Bedrock Geology of the Grand Lake Area Aroostook, Hancock Penobscot, and Washington Counties, Maine

GEOLOGICAL SURVEY BULLETIN 1201-E

Bedrock Geology of the Grand Lake Area Aroostook, Hancock Penobscot, and Washington Counties, Maine

By DAVID M. LARRABEE, CHARLES W. SPENCER, *and* DONALD J. P. SWIFT

CONTRIBUTIONS TO GENERAL GEOLOGY

GEOLOGICAL SURVEY BULLETIN 1201-E

Description of the rocks and geologic structure of an area in eastern Maine

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1965

UNITED STATES DEPARTMENT OF THE INTERIOR

STEWART L. UDALL, *Secretary*

GEOLOGICAL SURVEY

Thomas B. Nolan, *Director*

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402

CONTENTS

ILLUSTRATIONS

TABLES

CONTRIBUTIONS TO GENERAL GEOLOGY

BEDROCK GEOLOGY OF THE GRAND LAKE AREA, AROOSTOOK, HANCOCK, PENOBSCOT, AND WASHINGTON COUNTIES, MAINE

By DAVID M. LARRABEE, CHARLES W. SPENCER, and DONALD J. P. SWIFT

ABSTRACT

The Grand Lake area in eastern Maine generally has low relief and contains widespread glacial drift and many lakes and swamps. It is underlain chiefly by metasedimentary rocks of Silurian and Silurian(?) age and to a lesser extent by rocks of Ordovician and possible Cambrian age. Intrusive rocks of Devonian age underlie more than a third of the area. Northeast-trending grabens in the metasedimentary and igneous rocks have preserved unmetamorphosed rocks of Late Devonian through Pennsylvanian age. A diabase dike, possibly 100 miles long, trends southwest; it is younger than the Devonian granitic intrusives.

The predominant metasedimentary rocks are metasiltstone, impure quartzite, slate, and quartzite metaconglomerate. Thin units of rhyolitic metatuff, thin black metachert, limestone metaconglomerate, phyllite, and schist are present. The metasedimentary rocks are isoclinally folded; dips are steep—in places beds are overturned—and folds trend northeast. Most major folds plunge to the northeast. The total thickness of the stratigraphic section is estimated to be at least 10,000 feet.

The plutonic rocks are chiefly quartz monzonitic granite, but a large body of gabbro-diorite is present in the southeastern part of the area. The contact-metamorphic aureoles are three-fourths of a mile or less in width and, compared with adjacent wallrock, are characterized by retrograded cordierite, traces of chalcopyrite, increased biotite content, magnetite, and small amounts of iron sulfides. Chiastolite and sillimanite also occur in the gabbro-diorite contact aureole.

Faults of two ages, pre-Devonian and post-Pennsylvanian, are probably present. Pre-Devonian faults trend northeast, and post-Pennsylvanian faults trend northeast and northwest. Faults of northwest trend are probably latest, and generally are of less significance. The series of post-Pennsylvanian faults of northeast trend extends across the southeastern part of the area and into New Brunswick for perhaps as much as 50 miles. The post-Pennsylvanian faults may have determined in large degree the course of the St. Croix River south of Vanceboro, Maine.

Only minor amounts of iron sulfides and traces of chalcopyrite were noted in the rocks, but the rocks of certain areas may be favorable for geophysical studies and increased geochemical exploration. Aeromagnetic, ground magnetic, and ground electromagnetic surveys were successfully used to trace certain rocks beneath thick glacial drift in the northern half of the area—the only place where such surveys were made.

INTRODUCTION

The Grand Lake area, Maine, as referred to herein, covers about 2,500 square miles and is chiefly between lats 45°00′ and 45°50′ and longs 67°30′ and 68°30′, or between the St. Croix River on the east and the Penobscot River on the west and the villages of Orient and Wesley on the north and south respectively (fig. 1, pl. 1). Generally the surface is low and rolling. Lakes and swamps are common. Outcrops, the basis of the study, generally are few, small, and widely scattered. The swamps are mainly inaccessible, owing to dense undergrowth or impassable muck. Waterways were traveled by canoe or by boat; dry areas were crossed by jeep or on foot. All passable roads in the area mapped in plate 1 were traversed, as were most railroad routes. Pace-and-compass traverses were made in the bush between access routes in those parts of the area studied in detail.

A unique topographic feature surrounding some lakes is the stone wall or ice rampart, termed "lake rampart" by Hitchock (1862, p. 302). Most shallow lakes are at least partly surrounded by these ramparts, which range from 3 to 6 feet in height, average about 4 feet, and are highest on the northeast shore of West Musquash Lake. On the Danforth topographic quadrangle map, some of the ramparts are shown by contours around lakes, such as Baskahegan Lake. The boulders composing the stone walls or ramparts range in diameter from 1 to 6 feet but commonly are about 18 inches. Boulder pushing by modern ice that formed these wall-like features is indicated by troughs or grooves in the bottom sand of shallow water. The grooves are as much as 20 feet long, 1 foot wide, and 4 inches deep, and 18-inch boulders occupy the shoreward head of the troughs. These troughs are especially well formed near the west shore of Lower Hot Brook Lake in the Danforth quadrangle.

A belt of intrusive rocks extends southwest from Bathurst, New Brunswick (see "Geological map of the Maritime Provinces," Canada Geol. Survey, 1949) into eastern Maine, where it ends. The primary purpose of the investigation was to study the geology of the area at the end of this belt. Interest in this area was partly a result of the discovery of zinc-lead-copper deposits southwest of Bathurst (Canada Geol. Survey, 1957a). The project was originally designed to map the bedrock of only the Danforth quadrangle but later was expanded to include a much larger area.

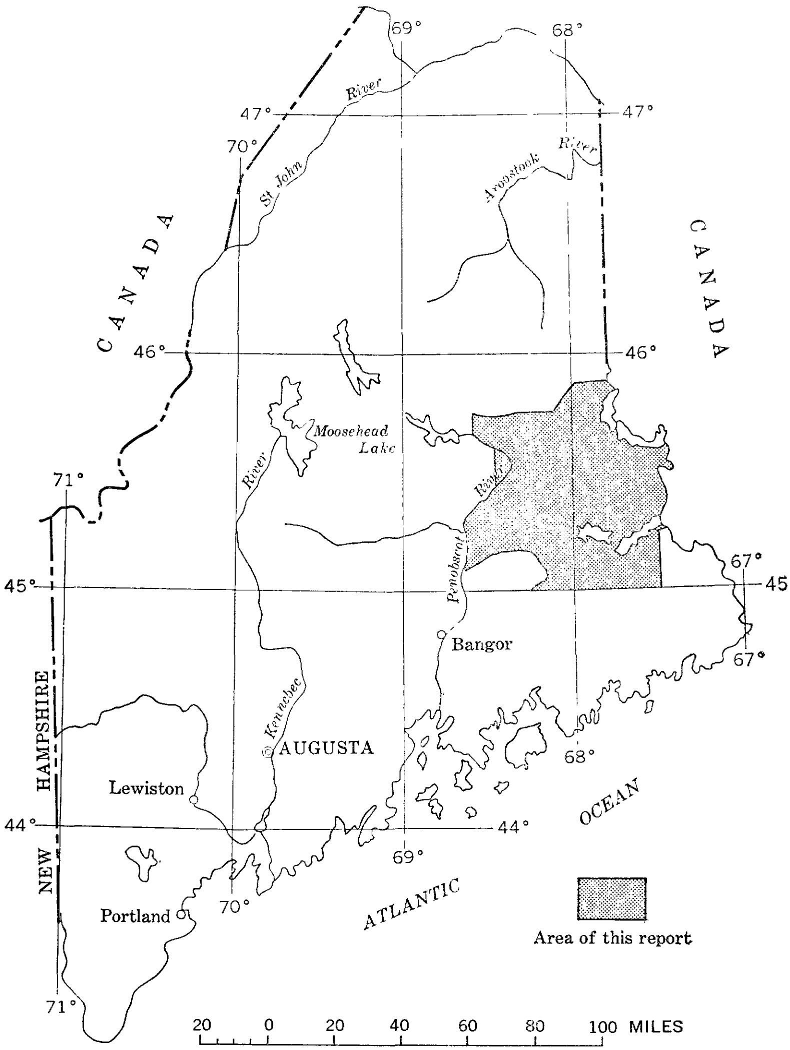

FIGURE 1.—Location of report area.

Detailed studies were made of a few quadrangles and of smaller selected areas; the results of this work were used as sources of information for reconnaissance mapping in the intervening areas. The final map (pl. 1) reflects new and additional information and geologic considerations and supersedes certain interpretations implicit in some of the earlier published maps for which we were responsible (Griscom and Larrabee, 1963; Larrabee and Spencer, 1963).

The metasedimentary rocks were assigned ages on the basis of: Collection of fossils obtained at only three localities (two of which yielded little evidence), widely scattered structural evidence of stratigraphic succession, and well-defined graded bedding and crossbedding in a few rock units. The paucity of outcrops and key beds in most of the area studied and the presence of similar lithologic units associated with rocks of apparently different ages have increased the difficulties of mapping the bedrock of this area. None of the very few published geologic maps of adjacent areas shows metasedimentary rocks of unquestioned age that extend into the Grand Lake area.

In 1954 the senior author spent 1 week reconnoitering the area, and in 1956 the project was undertaken by the Geological Survey as part of a program recommended by the President's Cabinet Committee on Minerals Policy (Nov. 30, 1954). C. W. Spencer was partner in the project in 1956 and 1957, and D. J. P. Swift ably served as field assistant during the summers of 1958 and 1959. Fieldwork was recessed in 1960, and in 1961 the senior author spent 6 weeks doing reconnaissance work. In 1962 Sven S. Svenson served as field assistant during mapping of the southeastern part of the area. The senior author accepts the responsibility for all geologic interpretations given herein.

Many place names used in this report could not be shown on the geologic map at the published scale. All rivers, lakes, or places may be located on the U.S. Geological Survey topographic quadrangle maps referred to herein.

Acknowledgments.—Locally, special assistance was given by the following individuals and companies: Mr. and Mrs. Larry Rideout, of Rideouts' Camps, Danforth; Mr. Paul Gilpatrick, Danforth; Mr. Beecher Scott, St. Croix, New Brunswick; officials of the St. Croix and St. Regis Paper Companies; the Eastern Corp.; and the Dead River Co. Woodsmen and others too numerous to list helped in many ways, particularly in the all-important matter of access.

Thanks also are given to Prof. J. B. Thompson, Jr., of Harvard University; Messrs. L. M. Cumming and W. H. Poole, of the Geological Survey of Canada; Mr. J. C. Smith, Chief Geologist of the New Brunswick Department of Lands and Mines; Mr. W. M. Tupper, of Carleton University, Ottawa, Ontario, for technical review of parts of the map; and to Mr. Dewey Amos, of Southern Illinois State University, for use of his unpublished manuscript and map of the geology of the Calais and Robbinston quadrangles. Mr. Bradford A. Hall, of the University of Maine, kindly furnished data on the Nicatous Lake quadrangle. The assistance of colleagues in the U.S. Geological Survey who reviewed various maps and manuscripts related to the area is likewise appreciated.

R. W. Bromery, F. C. Frischknecht, and J. W. Allingham were in charge of various geophysical studies made in the Danforth area at our request. Andrew Griscom was responsible for a most helpful aeromagnetic map of part of the area, prepared subsequent to geologic mapping. After the southeastern part of the area was mapped, M. F. Kane made gravity studies there. F. C. Canney was in charge of analysis of samples taken for geochemical exploration. Age determination of plutonic rocks were made by Henry Faul and analysts working under the direction of S. S. Goldich; rock analyses were made by members of the U.S. Geological Survey. The few fossils collected were identified by R. B. Neuman and W. A. Oliver, Jr., also of the U.S. Geological Survey.

GEOLOGY

Nineteen rock formations, rock units, or groups of units (table 1) have been mapped in the area; they range in age from Cambrian or Ordovician to Pennsylvanian. Metasedimentary rocks are older than Devonian, and sedimentary rocks are of Late Devonian through Pennsylvanian age. Intrusive rocks are chiefly of Devonian age; however, a diabase dike cuts the oldest Devonian granitic rocks and may therefore be Late Devonian or younger.

METASEDIMENTARY AND SEDIMENTARY FORMATIONS

CAMBRIAN OR ORDOVICIAN, UNDIFFERENTIATED

QUARTZITE AND COLORED SLATE

Perhaps 2,000 feet or more of argillaceous and chloritic quartzite, sandy metasiltstone, thin beds of green slate, and scarce thin beds and lenses of red and purplish-gray slates composes the rocks of this unit. The quartzite and sandy metasiltstone, commonly in beds ¼ to ½ inch thick, separated by paper-thin laminae of green slate, display minute crumpling by slippage along the slate laminae, and a later foliation. This predominantly impure quartzite unit contains beds and lenses of green slate from a few inches to 2–3 feet thick and, in a few places, lenses of red to purplish-gray slate 1–6 inches thick and commonly less than 100 feet long. At Knownothing Cove in Baskahegan Lake (Larrabee and Spencer, 1963), a few ⅛-inch nodules, originally hematite but now replaced by silica, occur in red slate. Exposures of a thin granule metaconglomerate containing blue quartz and pink feldspar are scarce.

