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Walter A. Anderson, State Geologist

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Contents: 26 page report

GRAVITY

AND ITS GEOLOGICAL INTERPRETATION

THE SEBAGO PLUTON AND VICINITY

SOUTHWESTERN MAINE

Geoscience Services of Salem, Inc.
180 North Policy Street
Salem, NH 03079
(603) 893-3124

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GEOSS

GRAVITY AND INTERPRETATION
SEBAGO PLUTON, SOUTHWEST MAINE

SUMMARY

Gravity data, available in the Public Domain, were reprocessed and used to prepare total Bouguer gravity anomaly maps, regional Bouguer gravity anomaly maps, and residual Bouguer gravity anomaly maps for the Sebago pluton and adjacent areas located in southwestern Maine.

An anomaly near Lisbon Falls had been previously interpreted incorrectly by others, used by them to infer thickness of the Sebago pluton, and subsequently used by the DOE as the basis, in part, to select the Sebago pluton as a preliminary candidate area for a possible high level radioactive waste repository. The Lisbon Falls anomaly consists of both a gravity high of a few milligals and a gravity low of a few milligals. On the basis of similarity of gravity anomalies, the Lisbon Falls anomaly correlates with anomalies attributed to granites designated as "Devonian granites" on the Maine Bedrock Geology Map and is not likely related to the Sebago pluton.

The Sebago pluton produces a small negative residual gravity anomaly of only 4 to 6 mgals. In the north portion of the body, the gravity anomaly correlates well with the mapped surface outcrop. In the south portion, however, the anomalies attributed to rock masses inferred to be present below the pluton clearly cross the mapped boundary.

On the basis of the gravity anomaly and the density contrast between the rock of the Sebago pluton and the country rock, measured by others, the bottom of the pluton reaches a maximum depth in Maine of perhaps 600 meters below sea level but is less than 300 meters throughout most of the pluton.

The location of maximum thickness is outside the candidate area proposed by the DOE for inclusion in the list of "potential acceptable sites for a high level nuclear waste repository in crystalline rock". On the basis of the gravity data, the average thickness throughout the candidate area is likely less than 300 meters.

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1. INTRODUCTION

The Sebago pluton, located in southwestern Maine, has been proposed by the U. S. Department of Energy (DOE, 1986) as one of twelve "potentially acceptable sites for a high level nuclear waste repository in crystalline rock". A significant factor in determining acceptability, apparently, was the thickness of the rock mass. However, the thickness was not known by direct measurement or even indirectly through interpretation of data for the Sebago pluton. Rather, it was inferred from an interpretation of gravity data **for a nearby small pluton** by Hodge et al. (1982).

The Maine Geological Survey requested Geoscience Services of Salem, Inc. to examine the gravity data available for the Sebago pluton area, to prepare maps of the gravity field using all available valid data, and to interpret the maps in geological terms. The work was done by Gene Simmons, Professor of Geophysics at The Massachusetts Institute of Technology, and Jeffrey Mann. Professor W. A. Bothner, University of New Hampshire, provided copies of his gravity data for the area that had been open filed by the U. S. Geological Survey. Dorothy Richter helped with the geological interpretation.

Previous work on gravity in the area includes that of Kane and Bromery (1968), Kane et al.(1972), and Hodge et al (1982).

The location of the study area is shown in Figure 1-1.

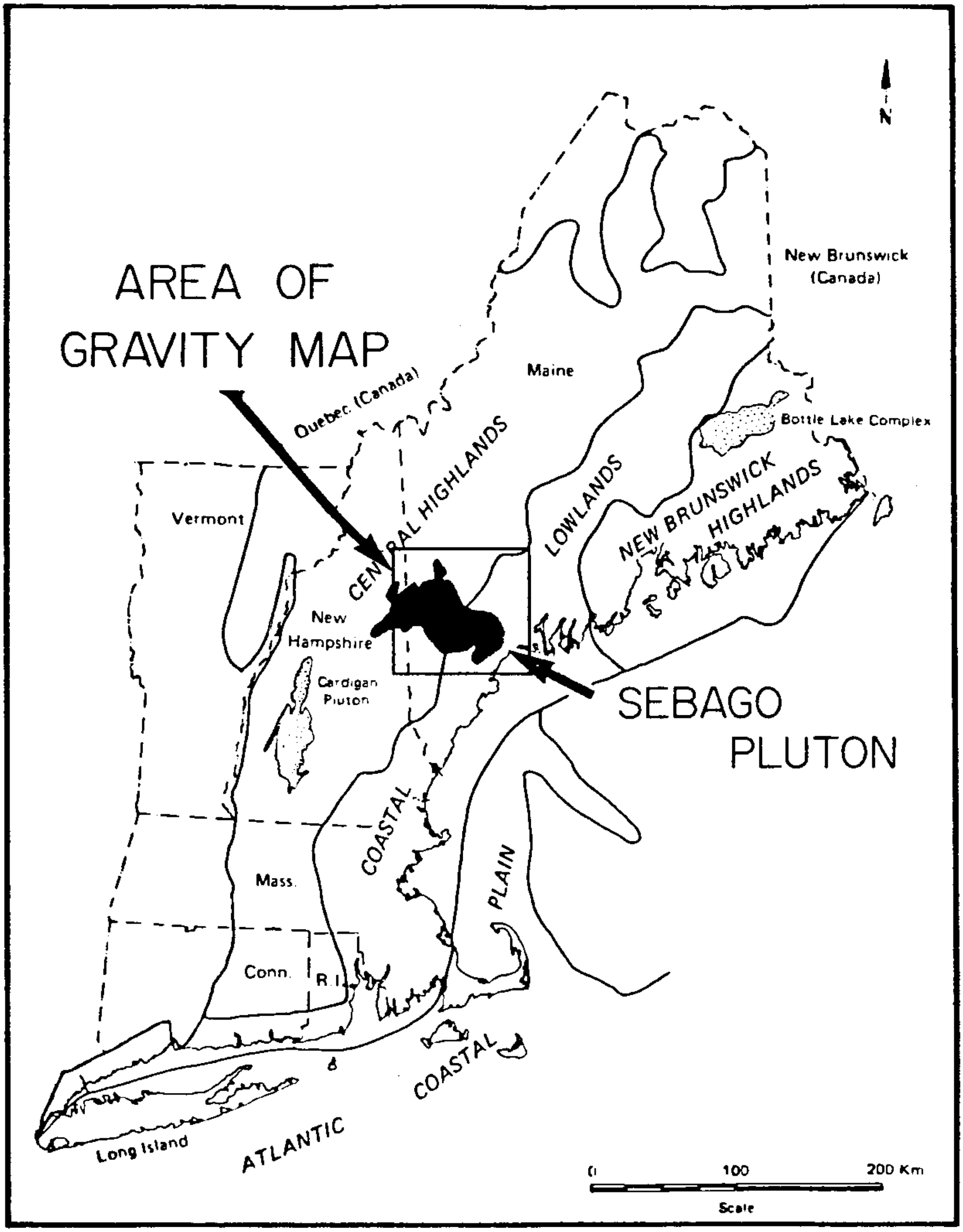

Figure 1-1. Location map. The Sebago pluton is in southwestern Maine and adjacent eastern New Hampshire.

2. PREPARATION OF GRAVITY MAPS

2.1 The Data

The data used in this report were obtained from the DMA data base, maintained and distributed by the National Oceanographic and Atmospheric Administration and from "Open-file" data of the U. S. Geological Survey, courtesy of Professor W. A. Bothner of the University of New Hampshire. The data of 17 investigators (or investigations) were used, including those referred to in the preceding paragraph. Of the 17 separate investigators/investigations, only 12 contributed more than 10 stations each.

Table 2.1-1 identifies the primary data sources used, giving credit for the original data.

2.2 Units

The value of gravity at the surface of the earth is nominally 980 cm/sec^2. This unit is too large for geophysical purposes. The usual unit used in geophysics, the one that we shall use throughout this report, is the milligal, defined by

$$1{,}000 \text{ mgals} = 1 \text{ cm/sec}^2$$

2.3 Bouguer Gravity Reduction

The value of gravity measured at the surface of the earth is affected by the positions of the sun and moon, elevation, distance from the earth's center, topography, and the subsurface distribution of density. Of these many factors, only the last carries geological information. Therefore, the measured values of gravity must be processed in order to extract geologically useful information.

The gravitational effects of the sun and moon are normally removed from the gravity data by the original investigator. However, the maximum combined effect is approximately 0.2 mgal, a negligible amount for the present report.

