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The Julian Deposit & Its Extension

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THE JULIAN DEPOSIT

and its

EXTENSIONS

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Introduction

This report presents the results of a study and interpretation of the data gathered during the winter surveying project of 1963 as supplemented by other data dating back to 1956. Information concerning the entire Julienne Iron Formation is available for the first time which permits a reasonable interpretation and logical conclusions concerning not only the exposed deposit but also its extensions under the lakes.

Surveys

The 1963 winter sounding-magnetic surveys over the ice of Wabush and Julienne Lakes were conducted during the period March 8 - April 10, 1963. The work was accomplished by a seven man party based at the Julian camp. Air transport was used from Wabush Lake. The party was led by Mr. William Blakeman and included Messrs. P. La Rush, D. Adams, J. Rae and three men from Newfoundland, Messrs. J. Crocker, E. Spurrell and E. Smith. Aside from a few windy days with sub-zero temperatures, only two days were lost due to inclement weather.

The Julian Mine grid was picked up at 10,000N x 10,000E and taken out on the ice to the west, north, east and south of the deposit. These control lines were surveyed and chained. Cross lines were established from these base lines and picketed for the magnetic and sounding surveys.

Three inch diameter holes were drilled through the ice with hand driven ice augers in about 3 minutes time. Depth of water was taken with a nylon cord on the end of which there was a heavy pipe weight. The length of line let out was determined by the number of wraps around a three foot winding board and by comparison with the survey chain in very deep water. The distribution of soundings is as follows.

	Holes	Foot Centers
Julienne Lake - eastern extension	120	500
Wabush Lake - western extension	84	500
Wabush Lake - mile 16 Bay	14	1000
Wabush - Julienne Narrows	24	1000
Lake Leila Wynne	19	1000 & 1500
Julienne Lake, Southeast Arm	64	1000 & 1500
Shallows in Southeast Arm	51	250 & 500

The magnetic survey was conducted by Mr. La Rush using a Jalandar vertical field, flux gate type magnetometer with a sensitivity of 20 gammas. This instrument operated perfectly and allowed the magnetic survey to be conducted at a rate of 45-50, 000 feet per day at 100 foot station intervals. The magnetic base used is at the east end of the old 1956 base line. Diurnal variations were observed of 200 gammas or less and have been corrected in the reduction of the magnetic data.

Regional Magnetic Setting

The regional magnetic setting of the I. F. is shown on the aero magnetic map. This is a total magnetic field map in which regional background has an arbitrary value of 3200 gammas. The absolute values of the earth's total magnetic field in this area is about 60, 000 gammas along a vector inclined about 75 degrees in the N30W direction. In this situation the vertical component is 96 per cent and the horizontal 26 per cent of the total field; thus comparisons between the total field and vertical field measurements are subject to an error of only 4 per cent.

The magnetic field induced by the presence of the magnetic iron formation is expressed as a magnetic response above the regional background. Note that such response begins up to about a mile away from the iron formation.

The map also shows the outline of the Julienne I. F. as determined from the ground survey. This shows that even a low magnetic ridge, such as at the west end, may be significant regarding the presence of I. F. Such subtle anomalies are not reliable for tracing the I. F., however, because of possible masking by the side effects of other nearby bodies of iron formation.

Thus, the western continuation of the Julienne I. F. is not truly defined with the 1/2 mile line spacing. It might connect with the I. F. in the island in Wabush Lake, or with the I. F. on the northwest shore of the lake. Likewise, the eastward extension is magnetically lost in the side effects of other nearby bodies of iron formation.

Principal Anomaly

The basic Julienne magnetic anomaly is a broad magnetic response of only moderate amplitude characterized by a rounded profile shape, often non-symmetrical and somewhat irregular in detail. The irregular surface details are clearly due to an unequal distribution of magnetite within the I. F. and will be treated later. For the moment the interpretation is concerned only with the amplitude and shape of the magnetic profile due to the magnetic response of the deep body of I. F. and ignoring the irregularities of the profile due to the upper part of the I. F. near surface.

Because an induced magnetic anomaly decreases as the square of the distance of observation increases, the anomalies obtained from two planes of observation can be compared and depth calculations made to the top of the magnetic body provided that true background values are known so as to yield an accurate measure of the amplitude of the anomaly.

