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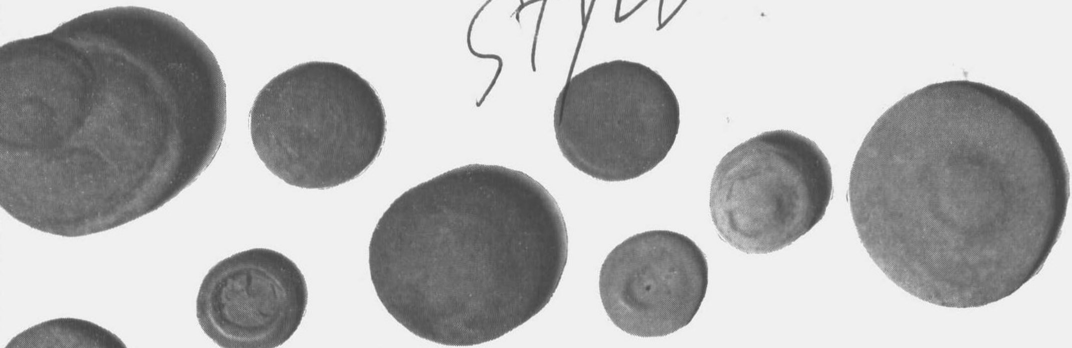

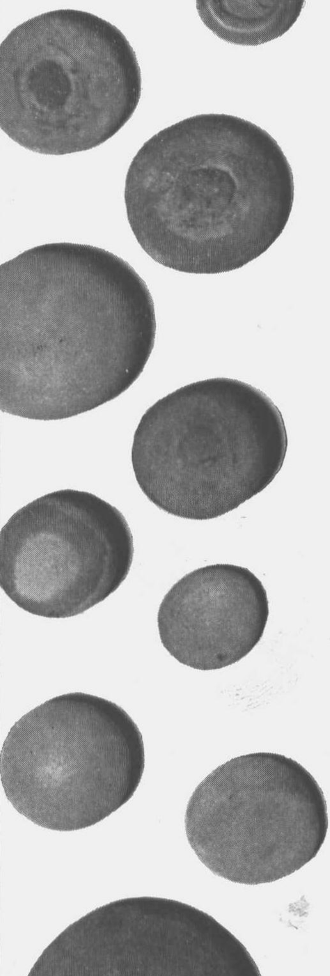

The Geology of

Button Bay State Park

by

HARRY W. DODGE, JR.

DEPARTMENT OF FORESTS AND PARKS
PERRY H. MERRILL, *Director*

VERMONT DEVELOPMENT DEPARTMENT

VERMONT GEOLOGICAL SURVEY
CHARLES G. DOLL, *State Geologist*

1962

Cover Picture: Selected "buttons" from the clay bank along the beach at Button Bay State Park. ($\times 0.8$).

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THE GEOLOGY OF BUTTON BAY STATE PARK

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INTRODUCTION

Button Bay State Park is located on the eastern shore of Lake Champlain with lake frontage on Button Bay (see maps, Figs. 1 and 2). This Vermont State Park is reached from the nearest large town, Vergennes, by proceeding southwest, toward Addison, on State Route 22A for .25 miles beyond the bridge over Otter Creek, thence, right on the Basin Harbor-Panton road for another 1.4 miles to the first road entering from the right. Turn right on this, the Basin Harbor road, and proceed for 4.5 miles, thence, left for 1.4 miles to Button Bay State Park (see map, Fig. 2, note arrows). A more direct road is planned to connect the Basin Harbor Road with the Park, however, this route has still not been completed.

Prior to its present name, Button Bay, the "sickle-shaped bay" on which Button Bay State Park is located was termed *Button Mould Bay*[1]. In "The Journal of William Gilliland" which is found in the "Pioneer History of the Champlain Valley" by Winslow C. Watson, Albany, 1863, and under the date of September 7, 1765, is found an entry which speaks of "his (Gilliland) overtaking '*the Governors and other gentlemen*'[2] at Button Mould Bay, and going aboard their sloop."

A book of charts by Captain William Chambers contains one entitled "Baye du Roche Fendue (Split-Rock Bay) and the soundings taken in August 1779." At the upper corner of the chart is the name "Button Mould Bay." The first appearance of the shortened version, Button Bay,

[1]Most of the information for this section was graciously supplied by Clara E. Follette, Librarian and Museum Director, Vermont Historical Society, Montpelier, Vermont, in a letter to the author dated April 26, 1961.

[2] "The governors (and other gentlemen) appear to have included Sir Henry Moore, Governor of New York, General Carleton, Governor of Quebec, Brig. General Philip Schuyler (and Adolphus Benzel, map maker). The activities of these persons on the lake at that time were evidently concerned with making observations, primarily to determine boundaries."

