# MAGNETOMETER MAP OF SOUTH DAKOTA

## Bruno C. Petsch

#### INTRODUCTION

Purpose of the Report of the United States, including South Dakota, but the results of these surveys are in company files and are seldom open to public inspection. The South Dakota Geological Survey began a magnetometer survey of the State in 1939 and although wrought with many interruptions and delays over the past 25 years, this report draws to conclusion the results of the survey.

Thus, the primary purpose of the magnetometer survey is to show the position of various anomalies in the State.

#### Field Methods and Procedures

The magnetometer survey of South Dakota consisted of magnetic observations or readings taken with an Askania, Schmidt-type vertical ground magnetometer. Readings were taken at stations 4 to 6 miles apart because:

(1) a reasonably large portion of the State could be mapped during each summer field season; (2) the regional program would not bypass any large magnetic features; and (3) trails in the sparsely populated country west of the Missouri River are generally about 6 miles apart. the Missouri River are generally about 6 miles apart.

The observations of the magnetometer survey have all been carried on the same plane. Dr. W. H. Jordan established this plan by arbitrarily assigning the value of 500 gammas to his number 60 magnetometer observation, which is located in the northwest corner of sec. 7, T. 96 N., R. 67 W., Charles Mix County, near the abandoned town of Wheeler (Jordan and Rothrock, 1940). The spot is now under the waters of the Fort Randall Reservoir. As the magnetic survey expanded, additional base stations were estab

lished forward, from which new areas were worked. The results of all the observations are thus plus or minus the 500 gamma plane established by Jordan.

#### MAGNETOMETER MAP OF SOUTH DAKOTA

The results of the magnetometer survey of South Dakota are shown on a base map of the State at a scale of 1/750,000. A data map showing data points and gamma readings is available on request from the Survey. The final tabulation illustrated by isogams, which are printed in red, is shown on the map. There is a data point and gamma reading placed inside of each anomaly. Each anomaly above 1000 gammas was given a name (table 1)

Table 1.--Anomalies in South Dakota having a magnetic intensity exceeding 1000 gammas.

Magnetic Anomaly	Magnetic Intensity (Gammas)	Depth to Pre € (feet)	Test Hole and Location	County
1. Mossman	1,379			Dewey
2. Stanley	3,390	4,062	Shamrock #2 Barrick SW SW 23-7N-26E	Stanley
3. Sedgwick	1,400	2,555	Hunt #1 State SW NE 24-116N-73W	Hyde
4. Long Lake	1,189			Codington
5. Hegna Creek	1,428			Roberts
6. Granite quarrie	es 2,044	Surface		Grant
7. Parkston	1,530	683	Palensky #1 Wagner SE SE 17-99N-61W	Hutchinso
8. Gavins Point	1,770			Yankton
9. Willowdale	3,458	750	SDGS #1 Holzbauer	Yankton
10. Jamesville	2,624	738	Rittershaus #1 James- ville Colony NW SW 29-96N-56W	Yankton
11. De Vol	1,215			Yankton
12. Spink	2,752	792	SDGS #1 Huebner	Union
13. Hub City	1,162			Clay
14. Langford	7,272	902	AMAX #1 Langford NW SW 12-125N-59W	Marshall
15. Veblen	1,066			Marshall
16. Bristol	8,484	1,535	AMAX #1 and #2 Bristol SW SW 29-122N-57W	Day
17. Crandall	8,152			Day
18. Oglala	1,075			Shannon
19. Minnesota line	1,043			Brookings
20. Stratford	1,079			Brown
21. N. Dak. line	1,364			McPherson
22. Reno Gulch	1,512	Surface		Pennington

#### History of Field Work

The present magnetic map began with the field work of Dr. W. H. Jordan of the Department of Physics at the University of South Dakota in 1939. His work was done in central South Dakota, and the results published in Reports of Investigations No. 33 and 37 by the South Dakota Geological Survey. Magnetic work was continued in 1941 by Dr. E. L. Tullis of the Department of Geological Engineering at the South Dakota School of Mines and Technology and the results published as a Report of Investigations No. 42. Dr. Wayne Marshall of the Department of Physics at the University of South Dakota continued the survey in 1942 but his work was not published. In 1943 and 1946 this writer continued the magnetometer survey and published a Report of Investigations No. 65 (Petsch and Carlson, 1950). There followed a 10-year period during which little magnetic work was done. In 1957 the writer continued the magnetic survey to completion of the entire State and this work, together with all previous work, was compiled to make the magnetic map of South Dakota (Petsch, 1958, 1959, 1960, 1961, 1962a,b).

