STATE OF ARKANSAS

Arkansas Geological Survey

GEORGE C. BRANNER
State Geologist

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A Geomagnetic Survey of the Bauxite Region in Central Arkansas

By
NOEL H. STEARN

LITTLE ROCK
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LETTER OF TRANSMITTAL

ARKANSAS GEOLOGICAL SURVEY
LITTLE ROCK, ARK., *Nov. 15, 1930.*

HON. HARVEY PARNELL,
Governor, State of Arkansas,
Little Rock, Arkansas.

SIR:

I have the honor to submit herewith the report, "A Geomagnetic Survey of the Bauxite Region in Central Arkansas," by Dr. Noel H. Stearn.

During the progress of magnetic field work east of Little Rock undertaken by Leo Yount, Inc., in 1929, it became apparent that there was a direct relationship between the earth's magnetic field and the syenite outcrops which occur in that area. It appeared, consequently, that if a magnetic survey were made of the entire bauxite area of central Arkansas, valuable information might be obtained in connection with the location of hitherto undiscovered masses of syenite, buried or otherwise, with which the Arkansas bauxite is associated. Acting on this basis, the services of Dr. Noel H. Stearn were obtained through W. C. McBride, Inc., of St. Louis, Missouri, and the present report is the result of his work in this area.

Although obviously the results of this work are not in any sense conclusive in that they indicate the presence or absence of bauxite, it is probable that the information obtained will prove useful in connection with exploration for new bauxite deposits in central Arkansas.

The prosecution of the field work on which this report is based, was made possible through the generosity of W. C. McBride, Inc., of St. Louis, Missouri, Justin Matthews and John F. Boyle of Little Rock, Arkansas, A. G. Blauner of Tulsa, Oklahoma, and the Geophysical Exploration Company of Beaumont, Texas.

Respectfully submitted,

GEORGE C. BRANNER,
State Geologist.

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ABSTRACT

The known deposits of bauxite in central Arkansas are genetically and geographically related to the known masses of igneous rock. It follows that the discovery of hitherto unknown igneous masses in this area may mean the discovery of associated deposits of bauxite. The known igneous masses have been exposed by post-Tertiary erosion. Drilling has shown that erosion has not proceeded far enough in the area to expose all the igneous masses which are flanked with bauxite deposits, and it is possible that there may be buried igneous masses as yet unknown which may also be associated with bauxite. The discovery of pronounced magnetic anomalies associated with isolated exposures of igneous rock in the region suggested that concealed igneous masses might be located by the magnetic method. A reconnaissance survey was therefore made over an area of approximately 1,100 square miles. Although the presence in the region of magnetic anomalies of different orders of magnitude complicates the interpretation of the results, the survey furnishes a body of data which supplements the known geological facts in such a way as to permit two inferences:

(1) That the potential bauxite-bearing region in central Arkansas can be extended to include an area of at least 165 square miles.

(2) That beneath the Gulf Coastal Plain in central Arkansas there lies an igneous province, nearly 400 square miles in extent, fringed with plugs and dikes of basic igneous rock.

A Geomagnetic Survey of the Bauxite Region in Central Arkansas

By Noel H. Stearn

INVESTIGATION AND ACKNOWLEDGMENTS

The magnetic field work on which this report is based was started in the summer of 1928 in connection with a regional survey of the oil and gas passibilities of an area included in Pulaski, Lonoke, Arkansas, Jefferson, Grant, Saline, and Hot Spring Counties, made for Leo Yount, Inc., of El Dorado, Arkansas, and W. C. McBride, Inc., of St. Louis, Missouri. The discovery of the striking relation between isolated igneous outcrops and areas of high magnetic intensity in T. 1 N., R. 11 W., gave rise to the idea of the present survey.

In accordance with the primary objective of the Arkansas Geological Survey to provide new basic data which may be used to direct exploration for deposits of bauxite in central Arkansas, further magnetic field work was done during the summer of 1929 and the winter of 1929-30, in order to complete the data necessary for this report.

Appreciation is due Leo Yount, Inc., and W. C. McBride, Inc., for permission to use the body of magnetic data which covers approximately the eastern half of the surveyed area. For information relative to the distribution of bauxite and syenite, appreciation is due the Republic Mining & Manufacturing Company, Phillip A. Dulin of the Dixie Bauxite Company, and J. B. Brown.

To George C. Branner, State Geologist of Arkansas, the writer is especially indebted for painstaking assistance in the preparation of the report.

PURPOSE

The purpose of the survey here reported was twofold:

(1) To attempt to locate by magnetic exploration hitherto undiscovered masses of the nephelite syenite with which the bauxite deposits in Arkansas are associated.

(2) To obtain whatever evidence a magnetic survey might afford to determine the location and extent of the buried igneous province in central Arkansas.

LOCATION OF THE BAUXITE REGION

The bauxite region of central Arkansas as it is now known is divided into two mining districts, the Bauxite district, which is about 4 miles east of Benton, in Saline County, and the Fourche Mountain district, which is immediately south of Little Rock, in Pulaski County (see fig. 1). These two districts are separated by about 12 miles of hitherto unproductive territory. Most of the output is obtained from the Bauxite district. That portion of the region which contains bauxite outcrops or is known to be underlain by bauxite includes an area of approximately 3.8 square miles.

