A BRIEF FOSSIL HISTORY OF VERMONT

Due to extensive metamorphism, erosion and glaciation, the fossil record in Vermont is limited and generally confined to the western third of the state. Although widely separated in geologic time, the fossil deposits found in Vermont tell vivid stories of three distinct periods in Vermont's geologic past.

VERMONT BACKGROUND GEOLOGY

Much of the bedrock in Vermont was originally deposited 500 million years ago as **ocean bottom sediments** in an ocean that no longer exists. We call this ancient ocean the **Iapetus** ("father of the Atlantic") **Ocean** and know it primarily by the fossils and sediments that it left behind. **Plate tectonic forces** slowly closed the Iapetus over many millions of years until it disappeared completely about 350 million years ago, leaving a high mountainous **suture zone** at the juncture of North America with northern Europe and Africa. The eroded roots of this suture zone exist today as the Appalachian Mountain chain of eastern North America.

Vermont is located directly in the middle of a northern portion of the Appalachians that runs up through Quebec and Newfoundland, and as a result of the intense heat and pressure caused by **subduction and compression**, most of the rocks here have been **metamorphosed** to some extent. This has had the unfortunate result (from a paleontological point of view) of recrystallizing most of the original materials and rendering the fossils unrecognizable.

For most of the 350 million years since this ocean closing event took place, Vermont has stood as a high mountainous alpine region, undergoing constant erosion. Mountainous regions seldom contain environments favorable for the preservation of fossils (why do we find so many fish fossils, but so few mountain goats and eagles?). For that reason we have **no record whatsoever of Mesozoic fossils in Vermont**. This is not to say that creatures such as dinosaurs didn't live and die in what is now Vermont for all those years, it only means that the fossils were not preserved or were subsequently removed by erosion. With the passing of the final glacial stage about 12,000 years ago, Vermont was reduced essentially to low rounded mountains, hills and valleys and through these fertile areas a number of **ice age mammals** such as wooly mammoths, caribou, and beaver followed the retreat of the glaciers. We have a modest fossil record of some of those animals.

From the above scenario, you can begin to see how the fossil record in Vermont consists primarily of ocean bottom sediments (from the Iapetus Ocean) protected from severe metamorphism along the Champlain Valley on the far western side of Vermont, and ice age plants and animals preserved in surface bogs and clay layers throughout the state. Let's briefly outline these fossils and see how they can be used to date the rocks and interpret our geologic history:

THE PALEOZOIC IAPETUS OCEAN

The animals that inhabited the **warm, shallow waters** of the **Iapetus Ocean** lived at a time when no plants or animals yet lived on land. **Trilobites** (such as *Olenellus* and *Isotellus*), **cephalopods and gastropods** (*Maclurites*), **bryozoans** (*Prasopora*) and **graptolites** are frequently found in the black shales and limestones along the islands of Lake Champlain that represent the ancient ocean muds. The island of **Isle la Motte** in Lake Champlain is known worldwide for its beautifully preserved fossilized reef structures. These reefs contain cephalopods, bryozoans and some of the earliest known corals and have been recognized as important scientifically because they represent an intermediate stage in the evolution of reefs. The black "marbles" of Isle la Motte have been quarried for over a hundred years and are prized for the intricate patterns that the fossils make when polished. Mineralized fluids have filled some of these fossils with beautiful crystals of calcite and quartz.

In areas that were at that time beaches, near-shore estuaries or river deltas, **trace fossils of worm borrows and mysterious animal tracks and ripple marks** are often found in the sandstones and clays. Some areas of limestone were subjected to metamorphism and have been transformed into beautiful marbles, some still retaining faint ghost-images of fossils. Because a succession of index fossils exists that allows us to identify the various ages and stages of this old ocean, we are also able to correlate one area to another in portions of the state which have been heavily folded or fractured. This is extremely useful because as any Vermont geologist knows: the rock is heavily folded and fractured just about everywhere in Vermont!

