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# ***Bedrock Geology of the North Windham 7 1/2' Quadrangle, Maine***

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## **INTRODUCTION**

The area of the North Windham quadrangle (see bedrock map and Figure 1) is underlain by Silurian-age metasediments of the Central Maine Sequence and by the Late Carboniferous-Early Permian-age muscovite-biotite granite and pegmatite of the Sebago batholith. The metasediments are assigned to the Hutchins Corner, Windham, and Rindgemere Formations and occupy the re-entrant between the main body of the Sebago batholith and the Westbrook tongue of the batholith (Osberg et al., 1985).

## **METASEDIMENTARY ROCKS**

### ***Hutchins Corner Formation***

The Hutchins Corner Formation, originally referred to as the Vassalboro Formation (Hussey, 1985; see Osberg, 1988, for reason for name change), consists of thin- to medium-bedded purplish gray quartz-plagioclase-biotite granofels with thin interbeds of greenish gray calc-silicate granofels with hornblende and sparing diopside. Grossularite occurs occasionally in zoned calcareous concretions within the biotitic granofels. Common within this assemblage are sporadic zones up to 2 meters thick of rusty-weathering sulfidic biotite-muscovite quartz schist, but aluminous pelitic zones are rare. The formation is not migmatized.

### ***Windham Formation***

The Windham Formation consists of metapelite and a thin unit of metamorphosed calc-silicate and ribbon metalimestone. The bulk of the formation is thin-bedded to massive biotite-muscovite-quartz schist with locally abundant sillimanite, staurolite, kyanite, and garnet, depending on grade of metamorphism. Thin interbeds of calc-silicate granofels are common. Less common

are thin to medium interbeds of feldspathic and slightly micaceous quartzite. Graded beds are rare. The calc-silicate member consists of moderately dark brownish gray quartz-biotite-calcite schist, and gray, buff-weathering ribbony-bedded fine-grained metalimestone (rarely coarsely crystallized enough to warrant the name "marble"). The ribbon lime member crops out in several narrow belts repeated by folding, and is the most significant unit for determining the structure of the metasediments. Rusty-weathering zones up to several tens of meters wide are common within the formation, particularly close to the ribbon lime member, but outcrops are not common enough for these zones to be separately mapped as members of the formation. None of the rocks of the Windham Formation are significantly migmatized.

### ***Rindgemere Formation***

Metapelite rocks along the west edge of the outcrop belt of the metasediments are tentatively assigned to the Rindgemere Formation. These rocks trend south into similar rocks in the Standish 7 1/2' quadrangle to the southwest which were correlated with the Rindgemere Formation by Hussey (1996).

The rocks of the Rindgemere Formation consist of rusty and non-rusty gray to silvery muscovite-biotite-quartz schist with staurolite, sillimanite, and garnet at appropriate metamorphic grade. Neither kyanite nor andalusite have been observed within the schist, although blue blades of kyanite occur abundantly in vein quartz in these rocks to the southwest in the Standish quadrangle. Commonly associated with the metapelite are variably thick interbeds and thin-bedded intervals of quartz-plagioclase-biotite granofels. This granofels is much more common in this band of pelites than in the pelites assigned to the Windham Formation. The Rindgemere Formation in the North Windham quadrangle is not migmatized.

