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Bedrock Geology of Mount Desert Island

Chapman, Carleton A.

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Carleton A. Chapman
University of Illinois, Urbana

Introduction

Mount Desert Island, the largest bedrock island on our Atlantic coast, lies on a long belt of lower and middle Paleozoic rocks that trends roughly parallel to the Maine coastline. The rocks of this belt were derived principally from magmatic sources over a geologically long period of time (probably Ordovician to Devonian). The older representatives, originally stratified pyroclastic materials and interlayered lava flows, constitute the (1) Ellsworth Schist, (2) Cranberry Island Series, and (3) Bar Harbor Series. The younger representatives, principally gabbroic and granitic intrusive rocks, constitute the (1) Bays-of-Maine igneous complex and (2) Maine coastal plutons.

In its central portion, Mount Desert Island is underlain by granite (probably Devonian) which in turn is surrounded by a nearly continuous fringe of older rocks (fig. 1). The granite core is composed of two distinct units, each representing one of the Maine coastal plutons. The larger and older body, the Cadillac Mountain pluton, is composed of coarse-grained hornblende granite. The smaller, younger body, the Somesville pluton, is composed largely of medium-grained biotite granite.

This dual pluton is bordered on the west and northwest by a gabbroic phase of the Bays-of-Maine igneous complex (probably Silurian-Devonian) out beyond which lies schist, gneiss, and quartzite of the Ellsworth Schist (probably Ordovician). The fringe rocks along the northeastern, eastern, and southern contacts consist largely of contact metamorphosed, well-bedded siltstone and sandstone of the Bar Harbor series (probably Silurian). The southern part of the island is made up of weakly metamorphosed volcanic tuff, lava flows, and intrusive felsite of the Cranberry Island Series (probably Silurian) and a granitic phase of the Bays-of-Maine igneous complex. A number of minor satellitic bodies of granite with arcuate form (fig. 1) represent ring-dikes.

Rock Units

Ellsworth Schist--The term Ellsworth Schist is now being used to include certain rocks on Mount Desert Island and nearby Bartlett Island that Shaler (1889) called the Bartlett's Island series. Though the latter term is the older and should have perhaps maintained priority, it has now fallen into disuse. The age of the Ellsworth Schist is probably Ordovician. It has been considered pre-Middlle Silurian (Smith et al, 1907; Chapman and Wingard, 1958).