These rocks are best exposed along the southeast and south shores of Baskahegan Lake (Larrabee, 1963e; Larrabee and Spencer, 1963). The purplish-gray slate, locally much thicker than along Baskahegan Lake, is exposed along U.S. Route 1 in the southeast corner of the Danforth quadrangle. The rocks extend northeastward into the Forest quadrangle (Larrabee, 1963a), where they are well exposed on islands and on the east shore of Drake Lake. All rocks except the

TABLE 1.—*Stratigraphic summary*

[Lithology: (M), magnetic survey made; (E), electromagnetic survey made]

Geologic time period	Rock unit	Radiometric age (in million years)		Lithology (thickness in ft)	Topographic expression	Quadrangle where best exposed	References
		Potassium-argon	Lead-alpha				
	Diabase dike			Medium grained; 200 (max). (M)	Low	Danforth	Griscom and Larrabee (1963).
Devonian through Pennsylvanian	Conglomerate and quartzite.			Hard, red quartzite conglomerate, gray quartzite conglomerate, and gray quartzite. Conglomerates contain pebbles and cobbles of quartzite, volcanic rocks, and, rarely, very fine grained light-gray biotitic granite. Total >500(?).		Nicatous Lake	Larrabee (1963d).
Devonian through Mississippian	Conglomerate and siltstone.			Soft, red conglomerate with calcareous cement; pebbles and cobbles of siltstone, quartzite, volcanic rocks; soft, red siltstone. Total >500(?).		Kellyland and Waite.	Larrabee (1963b, g).
Devonian	Quartz monzonite at Center Pond.	[1] 349, [2] 360	[1] 370, [2] 340	Commonly gray, coarse, in places porphyritic and slightly foliated biotitic quartz monzonite and granite.	Low, hilly; lakes formed.	Winn	Larrabee (1963i).
	Bottle Lake Quartz Monzonite.	[1] 342, [2] 370	[1] 410, [2] 380	Gray or pink, coarsely porphyritic biotitic or hornblendic quartz monzonite and granite.		Springfield, Scraggly Lake.	Larrabee (1963f,1964a [3]).
	Topsfield granitic facies.	[2] 372	[2] 400	Red coarse leucocratic quartz monzonite and granite; gray near north contact on Tomah Mountain.	High	Waite	Larrabee (1963g; 1964a [3]).
	Wabassus Quartz Monzonite.	[2] 356	[2] 420	Gray or pink, medium-grained biotitic or hornblendic quartz monzonite and granite.	High; lakes formed.	Wabassus Lake	Larrabee (1964a, b [3]).
	Love Ridge Quartz Monzonite.			Light-gray fine-grained biotitic quartz monzonite and granite.	High	Big Lake	Larrabee (1964b [3]).
	Chiputneticook Quartz Monzonite.	[2] 400	[2] 515	Light-gray coarse porphyritic biotitic quartz monzonite and granite; rapakivi texture common.	Low, hilly; lakes formed.	Danforth	Larrabee and Spencer (1963); Larrabee (1963b [3]).

	Pocamoonshine Gabbro-Diorite.		Gray-green to black olivine and hornblende gabbro; speckled hornblende diorite; gray granodiorite in Waite quadrangle.	Low; lakes formed.	Big Lake	Larrabee (1964b [3]).
Silurian	Slate at Baskahegan Stream.		Gray, calcareous slate and metasiltstone; 1,000+(?).	Low		Larrabee and Spencer (1963).
	Daggett Ridge Formation.		Gray-green quartzite metaconglomerate; quartzite; magnetite-bearing black slate and metasiltstone; tuffaceous metasiltstone; 2,000+(?). (M)	High; ridges formed.	Danforth	Larrabee and Spencer (1963); Griscom and Larrabee (1963); Larrabee (1963b [3]).
	Metasiltstone and slate.		Gray, carbonate-rich interbedded metasiltstone and slate; impure quartzite; granule metaconglomerate; tuffaceous metasiltstone; 2,000+(?).	Low to moderate.	Springfield, Danforth, Mattawamkeag.	Larrabee (1963c, f); Larrabee and Spencer (1963).
	Limestone metaconglomerate at Croperly Turn.		Gray limestone and siltstone metaconglomerate; 200.	Low	Danforth	Larrabee and Spencer (1963).
Silurian(?)	Kellyland Formation		Gray, carbonate-bearing interbedded metasiltstone and slate; impure quartzite; granule metaconglomerate; tuffaceous metasiltstone; 2,000+(?).	Low; lakes and swamps formed.	Kellyland, Big Lake.	Larrabee (1963b [3]).
Ordovician	Black slate, metachert, and tuff at Snow Mountain.		Black carbonaceous graptolite-bearing slate and thin metachert: weathers white and is commonly silicified; gray rhyolite metatuff containing lenses and balls of metachert; gray slate and metasiltstone; 1,000+(?). (E, M)	High	Danforth, Springfield.	Larrabee and Spencer (1963); Griscom and Larrabee (1963); Larrabee (1963f).
	Thick black slate and metasiltstone.		Soft, black slate and metasiltstone; exposed only in drill cuttings; 500(?).	Very low; swamps formed.	Danforth	Larrabee and Spencer (1963).
	Dark Argillite Division of Charlotte Group of Alcock (1946a, b).		Dark-gray to black slate and metasiltstone; phyllite; biotite and sillimanite schist; quartzite; and carbonaceous slate.	Low to hilly	Big Lake	Larrabee (1964b); Amos (1963).
Cambrian or Ordovician	Metasedimentary rocks.		Green argillaceous quartzite containing thin green slate beds and minor lenses of maroon and purple slate; 2,000(?).	Low	Danforth, Scraggly Lake.	Larrabee and Spencer (1963); Larrabee (1963e).

[1] H. Thomas, R. Marvin, and P. L. D. Elmore (written commun., July 2, 1962).
[2] Faul and others (1963).
[3] Stratigraphic unit named in the publication cited.

red slate crop out along the Maine Central Railroad between Forest and Tomah Stations, where they are strongly contorted. The impure quartzite exhibiting crumpled bedding and foliation, some green slate, and quartz-granule metaconglomerate crop out along Maine Route 6 west of East Musquash Lake.

There is some question whether the foliated and crumpled slaty layers in quartzite result from one or two separate and distinct periods of folding. If slippage along the now-slaty films and accompanying folding and crumpling was the sole cause, then the rocks are of Silurian age as indicated by Larrabee and Spencer (1963). However, if two periods of deformation occurred, as is now believed likely, the rocks are of Cambrian or Ordovician age.

These rocks resemble rocks of the Tetagouche Group of Ordovician age in New Brunswick (Canada Geol. Survey, 1957a), in that they include red slates containing small red nodules (although not of manganese minerals). They differ from the Tetagouche in the lack of closely associated volcanic rocks. They resemble the Grand Pitch Formation of late Precambrian or Early Cambrian age, in northeastern Maine (Neuman, 1962, 1964), in that green and red slates are interbedded with impure quartzite. The slate is in thin lenses here, whereas in the Grand Pitch locality the individual lenses are thicker and have a much greater aggregate thickness. These rocks of doubtful age more closely resemble those of the Grand Pitch Formation than those of the Tetagouche.

Several chloritic argillaceous quartzite outcrops on the south shore of Fourth Machias Lake, Nicatous Lake quadrangle (Larrabee, 1963d), are probably part of this unit. To the south, along the road in the northern part of the Lead Mountain quadrangle (fig. 2), outcrops of fine-grained purplish-gray pyritic biotitic quartzite, dark-gray metasiltstone and slate, and dark-gray quartz-sericite schist are also thought to be part of the unit and to extend into the southern part of the Nicatous Lake quadrangle because of the presence of glacial float. However, it is by no means certain that all these last-named rocks south of Nicatous Lake are Cambrian or Ordovician; they might well be part of the Dark Argillite Division of the Charlotte Group of Alcock (1946a, b), described in the next section of this report.

Although outcrops are lacking over wide areas where needed for determination of structural and stratigraphic relations with rocks of other ages, the rocks of Cambrian or Ordovician age are thought to have been faulted up into younger metasedimentary rocks prior to intrusion of the quartz monzonites. However, these areas in which structural relations are undetermined might contain unfaulted anticlines, and the rocks that would normally overlie them might be either missing or covered.

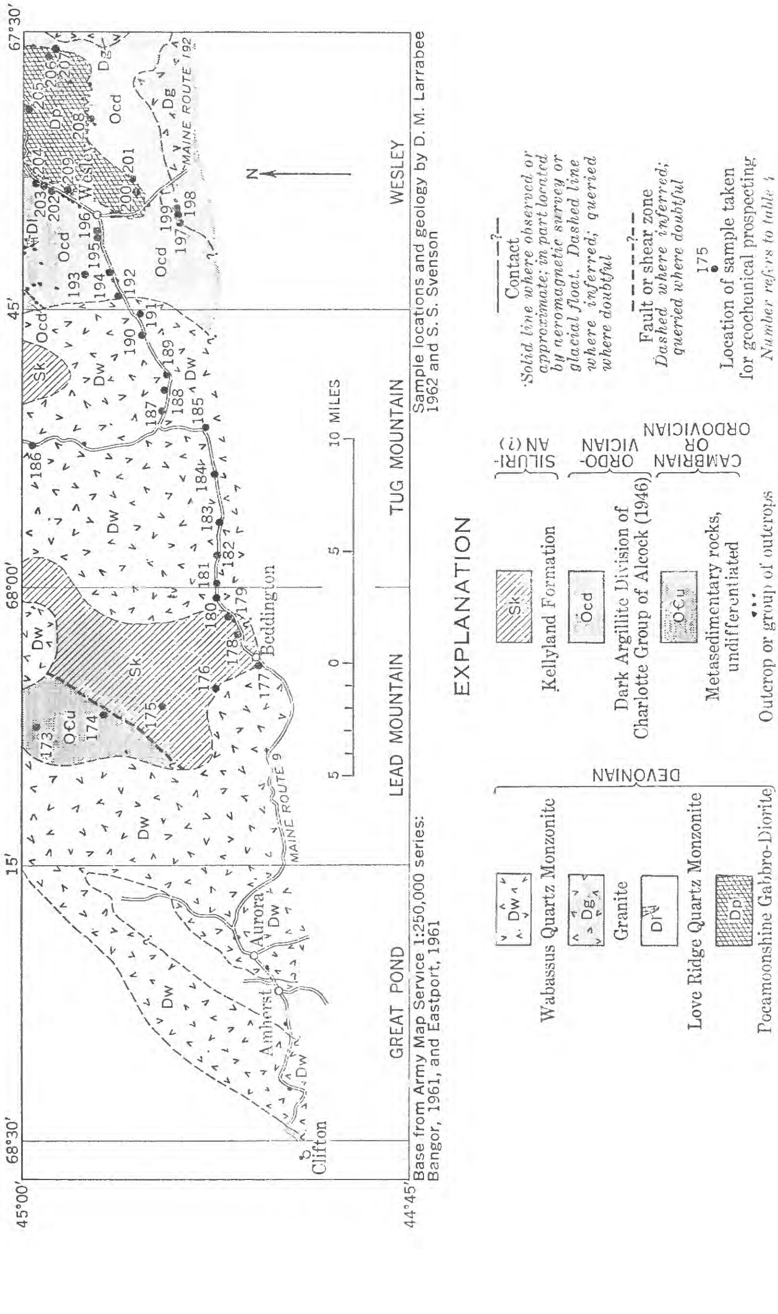

FIGURE 2.—Sample localities for geochemical exploration, and reconnaissance geology of the Beddington-Wesley area, Maine.

ORDOVICIAN

DARK ARGILLITE DIVISION OF THE CHARLOTTE GROUP OF ALCOCK (1946a, b)

The Dark Argillite Division exposed in the Big Lake quadrangle (Larrabee, 1964b) includes dark-gray or black phyllite and schist, gray argillaceous slightly metamorphosed sandstone and dark-gray metasiltstone, quartzite, thin gray slate, and black carbonaceous slate similar to rocks on Cookson Island, New Brunswick, which contain graptolites of Early Ordovician age (L. M. Cumming, R. B. Neuman, and V. G. Walmsley, written commun., Oct. 2, 1962). Tuffaceous beds occur west of North Beaverdam Lake. A careful search for graptolites in the bluffs and low outcrops along the east shore of Pocamoonshine Lake might be more fruitful than our own hasty attempt at collecting in 1962.

