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GEOLOGIC MAP AND CROSS SECTIONS OF THE SKOWHEGAN 15' QUADRANGLE, MAINE

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INTRODUCTION

The Skowhegan 15' Quadrangle lies just southeast of the axis of the Merrimack Synclinorium in the heart of what Rodgers (1970) has referred to as the Central Maine Slate Belt. Stratified rocks in the quadrangle are only slightly metamorphosed and serve as a key to the correlation of the intensely metamorphosed rocks of nearby southwestern Maine with the essentially unmetamorphosed rocks of northeastern Maine.

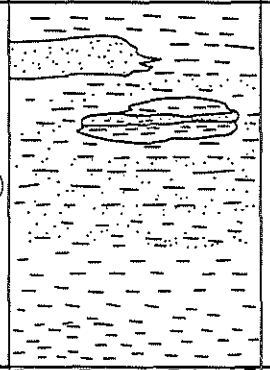
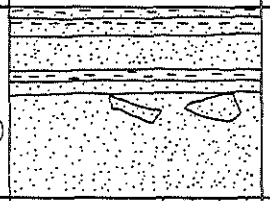
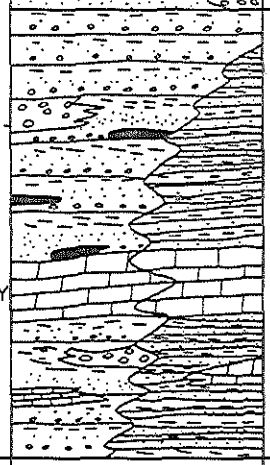
Early geologic reconnaissance by Jackson (1838, 1839) and Hitchcock (1861, 1862) described the primary sedimentary nature of most of the bedrock, and later works by Dale (1923) and Keith (1933) correctly defined the boundaries between the stratified and plutonic rocks in the area. Borns (1959) suggested subdivisions of the stratified rocks, and Osberg and others (1968) attempted a preliminary correlation of the Skowhegan rocks with those to the south and west. Ludman and Griffin (1974), Pankiwskyj and others (1976), and Ludman (1976) have described the regional tectonic and sedimentological setting of the rocks of the Skowhegan area.

STRATIGRAPHY

The Skowhegan Quadrangle is underlain by a thick sequence of slighly metamorphosed graywackes and shales, with subordinate but distinctive carbonaceous shale, argillaceous limestone, and polymictic granule conglomerate. All of these lithologies are commonly found in well graded, turbidite-like sequences, and all are present in several of the stratigraphic units recognized in the area. Distinctions between units of formation rank are based on bedding style, lithologic proportions, and mineralogy, and often prove difficult to make for isolated bedrock exposures.

Primary bedding features are generally well preserved except in the innermost zones of contact aureoles, and much of the original sedimentary textures of the clastic rocks remains. Graptolites have been discovered at two localities within the quadrangle and at over twenty more localities in the adjacent map areas (See Pankiwskyj and others, 1976). These fossils provide firm age control for three of the recognized formations, and indicate continuous deposition from at least Late Llandovery through Early Devonian time. Field relationships, faunal evidence, and deformational style suggest the original stratigraphic relationships illustrated in Figure 1.

FIGURE 1.
STRATIGRAPHIC COLUMN FOR SKOWHEGAN AND KINGSBURY QUADRANGLES

AGE		LITHOLOGY	FORMATION	THICKNESS
DEVONIAN(?)			* SEBOOMOOK FORMATION: REGULARLY & RYTHMICALLY BEDDED, WELL GRADED GRAY METASANDSTONE AND METAPELITE.	300 m EXPOSED
DEVONIAN(?)			* SOLON FORMATION: DARK GRAY HOMOGENEOUS SLATE AT BASE PASSING UPWARDS INTO SANDY SLATE, SLATE AND SANDSTONE, SLATE WITH SILTSTONE LAMINAE. LENSES (?) OF MASSIVE SANDSTONE.	2,000 m
SILURIAN AND DEVONIAN(?)			FALL BROOK FORMATION: * WELL GRADED VARIABLY CALCAREOUS SANDSTONE AND PELITE. * NON-CALCAREOUS SANDSTONE AND PELITE. * CALCAREOUS SANDSTONE WITH (SLIDE BRECCIA). THICK BEDDED CALCAREOUS METASANDSTONE WITH MINOR PELITIC PARTINGS.	1,000 m
SILURIAN	LUDLOW		PARKMAN HILL FORMATION: SULFIDIC CARBONACEOUS PELITE WITH SULFIDIC SANDSTONE, GRANULE CONGLOMERATE, (MINOR RIBBON LIMESTONE NEAR TOP *)	300 m
SILURIAN	WENLOCK LLANDOVERY		SANGERVILLE FORMATION: THICK BEDDED GRAYWACKE AND SLATE WITH HORIZONS OF RIBBON LIMESTONE; GRANULE CONGLOMERATE; HIGHLY CARBONACEOUS, SULFIDIC PELITE. WATERVILLE FORMATION: (EASTERN FACIES) THIN BEDDED ("PINSTRIPED") GRAYWACKE AND SLATE; HORIZONS OF RIBBON LIMESTONE.	SANGERVILLE: >2,000 m WATERVILLE: >1,000 m
			* NOT EXPOSED IN THE SKOWHEGAN QUADRANGLE	

SILURIAN SYSTEM

Sangerville Formation: The Sangerville Formation (Ludman and Griffin, 1974; Pankiwskyj and others, 1976) underlies a large part of the Skowhegan Quadrangle and has been traced for several tens of kilometers to both the southwest and northeast. The formation is extremely heterogeneous, and is characterized by abrupt vertical and lateral transitions. The Sangerville Formation is composed of four lithologic members, one of which forms the bulk of the formation. The others, found at several horizons, represent repetition of specific sedimentological-tectonic environments.

A member composed of metagraywacke and metapelite (Ss) comprises most of the formation. It is characterized by highly variable bedding thicknesses, and the variety is well exposed in exposures in the Wesserunsett Stream between Athens and Cornville and along Route 150 between Athens and Harmony. This member consists of light buff weathering, locally calcareous light gray metagraywacke and dark gray-black slates or phyllites, typically in well bedded, well graded sequences 4 cm to 1.5 m thick. Grain size and color changes are gradational within each graded bed regardless of thickness, and provide abundant primary facing indicators. Although bedding in a single large outcrop may span the entire thickness range described above, some horizons consist almost entirely of thick or thin bedded types. Metagraywacke; metapelite proportions are highly variable in the graded beds (10:1 to 1:3), with pelite becoming more abundant in the thinner beds. Grading is absent from some horizons, and some are composed entirely of slate (as at Lower Mills) or graywacke (Cornville at the bridge over Wesserunsett Stream). Convolute and cross-laminations, climbing ripple sets, scour and fill features, load casts, and soft-sediment folding and faulting are also well preserved. Ellipsoidal calcareous pods (Calc-silicate in hornfels outcrops) occur at several horizons but are most prominent in the upper most few meters of the formation as at the Great Eddy in Skowhegan.

Clasts within the metagraywacke are commonly flattened in one of the two prominent cleavages observed in the quadrangle, but can still be identified despite extensive pressure solution. Polymineralic lithic fragments and monomineralic clasts are typically poorly sorted and are set in an argillaceous (muscovite-chlorite-biotite), calcareous (calcite-ankerite),or fine grained detrital matrix. The nature of the clasts will be described more fully below. Some large (2.5 mm) muscovite flakes are ragged in outline and may be detrital.

In chlorite zone outcrops, those metagraywacke and metapelite beds which contain a ferroan carbonate phase (ankerite or siderite; in some samples both) weather to a hematite and limonite spotted appearance or, with deeper weathering, to a distinctive light red-brown weathering rind. The ferroan carbonates are destroyed at the biotite isograd so that this feature does not appear within contact aureoles, or in regionally metamorphosed rocks of biotite grade or above.

