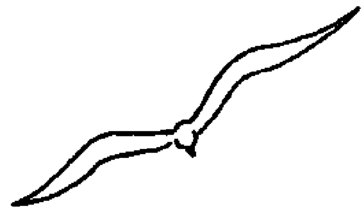
THE NATURE CONSERVANCY

GUIDEBOOK TO GEOLOGIC AND BEACH FEATURES OF THE RACHEL CARSON SALT POND AREA, NEW HARBOR, MAINE



Vandall T. King
and
Bruce W. Nelson

The Nature Conservancy is a national conservation organization receiving its support from the public, whose resources are devoted to the protection of natural areas and the diversity of life they support. The Conservancy is primarily interested in lands that are of significant ecological and environmental value and seeks to exemplify a new land ethic and to encourage intelligent land use.

The Nature Conservancy works in three ways to protect natural areas: by purchase of lands with funds raised through public subscription, by acceptance of donations of land, and by advance acquisition of land for local, state and federal governments.

A member-governed non-profit organization, the Nature Conservancy was incorporated in 1951 in the District of Columbia for scientific and educational purposes.

Wise use of resources has long been a concern of the Cooperative Extension Service/Maine Sea Grant Project, and The Nature Conservancy is happy to join with them in presenting these educational materials.

This publication is a result of Marine Advisory Services sponsored by NOAA Office of Sea Grant, Department of Commerce, under Grant #04-3-158-63. The U. S. Government is authorized to produce and distribute reprints for governmental purposes notwithstanding any copyright notation that may appear thereon.

MAINE SEA GRANT

BULLETIN 10

FOREWORD

The Maine Chapter of The Nature Conservancy believes that each preserve that it has acquired contains much of interest to both the casual and the scientific visitor.

We have long hoped for the time when it would be possible to initiate a series of informational publications on the various scientific fields each preserve possesses.

Rachel Carson served the Maine Chapter from its founding (1956) until her death in 1964. Because this site was one she used for study we feel extremely fortunate to initiate our program on this site.

It is also appropriate that the basic science of geology is the first topic.

We herewith express our appreciation to the authors, Vandall T. King and Bruce W. Nelson, and particularly to Paul D. Ring of the Ira C. Darling Center for Research, Teaching and Service of the University of Maine and Maine's Sea Grant Program.

Charles P. Bradford

Executive Director
Maine Chapter
The Nature Conservancy

The Rachel Carson Salt Pond Preserve is managed by the Maine Chapter of the Nature Conservancy. This organization is concerned with the preservation of unique or essential natural features. The preserve consists of two parts, the larger of which is a wooded hill on the western side of Route 32. The smaller, eastern part, the section described in this leaflet, is an area Rachel Carson often visited. The Salt Pond and this tidal section of the Atlantic offered her many opportunities to observe natural relationships.

The Salt Pond area (Fig. 1a and 1b) is a particularly good area for viewing certain geologic features. The rocks are well exposed and many features are duplicated along a proposed excursion route. The length of the route is about 1,170 feet (approximately 357 meters) on the north side of the Salt Pond. Total time of the field trip is a minimum of 60-75 minutes. Photographs are provided of each suggested stop. These photographs will allow you to find key geological features with minimum delay. At the end of each numbered descriptive paragraph, the distance from the Rachel Carson monument will be given in meters and feet. A glossary of terms is provided at the end of the leaflet.

EXCURSION ROUTE -- STOP DESCRIPTIONS

1. Start at the Rachel Carson monument, walk directly to the level of the beach to a stratified outcrop (Fig. 2a and 2b). Note that all of the strata are parallel except when near granite (white rocks). The dark gray rock is gneiss. The granite consists of two minerals: light gray quartz and white feldspar. Broken quartz surfaces are uneven and may have concoidal shaped chips broken from them. Feldspar breaks into flat surfaced fragments. Though the flat surfaces may be at different levels, they are all parallel and reflect light like a mirror while quartz does not.

2. Proceed north. You will come upon a unique feature of the area. A granite mass has been brecciated (broken) and recemented with thick quartz veins (Fig. 3a). Geologists frequently look for time sequences; the evidence here is obvious: granite then quartz. (145 ft., 48 m).

3. On the north side of the granite mass you can see a sill (Fig. 3b). Along the sill there are well exposed features around granite pegmatites (Fig. 3c). The layers of gneiss are bent to conform to the shape of the pegmatite. This bending of layers is often used by geologists as evidence that the layers of gneiss were there first and were warped by later forces.