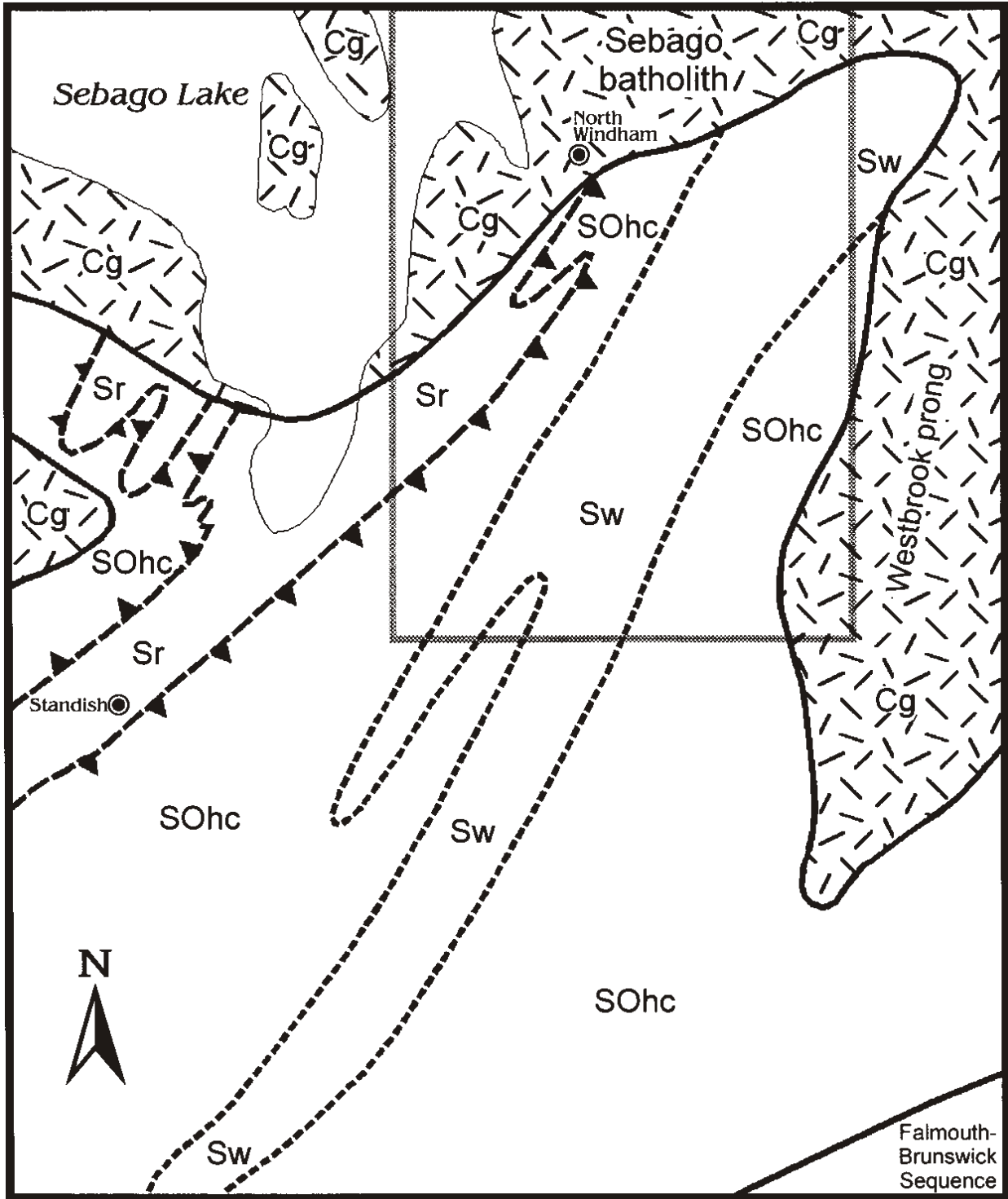


Figure 1. Simplified bedrock sketch map for the North Windham area. Gray rectangle shows approximate location of the North Windham 7.5' quadrangle. Letter symbols are as follows: SOhc = Hutchins Corner Formation, Sw = Windham Formation, Cg = granite and related igneous rocks (modified from Hussey, 1985).

## INTRUSIVE ROCKS

Intrusive rocks shown on the North Windham map sheet include granitoid rocks of the Sebago batholith and subordinate lenses within the metasediments, and basalt dikes of probable Mesozoic age. Outcrops of the Sebago batholith granite in the northern and western parts of the map area are sparse due to the extensive glacial till cover, but the contact can be mapped with reasonable certainty on the basis of the composition of boulders in the till. North and west of the contact as shown, the boulders are almost entirely of medium-grained, relatively even textured light gray biotite-muscovite granite. In the area of the southeastern corner of the map sheet, outcrops are more numerous. This part of the pluton consists of more heterogeneous granitoid rocks including two-mica granite, fine-grained medium gray slightly foliated biotite granodiorite, quartz diorite, and granitic pegmatite. Small lenticular bodies on the southeastern edge of the map sheet consist of similar fine-grained slightly foliated granite and granodiorite. Numerous individual occurrences of pegmatite with biotite, muscovite, black tourmaline (schorl), and garnet occur within the metasediments. All of the separate small granitoid occurrences are probably related in genesis and age to the Sebago batholith. Tomascak et al. (1996) report a U/Pb monazite age of 293 ± 2 Ma for granite of the Sebago batholith. Aleinikoff et al. (1985) report U/Pb monazite ages of 272 Ma for a pink phase and 282 Ma ages for a gray phase of the batholith. The U/Pb age on zircon from the Sebago batholith of 325 ± 3 Ma reported by Aleinikoff et al. (1985) would appear to be too old, and Tomascak et al. (1996) suggest that the zircons may have experienced complicated lead loss by metamictization.