Coarse clastic rocks with grains 2 mm to 2.5 cm in diameter are mapped as polymictic granule metaconglomerate (Ssc,Sscu), and often interfinger with the metagraywacke and metapelite member. Beds may be thick (greater than 1 m) and non-graded or may closely resemble the well graded sequences of the finer grained Ss rocks. The metaconglomerate occurs in continuous bands at two levels (upper and lower metaconglomerate members) within the formation and as isolated lenses. It is abundant in the northwest part of the quadrangle but has not been observed in the southeastern outcrop belt of the Sangerville Formation. Exposures at Malbon's Mills and on hills west-southwest of West Athens illustrate the variety of lithology, mineralogy, and bedding of these rocks. Some graded exposures contain nearly complete Bouma sequences (See Ludman, 1976), but most contain only the upper and lowermost Bouma zones. A turbidite origin is indicated.

The metaconglomerates are far less argillaceous than the metagraywacke and contain far less muscovite and chlorite. The matrix is nearly always fine grained (silt sized) detrital material, but in a few exposures calcitic and ankeritic cements have been recognizied. A wide variety of clasts--monomineralic grains and polymineralic lithic fragments--have been indentified, including: quartz, plagioclase, muscovite, microcline, chert, muscovite schist, felsic and mafic volcanic rocks, myrmekitic hypabyssal plutonic rock, and intraclasts such as slate and mud chips. At some exposures a single clast type may predominate, as in the blue quartz-rich exposures at Malbon's Mills, but most samples are decidedly polymictic. All of these clasts have also been identified in the metagraywacke, but the lithic fragment: monomineralic clast ratio is much higher in the metaconglomerate.

There is little discernible lithologic or bedding distinction between the upper and lower metaconglomerate members. The upper member appears to occur in massive, pelite-free beds more commonly than the lower member, but this may be a function of poor outcrop control. The distinction between the two members is based solely on position relative to the upper and lower limestone members.

Thinly and rhythmically interbedded dark gray argillaceous micritic metalimestone and non-calcareous metagraywacke, metapelite, and metasiltstone form the upper and lower metalimestone members of the Sangerville Formation (Ssl, Ssll), and a series of isolated lenses. Differential weathering produces a distinctive thinly ribbed surface in which the micrite dissolves to form lows, the less soluble non-calcareous rocks stand up as ribs. This unique weathering appearance is responsible for the designation of these rocks as "ribbon limestones" here and in Aroostook County where similar lithologies are exposed. The ribbon metalimestones are best exposed in the Wesserunsett Stream north of Route 150 at Athens and at Walton's Mill, at Harmony in Higgins Brook, and at Canaan.

In most exposures, limestone and non-calcareous rocks are intercalated on a scale of 1 mm to 10 cm. Thicker beds, up to 30 cm, are much more abundant in the lower metalimestone member (as at Athens) than in the upper (as at Harmony). Non-calcareous lithologies are also more abundant in the lower member, and these criteria serve to distinguish the two.

At chlorite grade the metalimestones are very fine grained, only slightly recrystallized lime muds (micrites) with up to 40% chlorite, muscovite, quartz, and plagioclase. Disarticulated pelmatazoan columnal segments have been found in the lower member at Athens and in correlative rocks at Dover-Foxcroft (Griffin, 1973), but no diagnostic fossils have been identified. The interbedded non-calcareous rocks are similar to the typical Sangerville metagraywackes and metapelites, but occasionally show extremely well developed cross-bedding.

With increasing metamorphic grade the metalimestone members undergo major mineralogic and textural changes and are significantly different in appearance than the chlorite grade exposures. Micrite layers recrystallize as fine to medium grained white marble, pelitic and psammitic layers as purplish biotite-rich granofels. Bands of green actinolite, blue-green diopside, brown idocrase and grossularite, and white prismatic wollastonite form parallel to original compositional layering, with the calc-silicate bands being more resistant to erosion than the pelitic and psammitic layers. A ribbed weathering is thus produced in which the originally more resistant layers have become less resistant because of metamorphism. Hornfelses of this type are well exposed on Porcupine Mountain, at the cross-roads just west of Joaquin Brook 2.8 miles east-southeast of Athens, and on the north slope of Talbot Hill.

Small isolated lenses of carbonaceous slate and phyllite with associated sulfidic and non-sulfidic metagraywacke and metamudstone (Ssr) occur at several horizons within the Sangerville Formation. In only one area, between Cass Corner and Athens, can this member be traced continuously for more than 0.75 km. Some lenses consist entirely of rusty weathering, sulfidic highly carbonaceous metapelite, whereas others contain the coarser clastic rocks thinly interbedded (2-8 cm) with the pelite. Thin (1-5 mm) non-sulfidic light gray weathering metasiltstone laminae are intercalated with the carbonaceous phyllite in many exposures.

In addition to the interfingering and lensing of the different members along strike, systematic regional cross-strike changes have also been observed in the Sangerville Formation (Ludman and Griffin, 1974; Pankiwskyj and others, 1976). Rocks in the Morrill Pond---Oaks Pond area in the south-central and south-eastern parts of the quadrangle are consistently finer grained, thinner bedded, and more pelitic than those exposed to the northwest of Skowhegan. The amount of interbedded metaconglomerate and of calcareous cement decreases from northwest to southeast.

Fossils from two outcrops of Ssr in the Skowhegan Quadrangle are not age diagnostic (Appendix 1), but those from several others in the Kingsbury, Guilford, and Dover-Foxcroft quadrangles provide firm ages for the formation. In the type area of the Sangerville Formation where the Fall Brook Formation rests directly upon the Sangerville, graptolites ranging from Late Llandovery through Early Ludlow have been collected from the Sangerville. In the Skowhegan Quadrangle, however, the Parkman Hill Formation lies between Sangerville and Fall Brook, and faunal evidence from the Kingsbury Quadrangle (Ludman, 1977) suggests a range of Late Llandovery through Middle Wenlock for the Sangerville. The lower contact of the Sangerville has not been recognized, so that it could be, in part, as old as Ordovician.

On the basis of faunal evidence and lithologic similarity, the Sangerville Formation is correlated with the eastern and western facies of the Waterville Formation and with the Mayflower Hill Formation in the adjacent Waterville area(Osberg, 1968). It is also correlated with the Rangeley and Perry Mountain formations of western Maine (Moench, 1970) by lithologic similarity and similarity of stratigraphic sequences. Particularly striking are the comparisons between uppermost Sangerville rocks at the Great Eddy in Skowhegan and the uppermost Perry Mountain rocks at Smalls Falls (Rangeley Quadrangle), and between well graded Sangerville metaconglomerates and the Rangeley C unit of Moench and Boudette (1970). Other detailed correlations with the highly metamorphosed rocks of southwestern Maine are discussed in Pankiwskyj and others (1976).

Waterville Formation eastern facies (Swe): In the adjacent Waterville Quadrangle, Osberg (1968, p.11-17) described the Waterville Formation eastern facies as consisting of thinly interlaminated phyllite and micaceous quartzite with distinctive ribbon metalimestone and carbonaceous metapelite members. Rocks exposed in the southeast corner of the Skowhegan Quadrangle resemble both Sangerville and eastern facies Waterville lithologies; they are mapped as Waterville Formation for reasons described below.

Exposures are sparse in the southeast corner of the Skowhegan Quadrangle, but representative chlorite-grade outcrops can be observed on Church and Nelson Hills, along Route 2 east of Canaan, and on the east shore of Sibley Pond. More extensive exposures crop out to the northeast in the Pittsfield Quadrangle. The dominant lithologies are buff weathering variably calcareous metasiltstone and greenish phyllite in thin (1-3 mm) "pinstriped" graded beds. Fine cross- and convolute laminations are well developed in the metasiltstone portions of the graded beds. Ribbon metalimestone on Nelson Hill appears to be a minor part of the formation. Carbonaceous pelite and metaconglomerate are absent in the Skowhegan Quadrangle and thicker beds are rare.