Figure 1 shows the areas covered by the various magnetometer surveys that contributed to the project. The map shows the author (who in each case was the surveyor), the area involved, and the year the report was published. In areas where reports of the work were not published, the date when the survey was made is included. The results of the unpublished surveys are included in the present report.

#### Selected Magnetic Anomalies

The magnetic anomalies of South Dakota can be grouped into two orders of magnitude. The first order is represented by 22 magnetic highs, each with a maximum greater than 1000 gammas (table 1). The second order has 149 magnetic high closures with magnitudes up to 1000 gammas. Magnetic anomalies below 500 gammas are generally scattered at random throughout the State. In contrast, those anomalies above 500 gammas which are connected directly as lobes, or superimposed on regional highs enclosed by the 500 gamma contour, are generally more isolated, as in a five-county area northeast of Pierre. A first order anomaly appears in a five-county area west of Watertown. The anomalous features are illustraied on the map.

The magnetic anomalies in excess of 2500 gammas are presented in more detail and include the Stanley, Willowdale, Jamesville, Spink, Langford, Bristol, and Crandall highs in the following text and figures.

#### Tamesville Anomaly

The Jamesville magnetic high (fig. 2) has a summit of 2624 gammas in sec. 30, T. 96 N., R. 56 W. Its axis is east-west, and the anomaly is about 5 miles long and 1 mile wide. It is part of a chain of highs including the Gavins Point high, that extends southward from Menno, South Dakota to Crofton, Nebraska, a distance of about 40 miles. This high is paralleled on the west by a long, narrow magnetic low that coincides probably with a A "wildcat" oil test (Rittershaus #1 Jamesville Colony in the NWSW, sec. 29, T. 96 N., R. 56 W., surface altitude 1160 feet) was drilled on the east end of the anomaly where a reading of 1749 gammas was obtained. The total depth was 1221 feet. In this test hole, Precambrian rocks were encountered at 738 feet and at least 400 feet of Precambrian core was recovered. A piece of the core that could be held by a magnet was chemically analyzed and 28 percent elemental iron reported. Willowdale Anomaly

## The Willowdale anomaly (fig. 3) has three maxima: 3458, 3413, and 3333 gammas in a straight line east-west on the axis. The anomaly is 3 miles long and about one-half mile wide. The anomaly is straight and its north flank has an even gradient of 2000 gammas in a half-mile to the north along its entirety. A deep magnetic low of -807 gammas parallels it on the north. The Willowdale anomaly is bounded on the west and at right angles by the Gavins Point high which is about 15 miles long and reaches 1770 ammas. The Willowdale magnetic high is 700 gammas higher than the Spink

anomaly, and its adjoining low extends 650 gammas lower. It has a simiar steep slope bordering a subnormal low, and opposite the steep slope is a large lobe of 1000 gammas extending southward at least 4 miles. It lies in the floodplain area of the James River. The ground surface is flat and is about 200 feet lower than that at Spink. The sharpness and intensity of the Willowdale anomaly suggests that the source of the magnetic energy is somewhat shallower than at Spink. The South Dakota Geological Survey test-drilled at the site of the 3413 gamma maximum. Precambrian rocks were encountered at 750 feet and a four-foot core was taken. Analysis of the core showed 13 percent iron.

A large magnetic high extending from central Clay County eastward into Iowa contains the Spink magnetic anomaly. It has a summit of 2752The Spink magnetic high trends southwest-northeast. The 1000 gamma contour encloses about 10 sections. The summit lies in the NW4 sec. 25, T. 93 N., R. 50 W. near the south end of the axis. Although the summit 1. 93 N., K. 50 W. near the south end of the axis. Although the summit is 2752 gammas, much of the quarter section has intensities of 2400-2600 gammas. The east side of the anomaly decreases by 2200 gammas in 1 mile. The entire eastern flank of the anomaly has a steep slope bordering on a subnormal low to the southeast. This abrupt change of the magnetic intensity indicates a sharp boundary of the subsurface mass which causes the Spink high.

Although the Spink magnetic high is locally very prominent, it is part of an anomaly which causes 137 square miles and is more than 24 miles.

of an anomaly which covers 137 square miles and is more than 24 miles long, which includes the Hub City high.

The Bouquer Gravity Map of the United States (American Geophysical Union, 1964) shows that the entire gravity field in South Dakota is below the zero milligal contour; a zero milligal high gravity closure on the map is confined to the Spink magnetic anomaly.

