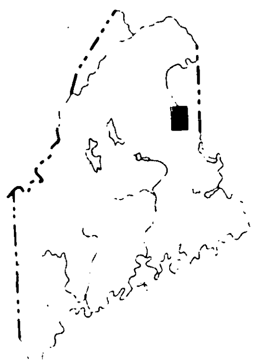
MAP GQ-1024

DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

GEOLOGIC QUADRANGLE MAPS OF THE UNITED STATES

GEOLOGIC MAP OF THE SMYRNA MILLS QUADRANGLE AROOSTOOK COUNTY, MAINE

By
Louis Pavlides



QUADRANGLE LOCATION

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PAVLIDES—SMYRNA MILLS, ME. 1:62,500 MAP GQ-1024

TO ACCOMPANY MAP GQ-1024

GEOLOGIC MAP OF THE SMYRNA MILLS QUADRANGLE, AROOSTOOK COUNTY, MAINE

By

Louis Pavlides

BEDROCK GEOLOGY

The sedimentary and volcanic rocks of the Smyrna Mills quadrangle have undergone weak regional metamorphism and, locally, a higher grade of thermal metamorphism. Because the original character of the regionally metamorphosed rocks is well preserved, the descriptive nomenclature of sedimentary and volcanic rocks rather than metamorphic rocks is used.

STRATIGRAPHY

CAMBRIAN(?) ROCKS

Grand Pitch Formation.—The unit lies along the southeast flank of the regional Weeksboro-Lunksoos Lake anticline (Pavlides and others, 1964, fig. 1, p. C30), henceforth referred to as the Weeksboro anticline. The internal stratigraphy of the Grand Pitch is complex and uncertain, and the dating of all of the Grand Pitch terrane as Cambrian(?) (Neuman, 1962) on the basis of *Oldhamia* is provisional. Ekren and Frischknecht (1967) subdivided the Grand Pitch in the Island Falls quadrangle, immediately to the west, according to the presence or absence of conductive carbonaceous black slate layers as determined by electromagnetic surveying methods. Reconnaissance electromagnetic surveys made only along the northwest margin of the Smyrna Mills quadrangle indicate the electromagnetically defined zones in the Island Falls quadrangle extend only a short distance into the Smyrna Mills quadrangle (F. C. Frischknecht, oral commun., 1964).

The volcanic-bearing unit of the Grand Pitch Formation (Ꞓgvc) strikes into a belt of electromagnetically conductive rocks in the Island Falls quadrangle mapped as the Allsbury Formation of Silurian age (Ekren and Frischknecht, 1967, pl. 1), but this narrow strip of rocks is included in the Grand Pitch in the Smyrna Mills quadrangle rather than the Allsbury. Volcanic rocks also have been reported from elsewhere in the Grand Pitch by Neuman (1967, p. 16). Poor exposures make the stratigraphic assignment of the volcanic-bearing unit to the Grand Pitch in the Smyrna Mills quadrangle provisional; these rocks may be equivalents of the Dunn Brook Formation (Silurian or Ordovician) to the northeast (Pavlides, 1964) or Ordovician volcanic units to the southwest (Ekren and Frischknecht, 1967, pl. 1).

Most of the Grand Pitch appears to be in fault contact with younger rocks to the southeast but is probably in stratigraphic contact with the younger Dunn Brook Formation at its northeast margin. This contact is probably an unconformity related to deformation in Late Cambrian or Early Ordovician time (Pavlides and others, 1964, p. C34) that has been named the Penobscot orogeny (Neuman, 1967).

ORDOVICIAN AND (OR) SILURIAN ROCKS

Dunn Brook Formation.—This unit does not crop out in the quadrangle, but its presence is inferred by projection from outcrops and aeromagnetic anomalies associated with these rocks to the northeast in the Howe Brook quadrangle.

