1-1-1974

Igneous Petrology of Some Plutons in the Northern Partof the Penobscot Bay Area

Wones, David R.

IGNEOUS PETROLOGY OF SOME PLUTONS IN THE NORTHERN PART OF THE PENOBSCOT BAY AREA

David R. Wones
U.S. Geological Survey, Reston, Virginia

Introduction

This field trip is designed to examine variations among some of the plutons in the Penobscot Bay area. The plutons, in general, form topographic highs on the mainland and dominate the geology of the major islands: Vinalhaven, Isle Au Haut, Deer Isle, Swans Island, and Mount Desert. Field observations, combined with appropriate laboratory studies, can provide estimates of depth of crystallization, variations of magmas in time and space, and, perhaps, absolute ages of the events within the intruded terrane.

These plutons have intruded a zone some 50 km (31 miles) wide (see Fig. 1; also Fig. 1, trip B-7) of fault bounded blocks that contain disparate lithologies including banded gneisses, marine sedimentary rocks, and volcanic rocks. (See trip B-7.)

The area may represent a plate boundary in Paleozoic time (Bird & Dewey 1970; Naylor 1971; Wilson, 1966). Magma composition may be related temporally to this feature, but there seems to be no valid documentation of a relationship between geologic setting and the composition of the intruding magmas.

In this discussion the new International Union of Geological Sciences (IUGS) recommendations on nomenclature are being followed and the term granite includes all rocks containing more than 20% quartz and having an alkali feldspar to plagioclase ratio greater than 0.5. Modes of some plutons are given in Table 1 and are plotted in Figure 2.

I would like to acknowledge the help of R. M. Hazen, D. M. Miller, and R. L. Trithart in the field studies, and of N. L. Hickling, E.G. Williams, and C. S. Zen in the laboratory studies. P. H. Osberg, D. W. Rankin, and D. B. Stewart gave generously of their time to help make this a better guidebook article.

Stratigraphy and Geochronology

The plutons of the area can be grouped into four types (Fig. 1), although the divisions of this classification scheme are based on both age and petrography and are somewhat arbitrary. Two plutons, the South Penobscot and the Mount Desert, contain rims of dioritic to granodioritic material which contains inclusions of mafic rocks and is intruded by later biotite and (or) hornblende granites. These two plutons are also sheared and faulted (Chapman, 1970; see trip B-7) so that significant tectonic activity post-dated their intrusion. The core materials are

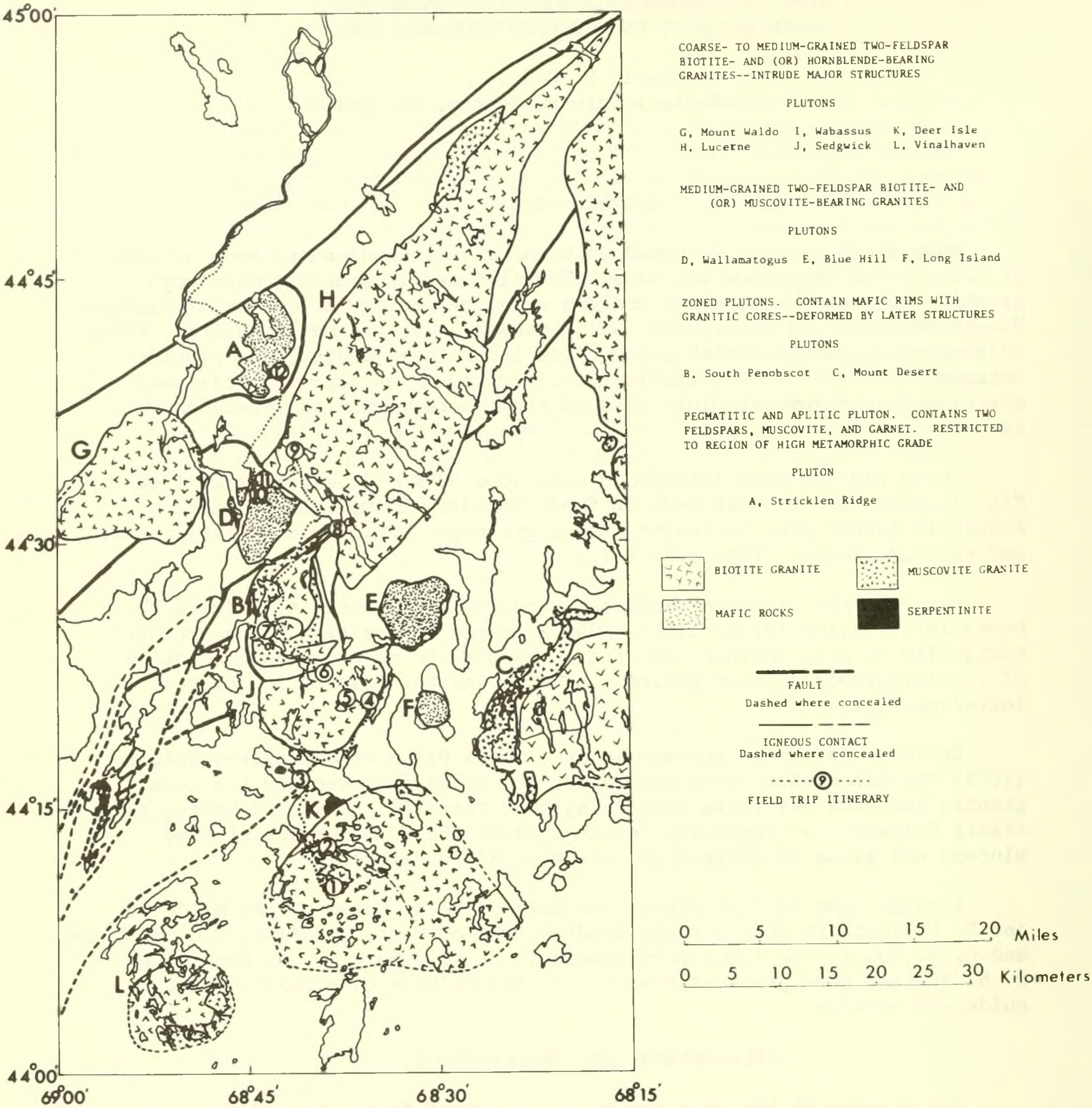

Figure Captions

Figure 1. Sketch map showing locations of plutons in the Penobscot Bay area, Maine. For geology of country rocks see Figure 1, trip B-7.

Table 1.--Modes of some granitic rocks in the Penobscot Bay region

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Quartz	28.13	28.02	24.8	31.33	25.43	8.3	25.1	31.17	33.09	30.26	28.35	32.95	28.84	23.68
Alkali feldspar	30.83	46.01	27.2	38.50	36.68	6.8	25.4	7.75	38.04	36.53	35.68	25.60	47.95	24.27
Plagioclase	35.06	24.44	39.4	24.15	28.20	65.3	41.4	50.42	19.89	26.66	27.60	28.59	14.33	41.67
Muscovite							1.4					5.74	5.97	1.42
Biotite			5.2			19.2	4.4	10.08				6.95	2.90	8.79
Chlorite			0.7											
Mafics[1/]	5.99	1.55		6.04	9.70				6.16	6.55	8.37			
Amphibole			0.4					0.80						
Opaques			1.2			0.3		0.08						

1. Stonington granite, Buckmaster Neck (Stop 1)
2. Aplite, Buckmaster Neck (Stop 1)
3. Oak Point Granite (of local usage) Mountainville (Stop 2)
4. Sedgwick granite (Stop 4)
5. Sedgwick granite (Stop 6)
6. South Penobscot pluton, matrix at Johnson Pt. (Stop 7)
7. South Penobscot granite, north of Johnson Pt. (Oliphant, 1969)
8. South Penobscot granite, inclusion in Lucerne Granite (of local usage) (Stop 8)
9. Lucerne Granite (of local usage) (Stop 9)
10. Leucocratic dike (Stop 9)
11. Lucerne Granite (average of 17 modes)
12. Wallamatogus granite, interior facies
13. Wallamatogus granite, rim facies (Stop 10)
14. Stricklen Ridge pluton, aplitic facies (Stop 12)

1/ Mafics includes all dark minerals.