TABLE 2.1-1

SOURCES OF DATA

NUMBER OF STATIONS	SOURCE
904	Bothner, Open-file USGS, 1986
6	Kane et al., 1972
312	Joyner, W. B.
433	USGS 1964
2	Geodetic Survey, 1967
2	Wolfe
191	Bean, R. J.
29	Iverson, R. M., 1955
8	Iverson, R. M., 1955
5	Woollard, G. P., 1947
111	Boston Edison
826	Welteraurer, R. and W. A. Bothner, USGS, 1976
29	Unidentified
372	Bothner, W. A.
75	Kane, M. F.
307	Hodge, D. F., USGS, 1976
95	USGS

The effects of elevation and distance from the earth's center are removed with the following equation. The resulting value is termed the "Bouguer gravity anomaly".

$$g_{BA} = g_{MEAS} - g_{LAT} + 0.3085h - 0.04188h\rho$$

where

g_{BA} is Bouguer gravity anomaly,

g_{MEAS} is the measured gravity value,

h is the elevation of the station in meters,

ρ is the density in g/cm^3,

and

$$g_{LAT} = 978031.8(1 + 0.0053024 \sin^2\theta - 0.0000058 \sin^2 2\theta)$$

and

θ is co-latitude.

The gravity value obtained with the above equations is strictly termed the simple Bouguer anomaly and includes the effects of topography. On the basis of our experience in calculating the topographic effects in other geographic areas and knowledge of the topography of the Sebago pluton area, the topographic effects for most stations in the area are estimated to be less than 0.25 mgal. They have not been included in the data processing.

2.4 Data Adjustment

Two adjustments to the database are necessary:

(1) A baselevel adjustment.
(2) Elimination of incorrect data.

2.4.1 Baselevel Adjustment

In measuring gravity in the field, only differences of gravity are actually measured. The value of gravity at a given station is then calculated from the "known" value for some station determined previously by some other investigator and reoccupied during the given investigation. Such "known" values may have been derived through several iterations of investigations. With such a procedure, the values for any particular investigation may be offset systematically from the values of an adjacent investigation. This offset is termed a difference in datum or a difference in baselevel.

The baselevels of different primary sources must be adjusted to the same value. Otherwise, anomalies that correlate with the area of a particular investigation will be produced. Fortunately, any significant differences in the various baselevels are easy to recognize and the adjustment is simple.

Each gravity investigation will typically have at least a few stations that coincide in location with one or more previous surveys. Therefore, we examine the gravity values at such "coincident" stations and adjust all values for a particular survey to minimize the absolute value of the difference for several such station pairs. This procedure insures that the gravity anomalies in the final contour maps are real.

2.4.2 Incorrect Data Elimination

The data set for every gravity survey is likely to contain a few errors. The sources of error are many and include reading the instrument, locating the station, using the wrong elevation, typing or keypunching data. Errors greater than a few milligals in the Bouguer gravity value are relatively easy to detect. For example, in the data set used for this report, we found two stations with values greater than 300 mgals, obviously incorrect in view of all other stations having values within the range +50 to -50 mgals. Other easily recognized erroneous types of stations are (1) a single station of a set that is well outside the general area of other stations of the set <u>and</u> differing by at least 2 mgals from the value expected on the basis of nearby stations of other investigations and (2) stations with elevations that are not possible for their given location. All of these "incorrect" values are generally recognized on preliminary contour maps in which relatively large anomalies are associated with single stations. Such stations are deleted from the data base before preparing the final maps.

It is important for this report, however, to note that gravity stations are not removed simply because they produce "single station" anomalies. Examination of the maps of this report will reveal the presence of at least two such stations producing residual gravity anomalies of 8 to 10 mgals. We <u>suspect</u> that the values are incorrect but neither elevations nor locations are clearly in error. Therefore, we have retained the stations and the maps show the resulting anomalies (identified as Anomaly B1 and E1 on the residual gravity map). The station producing Anomaly E1 is located within the boundary of the candidate area. Such stations, when and if the resulting anomalies become significant, should be reoccupied.

2.5 Total, Regional, and Residual Bouguer Gravity Anomaly

The "total Bouguer gravity anomaly" value was defined in equation 1. It approximates the contribution to the measured gravity of all subsurface density contrasts, at all distances from the gravity station (and in principle, throughout the entire earth). In practice, the interpreter is concerned with variations in density that occur within finite ranges -- say from the surface to shallow depths and from shallow depths to greater depths. Thus, the value of the total Bouguer gravity anomaly is divided into two parts termed "regional Bouguer gravity anomaly" and "residual Bouguer gravity anomaly". The regional values vary smoothly with horizontal distance (that is, they contain small gradients) and are likely produced by variations of density at considerable depth. The residual values, on the other hand, contain larger gradients, vary more sharply with distance, and must be caused by variations in density relatively near the earth's surface.

There are several methods of separating the total Bouguer gravity anomaly into regional and residual values including visual inspection and graphical smoothing of orthogonal gravity profiles, upward continuation, area averaging, and digital filtering. We have used area averaging for similar work for many years and used it for this report. In area averaging, the average value of gravity for a finite sized area is taken as the regional value and the residual value is the algebraic difference between the total value and the regional value. Typical values of the radius used for the averaging are 15, 20, 40, and 60 km.

3. GRAVITY MAPS OF SEBAGO PLUTON AND ENVIRONS

3.1 The Maps

The locations of the 2,500 stations used for this report are shown in Figure 3.1-1. As indicated above, the data were collected originally by 17 different investigators and/or different investigations (although 5 contributed less than 10 stations each).

The total Bouguer gravity anomaly map and the corresponding regional and residual Bouguer gravity anomaly maps are shown in Figures 3.1-2, 3.1-3, and 3.1-4, respectively, for the Sebago pluton and surrounding areas. These maps were prepared with the techniques described in Section 2 of this report. Four regional Bouguer gravity maps were prepared with values of 15, 20, 40, and 60 km used for the averaging radius. The 40-km map was selected as the best one to use for the present purpose because it showed little or no correlation with the gravity anomalies of interest in the total Bouguer gravity map and at the smallest radius. The regional gravity maps obtained with smaller values of radius showed correlations with the various anomalies, an undesirable attribute.

The anomaly at 70^{o} longitude, 44^{o} latitude was modeled by Hodge et al. (1982). The station locations and the residual gravity anomaly map for that area are shown in Figures 3.1-5 and 3.1-6, respectively.

3.2 The Interpretation

3.2.1 Areas Around Sebago Pluton

The individual gravity anomalies are due to density contrasts of different rock masses. Figure 3.2-1 shows the interpretation of the various anomalies.

Granitic rock masses in Maine have been known to produce gravity lows in the approximate range of 10 to 20 mgals since the work of Woollard in the late 1950's, unpublished except in the early gravity maps of the United States. The map of Kane et al. (1972) shows that several such anomalies occur over granite bodies intruded along strike in the country rocks of the Sebago pluton area. Those granite bodies are designated Devonian granites on the Maine Bedrock Geology Map (Osberg et al., 1985).