Green phyllite and slate.—The stratigraphic position and relationship of these sparsely exposed and poorly dated rocks (see table, locality F9) to the surrounding Smyrna Mills Formation and other formations in the area are uncertain. They appear similar to the phyllite and slate (also of equivocal Silurian or Ordovician age) in the southeast part of the Houlton quadrangle to the east (Pavlides, 1971). The proximity of Late Silurian fossils (see table, locality F8) at Smyrna Center in the Smyrna Mills Formation suggests this unit unconformably underlies the Smyrna Mills; however, it may be a block of older rock that slid into the Smyrna Mills sea in Silurian time.

Carys Mills Formation.—The Carys Mills Formation in Aroostook County ranges from Middle Ordovician to Early Silurian in age (Pavlides, 1968, p. 10-11). It grades into the overlying Smyrna Mills Formation (best seen at the underpass where I-95 crosses the contact). Graptolites on both sides of the contact, at localities F13 and F14, are of earliest middle Llandovery age. Poorly preserved graptolites have also been found on either side of the contact at locality F15A and B. Those within the Carys Mills (locality F15A) may be of latest early Llandovery age whereas those in the Smyrna Mills (locality F15B) may be of earliest middle Llandovery to Wenlock age (Pavlides and Berry, 1966, p. B55); these rocks are sheared and may be in fault contact (not shown on map). These rocks may also represent tongues of Carys Mills in the Smyrna Mills Formation (Ayrton and others, 1969, fig. 4 and p. 472), if these poorly preserved graptolites are the precise age assigned to them.

The Carys Mills Formation is in the core of the Aroostook-Matapedia anticlinorium and plunges beneath the Smyrna Mills Formation near Oakfield and Bates Ridge. Only the upper part of the formation is exposed in the quadrangle and fossils indicate these rocks may be all Silurian rather than partly Ordovician in age. It is also possible that on a regional scale the southern part of the Carys Mills is entirely time transgressive into the Silurian. The limestones in the cores of anticlines within "Rocks of Island Falls" to the west (Ekren and Frischknecht, 1967, pl. 1) are lithologic and, in part, stratigraphic equivalents of the Carys Mills Formation. If the Carys Mills is of increasingly younger age to the south, it may be lithologically equivalent to the thin-bedded limestone lenses of the eastern facies of the Waterville Formation of probable Wenlock or Ludlow age in the Waterville-Vassalboro area (Osberg, 1968, table 4 and pl. 1).

SILURIAN

Smyrna Mills Formation.—The Smyrna Mills includes rocks that range in age from British Graptolite Zone 19—middle Llandovery (loc. F13)—to early Ludlow (Pavlides and Berry, 1966). Absence of marker beds, discontinuity of bedrock exposures, complex deformation, and the obscuring effects of contact metamorphism over an extensive area underlain by the Smyrna Mills have prevented stratigraphic subdivision of the formation. The Smyrna Mills Formation contains lenses of iron and manganese deposits, but such deposits are more abundant in the Houlton quadrangle to the east (Pavlides, 1971) and apparently absent in coeval rocks to the west and southwest (described below), suggesting a facies change to the southwest. Some of the large magnetic anomalies associated with the contact metamorphic aureoles around the Hunt Ridge and Pleasant Lake plutons are caused by magnetite developed in such iron- and manganese-bearing deposits through contact metamorphism. The two broadly arcuate positive magnetic anomalies within Smyrna Mills terrane north of and unrelated to the thermal aureole zones also represent stratigraphic levels at which iron- and manganese-bearing deposits are localized. Such deposits crop out near localities F6 and F8.