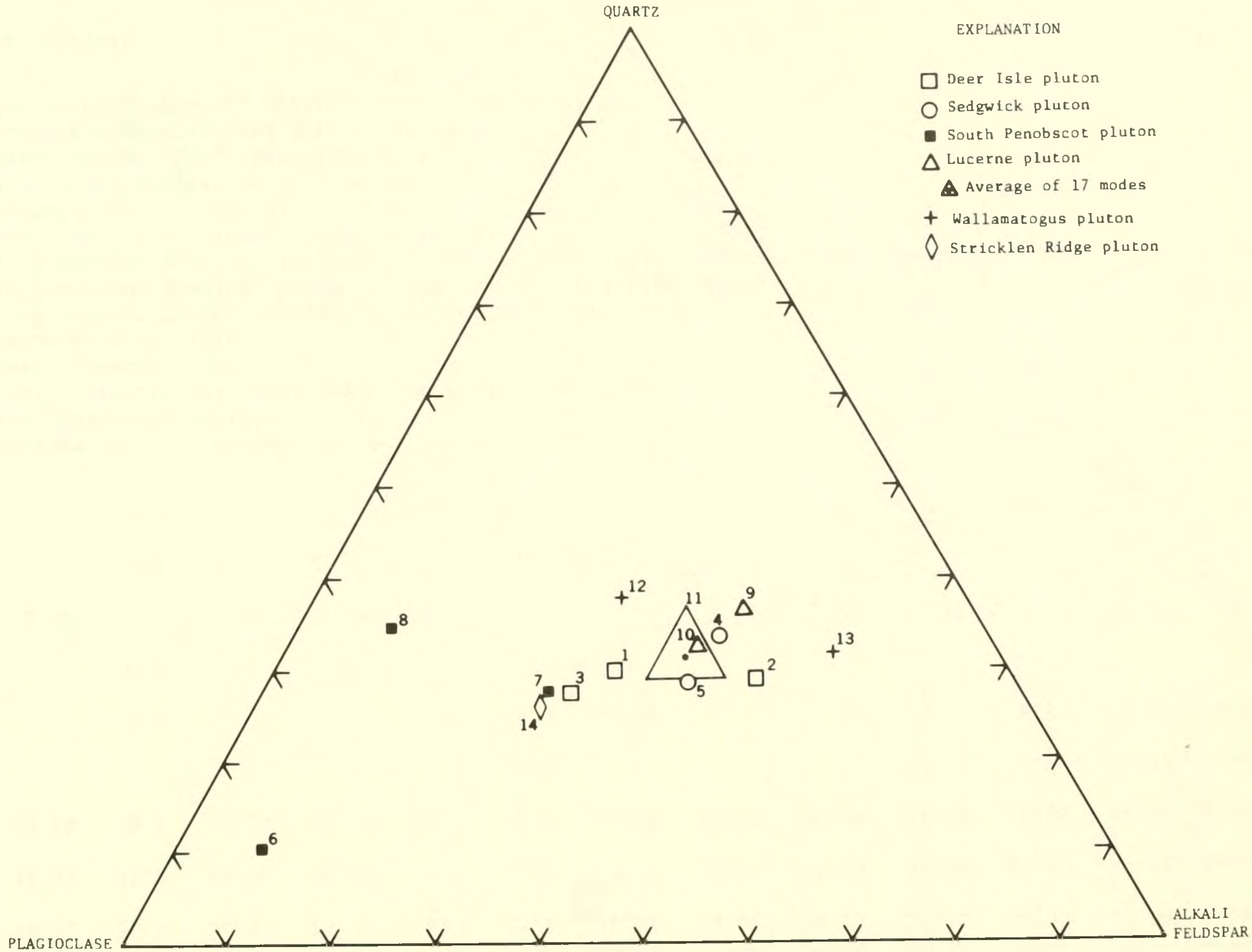

Figure 2. Quartz-plagioclase-alkali feldspar modal plots for plutons in Penobscot Bay area, Maine. Numbers correspond to columns in Table 1.

biotite and (or) hornblende granites which intrude the earlier rim material.

The Wallamatogus, Blue Hill, and Long Island plutons contain muscovite granite and tourmaline-bearing zones. The metamorphic aureole of the Wallamatogus pluton is more extensive than that of the Lucerne pluton. Although some minor shearing has been observed in the Wallamatogus pluton, these plutons are faulted to a lesser extent than the South Penobscot and Mount Desert plutons.

Biotite granites characterize the Mount Waldo, Lucerne, Wabassus, Sedgwick, Deer Isle, and Vinalhaven plutons. The granites within these plutons are generally medium to coarse grained and tend to have porphyritic facies with alkali feldspar phenocrysts. The Lucerne (Cavalero, 1965) and Vinalhaven (Smith, 1896) plutons have earlier mafic intrusives associated with them, but not the actual rim of diorite and granodiorite characteristic of the South Penobscot and Mount Desert plutons. The Deer Isle pluton has a hornblende-bearing rapakivi partial outer rim (Oak Point Granite, Stewart, 1956) which grades into the Stonington granite of the core. Unlike the muscovite granites, the biotite granites all seem to have narrow thermal aureoles as compared to their diameters.

The Stricklen Ridge pluton is quite different from the others in the region. It pervades, and is intimately mixed with inclusions of, the Passagassawakeag gneiss and the Copeland schist. It has a highly variegated texture ranging from aplite to pegmatite. Garnet and muscovite are ubiquitous, but biotite is less common. The pluton and its apophysal dikes are truncated by faults and all are confined to the fault block containing the Passagassawakeag gneiss (see Field Trip B-7).

Geologic evidence clearly makes the Lucerne pluton younger than the Wallamatogus and South Penobscot plutons. Indirect evidence also implies that the Mount Waldo pluton is younger than the Wallamatogus pluton. Other than these limits, the relative ages of the plutons cannot be established by geologic criteria. Brookins has compiled ages from the plutons derived from Rb-Sr and K-Ar methods and Table 2 results largely from his efforts. He has also provided a brief appendix for this excursion.

All of the plutons discussed herein, with the exception of the Stricklen Ridge pluton, are 375 ± 25 m.y. old and are Devonian. The isotopic age resolution is not good, but it appears that in the Penobscot Bay area, granitic intrusions are continuous rather than episodic. As can be seen by Table 2, the isotopic ages are not sufficient at present to resolve the relative time scale of these intrusions.

Preliminary work on the Stricklen Ridge pluton by Brookins (oral commun., 1974) indicates at least an Ordovician age, and the youngest migmatites in the Passagassawakeag gneiss contain zircons in which Zartman (oral commun., 1974) obtained preliminary Pb^{206}/Pb^{207} age of 430 ± 10 m.y.

Table 2.--Isotopic age determinations for some plutons in the vicinity of Penobscot Bay, Maine

Pluton	Age	Method	Investigator
Lucerne	356	K-Ar, biotite	Faul *et al.*, 1963
	402±13	Rb-Sr WR	Brookins, written commun. 1974
Mount Waldo	390±10	Rb-Sr WR	Brookins, in press
Wabassus	370	K-Ar, biotite	Faul *et al.*, 1963
Sedgwick	413±15	K-Ar, biotite	Brookins, in press
	395±15	Rb-Sr WR	Brookins, in press
Deer Isle	357±1	Rb-Sr WR	Brookins & Spooner, 1970
	355	K-Ar, biotite	Faul *et al.*, 1963
Vinalhaven	361±7	Rb-Sr WR	Brookins, in press
	399	K-Ar, biotite	Faul *et al.*, 1963
Wallamatogus	375±20	Rb-Sr WR	Brookins, written commun.
	384	K-Ar, muscovite	Faul *et al.*, 1963
Blue Hill	387	K-Ar, biotite	Faul *et al.*, 1963
	382±10	Rb-Sr WR	Brookins, in press
Mount Desert	394	K-Ar, biotite	Faul *et al.*, 1963
	429±13	Rb-Sr WR	Metzger & Bickford, 1972
South Penobscot	360±15	K-Ar, biotite	Brookins, in press
	403±15	Rb-Sr WR	Brookins, in press
Migmatite	430±10	Pb^{206}/Pb^{207}, zircon	Zartman, oral commun., 1974

Each pluton has its own particular characteristics as to modal variations, foliation, fabric, inclusion content, aplite content, aplite distribution, and alteration zones. Red coloration is common in the Vinalhaven, Deer Isle, and Mount Desert plutons, whereas the Stricklen Ridge, Wallamatogus, and South Penobscot are white. Red and salmon-colored areas are common in all of the other plutons.

