

GM 35766

REPORT ON COMPILATION OF LAC TIO GEOLOGICAL DATA

Documents complémentaires

Additional Files



Licence



Licence

Cette première page a été ajoutée
au document et ne fait pas partie du
rapport tel que soumis par les auteurs.

Énergie et Ressources
naturelles

Québec 

KENNCO EXPLORATIONS, (CANADA) LIMITED

REPORT

on

COMPILATION

of

LAC TIO GEOLOGICAL DATA

by

E. O. DEARDEN

February 12, 1958.

Ministère de l'Énergie et des Ressources
Gouvernement du Québec
Documentation Technique

DATE: 1958 FEV. 28

No. G.M.: 35766

TABLE of CONTENTS

	<u>Page</u>
Summary - - - - -	1
Recommendations - - - - -	3
Introduction - - - - -	4
General Statement - - - - -	4
Location - - - - -	4
History - - - - -	4
Regional Geology - - - - -	5
Geology - Lac Tio Deposit - - - - -	7
Nature of the Ore - - - - -	10
Aeromagnetics - - - - -	11
Diamond Drilling - - - - -	13
Ore Reserves - - - - -	18
References - - - - -	20

LIST of ILLUSTRATIONS

- Plate 1 Photomicrograph of Allard Lake Ore.
- Fig. 1a Regional Geology - Seven Islands-Havre St. Pierre Area.
- Fig. 1 Tio Mine - Ultimate Pit Layout.
- Fig. 2 Geological Plan - Lac Tio Ilmenite Deposit.
- Fig. 3 Aeromagnetic Anomaly - Lac Tio Area.
- Fig. 4 Claim Sketch - Lac Tio Area.
- Fig. 5 Index Map of Diamond Drilling - Tio Deposit.
- Fig. 5a Graph to show Standard Deviation from Average Grade (76.8%) using various drill hole spacings.
- Fig. 5b Summary of Tonnages and Grades - Lac Tio Orebody.
- Fig. 5c Level Plans Legend.
- Fig. 6 to
Fig. 22 Level Plans - Tio Mine.
- Fig. 23 to
Fig. 28 Vertical Sections - Tio Mine.

COMPILATION of LAC TIO GEOLOGICAL DATASUMMARY

The Lac Tio ilmenite-hematite deposit is located 25 miles north of Havre St. Pierre, a fishing village on the north shore of the St. Lawrence River. It is one of several similar deposits lying in the southeastern portion of one of the large Precambrian anorthosite masses which occur locally throughout the Grenville sub-province of Quebec. The Lac Tio deposit is roughly triangular in plan, with the apex to the south. Its dimensions are 3,600 feet north-south and 3,400 feet east-west. Its surface area is 140 acres.

The section west of Lac Tio is called the Cliff orebody and is separated by a large mass of barren anorthosite from the section designated the Main orebody lying north and east of Lac Tio. Diamond drilling of the Main orebody suggests a basin-like structure with the deepest ore lying near the centre of the orebody as now exposed. The ore is a black, coarse-grained aggregate of ilmenite, which contains numerous oriented microscopic lamellae of hematite.

Within the proposed pit area, diamond drilling, which was stopped at a depth of 300 feet, has outlined 58,221,000 tons averaging 89.1% or 86,569,000 tons averaging 81.8% ilmenite-hematite. Currently, the grade of ore shipped to the beneficiating plant at Sorel averages 87-90% combined oxides. Unless ore lower than 87% is shipped as mill feed, large tonnages of material averaging from 81% to

87% will become waste. Low-grade disseminated material averaging less than 40% ore mineral is continuous over a considerable portion of the eastern part of the proposed pit. Pit development has now reached the point where some consideration should be given to the possible upgrading or pre-treatment of this lower grade material.

Diamond drilling on 200 foot centres is the optimum for most efficient drill hole information. At present production rates, there appears to be little justification for increasing the density of drilling beyond a 200 foot spacing. An exception to this is the low-grade capping covering the eastern portion of the pit area. Little drilling has been done in the high ground west of the proposed pit. Further drilling will be necessary in this area before an estimate of tonnage and grade within reasonable limits can be made.

Airborne magnetometer surveys over approximately 1,700 square miles of the anorthosite mass revealed no previously undiscovered deposits. Strong negative anomalies were obtained from deposits of massive ilmenite. Although existing aeromagnetic coverage of the Allard Lake anorthosite mass extends fifteen miles north of the Tio orebody, there is always the possibility of the existence of commercial ilmenite deposits beyond this distance.

The airborne magnetic anomaly over the Tio deposit extends beyond the eastern and western limits of the orebody as outlined by surface outcrop. The Main and Cliff orebodies may be exposed por-

tions of a much larger orebody extending one-half mile to the west from Lac Tio. No drilling to test possible extensions of the Main orebody has been done to date.

RECOMMENDATIONS

In view of the unfavourable economic situation, there is obviously no urgency in drilling additional holes to supplement existing information regarding the Lac Tio ore occurrence. Therefore, the following recommendations represent current views on items to be considered in the design of a program to secure a more extensive picture of the orebody when needed:

1. Because all holes drilled to date within the confines of the present pit have been stopped at approximately three hundred feet of vertical depth, it is recommended, if additional holes are to be drilled within the pit limits, once the pit is deepened, that some of them (the number to be determined) be extended to greater depths with the object of determining where the bottom contact of the ore might lie.
2. Any new drilling should include a program for holes to the northwest and east of the orebody to test for possible extensions.
3. Eventually a diamond drilling program should be undertaken in the low grade capping area on the east and northeast sides of the orebody to gain a more definitive knowledge of grade for possible future beneficiation of lower grade material.
4. The present aeromagnetic coverage should eventually be extended to the north to eliminate any possibility of an ilmenite discovery being made within striking distance of the railroad.
5. Geological mapping of new exposures of ore should be done on an annual basis so that existing information may be brought up-to-date periodically and any recommendations premised thereon may be confirmed or revised accordingly.

INTRODUCTION

General Statement

This report is a review of the literature and an assemblage of plans and sections concerned with the Tio mine.

In part, it is the result of a six-month period in the 1956 field season during which the writer was directly concerned with a diamond drilling and geological program in the area. Reports and illustrations by various branches of the Kennecott organization have been referred to in the text and in the preparation of many of the figures enclosed. In particular, pit layout and the blocking out and estimation of ore reserves on level plans have been incorporated from a report by the Salt Lake City engineering staff. (Soderberg-1957)

Where possible, all plans and sections have been revised according to current information.

The primary purpose of this report is to provide a reference point with regards drilling and geological work should it be necessary to suddenly expand the mining operation.

Location

The Lac Tio ilmenite-hematite deposit lies 25 miles north of Havre St. Pierre, a fishing village on the north shore of the St. Lawrence River some 400 miles northeast of Quebec City. (Fig. 1a)

History

In 1941, J. A. Retty made a reconnaissance survey of the

region for the Quebec Department of Mines. His results, published in 1942 and 1944, described a number of small ilmenite occurrences on the shores of four lakes within the area. Several of these were staked by Montreal and Toronto interests. Two of the claim groups were later optioned by Kennco Explorations, (Canada) Limited and a third by The New Jersey Zinc Company.

During a detailed exploration program in 1946, Kennco geologists discovered eight ilmenite deposits, one of which was Lac Tio, the largest known body of ilmenite-hematite ore in the world.

Quebec Iron and Titanium Corporation - owned two-thirds by Kennecott Copper Corporation and one-third by The New Jersey Zinc Company - was organized in 1946 to equip and operate the new mining property. A railroad 27 miles in length was built (completed in 1950) to transport the ore to the St. Lawrence River at Havre St. Pierre. An electric furnace treatment plant, yielding a high purity iron and a titanium-rich slag, to process the ore was built at Sorel, Quebec, 550 miles up the river from Havre St. Pierre.

REGIONAL GEOLOGY

The regional geology of the Seven Islands-Havre St. Pierre area is shown on figure 1a. (Imbault-1953)

The Lac Tio ore deposit lies in the southeast part of the Precambrian shield, close to the contact between Precambrian rocks and Paleozoic limestones which fringe the Gulf of St. Lawrence at Havre

St. Pierre. The Precambrian rocks of the area consist of a group of metamorphosed sediments which are intruded by large masses of anorthosite and by smaller dykes, sills and irregular bodies of gabbro. These, in turn, are intruded by granite and allied rock types.

The most important rock unit is anorthosite. The Lac Tio deposit and all other known ilmenite occurrences of the area are within this rock type and undoubtedly bear a genetic relationship to it. A large mass of anorthosite and anorthositic gabbro, about 20 miles wide, extends from Magnet Point on the St. Lawrence River for a distance of 100 miles northeasterly almost parallel to the Gulf of St. Lawrence. The Lac Tio deposit lies halfway along the mass on the southeastern side. The anorthosite mass is one of several which are found scattered throughout the Grenville sub-province of the Precambrian shield.

In the vicinity of the Lac Tio deposit, the anorthosite is generally a light grey, medium to coarse-grained rock composed essentially of subhedral crystals of plagioclase feldspar (An 50-60). In the typical anorthosite, dark minerals are scarce and rarely make up over 5 per cent of the rock. Small amounts of hypersthene, augite and ilmenite occur interstitially to the feldspar. The feldspar crystals often show granulation along their borders, indicating that movement has taken place in the solid rock or in a crystal "mush" subsequent to the formation of the feldspar.

A system of fractures in the anorthosite forms a prominent regional pattern throughout most of the area. This system is composed of two steeply-dipping sets that are approximately at right angles. The more prominent set has a strike about north-south over most of the area. Movement along some of these north-south fractures has resulted in normal faulting. These features are reflected in the topography of the area, giving rise to steep cliff faces, and in many places produce a series of step-like structures.

The contact between granite and anorthosite to the south and southeast is represented by a foliated gabbroic border phase of the anorthosite. In this area, tongues and masses of granite are observed cutting the anorthosite along the contact. Also, pegmatite dykes, probably representing a late phase of the granite, are common along this zone cutting both the granite and the anorthosite-gabbro complex.

GEOLOGY - LAC TIO DEPOSIT

Figure 1 shows ultimate pit layout and forms an overlay to the geological plan. (Fig. 2)

The Lac Tio deposit is roughly triangular in plan, with the apex to the south. Its dimensions are 3,600 feet north-south and 3,400 feet east-west. Its surface area is 140 acres. A north-south valley cuts through the centre of the deposit forming Lac Grondin to the north and Lac Tio to the south. Approaching from the north, ilmenite is first exposed on the south shore of Lac Grondin and con-

tinues from this point southward to the north end of Lac Ano.

The section west of Lac Tio is called the Cliff orebody. It outcrops on a cliff rising 350 feet from the west shore of Lac Tio. It is elliptical in plan and is 1,240 feet north-south by 740 feet east-west. The Cliff orebody is a 200-foot thick tabular mass of ilmenite-hematite ore striking north-south and dipping ten degrees to the east. It is separated on the north from the Main orebody by a large tongue of barren anorthosite.

The Main orebody is north and east of Lac Tio. It is roughly rectangular in plan. It occupies the valley floor and extends up the valley sides for a maximum vertical distance of 400 feet. A lobe of the Main orebody extends southward along the east side of Lac Tio opposite the Cliff orebody.

A north-south fault zone cuts through the Main orebody west of the central valley and follows the west side of Lac Tio forming the scarp face of the Cliff orebody. The fault dips 70° to the east, but has an unknown displacement due to lack of horizon markers.

West of the fault, the Main orebody is 25 to 200 feet thick with a gentle dip to the west not exceeding five degrees. The ore east of the fault is the most important and extensive part of the deposit as now known. Diamond drilling in this area disclosed ore to a depth of 300 feet and many of the holes were bottomed in ore. The much greater thickness of the ore east of the fault is probably due to the down-

ward displacement of this section of the orebody.

Inclusions of anorthosite, as well as horizons of ilmenite-rich anorthosite, are found throughout the orebody on surface and in the diamond drill cores. These waste blocks have no consistency in size, shape or orientation. They are presumed to represent blocks of country rock engulfed by the ilmenite during emplacement.

East of the valley (from co-ordinate 10,500-E), the Main orebody is covered by a low-grade capping composed of alternating bands of ilmenite and anorthosite. These bands dip 10° to the east and appear to reflect the general flat-lying attitude of the deposit as a whole. The thickness of massive ore beneath this capping has not been determined. At the eastern extremity of the orebody the overlying low-grade material reaches a vertical thickness of as much as 280 feet, (D. D. H. 90-12), averaging less than 40% ilmenite. From figures 1 and 2, it may be seen that the low-grade capping occupies a third of the areal extent of the proposed pit layout.

It is evident from the above that, before many years, a program of stripping this low-grade material for beneficiation or stockpiling will be necessary to expose the high-grade sections below. In the past, practically none of this material has been mined. Pit development has now reached the point where some consideration should be given to the possible up-grading or pre-treatment of this lower grade material.

NATURE OF THE ORE

Megascopically, Lac Tio ore consists of crystal aggregates of thick, tabular ilmenite grains, up to 10 mm. across and 2 mm. thick, in parallel orientation, which produce a rough grain to the rock. Gangue minerals occur interstitially and include feldspar, pyroxene, biotite, pyrite, pyrrhotite and chalcopyrite. Although most of the ore is quite dense, near the fault zone it has a coarse, granular texture. The ore is strongly magnetic.

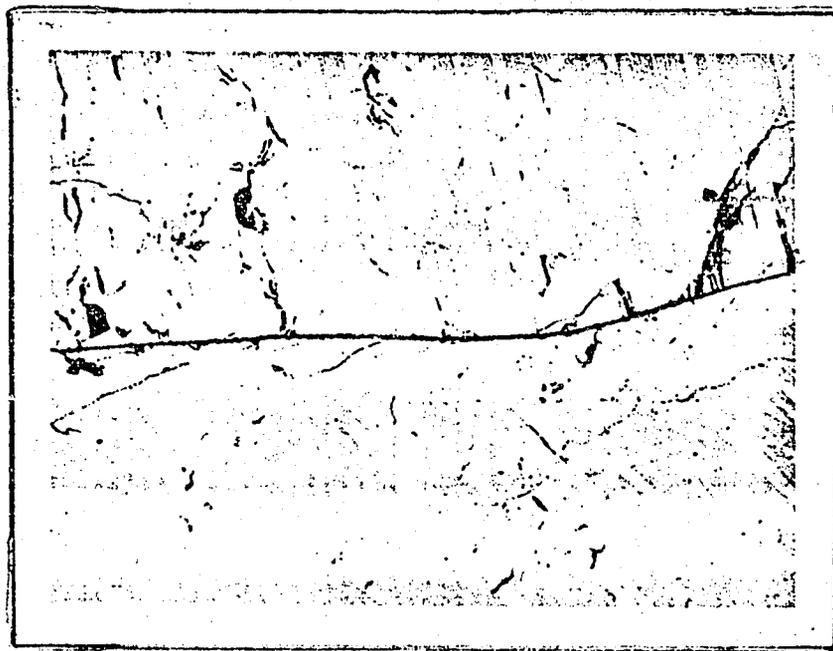


Plate i - Photomicrograph showing exsolution texture of Allard Lake ore. (dark ground mass - ilmenite; white lamellae - hematite) X. 250

Microscopically, the ilmenite grains are seen to contain discontinuous blades of hematite oriented parallel to the basal pinacoid of ilmenite. The hematite lamellae are all elongated parallel to one another in the same crystallographic orientation. Between rows of

coarse hematite blades are rows of much finer lamellae.

The Lac Tio mineral mixture consists of 75% ilmenite and 25% hematite. The intergrowth is so intimate and microscopic that mechanical separation is impossible, regardless of fineness of grind.

AEROMAGNETICS

In 1947 and 1951, aeromagnetic surveys were made of the region along the north shore of the St. Lawrence River between Magnet Point and the Romaine River. The areas covered are shown in figure 1 a. These surveys were conducted for the purpose of locating commercial deposits of ilmenite more accessible from the St. Lawrence River than the Lac Tio deposit discovered in 1946 by Kennco personnel.

The survey (Bourret-1949) was first carried out over the known ore occurrences to determine the magnetic response, after which the flight lines were extended to unexplored territory. No new deposits were discovered, but strong anomalies were obtained over all known major orebodies. Massive ilmenite deposits of any size are well defined by sharp depressions in field intensity and by small anomalous areas. The individual anomalies corresponded closely to the known positions of the orebodies as defined by geological work and diamond drilling.

Figure 3 (Uffen-1955) is a plan of the airborne magnetic anomaly over the Lac Tio area, with the outline of the orebody as presently exposed superimposed on it. Twelve hundred feet northwest of the

contact of the deposit, ilmenite outcrops are exposed over an area 2,600 feet in length and 25 to 350 feet in width. The outcrops appear to represent a flat-lying western extension of the Main orebody in part capped by anorthosite.

The magnetic profile of the outer boundary of the Lac Tio anomaly is characterized by a sharp decrease in field intensity by as much as 4,500 gammas. Strong negative anomalies are found over the Lac Tio deposit, as presently defined by drilling and geological work.

The magnetic low in the northwestern portion of the Tio anomaly is comparable in size and intensity to those found over the deposit as now known.

The Main and the Cliff orebodies may be exposed portions of a much larger orebody extending one-half mile to the west from Lac Tio. Further drilling within the anomaly limits would be necessary to fully delineate the deposit.

