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

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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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Introduction

The success of the forced field electrical methods for depth determination to various horizons depends on the geological setting of the area under study. The magnitude of contrast of electrical properties of the lithologic units in contact controls the success of the method. Several investigators (2, 3, 4, and 5) have reported that the electrical resistivity method has erratic success in areas underlain by glacial deposits. Very little work has been attempted in Iowa to test the feasibility of this method as an exploration tool. Dixon and Welp (4) concluded from their studies in Iowa that the method can be used for shallow investigations when conducted by experienced personnel. The author has shown (7) that the method can be used as a reconnaissance tool in glaciated regions. It is the purpose of this study to show that the electrical resistivity method can be used as a quantitative tool to locate the depth to bedrock and thereby provide data to map the bedrock configuration in detail.

Geology

The bedrock of the study area is Mississippian limestone (Burligton or Hampton) and Devonian shale (Maple Mill). The Mississippian outcrops in the eastern edge of section 2 (fig. 2) and in the northern portions of sections 16 and 17 (T 71 N R 3 W). Except for the area of these outcrops, the bedrock is overlain by glacial deposits which vary in thickness up to a maximum of approximately 400 feet in the buried valleys, with the average thickness of 100 feet. The Mississippian strata are essentially horizontal and vary in thickness from a few feet near buried valleys up to 100 feet in areas where the bedrock is high. Mississippian beds are absent where buried valleys are present, and the Devonian is present in the lower walls and valley bottoms. The Devonian shale has a maximum thickness of 300 feet when overlain by Mississippian beds, and can be as thin as 100 feet beneath buried valleys.

The bedrock configuration for Des Moines County, as determined from well log data obtained from the files of the Iowa Geological Survey and by an inventory of farm wells in the county during the summer of 1961, is presented in figure 1. It can be seen that two major buried channels are present in Des Moines County. A north-south channel parallels the Mississippi River down to Burlington, Iowa, and then crosses over into Illinois. A northwest-southeast channel labelled the Washington channel by Beveridge (1) intersects the north-south channel north of Burlington, Iowa. Of the two smaller channels present, one parallels the Washington channel and lies just to the north of it. The other is a tributary to the Washington channel trending

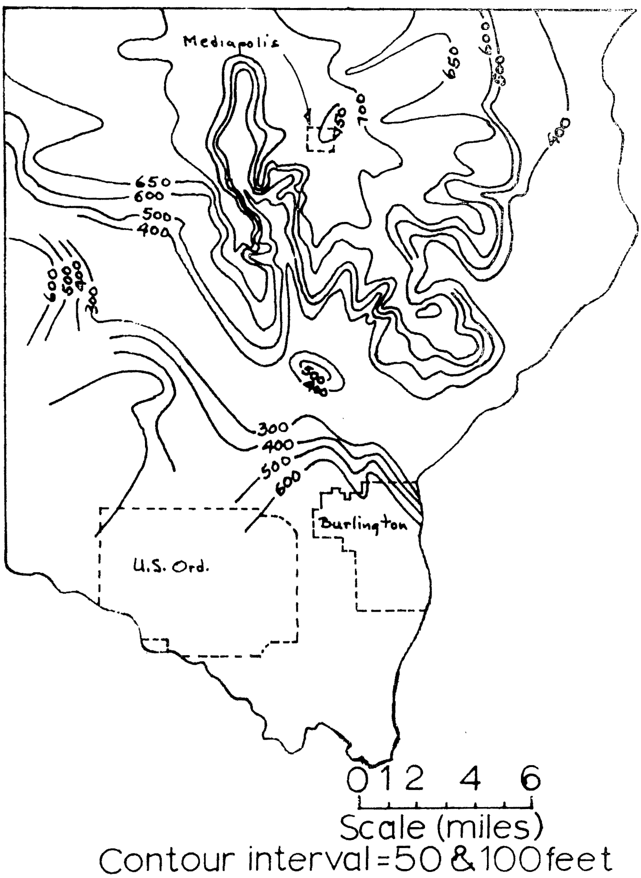

Figure 1. Bedrock configuration

almost north-south with its upper end several miles east of Mediapolis, Iowa. This study deals with a portion of this smaller channel. The reconnaissance survey reported by the author (7) in the Proceedings in 1963 dealt with the upper end of this small channel.

Method of Study

The instrument used in this study was constructed by Carl A. Bays and Associates of Urbana, Illinois. It is a Gish-Rooney type which has been modified so that the apparent resistivity can be read directly for each electrode spacing. The power source is a 12-volt storage battery which, in this case, was part of the standard equipment of the vehicle used for the transportation of the survey party.