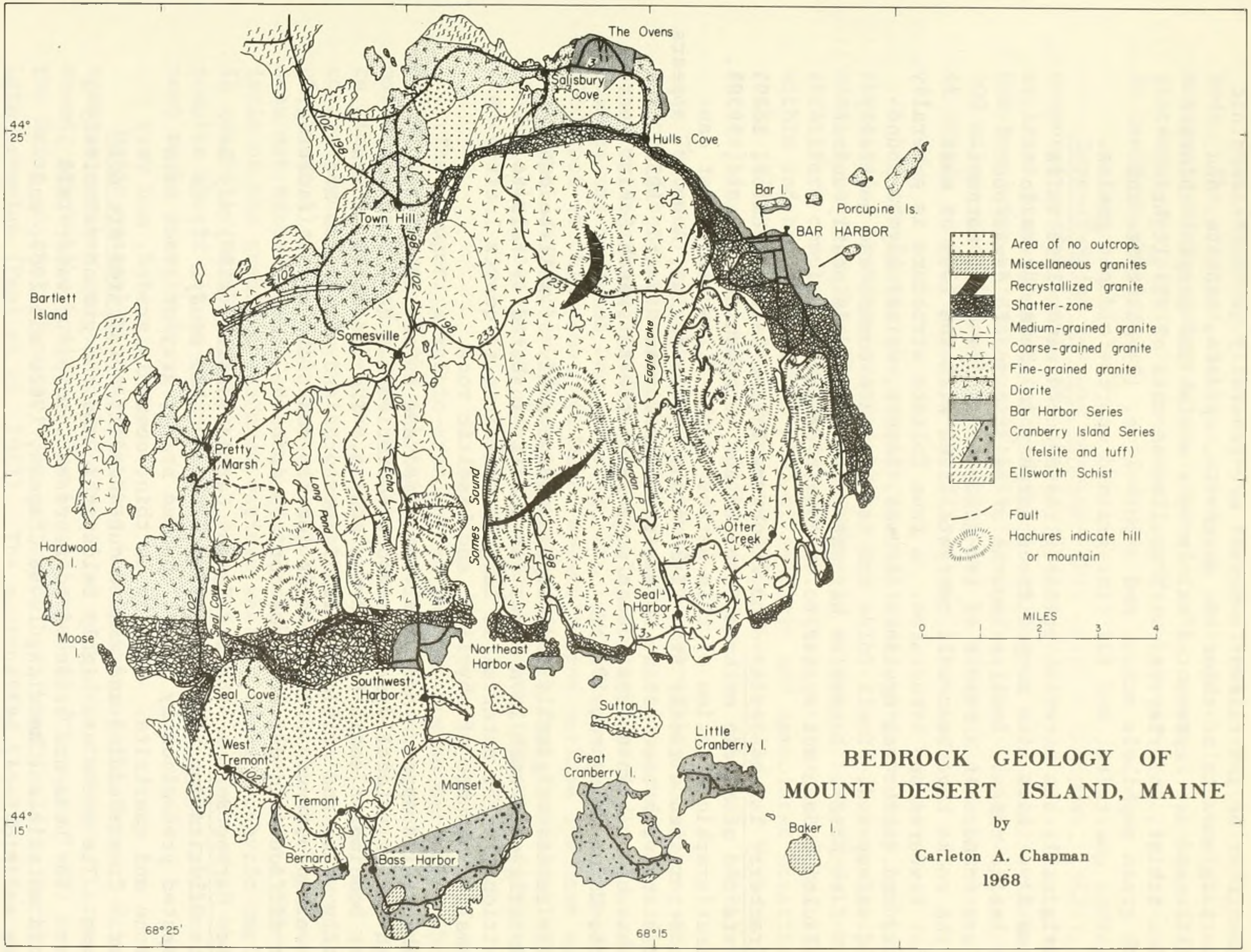

Figure 1. Bedrock geology of Mount Desert Island, Maine.

Reproduced from Chapman (1970) with permission of the Chatham Press, Inc.

The rocks of the Ellsworth Schist are generally quartzofeldspathic with varying amounts of chlorite, muscovite, epidote, biotite, and actinolite and are represented mainly by greenish and grayish chlorite and mica schist, interlayered with smaller amounts of (1) light to dark green amphibole schist and amphibolite, (2) quartzite and feldspathic quartzite, and (3) fine-grained quartz-feldspar gneiss.

Originally the material probably represented water-laid tuffs and some lava flows with compositions largely in the andesite to quartz latite range. Smaller amounts of pelitic and feldspar-poor rocks are found. As a result of low-grade to middle-grade metamorphism the rocks have been well recrystallized with the loss of most original textures and structures. A true foliate structure is generally present, and quartz segregations (lenses, layers, veins) may be abundant and widespread. Small folds and crinkles are common and generally trend N-S to NE-SW. Lineation has many variants and is nearly universal. Faulting does not appear to be common or extensive.

Cranberry Island Series--The Cranberry Island Series (Shaler, 1889) is considered of Middle or Late Silurian age (Chapman and Wingard, 1958). The stratigraphic relation of this series to the Ellsworth Schist cannot be determined directly from field study. This series, however, appears to correlate with the Castine Formation (Chapman and Wingard, 1958) which has been shown to rest unconformably on the Ellsworth Schist near Castine, Maine (Wingard, 1958).

The series originally was composed principally of well-bedded tuff interlayered with lava flows and locally injected by felsite. Compositionally the material is largely andesitic to quartz latitic with smaller amounts of rhyolitic and basaltic rock.

The series appears moderately deformed and layers dip at low to high angles. Locally a conspicuous foliation has developed and may cut bedding at small to moderate angles. The metamorphism was generally weak, and original volcanic textures and structures are still well-preserved. Lineation is locally conspicuous; but faulting, though difficult to detect, does not appear to be common.

