Maine Geological Survey
DEPARTMENT OF CONSERVATION
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OPEN-FILE NO. 82-30

Title: Bedrock Geology of the Fredericton 2-Degree Quadrangle, Maine

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Date: 1982

Financial Support: Preparation of this report was supported by funds furnished by the Nuclear Regulatory Commission, Grant No. NRC-04-76-291.

This report is preliminary and has not been edited or reviewed for conformity with Maine Geological Survey standards.

Contents: 16 page report and map

BEDROCK GEOLOGY OF THE FREDERICTON 2-DEGREE QUADRANGLE, MAINE

ABSTRACT

The United States portion of the Fredericton 2-degree Quadrangle contains parts of several major lithostratigraphic blocks, including the Central Maine sandstone belt; Aroostook-Matapedia belt; Miramichi Anticlinorium; Fredericton Trough; Calais Cambro-Ordovician belt; and the Coastal Volcanic belt. Each contains a distinctive suite of rocks, and the suites collectively span Cambrian through Early Carboniferous time. Pre-Silurian (Taconian?) folding and faulting have affected some rocks in the Miramichi Anticlinorium, and extensive multiphase Acadian folding and faulting have affected the entire region. Late Acadian and post-Acadian deformation appear to have been dominated by faulting.

Northeast-, north-, and northwest-trending fault systems have been mapped in the region. These were probably initiated during the Acadian Orogeny, but activity along some faults may be continuing today. Offset in the northeast-trending Norumbega Fault System was of a right-lateral strike-slip nature during its early (Acadian) stages of displacement, but changed to a dip-slip nature in post-Acadian movements. North-trending faults are of a dip-slip nature, but northwest-trending faults such as the Oak Bay Fault are probably of a left-lateral strike-slip type.

Neotectonism in the region involves rapid subsidence of the southeastern part of the map area, hinging about the United States extension of the Catamaran Fault. Seismicity along the Oak Bay Fault, and possible offset of glacial deposits along northeast-trending faults suggest that these structures may have been reactivated recently, and may be responsible for the measured subsidence.

INTRODUCTION

The United States portion of the Fredericton 2-degree Quadrangle contains portions of six lithostratigraphic blocks, each of which possesses a distinctive suite of stratified rocks (see Figure 1). The span of time represented by these rocks and the plutons that intrude them is Cambrian through Carboniferous (?), but an even longer geologic history is recorded in the area since even the youngest rocks are cut by faults.

The principal purpose of this report is to present the structural framework of the region, with special emphasis on brittle-fracture systems. Faults are abundant in the map area, and two have received much attention in the past: the northeast-trending Norumbega Fault Zone in the central part of the area, and the northwest-trending Oak Bay Fault at the southeast margin. Several others have been discovered and will be described below. In keeping with the goals of this report, stratigraphy

