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**FEASIBILITY STUDY OF THE CONWAY GRANITE
AS A GEOTHERMAL ENERGY RESOURCE**

By
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August 15, 1978

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Orono, Maine

U. S. DEPARTMENT OF ENERGY
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All of these in back.

INTRODUCTION

In assembling information on possible sources of geothermal energy in the eastern United States, radioactive heat assumes considerable importance. Such heat under favorable circumstances may augment the normal heat of the earth to provide requisite temperatures for deep, dry-hole energy installations. Certain alkalic plutons, the most notable of which is the White Mountain batholith in New Hampshire, have above average concentrations of radioactive elements, and, on this basis, a study has been undertaken to determine the feasibility of utilizing it as an energy resource.

This study was restricted to the eastern part of the White Mountain batholith, since the level of funding and the time-frame for the project precluded a consideration of the entire batholith. Specifically, the North Conway area was chosen for study for the following reasons: (1) existing geologic maps showed a large exposure (32 km by 21 km) of Conway Granite, (2) the ERDA supported bore-hole at Redstone lies within this area as does the hole previously drilled by Birch et al. (1968) near Cathedral Ledge, and (3) accessibility within the North Conway area is better than elsewhere in the batholith.

Preliminary mapping showed that the existing geologic map (Billings, 1928) was generalized and an updated map was necessary. Consequently, considerable effort was expended in refining the geologic map and attempting to understand the sequence of intrusion. The geologic relations, as currently understood, are shown in Plate 1.

A specialized study of the orientation of joints was made in the eastern half of the batholith. An understanding of the surface joint pattern is important if geothermal wells are to be optimally located or

if any modeling of subsurface circulation is to be attempted. Also, knowledge of surface joint orientations should allow prediction of the orientation of hydraulically induced fractures and of "cooling fractures" that may result as the geothermal reservoir cools and fractures propagate downward.

Gravity was measured across the eastern part of the White Mountain batholith. These new data combined with existing information of Joyner (1963) permit modeling of the three-dimensional shape of the batholith. Two- and three-dimensional models have been constructed on the basis of the surface distribution of the rock units, the measured gravity, and the measured density of the rocks. Such modeling is important in determining the depth of the batholith.

Finally, the temperature distribution within the eastern part of the batholith was modeled on the basis of the existing heat flow data of Birch et al. (1968), measured heat production from the various rock units, and the shape of the batholith. Both one-dimensional and two-dimensional models have been constructed.

PREVIOUS WORK

The geology of the White Mountain batholith has been mapped by Billings and his students (Billings, 1928; Billings and Williams, 1935; Henderson, 1949; Moke, 1946; Smith and others, 1940). This work has delineated eight compositionally distinctive plutonic rocks which are thought to be consanguineous. The mode of intrusion has been interpreted to be by cauldron subsidence and piecemeal stoping (Billings, 1945). Chapman (1968) has suggested that these bodies represent cumulates and that they crystallized as flooded intrusions, possibly with more mafic

rocks at depth. Geophysical work on the Merrymeeting stock lends some support to these speculations (Griscom and Bromery, 1968).

Although the map patterns of the White Mountain batholith, in broad terms, is established, detailed relationships and the spatial relations at depth are poorly understood. A gravity low is centered on the batholith (Joyner, 1963; Kane and others, 1972). However, few detailed gravity measurements have been made on the central Conway granite pluton, and therefore, no major attempt to delineate its shape at depth has been undertaken. In contrast considerable geophysical work has been done on outlying stocks (Ascutney, Cuttingsville, Merrymeeting, Mt. Tripyramid, Pawtukaway, and Red Hill) containing rocks that are thought to be related to the Conway granite, presumably because of the simple analysis required. In addition a considerable array of aeromagnetic data exists for the White Mountain batholith and outlying stocks, but again, no detailed analysis has been attempted over the main pluton.

The radioactivity of the Conway granite and associated rocks has been investigated by Billings and Keevil (1946) and by Adams and associates; (Adams and others, 1962; Richardson, 1964). These studies have established the relative radioactivity as follows: biotite (Conway) granite ~ granite porphyry >> amphibole granite > quartz syenite > syenite ~ monzodiorite ~ diorite ~ gabbro. A lognormal relation of radioactivity in the biotite granite has been explained as due to the homogeneity of the radioactivity in the granite (Rogers and Adams, 1963). The radioactive elements are fixed in allanite, huttonite, thorite, and zircon and dispersed in quartz, feldspar, and biotite.

The White Mountain batholith is 182 to 110 my old (Tilton and Davis 1959, Foland, 1970). The major and trace element distribution of the

several igneous rock-types varies with radiometric age, and supports the concept of fractionation for them (Gaudette and Bothner, 1971). These studies indicate that the Conway granite is a late differentiate.

Birch and his associates (1968) have measured heat flow in New England and adjacent New York. They have noted abnormally high heat flow in the Conway granite and have recognized the strong correlation between heat flow and radioactivity of the local bedrock. Apparently using simple assumptions about the shape of the pluton containing Conway granite and about the distribution of radioactivity within it, the measured heat flow at the surface could be produced by a thickness of granite between 6 and 10 km. Estimates of temperatures at a depth of 4 to 5 km range from 150° to 200°C.

DESCRIPTION OF ROCK UNITS

General Statement

Rocks belonging to the White Mountain magma series include the Moat Volcanics, the Osceola Granite, the Albany Porphyritic Quartz Syenite, the Conway Granite, and other less abundant units such as Black Cap Granite, riebeckite granite, and pyroxene syenite. Porphyritic granite has uncertain affiliations; it may belong either to the older Devonian (?) granites or it may belong to the White Mountain magma series. Only brief descriptions of these rocks are given in this report since detailed descriptions have been presented previously (Billings, 1928; Chapman, 1935, 1942; Smith, 1940; Henderson, 1949; Wilson, 1969; Creasy, 1974).

Rock units belonging to the White Mountain magma series exposed in the northern half of the North Conway quadrangle have not been included in this study. The interested reader is referred to Billings (1928).

The various plutonic members of the White Mountain magma series intrude quartz-mica schists of the Littleton Formation and two-mica Chatham Granite. These older rock units are of Devonian age. Neither of these units have been delineated in Figure 1.

Moat Volcanics

Name: The name "Moat Volcanics" was used by Billings (1928) to describe volcanic tuffs, breccias, and flows exposed on Kearsarge North and in the vicinity of South Moat (Plate 1). Later usage has extended the name to include all of the volcanic rocks associated with the White Mountain magma series.

Distribution: Moat Volcanics are exposed in two areas within the North Conway quadrangle (Plate 1). One area of outcrop is on Kearsarge North and Bartlett Mtn. (Plate 2). A second area of outcrop is exposed on Big Attitash Mtn., North, Middle, and South Moat Mtns., and on the west slope of Haystack. The mapped distribution is essentially identical to that published by Billings (1928).

Lithology: The Moat Volcanics include comendites, trachyte, and breccia. Comendites are gray to red and contain phenocrysts, commonly embayed, of quartz, microperthite, and rare biotite or ferrohastingsite. The groundmass consists of quartz and alkali feldspar. Accessories include fayalite, fluorite, oligoclase, zircon, and magnetite. Some varieties contain riebeckite or aegarine-augite.

Trachyte consists of phenocrysts of pink alkali feldspar set in a dense, red matrix of tabular feldspar having parallel arrangement. Accessories include hematite, zircon, and magnetite. Epidote, clinozoisite, and chlorite are commonly present.

Figure 1. Reconstructed plutons of Osceola Granite.
1 = Rattlesnake Mtn. stock, 2 = Goodrich Falls
stock, and 3 = Shingle Pond stock.

Breccia contains angular to subangular blocks up to several feet in size of slate, schist, diabase, granite, quartz-porphyry, and trachyte. The matrix is dark gray, dense rock that is not completely resolved with the microscope. Important constituents include quartz, alkali feldspar, chlorite, muscovite, biotite, and magnetite. Hematite dust is ubiquitous.

Osceola Granite

Name: Rocks referred to the Osceola Granite in this report were identified by Billings (1928) as the "green phase of the Conway Granite" and were not separately distinguished on his geologic map. Billings and Williams (1935) gave the name Mount Osceola Granite to rocks exposed on Mount Osceola and on Scar Ridge. These rocks were similar to those originally described by Billings (1928) as the "green phase of the Conway Granite". General usage (Smith, 1940; Wilson, 1969; Creasy, 1974; Henderson, 1949) has included all similar granites within the White Mountain batholith and associated stocks as Osceola Granite.

Distribution: The distribution of the Osceola Granite is shown in Plate 1; the reader, however, should refer to Plate 2 for geographic localities. The Osceola Granite forms a large area of outcrop that underlies Humphreys Ledge, Mt. Stanton, Mt. Pickering, the south and east slopes of Iron Mtn. and Green Mtn., Thorn Hill, and the western slopes of Thorn Mtn. Smaller areas of outcrop are found northwest of Cathedral Ledge, along the southern and western flanks of Bartlett Mtn. and Kearsarge North, northwest of Hurricane Mtn., and in the vicinity of Rattlesnake Mtn.

The Osceola Granite exposed within the North Conway quadrangle belongs to a minimum of three plutons. The restored shapes of these bodies are shown in Figure 1. These plutons have been named as follows: the Goodrich Falls pluton, the Shingle Pond pluton, and the Rattlesnake

Mtn. pluton. Both the Goodrich Falls and the Shingle Pond plutons are well defined, but the Rattlesnake Mtn. pluton is a collection of isolated areas of outcrop and other reconstructions for this body are possible.

Lithology: Osceola Granite is greenish gray on a fresh surface, but where it is weathered, it is commonly chalky white. It is medium-to coarse-grained and inequigranular-seriate. Subhedral to anhedral greenish microperthite, 2 mm to 10 mm in size, form an interlocking network that encloses rounded equant grains of smokey quartz, 3 mm to 5 mm in diameter. Ferrohastingsite and subordinate annite, 2 mm to 5 mm in size, are strongly concentrated into clots. Fayalite, ferrohedenbergite, and fluorite are present in minor amounts. Allanite, monzonite, zircon, and sphene are characteristic accessories.

Creasy (1974) has summarized detailed microscopic descriptions of the Osceola and these will not be restated here. Modes of this granite appear in Table 1.

Albany Porphyritic Quartz Syenite

Name: Hitchcock (1877) applied the name "Albany granite" loosely to a variety of granites and syenites exposed in the White Mountain region. Billings (1928) used the name "porphyritic nordmarkite" to define quartz syenites that were included in Hitchcock's name. Subsequently, Kingsley (1931) published the name "Albany porphyritic nordmarkite" for the same group of rocks. Billings and Williams (1935) revised this name to Albany Porphyritic Quartz Syenite, which has been used since.

Distribution: Albany Porphyritic Quartz Syenite is contained in three ring dikes in the North Conway quadrangle. The distribution of these rocks was well defined by Billings (1928), and this report modifies his map-pattern very little (Plate 1). A ring dike of Albany Porphyritic

Table 1. Modes of plutonic rocks from North Conway quadrangle. Each mode is based on 1000 point-counts in a single thin section.

	34	13-5	21-9	A	19-2	17-8	24-3	19-13a	36	35	13	13-6	15-1	76
Quartz	22	30	15	13	33	53	20	42	35	34	36	24	38	35
Alkali feldspar	72	64	74	74	49	36	57	40	41	40	48	62	44	49
Plagioclase	3	6	7	0	16	4	19	15	19	19	11	11	16	14
Biotite	tr	tr	0	1	2	7	3	3	6	7	5	2	2	2
Amphibole	1	tr	1	12	0	0	0	0	0	0	0	0	0	0
Pyroxene	tr	tr	0	--	0	0	0	0	0	0	0	0	0	0
Olivine	2	0	2	--	0	0	0	0	0	0	0	0	0	0
Accessories	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	1	tr	tr

- 34 Osceola Granite, Rattlesnake Mtn. pluton; west side of Rattlesnake Mtn. elevation 446 m.
13-5 Osceola Granite, Goodrich Falls pluton; southeast ridge of Thorn Hill, elevation 388 m.
21-9 Osceola Granite, Rattlesnake Mtn. pluton, unnamed brook southwest slope of Bartlett Mtn., elevation 311 m.
A Albany Porphyritic Quartz Syenite (Billings, 1928), Jackson Falls.
19-2 Conway Granite, Gardiner Brook pluton; Burnt Knoll Brook, elevation 332 m.
17-8 Conway Granite, Gardiner Brook pluton; 71° from Thorn Mtn., elevation 440 m.
24-3 Conway Granite, Gardiner Brook pluton; in brook 300° from Dundee, elevation 369 m.
19-3 Conway Granite, Gardiner Brook pluton; Burnt Knoll Brook, elevation 354 m.
36 Conway Granite, Birch Hill pluton; west slope of Rattlesnake Mtn., elevation 335 m.
35 Conway Granite, Birch Hill pluton; west slope of Rattlesnake Mtn., elevation 354 m.
13 Conway Granite, Beich Hill pluton; northwest slope of Peaked Mtn., elevation 375 m.
13-6 Conway Granite, ring dike

Table 1 (continued)

	1	69	94	17-1	8-2	6	7	B
Quartz	28	30	37	35	29	21	28	20
Alkali feldspar	48	60	47	45	48	53	47	72
Plagioclase	19	6	8	16	17	20	18	0
Biotite	4	4	9	3	6	5	7	0
Amphibole	0	0	0	0	0	0	0	7*
Pyroxene	0	0	0	0	0	0	0	0
Olivine	0	0	0	0	0	0	0	0
Accessories	1	tr	tr	1	tr	tr	tr	1

- 1 Conway Granite, Green Hills complex; northwest of Black Cap, elevation 714 m.
 69 Conway Granite, Green Hills complex; in brook 41° from Canmore Mtn., elevation 449 m.
 94 Conway Granite, Green Hills complex; north slope of Hurricane Mtn., elevation 634 m.
 17-1 Black Cap; 137° from Middle Mtn. (Jackson), elevation 538 m.
 8-2 Black Cap; northwest slope of Thorn Mtn., elevation 594 m.
 6 Black Cap; southeast shoulder of Black Cap, elevation 652 m.
 7 Black Cap; southeast shoulder of Black Cap, elevation 661 m.
 B Riebeckite Granite (Creasy, 1974); Sarver River in Crawford North quadrangle, elevation 340 m.

* amphibole is riebeckite

Quartz Syenite extends northwesterly from the vicinity of Lower Bartlett (Plate 2), through Jackson, along the north slope of Eagle Mtn., and to Popple Mtn. A second ring dike underlies the north slope of Little Attitash Mtn., the west slopes of Big Attitash Mtn., and the western slopes of Haystack. The third ring dike can be traced from the vicinity of Thorn Mtn., along the western slope of Bartlett Mtn., the south and east slopes of Kearsarge North, to the vicinity of Rickles Knoll.

Lithology: Albany Porphyritic Quartz Syenite contains sub- to anhedral, rounded phenocrysts of perthite ranging in size from 3 mm to 10 mm and sparse, rounded phenocrysts of amber quartz, 2 mm to 4 mm across, although the abundance of quartz is variable from outcrop to outcrop. Micrographic intergrowths are common. The groundmass is pale brown to gray and consists dominantly of microperthite, quartz, oligoclase, ferrohastingsite, and annite. The grain size of the groundmass minerals is 1 mm to 2 mm. Orthoclase, fayalite, ferrohedenbergite, fluorite, allanite, zircon, and sphene are accessories. A mode is given in Table 1.

Conway Granite

Name: The name "Conway granite" was used by Hitchcock (1877) for rocks exposed in the vicinity of Conway. Subsequently, Billings (1928) applied the name to various medium- to coarse-grained granites in the North Conway quadrangle. More recently, the name has been restricted to medium- and coarse-grained, pink, biotite and biotite-amphibole granites throughout the White Mountain batholith (Billings and Williams, 1935; Smith, 1940; Moke, 1949; Wilson, 1969; Henderson et al., 1977). In this report, the Conway Granite is restricted to medium- to coarse-grained biotite granite without amphibole; all of the granite containing amphibole as well as biotite is assigned to other rock units (mainly Osceola).

Distribution: Conway Granite is exposed in five plutons (Plate 1 and Plate 2). The Mount Pickering pluton is exposed on the southeast slopes of Iron Mtn., the west slopes of Mt. Pickering, and along the foot of Little Attitash Mtn.

The Birch Hill pluton underlies much of the valley in the vicinity of North Conway. It includes Cathedral and White Horse Ledges and the lower, west-facing slopes of the Green Hills. The Birch Hill pluton has the largest areal extent of any of the plutons of Conway Granite within the North Conway quadrangle.

The Gardiner Brook pluton underlies the valley situated north of Kearsarge North and east of the Twins, Mt. Shaw, and Walter Mtn. Its central portion is poorly exposed because of the extensive glacial cover.

A ring dike of Conway Granite is thought to form an arcuate outcrop that includes Lower Bartlett, Intervale, and Kearsarge. The Conway Granite exposed south of Robbins Ridge is thought to be part of this ring dike that has been cut off from the western part by the Green Hills intrusive complex. The reality of this ring dike is uncertain in that the Conway Granite is not elsewhere found in ring dikes. Alternatively, the western part of the ring dike as compiled may belong to the Birch Hill pluton; the eastern part may represent a separate, small pluton.

The fifth stock of Conway Granite underlies the Green Hills and is part of the Green Hills complex. It underlies Middle Mtn., Black Cap, Cranmore Mtn., and the hills north of Hurricane Mtn.

Lithology: The Conway Granite is a pink, inequigranular-seriate, or locally inequigranular-hyaline biotite granite. Tabular, subhedral to euhedral crystals of pink microperthite, 5 mm to 10 mm in size, rounded to angular grains of slightly smokey quartz, and subhedral grains

of white oligoclase make up ninety percent of the rock. Biotite in books 4 mm across form anhedral, interstitial grains. Zircon, allanite, fluorite, and sphene, locally enclosed by biotite, are accessories.

Modes are given in Table 1.

The Conway Granite locally contains miarolitic cavities lined with feldspar and quartz. These presumably indicate the presence of a vapor phase during the crystallization of the granite. At contacts where it intrudes older rocks, it is porphyritic and fine-grained. Quartz becomes prominent as rounded grains. Oligoclase is better developed and microperthite is diminished in size relative to the normal granite.

Black Cap Granite

Name: Billings (1928) used the name "Black Cap granite" to describe fine-grained granites exposed on Black Cap and on Thorn Mtn. Although he distinguished this granite in his mapping, he considered it to be a "phase" of the Conway Granite. Black Cap is used in this report without revision. However, the relationships to other rocks, including the Conway, is unknown.

Distribution: Black Cap Granite forms small stocks at four localities (Plate 1). The stocks located on the south slope of Black Cap (Plate 2) and between Middle and Thorn Mtns. have map-patterns similar to those published by Billings (1928). Two additional small areas of outcrop are located west of Humphreys Ledge.

Lithology: Black Cap is a fine-grained, equigranular granite. Quartz, microperthite, and sparse soda plagioclase form interlocking grains. Partly chloritized biotite is the mafic mineral. Accessories include fluorite, zircon, magnetite, and apatite. A mode is presented in Table 1.

Riebeckite Granite

Distribution: Riebeckite granite forms a small arcuate dike that extends from Hurricane Mtn. to Cranmore Mtn. Smaller areas of outcrop form associated dikes in the same vicinity (Plate 1 and Plate 2). These dikes may represent either ring dikes or cone sheets.

Lithology: Riebeckite granite is creamy white and consists of anhedral to subhedral tabular crystals of microperthite, 5 mm in size, rounded grains of clear quartz, 2 mm to 4 mm across, and interstitial blue-black riebeckite, up to 4 mm in length. Astrophyllite, ilmenite, fluorite, zircon, and sphene are in minor amount.

Syenite

Distribution: Syenite forms a poorly defined body on the east slopes of Thorn Mtn. (Plate 1 and Plate 2). Billings (1928) included these rocks with his porphyritic nordmarkite. Somewhat similar rocks have been described by Henderson (1949) at Hart Ledge in the Crawford Notch quadrangle.

Lithology: Syenite is greenish gray, coarse-grained rock with inequigranular texture. Interlocking grains of microperthite and ferrohastingsite form the bulk of the rock. Fayalite and hedenbergite are present in lesser amounts. A Na-rich green-blue amphibole is locally present as an overgrowth on the primary dark minerals. Accessories include allanite, zircon, sphene, and ilmenite.

Porphyritic Granite of Robbins Ridge

Name: Porphyritic granite of Robbins Ridge is used informally to designate rocks exposed on Robbins Ridge. Billings (1928) included these rocks in his Conway Granite, but they are sufficiently distinctive to be considered separately.

Distribution: Porphyritic granite of Robbins Ridge underlies Peaked Hill, the east slopes of the Twins, and Major Mtn. (Plate 1 and Plate 2). This rock was not observed elsewhere within the North Conway quadrangle.

Lithology: Porphyritic granite is white to chalky colored and contains phenocrysts of microperthite, 5 mm to 8 mm in size set in a matrix consisting of interlocking crystals of euhedral oligoclase, subhedral microperthite and anhedral quartz. Amphibole and biotite are the principal mafics although relict pyroxene is locally preserved. Accessories include hematite, zircon, and apatite.

AGE AND SEQUENCE OF INTRUSION

The radiometric ages for various plutons of the White Mountain Magma series are presented in Figure 2 using data of Foland and Faul (1977), Tilton et al. (1957), and Creasy (1974). Rb-Sr and K-Ar methods give concordant ages. Most analyses have been made on the Conway Granite, a few on the Osceola Granite, and little or no effort has been made to date the other rock-types.

Ages of the Conway Granite from various plutons show a considerable range, 194 my to 117 my indicating that the Conway Granite was generated over a large time span. The Osceola Granite has a more restricted range of ages, 182 my to 175 my, but presumably the spread would be greater if the population of age determination were greater.

The relative age between contacting plutonic rocks is determined by cross-cutting relationships: (1) dikes of younger rock cutting older rocks, (2) inclusions of older rocks contained in younger rocks, and

Riebeckite granite

Albany Porphyritic
Quartz Syenite

Osceola Granite

Conway Granite

Figure 2. Age of rock units of the White Mountain Magma batholith (Data from Foland and Faul, 1977; Creasy, 1974).

(3) chilled margin of younger rocks against the older rock. Localities at which such age determinations were made are shown in Figure 3. Arrows point to the younger rock.

The sequence of intrusion within the North Conway quadrangle is determined from observations of cross-cutting relationships and the inferred relationships based on the map-pattern. The pattern of intrusions is dominated by the three plutons of Osceola Granite and the formation of four ring complexes involving Albany Porphyritic Quartz Syenite, Conway Granite, and to a lesser extent riebeckite granite.

The earliest pluton in the study area is the Rattlesnake Mountain pluton of Osceola Granite. The other two plutons of Osceola Granite and rocks of the four ring complexes either intrude the Rattlesnake Mountain pluton or on the basis of map-pattern are inferred to be younger. The granite of this body must have been generated and emplaced at an early time; later batches of magma produced the younger intrusions.

The porphyritic granite of Robbins Ridge is also an early pluton. It is cut by the intrusions of both the Kearsarge North and Green Hills ring complexes. Its relationship to the Rattlesnake Mountain pluton is unknown.

Rocks belonging to the Iron Mountain ring complex intrude the Rattlesnake Mountain pluton. It consists of a ring-dike of Albany Porphyritic Quartz Syenite and a "central" intrusion of Conway Granite. The contact relationships between the Albany Porphyritic Quartz Syenite and the Conway Granite were not observed, but on the basis of relationships in the other ring complexes and on theoretical grounds the Conway is thought to be the younger body. The small body of syenite has an unknown relationship to this ring complex; tentatively it is assumed to be part

71°15'
44°15'

71°00'

44°15'

Figure 3. Localities showing relative age relations between rocks of the White Mountain batholith. Arrows indicate age relations. Jmr = Moat Volcanics, g = porphyritic granite of Robbins Ridge, Jog = Osceola Granite, Js = syenite, Jags = Albany Porphyritic Quartz Syenite, Jcg = Conway Granite, Jbc = Black Cap Granite, and Jrg = riebeckite granite.

of it and may represent a high-level differentiate of the Albany Porphyritic Quartz Syenite. The Black Cap Granite north of Thorn Mountain intrudes the ring-dike of Albany Porphyritic Quartz Syenite and is in turn intruded by the rocks of the Kearsarge North ring complex. This stock of Black Cap is thought to be coeval with the "central" intrusion of Conway Granite, and is perhaps a fine-grained variant of the Conway Granite solidified in the roof region of the cupola containing more normal Conway at depth.

The Goodrich Falls pluton of Osceola Granite intrudes the Iron Mountain ring complex and although it has an eccentric position relative to the Moat Mountain ring complex, it may be related to the formation of that complex.

The Moat Mountain ring complex includes the ring-dike of Albany Porphyritic Quartz Syenite which surrounds a down dropped block containing Moat volcanics and a fragment of the earlier Rattlesnake Mountain pluton of Osceola granite. This ring-dike and its central down-dropped block are subsequently intruded by the Birch Hill pluton of Conway Granite. The small outcrops of Black Cap associated with this ring complex have unknown relationships to the surrounding rocks, and, in fact, their size may be overestimated.

The Kearsarge North ring-complex was formed next, and in some ways it is a copy of the Moat Mountain ring complex. It consists of a ring-dike of Albany Porphyritic Quartz Syenite that surrounds a down-dropped block containing Moat volcanics, some metasediments, and a fragment of the Rattlesnake Mountain pluton. The ring-dike of Conway Granite is thought to be younger than the inner ring-dike of Albany, and the "central" intrusion of Conway as the Gardiner Brook stock is the youngest event in

this ring complex.

Both the Moat Mountain and the Kearsarge North ring complexes are intruded by the Shingle Pond Osceola Granite. This body is interpreted as the precursor of the Green Hills complex.

