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INTRODUCTION

The purpose of the study leading to this paper was to investigate more fully the nature of the important contact between the Kearsarge-central Maine lithotectonic sequence and the Falmouth-Brunswick lithotectonic sequence, from the central part of the Weeks Mills 7.5' quadrangle in the southwest to the northern part of the Brooks East 7.5' quadrangle in the northeast. This contact was previously examined by Pankiwskyj (1976), who concluded that it was a major fault, which he named the Hackmatack Pond fault. It separated the Vassalboro Formation of the Kearsarge-central Maine sequence to the northwest from rocks to the southeast which at that time were correlated with the Cushing Formation of the Casco Bay Group.

Subsequent to that study, Newberg (1985) accepted the contact between the two lithotectonic sequences to be the Hackmatack Pond fault; however, he included in the Vassalboro Formation several units which I considered to be members of the Cushing Formation. In particular, he considered the sulfidic rusty-weathering rocks of the Beaver Ridge Member of the Cushing Formation (Pankiwskyj, 1976) to be a rusty-weathering unit within the otherwise gray-weathering Vassalboro Formation.

Osberg (1988) agreed with Pankiwskyj (1976) and accepted the above noted rusty-weathering rocks as a member of the Cushing Formation; however, he considered the contact between the Vassalboro Formation (renamed by him as the Hutchins Corner Formation) and the Cushing Formation to be an unconformity, not a fault. Later, however, Osberg and Berry (1991) shifted to favoring the fault nature of the contact, as was originally suggested by Pankiwskyj (1976).

In a concurrent paper on the structure and stratigraphy to the southwest of the area of study, Hussey (1988) describes in detail all the formations which are part of the Casco Bay Group. He interprets this group as being represented in two distinct lithotectonic packages: the Falmouth-Brunswick sequence to the northwest and the Saco-Harpswell sequence to the southeast. The Falmouth-Brunswick sequence contains four members of the Cushing Formation (the Nehumkeag Pond Member, the Mount Ararat Member, the Torrey Hill Member, and the Richmond Corner Member). The Saco-Harpswell sequence contains the remaining members of the Cushing Formation (the Wilson Cove Member, the Peaks Island Member, the Bethel Point Member, the Merepoint Member, and the Yarmouth Island Member); as well as eight younger formations. Hussey (1988) also shows the Kearsarge-central Maine sequence separated from the Falmouth-Brunswick sequence by the Hackmatack Pond fault, and the Falmouth-Brunswick sequence separated from the Saco-Harpswell sequence by the Beech Pond fault, both interpreted as shallowly northwest-dipping thrusts. However, both the Beech Pond fault and the Hackmatack Pond fault are shown as cut off by the Flying Point fault, a major component of the Norumbega fault system, which postdates the Acadian orogeny.

Since the 1988 paper, Hussey (personal communication) has completely removed the lithologic units within the Falmouth-Brunswick sequence from the Cushing Formation and has raised all of them to formation status. In addition, the name Saco-Harpswell sequence has been replaced with the name Casco Bay sequence. I follow these schemes in this paper.

This report is the result of mapping carried out during the summer and fall of 1991 for the purpose of obtaining more evidence on the nature of the disputed contact between the Kearsarge-central Maine and Falmouth-Brunswick sequences. The conclusions reached are that the contact is indeed a major

fault, the Hackmatack Pond fault, as originally conceived by Pankiwskyj (1976). The report is divided into two sections: (1) stratigraphy and (2) structure.

In the section on stratigraphy, the Kearsarge-central Maine sequence in the study area contains only one formation, the Hutchins Corner Formation (SOh), which includes the Windsor Neck Hill Member (SOhw).

The Falmouth-Brunswick sequence in the study area is subdivided into five formations, listed in order of interpreted decreasing age: the Nehumkeag Pond Formation (On); the Marden Hill Formation (Om); the Parmenter Cemetery Formation (Op); the Beaver Ridge Formation (Ob); and the Carrs Corner Formation (Occ), which includes the Sandy Pond Member (Occs). All contacts appear to be conformable.

The Casco Bay sequence in the area of this study is divided into two formations. The older is the Cushing Formation, which is mapped as undifferentiated (Oc) and also subdivided into two members: the Wilson Cove Member (Ocwc) and the Whitten Hill Member (Ocwh). The younger formation is the Cape Elizabeth Formation (Oce), and the contact between it and the Cushing Formation is at least locally faulted. However, this contact was not studied in detail, and thus no conclusion is being reached about the nature of the contact in its entirety.

In the section on structure, nine faults are identified in the study area. The presumed oldest is the Hackmatack Pond fault, a shallowly northwestward dipping thrust, which forms the contact between the Kearsarge-central Maine lithotectonic sequence and the Falmouth-Brunswick lithotectonic sequence. The Beaver Ridge fault is close to and subparallel to the Hackmatack Pond fault and may be contemporaneous. It maps out entirely within the Falmouth-Brunswick sequence. The Saban Pond fault is younger than the Hackmatack Pond fault, since it offsets the latter. The relative age of the Meadow Brook fault with respect to the above faults is uncertain. However, since it is terminated at the Stantial Bog fault whereas the Hill 806 fault is not, the Meadow Brook fault is considered to be older than the Hill 806 fault. The Hill 806 fault is tentatively correlated with the Beech Pond fault, and they are considered a splay of the Norumbega fault system, which postdates the time of Acadian metamorphism. Finally there is the triplet of subparallel N80W-S80E trending faults: the Knox Ridge fault, the Stantial Bog fault, and the Jackson Corners fault. The first and second offset the Hill 806 fault, thus all three are considered to be the youngest faults in the area of this study.

STRATIGRAPHY

CASCO BAY SEQUENCE

General Statement

In the study area, the Casco Bay sequence is represented by two formations: the older Cushing Formation, mapped as undifferentiated (Oc), the Whitten Hill Member (Ocwh) in the middle part of the exposed section, and the Wilson Cove Member (Ocwc) at the very top of the section; and the younger Cape Elizabeth Formation (Oce), which is not subdivided.

Cushing Formation (Oc), including the Whitten Hill Member (Ocwh)

1. Name. The name Cushing was first used by Katz (1917) for a unit he called the Cushing Granodiorite from the type exposures on Cushing Island in Casco Bay. Since then these rocks have been generally reinterpreted to represent a complex package of dominantly fragmental felsic volcanic rocks, in many regions metamorphosed to high grades. As used by Hussey (1985), the Cushing Formation was subdivided into three lithotectonic belts: the Portland - Harpswell belt, containing four members; the Falmouth-Brunswick belt, containing four members; and the East Harpswell - Merrymeeting Bay belt, containing three members. Subsequently, Hussey (1988) combined the first and third of the above belts into the single Saco-Harpswell sequence, containing five members of the Cushing Formation, as well as eight younger formations. The Falmouth-Brunswick belt was renamed the Falmouth-Brunswick sequence, still with the same four members of the Cushing Formation.

Most recently, Hussey (personal communication), has removed the lithologic units of the Falmouth-Brunswick sequence from the Cushing Formation, and established them as four independent formations: Nehumkeag Pond Formation, Mount Ararat Formation, Torrey Hill Formation, and Richmond Corner Formation. Concomitantly the name Saco-Harpswell sequence was replaced with the name Casco Bay sequence, containing five members of the Cushing Formation: Yarmouth Island Member, Bethel Point Member, Peaks Island Member, Sebascodegan Member, and Wilson Cove Member. This definition of the Cushing Formation is followed in this paper.

In the area of this study, rocks assigned to the Cushing Formation are subdivided into the main undifferentiated part (Oc), composed mostly of gray- to buff-weathering felsic metavolcanic rocks; the Whitten Hill Member (Ocwh), composed of sulfide-bearing, punky- to rusty-weathering rocks; and the very distinctive Wilson Cove Member (Ocwc), which is described in a section of its own.

The name Whitten Hill Member of the Cushing Formation was first used informally by Pankiwskyj (1976). The type locality is along the crest of Whitten Hill in the northern part of the Liberty 7.5' quadrangle. The type section is in a brook about 400 meters to the southwest of Whitten Cemetery, between elevations of 500 feet and 580 feet.

2. Area of exposure. In the area of this study, rocks assigned to the Cushing Formation are found exclusively to the southeast of the Hill 806 fault, whose existence is uncertain; and also to the southeast of the Beech Pond fault, whose existence is only postulated. The Beech Pond fault was established by

Newberg (1985), and I tentatively correlate it with the Hill 806 fault. The southeastern contact of the Cushing Formation is with the Cape Elizabeth Formation, and the Wilson Cove Member of the Cushing Formation (Ocwc) is invariably present at the contact in the area of this study.

