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three localities, so it may be assumed that the disconformity is at least 150 miles in extent.

Although this evidence is quite persuasive, the knowledge of the geologic and geographic distribution of Middle Ordovician conodonts is far from complete. Subsequent work in this area could well alter the conclusions drawn here.

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# Geologic Interpretation of Magnetic Map, Keokuk County, Iowa[1]

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*Abstract.* In 1964, surface measurements of the vertical component of the earth's magnetic field were made in Keokuk County, Iowa. The geologic conditions responsible for the magnetic anomalies can be attributed almost entirely to changes in the lithology of the Precambrian crystalline basement complex about which no direct information is available. The basement complex probably includes granitic, basic igneous and/or metavolcanic rocks, and the estimated depth to the top of the complex is about 3,000 feet. There is little correlation between the magnetic anomalies and known Paleozoic structures, but knowledge of the structures is very limited.

[1] Presented with the permission of Dr. H. Garland Hershey, State Geologist, and Director of the Iowa Geological Survey.

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## Introduction

In 1964, surface measurements of the vertical component of the earth's magnetic field were made in Keokuk County, Iowa. This investigation is part of a continuing study by the Iowa Geological Survey to determine if magnetic anomalies are associated with known Paleozoic structures and to provide a magnetic map of southeastern Iowa. The results of an earlier magnetic survey in adjacent Washington County suggested a possible relationship between magnetic anomalies and Paleozoic structural features (Hase, 1964).

A tripod-mounted, Askania Torsion Magnetometer, Type Gfz, with a scale value of 228.4 gammas per scale division, was used to make relative measurements of the vertical magnetic intensity. Readings were interpolated to one hundredth of a scale division and were reproducible in the field to the nearest tenth scale division. The error due to reading the instrument does not exceed 50 gammas.

Most of the six hundred and ten field stations established in the county were at section corners. Where the section corners were not readily accessible, the interval between stations did not exceed two miles, and in areas of steep magnetic gradient the interval was shortened to half a mile. Several base stations were established, and one of these was re-occupied at intervals of several hours during the course of each day's survey to obtain a diurnal-variation curve for correcting the field-station readings. A latitude correction of 8½ gammas per mile was applied to the data, but the longitude correction is essentially zero and was not considered. Because of the low temperature coefficient of the instrument, no temperature correction was necessary. The corrected magnetic values at the field stations are relative to the primary base station in Washington County to which an arbitrary base value of 1,000 gammas was assigned (Hase, 1964).

## Geologic Setting

Keokuk County is covered by Pleistocene glacial till of the Nebraskan and Kansan stages ranging in thickness from 0 to 230 feet. Except for outliers of Pennsylvanian sandstone, shale and minor coal, the bedrock is Mississippian limestone, dolomite, siltstone or shale. The lower Paleozoic section includes limestone, dolomite, shale and sandstone of Devonian, Ordovician and Cambrian age and thin dolomite of Silurian age in the northeast quarter of the county (Thomas, 1959).

Extensions of the axes of the Skunk River anticline and possibly the Sperry or Oquawka anticline have been suggested in Keokuk County (Harris and Parker, 1964. Two elongate domes with closures of about 50 feet and 100 feet have been mapped on the base of the Haight Creek Member, Burlington Limestone in T. 74 N., R. 11 W. and T. 76 N., R. 10 W. respectively. The structure in T. 76 N., R. 10 W. is a part of the Keota dome where a petroleum discovery well was drilled early in 1963.

The deepest wells in the county have bottomed in the Cambrian St. Lawrence Formation. The top of the St. Lawrence Formation was encountered at 1,186 feet below sea level in the city well at What Cheer in sec. 10, T. 76 N., R. 13 W. and at 1,070 feet below sea level in the town of Harper in sec. 30, T. 76 N., R. 10 W. Just across the north border of the county in the city well at North English, Iowa County in sec. 36, T. 78 N., R. 11 W. the top of the St. Lawrence was encountered at 1,134 feet below sea level.

Employing an "average" thickness of 850 feet for the combined St. Lawrence Formation, Franconia Formation and the Dresbach Group, the top of the Precambrian crystalline basement complex in the county is estimated to be approximately 2,000 feet below sea level or 2,800 feet below surface. The thickness of the Cambrian section is poorly known, and the actual depth could range several hundred feet from the estimated average depth if the surface of the complex exhibits marked topographic relief.

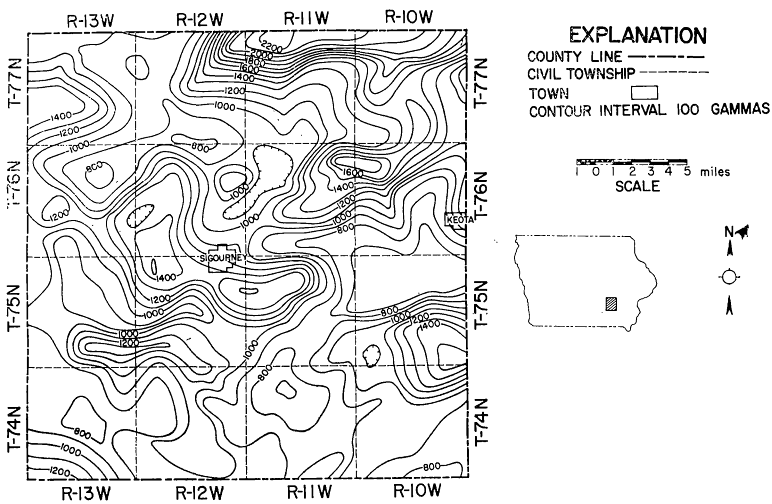


**Figure 1. Vertical intensity magnetic map, Keokuk County, Iowa.**

## Interpretation of Magnetic Map

If the earth was assumed to be magnetically homogeneous, the surface magnetic field would be undistorted and have a uniform distribution. Any departures from the assumed condition would cause local distortions of the idealized magnetic field which are termed magnetic anomalies. These anomalies, which are caused by variations in the concentration and distribution of the magnetic minerals, must be explained in terms of reasonable geologic conditions principally in the upper mantle. The intensity and shape of magnetic anomalies are due to many factors including the inclination and intensity of the earth's magnetic field, the size, shape, orientation and composition of the magnetic body, and the relationship of the remanent to the induced magnetization. Induced magnetization conditions are assumed in the interpretation inasmuch as no samples were available to determine the remanent magnetization. The interpretation of magnetic anomalies is rarely unique unless considerable geologic control data are available.