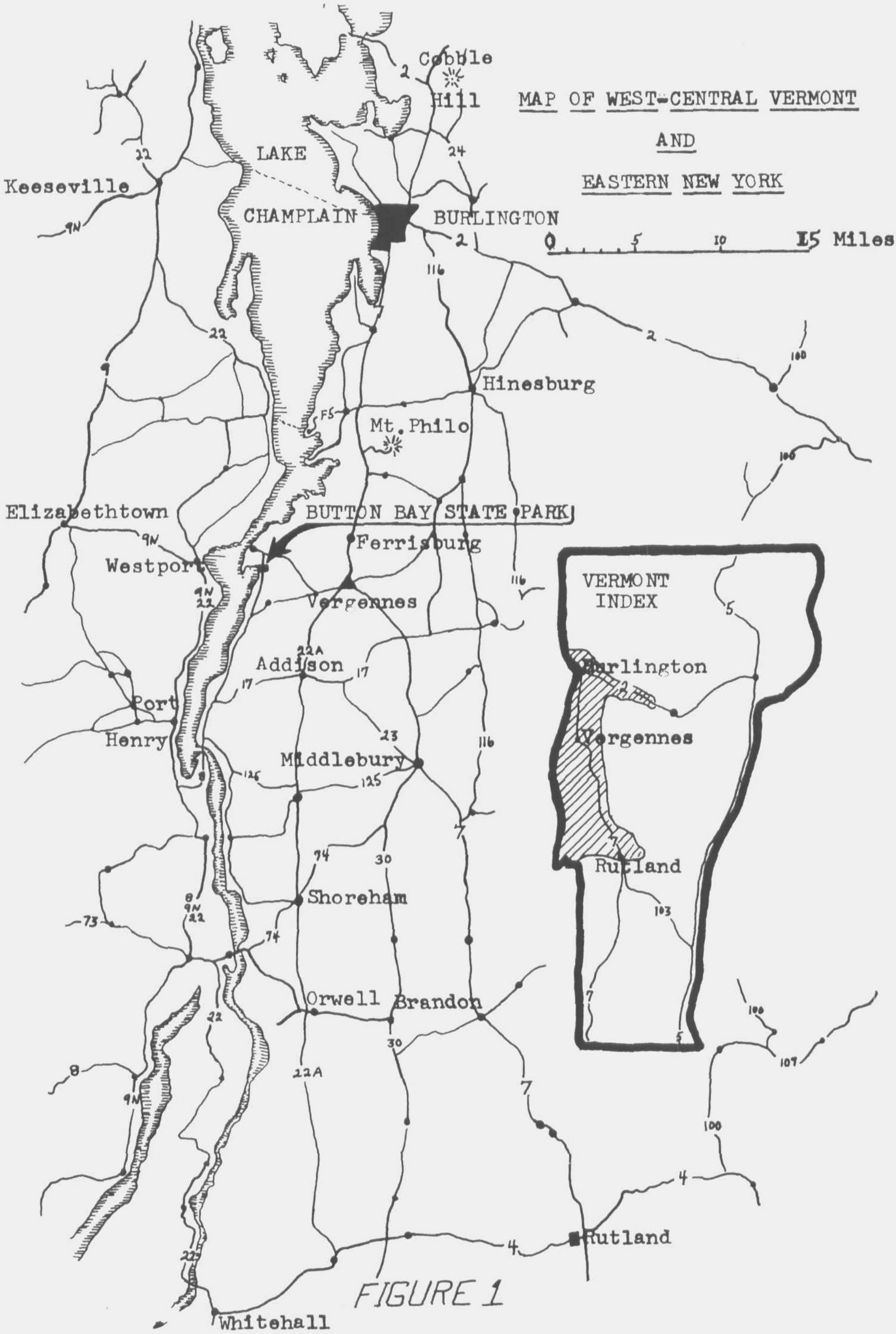
MAP OF WEST-CENTRAL VERMONT
AND
EASTERN NEW YORK
0 5 10 15 Miles
Cobble Hill
LAKE
CHAMPLAIN
BURLINGTON
Keeseville
Hinesburg
Mt. Philo
Elizabethtown
BUTTON BAY STATE PARK
Ferrisburg
Westport
Vergennes
Addison
Port Henry
Middlebury
Shoreham
Orwell
Brandon
Rutland
Whitehall
VERMONT INDEX
Burlington
Vergennes
Rutland

FIGURE 1

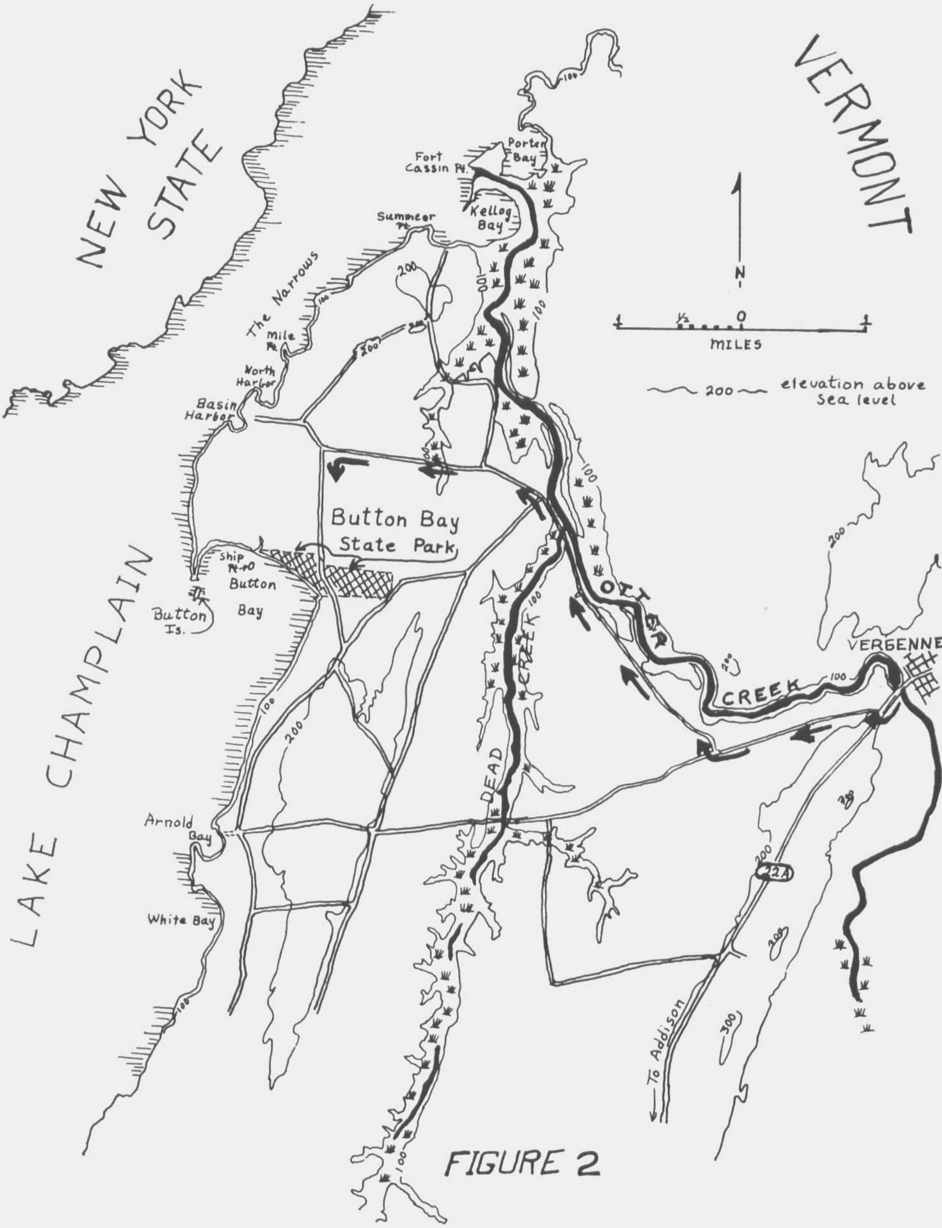
NEW YORK
STATE
VERMONT
LAKE CHAMPLAIN
Fort Cassin Pt.
Porter Bay
Kellog Bay
Summer Pt.
The Narrows
Mile Pt.
North Harbor
Basin Harbor
Button Bay State Park
Ship Pt.
Button Bay
Button Is.
Arnold Bay
White Bay
OTTER CREEK
DEAD CREEK
VERGENNES
22A
To Addison
N
½
0
1
MILES
200 elevation above Sea level

FIGURE 2

seems to be in Whitelaw's map of 1796 which was used as the frontispiece of the Census volume, "Heads of Families, Vermont, 1800."