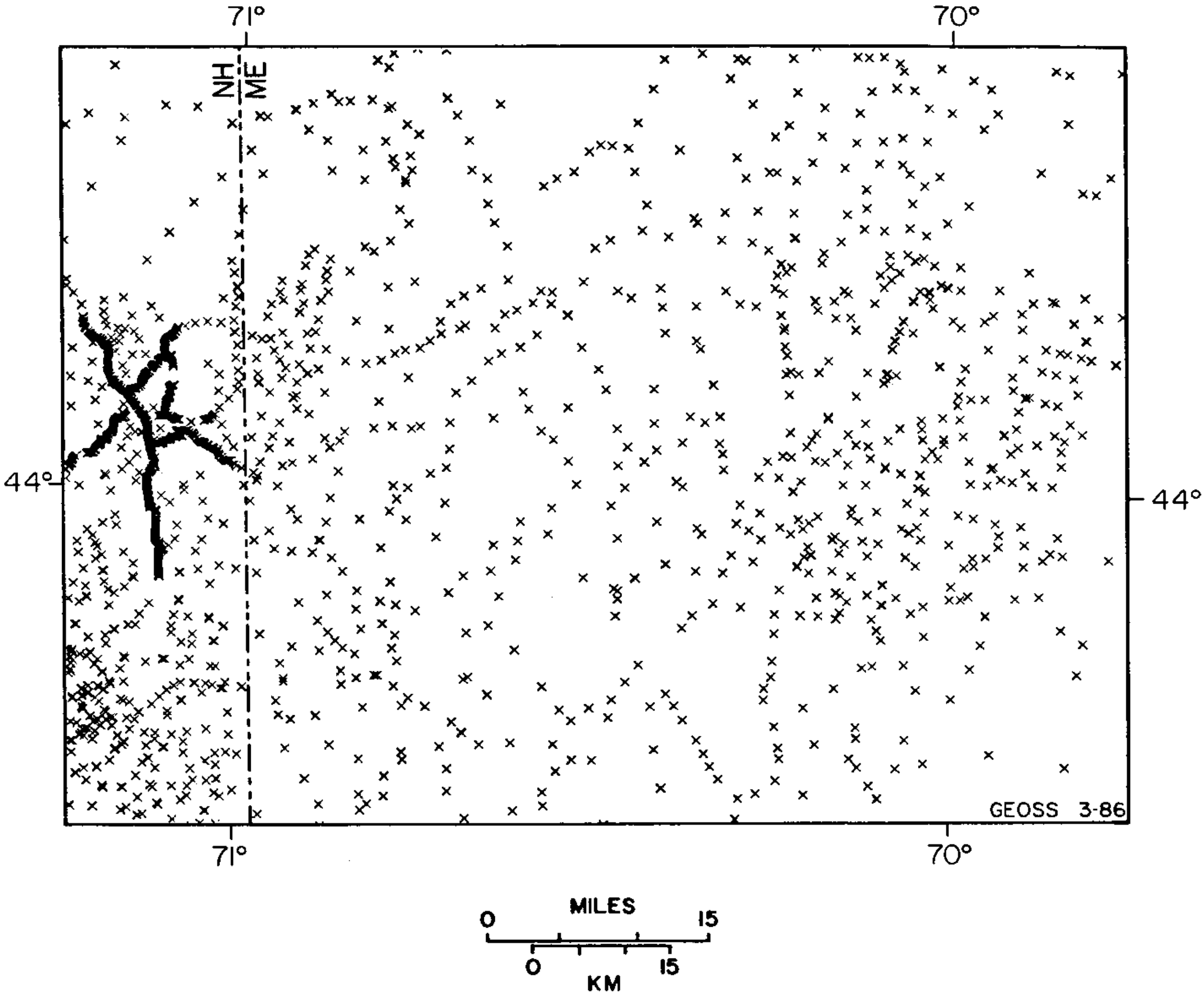

Figure 3.1-1. Gravity station locations for the Sebago pluton area. Approximately 2,500 stations have been established by 12 different investigators and/or investigations. The dark lines in western area represent closely spaced stations. All data were available from the Public Domain.

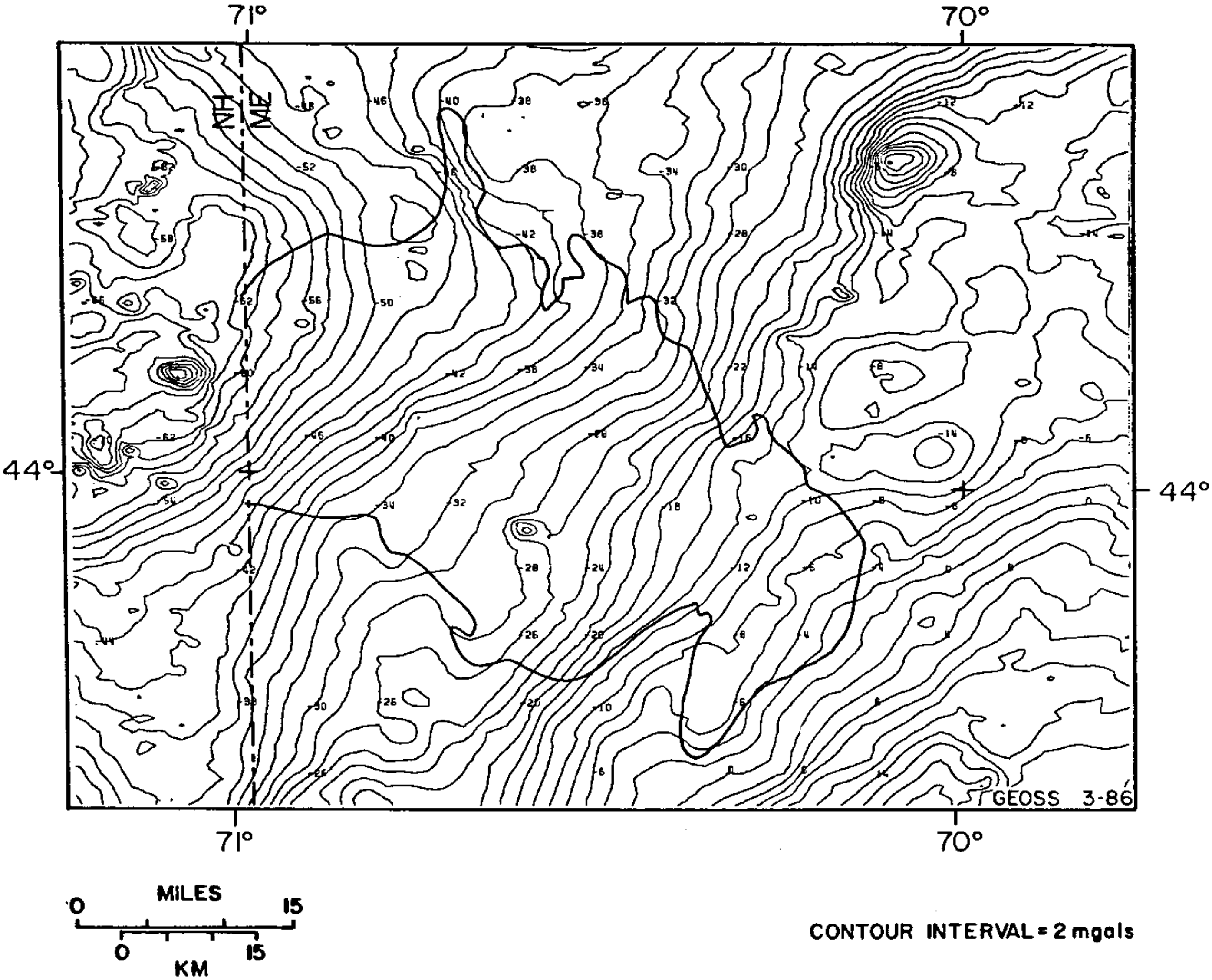

Figure 3.1-2. Total Bouguer gravity anomaly map for the Sebago pluton area. The contour interval is 2 mgals. The density used for the Bouguer reduction was 2.67 gm/cm^3. The station locations are shown in Figure 3.1-1.