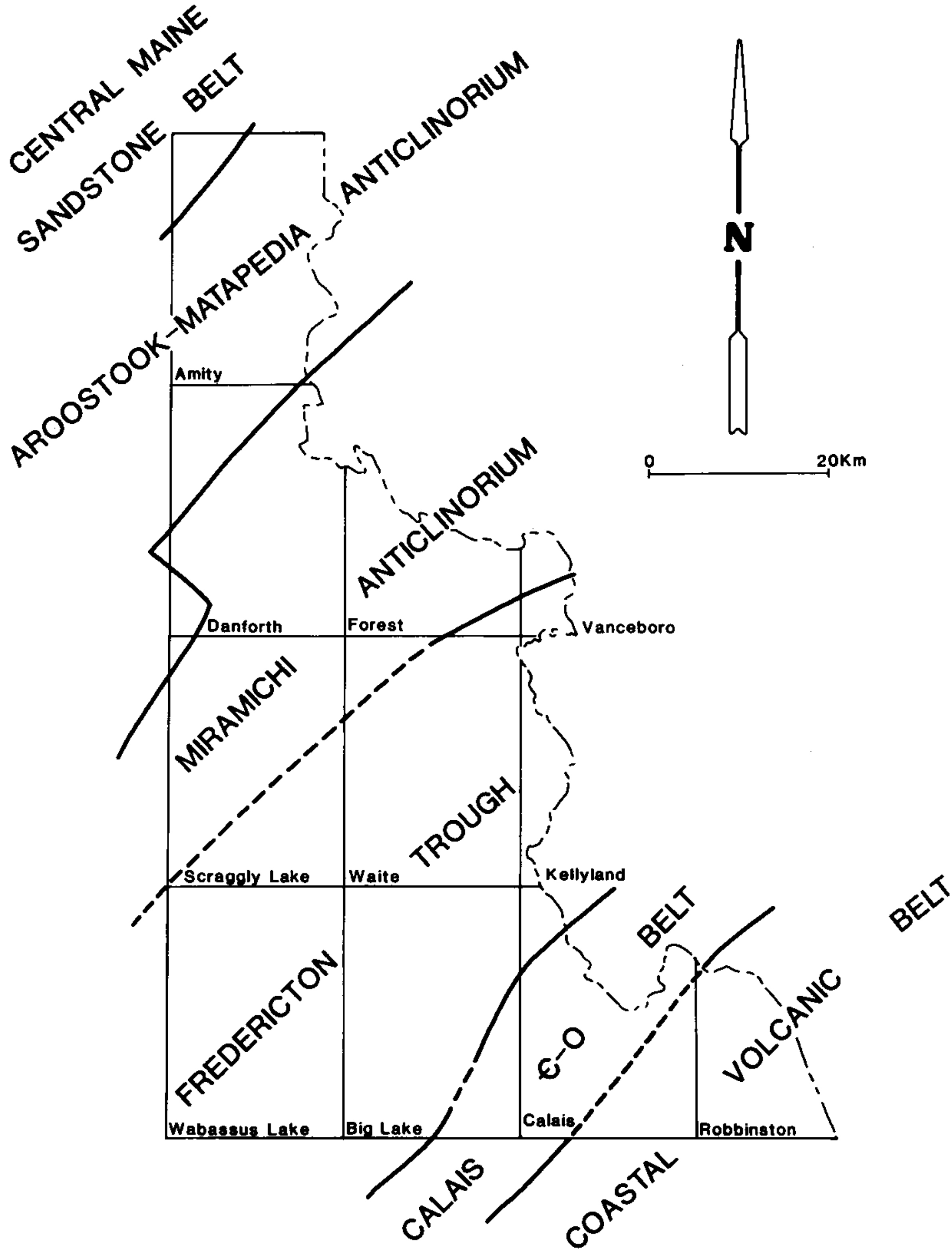

Figure 1

Map showing regional tectonic setting of the study area and locations of 15-minute quadrangles. (Geologic boundaries are dotted where they pass through plutons.)

and plutonism will only be briefly summarized. For more complete treatment, see Ludman (1980; 1981; in preparation), Ruitenberg and Ludman (1978), Abbott (1978), Amos (1963), Westerman (1972), and Ayuso (1979).

Data incorporated in this report are the results of my geologic mapping in eastern Maine since 1974, most of which was carried out at a scale of 1:62,500 for the Maine Geological Survey in the southern and central tiers of quadrangles. Nuclear Regulatory Commission support in 1977 and 1981 permitted reconnaissance mapping (1:250,000) in the northern part of the area. Major advances have been made in understanding the geology of the region since my preliminary report to the NRC several years ago (Ludman, 1977), particularly with regard to the importance of faulting.

PREVIOUS WORK

Most of the United States part of the Fredericton 2-degree Quadrangle was mapped in reconnaissance style by Larrabee and others (1965), but some detailed quadrangle maps had been published prior to my mapping program: Danforth (Larrabee and Spencer, 1963) and Big Lake (Larrabee, 1964a). Preliminary 1:62,500 maps are also available for the Kellyland, Vanceboro, and Wabassus Lake Quadrangles (Larrabee, 1963; 1964b). Results of my previous mapping are described in yearly open-file reports of the Maine Geological Survey, and have been summarized in Ludman (1978a, 1978b, 1981) and Ruitenberg and Ludman (1978). New detailed geologic maps of the Big Lake (Ludman, in review) and Waite (Ludman, in preparation) Quadrangles will be available soon.

Several small-scale and topical studies have also been completed. Abbott (1977, 1978), Amos (1963), Coughlin (1981), Houston (1956), Loiselle and Ayuso (1979), and Westerman (1972; 1981) have focused on aspects of the felsic and mafic plutonism in the region. Stratigraphic and structural details in small areas of the Calais, Robbinston, and Danforth Quadrangles have been reported by Senz (1979) and Mangini (1981); and DeMartinis (in preparation) and Bromble (in preparation) are examining details of thermal metamorphism in the Big Lake Quadrangle.

Faulting has also received special attention. Ludman (1977a) has shown that most boundaries between lithostratigraphic blocks in the map area are faults. Wones and Thompson (1979) evaluated possible post-Pleistocene offset along the Norumbega Fault Zone, and Ludman (1981) discussed the extent, nature, timing, and tectonic significance of the Norumbega Fault Zone in eastern Maine. Seismic activity indicates that the Oak Bay Fault may be active at the present time, and studies of neotectonism in Maine reveal rapid subsidence of the southeastern part of the map area, particularly in the Calais and Robbinston Quadrangles (see Thompson, 1980).

STRATIFIED ROCKS

Each of the six lithostratigraphic blocks shown in Figure 1 represents a package of rocks that is distinctly different from those of its immediate neighbors. Pre-Silurian rocks in the southern 2/3 of the map area form the cores of two "anticlinoria" that separate broad terranes underlain principally by rocks of Silurian, Siluro-Devonian, and Devonian age. In the northwestern part of the Amity 15-minute Quadrangle and throughout much of the adjacent Millinocket 2-degree Quadrangle, faults separate packages of rocks of presumed Silurian age from one another. From north to south, the six lithostratigraphic belts are:

(1) "Central Maine Sandstone Belt": Much of central Maine is underlain by thick sequences of sandstones and wackes, including the Madrid, Vassalboro, and Sangerville formations. Rocks (Ssm_2) continuous with these are inferred to underlie the northwest corner of the Amity Quadrangle, based on extension of contacts mapped in the eastern part of the Millinocket 2-degree Quadrangle.

Three types of sandstone are observed in this belt, and all are characterized by thick (20 cm to greater than 8 m), generally massive beds with very little interbedded argillaceous material. The three include green quartzwackes with a muscovite-chlorite matrix (mapped as part of the Smyrna Mills formation by Pavlides, 1974); gray to buff quartzofeldspathic wacke; pale red-brown weathering, light gray calcareous quartzwacke with large detrital muscovite flakes and variable amounts of pyrite and ferroan carbonate (ankerite, siderite).

Complex structural relationships and the reconnaissance nature of mapping prevent accurate determination of age and stratigraphic correlations. Fossiliferous Silurian rocks on strike to both northeast and southwest suggest that this package of massive sandstones is probably of Silurian and Siluro-Devonian age.

(2) Aroostook-Matapedia Anticlinorium: Pavlides (1974) divided the Aroostook-Matapedia rocks into the highly calcareous Carys Mills formation (SOc) and the less calcareous Smyrna Mills formation (Ssm) in the Houlton area, just north of the map area covered in this report. I have tentatively separated some of the massive Smyrna Mills sandstones as part of the Central Maine Sandstone Belt, but still recognize two mappable units correlative with those of Pavlides in the Amity and Danforth Quadrangles. Thin-bedded, very highly calcareous, dark gray siltstones and fine-grained sandstones are interbedded with calcareous phyllites in several localities that define discrete belts. These are probably correlatives of the Carys Mills formation. Some of these rocks are at the boundary between very calcareous siltstones and very silty argillaceous limestones, but true "ribbon rock" composed of interbedded micrite and slate has been observed at only one locality.

