University of Wisconsin-Extension

GEOLOGICAL AND NATURAL HISTORY SURVEY
3817 Mineral Point Road
Madison, Wisconsin 53705

M.E. Ostrom, State Geologist and Director

ANALYSIS OF CLAM LAKE GRAVITY AND MAGNETIC ANOMALIES

by

C. Patric Ervin

Open-File Report 77-1
8 p.

1977

Report: Analysis of Clam Lake Gravity and Magnetic Anomalies

Principal Investigator: C. Patrick Ervin

Purchase Order No: UTH 175 J 350 (9/13/77)

The recent aeromagnetic survey of northern Wisconsin revealed a short-wavelength, high amplitude anomaly near Clam Lake in Ashland County. The anomaly has an amplitude of 7000 gammas, but a wavelength of only 5.5 km. The sharp gradients suggest a shallow source.

To further define this anomaly, a small gravity survey was conducted by Northern Illinois University (NIU) and the Wisconsin Geological and Natural History Survey (WGS). The data were reduced by NIU using a density of 2.67 to produce the Bouguer anomaly map shown in Fig. 1. These data are on a floating datum. Attempts to tie this survey to the datum for the state gravity map (Ervin and Hammer, 1976) through coincident stations were unsuccessful due to the poor quality of the state data in this area.

GRAVITY INTERPRETATION

Before the gravity data can be interpreted, the regional, or long wavelength, component of the gravitational field must be removed to isolate that portion of the field, called the residual, that is associated with the local mass deviation. Inspection of the state gravity map shows that the proper form of the regional field in this area is not clear. After some experimentation, the simple regional field shown in Fig. 1 was selected. Note that it is not necessary for the regional field and the observed data to be on the same datum because the regional can be treated as simply a trend to be removed from the observed data. Hence, the only critical factor is the relative amplitudes between points of observation.

Subtraction of the regional field from the Bouguer map produced the residual Bouguer gravity anomaly shown in Fig. 2. The negative residual values in the northeastern part of the map are associated with a broad negative anomaly centered outside the boundaries of the study area, as shown on the state gravity map.

A diamond drill hole located on the anomaly by Inland Steel Company indicates that the body is a melagabbro whose top is approximately 100 feet below the surface. Using the observed depth and the horizontal shape suggested by the gravity and magnetic field distributions, a model was constructed on the assumption that the body is a plug that can be represented by a vertical prism with an essentially infinite depth extent. The model and the gravitational field calculated by a Talwani algorithm using a density contrast 0.50 g/cc are shown in Fig. 3. Considering the difficulty in selecting a proper regional field, the correspondence between the residual and calculated fields is quite good, except on the southwestern flank. The Anomaly Gravity Map in Fig. 1 indicates the presence of a second, smaller anomalous source in this area. Unfortunately, the density of the data is not sufficient to separate the gravitational fields of the two sources.

MAGNETIC INTERPRETATION

The total intensity magnetic field is shown in Fig. 4. The shape of the anomaly suggests that it cannot be assumed to be caused solely by induction in the earth's magnetic field. If induction was the sole source, the associated

minimum would lie on the north side of the anomaly with perhaps a slight skewness to the northeast. However, the Clam Lake minimum has a strong skewness to the northwest, which is interpreted to mean that the source rock contains a strong remanent polarization in a direction other than that of the earth's field. Attempts to model the anomaly assuming reasonable geologic constraints and induction only were unsuccessful, further supporting the interpretation of remanent polarization.

Because the body is not known to be exposed at any point, it is impossible to obtain an oriented sample from which the direction of polarization could be determined. Hence, a model for the observed anomaly cannot be readily calculated.

Although not an appropriate representation of the Clam Lake anomaly, a folio of models published by Andreasen and Zietz (1969) may serve as a rough guide to approximate values for the inclination and declination of the polarization vector. These models suggest a declination of about 60 degrees west of magnetic north and an inclination in the range of 30 to 50 degrees. This is in very good agreement with the polarization direction obtained by Books and others (1966) for the Keweenawan age Mellen gabbro. They report a mean declination of 69 degrees west of magnetic north and a mean inclination of 47.5 degrees. This suggests that the Clam Lake body is an offshoot of the Mellen gabbro.

