laboratory, gave an arithmetic mean of 79.6 p.p.m. by the dithiol-pyrosulphate method with a precision of 24.6 on 13 replicate determinations.

B. METHODS FOR DRILL CORE ANALYSIS

1. Copper and zinc

Weigh 1.0 g of the sample, attack with hydrochloric and nitric acids, and when this reaction has subsided, cool and add a few drops of bromine. Allow to stand for a few minutes, add 15 ml of (1:1) sulphuric acid, and evaporate to fumes. Cool, take up in water, and boil to dissolve soluble salts. Filter into a 250 ml volumetric flask and, when cool, dilute to the mark with water and mix. This solution is used for the determination of copper and zinc, and also for molybdenum on an aliquot by the thiocyanate or dithiol photometric procedures. A blank solution is prepared along with the samples following the method exactly save that the sample is omitted.

Determine copper and zinc in this solution by atomic absorption spectrophotometry, and calibrating the instrument with standard solutions in 2 per cent sulphuric acid. The range is 500 to 5000 p.p.m. of copper and 50 to 750 p.p.m. of zinc in the sample. If the sample solution is above the top standard for either copper or zinc prepare dilutions in 2 per cent sulphuric acid as required.

Some reference samples of copper ore similar in composition to the analytical samples were usually included in each batch of samples. Statistics calculated from replicate determinations so obtained gave coefficients of variation of 1.89, 0.35, 1.44 and 2.66 per cent on these samples containing, respectively, average determined contents of 0.459, 0.457, 0.462 and 0.079 per cent of copper. Zinc was also analysed in these samples. Arithmetic means of results reported in the range 72 to 142 p.p.m. of zinc, with coefficients of variation between

7.0 and 14.4 per cent.

These reference samples contain 0.468, 0.472, 0.470 and 0.076 per cent of copper as determined by an outside laboratory. No additional values for zinc are available, but the method was checked by analysing a standard sample containing 298 p.p.m. of zinc which gave 275, 288, 275 and 290 p.p.m. on four separate determinations.

2. Molybdenum

a) Thiocyanate photometric method. Using the same sample solution prepared as outlined for copper, pipette an aliquot of 15 ml into a separating funnel and determine molybdenum as the thiocyanate complex in isoamyl alcohol using the method described by Sandell (1965).

With each batch of samples, run a reference sample and standardise by carrying through the method 0, 10 and 20 micrograms of molybdenum on 15 ml aliquots of the blank solution prepared along with the samples. The range covered is from 20 to 700 p.p.m. of molybdenum in the sample.

b) Dithiol photometric method. Using the same sample solution prepared as outlined for copper, pipette an aliquot of 5 ml into a separating funnel, add 5 ml of hydrochloric acid, sp.gr. 1.18, mix and allow to cool. Determine molybdenum in this solution using the method described by Stanton and Mrs. Hardwick (1967) save that 2 ml of an iron solution containing approximately 1 mg of iron per ml in (1:1) hydrochloric acid is added to both sample and standard solutions. To accomodate the increased volume of these solutions double amounts of the reagent additions recommended in the published method are used, and the molybdenum dithiol complex is extracted by shaking for 2 minutes into 10.0 ml of carbon tetrachloride.

With each batch of samples, run a reference sample and standardise by carrying through the method 0, 5 and 10 micrograms of molybdenum on 5 ml aliquots of the blank solutions prepared along with the samples. The range covered is from 20 to 2000 p.p.m. of molybdenum in the sample.

c) Atomic absorption method. Weigh 5.0 g of the sample, and add 15 ml of nitric acid and 2 ml of hydrofluoric acid. Heat on the hot plate until brown fumes of nitrous oxide are expelled. Cool, add 2 to 3 drops of bromine and allow to stand for 5 minutes. Add 15 ml of hydrochloric acid, and evaporate to dryness. Take up the residue in 10 ml of hydrochloric acid and 25 ml of water. Boil for 15 minutes and when all soluble salts have dissolved, cool and transfer to a tube marked at 100 ml. Add 10 ml of an aluminium chloride solution containing 445 g of aluminium chloride in 1000 ml of 10 per cent hydrochloric acid solution, dilute to the mark and mix. Filter into a dry test tube and determine molybdenum by atomic absorption spectrophotometry, using the Boling burner with a reducing flame and calibrating the instrument with standard solutions of molybdenum containing similar concentrations of both hydrochloric acid and aluminium as the sample solutions. The range is from 40 to 350 p.p.m. of molybdenum in the sample, which may be increased by appropriate dilutions of the sample solution, or preferably by repeating the determination on a smaller sample weight.

This method was first developed at the Noranda Mines laboratory, Noranda, Quebec, and modified slightly by the Esperanza Mine laboratory of Duval Corporation.

d) Statistics on replicate determinations of molybdenum. Reference samples were analysed along with the analytical samples by each of the three methods used for molybdenum, and statistics calculated from these replicate determinations gave coefficients of variation of 2.77, 6.53, 4.02, 7.56 per cent by the thiocyanate method in four samples which contained, respectively, average determined contents of 265, 259, 259 and 78.2 p.p.m. of molybdenum against 238, 255, 232 and 80 p.p.m. reported by an outside laboratory. The first three of these samples were also analysed in replicate by the dithiol procedure, and coefficients of variation of 5.62, 4.91 and 11.35 per cent were obtained on arithmetic means of 264, 249 and 244 p.p.m. of molybdenum. Replicate results by the atomic absorption method are available only on the first two samples, and these gave coefficients of variation of 3.99 and 4.56 per cent on arithmetic means of 271 and 257 p.p.m. of molybdenum.

3. Gold and silver

Methods used for the determination of gold and silver in drill core samples are based on atomic absorption procedures described by Tindall (1965).

For silver, attack a 10 g sample with hydrochloric and nitric acids, and evaporate to dryness. Take up the residue in 25 ml of hydrochloric acid, 25 ml of water and 5 ml of 50 per cent urea solution.. Boil to dissolve soluble salts and remove oxides of nitrogen, and allow to cool. Dilute to 100 ml, mix and filter. Silver is then determined by atomic absorption spectrophotometry using the Boling burner, and calibrating the instrument with standard solutions of silver in 25 per cent hydrochloric acid. The range covered by this method is 1 to 50 p.p.m. of silver in the sample.

For gold, attack a 50 g sample by boiling for 15 minutes with 50 ml of hydrochloric and 25 ml of nitric acids. Add 50 ml of water and continue the heating until all salts are in solution. Filter using suction and wash twice with hot water. Cool, transfer to a 250 ml separatory funnel, and add 20 ml of methyl isobutyl ketone (MIBK). Shake for 30 seconds and, after allowing the phases to separate, discard the aqueous layer. Wash the MIBK twice with 10 per cent hydrochloric acid solution and determine gold in the organic phase by atomic absorption spectrophotometry using the standard burner and calibrating the instrument with standard solutions of gold in MIBK which have been prepared in a similar manner to the sample solutions. The range covered by this method is 20 to 4000 p.p.b. of gold in the sample (p.p.b.= parts per billion = parts per thousand million).

Two standard gold samples issued by the U.S. Geological Survey were run along with the analytical samples, and statistics calculated from replicate determinations gave coefficients of variation of 5.5. and 9.5 per cent on these two standards containing, respectively, average determined contents of 2.71 p.p.m. and 0.069 p.p.m. of gold, against the recommended values of 2.61 p.p.m. and 0.050 p.p.m. An internal laboratory standard sample containing 44 p.p.m. of silver gave a coefficient of variation of 4.8 per cent with an arithmetic mean of 44.1 p.p.m. calculated from the replicate results by the method used.

Nine samples which had been analysed for gold by the method described above were checked by a fire assay concentration procedure. The resulting gold-silver prill was dissolved and gold extracted into MIBK prior to atomic absorption determination using the method described by Huffman, Mensik and Riley (1967). Results obtained by the two methods showed good general agreement at the low levels of gold (less than 1 p.p.m.) in these samples, with a maximum difference of 0.060 p.p.m. of gold determined on one sample which assayed 0.480 p.p.m. and 0.540 p.p.m., respectively, by the fire assay concentration and acid attack procedures.

Table

Check analyses of drill core

Sample Nº	Cu %				Mo	
	Original sample		Duplicate sample		Original sample	
	Project	Contr.	Project	Duval	Project	Contr.
B2/8	1.13	1.12	1.13	1.22	200	300
B2/52	0.40	0.36	0.40	0.41	1100	1600
B9/2	1.06	1.08	1.03	1.11	66	100
B9/21	0.27	0.24	0.25	0.30	130	210
B11/5	0.66	0.58	0.64	0.69	140	180
B11/23	0.92	0.90	0.96	0.96	750	1000
P1/9	1.65	1.54	1.65	1.61	7	7
P1/12	1.21	1.10	1.19	1.18	8	8
M2/2	1.12	1.04	1.08	1.10	16	16
M3/2	1.98	1.98	1.87	1.93	10	7
M3/4	2.36	2.24	2.36	2.29	38	43

N.D. - Not determined
\- - Less than

samples by outside laboratories

p.p.m.		Ag p.p.m.			Au p.p.m.		
Duplicate sample		Original sample	Duplicate sample		Original sample	Duplicate sample	
Project	Duval	Contr.	Project	Duval	Contr.	Project	Duval
210	225	N.D.	2	2.4	N.D.	0.07	0.27
1050	1146	N.D.	1	0.68	N.D.	0.08	0.14
100	100	4.0	2	1.7	2.0	0.13	0.14
140	148	N.D.	1	0.68	N.D.	0.06	NIL
140	148	2.0	1	0.68	-0.1	0.10	0.24
790	802	N.D.	3	3.1	N.D.	0.10	0.24
8	10	6.0	5	3.4	1.0	0.54	1.06
7	10	5.9	5	3.4	-0.1	0.20	0.41
16	15	6.8	5	3.8	-0.1	0.06	0.17
8	13	10.0	10	6.8	-0.1	0.10	0.21
40	43	10.1	10	6.2	2.0	0.12	0.24

