NORTH DAKOTA GEOLOGICAL SURVEY
WILSON M. LAIRD, Director

Report of Investigations 9

Geomagnetic Survey Benson and Ramsey Counties North Dakota

by
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GEOMAGNETIC SURVEY OF PORTIONS OF BENSON AND RAMSEY COUNTIES NORTH DAKOTA

Introduction

During 1952, part of the program of the North Dakota State Geological Survey consisted of a geomagnetic survey in the vicinity of Devils Lake, North Dakota.

The survey of parts of Benson and Ramsey counties herein described includes Ranges 64 through 68 West and Townships 152 through 156 North, plus small portions of adjoining townships to the south and east. The total area of the survey is approximately twenty-five townships. The adjoining area to the west was surveyed during the same field season by Harold C. Haraldson, Geologist, of the North Dakota Geological Survey.

The work was undertaken in an attempt to provide magnetic information on the subsurface structure of the bed rock in the eastern part of the Williston Basin. This program was begun in 1951 and the results of the first investigation have been published in the North Dakota Geological Survey Report of Investigations No. 6 by N. N. Kohanowski. This study includes a magnetic map of Rolette and Towner counties, North Dakota. Efforts to tie the Benson and Ramsey counties map done by the writer, to that of Rolette and Towner counties studied by Mr. Kohanowski, were not so successful as could be desired, probably due to the differences in the instruments used in the two areas.

The area surveyed is almost entirely covered by glacial material. This consists chiefly of ground moraine in the northern part and end moraines, glacial outwash and lake beds in the southern part. The Pierre shale[1] underlies the drift everywhere in the area. There are a few exposures of Pierre shale on the south shore of Devils Lake north of Fort Totten, and along some of the watercourses to the south of the latter town.

The topography varies from the moderately rolling areas of low relief in the north to the low hills composed of drift mantled Pierre shale and end moraines in the south. The surface geology of the greater portion of the area surveyed is shown on the Preliminary Geologic Map of North Dakota published by the North Dakota Geological Survey in 1952. County road maps, prepared by the North Dakota Department of State Highways, were used for the base map.

Instruments, Adjustments and Calibrations

Through the courtesy of Mr. L. J. Peters of the Gulf Research and Development Company of Pittsburgh, Pennsylvania, a Gulf vertical component magnetometer with auxiliary magnets was used in making observations. Although this instrument is temperature compensated, a temperature correction curve was determined and found to be just under 1 gamma per degree. The instrument was calibrated by means of a Helmholtz coil before field work was begun. It was necessary to make another latitude adjustment at the main base point near Maza (NE corner, Section 1, T. 156N., R. 67W.) after which the instrument was re-calibrated by using the Helmholtz coil.

The scale values determined were 78.1 and 73.0 gammas per scale division. These values were obtained by using a heavier sensitivity weight than provided with the magnetometer in order to approach the sensitivity of the instrument used in the magnetometer survey of 1951. In the North Dakota Geological Survey's Report of Investigations No. 6, 1951, page 1, it is stated that the sensitivity of the instrument was maintained at from 86 to 91 gammas per scale division.

Instrument Data

Temperature correction—1 Gamma per degree centigrade
Scale Value
July 3—August 5, 1952 78.1 Gammas per scale division
August 5—Sept. 6, 1952 73.0 Gammas per scale division
The difference in the values between 73.0 and 78.1 Gammas per scale division was due to replacing the first sensitivity weight which had been borrowed from another instrument.

Plan of Survey

Where possible, observations were made at all township corners and at each mile in between them. Where the road-net did not correspond to the township lines, observation loops were set up to conform to the township boundaries as closely as possible.

Latitude adjustment and scale value determinations were made at the main base point at the NE corner of Section 1, T. 156N., R. 67W., near Maza.

Field Procedure

Procedures outlined on pages 118-158 in *Exploration Geophysics*, Second Edition, by J. J. Jakosky were employed in doing field work. Diurnal corrections were applied to every line of observation. The method used in making base station checks is as follows. After taking the first reading at township corner "A" and successive readings one mile apart to township corner "B", the instrument was returned to the starting point "A" where another reading was obtained. The next line of observations was started at "B", successive readings made at each mile to township corner "C" and the sub-base check reading obtained at "B". Thus four lines of observations were made to complete the traverse around one township.

Auxiliary magnet corrections were made as follows. At station "A" where the reading was so high as to make it evident that further increase in intensity would pull the scale of the instrument out of view, two reading were made, one with and one without the magnet. The difference between the two readings was recorded, and readings at successive stations were made with the magnet in the same position until a station "B" was reached where it was evident that the magnet was not needed. At this station as at "A" two readings were made, one with and one without the magnet. In this procedure it will be found that the difference between the two readings taken at "A" will not correspond exactly to the difference between the two at "B". The average of the differences is taken as the correction to be applied (added in this example) to all readings taken with the magnet in place.

Corrections for latitude and longitude were computed from the chart "Lines of Equal Vertical Intensity for 1945, United States", which is found in the U. S. Department of Commerce publication, "United States Magnetic Tables and Magnetic Charts for 1945", Serial 667. The latitude correction was found to be 10 gammas per mile and the longitude correction 3 gammas per mile.

Interpretation

Much has been written concerning the combined effect of the numerous and variable factors in the subsurface which give rise to magnetic anomalies. A brief discussion by Lahee[2] illustrates the inconsistencies to be expected in interpretation of the relationship between anomalies and subsurface structure.

