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The Lower Devonian Slate Problem of Western
and Northern Maine Revisited ¹

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ABSTRACT

Lower Devonian slates with associated sandstones crop out in western and northern Maine as thick and areally extensive stratigraphic units within major northern Appalachian synclinoria. The units crop out over 16,000 square kilometers and vary in thickness from 1045 to 6000 meters. Much of this extensive slate and sandstone outcrop belt has historically been treated as a chronostratigraphic unit. These chronostratigraphic rocks had been, and to a large extent still are, assigned to a single formation, the Seboomook Formation, without regard to different lithic characteristics and stratigraphic position or sequence within the outcrop belt.

Major, mappable, lithostratigraphic units within the "Seboomook" are identified on the basis of lithic characteristics, sand-shale ratios and sedimentary structures. These criteria produce the recognition of five major claystone and sandstone lithofacies, and their metamorphic equivalents. These lithofacies become the lithologies of several formations and their members, and are also the components in outcrop areas which have yet to be subjected to detailed mapping. The lithofacies are: 1) medium- to thick-bedded, massive claystone with rare parallel siltstone or sandstone laminae; 2) thin-bedded claystone with thin, commonly graded laminae of siltstone or sandstone; 3) claystone with abundant siltstone laminae; 4) thin-bedded sandstone (<10 cm) with thin (<10 cm) claystone; 5) medium- to thick-bedded sandstone with thin claystone or siltstone interbeds. Minor lithofacies of mappable dimensions include olistostromal pebble, cobble and boulder mudstone, syndepositionally slumped and folded claystone and sandstone, conglomerate, mafic greenstone (metabasalt), limestone and quartzite.

The presence of specific lithofacies and stratigraphic successions are not uniform across the outcrop belt. Lithofacies presence and stratigraphic successions vary with locality. Moderately clastic lithologies occur in southern and eastern outcrop areas while predominantly pelitic lithologies occur in northern and western outcrop area. The top of this stratigraphic sequence, although not preserved in most areas, is locally conformably overlain by, and is the partial facies equivalent of the Matagamon Sandstone and Tarratine Formation. Lithofacies distribution and stratigraphy are best known in the eastern outcrop area and incompletely known in the northern and northwestern outcrop areas.

Because of the demonstrated lithostratigraphic variability, it is proposed to assign these rocks to the Seboomook Group. The proposed group includes all slates with interbedded sandstones, and minor lithostratigraphic units of demonstrated or probable Lower Devonian age (exclusive of the Matagamon Sandstone, the Moose River Group, Fogelin Hill and Swanback Formations) north of the Sebago Batholith in southwestern Maine. The proposed group includes all lithic types previously and currently assigned to the Seboomook Formation, as well as members and submembers currently assigned to the Seboomook Formation, but formerly assigned to the Littleton Formation. The proposed group also includes undifferentiated slates and metasandstones in the north central interior. Formal formations that would be assigned to the proposed group include the Carrabassett, Hildreths, Mount Blue, Day Mountain, Temple Stream, Ironbound Mountain and Northeast Carry. The rocks at the former type section of the Seboomook Formation of Boucot (1961) are here designated the Northeast Carry Formation.

INTRODUCTION

The purpose of this report is to update and review the Lower Devonian slate problem in the northern Appalachians, as it pertains to a 16,000 square kilometer area in the northwestern one third of Maine (Figure 1). The paper reviews and presents new data pertaining to lithologic and stratigraphic details of these Lower Devonian slates and associated sandstones, and proposes extensive revisions in stratigraphic nomenclature. These slates and sandstones crop out in the Connecticut Valley - Gaspé, Moose River, and Kearsarge - Central Maine Synclinoria, forming a major depositional unit in the northern Appalachians.

The primary reasons for reviewing the slate problem and reexamining the stratigraphic nomenclature are: 1) the type section of the Seboomook Formation (Boucot, 1961) is not representative of the outcrop belt as a whole. Pollock (1985; in preparation) has demonstrated that the type section (Boucot, 1961) is a mappable unit that stratigraphically underlies units of identical (Pollock, unpublished) age, but of different mappable lithologies. 2) the "Seboomook Formation" as defined by Boucot (1961) and used by Doyle (1967) has undergone relatively extensive informal and formal subdivision and revision over the last 25 years by several workers. 3) the unit has been treated as a "de facto" group by various workers. Particulars relative to the latter include: a) Establishment of the Carrabassett (Boone, 1973), Ironbound Mountain (Marvinney, 1983; in preparation), and Northeast Carry (this paper) Formations from units which had previously been mapped as Seboomook Formation (Doyle, 1967). b)

Undifferentiated units previously assigned to the Littleton Formation (Doyle, 1967) were reassigned to separate, lithologically distinctive members and submembers of the Seboomook Formation (Pankiwskyj, 1979). c) Osberg, Hussey and Boone (1985) reassigned undifferentiated and unnamed Devonian slates and sandstones in Aroostook County to the Seboomook Formation, and d) reassigned slates that had (Doyle, 1967) been assigned to the Frontenac Formation to the Seboomook Formation. e) Finally, reconnaissance mapping indicates that the Seboomook within the northernmost outcrop area is divisible into mappable lithologically distinctive units (Boudette et al., 1976; Roy, 1980; and Osberg, Hussey, and Boone, 1985).

Boucot (1970) extensively reviewed Devonian slate problems in the northern Appalachians. The present paper is an outgrowth and an update of studies into these problems. Poorly fossiliferous slates of demonstrated, probable, or presumed Gedinian, Siegenian and Emsian age were assigned to two formations, the Littleton and Seboomook by Doyle (1967). Additionally Doyle (1967) did not assign other slaty units of presumed lower Devonian age to specific formations. Osberg, Hussey, and Boone (1985) assigned rocks of known and presumed Lower Devonian age to three formations, the Carrabassett, Ironbound Mountain and Seboomook. They recognized eight separate members in the Seboomook Formation, one of which consists of two submembers. Figure 2 illustrates the substantial net changes that have been made in the distribution of the Seboomook Formation between the Preliminary Bedrock Geologic Map of Maine (Doyle, 1967) and the Bedrock Geologic Map of Maine (Osberg, Hussey and Boone, 1985). The Seboomook Formation is the most areally extensive formation on each map. The numerous lithologic types assigned to the Seboomook as well as the wide time interval over which the slates and the associated sandstones were deposited indicate that a reexamination of the stratigraphic nomenclature is desirable.

It is proposed to elevate the Seboomook and Littleton Formations, and undifferentiated Silurian-Devonian metapelites (as mapped by Doyle, 1967), to the Seboomook Group. The proposed group includes slates and slate and sandstone associations and their metamorphic equivalents of demonstrated or probable Lower Devonian (late(?) Gedinian through early to middle Emsian) age north of the Sebago Batholith in southwestern Maine (Figure 2). The former type section of the Seboomook Formation (Boucot, 1961) is reassigned to the proposed Northeast Carry Formation (see Appendix). This formation is 4300 meters thick, and is mappable at scales of 1:500,000 and smaller. Figure 1 illustrates the partial distribution of this formation. A more precise distribution was shown by Pollock (1985).

AGE

The Seboomook Group (as defined in this paper) and its correlatives range from Late Gedinian through early to middle Emsian in age. Unequivocal Gedinian faunas have been recovered from slate lithologies near the base of the Seboomook and from the Bear Pond Limestone in the Greenville area (Boucot and Heath, 1969). Boucot (1970) indicated that faunas with distinctive New Scotland (Gedinian) aspect occur in several slate localities in southern Aroostook County. Boone (1970) recovered faunas of New Scotland age in the Fish River Lake Formation just below, and conformably, beneath slates of the Seboomook. St. Peter and Boucot (1981) reported a Gedinian age for basal beds of the Temiscouata Formation in northwestern New Brunswick directly across the international border from, and on strike, with slates of the Seboomook. The vast majority of faunas recovered from the Seboomook indicate a Siegenian age (Boucot, 1961, 1970; Boucot and Heath, 1969; Boudette, Hatch and Harwood, 1976; Hall, Pollock and Dolan, 1976;

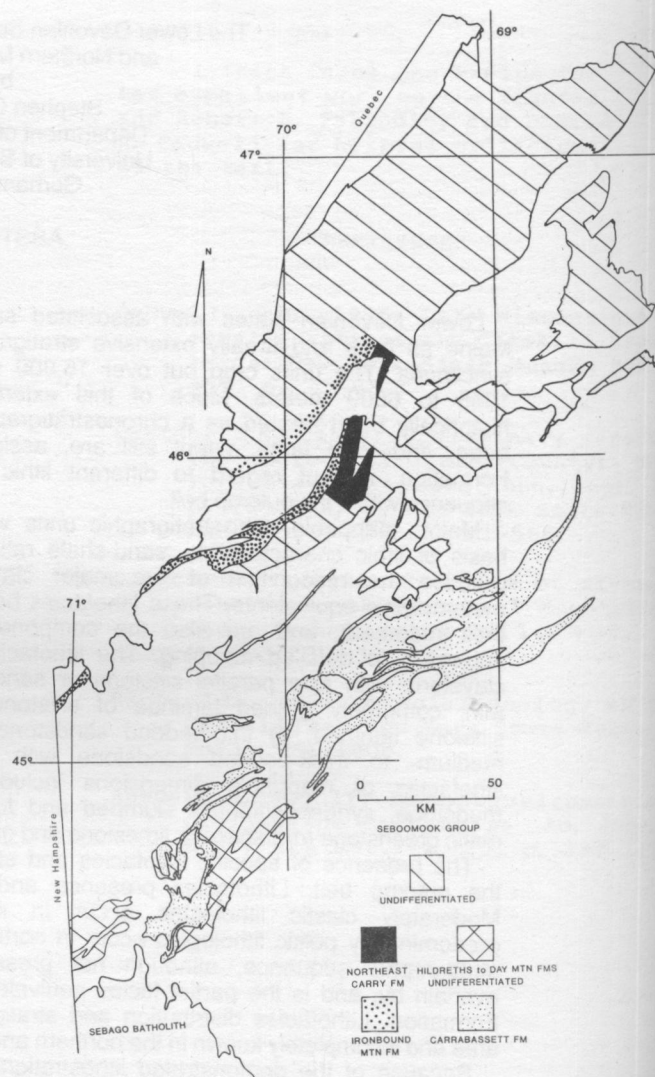


Figure 1 - Distribution of the Lower Devonian slate and slate and sandstone associations discussed in this paper. The diagram has been compiled from the Preliminary Bedrock Geologic Map of Maine (Doyle, 1967) and the Bedrock Geologic Map of Maine (Osberg, et al., 1985). The units shown as belonging to the proposed Seboomook Group were assigned to the Littleton, Seboomook, or undifferentiated and unnamed formations by Doyle (1967). The northern outcrop area (diagonal ruled) has been differentiated into several lithologically distinctive units by (Osberg, et al., 1985). Names have not been applied to these units to date, and for the purposes of this sketch map are not shown because these are not formally designated as formations or members in this paper. Only those names which have been formally proposed or used are listed on this diagram. The reader should consult the original source for the distribution of these unnamed units.