Aplite or leucocratic late-stage dikes are very common in the Vinalhaven and Deer Isle plutons and relatively uncommon in the Wallamatogus and Lucerne plutons. Magnetite is a common accessory in all of the biotite granites, except for the Lucerne pluton whose contacts can be mapped under the glacial cover by its characteristically low magnetic signature (Kane et al., 1971).

Relation of Plutons to Structural Setting

The plutonic varieties are not particularly related to the regional structures. In this area, the plutons are all located southeast of the "Norumbega" fault (see trip B-7), but outside this area, to the southwest and northeast, plutons occur on both sides of the "Norumbega" fault.

The South Penobscot and Mount Desert plutons seem to contain more mafic inclusions than the other plutons, and these inclusions could represent the southwestern extremity of Chapman's (1962) Bays-of-Maine complex.

Muscovite granites are notably less abundant in the Penobscot Bay area than they are in Western Maine or New Hampshire where binary granites are more common (Billings, 1956). There are no significant petrographic differences between plutons intruded on opposite sides of identified faults.

The physical appearance of a pluton is a complex function of its composition, rate of cooling, and interaction with its surroundings. As we shall see, the Lucerne pluton contains few aplites, is generally white and exceedingly coarse grained, and contains very little magnetite. The Deer Isle pluton, in contrast, contains many aplites, is reddened and medium grained and contains magnetite as a common accessory. What do these observations mean? Was the Lucerne intruded at a deeper erosional level, did it contain more or less volatile constituents, or did it cool more slowly than the Deer Isle?

Sweeney (1973) has considered the shapes of these plutons on geophysical evidence and his ideas are presented in an appendix.

The general lack of significant volumes of granodiorite or tonalite makes it unlikely that much oceanic crust was partially melted to yield these magmas. They appear to represent fusion of continental crust. The most appropriate present analogs along modern plate boundaries might be either the volcanic centers along the San Andreas fault system of California or those in the Aegean Sea.

The trip will examine the Deer Isle pluton (Stops 1 & 2), the Sedgwick pluton (Stops 4 & 6), the South Penobscot pluton (Stops 7 & 8), the Lucerne pluton (Stops 8, 9, & 11), the Wallamatogus pluton (Stops 10 & 11), and the Stricklen Ridge pluton (Stop 12).

References

Billings, M. P., 1956, Bedrock Geology, Part II of The Geology of New Hampshire, New Hampshire State Planning and Development Commission, 204 p.

Bird, J. M., and Dewey, J. F., 1970, Lithosphere Plate-Continental Margin Tectonics and the Evolution of the Appalachian Orogen: Geol. Soc. America Bull., v. 81, p. 1031-1060.

Brookins, D. G., In press, Geochronologic Contributions to Problems of Stratigraphy and Correlation in the Penobscot Bay Area, Eastern Maine with Regional Implications: in Symposium on New England Stratigraphy, Geol. Soc. America Memoir.

Brookins, D. G., and Spooner, C. M., 1970, The Isotopic Ages of the Oak Point and Stonington granites, Eastern Penobscot Bay, Maine: Jour. Geology, v. 78, p. 570-576.

Cavalero, R. A., 1965, Geology of the Clifton Township Area in the Orono and Great Pond Quadrangles, Maine, M.S. Thesis, University of Maine at Orono, 116 p.

Chapman, C. A., 1962, Bays-of-Maine Igneous Complex: Geol. Soc. America Bull., v. 73, p. 883-888.

Chapman, C. A., 1970, The Geology of Acadia National Park. Chatham Press Inc., (distributed by Viking Press), 128 p.

Faul, H., Stern, T. W., Thomas, H. H., and Elmore, P.L.D., 1963, Ages of Inclusion and Metamorphism in the Northern Appalachians: Am. Jour. Sci., v. 261, p. 1-19.

Kane, M. F., Harwood, D. S., and Hatch, N.L. Jr., 1971, Continuous Magnetic Profiles near Ground Level as a Means of Discriminating and Correlating Rock Units: Geol. Soc. America Bull., v. 82, p. 2449-2456.

Metzger, W. J., and Bickford, M. E., 1972, Rb-Sr Chronology and Stratigraphic Relations of Silurian Rocks, Mt. Desert Island, Maine: Geol. Soc. America Bull., v. 83, p. 497-504.

Naylor, R. S., 1971, Acadian Orogeny: An Abrupt and Brief Event: Science, v. 172, p. 558-560.

Oliphant, J. D., 1969, Geology of the Igneous Rocks in Southeastern Penobscot Township, Hancock County, Maine. S.M. Thesis, Univ. of Washington, 39 p.

Quinn, A. W., 1943, Settling of heavy minerals in a granodiorite dike at Bradford, Rhode Island: Am. Mineral., v. 28, p. 272-282.

Smith, G. O., 1896, The Geology of the Fox Islands, Maine. Published by the Author. Skowhegan, Maine, 78 p.

Stewart, D. B., 1956, Rapakivi Granite from Eastern Penobscot Bay, Maine: XX International Geologic Congress, Section XI-A, p. 293-320.

Stewart, D. B., and Roseboom, E. H., Jr., 1962, Lower Temperature Terminations of the Three-phase Region Plagioclase-Alkali Feldspar-Liquid: Jour. Petrology, v. 3, p. 280-315.

Wilson, J. T., 1966, Did the Atlantic close and then re-open?: Nature, v. 211, p. 676-681.

Itinerary

Mileage

0 Field trip begins at Perini Corp. quarry on Buckmaster Neck. Quarry. Buckmaster Neck, Oceanville, Stonington.

Stop 1. This property belongs to Perini Corp. who have graciously granted us permission to visit it. BE CAREFUL—the blocks in this quarry are in a metastable condition. They move easily; be sure you are not under one when it moves. Blocks on the west side of the quarry have moved 5-20 cm. since quarrying activity stopped. This quarry is located in the Stonington granite within the Deer Isle pluton. The quarrymen exploited the exfoliation joints and most recently used flame spallation method to cut the blocks. Note the boom for transferring blocks from the working face to the loading dock where they are weighed. For a variety of economic reasons, natural building stones have been supplanted by concrete and structural steel.

The grain size is highly variable with the alkali feldspar giving the granite a porphyritic quality. Pegmatitic pods contain feldspars as large as 2-4 cm. Sparse rapakivi-textured feldspars are present. The salmon perthite combined with the dark biotite, white plagioclase, and gray quartz make this an interesting and attractive building stone.

Late-stage aplite dikes are common. Most have an accumulation of mafic material on the footwall such as Quinn (1943) described for the Westerly, R. I., granites. However, one aplite on the upper level of the quarry has mafic accumulations on both the hanging wall and the footwall. Footwall segregations alone are due to gravitational settling, but segregations on both walls must be due to flow segregation. Inclusions are rare and highly variable. On the east wall, one can see how the granite near the surface is reddened along the joints; the color is due to disseminated flakes of hematite within the feldspar.

0.9 Turn right on Route 15 north.

1.8 Cross Inner Harbor Bridge into town of Deer Isle.

4.4 Turn right toward Sunshine.

5.8 Turn right toward Sunshine.

7.0 Park on left, walk ahead across Greenlaw Cove bridge to roadcut.

Stop 2. GREENLAW COVE. This road cut gives an excellent exposure of the Oak Point Granite (of local usage), the eastern and outer member of the Deer Isle pluton. Rapakivi texture is especially well developed here. Stewart (1956) and Stewart and Roseboom (1962) have discussed the magmatic origin of this texture using this granite as the basic observation. Note the large number of aplite dikes and the bright red-orange color of the alkali feldspars. Note the abundance of inclusions and the development of rapakivi porphyroblasts within the inclusions. Alteration is well developed along joints. The radial fracture pattern well developed here results from blasting for the roadcut.

Return to outcrops north of parking area. The intensely altered zone is now quartz and maximum microcline as opposed to the quartz, plagioclase, biotite, and orthoclase (and (or) intermediate microcline) of the original rock. The feldspars are homogenized, not perthitic; quartz veins are common, and the quartz is not milky. Aplites are not easily observed. These alteration zones are strongly magnetic.

Turn around and return to Route 15.

