Geologic Investigation of the Boyertown Magnetite Deposits in Pennsylvania

GEOLOGICAL SURVEY BULLETIN 995-D

A CONTRIBUTION TO ECONOMIC GEOLOGY

GEOLOGIC INVESTIGATION OF THE BOYERTOWN MAGNETITE DEPOSITS IN PENNSYLVANIA

By H. E. Hawkes, Helmuth Wedow, and J. R. Balsley

ABSTRACT

The magnetite deposits at and near Boyertown, Pa., consist of replacements of calcareous sedimentary rocks, both Paleozoic and Triassic, near the contacts of intrusive bodies of Triassic diabase. A zone along the northwest margin of the Triassic basin near Boyertown was considered a particularly promising location for the occurrence of the favorable calcareous host rocks and hence for the existence of undiscovered deposits of magnetite.

An exploration program based on this premise was conducted in 1943 and 1944. Two, deep diamond drill holes demonstrated the down-dip continuity of the principal magnetite deposit at Boyertown. A geologic and magnetic survey of a belt six miles west and three and a half miles northeast of Boyertown uncovered two relatively large magnetic anomalies in addition to the anomaly over the known deposit at Boyertown. In addition, five experimental airborne magnetometer traverses near Boyertown and an experimental ground magnetometer survey within the city of Boyertown were run.

INTRODUCTION

During the second half of the nineteenth century, the magnetite deposits at Boyertown were among the principal producers of iron ore in Pennsylvania. The mines were shut down shortly before the turn of the century and, except for a brief re-examination during the first World War, have not been reopened. A. C. Spencer (1908, p. 43–61) summarized all the available geologic information, including material from earlier papers by D'Invilliers (1883) and Willis (1886).

Since the appearance of Spencer's report, the magnetite deposits at Boyertown have twice been the subject of exploration programs. In 1916 and 1917 the Boyertown Ore Co., at that time owner of the property, pumped out the water in the principal workings and put down four exploratory diamond-drill holes in search of downward extension of ore. No production is reported for this period.

In 1943 and 1944, agencies of the Federal Government resumed exploration in the vicinity of the old mines and along a favorable belt on each side of Boyertown. During this period of activity, two diamond-drill holes were put down by the Defense Plant Corporation and logged by the U. S. Geological Survey; a magnetic survey in the immediate vicinity of the Boyertown deposits was made by the Bureau of Mines, and a geologic and magnetic survey of a belt six miles west and three and one-half miles northeast of Boyertown and five trial aeromagnetic traverses were made by the Geological Survey. The entire program was undertaken at the recommendation of the War Production Board.

The purpose of the present report is to place on record the significant data that have become available since Spencer's report in 1908.

With the growth of the city of Boyertown, all the former mine properties have been subdivided and sold as residential and commercial lots. Thus, at the present time the old workings all lie directly beneath built-up sections of the city, a factor that might complicate any plans to reopen the mines. A spur of the Reading Company railway connects Boyertown with the main line at Pottstown, seven miles to the south. Good highways lead from Boyertown to Reading, Pottstown, Philadelphia, and Allentown.

The Geological Survey project was under the direction of A. F. Buddington. Hawkes and Wedow conducted the bulk of geological and ground magnetometer investigation; Balsley was in charge of the aeromagnetic survey. B. F. Leonard assisted with the geologic mapping; Patricia W. Wedow and Roy Shuler assisted with the ground magnetic surveys. The Defense Plant Corporation has kindly given permission to publish their diamond-drill data on the Boyertown magnetite deposit. Especially valuable assistance was rendered by Mr. J. Ross Corbin, resident engineer for the Boyertown Ore Co. during the exploratory work in 1917. Mr. Corbin gave the writers copies of the geologic records of the diamond-drill holes put down in 1917, together with much other unpublished information.