Laboratory:

Project: U.N. Mineral Survey, Panama
Contr. : Contracting laboratory
Duval : Esperanza Mine laboratory, Duval Corporation

Table 4

Check analyses of geochemical

Sample №	Cu p.p.m.				
	Panama HCl A.A.	Guatemala HCl/H_2O_2 A.A.	Panama HCl/HNO_3 A.A.	Guatemala HCl/HNO_3 A.A.	Panama HCl A.A.
15987	1600	1400	1900	1700	50
15993	380	300	430	380	75
16512	2000	1600	2000	1800	60
17332	80	100	100	90	120
17463	140	110	160	120	10
17969	540	500	680	520	-5
20495	310	250	380	310	15
22968	560	450	690	500	15
23262	240	210	280	210	20
23367	360	310	430	300	80
23512	130	110	130	90	100
24010	120	90	120	100	15

A.A. - Atomic absorption determination
Col. - Colorimetric determination
\- - Less than

samples by an outside laboratory

Zn p.p.m.			Pb p.p.m.		Mo p.p.m.	
Guatemala $HCl/H2O2$ A.A.	Panama HCl/HNO_3 A.A.	Guatemala HCl/HNO_3 A.A.	Panama HCl A.A.	Guatemala HCl/H_2O_2 A.A.	Panama HCl Col.	Guatemala HCl/H_2O_2 Col.
60	65	60	35	30	85	70
60	80	70	35	30	24	20
50	70	60	55	40	120	125
100	140	80	50	50	-2	2
15	10	10	35	30	30	36
10	-10	10	90	100	220	250
15	25	20	25	40	43	40
20	30	20	15	40	460	500
25	25	20	10	30	-2	2
70	100	70	40	30	10	10
90	130	100	20	60	-2	2
15	15	15	15	30	45	36

Laboratory:

Panama:	U.N. Mineral Project, Panama
Guatemala:	U.N. Mineral Project, Guatemala

Table 5

Analyses of composite samples of core from all deep drill holes in the Cerro Petaquilla area

Drill hole a/	Nos. of samples in the composite	Cu%		Mo p.p.m.		Zn p.p.m.	
		b/	c/	b/	c/	b/	c/
B2	1 to 33	0.73	0.72	180	190	275	244
B2	34 to 56	0.29	0.30	138	140	250	280
B9	1 to 30	0.41	0.42	232	237	320	370
B9	31 to 59	0.20	0.21	61	59	140	170
B11	1 to 30	0.61	0.65	228	226	90	100
B11	31 to 71	0.25	0.25	37	30	100	105
P1	1 to 18	0.70	0.70	12	13	240	232
P2	1 to 19	0.39	0.40	9	7	170	158
P2	20 to 45	0.14	0.14	8	8	340	344
P3	1 to 25	0.39	0.39	62	64	85	95
P3	26 to 50	0.45	0.45	113	115	600	640
P4	1 to 29	0.15	0.15	20	22	640	570
P4	30 to 58	0.20	0.18	177	197	210	220
P5	1 to 29	0.34	0.34	114	111	213	213
P5	30 to 58	0.34	0.36	56	54	230	254
P6	1 to 29	0.20	0.22	56	61	225	216
P6	30 to 57	0.17	0.16	60	61	640	620
M9	1 to 30	0.10	0.10	68	67	330	350
M9	31 to 69	0.18	0.17	36	31	130	130

a/ - Prefixes B, P and M refer to the Río Botija, Río Petaquilla and Río Medio sectors, respectively. All drill hole locations are shown on maps 5, 5A and 6.

b/ - Results determined in the composite sample

c/ - Arithmetic mean of the contents in the corresponding individual samples.

Table 6

Semi-quantitative spectrographic

Element	Sample			
	B2(1-33)	B2(34-56)	B9(1-30)	B9(31-59)
Barium	0.1%	0.1%	0.1%	0.1%
Cobalt	--	--	--	--
Copper	1%	0.3%	0.5%	0.3%
Gallium	0.001%	0.001%	0.001%	0.001%
Gold	--	--	--	--
Lead	--	--	--	--
Manganese	0.05%	0.1%	0.05%	0.05%
Molybdenum	0.01%	0.01%	0.01%	0.005%
Nickel	--	--	--	--
Silver	-0.1 oz:t	-0.1 oz:t	--	--
Strontium	0.1%	0.1%	0.1%	0.1%
Titanium	0.5%	0.2%	0.5%	0.3%
Tungsten	PT	PT	PT	PT
Vanadium	0.01%	0.01%	0.01%	0.01%
Yttrium (Y_2O_3)	--	--	--	--
Zirconium	0.001%	0.001%	0.001%	0.001%
Rock forming metals				
Aluminium (Al_2O_3)	MH	MH	MH	MH
Calcium (CaO)	5%	5%	5%	5%
Iron (Fe)	3%	3%	3%	3%
Magnesium (MgO)	2%	2%	2%	5%
Silica (SiO_2)	H	H	H	H
Sodium (Na_2O)	M	M	M	M
Potassium (K_2O)	3%	3%	3%	3%

a/ These samples consist of six composites from deep drill Río Medio sector and one of Río Petaquilla sector drill core.

Code

H	-	High	(approx. 10 - 100%)
MH	-	Medium high	(approx. 5 - 50%)
M	-	Medium	(approx. 1 - 10%)

analyses of drill core samples

Nº a/				
B11(1-30)	B11(31-71)	M2/2	M3/4	P1/9
0.1%	0.1%	0.1%	0.1%	0.1%
--	--	--	--	0.005%
0.5-1%	0.5%	1-2%	2-3%	LM 2%
0.001%	0.001%	0.001%	--	0.001%
--	--	--	--	0.02 oz:t
--	--	0.01%	--	--
0.05%	0.05%	0.05%	0.05%	0.05%
0.01%	0.002%	--	--	--
--	--	--	--	0.001%
-0.1 oz:t	-0.1 oz:t	0.1 oz:t	0.3 oz:t	0.1 Oz:t
0.1%	0.1%	0.05%	0.05%	0.1%
0.3%	0.3%	0.5%	0.2%	1%
PT	PT	--	--	--
0.01%	0.01%	0.01%	0.01%	0.02%
--	--	--	--	0.005%
0.001%	0.001%	0.001%	0.001%	0.01%
MH	MH	MH	MH	MH
5%	5%	3%	3%	3%
3%	3%	5%	3%	5%
2%	2%	5%	2%	5%
H	H	H	H	H
M	M	LM	LM	M
3%	3%	2%	2%	-

holes in Río Botija sector, and two individual samples of

LM - Low medium (approx. 0.5 - 5%)
PT - Possible trace (Presence not certain)
\- - Less than

ANNEX V

COMPOSITE DRILL HOLE LOGS

CERRO PETAQUILLA AREA

CHART 1 - Río Botija sector, drill holes B-1, B-2, B-3, B-4, B-5, B-6, B-7, B-8.

CHART 2 - Río Botija sector, drill holes B-9, B-10, B-11, B-12, B-13.

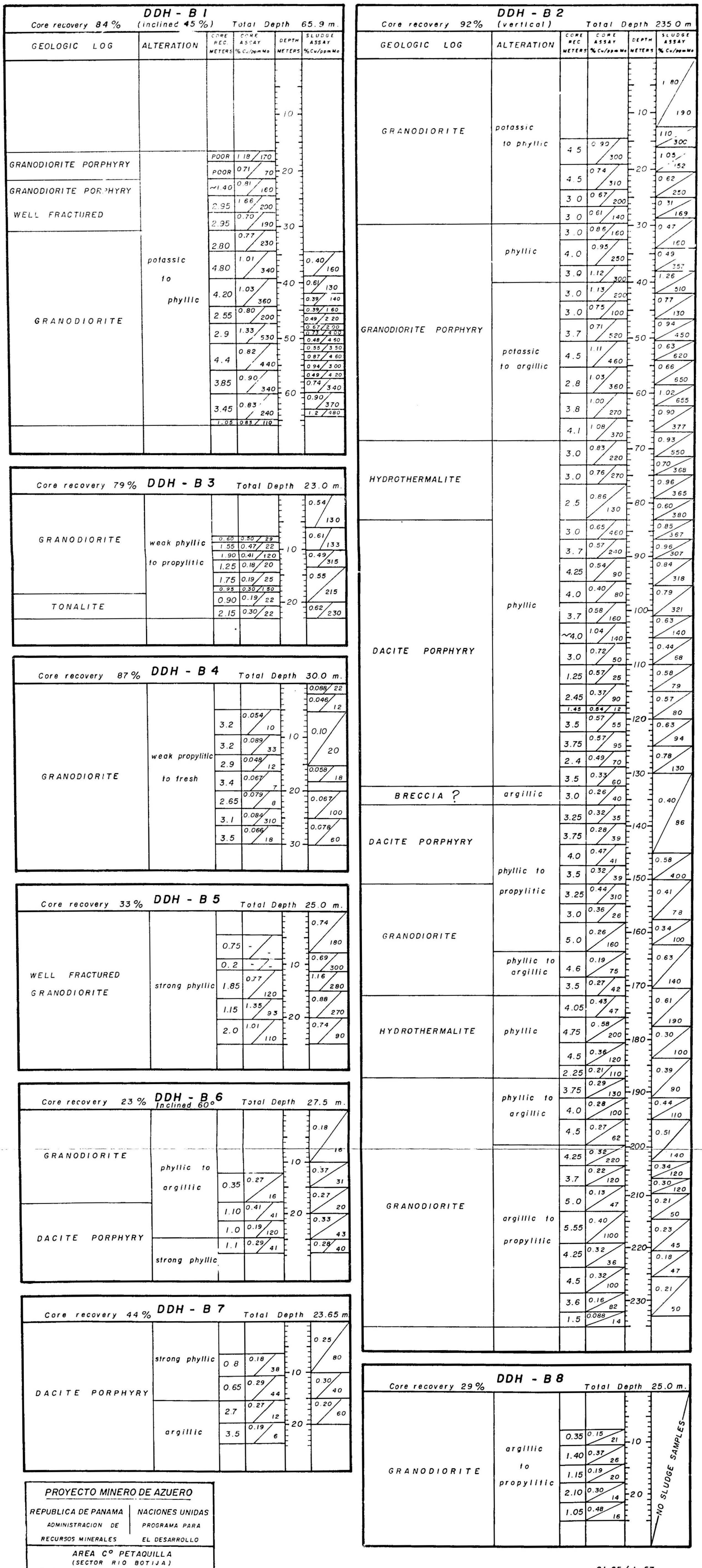
CHART 3 - Río Petaquilla sector, drill holes P-1, P-2, P-5, P-7, P-8.

