# ZINC AND COPPER DEPOSITS OF THE VAZANTE AREA, MINAS GERAIS, BRAZIL

by

Samuel L. Moore



This study was undertaken as a part of the cooperative program of the Brazilian National Department of Mineral Production and the U. S. Geological Survey under the auspices of the International Cooperation Administration of the Department of State.

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## ILLUSTRATIONS

# ZINC AND COPPER DEPOSITS OF THE VAZANTE AREA, MINAS GERAIS, BRAZIL

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## Abstract

A large body of zinc and copper mineralization is exposed in a line of low hills about 5 kilometers east of the small village of Vazante in the northwestern part of the state of Minas Gerais, Brazil. The Vazante area can be reached by roads leading north from the State of Sao Paulo, via Araxa; west from Belo Horizonte, Minas Gerais; and south from Paracatu, Minas Gerais.

The deposit is in branching, sub-parallel fault breccia zones. Calamine ($H_2Zn_2SiO_5$), and willemite ($ZnSiO_4$), along with small quantities of smithsonite ($ZnCO_3$), form the matrix of the fault breccia. The zinc mineralization is cut by narrow veins of chalcocite in platy crystal aggregate thought to be pseudomorphous after covellite. The chalcocite veins contain small quantities of sphalerite, galena, covellite and calamine.

Faults that contain breccia zones displace shale and dolomite. The sedimentary rocks are thought to be Silurian in age. The fault breccia zones have a regional trend of N 40° E and crop out over a strike length of more than four kilometers. The mineralization of the fault zones was observed to continue to the north for an additional four kilometers. The mineralized fault breccia zones range from a few meters to 60 meters in width. A large ore body is indicated that from available samples may average 35 percent zinc.

## INTRODUCTION

This study was undertaken as a part of the cooperative program of the Brazilian National Department of Mineral Production and the U. S. Geological Survey under the auspices of the International Cooperation Administration of the Department of State.

The small village of Vazante is located in the northwest part of the state of Minas Gerais, Brazil, close to the state of Goiás (Fig. 1). Vazante is located about 115 kilometers north of the city of Patos de Minas, which is the only city in the area capable of being reached by commercial airline (Nacional). A road leads north from Patos de Minas via Presidente Olegário and from Lagamar, which is passable throughout the year, except for short periods during the rainy season in December and January.

Large volumes of zinc and copper mineralization are exposed in Serra Varginha, Serra Poço Verde, and Serra Barrocão, which are about 5 to 8 kilometers east of the small village of Vazante (Fig. 2). Serra Varginha, Serra Poço Verde, and Serra Barrocão are separated from each other only by small corregos, and are in reality the southwest end of the Serra Barrocão which extends for over 40 kilometers to the northeast. The mineralized area can be reached by several ox cart trails that lead east from the small village of Vazante.

The southwest part of this ridge is locally called Serra Varginha (Fig. 2). This portion of the Serra is about 1,700 meters in length and is separated from the Serra Poço Verde by a small swale. Serra Poço Verde extends about 650 meters to the northeast, and it is also separated from the Serra Barrocão on the northeast by another small valley. The Serra Barrocão is 700 meters in length and is separated on the northeast from the main segment of the Serra Barrocão by still another corrego.

The southeastern slopes of the ridge composing the serras rise abruptly from the general level of the flood plains of the Rio Santa

The chemical analysis of the ore samples and the mineral identification were done by the laboratories of the Departamento Nacional da Produção Mineral. The writer would like to express his sincere thanks for the cooperation of all personnel in the D.N.P.M., and particularly to Professor Tavora, who identified the minerals in X-Ray studies; to Dr. Luiz Ignacio Miranda of L.P.M. of D.N.P.M., and to Dr. Carlos Pires Ferreira who analysed the ore samples. Thank is also due to Dr. Max G. White of the U. S. Geological Survey for the use of his laboratory for spectrographic studies of the mineral samples.

## GEOLOGY

### Introduction

The Vazante area, as well as the mineralized areas of the Serra Barrocão, Serra Poço Verde, and the Serra Varginha, is largely underlain by shale and dolomite. Shale composes the great majority of the rock column and underlies the soft rolling topography, and the dolomite underlies the angular ridges of the area.

The shales and the dolomites of the mineralized area have a regional trend of N35°-45°E and dip 25°-45° NW. These rocks are displaced by a branching sub-parallel regional fault system that traverses the crests of Serra Varginha, Serra Poço Verde and Serra Barrocão. Dolomites compose the southeastern hanging wall block of the Barrocão fault and are faulted against shales of the northwest block along the length of the crest of the serras (Plate I). The dolomites that underlie the southeastern slopes of the serras show little brecciation, local drag or

warping adjacent to the fault breccia zones. In contrast to the dolomites, the shales are shattered, brecciated and dragged adjacent to the fault breccia zones, and the fault breccia is mostly composed of shale fragments. The main northeast regional Barrocão fault and the Varginha fault are displaced by northwest cross faults which show no breccia zone at the surface.

