Bedrock Geology of the Shin Pond and Stacyville Quadrangles Penobscot County, Maine

GEOLOGICAL SURVEY PROFESSIONAL PAPER 524-I

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By ROBERT B. NEUMAN

SHORTER CONTRIBUTIONS TO GENERAL GEOLOGY

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A description of the lower Paleozoic stratigraphy and structure east of Mount Katahdin

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By Robert B. Neuman

ABSTRACT

The bedrock of the Shin Pond and Stacyville quadrangles, northern Penobscot County, Maine, is formed by Cambrian(?) to Lower Devonian sedimentary and igneous rocks in the chlorite zone of regional metamorphism and the nonmetamorphosed Katahdin Quartz Monzonite.

Complexly deformed slate, quartzite, and related rocks of the Lower Cambrian(?) Grand Pitch Formation are unconformably overlain by tuffaceous sandstone, tuff, and flows of the Lower or Middle Ordovician Shin Brook Formation in an anticlinorium in the central part of the area. Ordovician greenstone, largely of extrusive origin, and the Middle Ordovician Wassataquoik Chert (new) lie on the eastern and southern flanks of the anticlinorium. The Rockabema Quartz Diorite, altered and locally sheared and mylonitized, intrudes the Grand Pitch Formation and the Ordovician greenstone.

Upper Ordovician and Lower Silurian conglomerate on the northwestern flank of this anticlinorium and Lower Silurian conglomerate and sandstone on its southeastern flank were probably derived from an ancestral uplift in the position of the present structure. The presence of this anticlinorium throughout the Silurian is indicated by the contrast in facies of Silurian rocks on opposite flanks. Distinctive rocks on the northwest are calcareous siltstone, limestone, and volcanic rocks, whereas on the southeast, noncalcareous slate and siltstone (Allsbury Formation) predominate.

Lower Devonian rocks, consisting of dark slate and siltstone of the Seboomook Formation and the thick-bedded Matagamon Sandstone, overlie Silurian rocks to the northwest of the anticlinorium, but not those to the southeast.

The tectonic history of the area is complex. The Grand Pitch Formation was first deformed before the deposition of the Shin Brook Formation. This folding event, here named the Penobscot disturbance, probably affected a widespread area through Maine and southeastern Quebec. The ancestral anticlinorium of the Shin Pond-Stacyville area probably dates from the later Ordovician Taconic orogeny, as does the intrusion of the Rockabema Quartz Diorite. Acadian (Middle Devonian) orogeny considerably modified the central anticlinorium and the adjoining basins. A complex pattern of folds and faults, including a large right-lateral strike-slip fault system along its southeastern flank, was formed during this event, and the area was regionally metamorphosed at the same time. The posttectonic Katahdin Quartz Monzonite, which has a wide bordering breccia in this area, cuts across all these structures and represents the final phase of Acadian orogeny.

INTRODUCTION

PURPOSE AND MAJOR FINDINGS OF THE STUDY

Geologic mapping and related laboratory investigations in the Shin Pond and Stacyville quadrangles have yielded new information on stratigraphy, paleontology, igneous history, and structure that provides keys to the interpretation of the geologic history of northern Maine. The salient structural feature of the area is a large southward-plunging anticlinorium in which Lower Cambrian(?) and, Ordovician sedimentary and volcanic rocks and Late Ordovician or Early Silurian intrusive rocks are exposed. The Silurian sedimentary sequence on the northwestern flank of this anticlinorium includes distinctive calcareous sedimentary and volcanic rocks, whereas correlative rocks on the southeastern flank consist of a contrasting assemblage of slate, sandstone, and conglomerate. A major fault system on the southeastern flank of this fold has complexly shuffled these rocks. The Katahdin Quartz Monzonite, the youngest unit in the area, cuts across all structures; that this rock was emplaced by stoping is indicated by the breccia zone along its contact.

The area was selected for mapping because it seemed potentially rewarding for the deciphering of pre-Silurian stratigraphy. Dodge (1881), long ago, found Ordovician graptolites in exposures along Wassataquoik Stream in the central part of the Stacyville quadrangle; Smith (1928) found *Oldhamia*, which he believed to be a Cambrian fossil, at Bowlin Falls of the East Branch of the Penobscot River in the southeastern part of the Shin Pond quadrangle; and Boucot identified the Silurian-pre-Silurian boundary, trending diagonally across the northern part of the Shin Pond quadrangle, in the course of reconnaissance mapping (Boucot, Griscom, and others, 1964). Identification of this boundary in detail and the determination of the relations of Dodge's and Smith's localities to it were the original goals of the investigation.

The sequence of dark slate and chert in which Dodge found the graptolites, named Wassataquoik Chert in this report, is in a fault block on the southeastern flank of the anticlinorium. Rocks bearing the *Oldhamia*, the Grand Pitch Formation (Neuman, 1962), form the core of the anticlinorium. The Grand Pitch Formation lies beneath Silurian rocks traced by Boucot along the northwestern flank of the anticlinorium. Within the anticlinorium, Lower or Middle Ordovician fossiliferous rocks of the Shin Brook Formation (Neuman, 1964) were found to overlie the Grand Pitch. Around the southern margins of this structure the Grand Pitch is overlain by andesitic and basaltic volcanic rocks that underlie the Wassataquoik Chert.

The mapping that led to these conclusions yielded sufficient additional data to indicate that mapping of both quadrangles to their borders should be completed. As is described under "Stratigraphy," the Silurian rocks have proved to be complex. To the southeast of the anticlinorium they are a thick sparsely fossiliferous and monotonous sequence of slate, sandstone, and conglomerate, whereas the sequence on the northwest is thinner, more fossiliferous, and its parts are more readily distinguished.

HISTORY OF INVESTIGATIONS

Although the Shin Pond-Stacyville area was traversed by the first geologic investigators in Maine and has been visited by geologists intermittently for 125 years, its geology remained virtually unknown until recently. C. T. Jackson followed the East Branch of the Penobscot River and the Seboeis River in 1837. The ledges he described (Jackson, 1838, p. 24–30) are among those that we have studied, but his optimistic account of the geology and mineral wealth of the region was influenced by the political urgency to attract American settlers into the area under dispute with Canada; his report, therefore, is of little more than historic interest.

Hitchcock traversed these streams in 1861. His understanding of the geology was better, for he dated the limestone at Marble Pond in the Shin Pond quadrangle (Horseshoe Pond of Hitchcock, 1861, p. 403) as "lower Helderberg group of Upper Silurian rocks," and gave a structure section along the East Branch of the Penobscot River (p. 402) which indicated that he recognized some of the important structural features and the angular unconformity between the Grand Pitch Formation of the present report and the overlying beds. Hitchcock's geologic map was the first to include the Shin Pond-Stacyville area, but, unlike his text, it is difficult to reconcile with our findings.

A year after Hitchcock's traverse, Holmes (in Hitchcock, 1862, p. 359–376) traveled by road from Patten to Snowshoe Lake and Scraggly Lake, making geologic observations incidental to his primary purpose of collecting zoologic specimens. Most of his remarks concern the physiography, but he commented on the distribution of the "Helderberg limestone," giving localities where it had been seen.

No additional geologic observations were reported from this area for many years. A later geologic map of the State by Hitchcock (1885) is considerably different from its predecessor, but it still shows little comprehension of the principal geologic features of the Shin Pond-Stacyville area.

Dodge (1881) and Smith (1928; also Ruedemann and Smith, 1935) added the observations already referred to. Keith's (1933) geologic map of Maine seems not to make use of the information provided by these earlier geologists, and in the Shin Pond and Stacyville quadrangles it is not a significant improvement over those of Hitchcock. Keith's map shows a horseshoe-shaped body of greenstone that has been shown on most small-scale compilations to the present. Wing's (1951) report on the greenstones of the area repeats this horseshoe, but he also mapped a rhyolite concentric with it—the rock called Rockabema Quartz Diorite in this report.

Only recently, through the work of A. J. Boucot (1954, 1961; also Boucot, Griscom, and others, 1964), has a comprehension of the geology of northern Maine developed. His observations in the Shin Pond area, interpreted in the light of detailed knowledge of the Moose River synclinorium farther west, provided the framework and impetus of the present study. The recently published "Geologic and Aeromagnetic Map of Northern Maine" (Boucot, Griscom, and others, 1964) includes preliminary results of the present work (Neuman, 1960) and extrapolations based on it.

FIELDWORK AND ACKNOWLEDGMENTS

Six summer field seasons were devoted to geologic mapping of the Shin Pond and Stacyville quadrangles and to reconnaissance in adjacent areas. The traverse network was designed to pass within half a mile of every point on the Shin Pond quadrangle, with a somewhat greater spacing in the Stacyville, but almost every road, trail, stream, and high point giving promise of bedrock exposure in both quadrangles was visited.

Field observations were plotted on 1:48,000-scale enlargements of the publication edition of the topographic quadrangles.

The following served as assistants during the course of the work:

John Duane, 1957; Richard H. Raymond, 1958; Harlan H. Roepke, 1959; Richard P. Ulmer and S. David

Berger, 1961; S. David Berger, 1962; and John R. Griffin, 1963.

Stanisław Dżułyński, of the Polish Academy of Sciences, Crakow, joined in the fieldwork for 3 weeks in 1958, as did Nelson Aliste, of the Chilean Institute of Geological Investigations, Santiago, for 4 weeks in 1961.

Conferences were held frequently with D. W. Rankin who was mapping the Traveler Mountain quadrangle west of the Shin Pond and with E. B. Ekren who was mapping the Island Falls quadrangle on the east, and some of the mapping along the quadrangle boundaries was pursued jointly with these geologists. Rankin also studied about 150 thin sections from this area and, on the basis of these studies, contributed the petrographic descriptions of the igneous rocks in this report, for which I am very grateful.

A. J. Boucot visited us in the field several times when, in addition to making fossil collections, he stimulated the progress of mapping. His identification and interpretation of the brachiopods from the Silurian and Devonian rocks are essential to the stratigraphic interpretation of this report.

F. C. Frischknecht made several electromagnetic traverses in the Shin Pond quadrangle, concentrating particularly in an area south of Lower Shin Pond (Frischknecht, 1966).

By their prompt completion of the aeromagnetic maps, reprinted here, R. W. Bromery and his associates aided significantly in the geologic mapping (Bromery, 1962; Bromery, Long, and others, 1963). Bromery also conferred with me on the geologic interpretation of the aeromagnetic data, and the results of these conferences are incorporated in this report.

I am grateful to these colleagues for their specific contributions, and to many others, too numerous to name, who generously took the time to spend from a few hours to a day or more reviewing various aspects of the geology of this area, or who guided me over their areas of work where comparable features could be seen.

REGIONAL SETTING

The Shin Pond and Stacyville quadrangles (pls. 1–3) lie in the northern Appalachians geologic province southeast of the Connecticut Valley-Gaspé synclinorium, its most continuous structural element (Cady, 1960, p. 536). Based on characteristics of the bedrock, largely that of Silurian age (Naylor and Boucot, 1965, p. 155), this province in central and eastern Maine may be considered to consist of three parts—the northern calcareous belt, central slate belt, and coastal or southern volcanic belt. Although the northern calcareous belt is coextensive with the uninhabited woodlands of northern Maine, its geology is better known than that of the other parts; the reconnaissance geologic map by Boucot, Griscom, Allingham, and Dempsey (1964) is largely confined to this belt. The central slate belt is a broad band that extends northeastward from at least the longitude of Waterville. Its width from its northwestern boundary at the fault zone in the Stacyville quadrangle to its southeastern margin near Calais (Amos, 1963, p. 172) is about 70 miles.

A part of both the northern calcareous belt and the central slate belt, and a segment of the boundary between them, are included in the Shin Pond and Stacyville quadrangles. In the part of the slate belt incorporated in these and adjoining quadrangles, Silurian rocks are mostly slate and fine-grained sandstone with small amounts of coarser clastics and virtually no limestone or volcanic rocks. Contemporaneous rocks in the northern calcareous belt here consist of large amounts of conglomerate, limestone, and volcanic rocks, as well as calcareous siltstone.

Rocks of both belts are deformed and metamorphosed to the chlorite grade of regional metamorphism. Slaty cleavage is well developed in the argillaceous rocks, and most other rocks are crushed and sheared. Deformation patterns in the two belts are somewhat different, however. The central slate belt is characterized by abundant tightly compressed steeply plunging, minor folds; the Silurian and Devonian rocks of the calcareous belt are more regularly arranged, although the oldest rocks here (Grand Pitch Formation) are also complexly folded.

Bodies of intrusive rocks are far more common in the central slate belt than in the northern calcareous belt, but the Katahdin batholith, the largest intrusive body in Maine, straddles this boundary.

GLACIAL GEOLOGY

Pleistocene continental glaciers covered the Shin Pond and Stacyville quadrangles, but observation of glacial features was only incidental to the investigations leading to this report. Glacial deposits almost completely mantle bedrock over the broad area in the Stacyville quadrangle southeast of the Katahdin massif, but they are less extensive elsewhere in the two quadrangles.

Over most of the area the ground surface is covered by bouldery drift that is probably till in most places, but may locally be of glaciofluvial or glaciolacustrine origin. The drift in most places consists largely of rock debris of the same kind as the bedrock that underlies it, but it includes subordinate amounts of erratics derived from the more resistant formations to the northwest. Land utilization reflects the character of the drift and its local source, for farming is virtually confined to the areas of drift containing small rock fragments derived from the slaty and calcareous rocks of the slate belt. Sections through the drift can be seen in many small roadside pits. Some shallow pits show unsorted and unoriented rock fragments in a clay matrix that is probably till, but more commonly the pits are dug in crudely stratified coarse sand and cobbly and bouldery waterlaid gravel. The thickness of these deposits is unknown; some pits as much as 15 feet deep in waterlaid deposits do not reach bedrock, but others have bedrock floors beneath 5 feet or less of unconsolidated material.

A prominent line of eskers lies in the low ground, from southeast of the southern shore of Snowshoe Lake at the north-central edge of the Shin Pond quadrangle through Upper Shin Pond to Ackley Pond.[1] In some places the crests of these eskers stand 30 feet above the surrounding boggy lowlands and form ideal beds for roads and trails that have been built on them for many years. In a few places these eskers have been excavated for sand and gravel for road construction. The walls of these excavations show interstratified and lenticular cobbly and bouldery gravel and crossbedded coarse sand. Much of the gravel is coarse and contains well-rounded boulders that are more than a foot in diameter; the sand is a relatively minor constituent.

Although the banks of the major rivers that flow through the area are bedrock in many places, at a few places they are cut in gravel deposits. Where the valleys are broad, they are filled with unconsolidated materials. The narrow ridges of unconsolidated material in the valley of the East Branch of the Penobscot River in the southern half of the Stacyville quadrangle are undoubtedly eskers, but the bouldery gravel that forms the wider ridges along Wassataquoik Stream near Deasey Dam and the benches at the foot of Hathorn Mountain in the northern part of the Stacyville quadrangle may be terraces.

Thick glacial deposits containing boulders of Katahdin Quartz Monzonite mantle the lowlands of the southwestern quarter of the Stacyville quadrangle. The intricate topography of small irregularly shaped hills near the quadrangle boundary here suggests kames, but elsewhere, the topography on these deposits is a nearly featureless kame terrace.

The drift is so thin in most places that bedrock is commonly exposed by road construction or by overturned trees, and there are scattered isolated roches moutonnées a few square yards in area. Freshly exhumed outcrops, particularly of slaty rocks, preserve glacial striations that have an average azimuth of about N. 25° W. Some granite surfaces preserve larger grooves, a few inches deep and a foot or two apart, that have the same orientation.

None of these glacial features is distinguished on the map. The contours indicate those having topographic expressions, and the more extensive and thicker drift areas are presumably those where fewest bedrock observations were recorded.

[1] Diversion of the Seboeis River to its present course through the remarkable steep-walled chasm that contains Godfrey Pitch (see Jackson's (1838, pl. 6) woodcut) may have resulted from an ice dam that formed across an earlier channel of the river in the vicinity of Hot Pond.

DISTRIBUTION OF BEDROCK EXPOSURES

Probably no more than half of one percent of the area is exposed bedrock. Most exposures are in streambeds and banks; however, exposures were found at the summit of virtually every well-defined hill, on all mountaintops, and on the shores of most lakes and ponds. In the lowlands artificial exposures were found in the beds of ephemeral roads built for logging and in gullies that followed their abandonment; natural exposures were seen beneath overturned trees and in roches moutonnées. Exposures are too few, therefore, to permit following contacts on foot. Thus, although several of the contacts of the geologic map were seen in one place or another, most were not. Through most of their length, the boundaries shown are based on projections of strikes controlled by widely scattered exposures.

The northern two-thirds of the map is more reliable than the southern third, as in this area the blanket of surficial deposits obscures geology that is poorly understood.

STRATIGRAPHY

NOMENCLATURE

The rocks of northern Maine and of the Shin Pond and Stacyville quadrangles have not proved altogether amenable to classification that accords with conventional stratigraphic nomenclature. Although most of the bedrock of the report area is classed with formations that have been identified outside its boundaries, some of the more distinctive units are known from only a few exposures in a limited area. Because lithologic differences distinguish these from each other, or paleontologic evidence indicates that quite similar rocks are of different ages, each of these units may be given different names, as they were by Boucot (1961). Under this practice each quadrangle report might have its own set of names for virtually the same rocks in somewhat different combinations. Such a proliferation of names could serve more to confuse than to promote understanding.

Accordingly, a less formal nomenclature is adopted for the present report. Existing names are used wherever possible; some of these are older names, for the most part modified from their original definitions, and some are names resulting from recent work in adjacent quadrangles. New names resulting from the present work are limited to two: the Shin Brook Formation, whose fossils were recently described (Neuman, 1964), and the Wassataquoik Chert, newly defined herein. The remaining units, largely of Silurian age, are referred to by their lithologic character and their age inferred from paleontologic or stratigraphic evidence.

In this report the British twofold subdivision of the Silurian is used (Pavlides and Berry, 1966).

CAMBRIAN(?) SYSTEM

GRAND PITCH FORMATION

The Grand Pitch Formation, the oldest rocks in the Shin Pond and Stacyville quadrangles, consists of gray, green, and red slate and siltstone with about equal amounts of vitreous quartzite and lesser amounts of graywacke and tuff. The formation occupies the core of the anticlinorium that extends northeast across the Shin Pond quadrangle and beyond (Pavlides and others, 1964, p. C30) and the crest of the domical outlier to the north.

Originally named the Grand Falls Formation by Ruedemann and Smith (1935), the formation was renamed Grand Pitch to correct a homonymy, and its type section was designated at the Grand Pitch of the East Branch of the Penobscot River (Neuman, 1962).

Efforts to subdivide the formation meaningfully proved unsuccessful. Nevertheless, the red slate and siltstone are a minor but conspicuous part of the formation in the type section and through most but not all of the outcrop area. Such red beds crop out in scattered localities northward from Lunksoos Stream at the northern edge of the Stacyville quadrangle to the boundary of the formation with Silurian rocks, and through the outcrop belt north of the syncline that contains the Shin Brook Formation. However, no red rocks were found in the Grand Pitch south of this syncline or along the Seboeis River south of Jerry Brook. In these areas the Grand Pitch contains more coarse-grained quartzose graywacke and a few thin beds of fine-grained tuff, but gray slate and vitreous quartzite predominate in both areas. Although these contrasts may be due to stratigraphic and environmental differences, the red color may have been altered by metamorphism, perhaps that associated with the intrusion of the Rockabema Quartz Diorite to the south.

In that part of the Grand Pitch containing red beds, slate and quartzite are interbedded in about equal amounts, although with different proportions and thicknesses of the two from one exposure to the next.

Most commonly, slate beds are 2–4 feet thick, separated by about equal thicknesses of thin-bedded quartzite. Alternations of quartzite and slate in beds a few inches thick are also common. A few quartzite beds as much as 6 feet thick are massive, but most contain partings at intervals of a few inches. Slate beds are generally laminated, and contain silty bands. Most of these rocks are untinted light to dark gray. The darkest gray slates are carbonaceous and moderately conductice according to F. C. Frischknecht (written commun., 1961), who made a test slingram electromagnetic traverse across some exposures of them along Bowlin Brook between Bowlin Pond and Bowlin Falls. Most of the quartzite is medium gray, but some varieties are darker. Red beds, including slate and siltstone, are seldom more than 2 feet thick; sequences of these and the greenish-gray slate, siltstone, and quartzite associated with them are intercalated with the gray rocks in units generally no more than 10 feet thick.