3. Thickness. The lower contact of the Cushing Formation is not exposed in this area, being cut out by the Hill 806 - Beech Pond faults noted above. In the northeastern part of the area, the outcrop width of the entire formation is only 300 meters, but in the Palermo 7.5' quadrangle to the southwest, the outcrop width is up to 5 kilometers. No accurate thickness estimate for the entire formation is possible. The thickness of the section between the Wilson Cove Member and the Whitten Hill Member may be on the order of 200 meters, of the Whitten Hill Member itself about 100 meters, and of the section to the northeast of the Whitten Hill Member perhaps as much as 300 meters.

4. Lithology. The dominant rock type in the main undifferentiated part of the Cushing Formation is light gray to slightly buff weathering, highly variably bedded and laminated, typically fine- to medium-grained plagioclase-quartz muscovite biotite granofels. The following are subordinate for the formation as a whole, but locally abundant: salt and pepper biotite-plagioclase-quartz hornblende muscovite granofels; plagioclase-quartz-biotite-sillimanite-muscovite granofels; amphibolite with or without garnet, and commonly containing pods of plagioclase and diopside; and calc-silicate granofels.

The Whitten Hill Member is differentiated from the main part on account of the pronounced rusty-weathering aspect of its outcrops. They include quartz-plagioclase-muscovite granofels interbedded with quartz-muscovite-plagioclase schist; plagioclase-quartz-biotite hornblende schist; and quartz-plagioclase-muscovite-biotite garnet sillimanite schist.

5. Contacts. What would be presumed to be the lower contact of the Cushing Formation is not exposed on account of the presence of the Hill 806 - Beech Pond faults. Both the lower and upper, respectively the northwestern and southeastern, contacts of the Whitten Hill Member with the undifferentiated part are conformable and gradational. Alternating sections of gray-weathering rocks and rusty-weathering rocks are encountered in the contact zone. The contact of the undifferentiated part of the Cushing Formation (Oc) with the Wilson Cove Member (Ocwc) is also gradational and is discussed in the section relating to this member.

6. Correlation. As the name implies, rocks mapped as the Cushing Formation in the area of this study are correlated with the Cushing Formation as currently defined by Hussey (personal communication); i.e., restricted to the Casco Bay sequence. The Whitten Hill Member of this study, by virtue of its position near the middle part of the formation, is tentatively correlated with the Bethel Point Member of the Casco Bay area. The undifferentiated part which is to the northwest of (below) the Whitten Hill Member is tentatively correlated with the Yarmouth Island Member; and that part to the southeast of (above) the Whitten Hill Member is thus tentatively correlated with the Peaks Island Member.

Wilson Cove Member (Ocwc)

1. Name. The name Wilson Cove Member of the Cushing Formation was first used informally by Hussey (1971) for the unique mafic metavolcanics and associated rocks exposed on the west shore of Harpswell Neck in the Orrs Island 7.5' quadrangle. Identical rocks were noted in the Liberty 15' quadrangle by Pankiwskyj (1976).

2. Area of exposure. The Wilson Cove Member of the Cushing Formation forms a remarkably persistent belt through the entire southeastern part of this study area. It has been confidently traced from Marsh Stream in the East Dixmont 7.5' quadrangle, northeast of this study area, all the way to near Somerville in the Razorville 7.5' quadrangle, southwest of this study area - a distance of about 60 km. Osberg and others (1985) show this belt continuing to the southwest for another 8 km.

3. Thickness. On the basis of exposures in the Liberty 7.5' quadrangle, the thickness of the Wilson Cove Member is estimated at about 50 meters. This falls right in the middle of the 0 - 120 meter thickness estimated by Hussey (1988) in southwestern Maine.

4. Lithology. The Wilson Cove Member of the Cushing Formation is defined by a distinctive sequence of weakly to intensely rusty weathering, dark gray where fresh, fine- to coarse-grained, typically garnet-rich granofels and schist. In addition to the near ubiquitous garnet, the granofels contains quartz, plagioclase, and highly variable amounts of biotite hornblende grunerite, and up to several percent of sulfide minerals. The schist contains highly variable amounts of biotite muscovite garnet in addition to quartz, plagioclase, and sulfide minerals. The relationships among the rock types are difficult to establish, but thick and thin beds are encountered. Individual outcrops of granofels or schist lacking amphiboles and garnet are similar to rocks noted in the Whitten Hill Member of the Cushing Formation (Ocwh) and also to most rocks in the Beaver Ridge Formation (Ob) of the Falmouth-Brunswick sequence, but the garnet- and amphibole-rich rock types are unique and readily identifiable.

5. Contacts. What is interpreted as the lower contact, on the northwestern side of the unit, is with the main part of the Cushing Formation (Oc). It appears conformable and is seen, downwards in the section, as a decrease in the intensity of rusty weathering and increasing dominance of the plagioclase-quartz-biotite-muscovite granofels, which is the most common rock type of the main part of the Cushing Formation.

The southeastern contact is problematic. Rusty-weathering muscovite-biotite-quartz-plagioclase schist, mapped as part of the Wilson Cove Member, passes within a distance of about 10 meters into gray-weathering interbedded granofels and schist, mapped as part of the Cape Elizabeth Formation. Abundant

veins of pure quartz, some with vugs containing terminated quartz crystals, are noted in this contact zone. There is a good chance that this contact is a fault, and thoughts on this subject are expressed in the section on the Cape Elizabeth Formation.

6. Correlation. The rocks of this member are easily recognized as identical to those at Wilson Cove on the northwestern shore of Harpswell Neck in the Orrs Island 7.5' quadrangle, and were thus correlated by Pankiwskyj (1976). The Wilson Cove Member, as most recently described by Hussey (1988), is at the very top of the Cushing Formation of the Casco Bay sequence in southwestern Maine.

Cape Elizabeth Formation (Oce)

1. Name. The name Cape Elizabeth Formation was introduced by Katz (1917) for the shoreline exposures in the town of Cape Elizabeth, south of Portland, Maine. This name was first used in the area of this study by Pankiwskyj (1976). Prior to that, rocks now assigned to this formation were typically referred to as the Hogback Schist, a name introduced by Perkins and Smith (1925).

2. Area of exposure. In the area of this study, the Cape Elizabeth Formation is found in two separate belts. One is a thin belt, found only in the Brooks East and the Brooks West 7.5' quadrangles, and is bounded to the northwest by the Meadow Brook fault and to the southeast by the Hill 806 fault. This belt continues to the northeast out of the area of this study, but is cut off on the southwestern side by the Stantial Bog fault. The second belt of the Cape Elizabeth Formation forms the southeastern margin of this area of study. It is several kilometers wide, but only its northwestern margin is shown on the geologic map.

3. Thickness. The top of the Cape Elizabeth Formation is outside of the area of this study. Hussey (1985) states an estimated maximum thickness of 350 meters from the continuous section in the town of Cape Elizabeth.

4. Lithology. The Cape Elizabeth Formation, in the very limited area of this study, is a monotonous sequence of interbedded granofels and schist. The granofels is light to medium gray weathering and is composed of quartz-plagioclase-muscovite-biotite, forming beds ranging in thickness from 2 cm to 20 cm, and commonly containing partings of muscovite-biotite-garnet sillimanite. The schist is medium gray weathering and is composed of quartz-plagioclase-muscovite-biotite-garnet, forming beds ranging in thickness from 1 cm to 10 cm, and commonly containing thin partings of quartz and plagioclase. In freshly broken specimens, the granofels is commonly medium to dark gray, which is due to the presence of up to 1% of finely disseminated opaque minerals as well as 2%-4% biotite. The schist has a high degree of fissility due to the presence of large parallel grains of muscovite, 35% on the average but up to 75% in specimens which show well-developed partings of quartz and plagioclase. In most cases biotite is strongly subordinate to muscovite, which is opposite to the relative abundances in the Hutchins Corner Formation.

5. Contacts. Both contacts of the thin northwestern belt of the Cape Elizabeth Formation in this study area are faults, and are discussed in the sections on the Meadow Brook fault and the Hill 806 fault.

The northwestern contact of the southeastern belt of the Cape Elizabeth Formation is with the Wilson Cove Member of the Cushing Formation (Ocwc). This same relationship has been traced by this writer to the very western edge of the Razorville 7.5' quadrangle, to the southwest and outside of this study area. Wherever exposed, a rusty-weathering schist containing abundant veins of pure quartz, some with vugs containing terminated quartz crystals, is present between the typical gray granofels and schist sequences of the Cape Elizabeth Formation and the characteristic rusty-weathering garnet-rich amphibolite of the Wilson Cove Member. The nature of this contact is unclear. Hussey (1988) reports that, in southwestern Maine, the Cape Elizabeth Formation is found in contact with either the Wilson Cove Member of the Cushing Formation, with other members of the Cushing Formation, or with the Sebascodegan Formation. The contact could be a fault, or an unconformity, or it could even be a conformable contact with various lithologic units within the Cushing Formation which are facies of one another. The question then arises, why one thin member of the Cushing Formation, namely the Wilson Cove Member estimated to be not more than 120 meters thick, should be the sole unit in contact with the above-lying Cape Elizabeth Formation for the 50 km stretch from Coopers Mills in the southwest to near Jackson in the northeast? At present, this problem is unresolved.