In bedding style, the scarce thicker-bedded exposures are clearly of Sangerville type, but the vast majority of outcrops more closely resemble the eastern facies of the Waterville Formation exposed just to the south in the Waterville Quadrangle. The ankeritic character of some of the metasiltstones is a Sangerville characteristic, but the green color of the pelite is a Waterville trait, quite different from the grayish-black Sangerville slates at equivalent metamorphic grade.

The rocks in this part of the Skowhegan Quadrangle are believed to be a transitional facies between the thick-bedded Sangerville and thin-bedded ("pinstriped") Waterville formations, but are mapped as Waterville because of the characteristic bedding style exhibited by most outcrops.

Fossils have not been found in the Waterville Formation in the Skowhegan Quadrangle, but Berry (in Osberg, 1968, p. 32-33) suggested a Wenlock or Ludlow age for the formation from fossils in the Waterville Quadrangle. Ages from collections made in correlative rocks in the Stetson Quadrangle (Griffin, 1973) are in agreement with this age range, so that the formation is equivalent to at least the upper part of the Sangerville Formation.

Field relationships (Ludman and Griffin, 1974) indicate that the Sangerville and Waterville formations interfinger in the Pittsfield Quadrangle, with the thinner-bedded Waterville lithologies replacing the thicker-bedded Sangerville to the northeast. From bedding style and grain size differences, the Waterville Formation eastern facies is thought to be a more distal turbiditic lithofacies than the Sangerville, implying a source area to the west. The western facies of the Waterville Formation (Osberg, 1968) is equivalent to the Sangerville.

Parkman Hill Formation (Sp): The Parkman Hill Formation (Pankiwiskyj and others, 1976) consists of a variety of rusty-weathering, sulfidic coarse grained clastic metasedimentary rocks with abundant carbonaceous metapelite and very subordinate ribbon metalimestone. It forms several outcrop bands, two flanking the axis of the Currier Hill Syncline in the southern part of the quadrangle, and others in the northwest part where it is tightly folded and commonly in fault contact with adjoining units. Several different lithologies, intercalated in widely varying proportions at individual outcrops, comprise the Parkman Hill Formation, but cannot be mapped as separate members. Nearly all contain primary sulfide minerals whose alteration during weathering yields a characteristic rusty to slaggy appearance in all but the freshest outcrops.

Thick-bedded (10 cm to 2 m) dark gray sulfidic metasandstone, metagraywacke, and metasiltstone form a large part of the Parkman Hill Formation. These rocks are commonly associated with carbonaceous and non-carbonaceous metapelite, but not in the well-graded units typical of the Sangerville Formation. Most beds are massive, of homogeneous grain size, and show few of the primary turbidite features which are characteristic of the Sangerville. Some non-sulfidic metasandstones are also present but are subordinate to the pyrite-and pyrrhotite-rich varieties. These rocks are well exposed in roadcuts on Route 2 just east of the Great Eddy in Skowhegan.

Thick zones, up to 50 m, dominated by carbonaceous slate, phyllite, or schist are intercalated with the massive rocks described above. These zones contain highly sulfidic carbonaceous metapelite with abundant but very subordinate (15-25%) laminae 2-4 mm thick of sulfidic metasiltstone. A poorly developed graded bedding is commonly observed in the thinly laminated rocks.

Massive, poorly to non-graded granule metaconglomerate occurs in several outcrops, particularly in the northern outcrops of the formation in the Skowhegan Quadrangle and the adjacent Kingsbury Quadrangle. Both quartzose and polymictic types have been found, and both are similar to the massive metaconglomerates of the Sangerville Formation.

Two types of calcareous rocks are present in the Parkman Hill Formation, but are relatively rare. One, found throughout the formation, is a thin bedded (1-4 cm) sulfidic, highly calcareous metasiltstone which has the distinctive slaggy weathering of the rest of the formation, but is much less resistant to weathering and produces a ribbed weathering texture with interbedded metasandstones. The other type is a ribbon metalimestone indistinguishable from that of the Sangerville or Waterville formations. This lithology appears to be restricted to the uppermost horizons of the formation in the Kingsbury Quadrangle, and has not been found in the Skowhegan Quadrangle.

Although commonly similar in outcrop appearance to their Sangerville counterparts, the coarse clastic rocks of the Parkman Hill are unique in several ways. Nearly all clast types found in the Sangerville metaconglomerates have also been observed in the Parkman Hill metaconglomerates,but the latter are characterized by the predominance of siliceous clasts--quartzite, chert, monocrystalline quartz. The matrix of the Parkman Hill clastic rocks is far less argillaceous in general than that of the Sangerville rocks, and consists of fine grained (fine silt) quartzose material in low-grade outcrops, recrystallized quartz in the hornfelses. As a result, Parkman Hill rocks are generally grey as compared with the purplish Sangerville rocks in which biotite recrystallized from a highly argillaceous matrix. There is, however, sufficient overlap in rock types and bedding styles in the two formations to make identification from a single outcrop difficult.

Pyrite is the most common sulfide mineral, occurring as subhedral to euhedral cubes (recrystallized) in some carbonaceous metapelites, and as elongate blebs in metasiltstones and metasandstones. Pyrrhotite occurs in the higher metamorphic grades, and pyrite-pyrrhotite assemblages have been identified in several biotite and garnet grade exposures.

Reconstruction of the internal stratigraphy of the Parkman Hill Formation is complicated by intense folding and by the tendency of the carbonaceous metapelite to be the locus of small-scale fault zones. The contact with the Sangerville Formation is sharp and is drawn at the first sulfidic metapelite or metasandstone. There is often some shear along this contact, as at the Great Eddy in Skowhegan, because of the contrast in competence between carbonaceous metapelite and metagraywacke. The lower part of the formation appears to be characterized by the thick-bedded metasandstones with minor carbonaceous phyllite and calcareous metasiltstone, but bedding thickness decreases and carbonaceous metapelite increases upward so that these rocks dominate the upper part of the formation.

The ribbon metalimestone appears in the uppermost hundred meters. The upper contact zone consists of about 100 m of interbedded sulfidic carbonaceous metasiltstone and metapelite, and non-sulfidic thick-bedded biotite-rich metasandstones of the Fall Brook type (see below), with the contact mapped at the last sulfidic lithology.

The two southern outcrop bands differ from those to the north. As in the Sangerville Formation, grain size seems to decrease from northwest to southeast so that granule metaconglomerates are much less abundant in the south. Ribbon metalimestone has not been found in the southern belts, and carbonaceous metapelite is the dominant rock type as at Eaton Mountain. Along strike to the northeast, the formation seems to pinch out and is not found between the Sangerville and Fall Brook formations in the Dover-Foxcroft Quadrangle or between Waterville and Vassalboro formations in the Stetston and Pittsfield Quadrangles. This absence may be in part structurally controlled in the northern outcrop belts, but in the south it appears to be a primary sedimentary lithofacies transition. Osberg (1968) and Griffin (1973) report lenses of carbonaceous sulfidic metapelite just below Vassalboro rocks in their Sangerville and Waterville formations, and these correspond in lithology, bedding, and position to the Parkman Hill Formation. In some areas, the sequence of interbedded green and maroon phyllites occupies the Vassalboro/Sangerville contact zone. Bedding is similar to that in some of the Parkman Hill carbonaceous pelite and siltstone sequences, but the environment of deposition was presumably more oxidizing than in the depositional area of the Parkman Hill Formation where pyrite and carbon are preserved instead of hematite.