Neuman, 1967). St. Peter and Boucot (1981) have recovered faunas of early to middle Emsian age from the Temiscouata Formation in northwestern New Brunswick, on strike with slates of the Seboomook in northern Maine.

Paleontological ages, equivalencies and the extent of diachroneity of the Seboomook have not been everywhere established due to the unit's poorly fossiliferous nature. It is clear that the Seboomook in the Matagamon and Moosehead Lake areas is late Gedinian and early Siegenian and does not range into the late Siegenian or early Emsian. The paleontological age and age range in other areas and units are unknown (i.e. Ironbound Mountain, Hildreths, Mount Blue, Temple Stream and Day Mountain), or poorly known through one fossil locality (Carrabassett Formation; Espenshade and Boudette, 1964). It is only in the northern outcrop that the

Seboomook is considered to range in age from late Gedinnian through early to middle Emsian.

HISTORICAL BACKGROUND OF THE LOWER DEVONIAN SLATE PROBLEM

Perkins (1925) established a unit he termed Seboomook Slate. Perkins (p. 374) states: "...The rock in most outcrops is dark bluish slate...". But, he recognized specific lithologic variability of the unit and established what may now be termed reference localities. One of these demonstrated typical slate lithology and the other demonstrated sandstone or graywacke lithology. Boucot (1961, p. 169) wrote: "...It is now termed the Seboomook Formation because sandstone makes up a large part of it...". Exposures at Seboomook Dam and the eastern end of Seboomook Lake were designated the type section because: "...this is the thickest and best exposed, structurally uncomplicated section of the formation in the region." (p. 169). Work done in the state over the last 25 years has failed to disclose a section similar in extent, thickness or structural simplicity. Boucot described the formation as follows: "The Seboomook Formation consists almost entirely of cyclically-layered dark sandstone and slate. The cyclic layering resembles varves, and the sandstone layers grade upward into slate layers. ...The layers are fractions of an inch to several feet thick. ..." However, Boucot (1961) and Boucot and Heath (1969) clearly intended that slates within the Moose River Synclinorium be included within the formation. Boucot and Heath (1969, p. 34) stated: "Between Little Big Wood Pond and the Canada Falls - Rockwood Road the proportion of the slate in the Seboomook reaches 95%. On the northern shores of Moosehead Lake, slate makes up more than 50% of the unit. In the area of Seboomook Dam, however, arenaceous dark cyclically bedded sandstone makes up more than half the unit." It should be noted that the distance between Little Big Wood Pond and the Canada Falls - Rockwood Road is more than 40 kilometers parallel to the strike belt. In the same publication Boucot and Heath (1969) showed a reconnaissance sketch map of the Seboomook in the Allagash Lake area. Recent work (Pollock, 1983; in preparation) over the past several years in this area has found the Seboomook to be predominantly slaty. The absence of a reference section illustrating the predominance of slates within the Seboomook has proven to be unfortunate, inasmuch as slate was clearly intended to be a significant component of the Seboomook Formation. Upon visiting the type section at Seboomook Dam, however, one is clearly left with the impression that the Seboomook is a formation that is significantly composed of medium- and thin-bedded metasandstone.

The description of lithologies of the type section of the Seboomook Formation (Boucot, 1961) indicates that the unit consists predominantly of dark gray metasandstones, which is not generally consistent with the preponderance of gray slate lithologies seen in outcrop over much of the region. The lithologic pattern shown by Osberg, Hussey and Boone (1985) indicates that the Seboomook consists of interbedded pelite and sandstone. This, while reasonably consistent with a 1:500,000 scale, and the information available to them at the time of compilation does not bring out variations in sand-shale ratios that can be mapped at 1:500,000 and larger scales. The sand-shale ratios are not uniform or consistent over the entire region of outcrop. Stratigraphic units have been differentiated on the basis of these differing sand-shale ratios (e.g. Boone, 1973; Hanson, 1983; Pollock, 1985). This is also reflected by Osberg, Hussey and Boone (1985) where new formations and/or members of the Seboomook have been established in outcrop areas that had previously been undifferentiated.

Pollock and Hall (1984) have concluded that many active researchers consider outcrops at the type locality to be atypical of the majority of the outcrops of the Seboomook. Recent mapping (Pollock, 1985; in preparation) has confirmed that the type section (Boucot, 1961) is of relatively limited

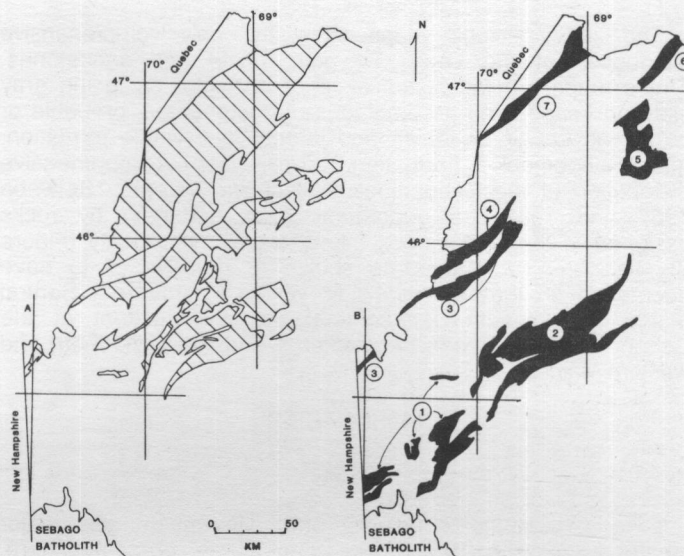


Figure 2 - Figure 2A illustrates the distribution of the Seboomook Formation (diagonal ruled area) as shown by Doyle (1967). Figure 2B illustrates the net changes that have been made since 1967. Area 1 was shown as Littleton Formation or unnamed Siluro-Devonian units by Doyle (1967), and as the Mt. Blue, Temple Stream, and Day Mtn. Members of the Seboomook Formation, the Carrabassett and Littleton Formations by Osberg, et al. (1985). Area 2 was shown as Seboomook Formation and Siluro-Devonian undifferentiated by Doyle and as Carrabassett Formation by Osberg et al. Area 3 was shown as Seboomook and Frontenac Formations by Doyle and as Ironbound Mountain by Osberg et al. Area 4 was shown as Seboomook Formation by Doyle and as Frontenac Formation by Osberg et al. Area 5 was shown as Siluro-Devonian undifferentiated by Doyle and as Seboomook Formation by Osberg et al. Area 6 was shown as Siluro-Devonian undifferentiated by both Doyle and Osberg et al. and is considered as unnamed slates belonging to the Seboomook Group in this paper. Area 7 was shown as Siluro-Devonian undifferentiated by Doyle and as Seboomook Formation by Osberg et al.

geographic extent, when compared with slate lithologies. Furthermore, the nature of the established type section has posed problems for workers who examine it and assume it to be characteristic of the entire Seboomook outcrop belt as a whole. This has posed particular problems when mapping or identifying the Seboomook in areas geographically removed from Boucot's (1961) type section. Because of the substantial metasandstone component of the type section, workers have adopted two contrasting points of view as to what constitutes the "Seboomook Formation". The first is that the Seboomook is intended to be a formation that dominantly consists of thin- to medium-bedded metasandstones, and the second is that the type locality at Seboomook Dam is unrepresentative of the Seboomook as a whole. What is important to note is that both of these points of view or interpretations have been applied over the past decade or so. The result of later (post-1961) studies in the Seboomook has then been twofold. There are those workers (notably Boone, 1973; Hanson, 1983; Marvinney, 1983; in preparation; and Pankiwskyj, 1979) who strictly apply the description of the established type section and use these lithologic descriptions for establishing new formations or members in what had been mapped as the Seboomook Formation, or for extending the Seboomook Formation into areas distant from the type locality. Secondly, there are those workers (notably Boudette, Hatch and Harwood, 1976; Hall, 1970; Hall, Pollock and Dolan, 1976; Hall and Stanley, 1973; Moench and Aleinikoff, 1985; Pollock, 1983; and Roy, 1980) who use descriptions more compatible with Perkins (1925) description of the Seboomook Slate when working in the Seboomook in the outcrop belt geographically removed from the type section established by Boucot (1961).

The state geologic maps show the only comprehensive distribution of the Lower Devonian slate and sandstones. These maps are the historical, prior basis for assigning gray slate and sandstone assemblages of documented, probable or presumed Lower Devonian age largely to a single formation, the Seboomook Formation. The first comprehensive distribution of the Seboomook was shown in 1967. Between 1967 and 1985 the geographic area underlain by rocks assigned to the Seboomook has changed significantly (Figure 2). The area of outcrop is shown to be less or to have decreased on the northeast limb of the Kearsarge - Central Maine Synclinorium. By contrast the areal extent of the Seboomook is shown to be greater in portions of northern and western Maine.