## ROCKS

### Dolomite

Dolomite underlies the southeast flanks of the Serra Varginha, Serra Poço Verde and Serra Barrocão, all of which rise in a steep slope about 150 meters above the flood plains of the Rio Santa Catarina. This dolomite layer is about 175 meters thick and is underlain and overlain by shales. The upper contact of the shale and the dolomite forms one of two parallel crest lines of the Serra. Another layer of dolomite about 15-20 meters thick is exposed about 100 to 150 meters northwest of the fault zone, and also forms a crest line.

The dolomite is a dense fine-grained, light buff to a blue gray rock that weathers to a medium gray color in outcrop. It contains many ribbon veinlets of quartz that are both concordant and discordant to the bedding. The dolomites adjacent to the Varginha fault in the southwestern part of Serra Varginha are pervaded by silicification and contain many quartz veins up to several inches in width.

The dolomite in the hanging wall block of the Barrocão fault shows little shattering adjacent to the fault breccia zone and there is little,

if any, mineralization into the dolomite. No dolomite fragments were recognized in the breccia zones of the Varginha or Barrocão faults, except for the silicified dolomite in the southwestern part of the Serra Varginha. Here, the silicified dolomite is moderately shattered and dragged into random dips and strikes, but only a few fragments of the silicified dolomite are present in the breccia zone.

Shale

Shale occurs above and below both layers of dolomite that are exposed in this area. There are few outcrops of shale except along the crest of the ridges where the shales cap the dolomites, and adjacent to the breccia zones of the northeast faults. In outcrop the shales are light tan to gray and sometimes show color banding. Adjacent to the fault breccia zones, the shale has been moderately indurated to low grade slate.

The shale adjacent to the breccia zones of the Barrocão fault is shattered and dragged into the fault zone, and is locally sheared into smeared out "schleiren" like masses. The shale along the Varginha fault is pervaded by silicification outward from the fault zone.

## FAULTS

Two sub-parallel fault zones exposed on the southwestern part of Serra Varginha can be traced for approximately two kilometers to the northeast along a N45°E regional trend. The southeastern branch is named for the Serra Barrocão, where its fault breccia zone is prominently exposed. The northwestern branch is named for the Serra Varginha, where the fault zone is exposed as a conspicuous low rocky ridge. These two

fault zones join, or the southeastern Barrocão fault zone cut off, the Varginha fault at the northeast end of the Serra Poço Verde. One fault zone continues to the northeast for approximately 100 meters where it is offset horizontally about 50 meters to the southeast by two parallel northwest cross faults. The Barrocão fault can be traced for over 500 meters to the northeast across the crest of the Serra Barrocão to a point where it passes under the valley alluvium. The fault zone crops out a short distance to the northeast and can be traced for at least four kilometers beyond the area mapped (Plate I). The southwestern extension of the Varginha and Barrocao fault are displaced by a N70°W cross fault and mineralization is apparently terminated by this cross fault.

Varginha fault

The Varginha fault is named for the Serra Varginha, where outcrops are expressed over many hundreds of meters as a low line of sharp serrate rock. The southwestern part of the fault trace is composed of a fault zone that is silicified and mineralized by veins of chalcocite. The fault zone is sheathed by a silicified zone that pervades the shales and dolomites adjacent to the fault zone. The silicified zone extends over 60 meters laterally and all of the dolomite wall rock is more or less silicified at the southwest end of Serra Varginha. The intensity of the silicification diminishes to the northeast along the trace of the Varginha fault zone. Approximately 1,000 meters northeast of its termination on the N70°W cross fault there is little silicification showing at the surface, and beyond this point the fault is mostly covered by a mantle

of soil for 500 meters. As the fault zone passes northeastward from the Serra Varginha to the Serra Poço Verde, it is again exposed as a silicified and mineralized breccia zone that flares to a width of over 50 meters at the crest of the Serra Poço Verde. This silicified breccia zone outcrops as a low angular ridge 5-10 meters high composed of dark gray breccia. The portion of the Varginha fault at the southwest end of Serra Poço Verde is composed of a silicified shear breccia zone about 5-10 meters wide that is largely mineralized by willemite. However, as the zone widens to the northeast the silicification diminishes, and the fault zone is predominantly a breccia zone composed of shale fragments cemented by the zinc silicates, calamine, and willemite, and by hematite and quartz which is cut by a few veins of chalcocite. Northeast of the apparent junction of the Barrocão fault and the Varginha fault the gangue minerals hematite and quartz contained in the fault breccia zone of the Varginha fault are absent. Willemite and the chalcocite veins are also absent, and the fault breccia zone that continues to the northeast is cemented only with calamine. The relative magnitude or direction of movement along this fault zone is not known due to the lack of knowledge of regional stratigraphy.