The aero magnetic survey shows a background of 3200 gammas, the ground magnetic survey showed background values of about 2500 gammas, the difference of 700 gammas is due only to the arbitrary assignment of base values. In that depth calculations from individual sets of data are insignificant; a general pattern of average anomaly amplitudes must be determined.

Figure 1 shows the average amplitude pattern of the ground and aero magnetic surveys, as determined from the smoothed out profiles, along the center of the I. F. from one end of the anomalous zone to the other and related to a common background value.

Note that both the ground and aero surveys become tangent near 2000E and 16, 500E and the values are 400 gammas above the true background. This occurs because the I. F. in these areas produces a 400 gamma response above background but the source of the response is so deep that there is virtually no difference in response between the ground and aero surveys. Note that between about 4000E and 15, 000E, there is a nearly constant difference of about 600 gammas between the ground and aero anomalies except for directly over the mine and east of 16,500E. This feature is due entirely to the fact that the ground survey is 500 feet closer to the source of the anomaly than the aero survey. The extra ground anomaly over the mine is due to the fact that observations were taken at zero depth. The apparent extra ground anomaly east of 16,500E is due to the fact that the aero survey failed to pick up the very narrow ground anomaly shown. We may thus conclude that the difference between curve A and the aero anomaly amplitude is a valid measure of the difference in magnetic response of observation at two elevations and can be used as a basis of depth calculations according to the formula,

$$\text{Depth} = \frac{\text{elev. diff.}}{\dfrac{\text{ground response}}{\text{aero response}} - 1} , \quad D = \frac{Z}{\dfrac{V_g}{V_a} - 1}$$

The data and results are as follows using Z as 500 feet.

Station	V_g	V_a	$\frac{V_g}{V_a} - 1$	Depth	Depth Averaged from Smooth Curve	Elevation of Observation	Averaged Elevation
2000E	400	400	indeterminate				
3000E	900	750	.2	1000	750	1730	980
4000E	1500	800	.9	560	760	1730	970
5000E	1900	900	1.1	460	800	1730	930
6000E	2200	1300	.7	720	850	1730	850
7000E	2600	1600	.6	830	900	1730	830
8000E	3200A	2300	.4	1250	1100*	1800	700*
9000E	3200A	2400	.3	1650	1300*	1900	600*
10000E	3200A	2400	.3	1650	1400*	1925	525*
11000E	3200A	2400	.3	1650	1400*	1800	400*
12000E	3000	2300	.3	1650	1300*	1750	450*
13000E	2700	2100	.3	1650	1000	1730	730
14000E	2600	1700	.5	1000	900	1730	830
15000E	2000	1000	1.0	500	800	1730	930
16000E	1100	900	.2	1000	750	1730	980
17000E	900	400	not comparable				

Note that depths calculated by this method suggest greater depths between 8000E and 13,000E. This is only apparent because V_g contains a contribution from the near surface I. F. which can not quantitatively be removed and the resulting depths are too great, as signified by the asterisk/*. Where the method is truly applicable out over the water, the top of the source of the anomaly is clearly at about elevation 900, corresponding to a depth of about 830 feet. This is quantitative corroboration of the general character of the anomaly suggesting a deep source for the magnetic response. In other words, most of the magnetic anomaly over the Julienne I. F. is due to magnetically susceptible iron formation lying below elevation 900. An 800 foot plus depth to the top of the magnetic body is close to the depth of 925 feet found at Wabush Lake for the bottom of the leached and oxidized I. F.

It may be reasonably concluded from the above that elevation 900 approximates the bottom of the oxidized portion of the Julienne I. F. and that below this elevation the I. F. is unleached and unoxidized, and it is the magnetite contained in the I. F. below elevation 900 that is responsible for the general character of the magnetics.

Secondary Anomaly

The magnetic details of the anomaly, such as irregularities and the contact shape and part of the amplitude of the anomaly, are due to the response of the top of the I. F.; that is, the top of the leached and oxidized portion which outcrops or lies near surface under the overburden.

As the plane of observation becomes closer and closer to a contact between magnetic and non-magnetic rocks, the resulting magnetic profile becomes sharper and sharper. This sharpness of magnetic contacts can be analyzed by the half maximum slope method to give a measure of the depth to the contact.