GEOLOGY

The magnetite deposits at Boyertown are situated at the northwestern edge of a belt of Triassic rocks extending through New Jersey and southeastern Pennsylvania into Maryland (fig. 11). The Triassic sedimentary rocks with associated intrustions of diabase constitute a sedimentary basin underlain and surrounded by older formations of early Paleozoic and pre-Cambrian age.

ROCK TYPES

The distribution of the principal rock types in the vicinity of Boyertown is shown in figure 12 and plates 16, 17, and 18. In plate 16 all pre-Triassic rocks are grouped, and in figure 12 and plates 17 and 18 the pre-Triassic rocks are differentiated as Cambrian-Ordovician and pre-Cambrian.

PRE-CAMBRIAN

The oldest rocks of the Boyertown area are the complex pre-Cambrian gneisses, marbles, and associated igneous rocks of the Reading prong to the northwest of the Triassic basin. In the vicinity

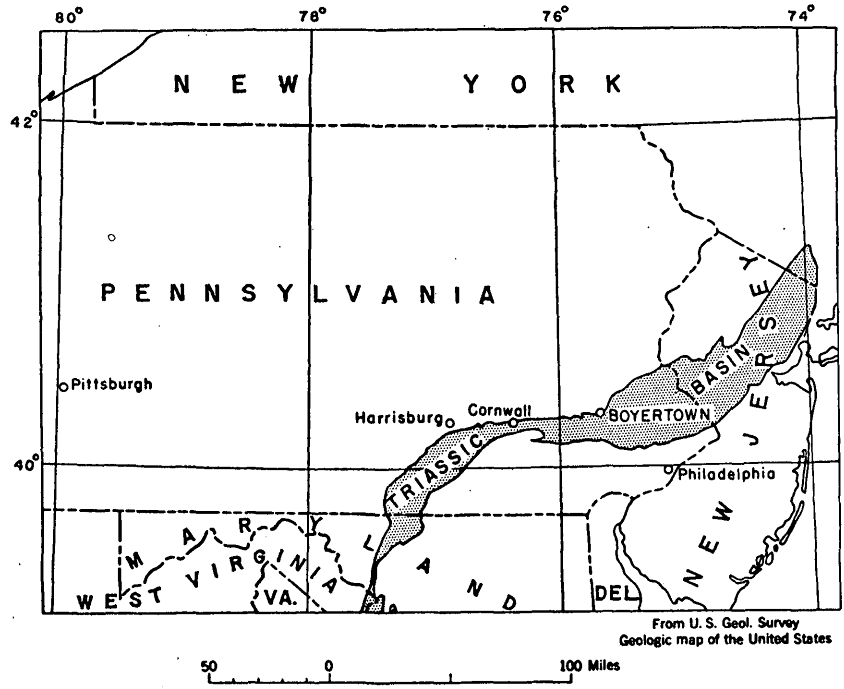

FIGURE 11.—Index map showing location of Boyertown and Triassic basin, Pa.

of Boyertown most of the rocks of the pre-Cambrian complex contain disseminated magnetite as a normal accessory mineral. The magnetic effect of such magnetite-bearing rocks is adequate to explain the anomalies observed in the pre-Cambrian areas. This effect is in no way related to any Triassic magnetite mineralization. The magnetic intensity observed over rocks of the pre-Cambrian complex ranges within wide limits from low over granitic gneisses to high over basic gneisses. Table 1 gives the average, maximum, and total range of magnetic observations over these and other rock types in the Boyertown area.

TABLE 1.—*Magnetic expression of rock types, vicinity of Boyertown, Pa.*

Rock type	Magnetic expression in gammas		
	Approximate average	Maximum observed value	Total observed range
Triassic:			
Diabase	+400	[1] +1, 000	1, 580
Metamorphosed sedimentary rocks	+500	[1] +1, 000	1, 310
Fresh sedimentary rocks	0	+80	130
Paleozoic sedimentary rocks	+70	+330	330
Pre-Cambrian gneisses	+300	+1, 310	1, 350

[1] In Triassic rocks the 1,000 gamma value was arbitrarily chosen as the threshold between normal magnetic response and anomalous magnetic indications of possible economic interest (see table 5).