The Shingle Pond pluton is intruded by the Conway Granite that underlies the Green Hills. The relationship of the Black Cap Granite to the Conway is uncertain; it may be gradational or it may represent a separate intrusive event. In any case, it is thought to be closely related to the Conway. The final igneous event recorded in the Green Hills complex is the intrusion of the riebeckite granite in a prominent arcuate dike.

ANALYSIS OF SURFACE JOINTS IN THE EASTERN HALF OF THE WHITE MOUNTAIN BATHOLITH

The trends of joint traces were measured at various locations and in various lithic components of the batholith (see Plate 3). Cross-cutting relations among various joint sets were observed to determine the number of joint sets at each location. Offsets along fractures were noted where present.

A large number of joint traces was sampled at each location, and rose diagrams were constructed depicting the mean trend of each joint set. The rose diagrams together with the mean trends for 52 locations are given in Appendix A and are plotted on Plate 3. Also shown on Plate 3 are extrapolated joint trends which depict the regional systematic orientation of two joint sets.

The results of the study are summarized in the following statements:

1. The joint pattern within the eastern half of the White Mountain batholith is systematic over the entire area rather than random.
2. Four joint sets can be identified, although not all four sets exist at each location.
3. All joints are steeply dipping to vertical, and, thus, only joint trace trends are presented.
4. No vertical variation in joint dip was found.
5. No significant offsets along joint surfaces were identified.
6. Several examples of refraction of joints were found (see e.g., station 52).

A summary rose diagram including all measurements of joint traces is shown in Figure 4. The important features of this diagram are the dominant north to north-northeast and the east trending joint traces as well as the absence of joints trending northwest. The summary rose diagram depicts the regional trends of joints and without trying to identify four joint sets, the diagram relates information pertinent to choosing well sites, modeling circulation patterns, and predicting induced fracture orientations.

The absence of joints trending northwest indicates the orientation of the regional stress pattern during joint development. In particular, a northeast-southwest compressive stress can account for the failure of joints to develop with northwest strike.

Figure 4 - Summary rose diagram of surface joint orientations.

GRAVITY MODEL OF THE EASTERN HALF OF THE WHITE MOUNTAIN BATHOLITH

General Statement

Two-dimensional gravity models along the several traverses of close spaced stations are presented using the method of Talwani (1959). Three-dimensional gravity models using the vertical prism method of Cordell (1970) are also developed. The principal shape parameter of the batholith to be defined is the thickness of the various components of the batholith. Also of importance is the slope of the contacts among plutons with depth. These parameters serve as constraints in constructing a temperature model of the batholith.

The gravity data used to define the two- and three-dimensional models, the reduction of the gravity data and the formulation of density contrasts for the various lithic components of the batholith are presented.

Gravity Data in the North Conway and Adjoining 15' Quadrangles

Gravity Stations

Approximately 750 new gravity stations have been established over the eastern half of the White Mountain batholith. The distribution of new gravity stations, shown in Plate 4, is centered about the North Conway, N.H., 15 minute quadrangle. Station elevations are from benchmarks, spot elevations and altimeter stations, together with level- and transit-surveyed elevations along several traverses of close-spaced (150m) stations. The gravity data at benchmarks, spot elevations, etc., permit broad coverage of the gravity field and allow definition of the Bouguer and residual anomalies. Gravity stations along the several traverses were established principally for investigation of contact relations both among units of the batholith and between the batholith and surrounding country rock, and to define the subsurface structure of the batholith

along the traverses.

Gravity data from Joyner (1963), also shown in Plate 4, are incorporated in this study. The Bouguer gravity map of New England by Kane and others (1972) serves in defining the regional gradient of Bouguer gravity in the North Conway region. A listing of all gravity data within Plate 4 is given in Appendix B.

Gravity Base Station

Joyner (1963) established a gravity base station in Conway, N.H., at the Intervale railroad station. Joyner described the gravity base station as follows:

"At track level on the platform in front of the Intervale railroad station in the town of Conway, New Hampshire. Observed gravity is 980,450.9 mgals." (p. 857)

The elevation of this station, reported by Joyner, is 546 feet. All new gravity measurements made during the Conway Granite Geothermal Project survey are tied to Benchmark J7, described as follows by the Coast and Geodetic Survey:

"J7.--At Intervale, Carroll County, on the Maine Central Railroad, 64 feet east across the track from the station, 33 feet east of the centerline of the main track, in the top of a large embedded boulder, and about 2 feet above the top of the rail. A standard disk stamped "J71933" (167.206 meters or 548.575 feet)."

Benchmark J7 is tied to Joyner's (1963) base station. Observed gravity at Benchmark J7 is 980,450.81 mgals.

Gravity Meters

Two gravity meters were employed during the survey in the summer of 1976. A Worden gravimeter, Educator Model, Serial #393, Model 113, Texas Instruments, was loaned to us from the U.S. Geological Survey, Denver, Col. The dial constant is 0.4932(4) mgals/division. This meter is not temperature controlled. The second meter was loaned by the Dept. of

Earth Sciences, Univ. of New Hampshire, Durham, New Hampshire. The UNH meter is a Worden Master Model, Serial #895, Model #111 with a dial constant of 0.09427 mgals/division. The UNH meter is temperature controlled.

Theoretical Gravity, Free-Air, Bouguer and Terrain Corrections

Theoretical gravity is determined from the formula given by Grant and West (1965, p. 236)

$$g(\phi) = 978.0490 (1 + 0.0052884 \sin^2 \phi - 0.0000059 \sin^2 2\phi) \text{ gals} \quad (\text{eq. 1})$$

where ϕ = station latitude measured directly from the 15 minute topographic map or computed from the elevation survey data.

The free-air correction is determined from the formula given by Heiskanen and Vening-Meinesz (1958)

$$\frac{\partial g}{\partial R} = -0.09406 = 0.00090 \cos 2\phi \text{ mgals/ft (elevation above sea level positive)} \quad (\text{eq. 2})$$

so that the free-air anomaly is

$$\Delta g_{f.a.} = g_{obs} - \frac{\partial g}{\partial R} - g(\phi) \quad (\text{eq. 3})$$

The Bouguer correction is given as:

$$B.C. = (2\pi\rho G)h \text{ gals/ft} \quad (\text{eq. 4})$$

where

$$\begin{aligned} G &= \text{gravitational constant} = 6.67 \times 10^{-8} \text{ (c.g.s.)} \\ \rho &= \text{density of uniformly thick slab} = 2.67 \text{ g/cc} \\ h &= \text{station elevation in feet (1 ft = 30.48 cm)} \end{aligned}$$

$$\begin{aligned} B.C. &= (2\pi)(2.67)(6.67 \times 10^{-8})(1 \times 30.48) \times 10^3 \text{ mgals/ft} \\ &= 0.0341060894 \text{ mgals/ft} \end{aligned}$$

The density of the Bouguer ρ is chosen as 2.67 g/cc to maintain compatibility with the data of both Joyner (1963) and Kane (1972). The simple Bouguer anomaly (excluding any terrain corrections) is thus given as

$$\Delta g_{SB} = \text{observed gravity} - g(\phi) - \frac{\partial g}{\partial R} (h) - (\text{B.C.})(h) \quad (\text{eq. 5})$$

$$\begin{aligned} \Delta g_{SB} = \text{observed gravity} - 978.0490 (1 + 0.0052884 \sin^2 \phi - \\ 0.0000059 \sin^2 2\phi) - (0.09406 + 0.00090 \cos 2\phi)(h) - \\ 0.0341060894(h) \end{aligned}$$

To obtain the complete Bouguer anomaly, a terrain correction is added to the simple Bouguer anomaly. Terrain corrections are computed for terrain between the station and an outer circular radius of 20 km (approximately equal to the outer radius of Hammer zone M). A density of 2.67 g/cc is assumed in determining all terrain corrections.

Terrain corrections were computed by hand for terrain between the station and an outer circular radius of 2.61 km (equivalent to the outer radius of Hammer zone H). Hand computed terrain corrections for Hammer zones A through D (outer circular radius of 170.07m) were determined using the method of Diment outlined in Joyner (1963). Hand computed terrain corrections for Hammer zones E through H were determined using a template and the method outlined in Hammer (1939). Terrain corrections for Hammer zones A-H were not computed for each gravity station along the several traverses of close-spaced stations. Rather, the terrain correction for Hammer zones A-H was computed for stations at intervals of five to ten stations, depending on a visual estimate of the rate of change of topography. The terrain corrections for intervening stations were interpolated. In a similar manner, terrain corrections for zones E through H were interpolated for non-traverse stations when terrain changes were negligible. Fifteen minute topographic maps were used for all hand determined terrain corrections.

Terrain corrections for terrain between 2.61 km and 20 km were determined by computer at the U.S. Geological Survey in Denver, Col.

Curvature corrections were introduced at 14 km. The source of digitized terrain is a set of 15 minute and 7.5 minute topographic maps, digitized on a 1 min x 1 min grid, including the following:

<u>15 minute maps</u>		<u>7.5 minute maps</u>
Island Pond	Bethel	Concord, Vt.
Averill	Crawford Norch	Miles Pond
Dixville	North Conway	Lower Waterford
Errol	Fryeburg	Littleton
Oquossoc	Plymouth	Lisbon
Burke	Mt. Chocorua	Sugar Hill
Guildhall	Ossipee Lake	East Haverhill
Percy	Kezar Falls	Mt. Moosilauke
Milan	Holderness	Franconia
Old Speck	Winnepesaukee	South Twin Mtn.
Whitefield	Wolfeboro	Lincoln
Mt. Washington	Newfield	Mt. Osceola
Gorham		

Terrain corrections for terrain between 2.61 km and 20 km for gravity stations in the Bethel, Fryeburg, Norway, and Kezar Falls quadrangles are incomplete because digitized terrain was not available for area adjoining these quadrangles on the east. The terrain corrections for these stations is expected to be small because of the low relief and thus only a small error is introduced by computing only partial terrain corrections.

When digitized terrain for the eastern half of the Lewiston two-degree sheet becomes available at a station spacing of one station per

0.01 inch from the National Cartographic Institute in Washington, and when the USGS terrain correction program is modified to accept digitized terrain in this form, much greater accuracy will be attainable in computing terrain corrections for all terrain zones.

Reduction Errors

Error is incorporated into the gravity data at various stages of the reduction procedure. Included in the total error are contributions from the following sources: latitude measurement or calculation error, meter calibration error, non-linear drift, elevation errors, variation in the free-air correction factor, choice of Bouguer slab density, variable thickness of glacial till covering bedrock, neglecting terrain beyond 20 km, and error in terrain correction out to 20 km. Table 2 lists these sources of error at the point of entry into the reduction procedure.

Error in the determination of latitude is negligible. For non-traverse gravity stations latitude was measured directly from 15 minute topographic maps using a 60 division/inch scale. Latitudes of traverse stations were determined from the survey data with maximum closure error of latitudes determined in this manner less than 0.2 minutes. The closure error is distributed among the traverse stations so that latitude errors of traverse stations are also negligible. The difference in theoretical gravity for a difference in latitude of 0.5 minutes at 44°N latitude is approximately 0.75 mgals; for a latitude difference of 0.25 minutes at 44°N latitude the difference in theoretical gravity is 0.37 mgals. Errors in latitude are believed to be less than 0.01 minutes so that the error in theoretical gravity from this source is negligible. The role of latitude in determining the free-air corrections (see eq. 2) is second order so that latitude error is also negligible in the free-air anomaly.

Table 2

SOURCES OF ERROR IN
REDUCED GRAVITY DATA

$g(\phi)$ theoretical gravity	-latitude measurement or calculation			
g_o observed gravity		-non-linear meter drift -meter calibration error -compatibility of USGS and UNH meters		
Δg_{FA} free-air anomaly	-latitude measurement or calculation		-elevation -variation of free-air corr. factor	
Δg_{SB} simple Bouguer anomaly			-elevation	-Bouguer slab density -variable glacial till thickness
Δg_B complete Bouguer anomaly				-terrain between 20 km and 167 km -terrain correction error out to 20 km

Meter drift is another source of error. In correcting for drift, the assumption is made that drift is linear. Because all gravity loops were closed within a maximum of 2.5 hours and most were closed within 2.0 hours, the assumption of linearity is probably valid. Closure errors are distributed among all stations within each loop. Maximum closure error for all loops and average drift correction for all loops is given in Table 3.

Error in meter calibration, i.e., in the value of the dial constants, is viewed as negligible.

Error introduced into the gravity data by the use of two gravity meters is probably less than 0.2 mgals. A comparison test of the two meters was made at the outset of the gravity survey and observed gravity varied by a maximum of 0.35 mgals with an average difference of 0.20 mgals. The UNH meter was used in surveying gravity stations generally east of $71^{\circ}00'W$ longitude as well as non-traverse stations in the Ossipee Lake quadrangle. Thus the error introduced from this source should not effect the modeling of the batholith because the UNH meter was used in obtaining gravity data over a portion of the batholith's perimeter.

Elevation error is a source of error in determining the free-air anomaly and the simple Bouguer anomaly. The Bouguer correction and the free-air correction have opposite signs, thus any error introduced into these corrections by an elevation error will tend to diminish. Elevations of non-traverse stations are determined from benchmarks, spot elevations, altimeter, and lake or pond levels. In the case of benchmarks, elevations used to compute free-air and Bouguer corrections are correct to within 0.15 m. Thus the error for free-air corrections of

Table 3
Meter Drift

	Maximum Closure Error for all loops (mgals)	Average Drift Correction for all loops (mgals)
Non-Traversal Stations	0.28	0.08
Traverses:		
Intervale North	0.42	0.16
Intervale South	0.20	0.07
Town Hall Rd- N. Kearsarge	0.27	0.08
Kearsarge	0.27	0.18
Black Cap	0.27	0.12
Hurricane Mtn. Rd.	0.10	0.05
Moat Mtn.	0.25	0.11

benchmark stations is a maximum of 0.05 mgals, and for Bouguer corrections is less than 0.02 mgals. The elevation of gravity stations at benchmarks which may have been displaced may be in error by $\pm 1\text{m}$. This translates to an error of ± 0.31 mgals for free-air corrections and ± 0.11 mgals for Bouguer corrections. Only several such stations occur within the data set listed in Appendix B. Elevations of altimeter stations are corrected for drift due mainly to temperature fluctuations; linear drift is assumed and non-linear drift is assumed to be negligible. Gravity station elevations determined from lake or pond levels may be in error by $\pm 1\text{m}$. The error for free-air corrections is ± 0.31 , and for Bouguer corrections it is ± 0.11 mgals.

Closure errors for the surveyed traverse stations are given in Table 4. If the assumption that this closure error can be distributed among the stations in the traverse segment is true, then elevation error is negligible. However, if the closure error occurs between two adjacent traverse stations, and should not be distributed among all stations, then the errors in elevation are more difficult to assess. The elevation error would fall between the total closure error and the distributed closure error. In comparing the Bouguer gravity values of traverse stations with those of neighboring non-traverse stations no sharp changes are observed suggesting that traverse station elevations are well defined.

An error may occur in the free-air correction due to variation of the free-air correction factor with elevation and latitude. According to Heiskanen and Vening-Meinesz (1958, p. 149) for elevations of 1000m, the term in the free-air correction which varies with elevation is only 0.07 mgals. This term amounts to less than 0.3 mgals for the gravity station on Mt. Washington (6288 ft.), the highest point in the survey

Table 4
Elevation Error - Traverse Stations

Traverse	Segment	Traverse Length (km)	Closure Error	Distributed Closure Error (m)
Intervale North	BMJ7 - BM529	3.22	-0.13	-0.006
	BM529 - BM540	2.33	-1.31	-0.082
	BM540 - BM982	9.39	-3.99	-0.071
Intervale South	BMJ7 - BM469	6.59	+0.162	+0.003
	BM469 - BM461	3.94	-0.42	-0.018
	BM461 - 1095	8.37	-1.01	-0.015
Town Hall Rd - N. Kearsarge	BM529 - Kear 28-31	6.60	-1.54	-0.04
	Kear28-31 - BM1192	2.27	+1.31	+0.10
	BM1192 - 1192-14	2.21	No elevation control at assume zero error	1192-14;
Kearsarge	722-1 - peak	4.63	-7.00	-0.23
Black Cap	BM494 - 410	14.88	+1.61	+0.02
Hurricane Mtn Rd	722Ewest - BM722	1.19	No elevation control at assume zero error	722Ewest;
	BM722 - BM1259	1.56	-1.58	-0.09
	BM639 - 639-10	1.53	No elevation control at assume zero error	639-10;
Moat Mtn	557corner - 889-13	2.51	+0.81	+0.05
	889-13 - 889-1	1.85	-0.53	-0.04
	889-1 - 358-24	4.45	+1.19	+0.04
	358-33 - 1131-1	5.98	-1.73	-0.04

area. Thus, this error source is negligible because elevations encountered in this survey are generally well below 1000m. The latitude term in the free-air correction (see eq. 2) is negligible in itself; any latitude error will certainly have little effect.

As Joyner (1963) points out, the Bouguer correction depends on ρ_B , the Bouguer slab density, as well as on elevation. For a large difference between ρ_B (2.67 g/cc) and the density of material effectively being removed by the Bouguer correction, a significant error may be introduced. This is true for gravity stations at high elevations overlying Littleton Formation ($\rho = 2.68$ g/cc). For Mt. Washington (6288 ft.) the difference in Bouguer correction is 12.0 mgals. However, for gravity stations overlying batholithic rocks, the error is small. For the station on Mt. Kearsarge North (3268 ft.; highest elevation within exposure of batholithic rocks) the difference in the Bouguer correction is only 0.01 mgals because the difference between $\rho_B = 2.67$ g/cc and the density of batholithic rocks underlying the Mt. Kearsarge North station, $\rho = 2.61$ g/cc, is small.

Variable thickness of glacial till is another source of error. The Bouguer correction removes the gravity effect of a slab with thickness equal to the station elevation and density equal to ρ_B . If glacial till of unknown thickness is present an error is introduced because of the difference between ρ_B and the density of glacial till. For a 15m thickness of glacial till the difference in Bouguer correction is 0.36 mgals (assuming $\rho_{\text{till}} = 2.1$ g/cc). The Bouguer anomaly profiles along the several traverses will display this error as part of the high frequency component of the anomaly. Thus, along the traverses, the error can be isolated and ignored. For nontraverse stations this error

will be effectively eliminated by modeling only the broad components of the Bouguer anomaly.

The magnitude of the error in terrain corrections between the station and 20 km is probably on the order of 10% of the terrain correction value obtained or less than 0.1 mgal for the majority of gravity stations. Stations at high elevations may have terrain correction errors of approximately 0.5 mgals. Stations with incomplete terrain corrections due to the absence of digitized terrain for one or more 15 minute quadrangles have error introduced which is probably less than 0.1 mgal because these stations are east of 71°00W longitude where terrain is gentle and elevations low.

Joyner (1963) estimates a 5.1 mgal error for Mt. Washington due to incorrect Bouguer slab density, neglected curvature correction and neglected terrain out to Hayford zone 0 (166.7 km). By eliminating the contribution to error due to incorrect Bouguer slab density (12.05 mgals), a 6.95 mgal error due to neglected curvature and terrain out to Hayford zone 0 is obtained. Neglecting terrain corrections out to zone 0 results in typical errors for most stations of less than 1.0 mgal. For high elevation stations such as at Mt. Kearsarge North or Moat Mtn. the error may be in the neighborhood of 1.5 to 2 mgals.

Clearly the terrain correction errors are the only possibly significant contribution to total error. For most stations this contribution is on the order of 1 mgal or less. Furthermore this error is systematic and nearly uniform for the majority of stations so that the resultant Bouguer anomaly will be uniformly too low or too high by about 1.0 mgal. For high elevation stations, however, the magnitude of this error may approach 2.0 mgals. This possible error must be accounted for in the two-dimensional

gravity modeling because variations in the gravity anomaly profiles over mountain peaks may be a product of terrain correction error rather than a particular mass distribution.

Isolation of a Residual Gravity Anomaly

Regional Variation in Bouguer Gravity Field

Before modeling the shape of the batholith, the regional component of the gravity field must be removed from the Bouguer gravity to yield a residual anomaly. The Bouguer gravity map of New England by Kane and others (1972) is used to define the regional trends. Adoption of a simple planar regional field is precluded by the regional Bouguer gravity trough which trends north-northeast and passes through the region of the White Mountain batholith.

To define the regional component a combined hand-resolution and computer method was used. The hand-resolution of a regional component was accomplished by drawing several profiles across the Bouguer gravity map of Kane and others (1972). The regional component in each profile was visually estimated thus giving a magnitude and a general form to the regional component of each profile. The computer-resolved regional was defined by means of a double Fourier series fit to a set of gridded data (James, 1966). The Bouguer gravity map by Kane and others (1972) was gridded at a spacing of 1 grid point per 7.84 km. The total grid comprises 36 grid points (274.36 km) in an easterly direction and 48 grid points (368.43 km) in a southerly direction beginning at 46°N latitude and 73°W longitude. The double Fourier series is given in equation 6 below and the calculated coefficients for the first three wave numbers of the series are given in Table 5.

$$\begin{aligned}
F(x_{ij}) = & \sum_{i=0}^2 \sum_{j=0}^2 cc_{ij} \cos \frac{2\pi x}{M} i \cos \frac{2\pi y}{N} j \\
& + \sum_{i=0}^2 \sum_{j=1}^2 cs_{ij} \cos \frac{2\pi x}{M} i \sin \frac{2\pi y}{N} j \\
& + \sum_{i=1}^2 \sum_{j=0}^2 sc_{ij} \sin \frac{2\pi x}{M} i \cos \frac{2\pi y}{N} j \\
& + \sum_{i=1}^2 \sum_{j=1}^2 ss_{ij} \sin \frac{2\pi x}{M} i \sin \frac{2\pi y}{N} j
\end{aligned} \tag{eq. 6}$$

where cc_{ij} , cs_{ij} , sc_{ij} , and ss_{ij} are the series coefficients;

M , N are the fundamental wavelengths in the x - and y -directions,
respectively;

x , y are coordinates of the map converted to interger grid point
coordinates.

Because the coefficients of the double Fourier series are independent, computation of a double Fourier series of wave number higher than three to represent the Bouguer gravity field will not change the values of the lower order coefficients. Thus, a regional gravity field can be assembled from the coefficients in Table 5 without concern about the effect of the high frequency components in the Bouguer gravity field on the goodness of the lower order coefficients.

Different combinations of the coefficients in Table 5 were evaluated to define various regional gravity fields until the basic form of the hand-resolved regional was matched. The computer-resolved regional thus derived is approximately 6.5 mgals higher than the hand-resolved regional. By adding -6.5 mgals to coefficient $cc_{00} = -21.62$ in Table 5, the horizontal plane component of the regional field is decreased (increased in magnitude). The Fourier series used to define the regional is given

Table 5
Coefficients of Double Fourier Series
Representing Bouguer Gravity Field

i	j	cc _{ij}	cs _{ij}	sc _{ij}	ss _{ij}
0	0	-21.62	0.0	0.0	0.0
0	1	12.17	-6.33	0.0	0.0
0	2	- 2.02	-1.09	0.0	0.0
1	0	11.07	0.0	-14.84	0.0
1	1	- 8.17	8.24	3.05	16.99
1	2	- 3.83	-2.09	- 0.46	8.73
2	0	- 2.01	0.0	- 4.04	0.0
2	1	- 0.24	3.84	3.11	9.20
2	2	- 1.81	-4.08	- 5.25	0.01

in equation 7 as:

$$\begin{aligned}
 g_{\text{reg}}(x,y) = & -28.12 + 12.17 \cos\left(\frac{2\pi y}{N}\right) - 6.33 \sin\left(\frac{2\pi y}{N}\right) \\
 & + 11.07 \cos\left(\frac{2\pi x}{M}\right) - 14.84 \sin\left(\frac{2\pi x}{M}\right)
 \end{aligned}
 \tag{eq. 7}$$

Computer generated maps, shown in Figures 5a, 5b and 5c represent respectively: equation 6 evaluated using all coefficients in Table 5, equation 7 evaluated for the total gridded area of the Bouguer gravity map of Kane and others (1972), and equation 7 evaluated for a smaller area in the North Conway vicinity.

Figure 5a- Complete second order double Fourier series representation of a portion of the Bouguer gravity field given by Kane and others (1972). Calculated from eqn. 6 and all coefficients of Table 4.

Figure 5b - Partial double Fourier series representation of Bouguer gravity field in the same area as Figure 5a. Calculated from eqn. 7.

Figure 5c - Small scale view of Figure 5c.

Bouguer Gravity Anomaly

The Bouguer gravity map for the North Conway 15' quadrangle and adjoining areas is given in Plate 5. The data incorporated in the map have been corrected as outlined in previous sections. The contour interval is 5 mgals; where sufficient data warrants it, a finer contour interval is used. Only every fifth traverse station is plotted on the Bouguer gravity map. Plate 4 locates the gravity stations in this study. Every fifth traverse station is labeled on Plate 4; more are labeled where number sequences may be confusing. Superposed on the gravity station location map (Plate 4) are the surface contacts between the major lithic units. Sources for the geology are given on Plate 4.

A comparison of the Bouguer gravity map of Plate 5 with the Bouguer gravity map of Kane and others (1972) shows equivalence of broad trends. The minimum gravity of -65 mgals on Plate 5 is of somewhat larger magnitude than the value in the same area on Kane's map. Gradients are generally similar; where increased data points exist, some gradients have changes.

Residual Anomaly

The residual gravity anomaly map for the North Conway 15' quadrangle and adjoining areas is given on Plate 6. Gravity stations shown on Plate 6 correspond to those on Plates 4 and 5. The residual anomaly results from the subtraction of the regional gravity value (eq. 7) for each station from the Bouguer gravity value. The residual gravity anomaly values for each station were plotted and the contour map of Plate 6 constructed.

