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INTRODUCTION

The Lower Androscoggin Valley - Casco Bay study area (Fig. 1) is underlain by a complex eugeosynclinal sequence of metasedimentary and metavolcanic rocks of Cambrian to Silurian age. These rocks include the Casco Bay Group of Cambro-Ordovician age and a sequence of formations of Late Ordovician to Silurian age. Polyphase deformation and metamorphism of the latter occurred during the Acadian Orogeny in Early Devonian time. The Casco Bay Group was regionally metamorphosed and deformed during the Acadian Orogeny and possibly during an early Ordovician event. The Casco Bay and Siluro-Ordovician sequences are extensively intruded by a variety of rocks ranging in age from Early Devonian to Jurassic or Cretaceous.

The Casco Bay Group and the Siluro-Ordovician sequences are separated by a premetamorphic syn-Acadian folded thrust fault. Post-Acadian to Late-Acadian high-angle faults, trending northeast, cross the Casco Bay area as a series of anastomosing breaks, some of which are normal faults, and others of which may be strike-slip faults with left-lateral displacement up to 50 kilometers. Major movement along these faults postdates Acadian folding and metamorphism but predates Devonian and Mississippian pluton emplacement. Minor reactivation postdates this plutonism.

This report is based on investigations by Pankiwskyj (1978) and Creasy (1979) in the Poland Quadrangle, Newberg (1981) in the Gardiner Quadrangle, and by the writer in the Lewiston quadrangle (Hussey, 1981a) and in the greater Casco Bay area (Hussey, 1971a, b; 1981 b, c, d). The 1:250,000 scale map (Plate I) accompanying this report shows the geology as best it can be interpreted from mapping done through the 1980 field season. Several problems of stratigraphic and structural interpretation exist, particularly in the Lewiston-Poland-Livermore area, and await resolution pending completion of mapping in the adjacent Waterville-Augusta area now underway by Osberg (personal communication). Until such information is available, the interpretation presented here must be considered preliminary and potentially subject to extensive revision.

PREVIOUS WORK

The first significant mapping in the Casco Bay area was by F.J. Katz (1917) who is responsible for naming and describing the units of the Casco Bay Group. Unfortunately, results of his detailed mapping were never published. Fisher (1941) conducted the first serious mapping of the lower Androscoggin Valley area, correlating the rocks of the Lewiston area with the fossiliferous sequence described by Perkins and Smith (1925) in the Waterville area. Fisher thus established a Silurian age for at least part of the highly metamorphosed and migmatized sequence of the Lewiston area.

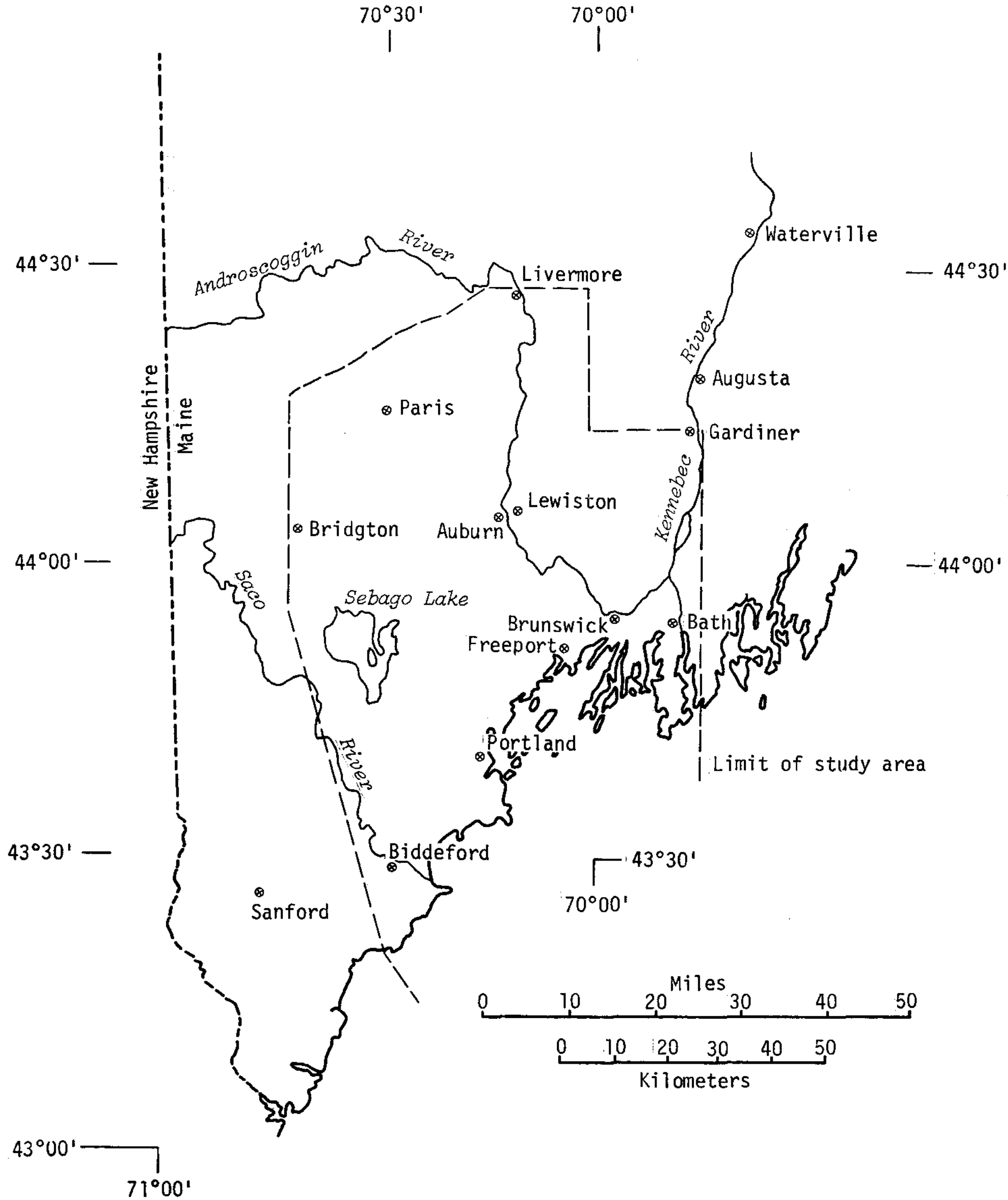

Figure 1. Map showing location of the Lower Androscoggin-Casco Bay study area.

STRATIGRAPHY

Casco Bay Group

The oldest rocks of the map area belong to the Casco Bay Group of Cambro-Ordovician age (Brookins and Hussey, 1978). Formations of this group include, in decreasing age, the Cushing Formation, Cape Elizabeth Formation, Spring Point Formation, Diamond Island Formation, Scarboro Formation, Spurwink Limestone, and Jewell Formation. The Macworth Formation, tentatively included with the Group, is inferred to be in fault contact with other formations of the Group, and thus its stratigraphic position remains in question. The lithologies and stratigraphic relations of these formations are summarized below. Further details are given by Hussey (1971a, b).

Lithology - The Cushing Formation is a complex and variable sequence of quartzo-feldspathic gneiss, calc-silicate gneiss, feldspathic sillimanite gneiss, amphibolite, marble, rusty-weathering sulfidic schist, garnet coticule, and well-bedded, generally sulfidic manganiferous metachert.

In the Portland area, the Cushing Formation consists of light to medium gray, massive to variably bedded quartz-plagioclase-biotite-muscovite gneiss. Conspicuous at many localities are relict pyroclastic structures such as crystal fragments of plagioclase and blue quartz, indicating a former crystal-tuff structure, and pebble to boulder-size clasts of metavolcanics and occasionally very dark gray metasediments (manganiferous metachert?) representing original agglomeratic structure. On the northwestern flank of the Cushing antiform, close to the Cape Elizabeth-Cushing contact, are two units of very rusty-weathering, white quartz-plagioclase-muscovite schist, which are 30-60 meters thick and probably represent original felsic tuff. These two units are not present at the corresponding position on the southeast flank of the antiform. Instead, at the Cape Elizabeth-Cushing contact is a 15-30 meter-thick sequence of thin, well-bedded dark gray quartzite and garnet-biotite schist, probably representing original bedded manganiferous chert. This sequence is not present at the Cape Elizabeth-Cushing contact on the northwest flank of the antiform.