CHART 4 - Río Petaquilla sector, drill holes P-3, P-4, P-9, P-10.

CHART 5 - Río Petaquilla sector, drill holes P-6, P-11, P-12, P-13, P-14, P-15.

CHART 6 - Río Medio sector, drill holes M-1, M-2, M-3, M-4, M-5, M-6, M-7, M-8, M-9.

COMPOSITE DRILL HOLE LOGS



DDH - B 1

Core recovery 84 % (inclined 45 %) Total Depth 65.9 m.

GEOLOGIC LOG	ALTERATION
GRANODIORITE PORPHYRY	potassic to phyllic
GRANODIORITE PORPHYRY WELL FRACTURED	
GRANODIORITE	

CORE REC. METERS	CORE ASSAY % Cu/ppm Mo
POOR	1.18/170
POOR	0.71/70
~1.40	0.81/160
2.95	1.66/200
2.95	0.70/190
2.80	0.77/230
4.80	1.01/340
4.20	1.03/360
2.55	0.80/200
2.9	1.33/530
4.4	0.82/440
3.85	0.90/340
3.45	0.83/240
1.05	0.83/110

SLUDGE ASSAY % Cu/ppm Mo
0.40/160
0.61/130
0.39/140
0.39/160
0.49/220
0.67/200
0.73/400
0.48/460
0.55/350
0.87/460
0.94/300
0.49/420
0.74/340
0.90/370
1.2/480

DDH - B 2

Core recovery 92% (vertical) Total Depth 235.0 m

GEOLOGIC LOG	ALTERATION
GRANODIORITE	potassic to phyllic
GRANODIORITE PORPHYRY	phyllic
	potassic to argillic
HYDROTHERMALITE	phyllic
DACITE PORPHYRY	
BRECCIA ?	argillic
DACITE PORPHYRY	phyllic to propylitic
GRANODIORITE	
	phyllic to argillic
HYDROTHERMALITE	phyllic
GRANODIORITE	phyllic to argillic
	argillic to propylitic

CORE REC. METERS	CORE ASSAY % Cu/ppm Mo
4.5	0.90/300
4.5	0.74/310
3.0	0.67/200
3.0	0.61/140
3.0	0.86/160
4.0	0.95/250
3.0	1.12/300
3.0	1.13/200
3.0	0.75/100
3.7	0.71/520
4.5	1.11/460
2.8	1.03/360
3.8	1.00/270
4.1	1.08/370
3.0	0.83/220
3.0	0.76/270
2.5	0.86/130
3.0	0.65/460
3.7	0.57/240
4.25	0.54/90
4.0	0.40/80
3.7	0.58/160
~4.0	1.04/140
3.0	0.72/50
1.25	0.57/25
2.45	0.37/90
1.45	0.54/12
3.5	0.57/55
3.75	0.57/95
2.4	0.49/70
3.5	0.33/60
3.0	0.26/40
3.25	0.32/35
3.75	0.28/39
4.0	0.47/41
3.5	0.32/39
3.25	0.44/310
3.0	0.36/26
5.0	0.26/160
4.6	0.19/75
3.5	0.27/42
4.05	0.43/47
4.75	0.58/200
4.5	0.36/120
2.25	0.21/110
3.75	0.29/130
4.0	0.28/100
4.5	0.27/62
4.25	0.32/220
3.7	0.22/120
5.0	0.13/47
5.55	0.40/1100
4.25	0.32/36
4.5	0.32/100
3.6	0.16/82
1.5	0.088/14

SLUDGE ASSAY % Cu/ppm Mo
1.80/190
1.10/300
1.05/152
0.62/250
0.31/169
0.47/160
0.49/357
1.26/510
0.77/130
0.94/450
0.63/620
0.66/650
1.02/655
0.90/377
0.93/550
0.70/368
0.96/365
0.60/380
0.85/367
0.96/307
0.84/318
0.79/321
0.63/140
0.44/68
0.58/79
0.57/80
0.63/94
0.78/130
0.40/86
0.58/400
0.41/78
0.34/100
0.63/140
0.61/190
0.30/100
0.39/90
0.44/110
0.51/140
0.34/120
0.30/120
0.21/50
0.23/45
0.18/47
0.21/50

DDH - B 3

Core recovery 79% Total Depth 23.0 m.

GEOLOGIC LOG	ALTERATION
GRANODIORITE	weak phyllic to propylitic
TONALITE	

CORE REC. METERS	CORE ASSAY % Cu/ppm Mo
0.60	0.50/29
1.55	0.47/22
1.90	0.41/120
1.25	0.18/20
1.75	0.19/25
0.95	0.30/150
0.90	0.19/22
2.15	0.30/22

SLUDGE ASSAY % Cu/ppm Mo
0.54/130
0.61/133
0.49/315
0.55/215
0.62/230

DDH - B 4

Core recovery 87 % Total Depth 30.0 m.

GEOLOGIC LOG	ALTERATION
GRANODIORITE	weak propylitic to fresh

CORE REC. METERS	CORE ASSAY % Cu/ppm Mo
3.2	0.054/10
3.2	0.089/33
2.9	0.048/12
3.4	0.067/7
2.65	0.079/8
3.1	0.084/310
3.5	0.066/18

SLUDGE ASSAY % Cu/ppm Mo
0.088/22
0.046/12
0.10/20
0.058/18
0.067/100
0.078/60

DDH - B 5

Core recovery 33 % Total Depth 25.0 m.

GEOLOGIC LOG	ALTERATION
WELL FRACTURED GRANODIORITE	strong phyllic

CORE REC. METERS	CORE ASSAY % Cu/ppm Mo
0.75	-/-
0.2	-/-
1.85	0.77/120
1.15	1.35/93
2.0	1.01/110

SLUDGE ASSAY % Cu/ppm Mo
0.74/180
0.69/300
1.16/280
0.88/270
0.74/90

DDH - B 6

Inclined 60°

Core recovery 23 % Total Depth 27.5 m.

GEOLOGIC LOG	ALTERATION
GRANODIORITE	phyllic to argillic
DACITE PORPHYRY	strong phyllic

CORE REC. METERS	CORE ASSAY % Cu/ppm Mo
0.35	0.27/16
1.10	0.41/41
1.0	0.19/120
1.1	0.29/41

SLUDGE ASSAY % Cu/ppm Mo
0.18/16
0.37/31
0.27/20
0.33/43
0.28/40

DDH - B 7

Core recovery 44 % Total Depth 23.65 m

GEOLOGIC LOG	ALTERATION
DACITE PORPHYRY	strong phyllic
	argillic

CORE REC. METERS	CORE ASSAY % Cu/ppm Mo
0.8	0.18/38
0.65	0.29/44
2.7	0.27/12
3.5	0.19/6

SLUDGE ASSAY % Cu/ppm Mo
0.25/80
0.30/40
0.20/60

DDH - B 8

Core recovery 29 % Total Depth 25.0 m.