Basalt dikes and sills occur relatively infrequently in the North Windham 7 1/2' quadrangle. Most are dark, aphanitic, non-porphyritic bodies ranging from 6 inches to 3 feet across. No radiometric ages are available, but they are of probable late Triassic to Jurassic age.

## STRATIGRAPHIC CORRELATIONS

The following correlation of the rocks of the North Windham area with the well-known stratigraphic sequence of the Waterville area is based on lithic similarity:

<u>North Windham area</u>	<u>Waterville area</u>
Rindgemere Formation	Sangerville Formation
Windham Formation	Waterville Formation
Hutchins Corner Formation	Hutchins Corner Formation

Rocks of the Hutchins Corner Formation have been mapped on the east side of the North Windham quadrangle around the Westbrook prong of the Sebago batholith and from there northeastward into the south-central Maine area. Within the North Windham quadrangle, this is the lowest unit of the Central Maine Sequence.

The Windham Formation is interrupted from its continuation with metasedimentary rocks to the northeast by the Sebago batholith (Figure 1). Because of the lack of continuity with the Central Maine Sequence on strike in south-central Maine, the writer (Hussey, 1971) gave this metapelite and metalimestone formation a separate name, correlating it with the Waterville Formation on the basis of lithic similarity. This correlation is confirmed in this study. Consequently the Windham Formation, like the Waterville Formation, is regarded to lie conformably above rocks of the Hutchins Corner Formation.

The writer (Hussey 1971) reported on what was at the time regarded to be a critical locality for topping sense within the Windham and Hutchins Corner sequence. Where U. S. Route 202 crosses over the Pleasant River (near the northeastern corner of the North Windham quadrangle), both the eastern and western contacts of the ribbon metalimestone member with surrounding metapelite of the Windham Formation are exposed. Within the metapelites adjacent to these contacts (1 meter on the west and 1.5 meters on the east) are slightly more quartzose beds 3 to 5 cm in thickness which appeared to be crudely graded, with tops to the southeast at both contacts. The consequence of this topping sense is to place the Hutchins Corner Formation above the Windham Formation, which was in agreement with the stratigraphic order reported by Osberg (1968) for the correlatives of these formations in the Waterville area at the time. This does not agree with the revised interpretation of Osberg (1988) in which he now places the Hutchins Corner Formation below the Waterville Formation, and in which the Sangerville Formation is conformably ABOVE the Waterville Formation. In drawing the correlations to the North Windham area we are confronted with the question of either believing the lithologic similarities or adopting the topping sense suggested by graded beds at the ribbon lime contact. After reexamining these "critical" graded beds, I conclude that grading is too crude as to override the lithic sequence correlation with the formations in the Waterville area. Until new and more reliable topping evidence is found, I opt for the lithic correlations with the Waterville area, and the consequent superposition of the Windham Formation above the Hutchins Corner.

The belt of pelitic rocks on the west side of the map sheet between the Hutchins Corner outcrop belt and the Sebago batholith, here assigned to the Rindgemere Formation, has been mapped into the North Windham area from the Standish and Buxton areas to the southeast. These rocks are correlated by Hussey (1989) with the Sangerville Formation in the south-central Maine area (Osberg, 1988), on the basis of lithic similarity. Formerly, this pelitic belt was mapped as part of the Windham Formation, but this interpretation is now abandoned because:

- 1) These rocks, with the moderate amount of metasandstone, have a closer lithic similarity to the Sangerville Formation than to the Waterville Formation.

- 2) No rocks similar to these pelites are known to exist below the Hutchins Corner Formation in south-central Maine, or its equivalent in the Rangeley area. As a consequence, the con-

tact between the Rindgemere and Hutchins Corner Formations cannot be conformable. The Waterville Formation is believed to be missing, and thus, the contact is inferred to be a fault as discussed below.

