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Bedrock Geology of the Westport 7.5' Quadrangle, Maine

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INTRODUCTION

Physiographic Setting

The Westport 7.5' quadrangle is located in the inner part of the south central (indented embayments) compartment (Kelley et al., 1989) of the Maine coast (Fig. 1). It is dominated by the narrow tidal estuaries of the Sheepscot River, Back River (Boothbay), Montsweag Bay and Back River (Westport/Woolwich), and Cross River. Open ocean lies 10 to 15 miles to the south. The tidal range in this area is approximately 9 feet. Tidal mud flats and salt marshes are very limited in the map area, being restricted to the heads of small coves. Water depths to estuary fill vary up to 90 feet in the Sheepscot River estuary, 35 feet in Cross River, 50 feet in Montsweag Bay/Back River (Westport/Woolwich), and 60 feet in Back River (Boothbay). The tidal estuaries are bordered by cliffed or glaciated bedrock shorelines affording excellent exposures of fresh bedrock. Relief of these seacliffs varies from a few feet to 150 feet as at Dogget Castle (east shore of Westport Island) and High Head in the southern part of Edgecomb, and 210 feet at Cushman Hill on the shore of Back River (Woolwich/Westport).

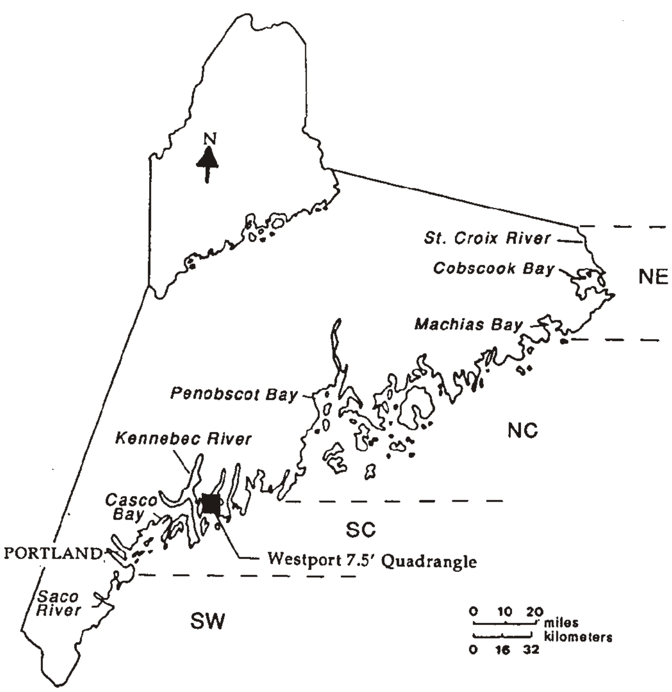


Figure 1. Location of the Westport 7.5' quadrangle (modified after Kelley et al., 1989).

Away from the shoreline the land is dominated by gently to moderately sloping, glacially sculptured bedrock knobs. Bedrock exposures, particularly of more resistant pegmatite sills, stringers, and dikes are abundant, and glacial deposits of any extent are quite rare. Glacial striations indicate a general ice movement direction of 170 degrees. In contrast, trends of the major estuaries and intervening ridges vary from approximately 190 to 205 degrees, closely paralleling the strike of bedding or foliation, and the Back River fault (Plate 1). This suggests that structurally-controlled preglacial or interglacial fluvial erosion rather than glacial sculpturing has been the primary agent for carving the estuaries of the SC compartment.

Settlement and Accessibility

No major villages or cities are located within the limits of the Westport 7.5' quadrangle, and settlement is sparse. In general, the shoreline of this area is not heavily developed for summer residential or recreational use as compared to adjacent areas of Boothbay Harbor, Harpswell, or Phippsburg. Access to the area is excellent via the public highway and private access lane network.

Bailey Point on the west side of Back River in the southern part of Wiscasset is the site of Maine Yankee Atomic Power Company, the only nuclear power facility in the state of Maine.

General Geology

The Westport quadrangle lies mostly within the Casco Bay lithotectonic belt in southwestern Maine (Fig. 2). At the eastern edge of the map area is the the antiformally folded thrust-bounded block (window) exposing the Cross River Formation which is interpreted to be equivalent to either the Cookson/Penobscot sequence or the Benner Hill sequence of the coastal lithotectonic block of Osberg et al., 1985. The bedrock of the quadrangle consists mostly of metasedimentary and metavolcanic rocks of high metamorphic grade that are extensively migmatized. Intrusive into these rocks are two-mica granite and associated pegmatite, and orthogneisses of granitic, syenitic, and quartz diorite composition. The granitic pegmatites, which are not mapped separately, are present in all formations of the area, in the two-mica granites, and in the orthogneisses. The rocks of the Casco Bay Group are tentatively assigned an age in the range from Late Precambrian to Early Ordovician, and the Cross River Formation is probably of Cambrian to Ordovician age. Intrusive rocks are provisionally assigned an age of Early Devonian.

The rocks are extensively deformed by upright south-plunging folds, one through-going north-northeast trending oblique-slip fault (Back River fault), and several minor faults with trends ranging from northeast to northwest. The metasedimentary sequence has been metamorphosed to upper amphibolite facies (mostly in the sillimanite zone and possibly sillimanite/K-feldspar zone).

Previous Work

The rocks of this area have not been previously mapped.

DESCRIPTION OF THE ROCK UNITS

Sebascodegan Formation (OZs)

Within the Westport quadrangle, the Sebascodegan Formation consists of interbedded salt-and-pepper textured, fine- to medium-grained, medium gray quartz-plagioclase-biotite-hornblende granofels and medium greenish gray calc-silicate granofels with diopside and hornblende. The former lithology characteristically occurs in beds 8 to 20 cm thick with 2 to 6 cm thick interbeds of the calc-silicate. Less characteristic, but comprising large areas of the outcrop belt, is massive medium gray quartz-plagioclase-biotite-hornblende granofels without interbedded calc-silicate. Rusty weathering, sulfidic muscovite-biotite-quartz-plagioclase schist occurs in 1 to 2 meter-thick intervals sporadically throughout the formation. Occasional graded beds are preserved, but more delicate structures such as cross bedding are not preserved at this grade of metamorphism. All exposures of the Sebascodegan Formation are extensively injected by concordant pegmatite stringers, but are not migmatized.