GEOLOGIC LOG	ALTERATION
GRANODIORITE	argillic to propylitic

CORE REC. METERS	CORE ASSAY % Cu/ppm Mo
0.35	0.15/21
1.40	0.37/26
1.15	0.19/20
2.10	0.30/14
1.05	0.48/16

NO SLUDGE SAMPLES

PROYECTO MINERO DE AZUERO

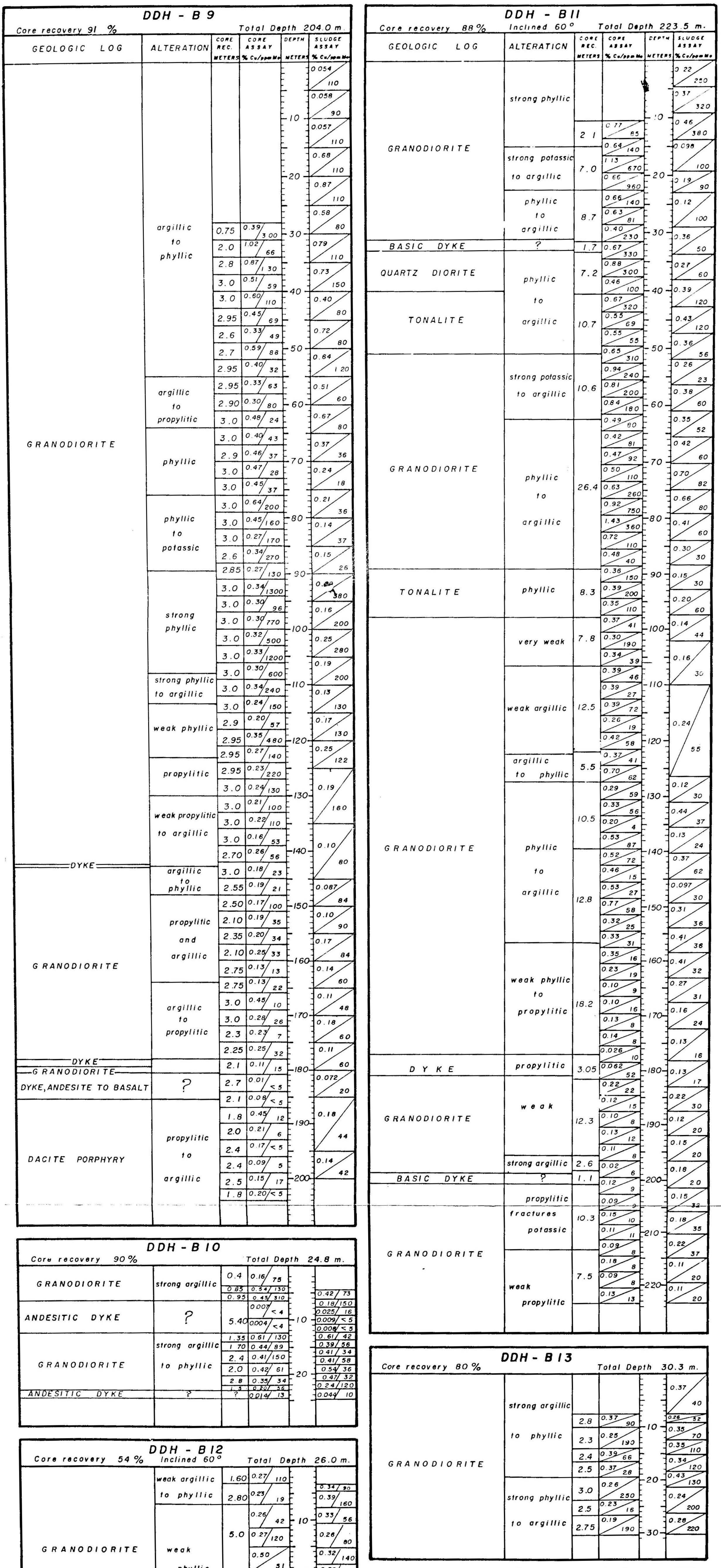
REPUBLICA DE PANAMA	NACIONES UNIDAS
ADMINISTRACION DE RECURSOS MINERALES	PROGRAMA PARA EL DESARROLLO

AREA Cº PETAQUILLA
(SECTOR RIO BOTIJA)
COMPOSITE DRILL HOLE LOGS
JUNE 1969

CHART I

GL 65/ I-57

COMPOSITE DRILL HOLE LOGS



PROYECTO MINERO DE AZUERO

REPUBLICA DE PANAMA	NACIONES UNIDAS
ADMINISTRACION DE RECURSOS MINERALES	PROGRAMA PARA EL DESARROLLO

AREA Cº PETAQUILLA
(SECTOR RIO BOTIJA)
COMPOSITE DRILL HOLE LOGS
JUNE 1969

CHART 2

GL 65/1-58

COMPOSITE DRILL HOLE LOGS

DDH - P6

Core recovery 48.5% Total Depth 214.3 m.

GEOLOGIC LOG	ALTERATION	CORE REC. METERS	CORE ASSAY % Cu/ppm Mo
	phyllic		
LEACHED CAPPING		0.25	0.08/110
		0.80	0.10/290
		0.40	0.09/110
		0.20	0.29/77
STRONGLY FRACTURED DACITE PORPHYRY	propylitic to phyllic	0.20	0.59/70
		0.10	0.65/86
		0.05!	0.27/29
		0.3	0.13/85
		0.5	0.09/43
		1.0	0.41/44
		0.9	0.23/38
		2.0	0.22/42
		1.1	0.39/64
		2.3	007/23
GRANODIORITE PORPHYRY		2.5	0.14/61
		2.6	0.13/59
STRONGLY TECTONISED DACITE PORPHYRY	irregular mainly propylitic and argillic. few zones phyllic	2.0	0.15/32
		2.4	0.23/43
		2.5	0.26/72
		2.8	0.12/27
ANDESITE - PORPHYRY, AMPHIBOLITIZED		2.5	0.12/20
		1.2	0.24/38
		1.5	0.09/23
ANDESITE PORPHYRY CALCITE AND ZEOLITES IN FRACTURES		2.0	0.16/35
		2.0	0.25/92
		2.1	0.25/55
		2.0	0.24/31
		1.5	0.21/35
		1.6	0.18/38
		2.3	0.22/21
		2.5	0.24/40
		2.2	0.17/29
		1.0	0.16/150
		1.0	0.18/71
		1.5	0.34/86
ANDESITE, WELL FRACTURED	argillic to phyllic	1.4	0.34/140
		1.3	0.22/30
		1.6	0.28/45
DIORITE TO GABBRODIORITE PORPHYRY	weak argillic to propylitic	0.3	0.26/49
		0.4	0.29/150
		1.2	0.39/120
		1.4	0.20/180
		1.0	0.19/74
		1.2	0.11/35
		2.4	0.11/25
		2.0	0.06/27
		1.5	0.04/19
		1.5	0.05/25
		1.7	0.11/37
		1.9	0.07/19
		2.3	0.05/26
		1.4	0.09/43
DIORITE TO GABBRODIORITE	very weak propylitic	2.2	0.04/21
		2.8	0.15/90
		3.7!	0.10/120
		2.4	0.05/17
		1.3	0.04/23

SLUDGE ASSAY % Cu/ppm Mo
0.095/110
0.083/170
0.079/260
0.057/200
0.063/240
0.15/260
0.15/270
0.18/330
0.20/300
0.06/230
0.20/76
0.36/62
0.20/64
0.23/67
0.17/82
0.25/160
0.18/120
0.29/120
0.15/83
0.097/38
0.31/110
0.18/60
0.18/59
0.58/130
0.34/120
0.40/120
0.56/180
0.36/130
0.35/90
0.35/80
0.23/90
0.27/120
0.41/90
0.38/94
0.69/300
0.39/380
0.60/430
0.47/180
0.038/64
0.036/68
0.05/63
0.18/100
0.18/110
0.058/62
0.073/51
0.11/71

DDH - P11

Core recovery 58 % Total Depth 33.5 m.

GEOLOGIC LOG	ALTERATION	CORE REC. METERS	CORE ASSAY % Cu/ppm Mo
LEACHED DACITE PORPHYRY	strong propylitic some argillic	1.4	0.04/<5
BRECCIATED DACITE PORPHYRY		1.7	0.34/87
		3.0	0.38/180
		2.0	0.34/250
		1.9	0.30/83
		2.2	0.31/80
		2.1	0.69/210
		2.0	0.59/76
		2.8	0.56/77

SLUDGE ASSAY % Cu/ppm Mo
0.11/45
0.31/46
0.32/55
0.49/95
0.43/140
0.94/55
0.33/70
0.81/95
0.98/120
0.99/180
0.72/130

DDH - P12

Core recovery 55% Total Depth 30.5 m.

GEOLOGIC LOG	ALTERATION	CORE REC. METERS	CORE ASSAY % Cu/ppm Mo
LEACHED ANDESITE	contact metamorphosed, and strong hydrothermalitic (potassic ?)	0.3	0.08/38
		1.9	1.05/11
ANDESITE, RICH OF MAGNETITE, PARTS COARSER AND GABBROIC		2.6	1.28/35
		2.2	2.74/57
		1.3	2.43/170
DACITE PORPHYRY	strong phyllic to potassic	0.9	1.40/16
		1.7	0.96/42
		0.75	1.67/1050
		1.5	1.23/670

SLUDGE ASSAY % Cu/ppm Mo
0.73/55
2.10/12
2.70/47
3.90/25
3.30/50
3.30/72
3.20/130
2.70/110
2.00/480

DDH - P13

Core recovery 64 % Total Depth 30.5 m.

GEOLOGIC LOG	ALTERATION	CORE REC. METERS	CORE ASSAY % Cu/ppm Mo
ANDESITE TO DACITE PORPHYRY	leached	0.5	0.10/30
ANDESITE BRECCIATED IN PARTS. MAGNETITE DISSEMINATIONS AND VIENLETS.	strong propylitic to phyllic weaker in depth	0.7	1.23/25
		2.0	0.91/63
		2.2	0.39/42
		2.7	0.45/27
BRECCIATED ZONE ?		2.7	0.32/201
ANDESITE		3.0	0.24/374
		1.5	0.36/33

SLUDGE ASSAY % Cu/ppm Mo
0.17/68
1.30/38
0.60/43
0.61/27
0.58/30
0.79/40
0.33/56
0.51/110
0.60/280
0.59/180

DDH - P14

Core recovery 38.0% Total Depth 30.5 m.

GEOLOGIC LOG	ALTERATION	CORE REC. METERS	CORE ASSAY % Cu/ppm Mo
DACITE PORPHYRY	strong leaching	1.5	0.09/10
DACITE PORPHYRY	partly leached	0.7	0.23/4
GRADUAL CHANGE TO ANDESITE	propylitic	1.0	0.17/5
BRECCIA	propylitic	2.6	0.13/20
WELL SHEARED ANDESITE	strong propylitic to argillic	3.0	0.09/24
		2.0	0.12/24

SLUDGE ASSAY % Cu/ppm Mo
0.11/23
0.14/14
0.16/24
0.50/10
0.50/10
0.32/15
0.46/24
0.18/14
0.19/16
0.25/17

DDH - P15

Core recovery 35.8% Total Depth 30.5 m.

