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CANADA

DEPARTMENT OF MINES AND RESOURCES

MINES AND GEOLOGY BRANCH

GEOLOGICAL SURVEY BULLETIN

No. 2

THE MAGNETOMETER AS AN AID IN
GEOLOGICAL MAPPING

BY

J.W. Ambrose



OTTAWA
EDMOND CLOUTIER
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
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THE MAGNETOMETER AS AN AID IN GEOLOGICAL MAPPING

INTRODUCTION

During the field season of 1944 an attempt was made by a Geological Survey party in charge of the writer to use a magnetometer as an aid in the geological examination of the west half of Beauchastel township¹, Témiskamingue county, Quebec. The instrument, an Askania vertical variometer (Plate I), was operated most of the season by a student assistant trained to the job in the field. The object of the work was to determine how far it is possible to trace various geological features such as contacts, dykes, and faults through drift-covered areas. At the close of the season it was concluded that, in general, the results where rigidly controlled by geological data were sufficiently legible to constitute a valuable aid in geological mapping, although in places erratic distributions of magnetic susceptibility on the underlying rocks made interpretation of the readings difficult or even impossible.

Investigations of this sort are commonplace with many mining companies operating in the Precambrian Shield, but the results are seldom published, and even less is published on how they were arrived at. Some Canadian scientists have in recent years made public the results of their work on the use of the magnetometer in such investigations, but their studies and reports are made from a geophysical viewpoint. Thus, A. A. Brant since 1937 has carried on a series of studies for the Ontario Department of Mines², and A. H. Miller has given a valuable account of several investigations in the Eastern Townships, Quebec, and in the Maritime Provinces³. These studies are very helpful, but nevertheless some laymen and geologists have found it difficult to evaluate the results or to estimate their use in the study of problems of day-to-day geological mapping. An interesting account of such use of the magnetometer was published recently by G. M. Schwartz⁴, who traced the contact of the Duluth gabbro for 50 miles by means of magnetic profiles.

The present report is intended to place on record the results of the several projects undertaken. It is hoped that they will demonstrate that useful results can be obtained with the magnetometer even by persons untrained in geophysical sciences, and that they will add something to the increasing knowledge of the use and limitations of this instrument in Precambrian terrain. With attention turning of necessity more and more to drift-covered areas the topic is perhaps timely.

ACKNOWLEDGMENTS

During 2 weeks of the field season the instrument was operated by Lear P. Wood and by J. F. MacDougall. For the remainder of the season it was operated by Douglas MacNiven. The mining companies on whose properties the projects were carried out gave every possible assistance by cutting lines and supplying information from diamond drilling. Thanks are due to J. E. Gill, A. R. Byers, A. C. Lee, J. E. Hawley, and Mrs. V. R. MacMillan for information and assistance. A. H. Miller, geophysicist with the Dominion Observatory, gave the writer his first instruction in the use of the magnetometer, and has since offered many kindly and helpful suggestions.

¹ For detailed geology of this area, See map of Western Beauchastel, Paper 45-17, Geol. Surv., Canada, 1945.

² Brant, A. A.: Review of geophysical work carried out by the Ontario Department of Mines; Mimeographed release, Ont. Dept. Mines, Jan. 1945; 5 pages.

³ Miller, A. H.: Investigations of Gravitational and Magnetometric Methods of Geophysical Prospecting; Publ. Dominion Observatory, vol. 9, No. 6, pp. 175-258 (1940).

⁴ Schwartz, G. M.: Tracing the Duluth Gabbro Contact With a Magnetometer; Econ. Geol., vol. 39, pp. 224-233 (1944).

INSTRUMENT

An Askania vertical variometer was used in all the projects. The instrument and a diagram to illustrate its working parts are shown in Plate I. Essentially it consists of an extremely sensitive magnetic balance mounted in such a way that it is affected by very small changes in the earth's magnetic field of force. A compass is placed on the tripod and the tripod head is oriented with respect to the magnetic meridian at that point. The compass is then removed and the instrument is placed on the tripod with the long axis of the magnetic balance horizontal and perpendicular to the plane of the magnetic meridian. Thus the horizontal component of magnetic force at that point is eliminated from the reading, and only the vertical component is determined.¹

One of the principal causes of the small variations observed in readings of adjacent points are local diversities in the earth's crust, that is to say, variations in the character and magnetic susceptibility of the rocks from place to place. Thus, if the variations in magnetic susceptibility are determined, they provide an indirect means for appraising the characteristics of the underlying rocks. Such small local variations in the magnetic field of force are called anomalies. Measurement of anomalies with an Askania variometer is a relatively simple matter, but to discover the underlying cause, where the rocks are hidden by overburden, may be most difficult. The empirical method adopted in the projects described was simply to observe the anomalies where the rock distribution was known, and then to assume that similar anomalies nearby indicated similar rock distribution.

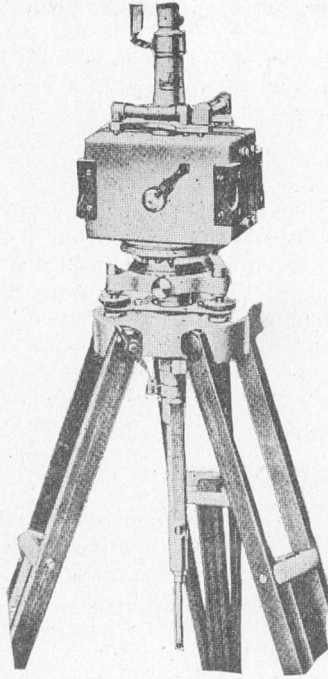
METHOD

Rock exposures are relatively numerous and large in the area in which the work was done as the country has been burned clean. Nevertheless, there are equally large or larger areas in which the rock is hidden below deep drift or alder swamps. As noted, much information on the character and distribution of the rock within these covered areas has been obtained by diamond drilling, but even with this assistance, together with information provided by outcrops, there are large gaps that formerly could only be filled in by guesswork. The magnetometric investigations were made in an endeavour to eliminate as much of this guesswork as possible, but as it would have required several magnetometers and operators to work over all the drift- and swamp-covered areas, investigations were limited necessarily to those of particular geological or economic interest.

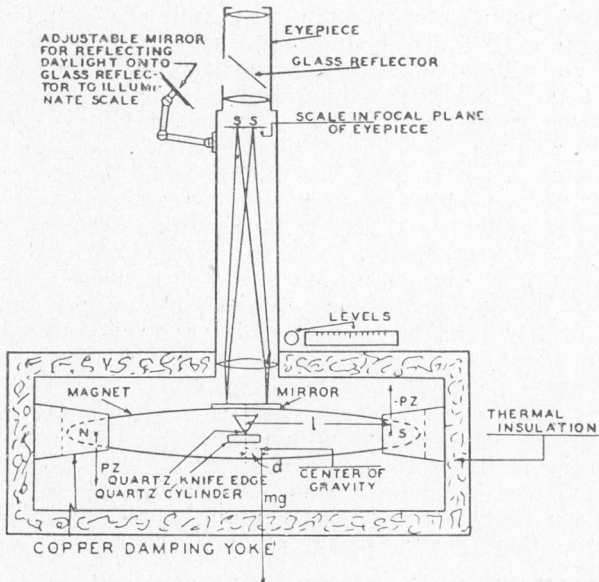
The procedure in each case was as follows:

- (1) Rock outcrops were mapped in detail. The scale of mapping ranged according to circumstances from 200 to 500 feet to an inch.
- (2) Diamond-drill holes were located, core logged, and plotted.
- (3) From this information, the position of the contact, shear zone, or dyke that was to be traced was fixed as closely as possible. A picket line was then cut along its supposed extension through drift-covered areas.
- (4) Cross-lines were then cut at right angles to the base-line at selected intervals, commonly 500 feet. One or more of the cross-lines were placed to intersect the feature to be followed where available information fixed most closely its position and character.
- (5) Readings of vertical magnetic intensity were made at intervals of 50 feet along the cross-lines, except in one project where readings were taken over much of the area examined at intervals of 100 feet.

¹For further information concerning theory, construction, and operation of magnetic variometer the reader may refer to such standard texts as:
 Eve and Keyes: Applied Geophysics; Cambridge University Press (1933), 2nd edition, Chapter II.
 Nettleton, L. L.: Geophysical Prospecting for Oil; McGraw-Hill Book Co., Inc. (1940), 1st edition, Chapters IX-XI.
 Heiland, C. A.: Geophysical Prospecting; Prentice-Hall, Inc. (1940), pp. 293-433.



A. An Askania vertical variometer.



B. Diagram of vertical variometer, to illustrate its working parts.
Reproduced by courtesy of McGraw-Hill Book Company, Inc.