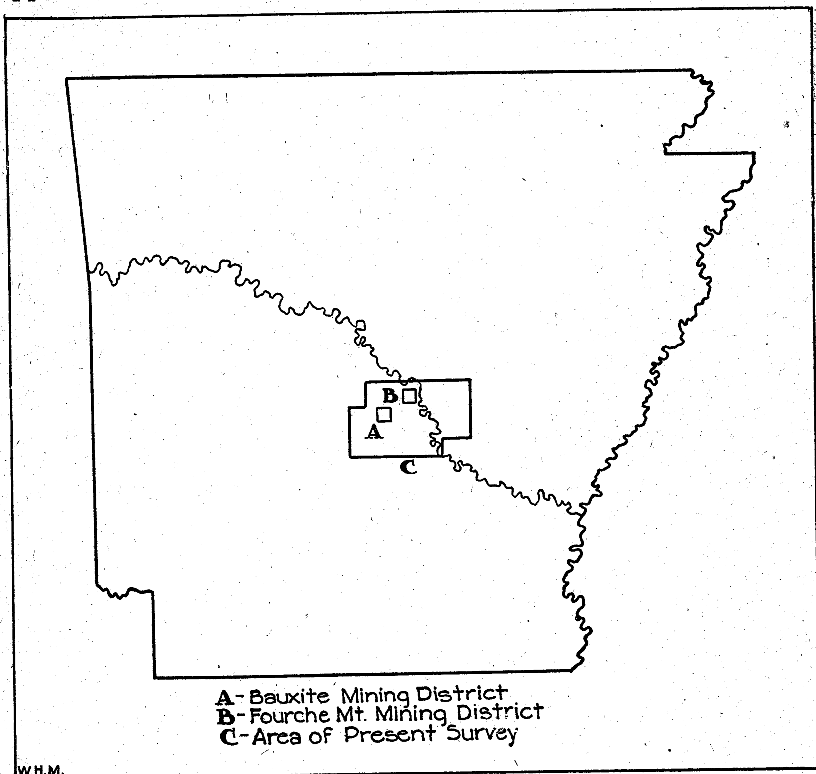


FIGURE 1.—Map showing location of the geomagnetic survey of the bauxite region in central Arkansas and the location of the bauxite mining districts.

GEOLOGY OF THE REGION

The geology of this region has been described in reports of the Geological Survey of Arkansas and the United States Geological Survey, and in several papers published in geological journals.[1]

The bauxite mining districts lie close to the geological feature in Arkansas known as the "shore line," which marks the boundary between the highly folded beds of Paleozoic slate, quartzite, and novaculite of the Ouachita Mountains and the nearly flat-lying beds of Tertiary clay, sand, and gravel of the Gulf Coastal Plain. The Tertiary formations are separated from the Paleozoic rocks by an overlapping unconformity, the general plane of which slopes southeastward at the

[1] See the appended bibliography.

rate of 104 to 112 feet to the mile, so that the surface of the Paleozoic rocks becomes progressively deeper toward the southeast. Protruding through the Tertiary sediments like islands at distances of 4 to 6 miles southeast of the "shore line" are masses of igneous rock, around which the Tertiary sediments have been deposited. These igneous masses consist chiefly of nephelite syenite (called blue and gray "granite" by common usage), but they include small intrusive dikes of very basic rocks such as fourchite and monchiquite. Flanking these protruding igneous masses, and apparently directly associated with them, are the known bauxite deposits, which occur in two distinct modes: (1) ore bodies of irregular shape and thickness, lying above or beside the igneous masses and grading into them; (2) ore bodies of apparently sedimentary origin, interstratified with the Tertiary deposits which surround the igneous masses.

ORIGIN OF THE BAUXITE DEPOSITS

In connection with any extensive exploration for bauxite, the problem first to be considered is that of the origin of the bauxite ores. Two theories of origin have been advanced:

(1) Dr. C. W. Hayes[2] holds that the bauxite is a result of the decomposition of syenite by heated alkaline descending water and the subsequent deposition of hydrous alumnium oxide during the later ascent and dilution of the same water.

(2) Dr. W. J. Mead[2] holds a theory that seems more nearly to fit the facts ascertained later. His conception of the origin of the bauxite deposits is as follows:

Large masses of nephelite syenite were intruded into folded beds of Paleozoic rock. Erosion subsequently removed the Paleozoic rocks overlying the nephelite syenite and exposed it to weathering. The bauxite ores were formed as lateritic deposits, or end-products of the weathering of the nephelite syenite. Because they were formed on the irregular surface of the exposed syenite, they suffered some contemporaneous erosion by streams. The entire area was then gradually covered by sediments of probable Tertiary age, consisting of clay, sand, gravel, and lenses of lignitic material. The areas of syenite and the associated deposits of bauxite suffered erosion contemporaneously with the deposition of the Tertiary sediments, but the superior resistance to erosion of the massive syenite caused it to stand in considerable relief above the surrounding areas of less resistant rocks on the Tertiary land surface, and some parts of the bauxite deposits were transported and interstratified with beds of sand and gravel around the border of the syenite area and in depressions within it.

[2] See the appended bibliography.

Post-Tertiary erosion has cut through the Tertiary sediments and exposed the underlying igneous rock and the bauxite.

The significant feature of this conception of the origin of the bauxite ores is that they were the result of the *surface weathering* of the nephelite syenite.

EXPLORATION OF THE REGION

In an exploration for bauxite two significant facts should be noted:

First, the known bauxite is genetically and geographically related to the known masses of igneous rock. It follows that the discovery of hitherto unknown igneous masses in this area may mean the discovery of associated deposits of bauxite.

Second, the known igneous masses and their associated bauxite deposits have been exposed by post-Tertiary erosion. It is therefore possible that post-Tertiary erosion has not proceeded far enough to expose all the igneous masses in the area; that there may still be buried igneous masses flanked with deposits of bauxite.

There is no limit to the depth at which these igneous masses may occur, but according to the theory of the lateritic origin of the bauxite expounded by Mead there is a definite limit to the depth at which they may be associated with bauxite. This limit is the depth of the surface of the Paleozoic rocks. Obviously no igneous intrusive mass in the Paleozoic rocks that was not subjected to the surface weathering necessary to form lateritic deposits would be expected to be associated with bauxite. The whole area whose surface rocks are of Paleozoic age is therefore eliminated from consideration in an exploration for concealed bauxite. Exploration is thus limited to the Coastal Plain region. But because the Paleozoic surface slopes southeastward beneath the Tertiary Coastal Plain sediments, there will be a limit beyond which any bauxite that might be discovered at this Paleozoic surface will lie too deep for economic exploitation. Of course this limit will shift with the shifting of economic factors, and even the present limit is not yet known.

There remains, however, an extensive area between and beyond the exposed igneous masses and between the "shore line" and the Arkansas River where the surface of the Paleozoic rocks may lie at depths of less than 2,000 feet and where exploration may disclose igneous masses not yet exposed by erosion. The remarkably close relations between the isolated exposures of igneous rock in T. 1 N., R. 11 W. and the areas of high magnetic intensity suggested that such concealed igneous masses might be located by the magnetic method.