The contact between the Sebascodegan Formation and the underlying upper member of the Cross River Formation is exposed along the west shore of Cross River approximately 520 m south of Oven Mouth (EC ninth. Note: The quadrangle map is divided into nine equal sections, which are designated northeast, east-central, southeast, south-central, central, and so forth, abbreviated NE, EC, SE, SC, C, and so forth.). At this locality, the Sebascodegan Formation shows even, undistorted bedding structurally on top of the Cross River Formation. Unfortunately the continuity of original sedimentary bedding is interrupted by a 3/4 m concordant pegmatite sill, thus obscuring the original contact. Below the pegmatite sill the Cross River Formation shows very contorted bedding. From regional synthesis, however, the contact is interpreted to be a major thrust fault separating the Casco Bay terrane from the Cross River Formation which belongs either to the Penobscot Bay or Benner Hill sequences in the coastal lithotectonic belt to the east (Hussey, 1988). The contact between the Sebascodegan and Cape Elizabeth Formations is exposed at several localities within the quadrangle, but due to the strongly migmatized nature of the Cape Elizabeth Formation, the original nature of the contact is unclear.

The thickness of the Sebascodegan Formation is difficult to estimate because of the amount of injected pegmatite and the extensive folding characteristic of the formation in many localities. The narrowest part of the outcrop belt where both the base and top of the formation are present is along the shore of Oven Mouth. Here the width of the outcrop belt is approximately 800 meters. Allowing for a modest amount of repetition due to folding, and the variable dip of bedding, the thickness of the formation at this point is about 400 to 500 meters. 500 m is the estimate arrived at for its thickness farther west in the Harpswell area (Hussey, 1985).

Unnamed Amphibolite Member (OZsa). A thin (generally less than 20 m) zone of dark gray medium- to coarse-grained hornblende-biotite-plagioclase amphibolite is mapped locally in the upper part of the Sebascodegan Formation. In places this looks like a metagabbro sill, particularly those exposures in the area of Parsons Creek (EC ninth) and the east shore of Back River between Barters Island and the Boothbay mainland (EC ninth), where it is characterized by nearly equant hornblende grains 4 to 5 mm in diameter. These exposures are very similar to the amphibolite exposed at Fogg Point in South Freeport. Elsewhere, it is a medium dark gray plagioclase-hornblende-biotite gneiss. It is discontinuous along strike and its thickness nowhere exceeds 20 meters.

Correlations. This belt of rock was mapped as the southern extension of the lithologically similar Bucksport Formation in east-central Maine (Osberg et al., 1985). On the basis of detailed mapping of the Casco Bay Group into the Boothbay 15' quadrangle (Hussey, work in progress), it became obvious that the relations between the Cape Elizabeth Formation and the Sebascodegan Member of the Cushing Formation in the eastern part of the Orrs Island 7.5' Quadrangle (Hussey, 1971) are essen-

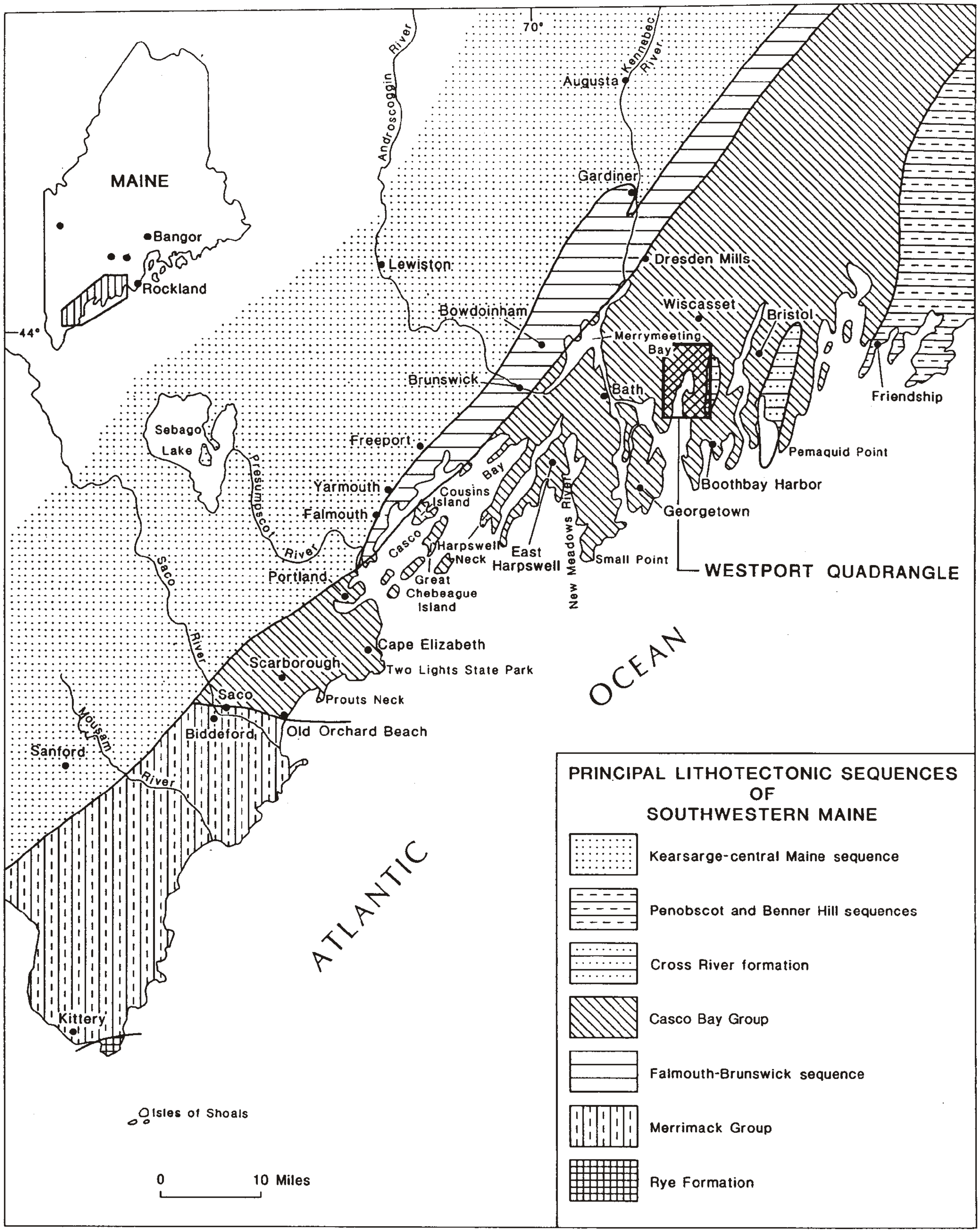


Figure 2. Location of the Westport 7.5’ quadrangle relative to the general lithotectonic sequences of southwestern Maine.

tially similar to the relations between the Cape Elizabeth Formation and the Bucksport Formation in the Boothbay area. Consequently, I proposed the correlation of the biotite and calc-silicate granofels of the Boothbay area with the Sebascodegan Member of the Cushing. Because of the extensiveness of this stratigraphic unit it was deemed appropriate to raise the status of the Sebascodegan from member to formation rank (Hussey, 1988).