In The Harpswell area, the writer divides the Cushing into an upper Sebascodegan Member, a middle Bethel Point Member, and a lower Yarmouth Island Member (Hussey, 1965). The Sebascodegan Member includes thinly interbedded quartz-plagioclase $\pm$ microcline-biotite gneiss, calc-silicate gneiss and feldspathic sillimanitic gneiss; and separately mapped lenses of calc-silicate gneiss, rusty-weathering sulfidic quartzo-feldspathic gneiss, and amphibolite with occasional marble. The Bethel Point Member consists of rusty-weathering quartz-muscovite-biotite schist with occasional interbeds of feldspathic and micaceous quartzite. The Yarmouth Island Member consists predominantly of light gray, poorly bedded to massive plagioclase-quartz-biotite-gedrite-garnet-cordierite gneiss with beds of very sillimanitic gneiss which have pseudomorphs and relict grains of staurolite. It includes thin mappable lenses of calc-silicate gneiss and amphibolite.

In the Yarmouth-Brunswick-Gardiner area the Cushing is divided into the Richmond Corner, Mount Ararat, and Nehumkeag Pond Members. The Richmond Corner Member consists of medium and dark gray quartz-plagioclase-biotite-garnet ± sillimanite gneiss, rusty-weathering sulfidic quartzo-feldspathic gneiss, marble, amphibolite, calc-silicate gneiss and coticule (reddish quartz-garnet granofels). The Mount Ararat Member consists of 2-10 cm alternating bands of light gray quartz-plagioclase-biotite granofels or gneiss, and dark gray biotite-rich amphibolite with extensive intervals of the light gray gneiss. The Nehumkeag Pond Member, mapped by Newberg (1981) in the Gardiner Quadrangle, consists of massive to variably bedded light gray quartz-plagioclase granofels and gneiss with essentially no dark minerals. The Nehumkeag and Mount Ararat Members also include separately mapped lenses of marble and hornblende-plagioclase amphibolite, the latter interpreted by Newberg (1981) as locally discordant, syntectonic, premetamorphic dikes.

In the Yarmouth to Brunswick area the writer maps a rusty-weathering muscovite-sillimanite-graphite-biotite-garnet-quartz schist previously assigned either to the Vassalboro Formation or to the Cushing Formation. As a result of recent mapping along the western edge of the Bath quadrangle, the rusty unit appears to occupy a position stratigraphically between the Mount Ararat and Richmond Corner Members, and is herewith assigned to the Cushing Formation. To the south of Brunswick this rusty unit occupies a belt between the Mount Ararat Member and the Vassalboro Formation, the Richmond Corner being cut out along the inferred premetamorphic thrust fault that forms the contact between the Cushing and Vassalboro Formations. Rusty schist and gneiss mapped by Newberg (1981) in the Gardiner area is in part equivalent to this unit. However, he interprets some of the rusty schist, particularly the roadcut exposures at Iron Mine Hill in the City of Gardiner, to represent sulfidic mineralization of the Vassalboro or Cushing lithologies along post-metamorphic faults.

The Cape Elizabeth Formation has a variable lithology depending on the grade of metamorphism. At low grade (chlorite, biotite, and garnet) the Cape Elizabeth is generally a thin-bedded alternation of fine-grained medium gray feldspathic and micaceous quartzite and medium dark gray phyllite, with small garnet porphyroblasts at garnet grade. The quartzose beds are characteristically finely laminated, and these laminae commonly show fine-scale soft-sediment slump deformation. Minor lithologies of the Cape Elizabeth at low grade include 20 to 30 cm beds of hard mica-poor or free feldspathic quartzite and minor calc-silicate granofels. In the chlorite zone more quartzose beds include ankerite and calcite. At staurolite grade the more quartzose beds are quartz-plagioclase-biotite-muscovite-garnet schist, and the more micaceous beds are biotite-muscovite-garnet schist with locally abundant staurolite and occasionally andalusite. At sillimanite grade sillimanite is locally abundant in the schistose beds, and at the K-feldspar-sillimanite grade the Cape Elizabeth is extensively migmatized and pegmatite-injected, with locally abundant sillimanite in irregular pegmatite lenses.

The Spring Point Formation is a heterogeneous sequence of metavolcanics and volcanogenic metasediments. In the South Portland - Scarboro area at garnet and lower grade, the Formation consists of medium greenish gray chlorite and/or actinolite-plagioclase-spessartitic garnet phyllite. Highly stretched felsic metavolcanic fragments, some very similar to those in the Cushing Formation, are locally common and suggest a pyroclastic origin for much of the Formation. In a few localities the rock is a more massive greenstone and may represent mafic flows. In the Harpswell area, the writer (Hussey, 1971b) divides the Spring Point into a lower mafic metavolcanic member, and an upper felsic metavolcanic and volcanogenic metasedimentary member. The lower member consists of thin to medium-bedded hornblende-garnet $\pm$ chlorite amphibolite with zones of dark reddish gray garnet-plagioclase-quartz-biotite granofels. The upper member consists of thin to medium-bedded light gray quartzo-feldspathic metasediments or felsic metatuff with minor interbeds of amphibolite and chlorite schist representing mafic metatuff.

The Diamond Island Formation is a massive black quartz-graphite-muscovite phyllite, locally with abundant pyrite, the weathering of which imparts yellow and orange staining to outcrops. Contorted paper-thin quartz veins occur commonly along cleavage planes.

The Scarboro and Jewell Formations are essentially identical, consisting of rusty and non-rusty weathering dark gray, light gray, and mottled greenish and purplish gray phyllites. At appropriate metamorphic grade garnet is common, and staurolite, chloritoid, and andalusite are locally abundant. 5 to 50 cm beds of micaceous quartzite and amphibolite are sporadically present throughout both formations. The Scarboro Formation includes a 5 to 20 meter-thick unit of gray metalimestone with thin quartzose phyllite interbeds close to the contact with the Diamond Island Formation. The Jewell Formation on Great Chebeague Island includes a unit herein referred to as the Chebeague Member, consisting of slightly chalky-weathering medium brownish gray feldspathic phyllite. This unit is interpreted to be the highest stratigraphic unit of the Casco Bay Group. (The Macworth Formation may be still higher, but its stratigraphic position is uncertain due to faulting.)

Between the Scarboro and Jewell Formations is the Spurwink Limestone, a 30 to 60 meter-thick sequence of thin-bedded medium gray fine-grained metalimestone with 2 to 4 cm quartzose mica phyllite interbeds.

The Macworth Formation (named the Macworth Slate by Katz, 1917) consists of finely-laminated medium brownish gray quartzose phyllite and minor rusty phyllite. Calcite is present in the southern third of the outcrop belt of the Formation; actinolite is present in the northern part of the outcrop belt, particularly on Cousins Island in Casco Bay, where the Macworth Formation superficially resembles the Vassalboro Formation. Rare interbeds with central zones of quartz granules have been observed, and thin felsic metatuff beds are locally present.

<u>Stratigraphic Relations and Age of the Casco Bay Group</u> - The writer now regards the Casco Bay Group to be of Cambro-Ordovician age rather than Devonian as earlier suggested (Hussey, 1968). The bases for this age assignment are: (1) general lithic similarity with Cambro-Ordovician sequences elsewhere in New England and the Canadian Maritimes, and (2) Rb/Sr whole-rock ages (Table I) reported by Brookins and Hussey (1978). They interpret the Rb/Sr ages of the Cushing Formation to reflect the age of volcanic activity, and not of a metamorphic event. Ages of the other formations, mostly metasedimentary, are established with much less certainty; some of the older ages reported for younger formations (as established by primary sedimentological structures at or near contacts) may reflect sediment admixtures from older source terrains, or possibly

TABLE I. Rb/Sr Ages for Casco Bay Rocks and Pegmatites, Portland-Orrs Island Area.

Rock Unit	
Cushing Formation	481 $\pm$ 40 ma
Spring Point Formation	539 $\pm$ 50 ma
Cape Elizabeth Formation	485 $\pm$ 30 ma
Scarboro Formation	509 $\pm$ 45 ma
Foliated pegmatite (*)	385 ma
Nonfoliated pegmatite (*)	375 ma

(Ages after Brookins and Hussey, 1978, and Brookins, personal communication (*).

the effect of weathering of subaerial volcanic terrains of the Cushing Formation, the erosion of which was probably the major contributor of sediments of the Cape Elizabeth and younger metasedimentary formations of the Casco Bay Group.

