Areas of distinctive magnetic character in southern New England and their geologic significance

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Introduction

An aeromagnetic map of southern New England compiled by Zietz, Gilbert, and Kirby (1972) at a scale of 1:~~500,000~~ 1:250,000 with 100 gamma contours reveals a wide variation in magnetic character across the region. The pattern of magnetic anomalies, their shapes and trends vary from place to place as does both the average magnetic intensity and its range. These changes are not random nor are they usually gradational, but generally take place at the boundaries of definable areas. Each area is characterized by some distinctive combination of anomaly, pattern, shape and trend, and intensity, range and average, that distinguish it from its neighbors.

The aeromagnetic map shows several broad northeasterly trending belts within each of which a number of areas can be defined by their distinctive magnetic characteristics. These areas of distinctive magnetic character are found to correspond to a single or to combined geologic provinces defined by stratigraphy and structure. The boundaries of these areas and the trends of magnetic anomalies within them match the geologic trends and structures well.

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With few exceptions the high-amplitude steep-gradient anomalies reflect the geology at or near the surface. The broad persistent northeast-trending anomalies in eastern New York State, however, are related to buried magnetic sources. In a few other areas of broad low magnetic relief the surface rocks may be weakly susceptible and the magnetic pattern may reflect buried geology. Magnetic patterns commonly extend across the boundaries of the Triassic basin indicating that most of the rocks of the basin have little magnetic effect. Igneous rocks in the Triassic basins, however, are an exception as many of those units form prominent narrow anomalies.

The map showing areas of distinctive magnetic character (Fig. 1) was designed to accompany the aeromagnetic map of Zeitz, Gilbert, and Kirby that is already in open file. Twenty-six areas of distinctive magnetic character chosen on the basis of 1. general level of magnetic intensity and 2. magnetic pattern caused by shape, trend, and amplitude of the magnetic anomalies have been delineated. Boundaries of these areas, many of which are strikingly displayed, are placed where there is a change in the general level of intensity and pattern of anomalies. These boundaries are derived exclusively from the aeromagnetic map and are not necessarily mapped geologic boundaries with the exception of the boundaries of the basins underlain by rocks of Triassic and Carboniferous age. These basins are separately delineated on the map, figure 1. Figure 1 is not a geologic interpretation of the aeromagnetic map but the discussions of the individual areas point out the general correspondence of magnetic patterns to

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lithology and structure. A geologic interpretation of the aeromagnetic map has been prepared separately at a scale of 1:250,000.

In the following discussion the intensities on the aeromagnetic map have been referred to as very high - 1,500 gammas and above, high - 1,300 to 1,500 gammas, moderate - 1,000 to 1,300 gammas, low - 800 to 1,000 gammas, very low - 800 gammas and less.

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Areas of Distinctive Magnetic Character

1) Salem-Cape Ann Area

The Salem-Cape Ann area is characterized by its high magnetic intensity and very high anomalies, forming one of the most prominent high-intensity areas on the map. The area is principally underlain by granitic rocks and lesser bodies of diorite and gabbro. The high intensities reflect the more basic rocks, which may be more extensive at depth. The southern and northwestern boundaries of the area of high intensity closely coincide with known faults and the seaward boundaries also may be fault controlled.

2) Sudbury-Melrose Area

The northeast- to east-northeast-trending high intensity magnetic anomalies in a zone of moderate intensity distinguish the Sudbury-Melrose area from adjacent ones. The magnetic pattern is similar to the pattern of mapped metavolcanic and metasedimentary rocks that are extensively intruded by diorite and gabbro. The high- to very high-intensity anomalies coincide with the more basic intrusives. The boundaries of the area are coincident with regional northeasterly-trending faults.

