Important Geological Features and Localities in Maine

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IMPORTANT GEOLOGICAL FEATURES AND LOCALITIES OF MAINE

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Introduction

The Maine Critical Areas Program and the Maine Geological Survey are compiling a list of the geologic topics and localities of Maine considered significant or unusual enough for further research and possible inclusion in the list of Maine's Critical Areas. To qualify for further study the geologic feature must have significant scientific or educational value. In addition, the geologic feature should either be unique to Maine or New England or be an outstanding example of a particular geologic phenomenon or feature.

In February, 1981, members of the geologic community of Maine were polled for geologic topics that were of interest to them. The compiled results of the 1981 questionnaire were recirculated in early 1982 for further comments from the geologists who live or work in Maine. This report combines the results of both surveys.

Purpose of this Study

The purpose of establishing an inventory of the significant geologic features of Maine is to prevent their destruction. Before work can begin in major construction projects there is a thorough search for features of historical or archeological significance. The Critical Areas Program

would establish lists of natural features, including geological features, that should also be protected, if possible, from destruction. In this way, significant geologic features would be preserved for future study.

This paper was prepared as a first step in the preservation of the critical outcrops and other geologic features upon which our understanding of the geology of Maine is based. In addition, some excellent examples of geological features or processes that have important educational values are included in this paper.

The Geology of Maine

There is great variety in the geology of Maine and it has been studied in increasing detail since John R. Rand formed the modern Maine Geological Survey in the late 1950's. The rocks range in age from the Pre Cambrian Chain Lakes massif in the vicinity of Coburn Gore, through most of the Paleozoic and into the Mesozoic. Structures are complex in southern and western Maine and somewhat simpler in the north. Fossiliferous rocks occur in all but southwestern Maine. Volcanic rocks occur in the coastal region and in the Central Maine Synclinorium. Plutonic rocks are associated with both volcanic belts and occur in central and western Maine as well. Within the past 10 to 20 years the rocks of Maine have been placed in a unifying plate tectonic setting. The surficial deposits of Maine include those assigned to the Wisconsin Stage of glaciation as well as fluvial, eolian, lacustrian, coastal, and estuarine deposits.

Important Publications

The Maine Geological Survey, under former State Geologists John R. Rand and Robert G. Doyle and the present State Geologist, Walter A. Anderson, has published widely on the geology of different parts of Maine (see appendix for publications list and the list of references cited in this paper). Numerous doctoral and masters theses written in the last 20 years describe Maine's geology at both quadrangle and outcrop scale. Some of the most useful publications are those of the New England Intercollegiate Geologic Conference (NEIGC) which conducts annual field trips in areas of recent geologic field work. Since 1960, the NEIGC has met in Maine 7 times: in 1960 in Rumford and vicinity; in 1965 in Brunswick and vicinity; in 1966 in the Mt. Katahdin region; in 1970 in the Rangeley area; in 1974 in the Orono area; in 1978 in the Calais area; and in the Presque Isle region in 1980. A bibliography of publications dealing with Maine geology was compiled by Hussey (1974).

Catalogue of the Critical Geologic Features of Maine

I. Bedrock Geology. Maine's bedrock geology is complex and diverse. It is suggested that the state be divided into four to six regions and that a geologist with expertise in a particular region be selected to research and prepare a planning report emphasizing the following features for that area.

A. Plutonic Rocks. Plutonic rocks are widespread in Maine, in New England and in the rest of the world and therefore do not in themselves make a suitable topic for further study. The following sub-categories have been suggested for inclusion in this paper:

1. Rare or unusual types plutonic rocks for educational purposes.

a. Rapakivi granite of Deer Island.
b. Hornblende pegmatitic gabbro near Wayne.
c. Agmenticus igneous complex (Hussey, 1965).
d. Others?