4. Proceed north along the beach following the high water line. A ridge of ledge can be seen (Fig. 4) which shows an excellent cross section of both a pegmatite sill and highly folded strata. Look closely at the pegmatite minerals.

Instead of being made of only two minerals, gray quartz and white feldspar, as the other pegmatites are, there are also pink to red garnet and, occasionally, black mica. The garnet (probably a variety called almandine) and the mica (biotite) are iron rich. The other granite rocks in the Salt Pond area do not contain these or any other iron rich minerals. Why are these minerals here? As the gneiss contains many iron rich minerals, it appears that some exchange of elements has taken place between the gneiss and the pegmatite. Small fragments of the gneiss may have been melted into the granite. The gneiss that was melted into the granite contributed its chemical elements to form new minerals. Local geology often influences ground water and area residents have much iron in their well water due to the iron rich gneiss bedrock. (565 ft., 187 m).

5. Further north beyond the ridge in #4, steplike erosional features are seen in the beach bedrock (Fig. 5a). Nearby are boulders (Fig. 5b) which have been separated from the ledge by the action of frost and surf along the strata. The boulders thus formed are elongated and account for the steplike appearance. (600 ft., 198 m).

6. Near the step-like rocks in stop #5, you will find a zone of rounded beach boulders (Fig. 6). Note that these boulders are made of light-colored granite There are few large dark boulders. Granite is a very erosion-resistant rock compared with gneiss, and for this reason these boulders are probably older (as boulders) than the elongated gneiss. Any gneissic boulders formed are soon broken into smaller rocks and pebbles. (800 ft., 265 m).

7. At the north end of the rounded boulder zone, the ledge juts up (Fig. 7a). Step-like erosion is apparent, and this ledge provides a good cross section of the strata. The strata are inclined to a high angle indicating that gravity is an important agent in the local erosion. (929 ft., 308 m).

This ledge is highly grooved (Fig. 7b) on the seaward side. The differential weathering is controlled by the different minerals in each layer and by the different grain sizes. Different minerals are weathered at different rates. Small grains, which increase the mineral surface area, weather faster than large grains. It is seen that the ledge is fragmented, and these fragments are easily separated by gravity. This area is one of comparatively rapid erosion. (960 ft., 318 m).

8. The most useful interpretive feature of the local geology is seen in the ledge of stop #8. A dike intersects a sill (Fig. 8a) and is, therefore, younger than the sill. The evidence for this interpretation is the inclusion of the sill in the dike (Fig. 8b).* The inclusion is a fragment that broke off from the solid sill when the then-liquid dike intruded into the gneiss. Note that the sill has a coarser grain size than the dike. (1045 ft., 346 m).

9. At Excursion stop #9 there is a drop-off (Fig. 9) from a granite mass down to gray gneiss. Below the drop-off there is a tide pool abundant with starfish, limpets, amphipods, etc. The abrupt change in rock type may appear strange, but the local evidence for this change is clear. A dike cuts the strata at right angles. (Note the channel in the figure from foreground to the sea.) Dikes are formed primarily by liquid rock intruding along a crack or fault. The force of the liquid increases the width of the crack. Granite is extremely thick as a liquid and can exert great pressure. Erosion has removed the rocks on the north side of this dike. (1175 ft., 390 m).

*Find this inclusion in Fig. 3c.

Dikes with a parallel orientation to the one noted in Fig. 9 are present in the beach area south of the Salt Pond (Fig. 10). This parallelism of fracturing suggests the area has undergone further stress after the cessation of rock folding and granite intrusion. New Harbor is parallel to the set of small dikes, and a common origin is suggested. No dike is visible at the head of the harbor, so it is likely that the fracturing of the rock was not accompanied by granite intrusion. The crack would be a zone of weakness that erosion could work along more easily than an unfractured coast line. Back Cove* is not so easily explained as its orientation seems to suggest erosion has tried to follow the structure of the rocks. The indented coast line in this part of Maine is reasonably parallel to the layering of the rocks. New Harbor is an exception.

SUMMARY

The detailed geology of the Pemaquid Peninsula is being investigated by Professor Arthur M. Hussey, II, of Bowdoin College. The only previous work done in the area appears to be a reconnaisance for the preliminary geologic map of Maine (Maine Geological Survey, 1967). On this map the rock units are described as stratified Devonian Age rocks. These rocks are gneisses which have a layering primarily due to the movement of the earth's crust which built the Appalachian Mountains that traverse central Maine. The direction of this stratification is N 35° E. In cross section these strata are intensely folded and, in most places, are steeply dipping (Fig. 7).