This part of the Grand Pitch Formation is well exposed, and several spectacular waterfalls spill over its thicker quartzite beds. Exposures are virtually continuous along the East Branch of the Penobscot River from the type locality at Grand Pitch downstream to Bowlin Falls, and in Bowlin Brook to the east. Shin Falls of Shin Brook and the Seboeis River from the Grand Lake Road bridge to Grand Pitch (of the Seboeis) also afford excellent exposures. At these places, as elsewhere through the outcrop belt, these rocks are complexly deformed. In some places deformation has obliterated sedimentary features, especially those of the slates, and in most places beds are nearly vertical.

Nevertheless, remarkable details may be seen in some places, most notably the trace fossil *Oldhamia smithi* Ruedemann. This fossil occurs in finely laminated micaceous red slate and siltstone both at Bowlin Falls (Smith, 1928; Ruedemann and Smith, 1935; Ruedemann, 1942) and about 500 feet southeast (downstream) of Grand Pitch of the East Branch (3629–CO; Neuman, 1962).[2] The fossils occur in the upper parts of graded layers, the lower parts of which are somewhat coarser grained and crossbedded. Fine-grained greenish-gray quartzite beds within a few feet of the fossiliferous layers are finely laminated and display crossbedding on a minute scale, with inclined sets from ½–1 inch thick; such beds as much as 3 feet thick are common throughout the formation. Similar greenish-gray quartzite also occurs in the lower parts of graded beds

[2] U.S. Geological Survey fossil locality numbers have been assigned to localities discovered during the course of the present investigations. Those from the Grand Pitch Formation and rocks of Ordovician age were entered into the Cambro-Ordovician catalog and are designated with the suffix "CO"; those from Silurian Devonian rocks are entered into the Siluro-Devonian catalog, designated "SD."

whose finer grained upper parts are red, but none of the red rocks in these color-graded sets yielded *Oldhamia.*

The imprints of sedimentary features on bedding surfaces is uncommon, perhaps because they were obliterated by differential movement along bedding surfaces. At one place about 300 feet northwest of Grand Pitch of the East Branch there are vertically oriented flute casts with a relief of almost an inch at the base of a fine-grained quartzite above gray slate. At a few other places, parting surfaces within laminated quartzites preserve rillmarks.

The Grand Pitch in the southern and southeastern parts of the outcrop area is almost identical to that in the northern parts. Although red beds are lacking here, it contains abundant greenish-gray slate and quartzite, some of which may have been metamorphically altered from red to green by iron reduction. Beds of quartzose graywacke with grains of quartz and feldspar as much as 1 cm in diameter are common in this area, but they have also been seen in association with red beds in Bowlin Brook.

The only volcanic rocks seen in the Grand Pitch are a few beds of crystal tuff near the southern boundary of the formation at exposures in the lower part of Davis Brook and on the shore of the Seboeis River opposite Gagnon Flats. The tuff beds, which are 1–6 feet thick, are interbedded with dark-gray slate and somewhat less abundant thin-bedded crossbedded quartzite. The turf is light gray, even textured, and fine grained, nearly uniform from top to bottom, and its contacts with sedimentary rocks both at the base and top are sharp. Thin sections of this rock show a well-oriented mat of elongate plagioclase crystals about 0.2 mm long that are partially altered to calcite and set in a very fine grained matrix that includes some epidote (Rankin, oral commun., 1964). Angular quartzite fragments as large as 3 mm and a few small rounded quartz grains are scattered through the sections, as are a few irregularly shaped patches of calcite as large as 3 mm and other patches of chlorite that have anomalous blue interference colors.

The Grand Pitch is probably no less than 5,000 feet thick, judging from the breadth of outcrop in the report area, but its thickness might be considerably greater.

The Grand Pitch is assigned an Early Cambrian(?) age to indicate that its classification as late Precambrian or Early Cambrian is equivocal (Neuman, 1962). The trace fossil *Oldhamia* might indicate an Early Cambrian age, as it has been found with Early Cambrian body fossils in the Weymouth Formation in Massachusetts (Howell, 1922). However, a late Precambrian age assignment cannot be excluded for those formations in which *Oldhamia* is the only fossil, such as the "Nassau Beds" of Ruedemann (in Cushing and Ruedemann, 1914, p. 70; see Zen, 1964, p. 57) in New York, the Bray Slate in Eire (Tremlett, 1959, p. 62), and the Grand Pitch.

Because the oldest rocks that overlie the Grand Pitch are of Early or early Middle Ordovician age, possibly part of it is Early Ordovician age. The possibility is considered to be remote, however, as the rock types associated with the beds bearing *Oldhamia smithi* Ruedemann characterize the formation throughout its outcrop area, and the significance ascribed to this fossil probably applies to the entire unit.

Probable equivalents of the Grand Pitch are the oldest rocks at several places in Maine and adjacent Quebec. In the Harrington Lake (Griscom, written commun., 1963) and The Forks (Post, oral commun., 1963) quadrangles, these rocks have been subdivided into three parts, and red beds are confined to the middle part. In adjacent Quebec, however, segregation of these older rocks, largely on the basis of the presence or absence of red beds, has shown that those parts with red beds (Caldwell Formation) both overlie and underlie parts without red beds (Rosaire Formation) (P. J. Lespérance, oral commun., 1963).

Rocks overlying the Grand Pitch are of several different kinds, but its upper contact is everywhere marked by a structural discontinuity. The contact with the Shin Brook Formation is exposed at the type section of that formation in Shin Brook, and on the southeast slope of Roberts Mountain in a small stream four-tenths of a mile west of the quadrangle boundary. At both places the Grand Pitch beneath the contact is gray slate and quartzite, as it is throughout this segment of the Grand Pitch outcrop belt. The close folding and crumpling characteristic of the outcrop belt are particularly evident in the Roberts Mountain exposures where the overlying Shin Brook contains much slate but is homoclinal.

Gray slate and quartzite of the Grand Pitch beneath the greenstones in the southern part of the outcrop belt near the Shin Pond-Stacyville quadrangle boundary are also intensely crumpled. The contact in this area is probably faulted locally and everywhere is abrupt. The lack of stratification in the overlying volcanic rocks through most of this area emphasizes the contrast.

Structural as well as lithic contrasts are most evident along the northern boundary of the Grand Pitch where the overlying rocks are of Silurian age. Exposures in Bowlin Brook show this contrast best; here north-dipping Silurian siltstone, sandstone, and conglomerate face away from intensely crumpled greenish-gray and red slate and thin-bedded crossbedded quartzite of the Grand Pitch. Northeastward, along the Seboeis River opposite the mouth of Sawtelle Brook, the northernmost Grand Pitch beds are quartzite with little slate, none of which is red. These and other exposures along this boundary indicate either that lithic assemblages of the Grand Pitch were originally of small areal extent or, more likely, that different parts of the formation, lie along the contact because of pre-Silurian and pre-Middle Ordovician structural relief.

ORDOVICIAN SYSTEM

SHIN BROOK FORMATION

A sequence of tuff, tuffaceous conglomerate, breccia, flows, and fossiliferous tuffaceous sandstone unconformably overlies the Grand Pitch Formation in the northeastern part of the Shin Pond quadrangle and the adjacent part of the Island Falls quadrangle. The sequence was named the Shin Brook Formation in a recent report on its fossils (Neuman, 1964), and a section measured along Shin Brook 2.3 miles northwest of Shin Pond village was designated its type section.

Gray to greenish-gray porphyritic rock with stubby to anhedral plagioclase crystals as large as 2 mm in an aphanitic matrix is the most common rock of the formation. Thin sections show that the rock is of intermediate composition and in the andesite-dacite range, and that as much as half the volume is formed of saussuritized plagioclase in a groundmass of felsic minerals and sericite.

Such rock occurs in thick, massive, and nearly uniform units, in thin beds, and with admixed rock fragments, some in such abundance as to form a breccia. Where the rock is massive and tens of feet thick, its origin as a tuff or lava flow cannot be determined; but it is most probably tuff where it occurs in well-defined beds a few inches thick, such as those near the top of the type section of the formation in Shin Brook (Neuman, 1964, p. E6). Scattered cognate rock fragments occur locally. Polymict breccia is common, with fragments of felsitic rocks as much as 4 inches in cross section and a few percent of quartzite in smaller fragments in a matrix that is largely plagioclase crystals. Most breccia fragments are nearly equidimensional, but an abundance of large whispy tabular fragments that might have been vesicular rock characterizes a distinctive layer just beneatth the fossiliferous sandstone at the southern end of Sugarloaf Mountain.

Clearly recognizable lava is rare in the Shin Brook Formation. In the exposure that is most convincingly a lava (SW¼, T. 6 N., R. 7 E., 1.65 miles N. 25° E. of Sugarloaf Mountain summit), flow banding parallel to the northwest regional dip is marked by closely spaced layers of concentrations of plagioclase crystals that are nearly parallel, except where they are deflected around rock fragments.

Stratified rocks, including slate, siltstone, sandstone and conglomerate, form a minor but important part of the formation, and some of the sandstone beds are richly fossiliferous. All but the finest grained of these are formed of volcanic detritus, and quartz grains are rare. Graded beds whose sets range in thickness from an inch to a foot are common. Some such beds a foot thick have coarse pebbly sandstone at the base and fine sandstone at the top, but the thinner graded beds begin with fine sandstone and grade into slate. Identifiable fossils were collected from sandstone beds at six places in the Shin Pond quadrangle and at two places in the Island Falls quadrangle (Neuman, 1964, p. E11). At a few places, as on Sugarloaf Mountain (Neuman, 1964, fig. 3, p. E11) the fossils are concentrated in shell layers at the base of individual beds, but they are more widely disseminated at most places.

These stratified layers appear to be lenses that occur at different levels through the sequence, which is composed predominantly of tuff or coarser unstratified fragmental rocks. Shelly sandstone occurs no more than 100 feet above the base of the formation along Townline Brook in the Island Falls quadrangle (Neuman, 1964, p. E12), but similar beds were not seen in the two places where rocks at this level are exposed in the Shin Pond quadrangle. The stratigraphic position of higher shelly layers is indeterminate, however, as only a few tens of feet is exposed at most outcrops.

Although the original structures and textures of the rocks of the Shin Brook Formation are preserved in a few places, more commonly the rocks are strongly sheared and these features are obliterated. In such places the coarse fragmental rocks remain recognizable, but their fragments are deformed, reoriented, and flattened parallel to shear surfaces. With the development of strong shearing, the sandstones are difficult to distinguish from tuffs except where some vestiges of fossils remain. The shearing, however, is helpful in distinguishing the Shin Brook Formation from the overlying metadiabase which was resistant to deformation.

Most outcrops of the Shin Brook Formation are on the southeastern limb of a doubly plunging syncline that is about equally divided by the Shin Pond-Island Falls quadrangle boundary. Exposures of the Shin Brook on the northwestern limb were seen on Sugarloaf Mountain and at one place to the northeast (0.4 mile west of Hot Pond), but its presence at these places and on the northwest limb in the Island Falls quadrangle (Ekren and Frischknecht, 1967) indicates that it is continuous on this limb beneath glacial drift. Although the Shin Brook is not exposed elsewhere in the Shin Pond quadrangle, there are a few outlying shallow synclines containing it in the Island Falls quadrangle (Ekren and Frischknecht, 1967).

The original thickness of the Shin Brook Formation is indeterminate, as the only rock that overlies it is metadiabase inferred to be a sill. Preserved thicknesses range from about 300 feet on the west face of Sugarloaf Mountain to about 2,500 feet southeast of Roberts Mountain near the eastern edge of the quadrangle.

The age of the Shin Brook has been estimated from its brachiopods (Neuman, 1964, p. E23) and trilobites (Whittington in Neuman, 1964, p. E33). The most abundant specimens of both phyla belong to new species: the brachiopod *Platytoechia boucoti* Neuman was placed in a new monotypic genus (Neuman, 1964, p. E19), and the trilobite *Annamitella? borealis* Whittington is most closely related to forms from North Viet Nam, Kazakhstan, Australia, and Argentina. From their studies of six brachiopod genera and nine trilobite genera, both authors conclude that the Shin Brook Formation is either of late Early Ordovician age or, more likely, earliest Middle Ordovician (Whiterock Stage of Cooper, 1956, p. 7).

UNNAMED VOLCANIC ROCKS (GREENSTONE)

Gray and greenish-gray fine-grained igneous rocks, probably largely of extrusive origin, crop out to the south and west of the Grand Pitch Formation. These rocks are collectively called greenstone, for greenish altered types are most common, but there is a considerable range in composition including basalt and andesite, and some that were probably dacitic. Their origin as intrusives or extrusives is indeterminate at most exposures, but pillow lava and flow breccia at a few places indicate that some, if not most, are extrusive. Rock of pyroclastic origin is uncommon.

As mapped, these rocks occur in six discrete areas, and are assumed to be bounded by one or more faults. They form some of the more prominent mountains and ridges of the report area and correspond in general to some of its major magnetic features.

These rocks are well exposed in many large ledges on the flanks and crests of ridges, but the exposures are almost massive and structureless except for widely spaced joints. Most weathered surfaces are dull brown, but those on the more felsic varieties are lighter colored, and some are nearly white.

In thin section the greenstone consists of randomly oriented plagioclase laths of barely resolvable dimensions, some as much as 3 mm long, and pyroxene, which forms as much as 10 percent of some specimens (D. W. Rankin, oral commun., 1964). Some specimens are porphyritic, but a few that are coarser grained are nearly equigranular. Nearly all this rock is strongly altered; the plagioclase is albite, and calcite, chlorite, and clinozoisite are secondary minerals. Andesine, however, was found preserved in one specimen and pyroxene is more commonly preserved. Undetermined opaque grains, probably magnetite, constitute a few percent of most specimens. Such rock could have been formed in a laval flow or a shallow intrusive body.

The largest of the six areas, about 1½ miles wide and more than 10 miles long, in the northwestern part of the Stacyville quadrangle, forms a double-crested line of ridges, including Deasey and Lunksoos Mountains, that is simulated by the magnetic contours. This area has been mapped northward into the Traveler Mountain quadrangle where it is exposed at Pond Pitch of the East Branch of the Penobscot River; here the volcanic rocks are overlain by conglomerate of Late Ordovician age (D. W. Rankin, oral commun., 1962). The unfaulted sequence from the Grand Pitch Formation through these volcanics to the Upper Ordovician conglomerate at Pond Pitch provides the best available evidence of both a minimum and maximum age for the volcanics.

Volcanic breccia forms a small but conspicuous part of this area, occurring apparently erratically with pillow lavas and the more common structureless rock. Most of the breccia consists of angular fragments of dark volcanic rocks an inch or two across in a fine-grained light-colored matrix. At two places, however (brook northwest of Deasey Mountain at the 1,000-ft contour and the west slope of the 1,360-ft hill at the 1,250-ft contour), fragments as much as 14 inches long have irregular and embayed shapes and altered margins that suggest flow breccia. The interpretation of these rocks as flow breccia is confirmed by Rankin's (oral commun., 1964) examination of thin sections cut from them. The fragments are of several kinds, including fine-grained porphyritic rock consisting of small plagioclase crystals in a submicroscopic matrix, spherulitic rock whose spherules of plagioclase lie in a felted mass of plagioclase, and devitrified glass. The matrix is devitrified glass whose perlitic cracks are outlined by iron strains, and alteration or reaction zones are common along the boundaries between fragments and matrix.

Breccia, possibly of pyroclastic origin, was seen at only one place (northwest corner of the Stacyville quadrangle in Little Spring Brook at the 620-ft. contour). Here, angular quartzite fragments as much as 2 inches in diameter and very fine grained dark igneous rocks are included in a fine-grained matrix whose texture and mineralogy are obscured by intense shearing and crystallization of secondary calcite.

Pillows occur at several places in the vicinity of Lunksoos Mountain. They are best displayed on the western spur of that mountain at the 1,600-foot contour where two layers of pillows are exposed on a southwest-sloping dip face. The pillows are closely packed, and range in diameter from 10 inches to 3 feet. They have nearly spherical upper surfaces, but several have narrow necks pointing downward. The pillows are made of the same fine-grained dark greenish-gray prophyritic rock as occurs in structureless exposures, and none was found with amygdules or textural variations that are commonly associated with pillows. The rock between pillows is light greenish-gray, presumably epidote-rich fine-grained breccia. Similar pillows were also seen in the east-facing slope south of Lunksoos Mountain down to the base of the volcanic sequence at the 800-foot contour.

The volcanic rocks of the area that includes Hunt Mountain are separated from those of the Deasey Mountain-Lunksoos Mountain belt by tuff breccia of probable Silurian age whose presence is reflected in the aeromagnetic map by a nonmagnetic saddle. The structural relations of the Hunt Mountain block are poorly known, but the block appears to contain an eastward-facing succession that grades upward into the Wassataquoik Chert.

The rocks of the western part of the Hunt Mountain block are similar to those of the Deasey-Lunksoos Mountain block to the north. In this area pillow lavas crop out in large exposures at the big bend of Wassataquoik Stream. To the east, however, and on Hunt Mountain, breccia predominates, and much of the rock is more felsitic than elsewhere. The sequence also contains some aphanitic flinty tuff and crystal tuff that become increasingly abundant toward the east as the contact with the Wassataquoik Chert is approached.

Volcanic breccia and felsitic rocks are also abundant on Whetstone Mountain, but east-facing pillow lava was seen at the northeastern point of the mountain. The structural and stratigraphic relations of these rocks are also poorly known; their slight deflection of the magnetic contours indicates that they do not extend beneath the drift much beyond their outcrop; along strike to the north, conglomerate crops out in Sandbank Stream.

The volcanic rocks of the belt that borders the Grand Pitch Formation on the east and southeast are largely fine-grained nearly featureless greenstone. This belt contains virtually no breccia, and its rare pillows are outlined by red and green chert rather than by epidote-rich breccia. The belt joins the Deasey Mountain-Lunksoos Mountain belt at a fault complex near the mouth of the Seboeis River and trends northward to Bear Mountain and beyond. It supports a line of ridges which, in the Stacyville quadrangle, corresponds to a linear magnetic anomaly. Near the boundary between the Stacyville and Shin Pond quadrangles, the volcanic rocks are hosts to an abundance of dikes and sills of Rockabema Quartz Diorite, and this area is mapped separately.

The rocks of this belt seem also to form an eastward-facing succession. At one place (NE¼SW¼, T. 4 N., R. 7 W., 1.7 miles S. 60° E. of the southern end of Lunksoos Lake, 600 ft. in altitude) where the contact is exposed, it is apparently unfaulted. Here the lowest few feet of volcanic rocks above the Grand Pitch Formation are fragmental rocks that were probably tuff. These contain angular fragments of quartzite and basaltic rocks, as much as 5 mm in diameter, in a fine-grained matrix of plagioclase laths, clinozoisite, and chlorite and clastic grains of quartz. Farther south, however, this contact is probably faulted.

The upper part of the volcanic sequence of the Bear Mountain outcrop belt is apparently faulted off and displaced by Silurian conglomerate, but volcanic rocks overlain by chert are also exposed in the narrow belt that corresponds to a small magnetic anomaly at Peaked Mountain. The rocks of the Peaked Mountain belt are almost entirely dark structureless greenstone, its monotonous character relieved only by amygdular varieties at a few places. Breccia is abundant near the southern end of the belt, but here it is probably of tectonic origin.

The sixth outcrop area of volcanics, at the eastern edge of the Shin Pond quadrangle, is the western prolongation of the large volcanic mass which to the east supports Mount Chase (Ekren, 1961, p. D43–D44; Ekren and Frischknecht, 1967), referred to by Ekren as the Mount Chase belt. This belt is also reflected in the magnetic contours, but adjacent linear magnetic anomalies that are probably reflections of magnetite-bearing sedimentary rocks should be distinguished from the broader anomalies that are due to the volcanic rocks.