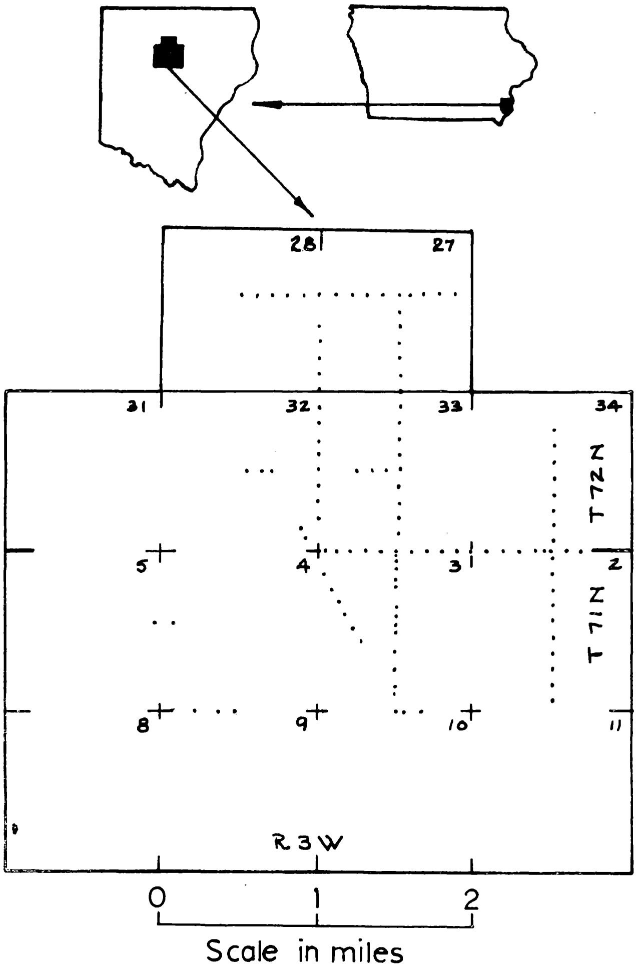

Figure 2. Location of Study Area and Resistivity Instrument Stations.

There are two standard field methods which can be employed in an electrical resistivity survey. The variable depth method requires that the four electrodes be equally spaced and that the spacing be increased a constant increment after each reading, while always maintaining equal spacing between electrodes. This will provide data for determination of the apparent resistivity at various depths, and was the method employed in this study. The constant depth method requires that a fixed electrode separation be selected and only one reading be made at each instrument station. This second method has been employed to the area north of the study area and is described by the author in an earlier publication (7).

The field party consisted of five persons, four men to operate electrodes and a fifth to run the instrument. Instrument stations were occupied along existing roads (fig 2), generally in the drainage ditch adjacent to the road. The topographic relief along a line of resistivity stations was very small and all station elevations were obtained by hand level.

The Wenner configuration was used for electrode spacing with the incremental change being constant for each station but varying from 3, 5, to 10 feet for different stations. When the profile was run to a depth of 200 feet or more, the 10-foot incremental change was employed. For the shallower profiles, either the 3 or 5 foot incremental change was used.

Approximately ten stations penetrating to a depth of 300 feet were occupied in an eight-hour day, and as many as 15 stations per day when the depth of penetration was less than 300 feet. The total number of stations occupied for this study was 110 (fig. 2).

The data were treated in two ways in order to arrive at the depth to bedrock. A straight arithmetic plot was constructed with "a" spacing or depth plotted on the y axis and the apparent resistivity plotted on the x axis. It is possible in simple two-layer cases to pick resistivity interfaces from a plot of this type. A second method employed required that the data be plotted on log-log paper in order that it might be compared to standard curves constructed by Mooney and Wetzel (6). Upon fitting the observed curve to the theoretical curve the depth to the resistivity interface could be determined and the specific resistivity for each unit evaluated. All of the data were treated as a straight arithmetic plot and only selected stations were compared to the theoretical curves. There are approximately 2,300 theoretical curves which can be used, therefore rendering this method of interpretation laborious.

Results

The bedrock configuration of the study area as determined from bore hole data is presented in fig. 3. The bedrock configuration as determined by a combination of resistivity data and bore hole information is shown in figure 4. In general it can be seen that several similarities do exist between the two figures and that the general pattern of valleys is the same. However, there are some major differences. The highest elevation found in figure 3 is 700 feet, whereas in figure 4 it is 730 feet (sec. 33). In figure 4, valleys are better delineated because the slopes are steeper. In figure 3, a broad depression trending east-west in sections 27