## STRUCTURE AND METAMORPHISM

The structure of the North Windham 7 1/2' quadrangle is dominated by slightly overturned northwest-verging  $F_2$  folds. Axial planes trend uniformly north-northeast, and axes vary from horizontal to gently northeast-plunging. No evidence of early recumbent  $F_1$  folds has been observed. No parasitic folds of either generation have been seen in outcrop, and the major fold picture has been determined primarily on across-strike repetition of the ribbon metalimestone member of the Windham Formation. Stereograms of bedding (Figure 2a) and schistosity (Figure 2b) illustrate the general uniformity of structure in the metasediments of the North Windham quadrangle. A crenulation lineation (axes of small chevron-style folds of schistosity) plunges uniformly to the northeast (Figure 2c).

The contact between the Hutchins Corner and Rindgemere Formations is inferred to be a major thrust fault, and may represent the extension of the Messalonskee Lake fault recognized by Osberg (1988) in the south-central Maine area. The thrust-fault interpretation is based on the absence of the Waterville Formation between the Rindgemere and Hutchins Corner Formations. The same relations in the south-central Maine area led Osberg (1988) to recognize the fault originally. The inferred thrust fault must predate the development of  $F_2$  folds because both formations remain juxtaposed across several  $F_2$  folds in the Standish area (Hussey, 1996; Figure 1).

The rocks of the North Windham quadrangle have been metamorphosed to the amphibolite facies (staurolite through sillimanite zones). This is a localized area of Barrovian metamorphism characterized by the appearance of kyanite instead of andalusite in the metamorphic facies series. Details of metamorphism have been described by Thomson and Guidotti (1988), and metamorphic zones mapped by them are shown in Figure 3. They interpret the Barrovian type metamorphism to be a static

post-tectonic Carboniferous event related to the underside of the Sebago batholith. Surrounding areas are characterized by Acadian-age Buchan facies series metamorphism in which the lower pressure aluminosilicate polymorph, andalusite, is present. Barrovian metamorphism is restricted to the reentrant along the south edge of the Sebago batholith, and it is possible that this represents a deeper part of the crust (characterized by higher pressure during latest stages of metamorphism) that has been uparched during the Mesozoic (Figure 3).

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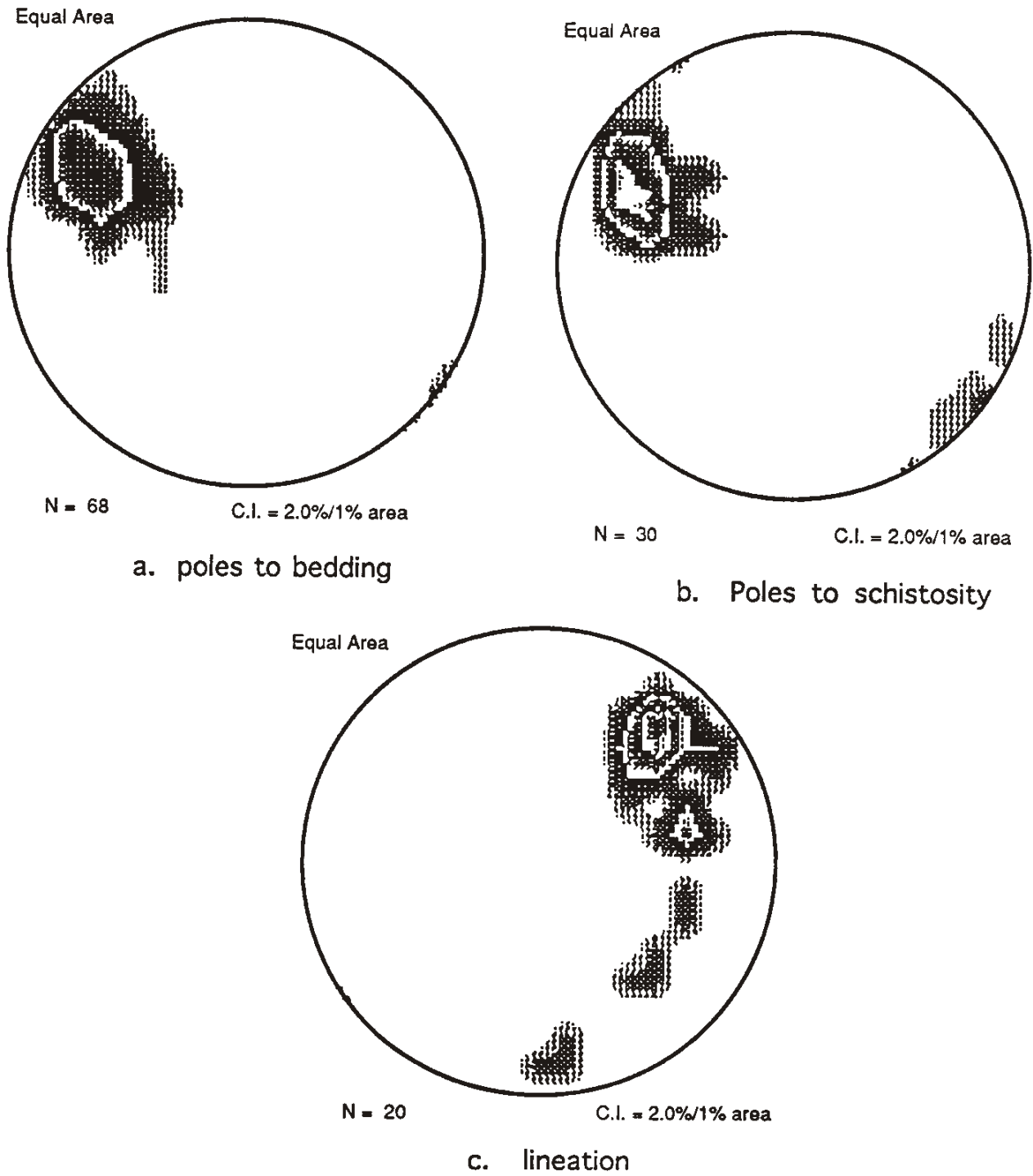