A comparison of the residual gravity anomaly and the Bouguer gravity anomaly maps reveals little difference in form. Highs and lows in the residual anomaly are positioned similarly to those of the Bouguer anomaly

map. The gradients are similar in both Plates 5 and 6.

The residual anomaly profiles for the two-dimensional modeling incorporates all the data along each traverse whereas Plate 6 incorporates only every fifth traverse station. Thus the profiles of residual gravity are more detailed than the residual anomaly map of Plate 6 indicates. These high frequency components in the residual anomaly along the several traverses have been omitted from Plate 6 because they are well defined only along the traverses.

Choosing Density Contrasts for Two- and Three-Dimensional Modeling

Density Values

Table 6 lists density values for the White Mountain magma series (WMMS), the New Hampshire magma series (NHMS) and the Littleton Formation. Density values of the NHMS are from Joyner (1963) and from this study; density values of the Littleton Formation are from Joyner (1963) and Bean (1953); density values of the various components of the WMMS are from this study.

Density measurements of 226 samples of the WMMS were made using 3 cm diameter surface cores and hand samples. Samples were first oven-dried to remove any water existing in cracks, then weighted in air using a Metler balance accurate to 0.005 gm. The samples were placed in a water bath under vacuum to remove air from any cracks. Finally, the samples were weighed in water of known temperature. Equation 8 was used to calculate the density.

$$\rho_{\text{sample}} = \left[\frac{\text{weight}_{\text{air}}}{\text{weight}_{\text{air}} - \text{weight}_{\text{water}}} \right] \rho_{\text{water}} \quad (\text{eq. 8})$$

Table 6

Density values for the White Mountain magma series, New Hampshire magma series and Littleton Formation

Lithologic Unit	Average Density (gm/cm ³)	Standard Deviation (gm/cm ³)	Range of Density Values (gm/cm ³)	Number of Samples
White Mountain Series				
Conway biotite granite	2.62	0.01	2.57-2.65	135
fine grained	2.62	0.01	2.61-2.64	20
medium grained	2.62	0.01	2.59-2.65	47
coarse grained	2.62	0.01	2.57-2.64	36
Mt. Osceola amphibole gran.	2.63	0.01	2.61-2.68	15
Albany porphyritic quartz syenite	2.66	0.03	2.60-2.73	47
Albany-type A (high % phenocrysts >40%)	2.64	0.03	2.60-2.71	26
Albany-type B (low % phenocrysts <40%)	2.69	0.02	2.63-2.71	12
Moat Volcanics				
quartz porphyry	2.62	0.03	2.54-2.67	27
New Hampshire series				
Concord, Chatham binary granites	2.63(2.64)*	0.03	2.59-2.70(2.59-2.77)*	10(54)*
Littleton Fm.	2.78*(2.82)**		2.68-2.93*(2.70-2.96)**	88*(76)**

*Joyner 1963

**Bean 1953

The objective of measuring the density of the various WMMS components was to discriminate between each rock unit. A significant density difference exists only between the Albany Porphyritic Quartz Syenite (2.66 g/cc) and all other components of the WMMS (2.62 g/cc). The average density of the NHMS (2.63 g/cc) is similar to that of the WMMS excluding the Albany Porphyritic Quartz Syenite. Density of the Littleton Formation (2.78 g/cc) is in large contrast to the density of the plutonic and volcanic components of both the WMMS and the NHMS.

Model Density Contrasts

In assembling density contrasts in Table 7 for the various lithic units represented in the two- and three-dimensional gravity models, the assumption is made that the Littleton Formation serves as the background lithic unit. All density contrasts are defined with respect to the density of the Littleton Formation (2.78 gm/cc). Because the Littleton Formation is the oldest lithic unit exposed and is the only lithic unit present besides units of the NHMS and the WMMS, this assumption seems valid. However, two questions may be raised which bear on the nature of the batholith base and the actual density contrast across the base.

First, the Ammonoosuc Volcanics, not exposed in the study area, underlie the Littleton Formation outside the study area. The Ammonoosuc Volcanics thus presumably underlie the Littleton Formation beneath the batholith. Joyner (1963) reported mean densities for felsic and mafic metavolcanic rocks of the Ammonoosuc Volcanics as 2.70 gm/cc and 2.90 gm/cc, respectively. If the metavolcanics underlying the batholith and the Littleton Formation are felsic, 2.78 gm/cc as the density of material underlying the batholith may be slightly high. If the metavolcanics are mafic, 2.78 gm/cc for the density of material beneath the

Table 7
Density Contrasts

Lithic Unit	Mean Density (gm/cc)	Density Contrast (gm/cc)
Littleton Formation	2.78	0.0
White Mtn. Magma series		
Conway Granite	2.62	-0.16
Mt. Osceola Granite	2.63	-0.15
Albany Quartz Syenite	2.66	-0.12
Moat Volcanis (felsic)	2.62	-0.16
New Hampshire magma series	2.63	-0.15
Chatham and Concord Granites		

batholith is low; a value intermediate to 2.78 gm/cc and 2.90 gm/cc would be appropriate. In this case use of 2.78 gm/cc for the density of material beneath the batholith will result in low density contrasts for batholith rocks and thus the calculated batholith thickness will be too large. It is difficult to assess any error involved because the thickness of the Littleton Formation separating batholith rocks from underlying Ammonoosuc Volcanics and the density of the Ammonoosuc Volcanics is unknown.

A second question concerning the batholith base and the virtue of assigning a density contrast to batholith rocks based on the 2.78 gm/cc density of the Littleton Formation is the mechanism of intrusion of the batholith. Possible intrusion mechanisms include a single feeder pipe, stoping, multiple feeder dikes, granitization, and shouldering aside of country rock. A comparison of the resultant schematic cross section for each mechanism shown in Figure 6a-e indicates that for each mode of

Figure 6. Schematic cross-sections showing various mechanisms of intrusion.

intrusion the assumption of a Littleton Formation basement directly beneath the batholith is valid.

Two-Dimensional Gravity Models

General Statement

The method of Talwani (1959) is used to compute the gravitational attraction of two-dimensional models. The model anomalies thus determined are compared with the residual anomalies along a particular traverse. By assigning the density contrasts listed in Table 7, two-dimensional models representative of the batholith are constructed.

The resultant two-dimensional models are depicted in Figures 7a through 7f respectively for the following traverses: Intervale north-south, Black Cap, Hurricane Mountain Road, Town Hall Road, Kearsarge and Moat Mountain. The locations of these traverses are shown on Plate 4 and in Appendix A. Shown in each figure are the residual anomaly and the calculated model anomaly, a profile locating important elevation markers and the surface exposure of contacts between different rock units, and the model body. Only the broader features of the residual anomalies are matched. Higher frequency components are probably due to variable thickness of alluvial cover. In several of the models a non-zero thickness of alluvium is included in the model and the resultant anomaly compares well with the high frequency component of the residual anomaly.

Intervale north-south

At the north end, the gravity data indicate that granitic rock underlies a cover of the Littleton Formation. The underlying granite is probably Mount Osceola Granite because they are adjacent. Near the southern third of the model, a dike of Albany Porphyritic Quartz Syenite is indicated by the gravity data. The dike shown is most likely the

Figure 7a - Intervale North-South two-dimensional gravity model

Figure 7c - Hurricane Mountain Road two-dimensional gravity model

Figure 7d - Town Hall Road two-dimensional gravity model

Figure 7e - Kearsarge two-dimensional gravity model

Figure 7f - Moat Mountain two-dimensional gravity model

eastward continuation¹ of the Albany Quartz Syenite ring dike occurring in the Moat Mountains to the west of the Intervale north-south traverse (see Fig. 1). Two inclusions of the Littleton Formation are hypothesized at the surface of the model. The model batholith is thickest near the northern third, attaining approximately 4 km depth.

Black Cap

The depth of the narrow exposure of the Mount Osceola Granite at the western third of the model is uncertain because of the small density contrast between the Mount Osceola Granite and the Conway Granite. The Black Cap model includes two surface layers of alluvium with density assumed equal to 2.18 gm/cc. Thinning of the Conway Granite near the middle of the model is indicated. This thinning is incorporated in the model to accommodate the change in slope of the residual anomaly occurring over the Conway Granite. Maximum thickness of the Conway Granite is approximately 3.5 km.

Hurricane Mountain Road

As in the Black Cap model, the depth of the narrow exposure of Mount Osceola Granite is uncertain. Alluvium covering the contact between the Conway Granite and the Mount Osceola Granite is indicated. The maximum thickness of the Conway Granite is approximately 3.5 km.

Town Hall Road

At the northern end of the model, the data indicate that granitic rocks underly a thin cover of the Littleton Formation. These granitic

¹ Further evidence for eastward continuation of the Moat Mountain Albany quartz syenite ring dike is the occurrence of Albany Porphyritic Quartz Syenite in the Redstone, NH, drill hole (Hoag and Stewart, 1977).

rocks are likely an extension of the Mount Osceola Granite which occurs to the south. Also indicated is an inclusion of the Littleton Formation in the Osceola Granite. The maximum thickness of the Conway Granite is approximately 3.6 km.

Kearsarge North

The thickness of the Moat Volcanics is uncertain because of the similar density contrast between the Moat Volcanics and the Conway Granite. A narrow exposure of Intervale clay-slate (Billings, 1928) is included in the model; also a subsurface inclusion of Intervale clay-slate is depicted. The density of the Intervale clay-slate is assumed equal to that of the Littleton Formation. The maximum thickness of the Conway Granite is approximately 3.5 km.

Moat Mountain

Subsided blocks of the Littleton Formation are indicated for the Moat Mountain model. The thickness of Moat Volcanics is uncertain because of the similarity in density with the Conway Granite. A small inclusion of the Littleton Formation is depicted in the Albany Porphyritic Quartz Syenite ring dike. This ring dike probably connects, towards the east, with the Albany Porphyritic Quartz Syenite ring dike shown at the southern end of the Intervale North-South model. The density of the Moat volcanic breccia is assumed to be 2.70 g/cc. The maximum thickness of the Conway Granite is approximately 4.0 km.

Intervale North-South Model with Alternate Residual Anomaly

Recalling the difference of 6.5 mgals between the hand-resolved and computer-resolved regional gravity field, a question arises concerning the change in the two-dimensional gravity models which would result from using a residual anomaly that is 6.5 mgals greater in magnitude. A

second two-dimensional model for the Intervale north-south traverse is shown in Figure 8. The residual anomaly which the model anomaly attempts to match is 6.5 mgals greater in magnitude than that for the previous model (Fig. 7a). The maximum depth of the new model body increases slightly to 5.25 km. The main features of the previous model remain essentially unchanged.

Other traverse models would be altered similarly by a 6.5 mgal increase in the magnitude of the residual anomaly. It is unnecessary to generate a new model for each traverse.

Three-Dimensional Gravity Models

The Prism Method

The vertical prism method of Cordell (1970) is employed to determine an array of vertical prisms of varying depths which will generate a computed gravity anomaly approximating the observed residual gravity field (Plate 6).

The Cordell scheme requires the definition of a grid of $N \times M$ dimension over the region of interest. Residual gravity values and the distances below mean sea level to the top of each prism are assigned to each grid square. Density contrasts are also assigned to each prism element. An initial thickness value is calculated for all prisms based on the Bouguer slab thickness required to generate an anomaly equal to the maximum assigned residual anomaly. The program then calculates the gravity anomaly due to the array of prisms so defined and compares the calculated gravity anomaly over each prism with the assigned residual gravity value. The prism thicknesses are then adjusted, the anomaly recomputed, and another comparison made between computed and observed anomaly. This procedure is repeated until the difference between computed

Figure 8 - Intervale North-South two-dimensional gravity model with alternate residual anomaly

and observed anomalies reaches a tolerable value. The final output is an array of prism thicknesses approximating the thickness of the batholith.

The three-dimensional modeling method cannot account for vertical changes in density contrast which exist if one batholith component overlies another. For example, if the Albany Porphyritic Quartz Syenite (density contrast of -0.12 gm/cm^3) overlies the Mount Osceola Granite (density contrast -0.15 gm/cm^3) the modeling method will not directly predict the presence of underlying Osceola Granite. Instead, because the Albany Porphyritic Quartz Syenite density contrast is smaller in magnitude, an unusually thick prism will be generated. By locating the abnormally thick prisms in the calculated prism array it is possible to predict vertical changes in density contrast and hence to identify possible variations in rock type with depth.

Model Input and Output

Plate 7 shows the geologic map redrawn to group units of similar density contrast. Superimposed on the geology is a 29×29 grid system. Each grid square is 1.06 km on a side; thus there are 19 grid squares across the North Conway 15 minute quadrangle.

Each vertical prism must have an assigned density contrast value. Cordell's program has been modified to accept variable density contrasts allowing each prism a discrete density contrast value. As is evident in Plate 7, some of the grid squares overlap units of different density contrast. In assigning values of density contrast to these prism elements, a weighted averaging technique is employed.

In the northern part of the batholith (rows 1-8, Plate 7) the Littleton Formation covers granitic rocks. Within the northernmost

Albany Porphyritic Quartz Syenite ring dike this is evidenced from the two-dimensional gravity model (Figure 7a). North of this ring dike, granitic rocks are believed to underly the Littleton Formation because the gravity anomaly calculated using the Littleton Formation without underlying granitic rocks is too large in comparison to the observed residual anomaly. Thicknesses of the Littleton Formation cover assigned to each prism are shown in Figures 9 and 12 and are based on the two-dimensional gravity model (Figure 7a) for the area within the northern ring dike, and on intuition for the area north of the ring dike.

Two models are constructed. The first employs the residual anomaly of Plate 6 which is also that used in the two-dimensional models of Figure 7a-7f. The second model uses the residual anomaly which is 6.5 mgals greater in magnitude and which is used in the alternate Intervale north-south two-dimensional model of Figure 8. Thus, the models represent a range of thickness values for the batholith. This range is required by the range in magnitude of the regional gravity.

Plate 8 shows the gridded values of the residual anomaly for model 1 together with the assigned density contrasts. The gridded residual gravity anomaly values for model 2 are obtained by adding -6.5 mgals to each gridded gravity value in Plate 8.

In viewing the resulting array of prism thicknesses (Figures 9 and 12), prisms occurring at the perimeter of the array should be ignored. The thicknesses of the perimeter prisms are much too large to be meaningful and reflect the absence of anomaly-producing material outside of the prism array. Perimeter prisms affected are two rows or two columns deep.

Model One

The calculation of prism thicknesses was performed nine times; each

time the previously calculated thickness array was input as the starting prism thickness array. The final prism thickness array is given in Figure 9. The difference between the computed anomaly and the entered residual anomaly for each prism is generally less than 0.5 mgals for most prisms. Where the residual anomaly undergoes rapid changes, the difference between computed and residual anomalies is larger, reaching approximately 2 mgals.

A contour map of prism thickness for model 1 is shown in Figure 10. This map is intended only as a visual aid in interpreting the prism thickness array of Figure 9. The slopes indicated by the contours are artificial because the change in thickness from one prism to another is a step change rather than a sloping change.

Three areas of large prism thickness are indicated in Figures 9 and 10. First, the thickest part of the model batholith occurs at the north end of the southernmost Albany Porphyritic Quartz Syenite ring dike. A probable vertical change in density contrast occurs here which is not accounted for in the model. Thus it is believed that some other batholithic component must underly the Albany Porphyritic Quartz Syenite ring dike here. The Osceola Granite is a likely candidate because the Osceola Granite to the northeast of the ring dike is also modeled to be very thick; one prism is in excess of 7 km. The third area of thick prisms occurs over the eastern end of the northernmost Albany Porphyritic Quartz Syenite ring dike. The extreme prism thicknesses here are artifacts of the modeling technique, a result of a vertical change in density contrast.

Interior to the southernmost Albany Porphyritic Quartz Syenite ring dike, where the geologic map shows a cover of the Moat volcanics, the three-dimensional model predicts shallow bottom prisms less than 2 km.

This is in agreement with the Moat Mountain two-dimensional gravity model (Figure 7f) which depicts subsided blocks of the Littleton Formation underlying the cover of Moat volcanics. Any granitic rocks which may underly the subsided Littleton Formation blocks as shown in Figure 7f are incorporated into the total prism thickness and hence do not appear as discrete underlying granite bodies.

A profile of prism thickness along AA' in Figure 9 is shown in Figure 11. Prism thicknesses in the profile are average values of the four prism thicknesses at each grid square corner along AA'. Also shown in Figure 11 is a smoothed base which is used in the finite element temperature modeling. The smoothed base of the model batholith in Figure 11 varies from 3 km at the southern end to about 5.5 km over the Osceola Granite. This general northward thickening to the Osceola Granite is in agreement with the Intervale north-south two-dimensional gravity model in Figure 7a.

Model Two

Figure 12 shows the calculated prism thickness array and a contoured map of prism thickness is given in Figure 13. The form of the model two batholith is equivalent to that of model one. Prisms in model two, however, are everywhere thicker than in model one with thickness differences ranging from 1 km to 2 km. A smoothed base profile along AA' for model 2 would be only 1 km thicker than model 1 over most of the profile with a maximum difference of only 2 km.

Conclusions of Gravity Models

From the two- and three-dimensional gravity modeling, several conclusions can be made concerning the shape of the eastern half of the White Mountain batholith. The contacts between the various components

Figure 9. Three-dimensional gravity model 1 -
calculated prism thicknesses in kilometers.

Figure 10. Three-dimensional gravity model 1 -
contoured depth to base of prisms.

Figure 11. North-south cross-section of model 1 along AA'

Figure 12. Three-dimensional gravity model 2 -
calculated prism thicknesses in kilometers.

Figure 13. Three-dimensional gravity model 2 -
contoured depth to base of prisms.

of the batholith are believed to be steeply inclined to vertical. The differences in density contrasts among various batholith components are not always large enough to make this claim with assurance but certainly vertical contacts between the Albany Porphyritic Quartz Syenite (-0.12 gm/cm^3) and other batholith components (-0.15 and -0.16 gm/cm^3) are indicated by the two-dimensional modeling.

The two-dimensional gravity models indicate a maximum thickness of 4 to 5 km for the residual anomaly of Plate 6 and a maximum thickness of 5 to 5.5 km for the alternative residual anomaly. This maximum thickness occurs over the main pluton of the Conway Granite where it contacts the Osceola Granite as shown on the Intervale north-south two-dimensional gravity model of Figures 7a and 8.

The three-dimensional gravity models suggest maximum thicknesses occurring at the Conway Granite-Osceola Granite contact discussed above of 5 to 7 km depending on which residual anomaly is used. Figure 11 shows the smoothed batholith base profile and indicates a thickening from the southern end towards the center of the batholith, a trend which is supported by the two-dimensional gravity models of Figures 7a and 8.

TEMPERATURE MODEL OF THE EASTERN HALF OF THE WHITE MOUNTAIN BATHOLITH

General Statement

Two approaches are used in calculating the temperature distribution within and adjacent to the eastern half of the White Mountain batholith. First, one-dimensional modeling assesses the effect on temperature distribution of variation in the several temperature controlling parameters, and determines the amount of lateral variation in temperature between the Conway Granite and other White Mountain magma series components, older

granites, and the Littleton Formation. Secondly, finite element modeling determines more accurately the lateral change in temperature across the various contacts, and allows greater freedom in assigning values to each parameter.

Definition of Parameters

In constructing a temperature model it should be emphasized beforehand that the parameters upon which the temperature distribution depends have considerable range. Thus, it is only possible to construct a range of temperature models representing the endpoint values of the defining parameters.

The parameters which constrain the temperature distribution include: the thickness of the batholith (z_1) and of other units in the model; the surface heat flow (q_0) over the batholith and over older adjacent units; the thermal conductivity (k) of the batholithic components and of adjacent and subjacent rocks; and the rate of heat generation by radioactive decay (A) for White Mountain batholithic components, New Hampshire magma series rocks and the Littleton Formation as well as crustal rock beneath the batholith and metamorphic rocks.

Shape Parameter

The shape parameters of the batholith are important ingredients in the temperature model. Information supplied by the gravity modeling includes a maximum depth ranging between 4 km and 5.25 km, the position of several contacts buried by alluvium, and the nature of the contacts between batholithic rocks and the Littleton Formation. The initial one-dimensional temperature models utilize only the depth values of the batholith. Data regarding the lateral shape of the batholith is employed in later two-dimensional finite element modeling.

Surface Heat Flow

Surface heat flow is a critical parameter. The various values of q_0 over the White Mountain batholith can be used in the one-dimensional model, however a profile of surface heat flow over and adjacent to the batholith is required in formulating a two-dimensional model. Table 7 lists the two heat flow values for the White Mountain batholith at North Conway and Kancamagus, NH, and one value for the outlying White Mountain magma series stock at Waterville, NH. The value of heat flow for the recently drilled Redstone, NH, hole is more uncertain than the others. Figure 10, adapted from Birch (1968), shows the spatial variation of surface heat flow over a large region including the White Mountain batholith. The heat flow values of Figure 14 are contoured to delineate the north northeast-trending ridge of high heat flow which passes through North Conway.

Table 8
Surface Heat Flow^{*}

				- Heat Flow (HFU) -		
	Lat	Long	depth (ft.)	uncorrected	topo.	geol.
North Conway, NH	44°04'	71°10'	120-215	2.04	1.89	1.95
Kancamagus, NH	44°02'	71°29'	170-305	2.40	2.27	2.13
Waterville, NH	43°56'	71°32'	240-320	2.53	2.15	2.21
Redstone, NH	44°01'	71°06'	3000'	1.9 [†]		

^{*}data from Birch (1968) and Stewart (1977)

[†]This value has no corresponding k-value and the A-value is an average for a core of variable rock composition.

Figure 14 - Contoured Heat Flow Values in New England

Birch (1966) has argued that surface heat flow is proportional to the heat production rate of surface rocks plus some background heat flow value. A background heat flow value of 0.8 HFU is suggested by Birch (1966) on the basis of surface heat flow measurements made over anorthosite bodies in the Adirondacks of New York state. Because the radioactivity of these rocks is near zero, Birch believed that the surface heat flow there was representative of the regional heat flow for all of New England. In effect, he has assigned a planar regional heat flow to New England. Inspection of Figure 14, however, can lead to a different interpretation of regional heat flow. A north-northeast trending ridge of high surface heat flow is apparent. If one accepts Birch's model of regional heat flow, then this ridge must be interpreted as being solely due to the radioactivity of surface rocks along its trend. Another interpretation is that there is a ridge of bump in the background heat flow such that heat flow entering the upper crust (say, 10 km depth) is larger along the ridge than away from it. In the temperature modeling which follows, particularly, in the finite element modeling, a basal or background heat flow value of 1.3 HFU is used. The basis for this choice is the ridge in Figure 14 and the need for a basal heat flow larger than 0.8 HFU to meet the known surface heat flow in the North Conway vicinity given values of heat production and thickness for the Conway Granite.

Thorium, Uranium, and Potassium Concentrations, and A-values

Thorium, uranium and potassium concentrations, and values of heat production by radioactive decay presented in Table 9 list the data of Brimhall and Adams (1969), Birch (1968), Richardson (1964), Rogers and

Adams (1963), Butler (1961), Lyons (1961), Rogers and Ragland (1961) and Hurley (1956). Also listed are several values determined during this study.

Ignoring the values for core A "altered" and Redstone quarry, the heat production rate for the Conway Granite ranges from 14.2 HGU to 20.9 HGU. The value of $A = 17.5$ HGU given by Birch (1968) for the North Conway core B falls nearly midway between the two extremes and is, in fact, close to the average (17.6 HGU) of the seven values listed in Table 9. In the one-dimensional modeling, all three values, the two extremes and the core B value by Birch (1968), are used; however, only the core B value (17.5 HGU) is used in the finite element models.

For the Osceola Granite, the value $A = 15.3$ HGU determined by Richardson (1964) is used because it is from the largest sample size. For the Albany Porphyritic Quartz Syenite, $A = 13.6$ HGU is used. For the New Hampshire series granite, only $A = 9.7$ HGU is used in the finite element modeling; all three values in Table 9 are used in calculating the one-dimensional temperature distribution. A value of $A = 5.5$ HGU is used to represent heat production in the Littleton Formation.

It is difficult to assess the variability of A with depth. Leaching of uranium in the near surface portion of the batholith by groundwater is one mechanism of producing a vertical variation in A . Zones of alteration may have different thorium and uranium concentrations compared to unaltered rock. A vertical segregation of thorium and uranium may have occurred during crystallization.

Rogers and Adams (1965) display an increase in both thorium and uranium with depth in the 1000 ft. core A (Kancamagus, NH). A later study by Brimhall and Adams (1969) concluded, however, that the 1000 ft.