Before the folding had been introduced into the rocks, granite-like bodies intruded their way between the strata (Fig. 3a). The granite was able to squeeze its way between the strata because it was a hot thick liquid. These rocks are granite pegmatites. After the folding, dikes cut across the strata.

Therefore, there are at least two, possibly three, generations of pegmatites at the Salt Pond area. The first (in time) followed the stratification of the gneiss. The granite pegmatite sills show very interesting pinch-and-swell boudinage (pronounced boo-di-nazh) features. Boudinage means "sausage" in French and is used by geologists to describe how the pegmatites seem linked together (Fig. 3b). The boudinage indicates a complex post-intrusion history.

Near the end of the route a granite dike cuts obliquely across the strata and cuts a sill (Fig. 9). Conclusive proof that this dike is younger than the sill is the fact that a small fragment of the sill (inclusion) is frozen in the dike (Fig. 8b). The dike is a fine, even grained granite and not a true pegmatite.

At the end of the route (Fig. 10), the youngest intrusion cuts the regional stratification at nearly right angles. Some of the pegmatites are probably genetically related to the Waldoboro granite which underlies part of the Pemaquid Peninsula (Jan Paterson, University of Buffalo, personal communication).

*See area map, Fig. 1a.

ROCKY BEACH AND UNCONSOLIDATED SEDIMENTS AT SALT POND

From the coastal indentation at the Salt Pond north toward Long Cove, rounded boulders and cobbles dominate the littoral zone. Most of these are locally derived and some gneissic slabs are only slightly offset from their original position within the bedrock. Over most of the area the flat slope of the shore is determined by the parent bedrock which underlies only a single layer of boulders. Too few boulders have accumulated to permit a true rocky beach to form with its characteristic steep slope. The fields of large boulders are seldom shifted by storm waves and form a fairly stable substrate for the rockweed that grows on them. The boulders which are tossed about in moderate storms are thus devoid of rockweed. The Salt Pond itself is a poor habitat for attached intertidal organisms because the cobbles and gravel particles covering the bottom are frequently rolled over one another and are always scraping off attached organisms.

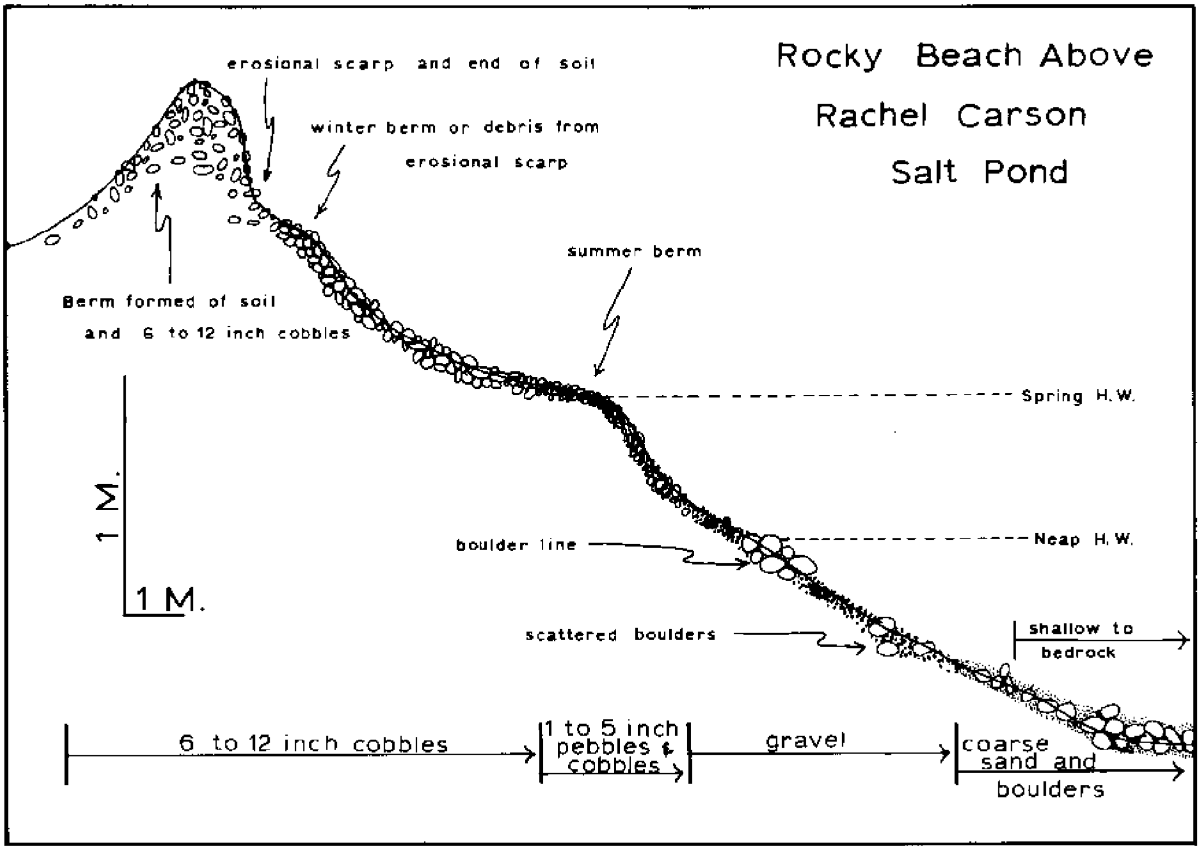
On the shoreward side of the Salt Pond gravel, pebbles and cobbles have accumulated to a depth of several feet. These smaller rocks are frequently tossed about by storm waves and have begun to form a true rocky beachface with a steep slope. The features of this beach can best be discerned by following a transect toward the shore from the southern utility pole near the Salt Pond (see illustration). Here the upper beach features are not affected by foot traffic or road fill.