The second map unit consists of very thin-bedded (pinstriped), light gray, fine-grained sandstones and darker gray slate or phyllite, both of which are non-calcareous (Ssm_l). Lenses of highly manganiferous siltstones and phyllite are intercalated with the pinstriped rocks in a few localities. This map unit is probably equivalent to thin-bedded lithologies in the Smyrna Mills formation. Interbedded thin and thick-bedded lithologies in the Danforth Quadrangle shown as Ssmu are tentatively assigned to the Smyrna Mills formation, but may be as old as Cambro-Ordovician.

(3) Miramichi Anticlinorium: A varied suite of sedimentary and volcanic rocks comprises the southwestern extension of the Miramichi Anticlinorium into Maine. The section begins with thick-bedded green and maroon quartzofeldspathic wackes and slates of probable Cambro-Ordovician age (€Os), and passes upward into a thick volcanic sequence that is at least in part of Caradocian (Middle Ordovician) age. The volcanic and volcaniclastic rocks are mostly of rhyolitic and dacitic composition on the west flank of the anticlinorium (Ovf), but basalts and basaltic tuffs dominate to the east (Ovm). Euxinic black shales and sulfidic sandstones lie above the volcanic sequence. By correlation with the Belle Lake Slate of adjacent New Brunswick, these are also of Ordovician age (Obl).

A section of Silurian and Devonian rocks lies unconformably above the Cambrian and Ordovician part of the Miramichi sequence, but complex folding and faulting have thus far prevented elucidation of primary stratigraphic relationships. Coarse boulder through pebble conglomerates of the Daggett Ridge formation (SDd), unnamed limestone conglomerates, and calcareous sandstones and siltstones (Dh) are probably equivalent to the Siluro-Devonian Pocowogamis Conglomerate, and the Devonian Canterbury Limestone and Hartin formation of New Brunswick, as described by Lutes (1979) and Venugopal (1978, 1979).

A unique package of volcanic and sedimentary rocks isolated by faults in the northwestern corner of the Danforth Quadrangle is of unknown age (€Dv). It consists of gray and maroon aquagene tuffs, dark gray cherts, coarse and fine-grained greenstones, coarse volcaniclastic conglomerates, maroon slates, and a black-weathering, highly manganiferous magnetite-bearing rock that appears to be a somewhat mineralized basalt.

(4) Fredericton Trough: The Fredericton Trough consists of two turbidite units that are unfossiliferous, but are considered to be of Silurian and Early Devonian age (see Ludman, in review). The oldest unit, the Digdeguash formation (Sd), is composed of gray to buff non-calcareous grits, graywackes, and dark gray slates. In contrast, the younger Flume Ridge formation (DSf) is generally calcareous. It contains red-brown weathering, light gray calcareous and ankeritic sandstones and siltstones, variably calcareous quartzofeldspathic wackes, and non-calcareous siltstones and phyllites. The bulk of the Flume Ridge formation consists of sandstones that are very similar to those of the Central Maine Sandstone Belt.

(5) Cambro-Ordovician rocks of Calais: A thick section of pre-Silurian rocks that passes through the Calais-Woodland area contains a wide variety of rock types. Collectively, these rocks are mapped as the Cookson formation (€Oc), but in larger scale mapping than that of the accompanying map, the formation has been subdivided into distinctive members, only some of which are shown here: highly carbonaceous shales; quartzite; volcaniclastic grits (€Ocg); thinly interbedded carbonaceous slate and sulfidic metasandstone (€Ocp); variably interbedded turbiditic sandstones and slate (€Os); and massive and pillowed basalts. The Cookson has been badly dismembered by faults of several ages, attitudes, and types of displacement, so that the relative ages of these members are not know. Fossils on Cookson Island, Oak Bay, New Brunswick, yield a Tremadocian age (earliest Ordovician) for a black shale member; some of the other rocks are younger, but many are apparently older and presumably of Cambrian age.

(6) Coastal Volcanic Belt: Silurian and Devonian rocks of the Coastal Volcanic Belt underlie much of the Eastport 2-degree Quadrangle, but some extend northward into the Calais and Robbinston Quadrangles. A distal facies of the volcanic belt is exposed along the St. Croix River southeast of Calais, and consists of the Oak Bay formation (a polymictic lithic conglomerate) and the Waweig formation (fine grained siltstones, sandstones, and sparse tuff beds). Both are of Silurian age, with the Oak Bay passing upward gradually into the Pridoli-aged Waweig.

A proximal facies of the volcanic belt crops out in the southeast corner of the Calais Quadrangle and in the Robbinston Quadrangle. Rocks of the Pridoli/earliest Devonian Hersey formation (SDh; very fine-grained siltstones, basaltic lavas, thin shell-hash beds), and the Early Devonian Eastport formation (De; dominantly vitric tuffs of varied composition) occur as patches isolated by extensive swaths of plutonic rock. Feldspathic and lithic tuffs exposed on Mt. Tom at the southeastern corner of the Calais Quadrangle (SDv) do not resemble any of the Silurian or Devonian units in the Eastport Quadrangle (see Gates, 1975), and are mapped separately.

Basaltic flows and basaltic tuffs in the southwest corner of the Calais Quadrangle (ODv) are of uncertain affinity. They are similar to both the pillow basalt member of the Cookson formation and some of the mafic lavas of the Coastal Volcanic Belt, and can not be distinguished by lithology alone.

Post-Acadian rocks: All of the stratified rocks described above were affected by the Early Devonian Acadian Orogeny, and have been folded, faulted, and regionally metamorphosed. Younger, clearly post-Acadian continental molasse occurs in two parts of the Fredericton 2-degree Quadrangle, and includes both sedimentary and volcanic rock.