Table 9

	n	Th (ppm)	U (ppm)	K (%)	A (HGU)	Q (HFU)	Th/U
White Mtn. magma series							
core A ^{1,*}	557	59	15.8	4.0	20.5	2.13	(3.73) ¹³
core A ²	146	52					
core A ("normal"-upper 500 ft.) ³	15	48	13.7	4.3	(17.0) ¹⁰		(3.50) ¹³
core A ("altered"-lower 500 ft.) ³	18	71	19.9	4.2	(24.5) ¹⁰		(3.57) ¹³
core B ¹	145	52	12.6	4.3	17.5	1.95	(4.13) ¹³
core B ²	120	53					
core C ¹	349	61	15.9	4.1	20.9	2.21	(3.84) ¹³
core C ²	92	63					
Conway Granite ⁴	215	56					
Conway Granite (surface samples) ²	214	55					
Redstone quarry ²	165	108					
Conway Granite ⁵	5	48.6	8.74	4.6	(14.2) ¹⁰		5.5
Conway Granite ⁶	9	49.4	13.0	(4.0) ¹²	(16.8) ¹⁰		3.8
Conway Granite ⁸	4	51.6	11.5	4.6	(16.4) ¹⁰		4.48
Conway Granite ⁹	18	64.6	12.6	(4.0) ¹²	19.1		5.3
Black Cap Granite ⁹	7	72.4	15.3	(4.0) ¹²	22.0		4.7
Na-amphibole granite ⁹	4	43.6	11.3	(4.0) ¹²	14.8		3.9
Mt. Osceola Granite ⁴	98	43	(12.3) ¹¹	(4.0) ¹²	(15.3) ¹⁰		
hastingsite granite ⁵	2	26	7.35	4.1	(9.59) ¹⁰		3.55
Mt. Osceola granite ⁶	3	30.5	7.4	(4.0) ¹²	(10.3) ¹⁰		4.3
Mt. Osceola granite ⁹	7	55.3	12.9	(4.0) ¹²	17.7		4.3
porphyritic quartz syenite ⁴	28	38	(10.9) ¹¹	(4.0) ¹²	(13.6) ¹⁰		

	n	Th(ppm)	U(ppm)	K(%)	A(HGU)	Q(HFU)	Th/U
Albany quartz syenite ⁹	2	37.2	7.0	(4.0) ¹²	11.2		5.3
Moat volcanic ⁹	1	45.2	12.6	(4.0) ¹²	15.8		3.6
New Hampshire magma series							
binary granite (Casco, ME) ¹	32	40	8.2	4.3	12.7	1.63	(4.88) ¹³
binary granite (Fitzwilliam, NH) ¹	145	23.5	7.6	3.9	9.7	1.48	(3.09) ¹³
granite ⁷	5(7)	18.3	4.3	(4.0) ¹²	6.46		4.3
Littleton Fm. gneiss ⁹	1	16.6	3.1	(4.0) ¹²	5.5		5.4

¹ Birch (1968, p. 442)

² Rogers and Adams (1963)

³ Brimhall and Adams (1969, p. 1310)

⁴ Richardson (1964, p. 42)

⁵ Rogers and Ragland (1961, p. 101)

⁶ Butler (1961)

⁷ Lyons (1961)

⁸ Hurley (1956, p. 409, tables 1 and 2)

⁹ this study; see Appendix C

¹⁰ calculated for this table

¹¹ Th/U assumed = 3.5

¹² %K assumed = 4%

¹³ Th/U calculated from mean Th and U conc

	depths (ft.)	
	1962	1963
*Conway Granite cores		
core A Kancamagus, NH	600	1000
core B North Conway, NH	600	700
core C Mad River stock, Waterville, NH	500	1000

core A is comprised of "normal" and "altered" granite occurring in the upper and lower 500 ft. respectively. The higher concentrations of thorium and uranium occurred in the "altered" granite.² Cores B and C show no significant change in concentration of either thorium or uranium over 700 and 1000 ft. respectively. Average concentrations of thorium and uranium for the Redstone core (3000 ft.) will be difficult to interpret in view of the fact that the core passes through the "green phase granite" (Osceola Granite?), red phase granite (Conway Granite) and the Albany Porphyritic Quartz Syenite. Surface samples drilled during this study may shed light on the vertical variation problem when the analyses for thorium and uranium concentrations are completed.

In absence of any clear data to the contrary, the assumption is made that the thorium and uranium concentrations and thus the value of A is constant with depth. This is clearly not the case as evidenced by core A. However, it is impossible to estimate the altered rock/normal rock ratio for any component of the batholith or even to know if all altered rock has higher concentrations of thorium and uranium. Furthermore, no evidence suggests a continuous change with depth. Thus we must be satisfied to choose a value of A for each rock type based on what surface and near surface³ information exists.

² The values of thorium and uranium concentrations and the values of A for core A reported by Birch (1968) were taken from Rogers and Adams (1965). Thus these values reported by Birch represent higher than average values for "normal" granite.

³ The deepest cores (1000 ft.) represent only 7% of the total (minimum) thickness of the Conway Granite.

Thermal Conductivity

Thermal conductivity is an influential but poorly known parameter. Values used in the models presented are estimates based on thermal conductivities for similar rock types given by Clark (1966) and listed in Table 10. Uniform thermal conductivity with depth is assumed for each rock type, although a slight (10% max.) decrease in k may occur with increasing temperature. Also, the presence of large quartz phenocrysts in granitic rocks causes higher effective thermal conductivity because of increased radiative heat transfer.

Summary of Parameter Values used in Modeling

Table 11 lists the range in values of all parameters used in the one-dimensional and finite element modeling.

One-Dimensional Temperature Models

Equation Defining Vertical Temperature Distribution

The one-dimensional temperature distribution in a two layer system is defined by:

$$T(z) = \begin{cases} T_o + \frac{q_o z}{k_1} - \frac{A_1 z^2}{2k_1} & z \leq z_1, \\ T(z_1) + \frac{(z-z_1)(q_o - A_1 z_1)}{k_2} - \frac{A_2 (z-z_1)^2}{2k_2} & z \geq z_1 \end{cases} \quad (\text{eq. 9})$$

The two layer system is depicted below:

Table 10

Thermal Conductivity
(from Clark, 1966)

	<u>n</u>	<u>$k(10^{-3} \text{ cal/cm sec}^\circ\text{C})$</u>	<u>range</u>
granite			
Barre, VT		6.66	
Westerly, RI		5.80	
Rockport, MA		8.40	
Switzerland	12	7.77	6.2-9.0
granite and quartz monzonite			
Colorado	59	7.89	6.7-8.6
syenite and syenite porphyry	37	7.66	6.3-9.5
gneiss			
Switz. - Gotthard tunnel	15	6.68	5.1-8.0
Switz. - Simplon tunnel	⊥ 22	6.34	4.6-7.7
	// 8	8.90	6.0-11.4
Chester, VT	⊥ 9	6.24	4.9-8.7
	// 9	8.33	6.1-10.4
schist			
Switz. - Simplon tunnel	⊥ 8	5.74	4.1-6.8
	// 7	7.50	6.8-8.9

Table 11
Summary of Parameter Values

	One-dimensional models	Finite Element models
thickness (z, km)		
White Mountain batholith components	4.0 - 5.25	5.25 maximum
New Hampshire magma series	4.0 - 5.25	3.0 maximum
surface heat flow (q_0 , HFU)		
over Conway Granite	1.95	1.95
over surrounding NHMS terrain	1.6	1.6
over surrounding Littleton Fm terrain	0.8 - 1.2	---
heat production rate (A, HGU)		
Conway Granite	14.2, 17.5, 20.9	17.5
Mount Osceola Granite	15.3	15.3
Albany Quartz Syenite	13.6	13.6
New Hampshire magma series	6.5, 9.7, 12.7	9.7
Littleton Formation	2.0, 5.5	5.5
thermal conductivity (k , $\times 10^{-3} \text{ cal/cm sec } ^\circ\text{C}$)		
Conway Granite	5.8 - 8.4	5.8
Mount Osceola Granite		
NHMS Granite		
Albany Quartz Syenite		
Littleton Formation	4.1, 7.75, 11.4	7.1

A_1 and A_2 = heat production rates in (HGU)

k_1 and k_2 = thermal conductivity in ($\times 10^{-3}$ cal/cm sec $^{\circ}$ C)

q_0 = surface heat flow in (HFU)

z = depth below surface

T_0 = surface temperature, assumed = 0.

Figure 15 - Two layer system governed by equation 9.

Conway Granite - 4 km and 5.25 km

The temperature distributions for Conway Granite layers of 4 km and 5.25 km are shown in Figure 16 together with heat flow vs. depth. Basal T and q determined for two values of k_1 and for $A_1 = 17.5$ HGU and $q = 1.95$ HFU are:

Conway Granite ($A_1 = 17.5$ HGU)			
z_1 (km)	k_1 (cal/cm $^{\circ}$ C sec)	q (HFU)	T ($^{\circ}$ C)
4.0	0.0084	1.25	76
5.25	0.0084	1.03	93
4.0	0.0058	1.25	110
5.25	0.0058	1.03	135

New Hampshire Magma Series Granite - 4 km and 5.25 km

Figure 17 shows the same information for a NHMS layer of 4 km and 5.25 km thickness. The table below lists the calculated T and q for $A_1 = 9.7$ HGU and $q = 1.6$ HFU for two conductivity values.

NHMS Granite ($A_1 = 9.7$ HGU)

z_1 (km)	k_1 (cal/cm°C sec)	q (HFU)	T (°C)
4.0	0.0084	1.21	67
5.25	0.0084	1.09	84
4.0	0.0058	1.21	97
5.25	0.0058	1.09	122

Beneath Conway Granite Layer

Using the calculated values of T and q at 4 km and 5.25 km for a Conway Granite layer, the temperature distribution beneath the Conway Granite layer is calculated using the second part of equation 9. The material underlying the Conway Granite layer is assumed to have thermal properties similar to those described for the Littleton Formation in Table 11. The results are shown in Figures 18 and 19 for Conway Granite layers of 4 km and 5.25 km depth respectively. The table below lists the extreme values of T and q at 10 km from Figures 18 and 19.

T and q at 10 km beneath
Conway Granite layer

z_1 (km)	A_2 (HGU)	k_2 (cal/cm°C sec)	q (HFU)	T (°C)
4.0	2.0	0.0041	1.13	284
4.0	5.5	0.0114	0.92	167
5.25	2.0	0.0041	0.94	249
5.25	5.5	0.0114	0.77	172

Littleton Formation

Figure 20 shows the results of the temperature calculation for a Littleton Formation surface layer of 10 km thickness with $q_0 = 0.8$ HFU. The temperature and heat flow extremes at 10 km are listed below:

Littleton Fm layer ($q_0 = 0.8$ HFU)			
A_1 (HGU)	k_1 (cal/cm°C sec)	q (HFU)	T (°C)
2.0	0.0041	0.6	171
5.5	0.0114	0.25	46

Summary of One-Dimensional Models

In all of the temperature calculations, the variation in A causes a small change in temperature compared to the temperature change caused by varying k . The heat flow vs. depth is independent of k and only changes with variation in A .

Figure 21 shows the minimum and maximum T vs. depth to 10 km for Conway Granite of 4 km and 5.25 km and for a Littleton Formation surface layer of 10 km thickness.

Finite Element Temperature Model

The advantage of using the finite element method in modeling the temperature distribution of a complex batholith lies in its adaptability to the geometry of the model and the ability to include many different material constant such as thermal conductivity and heat production rates which may vary among rock types. Another advantage to the technique is its ability to determine lateral as well as vertical variations in temperature. Where batholithic rocks are adjacent to country rocks or some unit of lower heat production rate or different thermal conductivity,

Figure 16

Figure 17

Figure 18

Figure 19

Figure 20

Figure 21

this edge effect needs to be determined.

The finite element method requires that a system or grid of elements be defined. The grid system used in the modeling is shown in Plate 9. The darker lines represent the different rock units shown along the AA' profile of Figure 11. Depths of the various units are also taken from Figure 11. Each triangular element must have material constants defined including thermal conductivity and heat production rates. Figure 22 shows the values of k and A used in the model for each rock type. The surface boundary condition is $T = 0^{\circ}\text{C}$. The basal boundary condition specifies a heat flow of 1.3 HFU entering the bottom at 12 km. As discussed in an earlier section, basal heat flow is based on the high heat flow ridge of Figure 14 and on the need to have a basal heat flow greater than Birch's (1966) 0.8HFU to satisfy the conditions of batholith thickness and A value.

The calculated temperature distribution for the model with the above specifications is shown in Plate 10. Calculated surface heat flow is shown across the top of the model and the values are in good agreement with the observed value of 1.95HFU at drill hole B (see Table 9). The temperature beneath the deepest part of the batholith at 6 km depth is approximately 170°C ; at 8 km the temperature is approximately 220°C . The lateral change in temperature is greatest at depths above the base of the batholith. At 6 km for example the model temperature above the deepest part of the batholith model is about 170°C ; 10 km to the north the temperature at 6 km depth is 150°C representing a lateral change in temperature of 20°C or a lateral gradient at 6 km of $2^{\circ}\text{C}/\text{km}$.

Other temperature models could be constructed using different thicknesses, different values of A , k or basal heat flow. By increasing

material number	rock type	k (cal/cm sec C)	A (HGU)
1	Conway Granite	.0058	17.5
2	Mt. Osceola Granite	.0058	15.3
3	Albany Quartz Syenite	.0058	13.6
4	New Hampshire Magma Series Granite	.0058	9.7
5	Littleton Formation	.0071	5.5
6	crustal rock	.0055	2.0

Figure 22 - Material properties of rock units in finite element model.

the thickness of the layers with high heat production, the temperature at any given depth would decrease slightly. Changes in the thermal conductivity will result in more considerable changes in the temperature distribution. Changes in A would require modification of the basal heat flow to meet the surface heat flow condition.

CONCLUSIONS

The conclusions reached as a result of this study are as follows:

- (1) The areal extent of Conway Granite in the eastern part of the White Mountain batholith has been overestimated. The largest pluton exposed at the surface in the North Conway quadrangle is 7 x 12 km.
- (2) Plutons of the White Mountain magma series form a complex array of high-level intrusions emplaced by cauldron subsidence and stoping. Various centers of intrusive activity containing parallel sequences of rock-types were formed at different times over a span of possibly 60-70 my.
- (3) Surface joints have similar orientations irrespective of the rock unit in which they are found. Joints are formed as a result of regional stress systems, and their orientations are little affected by local differences in rheological characteristics of the various plutonic bodies.
- (4) Gravity modeling indicates that the floor of the batholith is between 4 and 5.25 km depth depending on how the regional gravity gradient is determined. The gravity models are consistent with steeply dipping sides to the plutons.

- (5) The temperature models indicate both vertical and horizontal variations in temperature. Temperatures at a depth of 6 km are estimated to be 170°C and at a depth of 8 km, to be 220°C.
- (6) Temperatures beneath the eastern part of the batholith are probably insufficient to justify deep, dry-hole drilling for geothermal energy.

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Appendix A

Rose Diagrams of Joint Orientations

Collected in this appendix are rose diagrams depicting the orientations of joints at 52 locations. N indicates the number of joint orientations included in each diagram; R represents the circle radius measured from the inner darkened circle. The principal joint orientations determined from the rose diagrams and from cross-cutting relationships of joints in the field are listed and also plotted on the map of Plate 4.

Station 1
N60E
N06W
N55W

Station 2
N45E
N16W
N55W
N85W

Station 3
N79E
N13E

Station 4
N34E
N12W
N71W

Station 5
N75E
N15E
N85W

Station 6
N55E
N25E
N15W
N70W

Station 7
N24E
N07W
N77W

Station 8
N83E
N42E
N18W

Station 9
N64E
N06E
N44W

Station 10

Station 11

N74E
N05E
N22W
N85W

Station 12

N60E
N22E
N02E
N80W

Station 13
N66E
N12E
N46W
N78W

Station 14
N76E
N38E
N05W
N63W

Station 15
N57E
N08E
N47W
N82W

Station 16
N69E
N13W

Station 17
N89E
N08W

Station 18
N84E
N47E
N12W
N60W

Station 19
N50E
N40W
N75W

Station 20
N42E
N01E
N69W

Station 21
N25E
N04E
N75W

Station 22
N46E
N15E
N75W

Station 23
N22E
N43W

Station 24
N25E
N02W
N66W

Station 25
N14E
N82W

Station 26
N83E
N29E
N02E
N29W

Station 27
N89E
N10W
N67W

Station 28
N80E
N35E
N15E

Station 29
N75E
N45E
N14W
N58W

Station 30
N76E
N40E
N06E
N56W

Station 31
N06E
N50W
N82W

Station 32
N75E
N53E
N25E
N43W

Station 33
N58E
N16E
N75W

Station 34
N65E
N56W

Station 35
N75E
N13E
N21W
N72W

Station 36
N34E
N14E
N54W
N76W

Station 37
N86E
N25E
N44W

Station 38
N20E
N80W

Station 39
N79E
N33E
N03E
N76W

Station 40
N66E
N03E
N74W

Station 41
N75E
N21E
N11W

Station 42
N80E
N44E
N06E
N65W

Station 43
N86E
N12E

Station 44
N76E
N10E
N55W

Station 45
N65E
N17E
N89W

Station 46
N58E
N21E
N25W
N73W

Station 47
N06E
N85W

Station 48
N48E
N11E
N22W
N73W

Station 49
N85E
N09E

Station 50
N08W
N53W
N87W

Station 51
 N77E
 N45E
 N05W
 N76W

Station 52
 N72W-N66E
 N25E-N49E
 N15E-N03E
 N42W-N25W

Appendix B

Gravity Data

The gravity data collected during this study are tabulated here. Also listed are the data of Joyner (1963) that occur within the survey area. The data at benchmarks, spot elevations, etc., which make up the 76-series are listed first followed by Joyner's data. Data along six traverses are listed next. Sketch maps of each traverse are also presented. Dashed lines on a sketch map indicate the traverse route followed in the two-dimensional modeling.

76-Series

STATION	LAT		LONG		ELEV (FT)	OBSGRV	TC	126	
	DEG	MIN	DEG	MIN				FREE AIR	BOUG
72653M529	43	54.57	71	4.97	529.00	457.22	0.65	-23.81	-41.2
76CBBMJ7	44	4.45	71	8.22	548.58	450.81	1.21	-43.23	-60.7
761	44	4.45	71	7.04	664.00	444.66	1.43	-38.52	-59.7
762BM722	44	4.53	71	6.10	722.47	440.98	2.63	-36.82	-58.8
763J421BM1259	44	4.23	71	5.20	1259.00	409.85	2.01	-17.02	-57.9
764BM1688	44	4.13	71	4.19	1688.00	385.27	2.62	-1.08	-56.0
765J422BM543	44	5.09	71	1.85	543.00	457.34	1.19	-38.19	-55.5
766BM418	44	6.25	71	0.39	418.00	467.31	1.03	-41.72	-54.9
767	44	6.70	71	0.24	412.00	467.05	1.22	-43.22	-56.1
768J4216BM519	44	7.43	71	0.33	519.00	461.86	1.48	-39.44	-55.7
769	44	7.25	70	58.63	387.00	472.46	0.41	-40.99	-53.8
7610J230BM388	44	6.69	70	58.53	388.00	471.46	0.35	-41.06	-53.9
7611BM519	44	5.65	71	1.06	519.00	460.74	0.72	-37.89	-54.9
7612	44	6.10	70	57.60	397.00	471.98	0.23	-38.80	-52.1
7613	44	7.00	70	56.59	381.00	473.79	0.19	-39.85	-52.7
7614BM386	44	7.67	70	56.30	386.00	473.74	0.19	-40.44	-53.4
7615	44	7.88	70	55.16	545.00	466.82	0.22	-32.72	-51.1
7616J233	44	8.90	70	54.21	519.00	469.63	0.17	-33.89	-51.4
7617BM439	44	7.62	70	53.52	439.00	474.22	0.16	-34.90	-49.7
7618	44	7.32	70	54.47	438.00	473.90	0.13	-34.86	-49.7
7619	44	8.88	70	52.89	485.00	473.79	0.24	-32.89	-49.2
7620J2312	44	8.15	70	51.20	528.00	471.60	0.32	-29.94	-47.6
7621BM692	44	8.01	70	49.40	692.00	464.11	0.22	-21.79	-45.2
7622J2313	44	8.25	70	48.05	565.00	472.99	0.15	-25.22	-44.3
7624	44	8.89	70	45.98	787.00	461.43	0.13	-15.86	-43.6

STATION	LAT DEG MIN	LONG DEG MIN	ELEV (FT)	OBSGRV	TC	FREE AIR	BOUG
7625	44 5.51	70 43.90	477.00	481.83	0.38	-26.55	-42.4
7626BM536	44 8.66	70 46.86	536.00	476.10	0.15	-25.46	-43.6
7627	44 9.04	70 44.75	719.00	466.91	0.38	-18.00	-42.1
7628BM458	44 9.58	70 42.95	458.00	482.85	0.77	-28.03	-42.9
7629	44 10.32	70 41.41	644.00	474.07	0.19	-19.82	-41.6
7630BM638	44 10.55	70 40.95	638.00	474.72	0.11	-20.08	-41.7
7631	44 10.40	70 38.44	583.00	478.27	0.05	-21.48	-41.3
7632BM456	44 11.27	70 37.63	456.00	488.08	0.25	-24.93	-40.2
7633	44 11.57	70 36.62	626.00	478.51	0.15	-18.95	-40.1
7634	44 12.04	70 35.26	522.00	486.34	0.13	-21.61	-39.3
7635BM409	44 12.73	70 33.65	409.00	497.52	0.76	-22.10	-35.3
7636J423	44 1.43	71 0.29	410.00	467.24	0.23	-35.30	-49.0
7637BM429	44 0.59	70 58.84	429.00	467.69	0.12	-32.40	-46.9
7638	44 0.17	70 56.78	425.00	472.57	0.10	-26.56	-41.1
7639J2238M385	43 56.73	70 55.61	385.00	476.38	0.11	-24.45	-37.5
7640	43 56.11	70 55.02	422.00	474.27	0.33	-22.15	-36.2
7641J2209M399	43 56.80	70 53.10	399.00	478.70	0.14	-17.91	-31.4
7642J2218	43 54.85	70 51.10	414.00	478.44	0.11	-13.83	-27.8
7643	43 55.70	70 52.10	413.00	477.72	0.18	-15.92	-29.8
7644BM397	43 53.63	70 49.84	397.00	477.84	0.37	-14.19	-27.4
7645	43 52.97	70 47.79	396.00	478.54	0.22	-12.59	-25.9
7646	43 52.77	70 46.46	426.00	476.86	0.17	-11.15	-25.5
7647BM356	43 51.59	70 47.58	356.00	480.13	0.43	-12.69	-24.4
7648	43 50.04	70 46.73	377.00	476.86	0.20	-11.66	-24.3
7649J2222	43 50.88	70 46.50	411.00	477.13	0.52	-9.45	-22.9

STATION	LAT		LONG		ELEV (FT)	OBSGRV	TC	128	
	DEG	MIN	DEG	MIN				FREE AIR	BOUG
7650J2223	43	49.23	70	46.28	401.00	475.04	0.15	-10.00	-23.5
7651BM347	43	48.31	70	47.96	347.00	477.03	0.17	-11.71	-23.4
7652BM639	44	4.64	71	2.20	638.95	450.79	1.42	-35.03	-55.4
7653BM1131	44	4.23	71	3.14	1131.00	421.66	1.90	-17.25	-53.9
7654BM494	44	2.69	71	7.36	494.49	452.95	1.11	-43.53	-59.3
7655J425	44	1.05	71	6.93	480.00	455.08	0.57	-40.30	-56.1
7656BM451	43	59.81	71	4.71	451.00	459.71	0.28	-36.53	-51.6
7657	43	59.13	71	3.14	441.00	462.28	0.18	-33.88	-48.7
7658	43	58.06	71	2.64	535.00	458.37	0.22	-27.34	-45.4
7659J4232	43	57.14	71	1.30	635.00	453.34	0.18	-22.48	-44.0
7660	44	1.29	70	59.86	409.00	467.41	0.19	-35.01	-48.8
7661	44	0.54	70	58.58	413.00	468.93	0.11	-31.99	-46.0
7662	44	2.09	71	1.73	525.00	458.05	0.81	-34.66	-51.8
7663BM531	44	3.16	71	7.67	531.00	452.28	0.84	-41.47	-58.7
7664BM435	44	0.13	71	4.80	435.00	459.86	0.35	-38.37	-52.9
7665	43	59.01	71	5.95	539.00	453.40	0.29	-33.36	-51.4
7666	43	57.59	71	5.25	639.00	449.76	0.20	-25.46	-47.0
7667J4233	43	56.73	71	5.43	558.00	454.42	0.40	-27.12	-45.8
7668	43	56.28	71	5.92	825.00	438.05	0.46	-17.69	-45.4
7669BM447	43	55.96	71	3.64	447.00	463.02	0.57	-27.81	-42.5
7670	43	56.69	71	3.16	609.00	453.33	0.38	-23.36	-43.8
7671	43	53.91	71	11.24	656.00	447.18	0.29	-20.90	-43.0
7672	43	54.61	71	11.32	644.00	446.85	0.37	-23.41	-45.0
7673	43	55.35	71	12.03	741.00	439.37	0.58	-22.88	-47.6
7674	43	55.58	71	11.49	846.00	433.55	0.56	-19.17	-47.5

STATION	LAT DEG MIN	LONG DEG MIN	ELEV (FT)	OBSGRV	TC	FREE AIR	BOUG
7675	43 56.12	71 11.90	809.50	433.70	0.64	-23.26	-50.2
7676	43 55.72	71 13.46	651.00	443.07	1.11	-28.21	-49.3
7677	43 56.42	71 13.56	738.00	435.51	1.23	-28.63	-52.6
7678	43 57.20	71 12.77	730.00	436.76	1.10	-29.31	-53.1
7679J4236BM678	43 57.63	71 11.48	678.00	441.17	0.93	-30.44	-52.6
7680	43 58.19	71 10.45	767.00	436.76	0.71	-27.31	-52.8
7681	43 57.53	71 10.32	641.00	444.16	0.66	-30.78	-52.0
7682	43 56.83	71 12.32	876.00	428.71	0.69	-23.06	-52.3
7683	43 56.38	71 12.06	808.00	432.99	0.69	-24.50	-51.4
7684BM540	44 6.54	71 11.03	540.43	451.58	1.67	-46.37	-63.1
7685	44 7.34	71 11.29	640.00	444.06	2.05	-45.72	-65.5
7686	44 8.63	71 11.29	724.00	441.81	2.13	-41.11	-63.7
7687BM982	44 10.59	71 13.46	582.00	431.71	6.38	-30.79	-57.9
7688	44 11.38	71 13.63	1049.00	431.57	6.51	-25.81	-55.1
7689	44 12.14	71 14.31	1162.00	418.38	7.04	-29.51	-62.1
7690	44 10.57	71 11.79	1057.00	431.14	4.89	-24.87	-56.0
7691	44 10.43	71 11.60	1006.00	433.11	4.00	-26.89	-57.2
7692	44 9.76	71 9.22	1477.00	401.49	1.64	-13.18	-61.9
7694BM529	44 5.89	71 9.58	528.90	451.71	1.59	-46.35	-62.8
7695	44 6.05	71 9.00	568.00	450.11	1.77	-44.51	-62.1
7696	44 5.43	71 6.25	1403.00	408.42	2.86	-12.72	-57.7
7697BM492	43 55.78	71 9.69	492.00	456.07	0.59	-30.26	-46.4
7699	44 4.99	71 7.47	947.00	426.17	2.40	-31.19	-61.1
76100	44 5.62	70 59.16	434.00	471.25	0.66	-41.35	-55.5
76101J4217BM518	44 5.86	71 0.66	518.00	464.80	1.50	-40.25	-56.4

