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Title: Reconnaissance Bedrock Geology of the Sherman, Mattawamkeag, and Millinocket 15' Quadrangles, Maine

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Contents: 18 page report and 3 maps

INTRODUCTION

Reported here are the results of reconnaisance bedrock mapping in the Sherman, Mattawamkeag, and Millinocket quadrangles in Aroostook and Penobscot counties, Maine (Figure 1). This mapping is part of a program, begun in the Sherman Quadrangle during part of the 1975 field season, that has three long-term objectives:

1) To understand the transition from Silurian slaty rocks of the Houlton-Island Falls-Patten region to apparently Devonian slaty rocks southwest of Millinocket. This along-strike transition was not worked out prior to publication of the 1967 state bedrock map (Doyle, 1967) requiring an awkward cross-strike "break" in the map.
2) To undertake stratigraphic studies to define sediment transport directions. The belt of slaty rocks from Houlton to Greenville lies along a zone that is of tectonostratigraphic significance. It has been suggested (Hall and others, 1976; Roy, 1980a) that the Early Devonian sequence north of Mt. Katahdin and possibly also that of the Greenville area southwest of Mt. Katahdin were derived from the east. Since the Silurian slate/graywacke sequence to the east appears to be largely derived from the west (Neuman, 1967; Roy, 1980b) the Siluro-Devonian systemic boundary in the Millinocket-Greenville region may correlate with a reversal of sediment transport direction. Such a reversal of sediment transport would reflect tectonism to the east and subsidence to the west (Roy, 1980a).
3) To look for changes in structural features along strike from Houlton toward Greenville.

During the 1980 field season, five weeks were spent mapping in the eastern slate-graywacke sequence that appears to be entirely Silurian. A dated stratigraphic contact observed in the Sherman Quadrangle in 1975 was traced southwestward into the Millinocket Quadrangle. This contact between rocks assigned to the Allsbury Formation of Neuman (1967) and the Lawler Ridge Formation (new unit) is dated as within the Late Llandovery of the Silurian (Roy and Forbes, 1970) and is anticipated to provide some temporal control as the units are traced into terrains of higher metamorphic grade. In addition an attempt has been made to subdivide the rocks of Allsbury Formation since it forms such a broad belt trending across the Stacyville Quadrangle (Neuman, 1967) and into the Millinocket Quadrangle.

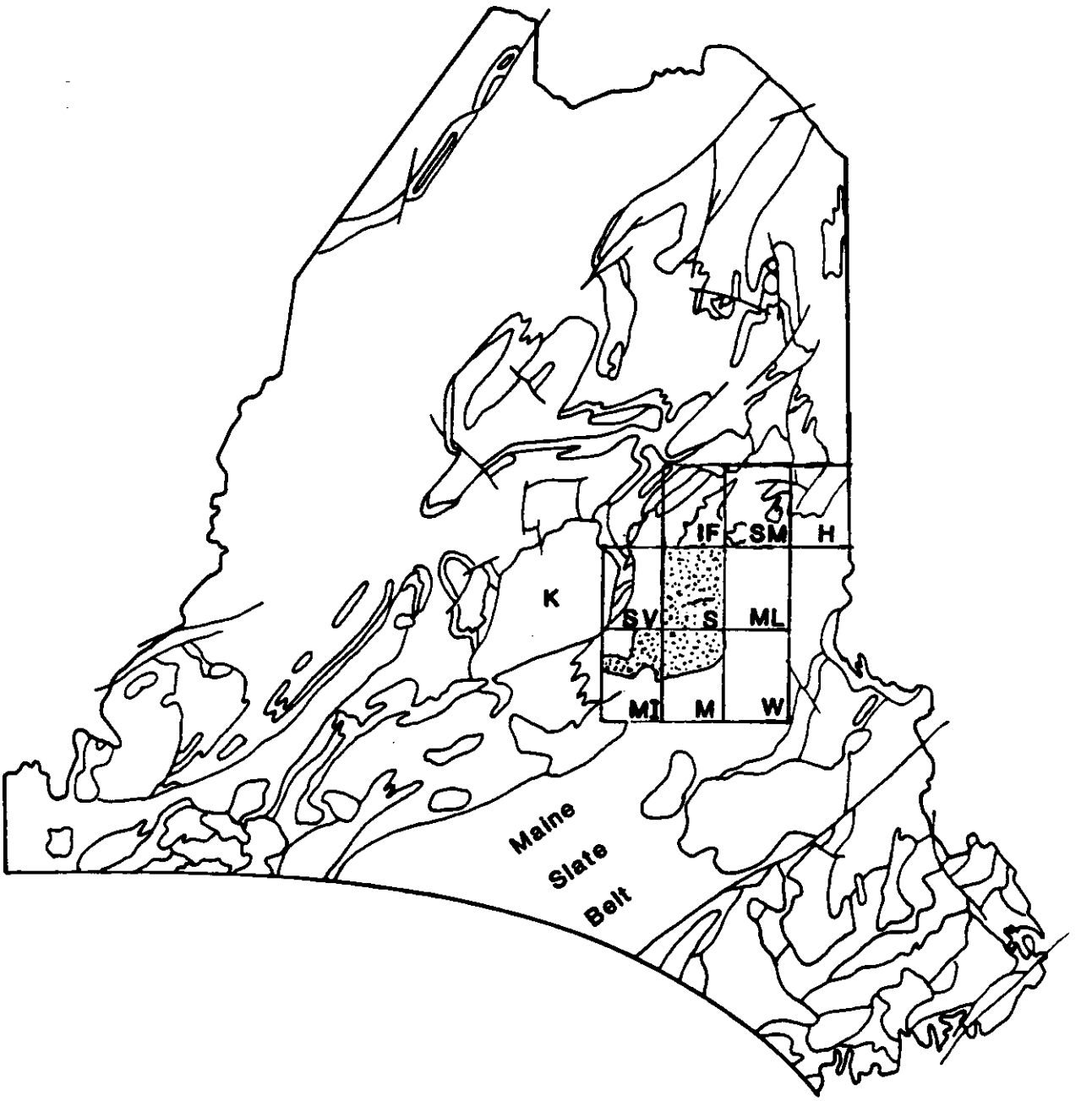


Figure 1. Location of the area covered by this report (stippled). Fifteen minute quadrangles referred to in the text are: IF, Island Falls; SM, Smyrna Mills; H, Houlton; SV, Stacyville ; S, Sherman; ML, Mattawamkeag Lake; MI, Millinocket; M, Mattawamkeag; and W, Wytopitlock. The Mt. Katahdin granite pluton is shown by "K".