CORE ANALYSIS

Samples of the core were obtained from the Inland Steel Company Diamond Drill Hole #1. A total of nine samples were selected by M. G. Mudrey, Jr., of the WGS as being representative of the section. The depth from top, density, and susceptibility for each are shown in Table 1.

In general, the densities are quite high. If the country rock is assumed to have a density 2.70 g/cc the computed contrast of 0.50 g/cc gives a model density of 3.20 g/cc, which is quite reasonable, even a bit low, when compared to the computed densities.

The susceptibilities are also quite high, even to the point of exceeding the capabilities of the instrument in several cases. The reason for obtaining different values when the core sample is inverted is somewhat uncertain, but probably results from the presence of a strong remanent polarization.

DISCUSSION

It should be noted here that another interpretation of the data is possible. Instead of a vertical body with remanent polarization, the source might be an inclined body dipping to the northwest. This interpretation is suggested by the steep magnetic gradient in this direction and the spreading of the southern contours. In fact, the regional magnetic and gravity maps both indicate that there is some relationship between the Clam Lake anomaly and the Mellen gabbro anomaly.

However, I believe that this model of the anomaly is probably incorrect for several reasons. Although an inclined model would deepen the low on the

northwest side of the anomaly, I believe that a minimum should still be present on the northeast side if the anomaly was caused solely by induction. Furthermore, the rock is a coarse-grained, unaltered gabbro containing up to 60% magnetite and ilmenite. It is a reasonable assumption that such a rock should contain a remanent component. Finally, the residual gravity exhibits a significant minimum between the Clam Lake anomaly and the positive area to the west. If the body were a simple, inclined feature, the anomaly would be a northwest-trending ridge whose amplitude steadily decreased.

TABLE I

Depth from top (feet)	Density (g/cc)	Susceptibility Top up	Susceptibility Top down
101.6	~~3.66~~ 4.20	*	*
155.4	~~3.69~~ 4.01	*	*
163.5	~~3.16~~ 3.45	*	*
188.5	~~3.65~~ 3.97	@	@
214.0	~~2.84~~ 2.99	4500	3000
230.0	~~4.05~~ 4.52	@	@
293.6	~~3.28~~ 3.60	21000	21000
346.2	~~2.91~~ 3.17	2100	200
350.5	~~4.09~~ 4.52	@	@

* core is too large to fit into instrument

@ susceptibility exceeds range of instrument

Andreasen, G. E., and Zietz, I., 1969, Magnetic Fields for a 4 x 6 Prismatic Model, U. S. Geol. Survey Professional Paper 666, 9 p.

Books, K. G., White, W. S., and Beck, M. E., Jr., 1966, Magnetization of Keweenawan Gabbro in Northern Wisconsin and its Relation to Time of Intrusion, U. S. Geol. Survey Prof. Paper 550-D, p. D117-D124.

Ervin, C. P., and Hammer, S., 1974, Bouguer Anomaly Gravity Map of Wisconsin, Wisconsin Geol. and Natural History Survey.