(6) The values of the readings, in gammas¹, were plotted as profiles along the cross-lines on the geological maps, due allowances being made for diurnal variations².

(7) Similarity of profiles on adjacent cross-lines was interpreted, in general, to mean that the feature known below the first cross-line extended at least as far as the second, and so on.

RATE OF WORK

A magnetometer party using an Askania vertical variometer should, for efficient operation in wooded country, consist of an instrument man and assistant, and three to four axemen. Under normal conditions, with stations at intervals of 50 feet, such a party will complete observations on $\frac{1}{2}$ to 1 mile of line a day. The number of stations occupied can be increased if the instrument is supplied with two tripods, for then the compass can be set on one while the magnetometer is being read on the other. Experience in the present instance indicated, however, that the rate of progress was determined by that at which lines could be cut and stations marked rather than on that of taking readings.

GENERAL GEOLOGY

Beauchastel township is in Noranda district, northwestern Quebec, about halfway between Noranda and the Ontario boundary. The west-central part of the township in which the magnetometer work was done is underlain by rocks of Precambrian age. Two main subdivisions are represented, namely, the Archæan, by an assemblage of volcanic rocks cut by a variety of intrusive, dykes, sills, and masses; and the unconformably overlying Proterozoic, by sedimentary rocks of Cobalt age. The whole is intersected by through-going dykes of diabase, generally considered to be Keweenawan in age.

The Archæan volcanic assemblage consists of basic to intermediate lavas and flow breccias interlayered with acidic varieties referred to as rhyolites or trachytes, all associated with pyroclastic rocks of several sorts. The pre-Cobalt intrusive rocks include dykes, sills, and masses of coarse- to medium-grained diorite, gabbro, quartz diorite, and quartz gabbro; a body of coarsely porphyritic ægerine-augite syenite accompanied by a swarm of dykes around its periphery; and dykes and sills of feldspar and quartz-feldspar porphyry, and felsite. No post-Cobalt intrusions, other than diabase dykes, are known.

The structure of the Archæan rocks is exceedingly complex. Flows strike in general nearly east, but locally they depart as much as 90 degrees from this trend. Over most of the area they dip 45 to 60 degrees north and face north, but in their northeastern exposures they face and dip west or southwest on the north limb of a syncline. Again, in their southeastern exposures they appear to dip much more steeply than the average for the area, and in places are vertical or even overturned. Here, too, they face for the most part south or southwest. This reversal in top does not necessarily imply an anticlinal structure, for the continuity of the flows is interrupted by two, and probably four, northeast-striking faults and by one or more that strike east. The dip of the east-striking fault (or faults) is known to range from 45 to 55 degrees to the north. The other faults are probably nearly vertical. Horizontal displacements, where determined, were to the west or northwest on the north side of the faults, relative to the rocks on the south sides.

The faults are of prime economic importance for their courses are marked by shear zones that here and there contain bodies of gold ore. As very few of them outcrop their positions and attitudes have been matters for intensive

¹ A unit of magnetic force, equal to approximately 1.6×10^{-5} of the earth's magnetic field.

² "The earth's magnetic field varies from place to place and, indeed, is continually changing during the day. These minor daily variations have been given a special name—the diurnal variations". Eve and Keyes: *Applied Geophysics*, second edition (1933), p. 23. See also Nettleton, U. L.: "Geophysical Prospecting for Oil"; McGraw-Hill (1940), Chapters IX and XI.

investigation by diamond drilling and geophysical examinations. Much has been learned by such means in combination with information gained from available outcrops, but there are many places where there are no data.

The Cobalt rocks, separated from those of Archæan age by a great unconformity, are gently folded and show some minor faulting, but in general they are little disturbed.

Dykes of Keweenaw (?) diabase form part of a system that is widespread in the Canadian Shield. They are the youngest rocks known in the area, aside, of course, from Pleistocene and Recent deposits, and are offset here and at Noranda, 10 miles to the east, by the Horne Creek fault.

DETAILS OF PROJECTS

In order to determine, so far as possible in one season, in what situations the magnetometer could be most usefully employed to supplement geological information gained from examination of outcrops, the following variety of projects was undertaken:

- (1) Delineation of a contact between massive diorite and acid volcanic rocks.
- (2) Delineation of the course of a dyke of 'Younger' diabase, intrusive into andesite flows.
- (3) Delineation of the same diabase dyke intrusive into acid volcanic rocks.
- (4) Delineation of the course of the Wasa Lake shear zone.
- (5) Delineation of the Arntfield shear zone, and of the outlines of intrusive bodies in the same area.
- (6) Delineation of the contact between sedimentary rocks of Cobalt age and the underlying Archæan complex.
- (7) Delineation of the Macfort shear zone and of the outlines of intrusive bodies in the same area.
- (8) Delineation of the Franceour No. 8 shear zone, and of the associated flows and intrusions.

PROJECT NO. 1

Purpose. To trace a contact between diorite and acid volcanic rocks, lots 25 to 28, rge. VI, Beauchastel tp.

Geological Notes. The diorite as exposed is a coarse-grained, massive, brownish weathering rock composed of white feldspar and pale green amphibole secondary after pyroxene. The amphibole forms clusters that stand up on the weathered rock to form warty surfaces. Some finely divided magnetite can be found in most specimens.

The volcanic rocks are fine- to very fine-grained lavas that weather buff, or grey, and are buff, grey, or pale green on fresh surfaces. Quartz grains are rare, but quartz-filled amygdules are fairly common. Hematite forms thin films on some joint planes.

About 10 feet of the contact is exposed in one outcrop, shown near the middle of Figure 1. The dip of the contact could not be determined, but the average dip of the flows in this vicinity is about 50 degrees north. The diorite is probably sill-like, and its contacts can be presumed to dip with the flows. The overburden probably deepens away from the outcrops to 50 or 60 feet thick in places.

Magnetometric Profiles. The base-line was started at the outcrop of the contact, and was cut east and west for a total distance of 3,900 feet along the supposed line of strike. Seventy-six readings were made on 4,400 feet of cross-lines.

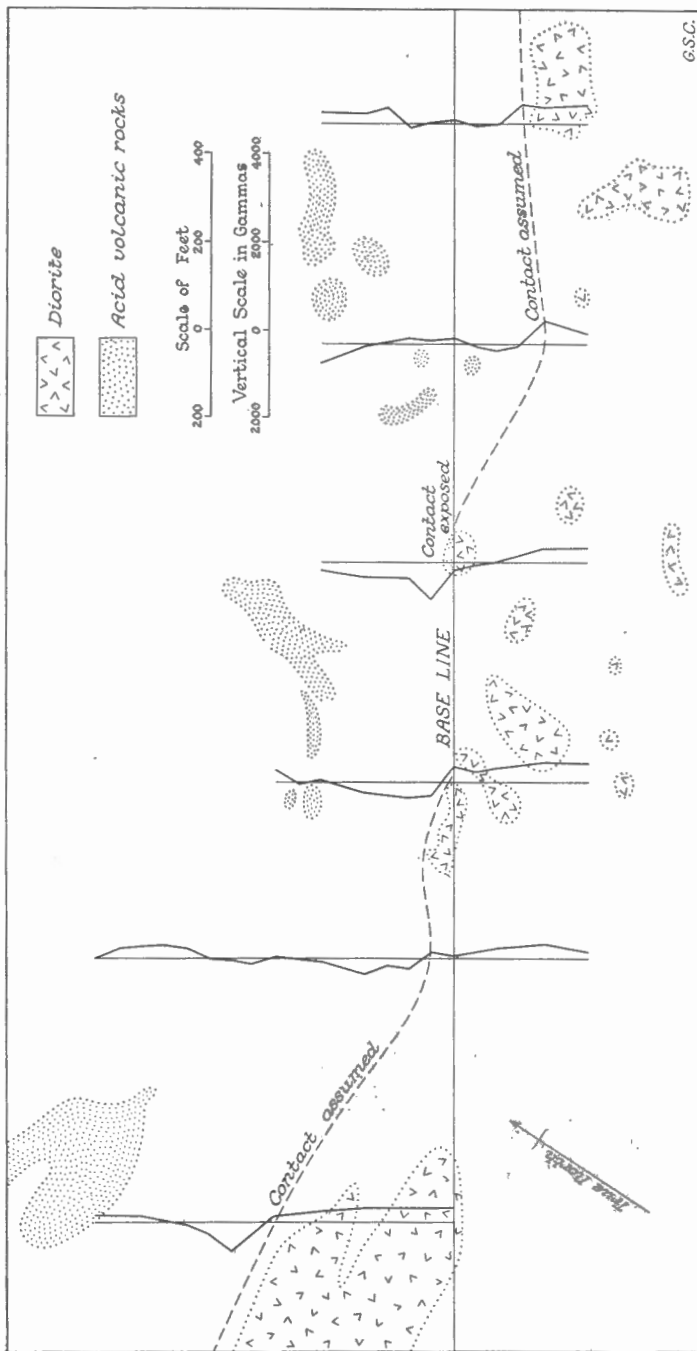


Figure 1. Magnetic profiles across diorite contact, lots 25 to 28, rge. VI, Beauchaste| township, Que.