Bar Harbor Series--The Bar Harbor Series (Shaler, 1889) may be of Late Silurian age but this matter needs further study. It is represented predominantly by well-bedded brown, gray or green metasiltstone and quartzite. Bedding is thin, commonly graded, and very regular. Cross-bedding and minute cut-and-fill structures are not uncommon. The rocks are highly feldspathic and the grains relatively angular. The beds are believed to represent, in part, water-laid volcanic materials (Chadwick, 1944; Chapman, 1962b and 1969; and Metzger and Bickford, 1972).

At the base of the series is a conglomeratic member (Chapman, 1957) which rests unconformably on weakly foliated volcanic rocks (presumably Cranberry Island Series) and carries pebbles and cobbles of the underlying material.

Over large areas these rocks show horizontal to gently dipping beds. The sharpest flexures are local and apparently associated with movements along steep faults. Normal faults of small extent and displacement are particularly common, and many appear directly related to cauldron subsidence.

Bays-of-Maine igneous complex--This complex (Chapman, 1962a), composed predominantly of layered gabbroic rocks and granites, extends at least from the west side of Pendbscot Bay to well into southern New Brunswick, a distance of 175 miles. The total length may exceed 300 miles; and although the complex may be somewhat discontinuous, it trends roughly parallel to the regional structure.

For simplicity the complex is subdivided into an older, gabbroic phase and a younger, granitic-granophyric phase. It is remarkably similar petrographically and structurally to many other bimodal stratiform complexes (Bushveld, Duluth, etc.). It was emplaced largely within and beneath a thick pile of volcanic and associated stratified rocks (Ellsworth Schist, Cranberry Island Series, and Bar Harbor Series) in late Silurian to middle Devonian time (Chapman, 1962a).

The early or gabbroic phase is highly variable, consisting of norite, gabbro, quartz gabbro, ferrogabbro, diorite, and quartz diorite. Layering (rhythmic, graded, and cryptic) and igneous lamination are common; and on Mount Desert Island the layered sequence may exceed 4000 feet in thickness. On Mount Desert Island perhaps the most common rock type, as well as the average compositional type, representing this phase falls close to the diorite-gabbro boundary (shown as diorite in figure 1).

The younger, granitic-granophyric phase forms an extensive sheet or capping on top of the gabbroic phase and beneath a roof of volcanic material (Cranberry Island Series). The rocks of this phase are medium to fine grained (mostly fine grained on Mount Desert Island) and range compositionally from granite to quartz diorite (fine-grained granite of figure 1). The mafic content (biotite and/or hornblende) generally does not exceed 5 or 10 percent of the rock. Biotite is more characteristic of the granitic textured variety whereas the granophyric variety is generally hornblende bearing. The granites of this phase of the complex should not be confused with those of still younger plutons, next to be described.

Maine coastal plutons--Cutting both phases of the Bays-of-Maine igneous complex and the older stratified rocks are numerous, large, round, stock-like bodies of granite referred to (Chapman, 1968) as the Maine coastal plutons. Some of these have been dated as Early to Late Devonian (Faul et al, 1963). The plutons are 5 to 10 miles across and are composed mostly of medium-to coarse-grained biotite granite. Hornblende granite is much less common.

Two of these plutons occur on Mount Desert Island. The older, Cadillac Mountain pluton is composed of a one-feldspar, hornblende granite with a coarse-grained hypidiomorphic granular texture (coarse-grained granite of figure 1). Much of the rock shows a typical cumulate texture. Alkali feldspar (perthite) occurs as closely packed subhedral to euhedral grains with quartz and small amounts of mafic minerals filling the interstices. Commonly more or less quartz is intergrown with the feldspar. The country rock marginal to this pluton has been severely shattered for as much as half a mile from the contact, thus forming a nearly continuous zone of breccia (shatter-zone of figure 1).

The younger or Somesville pluton, composed of biotite granite, cuts out a large portion of the older Cadillac Mountain pluton. The rock is largely a medium-grained, allotriomorphic granular, biotite granite (medium-grained granite of figure 1) with two feldspars (perthitic microcline and sodic plagioclase). The grain is coarsest in the southern and eastern parts, and a fine-grained phase constitutes a crescent-shaped mass in the central area. Over much of the pluton the rock is subporphyritic, and this texture is most prevalent in the finer grained varieties.