CAMBRIAN-ORDOVICIAN

The pre-Cambrian complex is overlain by a Cambrian-Ordovician sequence consisting, in the order of deposition, of a basal quartzite, a section of limestones and dolomites with minor interstratified quartzite, and a shale formation. These apparently correspond with the "No. I" sandstone, the "No. II" limestone, and the "No. III" shale of the Second Geological Survey of Pennsylvania (D'Invilliers, 1883). Accurate mapping of contacts within the Paleozoic sequence was not feasible because of the scarcity of outcrops. At the Boyertown mines the limestone formation is the host rock for the magnetite ore. As seen in diamond-drill cores from Boyertown, the limestone is white to steel gray, fine grained, and massive. Where it has been locally metamorphosed by diabase intrusions, the limestone has been largely altered to a complex of secondary silicate minerals.

Except in areas of magnetite mineralization, the Paleozoic sedimentary rocks are apparently nonmagnetic; the observed magnetic features over unmineralized Paleozoic rocks are probably largely or entirely the effect of the high magnetic relief due to disseminated magnetite in the underlying pre-Cambrian complex.

TRIASSIC SEDIMENTARY ROCKS

The most abundant Triassic sedimentary rocks are shale and sandstone. In many places near the northwestern border of the Triassic basin, these pass abruptly into conglomerates. Where the basin is flanked by the Paleozoic limestone formation, the border conglomerates commonly contain coarse cobbles of massive white limestone. The data of the magnetic survey in the vicinity of Boyertown indicate that, in the absence of metamorphism, the Triassic sedimentary rocks are essentially nonmagnetic.

Near intrusions of diabase the Triassic sedimentary rocks are locally metamorphosed to a hard, fine-grained, flinty rock known as "hornstone." The most conspicuous chemical effect of the baking is the reduction of the ferric oxide to produce a rock that is progressively pale pink or purplish, pale green, and greenish grey. Magnetite is a common alteration product, as indicated by the strong magnetic relief observed over areas of "hornstone." Another effect is the local silication of carbonate-bearing rocks to produce chlorite, garnet, a green amphibole, and probably a pyroxene. Fracture fillings of clear gypsum and large spangles of black, specular hematite replacing limestone pebbles are locally conspicuous in the drill cores from Boyertown. Many of the prominent hills in the Triassic basin are formed of "hornstone," which is relatively resistant to weathering.

TRIASSIC DIABASE

Dikes, sills, sheets, and irregular bodies of diabase intrude the Triassic sedimentary rocks. Where fresh, the diabase is dark grey, massive, and medium to coarse grained, except at the contacts, where fine-grained, chilled selvages occur. Magnetite is disseminated throughout the diabase as indicated both by thin-section study and by the relatively high magnetic intensity values associated with diabase as compared with unmetamorphosed Triassic sedimentary rocks. The diabase is more resistant to erosion than the Triassic sedimentary rocks, though commonly not as much so as the "hornstone."

QUATERNARY ALLUVIUM

The portion of the valley of West Swamp Creek shown in plate 17 is largely covered by a mantle of coarse alluvium consisting entirely of fragments derived from the pre-Cambrian upland to the northwest. Cobbles of gneiss up to a foot in diameter are common. The thickness, distribution, and coarse texture of this material suggest that it was deposited by a stream far more active than the present West Swamp Creek, perhaps during the melting of the ice front at the close of the Pleistocene. Areas of alluvium are shown on plates 17 and 18 only where they obscure the bedrock structure.

STRUCTURAL GEOLOGY

Faulting has been active along the northwest contact of the Triassic basin near Boyertown. The areal geologic pattern of plate 18 suggests a northeast-trending fault separating the Cambrian-Ordovician rocks from the pre-Cambrian complex to the northwest. The attitude of the fault plane, the direction of movement, and the age of faulting could not be determined.