LITHOFACIES

General

Criteria used to subdivide and differentiate the major lithofacies of the Seboomook Group, as proposed here, include sand-shale ratios, bedding characteristics and sedimentary structures. Using these criteria the Seboomook as expressed by Doyle (1967) has been divided into formations, members, submembers and lenses, as currently shown by Osberg, Hussey and Boone (1985). The outcrop area of the various formations, members and lenses is of sufficient geographic extent that they are accurately shown on map scales ranging from 1:500,000 to 1:24,000. The major lithofacies specifically included within the Seboomook Group, as proposed here, and shown on the 1:500,000 scale Bedrock Geologic Map of Maine (Osberg, Hussey and Boone, 1985) are the Carrabassett Formation and its members, the Ironbound Mountain Formation, and the Seboomook Formation. The latter includes four unnamed claystone units.

Minor lithofacies within the Seboomook Formation as shown by Osberg, Hussey and Boone (1985), and discussed in this paper, are differentiated on the basis of rock type. Minor lithofacies include conglomerates, mafic greenstones (metabasalts), limestone, and quartzite. These are volumetrically minor when compared with the claystone and sandstone lithologies. All units discussed have been subjected to at least one episode of regional metamorphism. Protolith designations are used throughout this section, and the reader should keep in mind that all rocks have been subjected to metamorphism which is different in grade in different outcrop areas, and ranges from zeolite through amphibolite facies.

Claystone and Sandstone Lithofacies

1. *Medium- to thick-bedded claystone with rare parallel laminae of sandstone or siltstone.* - The claystone beds commonly range from 15 to 30 cm or more in thickness. The thinner claystone beds are rarely graded from very fine siltstone or coarse claystone to finer claystone. Graded beds appear to occur at random. Bedding planes are indistinct, and where seen are delineated by very thin laminae (2mm) of very fine-grained siltstone. Figure 3 illustrates these features on the smaller scale. Commonly this lithofacies is characterized by "paper thin" slaty cleavages. Parallel siltstone laminae are the only sedimentary structures observed. This lithofacies is typical of portions of the Ironbound Mountain Formation, the massive metapelite member of the Carrabassett Formation, and the four unnamed pelitic units of the Seboomook Formation as well as undifferentiated portions of the Seboomook Formation as recognized by Osberg, Hussey and Boone (1985).

2. *Thin-bedded claystone with abundant interbedded siltstone laminae.* - The claystone beds commonly range from 1 to 10 cm in thickness. The beds are generally structureless, but textural gradation from coarser-grained claystone to finer-



Figure 3 - Claystone and very fine-grained siltstone slate. This is a thinner bedded variation of the medium- to thick-bedded claystones and siltstone which illustrates on a smaller scale the significant textural variations that are found in thicker bedded units. The lighter-colored siltstone laminae seen in this photograph are generally uncommon in this facies. The coin is 2.5 cm in diameter.

grained claystone is present locally. Burrows are rarely present in the claystone.

Thin laminae of siltstone or very fine-grained sandstone are abundant. These laminations are of two distinctive types. The first has clearly defined laminae with sharp upper and lower bedding planes, usually with parallel or ripple cross lamination. The second type has a sharp base, but exhibits textural gradation into the overlying claystone. These gradations are uniform and impart varve-like characteristics to the rocks. Average thickness of the siltstone laminae is 0.5 cm. These laminae number from 10 to 50 or more per meter. See Figure 4 for a representative photograph of this lithofacies. This is perhaps the most common lithofacies to be found in the Ironbound Mountain Formation and in the undifferentiated northern areas. This is also seen at the base of the massive claystone member of the Carrabassett Formation.

3. *Laminated claystone.* - This consists of claystone with abundant siltstone laminae. Bedding ranges from 10 to 30 cm in thickness. Beds are characterized throughout by discontinuous, wispy siltstone laminae, less than 0.3 cm thick. Ripples are relatively common, with pronounced mud flasers in the troughs and on the lee slopes of the ripples. See Figure 5 for a representative photograph of this lithofacies. This lithofacies is generally uncommon, and is found locally in the northwestern outcrop area.

4. *Thin-bedded sandstone with thin-bedded claystone.* - Beds are less than 10 cm thick, and sand-shale ratios are approximately 1:1 in this lithofacies. Sandstones of this lithofacies consist of poorly sorted, fine-grained sand to coarse-grained silt. Sandstone beds average 6 cm in thickness. Sole markings, such as flute or groove casts and parting lineations are uncommon. Sedimentary structures in these beds are the T_{1a} or T_c divisions of the turbidite sequence (Bouma, 1962). The T_c division is ripple cross-laminated. Climbing ripples are uncommon.

Claystone interbeds average 4 to 5 cm in thickness. They are most commonly structureless, but locally exhibit slight textural gradation or indistinct parallel lamination. Burrows are rare. This lithofacies is moderately common (see Figure 6 for a

Figure 4 - Claystone and siltstone laminae. The siltstone number from

represent: thin-bedded (1973), as unnamed

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Figure 4 - Thin-bedded claystone interbedded with siltstone laminae. Claystone beds are less than 5 cm thick, with the common to abundant siltstone laminae having an average thickness of between 0.5 and 0.8 cm. The siltstone laminae are devoid of sedimentary structures, and commonly number from 10 to 50 per meter. The coin is 2.5 cm in diameter.

representative photograph). This lithofacies is mapped as the thinly-bedded member of the Carrabassett Formation (Boone, 1973), as the Seboomook Formation (Hanson, 1983) and as unnamed members in the northern interior (Pollock, 1985).

5. *Medium- to thick-bedded sandstones with thin claystone or siltstone interbeds.* - This lithofacies is differentiated from the preceding lithofacies primarily on the basis of sand-shale ratios greater than one, and greater bedding thicknesses (Figure 7). This lithofacies consists of poorly sorted, fine- to very fine-grained quartzose and feldspathic sandstone. Sandstone beds range from 10 cm to 2 m in thickness. Sole markings on the sandstone beds are rare, but where seen include flute and groove casts and parting lineations. Sedimentary structures within the beds are consistent with those associated with turbidite or grain flow origin. These consist of the various permutations of the Tabc turbidite sequence (Bouma, 1962), with single Ta, Tb, or Tc divisions and commonly Tbc divisions. Commonly there is a slight decrease in grain size from the Ta or Tb through the Tc division. Well developed normal or reverse textural grading in the Ta division is uncommon. The Tc division may exhibit well developed convolute laminations, as well as current and climbing ripple laminations.

Claystone interbeds are thin - less than 10 cm, and usually less than 5 cm. This lithofacies exhibits moderate variation in that "packages" of the sandstones appear to differ based on differences in average bedding thicknesses and sedimentary structures. By this it is meant that certain packages of sandstones may have average bedding thicknesses of 30 cm

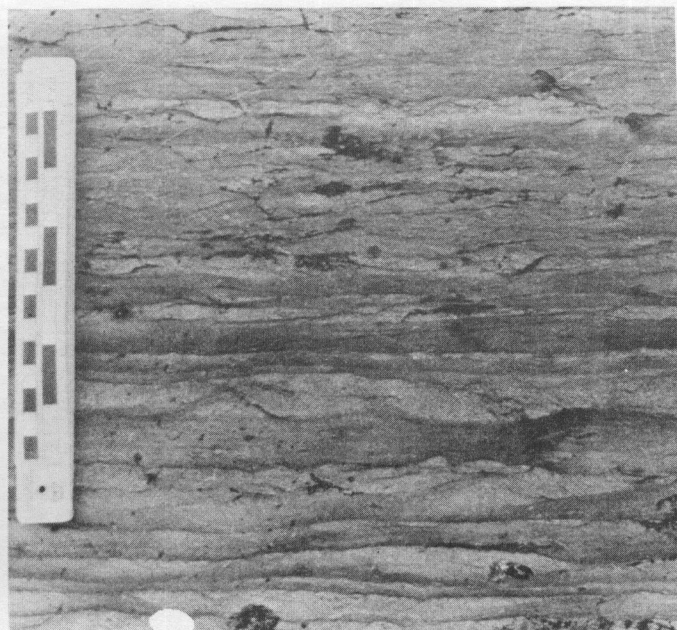


Figure 5 - Laminated claystone with abundant discontinuous siltstone laminae. Claystone beds are generally thin, averaging less than 4 cm thick. Siltstone laminae are commonly less than 0.5 cm thick, but locally may approach 1.0 cm. The thicker siltstone laminae commonly exhibit ripple cross-lamination.

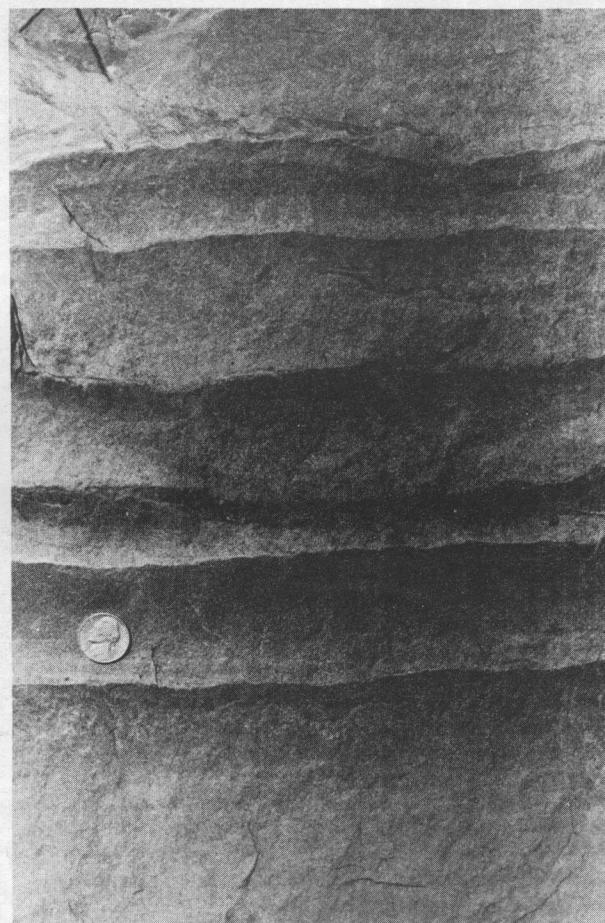


Figure 6 - Thin-bedded sandstone interbedded with thin-bedded claystone. Sand-shale ratios of this lithofacies are 1:1 and greater. The sandstone beds in this photograph grade upwards into the overlying claystone. Elsewhere the sandstones are ripple-laminated throughout. The claystones are generally devoid of sedimentary structures. The coin is 1.1 cm in diameter.