9.6 Turn right on Route 15.

10.1 Bear right toward Sedgwick.

12.4 Causeway at Deer Isle and Little Deer Isle.

Stop 3. The Causeway is made up of serpentized dunite quarried from the highest hill visible on nearby Little Deer Isle. The serpentite body has no exposed contacts, and it is uncertain whether it represents an ultramafic intrusion or a block of ultramafic material faulted into its present position.

Continue north on Route 15.

14.3 Deer Isle information center; continue right on Route 15.

15.0 Deer Isle bridge across Eggemoggin Reach.

16.5 Continue straight on Route 175 south toward Blue Hill.

20.0 Turn left on Route 172 north toward Ellsworth.

23.6 Bear left on old road and park.

Stop 4. This roadcut is in the southeastern part of the Sedgwick pluton. The elliptical outcrop pattern results from this nearly cylindrical mass plunging about 25° SE. In contrast to the Deer Isle pluton, notice the pale color and lack of aplitic material. A small red pegmatite seam containing muscovite and tourmaline is present. This fracture is interpreted to be a post-magmatic feature involving recrystallization of the granite in the presence of gas. The presence of muscovite here, and not in the granite proper, is attributed to the incongruent solubility of feldspar in the gas phase. Contrast this with the Wallamatogus granite (Stop 10).

23.7 Turn right on Route 172 south.

24.4 Sedgwick Grange. Turn right on Ridge Road.

27.2 Secondary Road on south side. Park on Ridge Road.

Stop 5. This road, built a decade ago by the operators of the Black Hawk mine in Blue Hill to supply access to a drilling program, is paved with sulfide ore from the mine. This brief stop is to provide you with a look at the mineralogy and assemblages within this copper-zinc-lead deposit.

Continue northwest on Ridge Road.

28.5 Intersection Route 176. Park in equipment park on left.

Stop 6. Northern contact of the Sedgwick pluton. In contrast to Stop 4, the Sedgwick granite is here coarser, and filled with inclusions. This would be the "footwall" of the plunging cylinder. Xenoliths are very common here. The contacts of the biotite granite plutons are abrupt and generally show only a few apophysal dikes. In contrast, the muscovite-bearing granites send out many apophysal dikes and tend to metasomatize the surrounding schists.

Turn left and continue on Route 176 west.

29.1 Turn right on Route 176 west towards Penobscot.

31.6 Go straight on Route 175 north towards Orland.

33.4 Cross brook and turn left on paved road.

34.3 Bear left past gray house marked "Webb."

34.5 Park in field. Outcrops are 200 m (660 feet) north along shoreline.

Stop 7. South Penobscot pluton, western border phase. This pluton has a rim of diorite containing many mafic inclusions. The inclusions range from gabbro to pyroxenite. Diabase intrudes the Castine Volcanics and in turn is intruded by the South Penobscot pluton which may be cosanguineous with the Castine Volcanics. The dioritic matrix is dominated by plagioclase and biotite and could have evolved from a mafic magma. Alternatively, a granitic magma could be contaminated by inclusions of gabbroic material, through which the magma has moved. This diorite grades into a granodiorite, which is intruded by a late central stock of biotite granite.

Return to Route 175.

35.6 Turn left on Route 175.

38.7 Turn right on Route 199 toward North Penobscot.

43.8 North Penobscot. Turn right on Route 15 south.

43.9 Turn left on paved road "Balsam Cove Campground."

44.5 Turn right on gravel road.

45.1 Turn right on gravel road marked "Lord."

45.8 Turn around area. Parking here is poor.

Stop 8. Dike of Lucerne Granite (of local usage) intruding a faulted contact between Penobscot Formation and the South Penobscot pluton. Outcrops in woods to east of blueberry field are Penobscot Formation. Outcrop in road is a dike of Lucerne Granite containing inclusions of the South Penobscot pluton, granodiorite phase. Note the very coarse grain size of the Lucerne Granite, even in the contact areas. This indicates either very slow cooling, or a low viscosity magma which permits rapid diffusion. The inclusions of South Penobscot have very little alkali feldspar (see Table 1). Contrast the inclusions of Penobscot Formation within the Lucerne with the Penobscot Formation in Stop 11.

Return towards North Penobscot.

46.5 Turn left on gravel road.

47.0 Turn right at chicken factory on Back Ridge road.

50.3 Cross U.S. Route 1, East Orland, continue straight ahead to Craig Brook National Fish Hatchery.

51.8 Craig Brook National Fish Hatchery. Continue straight to nature trail.

52.1 Park cars in parking area provided at nature trail. Follow Yellow Dot trail to the right.

<u>Stop 9</u>. Nature trail at Craig Brook U.S. National Fish Hatchery.

500'. Notice gravel outwash is predominately feldspar.

810'. Signpost 5. Friable Lucerne Granite. Gorge dissects massive granite. Sheeting is on the dimensions on 1-4 cm which is the size of the feldspars within the Lucerne. Friable Lucerne Granite is the chief source of road metal in the region between Bucksport and Ellsworth.

870'. As you cross the stream, note that the finer grained leucocratic dike is more resistant than the coarser Lucerne Granite.

940'. Signpost 6. Note how leucocratic dike (N.60°W., vertical) acts as a dam in the stream bed. Note also concentration of dark minerals along edge of dike. An inclusion of coarse Lucerne Granite is within the dike.

Those who wish to return to the parking area may do so via the Blue Dot trail.

1110'. Signpost 8. Leucocratic dike in stream bed. These dikes have tourmaline as the dominant mafic phase.

1200'. Cross stream bed. Note boulder of salmon-colored Lucerne Granite.

1600'. Large block of Lucerne Granite beginning to work loose. Many low ridges in the outcrop area of Lucerne are rubble piles of similar boulders. They imply bedrock nearby, even if they themselves are not in place.

2000'. Descent into the gorge on south (right) side of trail. Here is a typical "pavement" outcrop of Lucerne Granite.

Note 1) Large size of feldspars.
2) Irregular patches of quartz.
3) Rapakivi texture of feldspar.
4) Differential weathering of feldspar.
5) Golden luster of weathered biotites.
6) Foliation and lineation (N.20°E.) caused by alignment of feldspar.

Continue 300' downstream past fallen trees and large boulders. Undercut bank showing differential resistance to weathering of the Lucerne. The resistant area consists of red feldspar and is silicified.

Climb up north bank (right as you face downstream) and rejoin Yellow Dot trail to the east.

3100'. "Ledges" of Lucerne Granite. (When asking Maine natives for outcrops, one always asks for ledge, not bedrock.)

3200'. Signpost 13. Residual boulders of Lucerne.

3450'. Signpost 15. Turn right on Woods road.

4900'. Return to parking lot.

Return to U.S. 1.

53.7 Bear right.

53.8 Turn right on U.S. 1.

54.5 Turn left on paved road "Speed Limit 35."

55.1 Turn right on Route 15.

55.2 Turn left at "Live Bait."

56.9 Bear right.

57.5 Ledge of Wallamatogus interior muscovite-bearing facies on left side of road.

58.1 Park on right side of road.

Stop 10. Rim facies of Wallamatogus granite. The porphyritic phase of the Wallamatogus is sheared here, indicating some post-intrusion strain. Note muscovite crystals which appear to be interlocking and contemporary with the rest of the groundmass. Primary muscovite indicates a significantly more hydrous and peraluminous magma than that which crystallized to the biotite granites.

58.4 Cranes Corners. Turn right on Route 175 north.

59.1 Turn right onto farm belonging to Gilman Harriman. Drive up the driveway and park behind the house. Follow the track 1400'. At this point a large white pine lies S.42°E. Bear S.21°E. 500' to outcrop. Stay in single file and protect blueberries.

Stop 11. Metasomatized Penobscot Formation. This outcrop is gneissic Penobscot infiltrated by myriad fine-grained irregular dikes. Two dikes of Lucerne Granite transect the complex. In places some of the earlier (Wallamatogus?) dikes appear to coalesce with the Lucerne, but most are clearly older. Fragments of Wallamatogus may be found in the Lucerne 2000 m (6600 feet) east of this locality, establishing the Lucerne as the younger of the two granites. The Wallamatogus magma infiltrated the host rock and added potassium to form alkali feldspar within the Penobscot Formation.