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3) Boston Basin Area

The magnetic pattern over the Boston Basin is one of nearly uniform moderate to low intensity with few anomalies other than those resulting from man-made structures in metropolitan Boston and the large anomaly at Nahant (3a). The weak magnetic field is a reflection of the slightly metamorphosed sedimentary and volcanoclastic rocks of Carboniferous age that fill the basin. The anomaly at Nahant coincides with a gabbro pluton. The landward boundaries of the Boston Basin are mapped geologic contacts that match changes in the magnetics fairly well. The irregular southern boundary is principally fault controlled and shows up as a series of magnetic lows and it can be traced seaward several miles along a low. The submerged eastern boundary of the basin is not sharply demarked on the magnetic map, but may end against a broad low northeast-trending anomaly as shown (fig. 1).

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4) Grafton-Framingham Area

The Grafton-Framingham area is one of moderate magnetic intensities with low positive anomalies of diverse trends that are generally at variance with trends in adjacent areas. The area is underlain mostly by granitic rocks with smaller amounts of metavolcanic and metasedimentary rocks which are cut by several northeasterly to easterly-trending faults. The diverse trends of the anomalies reflect the change in strike of the bedrock units from northerly in the southeast part of the area to northeasterly in the northwest part of the area.

5) Western Rhode Island Area

The western Rhode Island area is distinguished by moderate magnetic intensity with low positive anomalies wrapped around a large broad positive anomaly.

The large broad positive anomaly in the southern part of the area closely coincides with the structural center of a large composite dome composed mainly of granitic rocks. Low positive anomalies are concentric with the outer margin of the dome and they also reflect the domal structure. In the northern part of the area, north-trending linear anomalies apparently reflect the distribution of narrow basic dikes. Anomalies of higher intensity (areas 5 a, b ~~and c~~) in the northeast are apparently caused by larger basic dikes and stocks.

Northeast-trending lineaments within the area correspond to traces of known and probable faults.

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6) Medfield-Blue Hills Area

Small irregular positive anomalies superimposed on a pattern of magnetic intensity slightly higher than that of surrounding areas typify the Medfield-Blue Hills area. Granitic rocks with pendants of metavolcanic and metasedimentary rocks underlie most of the area. Small bodies of diorite and gabbro are also present and cause the prominent magnetic highs. The principal structures are mirrored in the magnetic pattern and trend north and northeast to where they are cut off by faults at the border of the Boston Basin.

7) Narragansett Area and related basins

An almost featureless magnetic pattern of moderate intensity delineates the Narragansett Basin of Rhode Island and southeastern Massachusetts. Rocks in the basin are shales, sandstones and conglomerates that are strongly metamorphosed at only a few places. These rocks are non-magnetic and mask the effects of the underlying rocks except very locally at the edges of the basin. Similar rocks are exposed in small basins to the north and west (areas 7a, b and c) but because they are thin and small they cannot be distinguished magnetically.

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8) Southeastern Massachusetts and offshore areas

Southeastern Massachusetts is an area characterized by moderate magnetic intensity with subdued linear north-northeast- and northeast-trending positive anomalies. The magnetic intensity increases over Cape Cod, where high to very high intensity anomalies (8a, b, c and d) also have north-northeast and northeast trends. Offshore areas show much less detailed magnetic patterns owing mainly to the wider spacing of magnetic traverses, and lesser intensity in general because of increasing distances between aircraft and bedrock owing to increased sediment thickness and water depth seaward. The offshore area south of Cape Cod contains a broad high intensity anomaly (8e) in an otherwise moderate magnetic intensity field. The offshore area north of Cape Cod has moderately low magnetic intensities with broad low anomalies, except for a few high anomalies (8f, g and h). An anomaly southeast of Cape Ann has a strong northeast trend paralleling that on Cape Cod.

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Southeastern Massachusetts is almost entirely covered by surficial deposits, but it is probably underlain by granitic rocks, which is in agreement with the magnetic intensities. Some of the linear anomalies are known to be related to basic intrusive bodies; perhaps most are. The larger anomalies on Cape Cod (8a, b, c and d) are probably due to larger basic intrusive bodies and the high offshore anomalies (8e, f, g and h) may be caused by similar rocks. The offshore anomaly at 8e may overlie rocks similar to those causing the more detailed magnetic anomalies of the Salem-Cape Ann area.