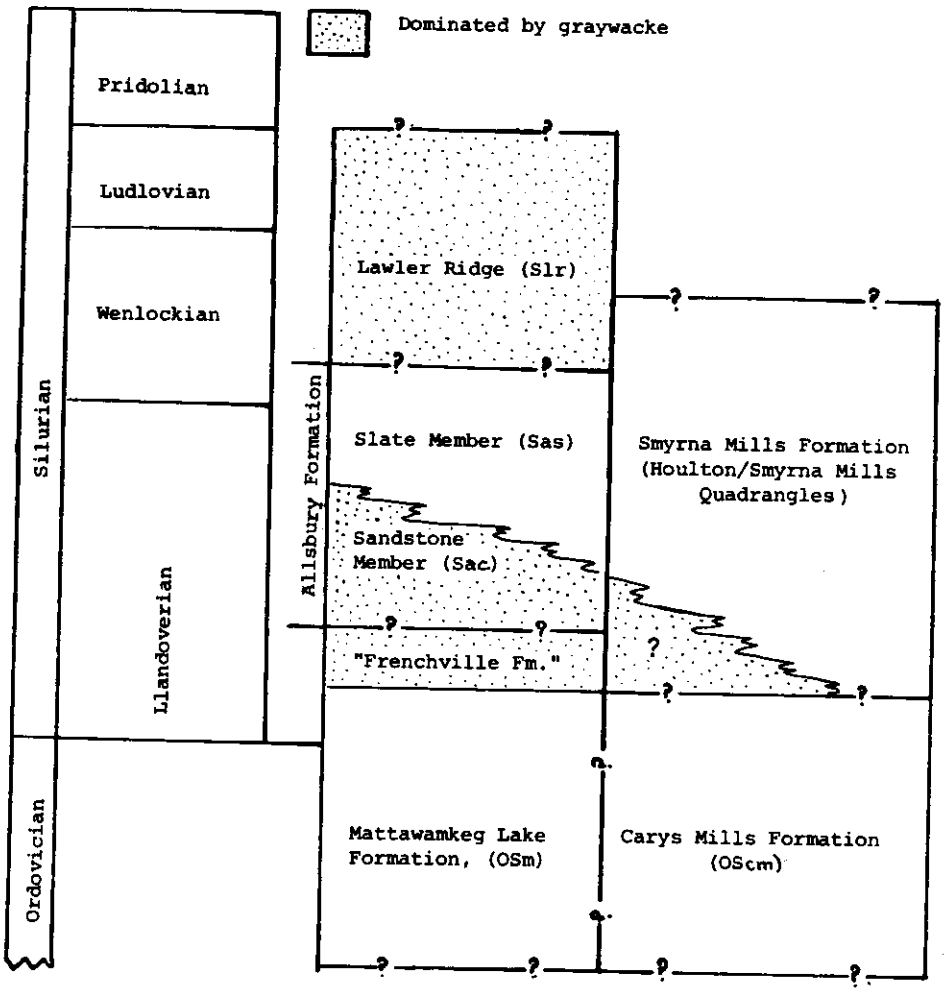
PREVIOUSLY ESTABLISHED STRATIGRAPHY

The quadrangles covered in this report have not been previously studied in a systematic fashion but have been examined by USGS geologists in connection with bedrock studies in adjacent regions. To the north the Island Falls Quandrangle was mapped by Ekren and Frischknecht (1967); simultaneously Neuman (1967) carried out bedrock and paleontological studies in the Shin Pond and Stacyville quandrangles. Pavlides (1971,1972) has described the Houlton and Smyrna Mills quadrangles thus completing the tier of quadrangles north of the present work. Larrabee and others (1965) made probes into the Mattawamkeag and Millinocket quadrangles in connection with their study of the Grand Lake area to the southeast. The region is on the eastern edge of aeromagnetic data presented by Boucot and others (1964); their map also shows generalized geologic information, especially the outlines of the major plutons.

Although the previous work adjacent to the area of the study has established a complicated stratigraphy involving units ranging in age from Late Precambrian (?) to possibly Mississippian (see Roy, 1980a, and Pavlides, 1973, for summaries), only the Silurian stratigraphy of the Stacyville, Island Falls, and Smyrna Mills quadrangles is of concern here.

Figure 2 illustrates the relevant stratigraphy of the Silurian east of the Weeksboro-Lunksoos Lake Anticline as established by Neuman (1967), Ekren and Frischknecht (1967), Pavlides and Berry (1966), and Pavlides (1972). Two more-or-less contemporaneous and lithologically similar slate-graywacke units (Allsbury and Smyrna Mills Formations) are widespread. The designation "Rocks of Island Falls" used by Ekren and Frischknecht (1967) for slate, graywacke, and "ribbon rock" limestone in the southeastern part of the Island Falls Quadrangle is abandoned in favor of the stratigraphic terminology of Pavlides (1968; 1972). The Frenchville Formation as used by Neuman (1967) is present in an inferred anticline in the southeastern corner of the Stacyville Quadrangle and is considered by him to be a temporal equivalent of un-named conglomerate and sandstone along the southeastern flank of the Weeksboro-Lunksoos Lake Anticline.