A test boring drilled by the State Geological Survey at the summit of the Spink magnetometer high in the NW4 sec. 25, T. 93 N., R. 50 W., on the

		Depth to top in feet
Cretaceous		
Greenhor	n Limestone	120
Dakota G	roup	195
Paleozoic-C	Cambrian (?)	
	limestone, shale, sandstone	618
Precambrian		792
	Total Depth	796
	4 inches long and 2 3/4 inches in diam rocks with a diamond bit. The followin	
Inches	Lithology	
0-12	Gabbro, with disseminated magnetite	e particles
12-18	Area of joints in gabbro filled with c	alcite
18-28	Gabbro, with magnetite particles	
28-39	Clay, green and reddish-brown with	calcite veins
39-54	Gabbro, with magnetite particles	

A partial chemical analysis in the laboratory of the State Chemist

Iron	14.47
Titanium dioxide	6.76
Magnesium oxide	1.89
Calcium oxide	10.39
Silica	33.43
Langford And	omaly

The Langford magnetic anomaly is 4 miles north and 1 mile west of Langford, Marshall County, A maximum intensity of 7272 gammas was recorded on the summit in the southwest corner of the southeast  $\frac{1}{4}$  of sec. 2, T. 125 N., R. 59 W. The anomaly is 3 miles long and 1 mile wide, A test boring penetrated Precambrian rocks at a depth of 902 feet on the

### Bristol Anomaly

The Bristol magnetic high is located  $l\frac{1}{2}$  miles east of the town of Bristol in Day County. The summit of the high is located in the SW $\frac{1}{4}$  sec. 29, T. 122 N., R. 57 W.; a reading of 8400 gammas was recorded in the southeast corner of sec. 30. It is probably the most spectacular anomaly in the

The vertical magnetic intensity at Bristol is probably much higher than 8400 gammas, but the Askania magnetometer that was used would not register above that figure. The large auxiliary magnet was inserted to its maximum, which retarded the scale of the magnetometer 6600 gammas. To take a reading on the summit of the anomaly with the Askania would neces sitate adjusting the magnet system in the magnetometer, and a chance would be taken that the zero temperature coefficient would be destroyed. nerefore, it was decided not to take readings on highs whose summits could be located within 160 acres. The anomaly was checked with a Varian M-49 magnetometer along the north-south section line road. The total magnetic intensity rises 12,000 gammas in the first one-half mile north of the summit. The 59-71,000 gammas range unit was too small to read the total intensity. Hence, it is not known how high the reading would be. In view of the fact that the total intensity of the United States is 60,000 gammas, it was assumed that the 49-71,000 range unit would be ample. The magnetometer was not equipped with the next highest range unit which is 69-81,000 gammas.

The anomaly is surrounded by magnetic lows; two miles north the inten-

sity reaches -298 gammas, which is the third lowest value measured in the State. A test boring at the location of the summit of the high penetrated Precambrian rocks at a depth of 1535 feet (fig. 5).

## Crandall Anomaly

The Crandall magnetic high in southwestern Day County has a summit 5 miles east and 2 miles north of Crandall. A reading of 8152 gammas was obtained in the southwest corner of sec. 20, T. 120 N., R. 58 W. A higher reading of 500 gammas of total magnetic intensity was taken  $\frac{1}{4}$  mile north with a Varian M-49 magnetometer. It is quite likely that a much higher value can be measured on the summit which lies somewher in the immediate vicinity, perhaps on the order of Bristol readings (fig. 5)

The Crandall high is about 4 miles long and trends southwest-northeast. The intensity drops to -57 gammas 2 miles to the northwest and 96 gammas 2 miles southeast of the summit. To date, no testwells have been drilled in the vicinity of the Crandall anomaly.

The Stanley magnetic high is situated almost in the center of the State. The anomaly with its related features covers the north half of Stanley County. The magnetic high has a summit of 3390 in sec. 27, T. 7 N., R. 26 W., which is comparable to the Willowdale high in Yankton County. The 2000 gamma isogam covers about one township. A deep low of -235 gammas parallels the anomaly about 10 miles northeast of its summit and

a low of 56 gammas is 8 miles northwest. The Stanley high is part of a magnetic trend which includes the Mossman high of 1379 gammas about 30 miles due north and a 700 gamma high about 30 miles southeastward. The Shamrock #2 Barrick oil test reached granite at a depth of 4070 feet. This boring is at the 3161 gamma reading about one mile north of the summit (fig. 6).

#### CONCLUDING STATEMENT

The data and maps contained in this report serve only as a tool to be used in conjunction with known and future geologic data in the interpreta-tion of the geologic history of South Dakota. No attempt is made to draw specific conclusions based solely on magnetic data. If, however, those persons who have an interest in the future develop-ment of the State's mineral and water resources can use the magnetic data contained herein in their exploration programs, then the report has fulfilled

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