Why the name Button Bay? H. M. Seely (1910, p. 274)[1] when discussing the shoreline of this bay states, "Besides shells, *concretions*[2], some of strange imitative forms (many shaped like animals), are loosened from the clay." He goes on to say that a "form particularly abundant in the banks of the bay (and on the beach) has the shape and size of a turned wood button-mold (mold is commonly spelled "mould" by the British), a disc with a hole in the center, plane (flat) on one side and convex on the other" (see Fig. 3 and cover picture). The abundance of these button mold-shaped concretions obviously led to the older name, Button Mould Bay which was later shortened to Button Bay.

THE GEOLOGY OF BUTTON BAY STATE PARK

If the visitor confines his wanderings to the State Park the most conspicuous geological features, or clues to the Park's past history, are concentrated in the clay banks and adjacent beach which border Lake Champlain (see Fig. 4). The clays which cover the entire Park record thousands of years of rather recent events, *geologically speaking*[3], which took place in the Champlain Valley. These clays also record a very significant phase in the development of present Lake Champlain. Before discussing the clays it will be necessary to outline some of the geological events which preceded the deposition of the clays, that is, some of those events which took place as the last glacial ice lobe slowly retreated up the Champlain Valley and into Canada. The author has borrowed heavily from an article by Donald H. Chapman entitled "Late-Glacial and Post-glacial History of the Champlain Valley" which was published

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[1] Seely, H. M., 1910, Preliminary Report of the Geology of Addison County; Vermont State Geologist, 7th Biennial Report, p. 257–315.

[2] Concretions consist of concentrations of certain chemical elements and compounds into regular or irregular masses. Many times the center of a concretion consists of a definite nucleus such as a grain of sand or shell fragment. For a general idea of the size and shape of the concretions seen along the Button Bay State Park beach see Fig. 3 and cover picture.

[3] These clays were deposited from marine waters which flooded the Champlain Valley after the final retreat of the glaciers which completely covered New England during the "Great Ice Age" or Pleistocene Epoch. The Pleistocene Epoch began approximately one million years ago and if the age of the Earth is considered to be five billion (5,000 million) years, then, the clays do record recent geologic history.

Figure 3. Water-worn concretions seen on the beach of Button Bay State Park. The button-mold shape of some concretions led to the incorporation of the word "Button" in the name Button Bay (Originally, Button-Mould Bay). The chisel portion of the Alpine ice ax head is about 5 inches long.

in the 1941–1942 "Report of the State Geologist on the Mineral Industries and Geology of Vermont, twenty-third of (the) Series."

During the final retreat of the last ice sheet to invade the New England states (some 11,000 to 12,000 years ago) an ice lobe, which occupied the Hudson-Champlain Valley, slowly wasted northward toward the Canadian border. Melt-water derived from the melting glacial ice together with atmospheric water (rain and snow) formed a succession of lakes dammed on the north by the glacial ice. These lakes emptied to the south through the Hudson Valley. This succession of lakes and intermediate lake stages will be discussed in the following paragraphs.

Figure 4. View of beach, Button Bay State Park, looking toward the southeast. The beach demonstrates several water-level and storm-level debris lines. Note the conspicuous lack of sand on this "clay" beach.

The oldest lake recognized by the geologists is termed "Lake Albany" and was confined to the Hudson Valley. At this time the area of present-day Lake Champlain, north of the Hudson Valley, was still covered by glacial ice which was slowly melting as the general regional climate throughout New England became warmer and warmer. Soon the whole Hudson Valley region began to *rise*[1] out from beneath the lake waters

[1] As the weight of the ice was removed from the Hudson Valley region the earth's crust, in way of adjustment to this removal of weight, slowly began to rise. Some geologists doubt whether the removal of ice weight alone can account for the crustal rise and propose other internal forces as partly or wholly responsible. The fact remains that the earth's crust did rise in this area.

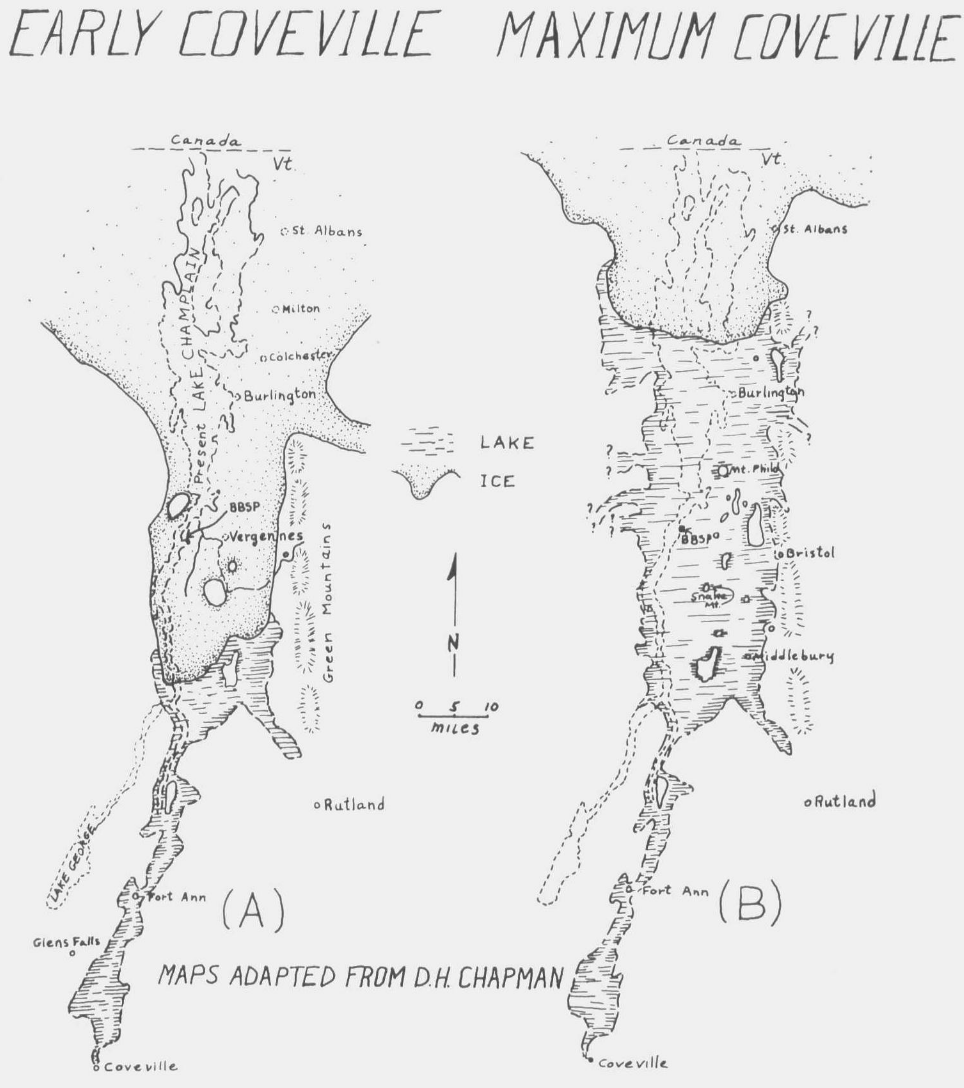
and "Lake Albany" shallowed. Eventually a rock ledge emerged just south of Schuylerville, New York (actually at Coveville, New York) over which the waters from a new lake, Lake Vermont, began to flow.