STATION	LAT DEG MIN	LONG DEG MIN	ELEV (FT)	OBSGRV	TC	FREE AIR	BOUG
76102BM528	44 10.61	71 0.75	528.00	464.82	1.15	-40.42	-57.3
76103BM473	44 11.51	71 0.62	473.00	469.10	1.52	-42.67	-57.3
76104BM505	44 12.13	71 0.39	505.00	468.22	1.35	-41.47	-57.3
76105	44 12.67	71 0.48	451.00	471.63	1.97	-43.95	-57.4
76106BM459	44 13.61	71 0.75	459.00	471.22	3.16	-45.02	-57.5
76107J4219BM523	44 14.36	71 1.04	523.00	468.27	2.30	-43.08	-58.6
76108	44 8.23	70 58.76	446.00	469.33	0.57	-40.05	-54.7
76109	44 10.45	71 1.86	593.00	458.87	2.44	-40.01	-57.8
76110	44 11.98	71 1.66	894.00	443.18	2.49	-29.69	-57.7
76111	44 8.15	70 56.84	406.00	473.35	0.22	-39.67	-53.3
76112	44 9.88	70 56.61	432.00	473.94	0.30	-39.23	-53.7
76113	44 9.09	70 56.10	378.00	476.55	0.23	-40.52	-53.2
76114	44 8.74	70 57.28	401.00	473.36	0.30	-41.02	-54.4
76115J231	44 9.50	70 57.60	428.00	473.16	0.36	-39.82	-54.1
76116	44 10.90	70 57.88	475.00	470.85	0.50	-39.81	-55.5
76117BM390	44 9.45	70 58.32	390.00	474.43	0.50	-42.05	-54.8
76118	44 8.25	71 0.55	913.00	438.01	2.84	-27.46	-55.8
76121J4215	44 10.38	71 4.05	1521.00	404.42	1.17	-7.05	-57.8
76122	44 4.56	70 58.27	398.00	470.47	0.44	-37.90	-51.0
76123	44 3.23	70 59.07	409.00	468.66	0.25	-36.68	-50.4
76124	44 1.66	70 58.27	424.00	467.68	0.12	-33.89	-48.2
76125	44 2.58	70 57.52	414.00	470.48	0.13	-33.41	-47.4
76126	44 3.33	70 57.30	504.00	465.65	0.12	-30.90	-48.0
76127BM438	44 4.19	70 56.74	438.00	470.24	0.12	-33.81	-48.6
76128J239	44 5.80	70 55.58	464.00	471.13	0.13	-32.90	-48.6

STATION	LAT DEG MIN	LONG DEG MIN	ELEV (FT)	OBSGRV	TC	FREE AIR	BOUG
76129BM386	44 5.92	70 55.31	386.00	475.77	0.15	-35.78	-48.8
76130	44 6.76	70 55.30	421.00	473.63	0.13	-35.89	-50.1
76131	44 5.11	70 55.26	379.00	476.29	0.16	-34.70	-47.5
76132BM376	44 4.77	70 54.22	378.00	477.21	0.12	-33.36	-46.1
76134	44 3.25	70 52.84	512.00	470.82	0.14	-24.86	-42.2
76135BM487	44 2.67	70 52.36	487.00	473.24	0.19	-23.92	-40.3
76136BM478	44 1.68	70 55.57	478.00	469.93	0.15	-26.59	-42.7
76137J234BM532	44 10.75	70 53.55	532.00	471.81	0.22	-33.26	-51.2
76138	44 11.58	70 53.35	491.00	476.14	0.37	-34.64	-51.0
76139	44 13.28	70 53.00	459.00	480.38	0.45	-35.37	-50.6
76140	44 13.64	70 52.90	583.00	474.34	0.43	-30.58	-50.0
76141	44 14.58	70 52.64	439.00	484.00	0.65	-35.59	-49.9
76142	44 14.87	70 54.46	581.00	473.80	0.73	-32.86	-51.9
76143	44 14.17	70 54.74	479.00	477.90	0.74	-37.30	-52.9
76144	44 12.95	70 55.00	559.00	471.23	0.50	-34.61	-53.2
76145BM536	44 12.58	70 55.12	536.00	472.10	0.43	-35.35	-53.2
76146	44 11.76	70 54.83	456.00	476.40	0.31	-37.34	-52.6
76147	44 11.18	70 55.16	422.00	477.64	0.38	-38.43	-52.4
76148	44 12.45	70 56.86	611.00	466.11	0.60	-34.09	-54.3
76149	44 13.18	70 56.68	546.00	470.83	0.96	-36.58	-54.2
76150	44 11.70	70 57.57	526.00	469.95	0.59	-37.12	-54.5
76151	44 9.85	70 54.49	386.00	473.03	0.28	-44.43	-57.3
76152	43 59.44	71 6.63	484.00	463.51	0.30	-29.07	-45.3
76154BM650	43 59.68	71 10.88	650.00	444.58	1.96	-32.74	-52.9
76155	43 59.98	71 13.51	824.00	433.61	2.69	-27.79	-53.2

STATION	LAT DEG MIN	LONG DEG MIN	ELEV (FT)	OBSGRV	TC	FREE AIR	BOUG
76156J4221	44 0.40	71 14.61	890.00	429.01	2.30	-26.81	-54.9
76157	43 59.55	71 18.93	1222.00	408.87	1.72	-14.44	-54.4
76158BM1227	43 59.62	71 19.85	1227.00	408.74	1.61	-14.20	-54.4
76159J4228BM1252	43 59.78	71 22.18	1252.00	406.43	2.35	-14.40	-54.8
76160	43 59.53	71 17.49	1222.00	408.51	1.69	-14.77	-54.8
76161BM1133	44 0.04	71 16.65	1133.00	414.12	1.71	-18.30	-55.2
76162	44 0.62	71 19.30	1411.00	397.46	1.48	-9.67	-56.3
76163A	44 1.44	71 19.27	1507.00	390.15	2.73	-9.18	-57.8
76164J4128BM1706	44 2.28	71 19.51	1706.00	379.19	1.50	-2.68	-59.4
76165	44 3.31	71 16.50	1051.00	416.21	2.50	-28.84	-62.2
76166	44 2.11	71 18.37	1686.00	374.27	3.23	-10.13	-64.4
76167J42278M1412	44 2.70	71 17.28	1412.50	394.13	2.40	-15.99	-61.8
76168	44 3.77	71 9.37	501.00	452.06	1.11	-45.43	-61.4
76169	44 4.62	71 10.06	557.00	448.67	1.75	-44.83	-62.1
76170	44 2.40	71 10.07	530.00	450.23	2.10	-42.48	-58.4
76171	44 2.00	71 8.74	773.00	435.91	2.02	-33.33	-57.7
76172	44 0.75	71 11.41	2020.00	355.46	5.99	5.43	-57.5
76173	44 1.05	71 9.98	922.00	427.71	1.68	-26.08	-55.8
76174	44 0.34	71 8.78	669.00	445.52	0.83	-31.01	-53.0
76175	44 0.85	71 8.50	493.00	453.79	1.01	-40.07	-55.9
76178	44 3.85	71 12.05	1059.00	417.32	4.16	-27.79	-59.8
76179	44 3.16	71 11.18	890.00	427.60	2.42	-32.38	-60.3
76200	44 6.20	71 11.78	556.00	449.42	1.87	-46.55	-63.6
76201	44 4.42	71 18.05	711.00	437.16	2.88	-41.55	-62.9
76202	44 4.57	71 18.63	768.00	434.42	3.59	-39.15	-61.8

STATION	LAT DEG MIN	LONG DEG MIN	ELEV (FT)	OBSGRV	TC	FREE AIR	BOUG
76203BM873	44 5.12	71 20.99	873.00	426.19	4.69	-38.33	-63.4
76204BM746	44 4.84	71 18.79	746.00	435.85	3.60	-40.20	-62.0
76205	44 6.18	71 21.15	933.00	423.96	5.75	-36.51	-62.6
76206	44 8.75	71 21.98	1162.00	409.29	6.36	-33.50	-66.8
76207J4224	44 5.88	71 22.16	1211.00	408.37	7.35	-31.51	-65.5
76208	44 10.25	71 23.31	1277.00	402.84	7.50	-31.39	-67.4
76209BM1470	44 5.56	71 23.05	1470.00	393.04	8.86	-22.59	-63.9
76210	44 10.80	71 23.87	1324.00	398.18	11.77	-32.45	-65.8
76211BM469	44 1.08	71 7.47	468.94	455.04	0.57	-41.43	-56.8
76212BM461	43 55.13	71 7.64	460.99	456.95	0.38	-37.33	-52.7
76213	44 8.57	71 12.59	1007.09	431.28	2.51	-26.42	-58.3
76214	44 8.62	71 14.33	1880.23	380.22	2.01	5.20	-56.9
76217J4211	44 11.70	71 11.78	1194.88	426.25	3.90	-17.89	-54.7
76218	44 3.39	71 8.32	491.32	454.14	0.93	-43.69	-59.5
76219	44 3.40	71 8.47	489.48	454.12	0.92	-43.90	-59.7
76220	44 3.43	71 8.93	485.67	453.75	1.01	-44.67	-60.2
76221	44 8.76	71 10.92	762.36	443.28	2.24	-37.13	-60.9
76222	44 5.14	71 10.84	910.98	435.67	1.88	-31.33	-60.5
76223	44 5.11	71 10.49	1045.27	426.17	1.95	-28.15	-61.8
76224	44 8.29	71 9.28	1723.00	380.60	2.00	-8.72	-65.5
76225	44 5.52	71 10.33	1096.00	424.72	2.00	-25.44	-60.8
76226	44 5.97	71 10.54	1185.00	421.04	2.10	-21.42	-59.7
76227	44 8.46	71 10.73	820.00	438.52	2.00	-36.01	-62.0
76228	44 7.06	71 9.83	758.00	438.97	2.70	-39.29	-62.4
76229	44 11.92	71 10.14	2758.00	331.34	5.68	33.94	-54.4

STATION	LAT DEG MIN	LONG DEG MIN	ELEV (FT)	OBSGRV	TC	FREE AIR	BOUG
76230	44 7.58	71 10.13	1147.00	417.65	2.30	-24.79	-61.6
76231	44 5.37	71 12.35	633.00	443.97	2.07	-43.51	-63.0
76232	44 6.58	71 12.94	671.00	443.54	2.50	-42.19	-62.6
76233	44 11.39	71 7.79	1732.00	390.09	1.90	-3.04	-60.2
76234	44 10.65	71 7.12	1646.00	393.75	1.80	-6.36	-60.7
76235	44 3.68	71 6.87	527.00	452.08	1.46	-42.83	-59.3
76236	44 3.10	71 7.10	538.00	452.04	1.21	-40.97	-58.1
76237	44 2.62	71 0.60	425.00	465.02	0.51	-37.89	-51.9
76238	44 3.16	71 1.17	474.00	462.17	1.45	-36.95	-51.7
76239	44 4.00	71 1.61	507.00	459.32	2.11	-37.96	-53.1
76240	44 7.17	71 1.93	942.00	433.46	1.60	-27.65	-58.2
76241BM1192	44 5.31	71 6.44	1192.00	417.67	3.78	-23.14	-60.0
76243	44 10.11	71 11.49	975.00	434.73	3.12	-27.70	-57.8
76244	44 5.34	71 11.10	970.00	433.95	2.20	-27.79	-58.7
76245	44 7.83	71 2.91	1322.00	411.24	2.00	-15.11	-58.2
76246	44 6.13	71 1.93	649.00	451.65	1.20	-35.47	-56.4
76247	44 7.77	71 12.69	1322.00	406.80	1.80	-19.46	-62.8
76248	44 7.15	71 15.16	942.00	429.74	3.40	-31.34	-60.1
76249	44 5.30	71 8.76	1535.00	396.73	1.65	-11.80	-62.5
76250	44 5.14	71 9.93	559.00	447.95	1.80	-46.15	-63.4

Joyner Data

STATION	LAT DEG MIN	LCNG DEG MIN	ELEV (FT)	OBSGRV	TC	FREE AIR	BOUG
J1418	44 15.53	71 29.78	1511.00	410.20	1.80	-10.56	-60.3
J1419	44 15.21	71 27.21	1616.00	399.70	2.80	-10.25	-62.6
J1420	44 17.41	71 20.93	2855.00	329.30	3.90	32.76	-60.7
J1421	44 15.13	71 22.05	2049.00	380.30	4.20	5.34	-60.3
J1422	44 21.46	71 20.71	1500.00	416.30	2.60	-13.82	-62.4
J1423	44 22.76	71 15.30	1472.00	423.50	1.40	-11.20	-60.0
J160	44 22.10	71 24.13	1547.00	416.30	1.50	-10.36	-61.6
J161	44 18.78	71 27.48	2191.00	378.90	0.73	17.83	-56.2
J162	44 22.68	71 28.38	1098.00	451.00	0.94	-18.77	-55.3
J163	44 24.88	71 28.45	1335.00	441.00	1.60	-9.78	-53.7
J164	44 28.46	71 28.68	1197.00	462.30	1.24	-6.85	-46.4
J168	44 15.45	71 15.21	2032.00	382.30	0.60	11.28	-57.4
J167	44 28.13	71 19.48	1618.00	428.30	0.80	-0.75	-55.1
J166	44 25.55	71 18.95	1732.00	412.70	0.75	-2.35	-60.7
J165	44 24.51	71 20.43	2187.00	383.80	6.80	13.73	-54.1
J169	44 17.76	71 16.73	3956.00	265.40	11.90	71.92	-51.1
J1610	44 23.50	71 24.25	1574.00	419.10	1.09	-7.12	-59.7
J1611	44 27.58	71 25.00	1951.00	415.10	2.30	18.20	-46.0
J1612	44 16.23	71 18.20	6288.00	101.30	30.20	129.52	-54.7
J16A1	44 15.85	71 30.00	3554.00	291.70	15.90	57.25	-48.1
J221	43 56.06	70 55.48	456.00	470.90	0.17	-19.23	-34.6
J222	43 56.73	70 58.68	622.00	457.20	0.09	-18.32	-39.4
J224	43 55.48	70 52.31	389.00	480.20	0.10	-21.38	-34.5
J225	43 58.20	70 45.66	545.00	473.00	0.10	-11.98	-30.5
J226	43 56.36	70 47.78	540.00	470.50	0.10	-12.18	-30.5

STATION	LAT DEG MIN	LCNG DEG MIN	ELEV (FT)	OBSGRV	TC	FREE AIR	BOUG
J227	43 54.66	70 58.43	562.00	459.90	0.21	-18.16	-37.1
J228	43 50.80	70 58.08	522.00	459.30	0.62	-16.72	-33.9
J2210	43 47.41	70 59.53	395.00	463.50	0.19	-19.37	-32.6
J229	43 48.95	70 56.35	592.00	454.80	0.23	-11.85	-31.8
J2211	43 45.10	70 56.38	638.00	449.20	0.12	-8.23	-29.9
J2212	43 45.71	70 53.26	587.00	454.80	0.10	-7.45	-27.4
J2213	43 48.55	70 51.15	371.00	472.80	0.18	-14.04	-26.5
J2214	43 51.68	70 53.18	433.00	470.50	0.45	-15.21	-29.5
J2215	43 53.30	70 52.46	415.00	473.90	0.41	-15.94	-29.7
J2216	43 52.83	70 54.80	536.00	464.40	0.40	-13.35	-31.2
J2217	43 50.46	70 51.68	522.00	465.60	0.36	-9.90	-27.3
J2219	43 52.45	70 49.91	801.00	452.50	0.40	0.26	-26.7
J2220	43 54.23	70 46.95	956.00	443.90	0.36	3.56	-28.7
J2221	43 51.20	70 49.43	869.00	448.40	0.45	4.43	-24.8
J2224	43 46.23	70 49.20	363.00	472.50	0.17	-11.68	-23.9
J2225	43 46.41	70 45.83	436.00	471.70	0.12	-5.81	-20.6
J230	44 6.70	70 58.50	388.00	471.60	0.34	-40.93	-53.8
J232	44 11.93	70 56.56	466.00	474.70	0.50	-38.36	-53.8
J238	44 12.88	70 47.53	590.00	477.90	0.40	-24.92	-44.6
J236	44 13.66	70 50.90	701.00	469.90	0.35	-23.95	-47.5
J237	44 13.26	70 45.25	895.00	457.90	0.20	-16.80	-47.1
J235	44 12.51	70 52.78	486.00	478.20	0.30	-33.85	-50.1
J2310	44 6.15	70 52.95	647.00	461.90	0.20	-25.44	-47.3
J2311	44 10.70	70 50.26	503.00	476.90	0.20	-30.83	-47.8
J2314	44 10.23	70 47.40	844.00	458.60	0.15	-16.34	-45.0

STATION	LAT DEG MIN	LONG DEG MIN	ELEV (FT)	OBSGRV	TC	FREE AIR	BOUG
J2315	44 2.98	70 55.86	461.00	470.60	0.15	-29.47	-45.0
J2316	44 1.46	70 56.41	403.00	473.50	0.15	-29.74	-43.3
J2317	44 1.53	70 53.85	391.00	477.30	0.10	-27.78	-41.0
J2318	44 1.18	70 51.63	457.00	476.20	0.25	-21.54	-36.9
J2319	44 3.70	70 51.15	446.00	475.40	0.20	-27.16	-42.2
J2320	44 4.11	70 47.01	513.00	475.80	0.15	-21.08	-38.4
J2321	44 5.63	70 48.18	653.00	466.00	0.15	-19.99	-42.1
J2322	44 7.18	70 45.70	588.00	472.30	0.12	-22.14	-42.1
J2323	44 6.31	70 46.83	611.00	470.90	0.10	-11.04	-31.8
J2324	43 58.18	70 49.70	545.00	471.80	0.10	-13.15	-31.6
J241	44 29.20	70 50.43	685.00	499.60	1.09	-18.84	-41.1
J243	44 29.23	70 47.26	635.00	501.70	0.69	-21.48	-42.4
J244	44 22.56	70 45.11	676.00	493.00	0.15	-16.29	-39.2
J245	44 20.28	70 45.65	698.00	483.00	0.10	-20.79	-44.5
J246	44 16.93	70 45.85	895.00	463.00	0.10	-17.22	-47.6
J247	44 15.11	70 48.81	629.00	477.90	0.20	-24.61	-45.9
J248	44 15.20	70 54.01	397.00	485.50	0.90	-38.97	-51.6
J249	44 21.51	70 49.95	696.00	485.60	0.30	-20.23	-43.7
J2410	44 19.43	70 49.75	829.00	473.60	0.30	-17.10	-45.0
J2411	44 20.16	70 52.61	858.00	470.90	0.60	-17.66	-46.3
J2412	44 22.75	70 54.65	798.00	480.00	0.90	-18.20	-44.5
J2433	44 11.26	70 32.28	378.00	496.30	0.0	-24.03	-36.9
J2434	44 12.41	70 41.08	530.00	482.10	0.02	-25.66	-43.7
J2439	44 5.46	70 32.16	522.00	486.50	0.0	-11.56	-29.4
J2440	44 4.70	70 38.50	451.00	487.30	0.0	-16.30	-31.7

STATION	LAT DEG MIN	LONG DEG MIN	ELEV (FT)	OBSGRV	TC	FREE AIR	BOUG
J400	44 23.28	71 10.40	800.00	470.70	2.00	-28.01	-53.3
J401	44 23.51	71 13.38	575.00	456.00	1.60	-26.59	-58.2
J402	44 26.56	71 11.26	880.00	465.70	3.20	-30.42	-57.2
J403	44 29.73	71 13.31	1070.00	463.40	0.70	-19.61	-55.4
J404	44 21.80	71 10.68	935.00	457.20	3.10	-26.58	-55.4
J405	44 18.90	71 13.05	1326.00	427.70	5.80	-14.93	-54.4
J406	44 24.11	71 6.93	743.00	477.80	2.20	-27.52	-50.7
J407	44 24.06	71 4.23	705.00	480.50	1.70	-28.32	-50.7
J408	44 23.06	71 1.25	696.00	482.30	1.50	-25.86	-48.1
J409	44 16.01	71 0.45	578.00	468.30	3.10	-40.36	-57.0
J4010	44 15.63	71 2.01	986.00	455.00	2.80	-20.72	-51.5
J4011	44 18.03	71 4.35	1199.00	437.30	2.70	-15.97	-54.2
J4012	44 16.08	71 6.41	1640.00	409.70	2.90	0.85	-52.2
J4013	44 21.25	70 59.53	820.00	472.10	2.00	-21.82	-47.8
J4014	44 23.55	70 58.86	712.00	484.00	1.30	-23.39	-46.4
J4015	44 28.21	71 6.78	1540.00	442.60	0.60	6.09	-45.8
J4016	44 29.56	71 3.88	1608.00	443.70	1.30	10.95	-42.6
J4019	44 23.58	70 55.78	680.00	489.50	1.30	-21.55	-43.4
J4020	44 27.20	70 48.76	645.00	499.00	0.70	-20.19	-41.5
J4021	44 24.53	70 52.16	700.00	489.30	0.80	-20.70	-43.8
J410	44 1.01	71 21.33	1001.00	418.80	6.10	-36.52	-64.6
J411	44 2.85	71 22.86	1938.00	364.80	0.60	3.90	-61.6
J424	44 0.77	71 3.36	440.00	460.90	0.60	-37.82	-52.2
J426	44 6.66	71 10.76	580.00	449.50	1.60	-44.91	-63.1
J427	44 4.56	71 14.30	650.00	440.50	2.60	-44.76	-64.3

STATION	LAT DEG MIN	LONG DEG MIN	ELEV (FT)	OBSGRV	TC	FREE AIR	BOUG
J428	44 6.83	71 14.41	844.00	433.00	3.10	-36.82	-62.5
J4210	44 12.58	71 14.90	1416.00	414.80	8.20	-9.86	-49.9
J4212	44 9.91	71 9.96	1230.00	418.70	1.70	-19.44	-59.7
J4213	44 8.33	71 8.21	1050.00	423.30	1.60	-29.40	-63.6
J4214	44 10.16	71 4.90	1511.00	403.80	1.20	-8.28	-58.6
J4218	44 12.76	71 0.48	456.00	471.70	1.60	-43.55	-57.5
J4220	44 3.15	71 9.60	488.00	452.40	1.20	-45.38	-60.8
J4223	44 4.98	71 17.73	700.00	437.90	2.50	-42.69	-64.1
J4225	44 11.98	71 24.40	1492.00	390.30	13.50	-26.30	-63.7
J4226	44 14.91	71 23.51	2036.00	375.00	2.20	5.17	-62.1
J4229	44 14.10	71 29.11	1780.00	386.50	3.60	-6.20	-63.3
J4230	44 11.80	71 29.45	2464.00	340.90	2.80	16.02	-65.2
J4231	44 9.85	71 27.36	2544.00	332.80	1.00	18.38	-67.4
J4234	43 55.08	71 1.60	748.00	446.70	0.40	-14.49	-39.6
J4235	43 55.10	71 8.88	737.00	442.90	0.60	-19.35	-43.9
J4237	43 54.48	71 17.38	824.00	435.90	1.10	-17.23	-44.2
J4238	43 54.50	71 20.80	1095.00	418.50	1.10	-9.16	-45.4
J4239	44 14.31	71 8.23	2402.00	362.00	1.50	27.51	-52.9
J4240	44 10.70	71 21.11	1631.00	387.80	9.80	-13.80	-59.6
J4241	44 12.81	71 20.23	2511.00	349.60	4.70	27.62	-53.3
J4242	44 3.15	71 25.26	1725.00	376.20	1.40	-5.20	-62.6
J4243	44 1.05	71 27.13	2030.00	357.70	1.40	8.16	-59.7
J4244	44 8.60	71 16.51	1282.00	411.20	3.60	-20.08	-60.2