Red boulder conglomerates, arkosic sandstones, mudstones, and basaltic lava flows of the Late Devonian Perry formation (Dps; Dpv) crop out at the southeast corner of the Robbinston Quadrangle. The formation rests unconformably on the Eastport, Hersey, and Leighton formations of the Coastal Volcanic Belt (see Gates, 1975, p. 10), and contains clasts of these units as well as of the Early Devonian Red Beach Granite.

Unnamed redbeds similar to those of the Perry formation but lacking the volcanic member crop out in small fault slivers in the Waite and Kellyland quadrangles (DMs). In the absence of faunal or radiometric age data, these rocks are assigned a post-Acadian (Late Devonian through Early Carboniferous) age, based on similarities to the Carboniferous basin of central New Brunswick.

DEFORMATION HISTORY

The deformation history recorded in the Fredericton 2-degree Quadrangle is both long and complex. It is also difficult to unravel because of the domainal nature of some of the structural elements. Acadian (Early Devonian) folding and faulting have affected all but the youngest rocks, and there are indications that pre-Acadian events affected Ordovician and Cambro-Ordovician rocks of the Miramichi Anticlinorium. Faunal and radiometric dating clearly indicate an Ordovician age for this early deformation, and a Taconian affinity is inferred. Post-Acadian deformation appears to be restricted to faulting, and although widely developed in the region, is difficult to date precisely.

<u>Taconic Orogeny</u>: The Siluro-Devonian Daggett Ridge formation lies unconformably upon the Cambro-Ordovician section in the Miramichi Anticlinorium, and its clasts are fragments of the older rock units. Many of the pelitic clasts exhibit multiple cleavages (as many as three), whereas the Daggett Ridge matrix contains only one. Mylonite clasts are also found in these conglomerates, indicating that both faulting and folding preceded deposition of the Daggett Ridge formation.

Folded foliations and cleavages, apparently folded lineations, refolded folds, and two inverted folds clearly indicate multiple deformation of the pre-Silurian Miramichi rocks. Recent mapping suggests that <u>two</u> of these deformations may well be Acadian, but an earlier one is most probably Taconian. Further detailed mapping is required to sort out these complex folding and faulting events.

<u>Acadian Orogeny</u>: Rocks of known and presumed Silurian and Siluro-Devonian age also show evidence of a multiple deformation history. Small domains associated with faults have the greatest numbers of cleavages, fold generations, and lineations, but two penetrative deformations are recorded throughout the Fredericton 2-degree sheet and adjacent parts of the Millinocket 2-degree Quadrangle.

In the Miramichi Anticlinorium and Matapedia section, these events appear to have been episodes of tight to isoclinal upright folding, both with north to north-northeast trending hinge surfaces. In the

Fredericton Trough and Calais Cambro-Ordovician belt, early upright isoclinal folding was followed by recumbent folding and southeast-over-northwest thrust faulting. The thick volcanic section exposed to the south in the Eastport 2-degree Quadrangle has experienced less intense deformation, perhaps because of the overall competence of the rocks.

Plutonism followed the second folding event in the north, and probably occurred between the two events in the Calais area. The larger plutons are shown in Figure 2, and named. Mafic bodies (Dm) were emplaced first, and several of these underwent extensive in situ differentiation (see Westerman, 1972; Coughlin, 1981). Felsic plutonism followed, and produced the largest bodies in the area (Dg). Masses of intermediate rock (Dd) include quartz diorite and diorite. These commonly occur at the boundaries between felsic and mafic plutons, and are possibly hybrid rocks formed by mixing of the felsic and mafic magmas.

Late stage Acadian faulting apparently began prior to emplacement of the mafic rocks, but persisted through the post-folding plutonic phase of the Acadian Orogeny. Two of the three major fault zones--the Norumbega and South Princeton-Crawford--apparently had their first displacement during the late stages of the Acadian Orogeny. The Oak Bay Fault, however, may have been younger.

Post-Acadian deformation: Unmetamorphosed post-Acadian sedimentary rocks of the Perry formation are tilted by faulting, and the unnamed molasse of the Waite Quadrangle (DMs) has been tilted to a near-vertical attitude along northeast-trending faults of the Norumbega system. Mississippian rocks on strike in New Brunswick are similarly affected, but Pennsylvania strata are not (Rast, 1981 personal communication), indicating a Carboniferous age for at least part of this deformation. Even younger offset is possible, and will be discussed below. Briefly, most of the post-Acadian deformation appears to be related to reactivation of the northeast trending faults, and displacement along northwest-trending faults.

FAULT SYSTEMS

Faults are common structural features in eastern Maine. Their ages and senses of displacement are difficult to pin down accurately for three reasons: 1) there is a paucity of radiometric and firm faunally-controlled ages of the affected rocks; 2) there is almost no control of the minimum ages of the faults; 3) many of the faults have been reactivated, thus making deciphering of their history extremely difficult. Indeed, it is probably that some of these faults are active today (see below). Faults in the map area can be grouped into three major categories by their strike: northeast-, north-, and northwest-trending. Within a single category, however, several ages and types of offset are recognized.

