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AEROMAGNETIC INTERPRETATION AND MINERAL INVESTIGATIONS IN THE BOLU, ÇANAKKALE-KARABIGA, DEMIRKÖY, EZINE, AND ORHANELI AREAS OF NORTHWESTERN TURKEY IN 1968

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CONTENTS

ILLUSTRATIONS

(Plates are in pocket)

TABLES

AEROMAGNETIC INTERPRETATION AND MINERAL INVESTIGATIONS IN THE BOLU, ÇANAKKALE-KARABIGA, DEMIRKÖY, EZINE, AND ORHANELI AREAS OF NORTHWESTERN TURKEY IN 1968

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ABSTRACT

This report reviews progress made during 1968 in the continuing joint Maden Tetkik ve Arama Enstitüsü (MTA)-U. S. Geological Survey (USGS) Mineral Exploration and Training Project, Subproject 2. Subproject 2 is concerned with aeromagnetic interpretation of MTA's aeromagnetic surveys, and ground investigations of selected aeromagnetic anomalies. This report includes new aeromagnetic maps for the Bolu, Canakkale-Karabiga, Demirköy, and Orhaneli areas and reviews ground investigations in five areas. Activities for each area are summarized below:

1. Bolu area: The aeromagnetic map shows two belts of anomalies related to regional magnetite-bearing formations and a group of discrete anomalies, some of which may reflect significant concentrations of magnetite. To date three of these anomalies have been checked on the ground and at one a metamorphic rock containing 14 percent magnetite was observed.

2. Çanakkale-Karabiga area: Ground checks were made of six aeromagnetic anomalies. At one locality (Çakirli Köyü) 6 km south of Marmara Sea a small magnetite deposit was found. The magnetic anomaly

over the area is 150 meters long, and a pit 3 meters deep in the center of the anomaly exposed massive magnetite boulders.

3. Demirköy area: The aeromagnetic map shows only one significant anomaly which was checked on the ground and found to be caused by minor magnetite at an intrusive contact.

4. Ezine area: A ground survey of 4.5 sq km area was made where magnetite boulders are locally present on the surface. No significant magnetic anomaly or iron mineralization were found.

5. Orhaneli area: The aeromagnetic map of the area showed regional magnetic anomaly patterns related to magnetite in mafic intrusives, ultramafic rocks, and mafic flow rocks. In addition 16 localized anomalies were identified. Most of these anomalies were checked on the ground but no significant iron deposits were found. The largest deposit found was a one-meter wide magnetite vein.

During the 1969 field season further investigation of anomalies in the Bolu and Orhaneli areas is planned.

INTRODUCTION

Purpose and scope of investigation

This is the second of a series of progress reports for Subproject 2 (Aeromagnetic Surveys and Mineral Investigations) of the Maden Tetkik ve Arama Enstitüsü (MTA)-U. S. Geological Survey (USGS) Mineral Exploration and Training Project conducted under the auspices of the Government of Turkey and the Agency for International Development, U. S. Department of State. Subproject 2 aims to perform aeromagnetic surveys, interpret aeromagnetic maps, investigate aeromagnetic anomalies on the ground, and conduct detailed studies of mineralized areas detected by the aeromagnetic surveys. Simultaneously, the subproject aims to provide training and experience for MTA personnel in the above activities.

The first report in this series (Jacobson and others, 1972) summarized activities during 1967 in the Ezine, Çanakkale-Karabiga, Marmara, and Kapidağ areas of northwestern Turkey. The present report describes results of the following activities:

1. Additional ground investigations in the Ezine and Çanakkale-Karabiga areas.
2. Aeromagnetic surveys in the Demirköy and Orhaneli areas flown in 1967, and an aeromagnetic survey in the Bolu area flown in 1968.
3. Aeromagnetic interpretation and ground geologic and magnetic investigations in the Bolu, Demirköy, and Orhaneli areas.

Acknowledgments

This report could not have been prepared without the assistance of R. Ozakçay and his aeromagnetic map compilation group, who compiled data obtained by the MTA aircraft and crew under the leadership of K. Koroğlu, Chief Pilot. The writers were assisted in the field examination of aeromagnetic anomalies by MTA geologists, R. Boğaz, A. Çan, F. Çalapkulu, H. Filibeli, A. Gümrükçu, K. Inan, and M. W. Shadaydeh, and by A. Lisenbee of Pennsylvania State University. The writers are also grateful for the support and assistance received from F. Ozelci, Chief of the MTA aeromagnetic survey section.