Application of this graphical method to the ground profiles generally gives greater depths on the north side than on the south side. This gives unrealistic results for both contacts because the anomaly is non-symmetrical for reasons other than depth differences. The depths determined for each section is the average of the North and South contacts as adjusted to give smooth longitudinal depth profile. While some individual depths are clearly far too shallow or deep, the depths indicated give a trend which probably is correct to within plus or minus 20 per cent.

Section	Depth	Section	Depth	Section	Depth
1000E-3000E	No determination	11500E	holes 7, 8, 20'	17000E	170'
3500E	200'	12000E	70'	17500E	190'
7000E	175'	12500E	130'	18000E	220'
4500E	150'	13000E	hole 9, 140'	18500E	260'
5000E	130'	13500E	130'		
5500E	110'	14000E	120		
6000E	90'	14500E	100'		
6500E	70'	15000E	95'		
7000E	55'	15500E	110'		
7500E	45'	16000E	130'		
8000E-11000E	outcrop	16500E	150'		

These depths of cover over the top of the iron formation are shown on figure 2 which is a diagrammatic representation of the I. F., over-burden and water depth situation along the center of the Julian Deposit and its extensions under the lake, approximately along the 10000N line.

Anomaly Symmetry - Depth Extension

Most of the magnetic profiles are distinctly non-symmetrical in that the magnetic plateau north of the I. F. is higher than on the south side. While this could be caused by rocks lying to the north of the I. F. which are slightly magnetic, it could also be due to a northward dipping extension of the iron formation.

This fact, plus the 800 foot plus depth to the top of the principal magnetic source strongly suggest the possibility of a deep depth extension of the Julienne I. F.; in fact, some kind of extension below elevation 1000 is required to account for the anomaly <u>if</u> the oxidized portion does indeed contain only 1% magnetite as indicated by the metallurgical tests of the 1957 drill core.

The type of depth extensions capable of explaining the magnetic effects, if due entirely to iron formation, are shown in figure 3 where profiles for various magnetic models are shown for comparison with representative ground and aero profiles across the deposit.

If body "A" is 900 feet deep and contains 1% magnetite it would yield an aero anomaly of only about 100 gammas. When the contribution of body "A", the oxidized I. F., is subtracted from the observed aero anomaly, we have a residual magnetic profile X which must be accounted for by iron formation lying below body "A".

The methods and calculations used for this study are too laborious to present here; therefore, only the results will be discussed. Body "B" (400 feet thick, 5% magnetite) yields profile curve B, which does not have enough amplitude or the correct shape. If, under B, we assume a horizontal slab 400 feet thick containing 15% magnetite, we obtain a curve for model B+C. While the amplitude is correct, the shape does not satisfactorily approximate curve "X".

If we assume body "D", dipping infinitely 30 degrees north from near elevation 1000 and containing 5% magnetite, the magnetic profile would approximate the curve shown for model "D". This curve is fairly close to curve "X", the observed aero less the response of the oxidized body "A".

Independent geophysical or other evidence is required to substantiate the model because of the non-uniqueness of magnetic parameters. Nevertheless, the representation is useful in indicating what sort of structural interpretation is necessary for the occurrence of the iron formation if the magnetic assumptions are valid.

Soundings - Glacial

The water depth sounding program procured depth of water information in various areas around the Julian Deposit. The results are presented on the 400 feet per inch maps but certain characteristics are discussed here.

Figure 4 shows an approximation of the location of elevation contours on the rock surface (beneath the overburden) and the outline of where the water becomes rapidly deeper. This presentation shows quite dramatically that there is a plateau or shelf of relatively flat surfaced overburden bordering each body of rock which probably originated as follows.

The deep holes in Wabush and Julienne Lakes north of the iron formation appear to lie parallel with the I. F., suggesting the presence in this area of a relatively soft body of rock associated with the Julienne structure which became deeply scowered by the glacier as it moved from northwest to southeast.

The ice tended to override the more resistant I. F. but nevertheless scowered it down deeply to elevation 1500 or lower at the ends of the present survey zone. The scowering action made a shelf east of the Julian hill at about elevation 1600 and a shelf at about 1650-1 southwest of the hill. Just why the present hill escaped complete destruction is not known.