The Magnetic Method of Exploration

The magnetic method of exploration is based on the fact that the earth acts as if it contained at its center a spherical magnet surrounded by a magnetic field of force. If this magnetic field were contained in a single homogeneous substance it would be perfectly symmetrical. But the outer shell of the earth lies within this magnetic field, and the earth's crust is composed of rock formations which differ in mineral content and therefore in magnetic permeability—that is, in their capacity to permit the passage of the "lines of force" which are conceived to define the earth's magnetic field. These lines of force crowd through rocks of high magnetic permeability and avoid rocks of low magnetic permeability. Thus there are local bunchings of the lines of force which produce regions of abnormally high magnetic intensity and there are regions of abnormally low magnetic intensity out of which the lines of force have been crowded into regions of high magnetic intensity. These abnormal regions are called magnetic anomalies because they are distortions of the ideal symmetry of the earth's magnetic field, and their presence indicates the existence in the earth's crust of substances having different magnetic permeabilities. The magnetic method of exploration, broadly speaking, consists in measuring by means of some instrument the anomalies that occur in the earth's magnetic field and interpreting them in terms of the geological formations that probably caused them. The measurement of the anomalies is direct and simple. The interpretation of the results is indirect and complex.[3]

The magnetic method is obviously most readily applicable to areas in which there are two types of rock having extreme differences in magnetic permeability. The magnetic permeability of a rock depends upon its mineral content, and, generally speaking, the higher its content of iron-bearing minerals the more permeable is the rock. Thus, although there are decided exceptions to this generalization, the iron content of the rock may be considered a qualitative index of its magnetic permeability.

Application of the Method to the Bauxite Region

In the bauxite region there are magnetic anomalies of three different orders of magnitude.

Anomalies of the first order of magnitude are caused by differences in the permeability of the various sedimentary formations that constitute the Paleozoic and Tertiary systems. For example, the permeability of the novaculite formation, which is composed of almost

[3] See Background for the application of geomagnetics to exploration, by Noel H. Stearn, Am. Inst. Min. and Met. Eng. Tech. Pub. No. 150.

pure silica, differs from that of the Tertiary clay that overlies it. But such differences are slight, and the anomalies caused by them are extremely minute, the variation being measurable at the most in tens of gammas[4] of magnetic intensity.

The differences in permeability between the bauxite deposits and the surrounding sediments are also of this order of magnitude. For this reason the small and irregular anomalies produced by the ore bodies themselves may be too slight to appear through the larger anomalies that are found throughout the area. Direct exploration for bauxite by the geomagnetic method may therefore be impracticable in this area.

Anomalies of the second order of magnitude are caused by the difference between the permeability of the acid igneous rocks (various phases of the nephelite syenite) and that of the rocks of the sedimentary formations. These anomalies are pronounced, being measurable in hundreds of gammas.

Anomalies of the third order of magnitude are caused by the difference between the permeability of the basic igneous rocks (fourchite and monchiquite) and the permeability of the sedimentary rocks and the acid igneous rocks. These extreme anomalies are measurable in thousands of gammas.

A general idea of the differences in the magnetic permeability of the rocks in the bauxite area may be obtained by comparing the iron oxide content of the various types of rock as shown by the following table:

ANALYSES OF THE ROCKS OF THE BAUXITE AREA[5]

	Eleolite (nephelite) syenite (massive)	Pulaskite (massive)	Eleolite (nephelite) syenite (dike)	Quartz syenite (dike)	Plagioclastic eleolite syenite	Fourchite (massive)	Amphibole monchiquite (dike)	Novaculite[6]	Tertiary clay (Wilcox), Saline Co.[7]	Tertiary limestone (Midway), Pulaski Co.[7]
SiO_2	59.70	60.03	59.23	62.96	58.74	42.03	43.50	99.45	67.92	12.12
Al_2O_3	18.85	20.76	19.98	13.45	20.85	13.60	18.06	.26	20.80	.97
Fe_2O_3	**4.85**	**4.01**	**4.72**	**3.54**	**4.15**	**7.55**	**7.52**	....	**1.40**	**.33**
FeO	....	**0.75**	....	....	....	**6.65**	**7.64**	....	....	....
FeS_2	....	....	....	....	....	**0.56**	....	....	....	....
TiO_2	....	....	....	....	....	3.70	2.10	....	.35	....
MnO	....	....	....	5.29	....	Trace	....	....	....	....
CaO	1.34	2.62	2.41	1.28	0.36	14.15	13.39	.12	.48	48.10
MgO	0.68	0.80	1.10	0.61	0.22	6.41	3.47	Trace	.09	.14
K_2O	5.97	5.48	5.76	5.19	4.23	0.97	1.30	.19	....	....
Na_2O	6.29	5.96	5.47	5.46	9.72	1.83	2.00	.54	....	....
P_2O_5	....	0.07	....	....	....	0.57	....	....	....	.12
H_2O	....	....	....	....	....	....	....	....	....	....
Ignition	1.88	0.59	1.38	2.77	1.82	1.08	1.22	.06	9.65	37.92
Total	99.56	101.07	100.05	100.55	100.09	99.10	100.20	100.62	100.69	99.70

[4] One gamma=1/100,000 of a gauss, C. G. S. unit of measure of magnetic force.

[5] The igneous rocks of Arkansas, by J. Francis Williams: Ann. Rep. Geol. Survey of Arkansas for 1890, vol. 2.

[6] Outlines of Arkansas mineral resources, by George C. Branner, p. 179.

[7] Information supplied by Arkansas Geological Survey.

The iron oxide content of the normal sediments in the bauxite region probably varies within $1\frac{1}{2}$ per cent; that of the acid igneous rocks between 4 to 5 per cent, and that of the basic igneous rocks between 14 to 20 per cent. The iron oxide content, however, cannot be considered a direct quantitative index of the magnetic permeability of a rock; it is merely a qualitative indication of a probable general order of magnitude of the permeability.

The anomalies of the order of magnitude first mentioned—that is, those caused by differences in permeability among the normal sedimentary formations of the region—although measurable, are not pertinent to the problems of this survey, for they are too minute for consideration in this connection. Within the region of major anomalies they are completely masked by anomalies of a higher order of magnitude. Elsewhere they may be amenable to measurement and interpretation. The presence in this region of anomalies of two other orders of magnitude gives rise to uncertainties in geological interpretation. For example, a pronounced anomaly in unknown territory might be attributed to an acid igneous rock near the surface or a basic igneous rock at greater depth. It is therefore desirable to make some estimate of the depth of the geological feature causing the anomaly. In certain places such an estimate can be made by simple vertical magnetic triangulation.

