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STRATIGRAPHY AND STRUCTURE OF CENTRAL MAINE

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Introduction

The Merrimack Synclinorium broadens from Connecticut to the northeast, reaching a width of over 70 miles in central Maine. The stratigraphy and pre-metamorphic deformational history of the northwest limb were described in detail at the 1970 NEIGC Rangeley meeting (Moench and Boudette, 1970; Moench, 1970). The purpose of our trip is to examine the stratigraphy in the axial region and on the southeast limb of the synclinorium in order to demonstrate Silurian and Early Devonian regional lithofacies patterns for the now greatly compressed sedimentary trough. In view of this purpose, igneous and metamorphic petrology will only be briefly summarized here.

The trip includes stops in the Bangor, Dover-Foxcroft, Kingsbury, Guilford, and Skowhegan 15' quadrangles. All lie in what is generally (unfairly, in our opinion) referred to as the monotonous slate belt of central Maine. Metamorphic grade is for the most part low, ranging from garnet zone in the northwest to chlorite in the central and eastern part of the area. Exceptions are in the highly recrystallized inner aureoles of the four granitic plutons (Fig. 1) in which andalusite, sillimanite, and wollastonite are developed in pelitic and calc-silicate rocks.

Primary sedimentary structures are well preserved and facing indicators are abundant in most units. Graptolites have been found in 25 new localities, some of which will be visited on the trip. Ages suggested by W. B. N. Berry for these fauna provide firm Silurian ages for the lower part of the section, and confirm complex facies relationships for rocks of Llandovery through Ludlow age. Sedimentation was apparently conformable from at least Late Llandovery through Early Devonian times.

Stratigraphy

Central Maine was part of the Central Clastic Belt of Boucot (1968) from Llandovery through Ludlow times, and most units show the lithologies and bedding characteristics of turbidites. Eight units of formation rank are recognized in the area of Figure 1. Fossil and structural evidence indicate the pre-Acadian deformation relationships represented schematically in Figure 2. In this paper, the metasedimentary rocks will be described by their protolith names without the prefix meta-. This is done to avoid awkward wording, and also because primary structures (and in some instances textures) are well preserved. It should be remembered that all rocks have been metamorphosed to at least the chlorite zone. Nomenclature is that currently used by the Maine Geological Survey and includes both formal and informal names.