59.2 Turn right onto Route 175 north.

60.8 Cross U.S. 1 onto Route 46 north.

61.1 Turn right onto Route 46 north.

65.8 Turn left toward East Bucksport Church.

66.0 Turn right. Drive through area of large gravel pits. These "ice contact" deposits are at about 200' above sea level and represent glacial outwash channeled here to the southwest because of the resistant hills made up of Lucerne Granite to the east. The major lakes in the area all trend to the southeast and are parallel to the observed glacial striae.

67.1 Turn right.

68.4 Notice hills to the east which are outcrops of the Lucerne pluton.

68.7 Park along road. Note outcrops on left.

Stop 12. Stricklen Ridge pluton. This pluton is not well exposed except in the woods. This is the only exposure we shall see and it is not typical. It contains much more biotite than the usual outcrop of this granite in which muscovite and garnet are the common accessories. ALTHOUGH BETTER OUTCROPS MAY BE SEEN IN THE HORSE PASTURE WEST OF THE ROAD, YOU ARE REQUESTED NOT TO GO ONTO THAT PROPERTY IN A LARGE GROUP. The Stricklen Ridge pluton is intimately mixed with the pendants and inclusions of the host rocks, which are either Passagassawakeag gneiss or, as is the situation here, the Copeland Formation. In the pasture west of the road, fragments of an amphibolitic layer can be seen which more or less outlines the anticlinal structure at the northeast end of the horst in which the Passagassawakeag gneiss, Copeland schist, and Stricklen Ridge granite are found.

69.1 Bear left.

72.2 Turn right on paved road.

73.7 Continue straight west.

75.0 Mylonite zone in Passagassawakeag gneiss.

75.6 Continue straight on gravel road.

75.8 Cross major fault zone.

76.1 Cross Johnson Mill road.

77.6 Turn right onto Route 15 north.

78.5 R.R. Crossing.

83.1 Intersection Route 1A. End of trip. To reach Orono follow signs to I-95 North.

IGNEOUS PETROLOGY OF SOME PLUTONS IN THE NORTHERN PART OF THE PENOBSCOT BAY AREA

Appendix A

Subsurface Density Distributions East and Northeast of Penobscot Bay, South-Central Maine

John F. Sweeney
Gravity Division, Earth Physics Branch, Ottawa, Canada

Introduction

Gravimetric studies over granites and adjacent supracrustal rocks to the east and northeast of Penobscot Bay in south-central Maine* has defined the configuration of the granitic intrusives, contributed to our knowledge of their mode and time of emplacement and improved our knowledge of exposed and unexposed lithologies.

All felsic intrusives are associated with well defined gravity lows (Figs. 1 and 2) which has resulted in the determination of the following gravimetrically derived properties (granites are discussed in order of their occurrence moving south to north):

The Deer Isle pluton (Stonington and Oak Point granites) are up to four km thick with vertical near surface contacts and a well defined deep zone offset to the northern half of the model (Fig. 3). The model together with the pattern of isoanomaly contours over the body (Fig. 1) suggests that the two granites remain in contact in the subsurface.

The Sedgwick pluton center of gravity occurs under the southern half of its exposure (Fig. 1) where the association of the maximum anomaly gradient with the wallrock contacts indicates their near vertical nature. The northern half of the body has inward dipping contacts (Fig. 3) and, overall, the intrusive is up to five km thick.

The anomaly pattern over the South Penobscot pluton (Fig. 1) indicates a symmetrical mass distribution with respect to its exposure (at least in a north-south direction) with steep but inward dipping contacts. Model results (Fig. 3) bear this out. However, the surrounding geology is complex and subsurface density distributions adjacent to this pluton are, therefore, uncertain.

The gravity pattern over the Wallamatogus pluton (Fig. 2) cannot be separated from that due to the adjacent Lucerne pluton, therefore, the two plutons are modeled together (Fig. 4). The intervening septum of dense metasediments (ρ = 2.79 g/cm^3) has minimum effect on the anomaly pattern between the two plutons (Fig. 2) which indicates that the metasediments

*Gravity data over the Deer Isle pluton and the Sedgwick and South Penobscot plutons were obtained and analyzed by Abbey (1972).

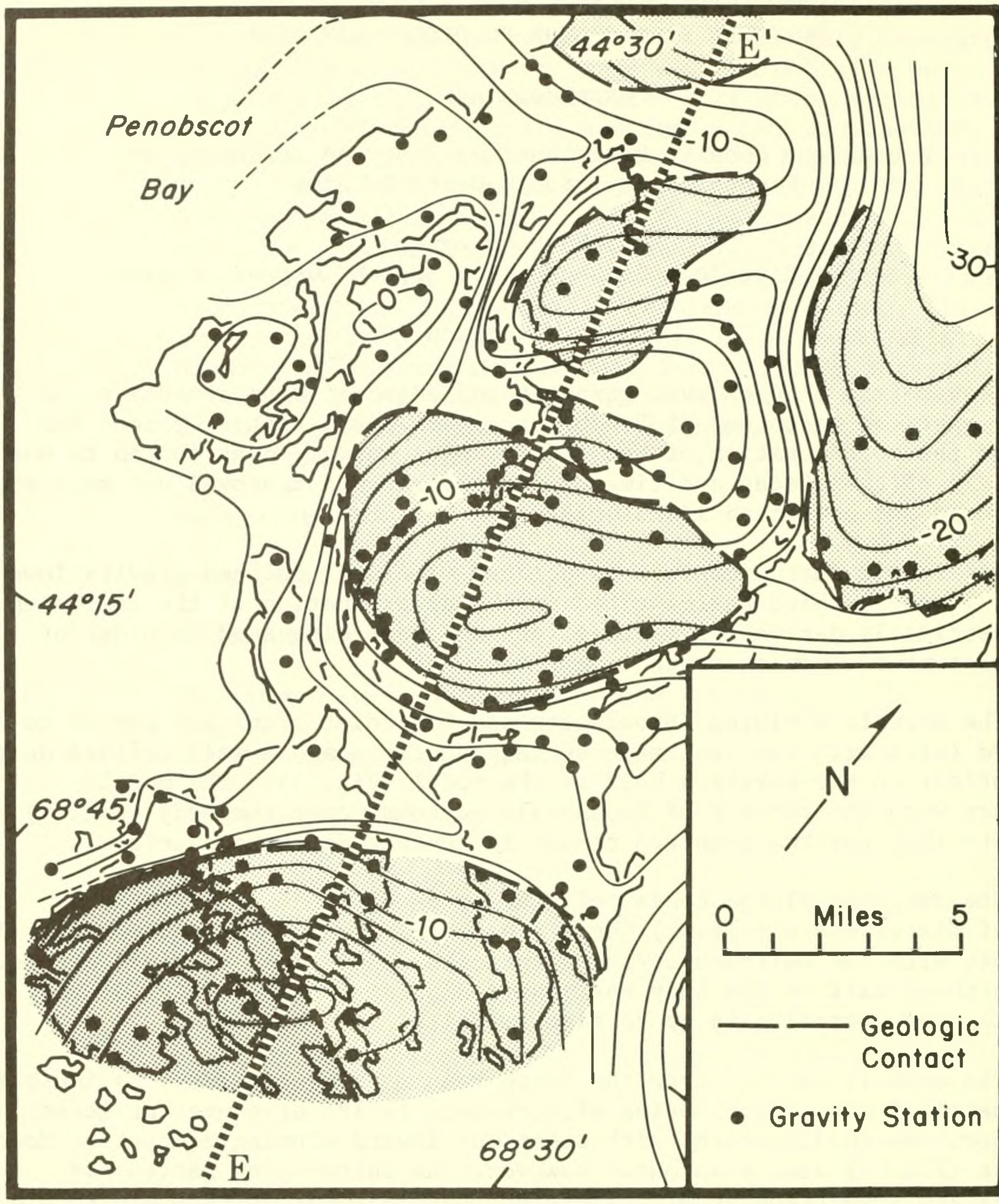

Figure 1. Bouguer anomaly map (two mgal contour interval) over the Deer Isle granites and, to the north, the Sedgwick and South Penobscot plutons. Redrawn from Abbey (1972).