Contacts between formations of the Casco Bay Group above the Cushing are conformable and sharp. However, the Cushing-Cape Elizabeth contact may be an angular unconformity. Evidence supporting this is as follows: (1) Wherever the contact between the Cape Elizabeth and Cushing Formations is seen at points across the strike belt of the Casco Bay Group, different lithologies of the Cushing are in contact with a lithically uniform basal Cape Elizabeth; (2) In the Pennellville area of Brunswick, the Cape Elizabeth-Cushing contact, when traced northeastward from the head of Maquoit Bay to the Brunswick Naval Air Station, gradually transgresses across, thus cutting out, approximately a 200-300 meter section of the upper part of the Cushing. Although this might also be interpreted as a fault contact, no evidence of minor faulting or shearing has been observed in near-contact exposures; and (3) At Chimney Rock in Cape Elizabeth (Casco Bay Quadrangle, approximately 1 km south of Portland Head Light)*, the basal 2 meters of the Cape Elizabeth Formation, although generally subpelitic, contains highly stretched granule-sized clasts of light and dark colored rock fragments of Cushing affinity. This granule zone is interpreted to be a basal granule conglomerate of the Cape Elizabeth Formation deposited unconformably on the Cushing.

In addition to the above given evidence for an unconformity at the base of the Cape Elizabeth Formation, the stratigraphic succession of formations of the Casco Bay Group is established from graded bedding at or near contacts at the following localities:

(1) Chimney rock: graded beds of basal Cape Elizabeth within 1 meter of the contact with the Cushing indicate Cape Elizabeth stratigraphically on top of Cushing.

(2) North end of Peaks Island: moderately well-developed graded beds in the Cape Elizabeth approximately 0.5 meter above the contact likewise indicate that the Cape Elizabeth is stratigraphically above the Cushing.

(3) At Prouts Neck, graded beds of basal Cape Elizabeth at the contact place the Cape Elizabeth on top of the Cushing.

(4) At Scotow Hill, Scarborough, a very distinct 8-10 cm graded bed with sand-sized clasts at the base occurs in the Scarboro Formation approximately 1 meter from the conformable contact with the Spring Point Formation, placing the Scarboro Formation stratigraphically above the Spring Point.

*The writer is grateful to Donald Newberg for bringing to his attention the significance of this critical locality.

Formations of the Siluro-Ordovician Sequence

Formations of Late Ordovician(?) to Late Silurian age in the study area include the Vassalboro, Waterville, Sangerville, Windham, and Parkman Hill Formations. These units are not here assigned to the Merrimack Group because of uncertainties of the age of the Group based on radiometric evidence from Massachusetts and New Hampshire localities (Lyons, et al., in press). These problems notwithstanding, I favor a correlation of the Vassalboro with the Berwick Formation and perhaps also with the Eliot and Kittery Formations, the formations that constitute the Merrimack Group in southwestern Maine.

Lithology - The Vassalboro Formation is a thick sequence of variably bedded medium gray quartz-plagioclase-biotite ± hornblende granofels, and calc-silicate granofels. Minor interbedded lithologies include biotite-quartz-plagioclase-muscovite-sillimanite schist (Freeport area) and rusty-weathering muscovite-biotite ± graphite schist. The latter lithology, in addition to its presence as thin beds and zones within the major granofels, forms a mappable unit in the Oak Hill area between Sabattus and Gardiner. In the Freeport area two outcrops of impure marble with abundant hornblende and diopside have been observed, but do not appear to form a mappable member within the Vassalboro. The thickness of the Vassalboro Formation is estimated by Osberg (1980) to be 3200 meters less the amount of repetition due to folding. This is an estimate of minimum thickness inasmuch as the base of the formation is nowhere exposed.

The Waterville Formation consists of thin-bedded biotite-sillimanite-muscovite-garnet schist, thinly laminated quartz-biotite-plagioclase granulose schist, and minor calc-silicate granofels. In the middle of this metapelitic sequence is a metalimestone member consisting of thin ribbony-bedded fine-grained marble with thin interbeds of quartz-biotite schist. At the base of the Waterville is a discontinuous, thin (25-35 meter) unit of very rusty-weathering quartz-muscovite-graphite schist. The thickness of the Waterville is estimated to be 1000 meters (Osberg, 1968).

The Windham Formation consists of variably-bedded muscovite-biotite-staurolite-sillimanite or kyanite-quartz schist and micaceous quartzite. In the middle of the Formation is a 75-100 meter thick metalimestone member consisting of thin ribbony-bedded gray metalimestone and fine-grained impure marble with thin interbeds of quartz-plagioclase-biotite schist. At the contact of the metalimestone and metapelite is a thin zone of fine-grained purplish-gray quartz-plagioclase-biotite granofels somewhat similar to the Vassalboro Formation. The Windham Formation is approximately 500-600 meters thick, but this is an estimate of the minimum thickness inasmuch as the base of the formation is not exposed.

The Sangerville Formation is traced on the southeast limb of the Currier Hill syncline of the Skowhegan area (Ludman, 1977) across the Livermore quadrangle to the northeast corner of the Lewiston 15'-quadrangle by Pankiwskyj et al. (1975). As here mapped, the Sangerville Formation includes parts of the Sabattus, Taylor Pond, and Androscoggin Formations of Fisher (1941). The Sangerville Formation is divided into three members which, in ascending stratigraphic order, are the Turner member (originally the Turner Formation of Warner and Pankiwskyj, 1965), the Patch Mountain Member (originally the Patch Mountain Formation of Guidotti, 1965), and the Anasagunticook Member (originally the Anasagunticook Formation of Pankiwskyj, 1964). Distinction between the Turner and Anasagunticook Members on a lithic basis is difficult in most of the study area due to the extensive migmatization of these units. This, in turn, renders a degree of uncertainty to the regional structural synthesis.

The Turner Member consists of non- to slightly rusty-weathering variably bedded to massive metapelite that, in most areas, is very extensively migmatized. The dominant lithology is quartz-garnet ± sillimanite ± muscovite schist with 5-35 cm interbeds of quartz-plagioclase-biotite granofels and schist. In the area just northwest of Oak Hill in Sabattus and Monmouth, the Turner Member is least migmatized and consists of thin to medium bedded alternations of fine-grained medium gray quartz-plagioclase-biotite granofels with thin interbeds of medium brownish gray biotite-muscovite-sillimanite-garnet-quartz schist. Graded bedding is common here. These rocks are distinguished from the Waterville by the relatively thicker, heavier-bedded granofels relative to the metapelite. They are very similar to the Mayflower Hill Formation of Osberg (1968).

Three minor units mapped as submembers of the Turner Member are:

(1) A distinctive highly migmatized schist and gneiss unit (Sstt, Plate I) informally referred to as the Thorncrag Hill schist (Hussey, 1981) consisting of very extensively migmatized dark gray metapelite characterized by very large (up to 4 cm) anhedral garnet poikiloblasts and locally abundant sillimanite. Thin dark greenish gray hornblende-rich calc-silicate beds and massive to slightly foliated amphibolite units up to 20 meters thick are sporadically present. This unit is equivalent to the Taylor Pond unit of Creasy (1979).

(2) A very rusty-weathering muscovite-biotite-garnet schist and garnet-biotite granofels.

(3) Very thin-bedded calc-silicate granofels and marble with minor dark brownish gray quartz-plagioclase-biotite granofels.

The thickness of the Turner Member is difficult to estimate because of extensive multiple deformation, but probably does not exceed 600 meters. The Thorncrag Hill unit is estimated to be up to 70 meters thick, the rusty schist about 50 meters, and the thin marble-calc-silicate unit approximately 20 meters.

The Patch Mountain Member of the Sangerville Formation consists of well-bedded alternations of light to medium greenish gray calc-silicate granofels, dark gray quartz-plagioclase-biotite ± hornblende granofels, and fine-grained granoblastic marble with abundant calc-silicate minerals. In places the Member consists of massive marble, and locally, thick beds of quartz-plagioclase-biotite granofels. In the area just east of Sabattus Mountain in Sabattus, the Patch Mountain consists of thin ribbon-bedded metalimestone with thin quartz-plagioclase-biotite schist interbeds and some punky-weathering medium brownish gray quartz-biotite-calcite granofels. The ribbony-bedded metalimestone is identical to the metalimestone member of the Waterville Formation. The thickness of the Patch Mountain Member probably does not exceed 200 meters.