Ground held by Quebec Iron and Titanium Corporation provides adequate coverage for possible lateral extensions. (Fig. 4)

In 1951, aeromagnetic coverage was extended to the west of the 1947 survey along the St. Lawrence River over an area which was considered to be potentially favourable ground for the discovery of commercial ilmenite deposits. (Uffen-1951) This survey disclosed no negative anomalies characteristic of massive ilmenite.

Although existing aeromagnetic coverage of the anorthosite ex-

tends fifteen miles north of the Tio orebody (Fig. 1a) there is always the possibility of the existence of commercial ilmenite deposits beyond this distance. If other mining companies were allowed to use the railroad, the coast would in effect move some twenty-five miles inland. Consideration should be given to extending aeromagnetic coverage to the north to eliminate any possibility of an ilmenite discovery being made within striking distance of the railroad.

DIAMOND DRILLING

A total of 31,768 feet of diamond drilling in three programs has been done on the Tio deposit. (Fig. 5)

<u>Year</u>	<u>Footage</u>	<u>No. of Holes</u>
1946-47	16,000	61
1950	10,168	164
1956	<u>5,600</u>	<u>28</u>
	31,768	253

Using a figure of 100,000,000 tons of proven ore and an average cost of \$4.00 per foot of drilling, cost of diamond drilling per ton of ore is one-tenth of a cent.

The 1946-47 drill program was restricted to the Main and Cliff orebodies as outlined by surface outcrop. No attempt was made to drill outside of the known ore zone, except for two holes at the Cliff orebody to outline its western extension. In the Main orebody the drill program was usually done with holes collared 200 feet apart along grid lines at 500 foot intervals. These holes were limited to a 300-foot vertical depth irrespective of whether or not they were in ore.

The 1947 drilling program was terminated when it became evident that sufficient ore was blocked out for mining.

In 1950, a series of diamond drill holes on a 50-foot grid plaque were put down in the southeastern portion of the Tio mine. A total of 164 drill holes were drilled to an average depth of 62 feet. The purpose of these holes was to obtain accurate information on the grade of ore that could be expected for mill-feed. These holes are of little use in the preparation of vertical sections outlining the configuration of the orebody.

The 1956 drill program was designed to supplement the 1946-47 drill program. This program was restricted to the open pit and to immediately adjacent areas. The 1956 drilling was done along lines intermediate to the 1946-47 program giving a 250-foot spacing. As was the case with earlier drilling, many of the holes were bottomed in massive ore. Vertical drill sections, representing a compilation of the 1946-47 and 1956 drilling, have been prepared across six east-west planes.

(Fig. 23 to Fig. 28)

West of the main fault zone, (co-ordinate 9, 200-E), ore is exposed over a wide area as a thin, flat-lying sill, from 25 to 200 feet thick, plunging gently to the west. No drilling to test a possible westward extension of the Main orebody has been done to date.

The ore east of the fault zone comprises the most important and extensive part of the Tio deposit. This area is also the most densely drilled portion of the Main orebody. The majority of holes

in the 1946-47, 1950 and 1956 programs were drilled in this area. Thick intersections of ilmenite were cut in holes A-1 to A-6, 90-0 to 90-7, B-0 to B-6, 80-0 to 80-7; all of these holes occur east of the main fault zone. Many of these holes proved the vertical continuity of the ore to a depth of 300 feet and a number of them were terminated in massive ore. Continuity of the ore in horizontal plane is shown by its numerous exposures.

To the north, diamond drill holes F-3, F-2, F-1 and A-10 delineate the north contact adjacent to the pit area; here, the contact is dipping steeply to the south.

On section "A", holes A-1 to A-4 appear to have cut the lower contact of the ore; 1,900 feet to the south, holes C-4, C-2, C-3 and C-1 also appear to have cut the floor of the ore. Intervening sections "9250", "90", "87" and "B" have not penetrated the floor of the ilmenite body. This suggests a basin-like structure with the deepest ore occurring east of co-ordinate 9,600-E. Feiss (1956) has proposed that the ore zone might follow a laccolithic pattern with a deep feeder pipe towards the centre of the deposit as presently exposed.

East of co-ordinate 10,500-E, massive ore to an undetermined depth is overlain by a low-grade capping containing up to 45% ilmenite. Diamond drill hole 90-12, after passing through 280 feet of low-grade material, cut 120 feet of high-grade massive ore. This hole as well as 9250-5 and B-12, all of which were drilled on the eastern fringe of

the deposit, bottomed in massive ore. The ore intersected in these holes appears to extend flatly to the east underneath a bordering anorthosite capping. Stepout drilling is necessary to fully delineate the eastern extent of the orebody.

In order to determine best drill hole spacing and least probable error in grade, a statistical study of the 1950 drilling program was made. (Dearden-1957) The graph (Fig. 5a) shows standard deviation from average grade (76.8% combined oxides) using various drill hole spacings. The average grade was calculated from 164 diamond drill holes at 50-foot spacing.

The point of maximum curvature is where the deviation from average grade increases very rapidly. This point could be regarded as the practical limit of drill hole spacing, should a knowledge of accurate grade be required. A 200-foot spacing is the optimum for most efficient drill hole information. However, under the present system of selective mining, an accurate knowledge of grade does not seem to be required. Should the rate of mining be so increased that selective mining is no longer practical, the shipping grade will fall closer to the average grade of the orebody. At production rates of up to 1,000,000 tons per season, there appears to be little justification for increasing the density of drilling beyond a 200-foot spacing.

Mine operations may require localized drill programs within and adjacent to the pit area to determine waste dump sites, mill site,

attitude of contacts, etc. In addition, little drilling has been done in the high ground west of the proposed pit; drill sections are on 500-foot spacing with individual holes from 400 to 800 feet apart. Further drilling will be necessary in this area before an estimate of tonnage and grade within reasonable limits can be made.

It should be pointed out that the densely drilled block of 1950 was considered typical of the entire orebody. Since the 1950 drill program was performed in high-grade, massive ore, the results of the statistical study cannot be considered valid for the low-grade capping of the Main orebody as it varies widely in grade. In addition, many of the 1946-47 drill holes cutting the capping were not analysed for low-grade material. Should beneficiation of the capping be contemplated, an accurate knowledge of grade would be necessary for the design of a concentration plant. Grade of the capping could be determined only by diamond drill sampling.

Diamond drilling completed to date on the Main orebody has only partially explored its potentialities with respect to depth and lateral extent. The ultimate depth and lateral configuration of the Main orebody can be determined by diamond drilling. A diamond drill program with these objectives in mind would involve drilling outside of the known ore zone to the northwest and to the east. (Fig. 3)

ORE RESERVES

Figures 6 to 22 inclusive are plans of the seventeen proposed pit levels. To facilitate comparison from level to level, these have been presented as acetate overlays. On each plan, the Salt Lake City engineering staff has blocked out inferred ore limits as derived from drill hole intersections and surface outcrop. Ore grades are indicated by colors. (Fig. 5c)

Figure 5b is a summary of tonnages and grades prepared by Mr. Soderberg (1957). Recoverable ore from the proposed pit ranges from 58,000,000 to 86,000,000 tons, depending upon the grade cut-off used. These figures do not include that portion of the Main orebody west of the fault and the Cliff orebody to the southwest.

The bottom of the designed pit is the 400-foot level, 245 feet below the present pit bottom which is at a 645-foot elevation. This is also the limit of present drill hole development at depth, although most of these holes were bottomed in ore. Accordingly, as pointed out by Mr. Soderberg, the ore calculated as recoverable from the designed pit is not necessarily indicative of the ultimate reserves. Drilling to maximum depth in the central portion of the orebody would, no doubt, disclose additional tonnages.

In the past, grade of ore shipped to the beneficiating plant at Sorcl has averaged 87-90% combined oxides. From the table summarizing tonnages and grades (Fig. 5b), 58,221,000 tons averaging

89.1% or 86,569,000 tons averaging 81.8% have been blocked out. Unless ore lower than 87% is shipped as mill feed, large tonnages of material averaging from 81% to 87% will become waste. Obviously, if the economics of the operation permit, lower grade material should be treated at Sorel.

E. O. Dearden
E. O. Dearden.

Toronto, Ontario,
February 12, 1958.

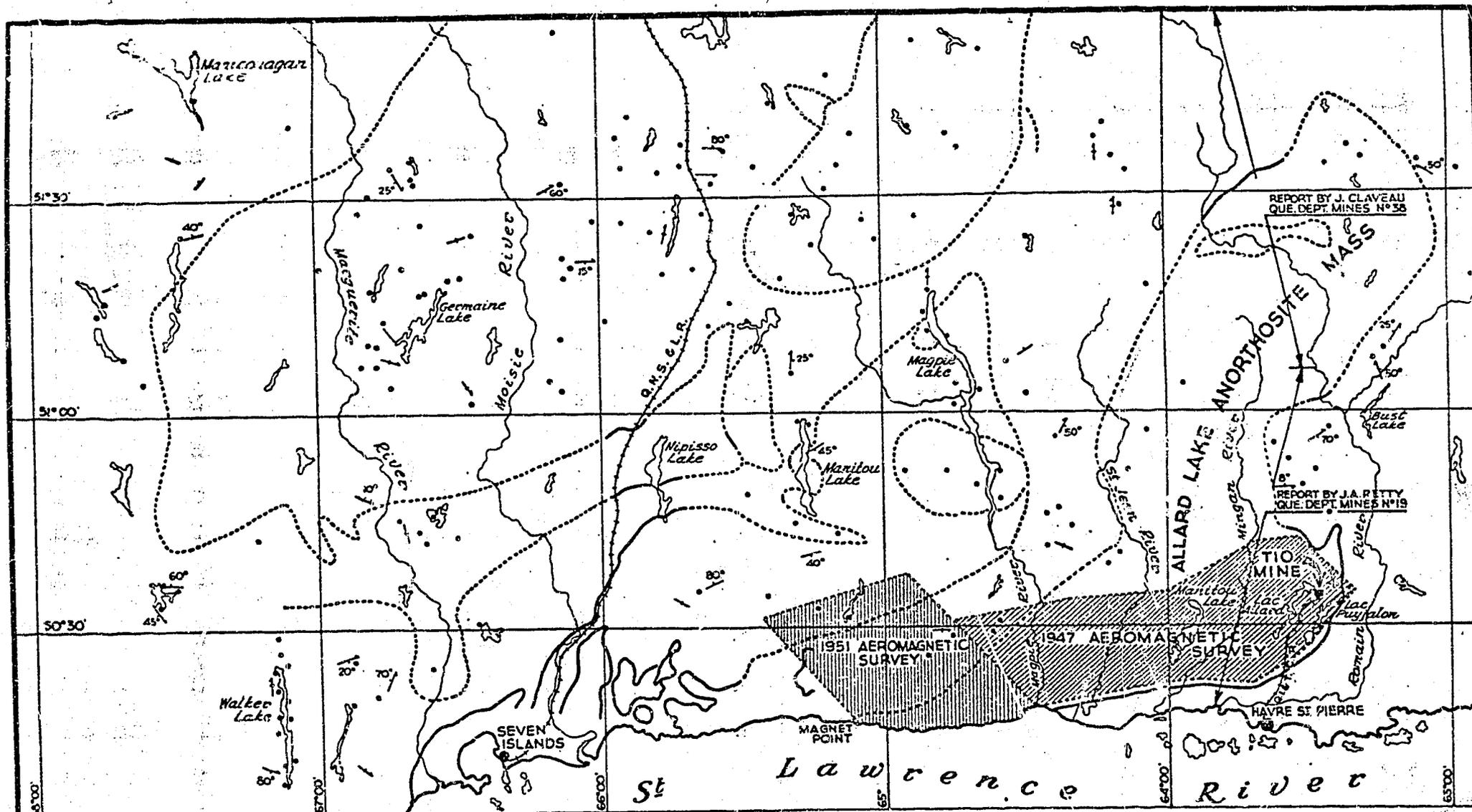
17
1.5
28.5

58
25
33

2.5'
13 years,
75
25'
325
min

REFERENCES

- Bourret, W. Aeromagnetic Survey of the Allard Lake District, Quebec, Econ. Geol., vol. 44, no. 8, pp. 732-740, 1949.
- Claveau, J. Upper Romaine Area, Saguenay County, Dept. Mines, Quebec, G.R. 38, 1949.
- Dearden, E. O. Report on Statistical Study of 1950 Drill Program (Lac Tio). (1957) Report in office files.
- Feiss, J. Report on Tentative Program for Lac Tio Area (1956). Report in office files.
- Hammond, P. Report on the Allard Lake Ilmenite Properties (1948). Report in office files.
- Hammond, P. Allard Lake Ilmenite Deposits, Quebec. Econ. Geol., vol. 47, no. 6, pp. 634-649, 1952.
- Imbault, P. Report on North Shore Reconnaissance (1953). Report in office files.
- Imbault, P. Project Proposal Ilmenite and Anorthosite North of Havre St. Pierre (1954). Report in office files.
- Mawdsley, J.B. St. Urbain Area, Charlevoix County, Quebec, Geol. Surv. Canada, Memoir 152.
- Retty, J. A. Preliminary report on the Lower Romaine River area, Saguenay County, Dept. Mines, Quebec, Prel. Rept. no. 171, 12 p., 1942.
- Retty, J.A. Lower Romaine River Area, Saguenay County, Dept. Mines, Quebec, G.R. 19, 1944.
- Soderberg, A. Report on Open Pit Design for Lac Tio Mine (1957). Report in office files.
- Uffen, R. J. Report on Aeromagnetic Surveys Manicouagan River Region and Sheldrake River Region (1951). Report in office files.
- Uffen, R. J. Report on Re-interpretation of the Aeromagnetic Maps of the Allard Lake Area (1955). Report in office files.

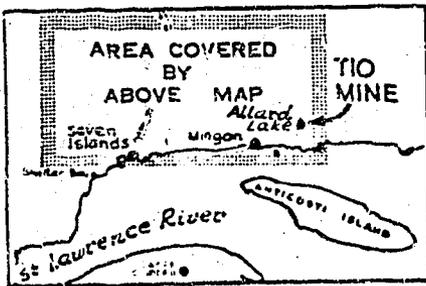


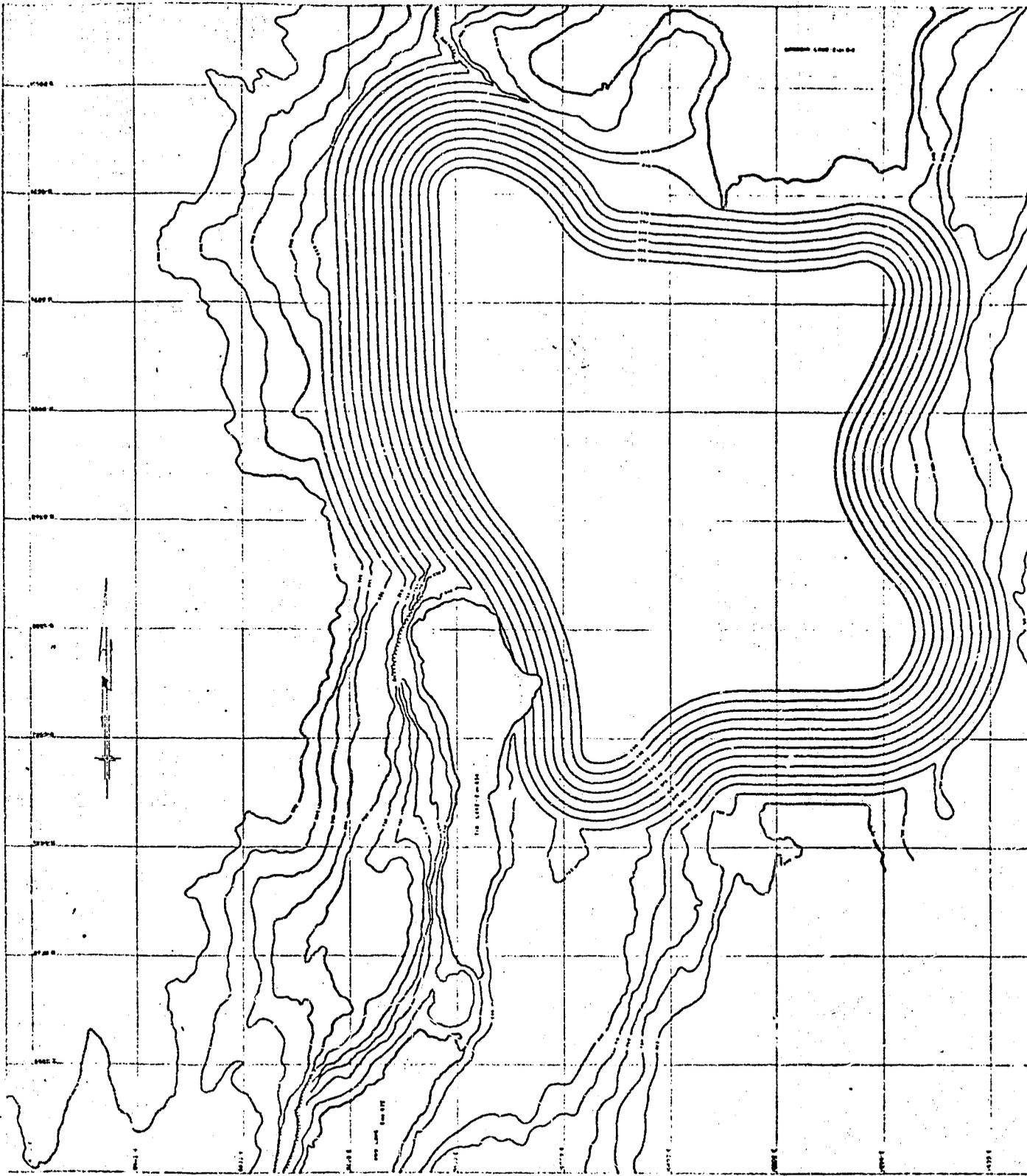
REPORT BY J. CLAVEAU
QUE. DEPT. MINES N° 38

