BERMUDA ZOOLOGICAL SOCIETY

*"to inspire appreciation and care of island environments"*

**Eco File - Information document**

# The Geology of Bermuda

*Information reproduced from*
*Lecture written by Robert Chandler, BZS Volunteer*
*for the Bermuda Natural History Course - September 2000*

## Plate Tectonics

Some12 to 20 billion years ago from a 'singularity' occurred the big bang where all matter, space and time were created. The simplest element, hydrogen formed huge gas clouds within which clusters of gas formed stars. Millions of stars formed a galaxy. Our sun is one of the stars of the Milky Way galaxy. Around our sun are the planets of the solar system which are thought to have formed about 4.5 billion to 6 billion years ago. The planets have cooled considerably although Jupiter and Saturn are still mostly gas. As the earth cooled a crust formed and gases remained above it. The crust broke up and water condensed from the primeaval atmosphere to fill up between the cracks. The crust we now call 'continents', the water 'oceans', and the surrounding gases 'air'.

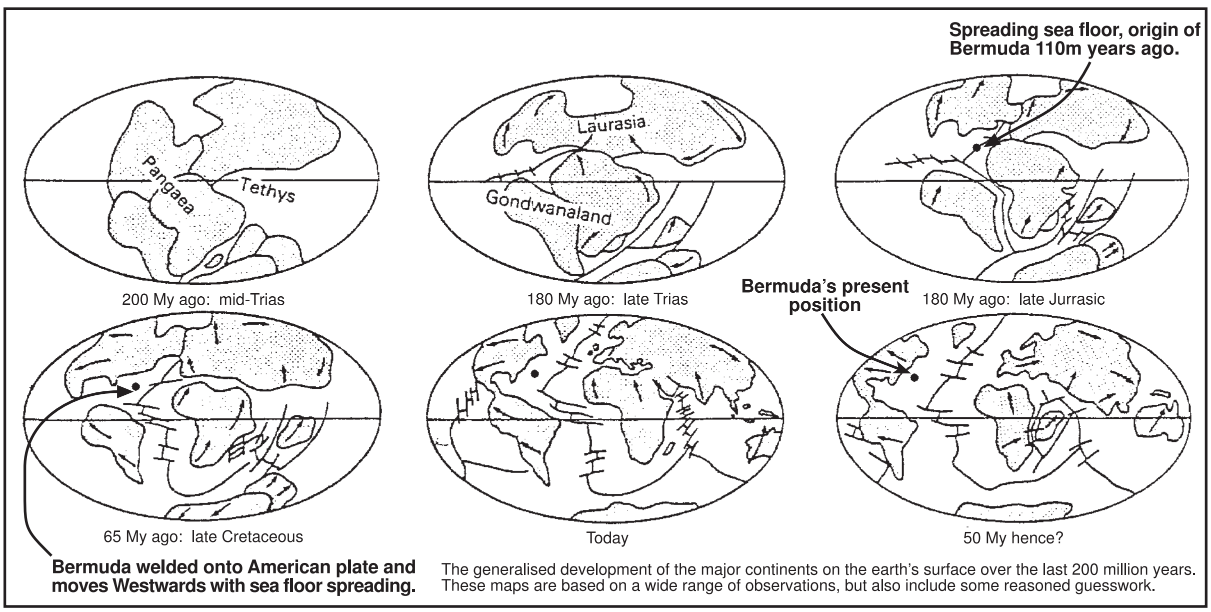
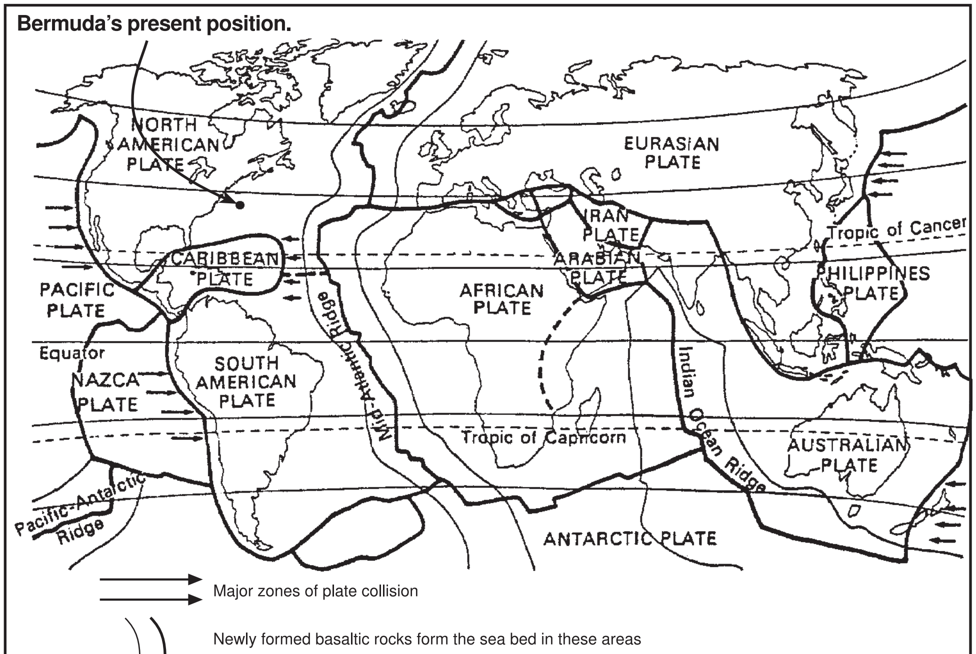



