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Significant Bedrock Features of the Maine Coast : Boothbay to Calais

Carol White

A. M. Hussey II

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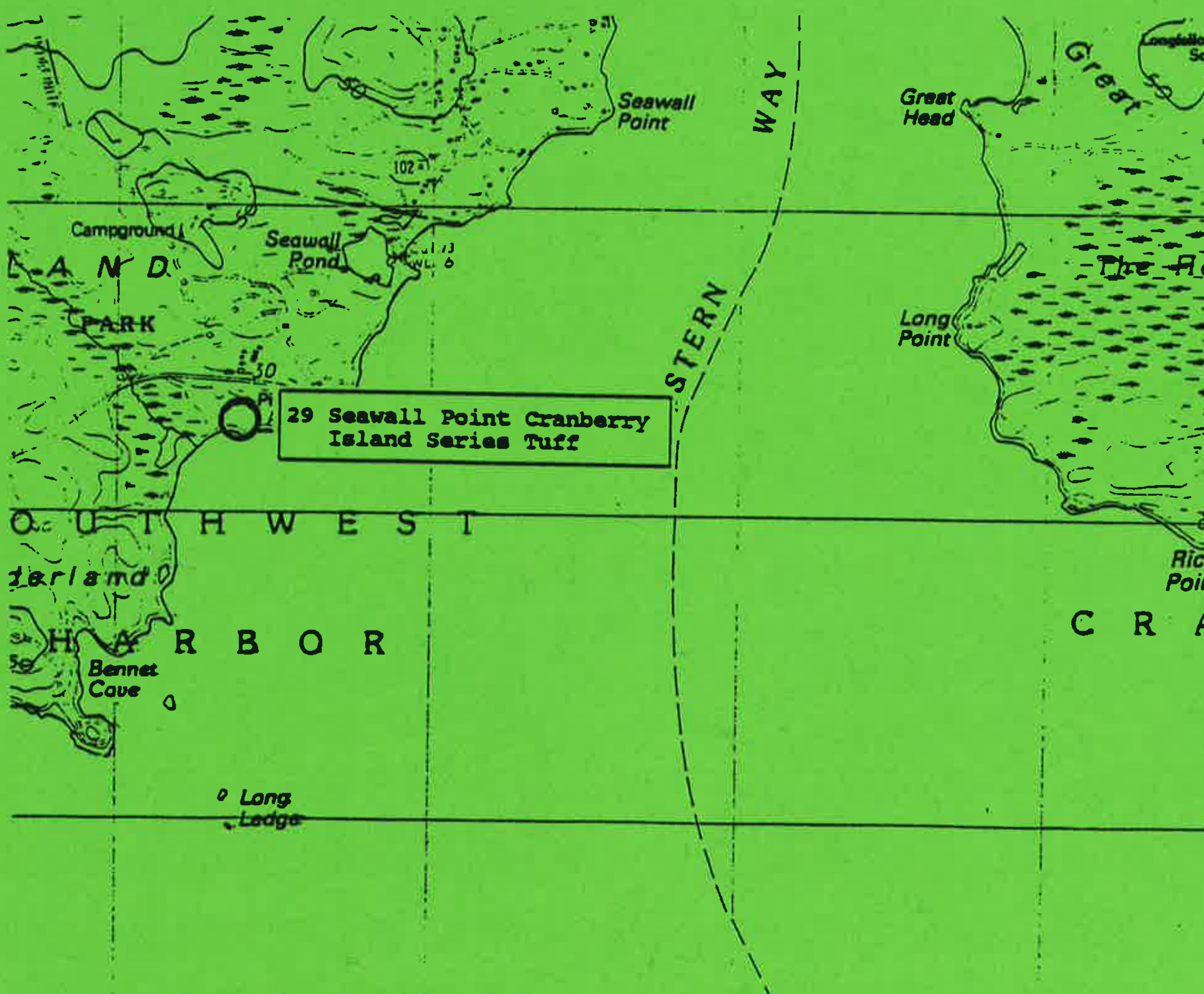

Executive Department

Maine State Planning Office
August 1989

SIGNIFICANT BEDROCK FEATURES OF THE MAINE COAST

BOOTHBAY TO CALAIS

by

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B. Lewis '89

INTRODUCTION

This report has been prepared for the Maine Critical Areas Program to document scientifically and educationally significant bedrock localities in central and eastern coastal Maine. The area evaluated in this report extends from Sheepscot Bay in Wiscasset to Passamaquoddy Bay, near Eastport. The study area is shown on Figure 1.

Superb coastal exposures of the bedrock formations in central and eastern coastal Maine provide valuable insight into the complex geologic history of eastern North America. The bedrock types found in this area include:

- a wide variety of sedimentary and metamorphic rocks ranging from Late Pre-Cambrian to Late Devonian in age
- intrusive igneous rocks of Early Devonian age
- volcanic rocks ranging from Late Pre-Cambrian to Early Devonian age

The sedimentary and volcanic rocks in the Eastport and Penobscot Bay areas are unusual in that they are only slightly metamorphosed. Consequently many of the original sedimentary and volcanic structure are well preserved in these rocks. Also fossils have been found in several locations in Penobscot Bay to Eastport region. These fossils can be used to help establish the relative ages of the rocks in the area. The presence of these relatively unmetamorphosed, fossiliferous rocks provide information essential to the interpretation of the geologic history of eastern North America.

Our present understanding of the geology and geologic history of Maine has been possible only through the hard work of many geologists. Over the past three decades the Maine Geological Survey has supported much of this work aimed at unscrambling the complex geology of the State. In the course of their work, geologists have discovered many rock exposures that have a key bearing on the interpretation of the regional geology. Many outcrops are visited and re-visited by these geologists and their colleagues in order to reaffirm or modify their interpretations of this geologically complex region.

Several of the sites discussed in this report have been included as stops on field trips sponsored by the New England Intercollegiate Geological Conference (NEIGC) and the Geological Society of Maine (GSM). Other sites described in this report are of outstanding educational value due to their accessibility and extent of clear exposure. These sites are frequently visited by educational and conservation groups from all over the New England area.

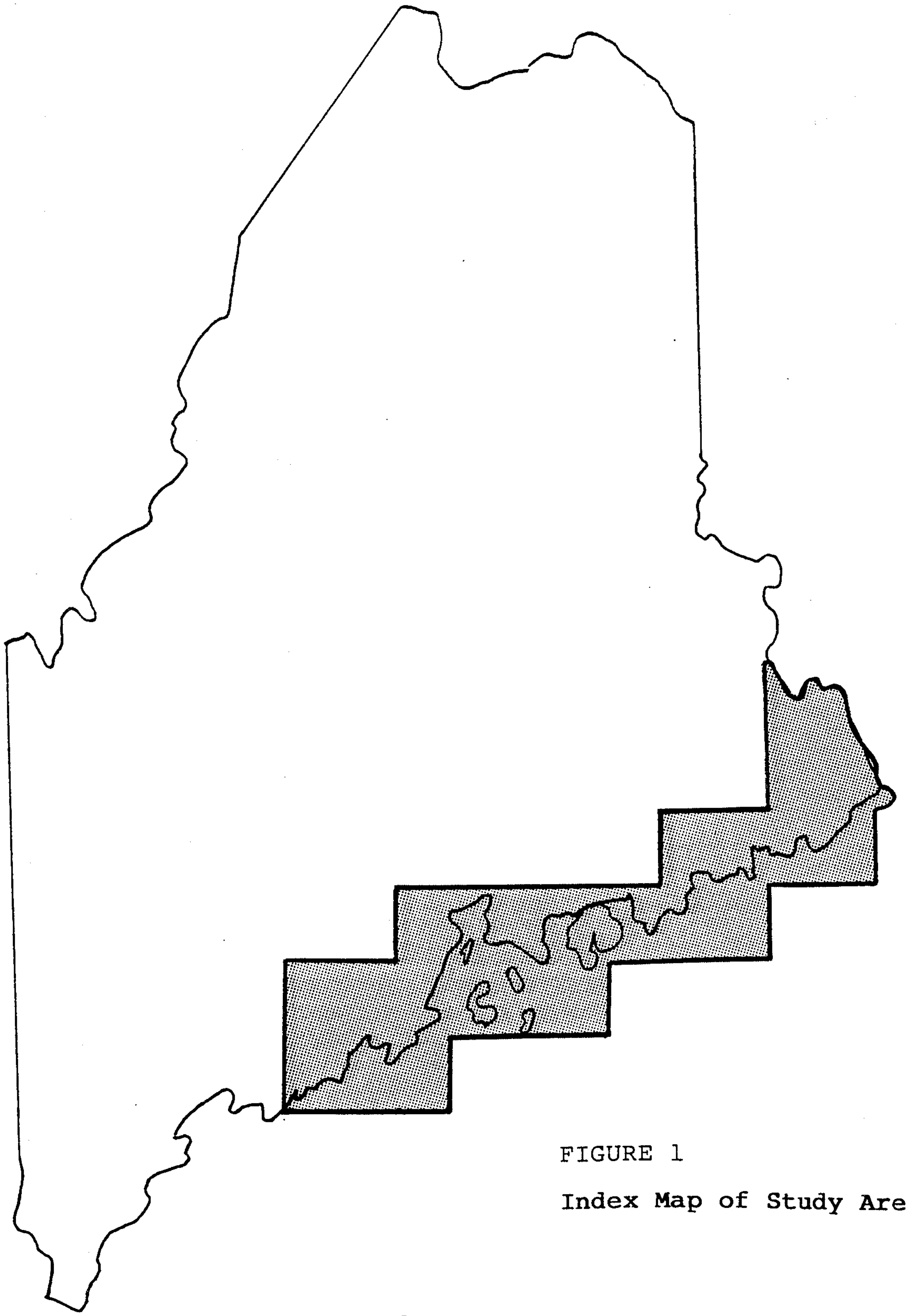


FIGURE 1

Index Map of Study Area

It is desirable that both types of outcrops, scientific and educational, remain accessible to future generations of geologists, students and interested persons. The importance of preserving critical rock exposures for continuing studies cannot be overemphasized. As our knowledge of regional geology expands, new interpretations emerge requiring re-evaluation of old localities. Continued protection of these critical sites is essential if scientific understanding is to progress. For these reasons the sites listed below are proposed for inclusion in the Maine Critical Areas Register.

Preservation of important bedrock sites requires the cooperation of the landowners in order to protect the sites from development, removal or burial. Private landowners should be made aware of the presence of critical bedrock features on their lands. If they are provided with some understanding of why these features are important they may assist in preserving them for future generations.

We acknowledge the assistance of the following geologists who have identified many of the areas that we have recommended in our report: Bruce Bouley, Callahan Mining Company; David Stewart, U.S. Geological Survey; and Olcott Gates, Senior Field Geologist, Maine Geological Survey and Professor Emeritus, Fredonia State College. These geologists also reviewed and checked the information they submitted for areas they recommended. We also acknowledge the able assistance of Beth Lewis with the compilation of the report and drafting of the illustrations.

TYPES OF SIGNIFICANT FEATURES

Several types of bedrock features are significant to the understanding of the geology of eastern coastal Maine. Significant features include outcrops and features critical to our understanding of Maine geology and exceptional examples of geological features or processes that have important educational values. The significant bedrock features of two other areas of the state - York County and Casco Bay have already been inventoried and described for the Critical Areas Program by A.M. Hussey (1977, 1978).

A report prepared for the Critical Areas Program **Important Geological Features and Localities of Maine** by D.W. Caldwell (1982) summarizes the geologic topics and localities considered unusual or significant enough to warrant further research and possible inclusion in the Maine Critical Areas Registry. Some of these significant features and a brief geologic description are included below:

Three basic categories of rocks in the Earth's crust are recognized: **Igneous**, **Sedimentary**, and **Metamorphic**.

IGNEOUS ROCKS

Igneous rocks are those that have formed from molten rock material generated deep within the Earth's crust. Magma may be injected into crustal rocks below the surface of the Earth to later cool and crystallize, forming intrusive igneous rocks such as granite (also called plutonic rocks). The molten rock or magma may also be extruded above the earth's surface to form volcanic igneous rocks rhyolite.

Intrusive Rocks: Intrusive, or plutonic rocks are rocks that were formed at a considerable depth beneath the earth's surface by crystallization of magma, or chemical alteration.

Specific features of plutonic rocks that are of educational or scientific value include:

1. Contact relationships
2. Outcrops where minerals have been collected for radiometric dating.
3. Unusual mineral occurrences or textures (rapakivi, etc.)
4. Rare or unusual plutonic sequences (e.g., Agamenticus complex)
5. Dikes and pegmatites

Volcanic Rocks: Volcanic rocks are generally fine-grained igneous rocks that formed as the result of volcanic action at or near the Earth's surface, either ejected explosively or extruded as lava. The magma may work its way to the surface and pour out vents of volcanoes to form lava flows. Some may be blown explosively out of volcanoes showering the countryside with volcanic ash and bombs. Geologists speak of lava flows or ash as extrusive igneous rocks.

Specific volcanic features of educational or scientific value include:

1. Lava flows and pillow basalts
2. Pyroclastic fragments, bombs and ash
3. Columnar jointing
4. Evidence of volcanic vents

SEDIMENTARY ROCKS

Sedimentary Rocks: Sedimentary rocks result from the accumulation and consolidation of loose sediment, or through the chemical precipitation. Sedimentary rocks are formed through the processes of:

1. deposition of particles (e.g. sand or silt, etc.) eroded from land and delivered by rivers to the ocean or other sites of deposition;

2. chemical precipitation of minerals on the bottom of an ocean or lake;

3. accumulation and preservation of organic matter such as the shells of oceanic organisms, or plant debris to produce fossils. (Figures 2,3,4,and 5)

Significant educational and scientific features of sedimentary rocks include:

1. Outcrops that contain fossils that have been used to date the sedimentary rocks.

2. Outcrops that contain sedimentary structures such as:

   flute casts
   graded beds
   ripple structures
   cross bedding, etc.

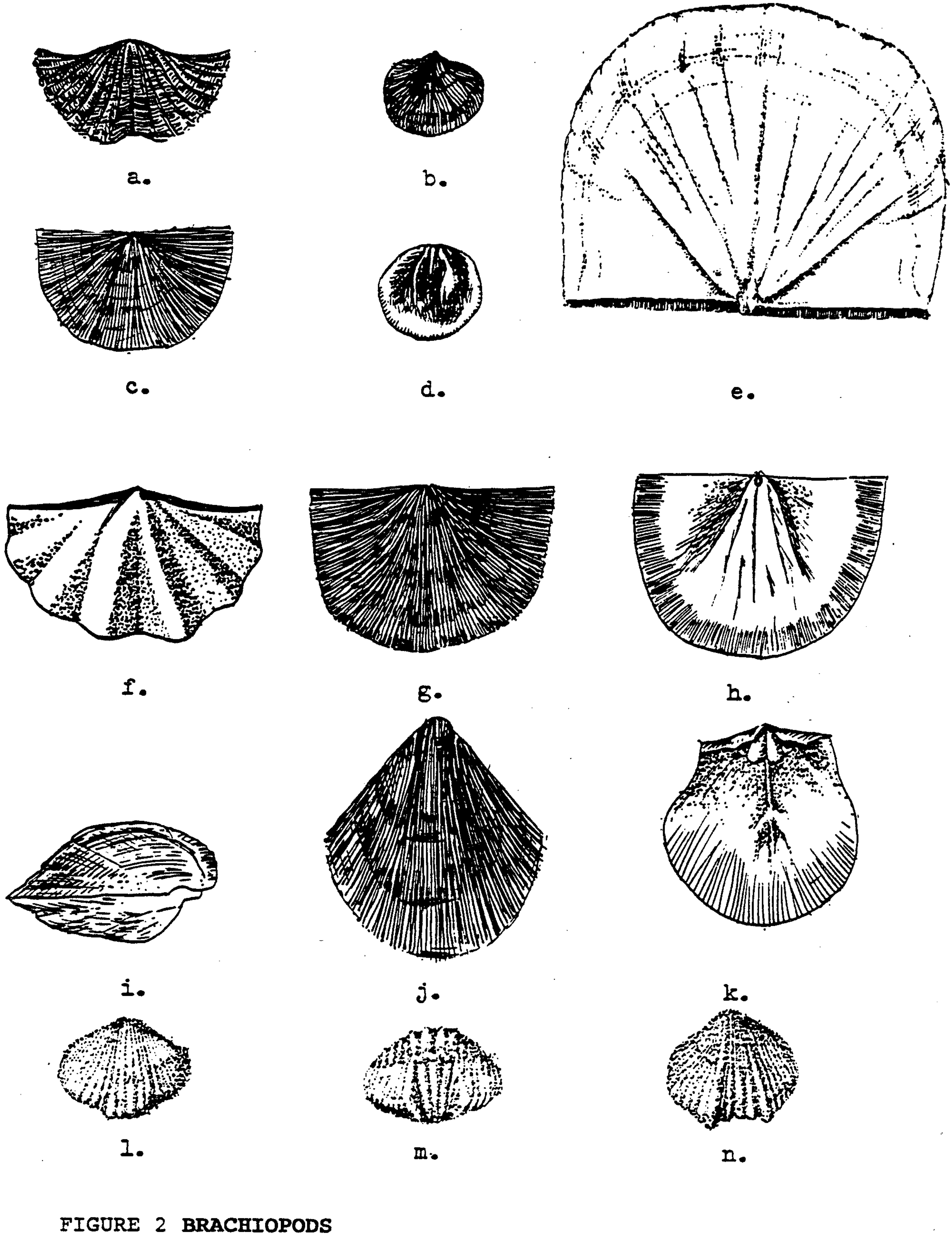


FIGURE 2 **BRACHIOPODS**

From Significant Bedrock Fossil Localities in Maine (Forbes, 1977). a. *Spirifer subcuspidatus* Schur var. *lateincisus* Scupin. b. (& d.) *Dalmanella drevermanni*. c. *Chonetes aroostookensis*. e. *Leptrostrophia magnifica*. f. *Spirifer cyminidis* var. *sparsa* Clark. g. *Leptostrophia magnifica* Hall. i. (& j. & k.) *Rensselaeria atlantica*. l. (& m. & n.) *Rhynchonella vellicata*, dorsal, front, and ventral view.

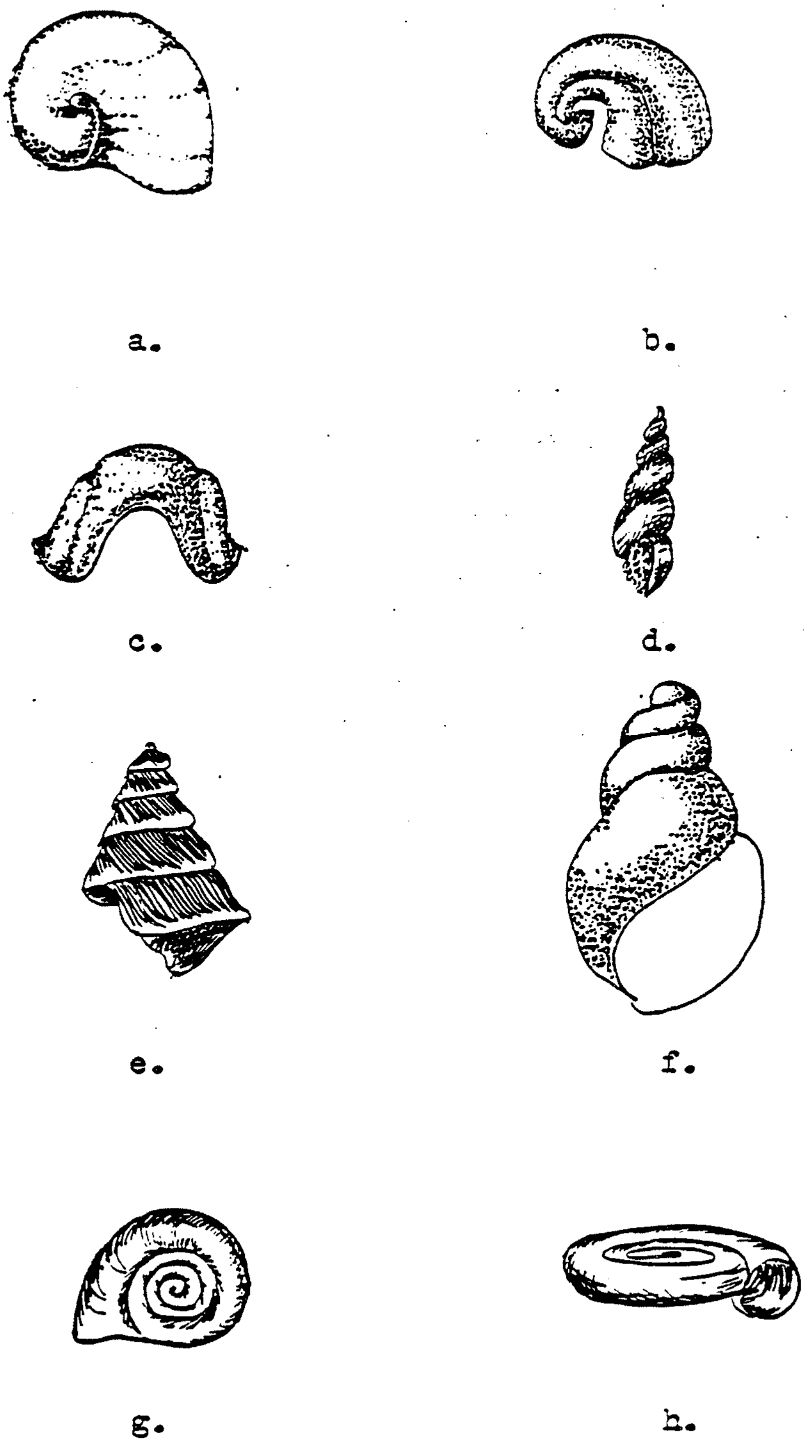


FIGURE 3 **GASTROPODS**

From <u>Significant Bedrock Fossil Localities in Maine</u> (Forbes, 1977). a. <u>Platyceras</u> <u>kahlebergensis</u>. b. (& c.) <u>Plectontus</u> cf. <u>derbyi</u>. d. <u>Eotomaria</u> <u>hitchcocki</u>. f. <u>Holopes</u> sp. g. (& h.) a gastropod.

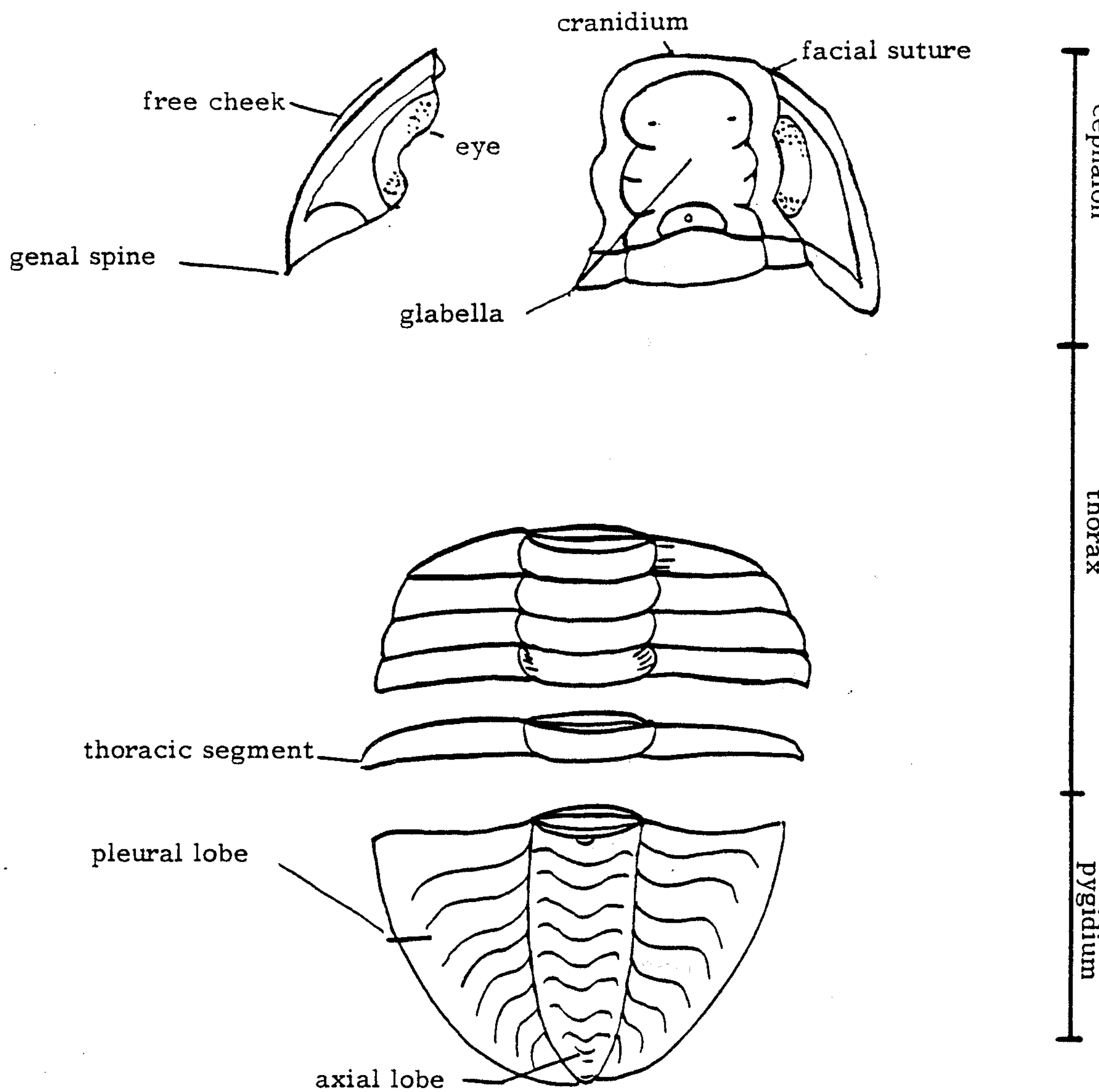


FIGURE 4 **TRILOBITE MORPHOLOGY**

From Significant Bedrock Fossil Localities in Maine (Forbes, 1977). An exploded view of the morphology of a trilobite.

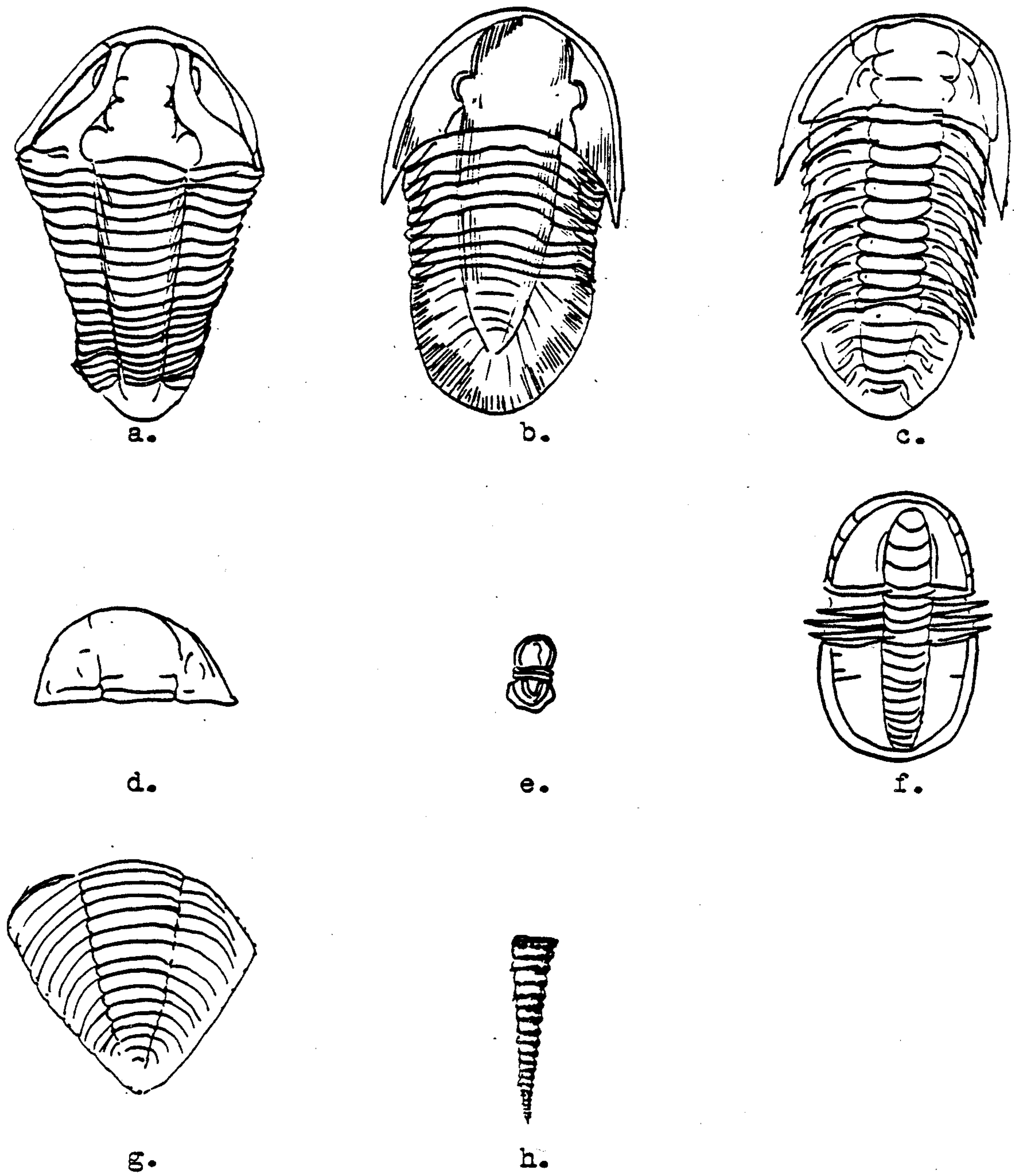


FIGURE 5 **TRILOBITES**

From Significant Bedrock Fossil Localities in Maine (Forbes, 1977). a. Calmene meeki. b. Isotelus gigas. c. Bathyuriscus rotundus. d. Phacops (Phacopidella) nylanderi. e. Agnostus interstrictus. f. Serrodiscuc speciosus. g. Homalonotus vanuxemi. h. Tentaculities scalaris.

3. Various sedimentary rock types:

   conglomerate
   sandstone
   siltstone
   melange, etc

4. Type localities for different formations

METAMORPHIC ROCKS

Metamorphic rocks: Metamorphic rocks are formed from pre-existing sedimentary or igneous rocks when they are forced into deeper levels in the Earth's crust by compressive forces. In the new environment at depth, these rocks are reconstituted by the elevated heat and pressure, into distinctively different rocks. For example, sandstone, a sedimentary rock resulting from the accumulation of silts and sands, may be recrystallized to form a quartzite, a metamorphic rock containing sand particles that are tightly welded together.

Significant educational and scientific features of igneous rocks include:

1. Classic or unusual mineral assemblages
2. Well developed metamorphic textures and structures such as schistosity, gneissic foliation, helecitic structure, porphyroblasts, etc.

GEOMORPHIC FEATURES

Bedrock Shoreline Landforms: Bedrock features that form as the result of wind and wave erosion to form unusual shapes and forms.

Significant bedrock landforms include:

1. Sea caves
2. Sea stacks
3. Rock arches
4. Blow holes
5. Wave-cut benches

DESCRIPTION AND INTERPRETATION OF GEOLOGIC FEATURES

One of the first tasks of a field geologist is to divide the rocks he examines into distinct mappable units called formations. A formation may consist of just one type of rock or it may consist of a uniform association of two or more rock types (e.g. thinly interlayered shale and sandstone). Two or more formations that have certain generalized similarities or are very closely associated geographically constitute a group. Minor units that can be recognized within formations are referred to as members. Formations are given formal names consisting of two parts. The first part is a place (e.g. town, river, mountain, etc.) where the formation exists or is well exposed. The second part consists of the word "Formation" where the unit consists of two or more closely associated rock types (e.g. the Ellsworth Formation); if the unit consists essentially of one rock type only, the rock-type name is generally used (e.g. Cutler Diabase).

STRATIGRAPHIC AND STRUCTURAL FEATURES

After defining the rock units, the field geologist must work out the stratigraphic relations of these units. By this we mean establishing the sequence in which they were deposited, and whether the units were deposited one upon the other without interruption, or whether there were periods of non-deposition and erosion. A period of non-deposition and erosion would represent an unconformity (Figure 6). Of particular importance to establishing the sequence of deposition are primary structures of the metasedimentary rocks such as graded bedding and cross bedding. Both of these features were formed at the time the sediments were deposited, and they preserve a directional sense of bottoms and tops as illustrated and annotated in Figure 7.

In regions such as the study area, the metasedimentary and metavolcanic rocks are not flat lying as they were at the time of their deposition. Instead, the layers, or beds, of these rocks are tilted or vertical; they have been deformed during ancient periods of crustal compression which geologists refer to as orogenies. During such times of compression, the rocks are folded into large anticlines and synclines, and broken by joints and faults. Minor structures such as cleavage, schistosity, lineation, parasitic folds, and kink banding are formed during these periods of deformation. Let us examine these deformation structures in more detail.

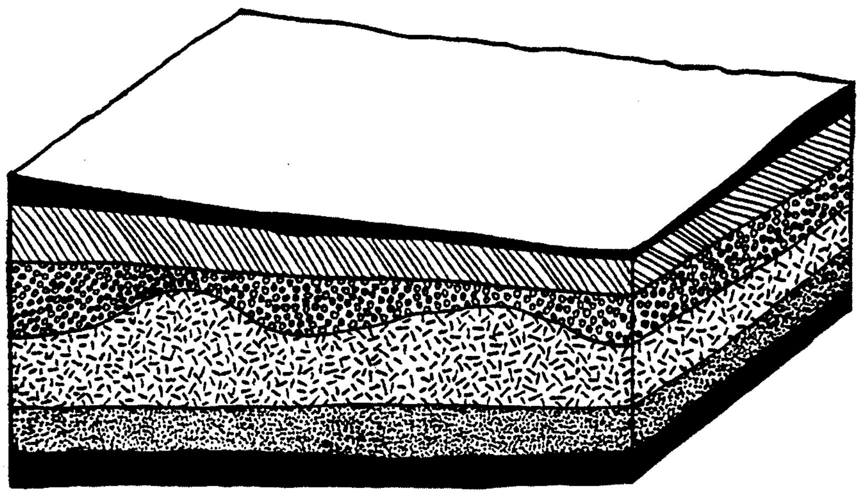


FIGURE 6 **UNCONFORMITY**

An unconformity indicates a gap in the rock record. The wavy line shows the boundary between sediments where erosion has taken place and subsequent deposition of younger sediments.

A. CROSS BEDDING

Laminations within beds

Current direction →

UP ↑

Bed 3

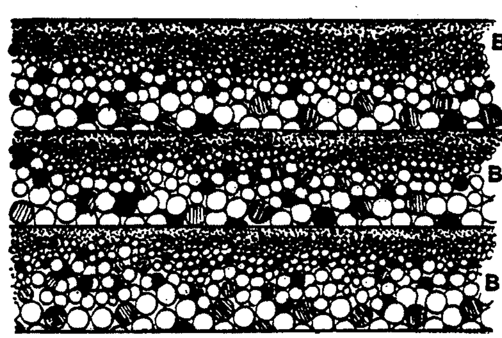
Bed 2

Bed 1

Note that the laminations (thin layering lines) are cut off by the next bed up. Bed 1 was laid down prior to Bed 2, and Bed 2 prior to Bed 3.

B. GRADED BEDDING

UP ↑



Bed 3

Bed 2

Bed 1

Note that in a given bed, grains are coarsest on the bottom, gradually become finer grained toward the top. There is an abrupt change to coarse grains again at the base of the next higher bed.

FIGURE 7 CROSSBEDDING AND GRADED BEDDING

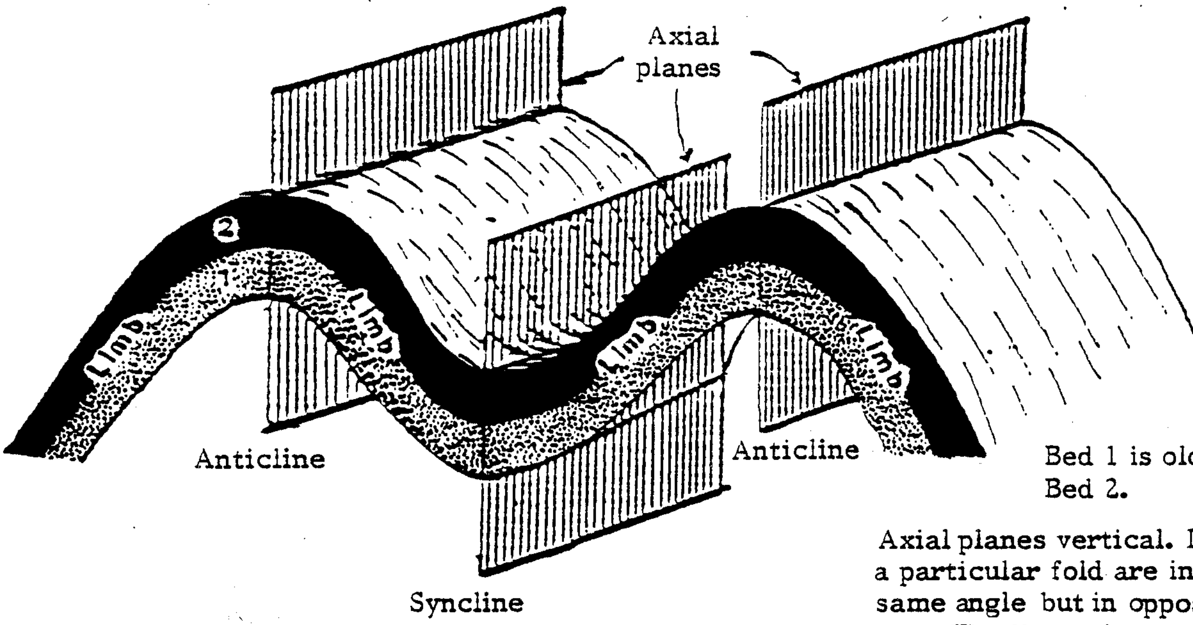
Folds. Folds, as the name implies, are sinuous bends of rock layers. Figure 8 and Figure 8B show some different types of folds and the nomenclature geologists use in describing them. Folds in their simplest form are shown in Figure 8. The up-arched fold is an anticline and the down-arched fold is a syncline. An imaginary plane passing through all the lines of highest curvature of the folded beds is referred to as the axial plane of the fold. The axial planes in these folds, divides them into symmetrical halves. The lines of maximum curvature of the folds, which in this case lie at the highest points of anticlines and the lowest points of synclines, are referred to as axes of the folds. The folds illustrated at the top of Figure 8 are said to be upright because the axial plane is vertical. The relatively straight parts of a fold lying between adjacent axes are limbs of the fold. Folds with inclined axial planes are said to be overturned (Figure 8, bottom) and those with horizontal axial planes are recumbent (Figure 8B, top).

When the limbs of a fold are parallel to each other, we speak of the fold as being isoclinal. Isoclinal folds may be upright, overturned, or recumbent (Figure 8B, middle). Parasitic folds are small scale folds that combine to make large folds (Figure 8B, bottom). Very frequently these small scale parasitic folds are what the geologist observes in the outcrop, and from them he can infer the nature of the larger folds.

Joints. Joints are relatively planar surfaces of rock breakage along which no slippage has occurred. Joints generally occur in sets, a set consisting of all the surfaces parallel to a given direction. Usually several sets are present in a particular rock unit (Figure 9). Joints are the most common of structures, being found in all rocks, both flat-lying and deformed sedimentary rocks, igneous rocks, metamorphic rocks, and even compacted sediments, particularly silt and clay.

Faults. Faults are surfaces of breakage where rocks on one side of the rupture have moved past those on the opposite side (Figure 10). The surface along which movement takes place is referred to as the fault surface. The intersection of the fault surface with the land surface defines the fault trace. Because the rock is frequently crushed as the blocks slide past each other, fault traces often form linear valleys (commonly referred to as lineaments).

Cleavage and Schistosity. Cleavage and schistosity are structures found in many metamorphic rocks by virtue of which they split readily in one direction like roofing slate. Cleavage is the term used when the rock is so fine grained that the individual minerals cannot be seen. Schistosity applies when the



Bed 1 is older than Bed 2.

Axial planes vertical. Limbs of a particular fold are inclined at same angle but in opposite directions. The limb of an anticline is also the limb of an adjacent syncline.

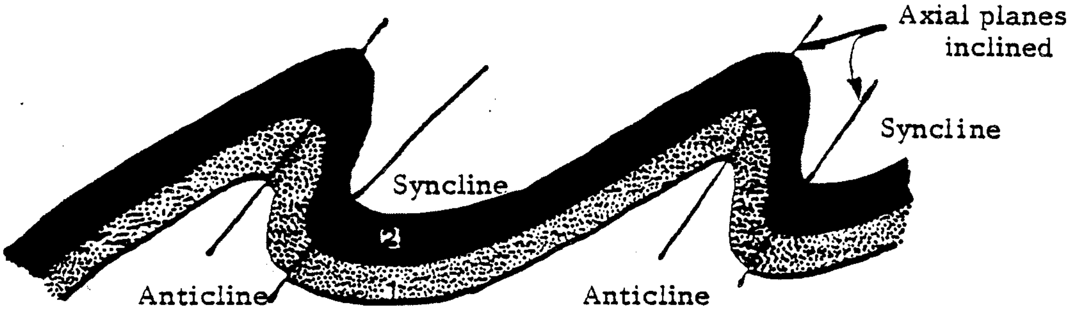
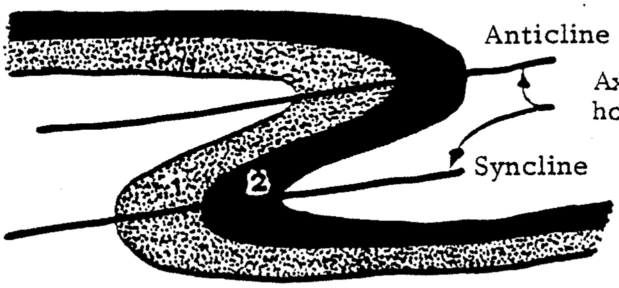
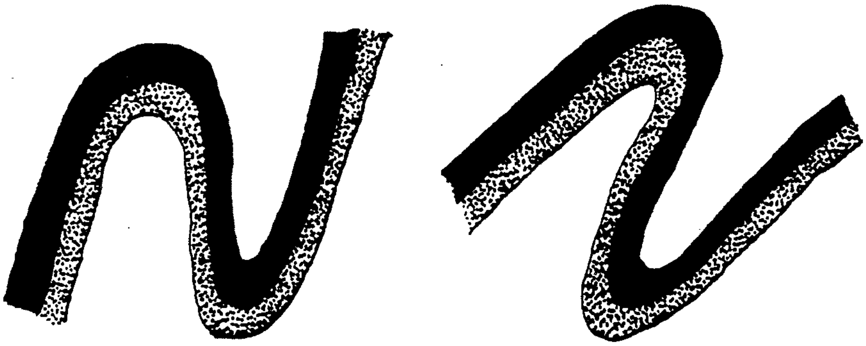


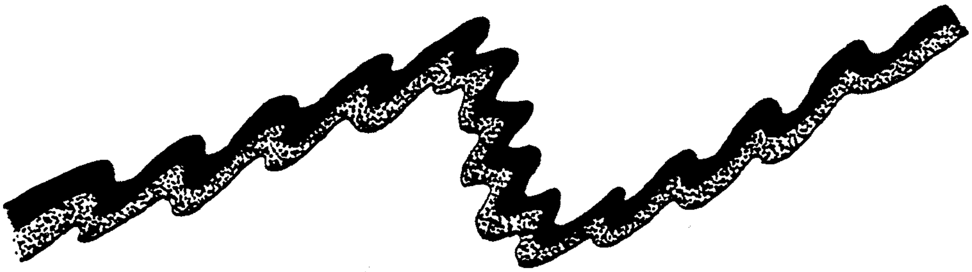
FIGURE 8 FOLDS I

TOP: Upright folds
Bottom: Overturned folds





Limbs are parallel to each other.



Parasitic folds are smaller-scale folds that make up larger folds.