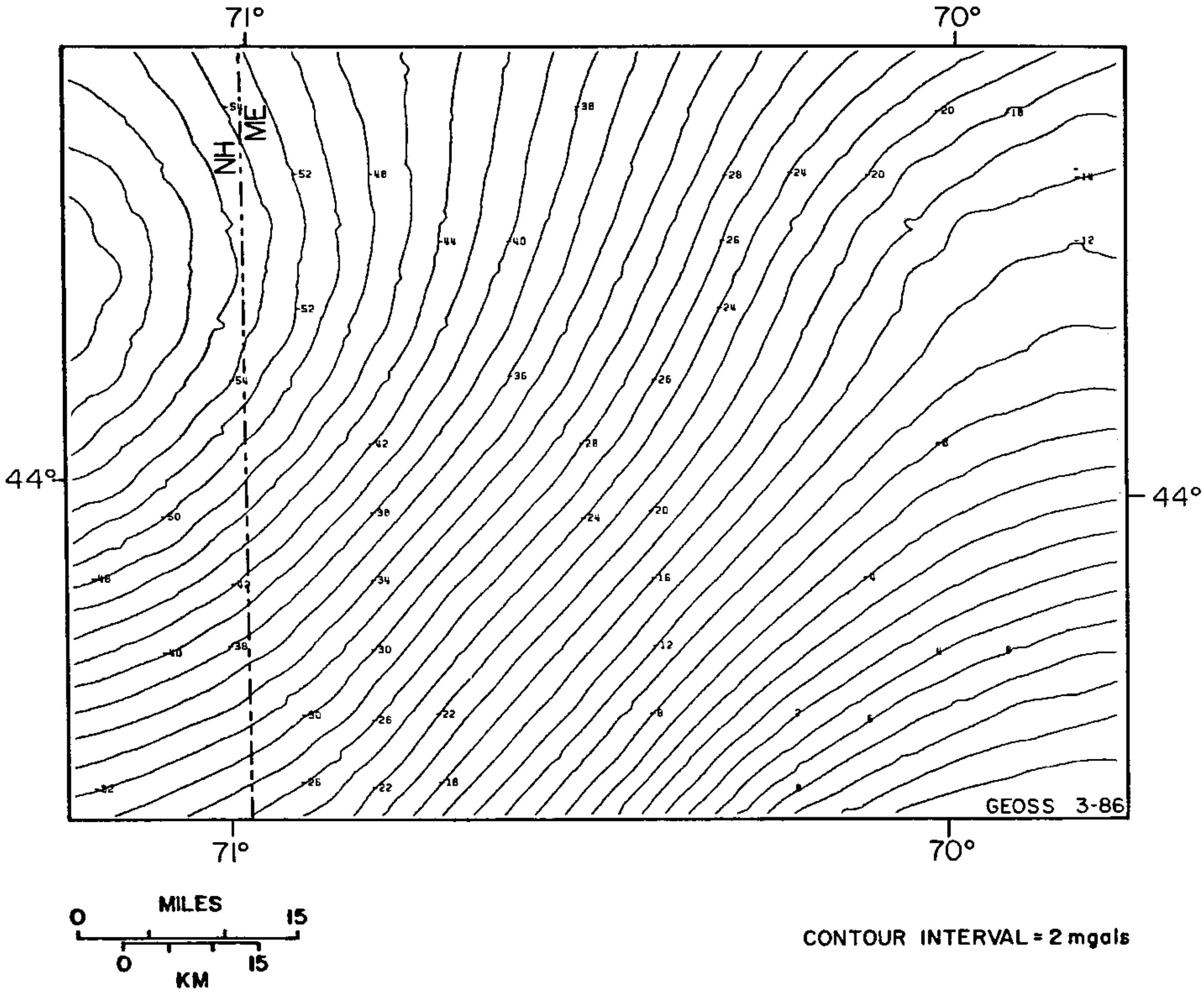

Figure 3.1-3. Regional Bouguer gravity anomaly map for the Sebago pluton area. The contour interval is 2 mgals. The density used for the Bouguer reduction was 2.67 gm/cm^3. The station locations are shown in Figure 3.1-1.

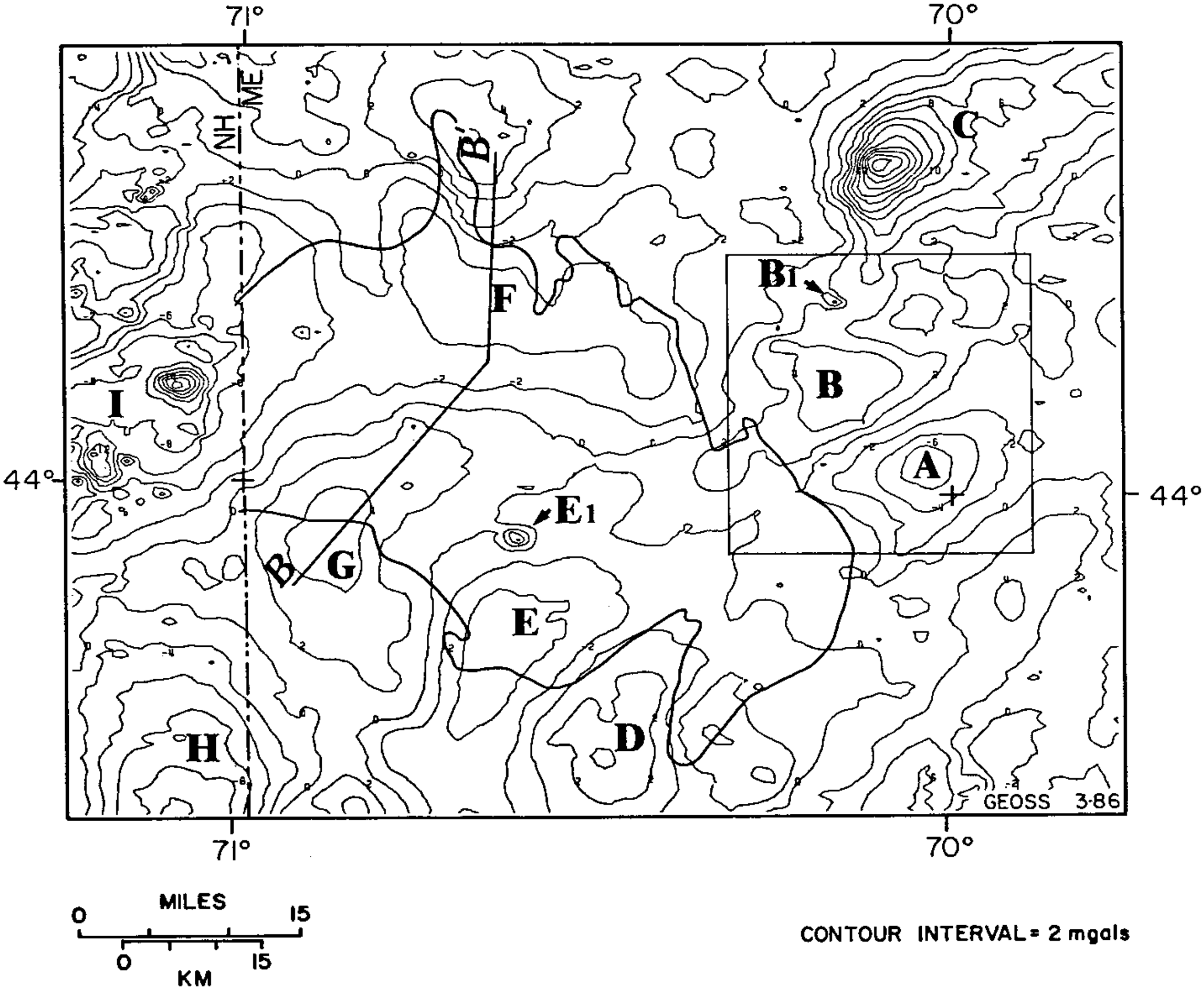

Figure 3.1-4. Residual Bouguer gravity anomaly map for the Sebago pluton area. The contour interval is 2 mgals. The density used for the Bouguer reduction was 2.67 gm/cm^3. The station locations are shown in Figure 3.1-1.

The large letters identify anomalies discussed in the text.

Anomalies B1 and E1 are based on single gravity stations and are not likely valid features.

The area within the box around Anomalies A and B is shown at larger scale in Figures 3.1-5 and 3.1-6.

Gravity along profile BB' is used to construct a model of the bodies that produce the gravity anomaly associated with the Sebago pluton.