The Anasagunticook Member of the Sangerville Formation is very similar to the Turner Member in the zone of extensive migmatization that characterizes its outcrop belt in the study area. It consists of variably bedded biotite-sillimanite-muscovite-garnet schist with many zones and beds of biotite quartzite and biotite metagraywacke (Pankiwskyj et al., 1976). The Member includes one and possibly two thin (30m) calc-silicate horizons consisting of interbedded quartz-tremolite-calcite-biotite-plagioclase granofels and quartz-diopside-plagioclase granofels, one of which is correlated with the Berry Ledge Formation of Guidotti (1965). The Anasagunticook also includes sporadic thin lenses of rusty-weathering schist. The thickness of the Anasagunticook Member is estimated to be 1000 to 1200 meters (Pankiwskyj, et al., 1976).

The Parkman Hill Formation is restricted to a narrow belt in the core of the Currier Hill syncline at the northern edge of the study area. It is composed of sulfide-rich, rusty-weathering metasandstone, quartz-rich granule metaconglomerate, and thinly laminated metasiltstone and metapelite. Osberg (1980) gives the thickness of the Parkman Hill in the Skowhegan area to the northeast of the study area as only a few tens of meters.

Stratigraphic Relations, Age, and Correlations - The Vassalboro-Waterville contact is conformable and abrupt. The Vassalboro-Cushing contact is interpreted to be a prematamorphic folded thrust. The Vassalboro-Cape Elizabeth contact in the Portland-Saco area is the postmetamorphic Nonesuch River Fault. The Waterville-Sangerville contact within the study area is inferred to be a postmetamorphic fault, but to the northeast, the contact is regarded to be conformable (Osberg, 1968). The Sangerville-Parkman Hill contact is also conformable (Pankiwskyj et al., 1976).

A Silurian age for the Waterville to Parkman Hill sequence is established from fossil occurrence in these formations from areas of central Maine where metamorphism is no higher than chlorite grade. According to Osberg (1980) and Pankiwskyj et al. (1976) the Waterville and Mayflower Hill Formations (the latter equivalent to the lower part of the Sangerville Formation) are of early Silurian age, the Sangerville Formation is Early to Middle Silurian, and the Parkman Hill is Late Silurian. Regarding the age of the Vassalboro Formation Osberg (1980, p. 280) states, "Considering the thickness of the Vassalboro Formation and the ages of the overlying formations, I think that the Vassalboro is probably Llandoverian, although the lower part of the formation could be as old as latest Ordovician."

The writer correlates the Vassalboro Formation with the Berwick Formation of southwestern Maine (Hussey, 1968). Osberg (1980) suggests a correlation of the Vassalboro with the Quimby Formation of western Maine, and the Oakdale Quartzite, Paxton Quartz Schist, and Hebron Formation of southern New England. Osberg (1980) suggests a correlation of the Waterville with the Turner-Patch Mountain-Anasagunticook sequence but these units are here regarded as equivalents of the Sangerville Formation, stratigraphically above the Waterville. Osberg correlated the Sangerville with the Rangeley Formation of western Maine. The Windham Formation was originally correlated with the Waterville Formation based on very close lithic similarity of the two formations (Hussey, 1971a), but critical sedimentary tops evidence indicates that the Windham Formation is below the Vassalboro Formation. A roadcut along U.S. Highway 202, approximately 6.8 km southwest of Gray, exposes both the upper and lower contacts of the southeastern belt of metalimestone of the Windham (Plate I). Graded beds one meter northwest of the northwestern contact indicate tops are southeast. This indicates that the metapelite southeast of this outcrop belt of the metalimestone is stratigraphically above the metalimestone. On this basis I interpret the Vassalboro lying to the southeast of this metapelite to be stratigraphically above the Windham Formation. The Windham may thus not be equivalent to the Waterville Formation despite the very close lithic similarity of the two. Alternatively the Windham may correlate with the Eliot Formation which lies below the Berwick Formation in southwestern Maine, and with the metapelite and marble unit within the Vassalboro Formation in the Gardiner 15-minute Quadrangle (Osberg 1980). It should be noted that Newberg (1981) regards these units to be the Waterville Formation, as shown on Plate I of this report.

INTRUSIVE ROCKS

Intrusive rocks occupy approximately one-third of the study area. They include two-mica granite, biotite granite, granodiorite, pegmatite, diorite, gabbro, feldspathoidal syenite and basic dike rocks. These rocks collectively represent an intrusive history spanning the time from the Early Devonian to the Cretaceous.

The principal plutons of the area are the Sebago Batholith (the largest pluton in Maine, with an estimated area of approximately 2000 km^2) and the Lyman, Biddeford, Saco, Leeds and Lake Androscoggin plutons. In addition many minor plutons, mostly of 2-mica granite, occur throughout the area. The Biddeford pluton is composed of medium-grained non-foliated light gray biotite granite. The Lyman, Leeds and minor unnamed plutons are composed of fine to medium-grained, irregularly and evenly textured, non- to moderately foliated biotite-muscovite granite. Pegmatite stringers and lenses are common in these granites. Accessory garnet is present in most of these 2-mica granite plutons, especially the minor plutons in the Casco Bay Group outcrop belt. The Sebago Batholith is composed of massive to moderately foliated biotite-muscovite granite. Creasy (1979) maps and describes two granitic phases of the Batholith in the Poland 15' quadrangle. An outer zone consists of 2-mica granite of much textural heterogeneity ranging from medium grained to pegmatitic, and containing abundant metasedimentary inclusions. The inner zone consists of 2-mica granite described as "broadly homogeneous in texture although gradation to pegmatitic texture may be present in single outcrops." Thin septa of metasediments are much less common than in the outer phase. The boundary between the two phases is irregular and gradational. Creasy notes the presence of a non-foliated pink biotite-muscovite granite without accompanying pegmatite on Black Cat Mountain near the southern edge of the Poland Quadrangle, and suggests this may be younger than the granites described above.

Foliated granodiorite forms an arcuate pluton approximately 4 km by 2 km, centered just west of the village of Sabattus.

Pegmatites of simple mineralogy (quartz, microcline, albite, biotite, muscovite, garnet, schorlite) are common throughout the study area in the sillimanite and sillimanite-K-feldspar metamorphic zones. They occur as elongate pods and lenses, irregular stringers, and regular-walled dikes. Pegmatites of the lenses, pods, and stringers are frequently foliated, and the thinner ones are commonly folded. Pegmatite dikes are generally massive, unfolded, and unfoliated.

The Saco pluton is composed of strongly foliated and lineated diorite. Similar diorite, older than the Sebago Batholith forms a small stock at the south end of the Westbrook portion of the Sebago Batholith. The original igneous mineralogy of both of these bodies has been changed almost completely either by regional metamorphism or by deuteric alteration, being now represented by saussuritized and sericitized feldspars, green hornblende, and chlorite. Relict labradorite, andesine, and augite are locally present.

Gabbro with minor syenite forms a 7 km-diameter pluton centered around Lake Androscoggin in Wayne. Both Phases are younger than the two mica granite of the Leeds pluton, and the regional pegmatites.

In the town of Litchfield feldspathoidal syenite forms a small stock approximately 5 km in diameter. Boulders believed to be glacially plucked from the pluton have yielded fine specimens of cancrinite, sodalite, nepheline, and large zircons.

Basic dikes, including basalt, diabase, camptonite, and monchiquite, are present throughout the study area in greatly varying abundance. They range in thickness from less than a centimeter to greater than 30 meters. These rocks are undeformed and unmetamorphosed, but frequently show markedly contrasting differences in deuteric alteration. These dikes cut all the metasedimentary units, pegmatites, and granitic plutons and are the youngest intrusives of the study area. They form a dike swarm, locally accounting for 20 percent of the outcrop area in a relatively narrow belt that extends from southwest of the study area into the Kennebunkport area. This swarm either terminates or trends out to sea just south of Biddeford Pool, Biddeford. Another minor swarm noted by the writer (Hussey, 1981) is located in a slightly east-west trending belt centered around the City of Lewiston. These dikes have a general ENE trend.