2. Specific outcrops within plutons of special scientific or educational significance.

a. Contact relationships, hornfels, skarn, e.g. the Moxie pluton--Seboomook Formation hornfels in Greenville--Jo-Mary Mountain area (Espenshade and Boudette, 1965); Sugarloaf gabbro in contact with massive cordierite (Boone, 1973).
b. Outcrops from which radioactive minerals were collected for dating.
c. Mineralization of plutonic rocks, such as the molybdenite plates near Togue Pond (Katahdin pluton) and sulphide mineralization of Attean pluton on Catheart Mountain (see also mineral localities).
d. Layered gabbros showing sedimentary-like structures, e.g. in the Cape Neddick area (Hussey, 1965), part of which was not accessible for study because of no trespassing signs on shore.
e. Series of outcrops within Katahdin and Moxie plutons and associated volcanic rocks from which an Acadian subduction zone has been reconstructed (Hon, 1980).

3. Dikes.

a. Multiple dikes.
b. Aplite and pegmatite dikes, because of their petrologic significance (Hon, 1980).
c. Dike swarms in Ogunquit area.

4. Pegmatites (see mineral localities).

5. Sea Floor gabbros, layer 3, Boyle Mountain Complex of Boudette part of Cambrian ophiolite sequence.

B. Volcanic Rocks. Unaltered, unmetamorphosed volcanic rocks are not common in New England (with the exception of the Mesozoic basalts in the Connecticut Valley) but are common in Maine, especially the rhyolitic rocks of the Central Maine Synclinorium

1. Basaltic volcanic rocks.

   a. Jim Pond volcanics--outstanding example of pillow lavas, Eustis to Moosehead Lake (Cambrian) (Boone, 1970).
   b. Flood basalts of St. John Valley (Devonian) (Hon, personal communication).
   c. Lower Devonian lava flows in Eastport quadrangle, show vesicules, weathered zones (Perry Formation, Gates, 1978).
   d. Others?

2. Rhyolitic and related volcanic rocks.

   a. Traveler, Spencer, Kineo rhyolite volcanic flows and ash beds, columnar jointing. Mount St. Helens type of eruptions associated with subduction zone now marked by Moxie pluton and the emplacement of the Katahdin pluton (Hon, 1980).
   b. Kennebec volcanics--porphyritic tonalite, etc. (Ordovician) (Boone, personal communication).
   c. Coastal volcanic belt?

C. Mineral Localities. The very rare mineral localities can be documented and registered through a streamlined process similar to that for very rare plants, e.g. Botanical Fact Sheets.

1. Mineral associated with pegmatites.

   a. Tourmaline (Thompson, 1977).
   b. Rose quartz crystals (Thompson, 1977).
   c. Rare minerals. Many with occurrences only in Maine or New England.
   d. Type localities of minerals discovered in Maine.
   e. Exceptional non-commercial pegmatites: e.g. rose quartz at Bumpus Quarry; large spodumene crystals in Newell Quarry at Newry.

2. Other rare or unusual mineral localities.

   a. Calc-silicate minerals: e.g. grossularite, diopside, scheelite, museum quality garnets in Pitts Tenny Quarry at Minot; world famous Sanford vesuvianite locality.

b. Sulphide minerals: e.g. molybdenite near Togue Pond, Katahdin pluton; pyrrotite, limonite, hematite at Katahdin Iron Works.
c. Sodalite and cancrinite at Litchfieldite localities, Litchfield.
d. Jasper, especially that associated with Jim Pond volcanics.
e. Others?

D. Sedimentary Rocks. Sedimentary rocks, especially those with low-grade metamorphism and containing fossils, are widespread in Maine, but occur elsewhere in New England only in the Connecticut River Valley and in Rhode Island. Only those outcrops of particularly rare types, those which are the type sections for certain sedimentary structures, those which have been dated from their fossils, or those which have other special features, should be included in the list for possible further study.

1. Unusual sedimentary rock types. Non-marine red conglomerates and sandstone of early Paleozoic age, e.g. Lobster Lake (Boone, personal communication).