Along the control profile, where the contact is exposed, readings over the acid volcanic rocks are positive, about plus 300 gammas. Fifty feet north of the contact they increase sharply, fall with a slightly steeper gradient to the contact itself, and then level off at low positive to moderate negative readings, about minus 300 gammas, over diorite. The profiles on either side, although differing in detail, are considered sufficiently similar to the control profile to justify extrapolation of the contact as shown. Furthermore, the asymmetric form of several of the profiles where they cross the supposed contact may be taken to support the suggestion that the contact actually dips north.

PROJECT NO. 2

Purpose. To trace a diabase dyke intrusive into basic volcanic rocks.

Geological Notes. A dyke of 'Younger' diabase is exposed cutting basic volcanic flows south of the highway about a quarter mile west of Aldermac siding. The diabase consists of a coarse- to fine-grained aggregate of calcic feldspar and pyroxene with a diabasic to gabbroic texture. Accessory magnetite and ilmenite are common.

The flows are of basic to intermediate composition, composed entirely of secondary minerals. Pillows and flow-breccias are common. The flows strike easterly, face south (?), and are vertical or dip steeply to the south or north.

The outcrops of diabase and basic volcanic rocks south of the highway occupy the north side of a low knoll some 500 feet across. North and south of the knoll the ground is swampy and heavily overgrown with alders. North of the highway the diabase again outcrops and cuts across acidic flows that form a prominent east-trending ridge. The position and strike of the diabase across this ridge are such that, in order to be continuous with the part of the dyke exposed south of the railroad, either the dyke must bend in the swamp-covered area or it must be displaced along a fault. Decision as to which of these possibilities is correct was important, for the Horne Creek fault offsets diabase dykes near the Horne mine, Noranda, 10 miles to the northeast, and on its westward extension it, or a branch of it, might pass along this valley. The magnetometer was employed to aid in the solution.

Magnetometric Profiles. Twenty-nine hundred feet of base-line and 10,900 feet of cross-lines were cut. Readings of vertical intensity were made along the cross-lines at intervals of 50 feet. Profiles of the intensities (*See Figure 2*) show a consistent 'high' or hump over the diabase dyke in contrast with the relatively lower uniform readings over the adjacent volcanic rocks. It is interesting to note that the form of the profiles remains undisturbed near power lines, fences, telephone lines, and the railroad.

The profiles trace the dyke northward from its outcrops near cross-line 8 to at least line 17, but it does not appear to extend to line 18. The extension at least as far as line 15 was confirmed later, when a diamond-drill hole, collared near the west end of line 18, intersected diabase at a vertical depth of about 400 feet. The position of the intersection suggests that the dyke dips about 80 degrees east. In this connection it may be noted that the magnetic profiles show, in general, a steeper slope on the west side of the hump than on the east, as might be expected in crossing an east-dipping magnetic body. The tendency for the anomalies to fade out in swampy areas, as along lines 5 and 13, is attributable to increasing depths of overburden. An erratic high reading was obtained near two diamond-drill stand-pipes on line 12.

The dyke was thus extended from its outcrops 1,200 feet south and 750 feet north, across swamps in both directions. Furthermore, the deduced position of its northern end relative to its outcrops across the volcanic ridge north of the

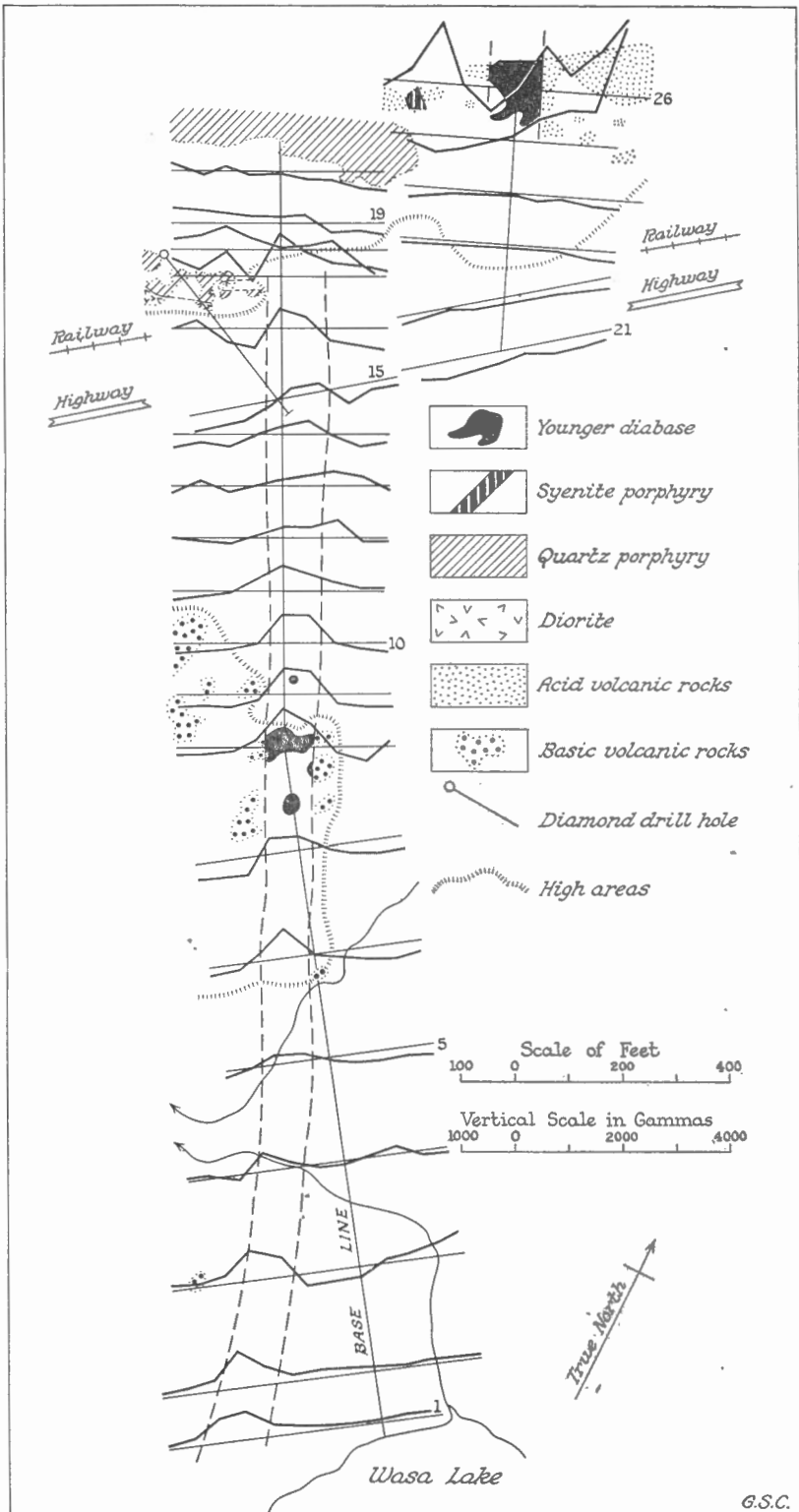


Figure 2. Magnetic profiles across diabase dyke, lots 25 and 26, rge. V, Beauchastel township, Que.

railroad suggests strongly that it had been displaced along a westward-trending fault through a horizontal distance of 400 feet, and that the fault trace lay between outcrops near line 17 and those near line 20.

An attempt was then made to confirm this gratifying advance towards the solution of the problem by tracing the southward extension of the part of the dyke exposed across the ridge of acid volcanic rocks (See lines 26 to 21, Figure 2). Unfortunately the effort failed because intensities over the acidic volcanic rocks, in contrast with those over the more basic varieties, proved to be highly erratic. The diabase failed to give a characteristic profile and could not be traced south by this means. That there is a fault in this vicinity is shown by drill intersections 1,000 feet or so east. The northern extension of the diabase dyke is such that the fault, if it offsets the dyke, must pass north of the outcrops near line 17. The probability is that the fault offsets the dyke horizontally about 400 feet, and, therefore, that it may be the Horne Creek fault or a branch of it.

PROJECT NO. 3

Purpose: To trace diabase dyke intrusive into acid volcanic flows.