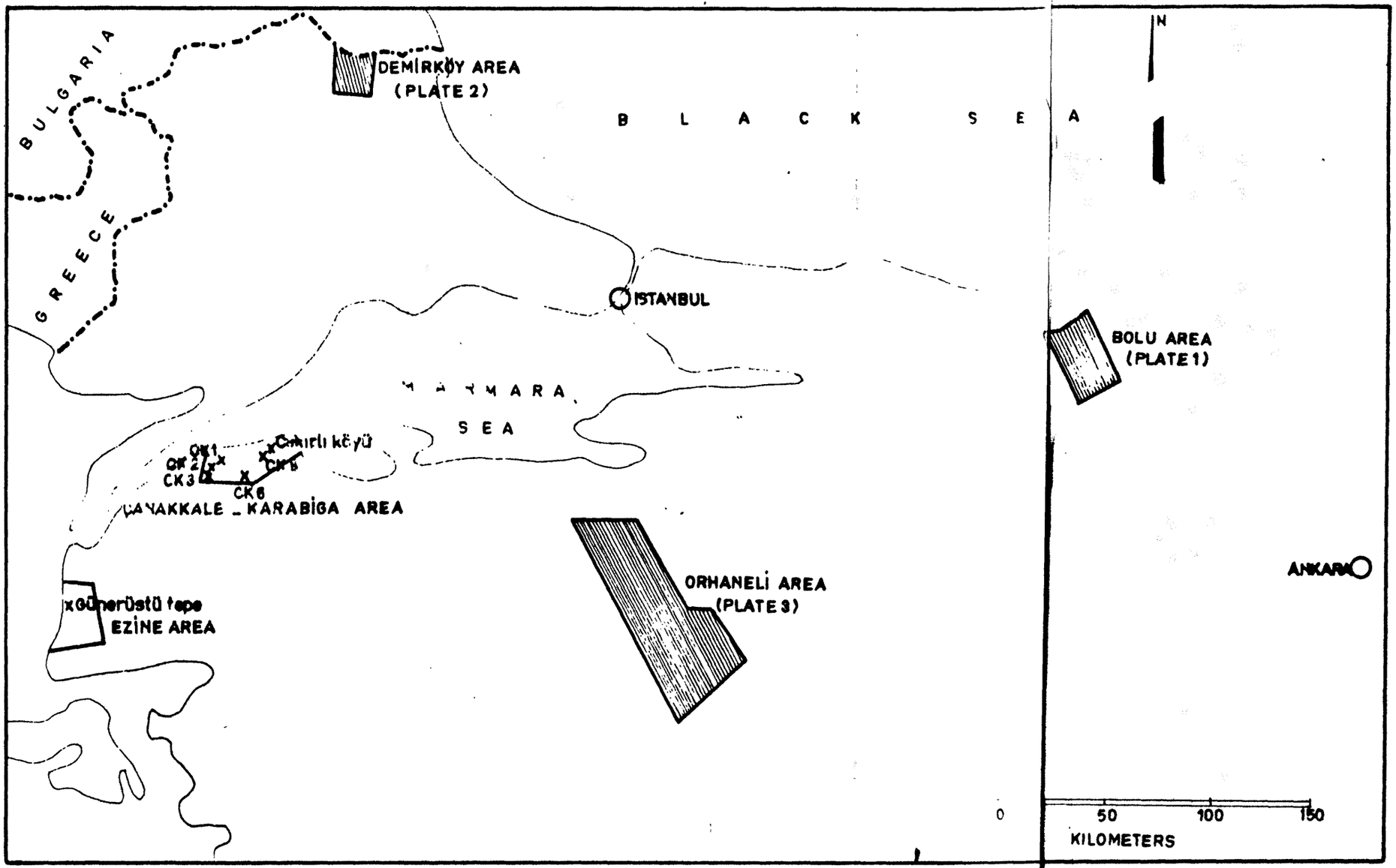
DESCRIPTION OF AREAS INVESTIGATED

The aeromagnetic surveys were conducted in five areas of northwestern Turkey (fig. 1) that have the following common characteristics:

1. Location near seacoast.
2. Granitic rocks intrude into older igneous, metamorphic, and sedimentary rocks.
3. Localized iron mineralization is present.