Several graptolite localities have been found in the Parkman Hill Formation in the Kingsbury Quadrangle (Ludman, 1977) which yield a range of Late Wenlock through Early Ludlow for the formation. These ages correspond with those found in the uppermost Sangerville/ Waterville rocks to the east, and confirm the lithofacies transition mentioned above.

The Parkman Hill Formation is correlated with the Smalls Falls Formation of the Rangeley-Phillips (Moench, 1970) and Little Bigelow Mountain (Boone, 1973) areas to the west on the basis of lithologic and sequential similarities. It is also equated with the Thompson Mountain Formation of the Buckfield Quadrangle.

SILURIAN AND DEVONIAN (?)

Fall Brook Formation (DSf): The Fall Brook Formation crops out in the axial region of the Currier Hill Syncline in the hornfels rim of the Hartland Pluton, and in a small tight syncline in the northwest part of the quadrangle. Its appearance in the northwest corner of the area is based on extensive exposures along strike to both northeast and southwest. This formation has been observed only at the biotite or higher grade of metamorphism, but primary bedding features are well preserved. Compared with the Sangerville

and Parkman Hill formations, the Fall Brook is a relatively homogeneous unit, both vertically and laterally, within the Skowhegan Quadrangle. Rocks exposed in this quadrangle comprise only the lower portion of the Fall Brook Formation; the higher horizons are well exposed in the Kingsbury and Anson quadrangles and will be discussed here for the sake of completeness.

Almost all of the Fall Brook Formation as exposed in the Skowhegan Quadrangle consists of a buff-weathering, variably bedded, variably calcareous pale purplish metasandstone and metasiltstone. Beds of calcareous metasandstone and metasiltstone whose thicknesses range from 15 cm to over 4 m, predominate and are characterized by a somewhat ribbed weathering pattern in which the somewhat more fissile metasiltstone forms the lows. Massive-appearing beds generally prove to be composed of numerous finely laminated sub-units in which pelite partings separate metasandstone layers. Calc-silicate beds, lenses, stringers, and cross-cutting veins are abundant. Most beds are of homogeneous grain size and show grading infrequently, but cross-bedding, defined by concentrations of biotite flakes, is common in the thicker bedded metasandstones. Gradation by composition--increasing argillaceous content--may be used for primary facing evidence.

In contrast to the formations described above, the Fall Brook Formation in the Skowhegan Quadrangle has very little interbedded pelitic material and almost no muscovite in the matrix of the metasandstones. Biotite-rich partings, parallel to the earliest cleavage are generally paper thin, and difficult to see in weathered exposures. Outcrops of the upper parts of the formation in adjacent quadrangles reveal a decreasing calcareous content, the appearance of muscovite-rich pelite, and the development of thinly and rhythmically graded beds. Soft-sediment slump and fault features, including a blocky sedimentary slide breccia, have been observed in the lower part of the formation in the Kingsbury Quadrangle. Sulfidic, highly carbonaceous metapelite apparently interbedded with Fall Brook metasandstones, crops out in the south-central part of the quadrangle. These rocks may be an infaulted lens of Parkman Hill rocks, but outcrop control is poor and they have been mapped with the Fall Brook.

Fossils have not been found in the Fall Brook Formation or any of its correlative units in western, central, or eastern Maine. As the formation lies above the Early Ludlow graptolites of the uppermost Parkman Hill Formation (Sangerville in the eastern part of the Guilford Quadrangle; Waterville in the Pittsfield Quadrangle) and below slates and sandstones containing Devonian (?) plant and animal remains (Espenshade and Boudette, 1967), the formation is assigned an age of Upper Silurian through Early Devonian.

The Fall Brook Formation is correlated with the Madrid Formation of western Maine(Moench, 1970; Boone, 1973), and the Vassalboro Formation to the south (Osberg,1968; Griffin,1973). Similar lithologies in the east and southeast near Penobscot Bay (Bucksport Formation) and in the Calais area in eastern Maine (Flume Ridge Formation) may also be correlative and would indicate a relatively homogeneous blanket of calcareous metasandstone whose extent covers much of Maine.

DEVONIAN SYSTEM

Stratified rocks younger than the Fall Brook Formation do not crop out in the Skowhegan Quadrangle, but do underlie large portions of the adjacent Kingsbury Quadrangle. They will be briefly mentioned here in order to present the complete local section.

The Solon Formation (Pankiwskyj and others, 1976) consists of massive dark gray slate, slate with very subordinate light gray metasiltstone, and a few lenses of massive metasandstone. It lies gradationally above the Fall Brook Formation as shown clearly in road cuts in the Kingsbury Quadrangle west of Mayfield Corner and is assigned an Early Devonian age. It is correlated with the Carabasset Formation of Boone (1973).

The Seboomook Formation consists of regularly and rhythmically interbedded medium gray non-calcareous metasandstone interbedded with equal amounts of dark gray slate. Its contacts with older rock in the Kingsbury Quadrangle are complex, probably involving late brittle faulting of a pre-metamorphic soft-sediment fault (Ludman, 1977). It is younger than the Solon Formation and is assigned a Devonian age (pre-Acadian).

STRATIGRAPHIC SUMMARY

The stratified rocks in the Skowhegan Quadrangle provide a sedimentologic record of Early Silurian through Early Devonian time, coveringthe interval between the end of the Taconic Orogeny and the beginning of the Acadian. This record may be summarized briefly as follows:

From Early Llandovery through Middle Wenlock times, erosion of Taconic highlands to the west of the Skowhegan area caused debris to be shed eastward, and to be deposited in a major regional trough (the Frederickton Trough). The clast composition suggests a crystalline terraine composed of volcanic rocks, schists, and granites or granitic gneisses. Bedding features indicate that deposition was by turbidity current action, and intraformational mineralogic and bedding variations within the quadrangle point to intermediate (Sangerville Formation) and distal (Waterville Formation) lithofacies. The proximal equivalent of these rocks is the Rangeley Formation of western Maine. Deposition was in a reducing environment as indicated by the ankerite/siderite and carbonaceous pelite of the Sangerville Formation. Ludman and Griffin (1974) demonstrated that the axis of the sedimentary trough passed through what is now the outcrop belt of the eastern facies of the Waterville Formation, and that an eastern, volcanic rich, source was possible for at least part of the Waterville. Although most deposition within the Frederickton Trough appears to have been by downslope-moving turbidity currents, it is possible that some material was deposited from axial (contour) currents. The ribbon metalimestones of the Sangerville and Waterville formations are concentrated near the axial region of the trough, but are absent from the western and eastern flanks in age-equivalent rocks. These metalimestones were probably derived from the Aroostook-Matapedia platform to the northeast, with axial currents bringing the lime muds to the southwest.

From Middle Wenlock to Early Ludlow times, a strongly reducing (euxinic) environment was developed on the western flank of the trough (Parkman Hill and Smalls Falls formations), but not in the axial region or on the eastern flank. During this time, the western highlands were considerably reduced in elevation, but periodically provided granule metaconglomerate detritus to the trough. High quartz: feldspar and rock fragment ratios in Parkman Hill metasandstone and granule metaconglomerate suggest deep chemical weathering in the source area, probably because of lower elevations and gentler topographic gradients.

With the onset of deposition of the Fall Brook Formation, the sedimentary regime changed abruptly. A homogeneous, uniform blanket of metasandstone completely covered the previous pattern of lithofacies, and appears to have covered the Early Silurian source areas to the west as well. The general subsidence thus indicated continued during the deposition of the flysch-like Solon and Seboomook formations.

STRUCTURE

The stratigraphic units just described have been subjected to several deformational events of varying intensity, style, and scale. Soft-sediment folding and slumping have occurred on an outcrop scale in the Skowhegan Quadrangle, and are postulated on a regional scale to the north (Ludman, 1977), and west (Moench, 1970. Three periods of post-lithification ductile deformation and at least one of brittle deformation subsequently affected the stratified rocks. Most exposures provide evidence for one or two of the ductile deformations; a few, such as at the dam at Harmony, reveal all three. In general, most structural trends are northeast to east-northeast trending, and bedding, cleavages, and foliations are very steeply inclined.