GEOLOGIC LOG	ALTERATION	CORE REC. METERS	CORE ASSAY % Cu/ppm Mo
GRANODIORITE	strong phyllic	0.9	0.46/35
GRANODIORITE PORPHYRY		1.5	0.35/70
ANDESITE	propylitic	0.8	0.02/7
DACITE PORPHYRY	strong phyllic	1.0	0.50/420
		2.2	0.35/65
		1.3	0.52/410
		1.0	0.64/130
	propylitic	1.2	0.19/57
	phyllic	1.0	0.35/81

SLUDGE ASSAY % Cu/ppm Mo
0.32/79
0.32/180
0.36/180
0.33/120
0.41/170
0.37/100
0.39/120
0.36/130
0.24/130
0.34/120

PROYECTO MINERO DE AZUERO

REPUBLICA DE PANAMA	NACIONES UNIDAS
ADMINISTRACION DE RECURSOS MINERALES	PROGRAMA PARA EL DESARROLLO

AREA C° PETAQUILLA
(SECTOR RIO PETAQUILLA)
COMPOSITE DRILL HOLE LOGS
JUNE 1969

CHART 5

GL 65/2 -61

COMPOSITE DRILL HOLE LOGS

DDH - M1

Core recovery 58 % Total Depth 32.0 m

GEOLOGIC LOG	ALTERATION	CORE REC. METERS	CORE ASSAY % Cu/ppm Mo
QUARTZ DIORITE	weathered propylitic phyllic	2.0	0.19/15
		1.55	0.19/6
	argillic to propylitic	2.65	0.16/5
		3.20	0.12/6
QUARTZ DIORITE PORPHYRY	strong phyllic to argillic	2.15	0.33/5
		1.10	0.24/5
		1.20	0.31/7
		1.60	0.43/59
		1.50	0.21/60

SLUDGE ASSAY % Cu/ppm Mo
0.21/17
0.37/<5
0.37/6
0.32/6
0.25/22
0.29/5
0.36/12
0.61/40
0.48/450
0.20/130

DDH - M2

Core recovery 76 % Total Depth 25.3 m.

GEOLOGIC LOG	ALTERATION	CORE REC. METERS	CORE ASSAY % Cu/ppm Mo
QUARTZ DIORITE	strong phyllic some argillic	?	1.67/27
		?	1.12/16
		~2.0	0.93/20
		2.3	0.62/7
		2.8	0.83/13
		1.5	1.23/12
DACITE PORPHYRY		2.5	1.48/83
		2.55	0.61/20
		2.0	0.42/10

SLUDGE ASSAY % Cu/ppm Mo
2.40/33
0.46/23 1.03/20
0.76/6
1.40/11

DDH - M3

Core recovery 81 % Total Depth 23.75 m

GEOLOGIC LOG	ALTERATION	CORE REC. METERS	CORE ASSAY % Cu/ppm Mo
GRANODIORITE	strong phyllic and argillic	0.7	1.69/11
GRANODIORITE PORPHYRY		2.5	1.98/10
		2.2	1.85/26
		2.75	2.35/38
		1.6	1.41/71
GRANODIORITE TO GRANITE		2.3	2.86/75
		2.7	1.45/160
		2.6	0.98/56
		1.9	1.26/22

SLUDGE ASSAY % Cu/ppm Mo
1.70/13
1.70/9
2.80/25
2.70/32
3.10/75
2.70/160
3.00/150

DDH - M4

Core recovery 90 % Inclined 45° Total Depth 29.0 m.

GEOLOGIC LOG	ALTERATION	CORE REC. METERS	CORE ASSAY % Cu/ppm Mo
GRANODIORITE	strong phyllic and argillic	?	1.15/170
		?	1.18/59
		2.5	0.88/150
		2.8	0.83/120
		3.0	1.60/67
		2.75	1.88/110
GRANODIORITE PORPHYRY		2.9	2.90/30
		2.9	1.15/150
		2.3	1.00/330
BRECCIATED ANDESITE PORPHYRY	metamorphosed	1.6	0.53/30
		1.6	0.62/500

SLUDGE ASSAY % Cu/ppm Mo
1.10/54
0.91/120
0.90/77
1.00/60
2.40/38
2.20/150
1.80/100
1.40/300
1.20/570

DDH - M5

Core recovery 79 % Total Depth 26.0 m.

GEOLOGIC LOG	ALTERATION	CORE REC. METERS	CORE ASSAY % Cu/ppm Mo
BRECCIA	propylitic, argillic only in fractures	2.4	0.65/190
		2.0	0.43/140
		1.8	0.09/150
		1.8	0.29/110
		2.7	0.16/120
		2.6	0.20/140
		2.8	0.36/130
		2.6	0.33/240
		1.5	0.056/100

SLUDGE ASSAY % Cu/ppm Mo
0.49/26
0.53/93
0.34/85
0.86/110
0.40/120
0.30/80
0.57/75
0.086/110

DDH - M6

Core recovery 79 % Total Depth 37.25 m.

GEOLOGIC LOG	ALTERATION	CORE REC. METERS	CORE ASSAY % Cu/ppm Mo
GRANODIORITE PORPHYRY	argillic to propylitic		
		1.3	0.22/180
DYKE BASALTIC		2.3	0.01/2
GRANODIORITE PORPHYRY	propylitic to argillic	3.0	0.01/7
DACITE PORPHORY		3.1	0.03/9
		3.0	0.01/10
	propylitic to phyllic	2.8	0.01/6
		3.0	0.06/6
		2.5	0.01/6
DYKE DACITE PORPHORY		1.5	0.04/10

SLUDGE ASSAY % Cu/ppm Mo
0.053/8
0.055/8
0.52/110
/
0.10/54
0.075/21
0.10/28
0.095/36
0.084/40
0.14/60
0.099/40
/
0.042/20

DDH - M7

Core recovery 90 % Total Depth 30.4 m.

GEOLOGIC LOG	ALTERATION	CORE REC. METERS	CORE ASSAY % Cu/ppm Mo
GRANODIORITE PORPHYRY	strong potassic	2.3	0.11/6
		1.8	0.21/9
	potassic to arg.	2.0	0.11/2
ANDESITE, AMPHIBOLITIZED	contact metamorphosed	2.3	0.32/65
		3.0	0.06/19
		3.0	0.06/12
		2.8	0.35/54
BRECCIATED FRACTURED CONTACT ROCK, MAINLY ANDESITE ?	propylitic to argillic strong in parts	1.35	1.11/1200
		2.90	0.22/130
		0.95	0.08/19
		2.6	0.83/130
		2.8	0.64/460

SLUDGE ASSAY % Cu/ppm Mo
0.19/130
0.29/29
0.28/10
0.29/26
0.21/23
0.067/8
0.45/93
0.31/37
0.53/38

DDH - M8

Core recovery 89 % Total Depth 26.2 m

GEOLOGIC LOG	ALTERATION	CORE REC. METERS	CORE ASSAY % Cu/ppm Mo
GRANODIORITE PORPHYRY	weak phyllic to argillic	1.8	0.09/6
	phyllic some argillic	2.0	0.08/4
		2.7	0.14/4
		3.0	0.09/4
		3.0	0.10/6
		3.0	0.07/5
		3.0	0.10/5
		2.15	0.16/5
		1.7	0.13/6

SLUDGE ASSAY % Cu/ppm Mo: NO SLUDGE TAKEN

DDH - M9

Core recovery 70.4 % Total Depth 214.3 m.

GEOLOGIC LOG	ALTERATION	CORE REC. METERS	CORE ASSAY % Cu/ppm Mo
BRECCIA	leaching, fragments phyllic matrix propylitic		
		0.4	0.09/32
		0.4	0.07/33
		0.5	0.06/26
		0.3	0.06/29
		0.7	0.08/23
		1.0	0.08/34
		1.4	0.07/64
ANDESITE, STRONGLY BRECCIATED	mainly strong propylitic but silicification in fragments.	2.6	0.07/240
		2.7	0.07/170
BRECCIA		2.8	0.16/55
		2.8	0.04/47
ANDESITE, IN PARTS BRECCIATED (BIG FRAGMENTS ?)		3.0	0.08/350
		2.8	0.17/47
		3.3!	0.17/49
		2.9	0.16/46
		2.4	0.12/50
		2.6	0.12/56
		1.8	0.21/69
		1.9	0.14/47
		2.7	0.09/30
		2.3	0.14/130
		2.6	0.09/52
		2.1	0.06/41
		1.2	0.07/24
		0.7	0.03/40
		1.75	0.06/66
		1.75	0.01/58
ANDESITE MAGNETITE DISSEMINATION		2.2	0.02/32
		1.8	0.09/60
	propylitic and argillic	2.6	0.16/17
		2.2	0.16/28
		2.2	0.17/49
		1.8	0.07/20
		2.0	0.21/34
DIORITE PORPHYRY	chloritization	2.5	0.25/57
		2.7	0.30/39
ANDESITE WEAK MAGNETITE DISSEMINATION	weak propylitic argillic increasing in depth	1.8	0.23/29
		2.3	0.16/31
		2.4	0.09/45
		2.5	0.14/26
		2.0	0.11/21
		2.3	0.35/34
		1.8	0.07/15
		2.3	0.16/22
		2.6	0.28/44
		2.6	0.09/22
		2.4	0.13/24
		2.5	0.17/23
		2.4	0.15/21
		2.1	0.19/41
		2.8	0.19/31
		2.5	0.38/42
		2.2	0.06/31
		2.3	0.17/16
		1.7	0.18/9
		1.7	0.25/12
		2.7	0.12/27
		2.7	0.19/24
		2.5	0.09/19
ANDESITE		2.6	0.15/40
		2.3	0.15/58
		2.7	0.22/33
		2.3	0.13/50
DYKE ANDESITIC	?	2.7	0.12/45
ANDESITE	propylitic to argillic	2.0	0.13/70
		2.6	0.25/28
		1.7	0.17/12
		1.9	0.18/30
		2.3	0.11/9

SLUDGE ASSAY % Cu/ppm Mo
0.23/77
0.16/55
0.15/49
0.09/34
0.09/43
0.09/42
0.07/96
0.12/120
0.04/40
0.14/31
0.15/43
0.12/77
0.13/48
0.11/41
0.10/44
0.07/57
0.07/55
0.06/56
0.04/47
0.12/55
0.06/47
0.08/28
0.07/26
0.12/49
0.15/26
0.17/25
0.11/46
0.11/45
0.15/43
0.15/42
0.34/30
0.14/30
0.15/27
0.14/26
0.09/13
0.05/58
0.12/30
0.11/36
0.12/38
0.18/50
0.16/56
0.16/52
0.18/53
0.15/52
0.20/43
0.17/37
0.18/35

CHART 6

PROYECTO MINERO DE AZUERO

REPUBLICA DE PANAMA	NACIONES UNIDAS
ADMINISTRACION DE RECURSOS MINERALES	PROGRAMA PARA EL DESARROLLO

AREA Cº PETAQUILLA
(SECTOR RIO MEDIO)
COMPOSITE DRILL HOLE LOGS
JUNE 1969

GL 65/3-62

ANNEX VI

A REVIEW OF EXPLORATION RESULTS AT CERRO PETAQUILLA

by A. G. Blucher, consultant

At the request of the Proyecto Minero de Azuero, a joint effort by the Republic of Panama and the United Nations Development Program, I have reviewed their work at Cerro Petaquilla.