The geology of different areas is shown in general form on the geologic map of Turkey, 1:500,000 scale, published by MTA in 1964. In the Bolu area the granitic rocks intrude older mafic intrusive rocks and Paleozoic(?) metamorphic rocks that are partly surrounded by Silurian-Devonian sedimentary rocks and locally overlain by Cretaceous-Paleocene limestone. In the Çanakkale-Karabiga and Demirköy areas the granite intrudes Paleozoic(?) metamorphic rocks and very local mafic intrusives or serpentine. In the Ezine area the granite intruded

FIG 1



INDEX MAP OF NORTHWESTERN TURKEY SHOWING AREAS INVESTIGATED

AREA OF AEROMAGNETIC SURVEY AND GROUND INVESTIGATIONS (SEE ALSO PLATES 1.2.3)

AREA OF GROUND INVESTIGATIONS ONLY

x Anomaly examined

Permo-Carboniferous limestones that are metamorphosed to marble along the western margin of the granite. In the Orhaneli area the granites are surrounded by large areas of serpentinized ultramafic rock, Permo-Carboniferous limestone, and Paleozoic(?) metamorphic rocks. Part of the Orhaneli area is also covered by Tertiary (Neogene) sediments.

The aeromagnetic maps reflect the distribution of magnetite in all the areas. Magnetite is present as local small massive deposits as well as disseminated within various rocks. The largest magnetite concentrations are in mafic and ultramafic rocks and in some metamorphic rock units.

AEROMAGNETIC INTERPRETATION

Methods

The aeromagnetic interpretation emphasized the evaluation of aeromagnetic anomalies which would represent magnetic iron deposits. Little study was made of broad magnetic anomalies related to ultramafic intrusive stocks or other broad features. The specific methods of interpretation employed were discussed in the first report of this series (Jacobson and others, 1972).

Bolu area

Patterns related to magnetite-bearing rocks

The regional geologic trend in the Bolu area is N. 70° E. Sedimentary, volcanic, and metamorphic formations parallel this trend (Zonguldak Sheet of the 1:500,000 scale geologic map of Turkey, 1964). The volcanic and metamorphic formations are in mountainous terrain and contain accessory magnetite which results in regional aeromagnetic patterns (pl. 1).

Two magnetic anomalous belts are present:

1. The northern belt may be correlated with the Eocene volcanic series exposed 34 km northwest of Bolu. On the basis of a brief field check the magnetic anomalies in the belt are believed to be caused by magnetite in andesite.

2. The southern belt may be correlated with the metamorphic rocks exposed 10 km north of Bolu and adjacent areas. These rocks include gneiss, schist, amphibolite (1:500,000 scale geologic map of Turkey, MTA, 1964), and in one locality gabbro(?) contains considerable magnetite. Considerable topographic relief as well as variable magnetite concentration are the cause of the observed magnetic pattern.

Anomalies related to magnetite in metamorphic rocks

Anomaly B 11 (anomaly numbers shown on pl. 1 and accompanying maps and tables) was examined on the ground and was found to be caused by 14 percent magnetite in metamorphic rocks near an intrusive contact. The nearby anomalies B 8, B 9, and B 10 may have a similar cause.

Other anomalies

Table 1 lists eighteen aeromagnetic anomalies in the Bolu area which have been identified (pl. 1) but not yet investigated in the field. These include five anomalies which may possibly reflect a significant concentration of magnetite and are considered first-priority exploration targets. The remaining anomalies are weak or are located in areas of known magnetite-bearing rocks, but verification by means of a field check is necessary.

Table 1.--List of aeromagnetic anomalies and possible cause. (No field examination made.)

Area	Anomaly No.	Magnetic relief	Calculated depth (meters)	Possible causes
Bolu	B1	150	-	Unknown
	B2	100	-	Unknown
	B3	100	-	Unknown
	B4	300	-	Unknown
	B5	500	-	Unknown
	B6	500	-	Unknown
	B7	100	-	Unknown
	* B8	500	-	Magnetite in metamorphic rocks.
	* B9	700	-	" " " " "
	* B10	400	-	" " " " "
	B12	300	-	Unknown
	B13	600	-	Unknown
	B14	300	-	Unknown
	B15			
	* B16	500	-	Unknown
	B17	75	-	Unknown
	* B18	550	-	Unknown
	B19	200	-	Unknown
	B20	500	-	Unknown
	B22			
Demirköy	D2	Regional gradient	-	Magnetite in granite
	D3	100	-	Magnetite in gabbro
Orhaneli	OR1	450	225	Magnetite in basic rocks
	OR2	1000	500+	Magnetite in granite
	OR6	900	200	Unknown
	* OR9	800	500+	Magnetite in granite near contact
	OR16	400	200	Unknown
	OR17	400	250	Unknown

* Anomalies for first-priority field examination.

