SOUTH DAKOTA

STATE GEOLOGICAL SURVEY

E. P. Rothrock, State Geologist

REPORT OF INVESTIGATIONS

No. 33

A MAGNETIC SURVEY OF SOUTH-CENTRAL SOUTH DAKOTA

GEOPHYSICS
W. H. Jordan

GEOLOGY
E.P.Rothrock

University of South Dakota
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A MAGNETIC SURVEY

OF

SOUTH-CENTRAL SOUTH DAKOTA

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W. H. Jordan, physicist

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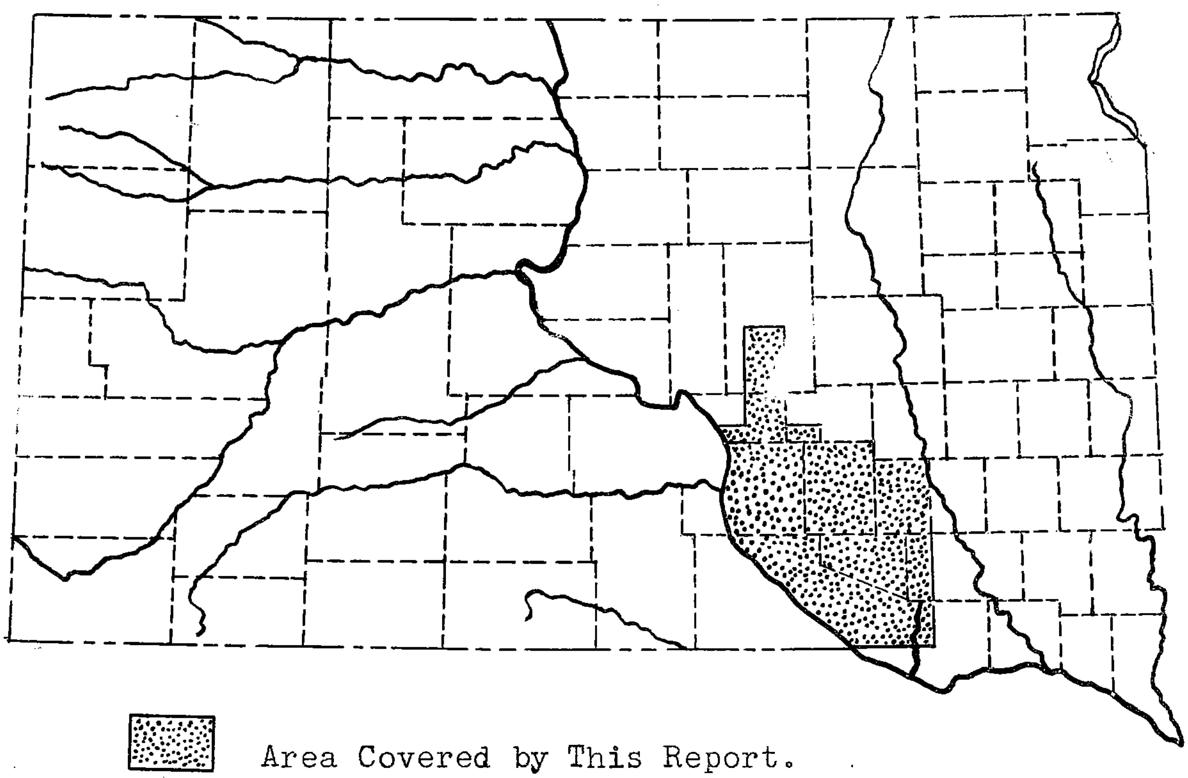


Area Covered by This Report.

INTRODUCTION

The hope that oil might be produced from South Dakota dates back to the early days of the oil industry. Attempts to find it, however, have been baffled by the lack of geological information to guide the prospector and driller. Not the least important has been the lack of data on regional structure. The recent success of the so-called basin drilling in other parts of the United States has revived a demand for such information and the Geological Survey has attempted to supply it.

A major difficulty in accumulating such data is the lack of rock exposures over so much of the State and the meagreness of good well records. The points where information could be obtained were widely separated and only the barest outline of the regional structure could be reconstructed. West of the Missouri River rock outcrops occur only in the deepest of the valleys while east of it a mantle of glacial drift conceals nearly all the bed rock.

The development of geophysical methods has offered a chance to obtain physical data, however, which if interpreted into geological terms might act as a guide to the driller. The work described in this report, therefore, is the first attempt to obtain data of this sort. Of the several possible methods of geophysical prospecting the magnetometer was chosen because it offered a means of covering a large area rapidly thus making it possible to outline the larger structural features rapidly and with sufficient accuracy for the purpose at hand. As explained later in this report, the magnetometer is affected by rocks of the pre-Cambrian group. The nearer these rocks lie to the surface the greater will be the magnetic pull. Since these rocks form the foundation on which all possible oil bearing strata lie, the mapping of their surface is, in effect, a mapping of the basin in which the sediments to be tested lie, and thus offers a guide for the prospector and driller.

It has been known for a long time that pre-Cambrian rocks come to the surface in a long ridge lying between Sioux Falls and Mitchell. West of Mitchell they plunge beneath the younger rocks and glacial drift and are lost to sight. The younger rocks are known to overlap on the sides of this ridge, completely filling the basin so that there are no indications of it in the topography.

The survey was started near Mitchell and continued over an area large enough to cover the top of this ridge, outline its westward extension and indicate the position and general shapes of the basins to the north and south of it. Smaller irregularities in the basin are also reflected in the magnetometer readings.

With this information available it is possible for the oil operator to select the regions where he wishes to do further prospecting with such instruments as the seismograph, gravimeter, or resistivity machine, or test with a core drill.

No attempt was made to choose drilling sites, the entire survey being designed to show regions which might be favorable for detailed prospecting.

AREA OF SURVEY

The region covered in the present survey is shown in the index map. The total area covered is about 3,300 square miles, including most or all of Davison, Aurora, Brule, and Douglas counties, over half of Buffalo and Charles Mix counties, and a portion of Hand County. A few stations were located in Jerauld, Hutchinson and Bon Homme counties.

The plan of the survey was to cover as completely as possible the country between the James and Missouri rivers south of U. S. Highway 16 which roughly follows the parallel between Mitchell and Chamberlain. In order to obtain data on the northern edge of the ridge, however, a profile six miles wide was run northward from this block as far as the city of Miller thus giving a double line of stations through the middle of Hand County.