In the Wesley quadrangle (Larabee, 1963h), south of the area of plate 1, tuffaceous beds occur on the shore of Second Chain Lake. Most of the unit in the northwestern part of this quadrangle consists of impure gray quartzite and thin phyllitic slate, but quartz-biotite schist also occurs. Interbedded thin white quartzite and dark-gray slate occur on the point one-quarter of a mile northwest of the thoroughfare between First and Second Chain Lakes, and thin quartz-granule metaconglomerate occurs on the shore of Second Chain Lake near the north edge of the quadrangle. The Dark Argillite Division of the Charlotte Group is characterized generally by a meager carbonate content and is more tightly folded and intensely metamorphosed than the Pale Argillite Division of the Charlotte Group of Alcock (1946a). The Pale Argillite Division has been assigned to the Kellyland Formation of Silurian(?) age (Larrabee, 1963b) and as such will be described later. Most outcrops along Maine Route 9 northeast of Wesley are iron stained and in a hornfels zone.

BLACK SLATE, METACHERT, AND TUFFACEOUS ROCKS OF SNOW MOUNTAIN

The rocks include interlayered thin black carbonaceous graptolite-bearing slate, as well as metachert beds one-quarter to 1 inch thick; rhyolitic tuffaceous metasedimentary rocks, in places weathering white, wholly or partly silicified, and containing lenses and balls of gray metachert; and brown-weathering gray slate and metasiltstone. The rocks are well exposed on the north and northwest slopes of Snow Mountain in the Danforth quadrangle (Larrabee and Spencer, 1963) and also along the lumber road on the east slope of Stetson Mountain. The graptolite-bearing slate and metachert are best exposed in a roadcut 1.5 miles northwest of Danforth, along the road to South Bancroft. Fossils were collected here in 1956, and some of them had been replaced by thin films of marcasite. They were identified as "* * *

Orthograptus sp and *Climacograptus* sp., portion of a branching form, probably a leptograptid; by itself the assemblage could be of either Middle or Late Ordovician age" (R. B. Neuman, written commun., Dec. 9, 1962). Outcrops of nonsilicified tuff are along Maine Route 169 near Upper Hot Brook Lake.

The metatuff, silicified in many outcrops in the Danforth and Springfield (Larrabee, 1963f) quadrangles, is calcareous in some places, as along Maine Route 6 at the west edge of the Scraggly Lake quadrangle (Larrabee, 1963e) and in the eastern part of the Springfield quadrangle. The resistant, silicified metatuff and associated black metachert and slate underlie most north-trending ridges, except those in the northern part of the area studied, which are underlain by hornfels; and they extend southwestward through Stetson Mountain in the Danforth quadrangle into the Springfield quadrangle, where they are present on Tolman Hill, Gates Hill, and elsewhere between Tolman School and Almanac Mountain. Pyrite and traces of pyrrhotite have been observed throughout the length of this unit; these minerals are more abundant within the hornfels zone of the quartz monzonite. Fine-grained almandite garnet in a thin lens less than 1 foot long was noted 0.6 mile southeast of South Springfield, but the outcrop was obliterated after 1954.

A considerable (500 ft (?)) thickness of black slate and metasiltstone underlies the rocks just described. The magnetic characteristics and topographic expression of the slate and metasiltstone are very different from those of the rocks of Snow Mountain (Griscom and Larrabee, 1963). The slate and metasiltstone are extremely soft and underlie swampy areas. Only cuttings and sludge from a well drill hole were available for study.

SILURIAN(?)

KELLYLAND FORMATION

The Kellyland Formation of Silurian(?) age (Larrabee, 1963b) is composed of interbedded sericitic pale-gray metasiltstone, arenaceous metasiltstone, argillaceous metasandstone and quartzite, and thin beds of darker gray slate. Average slate content of the rock is about 20 percent. Most beds contain 5 percent or more iron and calcium carbonates, a fact noted by MacKenzie (1940) but unrecognized in recent descriptions of the rocks referred to heretofore as the Pale Argillite Division of the Charlotte Group of Alcock (1946a). The metasiltstone and metasandstone beds contain more carbonate than does the slate, and some coarser beds are tuffaceous. Slate beds range locally from one-eighth inch to 4 feet in thickness; metasiltstone and metasandstone beds range from 4 inches to a maximum of 20 feet in thickness. Thinly laminated layers of light and dark metasandstone are scarce, as are thin beds of quartz-granule metaconglomerate associated with metasandstone and quartzite beds. Graded bedding and crossbedding are well displayed in most metasiltstone outcrops.

The largest outcrop of the Kellyland is at Grand Falls of the St. Croix River, near Kellyland, Maine (Larrabee, 1963b); here there is considerable range in thickness of medium-light-gray to medium-gray sericitic metasiltstone, sandy metasiltstone, and slaty metasiltstone having variable carbonate content, and phyllitic gray slate. Some thin lenses of black pyritiferous slate occur. Isoclinal folds, characteristic of the St. Croix River area, are well exposed here. In a strip 32 feet across strike, the measured thickness of metasiltstone ranged from 2 inches to 6 feet, and of slate from one-half to 24 inches. In this short strip are 46 alternating beds. This rock is best exposed, areally, in the strip along the St. Croix River from Vanceboro to Grand Falls. The thickness of the formation is not known because of small tight isoclinal folds and lack of key beds and continuous outcrops, but it doubtless exceeds 2,000 feet. Most wells in this formation yield hard water.

In the Nicatous Lake quadrangle (Larrabee, 1963d), south of the area shown as underlain by Kellyland, is a lenslike mass of light- and dark-gray thin-bedded metachert and metasiltstone, in places carbonate bearing. Some medium- to dark-gray impure quartzite is present. Silicified parts are irregularly distributed, and the degree of silicification varies in a hand specimen. Silicified breccia is locally abundant; pyrite is common. This rock unit might be Kellyland Formation silicified along a fault zone, or it might be an entirely different unit not heretofore observed in the general area.

No fossils definitely from the Kellyland Formation have been reported. Fragmental plant remains reported by MacKenzie (1940) might be from the Kellyland or from downfaulted blocks of Late Devonian through Mississippian age. Such blocks are known in this general area in New Brunswick and Maine.

Geologists who have studied the Charlotte Group of Alcock (1946a, b) have recognized the need for subdivision of this group beyond the present Pale and Dark Argillite Divisions. The starting point for such subdivision must be at formation level (Am. Comm. Strat. Nomenclature, 1961). To accomplish this, the rocks exposed along the St. Croix River between Vanceboro and Kellyland, Maine, were described, and the name Kellyland Formation and age Silurian(?) were assigned to them (Larrabee, 1963b). East of the river these rocks had been mapped as Pale Argillite Division (Alcock, 1946b) of Ordovician or earlier age. The relative ages of the Pale and Dark Argillites have long been questioned, but we are in agreement with Alcock in believing that the Pale Argillite is younger than the Dark Argillite, chiefly because it has been less folded and has been regionally metamorphosed to a lower grade.

The Kellyland is considered to underlie the Daggett Ridge Formation of Silurian age (Larrabee, 1963b) on the basis of obscure structural relations in the eastern part of the area, and to overlie the Dark Argillite on the basis of considerable stratigraphic evidence of graded bedding and crossbedding. The Kellyland may be the equivalent of the lower slate and siltstone unit in the Danforth quadrangle, where that unit underlies the Daggett Ridge Formation and overlies the limestone metaconglomerate at Croperly Turn.

The age of the Kellyland (Pale Argillite Division of the Charlotte Group) still is in doubt; we believe it to be Silurian, but it might be Ordovician.

SILURIAN

LIMESTONE METACONGLOMERATE AT CROPERLY TURN

The rock exposed in the pastures at Croperly Turn along the road from Danforth to South Bancroft (Larrabee and Spencer, 1963) is a metamorphosed limestone and siltstone metaconglomerate containing pebbles one-half inch or less in diameter and many fragments of crinoid stems, corals, and bryozoa. The rock is best exposed along U.S. Route 1 about 2.5 miles north of Danforth, where cobbles are as large as 14×3 inches but average less than 4×2 inches, and where the metaconglomerate contains and is bounded by layers of light- and dark-gray thermally metamorphosed metasiltstone; the carbonate pebbles and cobbles have been contact metamorphosed into marble. Cobbles as much as 4×6 inches and pebbles of coral occur; two specimens of *Tryplasma* sp., "limited to rocks of Silurian and Early Devonian age" (R. B. Neuman, R. S. Boardman, and W. A. Oliver, Jr., written commun., Jan. 8, 1958) were found. Also from the hornfels zone, a somewhat altered fragment of the favositid genus *Squameofavosites* was found, indicating a "post-Early Silurian age, essentially Middle Silurian" (W. A. Oliver, Jr., written commun., Aug. 18, 1961). The rock overlies the fossiliferous black slate of Ordovician age northeast of Snow Mountain and is lower in the stratigraphic sequence than the Daggett Ridge Formation of Silurian age; it is therefore considered to be Silurian.

The metaconglomerate has a maximum thickness of 200 feet at U.S. Route 1; the thickness of the formation and size of fragments decrease southwestward, where the beds pinch out along Upper Hot Brook Lake.

775-616—65——3

METASILTSTONE AND SLATE

In the Mattawamkeag quadrangle (Larrabee, 1963c), dark-gray slate in places exhibits faint cleavage or is phyllitic. Iron and calcium carbonate bearing metasiltstone and slate are well exposed along the road northwest from Molunkus, where metasiltstone and metasandstone beds commonly range from one-quarter inch to 4 feet in thickness and locally are as much as 20 feet thick. In a few exposures of beds of metasiltstone, thin laminae of light and dark metasandstone are present. Thin beds of quartz-granule metaconglomerate are associated with metasandstone and quartzite beds in places. The metasiltstone beds in many places have graded bedding and crossbedding. The average slate content of the formation is about 20 percent. The thickness of the formation has not been ascertained, but it appears to exceed 2,000 feet.

In the Mattawamkeag quadrangle, grayish-purple slate crops out along a road about 3.5 miles north-northwest of Macwahoc and north of Lower Henderson Brook. This rock may be the same age as the gray slate and metasiltstone, or it may be older.

The gray metasiltstone and slate occur in the northeastern part of the Millinocket quadrangle (Larrabee and others, 1964), but the chloritic slate at Grindstone Falls is chloritic and more phyllitic and may, therefore, be older. The rocks exposed at Grindstone Falls were reported by R. B. Neuman (oral commun., July 8, 1964) to be part of a continuous belt that he mapped across the Staceyville quadrangle and that he correlated with similar rocks in the Island Falls quadrangle (being studied by E. B. Ekren and F. C. Frischknecht, written commun., 1962).

Metasiltstone and slate containing iron and calcium carbonates are well exposed along the main road from Lincoln eastward through Lee, in the Winn quadrangle (Larrabee, 1963i). In places, beds of metasiltstone contain thin laminae of light and dark metasandstone or are interbedded with it in ⅛- to ½-inch thick layers. Thin beds of quartz-granule metaconglomerate are associated with metasandstone and quartzite in places, such as along the Penobscot River south of Winn. In parts of the Winn quadrangle, the metasedimentary rocks differ in certain respects from the metasiltstone and slate elsewhere and may be variations or facies of that map unit. In general, the metasedimentary rocks along Maine Route 6 between Lincoln and Lee are thinner bedded, more markedly banded, and richer in quartz and carbonate than are rocks of the series elsewhere; rocks northwest of the Penobscot River and those east of Lee are more typical. A fine-grained dark-gray sericitic quartzite that crops out at East Winn might be older than Silurian, but its relation to nearby rocks is unknown.

Similar carbonate-bearing metasiltstone and slate are well exposed along the main road in the northwestern part of the Wytopitlock quadrangle (Larrabee, 1963j), south of Reed, and near the center of the south boundary of the quadrangle. Many boulders of limestone conglomerate occur here, but the source was not apparent. If the source is nearby, the relation of this conglomerate to surrounding rocks is not clear. Generally, swamps and deposits of glacial drift are so extensive in the quadrangle that outcrops are scarce, in fact are scarcer than elsewhere in the area studied. The metasiltstone and slate unit is probably more than 2,000 feet thick.

DAGGETT RIDGE FORMATION

Chloritic argillaceous quartzite, quartzite metaconglomerate containing fractured pebbles and cobbles as large as 8×12 inches, gray and gray-green slate and metasiltstone, and thin lenses of magnetite-bearing interbedded black slate and metasiltstone compose the Daggett Ridge Formation (Larrabee, 1963b). The magnetite-bearing rocks crop out 2 miles northeast of Bancroft, in the eastern part of the Wytopitlock quadrangle (Larrabee, 1963j), where they were traced by ground magnetometer (R. W. Bromery, written commun., July 26, 1957). Aeromagnetic data indicate that the magnetite-bearing rocks are present in parts of the Danforth and nearby quadrangles (Griscom and Larrabee, 1963). A semiquantitative spectrographic analysis of this unit is given in table 2. Thin green cherty lenses of rhyolitic metatuff occur along Baskahegan Stream near South Bancroft in the Danforth quadrangle. The metaconglomerate crops out along Mill Priveledge Brook southeast of Wytopitlock village and on Ellen Wood Ridge in the southeastern part of the Wytopitlock quadrangle; it is well exposed along Baskahegan Stream 1.8 miles southwest of Trout Brook Ridge in the Danforth quadrangle. The formation is exposed over a distance of about 8,000 feet on Daggett Ridge and Jimmy Mountain in the Danforth quadrangle, where quartzite and metaconglomerate form most of the thickness, which is estimated to exceed 2,000 feet. The magnetite-bearing metasiltstone, estimated from magnetic data to be about 70 feet thick, contains total iron as Fe_2O_3, 20.6 percent; Mn, 1.8 percent; TiO_2, 0.62 percent; and P_2O_5, 0.28 percent (P. L. D. Elmore and S. D. Botts, written commun., Nov. 1, 1957). A Silurian age has been assigned to the formation on the basis of meager paleontologic evidence: "A single dorsal valve of an orthoid brachiopod with branching costae and an apparent faint concentric ornamentation was found in the metaconglomerate unit." (R. B. Neuman and P. E. Cloud, written commun., Nov. 22, 1957).