Demirköy area

The center of the Demirköy area, according to regional geologic maps, consists of a granite intrusive. The intrusive may be correlated with a broad magnetic anomaly (D 2) on the aeromagnetic map (pl. 2). The map also shows the approximate limit of granitic rocks, which represents a revision, based on magnetic contours, of the contact shown on the 1:500,000 scale geologic map of Turkey, Istanbul sheet.

The aeromagnetic map shows a prominent anomaly (D 1), just south of the village of Demirköy, which is apparently due to magnetite in a contact zone, as indicated by ground investigations described on page 4. Another anomaly (D 3) north of the granite corresponds to a small area of gabbroic rocks.

Orhaneli area

Regional patterns related to magnetite-bearing igneous rocks

Magnetite is present in the Orhaneli area as an accessory mineral in diverse rock types including felsic and mafic intrusives, andesite, and ophiolitic rocks. Areas where these rocks are exposed may be correlated with regional magnetic pattern (pl. 3). Areas where the magnetite-bearing rocks are not exposed are covered by Tertiary (Neogene) beds or contain older Mesozoic and Paleozoic sedimentary rocks (1:500,000 scale Geologic Map of Turkey, 1964, Izmir sheet).

The regional magnetic pattern having the greatest magnetic relief (pl. 3) corresponds to areas of mafic, ultramafic, and "ophiolitic" rocks. The magnetic relief varies with the magnetite content in the rock and with differences in aircraft terrain clearance in areas of relatively great topographic relief. The magnetic patterns related to areas of

granitic rocks show a characteristic low magnetic relief (pl. 3) owing to very small amounts of magnetite in these rocks. These normal magnetic patterns cover most of the area surveyed (pl. 3).

Anomalies in ultramafic rocks

The principal magnetic anomalies (tables 1, 2) of the Orhaneli area are located near Topuk village (pl. 3). In this area a granite stock intruded ultramafic rocks and apparently caused a redistribution of magnetite which resulted in both positive and negative magnetic anomalies. The anomalies are described in a subsequent section (p. 16).

Anomalies in areas of sedimentary rocks

Magnetic anomalies in areas of sedimentary rocks represent magnetic iron deposits or magnetite-bearing rocks beneath sedimentary cover. In the Orhaneli area three anomalies of this type (OR 8, OR 14, and OR 15) have been identified (pl. 3). One of these (OR 8) was inspected on the ground but its cause was not determined.

Anomaly at granite-marble contact

One anomaly (OR 9), having 800-gamma magnetic relief, is located at a granite-marble contact. Preliminary interpretation indicates that it is a broad anomaly possibly due to a local increase in magnetite content of the granite near the contact. However, the alternate possibility that some massive magnetite is present needs to be tested in the field.

Table 2. List of magnetic anomalies and mineral prospects examined in the field during 1968.

Area	Locality or anomaly	Examiners	Apparent cause of magnetic anomaly
Bolu	B11	Tümer, Bogaz, Jacobson	14% magnetite in metamorphic rocks.
	B15	Bogaz, Jacobson	10-20% magnetite in gabbro(?)
	B16A	Tümer, Gümrükçü	3% magnetite in andesite.
Çanakkale	CK1	Tümer, Çalapkulu	Few percent magnetite in mica schist.
Karabiga	CK2	Tümer, Shadaydeh	10-20% magnetite in calcareous mica schist.
	CK6	Tümer, Çalapkulu	Few percent magnetite in andesite.
	CK8	Tümer	10-20% magnetite in serpentine.
	Çakirli prospect	Tümer, Can, Jacobson	Massive magnetite; possible iron deposit.
Demirköy	D1	Tümer, Ozelci	About 10% magnetite in igneous rocks.
Ezine	Gonerustu Tepe	Tümer, Karahacioğlu	Very local magnetite near granite-marble contact.
Orhaneli	OR3	Inan	Unknown
	OR4	Karahacioğlu, Inan	Magnetite veins (7cm. maximum thickness).
	OR5	Jacobson	Magnetite destroyed during serpentinization of peridotite.
	OR7	Karahacioğlu	Magnetite veins.
	OR8	Karahacioğlu, Inan	Unknown
	OR10	Karahacioğlu, Inan	Unknown
	OR11	Karahacioğlu, Inan	Unknown
	OR12	Karahacioğlu, Inan	Magnetite in andesite.
	OR13	Karahacioğlu, Inan	Negative anomaly: Magnetite destroyed during serpentinization of peridotite(?).
	OR14	Karahagioğlu	Unknown
	OR15	Karahagioğlu	Unknown

FIELD INVESTIGATION OF MAGNETIC ANOMALIES AND MINERAL PROSPECTS

Bolu area

Field investigations were conducted in the Bolu area in November and December 1968. Only initial field checks were made of a few anomalies, and more work will be needed to evaluate the area. Ground investigations are hampered by rugged forest-covered mountain terrain.