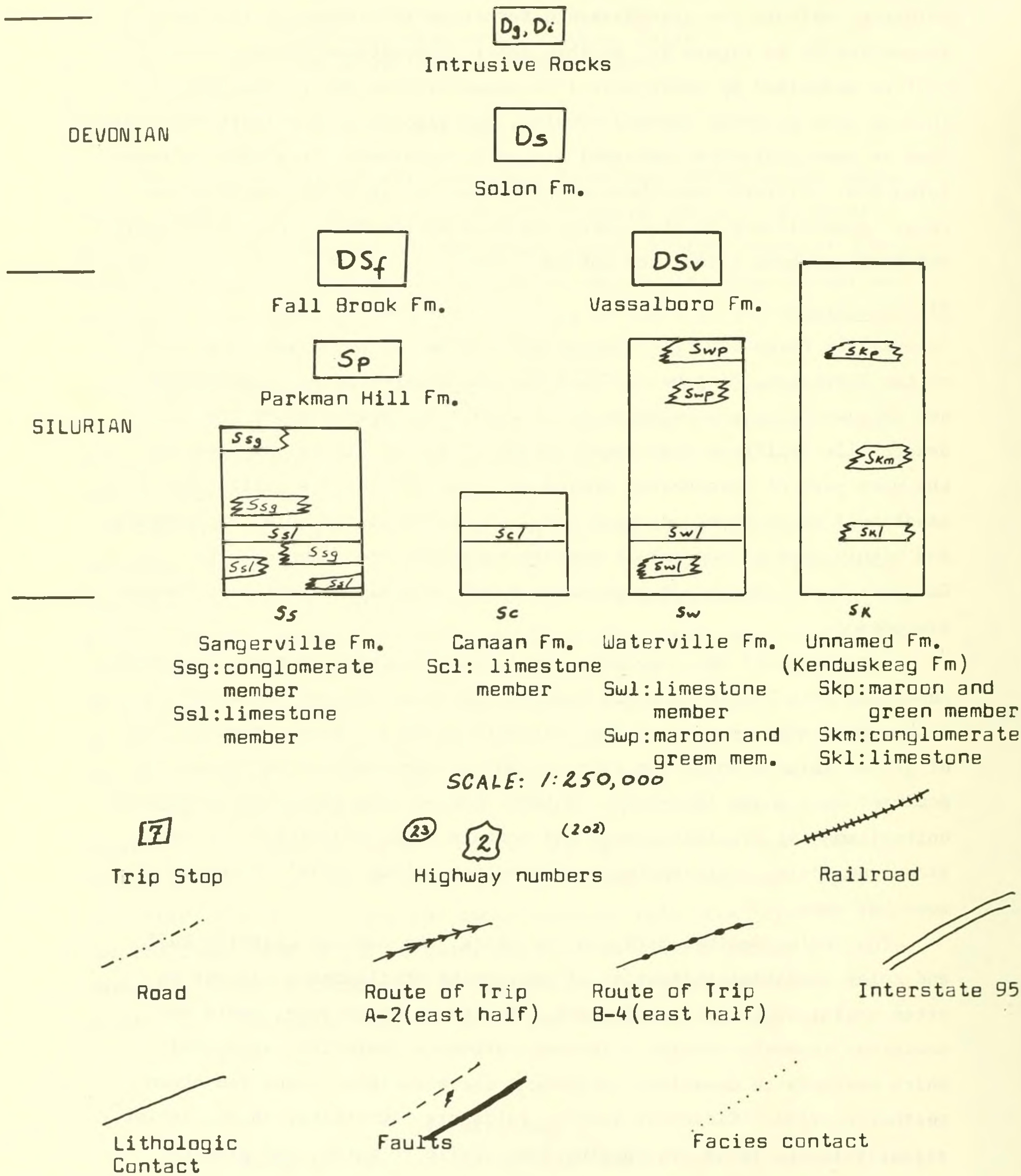
Silurian System

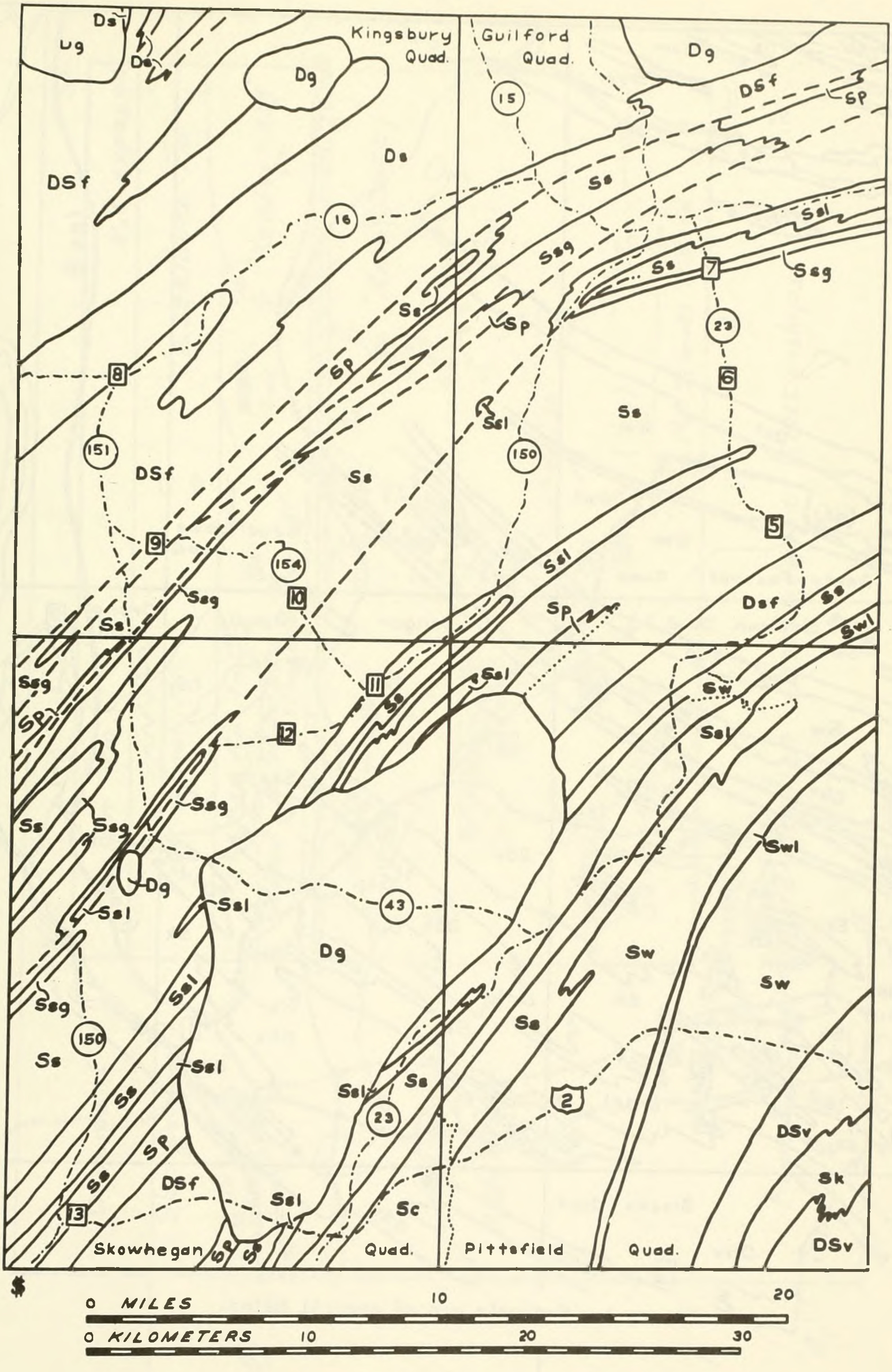
Sangerville Formation: The Sangerville Formation underlies large parts of the Skowhegan, Kingsbury, Guilford, and Dover-Foxcroft quadrangles and is named from exposures on Route 23 between North Dexter and Sangerville (Guilford Quadrangel; Stops 5, 6, 7). It is composed for the most part of interbedded shales and coarser clastics (siltstone, sandstone) of graywacke composition, but limestone, granule conglomerate, and highly carbonaceous shale members have also been mapped. The Sangerville is highly heterogeneous; rapid lateral and vertical changes are common.

Graywacke and shale members (Ss): Well graded sandstone, siltstone, and shale with highly variable bedding thickness and proportion of lithologies make up most of the Sangerville (70%). Most exposures are of graded units 8 cm to 1 m thick in which sandstone and siltstone are dominant over shale (8:1-2:1). Thinner bedded, sometimes interlaminated units (1mm-4cm) are less common and contain equal proportions of sandstone and shale. Soft-sediment deformation (slump folds) is common at some horizons.

The shales weather dark gray to black, the coarser clastics buff, and color gradation indicative of increasing argillaceous content is often useful as a facing indicator. In the chlorite zone, shale and sandstone commonly contain a ferroan carbonate (ankerite, siderite) which weathers to hematite, yielding a characteristic light red-brown weathering rind. Clasts of quartz, feldspars, quartzite, chert, schist, slate, volcanic fragments ranging from sialic to mafic, and granitic hypabyssal rocks have been identified in Sangerville sandstones. These

EXPLANATION FOR FIGURE 1(following pages)




Kingsbury Quad.
Guilford Quad.
Skowhegan Quad.
Pittsfield Quad.
Dg
Ds
DSf
DSv
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0 MILES 10 20
0 KILOMETERS 10 20 30