2. Type localities of formally accepted geologic formations, e.g. Trout Valley, Matagamon sandstone, Hurrican Mountain melange, Rangeley Conglomerate (Rangeley "B" of Moench, in press), Madrid, Smalls Falls, Vassalboro, Sangerville, Seboomook, Kittery, Eliot, etc., Formations, Casco Bay Group.

3. Outcrops which contain fossils which have been used to date the sedimentary rocks. (Forbes, 1977) Vassalboro Formation, etc.

4. Outcrops containing sedimentary structures which are well displayed and/or which have been used to work out younging direction in tightly folded rocks and therefore are the evidence upon which may hang the stratigraphic interpretation of a region. Such outcrops may also contain structural features such as cleavage-bedding, drag folds, mullions, kink bands, etc.

   a. Flute casts, dish and pillow structures, climbing ripples, graded beds, Bouma sequence of turbidites, (Roy, 1980).
   b. Sedimentary melange, e.g. outstanding outcrops of Hurricane Formation near west outlet, Indian Pond.
   c. Waterville-Vassalboro-Sangerville rocks. Critical for understanding the stratigraphy of the southern end of the Merrimack Synclinorium.

5. Others?

E. Metamorphic rocks. Regionally metamorphosed sedimentary rocks are very common in central and southern New England and are not unique to Maine. The classic Barrovian sequence of metamorphic grade is well displayed along strike from northeast to southwest in Maine and therefore may be considered worthy of further treatment. Contact metamorphism near plutonic rocks is not common in southern New England but is well developed around most gabbroic plutons and some granite plutons. The granite plutons which have contact aureoles were deeper-seated and therefore emplaced at a higher temperature than were those without widespread contact aureoles.

1. Unusual metamorphic assemblages or particularly good examples of metamorphic minerals.

    a. Cordierite. Carrabasset Valley Formation in contact with Sugarloaf Gabbro (Boone, 1973).
    b. Retrograde metamorphic effects, e.g. Boyle Mountain Serpentinite.
    c. Chain Lakes Massif.

2. Contact metamorphism.

    a. False graded bedding in Seboomook Formation next to Moxie Pluton.
    b. Calc-silicate metamorphism.

3. Others?
   Sillimanite, Andalusite, Staurolite associations?

F. Ore Deposits. Metalifferous deposits in Maine are associated with both the coastal and northern volcanic belts, with most of the mining occurring in the former. Ore deposits are less common in the rest of New England and no mines are presently operating there. There may be some interest in mines worked in the previous century or before.

1. Copper, lead, zinc sulphide ores.

2. Silver ores.

3. Oxidized iron ore at Katahdin Iron Works.

    a. Also apparently was source of pigment for Red Paint People.

4. Others?

G. Non-Metallic Mines. Rock quarries, lime quarries, gravel pits and the like probably do not meet the test for a critical geological feature, but certainly may be of interest.

1. Historic granite quarries, i.e., quarries from which rock was taken for the State House (Hallowell?), for the Washington Monument, for any famous statues or other art works.

2. Colonial lime quarries--"ribbon-lime" of south central Maine.

3. Other non-metallic deposits.

   a. Colonial brick yards.
   b. Peat bogs.

H. Structural Features. The geologic structural features of Maine are not unusual when compared with the rest of New England. In northern Maine the structure is less complex than other parts of the State or New England. Some structures are interesting because of the complexity, because of their continuity, or for their use in unraveling the stratigraphy or geologic (plate tectonic) history of a region.