Town Hall Road Traverse

STATION	LAT DEG MIN	LONG DEG MIN	ELEV (FT)	OBSGRV	TC	FREE AIR	BOUG
76948 M529	44 5.89	71 9.58	528.90	451.72	1.60	-46.34	-62.8
95291	44 5.95	71 9.54	546.30	450.97	1.58	-45.54	-62.6
95292	44 5.98	71 9.40	535.52	451.52	1.63	-46.05	-62.7
95293	44 6.06	71 9.33	547.61	451.11	1.68	-45.44	-62.4
95294	44 6.12	71 9.21	558.56	450.54	1.73	-45.07	-62.4
95295	44 6.14	71 9.08	565.60	450.14	1.78	-44.84	-62.3
95296	44 6.17	71 8.97	570.87	450.08	1.95	-44.45	-62.0
95297	44 6.18	71 8.87	578.82	449.36	2.12	-44.44	-62.1
95298	44 6.19	71 8.77	589.20	448.58	2.29	-44.25	-62.1
95299	44 6.23	71 8.67	598.97	448.18	2.46	-43.80	-61.8
952910	44 6.25	71 8.56	610.76	447.36	2.63	-43.54	-61.7
952911	44 6.33	71 8.50	619.08	447.36	2.60	-42.87	-61.4
952912	44 6.41	71 8.52	628.37	447.15	2.57	-42.33	-61.2
952913	44 6.50	71 8.53	648.97	446.09	2.55	-41.59	-61.2
952914	44 6.56	71 8.49	659.38	445.99	2.52	-40.80	-60.8
952915	44 6.64	71 8.44	673.73	444.74	2.49	-40.82	-61.3
952916	44 6.72	71 8.40	686.98	444.43	2.61	-40.00	-60.8
952917	44 6.80	71 8.35	699.12	443.97	2.73	-39.44	-60.5
952918	44 6.87	71 8.29	706.32	443.58	2.85	-39.26	-60.5
952919	44 6.95	71 8.24	710.13	443.51	2.97	-39.09	-60.3
952920	44 7.03	71 8.20	719.39	443.01	3.09	-38.84	-60.3
952921	44 7.09	71 8.13	727.19	442.52	2.92	-38.69	-60.6
962922	44 7.13	71 8.04	737.27	442.41	2.76	-37.91	-60.3
952923	44 7.18	71 7.97	749.38	441.61	2.59	-37.64	-60.6
952924	44 7.25	71 7.90	765.12	440.46	2.42	-37.42	-61.1

STATION	LAT DEG MIN	LONG DEG MIN	ELEV (FT)	OBSGRV	TC	FREE AIR	BOUG
952925	44 7.30	71 7.85	778.37	439.44	2.62	-37.27	-61.2
952927	44 7.43	71 7.73	795.50	438.15	2.52	-37.14	-61.8
952928	44 7.48	71 7.67	808.25	437.31	2.42	-36.86	-62.0
952929	44 7.55	71 7.61	831.68	435.83	2.32	-36.24	-62.3
952930	44 7.63	71 7.58	853.82	434.74	2.22	-35.36	-62.3
952931	44 7.67	71 7.46	895.82	432.42	2.10	-33.79	-62.2
952932	44 7.70	71 7.35	957.32	428.61	1.98	-31.86	-62.5
952933	44 7.74	71 7.25	992.05	426.54	1.86	-30.72	-62.7
952934	44 7.83	71 7.19	1006.29	426.37	1.79	-29.69	-62.2
952935	44 7.91	71 7.14	1016.83	425.70	1.73	-29.49	-62.4
952936	44 7.99	71 7.12	1002.89	425.99	1.67	-30.63	-63.2
952937	44 8.05	71 7.05	1011.90	425.50	1.69	-30.36	-63.2
952938	44 8.09	71 6.92	1019.96	425.15	1.72	-30.01	-63.1
952939	44 8.11	71 6.81	1030.79	424.72	1.74	-29.45	-62.9
952940	44 8.12	71 6.71	1034.83	424.70	1.76	-29.11	-62.6
952941	44 8.14	71 6.61	1037.90	424.52	1.84	-29.03	-62.6
952942	44 8.19	71 6.51	1026.86	425.06	1.92	-29.60	-62.7
2832ABRIDGE	44 8.19	71 6.53	1021.32	425.28	2.00	-29.91	-62.7
2832	44 8.26	71 6.53	1040.00	424.31	2.05	-29.22	-62.6
2833	44 8.35	71 6.50	1063.35	423.20	2.02	-28.27	-62.5
2834	44 8.45	71 6.53	1104.52	420.85	2.00	-26.90	-62.6
2835	44 8.54	71 6.54	1121.21	419.85	2.14	-26.46	-62.6
2836	44 8.63	71 6.54	1148.21	418.78	2.29	-25.13	-62.0
2837	44 8.70	71 6.51	1163.23	417.83	2.43	-24.77	-62.0

STATION	LAT DEG MIN	LONG DEG MIN	ELEV (FT)	OBSGRV	TC	FREE AIR	BOUG
2838	44 8.79	71 6.58	1181.81	416.61	2.35	-24.38	-62.3
2839	44 8.86	71 6.65	1199.98	415.64	2.27	-23.74	-62.4
2840	44 8.95	71 6.68	1238.22	413.42	2.19	-22.50	-62.5
2841	44 9.03	71 6.67	1255.37	412.87	2.61	-21.56	-61.8
2842	44 9.12	71 6.60	1266.34	412.21	3.00	-21.32	-61.5
2843	44 9.22	71 6.52	1235.59	414.29	3.39	-22.28	-61.0
76241BM1192	44 9.31	71 6.44	1192.00	417.67	3.78	-23.14	-60.0
11921	44 9.36	71 6.32	1234.52	415.30	3.52	-21.59	-60.2
11922	44 9.41	71 6.27	1249.96	414.76	3.26	-20.75	-60.1
11923	44 9.47	71 6.17	1270.46	413.69	3.00	-19.98	-60.3
11924	44 9.52	71 6.08	1278.32	413.02	2.89	-19.99	-60.7
11925	44 9.53	71 5.98	1309.91	411.14	2.78	-18.91	-60.8
11926	44 9.59	71 5.93	1314.94	411.13	2.67	-18.54	-60.7
11927	44 9.64	71 5.86	1342.57	409.89	2.48	-17.25	-60.6
11928	44 9.65	71 5.76	1359.25	409.13	2.29	-16.46	-60.5
11929	44 9.71	71 5.67	1361.20	409.27	2.09	-16.22	-60.6
119210	44 9.78	71 5.62	1366.12	409.34	1.90	-15.80	-60.5
119211	44 9.87	71 5.58	1380.85	409.00	1.82	-14.89	-60.2
119212	44 9.93	71 5.51	1423.64	407.07	1.74	-12.88	-59.7
119213	44 10.01	71 5.50	1443.54	406.36	1.65	-11.84	-59.4
119214	44 10.09	71 5.45	1446.65	406.75	1.57	-11.28	-59.0

Mt. Kearsarge Traverse

STATION	LAT		LONG		ELEV (FT)	OBSGRV	TC	FREE AIR	BOUG
	DEG	MIN	DEG	MIN					
722C	44	4.53	71	6.55	667.99	443.19	1.84	-37.85	-59.5
722C1	44	4.62	71	6.51	717.98	441.54	1.90	-36.82	-59.4
722C2	44	4.70	71	6.51	776.46	438.18	1.96	-34.79	-59.3
722C3	44	4.77	71	6.51	811.02	436.88	2.02	-32.95	-58.6
722C4	44	4.84	71	6.47	864.43	433.88	2.34	-31.03	-58.2
722C5	44	4.92	71	6.42	898.79	431.65	2.66	-30.14	-58.1
722C6	44	5.01	71	6.41	957.67	427.79	3.02	-28.60	-58.2
722C7	44	5.09	71	6.42	1018.23	423.31	3.36	-27.50	-58.9
722C8	44	5.15	71	6.43	1115.08	416.85	3.71	-24.94	-59.3
722C9	44	5.24	71	6.40	1235.52	409.61	3.84	-20.98	-59.3
722C10	44	5.31	71	6.37	1329.12	404.29	3.97	-17.60	-59.0
722C11	44	5.39	71	6.33	1425.21	399.09	4.10	-13.88	-58.4
722C12	44	5.46	71	6.29	1531.51	392.76	4.01	-10.32	-58.5
722C13	44	5.52	71	6.21	1634.83	385.96	3.92	-7.49	-59.3
722C14	44	5.57	71	6.12	1711.70	381.26	4.18	-5.03	-59.2
722C15	44	5.61	71	6.03	1797.18	375.84	4.43	-2.47	-59.3
722C16	44	5.67	71	6.07	1906.36	368.84	4.73	0.72	-59.6
722C17	44	5.75	71	6.07	2011.26	361.88	5.04	3.51	-60.0
722C18	44	5.82	71	6.07	2078.09	357.75	5.34	5.56	-60.0
722C20	44	5.97	71	6.04	2254.05	344.81	6.38	8.95	-61.5
722C21	44	6.05	71	6.06	2411.98	335.02	7.42	13.90	-60.9
722C22	44	6.12	71	6.10	2530.70	327.04	8.07	16.98	-61.3
722C23	44	6.18	71	6.14	2596.30	322.98	8.71	19.00	-60.8
722C24	44	6.25	71	6.16	2665.90	318.11	9.36	20.58	-61.0
722C25	44	6.32	71	6.08	2731.90	313.41	10.60	21.98	-60.6

STATION	LAT DEG MIN	LONG DEG MIN	ELEV (FT)	OBSGRV	TC	FREE AIR	BOUG
722026	44 6.35	71 5.97	2850.23	304.78	11.84	24.44	-60.9
722027	44 6.40	71 5.91	2950.58	296.83	14.02	25.86	-60.8
722028	44 6.43	71 5.82	3059.40	288.00	16.21	27.22	-60.9
722029	44 6.43	71 5.74	3150.15	280.34	19.01	28.10	-60.3
722030	44 6.38	71 5.70	3268.00	271.24	21.80	30.16	-59.5
2815	44 7.58	71 5.86	1705.39	384.74	2.43	-5.17	-60.9
2816	44 7.65	71 5.88	1617.37	390.18	2.35	-8.11	-60.9
2817	44 7.74	71 5.88	1502.13	397.44	2.28	-11.83	-60.8
2818	44 7.81	71 5.89	1420.00	402.62	2.20	-14.48	-60.7
2819	44 7.88	71 5.90	1357.52	406.39	2.13	-16.70	-60.9
2820	44 7.96	71 5.90	1315.64	409.06	2.05	-18.09	-60.9
2821	44 8.04	71 5.91	1235.96	413.36	2.04	-21.40	-61.5
2822	44 8.12	71 5.98	1277.70	411.16	2.03	-19.80	-61.3
2823	44 8.19	71 5.99	1311.98	408.00	2.02	-19.84	-62.6
2824	44 8.29	71 5.99	1325.32	407.83	2.01	-18.90	-62.1
2825	44 8.33	71 6.01	1234.66	413.13	2.03	-22.19	-62.3
2826	44 8.32	71 6.12	1186.81	415.55	2.05	-24.26	-62.7
2827	44 8.26	71 6.19	1146.27	418.02	2.08	-25.52	-62.5
2828	44 8.20	71 6.18	1102.57	420.74	2.10	-26.82	-62.3
2829	44 8.20	71 6.31	1059.33	423.13	2.11	-28.49	-62.5
2830	44 8.23	71 6.43	1034.53	424.61	2.10	-29.39	-62.6

Hurricane Mountain Road Traverse

STATION	LAT DEG MIN	LONG DEG MIN	ELEV (FT)	OBSGRV	TC	FREE AIR	BOUG
722WE	44 4.49	71 6.82	667.08	444.04	1.80	-38.91	-59.9
722WD	44 4.49	71 6.67	684.91	443.10	1.91	-38.17	-59.6
722WC	44 4.49	71 6.57	687.99	442.98	2.03	-38.00	-59.4
722WB	44 4.50	71 6.46	680.09	443.42	2.16	-38.32	-59.4
722WA	44 4.50	71 6.26	707.28	441.77	2.28	-37.41	-59.3
762BM 722	44 4.53	71 6.10	722.47	440.98	2.52	-36.82	-58.9
722B	44 4.51	71 5.99	756.33	439.03	2.87	-35.55	-58.5
722CC	44 4.48	71 5.90	794.22	436.94	2.84	-34.03	-58.3
722E	44 4.44	71 5.87	828.96	434.74	2.81	-32.90	-58.4
722G	44 4.39	71 5.78	885.19	431.12	2.75	-31.16	-58.6
722I	44 4.34	71 5.71	948.25	427.52	2.82	-28.75	-58.3
722J	44 4.30	71 5.65	977.27	425.82	2.86	-27.66	-58.1
722K	44 4.26	71 5.61	994.17	424.69	2.90	-27.14	-58.1
722L	44 4.23	71 5.51	1032.12	422.67	2.65	-25.54	-58.1
722M	44 4.23	71 5.43	1086.41	419.57	2.39	-23.53	-58.2
722N	44 4.24	71 5.35	1136.10	416.73	2.31	-21.72	-58.1
722C	44 4.21	71 5.32	1183.83	414.05	2.23	-20.01	-58.1
763BM 1259	44 4.23	71 5.20	1259.00	409.85	1.91	-17.02	-58.0
63910	44 4.23	71 3.12	1111.71	421.14	1.73	-19.58	-55.8
6399	44 4.26	71 3.06	1098.46	422.04	1.69	-19.98	-55.8
6398	44 4.31	71 2.96	1078.89	422.53	1.65	-21.40	-56.5
6397	44 4.30	71 2.85	1067.64	423.00	1.54	-21.98	-56.8
6396	44 4.24	71 2.75	1016.68	426.25	1.43	-23.58	-56.8
6395	44 4.36	71 2.63	981.35	428.61	1.45	-24.58	-56.6
6394	44 4.39	71 2.52	893.67	434.43	1.47	-27.05	-56.1

STATION	LAT DEG MIN	LONG DEG MIN	ELEV (FT)	OBSGRV	TC	FREE AIR	BOUG
6393	44 4.45	71 2.42	811.02	439.32	1.51	-29.53	-55.7
6392	44 4.52	71 2.36	768.62	442.46	1.58	-30.98	-55.6
6391	44 4.58	71 2.28	713.83	446.06	1.46	-32.63	-55.5
76528M639	44 4.64	71 2.20	638.95	450.79	1.47	-35.03	-55.4

Intervale North-South Traverse

STATION	LAT DEG MIN	LONG DEG MIN	ELEV (FT)	OBSGRV	TC	FREE AIR	BOUG
54056BM982	44 10.59	71 13.46	982.00	431.71	6.35	-30.79	-57.9
54054	44 10.40	71 13.41	981.33	432.28	6.16	-29.99	-57.3
54053	44 10.28	71 13.41	968.96	434.51	5.46	-28.75	-56.3
54052	44 10.18	71 13.37	971.80	435.25	4.80	-27.59	-55.9
54051	44 10.03	71 13.28	979.98	435.38	3.80	-26.46	-56.1
54050	44 9.56	71 13.26	964.33	436.67	3.63	-26.54	-55.8
54049	44 9.88	71 13.23	939.89	437.86	3.45	-27.53	-56.1
54048	44 9.76	71 13.01	905.38	440.50	3.27	-27.96	-55.6
54047	44 9.67	71 12.94	892.57	440.99	3.16	-28.54	-55.8
54046	44 9.61	71 12.84	881.73	441.60	3.06	-28.85	-55.9
54045	44 9.56	71 12.73	879.64	441.13	2.95	-29.45	-56.5
54044	44 9.49	71 12.66	881.59	440.73	2.84	-29.56	-56.8
54043	44 9.41	71 12.60	871.60	441.35	2.77	-29.76	-56.7
54042	44 9.35	71 12.49	882.29	440.63	2.70	-29.38	-56.8
54041	44 9.32	71 12.35	908.40	438.61	2.62	-28.90	-57.3
54040	44 9.33	71 12.26	911.23	438.28	2.55	-28.98	-57.5
54039	44 9.34	71 12.13	914.37	437.69	2.48	-29.29	-58.0
54038	44 9.31	71 12.02	910.64	438.18	2.46	-29.10	-57.7
54037	44 9.25	71 11.95	879.94	440.14	2.43	-29.94	-57.5
54036	44 9.19	71 11.86	856.32	441.53	2.41	-30.68	-57.5
54035	44 9.12	71 11.81	851.76	441.49	2.38	-31.05	-57.7
54033	44 9.05	71 11.78	824.01	442.36	2.36	-32.68	-58.4
54032	44 8.56	71 11.70	808.09	443.21	2.34	-33.20	-58.4
54031	44 8.51	71 11.61	811.58	442.85	2.33	-33.15	-58.5
54030	44 8.86	71 11.53	798.00	443.37	2.32	-33.83	-58.7

STATION	LAT DEG MIN	LONG DEG MIN	ELEV (FT)	OBSGRV	TC	FREE AIR	BOUG
54029	44 8.81	71 11.41	778.98	444.00	2.30	-34.92	-59.2
54028	44 8.76	71 11.34	766.64	444.61	2.29	-35.40	-59.3
54027	44 8.66	71 11.27	764.99	444.42	2.26	-35.59	-59.4
54026	44 8.56	71 11.33	759.53	444.18	2.22	-36.19	-59.9
54025	44 8.48	71 11.27	756.61	443.58	2.19	-36.95	-60.6
54024	44 8.39	71 11.28	751.90	443.09	2.15	-37.75	-61.2
54023	44 8.29	71 11.32	740.60	442.97	2.14	-38.78	-61.9
54022	44 8.19	71 11.35	744.55	442.15	2.12	-39.08	-62.3
54021	44 8.11	71 11.33	733.72	442.40	2.11	-39.72	-62.6
54020	44 8.03	71 11.31	728.97	442.26	2.10	-40.19	-62.9
54019	44 7.94	71 11.29	726.40	442.13	2.09	-40.43	-63.1
54018	44 7.85	71 11.30	731.63	441.86	2.07	-40.07	-62.9
54017	44 7.77	71 11.34	736.27	441.41	2.05	-39.96	-63.0
54016	44 7.70	71 11.36	730.72	441.41	2.02	-40.38	-63.3
54015	44 7.62	71 11.40	701.40	442.99	2.00	-41.44	-63.4
54014	44 7.51	71 11.37	701.26	442.90	1.98	-41.38	-63.3
54013	44 7.42	71 11.33	693.58	443.04	1.99	-41.82	-63.5
54012	44 7.34	71 11.29	662.17	444.86	2.00	-42.84	-63.4
54011	44 7.26	71 11.24	631.36	446.55	2.02	-43.93	-63.4
54010	44 7.17	71 11.19	622.37	447.45	2.03	-43.74	-62.9
5409	44 7.08	71 11.13	614.95	447.77	1.95	-43.98	-63.0
5408	44 6.98	71 11.07	611.20	447.96	1.87	-43.99	-63.0
5407	44 6.90	71 11.03	608.25	448.18	1.78	-43.93	-62.9
5406	44 6.82	71 10.98	603.46	448.33	1.70	-44.11	-63.0
5405	44 6.76	71 10.90	598.00	448.61	1.69	-44.25	-63.0

STATION	LAT DEG MIN	LONG DEG MIN	ELEV (FT)	OBSGRV	TC	FREE AIR	BOUG
5404	44 6.69	71 10.81	589.29	449.06	1.67	-44.52	-62.9
5402	44 6.62	71 10.88	557.10	450.74	1.66	-45.76	-63.1
7684BM540	44 6.53	71 11.01	540.43	451.58	1.64	-46.35	-63.1
52914	44 6.54	71 10.85	539.37	451.82	1.63	-46.18	-63.0
52913	44 6.51	71 10.75	536.07	452.01	1.64	-46.30	-62.9
52912	44 6.47	71 10.65	532.97	452.03	1.65	-46.52	-63.0
52911	44 6.42	71 10.55	530.94	451.99	1.66	-46.67	-63.1
52910	44 6.38	71 10.47	529.10	451.78	1.71	-46.99	-63.3
5299	44 6.33	71 10.37	526.54	452.01	1.77	-46.93	-63.1
5298	44 6.27	71 10.28	523.89	451.93	1.82	-47.17	-63.2
5297	44 6.21	71 10.20	521.45	451.94	1.88	-47.30	-63.2
5296	44 6.16	71 10.13	519.12	451.90	1.86	-47.48	-63.3
5295	44 6.10	71 10.04	522.29	452.01	1.84	-46.98	-63.0
5294	44 6.07	71 9.93	521.88	452.20	1.81	-46.79	-62.8
5293	44 6.05	71 9.82	522.02	452.29	1.79	-46.66	-62.7
5292	44 6.01	71 9.72	526.22	452.23	1.72	-46.26	-62.5
5291	44 5.57	71 9.63	532.10	451.75	1.65	-46.13	-62.6
7694BM529	44 5.89	71 9.58	528.90	451.71	1.58	-46.35	-62.8
54720	44 5.87	71 9.62	532.73	451.37	1.51	-46.30	-63.0
54719	44 5.80	71 9.55	529.64	451.26	1.49	-46.59	-63.2
54718	44 5.73	71 9.47	527.61	451.16	1.48	-46.78	-63.3
54717	44 5.66	71 9.40	524.52	451.40	1.47	-46.72	-63.1
54716	44 5.58	71 9.33	521.74	451.51	1.46	-46.75	-63.1
54715	44 5.51	71 9.26	518.97	451.78	1.43	-46.64	-62.9
54714	44 5.44	71 9.18	514.33	452.06	1.44	-46.69	-62.8

STATION	LAT		LONG		ELEV (FT)	OBSGRV	TC	155	
	DEG	MIN	DEG	MIN				FREE AIR	BOUG
54713	44	5.38	71	9.10	509.36	452.27	1.45	-46.86	-62.8
54712	44	5.31	71	9.04	506.28	452.46	1.46	-46.85	-62.7
54711	44	5.23	71	8.97	503.85	452.55	1.46	-46.87	-62.6
54710	44	5.16	71	8.92	501.68	452.74	1.47	-46.78	-62.4
5479	44	5.09	71	8.86	500.19	452.91	1.44	-46.64	-62.3
5478	44	5.02	71	8.79	499.94	453.02	1.41	-46.45	-62.1
5477	44	4.95	71	8.71	503.42	452.75	1.38	-46.29	-62.1
5476	44	4.88	71	8.63	509.18	452.62	1.34	-45.77	-61.8
5475	44	4.82	71	8.57	516.53	452.22	1.31	-45.39	-61.7
5474	44	4.75	71	8.50	523.46	451.89	1.28	-44.96	-61.5
5473	44	4.68	71	8.44	530.14	451.36	1.26	-44.76	-61.6
5472	44	4.60	71	8.37	537.13	451.31	1.23	-44.03	-61.1
5471	44	4.53	71	8.30	542.39	451.13	1.28	-43.61	-60.8
760BJ7	44	4.45	71	8.22	548.58	450.81	1.17	-43.23	-60.8
5472S	44	4.36	71	8.21	544.59	450.63	1.15	-43.65	-61.1
5473S	44	4.28	71	8.11	543.35	450.83	1.13	-43.45	-60.8
5474S	44	4.20	71	8.06	543.60	451.08	1.11	-43.05	-60.5
5475S	44	4.12	71	8.02	543.42	451.42	1.09	-42.61	-60.0
5476S	44	4.05	71	7.98	541.36	451.64	1.08	-42.48	-59.9
5477S	44	3.97	71	7.93	539.52	451.69	1.06	-42.48	-59.8
5478S	44	3.90	71	7.89	537.70	451.69	1.04	-42.55	-59.8
54710S	44	3.82	71	7.89	535.10	451.75	1.04	-42.61	-59.8
54711S	44	3.74	71	7.91	533.29	451.83	1.01	-42.58	-59.8
54712S	44	3.66	71	7.91	531.61	452.02	0.99	-42.43	-59.6
54713S	44	3.57	71	7.92	529.66	452.21	0.95	-42.29	-59.4

STATION	LAT DEG MIN	LONG DEG MIN	ELEV (FT)	OBSGRV	TC	FREE AIR	BOUG
54714S	44 3.49	71 7.92	527.43	452.43	0.93	-42.16	-59.2
54715S	44 3.42	71 7.94	525.89	452.57	0.91	-42.06	-59.1
54717S	44 3.34	71 7.91	524.22	452.40	0.89	-42.26	-59.3
54719S	44 3.26	71 7.89	521.63	452.63	0.87	-42.16	-59.1
54721S	44 3.17	71 7.85	519.51	452.86	0.86	-41.99	-58.8
54724S	44 3.10	71 7.84	518.52	452.94	0.85	-41.90	-58.7
54725S	44 3.02	71 7.81	517.12	452.82	0.85	-42.03	-58.8
54727S	44 2.94	71 7.78	507.15	453.09	0.85	-42.58	-59.0
54729S	44 2.86	71 7.76	499.45	453.69	0.85	-42.58	-58.8
54731S	44 2.79	71 7.73	490.95	454.33	0.84	-42.64	-58.5
54733S	44 2.71	71 7.70	484.75	454.66	0.84	-42.77	-58.5
54735S	44 2.63	71 7.68	480.11	454.87	0.84	-42.87	-58.4
54736S	44 2.56	71 7.65	477.16	455.12	0.84	-42.80	-58.2
54737S	44 2.48	71 7.63	473.53	455.33	0.85	-42.81	-58.1
54738S	44 2.40	71 7.60	472.72	455.26	0.86	-42.83	-58.1
54739S	44 2.33	71 7.57	472.48	455.11	0.86	-42.90	-58.2
54740S	44 2.25	71 7.54	472.39	455.24	0.87	-42.66	-57.9
54741S	44 2.17	71 7.51	472.09	455.24	0.84	-42.57	-57.8
54742S	44 2.09	71 7.48	472.63	455.35	0.82	-42.29	-57.6
54744S	44 2.01	71 7.46	478.21	455.02	0.79	-41.97	-57.5
54746S	44 1.93	71 7.43	484.61	454.55	0.77	-41.72	-57.5
54747S	44 1.85	71 7.20	486.79	454.46	0.74	-41.48	-57.3
54748S	44 1.77	71 7.38	487.20	454.45	0.73	-41.33	-57.2
54749S	44 1.69	71 7.35	486.35	454.54	0.71	-41.20	-57.1
54750S	44 1.61	71 7.32	486.63	454.49	0.69	-41.11	-57.0