A TINY WINDOW ON VERMONT ABOUT 25 MILLION YEARS AGO

A small and unusual deposit of lignite (crude coal) is found embedded in kaolinite near Forestdale,Vermont. Known as the "**Brandon lignite**", this isolated deposit contains the **seeds, twigs and leaves of subtropical trees and plants** and provides a rare glimpse at a time when the climate of Vermont was much different than it is now. The Brandon lignite is the only known "window" on the fossil record in Vermont during that hugh span from 350 million to 12,000 years ago that is otherwise unaccounted for, and is the finest deposit of Oligocene plant megafossils found in the northeastern United States. The fossil collection of the Perkins Museum at the University of Vermont has a large collection of Brandon lignite fossils.

THE POST-GLACIAL FOSSILS OF VERMONT

Like many regions of the northern United States, Vermont was heavily glaciated during the ice age and at one point sat beneath almost a mile of ice. The effect of the weight of all of this ice was to compress the land and depress it below sea level. When the ice melted and retreated, waters from the North Atlantic flooded the St. Lawrence and Champlain Valleys and created an inland sea known as the "**Champlain Sea**" which persisted for 2500 years. Into this sea came a variety of sea animals including **salmon, seals and the ancestors of beluga whales**. (One of the most prized fossils in our museum is the complete skeleton of a beluga whale found in Vermont...more on that story in just a bit) **Caribou, weasels, rabbits, elk and mammoth** moved through the opening lands, followed closely behind by the **first Native Americans**. Occasionally some of these animals became mired down and trapped in the many bogs and half-frozen swamps that covered the land. Their fossils are still unearthed by farmers, hikers and road crews.

THE CHARLOTTE WHALE

In 1849, while digging the first railroad in Vermont, workmen unearthed the strange bones of an animal which they had never before seen. Thinking it to be a strange horse, they continued to dig and damaged much of the skull before a scientist from the University could be contacted and brought to the scene. The scientist, Zadock Thompson, immediately knew that the workmen had found something unusual and proceeded to carefully collect all the bone fragments and take them back to his lab. Upon reconstructing the skeleton and showing it to other paleontologists in New York and Paris, Thompson realized that it was the fossil of a small white or "**beluga" whale** (*Delphinapterus leucas*).