9) Marlboro-Georgetown Area

The Marlboro-Georgetown area is a long narrow northeast-trending belt of moderate to low magnetic intensity. Except for a small area in the north, it is marked by subtle, low positive anomalies parallel to its boundaries. Magnetic intensity decreases generally toward the northeast. The southwestern part is not easily distinguished from the Grafton-Framingham area.

Northeast-trending metasedimentary and metavolcanic rocks intruded by granitic rocks underlie the area. Much of the lower magnetic intensity is underlain by granitic rocks. The area of low magnetic intensity in the northeast (9a) is over low-grade metavolcanic rocks of the Newbury basin.

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10) Norwich-Chelmsford Area

The Shrewsbury-Chelmsford area is a well defined, closely spaced group of elongate northeast-trending positive anomalies which are separated by narrow bands of moderate magnetic intensity. This pattern reflects the pattern of a group of northeasterly-striking metavolcanic and metasedimentary rocks that are bounded by faults to the northwest and southeast. Faults greatly restrict the area in its central part and cause variation in its width further south. The northern termination is at an intrusion of relatively non-magnetic granitic rocks. The abrupt change in the magnetic pattern at the south end of the area is the result of a prominent easterly-trending fault zone. The area widens at its southern end and there contains a few prominent negative anomalies. In the southern half the rocks are much more broken up by northwest-striking faults than to the north. A very high, irregularly elliptical anomaly at the south end of the area (10a) ~~(11a)~~ overlies a large gabbroic intrusion which also causes an associated magnetic low along its north edge.

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11) New London Area

New London is a broad, prominent arcuate area of high intensity anomalies that trend generally northeast to east, bending around to the central part of the area where trends are more diverse. The northern part of the area, 11a, is marked by a decrease in magnetic intensity from east to west. A decrease in intensity also occurs to the southwest and to the southeast (11b) under the seaward extensions of the area. The continuation of the area southeastward and southwestward out to sea has the lower intensity and broader configuration characteristic of the less detailed offshore magnetic patterns.

The onshore part of the New London area is composed of granitic rocks with interlayered metasedimentary and metavolcanic rocks, several units of which have high magnetic susceptabilities. The folded pattern of the steeply dipping rocks is roughly mirrored by the pattern of the magnetic anomalies.. The rocks with high susceptabilities apparently wrap around the south end of the Killingworth area, to the west, and extend out to sea.

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The north boundary of the area is a major easterly-trending fault zone. Metavolcanic rocks in the belt of moderate magnetic intensity along the northern side (11a) are apparently less magnetic although they intertongue eastward with rocks that are more magnetic. Most of the eastern part of the area (11b) is under water. The small onshore part consists almost entirely of granitic rocks and is marked by lower intensities; the offshore area may have similar bedrock.

12) East Long Island Area

The East Long Island area has lower intensities than those to the north. The anomalies in the area trend northeasterly in the western part of the area in general conformity with those in the New London area, but farther east there is a much greater divergence in trends. A prominent ear-shaped anomaly (12a) is in the northeastern part of the area. Bedrock in the area is covered by surficial deposits and water, but the lower magnetic intensities suggest a change in rock types from those to the north. The ear-shaped anomaly (12a) may be caused by a basic intrusive body.

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13) Colchester-Nashua Area

A magnetic pattern of moderate intensity that is nearly devoid of anomalies characterizes the Colchester-Nashua area, although its eastern boundary is sharply delineated by a magnetic low. North- to northeast-striking low-grade metasedimentary rocks intruded in places by elongate granitic bodies underlie most of the area. At the south end, the rocks are more intensely metamorphosed and form a broad gentle basin. The eastern boundary of the area is a fault, but the magnetic lows are at least in part an effect of the higher anomalies in the east.

14) Brimfield-Peterborough Area

The Brimfield-Peterborough area has moderate intensities similar to the Colchester-Nashua area, but is distinguished from it by numerous small narrow north to northeast-trending low positive anomalies, especially in its southern portion. The anomalies are less distinct to the northeast, where the areas are separated by only a slight difference in magnetic intensity on the flank of a broad low northeast-trending positive anomaly.