Calcareous slate (Sssl), provisionally considered a lens within the formation, contains poorly dated shelly faunas (F11 and F12). These shelly fossils are in marked contrast to the graptolitic faunas that characterize most of the Smyrna Mills Formation and nearby correlative units. If this unit is a lens, it may be a block of older rock that slid into the Smyrna Mills sea as a consequence of Taconic uplift in areas peripheral to the Aroostook-Matapedia belt of rocks, a belt that apparently was not directly disturbed by the Taconic orogeny and in which sedimentation continued during Taconian times (Pavlides and others, 1968, p. 76; Pavlides and Berry, 1966, p. B60). Associated lenses of grit and graywacke near the base of the Smyrna Mills support this hypothesis, because such sediments probably accumulated in a nearshore environment and subsequently were flushed into the more offshore, lower energy environment of the graptolitic facies. These coarse sands probably also reflect the early phases of the Taconic uplift in peripheral areas.

Rocks contiguous and stratigraphically equivalent with the Smyrna Mills Formation to the west in the Island Falls quadrangle include the Allsbury Formation and "Rocks of Island Falls." These two units are separated by a complex anticline that contains older rocks, mostly of the Mattawamkeag Formation (Ekren and Frischknecht, 1967, pl. 1). The Allsbury lies northwest of this anticline and "Rocks of Island Falls" crop out on its southeast flank. The Mattawamkeag Formation was originally projected into the Smyrna Mills quadrangle (Ekren and Frischknecht, 1967, pl. 1; Pavlides and Berry, 1966, fig. 1), but more recent mapping by the writer has limited the extent of the Mattawamkeag to the southwest within the Island Falls quadrangle. The Allsbury Formation is chiefly slate, graywacke, and lenses of black slate whose conductive properties can be traced by electromagnetic surveys. Such conductive black slate appears to pinch out toward the northeast and southwest edges of the Island Falls quadrangle (Ekren and Frischknecht, 1967, p. 28). The Allsbury of the Island Falls quadrangle with its lenses of carbonaceous, generally pyritic dark-gray and black slate (Ekren and Frischknecht, 1967, p. 14) is herein considered to be a local, partly euxinic facies coeval to parts of the Smyrna Mills Formation. The Smyrna Mills Formation and its contiguous correlatives described above are the temporal equivalents of the Allsbury Formation of Neuman (1967, pl. 1) farther southwest and to the Mayflower Hill and Waterville Formations of the Waterville-Vassalboro area (Osberg, 1968, p. 31-33). Osberg incorrectly correlated the Waterville with the Meduxnekeag Formation (Pavlides, 1965) which has since been raised to Group rank (Pavlides, 1966). Northern temporal equivalents of the Smyrna Mills Formation are, in part, the Maple Mountain Formation of the Howe Brook quadrangle (Pavlides, 1964), the Perham Formation of the Presque Isle area (Boucot and others, 1964, p. 33-40; Pavlides, 1968, p. 18-22), and, in part, the Spragueville Formation of northeastern Maine (Pavlides, 1968, p. 15-18).

Graywacke.—The wedge-shaped area chiefly of graywacke (Sg) in the north-central part of the Smyrna Mills quadrangle merges northeastward with conglomerate in the Howe Brook quadrangle. Graywacke at the base of the Maple Mountain Formation directly overlying the Dunn Brook Formation in the Howe Brook quadrangle has yielded brachiopods of Silurian age (Pavlides, 1964, p. B6). Because of the similar stratigraphic position of this graywacke to the Dunn Brook Formation in the Smyrna Mills quadrangle, it is also tentatively considered Silurian in age.

ORDOVICIAN(?) TO DEVONIAN(?) ROCKS

Greenstone.—Greenstone, sparsely exposed on a small hill in the northwest part of the quadrangle, resembles the Spruce Top Greenstone in the Howe Brook quadrangle (Pavlides, 1962, p. 24-28) and the greenstone to the southwest in the Mount Chase area (Ekren and Frischknecht, 1967, p. 5-6). A pronounced positive magnetic anomaly suggests that the greenstone may extend to the northeast beyond Dudley Brook. However, only rocks of the Grand Pitch Formation are discontinuously exposed along Dudley Brook. No outcrops of greenstone were found elsewhere to the northeast along the trend of the anomaly. The greenstone may possibly be one of a group of small plugs, others of which are not exposed.