6. Correlation. The correlation of the rocks of the Cape Elizabeth Formation in this area of study with those at the type locality in the town of Cape Elizabeth has already been stated. The Woodland Formation of eastern Maine bears considerable similarity to the Cape Elizabeth Formation, and they may be equivalent. Similarly, the Aziscohos Formation of the northwestern limb of the Kearsarge-central Maine synclinorium has some similarities, lithologically and possibly also stratigraphically with the Cape Elizabeth Formation, and may be equivalent. However, any correlation at this time between units in the Casco Bay sequence with units in the Kearsarge-central Maine sequence are highly speculative.

FALMOUTH - BRUNSWICK SEQUENCE

General Statement

In the area of this study, the Falmouth-Brunswick sequence is represented by five formations. Listed in interpreted decreasing age these are: the Nehumkeag Pond Formation (On); the Marden Hill Formation (Om) and its facies the Parmenter Cemetery Formation (Op); the Beaver Ridge Formation (Ob); and the

Carrs Corner Formation mapped as the undifferentiated part (Occ) and the Sandy Pond Member (Occs).

Nehumkeag Pond Formation (On)

1. Name. The name, Nehumkeag Pond Member of the Cushing Formation, was first proposed informally by Newberg (1981a,b) for exposures north of Nehumkeag Pond in the Wiscasset 15' quadrangle. Later, in his work in the Palermo 7.5' quadrangle, Newberg (1985) correlated all lithologic units dominated by buff-weathering felsic metavolcanic rocks with this member.

At this same time, as a result of his work in the Casco Bay region, Hussey (1985) formally subdivided the Cushing Formation into eleven members: four in the South Portland - Harpswell belt, four (including the Nehumkeag Pond Member) in the Falmouth-Brunswick belt, and three in the East Harpswell - Merrymeeting Bay belt. In his recent reinterpretation, (Hussey, personal communication), the four units within the Falmouth-Brunswick belt are removed from the Cushing Formation, and become independent formations within the Falmouth-Brunswick sequence. This is the scheme followed in this paper, and thus the renaming of the unit as the Nehumkeag Pond Formation.

2. Area of exposure. In the area of this study, rocks of the Nehumkeag Pond Formation are mapped in: (1) the core of a northeast-plunging anticline in the southern and southwestern part of the Palermo 7.5' quadrangle and the adjoining northwestern part of the Razorville 7.5' quadrangle; (2) the core of a doubly plunging anticline within rocks of the Beaver Ridge Formation, about 700 meters to the southeast of Dowe Pond, in the southern part of the Palermo 7.5' quadrangle; (3) to the southeast of the main belt of the Beaver Ridge Formation (from as far in the southwest as the boundary between the Razorville and Palermo 7.5' quadrangles to as far in the northeast as the central part of the Brooks West 7.5' quadrangles); (4) to the southeast of the long tongue of the Beaver Ridge Formation extending to the southwest from the Stantial Bog fault in the central part of the Brooks West 7.5' quadrangle to as far as the northeastern corner of the Liberty 7.5' quadrangle; (5) the core of a doubly plunging anticline within rocks of the Beaver Ridge Formation, about 2 kilometers to the northeast of the Stantial Bog fault. Typically, the southeastern margin of the Nehumkeag Pond Formation is at the Hill 806 - Beech Pond faults, to the southeast of which are rocks of the Casco Bay sequence.

3. Thickness. The lower contact of the formation is not exposed, and thus a minimum thickness of 350 meters is interpreted from the exposures in this area of study.

4. Lithology. The dominant rock type of the Nehumkeag Pond Formation is light gray to slightly buff weathering, highly variably bedded and laminated, typically fine- to medium-grained plagioclase-quartz biotite muscovite granofels, some with several percent of very conspicuous garnet. In addition, there are also present subordinate quantities of salt and pepper biotite-plagioclase-quartz hornblende muscovite granofels, amphibolite, calc-silicate granofels, and marble.

5. Contacts. The lower contact of the Nehumkeag Pond Formation is not exposed. The upper contact is with the Beaver Ridge Formation (Ob) or, if either the Marden Hill Formation (Om) or the Parmenter Cemetery Formation (Op) is present, with either of them. These contacts are gradational, and are described in the sections dealing with these three formations.

6. Correlation. The rocks assigned to the Nehumkeag Pond Formation in the area of this study are correlated with the same named rocks to the southwest, and are interpreted to represent the lowest stratigraphic unit within the Falmouth-Brunswick sequence.

Marden Hill Formation (Om)

1. Name. The name Marden Hill Member of the Cushing Formation was first used informally by Pankiwskyj (1976) for the thin unit, dominantly composed of mafic metavolcanic rocks, which is locally present immediately below the rusty-weathering rocks of the unit which in 1976 was referred to as the Beaver Ridge Member of the Cushing Formation. The name is here raised to independent formation status in line with the recent reinterpretation by Hussey (personal communication) of the stratigraphy in the type area. The type locality of the Marden Hill Formation is on the western and northwestern slopes of Marden Hill (not identified by name on the topographic map, but which can be spotted by the Carr triangulation station) in the central part of the Palermo 7.5' quadrangle. The type section is along the Mobil Pipeline directly east from Carrs Corner, in the eastern part of the Palermo 7.5' quadrangle.

2. Area of exposure. Rocks of the Marden Hill Formation are found locally below those of the Beaver Ridge Formation (Ob) and above, or near the very top, of the Nehumkeag Pond Formation (On), in eight areas: south from Deer Hill, in the northeastern corner of the Weeks Mills 7.5' quadrangle; about 2 km to the northeast from Deer Hill; in five separate lens-shaped belts within the main belt of the Beaver Ridge Formation, all in the central part of the Palermo 7.5' quadrangle (these five belts are interpreted as forming the cores of tight doubly plunging anticlines); and a small lens near the very top of the Nehumkeag Pond Formation in the western part of the Liberty 7.5' quadrangle.

3. Thickness. On the basis of the two areas of exposure of the Marden Hill Formation where both the lower and the upper contacts are exposed, the thickness of the formation is estimated at 25 meters.

4. Lithology. The Marden Hill Formation is distinguished from all other units within the Falmouth-Brunswick sequence by the dominance within it of mafic metavolcanic rocks. In addition to fine- to medium-grained dark gray amphibolite with rare garnet, the formation includes salt and pepper biotite-plagioclase-quartz hornblende garnet granofels, biotite-rich quartz-plagioclase schist with laminae of

plagioclase-quartz-biotite granofels, coarse-grained hornblende schist with lenses of coarse marble, and minor coarse-grained kyanite staurolite-bearing biotite-quartz-feldspar granofels in which the kyanite and staurolite are almost completely replaced with cordierite, sillimanite, and chlorite.

5. Contacts. Both contacts of the Marden Hill Formation, respectively with the Nehumkeag Pond Formation (On) below and with the Beaver Ridge Formation (Ob) above, are conformable and gradational. The lower contact is drawn with the increase in dominance, downwards in the section, of plagioclase-quartz-biotite-muscovite granofels, which is the most common rock type of the Nehumkeag Pond Formation. The upper contact is drawn with the increase, upwards in the section, of the intensity of rusty-weathering and a concomitant decrease in the plagioclase:quartz ratio.

6. Correlation. The Marden Hill Formation is a locally developed facies immediately below the sulfidic rocks of the Beaver Ridge Formation. Elsewhere in the region of this study, there is found immediately below the Beaver Ridge Formation either the Parmenter Cemetery Formation (Op) or the Nehumkeag Pond Formation (On). In southwestern Maine, Hussey (1988) shows a lithologic unit which is now the Mount Ararat Formation of the Falmouth-Brunswick sequence, composed of interbedded felsic and mafic metavolcanic rocks, in contact with and to the southeast of the Torrey Hill Formation, which is a rusty-weathering unit. The Marden Hill Formation is tentatively correlated with the Mount Ararat Formation.

Parmenter Cemetery Formation (Op)

1. Name. The name Parmenter Cemetery Formation is used here for the first time for the dominant calc-silicate granofels and plagioclase-quartz-biotite granofels, which are present locally immediately below the rusty-weathering rocks of the Beaver Ridge Formation. This unit was first mapped separately by Newberg (1985) who interpreted it as a marble unit (Ocnm) within the Nehumkeag Pond Member of the Cushing Formation. The type locality is immediately at Parmenter Cemetery, which is halfway between Saban Pond and Dowe Pond, in the southern part of the Palermo 7.5' quadrangle. The type section is directly north from Beech Pond, along the side of the main dirt road between Parmenter Cemetery and Maine Highway 3.