Barrocão fault

The Barrocão fault is named for the Serra Barrocão where the breccia zone attains its maximum width of 50 to 60 meters. The fault breccia zone can be traced from the southwestern end of the Serra Varginha along the crest of Serra Varginha northeastward along the crests of Serra Poço Verde and Serra Barrocão for a distance of over three kilometers. The fault was

observed to continue at least four kilometers to the northeast beyond the area mapped. The southwestern end of the fault breccia zone of the Barrocão fault is apparently terminated on a N70°E cross fault at the southwestern end of the Serra Varginha.

Calamine cements the entire strike length of the Barrocão fault breccia zone, except for about 100 meters of the breccia zone exposed on the Serra Varginha. Copper mineralization in this segment of the fault zone is composed of veins, stringer and boxworks of chalcocite which cut a silicified portion of the fault breccia zone.

Northeastward at the southeast end of the Serra Poço Verde, the Barrocão breccia zone pinches to a narrow fault zone and apparently becomes a single narrow fault plane. This fault segment may cut off the Varginha fault, but the relation of the junction of these two faults is not known. A single fault breccia zone about 50 meters wide continues to the northeast for about 100 meters where it is offset about 50 meters to the southeast by two parallel northwest cross faults. These parallel cross faults compose an upthrown block which forsets the southeast dipping Barrocão fault breccia zone to the southeast. The breccia zone of this fault is exposed along the northeast flanks of the Serra Poço Verde and the southwest flanks of the Serra Barrocão and can be seen in field exposure dipping 60° to 70° to the southeast.

The shales adjacent to the Barrocão fault are dragged and shattered by the fault movement. The fault breccia zone is composed of angular shale fragments and small horst blocks of shale that are dragged into the fault zone. The dolomite in the hanging wall of the fault is not warped

or shattered except for a small area at the southwestern end of the Serra Varginha where the dolomite is highly silicified. Here the dolomite is dragged into random dips and strikes adjacent to the fault zone.

## MINERALIZATION

Mineralization exposed in the Serra Barrocão, Serra Poço Verde and the Serra Varginha is exposed along four kilometers of a branching subparallel fault breccia zone. Zinc mineralization occurs as calamine ($H_2Zn_2SiO_5$), willemite ($Zn_2SiO_4$), and as smithsonite ($ZnCO_3$) that cement the fault breccia. Calamine composes the great volume of the zinc mineralization, with willemite comprising a significant, but much smaller, quantity of the ore. Smithsonite composes only a small quantity of the ore and is usually associated with calamine. Copper mineralization occurs as narrow veins, stringers and boxworks of chalcocite that contains small quantities of intercrystallized sphalerite, galena, covellite and calamine.

### Calamine

Granular and finely crystalline calamine cements the fault breccia zone of the Barrocão fault over a strike length of three kilometers. It also cements the breccia of the Varginha fault zone over a strike length of 500 meters along the crest of the Serra Poço Verde. The breccia zones that are cemented by calamine weather to low ridges of dark gray colored breccia that forms very rough serrate ledges. On fresh break the calamine breccia is a hard tenacious granular and crystalline rock. Portions of the calamine matrix, especially along the edges of the breccia zone, are

fractures, sheared and are a mass of mylonitized shale and calamine. In these areas, the rock is a tough indurated mass that dents but breaks with difficulty when struck with a hammer. The calamine is locally altered to smithsonite, and in these areas, the calamine is an earthy, porous rock.

Spectrographit analysis of the calamine matrix shows only zinc. X-Ray analysis also give the normal pattern of calamine.

Copper veins

Veins, stringers, and boxworks of chalcocite, containing small quantities of intercrystallized galena, sphalerite, covellite and calamine cut the silicified fault zone of the Varginha fault at the southwest end of the Serra Varginha and along the crest of Serra Poco Verde. Similar veins also cut a silicified portion of the Barrocão fault about 100 meters northeast of its intersection with sections line BB' (Plate II).

The veins and boxworks are usually discontinuous, and range from a knife-edge to about 10 cm. in width. The best outcrop of a vein system is exposed in a prospect pit at the southwestern end of Serra Varginha along the northwest side of the Varginha fault zone (Plate I).

The veins are composed predominantly of dark gray platy chalcocite, thought to be pseudomorphous after covellite. Smaller amounts of galena, sphalerite and calamine are intercrystallized with the platy chalcocite.

Spectrographic studies of the vein mineralization show copper, zinc, lead, silver and cadmium. At the surface the vein material is only slightly oxidized to azurite and there is little if any secondary enrichment of the copper mineralization.

Willemite

Willemite is exposed in the breccia zone of the Varginha fault at the southwestern end of the Serra Poço Verde. It is present over a strike length of approximately 200 meters, and is observed on the surface and in several prospect pits as a light pinkish gray dense crystalline aggregate, cementing the breccia zone of the Varginha fault. Here it is associated with calamine, and as the breccia zone of the Varginha fault widens to the northeast the quantity of willemite decreases with a corresponding increase in the calamine.