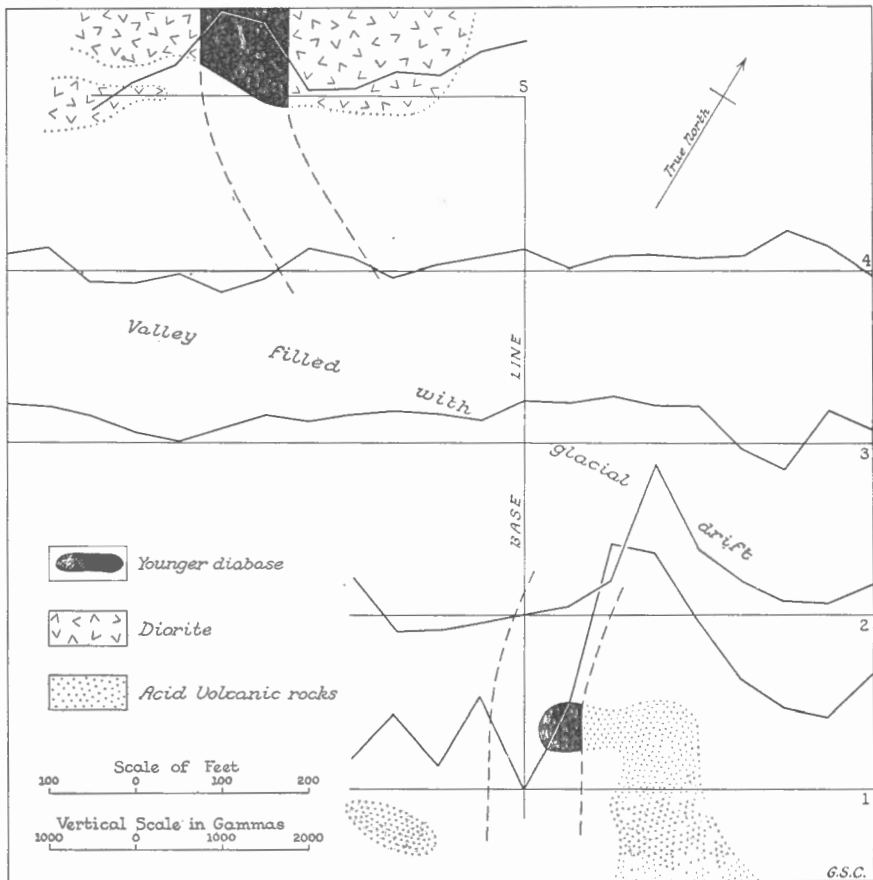


Figure 3. Magnetic profiles across diabase dyke, lots 24 and 25, rge. V, Beauchastel township, Que.

Geological Notes. The diabase dyke described under Project No. 2 extends northward across a ridge composed of east-striking acid volcanic flows and

breccias. On the north side the ridge falls off into a drift-filled valley about 700 feet wide. On the north side of the valley the diabase dyke is again exposed, here intrusive into coarse, massive diorite or gabbro. The position and attitudes of the outcrops of diabase (Figure 3) are such that, as in Project No. 2, the dyke must either be faulted along the drift-filled valley or it must bend to cross it.

The acid volcanic rocks are similar to those described under Project No. 1, except that here they carry an abundance of finely divided magnetite more or less unevenly distributed through the rock.

Magnetometric Profiles. Eight hundred and fifty feet of base-line and 3,710 feet of cross-lines were cut. Readings of vertical magnetic intensity were made along the cross-lines at intervals of 50 feet. The results are shown in profiles (See Figure 3). The profile along line 5, where the dyke cuts diorite, is similar in form to those across the dyke where it cuts basic volcanic rocks (Project No. 2). However, no characteristic humps appear on lines 3 and 4. Pronounced highs occur on lines 1 and 2, but in line 1 the high is east of the dyke and it seems to be even farther east on line 2. The data are regarded as insufficiently diagnostic to warrant deductions as to the course of the dyke across the valley.

PROJECT NO. 4

Purpose. To trace Wasa Lake shear zone.

Geological Notes. The Wasa Lake shear zone was discovered in the spring of 1944 by diamond drilling under the direction of J. E. Gill. Gold occurs in parts of the sheared material, and according to reports in the *Northern Miner* ore worth \$5.50 to \$6 a ton has since been outlined to the extent of some 4,400 tons for each vertical foot. The average dip of the shear zone is 49 degrees north. The sheared material is a buff to grey, silicified, quartz-sericite schist with more or less disseminated pyrite in small grains. Acid volcanic rocks, meta-rhyolites or meta-trachytes, form the hanging-wall except where some sections of intermediate and basic lavas have been cut off from the foot-wall rocks by the shear zone. Small lenticular bodies of diorite cut the hanging-wall rocks here and there.

Neither the shear zone nor the adjacent wall-rocks are exposed at the surface. Pillowed andesite flows outcrop about 500 feet south, and acidic rocks are exposed along the margin of a body of diorite about 1,000 feet north. The drilled section of the shear zone is covered by some 60 feet of overburden; the ground is swampy and is covered with an alder thicket.

Magnetometric Profiles. A section of the shear zone 650 feet long in lots 29 and 30 had been drilled before the magnetometric survey was made. Its position for this length was, therefore, known, but its extensions east and west were not. Cross-lines 1 to 16, inclusive, totalling 16,150 feet, were cut across the alder swamp into open cultivated ground on either side. A total of 349 readings of vertical magnetic intensity were made at intervals of 50 feet along the cross-lines (See Figure 4).

As shown in the magnetic profile from north to south on line 8, a marked decrease in magnetic intensity occurs near or at the projected contact between the hanging-wall rocks and the shear zone. On line 9 the anomaly is of about the same order of magnitude, but is not as steep and appears to be more nearly related to the andesite-rhyolite contact than to the shear zone. On lines 6 and 7, however, the magnitude, position, and form of the profile are strikingly similar to the same feature on line 8. Subsequent drilling placed the contacts and the shear zone as shown. The profile of line 5 suggests that the shear zone may continue at least that far. Drilling west of Aldermac siding showed that the Wasa shear did not go through in that vicinity. However, the southward-

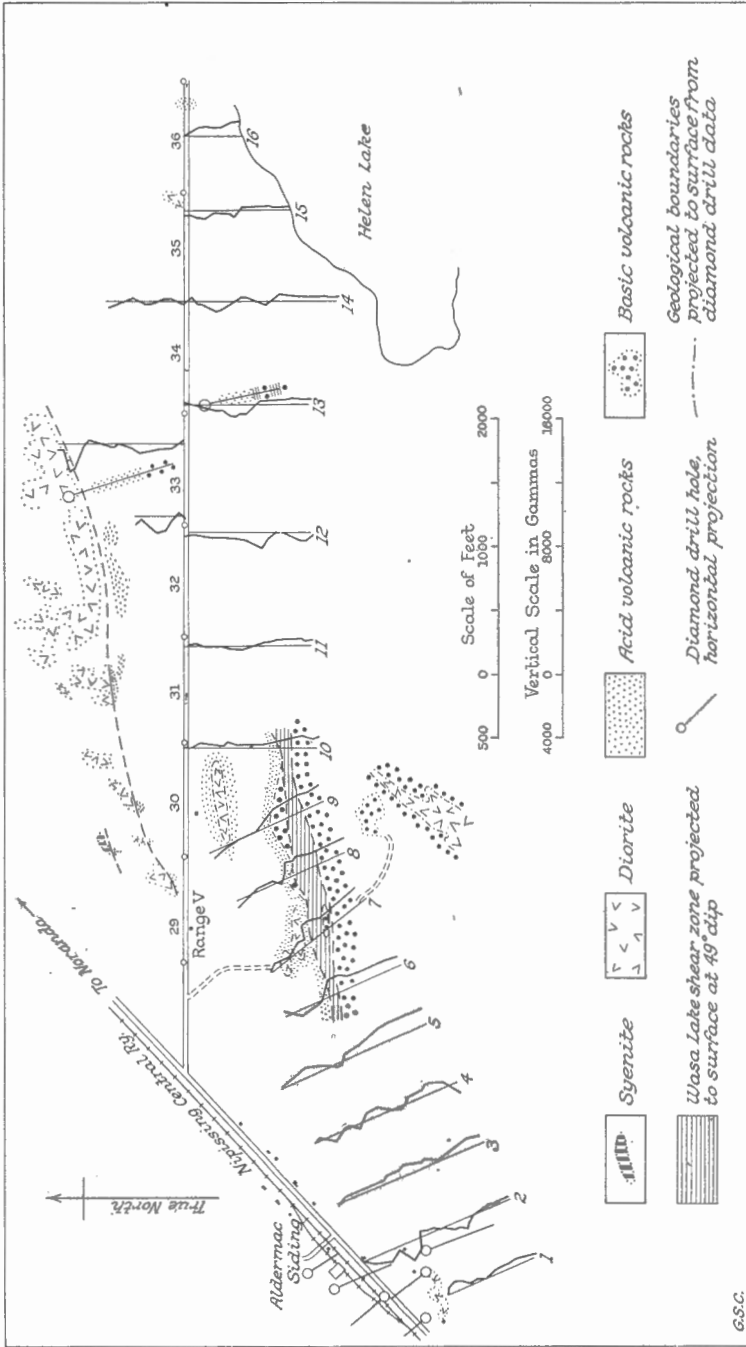


Figure 4. Magnetic profiles across Wasa Lake shear zone, Beauchastel township, Que.

trending drill hole south of the road near line 2 revealed a narrow section of sheared rocks very similar to sheared rocks in the zone farther east. Whether the two are parts of one continuous structural feature or of two parallel similar structural features is as yet uncertain.