FIGURE 8B **FOLDS II**

Top: Recumbent fold
Middle: Isoclinal folds
Bottom: Parasitic folds

JOINTS

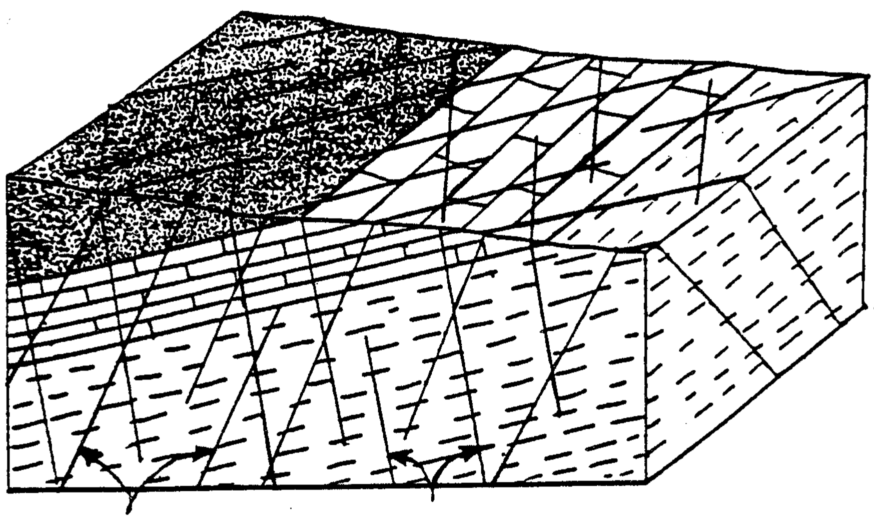
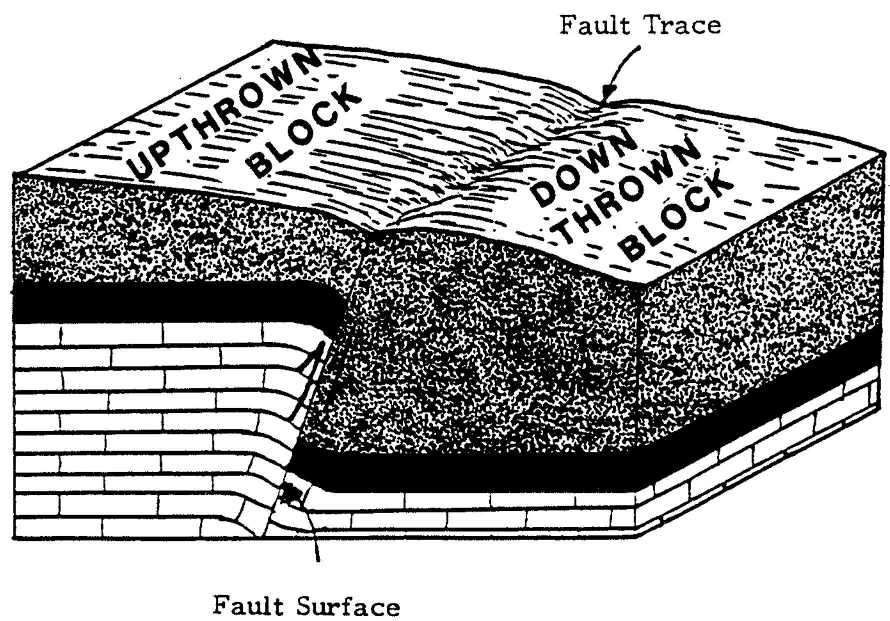


FIGURE 9 **JOINTS**

Block diagram showing tilted sedimentary sandstone, shale, and limestone cut by two joint sets.

FAULT



Half arrows indicate direction of rock slippage.

FIGURE 10 **FAULT**

Block diagram showing a fault. The left hand block having moved up and the right down as indicated by the half arrows. Faults may show movement in the opposite direction or sideways, in a horizontal sense.

mineral grains can be seen and identified without the aid of a microscope. It is quite apparent with schistosity that the ready ability to split is due to the presence of large amounts of the flaky mineral mica in parallel alignment throughout the mass of the rock. The structural importance of cleavage or schistosity is that they commonly form parallel to the direction of the axial planes of folds. They are invaluable tools to deciphering the picture of multiple deformation. A folded cleavage or schistosity would indicate at least two episodes of deformation had affected the rock --the first that formed the cleavage as an axial planar structure and the second that deformed it.

OVERVIEW OF THE GEOLOGY OF COASTAL MAINE

Figure 11 is a simplified geologic map of eastern coastal Maine, extending from Sheepscot Bay to Passamaquoddy Bay (Hussey, 1986). This map shows the distribution of the different types of bedrock in this region. These rocks range in age from Pre-Cambrian (over 500 million years ago) to Carboniferous (300 million years ago) in age. This rock sequence has been subdivided into two groups: stratified rocks and intrusive rocks. The stratified rocks include the volcanic, sedimentary and metamorphic rock types. Intrusive rocks include the granites, gabbros and ultramafic rocks that are frequently seen cropping out along eastern coastal Maine. The rock types comprising these groupings are summarized on Table 2.

GEOLOGIC HISTORY OF MAINE

The oldest rocks in Maine are Pre-Cambrian to Ordovician in age. At the present time the only rocks in the Coastal Lithotectonic Belt that are assigned a pre-Cambrian age based on a radiometric date are the rocks of the Rockland-Islesboro-North Haven sequence. These pre-Cambrian rocks in the Penobscot Bay area consist of metamorphosed schists and marbles that have been intruded by pegmatites. Radiometric dates of approximately 600 million years on the pegmatite suggest that the schist and marble that make up the country rock are at least 600 my or older (Stewart, 1974). The rocks of the Islesboro-Rockland-North Haven sequence are made up of a widely divergent lithologies including pillow basalts, shelf limestones, quartzites, sandstones and shales.

The Pre-Cambrian rocks exposed in the core of the Liberty-Orrington anticline consist of feldspathic gneisses and schists. These rocks are considered to be Pre-Cambrian in age due to the fact that they have been highly metamorphosed prior to the intrusion of Ordovician granitic rocks (Osberg, 1974). The next oldest group of rocks are the Casco Bay Group, and the Topsham sequence. The Casco Bay Group is thought to date from the pre-Cambrian to Ordovician based on a Rb/Sr date of approximately 480-490 my years. The rocks consist of a complex sequence of metasediments and metavolcanics.

In the Late Cambrian and Ordovician periods during a period of uplift and erosion, great thicknesses of sedimentary and volcanic rocks were deposited along what is the present day coastal Maine. This region of the State was part of a long narrow belt of sedimentation and volcanic activity that extended from the present day Alabama northeast to Newfoundland. The Maine landscape during Cambrian through Ordovician times was probably quite similar to the present day Japan, and its offshore volcanic islands. During this period in geologic history the entire State of Maine was submerged

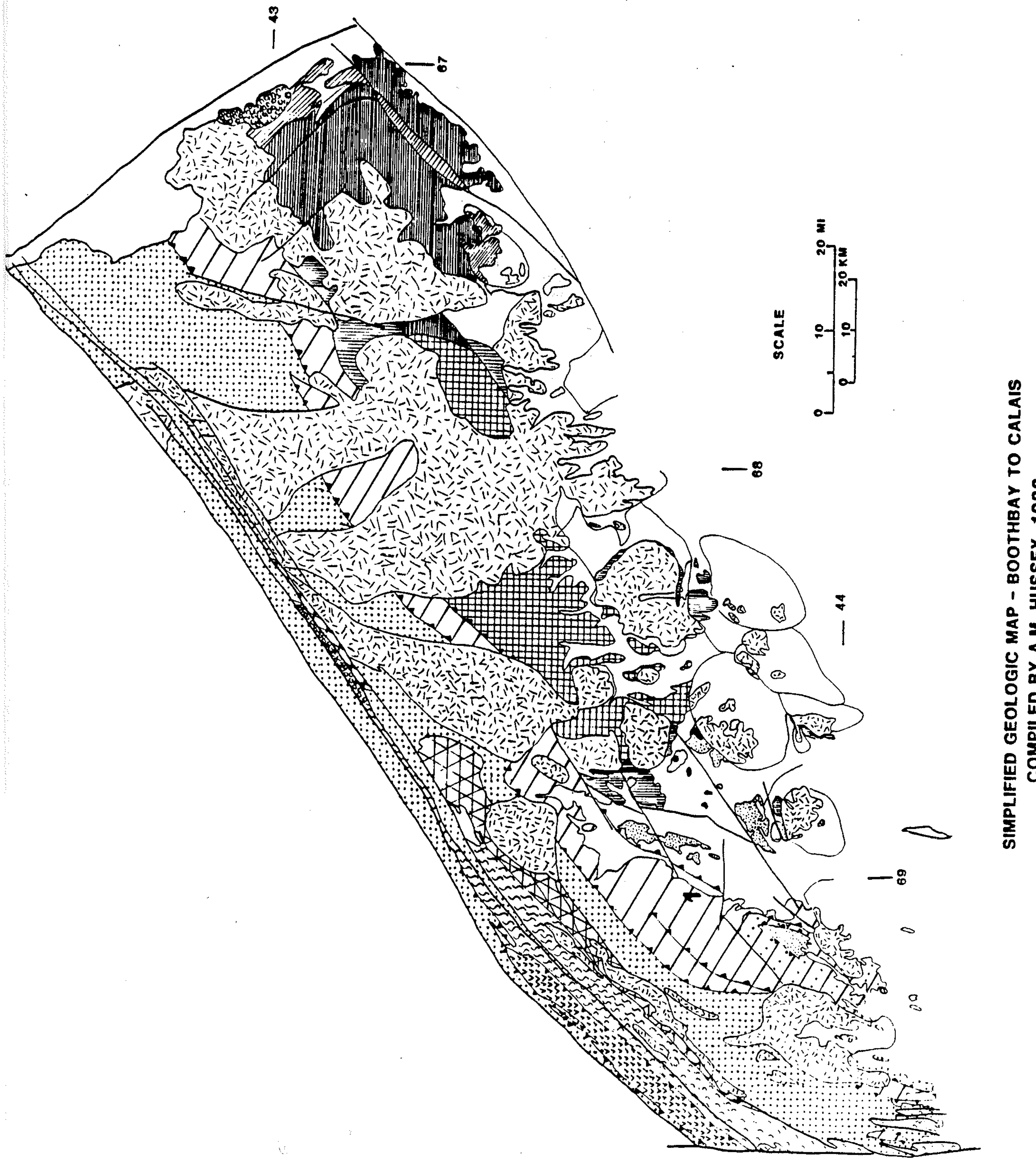


FIGURE 11 **SIMPLIFIED GEOLOGIC MAP - BOOTHBAY TO CALAIS**

LEGEND

Stratified Rocks

LATE DEVONIAN -	Conglomerates, fossiliferous sandstones and volcanic rocks. Perry Fm.
DEVONIAN	Volcanics and sedimentary rocks Eastport Fm.
SILURIAN	Volcanic and sedimentary rocks Leighton, Quoddy, Ames Knob, Hersey, Edmunds, Dennys, Cranberry Is. and Bar Harbor Fm.
ORDOVICIAN-DEVONIAN	Metasedimentary rocks Vassalboro, Sebascodegan (Bucksport Fm.), Flume Ridge and Appleton Fm. Casco Bay Group.
ORDOVICIAN	Volcanic and sedimentary rocks Benner Hill sequence
CAMBRO-ORDOVICIAN	Volcanic and sedimentary rocks Cookson - Penobscot sequence
PRE-CAMBRIAN-ORDOVICIAN	Metasediments and metavolcanics Casco Bay Group Topsham Sequence Passagasswaukeag Gneiss Ellsworth and Columbia Falls Fm.
PRE-CAMBRIAN	Volcanics and metasediments Islesboro-Rockland-North Haven sequence

Intrusive Rocks

DEVONIAN	Intrusive rocks, undifferentiated granites, gabbros
SILURIAN	Ultramafic rocks Deer Isle, Little Deer Isles, Union

TABLE 2

ROCK TYPES OF EASTERN COASTAL MAINE

Stratified Rocks

LATE DEVONIAN - age: 360 my ago	Conglomerates, fossiliferous sandstones and volcanic rocks. Perry Fm.
DEVONIAN age: 410 my ago	Volcanics and sedimentary rocks Eastport Fm.
SILURIAN age: 425 my ago	Volcanic and sedimentary rocks Leighton, Quoddy, Ames Knob, Hersey, Edmunds, Dennys, Cranberry Is. and Bar Harbor Fm.
ORDOVICIAN - DEVONIAN age: 450/370 my	Metasedimentary rocks Vassalboro, Sebascodegan (Bucksport Fm.), Flume Ridge and Appleton Fm. Casco Bay Group.
ORDOVICIAN age: 450 my ago	Volcanic and sedimentary rocks Benner Hill sequence
CAMBRO - ORDOVICIAN age: 485 my ago	Volcanic and sedimentary rocks Cookson - Penobscot sequence
PRE-CAMBRIAN - ORDOVICIAN age: 560/450	Metasediments and metavolcanics Casco Bay Group Topsham Sequence Passagasswaukeag Gneiss Ellsworth and Columbia Falls Fm.
PRE-CAMBRIAN age: 560 or older	Volcanics and metasediments Islesboro-Rockland-North Haven sequence

Intrusive Rocks

DEVONIAN age: 360 my ago	Intrusive rocks, undifferentiated granites, gabbros
SILURIAN age: 425 my ago	Ultramafic rocks Deer Isle, Little Deer Isles, Union

from Osbeg et al., 1985

under the ocean. At this time great thickness of mud, sand and limey sediments were deposited along the coast. Islands rising from the ocean floor were the sites of active volcanoes producing ash and lava flows that form the volcanic rocks found in the Coastal Lithotectonic Belt.

The rocks of the Ellsworth - Columbia Falls Formations consist of a mixed bag of metagraywakes, shales, and intermediate to felsic volcanics. These rocks have been radiometrically dated at 530 million years, which places them in the pre-Cambrian to Ordovician age group. Rocks of unequivical Cambrian age are not known in the study area. The younger rocks of Cookson - Penobscot block downeast have been dated palentologically from fossils on Cookson Island --consequently the older unit is assigned a Cambrian age. Rocks of Ordovician age are the Benner Hill Sequence which consists of rusty schists, interbedded siltstones, siltstones and shales. The rocks have been assigned an Ordovican age based on a fossil locality in the Rockland area.

Deposition of sediments and volcanics continued into the Silurian and Devonian periods. Some of these Silurian sediments are in unconformable fault or erosional contact with older and younger sediments. Several volcanic and sedimentary rocks have been assigned Silurian ages in the Coastal Lithotectonic Belt including the Castine volcanics, Ames Knob Formation, Bar Harbor and Cranberry Island Series, Edmunds, Dennys, Hersey, and Quoddy Formations. The rocks consist primarily of volcanics and interbedded sediments that were deposited in association with the volcanic activity during the Silurian period. These Silurian rocks tend to be fossiliferous and only slightly metamorphosed. The Castine volcanics vary in lithology from pillow lavas to intermediate and felsic breccias. Ultramafic rocks near Little Deer and Deer Isle have been assigned a Silurian Age.

In the Early Devonian period, approximately 390 million years ago a major episode of crustal deformation and mountain building occurred called the Acadian Orogeny. This period of folding and faulting is thought to have been caused by the collision of the Avalonian plate with the North American plate resulting in the consolidation of New England as part of the North American continent. Large masses of granitic and mafic magma were generated during the Acadian Orogeny, forming numerous large plutons throughout eastern coastal Maine. Emplacement of these plutons resulted in metamorphism and partial melting in some of the surrounding country rocks.

Some of the youngest rocks that have been identified in eastern coastal Maine are found along the Maine-New Brunswick border. The Perry Formation rocks consist of conglomerates, sandstones, rhyolites, tuffs and basalts of Late Devonian age. These rocks are thought to occur as thin, downfaulted slivers in limited exposures along the easternmost coast of Maine.

Approximately 250 million years ago, in the Late Triassic, large cracks in the crust formed the rift basins that make up the present day Connecticut Valley and the Bay of Fundy. As these basins eventually spread the result was inundation of the coastal area by what is the present day the Atlantic Ocean. Also during the Late Triassic period, the rift faulting opened up many cracks in the rocks which were subsequently filled with basaltic magma to form the numerous dikes that we see along the coast today.

Unfortunately, the rock record in eastern Maine ends in the Late Triassic and there is no detailed record of the geologic events in last 200 million years or so. The Atlantic Ocean probably developed into its present day form over this 200 million year period. Also, the rocks were exposed to the effects of wind and weather, and have slowly eroded during this time. The last major event that affected eastern North America was the advance of a continental ice sheet during the Quaternary Period approximately 1 million years ago. Thick sheets of ice flowed southerly across the state, deposits silts, sands and gravels, and sculpting the bedrock surface.

METAMORPHISM

In general, the metamorphic grade in the study region increases from northeast to southwest from Passamaquoddy Bay to Sheepscot Bay. The highest grade metamorphic rocks, those of sillimanite grade, occur in the Sheepscot Bay area. These sedimentary and volcanic rocks have been partially melted and recrystallized producing extensive tracts of highly deformed rocks called migmatites. Most of the original structures in these rocks have been obscured due to metamorphism. Fossils are extremely rare in the rocks in the mid-coastal region and only one locality in the Rockland area has been identified to date (Boucot et al.,1976). Marine fossils of Silurian and Devonian age are seen occasionally in the volcanics and sediments found along the easternmost tip of the State.

REGIONAL STRUCTURE

The rocks in the mid-and eastern coastal area comprise the central and eastern parts of the Coastal Lithotectonic Belt (Osberg et al.,1985). The rocks of the Coastal Lithotectonic Belt are a collage of several different terranes of unknown relation. This belt is tectonically separated from the rocks of inland central Maine by a major east-verging thrust, with minor dislocation along the Norumbega Fault. Many less extensive faults cross-cut the Coastal Lithotectonic Block. One significant cross-cutting fault in this block is the Turtle Head Fault which has been mapped in western Penobscot Bay and extends from the mainland to the island of Islesboro. This fault, interpreted to be an easterly directed thrust, may represent the edge of the Avalonaian terrrane - a microcontinent that was converging toward North America during Paleozoic time and which docked on eastern North America during the mid-Paleozoic.

It is theorized that a narrowing of the ocean during Early Devonian time, caused by the underthrusting of the ocean crust beneath the continental terrain, brought the two land masses together. It is also believed that this continental collision may have resulted in the Acadian Orogeny; a period of major rock deformation, mountain building and magma generation that occurred during the Devonian. Many of the rock structures and metamorphic features of the Coastal Lithotectonic Block are thought to have developed during the Acadian Orogeny.

CRITERIA FOR SIGNIFICANT GEOLOGICAL LOCALITIES

The localities within the eastern coastal section of Maine have been selected for evaluation as Critical Areas based on the following criteria:

1. Sites critical to the interpretation of regional geology
2. Important fossil localities
3. Type or reference localities of formations
4. Localities critical to radiometric dating of rocks
5. Exceptional exposures or areas useful for educational purposes.
6. Notable mineral localities
7. Notable exposures of structural features
8. Significant mine sites, mineral dumps and formerly active mineral processing sites.
9. Unusual bedrock landforms

INVENTORY METHODS

Inventory methods used in this study were similar to methods used in previous bedrock studies performed for the Critical Areas Program by A.M. Hussey II (Hussey 1977, 1978). Nominations were solicited from geologists familiar with the geology of the eastern coastal area. Some of the sites are not described in the literature, but have been provided to us by geologists familiar with specific areas of the state. In addition, sites were selected from published reports and field trip guides. Several localities recommended in the report have been popular field trip stops for both the New England Intercollegiate Field Conference and the Geological Society of Maine Annual Field Trips.

Information on the location, description and significance of each proposed site was tabulated on a site information sheet. Each site was provided with a numerical rating in each category based on their relative importance. Three levels of significance were established for the rating scheme: moderate, high and unique. These ratings were assigned numerical values of 1, 3 and 5 respectively. Each site was then assigned a final numerical rating that allows for a ranking of all the proposed sites.

AREA DESCRIPTIONS

The recommended sites are listed by their site index numbers on Table 1. Each site has been located on a U.S.G.S quadrangle map; each map has been assigned a number and the corresponding map number is listed in the site description. Table 3 is a list of the sites in numerical order. Table 4 lists the sites recommended to be placed in the Register of Critical Areas in order of their significance. A description of the location and geologic significance of each site is presented below.

TABLE 1
Site Listing

	NAME	QUADRANGLE		TOWN	COUNTY	SIGNIFICANT FEATURES	RECOMMENDED BY
1	Cape Elizabeth/Sebascodegan Contact	Pemaquid Point	7.5	East Boothbay	Lincoln	Conformable contact between Sebascodegan (formerly Bucksport) & Cape Elizabeth important in regional stratigraphic interpretation	A. Hussey
2	Ocean Point	Pemaquid Point	7.5	East Boothbay	Lincoln	Reference or type locality for Sebascodegan Formation - bedded quartz-plagioclase-biotite-hornblende granofels	A. Hussey
3	Lincoln Sill	Boothbay Harbor	7.5	Boothbay Harbor	Lincoln	Exposure of the Lincoln Sill - a 0 - 300' thick sill that was intruded during early stages of Acadian orogeny	A. Hussey
4	Fort Edgecomb	Westport	7.5	Edgecomb	Lincoln	Silimanite-grade Cape Elizabeth - includes abundant cordierite & dumorterite (rare)	A. Hussey
5	Rte 1 Exposure of Sebascodegan Formation	Wiscassett	7.5	Edgecomb	Lincoln	Upright isoclinal folding clearly displayed in Sebascodegan and fault well exposed in outcrop	A. Hussey
6	Edgecomb Gniess/Sebascodegan Contact	Wiscassett	7.5	Edgecomb	Lincoln	Conformable contact between Edgecomb Gneiss (E. Devonian) and Sebascodegan Formation	A. Hussey
7	Pemaquid Point	Pemaquid Pt	7.5	Bristol	Lincoln	Superb exposure of upright isoclinal folds in the Sebascodegan Formation, pegmatite dikes and sills.	A. Hussey
8	Amphilbolite Pillow Structures	Friendship	7.5	Friendship	Knox	Pillow stuctures preserved in high grade metamorphics Structures are undeformed & represent only site in southern Maine where submarine extrusive lavas are confirmed.	D. Newburg A. Hussey
9	Thomaston Quarry	Thomaston	7.5	Rockland	Knox	Quarry exposes the relationship of marble and metaquartzite of the Rockland-Rockport Sequence.	A. Hussey
10	Peridotite Nickel Prospects	West Rockport	7.5	Union	Knox	A series of nickel bearing pyrrhotite zones in a lenticular body of peridotite.	A. Hussey
11	Mount Battie Road & Summit	Camden	7.5	Camden	Knox	Exposures of late pre-Cambrian quartz-pebble metaconglomerate and metaquartzite with cross bedding on road.	A. Hussey
12	Limestone-clast Conglomerate	Camden	7.5	Rockport	Knox	Buff-weathering light-gray limestone-clast conglomerate and limestone matrix	A. Hussey
13	Bald Island Breccia	North Haven E.	7.5	Brooksville	Hancock	Sub-greenschist partly devitrified hyaloclastic breccia. Near total outcrop - spectacular exposures on barren and windswept islands.	Bruce Bouley

TABLE 1
Site Listing

	NAME	QUADRANGLE		TOWN	COUNTY	SIGNIFICANT FEATURES	RECOMMENDED BY
14	Spectacle Island Spatter Tephra & Breadcrust Bombs	Cape Rosier	7.5	Brooksville	Hancock	Volcanic phenomena incredibly well-preserved. Near total outcrop: spectacular exposures on barren and windswept islands.	Bruce Bouley
15	"Goose Falls Conglomerate" or Goose Pond Agglomerate	Cape Rosier	7.5	Cape Rosier	Hancock	A coarse, polymictic, volcanoclastic, pyroclastic unit. Contains felsic & intermediate volcanic fragments, as well as granitic cobbles of uncertain origin.	Bruce Bouley
16	Turtle Head Outcrop	Searsport	7.5	Isleboro	Waldo	A sequence of thin-bedded gray siltstone and Ss beds has been folded, refolded and cleaved several times.	D.B. Stewart
17	Spruce Island, Cradle Cove & Lime Island Precambrian Rocks	Islesboro & NHW	7.5	Isleboro	Waldo	Dated pegmatites on the shore East of the camp on Spruce Island is critical. Hornblende occurrences at northwestern and southern points on the island.	D.B. Stewart
18	Condon Point Pillow Lava	Sargentville	7.5	Brooksville (south of)	Hancock	Outcrops are bedded crystal/lithic tuffs, hyaloclastite pillow breccia & some intact pillows. Perfectly preserved original volcanic features.	Bruce Bouley
19	Ames Knobb Unconformity, North Haven Island	North Haven W.	7.5	North Haven	Knox	This locality is the basis for discrimination of terranes and provides paleontologic control for a large region.	D.B. Stewart
20	Stover Hill Pavement Exposures	Blue Hill	7.5	Blue Hill	Hancock	Finely laminated rocks consisting of quartz bands separated by bands bearing aluminosilicates and garnets.	Bruce Bouley
21	Shepardson Brook Siliciclastics	Penobscot	7.5	Brooksville	Hancock	Plasticly deformed siliciclastics reminiscent of Ellsworth lithology are caught up in a volcanic mudstone.	Bruce Bouley
22	Smelter/Slag Dump near closed Blue Hill Mine	Blue Hill	7.5	Blue Hill	Hancock	Copper slag carried from smelter furnace in cauldron-like vessels. Emptying results in molded forms with occasional copper stains.	Bruce Bouley
23	Bagaduce River Narrows Terrane Juxtaposition	Penobscot	7.5	Blue Hill	Hancock	A structural unconformity occurs between the Ellsworth Schist of Cambrian or Ordovician age and the younger Castine Volcanics of Devonian age.	Bruce Bouley
24	Punch Bowl Volcanic Rock	Sargentville	7.5	Sedgwick	Hancock	Impressive fragmental volcanic rock. Rhyolitic fragments in more mafic groundmass. Color contrast between clasts & matrix is spectacular.	Bruce Bouley

TABLE 1
Site Listing

	NAME	QUADRANGLE		TOWN	COUNTY	SIGNIFICANT FEATURES	RECOMMENDED BY
25	East Blue Hill Orbicular Granite	Blue Hill	7.5	Blue Hill	Hancock	Exceptional quality outcrops of a remarkable texture in fine-grained granite.	D.B. Stewart
26	Dunham Point Mine Stilpnonelane	Deer Isle	7.5	Deer Isle	Hancock	World-class mineralogical locality: much knowledge of the crystal structure of this mineral is based on specimens from the dump, now in the tidal zone.	D.B. Stewart
27	Deer Isle Pluton	Deer Isle	7.5	Deer Isle	Hancock	Excellent exposure of the Oak Point Granite. Rapakivi	D.B. Stewart
28	Deer Isle Causeway Quarry	Deer Isle	7.5	Deer Isle	Hancock	Quarry for rip-rap, Deer Isle causeway. Ultramafic rockcutting Castine Volcanics (Devonian).	D.B. Stewart
29	Seawall Point Cranberry Island Series Tuff	Bass Harbor	7.5	Southwest Harbor	Hancock	Exposure of Cranberry Is. Series Tuff intruded by dikes & unnamed granite w/ amazonite.	R. Gilman
30	Ellsworth Schist Shatter Zone	Bartlett Island	7.5	West Tremont	Hancock	Exposure of Ellsworth schist & Ellsworth schist in shatter zone. Good examples of parasitic S & Z folds.	R. Gilman
31	Somesville Granite	SW Harbor	7.5	Mount Desert	Hancock	Exposure of medium grained-two-feldspar-biotite granite.	R. Gilman
32	Cadillac Mountain Granite	Bar Harbor	7.5	Bar Harbor	Hancock	Exposure of Cadillac Mtn granite-one-feldspar-hornblende granite - older than Somesville.	R. Gilman
33	Bar Harbor Formation	Bar Harbor	7.5	Bar Harbor	Hancock	Exposure of interbedded silt & sandstone of the Bar Harbor Formation.	R. Gilman
34	Otter Point Structural Features	Seal Harbor	7.5	Bar Harbor	Hancock	Exposure of Bar Harbor Fomation dipping shoreward - evidence of cauldron subsidence.	R. Gilman
35	Eastern Head Basalts	Moose River	7.5	Trescott	Wahington	The lava flows at eastern head show excellent pillow structures, agglomerates with the basaltic lavas and pillow lavas.	O. Gates
36	Tuff Breccia, Little River Formation	Cutler	7.5	Cutler	Washington	Excellent exposures of Tuff Breccia are found along the shore are found along the Machias penninsula.	O. Gates
37	Great Head, Fossiliferous Conglomerates	Cutler	7.5	Cutler	Washington	Here a section of conglomerate eighty feet thick is well exposed. Fossils have been identified in the cobbles and the matrix of the conglomerate.	O. Gates
38	Culter Diabase	Cutler	7.5	Cutler	Washington	The diabase repeatedly intruded the surrounding country rock to form sills, dikes, lenticular plugs and irregular plutons.	O. Gates

TABLE 1
Site Listing

	NAME	QUADRANGLE		TOWN	COUNTY	SIGNIFICANT FEATURES	RECOMMENDED BY
39	Holmes Cove Keratophyres	Cutler	7.5	Cutler	Washington	The keratophyes occur as small dikes and irregular plutons that have been intruded into the Little River Formation.	O. Gates
40	Cutler Diabase Columnar Jointing	Cutler	7.5	Cutler	Washington	Excellent examples of columnar jointing and pillow lava structures exposed on shore.	O. Gates
41	Edmunds Tuff Breccia	West Lubec	7.5	Edmunds	Washington	Exposure of maroon, white to pink tuff breccias of Edmunds Formation - indicative of submarine pyroclastic flows or avalanche deposits.	O. Gates
42	Perry Formation Lava Flows	Eastport	7.5	Perry	Washington	Basalt lava flows exposed along the shore of Casco Bay basalt is amygdaloidal.	O. Gates
43	Quoddy Bay State Park Gabbro/Shale	Lubec	7.5	Lubec	Washington	Silurian to Devonian gabbros intrude Quoddy Formation Shales. Triassic fault basin to east.	O. Gates
44	Reversing Falls - Edmunds Bedded Tuffs	Pembroke	7.5	Pembroke	Washington	Fossiliferous bedded tuffs, siltstones, argillites and cherts.	O. Gates
45	Eastport Formation Sedimentary (Type) Section	Eastport	7.5	Eastport	Washington	Gray, green to maroon bedded shales. Siltstones and conglomerates of the Eastport Fm. Sedimentary and fossiliferous.	O. Gates
46	Perry Conglomerate - Typical Section	Eastport	7.5	Perry	Washington	Red-maroon coarse boulder & pebble conglomerate and arkosic sandstone.	O. Gates
47	Schooner Cove Fossil Locality	Pembroke	7.5	Pembroke	Washington	Limy siltstone & shale of Leighton Formation with numerous fossils of the Salopina Formation.	O. Gates
48	Quoddy Shale Type Section	Lubec	7.5	Lubec	Washington	black, siliceous siltstone, argillite and shale	O. Gates
49	Leighton Shale	Pembroke	7.5	Pembroke	Washington	Gray shale, siltstone & mudstone & lapilli tuff & tuff breccias.	O. Gates
50	Lubec Lead Mine	West Lubec	7.5	Lubec	Washington	Deposit discovered in mine. Significant minerals include Galena, Sphalerite, Calcophrite, Pyrite and Limonite.	A. Hussey
51	Lamb Cove Unconformity	Red Beach	7.5	Robbinston	Washington	Unconformity between basal conglomerate of the Perry Formation and Eastport volcanics.	O. Gates

TABLE 3

RECOMMENDED SITES BY MAP INDEX NUMBER

1. **Cape Elizabeth-Sebascodegan Contact**
   Quadrangle: Pemaquid Point 7.5'
   Town: East Boothbay

2. **Ocean Point**
   Quadrangle: Pemaquid Point 7.5'
   Town: East Boothbay

3. **Lincoln Sill**
   Quadrangle: Boothbay Harbor 7.5'
   Town: Boothbay Harbor

4. **Fort Edgecomb**
   Quadrangle: Westport 7.5'
   Town: Edgecomb

5. **Route 1 Exposure of the Sebascodegan Formation**
   Quadrangle: Wiscasset 7.5'
   Town: Edgecomb

6. **Edgecomb Gneiss/Bucksport Contact**
   Quadrangle: Wiscasset 7.5'
   Town: Edgecomb

7. **Pemaquid Point**
   Quadrangle: Pemaquid Point 7.5'
   Town: Bristol

8. **Amphibolite Pillow Structure**
   Quadrangle: Friendship 7.5'
   Town: Friendship

9. **Thomaston Quarry**
   Quadrangle: Thomaston 7.5'
   Town: Rockland

10. **Peridotite Nickel Prospects**
    Quadrangle: West Rockport 7.5'
    Town: Union

11. **Mount Battie Road & Summit**
    Quadrangle: Camden 7.5'
    Town: Camden

12. **Limestone-clast Conglomerate**
    Quadrangle: Camden 7.5'
    Town: Rockport

13. **Bald Island Breccia**
    Quadrangle: North Haven East 7.5'
    Town: Brooksville

14. **Spectacle Island Spatter Tephra and Breadcrust Bombs**
    Quadrangle: Cape Rosier 7.5'
    Town: Brooksville

15. **"Goose Falls Conglomerate" or Goose Pond Agglomerate**
    Quadrangle: Cape Rosier 7.5'
    Town: Cape Rosier

16. **Strongly Cleaved Rocks at Turtle Head, Islesboro**
    Quadrangle: Searsport 7.5'
    Town: Islesboro

17. **Spruce Island, Cradle Cove and Lime Island Precambrian Rocks**
    Quadrangle: Islesboro 7.5' and North Haven West 7.5'
    Town: Islesboro

18. **Condon Point Pillow Lava**
    Quadrangle: Sargentville 7.5'
    Town: Brooksville

19. **Ames Knobb Unconformity, North Haven Island**
    Quadrangle: North Haven West 7.5'
    Town: North Haven Island

20. **Stover Hill Pavement Exposures**
    Quadrangle: Blue Hill 7.5'
    Town: Blue Hill

21. **Shepardson Brook Siliciclastics**
    Quadrangle: Penobscot 7.5'
    Town: Brooksville

22. **Smelter/Slag Dump near closed Blue Hill Mine**
    Quadrangle: Blue Hill 7.5'
    Town: Blue Hill

23. **Bagaduce River Narrows**
    Quadrangle: Penobscot 7.5'
    Town: Blue Hill

24. **Punch Bowl Volcanic Rock**
    Quadrangle: Sargentville 7.5'
    Town: Sedgewick

25. **East Blue Hill Orbicular Granite**
    Quadrangle: Blue Hill 7.5'
    Town:Blue Hill

26. **Dunham Point Mine Stilpnonelane**
Quadrangle: Deer Isle 7.5'
Town: Deer Isle

27. **Deer Isle Pluton**
Quadrangle: Deer Isle 7.5'
Town: Deer Isle

28. **Deer Isle Causeway Quarry**
Quadrangle: Deer Isle 7.5'
Town: Deer Isle

29. **Seawall Point Cranberry Island Series Tuff**
Quadrangle: Bass Harbor 7.5'
Town: Southwest Harbor

30. **Ellsworth Schist Shatter Zone**
Quadrangle: Bartlett Island 7.5'
Town: West Tremont

31. **Somesville Granite**
Quadrangle: Southwest Harbor 7.5'
Town: Mount Desert

32. **Cadillac Mountain Granite**
Quadrangle: Bar Harbor 7.5'
Town: Bar Harbor

33. **Bar Harbor Formation**
Quadrangle: Bar Harbor 7.5'
Town: Bar Harbor

34. **Otter Point Structural Features**
Quadrangle: Seal Harbor 7.5'
Town: Bar Harbor

35. **Eastern Head Basalts**
Quadrangle: Moose River 7.5'
Town: Trescott

36. **Tuff Breccia, Little River Formation**
Quadrangle: Cutler 7.5'
Town: Cutler

37. **Great Head Fossiliferous Conglomerates**
Quadrangle: Cutler 7.5'
Town: Cutler

38. **Cutler Diabase**
Quadrangle: Cutler 7.5'
Town: Cutler

39. **Holmes Cove Keratophyres**
Quadrangle: Cutler 7.5'
Town: Cutler

40. **Cutler Diabase Columnar Jointing**
Quadrangle: Cutler 7.5'
Town: Cutler

41. **Edmunds Tuff Breccias**
Quadrangle: West Lubec 7.5'
Town: Edmunds

42. **Perry Formation Lava Flows**
Quadrangle: Eastport 7.5'
Town: Perry

43. **Quoddy State Park Gabbros and Shales**
Quadrangle: Lubec 7.5'
Town: Lubec

44. **Reversing Falls - Edmunds Bedded Tuffs**
Quadrangle: Pembroke 7.5'
Town: Pembroke

45. **Eastport Formation Sedimentary (Type) Section**
Quadrangle: Eastport 7.5'
Town: Eastport

46. **Perry Conglomerate - Typical Section**
Quadrangle: Eastport 7.5'
Town: Perry

47. **Schooner Cove Fossil Locality**
Quadrangle: Pembroke 7.5'
Town: Pembroke

48. **Quoddy Shale Type Section**
Quadrangle: Lubec 7.5'
Town: Lubec

49. **Leighton Shale**
Quadrangle: Pembroke 7.5'
Town: Pembroke

50. **Lubec Lead Mine**
Quadrangle: West Lubec 7.5'
Town: Lubec

51. **Lamb Cove Unconformity**
Quadrangle: Red Beach 7.5'
Town: Robbinston

TABLE 4

PRIORITIZED RECOMMENDED SITES TO BE PLACED IN THE REGISTER OF CRITICAL AREAS

Significance Rating	Name of Site
Unique	Amphibolite Pillow Structure
17	Quoddy Shale Type Section
16	Eastern Head Basalts
16	Great Head Fossiliferous Conglomerates
16	Spruce Island, Cradle Cove and Lime Island Precambrian Rocks
15	Reversing Falls - Edmunds Bedded Tuffs
15	Seawall Point Cranberry Island Series Tuff
14	Mount Battie Road & Summit
14	Peridotite Nickel Prospects
14	Quoddy State Park Gabbros and Shales
14	Schooner Cove Fossil Locality Shales
12	Bar Harbor Formation
12	Cutler Columnar Basalts and Pillow Lavas
12	Edmunds Tuff Breccias
12	Ellsworth Schist Shatter Zone
12	Holmes Cove Keratophyre
12	Ocean Point
12	Somesville Granite

<u>12</u>	Tuff Breccia, Little River Formation
<u>11</u>	Perry Formation Lava Flows
<u>10</u>	Condon Point Pillow Lava
<u>10</u>	Cutler Diabase
<u>10</u>	Dunham Point Mine Stilpnonelane
<u>10</u>	Eastport Formation Sedimentary Type Section
<u>10</u>	Perry Conglomerate - Typical Section
<u>10</u>	Spectacle Island Spatter Tephra & Breadcrust Bombs
<u>9</u>	Ames Knobb Unconformity, North Haven Island
<u>9</u>	Cadillac Mountain Granite
<u>9</u>	Cape Elizabeth - Sebascodegan Contact
<u>9</u>	Edgecomb Gneiss/Sebascodegan Contact
<u>9</u>	Fort Edgecomb
<u>9</u>	Lamb Cove Unconformity
<u>9</u>	Limestone-clast Conglomerate
<u>9</u>	Lincoln Sill
<u>9</u>	Route 1 Exposure of the Sebascodegan Contact
<u>9</u>	Smelter/Slag Dump near closed Blue Hill Mine
<u>9</u>	Thomaston Quarry
<u>8</u>	Turtle Head Outcrop
<u>6</u>	"Goose Falls Conglomerate" or Goose Pond Agglomerate

6	Pemaquid Point
6	Shepardson Brook Siliciclastics
6	Stover Hill Pavement Exposures Terrane Juxtaposition
5	Bagaduce River Narrows
5	Leighton Shale
3	Bald Island Breccia
3	Punch Bowl Volcanic Rock
3	East Blue Hill Orbicular Granite
2	Deer Isle Causeway Quarry
2	Deer Isle Pluton
2	Lubec Lead Mine
2	Otter Point Structural Features

SITE DESCRIPTIONS

Name: **Cape Elizabeth-Sebascodegan Contact**
Site/Index Map No: 1
Town: East Boothbay
County: Lincoln
Quadrangle: Pemaquid Point 7.5'
Significance: High; formation contact
Status: Recommended to be placed on Register
Recommended by: A.M. Hussey II
Reference: Hussey 1986, 1988

The contact between the Cape Elizabeth Formation and Sebascodegan Formation is clearly exposed here. The Sebascodegan was originally mapped as the Bucksport Formation, but lithic similarity, similarity of sequence, and facies interpretation suggest that these rocks correlate with the upper part of the Cushing Formation in the Harpswell area (Hussey, 1988). The contact is interpreted as a conformable sedimentary contact; this indicates that there is a sedimentary relationship between these units, rather than juxtaposition resulting from faulting or erosion. The Sebascodegan Formation exhibits graded bedding, observed as calc-silicate granofels grading into biotite granofels. At present, the topping significance of these beds is unknown. When this question is resolved, this locality will provide information crucial to the understanding of the regional tectonic evolution of mid-coastal Maine.

Name: **Ocean Point**
Site/Index Map No: 2
Town: East Boothbay
County: Lincoln
Quadrangle: Pemaquid Point 7.5'
Significance: High; structural features
Status: Recommended to be placed on Register
Recommended by: A.M. Hussey II
Reference: Hussey 1986

A superb example of the Sebascodegan Formation, this exposure consists of thin- to medium-bedded quartz-plagioclase-biotite-hornblende granofels and greenish-gray calc-silicate granofels. Upright folds with axial plunges, varying from gentle to the northeast to gentle to the southeast, are excellently displayed. Obliquely cross-cutting granite dikes have been deformed into asymmetric folds during layer-parallel flattening. Large pegmatite dikes are present and show evidence locally of forceful injection.

Name: **Lincoln Sill**
Site/Index Map No: 3
Town: Boothbay Harbor
County: Lincoln
Quadrangle: Boothbay Harbor 7.5'
Significance: High; cross-cutting relationships
Status: Recommended to be placed on Register
Recommended by: A.M. Hussey II
Reference: Trefethen 1937, Hussey 1986

The Lincoln Sill at McKown Point in Boothbay Harbor is a superb example of cross-cutting relationships. The sill consists of a tabular mass varying from 0' - 300' in thickness that was intruded into the lower part of the Sebascodegan Formation during the early stages of the Acadian Orogeny. The sill was subsequently cross-cut by pegmatite and granite stringers. This cross-cutting relationship allows the relative age relationships between the Lincoln Sill and the surrounding rock formations to be determined. The sill is a coarse-grained, dark gray, biotite schist with large conspicuous relict phenocrysts of purplish gray orthoclase. Prior to metamorphism, the sill was a syenite of unusual composition similar to shonkinite.

Name: **Fort Edgecomb**
Site/Index Map No: 4
Town: Edgecomb
County: Lincoln
Quadrangle: Westport 7.5'
Significance: High; minerals - corderite, dumortierite
Status: Recommended to be placed on Register
Recommended by: A.M. Hussey II
Reference: Hussey 1984, 1986

Fort Edgecomb exhibits is a 100 x 20' exposure of sillimanite-grade Cape Elizabeth Formation that has been injected by pegmatite stringers. At the contacts between the pelitic layers of the Cape Elizabeth Formation and the pegmatites, cordierite, a high-grade metamorphic mineral, can be seen. The mineral corderite is commonly found in contact- metamorphosed rocks and is used as an index for the grade or degree of metamorphism that has occurred at that location. In addition, the pegmatites at this locality carry tiny, scattered, needle-like grains of dumortierite, an aluminum-boron-silicate mineral. Dumortierite is uncommon in Maine, and is only known to occur at two other locations in the state.

Name: **Route 1 Exposure of the Sebascodegan Formation**
Site/Index Map No: 5
Town: Edgecomb
County: Lincoln
Quadrangle: Wiscasset 7.5'
Significance: High; folds, faults
Status: Recommended to be placed on Register
Recommended by: A.M. Hussey II
Reference: Hatheway 1969, Hussey 1984, 1986, 1988

This locality contains good exposures of lithologies and structures typical of the Sebascodegan Formation. At this locality, pegmatites of Acadian age and small quartz veins are folded by tight upright folds in the Sebascodegan Formation. The axial plane of one synclinal fold at this location is occupied by a 5-inch- thick quartz-plagioclase-biotite orthogneiss dike which clearly postdates the quartz vein development and upright folding. Exceptionally exposed at this locality is a late brittle fault. Incoherent fault gouge occupies the fault surface. The surfaces on the slickensides on the adjacent pegmatites suggest predominant strike-slip motion. The amount of displacement along the fault is indeterminate.

Name: **Edgecomb Gneiss/ Sebascodegan Contact**
Site/Index Map No: 6
Town: Edgecomb
County: Lincoln
Quadrangle: Wiscasset 7.5'
Significance: High; reference locality
Status: Recommended to be placed on Register
Recommended by: A.M. Hussey II
Reference: Hatheway 1969

Exposed in a road cut along US Route 1 is the conformable contact between the Edgecomb Gneiss and the Sebascodegan Formation. This is also the principal reference locality for the Edgecomb Gneiss, which is presumed to be Early Devonian in age. The Edgecomb Gneiss was intruded between the Cape Elizabeth Formation and the Sebascodegan Formation and occurs as a tabular, sill-like mass in mid-coastal Maine. It has been metamorphosed by the Acadian Orogeny.

Name: **Pemaquid Point**
Site/Index Map No: 7
Town: Bristol
County: Lincoln
Quadrangle: Pemaquid Point 7.5'
Significance: High; folds in the Sebascodegan Formation.
Status: Recommended to be placed on Register
Recommended by: A.M. Hussey II
Reference: Hussey, pers. comm.

This locality provides superb exposures of the Sebascodegan Formation. The Sebascodegan Formation consists of metamorphosed feldspathic sandstones, shale and calcareous shale to siltstones. At Pemaquid Point, the Sebascodegan Formation consists of calc-silicate granofels and biotite granofels. Excellent examples of upright folds are seen at the shoreline exposures. Pegmatite sills are found within these upright folds, and they display a "pinch and swell" structure. This locality is significant because of the variety of geologic environments and metamorphic conditions captured in the rocks. For this reason it is frequently visited by college and high school geology classes.

Name: **Amphibolite Pillow Structure**
Site/Index Map No: 8
Town: Friendship
County: Knox
Quadrangle: Friendship 7.5'
Significance: Unique; pillow structures in an amphibolite
Status: Recommended to be placed on Register
Recommended by: A.M. Hussey II
Reference: Hussey 1972, Newberg 1976

In shoreline exposures in Friendship, pillow structures are well-preserved in sillimanite-grade amphibolite. Pillow structures are ellipsoid, sac-like forms that are created when molten lava flows out under water and cools rapidly. Pillow structures provide evidence that the ocean was present at the time of volcanism. The pillows in Friendship are significant because they are unusually well-preserved in the high-grade metamorphic rocks, and the vesicular texture in the interior of the pillows is still visible. Also, this location is the only site in southern Maine where the oceanic environment for extrusion of basaltic lava can be clearly identified. Because the structure of the pillows is not significantly deformed, the high grade metamorphism of these rocks was probably a relatively static post-tectonic event.