In the segment of this belt exposed in the Shin Pond quadrangle, most exposures are massive, gray and greenish gray, and fine grained, indistinguishable from those of the other areas described above. Such rock from Mount Chase was described and illustrated by Ekren (1962, p. D44), who identified it as spilite. As in the Island Falls quadrangle (Ekren, 1962, p. D45), this belt in the Shin Pond quadrangle contains coarse-grained diabase whose chilled contacts and xenoliths of fine-grained rocks demonstrate its intrusive origin.

Little can be learned of the stratigraphic relations of the volcanic rocks from this belt, as all its boundaries appear to be faulted. Nevertheless, its position between the Grand Pitch Formation on the northwest and the Allsbury Formation on the southeast is consistent with the interpretation that the volcanic rocks of this belt had the same stratigraphic position as those of the other belts of greenstone.

The petrographic and stratigraphic features that they share suggest that the six outcrop areas were originally part of a single contiguous body of volcanic rocks. Their minimum age is established by Wassataquoik Chert where they are overlain by it. Their maximum age, or the age of their oldest parts, is less well established. Some may have been deposited contemporaneously with the Shin Brook Formation whose rocks have compositions that overlap those of this unit, but, other than this, no evidence of a greater or lesser age of the initiation of this volcanic event is available. Because of the similarity of its rocks throughout the area, however, this volcanic unit is considered to span no more than Middle Ordovician time.

The possibility remains, however, that some of the greenstone is of Silurian age, as suggested by the presence of Silurian tuff breccia and limestone in the fault complex in the Stacyville quadrangle; furthermore, Silurian rocks of this kind occupy a wide area in the northwestern part of the Traveler Mountain quadrangle (D. W. Rankin, written commun., 1963). Nevertheless, it seems more speculative to consider that greenstones of two ages are present than to consider that all are of about the same age.

The outcrop width provides an estimate of the thickness of these volcanic rocks. The 1½-mile width of the westward-facing succession of the Deasey-Lunksoos Mountain belt indicates that the succession contains at least 6,000 feet of these rocks above their lower contact with the Grand Pitch, and the eastward-facing succession of the Hunt Mountain area, almost twice as wide, probably contains about twice this thickness beneath the upper contact with the Wassataquoik Chert. Possibly half the Deasey-Lunksoos Mountain sequence is repeated in the lower part of the Hunt Mountain sequence. From these assumptions a thickness of about 9,000 feet is estimated for the volcanic pile where it is thickest in the Stacyville quadrangle. The 2½-mile width of the Mount Chase belt in the Island Falls quadrangle (Ekren and Frischknecht, 1967) suggests a similar or greater thickness.

The volcanic rocks thin to the north. They are no more than 1,000 feet thick at their northernmost exposures at Pond Pitch in the Traveler Mountain quadrangle (D. W. Rankin, oral commun., 1962), and northeast of Pond Pitch there are no such rocks between the Grand Pitch and Silurian rocks. Probably the volcanic rocks did not have uniform thicknesses over an extensive area, and original wide variations in thickness might be expected. Thus, although post-Taconic erosion may be responsible for their absence northeast of Pond Pitch, there is no evidence that they were originally deposited here.

METADIABASE

Gray and greenish-gray fine- to coarse-grained metadiabase of probable intrusive origin crops out in several small bodies, most of which are near Jerry Pond where the metadiabase intrudes the Grand Pitch Formation, and in a long narrow belt from Sugarloaf Mountain northeast to the quadrangle boundary and beyond, where the metadiabase is probably an unroofed sill in the Shin Brook Formation. The smaller bodies have neither topographic nor magnetic expression; but the larger body supports a line of ridges (Sugarloaf, Hay Brook, and Roberts Mountains) in the Shin Pond quadrangle and Lane Brook Hills and Green Mountain in the Island Falls quadrangle (Ekren and Frischknecht, 1967), and part of it corresponds approximately to northeast-trending linear magnetic anomalies of varying intensity (Bromery, 1962; Dempsey, 1962).

In both outcrop appearance and petrography these rocks are similar to the volcanic rocks just described, and the two units are probably closely related. The units are classed separately, however, because the metadiabase seems to be entirely of intrusive origin, based on its relations to other rocks, observation of its contact, and the absence of rocks of manifiestly extrusive origin.

The metadiabase is most clearly instrusive in the Jerry Pond area where it forms several sill-like bodies a few feet wide that are too small to be shown on the geologic map; these bodies parallel vertical beds of the Grand Pitch Formation. Contacts of the larger masses in this area were not observed, but the one on the southeast shore of Jerry Pond contains small tabular fragments of Grand Pitch quartzite.

The boundary between the metadiabase and the Shin Brook Formation (Neuman, 1964, p. E8) is sharp and, where traced along the southwest face of Sugarloaf Mountain, it is parallel to bedding of the Shin Brook Formation in some places but cuts across it sharply at others. A single exposure of metadiabase enclosed in the Grand Pitch Formation northwest of Hay Brook probably represents an apophysis from the feeder system of this sill.

Outcrops of the metadiabase are massive except for joints, some of which are filled by narrow veins of epidote. Weathered surfaces are brown, and they are dotted by white-weathered plagioclase phenocrysts and are pitted where calcite fillings of amygdules have been removed.

Thin sections studied by Rankin (oral commun., 1964) show that the rocks of the large sill have a wide range in texture. Some are porphyritic and have a microcrystalline groundmass that contains spherulites about 1 mm in diameter and phenocrysts of plagioclase laths about 2 mm long. Most are coarser grained and have a less pronounced contrast between groundmass and phenocrysts. In the rocks, oriented saussuritized plagioclase in a wide size range is the major component, some of it occurring as crystal aggregates in splayed bundles that suggest incomplete spherulites. Augite forms as much as a third of some specimens, occurring as phenocrysts and as intersertal grains in a subophitic groundmass. Calcite fills amygdules in some finer grained specimens and replaces as much as a third of the rock where alteration is most advanced. Chlorite and epidote are ubiquitous as alteration products. The apparent random occurence of spherulitic and amygdular varieties in the sill suggests that it is a composite body in which some quickly cooled parts are probably younger than the rest.

WASSATAQUOIK CHERT

Thin-bedded chert, including medium- to dark-gray, greenish-gray and red varieties, with volcanic rocks interbedded in some places, is here named the Wassataquoik Chert. The name is taken from Wassataquoik Stream; exposures about 1 mile northwest of its mouth near the middle of the Stacyville quadrangle, first described by Dodge (1881), are designated the type locality of the formation.

At the type section (fig. 1), exposures of chert are nearly continuous on the south bank of the stream for about 500 feet, and at one place where they extend across the stream, they serve as the foundation for the piers of a logging road bridge. Tightly compressed steeply plunging folds repeat the beds in these exposures, and the total thickness exposed is probably considerably less than 500 feet. The chert throughout these exposures is finely laminated and thin bedded. Beds 2–4 inches thick are separated by siliceous shale that is generally no more than a thin parting but in some places is as much as 6 inches thick. Several of these shaly interbeds contain poorly preserved graptolites, and one such bed near the eastern end of the exposures yielded conodonts.

Chert beds range in color from dark gray to light greenish gray in alternations from a fraction of an inch to several feet thick; these alternations are especially noticeable in cleanly washed exposures. The large-scale variations are between the darker gray beds and the lighter greenish ones. Conspicuous light-weathering greenish-gray chert forms a unit about 20 feet thick near the middle of the exposures; similar rock, complexly folded, forms the westernmost ledges. Most of the chert, however, is more nearly a neutral gray, ranging from medium to very dark shades.

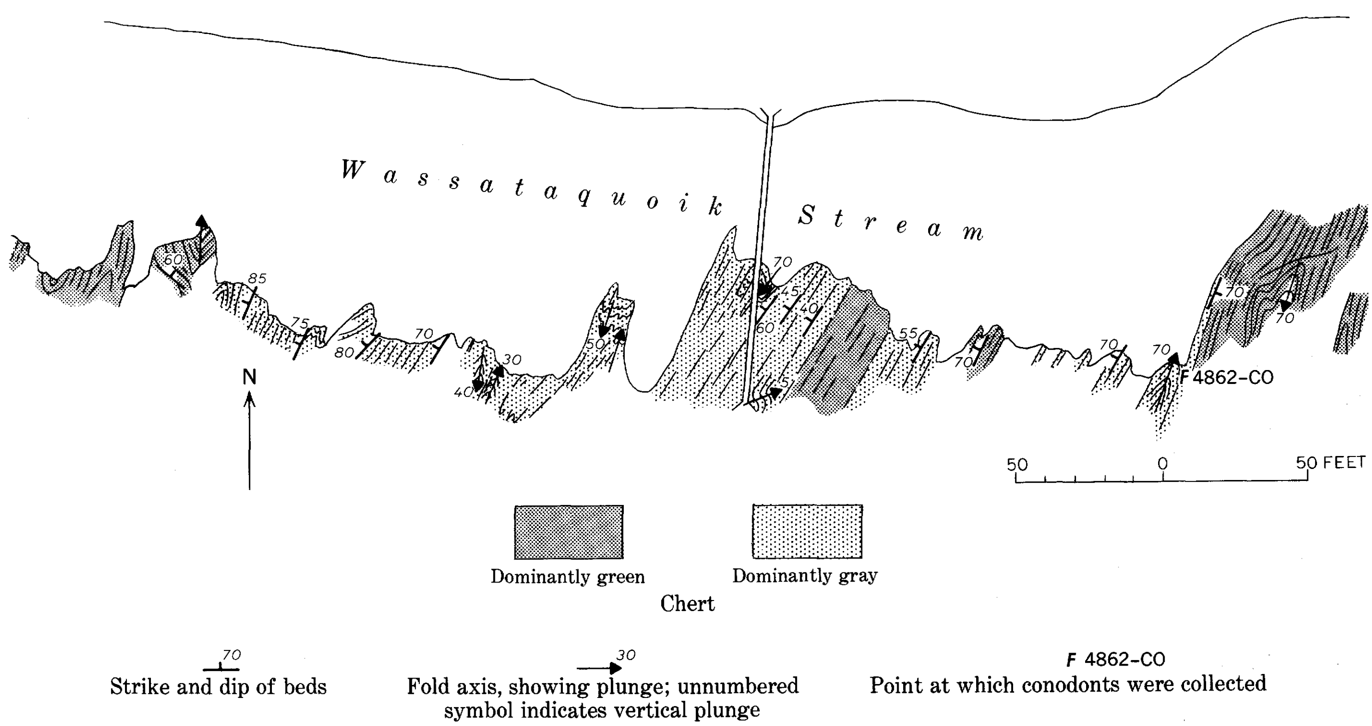

FIGURE 1.—Exposures at type locality of the Wassataquoik Chert at the bridge over Wassataquoik Stream about 1 mile northwest of its mouth, Stacyville quadrangle.

All the chert beds have small-scale features that are emphasized on weathered surfaces. Most beds are finely laminated and have poorly defined lighter and darker layers a millimeter or less thick. Some of the more persistent layers have nearly white weathered surfaces and are probably tuffaceous; others with rusty porous weathered surfaces are calcareous. Some small-scale bedding features are impersistent: in lieu of laminae, some layers have lighter colored stratifiorm lenses a few millimeters in dimension, and locally, lenticular calcite-rich nodules are as much as an inch thick and appear to have pushed chert beds apart.

None of these features permits the determination of tops of beds, and no criteria were found to indicate the stratigraphic succession in the Wassataquoik Stream exposures. The presence of several unlike rocks in the vicinity indicate that structural relations here are complex, and efforts to resolve these complexities have not been entirely satisfactory. Nevertheless, from Wassataquoik Stream, chert is continuously exposed southward on the ridge leading to Hunt Mountain, where the contact between it and the volcanic rocks of Hunt Mountain was found. From the evidence that the volcanic rocks of Hunt Mountain face eastward, and from other relations discussed below, it is likely that the chert in the Wassataquoik Stream exposures is largely overturned.

Including the type area and exposures that are probably contiguous with it, the Wassataquoik occurs in four outcrop areas in the Shin Pond and Stacyville quadrangles. These areas have no apparent magnetic expression, but the two that were traversed by Frischknecht (1966) proved to have high electromagnetic responses that are due to the high carbon content of their shaly beds. Such carbonaceous beds at least 5 feet thick are exposed in the northernmost outcrop area about 1 mile south of Lower Shin Pond, together with thin-bedded chert and felsitic tuff. Farther south, in the narrow outcrop belt east of Peaked Mountain, only gray chert is exposed, but Frischknecht's traverses along the Seboeis River at the American Thread Co. road and at several places to the north indicate the presence of carbonaceous shale.

Fine-grained vaguely bedded tuff containing fragments of biserial graptolites forms the basal parts of several graded beds whose upper parts are dark gray and cherty. Several such beds, each about a foot thick, are interbedded with chert about half a mile northeast of the type section at Wassataquoik Stream and to the south of Hunt Mountain near the contact with the greenstone.

Tuff and tuff breccia that contain vesicular fragments as much as 3 inches across alternate with gray, greenish-gray, and red chert in steeply dipping beds along Sandbank Stream for about 2,000 feet downstream from an altitude of 500 feet. These pyroclastic rocks occupy more than half of this interval, but, on the steep hillsides to the southeast, only dark-gray chert is exposed. These few exposures, and one of felsitic volcanic rocks in Trout Brook farther south, are all that could be found in that vicinity, and they constitute the basis for the largest but least well-documented outcrop area of the Wassataquoik Chert shown on the geologic map of the Stacyville quadrangle.

Graptolites collected by Dodge (1881, 1890) from the Wassataquoik Stream exposures long ago indicated the correlation of these rocks with the Normanskill Shale of New York. Smith's later collections, identified by Ruedemann (Ruedemann and Smith, 1935; Ruedemann, 1947, p. 73) confirmed this correlation. Although these exposures yielded a few fragmentary graptolites during the current investigations, additional good specimens were not found and no new forms from this place are added to the published lists. In addition to the fragmental graptolites, however, conodonts were found in one bed of siliceous shale about 6 inches thick near the eastern end of the Wassataquoik Stream (USGS loc. 4862–CO; fig. 1). These fossils are clearly of Middle Ordovician age and are closely related to those of the Baltic region (Sweet and Bergström, 1962, p. 1217; 1966).

A small collection of graptolites was also obtained from siliceous shale interbedded with chert at the northeast foot of Whetstone Mountain (USGS loc. 4860–CO). From here, Professor W. B. N. Berry, of the University of California, identified *Glyptograptus* aff. *G. euglyphus* var. *pygmea* (Ruedemann) and *Orthograptus whitefieldi* (J. Hall) (Berry, written commun., 1963). According to Berry, these are Middle Ordovician forms, probably indicative of the zone of *Climacograptus bicornis*, and further confirm the earlier Normanskill correlation of the rocks here included in the Wassataquoik Chert (see Berry, 1962, p. 710). Similar siliceous siltstone interbedded with chert in the Island Falls quadrangle has also yielded graptolites of this zone (Berry in Ekren and Frischnecht, 1967). The Wassataquoik probably also includes the succeeding zone (that of *Orthograptus truncatus* var. *intermedius*), as graptolites of that zone have been found in clasts in a conglomerate that presumably overlies it (see p. I 26).

Minimum thickness estimates of the Wassataquoik Chert range from about 300 feet based on the Wassataquoik Stream exposures to 1,500 feet based on the total width of the outcrop belt of which these exposures are a part. The Sandbank Stream exposures suggest that the formation thickens by the addition of tuff and, where these are abundant, the formation may be as much as 3,000 feet thick.

The conclusion that the Wassataquoik overlies the volcanic rocks of the area is based largely upon the apparently conformable boundary between them on the eastern side of Hunt Mountain, where several tuff beds are intercalated with chert for about 200 feet. The same contact seems to be more abrupt along the Seboeis River at the foot of Peaked Mountain and northward. The fault block of which it is a part appears to be a segment of the southeastern limb of the major anticlinorium of the area. This superposition of the Wassataquoik above the greenstone is consistent with both stratigraphic and structural interpretation.

The upper boundary of the Wassataquoik is mapped as a fault in most places. Conglomerate with clasts mostly of chert and siliceous shale obviously derived from the Wassataquoik were found at several places, suggesting that deposition of these beds apparently followed emergence of the Wassataquoik.

CONGLOMERATE AND SANDSTONE

Among the more surprising discoveries of the recent work in this area is the thick and varied succession of Upper Ordovician rocks between Pond Pitch and Haskell Rock Pitch of the East Branch of the Penobscot River in the Traveler Mountain quadrangle just west of the Shin Pond quadrangle. In the 4,000 feet between these points are conglomerates that at first were correlated with the conglomerate of Silurian age in the Shin Pond quadrangle. Examination of brachiopods from these beds and associated siltstones from the East Branch by Boucot and me, and of the trilobites by H. B. Whittington, showed that they are all of Ordovician age, some belonging to the Late Ordovician (Ashgill).

The lowest of these beds, just above greenstone at Pond Pitch (USGS loc. 3889–CO), is sandstone, the major constituent of which is green and gray slate chips, but it also contains scattered pebbles of quartz, quartzite, and volcanic rocks as much as 2 inches in diameter. This rock yielded brachiopods in some abundance, including the following genera:

Christiania	*Retrorsirostra*
Glyptorthis	*Rhynchotrema*
Hesperorthis	*Schizophorella*
Nicolella	*Triplesia*
Platystrophia	*Vellamo*
Ptychopleurella	

The presence of *Schizophorella* and a large *Retrorsirostra* similar to *R. carleyi* (Hall) suggests a Late Ordovician (Ashgill) age, although both these genera and the others listed occur elsewhere in older rocks of Caradoc age.

An isolated exposure of green siltstone about 300 feet to the east of this sandstone yielded brachiopods identified by Boucot as *Catazyga* cf. *C. anticostiensis* (Billings) (Boucot in Boucot, Field, and others, 1964, p. 104; pls. 3, 4) and *Fardenia* sp. (Boucot, written commun., 1961). He considers that these brachiopods indicate an Ashgill age.

Siltstone about midway through the succession (USGS loc. 4113–CO) yielded the trilobites *Sphaerocoryphe* cf. *S. thompsoni* Begg and *Diacalymene* sp., probable Ashgill forms according to Whittington (written commun., 1963). Siltstone that overlies the boulder conglomerate at Haskell Rock (USGS loc. 4412–CO) also contains Ordovician brachiopod *Christiania* sp. together with *Hirnantia* sp. Thus, most of the exposed sequence in the East Branch above the greenstone at Pond Pitch proves to be of Ordovician age, probably equivalent to the Ashgill Stage of Great Britain.

In the Shin Pond quadrangle, northeast of the East Branch exposures and along strike with them, similar appearing conglomerate and siltstone have yielded Lower Silurian fossils except at one exposure near the western edge of the quadrangle. Here, at about the 615-foot contour in Kimball Brook (USGS loc. 4456–CO), sandstone interbedded with conglomerate yielded Ordovician fossils. About 5 feet of beds is exposed, consisting of graded beds of conglomerate, sandstone, and siltstone, each about 1 foot thick. The conglomerate consists of well-rounded pebbles of quartz and quartzite, as much as 1 inch in diameter, and an abundance of gray and greenish-gray shale and slate fragments. The sandstone is quartzose and richly micaceous, containing flakes of muscovite as large as 3 mm; such rock forms about three-fourths of the exposure.

Brachiopods are common in the sandstone, but poorly preserved, their detail obscured by the rough sandstone matrix and by encrustations of limonite. Nevertheless, the following genera have been identified:

Glyptorthis
Nicolella
Orthambonites
Sowerbyella

As is true of the brachiopod assemblages from the East Branch, these genera range through the upper half of the Ordovician. In light of the information obtained there, however, these rocks are probably of Ashgill age.

This sandstone exposure probably represents the thin wedge edge of the Ashgill deposits of the East Branch. Similar conglomerate containing Lower Silurian fossils crops out about 1,200 feet to the northwest, and quartzite of the Grand Pitch Formation crops out about 200 feet to the southeast. Thus, the maximum breadth of the Ordovician outcrop is 1,400 feet along Kimball Brook, but these rocks may occupy only a small part of this interval. About a mile to the northeast, in Bowlin Brook, conglomerate containing Lower Silurian fossils immediately overlies the Grand Pitch Formation, and no Ordovician rocks have been seen elsewhere in this outcrop belt in the Shin Pond quadrangle.