Evidence from study of drill cores at Boyertown indicates fault movement along the basal contact of the Triassic sedimentary rocks with underlying Paleozoic limestone. Here also, the magnitude of the fault movement could not be determined.

The thick sequence of coarse conglomerates in the Triassic, lying directly against the contact, indicates that the fault was active at the time the sediments were laid down. The resulting contact surface may thus be a combination fault and unconformity and incidentally may have acted as the controlling factor in guiding the mineralizing solutions.

ECONOMIC GEOLOGY

A. C. Spencer (1908, p. 16), after an exhaustive study of all the magnetite deposits in the Triassic belt of Pennsylvania, concluded that ore is preferentially formed in calcareous rocks at or near the contacts of large masses of intrusive diabase. The calcareous host rocks may be either pre-Cambrian marble, Paleozoic limestones and dolomites, or Triassic limestone conglomerates.

At Boyertown the average dip of the northwest contact of the Triassic sedimentary rocks is about 35°, to the southeast, as illustrated by the structural contours on plate 19. The rocks directly beneath this contact are a complex of diabase and Cambrian-Ordovician limestones that have been subjected to varying degrees of metamorphism. Limestone lying within 200 feet of the lower contact of the Triassic sedimentary rocks is the host for all the known ore in the Boyertown mines (pl. 19). The Triassic contact thus serves as the upper limit for ore. The two principal ore bodies at Boyertown were the Gabel-Warwick and the Phoenix, both of which lie immediately below the lower contact of the Triassic sedimentary section (pl. 19). These bodies may join at depth, but exploration to date has not given a conclusive answer. The other smaller ore bodies are either isolated deposits or faulted segments of one of the principal deposits. The structure of these deposits is discussed at length in Spencer's report.

Spencer's plate IX shows several magnetite prospects lying within a few miles of the principal deposits at Boyertown. These include the Brower Mine, about 4,000 feet southwest of the Boyertown mines (pl. 18), the Fegley Mine, and two unnamed shafts about one mile southeast of Bechtelsville (pl. 17). The locations of the two unnamed shafts were taken by Spencer from the topographic map of Berks County, issued by the Second Geological Survey of Pennsylvania; neither Spencer nor the present authors found any evidence of old workings at either of these places. The location of one of the unnamed shafts apparently corresponds with the magnetic anomaly designated as a anomaly 1 on plate 17. The location of the other unnamed shaft does not correspond with any magnetic feature. This location may have been misplotted, as a caved shaft at a location not indicated on the earlier maps was found about a thousand feet east of this locality. (See pl. 17.)

DIAMOND-DRILL DATA

Since Spencer's report six exploratory diamond-drill holes have been put down to determine the continuity of the magnetite vein system down-dip from the old mine workings. The geologic data from these holes are given below.

DRILLING BY BOYERTOWN ORE COMPANY

The geologic records of the diamond drilling by the Boyertown Ore Company furnished by J. R. Corbin are given in table 2; locations of these holes are shown on plate 19. All the holes were drilled vertically. Elevations given in the table represent the present elevation of the ground surface at the drill site, determined with reference to the bench mark at the Boyertown Post Office. The sandstone and conglomerate referred to in these records are Triassic, and the limestone and quartz are Cambrian-Ordovician. The gneiss and diorite are probably diabase. Unfortunately, the core has been lost and no assay data are available.

DRILLING BY DEFENSE PLANT CORPORATION

The locations of holes A and B, drilled by the Defense Plant Corporation in 1943 and 1944, are shown in plate 19. Both holes were drilled vertically. Table 3 is a summary geologic record of cores from these holes prepared by the Geological Survey. Table 4 gives results of analyses of core samples from holes A and B done for the Defense Plant Corporation by the Mines Experiment Station, University of Minnesota. A weighted composite sample of the 32-foot mineralized section between 1167.9 and 1200.2 in hole B showed 31.47 percent magnetic iron, 0.02 percent Co, and 0.04 percent TiO_2 in addition to the elements listed in the table.