REPORT BY J.A. PETTY
QUE. DEPT. MINES N° 19

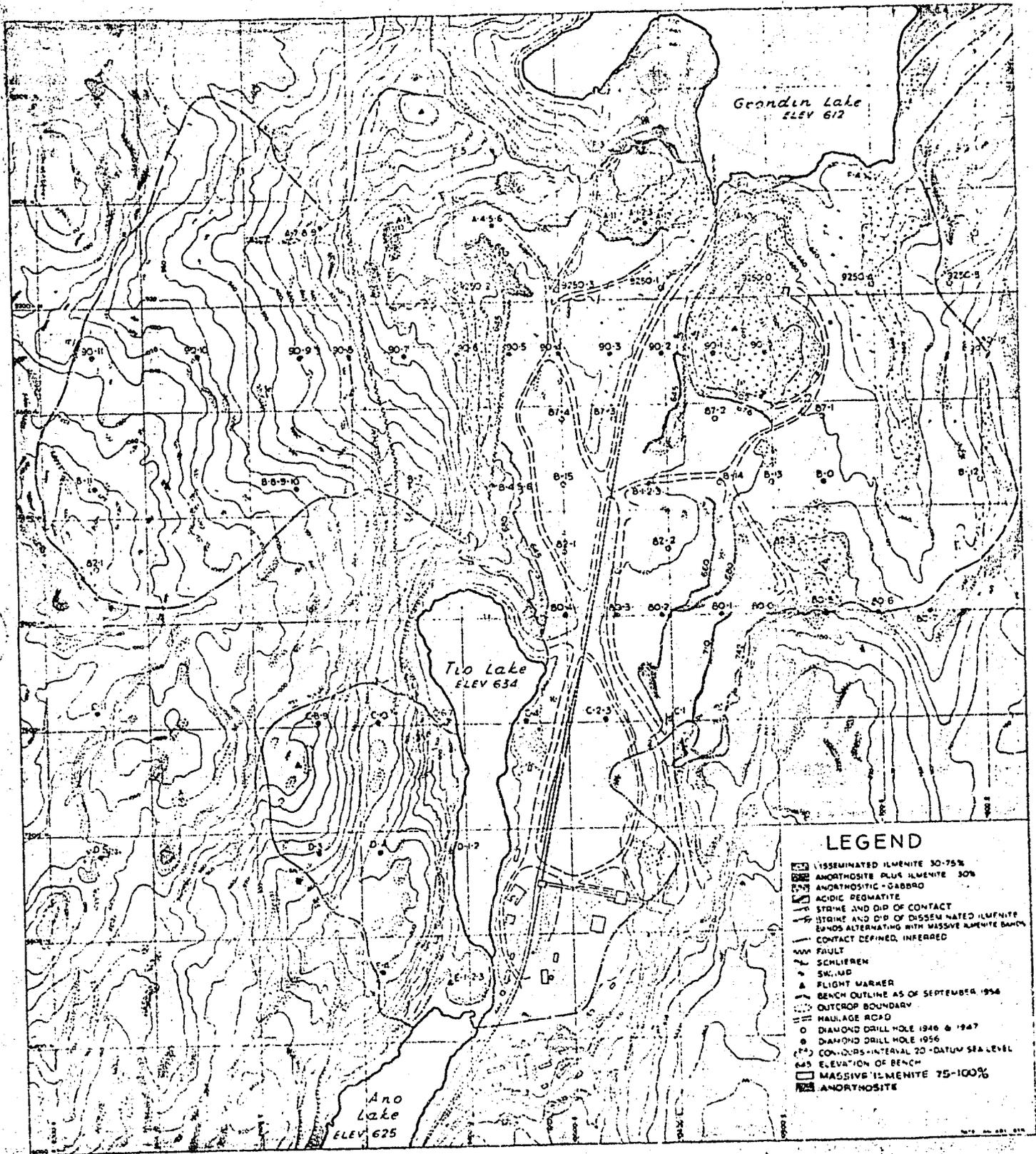
REGIONAL GEOLOGY SEVEN ISLANDS-HAVRE ST-PIERRE AREA

L E G E N D	
<ul style="list-style-type: none"> LIMESTONE - PALAEOZOIC GRANITIC ROCKS ANORTHOISITE SYENITIC GNEISS GABBRO META-SEDIMENTARY ROCKS 	<ul style="list-style-type: none"> OBSERVED EXPOSURE STRIKE AND DIP OF BEDDING STRIKE AND DIP OF GNEISSIC STRUCTURE GEOLOGICAL BOUNDARY (APPROXIMATE) GEOLOGICAL BOUNDARY (ASSUMED) BOUNDARY OF AEROMAGNETIC SURVEY

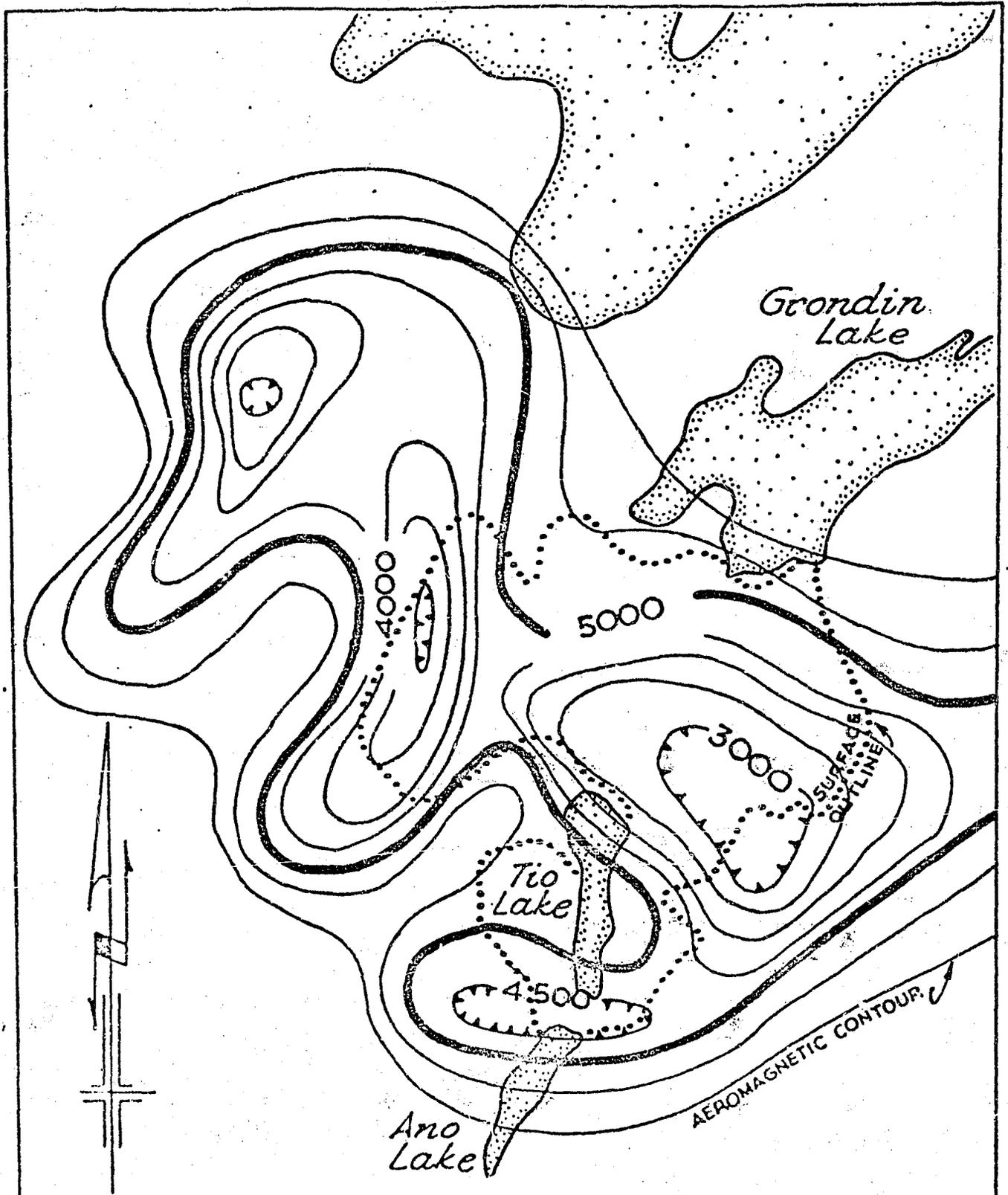




TIO MINE - ULTIMATE PIT LAYOUT



GEOLOGICAL PLAN
LAC TIO ILMENITE DEPOSIT



AEROMAGNETIC SURVEY - LAC TIO AREA

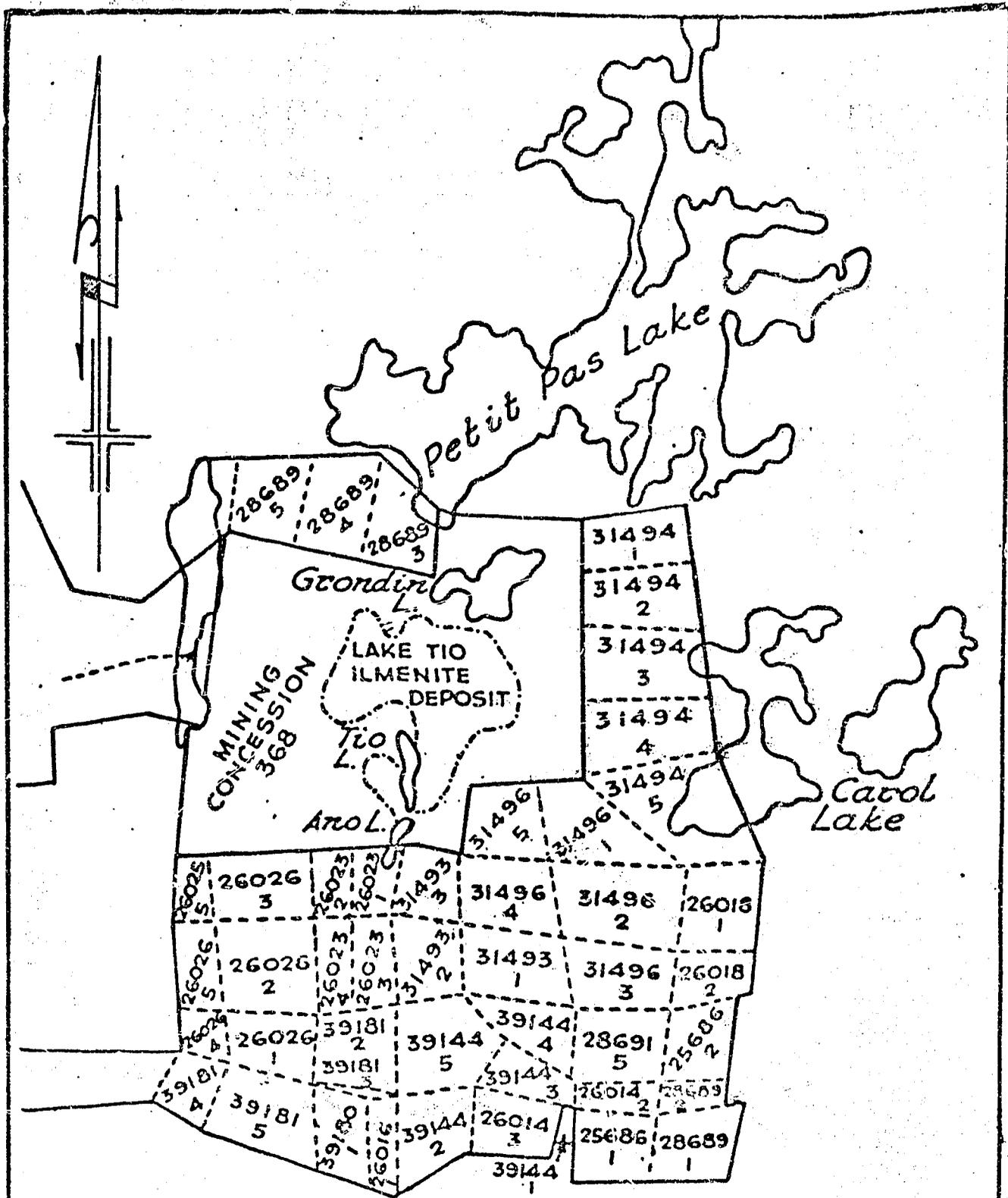
LEGEND

- SURFACE OUTLINE OF TIO MINE
- ==== AEROMAGNETIC CONTOUR - INTERVAL 500 GAMMAS



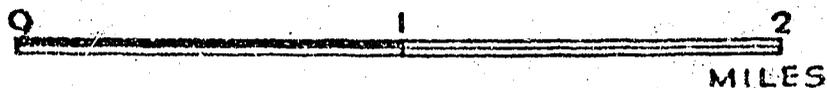
FEET

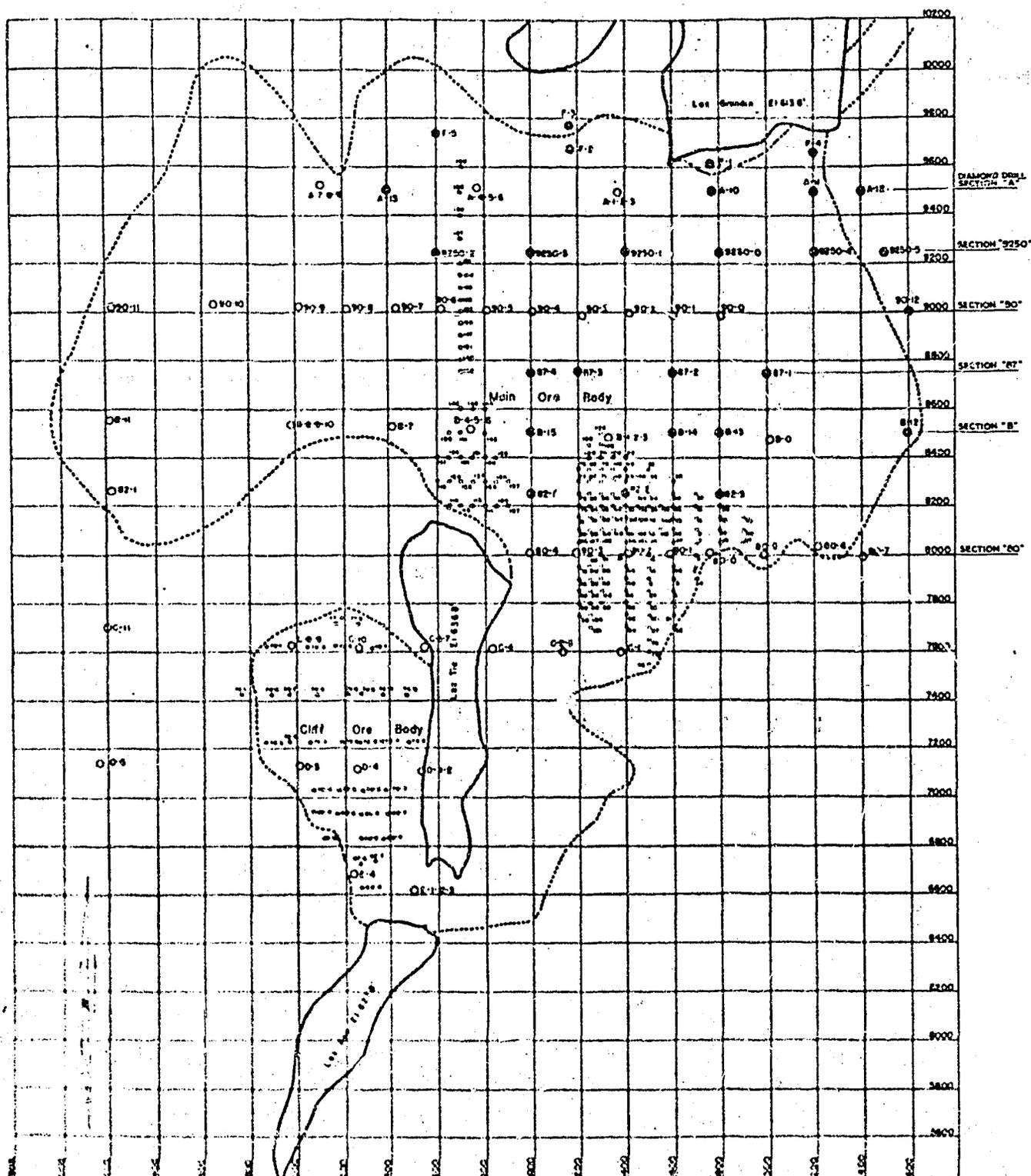
JANUARY, 1958



CLAIM SKETCH (JUNE 1955)