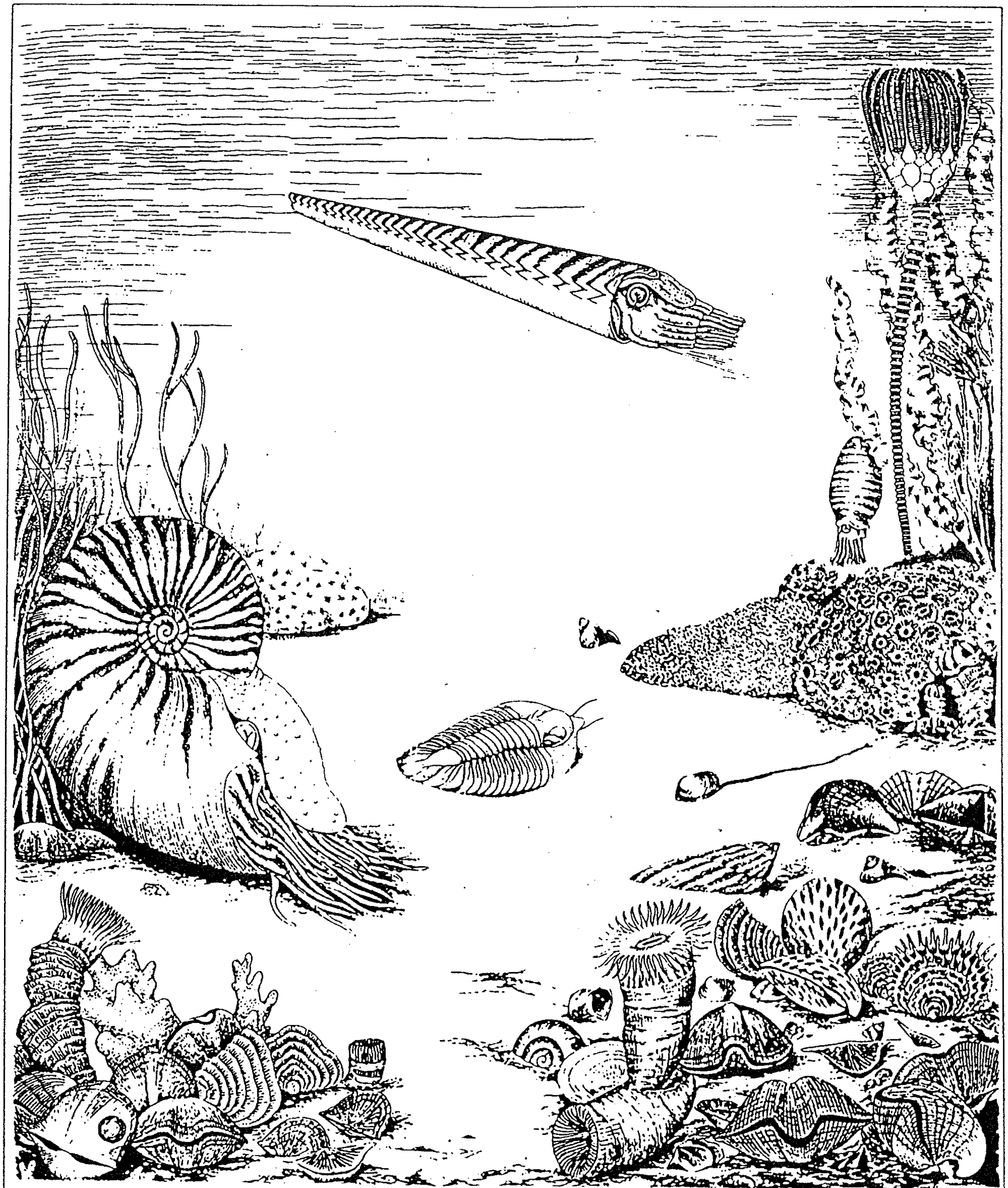
The question immediately became: "how do you get the skeleton of a whale buried in 10 feet of sand and clay in Vermont, hundreds of miles from the nearest Ocean?" This very interesting early use of **index fossils** allowed the early geologists to realize that areas of Vermont were once covered with marine waters and began their search for a reason for those waters. The whale was found along with fossils of **specific types of small bivalve clams** (Mya, Macoma) found only in marine waters, and as geologist began to find these same clams in other regions of the state they could begin to trace the outline of the Champlain Sea.

MODERN RESEARCH

Much of the paleontological research that takes place in Vermont today utilizes ***microfossils*** from the muds and clays of the Champlain Basin. Researchers first obtain core samples of the sediments they plan to study. They then dry and sift these sediments to remove the unwanted portions. Powerful microscopes are then utilized to sort and identify the tiny shells of one-celled protozoans known as **foraminiferans** ("forams"). Since these tiny animals were wide-spread and numerous, evolved quickly in time and are easily identified, they serve as valuable indicators of the delicate changes that took place in the climate during the 2500 year life of the Champlain Sea. These forams are valuable tools in allowing us to "fine-tune" our knowledge of the recent history of our area.

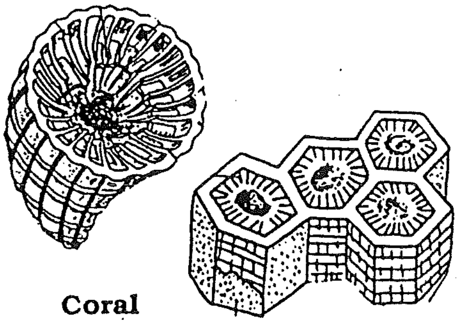
Jeff Howe
Perkins Museum of Geology
March, 1993

Fossils of the Lake Champlain Region



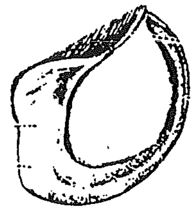
These animals lived here over 400 million years ago, when the area that is now the Lake Champlain Basin was part of a shallow tropical sea. The fossils were formed when shells, other hard parts of plants and animals or traces of the organisms, such as worm borings or animal tracks, were buried in limey mud. Over time, this mud cemented into limestone and shale.