At the top of the transect is a feature which appears to be a rocky frontal dune. It formed as winter storm waves tossed and rolled six to twelve inch cobbles ashore. Frontal dunes form on sandy beaches because the outermost edge of the beach grass stops the flow of sand flowing ashore. Though this feature resembles a sandy dune in shape, it is technically called a storm berm. A berm is an area of accumulation caused by water movement rather than winds. The berm is not presently forming; rather, it is being eroded away during heavy storms as evidenced by the scarp cut in the seaward face and the "scooped out" or concave upward shape of the profile in front of the scarp.

A flat shelf or winter berm occurs directly in front of the scarp. Rocks are deposited here by erosion of the scarp and by the moderately strong storm waves, common in winter, bringing material from below. This shelf defines the limit of terrestrial vegetation. Further down the profile some parts of the beach show another concave upward accumulation which might be interpreted as the summer berm. On sandy or pebbly beaches--as in the profile--the summer berm is an area of accumulation formed by gentle summer waves just above the level of the highest tides.

The profile illustrated is ephemeral, changing with each storm period. At times pebble bars may form below the lower berm in the profile. These may later be swept away or they may migrate up the profile as waves push them shoreward until they weld onto the summer berm. At other times the profile may be concave upward indicating loss of material to the sea by erosion of the beach face. When the transect was made (August, 1975), the profile below the berm was almost linear and not eroding markedly.

Note the general decrease in rock size from the storm berm to below the high water mark (the boulders occurring below high water may be too large to be thrown higher up). Grains up to about one foot in diameter are thrown high on the shore during heavy winter storms, but those smaller than about five inches return with the back swash. During milder storms grains up to about five inches in diameter are thrown to the base of the storm berm, but grains smaller than approximately one inch in diameter return with the back swash. This accounts for the decrease in grain size from top to the bottom of the profile.



GLOSSARY

BACKSHORE	The portion of a beach which is below the toe of the foredune but above the upper limit of wavewash at high tide; the berm is in this zone.
BERM	A low, impermanent, nearly horizontal or landward sloping beach of material thrown up and deposited by storm waves.
BOUDINAGE	(French for sausage). Strata that show extremely varying thicknesses.
BRECCIA	A rock that has been fractured by earth movements and recemented by a younger rock.
CONCOIDAL FRACTURE	Chip removed from a substance whose shape resembles a clam shell.
DEVONIAN AGE	A time period that began approximately 395 million years ago and ended 345 million years ago.
DIKE	A body of igneous rock that has been injected while molten into a fissure, often resisting erosion and standing like a wall.
FOLD	Rock layers that were originally parallel but have been warped and bent by earth forces.
FOREDUNE	A ridge of windblown sand held in place by vegetation just above the berm and above the highest limit of recent waves.
FORESHORE	The lower or outer, gradually seaward sloping, zone of the beach between the crest of the most seaward berm and the low water mark.
GNEISS	(Pronounced nice). A stratified rock composed of granular and flaky minerals.
INCLUSION	A fragment of rock that has been incorporated into another rock.
INTRUSION	The forcible entry of molten rock or magma into or between other rock formations; also, the intruded mass.
LITTORAL ZONE	The shore between high and low water marks.
OUTCROP	Any location where bedrock is exposed.
PEGMATITE	A coarse, irregularly grained rock.
SCARP	A low steep slope along a beach caused by wave erosion.
SILL	An intrusion that follows pre-existing strata.