TABLE 2.—*Geologic record of drilling by Boyertown Ore Co., 1916–17, furnished by J. R. Corbin*

Hole no.	Elev. (in feet)	Depth in feet		Rock
		From—	To—	
1	401. 9	5	739	Conglomerate; traces of magnetite at 721 feet.
		739	1, 415	Limestone and quartz.
2	397. 3	10	954. 5	Conglomerate and sandstone.
		954. 5	967	Magnetite ore.
		967	1, 002	Magnetite and limestone.
		1, 002	1, 343	Limestone.
3	394. 7	27	891	Sandstone and conglomerate.
		891	992	Gneiss.
		992	1, 006	Limestone.
4	397. 8	8	810	Conglomerate.
		810	1, 111	Limestone.
		1, 111	1, 195	Black limestone.
		1, 195	1, 512	Limestone.
		1, 512	1, 679	Diorite.

TABLE 3.—*Summary geologic record of drilling by Defense Plant Corporation 1943–44*

Hole	Elev. (in feet)	Depth in feet		Rock
		From—	To—	
A	397.8	0	613	Triassic sandstone, grit, and limestone conglomerate, showing effect of increasing metamorphism with depth.
		613	636	Ore zone: Cambrian-Ordovician limestone (?) intensely sheared, and replaced by magnetite, hematite, limonite, and green silication products.
		636	688	Moderately altered diabase.
		688	713	Clay containing fragments of Cambrian-Ordovician quartzite (?).
B	391.6	0	1,049.7	Triassic sandstone, grit, and limestone conglomerate, showing effect of increasing metamorphism with depth.
		1,049.7	1,051.1	Contact zone: chloritic rock containing disseminated magnetite.
		1,051.1	1,072.1	Cambrian-Ordovician limestone with scattered chloritic zones containing disseminated magnetite.
		1,072.1	1,090.3	Altered diabase, original features almost completely obliterated, with scattered chloritic zones containing disseminated magnetite.
		1,090.3	1,167.2	Relatively fresh diabase; scattered chloritic zones containing disseminated magnetite.
		1,167.2	1,200.2	Ore zone: Cambrian-Ordovician limestone (?) almost completely replaced by magnetite, actinolite, chlorite, serpentine, and secondary calcite.
		1,200.2	1,209.0	Fine-grained fresh diabase chill zone.
		1,209.0	1,304.4	Massive medium- to coarse-grained fresh diabase.

TABLE 4.—*Analyses of core samples from diamond-drill holes A and B*

Hole	Footage	Percent Total Fe	Percent Fe removed by Magnetic Separation	Percent Soluble Fe	Percent SiO_2	Percent S	Percent Cu	Percent P
A	612–622	7.80	1.43	7.02	------	------	------	------
	622–627	6.87	.62	6.64	------	------	------	------
	627–631	21.07	14.75	20.76	------	------	------	------
	631–636	23.62	17.65	23.16	------	------	------	------
B	1167.9–1172.7	36.49	33.15	------	19.06	0.52	0.03	0.055
	1172.7–1174.7	16.91	5.54	------	40.92	.53	.03	.078
	1174.7–1186.8	37.50	32.54	------	24.32	.43	.05	.045
	1186.9–1188.2	13.05	.27	------	38.34	.57	.02	.059
	1188.2–1200.2	43.53	39.08	------	19.98	.54	.05	.011

INTERPRETATION OF DRILL DATA

Three of the six diamond-drill holes encountered magnetite replacing Cambrian-Ordovician limestone below the Triassic sandstones and conglomerates. This exploration work has not indicated the continuity of ore between the Phoenix and Gabel-Warwick ore bodies. However, if a substantial part of this area is mineralized, the chances are good for a fairly large reserve of unmined ore.