Lake Vermont, with its rock ledge dam at Coveville, began to expand northward as the ice front retreated up the Champlain Valley. Several distinct stages in its development are now recognized in *features*[1] demonstrating past lake levels which are abundantly displayed close to Button Bay State Park. The "lake-level indicators" or features tell us, in addition to the number of distinct lake stages in a given area, something about past earth movements. A "line of lake-level-*elevation*"[2] is drawn through those features outlining each past lake or lake stage followed by a comparison of each line with those lines constructed for older and younger lakes or lake stages. If, for any two lake-level lines compared, these lines are not parallel, it can be assumed that the earth's crust was tilted during the time between the formation of their lake-level features. This idea of tilting of the earth's surface, which is supported through the study of successive lake levels, has proven the key to the present status of Lake Champlain.

At the beginning of its history Lake Vermont emptied to the south through an outlet channel located in the vicinity of Coveville, New York (see map, Fig. 5A). This stage in the development of Lake Vermont, often referred to as the Coveville Stage, saw lake waters fill the Champlain Valley from the Green Mountains on the east to a position west of the present New York-Lake Champlain shoreline. Such Vermont towns as Middlebury, Vergennes, Hinesburg, Burlington and Colchester would have been submerged beneath the lake waters (see map, Fig. 5B). Certain high areas such as Mount Philo, Pease Mountain and Cobble Hill show lake-level features along their sides which prove that these areas were islands rising above the level of this past lake. If you visit Mt. Philo State Park, located approximately **11** miles north of Vergennes, one of these lake-level features, a wave-cut terrace, can be seen at an elevation of 545

[1] As the ice retreated, a succession of lakes formed in the Champlain Valley. Each lake had a level waterline during its history and certain lakeshore features formed, as they do in any present-day lake, with respect to each past level water-line. For example, ridges of sand and gravel were heaped along the shoreline by lake waves. Wave-cut and wave-built flat areas or terraces were formed along the margins of lakes or along the sides of islands within a lake. Streams entering a lake built deltas by depositing materials it had carried down from the surrounding highlands.

[2] Elevation is measured in feet above the mean sea level of today, with mean sea level being zero feet.



EARLY COVEVILLE
MAXIMUM COVEVILLE
Canada
Vt.
St. Albans
Milton
Colchester
Burlington
PRESENT LAKE CHAMPLAIN
BBSP
Vergennes
Green Mountains
LAKE
ICE
N
0 5 10
miles
Rutland
LAKE GEORGE
Fort Ann
(A)
Glens Falls
Coveville
Mt. Philo
Bristol
Snake Mt.
Middlebury
(B)
MAPS ADAPTED FROM D.H. CHAPMAN

FIGURE 5

Figure 6. Looking west from the top of Mount Philo State Park. The Adirondack Mountains are on the skyline, Lake Champlain in middle background and the Champlain Lowlands stretch from Lake Champlain to the base of Mount Philo.

feet and on the south side of the hill (at the level of the second reverse turn in your trip to the *summit area*).[1]

Shortly after Coveville Lake Vermont reached its maximum size (see map, Fig. 5B), a southern gorge-outlet was formed at an elevation lower than the previous Coveville outlet in the vicinity of Fort Ann, New York (Fort Ann is located approximately 8 miles south of the

[1] A most impressive view can be gained from any one of the several lookout points at the summit level of Mt. Philo. Looking to the west, toward Lake Champlain, and south in the direction of Vergennes and Button Bay State Park, a three dimensional view of an old lake (Lake Vermont) can be seen. In this view the present Lake Champlain Lowlands represent the old lake bottom and the numerous hills rising above this Lowland were once islands or near-islands which dotted the surface of the lake. It takes very little imagination to place yourself on the "island of Mt. Philo" and to visualize a boat tied to a dock just below the rocky cliffs on which you stand. A trip to Mt. Philo with its spectacular view of the Champlain Lowlands (see Fig. 6) is recommended.