Magnetic Depth Finding

Magnetic depth finding is based on the principle of vector analysis. Any force can be studied as a vector quantity resolvable into any number of component forces. In figure 2, for example, the vectors H represent the actual recorded magnetic intensity by their length and the actual recorded magnetic inclination by their direction. The vectors H have been resolved into two components, Hn and Ha. The vectors Hn represent the normal magnetic intensity by their length and the normal magnetic inclination by their direction. The vectors Ha therefore represent the components of anomaly required to produce the resultant magnetic intensity H. The locus of intersection (P) of the extended components of anomaly (Ha) locates the position of the source of the anomalous force.

This method can best be applied in a situation where a single isolated point is the source of the anomaly and is surrounded by a homogeneous medium. Although this situation is geologically impossible, certain natural geological set-ups approach it closely enough to permit the use of the method. The method has been applied to three of the major local anomalies outlined by this survey and the results are given in this report.

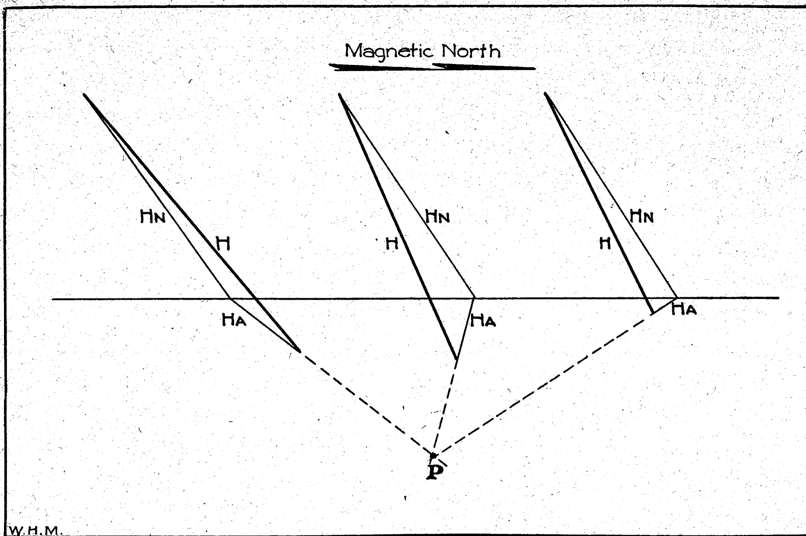


FIGURE 2.—Diagram showing the application of the magnetic triangulation method to depth finding.

THE MAGNETIC SURVEY

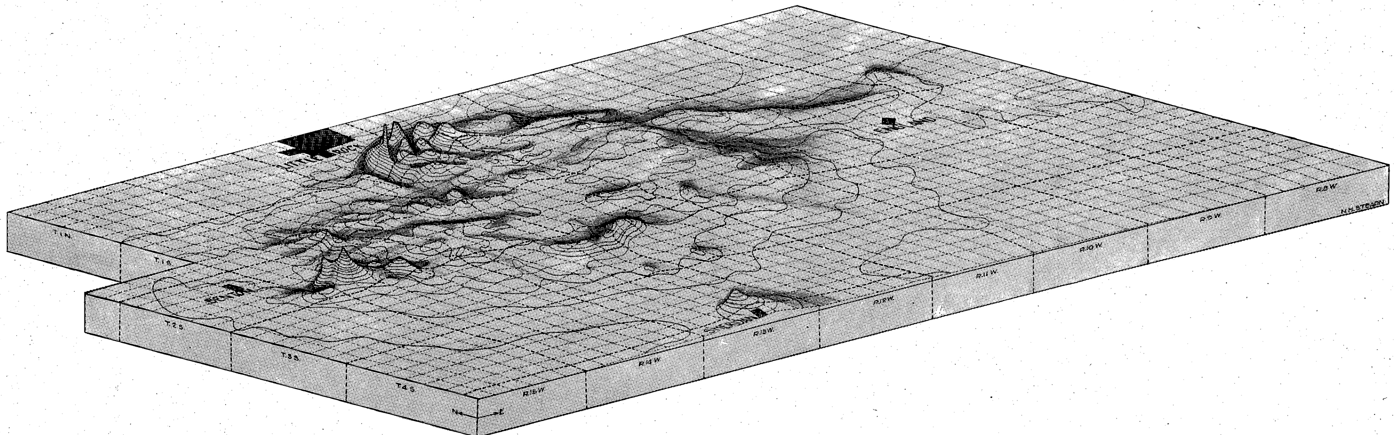
PROCEDURE

In making this survey the Hotchkiss superdip magnetmeter[8] was used to record variations in the intensity of the earth's magnetic field. The instrument was so adjusted that it was sufficiently sensitive to measure the anomalies of the second and third orders of magnitude already described without responding appreciably to anomalies of the first order.

Magnetic readings were taken at about 1,300 stations over an area of approximately 1,100 square miles—nearly 31 townships. The average spacing is therefore about 1.6 stations per square mile, or 1 station for approximately 400 acres. Although this is the average for the whole survey, the spacing actually varies roughly with the distance from the "shore line." The observations made near the "shore line" are spaced at intervals of about half a mile.

The interval lengthens eastward to a little more than a mile in the region east of the Arkansas River. This change in the interval is in accord with the change in the inferred depth to the masses causing the magnetic anomalies. The shallower these masses lie the less diffused is their effect at the surface, and therefore the smaller the station interval necessary to detect them. In the southwestern part of the area the stations are more widely spaced. This difference is made partly because of the inaccessibility of the region in winter and

[8] The Hotchkiss superdip: A new magnetometer, by Noel H. Stearn: Bull. Am. Assoc. Pet. Geol., vol. 13, No. 6, June, 1929.



ISOMETRIC PROJECTION SHOWING THE MAGNETIC INTENSITY OF THE BAUXITE REGION IN CENTRAL ARKANSAS partly because the existing stations seem sufficient to outline adequately the region of magnetic anomaly.

The stations average only 1 for each 400 acres, so that the present survey is purely a reconnaissance, designed only to outline the general magnetic features of the region and to indicate zones or areas of special interest.

In addition to the reconnaisssance survey three local transverses with a station interval of 440 yards were run to obtain depth-finding data.

