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GEOLOGY AND GEOCHEMISTRY OF THE ORE DEPOSITS AT VAUZE MINE

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QUEBEC DEPARTMENT OF NATURAL RESOURCES

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GEOLOGICAL REPORT

GEOLOGY AND GEOCHEMISTRY OF THE ORE DEPOSITS AT THE VAUZE MINE, NORANDA DISTRICT, QUEBEC

by

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INTRODUCTION

General Statement

The genesis of ore deposits of massive sulfide type in the Noranda area and their relationship to intrusive bodies have been the subject of numerous discussions. Most of the arguments were summarized by M.E. Wilson (1941). Since that time, four additional orebodies have been found: the East Waite, Quemont, Vauze, and Lake Dufault deposits.

The Vauze mine, which is the subject of this study is a small deposit of about 380,000 tons of ore. The country rock is relatively undeformed and regional metamorphism is of low grade. Detailed geological mapping on surface and underground was available and sufficient ore was still in place in 1963 for the present study.

The first part of this report concerns a geologic description of the deposits and country rock in the immediate vicinity of the Vauze mine and draws some conclusions on the origin of the ore. The second part concerns geochemistry of the country rock in the area of the Vauze orebodies.

Location and Access

The Vauze mine is situated in the Noranda mining district about 10 miles north and slightly west of the town of Noranda. It is located in Dufresnoy township at latitude 48°21'36"N and longitude 79°05'00"W. The surface plant of Vauze Mines Ltd. can be reached by a secondary road branching west from highway no 46 at a point 6 miles north of Noranda.

Topography

The level of Waite lake at 1,085 feet above sea level is the lowest elevation on the property. The mine area is surrounded by hills formed by resistant rock units with a breach in the eastern part. The highest point reaches 1,400 feet and is situated south of the mine in an area underlain by andesitic volcanic rocks. The area north of the mine is underlain by diorite which forms a hill with an elevation of about 1,370 feet. Except for swamps in the mine area, along the shores of Waite Lake, and to the east and northeast of the mine, bedrock outcrop is abundant forming about 25% of the surface.

History

Before the ore deposit was discovered in 1957, the property underwent several changes of ownership. In the

mid 1940's Mr. J. W. Forrest of Toronto and associates obtained claims in the area and consolidated them into one unit. In 1945, a new exploration company, Vauze Dufault Mines Ltd., acquired control of the property which consists of 33 claims covering an area of 2,840 acres in Dufresnoy township, with one adjoining claim in Duprat township. Geological and geophysical surveys were completed in 1945-46, and 1950-52. Seventy-seven holes were drilled and no significant commercial mineralization was found. In March 1956, an agreement was reached with the Consolidated Zinc Corporation of Canada Ltd., and following a reorganization, the name of the company was changed to Consolidated Vauze Mines Ltd. After detailed geological study and mapping under the direction of the Consolidated Zinc Corporation of Canada Ltd., drilling began in 1957. The first hole, V-77, intersected two feet of sulfides at a depth of 247 feet assaying 4.9% copper, 2.7% zinc, 1.74 oz. of silver per ton, and 0.03 oz. of gold per ton. Twenty holes were drilled in this program and a small massive sulfide deposit, known as the B-1 zone, was outlined. In 1958, drilling indicated an additional ore zone known as the B-2 zone. After further detailed drilling, reserves were estimated at 105,750 tons of ore grading 0.70% copper, 4.95% zinc, 2.28 oz. silver per ton, and 0.065 oz. gold per ton. In March 1960, shaft sinking began and subsequent underground development and exploration indicated ore reserves as

follows: (1) B-1 Zone: 144,000 tons of ore containing 6.0% copper, 4.7% zinc, 2.2 oz. silver per ton, and 0.054 oz. gold per ton; (2) B-2 Zone: 44,000 tons grading 2.5% copper. On the basis of these reserve figures, construction of a mill began in May 1961. In March of the same year, Vauze Mines Ltd. acquired Consolidated Vauze Mines Ltd. and two and one-half claims covering the mineralized area were converted to a mining concession (November 23, 1961). In August 1964, Sheridan Geophysics Ltd. of Toronto purchased a controlling interest in Vauze Mines Ltd. In the spring of 1965, Vauze Mines Ltd. was purchased by interests in the United States who ~~are~~ changed the name to North American Gas Ltd. The Vauze property is being retained by Sheridan Geophysics Ltd.

Production began on October 1, 1961. E. P. Graham (1964), mine manager at the Vauze Mine during most of the life of the mine, gives a full account of the history of mining, shaft-sinking, and milling operations including cost figures.

In october 1963, the B-1 zone was mined out and zinc production ceased. After 40 months of production, the mine was closed on January 31, 1965. Final production figures are shown in Table I. The B-1 zone produced about 163,000 tons of ore which contained 4.3% copper, 3.9% zinc, 0.035 oz. of gold per ton, and 1.56 oz. of silver per ton. The B-2 zone produced about 191,000 tons of ore containing 1.9% copper,

negligible zinc, 0.008 oz. gold per ton, and 0.20 oz. silver per ton.

TABLE I

TOTAL PRODUCTION - VAUZE MINES LTD.

Year	Tons Milled	Value of Metals ($)	Dividends ($)
'61	22,301	673,883	
'62	109,242	3,469,285	
'63	115,878	2,648,708	183,000
'64	125,965	*	
'65	11,372		
Total	384,758		

Year	Oz. Au	Oz. Ag	lbs. Cu	lbs. Zn
'61	751	31,648	1,962,808	405,202
'62	3289	100,593	9,704,818	3,451,970
'63	2148	87,478	7,002,110	3,482,568
'64	986	15,902	3,328,000	**
'65	161	1,384	331,556	
Total	7335	297,005	22,329,292	7,339,740

* Awaiting shipment of concentrates of metals to Europe to determine value for 1964-65

** Zinc production ceased at the end of October, 1963.

Acknowledgements

The writer wishes to thank the authorities of Vauze Mines Ltd. for allowing the study, giving access to mine maps and record and providing assistance in many other ways. C.D. Spence geologist for the Consolidated Zinc Corporation was particularly generous of his time and without him the study would not have been possible. W. Unto Jarvi, mine geologist E.P. Graham mine manager and D. Valentine, mine superintendant were all very cooperative.

Noranda Mines Ltd. through Dr Peter Price, provided financial support for a large part of the geochemical work.

I have appreciated the helpful assistance of Jean Descarreaux during the field season of 1963 and J. Fashakin for several months in 1964.

A graduate student at McGill, H.C. Sakrison, who was working on a somewhat similar project at Lake Dufault Mines Ltd. laid the groundwork for many sample preparation techniques and analytical procedures of volatile trace elements.

Finally, I thank my thesis director Dr. J.E. Gill for invaluable advices.

PREVIOUS WORK

M. E. Wilson's memoir (1941) on the Noranda District, Quebec is a classical description of the area. The Vauze Mines Ltd. property is contained within the accompanying Waite Area Map (455A) which is of a scale of 1 in. to 800 ft. Wilson describes the rock types in the area and establishes the basis for stratigraphic nomenclature of the various rock units.

Geological mapping was done in 1945 and 1946, when the property was held by Vauze Dufault Mines Ltd. When the property came under the control of the Consolidated Zinc Corporation, the property was remapped under the direction of R. C. J. Edwards. A large part of the mapping was done by C. D. Spence in 1956, 1957, and 1958, with the aid of air photos at a scale of 1 in. to 200 ft. His geological map of the property is presented as Plate I. R. C. J. Edwards, C. D. Spence, and Unto Jarvi, completed most of the underground geological mapping of the mine. Compilations of their maps are presented as Plates II, III, IV, V, VI, and VII. A good part of the geological data presented in the first part of this report is a result of the work of these men, particularly C. D. Spence. In addition, many of the ideas concerning origin of the ores were proposed by them.

The study of thin sections of the wallrock polished sections of the ore, and the mapping at a scale of 1 in. to 10 feet of certain underground workings, are the author's contribution to the basic data of this report.

In the field of geochemistry, several rock analyses of rhyolite, andesite, gabbro and granite are included in Wilson's report. Schindler (1933) studied the Waite area and concluded that some of the rocks were spilites because of the high content of Na_2O and the low content of K_2O. Riddle (1952) completed an extensive study of alteration of the wall rock for the base metal deposits of the area. He was able to classify various types of alteration based on different types of deposits.

PART I - GEOLOGY

GENERAL STATEMENT

The Vauze mine is in Precambrian terrain of the Superior Province. The Waite Lake area (Plate I) as mapped in detail by C. D. Spence forms the basis for a presentation of the geology of the area around the Vauze ore deposits. This work and that of Wilson (1941) served to establish the local stratigraphy which is now used by geologists of the Consolidated Zinc Corporation and of most mining companies in

the Noranda area. The description of the various rock types is based on observation of these units in the field and in diamond drill cores. Many of the outcrops shown on the Waite Lake area map were visited and the author is responsible for the conclusions drawn from the map.

STRATIGRAPHIC TERMINOLOGY

Wilson, in his 1941 report, did not propose formally a stratigraphic nomenclature for the Noranda district. However, he named various rock units on Figure 1, p. 7 and suggested correlations in his Table II, p. 25. The units under consideration in the Waite Lake area were named by Wilson as the Waite Hill andesite, Waite Lake rhyolite, Waite Lake siliceous rhyolite, Amulet rhyolite, Vauze Lake rhyolite, Vauze Creek andesite, Vauze Creek rhyolite, and the Dufresnoy diorite mass. Edwards (1960) proposed a slightly different nomenclature based on additional subsurface information (Table II). In Wilson's report (1941, Table II, p. 25), the Amulet rhyolite was considered one unit, but the Waite Hills-Amulet Hills-Vauze Creek-Powell-Pontiac andesites were considered a single unit when thickness was calculated. The Vauze Creek-Waite Lake rhyolite are treated as correlative, but the Vauze Lake and Waite Lake siliceous rhyolites are considered separately. Diamond drill hole information shows

that the unit which was called by Wilson the Waite Lake siliceous rhyolite continues in subsurface much further to the south, at least as far as the former East Waite ore body. The andesite which occurs above the Waite Lake siliceous rhyolite is a separate unit from that which occurs below. Edwards suggests, first of all, that the Waite Lake rhyolite and Waite Lake siliceous rhyolite be grouped and considered as part of the same period of rhyolitic volcanic activity ~~is~~ are that this unit be called the Waite rhyolite. In addition, the andesite that occurs above the Waite rhyolite is correlative to at least the upper part of the andesite in the Amulet area and therefore, ~~h~~he suggests that this andesite be named the Amulet andesite. The andesite which occurs below the Waite rhyolite is then called the Waite andesite. On surface, the stratigraphic sequence outlined by Edwards is well established in the Waite Lake area west of the large N-S diorite dike. Since correlations to the north of the Vauze mine and east of the diorite dike are uncertain, the nomenclature established by Wilson is retained. To the south of the surface pinchout of the Waite rhyolite, it is difficult, if not impossible, to distinguish between the Amulet and Waite andesites.

TABLE II

NOMENCLATURE OF SEVERAL VOLCANIC ROCK UNITS IN THE WAITE LAKE AREA

Geologic Age	Wilson (1941)	Edwards (1960)	
Lower Precambrian (Archean)	Waite Hills andesite	Amulet andesite	
	Waite Lake Siliceous Rhyolite Waite Lake Rhyolite	Waite Rhyolite	MINE SERIES
	Waite Hills andesite	Waite Andesite	
	Amulet Rhyolite	Amulet Rhyolite	

Edwards points out that many, and perhaps all the orebodies in the Noranda district are found within these four stratigraphic units and therefore has called this series of volcanic units the "Mine Series".

The following discussion of the volcanic rocks deals with the "Mine Series" as proposed by Edwards (Table III). On the basis of a detailed examination of diamond drill hole number V-77 (Consolidated Vauze Mines Ltd.,) a further subdivision of the Waite rhyolite has been made. Diamond drill hole V-77 was collared in diorite, penetrated about 110 feet of Amulet andesite, the entire Waite rhyolite and Waite andesite, and the upper 200 feet of the Amulet rhyolite. It was drilled to a depth of over 3,000 feet.

TABLE OF FORMATIONS

WAITE LAKE AREA

CENOZOIC	Unconsolidated sediments	Glacial and post-glacial deposits
PROTEROZOIC	Intrusive rocks	Diabase dikes
ARCHEAN	Intrusive rocks	"Steep" (Dufresnoy) diorite "Flat" diorite "Metadiabase" dikes Minor intrusive rocks (various ages)
	Volcanic rocks	Amulet andesite Waite rhyolite Vauze Mine Breccia Upper member Lower member Transitional dacite Waite andesite Amulet rhyolite

VOLCANIC ROCKS - "MINE SERIES"

Amulet rhyolite

The basal unit of the "Mine Series" is not exposed in the Waite Lake area and only about the upper 200 feet is penetrated by D.D.H. no. V-77. It was not studied as thoroughly as the other units. In general, the Amulet rhyolite is texturally more diverse than the Waite rhyolite. An outcrop southwest of Waite Lake near Dune creek shows a 200-feet thick section that may be of pyroclastic origin. Amygdules are common and, in places, so abundant as to indicate an original scoriaceous texture. Flow-top breccias are common. The rock is medium gray* with a bluish tinge on fresh surface, and it weathers to light bluish gray to pale blue-green. This unit is parallel to the upper units, striking about north-south and dipping about 30°E.

Waite andesite

The entire Waite andesite transected by D.D.H. No. V-77 produced 1,510 feet of core. Assuming a dip of 40°, this represents a true thickness of about 970 feet. In the Waite Lake area, this rock unit outcrops northwest of Waite Lake. The attitude and shape of pillows indicate a strike of N15°W to N20°E and dips of 15° to 40°E. The andesite is

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* All color descriptions are taken from the Geological Society of America's rock color chart.

usually light greenish gray to greenish gray, and weathers yellowish gray to grayish orange. The unit is remarkably uniform in texture and composition. Pillows are well developed and commonly contain radial amygdules. Flow-top breccias, amygdules filled with quartz and epidote, are common textures, and massive andesite units and a few thin tuff units are interbedded with pillowed units. The pillowed units are most abundant in core samples. From thin section examination, the major constituents are quartz, chlorite, epidote, plagioclase (probably albite), and actinolite. Minor constituents usually are pyroxene or uralite, calcite, rutile, and leucoxene with traces of ilmenite. The grain size is usually very fine, less than 0.01 mm. Relict plagioclase laths are fine grained also measuring about 0.03 by 0.01 mm. Quartz and epidote in amygdules are coarser grained. The contact between the Amulet rhyolite and the Waite andesite is marked by a thin bedded fine tuff that contains pyrite along bedding planes.

Transitional Dactic Rock Unit

Between the Waite andesite and the stratigraphically upper Waite rhyolite in D.D.H. No. V-77, 75 feet of core (approximate true thickness of 50 feet) consist of a medium-dark gray to moderate red, hard, and characteristically flow

brecciated rock. The matrix is darker colored than the fragments. In subsurface, this unit is correlated to that portion of the Waite rhyolite mapped by Spence as ribbon breccia south of Waite Lake and west of the northeasterly trending fault. The surface outcrops are ~~striking~~ spectacular. Large, light to medium gray, rounded, rhyolitic fragments up to several feet in diameter occur in a darker green flow-laminated matrix that contains quartz-filled circular spheres up to 1 foot in diameter. Some spheres have cavities in the center lined with quartz crystals; others have silica concentrically layered like agate.

Thin section studies of core samples from this unit show plagioclase phenocrysts in a fine-grained, mesh-work of relict plagioclase laths. The grain size of the matrix is less than 0.09 mm. and the phenocrysts are up to 0.5 mm. in length. A few partially altered phenocrysts are sodic oligoclase (An_{11}). Major constituents are plagioclase, epidote, and chlorite with minor clear mica, actinolite, and opaque minerals. Traces of rutile, ilmenite, sphene, and carbonate occur.

The textures of this rock resemble that of the andesites rather than that of the rhyolites. The sodic content of the plagioclase indicates a dacitic composition.

The contact between the transitional dacite and the Waite andesite or the upper Waite rhyolite is not sharp and is not marked by a tuffaceous unit.

Waite rhyolite

The rocks of this unit, which underlies the ore deposits outcrop mainly south of Waite Lake in the southwest corner of the Waite Lake area (Plate I). The rhyolite that outcrops east of the N-S diorite dike in the southern half of the map is considered correlative to the Waite rhyolite in the Vauze mine area. In general, the unit strikes N20° to 30°E and dips about 30°SE. The initial study of the rock unit in D.D.H. No. V-77 indicated 4 members. Subsequent thin section studies showed that the original lower member, which is considered correlative to Wilson's Waite Lake rhyolite, is sufficiently different to constitute a separate unit. The Waite rhyolite has, therefore three members separated mainly by textural features.

Lower Member. The lower member of the Waite rhyolite is the thickest member. It is exposed in 375 feet of core from D.D.H. No. V-77. Assuming a dip of 40° this represents a true thickness of about 240 feet. The lower member is typically a medium to light gray, massive, flinty rock. It contains a few thin beds

(less than 10 feet) of moderate red, flow-banded rhyolite. No attempts were made to subdivide surface exposures of the Waite rhyolite into lower and upper member but, in general, the outcrops seem to be more representative of the lower member. They consist of light-gray, massive and flinty rock and, in places, of spherulitic (?) or flow-brecciated siliceous rock. The thin section photograph of Plate P-4, although typical of many rhyolitic rocks, is more representative of the lower member. This flinty rock is formed by an interlocking, very fine-grained mixture of quartz and albite with minor scattered grains of calcite, magnetite, chlorite, clear mica, and epidote. Grain boundaries are irregular and serrated. Coarser-grained areas of quartz may represent a remnant scoriaceous texture. A ~~mixed~~ scoriaceous, spherulitic texture is represented in Plate P-5.

Upper Member. The upper member of the Waite rhyolite as observed in D.D.H. No. V-77 characteristically is a pink, flow-banded rhyolite. The 225 feet of core represent an approximate true thickness of 145 feet. This member is well exposed in underground workings, particularly on the 4th level (Plate V). In the mine area, it has a moderate red to mederate reddish brown color. The reddish coloured rhyolite was not seen in outcrops of the Waite rhyolite which is usually medium

to medium-dark gray and weathers to a lighter shade of gray. The flow bands are highly contorted and of variable thickness averaging about 5 to 10 mm. Thin sections of the rhyolite show a very fine-grained mixture of quartz and albite with minor amounts of carbonate, sericite, chlorite, magnetite, and very fine-grained hematite dust inclusions (Plate P-4). The banding is formed by concentrations of dark minerals - mainly chlorite and carbonate - along sub-parallel curved surfaces. The specimens contain here and there a relict phenocryst of plagioclase up to 2 mm. in length.

Vauze Mine Breccia Member. This member is not exposed on surface but is found in underground exposures (plates III and IV) and in diamond drill holes. It is an important member because it is restricted to the area underlying the ore deposits of the Vauze mine. Edwards and Spence (oral communication) have indicated that the Waite rhyolite thickens in the vicinity not only of the Vauze deposits, but also of other deposits in the Noranda district. The thickening in the Vauze mine area is due in large part to the presence of the Vauze mine breccia which attains a maximum thickness of about 170 feet. The ore deposits occur at the stratigraphic top of the unit. The Vauze mine breccia is formed of subrounded to angular fragments that are up to several feet across. The large fragments locally

are abundant but the average size is about 2-3 in. in diameter (Plate P-9). The rock is usually light to medium gray and the fragments are lighter-gray than the matrix. In places, as shown on Plate P-9, the fragments were picked up from pre-existing rhyolite flows and incorporated into the pyroclastic breccia. A portion of the breccia contains sulfide fragments and will be discussed under the section of this report dealing with the ore deposits. At the top of the breccia, interbedded fine to coarse tuff and chert commonly occur. In an outcrop, near coordinates 19,000 N and 3,000 E (Plate I), the interbedded tuff and chert unit is exposed. The unit which may be the stratigraphic equivalent of the Vauze Mine breccia is about one foot thick and has individual beds less than 4 mm. thick. Pyrite, pyrrhotite and a trace of chalcopyrite are concentrated along bedding planes.

Thin section studies of the matrix of the breccia indicate a pyroclastic origin (Plate P-2). The rock is composed of shard-like fragments in a siliceous matrix. Quartz, epidote, and calcite are major constituents with minor amount of sericite, chlorite, and ore minerals. Plate P-3 is a photomicrograph of the tuff that occurs at the contact. There is a strong similarity between the textures in the tuff sample and the breccia. The fragments are very sharp and long. Only the larger fragments (Plate P-9) show any rounding. There is no

apparent orientation of fragments and the matrix is formed by recrystallized silica. The matrix or cement most have been introduced at an early stage or deposited almost contemporaneously in order to prevent settling and alignment of particules and breakage of the fragile needle-like fragments. The evidence indicates a water-laid origin for the tuff and pyroclastic breccia.

Amulet Andesite

The upper unit of the "Mine Series", the Amulet andesite, outcrops south of Waite Lake on both sides of the large diorite dike (Plate I). The attitude of pillows and several internal flow contacts indicate a strike of N10° to 30°E and a dip of 20 to 40 SE. The unit is formed by a series of interbedded pillowed lavas and massive flows, with some flow top breccias and tuffs. The rock is greenish-gray to medium-gray and weathers, like most andesites in the area, from a light brown to a moderate yellowish brown. In D.D.H. V-77, the basal section of the Amulet andesite (177 feet) is a medium to light gray, aphanitic rock with quartz and chlorite amygdules. The 35 feet of andesite above the Waite rhyolite-Amulet andesite contact is medium to light gray, massive, and

contains, in places, feldspar phenocrysts that are up to 4 mm. long. If a 40° dip is assumed, the true thickness of this member is 22 feet. It is exposed in underground workings on the 3rd level (Plate IV) and was observed in surface exposures but its continuity is not established. On surface and on the 3rd level, this member is 15 to 20 feet thick and is capped by a layer of interbedded tuff and chert up to one foot thick. In a surface exposure near coordinates 21,000 N and 4,000 E (Plate I), it is pillowed, and the interpillow material is heavily mineralized with pyrite and pyrrhotite.

Portions of the andesite are "dioritized", as a result of contact metamorphic effects along large diorite dikes. Near the diorite-andesite contact, fractures and faults cut the andesite. The andesite becomes progressively coarser-grained as the fault or fracture plane is approached. This indicates that solutions and heat derived from the diorite can change an andesite to a diorite-looking rock. Dioritization of andesite can be pervasive, changing an entire andesite section into diorite, and can extend up to several ten's of feet into the intruded rock. Only remnant volcanic textures, such as pillows, can be used to distinguish between the two rock types. Andesite is most easily dioritized but "dioritized" rhyolite was seen on the 4th level of the mine

in the 4-229 south cross-cut. The Amulet andesite is estimated to be 20% dioritized for the first 140 feet of core. There are indications that this section is pillowed.

Thin section studies of the Amulet andesite generally show uniform textures and mineralogy and very little apparent change in composition. Amygdules as large as 10 mm. are generally filled with quartz, but a few are filled with chlorite or epidote. Although most of the original minerals have been altered by low grade regional metamorphism, textures usually are well preserved. The Amulet andesite is holocrystalline, fine-grained (less than 1 mm.), and porphyritic. Remnant plagioclase phenocrysts are up to 2 mm. in size. The grain size of the plagioclase ghosts in the matrix is only about .03 by .01 mm. (Plate P-1). The rocks are composed of a very fine-grained mixture of actinolite, chlorite, and quartz with minor albite and epidote. A few thin sections contain only partially altered plagioclase. The unaltered plagioclase is usually sodic andesine (An_{32}). The plagioclase laths usually are aligned in one direction along flow lineations, but not in the basal unit of the Amulet andesite (Plate P-7). The rock contains enough modal quartz (18%) to be called a dacite. Much of the quartz is contained in amygdules and it is difficult to ascertain whether the quartz is primary or secondary. Riddell (1952) was confronted with the same problem and, on the basis

of chemical analysis and section studies, concluded that most of the quartz was derived from the alteration of primary minerals.

In the vicinity of the ore deposits, the overlying andesite commonly is bleached over a thickness of less than 3 inches. A bleached andesite zone also occurs above the tuff-chert bed which caps the basal unit of the Amulet andesite. The bleached andesite, as seen in thin section, is a very fine-grained mixture of quartz, carbonate, chlorite, and sericite with minor amount of pyrite, actinolite, plagioclase (probably albite) and epidote.

INTRUSIVE ROCKS

General Statement

Wilson in his Table of formation (1941, p. 6) lists seventeen different ages of intrusives. There are more than seventeen rock types if variations within age groupings are considered. In the Waite Lake area, Spence (Plate I) subdivides the intrusive rocks into four classes: (1) minor intrusives and veins, (2) diorite, (3) meta-diabase and (4) diabase. The rocks considered here are the main intrusions in the area and those which directly affect the ore deposits at the Vauze mine. The only major intrusion that does not occur in the immediate vicinity of the Vauze mine is the Proterozoic N-S trending diabase dike.

Campbell (1962) has outlined the relative ages of intrusion in the Noranda district. The volcanic rocks were intruded first by diorite, then by granite and finally by diabase. He gives the age of intrusion of the diabase dikes as 1,740 million years and that of the diorite dikes as about 2,400 million years. In the Vauze mine area, the intrusive sequence (Table III) is in agreement with both Wilson and Campbell. The Proterozoic diabase dike intrusion was preceeded by diorite intrusion of two ages. The large N-S trending diorite mass, called by Wilson, the Dufresnoy diorite mass, is the youngest and is locally called the "Steep" diorite from its attitude. The "Flat" diorite has irregular contacts but, except at a few places, the dip is very low. The metadiabase dikes in the mine vicinity are older than diorite intrusion. The oldest intrusive rocks are those directly related to the deposition of volcanic rocks.

Minor Intrusives

Numerous minor intrusives rocks of diverse composition occur in most rock types in the Waite Lake area. Several of these, noted on the 4th level (Plate V), have the texture and composition of diorite and are probably associated with the "Steep" diorite. Two fine-grained siliceous dikes penetrated part of the ore body (Plate X). The dikes are about

one foot wide and terminate near the top of the ore zone. They were faulted and the fractures filled with quartz and minor chalcopyrite and pyrite. Near the edges of the dike, flow laminations were found. Thin section examination shows that the rock is formed of extremely fine-grained (less than 0.01 mm.) minerals. Quartz is the most abundant mineral possibly with some very fine-grained plagioclase. Chlorite is common with minor disseminated pyrite cubes which are more abundant near the contact. The dikes probably are related to the extrusion of rhyolite and were intruded after the deposition of the ore. The chalcopyrite that occurs in the crosscutting fault zones contains a minor quantity of small (less than 0.01 mm.) blebs of pyrrhotite whereas the chalcopyrite that occurs in the ore zone usually contains abundant pyrrhotite and a minor quantity of sphalerite. The chalcopyrite in the fault zones that cut the siliceous dike is believed to have been remobilized from the ore zone at the time of the dike intrusion.