**Diagram 1**

The crustal rocks are not ridgid but are broken into 'plates' which float and move over the denser mantle. About 180 million years ago the super continent Pangea broke up into two giant plates:

(1) Laurasia - comprising North America, Europe and Asia.
(2) Gondwanaland - comprising South America, Africa, India, Australia and Antarctica.

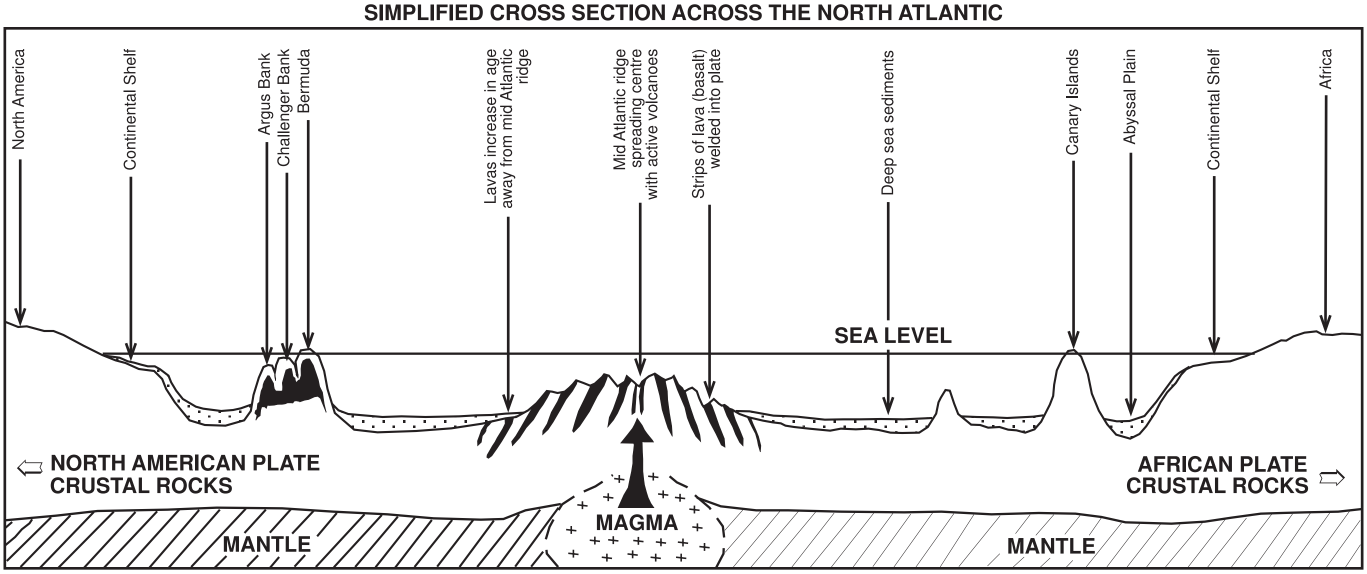



*The Earth's Crust is composed of Plates.*

**Diagram 2**

Bermuda was formed as a group of volcanoes (four?) on the Mid Atlantic Ridge about 110 million years ago. As sea floor spreading occurred Bermuda was welded onto the American plate andc carried along with it westwards away from the Mid Atlantic Ridge. Once it was removed from its magma source volcanic activity died out although it was renewed briefly 30-40 million years ago as the extinct volcanoes passed over a 'hot spot'. (See diagram 3).

**SIMPLIFIED CROSS SECTION ACROSS THE NORTH ATLANTIC**




**CROSS SECTION SHOWING THE MIGRATION WESTWARDS OF BERMUDA FROM MID ATLNTIC RIDGE**

**Diagram 3**

Map showing the location of Bermuda to Atlantic tectonic data. the numbers refer to ages from deep sea drilling project. The new trend lines are fracture zones. Filled circles are earthquake epicentres on the present spreading axis of the north atlantic ridge.