Anomalies related to magnetite in metamorphic rocks

Anomaly B 11 (pl. 1) was studied on the ground by means of a series of magnetic and geologic traverses in the Kaymaz Tepe-Topraklik Tepe area (1:25,000-scale topographic map G 27a2). The aeromagnetic anomaly was located on the ground at Topraklik Tepe where one traverse detected a 20-meter wide magnetic anomaly having a 14,000-gamma peak. The anomaly corresponds to an outcrop of magnetite-bearing foliated green metamorphic rock. The magnetite is present as subrounded to angular porphyroblasts in a fine-grained matrix. Magnetite content of one sample was 14 percent. The aeromagnetic anomaly thus may reflect a magnetite-bearing metamorphosed bed.

Anomalies related to magnetite in igneous rocks

Anomaly B 15 (pl. 1) was checked on the ground in the Doğanyuva Sirti area (1:25,000 scale topographic map G26b3) where a ground magnetic anomaly having maximum relief of 3000 gammas was found to correspond to a ridge containing gabbro(?) boulders. The boulders contained an estimated 10 to 20 percent magnetite, and a dikelike gabbro(?) intrusion

is the apparent cause of the anomaly. Anomaly B16 near the village of Yigilca (1:25,000 scale topographic map G26b2) was checked by magnetic and geologic traverse. The magnetic profile indicates a broad magnetic anomaly with half width of about 250 meters and maximum relief of about 3000 gammas. The anomaly corresponds to an area of andesite(?) having estimated magnetite content of 3 percent.

Çanakkale-Karabiga area

The Çanakkale-Karabiga area was extensively investigated in 1967 (Jacobson and others, 1972, p. 8-10). In 1968 additional fieldwork was done at anomalies CK3, CK6, and CK8, and initial field investigations were made at anomalies CK1, CK2, and CK13 (Jacobson and others, 1972, fig. 3).

Anomalies related to magnetite in metamorphic rocks

Anomaly CK1 near Susamalar village (1:25,000 scale topographic map H17b3) was found to be represented on the ground by a broad weak magnetic anomaly having a maximum magnetic relief of 700 gammas. The anomaly corresponds to an area of mica schist(?) containing a low percentage of magnetite. The aeromagnetic anomaly thus was caused in part by lower aircraft terrain clearance and in part by the magnetite in the mica schist(?).

A more detailed study was made of anomaly CK3 near Çamyurt village (1:25,000 scale topographic map H17b3) where a ground magnetic survey was conducted on traverse lines 50 meters apart, and the geology was examined. The results (fig. 2) show a magnetic anomaly 100 meters in diameter, having a 2,500-gamma peak corresponding to a local area of greater magnetite concentration in calcareous mica schist(?). The magnetite content was estimated at 10 to 20 percent. No magnetic anomaly was detected over the serpentine to the east.

Anomalies related to magnetite in igneous rocks

Additional field checks of anomalies CK6 and CK8 confirmed that they are related to magnetite in andesite(?) and serpentine respectively. Anomaly CK2 was investigated by magnetic and geologic traverses over Puruklu ridge (1:25,000 scale topographic map H17b4) which showed the presence of a broad weak magnetic anomaly that has a 700-gamma maximum. The anomaly corresponds to an area of magnetite-bearing granite adjoining a granite-schist contact. The granite is estimated to contain 5 to 10 percent magnetite.

Çakirli magnetite deposit

Field checking of aeromagnetic anomaly CK13 near the village of Çakirli 7 km south of Aksaz on the Marmara Sea Coast led to the discovery of two small strong magnetic anomalies (fig. 3) near an intrusive contact. The northern anomaly within the 10,000-gamma contour is 150 meters long and has a maximum magnetic relief of more than 15,000 gammas. It is an area of nearly flat topography on a contact between granite and metamorphic rocks, but there are no outcrops. Pit A in the center of the anomaly cut magnetite-bearing sand derived from granite from the