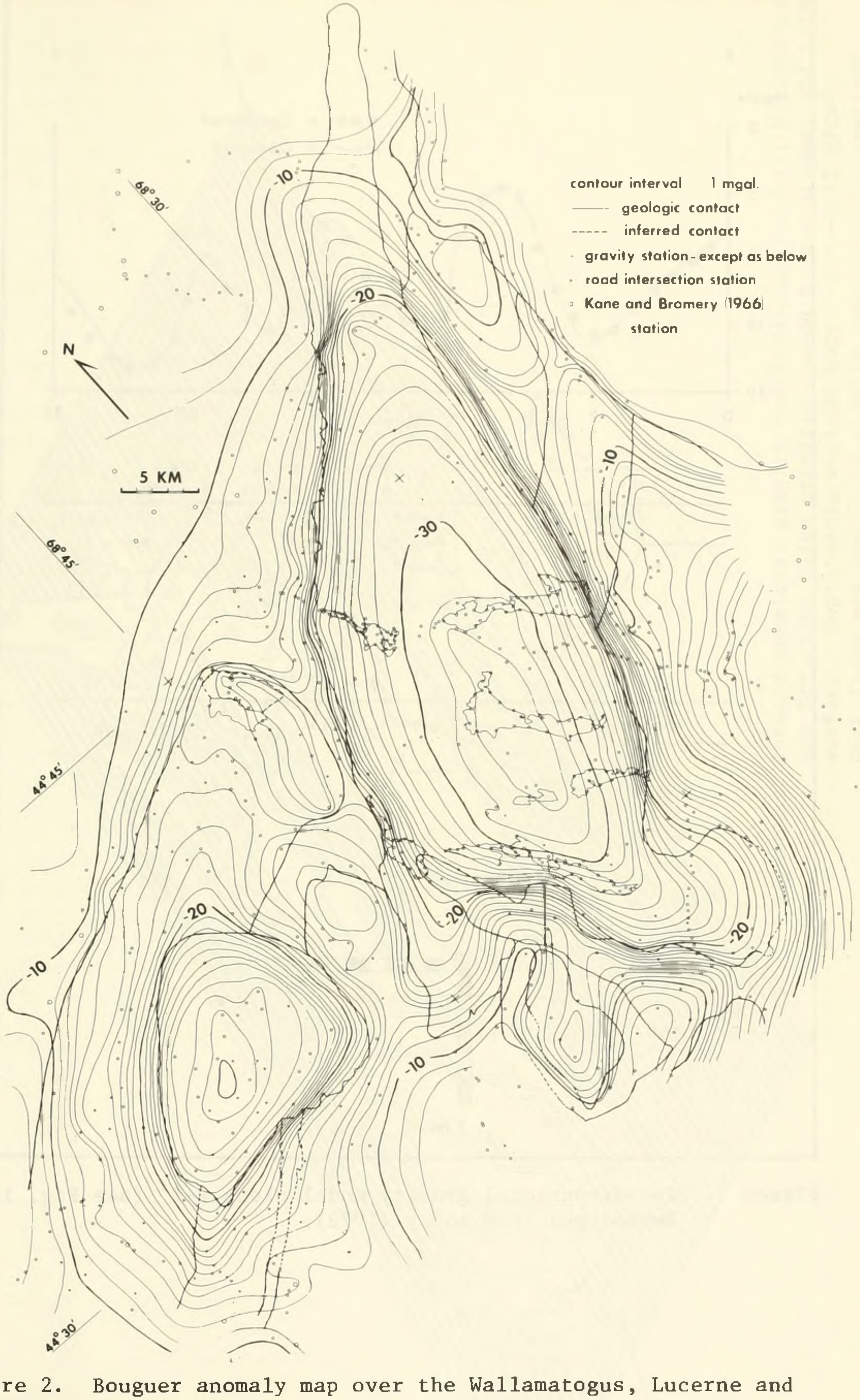

Figure 2. Bouguer anomaly map over the Wallamatogus, Lucerne and Stricklen Ridge plutons.

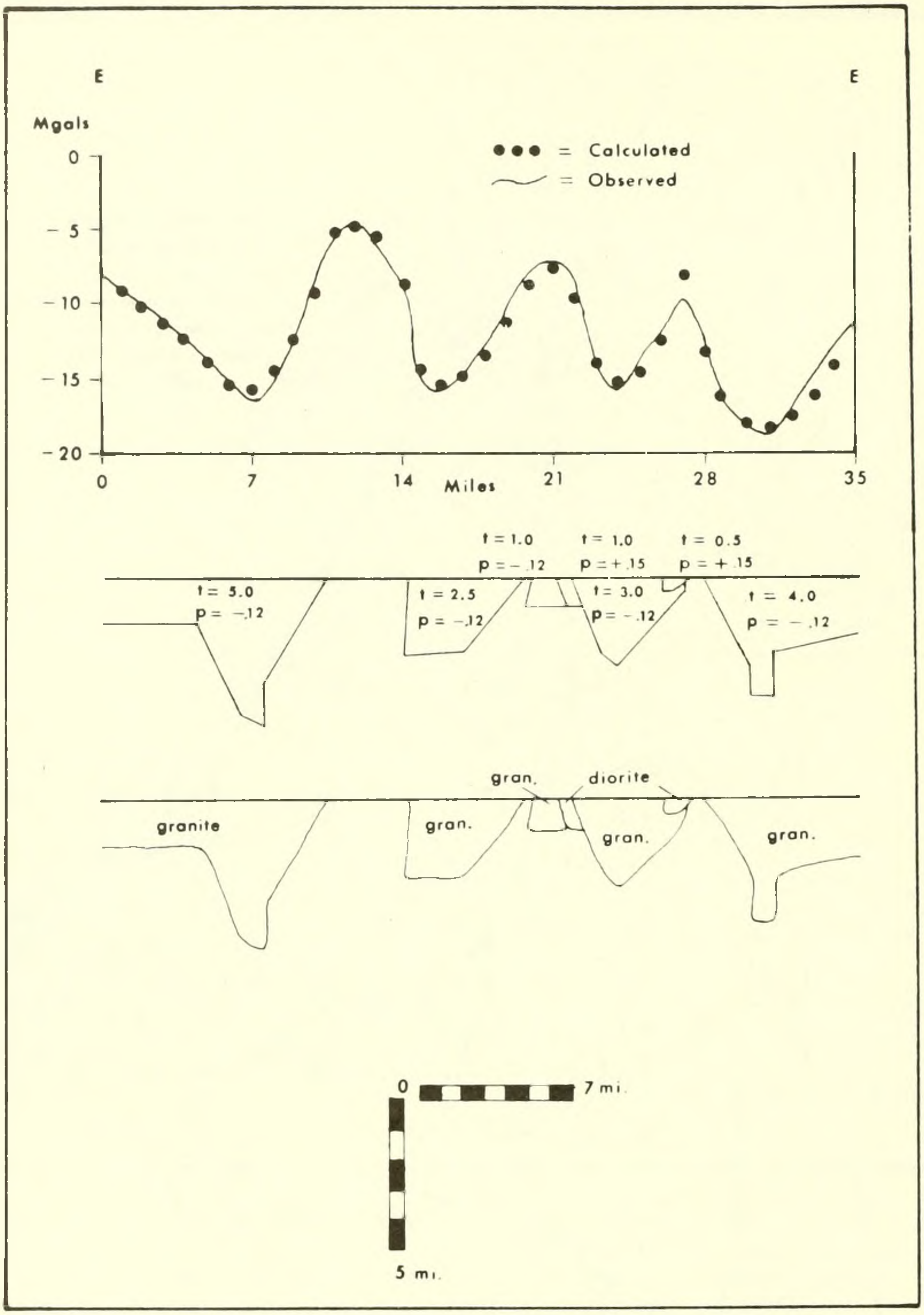

Figure 3. Two-dimensional gravity model along E-E' (see Fig. 1). Reproduced from Abbey (1972).