The magnetic readings were corrected for differences in temperature, for diurnal variation in magnetic intensity, and for differences in latitude and longitude, so that the figures obtained give the measure of the actual anomaly. These figures were then reduced to approximate gamma values. The middle error is estimated at ± 40 gammas. The results were plotted on a map, and isanomalous lines, or lines of equal variation in magnetic intensity, were drawn with these values as control. This procedure of course, introduces the assumption that the magnetic intensity changes uniformly between two stations having different values. A magnetic reading represents only the precise spot where it was taken, just as a drill core in an ore body represents only the ore in the core. But as values are assumed between drill holes, so values are assumed between magnetic stations; and as intensive drilling is likely to change the assumed value of an ore body, so a detailed magnetic survey is likely to change the shape of a magnetic anomaly. Thus a reconnaissance magnetic survey is only a feeler to locate magnetic anomalies.

Results

The results of the survey are shown on Plate I, "Map Showing Reconnaissance Survey of the Magnetic Intensity of the Bauxite Region in Central Arkansas" (in pocket). The significant features of the survey are shown on Plate II.

Immediately outstanding are two features: First, a general area of high magnetic intensity lying between Little Rock, Benton, Sheridan, and England; and, second, the presence within this area of pronounced local anomalies. The magnograph presents merely the facts regarding the earth's magnetic field. Interpretations drawn from these facts are only inferences.

General Igneous Area

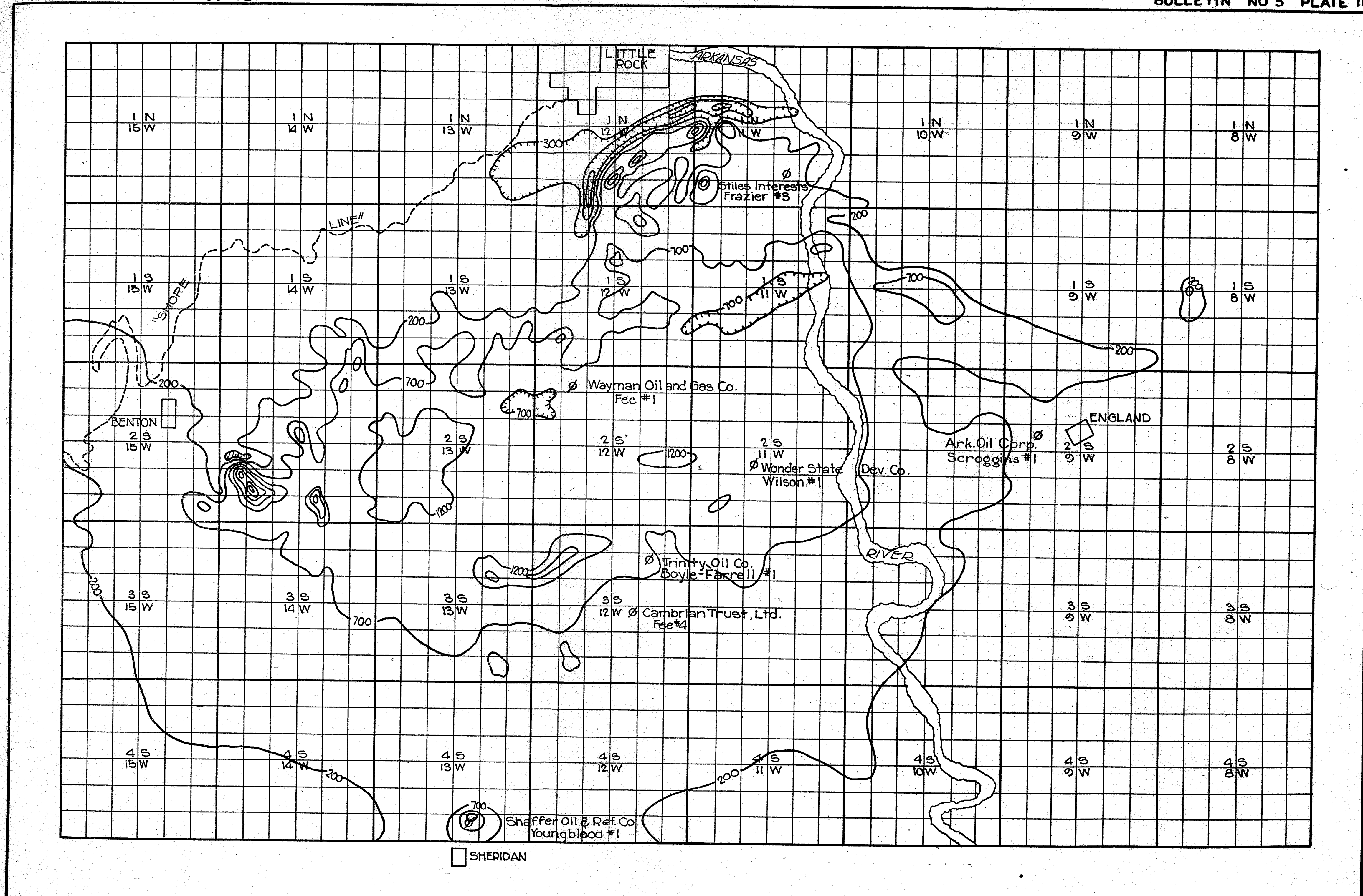
Plate III serves to clarify the outlines of the general area of high magnetic intensity. Over a territory of nearly 400 square miles there are variations in magnetic intensity ranging from about 1,500 gammas below the assumed normal to about 4,100 gammas above it. These variations are most pronounced in the vicinity of the two areas of igneous outcrop, one just south of Little Rock and the other just east of Benton, but over a territory of at least 340 square miles there is an anomalous increase in intensity of more than 500 gammas.

Because of its extent and its shape, because of the order of magnitude and the irregularity of the local magnetic anomalies within it, and because of the connection between certain of these local anomalies and the known exposures of igneous rock, this area of high magnetic intensity is supposed to be caused by an extensive igneous province whose limits correspond roughly with those of the area of anomaly.