TABLE 2.—*Semiquantitative spectrographic analyses of rocks*

[Analysts: C. L. Waring, H. W. Worthing, S. Berman, H. Bastron, and C. N. Pickett. 0, test made and none found; .., not tested; M, major constituent]

Field No.	64-56-L [1]	40-57-L [2]	52-59-L [3]	37-57-L [4]	10-54-L [5]	11-54-L [6]	20-54-L [7]	21-54-L [8]	119-62-L [9]	126-62-L [10]	127-62-L [11]	229-62-L [12]
Lab. No.	157840	157776	157777	151854	145858	145859	145860	145861	160901	160902	160903	160904
Si	M	M	M	..	..	..	..	..	M	M	M	M
Al	7	7	7	..	..	..	..	..	10	10	10	7
Fe	7	.3	.3	..	0.8	0.2	3	M	7	5	7	7
Mg	3	.15	.07	..	.01	.3	M	M	1.5	1	1	2
Ca	7	.7	.7	..	.4	.04	>1	.5	.2	.3	.5	7
Na	1.5	3	3	..	..	..	..	..	1.5	1	.7	3
K	.7	3	3	..	..	..	..	..	2	3	2	.7
Ti	.7	.07	.03	..	.2	.2	.9	.2	.7	.7	.5	1
P	0	0	0	0	0	0	0	0	.2	.2	.3	.5
Mn	.15	.015	.07	..	.04	.009	.08	.6	.1	.2	.15	.1
Ag	.000015	0	0	0	.0002	.001	.0005	.005	.00003	.00003	.00005	.00007
B	0	.003	.003	.004	0	0	0	0	.005	.007	.01	.003
Ba	.003	.015	.0015	.2	.4	.3	.08	.2	.1	.1	.1	.1
Be	0	.00015	.00015	.0004	0	0	0	0	.0001	.00015	.0001	.00007
Ce	0	0	0	0	0	0	0	0	.01	.01	.015	.01
Co	.003	0	0	.005	0	0	.001	.003	.003	.002	.007	.003
Cr	.007	.0003	.0003	.01	.002	.003	.01	.003	.02	.02	.02	.005
Cs	0	0	0	..	..	..	..	..	..	..	..	..
Cu	.003	0	.0003	.01	.01	.009	.009	.03	.005	.007	.005	.007
Dy	0	0	0	..	..	..	..	..	0	0	0	0
Er	0	0	0	..	..	..	..	..	0	0	0	0
Eu	0	0	0	..	..	..	..	..	0	0	0	0
F	..	..	..	..	..	..	..	..	..	..	..	..
Ga	.0007	.0007	.0007	.003	0	0	0	0	.002	.002	.002	.002
Gd	0	0	0	..	..	..	..	..	0	0	0	0
Hf	0	0	0	0	..	..	..	..	0	0	0	0
Ho	0	0	0	..	..	..	..	..	0	0	0	0
Ir	0	0	0	0	0	0	0	0	..	..	..	..

La	0	0	0	.02	0	0	0	0	.007	.01	.01	.007
Li	0	0	0	----	----	----	----	----	0	0	0	0
Lu	0	0	0	----	----	----	----	----	0	0	0	0
Mo	0	0	0	0	.002	.004	0	.0007	.0005	.0003	.0003	.0005
Nb	0	0	0	0	0	0	0	0	.003	.002	.003	.002
Nd	0.	0	0	----	----	----	----	----	0	0	0	0
Ni	.015	0	0	.02	.001	0	.004	.004	.01	.005	.01	.007
Os	0	0	0	0	----	----	----	----	----	----	----	----
Pb	.00015	.0007	.00015	.01	0	0	0	.003	.003	.005	.005	.005
Pr	0	0	0	----	----	----	----	----	0	0	0	0
Rb	0	0	0	----	----	----	----	----	----	----	----	----
Re	0	0	0	0	----	----	----	----	0	0	0	0
Rh	0	0	0	0	0	0	0	0	----	----	----	----
Ru	0	0	0	0	0	0	0	0	----	----	----	----
Sb	0	0	0	0	0	0	0	0	0	0	0	0
Sc	.0015	.0003	.0003	.002	0	0	.005	.003	.003	.003	.003	.005
Sn	0	0	0	0	0	0	0	0	0	.0003	0	0
Sr	.07	.03	.0007	.002	.002	0	.009	.003	.02	.03	.015	.07
Sm	0	0	0	----	----	----	----	----	0	0	0	0
Tb	0	0	0	----	----	----	----	----	0	0	0	0
Te	0	0	0	0	----	----	----	----	0	0	0	0
Tl	0	0	0	0	----	----	----	----	0	0	0	0
Tm	0	0	0	----	----	----	----	----	0	0	0	0
V	.015	.00015	.00015	.004	.005	.002	.004	.005	.05	.03	.03	.03
Y	.0015	.0007	.0007	.01	.003	.006	.006	.04	.007	.005	.005	.007
Yb	.00015	0	0	----	0	.0003	.0004	.001	.0007	.0005	.0005	.0007
Zr	.007	.003	.0015	.01	.006	.007	.02	.02	.02	.02	.015	.03

Looked for but not found: As, Au, Bi, Cd, Ge, Hg, In, Pd, Pt, Ta, Th, U, W, Zn.

[1] Diabase, center of 200-ft dike; Dark Cove, Danforth quadrangle.
[2] Chiputneticook Quartz Monzonite; Greenland Cove, Danforth quadrangle.
[3] Chiputneticook Quartz Monzonite; <200 ft from contact along main road west of Spruce Mountain, Forest quadrangle.
[4] Magnetite-bearing metasiltstone; Wytopitlock quadrangle northeast of Bancroft.
[5] Black metachert, 800 ft northwest of South Springfield, Springfield quadrangle.
[6] Graphitic schist; same outcrops as above.
[7] Garnetiferous, sericitic schist; 1.75 miles N. 62° W. of mouth of Lowell Brook, Springfield quadrangle (outcrop now obliterated).
[8] Garnetiferous pyritic lens from above outcrop.
[9] Hornfels from west contact zone of gabbro-diorite; 1.7 miles N. 28° W. of the mouth of Huntley Brook, Big Lake quadrangle.
[10] Hornfels from west contact zone of gabbro-diorite; at fire tower 1.25 miles northeast of Wesley, Wesley quadrangle.
[11] Hornfels from west contact zone of gabbro-diorite; at Post Office 1.8 miles northeast of Wesley, Wesley quadrangle.
[12] Gabbro-diorite at contact; 0.5 mile north of southern end of First Chain Lake, Wesley quadrangle.

SLATE AT BASKAHEGAN STREAM

This unit contains interbedded gray slate and metasiltstone, impure quartzite, and minutely laminated and crossbedded sandstone; slate predominates. These rocks are best exposed half a mile southeast of the settlement of South Bancroft, Danforth quadrangle (Larrabee and Spencer, 1963). The rocks are also well exposed along the Maine Central Railroad 1.25 miles east of the west boundary of that quadrangle and are believed to be of Silurian age as they overlie the Daggett Ridge Formation of probable Silurian age and are intruded by Chiputneticook Quartz Monzonite of Devonian age. The unit is probably about 1,000 feet thick.

DEVONIAN THROUGH MISSISSIPPIAN, UNDIFFERENTIATED

REDDISH-BROWN CONGLOMERATE AND SILTSTONE

The downfaulted rocks in the Waite quadrangle (Larrabee, 1963g) comprise soft red, pink, and gray siltstone that is carbonate bearing in some exposures and lacking carbonate in others; hard gray-green quartzite conglomerate that contains angular to rounded pebbles and cobbles in a red and gray calcareous matrix; and brownish-red siltstone. The conglomerate is brecciated at the outcrop west of U.S. Route 1, south of Waite. A glacial boulder of siltstone was found half a mile southwest of Waite, and a large conglomerate erratic was found on the southwest shore of Berry Brook Flowage. The presence of such erratics elsewhere is indicative of the existence of faults other than those shown on plate 1. Similar rocks are found along continuations of the faults and shear zones and along other faults of the same general northeast trend in the Kellyland quadrangle and as far southwest as the Nicatous Lake quadrangle (Larrabee, 1963d). These downfaulted rocks are similar to and on fault strike with the large downfaulted block of Upper Devonian through Mississippian conglomerate south of McAdam (Clark, 1961). In Canada, some of the sedimentary rocks associated with the conglomerate have been determined, through pollen identification, to be of Late Devonian age (L. M. Cumming, written commun., Dec. 11, 1962).

DEVONIAN THROUGH PENNSYLVANIAN, UNDIFFERENTIATED

RED AND LIGHT-GRAY CONGLOMERATE, SANDSTONE, AND QUARTZITE

These rocks, exposed in the Nicatous Lake quadrangle (Larrabee, 1963d), range from soft to hard poorly sorted coarse red conglomerate through interbedded red and light-gray quartzite conglomerate to light-gray quartzite conglomerate and sandstone. Well-rounded pebbles and cobbles one-eighth to 10 inches in diameter in the red conglomerate include quartzite, metasiltstone, calcareous metasiltstone, fine-grained gray biotitic granite (the source of which has not been located in the Grand Lake area), and some flat red siltstone cobbles one-half by 8 inches in cross section. The cement is calcareous in places but generally is sandy and siliceous. Some 2- to 5-foot interlayered beds of coarse red and gray conglomerate occur. The quartzite conglomerate is associated with 1-inch beds of finely laminated gray sandstone and quartzite. Information about exposures of these rocks at Gassabias Lake was furnished by Mr. Bradford A. Hall. Lithologic descriptions indicate that these rocks are correlative with the Upper Devonian through Pennsylvanian sequence in the eastern part of the McAdam district, New Brunswick (Clark, 1961). At one time rocks of these ages probably covered much of this area, but they have since been removed by post-Pennsylvanian erosion.

DEVONIAN INTRUSIVE ROCKS

POCAMOONSHINE GABBRO-DIORITE

Medium-gray-green to black gabbro-diorite is exposed on the shores of Pocamoonshine and Crawford Lakes in the Big Lake quadrangle (Larrabee, 1964b) and extends southward into the Wesley quadrangle (Larrabee, 1963h). The intrusive mass has an average width of about 3 miles and length of 15 miles; it is about 6 miles wide in the Wesley quadrangle. The rock ranges from fine-grained salt-and-pepper hornblende diorite to coarse-grained (one-half inch in diameter) olivine gabbro. In some places, the rock has a gabbroic texture, in others, diabasic. Clinopyroxene, which shows pronounced schiller structure, and most olivine are in part altered to brown hornblende. Most hornblende is poikilitic and exhibits relict schiller structure. Magnetite, apatite, and reddish-brown biotite are common. The rock is probably of Devonian age but is older than the granitic rocks. The gabbro-diorite locally is cut by 6- to 8-inch dikes of medium-grained (⅛–¼ in.) biotite granite. The radiometric age of the gabbro-diorite was not determined; chemical composition of the gabbroic facies is given in table 3.

All contacts are believed to dip outward; the western contact definitely dips outward. On the basis of width of the contact-metamorphic aureole, the dip is probably less steep on the western side than on the eastern. The western and southern contacts, at least, are of an interfingering nature: tongues of intrusive gabbro alternate with hornfels. This feature is well shown in outcrops along the St. Regis Paper Co. road south of Joe Hanscom Heath in the Wesley quadrangle. A small outcrop, which may represent a cupola, is near the south end of First Chain Lake. G. H. Espenshade (written commun., Aug. 11, 1956) reported the presence of gabbro south of Bog Lake along the main highway that extends southeastward across the Wesley quadrangle, and Chapman (1962) indicated its presence there as a wide east-northeast-trending band.