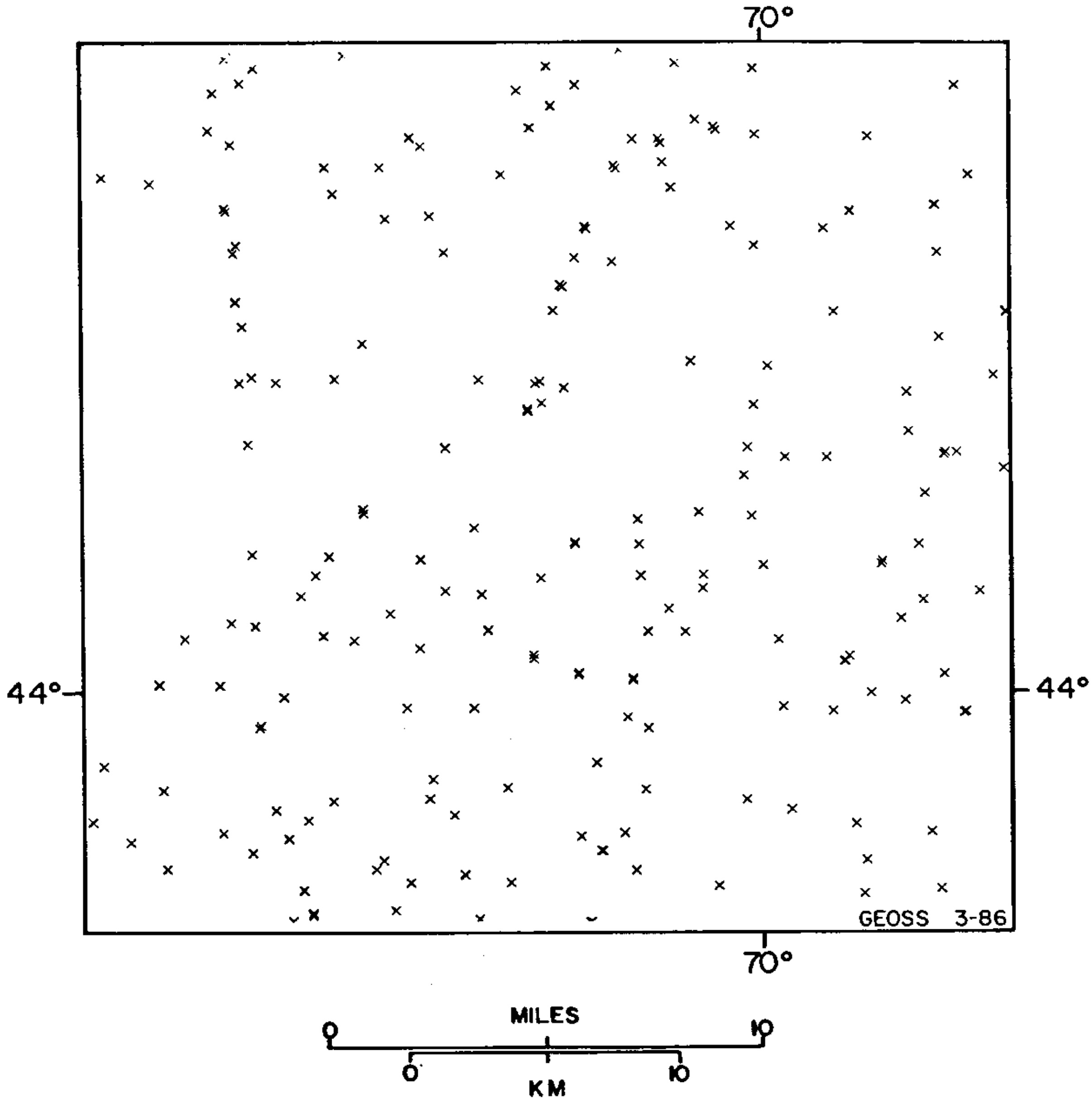

Figure 3.1-5. Gravity station locations for the Lisbon Falls area. Approximately 400 stations are within this area.

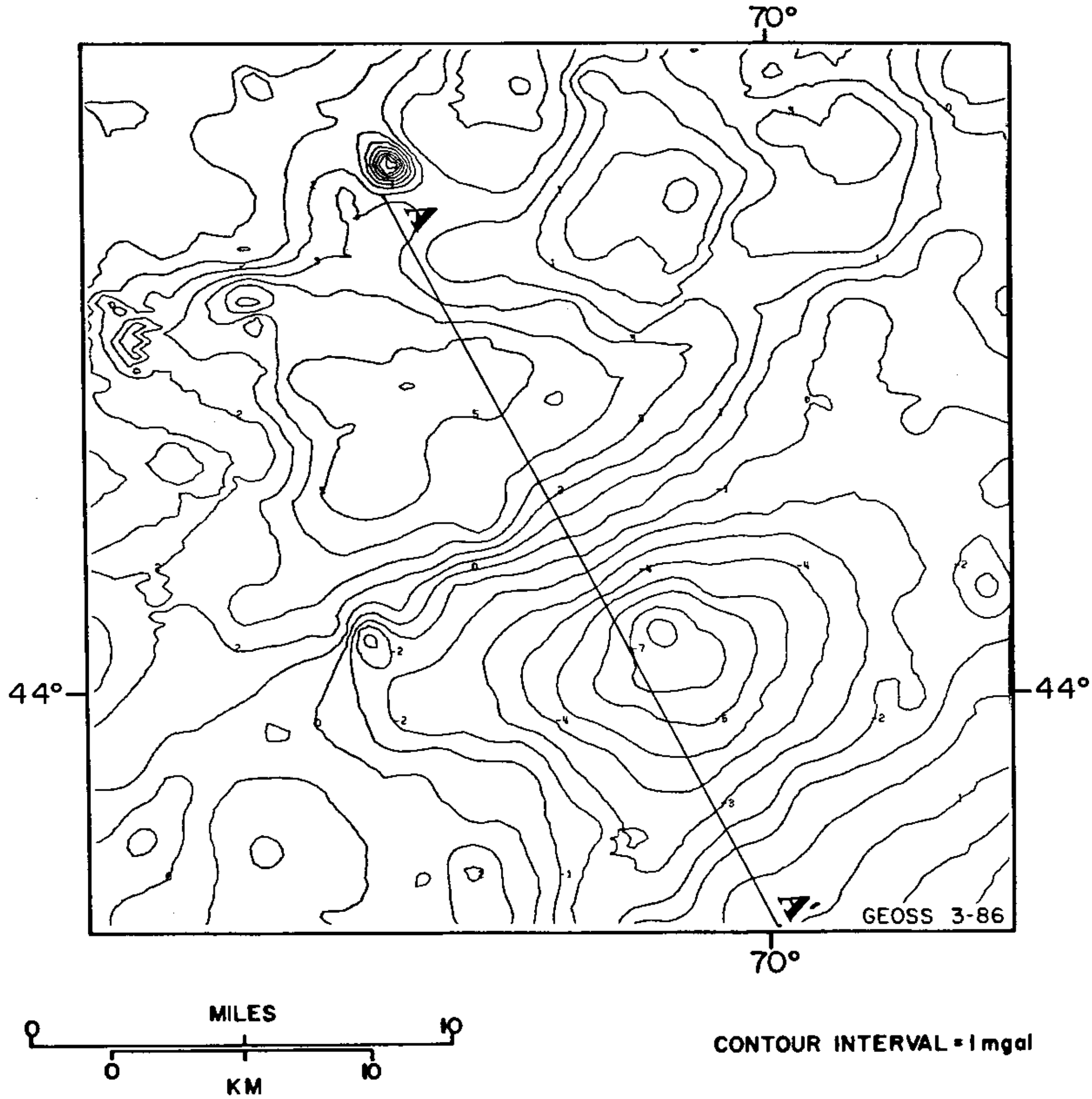

Figure 3.1-6. Residual Bouguer gravity anomaly map for the Lisbon Falls area. The contour interval is 1 mgal. The density used for the Bouguer reduction was 2.67 gm/cm^3. The station locations are shown in Figure 3.1-5.

A-A' marks the location of a profile modeled by Hodge et al. (1982) and also in this report.

The small sharp anomaly located on the map immediately north of the letter A is based on a single station and is probably not valid. However, it has been retained in the data set because neither elevation nor location are obviously in error.