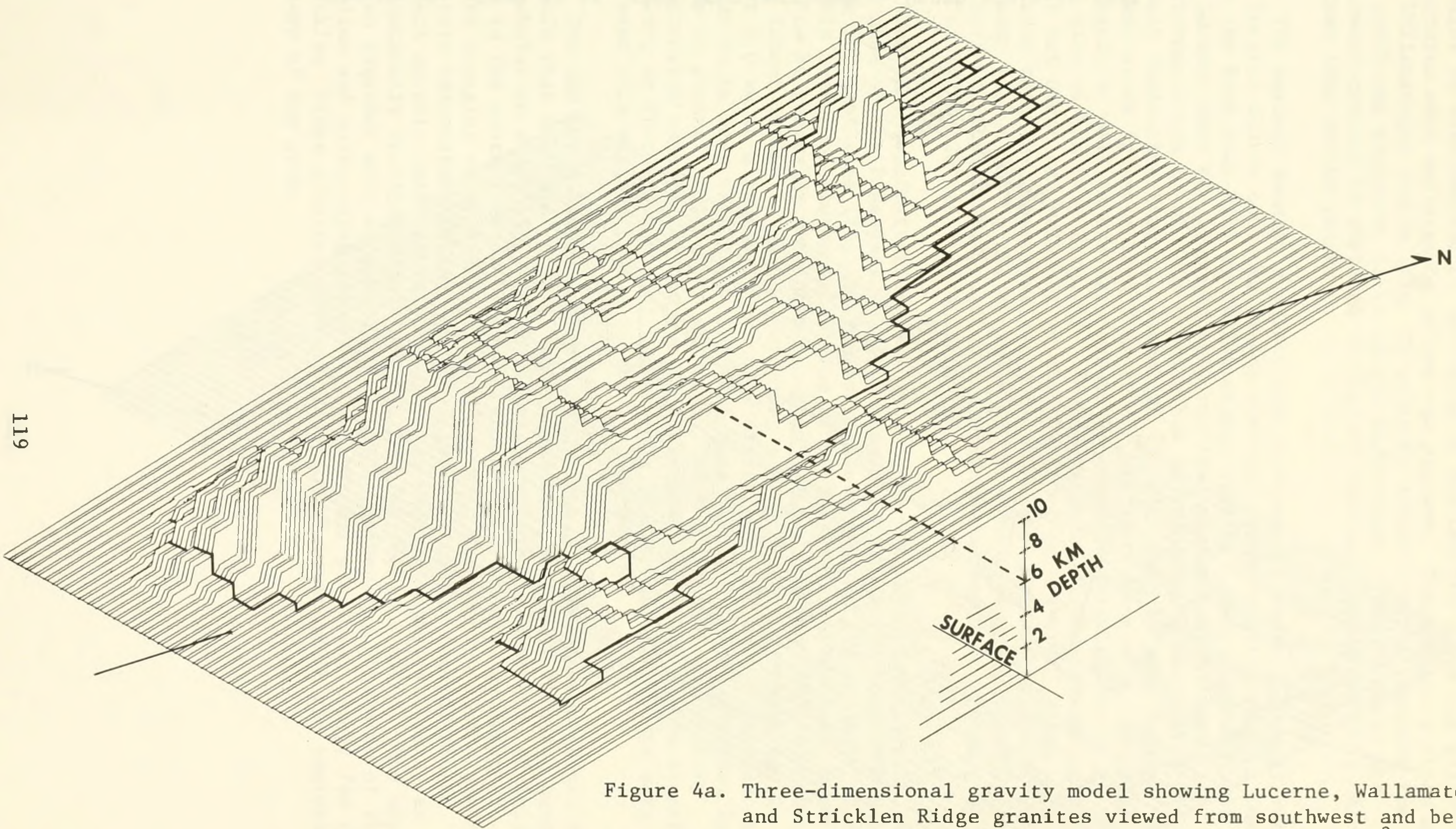

Figure 4a. Three-dimensional gravity model showing Lucerne, Wallamatogus and Stricklen Ridge granites viewed from southwest and below surface. Depth scale west of body. $\sigma = -0.12$ g/cm^3. Dark lines are surficial granite contacts. No vertical exaggeration.

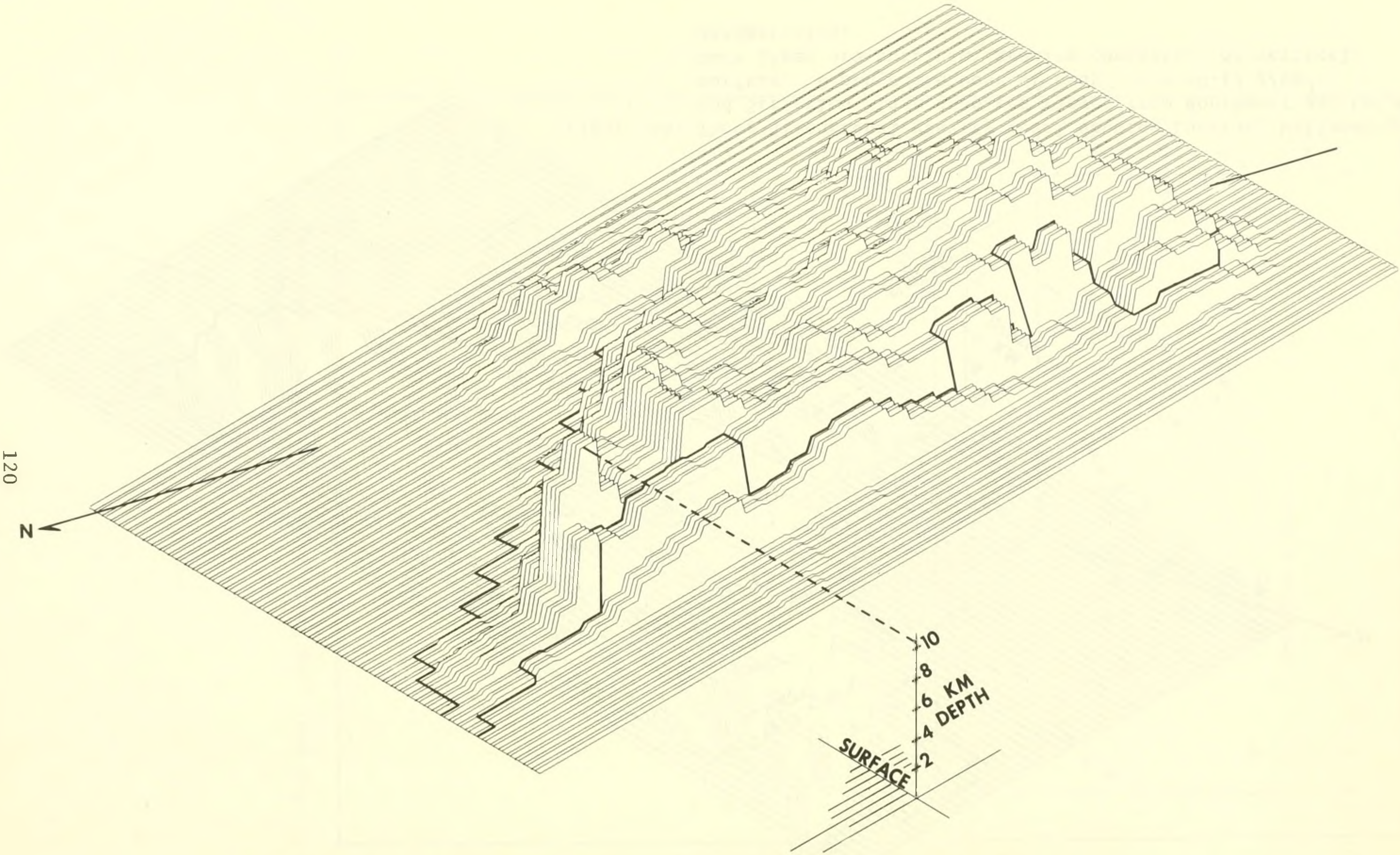

Figure 4b. Same as 4a, view from northeast. Depth scale is east of body.

are either quite thin or have been rendered similar in density to the granites by metasomatism or inclusion of low density dikes and sills associated with emplacement of the two plutons. The anomaly pattern over the Wallamatogus pluton (Fig. 2) suggests inward dipping contacts for the south and southwest parts of the body (Figs. 3 and 4) while the northwest contact is vertical to outward dipping. The Model (Fig. 4) is less than two km thick.

The maximum anomaly gradient zone corresponds remarkably well with the Lucerne pluton contacts except over the northernmost exposures and over the East Blue Hill and Wallamatogus plutons. This suggests that the Lucerne body has predominantly vertical contacts with depth. The northernmost ten km of this granite has no significant associated gravity anomaly indicating that the batholith is quite thin in this region. The deepest zones (greater than 7 km thick), which are somewhat linearly arranged, as well as the main volume of granitic material occurs on the east side of the body (Fig. 4). The significant thicknesses of granite built out under the wallrock on the east side of the model (Fig. 4b) indicate that the Lucerne-wallrock contacts dip very slightly toward the east (about 5°) in the region of maximum east-west surficial extent. The northwest contact is similarly inclined somewhat less steeply (as much as 15° to 20° east of vertical).