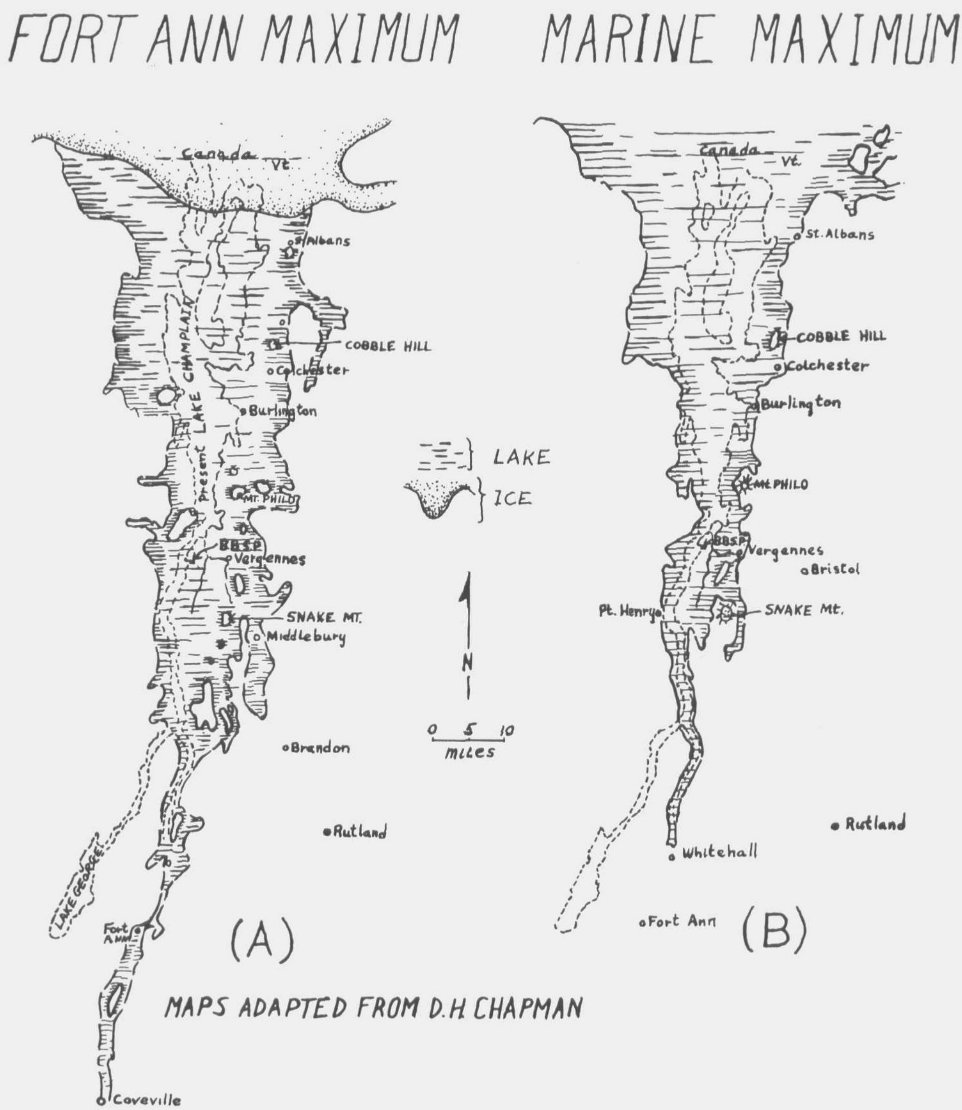

FORT ANN MAXIMUM
MARINE MAXIMUM
Canada
Vt.
St. Albans
COBBLE HILL
Colchester
Burlington
Present LAKE CHAMPLAIN
MT. PHILO
BBSP
Vergennes
Bristol
SNAKE MT.
Middlebury
Pt. Henry
Brandon
Rutland
Whitehall
LAKE GEORGE
Fort Ann
Coveville
LAKE
ICE
N
0 5 10
miles
(A)
(B)
MAPS ADAPTED FROM D.H CHAPMAN

FIGURE 7

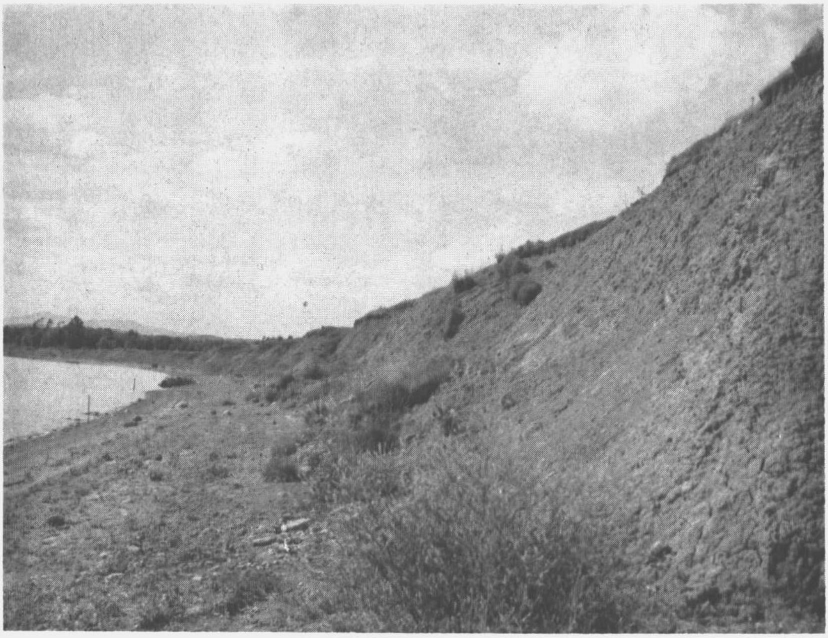


Figure 8. Beach and clay banks exposed along the Lake Champlain portion of Button Bay State Park. This view is toward the northwest and includes a major portion of the Park's lake frontage. Photo by Robert B. Williams.

present southern extremity of Lake Champlain). The level of Lake Vermont's water dropped to the new Fort Ann Stage (see map, Fig. 7A). Evidence for this new lake level is seen on the slopes of Mt. Philo, Snake Mountain and Cobble Hill. These lake-level features are parallel to and found 100 feet below those of the Coveville Stage. These parallel features, then, indicate that very little, if any, tilting of the earth's crust had taken place between the Coveville and Fort Ann lake stages.

This Champlain ice lobe continued to melt and retreat toward the Canadian border and beyond. As the glacial front approached the St. Lawrence valley, fresh water from Lake Vermont began to seep through the retreating ice lobe and into the marine waters which filled the St. Lawrence area. Several shoreline (lake-level) features are found at different elevations below the Fort Ann Stage of Lake Vermont and attest to a slow lowering of the lake level by the escape of fresh water to the north.

The conspicuous clays of Button Bay State Park were deposited during the next episode in the history of the Champlain Valley, a development heralded by continued retreat of the ice lobe and contact with the St. Lawrence marine waters. Let's take a look at the clays so well displayed along the Button Bay State Park beach and see if we can piece together their history.

THE CLAYS OF BUTTON BAY STATE PARK

The best location in the Park for a good look at the clays which cover the entire Park area is along the lake beach (see Figs. 4 and 8). The bank averages 23 feet in height measured from the beach to the top of the bank. The width of the beach varies seasonally and during storms as the water level of Lake Champalin fluctuates (see Figs. 4 and 8). A walk along the beach will reveal some interesting facts about the composition of the beach and the adjacent clay banks.

One cannot help observing the scarcity of *sand*[1] on the beach. The only adjacent material to build this beach is clay, which here contains a small quantity of sand and some concretions containing lime. The sickle shape of Button Bay keeps most foreign sand from the beach. The small patches of sand present soon give way to *blue clay*[2] which, in many places, forms the base of the beach. This blue clay can also be seen in the base of the bank in the southern portion of the Park, where it underlies and is therefore older than the *brown clay.*[3]

Actually very little of the blue clay is exposed in the Park. From other locations along the shore of Lake Champlain and in the more inland areas of the Champlain Lowlands geologists have found many clues to help our understanding of its history.

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[1] One word of caution, the Park authorities may import sand from other areas of Vermont to improve the swimming facilities along the beach. In this case, the abundant sand on the beach will not constitute the "natural beach composition" for Button Bay State Park.

[2] The blue color is due to the presence of ferrous iron (bivalent iron) together with iron compounds in which iron has its higher chemical valence (ferric iron). This ferrous iron demands a chemically reducing environment for its formation and indicates that the clays were deposited in a shallow sea or that they remained for some time beneath a stable water-table. They contained a fair quantity of decaying organic material.

[3] The brown color is due to the presence of the ferric hydroxide, goethite ($HFeO_2$).

Figure 9A. View of the Brown Clay at the base of the clay-cliff, Button Bay State Park. For scale, note the small ballpoint pen resting on top of ledge (left of center). A close-up view of this ledge (pen in same location) is seen in Figure 10.

Figure 9B. Close-up view showing general characteristics of the Brown Clay. Notice the vertical cracks in the clay. These cracks or joints are very common in the clays of this State Park.