Metadiabase

Intrusive rocks that are darker colored and finer-grained than diorite but coarser-grained than andesites, with abundant magascopic laths of plagioclase, are called diabase or metadiabase dikes. Many of these dikes occur within volcanic sequences of andesitic composition (Plate I). In the mine area, a metadiabase dike has a maximum thick-

ness of about 225 feet. Where the dike cuts the ore deposit, it is about 150-200 feet thick. Altered rhyolite xenoliths of the wallrock were observed on the 5th level. On fresh surface, the metadiabase is medium dark gray to dark greenish gray and fine grained. In thin section the rock is seen to be composed of a non-oriented meshwork of altered plagioclase laths in a dark very fine-grained matrix. Clear euhedral grains of quartz are common and probably represent quartz deposited at low temperatures. The average length of the relict plagioclase laths is about 0.4 mm. The major components are epidote and actinolite (in places andesine (An_{33})) with minor amount of quartz, chlorite, uralite and clear mica. Accessory minerals are pyrite, ilmenite, leucoxene after sphene, apatite and zircon. Calcite may be present in minor quantities - up to 10% by volume. There are no major variations between the metadiabase dike that occurs in the vicinity of the ore deposits and that which occurs in an area 500 feet away from the deposits. The dike rock near the ore deposit contains an estimated 2% more quartz and 4% more chlorite and also more uralite and unaltered plagioclase. Such variations are common in intrusive rocks and connot be attributed to alteration by hydrothermal solutions. Adjacent to the metadiabase dike, a rock composed of over 75% chlorite and fine-grained, highly birefringent clear mica represents altered rhyolite from the lower and upper members of the Waite rhyolite. Solutions which

so greatly altered the rhyolite certainly would have altered the "metadiabase" dike to a much greater extent.

It is concluded that the "metadiabase" dike, which is altered by regional metamorphism, is cut by the "Flat" diorite, and contains xenoliths of chloritized and sericitized Waite rhyolite, is post-ore.

"Flat" Diorite

The "Flat" diorite is the older of the two major diorite dikes. The relative age relationship was established on the basis of information provided by cores from a series of holes drilled in the vicinity of 23,000 N and 5,000 E (Plate I). The distribution pattern of the mass in the Waite Lake area is irregular but it has an east-west trending long axis. The general attitude of the "Flat" diorite mass is horizontal with an irregular base. Locally, the dip of the contact is as high as 80°, but, in general, it varies from 20° to 45°.

Thin sections show that the "Flat" diorite is more highly altered than the "Steep" diorite. Feldspars are altered with few exceptions to epidote. Original textures are well-preserved, but original minerals are altered. Thin sections taken from fine-grained, flow-banded diorite in the

chilled margin zone contain unaltered feldspar (andesine (An_{34})). In general, the major constituents are epidote and uralite, and, in places, plagioclase. The minor components are chlorite, actinolite, quartz and chlorite with calcite, zircon, magnetite and leucoxene as common accessory minerals.

"Steep" Diorite

The youngest diorite mass is the "Steep" diorite. It is a N-S trending dike, about 2,000 feet thick, that dips 80-85 E. From evidence of surface exposures and drill cores, the "Steep" diorite is formed by a minimum of three intrusions of similar composition. Internal chilled margins are common. The footwall contact is marked by a fault zone which varies from a few inches to tens of feet in width and contains abundant disseminated cubes of pyrite, in addition to traces of chalcopyrite. In the 4-229 south crosscut (Plate V) the fault zone is about 15 feet wide. Jarvi (oral communication) reports that massive sulfides were cut by the "Steep" diorite in a raise between the 3rd and 4th level. Studies of intrusive contacts in diamond drill cores in the vicinity of the Vauze mine indicate that the "Steep" diorite intruded the "Flat" diorite.

Megascopically, the unit is a medium to dark greenish gray, medium to coarse-grained rock on fresh surface. On weathered surface, the rock is a greenish gray to light brownish gray. In thin section (Plate P-8) the rock is holocrystalline, medium-grained hypidiomorphic-granular with plagioclase (An_{50-55}) and uralite as the most common constituents. Alteration has been almost pervasive. Plagioclase relicts up to about 30 mm. long are well preserved but the mineral has been altered mainly to epidote. Quartz, chlorite, and sericite are minor constituents. Actinolite commonly is a major constituent. Magnetite, ilmenite, apatite and sphene are typical accessory minerals. Alteration of minerals, particularly feldspar, is less pronounced in the finer-grained varieties which occur near contacts and form part of the chilled margins of the intrusive rock. There are variations within the intrusive. Some thin sections indicate that the rock is a gabbro in composition. The rock could be classified as a quartz gabbro or quartz diorite in some quartz-rich facies. The distribution of the various facies is not known.

Diabase Dikes

The diabase dike in the Waite Lake area is part of the McDougall dike (Wilson 1941, p. 46). Its width is from 20 to 50 feet and its attitude is near vertical.

The en échelon attitude of the dike is postulated on the basis of geophysical data.

Wilson describes the dikes as follows:

"All of the later diabase dikes are more or less brown coloured owing to the weathering of small scattered grains or crystals of pyrite. On freshly broken surfaces the diabase is a uniform, medium-grained, dark grey rock with a faintly speckled appearance. It consists chiefly of elongated to rectangular crystals of acid labradorite, augite filling the interspaces between the labradorite crystals and magnetite. In some thin sections, quartz, chiefly in micropegmatitic intergrowths with a feldspar of much lower refractive index, is present. In others quartz is entirely absent. The less common constituents are apatite, green amphibole, sericite and epidote, the amphibole being an alteration product from the augite and the epidote and sericite from the feldspar."

STRUCTURE

In the Waite Lake area (Plate I), the volcanic formations, have a general north-south strike and dip about 30°E. This probably is close to the attitude of the flows at the time of deposition. Only one is indicated; Major folds ~~are absent with on exception~~. An east-west trending axis of a broad, open anticline ~~is~~

~~indicated~~ lies just north of Waite Lake and west of the "Steep" diorite. Minor drag folds are associated with faults. The attitude of the contact between the Waite rhyolite and the Amulet andesite sharply changes in the vicinity of the Vauze ore deposits. South of Waite Lake and south of the "Flat" diorite cover, the contact strikes about N.20°E. and dips about 30°E. The change in attitude is caused by a thickening of the Waite rhyolite rather than by folding. The attitude of the basal contact of the Waite rhyolite in the same general area does not change.

No major regional faults occur in the Waite Lake area. Several minor faults that trend northeast-southwest are postulated in the southwest corner of the map (Plate I). Wilson (1941, p.51) infers a major east-west fault along the depression which contains Waite Lake and extends east of the lake. He points out the differences in the stratigraphy, particularly east of the "Steep" diorite. Correlations are obscure in this area but subsurface information does not seem to indicate a major fault west of the "Steep" diorite. The volcanic formations are continuous being interrupted only by diorite intrusion. The Waite andesite-Waite rhyolite contact can be traced north of Waite Lake. A fault is possible east of the "Steep" diorite where correlations are difficult to

establish and the attitude changes from a general northeast-southwest strike south of coordinate 23,500 N to a general northwest-southeast strike north of the 23,500 N coordinate.

Three minor faults are important in the Vauze mine area. Two faults cut one of the Vauze orebodies and are well exposed on the 1st level (Plate II). The fault to the east of coordinate 5,200 E and south of coordinate 22,600 N is a high angle reverse fault with right-hand strike slip of 50 feet. It strikes N 40°W and dips 70°E. The net slip is not known. The second fault, west of the first one, is a low angle, dip-slip, thrust fault. The net slip is about 47 feet. The fault plane curves from N 50°W to S 70°W and dips about 25°N. The ore deposits are drag folded by both faults which cut the "Flat" diorite. Neither fault can be traced for more than a few hundred feet. The third minor fault is a bedding plane fault. It occurs at the upper contact of the ore deposit and Amulet andesite, or where the ore is absent, at the Waite rhyolite-Amulet andesite contact. About 75% of all drill core that penetrated this contact and all underground exposures of the contact show evidence of faulting. It is a high to low angle, bedding, dip-slip, reverse fault. In the vicinity of the mine it strikes N 80°E and dips 30° to 60°S. The fault zone is less than an inch

to about 8 feet wide (Plate X). Horses of sulfides and andesite are common. The hanging-wall fault plane, which is the base of the Amulet andesite, formed the upper limit of mining and was well exposed. On this surface numerous slickensides and grooves indicate dip-slip movement. The fact that the bedding fault is cut by the two faults discussed above indicates that the bedding fault is the early fault. The final movement on the bedding fault was post-ore.

GEOLOGY OF THE ORE DEPOSITS AT THE VAUZE MINE

GENERAL STATEMENT

The Vauze mine was developed to exploit two zones of sulfide accumulation. The geology of each zone is distinct yet the two deposits may have been connected prior to the intrusion of diorite. The southern zone, called the B-1 zone or orebody, was composed generally of massive sulfides located just below the contact between the Waite rhyolite and the Amulet andesite. Portions of the Vauze mine breccia member of the Waite rhyolite form part of this ore zone. Major sulfide accumulations do not occur in the Amulet andesite. The northern zone, called the B-2 zone or orebody, is formed mainly of disseminated sulfides in chlorite. The host rock is chloritized and sericitized rhyolite from both the upper and lower members of the Waite rhyolite. The B-1 zone produced 163,000 tons of

ore that averaged 5.5% copper and 6.4% zinc. The B-2 zone produced 191,000 tons of ore that averaged 2.5% copper.

MINERALOGY

Pyrite

Pyrite and chalcopyrite are the most abundant sulfides in the Vauze orebodies. Pyrite tends to be concentrated in zones of uniform crystallinity and grain size. Within different zones, the grain size of pyrite varies from about 0.02 to 5 mm. Most grains are euhedral cubes or pyritohedrons. There are two generations of pyrite. The early pyrite, which is the most abundant, is well broken and fractured and has been replaced mainly by silica. Chlorite, quartz, and sphalerite with minor chalcopyrite occur in fractures within the early pyrite grains. Crystal outlines of early pyrite are in places difficult to discern. The later stage pyrite occurs in minor amounts throughout the ore zone as isolated cubes with rounded corners. The grain size is almost uniformly about 0.1 mm. Very minor fracturing has taken place, and no infilling was noted.

Chalcopyrite

Chalcopyrite is scattered throughout the ore zone in all types of ore, and has been observed as vein filling

in faults. It is most abundant in the massive sulfide zone. Chalcopyrite is interstitial between chlorite, quartz, pyrrhotite and sphalerite grains. Small (less than 0.01 mm.) blebs of chalcopyrite occur in most sphalerite grain. The texture of most sphalerite-chalcopyrite is identical to the textures shown by Hawley (1962, p. 140, fig. 68) and by Bastin (1960, p. 95, fig. 4). Bastin calls the texture a replacement of sphalerite by chalcopyrite along twinning directions and cleavage. Hawley suggests that the texture is the result of replacement of chalcopyrite by sphalerite and implies that the chalcopyrite blebs are remnants. In the polished specimens from the Vauze ore bodies one can note that the grain size of chalcopyrite is variable. It may reach 2 mm. and is dependant on the size of the available interstitial space: small grains occur in small spaces, coarse grains are found in large spaces. The fact that the size of the opening appears to control the grain size indicates that chalcopyrite was emplaced after the other minerals. Most chalcopyrite grains exhibit twinning. Large pyrrhotite grains are abundant in chalcopyrite but small "exsolution" blebs of pyrrhotite in chalcopyrite are rare. This indicates temperatures of deposition below 250°C (Lovering, 1958). In the northern ore zone, chalcopyrite occurs in fractures and disseminations in chlorite. Small (less than 0.05 mm.) sphalerite inclusions are common but pyrrhotite is absent.

Pyrrhotite

After pyrite and chalcopyrite, the next most abundant sulfide is pyrrhotite. Except for rare small (less than 0.01 mm.) blebs in chalcopyrite, pyrrhotite occurs in discrete crystals or groups of crystals up to 0.5 mm. but averaging about 0.1 mm. in diameter. The pyrrhotite grains commonly exhibit euhedral hexagonal outlines with sharp crystal boundaries. The margins of clusters of pyrrhotite crystals are smooth and curved. Some pyrrhotite clusters are concentrated and form indistinct layers in massive sulfides. Pyrrhotite rarely occurs outside the massive sulfide zone and almost invariably is associated with chalcopyrite. Some sphalerite grains are in contact with pyrrhotite but only two grains of sphalerite were observed with pyrrhotite inclusions in sphalerite. Pyrrhotite is absent in zones of abundant pyrite.

Sphalerite

Two generations of sphalerite are present. The early sphalerite occurs in irregular masses of variable grain size, from less than 0.01 mm. up to 2 mm. and contains abundant blebs of chalcopyrite. The later sphalerite occurs in veins and fault breccias and is free of chalcopyrite inclusions. This suggests temperatures of formation below 350°C. (Lovering, 1958). Small (less than 0.01 mm.) crystals of sphalerite commonly

are associated with chlorite-quartz rich layers. Sphalerite grains averaging about 0.5 mm. with curved irregular boundaries are found in chalcopyrite-pyrrhotite rich zones in the orebodies. Early sphalerite is most abundant and most plentiful in layered pyrite and quartz-chlorite zones. Some layers of almost pure early sphalerite, reach a thickness of 50 mm., but the average thickness is about 1.5 mm. Sphalerite in the northern ore zone is common and is most abundant as very fine grains (less than 0.03 mm.) in chlorite. Sphalerite also forms margins of vugs or pores, the centers of which are filled with chalcopyrite containing small (0.05 - 0.10 mm.) sphalerite inclusions. The sphalerite in the northern ore zone contains blebs of chalcopyrite as described above.

Magnetite

Magnetite occurs in abundance in two zones. In the southern massive sulfide ore zone, magnetite occurs only above the 2nd level (Plate VIII). In the area of the 1st level, magnetite is the most abundant mineral in the ore zone. In the northern disseminated sulfide zone, magnetite occurs in the upper zone of the orebody, at the 3rd level (375 feet).

In the southern zone, magnetite is equigranular (0.2 mm. average), euhedral and occurs as pods or lenses which average about 3

to 6 inches in diameter near the second level, but increase in size toward surface. It is associated with a small amount of quartz and chlorite grains and inclusions. Chalcopyrite, in minor quantities, is interstitial in magnetite-rich zones. This chalcopyrite is similar to that which occurs throughout the orebody.

In the northern zone, the magnetite is disseminated and occurs with chalcopyrite and bornite in chlorite zones. It is coarser-grained than in the southern zone, averaging 0.5 mm. in diameter. The grains are partially replaced by quartz and chlorite, and minor chalcopyrite occurs in fractures that cut the grains.

Bornite

Bornite was noted only in the northern ore zone and above the 4th level (550 feet). It is most abundant on the 3rd level near the southernmost extension of the ore zone (Plate IV) and near the diorite contact. It is a minor occurrence and was not noted elsewhere in the ore deposits. Bornite grain size is variable from small exsolution blebs of less than 0.01 mm. to irregular grains of about 1 mm. with curved boundaries. Bornite occurs with chalcopyrite and in the same general zone as magnetite but on a microscopic scale, magnetite grains are not closely associated with bornite.

Linnaeite (Co_3S_4)

Stumpfl and Clark (1964) found a copper-rich linnaeite in samples from the Vauze mine. In addition, they report the natural occurrence of Co_9S_8 in the same samples. One polished specimen from 4-75 crown pillar (Plate X, VX 74 B) contained a very small (less than 0.01 mm.) grain of linnaeite.

Non-Metallic Minerals

Quartz and chlorite are abundant constituent minerals in all ore zones. Quartz grains are subhedral and fine grained from less than 0.01 mm. to about 0.3 mm. Most of the coarser grains are clear with good crystal outlines suggesting low temperature formation. The fine-grained quartz also is clear but has irregular boundaries. Chlorite is euhedral in well-developed blades. It is disseminated throughout the ore zones but is more abundant in the northern zone. The blades are about 0.2 mm. long but in the northern zone they reach up to 3-4 mm. long.

Calcite is a minor constituent and usually is restricted to fault zones. Isolated calcite patches in the ore zone probably represent fault zones.

B-1 ORE ZONE

The B-1 ore body is located 350 feet southeast of the southwest corner of Waite Lake (Plate I). This ore zone is composed of two separate ore bodies, both of which almost are identical except in size (Plate XI). The small orebody is known as the "East Lens" and the large orebody is the "Main Lens". Very little data was available from the east lens because it almost was completely mined out when this study began. It produced about 14,000 tons of ore that contained about 3.5% copper and 2.5% zinc. The description of the B-1 orebody concerns the main lens. It is a tabular body that tapers to a point, from surface to a depth of 530 feet (Plate XI). The maximum strike length of the body is about 430 feet and its length down dip is about 750 feet. The thickness of the ore deposits in the zone varies from about 1 foot to 20 feet for an average of approximately 7 feet. The thickest sections of ore occur close to the eastern margin of the main lens above the 3rd level and below the 1st level.

The B-1 orebodies are located immediately below the Waite rhyolite-Amulet andesite contact, in the Vauze mine breccia member of the Waite rhyolite. The tuff beds that occur at the contact also contain sulfides and form part of this ore zone.

The three important faults that are found in the vicinity of the B-1 orebody have been discussed above. In addition, numerous small faults were mapped, which have no readily discernible pattern. Small faults (Plate X) can be traced for several feet into the sulfides of the ore zone owing to calcite filling along the fault. Most of them dissipate in the sulfide zone. Displacement, where discernible, is small, usually less than one foot. A fault along the footwall of the orebody is not as persistent as the hanging-wall fault nor as well defined. Like the hanging-wall fault, it is a high to low angle, bedding, dip-slip, reverse fault. The amount of net slip is unknown.

A small fault was noted in the 3075 crown pillar in the footwall at an angle to the attitude of the deposits and its extension could be seen in the hangingwall country rock. The only evidence of faulting in the sulfides was displacement of bedded or layered sulfides for a minimum horizontal distance of 1 foot. The fault plane was not evident in the sulfide zone.

The fault zone associated with the small faults is usually less than an inch thick and commonly contains calcite, quartz and minor pyrite. Epidote and minor chlorite were noted on the wallrock of several faults.

Detailed mapping of several sections of the main lens at a scale of 10 feet to 1 in (Plates VII, IX, and X) revealed various types of sulfides and the general pattern of their distribution. The sulfides types were mapped on the basis of differences in structure and texture but is was noted that the differences in texture reflected differences in mineralogy. Three general types of sulfides were recognized: (1) "Layered Sulfides" which occur roughly in the upper one foot of the ore zone and are composed mainly of pyrite and sphalerite; (2) "Massive Sulfides" which usually form the remainder of the ore zone and are composed primarily of chalcopyrite, pyrrhotite and pyrite; and (3) "Breccia Sulfides" which are the stratigraphic equivalent of the massive sulfides and are composed of fragments of chalcopyrite, pyrrhotite, sphalerite, and/or pyrite in a matrix of Vauze mine breccia.

Layered Sulfides

Layered sulfides occur just below the upper contact of the ore deposits with the Amulet andesite. Since the contact is faulted, they are just below the fault but at two locations, the layered sulfides were seen in contact with Amulet andesite without faulting. One location was above the 3rd level about 15 feet above station 116 and the other was in

the 4-75 crown pillar about 40 feet east of the 4-65 raise. At these places, the andesite was silicified and slightly bleached and was underlain by a unit of about 4 to 6 inches of interbedded fine tuff and chert with a minor amount of interbedded pyrite. The individual beds vary in thickness from 0.5 to 15 mm. with an estimated average thickness of 2 mm. Below the tuff-chert unit, within a few inches, pyrite progressively became the dominant mineral. Tuff was not abundant, and silica and chlorite were interbedded with pyrite, some sphalerite and very little chalcopyrite. The pyrite-chert (?) unit has individual beds (monomineralic units) up to 50 mm. thick with an average of about 2 mm. Individual beds have been followed up to 8 feet along the dip. At several localities the layered sulfides were noted to be absent, such as, for instance on the second level, near station 126 (Plate VIII). The layering or bedding in the sulfides is normally parallel to the contact. In the locality where layered sulfides are absent the attitude of the layers changes at the points where they return or disappear. From a position parallel to the upper contact the layers curve upward and are at an angle to the faulted contact. The implication here is that the last movement of the fault is post-layering. The thickness of the layered sulfides may reach about 6 feet, (Plate X), but the

estimated average is about 2 feet. Above the 3rd level, the basal contact of layered sulfides and massive or breccia sulfides is sharp (Plate P-10). Below the third level, in the west half of the 4-75 crown pillar, another variety of layered sulfides occurred. Thinly layered pyrite, sphalerite and quartz is present in about the upper 6 inches of the ore zone. Below that zone the sulphides also are layered but chalcopyrite and numerous fragments of chlorite and chloritized rhyolite are abundant. The chlorite fragments vary in size from less than a few millimeters up to 300 mm. (one foot), and average about 20 to 30 mm. They are rounded and tend to be concentrated in layers 30 to 50 mm. thick, and continuous along strike for several feet. This type of layered sulfide changes gradually over a distance of a few feet into massive sulfides. At the eastern end of the 4-75 crown pillar and just below the 2nd level near the location of D.D.H. No. 2-3 (Plate III), the layered sulfides become very siliceous and sphalerite is the abundant sulfide. The sphalerite is very fine-grained and the layers have a moderate reddish orange to pale reddish brown (honey) color. Throughout the layered sulfides, rounded to subrounded chlorite and chloritized rhyolite fragments are abundant. Their size is mall, averaging about 2 to 4 mm. and rarely exceeding 10 mm. in diameter.

Massive Sulfides

Massive sulfides are located stratigraphically below the layered sulfides. The thickness of the zone is variable from nothing, such as in the eastern part of the 4-75 crown pillar (Plate X) to a thickness of almost 20 feet near the eastern margin of the main lens above the 3rd level. The common massive sulfides are chalcopyrite and pyrrhotite. Quartz and chlorite are disseminated throughout and sphalerite is abundant. Within the massive sulfides, irregular patches of indistinct outlines are common. There are many sizes and varieties. One type consists of chlorite and chloritized rhyolite fragments that vary in size from 1 mm. to 1 foot and contain disseminated pyrite. Fragments of this variety rarely form more than 30% of the volume of the massive sulfide zone. Another variety of fragments are those formed by minerals distinct from the common minerals of the zone. Magnetite-rich fragments are abundant above the 2nd level and are illustrated on the map of the 2-65 raise (Plate VIII). In the western half of the 4-75 crown pillar (Plate X) fragments formed by either pyrite and quartz, or pyrite and sphalerite, or sphalerite-pyrrhotite and chalcopyrite are common. One fragment, 3 feet in length, with angular outlines and sharp contacts, was formed by massive sphalerite in a pyrite, chalcopyrite, pyrrhotite,

quartz matrix. The upper contact of massive sulfides and layered sulfide is sharp (Plate P-10) and generally ≅ parallel to the ore zone-Waite andesite contact. Patches up to 1 foot in diameter of chalcopyrite-rich massive sulfides occur in the hangingwall fault zone and as inclusions within the layered sulfides such as on the 3rd level, 3-65 raise (Plate IX). The lower contact is not as sharp as the upper contact. Generally, the massive sulfides contain more abundant pyrite beginning about one foot above the lower contact. This one-foot width is a transitional zone in which Vauze mine breccia becomes progressively more abundant until at the base, only disseminated pyrite occurs.

In isolated zones several feet in diameter, above the 3rd level and in massive sulfides, a peculiar form of pyrite was observed. The zone is formed by faintly layered pyrite and has a porosity estimated to be up to 30%. The pores are elongate parallel to layering and are up to 1 by 3 mm. in size. The average pore size is 0.05 mm. In the center of the zones the pores are empty, but as the margins of the zone are approached, they become filled with chalcopyrite and sphalerite. Minor quartz occurs with the pyrite which is similar in texture to the pyrite in layered sulfides. It is not known whether the porosity is original or secondary.

Breccia Sulfides

About a third of the ore zone exposed in the main lens in the 4-75 crown pillar (Plate X) is formed by breccia sulfides. The breccia sulfides interfinger with massive sulfides and are their stratigraphic equivalent. They are formed by sulfide fragments with the same matrix as the Vauze mine breccia (Plates P-11 (a) and (b)). The fragments are subrounded to angular, vary in size from less than 5 mm. to 2 feet in diameter, and are composed of any combination of minerals already discussed, except magnetite. Fragments were observed composed of sphalerite, pyrite, chalcopyrite, pyrrhotite, quartz and chlorite and various combinations of these minerals. Chalcopyrite-pyrrhotite, and pyrite (usually in coarse crystalline cubes up to 20 mm. across) are the most common fragment types. Several fragments were formed by fragments of sulfides and rhyolite and chloritized rhyolite in a Vauze mine breccia matrix, identical to that described previously. This represents a brecciated breccia. At least two periods of fragmentation and consolidation took place. The upper contact with the layered sulfides is sharp and the basal contact is obscure. The base of the ore zone is defined by the absence of sulfide fragments which are restricted to the upper few feet of the rock unit. On the 4th level near coordinates 22,200 N and 5,400 E two small pockets

of breccia sulfides were encountered. The pockets are bounded by faults but the relationship between the faults and the breccia sulfides is not well known. One pocket is stratigraphically about 50 feet below the contact. The contact between breccia sulfides and massive sulfides is gradational over several feet and is marked by an increase in the number of sulfide fragments and in the amount of sulfides (primarily pyrite) in the Vauze mine breccia.

The presence of patches or fragments of sulfides and rock within massive sulfides suggests that the massive sulfides and breccia sulfides have a similar origin.

Relationship of Ore to Intrusions

The relationship of the two siliceous intrusion in the ore zone in the 4-75 crown has been discussed under the general heading Minor Intrusives. The "Steep" diorite is reported as cutting the east lens of the B-1 ore zone between the 3rd and 4th levels. The "Flat" diorite cuts the main lens near the surface. An unfaulted contact of this diorite with the ore zone was observed in the stope east of the shaft on the 1st level (Plate II). The ore zone near the contact is formed mainly of magnetite with minor sphalerite, pyrrhotite and chalcopyrite. Several blocks of sulfides up to 1 foot in diameter

and of the same composition as the ore were noted up to 3 feet inside the diorite. Chalcopyrite was abundant and one block, about 6 inches in diameter, was composed mainly of sphalerite. The diorite was fine-grained and contained flow laminations. Layered sulfides were not observed in this area. The evidence indicates that the "Flat" diorite is post-ore.