Subsequently readings were made along lines 10 to 16, inclusive, and a hole was drilled at line 13. The satisfactory degree of correlation between the drop in the profile and the rhyolite-andesite contact (or shear zones?) can be judged from Figure 4. Again, on line 12 the position of the contact is probably indicated by the forms of the profiles, and although these, for lines 10 and 11, are not particularly diagnostic, the contact and shear zone may be supposed to continue from lines 10 to 13. Profiles 14 and 15 show two sharp declivities. One might hazard a guess that the northern of the two marks the position of the contact along which the shear zone is found farther west. The southern would then have to be accounted for by some new feature as yet unknown.

PROJECT NO. 5

Purpose. To trace the Arntfield shear zone.

Geological Notes. Bodies of gold ore were found near the Arntfield No. 3 shaft within a sheared zone that strikes, where known, about 30 degrees south of east and dips 45 degrees or so northeast. The eastward extension of the shear zone was not known much beyond line 4 (See Figure 5), and as shown in the figure there are no outcrops between line 4 and line 13, about 4,500 feet away. Furthermore, this part of the property, though open farm land, is mantled with 60 feet or more of boulder clay, and exploration thereunder by diamond drilling is slow, difficult, and costly.

When the Wasa Lake shear zone was discovered a little over 2 miles east and approximately on strike, and it was noted that the two are similar in dip and character of ore contained, the question naturally arose as to whether the two shears are the same shear. Even if they were not, the eastward extension of the Arntfield and the westward extension of the Wasa Lake shears are matters of geological interest with economic overtones that make tracing of their courses of importance.

Magnetometric Profiles. Vertical intensities were read at stations 50 feet apart along the north-south cross-lines 1 to 17. A total of 443 stations were occupied in 21,500 feet of cross-lines.

The profiles obtained are not regarded as sufficiently diagnostic to warrant projection of the Arntfield shear zone with any degree of certainty. A possible projection from near line 4 to near the southern end of line 7 is shown. As inspection will show, there are other dips equally strong in lines 5, 6, and 7 that might also mark the course of the shear.

Indeed, the question may be asked whether the profiles actually do indicate the presence of a shear zone, or whether their form is not due to a difference between the rocks in the hanging-wall and those in the foot-wall. In the section where the geology is known from mine workings (lines 1 to 4) the rocks on either side of the shear zone are lithologically different, and the influence of the shear zone on the form of the profiles is, therefore, a matter of some doubt.

Elsewhere the magnetic data did aid in interpretation of geology within the drift-covered area. A positive anomaly appears north of the base-line between lines 4 and 11. A diamond-drill hole near line 8 indicates that this anomaly is due to a body of quartz porphyry, and the extent of the anomaly is taken to indicate approximately the size and shape of the porphyry body.

Profiles on lines 11 to 17 lack sufficient geological data to make their interpretation more than suggestive¹. The southern margin of a diorite body there is probably indicated by the sharp declivities on profiles 12 and 13. The form of

¹ Since this work was completed some diamond drilling has been done near line 15. The information therefrom was not available when this paper was written. It should be of considerable assistance in arriving at a more complete and sounder interpretation of the magnetic data.

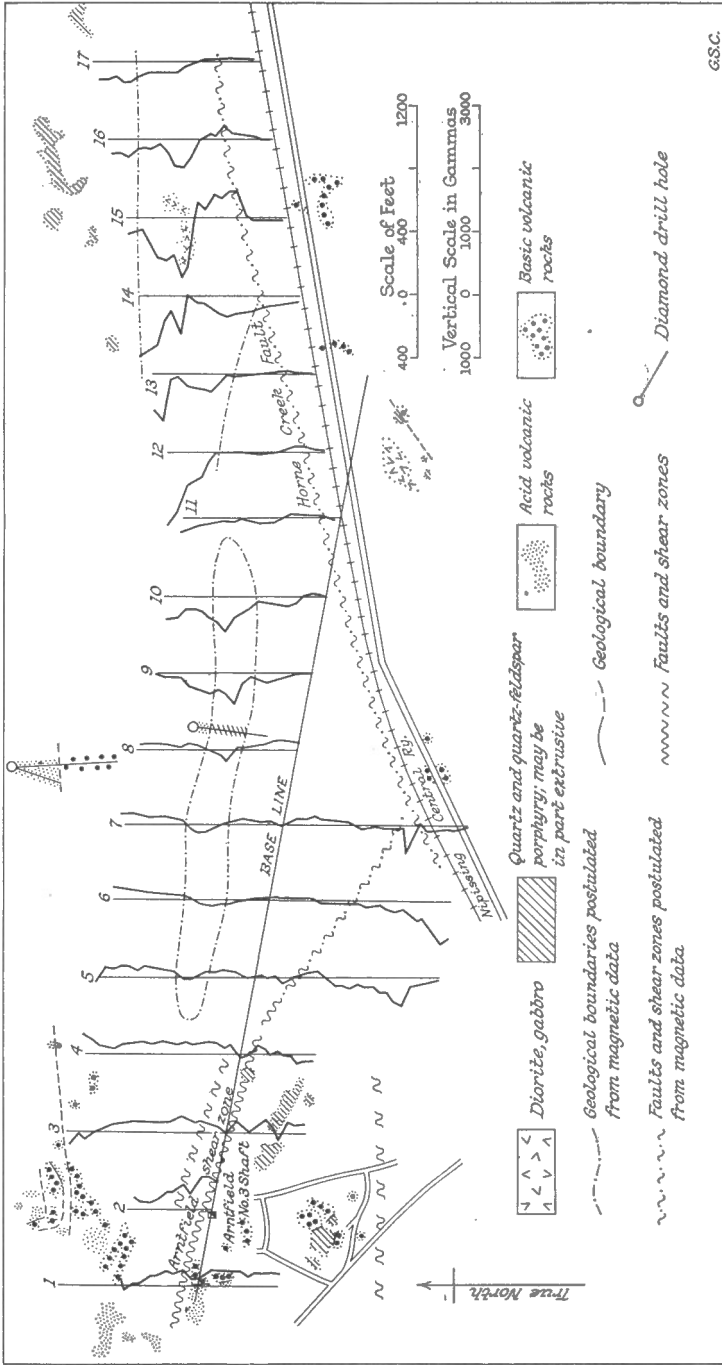


Figure 5. Magnetic profiles across part of Arnfield property, Beauchastel township, Que.

the profiles on 15 and 16 lends some support to the indicated suggestion that the diorite is terminated along the Horne Creek fault. The situation illustrates well on the one hand the need for a sufficient background of geological information, and on the other, the immediate extensions made possible, in some instances at least, where even a small amount of geological data is available.

PROJECT NO. 6

Purpose. To trace the Cobalt-Archæan contact: (a) on Arntfield property; (b) on Macfort property.

The Arntfield Property Sub-project

Geological Notes. The contact between the Cobalt sedimentary rocks and the underlying Archæan complex south of Arntfield is hidden beneath a swamp. Small outcrops of Cobalt conglomerate lie just east of the road to Arntfield, near line 1 (See Figure 6), and a larger outcrop of the same rock appears about 1,000 feet east of the north end of line 5. However, as the Cobalt is separated from the older rocks by a great unconformity, it was possible to suppose that these isolated outcrops were outliers, and that the main contact actually lay some distance south of them, perhaps even along the base of the large outcrops that form the Kekeko Hills. The position of the contact is a matter of economic importance; for the swamp-filled valley might mark the course of one of the main regional shear zones, the Larder Lake-Bouzan Lake fault zone. This zone is known elsewhere to carry large bodies of gold ore. If the Cobalt-Archæan contact lay south of it, prospecting and possible subsequent mining of ore found along it would be greatly simplified.