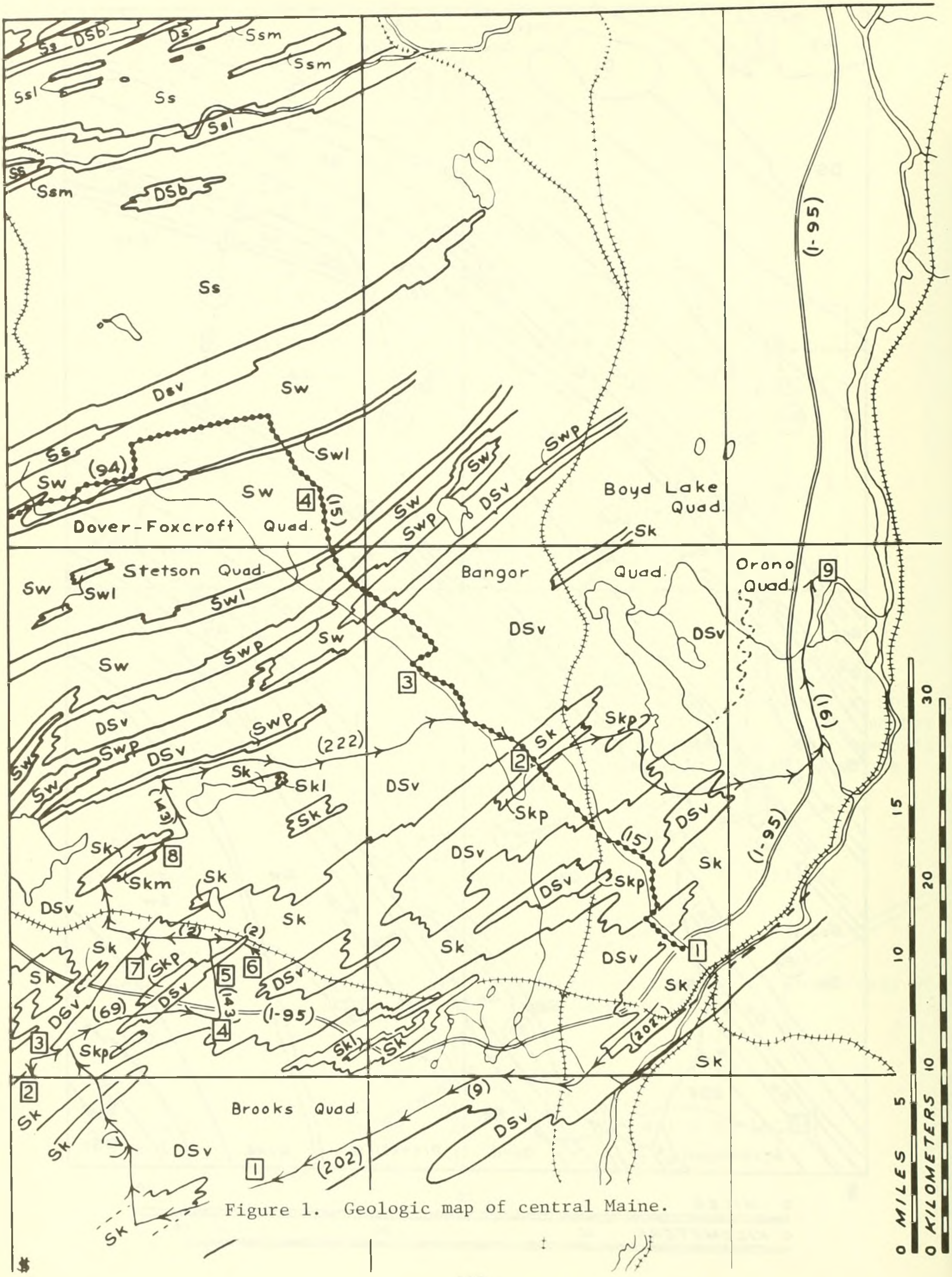

Figure 1. Geologic map of central Maine.

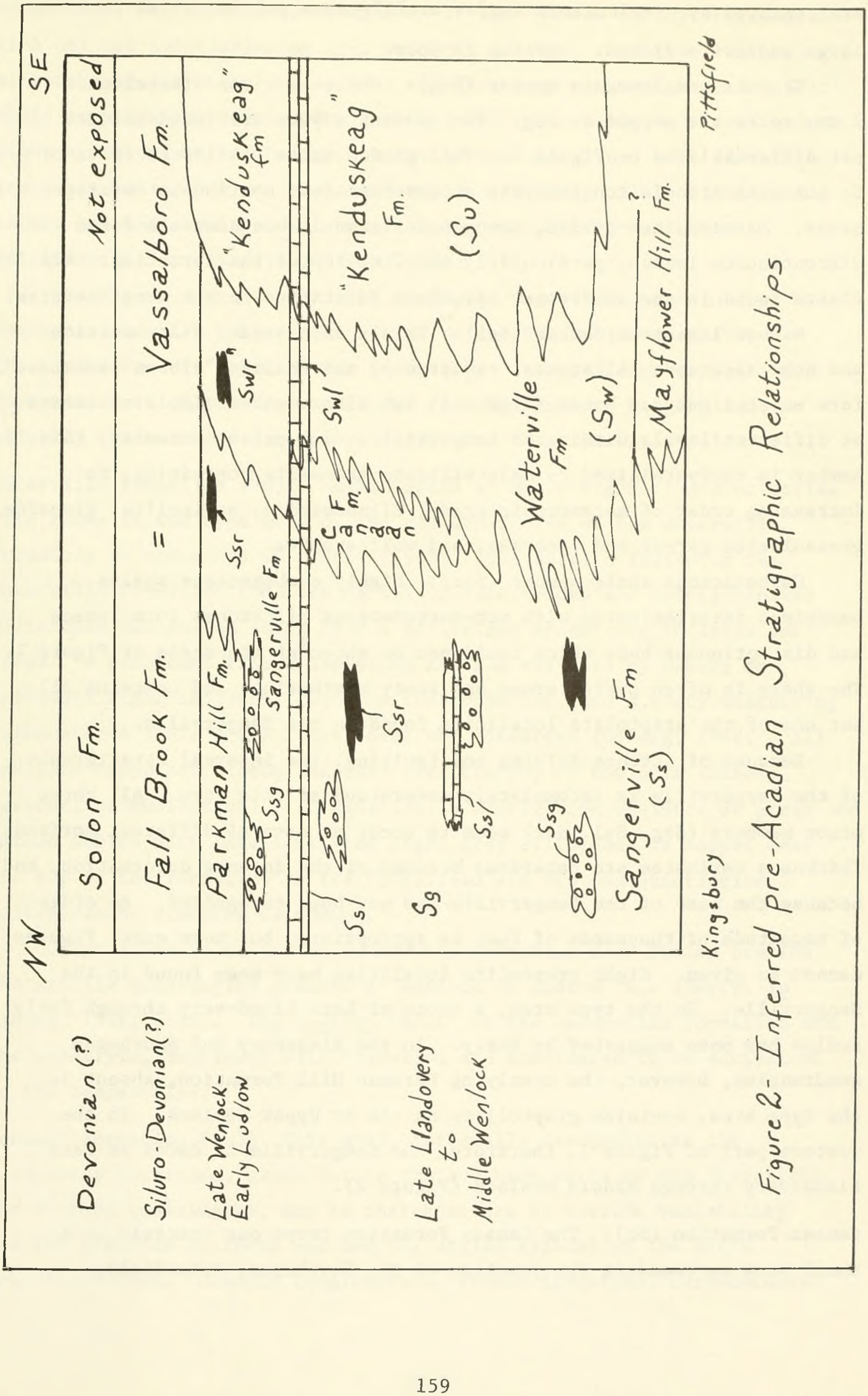

Figure 2- Inferred Pre-Acadian Stratigraphic Relationships

are cemented by a calcareous and/or argillaceous matrix, often with large muscovite flakes. Sorting is poor.

Granule conglomerate member (Ssg): Whenever clast size exceeds 2 mm, rocks are mapped as Ssg. Two bedding styles are found but are not differentiated on Figure 1. Well graded units similar to those of Ss but with granule conglomerate at the base form continuous outcrop bands. Massive, non-graded, homogeneous granule conglomerate forms discontinuous lenses, particularly near the top of the formation. All clasts found in the sandstones have been identified in the conglomerates.