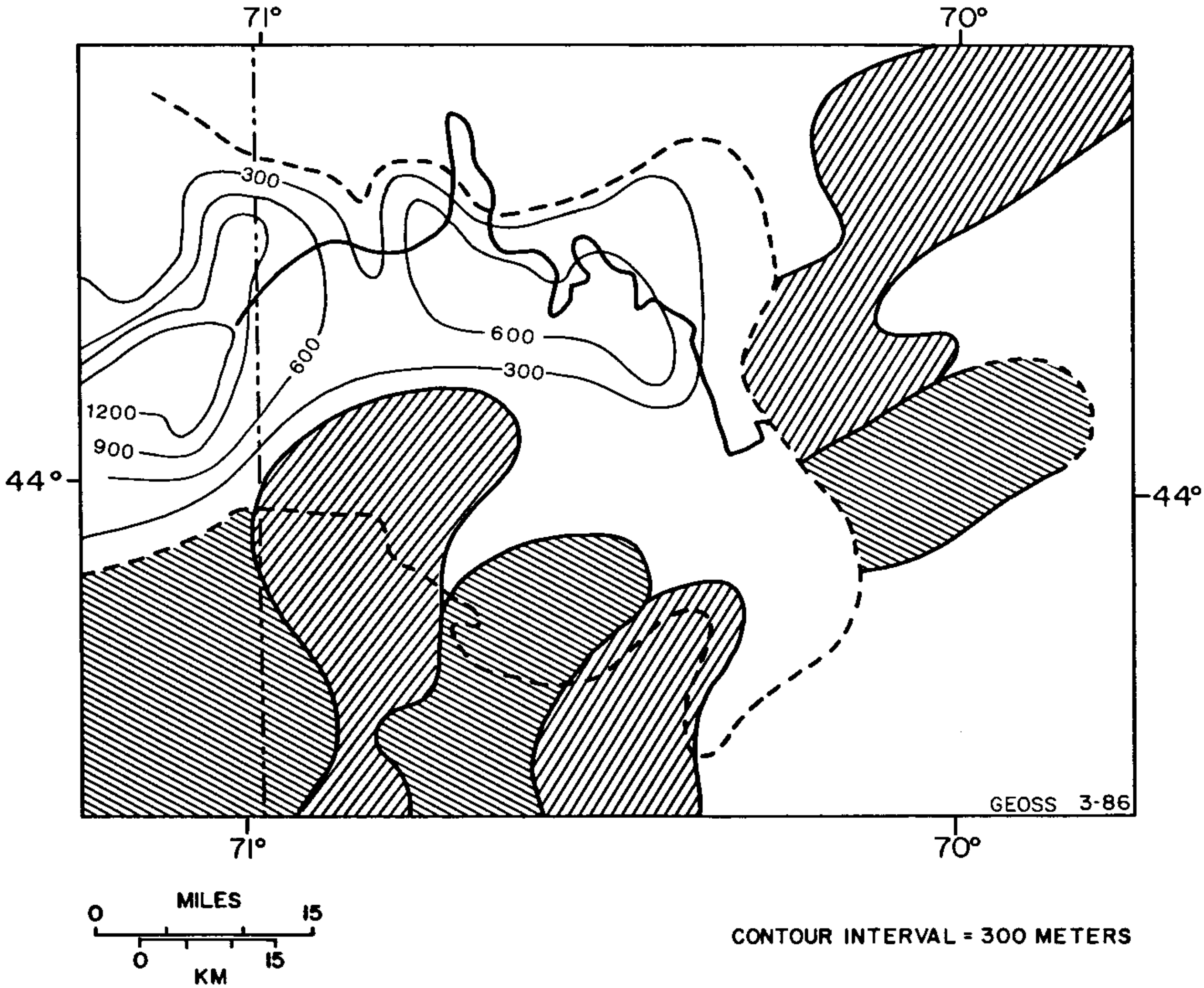

Figure 3.2-1. Interpretation of Residual Bouguer gravity anomaly map for the Sebago pluton area.

The patterns indicate distinct rock masses. Those sloping upwards to the right represent rock more dense than the surrounding rocks. Those sloping upwards to the left represent rock less dense than the surrounding rocks. See text for further discussion.

The heavy solid line is the mapped outline of the Sebago pluton. The heavy dashed line is the location of the subsurface boundary of the Sebago pluton inferred from the residual gravity map. On the south side, the residual gravity anomaly is too small to accurately delineate the location of the outer boundary in the subsurface. Thus, we suggest that the two lines coincide for practical purposes in that area and show them as dashed.

The contours are the depths in meters below sea level inferred for the bottom of the Sebago pluton from the residual gravity map. The contour interval is 300 meters.

Therefore, we infer that anomalies A, E, and H, marked on Figure 3.1-4, are caused by similar granitic masses. In further support of this interpretation, we note that small outcrops of such granite have been mapped within the area of each anomaly. However, it appears that the causative granite bodies are largely subsurface. This interpretation can be tested when sufficient heat flow data become available for the area -- the areas over the inferred granite bodies should have higher values of heat flow than the adjacent areas.

The metamorphic country rocks have higher densities than the granites, an inference drawn from the observation that country rocks have associated gravity highs and supported by the measured values reported by Hodge et al. (1982). Anomaly D correlates well with the mapped pattern of metamorphic rocks and is attributed to the density contrast between them and the adjacent granite. The southwestern portion of Anomaly B correlates well with metasedimentary rocks in a recumbent syncline. Anomaly C is attributed to mafic igneous rocks present largely in the subsurface and exposed at the surface at Wayne.

3.2.2 The Lisbon Falls Anomaly

3.2.2.1 Introduction

Hodge et al. (1982) reported a model to account for the Lisbon Falls Anomaly, shown as anomaly A on Figure 3.1-4. Their model appears to been accepted and subsequently used by the Department of Energy in the considerations that led to including the Sebago pluton in the list of "proposed potentially acceptable sites for consideration in the second high-level radioactive waste repository program". Thus, both their model and the exact nature of the anomaly assume considerable practical importance.

3.2.2.2 Residual Gravity Anomaly Map

The residual gravity anomaly map for the Lisbon Falls area is shown in Figure 3.1-6. The location of the profile modeled by Hodge et al. (1982) is shown as AA'.

Hodge et al. (1982) did not include a residual gravity map for the Lisbon Falls area in their publication. They did present gravity values along profile AA', reproduced in our Figure 3.2-2. Their values are presumably residual gravity values but they differ significantly from GEOSS' residual values and do not appear to us to be correct on the basis of visual observation of either their total Bouguer gravity anomaly map or the corresponding map

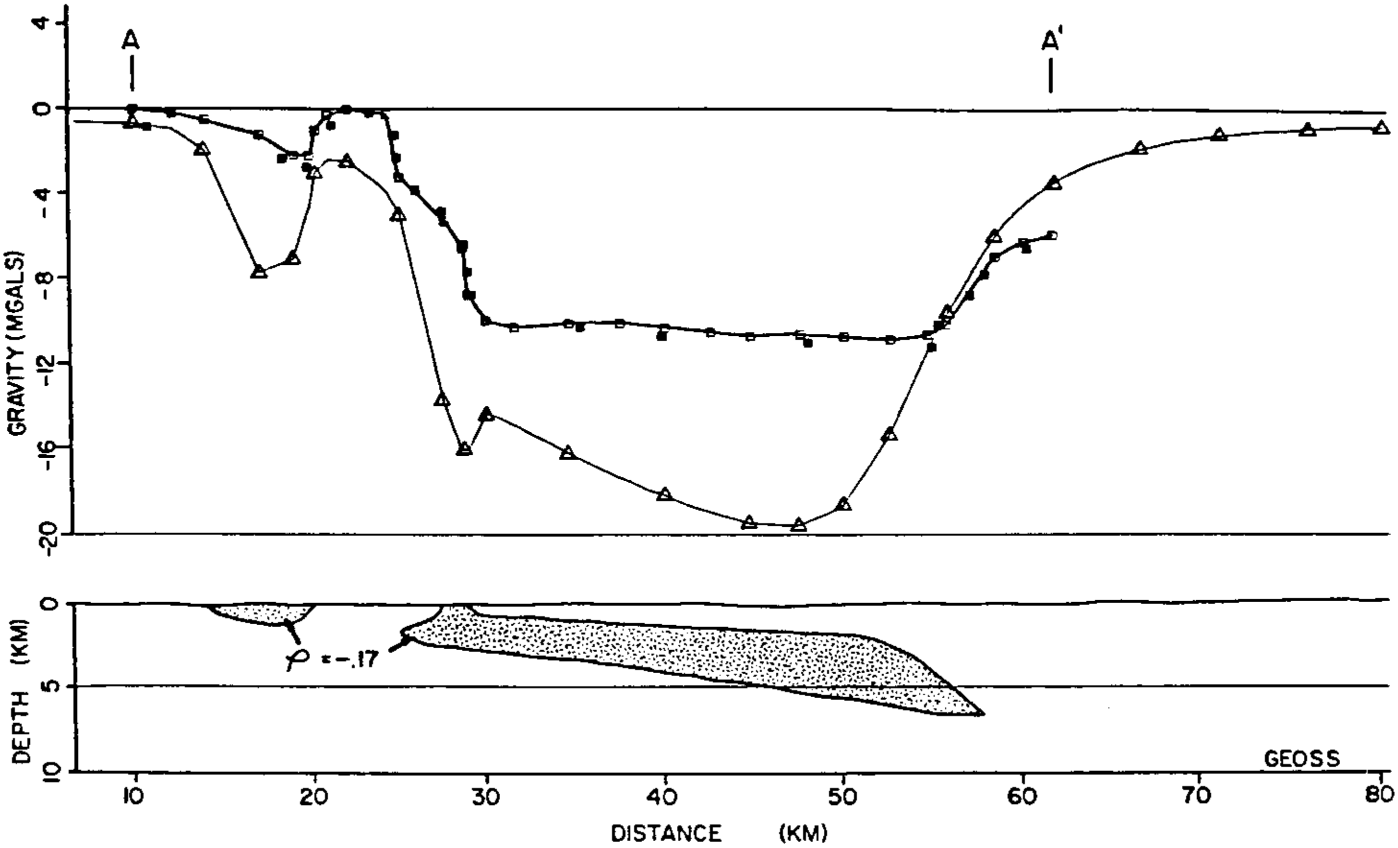

Figure 3.2-2. Gravity along the profile AA' in the Lisbon Falls area and a model of the subsurface distribution of rock.

On the gravity plot (upper figure):

The open squares represent observed gravity as given by Hodge et al. (1982).

The filled squares represent gravity calculated for the model as reported by Hodge et al. (1982).

The triangles represent gravity calculated for the model as determined by GEOSS.

On the model plot (lower figure):

The patterned area represents granite with a density contrast of -0.17 gm/cm^3.