Stratigraphically beneath the Smyrna Mills and Allsbury formations in the Island Falls Quadrangle are two units, the Mattawamkeag and Carys Mills Formations, that are of Ordovician or Ordovician and Silurian age. The Mattawamkeag Formation forms the core of a generally anticlinal structure that trends northeastward and plunges southwest into the Sherman Quadrangle. The limestone-rich lower part of the "Rocks of Island Falls" of Ekren and Frischknecht (1967) are here reassigned to the Carys Mills Formation of Pavlides (1968). The Carys Mills also outcrops in anticlines in the



Symbols used on plates I,II, and III.

45 Inclined and vertical bedding; dots indicate younging direction.

15 Inclined and vertical slaty cleavage.

Outcrop; no structural data.

40 40 Anticlinal and synclinal plunges.

—— —?— Stratigraphic contact. Queried where uncertain.

Stippled areas near Millinocket (Plate III); shows extent of contact metamorphism.

Figure 2. Summary of important stratigraphic units found in the Sherman, Millinocket, and Mattawamkeag quadrangles and in nearby quadrangles. Symbols used in Plates I, II, III are also shown.

Island Falls Quadrangle which plunge southward into the Sherman Quadrangle where exposures are scarce. The Carys Mills Formation is dated elsewhere as Middle Ordovician through Early Silurian in age with the limestone-rich phases generally yielding Early Silurian fossils. The as yet unfossiliferous Mattawamkeag is older than the Allsbury and Smyrna Mills Formations and is considered to be a temporal equivalent of the Carys Mills.

Allsbury Formation

The Allsbury Formation has been described in detail by both Ekren and Frischknecht (1967) and Neuman (1967). The formation consists dominantly of slate/phyllite and quartz-rich graywacke and arenite. The slate or phyllite is typically gray in color with a distinct phyllitic "sheen" on cleavage surfaces. Red, green, light greenish gray and black slate are seen in many outcrops. The lateral and vertical dimensions of these intervals are unknown but black slate intervals have been traced by Ekren and Frischknecht (1967) for strike-distances up to 15 - 20 kms using electromagnetic techniques. The slate or phyllite is typically non-calcareous but is calcareous in some outcrops. Pyrite is ubiquitous and conspicuous in many exposures showing black and dark-gray slate or phyllite.

Sandstone is interlayered with the pelitic beds on a scale ranging from a centimeter or so to several meters in thickness. In the lower Sandstone Member of the Allsbury these sandstone beds are quite prominent and many are apparently thick. The sandstone is generally best described as quartz graywacke with altered feldspar being variably abundant. Some beds of granule and pebble conglomerate are present in the Sandstone Member especially in its lower part (Neuman, 1967); the basal portions of thick graded sandstone beds also typically display granule- and pebble-size detritus. Pelitic rocks appear to be less in abundance in the Sandstone Member but this may reflect exposure tendency rather than true stratigraphic abundance. The pelitic rocks are usually gray-to-black in color and phyllitic.

The upper Slate Member of the Allsbury contains sandstone similar in composition to that of the Sandstone Member, but beds are thinner (few centimeters), finer grained, and subordinate to phyllite. Red and green slate/phyllite are common in the Slate Member. Both phyllite and sandstone are calcareous and thin micritic limestone beds are seen locally especially in the Sherman Quadrangle.

Although Neuman (1967) found the Slate Member to overlie the Sandstone Member in the northeastern part of the Stacyville Quadrangle, he recognizes (Neuman, personal communications, 1981) the possibility of a facies relationship between the members. The Sandstone Member may be a lower and western facies with the Slate Member being an upper and eastern facies.

Frenchville Formation

The Frenchville Formation as defined by Neuman (1967) was mapped in the core of a tight anticline in the southeastern corner of the Stacyville Quadrangle and named after the Frenchville Formation of more northerly Maine (Roy and Mencher, 1976). The feldspathic and lithic quartzose graywacke of the Frenchville are similar to the coarser sandstones of the Sandstone Member of the Allsbury and underlie the Slate Member of that formation as mapped by Neuman. In Plates I and III of this report similar rocks along strike from Neuman's Frenchville are included in the Sandstone Member of the Allsbury Formation.

"Rocks of Island Falls"

The name "Rocks of Island Falls" as used by Ekren and Frischknecht (1967) has largely been abandoned in favor of the terminology of Pavlides and Berry (1966) and Pavlides (1968). "The Rocks of Island Falls" was divided into an upper "slate and sandstone" unit that is identical to the Smyrna Mills Formation and a lower "limestone" unit which is assignable to the Carys Mills Formation. The "slate and sandstone" sequence is also very similar to Slate Member of the Allsbury Formation. One anticlinal occurrence of the lower "limestone" sequence is projected into the Sherman Quadrangle by Ekren and Frischknecht (1967) and is shown on Plate I of this report as a questionable anticlinal plunge of the Carys Mills Formation; as yet no outcrops of Carys Mills have actually been found in the Sherman Quadrangle (Plate I).

Mattawamkeag Formation

The Mattawamkeag Formation is a graywacke-slate sequence which underlies the Allsbury and Smyrna Mills Formations in the Island Falls Quadrangle. Ekren and Frischknecht (1967) assigned the unit to the Ordovician-Silurian because of its stratigraphic position; there are no fossils reported from the formation. The graywacke beds are much more lithic and feldspathic than those found in the overlying units and display a better-developed foliation as well. The graywacke beds range in thickness from a few centimeters to a few meters. Slate and graywacke are approximately equal in abundance.