Figure 2. Bedding, schistosity, and lineation orientations, North Windham 7.5' quadrangle, Maine: a. Poles to bedding, b. Poles to schistosity, c. Lineation (mostly axes of minor crenulations).

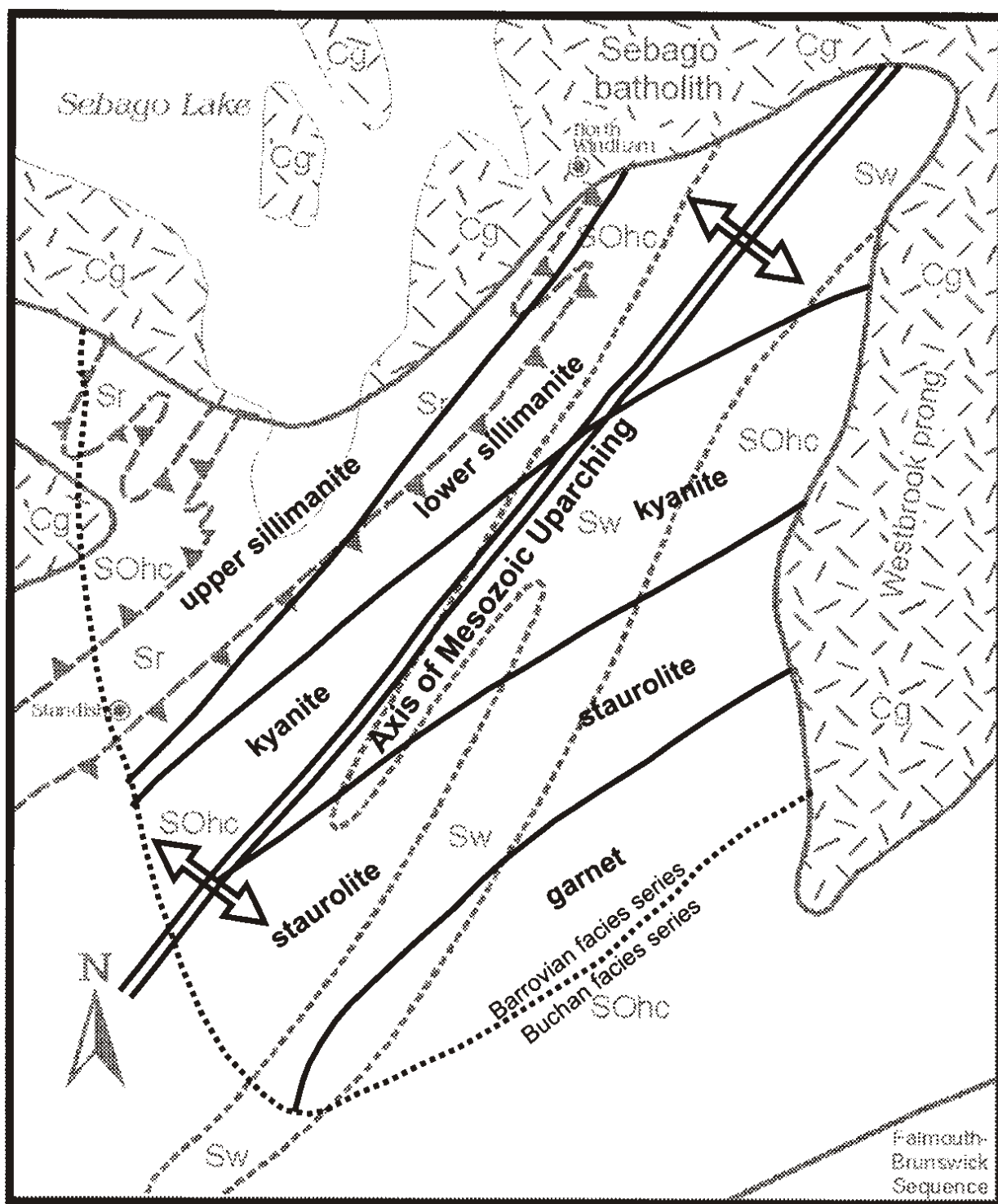
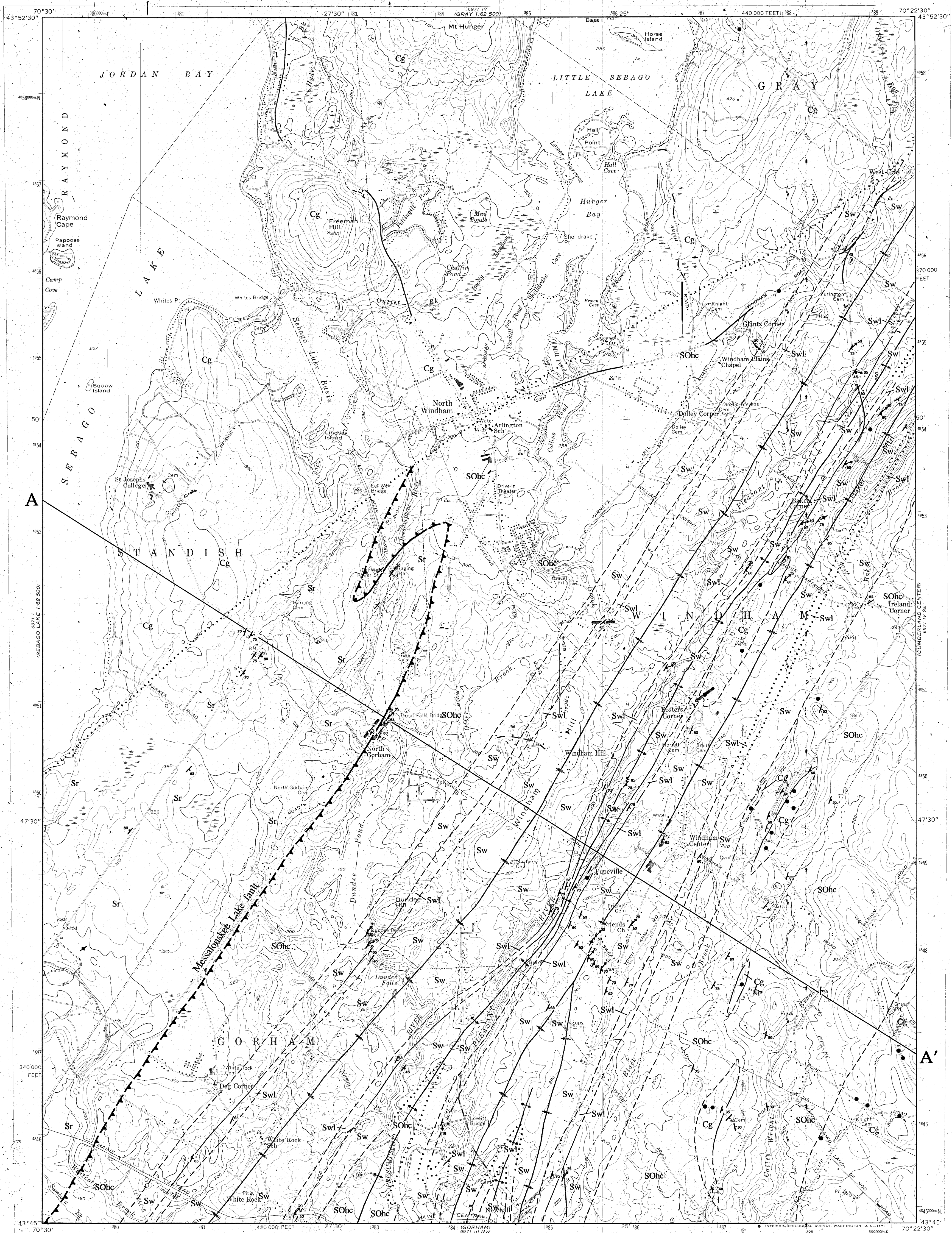
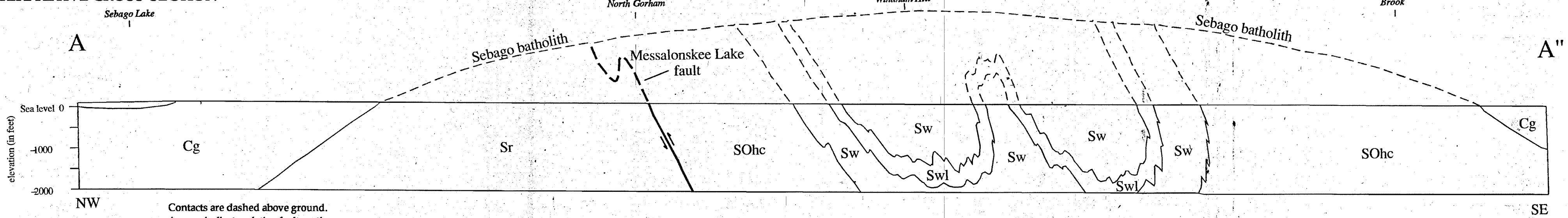