Fossils of the Lake Champlain Region

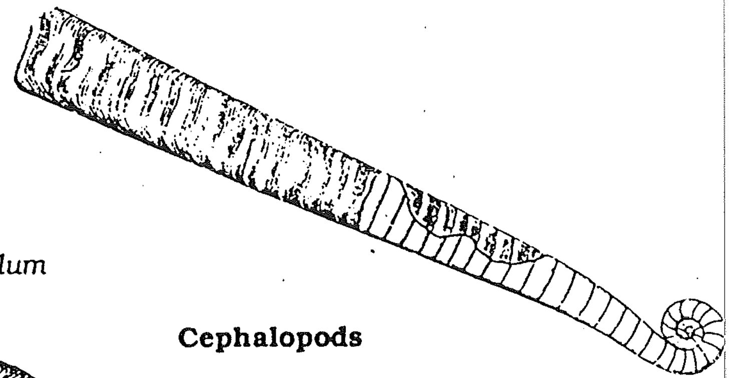


Coral

Corals are tiny flower-like animals that live in colonies. They are soft-bodied but secrete hard outer skeletons that form coral reefs. The fossils found in Vermont represent the first known species of coral.

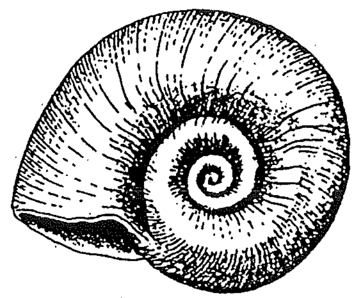


operculum



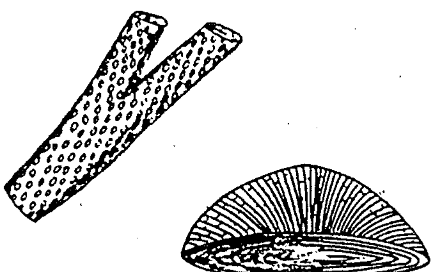
Cephalopods

Cephalopods are related to gastropods. Cephalopods lack feet and their shells are chambered. The cephalopods fossilized here are related to the chambered nautilus of today.



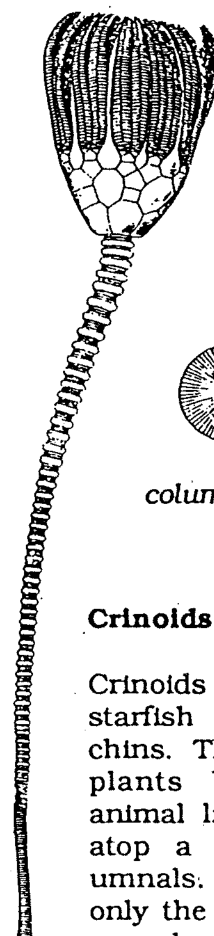
Gastropods

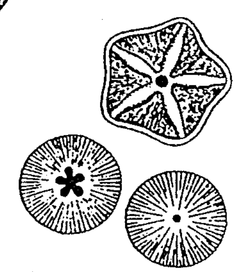
Gastropods or snails can be found in almost any habitat. All snails have a well-defined head with eyes and tentacles, a main body that houses the internal organs, and a foot. Many of the snail fossils of Lake Champlain are large. Sometimes all that remains is the operculum, a hard covering that protects the foot of the snail.



Bryozoans

Bryozoans are commonly called moss animals because of their appearance. Like coral, they are tiny soft-bodied animals that live in colonies. Each animal lives in its own chamber, giving the colony a honeycomb appearance. The most common bryozoan fossils here resemble twigs and gum drops.