"Interpretation of magnetic anomalies for their geologic meaning, is, however, by no means simple. In some places a distinct relationship has been demonstrated; but elsewhere very pronounced magnetic anomalies have not been correlated with known lithologic or structural features down to drilled depths of several thousand feet. In such cases the effects mapped may be from very deep-lying causes, not reached in the drilling. In wide areas the anomalies are so slight that although unquestionably they reflect definite conditions, they cannot safely be interpreted. In all magnetometer work, perhaps more than in any other class of geophysical surveying, one must keep firmly in mind that the net intensities may, and probably do, represent the resultants of many effects, from shallow depths and from greater depths, all combined in a manner to make their correct interpretation difficult. An irregular distribution of magnetite in a sandstone a few feet, or a few hundred feet, below the surface of the ground may alter or mask the effects of a large deep seated body."

Discussion of Results

Subsurface Control*

The Carter Oil Company's No. 1 McDiarmid well (Completed December 1, 1952) was drilled in NE NE 16, T. 154N., R. 65W., six miles east of the approximate center of the area, to a total depth of 3745 feet in granite. The elevation of the Pre-Cambrian surface is -2269 feet. This elevation corresponds closely to the elevation of the Pre-Cambrian in the F. H. Rhodes No. 1 R. R. Gibbens well about seventeen miles north of the McDiarmid well, in SW SE 17, T. 157N., R. 65W., (completed November 7, 1952) where the Pre-Cambrian surface elevation is -2272 feet.

About eighteen miles southeast of the McDiarmid well, the Northern Natural Gas Company's No. 1 Raymond Lee, NE NE 36, T. 154N., R. 63W., (completed January 17, 1953) bottomed in granite at an elevation of -1756.

About 23 miles north-northwest of the McDiarmid well the Wakefield Drilling Company's No. 1 E. L. Hild in SE SW 31, T. 158N., R. 66W., was completed December 13 1952. Here the Pre-Cambrian surface is at an elevation of -2583 feet.

Therefore the top of the Pre-Cambrian lies 300 feet lower 23 miles north-northwest of the McDiarmid well and 500 feet higher 18 miles to the southeast. From this evidence it appears that the Pre-Cambrian surface dips to the west at an average rate of less than 50 feet per mile.

If the anomalies shown on the central strip of the map were due to the glacial drift which is present everywhere in the area, or to Post-Pre-Cambrian sediments, it seems reasonable to assume that the magnetic contours would be more regular with fewer abrupt changes over an area of this extent.

It has already been observed that Pierre shale underlies the drift everywhere in the area. West of Fort Totten in an area of recessional moraines[3] there is a 1400 gamma anomaly. East of Fort Totten a line of observations crosses outwash and recessional moraines[4] on higher ground and observations recorded show little variation in vertical intensity. Thus it is suggested that the glacial drift and the Pierre shale do not exert appreciable influence on the magnetometer observation in this area. If any of the anomalies were due to concentrations of magnetic minerals in lake sediments, such features should show up on the line of observations east of Minnewaukan, which crosses the dry lake bed. Lacking better evidence the anomalies are considered to be due to the influence of the Pre-Cambrian rocks or small intrusives in the Pre-Cambrian.

The 500 gamma anomaly east of Maza at the north edge of the map appears as a high point on a low but pronounced Pre-Cambrian ridge which extends south-southwest to an 1100 gamma anomaly west of Ramsey. The ridge becomes narrower south of Ramsey until it reaches the 1400 gamma anomaly west of Fort Totten. The 100 gamma low around Leeds in the northwest corner of the map can probably be discounted as due to industrial disturbances. The line of observations which includes the 100 gamma high near Essex cannot be given too much credence since it was not tied back in to the rest of the survey.

Conclusions

It is considered good practice to compare results of the magnetometer method with other results from the same area such as a torsion balance or a gravimeter survey. Lacking an alternate means to check the magnetometer method, the value of any recommendation is doubtful. Magnetic anomalies associated with known structures have varied from as little as 30 gammas up to 600 gammas or more. In view of this, there are several locations within the limits of the survey that are worthy of more detailed geophysical consideration.

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[1] Simpson, H. E., "The Physiography of the Devils-Stump Lake Region, North Dakota," North Dakota Geological Survey 6th Biennial Report, pp. 125-126, 1912.

[2] Lahee, F. H., Field Geology, 5th Edition, pp. 760-762. McGraw-Hill Book Company, 1952.

[3] Tetrick, P. R., "Glacial Geology of the Oberon Quadrangle," North Dakota Geological Survey, Bull. 23, Plates I and II, 1949.

[4] Easker, D. G., "Geology of the Tokio Quadrangle," North Dakota Geological Survey Bulletin 24, Plates I and II, 1949.

* All well data from Petroleum Information, Rocky Mountain Report.

R 68 W R 67 W R 66 W R 65 W R 64 W

T 156 N T 155 N T 154 N T 153 N T 152 N

MAZA GARSKE LEEDS NILES WEBSTER CHURCHS FERRY PENN BRINSMADE GRAND HARBOR TILDEN RAMSEY COMSTOCK DEVILS LAKE ESSEX BENSON COUNTY RAMSEY COUNTY KEITH MINNEWAUKAN DRY LAKE BED LALLIE FORT TOTTEN FLORA JOSEPHINE OBERON TOKIO

5100 5200 5300 5400 5600 6000 6200 5800 6600 6661

BY MILLER HANSEN, 1953

GEO-MAGNETIC MAP

PORTIONS OF BENSON AND RAMSEY COUNTIES, NORTH DAKOTA

1 INCH = 2 MILES

MAGNETIC CONTOUR INTERVAL 100 GAMMAS, 200 GAMMAS WHERE INDICATED

DRY HOLE