Ages - Several of the plutons and minor intrusives have been radiometrically dated. Gaudette et al. (in review) give Rb/Sr ages of 341 $\pm$ 12 ma for the Biddeford pluton, 322 $\pm$ 12 ma for the Lyman pluton, and 307 $\pm$ 20 ma for the Saco Pluton. The 307 ma age for the Saco pluton is perplexing in view of the strongly lineated and foliated character of the pluton. Although the Nonesuch River Fault cuts centrally through this pluton, foliation and lineation is not restricted to the fault zone, but is pervasive throughout the pluton. This led the writer earlier to regard the Saco Pluton as a syn-Acadian intrusive older than the granitic plutons of southwestern Maine. This anomaly of a strongly deformed but apparently young intrusive remains a problem for future resolution.

A K/Ar age of 234 ± 6 ma is reported by Foland and Faul (1977) for the Litchfield pluton, and for the Androscoggin Lake pluton. Northern Utilities Corp. (1975) report K/Ar ages ranging from 297 ± 11 ma to 244 ± 9 ma. Despite these values, Northern Utilities Corp. (1975) believes these plutons to be of Devonian age and that the younger ages reflect cooling in the Carboniferous. McHone and Trygstad (in press) report K/Ar whole rock ages for basic dikes in the study area ranging from 200 ± 9 ma to 124 ± 6 ma, indicating a range from Late Triassic to Cretaceous as the time of intrusion of these dikes.

STRUCTURE

Folds - All of the stratified rocks of the Lower Androscoggin Valley-Casco Bay area have been multiply deformed. The two general sequences, Cambro-Ordovician Casco Bay Group and Siluro-Ordovician sequence, each have been affected by two major deformations and several minor episodes.

The deformational history of the Casco Bay Group is best understood in the Small Point area of Phippsburg, and the shoreline exposures in Cape Elizabeth. In the following discussion, folding sequence is designated as F_1, F_2, F_3, etc., F_1 comprising the oldest folds. Deformational events corresponding with these fold sequences are given as D_1, D_2, D_3, etc.

In the Small Point area, F_1 structures are meso- to macroscopic scale recumbent isoclines of unknown facing direction. These may be related to major recumbent folds of scale comparable to those postulated by Osberg (1980) for the Silurian sequence of central Maine, but definitive evidence for such large-scale structures is lacking in the rocks of the Casco Bay Group. F_2 structures are small-scale very tight isoclinal recumbent folds of fracture cleavage axial-planar to F_1 folds. F_3 structures include small-scale mesoscopic upright to slightly overturned asymmetric folds. These are congruent with macroscopic folds defined by the pattern of mappable lithic units in the Small Point area. The mesoscopic F_3 structures have a folded muscovite schistosity, but locally biotite has been recrystallized to form a schistosity parallel to axial planes of F_3 folds. In the Harpswell area to the west, major folds as defined by map pattern (Hussey, 1971b) correlate with F_3, indicating D_3 was a major folding event. In the Orrs Island area, subsequent folding events are of minor nature. F_4 and F_5 are minor crenulations of earlier lineations and schistosity; F_6 structures are steeply-dipping kink bands with consistent left-lateral kinking sense.

In the Cape Elizabeth area, the Cape Elizabeth Formation preserves F_1 parasitic mesoscopic east-facing recumbent isoclines, and upright folds correlated with F_3 structures of the Small Point area. F_3 folds at Cape Elizabeth deform both upward and downward facing bedding sequences indicating the presence of both inverted and upright limbs of intermediate-scale F_1 recumbent folds. F_2 structures of the Small Point sequence are not developed in the Cape Elizabeth area.

The Siluro-Ordovician sequence has been deformed by large-scale early west-facing recumbent isoclines, and later large-scale upright to overturned folds. Recumbent folding in the Lewiston-Bryant Pond area is suggested by the numerous reclined and recumbent mesoscopic-scale folds seen in outcrops. These folds deform migmatite stringers and gneissic foliation of the Sangerville rock units, and are in turn deformed by later upright to moderately overturned folds. Guidotti (1965, p. 70) suggested similar relations for an area of the Bryant Pond 15-minute Quadrangle north of the Moll Ockett Fault.

In the Lewiston area two contrasting fold domains are recognized: the Oak Hill fold domain and the Lewiston fold domain (Hussey, 1981). The Oak Hill fold domain is characterized by tight upright folds and the virtual absence of pegmatites and migmatitization. This domain extends from the area in Sabattus and Litchfield to the north and northeast beyond the study area. Within this domain in central Maine, Osberg (1980) recognizes large-scale recumbent folds on the basis of downward-facing bedding sequences deformed by the upright folds. The Lewiston fold domain is characterized by extensive meso- and macroscopic-scale reclined folds, an abundance of pegmatites, and extensive migmatization of the metasedimentary sequence. This fold style characterizes the area from Lewiston to Bryant Pond in a belt 10-50 km wide, concentric to the eastern contact of the Sebago Batholith. The northeastern limit of this domain coincides roughly, but not exactly, with the change from northeast to northwest structural trends. Most of the northwest or southeast converging lithic map patterns within this domain, particularly around the City of Lewiston, depict reclined folds with north to northeast axial plunges, not upright or overturned folds with northwest or southeast plunging axes. The northwest-trending folds are due in part to refolding of F_1 recumbent or reclined folds by F_2 described below, and by deflection of the F_1's by syntectonic injection of the Sebago Batholith.

The digitate outcrop belt of the Patch Mountain Member of the Sangerville Formation through the City of Lewiston is interpreted to define the axial zone of a major recumbent west-facing syncline. The key to interpreting this belt as a synclinal axis is the repetition of the Thorncrag Hill schist and the rusty schist units symmetrically on either side of the Patch Mountain (Hussey, 1981). This recumbent fold is refolded by several late folds of imperfectly known geometry that are correlated with the late upright folds (F_2) of the Oak Hill domain. The F_2 structures of the Lewiston domain appear to be much more open than Oak Hill F_2's, a condition probably related to migmatization. I interpret the difference in fold styles between the two domains to be due to migmatization related to the syntectonic emplacement of the Sebago Batholith. The domain boundary is coincident with the front of migmatization, and the wide migmatite belt suggests that the Sebago Batholith contact dips relatively gently to the northeast.

Figure 2 is a generalized geological map of the Lewiston-Bryant Pond area showing my interpretation of early and late folds, and Figure 3 is a generalized cross-section sketch across this belt.

Faults - Major faults of the study area are shown on Plate I, and their names are given in Figure 4 and Plate I.

The contact between the Casco Bay Group and the Vassalboro Formation is interpreted to be a major premetamorphic folded thrust (Hussey and