1. Complex structures at Tumbledown Mountain, Weld.

2. Norembega fault, neotectonic(?) in part.

3. Off-set striated pavement, e.g. Boyd Lake Dump, Ragged Lake (west shore), Norembega fault.

4. Outcrops showing 3 periods of folding, e.g. "butterfly fold" in Carrabassett Valley.

5. Others?

I. Features in rocks or associations of rock type and structural features which have a plate tectonic implication.

II. Glacial Geology. Erosional and depositional features of glaciers occur in all of New England and in the rest of the northern tier of the United States. Some of the glacial features of Maine are unique either to the United States or to New England and are therefore well suited for inclusion in this paper and for further study by the Critical Areas Program. In the following list, the features suitable as topics for critical areas reports are underlined.

A. Erosional Features.

1. Glacial flow indicators

a. Stoss and lee forms, e.g. Starks school yard; Route 15 in Abbott.
b. "Chattermarks" Sea Wall, Mt. Desert; town parking lot, Greenville.
c. Rat tails and ice cream cone structures, e.g. near Ragged Lake; those indicating northward flow of ice in St. John Valley.
d. Outcrops showing multiple flow direction.

2. U-Shaped Valleys; Cols.

3. Cirques, Tarns and Aretes. Maine has more (maybe 20), and better developed cirques than do New Hampshire and Vermont, where these features have been reported. Only three on Katahdin (North, Great, and South Basins) were sites of alpine glaciation during and perhaps following the disappearance of the last ice sheet. Others occur in the Sugarloaf to Old Speck area of Maine.

4. Fluted till, in Athens, Wilton, and some drumlins, such as those in Eliot, Maine and vicinity which contain deltaic deposits.

B. Till

1. Multiple tills. New Sharon till locality. Probably the only known early Wisconsin till (equivalent ? to the Becancour till of the St. Lawrence Valley) in New England. Overlying organic layer contains wood (flattened spruce logs and twigs, and cedar and spruce cones, seeds), beetle wings and legs, and a rich pollen assemblage. Organic layer is in turn overlain by middle(?) and late Wisconsin till.

2. "Laminated" till. Till with interbedded silt layers, e.g. at Austin Stream, Bingham, New Sharon, Dead River in Dallas Plantation, Kingsbury Stream.

3. Drumlins.

C. Moraines. Moraines are well developed in coastal regions of southern New England but do not occur or have not been recognized in other parts of New England other than Maine. Several types of moraines occur in Maine, some of which don't occur in southern New England at all.

1. Moraines associated with the marine submergence in coastal regions and in the valleys of the large rivers of Maine (Thompson, 1982), de Geer or annual moraines. Elongate glacial marine deltas with ice contact proximal slopes, e.g. Merriland Ridge in Wells, Waldoboro Moraine in Lincoln County, Pineo Ridge near Cherryfield. Till moraines.

2. End moraines above the marine submergence.

   a. Moraines deposited by alpine glaciers, e.g. near Basin Pond, Mt. Katahdin.
   b. Moraines deposited by continental glaciers, e.g. in Aroostook County and elsewhere.

3. Rogen moraine. Till ridges developed within the ice, some distance from margin. Outstanding examples in Norcross quadrangle.

4. Other moraine types.

5. Rock glaciers. The one in North Basin may be active and is probably the only one in Maine and the only one of two or three in New England. They apparently occur only in cirques and may be the residue of alpine glaciers.

D. Meltwater Deposits.

1. Eskers (Borns, 1979), e.g. Belgrade esker system.

2. Glaciomarine deltas (Borns, 1977).

3. Well developed morphosequences. Morphosequences are glacial stream deposits consisting of an ice contact proximal part and a distal outwash portion. The two deposits together have a significance similar to that of an end moraine (Koteff and Pessl, 1981). These have been mapped by Thompson, Holland, Hansen and Caldwell in many parts of the State. The only type unique to Maine (non-ice contact marine) occurs in Garland, Dover-Foxcroft quadrangle. (Caldwell, Hanson, and Thompson, in prep.)

4. Marine Clay. Presumpscot Formation is unique to the United States. Type locality in Portland-Gorham area contains large molluscan fossils. Reported walrus and other marine vertebrate skeletons. C-14 dates range from 13,320 BP to 12,000 PB (Stuiver and Borns, 1975).