Wallrock Alteration

Megascopic wallrock alteration in the vicinity of the main lens of the B-1 ore zone is slight. The Amulet andesite in places is bleached for a few inches. Thin section studies reveal that the bleaching is a reflection of intense sericitization. The andesite is also silicified but the extent of silicification is not well defined. The matrix of the Vauze mine breccia in the transitional basal contact zone below massive sulfides is strongly chloritized up to 6 inches below the contact. In the breccia sulfide zone, there are numerous fragments of strongly chloritized rhyolite but the matrix is only weakly chloritized. The breccia is darker near the ore zone due to a higher degree of chloritization.

B-2 ORE ZONE

The horizontal projection of the B-2 orebodies lies at the easternmost edge of Waite Lake (Plate I). The

B-2 ore zone is formed by two cylindrical ore shoots, known as the east ore shoot and the west ore shoot (Plate XI). The east ore shoot produced about 82,000 tons of ore that contained about 3.0% copper and the west ore shoot produced about 94,000 tons of ore that contained about 2.0% copper. The east ore shoot has an average diameter of about 40 feet. It is terminated above the 3rd level by diorite and its base is the upper contact of a metadiabase dike (figure 2). The axis of the cylinder is about 460 feet long and plunges 65° at N 40° W. The west ore shoot is shaped like an inverted golf club. The section below the 3rd level is cylindrical with an average diameter of 40 feet. The axis of the cylinder is about 300 feet long and plunges 70° at N 45° W. Above the 3rd level, the orebody is shaped like a bun with an average diameter of about 70 feet. The axis of the cylinder is about 190 feet long and plunges 10° at N 10° W. Both orebodies occur in the Waite rhyolite. The first four levels of the mine, south of the shaft, are in the upper member of the Waite rhyolite (figure 2). It was not possible to separate the rhyolite into members in the area north of the shaft because of alteration of the rock.

Although both ore shoots occur in rhyolite, they are slightly different. The east ore shoot is cylindrical

and regular, and the ore is composed of disseminated chalcopyrite in coarse crystalline chlorite. Some of the chlorite crystals are up to 3 mm. across. Disseminated pyrite is present in minor amounts. The west ore shoot is somewhat irregular in shape. The chalcopyrite is disseminated and occurs as fracture-filling in the chlorite matrix of a brecciated rhyolite (Plate P-12). The fragments of rhyolite are as large as 15 feet across and have been chloritized and sericitized. However, the ore minerals, except for very minor disseminated pyrite, occur in the matrix of the breccia which is constituted of massive chlorite. Disseminated and vein filling ore minerals were deposited below the metadiabase dike, but not in sufficient quantities to form minable deposits.

The wallrock in the B-2 ore zone has been profoundly altered. On the 3rd and 4th levels, the transition in the Waite rhyolite can be traced from a pink, rock flow-banded and altered only by regional metamorphism to a dark green, highly altered rock. The chloritization and sericitization of wallrock transcends stratigraphic boundaries. The alteration zone is cylindrical is shape (figure 2 and Plates IV, V, VI, and VII) and has been traced by drill core to the Waite andesite. The stratigraphically highest exposures occur on the 3rd level (Plate IV). Where the alteration is mainly chloritization. At greater depths sericitization

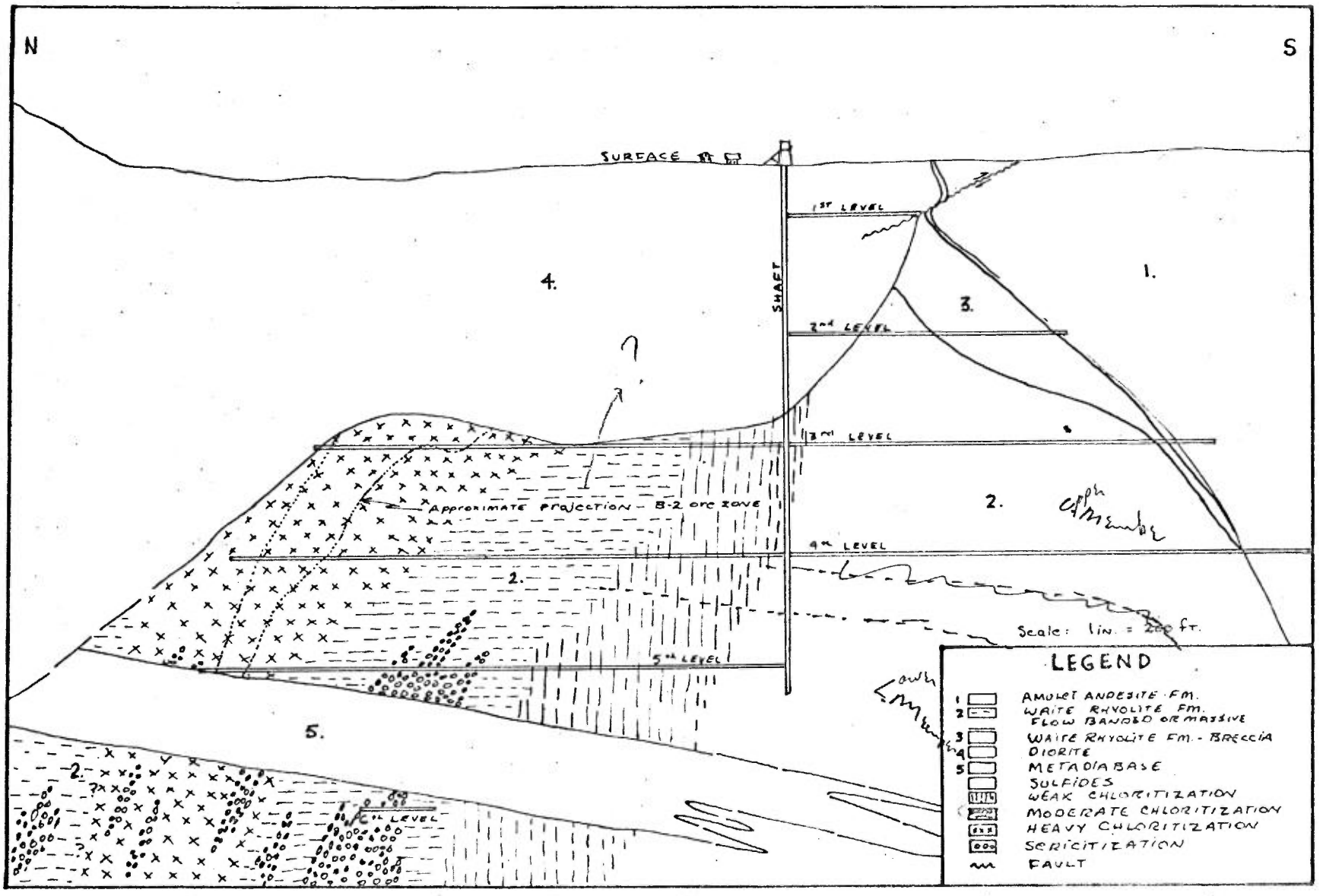

Figure 2

GENERALIZED NORTH-SOUTH VERTICAL SECTION, VAUZE MINE, NORANDA DISTRICT, QUEBEC

and chloritization of wallrock are pervasive (Plates P-13 and P-6). In D.D.H. M-20 (Waite Lake Mines Ltd.) the Waite andesite is fractured, moderately chloritized and sericitized and traces of chalcopyrite and pyrrhotite are found in fractures.

Coinciding with the increasing intensity of alteration as the center of the B-2 zone is approached, there is an increase in the degree of brecciation and fracturing of the wallrock. The shape of the B-2 ore zone and its wallrock alteration extensions at depth indicate that this zone was the channelway for hydrothermal solutions that deposited sulfides in fractures, starting at a depth of about 2,000 feet and altered the wallrock moderately from at least 2,000 feet to 1,000 feet and intensely above 1,000 feet. For this reason the B-2 ore zone commonly is referred to as the "pipe" zone.

Two intrusions cut the B-2 ore zone. The upper end of the east and west ore shoots is abruptly terminated by the "flat" diorite (figure 2). The metadiabase dike that occurs near the 5th level also cuts both ore shoots. On the 5th level the metadiabase dike contains several large (up to 2 feet) rounded fragments of chloritized rhyolite which appear to be identical to the adjacent wallrock. The metadiabase dike shows no strong alteration effects nor brecciation. Unto

Jarvi (Oral communication) reports that in the vicinity of the ore shoots, the "Flat" diorite is not strongly altered or brecciated.

ORIGIN OF THE ORES

Based on the regional and detailed studies of the volcanic rocks and the ore deposits at the Vauze mine, a number of conclusions regarding time relationships can be drawn.

1. The "flat" diorite cuts both the B-1 and B-2 orebodies. If the diorite was pre-ore, the body would have acted as the impervious caprock which trapped the solutions and caused deposition of ore minerals. If this were true, the sulfide xenoliths would be the result of selective replacement. Since the Vauze mine breccia is thickest near the diorite contact, the thickest sections of ore might be expected near the contact. On the contrary, the ore zone is thinner near the contact than at some places away from the contact.

Similar geometric considerations might have been expected in the B-2 zone. The west ore shoot does show a change in attitude and a pronounced enlargement of the mineralized zone. The east ore shoot does not. It is terminated abruptly by the "flat" diorite.

The diorite at the contact of the B-2 and B-1 ore zones should be hydrothermally altered and contain some substantial mineral deposits within the fractured rock, particularly along the faulted contact. This is not the case. Therefore, based on geometric relationships between alteration zone, ore deposits and diorite, and on isolated xenoliths of sulfides in diorite, it is concluded that the ore deposits at the Vauze mine were formed prior to intrusion of the "flat" diorite. Since the "flat" diorite is cut by the "steep" diorite, the ore deposits are pre-diorite.

The occurrence of magnetite in both the B-1 and B-2 ore zones may be related to diorite intrusion. Tsusue (1962) describes a magnetite, pyrrhotite, pyrite relationship in Japan where the magnetite zones are shown to be the result of contact metamorphic effects caused by the intrusion of quartz diorite. The magnetite zones in the Vauze deposits spacially are related to diorite intrusion. Unfortunately, only one-half of the intrusive contact remains. The association could be fortuitous, as the occurrence of magnetite also may reflect a change of physico-chemical conditions at the time of deposition.

2. The "metadiabase" dike cuts the B-2 orebodies. There is no evidence of alteration or deposition of ore minerals within the dike. Xenoliths of chloritized wallrock are contained within the dike. Therefore, the "metadiabase" dike is considered as post-ore.

3. The relationship between two minor siliceous dikes probably related to rhyolite volcanism has been discussed on pp. 26-7 and it was considered that the B-1 ore deposits were pre-siliceous dike.

4. The most important time relationship can be established from evidence obtained from a study of the B-1 ore zone and particularly of the type of ore known as breccia sulfides (Plate P-11 (a) and (b)). The three possible modes of formation of this ore are: (1) selective replacement of special rock fragments in a Vauze mine breccia; (2) brecciation with inclusion of sulphide fragments as a result of tectonic forces; and (3) deposition of the sulfides prior to formation of the upper part of the Vauze mine breccia and subsequent inclusion of sulfide fragments during formation of the rock unit, i.e. contemporaneous deposition. Breccias of a similar type occur at several localities in the Noranda district. Price (1948) describes pyrite fragments in tuff beds in the No. 5 sulphide zone at Noranda Mines and Price and Bancroft (1948) mention similar zones at the Waite mine. The origin of the fragments has been attributed by the authors to selective replacement.

Thin section studies indicate that the Vauze mine breccia matrix has a pyroclastic origin. The angularity

of the fragments, particularly of sulfide fragments such as that shown on Plate P-11 (a), would not be retained if the breccia were formed by tectonic processes. Horses of sulfides in the hanging wall fault zone are all rounded. Therefore, a tectonic breccia origin is rejected.

Replacement textures occur in specimens from these deposits. Early pyrite and magnetite are replaced by quartz and chlorite. Late pyrite replaces all early minerals. Textures in chalcopyrite and sphalerite are interpreted by some authors as replacement textures. If the hypothesis of selective replacement is admitted, one of the following sets of conditions must have existed to explain the diverse mineralogy of the fragments. (A) The fragments, prior to replacement, were of different compositions and the solutions remained relatively constant in composition during replacement. (B) If the replaced fragments were of the same composition, the composition of the solutions would have had to change. (C) The composition of the fragments differed and the composition of the fluids changed.

The last set of conditions is the most logical if selective replacement is the primary mode of deposition. It is reasonable to assume that the B-1 and B-2 orebodies are related. No direct connection can be established, but

projection of the axes of the B-2 orebodies and the long axis of the main lens of the B-1 ore zone intersect. In addition, the Waite-Amulet massive orebodies have similar alteration zones which are directly connected to them (Price and Bancroft, 1948; Suffel, 1948). Then, the solutions that formed the B-2 orebodies also formed the B-1 orebodies. The ore deposits in the B-2 zone indicate changing chemical conditions of the solutions. Sericitization was followed by chloritization and finally by deposition of ore minerals. Paragenetic ore mineral relationships indicate that pyrite was deposited first, followed by sphalerite and lastly, by chalcopyrite with minor exsolved pyrrhotite. However, there is no evidence of vastly fluctuating chemical conditions. One can only speculate about the original composition of the fragments. The only fragments other than the sulfide fragments seen in the Vauze mine breccia are chloritized rhyolite, flow-banded rhyolite, scoriaceous rhyolite, spherulitic rhyolite and massive chlorite (Plates P-11 (a) and P-2).

The easiest way to explain the occurrence of sulfides fragments is that of contemporaneous deposition of the breccia as a whole. The immediate vicinity of the Vauze mine was a site of hydrothermal and volcanic activity and it does not seem unreasonable, then, to conclude that sulfides were

deposited in the throat of a vent which was the source of the pyroclastic debris of the Vauze mine breccia. Brecciation of the sulfides probably was produced by the explosive activity in the vent area and fragmental sulfides were included in the upper portions of the rock unit along with other volcanic fragments.

If the breccia sulfides represent contemporaneous deposition of sulfide and rock fragments, then the bulk of the sulfides were deposited prior to deposition of the overlying fine tuff and chert beds and prior to deposition of the Amulet andesite.

The evidence obtained from geologic studies of the ore deposits at the Vauze mine supports a hydrothermal-sedimentary origin of the ore deposits. Temperature studies by Campbell (1962) and Clark (1965) by the method of pyrrhotite-pyrite geothermometry indicate primary deposition temperatures of about 525°C. Mineralogical associations indicate two temperatures: the sphalerite with chalcopyrite blebs is used to indicate temperatures of formation in excess of 350°C; chalcopyrite with pyrrhotite exsolution blebs also indicate temperatures of formation in excess of 250°C. However, a later sphalerite probably was deposited at temperatures lower than 350°C.

Interpretation of temperature data is difficult because the data may reflect secondary temperature effects. No part of the Vauze ore deposits is farther than 500 feet away from either the "steep" or the "flat" diorites which are post-ore. The "steep" diorite is 2,000 feet wide. Jaeger (1957) in a study on the intrusion of the dolerites showed that wallrock temperatures have to be below 300°C to obtain chilled borders in the intrusion and that wallrock temperatures, though dependant on thermal conductivity, could attain temperatures of 600 to 700°C. Certainly an intrusion of this magnitude, which caused dioritization of the andesites could effect the textures and distribution of sulfides in nearby deposits.

Although traces of pyrite and chalcopyrite are widespread in the tuff along the rhyolite-andesite contact, major accumulations of ore minerals occur in very restricted areas. Petrographic evidence indicates that the rocks enclosing the ore deposits of the B-1 ore zone were deposited under water. The restricted area of deposition would not indicate deposition caused by a chemical reaction between hydrothermal solutions and sea water (exhalative-sedimentary origin of Oftedahl, 1958) or a syngenetic origin as proposed by workers in the Rhodesian copperbelt (Mendelsohn, 1961) where deposits are very widespread.

The "Kuroko" type ores of Japan are the most similar modern analogy to the Vauze ore deposits (Kinoshita, 1929), (summarized in Park and MacDiarmid, 1964). The Japanese deposits were formed in rhyolite-andesite flow and pyroclastic rock sequences of Miocene age. The deposits are capped by tuff and chert and are zoned. The upper ore zone is formed by layered sphalerite and galena with barite and is underlain by chalcopyrite-pyrite ore. Silicified and pyritized volcanic breccia underlies the ore zone. The orebodies usually occur on a thickened rhyolitic rock sequence and are associated with a pipe zone and magnesium metasomatism of the wallrock. The similarities with the Vauze deposits are striking except for the presence of galena and barite in the upper ore zone. It is agreed that hydrothermal solutions carried the metals but the method of emplacement of the Japanese ores is believed to be either replacement of tuff and breccia or chemical precipitation.

The B-2 ore deposits at the Vauze mine were formed by deposition from metal-bearing solutions of hydrothermal origin with partial replacement of wallrock along fractures. The B-1 zone was formed by two processes. The massive and breccia sulfides were formed by the mechanical accumulation of fragments produced by brecciation of open-space telethermal ore deposits caused by explosions which simultaneously ejected rock fragments. The layered sulfides probably were formed by

chemical depostion, perhaps as the hydrothermal solutions interacted with marine waters. What processes or set of physico-chemical conditions actually caused sulfides to deposit is not known. But the geologic evidence at the Vauze mine indicates deposition during the last stages of rhyolitic volcanic activity prior to deposition of the overlying andesitic rocks.

SUMMARY AND CONCLUSIONS

The following points summarize the results of the first part of the report and also contain the principal conclusions regarding the geology of the ore deposits of the Vauze mine.

(1) Volcanic rocks are the oldest rocks in the Waite Lake area. Volcanic activity in the area began with extrusion of andesite followed by extrusion of rhyolite and usually terminated by deposition of tuff and chert with sulfides.

(2) At the conclusion of the Waite andesite-Waite rhyolite period of volcanic activity, the Vauze mine deposits were formed.

(3) Regional metamorphism altered most rocks in the area to the greenschist facies. However, many primary

textures are preserved, such as flow banding, pillow, and breccia textures.

(4) Faulting and folding are minor in the Waite Lake area and followed ore deposition.

(5) The oldest intrusive rocks consist of numerous minor intrusions with compositions similar to the rocks which contain them. They are related to the volcanic activity which produced the extrusive rocks. Some cut the Vauze ore deposits.

(6) The "metadiabase" dike cuts the northern ore zone at the mine and is the next youngest intrusion.

(7) The "flat" diorite dike cuts the "metadiabase" dike and the northern and southern orebodies.

(8) The "steep" diorite cuts the "flat" diorite and is the youngest of the large intrusive rocks. Only the Proterozoic diabase dikes are younger in age.

(9) Although not physically connected, the northern B-2 ore zone and the southern B-1 ore zone are related. Prior to the intrusion of the diorite dikes, the two zones were connected. Separation was caused by intrusion, and the connecting link probably was removed by erosion.

(10) The occurrence of sulfide fragments of various compositions in a pyroclastic rhyolite breccia is the basis to infer a pre-Amulet andesite formation of the Vauze ore deposits.

(11) The northern ore deposits were formed by hydrothermal solutions and are fracture-filling, replacement-type deposits.

(12) The southern ore deposits were formed by two processes: (a) the massive sulfides and breccia sulfides were ~~mechanically~~ formed during volcanic activity that produced pyroclastic debris; and (b) the layered sulfides represent recrystallized, chemically precipitated deposits, such as the Japanese "Kuroko" type deposits, and formed as a result of the reaction between hydrothermal solutions and marine waters.

(13) The "connecting link" between the two ore zones contained the evidence regarding origin of deposition of the massive and breccia sulfides of the B-1 ore zone. The deposits are postulated to have been telethermal deposits, i.e., formed near surface because of the sudden release of pressure and lowering of temperature.

PART II - GEOCHEMISTRY

GENERAL STATEMENT

This part of the report contains total chemical analyses of the various rock types in the Waite Lake area and the results of analyses for major constituents by X-ray fluorescence and for volatile trace elements by optical spectrograph. The latter analyses were made to determine the distribution of various elements in the wallrock around the ore deposits in order to investigate chemical guides in the search for ore deposits.

TOTAL CHEMICAL ANALYSES

Tables IV, V, VI and VII contain total chemical analyses from particular rock types of the Waite Lake area. Norms were not calculated owing to the complex mineralogy.

Amulet Andesite

Sample 1 in table IV represents the basal 225 feet of the Amulet andesite. The hole from which the core was analyzed is located about 2,500 feet south of B-1 orebody. The composition is almost similar to Wilson's andesite (1941, p.14) and it closely approximates Vinogradov's data (1956) for median rocks with the following slight differences: the andesite in the Waite Lake area contains more FeO and MgO and lower amounts of Al_2O_3 and K_2O. Sample 2 was taken from the Amulet andesite east of the "steep" diorite. It is closer in composition to Vinogradov's (1956) median rock or Nockolds' (1954) average andesite. The TiO_2, MnO, and K_2O contents is very similar in samples 1 and 2. The andesite east of the

TABLE IV

CHEMICAL COMPOSITION OF THE ANDLET ANDESITE

CONSTITUENT	Sample 1	Sample 2	A.Wilson	B.Vinogradov	C.Nockolds
SiO_2	57.87	53.30	54.02	57.0	54.20
TiO_2	1.11	1.12	1.63	0.79	1.31
Al_2O_3	144593	16.63	15.67	17.5	17.17
Fe_2O_3	2.04	1.42	2.38	3.72	3.48
FeO	6.16	5.86	8.46	3.31	5.49
MnO	0.16	0.16	0.01	0.17	0.15
MgO	4.62	4.18	4.12	3.64	4.36
CaO	6.12	8.31	7.14	6.70	7.92
Na_2O	3.23	3.06	4.04	3.62	3.67
K_2O	0.69	0.62	0.64	2.01	1.11
Li_2O	0.000	0.001			
P_2O_5	0.19	0.17	0.44	0.25	0.28
H_2O -	2.68	3.54	0.77	0.83	0.86
H_2O -	0.02	0.02	0.04		
CO_2	0.17	1.19	Nil		
ZrO_2	0.014	0.014			
F	0.06	0.06			
Cl	0.01	0.01			
S	0.05	0.24	0.09		
Cr_2O_3	0.001	0.007			
NiO	0.003	0.007			
BaO	0.019	0.020			
SrO	0.020	0.19			
CuO	0.004	0.006			
CoO	0.001	0.002			
ZnO	0.01	0.01			
V_2O_3	0.025	0.037			

Note: All values are weight percentages.

1. Amulet andesite; Waite Lake area; Duprat Township, Quebec; Waite Lake Mines Ltd; from D.D.H. M-26, depth 15-240 ft; coordinates 23,095N, 4,878E.

2. Amulet andesite east of the "Steep" diorite; Waite Lake area, Dufresnoy Township, Quebec; Vauze Mines Ltd; from D.D.H. V-178, depth 270-1130 ft; coordinates 29,300N, 16100E.

A. Wilson - massive andesite, Dufresnoy Township.

B - Vinogradov - median rock

C - Nockolds - (average) andesite.

diorite contains more CO_2. This is shown in the modal composition by a higher tenor of calcite.

Waite Rhyolite

Samples 3, 4, and 5 in table V are from the various members of the Waite rhyolite. The only notable difference is in the larger amount of Fe_2O_3, FeO, MgO, and CaO in the Vause mine breccia due to its slight alteration. The composite samples of the Waite rhyolite have almost similar composition. As in the Amulet andesite samples, there is a high CO_2 content in sample 7 from east of the diorite. Although the amounts of Na_2O and K_2O vary slightly, the ratio of the compounds approaches that of Vinogradov's acid rock (Vinogradov, 1956). Sample 6 contains less K_2O, Al_2O_3 and more silica than average rhyolites (Vinogradov, 1956 and Nockolds, 1954). The composition of the Waite rhyolite is very uniform.

Waite Andesite and Transitional Ducite

The samples of the Waite andesite (Table VI) were taken principally to compare the composition of the unit as a whole and its composition in the pipe zone. The composition is strikingly similar to that of the Amulet andesite (Table IV). The following significant changes are noted in the pipe zone: there is an increase in FeO and MgO and a decrease in CaO and Na_2O. This indicates alteration of the feldspars and accounts for the greater abundance of chlorite in thin section.

By comparison, sample 10 contains more TiO_2 and FeO and less Al_2O_3

TABLE V

CHEMICAL COMPOSITION OF THE WAITE RHYOLITE

TUENT	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7	A.Vinogradov	B.Kockol
	72.90	74.60	74.76	76.42	72.72	71.00	73.66
	0.25	0.20	0.20	0.19	0.24	0.34	0.22
	10.90	11.43	11.50	11.08	11.00	14.30	13.45
	2.51	1.84	1.77	1.22	1.22	1.54	1.25
	2.86	1.54	2.05	1.54	2.71	1.85	0.75
	0.04	0.03	0.03	0.04	0.09	0.05	0.03
	1.02	0.66	0.77	0.60	0.30	0.74	0.32
	1.64	1.42	0.81	1.61	2.46	1.82	1.13
	3.83	3.87	4.89	4.37	2.10	3.62	2.99
	1.09	1.72	1.18	1.15	2.52	4.02	5.35
	0.000	0.000	0.000	0.000	0.000		
	0.04	0.04	0.04	0.02	0.02	0.145	0.07
	1.15	0.98	0.75	0.61	1.23	0.75	0.78
	0.03	0.03	0.03	0.01	0.02		
	1.43	1.31	0.69	0.53	2.86		
	0.02	0.03	0.04	0.04	0.027		
	0.05	0.04	0.06	0.05	0.07		
	0.01	0.01	0.01	0.01	0.02		
	0.06	0.02	0.20	0.02	0.23		
	0.001	0.001	0.001	0.001	0.001		
	0.001	0.001	0.001	0.001	0.001		
	0.03	0.045	0.045	0.040	0.040		
	0.015	0.007	0.006	0.012	0.008		
	0.026	0.001	0.005	0.002	0.002		
	0.001	0.001	0.001	0.001	0.001		
	0.00	0.00	0.00	-	-		
	-	-	-	0.00	-		

All values are weight percentages.

3. Waite rhyolite, Vauze mine breccia member; Waite Lake area, Dufresnoy Township, Quebec; Vauze Mines Ltd; from D.D.H. V-77, depth 260 - 380 ft; coordinates 22,292N, 5122E.

4. Waite rhyolite, Upper member; Waite Lake area, Dufresnoy Township, Quebec; Vauze Mines Ltd; from D.D.H. V-77, depth 390 - 600 ft; coordinates 22,292N, 5122E.