The rocks cut in hole B indicate two ages of diabase. The diabase section in this hole between 1072.1 and 1167.2 is highly altered and veined with magnetite-bearing material, suggesting that it had been emplaced prior to at least some of the magnetite mineralization. The lower diabase, below 1200.2, however, is fresh and entirely free of magnetite veining and probably either post-dates the ore or was emplaced contemporaneously with the formation of the ore. Much of the upper altered diabase was definitely recognized as diabase only after very careful study of the texture and mineralogy both in hand specimen and thin section. Such rock could easily have been misidentified in earlier investigations of the underground workings and drill cores. It is likely that rock reported in Corbin's, Spencer's, and the earlier records as syenite, gneiss, greenstone, serpentine, diorite, and in some places even limestone, may all be phases of the diabase.

MAGNETIC SURVEY DATA

The U. S. Bureau of Mines in 1943 made a magnetometer survey over and adjoining the known ore of the Boyertown deposits. The Geological Survey in 1944 rechecked some of this work, made a regional survey west and northeast of Boyertown in an effort to locate new deposits of magnetite, and conducted an experimental field tryout of the airborne magnetometer using data from the regional survey for magnetic control.

BUREAU OF MINES

The data of the Bureau of Mines magnetic project at Boyertown are presented in an unpublished report entitled "A magnetic survey of the Boyertown magnetite deposits located in Berks County, Pennsylvania," by F. W. Lee, H. E. Kuehn, and G. E. Dent, September 1943. The magnetic contours established by the Bureau of Mines over the Gabel-Warwick ore body are reproduced in plates 18 and 19.

The Bureau of Mines survey was extended to the northeast of the Gabel-Warwick area as far as Philadelphia Avenue. At the time of the survey, the area over the Gabel-Warwick ore body was an open field and relatively free of artificial magnetic disturbances. However, the area northwest of Second Street was within the built-up part of the city of Boyertown. An experimental resurvey of the area northeast of Second Street by the Geological Survey showed that the magnetic pattern resulting from geologic features is completely overshadowed by that resulting from man-made contributions to the magnetic field, such as steel-framed buildings, machinery, electrical transformers, and buried pipes. For that reason none of the magnetic data reported by the Bureau of Mines northeast of Second Street and southeast of Washington Street are believed to have any geologic significance.

GROUND SURVEY BY GEOLOGICAL SURVEY

The instrument used by the Geological Survey was an Askania Schmidt-type, magnetic vertical balance, noncompensated for temperature and set for a sensitivity of 16.4 gammas per scale division. Field procedure followed that outlined by Joyce (1937, p. 74–83).

The magnetic datum or zero-value was arbitrarily chosen as the average of values obtained over areas of Triassic sandstones west of Boyertown that are magnetically flat. Magnetic contours shown on the maps represent the excess or deficiency of the observed values with respect to this magnetic datum.

The ground magnetometer survey was extended from Boyertown along the contact of Triassic and pre-Triassic rocks as far as Eshbach on the northeast and Earlville on the west. Plates 17 and 18 and figure 12 present the data in the form of magnetic contours; observed magnetic values are not plotted on these maps because of space limitations. The location of the traverses in the area between plate 18 and figure 12 is indicated on plate 16. Inasmuch as the total magnetic relief in this area did not exceed 200 gammas, the data are of little or no economic significance and are not reported.

AIRBORNE MAGNETOMETER TRAVERSES BY GEOLOGICAL SURVEY

So far as the authors are aware, the first use of the airborne magnetometer in the Western Hemisphere as a geophysical prospecting instrument over known geological and magnetic conditions was made by a research crew under the direction of J. R. Balsley of the Geological Survey at Boyertown in April 1944. The equipment used was the AN/ASQ–3A Magnetic Airborne Detector developed at Bell Telephone Laboratory under Naval Ordnance Laboratory contract and subsequently modified under supervision of the Geological Survey to a geophysical mapping instrument.