LAC TIO MINE

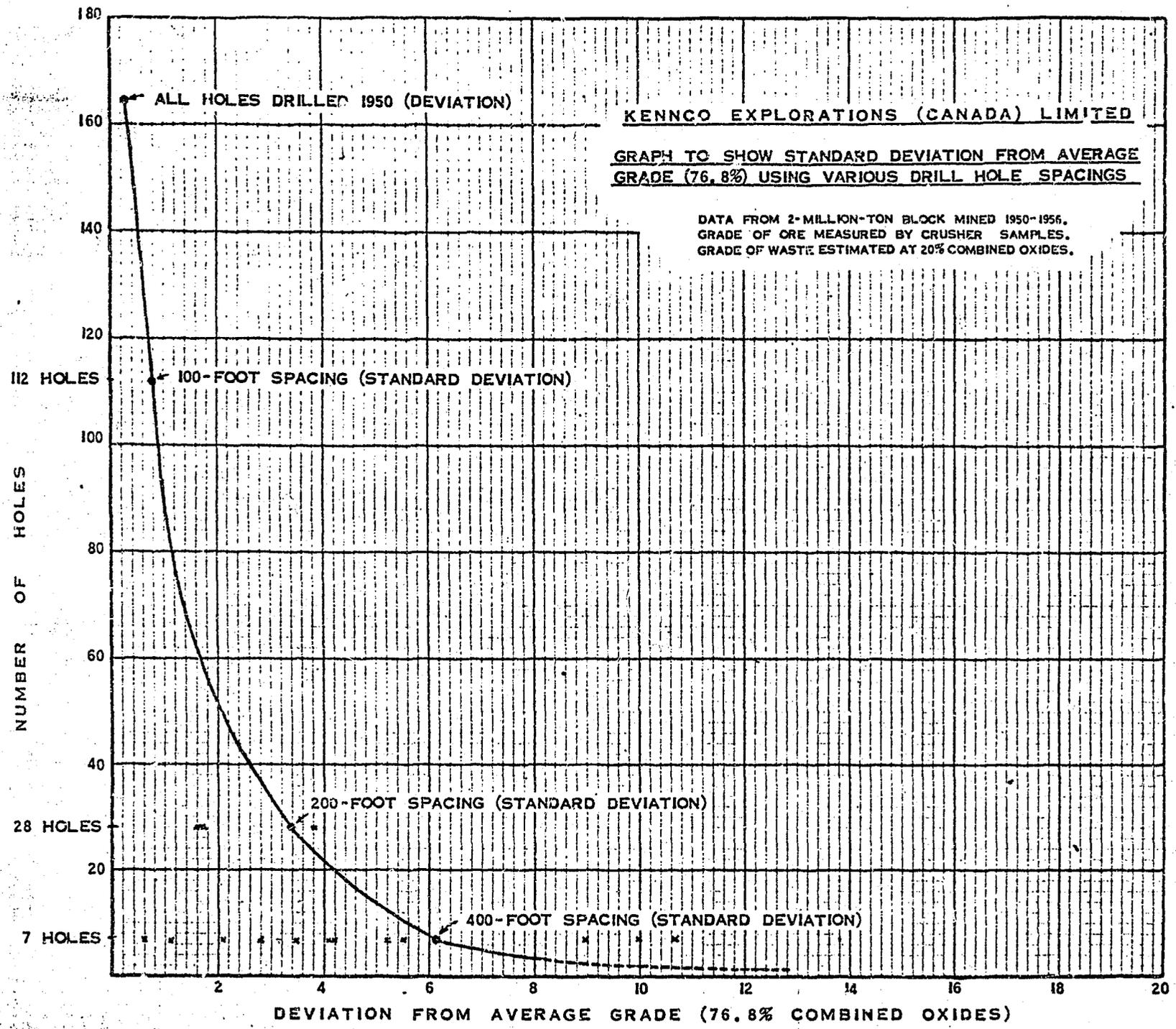




- 1946-47 DD Program
- 1948 DD Program (Cliff Ore Body)
- 1950 DD Program
- 1958 DD Program



Index Map of Diamond Drilling Tio Deposit



Extracted from Report by A. Soderberg- "Open Pit Design for Lac Tio Mine"-March 14, 1957.

SUMMARY OF TONNAGES
AND GRADES
IAC TIO ORE BODY

%	East Side Above El. 645			West Side Above El. 645			El. 645 to El. 400			TOTALS		
	Tons 1000	%	Tons x % 1000	Tons 1000	%	Tons x % 1000	Tons 1000	%	Tons x % 1000	Tons 1000	%	Tons x % 1000
Ilmenite												
80-100	3,141	88.6	278,233	8,411	88.0	740,112	46,669	89.3	4,168,165	58,221	89.1	5,186,510
70-80	565	75.6	42,719	263	74.0	19,462	11,636	74.3	865,135	12,464	74.4	927,316
70-100	3,706	86.6	320,952	8,674	87.6	759,574	58,305	86.3	5,033,300	70,685	86.5	6,113,826
60-70	263	69.9	18,384	399	67.5	26,918	8,622	64.2	553,606	9,284	64.5	598,903
60-100	3,969	85.5	339,336	9,073	86.7	786,492	66,927	83.5	5,586,906	79,969	83.9	6,712,734
50-60	463	57.4	26,575	589	57.0	33,573	5,548	55.7	308,869	6,600	55.9	369,017
50-100	4,432	82.6	365,911	9,662	84.9	820,065	72,475	81.3	5,895,775	86,569	81.8	7,081,751
40-50	449	45.2	20,303	185	40.9	7,567	3,182	44.5	141,505	3,816	44.4	169,375
30-40	961	37.1	35,653				2,938	36.0	105,630	3,899	36.2	141,263
20-30	954	23.3	22,244	62	29.2	1,810	1,402	26.2	36,688	2,418	25.1	60,742
20-50	2,364	33.1	78,180	247	38.0	9,377	7,522	37.7	283,823	10,133	36.7	371,380
0-20	5,469	0.7	3,722	2,939	3.1	9,162	5,566	3.6	19,915	13,974	2.3	32,799

LAC TIO MINE

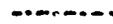
LEVEL PLANS FOR OPEN PIT

LEGEND

FAULTS



OUTLINE OF OREBODY



UPPER CONTOUR OF LEVEL



LOWER CONTOUR OF LEVEL

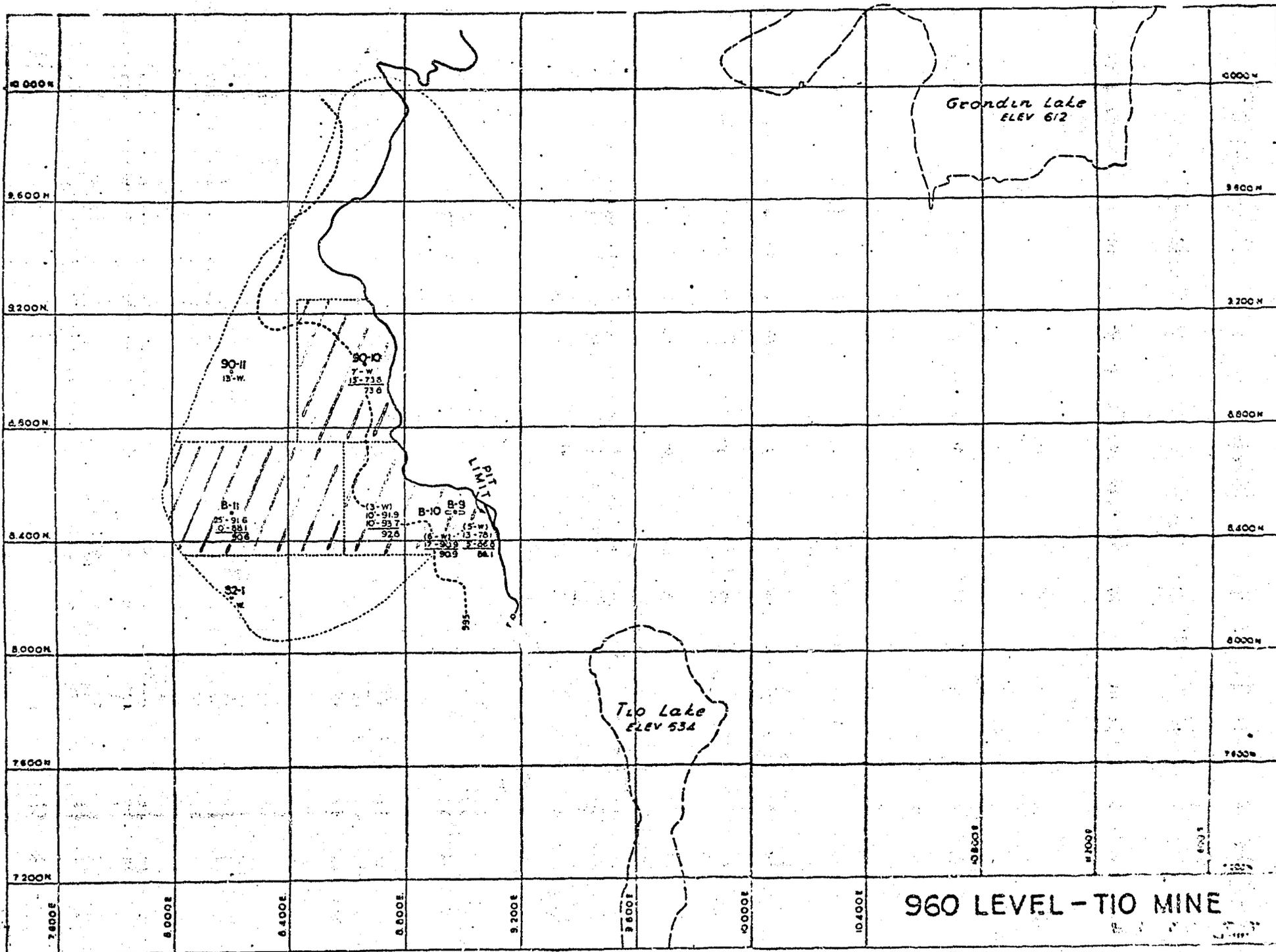


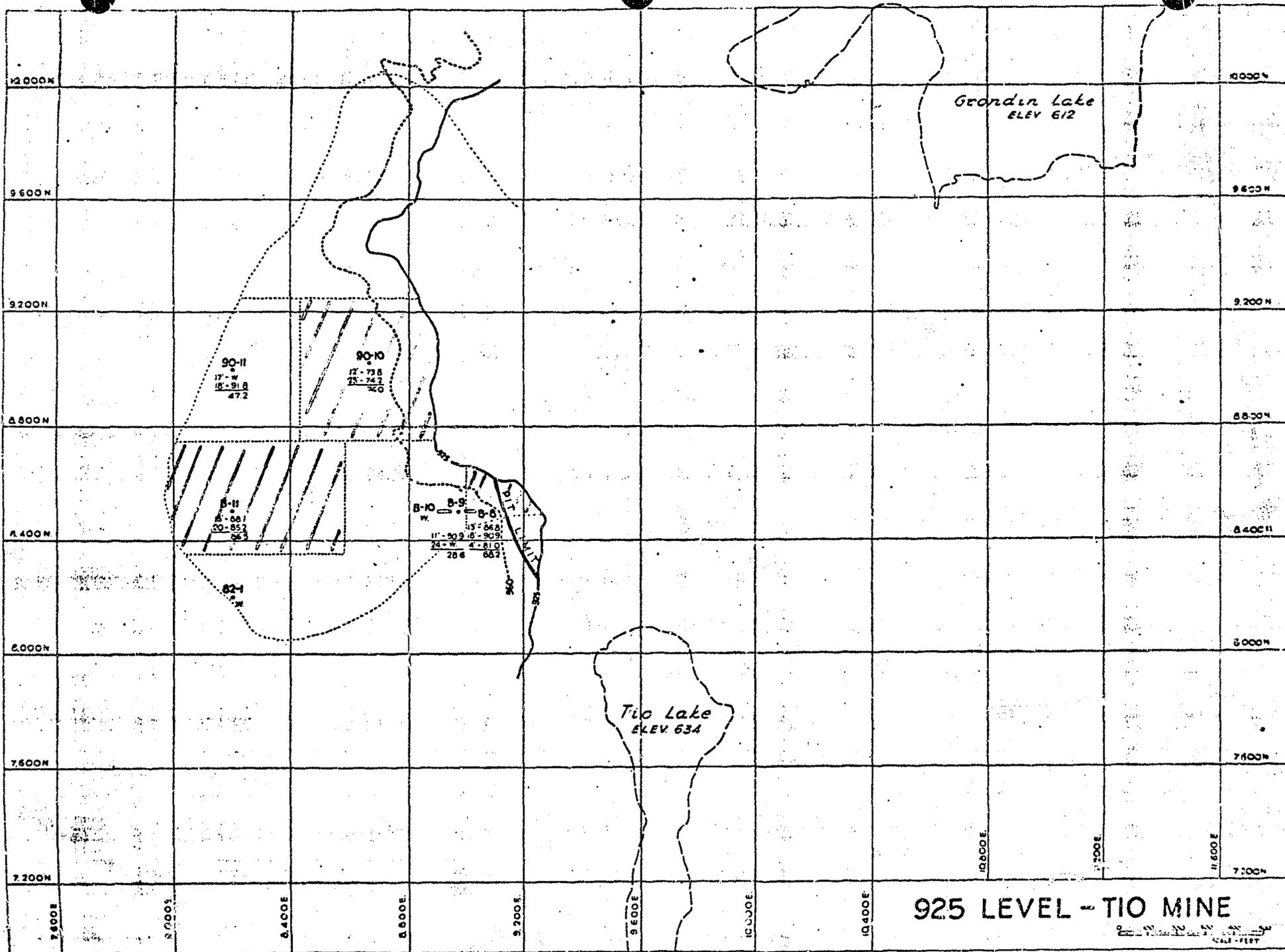
NOTATIONS:

B - 10	B - 9 6' - W	B - 8 (Drill Hole No.)	
25' - 90.6 10' - 88.1	17' - 90.9 12' - 88.6	27' - 50.5 8' - 92.0	(Length & Grades of Core)
89.9	74.5	60.0	(Avg. Grade of Core over Level Interval)
	74.8		(Avg. Grade of Ore in Block)