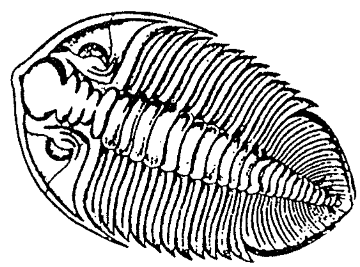




columnals

Crinoids

Crinoids are related to starfish and sea urchins. They look like plants because the animal lives in a cup atop a stalk of columnals. Most often, only the fossilized columnals are found.



Trilobites

Trilobites, ancient lobster-like creatures, are true representatives of their time. They first appeared about 520 million years ago, reached their height about 440 million years ago, and were extinct 400 million years ago. Like lobsters and crabs, they shed their shell to grow, leaving behind many fragments to fossilize.

Brachiopods

Brachiopods are one of the easiest fossils to find. A brachiopod shell looks like a clamshell, but has a distinct ridge running down the center. There are brachiopods living today.

Please Note:
Fossil collecting is not permitted on state lands.

THE CHARLOTTE WHALE

A 12,500 - 10.000 YEAR-OLD POST-GLACIAL ANCESTOR OF MODERN WHITE (BELUGA) WHALES, FOUND IN CHARLOTTE, VERMONT IN 1849

HISTORICAL BACKGROUND

In 1849, while constructing the first railroad between Rutland and Vermont, workman uncovered the bones of a strange animal in a swampy area northwest of Mt. Philo in Charlotte, Vermont. First thinking the bones to be that of some type of horse, the workman continued to dig, significantly shattering much of the skull and carrying pieces away with the removed dirt. It wasn't until a local resident, John G. Thorp, happened upon the site and recognizing the bones to be those of an animal unfamiliar to 19th Century Vermont, convinced the foreman to discontinue digging.

While the workman continued their excavation at a different location, Zadock Thompson was called in from the University of Vermont to investigate the site. Thompson was well known locally as a man of science, and as the author of "Thompson's Vermont", a chronicle of Vermont natural history. Thompson made two trips to the site, laboriously removing the bones from the dense blue-grey clay in which it was imbedded and carefully collecting bone fragments from the piles of discarded dirt. He then took them back to his laboratory and reconstructed the skeleton, using a knowledge of comparative anatomy gained from preparing and mounting the skeletons of many animals from the Champlain Basin. After consulting Georges Cuvier's classic 1825 work on fossil bones and seeking the advice of Harvard Professor Louis Agassiz, Thompson decided the specimen closely resembled that of a modern white whale and proposed the provisional name *Delphinus vermontanus* until the exact relationship could be determined.(1)

The skeleton that Thompson pieced together can still be seen just inside the main entrance to the Perkins Museum of Geology in Perkins Hall on the campus of the University of Vermont (UVM). Still housed in the oak and glass case built for it before the turn of the century, Thompson's original wires, labels and reconstructions of wood and burlap are visible. The careful observer will also note that Thompson's reconstruction is not completely correct. For example his placement of the front scapula (shoulder blade) and the arrangement of some of the ribs and vertebra are somewhat in error. However, since the skeleton is considered to be a more important historical specimen than an anatomical one, no further reconstructions are planned. For now, Thompson's initial effort will stand.

Unfortunately, because Thompson immersed the bones in an "animal glue" to strengthen them and preserve them from desiccation after removing them from the clay, it is not possible to establish the age of the specimen through Carbon^{14} dating. Presently, we are only able to say with any certainty, that the whale lived at some point during the 2500 year span of the Champlain Sea. Other means are being sought to establish a more precise age.

GEOLOGIC BACKGROUND

For many hundreds of thousands of years, New England was covered by a succession of huge glacial ice sheets that advanced and retreated over the land, grinding the surface and leaving behind deep deposits of sand, silt and gravel. Some of these ice sheets were in excess of a mile in thickness and the weight of this enormous mass depressed the surface of the land in much the same way that a floating log floats lower in the water when a turtle climbs upon it. Approximately 12,500 years ago, the last of these glacial sheets retreated far enough north to allow the waters of the Atlantic Ocean to flood into the Champlain Basin, which was now depressed below sea level, inundating it with marine waters. For 2500 years following that, this region existed as an arm of the Atlantic Ocean known as the Champlain Sea. Into this sea moved a variety of marine animals including mollusks, sea urchins, squid, herring and cod. and following them came a number of mobile predators including salmon, seals and white whales.