Their proposal is that at Cerro Petaquilla there exists extensive copper and molybdenum mineralization, and that their work to date shows results of sufficient promise to warrant further exploration by a major mining organization.

These conclusions are amply justified. The critical data are discussed below.

SUMMARY AND CONCLUSIONS

The exploration studies in the Cerro Petaquilla Area have been accomplished at a level of professional competence acceptable to the standards of the international mining industry.

Because of problems of logistics and the limited time available, the results to date can only be considered as preliminary and as a partial test. Several soil anomalies have not been tested by drilling, and several zones of alteration have not been studied to their limits. The majority of the drillholes were made with the Winkie Drill and achieved only very shallow penetrations. Compounding this difficulty was the fact that the Winkie holes were, of necessity, located on bedrock outcrops in quebradas, and could not often be placed in the best testing location. An example of this is the offset location of P-13 and P-14, drilled to test the long magnetic anomaly in which P-9 and P-12 found good values.

Nothwithstanding these limitations the drilling program showed large volumes of low grade copper and molybdenum mineralization---sub-economic under present circumstances---and several areas of good grade primary mineralization. Results suggest that the better zones may be relatively small in comparison with the entire zone of alteration, but in no case have they been completely defined and limited.

The geographical location, terrain, and climate of this prospect are difficult. The geologic-economic favorability has been diminished somewhat by the information gained to date; i.e., diminished from the very large possible potential suggested by the discovery outcrops. However, the occurrence of ore-grade material has been confirmed, and the preliminary work done is sound enough to furnish a reliable basis for further exploration. It remains to be determined whether or not there is sufficient tonnage to be economic under the as yet undetermined ownership-taxation circumstances.

GEOLOGY AND MINERALIZATION

The Cerro Petaquilla Area is in a region of submountainous topography, rain forest vegetation, and thin residual soil cover. Bedrock outcrops amount to only a fraction of one per cent of the surface area. Geologic mapping is largely a matter of projecting rock contacts long distances on the basis of residual rock fragments, soil texture, and occasional outcrops.

A granodiorite-diorite-porphyry complex intrudes andesitic volcanic rocks. Most of the intrusive rocks are hydrothermally altered---varying from weak propyllitic alteration to intense silicification and sericitization. There are several mineralized breccia pipes.

Chalcopyrite and molybdenite occur as discrete grains and as veinlets in the intrusive rocks and in the andesite in some places. The breccia pipes appear to be only weakly mineralized.

This mineralization is typical of primary porphyry copper deposits. There are great volumes of rock containing 0.2 - 0.5% Cu, and several zones of higher grade mineralization ranging from 0.7% Cu to 2.0% Cu. Molybdenum values may average 0.02 - 0.03%.

Unfortunately, the post mineral history of the region has been such that secondary enrichment is negligible or nil. An economic occurrence must depend almost entirely on primary values.

GEOCHEMICAL-GEOPHYSICAL CONSIDERATIONS

At Cerro Petaquilla the ground surface chemical environment is ideal for geochemical prospecting. The soil is shallow and residual. Heavy rainfall maintains an equilibrium of neutrality---usually very slightly acidic. Soil samples accurately reflect the metal values of underlying rocks. The 20 meter sample interval along 200 meter spaced grid lines gives an accurate picture.

Copper anomalies are clearly defined, and molybdenum anomalies are generally coordinate with and within the copper anomalies. An exception may be at Botija Abajo where a molybdenum anomaly coincides with relatively low copper values in an unusually acidic environment. This area was not visited during the examination, but the geochemical relationships suggest the possibility of a zone of higher total original sulfides and more intense leaching of copper.

Regarding geophysical characteristics the terrain is likewise rather simple, but it is not so amenable to modern exploration methods. The electromagnetic and self potential surveys performed to date have not produced diagnostic results. Magnetometer surveys have aided in outling intrusive contacts and may be of some use in finding ore. Because the total sulfide content is generally low, geophysical methods may not have large application here.

SAMPLE HANDLING AND ASSAYING

In reviewing the core, the assaying procedures, the core recovery, and sludge collection, I find no possibility of large error. Possibly, core recovery is somewhat over-estimated. Sludge recovery was done by primitive methods, and no valid core-sludge weighted average can be arrived at. However, contrary to the usual case, core recovery was usually better in the ore-grade drillholes than in those in waste, and sufficient for a preliminary drilling program. Similarly, sludge assays, over long segments of drillhole appear to confirm the values in the core.

Sample handling, core splitting, and assaying procedures appear to be equal to or better than what might be found in the ordinary exploration project. Check assays from commercial laboratories confirm this.

RECOMMENDATIONS

Given a favorable politico-economic environment a porphyry copper deposit of moderate size and relatively low grade might be developed here. The possibility of a larger and higher grade ore deposit have not been fully tested.

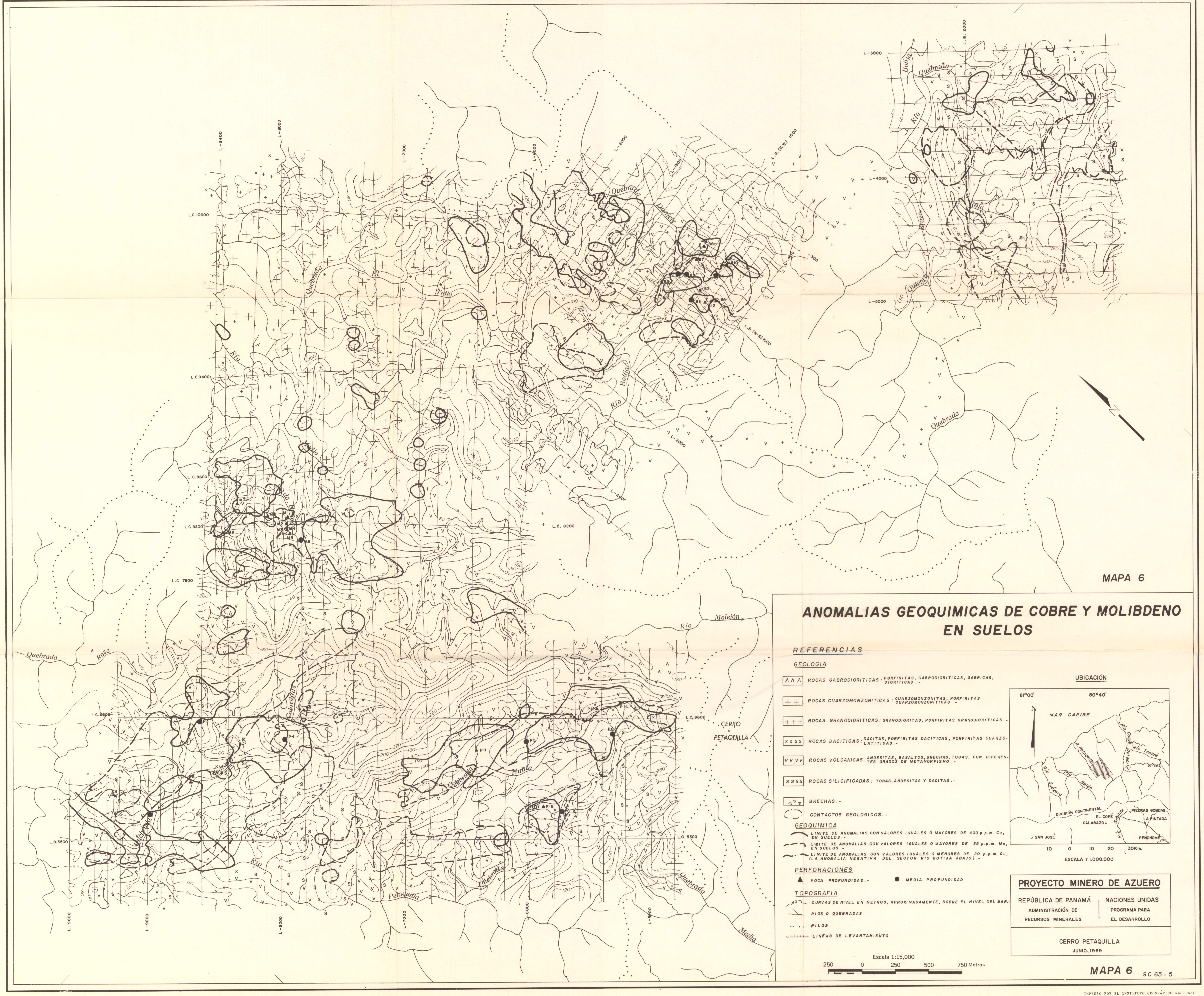
The resutls of this preliminary exploration program justify a second stage program.