Southeast of the iron formation and quartzite the ice movement was parallel with the geologic trends, so that a long scowered channel developed in what is now the southeast arm of Julienne Lake and a smaller scaled channel developed in the Leila Wynne area.

As the glacial ice melted, it released its contained load of debris. This debris accumulated in the deep parts of the glacial melt waters. As more surface ice melted, more debris was released, and as the lake waters receded they carried much of this debris with them, thus concentrating much of the glacial debris in the deeper areas.

But much of the deep channels and areas were already filled with, as yet unmelted, ice. The debris was thus forced to pile up between the above water land and these blocks of ice. When these ice blocks finally melted, they left what are now the deeper holes in the bottom of the lake.

Thus we see a relatively flat, broad and deep pile of glacial debris surrounding all land above elevation 1800 (the recent level of the lake). These shelves extend outwards for several thousand feet and shelves from adjacent areas run together.

Thus, in the shallow waters at the Julienne Narrows and west of these, there are deep piles of debris piled into the deep channel. The shallow water areas east of the Julienne hill and at the railroad crossing are similarly probably thick deposits in a channel. The Julian neck is a similar situation but in this case the rock elevation is probably not very far below elevation 1700.

The glacial debris is generally a homogeneous mixture of silt, sand, gravel and boulders deposited under waters and with little to no subsequent reworking. Classification by size has taken place locally; the proposed townsite area is an example where we find sandy-silt sized materials as lake bottom sediments.

Localized deposits of sand occur, associated with or near the present lake levels, in sheltered bays and coves, or as eskers and their associated outwash sand planes. Gravel deposits occur only where wave or current action has washed the sand-silt sized fractions away, such as along wave cut benches or sometimes within eskers and covered up by the later deposited sand.

The unsorted glacial debris is, in general, fairly permeable and drains rapidly while the silt-sand soils are more imperveous. Both are typically well compacted and solid in their undisturbed state, but due to a high water content they change to a very fluid state when disturbed and will remain so unless they are well drained.

Magnetics - Mineralogy - Stratigraphy

The details of the magnetic profiles show five to seven magnetic ridges and one characteristic low which can be readily correlated from one end of the anomalous zone to the other except for near the ends of the zone where the anomaly becomes very subtle. For the most part these highs can be located on every adjacent profile but there are a few exceptions.

There can be no question that these magnetic ridges and valleys are the magnetic expression of distinct stratigraphic horizons contained within the iron formation. An examination of these features in relation to the known mineralogic varieties of the iron formation as expressed in outcrop shows the following.

Ridge 1 - Associated with the granular, spec-granular and spec-silicate variety along the south side of the deposit.

Ridge 2 - Associated with spec-granular and granular near station 7 in the trench area.

Ridge 3 - Associated with specular hermatite near station 8 of the trench and test pit number 1. Occurs east of 9000E only.

Ridge 4 - Associated with spec-granular near specular variety near station 11 of the trench.

Valley - A pronounced magnetic low found about 200 feet north of the ferruginous quartzite zone.

Ridge 5 - Associated with the specular hematite zone seen near station 10 in the trench and test pit 3.

Ridge 6 - Associated with spec-silicate zone along the north side of the deposit, and slightly north of the zone in some areas.

Ridge 7 - Associated with the spec-silicate zone found in hole 3.

The obvious deduction from the above is that the magnetic ridges are associated with specular hematite bearing iron formation. This would appear to be contrary to the expected where magnetic highs should reflect the presence of magnetite. The reason for this reversed situation is but another expression of the completely oxidized nature of the Julienne Iron Formation where all former magnetite has been ozidized to martite.

The specular hematite produces the higher induced magnetic response because, for some unknown reason, all specular hematite in the Wabush Lake area is slightly paramagnetic. This can be observed when a hand magnet is placed near loose flakes of specular hematite and movement of the flakes occurs. The magnetic susceptibility of the specular hematite appears to be about 1000 (600 - 1400) x 10^{-6} c.g.s. units, which corresponds to an equivalent magnetite content of 1/2 to 1 per cent as determined by laboratory tests on Wabush ores in 1957 by Prof. L. Bacon.

It may be concluded that the magnetic ridges are an expression of and mark the location of predominately specular hematite zones within the iron formation. With more definitive magnetic information over the outcropping body, the magnetics may be usefully used to trace these zones from outcrop to outcrop and help solve the existing correlation problems.