Careful analysis of sediments deposited in the Champlain Sea indicates that by 10,000 years ago, the land in the Champlain Valley had rebounded sufficiently (like the log floating higher in the water once the turtle finally jumps off) to raise it above sea level and to allow the brackish water of the basin to slowly be replaced by fresh water from the local rivers and streams. It was at this time that the present Lake Champlain was born. Evidence of this glacial rebound can be seen in the fact that the mean level of Lake Champlain is now 95 feet above sea level and the Charlotte whale was found another 60 feet above the level of the lake.

WHITE WHALES

The White Whale (*Delphinapterus leucas*) is known by a variety of names including "beluga", "white porpoise", "white squidhound" and "sea canary". It is a toothed whale recognized by its brilliant white to grey-white color, prominent forehead knob or "melon", and lack of a dorsal fin. It is distributed in the coastal waters of polar/boreal areas, and frequents a number of habitats from open arctic waters, to the calving edges of glaciers, to the brackish waters of estuaries and river mouths. As a frequent inhabitant of estuaries and rivers, white whales are clearly more tolerant of fresh water than other whales. The present population of white whales numbers between 40,000 to 50,000 animals including a small and rapidly declining population of approximately 500 in the Gulf of the St. Lawrence (Evans, 1987).

The remains of seventeen fossil white whales found in Pleistocene clay and sand deposits in eastern Ontario, Quebec and Vermont indicate an extensive distribution in the Champlain Sea approximately 11,000 years ago (Stewart, 1989). The Charlotte whale contains the most complete post-cranial remains of the Champlain specimens yet found, and although found almost 150 years ago, the circumstances surrounding its discovery are well documented and of continuing value (Thompson, 1850, 1853; Perkins, 1908).

PRESENT UNDERSTANDING OF THE CHARLOTTE WHALE

During the summer and fall of 1992, a group of researchers from the Geology Department at the University of Vermont[2] combed old maps, records and articles in an effort to locate the original site of the Charlotte whale. Even though the original distances recorded by Zadock Thompson (Thompson, 1853) proved to be in error, a locality was settled upon that was estimated to be accurate to within 50'-100', and was representative of the local environment. The designated site was near the base of the western side of a small sandy hill (approximately 50' - 60' tall) that occupied the south end of a long, low, north-south trending ridge. The land opens out westward from this point into low rolling fields for approximately 1/2 mile, rising again to another lower north-south ridge. Exposed bedrock on this second ridge is a dense siliceous limestone, dipping gently to the east. From there the land drops steadily for another 1 1/2 miles towards Barton's Bay of Lake Champlain.

The whale was reported by Thompson (1850, 53) to be found 8' - 10' below the surface of the land in a layer of sticky blue-grey clay that underlies much of the region. Thompson also reported finding bits of plant material along with the specimen and interpreted this to indicate a "quagmire" or "salt marsh". Hand auger cores taken from the site in November of 1992 also found remains of carbonaceous materials although these materials have not yet been identified. Although subjected to surface erosion over the last 10,000 years, the lay of the land indicates that the whale site was potentially a shallow near-shore estuary at the edge of a small island or underwater ridge.

Shell fossils such as *Mya arenaria, Saxicava rugosa, Mytilus edulis, Sanguinolaria fusca* and *Nucula sp.* were found in association with the skeleton (Perkins, 1908) and can also be found in many areas throughout the Champlain Basin, indicating shallow marine environments. Using these shell fossils, marine beaches have been interpreted to exist as high in elevation as the base of Mt. Philo and as low as 20' above the present Lake Champlain beach. Fragments of these shell fossils were also pulled up in the recent coring efforts.