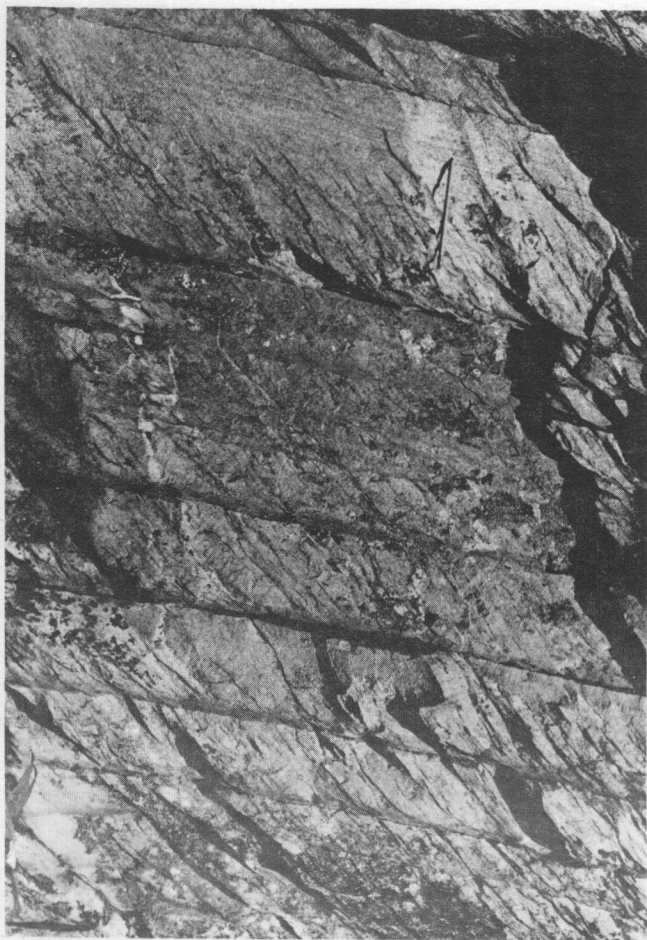


Figure 7 - Medium-bedded sandstone interbedded with thin claystone. The sandstone beds shown here are characterized by cleavages. Sedimentary structures are generally absent in the low portions of the beds. The upper portions of the beds commonly exhibit parallel lamination. These beds are interpreted to be turbidites which exhibit the Ta (massive) and Tb divisions. These features are seen in the above photograph with the Tb division seen in the bed to the right. Claystone beds are characteristically thin, averaging less than 4 cm. See text for discussion of other sedimentary structures. These rocks are from the newly proposed Northeast Carry Formation. Outcrop is located northeast of Cassidy Deadwater in the Northeast Carry 15' quadrangle. Pencil is approximately 15 cm long.

and exclusively exhibit the Tb or Tbc divisions with the Tc division showing poorly developed convolute lamination. Other packages may exhibit average bedding thicknesses of 15 cm and show very well developed convolute laminations. Still other packages may consist of massive or graded sandstone beds 60 cm to 1 m thick. The immediate visual impression is that these are three very different lithofacies. Ultimately it may be desirable to differentiate the packages thus, although no attempt is made to do so at this time. The Northeast Carry Formation (new name, see Appendix) with type locality at Seboomook Dam and Seboomook Lake belongs to this lithofacies.

6. Claystones and sandstones as intraformational folds. -

This lithofacies includes, or is included within, any of the facies listed above. The folds are genetically related to slumping within the depositional environment. The scale and extent of the horizons containing these structures are extremely variable. The structures may be of purely local extent, with dimensions of a few centimeters, or they may be present in zones traceable for a kilometer or more. Hall (1973) has documented the nature of these folds. He found the folds to have axes parallel to the paleoslope. The paleoslope was determined by analysis of current-generated structures in the

sandstones of the non-intraformationally folded units. The folds are generally identified by their lack of slaty axial plane cleavage as well as by differences between their fold style and that of tectonic folds.

This lithofacies is a hallmark, particularly in the northern outcrop areas. Similar structures were reported as hallmarks of the Temiscouata Formation (i.e. Seboomook) in northwestern New Brunswick by St. Peter and Boucot (1981).

7. Claystone containing pebbles, cobbles and boulders. -

This lithofacies may be considered a variant of the conglomerates discussed below under "minor lithofacies". The rocks are olistostromes, and consist of a claystone matrix supporting subrounded to angular pebbles, cobbles and small boulders of claystone, gabbro or diorite, felsite, intermediate volcanics and greenstone as well as "knots" or "broken" discontinuous beds of sandstone. This lithofacies was reported by Boucot and Heath (1969) on the northwest arm of Moosehead Lake, by Hall and Stanley (1973) and Hall, Pollock and Dolan (1976) in the Matagamom Lake area and by Pollock (1985) in the southeastern Caucomgomoc Lake quadrangle. This lithofacies is of very limited outcrop on Moosehead Lake, and of moderately limited outcrop in the Matagamom Lake area. However, this lithofacies forms a belt approximately 8 km long by 1.5 km wide in the Caucomgomoc Lake quadrangle. It is also a minor lithofacies of the Ironbound Mountain Formation.

Minor Lithofacies

8. *Conglomerate.* - This lithofacies consists of the unnamed conglomerate of Pollock (1983) and the conglomerate of the Day Mountain and Temple Stream (Pankiwskyj, 1979), as well as conglomerates reported by Boucot and Heath (1969) and Hall (1970). The unnamed conglomerate consists of pebble- to cobble-sized clasts of angular to subrounded aphanitic felsic to intermediate volcanics. This conglomerate is clast-supported. Bedding is indistinct, and poorly defined cross-stratification and crude grading are exhibited locally. The conglomerates of the Day Mountain and Temple Stream are overall finer-grained than the unnamed conglomerate. Maximum grain size is 0.6 cm and the clasts are dominantly metasedimentary and metaigneous. Bedding is also more distinctive and thinner in the Day Mountain and Temple Stream and textural gradation in the beds is more common than in the unnamed conglomerate. The conglomerates reported by Boucot and Heath (1969) and Hall (1970) are minor components that generally occur near the unconformity at the base of the Lower Devonian slate section. Clasts are usually metasedimentary (red and green phyllites, limestone) or igneous or metaigneous. These conglomerate beds are reported to be relatively thin- less than 2 m thick.

9. *Greenstone.* - Two greenstone localities are noted within the Lower Devonian slates. These are the Camera Hill greenstone (Boucot, 1961) and an unnamed greenstone (Boudette, Hatch and Harwood, 1976). Both are green to dark green and aphanitic with microlites or phenocrysts of feldspar. Volcanic features or textures are not well developed in either. Due to the limited outcrop extent of the Camera Hill greenstone, and the current uncertainty of stratigraphic position it is recommended that it be treated as an informal stratigraphic unit until such time as future studies establish it as a member or lentil of a formally defined formation.

10. *Limestone.* - The limestone consists of the Bear Pond limestone (Boucot, Harper and Rhea, 1959) and the metalimestone subunit of the Day Mountain (Pankiwskyj, 1979). The Bear Pond consisted of a single outcrop and was not treated as a member by Osberg, Hussey and Boone (1985). Due to the limited outcrop extent the member rank and name should be eliminated. This outcrop is described as a fossiliferous bioclastic limestone. The limestone of the Day Mountain is a thinly-bedded clastic metalimestone or

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11. *Quartzite*. This was originally designated the "Hafey Mountain Sequence" by Boudette, Hatch and Harwood (1976), and was revised by Roy (1980). It is an orthoquartzite, with minor sandstone and siltstone, and is locally conglomeratic. Beds are massive and up to 8 m thick. The quartzite is estimated to range between 0 and 650 m thick (Boudette, Hatch and Harwood, 1976). Impure biotitic quartzite also occurs as small lenses within the massive metapelite member of the Carrabassett.

STRATIGRAPHY

General

Knowledge of the detailed stratigraphy of the Lower Devonian slate and sandstone associations is very uneven at this date. Several areas have been subjected to detailed mapping and analysis, while other areas, particularly the northern interior, have been examined only in general reconnaissance. Figure 8 illustrates existing stratigraphies that have been established in various portions of the outcrop belt. Work by various individuals over the past 12 to 25 years has documented certain local aspects of the stratigraphy. Existing knowledge of the physical stratigraphy is based on work done primarily on the eastern margin of the outcrop belt, and secondarily in the interior and northwestern margin of the outcrop.

Reconnaissance has been done in the northwestern interior of the group. The eastern margin of the outcrop is where the base of the Seboomook Group is best known. The stratigraphic base has also been defined following recent work by Marvinney (1983) and Pollock (1983; in preparation) in the central interior of the outcrop. Boone (1970), Roy (1980) and Pollock (unpublished) have locally defined the base of the Seboomook in the northern outcrop. To facilitate discussion in this section of the paper I have arbitrarily differentiated the Seboomook Group into several geographic zones (Figure 8).

Two generalities or tentative conclusions are made. These are: 1) the stratigraphic top is not preserved, or at least not recognized at this time except in the localities on the eastern margin; 2) the rocks young and thicken to the northwest. Thickness estimates of between 1500 and 6000 m are common. Thicknesses range from 1045 to 1200 m in the Matagamoc Lake area (Hall, Pollock and Dolan, 1976, and Neuman and Rankin, 1966, respectively) and 670 m in the Moose Head Lake area (Hall, Pollock and Dolan, 1976) to 3000 m in the Rangely area (Hatch et al., 1983) and 6500 m in northwestern Aroostook County (Boudette, Hatch and Harwood, 1976). Boucot (1961) estimated a thickness of between 3000 and 6000 m in the Moose River Synclinorium. Recent reinvestigations within this area (Pollock, in preparation) indicate that this estimate is within reason, and may be somewhat conservative. Marvinney (written communication) estimates the Ironbound Mountain Formation to be approximately 900 m thick; and Pollock (this paper) estimates the thickness of the Northeast Carry Formation to be 4300 m, and that of the overlying slates to be between 1000 and 3000 m giving a maximum thickness of approximately 8200 m.