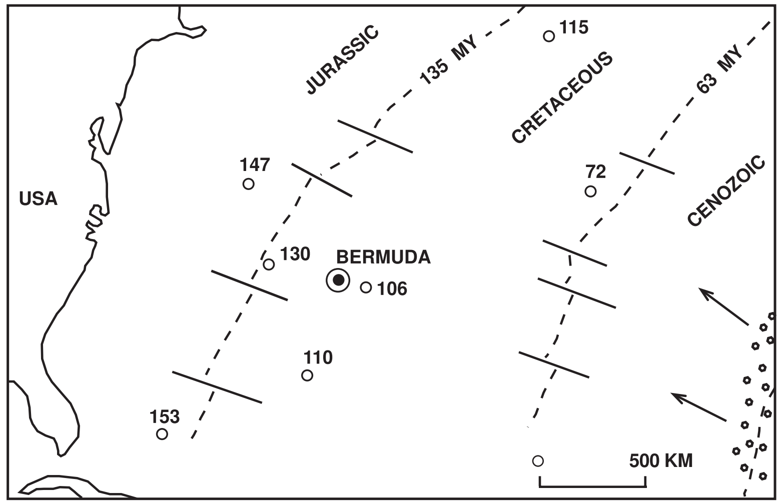



Diagram 4

THE BERMUDA SEAMOUNT

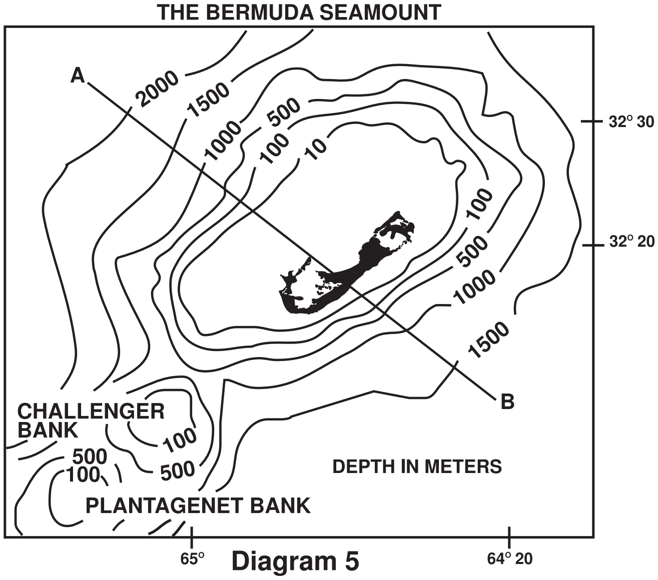



Diagram 5

CROSS SECTION ON A–B

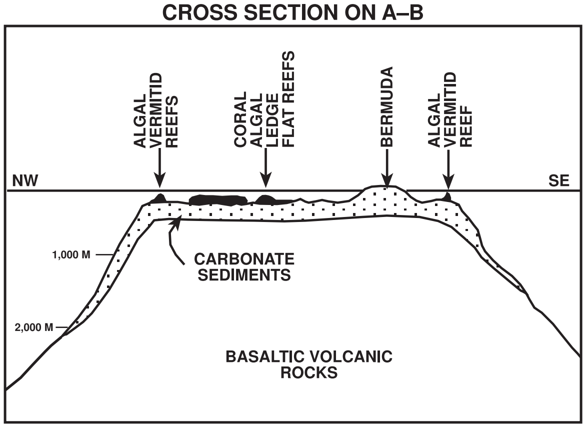



Diagram 6

Bermuda occurs on the south eastern margin of a flat, barely submerged seamount. The volcanic pinnacle rises some 4,000 meters from the sea floor. It is overlain with a thin veneer of carbonate deposits (average depth 75m to the volcanic basalt below). Volcanics lie 35m deep at Castle Harbout and 115m in the western parishes.

## Sediments

Once the volcanoes reached sea level erosion by the sea occurred and they were planed off to form a fairly level platform (diagram 6). Bermuda was within the tropics at this time and corals began to grow in the shallow waters to form fringing reefs around the platform. Reef corals and reef organisms died and were broken up to form sediments which accumulated to great depth and were compressed to form marine limestones which completely covered the volcanic basalt lava flows. Apart from dripstone deposits in caves and the calcareous crusts beneath soils, Bermuda's surface rocks are biologically produced.