ORDOVICIAN OR SILURIAN SYSTEM

ROCKABEMA QUARTZ DIORITE

Altered quartz diorite, including medium-grained equigranular and porphyritic facies and fine-grained porphyritic facies, crops out in a dumbbell-shaped area whose southwestern half includes the area around the Shin Ponds. Its name was taken from Rockabema Lake in the northeastern half in the Island Falls quadrangle (Ekren and Frischknecht, 1967). Wing (1951, map 5) mapped this rock as rhyolite in a crescentic body within a crescent of greenstone, but noted (p. 57) its close association with shale, as described in the next paragraph. The broader parts of the Rockabema outcrop area in both quadrangles contain lakes and large ponds, and the surrounding topography is subdued. The Rockabema has low magnetic values, but there are a few small northeast-trending magnetic anomalies within its outcrop area that might be due either to local concentrations of magnetite within the Rockabema or to unexposed inclusions of the Grand Pitch Formation that contain magnetite produced by contact metamorphism.

Through much of its extent the boundary of the Rockabema is shown on the geologic map of the Shin Pond quadrangle by a broad zigzag pattern. Where the contact is with the Grand Pitch Formation, use of this pattern indicates outcrops of Rockabema, a few feet to 50 feet or more wide, whose contacts parallel beds of the Grand Pitch; these rocks occur together through broad zones 1 mile or more wide. These relations are well displayed both along the road between Shin Pond village and the township corners 1½ miles to the north and along the woods road and township line to the east of the corners. In this area an isolated patch of Grand Pitch Formation appears to be a large inclusion within the Rockabema; the small body of Rockabema 3 miles to the northeast of the Grand Pitch patch shows that it also occurs as small bodies at considerable distance from the main body.

On the southwest sawteeth represent an indefinite and approximate boundary, southwest of which for several miles the belt of greenstone contains an abundance of dikes and irregularly shaped bodies of a fine-grained porphyritic felsitic facies of the Rockabema. Relations between these rocks are complex, but they are interpreted from the place where the rocks are best exposed (Shin Pond quadrangle, SW¼SE¼, T. 5 N., R. 7. W., 1 mile N. 50° E. of the mouth of Ragged Brook at the top of the cliffs west of the Seboeis River). Here, greenstone about 18 feet wide is bordered for about 50 feet by porphyritic felsite with embayed contacts parallel to the N. 20° E. regional strike. Projected downstream across a covered interval of about 5 feet, the felsite on the southeast side of this greenstone meets another ledge of greenstone, which contains a north-striking dike of felsite about 1 foot wide. These relations suggest that the felsite was intruded into fractured and broken greenstone, and that the area shown as Ovr on the geologic map is a megabreccia of greenstone with a quartz porphyry matrix.

Breccia with smaller fragments (from a few inches to 2 ft. in average diameter) of greenstone and Grand Pitch quartzite in about equal amounts is well exposed on the Shin Pond-Pattern road about 0.2 mile south of the bridge over the throughfare connecting the Shin Ponds. Inclusions form about 80 percent of the rock in these exposures, and fine-grained quartz diorite fills interstices between them. Greenstone or metadiabase inclusions are common at several other places, but Grand Pitch xenoliths were not seen other than in this breccia.

Much of the Rockabema is cataclastically sheared; steep shear surfaces strike N. 20° to 25° E., parallel to the regional structural trend. All exposures of the Rockabema in the vicinity of Upper Shin Pond show this cataclastic structure, and thin bodies of it within the Grand Pitch near the fault at the eastern edge of the area are reduced to mylonite. Cataclastic structure is largely absent around Lower Shin Pond; most exposures in this area are massive, and have neither foliation nor oriented mineral grains.

Study by Rankin (oral commun., 1964) of thin sections showed that the Rockabema is much the same in the Shin Pond quadrangle as in the Island Falls where it was studied by Ekren and Frischknecht (1967, p. 9–10). The texture of the light-colored more equigranular coarse-grained rock is subhedral (= hypautomorphic of Ekren and Frischknecht, 1967, p. 9), with some granophyric intergrowths of quartz and feldspar. An incipient porphyritic texture is suggested by the clustering of like minerals. Feldspar is slightly more abundant than quartz, and together they compose about 95 percent of the rock. As much as one-third of the feldspar in some specimens is potassic, some slightly perthitic, indicating a compositional range of the rock from quartz diorite to granodiorite. Plagioclase crystals are typically zoned and largely altered to calcite and sericite except at their outer margins. Some of the larger plagioclase and quartz crystals envelope small subhedral plagioclase crystals. Chlorite and epidote pseudomorphs after biotite form about 5 percent of the rock, and there are accessory amounts of apatite, zircon, and opaque minerals.

A thin section of coarsely porphyritic Rockabema from a roadcut on the Shin Pond-Patten road, 0.45 mile south of the bridge over the thoroughfare connecting the Shin Ponds, showed a distinctly different texture. The rock contains nearly equal amounts of phenocrysts and groundmass, and some quartz and feldspar crystals are as large as 10 mm. Somewhat more than half the phenocrysts are quartz in subhedral to severely corroded crystals, with saussuritized plagioclase slightly less abundant, and, more rarely, granophyric intergrowths of quartz and feldspar. Chlorite and epidote aggregates, no more than 4 mm long, are pseudomorphous after biotite and form about 5 percent of the phenocrysts. The groundmass is mostly nondescript intergrowths of quartz, feldspar, chlorite, epidote, and, locally, patchy calcite, but it contains a few small spherulites of quartz and feldspar enclosing small quartz grains. Small areas of groundmass now occur within quartz phenocrysts, perhaps after fluid inclusions. A chemical analysis of a sample of this rock was published by Ekren and Frischknecht (1967, table 3).

The traces of granophyric texture preserved in the more equigranular rock indicate that part of the Rockabema is a hypabyssal instrusive. Although the coarse porphyry described above is near the central part of the area mapped as Rockabema, its spherulitic fine-grained groundmass indicates that it cooled more quickly than the equigranular rock. Most of the Rockabema east of Lower Shin Pond is extremely fine grained porphyritic felsite, suggesting the presence here of a broad quickly cooled marginal zone.

Thin sections from sills of Rockabema in the Grand Pitch Formation, and from similar rock associated with the greenstone, show features typical of small shallow quickly cooled intrusives and confirm the field interpretation of these rocks as apophyses of the Rockabema. In these thin sections the phenocrysts are euhedral to subhedral crystals of quartz and feldspar (largely saussuritized plagioclase) in nearly equal but varying proportions; some sections have minor amounts of partially chloritized biotite. They range in average diameter from ½ to 3 mm and form from 10 to 50 percent of the rock. Many phenocrysts have corroded outlines; some have cracks filled with groundmass, but others are more distinctly broken as matching parts can be identified nearby each other. The groundmass shows considerable variation: in one specimen it is nondescript epidote-rich felsite; similar material in another has perlitic cracks and contains amygdules of chlorite-rimmed quartz; and in a third, alined plagioclase crystals suggest trachytic texture.

The age of the Rockabema can be established only within broad limits. Its cataclastic deformation and the pervasive alteration of plagioclase and biotite stamp the Rockabema as older than the many unaltered and undeformed well-dated Devonian intrusives of the region (Faul and others, 1963). Cobbles and pebbles of the Rockabema in conglomerate of Early Silurian (late Llandovery) age confirm its antiquity, and it is certainly younger than the Middle Ordovician volcanic rocks that it intrudes. Closer bracketing might have been provided by the presence of Rockabema fragments in the Late Ordovician conglomerate in the Traveler Mountain quadrangle, but none was found there (D. W. Rankin, oral commun., 1964). The Rockabema is therefore dated as younger than Middle Ordovician and older than late Early Silurian, but there is no basis for assigning it exclusively to one system or the other.

SILURIAN SYSTEM

As outlined in the introduction of this report, strata of Silurian age on opposite sides of the anticlinorium containing the rocks just described are of strongly contrasting facies. Those on the northwest flank are thinner, better differentiated, and better understood than those on the southeast, and are described first in the following paragraphs.

NORTHWESTERN SEQUENCE

Calcareous siltstone with limestone in thin interbeds and small nodules is the most common rock of the northwestern flank, or northwestern sequence, and such rock forms part of this sequence throughout the report area. Fossils indicate that rock of this kind is of different ages from place to place. Limestone, volcanic rocks, and conglomerate also form parts of the northwestern sequence, and these also occur at different levels from place to place. With such marked variations, and with incomplete exposures, no single section can be selected as representative of the northwestern sequence. Thus, the best exposed section of the area (p. I 16–17) contains four mapped units, but this sequence of units cannot be matched beyond short distances along strike in either direction.

CONGLOMERATE OF EARLY SILURIAN (LATE LLANDOVERY) AGE

Thick-bedded gray pebble conglomerate is the most abundant rock in the basal part of the northwestern sequence of Silurian rocks at the western edge of the Shin Pond quadrangle. Interbedded with the conglomerate are lesser amounts of gray micaceous sandstone and gray and red siltstone and slate. Units 1–3 of the geologic section measured along Bowlin Pond Road belong to this group of rocks.

Silurian sequence along Bowlin Pond Road, T. 5 N., R. 8 W., Shin Pond quadrangle

[Measured with tape and compass by R. B. Neuman and H. H. Roepke, August 1959. Exposures are scattered through the woods, mostly west of the road (fig. 2). Beds strike N. 40° to 65° E., and dip 50° to 65° NE. Outcrop width and thickness are given to the nearest 5 feet]

	Outcrop width (feet)	*Thickness 85 percent of outcrop width (feet)*
Lower Devonian Rocks:		
Seboomook Formation: Siltstone, dark-gray, in beds 4–6 in. thick; basal parts formed of fine-grained crossbedded sandstone ½–1½ in. thick	100+	100+
Covered internal	30	25
11. Siltstone, gray, sandy, noncalcareous; bedding obscure but shown in subtle contrast between more and less sandy parts; scattered small fragmentary brachiopods (USGS loc. 7448–SD)	30	25
Covered interval	250	215
Upper Silurian Rocks, at least in part:		
10. Siltstone, gray, calcareous; bedding surfaces even, planar, at 2- to 10-in. intervals; widely scattered comminuted organic debris	100	85
9. Calcarenite, largely pelmatozoan debris; silty partings, irregular and discontinuous; stromatoporoids and favositid corals as much as 6 in. in cross section	60	50
8. Siltstone, calcareous; contains silty limestone nodules a few inches in diameter, irregularly distributed	30	25
Covered interval	85	70
7. Siltstone, calcareous, gray; largely massive, but with a few scattered silty limestone nodules 1 or 2 in. in diameter, in beds 5–10 in. thick, separated by fine-grained limestone beds 1–2 in. thick, some of which are cut into boudins by partitions of siltstone parallel to slaty cleavage	200	170
Covered interval	80	70
6. Siltstone, gray, calcareous; in faintly laminated beds separated by prominent partings at intervals 2–10 in. apart; brachiopods fragmentary, scarce, *Monograptus* sp. rare	75	65
Covered interval	100	85
5. Siltstone, calcareous, like unit 6 above	60	50
4. Siltstone and fine-grained sandstone, calcareous, light-gray; mostly in well-defined graded beds 4–8 inches thick, some prominently laminated. A dark-gray noncalcareous siltstone bed 3 ft thick, 60 ft above the base of the unit, contains abundant brachiopods, trilobites, and corals (7429–SD)	85	70
Total Upper Silurian		1, 000±
Lower Silurian rocks:		
3. Pebble and granule conglomerate, sandstone, and siltstone, calcareous; in well-defined graded beds 4–8 in. thick; fragments of brachiopods and corals	50	45
Covered interval	40	35
2. Conglomerate, with rounded pebbles and granules, mostly of quartz, but with abundant felsitic volcanic rocks and tabular fragments of slate and siltstone as much as 6 in. long; beds poorly defined, about 4 ft thick; scattered brachiopods, tabulate and rugose corals (7427–SD)	75	65
Covered interval	30	25
1. (Beds exposed in floor of Bowlin Pond Road.) Siltstone, greenish-gray, and fine-grained sandstone; 2 beds of granule conglomerate each about 10 in. thick	6	5
Total Lower Silurian exposed	201	170
Beds below not exposed; distance to Grand Pitch Formation estimated	675	575
Lower Cambrian(?) rocks:		
Grand Pitch Formation: Light-greenish-gray quartzite with interbedded gray, greenish-gray, and red slate and siltstone (not included in line of section).		

Well-rounded siliceous pebbles and granules are the most common components of this rock. About half are milky quartz; the remainder are quartzite, felsite, chert, and greenstone, listed in order of decreasing abundance. Small chips to tabular fragments, as much as 6 inches in length, of gray and greenish-gray slate and siltstone like those of the Grand Pitch are minor components of the conglomerate in most places, but locally they are more abundant than the roundstones. The rock is poorly sorted, and the matrix is made of smaller particles of the same materials with a few percent of interstitial carbonate cement. Fragments of large thick-shelled brachiopods and a few solitary rugose corals and fragments of tabulate colonies are widely scattered through the conglomerate at several places, but many beds apparently are unfossiliferous. Massive beds of conglomerate as much as 6 feet thick are common, but

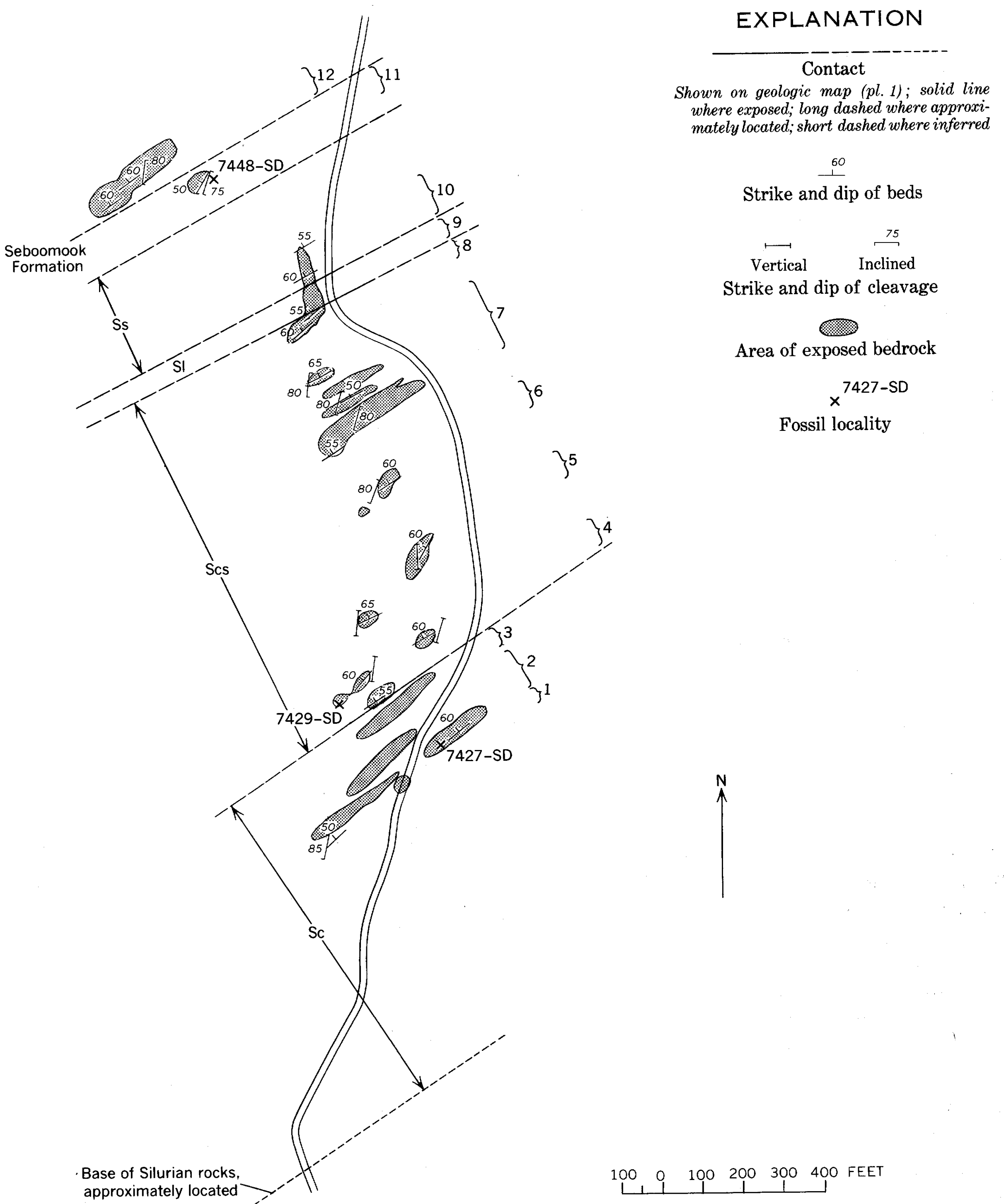

FIGURE 2.—Location of exposures and units of Silurian sequence along Bowlin Pond Road, Shin Pond quadrangle, described in geologic section, page I 16. Letter symbols are explained on plate 3.

some are more regularly bedded and have crudely graded layers 4 inches to 2 feet thick.

Dark-gray micaceous sandstone and siltstone are interbedded with conglomerate near the base of the sequence in Bowlin Brook and at several places along Kimball Brook. The sandstone consists mostly of angular quartz grains in a dark chloritic matrix that makes up about 20 percent of the rock. The basal parts of most sandstone layers consist of grains about a millimeter in diameter, and grain size decreases upward to parts that are siltstone and silty shale or slate. Such graded sets, which are 2–4 inches thick, commonly have load casts at their bases. Thin beds of conglomerate are interbedded with such sandstone; several of these conglomerates, formed mostly of Grand Pitch slate fragments, yielded diagnostic Silurian fossils in Kimball Brook at an altitude of 640 feet.

Rocks belonging to this unit have been mapped northeastward from the western edge of the Shin Pond quadrangle in a belt whose width ranges from 1,000 to 5,000 feet. Beds are probably repeated by folding in the widest part of this belt, judging from the range of strikes and dips on the southern shore of Kimball Pond and along Kimball Brook. These rocks are estimated to be about 550 feet thick in the vicinity of Bowlin Brook. Only the uppermost beds are exposed in the Bowlin Pond Road section (fig. 2), and only the basal beds are exposed in the bed of the brook to the northeast. Conglomerate was not found east of the Jerry Pond Tote Road, and the unit is presumed to wedge out in that vicinity.

The conglomerate unit is dated as Early Silurian and is correlated with the C_4 to C_5 Substages of the upper Llandovery Stage of southern Wales (see Jones, 1925, p. 367–373; Williams, 1951, p. 128–131), according to Boucot (written commun., 1964; Boucot and Thompson, 1963, p. 1318), on the basis of brachiopods, especially *Stricklandia lens ultima* Williams, collected at the following two places.

From conglomerate interbedded with sandstone in Kimball Brook at an altitude of 640 feet (7426–SD) Boucot identified:

Chilidiopsis? sp.
Pentamerus sp.
Plectatrypa? sp.
Plectodonta sp.
Protomegastrophia sp.
Resserella sp.
Stricklandia lens ultima Williams

From unit 2 of the Bowlin Pond Road section (pl. 3) he identified:

Dalejina? sp.
Nucleospira? sp.
Stricklandia lens ultima Williams

This collection also contains a species of *Halysites*.

In addition to these collections studied by Boucot, *Stricklandia*, *Pentamerus*, and molds of solitary rugose corals were seen in unit 2 of the Bowlin Pond Road section, and *Pentamerus* was seen in conglomerate about 150 feet above the Grand Pitch Formation in Bowlin Brook (7428–SD).

Boucot (written commun., 1963, 1964) correlated these beds with the Frenchville Formation of the southeastern sequence of Silurian rocks in the area of this study, and in the Presque Isle quadrangle (Boucot, Field, and others, 1964, p. 31), and with the unnamed conglomerate on the southeastern flank of the anticlinorium. Other correlatives of these rocks are discussed, together with their paleogeographic implications, in a recent paper describing the fossils of the Clough Formation of New Hampshire (Boucot and Thompson, 1963).