80% - 100% ILMENITE	--	
70% - 80% ILMENITE	--	
60% - 70% ILMENITE	--	
50% - 50% ILMENITE	--	
< 50% ILMENITE	--	

Fig. 5c





Grandin Lake
ELEV 612

Tio Lake
ELEV 634

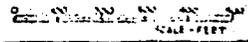
90-11
17'-W
18'-91.8
47.2

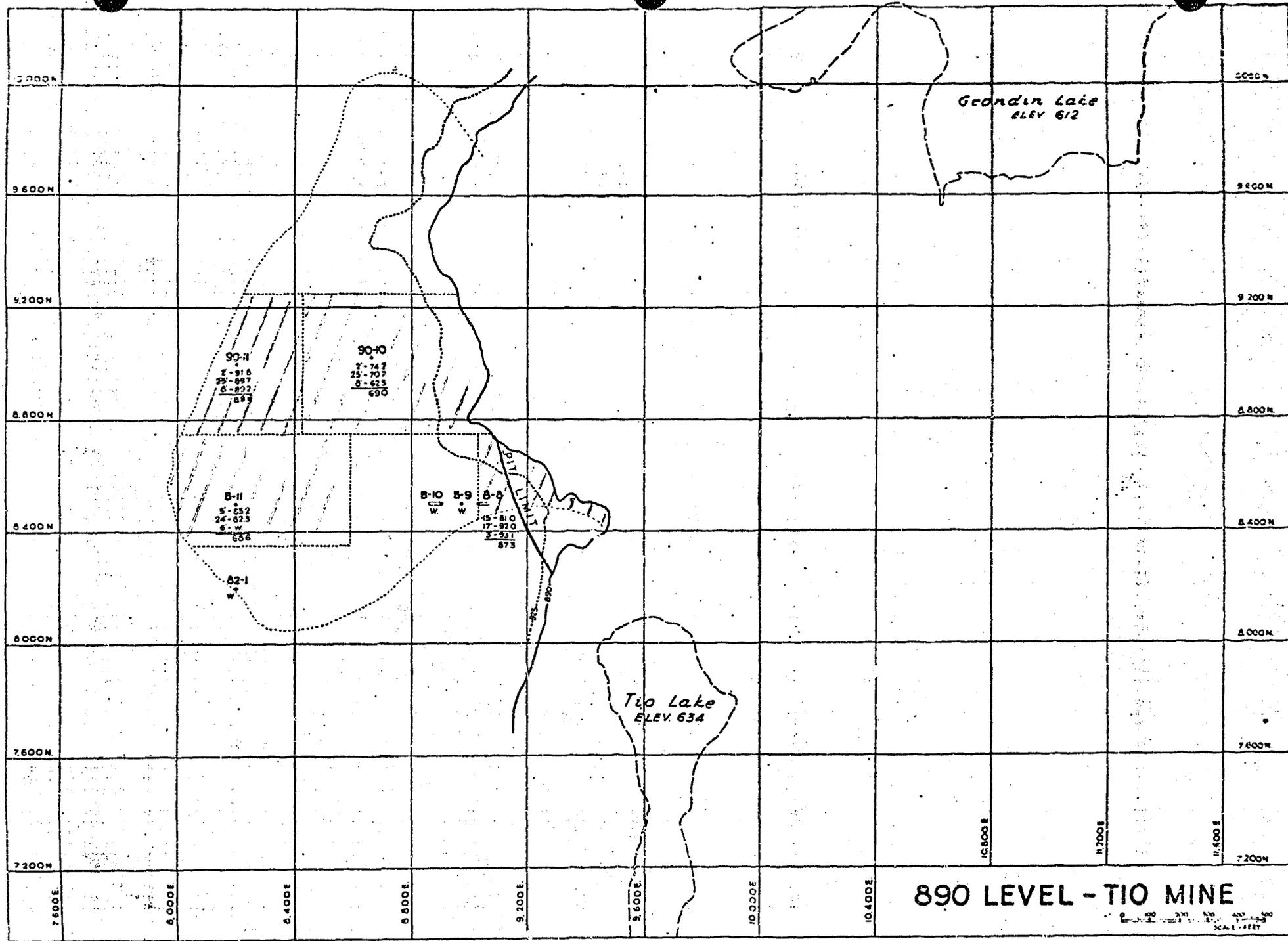
90-10
12'-73.8
18'-74.1
20

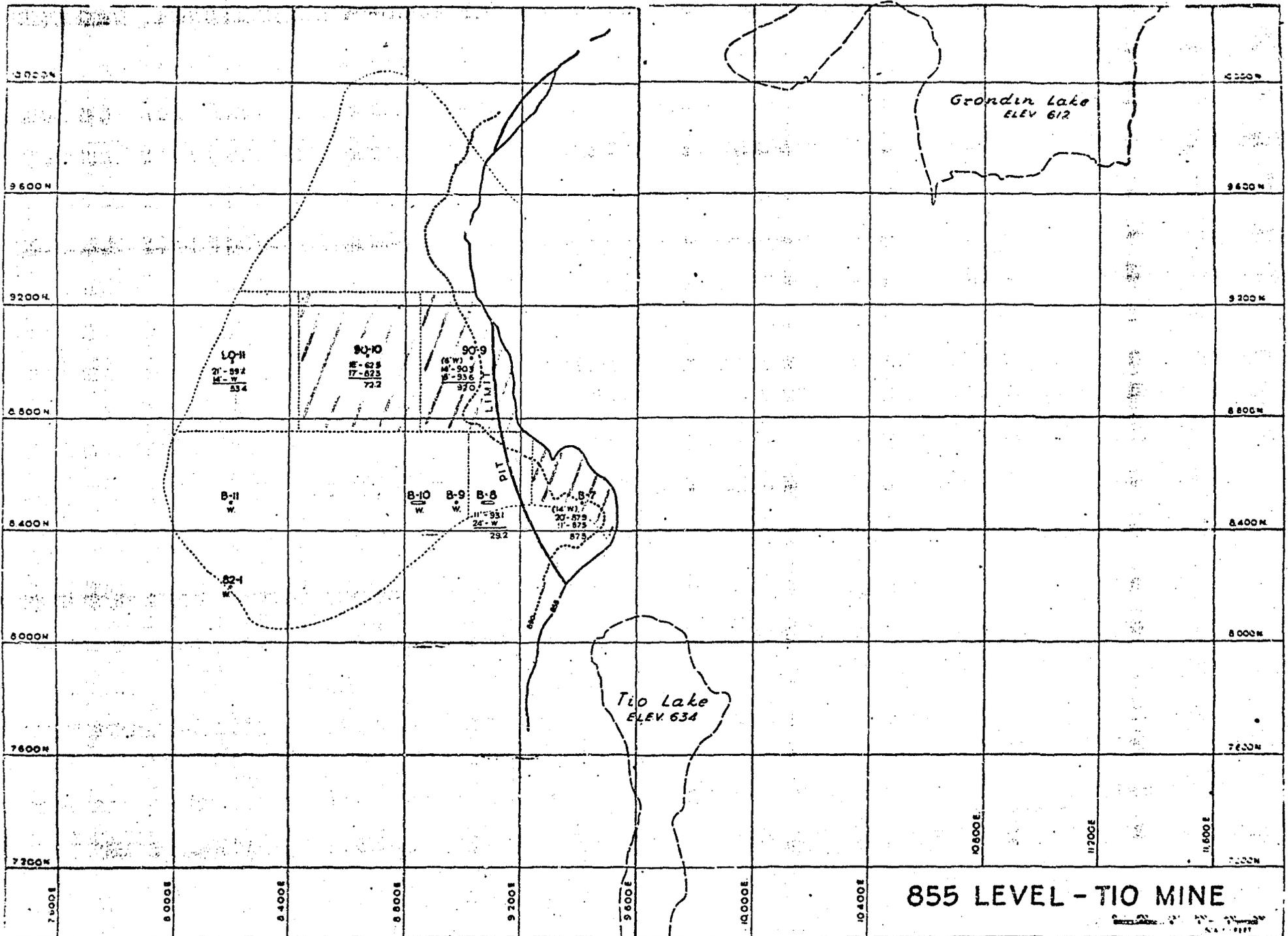
8-11
8'-68
32'-85.2
56.3

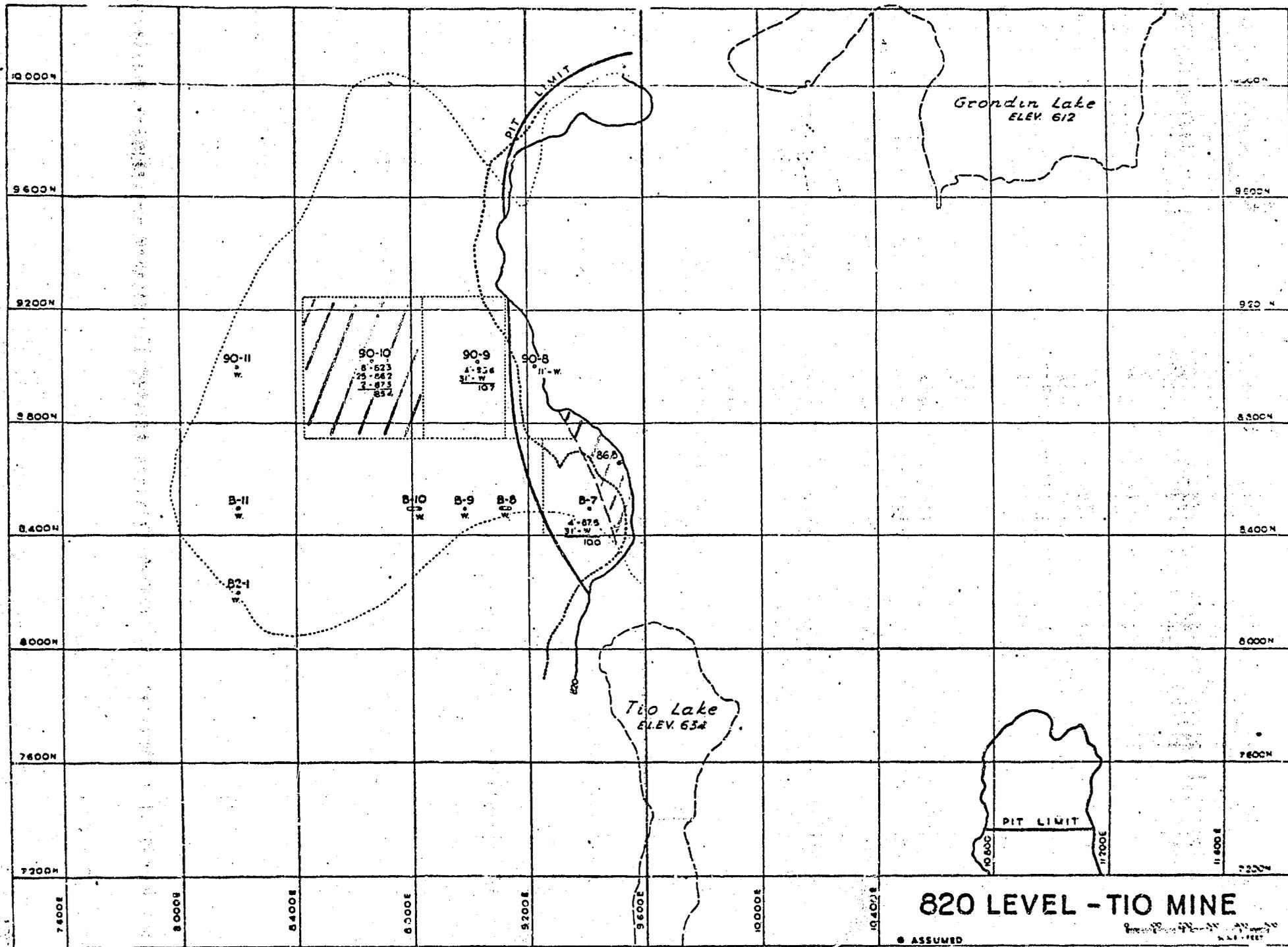
8-10 8-9 8-6
W. 11'-30.3 6'-90.9
24'-W 4'-81.0
28.6 68.7

925 LEVEL - TIO MINE





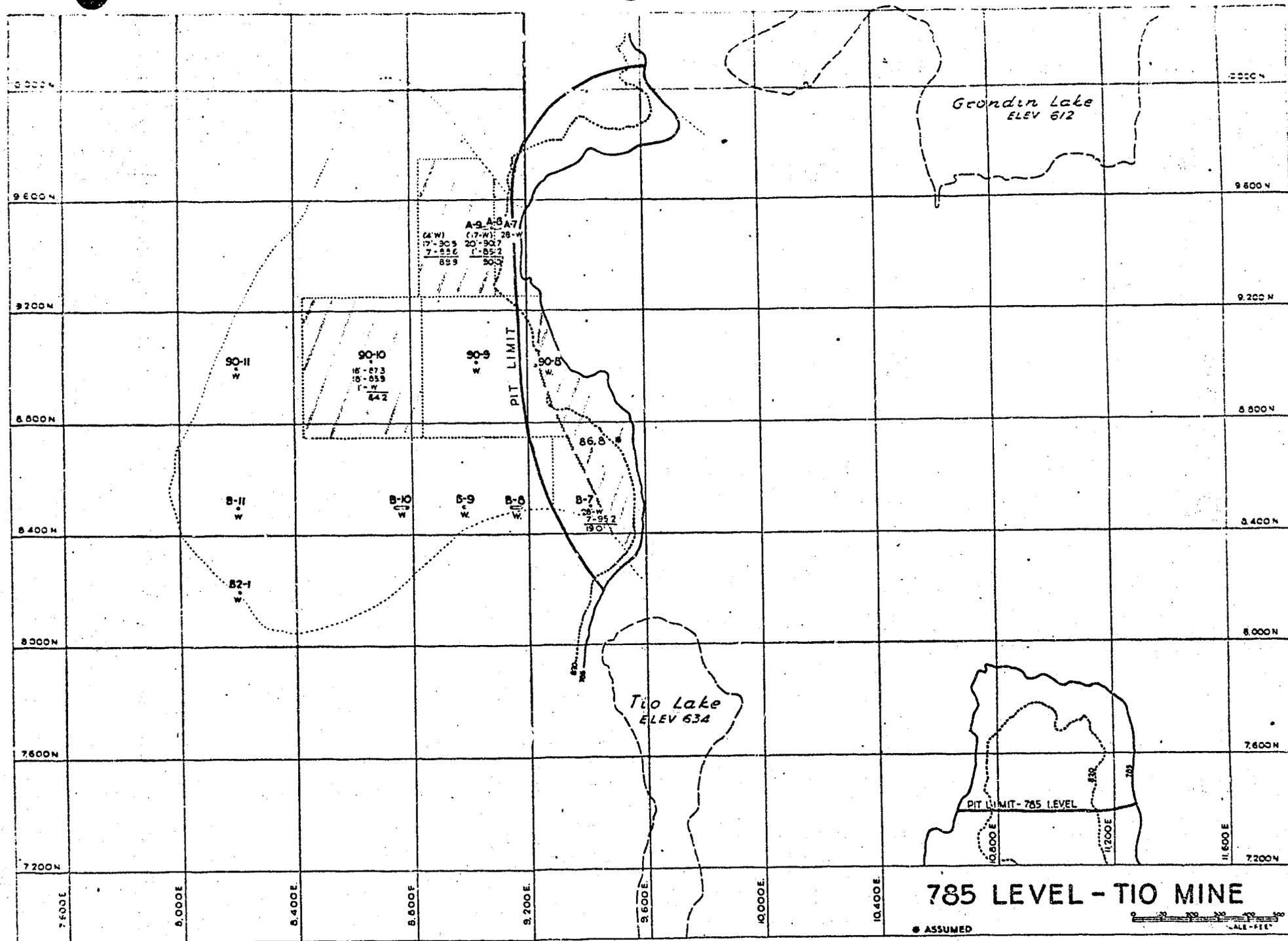




820 LEVEL - TIO MINE

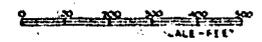
● ASSUMED

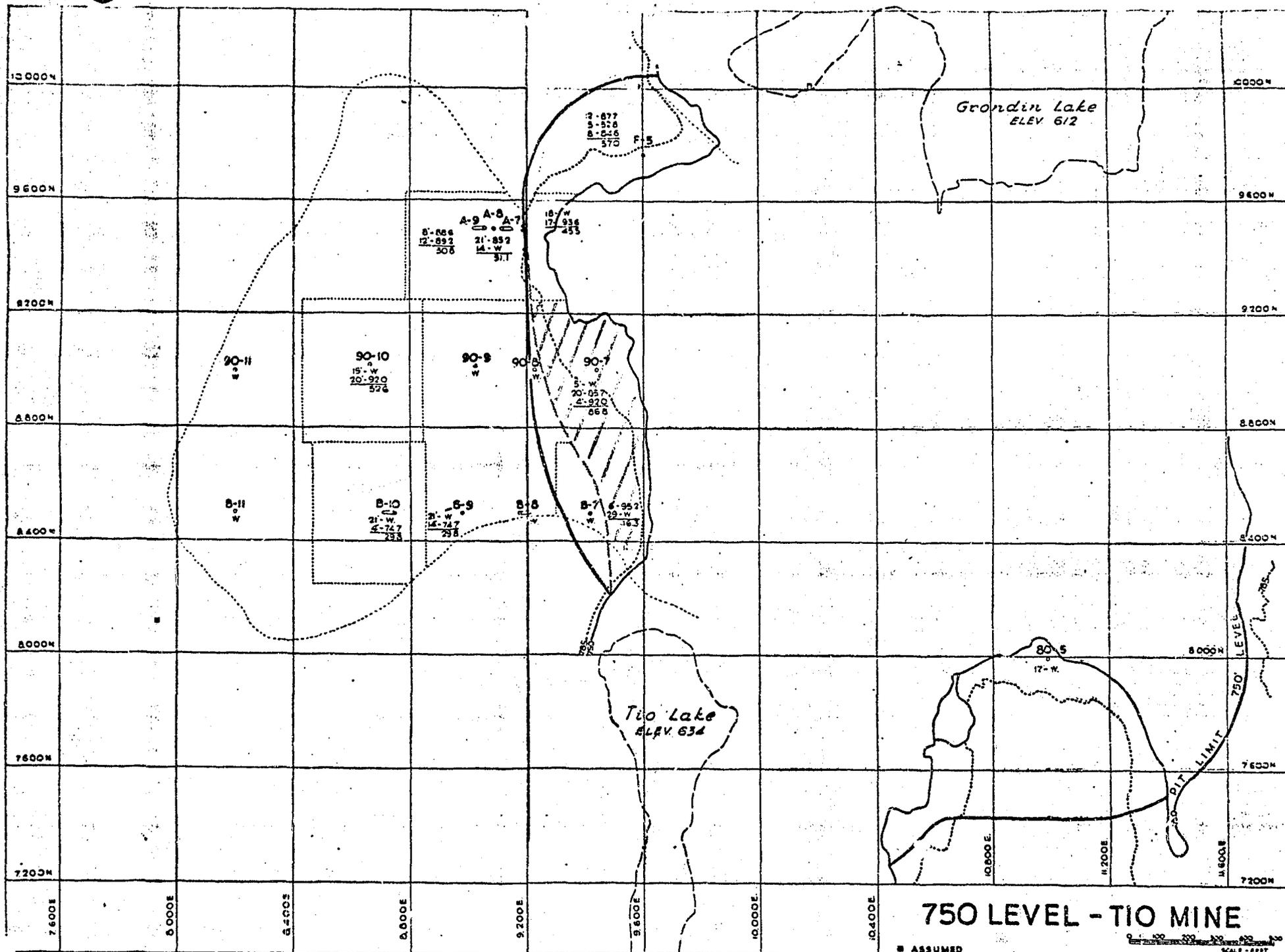
Scale: 1" = 400' (approximate)