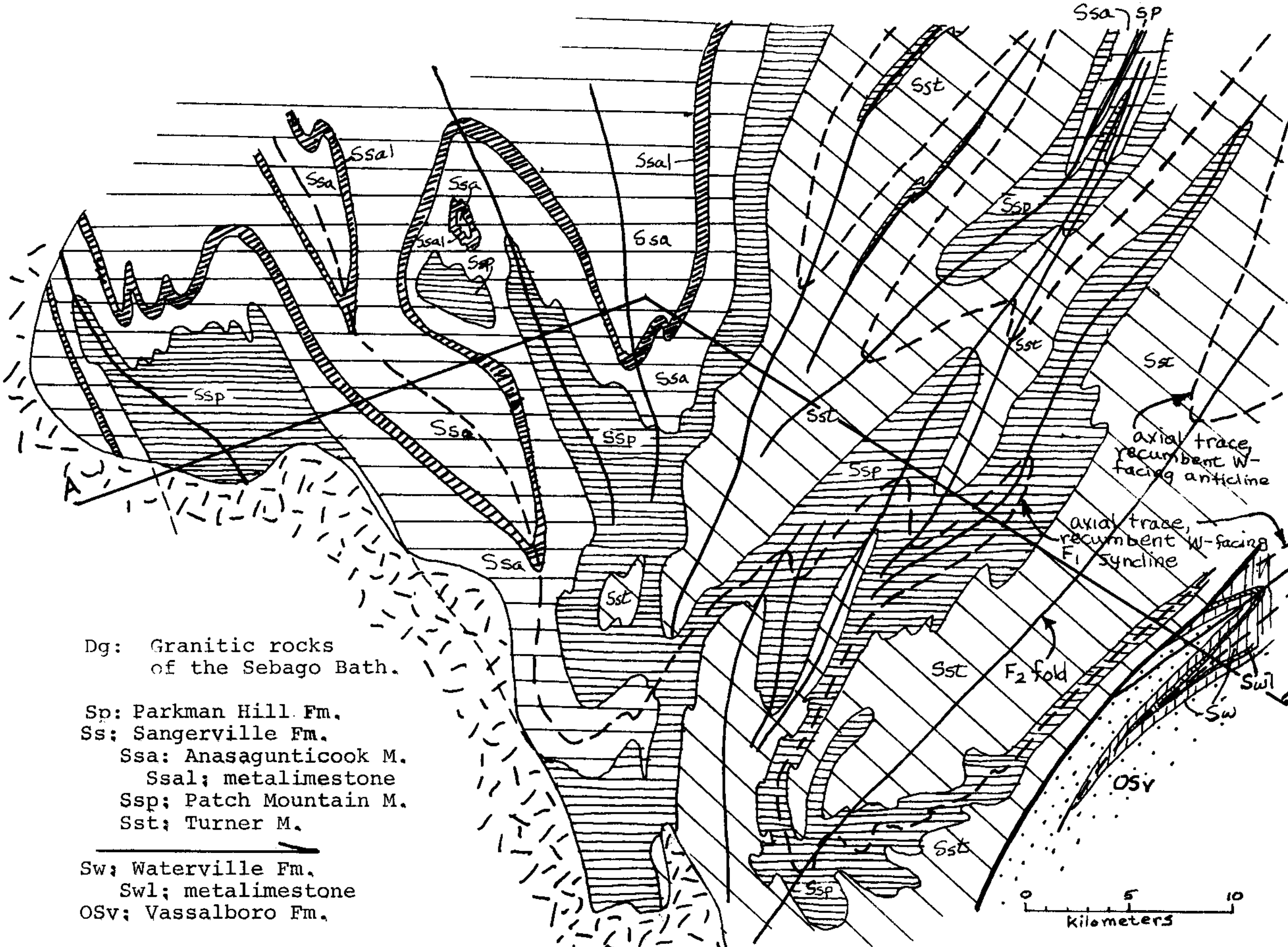

Figure 2. Generalized geological sketch map of the Lewiston-Livermore-Bryant Pond area, Maine. Smaller plutons, Ben Barrows Fault and Moll Ockett Fault omitted.

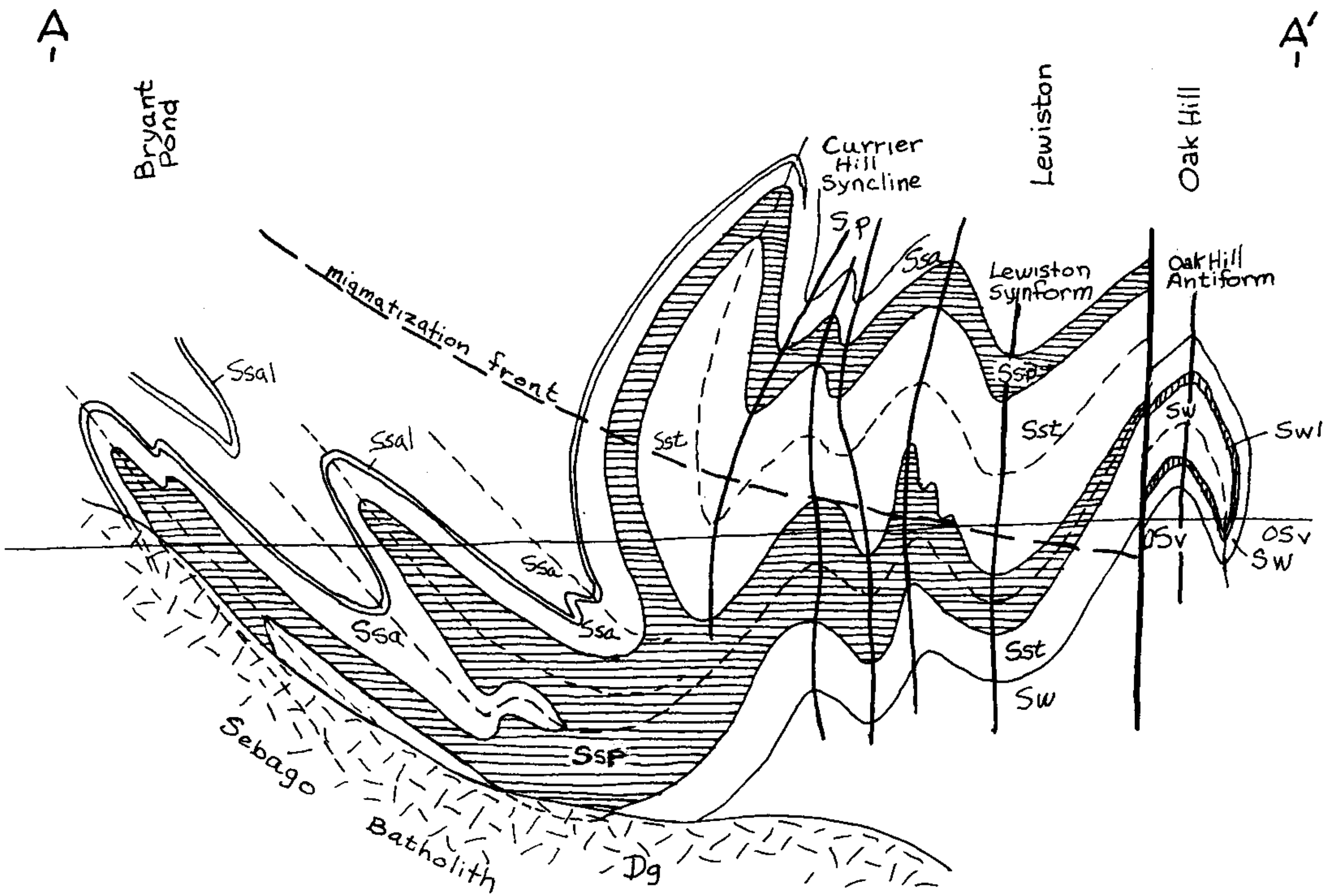

Figure 3. Cross-section sketch along section A - A' (Fig. 2) from the Bryant Pond area to the Oak Hill area, Sabattus. Not to scale. Lithic symbols same as for Plate I.