DEVONIAN ROCKS

Slate.—The slate unit in the north-central part of the quadrangle is Helderbergian Age according to shelly fossils obtained from weathered slate rubble and boulders in till (F1). The boulders are of local origin because bedrock within this unit immediately to the north in the Howe Brook quadrangle contains shelly fragments unsuitable for dating. The Helderbergian Age indicates the slate unconformably overlies the Smyrna Mills Formation and the graywacke unit. No contacts between the units are exposed in the Smyrna Mills quadrangle but to the northeast in the Howe Brook quadrangle the graywacke unit, which there is a conglomerate, is exposed in a nearly vertical, sharp contact with the slate unit. The unconformity at the base of the slate unit may represent the Salinic disturbance (Boucot, 1962; Pavlides and others, 1964, p. C35).

STRUCTURE

Aroostook-Matapedia anticlinorium.—The southern end of the Aroostook-Matapedia anticlinorium, whose core contains rocks of the Carys Mills Formation and its lithologic and temporal equivalents in Canada (Pavlides and others, 1968, p. 76-77), is in the Smyrna Mills quadrangle. In the central part of the Houlton quadrangle, the anticlinorium abruptly bends from a southeasterly to westerly trend (Pavlides, 1968, pl. 1). At the east edge of the Smyrna Mills quadrangle, the anticlinorium divides into two anticlines which plunge southwesterly and westerly. The Carys Mills Formation plunges beneath hornfels of the Smyrna Mills Formation at the southwest end of Bates Ridge along the southwest-trending anticline. The west-trending anticline carries the Carys Mills beneath the Smyrna Mills Formation near Oakfield. This anticline is warped convexly northward probably owing to the emplacement of the Cochrane Lake and Hunt Ridge plutons, but the regional sigmoidal flexure of the Aroostook-Matapedia anticlinorium in the Houlton-Smyrna Mills area, that also has affected rocks to the southwest (Pavlides and others, 1964, fig. 1), is a result of regional tectonics.

Folds.—Except for the Grand Pitch Formation, the sedimentary rocks are characterized by close folds having wavelengths of several to hundreds of feet, upright to slightly inclined axial surfaces, and moderate to steep plunges. Such folds are probably lower order folds on the flank and hinge areas of larger folds as schematically shown in cross section A-A′. Consequently, steep to vertical bedding attitudes are characteristic throughout the region. Small folds, plunging moderately east-northeasterly and overturned 40° to 30° to the south, are present in the fault-bounded block immediately north of the community of Smyrna Mills. This overturning, however, is probably related to movements along the bounding faults. The regional plunge of the folds is generally to the west or southwest, but locally minor folds plunge east and northeast implying the presence of doubly plunging folds, which is also suggested by some of the map patterns. In general, folds developed in post-Grand Pitch terrane are flexural folds (Donath and Parker, 1964), some of which have been slightly thickened in their crest and trough areas.

Passive slip folds (Donath and Parker, 1964) or shear folds are common within the Grand Pitch Formation. Such folds commonly have wavelengths of a few feet or less. Flexure flow folds are present in slate on a microscopic scale and in thick-bedded quartzite layers.

Cleavage.—Slaty cleavage with vertical to steep dips is well developed in all the sedimentary rocks but is more widely spaced in silty and sandy rocks than in slates. Where folds trend northeast, the slaty cleavage is about parallel to the trace of their axial surfaces, as in the northwest part of the quadrangle. In the eastern part of the quadrangle, northeast-trending slaty cleavage is athwart the northwest- to west-trending trace of the axial surfaces of folds, suggesting this cleavage formed under the stress field operating at about the time the Aroostook-Matapedia anticlinorium was warped.

Northwest-trending fracture cleavage is present locally in slate of the Smyrna Mills Formation and the slate unit of Devonian age. Typically, it is a steep to vertically dipping, closely spaced foliation (S_2) along which differential strike slip movement has rotated slaty cleavage (S_1) macro- and microlithons into small kink bands. Some of the northwest-trending cleavage at the east margin of the quadrangle may be an incipient fracture cleavage.