5. Waite rhyolite, Lower member; Waite Lake area, Dufresnoy Township, Quebec; Vauze Mines Ltd.; from D.D.H. V-77, depth 610 - 980 ft; coordinates 22,292N, 5122E.

6. Waite rhyolite, Composite sample 900 ft. south of Vauze ore deposits; Waite Lake area, Dufresnoy Township, Quebec; Vauze Mines Ltd.; from D.D.H. V-133, depth 570 - 1100 ft.; coordinates 21,806N, 5133E.

7. Waite rhyolite, Composite sample east of the "Steep" diorite; Waite Lake area, Dufresnoy Township, Quebec; Vauze Mines Ltd.; from D.D.H. V-177, depth 400 - 790 ft.; coordinates 28,300N, 16,400E.

A. Vinogradov - acid rock.

B. Nockolds - average calc-alkali rhyolite.

TABLE VI

CHEMICAL COMPOSITIONS OF THE WAITE ANDESITE AND THE TRANSITIONAL DACITE

CONSTITUENT	Sample 8	Sample 9	Sample 10	A. Hockolds
SiO_2	55.35	53.86	62.66	63.58
TiO_2	1.18	1.04	0.85	0.64
Al_2O_3	15.00	14.56	13.80	16.67
Fe_2O_3	1.55	1.36	1.73	2.24
FeO	7.42	9.16	6.90	3.00
MnO	0.16	0.10	0.14	0.11
MgO	5.03	7.44	2.31	2.12
CaO	5.72	2.49	2.48	5.35
Na_2O	3.82	1.38	3.84	3.98
K_2O	0.85	1.01	1.29	1.40
Li_2O	0.000	0.001	0.000	
P_2O_5	0.18	0.13	0.27	0.17
H_2O +	2.85	5.37	2.71	0.56
H_2O -	0.07	0.02	0.05	
CO_2	0.51	1.41	0.60	
ZrO_2	0.014	0.01	0.01	
F	0.09	0.09	0.07	
Cl	0.00	0.01	0.01	
S	0.24	0.60	0.16	
Cr_2O_3	0.001	0.001	0.001	
V_2O_3	0.035	0.035	0.003	
NiO	0.006	0.007	0.001	
BaO	0.029	0.035	0.040	
SrO	0.017	0.005	0.014	
CuO	0.004	0.012	0.002	
CoO	0.001	0.001	0.001	
ZnO	0.01	0.02	0.01	

Note: All values are weight percentages.

8. Waite andesite, Composite sample; Waite Lake area, Dufresnoy Township, Quebec; Gauss Mines Ltd.; from D.D.H. W-77, depth 1080 - 2560 ft.; coordinates 22,292N, 5122E.

9. Waite andesite, Composite sample in "pipe" zone, Waite Lake area, Duprat Township, Quebec; Waite Lake Mines Ltd.; from D.D.H. M-20, depth 1120 - 2200 ft.; coordinates 23,095N, 4878E.

10. Transitional Dacite; Unit between Waite rhyolite and Waite andesite; Waite Lake area, Dufresnoy Township, Quebec; Vauze Mines Ltd.; from D.D.H. W-77, depth 990 - 1090 ft.; coordinates 22,292N, 5122E.

A. Nockolds - average dacite.

TABLE VII

CHEMICAL COMPOSITIONS OF SOME MAJOR INTRUSIVE ROCKS

CONSTITUENT	Sample 11	Sample 12	Sample 13	Sample 14	A. Nockolds
SiO_2	49.42	48.52	59.56	53.91	51.86
TiO_2	0.94	1.42	0.93	1.48	1.50
Al_2O_3	14.64	12.90	14.18	14.72	16.40
Fe_2O_3	2.11	3.53	1.85	2.53	2.73
FeO	9.12	11.31	5.06	7.12	6.97
MnO	0.22	0.27	0.17	0.16	0.18
MgO	6.80	6.25	4.27	5.00	6.12
CaO	10.17	10.11	4.77	6.50	8.40
Na_2O	2.32	1.94	3.11	3.40	3.36
K_2O	0.30	0.40	1.66	0.26	1.33
Li_2O	0.00	0.000	0.001	0.000	
P_2O_5	0.07	0.10	0.19	0.27	0.35
H_2O -	2.70	2.70	2.75	3.44	0.80
H_2O -	0.02	0.04	0.03	0.05	
CO_2	0.64	0.15	1.04	1.00	
ZrO_2	0.00	0.00	0.01	0.01	
F	0.07	0.05	0.10	0.05	
Cl	0.06	0.02	0.01	0.01	
S	0.13	0.13	0.09	0.12	
Cr_2O_3	0.001	0.001	0.006	0.001	
NiO	0.026	0.005	0.005	0.002	
BaO	0.008	0.008	0.046	0.012	
SrO	0.012	0.001	0.021	0.02	
CuO	0.012	0.026	0.002	0.004	
CoO	0.004	0.004	0.001	0.001	
ZnO	0.01	0.01	0.01	0.01	
V_2O_3	0.046	0.064	0.021	0.03	

Note: All values are weight percentages.

11. "STEEP" Diorite, (Wilson's 1941) Dufresnoy diority mass; Waite Lake area, Dufresnoy Township, Quebec; Vauze Mines Ltd.; from D.D.H. V-162, depth 10 - 760 ft.; coordinates 20,806N, 563E.

12. "FLAT" Diorite; Waite Lake area, Duprat Township, Quebec; Waite Lake Mines Ltd.; from D.D.H. M-21, depth 40-380 ft.; coordinates 22,898N, 4383E.

13. "METADIABASE", Composite sample 500 ft. south of "pipe" zone; Waite Lake area, Dufresnoy Township, Quebec; Vauze Mines Ltd.; from D.D.H. V-77, depth 850-860 ft. and 940-960 ft.; coordinates 22,292N, 5122E.

14. "METADIABASE", in area of "pipe" zone; Waite Lake area, Dufresnoy Township, Quebec; Vauze Mines Ltd.; from D.D.H. V-78, depth 740 - 875 ft.; coordinates 23,903N, 5074E.

A. Nockolds - average diorite.

and CaO than Nockolds' (1954) average dacite. The Na_2O and K_2O contents are almost identical.

Intrusive Rocks

The analyses (table VII) show that the "steep" diorite is closer to a gabbro in composition whereas the "flat" diorite (sample 12) is closer to an average diorite (Nockolds 1954). The slight differences do not justify a change in terminology.

Samples 13 and 14 were taken from the metadiabase in order to compare the unit near, and away from the pipe zone. The results indicate a basic difference not attributable to alteration. The sample away from the pipe (sample 13) has a very high silica content. In thin section abundant clear euhedral quartz grains are noted. Otherwise the rocks are quite similar.

Conclusion

The chemical analyses indicate that the classification of the rocks as rhyolites and andesites is correct. Their high content of Na_2O, compared to a low content of K_2O and Al_2O_3 confirms Schindler's (1934) observations that the rocks are spilitised.

GEOCHEMISTRY OF VOLATILE TRACE ELEMENTS AND MAJOR CONSTITUENTS

General statement

The major object of this study is to detect anomalous chemical conditions in the vicinity of the ore deposits. As most ore deposits

in the area are stratigraphically controlled, the geochemical study was concentrated near the favorable contact.

The sampling techniques and analytical methods used are described in the Appendix.

Distribution of the volatile trace elements

A method of X-ray fluorescence was used to determine the elements Cu, Zn, Pb, Ag, Sn, In and Cd (see Appendix).

Under each element, the precision of the method and the distribution within various geological units are discussed.

Copper

The precision of five copper values is variable (see table VIII in Appendix). At the 95% confidence level the error ranges from 9.5 to 21.2%. For the five copper values, the precision of the methods is the maximum error or 21%. Thus, for example, if a sample has an indicated mean of 1000 ppm, 95 times out of 100, the true mean will be between 790 and 1210 ppm.

Two major difficulties arose and hampered good results for copper. First, there is a high content in most rocks even far away from the ore deposits. The high background value attenuates the copper halo. Second, because many samples contain sulfides, serious copper contamination is difficult to eliminate. Sample preparation equipment is contaminated

even though meticulous cleaning procedures are followed.

Distribution of copper values in Vauze rocks is illustrated in figures 5, 6, 7 and 8, and on Maps XV, XIII, XXI and XXIII.

The analysis of variance shows that there is little variation of copper content in rock units near or adjacent to the Vauze ore deposit as compared with rock units at distances of several thousands of feet. However, an anomalous copper condition exists near the ore deposits, but a study of copper values obtained from the contact tuff (Map XV) shows that large halos are not apparent. The same conclusions can be reached from a study of the vertical sections (fig. 5, 6, 7 and 8, and Map XIII). The Vauze mine breccia contains high copper values, some greater than 4,000 ppm (Map XIII). In general, the copper content of the Amulet andesite is higher than that of the Waite rhyolite, except in D.D.H. Nos. V-119 and M-11 (Map XIII, V-68 (fig. 6), V-158 (fig. 7), and V-85 (fig. 8). The detail samples from underground workings show the same general relationships, i.e. higher copper content in the Amulet andesite and an anomalous area less than 100 feet across. The distribution of copper values in the pipe zone (B-2 ore zone) is erratic. The nature of the pipe zone mineralization which occurs as dissemination and fracture filling in brecciated altered rhyolite would explain the erratic distribution of the volatile trace elements.

In summary, the precision of the analytical copper method is ± 21%. The copper anomaly near the ore deposits is very restricted, and the

copper content of the Amulet andesite is higher than that of the Waite rhyolite except for the Vauze mine breccia member. The tuff at the contact contains high background values of copper.

Zinc

Of all elements analyzed, zinc is the least accurate. The poor results can be attributed in large part to the intensity in the region of the zinc spectral line. Zinc content ranges from a theoretical low value of -400 ppm (measured on a relative scale) to 10,000 ppm. Using the largest probable error at the 95% confidence level, the precision of the method is ± 38%.

The distribution of zinc values are shown in figures 5, 6, 7 and 8, and on Maps XVI, XIII, XXI and XXIII. Map XVI contains interesting results. The value of zinc in the contact tuff samples increases markedly at a distance of about 300-400 feet from the Vauze deposit. The difference in values, as shown in the variance analysis, is great enough to overcome precision and contamination effects on individual samples. There is a suggestion of a similar increase at the East Waite deposit. Tuff samples from D.D.H. Nos. M-25 and M-26 gave anomalous results. The anomalies are real but it should be noted that several geological features may cause anomalous zinc values. The post-ore intrusion of diorite and other igneous rocks could have been accompanied by hydrothermal solutions responsible for the deposition of enough zinc to cause anomalous values. Holes V-128, V-126 and V-89 situated near B-1 ore deposit and very close to a low angle thrust fault which cut and drag

folded the deposit, contain very high zinc values. The anomalous content may be related to the fact that the fault zone has been permeated by solutions. Several fault breccias were noted in underground workings that contained coarse crystalline sphalerite in the matrix.

The Amulet andesite contains more zinc than the Waite rhyolite. Map XIII shows a marked increase in the content of zinc in the Amulet andesite over the Vause ore deposit. The analysis of spot samples is not considered reliable, but it indicates low zinc content of the overlying andesite in each hole. This points to the necessity of caution in the interpretation based on zinc analysis alone. The underground samples show the same general results.

The samples of Amulet andesite immediately adjacent to B-1 ore zone on both the 3rd and 4th levels (VG-41, VG-181) have low zinc content. The same situation is noted in several diamond drill core samples (V-100, V-126, fig.9; V-130, V-86, fig.10; V-158, V-83*, fig.11; and V-134, Map XIII). The cause of the low zinc values just above the ore zone contact is unknown.

To summarize the results of zinc analysis: 1) the precision is poor, being only 38% at the 95% confidence level; 2) even with poor precision, the zinc content is variable enough to give valid anomalies

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* The correlation of tuff at the Amulet andesite-Waite rhyolite contact as presented in fig. 11 and similar figures of vertical section B-A, is open to question on the basis of chemical data. The tuff bed 100 feet lower than the correlated tuff bed is the more likely true contact.

which can be related to ore deposits; 3) the extent of the zinc halos is a minimum of 300 to 400 feet along the contact and values higher than background are observed in samples of the overlying andesite; 4) background zinc values of andesite samples are higher than those of rhyolite samples.

Lead

The precision for lead was established for values of 500 ppm. The majority of values in Vauze samples are near, or less than, 500 ppm. Therefore, the precision of 15% given in Table VIII is valid for this study. The lower limit for an accurate analysis is 50 ppm.

The distribution of lead values is shown in figures 5, 6, 7 and 8, and on Maps XVII, XIII, XVI and XXIII. Very little detectable lead is found in either rhyolite or andesite but some is contained in most samples of tuff. The increase in lead content toward the Vauze B-1 orebody is abrupt, the halo extending only for 100 to 200 feet. Three holes in the vicinity of the mine, V-128, V-126 and V-89 contain high lead values as well as high zinc values. It is possible that the lead was carried by solutions related to the thrust fault described above in the section on zinc. The only galena found in the mine area occurred in a thin carbonate-filled fault. Two other holes, Nos. M-25 and S-138 (Waite Amulet hole), have high lead values. This anomaly occurs in the same general area as the zinc anomaly. Even though D.D.H. M-26 contains low detectable zinc, spot samples indicate high values in andesite and rhyolite. Background lead values for andesite and rhyolite are below the detecta-

ble limits of the analytical methods. High detectable lead values generally are confined to the wallrock in the immediate vicinity of the ore deposit (figures 5, 6, 7 and 8 and Map XIII).

Most wallrock samples do not contain detectable quantities of lead except in the immediate vicinity of the ore deposit. The maximum lead halo is 100 to 200 feet. Lead anomalies are coincident with zinc anomalies.

Silver

The analysis method for silver is the most accurate (Table VIII). The tests made over a range of values from 10 ppm to 500 ppm indicate a maximum error of 10% at the 95% confidence level. The lower limit of accurate silver analysis is 10 ppm. The upper limit of detectability was not defined because the silver content of all Vauze samples is below 500 ppm. Most samples contain less than 100 ppm silver.

The distribution of silver values is illustrated on figures 9, 10, 11 and 12 and on Maps XVIII, XIV, XXI and XXIII. As in the case of lead, detectable amounts of silver tend to occur in tuff samples at the Waite rhyolite-Amulet andesite contact. The background content of the andesite and rhyolite samples is below the detectable limits of the method, except for those immediately adjacent to the ore zone. The tendency in the vicinity of the ore deposit is for higher silver content in andesites than in rhyolites (Map XIV, V-93, V-132, V-134; fig. 9, V-126; fig. 10, V-88; fig.11, V-85). The underground samples tend to show the same pattern (Maps XXI and XXIII). The distribution of values of the silver

content of tuffs is not as well defined as for zinc and lead, but definite trends are evident. The extent of a halo around the Vauze ore deposit is not well defined owing to the difficulty of determining the background value.

The silver results can be summarized as follows: The precision is 10%; the silver content of andesites and rhyolites is less than the detectable limit, except immediately adjacent to the ore deposits; silver anomalies occur near and over ore deposits but the halos are not well delimited.

Tin

Precision data are obtained only for two values of tin content - 500 and 100 ppm. The tin content of all Vauze samples except two is below 500 ppm. The lower limit of accurate analysis is 80 ppm. At the 95% confidence level, the precision of the analytical method is 25%.

The distribution of tin values is shown on figures 9, 10, 11 and 12, and on Maps XIX, XIV, XXI and XXIII. Map XXI, showing the distribution of values in underground chip samples from the 3rd level, indicate that very few samples of rhyolite contain tin in detectable amounts. The andesite contains detectable amounts which increase markedly near the ore deposit. The distribution is not the same for the 4th level samples (Map XXIII) which indicate a content of the andesite below detectable limits. A tin anomaly occurs in tuff samples near the Vauze ore deposit (Map XIX). The halo is very restricted and extends to less than 100 feet. The three holes that contain high zinc and lead

value, V-128, V-126 and V-89, and D.D.H. nos. M-25 and M-26, also contain high tin. The background values for tin in andesite and rhyolite is below the detectable limit except in a few andesite samples. Like in the case of silver, detectable quantities of tin occur in both andesite and rhyolite immediately adjacent to the Vauze ore deposit (e.g. fig.9, V-126; and fig. 10, V-86).

The analysis method for tin has a precision of 25%. Tin anomalies occur over ore deposits, but the halo is very restricted - less than 100 feet. The average tin content of andesites and rhyolites is below the detectable limit, but increases in wallrock adjacent to the ore deposit.

Indium

Initial results from Vauze samples indicated that a large number of samples contained detectable amounts of indium. But, when all data were gathered, the values had no distinct trends. In the optical spectrochemical method, indium is used as internal standard and this may cause contamination. The source of contamination during the sample preparation procedure is not known.

At the 95% confidence level, the precision of the analytical method for indium is 20%. The lower limit of accurate detection is 2.0 ppm. The method is very sensitive to indium and the content of most samples is below 50 ppm.

The distribution of indium content in Vauze samples is shown on figures 9, 10, 11 and 12, and on Maps XX, XIX, XXI and XXIII. A discerni-

ble pattern of distribution of indium content is not apparent. One possible exception is the pattern shown on Map XX which represents the indium content of tuff samples. No anomaly or halo is apparent over or near the Vause B-1 ore zone. However, an anomaly occurs in the same general vicinity where zinc, lead, silver and tin contents were anomalous near D.D.H. Nos. M-25, M-26, M-10 and M-11. M-12 has a very high indium content. Underground samples on the 3rd level (Map XXI) suggest higher indium content in andesite rocks. The 4th level samples (Map XXIII) have almost the same amount of indium for both andesite and rhyolite.

The absence of any pattern in the distribution of indium strongly suggests contamination during analytical procedures. The precision of the method is 20% and detectability is low (2.0 ppm).

Cadmium

The qualitative work on Vause samples at the beginning of the study indicated detectable amounts of cadmium. After having analysed about half of the Vause samples, only two were found to contain detectable amounts of cadmium. After all data were obtained and standard samples plotted on graph paper for working curves, cadmium sensitivity was shown to be very poor. The lower limit of accurate detectability is about 500 ppm and the cadmium content of almost all Vause samples are below that limit.

Distribution of major constituents

Slightly less than 50 samples of tuff and underground chip were

analysed for major constituents by X-ray fluorescence and optical spectrography. The precision of the techniques are described in the Appendix. Only trends can be postulated from the results. The 3rd level chip samples show variations of chemical composition near the B-1 ore zone. The 4th level samples were selected to show changes in chemical composition near the B-2 pipe or zone. The last set of samples are from the tuff bed at the Waite rhyolite-Amulet andesite contact. The variations are discussed below.

B-1 Zone

The important consideration in this zone is the variation in composition within rock units as the contact or ore zone is approached (Map XXII). Three compounds, TiO_2, CaO and MnO show no significant change but the andesite contains more abundant amounts of all three. The distribution of K_2O is erratic. Total Fe, MgO and Na_2O amounts are higher in andesites but decrease systematically as the contact zone is approached. From about 50 feet above the ore deposit, total Fe changes from 13.70 to 7.95% 5 feet above the contact; in the same samples MgO changes from 6.18 to 2.50%, and Na_2O changes from 1.64 to less than 0.10%. In the same samples, SiO_2 increases from 55.73 to 63.30%. In the samples of the Waite rhyolite, total Fe and MgO amounts increase from 30 to 40 feet below the ore deposit to a few feet below the contact. Total Fe increases from 1.65 to 4.13% and MgO increases from .04 to 2.35%. Na_2O decreases from 3.00 to 1.64%. SiO_2 appears to decrease but the distribution of values is erratic.

B-2 Zone

Samples of the B-2 ore zone were selected to show chemical variations in the Waite rhyolite from unaltered rock to brecciated chloritized rock (Map XXIII). The volatile trace elements and several major constituents such as SiO_2, K_2O, total Fe, and MgO have erratic distribution. TiO_2 and MnO amounts are consistent in most samples regardless of the amount of alteration. There is a decrease in the amounts of CaO and Na_2O in samples taken near the B-2 ore zone relatively to those taken 250 to 300 feet south. The decrease is from 1.20-0.87% to 0.20-0.40% CaO, and from 1.00-2.00% to 0.10-0.20% Na_2O.

Waite rhyolite-Amulet andesite Contact Tuff

The results of major constituent analysis of tuff samples (shown on Map XXIV) are not conclusive. None of the compounds show systematic variations. The only conclusion that can be reached is that the tuff is chemically closer to andesite than to rhyolite. The silica content is low — near andesite — but the values are erratic varying between 48.43% and 65.17%. The TiO_2 and CaO content is slightly lower than that of most andesite samples.

SUMMARY

The purpose of the chemical analysis was to study the distribution of select elements and compounds around the Vauze ore deposits, particularly in the tuff lying between the Waite rhyolite and the Amulet andesite.

Analysis of Vauze samples for 15 elements and compounds was comple-

ted. About 300 samples were analyzed for the following volatile trace elements: Copper (Cu), Zinc (Zn), Lead (Pb), Silver (Ag), Tin (Sn), Indium (In), and Cadmium (Cd). About 50 samples were analyzed for the following constituents: SiO_2, TiO_2, CaO, K_2O, MnO, total Fe, MgO and Na_2O.

The results of the volatile trace element analyses were not to expectations. They may be summarized as follows:

1) The cadmium content is below detectable limits.
2) The copper and indium results are poor due to contamination.
3) Zinc distribution shows an anomalous halo which extends up to 400 feet away from the ore along the contact tuff horizon.
4) Lead, silver and tin results indicate anomalous halos but less extensive than that for zinc.
5) A large anomaly in most of the volatile elements is indicated near the corner of the properties of Vauze Mines Ltd, Waite Lake Mines Ltd and Waite Amulet Mines Ltd.
6) Both the andesite and rhyolite in the immediate vicinity of the B-1 orebody contain anomalous amounts of most volatile elements. In the rhyolite, the halos are restricted usually to less than a few feet or tens of feet except where the Vauze mine pyroclastic breccia is thick. The halo in the underlying andesite extends up to 100 feet in places, but the rock unit is cut by diorite and a complete evaluation of the distribution of trace elements was not possible.

The analyses of the major constituent indicate alteration of both the andesite and rhyolite adjacent to the conformable ore deposit. The andesite is silicified and has lost some Fe and MgO. Fe and MgO have been added to rhyolite and Na_2O content has decreased. Changes in the andesite occur up to 50 feet away from the ore contact. In the rhyolite the change is apparent 30 to 40 feet from the contact. The changes in the pipe zone are not as well defined. Fe and MgO have been added in zones of chloritization. The content of Na_2O, CaO and K_2O decreases toward B-2 ore zone. The distribution of major constituents in tuff shows no distinct trends.

The most reliable sampling technique is core splitting. This method, however, is not always feasible. Results obtained by the systematic sampling procedure are reliable. The spot sample procedure used in sampling diamond drill cores is inadequate.

It is concluded that the presence of an ore deposit in this area can give rise to detectable geochemical anomalies. The zinc anomalies are the largest, but these and some of the other anomalies may be caused by geologic conditions other than the presence of an ore deposit. Tuff samples can give first indications of anomalous conditions. It is believed that systematic sampling and analysis of andesite and rhyolite for zinc and lead and for the major constituents Na_2O, MgO and total Fe, can give valuable information on possible areas of ore deposition.

APPENDIX

Sampling Techniques

A method of systematic sampling was used to eliminate bias on the part of the sampler. Four procedures were used. (1) The entire core of the tuff beds which lie at the contact was split and sampled. Most diamond drill cores from the Waite Lake and Vauze Mine properties and only select cores from the Waite-Amulet property were sampled. (2) Samples were taken of the other rock units 100 feet above and below the Waite rhyolite-Amulet andesite contact. The rock units were separated on the basis of color, texture and mineralogy. The minimum thickness of the sampled sections was 12.5 feet and the maximum 100 feet. Each sample consists of 2-in. pieces of whole core taken systematically at intervals of 18 inches. (3) Another procedure consisted of taking four spot samples of whole core 4-in. in length 50 feet and 25 feet below and above the Waite rhyolite-Amulet andesite contact. (4) The last sampling procedure involved taking chip samples at intervals of 5 feet at various underground workings.

Sample Preparation

The preparation techniques used are standard procedures for geochemical analyses at McGill University. Minor changes were required because of the large number of samples that had to be processed. The exact steps are outlined in figure 3. A five place weighing accuracy was used. The sample and added material were thoroughly mixed. Poor mixing can introduce very large errors because the ratio between known

compounds and unknowns would not be uniform throughout the sample.

Due to alumina contamination by the ceramic plates used in pulverizing, analyses for Al_2O_3 were not done. To some extent, there is also iron contamination by the plates used in crushing. However, the sample at this stage is very large and the effects of contamination which were not evaluated experimentally are likely to be small.

Analytical Methods

Three analytical methods were used for determination of elements and compounds (fig.3). 1- The first method which requires fusing of the samples is by the General Electric XRD-3 X-ray fluorescence equipment. It was used for quantitative determination of SiO_2, TiO_2, CaO, K_2O, total Fe, and MnO. 2- D-c arc excitation and the Jaco planegrating 3.4 meter spectrograph was used to detect the light constituents MgO and Na_2O. 3- The third method was used to detect certain volatile trace elements like Ag, Sn, Cd, Zn, Cu and Pb after a qualitative work was done to find out which elements were detectable. The procedure, based on work done by Ingamells and Suth (1963), is semi-quantitative. Powdered samples were mixed to graphite in the proportion of 10 parts to 1. The graphite contained 1.0% Sb for an internal standard. The samples were packed in 3/16 in. diameter electrodes, covered with boiler caps and arced for 1 minute at 15 amps with the spectral range control at 9.87 for second order exposures.

In the optical spectrochemical procedures, the calculations to ob-

tain relative intensity ratios were done on McGill's IBM 7040 computer.

Precision of volatile trace elements analyses

It is necessary to note that the analytical method used for the determination of the volatile trace elements is semi-quantitative. The values in parts per million are only relative and are reliable within limits set by the precision of the method which is established in the following way. The analysis of a sample for one element is repeated and, assuming normal distribution, statistical tests are applied to the results. The precision of the analysis is then established at a particular amount, such as 100 ppm. This procedure is repeated for various element contents in order to establish the precision over a range of values.

Many analytical procedures, particularly those used in this study, have a lower and an upper limit of detectability. Optical spectrochemical methods rely on photographic methods for quantitative results. When the intensity of a spectral line approaches the intensity of the background, larger errors in detection occur. Very dark lines (high concentrations) introduce the same type of errors. A negative value indicates the presence of an element but does not allow even an estimation of the values.