### Sources of sediments today and in the past

1. Algae - coraline red, calcareous green
2. Foraminifera - especially homotrema
   - adds pink particles to beach and sediments.
3. Corals
4. Mollusks
5. Sea urchins
6. Serpulid worms - secretes a tube in which it lives.
7. Since these organisms and their secretions break up with erosion, ingestion by other organisms and time, the fragmented bits can be called bioclastic sand.

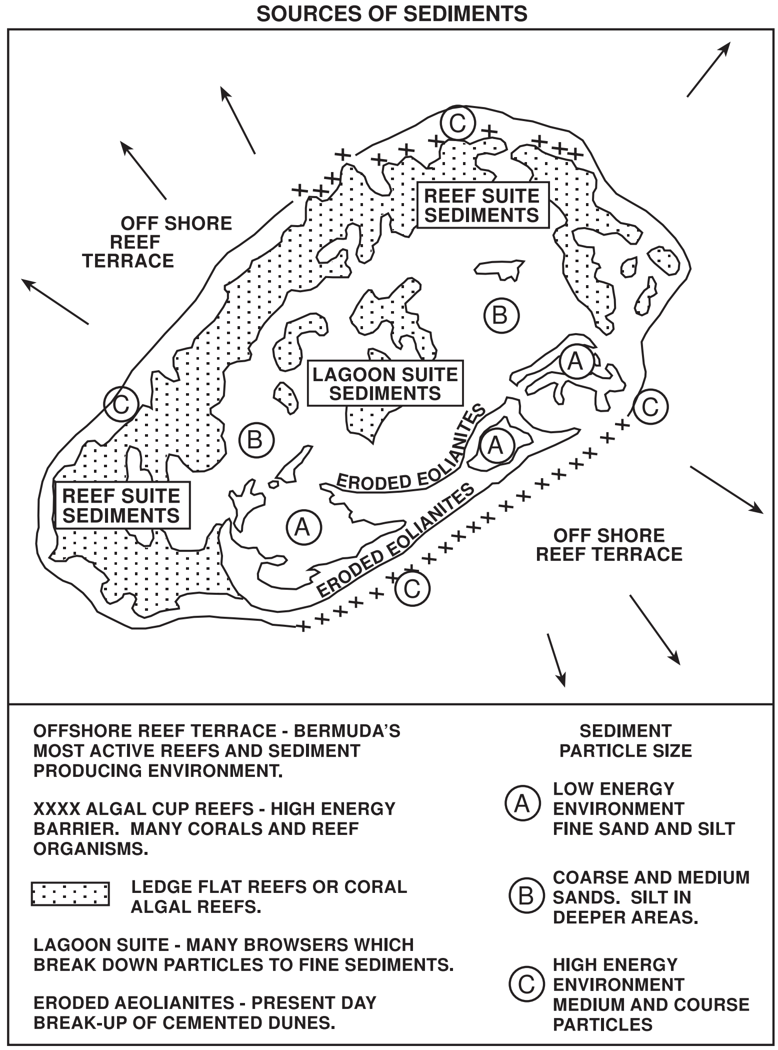



**Diagram 7**

Note: The Bermuda Platform consists of a central lagoon 8-18m deep with a peripheral rim of reefs and shoals. Outside the rim is the main reef terrace. within the rim are numerous patch reefs. Bermuda is a pseudo-atoll, major differences are high hills of the islands, mostly submerged reefs of the rim and a wide reef front-terrace.

<u>The Great Ice Age</u> During the pleistocene period which began about 2 million years ago the climates of the world changed. Over the past million years or so there have been between 5 and 7 advances of ice from the polar caps when sea level fell, and 4 or 5 interglacial periods when climates were warmer and sea level has risen (often higher than its present position). Bermuda was not glaciated but was affected by (i) falling sea levels; (ii) rising sea levels.

FALLING SEA LEVEL (COLDER CLIMATES)