STRATIGRAPHIC UNITS IN THE REGION OF THIS REPORT

Two stratigraphic units have been found to be widespread in the Sherman, Mattawamkeag, and Millinocket quadrangles. The Allsbury Formation underlies the northwestern halves of the Sherman and Millinocket Quadrangles with the Lawler Ridge

Formation underlying the southeastern parts of those quadrangles and virtually all of the Mattawamkeag Quadrangle. The contact between the units trends N30E across the region crossing I95 just east of Little Salmon Stream Lake in the southwestern corner of the Sherman Quadrangle (Plate I). The Lawler Ridge overlies the Allsbury.

The best exposures of the Lawler Ridge and upper/eastern Slate Member of the Allsbury are to be seen along I95. Large exposures along the East branch of the Penobscot River in the Millinocket Quadrangle provide the best easily-accessible views of the lower/western Sandstone Member of the Allsbury. Both members of the Allsbury are well exposed in the bed of the West Branch of the Penobscot River between the Quakish Dam and the Grand Falls; both units are contact metamorphosed at and just below the dam.

Allsbury Formation

The Allsbury Formation as mapped in the quadrangles studied here is identical to that described by Neuman (1967) and therefore will not be treated extensively here. An attempt has been made to subdivide the formation into members on the basis of graywacke abundance. The Allsbury does appear to be divisible on such a basis into a largely lower and western graywacke phase and an upper and eastern graywacke-poor (slate-rich) phase. These phases are provisionally equated here with the Sandstone (Sac) and Slate (Sas) Members of the Allsbury as used by Neuman (1967).

As presently mapped in the Sherman and Millinocket quadrangles, however, the Sandstone Member is inferred to be more widespread in the Stacyville Quadrangle than shown by Neuman. The exposures of the Sandstone Members along the East Branch of the Penobscot River and in the northwestern corner of the Sherman Quadrangle are along strike from the belt of "Frenchville Formation" shown by Neuman in the Stacyville Quadrangle. All easily accessible exposures of Allsbury and Frenchville in the southeastern part of the Stacyville Quadrangle (Hersey and Stacyville townships) were reviewed during the present study and found to be compatible with the members as used in this report. The rocks of the "Frenchville Formation" are not differentiable from those along the East Branch at Grindstone Falls or Meadow Brook Rips. Neuman (1967, page I24) assigned the Grindstone Falls sequence to the Allsbury but placed it in the Slate Member. Experience in the Millinocket and Sherman Quadrangles suggest that the sequence at Grindstone Falls is typical of the more graywacke-rich phase which fits Neuman's description of the Sandstone Member somewhat better than his description of the Slate Member.

The Sandstone Member as mapped in this study typically exceeds 50% quartzofeldspathic graywacke in stream and man-made exposures. The graywacke beds range from

a few centimeters to a few meters in thickness and commonly show grading and sedimentary structures typical of turbidites. The interbedded phyllite is almost exclusively gray-to-black in color and commonly noncalcareous. Mesoscale folds are generally not present in outcrops of this member and wide belts of apparently homoclinal section are present locally (e.g. East Branch of Penobscot River and in the Millinocket area).

The Slate Member is predominantly gray variably pyritic slate or phyllite with thin beds of quartzofeldspathic graywacke. In some outcrops the interlayering is on the scale of 2 to 15 centimeters producing a "ribboned" appearance. Red and green slate are common especially in eastern parts of the Slate Member belt. Thin micritic limestone beds have been observed in a few outcrops but they never form extensive sequences.

Black slate is also a minor lithology but there seems to be a prominent horizon of such slate near the upper contact of the member with the overlying Lawler Ridge Formation. This upper black slate horizon is well exposed at the contact along I95 near Little Salmon Stream Lake where it is dated as Late Llandovery.

Lawler Ridge Formation

The Lawler Ridge Formation is a newly established unit. It overlies the Allsbury Formation in the region of this report and is probably equivalent to the upper parts of the Smyrna Mills along strike to the northeast. The unit is well exposed in road cuts along I95 from south of Medway in the Millinocket Quadrangle to Lawler Ridge in the Sherman Quadrangle. It may also be seen at the Medway Dam on the West Branch of the Penobscot River and at the Mattaseunk Dam along the main course of the Penobscot River.

The Lawler Ridge is distinctly different from the underlying Allsbury Formation, especially the Slate Member with which it is in contact. The Lawler Ridge consists of medium- to thick-bedded quartz-rich graywacke interlayered with thin beds of gray slate or phyllite. Based on large exposures of the formation the slate/phyllite proportion is estimated to be less than 20-30 percent. The formation is most commonly seen in small pavement exposures which are almost always found to be rust-weathering graywacke. Slaty cleavage is normally parallel or nearly parallel to bedding.

The sandstone of the formation is typically fine- to medium-grained, quartzofeldspathic graywacke that is medium-gray on fresh surfaces but takes on a distinctive rust-orange weathering color. The graywacke shows a well developed foliation that is usually at a low angle with respect to the bedding. Grading and lamination are present in some beds, especially thin beds, but most beds appear very homogene-

ous in grain size. Graywacke beds to 5 meters or so thick have been observed; many of the thicker beds can be shown to contain more than one sedimentation unit. Disseminated pyrite porphyroblasts are common and carbonate cement is also evident in many of the graywacke beds. Flute casts and other sole features may be seen on bottoms of some beds in extensive exposures.

The slate or phyllite is gray-to-black in color and commonly pyritic. The pelite beds are not significantly different from those of similar color in the underlying Allsbury Formation.

Age of the Allsbury and Lawler Ridge Formations

Neuman (1967) and Roy and Forbes (1970) have summarized the fossil collections and age of the Allsbury. All of the collections come from the Slate Member of the formation and collectively indicate an age span within the Silurian of Late Llandoverian to possibly as young as Early Ludlovian. It is likely that the Allsbury gets no younger than Late Llandoverian or earliest Wenlockian if the Late Llandoverian age of the Lawler Ridge locality (Roy and Forbes, 1970; Plate I) holds up.