Name: **Thomaston Quarry**
Site/Index Map No: 9
Town: Thomaston
County: Waldo
Quadrangle: Thomaston 7.5'
Significance: High; reference locality
Status: Recommended to be placed on Register
Recommended by: A.M. Hussey II
Reference: Osberg, P. & C. Guidotti 1974

The inactive quarry in Thomaston, located southeast of the cement plant, provides excellent exposures of the white quartzite and marble that characterize the Rockland-Rockport marble sequence. The metasedimentary rocks in this group consist of white glassy quartzites, quartzite conglomerates, thinly bedded white and gray marbles, limestone conglomerates and quartz-mica- garnet-andalusite schist.

Name: **Peridotite Nickel Prospects**
Site/Index Map No: 10
Town: Union
County: Knox
Quadrangle: West Rockport 7.5'
Significance: High; significant minerals
Status: Recommended to be placed on Register
Recommended by: A.M. Hussey II
Reference: Rand 1958

A series of nickel bearing pyrrhotite zones in a lenticular body of peridotite. Notable minerals include pyrrhotite, pentlandite, chalcopyrite, magnetite and sphalerite.

Name: **Mount Battie Road & Summit**
Site/Index Map No: 11
Town: Camden
County: Waldo
Quadrangle: Camden 7.5'
Significance: Unique; structural features; reference locality
Status: Recommended to be placed on Register
Recommended by: A.M. Hussey II
Reference: Osberg, unpubl.

A thinly-laminated metaquartzite displaying cross-bedding is exposed along the access road to the summit of Mt. Battie. These exposures display excellent examples of primary sedimentary features - cross-bedding and laminations. These features aid in the interpretation of ancient geologic environments. At the summit of Mt. Battie, there are exposures of a quartz pebble metaconglomerate. This rock unit is unusual in that it is thought to be Late Precambrian in age, over 500 million years old.

Name: **Limestone-clast Conglomerate**
Site/Index Map No. 12
Town: Rockport
County: Waldo
Quadrangle: Camden 7.5'
Significance: High; excellent exposure of marble and quartzite
Status: Recommended to be placed on Register
Recommended by: A.M. Hussey II
Reference: Osberg and Guidotti 1974

This exposure is an excellent example of the Rockland-Rockport sequence referred to as Unit 1. At the eastern end of the exposure, the outcrop is a buff weathered, light-gray limestone clast conglomerate with a limestone matrix. The clasts in the limestone appear to be only slightly deformed. At the western end of the exposure, an interbedded marble and dark gray biotite quartzite crop out. Here, folds with axial plane surfaces that vary from steep to nearly horizontal are seen.

Name: **Bald Island Breccia**
Site/Index Map No: 13
Town: Brooksville
County: Hancock
Quadrangle: North Haven East 7.5'
Significance: Moderate; exposure of volcanic breccia, educational
Status: Recommended to be placed on Register
Recommended by: Bruce Bouley
Reference: Bouley 1978

This locality exhibits subgreenschist (prehnitepumpellyite) and partially devitrified hyaloclastite breccia all along the northeast corner of the island. A breccia is formed from angular fragments of volcanic fragments pyroclasts, that have welded together to form a single rock mass. A near-total outcrop, there are spectacular exposures on the island.

Name: **Spectacle Island Spatter Tephra & Breadcrust Bombs**
Site/Index Map No: 14
Town: Brooksville
County: Hancock
Quadrangle: Cape Rosier 7.5'
Significance: High; superb preservation of volcanic features - tephra, bombs
Status: Recommended to be placed on Register
Recommended by: Bruce Bouley
Reference: Bouley 1978

Here are volcanic phenomena incredibly well-preserved. It is a near-total outcrop, clearly representing a volcanic throat, and there are spectacular exposures on barren and windswept islands. These features, called pyroclasts, represent fragments of volcanic rock that were ejected into the air during an eruption. These volcanic features of the Castine Formation are seen on many islands of Penobscot Bay. The tephra deposits and bombs are typical of the mafic and intermediate composition sections of the Castine Formation.

Name: **"Goose Falls Conglomerate" or Goose Pond Agglomerate**
Site/Index Map No: 15
Town: Cape Rosier
County: Hancock
Quadrangle: Cape Rosier 7.5'
Significance: High; reference locality, excellent exposure of volcanic agglomerate
Status: Recommended to be placed on Register
Recommended by: Bruce Bouley
Reference: Bouley 1978

This peculiar agglomerate mass occurs at the reversing falls of Goose Pond, now dammed. It consists of unsorted heterolithic fragmental rock with a considerable juvenile component of clasts and matrix; it almost certainly represents a directed blast deposit that occurred during some major magmatic/tectonic event during the growth of a Late Silurian volcanic edifice. A coarse, volcanoclastic, pyroclastic unit, it contains felsic and intermediate volcanic fragments, as well as granitic cobble of uncertain origin. Yoked to this rock, both geographically and geologically, are the volcanic domes that occur at the Harborside Mine site and elsewhere on Cape Rosier. The dome forming the conspicuous hill west of the Penobscot open pit locality may also be considered a classic rhyolite dome locality.

Name: **Strongly Cleaved Rocks at Turtle Head,Islesboro**
Site/Index Map No: 16
Town: Islesboro
County: Waldo
Quadrangle: Searsport 7.5'
Significance: High; structural features
Status: Recommended to be placed on Register
Recommended by: D.B. Stewart
Reference: Stewart 1974

Here is an excellent exposure of cleavage development and refraction across sand-pelite packages. A sequence of thin- bedded grey siltstone and Ss beds has been folded and cleaved several times. Axial plane cleavage becomes highly developed, spectacular cleavage refraction is seen across sandy silty beds, and extensive chemical migration has formed new mineral layerings parallel to cleavage. The minerals are chlorite, muscovite, albite and quartz. The sequence of cleavage orientations probably results from rotations of compression axes during fault motion, rather than recrystallization during epochs of deformation.

Name: **Spruce Island, Cradle Cove and Lime Island Precambrian Rocks**
Site/Index Map No: 17
Town: Islesboro
County: Waldo
Quadrangle: Islesboro 7.5' and North Haven West 7.5'
Significance: Unique; Pre-Cambrian date
Status: Recommended to be placed on Register
Recommended by: D.B. Stewart
Reference: Stewart 1974

The dated (620 my) pegmatite on the shore east of the camp on Spruce Island is critical, and hornblende occurrences at the northwestern and southern points on this island have also yielded important dates of 660 ±10 m.y., for the high-grade metamorphism. The muscovite pegmatite in impure marble directly below the A-frame camp, a Precambrian pegmatite noted by Smith, Bastin & Brown, has been isotopically dated (K/Ar: 594+18 m.y., 599+15 m.y.). The Rb/Sr mineral isochron, performed by Brookins & Stewart, yields 620+18 m.y. In addition to the impure marble,

garnet-bearing schist crops out on the eastern shore of the cove southeast of the dolomite.

The Precambrian rocks at the landing at Dark Harbor Boat Yard Corporation at Cradle Cove, Seven Hundred Acre Island, are found in individual beds approximately 10 m. thick, varying greatly in composition. Thin beds of quartzite and carbonate suggest mio geo byn sedimentation. Also, feldspathic gneiss, greenstone and amphibolite indicate igneous formation. Meta- large garnets, andalusite to chiastolite are present. Rb/Sr data yields an age of 750+ 100 m.y.

Name: **Condon Point Pillow Lava**
Site/Index Map No: 18
Town: Brooksville
County: Hancock
Quadrangle: Sargentville 7.5'
Significance: High; classic pillow lava
Status: Recommended to be placed on Register
Recommended by: Bruce Bouley
Reference: Bouley 1978

The classic texture and morphology of the tubular and budding pillows are phenomenally well-preserved at this locality, which is accentuated by the tides of Penobscot Bay. The outcrops are bedded crystal/lithic tuffs, hyaloclastite pillow breccia and some intact pillows. Original volcanic features are perfectly preserved: euhedral feldspars in volcanic tuffs, spherical vesicles, and undeformed pillows.

Name: **Ames Knobb Unconformity, North Haven Island**
Site/Index Map No: 19
Town: North Haven Island
County: Knox
Quadrangle: North Haven West 7.5'
Significance: High; stratigraphic relationships
Status: Recommended to be placed on Register
Recommended by: D.B. Stewart
Reference: Stewart 1974

This locality is the basis for discrimination of terranes and provides paleologic control for a large region. Here the unconformity between the Ellsworth Schist and the Castine Volcanics is well exposed. This unconformity, first recognized by Wingard in 1958, has folds with amplitudes ranging from 5 to 70 meters.

Name: **Stover Hill Pavement Exposures**
Site/Index Map No: 20
Town: Blue Hill
County: Hancock
Quadrangle: Blue Hill 7.5'
Significance: Moderate; exposure of Castine Volcanics
Status: Recommended to be placed on Register
Recommended by: Bruce Bouley
Reference: Bouley, pers. comm.

At this locality, finely laminated rocks consist of quartz bands separated by bands bearing aluminosilicates and garnets. The best exposures face west and are easily accessible on foot from the road to First Pond.

Name: **Shepardson Brook Siliciclastics**
Site/Index Map No: 21
Town: Brooksville
County: Hancock
Quadrangle: Penobscot 7.5'
Significance: High; significant age relationships
Status: Recommended to be placed on Register
Recommended by: Bruce Bouley
Reference: Bouley 1978

Here plastically deformed siliciclastics reminiscent of Ellsworth lithology are caught up in a volcanic mudstone. It is thought of as basal Castine succession with erosional clasts of Ellsworth, thereby documenting the relative age relationships. An alternative explanation is that a slump feature where chemical sedimentary basinal deposits from an intervolcanic hiatus were caught up in a seismically driven mass wasting event.

Name: **Smelter/Slag Dump near closed Blue Hill Mine**
Site/Index Map No: 22
Town: Blue Hill
County: Hancock
Quadrangle: Blue Hill 7.5'
Significance: High; former active mine site
Status: Recommended to be placed on Register
Recommended by: Bruce Bouley
Reference: Rand 1958

At the closed Blue Hill Mine, it appears that copper slag was carried from a smelter furnace in cauldron-like vessels which were emptied after the slag had partly or completely solidified. The resulting forms are reminiscent of jell-o knocked out of molds; they resemble in physical appearance oversized WWII German helmets. This type of smelting/slag vessel was peculiar to the industry at a certain time in its development, and there is extensive development. Copper stain and an occasional blob of native copper can be found.

Name: **Bagaduce River Narrows Terrain Juxtaposition**
Site/Index Map No: 23
Town: Blue Hill
County: Hancock
Quadrangle: Penobscot 7.5'
Significance: High; unconformity
Status: Recommended to be placed on Register
Recommended by: Bruce Bouley
Reference: Bouley,pers. comm.

Here a structural unconformity occurs between the Ellsworth Schist of Cambrian or Ordovician age and the younger Castine Volcanics of Devonian age. This locality is THE critical locality for discussing relative age relationships between the Ellsworth and Castine terrains. The unconformity initially had hundreds of feet of relief and is thought to have subsequently folded. The cordierite/andalusite rocks present are important time limiters insofar as they record the thermal overprint of the South Penobscot pluton, which has been dated. The metamorphic differences between the Ellsworth an Castine rocks are clearly evident in this outcrop exposure.

Name: **Punch Bowl Volcanic Rock**
Site/Index Map No: 24
Town: Sedgwick
County: Hancock
Quadrangle: Sargentville 7.5'
Significance: Moderate; exposure of volcanic rocks
Status: Recommended to be placed on Register
Recommended by: Bruce Bouley
Reference: Bouley 1978

Impressive fragmental volcanic rock makes up most of the shore line. It consists mostly of rhyolitic fragments in more mafic, perhaps even muddy, groundmass. The color contrast between the clasts and matrix makes for a most spectacular outcrop. These rocks were formed during the period of volcanism that formed the Castine Volcanic series.

Name: **East Blue Hill Orbicular Granite**
Site/Index Map No: 25
Town: Blue Hill
County: Hancock
Quadrangle: Blue Hill 7.5'
Significance: Moderate; interpretive, unusual igneous rock
Status: Recommended to be placed on Register
Recommended by: D.B. Stewart
Reference: Stewart, pers. comm.

The orbicular granite at East Blue Hill, between the highway bridge and the cove, consists of exceptional quality outcrops of a remarkable texture in fine-grained granite. An orbicular granite contains unusual spherical grains that are usually arranged in continuous layers in the rock. it is very unusual for a igneous rock to have these spherical grains, rather than the typical angular.

Name: **Dunham Point Mine Stilpnonelane**
Site/Index Map No: 26
Town: Deer Isle
County: Hancock
Quadrangle: Deer Isle 7.5'
Significance: High; significant mineral
Status: Recommended to be placed on Register
Recommended by: D.B. Stewart
Reference: Stewart, pers. comm.

The stilpnonelane at the Dunham Point Mine constitutes a world-class mineralogical locality. Much knowledge of the crystal structure of this mineral is based on specimens from the dump, now in the tidal zone. Stilpnonelane is a greenish black mineral that occurs in mica-like plates, fibrous forms, and velvety bronze incrustations.

Name: **Deer Isle Pluton**
Site/Index Map No: 27
Town: Deer Isle
County: Hancock
Quadrangle: Deer Isle 7.5'
Significance: High; radiometric date; excellent exposure
Status: Recommended to be placed on Register
Recommended by: D.B. Stewart
Reference: Stewart 1974

Here are dated outcrops of coarse-grained Rapakivi granite in the Deer Isle pluton. Rb/Sr (WR) dating yields an age of 357+ 1 m.y. This locality is an excellent exposure of the Oak Point granite, an eastern and outer member of the Deer Isle Pluton. The hornblende-bearing rapakivi texture is especially well-developed. There is a large number of opalite dikes, and the bright red-orange color of alkali feldspars is visible. There is an abundance of inclusions and development of rapakivi porphryblasts with inclusions. The alteration is well-developed along joints. The radical fracture pattern may be seen because of blasting for the roadcut.

A "Rapakivi" granite is a granite that contains orthoclase feldspar crystals hat are mantled with plagioclase. The term was first used Urban Hjare to describe crumbly stone in certain outcrops in Finland. these rocks are often coarse grained and consequently the feldspars weather easily to form "rotten stone", or Rapakivi in Finish.

Name: **Deer Isle Causeway Quarry**
Site/Index Map No: 28
Town: Deer Isle
County: Hancock
Quadrangle: Sargentville 7.5'
Significance: Moderate; ultramafic plutonic rock; cross-cutting
Status: Recommended to be placed on Register
Recommended by: D.B. Stewart
Reference: Stewart 1974

At the quarry for rip-rap, at the Deer Isle causeway, there is an exposure of ultramafic rock cutting Castine Volcanics. This hornblende rich diorite,intruding the Castine Volcanics, is thought to be Devonian in age.

Name: **Seawall Point Cranberry Island Series Tuff**
Site/Index Map No: 29
Town: Southwest Harbor
County: Hancock
Quadrangle: Bass Harbor 7.5'
Significance: High; good exposure; amazonite mineral occurrence
Status: Recommended to be placed on Register
Recommended by: R. Gilman
Reference: Gilman 1986

At Seawall Point, the Cranberry Island Series tuff and granite are exposed. There are lithic fragments of aphanitic volcanics and intrusions of diabase dikes. The age relationship of the granite exposures to other granites is unknown. There are examples of unusual blue-green amazonite feldspar crystals.

Name: **Ellsworth Schist Shatter Zone**
Site/Index Map No: 30
Town: West Tremont
County: Hancock
Quadrangle: Bartlett Island 7.5'
Significance: High; structural features
Status: Recommended to be placed on Register
Recommended by: R. Gilman
Reference: Gilman 1986

Here is an example of the Ellsworth schist in a fine-grained matrix of the shatter zone, as well as exposures of the Ellsworth schist not in the shatter zone. The Ellsworth schist displays S & Z parasitic folds. The rocks that make up the schist are typically highly deformed with numerous small folds and crinkles. The age of these rocks is not certain, but at the present time they are thought to be Ordovician in age.

Name: **Somesville Granite**
Site/Index Map No: 31
Town: Mount Desert
County: Hancock
Quadrangle: Southwest Harbor 7.5'
Significance: High; good exposure
Status: Recommended to be placed on Register
Recommended by: R. Gilman
Reference: Gilman 1986

The Somesvillle Granite is a medium-grained, biotite granite, rich in feldspars. It is younger than the Cadillac granite. This intrusive igneous rock is thought to be Devonian in age. It was intruded into the older Cadillac granite. The Somesville Granite can be distinguished from the Cadillac granite by the presence of two feldspars perthite microcline and sodium plagioclase.

Name: **Cadillac Mountain Granite**
Site/Index Map No: 32
Town: Bar Harbor
County: Hancock
Quadrangle: Bar Harbor 7.5'
Significance: High; good exposure
Status: Recommended to be placed on Register
Recommended by: R. Gilman
Reference: Gilman 1986

Here are exposures of the Cadillac Mountain Granite with oriented inclusions of saucer-shaped dark rocks. The best exposures of these are on Great Hill just north of this location. The granite is a one-feldspar-hornblende granite with a coarse-grained hydromorphic texture, older than the Somesville granite. When the pluton intruded the country rock, the Ellsworth Schist, it formed a shatter zone that extends for as much as a half a mile from the contact.

Name: **Bar Harbor Formation**
Site/Index Map No: 33
Town: Bar Harbor
County: Hancock
Quadrangle: Bar Harbor 7.5'
Significance: Unique; reference locality
Status: Recommended to be placed on Register
Recommended by: R. Gilman
References: Gilman 1986

This exposure of the Bar Harbor Formation exhibits thin- to thick-bedded sandstone and siltstone interbedded with light-colored, microcrystalline rock. Some visible sedimentary features are cut/fill structures, cross-bedding and graded bedding. These rocks may have originally been deposited as water-laid volcanic materials. It is thought to be Silurian in age.

Name: **Otter Point Structural Features**
Site/Index Map No: 34
Town: Bar Harbor
County: Hancock
Quadrangle: Seal Harbor 7.5'
Significance: Moderate; structural features
Status: Recommended to be placed on Register
Recommended by: R. Gilman
Refernces: Gilman 1986

The exposure at Otter Point Cliff consists of variously colored quartzite and metasiltstone with bedding dipping shoreward toward a body of hornblende granite. There is evidence of cauldron subsidence along the ring-fracture zone.

Name: **Eastern Head Basalts**
Site/Index Map No: 35
Town: Trescott
County: Washington
Quadrangle: Moose River 7.5'
Significance: Unique; volcanic features
Status: Recommended to be placed on Register
Recommended By: O.Gates
Reference: Gates 1961

Eastern Head contains superlative exposures of balsaltic lavas and agglomerates of the Little River Formation. The rocks were formed during a period explosive volcanism that occurred during the Silurian period. The lava flows at Eastern Head show excellent pillow structures with elliptical shaped bulbs that are up to three feet in length. Fine black siliceous material, probably ash, can be found between the pillow structures. Excellent exposures of basaltic agglomerate are also seen at Eastern Head. The agglomerates interfinger with the basaltic lavas and pillow lavas. Eastern Head may represent the location of one of the original volcanic vents.

Name: **Tuff Breccia, Little River Formation**
Site/Index Map No: 36
Town: Culter
County: Washington
Quadrangle: Cutler 7.5'
Significance: High; volcanic features
Status: Recommended to be placed on Register
Recommended By: O.Gates
Reference: Gates 1961

Excellent exposures of tuff breccia are found along the shore of the Little Machais peninsula. The tuff breccias along the west shore of Little Deer Island consist of fragments of volcanic rocks in a matrix of tuff (volcanic ash). Some of the fragments contained in the breccia are up to 20 feet wide and ten feet long. These rocks were formed from the explosive activity associated with volcanism, and are often found quite close to the ancient volcanic source or vent. Here, the tuff breccia contains fragments and blocks of all the rock types found in the Little River Formation. The blocks are surrounded by a pumice lapilli and small angular rock fragments.

Name: **Great Head Fossiliferrous Conglomerates**
Site/Index Map No: 37
Town: Cutler
County: Washington
Quadrangle: Culter 7.5'
Significance: Unique; conglomerate, fossils
Status: Recommended to be placed on Register
Recommended By: O.Gates
Reference: Gates 1961

The most spectacular exposure of the Little River Conglomerate is at Great Head. Here a section 80 feet thick is well exposed. Several different rock types make up the clasts in the conglomerate including limestone, argillite and chert. Brachiopod fossils have also been identified in the limy cobbles and on the matrix of the conglomerate. In addition to the conglomerate, argillite and silty limestone, typical of the bedded rocks in the Little River Formation are also exposed at Great Head.

Name: **Cutler Diabase**
Site/Index Map No: 38
Town: Cutler
County: Washington
Quadrangle: Cutler 7.5'
Significance High; intrusive rocks
Status: Recommended to be placed on Register
Recommended By: O. Gates
Reference: Gates 1961

The Cutler Diabase is an intrusive igneous rock composed primarily of the minerals labradorite and pyroxene. The diabase repeatedly intruded the surrounding country rock to form sills, dikes, lenticular plugs and irregular plutons. One of the most outstanding exposures of the Cutler Diabase is found on the south shore of Deer Isle. A section approximately 40 feet thick is exposed at this location. Here the diabase exhibits the distinctive banding that is characteristic of this rock. The banding varies from approximately an inch to a foot in thickness and appears as alternating light and dark layers reflecting composistional variations.

Name: **Holmes Cove Keratophyres**
Site/Index Map No: 39
Town: Cutler
County: Washington
Quadrangle: Cutler 7.5'
Significance: High; exposure of intrusive rocks
Status: Recommended to be placed on Register
Recommended By: O. Gates
Reference: Gates 1961

The keratophyres of the Cutler area consist of a glassy porphyry of feldspar and quartz minerals. The keratophyres occur as small dikes and irregular plutons that have been intruded into the Little River Formation. Keratophyre is well exposed at Holmes Cove. Here the rock occurs as concordant and discordant lenses in the bedded tuffs. The feldspar phenocrysts exhibit a wide range in grain size and orientation. Fragments of the keratophyre are found in the tuff breccias at both locations.

Name: **Cutler Columnar and Pillow Basalts**
Site/Index Map No: 40
Town: Cutler
County: Washington
Quadrangle: Cutler 7.5'
Significance: Volcanic features - columnar jointing, pillow basalt
Status: Recommended to be placed on the Register
Recommended by: Olcott Gates
References: Gates 1961

Excellent exposures along the shore of diabase exhibiting well-developed columnar jointing cut by older diabase or gabbro. Diabase dikes ranging from a few feet to 20 feet wide are numerous along this section of the shore.

Name: **Edmunds Tuff Breccias**
Site/Index Map No: 41
Town: Eastport
County: Washington
Quadrangle: West Lubec 7.5'
Significance: Unique; reference locality
Status: Recommended to be placed on Register
Recommended by: O. Gates
Reference: Gates 1975

The Edmunds Formation Tuff Breccias consist of maroon, white pink, and purple tuff breccia. Rhyolite & calcite occur locally with basalt fragments. The formation is massive locally, grading up into bedded tops and down into mixed fragments and mudstones. Submarine pyroclastic flows or avalanche deposits form tongues which thicken to the north and interfinger with fine-grained marine sedimentary rocks composed of several separate debris flows. The formation is deposited on the flank of a partially submerged explosive volcano.

Name: **Perry Formation Lava Flows**
Site/Index Map No: 42
Town: Perry
County: Washington
Quadrangle: Eastport 7.5'

Significance: High; exposure of volcanic rocks
Status: Recommended to be placed on Register
Recommended by: O.Gates
Reference: Gates 1975

This locality of the Perry Formation consists of basalt lava flows exposed along the shore of Passamaquoddy Bay. The flows are composed of altered labradorite-augite amygdaloidal basalt. There are also some zeolites, and quartz and chalcedony in rugs and vesicles (amygdaloidal).

Name: **Quoddy State Park Gabbros and Shales**
Site/Index Map No: 43
Town: Lubec
County: Washington
Quadrangle: Lubec 7.5'
Significance: Unique; reference locality; Fundy fault
Status: Recommended to be placed on Register
Recommended by: O. Gates
Reference: Gates 1975

In this example of the Quoddy Formation, gabbros intrude Quoddy shale. Silurian to Devonian gabbros intrude grey to black siliceous shale of the Quoddy Formation. Offshore, parallel to the coast, is the Fundy Fault, a border fault on Triassic rocks in Fundy Bay. Across the bay, at Grand Manan, is a sill of Triassic diabase.

Name: **Reversing Falls - Edmunds Bedded Tuffs**
Site/Index Map No: 44
Town: Pembroke
County: Washington
Quadrangle: Pembroke 7.5'
Significance: Unique; volcanic rocks, fossils
Status: Recommended to be placed on Register
Recommended by: O. Gates
Reference: Gates 1975

The Edmunds Formation Bedded Tuffs are Silurian and consist of fossiliferous grey to black tuffaceous siltstones, argillites and cherts. They exhibit thinly-laminated, graded bedding & local plastic distortion. The fossils include brachiopods, pelecypods and gastropods. Less common are trilobites, corals, ostracodes and orthoceroids.

Name: **Eastport Formation Sedimentary Type Section**
Site/Index Map No: 45
Town: Eastport
County: Washington
Quadrangle: Pembroke 7.5'
Significance: Unique; Type section
Status: Recommended to be placed on Register
Recommended by: O. Gates
Reference: Gates 1975

This locality consists of the uppermost rocks, Devonian in age, of the Eastport Formation. There are shallow-water bedded shales, siltstones and conglomerates of the upper Eastport Formation; these are grey, green and maroon in color. Ripple marks, cross-bedding, current-cut and filled channels, uneven bedding and mud cracks all indicate shallow water deposition. Fossils include lingulids, pelecypods, gastropods and ostracodes of Devonian age. The North-west trending of the Oak Bay Fault, which may still be active, separates Moose Island and Deer Island.

Name: **Perry Conglomerate - Typical Section**
Site/Index Map No: 46
Town: Perry
County: Washington
Quadrangle: Eastport 7.5'
Significance: High; exposure of Devonian rocks
Status: Recommended to be placed on Register
Recommended by: O. Gates
Reference: Gates 1975

The Upper Devonian Perry Conglomerate consists of red and maroon coarse boulder & pebble conglomerate, as well as arkosic sandstone. These rocks, deposited in a post-Acadian fault basin, include clasts and cobbles of Red Beach granite, as well as other Silurian and Devonian rocks.

Name: **Schooner Cove Fossil Locality**
Site/Index Map No: 47
Town: Pembroke
County: Washington
Quadrangle: Pembroke 7.5'
Significance: Unique; fossils
Status: Recommended to be placed on Register
Recommended by: O. Gates
Reference: Gates 1975

This exposure of the Leighton Formation consists of grey to blue-grey, somewhat limy siltstone and shale, grading into tuffs and tuffaceous siltstones towards Denbow Neck. The Late Silurian fossils are genus Salopina: rhynchonellid brachiopods, gastropods, ostracodes, and a few trilobites.

Name: **Quoddy Shale Type Section**
Site/Index Map No: 48
Town: Lubec
County: Washington
Quadrangle: Lubec 7.5'
Significance: Unique; Type section, fossils
Status: Recommended to be placed on Register
Recommended by: O. Gates
Reference: Gates 1975

The section consists of dark grey to black, rusty-weathering pyritiferous thinly-bedded siliceous siltstone, argillite and shale. The graded laminations of broken feldspar crystals are the only evidence of volcanic activity, and the section is separated from younger rocks by the Lubec Fault Zone. Evidence of brachiopods has been reported by Bastin & Williams (1914), and Late Llandovery Monograptus have been reported by Berry & Boucot (1970).

Name: **Leighton Shale**
Site/Index Map No: 49
Town: Pembroke
County: Washington
Quadrangle: Pembroke 7.5'
Significance: Moderate; reference locality
Status: Recommended to be placed on Register
Recommended by: O. Gates
Reference: Gates 1975

At this locality, the Leighton Shale is a gray shale, siltstone and mudstone, locally calcareous, exhibiting lithic lapilli tuff & tuff breccia, rhyolite and calcite. There are submarine clastic flows and a tuff breccia avalanche, as well as evidence of Salopina fauna of the late Silurian.

Name: **Lubec Lead Mine**
Site/Index Map No: 50
Town: Lubec
County: Washington
Quadrangle: West Lubec 7.5'
Significance: High; former active mine; significant minerals
Status: Recommended to be placed on Register
Recommended by: A.M. Hussey II
Reference: Rand 1958

This deposit was discovered in 1828 and operated intermittently as a small mill until the turn of the century. Shafts 180 feet deep were reportedly dug at this site. The signifcant metal-bearing minerals include galena, sphalerite, calcopyrite, pyrite, and limonite.

Name: **Lamb Cove Unconformity**
Site/Index Map No: 51
Town: Robbinston
County: Washington
Quadrangle: Red Beach 7.5'
Significance: High; Acadian Unconformity
Status: Recommended to be placed on Register
Recommended by: O. Gates
References: Gates 1975

At this portion of the Acadian Unconformity, basal conglomerate of the Perry Formation (Upper Devonian) rests unconformably on the Eastport volcanics. The plane of the unconformity is generally smooth and gently undulating, with only local irregularities; the conglomerate clasts are well-rounded and of widely varying lithologies.

CONCLUSIONS AND RECOMMENDATIONS

1. Based on the exceptional scientific and educational value, the 51 sites listed on Table 1 and Table 4 should be evaluated for inclusion in the Register of Critical Areas.

2. There is little information available for many areas in the Penobscot Bay area,on the numerous islands off the eastern Maine coast and for the area extending from Bar Harbor to Machais. Efforts should be made to work with geologists studying these areas to identify and document new candidate Critical Areas.

3. We recommend that further work be done to identify bedrock landforms such as sea caves, sea stacks, arches, etc.

4. An educatinal brochure on coastal bedrock geological features should be prepared.

REFERENCES

Bastin, E.S. ad Williams, H.S., 1914, Eastport Folio, Maine: U.S. Geological Survey Folio 192.

Bouley, B., 1978, Volcanic Statigraphy, Stratabound sulfide Deposits and Relative Age Relationships in the East Penobscot Bay Area, Maine, unpub. PhD Thesis, University of Western Ontario.

Caldwell, D.W., 1982, Important Geological Localities and Features in Maine: Maine Geological Survey and Maine State Planning Office, Augusta, Maine

Forbes, William H., 1977, Significant Bedrock Fossil Localities in Maine and Their Relevance to the Critical Areas Program, Planning Report Number 46, Maine State Planning Office, Augusta, Maine.

Gates, O., 1961 The Geology of the Cutler and Moose River Quadrangles, Washington County, Maine: Maine Gelogical Quadrangle Mapping Series No. 1.

Gates, O., 1975, Geologic map and cross sections of the Eastport quadrangle, Maine: Maine Geological Survey Map Series GM-3

Gilman, R., 1986, Geology of Mount Desert: Geological Society of Maine Field Trip Guide, 18p.

Hatheway, R.B., 1969, Geology of the Wiscasset 15' Quadrangle: unpublished. PhD thesis, Cornell University.

Hussey II, A.M., 1972, recon. mapping, Maine Geological Survey

Hussey II, A.M., 1977, Significant Geologic Localities in the Casco Bay Group; Planning Report 37, Critical Areas Program, Augusta, Maine

Hussey II, A.M., 1978, Significant Geologic Localities in Coastal York County; Planning Report 56; Critical Areas Program, Augusta, Maine

Hussey II, A.M., 1986, in Guidebook for Field Trips in Southwestern Maine., NEIGC 78th Annual Meeting, Bates College, Lewiston, Maine

Hussey II, A.M., 1984, Bedrock Geology of the Boothbay 15' Quadrangle, Maine: Geological Society of Maine, Guidebook for Field Trip.

Ludman, A.,1978, Guidebook for field trips in southeastern, Maine and southwestern New Brunswick, NEIGC 70th Annual Meeting

Newberg, D., 1976, recon. mapping, Maine Geological Survey

Osberg et al, 1985, Bedrock Geologic Map of Maine, Maine Geological Survey, Augusta, Maine

Osberg and Guidotti, 1974, in Geology of East Central and North Central Maine: NEIGC 66th, Annual Meeting University of Mane, Orono

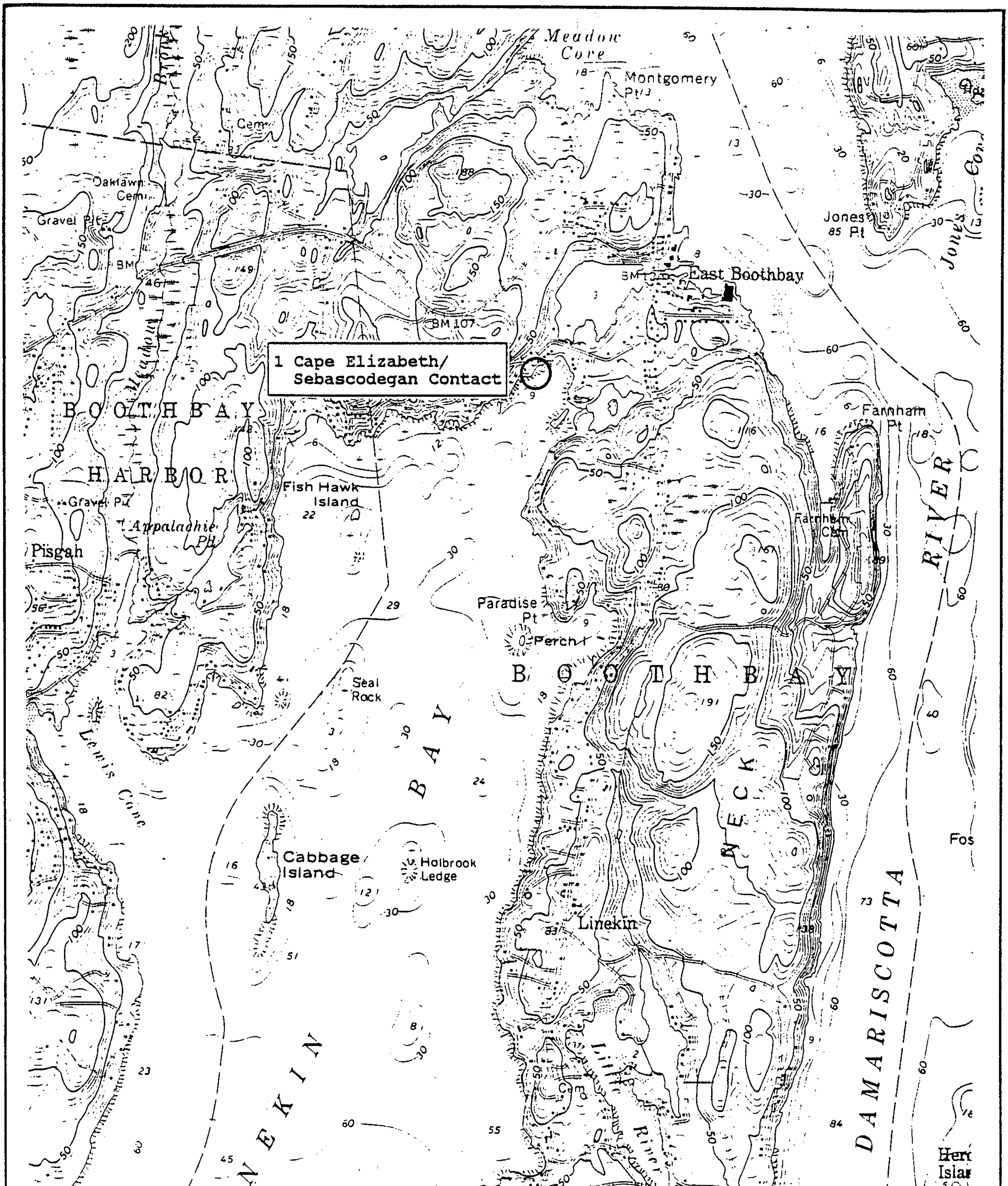
Rand, J.R., 1958, Maine Metal Mines and Prospects, Dept. of Economic Development, Augusta, Maine

Stewart, D. B., 1974, in Geology of East Central and North Central Maine, 66th Annual NEIGC, University of Maine, Orono

Trefethen, J.M., 1937, The Lincoln Sill, Journal of Geology, V.45, p. 353-380.

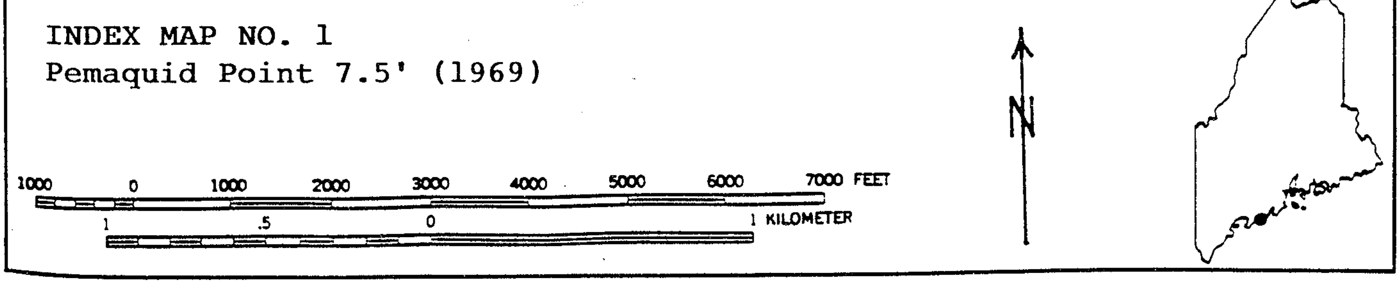
APPENDIX A

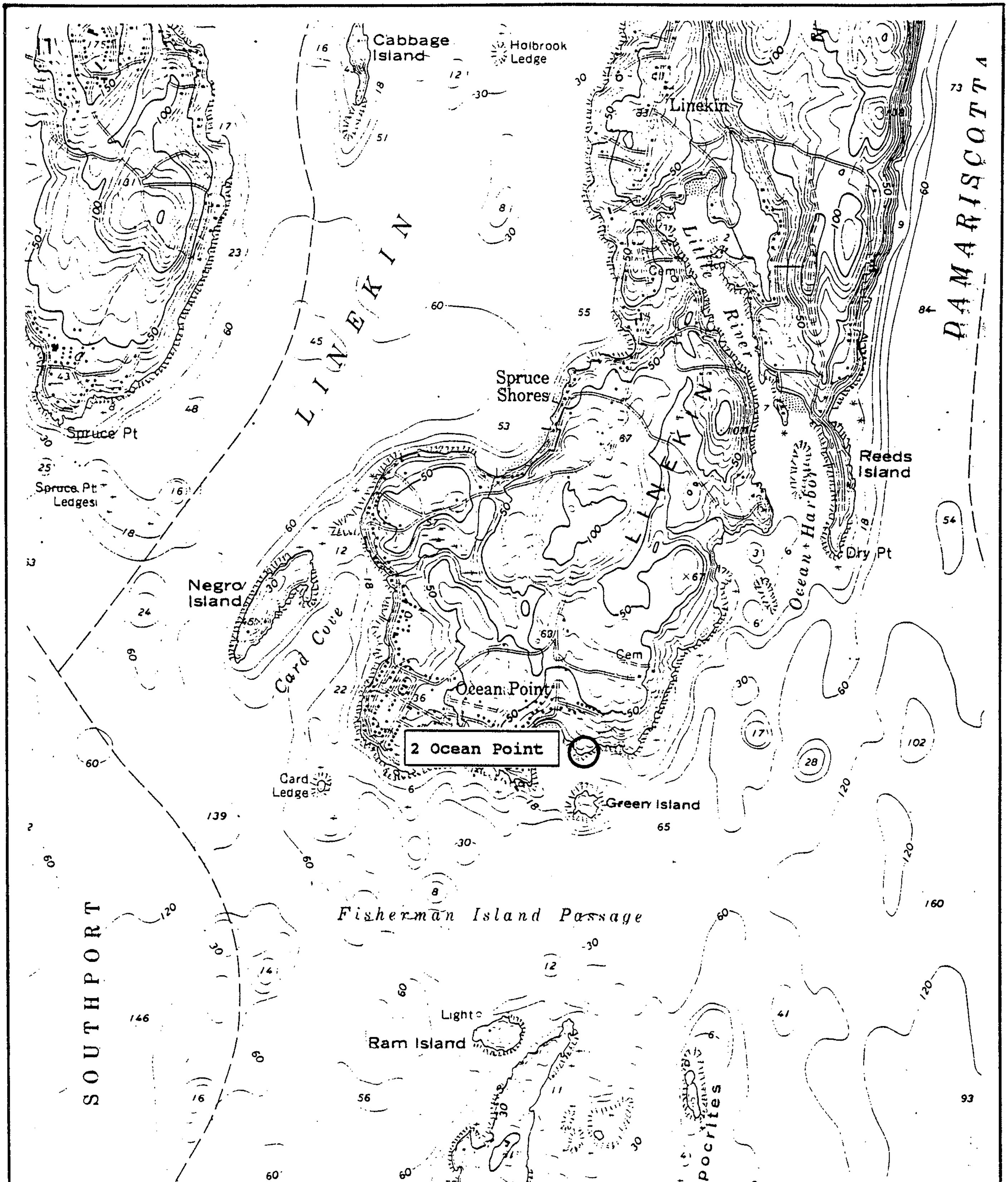
SITE LOCATION MAPS



INDEX MAP NO. 1

Pemaquid Point 7.5' (1969)





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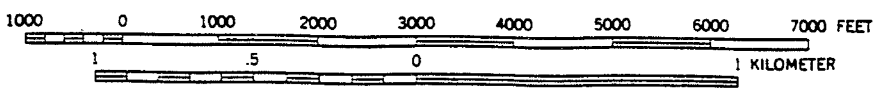

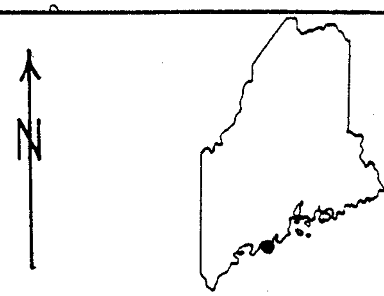

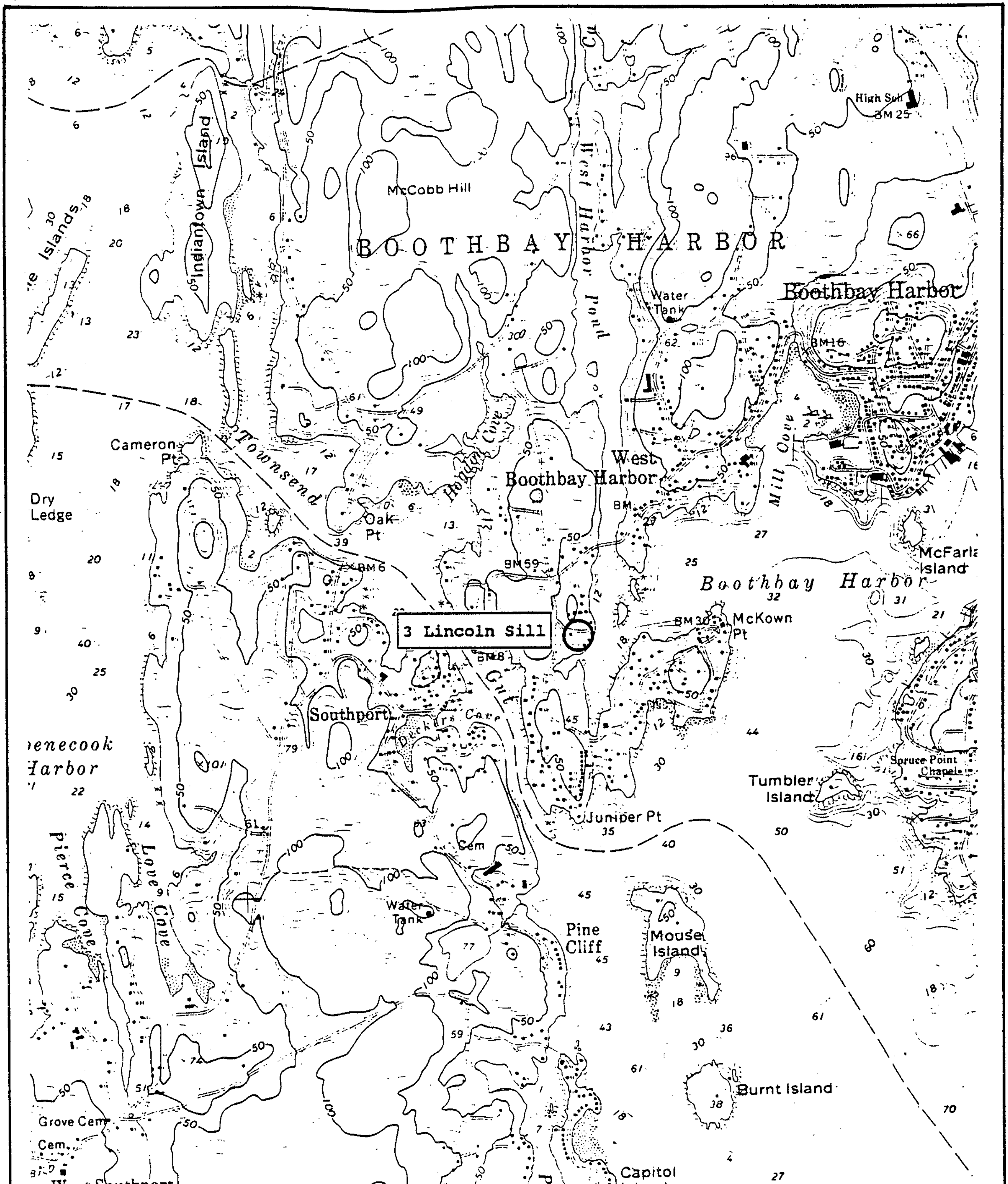

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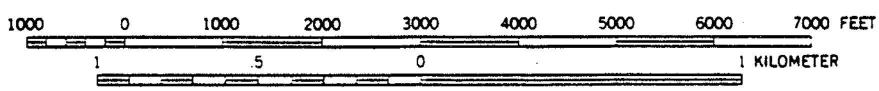