2. Area of exposure. Rocks of the Parmenter Cemetery Formation are found locally below those of the Beaver Ridge Formation (Ob) and above those of the Nehumkeag Pond Formation (On) in three areas: a long belt to the west of Beech Pond in the southern part of the Palermo 7.5' quadrangle and the northern part of the Razorville 7.5' quadrangle; another belt about 1 km to the west, with an exposure near Palermo School; and in a small anticline within the main belt of the Beaver Ridge Formation, about 750 meters southeast from Dowe Pond, also in the Palermo 7.5' quadrangle.

3. Thickness. On the basis of the type section north from Beech Pond, the thickness of the Parmenter Cemetery Formation is estimated at about 25 meters.

4. Lithology. The Parmenter Cemetery Formation is distinguished from all other units within the Falmouth-Brunswick sequence by the dominance within it of calcareous rock types. The most common rock is a medium- to coarse-grained, gray to punky weathering, plagioclase-quartz-biotite granofels with variable quantities of garnet, calcite, and calc-silicate minerals. This rock is typically massively interbedded with plagioclase-quartz-biotite granofels. Also present are beds of hornblende schist with lenses of biotitic marble, and also minor amounts of medium-grained dark amphibolite.

5. Contacts. Both contacts of the Parmenter Cemetery Formation, respectively with the Beaver Ridge Formation (Ob) above and the Nehumkeag Pond Formation (On) below, are conformable and gradational. The lower contact is drawn, downwards in the section, with the increasing dominance of plagioclase-quartz-biotite-muscovite granofels, which is the most common rock type of the Nehumkeag Pond Formation. The upper contact is drawn, upwards in the section, with the increase in the intensity of rusty weathering and a concomitant decrease in the plagioclase:quartz ratio.

6. Correlation. The Parmenter Cemetery Formation is a locally developed facies immediately below the sulfidic rocks of the Beaver Ridge Formation. Elsewhere in the area of this study, there is found immediately below the Beaver Ridge Formation either the Marden Hill Formation (Om) or the Nehumkeag Pond Formation (On). The Marden Hill Formation is tentatively correlated with the Mount Ararat Formation of the Falmouth-Brunswick sequence in southwestern Maine, as currently defined by Hussey (personal communication). The Parmenter Cemetery Formation is also thus stratigraphically correlated with the Mount Ararat Formation.

Beaver Ridge Formation (Ob)

1. Name. The name Beaver Ridge Member of the Cushing Formation was first used by Pankiwskyj (1976) for the most prominent and persistent belt of rusty-weathering rocks within the unit which at that time was correlated with the Cushing Formation of the Casco Bay region. The name is here raised to independent formation status in line with the recent reinterpretation of the stratigraphy in the type area by Hussey (personal communication). The type locality of the Beaver Ridge Formation is the summit area of Beaver Ridge, in the northern part of the Liberty 7.5' quadrangle. The type section is along the paved road between Hutchins Corner and Thurstons Corner, about 1.75 km west from Thurstons Corner, also in the Liberty 7.5' quadrangle.

2. Area of exposure. The Beaver Ridge Formation forms a persistent belt, which is only 150 meters wide in the Weeks Mills 7.5' quadrangle (the southwestern part of the study area), widens

to over 2.5 km in the Brooks West 7.5' quadrangle due to folding, and is again about 150 meters wide in the Brooks East 7.5' quadrangle (northeastern part of the study area). In addition, a long, but thin, tongue-like belt of rocks of this formation is exposed in the trough of a northeast-plunging syncline, extending from the Stantial Bog fault in the central part of the Brooks West 7.5' quadrangle to as far southwest as the northeastern corner of the Liberty 7.5' quadrangle. Locally, rocks of the Beaver Ridge Formation are overlain by klippen of the Hutchins Corner Formation along the Hackmatack Pond fault.

3. Thickness. On the basis of the belts of least width, both in the Weeks Mills and in the Brooks East 7.5' quadrangles, the thickness of this formation is estimated at about 125 to 150 meters.

4. Lithology. The Beaver Ridge Formation is distinguished from all other units within the Falmouth-Brunswick sequence in the area of this study by the consistent rusty-weathering aspect of the rocks. There are lenses of rusty-weathering rocks within all parts of the otherwise gray-weathering Nehumkeag Pond Formation and Carrs Corner Formation, but all continuous extensive sections are here included into the Beaver Ridge Formation. The most common rock types range from punky and only weakly rusty-weathering to intensely rusty-weathering, slightly to richly sulfidic and locally also graphitic, biotite-muscovite-quartz-plagioclase granofels, biotite-muscovite-plagioclase-quartz granofels, biotite-muscovite garnet sillimanite schist, and minor calc-silicate granofels. Typical outcrops consist of both granofels and schist, but their bedding relationships and ratio to one another are difficult to ascertain due to the intensity and depth of weathering. However, beds of both granofels and schist as thin as 3 cm and as thick as 20 cm have been noted. Mica-richer partings, alternating with mica-poorer partings, are common in the granofels, and as a result, the granofels exhibits a poor quality fissility. However, partings of practically pure mica alternating with mica-poorer partings are very common in the schist, and, due to this, the schist exhibits a very good fissility. In least weathered specimens, the granofels is light to medium gray and the schist is dark gray. Locally present in the lower part of the Beaver Ridge Formation, especially near contacts with the Parmenter Cemetery Formation (Op), are alternating beds of rusty-weathering biotitic granofels and greenish calc-silicate granofels. Near contacts with the Marden Hill Formation (Om) are locally present beds of rusty-weathering amphibolite and/or marble.

5. Contacts. The upper contact of the Beaver Ridge Formation is with the Carrs Corner Formation (Occ) and is conformable and gradational. It is the most gradational contact in the area of this study. Upwards in the section from the Beaver Ridge Formation, the intensity of rusty-weathering of the entire rock decreases through an outcrop width of up to 20 meters; however, rusty-weathering along mica-rich partings persists for up to 50 meters. Throughout this transition zone, the rock remains a very prominently laminated biotite-rich quartz-plagioclase muscovite granofels with rare garnet and/or calcite and a biotite-poor quartz-plagioclase granofels.

The lower contact of the Beaver Ridge Formation is with either the Parmenter Cemetery Formation (Op), the Marden Hill Formation (Om), or with the Nehumkeag Pond Formation (On), and is conformable. Downwards in the section from the Beaver Ridge Formation, there is a rapid decrease in the amount of sulfide minerals, and consequently in the intensity of rusty weathering; also there is a concomitant increase in the plagioclase:quartz ratio. The resulting rock is the typically poorly- to well-laminated plagioclase-quartz-biotite-muscovite granofels, which is the dominant rock type within the Nehumkeag Pond Formation. Thin beds of calc-silicate granofels, of marble, or of amphibolite are locally present near the contact, especially wherever the underlying unit is the Marden Hill Formation or the Parmenter Cemetery Formation.

6. Correlation. In the area of this study, the Beaver Ridge Formation is close to the northwestern margin of exposure of the Falmouth-Brunswick sequence, that is, close to the Hackmatack Pond fault. Sixty kilometers to the southwest, in the Brunswick area, Hussey (1988) shows a prominent rusty-weathering lithologic unit, which is now the Torrey Hill Formation, in a very similar structural setting. The unit to the northwest of the Torrey Hill Formation, now named the Richmond Corner Formation, is in part very similar to the laminated biotitic granofels of the lower part of the Carrs Corner Formation, the part immediately above the contact with the Beaver Ridge Formation in the area of this study. The unit to the southeast of the Torrey Hill Formation, now named the Mount Ararat Formation, contains prominent beds of amphibolite and thus has some similarity with the Marden Hill Formation in the study area. On account of the similarity between these two cross sections, the Beaver Ridge Formation is correlated with the Torrey Hill Formation.

Carrs Corner Formation (Occ), including the Sandy Pond Member (Occs)

1. Name. The name Carrs Corner Formation is used here for the first time, for the dominantly biotitic felsic metavolcanic rocks within the Falmouth-Brunswick sequence which are to the west of, and interpreted as being stratigraphically above, the Beaver Ridge Formation (Ob). Earlier, Pankiwskyj (1976) had correlated these rocks with the Cushing Formation. In addition, the name Sandy Pond Member of the Cushing Formation was used for the numerous lenses which contain significant quantities of very distinctive rock types in addition to those typical of the formation as a whole, such rocks as coarse-grained granofels with relict kyanite staurolite, garnet-rich amphibolite, hornblende schist, and marble. However, in line with recent reinterpretations by Hussey (personal communication) of the stratigraphy to the southwest, all rock units within the Falmouth-Brunswick sequence are removed from the Cushing Formation and raised to independent formation status. Thus in

the area of this study, these rocks are now assigned the new name Carrs Corner Formation (Occ) and those originally assigned to the Sandy Pond Member of the Cushing Formation are now the Sandy Pond Member of the Carrs Corner Formation (Occs).