Five holes had been drilled as shown. They disclosed that the Cobalt-Archæan main contact lies along the north side of the swamp at that point. Furthermore, they showed that the contact dipped about 45 degrees south—a most surprising disclosure, as dips of the Cobalt beds are in general around 15 degrees. Thus, unless the contact swings south as it goes east, a very considerable thickness of Cobalt would underlie the swamp and hence overlie any possible fault zone. An attempt was, therefore, made to trace the contact by means of magnetic data.

Magnetometric Profiles. One hundred and forty-three stations, placed 50 feet apart, were occupied along 6,900 feet of cross-lines. A trail along the power lines was used as a base-line. As the profiles show (See Figure 6), vertical intensities decrease gradually as the contact is approached from the Cobalt towards the Archæan. The sharp drop near the contact on line 1 is probably an erratic low due to the influence of a nearby pile of scrap iron. No similar lows appear on any of the other lines, and the profiles must be classed as non-diagnostic in so far as the precise position of the contact is concerned. The profiles do give, perhaps, a poor indication that it does not swing very far south.

The Macfort Property Sub-project

Geological Notes. On the Macfort property the Cobalt-Archæan contact also lies below a swamp, and surface outcrops are insufficient to place it within rather wide limits (See Figure 7). Also, the position of the contact is of economic significance, for it determines the accessibility of a section through which the same major regional shear zone may pass. Certainly less is known about the contact here than on the Arntfield, for no diamond drilling has been done in this part of the Macfort property.

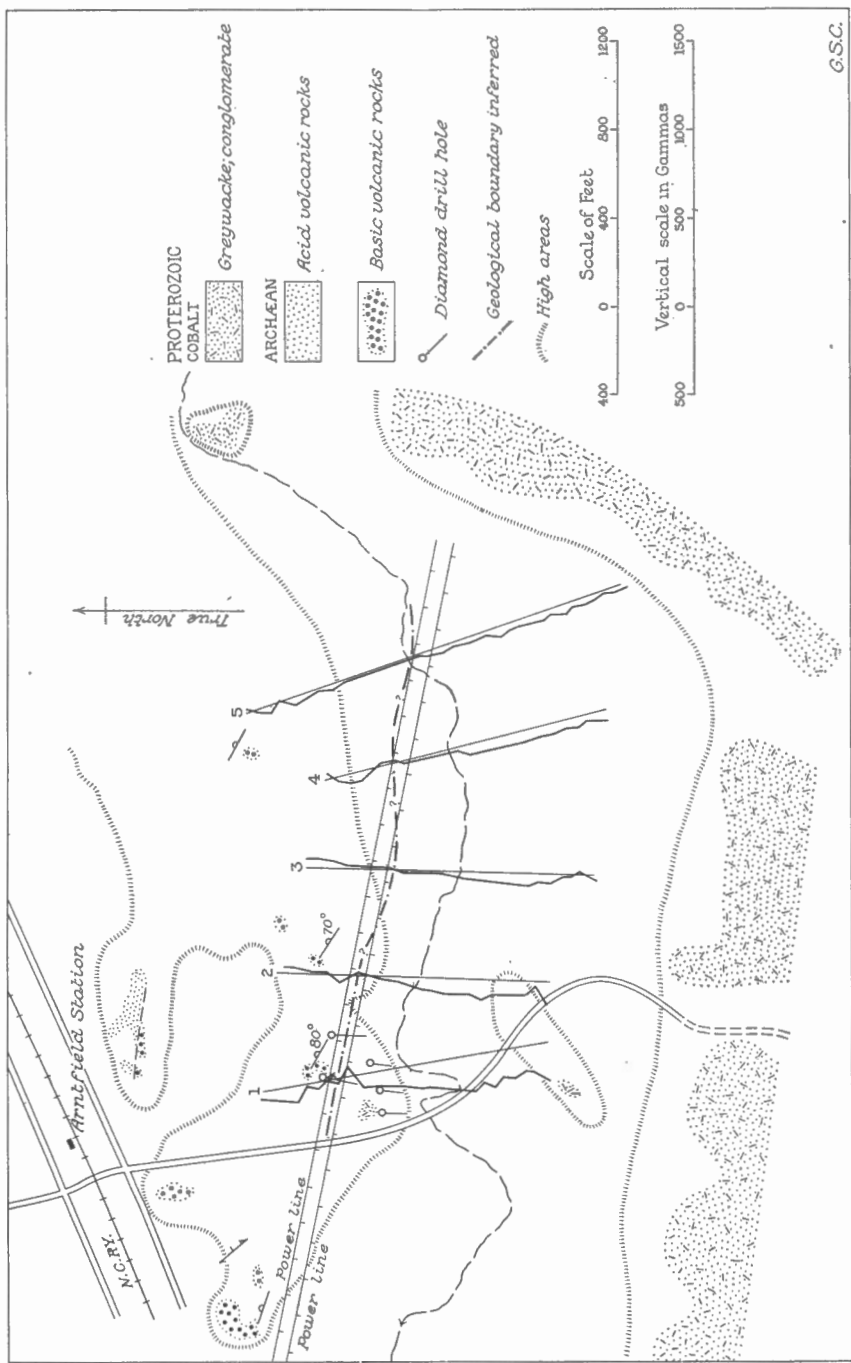


Figure 6. Magnetic profiles across Cobalt-Archæan contact, near Arnfield, Que.

Magnetometric Profiles. One hundred and ten readings of vertical magnetic intensity were made at stations placed 50 feet apart along 5,300 feet of cross-lines (See Figure 7, south of railroad track, lines 15-45). The profiles are even less helpful than those obtained at Arntfield. A guess might be hazarded from the forms of the profiles along lines 15, 25, and 35, that the contact lies nearly parallel to and about 500 feet south of the railroad, but the almost horizontal profile of line 45 gives no indication whatever that a contact has been crossed. The magnetic data are not regarded as being of any assistance in this instance.

PROJECT NO. 7

Purpose. To trace diorite contacts on the Macfort property.

Geological Notes. Four hundred feet east of Samia Lake, just south of the base-line, a shear zone some 5 feet wide is exposed between massive diorite on the north and basic volcanic breccia on the south. The shear zone strikes east and dips about 55 degrees north. Gold in encouraging amounts is found in this shear in trenches near line 11. Fifty feet south of the shear a zone of sheared carbonatized rocks 50 feet wide underlies a narrow linear valley. Both these shear zones strike east and may continue eastward south of Lake Fortune, or they may be offset along a fault. The distribution of gold along the northern shear—none or very little is known along the other—led to the hypothesis that the most favourable places for gold deposition are where foot- and hanging-wall rocks of different competence are in contact along the shear zone. The location of the eastward continuation of the shear zones and the distribution of the diorite masses thus became matters of considerable interest.

Massive diorite occupies most of the narrow part of the isthmus between the lakes and is exposed in the east part of the property along and south of Lake Fortune. Small, isolated outcrops are seen near the south end of line 6 on the south shore of Samia Lake.

Diamond drilling had been done from Lake Fortune, as shown (See Figure 7). The formations encountered are projected up their dips to the surface, thus giving an apparent exaggeration to the lengths of the holes.

Magnetometric Profiles. Cross-lines had been cut in prospecting the property. Readings of vertical magnetic intensity were made at stations 100 feet apart along lines 1 to 10, inclusive. Near the shear zones a few stations were read at intervals of 50 feet. The profiles so obtained are shown on Figure 7.