785 LEVEL - TIO MINE

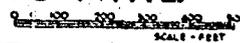
● ASSUMED

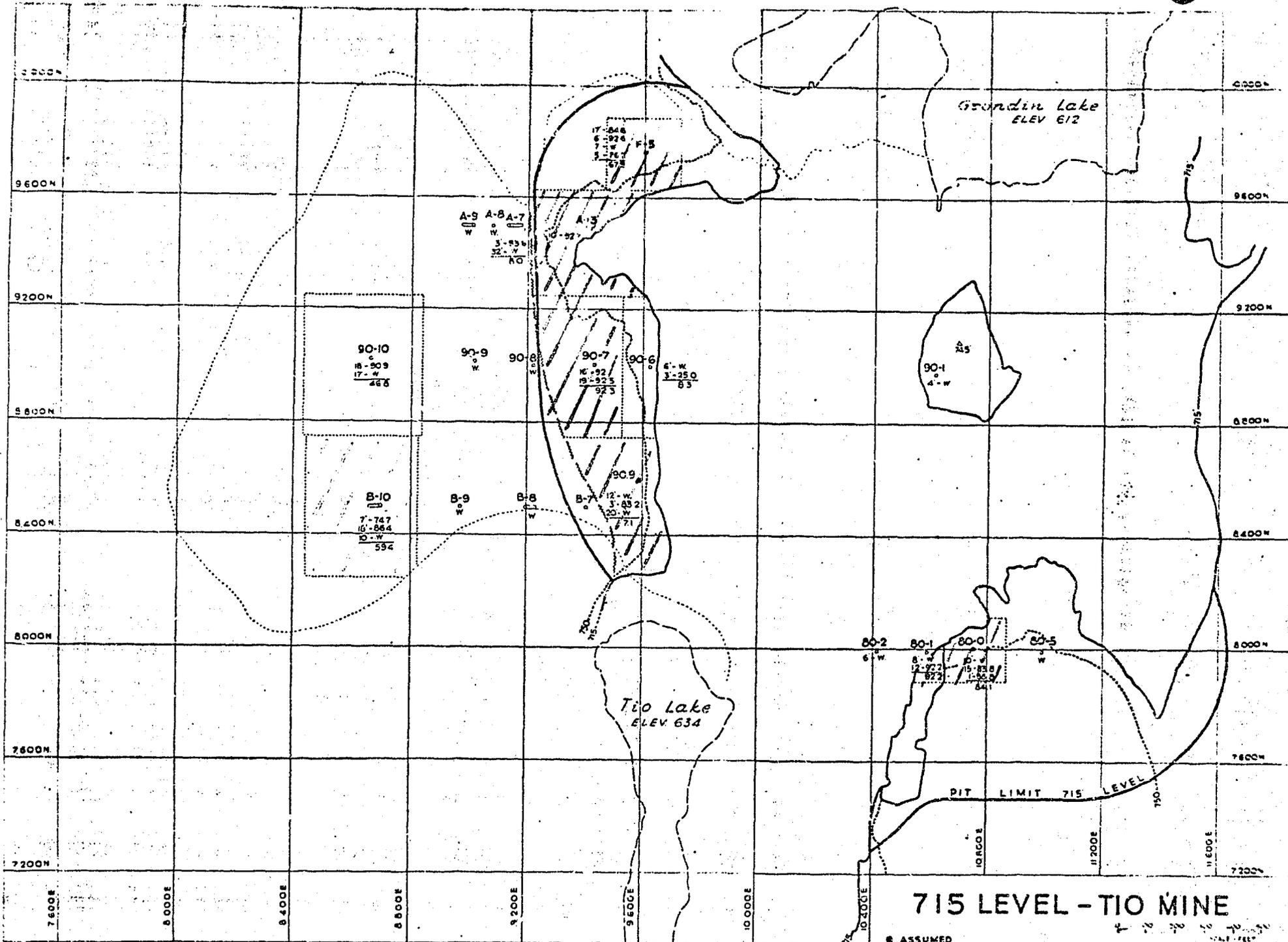




750 LEVEL - TIO MINE

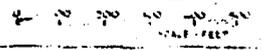
■ ASSUMED

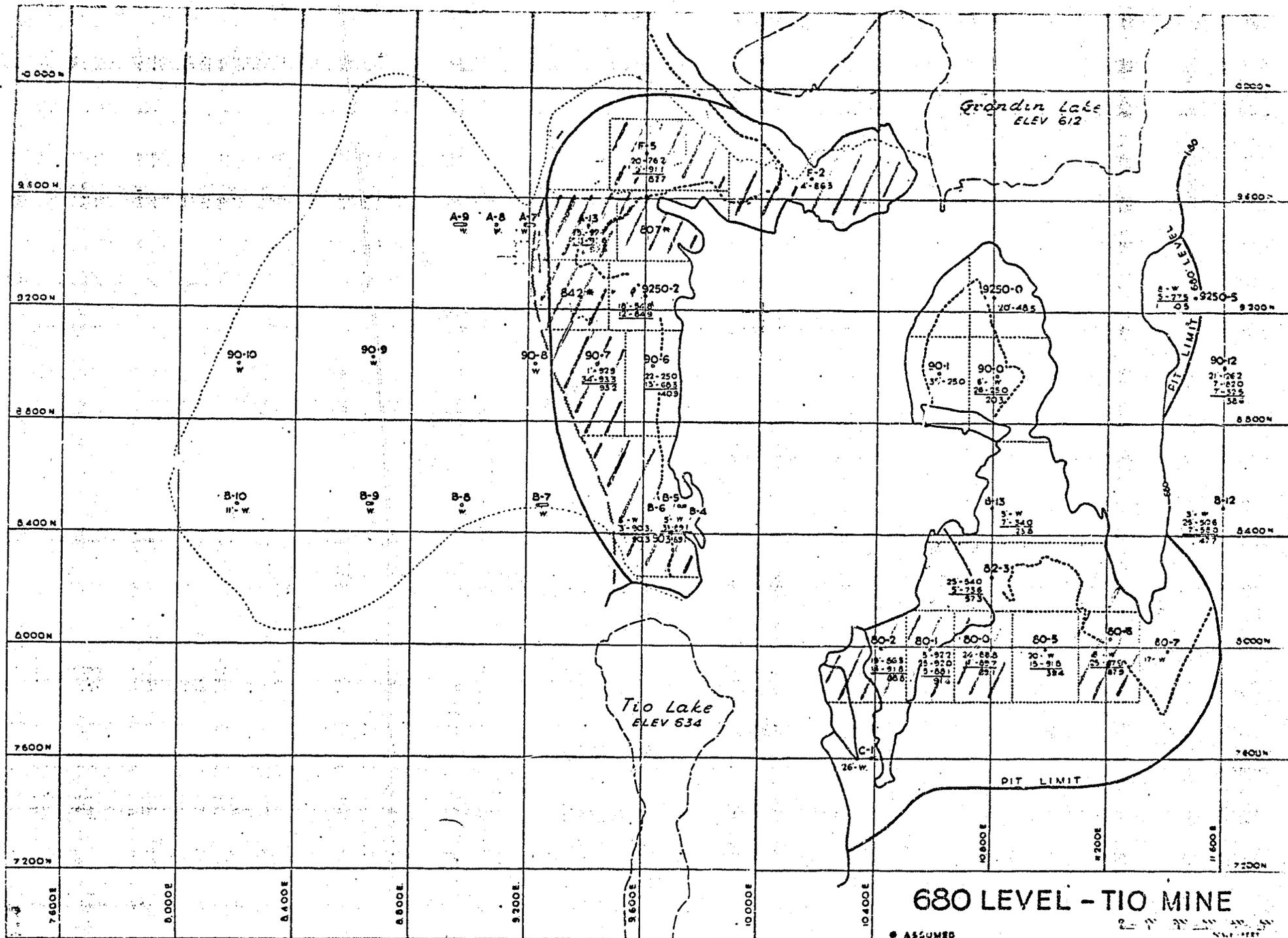




715 LEVEL - TIO MINE

8 ASSUMED

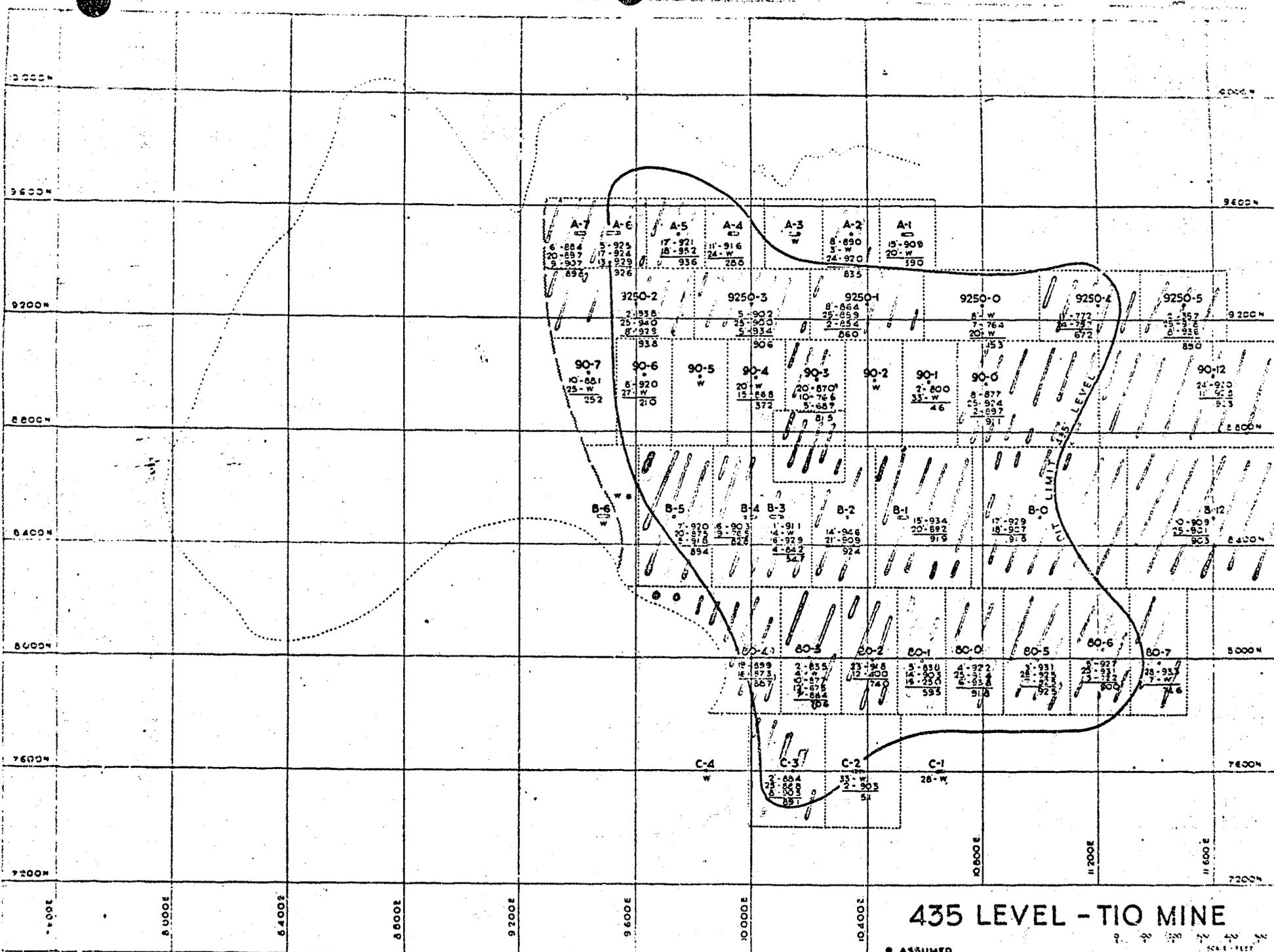




680 LEVEL - TIO MINE

• ASSUMED

2" = 100'



435 LEVEL - TIO MINE

• ASSUMED

11 600 E 11 600 E 11 600 E 11 600 E 11 600 E

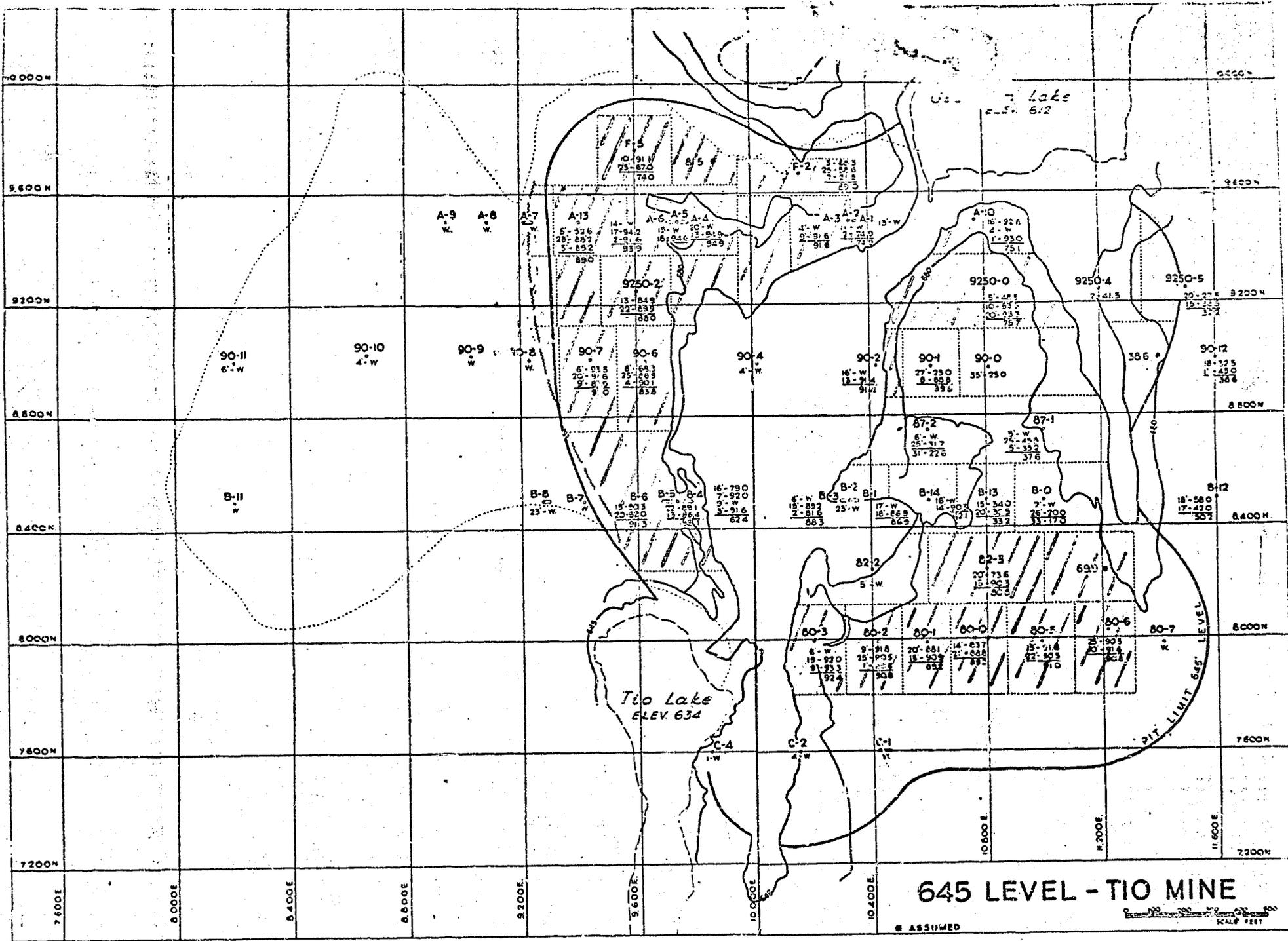
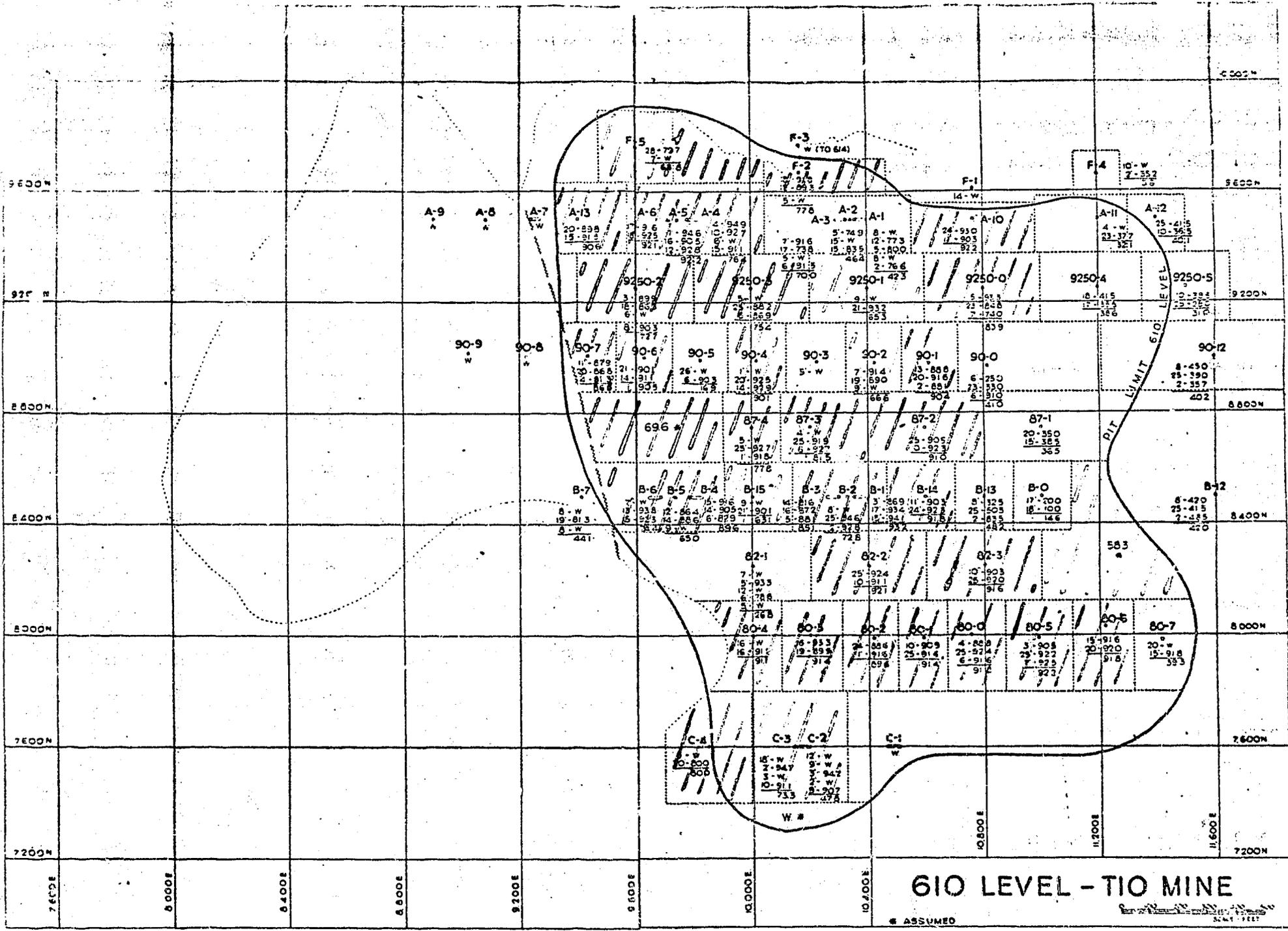