In August 1849 the incomplete skeleton of a *whale*[1] was found in a railroad cut being excavated for the Rutland and Burlington Railroad. This cut was located approximately 12 miles south of Burlington and a mile east of Lake Champlain. The significant fact about this "find" is that these bones were found in the same type of blue clay that occurs at the beach in Button Bay State Park. Clam and oyster shells (Pelecypods) were found in association with the whale bones. These *pelecypod shells*[2] and the whale bones show that these animals lived and died in cold marine waters. Lake Champlain today is a fresh-water lake and the fish and other organisms in it are those of fresh, not salty water. Yet the blue clays (and we are soon to learn, the brown clays) hold evidence proving the existence of sea water in an area where a fresh-water lake is found today. Can this be explained?

The brown clay forms most of the Park's clay banks (see Figs. 9A and B). It can be examined easily by the visitor. The bank is composed of clay and variable amounts of *fine sand*[3] in thin lens-shaped bodies. The hard dry outer clay, if rain has not just fallen, of the upper 15 feet of the bank appears light brown or tan-white and commonly contains interspersed white and blue streaks. In the section of the bank which was the object of detailed study, two conspicuous *convoluted beds*[4] were found, one 5 feet above the beach, the other nearly 2 feet above the first.

Shells of *pelecypods*[5] occur at two and perhaps three levels within the bank. They can be seen easily in many slumped clay bodies along the beach (see Fig. 10, in which the shells are mainly *Macoma* and *Saxicava*). These shells once belonged to living animals whose very close relatives and identical younger generations are found living today in cold Arctic

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[1] This fossil whale is scientifically known as *Delphinapterus vermontanus* (*Thompson*).

[2] The pelecypods found are scientifically known as *Macoma groenlandica* and *Saxicava rugosa*.

[3] The size limits of sand lie between 2mm in diameter (largest) and 1/16mm in diameter (smallest). Two millimeters (mm) equals approximately 2/25 inches. Fine sand would fall between 1/4mm and 1/8mm in diameter.

[4] Convolute beds show their layers thrown into a series of folds (some quite irregular) which result from the pressing weight of overlying sediments on highly plastic layers beneath. Some feel that these folds were the result of actual flowage of the layers in the direction of their tilt, and others credit the distorted bedding to the pressing weight of large boulders. These dragged across the layers while still frozen to overriding glacial ice.

[5] The author noted both *Macoma groenlandica* and *Saxicava rugosa* (see Fig. 10 and Plate 1, Sketches 3 and 4).

Figure 10. Close-up view showing the pelecypod (clam) shells which occur within the Brown Clays. Note small Ballpoint pen for scale. These shells tell us of the marine origin for these clays. The pelecypods here are *Saxicava* and *Macoma*.

waters. Brown clays were deposited in a marine Champlain Sea. How did these marine waters get into the Champlain Valley?

Remember from the previous discussion of Lake Vermont that as the Champlain ice lobe retreated into Canada, fresh water from Lake Vermont began to seep through the ice lobe into the St. Lawrence Valley. This seepage caused a gradual lowering of the Lake Vermont water-level until the lake reached a stage lower than the marine waters of the St. Lawrence Sea. Soon the sea water began to flood Lake Vermont and true marine conditions were reached. These marine waters reached as far south as Whitehall, New York, which is located near the southern end of present-day Lake Champlain.

The maximum area covered by the Champlain Sea did not equal the greatest size attained by the fresh waters of Lake Vermont. For instance, the sea did not extend as far east as the Green Mountains except in the very northernmost region of Vermont. In the vicinity of Button Bay State Park these waters extended less than a mile east of Vergennes, and the towns of Middlebury, Hinesburg and Charlotte would have been entirely above water (see map, Fig. 7B).

It has been postulated that marine waters extended throughout the length of the Champlain Valley and into the Hudson Valley, forming a continuous strip of marine water from the Gulf of St. Lawrence to the Atlantic Ocean at the mouth of the Hudson River. If this were true, New England would have been an island only a few years ago (geologically speaking). The weight of evidence available today does not support the prior existence of this connecting ribbon of sea water. Today Lake Champlain contains fresh water again, and the marine conditions have retreated back into the Gulf of St. Lawrence. What happened to permit a return to fresh water conditions?

The lakes and lake-stages discussed are known from the presence of various shoreline features, most of which are now "high and dry." Each lake or lake-stage has its own set of lake-level features. An interesting fact emerges from a study of any one former lake. The present elevation above sea level of delimiting lake-level features is *not* the same throughout. To explain this more fully, the present elevation of those features formed when the Champlain Sea was at its maximum extent will be examined.

At Shelburne Falls the present elevation of these features is 300 feet, at St. Albans 440 feet, and at Roxton, Quebec, 552 feet. It will be noted that proceeding from south (Shelburne Falls) to north (Roxton) a difference of over 250 feet is found between features formed at an identical time in the past. The water in any lake is practically level. It therefore follows that the present 300, 440 and 552 foot elevations of the shoreline features are the result of subsequent tilting of the earth's surface. Perhaps the following reference to the water level of present Lake Champlain will help in your understanding of this tilting.

The present-day average level of the water in Lake Champlain is about 92 feet above the level of the Atlantic Ocean. This water-level elevation is constant throughout the extent of Lake Champlain and *is* *not*, say, 92 feet at Button Bay and 192 feet at Burlington. Again, the only way that features demonstrating past lake margins or levels could, for any one lake or lake-stage, now exist at different elevations would be if some earth movements took place after the formation of the features, resulting in a change from their original elevations.

The earth's crust has been tilted, higher in the north than in the south, during recent times. This tilting provides the clue to the formation of present-day Lake Champlain. Major tilting took place after the maximum marine invasion. Tilting continued, at a decreasing rate, perhaps, to the present day. This tilting, with greater relative rise in the northwest, eventually reached a point where marine waters were excluded from the Champlain Basin.

Fresh water slowly diluted the salty marine water. The lake gathered more and more fresh water through rain and melting snow, and a new outlet formed in the north, in the approximate location of the present Richelieu River. The area of Lake Champlain slowly increased to its present size, and the clays which once formed lake and sea bottom became the "hard earth" of the Champlain Lowlands. Continued tilting caused flooding of the streams, especially in the southern portion of Lake Champlain, such as the now swampy Otter Creek and its tributary Dead Creek (see map, Fig. 2). This concludes the story of the Park clays. From the rocks which crop out within a short walking distance of Button Bay State Park a much older segment of geologic history can be studied.

THE OLDER ROCKS

The rocks which underlie Button Bay State Park can be seen along the small creek which is located just south of the Park. It is suggested that the visitor walk southward (to the right if approaching the road from the lake front) along the main park road until the first culvert beneath the road is reached. Looking down the creekbed toward the lake, one can readily see the older rocks (see A, Figure 11). *Fossils*[1] are found in these tilted rocks which tilt or dip toward the northeast and "strike" northwestward. Fossils date the rocks underlying Button Bay State

[1] Fossils are the preserved evidence of past life (animal or plant) as found in rocks or sediments, for example, the clams found in the clays. They may be direct evidence, such as the actual shells or mineralogically replaced shells of long-dead animals; or indirect evidence, such as the tracks or trails of animals now preserved in rocks.