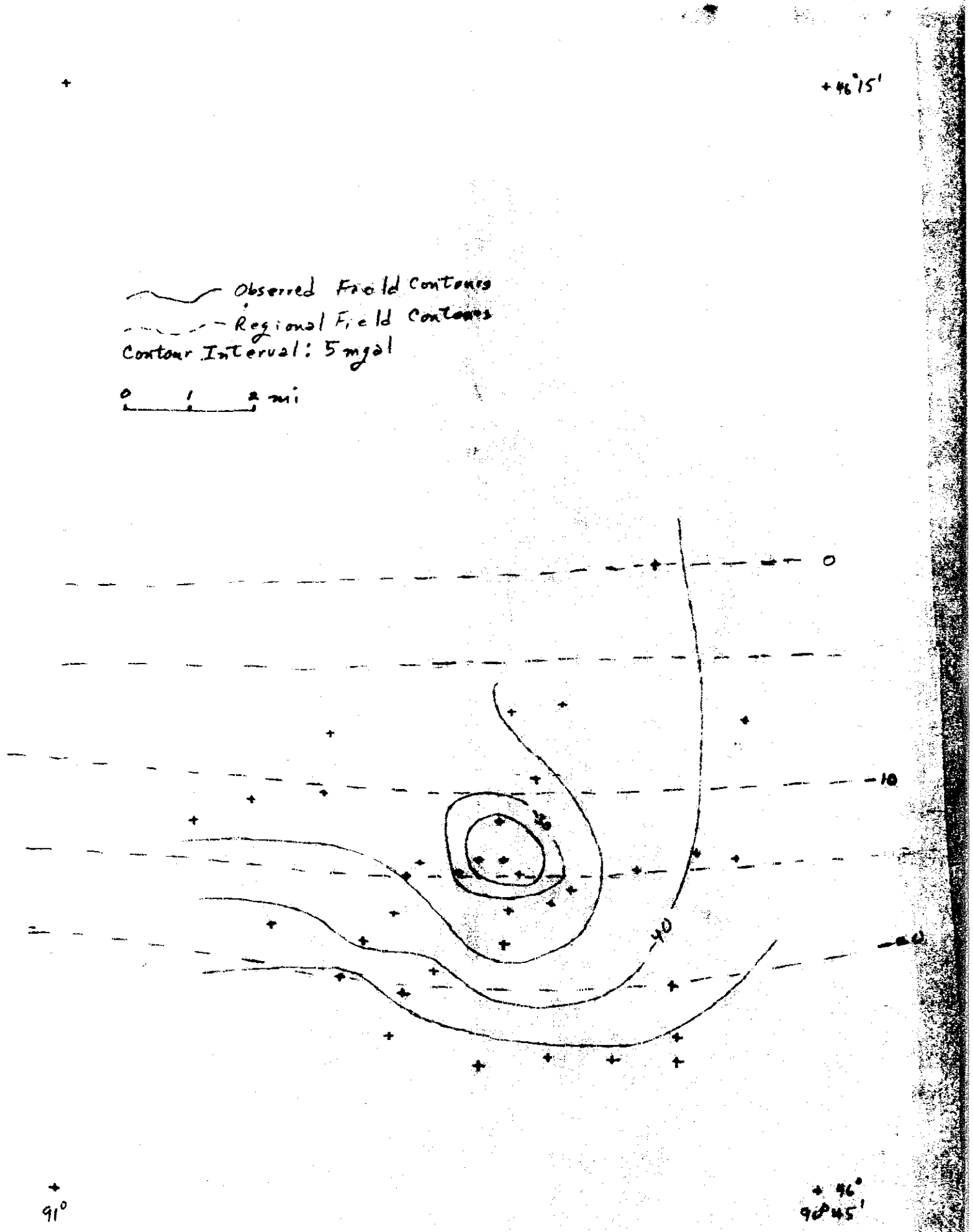
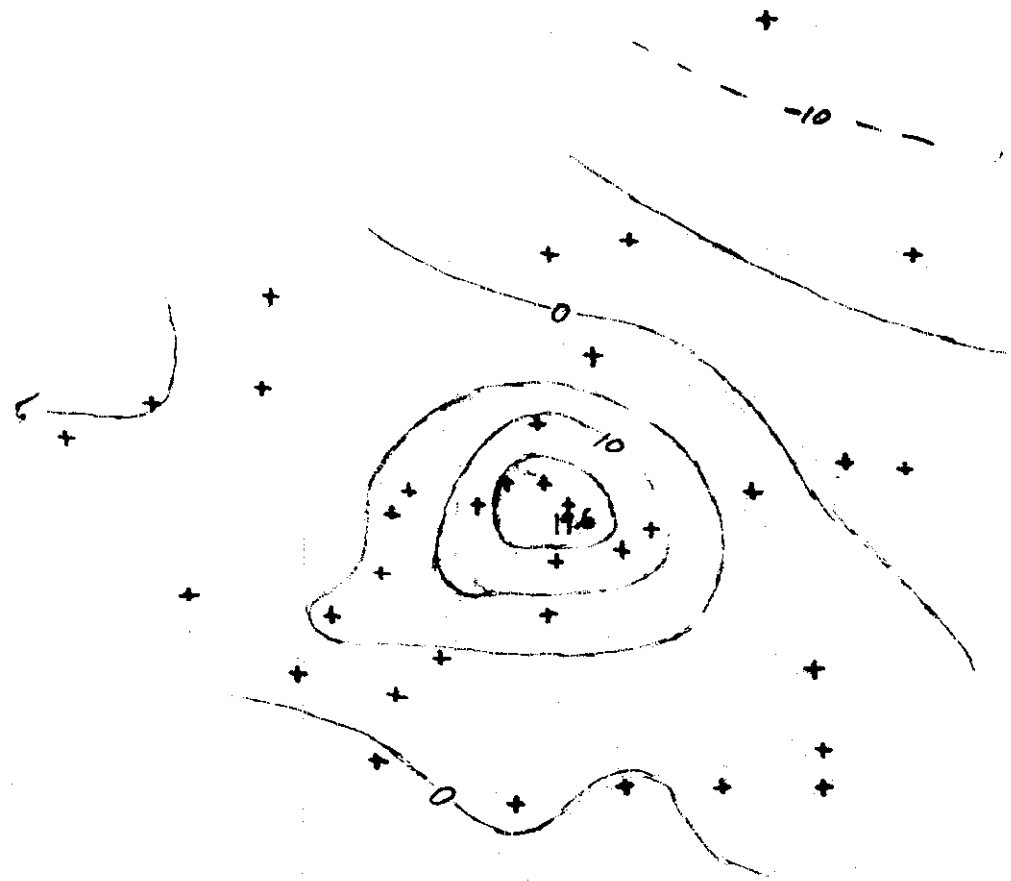