5. Outwash deposits are not unusual in themselves but would have educational value if they displayed bed forms from which to determine flow regime and direction, e.g. ripple drift, A, B, and C type ripple drift, cross lamination, linear and cuspate ripples, dish and pillow structures, e.g. West Branch Penobscot, Farmington, Lower Richardson Lake, etc.

E. Beach Deposits associated with marine submergence, e.g. along I-95 near Androscoggin River Bridge; along Piscataquis River east of Dover-Foxcroft.

F. Eolian Deposits (non-coastal).

1. Active, near Wayne, Sandy River, Kennebec River, Freeport.

2. Fossil, associated with glacial lakes, outwash plains or glacial marine strand lines, e.g. Sandy River Valley; Piscataquis River Valley east of Dover-Foxcroft.

3. Sand blasted stones (ventifacts).

4. Others?

III. Geomorphology. In the following list, the features suitable as topics for critical areas reports are underlined.

A. Fluvial.

1. Reverse deltas. Absolutely unique in the United States. Examples occur on the Saco, Androscoggin, Penobscot and Kennebec Rivers.

2. Uncontrolled rivers and streams for hydrologic research.

3. Water falls and gorges (Brewer, 1978a, 1978b).

4. Reversing water falls created by high tidal ranges, e.g. at Pembroke.

B. Coastal.

1. Cobble beaches, such as Jasper Beach

2. Tombolos and carbonate beaches.

3. Tidal inlets, e.g. Morse River, Ogunquit River.

4. Erosional features in rock; arches, stakes, caves and blow holes.

C. Shoreline features of lakes; sand beaches.

1. Large sandy beaches where fine to medium grained outwash is exposed on lake shore, especially those presently without development, e.g. east shore of Lower Richardson, southwest corner of Lobster, northeast shore of Harrington Lakes.

2. Sand and fine gravel bodies which are miniature forms of such coastal features as barrier islands, tombolos, spits and pocket beaches, all of which occur on Chesuncook Lake, for example.

3. Black sand beaches (hornblende, magnetite ?), e.g. Lothrop Island, Androscoggin Lake, Wayne.

4. Places where small streams cross sandy beaches, features which resemble miniature inlets with ebb-tide deltas occur. Examples occur on lower Jo-Mary Pond, among others, and also at lake outlets where some reverse deltas occur, e.g. Lovewell Pond on the Saco, Lobster and First Debsconeas Lakes on the West Branch Penobscot.

5. Ice shored ridges--Taylor Pond, Attean Quadrangle, Attean Pond.

D. Groundwater.

1. Springs, such as boiling springs, artesian springs associated with glacial lake or marine clays partly covering sand and gravel aquifers, e.g. near Dayton, and warm springs.

2. Aquifers with connate water from marine submergence.

E. Caves. Caves are not common in New England or Maine.

1. Limestone (?) caves, e.g. near Enchanted Pond (?).

2. Slab or polar caves, e.g. Old Bluff, Chesterville; Pamola Caves, Katahdin.

F. Landscape Study. There exist in Maine some exceptional vantage points from which important geologic relations may be visualized.

1. Views of Katahdin Pluton and associated Traveler volcanics.

   a. Top of the World, Patten
   b. Hurricane Deck, CCC project, East Branch Penobscot.

2. Views of Bigelow, etc.

    a. Eustis Ridge.
    b. Others?

3. Mountain summits above timberline. These generally contain arctic flora and have been registered as botanical features (see Permafrost features).

G. Permafrost Features.

1. Active permafrost exists on Sugarloaf and probably on all mountain summits listed in F.3. above.

2. Active patterned ground features. Miniature stone nets and stripes on Traveler Mountain and Katahdin.

3. Fossil patterned ground features occur on table land and on other high peaks above timberline.

4. Ice-wedge casts and convolute structures.

    a. Brassua Lake.
    b. Carrying Place Bog, Quoddy Head, also contains raised bog with arctic flora.
    c. Others?