TABLE 3.—*Chemical composition of some intrusive rocks analyzed by the rapid method (Shapiro and Brannock, 1963)*

[Analysts: P. L. D. Elmore, S. D. Botts, G. Chloe, L. Artis, and H. Smith]

Field No.	40-57-L [1]	52-59-L [2]	313-62-L [3]	139-62-L [4]	82-62-L [5]	95-62-L [6]	151-62-L [7]	64-56-L [8]
Lab. No.	157776	157777	161500	160900	160897	160898	160899	157840
SiO_2	74.3	76.3	74.6	70.2	48.8	48.2	64.3	52.2
Al_2O_3	14.3	13.5	13.4	16.5	16.0	16.3	14.8	16.2
Fe_2O_3	.3	.2	.71	.52	1.9	.90	1.6	1.0
FeO	.72	.59	1.0	1.4	8.2	7.9	4.2	8.2
MgO	.39	.23	.19	.69	9.2	12.7	2.6	6.5
CaO	.82	.52	.48	2.7	11.3	12.6	4.4	10.7
Na_2O	3.5	3.5	3.2	3.8	1.5	.55	3.0	2.3
K_2O	4.4	4.4	4.9	2.3	.50	.06	2.2	.40
H_2O-	.81	.56	.12	.12	.08	.12	.08	.93
H_2O+			.86	1.3	1.6	.67	1.9	
TiO_2	.18	.08	.17	.34	.94	.25	.86	.81
P_2O_5	.22	.26	.06	.23	.18	.04	.24	.15
MnO	.06	.12	.04	.00	.13	.07	.00	.20
CO_2	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05
Sum	100	100	100	100	100	100	100	100
Powder density by air pycnometer	----------	----------	2.63	2.69	3.02	3.09	2.80	----------

[1] Chiputneticook Quartz Monzonite; 3,500 ft from contact, Greenland Point, Danforth quadrangle.
[2] Chiputneticook Quartz Monzonite; <200 ft from contact, west of Spruce Mountain, Forest quadrangle.
[3] Wabassus Quartz Monzonite; 1 mile west of contact, east of Munson Island, Wabassus Lake quadrangle.
[4] Love Ridge Quartz Monzonite; 3,000 ft from contact, west of Pug Lake, Big Lake quadrangle.
[5] Pocamoonshine Gabbro-Diorite; 4,000 ft from contact, west of Middle Ground, Big Lake quadrangle.
[6] Pocamoonshine Gabbro-Diorite; 4,000 ft(?) from contact, west slope of Pocamoonshine Mountain, Big Lake quadrangle.
[7] Granodiorite; Berry Brook Flowage, Waite quadrangle.
[8] Diabase dike; Dark Cove, Danforth quadrangle.

Granodiorite was found in three very small, closely spaced islands in Berry Brook Flowage near the mouth of Berry Brook, in the Waite quadrangle (Larrabee, 1963g). The rock typically is coarse grained and has a salt-and-pepper appearance. Dark-green to black hornblende in crystals averaging 1/8 to 3/16 inch in length locally replaces a nearly colorless amphibole containing much magnetite dust, and occurs with white plagioclase and orthoclase and greenish-black biotite, much of which has altered to chlorite. Perhaps half the plagioclase has altered to sericite; the alteration was unaffected by fractures or by crystal zoning. Some poikilitic feldspar phenocrysts are one-half inch in diameter. The biotite commonly contains zircon. This granodiorite appears similar megascopically to some of the Pocamoonshine Gabbro-Diorite at Pocamoonshine Lake and, although chemical compositions are very different (table 2), there might be a subsurface connection.

CHIPUTNETICOOK QUARTZ MONZONITE

The Chiputneticook Quartz Monzonite is best exposed on islands and shores of the Chiputneticook Lakes, along the United States–Canadian border. Outcrops are most common in the Danforth, Forest, and Vanceboro quadrangles. The type locality is at Greenland Cove, Grand Lake, in the Danforth quadrangle (Larrabee and Spencer, 1963). The rock ranges from light- to medium-gray coarse-grained biotitic porphyritic quartz monzonite to a light-gray granite, and the average grain size exceeds one-quarter inch. Commonly porphyritic, the euhedral potassic feldspar phenocrysts one-quarter by 1 inch to one-half by 2 inches show rapakivi texture in places. Porphyritic texture generally extends to within a few feet of the border of the pluton. The intrusive body is exposed intermittently for about 16 miles northwestward and at least 40 miles northeastward into New Brunswick. The age as determined by the potassium-argon method is about 400 m.y. (million years) in the Danforth quadrangle (Faul and others, 1963) and 380 m.y. in the Fosterville, New Brunswick, area (Tupper and Hart, 1961). The large mass intrudes metasedimentary rocks of Silurian and older age and is considered to be Devonian.

LOVE RIDGE QUARTZ MONZONITE

Light-gray fine-grained biotitic quartz monzonite and granite are best exposed on the southeast side of Love Ridge, between Pug Lake and North Beaverdam Lake in the Big Lake quadrangle (Larrabee, 1964b). The light-gray nonporphyritic to slightly porphyritic rock has an average grain size of 1/16 to ¼ inch; it contains about 5 percent brown biotite, less muscovite, traces of hornblende, apatite, zircon, and pyrite. The rock is sheared and granulated at the type locality. Exposures extend southeastward a short distance east of South Beaverdam Lake in the Wesley quadrangle (Larrabee, 1963h). It intrudes rocks of Silurian (?) age and has not been metamorphosed. The rock is probably of Devonian age, but radiometric age was not determined.

A small northwest-trending sugary-textured biotite-rich quartz monzonite dike occurs in a breccia zone on the northeast shore of Second Chain Lake in the Big Lake quadrangle; it may be related to the Love Ridge Quartz Monzonite.

WABASSUS QUARTZ MONZONITE

The Wabassus Quartz Monzonite, in places a granite, is best exposed along the east shore of Grand Lake between Grand Lake Stream and Dyer Cove Point, and in the road to Wabassus Lake between Grand Lake Stream village and Grand Lake Brook, in the Wabassus Lake quadrangle (Larrabee, 1964a). Wabassus Mountain is made up of this rock (Rand, 1958). The quartz monzonite is commonly equigranular; its particles range from ⅛ to ⅜ inch in size. In the few exposures where the rock is porphyritic, microcline phenocrysts $\frac{1}{4} \times \frac{1}{2}$ inch to 1 inch long were observed. The rock is medium gray and leucocratic on Amazon Mountain in the Big Lake quadrangle, but elsewhere it is pink or light gray and biotitic or hornblendic. Where exposed in the southeastern part of the Nicatous Lake quadrangle, it is gray, medium to coarse grained, and in places porphyritic. Sheared quartz monzonite crops out along the road and also at Nicatous Lake. In the Nicatous Lake quadrangle the rock in most exposures is light gray, but in a few places it is pink or flesh colored. Dark minerals consist of biotite and scarce hornblende, which becomes more abundant near inclusions and borders of the pluton. In general, this rock appears to be somewhat finer grained and less porphyritic than the Bottle Lake Quartz Monzonite. Although the age of a sample taken in the Wabassus Lake quadrangle was not determined, quartz monzonite probably of the same pluton, where crossed by Maine Route 9 to the southwest, was determined to be about 356 m.y. by the potassium-argon method or 420 m.y. by the lead-alpha method (Faul and others, 1963).

BOTTLE LAKE QUARTZ MONZONITE

The main mass of Bottle Lake Quartz Monzonite as exposed in the Springfield and Scraggly Lake quadrangles is a gray and pink coarse-grained (¼–½ in. avg grain size) biotitic or hornblendic and porphyritic quartz monzonite and granite pluton that extends from the Waite quadrangle (Larrabee, 1963g) southwestward into and westward across the Scraggly Lake and Springfield quadrangles and into the Winn quadrangle (Rand, 1958; Doyle and others, 1961; Larrabee, 1963e, f, i). It also occurs in the Wabassus Lake (Larrabee, 1964a), Nicatous Lake (Larrabee, 1963d), Saponac, and Passadumkeag quadrangles (Larrabee and others, 1964). The rock is well exposed 1 mile northwest of Bottle Lake, along the road from Springfield south to that lake in the Springfield quadrangle, where euhedral phenocrysts of potassic feldspar as large as 1¼ x 1 inch have rapakivi texture. Randomly oriented rounded gray phenocrysts are present in rock outcrops one-half mile southeast of Mattakeunk Pond and east of Porcupine Mountain, in the Winn quadrangle. Porphyritic texture is common, and phenocrysts 2 inches long and 1 inch across are not uncommon. The northern contact of this intrusive rock is exposed in a recent cut along the St. Croix Paper Co. pulpwood haulage road northwest of West Musquash Lake, in the Scraggly Lake quadrangle. In the Winn quadrangle, the northern contact is exposed southeast of Mattakeunk Pond. The location of the northern contact elsewhere in this quadrangle was determined chiefly by Doyle, Young, and Wing (1961). The distribution of pink and gray rock is random rather than systematic. The hornblende content appears largest near inclusions, as along the road between Middle and Upper Chain Lakes, in the Nicatous Lake quadrangle.

In the Nicatous Lake quadrangle, the rock is well exposed south of the outlet of Lower Chain Lake and at the road crossing the outlet of

Upper Chain Lake, where it is gray, coarsely porphyritic, and hornblendic. At the second locality, inclusions of fine-grained biotite schist are common, and these contain porphyroblasts of microcline and hornblende. Where exposed in the northern part of Nicatous Lake, the rock is flesh colored, hornblendic and biotitic, and coarsely porphyritic, and contains microcline phenocrysts as large as 5/8 x 1½ inches. On the basis of the distribution of large angular glacial boulders of the intrusive rock (elsewhere useful in determining boundaries), the southern boundary of the mass seems to be as shown at Nicatous Lake; however, a Bouguer gravity anomaly indicates that the boundary is 1.4 miles north of this. This difference can be explained most logically by inferring a sharp roll in the contact at shallow depth (Martin Kane, oral commun., July 18, 1963).

The northeast tip of the pluton, extending into the Waite quadrangle and referred to as the Topsfield granitic facies, is quite different from the main mass. There may be a gradational change in the vicinity of the North Branch of Vickery Brook, in the Scraggly Lake quadrangle. The Topsfield granitic facies, well exposed along U.S. Route 1, 2.5–3.5 miles north of the village of Topsfield in the Waite quadrangle, is chiefly a pinkish-red aggregate of microcline, quartz, plagioclase, and a little muscovite, biotite, and hornblende. The rock is medium to coarse grained, and the average length of the feldspar crystals is about one-quarter inch. Rapakivi texture has been observed (Forsyth, 1955), as have traces of pyrite. Along the northern boundary of the granite, where crossed by U.S. Route 1, the rock is light gray and contains very little mica or hornblende; here the texture is similar to that of the red granite. The width of this zone or facies is about one-quarter mile. A pink aplite dike 6 inches thick cuts the red granite along U.S. Route 1.

The rock is intensely jointed and sheared in a northwest direction, and weathering and erosion have penetrated deeply along these planes. This is well shown on Farrow Mountain in the Scraggly Lake quadrangle, as indicated on the topographic map and aerial photographs and reported by Mr. William Forsyth (oral commun. Aug. 1954). Good fresh outcrops are found along the new road from East Musquash Lake southwest toward the fire tower, where alteration along shear zones is apparent. A sample of this granite taken along U.S. Route 1 contained 0.003 percent equivalent uranium and 0.001 percent uranium (Nelson and Narten, 1951).

The age of a sample taken from the Bottle Lake locality is about 342 m.y. as determined by the potassium-argon method (H. Thomas, R. Marvin, and P. L. D. Elmore, written commun., July 2, 1962) or about 410 m.y. as determined by the lead-alpha method (T. W. Stern, written commun., Mar. 23, 1962). The age of another sample of this rock taken from along the road from West Musquash Lake to Upper Oxbrook Lake, in the Scraggly Lake quadrangle, is 370 m.y. by the potassium-argon method, or 380 m.y. by the lead-alpha method (Faul and others, 1963). The reason for the considerable difference in analytical age values for samples from the two localities has not been determined.

The age of the Topsfield granitic facies rock, as determined on a sample from along U.S. Route 1, is 372 m.y. by the potassium-argon method, or 400 m.y. by the lead-alpha method (Faul and others, 1963). Both facies of this quartz monzonite are quite different from the Chiputneticook Quartz Monzonite in the Danforth (Larrabee and Spencer, 1963), Forest, and Vanceboro quadrangles.

QUARTZ MONZONITE AT CENTER POND

The quartz monzonite and granite at Center Pond, in the Winn quadrangle, are gray or rarely pink, medium-grained equigranular, and locally porphyritic. Phenocrysts in the porphyritic parts are tabular, consist of microcline, and are about 1 inch long and one-quarter inch wide. The rock is composed of about equal amounts of quartz, plagioclase, and microcline, and lesser amounts of biotite and muscovite. Foliation, probably a primary flow structure, is expressed by the subparallel alinement of microcline phenocrysts, thin biotite books, and biotite-rich lenses as much as 12 inches long and 4 inches thick. This small pluton extends north, east, and south from Lincoln (Larrabee, 1963i).