Geologic Considerations

The present magnetic data suggests that some of the correlations shown on Geology Plan II may be somewhat in error. If this proves to be the case, certain changes in correlation will be required. It suggests a shift of the ferruginous quartzite zone a few hundred feet north around 8500 to 9000E, it indicates that the specular zone near trench station 8 pinches out around 9000E and does not correlate with the one outcropping near survey point J. It further suggests that the specular-silicate zone near trench station 24 may join with the test pit 5 area and that the specular-silicate of hole 3 is completely separate. This would suggest that the specular-silicate of trench station 20-21 loses its silicate fraction and becomes the specular zone between pits 3 and 4. And finally, it suggests that the specular zone at trench station 17-19 may correlate with the specular zone north of pit 2.

All of these suggested changes in correlation are reasonable and may yet be demonstrated. What it basically does is suggest that cross folding is less important than previously thought and indicates that more weight should be placed upon a stratigraphic-structural interpretation which emphasizes trends more parallel to the long dimension of the iron formation.

The reduction in width of the I. F. to about 1/2 to 3/4 of its eastern width west of 9000E, and eventually decreasing to less than 1/2 farther west, could be due to a decreasing overall stratigraphic thickness or thinning westward to a near pinch out west of 1000E. Alternatively there may be a gradual eastward plunge if the body is a sort of synclinal fold such that the I. F. comes out of the ground going westward; this would be contrary to the magnetic interpretation of a very deep body in this western end, however.

To the east the I. F. seems to remain essentially at a constant width out to about 17, 000E after which nearly all trace of the anomaly is lost except for the southern magnetic ridge. This change occurs where the water depths increase rapidly to about 200 feet deep. There is some magnetic evidence on line 19, 000E that the full width of the iron formation may again be present, and from the aero magnetic survey it would appear possible that the anomaly could be traced out to somewhere around 22, 000E.

The magnetic interpretation indicates continuity of the I. F. beyond 16,000E, yet the ground survey loses the magnetic expression of the top of the I. F. in the area of the deep hole. This suggests that the I. F. is indeed continuous out to 19,000E and beyond and probably in its full width, but its upper surface in the 16,000 - 19,000E area along its north side has been removed by glacial scower.

Therefore, the magnetic contact at about elevation 1600 to 1500 shifts progressively southeast of 16,000E, but the geologic contact along the north side of the iron formation continues straight east but becomes extremely deep under the hole and is magnetically indistinguishable east of 16,000E by the ground magnetic survey.

While the information gathered in the winter program of 1963 has served to enlarge the fund of information relative to the entire Julienne iron formation and allowed several reasonable deductions and interpretations of useful value, it still leaves unanswered the question which is basic to the whole Julian development, that is, where does the iron formation go at depth?

In that no definitive evidence was gathered in this program which is capable of answering this question, nor in fact can it ever be answered by surface work of the type conducted to date regardless of how extensive or thorough it is, there is no point in indulging in speculations about the problem here. Deep drilling and gravity surveys appear to be the only methods capable of determining the value of the depth extensions of the iron formation below elevation 1000 feet.

Conclusions

The magnetic evidence may reasonably be interpreted to demonstrate that the bottom of the leached and oxidized portion of the Julienne iron formation lies somewhere near elevation 1000 feet and that it is the unoxidized iron formation below this which is responsible for most of the observed induced magnetic anomaly associated with the Julienne iron formation. This body may extend well beyond the area surveyed and it may dip to the north at depth.

The near surface top of the oxidized iron formation is responsible for the magnetic details of the anomaly. Depth calculations based upon these details show that there is an orderly change in the elevation of the top of the iron formation which has been determined for depths of up to around 200 feet. The surface and subsurface expression of the Julienne iron formation has been traced for a distance of about 16, 000 feet. The widths of the iron formation vary from around 2000 feet west of 9000E to about 2800 feet east of 10, 000E. The magnetically high ridges within the anomalous zone apparently correspond with stratigraphic horizons which are predominately specular hematite.

The sounding and other evidence suggests that there is a deep glacially scowered channel north of and parallel with the Julienne iron formation which probably marks the presence of some soft rock unit. Another channel occurs in the southeast arm of Julienne Lake although in this case the channel parallels the geologic structures of the gneissic rocks.