The large difference between the observed gravity determined by GEOSS and that published by Hodge et al. (1982) is probably due to their failure to remove the regional gravity field correctly. The large difference between the value of gravity calculated by GEOSS and that published by Hodge et al. (1982) is attributed to computational error: apparently a factor of 2 is missing.

of our Figure 3.1-2.

The GEOSS residual gravity map for the Lisbon Falls area shows two distinct gravity anomalies. One is a gravity high, the other is a gravity low. The gravity low must be due to rock with a density less than that of the surrounding rocks; the gravity high must be due to rock with a density greater than that of the surrounding rocks. Therefore, models of density to account for the gravity must include both positive and negative density contrasts.

3.2.2.3 Geologic Models for the Lisbon Falls Anomaly

Unfortunately, the model of Hodge et al. (1982) is incorrect. We have the following objections to it:

1. The profile of observed gravity used for comparison with the calculated gravity differs significantly from the contour map given by Hodge et al. even if their total Bouguer gravity anomaly map is modified by subtracting any plausible regional gravity field. It also differs significantly from the gravity maps given in this report based on the same data. We suggest that the observed gravity values used by them are likely incorrect.

2. The calculated values for the model will not fit the observed gravity (either the values shown on their map or the values given on the residual gravity map of this report) if the calculations are continued for larger distances at either end of their model. In order for the model to be possible, the values of the calculated gravity must be, or approach, zero near both ends of the model; however, they do not.

3. The calculated values shown by them are incorrect by a factor of 2 at all locations.

4. They failed to recognize the presence of two different causative bodies. One produces a gravity **low** of about 6 to 7 mgals. The other produces a gravity **high** of 4 to 6 mgals. There definitely is not a gravity low of 10 mgals as modeled by them.

The validity of our contention that an error of a factor of 2 is present in their results can be shown very simply. The model, reproduced in Figure 3.2-2, is a gently dipping subsurface slab approximately 2 1/2 km thick with a density contrast of

$-0.17\ gm/cm^2$. The gravity anomaly due to an infinite slab of thickness h is a satisfactory approximation in the central area of the slab. The value can be calculated with the following equation given in introductory geophysics texts (see, for example, Telford et al., 1976):

$$g = 41.89\ \rho h \qquad (2)$$

where

g is value of gravity in mgals,
h is the elevation of the station in kilometers,
ρ is the density contrast in g/cm^3,

For a density contrast of $-0.17\ gm/cm^2$, the gravity anomaly due to a slab 2.5 km thick is 18 mgals, approximately twice the value shown by Hodge et al. (1982).

The gravity values calculated by GEOSS for the same model is also shown in Figure 3.2-2. Those values do not fit the observed gravity as determined by Hodge et al. (1982) or as determined by GEOSS for this report. Therefore, the model is not possible.

A model that uses the density contrast of -0.17 mgal between the granite and the metamorphic country rocks is shown in Figure 3.2-3. Because (1) the observed gravity anomaly is only 7 mgals, not 10 as Hodge et al. (1982) used and (2) the gravity calculation does not contain the factor of 2 error, the thickness of the causative body is significantly reduced from their thickness. Furthermore, because the anomaly is not "flat bottomed" as shown by Hodge et al. (1982), the slab is not as wide as their model.

3.2.3 The Sebago Pluton

The gravity effect of the Sebago pluton is small, as noted previously by Hodge et al. (1982). Indeed, because of the strong regional gravity gradient in the area, it is only after making the residual/regional separation that one can detect the presence of any anomaly. The maximum absolute value of the anomaly is only some 4 to perhaps 6 mgals. The nature and geometry of the rock mass are inferred in several ways. The mapped north edge of the pluton correlates well with the gravity anomaly. In that area, we have used the density contrast between the rock of the Sebago pluton and the metamorphic country rock, as measured by Hodge et al. (1982) and the model of a thin slab to contour the bottom of the pluton. The contours shown on Figure 3.2-1 are therefore depths in meters below the Geoid, or for all practical purposes, the depth below sea level. The maximum depth in Maine is approximately 600 meters. Furthermore, the area within the

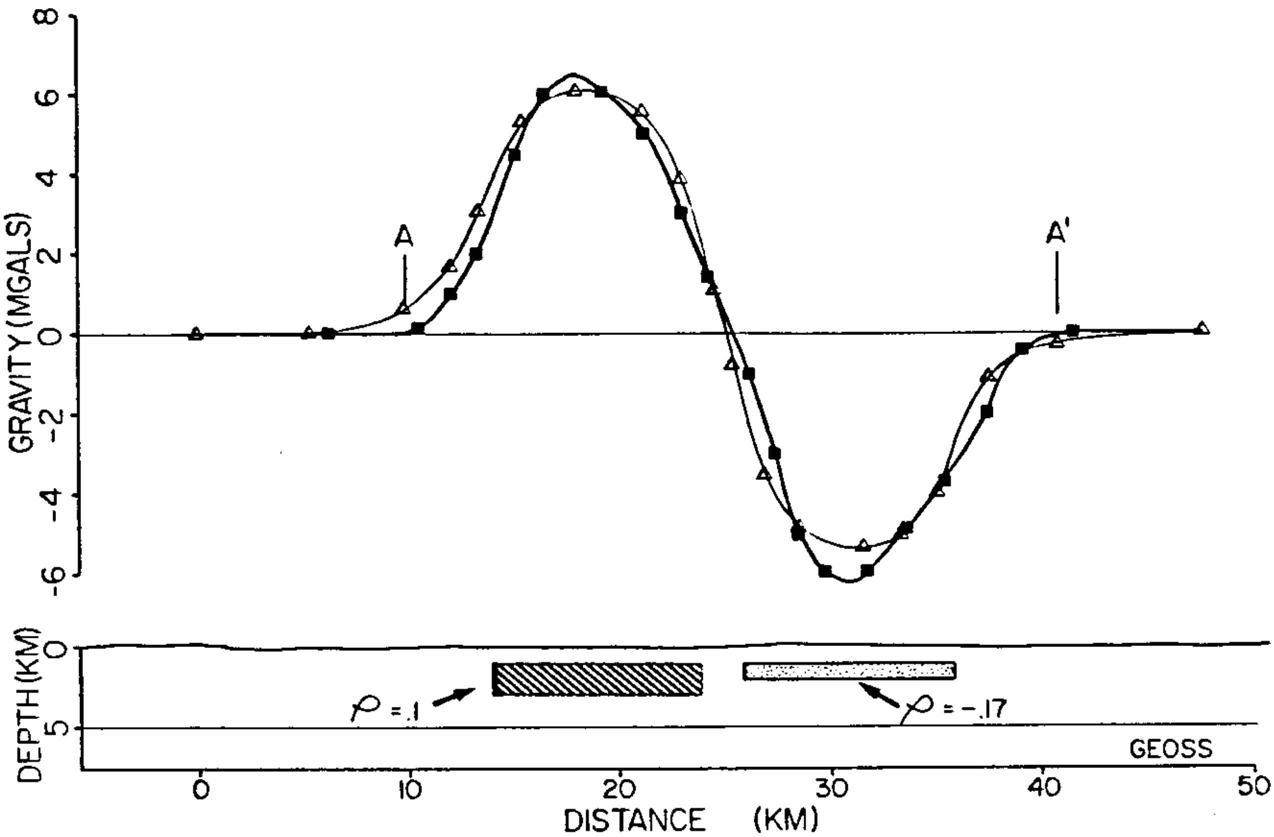

Figure 3.2-3. Gravity along the profile AA' in the Lisbon Falls area and preferred model of the subsurface distribution of rock. The density contrast for the granite, -0.17 gm/cm^3, is the value reported by Hodge et al. (1982) and also used by them for their model. The gravity values shown here are residual Bouguer gravity anomalies taken from Figure 3.1-6.

600 meter depth contour is well outside the proposed preliminary candidate area (DOE, 1986, Figure 3-96). Within the proposed preliminary candidate area, the bottom of the pluton lies at a depth less than 300 meters below sea level, as determined from the gravity anomaly. The local average surface elevation (with the radius of averaging being 10 kilometers) is estimated to vary between 30 and 300 meters. Although more detailed work would be required to provide the basis for isopach maps of the thickness of the rock mass beneath the proposed preliminary candidate area, the present maps are adequate to show that the thickness is likely less than 300 meters for a considerable portion of the area.

Along the northeastern side of the pluton, a zone 10 to 25 kilometers wide contains abundant country rock mixed with the granitic rock of the pluton. The inner border of that zone, as mapped geologically, correlates well with the 2 mgal contour of the residual gravity map, Figure 3.1-4. The anomalies A and B terminate against the outer mapped border. It would appear therefore that the gravity map reflects accurately the effects of the pluton in the northeast area.