Figure 3. Barrovian metamorphic zones and isograds in the North Windham area as mapped by Thomson and Guidotti (1988).





# INTERPRETIVE CROSS-SECTION



## EXPLANATION

### INTRUSIVE ROCKS

Mesozoic  
Basalt and diabase. Occurs as dikes and sills up to 3 feet (1 meter) thick.

Carboniferous to Permian  
Cg  
Granitoid rocks, including two-mica granite, granodiorite, quartz diorite and granitic pegmatite.

### STRATIFIED ROCKS

Silurian  
Sr  
Rindgemere Formation  
Rusty and non-rusty-weathering muscovite-biotite-quartz schist (locally with sillimanite, staurolite, garnet, and kyanite, depending on metamorphic grade), and quartz-plagioclase-biotite-muscovite granofels and schist.

Sw  
Windham Formation  
Non-rusty- and rusty-weathering biotite-muscovite-quartz schist (with kyanite, staurolite, sillimanite and garnet depending on metamorphic grade), with thin interbeds of calc-silicate granofels and rare quartz-plagioclase-biotite granofels.

Swl  
Metallimestone member  
Impure marble, calc-silicate granofels, and calcite-rich quartz-plagioclase-biotite granofels and schist.

### Late Ordovician or Silurian

SOhc  
Hutchins Corner Formation  
Mostly purplish-gray biotite-quartz-plagioclase granofels with thin interbeds of greenish calc-silicate granofels.

### STRUCTURAL SYMBOLS

- Outcrop with no structural data.
- Bedding, topping sense unknown (inclined, vertical).
- Upright bedding.
- Overturned bedding.
- Schistosity (inclined, vertical). Foliation in granitoid rocks.
- Lination (combined with bedding or schistosity symbol). cr: crenulation; ch: cleavage/bedding intersection.

Axial trace of syncline

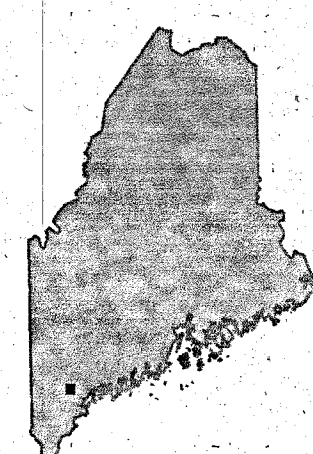
Axial trace of anticline

Thrust fault

Contact

Lines on the map are solid where approximately placed, dashed where inferred, and dotted where uncertain.

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Quadrangle Location

## BEDROCK GEOLOGY OF THE NORTH WINDHAM QUADRANGLE MAINE

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