Soft-sediment deformation

Evidence of small-scale deformation contemporaneous with deposition of the Sangerville, Waterville, and Fall Brook formations has been observed in the Skowhegan quadrangle. The distinction between soft-sediment deformation and the pervasive post-lithification isoclinal folding is difficult because the two are in most instances coaxial, but in some exposures, tectonic refolding of soft-sediment structures may be observed.

The soft-sediment deformation is characteristically restricted to a single bed or a thin sequence of beds isolated between apparently undisturbed strata in which facing indicators suggest a conformable and homoclinal section. Sedimentary breccias composed of disarticulated fragments of graywacke or pelite in a graywacke matrix are often associated with these folds. Considerable bed thickening in fold noses, blunt fold noses even in thinly bedded pelitic layers, and highly variable trends of hinge lines are typical of the soft-sediment folding. Other criteria are enumerated by Griffin (1973). The

soft-sediment deformation is attributed to plastic flow in a sequence of partially lithified, water-rich turbidites. Disruption of somewhat more nearly lithified sediment resulted in a more brittle type of deformation and the production of the sedimentary breccias.

Post-lithification deformation

Post-lithification folding has caused nearly every outcrop of stratified rock in the Skowhegan Quadrangle to display near-vertical bedding and cleavage. Three periods of tectonic folding (F_1, F_2, F_3) are recognized, with each episode resulting in a characteristic style and scale of deformation. Of these fold episodes, the first (F_1) was the most important and is responsible for most of the present outcrop pattern in the quadrangle. The two subsequent episodes of folding do not seem to have greatly modified this F_1 pattern, although a marked change in structural trends in the Kingsbury and Guilford quadrangles may reflect deformation associated with F_2.

F_1: Upright close to isoclinal folds attributed to F_1 can be observed at outcrop scale at several localities, but are best developed at the Powerhouse Island in Skowhegan, north of Route 150 in the Wesserunsett Stream at Athens, and at Harmony. These folds are north-east trending with near vertical hinge surfaces. Plunges are gentle to both northeast and southwest, but steepen in the vicinity of the Hartland Pluton.

In metapelites and ribbon metalimestones an axial plane cleavage (S_1) is strongly developed, and in some instances a foliation expressed by alignment of micas and chlorite parallels the cleavage. In coarser clastic rocks, the foliation is expressed by preferred alignment of deformed clasts, diagenetic carbonates, and sulfides. Pressure solution was an important factor in producing this foliation, and well defined pressure shadows and opaque rims of insoluble residue can be observed in thin section around ferroan carbonates and large quartz clasts.

The response of the different rock types in the area to F_1 is highly variable. Ribbon metalimestones are typically found in very tight folds in which bed thickness in fold hinges may exceed that on the limbs by 10-20X(as at Athens). Massive metasandstones and metaconglomerates yield much more concentric-type folds with far less distortion of bed thickness. Interbedded metasandstones and metapelites respond with an intermediate fold style. Flexural flow is associated with all F_1 folds to some degree.

F_1 folds have also been observed on microscopic and megascopic scales, with reversals of primary facing indicators defining the large scale fold hinges. Regional scale F1 folds with wavelengths of 10-15 km are traceable toward the western part of the state (Pankiwskyj and others, 1976), sharply defined by symmetrical repetition of stratigraphic units. There are several orders of smaller-scale folds; those within the Skowhegan Quadrangle are shown in the cross-section accompanying the geologic map. The major folds within the area--the Currier Hill Syncline in the

south-central part of the Quadrangle and the Chapman Hill Anticline in the northwest--are themselves minor folds associated with the axial region of the Merrimack Synclinorium. The axis of this major, New England wide structure lies just to the northwest of the Skowhegan Quadrangle, in the Anson and Bingham quadrangles.

F_2: Throughout the Skowhegan Quadrangle, a strongly penetrative fracture cleavage (S_2) trends 015 to 350 in pelitic and calcareous rocks. This cleavage clearly truncates both bedding and S_1. In the southern part of the quadrangle where bedding and S_1 trend approximatly 030 to 045, the angle between S_1 and S_2 is small and S_2 may be difficult to identify. To the north and in the adjacent Kingsbury Quadrangle where bedding and S_1 trend 060-080, S_2 is nearly perpendicular to both and is far more obvious. A very weak preferred alignment of chlorite and muscovite and of pressure shadows surrounding ferroan carbonates is developed parallel to S_2 in some exposures. In some rocks, pressure shadows associated with F_1 are clearly deformed and aligned by S_2. In very massive rocks such as the metaconglomerates, S_2 is extremely difficult to identify.

Folds associated with the S_2 cleavage (F_2) are rarely visible and are best developed in Sangerville metalimestones at Harmony and in Waterville metapelites near Canaan. F_2 folds are characteristically north-trending, steeply plunging asymmetric folds in which bedding, S_1, and F_1 hinge surfaces are clearly deformed. Throughout the Skowhegan Quadrangle, F_2 folds exhibit the same asymmetry-they are dextral. In ribbon metalimestones these folds have a more concentric aspect than F1. In Waterville phyllites best exposed in the Pittsfield Quadrangle to the east, F_2 was produced by passive slip. F_2 thus appears to have been a less plastic event than F_1 and may have occurred at a shallower crustal level.

Large scale F_2 folds have not been observed in the map area, but the widespread regional development of S_2 points to a regional extent for this fold episode. The marked change in F_1 structural trends from northeastward to east-northeast in the Kingsbury and Guilford quadrangles may represent an F_2 fold of regional magnitude. In the Dover-Foxcroft Quadrangle, Griffin (1973) has observed a conjugate set of folds which deform early isoclinal folds traceable into F_1 in the Skowhegan area. He has designated this late set of folds as F_{2v} (sub-vertical hinge surfaces) and F2h (sub-horizontal hinge surfaces). F_2 in the Skowhegan Quadrangle corresponds in attitude and style to F_{2v}: F_{2h} has not been recognized.

F_3: Small scale broad warping of S_1 and S2 occurs throughout the quadrangle, but is best displayed in Higgins Brook at and downstream of the dam at Harmony. The warps (F_3) trend west-northwest, have vertical hinge surfaces and plunge steeply to vertically. Most are concentric in style. Neither axial plane cleavage nor foliation are associated with F_3 folds, although at Harmony a wide-spaced joint set is oriented parallel to the F_3 hinge surfaces. The regional significance of F_3 appears to be minor.

Faulting

Regional scale late stage brittle deformation has affected all of the stratified rocks and some of the plutonic rocks of the quadrangle. Actual fault surfaces are rarely visible, so that a variety of criteria have been used to infer the presence and extent of faults, including: gouge, mylonite, slickensides, traceable zones of intensely deformed bedding, abrupt stratigraphic discontinuity, concentrations of vein quartz in outcrop and in float trains, aligned springs in dense metasedimentary rock, and the abrupt northeastward change of the course of the Kennebec River between Norridgewock and Skowhegan. In all cases a combination of at least three of these criteria was required before a fault was mapped.

The faults trend northeastward, generally parallel to or at a low angle to bedding. Several faults occur at contacts between incompetent and competent lithologies as between Ssr and Ss, Ssl and Ss, Sp and Ss or DSf. The steep plunges of the observed slickensides suggest dip-slip motion along the faults, and fault surfaces appear to have been near-vertical. Stratigraphic control suggests that the northwest sides of the faults have moved down relative to the southeast, but the amount of displacement is difficult to estimate because of the steep dip of the faulted rocks. Most fault zones are not mineralized by anything other than vein quartz, but the fault parallel to the Kennebec River in Skowhegan contains chalcopyrite and bornite as well. The fault zones appear to be narrow--100 feet--as compared with the broad zones associated with post-Acadian (Triassic??) faults in southern and eastern Maine.