Emplacement of the plutons

The mode of emplacement of the two plutons on Mount Desert Island is considered (Chapman, 1953) to be by ring-fracturing and cauldron subsidence. The same explanation appears to hold for the other Maine coastal plutons (Chapman, 1968). The supporting evidence is as follows: (1) sub-circular outline of the plutons; (2) smoothly-curved, sharp boundaries; (3) paucity of granitic apophyses; (4) ring-dikes passing into shatter-zones and breccia; (6) contact zone of brecciation (shatter-zone of figure 1) around the plutons; (7) web vein patterns and web breccia patterns (Chapman, 1968) in adjacent country rock; (8) external centripetal dip pattern (Chapman, 1953) in adjacent country rock; and (9) chilled contact zones implying rapid ascent of magma.

In the case of the Cadillac Mountain pluton, the subsiding block appears to have been completely detached from the country rock and to have dropped entirely below our present level of observation. After the magma crystallized, further subsidence in the northwestern part of the pluton disturbed the granite and locallized its recrystallization along arcuate belts (recrystallized granite of figure 1). Nearly contemporaneously subsidence created a number of ring-dikes in the western part of the island and vicinity. Subsequently the Somesville pluton formed, but in this case the subsiding block was not completely isolated from the rest of the country rock by arcuate fractures. It remained attached along the northern and western sides and subsided mostly along the southern and eastern sides. This differential movement caused the block to tilt to the southeast as it flexed in hinge-like fashion along the attached sides. Magma entered the gap to the southeast and spread up over the depressed portion of the block to form an incomplete ring-dike of medium-grained biotite granite. A second subsidence and flexing soon followed, and a new and smaller gap in the central and perhaps incompletely crystallized portion of the ring-dike opened. This led to the formation of a second ring-dike of crescent shape and fine-grained texture within the first. This younger intrusion is not shown on the geologic map (fig. 1).

Pattern of consolidation in the plutons

On a textural-structural basis the Cadillac Mountain pluton may be divided into three concentric and more or less distinct zones (Chapman, 1969): (1) contact zone, (2) marginal zone, and (3) central zone. The outermost or contact zone (several hundred yards wide) is composed of the finest-grained hornblende granite. At its inner edge the zone is essentially free of inclusions; but toward the outer edge it becomes crowded with angular, blocky xenolithic material and gradually passes into the shatter-zone of the country rock.

Immediately in beyond the contact zone is the marginal zone. Here the granite is coarser grained and grades inward to slightly coarser rock of the central zone, within roughly 5 or 6 hundred yards. The inclusions of the marginal zone differ strikingly from those of the contact zone. They are well rounded, highly elongate (tabular or lenticular), and show very perfect dimensional parallelism. The boundary between the contact zone and the marginal zone is marked by the sudden appearance of these inclusions in large size and number. Though the perfection of dimensional parallelism of inclusions remains essentially unchanged across the marginal zone, there is a gradual and noticable decrease in their size and abundance toward the center of the pluton.

Throughout the central zone inclusions uncommonly exceed 3 inches in length; only a few occur per square yard of outcrop surface; and preferred orientation is much less conspicuous.

The preferred orientation of these tabular and lenticular bodies establishes a planar structure for the rock. Throughout the central zone of the pluton this planar structure is essentially horizontal. In the marginal zone, however, the structure is inclined with dips ranging up to 35 degrees. Dip direction here is always radial, toward the interior of the pluton. The structure-pattern over the pluton, therefore, is considered (Chapman, 1969) to be saucer-shaped. It, thus, supports the idea that the hornblende granite formed in a floored magma chamber in the bottom of which feldspar (and perhaps hornblende and quartz) and xenoliths continued to accumulate, under direct gravitational control and influence of convection currents, to build upward a stratiform body of crystalline rock. This pattern of consolidation, from the bottom upward, appears representative of many of the other plutons.