The small narrow anomalies in the southern portion reflect pyrrhotite metasedimentary rock and metavolcanic rock interlayered in non-magnetic metasedimentary rock. The broad patches of lower intensities in much of the central part of the area reflect the presence of widespread relatively non-magnetic granitic rock; the broad low positive anomaly in the northeastern part of the area is apparently caused by a granitic gneiss.

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15) Monson-Keene Area

The central portion of the Monson-Keene area is readily identifiable by its elongate northerly very high intensity trending anomalies (15a). The magnetic intensity is lower to the south end where the area narrows and pinches out and in the detached part farther south (15b). The magnetic intensity of the more widely separated anomalies to the north are also lower except for two isolated high anomalies. The magnetic highs in the area are almost exclusively related to the presence of the metavolcanic rocks. In the north these rocks become separated by granitic bodies and mantled by non-magnetic metasedimentary rock. The metavolcanic rocks to the south are less magnetic, possibly as the result of retrograde metamorphism.

16) Killingworth Area

The bell-shaped Killingworth area is characterized by linear anomalies of moderate intensity that wrap around a central area of slightly lower intensity that contains indistinct anomalies. The sinuous anomalies around the outer part of the area are underlain by amphibolite and other layered metavolcanic rocks; the central part is underlain by less magnetic granitic gneiss.

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17) Stony Creek Area

The Stony Creek area has a general low magnetic intensity that increases to moderate toward the southeast. Anomalies in the area have strong northeast trends and terminate abruptly at the southern border of the Killingworth area. The eastern boundary is marked by a relatively sharp increase in intensity; the western boundary is marked by a lineament bordering a zone of weak anomalies.

Most of the Stony Creek area is under Long Island Sound, the exposures along the shore are mostly granitic gneiss and those to the north mostly schist.

18) Rockville-Hampden Area

The Rockville-Hampden area is one of moderate to low magnetic intensity with north-trending positive and negative anomalies in the north that die out southward. The western boundary of the area where it is in contact with the Monson-Keene area is not closely defined. The western boundary, however, is arbitrarily chosen as the mapped border of the Triassic Basin and its magnetic expression is not everywhere apparent.

The area is composed chiefly of granitic gneiss of low magnetic susceptibility. On the north the gneiss is flanked by and includes narrow bands of metavolcanic rock that correspond well to the narrow low positive anomalies. The negative anomaly at the south end of the area, at least in part, overlies metasedimentary rock.

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19) Belchertown-Pelham Area

A prominent negative anomaly separates the Belchertown-Pelham area from the Rockville-Hampden area on the south. North of this negative anomaly the area is one of moderate to low magnetic intensity as distinct from the area to the east. The western border is the mapped boundary of the Triassic basin, and is very poorly expressed magnetically.

20) Goshen Area

The Goshen area is characterized by a low intensity magnetic field in which are scattered a few circular anomalies of moderate intensity. The western boundary is sharply defined along a magnetic high, and the southern boundary less sharply defined. Its eastern boundary is chosen as the edge of the Triassic basin and again is not delineated by a change in magnetic intensity.

The area is underlain by low-grade metasedimentary rocks, mostly schist, phyllite and quartzite. The circular anomalies closely correspond with gneiss domes that are mantled by metavolcanic rocks.

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21) Triassic Basin

The Triassic Basin is an area of where the overall magnetic intensity is low in the south and increases slightly towards the north. It is crossed by north to northeast-aligned low positive and negative anomalies. The boundaries of the basin are, with few exceptions, not defined by the magnetic pattern.

Rocks within the basin are unmetamorphosed sandstones, shales, and conglomerates interlayered with basaltic lava flows and intruded by diabase dikes. Although the basalts and diabases are strongly magnetic, they tend to be thin and thus do not produce striking magnetic highs. The distribution of these rocks, however , closely coincides with the sinuous low anomalies throughout the basin. Northeast trending faults that cut the basalt flows clearly show up as lineaments. Magnetic patterns underlying the non-magnetic sedimentary rocks, especially in the southern part of the basin may be due in part to magnetic effects of underlying crystalline rocks.