Some of the slaty cleavage (S_1) has small strike slip offsets and may be incipient slip cleavage or a gradation to slip cleavage. Within the Grand Pitch Formation well-developed slip cleavage is characteristic and has led to the transposition structures of passive folding described above. Such slip cleavage may be related to the complex deformational history of the Weeksboro anticline (Pavlides and others, 1964). Perhaps the original cleavage was a slaty cleavage (Penobscot orogeny) transformed into a slip cleavage by the later Taconic and Acadian orogenies that affected this terrane.

Boudinage.—Well-formed boudins and pull-apart features are present locally within the Grand Pitch Formation. Such structures also occur near the margin of contact-metamorphosed limestone of the Carys Mills Formation in the B & A railroad cut in the central part of the quadrangle about one-half mile east of Timoney. These structures and the corrugations in the calc-silicate rocks at the east end of I-95 may have formed, in part, by stresses generated during the emplacement of nearby intrusive rocks.

Faults.—Faults have been inferred from abrupt terminations of lithologies or juxtaposition of dissimilar structures. They are assumed to dip steeply and probably have both dip slip and strike slip components of unknown magnitude. Based on the southward overturned folds in the fault block immediately north of the community of Smyrna Mills, this block is assumed to be bounded on its north side by a northward-dipping reverse fault upthrown on its north side (see cross section A-A′).

INTRUSIVE ROCKS

PLUTONS

Poorly exposed, small plutons, enclosed by hornfels, occur within the southern half of the quadrangle. The Hunt Ridge and Pleasant Lake plutons appear to be zoned, with biotite and biotite-hornblende granite in their inner portions and rocks in the compositional range of biotite- and hornblende-bearing quartz diorite, adamellite, and granodiorite generally along their margins. The highly perthitic hornblende-biotite granite in the Cochrane Lake pluton may have a less felsic phase only along its eastern margin, where biotite-hornblende adamellite occurs on the north shore of Cochrane Lake. The small pluton on Delight Ridge contrasts with the other plutons in that it apparently lacks biotite and hornblende, but does contain minor muscovite. Two other small granitic intrusions are inferred from the presence of locally derived boulders or from a few scattered outcrops.

The plutons cut folded rocks of the Smyrna Mills and Carys Mills Formations and have metamorphosed them in a thermal aureole. K-Ar ages of biotite from the Hunt Ridge pluton (397 m.y.) and the Pleasant Lake pluton (384 to 387 m.y.) (Faul and others, 1963) indicate a Devonian emplacement. The plutons are post-kinematic, emplaced as relatively hot, near-surface intrusions after the first pulse of major Acadian folding.

DIKES

Granitic dikes (Dgd), apparently satellitic to the Cochrane Lake pluton, occur at several places. In contrast, the injected zone on the northeast side of the Hunt Ridge pluton consists of hornfels that has been abundantly intruded by granitic sills and dikes presumably derived from the pluton. Felsitic and greenschist dikes (DSd) elsewhere in the quadrangle are regionally metamorphosed and are older than the granitic rocks satellitic to plutons.

METAMORPHISM

Regional metamorphism.—Most of the rocks are at chlorite grade. In thin section, metamorphic chlorite and muscovite are larger (locally several times larger) and better developed than the detrital chlorite and muscovite. Some large mica flakes along bedding surfaces are probably detrital because they are bent, in contrast to the straight flakes of metamorphic mica. Locally, limestones in the Carys Mills Formation have undergone minor textural modification and contain carbonate rhombohedra several sizes larger than the general granular matrix carbonate.