The sharp anomalies in profiles 10 and 9 are taken to indicate the position of the south margin of the diorite. Diorite is exposed on the north side of a small outcrop about midway between lines 9 and 8, 300 feet south of the base-line, which serves to fix the contact at that point. However, on profile 8 an anomaly similar to those on 10 and 9 is displaced with respect to them about 100 feet north, and on profile 7 such an anomaly is lacking. The suggestion is that the diorite body ends abruptly along a line that trends northeast. This line is directly on strike with a fault that is postulated on evidence obtained north of the area shown, between Lake Fortune and King of the North Lake. The horizontal displacement on the fault there appears to be left hand, and from 1,000 to 1,500 feet. In the area of Figure 7 a body of diorite is exposed on the shore of Lake Fortune at the north end of line 5. That this body may be the offset continuation of the diorite that terminates near line 8, the offset being along the northeast-trending fault described above, offers a plausible explanation of the abrupt termination of the diorite and of the appearance of an isolated body of the same rock. The horizontal offset would be left hand and of about 900 feet, corresponding fairly well with the fault north of Lake Fortune. It may be noted as well that such a fault would be parallel to, and

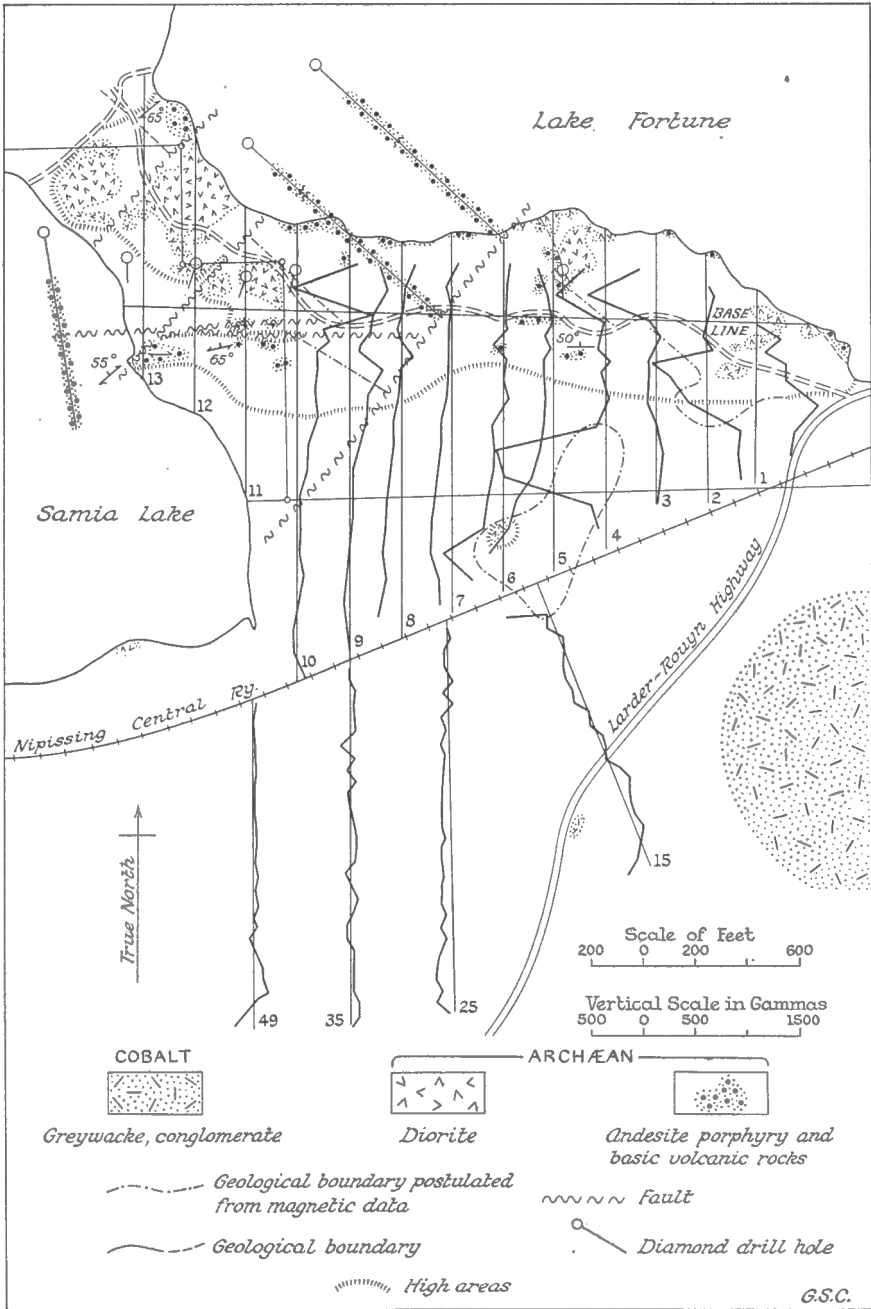


Figure 7. Magnetic profiles across part of Macfort property. Dasserat township, Que.

show offset in the same sense as, a well-established fault that occurs just east of Lake Fortune. The two small faults shown across the narrowest part of the land neck between Samia Lake and Lake Fortune may be branches of the proposed fault.

If correct, the hypothesis that a northeast-striking fault exists as shown, opens up interesting possibilities. The Lake Fortune shear outcrops east of the area of Figure 7. It is a well known zone of sheared, carbonatized rocks, exposed at the east end of the lake along the south shore. It strikes west, and some 1,500 feet west of the east end of the lake the shoreline curves southward and continuity of the zone is hidden below the lake. Some moderately sheared, mildly carbonatized rocks near the north end of line 1 were exposed in a trench during the summer of 1944. Although somewhat off strike, they were supposed to be the continuation of the main Lake Fortune shear, but the development of schistosity and the amount of carbonate do not compare with material in the zone as exposed farther east. The same objection holds true for material exposed in a trench between lines 4 and 5. Lacking an alternative, these can be reluctantly accepted as the shear zone's continuation. However, the possible fault presents an attractive alternative, namely, that the Lake Fortune shear zone strikes west to skirt the shore of the lake to where it encounters the proposed northeast fault at a point somewhere north of line 5. If it is there displaced, as the diorite may be, its offset continuation should appear on the west side of the proposed fault on strike with the carbonatized zone noted near lines 10 and 11. The fact that the Lake Fortune shear is offset in just this manner along the known fault east of Lake Fortune lends support to such an idea. Although the possibility is admittedly only an alternative explanation of the data in hand, its validity might bear testing when further prospecting for gold deposits in the Lake Fortune shear zone is undertaken in this vicinity.

PROJECT NO. 8

Purpose. To trace shear zones and contacts of intrusions on the Francœur property.

Geological Notes. Flows, flow breccias, agglomerates, and tuffs of acid and basic volcanic rocks are fairly well exposed southeast and north of the Francœur No. 2 shaft. The two main types of rocks form alternating layers that strike nearly east and dip 45 to 60 degrees north. Diorite, intrusive into acid volcanic rocks, is exposed some 2,000 feet northwest of the shaft. The main shear zone, which contains some of the Francœur ore, has been traced in mine workings and by diamond drilling as shown in Figure 9. Another shear, named the No. 8 shear zone, is known 900 feet north of the main zone. Both shear zones dip 45 to 50 degrees north.

Two geological problems of interest when the examination was being made were: where does the westward extension of the No. 8 shear zone lie; and what is the outline of the diorite body northwest of the shaft. A magnetometer survey was undertaken in an attempt to solve these problems.

Magnetometric Profiles. Two hundred and two readings of vertical magnetic intensity were made at stations placed 50 feet apart along 9,700 feet of cross-lines. The anomalies obtained were exceptionally large, in places approaching 4,000 gammas above the general average for the area. The magnetic data are represented in Figure 8 in profiles, and in Figure 9 in isomagnetic contours drawn at intervals of 500 gammas.

Inspection of the profiles of Figure 8 shows that the magnetic data make possible several interpretations of the outline of the diorite body. The forms of the contours of Figure 9, themselves the result of extensive interpolation and interpretation, indicate at least three possibilities: the diorite may cut off at the base of "high 4" (interpretation adopted in Figure 8); it may extend