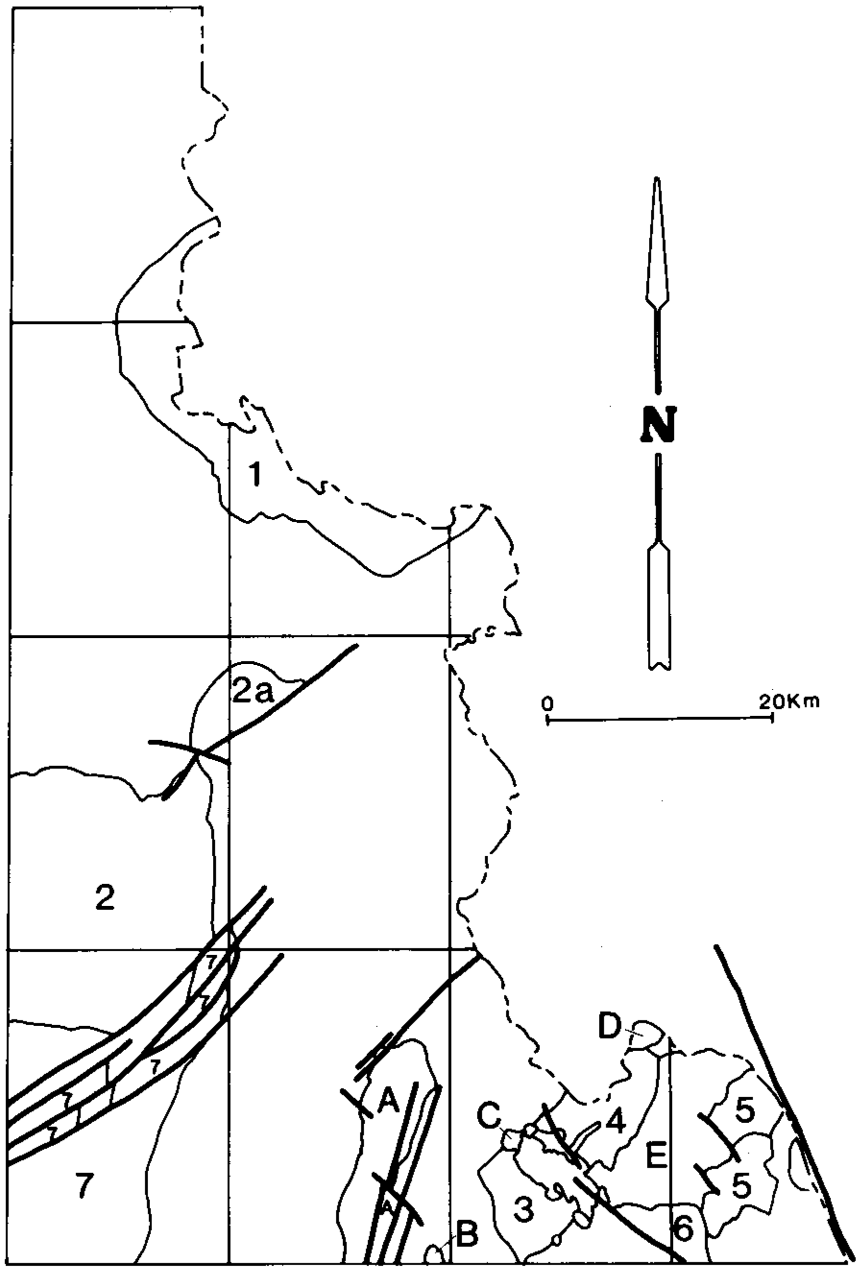

Figure 2

Map showing major plutonic bodies of the Fredericton 2-degree Quadrangle. Felsic plutons: 1-Pokiok Batholith; 2-Bottle Lake Pluton; 2a-Topsfield phase of Bottle Lake pluton; 3-Meddybemps Granite; 4-Baring Granite; 5-Red Beach Granite; 6-Charlotte Granite; 7-Lead Mountain Pluton. Mafic and intermediate plutons: A-Pocomoonshine Gabbro-Diorite; B-Love Lake Quartz Diorite; C-Staples Mountain Gabbro; D-St. Stephen Gabbro; E-Unnamed diorite.

Northeast-trending faults: Northeast-trending faults cut all rocks in the region, and swing to a more northerly attitude between the Pokiok and Bottle Lake plutons in the Danforth Quadrangle. These faults include those assigned by Wones and Thompson (1979) to the Norumbega Fault Zone, as well as several others. These faults have a very poor topographic expression in the heavily glaciated region, but the southwest-trending segments of the St. Croix River appear to be fault-controlled in many instances.

In the Fredericton 2-degree Quadrangle, the Norumbega Fault Zone consists of several faults and shear zones, and is approximately 4-5 miles wide. Mappable faults are identified by zones of cataclasis up to a half mile in width, and by concentrations of asymmetric (dextral) steeply plunging small-scale folds probably caused by drag. Slickensided surfaces parallel to these faults are ubiquitous, and suggest offset that was nearly entirely strike-slip in most instances. Plunges of the slickensides range from 0-25 degrees, and mylonitic foliation, shear surfaces, and hinge surfaces of the minor folds are uniformly nearly vertical. These attitudes and the dextral nature of the minor folds suggest that the faults of the Norumbega zone are nearly vertical right-lateral strike-slip faults, a conclusion supported by Stewart and Wones' (1974) measurement of offset of plutons in the Bangor 2-degree Quadrangle to the southwest.

The Norumbega faults can be traced through the Bottle Lake pluton as shear zones, and offset of pluton contacts shown by Loiselle and Ayuso (1979) further suggest right-lateral offset. Mylonitization within the plutons is not as extensive as in the country rock, and it is possible that much of the displacement preceded emplacement of the granites.

There is abundant evidence that the last movement of the Norumbega faults was of a dip-slip nature. The post-Acadian molasse beds are juxtaposed against mylonitized Flume Ridge sandstones in several places, but show no signs of cataclasis themselves. They have also been tilted to near-vertical positions along the fault traces. The small slivers of DMs were probably preserved by high-angle normal fault reactivation of the Norumbega strike-slip faults, and presumably represent down-dropped remnants of a more extensive Carboniferous molasse blanket that once covered eastern Maine.