The type location of the Carrs Corner Formation is in the immediate vicinity of Carrs Corner in the eastern part of the Palermo 7.5' quadrangle and that of the Sandy Pond Member is at the tip of the prominent long peninsula jutting into Sandy Pond from the southwest, in the southern part of the Unity 7.5' quadrangle. The type section for both, however, is along both sides of the dirt road, not shown on the topographic map, which goes off to the northwest from the main Palermo - North Palermo road, starting about 250 meters southwest of Carrs Corner, in the central part of the Palermo 7.5' quadrangle. This section has been described in several field guides: Pankiwskyj (1978, p. 8, Stop #11) or Osberg and Berry (1991, p. 372, Stop #11).

2. Area of exposure. The Carrs Corner Formation is the youngest unit of the Falmouth-Brunswick sequence and forms a persistent belt along the northwestern margin of this sequence, from the very southwestern limit of the study area between Windsor and Windsor Station in the central part of the Weeks Mills 7.5' quadrangle to just northeast of Jackson Corners in the northeastern part of the Brooks West 7.5' quadrangle. Farther to the northeast the Carrs Corner Formation is cut out by the Hackmatack Pond fault.

The distinct lenses which are mapped out as the Sandy Pond Member range from as small as a single outcrop up to 700 meters by 100 meters. Fifteen such lenses are shown, from the northeastern part of the Weeks Mills 7.5' quadrangle to the southeastern part of the Unity 7.5' quadrangle. The stratigraphic position of the lenses ranges from immediately above the Beaver Ridge Formation to several hundred meters above this contact.

3. Thickness. Only a minimum estimate of thickness of the Carrs Corner Formation is possible because its upper contact is cut off by the Hackmatack Pond fault. A minimum thickness is estimated at 250 meters to 300 meters. The width of the individual lenses of the Sandy Pond Member is as much as 100 meters. Taking into account the thickening of the section due to folding, the thickness of the lenses is estimated as up to 50 meters.

4. Lithology. The dominant rock type within the undifferentiated part of the Carrs Corner Formation (Occ) is quite similar to that which comprises the bulk of the Nehumkeag Pond Formation (On), which is also part of the Falmouth-Brunswick sequence, and also to that which dominates the Cushing Formation (Oc), which is part of the Casco Bay sequence. This rock type is light gray to slightly buff weathering, highly variably bedded and laminated, typically fine- to medium-grained plagioclase-quartz biotite muscovite garnet granofels. Present also are subordinate quantities of: amphibolite with or without garnet; salt and pepper biotite-plagioclase-quartz hornblende muscovite granofels; very pale green calc-silicate granofels forming thick beds or interbedded with purplish-gray biotitic granofels; and marble. What distinguishes the Carrs Corner Formation from the Nehumkeag Pond Formation and the Cushing Formation is the presence of a very prominently laminated biotite-rich quartz-plagioclase muscovite granofels with rare garnet and/or calcite and a biotite-poor quartz-plagioclase granofels. This laminated rock resembles similar ones mapped in the Hutchins Corner Formation, and Newberg (1985), working in this very area, included them in the Hutchins Corner Formation. However, I assign them to the Carrs Corner Formation for two reasons: (1) their presence within the very gradational contact with the Beaver Ridge Formation (Note that Newberg considered the Beaver Ridge rusty lithologies as part of the Hutchins Corner Formation); and (2) the intimate association of the above-noted strongly laminated rocks with lenses containing rock types mapped out as the Sandy Pond Member of the Carrs Corner Formation. This writer has not seen such types of rocks anywhere within the Hutchins Corner Formation.

The Sandy Pond Member (Occs) is distinguished from the main undifferentiated part of the Carrs Corner Formation (Occ) by the dominating presence of several rock types other than plagioclase-quartz-biotite-muscovite granofels. The most definitive special rock type is gray to buff weathering, light gray where fresh, typically coarse-grained quartz-plagioclase-biotite garnet granofels or schist with relict kyanite staurolite, which are in part to completely replaced by cordierite, sillimanite, and chlorite. This rock type is present in massive beds up to 10 meters thick. Also mapped within the Sandy Pond Member are: gray, coarse-grained plagioclase-rich amphibolite composed of hornblende-garnet-biotite grunerite; medium-grained hornblende-rich amphibolite; and coarse-grained hornblende schist containing lenses of coarse-grained marble with minor biotite hornblende. In between outcrops of the above-noted special rock types are commonly also found types of granofels typical of the main undifferentiated part of the formation. Both massive as well as thinly laminated beds are present, and in some are found up to several percent of calcite and/or a few percent of calc-silicate minerals. Within the Hackmatack Pond fault itself, and nowhere else, there is commonly found a very dense, well-foliated quartzite with up to 20% magnetite.

5. Contacts. The upper contact of the Carrs Corner Formation is not exposed in the area of this study due to the presence of the Hackmatack Pond fault, which separates the Falmouth-Brunswick sequence to the southeast from the Kearsarge-central Maine sequence to the northwest.

The lower contact of the Carrs Corner Formation is with the Beaver Ridge Formation and is the most gradational contact mapped in the entire area. Even though this contact is described in the section on the Beaver Ridge Formation, it is considered to be of sufficient importance for the description to be given here as well. Upwards in the section from the Beaver Ridge Formation, the intensity of rusty-weathering of the entire rock decreases through an outcrop width of up to 20 meters; however, rusty-weathering along mica-rich partings persists for up to 50 meters. Throughout this transition zone, the rock is invariably the very prominently laminated biotite-rich granofels and biotite-poor granofels noted in the section on lithology.

The contacts of the Sandy Pond Member are gradational with both the Beaver Ridge Formation (Ob) and with the main undifferentiated part of the Carrs Corner Formation (Occ). There is no one particular rock type of the Sandy Pond Member which forms the margin of the member.

6. Correlation. The Carrs Corner Formation is correlated with the Richmond Corner Formation as currently interpreted by Hussey (personal communication). Aiding this correlation is Hussey's (1985) description of this unit, at that time referred to as the Richmond Corner Member of the Cushing Formation, as a "heterogeneous association of mostly metasedimentary rocks including: 1) medium gray quartz-plagioclase-biotite-garnet granulose schist (the predominant lithology); . . . which closely resembles the high grade Vassalboro rocks exposed to the west." Note here that since the time of that writing, the name Hutchins Corner has replaced the name Vassalboro. The above-quoted observation of Hussey is practically identical to my description of the strongly laminated rocks mapped in the lower part of the Carrs Corner Formation, immediately above the contact with the Beaver Ridge Formation.

Rocks of the Sandy Pond Member constitute a complex depositional facies of volcanogenic as well as non-volcanogenic clastic material, the latter including both organic and inorganic detritus. The physical separation of the lenses of this member implies the existence of local environments, each of short duration, but recurring over a large area for a prolonged time. Thus there is no implied time correlation among the various lenses. Conditions which were necessary for the deposition of these rocks were most common after the deposition of the primarily detrital rocks of the Beaver Ridge Formation. However, kyanite staurolite-bearing granofels, the most distinctive special rock type in the Sandy Pond Member, is also locally developed within the Marden Hill Formation, which is immediately below the Beaver Ridge Formation. In addition, scattered individual outcrops of any of the special rock types of the Sandy Pond Member are also found within the Nehumkeag Pond Formation and also within the main undifferentiated part of the Cushing Formation in the area of this study. Similarly, Hussey (1988) notes sillimanite staurolite-bearing feldspathic gneisses within the Yarmouth Island Member of the Cushing Formation and also massive hornblende schist with lenses of marble in the Peaks Island Member of the Cushing Formation. Thus no chronological correlation among these lenses is ever implied.

KEARSARGE - CENTRAL MAINE SEQUENCE

General Statement

In the area of this study, the Kearsarge-central Maine sequence is represented by only one formation, the Hutchins Corner Formation, which is mapped as the undifferentiated part (SOh) and the Windsor Neck Hill Member (SOhw).

Hutchins Corner Formation (SOh), and including the Windsor Neck Hill Member (SOhw)

1. Name. The name Hutchins Corner Formation was first used by Osberg (1988) for rocks underlying the Waterville Formation, and replacing the original name of Vassalboro Formation. This last name had gone through a number of changes of meaning and continuation of its usage was causing confusion. Perkins and Smith (1925) first used the name Vassalboro Sandstone for the massive bedded bluish graywacke cropping out between the Kennebec River and China Lake in south-central Maine. Fisher (1941) amended this name to the Vassalboro Formation due to the presence of numerous interbeds of argillaceous rocks. Barker (1961) concurred with this redefinition, as did Osberg (1968), who described in detail the rock types encountered at different metamorphic grades. At that time, rocks of the Vassalboro Formation were mapped as overlying those of the Waterville Formation, and were assigned a Devonian or Silurian age.

Extensive mapping in the 1970s primarily by Ludman and by Griffin, much of it summarized in Pankiwskyj and others (1976), and then in the early 1980s by Newberg (1984, 1985) led Osberg (1988) to conclude that the rocks mapped within the Vassalboro Formation could be correlated in part with those of the Sangerville Formation, the Waterville Formation, and of the Mayflower Hill Formation, thus including rocks older than the Waterville Formation. It was then decided to abandon this name. To replace it, the name Hutchins Corner Formation was assigned to the belt of dominant metagraywacke and minor metapelite lying to the southeast of the main belt of the Waterville Formation at its type locality in Waterville. This is the definition used in this study.