Geologic control in Keokuk County is limited to knowledge of the lithology, shallow structure and probable thickness of the Paleozoic sedimentary rocks. No drill hole has penetrated the Precambrian crystalline basement complex. Inasmuch as the Paleozic sedimentary rocks and the glacial till do not contain significant amounts of minerals with high magnetic susceptibility, the geologic conditions responsible for the magnetic anomalies can be attributed almost entirely to differences in the lithology of the basement complex.

On the magnetic map (fig. 1) the trend of the long axes of the anomalies suggests an easterly strike for the rocks in the crystalline basement complex. There is more magnetic expression in the northern three-fourths of the county than in the southern one-fourth which suggests a discontinuity at depth, possibly a contact between two large rock masses of rather different magnetic susceptibility. In general, basic igneous and metavolcanic rocks are more strongly magnetic and produce more intense anomalies than granitic rocks which are weakly magnetic by comparison and produce a low and rather featureless magnetic level. Very probably all of the anomalies of several hundred or more gammas are due to changes in lithology within the crystalline basement complex and not to relief on the surface of the complex.

A comparison of the magnetic map with the structure map on the base of the Haight Creek Member, Burlington Limestone (Harris and Parker, 1964) shows very little correlation of magnetic anomalies and major Paleozoic structural trends. The composite magnetic high in the northeast corner of the county coincides approximately with a structural high. The Keota dome is near the southern end of this magnetic high. The magnetic high near Sigourney lies along the extension of the Skunk River anticline, but the anomaly trends easterly and the structure trends northwesterly. A magnetic nose of 50 to 100 gammas occurs in the vicinity of the structural dome on the Skunk River anticline in the northeast corner of T. 74 N., R. 11 W. The magnetic anomaly in T. 74-75 N., R. 10 W. does not coincide with any closed structural features indicated on the map by Harris and Parker.

The apparent lack of coincidence of the magnetic anomalies and the major Paleozoic structural trends and the intensity of the magnetic anomalies suggest that sedimentary draping over topographic highs on the surface of the crystalline basement complex probably did not exert the dominant control over the location of these Paleozoic structures. It should be emphasized, however, that knowledge of the Paleozoic structures in the county is limited, and knowledge of the composition and configuration of the crystalline basement complex is nil.

The magnetic anomalies do not coincide with any gravity anomalies shown on the Bouguer gravity map (Mack and Associates, 1962a) or the 15th order residual gravity map of Iowa (Mack and Associates, 1962b). A narrow, northwesterly trending, positive residual gravity anomaly is shown in T. 76 N., R. 12 W, in T. 77 N., R. 12 W., and in T. 77 N., R. 13 W. which is the general locus of a magnetic low. Direct comparison of the gravity and magnetic maps is hazardous however, inasmuch as only 24 gravity stations were established in Keokuk County and the intervals between stations ranged from 2 to 8 miles. Magnetic stations were spaced at intervals of one mile throughout most of the county.

Depth estimations from magnetic anomalies are based on the fact that the steepness of the gradient of the sides of an anomaly is a measure of the maximum possible depth to the upper surface of the polarization contrasts within the crystalline basement complex. Only the anomaly in T. 74-75 N., R. 10 W. was considered suitable for depth analysis because of its relative isolation from other anomalies. Applying the Peters' slope method of analysis to the anomaly (Peters, 1949) and assuming that the width of the causative body is considerably greater than the depth to the top of the basement complex, the average calculated depth is about 3,300 feet over a range from 2,700 to 4,000 feet. The best estimate for the depth to the basement complex surface is about 3,000 feet which is the mean value of the average calculated depth of 3,300 feet by magnetic anomaly analysis and the inferred depth of 2,800 feet from the estimated thickness of the Paleozoic sedimentary section.

## Conclusions

The geologic conditions responsible for the magnetic anomalies can be attributed almost entirely to changes in the lithology of the Precambrian crystalline basement complex about which no direct information is available. It is suggested that the lithology of the basement complex includes granitic, basic igneous and/or metavolcanic rocks which trend easterly. The estimated depth to the top of the crystalline basement complex surface is about 3,000 feet.

There is little correlation between the magnetic anomalies, major Paleozoic structural trends and gravity anomalies in the county. Knowledge of the Paleozoic structures is very limited, however, and direct comparison of gravity and magnetic maps is hazardous because of the few gravity stations in the county.

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# Detailed Mapping of the Bedrock Configuration in Des Moines County, Iowa, With an Electrical Resistivity Instrument

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*Abstract.* A Gish-Rooney type earth resistivity apparatus was used to obtain depth to bedrock at 110 instrument locations in north-central Des Moines County, Iowa. The variable depth method was employed in an area where some bore hole information was already available. The features on the resultant bedrock configuration map are more clearly defined than those on a map produced from bore hole data only. The resultant map is considered to be more reliable. The reliability of the method depends on the geologic conditions and the amount of data available prior to the study.

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