Park as Middle *Ordovician.*[1] The most abundant fossil is a trilobite, *Triarthrus*, but, even this ancient *arthropod*[2] is not easily found in these limestones and limy shales. A sketch of *Triarthrus* (that portion found fossilized) appears in Plate 1. These rocks containing *Triarthrus beckii* belong to the Stony Point formation and are of late Sherman Fall or Denmarkian age.

One of the jobs of the geologist is to reconstruct the paleogeography (ancient geography) of a region. The different kinds of rocks present and their distribution patterns, together with the types of fossil plants and animals found, tell the geologist of past lands and seas, warm and cold climates. The rocks of the Stony Point formation (the rocks which underlie most of the Park) tell of warm marine waters, a past sea, bordered by relatively low land areas. The fossils contained in the Stony Point formation attest to the presence of relatively shallow marine waters. The fact that these Ordovician rocks are tilted and broken by faults proves that *major earth movements*[3] took place sometime after their lithification.

PLATE I: EXPLANATION

1A, B, C; *Maclurites magnus* Lesueur (X 0.5). Lower, upper and side views. Crown Point limestone. GASTROPOD (snail).

2; *Triarthrus beckii* Green (X 3). Top view of central part of head region. Stony Point shale. TRILOBITE.

3; *Saxicava* (X 3). Pleistocene marine clays. PELECYPOD.

4; *Macoma* (X 3). Pleistocene marine clays. PELECYPOD.

5A, B; *Rhinidictya* (X 9 and X 1). Orwell limestone. BRYOZOAN.

6A, B, C; *Cryptolithus tesselatus* Green (X 2). Top, side and front views. Glens Falls limestone. TRILOBITE.

7; *Rafinesquina*. Internal view. Orwell and Glens Falls limestones. BRACHIOPOD.

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[1] Geologic time is divided into four Eras which are designated from oldest to youngest: Precambrian, Paleozoic, Mesozoic, and Cenozoic. Each of these Eras is divided into geologic Periods of time. The Ordovician Period is next to the oldest Period of the Paleozoic Era. This Period began some 420 million years ago, and ended approximately 360 million years ago.

[2] Present Arthropods include the insects, spiders and crabs. Arthropods, which are invertebrate animals (without backbones), are characterized by jointed legs, chitinous outer covering and segmented body parts. Trilobites were very numerous in the early Paleozoic seas, but became extinct before the end of that Era.

[3] The folding and the faulting of the Ordovician rocks took place sometime between the closing phases of the Ordovician Period and the beginning of late Silurian time (between 360 and 330 million years ago). Usually these earth movements are ascribed to the Taconic Disturbance which took place at the end of the Ordovician Period.

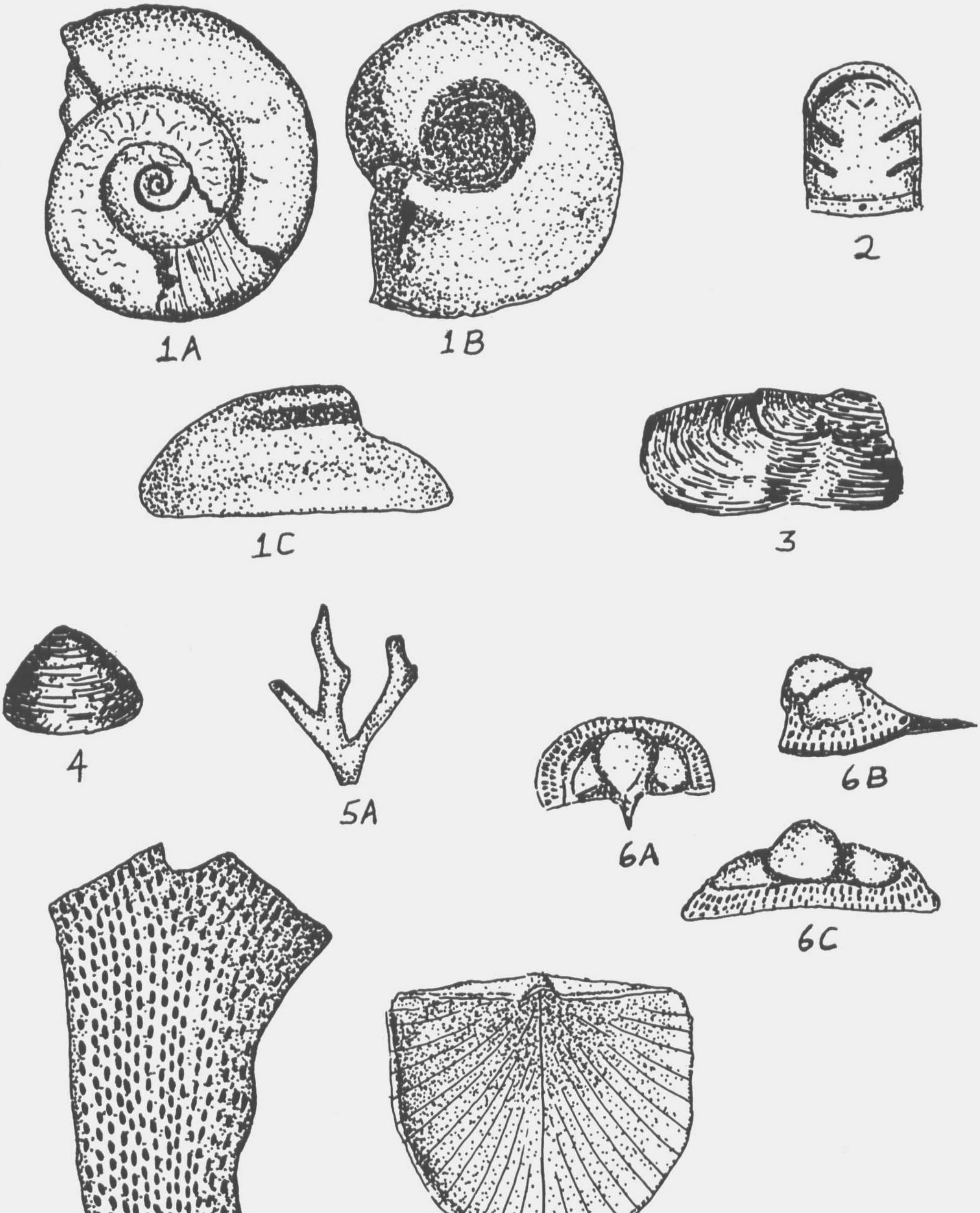
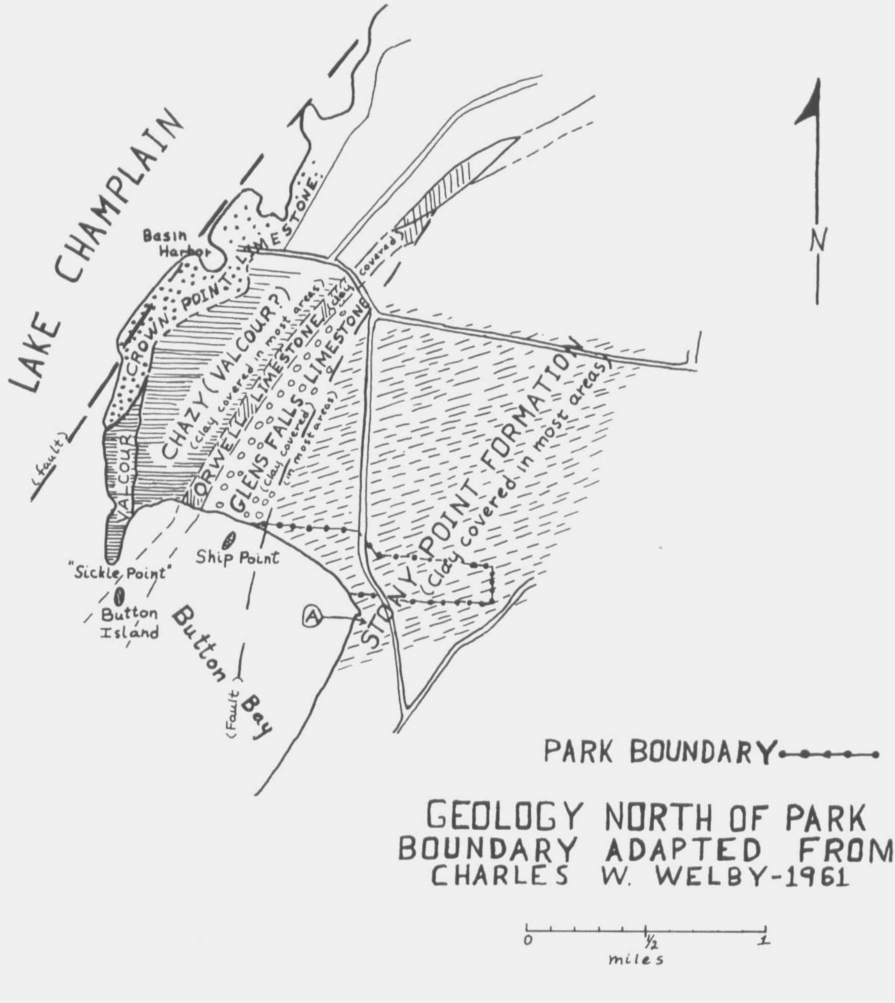