The field work was done during the months of July and August, 1939. The senior author made the observations, assisted by Mr. Joe Slouber whose able and enthusiastic help was an important factor in bringing the survey to a successful conclusion.

THEORY OF MAGNETIC SURVEYS

It is well known that if a piece of magnetic material is placed in a magnetic field the field will be concentrated in the region of the magnetic material. For example, if a bar of iron is placed in the neighborhood of a magnet, the magnetic lines of force coming from the north pole of the magnet will tend to go toward the nearer end of the iron bar, go through the bar, and out the other end and back to the south pole of the magnet. Hence the lines will be grouped closely together near the ends of the bar and the magnetic field will be relatively strong at those points. The iron bar acts as though it were a better "conductor" of the lines than the surrounding air and the lines seem to take the path of least "resistance."

These facts, with which every student of physics is familiar, are of considerable importance to geology due to two circumstances. First, the earth has a magnetic field around and in it. In many respects the field behaves as though there were a large magnet at the earth's center. Second, the granite and other igneous rocks underlying the sedimentary rocks contain considerable iron and are, therefore, somewhat magnetic. Hence the magnetic lines of force comprising the earth's field tend to follow through these rocks and if these rocks are folded upward into a ridge in any region then the magnetic field will be stronger over the ridge. Thus the presence of the ridge could be detected by measurements on the earth's magnetic field, even though the ridge were buried under thousands of feet of sedimentary rock.

The above explanation can be made somewhat clearer by referring to Figure 1 where a cross section of the earth is shown. The underlying magnetic rocks are shown pushed up near the surface at B, representing a geologic structure. The earth's magnetic field is represented by the sloping arrows called vectors, the direction of the arrows being the direction of the field and the length of the arrows being proportional to the strength of the field. The arrows are shown longer over the top of the structure, indicating that the earth's field is strongest at this point. The vertical arrows, representing the vertical component of the earth's field, must also be longer at this point since they are obtained by drawing a vertical line from the base of each vector to the ground. Thus the

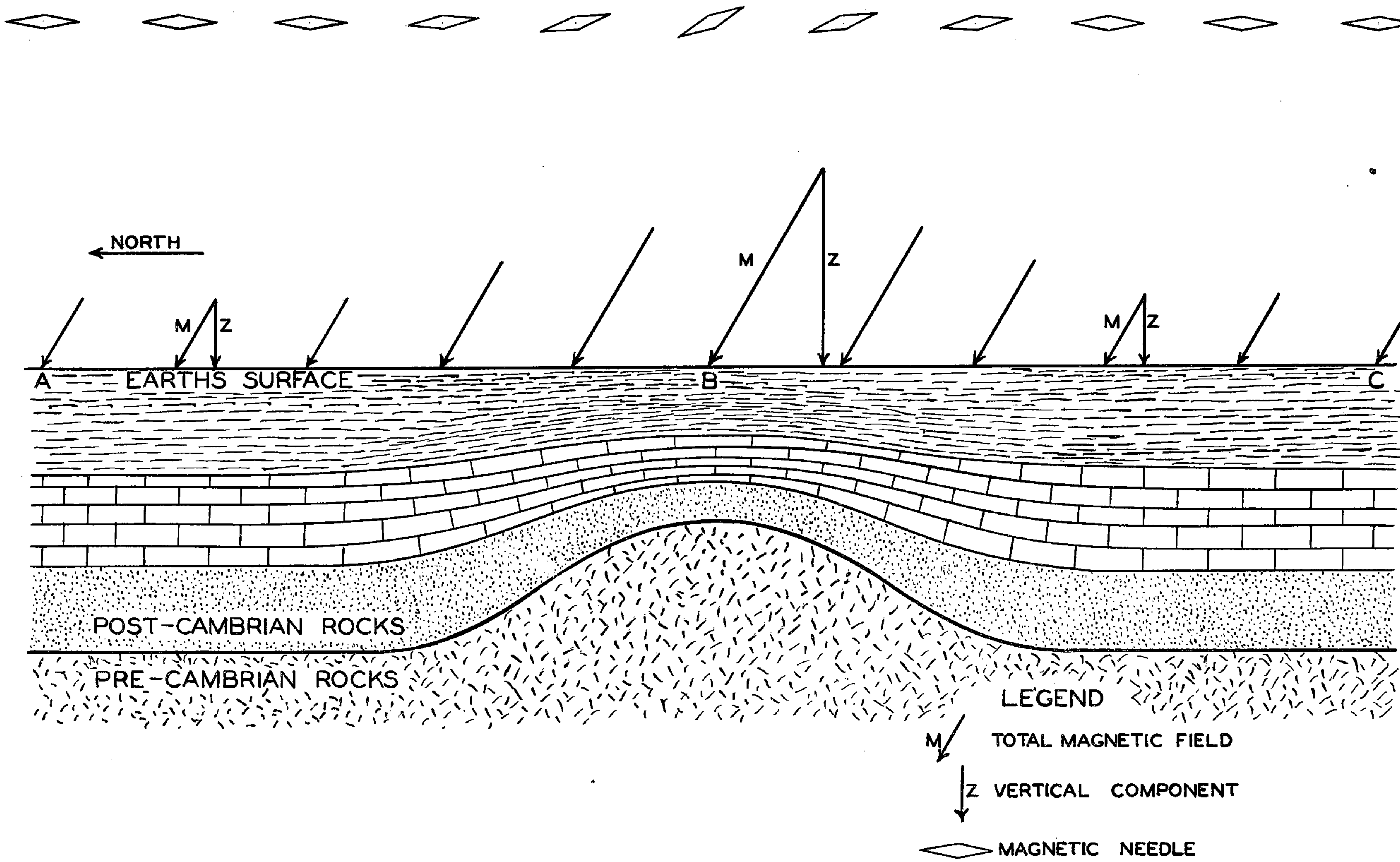


FIGURE 1 MAGNETIC FIELD NEAR GEOLOGIC STRUCTURE

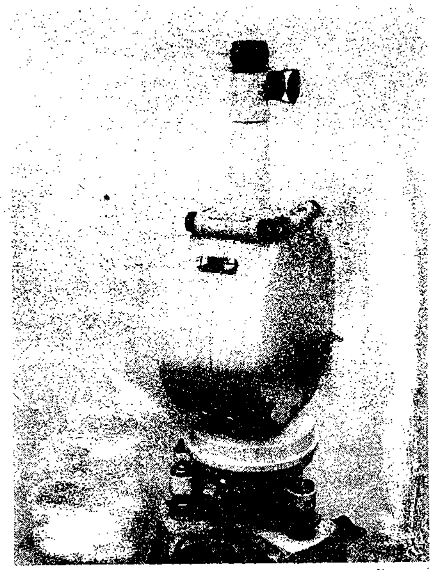
vertical component (z) of the earth's magnetic field is greatest near the top of a geologic structure.