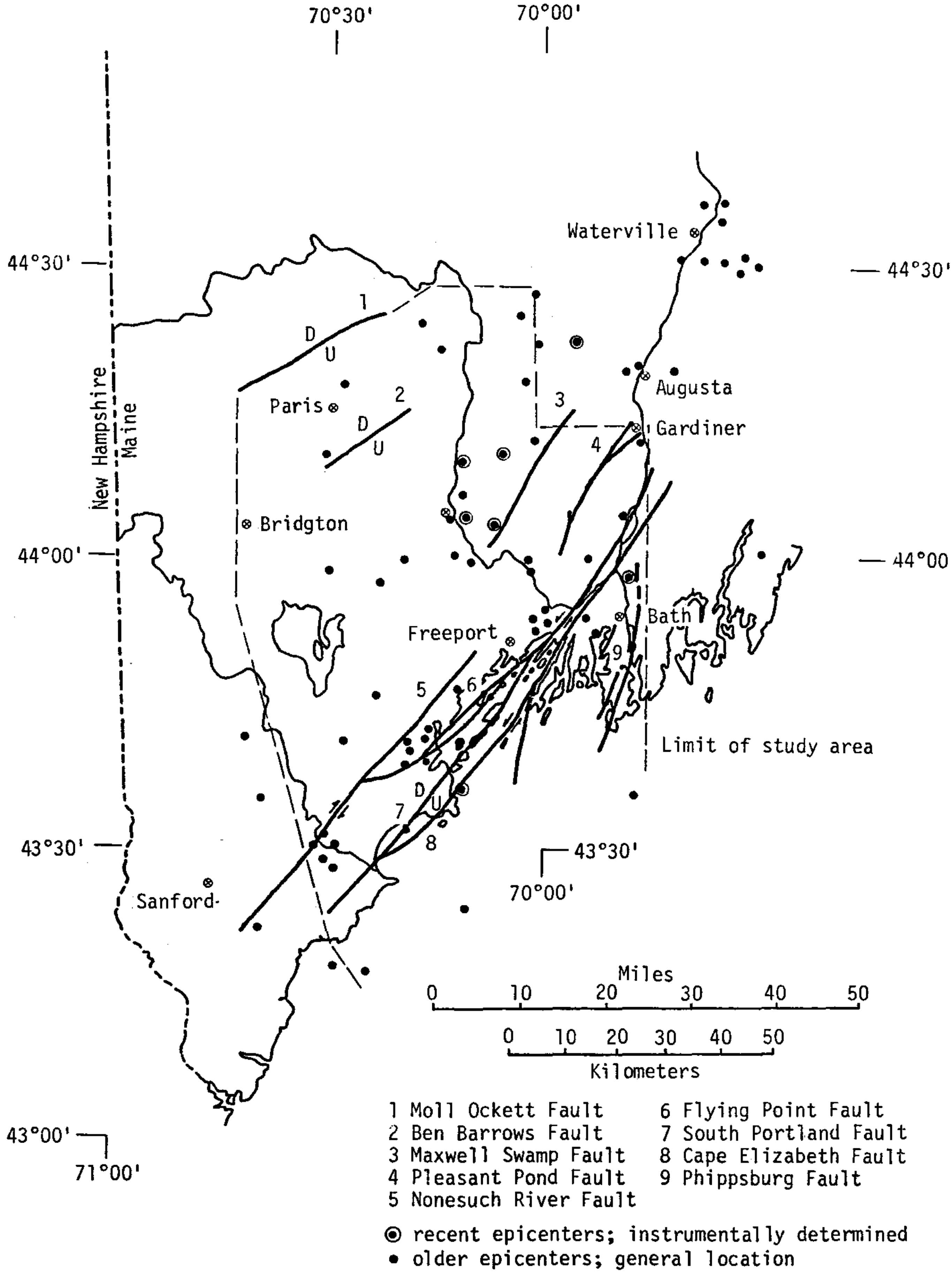

Figure 4. Locations of Earthquake Epicenters (1776-1979) and Postmetamorphic Faults in the Lower Androscoggin Valley - Casco Bay Area.

Pankiwskyj, 1976; Pankiwskyj, 1970; Osberg, 1980; and Newberg, 1981). The basis for this interpretation is very speculative, resting primarily on the inferred difference in age of the two sequences on either side. Alternatively, the contact may be an angular unconformity with the Vassalboro resting on the Cushing.

Hussey (1971a, b; 1981b, c, d) has mapped a northeast trending series of postmetamorphic faults extending through the Portland-Brunswick area which are collectively referred to as the Norumbega Fault System. Included in this Zone are the Nonesuch River, Flying Point, South Portland, Cape Elizabeth, and Phippsburg Faults, and an unnamed fault just east of Macworth Island in Casco Bay. The northwestern-most of these, the Nonesuch River Fault, has been traced southwestward into New Hampshire (Hussey, 1978), but can be followed to the northeast only as far as Yarmouth. Evidence for the Nonesuch River Fault is as follows:

(1) Juxtaposition of Vassalboro and Cape Elizabeth Formations.

(2) The marked topographic lineament formed by the Nonesuch River, the Presumpscot River northeast of Westbrook, and the short NE-SW course of the Saco River in the outcrop belt of the Saco pluton.

(3) Truncation of metamorphic isograds in the Cape Elizabeth Formation, resulting in the juxtaposition of staurolite-grade Vassalboro against chlorite to garnet grade Cape Elizabeth.

(4) Structural contortion and quartz veining of the Cape Elizabeth Formation exposures in the Nonesuch River bed south of Gorham.

Although positive evidence for continuation of the Fault northeast of Yarmouth is lacking, it may possibly extend northeast to join the Pleasant Pond Fault of Newberg (1981). Hussey & Newberg (1978) suggest significant right-lateral strike-slip movement for the Fault in southwestern Maine.

The Flying Point Fault is traced from its inferred junction with the Nonesuch River Fault (south of Gorham) through Brunswick to the Richmond area, where it may extend well beyond the study area. In the Portland area this fault juxtaposes non-migmatized Greenschist Facies to low Amphibolite Facies Macworth Formation on the southeast against pegmatite-injected, migmatized upper Amphibolite Facies Cushing and Vassalboro Formations on the northwest. Rocks of the Casco Bay Group of comparable grade and degree of migmatization southeast of the fault are encountered only northeast of Merrymeeting Bay between Bowdoinham and Woolwich, suggesting a possible 50 to 60 kilometers of left-lateral strike slip movement, assuming net movement is strictly horizontal. The actual movement may be considerably less if (1) net movement includes a significant component of dip slip; and (2) metamorphic isograd surfaces are gently dipping. Splays related to the Flying Point Fault can be seen in shoreline exposures at Johns Point on Flying Point, Freeport. Here, rocks of the Cushing have been brecciated, and the foliation contorted and cut by numerous slickensided surfaces. Slickensides are generally steep, indicating that the latest movement was nearly dip slip. Localities where the position of this fault is closely determined (within 25 m) include Sturdivant Island, Cumberland; Bartlett Point, Falmouth (Bodine, 1965) and the small cove separating Flying Point from the Freeport mainland.

The South Portland Fault is indicated primarily by the omission of units of the Casco Bay Group in the South Portland to Great Chebeague Island area. This is probably a normal fault down-dropped to the northwest. The amount of slip probably does not exceed a few hundred meters.

The Cape Elizabeth Fault has been traced by Hussey (1971a, b) and Newberg (1981) from the Old Orchard Beach area to and beyond Dresden Mills (6 km east of Richmond and just east of the study area). Pankiwskyj (1978) has traced this fault to the northeast into the Norumbega Fault of Stewart and Wones (1974). The Cape Elizabeth Fault is well exposed in a one-kilometer wide zone along the shoreline in the Ram Island Farm area of Cape Elizabeth. Here, exposures of the Cape Elizabeth Formation show numerous variably-oriented high-angle faults that are locally filled with breccia or gouge. The zone includes a low-angle west-dipping thrust fault of unknown but potentially significant throw. This thrust fault may not be related to the principal movement of the Cape Elizabeth Fault. The major break of the Cape Elizabeth Fault is occupied by a 5 to 10 m vein of milky quartz that can be traced approximately 2 km to the northeast and along which different units of the Cushing Formation are juxtaposed against the Cape Elizabeth. In the area of Harpswell Neck, Harpswell, the offset of the Cape Elizabeth-Cushing contact and the sillimanite/andalusite metamorphic isograd suggest possible left-lateral slip movement of 4 to 5 kilometers, but this may also be significantly less if there was a major component of dip-slip motion and if the formational contacts as well as the isograd have a moderate to gentle dip.

The Phippsburg Fault follows a marked topographic lineament from Small Point to Phippsburg village (Hussey, work in progress). Although net movement along the fault must be very minor, this may be a very significant break -- the April 1979 earthquake epicenter lies within a few hundred meters of an extension of the topographic lineament in the Woolwich area. In addition, exposures of the Cape Elizabeth Formation along State Highway 127 at the north end of Arrowsic Island show extensive slickensiding adjacent to where the lineament crosses the highway (J.R. Rand, personal communication).

An unnamed fault is inferred to form the eastern contact of the Macworth Formation. This is postulated on the basis that the Casco Bay Group metapelites to the east are at higher metamorphic grade than the Macworth rocks and that the Macworth contact truncates regional metamorphic isograds of these metapelites.

Hussey (1981) and Newberg (1981) map a high-angle fault extending along the linear lowland just west of Oak Hill in the Sabattus-Litchfield area. This fault, herein named the Maxwell Swamp Fault, is indicated by the topographic lineament and by the omission of the Waterville Formation between the Vassalboro and Sangerville Formations at the south end of Oak Hill. The southern termination of this fault is uncertain because of the strong migmatization in the Lisbon area, where the topographic lineament dies out.

Creasy (1970) maps in the Hebron area of the Poland Quadrangle a northeast-trending normal fault which he named the Ben Barrows Fault. The fault is documented on the basis of offset of lithic contacts, and silicified and sheared zones within granites of the area. He regards the Ben Barrows fault to be a postmetamorphic normal fault downdropped to the northwest and having dip-slip movement of 1-2 km.

Twelve kilometers to the northwest of the Ben Barrows Fault, Guidotti (1965) mapped the Moll Ockett Fault. It has a trend parallel to the Ben Barrows Fault and is recognized on the basis of (1) a sharp topographic break; (2) sharp lithic and stratigraphic contrasts on either side; (3) contrasting change in structural styles and patterns: (4) presence of breccia at several places along the fault trace; and (5) strong retrograde metamorphism. Guidotti regards the fault as a normal fault dipping 60 to 80 degrees to the northwest and downdropped to the northwest.