Under ultra-violet light, it fluoresces, and X-Ray, as well as powder studies, show it to be willemite.

Smithsonite

Small quantities of smithsonite are associated with the calamine that cements the breccia zones of the Barrocão faults. It is a soft, earthy, vuggy, porous white to yellow-white mineral and is a typical "dry bone" zinc carbonate ore. The smithsonite retains the bladed structure of the calamine and, in some areas, it can be seen to replace the calamine along fractures. The smithsonite comprises only a small percentage of the zinc ore.

Hematite

Hematite occurs in the northwestern part of the Varginha fault on the crest of the Serra Poço Verde, and is the only iron mineral observed. Pyrite and iron or zinc gossans of any type are conspicuously lacking in this deposit.

## RESERVES

This deposit is in the earliest stage of exploration. The large and continuous mineralized fault breccias are well exposed in outcrops and by a few pits. Topographic relief of as much as 100 meters along the outcrop indicates that at least parts of the deposit extend to this depth. No tonnage estimate is made owing to the lack of underground exploration, but the area of ore-bearing fault breccia exposed at the surface is at least 69,000 square meters, or about 170,000 metric tons per meter of depth. This can be divided into areas of mineralized breccia as follows:

| Area | Square meters | Type of sample | Percent Zinc |
|---|---|---|---|
| 1 | 25,000 | Four chip samples across mineralized breccia | 39.8 |
| | | | 37.6 |
| | | | 39.8 |
| | | | 34.6 |
| 2 | 10,000 | One chip sample across mineralized breccia | 38.8 |
| 3 | 5,400 | One chip sample across mineralized breccia | 39.8 |
| 4 | 6,750 | One chip sample across mineralized breccia | 43.4 |
| 5 | 15,000 | Four samples from pits | 48.0 |
| | | | 52.4 |
| | | | 47.9 |
| | | | 51.8 |
| | | Chip sample across mineralized breccia | 48.5 |
| 6 | 7,000 | Two chip samples across mineralized breccia | 41.4 |
| | | | 45.8 |

All samples were assayed by the laboratories of the Departamento Nacional da Produção Mineral.

Summary and conclusions

The mineralization of the fault breccia zones exposed on the Serra Barginha, Serra Poço Verde and the Serra Barrocão is composed primarily of zinc silicates and some copper mineralization. The greatest volume of zinc mineralization occurs in the fault breccia zone of the Barrocão fault. This fault structure has a strike length of three kilometers and ranges in width from a few meters to up to 60 meters. The fault zone is composed of angular shale fragments set in a virtually solid matrix of calamine. Large volumes of zinc ore are also exposed on the crest of the Serra Poço Verde in the northeastern part of the Varginha fault (Plate I). This body of ore is approximately 500 meters long and ranges in width from about 5 meters to over 50 meters. The fault zone is composed of an indurated massive mixture of calamine and willemite, along with some hematite and chalcocite veins.

The ore exposed in the Barrocão fault breccia averages about 40.0% zinc, and this very high tenor is due solely to the massive calamine that comprises the matrix of the fault breccia zone. The average tenor of the zinc mineralization exposed in the Varginha fault is somewhat higher and averages close to 50.0% zinc. This average grade is extremely high, but the reason seems to lie in the presence of large quantities of willemite in the ore and the sparse amount of breccia fragments that occurs in this part of the Varginha fault. The ore of the Varginha fault zone is composed of a mixture of willemite and calamine and a small quantity of hematite and chalcocite.

Chalcocite veins are exposed locally along the trace of the Varginha fault and in a small area of the Barrocão fault about 100 meters northeast of the cross section line BB', Plate I, and the Barrocão fault. These

chalcocite veins average only a few centimeters in width and are usually widely spaced or discontinuous within the fault zones. The vein material is composed primarily of compact platy chalcocite intercrystallized with lesser amounts of calamine, sphalerite, galena and covellite. Select assays of the crystalline vein material assayed 36.6% Cu and 24.5% Zn. No analyses are presently available for the other metals; however, spectrographic studies of the vein material shows silver, lead and cadmium to be present in the veins.

Further development of these narrow vein systems may prove to be economic, but the outlook for a large volume of copper ore is not encouraging.

The outcrop of the mineralized fault zones is exposed over a strike length of approximately four kilometers along the crests of Serras Varginha, Poço Verde and Barrocão, and the ore exposed at surface in all localities averages approximately 40.0% zinc.

Evidence for the vertical continuity of part of the mineralized fault breccia can be observed in a valley that separates the Serra Poço Verde from the Serra Barrocão. Here the mineralized breccia zone of the Barrocão fault can be traced in continuous outcrop from the crest of the Serra Barrocão and the crest of the Serra Poço Verde to the lower slopes of the valley that separates the serras. The mineralized breccia zone has a N45°E trend and dips 60° to 70° SE. This can be observed over a vertical distance of 100 meters cutting the N40°E, 35°NW trending dolomites. Further evidence for the depth of the mineralized fault breccia is exposed in an upthrown fault block that underlies the floor of this valley. The mineralized breccia of the Barrocão fault is offset to the southeast, and the ore exposed in this upthrown fault block is thought to be a

horizon 50 to 100 meters below the present level of erosion; thus, it appears that the mineralization of the fault breccia continues below the present level of erosion.