Zone 1

In zone 1 the stratigraphic succession is reasonably well established. The Siluro-Devonian Madrid or Fall Brook Formation is conformably and gradationally overlain by the Carrabassett Formation. The Carrabassett, in turn, is locally conformably and gradationally overlain by the Hildreths Formation (Pankiwskyj, 1979), or by unnamed metapelites and metasandstones assigned to the Seboomook (Boone, 1973). Where the Hildreths is present, it is conformably overlain by

the Mount Blue Formation (new stratigraphic rank, see Appendix; Pankiwskyj, 1979), or by undifferentiated and unnamed Devonian(?) rocks (Moench, 1971) presumed to be equivalent to the Seboomook.

Pankiwskyj (1979) reassigned rocks of the Littleton Formation (Doyle, 1967) to the Seboomook Formation, and recognized sufficient lithologic contrasts within the Seboomook of this zone to establish separate units characterized not only by different sand-shale ratios, but also by different textures of the metasandstones. The recognized stratigraphic succession is the Carrabassett, Hildreths, Mount Blue, Temple Stream and Day Mountain Formations. The Mount Blue Formation is characterized by metasilstones and metapelites while the Temple Stream Formation (new stratigraphic rank, see Appendix) is characterized by rusty-weathering sulfidic schists. The Day Mountain Formation (new stratigraphic rank, see Appendix) is characterized by metaconglomerates, metalimestones, metasilstones and metapelites. By contrast, Osberg, Moench and Warner (1968) reported a graywacke-rich section overlying the lithologies now assigned to the Carrabassett Formation, and did not differentiate the stratigraphically higher unit into informal or formal members. Subsequently, however, Osberg, Moench and Warner's (1968) work was refined into the Carrabassett, Hildreths, and undifferentiated sandstones of the Seboomook Formation (Osberg, Hussey and Boone, 1985).

To the north, within the Carrabassett Valley, Boone (1973) established an internal stratigraphy for the Carrabassett Formation using sand-shale ratios to produce a lower massive metapelite with lenses of metasandstone and quartzite, and an upper thinly-layered metawacke and metapelite (schist) member. Northeast of the Carrabassett Valley and Little Bigelow Mountain areas the Carrabassett is predominantly a massive metapelite with lenses of thinly-layered metasandstone and quartzite (Osberg, Hussey and Boone, 1985).

The Hildreths Formation is a thin but prominent calcsilicate unit which separates the upper thinly-layered (schist) member of the Carrabassett Formation from a thin-bedded metapelite (schist) and metasandstone of the Seboomook in the Little Bigelow Mountain area of western Maine. In the Little Bigelow Mountain area, Boone (1973) was able to produce a rudimentary stratigraphy of two informal members in the Seboomook overlying the Hildreths. These two units consist of a lower, thinly-bedded metapelite mentioned above and an upper, thicker-bedded metasandstone and metapelite.

Zone 2

In the Greenville area, what is now shown as Carrabassett by Osberg, Hussey and Boone (1985) had been considered Seboomook by Espenshade and Boudette (1964) and Seboomook or Siluro-Devonian undifferentiated by Doyle (1967). As mentioned previously, Boone (1973) established the Carrabassett Formation for the pelitic slate or schist that underlies a predominantly metasandstone section similar to that observed at Boucot's (1961) type locality of the Seboomook Formation at Seboomook Dam. In zone 2 the Carrabassett is predominantly a massive metapelite which overlies the Siluro-Devonian Madrid Formation. The upper contact between the Carrabassett and the undifferentiated Seboomook is drawn on the basis of the lithologic change from metapelites to metasandstones with interbedded metapelites. Visual comparison of these metasandstones with those that crop out at Seboomook Dam have been the primary basis for the previous extension of the usage of the term Seboomook in this zone. The Hildreths Formation is locally present between the Carrabassett Formation and the metasandstones.

The thicknesses estimated for the Lower Devonian slates in these two zones are substantially thinner than for the northern zones. Thickness ranges from approximately 2100 m in the north (Hanson, 1983) to between 1600 m and 4000 m in the

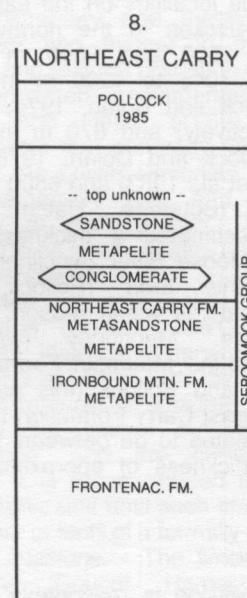
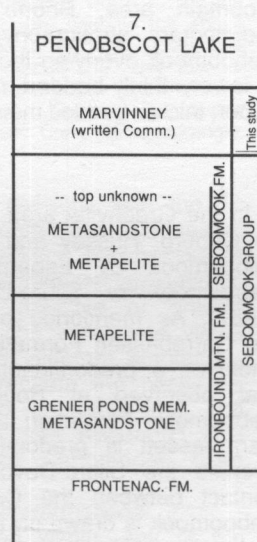
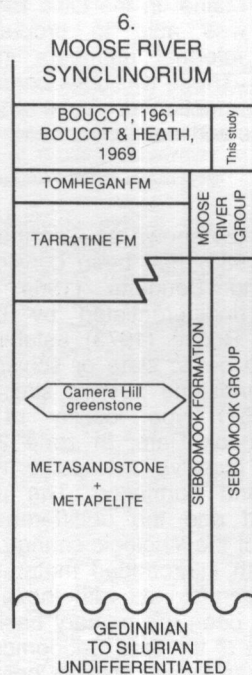
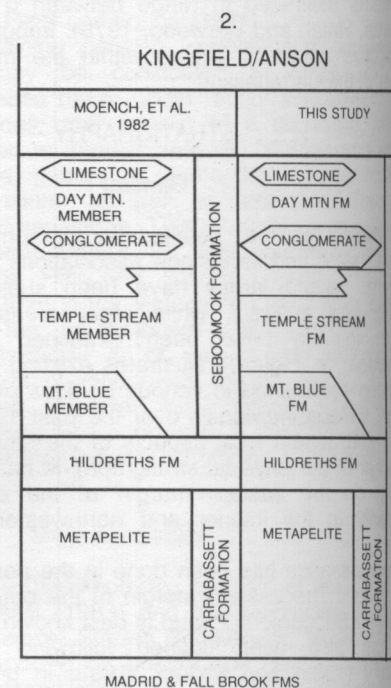
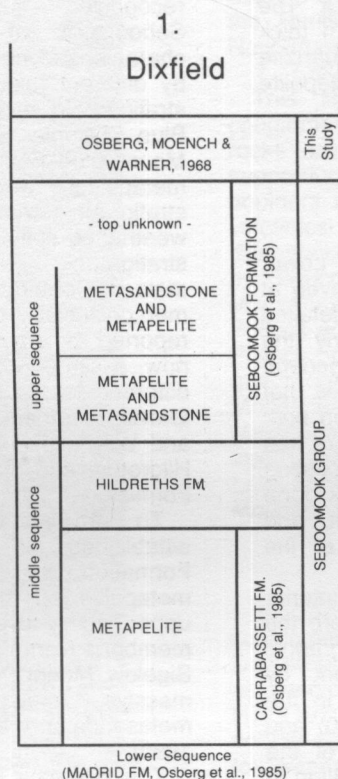
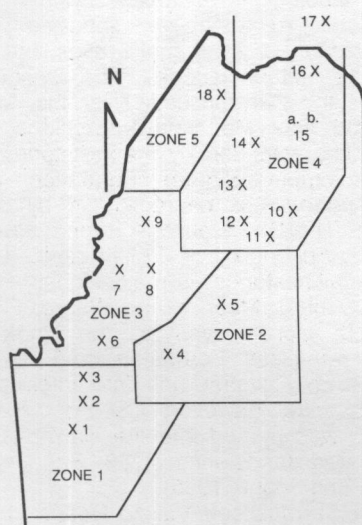
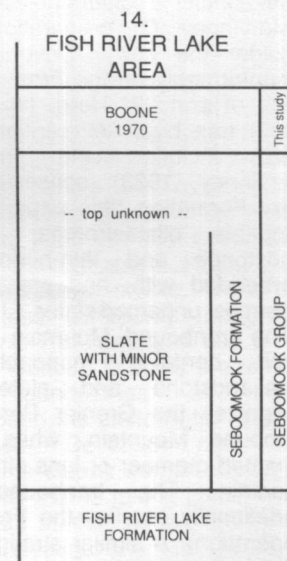
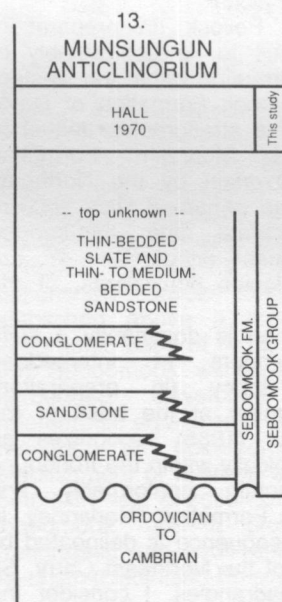
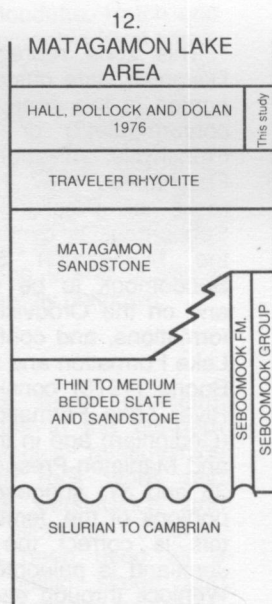
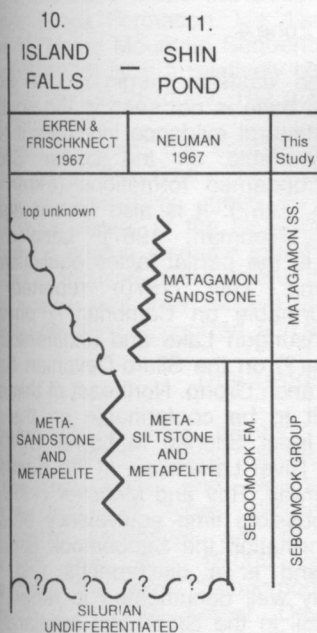
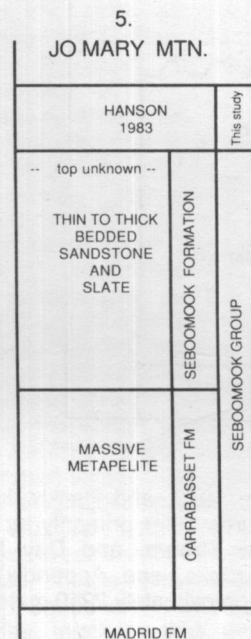
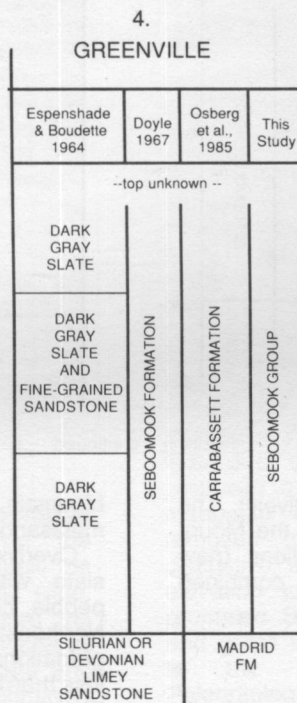
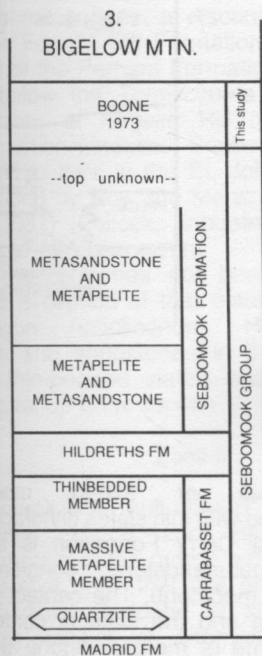