Although this survey was chiefly experimental, the resulting data are of general geological interest. Two airborne traverses were run northeast of Boyertown to coincide roughly with ground traverses. Three other short traverses without magnetic ground control were run across the old workings at Boyertown. Location of these traverses are shown on plates 16, 17, 18, and 19, and the data are given

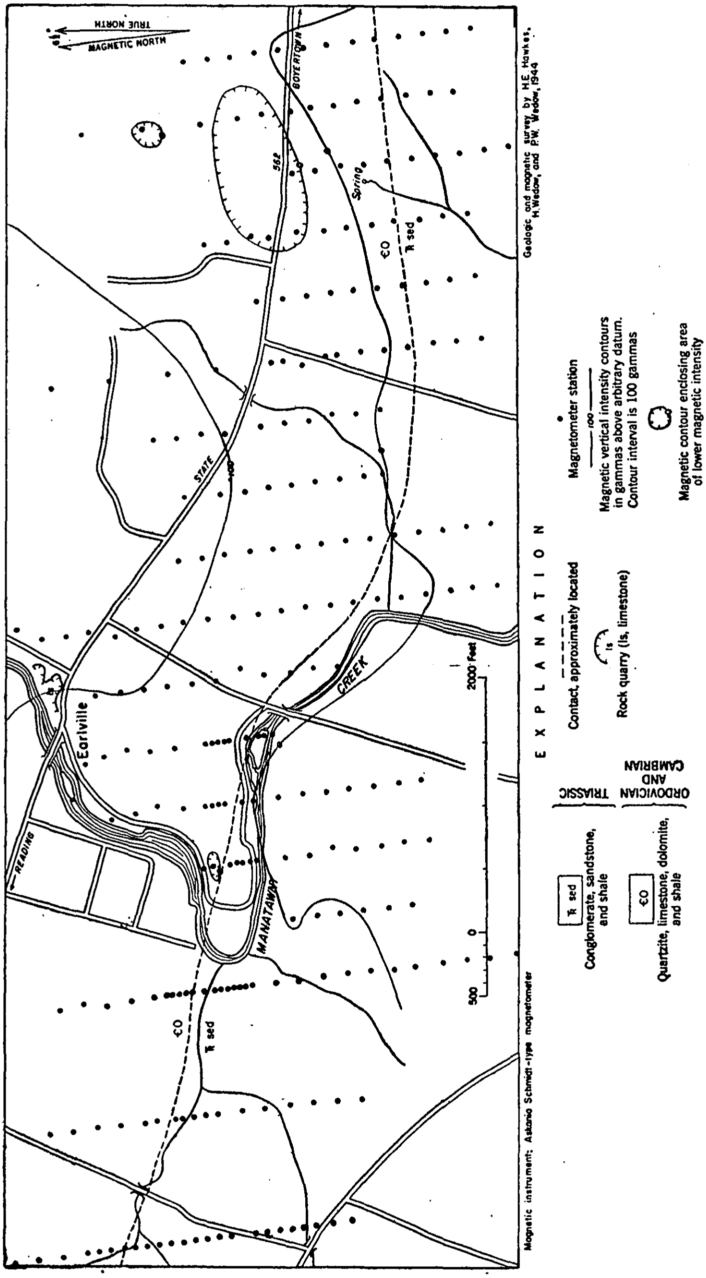

FIGURE 12.—Magnetic and geologic map of area in vicinity of Earlville, Pa.

in plate 20. It is interesting to note that the 600-foot and 900-foot aeromagnetic traverses over the city apparently reflect the magnetite ore bodies of both the Gabel-Warwick Mine and the Phoenix Mine. On the 300-foot flight these same magnetic features, however, are partially masked by the industrial anomalies that made much of the ground survey essentially useless.