The precision of a method is calculated on the basis of its probable error at the 95% confidence level. The error is calculated by the following formula:

P.E. of the mean = $\frac{1.96\ (s/n-1)\ (100)}{\bar{x}}$ where

$\bar{x}$ = arithmetic mean

± 1.96 is the confidence coefficient at 95% level

s = standard deviation

n = number of samples

To determine significant differences in element content, the samples were classified into 16 groups (table IX) based on rock type and geologic environment. To test the null hypothesis assuming normal distribution, analysis of variance was done. The Snedecor F test led to the data presented on table X. Comparisons were made only between samples of the same rock type. For example, rhyolite samples from the pipe zone are compared to rhyolite samples in the vicinity of the southern ore zone but andesite samples are not compared to rhyolite.

Precision of major constituents analyses

The major constituents analyses were carried out by two well established techniques. The content of SiO_2, TiO_2, CaO, K_2O, MnO and total Fe, was obtained by X-ray fluorescence analytical procedures, and that of MgO and Na_2O by optical spectrographic analytical procedures. The probable error at the 95% confidence level was established for each compound (Table VIII). Samples VG-352 were used to determine the precision of the analysis by X-ray fluorescence. Five duplicate samples were made and analysed after secondary crushing to establish the total error of the method. The optical spectrochemical analysis error was established by ten repititions of analysis of samples V-77 and V-82 E. In addition, the MgO analysis for sample VG-352 was repeated five times. The Na_2O content of VG-352 was below the limit of accurate detectability and could not be used.

TABLE VIII

PROBABLE ERROR FOR VARIOUS CONSTITUENTS OF VAUZE MINE SAMPLES

CONSTITUENT	ANALYTICAL METHOD	SAMPLE NO.	n	$\bar{x}$	s^2	s	C	P.E.$_{95}$(%)
SiO_2	XF-M	VG 352	5	73.67	4.80	2.19	.04	4.4 (≤ 20%)
TiO_2	XF-M	VG 352	5	0.17	0.0036	0.06	.13	13.0
CaO	XF-M	VG 352	5	0.14	0.0049	0.07	.21	20.4
K_2O	XF-M	VG 352	5	1.25	0.16	0.40	.13	12.9
MnO	XF-M	VG 352	5	.03	0.000025	0.005	.12	11.8
Total Fe.	XF-M	VG 352	5	5.21	0.42	0.65	.14	13.2
MgO	OS-M	VG 352	5	3.56	0.03	0.18	.04	3.6
MgO	OS-M	V 77 F	10	4.83	0.04	0.20	.03	1.9
MgO	OS-M	V 82 B	10	2.74	0.05	0.22	.06	3.9
Na_2O	OS-M	V 77 F	10	4.12	0.55	0.74	.07	4.6
Na_2O	OS-M	V 82 B	10	1.78	0.30	0.55	.11	7.0

XF-M, X-ray Fluorescence major element procedure; OS-M, Optical Spectrochemical major element procedure; OS-V, Optical Spectrochemical Volatile trace element procedure; n, number of analyses; $\bar{x}$, sample mean (major elements expressed as weight per cent, volatile trace elements expressed as parts per million; s^2, sample variance; s, sample standard deviation; C, coefficient of variation; P.E.$_{95}$(%) probable error of the sample mean at 95% confidence level.

CONSTITUENT	ANALYTICAL METHOD	SAMPLE NO.	n	$\bar{x}$	s^2	s	C	P.E.$_{95}$(%)
Zn	OS-V	V 83 B	4	755	47524	218	.34	38.0
Zn	OS-V	V 86 B	4	1750	122500	350	.24	27.1
Zn	OS-V	500 ppm Std.*	12	500	6889	83	.23	13.4
Ag	OS-V	500 ppm Std.	11	500	9025	95	.17	10.3
Ag	OS-V	100 ppm Std.	9	100	81	9	.14	10.2
Ag	OS-V	50 ppm Std.	12	50	144	12	.28	17.5
Ag	OS-V	10 ppm Std.	10	10	196	14	.21	13.4
Sn	OS-V	500 ppm Std.	12	500	28900	170	.25	14.8
Sn	OS-V	100 ppm Std.	9	100	2500	50	.37	25.5
In	OS-V	50 ppm Std.	11	50	196	14	.25	14.9
In	OS-V	10 ppm Std.	8	10	6.25	2.5	.22	16.0
In	OS-V	5 ppm Std.	11	5	4.0	2.0	.32	19.6
Cu	OS-V	V 117	4	1220	17689	133	.08	9.5
Cu	OS-V	500 ppm Std.	11	500	27225	165	.28	17.3

* 500 ppm Std., the 500 parts per million standard sample.

CONSTITUENT	ANALYTICAL METHOD	SAMPLE NO.	n	$\bar{x}$	s^2	s	C	$P.E._{95}(\%)$
Cu	OS-V	100 ppm Std.	9	100	1600	40	.31	21.2
Cu	OS-V	50 ppm Std.	12	50	625	25	.27	15.8
Cu	OS-V	10 ppm Std.	10	10	625	25	.22	20.9
Pb	OS-V	500 ppm Std.	12	500	19600	140	.18	10.6
Pb	OS-V	100 ppm Std.	9	100	2304	48	.22	15.2

TABLE IX

GROUPING OF ROCK SAMPLES FOR ANALYSIS OF VARIANCE

GROUP NO.	AREA (of Plate XII)	ROCK TYPE	REMARKS
1	A	Rhyolite	
2	A	Rhyolite	From D.D.H. Nos. M-25, M-26, M-10
3	A	Rhyolite	Near Vauze ore deposit.
4	A	Vauze Mine Breccia	Stratiegraphically directly below Vauze ore diposit.
5	A	Rhyolite	From underground chip samples of unaltered Rhyolite.
6	A	Rhyolite	From underground chip samples near "Pipe" zone - Chloritized Rhyolite
7	A	Andesite	
8	A	Andesite	Spot samples from D.D.H. Nos. M-25, M-26, M-10.
9	A	Andesite	Near Vauze ore deposit.
10	A	Andesite	From underground chip samples.
11	A	Tuff	Near ore zone.
12	A-S	Tuff	From D.D.H. Nos. M-25, M-26, M-10
13	A	Tuff	
14	BS	Tuff	
15	BNE	Tuff	
16	BNW	Tuff	

TABLE X

COMPILATION OF ANALYSIS OF VARIANCE DATA FOR VOLATILE TRACE ELEMENTS

GROUP COMPARISONS	Ag	Cu	In	Pb	Sn	Zn	TOTAL NO. OF X'S
1-2	X	O	O	X	O	X	3
1-3	X	O	X	O	X	X	4
1-4	X	X	X	X	O	X	5
1-5	X	O	O	X	O	X	3
1-6	X	X	X	O	X	X	5
2-3	X	O	O	X	X	X	4
2-4	O	X	X	X	O	O	3
2-5	X	O	O	X	O	X	3
2-6	O	X	O	X	X	X	4
3-4	X	X	X	X	X	X	6
3-5	X	O	O	O	O	O	1
3-6	X	X	O	O	X	X	4
4-5	X	X	X	X	X	X	6
4-6	O	O	X	X	X	X	4
5-4	X	X	O	O	X	X	4
7-8	X	O	X	X	O	X	4

X - A significant difference occurs between sample variances.

O - No significant difference exists between sample variance.

GROUP COMPARISONS	Ag	Cu	In	Pb	Sn	Zn	TOTAL NO. OF X'S
7-9	X	0	0	X	X	0	3
7-10	X	0	0	0	X	X	3
8-9	X	0	X	0	X	X	4
8-10	X	0	0	X	X	X	4
9-10	0	0	0	X	0	X	2
11-12	X	0	X	0	0	0	2
11-13	0	0	X	X	X	0	3
11-14	X	0	0	0	X	0	2
11-15	X	0	0	0	X	X	3
11-16	X	0	X	0	0	0	2
12-13	X	X	X	0	X	0	4
12-14	X	X	X	0	0	0	3
12-15	0	0	X	0	X	X	3
12-16	0	0	X	0	0	0	1
13-14	X	0	0	X	0	X	3
13-15	X	X	0	0	0	X	3
13-16	0	X	X	X	0	X	4
14-15	X	X	0	0	0	X	3
14-16	0	0	X	0	0	0	1
15-16	X	0	X	X	0	X	4

X - A significant difference occurs between sample variances.

0 - No significant difference occurs between sample variances.

The precision of MgO and Na_2O analysis as presented in the table is the total error of the method at the 95% confidence level.

With the X-ray procedure, except in the case of CaO analysis, all error values are below 13.2%. The higher probable error for CaO can be attributed to the low amount of CaO in sample VG-352. Therefore, except for values close to the lower limit of accurate detectability, the precision of analysis by X-ray fluorescence is ± 13%. For MgO, the maximum probable error is ± 4% and for Na_2O, 7.0%.

The 4.4% precision of the SiO_2 content shown on Table VIII is misleading. The precision is only as good as the precision of the standard working curve from which the values are taken. The working curve is drawn from a series of samples with known silica content which have been prepared in the same manner as the samples to be analysed. In the X-ray fluorescence analytical procedures, the silica content of the standards is plotted against the number of counts per 20 seconds. The curves obtained for other compounds are satisfactory but in the case of silica, the points are scattered and the resulting curve is questionable. The true precision is much less accurate than the 4.4% indicated in the table. An estimation of the error by drawing parallel curves containing most of the scattered points, gives about ± 20%. At 70.00% SiO_2, the error is ± 14.00%. At 50.00% SiO_2, the error is ± 10.00% SiO_2.

TABLE XI

COMPILATION OF ANALYSIS OF VARIANCE DATA FOR MAJOR CONSTITUENTS

GROUP COMPARISONS	SiO_2	TiO_2	MnO	MgO	CaO	Na_2O	K_2O	Fe	TOTAL NO. OF X'S
11-12	X	0	0	0	0	0	0	0	1
11-13	X	0	X	0	0	0	0	0	2
11-10	X	X	X	0	0	0	0	0	3
11-5	X	0	0	0	0	0	0	0	1
11-6	X	X	0	0	0	0	0	0	2
12-13	0	0	0	0	0	0	0	0	0
12-10	0	0	0	0	0	0	0	0	0
12-5	0	0	X	X	X	0	0	X	4
12-6	0	0	X	X	X	0	0	0	3
13-10	0	0	0	0	0	0	0	0	0
13-5	0	0	X	0	0	0	0	0	1
13-6	0	0	X	0	0	0	0	0	1
10-5	0	0	X	0	X	0	0	0	2
10-6	0	0	X	0	X	0	0	0	2
5-6	0	X	0	0	0	0	0	X	2

X - A significant difference occurs between sample variances.

0 - No significant difference exists between sample variances.

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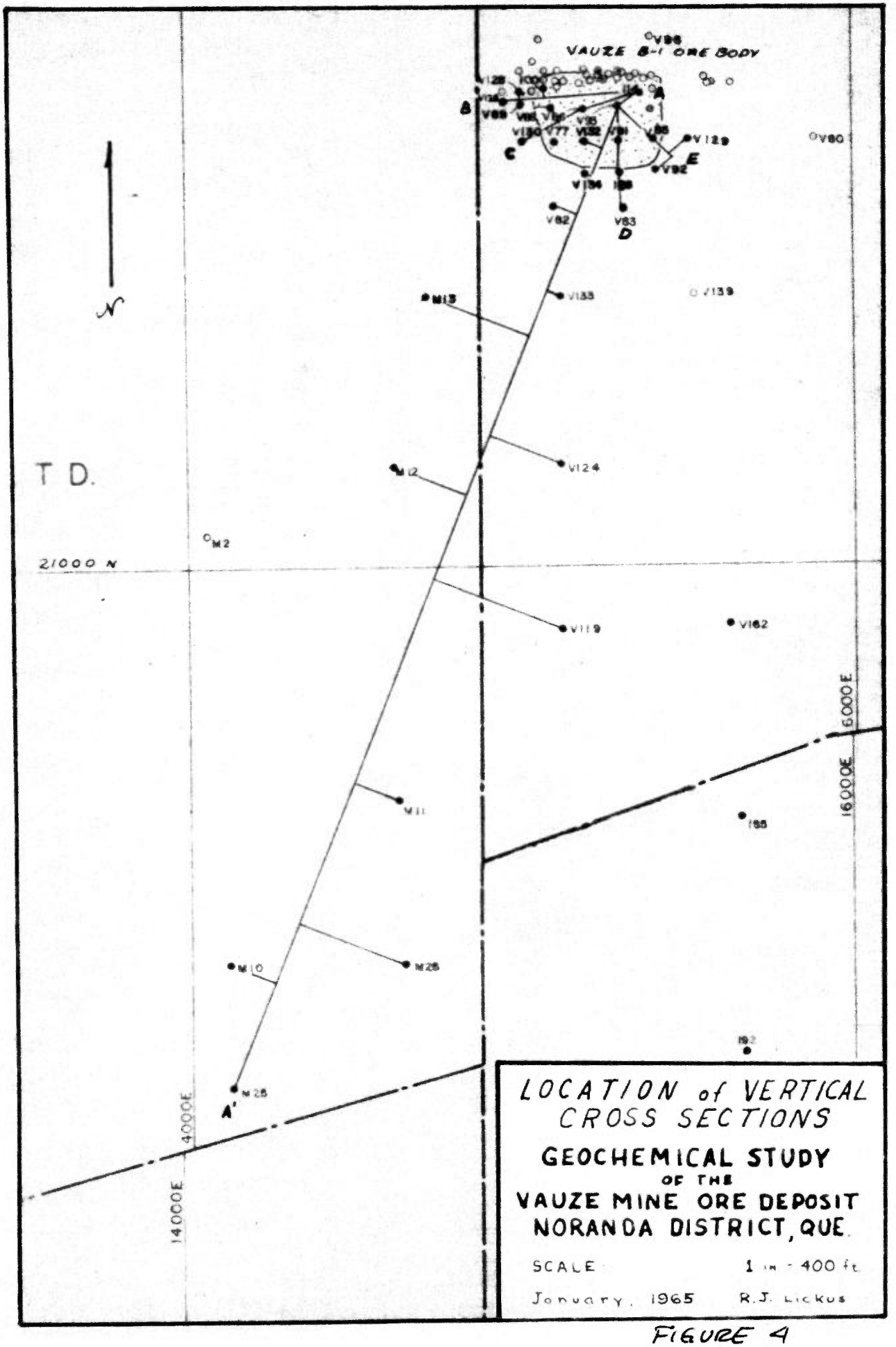


LOCATION of VERTICAL CROSS SECTIONS

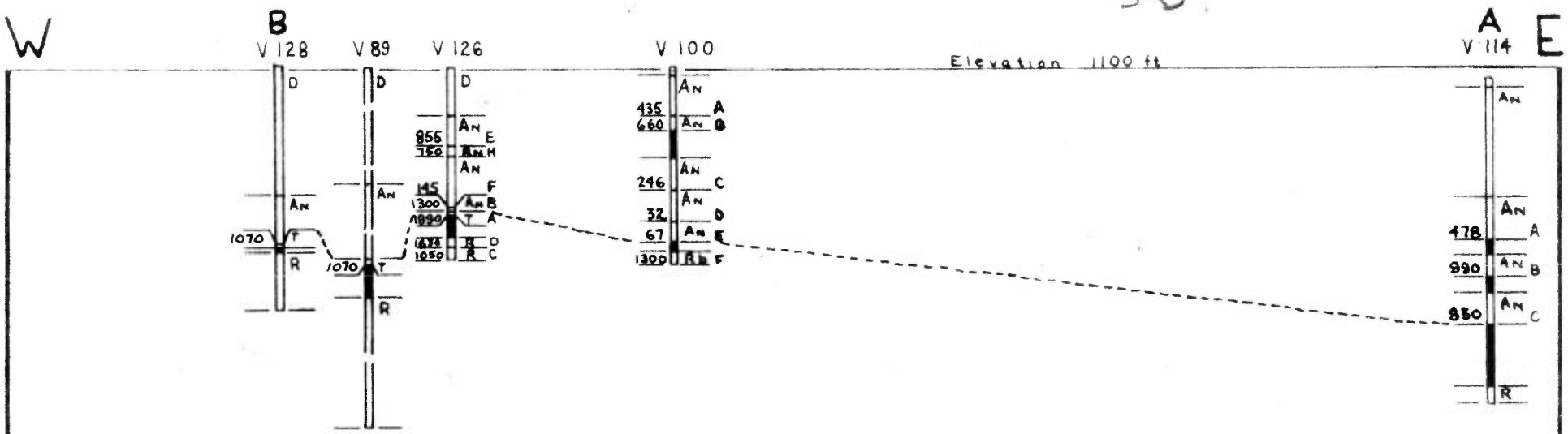
GEOCHEMICAL STUDY OF THE VAUZE MINE ORE DEPOSIT NORANDA DISTRICT, QUE.

SCALE 1 in = 400 ft

January, 1965 R.J. Lickus

FIGURE 4

N.B. ~~Les résultats pour 3 éléments~~ Pour réduire le nombre de cartes, nous avons groupé les résultats de 3 éléments sur la même carte.



- LEGEND -

Diamond Drill Hole Type

Rock Sample No.

ppm

30

40

D - Tuff

An - Amulet Andesite

Cre Zone - Vauze Breccia

Rh - Waite Rhyolite

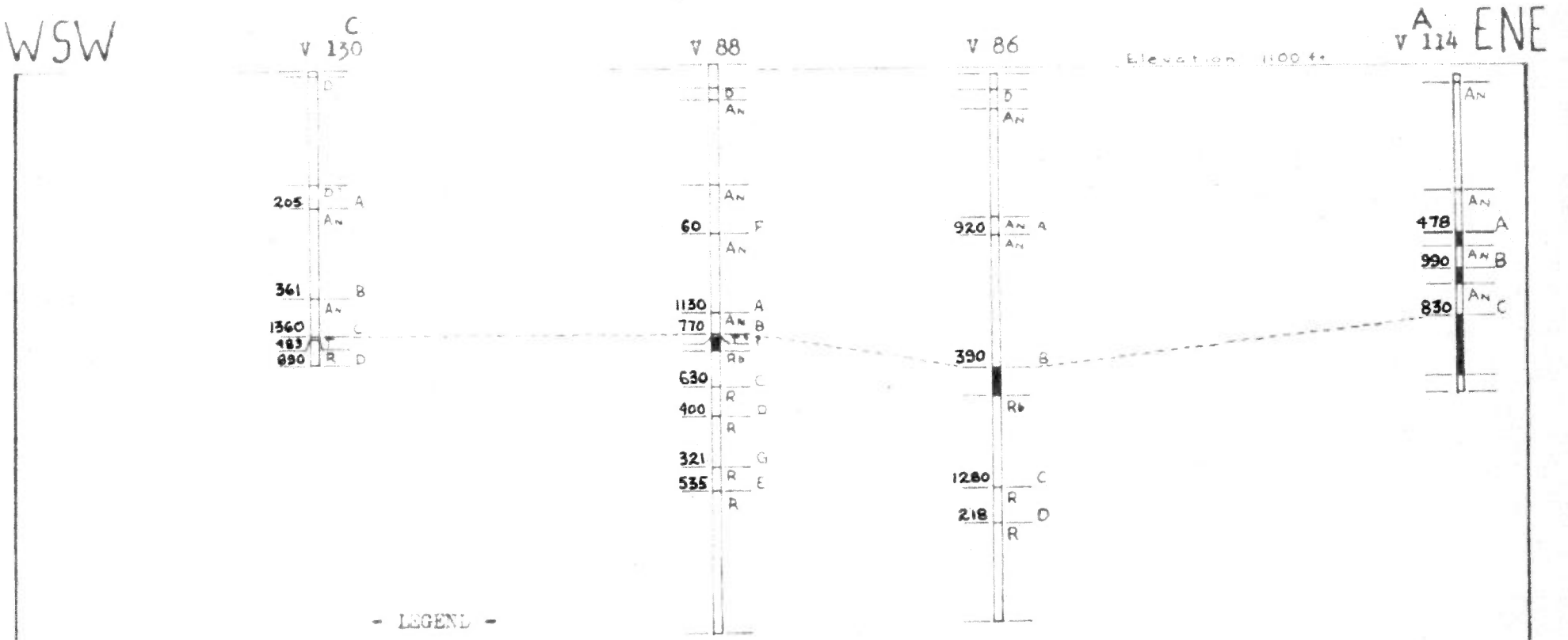
Contact

VERTICAL SECTION, B-A
DISTRIBUTION of COPPER
GEOCHEMICAL STUDY
of
VAUZE MINES LTD and
WAITE LAKE MINES LTD AREA
QUEBEC

HORIZONTAL SCALE: 1 IN. = 50 ft.
VERTICAL SCALE: 1 IN. = 100 ft.
JANUARY 1965 R.J. LICKUS

FIGURE 5

A-2



- LEGEND -

Diamond Drill Hole | Rock Sample Type No.

ppm

318 — D

nd — An — A

Ore Zone

An - Amulet Andesite
R - Waite Rhyolite
Rb - Waite Rhyolite Vauze Breccia
T - Tuff
D - Diorite

------ Andesite-Rhyolite Contact

VERTICAL SECTION, C - A

DISTRIBUTION of COPPER

GEOCHEMICAL STUDY

of

VAUZE MINES LTD and WAITE LAKE MINES LTD AREA

Quebec

Horizontal Scale: 1 in - 50ft
Vertical Scale: 1 in - 100ft

January, 1965 R. J. Lickus

A-3

FIGURE 6

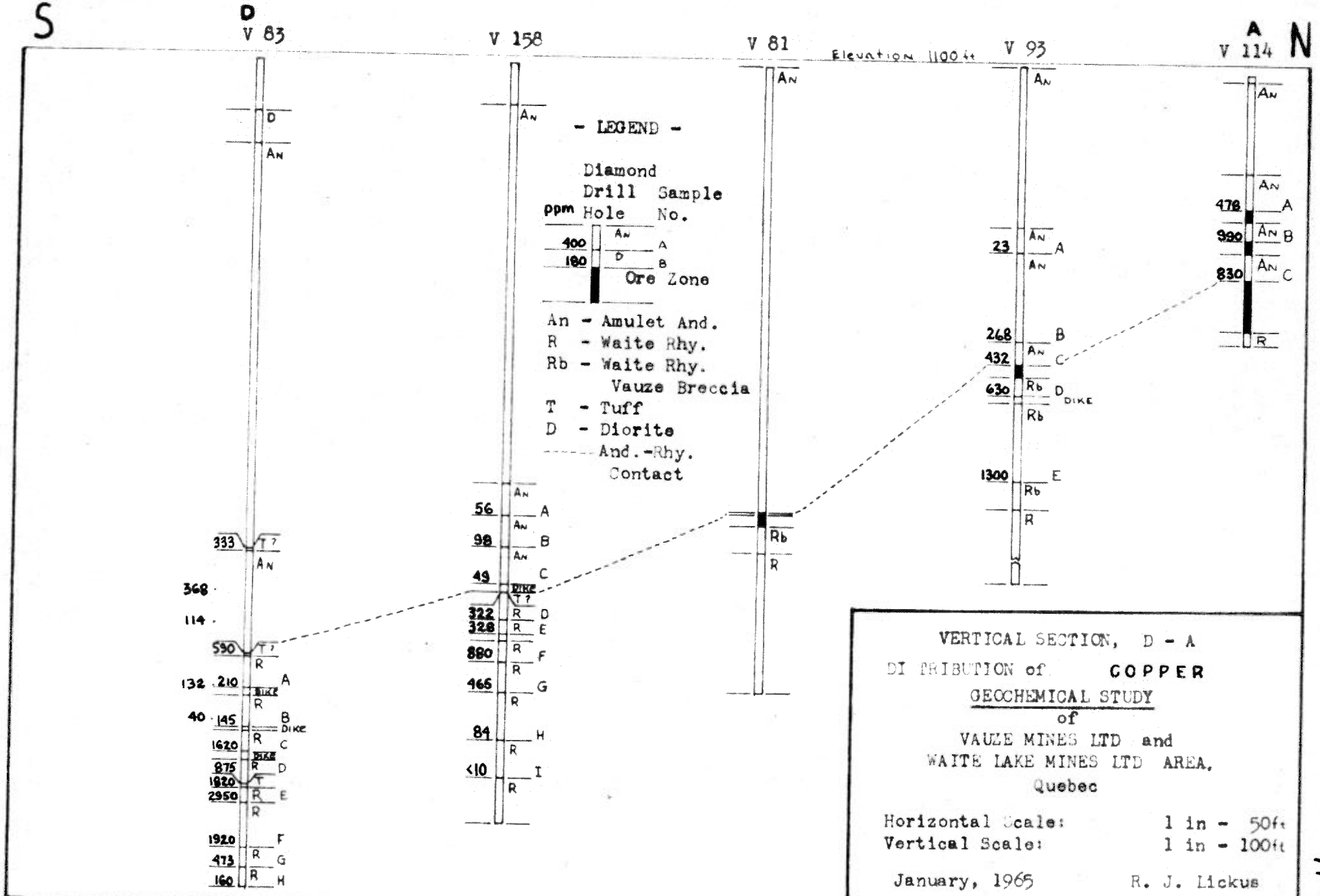

S
D
V 83
V 158
V 81
Elevation 1100 ft
V 93
A
V 114
N
- LEGEND -
Diamond Drill Hole No.
Sample
ppm
400
180
Ore Zone
An - Amulet And.
R - Waite Rhy.
Rb - Waite Rhy.
Vauze Breccia
T - Tuff
D - Diorite
And.-Rhy. Contact
333
368
114
590
132
210
40
145
1620
875
1820
2950
1920
473
160
56
98
49
322
328
880
465
84
<10
23
268
432
630
1300
478
990
830
VERTICAL SECTION, D - A
DISTRIBUTION of COPPER
GEOCHEMICAL STUDY
of
VAUZE MINES LTD and
WAITE LAKE MINES LTD AREA,
Quebec
Horizontal Scale: 1 in - 50ft
Vertical Scale: 1 in - 100ft
January, 1965
R. J. Lickus