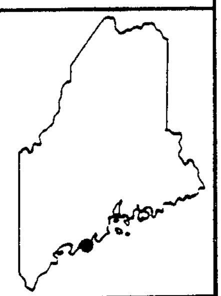

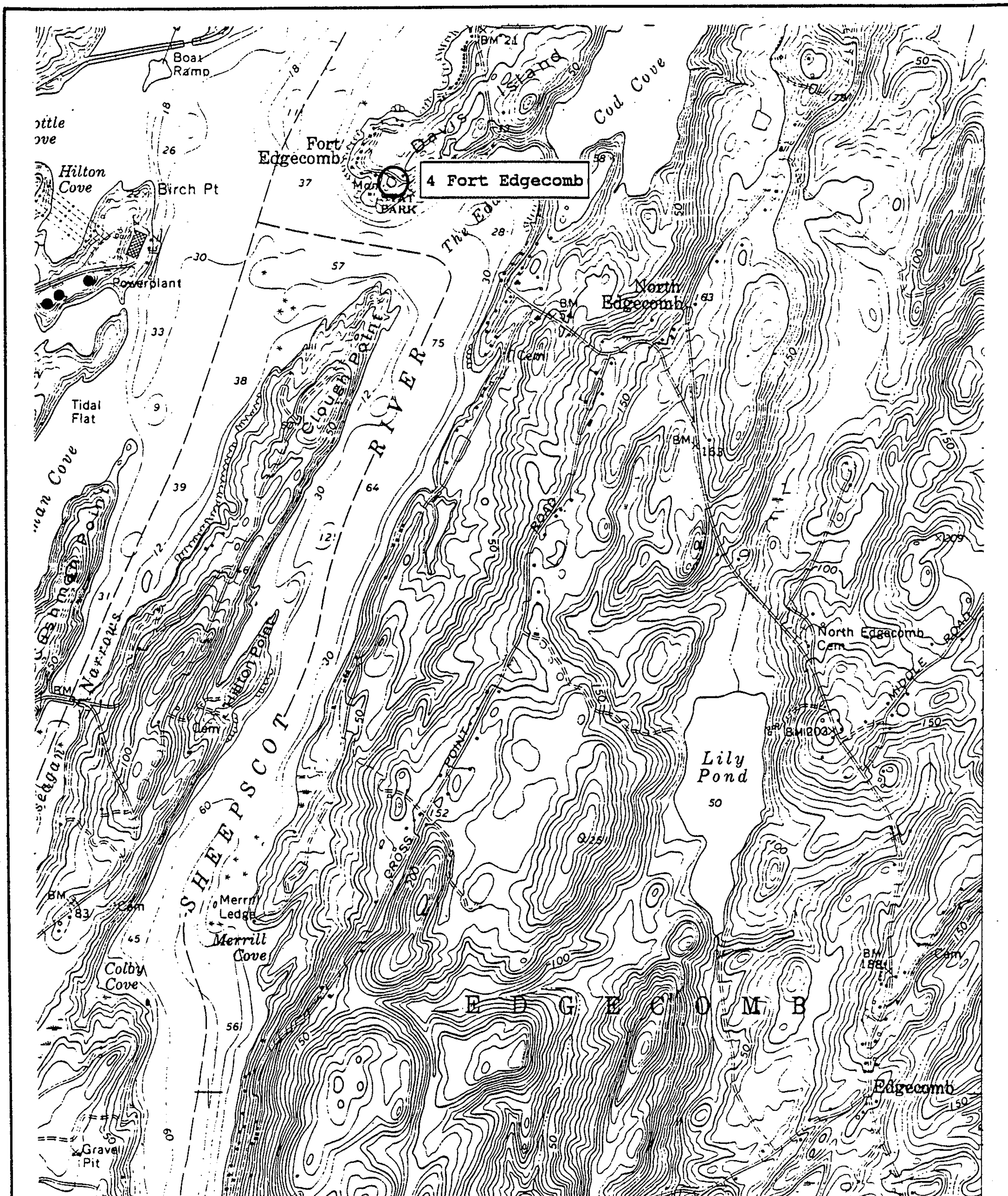

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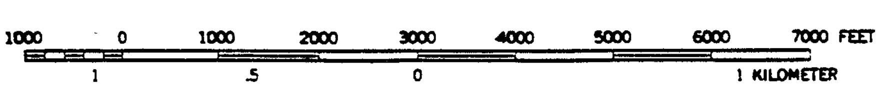

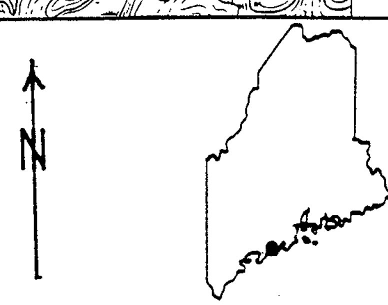

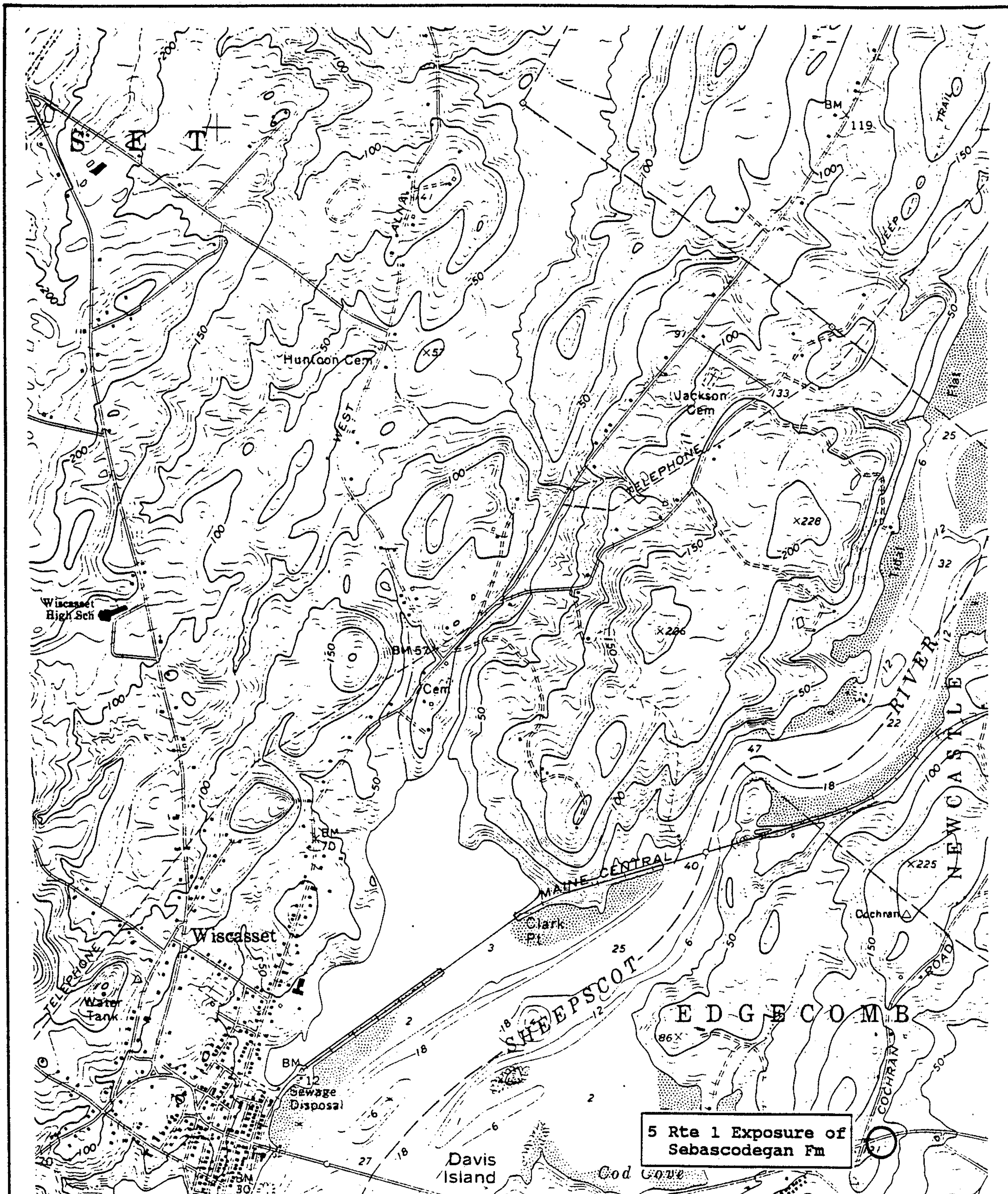

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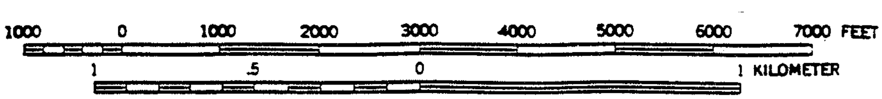

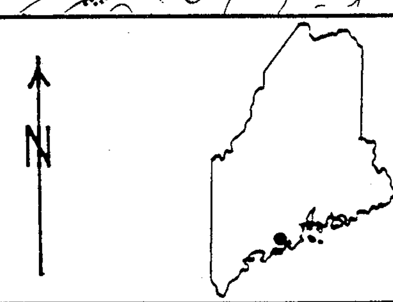

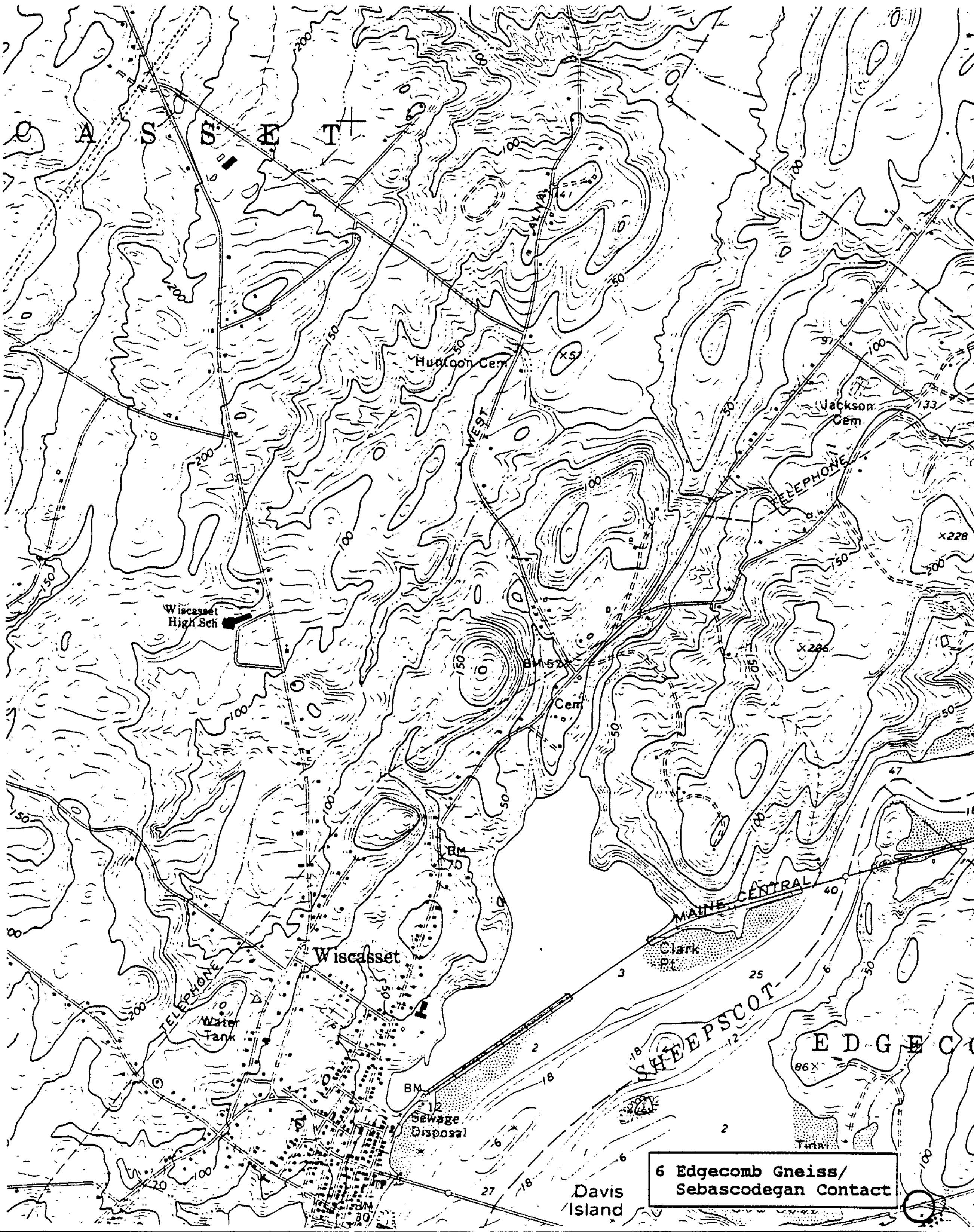

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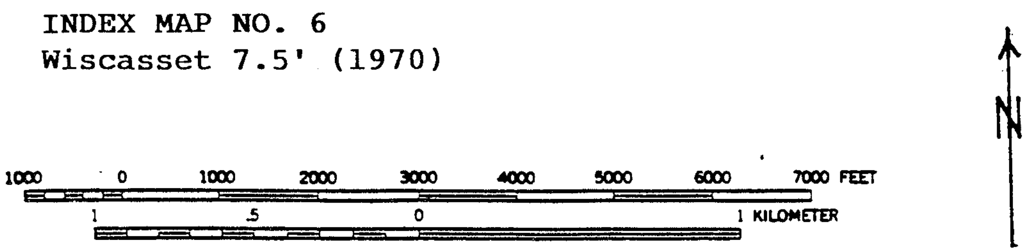

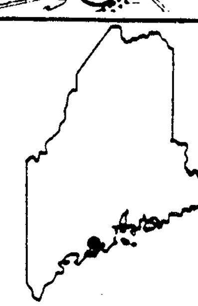

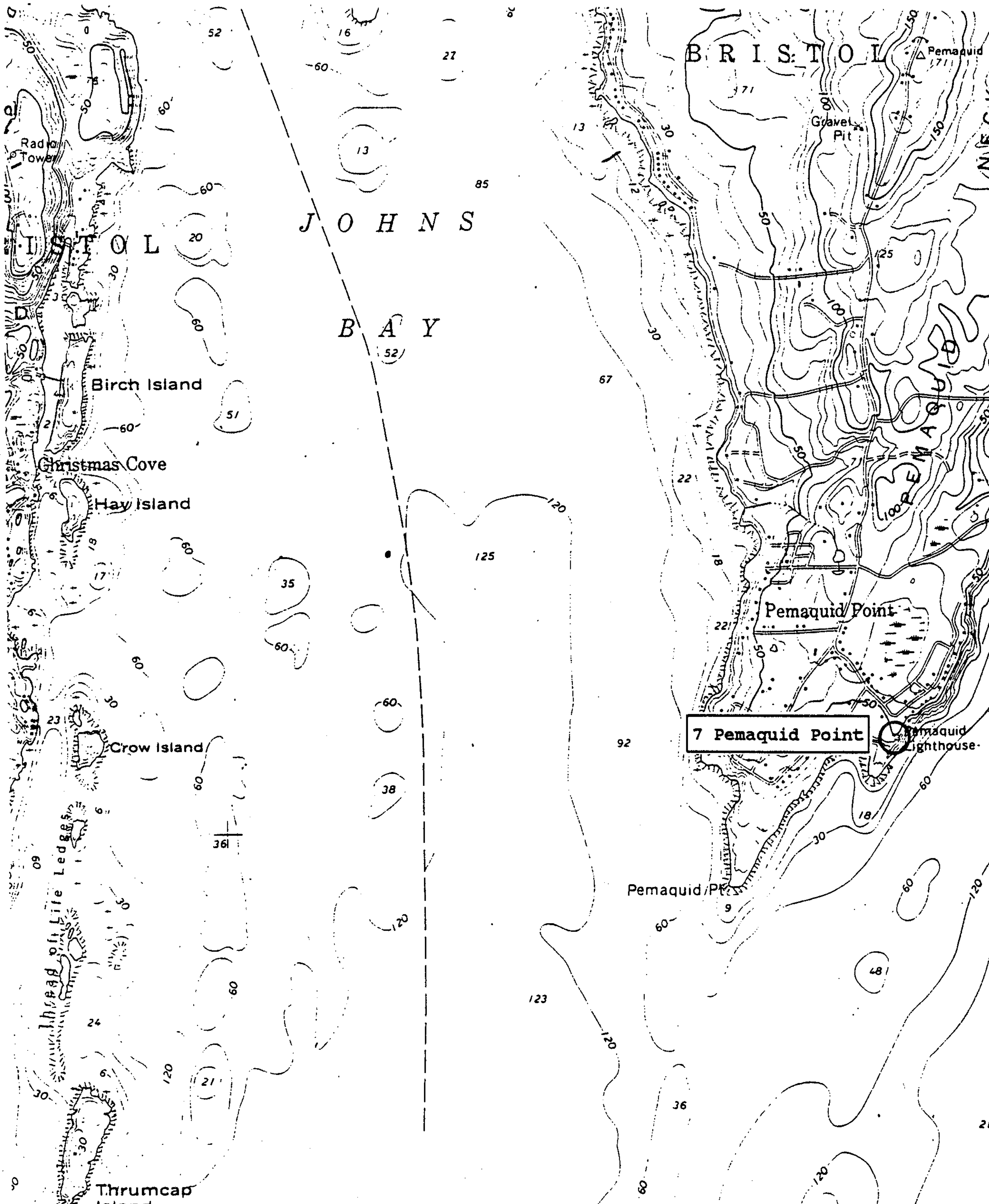

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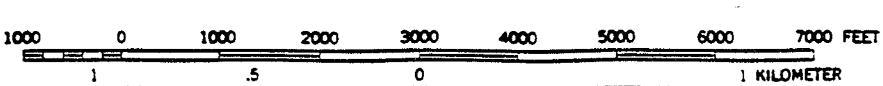

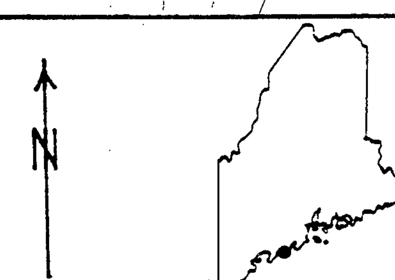

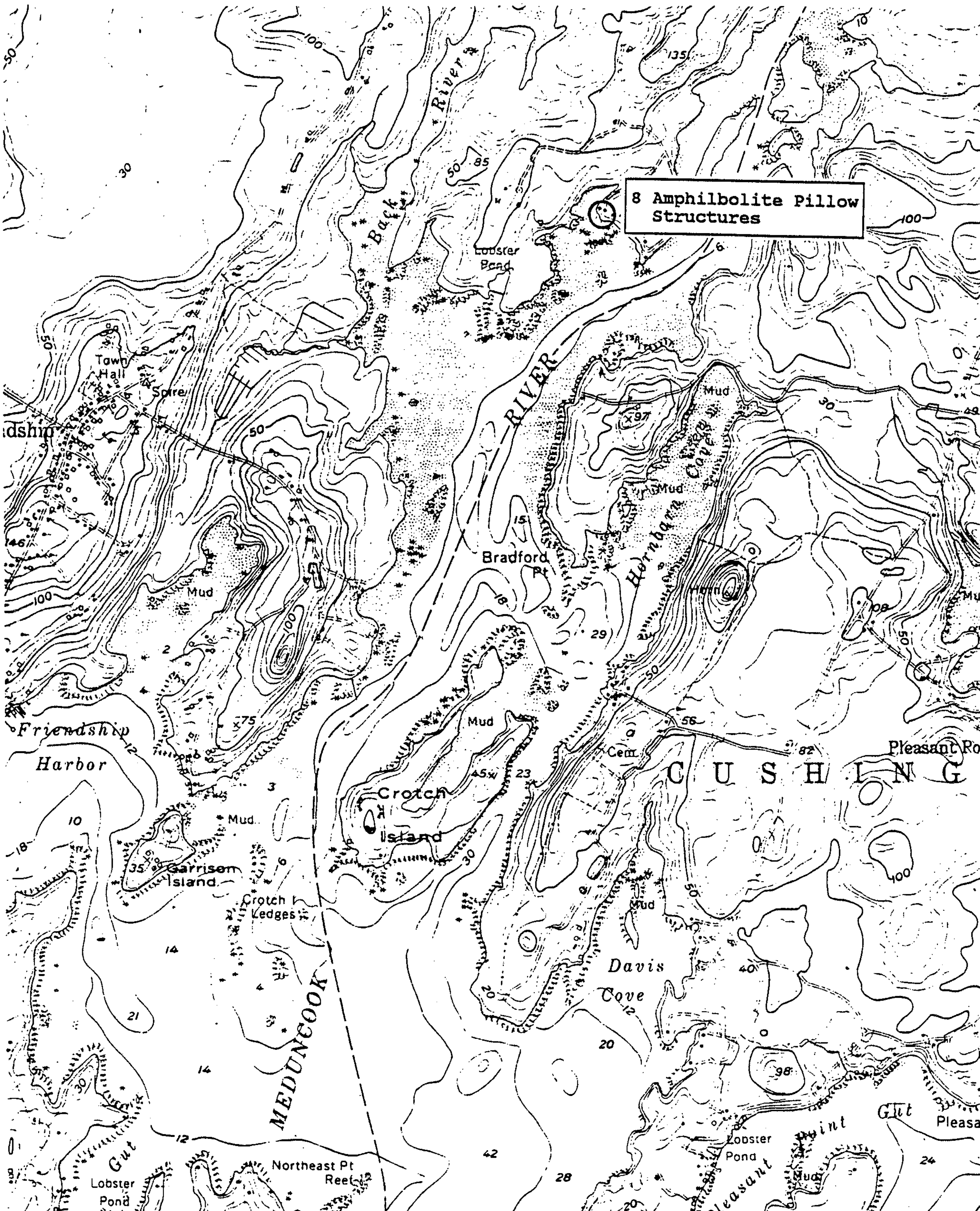

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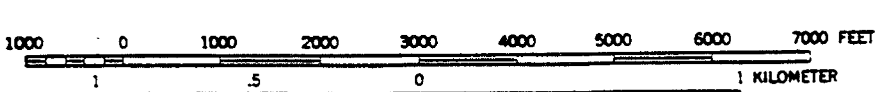

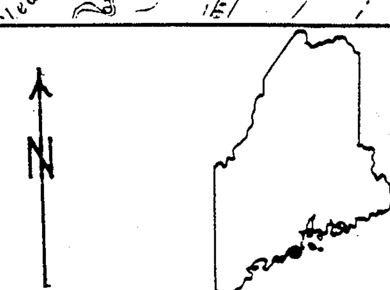

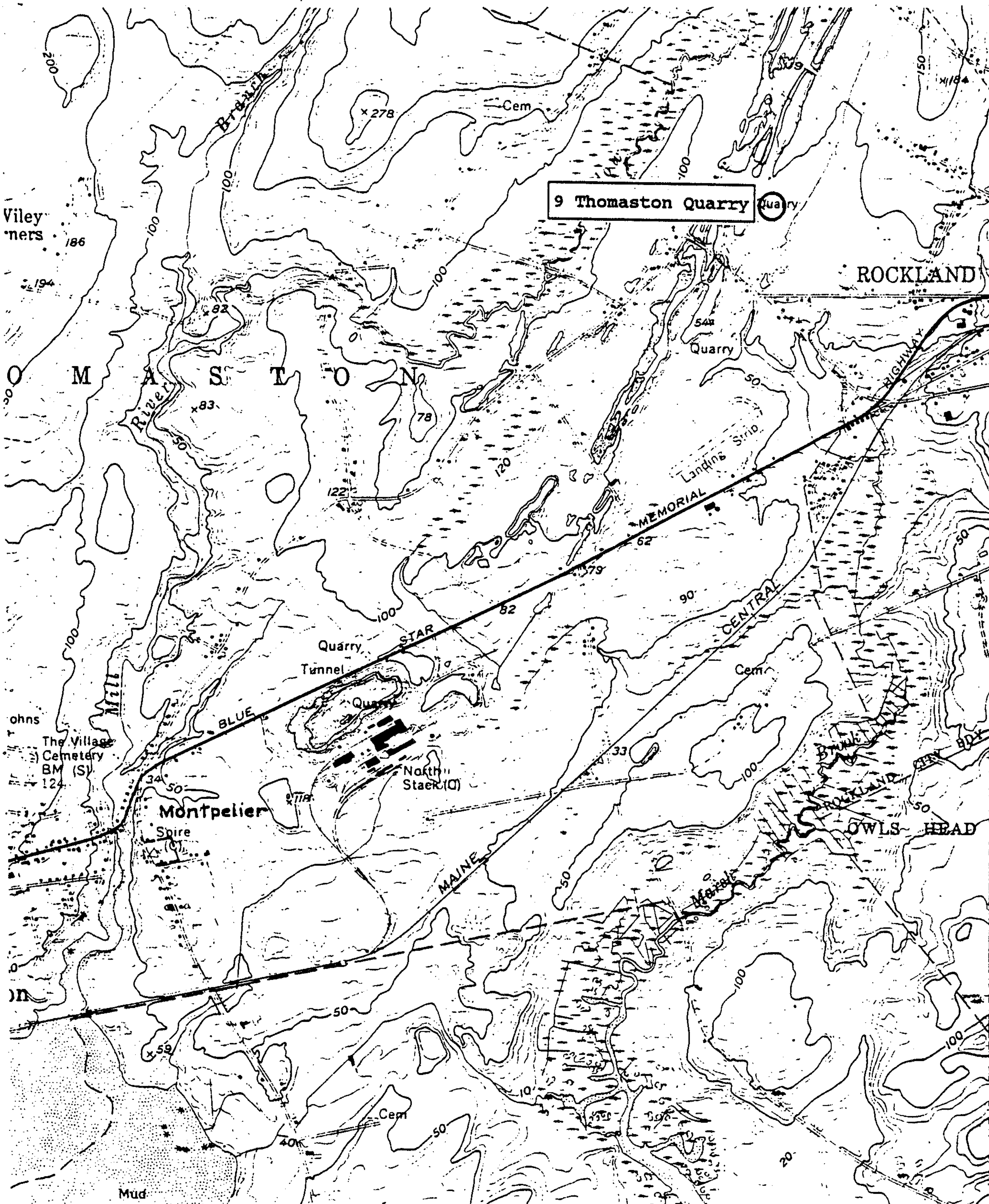

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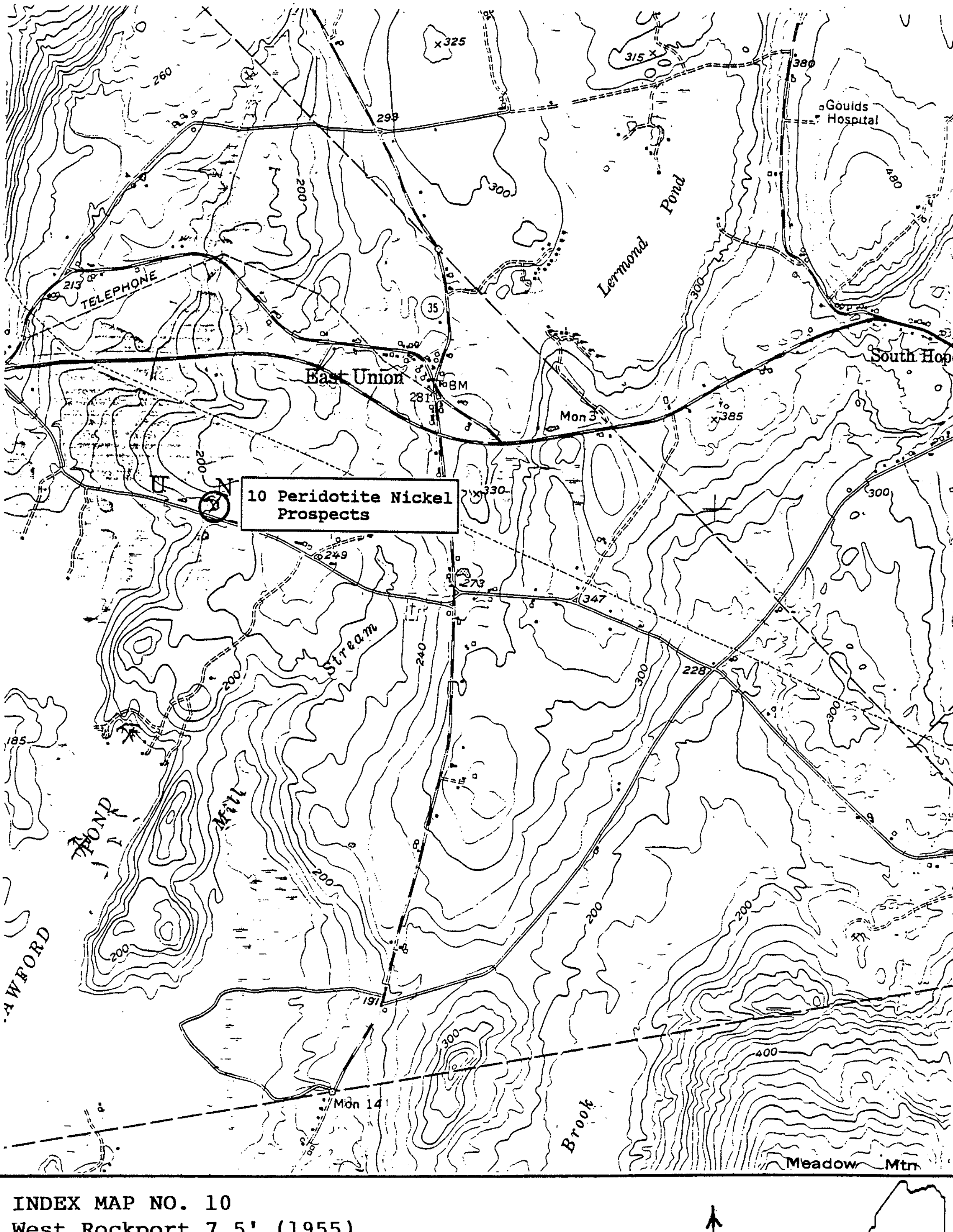

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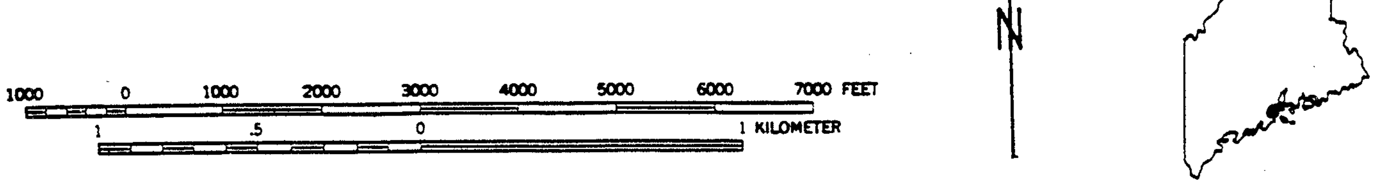

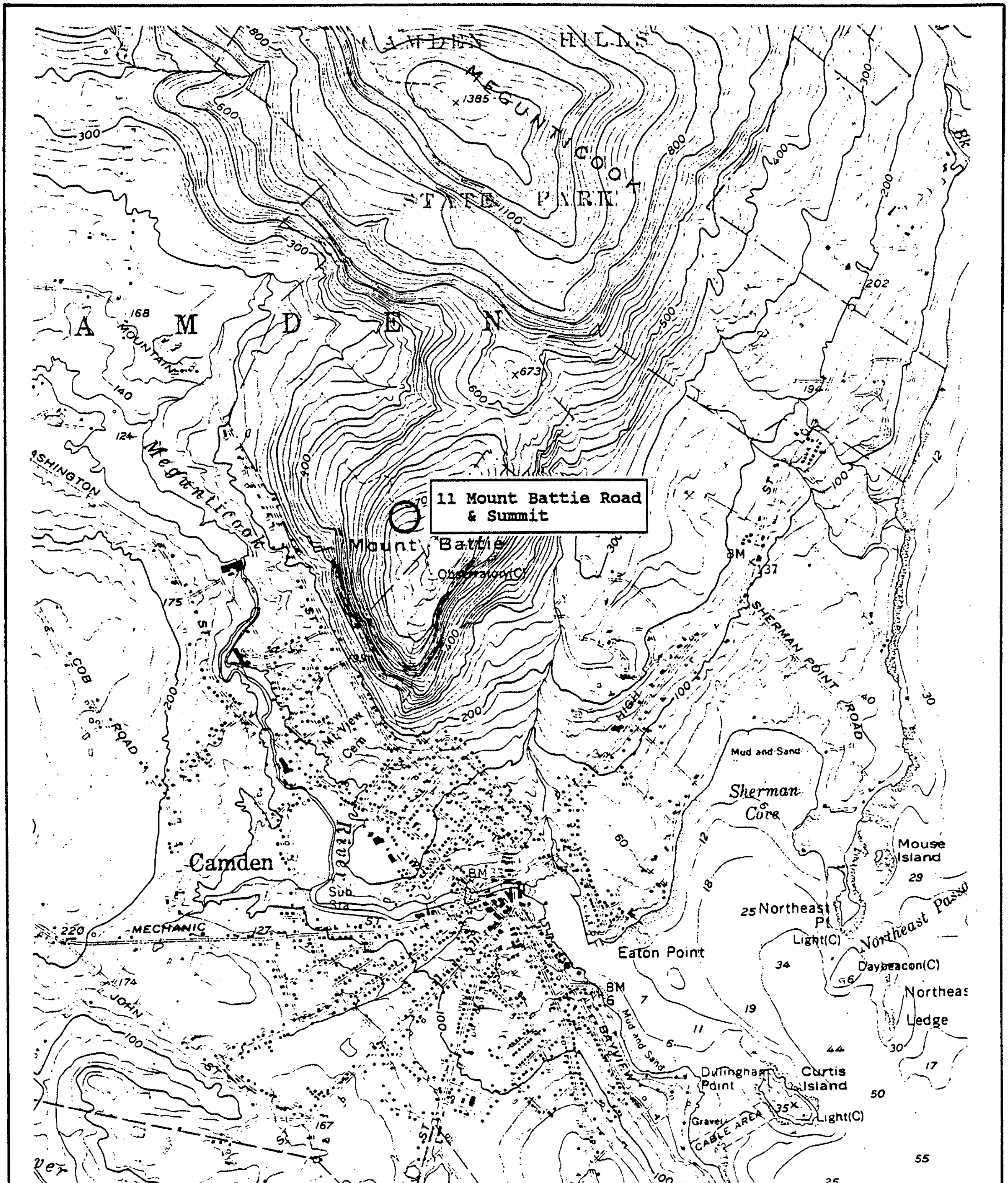

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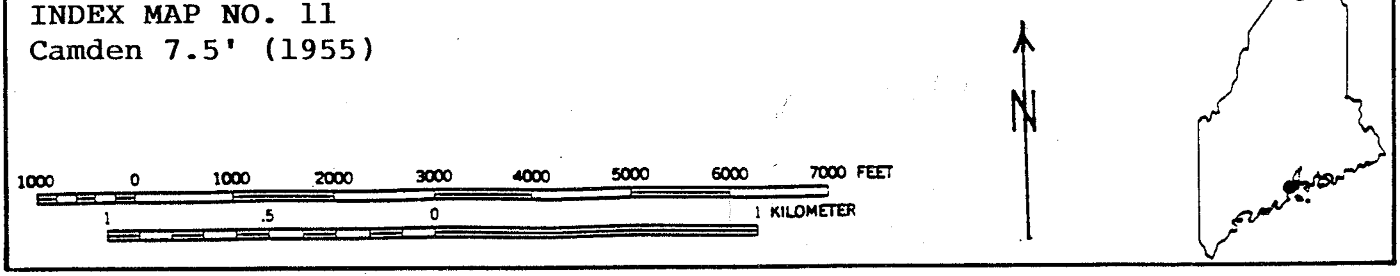

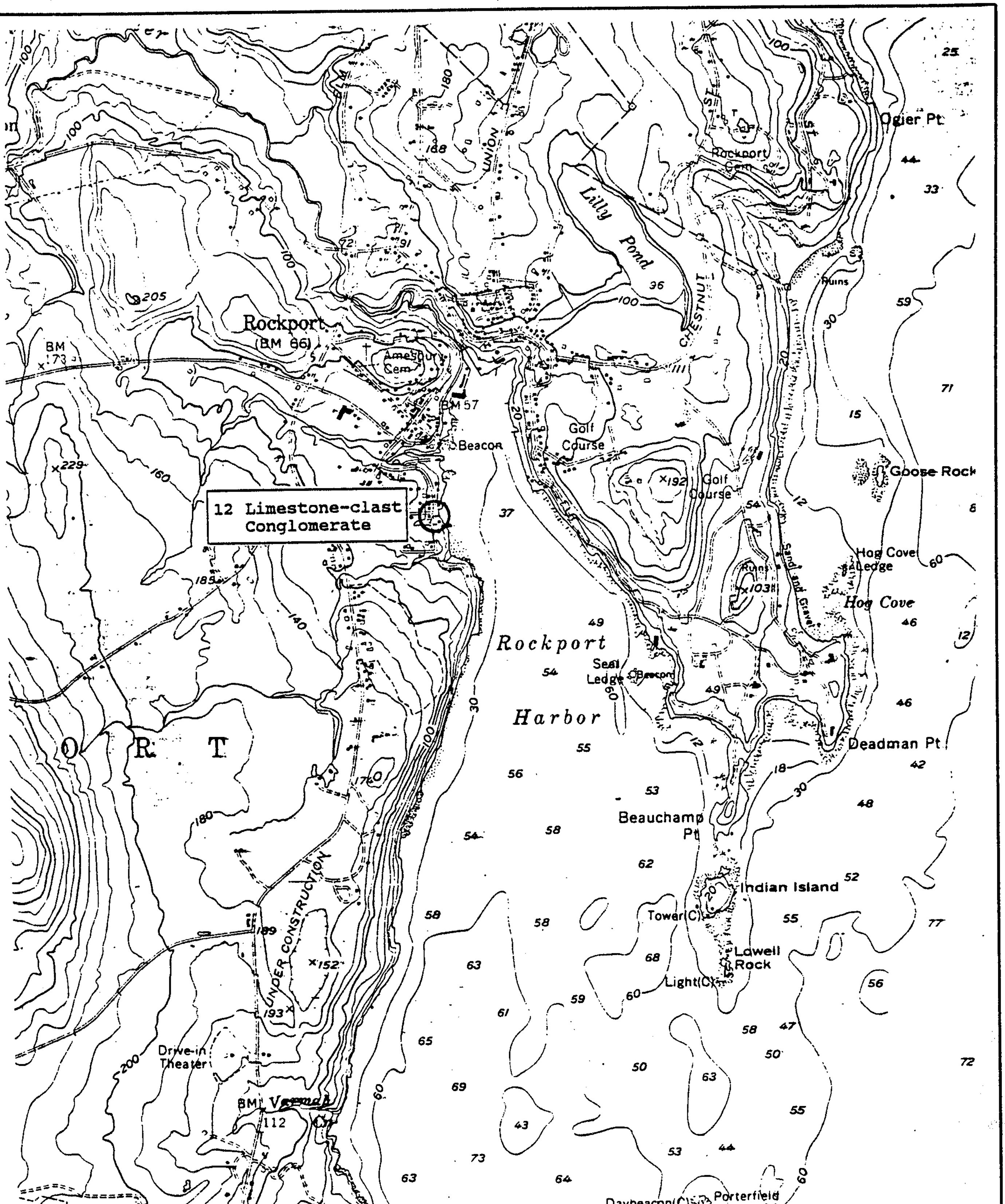

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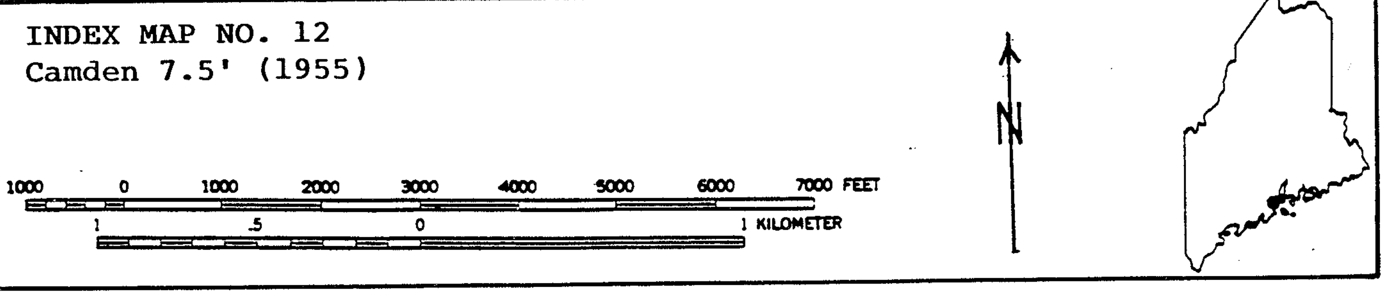

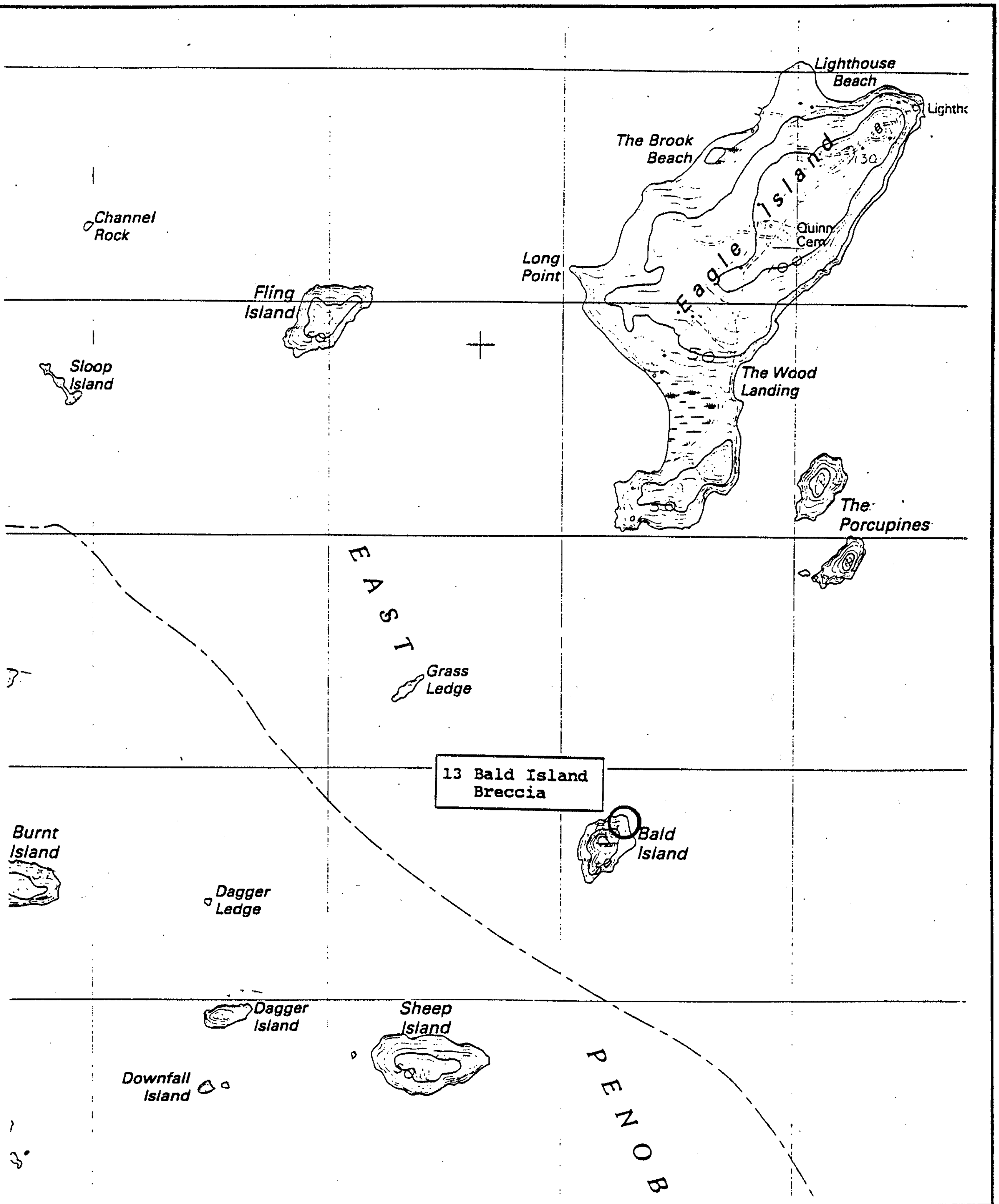

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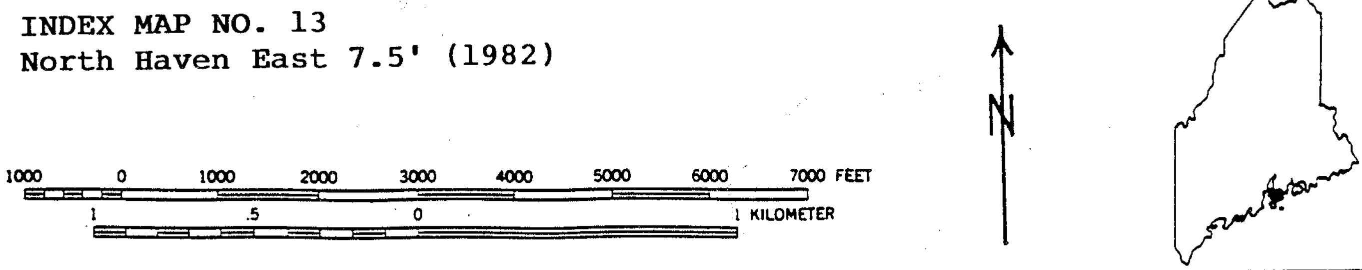