The timing of the faulting can be determined within limits provided by other structural, plutonic, and metamorphic elements within the area. F_1 folds are clearly truncated by the faults, but the consistent orientation of S_2 suggests that it occurred after the faulting. Two lines of evidence suggest that the faulting occurred prior to emplacement of the Hartland Pluton: 1) contact metamorphic isograds do not appear to have been affected by the faulting; 2) the Kennebec River Fault connects the Hartland and Belgrade Lakes (Norridgewock Quadrangle) plutons and is a zone of higher grade (garnet) contact metamorphism, suggesting that both plutons were emplaced along a previously existing fault. Continued displacement or reactivation of this fault may have been the cause of cataclasis and extensive alteration of the Hartland Pluton at Jewell Hill (see below).

IGNEOUS ROCKS

Plutonic rocks, mainly of granitic composition, underlie a large portion of the Skowhegan Quadrangle and intrude all of the stratigraphic units present. Granite and granodiorite of the Hartland Pluton comprise almost all of the igneous rock; two small bodies of andesite and a single dike of basalt make up the remainder. Representative modal analyses of these rocks are given in Table 1. All three rock types are younger than the major deformation (F_1), but some have been affected by faulting.

TABLE I.

REPRESENTATIVE MODAL ANALYSES OF PLUTONIC ROCKS

	GRANITIC ROCKS					
	FOLIATED GRANITE, CHASE HILL	GRANODIORITE, JEWELL HILL	WEAKLY FOLIATED GRANITE, LOOMIS HILL	NON-FOLIATED GRANITE, LOOMIS HILL	FOLIATED GRANODIORITE, FROM OLD QUARRY ON JUDKINS FARM, 2.75 mi.; 330° FROM CANAAN	NON-FOLIATED GRANITE, PORCUPINE MOUNTAIN
QUARTZ	30.0	30.5	38.0	38.0	16.8	41.0
MICROCLINE	25.0	16.8	34.6	30.4	27.6	30.8
PLAGIOCLASE	21.0	31.6	18.4	27.4	39.8	25.8
BIOTITE	18.0	3.8	7.2	2.4	12.6	1.8
HORNBLENDE	3.5	2.8	1.2	0.2	—	—
MUSCOVITE	—	—	—	—	—	1.0
ACCESSORY MINERALS	2.5	0.4	0.2	1.2	3.3	0.4

INTERMEDIATE AND MAFIC ROCKS

ANDESITE	
QUARTZ	3.0
PLAGIOCLASE	62.2
BIOTITE	19.4
HORNBLENDE (pseudomorphs of biotite and calcite)	12.6
ACCESSORIES	2.6

BASALT	
PLAGIOCLASE	39.6
CLINOPYROXENE	20.8
ORTHOPYROXENE	2.2
OLIVINE (pseudomorphs of antigorite)	29.2
ACCESSORIES	4.2

The intrusive rocks will be treated in their order of emplacement; andesite, granite, basalt.

Andesite: Two small bodies of andesite intrude Sangerville ribbon metalimestone and metagraywacke in the town of Athens, both east and west of the junction between Routes 150 and 151, and a small dike of similar rock cuts metalimestone under the powerline on Route 150, 1.25 km south of Cass Corner. The andesite occurs in two distinctly different textural types, and both have been affected by the thermal metamorphism accompanying emplacement of the Porcupine Mountain apophysis of the Hartland Pluton. In Athens, the andesite is in the biotite zone, whereas south of Cass Corner it is in the chlorite zone. Poor outcrop control in fields north of Athens prevents determination of the total surficial extent of the larger bodies; they are probably part of a single mass.

The textural variations include a uniformly fine grained rock containing white-weathering feldspar laths, a dark matrix, and some metamorphosed mafic minerals which are somewhat darker than the rest of the matrix, and a porphyritic type in which 5-8 mm phenocrysts of white weathering plagioclase feldspar and altered ferromagnesian minerals are set in a dark groundmass. The actual groundmass color is a function of metamorphic grade; abundant biotite north of Athens produces a purplish tint while south of Cass Corner, in the chlorite zone, the rock is a greenish gray.

In thin section, plagioclase (An38 by combined Carlsbad/Albite twin method) is the dominant mineral in both groundmass and phenocryst populations. Biotite flakes up to 2.5 mm across are scattered throughout the groundmass and also occur with calcite as pseudomorphs after an amphibole north of Athens. Chlorite is the replacement phase south of Cass Corner, and relict hornblende persists at that locality. Excellent euhedral amphibole shapes are preserved in the pseudomorphs in both localities.

The age of the andesite is clearly bracketed by its structural and metamorphic relationships. It is post F_1 since it truncates S_1, but it must pre-date the Porcupine Mountain intrusive. Since F_1 affects rocks as young as Early Devonian in the adjacent Kingsbury Quadrangle, and since the Hartland Pluton has been dated as Middle Devonian (see below), the andesite emplacement date is narrowly restricted.

Granitic rocks: Granitic rocks of the Hartland Pluton and its apophyses on Porcupine Mountain and West of Athens are clearly discordant, have sharp contacts with host rocks of all compositions, and have created well defined contact aureoles in host rocks of low (greenschist facies) regional metamorphic grade. They are thus post-kinematic, shallow crustal (epizonal) rocks.

The Hartland Pluton has an areal extent of approximately 200 km^2, most of which lies within the Skowhegan Quadrangle. It is named, however, for prominent hillside exposures in the town of Hartland in the adjacent Pittsfield Quadrangle. It is an irregular-shaped

mass, somewhat elongate in the direction of regional structural trends. Topographically, the pluton underlies a basinal area within which Great Moose Lake, Barker, Stafford, and Starbird ponds, and several swamps are located. Exposures in this basin are sparse and deeply weathered. A rim of hills bordering the basin are either composites of hornfels and granite (Eaton Mountain; Waite and Talbot hills) or granite from which the hornfels cap has been completely or nearly completely removed (Whittemore, Foster, Tibbetts hills). Roof pendants at the Chase Hill fire tower and the abundance of xenoliths elsewhere indicate that the exposures are of the uppermost portion of the pluton.

The pluton is composed of a variety of buff to light gray weathering, medium to coarse grained (2.5 mm to 2.5 cm), light gray rock which ranges from granite to granodiorite in composition (See Table 1). Most is hypidiomorphic granular, but weakly to very strongly foliated (Chase, Goodwin, Tibbetts hills) and porphyritic (Waite, Chase, Goodwin hills) varieties occur near the margins. Plagioclase phenocrysts up to 4.0 cm long typefy the porphyritic varieties. Foliation is defined by alignment of biotite flakes, tabular plagioclase crystals, and schlieren. Its concentration at the margins of the pluton and absence at the center indicate that it is a primary feature developed during emplacement of a viscous magma. A cataclastic texture--crushed feldspars, sutured quartz, bent and folded biotite--and highly saussuritized and kaolinized feldspars found at Jewell Hill indicate post-crystallization brittle deformation of the pluton.

The mineralogic variation within the Hartland Pluton does not appear to follow any systematic geographic or petrologic pattern. The pluton is composed of hornblende-biotite granite and granodiorite; the muscovite and garnet-bearing lithologies are found only at contacts and probably result from assimilation of pelitic and calcareous xenoliths. Except for the highly altered rocks at Jewell Hill, feldspars are generally quite fresh. Partial deuteric alteration of biotite and hornblende to chlorite is common, but at Jewell Hill replacement by chlorite is complete. Zircon, apatite, and allanite are common accessories.