Ribbon limestone member (Ssl): Thinly interbedded silty micrite and non-calcareous siltstones, sandstones, and shales ("ribbon limestone") form several outcrop bands (Figure 1) but also occur as isolated lenses at different levels within the Sangerville. In contact aureoles, this member is recrystallized to calc-silicate granulite containing, in increasing order of metamorphic grade, clinozoisite, actinolite, diopside, grossularite garnet and idocrase, and wollastonite.

Carbonaceous shale member (Ssr): Highly carbonaceous shales, sometimes interlaminated with non-carbonaceous siltstones form lenses and discontinuous beds which could not be shown at the scale of Figure 1. The shale is often pyritiferous and rusty weathering, and contains all but one of the graptolite localities found in the Sangerville.

Because of intense folding and faulting, the internal stratigraphy of the Sangerville is incompletely understood at this time. All three minor members (Ssg, Ssl, Ssr) seem to occur at several different horizons. Thickness estimates are hazardous because of the intense deformation, and because the base of the Sangerville has not been recognized. An order of magnitude of thousands of feet is appropriate, but more exact figures cannot be given. Eight graptolite localities have been found in the Sangerville. In the type area, a range of Late Llandovery through Early Ludlow has been suggested by Berry. In the Kingsbury and Skowhegan quadrangles, however, the overlying Parkman Hill Formation, absent in the type area, contains graptolites as old as Upper Wenlock. In the western part of Figure 1, therefore, the Sangerville is dated as Late Llandovery through Middle Wenlock (Figure 2).

Canaan Formation (Sc): The Canaan Formation crops out sparsely in a small area surrounding the junction of the Skowhegan, Pittsfield, Waterville, and Burnham quadrangles. It consists of thinly interbedded (1-5 cm) and interlaminated (1-5 mm) buff or light red-brown weathering siltstone of graywacke composition and dark gray to green shales. Silt/shale couplets are nearly always well graded, and delicate cross laminations are abundant in the upper parts of the siltstone. The siltstones are quite calcareous and contain ferroan carbonate. Ribbon limestone lenses and beds are abundant but granule conglomerate is absent. Siltstone:shale ratios range from 2:1 to 1:3.

The Canaan interfingers with the Sangerville Formation to the southwest and with the eastern facies of the Waterville Formation to the northeast. It represents a facies type intermediate between these formations; thinner bedded and finer grained than the Sangerville, slightly thicker bedded and more calcareous than the Waterville.

Waterville Formation (Sw): Rocks mapped as Sw in Figure 1 are on strike with those in the type area of the eastern facies of the Waterville Formation as redefined by Osberg (1968). The eastern facies of the Waterville Formation consists of thinly interbedded and interlaminated siltstones and shales which have a pinstriped appearance in large outcrops. A prominent ribbon limestone horizon was used by Osberg to delineate tight isoclinal folds in the formation, and a rusty weathering carbonaceous shale forms lenses near the limestone (Osberg, 1968; p 11) and also crops out discontinuously near the top of the unit (Osberg, personal communication). In addition, a distinctive sequence of green and maroon shales with interlaminated light gray siltstones is mapped near the top of the formation in the Pittsfield and Stetson quadrangles. Soft-sediment slumping is common.

Graptolites found in the Waterville Formation near Benton Station (Waterville Quadrangle) yielded a "Wenlock or Ludlow" age (Berry, <u>in</u> Osberg, 1968; p 33). The <u>western</u> facies of the Waterville Formation and the underlying Mayflower Hill Formation are considered to be equivalent to the Sangerville.

Unnamed Formation (Su): This unit, informally designated as the Kenduskeag Formation, crops out in the southern parts of the Pittsfield and Stetson quadrangles, and is characterized by extreme variability and the presence of rocks and bedding styles typical of the units described above. Granule conglomerate, ribbon limestone, carbonaceous shale, and maroon and green shale are abundant but subordinate to graywacke/shale units with bedding similar to that of the Waterville and Vassalboro (see below) formation. These rock types are interlayered and interfinger irregularly; large outcrops may contain several different bedding styles.

Sedimentary breccias and chaotic zones are more abundant in this formation than in other units, and slump folding is most common here. Some of the coarser lithologies contain a high proportion of volcanoclastic debris, and some of the finer beds may be ash fall deposits.

Age and thickness are unknown at this time. The Kenduskeag is correlated with the Waterville and Sangerville formations, but may be somewhat younger in part (Figure 2).

Parkman Hill Formation (Sp): In the western part of Figure 1, the Sangerville is overlain by the distinctive rusty-weathering Parkman Hill Formation named by Pankiwskyj (in press) for exposures in the Anson Quadrangle. Over 60% of the formation consists of carbonaceous sulfidic shale interlaminated with non-carbonaceous, sparsely sulfidic siltstone and sandstone. Thick bedded (10-35 cm) sulfidic quartzose sandstones and non-sulfidic sandstones are also abundant, and are much less argillaceous than the comparable-sized clastics of the underlying Sangerville. Sulfidic granule conglomerate (somewhat more quartzose than the Sangerville varieties) and ribbon limestone are present, particularly near the top of the formation.

The Parkman Hill Formation thins to the east and interfingers with the Sangerville in the Guilford and Pittsfield quadrangles. In its stratigraphic position are discontinuous lenses of rusty-weathering carbonaceous shales (Waterville, Guilford, Dover-Foxcroft quadrangles) or the maroon and green shale of the Waterville Formation (Stetson, Pittsfield quadrangles). A maximum thickness of 300 m is suggested by Pankiwskyj (in press) for the western part of Figure 1. Well preserved graptolites yield Late Wenlock through Early Ludlow ages for the Parkman Hill Formation in the Kingsbury and Guilford quadrangles.

Siluro-Devonian(?)

Fall Brook Formation (DSf): The Fall Brook Formation was defined by Pankiwskyj (in press) as a series of generally thick-bedded calcareous sandstones with subordinate shales which lies above the Parkman Hill

Formation. The Fall Brook is divided here into three members, two of which will be seen on the trip. These members are not distinguished on Figure 1.

Thick bedded sandstone: Most of the Fall Brook consists of thick beds (20 cm - 2 m) of slightly calcareous sandstone and siltstone. Shale is an extremely minor component of this member. Outcrops appear massive but thin shale partings may be seen on fresh surfaces. Graded bedding is only rarely developed. Some highly calcareous layers weather rapidly and give a ribbed appearance to outcrops. At biotite grade and above, calc-silicate pods, stringers, and beds are common, and the formation has a light violet color due to finely disseminated biotite flakes. In unstained thin sections the sandstones seem to consist of well-sorted quartz grains in a biotite-calcite matrix. Muscovite is rare. Stained sections of the sandstone reveal up to 25% untwinned plagioclase feldspar in some specimens.