PLATE 1

GEOLOGIC MAP
OLDER ROCKS



GEOLOGY NORTH OF PARK BOUNDARY ADAPTED FROM CHARLES W. WELBY-1961

FIGURE 11

From the north boundary of the Park and along the Lake Champlain shoreline older and older Ordovician rocks are *encountered.*[1] The rocks (see geologic map, Fig. 11), primarily tilted marine limestones, display a variety of fossils, some of which are illustrated in Plate 1. Figure 12 is a view of the west side of Button Island showing an 18-inch thick reefy zone in the Orwell limestone. The reefy zone is composed largely of tumbled heads of colonial corals and stromatoporoids. A selected list of reference books and articles, some of which contain plates picturing Ordovician fossils, is found at the end of this section.

Ordovician and older rocks were lifted, folded and faulted during the Taconic Disturbance. Dramatic evidence for this period of crustal instability is seen in the Champlain Thrust, a major series of faults which can be seen east of Button Bay State Park. The evidence for such a fault system, which is more fully discussed in another pamphlet, is readily seen on Mount Philo where older Cambrian rocks have overridden (been thrust over) younger Ordovician ones.

As time passed in the Button Bay region younger and younger sediments were deposited over the top of folded and eroded Ordovician rocks. These sediments became rock and in turn slowly broke into fragments which were transported to other areas where they were deposited again as sediments. The glaciers passed over, leaving their rock debris behind as they wasted northward. Marine clays were slowly deposited from the waters of the Champlain Sea. Today only the marine clays resting on the beveled edges of Middle Ordovician rocks can be seen in the Park.

The history of the earth is open for all to read. Button Bay State Park can tell us only the history which is recorded in its clays and underlying rocks. As we have seen, there are certain giant geologic time gaps in the Park area, but many of these do not exist in other places and in other Parks. If this pamphlet has stimulated an interest in filling in

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[1] A walk along the beach in the direction of Button Island or "sickle point" (west and then south from the northern boundary of the Park) traverses the following geologic formations: the Glens Falls limestone which can be seen on Ship Point (actually an island off the northern end of the Park); the Orwell limestone, seen on Button Island; the Valcour formation which makes up "sickle point"; and the Crown Point limestone which is found on the Basin Harbor-side of "sickle point." These rock units belong to the Chazyan Stage (Crown Point limestone and Valcour formation) and the next younger Mohawkian Stage (Orwell and Glens Falls limestones) of the Middle Ordovician Champlainian Series.

Figure 12. Bedded Orwell limestone on open-lake side of Button Island, showing patches of stromatoporoids and colonial corals (white areas). Photo by C. W. Welby.

these time gaps through your study of rocks in other places, then it has fulfilled its purpose. The present interest in Space demands a good long look at the Planet Earth. Good Hunting!

SUGGESTED READING

Historical Geology, by Carl O. Dunbar, John Wiley & Sons, Inc., New York, 1960. Good general treatment of what the rocks can and do tell geologists about the history of the Earth.

Handbook of Paleontology for Beginners and Amateurs, Part 1, The Fossils, by Winifred Goldring, New York State Museum Handbook 9 (obtainable from: Paleontological Research Institution, 190 Dearborn Place, Ithaca, N. Y.).

Fossils, An Introduction to Prehistoric Life, by W. H. Matthews III, 1962, Barnes and Noble, Inc., New York. Earth history and paleontology, a general guide for the amateur collector.

Bedrock Geology of the Central Champlain Valley of Vermont, by Charles W. Welby, 1961. Vermont Geological Survey Bulletin 14. Standard work for the geology in the region of Button Bay State Park.

Paleontology of the Champlain Basin in Vermont, by C. W. Welby, Vermont Geology Series, Vermont Geological Survey. A treatise on the paleontology of the Champlain Basin designed for the amateur. In press.

Index Fossils of North America, by H. W. Shimer and R. R. Shrock, 1944, John Wiley & Sons, Inc., New York. Contains many plates depicting several of the fossils found in and adjacent to Button Bay State Park.