Figure 8 - Eighteen composite stratigraphic columns and their approximate locations. These are intended to demonstrate the lithologic variability of the Lower Devonian slate and sandstones assigned to the Seboomook Group as defined in this paper. This diagram synthesizes the known and inferred stratigraphic sequences and lithofacies assignments as discussed in the text. Thicknesses are not to be inferred from the diagram. See text and original sources for further discussions.



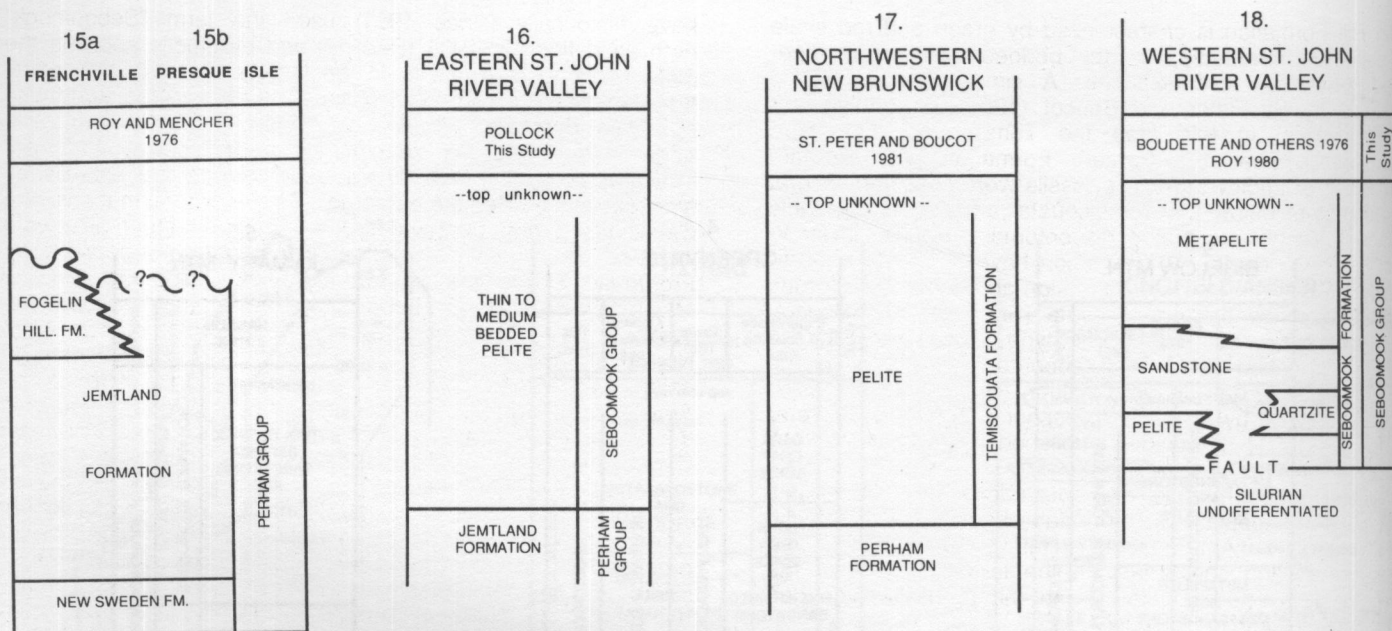


Figure 8 - continued

south (Boone, 1973, and Pankiwskyj, 1979, respectively). The latter two figures differ primarily by the presence of the Mount Blue, Temple Stream, and Day Mountain Formations (new stratigraphic ranks, see Appendix) which have a combined thickness of approximately 2250 meters.

Zone 3

Boucot, Harper, and Rhea (1959) and Boucot and Heath (1969) recognized, in the eastern areas of zone 3, an unconformity between the Seboomook and Gedinnian-age Beck Pond Limestone; the Silurian Hardwood Mountain Formation; and pre-Silurian granites and gneisses. The Seboomook is successively overlain by the Tarratine and Tomhegan Formations in the Moose River Synclinorium. This upper contact is conformable and gradational.

Marvinney (in preparation) and Pollock (in preparation) consider the Lower Devonian slates to lie conformably or disconformably on the Frontenac Formation within the western areas of zone 3. Here, the Seboomook Formation of Doyle (1967) has been differentiated into a stratigraphic sequence which includes the Ironbound Mountain Formation (Marvinney, 1983), consecutively overlain by the Northeast Carry Formation (this paper), and an unnamed slaty section. Mappable olistostromes, conglomerate and thin-bedded sandstones and thin-bedded slates (lithofacies 4) are interbedded with, and are partial facies equivalents, of the uppermost unnamed slates.

The Ironbound Mountain Formation is dominantly a slate which contains mappable members of interbedded metasandstone and slate. Marvinney (in preparation) recognizes the Grenier Ponds Member at the base of the Ironbound Mountain, while Pollock (1985) recognizes an unnamed member or lens stratigraphically within the Ironbound Mountain. The Ironbound Mountain conformably and gradationally overlies the Frontenac Formation (Marvinney, in preparation). A similar stratigraphic sequence is delineated by Pollock (in preparation) in portions of the Northeast Carry, St. John Pond and Allagash Lake quadrangles. I consider the Frontenac to be a partial facies equivalent to the Ironbound Mountain in the northwestern Caucomgomoc Lake and southwestern Allagash Lake quadrangles. The Northeast Carry Formation (see Appendix) consists of those rocks that made up the type section of the Seboomook Formation (Boucot, 1961). The unit conformably overlies the Ironbound

Mountain, and consists of thin-to medium-bedded metasandstones interbedded with thin slates (lithofacies 5).

Overlying the Northeast Carry Formation is an unnamed slate with lenses of metasandstone, conglomerate, and pebble, cobble or boulder mudstone. The contact between the Northeast Carry Formation and the slate is conformable and gradational, with the volume of metasandstone decreasing to less than 10% of the rock over a stratigraphic distance of 15 m. The exact stratigraphic level of the minor lithofacies relative to the stratigraphic contact with the Northeast Carry Formation has not been established at this time, but the minor lithofacies are stratigraphically above the Northeast Carry Formation, based on field mapping and structural projections associated with the plunges of regional folds.

Zone 4

This zone represents the eastern margin of the Lower Devonian slate outcrop. The base is not seen in the southern portion of this zone, but structural evidence indicates it to be conformable(?) or disconformable on the Lower Silurian Frenchville, Allesbury and unnamed formations (Ekren and Frischknect, 1967; Neuman, 1967). It is also faulted against rocks of Presilurian age (Neuman, 1967). Locally, the Seboomook is overlain, or is the partial facies equivalent of, the Matagamon Sandstone. Hall (1970) reported the Seboomook to be unconformable on Cambrian(?) phyllites, and on the Ordovician Munsungun Lake and undifferentiated formations, and conformable(?) on the Siluro-Devonian Spider Lake Formation and East Branch Group. Northeast of this area, Boone (1970) considered it to be conformable on the Fish River Lake Formation of Upper Silurian to Lower Devonian (Gedinnian) age in the Fish River Lake area. In the Castle Hill and Mapleton-Presque Isle areas, Roy and Mencher (1976, p. 35 and 37) suggested a possible time equivalency between portions of the Jemtlund Formation the Seboomook Group. If this is correct the Jemtlund is a diachronous unit. The Jemtlund is paleontologically well documented to range from Wenlock through early Pridoli in the Stockholm-Jemtlund and Frenchville areas (Roy, 1971, Roy and Mencher, 1976, p. 32 and 40). In these two areas the Jemtlund is conformably overlain by the Fogelin Hill Formation which is considered to range in age from Pridoli through Siegenian(?). The Jemtlund consists of thinly interlayered shale, laminated and nonlaminated silty shales, and (calcareous) graywackes. The

Fogelin Hill Formation is characterized by green and red shale and slate interbedded with thin-bedded calcareous fine-grained sandstone and siltstone. A similar stratigraphy is recognized by St. Peter and Boucot (1981) in northwestern New Brunswick. In this area the Temiscouata Formation conformably overlies the Perham Formation. The Perham Formation is of Ludlow age. The fossils were collected several hundred meters below the Temiscouata, and the stratigraphic evidence does not suggest a disconformity. Rocks similar in lithology to the Fogelin Hill Formation have been observed in the upper part of the Perham Formation above the fossiliferous horizon and below the Temiscouata (St. Peter and Boucot, 1981). Exposures of Fogelin Hill type rocks between the Jemtland Formation and the Seboomook Group have not been recovered to date in the St. John River Valley, between the areas mapped by Roy and Menscher (1976) and St. Peter and Boucot (1981) (Pollock, unpublished). Poor outcrop is a probable factor in this observation.