There are piles of glacial debris occurring as a shelf like deposit surrounding all bodies of land and the Julienne Hill. These shelves of debris are relatively flat between elevations 1680 and about 1750. Their bottoms depend upon the rock configuration but depths of debris of up to 200 feet are known.

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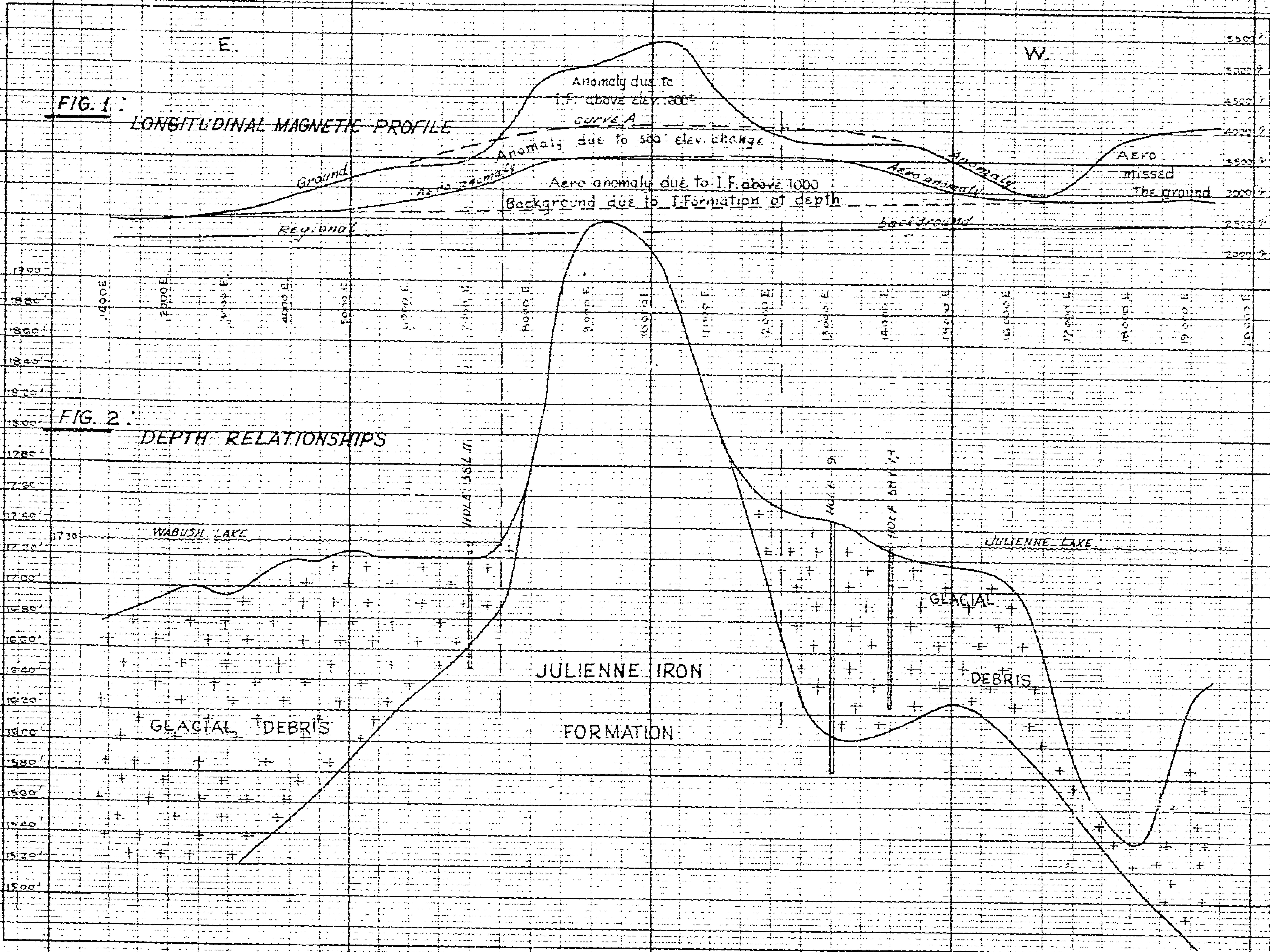
FIG. 1.: LONGITUDINAL MAGNETIC PROFILE