The Lawler Ridge Formation has produced no fossils as yet. It is likely to be entirely Silurian based on general correlation with well-dated formations along strike to the northeast. It is safe to say it is Late Llandoverian or younger and probably it is largely Wenlockian and Ludlovian. Similar rocks, mapped as part of the Smyrna Mills Formation by Pavlides (1971), in the southeastern part of the Houlton Quadrangle contain fossils from the Late Llandoverian, Wenlockian, and Early Ludlovian; however, careful correlation of the Lawler Ridge with the Houlton sequence has not been done.

STRUCTURE

The region mapped in this study is part of the extensive Maine Slate Belt which forms the core of the Merrimack Synclinorium (Roy, 1980a). The belt is characterized by a prominent upright foliation which is generally axial planar to essentially upright nearly isoclinal folds.

Macroscopic Structural Features

Large-scale folds have proven difficult to define. Monotonous slate-graywacke terrains are well known to defy attempts to delineate folds with wavelengths larger than the scale of an outcrop (Mesoscopic scale) and in cases where exposures are scattered it is also impossible to map folds with wavelengths less than the outcrop spacing in the absence of marker horizons.

The stratigraphic subdivision of the Allsbury, previously described, illuminates a possible major synclinal structure near Millinocket (Plate III) in which the Slate Member occupies the axial terrain. The wavelength of that fold is on the order of 6 kms. Northwest of Sherman Station (Plate I) an anticline cored by the Sandstone Member has an apparent wavelength of about 2 km. Since it is likely that the contact between the Sandstone and Slate Members is a facies boundary and not a true temporal marker horizon, its use in the definition of large folds is somewhat limited but at the moment it is the only "marker" present in the Allsbury belt.

Along the East Branch of the Penobscot River, downstream from Grindstone Falls, a 2.4 km thick section of the Sandstone Member appears to be homoclinal, not to be repeated by a major fold. This substantial section of unrepeated strata provides indirect evidence of the presence of folds on the scale of several kilometers in wavelength and is therefore consistent with the scale of folding suggested by repetitions of the contact between the Sandstone and Slate Members of the Allsbury Formation.

The long northeast-trending Allsbury-Lawler Ridge contact marks the northwestern boundary of a major synclinorial structure cored by the Lawler Ridge Formation. As yet the southeastern extent of the belt of Lawler Ridge rocks has not been established but the southeastern margin must lie east of the Mattawamkeag Quadrangle which appears to be completely underlain by the formation. The synclinorium appears to plunge northeastward as suggested by data presented below.

The general character of the regional fold style is indicated by π-diagrams of bedding (S), slaty cleavage (S_1), and small-scale fold-plunge data shown in Figures 3, 4, and 5. The S and S_1 data are plotted for the Allsbury (Figure 3) and Lawler Ridge (Figure 4) domains. Subdivisions of the Allsbury domain produced no new information. The small-scale fold plunges for both domains are plotted together because only a few fold plunges are available for the Lawler Ridge terrain (2 out of 37).

The π-diagrams for the Allsbury belt (Figure 3) suggest it to be a homogeneous fold domain with respect to both bedding (S) and slaty cleavage (S_1). The folds are noncylindrical and are dominantly tightly appressed, nearly isoclinal folds. The S-pole data suggest an average axial plane orientation of between N15E and N30E and vertical while the S_1-pole data show an average cleavage orientation of N30E and essentially vertical. The S_1 cleavage is therefore approximately axial plane. The range of bedding dips of 50° to 90° occur in beds striking parallel to the axial plane. Beds with strikes perpendicular or nearly perpendicular to the axial plane have a broader range of dips reflecting fold plunges to the northwest (dominant?)