Late magmatic activity resulted, for the most part, in quartz-rich veins injected into the country rock adjacent to the pluton. Three narrow (up to 10 cm) quartz-feldspar and quartz-feldspar-biotite pegmatite dikes and several fine grained pale pinkish-brown aplite dikes were found near the western margin of the pluton intruding the granitic rocks. Arsenopyrite is concentrated in some of the veins near Waite Hill, and residents of the area near Porcupine Mountain report high concentrations of copper in their well water, but mineralization accompanying the pluton appears to have been minor.

The rocks of the Hartland Pluton intrude folded (F_1) rocks of the Sangerville, Parkman Hill, and Fall Brook formations. K/Ar ages of 356 and 375 m.y. were obtained from biotite in foliated granite on Devil's Head in the Pittsfield Quadrangle, yielding a Mid-Devonian age for the pluton (Faul and others, 1963 ; Hurley in Borns, 1959). This date serves as a control for the age of the Acadian Orogeny in central Maine.

Gravity (Kane and Bromery, 1966), metamorphic, and reconnaisance petrographic data indicate that the Hartland and Belgrade Lakes plutons are probably connected at shallow depth. Both are assigned to the post-kinematic, Middle Devonian New Hampshire Magma Series of Billings (1955).

Basalt: A single 20 cm thick basalt dike is exposed on the southwest bank of the Kennebec River directly opposite the Skowhegan Municipal Building, but is too small to be shown on the map. Despite its small size, the dike has well developed chilled margins and incipient jointing perpendicular to its contents with the Parkman Hill Formation. It is a fine grained, dull reddish-brown weathering, dark gray rock with a few dark green to black phenocrysts.

In thin section, the rock displays an ophitic texture involving laths of labradorite (An70 by Michel-Levy method) and augite. Antigorite pseudomorphs represent euhedral olivine phenocrysts. The olivine is the only altered mineral in the rock, plagioclase and augite being fresh. This suggests a post-metamorphic (contact and regional) origin for the dike, so that it is younger than the Hartland Pluton, but its age cannot be more precisely determined at this time.

METAMORPHISM

Although the stratified rocks of the Skowhegan Quadrangle have been intensely and multiply deformed, the regional metamorphism accompanying the deformations was of low grade, mostly the chlorite zone (lower greenschist facies). Regional grade increases locally toward the northwest and biotite and garnet zone exposures underlie the northwest corner of the quadrangle. An extensive contact metamorphic overprint produced by the Hartland Pluton resulted in extensive recrystallization at the pluton border and clearly controlled the location of the biotite isograd surrounding the granitic rocks.

All of the metasedimentary rock types described above have been subjected to conditions ranging from chlorite to sillimanite grade (greenschist to hornblende hornfels facies), but primary features including fossils are preserved in all but the innermost parts of the contact aureoles. The metamorphic mineralogy, structural styles, and nature of the plutonic/metasedimentary rock contacts indicates a low pressure environment during both regional and contact metamorphism.

Metamorphism has produced high-grade rocks which bear little resemblance to their low-grade protoliths because of significant changes in mineralogy and texture. Some of these have been briefly described in the stratigraphy section. Reaction to the agents of metamorphism will be described by textural and mineralogic changes.

Textural changes: The nature of textural change depends strongly on protolith composition and texture. Coarse clastic rocks (metaconglomerate, metasandstone) display gradual coarsening of the finer grained detrital matrix, but little recrystallization of the large clasts. Clast/matrix boundaries remain distinct until the highest

grade seen, at which point the internal clast textures recrystallize or the clast reacts with the matrix and the boundary disappears. Micritic layers of the ribbon metalimestone undergo significant coarsening of grain size (up to 1.5 cm) with progressive metamorphism and become fine grained marbles in most instances at granite contacts. Pelitic rocks become dense, fine grained hornfelses near the Hartland Pluton, with a few large (3.5 cm) andalusite porphyroblasts developed as at Eaton Mountain.

Foliations parallel to S_1 and S_2 cleavages develop to varying degrees in the different rocks. Muscovite, chlorite, and biotite flakes define a foliation parallel to S1 in most argillaceous metasiltstones and some metalimestones. Flattened clasts in coarser rocks parallel this foliation as well. F_2 folds at Harmony have developed a weak foliation of muscovite and chlorite. Large prismatic porphyroblasts (andalusite in pelitic rocks, wollastonite in calc-silicates) show a planar parallelism, but not a mineral lineation. In the calc-silicates, minerals such as diopside and actinolite are commonly developed at triple junctions between grains of calcite.

Mineralogy: Distinct zones of progressive contact and regional metamorphism have been mapped, and the isograds for pelitic rocks are shown on the map. The observed zonation in pelitic and calcareous rocks is:

PELITIC		CALCAREOUS
Regional	Contact	
chlorite	chlorite	chlorite-muscovite-calcite
biotite	biotite	biotite/ phlogopite
garnet	andalusite	actinolite
	sillimanite	diopside
		grossularite-idocrase
		wollastonite

Pelitic and calcareous lithologies are intimately interlayered in ribbon metalimestones and where calcareous pods occur in argillaceous siltstone beds. In both instances, distinct zoning develops; calc-silicate cores grade outward toward pelitic assemblages in the rims where pods had existed, and compositional banding parallel to original layering forms in the metalimestones.

No distinction is made in the map between contact and regional metamorphic isograds, and the biotite isograds shown are further simplifications of the metamorphic histories. The first appearance of biotite in rocks of the Skowhegan area is brought about by one of several possible reactions. In pelitic rocks, reactions between phengitic muscovite and chlorite probably yield biotite and a less phengitic muscovite. In rocks containing a ferroan carbonate, muscovite and the carbonate react to produce biotite (Ludman, 1975). This latter reaction occurs at lower temperatures than the former, but the

interbedding of ankeritic/sideritic rocks and non-cancareous rocks is on such a fine scale that distinction between pelitic and calcareous biotite isogrades is impossible. Either biotite isograd is marked by a distinctive change in color from greenish gray in the chlorite zone to pale purple in the biotite zone.

Evidence of retrograde metamorphism has been found in the high grade pelitic rocks. Andalusite porphyroblasts at Eaton Mountain are partially to completely replaced by muscovite, and biotite flakes from that locality are partly chloritized.

SUMMARY OF GEOLOGIC HISTORY

1) Continuous deposition from Early Silurian (Late Llandovery) to Early Devonian (?) of a thick pile of essentially turbiditic sedimentary rocks followed Taconic deformation. Most of the sediments were derived from a crystalline source to the west, but some of the eastern facies Waterville rocks may have been derived from an eastern source and the ribbon metalimestone may have been deposited by axial currents from the northeast.

2) These sedimentary rocks were deformed during the main phase of the Acadian Orogeny, with resulting upright isoclinal folds, brittle deformation, and regional metamorphism ranging from chlorite to garnet grade.

3) Small scale (?) fold episodes (F2, F3) further deformed the rocks in what may have been later episodes of the Acadian Orogeny, with weak greenschist facies regional metamorphism possibly accompanying F2.

4) The major plutonism in the area, the emplacement of granitic rocks of the Hartland Pluton, occurred in Middle Devonian time, and was accompanied by extensive contact metamorphism.

5) Some late brittle fracturing affected the crystallized granitic rocks.

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APPENDIX I Description of fossil localities and assemblages in the Skowhegan Quadrangle.

Sangerville Formation

Location: North side of Route 150 just west of jeep trail to Peeks Hill
Lithology: Carbonaceous pelite (Ssr)
Fauna: Monograptus sp. (plain thecae)
Monograptus, sp. (probable hooked thecae)
Monograptus flemingii group (?) (distorted specimens)

Age: Silurian, possibly Wenlockian; if M. flemingii is present, age is Wenlockian.

Parkman Hill Formation

Location: North side of road leading east from major road, approximately 1.5 miles north of West Athens.
Lithology: Carbonaceous pelite interbedded with sulfidic metasiltstones.
Fauna: Monograptus sp. (tubular thecae) similar to M. dubius group
Monograptus sp. (hooked thecae, possibly M. flemingii)

Age: Silurian, possibly Wenlockian.