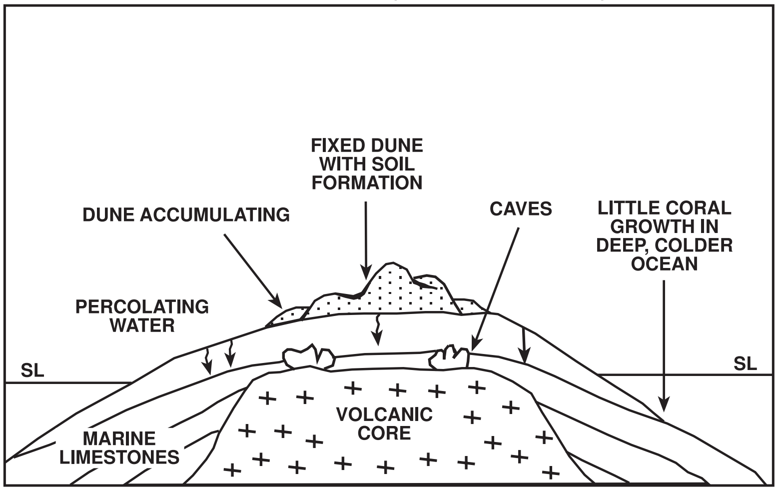



Diagram 8

**Falling sea level (colder climates)**

Exposure of the Bermuda platform as sea level fell meant much of the sediment was exposed. This was quickly blown up into large dunes. They were cemented by rainfall (diagram 14) to become aeolian lime stones, but additional dunes were steadily formed to the seaward side of the old. On the weathered, stabilized dunes red soils developed. Acidic rainfall percolating through the porous dunes and porous marine limestones formed caves with many speleotherms. Coral growth during these cold periods - remember there were at least five - was retarded.

RISING SEA LEVEL (WARMER CLIMATES)

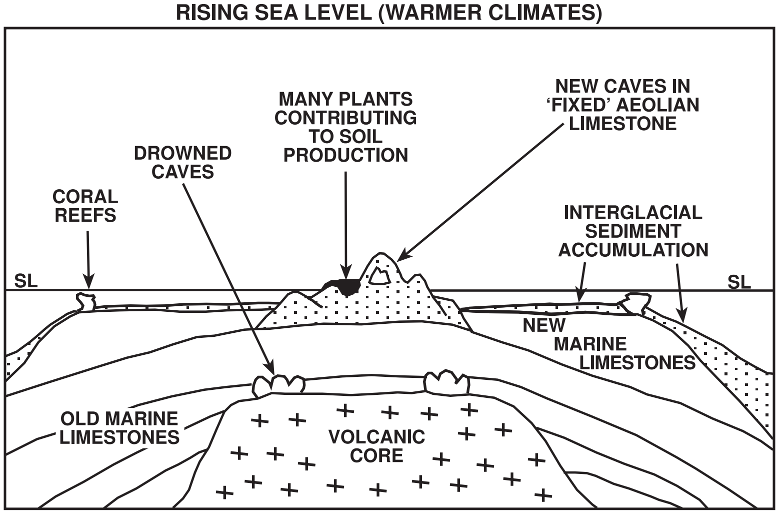



Diagram 9

**Rising sea level (warmer climates)**

With warmer climates and the associated rise in sea level the platform was drowned. Dune building still occurred but not on the same scale as during glacial periods. (perhaps similarly to dune building present on some south shore beaches today.) Many sediment-producing organisms thrived and marine limestones were deposited again. Lush vegitation, especially palmetto and cedar added depth to the soils. Existing caves were drowned but newer ones formed in the harder, cemented aeolian limestones of the former dunes.

SECOND FALL IN SEA LEVEL

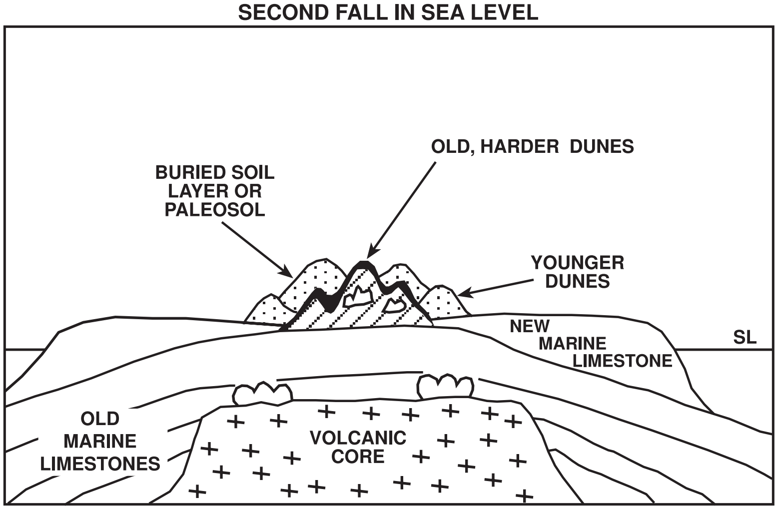



Diagram 10

Note: each glacial period produced new dunes which accreted themselves laterally (i.e., to the seaward margin of the earlier more solidified ones). they often built quickly and plants and soil layers were buried and preserved. Many fossil palmetto trunks and imprints can be found in Bermuda's older aeolianite. Buried soil layers are called paleosols. There are two types; (i) well-developed, deep red representing interglacial accumulation; (ii) poorly developed, pale colour, not deep probably representing a brief interruption in the glacial cycle. Remember, these stages were repeated several times.