Thinly interbedded sandstone and shale: In several thin horizons within the Fall Brook, sandstones are thinly interbedded (up to 6 cm) with shale in graded sets. These sandstones are less calcareous than those of the massive member, and contain considerably more muscovite. The shale, at biotite grade and above, is typified by large (2 mm) poikiloblasts of biotite.

Transition member: The top of the Fall Brook consists of a series of well graded sandstones and shales in beds 10-30 cm thick. Feldspars and rock fragments up to 2 mm are found at the base of the graded sets, and scour-and-fill features are common. Calc-silicate beds and pods are abundant. Sandstone:shale ratios of 5:1 in these beds gradually diminish upwards and the beds thin. This gradation continues into the gray, dominantly shale base of the overlying Solon Formation.

Fossils have not been found in the Fall Brook Formation. It overlies the Early Ludlow fossils of the Parkman Hill and Sangerville formations and is definitely older than the Devonian(?) Solon Formation. A Siluro-Devonian age (Late Ludlow through Early Devonian) is assigned and a thickness of approximately 1,000 m is suggested.

Vassalboro Formation (DSv): Rocks very similar to those of the Fall Brook Formation and which lie above the Waterville and Sangerville formations in the Pittsfield and Stetson quadrangles are on strike with the type locality of the Vassalboro Formation as defined by Osberg (1968).

Bedding style, lithology, and thickness as described by Osberg are similar to those of the Fall Brook, but most Vassalboro outcrops are seen at lower metamorphic grade (chlorite) than the Fall Brook (biotite, garnet).

Devonian(?) System

Solon Formation (Ds): The youngest sedimentary rocks in the area of Figure 1 are the shales and rhythmically interbedded sandstone/shale graded sets of the Solon Formation, first named by Pankiwskyj (in press). The Solon is restricted to the northern part of the map area, presumably having been removed by erosion from the synclinal structures to the south.

The lowest part of the Solon is a dark gray silty shale with minor lighter gray weathering beds of siltstone which are commonly sheared and strung out along cleavage surfaces. These shales alternate with rhythmically interbedded light gray sandstones and shales above the base of the formation.

Poorly preserved brachiopods have been found in the Greenville Quadrangle in rocks mapped continuously with the Solon (Espenshade and Boudette, 1964; 1967). An Early Devonian age was suggested for these fauna and is assigned to the Solon.

Regional Correlation and Interpretation of Sedimentation

Correlation with the stratigraphy of the western limb of the Merrimack Synclinorium in Maine (Moench, 1970; Moench and Boudette, 1970) is shown in Table 1. The correlations are essentially those suggested by Osberg, Moench, and Warner (1968) but have the benefit of the recently discovered graptolite based ages.

Interpretation of regional lithofacies patterns shows that the filling of the original sedimentary trough was accomplished in two distinct stages. These are discussed here as the Llandovery-Early Ludlow and the post-Early Ludlow, although Ordovician metasediments almost certainly lie beneath the Sangerville.

Llandovery-Early Ludlow: The correlative Rangeley+Perry Mountain--Sangerville-Waterville formations are interpreted as proximal, intermediate, and distal turbidites respectively, derived from a geanticlinal terrain to the west and transported downslope to the east.

Table 1: Regional correlation in the Merrimack Synclinorium, Maine

	WNW		ESE
Devonian(?)	Seboomook Formation	Solon Formation	---
Siluro-Devonian	Madrid Formation	Fall Brook Formation	Vassalboro Formation
SILURIAN	Smalls Falls Formation	Parkman Hill Formation	
	Perry Mountain Formation	Sangerville Formation	Waterville Formation
	Rangeley Formation		Mayflower Hill Formation

Comparison of thickness estimates and grain sizes of equivalent units shows that formations thin and grain size decreases toward the east. What little faunal evidence is available supports the paleoslope inference, and indicates a bathyal to abyssal environment (Griffin, 1973). Bedding thickens and grain size increases again in the Kenduskeag to the east. An eastern source area, presumably the Silurian coastal volcanic terrain of Gates (1967) is inferred for this formation. The eastern third of Figure 1 lay at or near the axis of the original sedimentary trough and shows the interfingering of sediments derived from both east and west. Reduction of the western source area led to the deposition of the generally fine grained Smalls Falls and Parkman Hill formations in an euxinic environment.

Post Early Ludlow: The environments of deposition described above and characterized by rapid lateral lithologic variations were abruptly ended by deposition of an apparently homogeneous thick blanket of sandstone (Madrid-Fall Brook-Vassalboro), followed by a thick turbidite sequence (Seboomook-Solon) in which direction of sediment transport is difficult to interpret. This interruption may have been due to uplift associated with the Ludlovian Salinic Disturbance (Boucot, 1968).

Structure

Outcrops in central Maine are characterized by northeast strikes and vertical and near-vertical dips. The rocks have been subjected to intense polyphase deformation--folding of four generations and faulting--and intrusion by granitic plutons. Folds seen in outcrop may be attributed to one of the four stages of tectonic deformation or to soft-sediment slumping.

Slump Folds

Slump folds are tight isoclinal folds of small scale (2.5 cm - 1.5 m wavelength). Larger scale slump folds may be present but cannot be demonstrated due to limitation of outcrop size. Slumps occur as right laterally asymmetric anticline-syncline sets restricted to a narrow stratigraphic horizon and bounded by "undisturbed" beds. The folded horizon is commonly separated from confining beds by a sedimentary decollément at the base and a welded contact at the top. The rocks deformed plastically, presumably while still partially saturated with water, and large folded fragments in sedimentary breccia are common. The slump folds have been rotated into the vertical position by the first major tectonic deformation, and have been cut by cleavages associated with the tectonic folds. Typical features of slump folds are shown in Figure 1 of Trip A2, this volume.

Tectonic Folds

Four stages of tectonic folding (F_1, F_2, F_3, F_4) are recorded in central Maine, but the first was the most important.

F_1 folding was responsible for the major fold axes and tight isoclinal minor folds in central Maine. Despite the vertical nature of most beds, it is thought that the large scale folds (10-20 km wavelength) are relatively open structures. Small scale folds include those with wavelengths of 120-370 m and .3-2 m. The 120-370 m wavelength folds can often be traced across several quadrangles. This fact, the parallelism of fold limbs over 10's of kilometers, and the generally gentle plunges of minor fold axes indicate that the regional structures are gently (doubly) plunging. An axial plane cleavage is associated with F_1 folds, and the larger clasts have their longest axes aligned parallel to this cleavage. Response to F_1 deformation is dependent on rock type. Ribbon limestones and thinly bedded silt/shale sets are extremely tightly folded with very sharp hinges while thick bedded sandstones and granule conglomerates have blunt hinges and are somewhat more open. Shearing has removed the hinge areas of many F_1 folds so that opposing limbs are juxtaposed along the shear surface. In many such instances, the west-facing limb of the fold has been shortened. The F_1 folds are truncated by Middle Devonian granitic plutons and are considered to be the result of the main phase of the Acadian Orogeny.