Average Beach Face Slopes Compared to Sediment Diameters

Type of Beach Sediment	Size	Average Slope of Beach Face
Very fine sand	1/16-1/8 mm	1^{o}
Fine sand	1/8-1/4 mm	3^{o}
Medium sand	1/4-1/2 mm	5^{o}
Coarse sand	1/2- 1 mm	7^{o}
Very coarse sand	1- 2 mm	9^{o}
Granules	2- 4 mm	11^{o}
Pebbles	4- 64 mm	17^{o}
Cobbles	64-256 mm	24^{o}

Source: Inman, Douglas L. "Sediments: Physical Properties and Mechanics of Sedimentation." Submarine Geology. Francis P. Shepard. New York: Harper & Row, Publishers, 1963.

Recommended reading in Maine geology:

Bulletin #11, The Geology of Sebago Lake State Park, A. L. Bloom.
#12, The Geology of Baxter State Park and Mt. Katahdin, D. W. Caldwell.
#14, The Geology of Southern York County, Maine, A. M. Hussey, II.
#17, The Geology of Mount Blue State Park, K. A. Pankiwskyj.

Inquiries about current prices of these publications should be addressed to: Bureau of Geology
Dept. Conservation
State House
Augusta, Maine 04330

Also suggested:

Freeman, Thomas. Field Guide to Layered Rocks. Boston: Houghton-Mifflin Co., 1971.
Shimer, John. Field Guide to Landforms in the U. S. New York: Macmillan & Co., 1972.

ACKNOWLEDGEMENT: The authors gratefully appreciate the critical review of the original manuscript by Professor Arthur M. Hussey, II.