In addition to the principal part of the Hutchins Corner Formation (SOh) which is composed of gray weathering rocks, a rusty weathering unit, the Windsor Neck Hill Member (SOhw), is separated out in this study. This name is being used here for the first time. Prior to this report, rusty-weathering sequences within the Hutchins Corner Formation had been referred to as unnamed rusty weathering members. The type locality is at Windsor Neck Hill in the northern part of the Weeks Mills 7.5' quadrangle. The type section is about 500 meters east of Palermo, in the Palermo 7.5' quadrangle, along the main road from Palermo to North Palermo.

2. Area of exposure. In the area of this study, the Hutchins Corner Formation primarily underlies the region to the northwest of the Hackmatack Pond fault extending from near Windsor, in the central part of the Weeks Mills 7.5' quadrangle, to near Jackson, in the Brooks East 7.5' quadrangle. Rocks of the Falmouth-Brunswick sequence are present everywhere to the southeast of this main tract of the Hackmatack Pond fault. Four other exposures of the Hutchins Corner Formation are mapped as klippen on top of the Beaver Ridge Formation of the Falmouth-Brunswick sequence. The floors of all these klippen are

considered to be the folded surface of the Hackmatack Pond fault.

3. Thickness. No accurate estimate of the total thickness of the Hutchins Corner Formation can be made on the basis of the current study. The upper contact of the formation, with the Waterville Formation, is mapped by Newberg (1985) as close as 2 km to the northwest of the Hackmatack Pond fault in the vicinity of Palermo, but as far as 3 km in the vicinity of North Palermo. In this same stretch, the distance from the Windsor Neck Hill Member (SOhw) to the Hackmatack Pond fault also increases, from .5 km near Palermo to over 1 km near North Palermo. Moreover, near Windsor, in the Weeks Mills 7.5' quadrangle, this particular distance is only 150 meters. Also the distance from the Windsor Neck Hill Member to the base of the Waterville Formation increases from southwest to northeast. Thus the entire width of the Hutchins Corner Formation increases to the northeast, in part because of repetition due to folding, but also due to faulting.

Osberg (1988) gives an estimate of 540 meters of total exposed section, after taking into consideration the nature of the folding. I agree with this estimate. The thickness of the Windsor Neck Hill Member is estimated at about 75 meters, based on the width of the belt near Palermo.

4. Lithology. The Hutchins Corner Formation, as established in the area of this study, is composed of the principal part (SOh) and the Windsor Neck Hill Member (SOhw). The principal part (SOh) is represented by gray to slightly rusty weathering, light gray where fresh, highly variably bedded, moderately calcareous to non-calcareous quartz-plagioclase-biotite muscovite granofels; interbedded with typically far less abundant thin sets of medium gray quartz-plagioclase-biotite-muscovite granulose schist interlaminated with dark gray biotite-quartz-muscovite-plagioclase garnet sillimanite schist. This represents dominant calcareous graywacke metasandstone with subordinate interlaminated metasiltstone and metashale. The metasandstone is found in beds from 5 cm to 1 meter thick, but with poorly defined upper and lower margins. Within the beds are found alternating laminae of biotite-richer and biotite-poorer granofels, giving the rock a pinstriped appearance. The laminae range from plane and parallel, except where they converge at quartz boudins, to intricately drag folded or irregularly convoluted. The thickness of each such lamina ranges from about 1 mm up to several centimeters. The lighter colored, biotite-poorer laminae tend to be thicker that the darker ones. Wherever laminae thicker than about 1 cm each are encountered, the lighter colored ones commonly, but not invariably, contain some calcite and/or some actinolite. Associated with the metasandstone just described, there are present beds from 1 cm to several centimeters thick, of interbedded metasiltstone and metapelite. The metasiltstone itself is typically composed of alternating lighter and darker colored laminae, the latter more conspicuously biotite-rich than the darker colored laminae in the metasandstone. The metapelite, on the other hand, is commonly found in homogeneous layers as thick as several centimeters and is very dark gray in color and contains numerous megacrysts of biotite.

Sulfide-bearing, rusty-weathering rocks are present within the Hutchins Corner Formation and possibly represent more than one stratigraphic horizon. In this study, only one such is mapped out and, due to its continuity, is assigned the status of the Windsor Neck Hill Member (SOhw). Identification of different rock types in this member is much more difficult than in the gray weathering principal part, but both granofels and schist are present. Thin laminae are present in the granofels, but they are less apparent than those in the principal part. Also the quartz:plagioclase ratio is somewhat higher in the Windsor Neck Hill Member than in the principal part.

5. Contacts. In the area of this study, the lower contact of the Hutchins Corner Formation is not exposed, due to the Hackmatack Pond fault. The upper contact with the Waterville Formation is to the northwest of the limit of the study area. Internally, both contacts of the Windsor Neck Hill Member with rocks of the principal part are gradational over a distance of as little as 5 cm to as much as 1 meter.

6. Correlation. The Hutchins Corner Formation is considered to represent the oldest rocks on the southeastern flank of the Kearsarge-central Maine synclinorium. To the southeast, and separated from the Hutchins Corner Formation by the Hackmatack Pond fault, are older rocks belonging to the Falmouth-Brunswick sequence. Thus the Hutchins Corner Formation is possibly equivalent to rocks as young as the Rangeley Formation or as old as the Quimby Formation of the northwestern flank of the Kearsarge-central Maine synclinorium, and their age is considered as late Ordovician to earliest Silurian. The Hutchins Corner Formation also resembles quite closely the Flume Ridge Formation of eastern Maine, and is tentatively correlated with it.

STRUCTURE

General Statement

Nine faults are mapped out in the area of this study. Listed below, in interpreted order of decreasing age, these are:

1. Hackmatack Pond fault, a shallowly northwestward dipping thrust, which forms the contact between the Kearsarge-central Maine sequence to the northwest and the Falmouth-Brunswick sequence to the southeast;
2. Beaver Ridge fault, to the southeast and subparallel to the Hackmatack Pond fault, and possibly related to it; mapping out entirely within the Falmouth-Brunswick sequence;
3. Saban Pond fault, also mapping out entirely within the Falmouth-Brunswick sequence, but younger than the Hackmatack Pond fault, because it sets off the trace of that fault;
4. Meadow Brook fault, possibly a thrust, which forms the contact between the Falmouth-Brunswick sequence to the northwest and the Casco Bay sequence to the southeast;

5. Hill 806 fault, possibly the northwestern-most splay of the Norumbega fault system; postdates the time of Acadian metamorphism;

6. Beech Pond fault, possibly a continuation to the southwest of the Hill 806 fault;

7. Knox Ridge fault, 8. Stantial Bog fault, and 9. Jackson Corners fault form a triplet of N80W-S80E-trending faults which offset all stratigraphic contacts that they cross and also the trace of the Hill 806 fault; possibly outlining a graben.

Hackmatack Pond Fault

1. Name. The name Hackmatack Pond fault was first used by Pankiwskyj (1976) to describe the nature of the contact between the dominantly calcareous metasedimentary rocks of what is now named the Hutchins Corner Formation (which is part of the Kearsarge-central Maine lithotectonic sequence) and the dominantly clastic metavolcanic rocks of what is now named the Carrs Corner Formation (which is part of the Falmouth-Brunswick sequence). At the time of the original definition, these two formations were respectively the Vassalboro Formation and the Cushing Formation. The best exposures of rocks across this contact were first noted about 450 meters to the southwest from Hackmatack Pond, in the southwestern part of the Palermo 7.5' quadrangle. This is the type section.

2. Area of expression of the Hackmatack Pond fault and the rocks exposed in the fault contact zone. In the area of this study, the main trace of the Hackmatack Pond fault extends from Greeley Road, immediately south of Windsor Neck Hill Cemetery in the central part of the Weeks Mills 7.5' quadrangle, to as far to the northeast as the bridge across Sandy Stream in Freedom Village in the southern part of the Unity 7.5' quadrangle. To the northeast from there, the trace of the fault is offset to the right by the Knox Ridge fault, and farther to the northeast it is offset to the left by the Jackson Corners fault. Throughout this entire span, typical rocks of the Hutchins Corner Formation (SOh) or (SOhw) are mapped to within 5 meters of rocks of either the Sandy Pond Member (Occs) or of the main undifferentiated part of the Carrs Corner Formation (Occ). However, within the 5 meter zone just noted, there are found at several localities one or more of the following rock types: coarse-grained garnet amphibolite, foliated quartzite with up to 20% magnetite, quartz granofels composed of alternating .5 mm - 1 mm thick biotite-rich laminae and 1 mm - 2 mm thick biotite-lacking laminae. All of these rock types commonly show tight convoluted folds with shallow plunges and abundant quartz veins which are sheared out to form small lenses.