FIG. 1. BOUGUER ANOMALY GRAVITY MAP

+46°15'

contour Interval: 5 mgal

0 1 2 mi



91°

+46°
98°45'

FIG. 2. RESIDUAL ANOMALY

Contour Interval: 5 mgal

0 1 2 mi

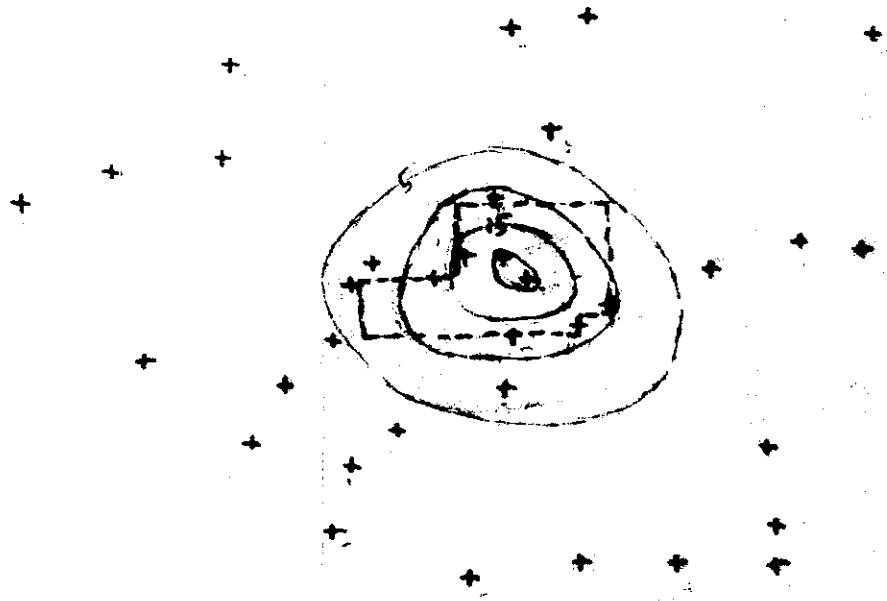


Fig. 3. CALCULATED FIELD & MODEL