There is little doubt that the mineralized fault zones that underlie the Serra Varginha, Serra Poço Verde and Serra Barrocão comprise a major zinc ore body, and further development of the mineralized fault zones may reveal economic quantities of copper, silver and lead. A large area that contains zinc ore with an average tenor of 35.0% to 40.0% zinc is exposed. The full potential of the mineralization in the fault breccia zones will be known only when these breccia zones are systematically explored by a drilling and underground development. Also, the mineralization of the Barrocão fault breccia zone was observed to continue to the northeast beyond the area covered in this report for another four kilometers. A regional search and evaluation of the Vazante area may reveal other non-ferrous ore bodies.

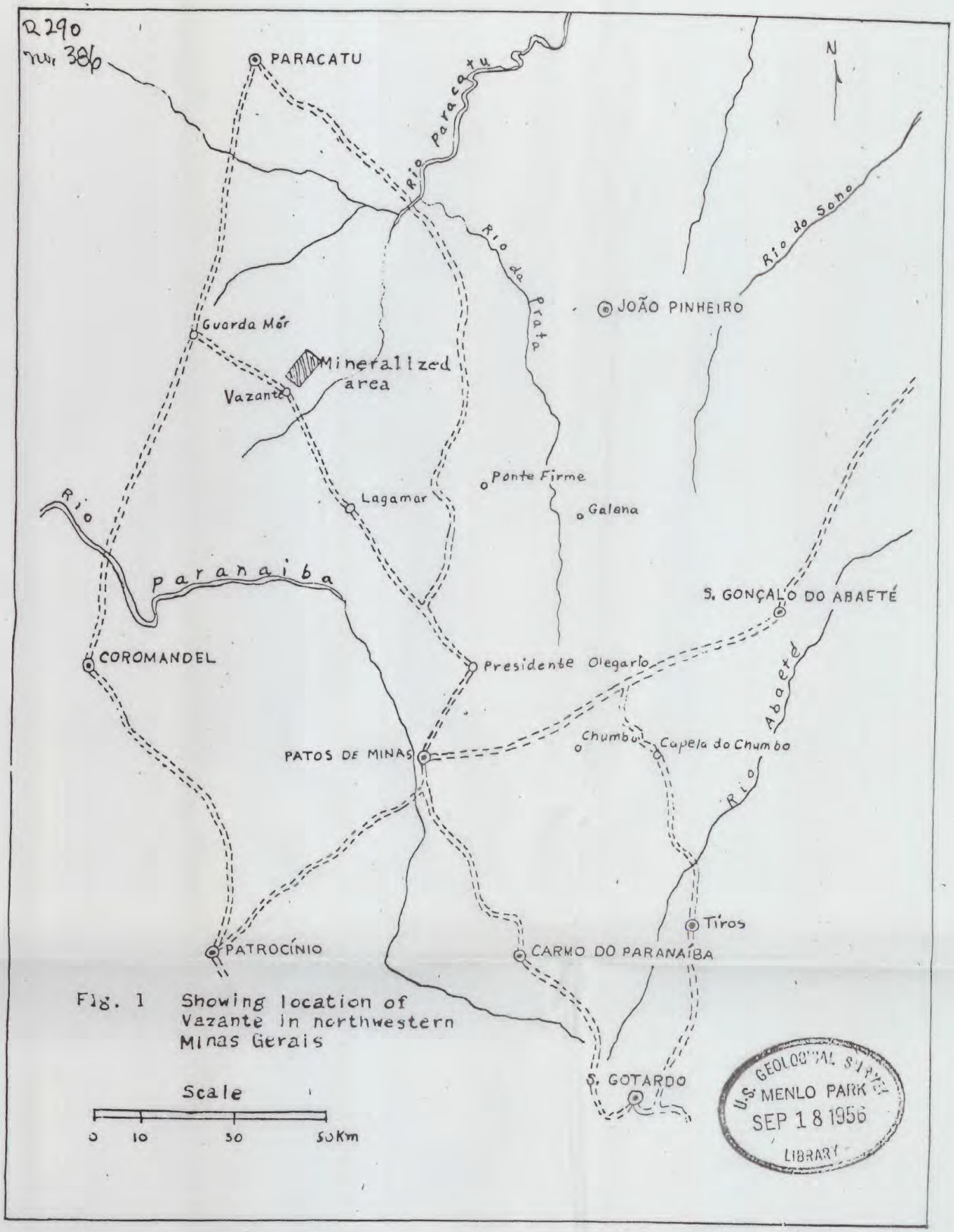



Fig. 1 Showing location of Vazante in northwestern Minas Gerais

(200)
R240
no. 386

EXPLANATION

Serra

Road

Ox cart trail

Trail

Bridge

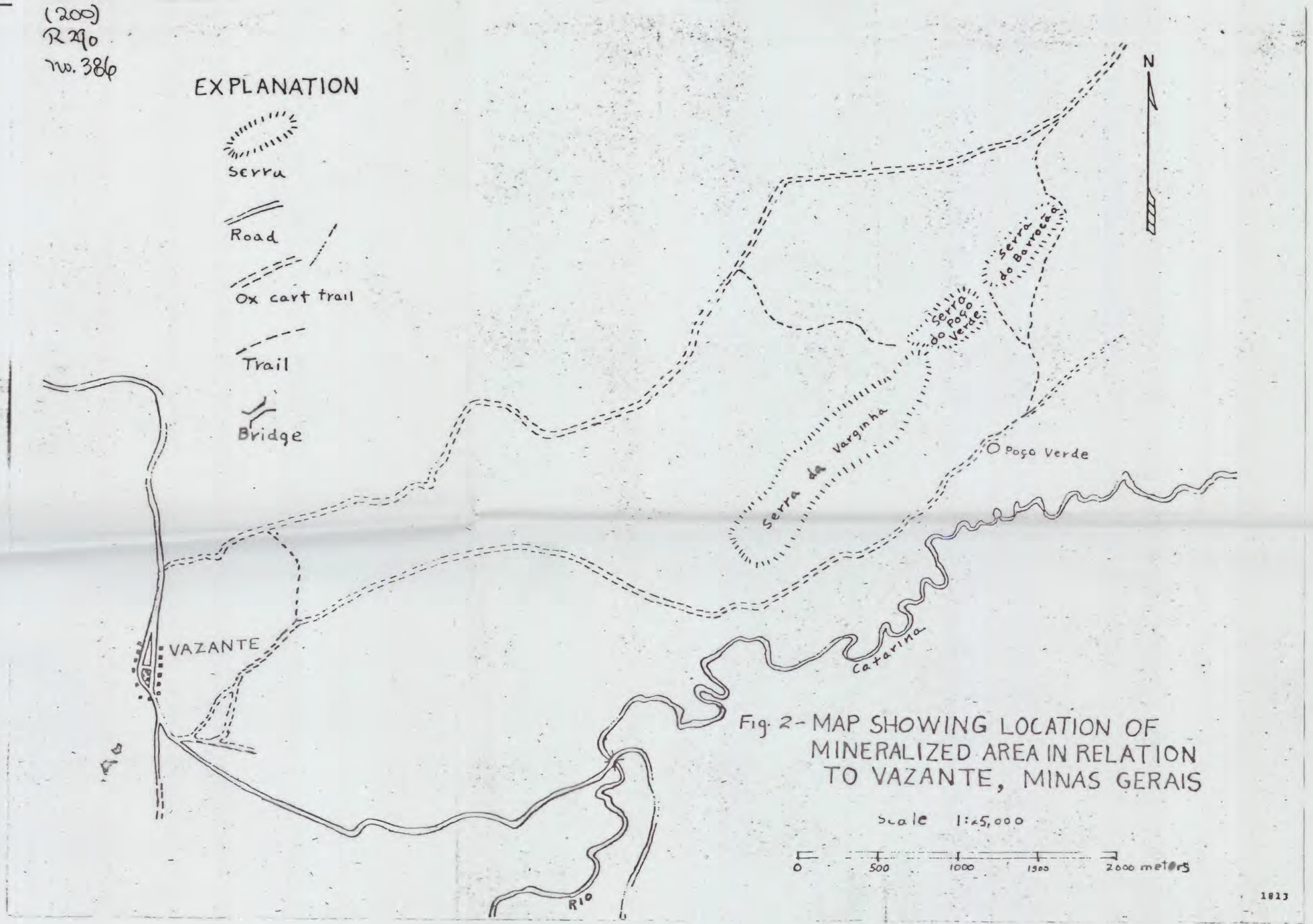



Fig. 2 - MAP SHOWING LOCATION OF MINERALIZED AREA IN RELATION TO VAZANTE, MINAS GERAIS

Scale 1:25,000

0 500 1000 1500 2000 meters

1813

56-82

EXPLANATION

Silurian (?)