The age of a sample from along the highway south of Center Pond was determined as about 370 m.y. by the lead-alpha method (T.W. Stern, written commun., March 23, 1962), or 349 m.y. by the potassium-argon method (H. Thomas, R. Marvin, and P. L. D. Elmore, written commun., July 2, 1962). The age of the same sample was determined as 350 m.y. by the rubidium-strontium method, but the uncertainty factor was very high (100 m.y.) because of a large amount of normal strontium relative to radiogenic strontium (C. E. Hedge, and F. Walthall, written commun., July 2, 1962). A sample from nearby was determined to be about 340 m.y. by the lead-alpha method, or 359 m.y. by the potassium-argon method (Faul and others, 1963). The quartz monzonite is considered to be of Devonian age.

MINOR INTRUSIVES

Quartz-feldspar porphyry.—Fresh fine-grained light-gray porphyry containing $\frac{1}{16}$-inch euhedral phenocrysts of quartz and microcline, and biotite and fine muscovite in a very fine grained groundmass of quartz and feldspar intrudes contact-metamorphosed metasiltstone of the Kellyland Formation along the road about three-quarters of a mile southwest of Chain Island, near the northeast corner of the Nicatous Lake quadrangle (Larrabee, 1963d). The size and shape are unknown but the intrusive is assumed to be small and dikelike. The age relation to nearby quartz monzonite also is unknown.

Quartz veins, pegmatite and aplite dikes.—Small quartz veins as well as pegmatite and aplite dikes occur in the contact metamorphic aureoles of the quartz monzonite plutons and in the intrusive masses themselves. No dikes of appreciable size were observed; most of the pegmatites are less than 2 feet thick, and the aplites are less than 6 inches thick. Forsyth (1955) mentioned a larger pegmatite on the west slope of Greenland Mountain, in the Danforth quadrangle, in which crystals of perthite are 18 inches in diameter, but we couldn't find the dike because of thick underbrush.

A still larger pegmatite was reported on the western slope of Getchell Mountain, in the Springfield quadrangle, by Rand (1957), but no details are available.

Basalt.—A basalt dike 18 feet wide strikes north and dips 65° E. in hornfels of the Dark Argillite Division of the Charlotte Group of Alcock (1946a) in an outcrop along the road 1.75 miles southeast of South Princeton and outside the area mapped.

POST-DEVONIAN DIABASE

A fine- to medium-grained steeply dipping diabase dike, containing 3–5 percent magnetite, is about 200 feet wide at its only known outcrop in the area mapped, in Dark Cove in the Danforth quadrangle. This occurrence, normally under water but visible, is on the east side of the island in Dark Cove and on the west shore of the nearby peninsula to the east; the rock crops out when the lake level is abnormally low (Larrabee and Spencer, 1963). The dike cuts quartz monzonite of Devonian age and has been traced for about 100 miles, chiefly west-southwest, by aeromagnetic methods (Wing, 1959; Allingham, 1960; Griscom and Larrabee, 1963). It was traced in the Trout Brook area of the Danforth quadrangle by ground magnetometer in July 1957 by R. W. Bromery. The dike is similar to rock in an outcrop about 4 miles east of South Dover and in a quarry near Maine Route 23 about 1 mile north of Lake Wassookeag, near Dexter (G. H. Espenshade, oral commun., April 1961).

STRUCTURE AND METAMORPHISM

In some places, major folds, such as the anticline at Danforth and syncline east of South Bancroft, are open and have minor folds on their limbs. Minor folds are isoclinal; dips are approximately perpendicular and in places beds are overturned. This type of folding is found particularly in the westernmost and easternmost parts of the area; in the easternmost part the Silurian(?) rocks might be in a northeast-plunging synclinorium. Axial-plane cleavage is a feature of the thin slates so common in the area, but it ranges from poorly formed to phyllitic and is nowhere as perfectly formed as in thickly bedded roofing slates. In most outcrops cleavage is parallel or nearly parallel to bedding, except in crests and troughs of folds. This characteristic was also noted in the Calais area by Amos (1963). Fracture cleavage is common in the more quartzitic beds, and gashes filled with quartz or calcite occur in pebbles and cobbles of the quartzite conglomerate along Baskahegan Stream southeast of South Bancroft, in the Danforth quadrangle, and south of Hawkins Brook and about 3½ miles south of Bancroft, in the Wytopitlock quadrangle. Many calcite-filled fractures were observed in rocks along the Mattawamkeag River near the north edge of the Danforth quadrangle, and in the railroad cut at Bancroft. Some major lineaments, such as Stetson Mountain, which is about 10 miles long and consists of silicified rhyolitic metatuff, are due to folding of resistant rocks. Minor folds on the flanks of this mountain and general lineaments elsewhere, as on the limbs of the syncline south of Bancroft, are readily apparent in high-altitude aerial photographs.

Most large intrusive bodies trend northeast and parallel the major structures, although contacts are crosscutting. The large mass south of Springfield trends more to the east, although north of Topsfield it turns to the northeast. The gabbro-diorite mass at Pocamoonshine Mountain trends north. Other large intrusives of granitic and gabbroic nature south of the area mapped and near Calais are reported to trend northeast if rocks of grossly similar characteristics are grouped, as noted by Chapman (1962).

Faults apparently are of two general ages: one prior to the Devonian intrusions and one after Pennsylvanian sedimentation. The trend of major faults of both ages is generally northeast. The pre-Devonian faults are north of Baskahegan Lake and south of Tomah. The presence of these faults is inferred largely from a sharp change in strike of beds in the southeastern part of the Danforth quadrangle (Larrabee and Spencer, 1963) and the presence of what appear to be older beds without the intervening Ordovician rocks to the west. These Ordovician rocks, although possibly present beneath glacial drift, are not represented among the outcrops along Baskahegan Stream north of Baskahegan Lake. The post-Pennsylvanian faults are more conspicuous and have two general trends: northeast and northwest. The northwest-trending faults are later; the northeast-trending faults are of greater length. A northeast-trending fault along the quartz monzonite ridge south of Wabassus Lake is apparent in aerial photographs. The post-Pennsylvanian faults are most conspicuous in the southeastern third of the area mapped.

Most faults seem to be normal, but paucity and small size of exposures leaves this in question. Grabens containing Upper Devonian, Mississippian, and Pennsylvanian rocks are present in the Kellyland, Waite, Wabassus Lake, and Nicatous Lake quadrangles. Major northeast-trending faults and shear zones have been traced by means of glacial erratics and outcrops in a strip from Nicatous Lake to the St. Croix River; this strip parallels and is on strike with the Springhill fault near Fredericton, New Brunswick (J. C. Smith, written commun., Dec. 5, 1962), and thus may add about 50 miles to the length of the strip as shown on the map (pl. 1). A positive aeromagnetic anomaly, which may indicate a buried dike, was detected over part of this fault zone in the Waite quadrangle (Trefethen, 1953) and extends through Neal and McLain Mountains into New Brunswick (Canada Geol. Survey, 1957b). The faults probably continue southwest of Nicatous Lake. These major faults and shear zones parallel the Lubec (Bastin and Williams, 1914) and Fundy faults,[1] southwest of the area mapped, and the diabase dike to the northwest. A northwest-trending fault probably accounts for the offset at the north end of Stetson Mountain, and other faults are probably reflected in the trends of Third Machias and Wabassus Lakes.

The courses of the St. Croix River may be partly controlled by faults. The straight, southeast trends of the river contrast sharply with the adjacent southwest courses, and especially with the southwest course in the intensely sheared rocks 4 miles southeast of Lambert Lake. The southeast courses of the river are approximately parallel to the Oak Bay fault,[1] along which the St. Croix River flows southeastward beyond the area mapped; the southeast course at Vanceboro is on strike with and parallels the Oak Bay fault.

Although no angular unconformity was noted between the Ordovician and Silurian rocks near Danforth, perhaps because of lack of suitable outcrops outside the intrusive-disturbed zone, such an unconformity may be present southeast of Princeton, where its presence is inferred from a 30° change in bedding strikes. In the same general area of better-than-average outcrops are four intersecting faults, which have contributed nothing toward clarification of this feature.

---

[1] Cumming, L. M., 1962, Geologic map of the Passamaquoddy Bay area, Maine and New Brunswick: Canada Geol. Survey, unpub. map distributed at Geol. Field Excursion, St. Stephen, New Brunswick, August 1962, scale 1 in.=2 miles.

Most metasedimentary rocks in the area exhibit the chlorite grade of metamorphism, but some of the older rocks in the southeast corner of the area have been metamorphosed to the higher, biotite and sillimanite grade. The Ordovician rocks in the southeastern part of the area are more phyllitic and schistose than are the Silurian(?) rocks, which are noted for their high content of slate, metasiltstone, and quartzite. The 5 percent or more carbonate content of the Silurian(?) and Silurian rocks generally is much higher than that of known Ordovician rocks in the area.

The contact metamorphism around bodies of quartz monzonite in most places is limited to an aureole less than three-quarters of a mile wide and varies with the dip of contact, strike of rocks at the contact, and type of rocks affected. In general, aureoles are more extensive in slate and metasiltstone than in impure quartzite. The aureoles are marked by an increase in magnetite and biotite, as well as by the presence of traces of chalcopyrite and pyrrhotite. Rocks that have been contact metamorphosed are most readily recognized by their pitted, weathered outcrops. The pits are due to breakdown of knots of quartz, sericite, and chlorite, which were produced by the retrograde metamorphism of cordierite, some of which remains. Near the outer limits of the aureole these pits are the size of a pinhead; near the intrusive contacts they are the size and shape of rice grains.

Aureoles surrounding the gabbro-diorite are marked by increased amounts of the previously mentioned contact minerals, plus sillimanite, graphite, and crystals of chiastolite as large as ½ x 6½ inches. Hornfels formed in the aureole of an intrusive is topographically higher than the intrusive itself in some parts of the area, notably in the Danforth quadrangle. In other parts of the area the intrusive rocks are topographically prominent but contain many lakes.

Contact metamorphism has darkened rocks throughout large areas indicated on maps as underlain by the Dark Argillite Division of the Charlotte Group of Alcock (Alcock, 1946a, b; MacKenzie and Alcock, 1960a, b; Amos, 1963) and thus has intensified the problem of separating and mapping the Kellyland Formation (Pale Argillite) and the Dark Argillite. Because of this metamorphism, some originally lighter rocks (Pale Argillite) may have been grouped with the Dark Argillite; thus, rocks that are now dark may not everywhere belong to the same stratigraphic unit. Such metamorphism obscures the contact relations of the Kellyland (Pale Argillite) and Dark Argillite in the Big Lake quadrangle.

A comparison of geologic and aeromagnetic maps (Canada Geol. Survey, 1957b, c) of nearby areas in New Brunswick is of interest because there are many pronounced magnetic anomalies in the Dark Argillite, and the shapes of some resemble those of buried intrusives or of contact aureoles. Thus the darkening of the Dark Argillite elsewhere, where intrusive rocks have not been observed at the surface, may be partly the result of contact metamorphism.

GEOPHYSICAL INVESTIGATIONS

In 1953 the Maine Geological Survey had Aero Service Corp. conduct an aeromagnetic survey over an area about 8 miles wide and 36 miles long across central Waite, western Forest, and eastern Danforth quadrangles (Trefethen, 1953; Forsyth, 1955). In 1956, 1957, and 1958, the U.S. Geological Survey conducted an aerial survey over the Amity, Danforth, Forest, and Vanceboro quadrangles, and part of Wytopitlock quadrangle (Griscom and Larrabee, 1963). This work was most useful, as it covered some entire quadrangles. We were able to locate the causes of the sharp anomalies north of Danforth and north of Bancroft and thus were enabled to project geologic boundaries of magnetic formations beneath areas of thick glacial cover. This work also was of use in tracing the faintly magnetic, pyrrhotitic black slate and metachert of Snow Mountain under similar cover where outcrops were small and scarce.

The aeromagnetic studies were conducted by R. W. Bromery and J. W. Allingham; they and their colleagues assisted us greatly in the preliminary evaluation of the data for immediate field use. Later, in 1961, Andrew Griscom compiled the final aeromagnetic data for publication (Griscom and Larrabee, 1963) and prepared a more detailed analysis of the relation of the aeromagnetic data to geology.

An airborne scintillometer was used with the magnetometer, but because of the many lakes, swamps, and thick glacial overburden, data from this instrument were not usable.

Electromagnetic surveys were made with ground equipment in the Danforth quadrangle. Frank C. Frischknecht and his associates made several miles of ground surveys in various places to assist in tracing the graphitic beds of Snow Mountain (Frischknecht and Ekren, 1960). This assistance was valuable in tracing the beds over a contorted course under as much as 52 feet of drift on the hill 1.7 miles north of Danforth, and elsewhere. In tracing the same formation southward on Stetson Mountain and Bennett Ridge, however, inconsistent results were obtained. The lack of anomalies over some outcrop areas of the same rock indicated some change in distribution or nature of carbon in the interbedded black slate and metachert. Therefore, in areas lacking anomalies and outcrops, we were unable to show the absence of the formation; that is, negative evidence was not considered. A traverse across the magnetite-bearing zone in western Danforth-eastern Wytopitlock quadrangles was made in order to locate any conductive beds or sulfide mineralization associated with the magnetite-bearing beds, but no anomaly was observed.