Due to the inferred older age for the Sebascodegan Formation (Late Precambrian to Early Ordovician), the correlation with the Bucksport Formation is now questioned. Ruitenberg and Ludman (1978) correlate the Flume Ridge Formation of probable Silurian to Early Devonian age in eastern Maine with the Bucksport Formation. All three formations, Sebascodegan, Bucksport, and Flume Ridge occupy the same general strike belt, interrupted by major granitic bodies (Osberg et al., 1985). This requires major reassessment of the assumptions on which ages of the three formations are based.

Cape Elizabeth Formation (OZce)

The Cape Elizabeth Formation occupies the greatest area in the Westport quadrangle. It consists of medium gray quartzo-feldspathic gneiss and pelitic gneiss, with minor amphibolite and calc-silicate. In nearly all exposures the formation is migmatized to some extent and injected by pegmatites. Where least migmatized, such as at Hubbard Point on Hockomock Bay (SW ninth) the lithology is thin-bedded fine- to medium-grained quartz-plagioclase-biotite granofels and biotite-quartz-muscovite-sillimanite-garnet schist, very similar to the Cape Elizabeth Formation exposures in the Orrs Island quadrangle to the west (Hussey, 1971). Throughout most of its exposure it is moderately migmatized and gneissic in texture, but the bedding is crudely preserved, as is the quartzofeldspathic or pelitic composition. Where most strongly migmatized, the formation is a swirly feldspathic gneiss with moderate amounts of sillimanite, biotite, and garnet scattered throughout. The more quartzose beds and rare calc-silicate and amphibolite beds are present as non-migmatized, disaggregated, randomly oriented slab-shaped rafts in the swirly migmatite. In general, the degree of migmatization increases eastward in the map area.

Amphibolite/Calc-Silicate Member (OZcea). Amphibolite and calc-silicate with associated intervals of migmatized pelitic gneiss like the main phase of the Cape Elizabeth form a thin marker unit within the Cape Elizabeth Formation. It consists of dark gray amphibolite of simple mineralogy (hornblende, plagioclase, minor biotite) and medium greenish gray hornblende-diopside-plagioclase granofels and gneiss with conspicuous reddish orange anhedral to euhedral grossularite grains up to 15 mm in diameter. Interbedded with these lithologies are intervals of variable thickness of migmatized biotite-quartz-plagioclase-sillimanite gneiss and quartz-plagioclase-biotite gneiss.

This unit has been traced in several fold-limb belts within the Westport quadrangle, and it has been observed within the southern part of the Wiscasset quadrangle to the north by Newberg (1987, pers. commun.). Within the Westport quadrangle, parts of these belts are shown by a special symbol (see map) indicating positions where the member is inferred to exist beneath surficial cover based on structural interpretation. The thickness of the unit is variable, never exceeding 30 meters; it may pinch down to 0 in those areas where inferred but not observed.

Cross River Formation (Ocrl and Ocru)

The Cross River Formation, named from exposures in the southeastern edge of this quadrangle (Hussey, 1988), is divided into two unnamed members, **Ocrl**, the lower member and **Ocru**, the upper member. The lower, and most extensive, member is an extremely migmatized sulfidic metapelitic gneiss. In a few small areas the degree of migmatization is slight enough to show that the original metamorphic rock was interbedded sulfidic, very rusty-weathering sillimanite- and graphite-bearing mica schist and feldspathic and micaceous metawacke. In most parts of its outcrop the lower member consists of nebulitic rusty-weathering gneiss with relict schist schlieren and slabby disoriented rafts of non-migmatized quartzo-feldspathic beds and, rarely, amphibolite beds. Megacrysts of feldspar 5 - 20 mm in size are common throughout most of the nebulitic gneiss giving it a popcorn appearance.

The upper member is non-rusty weathering and not strongly migmatized. The uppermost part is very fine-grained salt-and-pepper textured quartz-plagioclase-biotite granofels with fine euhedral garnets locally. Bedding is not apparent. The lower part consists of the same lithology with 4 to 25 cm beds of medium gray biotitic and garnetiferous fine- to coarse-grained amphibolite scattered irregularly throughout.

The thickness of the members is difficult to estimate due to the extent of migmatization of the lower member and the irregular low dip of foliation of the two units. Furthermore, the base of the lower unit is not exposed. The upper unit probably does not exceed 40 meters in thickness.

INTRUSIVE ROCKS

General Statement

The igneous rocks of the Westport quadrangle include two-mica granite plutons, foliated and non-foliated pegmatites, and several orthogneiss bodies of essentially stratiform shape and markedly varying lithologies. These orthogneisses include the Edgecomb Gneiss first recognized by Hatheway (1969) in the Wiscasset area to the north; the Lincoln Sill, first mapped by Trefethen (1937), and the Oak Island Gneiss, mapped for the first time in this study.

Two-Mica Granite

Three small granite plutons are mapped in the Westport quadrangle. At the northern edge of the map just south of the village of Wiscasset, is an irregular 1 x 2 km pluton that extends a short distance north of the quadrangle. This is a medium to light gray to buff, fine- to medium-grained, generally massive and non-foliated biotite granite. Muscovite is scarce. A second pluton extends parallel to the strike of foliation and bedding approximately 2.5 km from the southern edge of the quadrangle north-northeastward. It is 0.35 km at its widest. The pluton consists of medium light gray, medium- to fine-grained, evenly foliated biotite-muscovite granite. The third body extends from the shore of Back River at the Maine Yankee nuclear power plant (C ninth) northward for 1.5 km. It is 0.4 km at its widest point in the vicinity of the power station. Lithologically it is a fine- to medium-grained light gray, buff-weathering foliated to massive biotite-muscovite granite. Accessory garnet is present but sparse. Locally, small vugs mark the positions where small lensoid grains of sillimanite have been weathered out. Stringers of medium- to coarse-grained pegmatitic granite cut almost all exposures of these granites.

Pegmatite

Pegmatite lenses, sills, dikes, and irregular stringers of varying sizes are common throughout the quadrangle and intrude all other rocks, including the granite plutons and orthogneiss bodies. None of these pegmatites have been separately mapped. Most of these pegmatites are of simple mineralogy, consisting of quartz, perthitic microcline, albite, biotite, muscovite, garnet, and occasionally black tourmaline. Many of the concordant pegmatites are moderately to strongly foliated and show the effects of very local assimilation of country rock, particularly those in the Cape Elizabeth Formation. Sillimanite is a very common accessory mineral in pegmatites that intrude sillimanite-rich zones of the formation, whereas the mineral is absent where the pegmatites intrude the less aluminous parts of the formation. In addition, the K-feldspar of the pegmatites in the aluminous schists is characteristically pink to orange in color, whereas in the non-aluminous parts of the Cape Elizabeth Formation the K-feldspar is pale buff in color. Accessory dumortierite occurs very sparingly in those pegmatites that have an association of both black tourmaline and sillimanite. Pale blue cordierite occasionally occurs in metamorphic reaction zones at the contacts of pegmatite with moderately aluminous country rock. Both dumortierite and cordierite can be seen in exposures along the shore at Fort Edgecomb (NE ninth).