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Itinerary

Mileage

0 Assembly point for trip is parking area at Acadia National Park Headquarters Building, 0.3 mile south of village of Hulls Cove (just off route Me. 3). Starting time 9:00 A.M. Park near the granite steps leading to the headquarters building. Try to arrive at least 30 minutes early to

permit a brief visit to the new Park Headquarters Building where complimentary copies of the park map may be obtained. As you climb the steps, note the large granite blocks used in the balustrade. This material, quarried at Stonington on Deer Isle, is much coarser than the granite of Mount Desert Island. Megacrysts of K-feldspar attain lengths of two inches and many show rapakivi structure.

Of the 22 stops described here, about 15 will be selected depending upon the weather, visibility, tide, size of group, and interests of participants. Stops of the most general interest are placed first for the benefit of those who may wish to leave the field party early.

Leave parking area; drive southeast on the "New Park Road" to Bar Harbor.

0.7 Stop 1. Paradise Hill Overlook. Park in area on left side of road. If visibility permits, the geology of the northern part of Frenchman Bay and surrounding region will be explained. Otherwise this stop will be ommitted.

1.2 New Duck Brook Bridge. Built of biotite granite from Hall Quarry in the town of Mount Desert. Just beyond the bridge are outcrops in the shatter-zone heavily stained with limonite.

2.0 Turn left to route Me. 3. On right is fresh cut in the shatter-zone showing somewhat rounded blocks of the Bar Harbor Series in granitic matrix.

2.8 STOP SIGN at route Me. 3. Cross route Me. 3 and proceed eastward into Bar Harbor village (on West Street).

3.5 Stop 2. Municipal pier. Park on the pier and walk to the outer end of the pier. Observe the structure of the Porcupine Islands to your front. Gently inclining beds of the Bar Harbor Series near the water level are overlain by thick cappings of a gabbro sill.

Now follow the "Shore Path" which starts near the pier and leads eastward, just above the sand beach and past the hotel. Examine the outcrop of mafic dike at the east end of the beach and, then beyond, the rocks along the shore (siltstone and sandstone of the Bar Harbor Series).

Return to the parking area. Drive on around the loop, leave the parking area, and start back down West Street.

3.6 Turn left up the hill on Main Street and drive southward through the village (on route Me. 3).

5.1 Junction of route Me. 3 and Schooner Head Road. Bear right on route Me. 3.

6.1 Turn right to Ocean Drive

6.2 Turn right to Ocean Drive

6.3 Turn right. You are now on a one-way road (Ocean Drive).

7.5 Stop 3. Champlain Mountain Overlook. Park in area at left side of road (elevation 253 feet). If the visibility permits, the geology of the southern part of Frenchman Bay will be explained. This location lies at the contact between the shatter-zone and the body of hornblende granite (coarse-grained granite of figure 1). At the south end of the road-cut is granite fairly typical of the contact zone of the Cadillac Mountain pluton. To the north the Bar Harbor Series is represented by huge blocks, with vari-colored beds of metasiltstone and quartzite, enclosed or cut by veins and dikes of granite.

9.6 Stop 4. Sand Beach. A one-minute stop on road. Do not get out of cars. Look across the small pond to the ridge on the sky line. The light colored exposures on the ridge are granite, part of a small ring-dike within the shatter-zone.

11.8 Stop 5. SLOW!! Turn sharp right into Otter Point parking area and park. Walk out of the parking area by the east exit (same route that you entered). LOOK LEFT!! Then cross Ocean Drive and climb down onto the shore. Observe the huge mass (over 300 feet long) of varicolored quartzite and metasiltstone (Bar Harbor Series) with bedding dipping shoreward toward the body of hornblende granite. These beds were inclined downward along a ring-fracture zone as cauldron subsidence provided room for the influx of granitic magma.

Walk westward along the shore, through a narrow shatter-zone, into the contact type of hornblende granite. Compare the granite in the outcrop here with that in the huge glacial boulders.

Return to the parking area and drive out of the area by the west exit. LOOK LEFT!! Then turn right onto Ocean Drive.

12.7 Otter Creek causeway. To the north (right) from the causeway observe Cadillac Mountain (Elev. 1530 ft.) separated from Flying Squadron (Dorr) Mountain (elev. 1270 ft.) by a deep glaciated notch. Just ahead begins a long continuous road-cut through the marginal zone of the Cadillac Mountain pluton (hornblende granite).