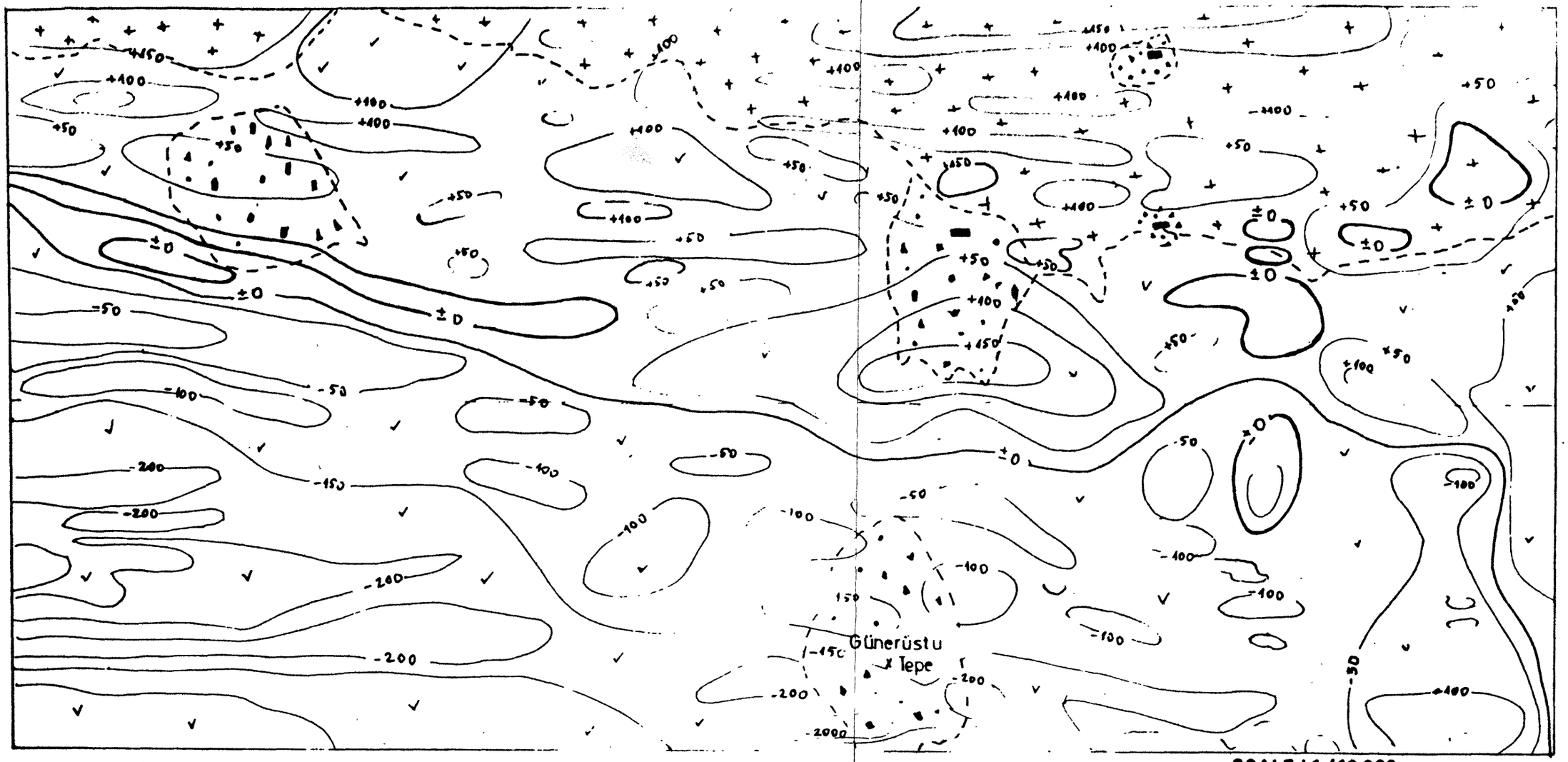
surface to 2 meters. From 2 to 2.5 meters the pit exposed 20- to 40-cm magnetite boulders in magnetite sand. The second anomaly to the southwest is smaller and weaker. Pit B in the center of the anomaly cut serpentine containing magnetite veins ranging from 0.5 to 2 cm in width from near the surface to a depth of 125 cm.

Demirköy area

A detailed investigation was made of anomaly D 1 (pl. 2) just south of the village of Demirköy. In the anomalous area an intrusive contact was observed between granite and metamorphic rocks. A skarn zone at the contact contains epidote, garnet, and magnetite. The magnetite in the skarn is the apparent cause of the anomaly and no indication of a massive iron deposit was found. The magnetic map (fig. 4) shows a weak anomaly having a single magnetic gradient or step anomaly, which is generally indicative of a contact.