(-) Arthur G. Blucher

7 July 1969

ÁREA 65 — CERRO PETAQUILLA

EDICIÓN 1-ARM



MAPA 6

ANOMALIAS GEOQUIMICAS DE COBRE Y MOLIBDENO EN SUELOS

REFERENCIAS

GEOLOGIA

ΛΛΛ	ROCAS GABRODIORITICAS: PORFIRITAS, GABRODIORITICAS, GABRICAS, DIORITICAS.-
++	ROCAS CUARZOMONZONITICAS: CUARZOMONZONITAS, PORFIRITAS CUARZOMONZONITICAS.-
+++	ROCAS GRANODIORITICAS: GRANODIORITAS, PORFIRITAS GRANODIORITICAS.-
XXXX	ROCAS DACITICAS: DACITAS, PORFIRITAS DACITICAS, PORFIRITAS CUARZO-LATITICAS.-
VVVV	ROCAS VOLCANICAS: ANDESITAS, BASALTOS, BRECHAS, TOBAS, CON DIFERENTES GRADOS DE METAMORFISMO.-
SSSS	ROCAS SILICIFICADAS: TOBAS, ANDESITAS Y DACITAS.-
△▽△	BRECHAS.-
	CONTACTOS GEOLOGICOS.-

GEOQUIMICA

- LIMITE DE ANOMALIAS CON VALORES IGUALES O MAYORES DE 400 p.p.m. Cu, EN SUELOS.-
- LIMITE DE ANOMALIAS CON VALORES IGUALES O MAYORES DE 25 p.p.m. Mo, EN SUELOS.-
- LIMITE DE ANOMALIAS CON VALORES IGUALES O MENORES DE 20 p.p.m. Cu, (LA ANOMALIA NEGATIVA DEL SECTOR RIO BOTIJA ABAJO).-

PERFORACIONES

▲ POCA PROFUNDIDAD.- ● MEDIA PROFUNDIDAD

TOPOGRAFIA

- 160 CURVAS DE NIVEL EN METROS, APROXIMADAMENTE, SOBRE EL NIVEL DEL MAR.-
- RIOS O QUEBRADAS
- FILOS
- LINEAS DE LEVANTAMIENTO

Escala 1:15,000

250 0 250 500 750 Metros

PROYECTO MINERO DE AZUERO

REPÚBLICA DE PANAMÁ	NACIONES UNIDAS
ADMINISTRACIÓN DE RECURSOS MINERALES	PROGRAMA PARA EL DESARROLLO

CERRO PETAQUILLA
JUNIO, 1969

MAPA 6 GC 65 - 5

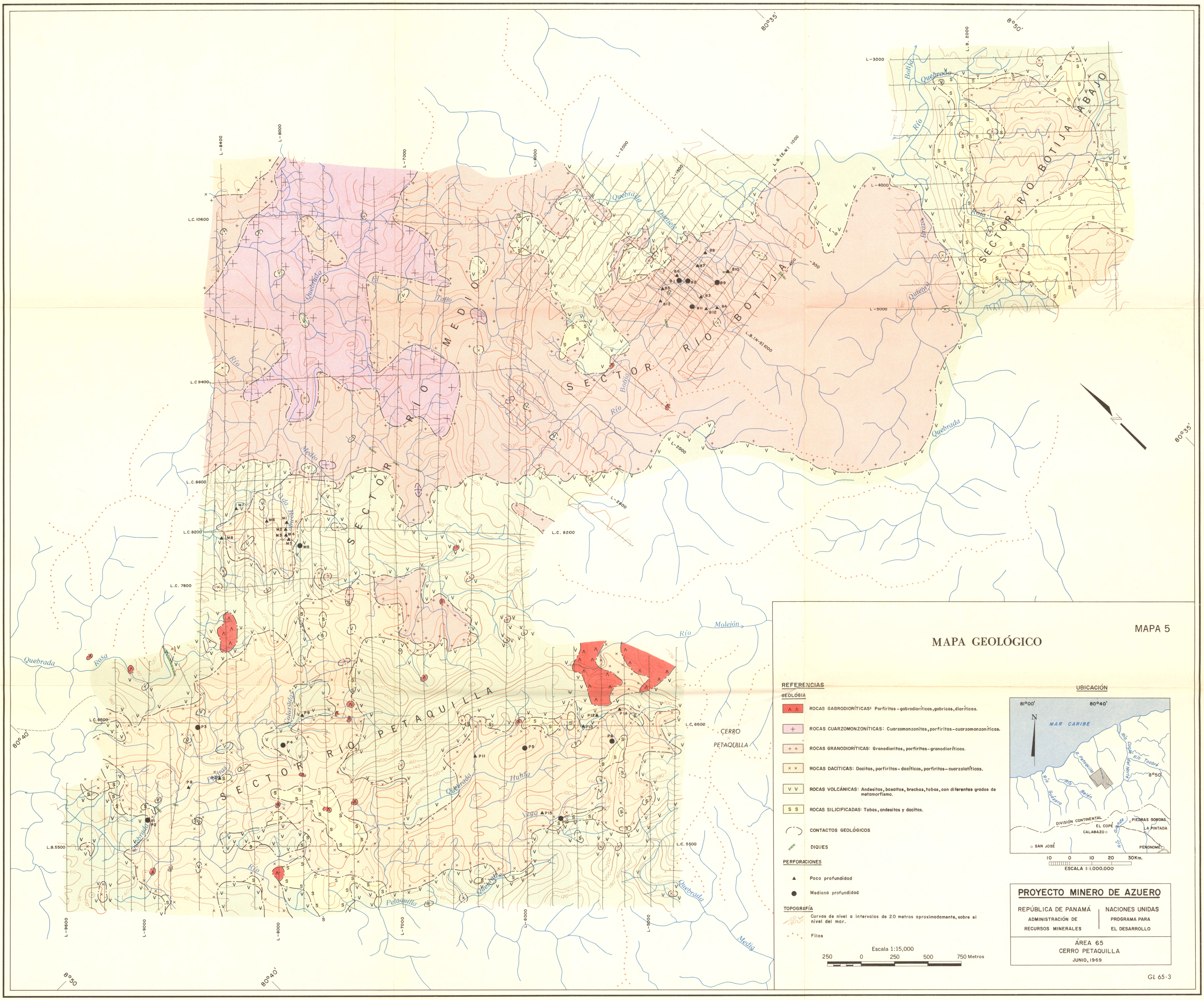
IMPRESO POR EL INSTITUTO GEOGRÁFICO NACIONAL
"Tommy Guardia" Agosto de 1959.

PANAMÁ, GEOLÓGICO 1:15.000

ÁREA 65 — CERRO PETAQUILLA

EDICIÓN 1-ARM

MAPA 5



MAPA GEOLÓGICO

MAPA 5

REFERENCIAS

GEOLÓGIA

∧ ∧	ROCAS GABRODIORÍTICAS: Porfiritas-gabrodioríticas, gabricas, dioríticas.
+	ROCAS CUARZOMONZONÍTICAS: Cuarzomonzonitas, porfiritas-cuarzomonzoníticas.
+ +	ROCAS GRANODIORÍTICAS: Granodioritas, porfiritas-granodioríticas.
× ×	ROCAS DACÍTICAS: Dacitas, porfiritas-dacíticas, porfiritas-cuarzolatíticas.
V V	ROCAS VOLCÁNICAS: Andesitas, basaltos, brechas, tobas, con diferentes grados de metamorfismo.
S S	ROCAS SILICIFICADAS: Tobas, andesitas y dacitas.
⌒	CONTACTOS GEOLÓGICOS
⫽	DIQUES

PERFORACIONES

▲	Poca profundidad
●	Mediana profundidad

TOPOGRAFÍA

100 80	Curvas de nivel a intervalos de 20 metros aproximadamente, sobre el nivel del mar.
• • •	Filos