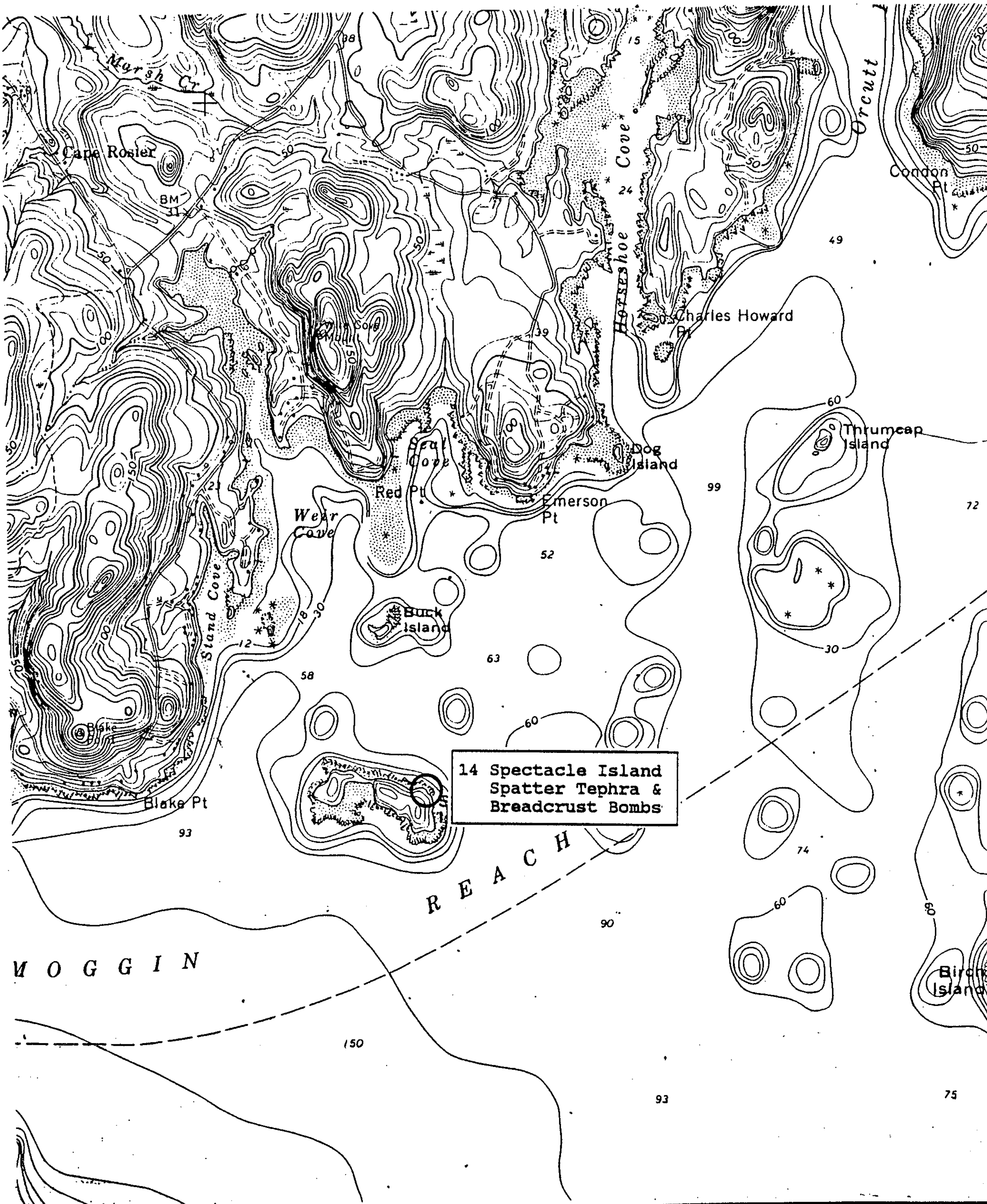

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Cape Rosier 7.5' (1973)

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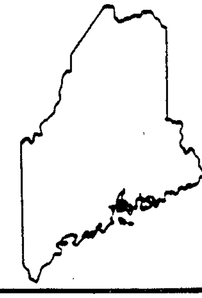

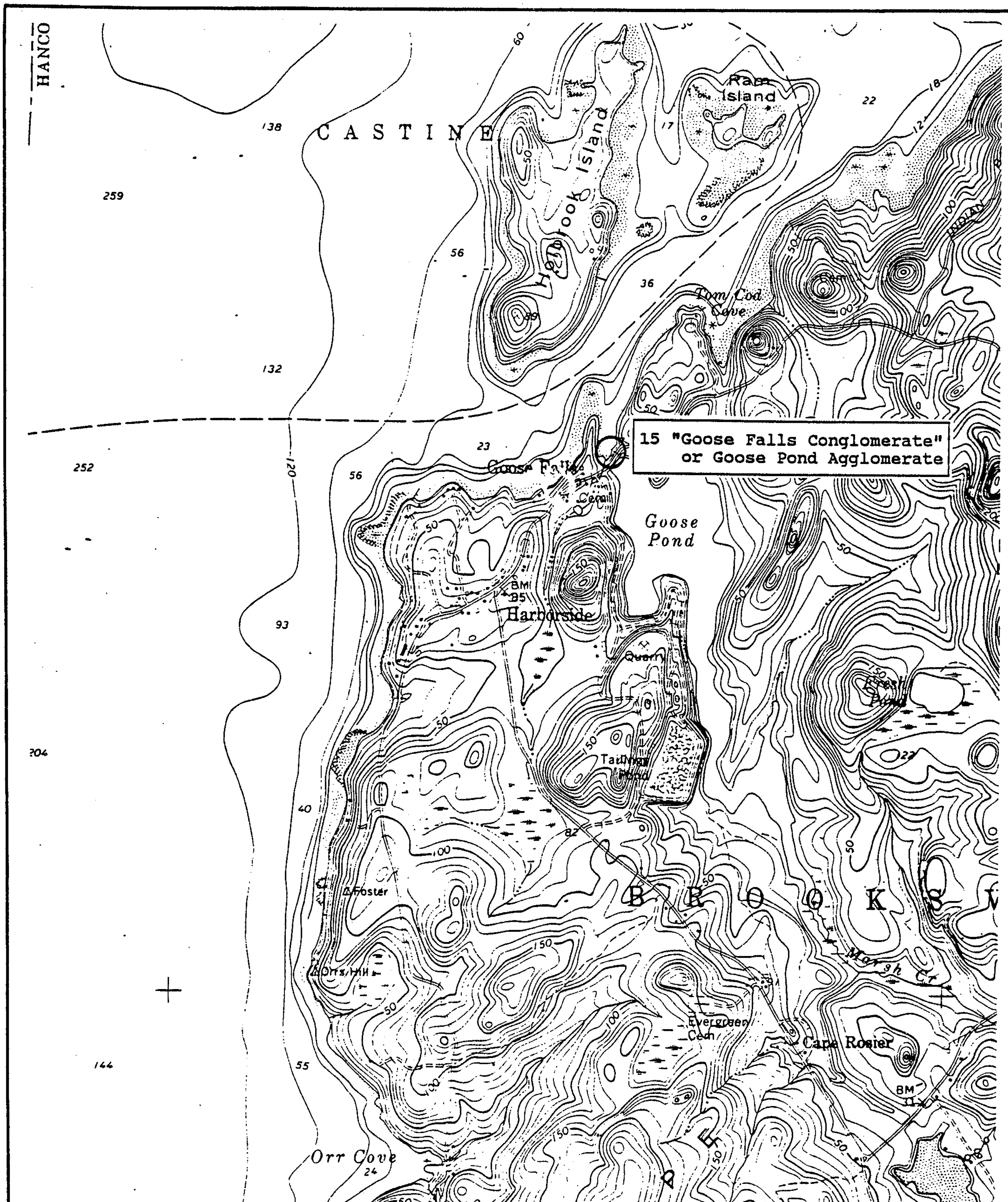

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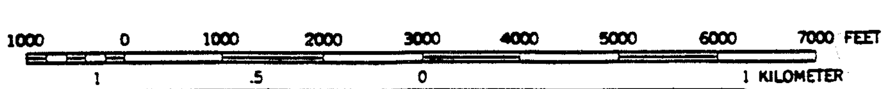

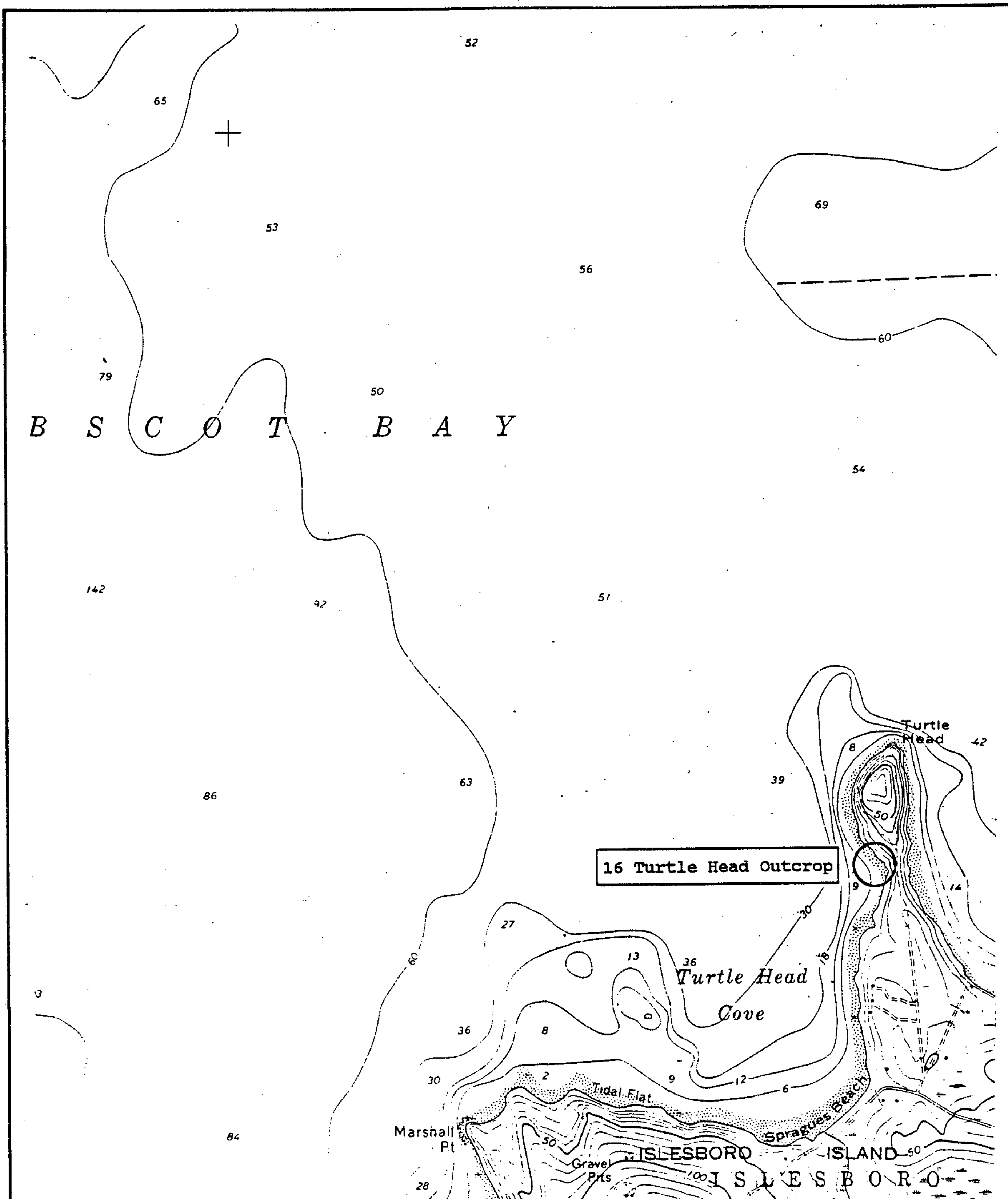

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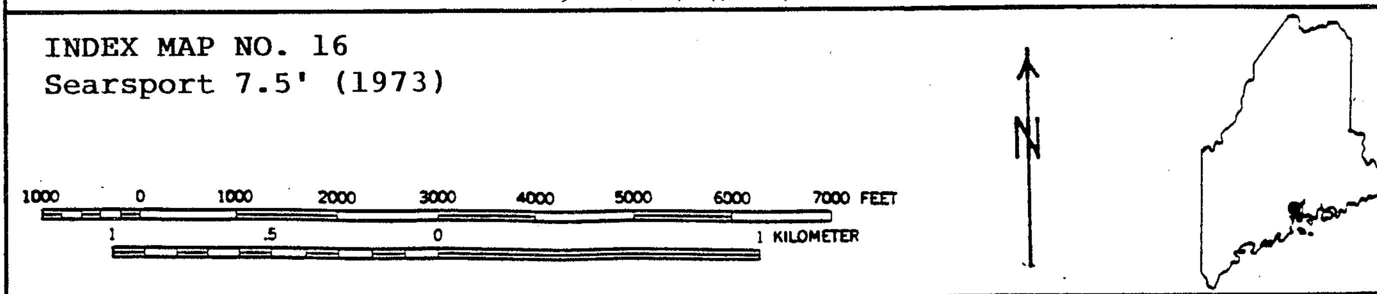
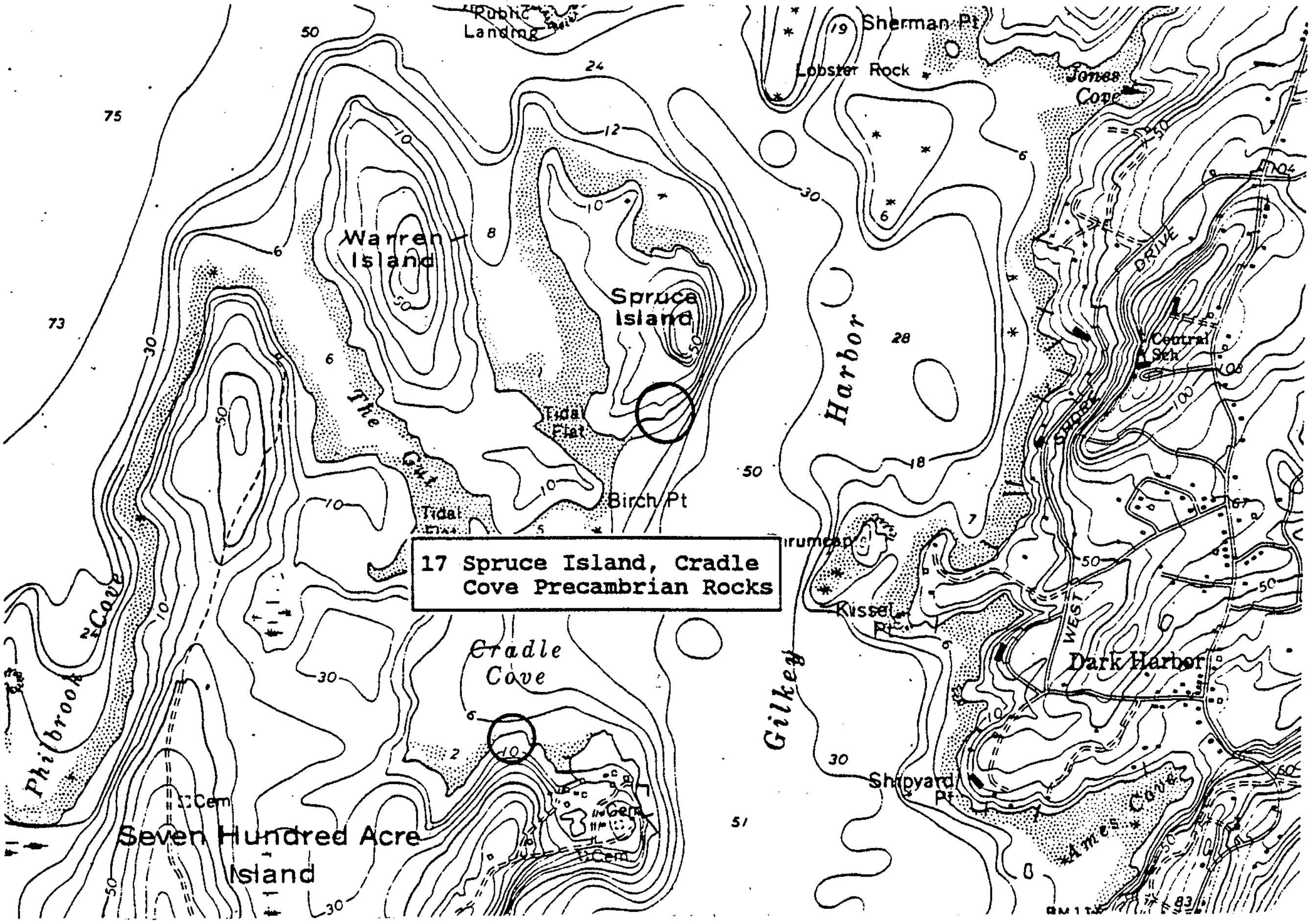
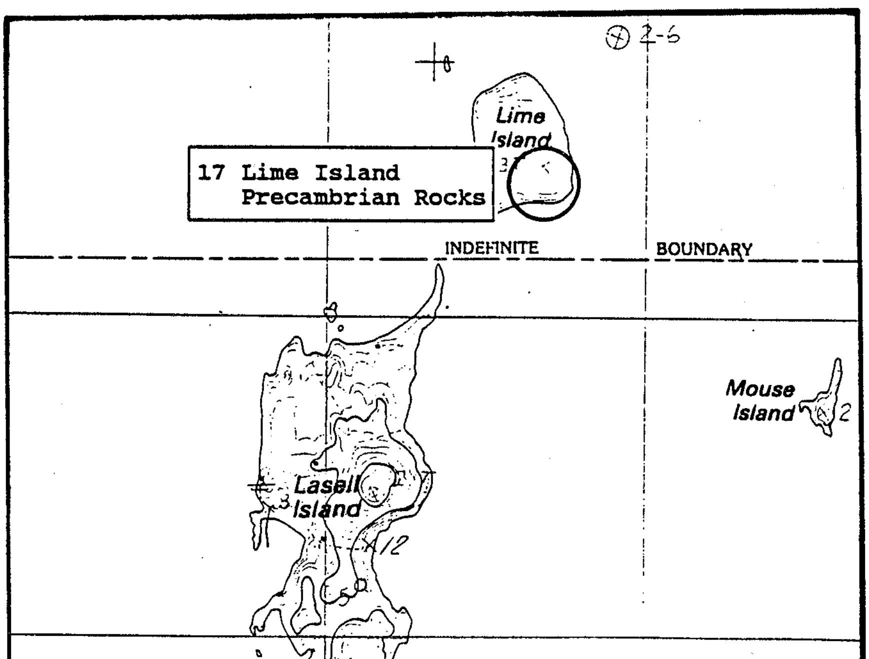




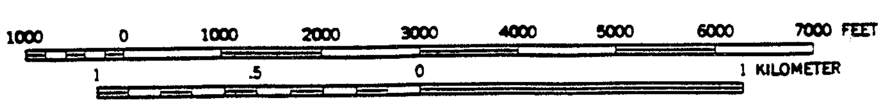
[Islesboro 7.5 (1973)]

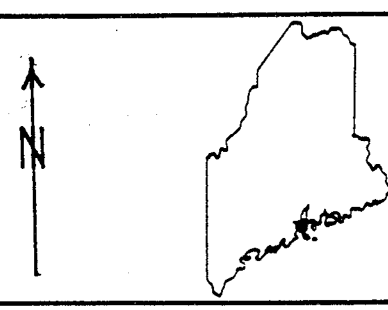


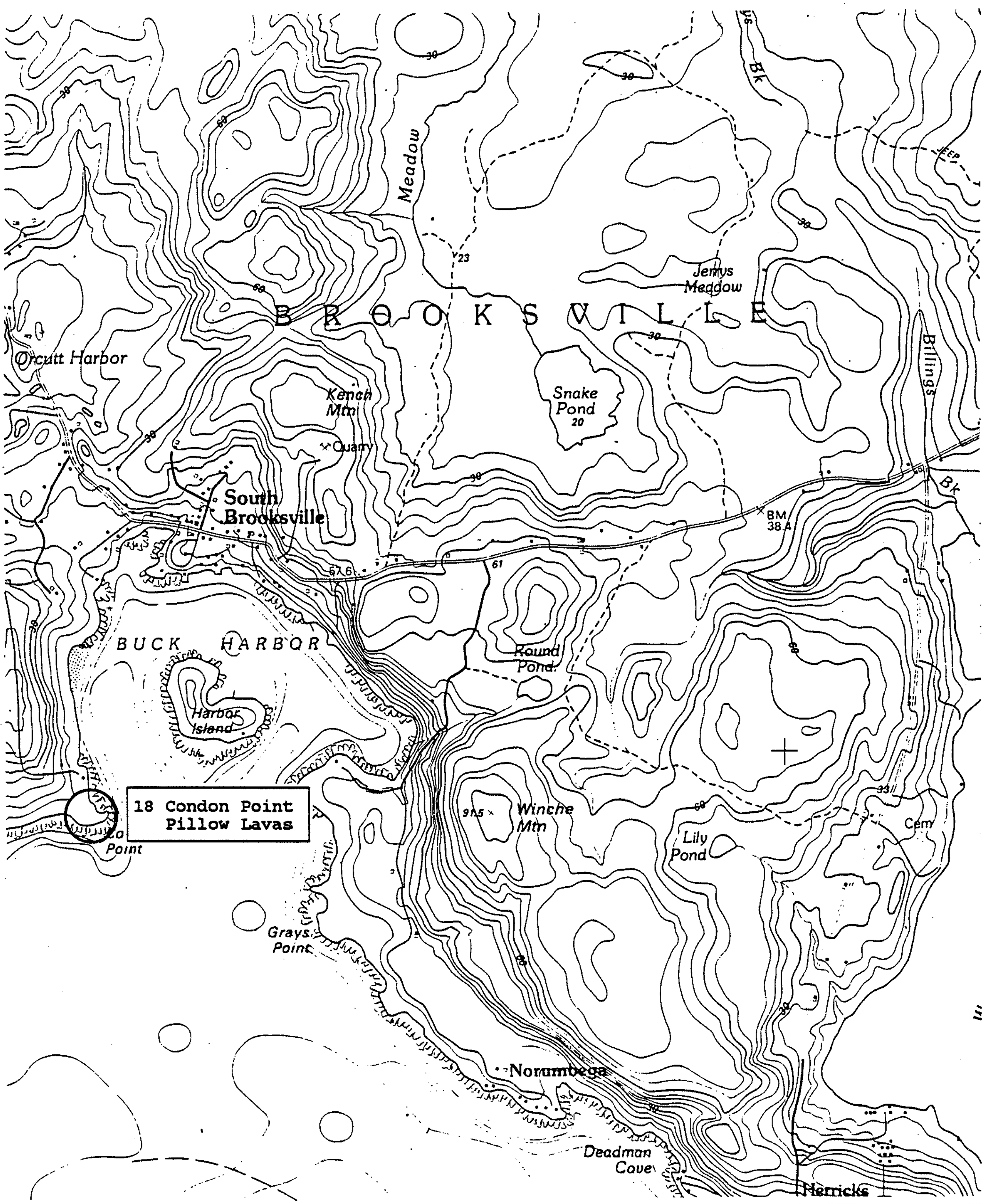
Lime Island is located 2¼ miles south of the southern peninsula of Seven Hundred Acre Island.

[North Haven West 7.5' (1983)]

INDEX MAP NO. 17
Islesboro 7.5' (1973)
& North Haven West 7.5' (1983)







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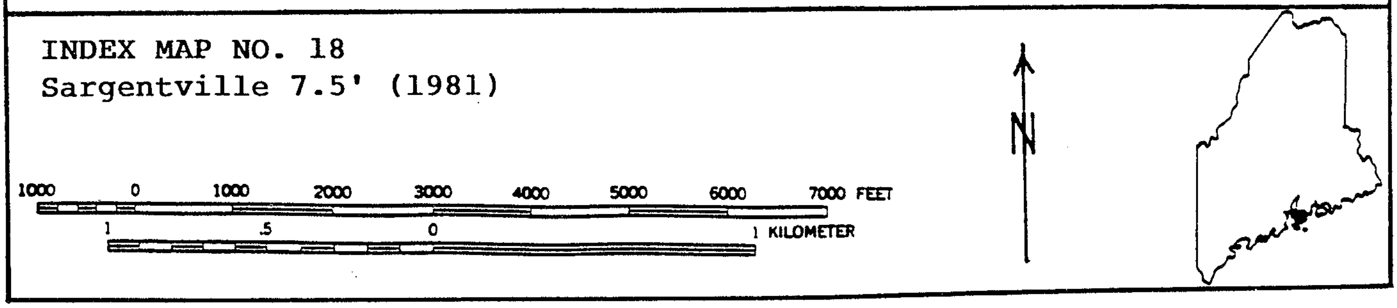
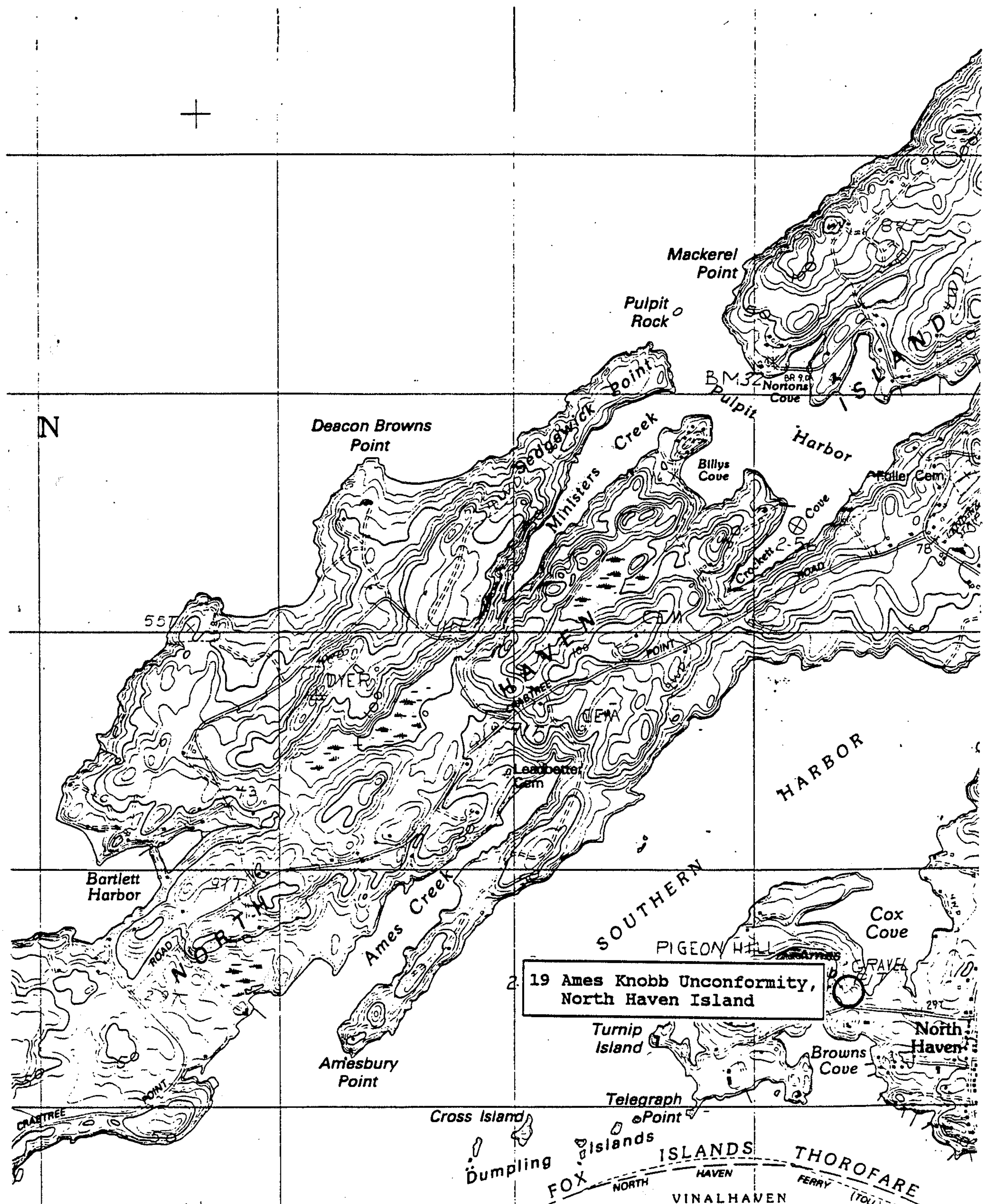
Sargentville 7.5' (1981)





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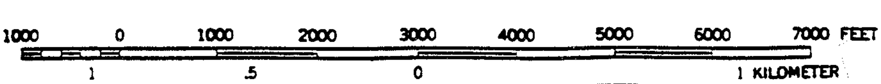

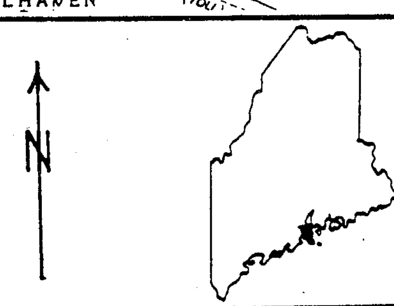

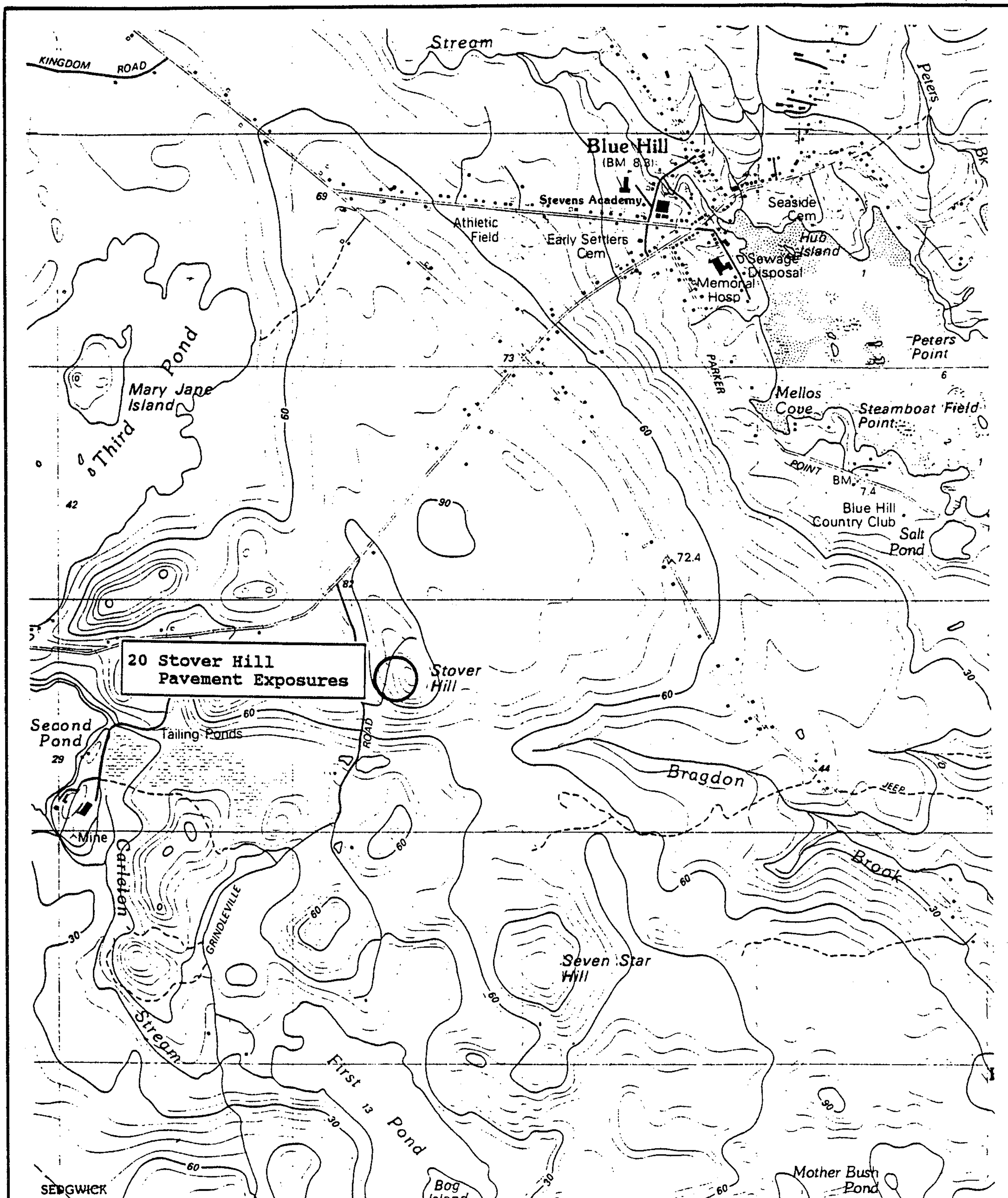

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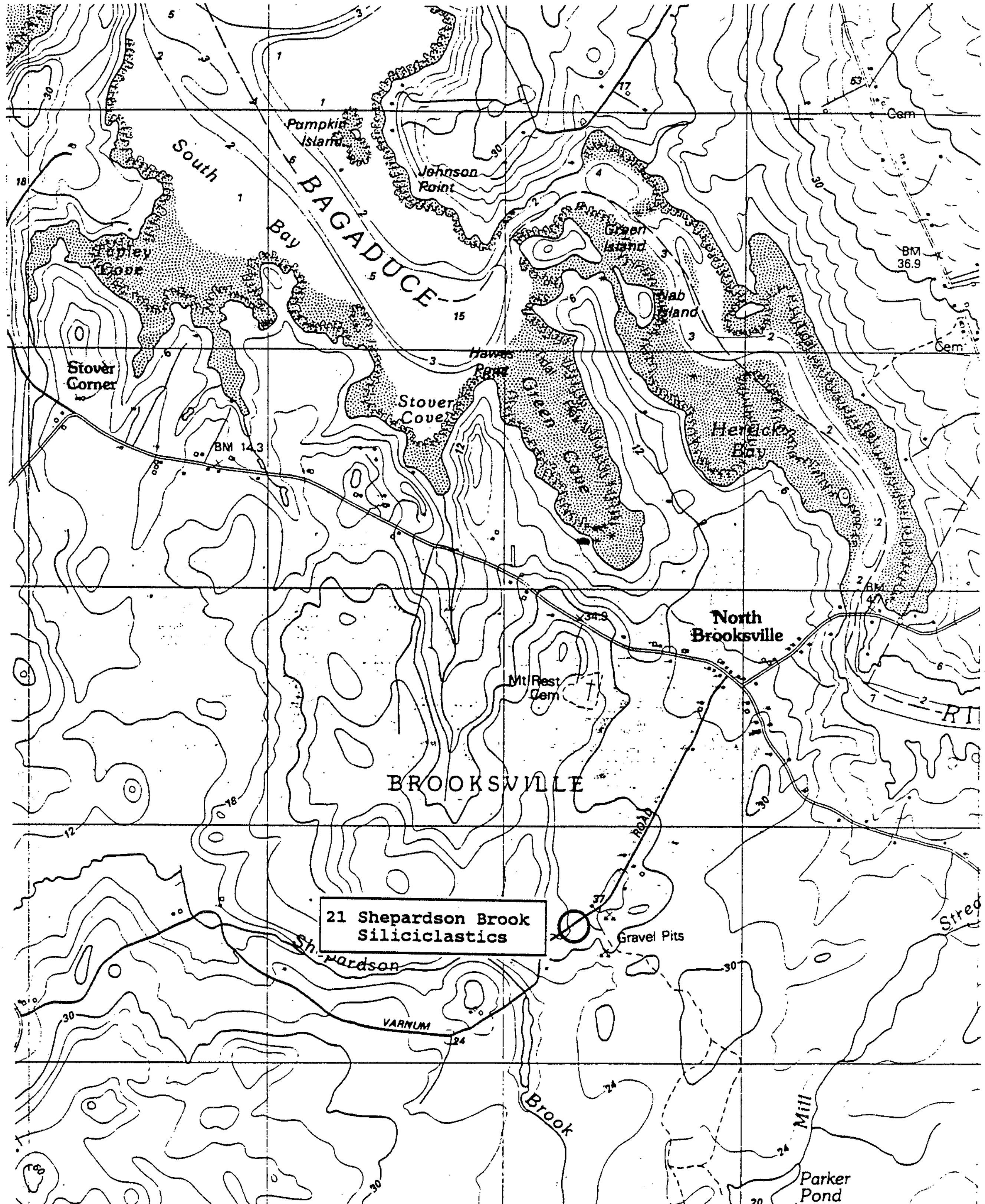
Blue Hill 7.5' (1981)



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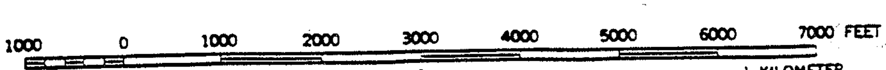
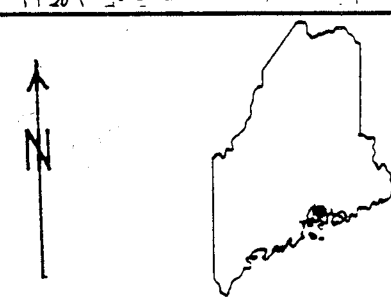
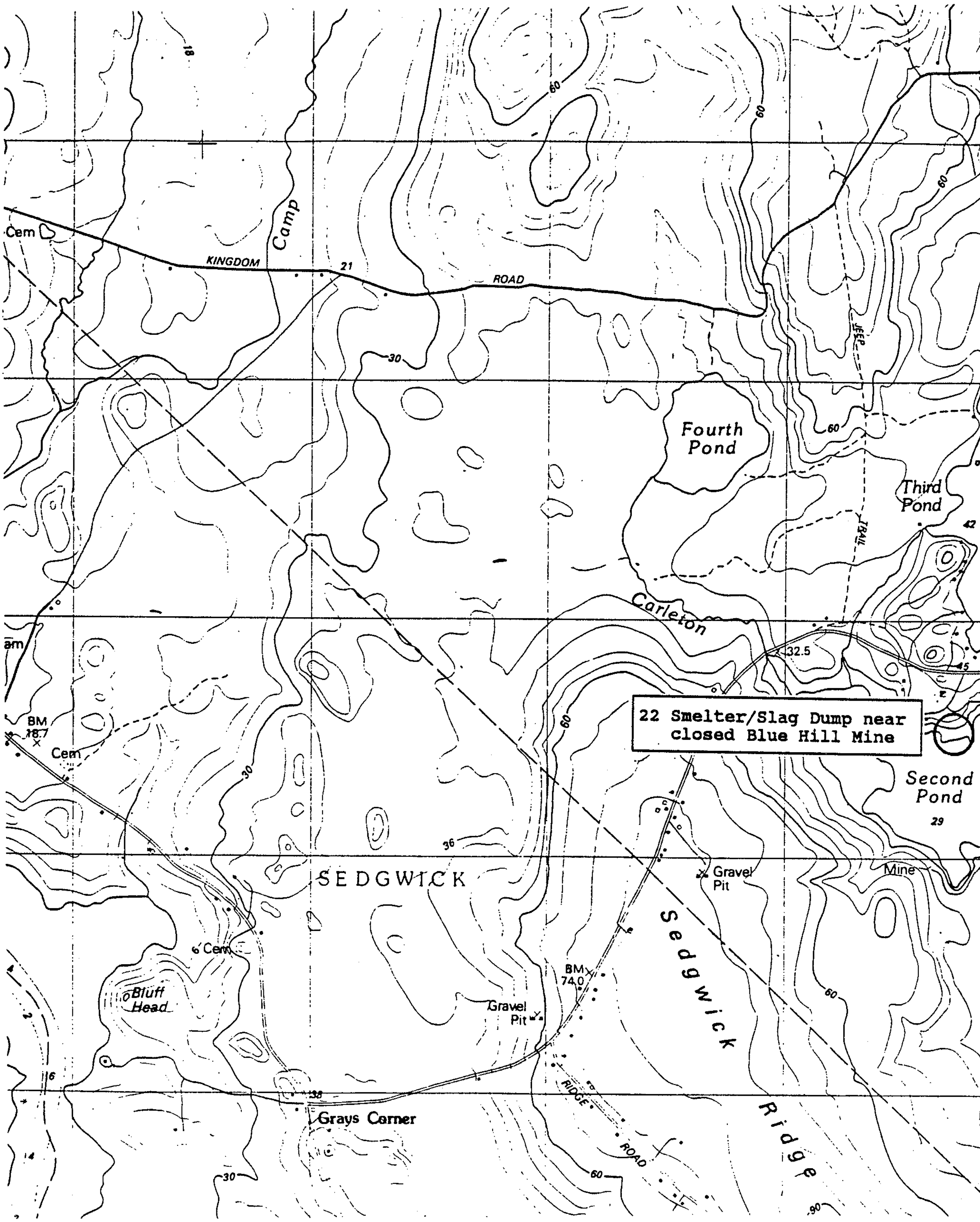
Penobscot 7.5' (1981)







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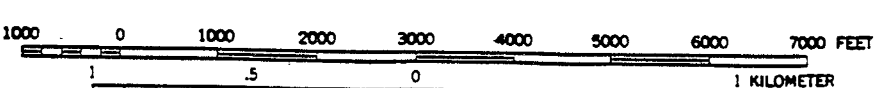
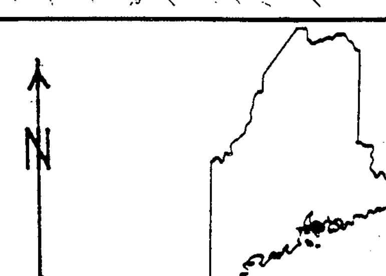
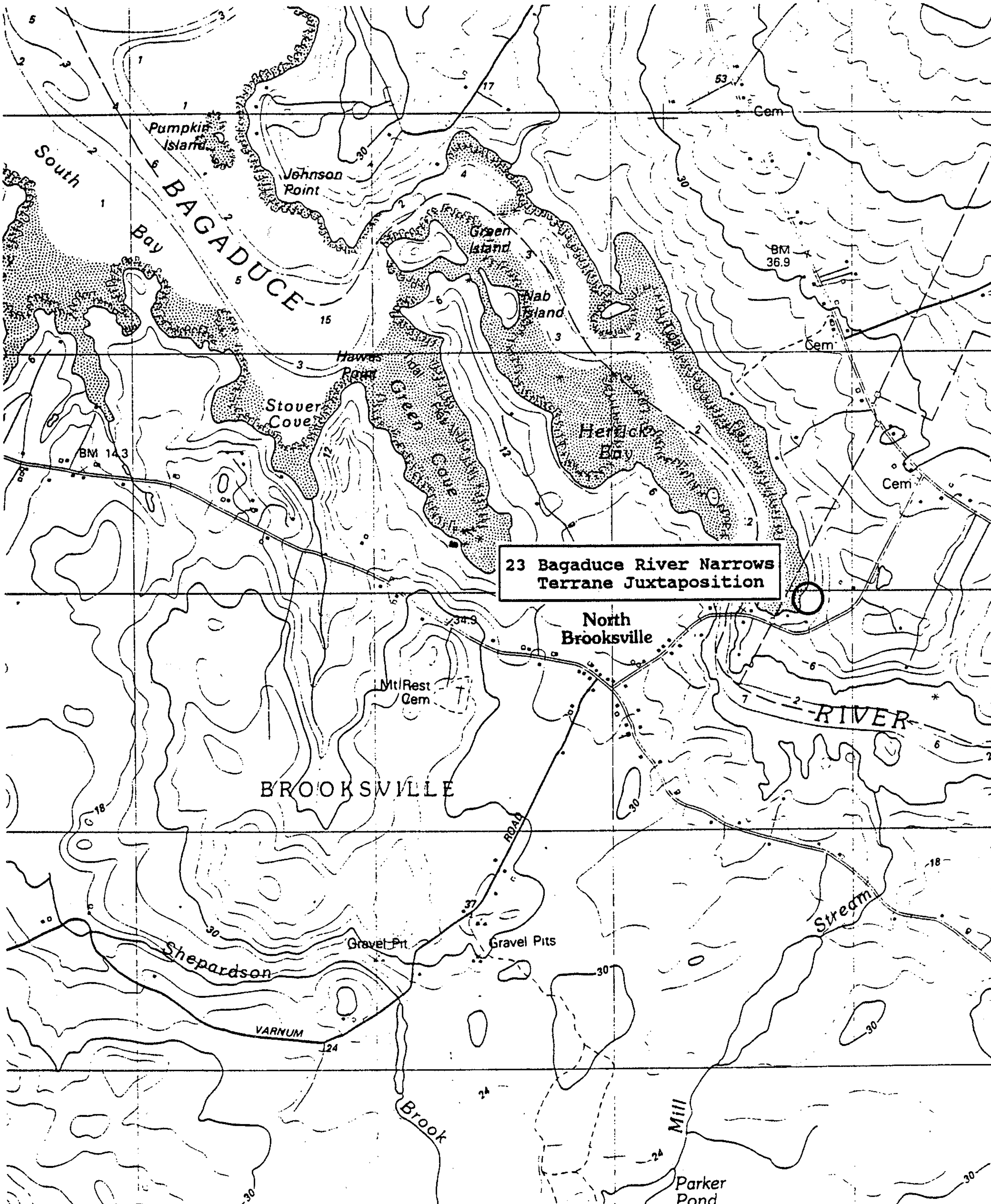
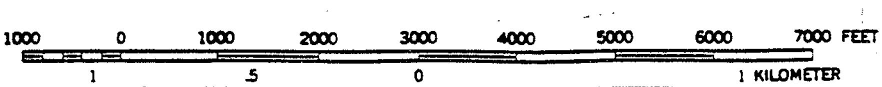
Penobscot 7.5' (1981)