Fig. 14

645 LEVEL - TIO MINE

ASSUMED

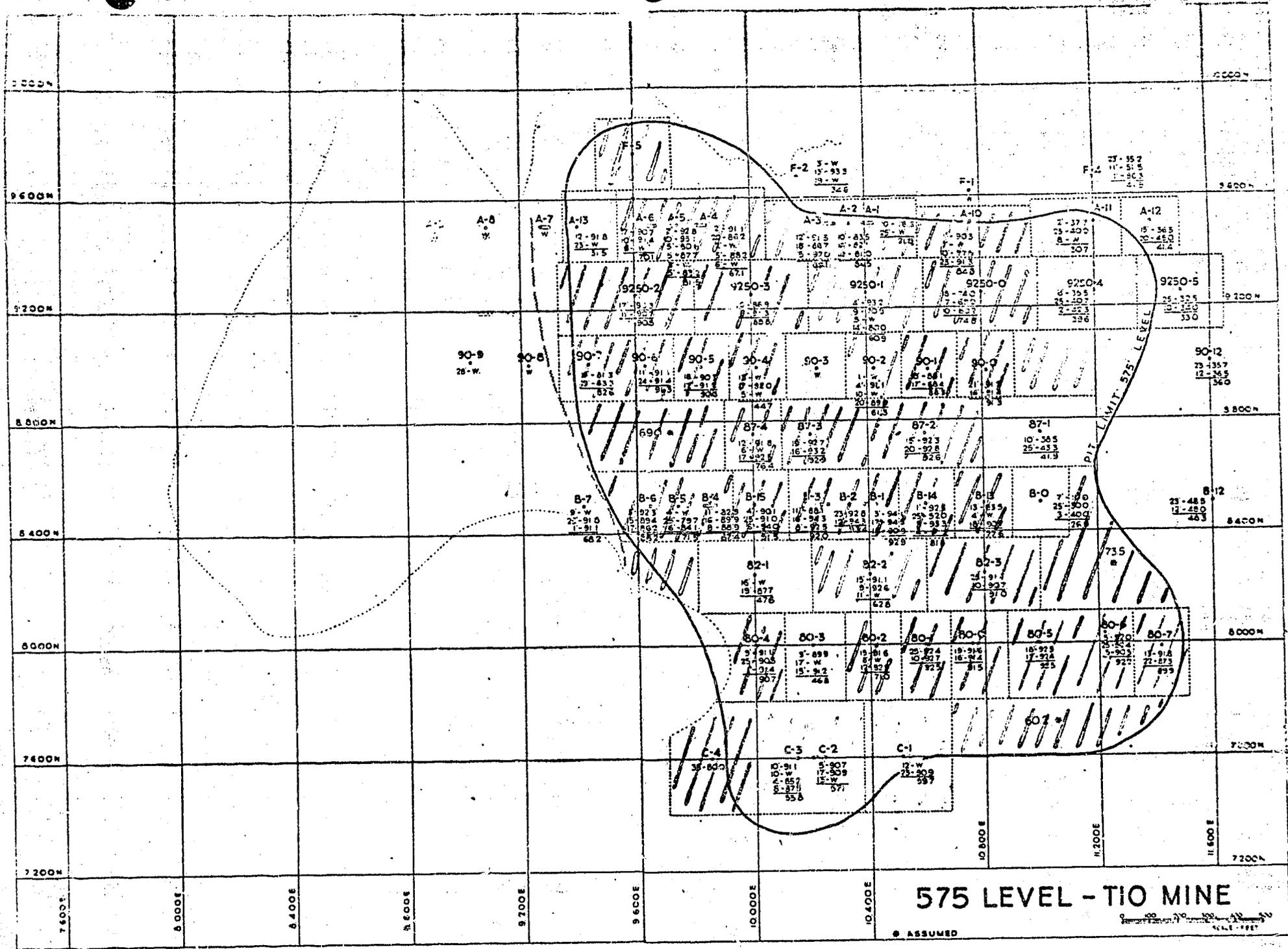
SCALE FEET



610 LEVEL - TIO MINE

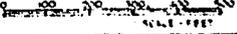
ASSUMED

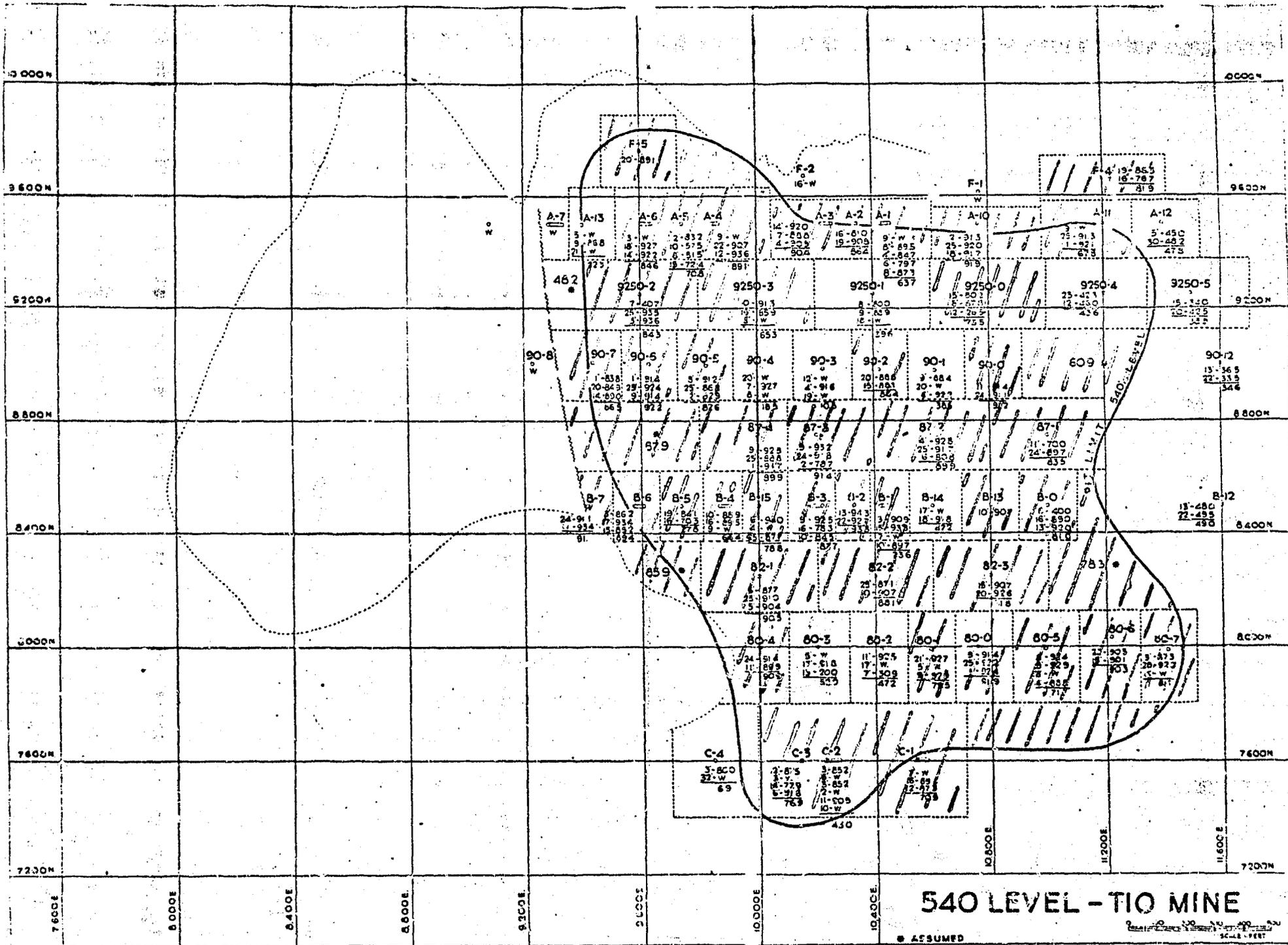
SCALE FEET



575 LEVEL - TIO MINE

● ASSUMED

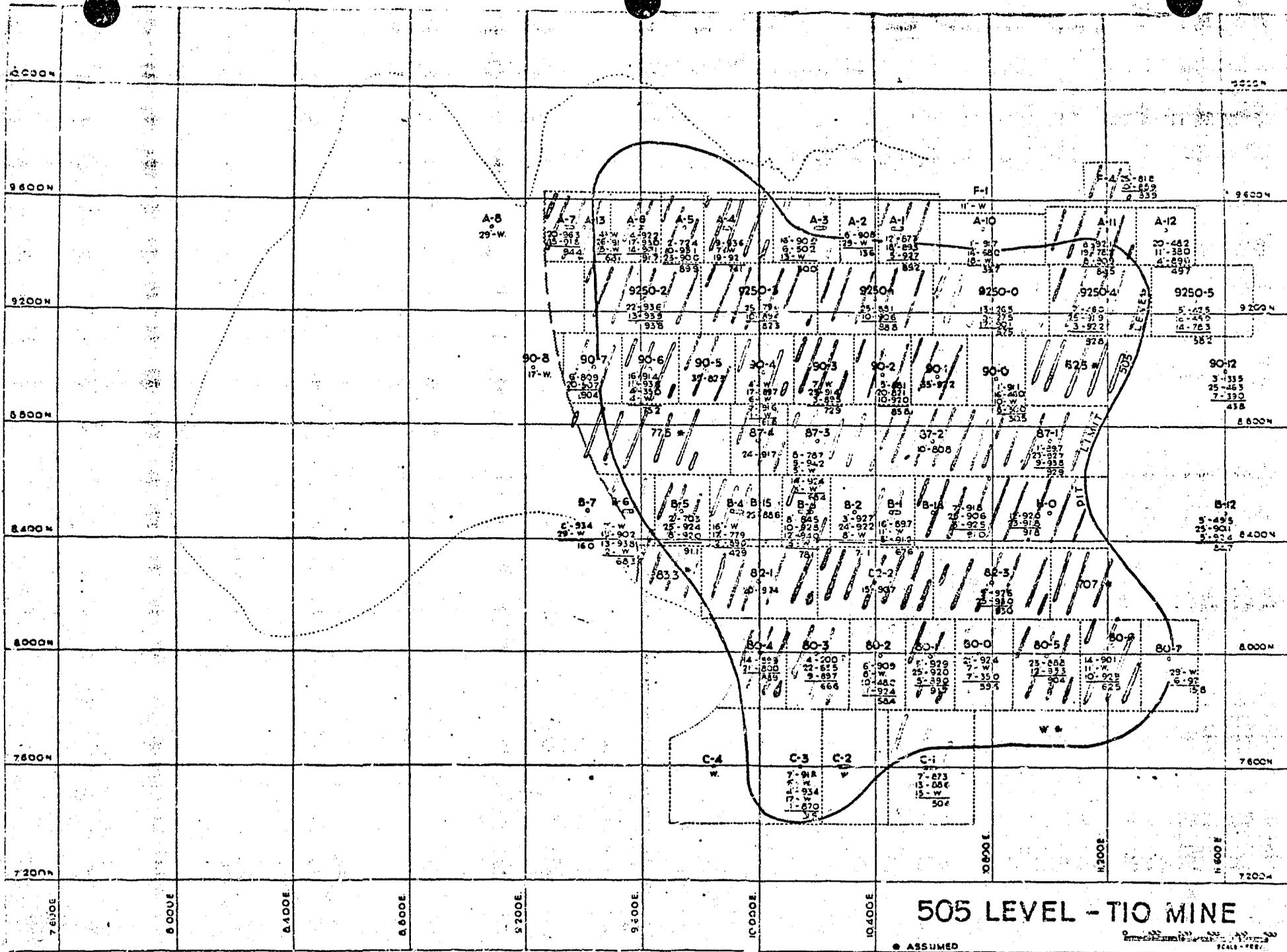




540 LEVEL - TIO MINE

• ASSUMED

SCALE - FEET

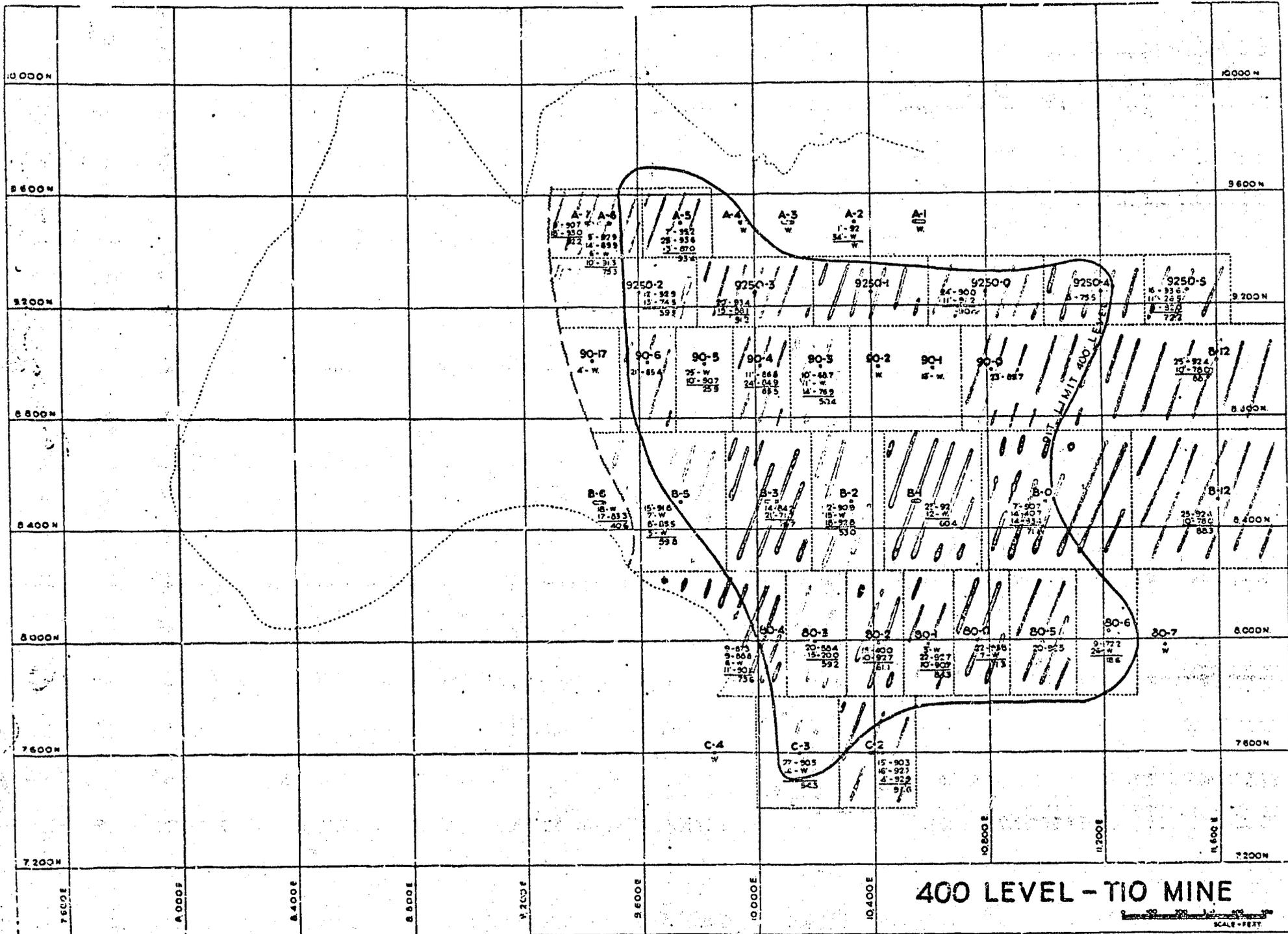


505 LEVEL - TIO MINE

● ASSUMED

SCALE - FEET

FIG. 19



A-1
1-97
34-W

A-2
1-97
34-W

A-3
W

A-4
W

A-5
7-952
28-938
3-970
938

A-6
1-907
8-330
11-899
12-899
6-W
10-913
753

9250-1
11-914
12-921
914

9250-2
11-929
12-743
597

9250-3
12-914
12-921
914

9250-4
24-900
11-912
107

9250-5
6-938
11-938
8-938
727

90-1
5-W

90-2
W

90-3
10-887
11-W
14-782
534

90-4
11-888
24-888
888

90-5
25-W
12-907
253

90-6
21-854

90-17
4-W

80-1
5-W

80-2
W

80-3
12-92
64

80-4
14-847
21-717
717

80-5
15-808
18-808
530

80-6
7-907
14-707
14-907
14-907
717

80-7
25-924
10-780
803

80-12
25-924
10-780
803

B-0
12-92
64

B-1
12-92
64

B-2
15-808
18-808
530