CALCAREOUS SILTSTONE OF EARLY OR LATE SILURIAN (LATE LLANDOVERY TO WENLOCK) AGE

Light-gray calcareous siltstone and fine-grained sandstone above the conglomerate just described, and beneath the limestone to be described in the following section, are included in this category. At the Bowlin Pond Road section (fig. 2), units 4–8 assigned to it measured 580 feet in thickness. These rocks extend southwest to Kimball Pond and probably beyond. To the northeast they have been traced to Marble Pond, but their wedging out a short distance beyond is conjectural, in the absence of the overlying limestone and the lack of paleontologic control.

These rocks are commonly well bedded, but they are massive or obscurely bedded in a few places. Some of the siltstone is laminated, and many beds have basal parts of fine-grained sandstone. Thin interbeds of limestone are common, as are limestone nodules and fragmentary brachiopods, tabulate coral colonies, and stromatoporoids. Partitions of siltstone parallel to the pervasive slaty cleavage cut the thin limestone layers into elongate pods, similar to the effect of boudinage on quartzite interbeds in shale. On weathering, these discontinuous beds and other limestone areas are recessed behind the less soluble brown-weathered siltstone in exposure faces; some geologists refer informally to such rock as "pitrock."

A thin bed of dark-gray noncalcareous siltstone near the top of unit 4 of the Bowlin Pond Road section yielded abundant brachiopods which Boucot (written commun., 1964) identified and dated as of late Llandovery or Wenlock age. He listed the following forms from this locality:

Atrypa "reticularis"
Brachyprion? sp.

Chilidiopsis sp.
Cyrtia sp.
Dalejina sp.
Eospirifer cf. *E. radiatus* (Sowerby)
Glassia? sp.
Howellella sp.
Isorthis sp.
Leangella sp.
Leptaena "rhomboidalis"
Merista sp.
Plectodonta sp.
Resserella sp.
Sieberella? sp.
Skenidioides sp.
Sphaerirhynchia sp.

LIMESTONE OF LATE SILURIAN (WENLOCK OR EARLY LUDLOW) AGE

Limestone, largely reefal and reef detritus, is best exposed around the southern and eastern shore of Marble Pond. Although as much as 500 feet of limestone is exposed in this area, only 50 feet of it was measured in the Bowlin Pond Road section (unit 9). It was not seen elsewhere, but float along the East Branch of the Penobscot River near Haskell Rock in the Traveler Mountain quadrangle suggests that it is buried beneath drift in the lowlands bordering Haskell Rock Deadwater.

A small island about midlength of Marble Pond may represent an exhumed reef, and the nearby lakeshore deposits, related reef detritus. The rock of the island appears to be massive on its weathered upper surface, but waterlevel caves have cut through it; in these caves the rock is seen to consist of a framework of stromatoporoids with pelmatozoan debris filling the interstices. The lakeshore exposures are bedded accumulations of organic debris, including large fragments of heliolitid, favositid, and halysitid corals and stromatoporoids in a matrix of calcarenite with scattered quartz grains. Beds from a few inches to a foot thick are defined by siltstone partings that are bent into the surfaces of slaty cleavage to form partitions similar to those of the limestone interbedded with siltstone just described.

Calcarenite rich in brachiopods, but largely lacking in coralline material, occurs near the base of the limestone unit 500 feet east of the westernmost point of the pond (7430–SD). On the basis of the general aspect and richness of the assemblage, Boucot (written commun., 1964) considers it to be of early Late Silurian age, equivalent to the Wenlock or early Ludlow Stages of Great Britain. He listed the following brachiopods:

Amphistrophia funiculata (McCoy)
Atrypa "reticularis"
Atrypina? sp.
"Camarotoechia" sp.
Dalejina sp.
Delthyris sp.
Gypidula sp.
Leptaena "rhomboidalis"
Leptaenisca? sp.
Merista sp.
Meristina sp.
Orthostrophia sp.
Plectodonta sp.
Resserella sp.
Rhynchospira sp.
Shaleria? sp.
Sphaerirhynchia sp.
"Whitfieldella" sp.

CALCAREOUS SILTSTONE OF LATE SILURIAN (EARLY LUDLOW) AGE

The extensive outcrop belt mapped under this category in the northern part of the Shin Pond quadrangle consists largely of gray calcareous siltstone. The rocks so mapped above the limestone in the Bowlin Pond Road section (fig. 2, unit 10), are not appreciably different from those below it, and their age is inferred from their stratigraphic position, as they yielded no diagnostic fossils. The belt is represented by only scattered outcrops on the 5-mile sector between the area of this section and the exposures at the mouth of Sawtelle Brook. Here, the rock is a uniform sequence of siltstone with thin and discontinuous limestone beds and nodules and fragments of limestone; about 500 feet of it is exposed downward from its contact with the Seboomook Formation, but its contact with older beds was not seen. The few identifiable fossils collected from these exposures (7431–SD) include *Coelospira* sp. and *Meristina* sp., which indicate a Silurian age, but they do not permit a more precise correlation (Boucot, written commun., 1964).

These rocks are not exposed along strike to the northeast in the Shin Pond quadrangle, although abundant blocks of calcareous siltstone along the old Matagamon Tote Road northwest of Spring Pond indicate their presence nearby. Still farther northeast, however, where there are no exposures, aeromagnetic data indicate a reverse fault which may have cut out these rocks. They may reappear at the eastern boundary of the Shin Pond quadrangle beneath the swamps of Lane Brook, because along strike in the Island Falls quadrangle, such rocks, together with some older Silurian conglomerate have been mapped as "Silurian rocks, undifferentiated" (Ekren and Frischknecht, 1967).

Similar siltstone forms the flanks of a dome in the northeastern part of the Shin Pond quadrangle. Outcrops in this area are widely scattered, and the relations shown on the geologic map (pl. 1) combine interpolations drawn between them and inferences drawn from the aeromagnetic map (Bromery, 1962). Accordingly, red polymict conglomerate that crops out west of White Horse Lake is shown as a lens between the Grand Pitch

Formation and the Silurian siltstone. Calcareous siltstone that completely encircles the dome is overlain to the south and east by tuffaceous volcanic rocks that are the probable cause of the magnetic anomalies of the area. Although these rocks are described in the paragraphs that follow, only the siltstone at White Horse Lake and the limestone lens to the east yielded Late Silurian fossils; the conglomerate may be somewhat older and the volcanic rocks younger.

The conglomerate is a massive rock in which stratification could be seen only in the shape orientation of its rock fragments. It contains rounded cobbles of greenstone and vesicular lava as much as 8 inches in diameter, smaller cobbles and pebbles of these rocks, quartz, and quartzite, and angular chips of gray and greenish-gray slate and siltstone in a red-stained coarse-grained sandstone matrix. Although this is the only place where such rock is known in the Shin Pond quadrangle, the conglomerate has been seen at several places in the vicinity of Grand Lake Seboeis in the adjacent quadrangle to the north, where it appears to be part of the Silurian sequence.

The siltstone of the scattered exposures around this dome is like that just described, limestone in thin beds and discontinuous pods being common at many places. Organic debris is abundant in both the limestone layers and scattered through the siltstone, but fossils preserved well enough to be taxonomically and stratigraphically useful are rare, probably owing to the slaty cleavage which is well developed in this area.

Fossils indicating the Late Silurian age of these rocks were obtained from two places near the southern end of White Horse Lake. A small uncharted island in the southeastern part of the lake (7432–SD) yielded an unnamed species of *Janius* (Boucot, 1963, p. 699, pl. 103, figs. 7–9). Exposures on the lakeshore just west of the outlet of the lake (7433–SD) yielded the following brachiopods:

Amphistrophia cf. *A. funiculata* (McCoy)
Conchidium sp.
Howellella sp.
Meristina sp.
Plectodonta sp.

Boucot (written commun., 1964) who identified this collection, wrote that the presence of *Conchidium* indicates its Late Silurian (early Ludlow) age.

Although this age assignment is confirmed by fossils from a limestone lens to be discussed in the next paragraph, the presence of *Kozlowskiellina* sp., and *Orthostrophia* cf. *O. strophomenoides* (Hall) with *Dicoelosia* sp. and other fossils in identical siltstone about 2,000 feet north of the quadrangle boundary (7434–SD; 2,000 ft east of the 35-minute meridian) (see Boucot and others, 1964, p. 84) indicates that there are in this area rocks of Early Devonian (New Scotland) age. The thickness of such rocks and their relations to those of Late Silurian age are not known.

A lens of fine-grained silty limestone, as much as 300 feet thick, was traced for about 1 mile in the northeast corner of the Shin Pond quadrangle where it overlies the siltstone just described and underlies tuffaceous volcanic rocks. Half or more of the rock consists of colonial organisms, including large lamellose forms that are probably stromatoporoids, smaller digitate stromatoporiods, and tabulate and rugose corals. Oliver (written commun., 1963) identified the following forms in three collections from this lens, and concluded that they indicate a Late Silurian (Ludlow) age.

	USGS locality numbers [1]		
	7165–SD	7164–SD	7166–SD
Stromatoporoid: *Clavidictyon* sp	×	×	×
Tabulate corals:			
Favosites intermittens (Stumm)	×	----	----
Halysitid cf. *Cystihalysites amplitudulatus* Lambe.	×	×	----
Thamnopora sp	×	----	----
Rugose corals:			
Entelophyllum sp. 1 Oliver (1962, p. 15).	×	----	×
Tryplasma nordica Stumm	×	----	----

[1] The collections were made at three points on the hillside where the lens is exposed: 7164–SD at 820-ft contour, 7165–SD at 850-ft contour, and 7166–SD at 860-ft contour.

Limestone of the same age also occurs in the central part of the Stacyville quadrangle. The two areas of Upper Silurian limestone are shown with the same pattern and symbol on the geologic maps. This is the only unit common to both the northwestern and southeastern sequences. The Stacyville exposures are described below with the southeastern sequence (p. I 26–27).

The Silurian sequence in the northwest corner of the Shin Pond quadrangle is considerably different from the rocks just described. Beneath the southeast-facing succession is greenish-gray chloritic schist that in places contains nonschistose lenses of fragmental greenstone which indicate its original composition. Similar greenstones with a wide range of schistosity and texture occur in the northern part of the Traveler Mountain quadrangle where Rankin (oral commun., 1962) found that they are associated with fossiliferous Silurian rocks. Just north of the quadrangle boundary, brilliant light-red schist indicates subaerial weathering of these volcanic rocks before deposition of the conglomerate that overlies it. The conglomerate, exposed in massive ledges, consists of rounded greenstone cobbles and pebbles in a tuffaceous matrix. This rock apparently represents very local accumulations, as it is present in some places but absent in others along strike.

Younger diabase intrusives intervene between these rocks and calcareous siltstone to the south. Just north of the shore of the arm of Scraggly Lake (known locally as the Back Room) in the northwest corner of the quadrangle are ledges of obscurely bedded gray calcareous siltstone (7437–SD). Fossil fragments are abundant in this rock, but the only identifiable form obtained from it is *Amphistrophia* cf. *A. funiculata* (McCoy) (Boucot, written commun., 1962). Quite different rocks are exposed in ledges separated from this siltstone by a covered interval about 50 feet wide.

The following sequence was measured at these ledges at the east end of the "Back Room," at BM 726:

Unit	*Feet*
4. Top bed exposed; conglomerate, gray, polymict; rich in pebbles of volcanic rocks, with quartz subordinate	6
3. Siltstone, light-gray, calcareous; abundant brachiopods and fragments of tabulate corals (7435–SD)	4
2. Siltstone, dark-gray, with rounded cobbles of lighter colored siltstone and fine-grained sandstone like that of unit below	2
1. Siltstone and fine-grained sandstone, greenish-gray; thin bedded and flaggy at base, but with beds about 1 ft. thick near top; to base of exposures	30

Intraformational conglomerate similar to unit 2 of this sequence, but containing fossils, is exposed on the north shore of the large island near the middle of the "Back Room" (7436–SD). Overlying it, and forming most of the island, is greenish-gray sandstone in thick faintly laminated beds, totaling about 50 feet thick; such sandstone forms several other small islands in this part of Scraggly Lake.

Dating of this sequence is based upon Boucot's study (written commun., 1962) of fossils from unit 3 of the sequence described above. Identifiable brachiopods in collections made here are:

Amphistrophia? sp.
New stropheodontid genus
Atrypa "reticularis"
Coelospira saffordi (Foerste)
Fascicostella? sp.
Isorthis sp.
Protathyris? sp.

Boucot wrote (written commun., 1962) that the new stropheodontid genus in this assemblage, most similar to a form that occurs in the lower Ludlovian Hemse Group of Gotland, suggests a like age for these rocks.

From the conglomerate on the island Boucot identified (written commun., 1964) the following brachiopods:

Atrypa "reticularis"
Howellella sp.
Isorthis sp.
Mesodouvillina sp.
Sphaerirhynchia sp.

Although this assemblage does not indicate any specific part of the Silurian, it is consistent with the Ludlow age indicated by the fossils of the preceding list.

In summary, the Upper Silurian rocks of the northwestern sequence are heterogeneous, and they are well dated by fossils at only a few places. On the southwest the sequence consists only of calcareous siltstone about 300 feet thick, whose age is estimated only from its position between limestone of Wenlock or early Ludlow age and the Seboomook Formation of Early Devonian age. Northeastward this siltstone is somewhat thicker in exposures in Sawtelle Brook, but here, too, it is dated only by its position immediately beneath the Seboomook. Similar rock around the flanks of the dome to the northeast, and in the Island Falls quadrangle (Ekren and Frischknecht, 1967), are more positively dated by fossils. In the northwestern part of the Shin Pond quadrangle, where the sequence is about a thousand feet thick, it contains conglomerate and sandstone as well as calcareous siltstone with diagnostic fossils. A few miles farther west in the Travaler Mountain quadrangle are volcanic rocks interbedded with tuffaceous sandstone that also contains fossils of early Ludlow age (Naylor and Boucot, 1965, p. 162).

VOLCANIC ROCKS OF LATE SILURIAN OR EARLY DEVONIAN AGE

Volcanic rocks, including tuff, breccia, and probably some flows of intermediate to mafic composition, overlie Upper Silurian siltstone in the northeastern corner of the Shin Pond quadrangle. Exposures of these rocks correspond to pronounced magnetic anomalies. Presence of these rocks beyond these exposures is suggested by the magnetic contours in this area; they are presumed to be responsible for the magnetic gradient that slopes southeastward from their outcrop, and the reverse fault in this area is based on this premise.

Breccia consisting mostly of scoriaceous fragments in a fine-grained highly chloritized and intensely sheared groundmass is confined to the vicinity of the T. 7 N., R. 7 W.–T. 6 N., R. 6 W. township corners. The most common rock in this area contains nearly equal amounts of scoriaceous fragments and matrix. About half of the fragments consist of vesicles that range in diameter from 1/4 to 1 mm; most are round in section and clearly separated from each other, but a few coalesce, and some near the edges of fragments or in shear zones are flattened. The vesicles are outlined by opaque rims. Although some are filled with chlorite, most are filled with calcite, and parts of some fragments are large crystals of calcite that include several vesicles and their surounding framework. The original texture and mineralogy of the matrix of the breccia is largely obliterated by secondary chlorite, but in a few places tiny sericitized plagioclase crystals are preserved, suggesting a tuffaceous origin.

Crystal tuff rich in plagioclase, and with cognate rock fragments about 4 mm across, are associated with the breccia, as is 3 feet of medium- to coarse-grained well-bedded green sandstone at one place 750 feet northwest of the township corners.

Sheared fine-grained volcanic rocks occupy the volcanic belt in the northeast corner of the Shin Pond quadrangle. They are separated from the breccia at the township corners by a covered interval of about 1½ miles. Although the original composition and texture of most of these rocks has been obscured by deformation and alteration, in one thin section studied by Rankin (oral communi., 1964) shards are preserved together with crystals of plagioclase and clinopyroxene. Another specimen with abundant plagioclase crystals has a spherulitic groundmass. These rocks form a distinct unit between the Upper Silurian limestone below and the overlying Seboomook Formation. The outcrop width of about a thousand feet is probably about twice the thickness of the unit, judging both from the low dip of the underlying limestone and the asymmetry of the magnetic contours.

The areas of the strong magnetic maxima west and northwest of the township corners were intensively searched for outcrop, but the only one found was at the subsidiary magnetic peak 2.2 miles N. 72° W. of the corners. Here, the rock is strongly altered, porphyritic, rich in calcite, and contains phenocrysts as large as 1 mm, mostly of plagioclase with about 10 percent quartz in a microcrystalline groundmass; it probably originally was a flow of andesitic composition. In this area, as to the northeast, the volcanic rocks lie between the Upper Silurian siltstone and the Seboomook Formation. The gentle southwest slope of the magnetic contours, contrasted with their steepness to the northeast, indicates that these volcanic rocks extend beneath the surface for several thousand feet down the trough of the syncline in which they lie.

Upper Silurian mafic and intermediate volcanic rocks in the northern part of the Traveler Mountain quadrangle indicate the age of volcanic rocks in the northwest corner of the Shin Pond quadrangle. A large unmapped area in the Grand Lake Seboeis quadrangle separates these rocks from the unit just described. Volcanic rocks of Early Devonian age are also known in the region (Boucot, Field, and others, 1964, p. 40). Inasmuch as there is no geologic evidence to suggest the affinities of the volcanic rocks of this unit to one or the other system, they are here classed as of Late Silurian or Early Devonian age.

SOUTHEASTERN SEQUENCE

In contrast to the sequence just described, the southeastern sequence of Silurian rocks consists largely of noncalcareous slate, but sandstone and conglomerate are abundant in some parts of it. The main parts of the sequence is assigned to the Frenchville and Allsbury Formations, described below. To the west and northwest of the Allsbury, and separated from it by one or more faults, are conglomerate, limestone, and tuff that together with Ordovician rocks form a fault complex on the southeast flank of the major anticlinorium of the area. The limestone and volcanic rocks of this complex suggest affinities with the northwestern sequence, but the conglomerate and the slate that are interbedded with it resemble parts of the Allsbury. Accounts of these rocks, which remain unnamed, follow those of the Frenchville and Allsbury.

FRENCHVILLE FORMATION

Gray fine- to coarse-grained feldspathic sandstone and conglomerate in a narrow outcrop belt in the southeast corner of the Stacyville quadrangle are classed with the Frenchville Formation of the Presque Isle area (Boucot, Field, and others, 1964, p. 31). Most of this rock in the Stacyville quadrangle is medium- to coarse-grained sandstone in massive beds 2–4 feet thick, but it contains lesser amounts of fine-grained quartzitic sandstone and some conglomerate. Gray and greenish-gray slate and siltstone are minor constituents that occur largely as thin partings between sandstone layers, but slate and siltstone a few feet thick occur from place to place throughout the outcrop belt. Conglomerate in most places is less abundant than sandstone; in it are rounded pebbles of quartz, quartzite, feldspar, and felsitic volcanic rocks, most less than half an inch in diameter, and small chips of medium- and dark-gray slate. Limestone fragments are rare in the southern part of the outcrop belt, but they are more common to the north. West of Maine Highway 11, 1.8 miles southwest of Stacyville, limestone cobbles as much as 2 inches in cross section are the most common component of some beds.

Pebble conglomerate in a roadside ledge 2.9 miles southwest of Stacyville (USGS loc. 7438–SD) yielded a few poorly preserved brachiopods which Boucot identified (written commun., 1963) as a species of *Pentamerus* like that from the Frenchville Formation farther north.

The similarity of the rocks and their fossils of the Stacyville quadrangle to the Frenchville Formation of the Presque Isle area governed the decision to identify them as Frenchville, although no rocks are so identified in the 50-mile interval that separates these outcrop areas. From structural data the position of the Frenchville Formation in the Stacyville quadrangle is equivocal; however, implicit in its identification as Frenchville is its stratigraphic position low in the southeastern Silurian sequence, and thus presumably beneath the Allsbury Formation in the core of an anticline.

Similar but unfossiliferous sandstone with more and coarser conglomerate has been identified as a lenticular unit between the Allsbury Formation and the underlying Mattawamkeag Formation in the Island Falls quadrangle (Ekren and Frischknecht, 1967). Sandstone and conglomerate mapped as the lower member of the Allsbury to the northwest in the Stacyville quadrangle may also be equivalent to the Frenchville; but these rocks are somewhat different, and they lack fossils. More certainly equivalent are at least part of the conglomerate and associated rocks in the fault blocks farther west in the Stacyville and Shin Pond quadrangles and the conglomerate at the base of the northwestern sequence of Silurian rocks in the Shin Pond quadrangle.