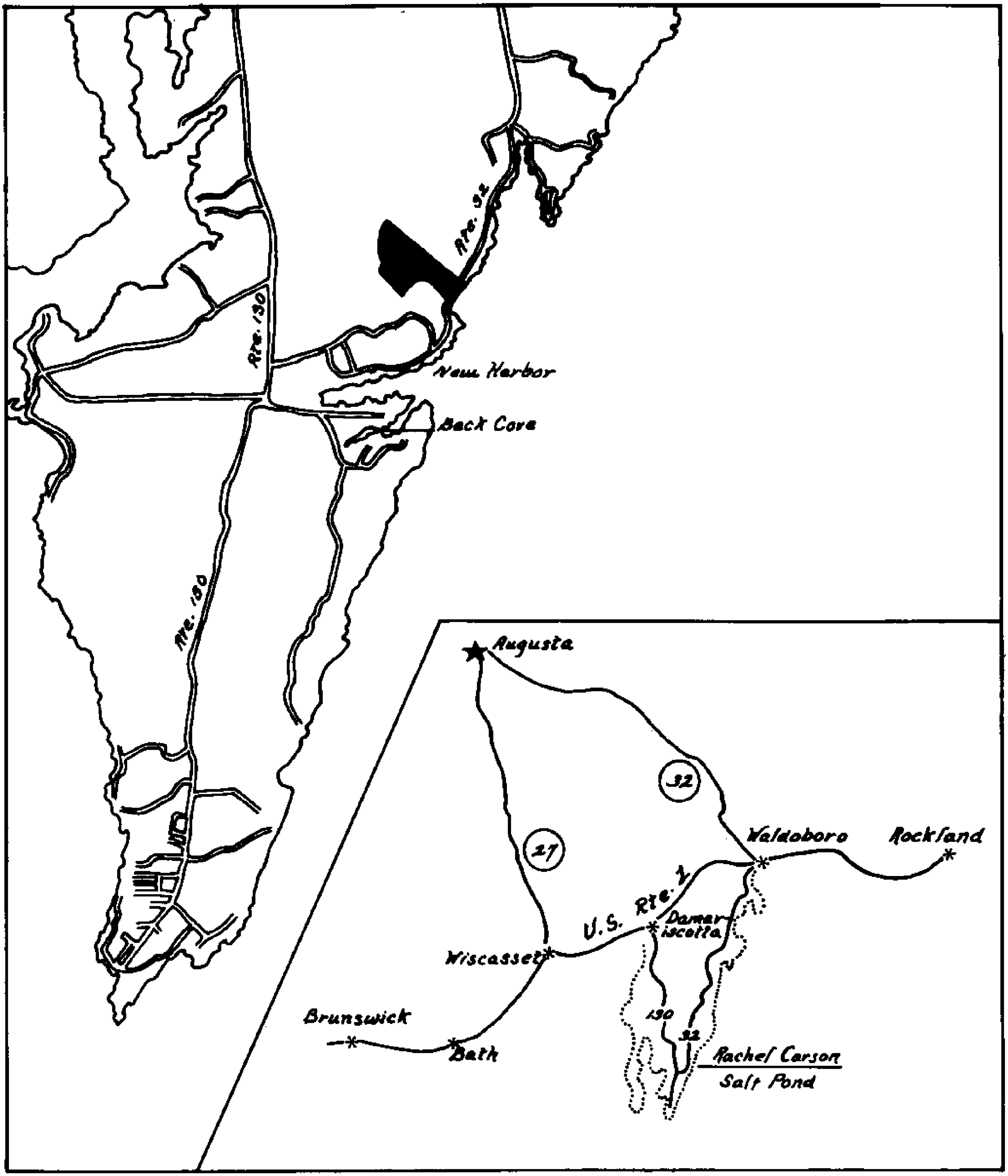


Fig. 1a. Pemaquid Point. Black area indicates The Nature Conservancy Salt Pond Preserve. Inset shows major routes to Rachel Carson Salt Pond.