OUTLINES

The general outlines of this inferred igneous province are shown by Plate IV. Throughout this province igneous rocks probably occur at depth, but the depth certainly varies as extremely as the irregularities of an intruding magma would naturally vary. For example, within this area the Wayman Oil & Gas Company Fee No. 1 well, in sec. 5, T. 2 S., R. 12 W., was drilled, as reported, to a depth of 3,410 feet without encountering any rock recognized as igneous, although its bottom is in a rock classified by the driller's log as "black hard sand," which might be a basic igneous rock. The Stiles Interests Frazier No. 3 well, in sec. 27, T. 1 N., R. 11 W., is reported to have reached a depth of 1,005 feet. The log of this well shows no igneous rock, but an unconfirmed driller's report indicates that the drill may have encountered igneous rock at a depth of about 740 feet. The Wonder State Development Company's Wilson No. 1 well, in sec. 21, T. 2 S., R. 11 W., encountered a granitic rock at a depth of 1,544 feet and penetrated it 3 feet, until it became so hard that no further progress could be made. The Trinity Oil Company's Boyle-Farrell No. 1 well, in sec. 11, T. 3 S., R. 12 W., reached a depth of 2,003 feet, ending in unclassified "hard rock," into which the drill penetrated about 3 feet. The Cambrian Trust Ltd. Fee No. 4 well, in sec. 22, T. 3 S., R. 12 W., which is at the very edge of the igneous province, went to a depth of 2,064 feet without encountering recognized igneous rock. These are the only wells within the hypothetical boundaries of the igneous province that reached sufficient depths to be significant.

Plate III shows that the northwest boundary of the area of high magnetic intensity is more abrupt than the south and southeast boundaries. This abruptness may be due to the shallower depths of the igneous rocks in the northwestern part of the area. The magnetic effect of igneous rocks that lie at great depths becomes diffused at the earth's surface. The south and east boundaries of the igneous area



MAP SHOWING OUTLINES OF THE AREA OF HIGH MAGNETIC INTENSITY IN CENTRAL ARKANSAS are therefore less precise than the northwest boundary. It is impossible to estimate the degree of precision represented by the hypothetical boundaries to the igneous province as shown on Plate IV. All that can be said is that they are approximately correct.

An area of low magnetic intensity flanks the northern extension of the igneous province, bordering the outcrop of igneous rock in the Fourche Mountain district. This area of low intensity is the natural result of the relation between the inclination of the earth's magnetic field and the center of magnetic mass of the intrusive igneous rock and indicates an abrupt and steep termination of the igneous mass.

OUTLIERS

Beyond the hypothetical limits of the igneous province there are what seem to be outlying igneous plugs, which cause the local magnetic anomalies in T. 1 S., R. 8 W., northeast of England, and in T. 4 S., R. 13 W., near Sheridan (see Pl. III). The fact that the igneous province is fringed on the east and south by such plugs is established by the discovery of similar anomalies 3 miles northwest of Rison and 3½ miles southwest and 5 miles west of Pine Bluff. Drilling has shown that the magnetic anomalies near Rison and Sheridan[9] are caused by masses of basic igneous rock such as might occur in plugs. It is therefore reasonable to suppose that the other similar anomalies have similar causes.

The magnetic triangulation method of depth-finding was first tested over the outlying igneous plug near Sheridan, the approximate depth of which has been established by drilling.

The depth-finding traverse was run along the Sheridan-Little Rock highway, which passes about 330 feet east of the Shaffer Oil & Refining Company's Youngblood No. 1 well. The plotted depths indicate that the peak of the plug encountered by the well lies about 600 feet south of it, at a depth of about 2,130 feet. The well is not exactly in the plane of the depth-finding profile. There is a discrepancy of about 66 feet, or 2.9 per cent, between the depth to the igneous plug recorded by the well log and the depth recorded by the magnetic triangulation method of depth-finding, but the figure obtained may be considered an unusually close approximation, because the geological set-up is especially favorable. The isolation, apparent regularity, small size, and considerable depth of the plug all lend themselves to unusual precision of magnetic depth-finding results.

[9] Well near Sheridan—Shaffer Oil & Refining Company's Youngblood No. 1 well, in sec. 34, T. 4 S., R. 13 W. Well near Rison—Arkansas Natural Gas Corporation's Tate No. 1 well, in sec. 4, T. 9 S., R. 11 W. Other wells drilled on magnetic "highs" in the Coastal Plain of Arkansas which encountered igneous rocks are the Texas Company's Hammond No. 1 well, in sec. 23, T. 17 S., R 2 W., and the Texas Co.'s Gay No. 1 well, in sec. 33, T. 16 S., R. 4 W.

LOCAL ANOMALIES

Within the area of high magnetic intensity there are local pronounced variations. Many of these local anomalies are obviously associated with outcrops of the nephelite syenite (see sec. 20, T. 1 N., R. 11 W.; sec. 31, T. 1 N., R. 11 W.; sec. 3, T. 1 S., R. 12 W.; sec. 9, T. 1. S., R. 12 W.; sec. 1, T. 2 S., R. 14 W.; sec. 2, T. 2 S., R. 14 W.; sec. 34, T. 2 S., R. 14 W.) or of the basic fourchite (see sec. 33, T. 1 N., R. 12 W.). The magnetic stations are located fortuitously, so that a station falls upon an igneous outcrop only occasionally. A detailed survey of the magnetic variations of the outcrops themselves might show that they reflected even more faithfully the masses of known igneous rock. However, the coincidences between igneous outcrops and magnetic anomalies are sufficient to establish a relation of cause and effect between them which can logically be extended to local anomalies that are unassociated with surface igneous rocks.

The most striking of these local anomalies is that found in sections 29, 30, 31, 32, T. 2 S., R. 14 W. This anomaly, the maximum recorded reading of which is about 4,128 gammas, is of an order of magnitude comparable to that obtained over the outcrop of fourchite in sec. 33, T. 1 N., R. 12 W. It is also comparable to that obtained over the plug of diamond-bearing peridotite near Murfreesboro,[10] and the basic igneous rocks near Rison and Sheridan.[11] The inference is therefore