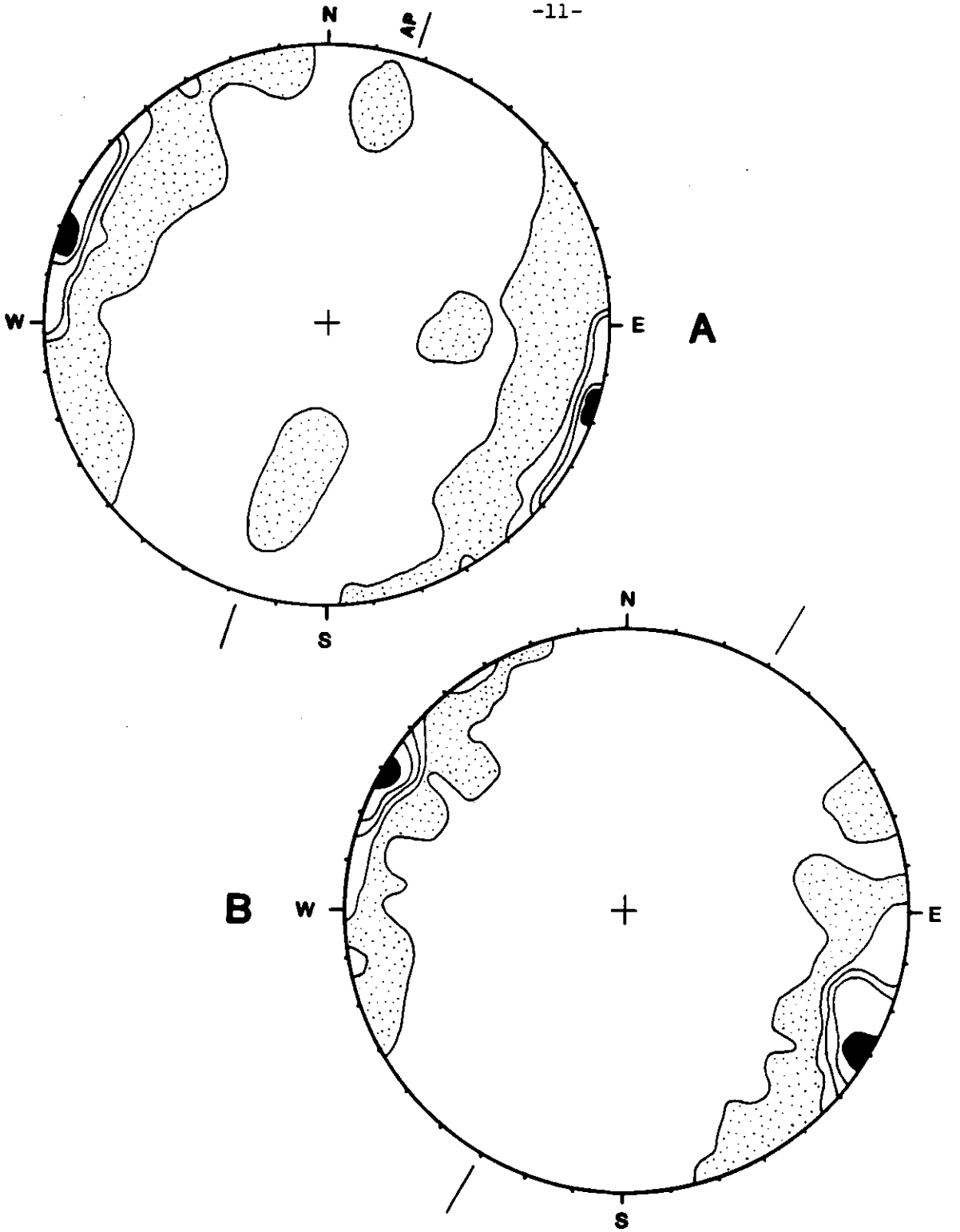


Figure 3. A) π-diagram of 161 bedding poles from the Allsbury Formation. The index line marked "AP" represents the strike of the axial plane suggest by the data. B) π-diagram of 166 poles of slaty cleavage (S_1) from the Allsbury Formation. The index line gives the general strike of the slaty cleavage suggested by the maxima. For both diagrams contours represent 0%, 5%, 10%, 15%, and 20% per 1% area; stippled regions lie between 0% and 5% per 1% area; solid shading indicates greater than 20% per 1% area.

and southeast.

The π-diagrams for the Lawler Ridge domain (Figure 4) give results similar to those for the Allsbury with one important difference. The data on the diagrams for both S and S_1 in the Lawler Ridge show four maxima (paired maxima on opposite sides of the diagram) and hence do not represent a single homogeneous domain. Since the broad Lawler Ridge domain has not as yet been subdivided in detail due to the low abundance of data, it is only possible to speculate at this time about the reasons for the multiple maxima.

Probably the simplest explanation is that there is a regional bend in the Lawler Ridge belt from about N10E in the south (largely in the Mattawamkeag Quadrangle) to N30E (Sherman Quadrangle). The change in direction is not pronounced but seems to show up when Plate I, II, and III are viewed together. Though at the moment this explanation is favored, it is possible to explain the multiple maxima as due to superposition of a later set of broad, open folds that have nearly vertical axes. The only indications of the possibility of such secondary folding on the mesoscopic scale are low amplitude folds seen best at locality 2854, described below. These warps are seen thus far <u>only</u> in exposures of the Slate Member of the Allsbury, but they are not common and may not be widespread.

The common occurrence of beds with northwest strike and northeast dip (Figure 4A) is consistent with the presence of northeastward plunging folds within the belt. Most of these folds are apparently larger than the typical outcrops.

No major faults have been established in portions of the three quadrangles that have been mapped so far. It is likely that major faults are present but as yet the outcrop data is insufficient to locate them.

Mesoscale Features

Mesoscale structure features include the following:

1) F_1 folds of bedding with S_1 cleavage parallel to the axial planes.
2) Rare F_2 folds that fold both bedding and the S_1 cleavage.
3) Kink bands.
4) Transposed or "disrupted" bedding.

<u>Small-scale F_1 Folds</u>. F_1 folds as seen in outcrops are generally similar or concentric in form with moderate to steep plunges. The F_1 folds from both the Allsbury (35) and Lawler Ridge (2) formations are depicted in Figure 5. The data suggest a broad girdle corresponding to a plane with an attitude of N25E and vertical. This plane corresponds nicely with the average slaty cleavage orientation within the Allsbury Formation (Figure 3B). The girdle is consistent with a pattern of non-cylincrical and doubling plunging folds in which fold plunges range from 0° to 90°.