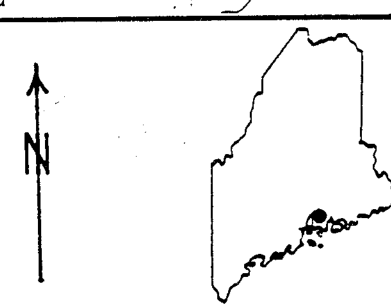


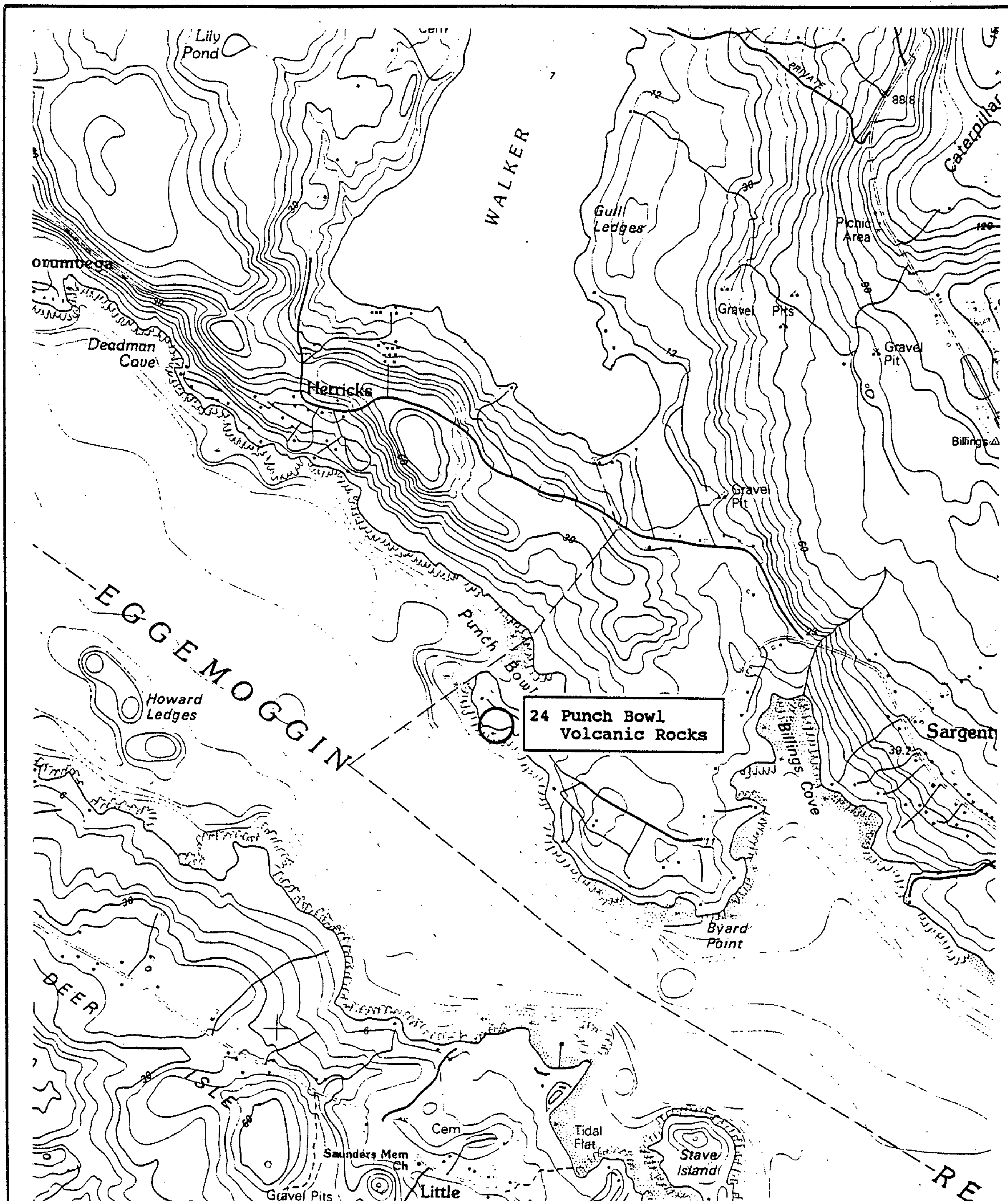




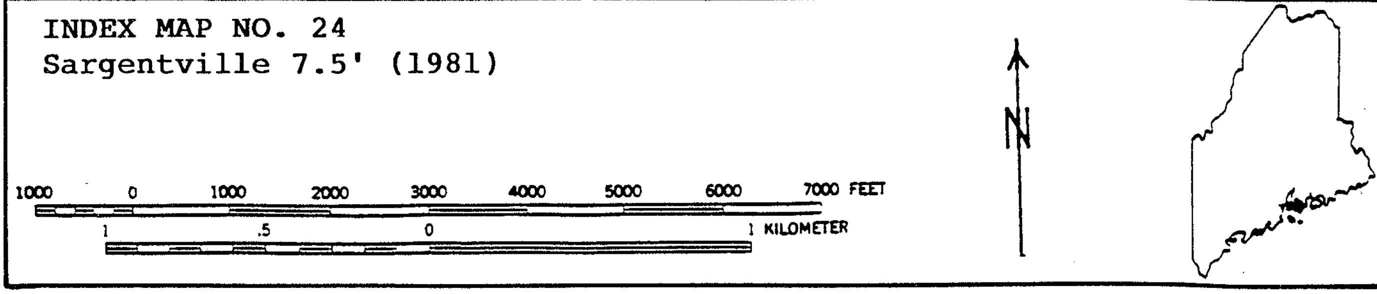
INDEX MAP NO. 23
Penobscot 7.5' (1981)

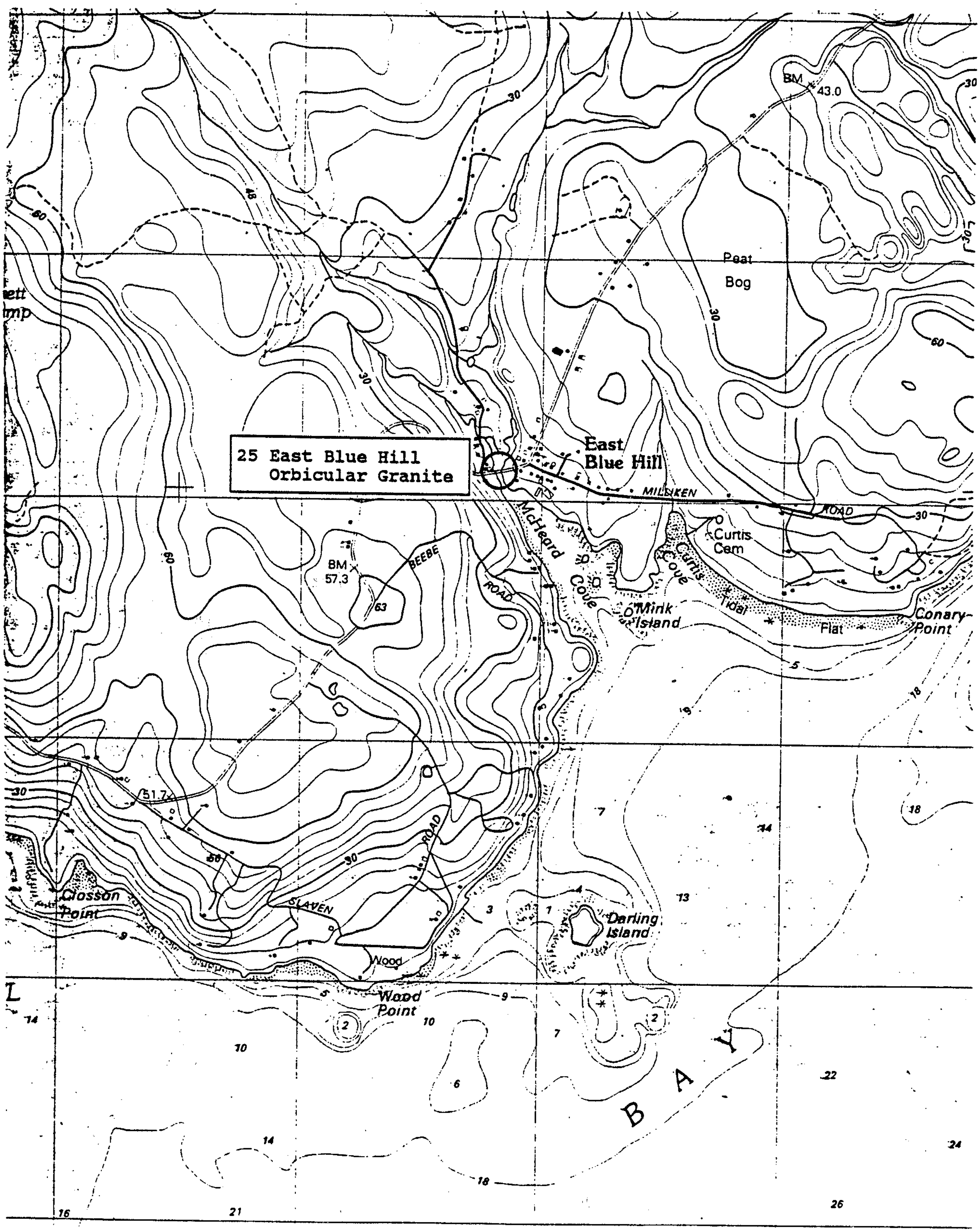




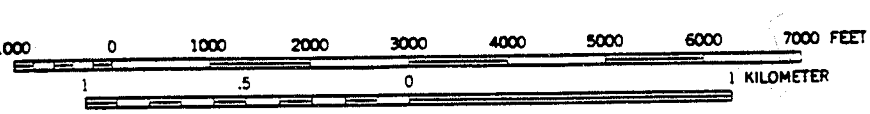


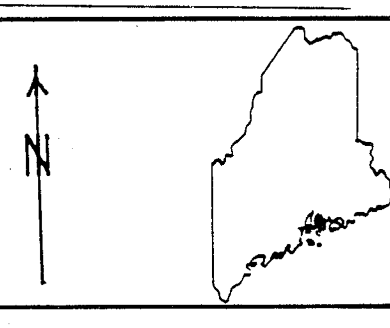
INDEX MAP NO. 24
Sargentville 7.5' (1981)

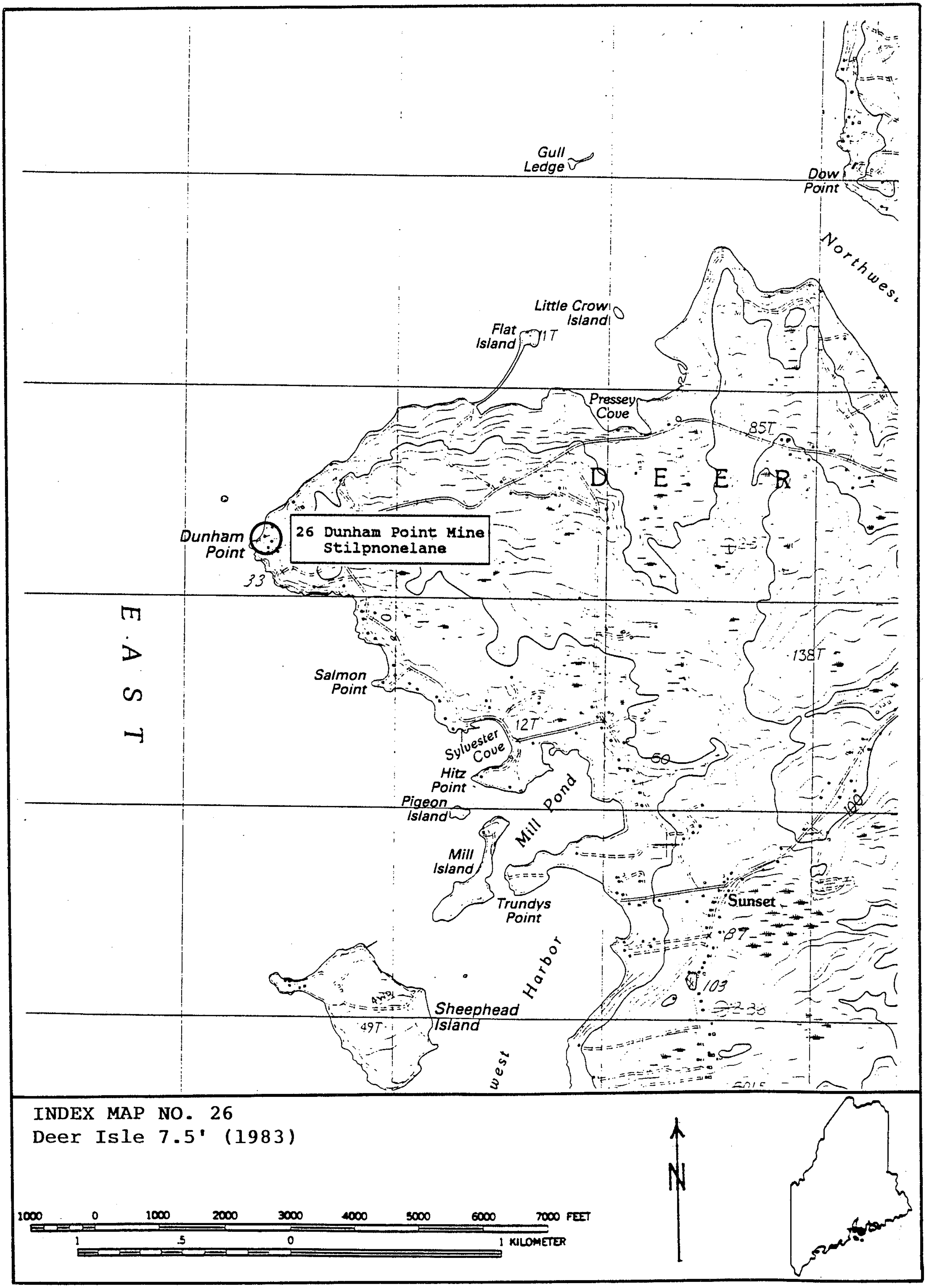




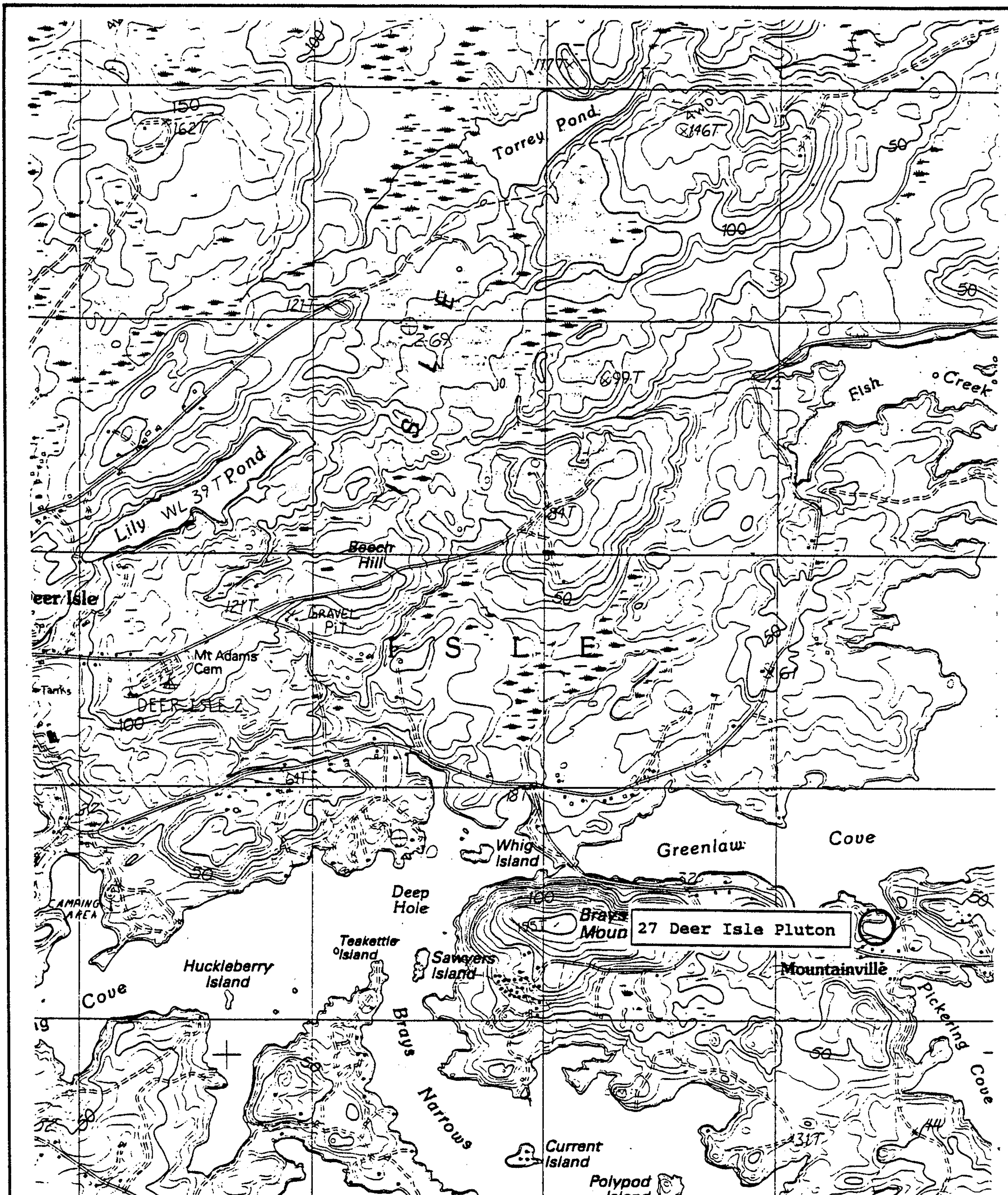
INDEX MAP NO. 25
Blue Hill 7.5' (1981)



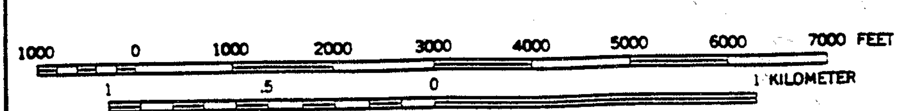


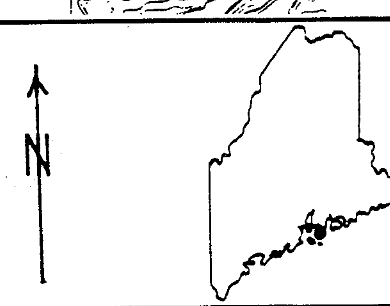


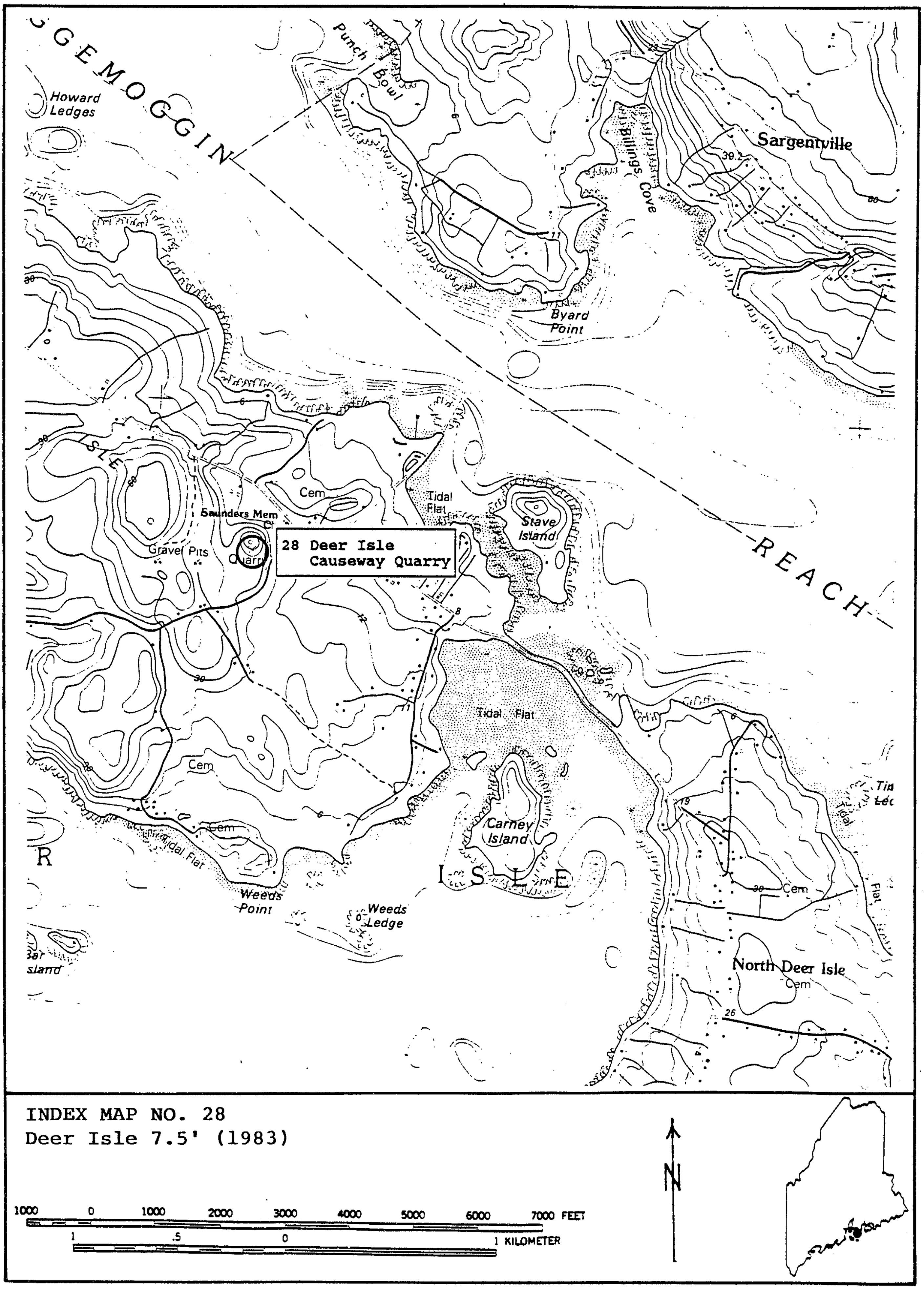
INDEX MAP NO. 26
Deer Isle 7.5' (1983)



INDEX MAP NO. 27
Deer Isle 7.5' (1983)

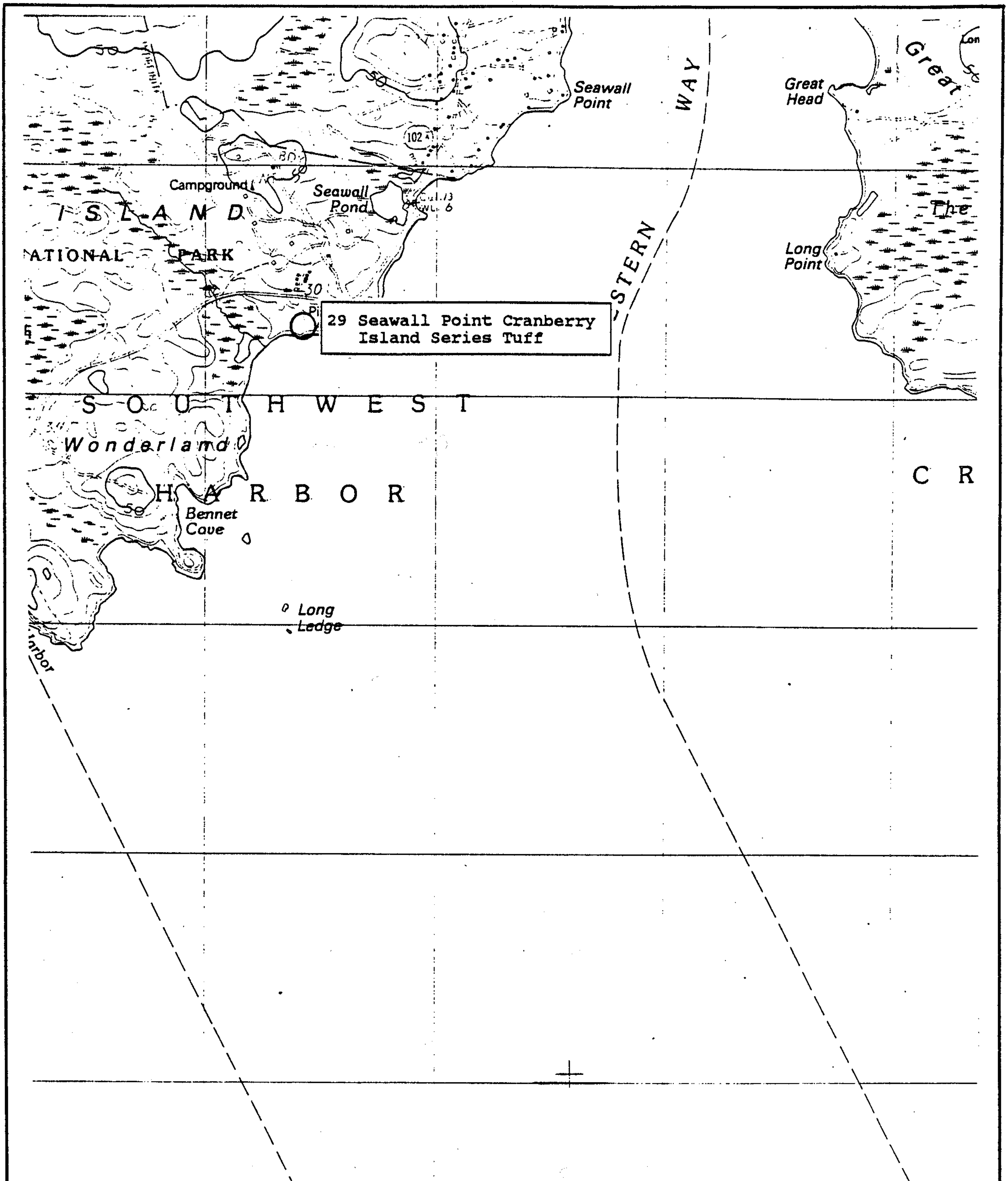






INDEX MAP NO. 28

Deer Isle 7.5' (1983)



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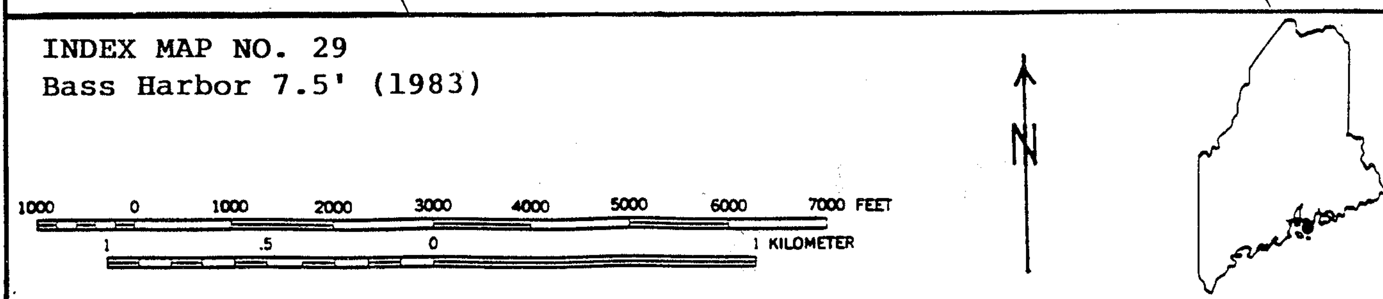
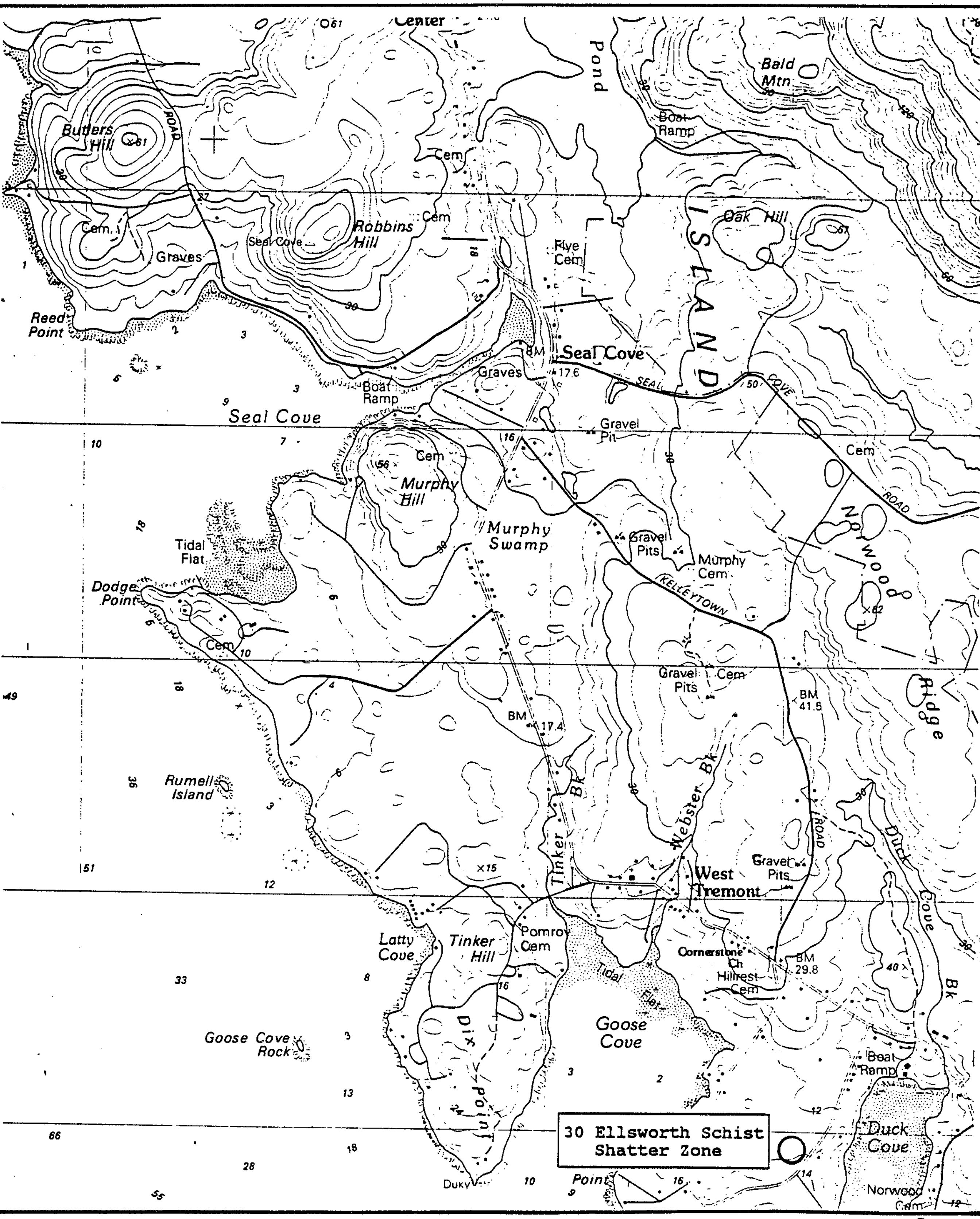
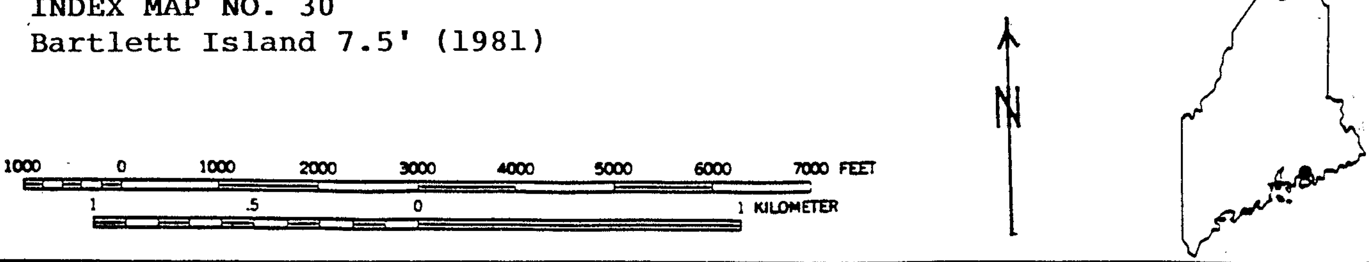
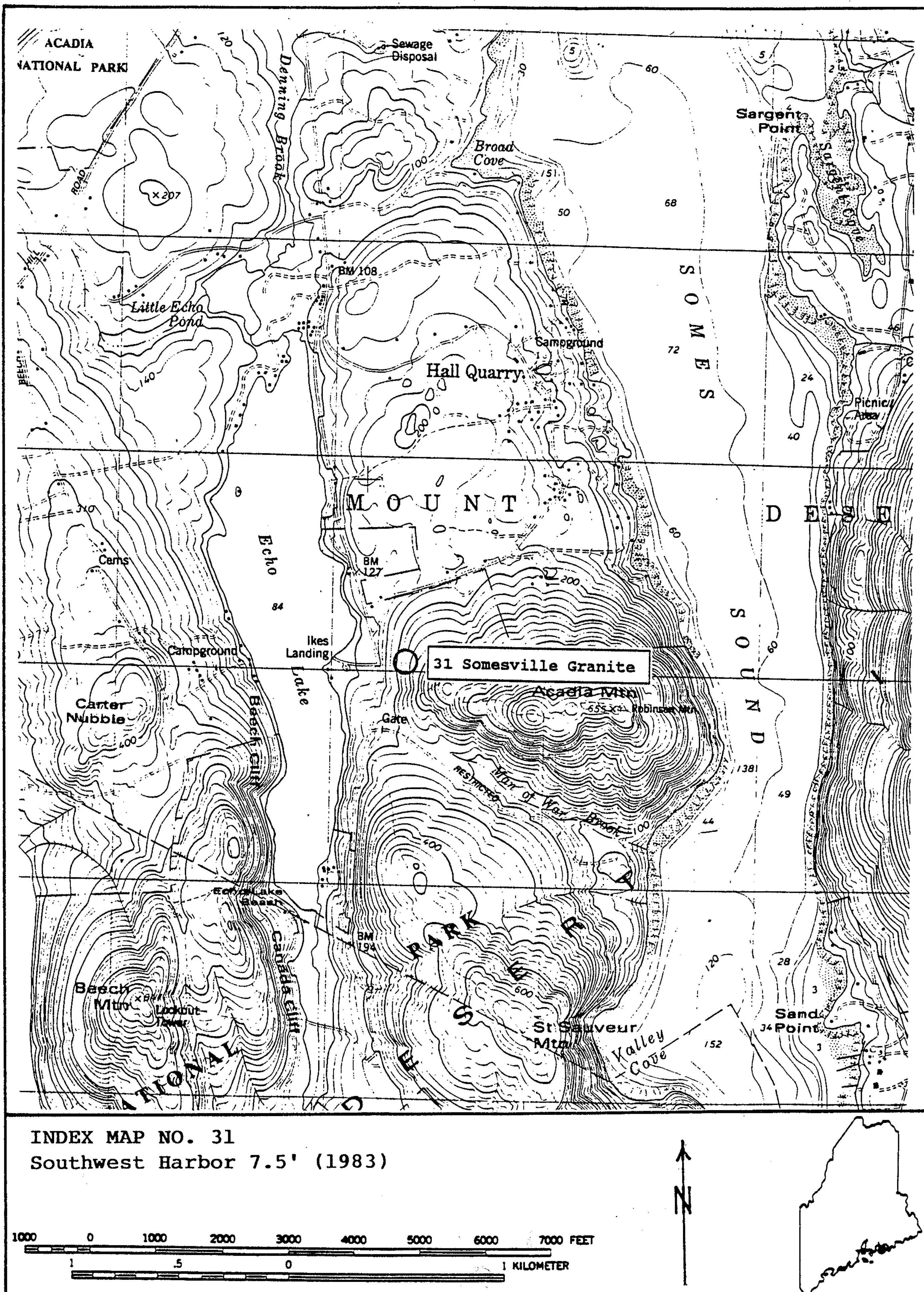
Bass Harbor 7.5' (1983)



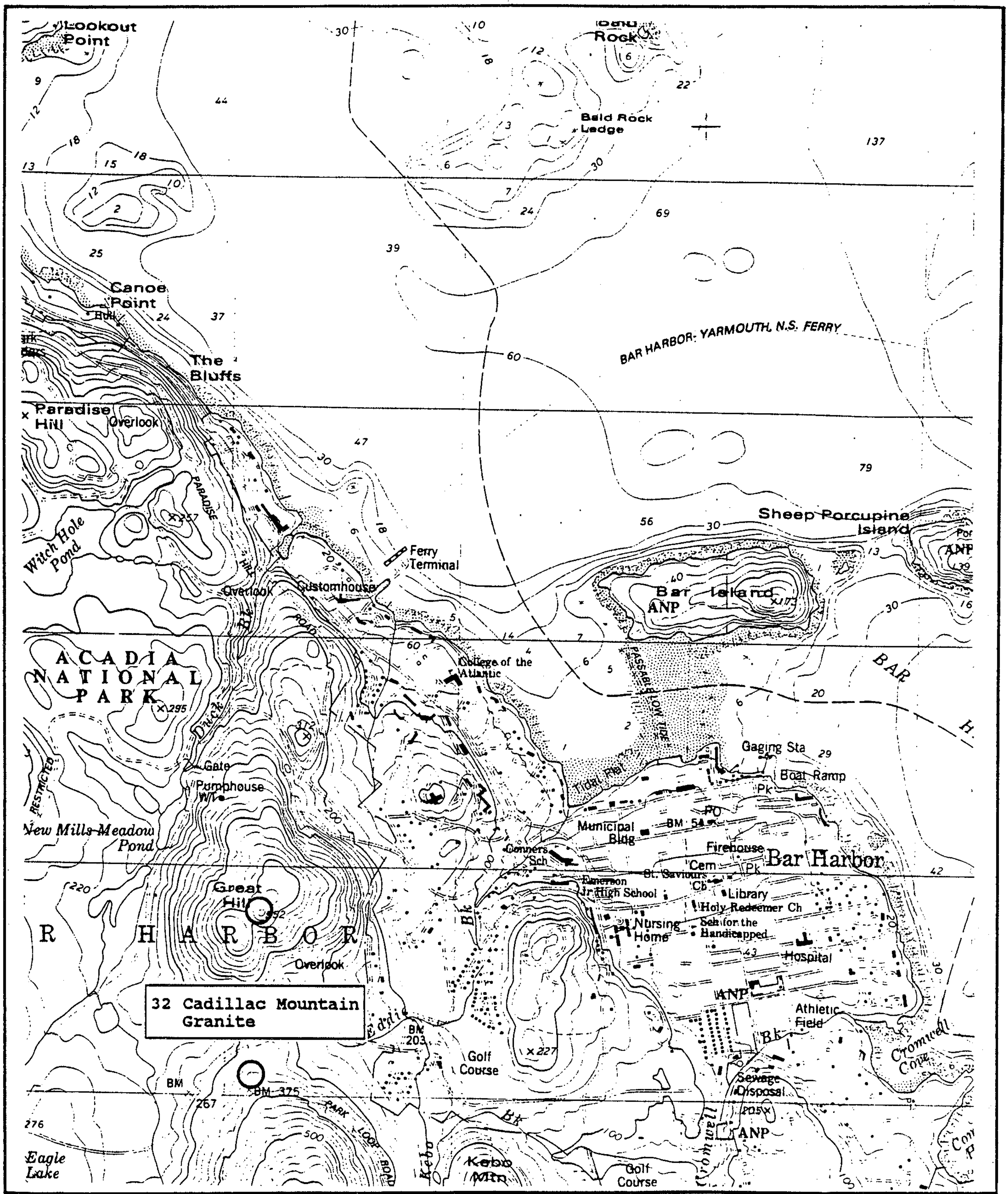


INDEX MAP NO. 30
Bartlett Island 7.5' (1981)

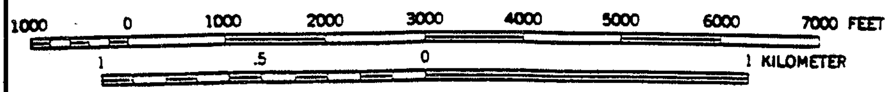


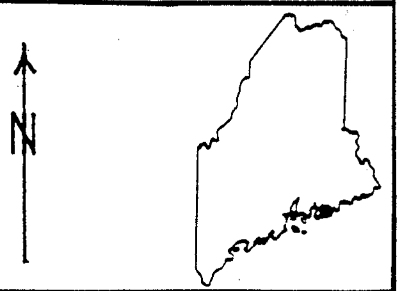


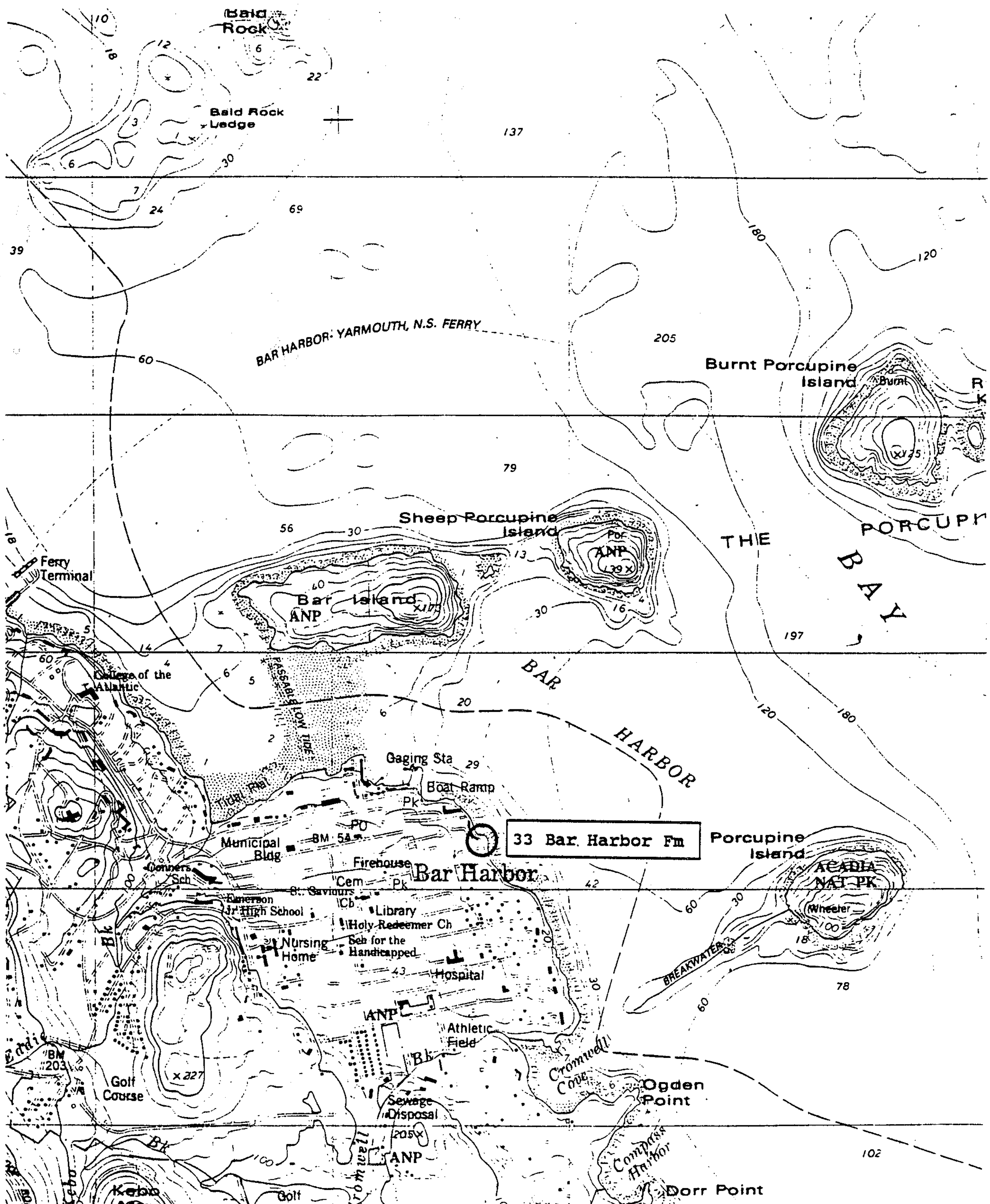
INDEX MAP NO. 31
Southwest Harbor 7.5' (1983)



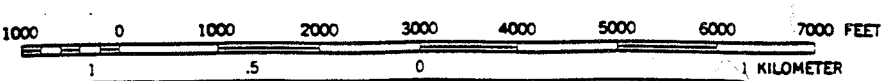
INDEX MAP NO. 32
Bar Harbor 7.5' (1982)