Ezine area (Gonerüstü Tepe)

A detailed investigation was made of an area 3 km long and 1.5 km wide, 16 km southwest of the town of Ezine, where local magnetic anomalies and local magnetite boulders were previously seen near a granite-marble contact (Jacobson and others, 1972, p. 6). East-west magnetic and geologic traverses were made 100 meters apart over the entire area and the data compiled in figure 5. Magnetic measurements (fig. 5) show a flat magnetic pattern in which magnetic intensities range from -200 gammas to +150 gammas. Three magnetometer stations showed anomalous magnetic values of about 3000 gammas, probably related to magnetite boulders or a very local pocket of magnetite in bedrock. The area is nearly flat and generally devoid of outcrop except



EXPLANATION

- Granitoutc rops and boulders
- Alluvium with granite and marble boulders
- Alluvium with granite marble and magnetite boulders
- Inferred geologic contact
- +100 Magnetic contour (gammas)
- Single station magnetic high

SCALE : 1 /10 000

0 250 500 M

MAGNETIC AND GEOLOGIC MAP OF THE GÜNERÜSTÜ TEPE AREA NEAR EZINE

Magnetic survey by: Ural TÜMER and Hamit KARAHACIOĞLU
Geology by Hüseyin FİLİRELİ

some granite exposures on the east side (fig. 5). Consequently, float was mapped and the areas containing sparse magnetite boulders were outlined. The boulders contain approximately 58 percent iron. No evidence was found for the existence of a significant magnetite deposit.

Orhaneli area

Ground checks of 11 aeromagnetic anomalies were made during 1968 following the preliminary aeromagnetic interpretation which identified 15 prominent anomalies (pl. 3).

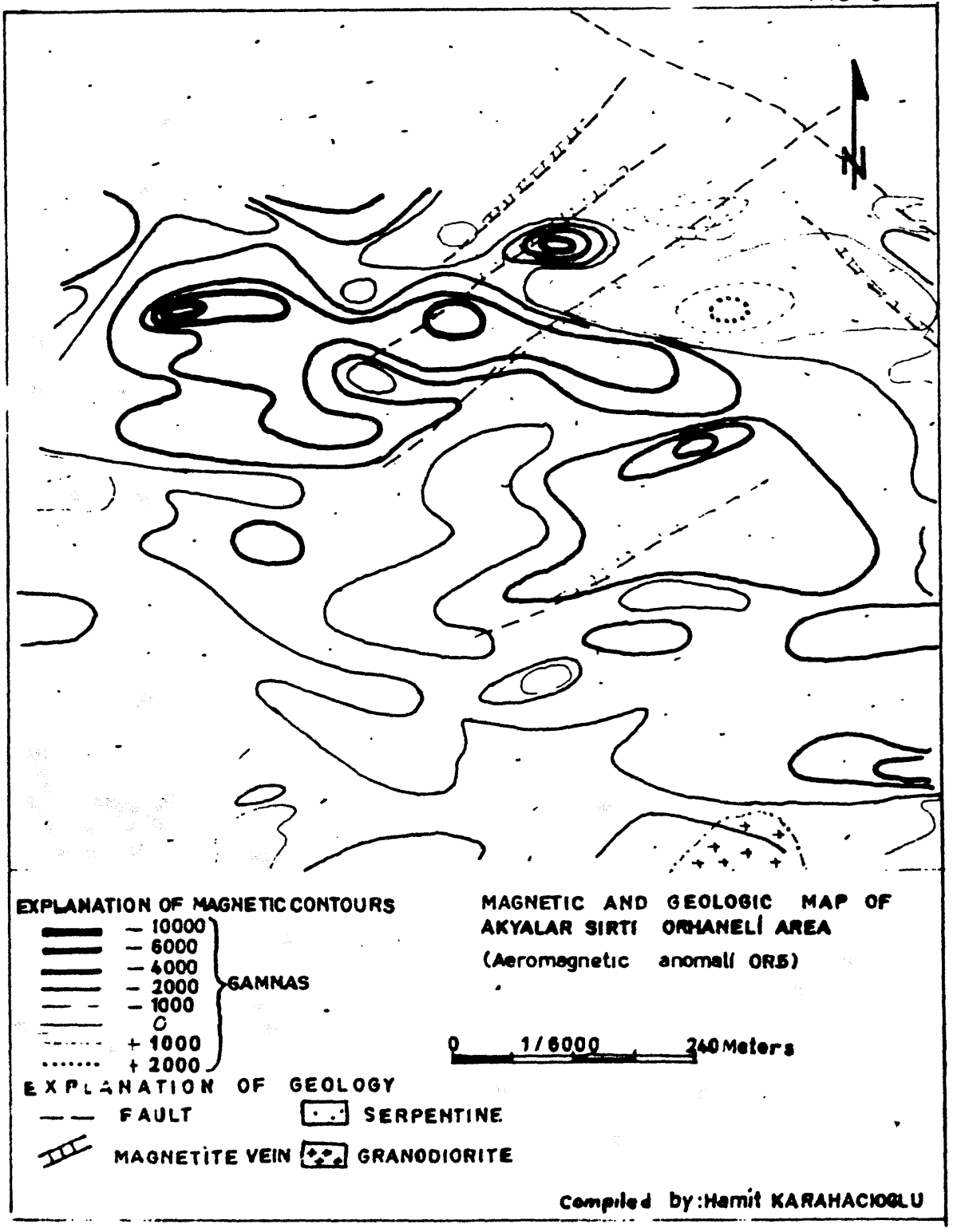
Negative anomalies related to magnetite in ultramafic rocks