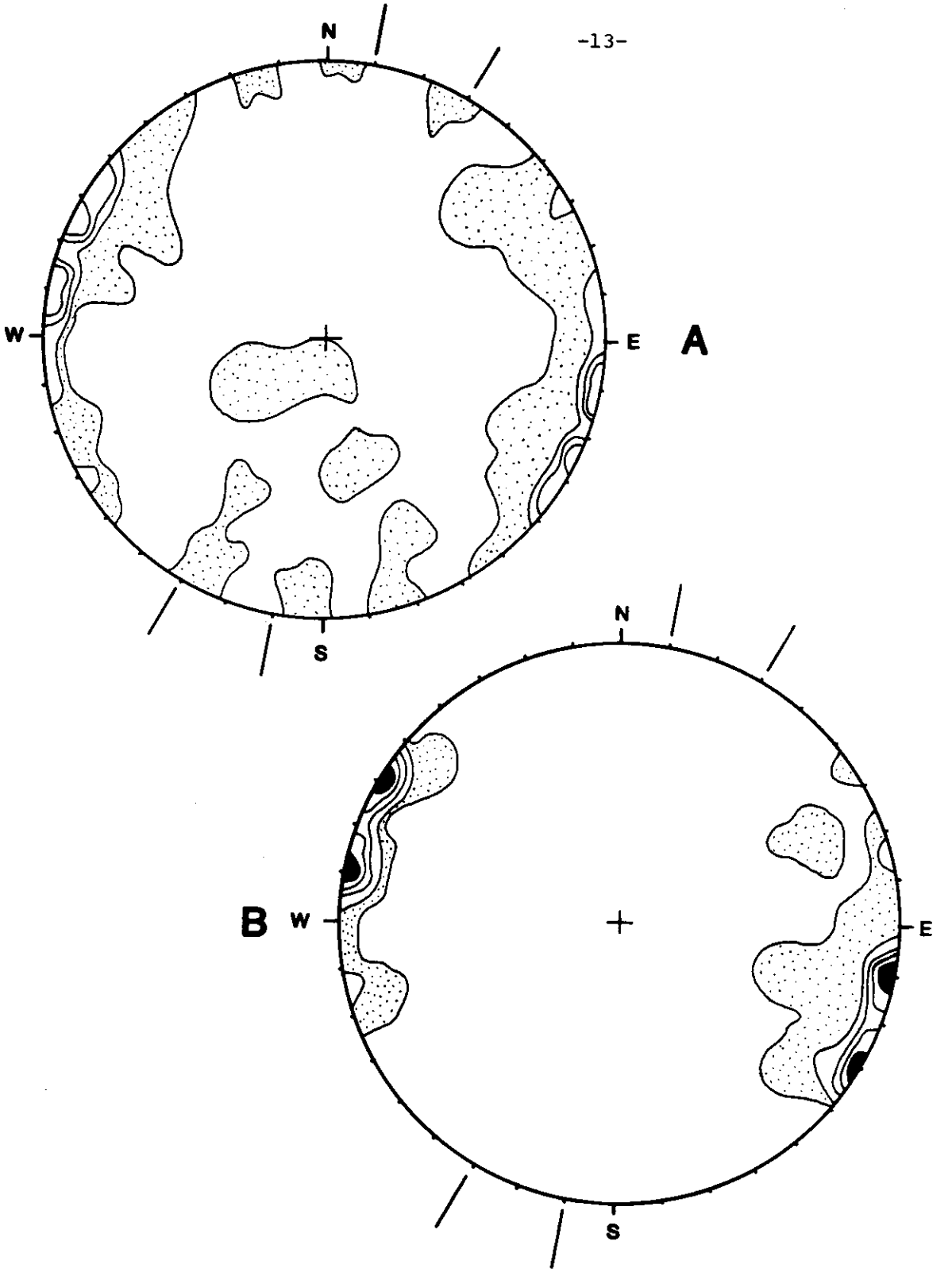


Figure 4. A) π -diagram of 95 bedding poles from the Lawler Ridge Formation. Index lines represent the strikes of axial planes suggested by each set of paired maxima. B) π -diagram of 49 slaty cleavage poles from the Lawler Ridge Formation. Index lines show the general strikes of the slaty cleavage suggested by each set of paired maxima. For both diagrams contours represent 0%, 5%, 10%, 15%, and 20% per 1% area; stippled regions lie between 0% and 5% per 1% area; solid shading indicates greater than 20% per 1% area.