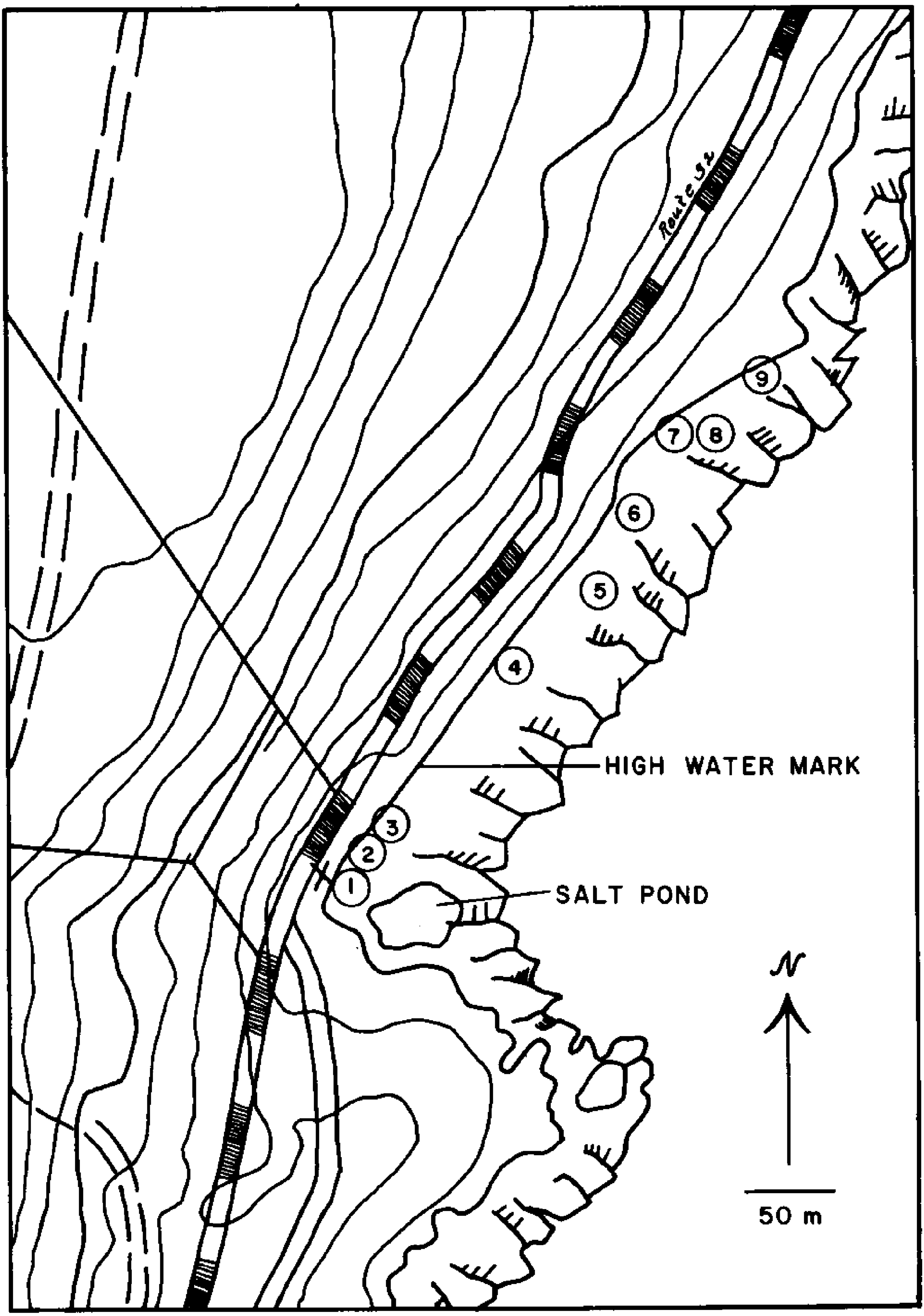


Fig. 1b. Excursion route. "X" marks starting point, Rachel Carson monument.

Fig. 2a. View from the Rachel Carson Monument looking south.

Fig. 2b. Strata and pegmatites.

Fig. 3a. Sill intersecting granite (looking south).

Fig. 3b. Pegmatites with boudinage shapes.

Fig. 3c.

Warped strata around boudinage pegmatites.

Fig. 4. Outcropping ridge with cross section.

Fig. 5a. Step-like erosional features in bedrock

Fig. 5b. Elongated boulders.

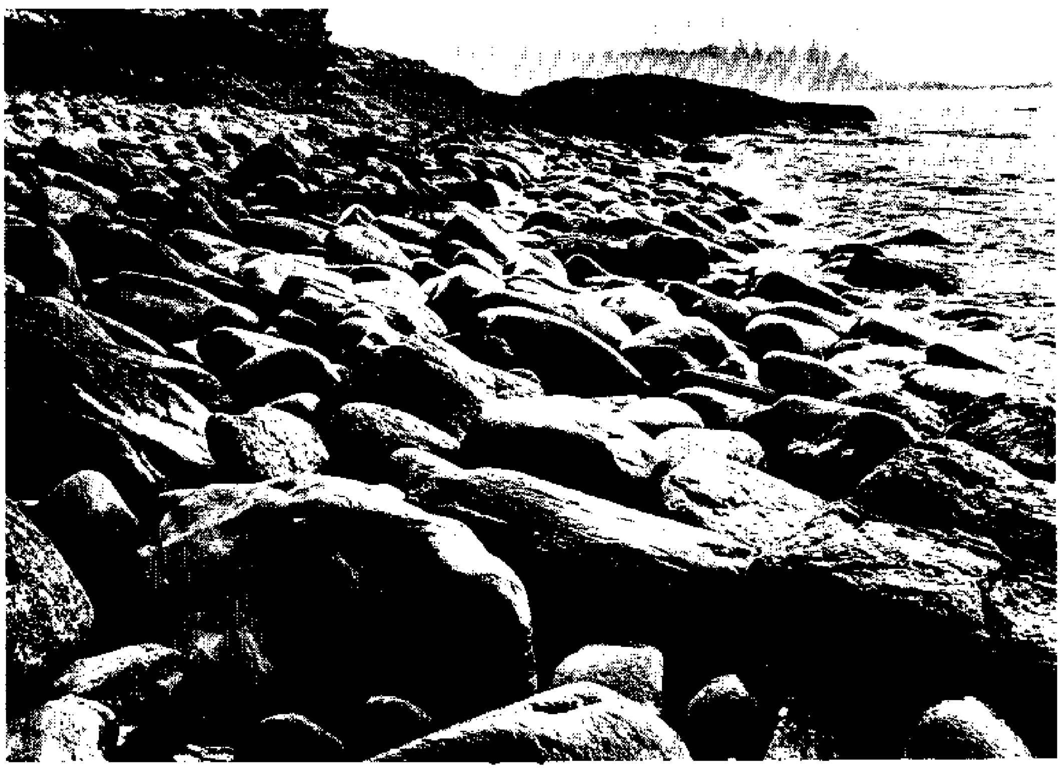


Fig. 6. Rounded boulder zone.