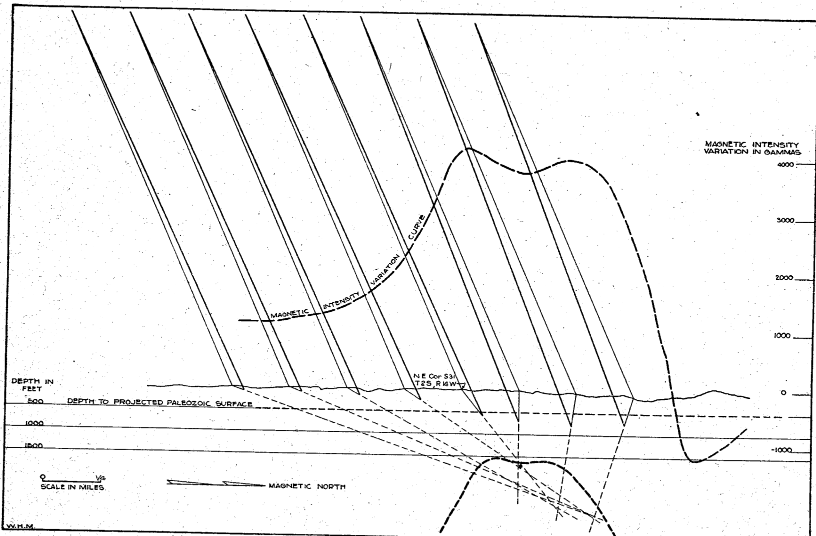
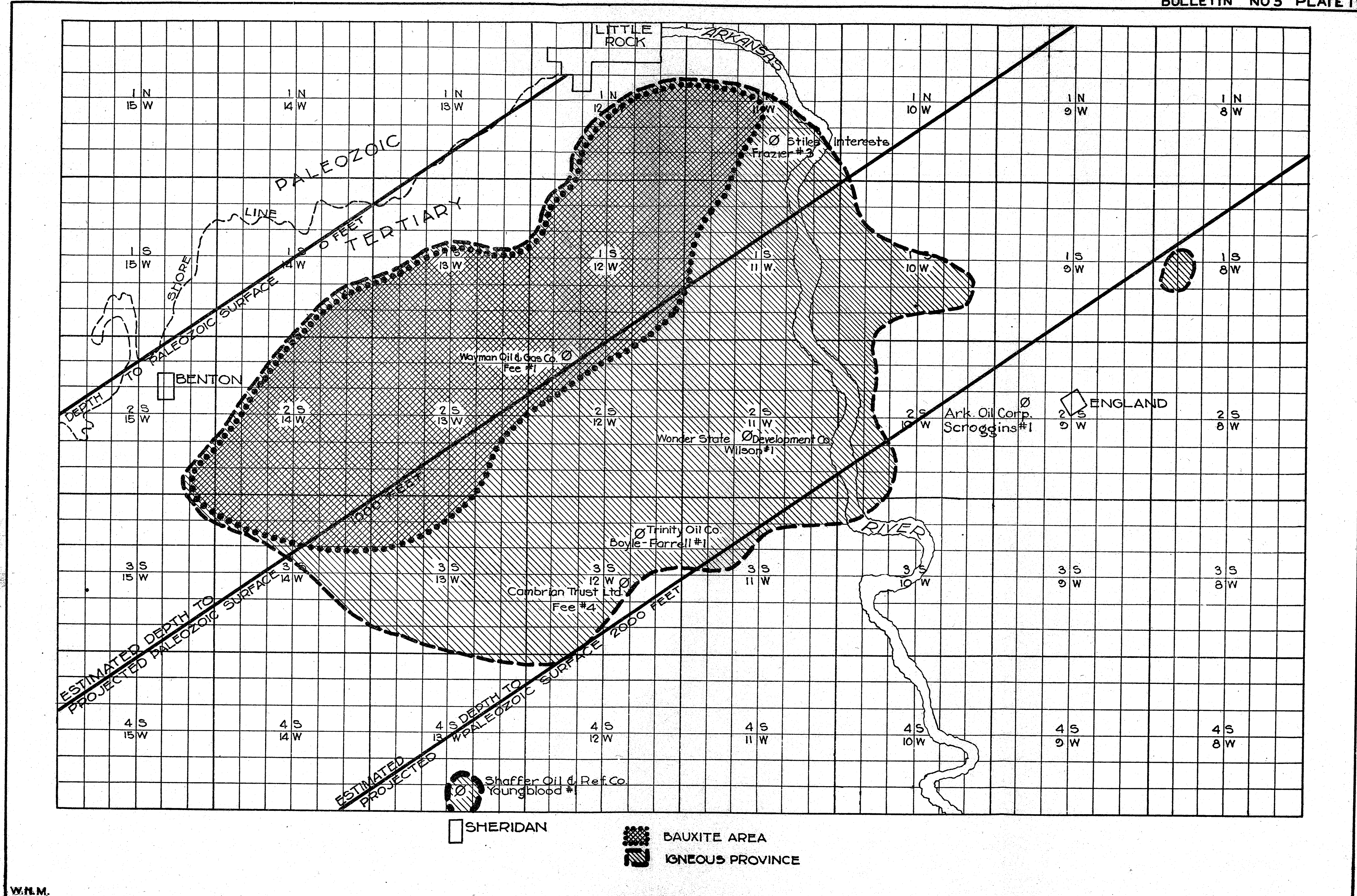


FIGURE 3.—Diagram showing application of the magnetic depth finding method to anomaly in the southwest portion of T. 2 S., R. 14 W.

[10] Diagnostic report on a geomagnetic survey of the diamond-bearing area of Arkansas, by Noel H. Stearn, furnished by courtesy of Leo Yount, Inc., El Dorado, Arkansas, and W. C. McBride., Inc., St. Louis, Mo.

[11] Report on the oil and gas possibilities of the eastern extension of the Ouachita Uplift, by Noel H. Stearn and George C. Branner, furnished by courtesy of Leo Yount, Inc., El Dorado, Arkansas, and W. C. McBride, Inc., St. Louis, Mo.



MAP SHOWING HYPOTHETICAL BOUNDARIES OF THE IGNEOUS PROVINCE AND THE BAUXITE AREA IN CENTRAL ARKANSAS unavoidable that this anomaly is caused by a basic igneous rock. The shape of the anomaly suggests an irregular plug or a short, thick dike, and its abruptness suggests that the cause of it lies relatively close to the surface.

Although several factors here, including proximity to the igneous outcrops with their high magnetic anomalies, irregularity of shape, variation in magnetic intensity, and probable shallow depth, are not likely to yield precise results by the magnetic triangulation method of depth-finding, a magnetic north and south depth-finding traverse was run from northeast corner of sec. 31, T. 2 S., R. 14 W. Figure 3 shows the plotted results of this survey and the interpretation of the data obtained. The depth to the crest of the inferred basic intrusive in the plane of the depth-finding profile is indicated as approximately 1,600 feet. The error here may be much greater than that in the measurement of the depth of the Sheridan plug, on account of the difference between the geological conditions surrounding the two intrusives. If the percentage of error here is 20 per cent the depth to the crest of the intrusive would be between 1,280 and 1,920 feet.