ALLSBURY FORMATION

Most of the southeastern half of the Stacyville quadrangle and a small part of the Shin Pond quadrangle are underlain by slate, sandstone, and conglomerate included in the Allsbury Formation (Ekren and Frischknecht, 1967). As defined in the Island Falls quadrangle report (Ekren and Frischknecht, 1967, p. 13), the formation consists dominantly of graywacke and black, dark-gray, and green slate. Ekren and Frischknecht were able to distinguish black slate units electromagnetically, and their map shows 10 bands of these across the outcrop belt along the parallel that includes the Allsbury Road, the type locality of the formation, where they constitute about 10 percent of the formation.

The Allsbury Formation in the Shin Pond and Stacyville quadrangles is part of the same outcrop belt as the type locality, but here it probably includes somewhat older rocks. About one-fourth of the older unit, here classed as the sandstone member of the Allsbury Formation, consists of coarse-grained sandstone and conglomerate interbedded with gray and green slate. The overlying member of the formation consists mostly of gray and greenish-gray slate and some red slate and greenish-gray fine-grained sandstone. These members are not recognized in the Island Falls quadrangle where dark carbonaceous slate appears to be more abundant than in the area of this report. Part of this difference may be due to the application of geophysical methods of tracing such beds in the Island Falls area, but outcrop observations also suggest that they are more abundant there.

SANDSTONE MEMBER

The sandstone member of the Allsbury Formation crops out in a faulted anticline north and west of the overlying upper member. This area includes two distinct linear magnetic anomalies in the Shin Pond quadrangle that may reflect magnetite-rich sandstone beds. Farther south, however, in the Stacyville quadrangle, a low linear magnetic anomally is oblique to the southern limits of the member as determined from outcrop observations.

The member consists of sandstone and minor amounts of pebble conglomerate interlayered with equal or greater amounts of slate and siltstone. At most exposures, sandstone forms the basal parts of beds whose upper parts are slate or siltstone. Some sandstone beds, 4–6 feet thick, are well graded; in these beds rounded quartz and felsite pebbles as much as 2 inches in cross section form the basal parts, which grade into coarse- and medium-grained sandstone, with siltstone and slate a few inches thick at their tops. A few unidentifiable fragments of fossils, including pelmatozoan debris and a rugose coral, were seen in the conglomeratic base of one such bed at the crest of the ridge 0.7 mile southeast of Lunksoos Camp. Although contrasting grain size and interbeds make bedding apparent at many exposures, some large ledges appear to be massive, suggesting that some coarse-grained sandstone beds are more than 10 feet thick. In some places bedded and massive sandstone appears to form outcrop belts as much as a thousand feet wide, but none of these could be traced for more than half a mile.

Thin sections of several sandstone beds show that nearly 90 percent of the clasts are quartz; the remainder consists of a few percent each of sericitized feldspar, quartzite, quartz-feldspar intergrowths, scattered flakes of muscovite, and a few carbonate grains. Clasts in most specimens are angular, but in a few they are well rounded. These clests are embedded in a silty and micaceous matrix that forms 10–20 percent of the rock. Such rock might be classed as quartz graywacke.

Quartz graywacke also occurs in the basal parts of graded beds that are 1–12 inches thick, where it forms as much as half of some layers. The siltstone and slate of the upper parts of these layers, as well as siltstone and slate elsewhere in this unit, are greenish gray and medium to dark gray and are finely laminated; they are identical to those of the upper member of the Allsbury.

The thicker coarser sandstone beds are more abundant in the lower part of the exposed section than higher up. They are especially abundant along the western boundary of Patten Township and to the east along the American Thread Co. Road where they are exposed for nearly a thousand feet. Similar rock was also found higher in the member at several places, as along the trail three-fourths of a mile northwest of the intersection of the Happy Corners and Frenchville roads, and farther south on the ridge southeast of Lunksoos Camp.

The base of the sandstone member is not exposed. Its top, drawn to include the thicker and more abundant sandy beds, conforms well with structural information in outlining the anticlinal outcrop area. At the boundary between the Shin Pond and Stacyville quadrangles the exposed thickness of the sandstone member is probably about 5,000–7,500 feet, but small amplitude folds prohibit a closer approximation.

The sandstone member is probably at least in part the same age as the Frenchville Formation, as they both are overlain by the slate member of the Allsbury. However, fossils that might confirm this correlation were not found in the sandstone member. The sandstone member of the Allsbury has more conglomerate than the Frenchville, and most of its sandstone is darker and has closer affinities to graywacke. Conglomerate is even more abundant and coarser in the fault blocks to the west, and fossils in standstone associated with them indicate that they are coeval with the Frenchville (p. I 25). These three occurrences therefore suggest a wedge of coarse clastic rocks of about the same age that were derived from the northwest.

SLATE MEMBER

Medium- to dark-gray, greenish-gray, and red slate and siltstone and a few beds of fine- to medium-grained sandstone, poorly exposed in the southeastern third of the Stacyville quadrangle, form the slate member of the Allsbury Formation.

These fine-grained rocks are a monotonous lot. In most places finely laminated darker finer grained layers alternate with lighter colored ones that are somewhat coarser grained at intervals of one to a few millimeters. The basal parts of some beds are fine-grained calcareous sandstone or siltstone, some with small-scale crossbedding, which grade upward into slate.

Although slate is considerably more abundant than siltstone, beds as much as 10 feet thick are formed of light-gray calcareous siltstone with closely spaced thin slaty partings. Beds of siltstone 4–10 inches thick with convoluted bedding are rare but distinctive components of the member. Such beds are well exposed in the barnyard east of Maine Highway 11, 1.5 miles south of Stacyville, and in ledges in the East Branch of the Penobscot River, 1.1 miles south of the railroad bridge at Grindstone in the Millinocket quadrangle.

Red shale with associated green siltstone also occurs at several places. The green siltstone forms the basal parts of graded beds, 1–2 inches thick; the upper half or more of these beds is red slate. Tightly folded rock of this kind is exposed just west of the abandoned schoolhouse on the Happy Corners Road, 0.3 mile west of the Stacyville quadrangle boundary and at several other places.

Most of the sandstone of the slate member of the Allsbury is identical with that of the sandstone member. One fine-grained sandstone bed in Mud Brook near the mouth of Alder Brook has brown-weathered spots, a 1 or 2 mm in diameter, that are probably weathered ankerite. Such rock is also a minor but distinctive part of the Silurian sequence in the Houlton quadrangle to the east (Pavlides, oral commun., 1963), and it was seen in the Sherman quadrangle on the hilltop southeast of Doble School.

Graptolites from dark-gray carbonaceous slate at three places in the Stacyville quadrangle were identified by Berry (written commun., 1962, 1963); strong compression and deformation made specific identification of many specimens uncertain.

Bangor and Aroostook Railroad, 0.56 mile southwest of BM 472 feet (7439–SD):

Monograptus cf. *M. priodon* (Bronn)
Monograptus sp. (with thecae apparently hooked)
Monograptus sp.

West Branch of Mud Brook, 445-foot contour, 100 feet north of trail crossing (7440–SD):

Monograptus sp. (broad hooked thecae, somewhat reflexed)

West Branch of Mud Brook, 450-foot contour, about 200 feet north of trail crossing (7441–SD):

Monograptus sp. (slender hooked thecae)
Monograptus sp. (slender thecae, apparently square)

Identical rock in the Sherman quadrangle, 2 miles S. 80° E. of its northwest corner, in Fish Stream, 2,400 feet west of Maine Highway 11 (7442–SD) contained:

Monograptus dubius (Suess)
Monograptus sp.

A single specimen of a species of *Monograptus* with "dichograptid" thecae was also found in fine-grained sandstone north of the Happy Corners Road, 0.4 mile west of Maine Highway 11 in the Sherman quadrangle (7443–SD).

In summarizing the significance of these collections, Berry (written commun., 1963) noted that *Monograptus dubius* (Suess) ranges through the British Wenlock into the Ludlow (see Elles and Wood, 1901–18, p. 523), overlapping the range of *M. priodon* (Bronn). Monograptids with hooked thecae range from the upper part of the Llandovery into the Wenlock. Thus, the graptolites may all be of early Wenlock age, or they may represent the span from late Llandovery (as at Mud Brook) into early Ludlow.

Correlation of the slate member of the Allsbury with the Perham Formation of the Presque Isle area (Boucot and others, 1964, p. 33) is indicated by these fossils, the similarity of their rocks, and their similar stratigraphic relations.

UNNAMED CONGLOMERATE AND ASSOCIATED ROCKS

The fault complex that borders the Allsbury Formation on the west contains, in addition to Ordovician rocks, long narrow belts of conglomerate, coarse-grained sandstone, and enigmatic patches of limestone and tuff breccia. These rocks may be closely related to those of the Allsbury Formation, but they are classed separately because they contain an abundance of rocks that cannot be matched with any part of the Allsbury east of the fault system.

CONGLOMERATE

Pebble and cobble conglomerate with boulders as much as 1 foot in diameter, some in thick unbedded masses, is the characteristic rock of these fault blocks. The most common clasts are fine- to coarse-grained quartzite like that of the Grand Pitch. Some exposures are formed almost exclusively of quartzite clasts and of green slate chips that are also apparently derived from the Grand Pitch. Other components include greenstone, of which the largest boulders are formed; and, locally, quartz diorite similar to the Rockabema; dark chert; felsite; and other rocks. The matrix is a mixture of slate fragments squeezed between grains and sericite-rich graywacke. A few places show grading from conglomerate to coarse-grained sandstone. Part of a large thin section from one such graded bed (from the west bank of the Seboeis River 1.3 miles south of the Stacyville quadrangle boundary) contains rounded granules of quartzite and greenstone 2–5 mm in diameter, and slate chips as large as 10 mm in a matrix of coarse- to fine-grained feldspathic sandstone in a chloritic paste. By gradual decrease in grain size and abundance of larger fragments, this rock grades into coarse-grained sandstone consisting of about 60 percent angular quartz grains and about 10 percent each of feldspar and pyroxene in a sericitic matrix that forms the remaining 20 percent of the rock. This concentration of detrital pyroxene suggests that elsewhere, detrital magnetite might be present in sufficient quantities to cause local magnetic anomalies, such as the one that corresponds to the northermost fault block south of Lower Shin Pond.

The clasts of quartz diorite are of special interest in that their petrographic similarity to the distinctive rocks of the Rockabema indicates their evident source. Large rounded pebbles and cobbles of such rock, 1–3 inches in diameter, form a few percent of the clasts of conglomerate in the northeasternmost fault block and in the block to the southwest as far south as Moose Brook, about 1 mile north of the Shin Pond-Stacyville quadrangle boundary. Thin sections of several of these clasts are similar to those from the more equigranular coarse-grained Rockabema, and differ from it only in that the biotite of the clasts is unaltered, whereas the biotite in outcrop specimens of Rockabema is altered to chlorite.

Concentrations of clasts of chert and siliceous siltstone of apparent local derivation in conglomerate outcrops farther south are noted below.

Slate and siltstone interbeds form minor parts of these fault blocks. The northern block contains one bed of dark-gray carbonaceous slate, about 50 feet thick, that was traced electromagnetically by Frischknecht and Ekren (1960, p. 124–125) for about 1½ miles from just east of the Shin Pond Road southwestward towards Sucker Brook. The fine-grained beds seen farther south are not notably carbonaceous, but they are somewhat lighter colored, greenish-gray and silty, and form interbeds from a few inches to a few feet thick between beds of conglomerate and sandstone.

No fossils were found in these rocks in the northernmost fault block, but the one farther south yielded fragmentary Early Silurian brachiopods and corals at one exposure. These fossils occurred in a small lens of coarse-grained calcareous sandstone enclosed in a lens of coarse boulder conglomerate on the west bank of the Seboeis River about 1,200 feet south of Bench Mark 382 in the Stacyville quadrangle about 2 miles south of its northern boundary (7444–SD). Although shell fragments were abundant in this lens, only a few specimens were identifiable generically and none specifically. The Early Silurian (late Llandovery) age of the rock is established, however, by the presence of *Dolerorthis* sp., *Leangella* sp. and *Stricklandia* sp. together with *Halysites* sp. (Boucot, oral commun., 1961).

Outcrops of these conglomeratic rocks are more abundant in the two more northerly fault blocks than in those farther south. Toward the south, where bedrock is largely buried beneath surficial debris, similar conglomerate and associated rocks are exposed in three areas which are interpreted to represent other fault blocks. The overlapping features of the rocks in these areas indicate the affinities between them.

Gray polymict conglomerate crops out along Sandbank Stream between 520 and 620 feet in altitude; the outcrop width of the conglomerate is about 1,500 feet. Most of this rock is thick bedded and has many uniform beds of both conglomerate and coarse-grained sandstone as much as 4 feet thick. Some beds grade from coarse cobbly and pebbly parts into sandstone, and from these graded beds the succession is interpreted to face westward. Most of the bedding is lenticular, however, with thin bands of pebbles and lenses of pebbly conglomerate included in layers of coarse-grained sandstone. A few beds of gray slabby siltstone were also seen.

Rock fragments are abundant in the conglomerate in Sandbank Stream. The largest are rounded greenstone boulders as much as 1 foot in diameter. Gray fine- to medium-grained quartzite like that of the Grand Pitch is the most common rock of the pebble class, but dark chert and siliceous siltstone like those of the Wassataquoik are also abundant and are dominant in the easternmost and presumably lowest beds of the exposed sequence. The fragments are rounded but oblate to tabular, and are well oriented parallel to bedding. The matrix consists of quartz grains 1–3 mm in diameter and small chips of green and gray phyllite that are compressed and folded into spaces between round hard grains. This rock contains a few scattered and indeterminate fossils, including rugose and tabulate heliolitid corals and poorly preserved undeterminable dalmanellid brachiopods.

Chert-rich conglomerate like that of the Sandbank Stream exposures also crops out on Millinocket Ridge about 750 feet south of its summit. In addition to chert, this conglomerate contains rounded pebbles of quartzite and several large slabs of dark-gray siliceous siltstone that contain abundant graptolites. About 500 feet northwest of this exposure 30 feet of dissimilar beds is exposed in a bulldozed roadbed. Dark-gray siltstone interbedded with fine- to medium-grained sandstone 1–6 inches thick forms the lower 10 feet of these exposures, as determined from scouring and graded bedding of the sandstone. These beds are overlain by bedded volcanic breccia. It consists of angular fragments of felsitic volcanic rocks in a matrix of felted tiny plagioclase crystals and a few crystals as large as 2 mm. Breccia beds through about 20 feet of exposure, each about 1 foot thick, are separated by thin interbeds of siltstone and fine-grained sandstone.

Neither the siltstone nor the breccia yielded fossils, but Middle Ordovician graptolites were obtained from the rock fragments in the conglomerate. Berry (written commun., 1963) identified the following forms from collections made here:

Amplexograptus macer (Ruedemann)
Amplexograptus n. sp.
Climacograptus cf. *C. brevis* Elles and Wood
Climacograptus cf. *C. scharenbergi* Lapworth
Climacograptus sp. indet.
Dicranograptus cf. *D. nicholsoni* Hopkinson
Orthograptus truncatus cf. var. *intermedius* Elles and Wood
Orthograptus truncatus var. *pertenius* (Ruedemann)
Orthograptus truncatus var. *nexus* (Ruedemann)

These graptolites belong to the *Orthograptus truncatus* var. *intermedius* zone (Zone 13 of Berry, 1960), equivalent to the Trenton Limestone of New York, according to Berry. They are thus from a zone younger than those found in outcrops of the Wassataquoik Chert. Inasmuch as they occur in clasts, they only establish the maximum age of the conglomerate and of the siltstone and breccia that overlie it.

BRECCIA

Bedded tuff breccia containing fragments of limestone that seems to be closely related to these conglomerates crops out over several acres on the 1,020-foot hill, 2.24 miles N. 70° W. of the mouth of Wassataquoik Stream. Most of the fragments in this rock are angular felsitic volcanic rock, including many that were scoriaceous, some as much as 6 inches in average diameter. Limestone pebbles are rare in parts of the rock, but at irregular intervals from a few inches to a few feet there are concentrations of them parallel to bedding surfaces. The matrix of the rock is medium-gray crystal tuff with abundant large plagioclase crystals as large as 3 mm.

Limestone pebbles are rounded and range from ½ to 2 inches in diameter. Some of the pebbles are calcarenite, rich in pelmatozoan debris, some are fragments of heliolitid tabulate corals, and a few are silty limestone; one, at the southwest edge of the summit of the hill (7447–SD), contains a fragment of a brachiopod shell that is probably a pentamerid, indicative of a Silurian age, according to Boucot (written commun., 1964). Although this shell does not exclude an Early Devonian age for this breccia, the presence of other Silurian rocks nearby, together with the absence of similar rocks of Early Devonian age, suggests that a Silurian age is most probable.

These rocks are separately mapped because their outcrop area is large. Other tuffaceous rocks in small isolated exposures that are included with the unnamed Silurian conglomerate unit are those of Millinocket Ridge, described above, and chert-rich conglomerate in a tuffaceous matrix, at the base of the east face of Hunt Mountain about a mile south of Wassataquoik Stream.

LIMESTONE

Limestone of Late Silurian age also crops out in the central part of the Stacyville quadrangle north of Owen Brook where it is probably a fault wedge. The rock in this area includes nearly white and pink coarse-grained calcarenite and gray fine-grained limestone, much of which is argillaceous. Stratification has been obliterated in most places by intense shearing. It was probably originally obscure in the coarse-grained rocks that are rich in large stromatoporoids and favositid corals, similar to the reefal limestone at Marble Pond. The area also includes massive fine-grained argillaceous limestone which in places contains fragments of calcarentite, stromatoporoids, and favositid corals comparable to the bedded reef detritus at Marble Pond.

Large but deformed brachiopods of the genus *Conchidium* were obtained in abundance from gray fine-grained limestone 2,600 feet N. 32° W. of the mouth of Owen Brook (7445–5D) and from nearby float of pink coarse-grained limestone. These date the rock as Late Silurian. Identifiable fossils were not collected from ledges elsewhere in the area, but the colonial rugose coral *Entelophyllum* was identified (Oliver, oral commun., 1964) in a loose block from east of the Telos Tote Road, and confirms the Late Silurian age of this body of limestone.

DEVONIAN SYSTEM

Sedimentary rocks of Early Devonian age include the Seboomook Formation (Perkins, 1925, p. 374–375; Boucot, 1961, p. 169–170) and the Matagamon Sandstone (Rankin, 1965). These rocks are exposed in the northern part of the Shin Pond quadrangle, and related rocks crop out throughout northern Maine (Boucot, Griscom, and others, 1964). Significantly, no Devonian sedimentary rocks have been reported from the slate belt to the southeast except for the Upper Devonian posttectonic Perry Formation in the southeastern part of the State.

Igneous rocks of Devonian age are more widespread. Those in the area studied include a part of the Katahdin Quartz Monzonite body in the Stacyville quadrangle and granophyre and diabase in the Shin Pond quadrangle.

SEBOOMOOK FORMATION

Graded beds of fine-grained gray sandstone and dark-gray siltstone and slate typical of the Seboomook Formation lie in a broad syncline in the northwestern part of the Shin Pond quadrangle and in a smaller syncline in the northeast corner of the quadrangle. In typical outcrops of this formation, beds average about 4 inches thick; some are as thin as 2 inches, and a few are as much as 1 foot thick. The basal sandy parts, about a fourth of each layer, are almost everywhere crossbedded. The gradation from sandstone to siltstone and slate takes place by the intercalation of thin dark laminae of fine-grained material with sandstone, which gradually increase in abundance and thickness upward so that the upper parts of each are nearly homogeneous slate.

Fine-grained feldspathic sandstone in massive beds are as much as 2 feet thick, and in laminated and crossbedded layers, are interbedded with the graded layers at several places. Sequences of such beds as much as 15 feet thick were seen in a few places, but thicknesses of 5 feet are more common. Sandstone of this kind comprises only a few percent of the formation through most of the outcrop area. Virtually the same rock characterizes the Matagamon Sandstone, and the boundary between the Matagamon and the Seboomook is drawn where thick beds of sandstone are more abundant than slate and siltstone.