If a magnet were balanced in a horizontal position above point A and carried from there to point C the position it would assume is indicated by the diamond-shaped figures shown in Figure 1. Over the point B it would be displaced from its horizontal position due to the stronger vertical field.

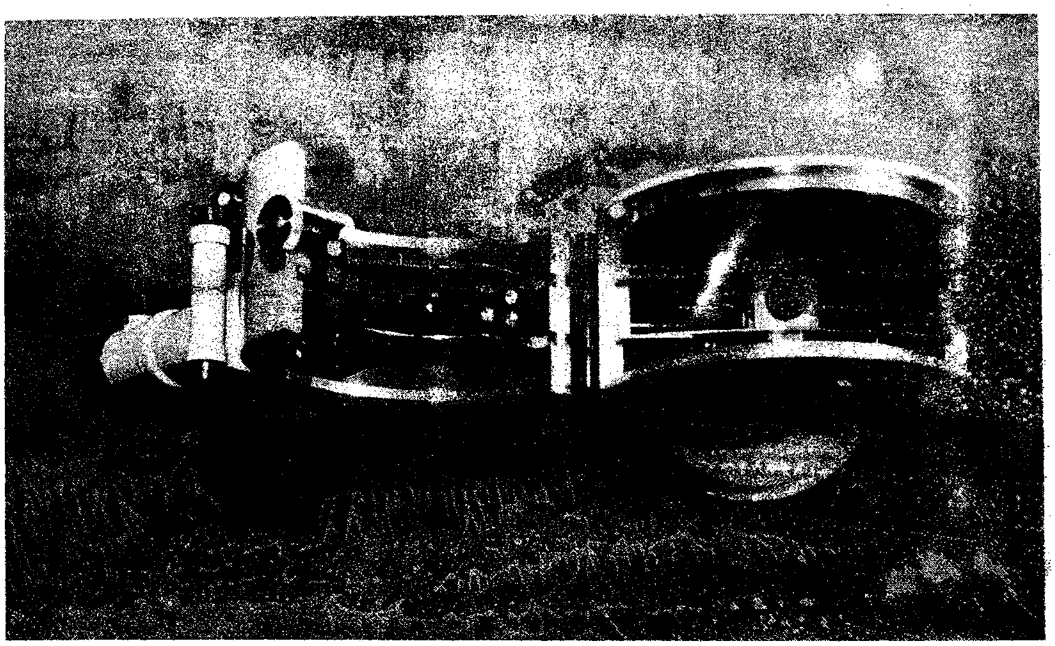
Actually any change in the basement rocks, such as folds or faults, or even changes in chemical composition will be reflected by changes in the earth's magnetic field. Hence, even after the earth's magnetic field has been carefully measured over a region and the anomalies noted, it may still be a difficult problem to decide what sort of geologic structure is producing the anomalies observed. If something about the geology of the region is already known, however, a competent geologist can frequently interpret the results of a magnetic survey in terms of actual geologic structure.

While it would be desirable to have a complete description of the magnetic field at every point, i.e. the direction and intensity, it will usually suffice to know only the vertical component of the earth's field. Since this one quantity can be measured quite accurately and quickly, it was the only one measured in this survey.

THE SCHMIDT TYPE MAGNETOMETER



Magnetometer Mounted on Tripod for Field Use



Magnetometer Case Opened
With Magnetic System in Place

PLATE I

THE MAGNETOMETER

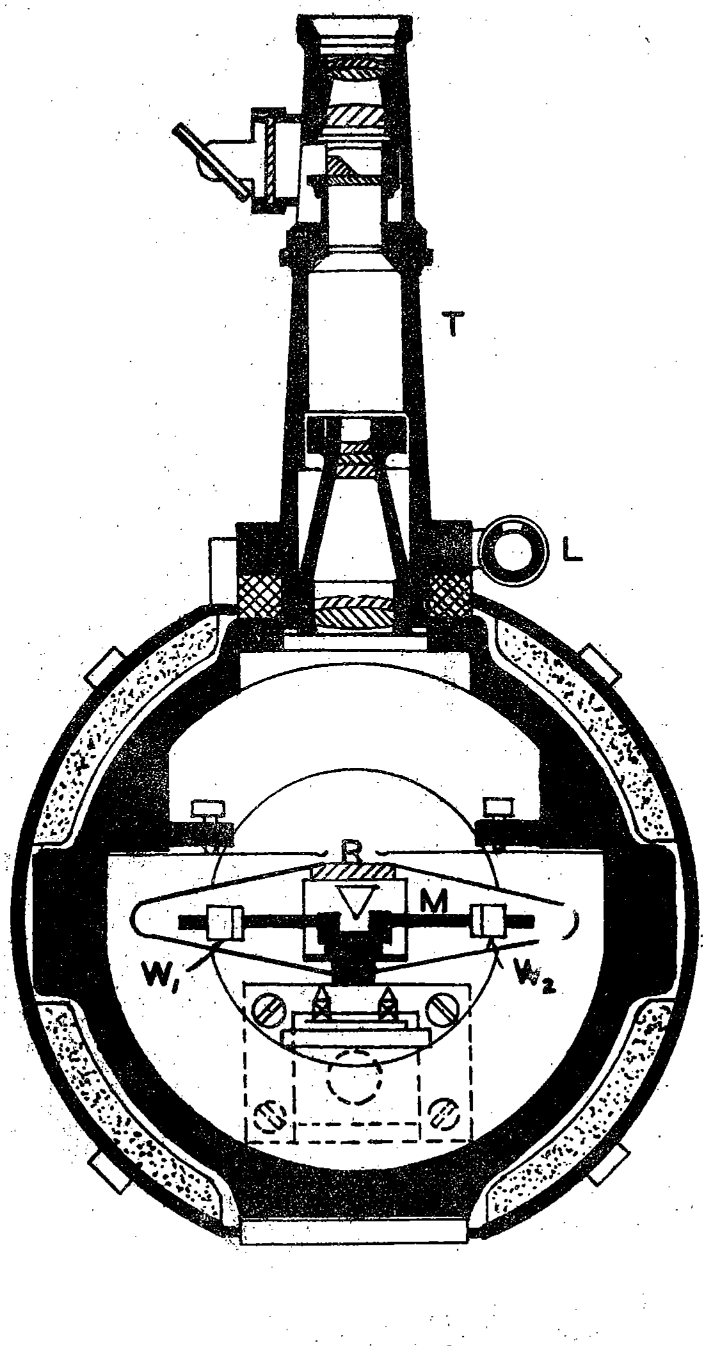
Any instrument suffiбiently sensitive to indicate the changes in vertical intensity from place to place could be used. In this survey a Schmidt type of magnetometer was used. It consists, essentially, of a a magnet M (Figure 2) to which is attached a pair of quartz knife edges which rest on a pair of quartz bearings. Thus the magnet is free to turn about an axis through the knife edges, and since in use this axis is always oriented along the magnetic meridian, only the vertical component of the earth's field is effective in producing rotation. This component tends to rotate the magnet to a vertical position. This is prevented by moving the counterweights W_1 and W_2 until the magnet is just balanced in a horizontal position.