FIGURE 7

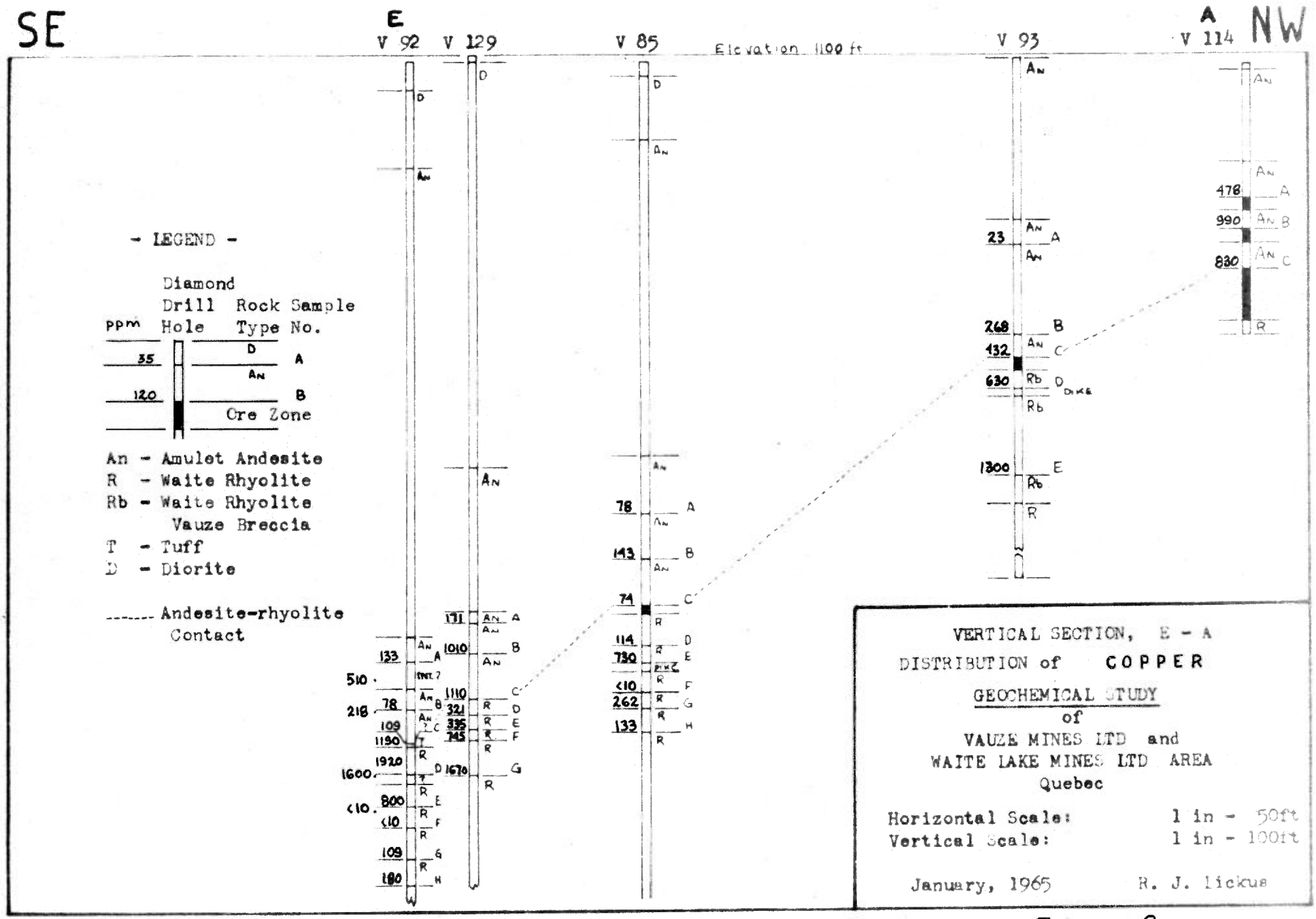
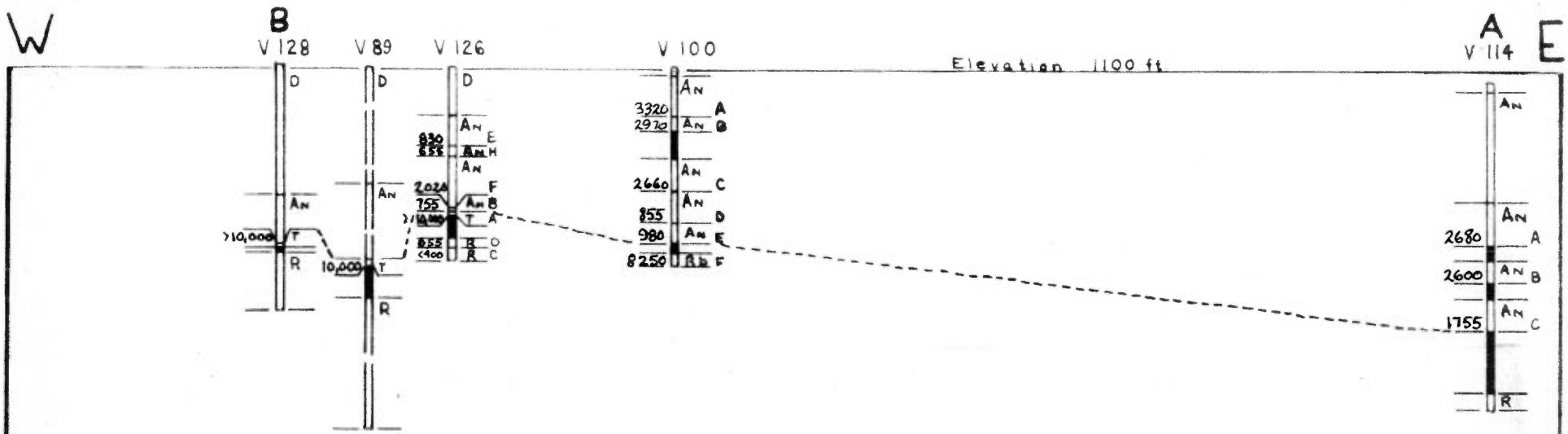
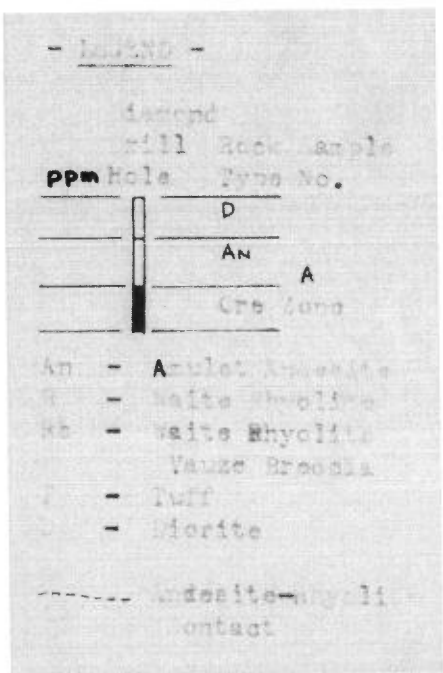

SE
E
V 92
V 129
V 85
Elevation 1100 ft
V 93
A
V 114
NW
- LEGEND -
Diamond Drill Hole
Rock Type
Sample No.
ppm
35
120
D
An
A
B
Ore Zone
An - Amulet Andesite
R - Waite Rhyolite
Rb - Waite Rhyolite Vauze Breccia
T - Tuff
D - Diorite
Andesite-rhyolite Contact
510
218
1600
<10
133
78
109
1190
1920
800
<10
109
180
131
1010
1110
321
335
345
1670
78
143
74
114
730
<10
262
133
23
268
132
630
1300
476
990
830
VERTICAL SECTION, E - A
DISTRIBUTION of COPPER
GEOCHEMICAL STUDY
of
VAUZE MINES LTD and
WAITE LAKE MINES LTD AREA
Quebec
Horizontal Scale: 1 in - 50ft
Vertical Scale: 1 in - 100ft
January, 1965
R. J. Lickus

FIGURE 8

A-5

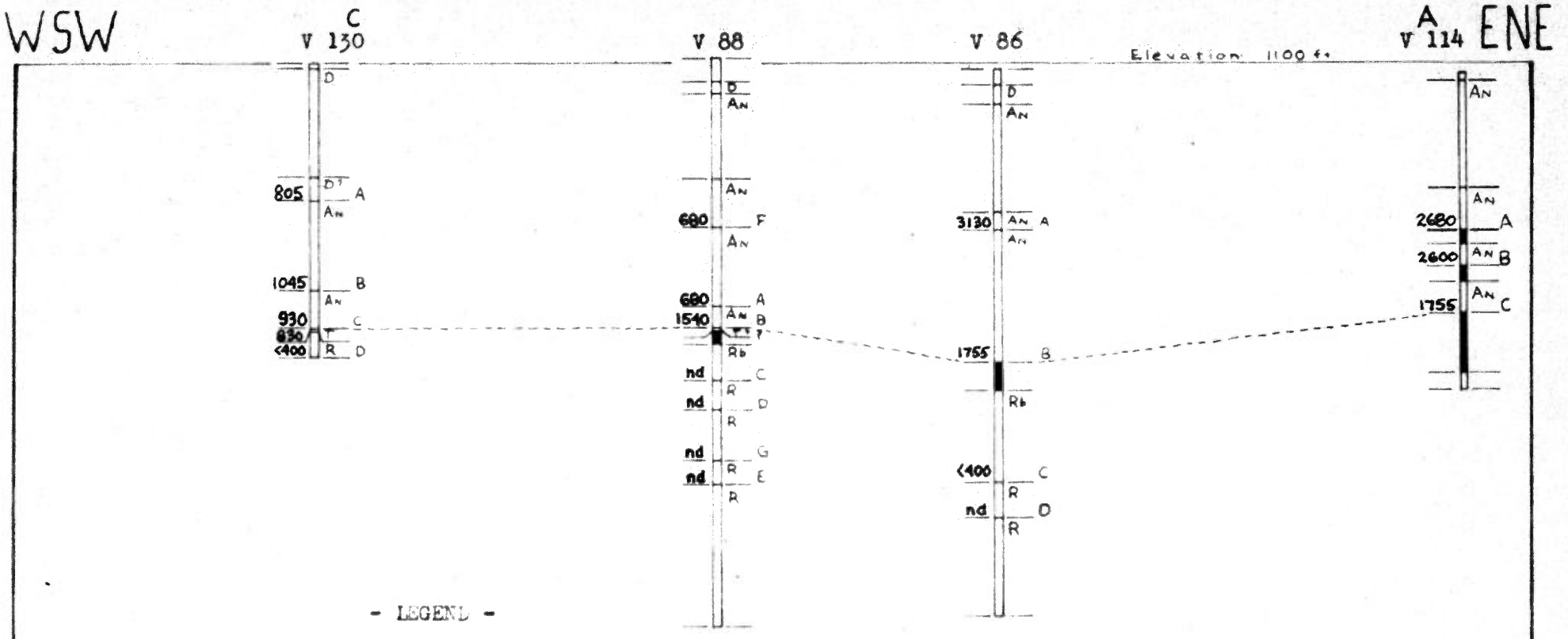




VERTICAL SECTION, B-A
DISTRIBUTION of ZINC
GEOCHEMICAL STUDY of VAUZE MINES LTD and WAITE LAKE MINES LTD AREA
QUEBEC

HORIZONTAL SCALE: 1 IN. = 50 ft.
VERTICAL SCALE: 1 IN. = 100 ft.
JANUARY 1965
R. J. LICKUS

FIGURE 9



VERTICAL SECTION, C - A

DISTRIBUTION of ZINC

GEOCHEMICAL STUDY

of

VAUZE MINES LTD and WAITE LAKE MINES LTD AREA

Quebec

Horizontal Scale: 1 in - 50ft

Vertical Scale: 1 in - 100ft

January, 1965 R. J. Lickus

A-7

FIGURE 10

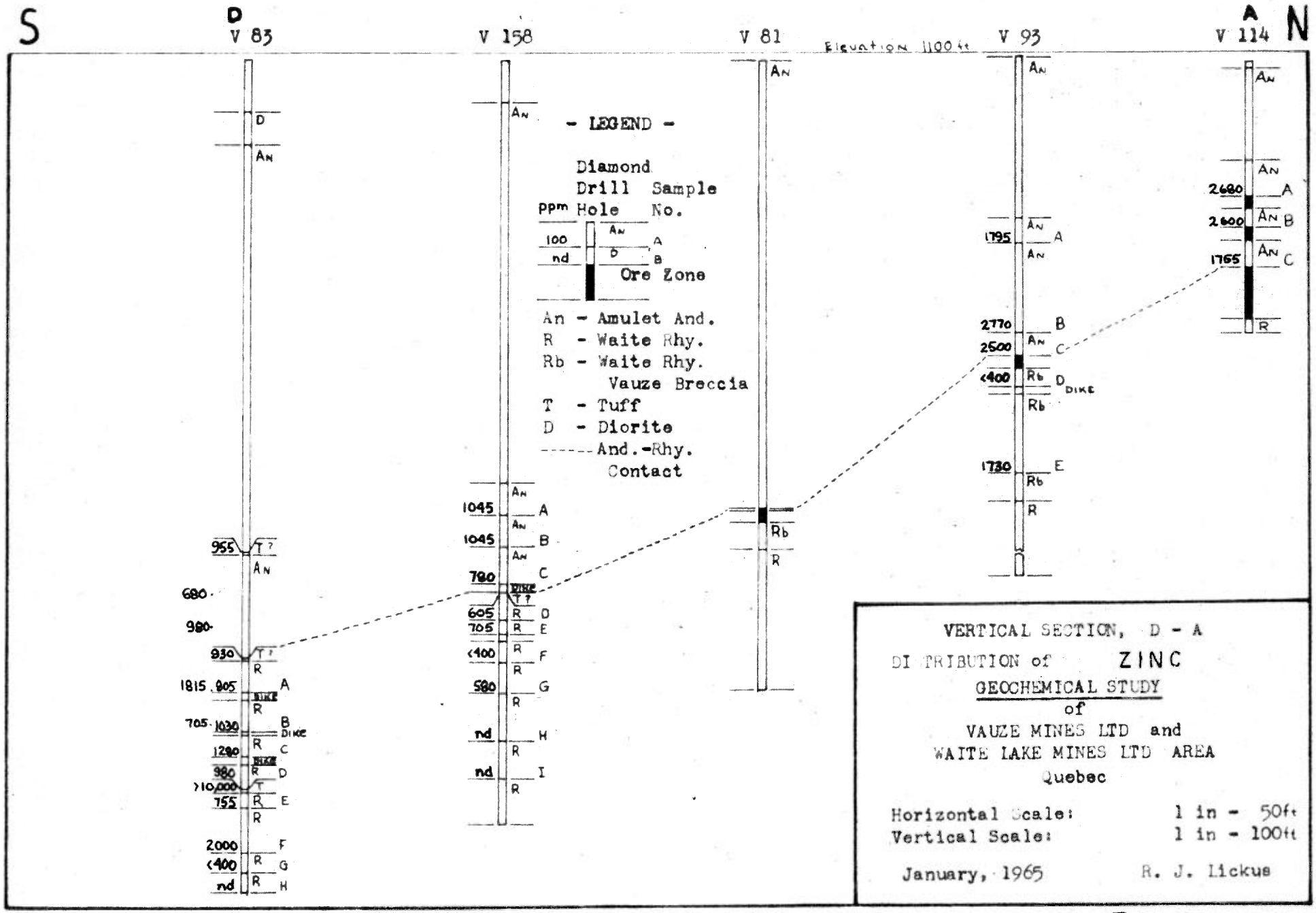

S
D
V 83
V 158
V 81
Elevation N 1100 ft
V 93
A
V 114
N
- LEGEND -
Diamond Drill Sample
ppm Hole No.
100 nd
Ore Zone
An - Amulet And.
R - Waite Rhy.
Rb - Waite Rhy.
Vauze Breccia
T - Tuff
D - Diorite
And.-Rhy. Contact
955
680
980
930
1815
905
705
1030
1290
980
>10,000
755
2000
<400
nd
1045
1045
780
605
705
<400
580
nd
nd
1795
2770
2500
<400
1730
2680
2600
1765
VERTICAL SECTION, D - A
DISTRIBUTION of ZINC
GEOCHEMICAL STUDY
of
VAUZE MINES LTD and
WAITE LAKE MINES LTD AREA
Quebec
Horizontal Scale: 1 in - 50ft
Vertical Scale: 1 in - 100ft
January, 1965
R. J. Lickus

FIGURE 11

A-8

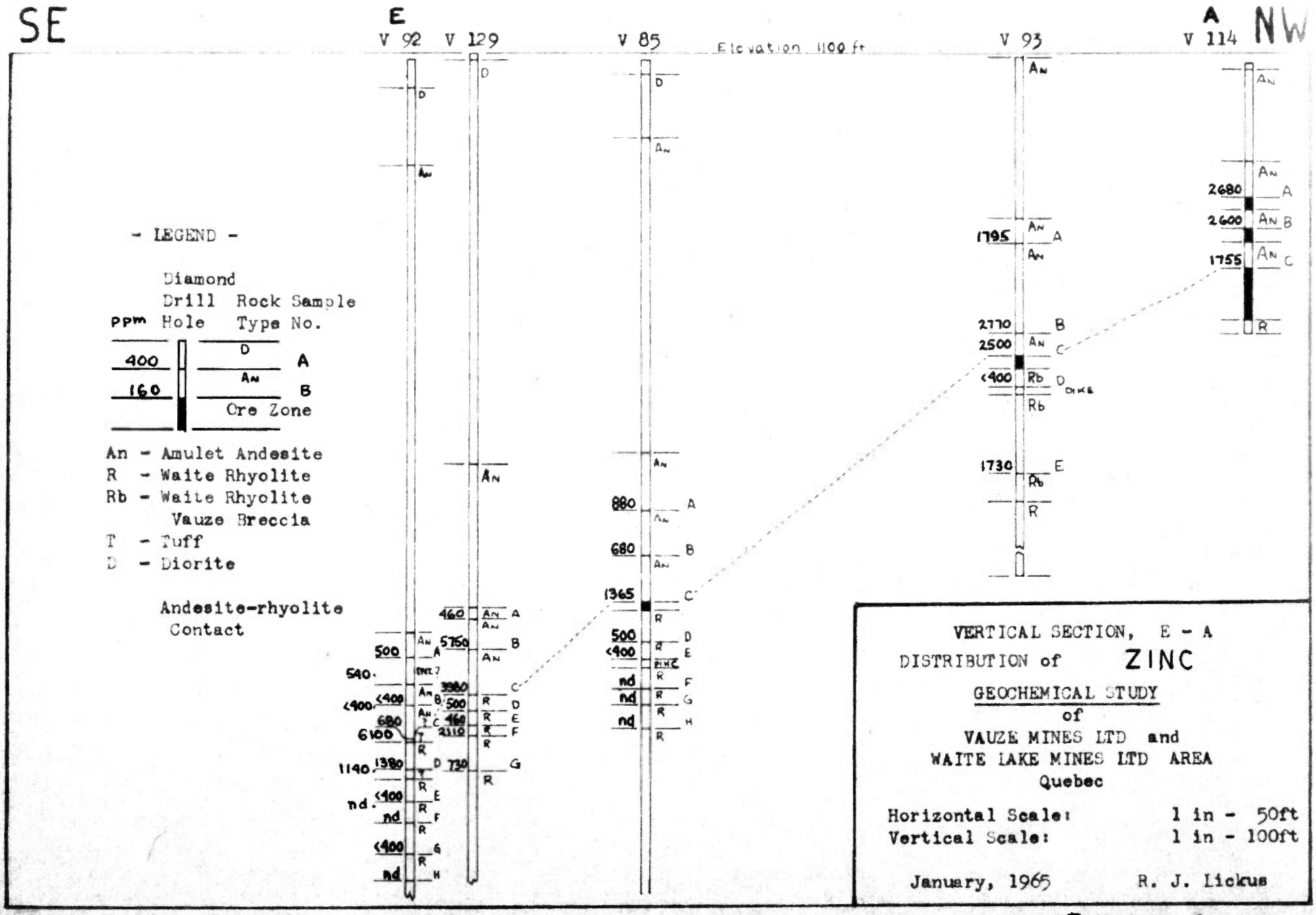
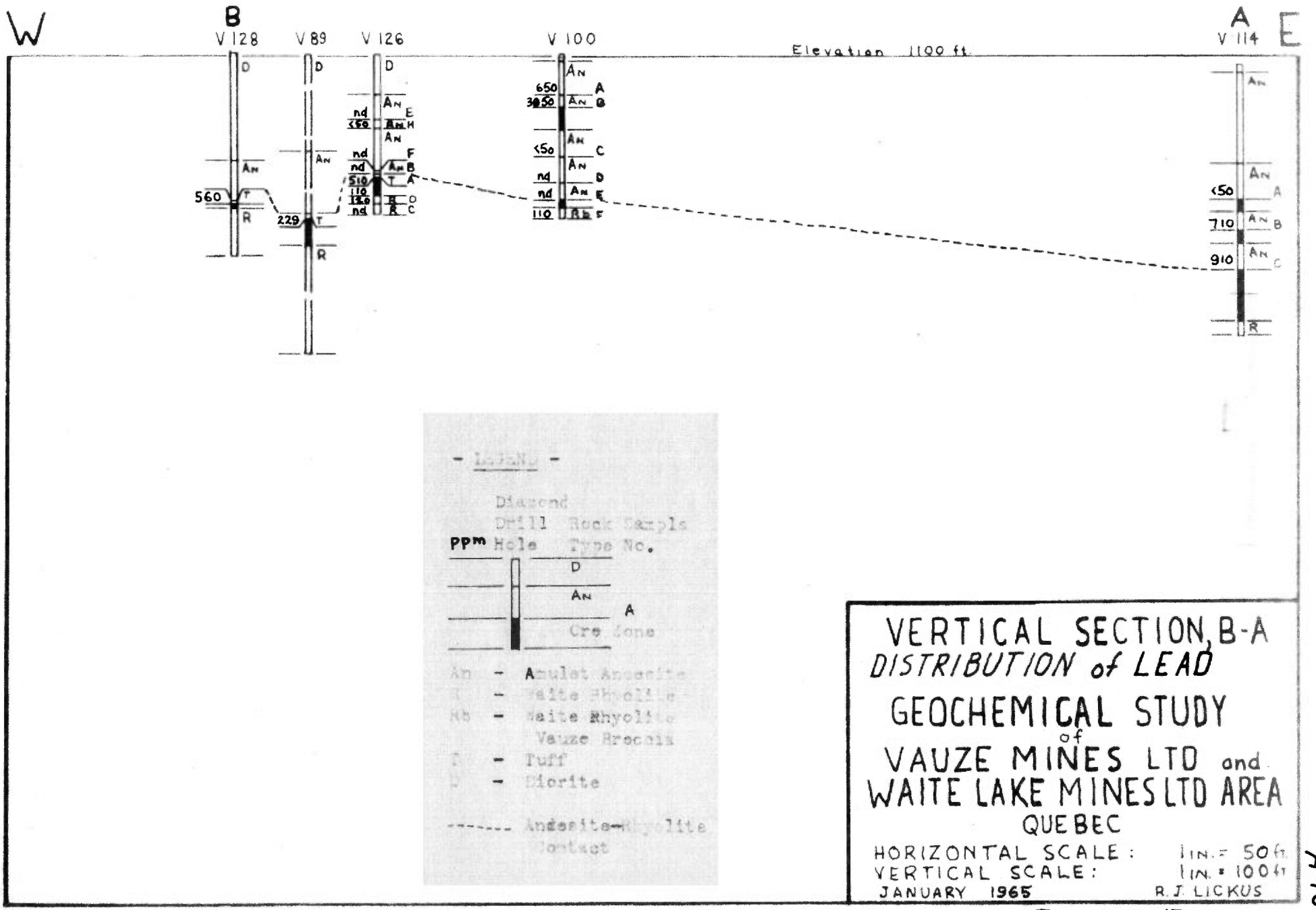

SE
E
V 92
V 129
V 85
Elevation 1100 ft
V 93
A
V 114
NW
- LEGEND -
Diamond Drill Hole
Rock Sample Type No.
ppm
400
160
D
An
A
B
Ore Zone
An - Amulet Andesite
R - Waite Rhyolite
Rb - Waite Rhyolite Vauze Breccia
T - Tuff
D - Diorite
Andesite-rhyolite Contact
VERTICAL SECTION, E - A
DISTRIBUTION of ZINC
GEOCHEMICAL STUDY
of
VAUZE MINES LTD and
WAITE LAKE MINES LTD AREA
Quebec
Horizontal Scale: 1 in - 50ft
Vertical Scale: 1 in - 100ft
January, 1965 R. J. Lickus

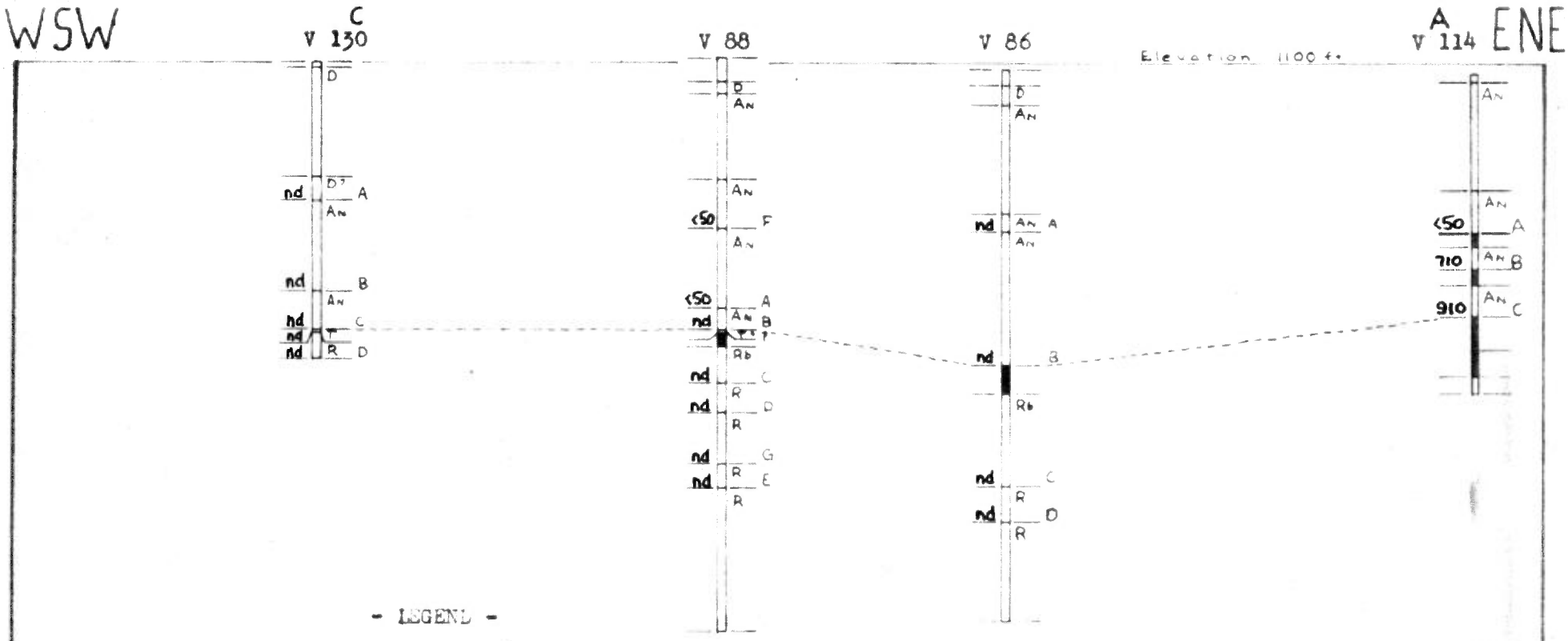
FIGURE 12



VERTICAL SECTION, B-A
DISTRIBUTION of LEAD
GEOCHEMICAL STUDY
of
VAUZE MINES LTD and WAITE LAKE MINES LTD AREA
QUEBEC

HORIZONTAL SCALE: 1 IN. = 50 ft.
VERTICAL SCALE: 1 IN. = 100 ft.
JANUARY 1965 R. J. LICKUS

FIGURE 13



- LEGEND -

Diamond Drill Hole — Rock Type — Sample No.