Pegmatites hosted by the Sebascodegan Formation tend to have more regular walls, and the mineral assemblage is a simple association of quartz, perthite, muscovite, biotite, garnet, and sparing black tourmaline. Aluminous minerals such as sillimanite and dumortierite are not present. Perthite of these pegmatites is pale buff to white, never pink or orange. Black tourmaline is most common in cross-cutting dikes and is commonly distributed in near-contact zones as prisms elongated perpendicular to the contact.

Edgecomb Gneiss

The Edgecomb Gneiss, mapped in the Wiscasset quadrangle to the north by Hatheway (1969), extends 3.5 km into the Westport quadrangle. Here it is a concordant sill approximately 200 m in its width of outcrop. Lithically it is a dark gray medium- to coarse-grained conspicuously porphyroblastic gneiss composed of plagioclase porphyroblasts, and a groundmass consisting of plagioclase, biotite, hornblende, and minor quartz. Prior to metamorphism the Edgecomb Gneiss was probably a diorite. It was intruded along the Sebascodegan-Cape Elizabeth contact.

Lincoln Sill

The Lincoln Sill is present in two separated outcrop belts, the northern one extending from the Liberty area south to the vicinity of Newcastle, and the southern one occupying a belt around the south end of the Boothbay antiform. In this southern belt, it crops out most extensively in the Boothbay Harbor quadrangle to the south and is exposed in the Westport quadrangle only where it terminates at the south end of Knickerbocker Lakes (SE ninth). It is composed of medium- to coarse-grained conspicuously porphyroblastic, dark gray biotite-hornblende-K-feldspar gneiss. The porphyroblasts are up to 2 cm in length, oriented parallel to foliation, and are composed of medium-gray, conspicuously zoned orthoclase feldspar. Prior to metamorphism this gneiss was a variety of basic syenite, similar to shonkinite. In this southern outcrop belt the Lincoln Sill intrudes the Sebascodegan Formation close to its contact with the Cape Elizabeth Formation.

Oak Island Gneiss

The Oak Island Gneiss crops out in a narrow belt extending from the Maine Central Railroad tracks near the Wiscasset Airport southward into the Boothbay Harbor quadrangle. Total length of exposure in the Westport quadrangle is approximately ten kilometers, and width varies between 250 and 650 m. The outcrop belt is offset 1.2 km by apparent left-lateral movement along the Back River fault. The dominant lithology of this unit is a light pink to light gray moderately foliated granite gneiss cut by relatively abundant irregular stringers of pink pegmatite. Associated with this, particularly on Oak Island and the western half of Chewonki Neck (WC ninth) are concordant layers 6 cm to several meters thick of medium dark gray dioritic gneiss. Concordant stringers of strongly migmatized metapelite of the host Cape Elizabeth Formation are common within the granitic gneiss, and foliation of the granite gneiss is commonly defined by discontinuous thin clots of muscovite and sillimanite.

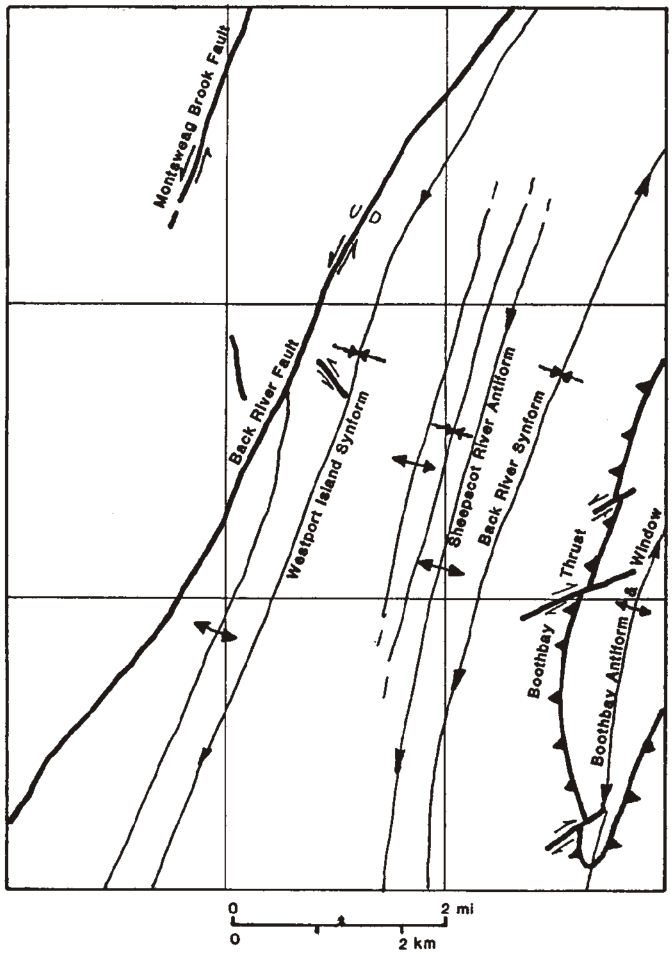


Figure 3. Names of major folds and faults in the Westport quadrangle. Arrows along the fold axial traces indicate directions of plunges.

STRUCTURE

The major structures of the Westport quadrangle include the Back River fault, the Boothbay folded thrust, and several inferred and mapped folds with gentle southerly plunges. Several minor high-angle faults trend ENE and NW. Minor folds are frequently observed in outcrop and deform bedding, schistosity, gneissic foliation, and migmatite stringers. The names of the principal are given in Figure 3.

Folds

Major folds in the area (Fig. 3) have been classified as F_2 folds in the overall Casco Bay fold hierarchy (Hussey, 1988), based on the north-northeasterly trend of mapped fold axes. These folds deform schistosity (possibly related to earlier recumbent folding, F_1), and gneissic foliation. The major mapped folds define a pattern suggesting a major anticlinorial zone to the east and synclinorial to the west. The folds classified as F_2 parasitic folds (axial planes and axes shown symbolically on Plate I) deform schistosity, gneissic foliation, and thin migmatite stringers. These minor folds have upright to steeply dipping axial planes, gentle plunges (mostly southerly), relatively tight limbs, and chevron-style to rounded arch bends. The folds classified as F_3 are similar to F_2 folds in that they deform schistosity, gneissic foliation and migmatite stringers. They are distinguished in the field on the basis of a chevron-style of folding, axes that are steeply inclined, and plunging in a direction at a large angle to the strike of the axial planes, and axial planes striking 30 to 80 degrees to the general N20E structural trend. Furthermore, F_3 folds are restricted to a 1 to 2 km-wide zone on the southeast side of the Back River fault. They are most numerous in the vicinity of Davis Island and Clough Point (NE ninth, Plate I). A plot of the poles to axial planes of F_2 and F_3 folds given in Figure 4 fails to show as significant a difference between these trends. There is a slight suggestion of two separate fold axial plane sets, one averaging about N10E in strike and vertical; the other averaging approximately N15W with a dip to the southwest at approximately 80 degrees. Plot of fold axes (Fig. 5) indicates a general plunge trend to the south- southwest with angles of plunge concentrated between 35 and 5 degrees. Mineral and mullion lineations (Fig. 6) are quite consistent with the fold axes mapped in the field as F_2. Very few lineations observed are steep, most having a direction of plunge to the south-southwest at an average plunge angle of 5 to 20 degrees. This is in broad agreement with the average plunge of parasitic F_2 fold hinges.