Now if the instrument is moved to another place where the vertical intensity is different the position of balance will be changed slightly. The change in the balance position is observed through the telescope T by the reading of cross-hair and scale, the motion of the cross-hair across the scale being produced by the rotation of the mirror R which is cemented to the magnet. Thus the difference in vertical intensity between magnetometer stations can be readily computed from the constants of the instrument and the observed deflection.

The unit of magnetic intensity used in this work is the gamma which is defined as one-hundred-thousandth of an oersted.[1] One scale division on the instrument used corresponded to a difference of 10.7 gammas. Hence the instrument could be read to an accuracy of about 1 gamma.

1. One oersted is the strength of a magnetic field which exerts one dyne of force on a unit magnetic pole.

SECTIONAL DRAWING OF VERTICAL FIELD BALANCE



LEGEND

M - MAGNETS
R - PLANE MIRROR
W_1 - COUNTERWEIGHT
L - LEVEL
T - TELESCOPE
W_2 - COUNTERWEIGHT

FIGURE 2

PROCEDURE

The magnetometer stations were located at about six mile intervals in a square array. This interval was chosen after considering the area to be covered, the time allotted and the geological detail desired. It was decided at the outset that only the broad, general features of the subsurface topography were desired; that if any regions proved to be particularly interesting it would be surveyed in more detail at a later date. In short, this was to be a regional survey and as large an interval as possible would be selected which would not miss any large features. Actually the six mile interval and square array were not rigidly adhered to, but rather the stations were located so as to be connected by good roads, thereby saving considerable time in traveling between stations.

The differences in vertical intensity between each station and all of its neighboring stations were measured. In the future, this measurement of the difference in intensity between two stations will be spoken of as a "tie". Thus a station inside the network of stations would be "tied" to four other stations so that each "square" in the network was tied on all sides. Since each circuit must "close", this gave us an excellent check on our work as we went along, as well as an increased accuracy to the survey, because the closure errors were later distributed by a least squares calculation.

The actual measurement of the vertical intensity differences between stations is complicated by the fact that the earth's field fluctuates. Changes of 15 gamma in 30 minutes are not uncommon. During magnetic storms the fluctuations were so violent and rapid that work had to be suspended until the storm subsided.

There are two ways of minimizing the errors brought about by these fluctuations. One is to use two magnetometers, keeping one stationary to record the changes with time while the other instrument is moved from station to station. The other way is to return frequently to the initial station and observe the change taken place during the absence. Having but one instrument, we necessarily used the second method.

The procedure actually was as follows. First we would take a reading at station A, then drive to station B for a reading there. After this reading, we would return to station A to see what change had taken place during our absence and then finally go back to station B for a second reading. This last reading would complete the tie A to B and also serve as the first reading on the tie B to C which would be performed in a similar manner.

On quiet days, that is, days when the earth's magnetic field was fairly steady, we occasionally made a tie by taking a reading at A, then at B, and then back to A to complete the tie. This was done when all the ties from station B had already been completed so that if the tie were completed in the usual manner the last reading at B would not have served as the first reading of another tie. Probably not more than ten per cent of the ties made were of this type and these were given a weight of one-half when the closure errors were distributed.

Table I is a reproduction of the data taken on July 25, which is chosen as a representative sample. Column 1 is the number of the station. Column 2 is the time at which the reading was taken. Column 3 is the temperature of the instrument, recorded but not used. Column 4 is the reading with the north pole of the magnet pointing toward magnetic east while column 5 is the reading with the instrument turned through 180 degrees. Column 6 is the average of column 4 and 5 and is taken to be the true reading. The readings in this column are multiplied by 10.7 to convert them from scale divisions to gammas and recorded in column 7.

The method of using this data to find the difference in magnetic intensity is illustrated by the accompanying graph which is drawn for the data in the foregoing table (Figure 3). On this graph the magnetic intensity at each station is plotted as a function of the time. The crosses are the plotted