The Grand Pitch Formation locally contains biotite and apparently attained a slightly higher grade of metamorphism than the other rocks in the quadrangle. This may reflect the more complex tectonic history of the Weeksboro anticline (Pavlides and others, 1964, p. C34). The greenstone near the northwest edge of the quadrangle, however, contains a greenschist facies assemblage of oligoclase, chlorite, zoisite, and tremolite. Relatively fresh augitic pyroxene that locally ophiticly encloses plagioclase is probably an unstable relict mineral representing metamorphic disequilibrium (Pavlides, 1962, p. 33).

Contact metamorphism.—Resistant aureoles of hornfels surround the felsic plutons. Hornfels of the Smyrna Mills Formation forms hills and mountains surrounding the larger plutons. This hornfels apparently has abundant magnetite resulting from contact metamorphism and is marked by high magnetic relief in contrast to the low magnetic relief of the pluton. The contact metamorphosed limestones of the Carys Mills Formation have lower topographic relief and are less magnetic than hornfels of the Smyrna Mills.

Contact metamorphosed rocks, with minor local exceptions, generally are aphanitic or have silt or fine sand grain sizes. Definitive mineralogic criteria of metamorphic grade normally can be observed only microscopically. Brittleness and color are the normal field criteria for recognizing these thermally altered rocks. Because of the fine grain size and insufficient exposures, isograds have not been drawn within the contact aureoles.

The horizons containing lenticular iron and manganese deposits within the Smyrna Mills Formation on the south flank of the Aroostook-Matapedia anticlinorium strike into the thermal aureole from the Houlton quadrangle (Pavlides, 1971). Such deposits at the west edge of the Houlton quadrangle are dark-gray to black, compositionally layered, fine- to medium-grained magnetic meta-ironstones. They appear somewhat similar to some of the manganiferous eulysites described by Tilley (1936), but they lack pyroxene. The contact metamorphosed deposit northwest of Hunt Ridge is the only such deposit in the Smyrna Mills quadrangle. Its high magnetite content produces the largest positive aeromagnetic anomaly known in Maine.

Metalimestones of the Carys Mills Formation generally have tremolite in the outer part of the aureoles and diopside in the inner part. Locally, as in the easternmost outcrops of thermally metamorphosed Carys Mills Formation along I-95 at the eastern edge of the quadrangle, very high rank calc-silicate rocks with some coarse-grained metacrysts are present. These rocks have assemblages that place them within the pyroxene-hornfels metamorphic facies, which probably means that granitic rocks, intruded at relatively high temperatures, occur at shallow depth approximately midway between the highly perthitic granite of the Cochrane Lake pluton and the inferred granitic mass to the east near Bradbury Lake.

Felsic dikes intruded prior to the emplacement of the plutons have also been modified by contact metamorphism; fine-grained tremolite is only present in dikes within the aureoles.

ECONOMIC GEOLOGY

SAND AND GRAVEL

Sand and gravel is the most important mineral resource presently exploited in the quadrangle. It is obtained from ice-contact deposits, roughly indicated by the distribution of gravel pits. Sand and gravel resources are abundant enough to meet the needs of the local communities for the foreseeable future.

DIMENSION STONE

Granite used for dimension stone may have been quarried near Ludlow at the turn of the century (Williams and Gregory, 1900, p. 107). This granite may have come from the Cochrane Lake pluton within which an old quarry was found. Perkins (1930, p. 10) refers to granite being quarried about 1929 "on the west side of Drew Lake," a local name for Meduxnekeag Lake. Presumably this granite came from the eastern part of the Hunt Ridge pluton along the lake shore, but no old quarries were found in this area. There is currently no active quarrying for granite.