Internal stratigraphy has not been delineated within this zone, with the exception of that established by Hall (1970) in the Munsungun Anticlinorium. Hall (1970) recognized conglomerates and sandstones in the lower portions of the section, with thin-bedded slates and thin-to medium-bedded sandstones higher up in the section.

Zone 5

The Seboomook is in fault contact with pre-Lower Devonian rocks (Boudette, Hatch and Harwood, 1976) on the northwestern margin of the outcrop belt. At or near the fault, the section consists of units that are predominantly pelitic slate, wacke, or quartzite. Boudette et al. (1976) considered the Seboomook to consist of alternating belts of calcareous graywacke, gray slate and cyclically bedded gray slate and sandstone. They noted a lower section of predominant graywacke lithofacies and an upper section of predominant slate lithofacies. These lithofacies may represent interfingering lithofacies or northeast plunging folds (Boudette, Hatch, and Harwood 1976). Roy (1980) concurred with the fault contact and the general stratigraphic sequence. Roy (1980) noted a stratigraphic base where the Seboomook overlies the Silurian Fivemile Brook Formation. He also noted that the quartzite (formerly "Hafey Mountain Sequence" of Boudette, Hatch and Harwood, 1976) is at a relatively high stratigraphic level within the slates and sandstones. The quartzite is considered to thin to the southwest.

Overall, however, the stratigraphy of zone 5 is not well established at this time. The remoteness of the area, the general inaccessibility, generally poor outcrop, and the monotonous nature of the Seboomook have not encouraged geologists to pursue research into the Seboomook in this area. Detailed distribution of the various lithofacies at 1:250,000 and larger scales, and their relative vertical and lateral positions are only now being recognized, and are still largely unknown.

DISCUSSION

Boucot (1970) ably pointed out the major problems connected with the Lower Devonian slates in the northern Appalachians. Local and regional lithofacies relationships illustrate that rock types, proportions of rock types and stratigraphic sequences are of variable persistence and uniformity over the 16,000 square kilometer outcrop. Historically, the term "Seboomook" has been used as a synonym for these Lower Devonian pelitic slates and sandstones and other minor rock types in northwestern Maine. Work subsequent to the Preliminary Geologic Bedrock Map of Maine (Doyle, 1967) has done much to disclose the stratigraphic and lithologic complexities. This work has shown that large portions of the outcrop are substantially more pelitic than the type section of the Seboomook Formation (Boucot, 1961) would suggest. To this end, workers in the Seboomook

have historically (since 1961) used the term "Seboomook" both as defined in 1925 (Perkins) and by strictly applying the 1961 (Boucot) redefinition. In the latter case, two formations, the Carrabassett Formation (Boone, 1973) and the Ironbound Mountain Formation (Marvinney, 1983; in preparation) have been established as dominantly pelitic slates that are stratigraphically beneath lithofacies similar to the established type section at Seboomook Dam. These two formations, the Carrabassett and portions of the Ironbound Mountain, were included or partially included within the Seboomook or Frontenac Formations on the Preliminary Geologic Map of Maine (Doyle, 1967). The splitting of the unit into units of identical rank, i.e. Carrabassett, Ironbound Mountain, and Northeast Carry Formations, indicates that a group should be established following Articles 19b, 19g and 28c of the North American Stratigraphic Code (1983). It is proposed to establish the Seboomook Group, and to introduce the name Northeast Carry Formation, for the metasandstones and slates which made up the type section of the Seboomook Formation (Boucot, 1961), into the quadrangles in the vicinity of Northeast Carry. Established formations to be included in the proposed group would be: Carrabassett, Ironbound Mountain, Hildreths, and Northeast Carry Formations. The formally named Day Mountain, Temple Stream and Mount Blue members of the Seboomook Formation (Pankiwskyj, 1979), located in the southeastern portions of the outcrop belt, are proposed to be raised to formation status. These three units are mappable at 1:500,000 and smaller scales, are areally removed from the main outcrop belt, are lithologically distinctive, and are of sufficient areal distribution to warrant the elevation to formation status. These are assigned to the proposed Seboomook Group based on stratigraphic position and gross lithologic similarities, much as they were assigned to the Seboomook Formation (Pankiwskyj, 1979). Paleontologic age and equivalencies have not been established for these.

The Seboomook Group also includes an unnamed conglomerate, two mafic greenstones, and pelite and quartzite units in Piscataquis and Aroostook Counties as shown on the Bedrock Geologic Map of Maine (Osberg, Hussey and Boone, 1985). In addition the unnamed olistostrome and thin-bedded wackes with thin interbedded slates (lithofacies 7 and 3 of this report; Pollock, in preparation) are included in the proposed group.

The proposed revision in nomenclature is such that it provides a framework for expressing the natural stratigraphic, temporal and sedimentologic relationships of the associated formations that is useful in mapping and regional stratigraphic analysis. The establishment of a group provides a sense of temporal and geographic continuity. While the knowledge of the internal stratigraphy of the proposed group is admittedly incomplete, that which has been at least partially established illustrates transitional and/or conformable stratigraphic relationships between formations and/or members. These are established above a more or less commonly recognized stratigraphic base of regional extent. The continued use of the term "Seboomook" will allow future workers to apply the term to interbedded claystones and sandstones and their metamorphic equivalents, as has been the custom, for rocks of presumed or documented lower Devonian age. The establishment of a group at this time clearly demonstrates the complexity and direction of research that is taking place in the Seboomook, and it provides a useful base for future stratigraphic and sedimentologic investigations into the lower Devonian (Gedinnian-Emsian) of northern Maine.

ACKNOWLEDGEMENTS

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APPENDIX

FORMAL STRATIGRAPHIC UNITS IN THE PROPOSED SEBOOMOOK GROUP

Ironbound Mountain Formation

General. - The Ironbound Mountain Formation has been defined by Marvinney (1983; in preparation) for rocks that conformably overlie the Frontenac Formation (Ordovician to Devonian), and conformably underlie the Northeast Carry Formation (formerly Seboomook Formation). The unit was mapped as Frontenac by Doyle (1967) and Boucot and Heath (1969). Pollock (unpublished) shows rocks of similar lithology and stratigraphic position on the northwest limb of the Boundary Mountains Anticlinorium in the Allagash Lake and Baker Lake quadrangles. The Ironbound Mountain Formation was treated as the Seboomook Formation in these two quadrangles by Doyle (1967) and Osberg, Hussey and Boone (1985). The type locality is along the Pittston Farm - Rockwood road beginning at BM 1402 (0.6 km NNW of the junction of Pittston Academy, Plymouth, Soldiertown and West Middlesex Canal Grant townships) continuing south to the next 1402 benchmark (Marvinney, written communication Dec. 3, 1985).

Distribution. - The unit crops out on the southeastern and northwestern limbs of the Boundary Mountains Anticlinorium in west central Maine. The unit is named (Marvinney, in preparation) for Ironbound Mountain in the Penobscot Lake quadrangle.

Lithology. - Dark gray claystone or siltstone slate and phyllite with subsidiary amounts of quartzose and lithic sandstones. Additionally, olistostromal units similar to lithofacies 6 (described above) are recognized locally. Bedding within the slates ranges from thin (5 cm) to moderately thick (30 to 45 cm). The sandstones are mappable locally as separate members (Grenier Ponds Member, Marvinney, written communication) and lenses (Pollock, 1985). Sandstone beds range in thickness from 15 cm to 2 m. Average thickness varies with locality from 15 cm to 1 m.

Thickness and Age. - The unit in the type locality of the Penobscot Lake and Seboomook Lake quadrangles is estimated to be between 800 and 1200 meters thick. The unit is considerably thicker on the northwestern limb of the Boundary Mountains Anticlinorium where Pollock (unpublished) estimates an incomplete section to range between 3000 and 5000 meters thick. To date no fossils have been recovered from the Ironbound Mountain Formation. Osberg, Hussey and Boone (1985) have assigned an arbitrary Lower Devonian (Gedinnian) age to the unit. This is bolstered in part by the unit's conformable relationship with the overlying Northeast Carry Formation (see below) which is known to be of Siegenian (Oriskany-Becraft) age (Boucot, 1961, 1970).

Northeast Carry Formation (new name)

General. - The name Northeast Carry Formation is proposed for sandstones that crop out on the northwest limb of the Moose River Synclinorium in the Northeast Carry 15' quadrangle. The type section is designated to be in the northeast quarter of the Seboomook Lake and northwest quarter of the Northeast Carry quadrangles. The type section is extensively exposed on the south shore of Seboomook Lake southeasterly to Seboomook Dam and intermittently along the West Branch Penobscot River to the vicinity of the "Old Roll Dam". Reference localities and partial sections are designated on the north shore of Seboomook Lake in the Seboomook Lake quadrangle and on the southwest shore, and wooded exposures on Loon Lake in the Caucomgomoc Lake quadrangle. The type section of the Northeast Carry Formation is identical in location to the Seboomook Formation of Boucot (1961) and to sandstones of the Seboomook Slate of Perkins (1925). The Northeast Carry Formation conformably overlies the Ironbound Mountain Formation in the Seboomook Lake and Caucomgomoc Lake quadrangles. The unit is conformably overlain by a thick section of unnamed slates in the Northeast

Carry and Caucomgomoc Lake quadrangles.

Distribution. - The unit currently is known to crop out in northeast-trending belts on the northwest limb of the Moose River Synclinorium in the Northeast Carry and Caucomgomoc Lake quadrangles. The Northeast Carry Formation is continuous in extent on the northwestern strike belt and within cores of two small, doubly plunging anticlines in the Northeast Carry quadrangle. The distribution has not been completely mapped in the southern portions of the Northeast Carry quadrangle in the adjoining Seboomook Lake and Penobscot Lake and quadrangles or in those to the south and north.