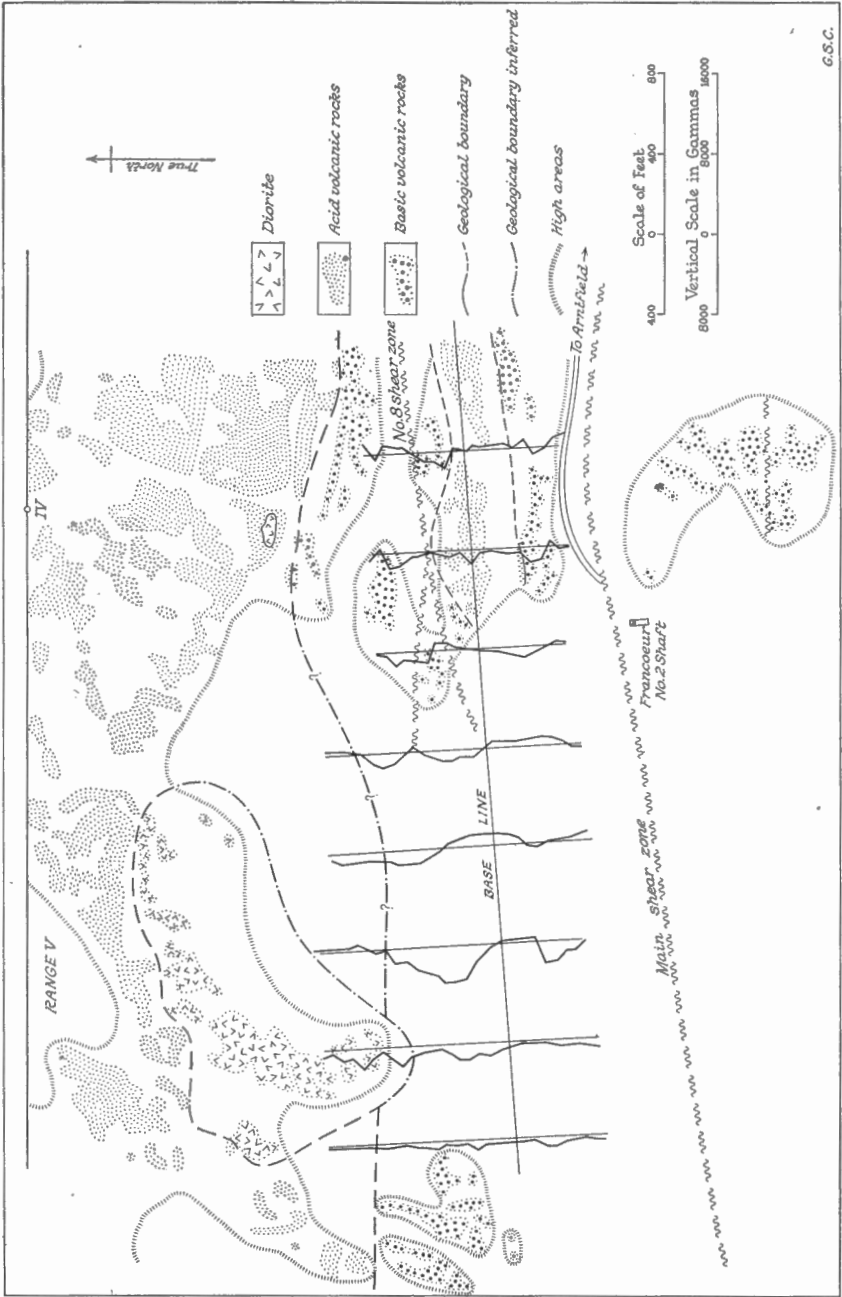


Figure 8. Magnetic profiles near Francœur mine, Beauchastel township, Que.

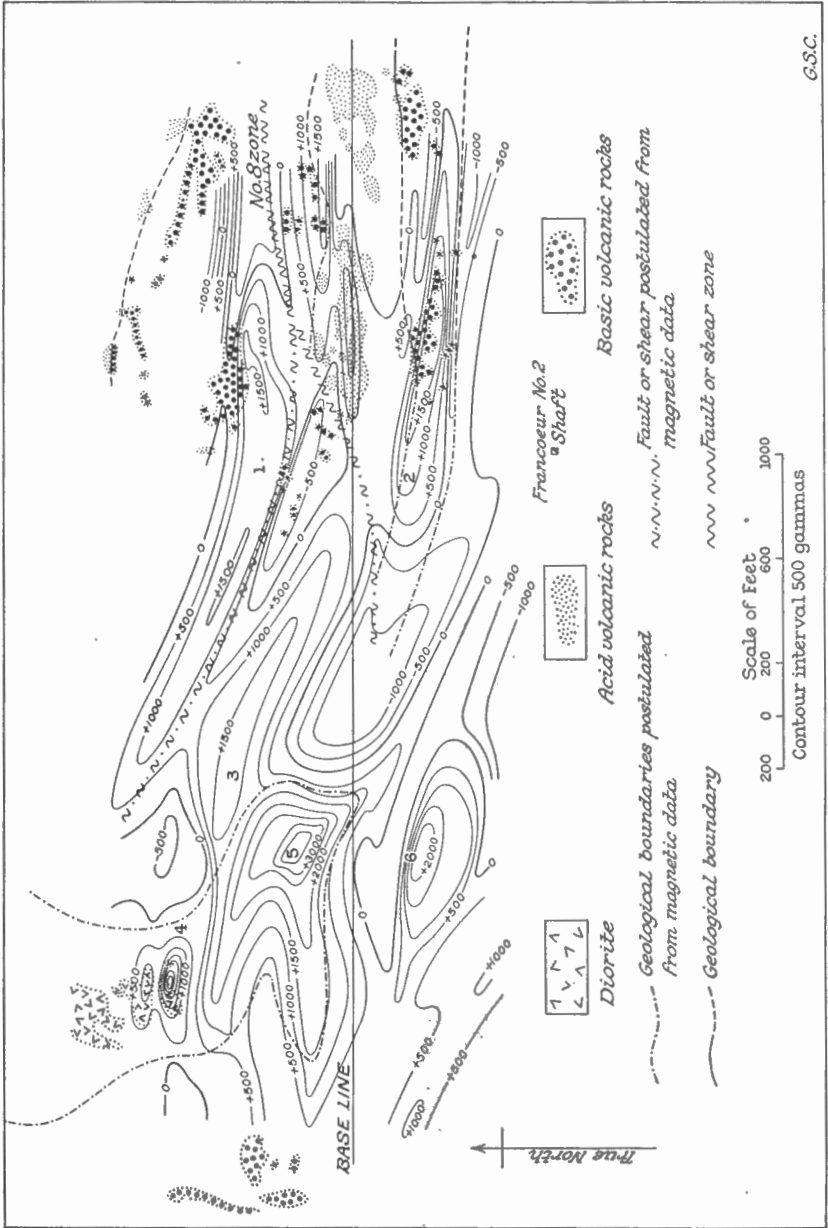


Figure 9. Isomagnetic contour map, showing vertical magnetic intensities, near Francœur No. 2 shaft, Beauchastel township, Que.

southward to include "high 5" as well; or it may also extend eastward to include "high 3". To arrive at the correct interpretation, one or both of two things may be done. Either a series of strategically located diamond-drill holes might be put down, or magnetic readings might be made on supplementary, more closely spaced cross-lines. If the second course were adopted, some drilling would eventually be necessary for final confirmation.

The course of No. 8 shear zone seems somewhat clearer. The forms of the profiles are not particularly helpful, but from the contours it is clear that the zone, where known, lies close to the southern margin of "high 1". Westward one branch may split off to the southwestward. The other may continue along the base of the anomaly that appears to be in the form of a narrow, northwest-trending ridge, with a steeper slope on the southern than on the northern flank. The ridge may be the magnetic expression of one particular north-dipping layer of rock. By carrying the supposition one step farther it may be suggested that the No. 8 zone follows along the south margin of the rock layer that gives rise to the anomaly.

RECAPITULATION

From the foregoing descriptions it is seen that the results of the investigations ranged from completely successful, as in the tracing of a diabase dyke intrusive into andesite (Project No. 2), to unsatisfactory, as in the effort to delineate the Cobalt-Archæan contact (Project No. 6). Of the eight projects undertaken, definitely useful information was gained in all but two, the Cobalt-Archæan project already mentioned, and the attempt to trace a diabase dyke intrusive into acid volcanic rocks (Project No. 3). Intrusive diorite contacts were delineated clearly in Project No. 1, and fairly satisfactorily on the Arntfield property (Project No. 5), but data on the Francœur property were insufficient to do better than to indicate three possible positions of a diorite contact. On the Macfort, the indicated distribution of diorite led to a new structural hypothesis, still to be tested.

Individual flows or groups of flows stand out fairly clearly, especially in the form of the isomagnetic contours in the Francœur project.

Shear zones were traced successfully on the Wasa Lake property (Project No. 4) and possibly at Francœur. This success is not believed to be due to differences of magnetic intensities provided by the shear zones as such, but to the fact that the shear, at Wasa at least, forms the contact between rocks of differing magnetic susceptibility. In other words, the contact was traced and in this instance the contact and the shear zone were coincident.

To conclude, on the basis of the small number of projects undertaken, and making allowances for the inexperience in field operation of the magnetometer and office interpretation of the data, it can be stated that magnetic data can be of real value in mapping as a supplement to geological observations. The data appear to be most useful in outlining intrusive bodies, particularly diorites or gabbros, and in tracing individual rock units such as a flow or groups of flows, if that unit lies between rocks differing in magnetic susceptibility. Where shear zones lie along contacts between such rocks, they can likewise be traced. It appears unlikely, however, that they can be traced where the rocks on either side are the same, as, for example, where both are andesites or both rhyolites of the same or closely similar susceptibilities. In the two projects attempted, sedimentary rocks do not differ sufficiently in magnetic susceptibility from volcanic rocks to facilitate their distinction. It is safe to assume, for the present at least, that it cannot be predicted with assurance whether or not magnetic data will be of value in extending geological information in drift-covered areas. Each situation is a separate problem, and although some generalizations are suggested, they may not hold true in any specific instance. Thus, in order to find out if it will work, it must be tried. So far the results show that in most instances it does work, in places with notable success.