ppm
200
680
Ore Zone

An - Amulet Andesite
R - Waite Rhyolite
Rb - Waite Rhyolite Vauze Breccia
T - Tuff
D - Diorite

-------Andesite-Rhyolite Contact

VERTICAL SECTION, C - A

DISTRIBUTION of **LEAD**

GEOCHEMICAL STUDY

of

VAUZE MINES LTD and WAITE LAKE MINES LTD AREA

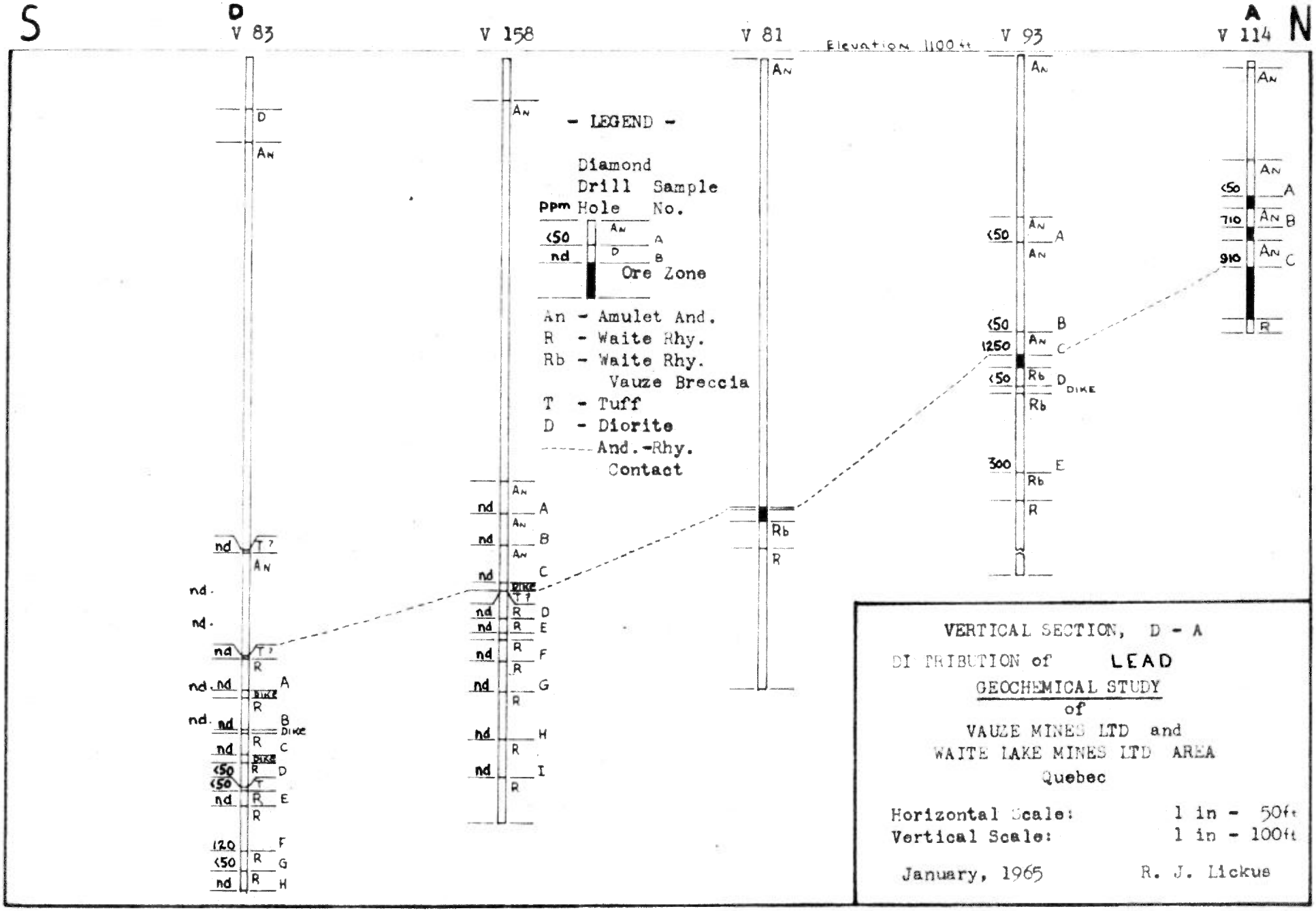
Quebec

Horizontal Scale: 1 in - 50ft
Vertical Scale: 1 in - 100ft

January, 1965 R. J. Lickus

A-11

FIGURE 14



A-12

FIGURE 15

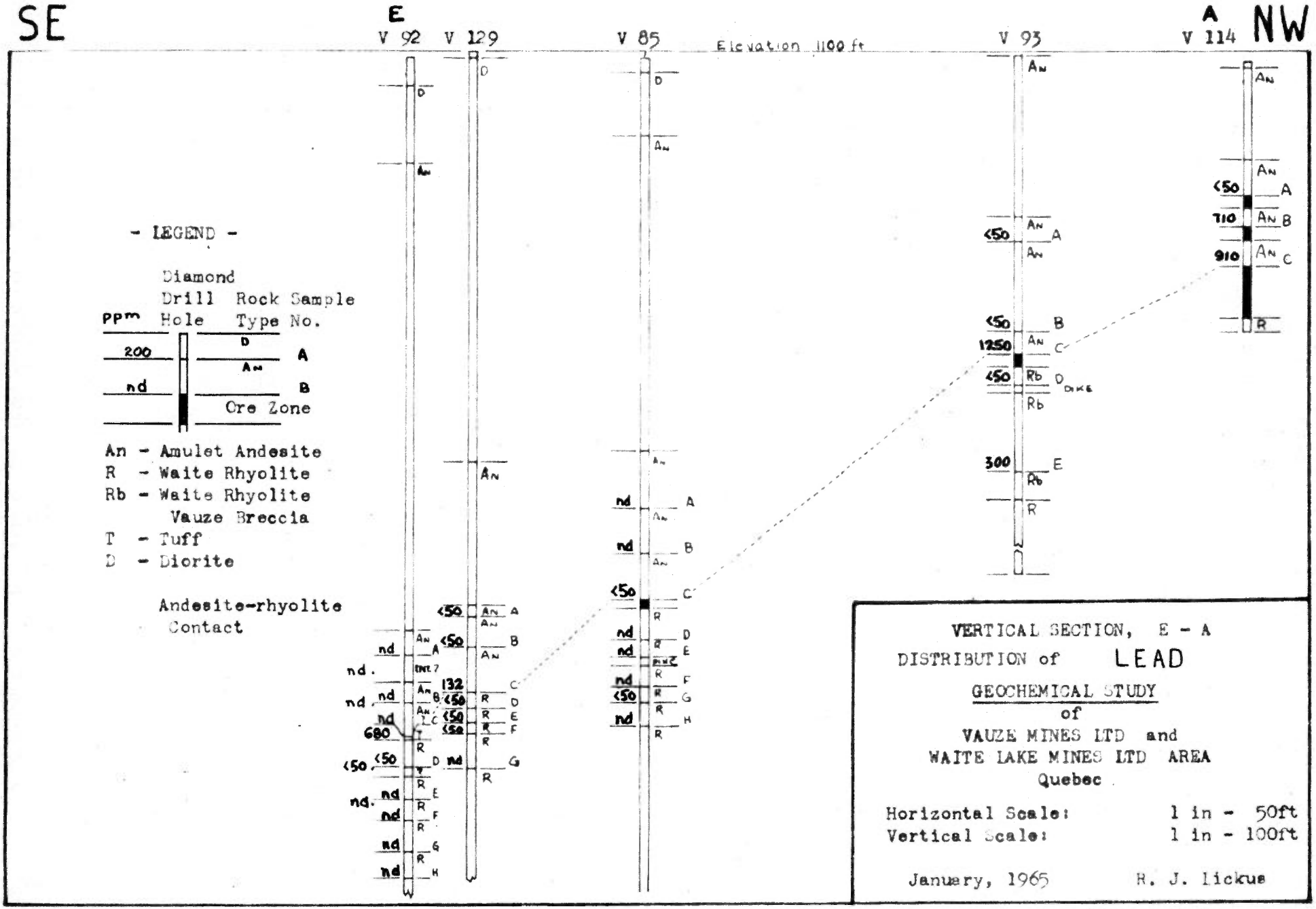
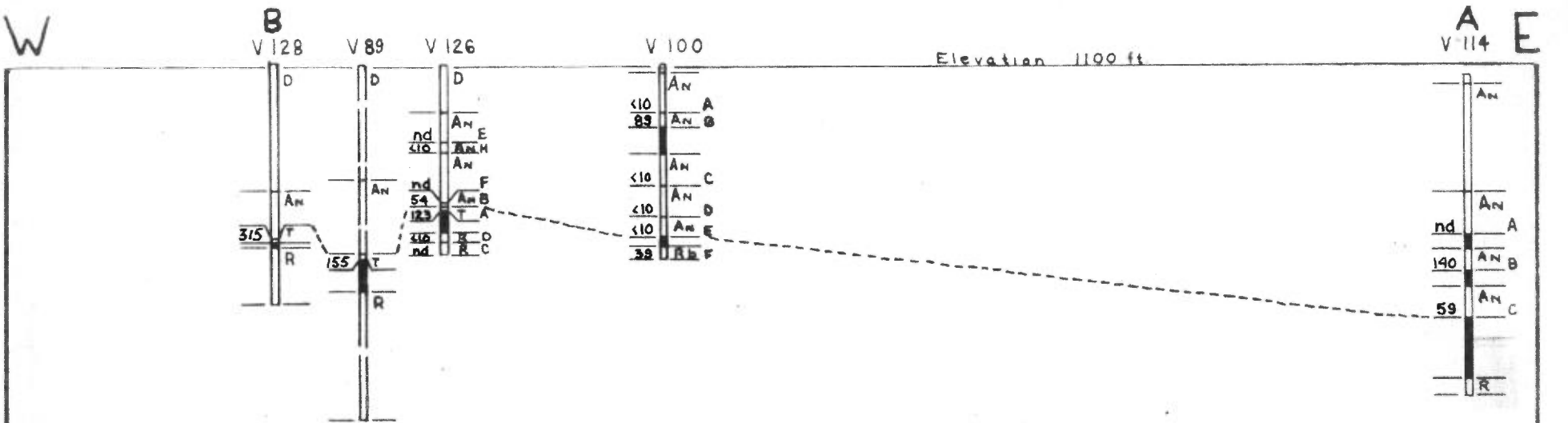


FIGURE 16

A-13

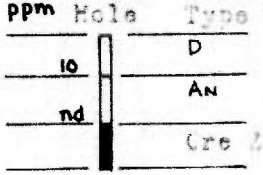


- LEGEND -

Diamond Drill Hole

Rock Sample Type No.

ppm



AN - Amulet Andesite

R - Waite Rhyolite

Rb - Waite Rhyolite
Vauze Breccia

T - Tuff

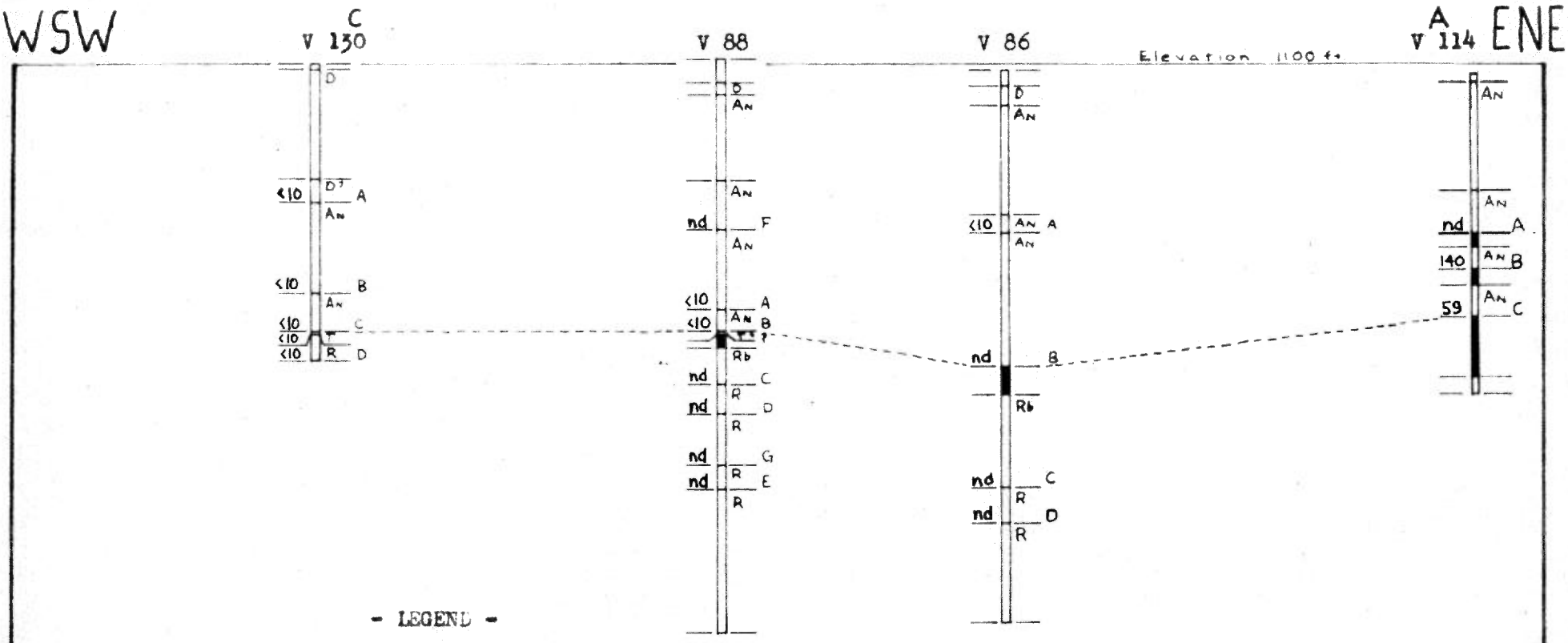
D - Diorite

------ Andesite-Rhyolite Contact

VERTICAL SECTION, B-A
DISTRIBUTION of SILVER
GEOCHEMICAL STUDY of VAUZE MINES LTD and WAITE LAKE MINES LTD AREA
QUEBEC

HORIZONTAL SCALE: 1 IN. = 50 ft.
VERTICAL SCALE: 1 IN. = 100 ft.
JANUARY 1965 R. J. LICKUS

FIGURE 17



- LEGEND -

Diamond Drill Hole | Rock Type | Sample No.

ppm

<10 | D

nd | An | A

Ore Zone

An - Amulet Andesite
R - Waite Rhyolite
Rb - Waite Rhyolite Vauze Breccia
T - Tuff
D - Diorite

------ Andesite-Rhyolite Contact

VERTICAL SECTION, C - A
DISTRIBUTION of SILVER
GEOCHEMICAL STUDY
of
VAUZE MINES LTD and
WAITE LAKE MINES LTD AREA
Quebec

Horizontal Scale: 1 in - 50ft
Vertical Scale: 1 in - 100ft

January, 1965 R. J. Lickus

FIGURE 18

A-15

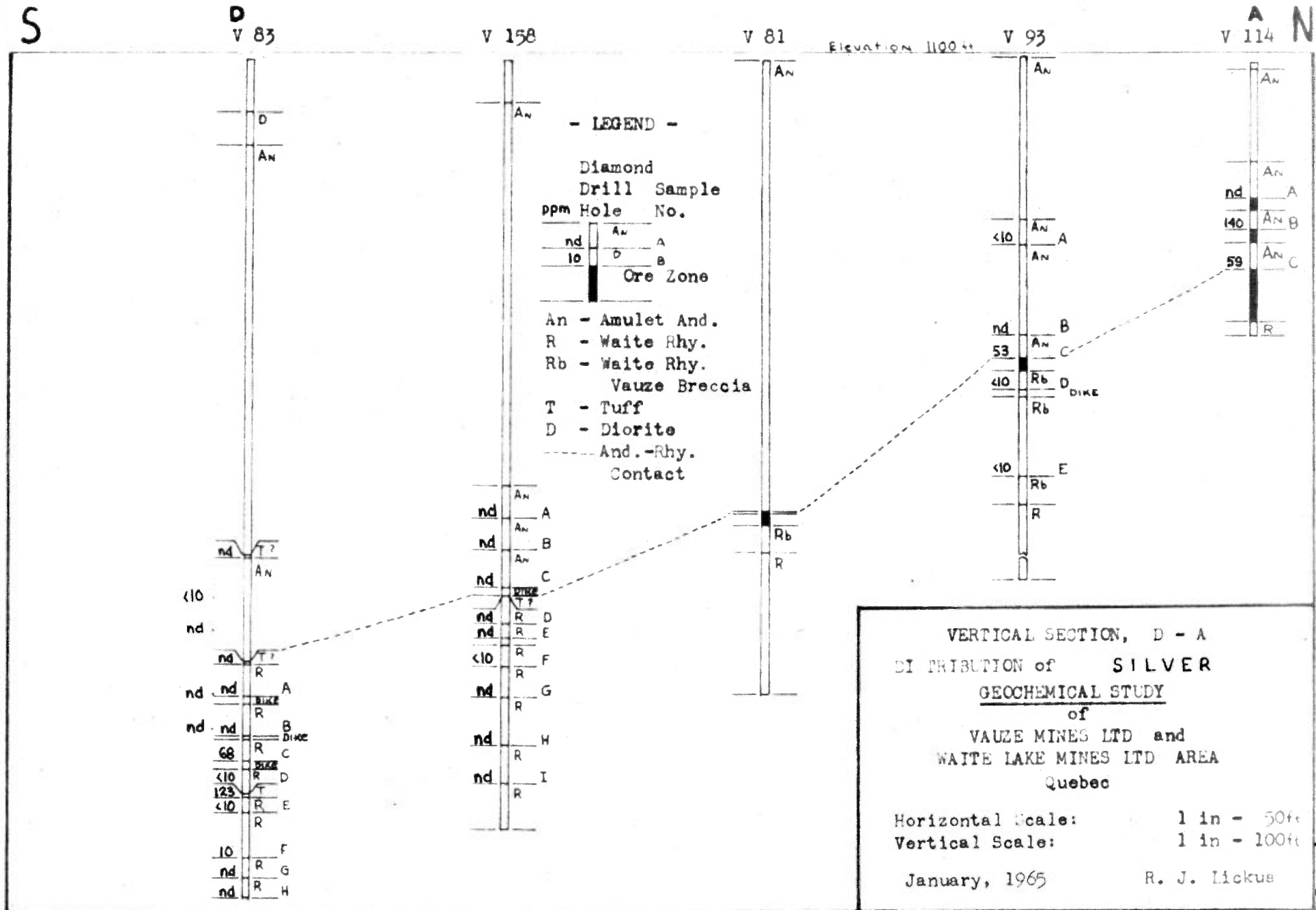

S
D
V 83
V 158
V 81
Elevation 1100 ft
V 93
A
V 114
N
- LEGEND -
Diamond Drill Sample
ppm Hole No.
Ore Zone
An - Amulet And.
R - Waite Rhy.
Rb - Waite Rhy. Vauze Breccia
T - Tuff
D - Diorite
And.-Rhy. Contact
VERTICAL SECTION, D - A
DISTRIBUTION of SILVER
GEOCHEMICAL STUDY
of
VAUZE MINES LTD and
WAITE LAKE MINES LTD AREA
Quebec
Horizontal Scale: 1 in - 50ft
Vertical Scale: 1 in - 100ft
January, 1965
R. J. Lickus
A-16

FIGURE 19

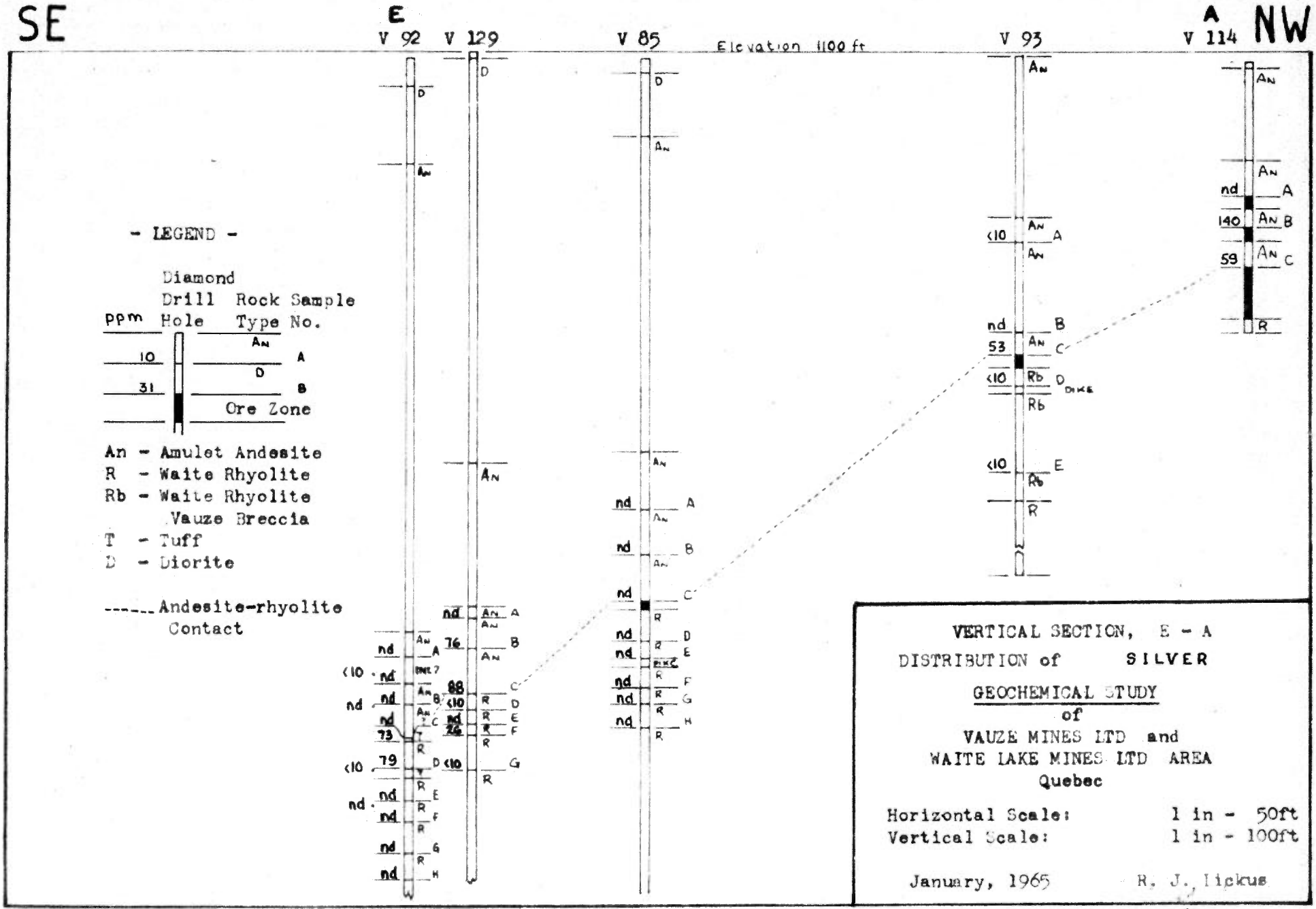
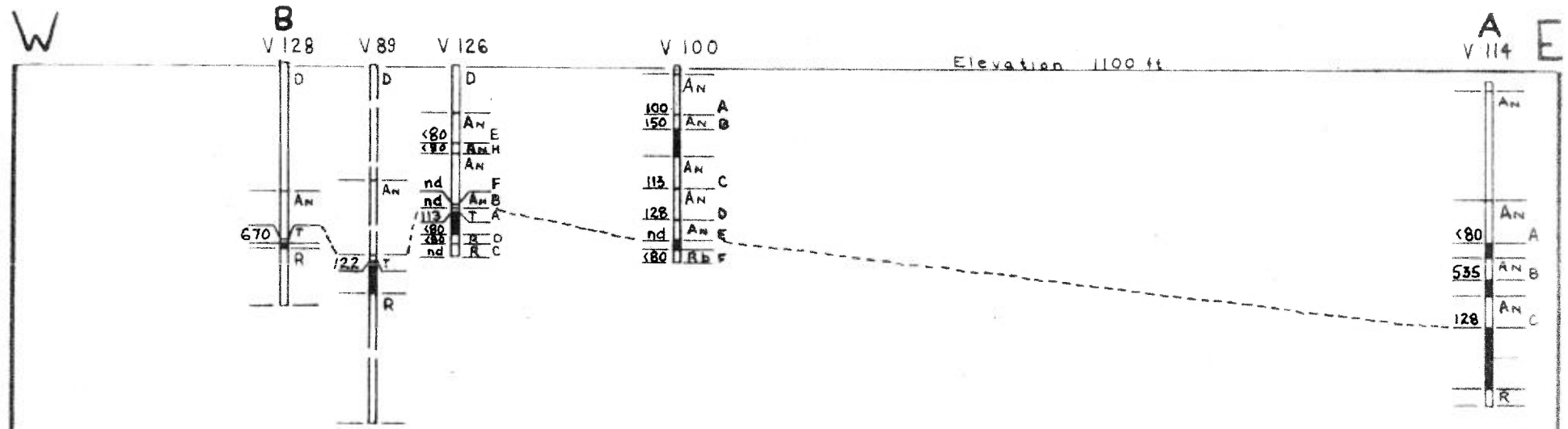