In general, bedding, schistosity, and gneissic foliation are parallel to each other (Figs. 7, 8, 9). In almost all instances no angular difference between bedding and schistosity is observed in outcrop to suggest that the latter structure might be parallel to the axial planes of F_2 folds. Schistosity apparently predates development of F_2 structures, and may be related to development of F_1 recumbent structures (not apparent in this quadrangle).

Gneissic foliation in the metamorphic rocks is mainly produced by the parallelism of thin segregation or injection stringers of quartzo-feldspathic material during migmatization and pegmatite genesis. In the granitic plutons and orthogneisses, foliation is the result of parallelism of biotite flakes and thin tabular schlieren. Within the Lincoln Sill, as observed in the adjacent quadrangles, foliation is essentially a crude schistosity. Gneissic foliation appears to relate to high-grade metamorphism during which time migmatization also occurred. This most likely took place just before and during the development of F_2 folds.

Faults

The following three types of faults are present in the Westport quadrangle:

(1) High-angle faults with moderate (up to 1.2 km) apparent left-lateral slip. The principal fault of this type, and the largest fault in the quadrangle is the **Back River fault** extending through the map area from Hockomock Bay (SW ninth) northeastward through Montsweag Bay and Back River (between

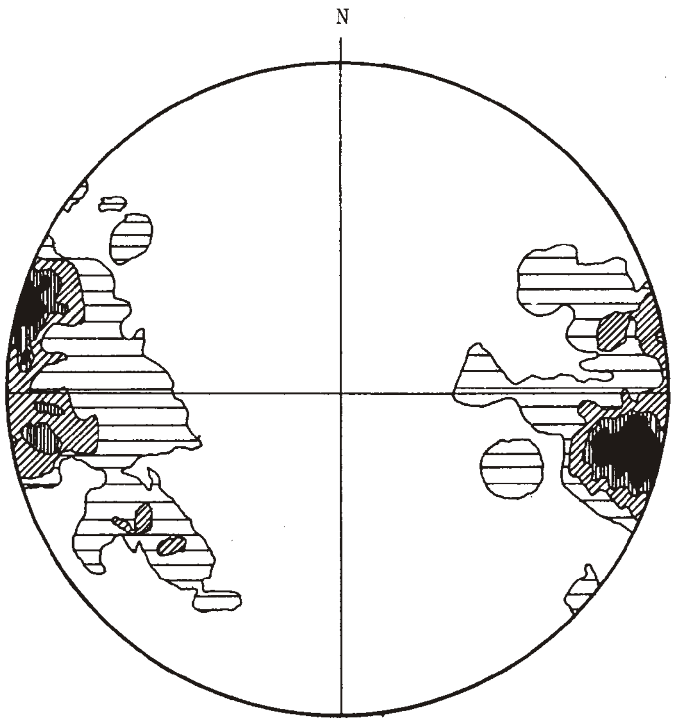
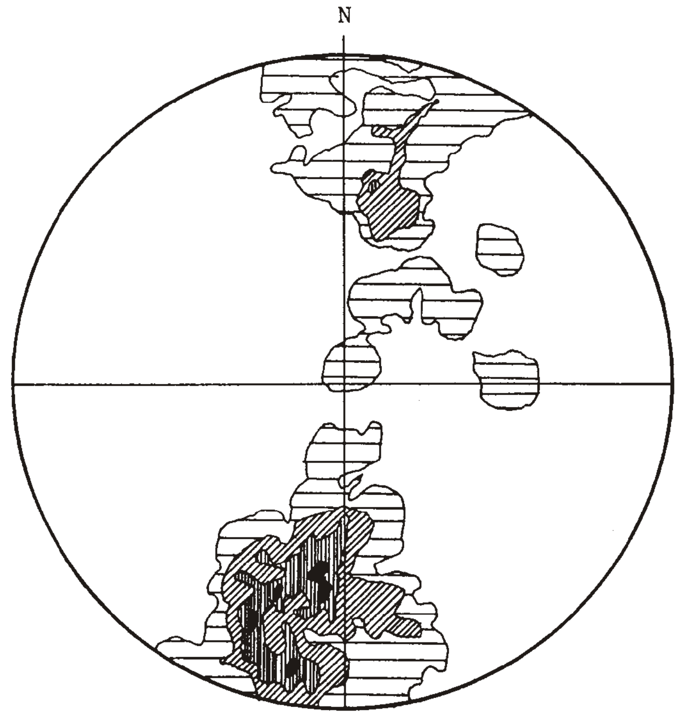


Figure 4. 100 poles to axial planes of F_2 and F_3 folds, Westport quadrangle. Lower hemisphere plot. Density contours of 2 - 4 - 7 - 9+ points per 1% area.



Figrue 5. 100 axes of F_2 and F_3 folds, Westport quadrangle. Lower hemisphere plot. Contour densities of 2 - 4 - 6 - 8+ points per 1% area.

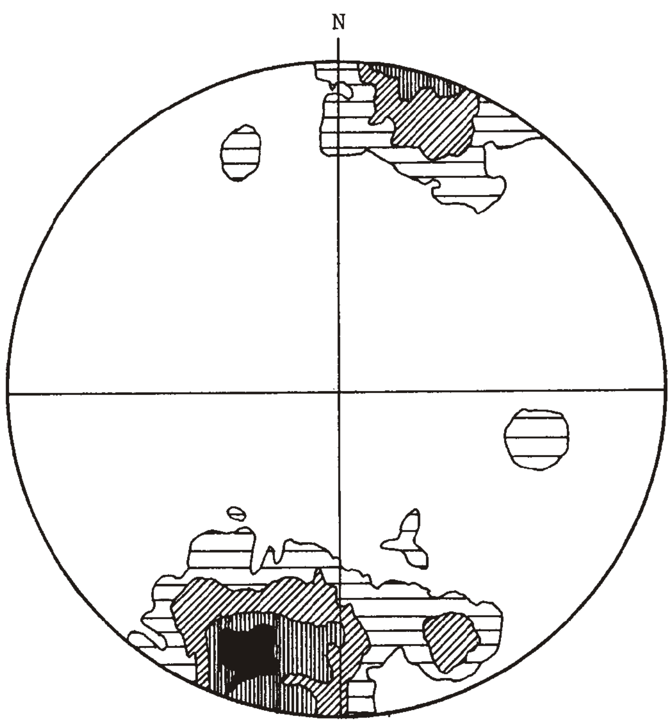


Figure 6. 125 mullion and mineral alignment lineations, Westport quadrangle. Density contour 1 - 4 - 8 - 12+ points per 1% area.