The exposure of gray siltstone with thin sandy seams at the top of the Bowlin Pond Road section (7448–SD, p. I 16) is included within the Seboomook Formation, although it is unlike other rocks so classed. This exposure yielded a few small fragmentary brachiopods identified by Boucot (oral commun., 1964) as an ambocoelid, probably *Metaplasia*, and *Plectodonta* sp., indicating an Early Devonian age. Inasmuch as this exposure is at or near the base of the Seboomook, it agrees with the Early Devonian age of the formation as indicated earlier by Boucot (1961, p. 170).

The Seboomook is about 5,000 feet thick at the western edge of the Shin Pond quadrangle where it is overlain on the north by the Matagamon Sandstone. Because the Matagamon is interpreted to replace the Seboomook in this area, this is a minimum thickness. Elsewhere, it is probably thicker, but minor folding and the absence of an overlying unit prohibit confident thickness estimates. It may be as much as 8,000–10,000 feet thick along the line of the structure section through the Shin Pond quadrangle (fig. 1), about half the maximum thickness assigned to it in its type area (Boucot, 1961, p. 170).

MATAGAMON SANDSTONE

Thick beds of gray medium- to fine-grained sandstone on and near Hay Mountain at the Western edge of the Shin Pond quadrangle represent the northeastern part of a sandstone body named the Matagamon Sandstone by Rankin (1965). The most conspicuous outcrops of the formation are beds, 1–2 feet thick, that are nearly massive, but thin-bedded, and platy sandstone is also common. The arcuate ridges northwest of Hay Lake supported by large ledges of these resistant rocks are among the most evident topographic expressions of bedrock structure to be seen in the State of Maine (Rankin, 1965, fig. 3, p. F6).

Although textures through the sandstone beds are nearly uniform, fine laminations, crossbedding, and channel fill are outlined in most of them by small differences in grain size. The sand grains are angular to subrounded, well sorted, and most fall in a diameter range of ½ to ¾ mm. Quartz forms about 90 percent of the rock; a few percent of other constituents includes feldspar, quartzite, greenstone, and carbonate grains; and about 5 percent forms a microcrystalline micaceous matrix. In a few beds small chips of shale and siltstone are common.

Most of the rock is unfossiliferous, but a few beds contain scattered fragmentary mollusks. Just east of the summit of Hay Mountain one 6-inch bed crowded with brachiopods was found (7715-SD). From a sample of this bed Boucot (written commun., 1962) identified the following:

Acrospirifer sp.
Beachia sp.
"*Chonetes*" *canadensis* Billings
Coelospira dichotoma (Hall)
Costellirostra sp.
Cyrtina sp.
Leptocoelia flabellites (Conrad)
Meristella arcuata Hall

Boucot (written commun., 1962) wrote that the *Beachia* in this assemblage, together with the other genera and species present indicates its Becraft-Oriskany age, coeval with the Tarratine Formation of the Moose River Synclinorium (Boucot, 1961, p. 165-167). Rankin (1965, p. F9) concluded that the Matagamon is a local sandstone facies of the Seboomook, paralleling Boucot's (1961, p. 167) interpretation of the relations of similar sandstone of the Tarratine Formation and the Seboomook Formation in the Moose River Synclinorium.

The segment of the Matagamon in the Shin Pond quadrangle is about 4,500 feet thick. As the syncline in which it occurs plunges southwestward, younger beds are preserved in this direction, as is the overlying quartz latite of Traveler Mountain (Neuman and Rankin, 1966, p. 15).

KATAHDIN QUARTZ MONZONITE

Medium-gray to light-gray, medium-grained massive granitic rock along the western boundary of the Stacyville quadrangle represents the eastern extremity of the Katahdin batholith. Its eastern boundary is a contact zone consisting of a breccia of partially assimilated and hornfelsed sedimentary rocks in a granitic matrix. Rocks of the batholith have long been referred to as granite (Caldwell, 1960, p. 5-10), but in the light of Griscom's unpublished information, they are now classed at quartz monzonite (Griscom, 1966, p. 36).

Exposures of the Katahdin were found on a few prominent hilltops and eroded hauling roads on their flanks and at Orin Falls and Deasey Dam in Wassataquoik Stream. They are all nearly massive and structureless except for a few widely spaced joints. Texture and mineralogy appear to be uniform in most places, but the rock is locally altered and pink. Dark fine-grained biotite-rich ellipsoidal inclusions a few inches in diameter are rare in outcrops; some have none, but a few drift boulders have several, each a foot or more in diameter, which indicates that at some places they are abundant.

The Katahdin is a hypidiomorphic granitic rock consisting of about two-thirds feldspar, one-third quartz, and between 5 and 10 percent biotite. In identical rock in the Harrington Lake and Katahdin quadrangles Griscom (written commun., 1963) found that about half of the feldspars are potassic, including either microcline, orthoclase, or both. The plagioclase is zoned, grading from more calcic cores to more sodic rims, and has an average composition of oligoclase (An22). Feldspar crystals are anhedral, and many are as much as 10 mm across in section. Quartz crystals are better formed and more nearly euhedral, but they are about half the size of the feldspars. The biotite crystals, about half the size of the quartz grains, are anhedral but undeformed.

The pink color of the altered rock is due to discoloration of the feldspars (probably both the potassic and sodic forms), and in such rock the biotite is altered to chlorite. Rock thus altered occurs both in well-defined zones a few inches wide parallel to joints, as at Orin Falls and on Wassataquoik Mountain, and over wider areas that include entire ledges tens of feet in area, such as the one at Deasey Dam.

Griscom (written commun., 1963) found that biotite-bearing quartz monzonite and the associated altered phase, like that in the Stacyville quadrangle, form by far the most widespread and abundant of the three facies of the Katahdin that he distinguished in the Katahdin and Harrington Lake quadrangles. The other two facies—one that is finer grained and contains hornblende, the other having a distinctive granophyric texture—were not found in the Stacyville quadrangle.

Breccia consisting of fragments of thermally altered and partially assimilated sedimentary rocks in a granitoid matrix crops out in several places in a belt that forms a border zone between the main body of the Katahdin Quartz Monzonite and the sedimentary and volcanic rocks that it intrudes.

The rocks in this zone vary widely in several respects. The average size of rock fragments ranges from a few inches to 10 feet or more. Where the fragments are small, as on Kelloch Mountain, the whole rock is composed of about equal amounts of xenoliths and granitic matrix. There the granitoid rock has a prominent gneissic structure, and the tabular fragments 1–3 inches long are apparently plastically deformed and steeply dipping. Reaction rims surround some of the xenoliths, but in places their boundaries are indefinite, frayed, and whispy.

Exposures three-fourths of a mile southeast of Wassataquoik Mountain and drift boulders at many places indicate that there is a gradation from such gneissic rock through that in which xenoliths average 6–12 inches in size and are weakly to randomly oriented to parts in which xenoliths are 10 feet across or larger and have granitic septa of comparable size. The exposures in Wassataquoik Stream and on Black Cat Mountain in the Norcross quadrangle to the southeast are of this kind.

Most of the xenoliths are medium- to fine-grained laminated sandstone and contain small but variable amounts of feldspar, abundant biotite, and minor muscovite. Laminations reflect changes in composition, the dark mica-rich bands alternating with those that are more quartzose; some are in graded sets. One large block in Wassataquoik Stream, finer grained than others seen, lacked biotite, but its purplish color resembles that of cordierite-bearing hornfels.

The granitic matrix is also highly variable in composition and grain size, ranging from a fine-grained aplite to pegmatite and from some that is quartz-rich to parts that are virtually devoid of quartz.

In a few places the biotite of both the xenoliths and the granitic matrix is altered to chlorite and the feldspars are sericitized, but this alteration is not accompanied by discoloration as it is in the quartz monzonite.

The continuity, width, and dip of the breccia zone as shown on the geologic map and section C–C′ (pl. 3) are conjectural, as outcrops of it were seen at only four places in the Stacyville quadrangle. It apparently terminates a short distance north of the exposures in Wassataquoik Stream, as high magnetic values just north of these exposures indicate the presence of greenstone in the drift-covered area north of the stream. Although the breccia crops out in the bed of Wassataquoik Stream, to the south it is found on hilltops. Its greatest exposed width of 2,500 feet is on Kelloch Mountain where it crops out on both the northwestern and southeastern slopes. To the southwest, by the roadside 2 miles southwest of Millinocket Ridge, and on the 640- to 660-foot ridge northeast of the northeast corner of Millinocket Lake, drift boulders indicate its presence; farther southwest the breccia is exposed on Black Cat Mountain overlooking the southwest corner of Millinocket Lake in the Norcross quadrangle.

The contact of the breccia with the main body of the Katahdin Quartz Monzonite or the enclosing country rock was not seen anywhere. Probably both are gradational, as suggested by reconnaissance observations farther south in the Norcross quadrangle where highly deformed hornfels without granite occurs more than 5 miles south of Black Cat Mountain, both at the outlet of the Twin Lakes and in roadside ledges along Maine Highway 11 opposite Partridge Cove.

The dip of the breccia zone is suggested by its xenoliths, most of which are laminated quartz-rich argillaceous rocks, more similar to rocks of the Allsbury Formation than to any other unit of the area. Greenstone appears to be absent, although the magnetic peak about a mile southeast of Kelloch Mountain suggests the presence of a large greenstone xenolith beneath the drift. It is thus inferred that the quartz monzonite and its border breccia cuts the Allsbury beneath the surface, and presumably east of the downward projection of the bordering greenstone.

Radiometric age determinations were made on biotite from coarse pegmatite matrix of this breccia collected on the southwest bank of Wassataquoik Stream, 1.1 miles downstream (southeast) of Deasey Dam (Faul and others, 1963, loc. Me 30, p. 4, 5, 8, and 12). Its Rb-Sr age is 355 million years, but the K-Ar age is 390 million years; the latter is consistent with K-Ar ages determined from other intrusive rocks to the east and northeast. Faul and others (1963, p. 5) noted that this age is greater than the 356- and 361-million-year K-Ar dates determined for Katahdin rocks farther west. One of the samples upon which this comparison is based is a diorite (Me 6 of Faul and others, 1963, p. 5, 12) that Griscom (1966, p. 37) considers to be intruded into and younger than the Katahdin; the other sample (Me 7) taken only 1½ miles from the diorite, may have been altered by the younger intrusive. Thus, the relative radiometric ages of the main body of the Katahdin and the bordering breccia are yet to be established. The Katahdin is certainly younger than the several Lower Devonian formations that it intrudes (see Boucot, Field, and others, 1964). Its boundaries cut sharply across regional structures, which fact, together with its lack of internal structure, indicates that it postdates Middle Devonian (Acadian) regional deformation. That its intrusion is a late event of this orogeny is indicated by the radiometric ages.

GRANOPHYRE AND DIABASE

Light-colored granophyre crops out in two small bodies on Snowshoe Mountain and at the western border of the Shin Pond quadrangle where it is the eastern edge of a more extensive body that extends for several miles westward in the Traveler Mountain quadrangle (Neuman and Rankin, 1966, p. 10). In the same area, dark coarse-grained diabase crops out around the "Back Room" of Scraggly Lake and in a south-dipping sill on Owls Head.

Outcrops of the granophyre are light gray and closely jointed, but they lack cleavage or foliation. The rock is porphyritic; its phenocrysts are about 3 mm across, about four times the size of its groundmass grains. Rosettes of feldspar 2–3 mm in diameter are abundant and are the characteristic feature of the rock. In thin section, plagioclase phenocrysts are subhedral to euhedral, zoned, and sericitized (D. W. Rankin, oral commun., 1964). Biotite phenocrysts are partially altered to chlorite, and contain zircon crystals, as much as 0.5 mm in diameter, that are rimmed by pleochroic halos. The groundmass is a microfelsite of intergrown quartz and feldspar.

Fine-grained rhyolitic rock at the northern tip of the easternmost outcrop area probably represents a chilled margin of the granophyre. This rock is medium gray, darker than the normal granophyre, and has clustered phenocrysts of euhedral and zoned plagioclase as large as 3 mm. In thin section, Rankin (oral commun., 1964) found abundant plagioclase spherules with granophyric textures in their outer parts in a quartz-rich microcrystalline groundmass. A few grains of pyroxene, not seen in the granophyre, are the most conspicuous mafic component, together with a few chloritized biotite crystals.

Exposures of diabase are nearly massive and have widely spaced joints. Most of the rock is coarse grained, and contains mafic minerals (probably pyroxene) and plagioclase crystals as large as 10 mm. A closely associated rock about 500 feet north of the north shore of Scraggly Lake is dense and microcrystalline, except for abundant calcite pods about 0.5 mm in diameter.

Both the granophyre and diabase intrude the Seboomook Formation, which is visibly altered as much as 1,500 feet from them. In this alteration zone the Seboomook is harder than elsewhere and retains only vestiges of slaty cleavage; its argillaceous beds sparkle with fine-grained biotite and muscovite. These intrusive rocks thus postdate the regional deformation, and are probably of about the same age as the Katahdin Quartz Monzonite to which they may be genetically related.

STRUCTURE

The rocks of the Shin Pond and Stacyville quadrangles, together with those of most of northern and eastern Maine, have been folded and more or less metamorphosed by one or more early Paleozoic orogenies. The last of these, the Acadian orogeny of probable Middle Devonian age, deformed the youngest sedimentary rocks of the area, but it left its stamp on all the older rocks as well. The anticlinorium in the central part of the area may have been formed during the Ordovician Taconic orogeny, and the Cambrian(?) Grand Pitch Formation was deformed in an earlier orogeny during Cambrian or Early Ordovician time. It is thus convenient to examine first the structural features of the youngest rocks, those of Silurian and Devonian age, and second, discuss those that are older and more complexly deformed.

NORTHWESTERN SYNCLINE

The syncline in the northwestern third of the Shin Pond quadrangle plunges southwestward, and down plunge, beyond the Shin Pond quadrangle boundary it contains the youngest rocks of the region. These, in the Traveler Mountain quadrangle, include a thick sequence of Devonian volcanic rocks (quartz latite of Traveler Mountain as used by Neuman and Rankin, 1966, p. 15) and sedimentary rocks derived from them (Trout Valley Formation of Dorf and Rankin, 1962). These rocks and the Matagamon Sandstone do not have the slaty cleavage that pervades and characterizes those of the Seboomook and the underlying formations on the flanks of this fold, nor are they as intricately and closely folded. Thus, the more argillaceous and plastic rocks of the syncline are concentrated in its older formations, and the younger rocks are structurally more competent.

The superposition of a thick competent sequence above a large mass that is less competent may explain the eastward plunges of minor folds on the southeastern limb of the syncline, shown both by the outcrop pattern of Silurian formations near Marble Pond and the mouth of Sawtelle Brook and by the lineation formed by the intersection of steep northeast-striking cleavage on bedding surfaces with more easterly to northwesterly strikes. These plunges are opposite to those of the major structure of which they are a part. Perhaps the massive rocks on the southwest restricted normal response to rock flow, forcing the weaker rock away and up plunge.

The imprint of the younger (Acadian) cleavage upon an older cleavage is shown by the folded bedding and cleavage in the Grand Pitch Formation at the up-plunge end of this fold in the northeastern part of the Shin Pond quadrangle. Here, lustrous partings parallel to bedding laminations and to thin quartzite beds mark the older cleavage. These surfaces are tightly crumpled by chevron folds whose steep axial planes with northeast strikes are parallel to the cleavage of the younger rocks farther southwest.

SLATE BELT

Vertical structures, predominate in the slate belt. Both bedding and slaty cleavage nearly everywhere are within 10° of vertical, and in most places cleavage is parallel to bedding or nearly so. Where they diverge, they differ more in strike than in dip, and the lineation formed by their intersection is therefore also nearly vertical. Where slate and sandstone are in interbedded graded sets, slaty cleavage is refracted, and the angle between the strike of bedding and cleavage is progressively more acute with decrease in grain size. Divergence of the strikes of bedding and cleavage is most pronounced in the axial region of the large southwest-plunging anticline at the western margin of the belt and at the few exposures of vertically plunging minor folds. The number of minor folds exposed, however, may be less than their abundance, as their rocks are more fractured and hence more susceptible to erosion and surficial cover than are the rocks whose cleavage is more nearly parallel to bedding.

The steep plunges indicated by minor folds and bedding-cleavage intersections seem not to be reflected in the mapped boundaries of rock units and in the larger structures of the area. Detailed delineation of stratigraphic boundaries, however, is hampered by limited exposure and by the similarity of rocks of adjacent formations and their apparent gradational relations. Nevertheless, where thin units have been traced in detail through the surficial cover, as were the conductive beds of the Allsbury Formations in the Island Falls quadrangle (Ekren and Frischknecht, 1967), they seem to form simple straight northeast-trending bands; larger units in this area and elsewhere have been mapped along strike for tens of miles with nearly straight boundaries.

The explanation of the apparent contradiction of the major structures by the minor ones may lie in the tectonic setting of the slate belt. With a width of about 70 miles, the slate belt is the broadest area of incompetent nearly homogeneous deformed rocks in the Appalachian Mountain system, and it lies between two belts of more competent rocks, all tightly compressed, presumably simultaneously during the Acadian orogeny. Thus confined, the principal direction of stress relief was probably upward, with subordinate horizontal movements along vertical shear surfaces. The long, narrow major folds may therefore conform to the shape of the sedimentary basin, whereas the minor structures may represent local accommodations to differential stresses.

CENTRAL ANTICLINORIUM

The large anticlinorium of the Shin Pond-Stacyville area is the southwestern part of a more extensive feature named the Weeksboro-Lunksoos Lake anticline in a recent summary of the geology of northeastern Maine (Pavlides and others, 1964, p. C30). Tightly folded rocks of the Grand Pitch Formation form the core of this fold. These rocks are unconformably overlain at different places by the Shin Brook Formation, by Middle Ordovician volcanic rocks, by Upper Ordovician and Lower Silurian conglomerates, and probably by Silurian calcareous siltstone.

Steep to vertical bedding and cleavage characterize the structure of the Grand Pitch throughout its outcrop area, and individual outcrops display tightly compressed folds and faults at several places. At the Grand Pitch of the Seboeis River (fig. 3) a series of folds on the east bank include a steep-limbed carinate anticline and other folds that are more open. At Shin Falls nearly vertical beds of quartzite and slate crop out through about 500 feet of nearly continuous exposure in which opposite-facing segments identified by their sedimentary structures are separated from each other by vertical faults. At the Grand Pitch of the East Branch of the Penobscot River, the thick quartzite bed that forms the lip of the falls is cut by a vertical fault, and both upstream and downstream interbedded quartzite and slate form steep-limbed nearly isoclinal folds with plunges in several directions. Cleavage and axial planes of most folds through this outcrop area strike northeastward and dip steeply. Toward the west, however, they strike north or northwest, approaching parallelism with the greenstone boundary on the west.

The Grand Pitch is thus complexly deformed, but in few places is its cleavage folded as it is in the dome in the northeastern part of the Shin Pond quadrangle. The fold pattern of this area is thus largely conformable with those of the younger rocks in the adjoining synclines. That at least part of the deformation of the Grand Pitch antedates the Lower or Middle Ordovician Shin Brook Formation is indicated by the contrast in deformation at the Grand Pitch-Shin Brook contact and by the presence of Grand Pitch slate and quartzite in basal conglomerates in the Shin Brook Formation (Neuman, 1964, p. E4).