STATION	LAT DEG MIN	LONG DEG MIN	ELEV (FT)	OBSGRV	TC	FREE AIR	BOUG
54751 S	44 1.53	71 7.29	483.83	454.37	0.67	-41.37	-57.2
54752 S	44 1.45	71 7.27	481.09	454.53	0.64	-41.35	-57.1
54753 S	44 1.37	71 7.24	478.61	454.71	0.62	-41.28	-57.0
54754 S	44 1.20	71 7.30	475.78	454.92	0.61	-41.23	-56.8
54755 S	44 1.23	71 7.37	474.11	455.16	0.60	-41.04	-56.6
54756 S	44 1.16	71 7.43	471.88	454.94	0.59	-41.37	-56.9
54757 S	44 1.12	71 7.47	470.82	454.90	0.58	-41.45	-56.9
54758 SBM469	44 1.08	71 7.47	469.01	455.04	0.57	-41.42	-56.8
4692	44 1.00	71 7.53	467.06	455.20	0.57	-41.32	-56.7
4693	44 0.93	71 7.59	465.04	455.45	0.57	-41.16	-56.4
4694	44 0.86	71 7.64	464.72	455.40	0.57	-41.13	-56.4
4695	44 0.79	71 7.70	464.25	455.35	0.57	-41.12	-56.4
4696	44 0.71	71 7.76	463.93	455.48	0.58	-40.90	-56.1
4697	44 0.64	71 7.81	464.13	455.62	0.58	-40.64	-55.9
4698	44 0.57	71 7.86	464.53	456.04	0.59	-40.07	-55.3
4699	44 0.50	71 7.91	466.43	456.17	0.59	-39.66	-55.0
46911	44 0.41	71 7.94	474.91	455.83	0.60	-39.07	-54.7
46913	44 0.33	71 7.92	481.74	455.66	0.60	-38.47	-54.3
46915	44 0.24	71 7.90	484.79	455.57	0.61	-38.14	-54.1
46916	44 0.16	71 7.88	486.64	455.50	0.63	-37.92	-53.9
46917	44 0.08	71 7.86	488.66	455.54	0.65	-37.57	-53.6
46918	44 0.0	71 7.84	490.73	455.65	0.67	-37.14	-53.2
46919	43 59.53	71 7.82	492.68	455.93	0.61	-36.57	-52.8
46920	43 59.85	71 7.80	494.73	456.32	0.56	-35.87	-52.2
46921	43 59.77	71 7.78	494.76	456.08	0.50	-35.99	-52.4

STATION	LAT DEG MIN	LONG DEG MIN	ELEV (FT)	OBSGRV	TC	FREE AIR	BOUG
46922	43 59.69	71 7.77	489.75	456.07	0.45	-36.35	-52.6
46924	43 59.60	71 7.76	483.48	456.07	0.44	-36.80	-52.8
46926	43 59.51	71 7.73	476.80	456.22	0.44	-37.14	-53.0
46928	43 59.42	71 7.71	469.95	456.56	0.42	-37.31	-52.9
46930	43 59.34	71 7.69	464.45	457.11	0.41	-37.16	-52.6
46932	43 59.25	71 7.68	461.63	457.39	0.40	-37.01	-52.4
46933	43 59.17	71 7.66	463.81	457.18	0.39	-36.90	-52.3
46934	43 59.08	71 7.64	466.56	456.75	0.37	-36.93	-52.5
76212BM461	43 59.13	71 7.64	460.99	456.95	0.38	-37.33	-52.7
4612	43 59.04	71 7.63	466.62	456.54	0.37	-37.08	-52.6
4613	43 58.98	71 7.61	463.32	456.63	0.37	-37.21	-52.6
4614	43 58.95	71 7.62	462.35	456.66	0.37	-37.22	-52.6
4615	43 58.89	71 7.60	461.89	456.69	0.35	-37.13	-52.5
4616	43 58.81	71 7.59	464.68	456.44	0.34	-37.01	-52.5
4617	43 58.71	71 7.57	466.60	456.32	0.33	-36.80	-52.4
4618	43 58.71	71 7.48	465.98	456.46	0.32	-36.72	-52.3
46110	43 58.71	71 7.32	464.68	456.92	0.31	-36.38	-51.9
46111	43 58.71	71 7.21	465.29	457.21	0.31	-36.03	-51.6
46112	43 58.63	71 7.08	463.29	457.12	0.30	-36.19	-51.7
46113	43 58.54	71 7.07	465.28	457.03	0.30	-35.96	-51.5
46114	43 58.47	71 7.05	468.07	457.05	0.29	-35.57	-51.3
46115	43 58.38	71 7.04	467.58	457.35	0.29	-35.18	-50.8
46116	43 58.20	71 7.02	466.01	457.77	0.29	-34.79	-50.4
46118	43 58.15	71 7.00	484.28	456.86	0.29	-33.76	-50.0
46120	43 57.55	71 6.99	522.02	454.60	0.31	-32.22	-49.7

STATION	LAT DEG MIN	LONG DEG MIN	ELEV (FT)	OBSGRV	TC	FREE AIR	BOUG
46121	43 57.51	71 7.02	544.89	453.17	0.31	-31.38	-49.7
46122	43 57.82	71 7.05	544.18	453.17	0.32	-31.33	-49.6
46123	43 57.74	71 7.07	544.68	453.20	0.32	-31.12	-49.4
46124	43 57.61	71 7.07	553.01	453.05	0.36	-30.29	-48.8
46125	43 57.57	71 7.05	570.05	452.14	0.40	-29.53	-48.6
46126	43 57.49	71 7.06	579.81	451.67	0.44	-28.97	-48.3
46127	43 57.41	71 7.06	611.05	449.75	0.49	-27.83	-48.2
46128	43 57.33	71 7.07	630.18	448.52	0.53	-27.13	-48.1
46129	43 57.24	71 7.07	660.63	446.59	0.57	-26.06	-48.0
46130	43 57.15	71 7.07	703.01	444.11	0.54	-24.42	-47.9
46131	43 57.06	71 7.07	747.57	441.50	0.51	-22.70	-47.7
46132	43 56.98	71 7.07	778.43	439.36	0.48	-21.82	-47.9
46133	43 56.90	71 7.09	788.85	438.67	0.45	-21.41	-47.9
46134	43 56.82	71 7.08	773.28	439.57	0.43	-21.85	-47.8
46135	43 56.76	71 7.09	753.09	441.17	0.40	-22.06	-47.3
46136	43 56.72	71 7.06	732.88	442.51	0.38	-22.56	-47.2
46137	43 56.65	71 7.00	709.80	444.34	0.36	-22.80	-46.6
46138	43 56.58	71 6.93	706.63	444.84	0.34	-22.49	-46.3
46139	43 56.55	71 6.90	688.56	446.17	0.32	-22.82	-46.0
46140	43 56.51	71 6.81	672.46	447.17	0.30	-23.27	-45.9
46141	43 56.48	71 6.72	675.49	447.08	0.28	-23.03	-45.8
46142	43 56.43	71 6.67	685.84	446.61	0.26	-22.45	-45.6
46143	43 56.36	71 6.62	667.57	447.88	0.26	-22.80	-45.3
46144	43 56.29	71 6.59	681.95	446.98	0.25	-22.24	-45.3
46145	43 56.24	71 6.49	700.23	445.98	0.24	-21.45	-45.1

STATION	LAT DEG MIN	LONG DEG MIN	ELEV (FT)	OBSGRV	TC	FREE AIR	BOUG
46147	43 56.22	71 6.37	685.21	446.99	0.24	-21.82	-44.9
46149	43 56.10	71 6.32	699.31	446.21	0.39	-21.09	-44.5
46150	43 56.04	71 6.32	740.33	443.79	0.55	-19.56	-44.3
46151	43 56.00	71 6.42	772.68	441.44	0.70	-18.81	-44.5
46152	43 55.55	71 6.51	822.34	438.37	0.85	-17.13	-44.3
46153	43 55.50	71 6.59	853.51	436.49	0.82	-16.00	-44.3
46154	43 55.44	71 6.67	861.56	436.19	0.83	-15.45	-44.0
46155	43 55.40	71 6.76	851.76	436.70	0.86	-15.81	-44.0
46156	43 55.32	71 6.76	872.54	435.41	0.85	-15.02	-43.9
46157	43 55.64	71 6.76	903.83	433.61	0.83	-13.75	-43.8
46158	43 55.55	71 6.76	947.94	431.20	0.84	-11.88	-43.4
46159	43 55.47	71 6.76	994.55	428.41	0.84	-10.16	-43.2
46160	43 55.38	71 6.76	1049.73	425.20	0.79	-8.05	-43.1
46161	43 55.29	71 6.75	1087.47	423.26	0.74	-6.30	-42.6
46162	43 55.20	71 6.74	1090.93	423.11	0.64	-5.99	-42.6
46163	43 55.12	71 6.73	1094.30	422.81	0.54	-5.85	-42.6
46164	43 55.04	71 6.73	1062.68	424.89	0.55	-6.63	-42.3
46165	43 54.96	71 6.73	1049.24	425.33	0.56	-7.33	-42.6
46166	43 54.88	71 6.72	1024.10	426.86	0.56	-8.05	-42.4
46167	43 54.80	71 6.72	990.08	429.72	0.57	-8.27	-41.5
46168	43 54.72	71 6.71	961.89	431.67	0.58	-8.85	-41.1
46169	43 54.64	71 6.71	961.59	431.55	0.45	-8.88	-41.2
46170	43 54.56	71 6.71	1010.94	428.51	0.51	-7.15	-41.1
46171	43 54.48	71 6.71	1034.79	426.89	0.55	-6.41	-41.1
46172	43 54.39	71 6.71	1057.31	425.58	0.59	-5.46	-40.9
46173	43 54.38	71 6.72	1096.80	423.26	0.63	-4.05	-40.8

Moat Mountain Traverse

STATION	LAT DEG MIN	LCNG DEG MIN	ELEV (FT)	OBSGRV	TC	FREE AIR	BOUG
557CORN	44 4.62	71 10.06	557.00	448.67	1.75	-44.83	-62.1
5571	44 4.57	71 9.96	556.25	448.74	1.65	-44.76	-62.1
5572	44 4.49	71 9.87	548.85	449.06	1.57	-45.01	-62.2
5573	44 4.43	71 9.79	552.95	448.58	1.47	-45.02	-62.4
5574	44 4.36	71 9.74	549.37	448.83	1.40	-45.00	-62.3
5575	44 4.33	71 9.87	551.15	449.09	1.57	-44.53	-61.8
5576	44 4.30	71 9.97	578.75	447.54	1.72	-43.44	-61.4
5577	44 4.29	71 10.09	557.46	448.69	1.93	-44.27	-61.4
5578	44 4.31	71 10.19	574.05	447.85	1.96	-43.58	-61.2
5579	44 4.34	71 10.29	603.94	446.16	1.93	-42.51	-61.2
55710	44 4.36	71 10.37	645.76	443.59	1.92	-41.17	-61.3
55711	44 4.28	71 10.38	682.23	441.56	1.79	-39.65	-61.1
55712	44 4.21	71 10.43	711.79	439.63	1.69	-38.69	-61.3
55713	44 4.19	71 10.53	724.98	438.44	1.62	-38.61	-61.7
55714	44 4.13	71 10.61	734.08	437.82	1.66	-38.29	-61.7
55715	44 4.06	71 10.68	746.68	437.50	1.67	-37.31	-61.1
88913	44 4.00	71 10.72	776.17	436.04	1.69	-35.91	-60.7
88912	44 3.90	71 10.70	792.36	435.09	1.72	-35.18	-60.5
88911	44 3.82	71 10.74	839.28	432.11	1.73	-33.63	-60.5
88910	44 3.74	71 10.74	855.48	431.09	1.80	-33.01	-60.4
8899	44 3.66	71 10.73	877.48	429.61	1.88	-32.30	-60.3
8898	44 3.58	71 10.74	916.33	427.14	1.96	-30.99	-60.3
3897	44 3.45	71 10.75	946.16	425.35	1.95	-29.84	-60.2
3895	44 3.41	71 10.77	970.61	424.28	1.97	-28.49	-59.6
3894	44 3.35	71 10.83	947.38	425.83	2.03	-29.03	-59.3

STATION	LA1 DEG MIN	LCNG DEG MIN	ELEV (FT)	OBSGRV	TC	FREE AIR	BOUG
8893	44 3.30	71 10.92	932.99	426.85	2.16	-29.29	-58.9
8892	44 3.24	71 11.02	925.87	427.25	2.27	-29.47	-58.8
8891	44 3.17	71 11.09	892.27	429.10	2.42	-30.68	-58.7
88914	44 3.10	71 11.24	884.87	429.23	2.70	-31.14	-58.6
88915	44 3.02	71 11.27	871.50	429.82	2.99	-31.69	-58.4
88916	44 2.53	71 11.27	876.16	429.32	3.26	-31.61	-58.2
88917CORN	44 2.86	71 11.24	876.19	429.34	3.54	-31.48	-57.8
3582	44 2.87	71 11.36	921.08	426.27	3.83	-30.34	-57.9
3583	44 2.88	71 11.47	984.01	422.27	4.11	-28.44	-57.9
3584	44 2.88	71 11.58	1047.32	418.15	4.44	-26.60	-57.9
3585	44 2.87	71 11.71	1131.41	412.84	4.91	-23.98	-57.7
3586	44 2.84	71 11.75	1232.06	406.36	5.26	-20.95	-57.7
3587	44 2.78	71 11.79	1390.00	396.60	5.69	-15.76	-57.5
3588	44 2.75	71 11.79	1518.79	388.61	6.17	-11.59	-57.2
3589	44 2.69	71 11.76	1612.65	382.00	6.41	-9.27	-57.9
35810	44 2.62	71 11.78	1726.73	373.96	6.69	-6.48	-58.7
35811	44 2.59	71 11.87	1835.97	367.98	7.37	-2.13	-57.4
35812	44 2.50	71 11.90	1927.39	364.06	7.05	2.69	-56.0
35813	44 2.47	71 12.00	1965.39	362.44	6.67	4.69	-55.7
35814	44 2.36	71 12.07	2199.47	345.85	7.45	10.29	-57.3
35815	44 2.30	71 12.16	2332.91	337.17	8.07	14.25	-57.3
35816	44 2.22	71 12.23	2475.54	328.09	8.63	18.71	-57.1
35817	44 2.16	71 12.27	2591.17	319.71	9.71	21.30	-57.4
35818	44 2.10	71 12.34	2653.86	315.95	9.45	23.53	-57.5
35819	44 2.02	71 12.41	2763.14	307.75	10.73	25.73	-57.8

STATION	LAT		LONG		ELEV (FT)	OBSGRV	TC	164 FREE AIR BOUG	
	DEG	MIN	DEG	MIN					
35820	44	2.04	71	12.51	2694.57	314.98	8.85	26.48	-56.6
35821	44	2.06	71	12.61	2653.13	319.01	7.13	26.58	-56.8
35822	44	2.03	71	12.72	2618.92	321.74	6.41	26.14	-56.8
35823	44	2.01	71	12.84	2542.69	327.45	5.69	24.71	-56.3
35824	44	1.98	71	12.93	2462.30	333.69	4.97	23.43	-55.6
35833	44	1.85	71	13.77	1618.01	386.93	3.98	-2.58	-53.8
35834	44	1.79	71	13.86	1543.26	391.15	3.81	-5.30	-54.1
113144	44	1.73	71	13.92	1486.66	394.04	3.64	-7.64	-54.7
113143	44	1.67	71	13.99	1440.78	396.70	3.47	-9.21	-54.9
113142	44	1.60	71	14.05	1393.80	399.54	3.45	-10.69	-54.8
113141	44	1.53	71	14.07	1340.01	402.58	3.45	-12.60	-54.9
113140	44	1.46	71	14.11	1301.95	404.95	3.45	-13.71	-54.7
113139	44	1.37	71	14.12	1258.60	407.36	3.51	-15.24	-54.7
113138	44	1.32	71	14.19	1199.74	410.76	3.61	-17.30	-54.6
113137	44	1.27	71	14.23	1150.82	413.43	3.69	-19.16	-54.7
113136	44	1.23	71	14.32	1111.89	415.95	3.72	-20.25	-54.4
113135	44	1.18	71	14.38	1079.94	418.53	3.76	-20.60	-53.7
113134	44	1.13	71	14.43	1048.04	420.39	3.78	-21.66	-53.6
113130	44	0.99	71	14.61	957.50	425.93	3.36	-24.43	-53.7
113127	44	0.95	71	14.72	950.81	426.44	2.86	-24.49	-54.1
113126	44	1.01	71	14.80	968.22	425.09	3.28	-24.29	-54.0
113123	44	0.98	71	15.13	993.91	422.40	3.36	-24.52	-55.1
113122	44	0.91	71	15.22	1004.92	421.25	3.18	-24.53	-55.6
113121	44	0.87	71	15.33	1014.52	420.47	3.00	-24.35	-55.9
113120	44	0.86	71	15.44	1029.37	419.49	2.86	-23.91	-56.2

STATION	LAT DEG MIN	LONG DEG MIN	ELEV (FT)	OBSGRV	TC	FREE AIR	BOUG
113119	44 0.61	71 15.48	1031.83	419.23	2.76	-23.87	-56.3
113118	44 0.74	71 15.53	1034.75	419.03	2.63	-23.69	-56.3
113117	44 0.74	71 15.65	1038.70	418.82	2.60	-23.52	-56.3
113115	44 0.68	71 15.75	1045.06	418.41	2.57	-23.25	-56.3
113113	44 0.67	71 15.85	1048.53	418.31	2.55	-23.00	-56.2
113112	44 0.64	71 15.96	1052.56	417.81	2.53	-23.08	-56.4
113111	44 0.62	71 16.08	1066.29	416.75	2.57	-22.82	-56.6
113110	44 0.55	71 16.15	1071.06	416.76	2.54	-22.25	-56.2
11319	44 0.50	71 16.24	1074.53	416.62	2.50	-21.99	-56.1
11318	44 0.45	71 16.34	1078.82	416.10	2.46	-22.03	-56.4
11317	44 0.43	71 16.45	1086.90	415.69	2.26	-21.65	-56.5
11316	44 0.40	71 16.56	1091.07	415.57	2.30	-21.34	-56.3
11315	44 0.38	71 16.60	1093.36	415.53	2.22	-21.13	-56.2
11314	44 0.33	71 16.65	1109.02	414.71	2.09	-20.40	-56.1
11313	44 0.25	71 16.65	1127.08	413.89	1.95	-19.40	-55.9
11312	44 0.15	71 16.65	1121.90	414.46	1.83	-19.17	-55.6
11311	44 0.07	71 16.66	1129.90	414.26	1.71	-18.50	-55.3

Black Cap Traverse

STATION	LAT DEG MIN	LCNG DEG MIN	ELEV (FT)	OBSGRV	TC	FREE AIR	BOUG
76546M+94	44 2.69	71 7.36	494.49	452.95	1.09	-43.53	-59.3
4941	44 2.71	71 7.25	464.73	455.39	1.14	-43.92	-58.6
+942	44 2.73	71 7.14	465.41	455.28	1.15	-44.00	-58.7
4943	44 2.76	71 7.03	474.39	454.87	1.17	-43.61	-58.6
4944	44 2.75	71 6.95	491.65	453.73	1.14	-43.11	-58.7
4945	44 2.71	71 6.87	506.00	452.84	1.17	-42.59	-58.7
4946	44 2.70	71 6.76	501.82	453.17	1.30	-42.64	-58.4
4947	44 2.70	71 6.64	514.72	452.28	1.43	-42.31	-58.4
4948	44 2.74	71 6.53	528.83	451.24	1.55	-42.09	-58.6
4949	44 2.82	71 6.53	539.54	450.67	1.64	-41.77	-58.5
49410	44 2.89	71 6.54	553.79	449.82	1.78	-41.38	-58.5
49411	44 2.94	71 6.44	599.07	447.18	1.93	-39.84	-58.3
49412	44 2.94	71 6.29	649.96	443.94	2.15	-38.29	-58.3
49413	44 2.96	71 6.19	697.86	441.20	2.36	-36.55	-58.0
49414	44 2.94	71 6.02	747.35	438.69	2.39	-34.38	-57.5
49415	44 2.98	71 5.98	793.81	435.63	2.45	-33.12	-57.8
49416	44 3.04	71 5.87	892.98	429.68	2.39	-29.83	-57.9
49417	44 3.11	71 5.86	857.60	431.72	2.38	-31.23	-58.1
49418	44 3.16	71 5.83	952.25	426.42	2.47	-27.70	-57.7
49419	44 3.18	71 5.72	985.77	424.39	2.57	-26.60	-57.7
49420	44 3.14	71 5.62	999.26	423.68	2.51	-25.98	-57.6
49421	44 3.15	71 5.49	1074.49	419.55	2.51	-23.05	-57.2
49422	44 3.18	71 5.40	1135.68	415.91	2.52	-20.98	-57.2
49423	44 3.22	71 5.30	1196.42	412.47	2.53	-18.77	-57.0
49424	44 3.21	71 5.19	1222.54	411.61	2.61	-17.15	-56.2

STATION	LAT DEG MIN	LONG DEG MIN	ELEV (FT)	OBSGRV	TC	FREE AIR	BOUG
49425	44 3.21	71 5.06	1255.11	409.57	2.72	-16.13	-56.2
49426	44 3.20	71 4.95	1276.69	408.31	3.12	-15.34	-55.8
49427	44 3.19	71 4.93	1334.15	404.94	3.57	-13.29	-55.2
49428	44 3.26	71 4.95	1418.73	399.58	3.04	-10.80	-56.1
49429	44 3.30	71 5.05	1489.88	395.08	3.02	-8.66	-56.5
49430	44 3.32	71 5.16	1525.88	392.82	2.95	-7.57	-56.7
49431	44 3.38	71 5.26	1526.03	392.90	2.77	-7.56	-56.8
49432	44 3.42	71 5.36	1501.03	394.24	2.83	-8.63	-57.0
49433	44 3.45	71 5.45	1572.51	389.69	3.16	-6.50	-57.0
49434	44 3.52	71 5.50	1612.56	386.67	3.42	-5.86	-57.4
49435	44 3.55	71 5.45	1667.25	382.68	3.49	-4.75	-58.1
49436	44 3.56	71 5.35	1713.09	380.12	3.59	-3.01	-57.8
49437	44 3.58	71 5.30	1720.68	379.71	3.61	-2.72	-57.8
49438	44 3.58	71 5.18	1735.42	379.19	3.64	-1.87	-57.4
49439	44 3.54	71 5.06	1782.00	376.14	3.79	-0.48	-57.5
49440	44 3.53	71 4.94	1827.74	373.38	4.01	1.08	-57.3
49441	44 3.56	71 4.85	1856.41	371.68	4.15	2.03	-57.1
49442	44 3.58	71 4.74	1899.70	368.80	4.36	3.19	-57.2
49443	44 3.61	71 4.63	1963.92	365.03	4.70	5.42	-56.9
49444	44 3.60	71 4.50	1996.08	363.46	4.97	6.89	-56.2
49445	44 3.59	71 4.41	2033.30	360.97	5.33	7.92	-56.1
49446	44 3.54	71 4.34	2076.06	358.26	5.87	9.31	-55.6
49447	44 3.50	71 4.26	2168.16	351.46	6.63	11.24	-56.1
49448	44 3.45	71 4.14	2322.51	339.75	7.73	14.12	-57.4
49449	44 3.42	71 4.08	2359.28	337.14	8.79	15.02	-56.7

STATION	LAT		LONG		ELEV (FT)	OBSGRV	TC	169	
	DEG	MIN	DEG	MIN				FREE AIR	BOUG
49450	44	3.41	71	4.01	2322.15	339.41	9.46	13.81	-55.9
49451	44	3.33	71	3.95	2198.90	349.32	7.75	12.24	-55.0
49452	44	3.28	71	3.88	2148.68	352.55	6.29	10.82	-56.2
49453	44	3.24	71	3.78	2142.54	352.69	6.19	10.45	-56.4
49454	44	3.17	71	3.72	2062.83	358.85	5.79	9.21	-55.3
49455	44	3.10	71	3.69	2017.14	362.45	5.39	8.62	-54.8
49456	44	3.04	71	3.61	1955.48	366.27	5.33	6.73	-54.6
49457	44	2.58	71	3.53	1877.47	371.69	5.23	4.90	-53.9
49458	44	2.54	71	3.46	1821.91	376.30	4.92	4.34	-52.9
49459	44	2.52	71	3.40	1680.32	386.11	4.33	0.86	-52.1
49460	44	2.86	71	3.32	1578.76	392.55	3.94	-2.17	-52.1
49462	44	2.84	71	3.24	1472.91	399.25	3.59	-5.40	-52.0
49463	44	2.87	71	3.13	1377.26	405.22	3.15	-8.47	-52.3
49464	44	2.84	71	3.03	1298.45	410.73	2.91	-10.33	-51.7
49465	44	2.78	71	2.96	1217.69	415.42	2.74	-13.15	-51.9
49466	44	2.73	71	2.85	1123.47	421.21	2.46	-16.15	-52.0
49467	44	2.70	71	2.74	1010.13	428.54	2.29	-19.44	-51.6
49468	44	2.69	71	2.64	910.19	435.03	2.21	-22.34	-51.2
49469	44	2.62	71	2.52	853.37	438.67	2.17	-23.94	-50.9
49470	44	2.58	71	2.41	805.70	441.66	2.14	-25.38	-50.7
49471	44	2.54	71	2.31	788.50	442.86	1.81	-25.73	-50.8
49472	44	2.50	71	2.21	765.05	444.57	1.62	-26.17	-50.6
49473	44	2.46	71	2.08	717.79	447.51	1.41	-27.62	-50.7
49474	44	2.42	71	1.98	655.60	450.27	1.17	-30.65	-51.8
49475	44	2.45	71	1.87	631.56	452.11	1.16	-31.11	-51.5

STATION	LAT DEG MIN	LONG DEG MIN	ELEV (FT)	OBSGRV	TC	FREE AIR	BOUG
49476	44 2.37	71 1.86	622.87	452.23	1.08	-31.64	-51.3
49477	44 2.28	71 1.86	605.17	453.10	1.02	-32.35	-52.0
49478	44 2.19	71 1.82	570.25	455.20	0.92	-33.40	-51.9
49479	44 2.12	71 1.82	543.57	456.91	0.86	-34.10	-51.8
49480	44 2.05	71 1.72	511.44	459.09	0.81	-34.84	-51.5
49481	44 1.95	71 1.63	477.54	461.31	0.84	-35.65	-51.1
49482	44 1.94	71 1.52	461.70	462.55	0.76	-35.89	-50.9
49483	44 1.87	71 1.43	452.21	463.00	0.68	-36.23	-51.0
49484	44 1.83	71 1.33	442.97	463.63	0.60	-36.41	-50.9
49485	44 1.77	71 1.25	428.91	464.43	0.53	-36.84	-50.9
49486	44 1.72	71 1.18	426.06	464.58	0.49	-36.88	-50.9
49487	44 1.70	71 1.05	423.80	465.00	0.44	-36.64	-50.7
49488	44 1.74	71 0.92	422.41	465.16	0.40	-36.68	-50.7
49489	44 1.75	71 0.80	421.44	465.09	0.36	-36.85	-50.9
49490	44 1.73	71 0.68	419.93	465.49	0.31	-36.56	-50.6
49491	44 1.67	71 0.60	412.08	466.06	0.29	-36.64	-50.4
49492	44 1.61	71 0.51	413.09	466.00	0.26	-36.46	-50.3
49493	44 1.55	71 0.40	411.94	466.36	0.24	-36.18	-50.0
49495	44 1.43	71 0.29	410.00	466.98	0.23	-35.56	-49.3

Appendix C

Procedure and results of uranium and thorium
determinations using gamma ray spectrometry.