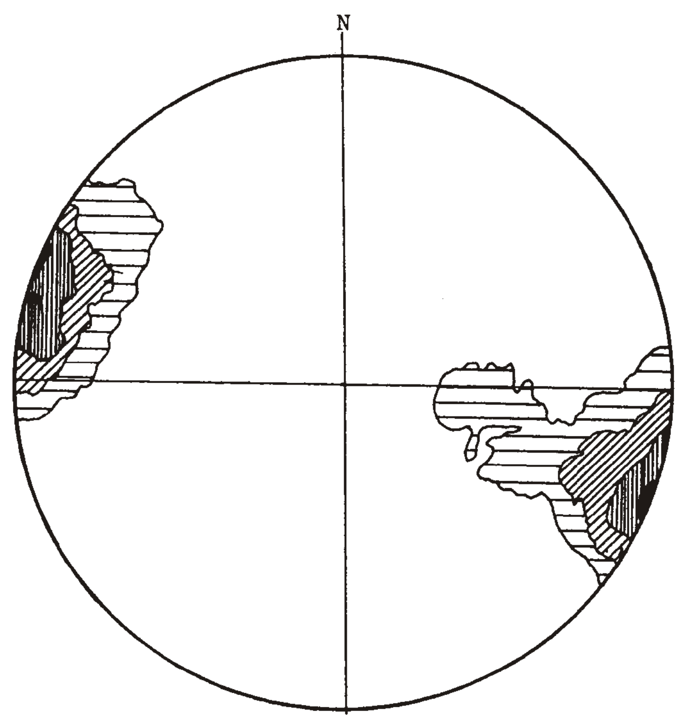


Figure 7. 250 poles to bedding, Westport quadrangle. Lower Hemisphere plot. Density contours of 2 - 6 - 10 - 16+ points per 1% area.

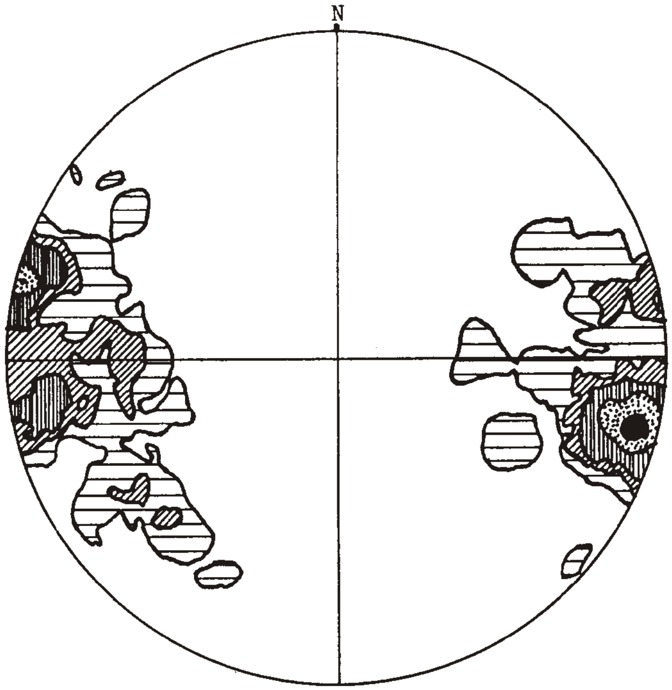


Figure 8. 100 poles to schistosity, Westport quadrangle. Lower hemisphere plot. Density contours of 2 - 4 - 6 - 8 - 12+ points per 1% area.

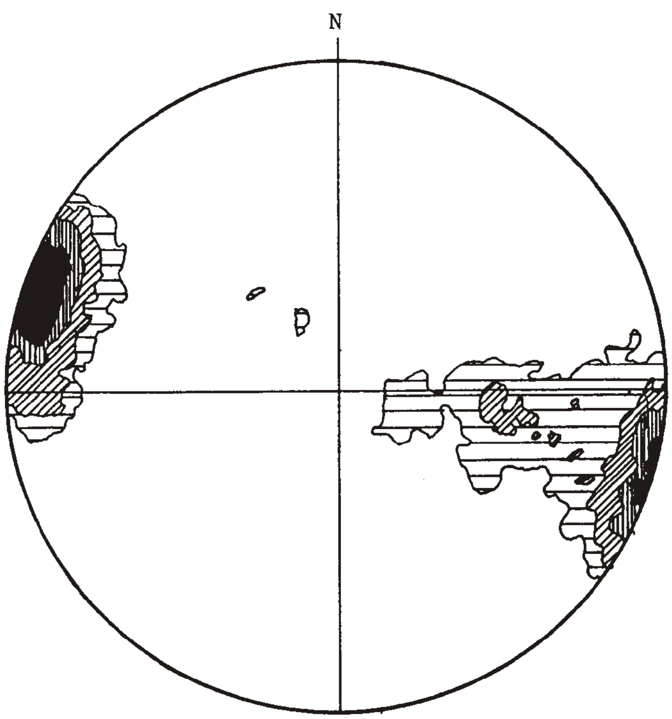


Figure 9. 250 poles to gneissic foliation, Westport quadrangle. Lower hemisphere plot. Density contours of 2 - 4 - 8 - 12+ points per 1% area.

Wiscasset and Westport) to Wiscasset and beyond, north of the map area. Hatheway (1969) mapped the same fault in the Wiscasset quadrangle. The evidence for the fault is as follows:

(a) Offset of the OZcea unit between Hockomock Bay and Montsweag Bay by approximately 1.2 km. The sense of offset is apparent left-lateral.

(b) Offset of the Oak Island Granite Gneiss in the same area, by the same amount.

(c) Termination of the granite pluton at Bailey Point (C ninth).

(d) Strong retrograding of biotite to chlorite in the Cape Elizabeth Formation in the area between Bailey Point and Cushman Cove (NC ninth). The variation in retrograding is particularly well illustrated in the shoreline exposures in the small cove to the west of Berry Island (NC ninth). In those exposures closest to the trace of the Back Cove fault retrograding is essentially complete, but with distance westward from the fault the degree of retrograding decreases. Along the westernmost edge of that cove the biotite is essentially unaltered.