Other northeast-trending faults form boundaries between litho-stratigraphic blocks both north and south of the Norumbega Fault Zone. The fault that separates the Fredericton Trough section from that of the Miramichi Anticlinorium may be a part of the Norumbega system, but that which separates the Miramichi from the Matapedia rocks is not. Based on outcrop patterns and magnetic data in the Danforth Quadrangle, this fault is thought to be—at least locally—a thrust along which the Matapedia rocks have moved southeastward over the Miramichi suite. Other, possibly related faults are mapped within the Miramichi suite in the Danforth and Waite Quadrangles. In New Brunswick, two of these faults have been named--the Catamaran-Woodstock Fault at the Matapedia/Miramichi boundary, and the Meductic Fault within the Miramichi section.

Northeast-trending faults dismember the Cookson formation in the Calais and Big Lake Quadrangles, but details of this faulting could not be shown at the scale of the accompanying map. These faults are southeast-over-northwest thrusts, of presumed late Acadian age. Similar faults in the southwest corner of the Calais Quadrangle may represent thrusting of the Coastal Volcanic Belt over the older Cookson rocks.

North-trending faults: The South Princeton-Crawford Fault Zone contains several north- to north-northeast trending high-angle faults in a zone approximately 1.5 miles wide. These faults cut both stratified and plutonic rocks, with a dip-slip displacement suggested by slickensides and structural/stratigraphic reconstruction. In all cases, the east side of the faults appears to have moved downward relative to the west side. Intensely sheared igneous rock and mylonitized metasedimentary rocks define individual faults. These faults have a strong topographic expression: aligned ponds, valleys, and stream valleys in the Big Lake quadrangle follow bands of mylonite and faulted contacts between members of the Cookson formation.

North-trending faults and shear zones have also been mapped at the western part of the Big Lake Quadrangle, but they do not appear to offset stratigraphic contacts. As a result, the sense of movement and tectonic significance of these faults are unknown at this time. Dominantly vertical offset would fit the observed map patterns and would be consistent with displacement in the South Princeton-Crawford fault zone.

Northwest-trending faults: The recognition of abundant northwest-trending faults represents a major advance in our understanding of the geology of the region. Wherever exposures are abundant and rock types are varied, as in the Danforth Quadrangle, formation contacts are commonly found to be offset in a left-lateral manner by distances ranging from a fraction of a mile to a mile. Although mylonites are not developed in these faults, numerous slickensided surfaces and steeply plunging sinistral drag folds are concentrated near the displaced contacts.

Where bedrock exposures are sparse and the exposed rocks are of a uniform type, such faults are more difficult to map. Northwest-trending shear zones do cut some of the granites, but without significant offset of granite/host rock contacts. Offsets similar to those in the Danforth area have been recognized to the south, where both plutonic and metasedimentary rocks are affected. In all instances, the amount of separation along the faults seems to be relatively small.

The largest single fault of this type is the Oak Bay Fault. This fault trends roughly along the Maine-New Brunswick border from Passamaquoddy Bay to Oak Bay, New Brunwick, and truncates all rocks in the immediate area. Unfortunately, both it and other faults that parallel it can not be traced long distances through the heavily glaciated region. I have mapped northwest-trending faults in the St. Croix River because of apparent offset of formation boundaries as mapped in both Maine and New Brunswick, and because of shear zones visible in exposures at Woodland below the dam. The course of the St. Croix River includes numerous right-angle changes from southwest to southeast flow directions, and I feel that these changes reflect control by both northwest and northeast-trending faults.

NEOTECTONISM

Several lines of evidence suggest that tectonism in the map area is continuing today in the form of faulting. A study of modern crustal warping (see Thompson, 1980) indicates that southeastern Maine is currently subsiding at rates as high as 9 mm/year (Tyler and Ladd, 1980; see also Figure 3, below). The hinge about which subsidence is taking place appears to correspond closely with the fault that separates the Miramichi and Matapedia terranes. Modern activation of high-angle northeast-trending faults is thus a distinct possibility, and to check this I have examined topographic maps for possible indications of offset topographic features. There are two zones in the Kellyland and Waite Quadrangles (on strike with faults mapped in the Big Lake Quadrangle) in which there is possible offset of topographic features along northeast-trending faults. The offsets--of drumlinoid features--are of an apparent left-lateral nature, suggesting that if the northeast-trending faults are indeed active today and involved with the subsidence measured by Tyler and Ladd (1980), they would have an oblique-slip displacement (left-lateral, west side up?). To my knowledge there is no data concerning active seismicity in the vicinity of these zones. My preliminary traverses in the vicinity of these potentially active faults produced no clear-cut evidence for offset of glacial features, but more work is certainly needed before the possibility can be ruled out. In addition to fieldwork, examination of recent aerial photographs and establishment of a local seismic net would be most helpful.

Modern seismicity along the Oak Bay Fault has been detected by local stations of the Northeastern U.S. Seismic Network, and indicates current activity in the vicinity of this fault. The significance of this seismicity with respect to the regional subsidence is unknown at this time. Detailed surficial mapping along the traces of other northwest-trending faults in the region will help demonstrate whether or not these too are active.