THE FORMATION OF ACCRETIONARY SAND DUNES

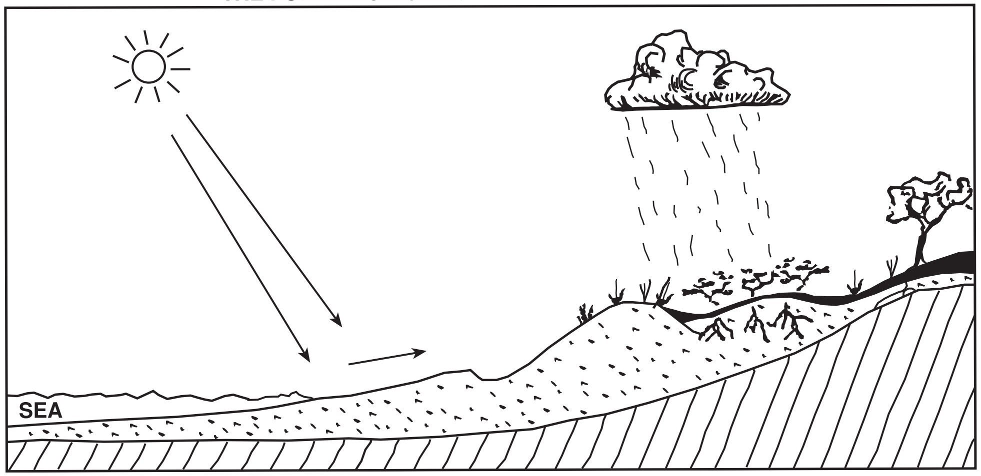



Diagram 11

Add the following labels or numbers:

1. Waves wash sand onto the beach.
2. Sun dries the sand.
3. Wind blows up the beach.
4. Sand dunes formed by wind-blown sand.
5. Plants and roots fix dunes.
6. Rain falls onto sand. It is weak carbonic acid.
7. Chemical reaction. Percolating rain makes each particle of sand sticky when water evaporates there is a fragile cement holding the grains together at contact points.
8. Aeolian limestone. Process (6) and (7) repeated many times eventually producing a hard rock.

CROSS SECTION OF DUNE

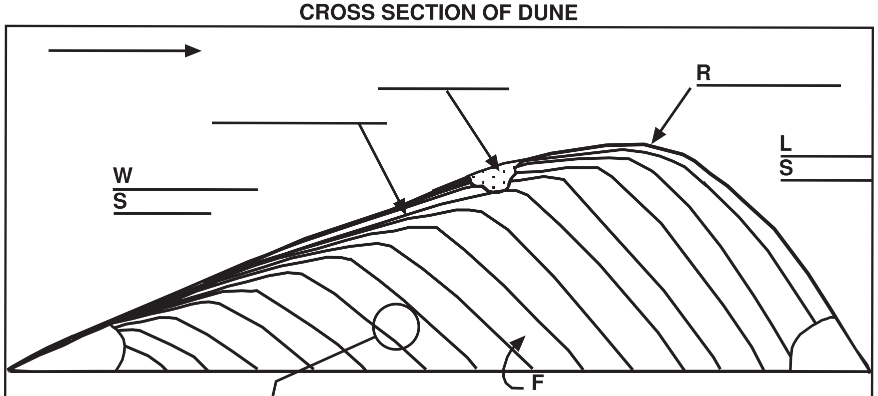



Diagram 12

FALSE BEDDING PLANES

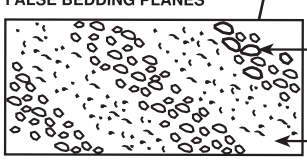


Diagram 13

COARSE PARTICLES BLOWN BY ________________ WINDS (GENTLE/STRONG) AND CEMENTED ONLY BY CONTACT POINTS LEAVING LARGE PORES, ∴ EASILY ERODED.

FINER PARTICLES BLOWN BY ________________ WINDS (GENTLE/STRONG) STRONGLY CEMENTED, SMALL PORES RESISTANT TO EROSION.

Add the following labels or numbers:

1. Windward and leeward slope.
2. Onshore winds.
3. Topset/beds.
4. Foreset/beds.
5. Rollover.
6. Blowout (in storms vegetation may get ripped out. The pocket sides are stable with adjacent roots. the pocket quickly fills - an irregularity often seen in rocks).
7. The typical windward angle, 12-15$^o$ and leeward angle, 25-300$^o$.