TABLE I

Log of Readings

Magnetometer Survey

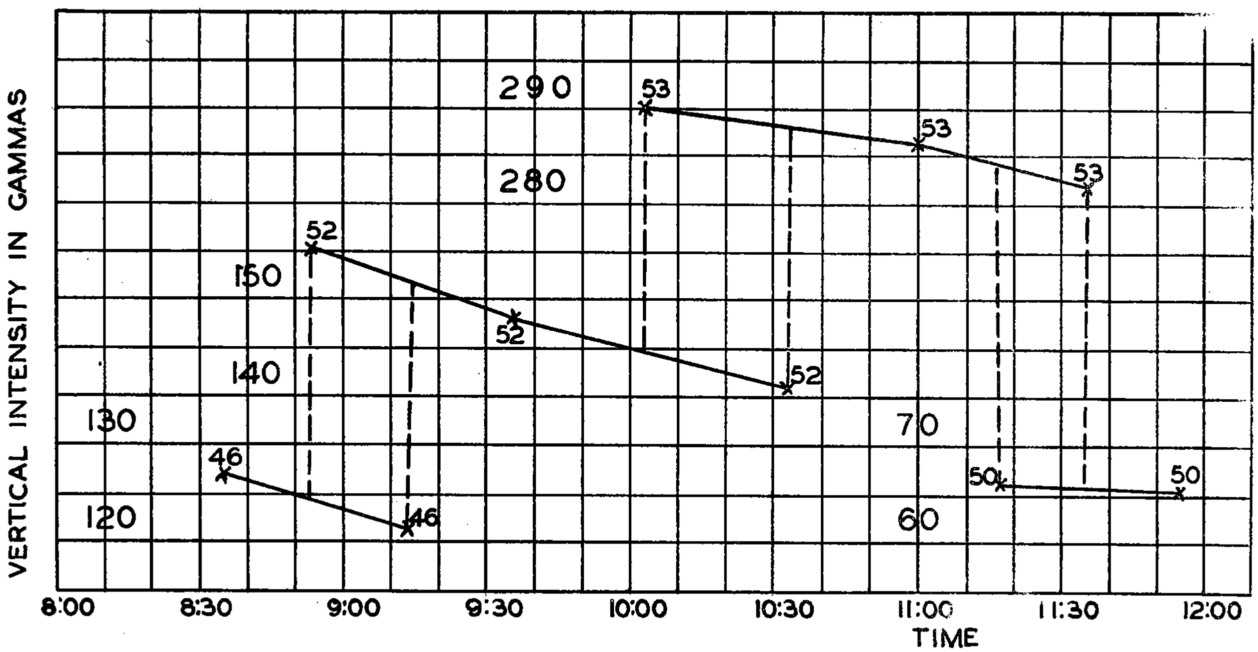
W.H.Jordan
July 25, 1939

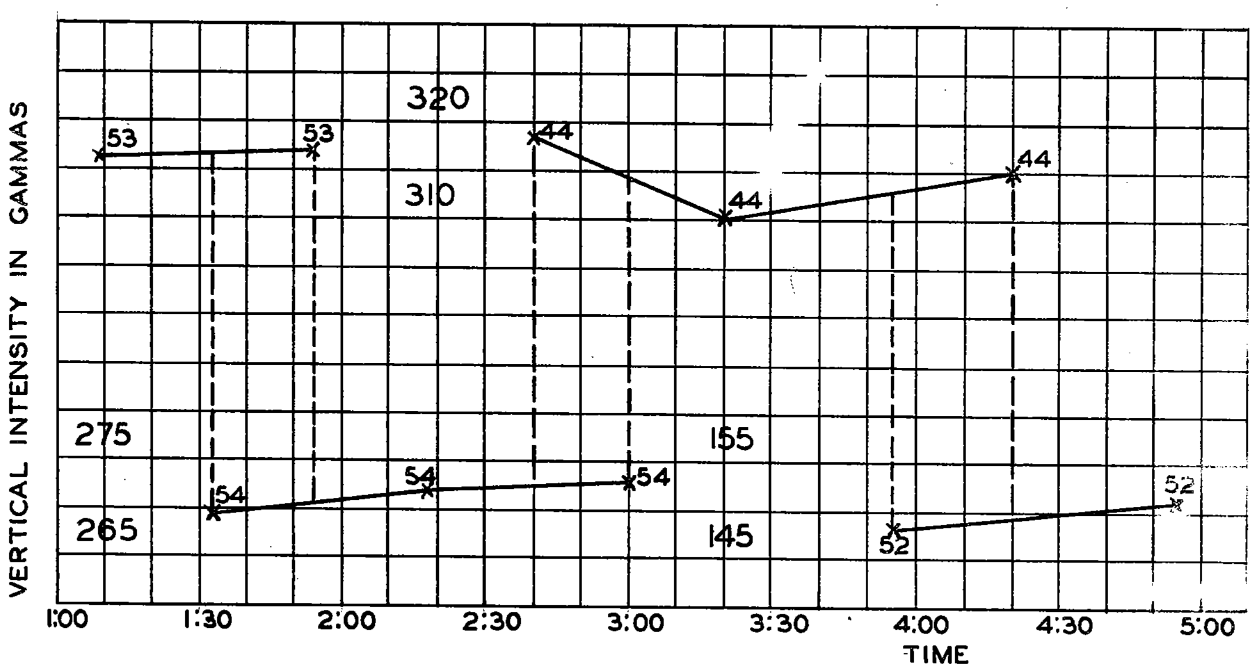
Geddes Vicinity

Scale Value, 10.7

Station No.	Time	Temp	Readings N to E	Readings N to W	Readings Mean	Gamma
46	8:34	21.9	11.9	11.9	11.9	127
52	8:53	24.3	14.6	14.3	14.4½	155
46	9:14	26.3	11.8	10.8	11.3	121
52	9:35	28.2	13.7	13.9	13.8	148
53	10:05	29.7	27.0	27.2	27.1	290
52	10.33	30.8	13.2	13.2	13.2	141
53	11:00	31.7	26.7	26.7	26.7	286
50	11:18	32.1	6.2	6.2	6.2	66
53	11:37	32.8	26.3	26.4	26.3½	282
50	11:55	33.2	6.0	6.2	6.1	65
53	1:12	33.2	26.8	26.6	26.7	286
54	1:33	33.8	25.1	25.1	25.1	269
53	1:55	34.5	27.1	26.4	26.7½	287
54	2:18	35.0	25.7	25.1	25.4	272
44	2:40	35.2	29.8	29.6	29.7	318
54	3:00	35.3	25.7	25.3	25.5	273
44	3:20	35.7	29.0	28.8	28.9	310
52	3:56	36.2	13.8	13.9	13.8½	148
44	4:30	36.4	29.6	29.3	29.4½	315
52	4:55	36:0	14.1	14.2	14.1½	151