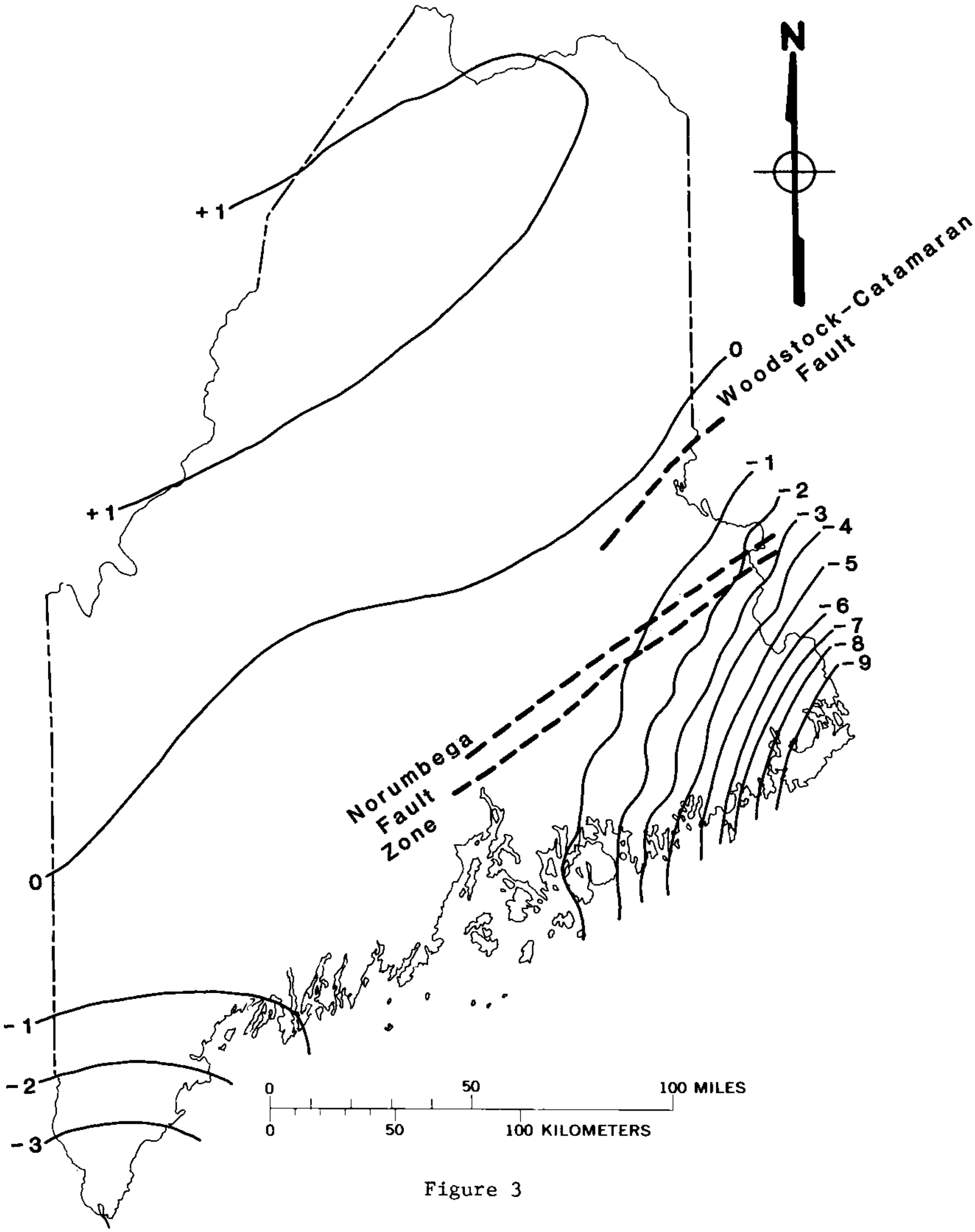

Figure 3

Map showing rates of relative crustal subsidence (mm/yr) of Maine (after Tyler and Ladd, 1980).

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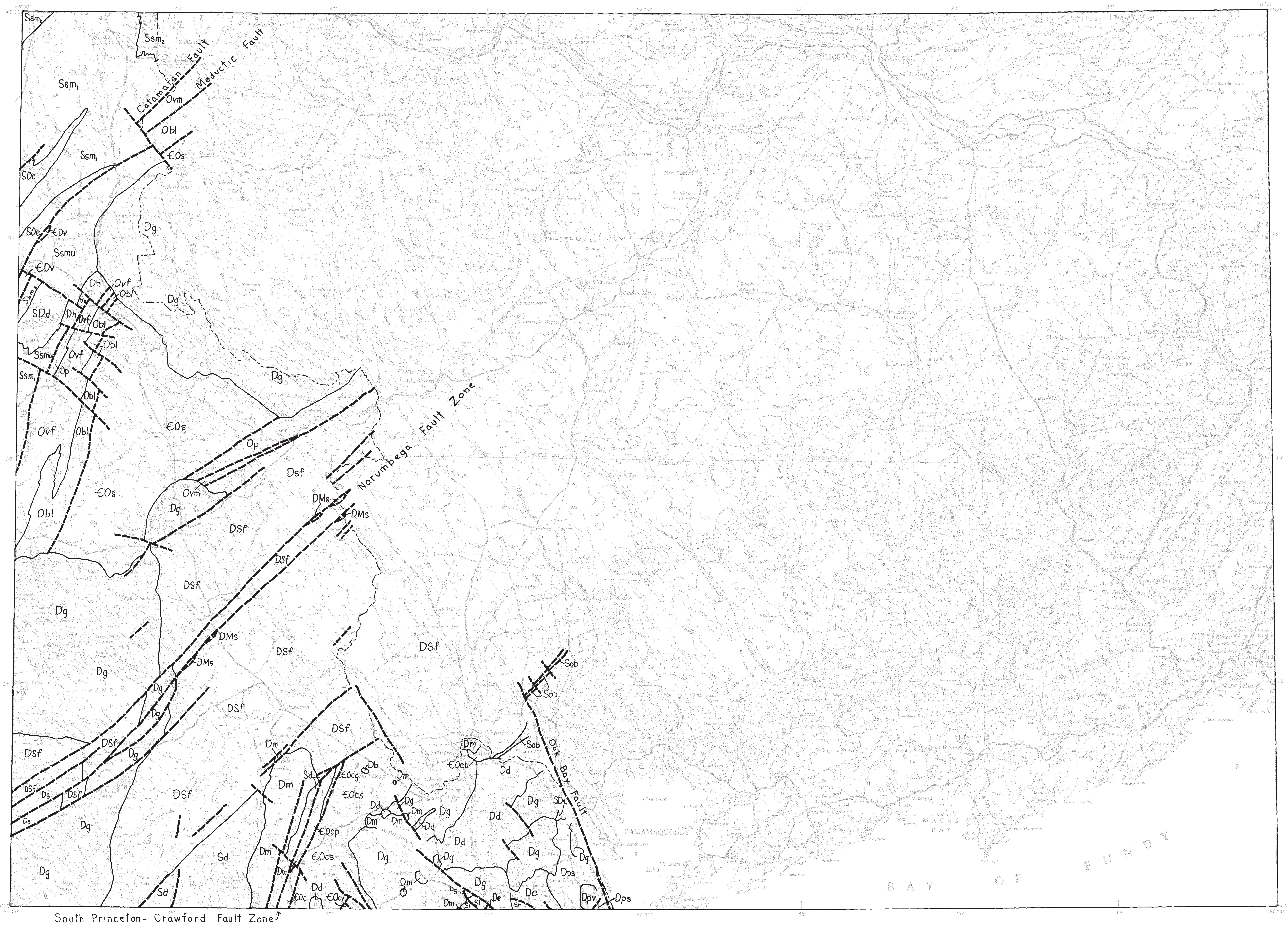