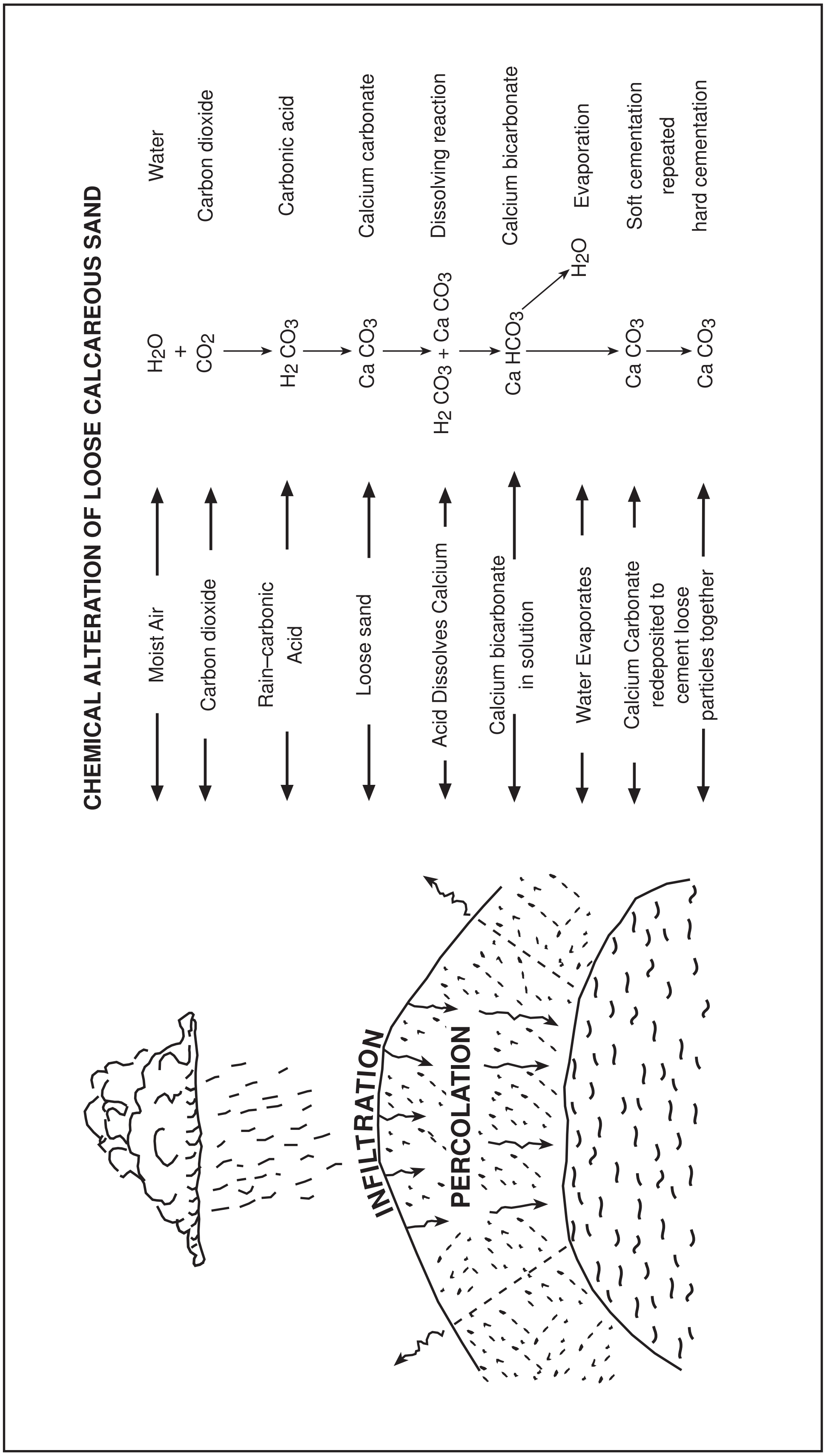

CHEMICAL ALTERATION OF LOOSE CALCAREOUS SAND
INFILTRATION
PERCOLATION
Moist Air
Carbon dioxide
Rain–carbonic Acid
Loose sand
Acid Dissolves Calcium
Calcium bicarbonate in solution
Water Evaporates
Calcium Carbonate redeposited to cement loose particles together
$H_2O$ + $CO_2$ → $H_2CO_3$ → $CaCO_3$ → $H_2CO_3 + CaCO_3$ → $CaHCO_3$ → $H_2O$
$CaHCO_3$ → $CaCO_3$ → $CaCO_3$
Water
Carbon dioxide
Carbonic acid
Calcium carbonate
Dissolving reaction
Calcium bicarbonate
Evaporation
Soft cementation
repeated
hard cementation