Dolomite

Shale

Fault breccia zone

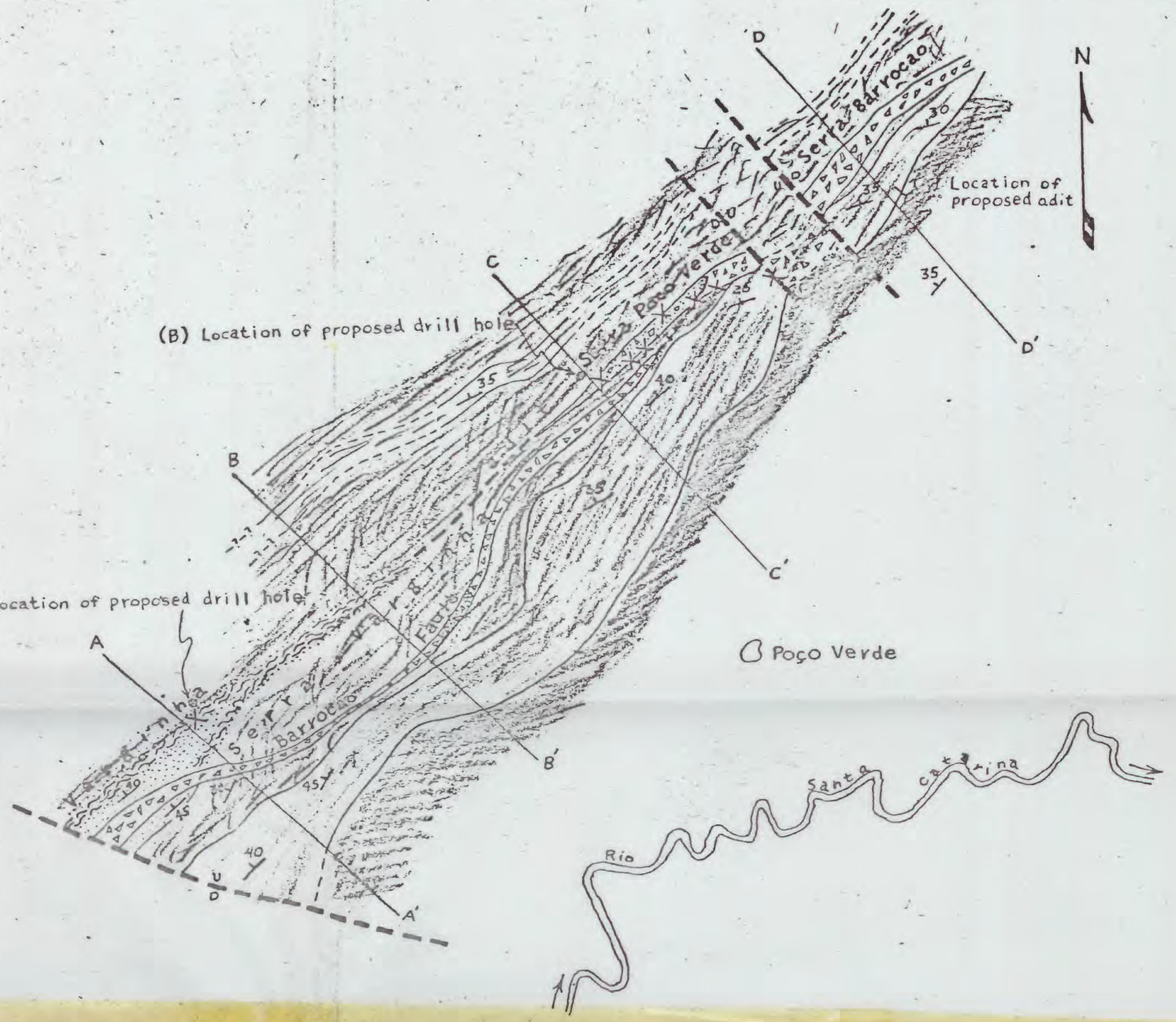
Fault zone

Fault

Silicified rock

Prospect pit

Dip and strike




GEOLOGIC SKETCH MAP AND STRUCTURAL CROSS SECTIONS OF VAZANTE AREA, MINAS GERAIS

Scale

Approximately 1:12,500