METHOD OF CORRECTING FOR DIURNAL MAGNETIC VARIATION





X 53 OBSERVED READING OF STATION INDICATED BY NUMBER

FIGURE 3

UNADJUSTED STATION GRID

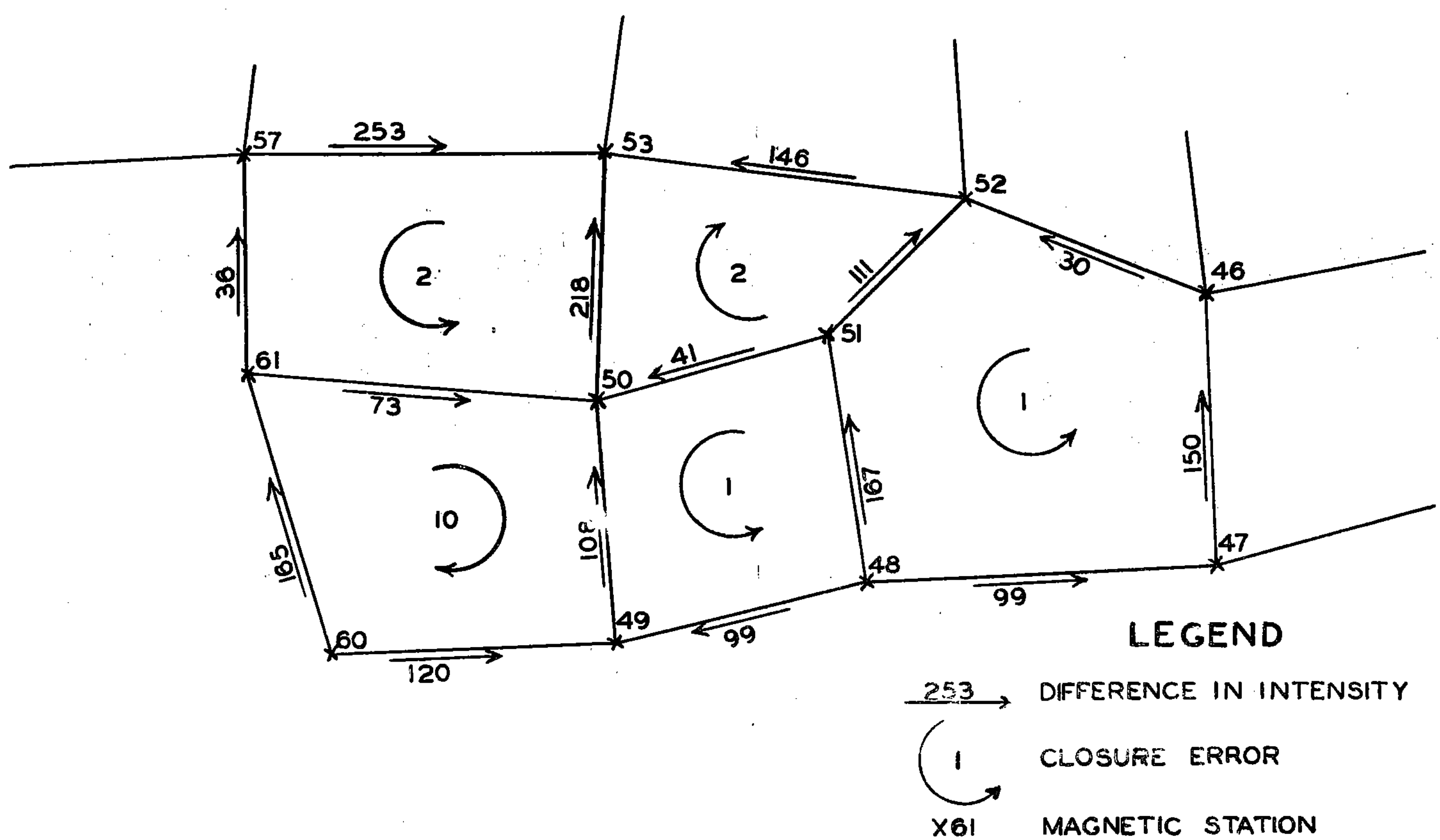


FIGURE 4

ADJUSTED STATION GRID

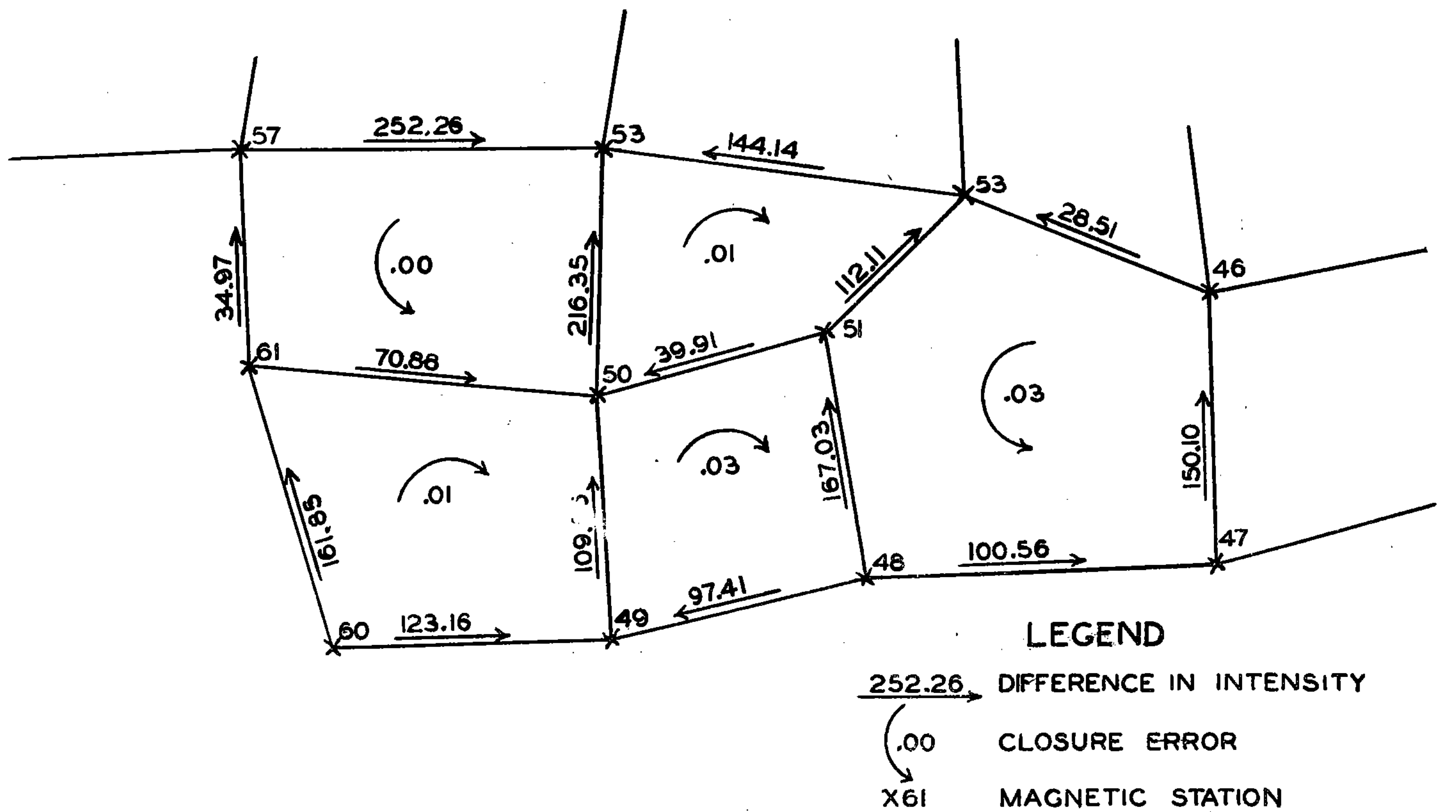


FIGURE 5

points, the small numbers near each cross being the number of the station. The solid lines connecting the crosses represent the value of the intensity at the particular station during the interval between readings, a linear variation with time being assumed. The vertical dotted lines then give the difference in vertical intensity between stations. Thus at 8:53 a.m. the reading at station 52 was 155 gammas, while at the same time the reading at station 46 would have been 124 gammas, assuming a steady change at station 46. The difference is then 155 minus 124 or 31 gammas. Similarly at 9:14 the reading at station 46 was 121 gammas, while the reading at station 52 would have been 151 gammas, the difference now being 151 minus 121 or 30 gammas. From this we conclude that the intensity at station 52 is between 30 and 31 gammas higher than at station 46. Since no attempt was made to achieve accuracy better than one gamma, this would have been recorded as 30 gammas difference.

In this manner the differences in intensity between each station and its neighbors were found. These differences were recorded on a map showing the location of the stations, the numbers being placed along a line connecting the two stations whose difference had been measured. This is shown on the accompanying sketch (Figure 4) which is but a small portion of the total network and is reproduced only for the purpose of clarifying this discussion. The straight arrows alongside the numbers representing the difference in vertical intensity point to the station of higher intensity. The curved arrows show the direction of the closure error, the amount shown inside the arrow being obtained by adding the differences around the circuit. The method of distributing the closure errors by the method of least squares will not be discussed here save to say that it involves setting up a set of simultaneous equations, one for each circuit, and solving them.[1] In this case, one set of 62 equations was solved. That the circuits will now close is shown in the next figure (Figure 5) which shows the corrected differences in intensity.

Knowing the differences in intensity, the assignment of "magnetic altitudes" to each station was quite easy.

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1. For a discussion of this method see Leland's Practical Least Squares, McGraw-Hill Book Company, 1921.

Station 60 was selected as a base and arbitrarily assigned the value of 500 gammas. From Figure 4 we see that station 49 is 123.16 gammas more than station 60, hence its value is 623.16 or 623 gammas. Station 48, being 97.41 gammas less than station 49, would have a value of 525.75 or 526 gammas. In a like manner the relative magnetic intensity for all of the stations were found.