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MAINE GEOLOGIC MAP SERIES GM-5

GEOLOGIC MAP OF THE SKOWHEGAN QUADRANGLE

BY

ALLAN LUDMAN

1977

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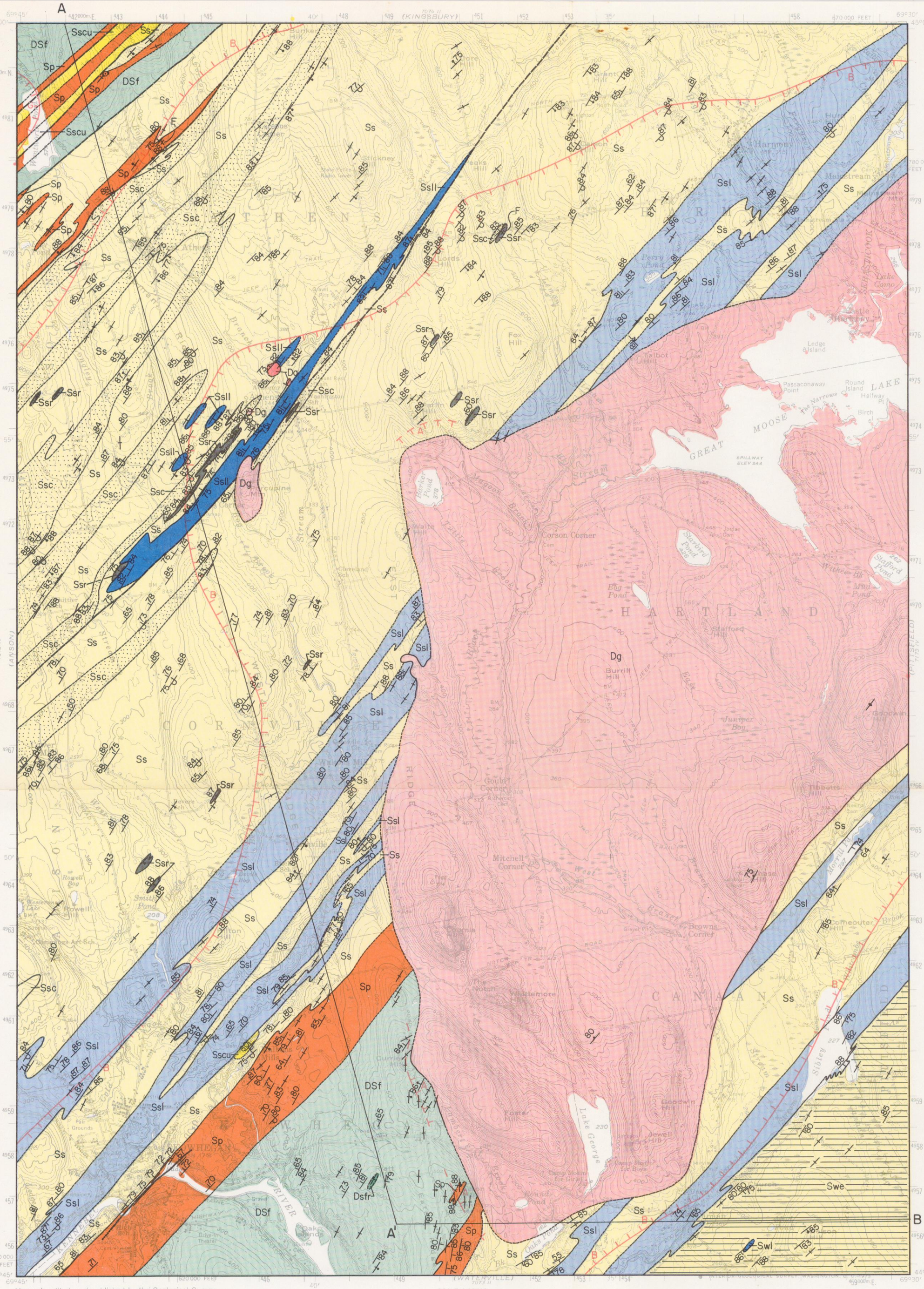


EXPLANATION

PLUTONIC ROCKS

GRANITIC ROCKS OF THE HARTLAND PLUTON

Dg

PRE-GRANITIC HORNBLENDE ANDESITE

Da

STRATIFIED ROCKS

FALL BROOK FM.: CALCAREOUS METASANDSTONES AND CALC-SILICATE GRANOFELS; Dfsr: RUSTY-WEATHERING PYRITIFEROUS CARBONACEOUS PHYLLITE.

DSf

PARKMAN HILL FM.: RUSTY-WEATHERING PYRITE AND PYRRHOTITE-BEARING METASANDSTONES; METASILTSTONES; RUSTY-WEATHERING SULFIDIC HIGHLY CARBONACEOUS PHYLLITES AND SLATES; MINOR GRANULE METACONGLOMERATE.

Sp

SANGERVILLE FM.:

Ss: VARIABLY BEDDED GENERALLY WELL GRADED CALCAREOUS (±ANKERITE) AND DARK GRAY METAPELITE.

Sscu: UPPER POLYMICTIC GRANULE METACONGLOMERATE.

Ssc: LOWER POLYMICTIC GRANULE METACONGLOMERATE.

Ssl, Ssll: UPPER AND LOWER RIBBON METALIMESTONES.

Ssr: RUSTY-WEATHERING SULFIDIC CARBONACEOUS SLATE AND PHYLLITE.

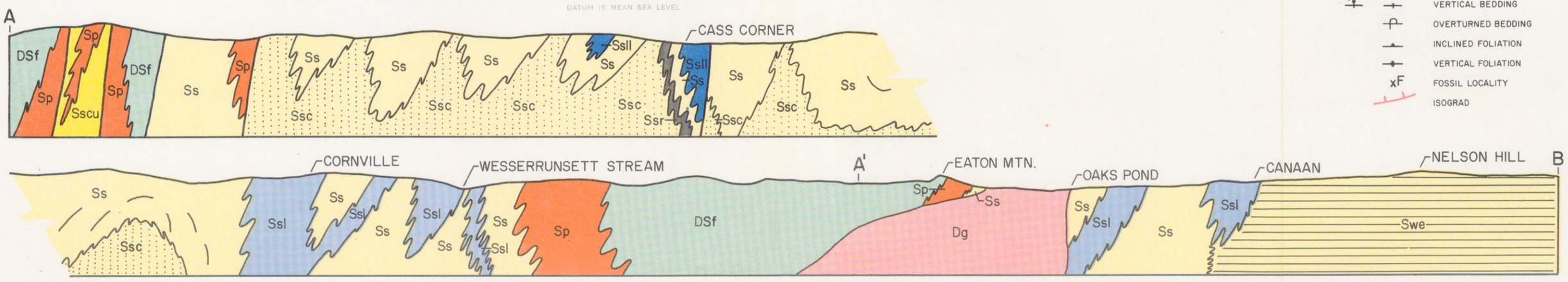
WATERVILLE FM.:

Swe: VERY THINLY INTERLAMINATED METASILTSTONE AND SLATE

Swl: RIBBON METALIMESTONE

DEVONIAN

SILURIAN

SYMBOLS

- OBSERVED ROCK CONTACT
- COVERED ROCK CONTACT
- INFERRED ROCK CONTACT
- OBSERVED FAULT
- COVERED FAULT
- INFERRED FAULT
- DOT INDICATES FACING DIRECTION — INCLINED BEDDING
- VERTICAL BEDDING
- OVERTURNED BEDDING
- INCLINED FOLIATION
- VERTICAL FOLIATION
- xF FOSSIL LOCALITY
- ISOGRAD