0 500 1000 meters

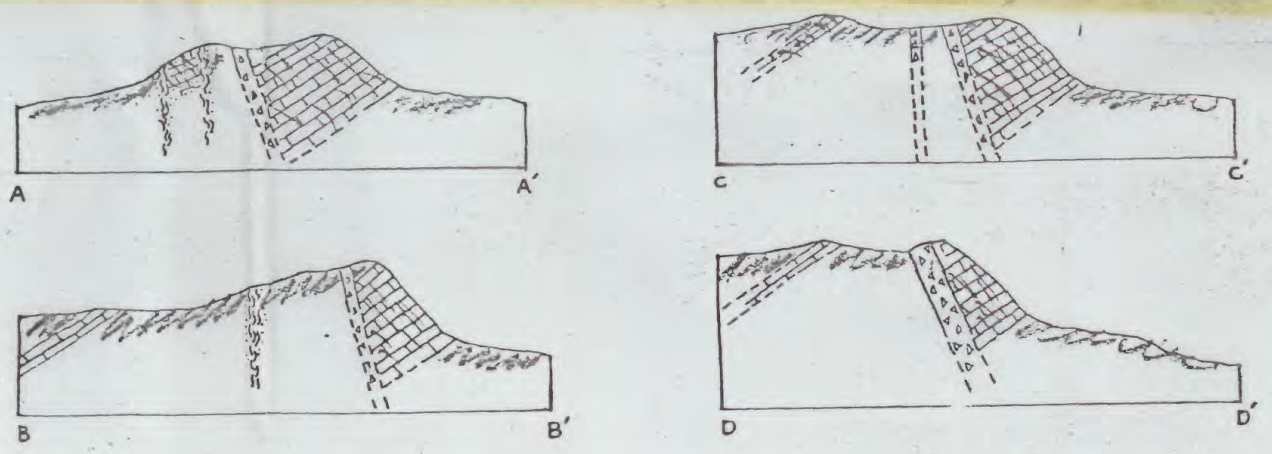



PLATE I

1813

(200)
R290

no. 380

A SKETCH MAP SHOWING MINERALIZED FAULT ZONES, ASSAYS, AND LONGITUDINAL SECTIONS OF ORE.

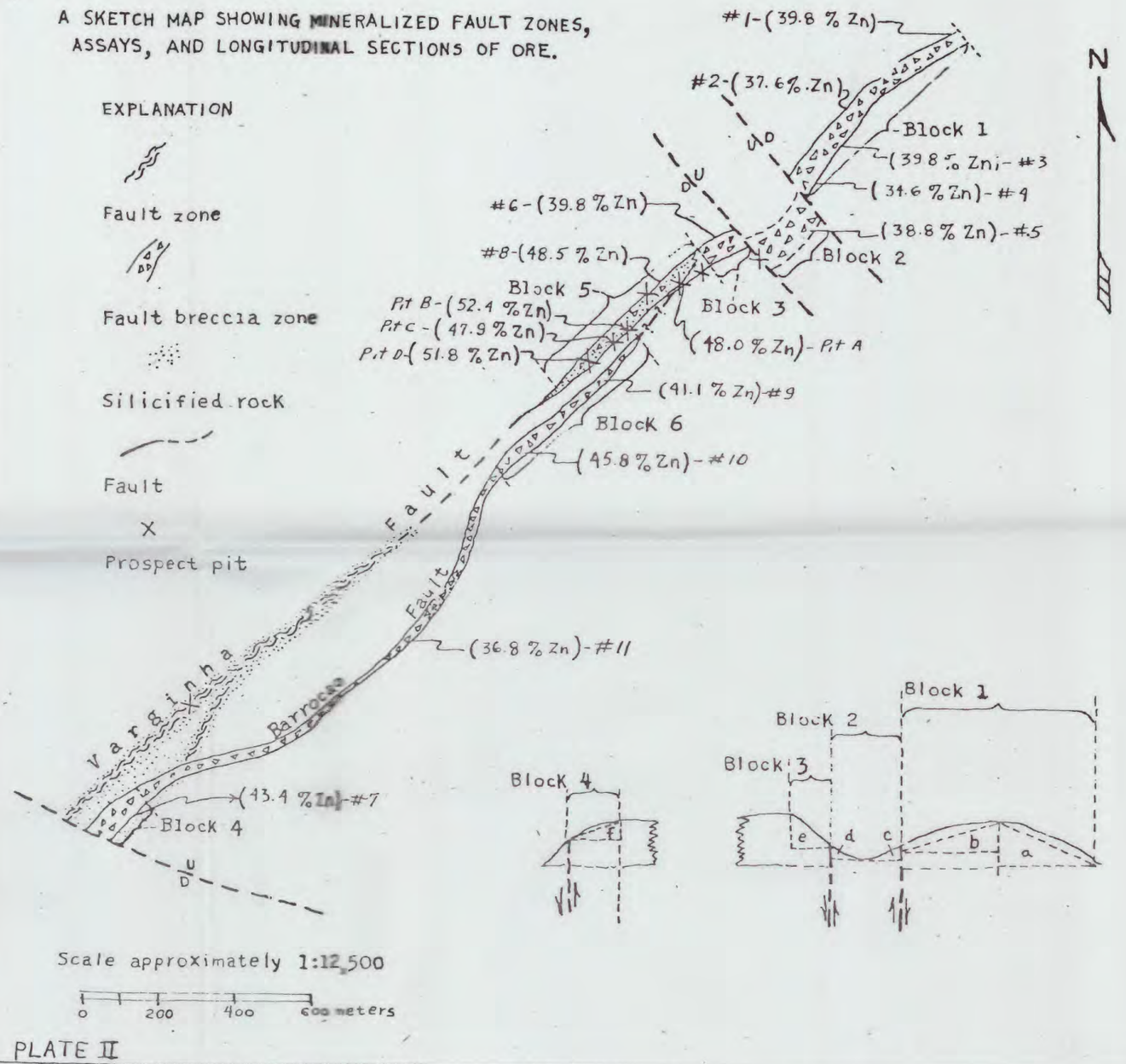



PLATE II

1813

56-82