These figures, broad as they are, have a definite significance. The depth to the projected Paleozoic surface in the vicinity of this anomaly (see Pl. IV) is approximately 500 feet. If the crest of the intrusive causing the anomaly lies even at as shallow a depth as 1,200 feet, it never reached the Paleozoic surface. It is therefore of no interest in an exploration for bauxite unless it is intruded into a

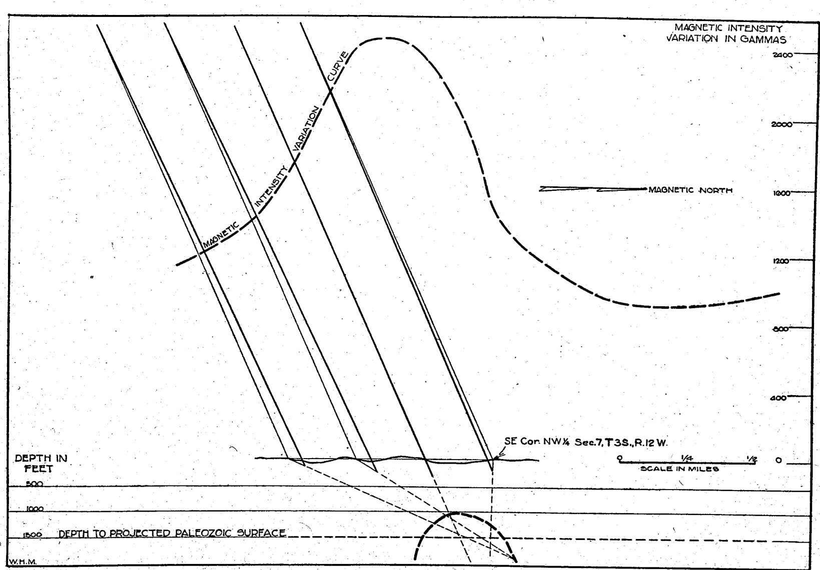


FIGURE 4.—Diagram showing application of the magnetic depth finding method to anomaly in the north portion of T. 3 S., R. 12, 13 W.

nephelite-syenite mass that reached the Paleozoic surface, but it may be of economic interest as a possible diamond-bearing plug.

Another impressive local anomaly that is unassociated with any igneous exposure extends from sec. 11, T. 3 S., R. 13 W., to sec. 4,, T. 3 S., R. 12 W. Here again the order of magnitude of the anomaly, the maximum recorded reading of which is about 2,408 gammas, suggests that it is caused by a mass of basic igneous rock. The shape of the anomaly suggests a dike.

A depth-finding traverse was run along the Little Rock-Sheridan highway where it crosses the anomaly along the range line between T. 3 S., R. 12 W., and T. 3 S., R. 13 W. Figure 4 shows the plotted results of this traverse and their interpretation. The diagram indicates a minimum depth of approximately 1,100 feet. With a possible error of 20 per cent the depth indicated would be between 880 and 1,500 feet. The projected depth to the Paleozoic surface in the vicinity of this anomaly is about 1,320 feet. Thus the indication is that this intrusive mass reaches the Paleozoic surface or even protrudes above it, as do the exposed igneous masses.

This anomaly, however, lies just south of the main body of igneous rock, so that the changes in the inclination of the earth's magnetic field over it might be materially influenced by the regional anomaly. Unquestionably there is some interference, for the source of the local anomaly (see fig. 4) lies north of the crest of intensity. An idea of the effect of this interference can be obtained by assuming that the regional anomaly causes a uniform variation of one degree in the inclination of the earth's magnetic field in the vicinity of the local anomaly. If this extreme assumption were true the minimum depth to the source of the local anomaly would be about 1,800 feet. If the 20 per cent allowable for error is sufficient to cover the effect of this interference the intrusive mass may reach the Paleozoic surface.

The other local anomalies in this province are of an order of magnitude that makes interpretation more ambiguous. They may be caused by the proximity of the nephelite syenite to the surface or by the presence of a basic rock, such as fourchite, at greater depth. At some places a concentration in the Tertiary sediments of magnetite derived by erosion from the fourchite might produce an anomaly, but as the known fourchite is of small extent this possibility is almost negligible.

POTENTIAL BAUXITE AREA

Plate IV shows the generalized boundaries of the area that is considered most favorable for prospecting for bauxite. Of course the possibility of the existence of bauxite throughout the entire igneous province and along its flanks cannot be ignored, but the area outlined may reasonably be preferred.

The outline of the large potential bauxite area shown in Plate IV is based on two considerations—first, the continuity of the zone of pronounced magnetic anomalies that embraces the two areas of igneous outcrop and extends across the intervening territory; second, the estimated depth to the projected Paleozoic surface, which within the boundaries of the potential bauxite area does not exceed 1,200 feet.

The continuous zone of magnetic anomalies connecting the two outcrops of igneous rock constitutes perhaps the first definite though not necessarily conclusive evidence in support of the long-maintained suspicion that the two areas of syenite outcrop are connected beneath the present surface.

The local magnetic anomalies (see Pl. III) in T. 1 S., R. 10 W.; T. 1 S., R. 11 W.; T. 2 S., R. 12 W.; T. 3 S., R. 12 W., and T. 3 S., R. 13 W., justify an interest in these areas also. It is perhaps noteworthy that the Wilson No. 1 well of the Wonder State Development Company, which encountered a granitic rock at a depth of 1,544 feet, is drilled directly on the projected strike of the magnetic anomaly in secs. 23 and 24, T. 2 S., R. 12 W. In these areas, however, exploration must be carried to a depth that may now be considered impracticable.

The area that holds the greatest promise for an exploration for bauxite covers about 165 square miles. This area is, of course, not everywhere underlain by bauxite, but exploration for bauxite within it has a legitimate and logical chance of discovering new deposits. Within this area there are certain smaller areas where local magnetic anomalies seem to indicate increased chances for successful prospecting. To test this area it will be desirable to undertake detailed exploration by magnetic or other approved geophysical means, to be followed by drilling. The proportion of this area actually underlain by bauxite is unpredictable but is undoubtedly small.

CONCLUSIONS

This survey furnishes a body of data which supplements the known geological data in such a way that it seems permissible to draw two valuable general inferences:

(1) That the potential bauxite-bearing region in central Arkansas can be extended to include an area of at least 165 square miles, within which certain localities appear to be preferable for prospecting for bauxite.

(2) That beneath the Coastal Plain of central Arkansas there lies an igneous province, nearly 400 square miles in extent, fringed with plugs and dikes of basic igneous rock.

The existence of this igneous province has already been suspected, but no definite evidence to support the suspicion has heretofore been presented.

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