In addition to the changes in the earth's magnetic field brought about by geological structures there is a steady change in value from the equator to the magnetic poles. In South Dakota this amounts to an increase in vertical intensity of about 8.7 gamma for every mile that one goes toward the North and about 3.6 gamma for every mile that one goes toward the East. For example, since station 49 is six miles due east of station 60 we should normally expect an increase of 3.6 x 6 or about 22 gammas. The amount of correction for latitude and longitude was found for every station and the amount subtracted from the true relative intensities as found in the previous paragraph. These corrected relative intensities are listed for each station.in Table II which follows.

The stations were located on a map of the region and the corrected relative intensity of each station indicated. Contour lines were then drawn through points of equal vertical intensity. The result is shown on the large magnetic map at the nd of this report.

RESULTS

The anomalies encountered in this survey are fairly large, the total relief being nearly 1500 gamma. The lowest reading, 65 gamma, was obtained at station 86 located South-East of Gann Valley. The highest reading, 1530 gamma, was obtained just West of Parkston. The highest gradient observed was between station 109 and 110 which are located very near the line between Hand and Buffalo counties, the gradient there being 130 gamma per mile.

Perhaps the most interesting feature shown on the accompanying magnetic map is the magnetic ridge extending due East from Parkston to Platte. The crest of the ridge dips only slightly between Corsica and Platte with the flanks dipping sharply to the North and the South. At Platte the ridge swings North-East toward Chamberlain. The ridge is less well defined in this region since the crest is dipping toward the Northeast.

The next most prominent high occurs about on the line between Buffalo and Hand counties. The magnetic gradient here makes this anomaly particularly interesting and we hope to investigate it further next summer.

Two other magnetic highs are large enough to deserve particular mention. One is centered near Red Lake and the other just North of Geddes. Each occurs near the crest of the ridge previously mentioned. Two smaller highs occur in the southern part of Aurora County with a valley projecting southward between them.

TABLE II

Location of Stations
and
Magnetic Intensities

Station	Range	Township	Section	Corner	Corrected Interval
1	59	102	6	NW	494
2	60	102	36	SE	769
3	59	101	31	SW	1032
4	60	99	9	NW	1349
5	60	98	9	NW	1368
6	60	97	4	SW	765
7	60	96	5	SE	475
8	59	104	31	SW	466
9	60	104	1	NE	379
10	61	103	22	SW	327
11	62	103	20	SW	367
12	63	103	19	NW	219
13	64	102	13	NE	309
14	64	102	36	SW	745
15	63	101	31	SW	624
16	64	99	16	SW	713
17	63	98	30	SW	769
18	63	97	30	NW	653
19	62	97	30	NE	715
20	61	97	29	NE	720
21	61	104	14	SW	436
22	61	102	22	NW	588
23	61	101	9	SE	790
24	61	100	15	SE	971

Station	Range	Township	Section	Corner	Corrected Interval
25	62	99	14	SW	1026
26	61	99	15	SE	1530
27	61	100	15	SE	1330
28	62	101	5	NW	466
29	62	104	16	SE	272
30	63	104	14	SW	119
31	62	101	16	SE	558
32	63	100	19	NE	682
33	62	100	16	SW	784
34	63	99	13	SE	860
35	61	98	26	SW	1083
36	62	98	23	SW	859
37	63	98	25	SE	812
38	63	99	18	SE	778
39	64	96	24	NE	546
40	63	95	23	NE	465
41	62	96	18	SE	622
42	61	96	20	N	585
43	65	100	21	NE	605
44	65	99	14	SW	783
45	65	98	6	NE	684
46	65	98	36	SE	649
47	65	97	36	SE	551
48	66	96	2	NE	475
49	67	96	1	SE	601
50	67	97	13	NE	667