The map pattern shown in Figure 1 is dominated by a sinusoidal change in regional trend from N30E in the west, through N70-80E in the central part, to N50E in the east. This is the only mappable expression of F_2 folding. Most F_2 folds are small scale features (5-20 cm wavelength). In the eastern part of Figure 1, two conjugate folds are attributed to F_2 deformation. Folds with vertical axial surfaces (F_{2v}) are most abundant; folds with horizontal axial surfaces (F_{2h}) are subordinate, possibly because most outcrops are two-dimensional pavements. F_2 folds are best developed in thin-bedded rocks (ribbon limestones, Waterville-type pinstriped rocks). A strongly penetrative axial plane fracture cleavage (N10E-N10W) associated with F_{2v} is well developed, however, in thicker bedded rocks. This cleavage is nearly parallel to F_1 cleavage in the west, but is nearly perpendicular to it in the central and eastern parts of the map area. Plunges of F_{2v} folds are moderate to steep (40-80°). In the Stetson Quadrangle, F_2 folding is clearly post-metamorphic. It is thus post-major Acadian deformation but may be due to some later phase of that orogeny.

Small scale open warping of F_2 and F_1 folds is visible in some large outcrops and is designated as F_3. Axial planes of these folds trend N60-70W and plunges are steep. Axial plane cleavage is not well developed, but the most common joint set parallels the axial trend.

A set of east-west trending, generally left-lateral kinks which can be observed in the thinner bedded lithologies in the eastern part of Figure 1 is the last product of folding in the area and is designated as F_4. F_4 folding has not been observed in the western part of the area.

Faults

Intense shearing occurs in the northwestern part of Figure 1. High angle faults are mapped by the presence of gouge, silicified breccias, mylonite, outcrops consisting entirely of vein quartz, and by sharp discontinuities in map trends of stratigraphic units. The faulting was a brittle phenomenon; sandstones are badly shattered and injected with veins of quartz and calcite. Displacement and age of the faulting are not fully understood at this time. Movement in most cases appears to have been dip-slip with the northwest block downdropped. In some cases, slickensides suggest strike-slip movement and map patterns suggest right-lateral movement.

F_1 folds are truncated by the faults, but the relationships between the shearing and the later fold episodes are unclear. Intrusion of the Porcupine Mountain apophysis of the Hartland Pluton (Skowhegan Quadrangle) seems to post-date faulting; in this case, faulting should be pre-contact metamorphism. F_2 folds, however, are post-metamorphic and do not seem to be disturbed by the faulting.

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Itinerary

Mileage	
	Meet in parking lot behind the Mammoth Mart on Harlow St. (immediately west of U.S. Post Office). Trip will assemble near the Morse Covered Bridge.
0	Upon leaving the parking lot turn left and drive west on Harlow St.
0.2	Bridge over Kenduskeag Stream.
0.3	Pull over to right and park on shoulder of road.
	Stop 1. "Kenduskeag formation". Sequence of massive fine-grained quartzite beds one to two feet thick interbedded with thin alternating layers of phyllite and coarse metasiltstone. The latter are ¼ to ½ inch thick. Sedimentary breccia, possible slump folds, tight isoclinal folds (F_1), small-scale horizontal folds (F_2), and minor shears (S_5) can be observed.
	Return to vehicles and proceed northwest on Harlow St.
0.5	Bear left (south) at "Y" onto Fourteenth Street.
0.9	Stop sign. Turn right (NW) onto Ohio Street.
1.1	I-95 Overpass. Continue straight.
2.4	Stop sign. Turn right (NE) onto Griffin Road.
2.5	Bridge over Kenduskeag Stream. Outcrop of "Kenduskeag formation" to right (S).
2.7	Blinking yellow traffic light. Turn left (N) onto Kenduskeag Road.
4.3	Stop sign. Turn left (W) onto Route 15 North (Broadway St.)
5.7	Bridge over Kenduskeag Stream at Six Mile Falls. Outcrops of "Kenduskeag formation" to right in stream.
6.5	Bangor & Aroostook Railroad overpass. Outcrop at left (S) is "Kenduskeag formation", intruded by a plagioclase granulite dike.
9.4	Bridge over Kenduskeag Stream. Park on right shoulder by trailer camp. The outcrop to be viewed is under the bridge.

Stop 2. Maroon and green phyllite member of "Kenduskeag formation".

Sequences of maroon and green phyllite and coarse meta-siltstone with beds ½" to 1" thick occur in both the "Kenduskeag formation" and the Waterville formation.

Graded beds and left-lateral kink bands (F_4) are present. Trace fossils have been found in this lithology although as yet none have been observed at this outcrop.

Return to vehicles and continue north on Route 15.

10.2 Outcrop of "Kenduskeag formation" on left (SW).

12.3 Outcrop of "Kenduskeag formation" on left in Kenduskeag Stream.

12.5 Town of Kenduskeag. Gas available.

13.4 Road runs along top of esker here.

13.8 Bear left (west) onto side road at "Covered Bridge" sign.

15.4 Turn sharp left (south).

15.7 Robyville Covered Bridge (1876).

Drive through bridge and park on shoulder of road. The outcrops to be viewed are on the south bank of the stream, west of the bridge.

Stop 3. Vassalboro formation.

Massive fine-grained quartzite in beds 2 to 3 feet thick. Some of the beds are graded, and are phyllitic at the top. Tops are to the south.

Turn around and drive north on the dirt road.

16.2 Five-way intersection. Take second road to right and proceed east.

17.3 Intersection with Route 15. Turn left (north). Esker.

18.2 Corinth Knoll Picnic Area.

19.2 Outcrops of Waterville formation on both sides of road.

22.4 Town of East Corinth. Gas available. Continue on Route 15.

24.0 Small outcrops of "ribbon lime" in fields on either side of road.

24.1 Intersection with Route 11. Continue on Route 15. View of Charleston Ridge on horizon ahead. The ridge is underlain by Vassalboro formation.

25.9 Park on shoulder of road at top of hill. View of Charleston Air Force Base ahead.

<u>Stop 4</u>. Waterville formation.
Thin alternating phyllite and metasilstone layers 1/8" to 1/4" thick.

Isoclinal folds (F_1) and axial plane cleavage (S_1) are present. Some of the isoclinal folds are probably of slump origin and there may be a sedimentary decollement present (see Griffin and Lindsley-Griffin, Trip A-2). Both horizontal and vertical folds (F_2) and their associated fracture cleavages (S_2) may also be seen.