Escala 1:15,000
250 0 250 500 750 Metros

UBICACIÓN

10 0 10 20 30Km.
ESCALA 1:1.000.000

PROYECTO MINERO DE AZUERO

REPÚBLICA DE PANAMÁ	NACIONES UNIDAS
ADMINISTRACIÓN DE RECURSOS MINERALES	PROGRAMA PARA EL DESARROLLO

ÁREA 65
CERRO PETAQUILLA
JUNIO, 1969

GL 65-3

FUENTES DE INFORMACIÓN

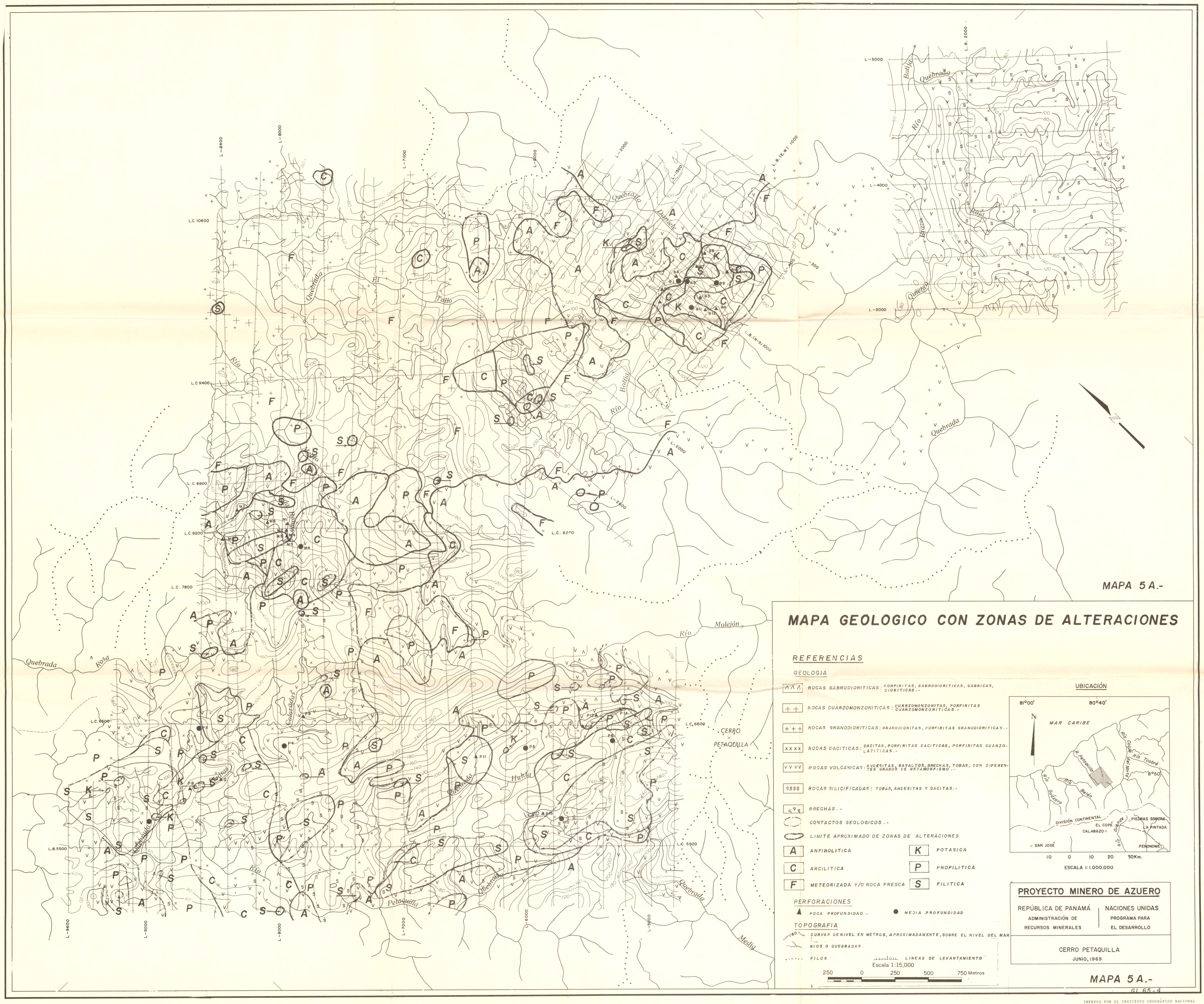
1 - Fotografías aéreas a escala 1:60.000
2 - Datum altimétrico por barómetro llevado en helicóptero. Curvas de nivel a base de tránsito y clinómetros. Red con Tránsito y Brújula.
3 - Datos geológicos obtenidos en campo.

IMPRESO POR EL INSTITUTO GEOGRÁFICO NACIONAL
"Tommy Guardia" Agosto de 1969. 1000

CERRO PETAQUILLA, DONOSO, PANAMÁ

ÁREA 65 — CERRO PETAQUILLA

EDICIÓN



MAPA GEOLOGICO CON ZONAS DE ALTERACIONES

REFERENCIAS

GEOLOGIA

ΛΛΛ ROCAS GABRODIORITICAS: PORFIRITAS, GABRODIORITICAS, GABRICAS, DIORITICAS.-

++ ROCAS CUARZOMONZONITICAS: CUARZOMONZONITAS, PORFIRITAS CUARZOMONZONITICAS.-

+++ ROCAS GRANODIORITICAS: GRANODIORITAS, PORFIRITAS GRANODIORITICAS.-

XXXX ROCAS DACITICAS: DACITAS, PORFIRITAS DACITICAS, PORFIRITAS CUARZOLATITICAS.-

VVVV ROCAS VOLCANICAS: ANDESITAS, BASALTOS, BRECHAS, TOBAS, CON DIFERENTES GRADOS DE METAMORFISMO.-

SSSS ROCAS SILICIFICADAS: TOBAS, ANDESITAS Y DACITAS.-

▽ BRECHAS.-

CONTACTOS GEOLOGICOS.-

LIMITE APROXIMADO DE ZONAS DE ALTERACIONES

A	ANFIBOLITICA	K	POTASICA
C	ARCILITICA	P	PROPILITICA
F	METEORIZADA Y/O ROCA FRESCA	S	FILITICA

PERFORACIONES

▲ POCA PROFUNDIDAD.-

● MEDIA PROFUNDIDAD

TOPOGRAFIA

160 CURVAS DE NIVEL EN METROS, APROXIMADAMENTE, SOBRE EL NIVEL DEL MAR

RIOS O QUEBRADAS.

...... FILOS

LINEAS DE LEVANTAMIENTO

Escala 1:15,000

250 0 250 500 750 Metros

UBICACIÓN

ESCALA 1:1.000.000

PROYECTO MINERO DE AZUERO

REPÚBLICA DE PANAMÁ	NACIONES UNIDAS
ADMINISTRACIÓN DE RECURSOS MINERALES	PROGRAMA PARA EL DESARROLLO

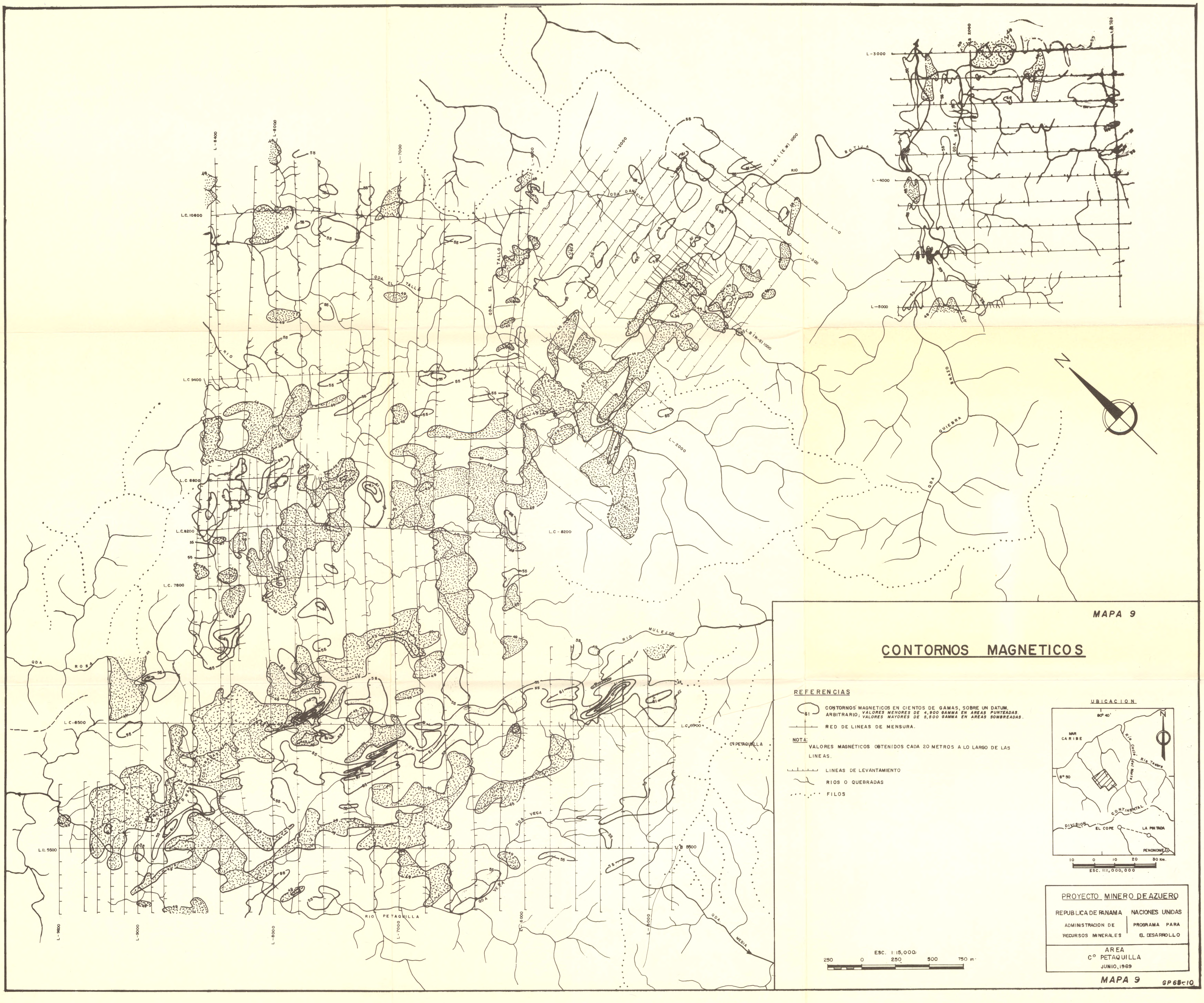
CERRO PETAQUILLA

JUNIO, 1969

MAPA 5 A.-

GL 65-4

IMPRESO POR EL INSTITUTO GEOGRÁFICO NACIONAL
"Tommy Guardia" Agosto de 1969. 1000



MAPA 9

CONTORNOS MAGNETICOS

REFERENCIAS

CONTORNOS MAGNETICOS EN CIENTOS DE GAMAS, SOBRE UN DATUM, ARBITRARIO; *VALORES MENORES DE 4,900 GAMMA EN AREAS PUNTEADAS. VALORES MAYORES DE 5,500 GAMMA EN AREAS SOMBREADAS.*

RED DE LINEAS DE MENSURA.

NOTA:

VALORES MAGNETICOS OBTENIDOS CADA 20 METROS A LO LARGO DE LAS LINEAS.

LINEAS DE LEVANTAMIENTO

RIOS O QUEBRADAS

FILOS

PROYECTO MINERO DE AZUERO

REPUBLICA DE PANAMA	NACIONES UNIDAS
ADMINISTRACION DE RECURSOS MINERALES	PROGRAMA PARA EL DESARROLLO

AREA
Cº PETAQUILLA
JUNIO, 1969

MAPA 9

GP 68-10

IMPRESO POR EL INSTITUTO GEOGRÁFICO NACIONA
"Tommy Guardia"   Agosto de 1969.