(e) Offset of the Edgecomb Gneiss in the vicinity of Wiscasset to the north of the map area. Hatheway (1969) mapped about the same apparent left-lateral offset as noted above for the offset of the OZcea and Oak Island Granite Gneiss units.

The close association of F_3 parasitic folds to the Back River fault as noted above suggests that the development of these is related to movement on the fault.

Another fault of similar geometry to this is inferred to occupy the upper, linear-trending valley of Montsweag Brook between U. S. Route 1 and the north edge of the map (NW ninth). Evidence for this fault is the apparent offset of the OZcea unit along Montsweag Brook.

(2) Short high-angle oblique faults . These unnamed faults trend either ENE or NW, and involve minor movement (generally less than 150 m). They can often be traced as topographic lineaments but for distances usually less than 1 km before their topographic expression dies out.

(3) Folded thrust fault. The contact between the Sebascodegan and Cross River Formations is inferred to be a major folded thrust, named the **Boothbay thrust** (Hussey, 1988). This is a major terrane boundary against which the Cross River Formation, a correlative of either the Benner Hill sequence or the Penobscot-Cookson sequence, on the lower plate is juxtaposed against the Casco Bay sequence. The former sequence is exposed in a window in the core of the doubly plunging Boothbay antiform.

METAMORPHISM

Detailed studies of the metamorphism of the Westport quadrangle have not yet been made. Based on field examination and the examination of a few thin sections from the area, the pelitic rocks have been metamorphosed to sillimanite grade, and in places at least to sillimanite-K-spar grade. The Cape Elizabeth and Cross River Formations are extensively migmatized throughout most of the area, and in many areas the original metasedimentary association of quartzo-feldspathic beds (metawackes) and the metapelites is lost. The Sebascodegan Formation, on the other hand, is injected by pegmatites of thickness varying from a cm or so to 50 m, but the original metasedimentary character, including relict bedding, is generally preserved.

Metapelitic parts of the Cape Elizabeth Formation are composed of biotite, muscovite, sillimanite in the form of fibrolite, quartz, garnet (not generally abundant), and locally cordierite. Cordierite most commonly occurs in biotitic reaction zones against pegmatite stringers. Zircon and/or monazite are common accessories as evidenced by the abundance of pleochroic halos in biotite and cordierite. Pegmatite stringers that intrude the pelitic portions of the formation commonly have pink K-feldspar and relatively abundant sillimanite. Those pegmatites which, in addition, have black tourmaline also tend to have accessory amounts of blue dumortierite. Pegmatites that intrude the metawackes generally have pale buff to white K-feldspar and do not have sillimanite or dumortierite. These relations, where the mineralogy of the pegmatites closely correlates with the composition of the host rocks, suggests very local derivation from, and assimilation of the country rock.

AGE OF DEFORMATION, INTRUSION, METAMORPHISM

Although no radiometric ages have yet been made of rocks within the limits of the Westport quadrangle, age determinations from adjacent areas just south and northeast suggest that the major tectonic event in this area was the Early Devonian Acadian orogeny. West et al. (1988a) report a Ar/Ar age of 350   4 Ma for amphibolite in the Boothbay Harbor quadrangle (just south of the Westport quadrangle). This is interpreted to be the age of cooling following metamorphism of the rock during the Acadian orogeny. The Waldoboro pluton, 25 km northeast of the Westport quadrangle, has yielded a Rb-Sr whole rock age of 367   4 Ma (Knight and Gaudette, 1987) consistent with intrusion during the Acadian orogeny. Rb/Sr whole rock ages are given by Brookins and Hussey (1978) for the Cape Elizabeth and Cushing Formations (485   30Ma, and 481   40Ma, respectively) in the Portland-Orrs Island area. Gaudette et al. (1984) reports an Rb/Sr whole rock age for the Mt. Ararat Formation in the Richmond area, southern Maine, of 494   25 Ma. In light of the Ar/Ar ages indicating the latest heating/metamorphism event was associated with the Acadian orogeny, the significance of the Rb/Sr ages is equivocal. On the basis that the Acadian metamorphism would likely have reset the Rb/Sr systems at least partially, these ages indicate that the time of sedimentation and volcanism to form these rock units must have been some time earlier than the given age, and may have been as early as Late Proterozoic.

No ages suggestive of Alleghenian deformation or thermal activity have yet been reported from this belt, although whole-rock Rb-Sr and zircon ages of 325-328 Ma have been reported for the Sebago granite intrusive into the central Maine sequence west of the Norumbega fault (Aleinikoff et al., 1985), and Ar/Ar ages in the range 278-272 Ma for amphibolites in the Brunswick-Falmouth area west of the Flying Point fault have been reported by West et al. (1988b).

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INTRUSIVE ROCKS

Dg	Massive to foliated biotite muscovite granite locally with garnet.
Dgd	Medium gray, fine-grained, weakly foliated biotite granodiorite
Dgn	**Oak Island Gneiss**: Foliated biotite muscovite granite orthogneiss.
Deg	**Edgecomb Gneiss**: Coarse porphyroblastic, medium gray, quartz-poor plagioclase-microcline-biotite-hornblende orthogneiss.
Dls	**Lincoln Sill**: Dark gray, biotite-hornblende-microcline blastoporphyritic gneiss with relict phenocrysts of K-feldspar.

(Pegmatite stringers, sills, and dikes have not been mapped separately, but are present in all rocks throughout the quadrangle.)