FIG. 2.: DEPTH RELATIONSHIPS



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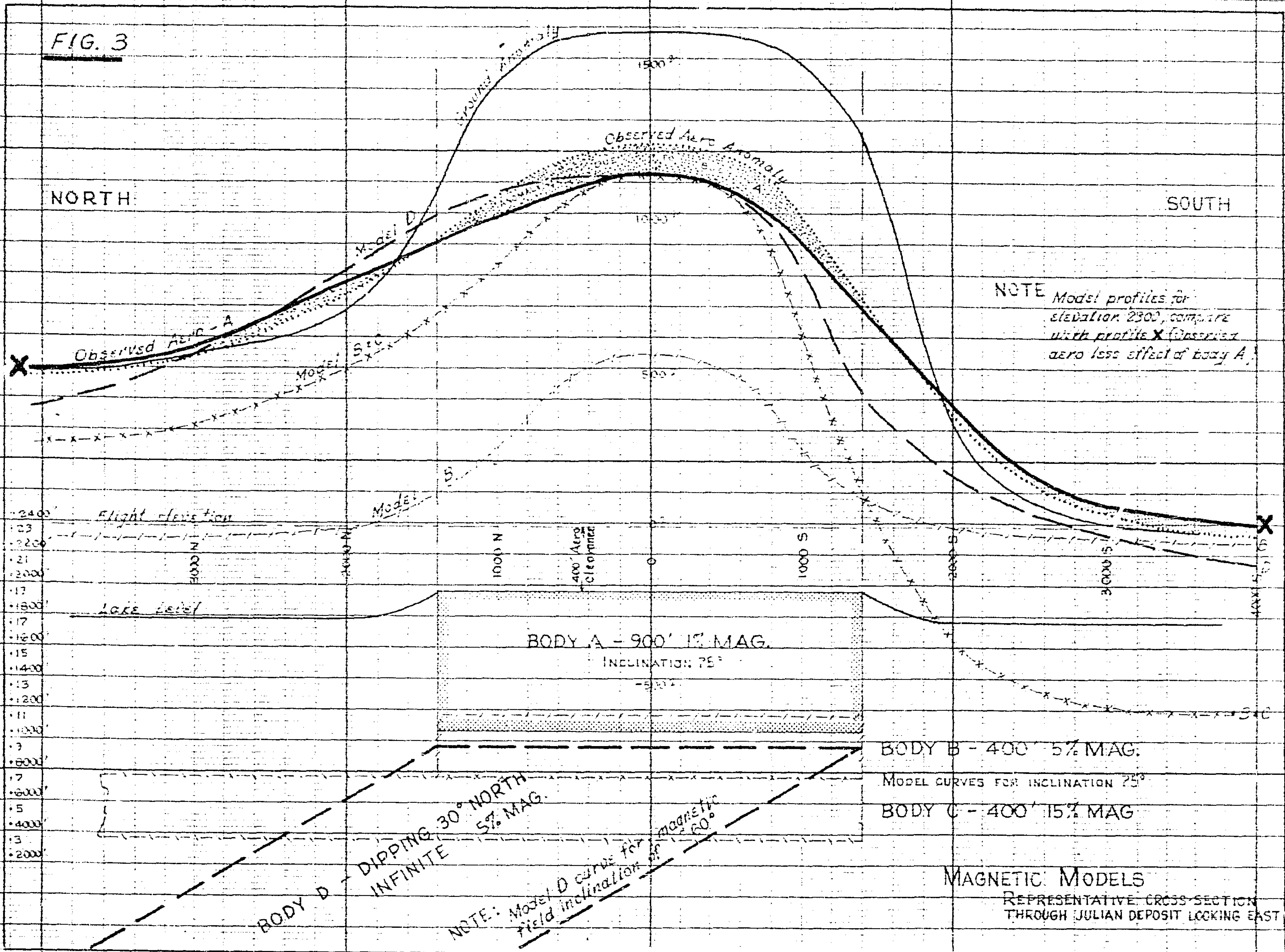

FIG. 4

JULIAN IRON CORP.

JULIAN AREA
GLACIAL TOPOGRAPHY

SCALE 1:40,000	DATE MAY 1963	No. 595
DWG	APP	FILE No.

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