Lithology. - The unit is predominantly a greenish gray to medium dark gray, poorly sorted very fine- to fine-grained sandstone. Cyclically interbedded with the sandstones are medium dark to dark gray metasiltstones or claystone slates. The sandstones predominate in most localities. Sandstone slate ratios range from approximately 6:4 to 9:1. Bedding thicknesses and sedimentary structures within the sandstones are variable. Sandstone bed thicknesses range from approximately 8 cm to slightly more than 1 m. Average thicknesses are between 20 and 30 cm. Sedimentary structures in the sandstones are generally sequentially arranged in a manner attributed to deposition from turbidity currents or grain flows. In the Northeast Carry Formation these commonly include a basal parallel-laminated zone overlain by current (commonly over steepened) or climbing ripples or convolute lamination. The convolute laminations are especially well developed in the type section, and are less common elsewhere. Locally the units exhibit well developed grading in the basal portion of the beds. Other structures present, but not necessarily common or abundant, include sole markings such as flute or groove casts and parting lineations.

The metasiltstone or claystone slate lithologies are subsidiary to the metasandstone. These occur as single thin (1 to 15 cm) beds between the metasandstone or as thin-bedded sequences several meters thick. The several meter thick sequences consist predominantly of thin beds (1 to 15 cm) of claystone slate characterized by thin (0.5 cm) laminae of metasiltstone. The metasiltstone laminae are most commonly continuous over the outcrop, and locally exhibit grading or very small scale current ripples.

Thickness and Age. - The unit is estimated to be 4300 meters thick in the type section. This section is apparently one of the thickest and structurally least complicated within the Seboomook Group outcrop belt. Boucot (1961) estimated the Seboomook within the Moose River Synclinorium to range between 3000 and 5000 meters in thickness. This included the slates that Pollock (in preparation) has demonstrated to overlie the metasandstones of the Northeast Carry Formation. Boucot (1961) has clearly demonstrated a Lower Devonian (Siegenian (Oriskany-Becraft)) age for this unit in the Northeast Carry quadrangle.

Carrabassett Formation

General. - The Carrabassett Formation was defined by Boone (1973) for rocks conformably overlying the Silurian Madrid Formation in the Little Bigelow Mountain quadrangle in west central Maine. The Preliminary Geologic Map of Maine (Doyle, 1967) showed the unit to consist of unnamed units of Silurian or Devonian age in the type locality. To the northeast, in the central interior region Doyle (1967) showed it as unnamed Siluro-Devonian and Seboomook Formation. These were located in different strike belts, the latter to the southeast and the former to the northwest. This unit then, has clearly been separated from several units one of which was the Seboomook Formation of Doyle (1967).

Distribution. - The unit, as shown by Osberg, Hussey and Boone (1985), crops out on the northwestern limb of the Kearsarge-Central Maine Synclinorium southeast of the Bronson Hill and Lobster Mountain anticlinoria. Outcrop is also in the cores of various smaller synclinal structures (Pankiwskyj, 1979; Osberg, Hussey, and Boone, 1985).

Lithology. - The Carrabassett Formation consists of three (formerly four) mappable members. These are a lower massive pelitic member; an upper thinly-layered member which consists of approximately subequal proportions of pelitic schist and quartzite; and a third member which consists of quartzite and metaquartzwacke as lenses at different stratigraphic horizons. The fourth member, the highest stratigraphically, is a calcsilicate or calcsilicate bearing plagioclase - biotite schist which has been reassigned to the Hildreths Formation by Moench et al. (1982).

Thickness and Age. - Estimates of the thickness of the Carrabassett are provided by Boone (1973) in the type locality and by Pankiwskyj (1979) and Hanson (1983). These estimates range from 1600 meters in the Little Bigelow, Kingfield and Anson quadrangles to 1800 meters in the Jo Mary Mountain quadrangle to the northeast. The age of the Carrabassett is known only from poorly preserved fossils collected by Espenshade and Boudette (1964) in what was correlated with the Seboomook Formation. The age of these fossils is not known conclusively, but is most probably Lower Devonian.

Hildreths Formation

General. - The Hildreths Formation was defined by Osberg, Moench and Warner (1968). The type locality is near Hildreths Mills in the Dixfield quadrangle. The unit is conformable between the underlying Carrabassett Formation and metasiltstones identified as the Mount Blue Formation of the Seboomook Group in the southwest, and as undifferentiated Seboomook Group in the northeast. This unit was mapped by Boone (1973) and included as the upper member of the Carrabassett Formation in the Little Bigelow Mountain quadrangle. The unit was also identified and mapped in a single outcrop in the Kingfield quadrangle by Pankiwskyj (1979).

Distribution. - The unit crops out in a discontinuous strike belt located on the northwest limb of the Kearsarge-Central Maine Synclinorium in southwest central Maine.

Lithology. - The lithologies of the Hildreths are distinctive compared with other lithologies of the Seboomook Group, and serve as a prominent stratigraphic marker in the outcrop belt. The unit is a rusty-weathering calcareous metasandstone, massive calcsilicate granulite and marble. Calcsilicate pods or ellipsoids are locally developed. Locally the unit is described as actinolite schist, calcsilicate biotite schist and calcsilicate quartzite.

Thickness and Age. - The unit is estimated to be between 60 and 240 meters thick by Osberg, Moench and Warner (1968), 120 meters by Boone (1973) and between 60 and 250 meters by Pankiwskyj (1979). No fossils have been recovered from this unit. The unit has been assigned a Lower Devonian age on the basis of position in the stratigraphic section by Osberg, Moench, and Warner (1968), Boone (1973), Pankiwskyj (1979), and Osberg Hussey and Boone (1985).

Mount Blue Formation (new stratigraphic rank)

General. - This unit was shown by Doyle (1967) as undifferentiated units equivalent to the Lower Devonian Littleton Formation in New Hampshire. Pankiwskyj (1979) defined this unit as the Mount Blue Member of the Seboomook Formation, and was shown as such by Osberg, Hussey and Boone (1985). The type locality is on the summit of Mount Blue in the Dixfield quadrangle (Pankiwskyj, 1979).

Distribution. - The unit crops out in discontinuous outcrop belts on the southern portion of the northwestern limb of the Kearsarge - Central Maine Synclinorium. This unit is in sharp, conformable contact on top of the Hildreths or Carrabassett Formation.

Lithology. - The unit is a (locally) rusty-weathering rhythmically interbedded metasiltstone and metapelite. Ratios of metasiltstone to metapelite are 1:1 to 1:2. The unit resembles

the upper member of the Carrabassett Formation.

Thickness. - Pankiwskyj (1979) considered the Mount Blue Formation to range between 500 and 750 meters in thickness.

Temple Stream Formation (new stratigraphic rank)

General. - This unit was also shown by Doyle (1967) to be part of the undifferentiated section which correlated with the Littleton Formation in New Hampshire. Pankiwskyj (1979) designated this the Temple Stream Member of the Seboomook Formation (Boucot, 1961) and was shown as such by Osberg, Hussey and Boone (1985). The type locality is in Temple Stream between elevations 730' and 790' in the Dixfield quadrangle.

Distribution. - This unit crops out on the margins of a regional synclinal structure on the southern portion of the northwest limb of the Kearsarge - Central Maine Synclinorium. The unit is gradationally conformable on top of the Mount Blue Formation, but typically forms the sole of the Rumford Allochthon in the northern outcrop belt where the Mount Blue Formation is missing.

Lithology. - The rocks of the Temple Stream Formation as defined by Pankiwskyj (1979) consist of rusty-weathering sulfidic metapelite, metasiltstone, and metaconglomerate with subordinate calcareous biotitic metasandstone and calcareous biotitic metapelite.

Thickness. - Pankiwskyj (1979) considered the Temple Stream Formation to range between 200 and 300 meters in thickness.

Day Mountain Formation (new stratigraphic rank)

General. - This formation is the uppermost of the stratigraphic units to be assigned a new rank. The Day Mountain was shown by Doyle (1967) as part of the undifferentiated rocks that correlated with the Lower Devonian Littleton Formation in New Hampshire. Pankiwskyj (1979) mapped this as the Day Mountain Member of the Seboomook Formation. Pankiwskyj (1979) subdivided this into the main portion of the unit and two mappable submembers. This formation is now considered to consist of three members. These are: 1) a metaconglomerate which is only locally developed and exposed; 2) a metalimestone member, also only locally developed and exposed, and 3) rhythmically graded-bedded metasiltstone and metapelite which forms most of the formation. Pankiwskyj (1979) designated the type section of this unit on Day Mountain in the Kingfield quadrangle.

Distribution. - This formation crops out in the core of a regional synclinal structure in the southern portion of the northwest limb of the Kearsarge - Central Maine Synclinorium. The unit also forms the uppermost part of the Rumford Allochthon (Pankiwskyj, 1979) in the northernmost portion of its outcrop area. Pankiwskyj (1979) considered the Day Mountain to be gradational and to intertongue with the underlying Temple Stream Formation. Younger units are not preserved in the area, and this is the uppermost stratigraphic unit in this portion of the state.

Lithology. - Pankiwskyj (1979) described the metaconglomerate member as a polymict granule metaconglomerate and coarse graywacke metasandstones. The graywackes are commonly graded and interbedded with metasiltstone or metapelite. The metalimestone member is described as a locally rusty-weathering arenaceous metalimestone or calcareous metasiltstone. The principal member of the Day Mountain consists of a generally non-rusty-weathering rhythmically-bedded metasiltstone and metapelite virtually indistinguishable lithologically from the Mount Blue Formation.

Thickness. - Pankiwskyj (1979) listed the thicknesses of these members as follows: metaconglomerate, 350 meters; metalimestone variable, but up to 250 meters; and the principal member approximately 700 meters giving a total thickness of approximately 1000 meters for the Day Mountain.

The Group have assembled structural data for these carboniferous rocks of the State. E (1979), u in conodo have conc Appalachian temperatures expected a near-surface formation of fluid (Silurian) concluding temperatures at least found the studying Tully-correlation Formation the eastern State, co Northeast