B-3
14-847
21-717
717

B-4
15-808
18-808
530

B-5
15-910
7-W
6-855
598

B-6
18-W
17-833
406

C-2
15-903
16-907
4-852
976

C-3
77-905
543

C-4
W

80-4
9-875
9-808
8-W
11-907
736

80-5
15-808
18-808
530

80-6
15-803
16-907
4-852
976

80-7
9-772
24-714
188

80-12
25-924
10-780
803

90-1
5-W

90-2
W

90-3
10-887
11-W
14-782
534

90-4
11-888
24-888
888

90-5
25-W
12-907
253

90-6
21-854

90-17
4-W

9250-1
11-914
12-921
914

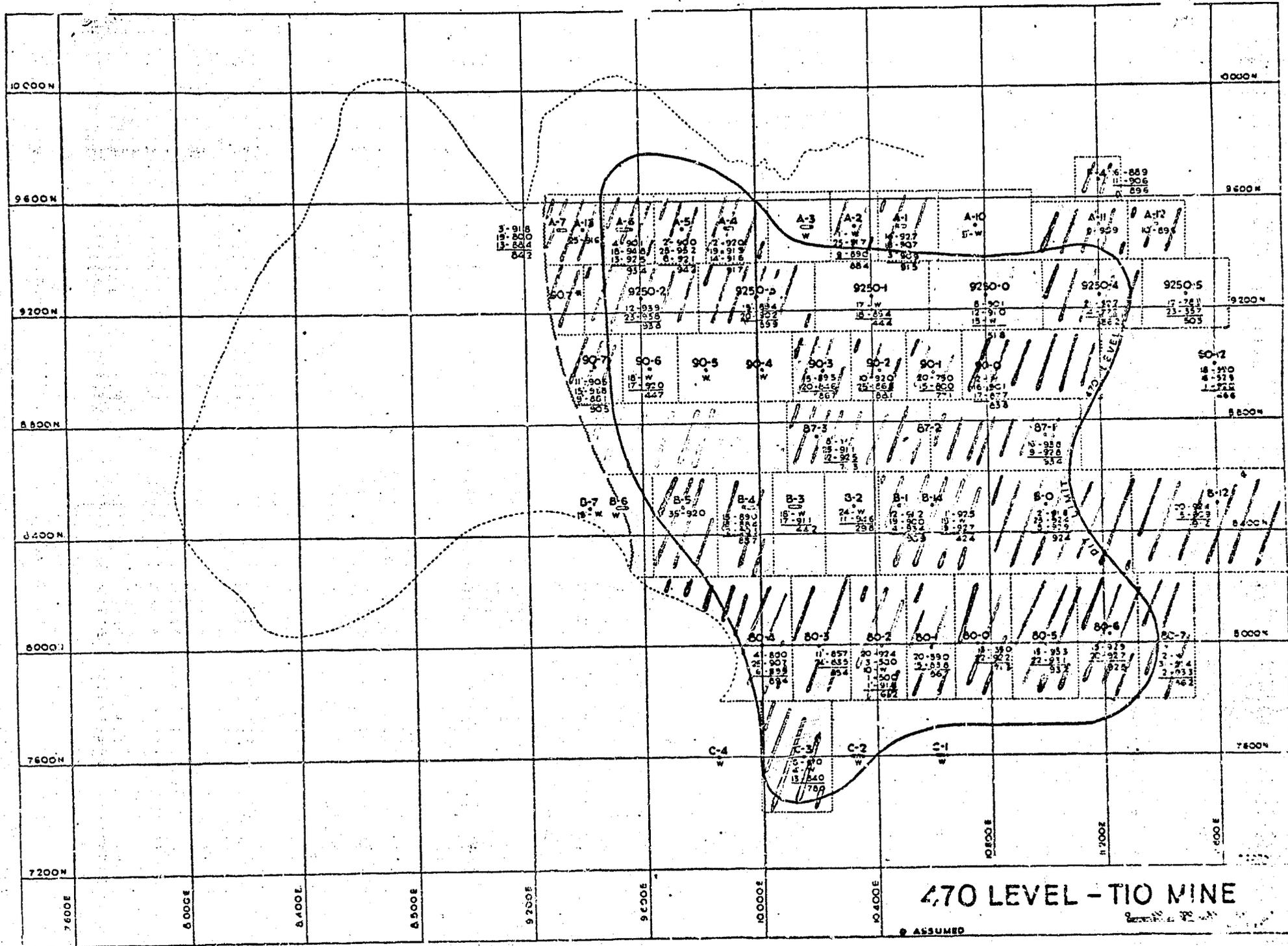
9250-2
11-929
12-743
597

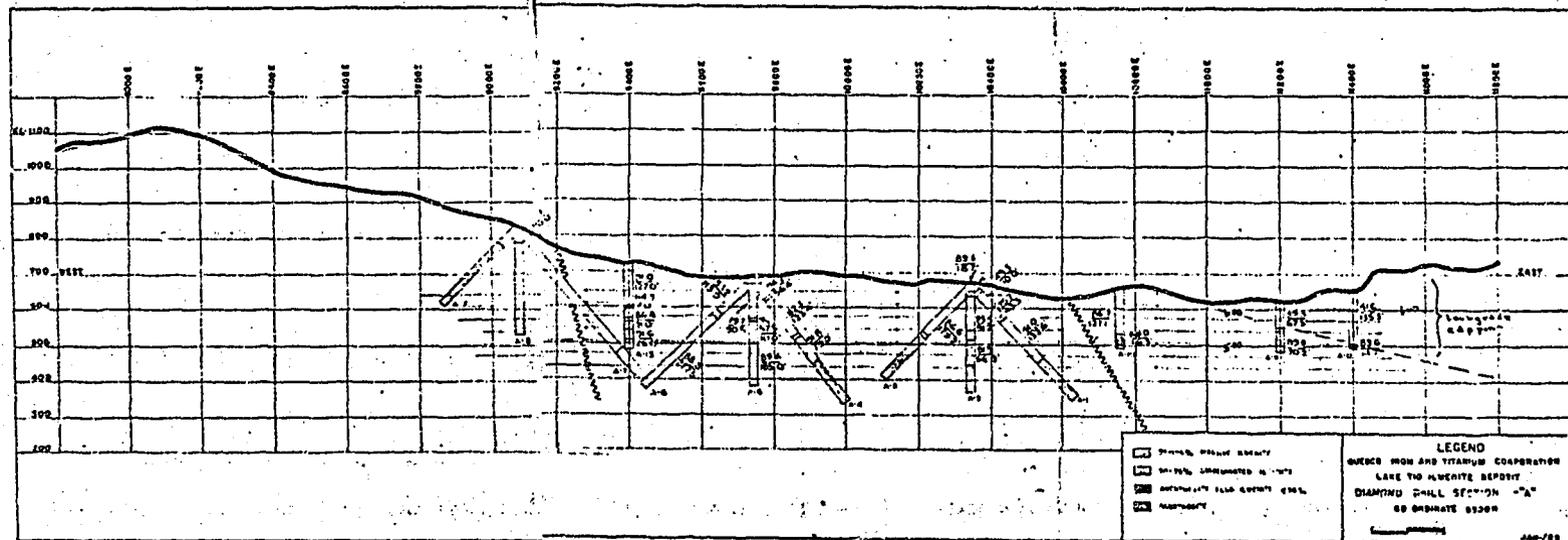
9250-3
12-914
12-921
914

9250-4
24-900
11-912
107

9250-5
6-938
11-938
8-938
727

LIMIT 400 LEVEL





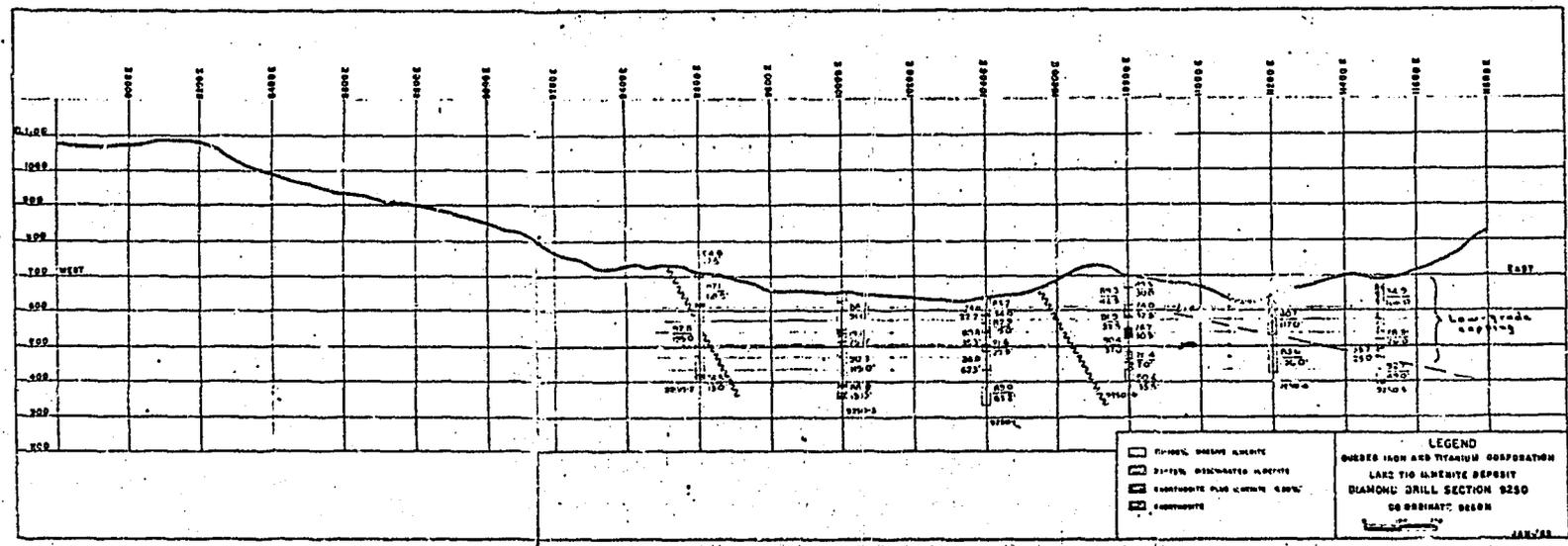


Fig. 1

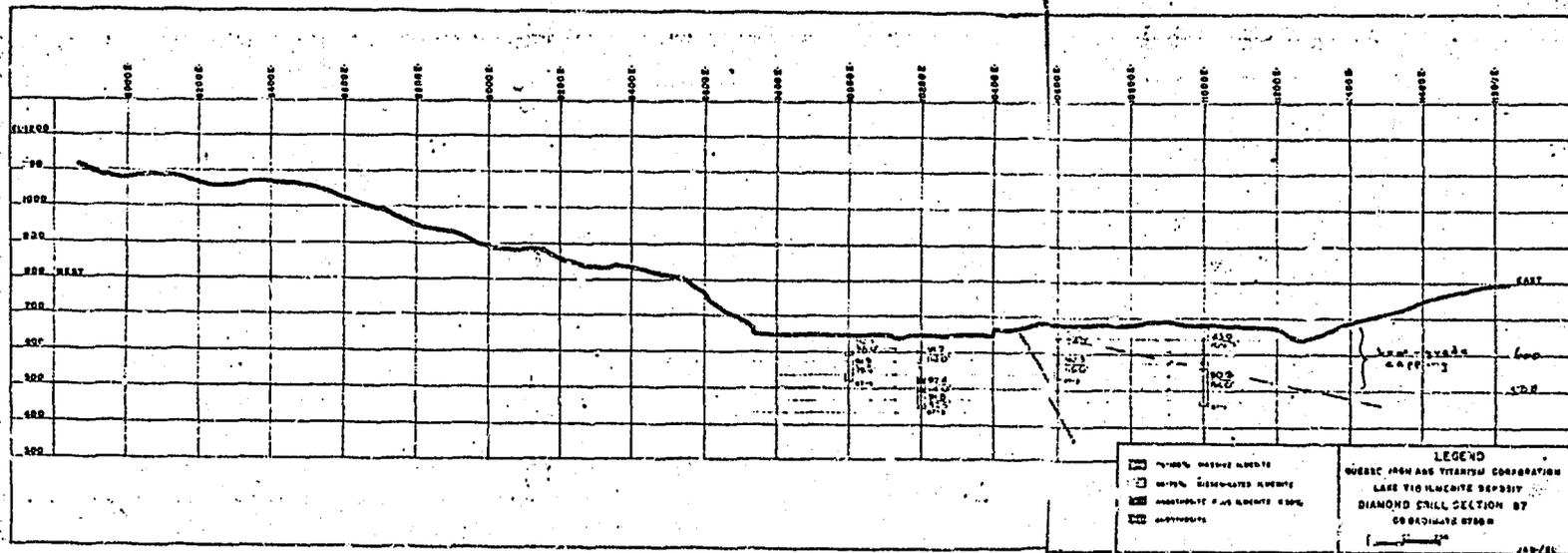
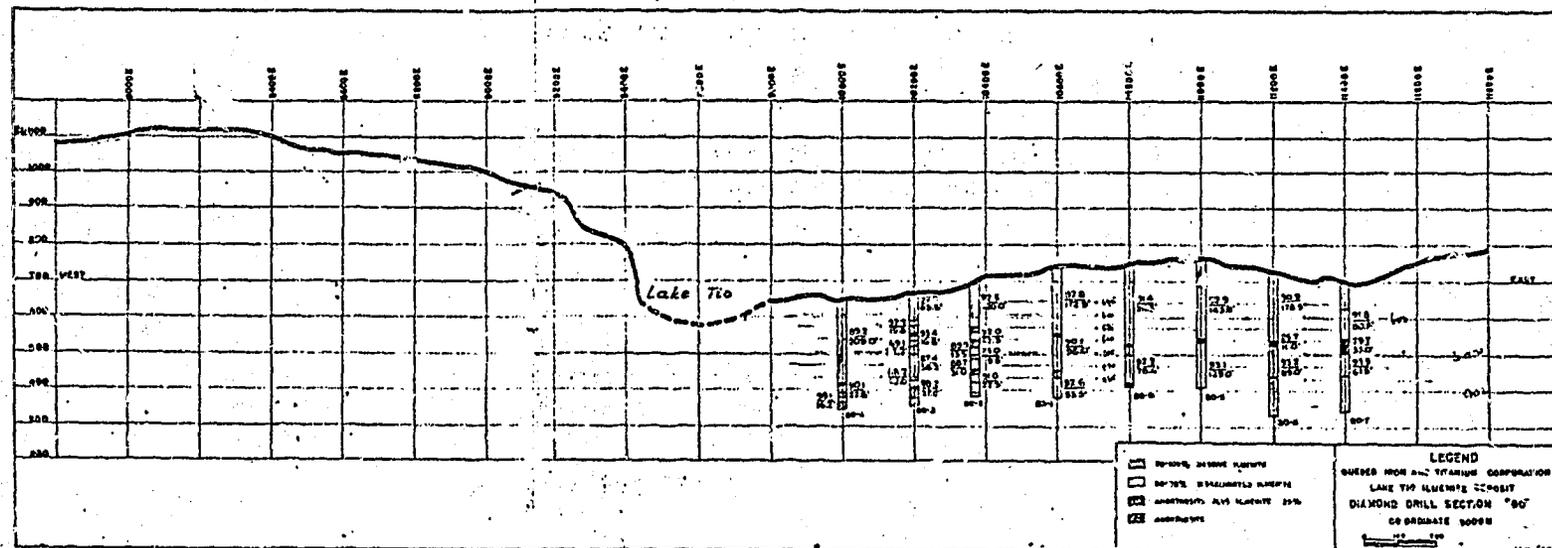


Fig. 26



10-100% DIAMOND DRILL SECTION
 50-75% DIAMOND DRILL SECTION
 25-50% DIAMOND DRILL SECTION
 0-25% DIAMOND DRILL SECTION

LEGEND
 QUERES MIN AND TITANIUM CORPORATION
 LAKE TIO ALUMINA CONCENTRATOR
 DIAMOND DRILL SECTION "80"
 COORDINATE 90000
 1" = 100'