Station	Range	Township	Section	Corner	Corrected Interval
51	66	97	4	SE	603
52	65	98	19	SE	678
53	67	98	13	SE	840
54	66	99	17	SW	770
55	66	100	12	NW of NE¼	497
56	67	100	12	NW of NE¼	504
57	68	98	13	SW	614
58	68	100	11	NE	535
59	68	99	13	SE	755
60	67	96	7	NW	500
61	67	97	11	NE	614
62	68	98	15	SE	515
63	67	99	30	NW	723
64	69	99	20	SW	470
65	69	100	19	SW	467
66	69	101	16	NE	380
67	66	101	14	SW	555
68	69	100	24	SE	547
69	70	100	18	NW	341
70	66	101	2	NW	618
71	65	101	3	NE	251
72	65	102	10	NE	184
73	66	102	10	NE	331
74	66	103	10	SW	254
75	65	103	11	SW	90

Station	Range	Township	Section	~~Corner~~	Corrected Interval
76	67	101	3	NW	514
77	67	103	10	SW	494
78	67	102	10	NW	372
79	68	102	22	NE	580
80	68	103	14	SW	402
81	69	102	22	NE	526
82	69	103	14	NW	284
83	68	104	4	NE	344
84	67	104	3	NW	164
85	68	105	4	NE	199
86	67	105	3	NE	65
87	70	104	27	SE	388
88	71	104	27	SE	288
89	71	103	23	SW	355
90	70	103	26	NE	654
91	71	102	14	SW	275
92	70	102	14	SE	384
93	70	101	10	NE	273
94	71	100	17	NE	261
95	71	105	36	SW	396
96	71	105	1	NW	238
97	71	106	3	NW	485
98	70	106	8	SE	409
99	70	106	35	NE	354
100	70	105	26	SE	408

Station	Range	Township	Section	Corner	Corrected Interval
101	69	104	9	NE	168
102	69	106	34	NE	254
103	67	106	12	NW	128
104	69	107	26	SW	133
105	68	106	3	SW	186
106	67	107	13	NW	235
107	69	108	34	SW	101
108	68	107	9	SE	155
109	68	108	4	SE	849
110	69	108	10	NE	196
111	68	109	3	SE	585
112	68	110	10	NE	696
113	68	111	2	SW	342
114	68	112	12	NW	135
115	69	109	2	SE	672
116	69	110	1	SW	434
117	69	111	11	NE	435
118	69	112	2	SE	352

GEOLOGIC INTERPRETATION

Though it is always unwise to draw geological conclusions dogmatically from magnetic data, especially in regions where so little is known of the subsurface stratigraphy, the data obtained on this survey is sufficiently clear to warrant the following deductions:

1. The pre-Cambrian ridge between Sioux Falls and Mitchell extends westward at least as far as Chamberlain.

2. The pre-Cambrian surface slopes rapidly from this axis into basins north and south of the ridge, allowing the overlap of post-Cambrian strata from at least the late Paleozoic through the Cretaceous systems.

3. The surface of the pre-Cambrian is not a smooth plain but contains elevations and depressions which could be reflected as structures in the overlying rock.

The survey was started at Mitchell because the westernmost outcrops of pre-Cambrian occur in the James Valley five or six miles south of that city. Examination of pre-Cambrian rocks showed them to be more highly magnetic than most post-Cambrian sediments. They are also known to be intruded in various places with granite and various other igneous rocks all of which are more highly magnetic than most post-Cambrian sediments. Thus, unless disturbed by highly magnetic sediments such as magnetite sands, which do not appear to exist, the magnetic intensities should be a record of the deflection of the earth's magnetic lines of force by the pre-Cambrian rocks and the magnetic map can be interpreted as an indication of the irregularities in the pre-Cambrian surface. High intensity means that it is near the surface and low means that it is more deeply buried.

A line of high readings between Parkston and Platte indicates the crest of the ridge. From this crest the magnetic intensities decline to the north and to the south, indicating a persistent slope in both directions. At Platte the line of high readings turns sharply toward the northwest and continues to Chamberlain. It is not known what becomes of the ridge across the Missouri River as the survey was not carried that far.

The continuation of the ridge to the west is of particular interest since there has been some tendency to consider it as the northward end of the Nemaha ridge--a similar structure in eastern Kansas. The east-west trend of the South Dakota ridge suggests that it is genetically connected with the pre-Cambrian structures of Wisconsin and Minnesota rather than with the one to the south.

The readings along the crest diminish from 1400 gamma near the outcrop at Parkston to 600 gamma near Chamberlain. This corresponds with the information obtained from artesian wells to the effect that the crest of the ridge plunges westward. It has not been reached in well drilling at a depth of 983 feet at Chamberlain and probably lies at two or three times that depth below the surface.

The pre-Cambrian ridge is the dominant feature in the area covered. Another interesting feature, however, appeared at the northern end of the area mapped in southern Hand County where a very sharp dip southward seems to indicate a secondary ridge, separated from the main ridge by a deep structural trough. The readings on this northern ridge are fully as high as those on the main ridge near Chamberlain indicating that the "granite" must be about the same distance below the surface. Unfortunately the field season did not allow following the second ridge but enough was mapped to show that it is an important feature.

Smaller knobs or magnetic "highs" such as those between Chamberlain and Kimball, south of White Lake and Plankinton, and between Platte and Geddes may represent intrusions of highly magnetic volcanic rock or hills in the pre-Cambrian surface. The latter would seem to be a more plausible interpretation since that condition exists farther east where the quartzite surface can be studied from outcrops and shallow wells. Buried hills of this type have been of considerable importance in the accumulation of some oil fields, due to the fact that the younger sediments tended to settle over the tops of these hills making structural domes in which oil could be trapped. Near the pre-Cambrian outcrops such structures would be of little significance but where deeply buried they are worth investigation.

Let it be emphatically stated that the magnetometer is not an oil finding instrument. Unfortunately no such contrivance has been invented, though many attempts have been made. The best that magnetic readings or any other geophysical method can do is indicate areas in which structural conditions prevail which would permit accumulation of oil and gas if the necessary source and reservoir rocks are present in the section. Since strata which could act as source and reservoir rocks do occur in the South Dakota section, these magnetometer "highs" offer interesting places for prospecting where the pre-Cambrian surface is sufficiently buried.

In summary, this survey has outlined a portion of the divide between a large basin to the south and east in Iowa and Nebraska and one to the north and west in our own state. Sedimentary rocks have accumulated in both basins which have made them interesting as both oil and water prospects. Whether the irregularities mentioned above or the pinching out of sands and other formations at the edge of the basins can cause accumulations of oil and gas remains to be proven by drilling. It is hoped that as stratigraphic data is accumulated the results of this investigation will be of increasing value in reducing the chances of failure by indicating the more favorable prospecting areas.