H. Soils.

1. Saprolite, probably residual from the Tertiary Period.

    a. Ferromagnesian rocks.

        1. Agmenticus complex along Maine Turnpike.
        2. Moxie Pluton in Greenville area.
        3. Iron ore at Katahdin Iron Works.

    b. Sialic rocks.

        1. Katahdin Pluton, Abol Crossing, 1976 Burned Area.
        2. Golden Road, near Millinocket Lake.

Recommendations for Further Research

A number of Maine-oriented geologists have made suggestions concerning methods of choosing geologists to research geologic subjects for the Critical Areas Program in the future. While the choice of researchers in the past has been both obvious and excellent, e.g. Eskers of Maine, by Hal Borns; Fossils of Maine, by Bill Forbes, many of those who responded to the questionnaire felt that a committee should be set up to insure that the best possible researchers continue to be selected. Nearly everyone felt that the Maine Geological Survey should play a larger role in choosing both topics and researchers, as the Survey knows more about both than anyone else. Other suggestions were that requests for proposals should be circulated when a new geologic topic is to be researched, and the researcher be selected on the basis of the best proposal.

Suggested Topics for Study in the Near Future

There appears to be a fairly wide concensus among Maine geologists that a study of significant bedrock outcrops should be considered soon by the Critical Areas Program. This study might include a compilation of the type localities of important geologic units within the state, outcrops which are critical in understanding the stratigraphy of a broad section of the state, and perhaps those which contain other unusual geologic features or which have important educational aspects. Because no geologist is

completely familiar with all the rock units in the State, it is suggested that 3 or 4 geologists be selected to conduct this research, each being assigned to an area in which he has special knowledge.

Publications

Nearly everyone responding to the questionnaire felt that a better medium for publishing the geologic studies should be found. Many mentioned Bill Forbes' excellent summary of the fossils of Maine as an example of a work that deserved a wider and somewhat more substantial medium for publication. It was also suggested that the State Geologist was the logical arbitrator to determine which critical area reports were worthy of wider publication and what format of publication would be the most suitable.

Conclusions

Maine has many unique geological features which should be preserved for future scientific study or used for educational purposes. The Critical Areas Program and the Maine Geological Survey working together offer the best means of achieving this worthwhile goal. A catalogue of Maine geological features has been prepared that should be reviewed by the Critical Areas Program for consistency with their requirements and by the

Maine geological community for errors and omissions. The completed document would then serve as a guide for the preservation of worthwhile geologic features in Maine.

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CRITICAL AREAS PROGRAM LIST OF GEOLOGICAL PLANNING REPORTS

Number	Title	Author	Date	Pages
31	Maine Tourmaline Localities	Woodrow B. Thompson	5/77	38
37	Significant Geologic Localities in the Casco Bay Group, Southern Maine	Arthur M. Hussey II	6/77	53
40	Rose Quartz Crystal Localities in Maine	Woodrow B. Thompson	3/77	22
46	Significant Bedrock Fossil Localities in Maine	William H. Forbes	9/77	97
53	Emerged Glaciomarine Deltas in Maine	Harold W. Borns	11/77	32
54	Geological and Botanical Features of Sand Beach Systems in Maine	Bruce W. Nelson L. Kenneth Fink, Jr.	3/78	163
56	Significant Geologic Localities in the York County Coastal Zone	Arthur M. Hussey II	4/78	31
60	Waterfalls in Maine	Thomas Brewer	7/78	43
64	Gorges in Maine	Thomas Brewer	7/78	28
67	Eskers in Maine	Harold W. Borns	8/79	44
74	Whitewater Rapids in Maine	Janet McMahon	6/81	162
75	Jasper Beach, Machiasport, Maine	Barry S. Timson	7/81	30


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