Return to vehicles and continue north on Route 15.

27.3 Outcrop of Waterville formation on right (east).

27.5 Town of West Charleston. Turn left (west) onto side road.

29.4 Outcrop of Waterville formation on right (north).

29.9 Road crosses an asker.

30.2 Outcrop of Waterville formation on left (south).

31.6 Outcrops of Waterville formation on both sides of road.

32.3 Intersection. Turn left (south).

32.3 Outcrops of Waterville formation.

33.3 Intersection. Town of Garland. Turn right (west) onto Route 94 West.

33.4 View of Garland Pond to left (south). "Ribbon lime" member of Waterville formation exposed on shore.

34.3 Outcrop of Waterville formation on right (north).

39.3 Just beyond bend in Route 94 bear right onto dirt road by Puffers Pond.

39.6 Outcrop of ribbon lime on right (east).

39.9-40.4 Small outcrops of Waterville formation on both sides of road.

40.4 Contact with "Sangerville formation".

40.6 Intersection with paved road. Turn right (east).

40.9 At "Y" bear right. Park off road.

<u>Optional Stop A</u>. Waterville-"Sangerville" contact.
Outcrops of "Sangerville" and Waterville formations separated by an 80' covered interval.

Northern outcrop: "Sangerville formation". Well-graded, fine-grained, quartzite beds 6" to 1' thick with black phyllite tops 2" to 3" thick. Tops are to the north.

Southern outcrop: Waterville formation. Thin-bedded alternating phyllite and metasiltstone layers ½" thick.

Turn around at Dexter Dump and return eastward along road.

41.5 Intersection with dirt road. Continue straight. Remain on Main Street to stop light.

42.1 Traffic light in Dexter. Turn right (north) onto Route 7.

42.4 Turn left onto Route 23 (Dam Street). Cross Maine Central Railroad tracks and bear right on Route 23.

42.8 Outcrop of "Sangerville formation" on left (west).

42.9 Lake Wassookeag. Continue straight.

44.0 "Y" intersection. Remain on Route 23.

44.9 Outcrops of "Sangerville formation".

45.2 Outcrops of "Sangerville formation".

45.8 Park off road in parking lot.

Stop 5. "Sangerville formation" and rusty-weathering phyllite member.

Fine-grained calcareous quartzite, with graded beds, cross-laminae, and possible sedimentary breccia.

Northeast-plunging disharmonic isoclinal fold (F_1), and axial plane cleavage (S_1) are present.

Ninety feet to the south is a small roadcut outcrop on the east side of Route 23 of black carbonaceous phyllite with well-developed axial plane cleavage (S_1). Weathered surfaces are rusty-colored due to weathering of pyrite.

Graptolites collected from this locality have been identified by W.B.N. Berry (pers. comm. to Griffin, 1967, 1970). The fauna consists of:

Cyrtograptus ? sp.
Monograptus praedubius ?
Monograptus sp. (of the *M. dubius* group)
Monograptus sp. (in the *M. priodon*--*M. flemingii* group--possibly *M. flemingii*.

Berry (pers. comm., 1967) states that the age is "In the span of Late Llandovery--Wenlock. If the *M.* sp. in the *M. priodon*--*M. flemingii* group is indeed *M. flemingii* then this collection would indicate a Wenlock age."

Continue north on Route 23.

46.1 Outcrops of "Sangerville formation".

46.7 Bridge over stream at North Dexter. Outcrop of "ribbon bon lime" in stream.

47.4-47.6 Outcrops of "Sangerville formation" along road.

47.8 Outcrop of "Sangerville formation". Bedding is near-horizontal here because it is at the crest of a major fold (F_1). Outcrop also affected by second folding (F_2).

48.9-49.3 Outcrops of "Sangerville formation" along road. Good graded bedding visible.

49.5 Park on shoulder of road just before the top of the hill.

Stop 6. "Sangerville formation".
Fine-grained calcareous quartzite, well-graded, with black phyllitic tops. Beds are 6" to 3' thick, phyllite layers are 2" to 10" thick. Tops are to the south.

This is a typical outcrop of the "Sangerville formation". Axial plane cleavage (S_1) and a fracture cleavage (S_2) are present.

Return to vehicles and proceed north on Route 23.

49.8-50.4 Outcrops of "Sangerville formation".

50.6 Pleasant Acres Picnic Area.

Continue north on Route 23.

51.4-51.7 Outcrops of "Sangerville formation".

51.8 View of Piscataquis River Valley; Manhanock Pond to left.

Just beyond Sangerville town line sign, park on shoulder of road.

Stop 7. Polymictic granule conglomerate member of the "Sangerville formation".
Consists of thick beds (here 10'), sometimes graded, of quartz, feldspar, and phyllite chips.

Continue north on Route 23.

52.1 Outcrop of polymictic conglomerate on left (west).

53.0 Town of Sangerville. Outcrops of "ribbon lime", coarse quartzite, and calcareous quartzite in Carlton Stream north of bridge.

Proceed north through town on Route 23.

53.4 Piscataquis River.

53.5 Bear left at "Y" onto Route 16. For the next 2.2 miles, outcrops are "Sangerville formation".

54.8 Turn left, remaining on Route 16, and cross the Piscataquis River.

54.9 Turn right, drive west on Route 16.

55.7 Senior Citizens Home; the flagpole in the yard is set in an outcrop of polymictic conglomerate.

58.5 Town of Abbot Village. Cross the Piscataquis River and remain on Route 16. Outcrop of "Fall Brook formation" visible in river.

58.6 Turn left on Route 16 to Bingham.

61.9 Side road on left, immediately followed by outcrops of "Solon formation".

62.5 Bridge over Thorn Brook, a tributary of Kingsbury Stream.

65.0 Outcrop of "Solon formation" on right.

70.3 Kingsbury Center. Remain on Route 16.

70.5 Kingsbury Pond picnic area.

71.1 Mayfield town line.

72.9 Turn left on Route 151 and park.

Stop 8. Contact between Fall Brook and Solon formations

Start traverse on north side of Route 16 at culvert and walk west on Route 16. Metamorphic zone is garnet, highest grade seen on the trip.

Calcareous biotite-metasandstone with rare pelitic partings representative of typical Fall Brook metasandstone passes upward (to the west) into well graded metasandstone, metasiltstone, and phyllite with garnetiferous calc-silicate granulite layers and pods. Abundant facing indicators (graded beds, scour and fill, load phenomena) show that tops are toward the northwest. Bedding thins and pelite becomes more abundant to the northwest.

Cross to south side of road at break in outcrop and continue west.

First outcrops on south side of Route 16 are typical gray phyllites of the Solon Formation, with minor light gray metasiltstone laminae and disrupted laminae. The mineral assemblage in the phyllites here is muscovite-biotite-garnet-chloritoid-quartz-plagioclase. Chlorite is present as a retrograde product from chloritoid and garnet.