14.4 Stop 6. Little Hunters Beach. Park off road at right. Walk across road, climb down to the cobble beach, and walk out along the west side of the cove to the high bare ledges of breccia in the shatter-zone. Here beds of the Bar Harbor Series and large masses of dolerite (fine gabbro) have been involved in brecciation.

Return to the cars and continue driving along Ocean Drive.

14.7 Stop 7. Hunters Beach Head. A one-minute stop on left side of road. Do not get out of cars. Observe granite dikes cutting dolerite (fine gabbro) and beds of the Bar Harbor Series, all in the shatter zone.

17.5 ONE-WAY ROAD ENDS HERE!! Bear right onto Jordan Pond Road.

18.5 Road begins to climb west slope of Pemetic Mountain. Excellent road-cuts in coarse-grained granite of the central zone of the Cadillac Mountain pluton. Note jointing and inclined sheeting. To left is Jordon Pond in a U-shaped valley cut by glacial ice. Ahead are The Bubbles, two reshaped hills with steep slopes, plucked by the glacier, facing us. Near the crest of the nearest Bubble is a huge boulder, an erratic of very coarse granite carried from its source at least 20 miles to the northwest.

21.6 Stop 8. Eagle Lake overlook (elev. 485 ft.) A one-minute stop on left side of road. Do not get out of cars. Below is Eagle Lake. At its left end are The Bubbles exhibiting their asymmetrical outline. Beyond The Bubbles is Sargent Mountain (elev. 1373 ft.). On a clear day Blue Hill may be seen to the west, roughly 18 miles away.

22.3 Pass the Summit Road to Cadillac Mountain

22.9 Keep left at road junction

23.3 Eagle Lake Road overpass

23.4 Stop 9. Turn right on side road and then park on right about 50 yards ahead (just short of junction with route Me. 233. Walk to route Me. 233 just ahead and turn left. Proceed to the deep road-cut near the underpass. CAUTION!! STAY OFF THE ROAD! TRAFFIC USUALLY MOVES FAST HERE, AND VISIBILITY ALONG ROAD IS POOR. The hornblende granite here, in the marginal zone of the pluton, is a little coarser than that of the contact zone. Note the horizontal sheeting and steep jointing. Study the size, shape, arrangement, and distribution of xenoliths in the granite.

Return to the cars. Drive to route Me. 233.

23.5 Turn right onto route Me. 233.

24.8 Stop 10. LUNCH. Turn right into Eagle Lake parking area and park.

25.7 Stop 11. Park off road at right. Walk ahead to the low outcrops on right side of road. Compare the coarser, uniform texture of the hornblende granite here (central zone of the pluton) with that of the granite seen in the marginal and contact zones. Note the paucity of xenoliths. Just ahead the granite takes on an inequigranular texture (pseudoporphyritic). This rock is the recrystallized granite of figure 1.

26.5 Keep left on route Me. 233.

28.4 STOP SIGN. Junction with route Me. 198. Turn right. We now drive around the north end of Somes Sound, a flooded valley (fjord) cut deeply through the mountains to the south (left of road). Note medium-grained biotite granite (Somesville pluton) in several road-cuts.

29.9 STOP SIGN. Junction with route Me. 102. Turn left.

30.1 Enter Somesville, oldest settlement on Mount Desert Island. WARNING!! SPEED LIMIT STRICTLY ENFORCED.

30.8 Bear left at road junction toward Southwest Harbor.

32.1 Stop 12. At junction with Hall Quarry road. Park in area on right side of route Me. 102. Biotite granite of the Somesville pluton. This is the younger, finer-grained phase of the pluton which constitutes the youngest ring-dike of the area.

36.5 TRAFFIC LIGHT. Southwest Harbor village. Continue straight ahead.

37.1 Bear left at junction with route Me. 102A.

40.4 Turn left to Seawall Picnic Area on the shore.

40.6 Stop 13. Turn right and then park on the beach to the left of the road. Outcrop along shore represents weakly metamorphosed volcanic material (mostly ash and tuff) of the Cranberry Island Series.