MANGANESE DEPOSITS

Several sedimentary iron- and manganese-bearing deposits are within the Smyrna Mills Formation, but are not as abundant as in the Houlton quadrangle to the east (Pavlides, 1971). Chemical analyses of eight selected hand specimens of meta-ironstone from the contact metamorphosed deposit northwest of Hunt Ridge in Oakfield Township, the only deposit for which analyses are available in the Smyrna Mills quadrangle, give an average content (in percent) of 29.3 Fe, 7.6 Mn, and 0.9 P; the most ferruginous specimen contains 47.9 Fe, 4.3 Mn, and 0.5 P, whereas the most manganiferous specimen contains 11.3 Mn, 18.7 Fe, and 0.5 P. A ground magnetometer survey over the glacial drift covering the meta-ironstone indicates several steeply dipping deposits, 50 to 100 feet wide, which individually produce narrow positive magnetic anomalies but that appear as a single aeromagnetic anomaly (Kane and others, 1966). The trench from which the samples were collected probably exposed only a few feet of width across one of these lenses.

Deposits unaffected by contact metamorphism include the one near Smyrna Center that consists of a half-foot-thick layer of siliceous carbonate rock. Another, near Dudley, approximately 3 miles north of the community of Smyrna Mills, is 25 feet thick and is of the hematitic variety. The mineralogy of the various Aroostook manganese "ore" types has been described elsewhere (Pavlides and Milton *in* Pavlides, 1962, p. 50-64). Some Aroostook sedimentary manganese- and iron-bearing deposits were considered to have accumulated in nearshore environments such as barred lagoons or estuaries (Pavlides, 1962, p. 91). However, it is now known that these deposits are restricted to the graptolitic Smyrna Mills Formation or its equivalents elsewhere, which suggests that they were deposited in a more open sea environment, as suggested earlier by White (1943, p. 142).

OTHER POTENTIAL RESOURCES

The drainage areas of the plutons and their associated contact aureoles were reconnoitered geochemically by stream-sediment sampling. A minor molybdenum anomaly was found within the southern part of the Hunt Ridge pluton (Pavlides and Canney, 1964), along the small stream that drains into the northwest corner of Skitacook Lake.

Other potential resources in the quadrangle may be local, small deposits of peat or marl in some of the swamps; hornfels from the contact aureoles may be usable as a source for road metal. Prospecting and testing are needed to evaluate these suggested minor resources.

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TABLE 1—*Fossils from the Smyrna Mills quadrangle, Maine*

Map locality no.[1]	U.S. Geol. Survey fossil locality no.	Fauna[2]	Age	Authority
F1	USNM 17324[3]	*Costellirostra* sp. *"Gypidula"* sp. *Leptaena "rhomboidalis"* *Leptocoelia*? sp. *Strophonella* cf. *S. punctulifera* unident. brachiopods coral acidaspid trilobite crinoid	Middle to late Helderberg	A. J. Boucot, 1969, written commun.
F2	SD-7423	Graptolites	Early Ludlow: *Monograptus nilssoni* and *M. scanicus* zone.	Pavlides and Berry, 1966.
F3	SD-7422			
F4	SD-7398	Graptolites	Late Wenlock	Pavlides and Berry, 1966.
F5	SD-7399			
F6	SD-7419	Graptolites	Early Ludlow: *Monograptus nilssoni* and *M. scanicus* zone.	Pavlides and Berry, 1966.
F7	SD-7420			
F8	SD-7421			
F9	SD-8409	Graptolites: thin flexuous stipe fragments—may be from a leptograptid or dicellograptid	Later part of Ordovician(?) (identification and age questionable)	W.B.N. Berry, 1963, written commun.
F10	--------	Pelmatozoan debris	--------	--------
F11	SD-8410	*Isorthis*(?) and sphaeri-rhynchid	Silurian or Devonian	A. J. Boucot, 1963, written commun.
F12	SD-8411	*Platyceras* sp. and favositid corals	Silurian or Early Devonian	A. J. Boucot, 1961, written commun.
F13	SD-7452	Graptolites	Middle Llandovery, British Graptolite Zone 19	Pavlides and Berry, 1966.
F14	SD-7451			
F15A	SD-7392	Graptolites	Early Llandovery	Pavlides and Berry, 1966.
F15B	SD-7393		Middle Llandovery to Wenlock	
F16	SD-7397	Graptolites	Late Llandovery to Wenlock	Pavlides and Berry, 1966.
F17	SD-7395	Graptolites	Late Llandovery, in the interval of Br[illegible]h Graptolite Zones 22 (*Monograptus turriculatus*) to 24 (*M. griestoniensis*).	Pavlides and Berry, 1966, p. B52, B56-B57, B59.
F18	SD-7404	Graptolites	Wenlock to Ludlow	Pavlides and Berry, 1966.
F19	SD-7424	Graptolites	Ludlow	Pavlides and Berry, 1966.