Cleavages associated with both F_1 and F_{2v} are well developed in the Solon phyllites, less well displayed in the Fall Brook, and cleavage/cleavage lineations are prominent.

Return to cars and continue south on Route 151

74.6 Poor outcrop of Fall Brook sandstones on right

76.8 Brighton center; turn left (east) onto Route 154 toward Wellington

77.3 to 78.0 Small outcrops of Fall Brook to left

78.8 Cross outlet of Trout Pond

78.9 Stop 9: Parkman Hill Formation; park on right shoulder.

Several Parkman Hill lithologies are visible here. Poorly preserved fragments of monograptids from this locality have been assigned a Silurian (?) age by W.B.N. Berry. Rock types include:

Highly carbonaceous pelite and intercalated sulfidic metasiltstone. Pyrite stringers are parallel to cleavage. Rusty weathering illustrated here is typical of the formation.

Non-sulfidic metasandstone and finely interlaminated pelite and metasiltstone are interlayered with the "rusties" and are clearly distinguished by a lack of the characterstic weathering.

Minor sulfidic quartzose metasandstone occurs in beds 8cm thick.

Continue east on Route 154. If time permits, log from 79.6 to 82.1 will be followed. If not, continue on Route 154.

79.6 Turn right at fork onto dirt road.

79.7 Pass outcrops of medium bedded Sangerville metasandstones.

79.8 Pass rusty-weathering Parkman Hill carbonaceous pelites containing well-preserved monograptids indicative of Early Ludlow-Late Wenlock age.

80.2 Cross excellent pavement outcrops of Sangerville turbidites.

80.5 Entrance to field on right; small fault slice of Parkman Hill Fm.

81.5 Turn left onto dirt road. Pavement outcrops are of thinly interlaminated pelite and siltstone of the Sangerville Fm.

82.1 Turn right onto Route 154.

83.0 Pass Sangerville metasandstones in roadside and stream outcrops to right.

83.2 Wellington; turn right (south) toward Harmony.

83.9 Pass chlorite zone Sangerville metasandstone and pelite on right.

85.4 Stop 10: Small pavement outcrop of Sangerville Formation metasandstone and pelite in the chlorite zone. Sandstones and pelite here are highly ankeritic; weathering of ankerite to hematite produces typical reddish brown spotted appearance of Sangerville in the chlorite zone.

Deformation in the sandstones appears to be soft-sediment slumping modified by tectonic shearing.

Continue south on Route 154.

88.2 Junction with Route 150. Continue across 150 bearing slightly to the right.

88.5 Bear right into Harmony center; park in front of Barber Salon on the right.

Stop 11: Walk north into Higgins Brook and climb to extensive exposures of Sangerville ribbon limestone at the Harmony dam.

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Three generations of folds (F_1, F_2, F_3) are clearly visible, with marker beds of feldspathic metasandstone and boudinaged quartz veins being extremely helpful in outlining the folds.

Extremely tight isoclinal folds with vertical axial surfaces (F_1) trend N40E, essentially parallel to the spillway of the dam. F_1 cleavage is well developed in the micrite layers of the limestone.

F_1 isoclinal folds are refolded by N10E trending right-handed asymmetric minor folds visible across the entire outcrop but best displayed by a feldspathic metasandstone bed near the dam. F_2 cleavage is well developed in both micrite and sandstone beds. Both F_1 and F_2 cleavages are filled with quartz and calcite.

F_3 is represented by open warping best illustrated by the quartz vein close to the dam. Joints at the outcrop are parallel to the N65W axial trend of the warps.

Continue west on road, across Higgins Brook and uphill.

88.9 Turn left (west) onto Route 150

90.4 Pass outcrops of Sangerville sandstone and pelite on right.

91.7 Pass Athens town line and park.

Stop 12: Badly fractured Sangerville sandstone and pelite is on strike with Stop 10, but is at biotite grade here. Ankerite is replaced by prograde pseudomorphs composed of biotite, muscovite, and quartz. Graded bedding is clearly visible.

F_1 axial plane foliation in the pelites is clearly out by by the F_2 cleavage, best illustrated at the top of the outcrop.

Continue west on Route 150

92.0 Pass graptolite-bearing (possibly Wenlock) highly carbonaceous pyritiferous pelite in the Sangerville associated with massive granule conglomerate to west.

94.3 Pass Sangerville sandstone and pelite on left

96.2 Junction with Route 151; bear left into Athens

96.4 In Athens center at junction with Route 43. Bear Right on Route 150 towards Skowhegan.

96.5 Cross Wesserunsett Stream. Excellent Sangerville ribbon limestone to left and about 25-100 yards upstream. Sangerville sandstones just upstream of bridge, carbonaceous pelite and granule conglomerate downstream.

96.5 Route 150 swings to right; hill at 11 o'clock is Porcupine Mountain apophysis of the Hartland Pluton.

97.3 Calc-silicate hornfels in Porcupine Mountain aureole.

98.4 Junction with Route 43; continue south on Route 150

98.9 Sangerville siltstones and pelite cut by small andesitic dike under the powerline at left.

99.9 Sangerville sandstones and pelites in fields to both sides of road

105.2 Sangerville ribbon limestone on hillside to left.

107.5 Bear left at intersection north of Skowhegan center.

108.3 Junction (unmarked) with Route 2 near center of Skowhegan. Turn left (east) onto Route 2.

109.0 Park opposite gas station and walk on path to Great Eddy of the Kennebec River. Beware of the poison ivy.

Stop 13: Contact between Sangerville and Parkman Hill formations.

The uppermost Sangerville rocks here are medium to thin bedded metasandstones and phyllites in well graded and strongly laminated units reminiscent of the uppermost rocks of the Perry Mountain Formation at Smalls Falls (Moench, and Boudette, 1970). Large prograde pseudomorphs after ankerite are prominent in the pelite. Calcareous pods (not yet calc-silicate) are abundant near the top of the Sangerville.

Parkman rocks here include carbonaceous pelite and thin beds of sulfidic metasiltstone. Sulfied (pyrite and pyrrhotite) occurs as blebs elongated parallel to F_1 cleavage in the pelite and siltstone. Massive sulfidic and non-sulfidic quartzose sandstones of the Parkman Hill Formation are exposed 0.1 mile to the east on Route 2.

Trip ends here. To rejoin Route 95 south, make a U-turn and drive back to Skowhegan. Drive past the intersection with Route 150 at the post office and follow signs to Route 201 south. Take 201 south until entrance to Interstate 95.

To return to Orono, continue east on Route 2 to Newport, then follow signs to entrance to Interstate 95 NORTH to Orono.