The north-south trending elongate anomaly trough over the isoclinal fold nose of the Passagassawakeag gneiss adjacent to the Lucerne pluton along its west side (Fig. 2) indicates the extent of the concentration of largely unexposed pluton called the Stricklen Ridge. Figure 4a shows the body to be generally over three km thick, 1.5 to 3.0 km wide and over 11 km long (about $10^2 km^3$ in volume) widening at its exposed northern end to about 5.0 km in a generally easterly direction. Its east side contacts appear to be near vertical. The west side contacts appear somewhat less steep in general and may dip outward. The influence of low density nonintrusive material within the Passagassawakeag gneiss may be significant, however, so that the apparent outward dip of the Stricklen Ridge body on its west side may not be due to the intrusive.

Two and three dimensional modeling based on gravity maps (Figs. 1 and 2) reveals that the major granite intrusives are relatively thin and equant to tabular in shape with steeply dipping contacts. Steepening of foliation dips in the contact zones of the Lucerne pluton, gravity evidence of upward dragging of modeled bodies adjacent to the Lucerne pluton and the moderate temperature maximum of the relatively narrow Lucerne pluton contact aureole indicate intrusion of the Lucerne magma, at least, as a plastically yielding highly viscous body, probably a solid. The apparent shapes together with structural and contact metamorphic features of the granites and surrounding rocks suggest that all granites, except for the Stricklen Ridge granite, were emplaced at a late stage in the tectonic history of the area.

The Stricklen Ridge pluton intrudes a high grade (sillimanite) gneiss. The gravity evidence (Fig. 2) shows this body to be elongated approximately perpendicular to regional foliation trends, not typical for stress induced accumulations. Also, the fairly steep anomaly gradients associated with this body indicate steep sharply defined contacts, not diffuse ones as might be expected with metamorphic accumulations. Hence, it is felt that the Stricklen Ridge pluton was originally an igneous intrusive which was subsequently metamorphosed and faulted.

References

Abbey, D. A., 1972, A Gravity Study of Several Maine Coastal Plutons, Southeastern Maine, MA Thesis, SUNY at Buffalo, 79 p.

Sweeney, J. F., 1971, Some Aspects of Two Granite Plutons in Southeastern Maine as Revealed by a Detailed Gravity Survey, Geol. Soc. Am. Abstracts with Programs, v. 3, no. 7, p. 726.

______________, 1972, Detailed Gravity Investigation of the Shapes of Granitic Intrusives, South-Central Maine, and Implications Regarding Their Mode of Emplacement, Ph.D. Thesis, SUNY at Buffalo, 117 p.

______________, 1973, Discovery of Intrusives and Subsurface Density Distributions, South-Central Maine, Trans. Am. Geophys. Union, v. 54, no. 4, p. 460.

IGNEOUS PETROLOGY OF SOME PLUTONS IN THE NORTHERN PART OF THE PENOBSCOT BAY AREA

Appendix B

D. G. Brookins, Department of Geology, University of New Mexico, Albuquerque, New Mexico 87131

Introduction

The purpose of this appendix is to familiarize the 1974 NEIGC participants with available radiometric age data for granitic rocks to supplement the report by Wones (this Guidebook). The locations with names of granites for which age data are available elsewhere in this Guidebook. As work is currently being carried out on these granites, many of the data are preliminary. The data in Table 1 are so marked to indicate which data are considered highly reliable, etc. Mineral K-Ar and Rb-Sr age data are reported separately from whole rock Rb-Sr data as discrepancies between mineral and whole rock dates are not uncommon.

Constants used for the age calculations are as follows: ^{40}K: $\lambda_e = 0.585 \times 10^{-10}/y$, $\lambda_B = 4.72 \times 10^{-10}/y$. ^{87}Rb: $\lambda_B = 1.39 \times 10^{-11}/y$. Standard methods were used for the Rb-Sr chemistry and mass spectrometry (e.g. for previously unreported dates; see also Brookins and others, 1973). The York least squares method has been used for Rb-Sr isochron construction and initial ratio (R_o) determination. Only the preliminary age data are given in Table 1; the complete set of data will be formally published later.

References

1 Faul, H., Stern, T. W., Thomas, H. H., and Elmore, P.L.D., 1963, Ages of Inclusion and Metamorphism in the Northern Appalachians: Am. Jour. Sci., v. 261, p. 1-19.

2 Brookins, D. B., and Sponner, C. M., 1970, The Isotopic Ages of the Oak Point and Stonington granites, Eastern Penobscot Bay, Maine: Journal Geology, v. 78, p. 570-576.

3 Brookins, D. G., and Wingard, P. S., 1973, K-Ar Dates from the Castine-Blue Hill Area, Maine, Isochron/West 8, p. 1.

4 Brookins, D. G., Berdan, J. M., and Stewart, D. B., 1973, Isotopic and Paleontologic Evidence for Correlating Three Volcanic Sequences in the Maine Coastal Volcanic Belt, Geol. Soc. Amer. Bull. 84, p. 1619-1628.

5 Brookins, D. G., In press, Geochronologic Contributions to Problems of Stratigraphy and Correlation in the Penobscot Bay Area, Eastern Maine with Regional Implications: in Symposium on New England Stratigraphy, Geol. Soc. America Memoir.

6 Brookins, D. G. (unpublished work).

7 Zartman, R. E., Hurley, P. M., Krueger, H. W., and Giletti, B. J., 1970, A Permian Disturbance of K-Ar Radiometric Ages in New England: Its Occurrence and Cause, Geol. Soc. Amer. Bull., v. 81, p. 3359-3373.

8 Metzger, W. J., and Bickford, M.E., 1972, Rb-Sr Chronology and Stratigraphic Relations of Silurian Rocks, Mt. Desert Island, Maine: Geol. Soc. America Bull., v. 83, p. 497-504.

Table 1: Age Data For Granitic Plutons

Granite	Age (m.y.)	R_o*	Method**	Reference
Stonington	350, 360	---------------	K-Ar B	1
Stonington	341 ± 21	0.7050 ± 0.0006	Rb-Sr WR	2
Oak Point	354	---------------	K-Ar B	1
Oak Point	343 ± 15	---------------	K-Ar B	3
Oak Point	357 ± 1	0.7045 ± 0.0001	Rb-Sr WR	2
Vinalhaven	361 ± 7	0.705 ± 0.001	Rb-Sr Wr	4
Sedgwick	413 ± 15	---------------	K-Ar B	3
Sedgwick	395 ± 15	0.706 ± 0.002	Rb-Sr WR	5
East Blue Hill	387	---------------	K-Ar B	1
East Blue Hill	391	(0.710)	Rb-Sr B	1
East Blue Hill	392 ± 12	0.707 ± 0.002	Rb-Sr WR	5
South Penobscot	360 ± 15	---------------	K-Ar B	3
South Penobscot	393 ± 15	(0.706)	Rb-Sr B	6
South Penobscot	403 ± 15	0.706 ± 0.002	Rb-Sr WR	6
Wallamatogus	379	---------------	K-Ar M	1
Wallamatogus	413	(0.710)	Rb-Sr M	1
Wallamatogus	330	---------------	K-Ar B	1
Wallamatogus	349	(0.710)	Rb-Sr B	1
Wallamatogus	(375 ± 20)	(0.715 ± 0.005)	Rb-Sr WR	6
Mt. Waldo	325	---------------	K-Ar B	7
Mt. Waldo	390 ± 10	0.705 ± 0.002	Rb-Sr WR	6
Lucerne	385	---------------	K-Ar B	1
Lucerne	402 ± 13	0.714 ± 0.002	Rb-Sr WR	6
Cadillac Mtn.	397	---------------	K-Ar B	1
Cadillac Mtn.	398	(0.710)	Rb-Sr B	1
Cadillac Mtn.	369 ± 35	0.7071 ± 0.0015	Rb-Sr WR	8
Somesville	389	---------------	K-Ar B	1
Somesville	419 ± 16	0.7060 ± 0.0026	Rb-Sr WR	8

* R_o = initial $^{87}Sr/^{86}Sr$; () indicate assumed values.

** B = biotite, M = muscovite, WR = whole rock