To the northeast of the Jackson Corners fault, the belt of the Carrs Corner Formation (Occ) which is in contact with the Hackmatack Pond fault thins, and the last exposure is on Route #7, just north of Jackson Corners. Everywhere else in the study area, the Hackmatack Pond fault is drawn between rocks of the Hutchins Corner Formation and the Beaver Ridge Formation (Ob). This includes the two klippen to the southwest of the Knox Ridge fault, the small klippe between the Stantial Bog fault and the Jackson Corners fault, and also the syncline-shaped klippe opening to the northeast, with rocks of the Hutchins Corner Formation in its trough (and whose axis is offset to the left by the Jackson Corners fault). None of the three rock types noted at the end of the preceding paragraph have been found within the zone of the Hackmatack Pond fault where the Beaver Ridge Formation is in contact with the fault. Instead, what is most commonly seen is: slightly- to strongly-rusty weathering biotite-muscovite garnet schist and quartz-biotite-muscovite granofels, both with a prominent foliation expressed by undulating large grains of mica. This mica foliation itself is commonly tightly folded. In the northwestern part of the Brooks East 7.5' quadrangle, good exposures of this can be seen in Great Farm Brook, southwest of Jackson Village.

On the other hand, the contact seen in the North Branch of Marsh Stream about 2.5 km east of Jackson Village, between the Hutchins Corner Formation and rocks mapped as the Beaver Ridge Formation, shows neither shearing nor tight folding of an older foliation. It is possible that the rusty-weathering rocks seen at this locality are of the Hutchins Corner Formation, perhaps of the Windsor Neck Hill Member (SOhw) and not of the Beaver Ridge Formation.

3. Geophysical evidence for the Hackmatack Pond fault. Stewart and others (1991) describe a strong seismic reflector which originates at the mapped trace of the Hackmatack Pond fault and which in the seismic profile is seen dipping to the northwest at about 25° to depths of about 10 km. This can be interpreted as a southeastward-directed thrust of the Kearsarge-central Maine sequence over the Falmouth-Brunswick sequence; or conversely, a partial subduction of the Falmouth-Brunswick sequence to the northwest and under the Kearsarge-central Maine sequence. Most of the remaining parts of the field area have not been the subject of geophysical studies and, therefore, there is no geophysical expression of any of the other faults.

4. Extrapolation and correlation. In agreement with me, Hussey (1988) considers that the contact between the Kearsarge-central Maine sequence and the Falmouth-Brunswick sequence is a major fault. He shows such a fault in southwestern Maine and correlates it with the Hackmatack Pond fault. Apparently, however, the fault zone is not exposed in outcrop in his area of study. The fault is shown extending as far to the southwest as the estuary of Presumpscot River north of Portland. There it is shown truncated by the Flying Point fault, which is considered one of the splays of the Norumbega fault system.

The farthest to the northeast that I have tentatively traced the Hackmatack Pond fault is the southeastern part of the East Dixmont 7.5' quadrangle. Reconnaissance mapping in the adjoining Snow Mountain 7.5' quadrangle suggests that the Hackmatack Pond fault is truncated in this region by the Hill 806 fault, which is one of the splays of the Norumbega fault system, possibly the northwestern-most one. In the section on the Hill 806 fault in this paper, I speculate on the correlation of the Hill

806 fault and the Flying Point fault. Wones (1991) maps a Norumbega system fault in the southwestern quadrant of the Bucksport 15' quadrangle, in the very area where I extend the Hill 806 fault.

Beaver Ridge Fault

1. Name. The name Beaver Ridge fault is used here for the first time. It is derived from a hill of that name in the northern part of the Liberty 7.5' quadrangle. The type section is in the very northern part of this quadrangle, in the steep south-facing cliffs about 300 meters northeast of the word "Ridge" in the name Beaver Ridge on the topographic map.

2. Area of expression of the Beaver Ridge fault and the rocks exposed in the fault contact zone. The Beaver Ridge fault is drawn from near the topographic summit of Beaver Ridge in the northwestern part of the Liberty 7.5' quadrangle to about 1 km northwest of Knox Corner in the southeastern part of the Unity 7.5' quadrangle, a distance of about 8 kilometers. The type section, noted above, is the only location seen so far with good exposures across the fault contact zone. From southeast to northwest are found: plagioclase-quartz-biotite-muscovite granofels assigned to the main undifferentiated part of the Carrs Corner Formation (Occ), followed by 40 meters of sulfidic quartzose granofels assigned to the Beaver Ridge Formation (Ob), then several meters of rusty-stained quartz vein, followed by several meters of rusty-weathering plagioclase-quartz granofels, followed by a section of gray-weathering plagioclase-quartz-biotite granofels which is assigned to the main undifferentiated part of the Carrs Corner Formation (Occ). The fault is drawn through the section composed of quartz vein.

The Beaver Ridge fault is tentatively interpreted as a thrust, perhaps parallel to and with the same movement sense as the Hackmatack Pond fault, whose trace is only 300 meters to the northwest. In part, the Beaver Ridge fault shears off the northwestern limb of what otherwise would be an anticline with the Beaver Ridge Formation in the core and the Carrs Corner Formation on the flanks. This fault is a local feature which does not correlate with other structures.

Saban Pond Fault

1. Name. The name Saban Pond fault is used here for the first time. It is derived from a pond of that name in the southern part of the Palermo 7.5' quadrangle, west from Lever Hill. The type section is at 530' elevation in the bed of the unnamed brook, shown merely as a gully on the topographic map, about 250 meters northwest of Saban Pond.

2. Area of expression of the Saban Pond fault and the rocks exposed in the fault contact zone. The Saban Pond fault is drawn entirely within the Palermo 7.5' quadrangle, for a minimum length of about 3 kilometers. On the basis of the apparent offsets of the lithologic contact between the Beaver Ridge Formation (Ob) and the Nehumkeag Pond Formation (On) and also the offset of the trace of the Hackmatack Pond fault, the Saban Pond fault is interpreted as a left-lateral strike-slip fault. In the type section noted above, the Beaver Ridge Formation (Ob) to the northwest is separated from the Nehumkeag Pond Formation (On) to the southeast by a four meter thick section composed of roughly equal volumes of sulfidic, moderately rusty-weathering biotite-muscovite-quartz-plagioclase schist and of 1 mm to 1 cm thick lenses of pure vein quartz. About 1 1/4 km northeast of this type section, at 650' elevation on top of a small rise west from Bowler Pond, a similar section of rusty schist injected with vein quartz is encountered between the Hutchins Corner Formation (SOh) to the northwest and the Beaver Ridge Formation (Ob) to the southeast. This fault is a local feature which does not correlate with other structures.

Meadow Brook Fault

1. Name. The name Meadow Brook fault is used here for the first time. The name is taken from a brook of that name in the eastern part of the Brooks West 7.5' quadrangle. There are no known exposures of this fault and, therefore, no type section.

2. Area of expression of the Meadow Brook fault and the rocks exposed near the fault zone. The trace of the Meadow Brook fault is drawn with confidence from its southwestern terminus, where it is cut off by the Stantial Bog fault, to where it is offset by the Jackson Corners fault in the northeast. This stretch is entirely within the Brooks West 7.5' quadrangle. The existence of the fault to the northeast of the Jackson Corners fault is speculative.

The closest that the fault zone has been examined is near the top of the near 600'-elevation hill, which is about .5 km to the southeast from Stantial Bog, in the central part of the Brooks West 7.5' quadrangle. In this location, a shallow 12 meter wide gully, parallel to regional strike, separates rusty-weathering granofels and schist assigned to the Beaver Ridge Formation (Ob) of the Falmouth-Brunswick sequence to the northwest from interbedded gray-weathering granofels and mica-rich schist assigned to the Cape Elizabeth Formation (Oce) of the Casco Bay sequence to the southeast. The Meadow Brook fault is not drawn through this gully because of any evidence of faulting, but because the contact between these two units is not expected to be conformable on the basis of regional interpretations of stratigraphy.

Immediately to the southwest of the Stantial Bog fault, the contact between rocks of the Falmouth-Brunswick sequence and rocks of the Casco Bay sequence is at the Hill 806 fault, which I consider to be one of the splays of the Norumbega system. Farther to the southwest the contact is along the Beech Pond fault of Newberg (1985), which I have not seen exposed. Tentatively, however, the Beech Pond fault is correlated with the Hill 806 fault. Yet farther to the southwest, in the Casco Bay area, the two sequences are separated by the Flying Point fault, which appears to be a splay of the Norumbega system. The importance of the Meadow Brook fault is that it is the oldest fault yet mapped

which separates the Falmouth-Brunswick sequence from the Casco Bay sequence. Possibly it is the principal fault, perhaps a thrust, which expresses the docking of two separate terranes, the terrane represented by the Falmouth-Brunswick sequence to the northwest and the terrane represented by the Casco Bay (Avalonian?) sequence to the southeast.