FIGURE 20

A-17



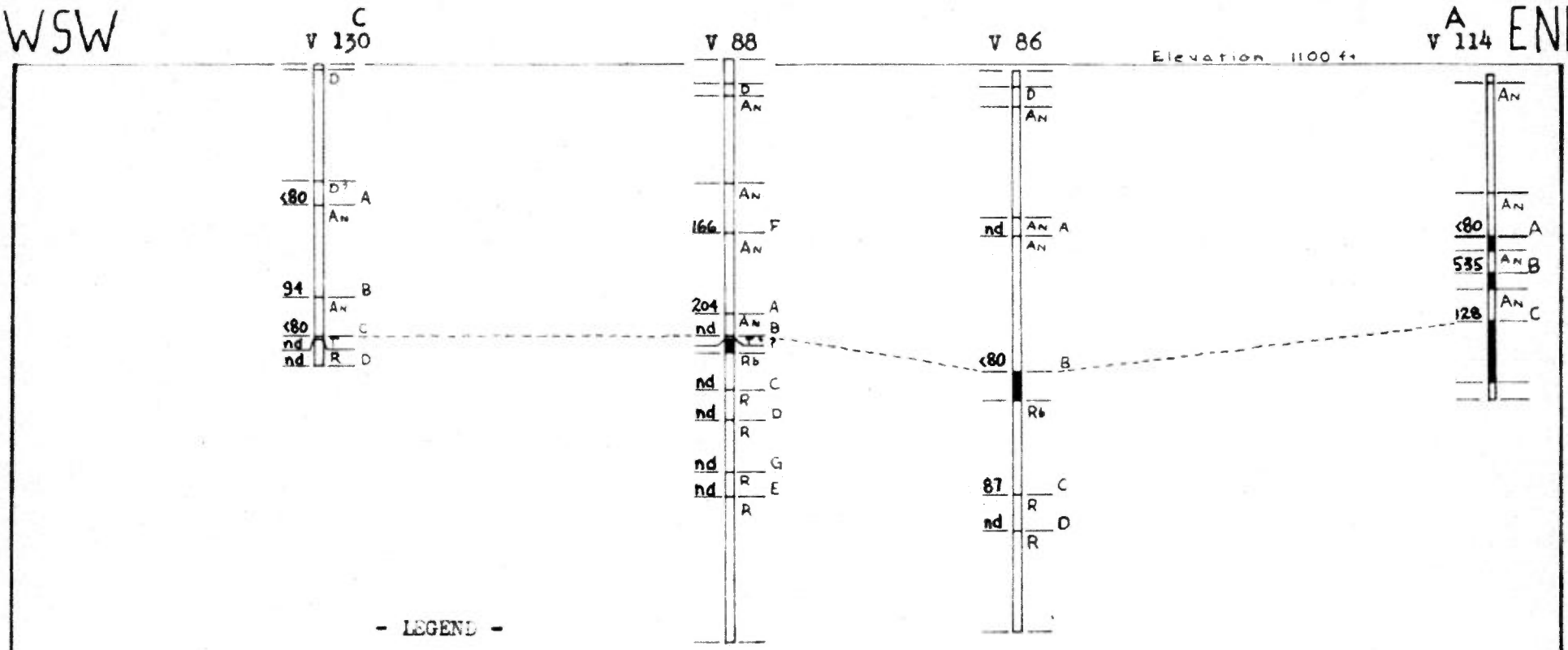
ppm
100
nd
D
AN
A
Ore Zone

VERTICAL SECTION, B-A
DISTRIBUTION of TIN
GEOCHEMICAL STUDY
of
VAUZE MINES LTD and
WAITE LAKE MINES LTD AREA
QUEBEC

HORIZONTAL SCALE: 1 IN. = 50 ft.
VERTICAL SCALE: 1 IN. = 100 ft.
JANUARY 1965 R.J. LICKUS

FIGURE 21

A-18



A-19

FIGURE 22

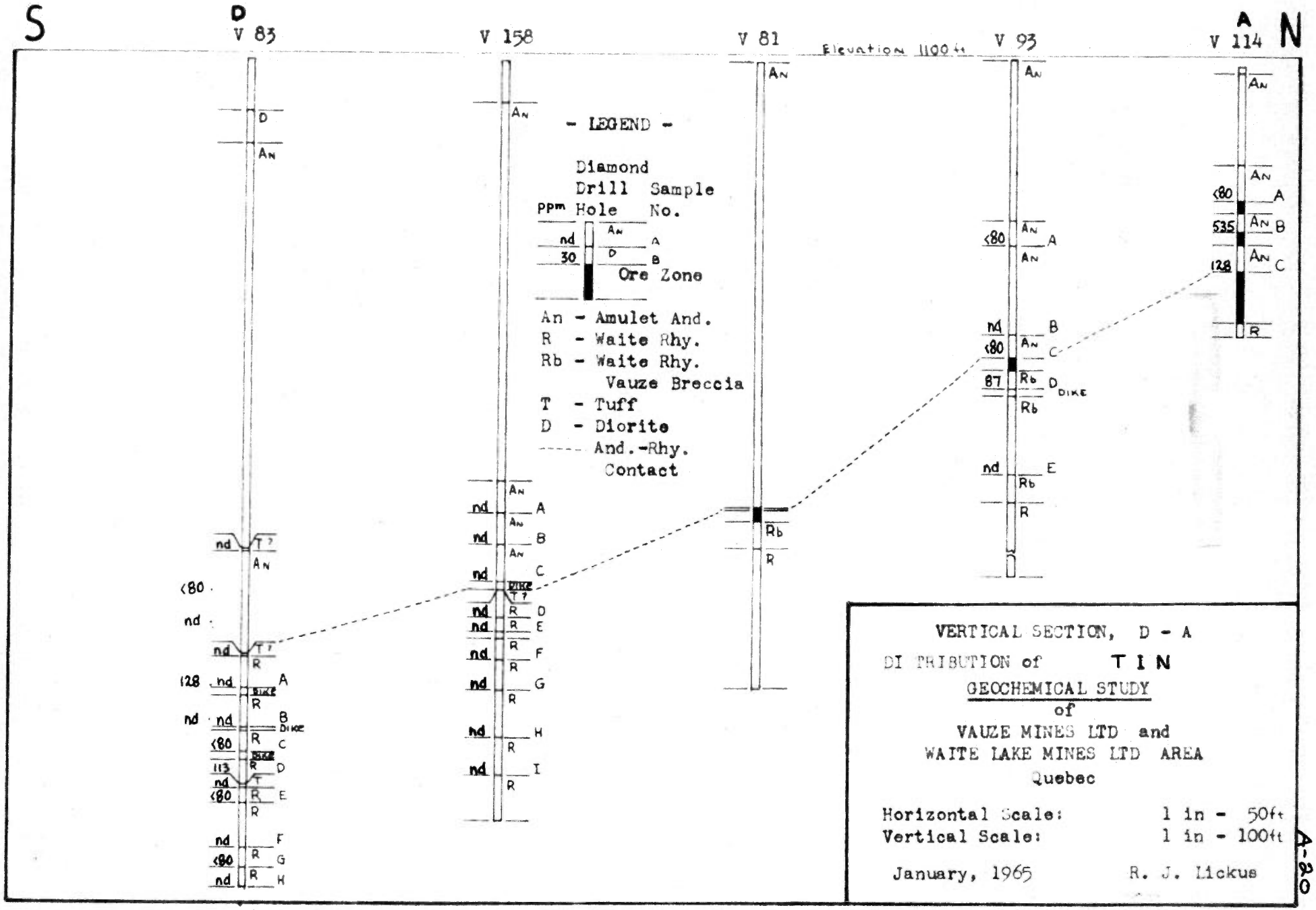

S
D
V 83
V 158
V 81
Elevation 1100 ft
V 93
A
V 114
N
- LEGEND -
Diamond Drill Sample Hole No.
ppm
nd
30
Ore Zone
An - Amulet And.
R - Waite Rhy.
Rb - Waite Rhy. Vauze Breccia
T - Tuff
D - Diorite
And.-Rhy. Contact
<80
128
87
535
113
DIKE
VERTICAL SECTION, D - A
DISTRIBUTION of TIN
GEOCHEMICAL STUDY
of
VAUZE MINES LTD and
WAITE LAKE MINES LTD AREA
Quebec
Horizontal Scale: 1 in - 50ft
Vertical Scale: 1 in - 100ft
January, 1965
R. J. Lickus
A-20

FIGURE 23

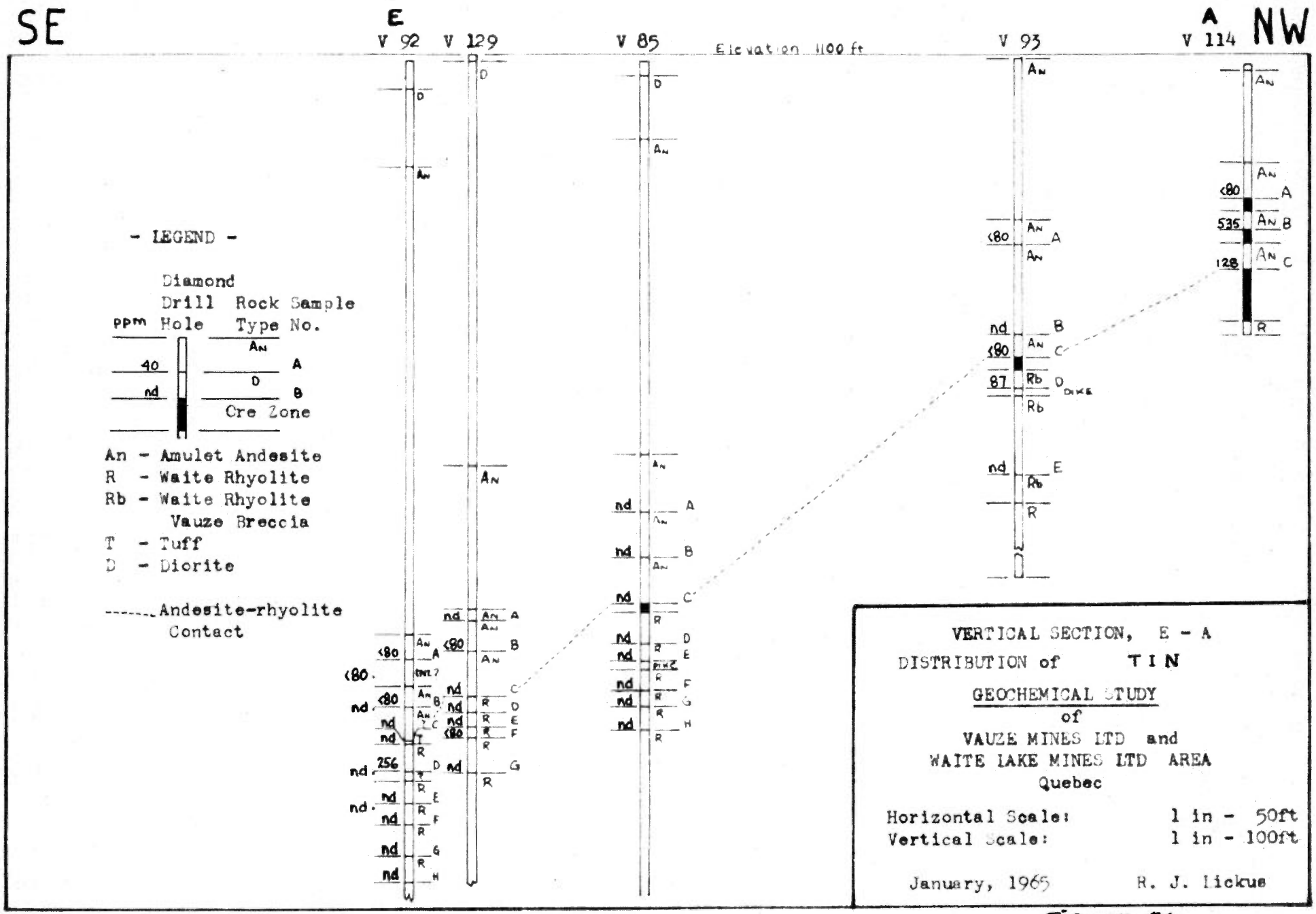
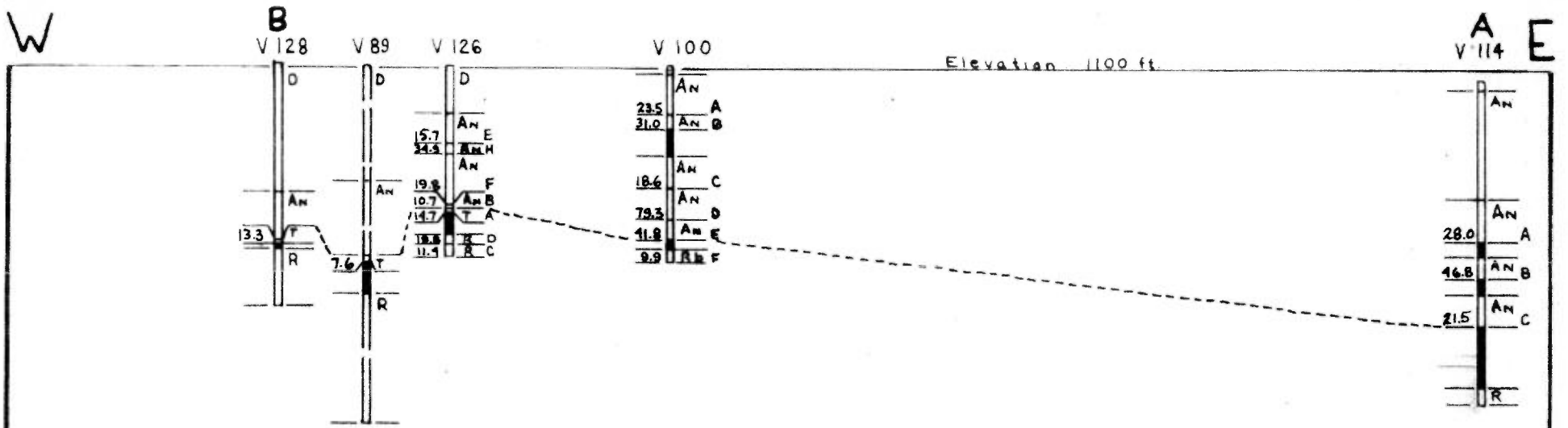


FIGURE 24

A-21



- LEGEND -

Diamond Drill Hole

ppm

30.0

4.9

Rock Samples Type No.

D

AN

A

Cre Zone

An - Amulet Andesite
R - Waite Rhyolite
Rb - Waite Rhyolite Vauze Breccia
T - Tuff
D - Diorite

Andesite-Rhyolite Contact

VERTICAL SECTION, B-A
DISTRIBUTION of INDIUM
GEOCHEMICAL STUDY of VAUZE MINES LTD and WAITE LAKE MINES LTD AREA
QUEBEC

HORIZONTAL SCALE: 1 IN. = 50 ft.
VERTICAL SCALE: 1 IN. = 100 ft.
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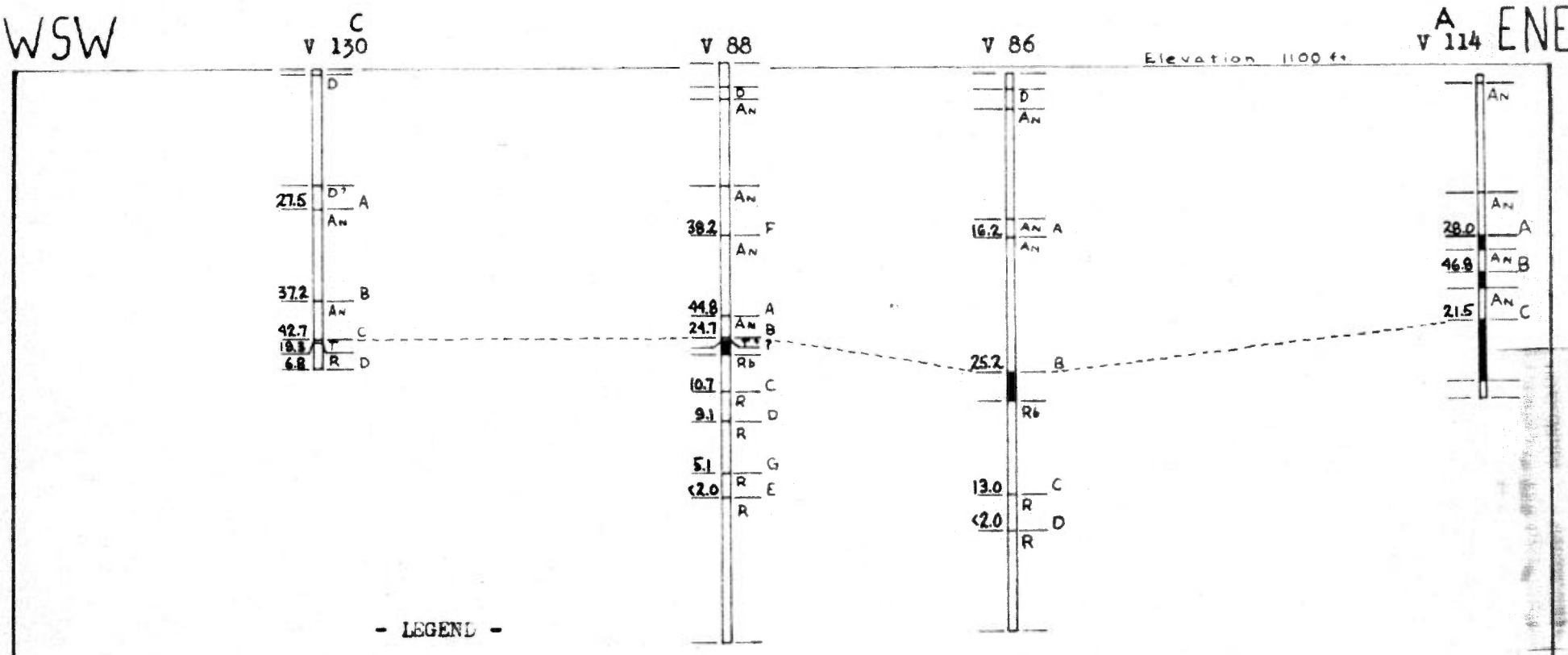
A-29

FIGURE 25



- LEGEND -

Diamond Drill Hole | Rock Type | Sample No.

ppm

10.1 — D

8.6 — AN — A — Ore Zone

An - Amulet Andesite
R - Waite Rhyolite
Rb - Waite Rhyolite Vauze Breccia
T - Tuff
D - Diorite

------Andesite-Rhyolite Contact

VERTICAL SECTION, C - A
DISTRIBUTION of INDIUM
GEOCHEMICAL STUDY
of
VAUZE MINES LTD and
WAITE LAKE MINES LTD AREA
Quebec

Horizontal Scale: 1 in - 50ft
Vertical Scale: 1 in - 100ft

January, 1965 R. J. Lickus

FIGURE 26

A-23

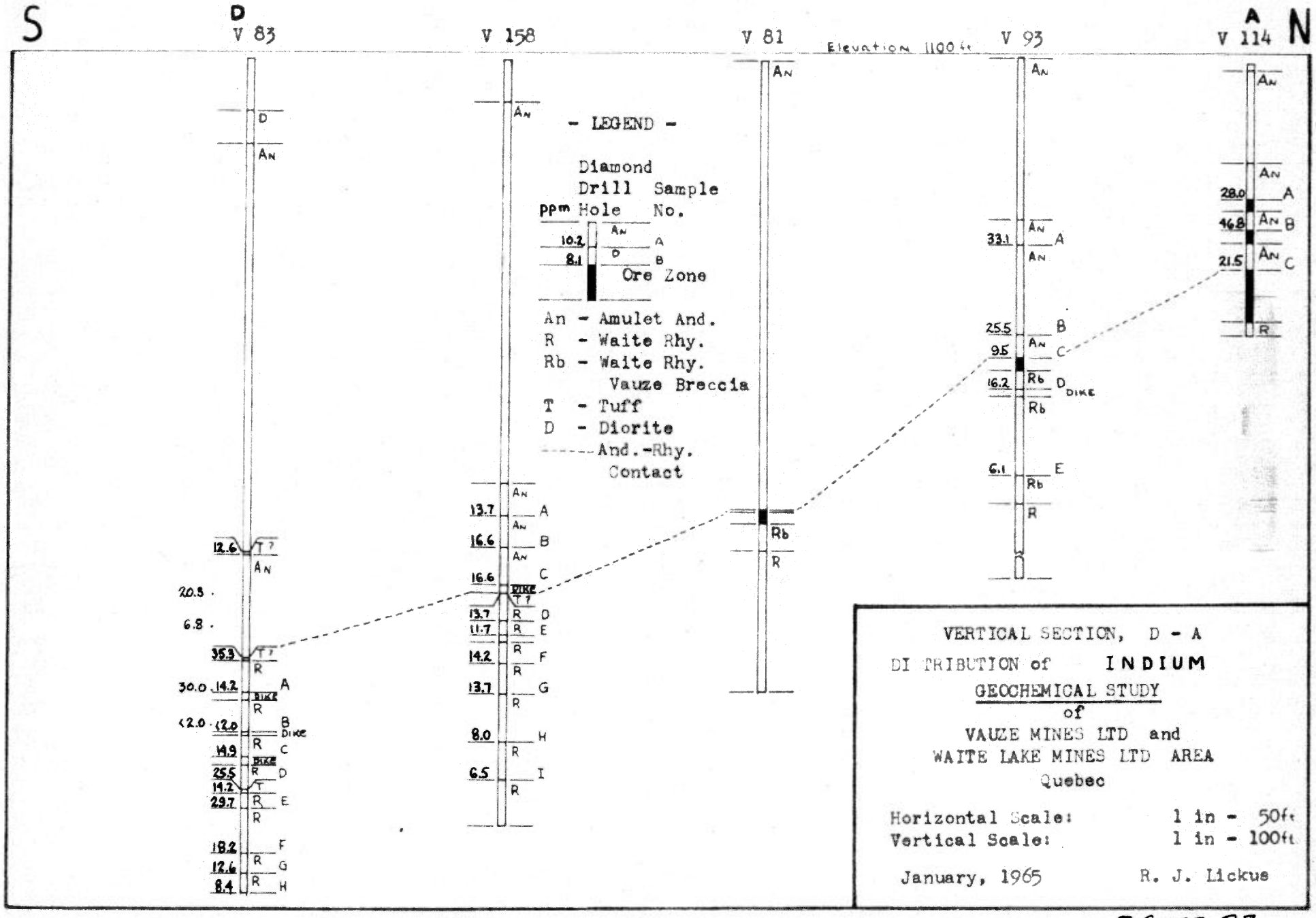

S
D
V 83
V 158
V 81
Elevation 1100 ft
V 93
A
V 114
N
- LEGEND -
Diamond Drill Sample
ppm Hole No.
Ore Zone
An - Amulet And.
R - Waite Rhy.
Rb - Waite Rhy.
Vauze Breccia
T - Tuff
D - Diorite
And.-Rhy. Contact
VERTICAL SECTION, D - A
DISTRIBUTION of INDIUM
GEOCHEMICAL STUDY
of
VAUZE MINES LTD and
WAITE LAKE MINES LTD AREA
Quebec
Horizontal Scale: 1 in - 50ft
Vertical Scale: 1 in - 100ft
January, 1965
R. J. Lickus

FIGURE 27

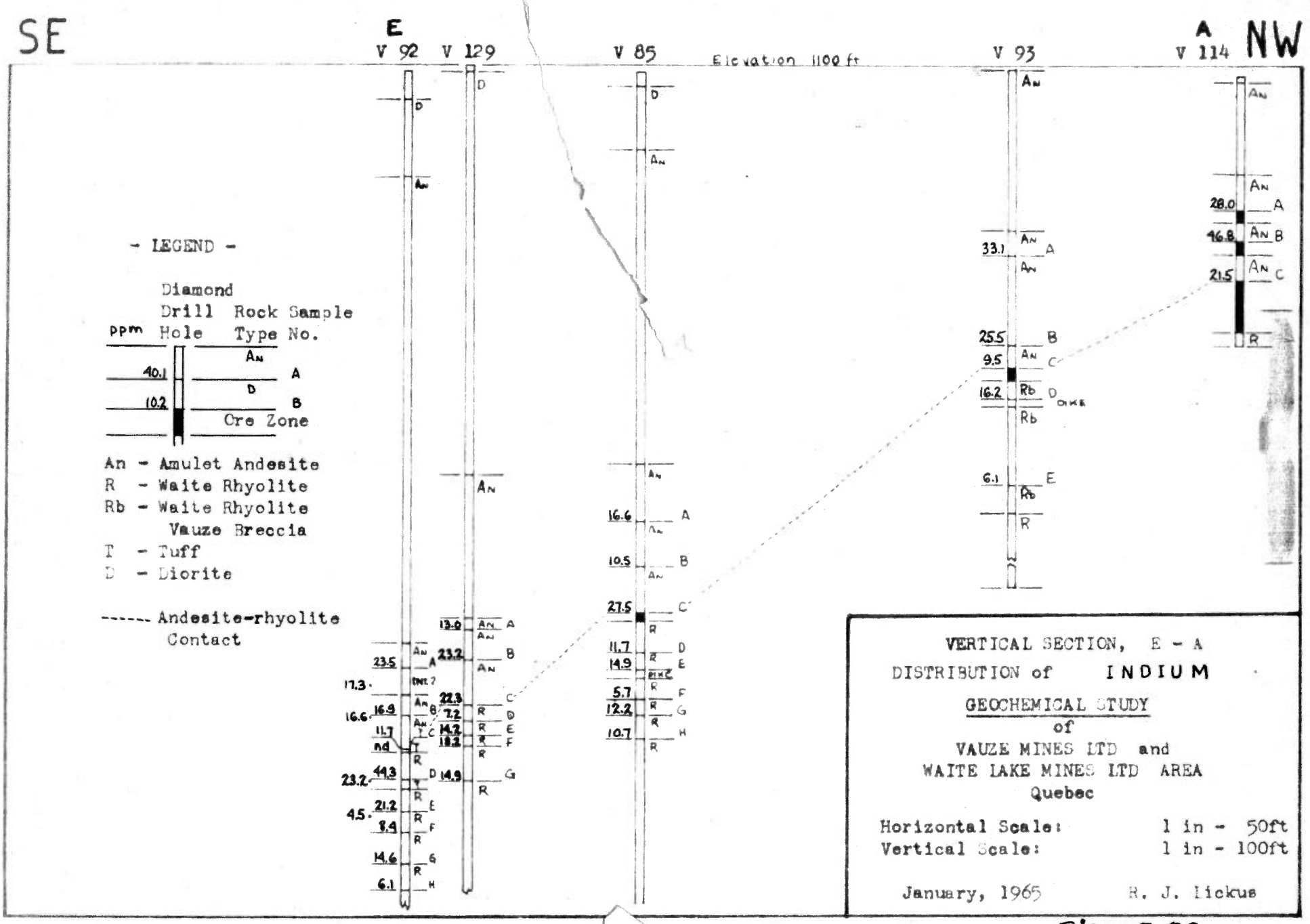


FIGURE 28

A-25