In the Orhaneli area, many negative magnetic anomalies are present (pl. 3). Two of the most prominent of these negative anomalies (OR 5, and 13) were examined. Both anomalies are in areas of serpentinized ultramafic rocks (peridotite? and dunite?) surrounded by unserpentinized ultramafic rocks. It is likely that the serpentinization process destroyed magnetite and that the magnetic anomalies are due to a relative deficiency of magnetite in an area of magnetite-bearing rocks. At anomaly OR 5 (fig. 6) a detailed magnetic and geologic survey was made which showed the presence of a 600-meter-long negative magnetic anomaly in an area of serpentinized ultramafic rocks cut by faults and magnesite veins. Some chromite is also present. A traverse across anomaly OR 13 revealed a negative magnetic anomaly in an area of serpentinized ultramafic rocks locally containing asbestos in fractures.

Anomalies related to magnetite in volcanic rocks

A field check of anomaly OR 12 (pl. 3) indicated the presence of a weak magnetic anomaly apparently caused by small amounts of magnetite in andesite.

FİG: 6


N
EXPLANATION OF MAGNETIC CONTOURS
– 10000
– 6000
– 4000
– 2000
– 1000
0
+ 1000
+ 2000
GAMMAS
MAGNETIC AND GEOLOGIC MAP OF AKYALAR SIRTI ORHANELİ AREA
(Aeromagnetic anomali OR5)
0 1/6000 240 Meters
EXPLANATION OF GEOLOGY
FAULT
SERPENTINE
MAGNETITE VEIN
GRANODIORITE
Compiled by: Hamit KARAHACIOGLU

Anomalies related to magnetite veins in ultramafic rocks

Detailed ground magnetic surveys were made at aeromagnetic anomalies OR 4 and OR 7 (pl. 3); magnetic traverses were 50 meters apart. At anomaly OR 4 the geology was also mapped. The ground magnetic anomalies at OR 4 (fig. 7) correspond to areas of small irregular granodiorite apophyses intruded into mafic and ultramafic rocks. Thin veins, a maximum width of 7 cm wide, were observed in the ultramafic rocks near the granodiorite contact. The anomaly was probably caused by these thin magnetite veins, but also may be due in part to accessory magnetite in the granodiorite. At anomaly OR 7, a 200-meter wide irregular magnetic anomaly was outlined on the ground in an area of ultramafic rocks cut by magnetite veins. The veins are commonly 2-3 cm wide, but one vein one meter wide was also noted.

Anomalies of unknown cause

Field checks were made of 6 aeromagnetic anomalies (OR 3, 8, 10, 11, 14, 15) by means of magnetic and geologic traverses. No significant ground magnetic anomaly was found and no magnetite was observed on the surface. Most of the anomalies are in areas of metamorphosed sedimentary rocks. Further study is needed.

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Jacobson, H. S., Özelci, F., Yazgan, D., Hatay, N., and Karahacioğlu, H., 1972, Aeromagnetic interpretation and mineral investigations in the Ezine, Çanakkale-Karabiga, Marmara, and Kapidağ areas of northwestern Turkey: U. S. Geol. Survey open file rept. (IR) TU-4, 13 p., 8 figs., 1 table.

Türkiye jeologi haritasi, 1964: MTA, geologic map of Turkey series, Istanbul, Izmir, and Zonguedak sheets, 1:500,000 scale.

EXPLANATION OF MAGNETIC CONTOURS

− 1000
0
+ 1000
+ 2000
+ 4000
+ 6000
} GAMMAS

EXPLANATION OF GEOLOGY

Inferred contact

Granodiorite

Diorite, Dunite and Serpentinized Dunite

0 1/3000

Compiled by: Hamit KARAHACIOG

MAGNETIC AND GEOLOGIC MAP OF AEROMAGNETIC ANOMALY CR4 ORHANELİ AREA