Results of airborne electromagnetic surveys of the faulted and sheared areas in the Waite, Nicatous Lake, and Wabassus Lake quadrangles, and of all of Big Lake and the northern third of Wesley quadrangles would be helpful in locating possible sulfide mineralization. Aeromagnetic traverses would also be of much assistance in tracing the contacts of the gabbro-diorite mass in the Big Lake quadrangle, and in determining whether a subsurface connection exists between it and the small granodiorite mass exposed in southern Waite quadrangle.

Twenty oriented specimens were taken from various rocks in the Danforth quadrangle by us and by J. W. Allingham for studies of remanent magnetization. The results of these studies, made in 1957 by W. E. Huff on equipment then available, are too few and too inconclusive to be of value.

GEOCHEMICAL EXPLORATION

A total of only 209 samples, 3 of which were rock and the rest sediment, was taken in the eastern part of the area studied (pl. 1, fig. 2; table 4). Sediment sampling was hindered by the sluggish nature of most streams. Swampy, vegetation-choked tributaries were not amenable to obtaining samples of anything but organic muck, which was considered unusable at the time of sampling. The number of samples obtained from each quadrangle is as follows: Amity, 1; Big Lake, 33; Danforth, 31; Forest, 13; Kellyland, 6; Lead Mountain, 8; Nicatous Lake, 11; Scraggly Lake, 18; Springfield, 12; Tug Mountain, 11; Wabassus Lake, 24; Waite, 23; and Wesley, 18 (table 4).

The samples were analyzed by F. C. Canney, Edwin V. Post, and others. No outstanding anomalies were reported, but some samples are of mild interest and may deserve further attention; these are:

1. Sediment (No. 34) from outlet of pond three-eighths of a mile north of Forest Station in the Forest quadrangle.
2. Rock (No. 193) from southwest end of First Chain Lake near northwest corner of the Wesley quadrangle.
3. Sediment (No. 190) from stream 0.75 mile southeast of Breakneck Hill, in the Tug Mountain quadrangle, and along the Airline Highway (Maine Route 9).

As indicated by Post and Hite (1963), an appreciable amount of manganese-iron oxides is associated with many of the heavy-metal anomalies, and these oxides are known to be efficient scavengers of some metals, notably zinc. The effect of such scavenging on the interpretation of geochemical surveys of drainage systems is not completely understood. Therefore, caution should be used in the interpretation of heavy-metal anomalies, with full realization that the anomalies may represent a natural enrichment of metal from unmineralized source rocks rather than a mineral deposit.

ECONOMIC GEOLOGY

SAND, GRAVEL, AND GRANITE

Sand and gravel deposits generally are common, but the best sources are in eskers, many of the largest of which are identifiable on the topographic quadrangle maps. Kames and outwash plains supply much gravel, and in places even the sandy till is used for road metal. Quality and proportions of sized material vary with type of deposits as well as within a single deposit; this is especially true of small deposits. In general, topographic maps indicate eskers of appreciable size.

Where gravel deposits of any kind are lacking, either gravel must be hauled for considerable distances or crushed stone must be used for road metal. Portable crushers are the logical answer in some areas where quartz monzonitic granite or gabbro-diorite are available.

Many sources of coarse-grained granitic rock are available for dimension or crushed stone and are accessible, as indicated on the map. The stone was quarried near Danforth and used locally many years ago. Generally, the finer grained nonporphyritic rocks are preferable as building stone, but very coarse grained porphyritic granites are sold widely. Currier (1960) gave a good description of methods and problems, including various economic factors, to be considered in advance of any quarry operation for dimension stone.

MINOR PROSPECTS

The abandoned Bub Bailey gold prospect, northwest of Flagstaff Mountain, in the Danforth quadrangle (pl. 1), was reported by Mr. G. F. Kinney, of Danforth, to have been opened about 1890. It was worked by Bub Bailey in the period 1920–25, and last worked for a short time in 1953 by John Kelly, of Bangor, assisted by Mr. Kinney. The prospect is on land now reportedly owned by the St. Regis Paper Co.

The prospect is a small trench that follows a quartz vein trending N. 24° W. and dipping 85° NE. Slickensides rake 25° SE. The vein is reported to have ranged from 2 to 6 inches in width; it cuts contact-metamorphosed gray sericitic metasiltstone and impure quartzite containing biotite and retrograded cordierite. The cut, excavated by hand methods, ranges from 4 to 6 feet in depth, 2 to 5 feet in width, and is about 50 feet long. Only a trace, if any, of gold was found by the prospectors, and the material remaining in the dump is apparently unmineralized.

TABLE 4.—*Partial chemical analyses*[1] *of stream sediments from the Grand Lake area, Maine*

[Results given in parts per million. Analysts: G. A. Nowlan, L. E. Patten, W. W. Janes, and G. H. Van Sickle]

Sample	Cu	Pb	Zn	Ni	Mo	cx HM[2]	cx Cu[3]	Remarks	Sample	Cu	Pb	Zn	Ni	Mo	cx HM[2]	cx Cu[3]	Remarks
Amity quadrangle																	
1	10	<25	25	----	<4	2	<1	400 ppm Mn.									
Big Lake quadrangle																	
140	10	25	150	25	----	10	----		157	10	<25	50	25	<2	1.5	1	
141	10	<25	50	25	<2	6	<1		158	10	<25	50	15	----	4	<1	
142	<10	<25	50	25	<2	3	<1		159	15	25	50	25	<2	2	<1	
143	20	<25	50	40	<2	2	<1		160	<10	<25	25	25	<2	1	<1	
144	<10	<25	50	40	<2	6	<1		161	{60	25	75	75	----	22	} <1	Rechecked; check further.
145	<10	<25	50	40	<2	2	<1			{15	25	75	40	4	10		
146	15	50	125	50	8	36	2	75 ppm Co.	162	10	25	25	25	<2	6	<1	
147	<10	<25	50	25	<2	13	<1		163	15	25	25	25	2	4	<1	
148	30	<25	50	50	<2	2	<1		164	20	25	50	25	2	6	<1	
149	15	25	50	15	----	4	<1		165	10	<25	50	<25	----	3	<1	
150	10	<25	50	15	----	8	<1		166	----	----	----	150	----	----	----	Sample of bedrock.
151	10	<25	50	15	----	6	----		167	10	<25	75	75	----	2	<1	
152	15	<25	50	15	----	1.5	<1		168	<10	<25	100	15	----	2	<1	
153	15	<25	50	15	----	6	<1		169	20	25	100	75	2	13	4	40 ppm Co.
154	<10	<25	25	<15	----	4	<1		170	<10	<25	50	25	<2	1	<1	
155	10	<25	75	40	<2	----	<1		171	10	25	100	15	----	32	<1	
156	<10	<25	75	40	<2	8	<1		172	<10	<25	50	15	----	4	<1	
Danforth quadrangle																	
2	<10	<25	75	----	<4	17	<1	500 ppm Mn.	19	{10	25	50	----	<4	5	6	600 ppm Mn.
3	10	25	50	----	<4	.5	1	500 ppm Mn.		{20	25	25	----	<4	----	----	1,000 ppm Mn.
4	10	25	50	----	<4	9	<1	2,500 ppm Mn.	20	20	25	125	----	----	16	1	
5[4]	<10	<25	25	----	----	3	<1		21	15	50	100	----	----	>45	<1	
6[4]	<10	25	25	----	----	----	----		22	10	25	25	----	<4	3	<1	1,000 ppm Mn.
7[4]	----	----	----	----	----	100	----		23	{<10	25	75	----	4	4	<1	15,000 ppm Mn.
8	10	25	50	----	<4	2	<1	250 ppm Mn.		{20	25	25	----	<4	----	<1	500 ppm Mn.
9	10	<25	50	----	<4	5	<1	750 ppm Mn.	24	10	25	25	----	<4	7	<1	2,000 ppm Mn.
10	10	<25	75	----	<4	3	<1	250 ppm Mn.	25	40	200	75	----		22	----	
11	40	25	100	----	----	19	3		26[4]	(Chemical analysis of water only)							
12	20	<25	75	----	<4	9	<1	125 ppm Mn.	27	10	50	25	----	<4	----	----	
13[4]	20	25	75	----	4	4	2	500 ppm Mn.	28	20	<25	75	----	----	4	1	
14	<10	<25	25	----	<4	.5	<1	250 ppm Mn.	29	10	<25	25	----	<4	3	<1	<50 ppm Mn.
15[4]	10	25	500	----	8	>100	----	50,000 ppm Mn.	30	10	25	25	----	<4	7	<1	250 ppm Mn.
16[4]	25	<25	750	----	<4	2	<1	750 ppm Mn.	31	20	25	25	----	<4	7	----	1,000 ppm Mn.
17[4]	10	<25	50	----	4	5	<1	400 ppm Mn.	32	10	25	25	----	<4	2	<1	500 ppm Mn.
18	10	<25	50	----	<4	2	1	1,500 ppm Mn.									

Forest quadrangle																
33	------	------	------	------	------	------	------	Rechecked; check further.	39	15	25	100	------	------	25	<1
34	20	600	75	------	------	45	3		40	15	25	25	------	------	5	1
	30	75	150	50	------	19	<1		41	20	25	50	------	------	1	2
35	20	25	75	------	------	7	1		42	10	<25	50	------	------	7	<1
36	<10	<25	25	------	------	<.5	1		43	10	<25	50	------	------	5	1
37	20	25	300	------	------	>45	1		44	10	25	100	------	------	30	<1
38	15	25	100	------	------	11	<1		45	20	25	50	------	------	<.5	1.5
Kellyland quadrangle																
99	10	<25	25	25	<2	1.5	<1		102	<10	<25	50	15	------	17	<1
100	15	25	75	40	------	15	<1		103	<10	<25	50	15	------	8	<1
101	<10	25	75	15	------	8	<1		104	15	<25	50	25	------	1.5	<1
Lead Mountain quadrangle																
173	10	<25	25	15	<2	1.5	<1		177	10	<25	50	25	<2	2	<1
174	10	<25	50	25	<2	1.5	<1		178	10	<25	50	25	<2	1.5	<1
175	<10	<25	50	25	2	6	<1		179	<10	<25	50	25	<2	10	<1
176	10	<25	25	25	<2	1.5	<1		180	15	<25	75	25	4	10	<1
Nicatous Lake quadrangle																
105	<10	<25	<25	15	<2	1.5	<1		111	10	<25	25	25	<2	1.5	2
106	10	<25	25	15	<2	1	<1		112	<10	<25	25	<25	------	3	<1
107	<10	<25	25	15	<2	1.5	<1		113	<10	<25	50	<15	------	4	<1
108	10	<25	25	25	<2	6	<1		114	<10	<25	50	<15	------	6	<1
109	10	<25	25	25	<2	3	<1		115	10	<25	75	15	<2	4	<1
110	10	<25	125	25	8	65	<1									
Scraggly Lake quadrangle																
58	<10	<25	50	25	<2	1.5	<1		67	15	<25	25	40	<2	1	1
59	10	<25	50	40	<2	3	<1		68	20	<25	50	40	<2	4.5	1
60	30	<25	50	50	<2	1.5	6	Hornfels zone.	69	10	<25	25	25	<2	1.5	<1
61	10	<25	25	15	<2	3	<1		70	<10	<25	25	15	<2	1	<1
62	10	<25	25	15	<2	2	<1		71	10	<25	25	25	4	1.5	<1
63	10	<25	50	25	<2	10	<1		72	<10	<25	75	15	<2	.5	<1
64	20	25	50	25	4	17	<1	Mo mildly interesting. Hornfels zone.	73	<10	<25	25	15	<2	.5	<1
65	15	25	15	40	6	4	2		74	<10	<25	50	15	------	8	<1
66	30	<25	50	40	3	1	1		75	10	<25	75	15	------	3	<1

See footnotes at end of table.