Several minor unnamed faults are shown in Plate I. Many of these are silicified zones for which offset cannot be demonstrated. Many minor northwest-trending faults in the Harpswell-Portland area are parallel to left-lateral kink bands (F_6), and may represent situations where deformation has exceeded the limits of kinking and passed on into minor left-lateral strike-slip faults. Many intraformational gouge zones, breccia zones, slickensided surfaces, and silicified zones have been observed in outcrop throughout the study area, but are too small to be represented on Plate I.

Figure 4 shows the locations of earthquake epicenters during the years 1776 to 1979 (after Chiburis, 1981) and the postmetamorphic faults discussed above. Epicenters marked by encircled dots are those for which Richter values are given. It is assumed that these are earthquakes whose epicenters have been determined by the modern instrumental seismic network and thus are more precisely located than older ones. Although epicenters occasionally plot close to mapped faults, the total distribution of epicenters shows no preferred concentration relative to known faults. An exception to this may be the Portland area, where several epicenters appear to lie close to the intersection of the Nonesuch River and Flying Point Faults, and the Bath area where the April 1979 epicenter lies close to the Phippsburg Fault. This suggests the possibility that some of the faults of the Norumbega Fault system may be intermittently active.

METAMORPHISM

The stratified rocks of the study area have been metamorphosed in a low-pressure intermediate (Buchan-type) facies series from lower Greenschist Facies to upper Amphibolite Facies. Pelitic rocks are characterized at intermediate grade by the presence of andalusite, cordierite, and staurolite apparently overlapping the lower temperature part of the sillimanite stability field. The presence of kyanite in the Gorham-Gray area suggests a transition there to a higher pressure Barrovian-type metamorphism.

Pelitic rocks in the Small Point area, now at andalusite and sillimanite grades of metamorphism, preserve 2 to 4 cm long pseudomorphs of muscovite after chiastolite, suggesting an earlier intermediate to high grade of metamorphism.

Retrograde metamorphism has variably affected the entire study area, and is generally expressed in the partial to complete chloritization of biotite. Chloritization is particularly strong in the quartzo-feldspathic rocks of the Cushing Formation adjacent to the Flying Point and Cape Elizabeth Faults in the Brunswick-Gardiner area.

TIME OF DEFORMATION AND METAMORPHISM

The conformable sequence comprising the Vassalboro through Parkman Hill was deformed during the Acadian Orogeny of Early Devonian time. A younger age of deformation corresponding to an Alleghanian event in Permian time that is recognizable in other parts of the northern Appalachians is ruled out for this area by the fact that postorogenic granitic plutons, the Lyman of Mississippian age and the Biddeford of Middle Devonian age, truncate structures of the metasedimentary sequence. A Taconian event of Late Ordovician age is ruled out because of the inferred Late Ordovician to Silurian age for the Vassalboro Formation. This Formation was thus being deposited at the same time the Taconian Orogeny was deforming pre-Silurian sequences in more westerly parts of the northern Appalachians.

The Casco Bay Group may have been affected by a pre-Silurian orogenesis. The Cape Elizabeth-Scarboro sequence at Small Point in Phippsburg has undergone an earlier metamorphism to andalusite grade as noted above. Subsequently these rocks were metamorphosed to andalusite, sillimanite, and sillimanite-K-spar grades as indicated by the present prograde metamorphic mineral assemblages. Inasmuch as there appears to be no metamorphic discontinuity between rocks of the Casco Bay Group and those of the Siluro-Ordovician sequence in the Brunswick-Gardiner-Lewiston area, the present prograde metamorphic assemblage of the Casco Bay Group is most likely a result of the Acadian Orogeny. Because the F_3 folds of the Casco Bay Group are in part synchronous with the development of the present prograde mineral assemblage (the biotite axial-plane schistosity associated with these folds), D_3 is considered to be an Acadian orogenic event. The older metamorphism and possibly the earlier recumbent folding (F_1 and F_2) may be related to an earlier pre-Taconian orogeny, perhaps the Penobscot Dirsturbance of Neuman (1967).

The postmetamorphic Nonesuch River Fault underwent principal movement prior to emplacement of the Lyman and Saco Plutons, whose contacts with the Vassalboro Formation have not been offset where the fault trends into them. Reactivation of the fault after emplacement of the Plutons is suggested by a topographic lineament within both plutons (Hussey and Newberg, 1978). This later movement was not of sufficient magnitude to offset the Lyman-Vassalboro contact. Similarly the postmetamorphic Cape Elizabeth Fault appears to follow a topographic lineament in the Biddeford Granite, but, again, the Biddeford-Vassalboro contact is not appreciably offset.

Consequently, major strike-slip movement inferred for this fault must have predated Middle Devonian time. It is concluded that major postmetamorphic strike-slip faulting is an event that took place at the close of the Acadian Orogeny. The topographic lineament in the Biddeford granite, may represent normal faulting associated with the development of the South Portland Fault, which is downdropped to the northwest. Other faults in the study area that involve normal-type movement with downdropping to the northwest are the Ben Barrows and Moll Ockett Faults to the northwest. This normal faulting cannot be precisely dated, but speculatively is correlated with Late Triassic rifting in other parts of the northern Appalachians.

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EXPLANATION

INTRUSIVE ROCKS

MISSISSIPPIAN:	Mg:	GRANITE (LYMAN PLUTON)
LATE DEVONIAN(?):	Ds:	FELDSPATHOIDAL SYENITE (LITCHFIELD PLUTON)
	Dgb:	GABBRO AND SYENITE (ANDROSCOGGIN LAKE PLUTON)
EARLY AND MIDDLE DEVONIAN:	Dg:	GRANITE
	Dgd:	GRANODIORITE
	Dqd:	QUARTZ DIORITE AND DIORITE

STRATIFIED ROCKS

LATE SILURIAN:	Sp:	PARKMAN HILL FORMATION
EARLY TO MIDDLE SILURIAN:	Ss:	SANGERVILLE FORMATION
		Ssa: ANASAGUNTICOOK MEMBER
		Ssal: METALIMESTONE
		Ssp: PATCH MOUNTAIN MEMBER
		Sst: TURNER MEMBER
		Sstt: THORNCRAG HILL SUBMEMBER
		Ssr: RUSTY SCHIST LENSES IN SANGERVILLE FORMATION
EARLY SILURIAN(?):	Sw:	WATERVILLE FORMATION (INCLUDES WINDHAM FORMATION)
		Swl: METALIMESTONE MEMBER
LATE ORDOVICIAN(?) TO EARLY SILURIAN(?):	SOv:	VASSALBORO FORMATION
		SOvv: FELSIC VOLCANIC MEMBER
CAMBRIAN TO ORDOVICIAN: CASCO BAY GROUP	O€?m:	MACWORTH FORMATION
	O€j:	JEWELL FORMATION
	O€sk:	SPURWINK LIMESTONE
	O€s:	SCARBORO FORMATION
	O€sd:	SPRING POINT AND DIAMOND ISLAND FORMATIONS
	O€ce:	CAPE ELIZABETH FORMATION
		unconformity (?)
	€Oc:	CUSHING FORMATION
		€Ocr: RUSTY GNEISS AND SCHIST WITHIN THE CUSHING FORMATION
		€Ocm: MARBLE
		€Oca: HORNBLENDE-PLAGIOCLASE AMPHIBOLITE
		€Ocma: MOUNT ARARAT MEMBER
		€Ocrc: RICHMOND CORNER MEMBER
		€Ocn: NEHUMKEAG MEMBER
		€Ocs: SEBASCODEGAN MEMBER
		€Ocb: BETHEL POINT MEMBER
		€Ocy: YARMOUTH ISLAND MEMBER

FORMATIONAL CONTACT

THRUST FAULT (TEETH ON UPPER PLATE)

HIGH ANGLE FAULTS (UNDIFFERENTIATED)

STRIKE-SLIP FAULT (ARROWS INDICATE RELATIVE MOTION)

U
D
GRAVITY FAULT (D: DOWNTHROWN SIDE, U: UPTHROWN SIDE)

LIMIT OF COMPILATION

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PRELIMINARY

BEDROCK AND BRITTLE FRACTURE MAP OF THE LOWER ANDROSCOGGIN-CASCO BAY AREA

1:250,000

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