INTERPRETATION OF MAGNETIC DATA

Plate 17 presents the data of the magnetic survey between Eshbach and New Berlinville, northeast of Boyertown. Two large areas of strong magnetic attraction, shown as anomalies 1 and 2, and two minor areas, shown as anomalies 3 and 4, were found within the limits of this area. A detailed magnetic map of anomaly 1 was issued by the Geological Survey in 1945 as press notice No. 109660 entitled "Magnetic anomaly near Bechtelsville, Pa." Although it is probable that all of these anomalies reflect deposits of magnetite, the degree of concentration of magnetite and the detailed dimensions of the deposit cannot be determined from the magnetic data alone without supplementary trenching or drilling.

Plate 18 shows magnetic data for the area immediately southwest of Boyertown, including the area over the Gabel-Warwick deposit at Boyertown. Observations at two stations southwest of the mines gave values greater than 1,000 gammas, shown on plate 18 as anomalies 5 and 6. Although it is possible that these together with the more continuous belt of intensity greater than 500 gammas reflects a mineralized zone at depth, it is more probably only the effect of disseminated magnetite in the metamorphosed Triassic sedimentary rocks.

Table 5 gives data on the relative areal extent and intensity of anomalies 1 to 6, together with corresponding data over the known magnetite deposits of the Boyertown area.

Figure 12 presents magnetic data in the vicinity of Earlville, six miles west of Boyertown. At this locality D'Invilliers (1883, p. 333) reports:

> Some strong indications of the presence of magnetic iron ore are next met with south of Earlville in Amity township, in the neighborhood of High's mill, where there is a large development of the Mesozoic conglomerate. No tests, however, have been made there to my knowledge, though there is a great deal of magnetic attraction.

The data of the present survey did not confirm D'Invilliers' observations, which may have been influenced by some erratic artificial attraction.

TABLE 5.—*Principal magnetic anomalies, Boyertown, Pa., and vicinity*

	For location see plates	Areas enclosed by 1,000 gamma contour, in square feet	Number of observations over 1,000 gammas	Maximum observed intensity in gammas
Anomalies over known magnetite deposits:				
Boyertown mines	18, 19	86, 000	61	2, 350
Brower mine	18	0	0	750
Fegley mine	17	1, 000	5	2, 020
Caved shaft 1,500 feet northeast of anomaly 1	17	0	0	880
Other anomalies:				
1	17	725, 000	174	3, 230
2	17	615, 000	9	1, 680
3	17	70, 000	5	1, 540
4	17	----------	1	1, 080
5	18	----------	1	1, 360
6	18	----------	1	1, 030

An attempt at correlation of the geologic and magnetic data of plates 17 and 18 and figure 12 show several significant relationships. It is apparently possible to relate rock types with the observed magnetic pattern, as summarized in table 1. It is also apparent that negative magnetic anomalies are commonly associated with large positive anomalies. These characteristically occur on the north sides of the areas of positive anomaly and appear to be the effect of north-seeking, or negative, magnetic poles induced by the earth's field along the north and under sides of magnetic bodies of diabase, hornstone, or magnetite ore.

CONCLUSIONS

The existence of magnetite down-dip from the old workings in the Boyertown magnetite deposits has been demonstrated by diamond drilling. No conclusions as to continuity, grade, and tonnage of ore in this extension are possible without more drilling.

Areal magnetic exploration has spotted two relatively large magnetic anomalies in addition to that over the known deposit at Boyertown. These are probably the surface magnetic effects of magnetite deposits buried at depth. Although the magnetic data indicate that the amount of magnetite in each of these deposits is considerably larger than that in the Boyertown deposits, no evidence was found to indicate whether that magnetite is sufficiently concentrated to be classed as ore. With the exception of four minor anomalies, the remainder of the area surveyed was shown to be relatively nonmagnetic and of no economic promise.

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