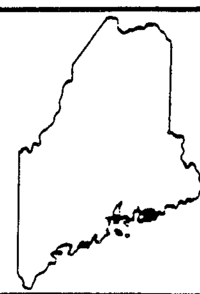


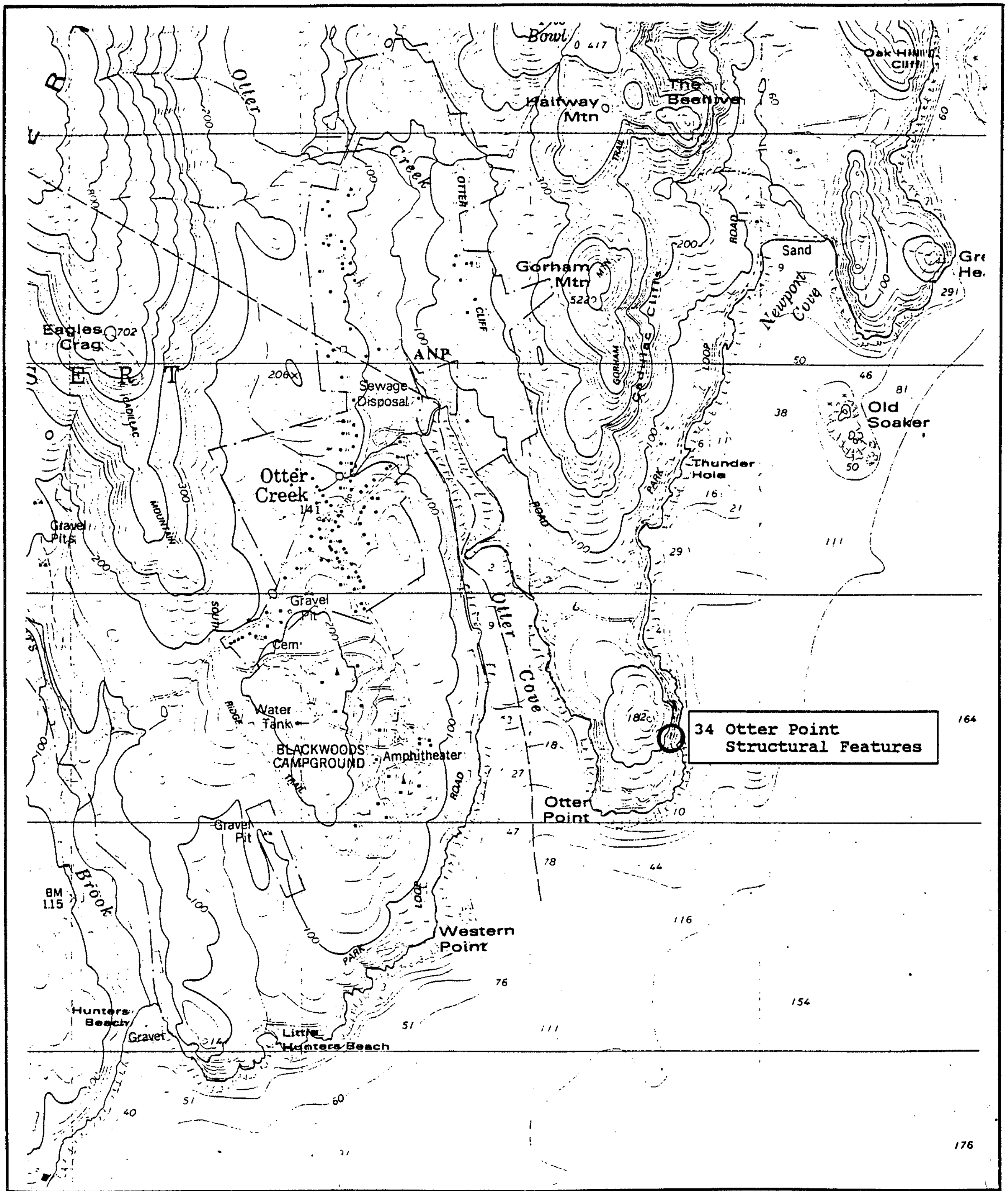




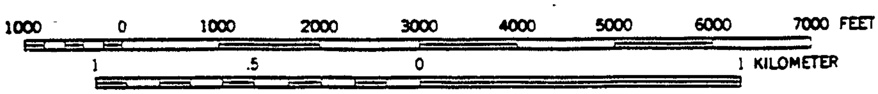
INDEX MAP NO. 33
Bar Harbor 7.5 (1982)

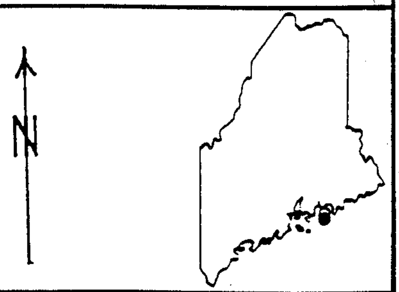


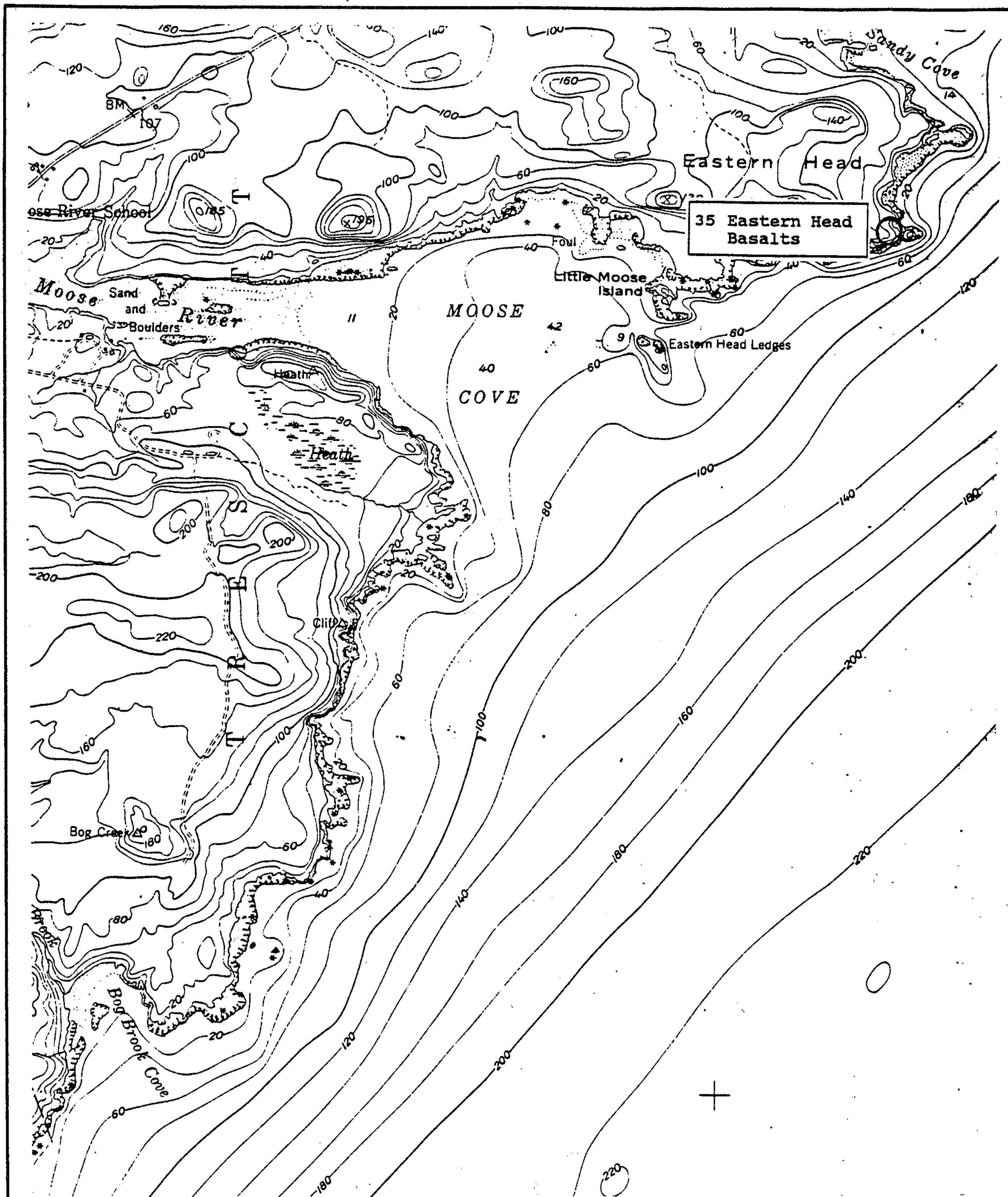




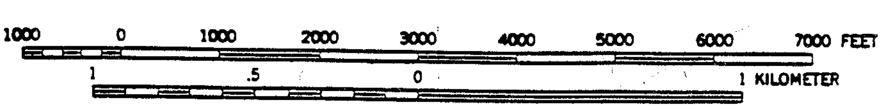
INDEX MAP NO. 34
Seal Harbor 7.5' (1983)

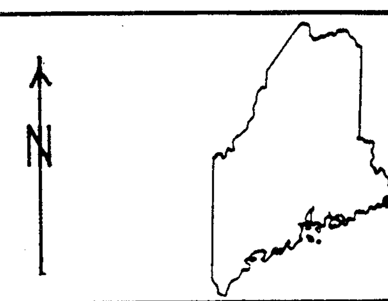


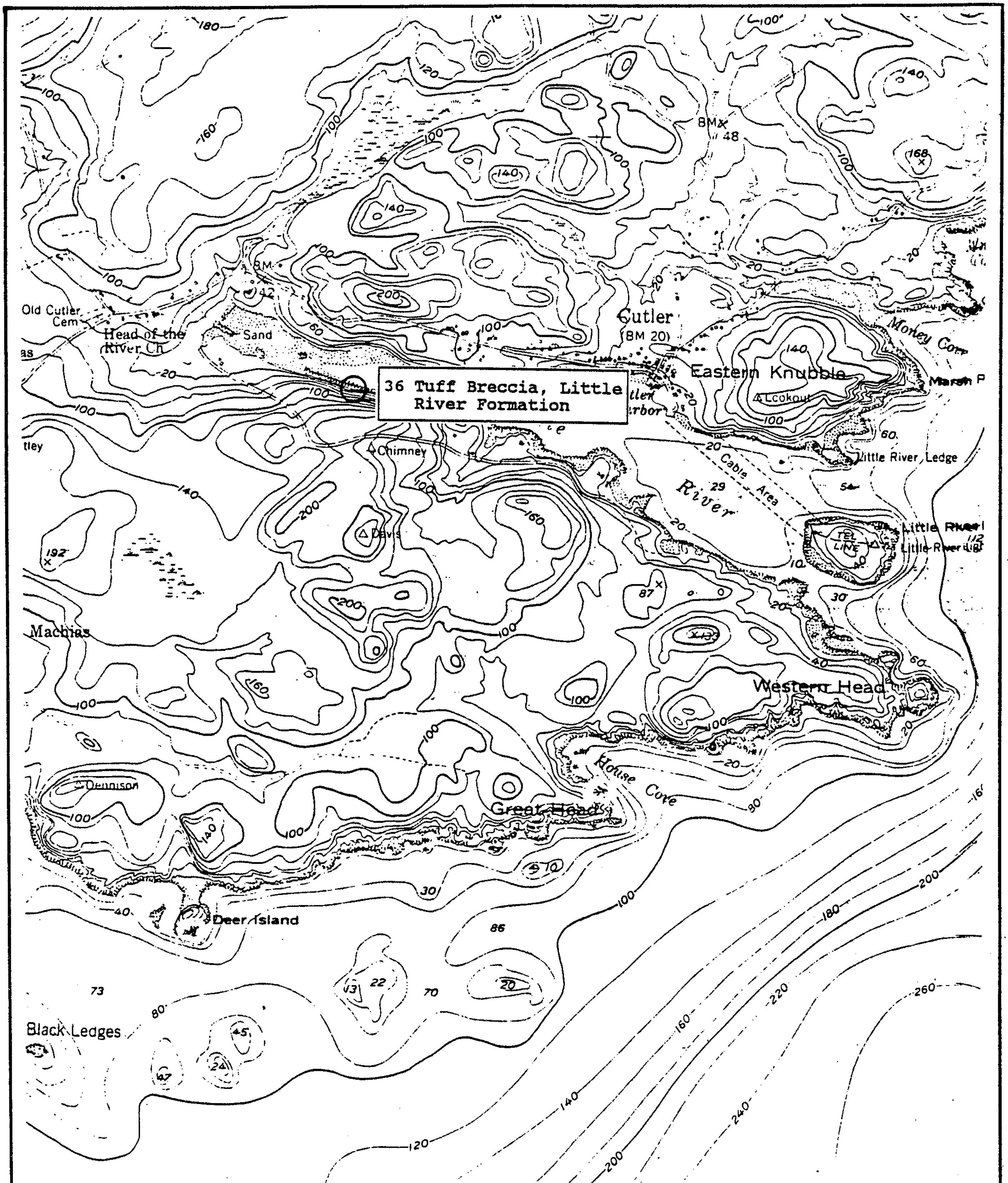




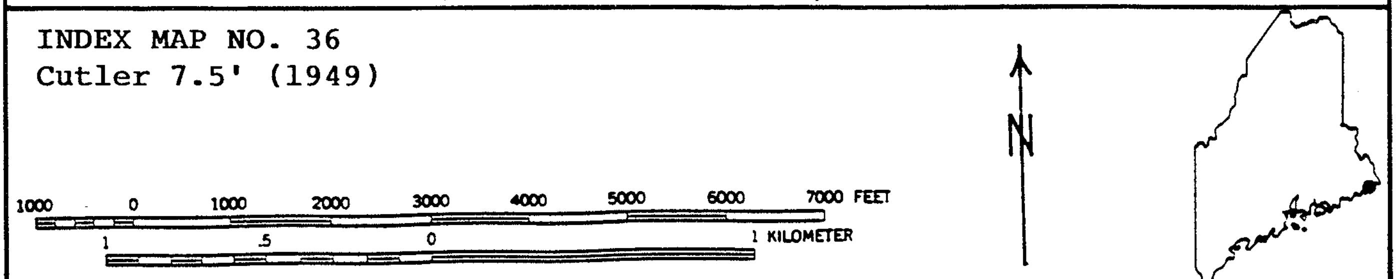
INDEX MAP NO. 35
Moose River 7.5' (1949)

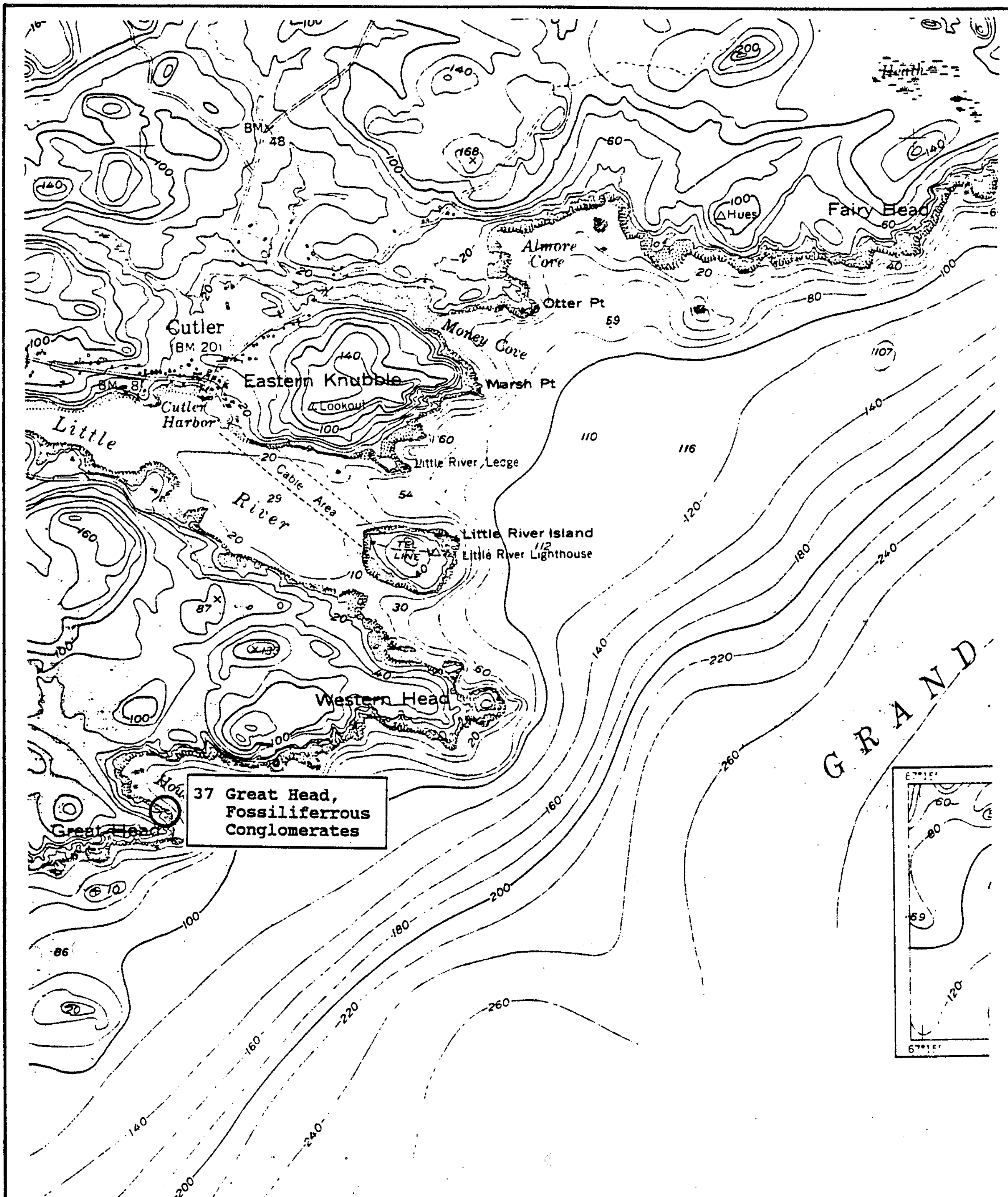




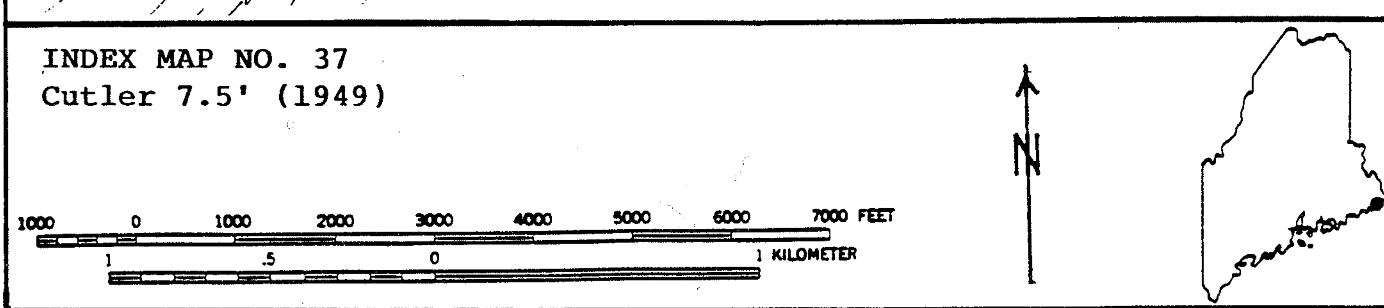


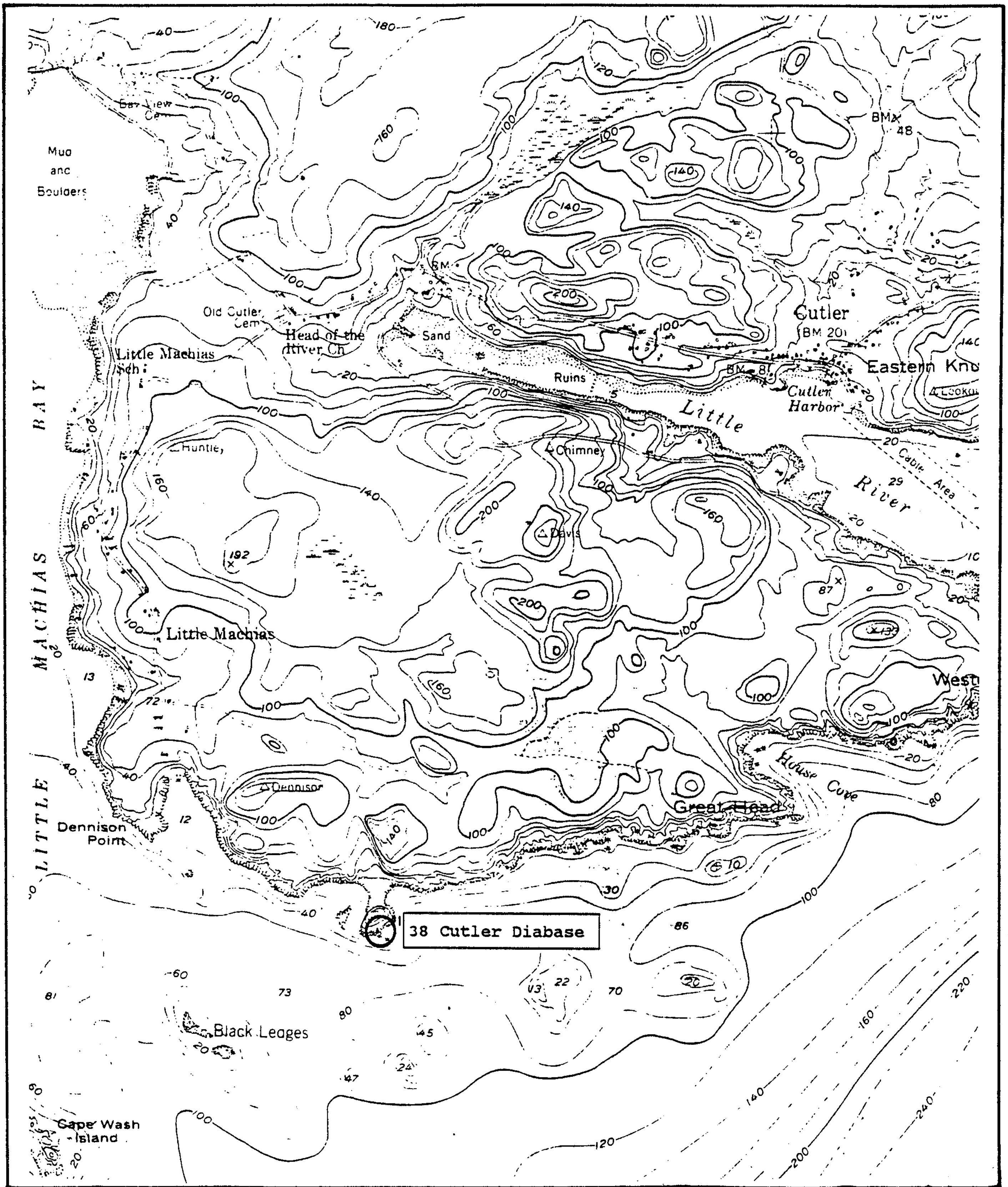
INDEX MAP NO. 36
Cutler 7.5' (1949)



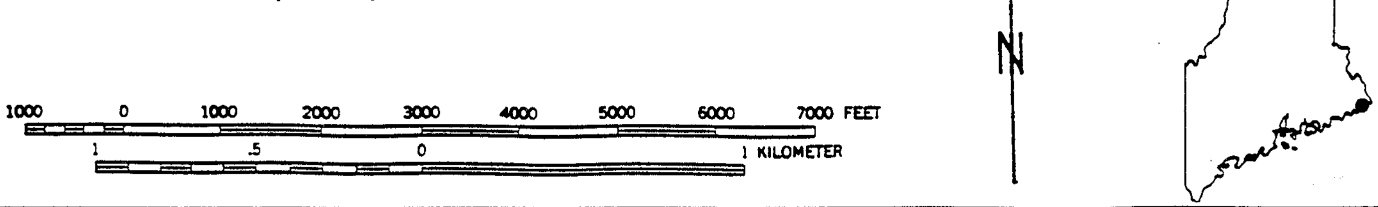


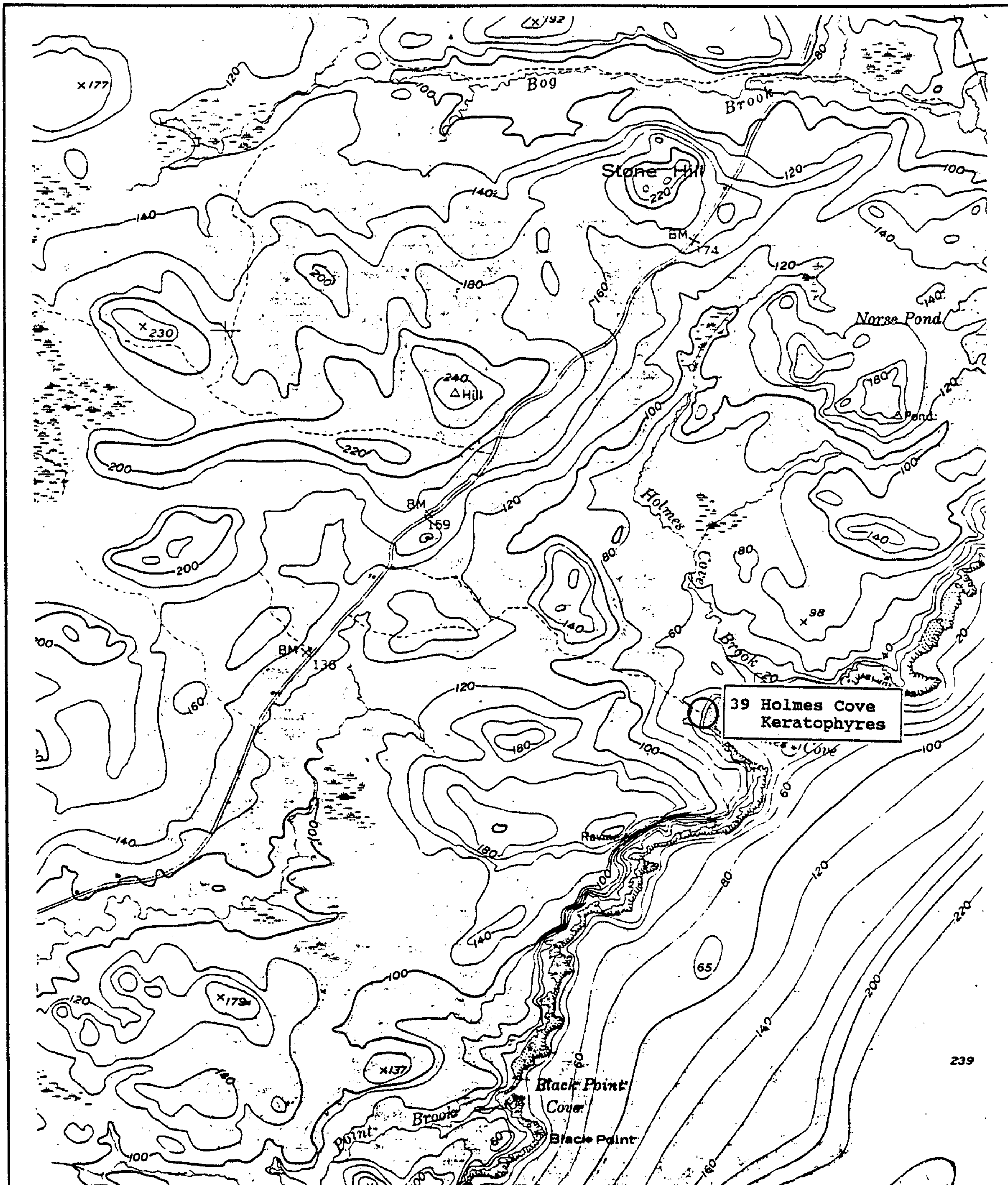
INDEX MAP NO. 37
Cutler 7.5' (1949)



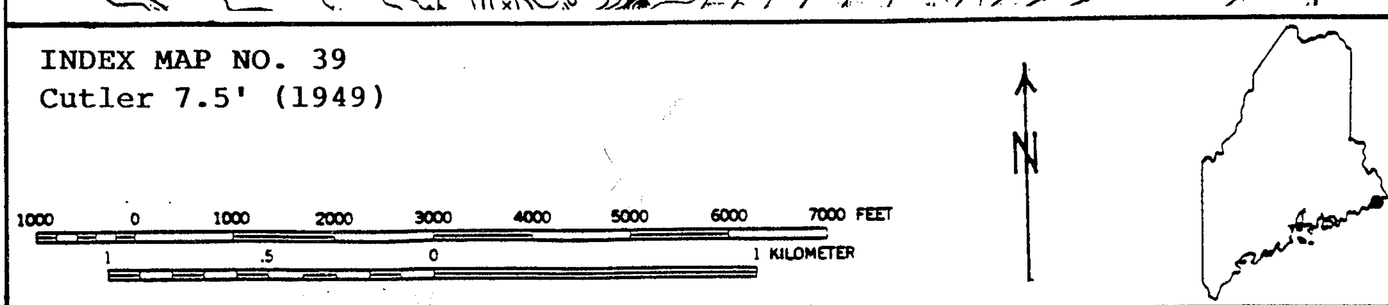


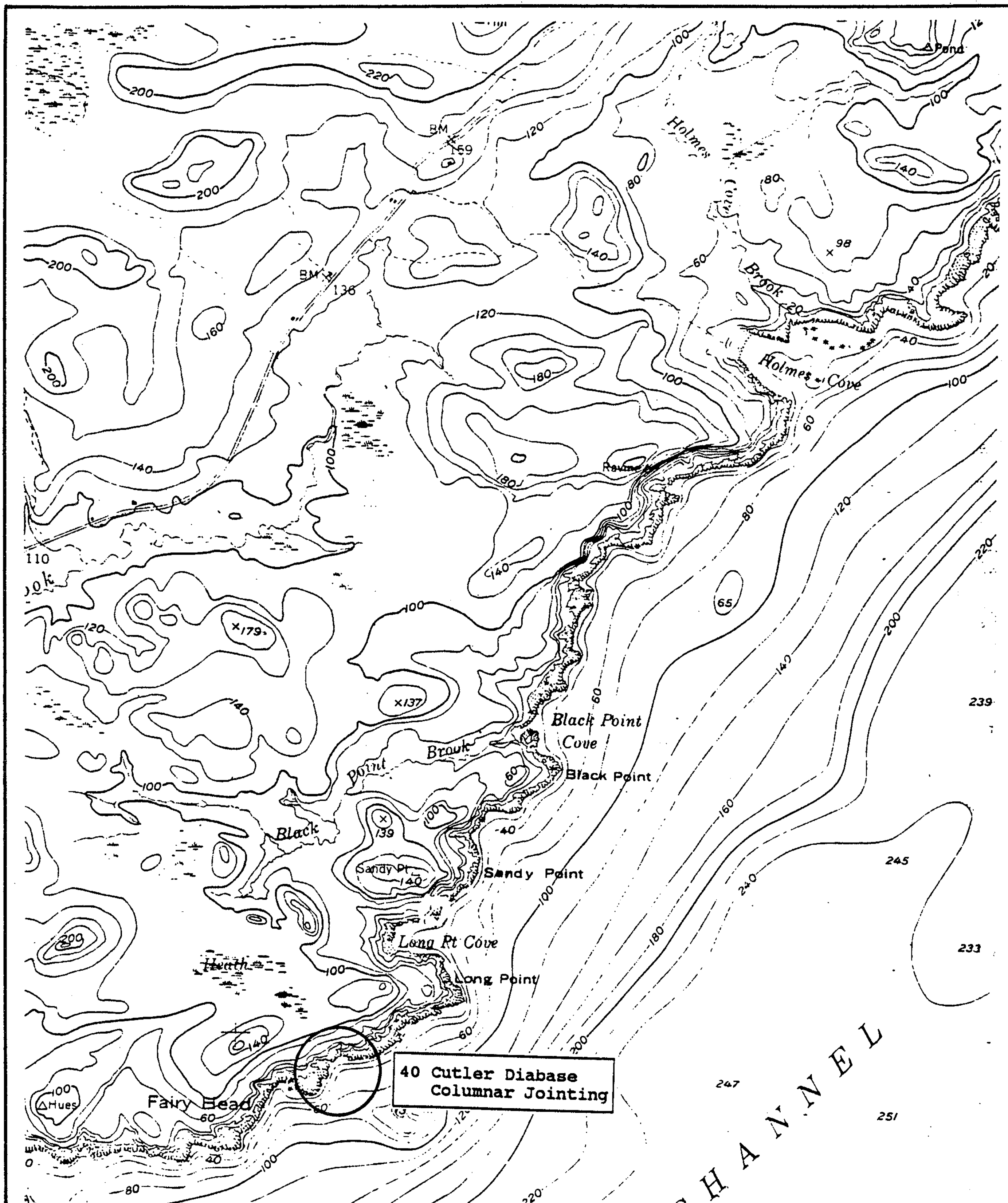
INDEX MAP NO. 38
Cutler 7.5' (1949)



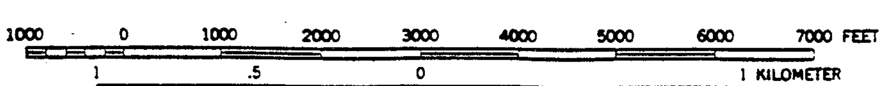


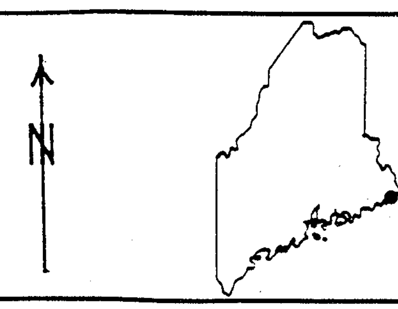
INDEX MAP NO. 39
Cutler 7.5' (1949)

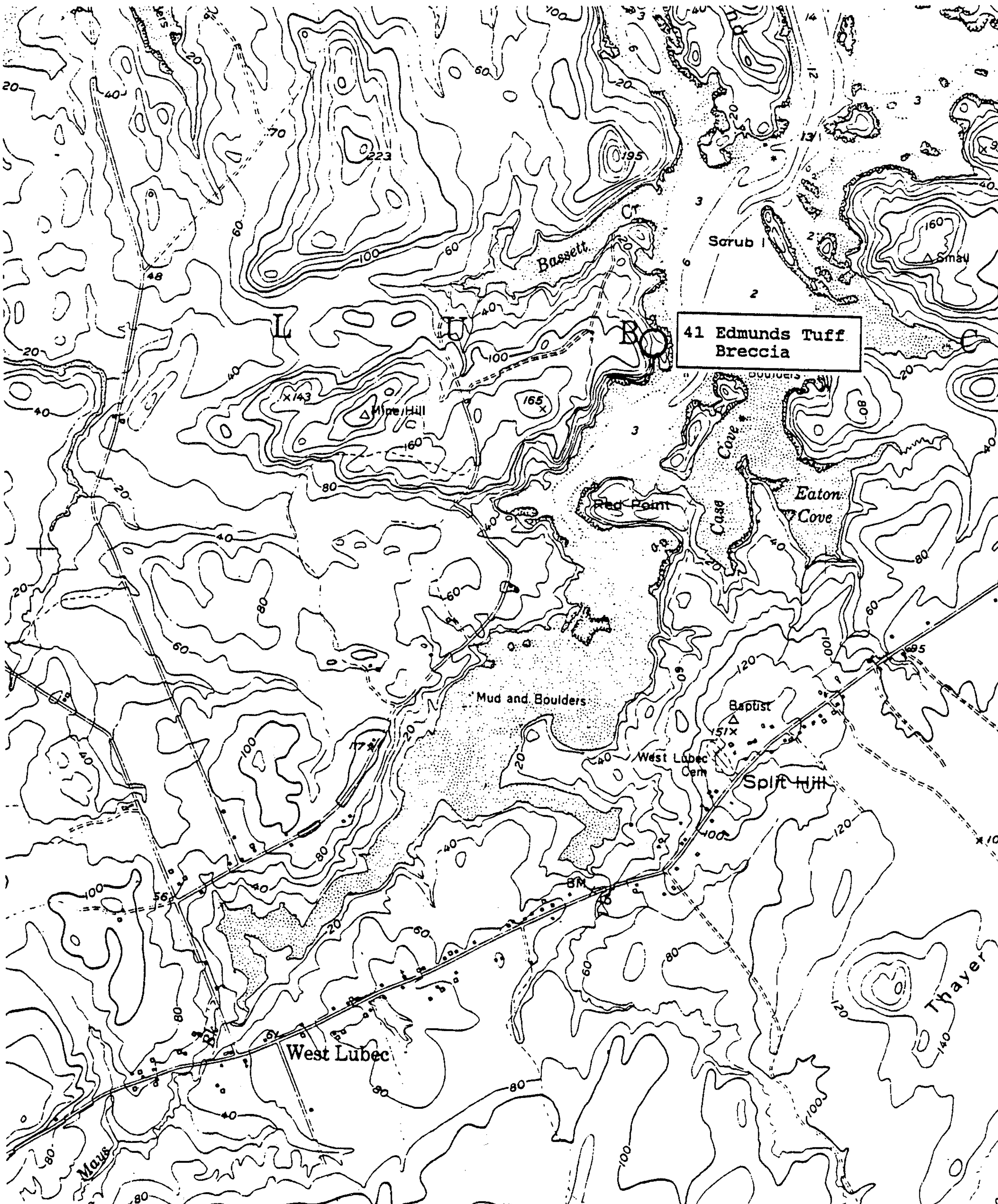




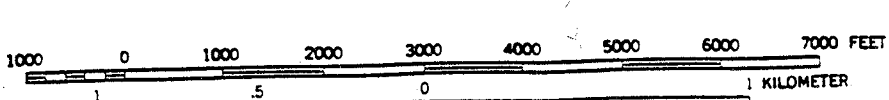
INDEX MAP NO. 40
Cutler 7.5 (1949)

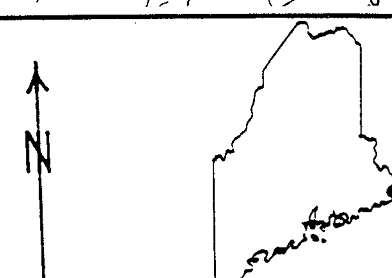


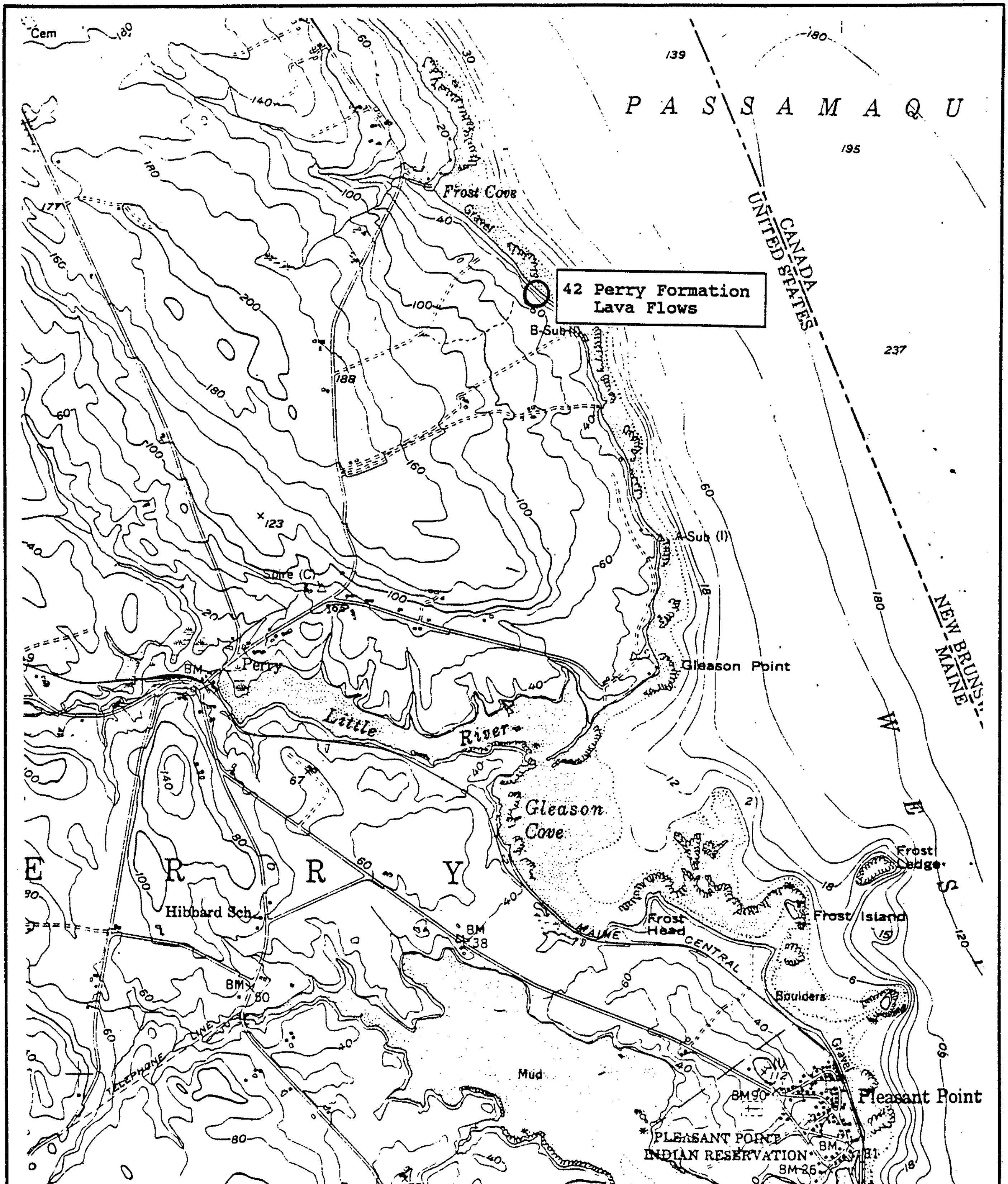




INDEX MAP NO. 41
West Lubec 7.5' (1949)



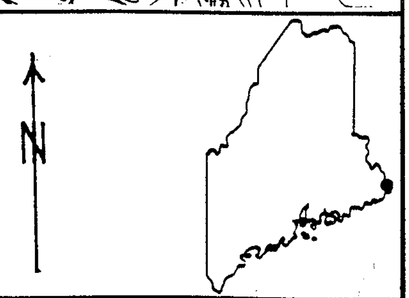


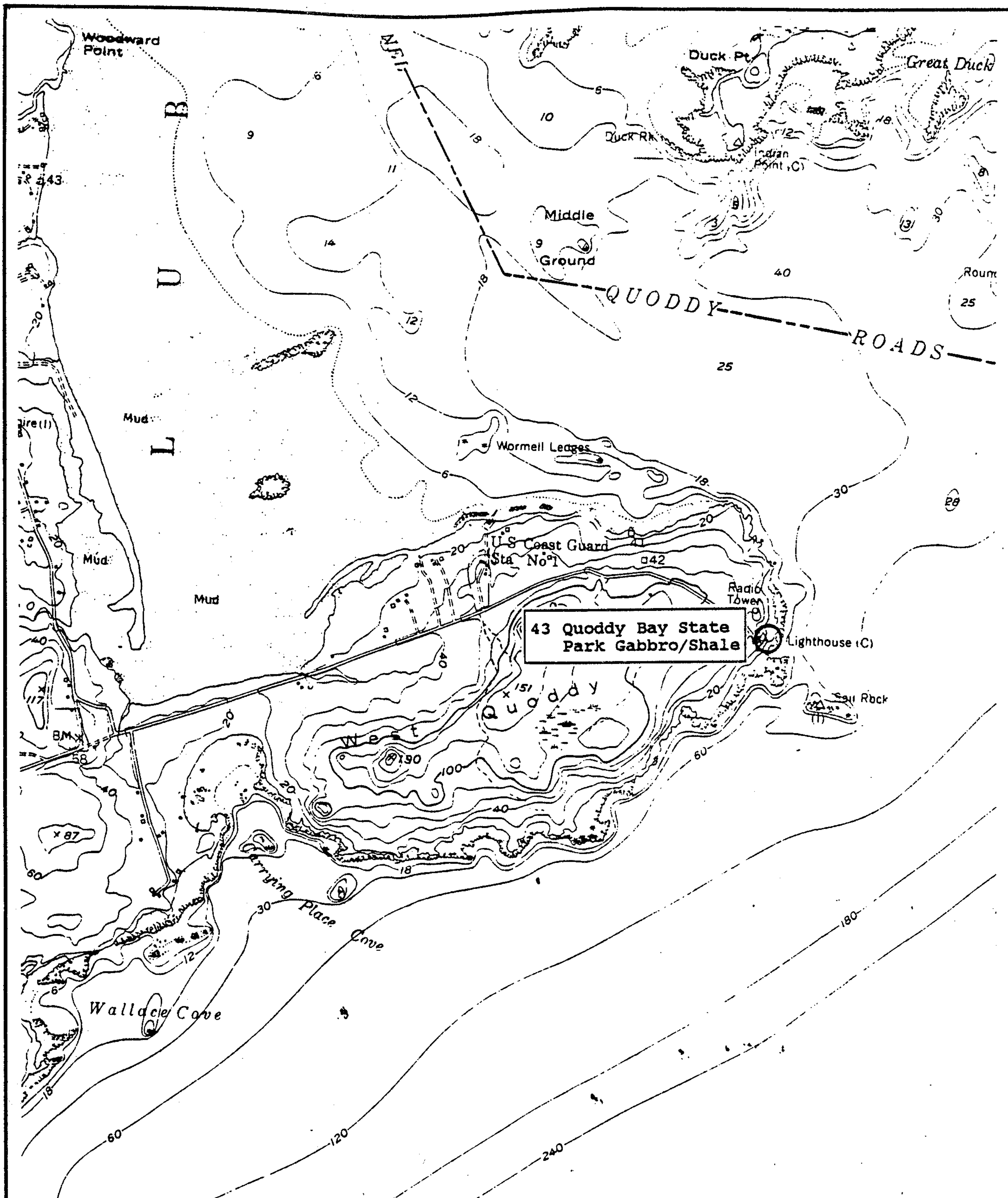


INDEX MAP NO. 42
Eastport 7.5' (1949)