Hill 806 Fault

1. Name. The name Hill 806 fault is used here for the first time. It is derived from a hill, unnamed on the 1983 provisional edition of the topographic map of the Brooks West 7.5' quadrangle, which is marked with the symbol 806 T. This location is in the central part of the quadrangle, about 1 km east from Stantial Bog. The type section is in the very eastern part of this quadrangle, along the crest of a ridge which extends from Styles Cemetery in the south to Hill 765 T in the north.

2. Area of expression of the Hill 806 fault and the rocks exposed in the fault contact zone. North of the Stantial Bog fault, in the Brooks West 7.5' quadrangle, the Hill 806 fault separates a thin sliver of the Cape Elizabeth Formation (Oce) to the northwest from the Cushing Formation (Oc) to the southeast. Both of these formations are in the Casco Bay sequence. South of the Stantial Bog fault, the Hill 806 fault is drawn between the Nehumkeag Pond Formation (On) of the Falmouth-Brunswick sequence to the northwest and the Cushing Formation (Oc) of the Casco Bay sequence to the southeast. These two formations are composed of rock types very similar to one another, thus the tracing of the Hill 806 fault in between them is very much more difficult.

On the basis of the best exposures in the area north of Styles Cemetery, the movement along the Hill 806 fault produced a protomylonite composed of not more than 15% dynamically recrystallized minute mineral grains along with about 85% relict strained mineral grains. This is primarily exhibited in the mica-poor metavolcanic rocks of the Cushing Formation. Rare, but conspicuous grains of blue quartz can be seen in this rock. In the interbedded granofels and mica-rich schist of the Cape Elizabeth Formation, the deformation is primarily expressed as a very rigorous alignment of mica grains and an abundance of pinched-off lenses of quartz-plagioclase, but only a bare trace of mylonitization.

The degree of mylonitization decreases to the southwest from the type section. Thus in the exposures in Halfmoon Stream, in the extreme southwestern corner of the Brooks West 7.5' quadrangle, there are only a few percent of dynamically recrystallized minute mineral grains, but optically strained mineral grains abound, as does rigorous parallelism of mica mineral grains. Farther to the southwest, in the northeastern part of the Liberty 7.5' quadrangle, the Hill 806 fault is tentatively shown as folded to the northwest and there is drawn through a number of excellent exposures of metavolcanic rocks which exhibit a very strong foliation due to parallelism of mica and amphibole mineral grains, but no mylonitization. It is possible that the deformation in these exposures is the result not of the Hill 806 fault, but of another fault, parallel to and northwest of the Hill 806 fault. Another possibility is that the Hill 806 fault was offset by one or several late east-west trending faults with a dextral displacement sense. A similar offset is also shown by the map pattern of the Wilson Cove Member of the Cushing Formation (Ocwc) about 1 kilometer to the northwest of Hogback Ledge. The Knox Ridge fault shown to the north-northeast of this area is an example of this type of late fault.

3. Geophysical evidence for the Hill 806 fault. I am not aware of any geophysical evidence for the Hill 806 fault. It is considered to be one of the splays of the Norumbega fault system, perhaps the northwestern-most one. This fault system shows a strong collective signature in seismic profile (Stewart and others, 1991).

4. Extrapolation, correlation, and speculation. To the northeast of the study area, the Hill 806 fault has been tentatively traced by the writer into the lineament shown by Thurlow Brook in the southeastern part of the East Dixmont 7.5' quadrangle. On strike, in the Bucksport 15' quadrangle, is found the northwestern-most splay of the Norumbega system faults, as drawn by Wones (1991). It is shown crossing the Penobscot River just north of Orrington. Osberg and others (1985) show this splay of the Norumbega system continuing to the northeast as far as West Grand Lake. In the study area, the Hill 806 fault is confidently drawn to the southwest only as far as the southwestern corner of the Brooks West 7.5' quadrangle, where are found exposures in Halfmoon Stream showing very incipient mylonitization. Southwest from there, this fault is tentatively drawn through strongly plastically deformed exposures of both felsic and mafic metavolcanic rocks to the east and northeast of West Montville, in the northeastern part of the Liberty 7.5' quadrangle. These could belong to either the Nehumkeag Pond Formation or to the Cushing Formation. Alternatively, these rocks may have been deformed by another fault. On strike to the southwest there is neither mylonite nor strongly deformed rocks. However, Newberg (1985) shows a fault, named by him the Beech Pond fault, entering the Liberty 7.5' quadrangle from the Palermo 7.5' quadrangle about 800 meters north of Nutter Pond. This location is on strike with the above-noted exposures near West Montville. I have not seen any exposures of the Beech Pond fault. Newberg (1985) does not indicate any outcrop locations closer than 150 meters to the fault trace, and does not explain in the text his reason for this fault. However, if the Beech Pond fault does in fact exist as shown, then the Hill 806 fault or another fault to the northwest of and parallel to it could be correlated with it, which I tentatively do. Then if one were to extend the Beech Pond fault to the southwest of the Palermo 7.5' quadrangle, it could possibly hook up with a major fault shown both by Newberg (1984) and by Osberg and others (1985) as terminating in the Kennebec River between South Gardiner and West Dresden. Hussey (1988) interprets this fault differently, but it could be related to the Flying Point fault, which appears to be a splay of the Norumbega system.

As most recently interpreted by Hussey (personal communication), the Flying Point fault separates the Falmouth-Brunswick sequence from the Casco Bay sequence. If all the speculation in the above paragraph is on track, then the Hill 806 fault could perform this same function in this area of study. Thus all of the mapped rock units in this study which are to the northwest of the Hill 806 fault - Beech Pond fault, but to the southwest of the late Stantial Bog fault, have been correlated with different formations of the Falmouth-Brunswick sequence. To the southeast of the Hill 806 - Beech Pond fault, mapped units are correlated with different formations of the Casco Bay sequence. However, to the northeast of the Stantial Bog fault the Meadow Brook fault, which is older than the Hill 806 fault, forms the boundary between the two sequences.

Beech Pond Fault

1. Name. The name Beech Pond fault was first used by Newberg (1985). He shows it extending from the southern edge of the Palermo 7.5' quadrangle, just west of Beech Pond, to the eastern edge of the quadrangle, just north of Nutter Pond. In a schematic cross section it is shown by him as a high angle fault, with the northwestern side having moved down relative to the southeastern side.

2. Area of expression of the Beech Pond fault and the rocks exposed near the fault zone. In this study, I show the trace of the Beech Pond fault very close to the position given by Newberg (1985). It should again be noted here that I have nowhere seen any exposure of this fault in outcrop; however, it is pressed into service in part to account for the disappearance of a belt of the Beaver Ridge Formation (Ob) and of the Parmenter Cemetery Formation (Op) in the northwestern part of the Razorville 7.5' quadrangle, but primarily to serve as a continuation of the regionally important Hill 806 fault.

3. Correlation and extrapolation. The Beech Pond fault is tentatively correlated with the Hill 806 fault of this study. The reader is referred to the extensive speculation on the subject of these two faults in the final section on the Hill 806 fault in this study.

Knox Ridge Fault, Stantial Bog Fault, Jackson Corners Fault

These three presumed late faults were not observed in outcrop. They are treated together in this section because all three were drawn to account for similar style effects on several lithologic units as well as on older faults.

1. Names. All three names are being used here for the first time. The Knox Ridge fault is named for the prominent ridge in the southeastern part of the Unity 7.5' quadrangle. The Stantial Bog fault is named after a bog of that name in the central part of the Brooks West 7.5' quadrangle. The Jackson Corners fault is named after the road intersection in the northeastern part of the Brooks West 7.5' quadrangle. Since the faults were not observed in outcrop, there are no type sections.

2. Justification for the faults. The basis for all of these faults is the coincidental displacement of a number of contacts along three separate lines, all three parallel to one another, with the trend N80W-S80E. On the geologic map of this study, a dextral offset is indicated for the Knox Ridge fault and a sinistral for the Jackson Corners fault. These indications merely record the surface offsets of the contacts and do not necessarily express the actual direction of movement along the faults. Given a 25 NW dip for the Hackmatack Pond fault (Stewart and others, 1991), the Knox Ridge fault and the Jackson Corners fault could also be interpreted as normal faults, outlining a graben inbetween them. No movement sense is indicated for the Stantial Bog fault. Since the Nehumkeag Pond Formation is considered to be older, hence below, the Beaver Ridge Formation, the structure drawn to the southwest of Stantial Bog would represent a northeast-plunging syncline. A relative down movement of the north wall of the Stantial Bog fault could then account for the offsets observed. To be consistent, this interpretation would require steep northwest dips at depths for the Wilson Cove Member of the Cushing Formation (Ocwc), which is shown offset by the fault. The foliation measured in the rocks is within 10^{o} of vertical, which does not invalidate the above structural interpretation.

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