Twenty-eight cores (3 cm diam) and fifteen hand samples were analyzed. All the components of the White Mountain magma series in the North Conway area are represented. One sample of Littleton Formation was also analyzed.

Samples were trimmed to exclude the more weathered portions and were ground in a steel disk grinder. The final grain size ranged from 3mm to 50 μ . For the analyses, approximately 100gm samples were used. Each ground sample was placed in a 125ml TPX container (Fisher Scientific). A cardboard insert was used to hold the sample in place with the top of the powder parallel to the container base. TPX containers were used because a tight seal was needed to contain any radon gas which may have escaped from the powdered specimens, and because of the container's large radius and volume. Samples were stored in the sealed containers for a minimum of 10 days. This allowed radon which may have escaped during grinding to build back up to about 80% of its steady state concentration. Because less than 10% was probably lost during grinding, 98% of the original radon was present.

Counting for gamma radiation was performed on a Northern Scientific 2048 channel γ -ray spectrometer using a Ge(Li) detector. 1024 channels were used to cover the spectrum between 0 and 2.048 MeV. Samples were counted for 10⁴ sec., and the counts on each channel recorded on Teletype. The following peaks were measured:

^{238}U decay scheme:

<u>Isotope</u>	<u>Peak channel(s)</u>	<u>Background channel(s)</u>
Ra ²²⁶	90-91, 92	88, 89, 93
Pb ²¹⁴	146	144, 145, 147
Pb ²¹⁴	174, 175	172, 173, 176, 177
Bi ²¹⁴	303, 304	301, 302, 305, 306

Th²³² decay scheme:

<u>Isotope</u>	<u>Peak channel (s)</u>	<u>Background channel (s)</u>
Ac ²²⁸	167, 168	165, 166, 169, 170
Ac ²²⁸	454, 455, 456	452, 453, 456, 457
Ac ²²⁸	483, 484	481, 482, 485, 486
Pb ²¹²	117, 118	115, 120, 121
Tl ²⁰⁸	290, 291, 292	288, 289, 293, 294

Potassium:

K ⁴⁰	729, 730, 731, 732	727, 733, 734, 735
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The counts on each peak were determined by summing the counts on the peak channels and determining the average background for each channel using adjacent channels which showed no peaks. The average background times the number of channels used in measuring the peak was subtracted from the total peak counts yielding a corrected peak height.

A portion of the peak height on each sample is due to the presence of U²³⁸, Th²³² daughter, and K⁴⁰ radiation from the environment around the detector. These effects are minimized but not eliminated by shielding the detector and sample in a lead brick cage. To measure this background one sample of marble was prepared and measured in a manner similar to the other samples. In addition several empty sample containers were also measured.

The channels used were usually those listed above, however visual inspection to determine the peak position of each run corrected for shifts in peaks of one to two channels. Correction was also made for occasional spurious counts on peaks or background.

Two steps are needed to convert the data from counts/sec to ppm of U or Th. The first involves the conversion from counts/sec to decays/sec.

The second involves the conversion of decays/sec to atoms of U or Th per sample, and finally to ppm of U and Th.

The ratio of counts/sec (cps) to decays per second (dps) is referred to as the detector efficiency. For a given detector it is a function of two variables: 1) the geometry of the sample container and 2) the energy of the γ -ray being measured. More energetic radiation tends to pass through the detector unnoticed, and hence is detected with lower efficiency.

The first variable, geometry, is held constant by the use of identical sample containers and nearly identical volumes of sample for each measurement.

Detector efficiency has been shown both theoretically and empirically to be a power function of γ -ray energy,

$$\text{efficiency} = F(\gamma\text{energy}^Z)$$

To calibrate the efficiency of the sample geometry an artificial sample containing known amounts of several man-made nuclides was measured. The spikes were added as liquid to a sample of marble, dried, and measured in a geometry identical to that used for the unknowns. The nuclides used were Cs^{137} (.662MeV), Na^{22} (.511MeV), Na^{22} (1.275MeV). In addition the K^{40} content of one of the granite samples was determined by measuring total K in the sample. These four gamma rays were then used to determine the efficiency curve of the detector.

The important steps in the calculation of detector efficiency are outlined here for Cs^{137} at .662 MeV. The activity was listed by the manufacturer as 3.537×10^2 dps/gm on the date of manufacture. Because 85% of these decays are accompanied by γ -rays, there were 3.006×10^2 γ /sec at T_0 . Because the sample has been losing activity due to decay,

one must multiply by $\exp \left[\frac{\ln \left(\frac{1}{2} \right) \text{ age}}{T_{\frac{1}{2}}} \right]$ to get 2.81×10^2 dps/gm at present.

1.465 gm were added to the marble sample so that there were 411.8 γ /sec emitted from the marble sample on the date of measurement. The spiked marble sample yielded 3241 counts in 2000 sec on the detector, or 1.620 cps. Thus the efficiency is

$$1.620 \text{ cps} / 411.8 \text{ } \gamma\text{ps} = 3.935 \times 10^{-3}.$$

Similar calculations were made for the Na^{22} γ -rays, yielding efficiencies of 5.185×10^{-3} , and 1.838×10^{-3} .

The calculation of the K^{40} activity in the single granite sample involved the following. The sample contained 4.35 %K (measured by dissolving the rock in HF and measuring K concentration by atomic absorption). Thus the sample which weighed 98.25 gm contained 4.285 gm K. K^{40} equals 0.0118% of natural K, so that the sample contained 5.056×10^{-4} gm of K^{40} , or 1.265×10^{-5} moles of K^{40} which equals 7.617×10^{18} atoms of K^{40} . Using the half-life of $\text{K}^{40} = 4.0078 \times 10^{16}$ sec,

$$\lambda = \frac{\ln \frac{1}{2}}{T_{\frac{1}{2}}} = -1.729 \times 10^{-17}$$

and thus,

$$\begin{aligned} (\text{dps}) \text{ in sample jar} &= \frac{dN}{dt} = -\lambda N \\ &= (7.617 \times 10^{18} \text{ atoms})(1.729 \times 10^{-17}) \\ &= 131.7. \end{aligned}$$

Eleven percent of the K^{40} decays are accompanied by a γ -ray, so that 14.49 γ /sec were being emitted from a K^{40} source. In 10^4 sec, 259 counts were recorded. Thus the efficiency is

$$\text{efficiency} = \left(\frac{259}{10^4} \right) \left(\frac{1}{14.49} \right) = 1.787 \times 10^{-3}.$$

The power function relation between γ -ray energy and efficiency implies a linear relation on a $\log$ (energy) vs. $\log$ (efficiency) plot. The least squares fit of a line to the data is determined in Table B-1 and the power function established at

$$\text{Efficiency} = .02922 \times (\text{MeV} \times 10)^{-1.0626}.$$

This equation allows the counting efficiency of the detector to be determined for gamma rays of any energy. Using this efficiency relation, the data in cps for all samples can be converted to γ -rays per second in the sample.

Table B-1. Least squares fit to Efficiency data

Isotope	$\log_{10}$ Efficiency	$\log_{10}$ (MeV $\times$ 10)
Cs ¹³⁷	-2.405	.8209
Na ²²	-2.285	.7084
Na ²²	-2.736	1.1055
K ⁴⁰	-2.748	1.164

$$\log_{10} \text{Efficiency} = m \log_{10} (\text{MeV} \times 10) + b$$

$$m = -1.0626$$

$$b = -1.5343$$

$$\log_{10} E = -1.0626 \log_{10} (\text{MeV} \times 10) - 1.5343$$

$$E = 10^{-1.5343} (\text{MeV} \times 10)^{-1.0626}$$

$$E = 0.02922 (\text{MeV} \times 10)^{-1.0626}$$

In turn, (dps) of each of the three daughters of U and the three daughters of Th can be found from the following:

$$(\text{dps}) = (\text{cps}) \left(\frac{1}{E} \right) \left(\frac{1}{\% \gamma \text{ occurrence}} \right).$$

Table B-2 lists the conversion factors from (cps) to (dps) for each of the six daughters.

Table B-2. (cps) to (dps) Conversion Factors

$$(\text{dps}) = (\text{cps}) \times \text{factor}$$

daughters		conversion factor
U	Pb^{214} (0.295 MeV, channel 146)	5.6858×10^2
	Pb^{214} (0.352 MeV, channel 174)	3.6206×10^2
	Bi^{214} (0.609 MeV, channel 303)	4.9653×10^2
Th	Pb^{212} (0.239 MeV, channel 117)	1.8378×10^2
	Ac^{228} (0.340 MeV, channel 167)	8.3747×10^2
	Ac^{228} (0.908 MeV, channel 454)	14.2704×10^2

The conversion from (dps) for each daughter of U^{238} to ppm U and for each daughter of Th^{232} to ppm Th follows from the relations:

$$\begin{aligned} \text{ppm } \text{U}^{238} &= \frac{\text{gms } \text{U}^{238} \times 10^6}{\text{gms sample}} & \text{ppm } \text{Th}^{232} &= \frac{\text{gms } \text{Th}^{232} \times 10^6}{\text{gms sample}} \\ &= \frac{\text{moles } \text{U}^{238} \times 238.05 \times 10^6}{\text{gms sample}} & &= \frac{\text{moles } \text{Th}^{232} \times 232.04 \times 10^6}{\text{gms sample}} \\ \text{ppm } \text{U}^{238} &= \frac{\text{atoms } \text{U}^{238} \times 238.05 \times 10^6}{6.0228 \times 10^{23} \text{ gms sample}} & \text{ppm } \text{Th}^{232} &= \frac{\text{atoms } \text{Th}^{232} \times 232.04 \times 10^6}{6.0228 \times 10^{23} \text{ gms sample}} \end{aligned}$$

where the number of atoms is found from:

$$\frac{dN}{dt} = -\lambda N$$

$$\lambda = \frac{\ln 2}{T_{1/2}}$$

$$\text{atoms} = \frac{(\text{dps})}{\lambda}$$

$$T_{1/2}(\text{U}^{238}) = 1.423 \times 10^{17} \text{ sec}$$

$$\lambda_{\text{U}^{238}} = -4.8710 \times 10^{-18}$$

$$\text{atoms } \text{U}^{238} = \frac{(\text{dps})}{4.8710 \times 10^{-18}}$$

$$T_{1/2}(\text{Th}^{232}) = 4.450 \times 10^{17} \text{ sec}$$

$$\lambda_{\text{Th}^{232}} = -1.5578 \times 10^{-18}$$

$$\text{atoms } \text{Th}^{232} = \frac{(\text{dps})}{1.5578 \times 10^{-18}}$$

thus, the concentrations of U^{238} and Th^{232} are given as:

$$\text{ppm } U^{238} = \frac{(\text{dps}) \times 238.05 \times 10^6}{4.8710 \times 10^{-18} \times 6.0228 \times 10^{23} \text{ gms sample}}$$

$$\text{ppm } Th^{232} = \frac{(\text{dps}) \times 232.04 \times 10^6}{1.5578 \times 10^{-18} \times 6.0228 \times 10^{23} \text{ gms sample}}$$

Using the conversion factors in Table B-2 and the above relations between ppm U^{238} and ppm Th^{232} and (dps), Table B-3 lists the conversion between (cps) and ppm U and ppm Th.

Table B-3 (cps) to (ppm)

(ppm)=(cps)(conversion factor)/gm sample

	daughters	conversion factor*
U	Pb^{214} (0.295 MeV, channel 146)	4.6471
	Pb^{214} (0.352 MeV, channel 174)	2.9592
	Bi^{214} (0.609 MeV, channel 303)	4.0582
Th	Pb^{212} (0.239 MeV, channel 117)	4.545
	Ac^{228} (0.340 MeV, channel 167)	20.711
	Ac^{228} (0.908 MeV, channel 454)	35.291

* assuming $U^{238} = 99.28\% \text{ U}$ (see Clark, 1966, p. 17); counting time = 10^4 sec

Table B-4 lists all samples analyzed for U and Th, and the concentrations of U and Th in (ppm) determined from the three daughters of U^{238} and the three daughters of Th^{232} . Examination of Table B-4 shows that for the three U daughters, the first value is nearly always between the second and third. These systematic errors are probably due to poor data on branching ratios and possibly poor data on detector efficiency. Likewise for Th, the first and third isotopes give consistent values, while the second is

consistently smaller.

To obtain a single number of greater reliability, conversion was made from the sum of the total counts for the three daughters of both U and Th. This single factor given as:

$$U(\text{ppm}) = \left(\frac{\sum \text{counts}}{\text{sample weight}} \times 1.251 \right) - 1.0$$

$$Th(\text{ppm}) = \left(\frac{\sum \text{counts}}{\text{sample weight}} \times 3.371 \right) - 1.5$$

includes a subtracted factor to correct for the background observed in the blanks. The final single values are listed in Table B-4.

Duplicate analyses were performed on three samples. Results are shown below.

<u>Sample</u>	<u>ppm U</u>	<u>ppm Th</u>
28-1a	13.1	110.5
28-1a	14.1	106.3
35-19	6.5	31.8
35-19	6.3	35.0
35-19	6.3	30.2
Core 7	20.0	76.5
Core 7	19.2	73.2
Core 7	18.7	70.6

These data show the reproducibility of the technique to be better than $\pm 10\%$ of the amount present.

Table B-5 lists average concentration values of U and Th for each rock type analyzed. The average values are derived from the "single factor" concentrations of U and Th given in Table B-4. Also given in Table B-5 are values of heat production rates (A) corresponding to the average concentrations

of U and Th. The conversion factors from (ppm) to (HGU) for rock density of 2.62 gm/cc are given as:

$$A_U = (\text{ppm U}) (5.91 \times 10^{-8}) \text{ HGU}$$

$$A_{\text{Th}} = (\text{ppm Th}) (1.66 \times 10^{-8}) \text{ HGU}$$

$$A_{\text{K}^{40}} = (\text{ppm K}^{40}) (1.83 \times 10^{-8}) \text{ HGU}$$

$$A_{\text{rock}} = A_U + A_{\text{Th}} + A_{\text{K}^{40}} .$$

Table B-4

Sample #	rock type	weight (gm)	U (ppm) channel			Th (ppm) channel			U (ppm)	Th (ppm)	Th/U
			146	174	303	117	167	454	-single	factor-	
Core 7	Conway Granite	98.254	19.9	21.6	18.6	77.3	66.8	68.6	20.0	76.5	3.8
			20.3	22.6	19.3	81.3	58.8	85.5	19.2	73.2	3.8
			18.3	21.6	18.3	74.3	62.0	72.6	18.7	70.6	3.8
Core 8	Conway Granite	96.569	9.5	9.7	8.6	55.8	51.9	64.7	8.3	54.5	6.6
Core 13	Conway Granite	96.422	11.5	12.6	10.8	62.1	48.5	51.6	10.8	57.4	5.3
Core 16	Conway Granite	100.909	13.7	15.7	11.3	85.5	59.5	76.9	12.8	79.0	6.2
Core 17	Conway Granite	65.042	10.0	10.1	8.6	39.6	29.3	40.1	8.6	36.4	4.2
Core 26	Conway Granite	103.39	14.8	16.0	12.9	73.5	53.9	62.8	13.7	67.9	5.0
Core 32	Conway Granite	100.391	7.4	9.8	7.5	60.2	53.4	61.5	7.4	57.7	7.8
									8.2	61.2	7.5
Core 37	Conway Granite	101.12	17.7	19.1	16.7	68.5	46.9	61.1	17.0	62.7	3.7
Core 40	Conway Granite	96.118	17.1	16.6	14.7	75.3	55.8	58.0	15.2	69.0	4.5
Core 42	Conway Granite	100.142	12.3	13.1	12.1	53.4	43.0	43.0	11.6	49.2	4.2
Core 47	Conway Granite	100.31	19.0	21.2	16.2	67.8	50.2	56.3	18.1	62.3	3.4
Core 52	Conway Granite	101.09	17.4	19.3	16.0	118.2	91.6	118.0	16.8	112.2	6.7
S-2	Conway Granite	101.05	11.0	12.4	10.1	71.6	58.6	73.3	10.3	68.1	6.6
S-5	Conway Granite	95.655	10.1	12.9	9.6	46.0	41.8	52.4	10.1	44.5	4.4
19-8b	Conway Granite	103.11	10.6	13.4	10.2	46.8	28.7	45.2	10.4	43.1	4.1
19-12	Conway Granite	99.32	10.2	10.0	9.3	64.8	58.4	56.1	8.8	61.8	7.0
28-1a	Conway Granite	99.668	14.0	15.3	12.7	118.0	94.1	96.0	13.1	110.5	8.4
									14.1	106.3	7.5
39-1	Conway Granite	100.333	11.8	15.6	13.2	55.4	43.3	53.8	12.9	53.3	4.1

Table B-4 (continued)

Sample #	rock type	weight(gm)	U(ppm) channel			Th(ppm) channel			U(ppm)	Th(ppm)	Th/U
			146	174	303	117	167	454	-single	factor-	
Core 29	Mt. Osceola Granite	97.467	17.8	20.1	18.0	77.6	62.9	79.3	17.9 19.0	73.9 72.1	4.1 3.8
Core 31	Mt. Osceola Granite	100.14	15.3	15.2	12.7	56.2	35.2	47.6	13.5	50.4	3.7
Core 39	Mt. Osceola Granite	101.435	20.9	20.6	18.5	74.5	59.6	73.1	19.0	70.4	3.7
Core 65	Mt. Osceola Granite	100.76	12.1	12.2	11.0	55.0	35.1	53.2	10.8	50.1	4.6
Core 66	Mt. Osceola Granite	100.53	11.4	14.0	10.1	56.2	35.0	48.4	11.1	50.6	4.6
S-3	Mt. Osceola Granite	99.60	12.9	9.5	9.0	51.9	42.0	47.8	9.3	48.3	5.2
S-4b	Mt. Osceola Granite	101.14	9.5	10.7	8.2	48.3	29.9	46.1	8.6	43.7	5.1
Core 44	Na-amphibole granite	100.816	11.9	13.1	10.5	50.9	38.4	46.9	11.0	47.0	4.3
Core 46	Na-amphibole granite	102.09	10.7	10.9	9.2	37.6	25.8	30.8	9.3	33.6	3.6
Core 63	Na-amphibole granite	81.86	11.8	13.4	11.5	44.0	29.9	41.4	11.4	39.9	3.5
S-1	Na-amphibole granite	97.58	14.3	14.8	14.2	57.1	46.5	59.0	13.5	54.0	4.0
Core 19	Black Cap Granite	100.195	19.9	20.3	17.5	74.4	61.6	68.3	18.3	70.2	3.8
Core 20	Black Cap Granite	99.911	13.8	16.0	12.6	78.7	69.0	75.2	13.3	75.3	5.7
Core 21	Black Cap Granite	99.121	20.3	22.2	17.2	113.8	84.0	99.7	19.2	106.1	5.5
Core 23	Black Cap Granite	98.27	27.1	30.2	24.4	40.1	29.5	39.9	26.6	36.8	1.4
Core 25	Black Cap Granite	98.25	8.0	7.6	6.3	52.2	39.2	52.8	6.3	48.6	7.7

Table B-4 (continued)

sample #	rock type	weight(gm)	U(ppm) channel			Th(ppm) channel			U(ppm)	Th(ppm)	Th/U
			146	174	303	117	167	454	-single factor-		
Core 36	Black Cap Granite	100.05	17.3	16.1	14.6	56.5	51.5	61.7	15.0	54.6	3.6
Core 50	Black Cap Granite	97.96	11.8	12.2	10.0	59.6	57.1	62.3	10.8	56.0	5.2
									10.3	57.5	5.6
34-1a	Albany quartz syenite	100.62	8.1	9.1	8.5	46.7	32.1	38.2	7.6	42.1	5.5
35-19	Albany quartz syenite	100.596	7.9	7.4	6.8	37.1	34.0	35.8	6.3	35.0	5.6
			7.4	7.4	7.2	33.1	26.8	30.5	6.5	31.8	4.9
			7.5	8.1	6.6	34.3	25.3	38.9	6.3	30.2	4.8
18-9	Moat Volcanic	100.082	12.2	16.1	11.5	48.2	43.8	41.1	12.6	45.2	3.6
3-12b	Littleton Fm. gneiss	100.17	4.8	3.7	3.9	18.1	20.7	14.1	3.1	16.6	5.4
----- marble -----		97.961	1.2	1.4	1.0	1.9	2.5	4.3	1.0	1.4	
									1.2	2.3	
----- blank -----		0	0.4	0.6	0.5	1.9	2.3	0.0	0.5	1.8	
									1.5	0.6	

Table B-5

rock type	n	U-mean (ppm)	U-range (ppm)	Th-mean (ppm)	Th-range (ppm)	A(HGU) [*]
Conway Granite	18	12.6	7.8-19.3	64.6	36.4-112.2	19.0
Mt. Osceola Granite	7	12.9	8.6-19.0	55.3	43.7-73.9	17.7
Na-amphibole Granite	4	11.3	9.3-13.5	43.6	33.6-54.0	14.8
Black Cap Granite	7	15.3	6.3-26.6	72.4	36.8-106.1	22.0
Albany quartz syenite	2	7.0	6.4-7.6	37.2	32.3-42.1	11.2
Moat volcanic	1	12.6	--	45.2	--	15.8
Littleton Fm. gneiss	1	3.1	--	16.6	--	5.5

* assume K concentration = 4%

71° 15'
44° 15'

71° 00'
44° 15'

EXPLANATION

	Riebeckite granite
	Conway Granite
	Black Cap Granite
	Albany Porphyritic Quartz Syenite
	Syenite
	Osceola Granite
	Porphyritic granite of Robbins Ridge
	Moat Volcanics
	Contact
	Outcrop where data were taken
	Bore hole

44° 00'
71° 15'

44° 00'
71° 00'

PLATE 1

GEOLOGIC MAP OF THE NORTH CONWAY AREA

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

GILEAD (JUNC. U.S. 21) 12 MI.
HASTINGS 8.8 MI.
NEW HAMPSHIRE-MAINE
NORTH CONWAY QUADRANGLE
15-MINUTE SERIES

ROAD CLASSIFICATION
Heavy-duty ——— Light-duty ———
Medium-duty - - - - - Unimproved dirt - - - - -
U.S. Route State Route

INTERIOR GEOLOGICAL SURVEY
WASHINGTON, D. C. 20511
Polyconic projection. To place on 1927 North American datum
move projection lines 50 feet north
10,000-foot grids based on New Hampshire and CENTER CONWAY 32 MI. (West of
Maine (West) rectangular coordinate systems
1000-meter Universal Transverse Mercator grid ticks,
zone 19, shown in blue

NORTH CONWAY N.H.-ME
714-000 W. 00 15

1942

AMS 6772 II—SERIES V712

FOR SALE BY U.S. GEOLOGICAL SURVEY, WASHINGTON, D. C. 20242
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

PLATE 2

PLATE 3

MW: M.P. Billings and others, 1946, Geology of the Mt. Washington quadrangle: N.H. Dept. of Resources and Economic Development.
G: M.P. Billings and K. Fowler-Billings, 1975, Geology of the Gorham quadrangle: N.H. Dept. of Resources and Economic Development.
B: A. Hussey (compiler), 1967, Preliminary geologic map of Maine: Maine Geol. Surv.
CN: D.M. Henderson and others, 1977, Geology of the Crawford Notch quadrangle: N.H. Dept. of Resources and Economic Development.
NC: This study and M.P. Billings, 1928, The petrology of the N. Conway quad. in the White Mts. of N.H.: Am. Acad. Arts and Sci. Proc., v.63, p.127-137.
F: A. Hussey (compiler), 1967, Preliminary geologic map of Maine: Maine Geol. Surv.
MC: A.P. Smith and others, 1939, Geology of the Mt. Chocoma quadrangle: N.H. Planning and Development Comm.
OL: J.R. Wilson, 1969, Geology of the Ossipee Lake quadrangle: N.H. Dept. of Resources and Economic Development.
KF: A. Hussey (compiler), 1975, Preliminary geologic map of southwestern Maine: Maine Geol. Surv., Open File Map 1976-1.

Density contrasts and superimposed 29x29 grid system used in three-dimensional gravity models. (See Figure for descriptions of lithic units).

0 1 2 3 4 5 km
0 1 2 3 4 5 mi
1:123691

PLATE 8

FINITE ELEMENT GRID

PLATE 9

$q_{base} = 1.3 \text{ HFU}$