STRATIFIED ROCKS

CASCO BAY BLOCK

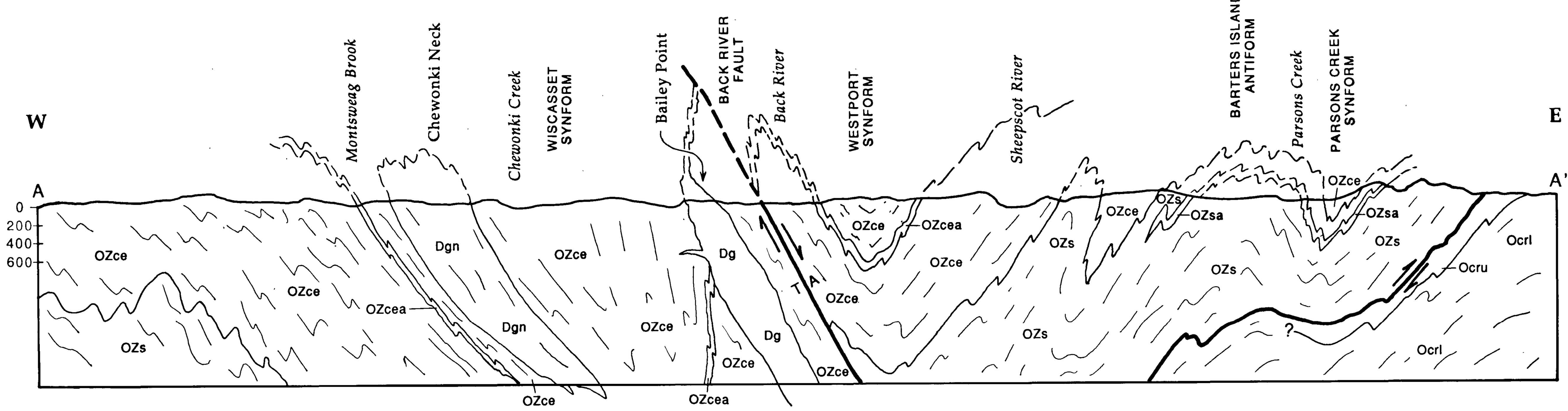
OZce	**Cape Elizabeth Formation**: Medium-grained, quartz-plagioclase-biotite schist and gneiss, locally with garnet, muscovite, and sillimanite. With the exception of minor areas, is moderately to strongly migmatized and pegmatite injected.
OZcea	Amphibolite and red and green calc-silicate gneiss with garnet, diopside, and hornblende, locally coarse-grained and skarn-like. Interbedded with OZce lithology above.
OZs	**Sebascodegan Formation**: Dark gray, quartz-plagioclase-biotite-hornblende granofels with or without interbeds of greenish gray calc-silicate granofels; minor rusty-weathering sulfidic quartz-plagioclase-biotite-muscovite schist.
OZsp	Pelitic lenses essentially identical to OZce lithology.
OZsa	Salt-and-pepper-textured amphibolite.

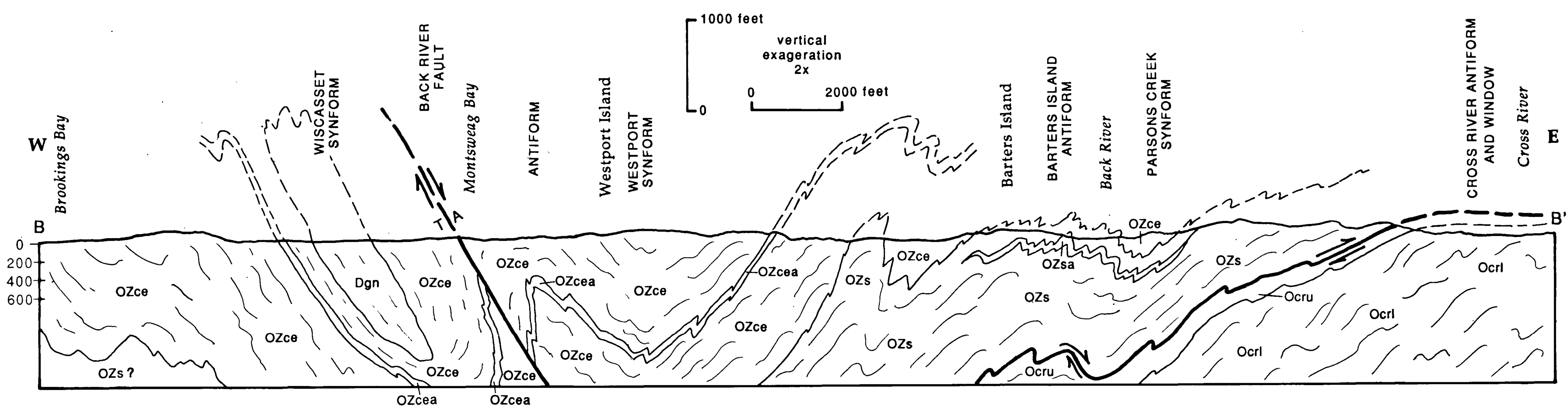
BENNER HILL / PENOBSCOT BLOCK

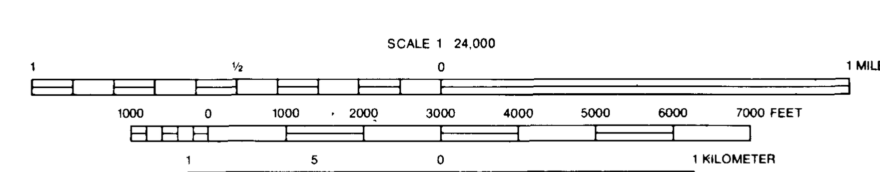
Ocr	**Cross River Formation**
Ocru	Upper member: Medium gray, salt-and-pepper-textured quartz-plagioclase-biotite-garnet granofels, with interbeds and zones of irregularly textured biotite-hornblende-garnet gneiss and amphibolite.
Ocrl	Lower member: Generally very rusty, thoroughly migmitized quartz-plagioclase-biotite-muscovite gneiss; local zones of very rusty weathering muscovite sillimanite-graphite-biotite gneiss. Restitic rafts of non-rusty quartz-plagioclase-biotite granofels and rarely amphibolite.

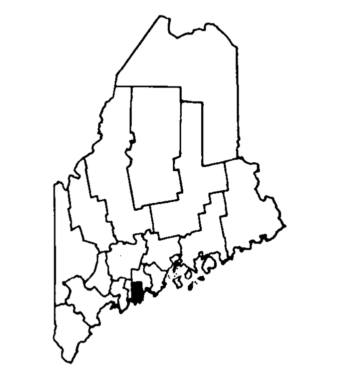
STRUCTURE SYMBOLS

- Bedding (inclined and vertical)
- Foliation, including schistosity (inclined and vertical)
- Lineation (combined with bedding or foliation)
  - mu: mullions
  - m: elongate mineral alignment
  - cr: crenulation of schistosity
  - ms: elongate mineral streaks
  - q: quartz veins
- Foliation of orthogneiss and foliated granite (inclined and vertical)
- Axial plane of minor folds (inclined and vertical)
  - F1 folds
  - F2 folds
  - F3 folds
- Direction and angle of plunge of axis of minor folds (combined with axial plane symbol or rotational sense symbol for minor folds)
- Sinistral rotation sense of minor folds
- Dextral rotation sense of minor folds
- Synformal minor folds
- Antiformal minor folds
- Stratigraphic or intrusive contact
- High angle oblique-slip fault on map
  - U - upthrown side
  - D - downthrown side
- High angle oblique-slip fault on cross-section
  - A - movement away from observer
  - T - movement toward observer
- Folded-thrust fault. Teeth on upper plate
- a - - - a - Inferred position of OZcea based on structural interpretation









Quadrangle Location

RECONNAISSANCE

BEDROCK GEOLOGY OF THE WESTPORT QUADRANGLE, MAINE

BY

ARTHUR M. HUSSEY II

1992

Maine Geological Survey
DEPARTMENT OF CONSERVATION
Augusta, Maine
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