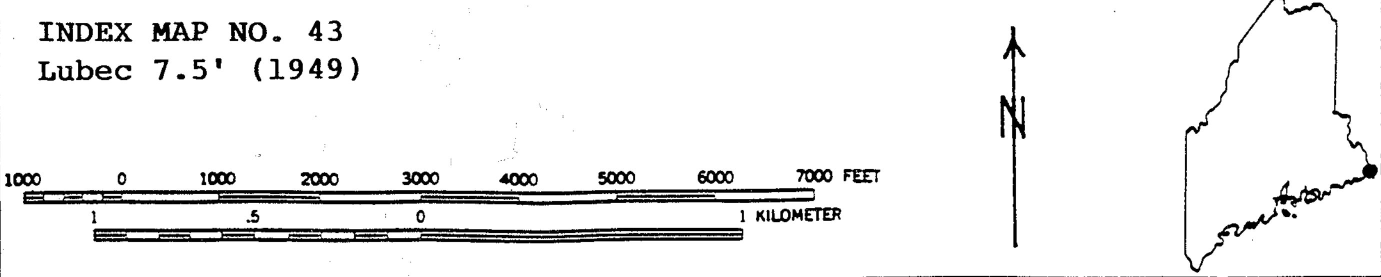
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

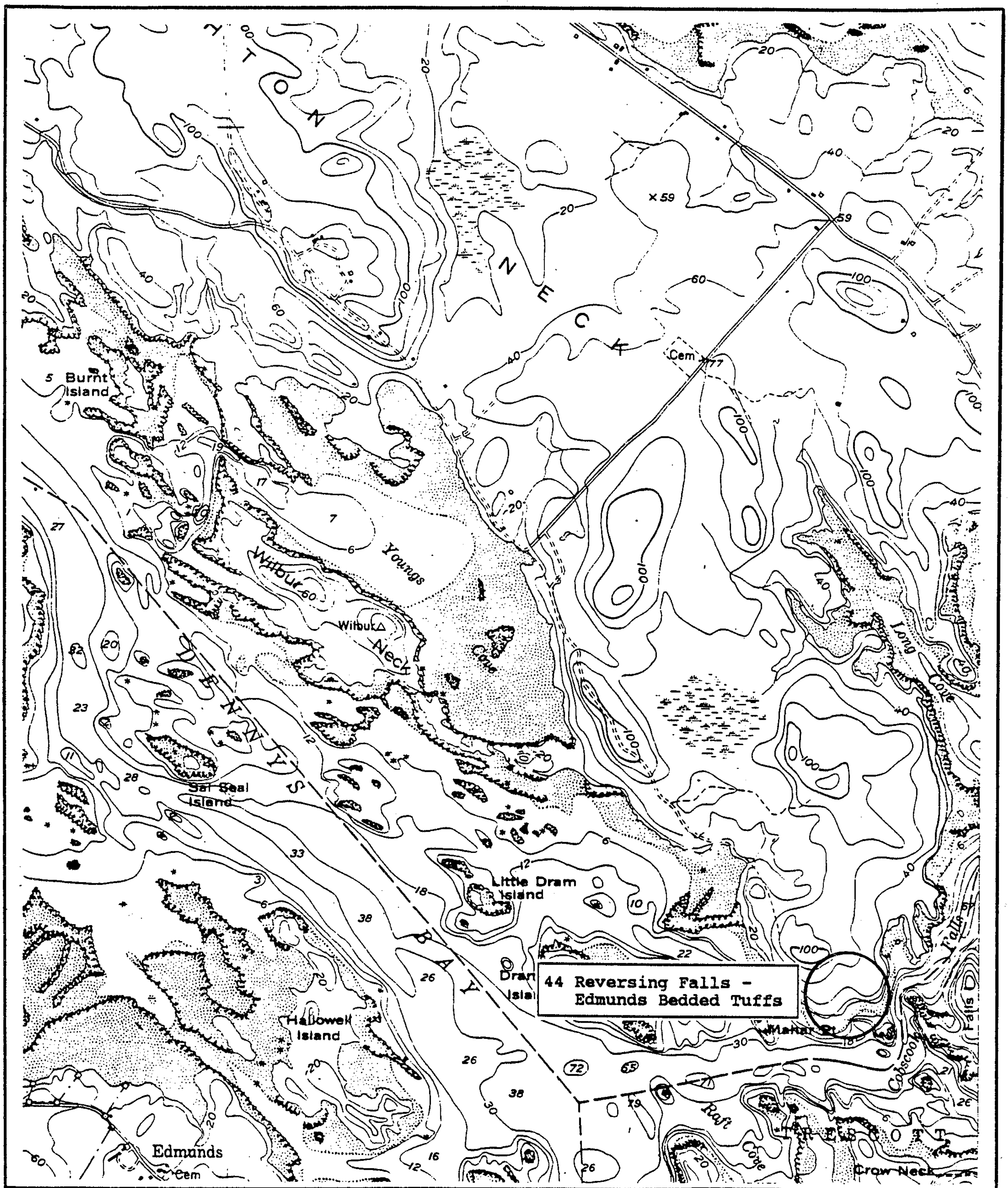
1 .5 0 1 KILOMETER



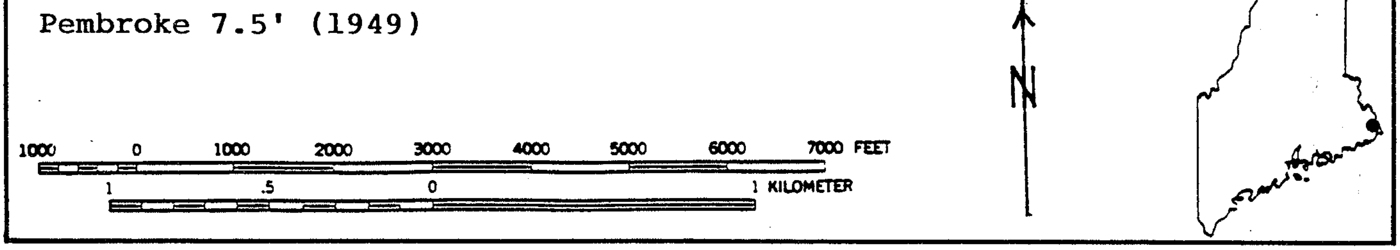


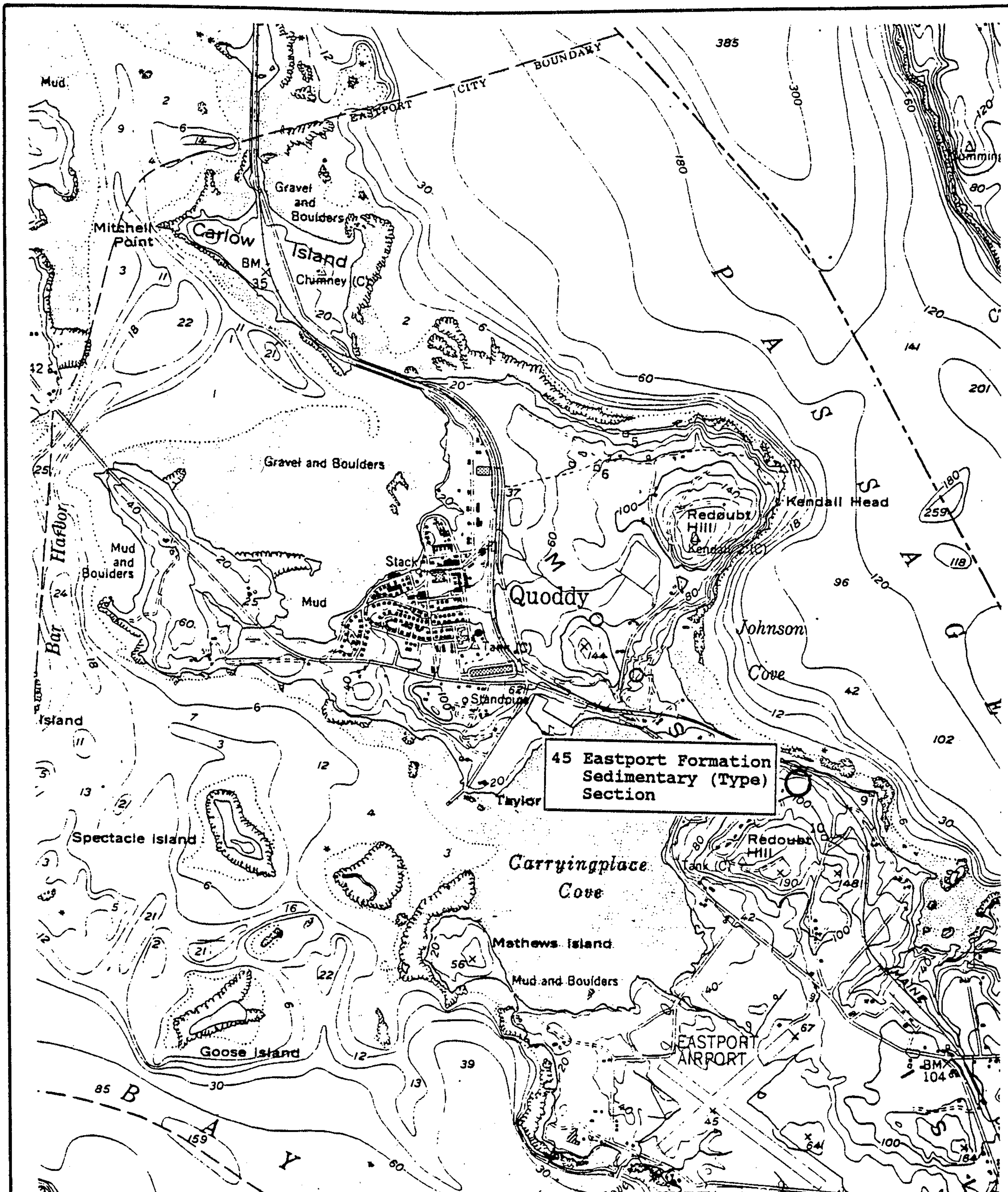
INDEX MAP NO. 43
Lubec 7.5' (1949)



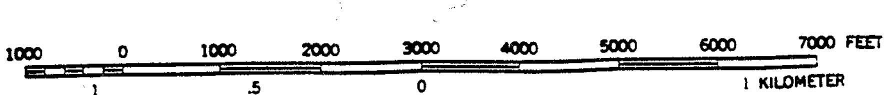


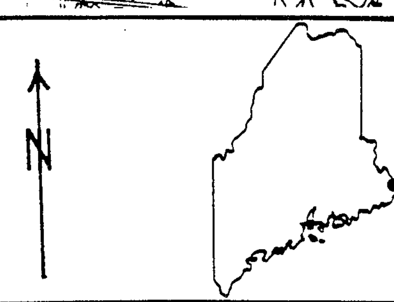
INDEX MAP NO. 44
Pembroke 7.5' (1949)

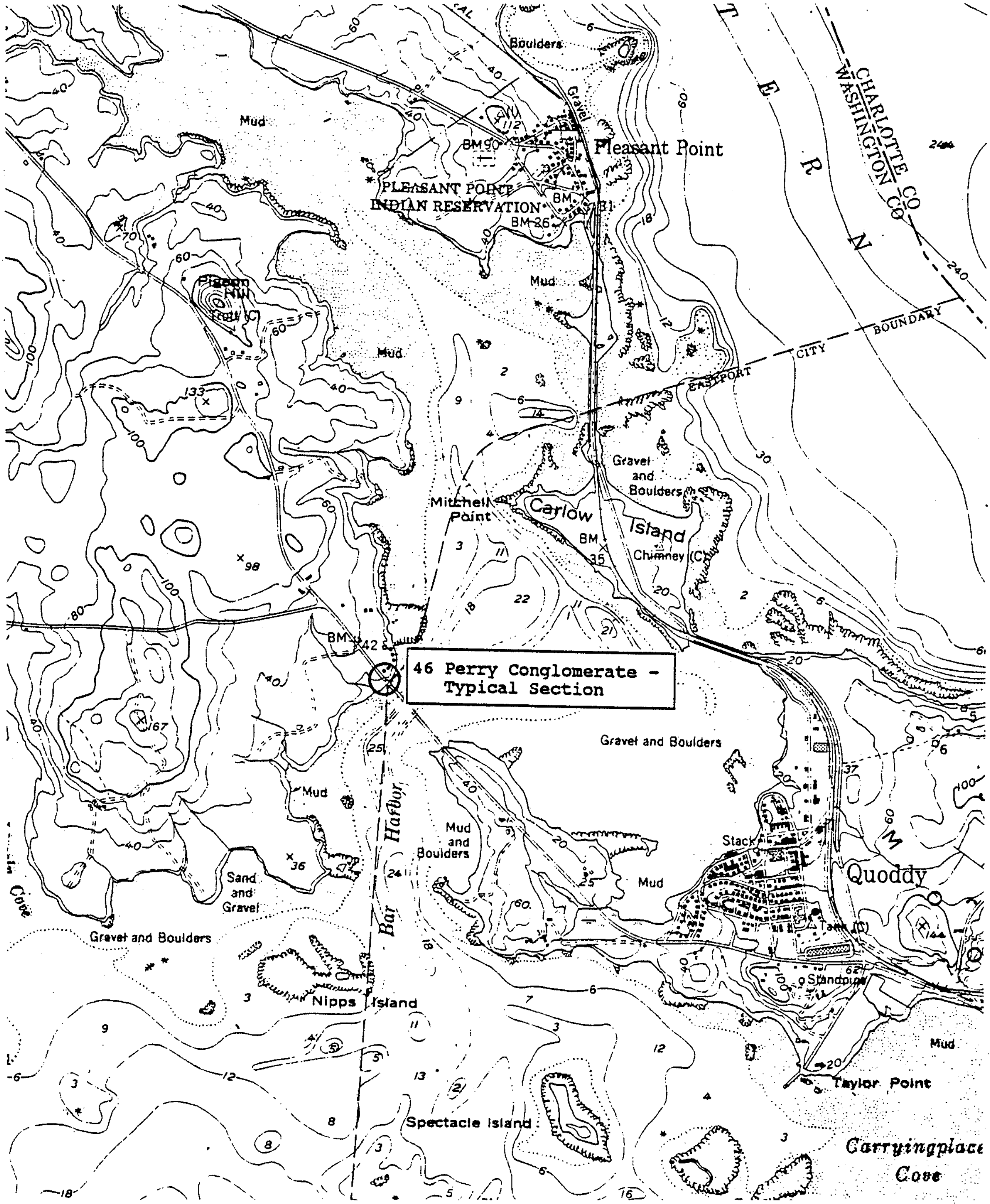




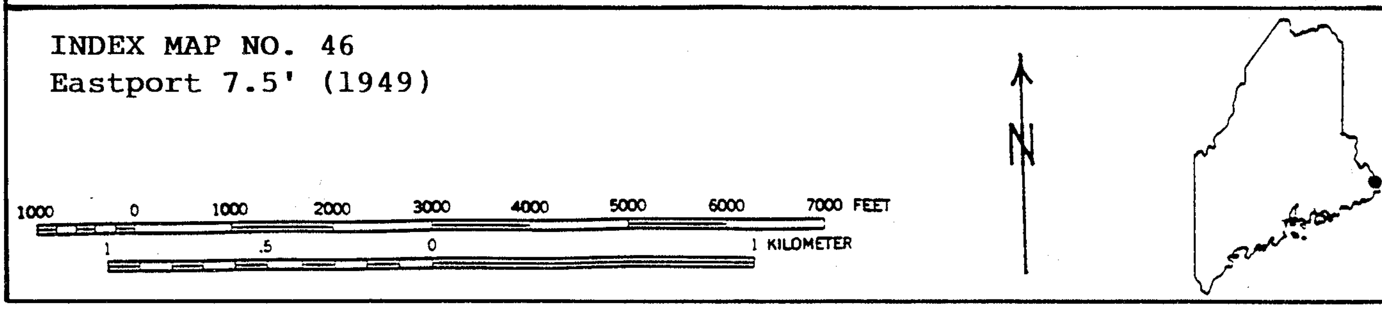
INDEX MAP NO. 45
Eastport 7.5' (1949)

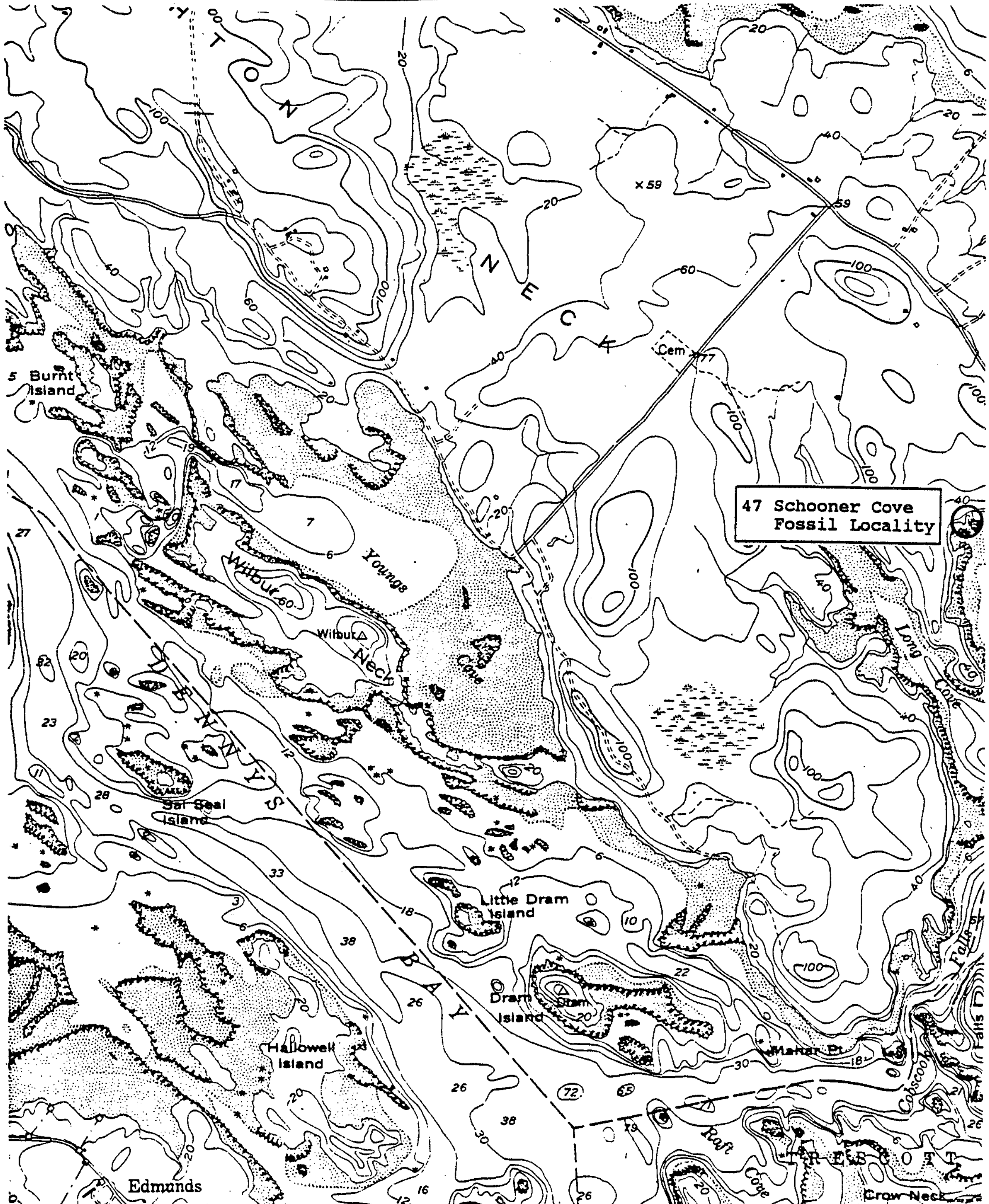




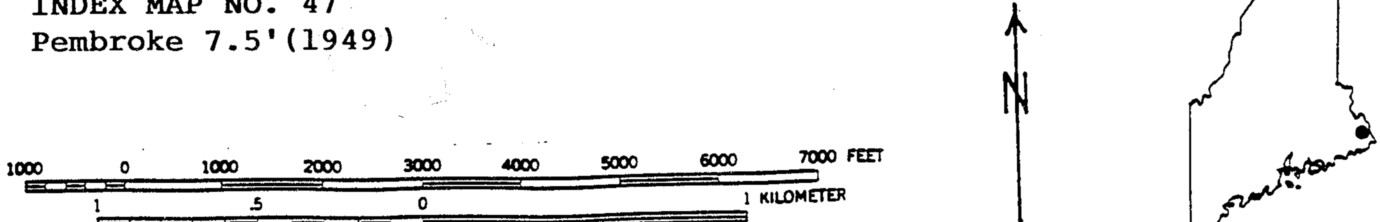


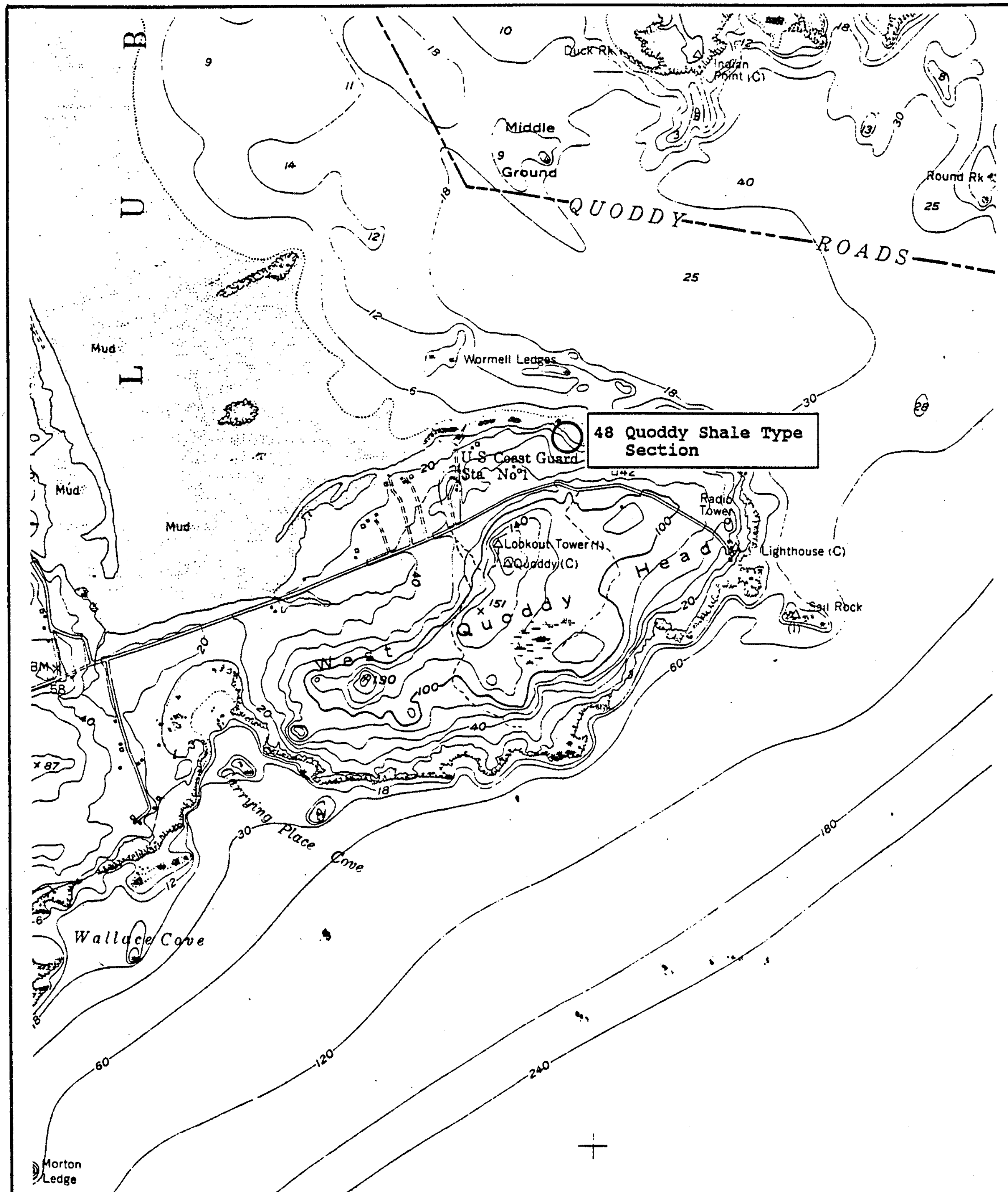
INDEX MAP NO. 46
Eastport 7.5' (1949)



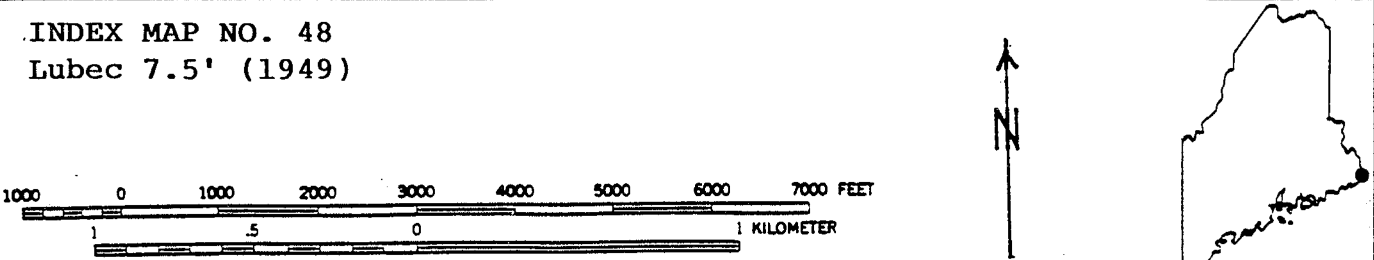


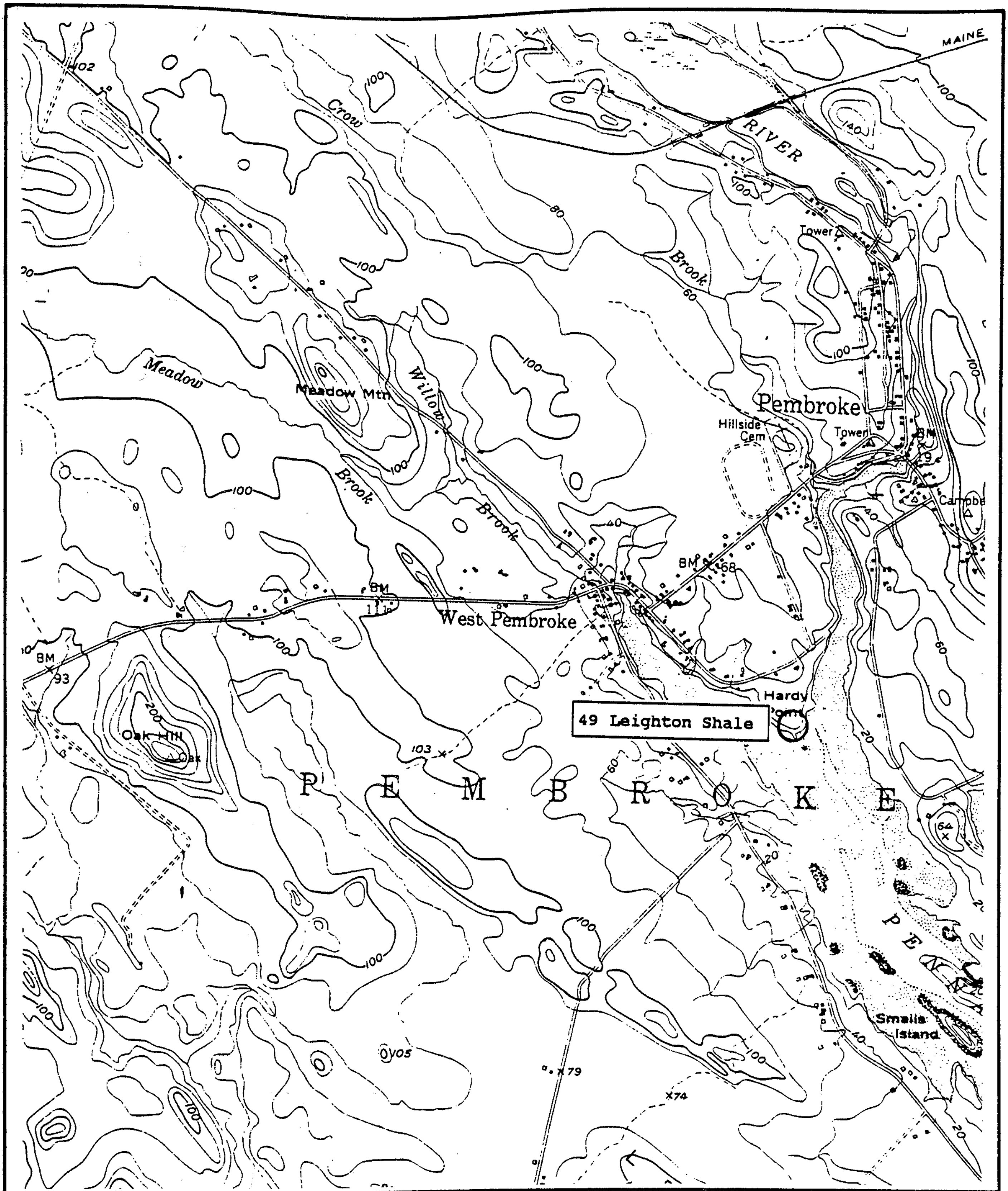
INDEX MAP NO. 47
Pembroke 7.5'(1949)



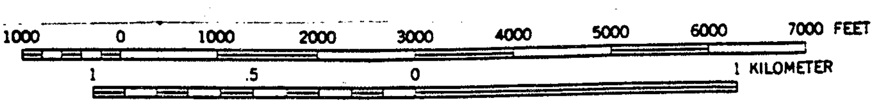


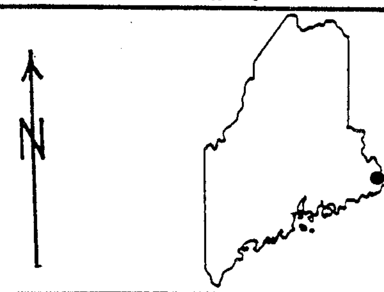
INDEX MAP NO. 48
Lubec 7.5' (1949)

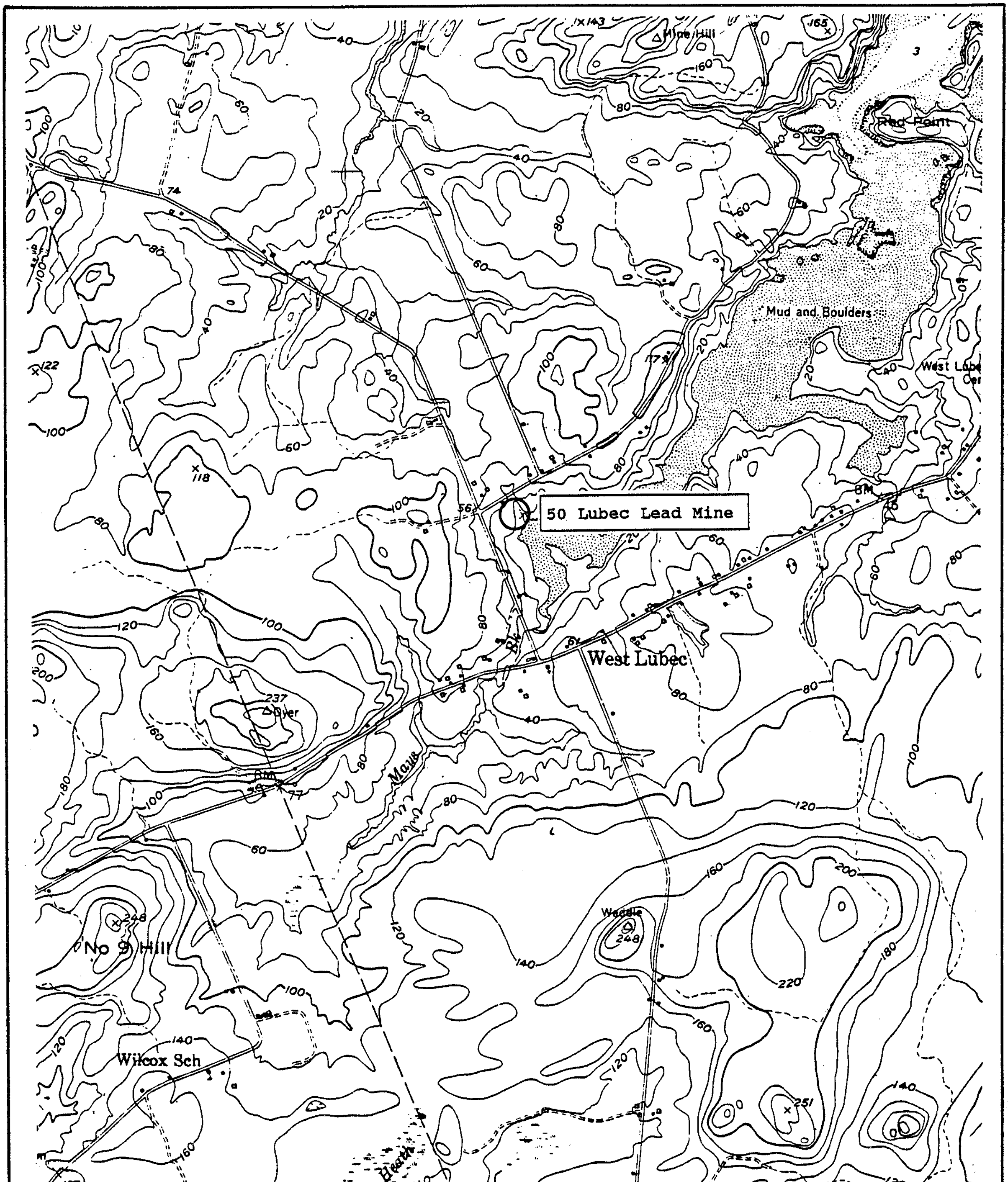




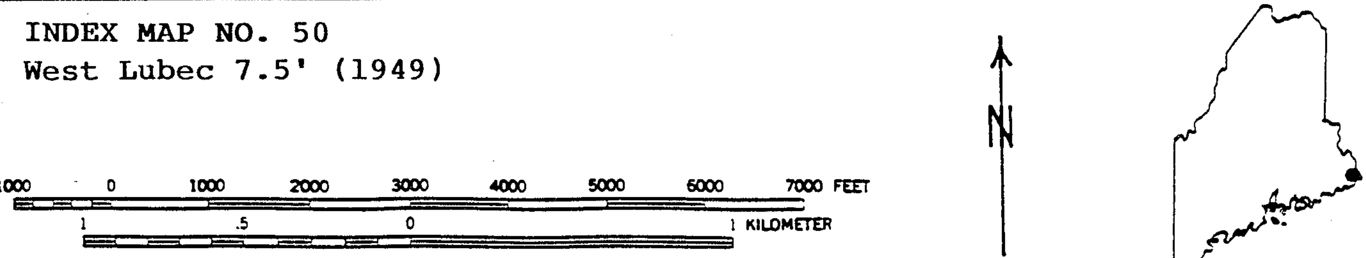
INDEX MAP NO. 49
Pembroke 7.5' (1949)







INDEX MAP NO. 50
West Lubec 7.5' (1949)



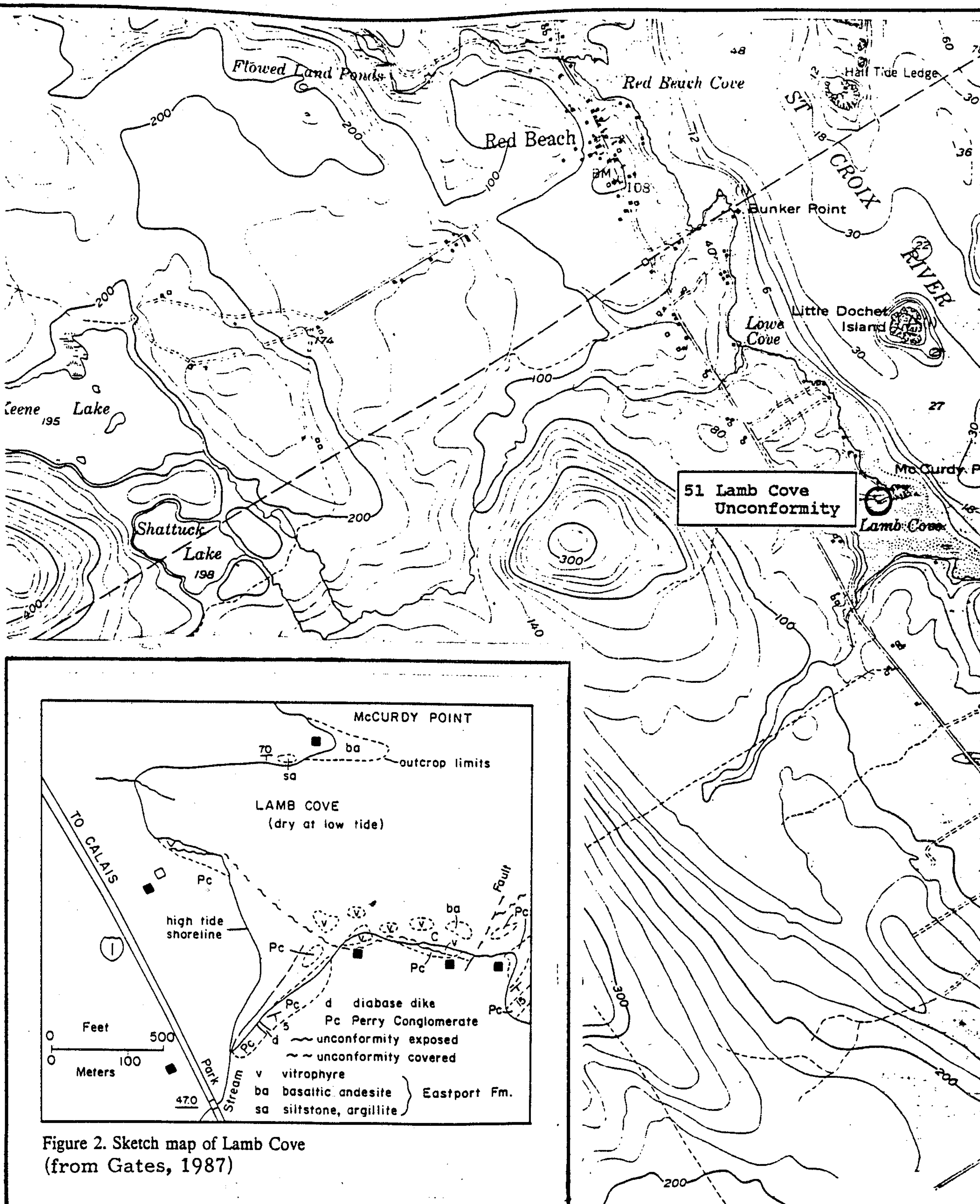
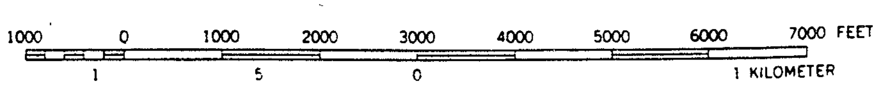
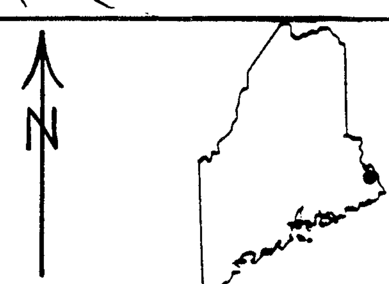


Figure 2. Sketch map of Lamb Cove
(from Gates, 1987)

INDEX MAP NO. 51
USGS Red Beach 7.5' (1949)





APPENDIX B

BIBLIOGRAPHY BY QUADRANGLE

Abbott, R.N., Jr., 1977, Petrology of the Red Beach granite near Calais, Maine, Ph.D. dissert., Harvard Univ., Cambridge.

Amos, D.H., 1963, Petrology and age of plutonic rocks, extreme southeastern Maine: Geol. Soc. Amer., Bull., v. 74, p. 169-194.

Bastin, E.S., 1908, Geologic Atlas of the United States - Rockland Folio: U.S. Geol. Surv., Folio 158, 15 p.

Bickel, C.E., 1971, Bedrock geology of the Belfast quadrangle, Maine: Ph.D. dissert., Harvard Univ., Cambridge, 342 p.

Biggi, R.J., and Hodge, D.S., 1982, Gravity studies over the Bays-of-Maine igneous complex: Geol. Sci. Maine, Bull. 2, p. 1-15.

Chapman, C.A., 1970, The Geology of Acadia National Park: The Chatham Press, Old Greenwich, Conn., 128 p.

Dow, G.M., 1965, Petrology and Structure of North Haven Island and vicinity, Maine, Ph.D. dissert., Univ. of Illinois, Urbana.

Gates, O., 1961, Geologic Map of the Cutler and Moose River 7.5' quadrangles, Maine: Maine Geol. Surv., Bull. 13, 65 p.

Gates, O., unpublished reconnaissance and detailed mapping.

Gates, O., Bedrock geology of the Machias, Columbia Falls, and Great Wass Island 15' quadrangles, Maine: Maine Geol. Surv., Open-File Map 81-11.

Gates, O., in press, Reconnaissance bedrock geology of the Bois Bubert 7.5' quadrangle, Maine: Maine Geol. Surv., Open-File Map.

Gates, O., 1978, reconnaissance bedrock geology of the Gardner Lake 15' quadrangle, Maine: Maine Geol. Surv., Open-File Map 78-3.

Gates, O., 1975, Geologic map and cross sections of the Eastport quadrangle, Washington County, Maine: Maine Geol. Surv., Map GM-3, 19 p.

Gilman, R.A., unpublished reconnaissance and detailed mapping.

Gilman, R.A., 1961, Petrology and structure of the Millbridge-Whitneyville area, Maine: Ph.D. dissert., Univ. of Illinois, Urbana.

Guidotti, C.V., 1979, Preliminary bedrock geology of the Tenants Harbor and a portion of the Friendship 7.5' quadrangles, Maine: Maine Geol. Surv., Open-File Report 79-16, 12 p.

Hatheway, R.B., 1969, Geology of the Wiscasset quadrangle, Maine, Ph.D. dissert., Cornell Univ., Ithaca, 166 p.

Hodge, D.S., Abbey, D.A., Harbin, M.A., Patterson, J.L., Ring, M.J., and Sweeney, J.F., 1982, Gravity studies of subsurface mass distributions of granitic rocks in Maine and New Hampshire: Am. Jour. Sci., v. 282, p. 1289 - 1324.

Hussey, A.M. II, unpublished reconnaissance and detailed mapping 1972-present.

Hussey, A.M. II, and Pankiwskyj, K.A., 1975, Preliminary geologic map of southwestern Maine: Maine Geol. Surv., Open-File Map 75-19.

Hussey, A.M. II, 1971, Reconnaissance bedrock geology of the Friendship 7.5' quadrangle, Maine: Maine Geol. Surv., Open-File Map 71-9.

Karner, F.R., 1962, Petrology of the Tunk Lake granite pluton, southeastern Maine: Ph.D. dissert., Univ. of Illinois, Urbana.

Kirk, A., 1971, Petrology, structural geology, and metamorphism of the Boothbay Harbor Area, Maine: M.S. thesis, Buffalo Univ., Buffalo, 108 p.

Ludman, A., 1977, Reconnaissance bedrock geology of the Calais 15' quadrangle, Maine: Maine Geol. Surv., Open-File Map 77-4.

McGregor, J.D., 1965, Geology of the Ellsworth quadrangle and vicinity: Ph.D. dissert., Univ. of Illinois, Urbana.

McSwiggen, P.L., 1978, Stratigraphy, structural geology, and metamorphism of the northeast extension of the Liberty-Orrington antiform, south-central Maine: M.S. thesis, Univ. of Maine, Orono, 128 p.

Metzger, W.J., 1959, Petrography of the Bar Harbor series, Mt. Desert Island, Maine: M.S. thesis, Univ. of Illinois, Urbana.

Newberg, D.W., unpublished reconnaissance mapping.

Newberg. D.W., 1979, Bedrock geology of the Waldoboro East and Waldoboro West 7.5' quadrangles, Maine: Maine Geol. Surv., Open-File Report 79-19, 16 p.

Norton, S.A., unpublished reconnaissance mapping.

Osberg, P.H., unpublished reconnaissance and detailed mapping.

Osberg, P.H., and Guidotti, C.V., 1974, Geology of the Camden-Rockland Area, in Osberg, P.H.(ed.), New England Intercollegiate Geological Conference Guidebook for Field Trips in East-central and North-central Maine, p. 48-60.

Smith, G.O., Bastin, E.S., and Brown, C. W., 1907, Geologic Atlas of the United States - Penobscot Bay Folio: U.S. Geol. Surv., Folio 149, 14 p.

Stewart, D.B. unpublished reconnaissance and detailed mapping.

Stewart, D.B., 1956, Rapakivi granite of the Deer Isle Region, Maine: Ph.D. dissert., Harvard Univ., Cambridge.

Stewart, D.B., and Lux, D.R., 1988, Lithologies and metamorphic age of the Precambrian rock of Seven Hundred Acre Island and vicinity, Islesboro, Penobscot Bay, Maine. Geological Society of America, Abstracts with Program, v.20, p.73.

Stewart, D.B., and Wones, D.R., 1974, Bedrock Geology of northern Penobscot Bay area, in Osberg, P.H.(ed.), New England Intercollegiate Geological Conference Guidebook for Field Trips in East-central and North-central Maine, p. 223-239.

Trefethen, J.M., unpublished notes and maps from the 42d New England Intercollegiate Geological Conference.

Ward, J.G., 1972, Petrology of the rapakivi granite of the Great Wass Island Pluton, Washington County, Maine: Ph.D. dissert., Univ. of Illinois, Urbana, 376 p.

Wones, D.R., 1980, Contributions of crystallography,mineralogy, and petrology to the geology of the Lucerne pluton, Hancock County, Maine: Am. Mineral, v. 65, p. 411-437.

Wones, D.R., unpublished reconnaissance and detailed mapping.