Along the north side of the pluton, the mapped boundary is approximately parallel with the gravity contours. However, the gravitational effect extends farther north than the mapped surface extent of the pluton. We suggest that the Sebago pluton extends in the subsurface approximately 10 to 15 km northward. The outermost boundary of the pluton in the subsurface is shown on Figure 3.2-1.

The residual gravity along profile BB' is shown in Figure 3.2-4. This profile extends across the northern edge and well into the central area of the pluton. The model of a thin slab of low density rock, also shown in figure 3.2-4, accounts well for the observed gravity. The density contrast used for the Sebago pluton, $-0.17\ gm/cm^3$, is based on the value measured by Hodge et al. (1982). The value used for the density contrast of the causative body north of the Sebago pluton, $+0.10\ gm/cm^3$, is a reasonable, but assumed, value. The two values, of course, are entirely independent and the value used for the small gravity high has no effect on either the density required, or the thickness, of the Sebago pluton.

The southern half of the pluton appears to be quite thin, probably less than 300 meters. The gravity anomalies of at least three other rock masses, labeled D, E, and H on Figure 3.2-1, "ignore" the mapped boundary and extend across half the pluton. With a contour interval of 2 mgals, even a 1 mgal effect due to the presence of the Sebago pluton should be seen on Figure 3.2-1.

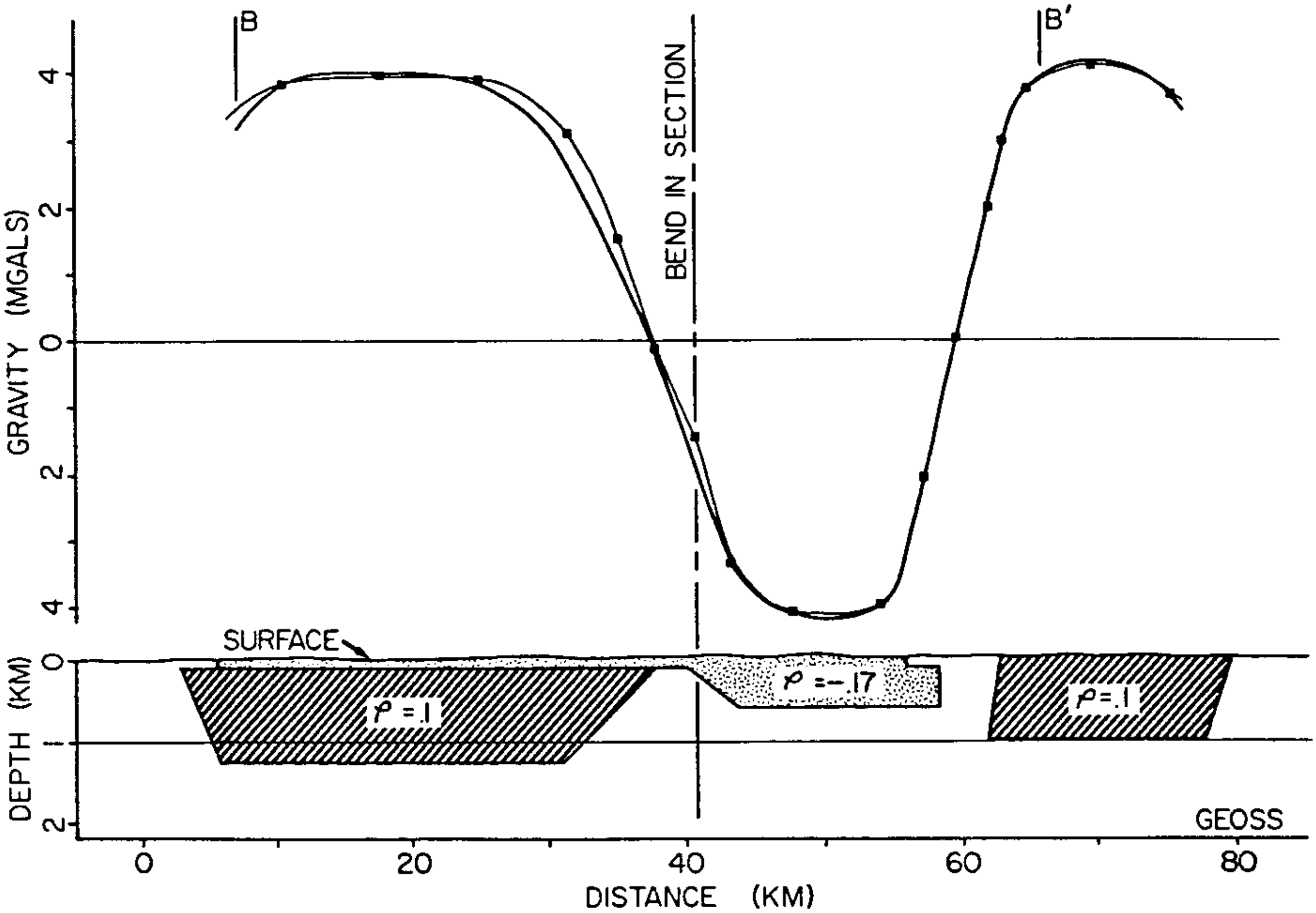

Figure 3.2-4. Gravity along the profile BB' in the Sebago pluton area and preferred model of the subsurface distribution of rock. The density contrast for the granite, -0.17 gm/cm^3, is the value reported by Hodge et al. (1982) for rocks of the Sebago pluton and the country rock. The gravity values shown here are residual Bouguer gravity anomalies taken from Figure 3.1-4. Note that there is a bend in the profile.

We therefore conclude that the southern half of the pluton is very thin, probably less than 300 meters.

4. DISCUSSION

The thickness of the Sebago pluton is an important consideration for the selection of the rock mass as a "proposed potentially acceptable site for consideration in the second high level radioactive waste repository program". The estimates available previously were based on the work of Hodge et al. (1982), which unfortunately was incorrect.

The estimates of thickness given in this report are based on the values of density reported by Hodge et al. (1982). Because the number of samples was relatively small and the possibility that important geologic units are either poorly sampled or not sampled at all, the uncertainties in the densities might be large. Because the thickness of the Sebago pluton is proportional to the magnitude of the density contrast, the uncertainty in thickness might also be considered relatively large.

The following argument, however, strongly supports the view that the density contrast, and therefore the thickness estimate, is essentially correct. The country rocks adjacent to the Sebago pluton extend northeast and southwest from the pluton. Several Devonian granites are intruded into those same units along strike and produce anomalies of 10 to 15 mgals magnitude. The causative body for the Lisbon Falls anomaly, a Devonian granite, intruded in the same country rocks as the Sebago pluton, and within a few kilometers of the Sebago pluton, produces an anomaly of similar magnitude (that is, 10 to 15 mgals). However, the magnitude of the anomaly due to the Sebago pluton is only 30 to 40 % as large (4 to 6 mgals). Either the density of the Sebago pluton is 1/3 the density of the other plutons, or the thickness is 1/3 the thickness of the other plutons, or some appropriate combination thereof. The density of granites varies little; it is 2.65 plus or minus 0.02 gm/cm^3 regardless of age. We conclude, therefore, that the thickness of the granite masses in southwestern Maine is the parameter that varies and not the density of the country rocks.

5. CONCLUSIONS

The separation of the total Bouguer gravity anomaly field into regional and residual gravity fields facilitates the recognition and delineation of small amplitude residual gravity anomalies in southwestern Maine.

The residual gravity anomaly in the Lisbon Falls area, originally modeled by Hodge et al. (1982) as a single negative anomaly, consists of a gravity low of about 7 mgals toward the south and a gravity high of 4 to 6 mgals toward the north. Thin slabs of material account satisfactorily for the observed anomalies: One, presumably granite, only 3/4 km thick with density contrast of -0.17 gm/cm^3 toward the south; the other, 1 1/2 km thick with density contrast of $+0.10$ gm/cm^3 toward the north.

The residual gravity anomaly over the Sebago pluton is small, closely correlated with mapped boundary on the north side of the pluton, closely correlated with a mapped border phase of the pluton on the northeast side, but cut clearly by the anomalies due to underlying rock masses in the southern portion of the pluton. The detailed interpretation of the anomaly shows that the pluton probably extends to a maximum depth of approximately 600 meters below sealevel near its northern edge. The bottom is less than approximately 300 meters below sealevel throughout the southern 2/3 of the pluton. Because the average surface elevation ranges between 30 and 300 meters, the thickness of the pluton throughout a significant fraction of the preliminary candidate area is probably less than 300 meters.

6. REFERENCES

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