PRELIMINARY

BEDROCK AND BRITTLE FRACTURE MAP OF THE FREDERICTON 2° SHEET, MAINE

COMPILED BY

ALLAN LUDMAN

1982

Maine Geological Survey

DEPARTMENT OF CONSERVATION

WALTER A. ANDERSON STATE GEOLOGIST

OPEN FILE NO. 82-30

EXPLANATION

PLUTONIC ROCKS

Dg	Granitic rocks, including granite, granodiorite, and quartz monzonite.
Dm	Mafic rocks, including differentiated layered gabbros; norites, undifferentiated gabbros.
Dd	Intermediate rocks, including diorite and quartz diorite.

STRATIFIED ROCKS

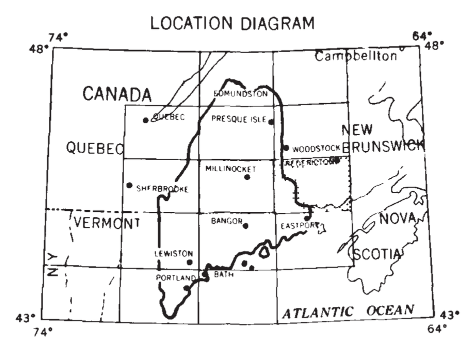
DMs	Unnamed red to pink boulder conglomerate, lithic sandstone, mudstone, shale in the Waite and Kellyland quadrangles.
Dp	Perry Formation; Dps-red conglomerates, lithic and arkosic sandstones, mudstones; Dpv-basaltic lava flows.
De	Eastport Formation: lithic and crystal tuffs, fine-grained siltstones.
Dh	Hartin Formation: fine grained calcareous sandstones (includes minor limestone conglomerate)
SDh	Hersey Formation: fine grained siltstones, mudstones, shell-hash beds, and subordinate basaltic lava flows.
SDd	Daggett Ridge Formation: boulder through pebble conglomerate, lithic sandstone, subordinate slates.
SDv	Unnamed porphyritic volcanic rocks.
SDvu	Unnamed thermally metamorphosed siltstones, sandstones, and tuffs.
DSf	Flume Ridge Formation: variably calcareous and ankeritic quartzose and quartzofeldspathic sandstones, siltstones, and minor slate and phyllite.
Sob	Oak Bay Formation: polymict lithic conglomerate and lithic sandstones.
Sd	Digdeguash Formation: polymictic grits and graywackes interbedded in graded turbiditic beds with dark-gray slate.
Ssm	Smyrna Mills Formation: Ssm_1-thin-bedded non-calcareous fine grained sandstone and slate with lenses of manganiferous slate; Ssm_2-thick-bedded green quartzwackes with muscovite-chlorite matrix (variably calcareous); Ssmu-undifferentiated Smyrna Mills rocks.
SOc	Carys Mills Formation; highly calcareous fine-grained sandstones, siltstones, and phyllites.
Obl	Belle Lake Slate: interbedded rusty weathering, pyritiferous carbonaceous slate, graywacke, quartzwacke.
Ovf	Unnamed felsic volcanic and volcaniclastic rocks.
Ovm	Unnamed mafic volcanic rocks.
Op	Thin-bedded sandstones and gray slates, with minor manganiferous siltstones. Locally sulfidic.
ꞒOs	"Baskahegan Lake Formation" undifferentiated: thick-bedded maroon and green quartzofeldspathic and quartzwackes with subordinate maroon and green slate; thin-bedded maroon and green slate; thin-bedded maroon and green slates with subordinate maroon and green siltstones, sandstones.
ꞒOc	Cookson Formation: ꞒOcp-thinly interbedded carbonaceous slate and sulfidic sandstone; ꞒOcg-monomictic volcaniclastic grit with subordinate carbonaceous slate; ꞒOcs-rythmically interbedded sulfidic quartzwacke and slate; ꞒOcu-undifferentiated Cookson lithologies including pillow basalts, carbonaceous slates, turbiditic metasandstones, migmatites.

ROCKS OF VERY UNCERTAIN AGE

ODvm	Unnamed basaltic tuffs, massive basalts, pillow basalts in the southwest corner of the Calais quadrangle (may belong to either Cookson Formation or Siluro-Devonian coastal volcanic belt).
ꞒDv	Unnamed greenstones, vitric tuffs, tuff breccias, volcaniclastic rocks, maroon slates, highly manganiferous magnetite-bearing rock (may belong to Miramichi Ordovician volcanic section, or Miramichi Devonian volcanic section).

Scale 1:250,000

20 Statute Miles · 30 Kilometers · 15 Nautical Miles



SYMBOLS

- fault
- Contact

Preparation of this map was supported by funds furnished by the Nuclear Regulatory Commission Grant No. NRC-04-76-291 and the Maine Geological Survey.