TABLE 4.—*Partial chemical analyses*[1] *of stream sediments from the Grand Lake area, Maine*—Continued

Sample	Cu	Pb	Zn	Ni	Mo	cx HM[2]	cx Cu[3]	Remarks	Sample	Cu	Pb	Zn	Ni	Mo	cx HM[2]	cx Cu[3]	Remarks
Springfield quadrangle																	
46	<10	<25	25	15	<2	3	<1		52	10	<25	50	25	<2	1.5	<1	
47	<10	<25	25	25	<2	3	<1		53	15	<25	25	40	<2	1.5	<1	
48	10	<25	25	25	<2	.5	<1		54	15	<25	100	40	<2	15	<1	
49	<10	<25	25	15	<2	2	<1		55	15	25	50	25	<2	1.5	1	
50	10	25	100	25	<2	6	<1		56	15	<25	100	50	<2	8	2	
51	<10	<25	25	25	<2	1.5	<1		57	30	<25	50	75	<2	8	2	
Tug Mountain quadrangle																	
181	10	<25	50	25	<2	2	<1		187	10	<25	25	15	<2	1.5	<1	
182	<10	<25	<25	75	<2	1.5	<1		188	10	<25	50	25	3	34	<1	15 ppm Co.
183	10	<25	25	15	<2	1.5	<1		189	10	<25	25	15	<2	1.5	<1	
184	10	25	50	25	12	8	<1	Mo slightly anomalous.	190	10	100	250	25	60	<80	<1	Check further. 300 ppm Co.
185	25	25	25	25	8	2	<1		191	10	<25	25	25	<2	1.5	<1	
186	<10	<25	25	15	<2	1	<1										
Wabassus Lake quadrangle																	
116	10	25	75	15	------	1.5	<1		128	20	<25	75	20	------	----------	----------	
117	15	50	100	15	------	36	<1		129	15	<25	75	40	<2	----------	----------	
118	<10	50	75	15	------	28	<1		130	<10	<25	50	25	<2	8	<1	
119	<10	<25	25	25	<2	1.5	<1		131	10	<25	100	50	<2	----------	----------	
120	10	25	150	15	------	2	<1		132	10	<25	50	25	<2	15	<1	20 ppm Co.
121	10	50	125	15	------	17	<1		133	20	<25	50	25	<2	----------	----------	
122	<10	<25	25	<15	------	2	<1		134	<10	<25	<25	15	<2	1.5	<1	
123	<10	25	50	<15	------	15	<1		135	<10	<25	25	25	<2	.5	<1	
124	<10	<25	25	<15	------	3	<1		136	10	<25	<25	25	2	----------	----------	
125	15	<23	75	25	------	3	<1		137	<10	<25	25	25	<2	4	<1	
126	10	25	150	15	------	22	<1		138	<10	<25	50	25	2	4	<1	
127	10	<25	10	25	<2	3	<1		139	<10	<25	25	15	2	1.5	<1	

Waite quadrangle

76	20	25	75	------	------	10	1	
77	15	25	100	------	------	11	<1	
78	15	<25	75	------	------	5	1	
79	30	25	50	------	------	<.5	1	
80	30	25	75	------	------	5	3	
81	15	25	100	------	------	11	1	
82	20	50	75	------	------	3	1	
83	30	<25	75	------	------	.5	2	
84	40	<25	75	50	<2	2	4	Hornfels drainage.
85	15	<25	50	40	<2	3	<1	
86	10	<25	50	40	<2	4	1	
87	20	<25	125	50	2	10	3	

88	20	<25	75	25	2	24	<1	15 ppm Co.
89	10	<25	50	25	<2	4	<1	
90	10	25	75	25	<2	30	<1	40 ppm Co.
91	10	<25	50	25	<2	6	<1	
92	10	<25	50	40	------	4	<1	
93	20	25	75	50	------	3	3	3 pp cxCu, mildly interesting.
94	10	25	100	40	2	26	<1	40 ppm Co.
95	<10	<25	50	15	------	6	<1	
96	30	25	75	40	------	3	1	
97	<10	<25	75	25	------	3	<1	
98	10	<25	75	25	------	6	<1	

Wesley quadrangle

192	<10	<25	25	15	<2	1.5	<1	
193	60	150	200	25	<2	----------	----------	15 ppm Co. Sample of bed-rock.
194	10	<25	50	25	------	6	<1	
195	<10	<25	25	15	<2	1.5	<1	
196	10	<25	75	25	<2	4	<1	
197	10	<25	25	25	<2	3	<1	
198	10	<25	25	25	<2	.5	<1	
199	<10	<25	50	25	<2	3	<1	
200	15	<25	50	40	<2	21	<1	40 ppm. Co

201	10	<25	25	15	<2	2	<1	
202	15	200	50	<15	------	----------	<1	Check further.
203	10	<25	25	<15	------	4	<1	
204	10	25	25	<15	------	----------	<1	
205	10	<25	50	25	------	3	<1	
206	10	<25	50	75	------	1.5	<1	
207	<10	<25	<25	50	------	.5	<1	
208	<10	<25	25	<15	------	2	<1	
209	40	<25	100	15	------	----------	----------	15 ppm Co. Sample of bed-rock.

[1] Samples analyzed by rapid semiquantitative field methods described by Ward and other (1963).

[2] Cold citrate-soluble heavy metals (principally undifferentiated copper, lead, and zinc) expressed as parts per million as compared with standard samples containing known amounts of zinc.

[3] Cold-acid extractable copper.

[4] Sample taken by F. C. Canney.

Another trenched site is on McLain Mountain, in the Waite quadrangle. Here several very small trenches explore minute quartz veins in a shear zone. Nothing is known of the history of this small venture.

In the early 1950's a well was drilled for oil at Brookton, in the Danforth quadrangle. It penetrated the red and green slate and green quartzite of Cambrian or Ordovician age and was open to a depth of about 350 feet in 1959, when the well cuttings were examined at the site. The oil originally found at the site probably was motor oil, not crude.

REFERENCES CITED

Alcock, F. J., 1946a, Preliminary map, St. Stephen, Charlotte County, New Brunswick: Canada Geol. Survey Paper 46–2.

——— 1946b, Preliminary map, Honeydale, New Brunswick: Canada Geol. Survey Paper 46–3.

Allingham, J. W., 1960, Use of aeromagnetic data to determine geologic structure in northern Maine, *in* Short papers in the geological sciences: U.S. Geol. Survey Prof. Paper 400–B, p. B117–B119.

American Commission on Stratigraphic Nomenclature, 1961, Code of stratigraphic nomenclature: Am. Assoc. Petroleum Geologists Bull., v. 45, no. 5, p. 645–665.

Amos, D. H., 1963, Petrology and age of plutonic rocks, extreme southeastern Maine: Geol. Soc. America Bull., v. 74, p. 169–194.

Bastin, E. S., and Williams, H. S., 1914, Description of the Eastport quadrangle, Maine: U.S. Geol. Survey Geol. Atlas, Folio 192, 15 p., 4 maps.

Canada Geological Survey, 1949, Geological map of the Maritime Provinces (New Brunswick, Nova Scotia, and Prince Edward Island): Canada Geol. Survey Map 910A.

———1957a, Bathurst-Newcastle area, New Brunswick: Canada Geol. Survey Prelim. Ser. Map 1–1957.

——— 1957b, Rolling Dam, New Brunswick: Canada Geol. Survey Geophysics Paper 594, aeromagnetic map.

——— 1957c, St. Stephen, New Brunswick: Canada Geol. Survey Geophysics Paper 595, aeromagnetic map.

Chapman, C. A., 1962, Bays-of-Maine igneous complex: Geol. Soc. America Bull., v. 73, no. 7, p. 883–887.

Clark, R. K., 1961, McAdam, York and Charlotte Counties [New Brunswick]: New Brunswick Dept. Lands and Mines, Mines Br., Geol. Notes P. M. 59–4, 12 p.

Currier, L. W., 1960, Geologic appraisal of dimension-stone deposits: U.S. Geol. Survey Bull. 1109, 78 p.

Doyle, R. G., Young, R. S., and Wing, L. A., 1961, A detailed economic investigation of aeromagnetic anomalies in eastern Penobscot County, Maine: Maine Geol. Survey Spec. Econ. Studies Ser. 1, 69 p.

Faul, Henry, Stern, T. W., Thomas, H. H., and Elmore, P. L. D., 1963, Ages of intrusion and metamorphism in the northern Appalachians: Am. Jour. Sci., v. 261, p. 1–19.

Forsyth, W. T., 1955, Airborne magnetometer investigations in eastern Maine: Maine Geol. Survey, Rept. State Geologist 1953–54, p. 31–45.

Frischknecht, F. C., and Ekren, E. B., 1960, Mapping conductive strata by electromagnetic methods, *in* Short papers in the geologic sciences: U.S. Geol. Survey Prof. Paper 400–B, p. B121–B125.

Griscom, Andrew, and Larrabee, D. M., 1963, Aeromagnetic interpretation and preliminary geologic map of the Danforth area, Maine: U.S. Geol. Survey Geophys. Inv. Map GP–423.

Hitchcock, C. H., 1862, Geology of Maine: Maine Sci. Survey, Second Ann. Rept. * * * Natural History and Geology, 1862, p. 221–430.

——— 1870–85, The geology of northern New England: 5, 4, 17 p. [folio contains: Geology of Vermont, printed 1870, 1882; Geological map of Maine, Geology [of Maine], printed 1885; Geological map of New Hampshire and Vermont, Topography [of New Hampshire], Geology [of New Hampshire], printed 1873].

Larrabee, D. M., 1963a, Bedrock reconnaissance map of the Forest quadrangle, Maine: U.S. Geol. Survey open-file map.

——— 1963b, Geologic map and section of the Kellyland and Vanceboro quadrangles, Maine: U.S. Geol. Survey Mineral Inv. Field Studies Map MF–269.

——— 1963c, Bedrock reconnaissance map of the Mattawamkeag quadrangle, Maine: U. S. Geol. Survey open-file map.

——— 1963d, Bedrock reconnaissance map of the Nicatous Lake quadrangle, Maine: U.S. Geol. Survey open-file map.

——— 1963e, Bedrock reconnaissance map of the Scraggly Lake quadrangle, Maine: U.S. Geol. Survey open-file map.

——— 1963f, Bedrock reconnaissance map of the Springfield quadrangle, Maine: U.S. Geol. Survey open-file map.

——— 1963g, Bedrock reconnaissance map of the Waite quadrangle, Maine: U.S. Geol. Survey open-file map.

——— 1963h, Bedrock reconnaissance map of the northern one-third of the Wesley quadrangle, Maine: U.S. Geol. Survey open-file map.

——— 1963i,Bedrock reconnaissance map of the Winn quadrangle, Maine: U.S. Geol. Survey open-file map.

——— 1963j, Bedrock reconnaissance map of the Wytopitlock quadrangle, Maine: U.S. Geol. Survey open-file map.

——— 1964a, Reconnaissance bedrock geology of the Wabassus Lake quadrangle, Washington County, Maine: U.S. Geol. Survey Mineral Inv. Field Studies Map MF–282.

——— 1964b, Bedrock geologic map of the Big Lake quadrangle, Washington County, Maine: U.S. Geol. Survey Geol. Quad. Map GQ–358.

Larrabee, D. M., and Spencer, C. W., 1963, Bedrock geology of the Danforth quadrangle, Maine: U.S. Geol. Survey Geol. Quad. Map GQ–221.

Larrabee, D. M., Spencer, C. W., and Swift, D. J. P., 1964, Bedrock geology of the Grand Lake area, Maine: U.S. Geol. Survey open-file map.

MacKenzie, G. S., 1940, The St. Stephen map-area, Charlotte County, New Brunswick: New Brunswick Dept. Lands and Mines Geol. Notes, 39 p.

MacKenzie, G. S., and Alcock, F. J., 1960a, Geology, St. Stephen, Charlotte County, New Brunswick: Canada Geol. Survey Map 1096A.

——— 1960b, Geology, Rolling Dam, Charlotte County, New Brunswick: Canada Geol. Survey Map 1097A.

Nelson, J. M., and Narten, P. F., 1951, Reconnaissance of radioactive rocks of Maine: U.S. Geol. Survey TEI–68, 43 p., issued by U.S. Atomic Energy Comm. Tech. Inf. Service, Oak Ridge, Tenn.

Neuman, R. B., 1962, The Grand Pitch Formation: New name for the Grand Falls Formation (Cambrian?) in northeastern Maine: Am. Jour. Sci., v. 260, p. 794–797.

——— 1964, Fossils in Ordovician tuffs, northeastern Maine: U.S. Geol. Survey Bull. 1181–E, 38 p.

Post, E. V., and Hite, J. B., 1963, Heavy metals in stream sediment, west-central Maine: U.S. Geol. Survey Mineral Inv. Field Studies Map MF–278.

Rand, J. R., 1957, Maine pegmatite mines and prospects and associated minerals: Maine Geol. Survey Minerals Resources Index no. 1, 43 p.

——— 1958, Aeromagnetic and geologic reconnaissance survey of portions of Penobscot, Hancock and Washington Counties, Maine: Maine Geol. Survey GP & G Survey no. 3, 5 p.

Shapiro, Leonard, and Brannock, W. W., 1963, Rapid analysis of silicate, carbonate, and phosphate rocks: U.S. Geol. Survey Bull. 1144–A, 56 p.

Trefethen, J. M., 1953, Airborne magnetometer survey, Forest City area, eastern Maine: Maine Geol. Survey map, scale 1: 62,500.

Tupper, W. M., and Hart, S. H., 1961, The age of granite complexes in the Central Highlands and western part of the Southern Highlands of New Brunswick: Carleton Univ. Dept. Geology, Geol. Paper 61–1, 9 p.

Ward, F. N., Lakin, H. W., Canney, F. C., and others, 1963, Analytical methods used in geochemical exploration by the U.S. Geological Survey: U.S. Geol. Survey Bull. 1152, 100 p.

Wing, L. A., 1959, An aeromagnetic and geologic reconnaissance survey of portions of Penobscot, Piscataquis, and Aroostook Counties, Maine: Maine Geol. Survey GP & G Survey no. 4, 18 p.

U.S. GOVERNMENT PRINTING OFFICE : 1965