Walk northward along shore a few hundred yards to observe mafic dikes cutting the metavolcanic rocks. If beach conditions are favorable, the contact between these rocks and a fine-grained sugary granite (miscellaneous granites of figure 1) may be observed. To the north, the granite.

speckled and mottled with hematite, carries abundant pods and veins of quartz and microcline (some amazonite).

Walk back to cars by the road and drive out to route Me. 102A.

40.8 Turn left onto route Me. 102A.

42.0 Turn right at Bass Harbor Head road.

44.3 Keep right at road junction.

44.6 <u>Stop 14</u>. Park on right side of road. Exposure of felsite of the Cranberry Island Series.

44.7 Road junction with route Me. 102. Turn left.

45.7 Keep right along the main road.

48.0 <u>Stop 15</u>. Junction with Dix Point road. Park along road. Exposure of fine-grained granite (granitic-granophyric phase of the Bays-of-Maine igneous complex).

50.0 Bridge over Seal Cove Brook. Turn left on side road just beyond bridge.

50.6 <u>Stop 16</u>. Park along road near shore of Seal Cove. If tidal conditions are favorable, rocks of the Ellsworth Schist may be studied. These somewhat pelitic schists show folded and crinkled bedding and foliation and abundant concordant quartz veins and pods.

Face the water and then turn left and walk along the shore to observe a granite-schist breccia, representing part of the shatter-zone formed during the intrusion of the granitic plutons.

Return to the cars and drive back to route Me. 102.

51.2 Turn left on route Me. 102.

51.3 <u>Stop 17</u>. Park along route Me. 102. Exposure of light colored quartz diorite of the gabbroic phase of the Bays-of-Maine complex.

54.4 Turn right on Long Pond Fire Road.

55.0 <u>Stop 18</u>. Park along road. About 250 feet west of highest point of fire road is side road to old quarry. Two phases (medium-grained and fine-grained) of the Somesville pluton may be observed here, and a small dike of the finer cuts the coarser rock.

Return to cars. Turn cars around at quarry road entrance and drive back to route Me. 102.

55.7 Turn right on route Me. 102.

56.2 Turn left at road junction.

56.5 Keep right at road junction.

59.2 Mount Desert - Bar Harbor townline.

60.6 Indian Point road junction, keep to left.

61.0 Stop 19. Park on side of road. Good exposure of the gabbroic phase of the Bays-of-Maine igneous complex.

62.4 STOP SIGN. Junction with routes Me. 102 and 198. Turn left.

64.4 STOP SIGN. Junction with route Me. 3. Continue straight ahead.

64.8 Stop 20. Turn right opposite information booth (before crossing bridge) into Thompson Island Picnic Area and park. Walk to the shore and examine the light greenish gray gneiss (Ellsworth Schist). Locally the rock is more properly a schist. Originally this material was probably well-bedded ash and tuff. Irregular, discordant quartz veins are numerous.

Drive back out of the parking area to the main road.

65.0 Turn left on route Me. 3.

65.4 Keep left on route Me. 3 at road junction.

68.6 Turn left onto Hadley Point Road and drive to the shore.

69.3 Stop 21. Hadley Point. Park on beach. At the water's edge, to your right front as you face the water, is a large outcrop of Ellsworth Schist. These somewhat pelitic rocks show marked foliation and crinkled layers. Concordant with the layers are thin, discontinuous veins and lenses of quartz.

Drive back up the hill to the main road.

70.0 Turn left on route Me. 3.

72.1 Turn left and follow sign to Sand Point.

72.8 Stop 22. Park off road on left near cabin area entrance. We have special permission from the property owners to walk down through the cabin area to the shore. Proceed to the shore, turn right at the beach, and follow the shoreline to the high cliff with large caves at its base. CAUTION!! BE ON GUARD FOR FALLING ROCK! The cliff is held up by a microcrystalline rock (felsite) which in fresh exposure shows well-developed bedding. This material is part of the Bar Harbor Series, and more typical examples will be seen further along the beach.

Retrace your steps back to the cars.

73.7	Turn left onto route Me. 3 toward Hulls Cove.
75.2	Hulls Cove
75.5	Entrance to Acadia National Park. Turn right.
75.55	Turn right into Park Headquarters parking area. END OF TRIP.