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Five areas of Triassic sedimentary rocks lie outside the main basin. Three minor areas, two to the north (21a and b) and one to the west (21c) are small and cannot be distinguished from the surrounding rocks. The larger, Pomperaug basin (21d), is outlined only on its northwest and southeast sides. The largest area (21e) in the southwest corner of the map can be distinguished moderately well by a change in trend in the magnetic pattern. Anomalies within areas 21d and 21e correspond extremely well with basalts and diabases in the basins.

22) Bridgeport Area

The Bridgeport area is one of generally low to very low magnetic intensity with strong linear north-northeast to northeast-trending anomalies of moderate intensity. The western boundary is marked by a slight increase in magnetic intensity, and by a loss of the linear anomalies. The northwestern part of the area is underlain by granitic gneisses with minor metavolcanic and metasedimentary rocks. The highest magnetic anomaly is caused by a serpentinite body and the linear one to the northeast of it by metavolcanic rock.

23) Norwalk-Collinsville Area

Broad elliptical anomalies of low to moderate intensity in an almost featureless background of lower magnetic intensity serve to separate the Norwalk-Collinsville area from adjoining areas.

Metasedimentary rocks of low to high grade underlie most of the flat, featureless area. Gneiss domes of metasedimentary and metavolcanic rock form the elliptical highs. Shapes of the domes in the northern part of the area correspond very closely with the magnetic anomalies, but relations in the southern part of the area and offshore are not entirely clear.

24) Danbury-Rowe Area

Closely spaced anomalies of moderate to high relief are typical of the Danbury-Rowe area. The general level of magnetic intensity increases toward the northwest. The most prominent trend in the magnetic pattern is toward the northeast, parallel to the boundaries of the area, but many diverse and curvilinear anomalies are present along the southeast side. The curvilinear trends are usually arcuate and convex to the northwest; they are most conspicuous as magnetic lows between positive highs. Numerous north-northeast and northeast-trending lineaments cross the area and appear to terminate against the northwest boundary of the area.

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The Danbury-Rowe area is one of complicated stratigraphy and structure. In general, the low intensity negative anomalies overlie bands of limestone, quartzite, and granitic gneiss in the southern part of the area; in the central part of the area, they are over granitic gneisses and some schists. The high intensity anomalies are over magnetite-bearing gneisses, schists and metavolcanic rocks. In most places, trends of the individual anomalies correspond very well with the configuration of the bedrock units; in a few places the magnetic pattern does not reflect the distribution of mapped bedrock units. The numerous north-northeast and northeast-trending lineaments that cross the area and mark the termination of magnetic anomalies coincide in many places with known faults and fault zones. Many of these almost certainly coincide with faults or fault zones.

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25) Beacon-Pittsfield Area

A very conspicuous anomaly of very high magnetic intensity occurs in the southwest part of the Beacon-Pittsfield area (25a). Northeast of this conspicuous anomaly magnetic intensity becomes moderate, and the area contains scattered small northeast and northwest-trending anomalies and several north-northeast-trending lineaments (25b).

The area is underlain by phyllite, limestone, quartzite, gneiss, and schist. The prominent high anomaly in the southwest is not entirely explained by the metamorphic rocks exposed at shallow depths. Most of the scattered anomalies to the north are caused by exposed magnetite-bearing schists and gneisses.

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26) Catskill-Bennington Area

The Catskill-Bennington area is dominated by a broad east-northeast-trending anomaly of high magnetic intensity paralleled on the southeast by a broad lower intensity anomaly. North of the dominant anomaly the magnetic pattern seems to reflect a superposition of a more northerly trend upon the east-northeast trend. The more northerly trend is most clearly expressed in the northeast corner of the area by a distinct positive anomaly of high amplitude.

Phyllites, limestones, and quartzites are the principal rock types exposed in the area; they are known to conformably overlie crystalline rocks. The distribution of these surface rocks does not correspond to the strong northeast trend of the magnetics in most of the area, and the low gradient of the dominant anomaly suggests that the magnetic pattern is caused by strongly magnetic crystalline rocks at considerable depth. Such highly magnetic rocks are exposed along strike southwest of the area.

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