The Shin Brook Formation lies in a doubly plunging canoe-shaped syncline within the anticlinorium. Its rocks are cut by steeply dipping northeast-trending cleavage, and they are deformed to the near obliteration of sedimentary structures and fossils in some places. Beds of the Shin Brook dip regularly, however, and they are not crumpled, as are those of the Grand Pitch. The contrast is well displayed in the small brook shown

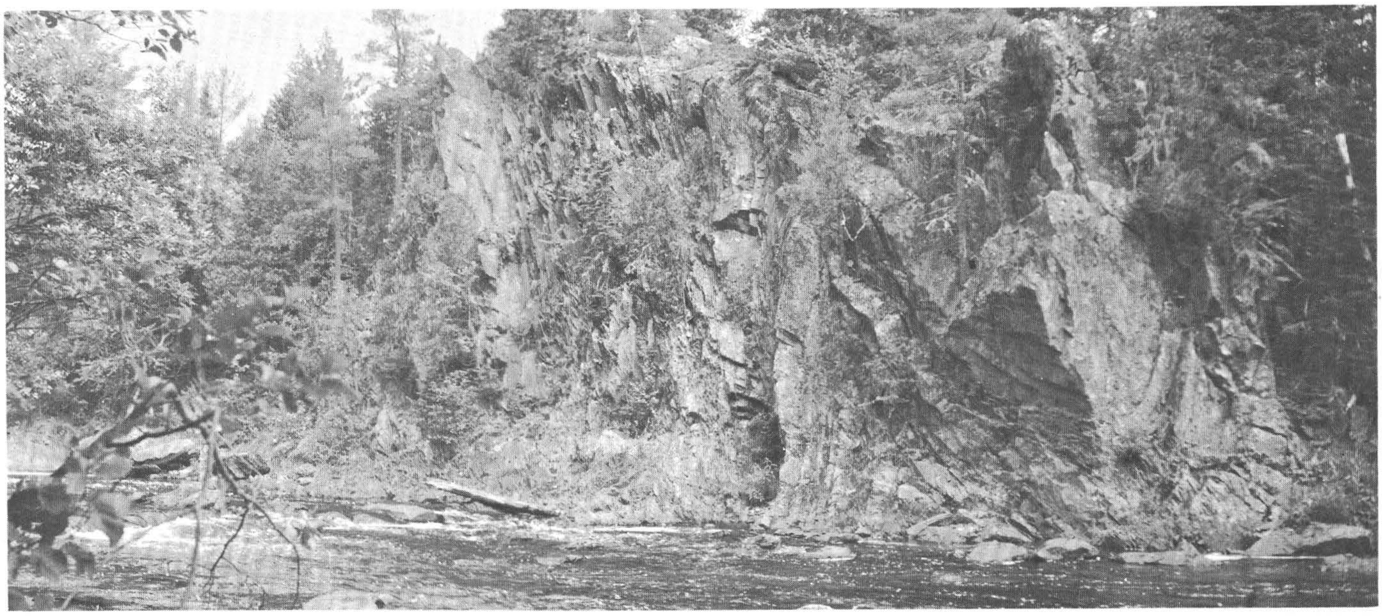

FIGURE 3.—Folds in the Grand Pitch Formation, east bank of the Grand Pitch of the Seboeis River. Cliff is about 25 feet high.

with a waterline on the southeastern slope of Roberts Mountain near the eastern border of the Shin Pond quadrangle. Southeast of the contact here, interbedded slate and quartzite of the Grand Pitch are tightly folded, but northwest of and above a basal cobble conglomerate of the Shin Brook, interbedded cleaved tuffaceous sandstone and slate dip steeply northwest but are not crumpled. Deformation of the Shin Brook Formation thus resembles that of the Silurian rocks on the northwestern flank of the anticline, and the contact of the Grand Pitch and the overlying beds in both places is the same kind of angular unconformity.

The Grand Pitch was thus folded, and cleavage was developed in it before deposition of the Shin Brook Formation. An angular unconformity beneath Ordovician rocks has been reported elsewhere in Quebec and Maine, and it probably is an important feature of considerable regional extent. This unconformity was first noted between the Caldwell and Beauceville Groups in the Eastern Townships of Quebec (Cooke, 1955; Riordon, 1957). A similar contrast occurs in the Spider Lake quadrangle where Bradford Hall, of the University of Maine, has shown me tightly folded quartzite, limestone, and slate in Chase Brook beneath more regularly folded Middle Ordovician graywacke. Similar structural contrasts have been reported in the Danforth quadrangle between the variegated slate and green quartzite near Baskahegan Lake and the somber better ordered rocks that surround them (Larrabee and Spencer, 1963), and between "Cambrian or Ordovician" phyllite and the Ordovician Kennebec Formation on the southeast flank of the Moose River synclinorium (Boucot, 1961, p. 183–184).

Because this folding antedates events commonly assigned to the Taconic orogeny (see Boucot, Field, and others, 1964, p. 88–93), it probably should be recognized separately, and the name "Penobscot disturbance" is here suggested for it. Based on the rocks of the Shin Pond quadrangle, the Penobscot disturbance marks the development of folds and slaty cleavage later than late Precambrian or Early Cambrian time and earlier than early Middle Ordovician time.

In this area, and elsewhere where it has been described, the Acadian orogeny is superimposed on that of the Penobscot and on that of the Taconic where Taconic deformation is demonstratable. The common absence of folded cleavage, however, indicates that the stress fields of both the Penobscot and Acadian orogenies were the same over considerable areas. Thus, it is impossible to discriminate the effects of these events in most exposures. Nevertheless, the structures of the Grand Pitch Formation are extremely complex where exposures are good, as at the Grand Pitch of the East Branch of the Penobscot River; their pattern is reminiscent of the model of superimposed folds constructed by Weiss (1959, p. 97).

Deformation of the rocks of the anticlinorium can thus be related to the Penobscot and Acadian orogenies. The effects of a Late Ordovician Taconic orogeny are more difficult to identify. The angular unconformity attributed to the Taconic in the East Branch of the Penobscot River (Boucot, Field, and others, 1964, p. 90) is based on erroneous information: the conglomerate and breccia presumed to be beneath the unconformity contain fossils (p. I 13) that are as indicative of an Ashgillian age as are those in the gray slates that were stated to overlie them, and geologic evidence is inadequate to establish their superposition. Nevertheless, because the oldest Silurian rocks in this area are of late Llandovery age, the boundary between Ordovician and Silurian rocks here probably represents a disconformity which can be assigned to the Taconic orogeny.

More active events assignable to the Taconic orogeny are the formation of an uplift similar to, but probably smaller than, the present anticlinorium and the intrusion of the Rockabema Quartz Diorite. The presence of fragments of the Rockabema, together with Grand Pitch and greenstone fragments, in the Lower Silurian conglomerate of the fault blocks on the southeast flank of the anticlinorium, clearly indicates that these rocks were exposed in Early Silurian time and that the anticlinorium was the source of a wedge of Lower Silurian clastic rocks. Likewise, on the northwestern flank of the anticlinorium Upper Ordovician and Lower Silurian conglomerates have Grand Pitch and volcanic constituents, but none from the Rockabema; the source of these conglomerates is less evident, but because the nearby older rocks on the southeast do not include any Rockabema, it is reasonable to postulate a southeasterly source for them. The nonuniform distribution of the underlying volcanic rocks must at least in part be due to Late Ordovician erosion, but the extent of this erosion must be inferred from an understanding of their original distribution, which is not known.

Clasts that were probably derived from the anticlinorium in conglomerates of Early Silurian age on opposite flanks of the anticlinorium furnish the most direct evidence of its presence at that time. That the anticlinorium persisted is suggested by the contrasts in facies on its opposite flanks through the upper part of the Silurian, although it was apparently reduced in relief. It may have marked a rise in the bathymetric profile on which were deposited such reef deposits as the limestones of Owen Brook in the Stacyville quadrangle and in Bradford Brook in the Island Falls quadrangle (Ekren and Frischknecht, 1967).

FAULT ZONE BETWEEN SLATE BELT AND CENTRAL ANTICLINORIUM

The discontinuous distribution of rocks on the southeastern flank of the anticlinorium, together with locally intensely sheared and crushed rocks, indicates that a fault system lies here. Such large features as the anticline containing the lower member of the Allsbury Formation and the homoclinal Mount Chase belt of greenstone are cut by faults of this system, and coarse Lower Silurian conglomerates are separated from finer grained contemporaneous rocks by them.

Shear zones and other local features confirm the presence of faults in some places. North of the greenstone body at the eastern edge of the Shin Pond quadrangle for about 1½ miles, greenstone, quartzite, and thin bodies of Rockabema Quartz Diorite are intensely sheared and mylonitized; similarly, for about half a mile east of Peaked Mountain, phyllites of the Allsbury Formation are crumpled and sandstones interbedded with them are intensely crushed.

North of the mouth of the Seboeis River the distribution of rocks can be explained by two or three nearly parallel faults with two connecting branches. Southward, however, where exposures are largely mantled by surficial deposits, the pattern seems less orderly. In this area Upper Silurian limestone and Lower Silurian conglomerate and tuff seem to be inserted into Ordovician greenstone and chert. Approximately located boundaries indicate that some outcrop areas are long and narrow, but others are nearly equidimensional.

The Upper Silurian limestone is conspicuous among the latter because of its distinctive lithology, its well-established age, and its possible economic importance. Throughout the limestone outcrop area this rock is intensely sheared, but unlike most of the area where shear surfaces have a fairly constant northeast strike, the strike of shear surfaces here ranges from N. 20° W. to N. 20° E. Only on the northwest is the boundary between the limestone and adjacent rock closely located, and here it abuts against greenstone. Wassataquoik Chert crops out to the south and east of the limestone; to the northeast of the limestone is Lower Silurian conglomerate, but there are no exposures for several miles in this direction.

The entire fault system is interpreted to have a dominant strike-slip displacement with a right-lateral sense, the rocks on the east having moved southward with respect to those on the west. Although the amount of movement is not known, the insertion of conglomerate west of greenstone south of the Shin Ponds indicates a minimum movement of 1 mile, and the longer fault blocks suggest that the total displacement was considerably greater. The limestone, according to this interpretation, may have been caught in a structural eddy, although its high stratigraphic position suggests that it may not extend more than a few hundred feet beneath the surface.

The fault system probably continues considerably beyond the Shin Pond and Stacyville quadrangles, but to the southwest it apparently strikes into the Katahdin batholith and its wide contact zone. Ekren and

Frischknecht (1967) indicates its continuation into the Island Falls quadrangle. Here, the presence of one branch of it along the southeastern shore of Rockabema Lake is made obvious by mylonitized Rockabema Quartz Diorite on the eastern shore of the lake and tectonic breccia of Grand Pitch slate and quartzite on an island near its eastern tip. The northeasterly continuation of the main fault of this system is suggested by the easterly disappearance of the sandstone member of the Allsbury Formation and by several features in the vicinity of the West Branch of Mattawamkeag Stream (see Ekren and Frischknecht, 1967, pl. 1). Among these are(1) the southwestward convergence of conductive beds, one of which bears Middle Ordovician graptolites, with limestone of probable Silurian age and Allsbury Formation; (2) the small fault blocks of crossbedded fine-grained quartzite probably belonging to the Grand Pitch Formation in the Upper Falls of East Hastings Brook and on Shoaler Mountain; and (3) the juxtaposition of the Grand Pitch Formation and rocks probably equivalent to the Allsbury Formation at the Island Falls-Smyrna Mills quadrangle boundary and northeastward (Pavlides and others, 1964, p. C30). Evidence for this fault system can thus be found through at least 40 miles, and this suggests that it is one of the major tectonic features of the region.

KATAHDIN BATHOLITH

The geologic boundaries in the vicinity of the Katahdin batholith are largely inferred, but it is clear that along the northern segment of this boundary in the Stacyville quadrangle the Katahdin is in contact with greenstone that disappears southward. A moderate eastward dip of the boundary of the Katahdin batholith in the Stacyville quadrangle (pl. 3, section *C–C′*) is suggested by the inferred width of the breccia zone and by the rock fragments that it contains. Inasmuch as these resemble the Allsbury Formation, and no fragments of greenstone were identified (p. I 29), the Katahdin is probably in contact with the Allsbury for a considerable distance beneath the surface but with greenstone for a considerably lesser distance.

The lower boundary of the greenstone parallels its contact with the Katahdin, as do minor structures of the Grand Pitch for about a mile eastward. These conformable features may have been rotated into their present orientation by shouldering of the Katahdin, but these relations may also be fortuitous, as similar northwest-trending outcrop belts are cut off sharply by the Katahdin in the northwestern segment of the batholith boundary (Boucot, Griscom, and others, 1964).

The regional geologic map (Boucot, Griscom, and others, 1964) shows that these belts lie on the northeast limb of a large northwest-plunging anticline. Thus, northwest-trending anticlines lie both to the west and east of the Katahdin batholith, with a complementary syncline between them that is now largely occupied by quartz monzonite. Such large northwest-trending folds are anomalous in this region of nearly consistent northeast-trending structures.

The presence of a broad breccia zone at the margin of the batholith in the Stacyville quadrangle suggests that the Katahdin was emplaced by stoping. It is thus probable that the northwest-trending structures in the region bordering the Katahdin batholith antedate the intrusion, and more likely are indications of a deep-seated structural anomaly that governed the emplacement of the large batholith than superficial results of the intrusion. Alternatively, this area of anomalous structures may indicate that there was an early syntectonic phase of the Katahdin intrusion that influenced structures developing around it, which was followed by the posttectonic final phase.

PALEOGEOGRAPHIC INTERPRETATIONS

The sedimentary rocks of the Shin Pond and Stacyville quadrangles are here considered in the context of their correlatives in the northern Appalachians region. For the pre-Silurian, only broad generalizations can be made. Silurian paleogeography has been outlined by Boucot and coworkers in two recent papers (Boucot and Thompson, 1963; Naylor and Boucot, 1965). Some of the conclusions in both papers were based on data and collections of fossils resulting from the present investigations. These and additional data suggest further refinements of their conclusions.

An understanding of the paleogeography of Grand Pitch time is hindered by uncertain correlations with similar rocks exposed in uplifts over a wide part of the region. Probable correlatives include the several areas shown on the "Geologic and aeromagnetic map of northern Maine" (Boucot, Griscom, and others, 1964) as Cambrian slate and quartzite, and most, if not all, of the unit classed as undifferentiated sedimentary rocks of Cambrian or Ordovician age. Most of these, like the Grand Pitch of the Shin Pond, Stacyville, and adjacent quadrangles to the northeast (Pavlides and others, 1964, p. 28) are confined to the cores of relatively small uplifts in northern Maine. Similar rocks of the Rosaire and Caldwell Formations form a more extensive outcrop belt in Quebec just northwest of the international boundary, and one small area in the southeastern part of the slate belt occurs in the southeastern part of the Danforth quadrangle (Larrabee and Spencer, 1963). The very similar appearance of the rocks through this extensive area suggests that they are parts of a broad sheet whose margins and sources are not evident.

The paleogeography of Shin Brook time is also speculative, as few correlative rocks are known in the northern Appalachian region. Black slate of Arenig age on Cookson Island in Oak Bay near Calais, Maine (Cumming, *in* Smith, 1960, p. 6), is the only probable correlative near the borders of the State. Parts of the Deepkill Shale and Poultney Slate in New York (Berry, 1962, p. 709; 1961, p. 226), and the Levis Shale in Quebec (Raymond, 1914), are also of this age. The Shin Brook Formation was correlated with the Table Head Formation in western Newfoundland (Whittington in Neuman, 1964, p. E33). In north-central Newfoundland, on New World Island, tuffaceous sandstone recently discovered by Prof. Marshall Kay (oral commun., 1964) has yielded several brachiopods and trilobites hitherto known only in the Shin Brook.

These scattered occurrences offer few clues to the paleogeography of the time. Much of the central part of the northern Appalachians was probably bordered by deep water, as this is the most likely interpretation of the environment of dark graptolite-bearing shale and slate. The small fragment of the record preserved in the central part of the region in the Shin Brook Formation and its possible correlatives suggests that either the sea covered only a small part of the region, or it left only thin deposits that were subsequently removed by erosion, except in the vicinity of large accumulations of locally derived volcanic debris.

Younger Ordovician rocks of Wassataquoik Chert age are more uniformly distributed. Dark-gray slate and shale, much of which is cherty, containing graptolites of Berry's (1960) Zones 12 and 13, occur from place to place throughout northern Maine, from Danforth on the east (Larrabee and Spencer, 1963) to the Rangely Lakes area on the west, and at other places in Quebec and New Brunswick. These rocks, too, suggest deposition in deep water. Interbedded tuff in the Stacyville quadrangle and sandstone composed of volcanic detritus elsewhere at several places across northern Maine, together with associated greenstone, indicate that contemporary volcanism was widespread. Coeval limestone in Aroostook County ("ribbon rock" of Pavlides and others, 1961=ribbon rock member of the Meduxnekeag Formation of Pavlides, 1965=Carys Mills Formation of the Meduxnekeag Group of Pavlides, 1966, p. A55) was probably deposited in a basin that was isolated from the source of volcanic debris.

The northern Appalachians contain few equivalents of the Upper Ordovician rocks of the Shin Pond and Traveler Mountain quadrangles. In Maine, the Pyle Mountain Argillite in the Presque Isle quadrangle (Boucot, Field, and others, 1964, p. 20) and perhaps part of the volcanic sequence near Ashland (Neuman, 1963) are the only known probable equivalents. To the northeast, on the Gaspé Peninsula, Quebec, at least part of the Whitehead Formation is of Late Ordovician age (Schuchert and Cooper, 1930, p. 164); although the Carys Mills Formation of the Meduxnekeag Group forms the southwestern part of the same outcrop belt that contains the Whitehead, it has not yet yielded Upper Ordovician fossils. Thus, the interconnections between these scattered occurrences remain unknown.

The Silurian rocks of the Shin Pond and Stacyville quadrangles yield more specific paleogeographic information. The contrasts between the northwestern and southeastern sequences—differences in their stratigraphy, composition, and the distribution of their rocks—are especially significant. In the northwestern sequence the similarity of the Upper Ordovician to the Lower Silurian conglomerates in Kimball Brook and the occurrence of both in the same area suggest that the source and depositional basin of both were virtually the same. Their wedgelike terminations shown on the geologic map of the Shin Pond quadrangle are conjectural, but alternatives would require more abrupt terminations that would imply a more irregular subconglomerate topography. The absence of these rocks along strike to the northeast may be due to a fault such as the one in the Hay Brook area, but such a fault is not required to explain the stratigraphic relations. More likely, the edge of the Upper Ordovician conglomerate outcrop is nearly that of the original deposit, which was overstepped eastward by Lower Silurian conglomerate, which was, in turn, overstepped by younger Silurian rocks to a maximum sedimentary cover in the Late Silurian.

The presence of fragments of Rockabema Quartz Diorite in Lower Silurian conglomerate in the fault blocks southeast of the anticlinorium and the southeastward decrease in size and amount of clastic debris indicate that the anticlinorium stood above sea level during the Early Silurian. The source of the coeval conglomerate on the northwest flank of the anticlinorium is not as evident, but it is likely that its clastic components were derived from the opposite slopes of the same source area.

To the east in Aroostook County the occurrence of Early Silurian graptolites in fine-grained rocks (Pavlides and Berry, 1966) contiguous with those of the southeastern sequence of the Shin Pond and Stacyville quadrangles, and the presence of the Frenchville Formation farther north (Boucot, Field, and others, 1964), indicate the widespread extent of the Early Silurian sea. By contrast, the few occurrences of

Lower Silurian rocks in the northwestern sequence suggest that the sea crossed the ancestral anticlinorium only locally through saddles. The large area to the northwest apparently remained emergent through this epoch.

The overlap of successively younger beds in the Marble Pond area appears to record the transgression of the sea to its maximum extent in the Late Silurian. In the northwestern sequence of Upper Silurian rocks, conglomerate interbeeded with calcareous siltstone near Scraggly Lake, together with the conglomerate near Whitehorse Lake and the volcanic rocks in the Traveler Mountain quadrangle (Naylor and Boucot, 1965, p. 162), shows that much of the terrigenous material was derived from local sources of short duration.

Upper Silurian rocks of the southeastern sequence are all fine grained, suggesting that the anticlinorium was reduced in relief and was no longer an important source of detritus. The persistence of this structure is evident from its presence on the dividing line between the contrasting facies of Upper Silurian rocks, but there is no evidence to indicate whether or not it was completely covered by the Late Silurian sea. The clean reefal limestone in the Stacyville quadrangle does indicate, however, that the sea in this area was shallow and nearly free of terrigenous debris.

The regimen of the Lower Devonian Seboomook Formation and Matagamon Sandstone was significantly different from that of the Late Silurian. The thick mass of Lower Devonian fine-grained rocks in many respects resembles the Silurian rocks of the slate belt, but the Devonian outcrop belt largely corresponds to that of the Silurian carbonate belt. The lack of proved Lower Devonian rocks from the slate belt implies that this belt received little or no sediment during Early Devonian time. Possibly it was a source of much of the fine-grained detritus that entered this segment of the Gaspé-Connecticut River synclinorium in Early Devonian time.

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