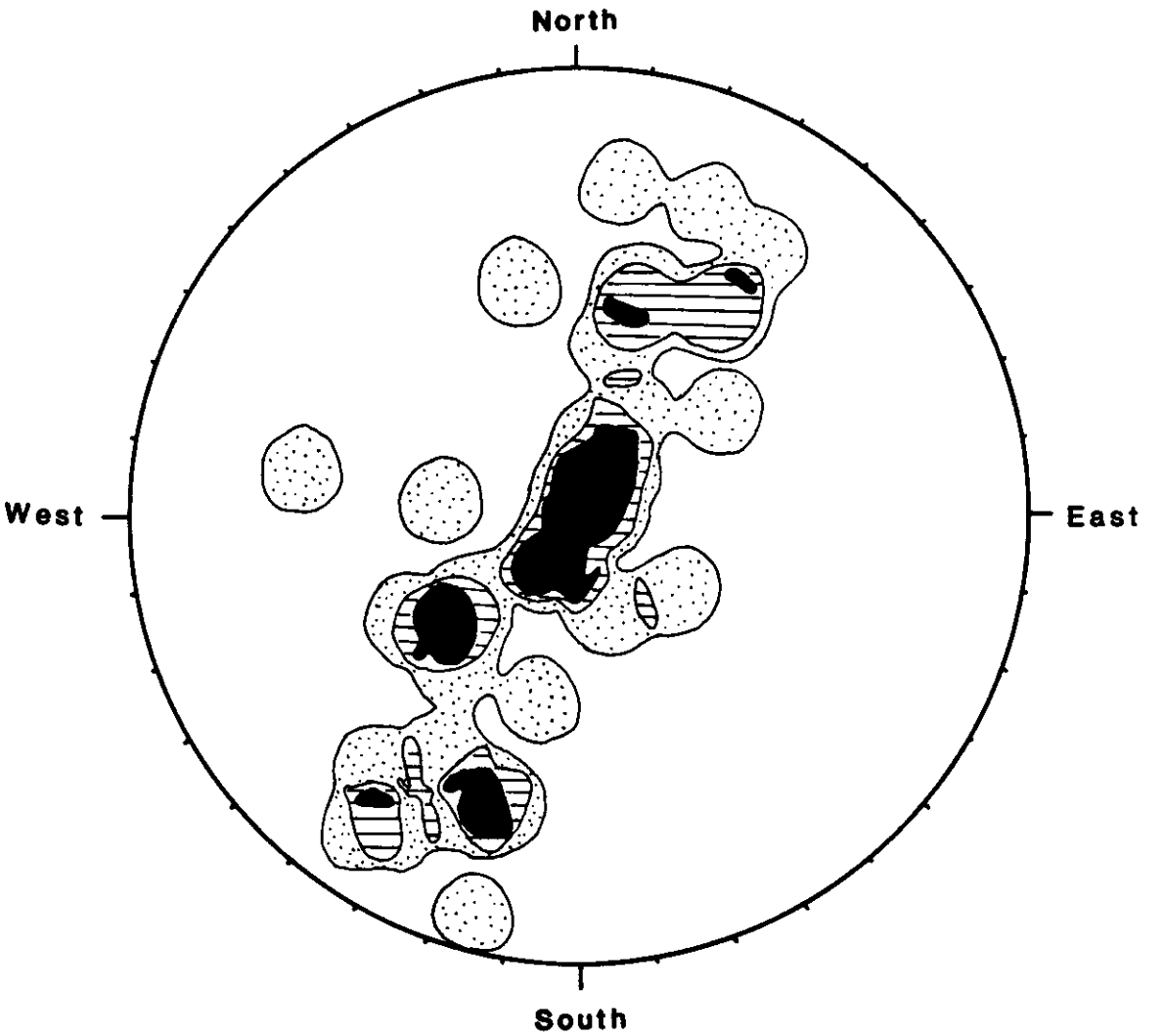


Figure 5. π-diagram for 37 F_1-fold axial plunges. White areas have no poles; stippled areas have 2-5% per 1% area; ruled areas have 5-8% per 1% area; solid areas have greater than 8% per 1% area.

The maxima in the diagram may represent subdomains of more limited range in plunge direction and magnitude but as yet these subdomains have not been delineated.

An excellent plane, noncylindrical, doubly plunging, similar fold is well exposed at locality 2363 on I95 south of Island Falls in the Sherman Quadrangle (Plate I). The axial plane of the fold is N35E and vertical with a northeast plunge of 30° and a southwest plunge of 16°. Numerous fold plunges are also present at the large exposure at the Sherman Exit on I95 (Plate I).

F_2 Folds. Rare coherent F_2 folds are well seen at locality 3008 just below Grand Falls on the West Branch; in the extensive exposure at Ledge Falls on the East Branch of the Penobscot River; and at locality 2854 on I95. The F_2-folds fold the S_1 cleavage as well as the bedding.

At locality 3008, the F_2-folds are open concentric folds plunging 65° in the S55W direction and have wavelengths of about 30 cm and amplitudes of 10 cm or so. At Ledge Falls, the F_2-folds appear to be related to faults that parallel the dominant S_2 cleavage fabric. The F_2-folds strike parallel to the faults and have plunges up to 50°. At locality 2854, low amplitude warps with wavelengths of 30-60 cm have an average plunge direction of 76° in a N50W direction.

Kink Bands. Kink bands may be seen folding the S_1 cleavage in a few outcrops of the Slate Member of the Allsbury Formation. As yet data is insufficient to establish the age relations of the kinks to other post-S_1 folds or to determine their systematic orientations.

Transposed or Disrupted Bedding. One of the more interesting structural characteristics of the Slate Member of the Allsbury is the variable importance of bedding transposition (or disruption) due to translation and boudinage parallel the S_1 cleavage.

Disruption of bedding continuity is seen, especially in large exposures, to range from fairly simple offsets (or "slips") along faults that are quasiparallel to bedding, through mild boudinage in beds which are broken into rectilinear pieces, to whole-sale disruption of the fold pattern and the production of "delimbed" fold hinges, lensoid bed fragments, and fault-bounded packages of coherent strata. Ledge Falls on the East Branch (Plate III) displays the first or simplest case; local boudinage with vertical elongation is nicely seen in the exposures of the Sherman Exit on I95 (Plate I); and complete disruption is seen in a large bedrock surface at the foot of Dolby Dam on the West Branch of the Penobscot River about 2 kilometers upstream from East Millinocket.

The severely disrupted rocks at Dolby Dam extend southwestward for about 1.5 to 2 kilometers as judged by examining a series of exposures along the powerline paralleling the West Branch on its south side. Though the zone of disruption seems to be fairly broad along the river it does not appear to be present to the northeast along the East Branch. At present it is not possible to map the extent of the zones of disruption but they may be of variable size and separated by zones of considerably less-disrupted folded rocks.

So far the disrupted zones have been recognized only in the Slate Member of the Allsbury Formation. The zones presumably represent volumes of deformed rock that have undergone considerable extensional strain during deformation. It is likely, but not yet established, that the extensional strain direction is vertical or nearly vertical. It could be that all of the slate belt in this region is "disrupted" to some degree and that most outcrops are too small to show the disruption clearly. The small outcrops may provide the observer with a few slip surfaces but do not give an accurate picture of the extent or degree of structural dislocation in the folded rocks.

METAMORPHISM

No adequate study of metamorphic grade has been made on the rocks of the three quadrangles. Pelitic rocks everywhere in the study area except around Millinocket appear to be of low greenschist grade since quartz-muscovite-chlorite-carbonate-pyrite assemblages are readily seen in hand specimens. The nature of the feldspar is not known, but is probably albite. The sandstones show essentially the same mineral assemblages. Ekren and Frischknecht (1967) and Pavlides (1971, 1972) came to essentially the same conclusions as to metamorphic grade for the same belt of rocks in Island Falls, Smyrna Mills, and Houlton quadrangles.

In the vicinity of Millinocket contact metamorphism has affected the rocks of the Allsbury Formation producing much darker colored metagraywacke and metapelite. These rocks have not been studied in thin section but it is presumed that metamorphic assemblages similar to those reported by Ekren and Frischknecht (1967) and Pavlides (1971, 1972) for similar aureole rocks to the northeast are present.

Outcrops of granite have been found just to the west of Millinocket in the Norcross Quadrangle (see Plate III). The granite is similar to that of the Katahdin pluton but it is not clear whether the outcrops are part of the Katahdin body or a separate pluton.

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