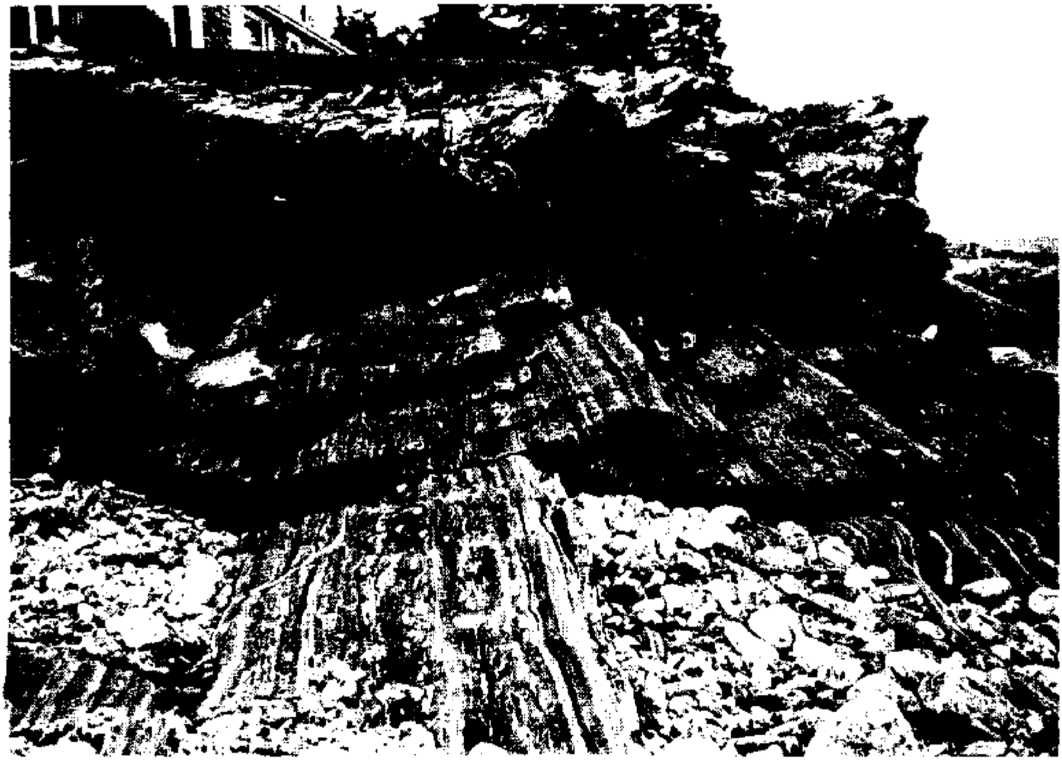


Fig. 7a. Ridge cross section and step-like features.

Fig. 7b. Differential weathering of strata.

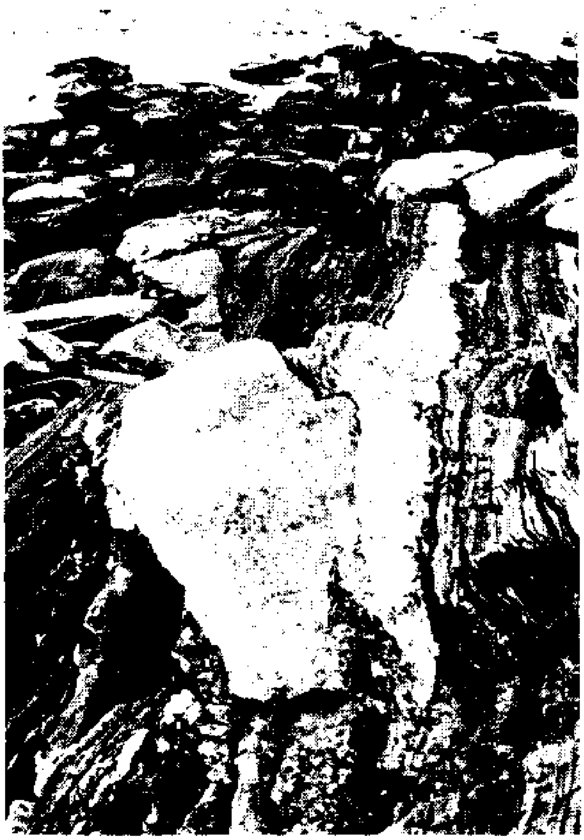


Fig. 8a. Dike intersecting sill (inclusion).

Fig. 8b. Inclusion in dike.

Fig. 9. Dike and drop off at end of excursion.

Fig. 10. Dike on south shore parallel to that in Fig. 9.

Fig. 11. Salt Pond view facing rocky beach.