Because of these varying shore levels, and because there is presently no way to precisely date the whale within the 2500 year interval of the Champlain Sea, it is not possible to determine exactly how deep the water was at the whale site at the time of the whale's death and therefore the exact nature of its environment. Thompson's interpretation of a salt marsh is problematical because of the presence of the fine blue clay, generally an indicator of a deeper environment. These clays could however, be redeposited upland sediments from an earlier, deeper fresh water glacial lake known as Lake Vermont, quite possibly traveling no farther than the small hill to the immediate east of the site.

There is no evidence at the whale site of beach sediments and so the popular conception that this whale "beached" itself is unfounded. What is most likely is that the Charlotte whale died in shallow water in a marshy area near shore where it was not subject to predators and was slowly covered by fine sediment. There have been no observed teeth marks on the bones to indicate scavengers and the bones were found in perfect alignment indicating that they were not scattered following death. Although the sex of the specimen is not known, generally only females and their young come into shallow near-shore areas, with the rest of the herd remaining in open waters. Consequently, there is a high probability that this fully grown adult is a female of the species.

Little is actually known about the vertebrate populations of the post-glacial Champlain Sea. The bulk of our knowledge comes from isolated fossils preserved in concretions and occasional bone fragments that show up in the Champlain muds and clays. Only rarely is a fossil of the quality of the Charlotte whale discovered. Current work on the sediments of the Champlain Sea by researchers at the University of Vermont and elsewhere is providing us with a the means to more accurately chart the minor changes in climate and water characteristics over the years and to date these events more precisely. With advancing technologies, the Charlotte whale and others like it will continue to yield new insights into ancient environments to workers in the future.

Does the finding of one whale skeleton in a field in Charlotte, almost by accident, mean that others could potentially be found in the area? The answer to this is most certainly "yes". However, because our excavation mechanisms have become so modernized, we now dig up the ground at an unprecedented rate and no longer look as carefully as we once did. Once the ground has been disturbed, it provides little use to investigative science. Who knows how many other important fossil specimens have and will be destroyed in the process?

(1) There is presently insufficient evidence to indicate that the Charlotte whale has experienced sufficient genetic isolation from modern populations to warrent its designation as a distinct species or subspecies. The present designation stands as "*Delphinapterus leucas*", or that of a white whale.

(2) J. Howe, S. Bechtel, M.A. Schlegel, R. Tritheart, S. Wright)

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1/93

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9/03/92

TAKE OUR WEB GEOLOGICAL TIME MACHINE

We have a text-only version of this page.

Introduction to Geology | **Navigating our Geology Wing**

(mya = million years ago)

Phanerozoic Eon (544 mya to present)	Cenozoic Era (65 mya to today)	Quaternary (1.8 mya to today) Holocene (11,000 years to today) Pleistocene (1.8 mya to 11,000 yrs) Tertiary (65 to 1.8 mya) Pliocene (5 to 1.8 mya) Miocene (23 to 5 mya) Oligocene (38 to 23 mya) Eocene (54 to 38 mya) Paleocene (65 to 54 mya)
	Mesozoic Era (245 to 65 mya)	Cretaceous (146 to 65 mya) Jurassic (208 to 146 mya) Triassic (245 to 208 mya)
	Paleozoic Era (544 to 245 mya)	Permian (286 to 245 mya) Carboniferous (360 to 286 mya) Pennsylvanian (325 to 286 mya) Mississippian (360 to 325 mya) Devonian (410 to 360 mya) Silurian (440 to 410 mya) Ordovician (505 to 440 mya) Cambrian (544 to 505 mya) Tommotian (530 to 527 mya)
Precambrian Time (4,500 to 544 mya)	Proterozoic Era (2500 to 544 mya)	Neoproterozoic (900 to 544 mya) Vendian (650 to 544 mya) Mesoproterozoic (1600 to 900 mya) Paleoproterozoic (2500 to 1600 mya)
	Archaean (3800 to 2500 mya)	
	Hadean (4500 to 3800 mya)	

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