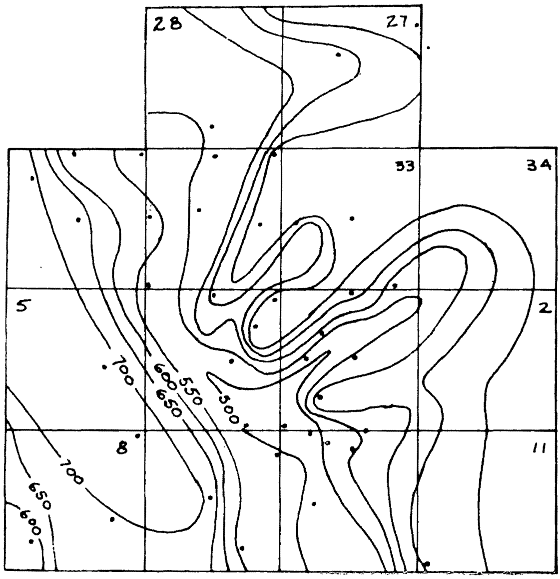

Figure 3. Bedrock configuration map as determined from bore hole data.

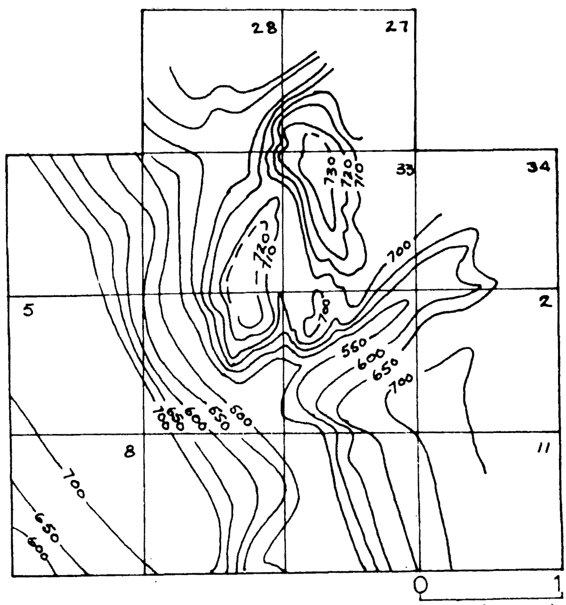

Figure 4. Bedrock configuration as determined from bore hole and resistivity data.

and 28 is resolved in figure 4 to a much narrower channel which probably terminates within section 27. In figure 3 a small channel is indicated in the southern part of sections 32 and 33 and the northern part of sections 3 and 4. In figure 4 it can be seen that this valley probably has more north-south trend than an east-west trend.

SUMMARY

In summary it can be said that by adding more control to the already available data, a more reliable map can be produced. The reliability of the method depends on the geological conditions and the amount of data available prior to the study.

Where the electrical properties of the various layers in contact are appreciably different, interfaces between them can be easily determined, but when electrical properties are similar, determination of the interface can be difficult. In this study, glacial till in contact with limestone produced a large contrast of electrical properties. In areas where shale directly underlies glacial till, the contrast of electrical properties is not as great and, therefore, the interface between them is not as easily detected. It is hoped that in the near future data can be collected in an area where shale is the bedrock material in order to evaluate the method in this geologic setting.

The geophysical methods are only tools to be used by the geologist just as bore holes are employed. Other geological data is needed to tie to and help correlate the geophysical information. The amount of geological data needed is generally a function of the experience of the interpreter; the more experience, the less geological information needed. It cannot be emphasized enough that other data of a geological nature is needed, no matter how experienced the interpreter. It is the feeling of this investigator that where the resistivity method and other geophysical methods are applicable they should be used in conjunction with a drilling program to provide the most efficient and economical method of subsurface investigation.

ACKNOWLEDGEMENTS

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The Effects of the Alaskan Earthquake of March 27, 1964, on Ground Water in Iowa[1]

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Abstract. The large Alaskan earthquake of March 27, 1964, affected all the major aquifers in Iowa. The effects included (1) seismic fluctuations of the water level; (2) turbid water; and (3) a permanent change in some water levels. A change in the porosity of the aquifers is postulated as an explanation for the permanent water-level changes.

INTRODUCTION

At 9:36 p.m. Iowa time (Central Standard) on March 27, 1964, a large earthquake occurred 80 miles east of Anchorage in south-central Alaska. This earthquake was one of the largest ever recorded on the North American continent; its magnitude was between 8.4 and 8.6 on the Richter Scale. The energy released by the shock was about three times as much as was released by the San Francisco earthquake of 1906, and more than 150 times the amount released by the Hebgen Lake, Montana, earthquake of 1959. Reports by Grantz and others (1964) and the U. S. Coast and Geodetic Survey (1964) describe the location and effects of the earthquake in Alaska. The effects of this quake in the United States and as far away as Puerto Rico are

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