[1]Fossil localities:

F1 About 100 feet of gray calcareous fossiliferous boulders and slate rubble believed to be of local origin along logging road in woods in T. 7, R. 3: 24,800 feet N. 53°30'W. from northeast corner of Smyrna Township.

F2 Green quartzite in streambed on west side of logging road in woods in Smyrna Township; 11,050 feet S. 74°W. from northeast corner of Smyrna Township.

F3 Gray-green siltstone about 50 feet south of Mill Brook on east side of Kennedy Tote Road in Smyrna Township; 8,150 feet S. 61°31'W. from northeast corner of Smyrna Township.

F4 Black carbonaceous and sulfidic slate on east bank of the North Branch Mattawamkeag River approximately 1,500 feet north of Dudley in Smyrna Township.

F5 Black carbonaceous and sulfidic slate at Dudley in Smyrna Township, about 8 feet west of Bangor and Aroostook railroad tracks.

F6 Green siltstone at Dudley in Smyrna Township about 8 feet west of Bangor and Aroostook railroad tracks and about 10 feet from where tote road reaches Dudley (siding).

F7 Gray-green siltstone on northwest side of tote road about 125 feet southwest from where the road enters Dudley (siding) in Smyrna Township.

F8 Gray calcareous siltstone at northwest end of field, southeast of road bend at Smyrna Center in Smyrna Township.

F9 Green phyllite and slate on west side of road about 9,000 feet northwest of Ludlow in Smyrna Township.

F10 Gray calcareous slate at northwest end of Jim White Road in Ludlow Township.

F11 Gray calcareous slate at north end of field in Smyrna Township approximately 10,000 feet northwest of Ludlow.

F12 Gray calcareous slate in small roadcut on north side of U.S. Rte. 2 in Smyrna Township approximately 850 feet east of intersection with south-trending road to Timoney Lake.

F13 Dark-gray slate in roadcut, west side of road to Timoney Lake, Smyrna Township, about 2,800 feet south of junction of this road with U.S. Rte. 2 and north of overpass of I-95.

F14 Dark bluish-gray platy limestone in roadcut, west side of road to Timoney Lake, Smyrna Township, about 3,500 feet south of junction of this road with U.S. Rte. 2 and immediately south of overpass of I-95.

F15A,B In Smyrna Township, exposures extend about 120 feet along east side of Currie Road about 1,400 feet south of junction of this road with U.S. Rte. 2. F15A, gray-green phyllitic limestone, and F15B, gray-green quartzite, are 65 and 50 feet south, respectively, from the north end of the outcrop.

F16 Green siltstone and slate in Merrill Township about 9,500 feet northwest of Smyrna Mills on east side of barn in field on southwest side of Maine Rte. 212.

F17 Gray-green siltstone and slate about 1,700 feet northeast of Dyer Brook on south side of road between Dyer Brook and Oakfield.

F18 Dark-gray pyritic hornfels in bed of old wagon road that crosses the south end of Sam Drew Mountain in Oakfield Township and about 1,000 feet east of Moose Brook.

F19 Reddish-brown hornfels in cut on southeast side of U.S. Rte. 2 in Dyer Brook Township about 13,500 feet southwest of Dyer Brook.

[2]Complete fauna are listed only for those fossil localities not previously described in the literature. The reference for a previously described fauna is given in the last column.

[3]U.S. National Museum number.