**Diagram 14**

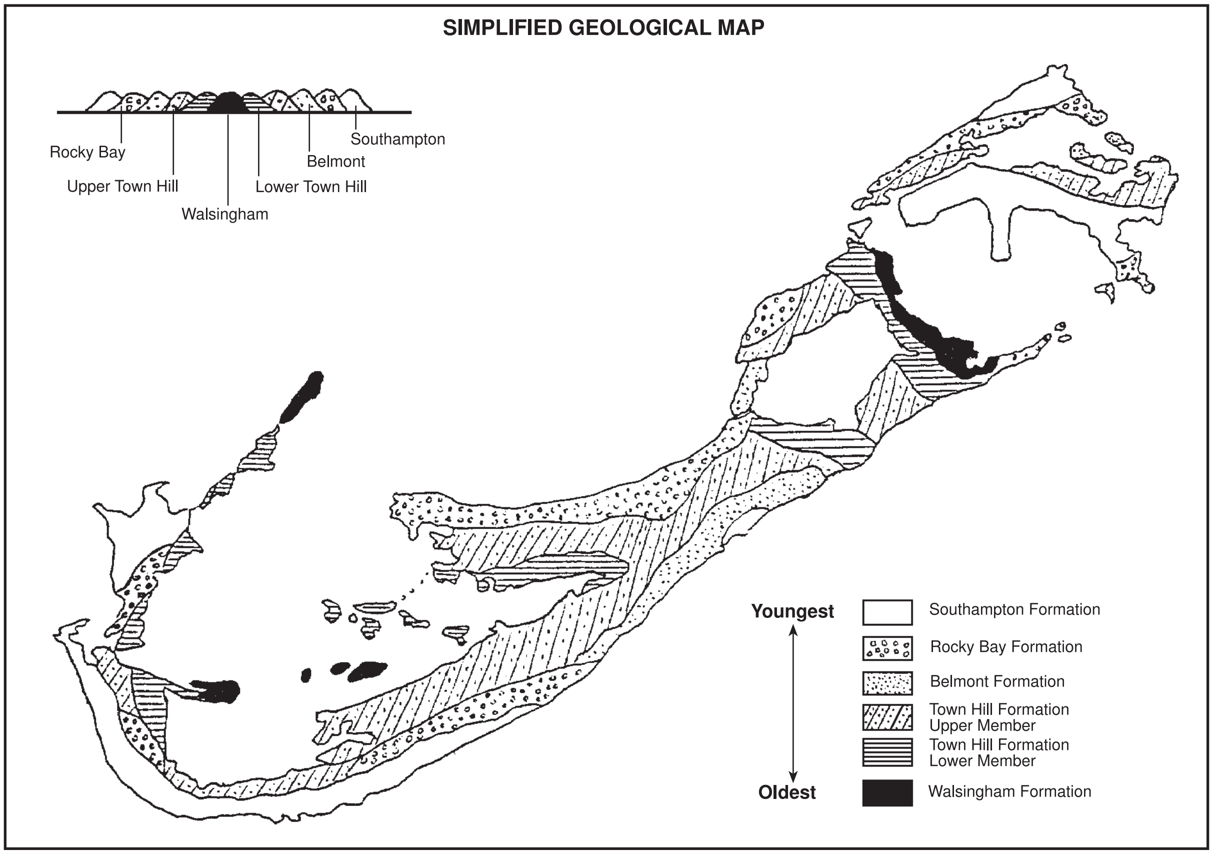
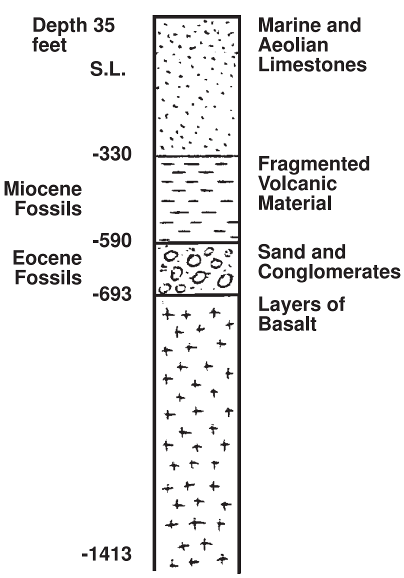



**Diagram 15**

**A vertical cross section of rock types with increasing age with depth is called a geologic column**

**A SIMPLE COLUMN FOR BERMUDA**




**Core Drilled at Gibbs Hill Lighthouse in 1912**

**Diagram 16**

**A SUGGESTED CORRELATION OF THE BERMUDA COLUMN WITH GLACIAL AND INTERGLACIAL EPOCHS**

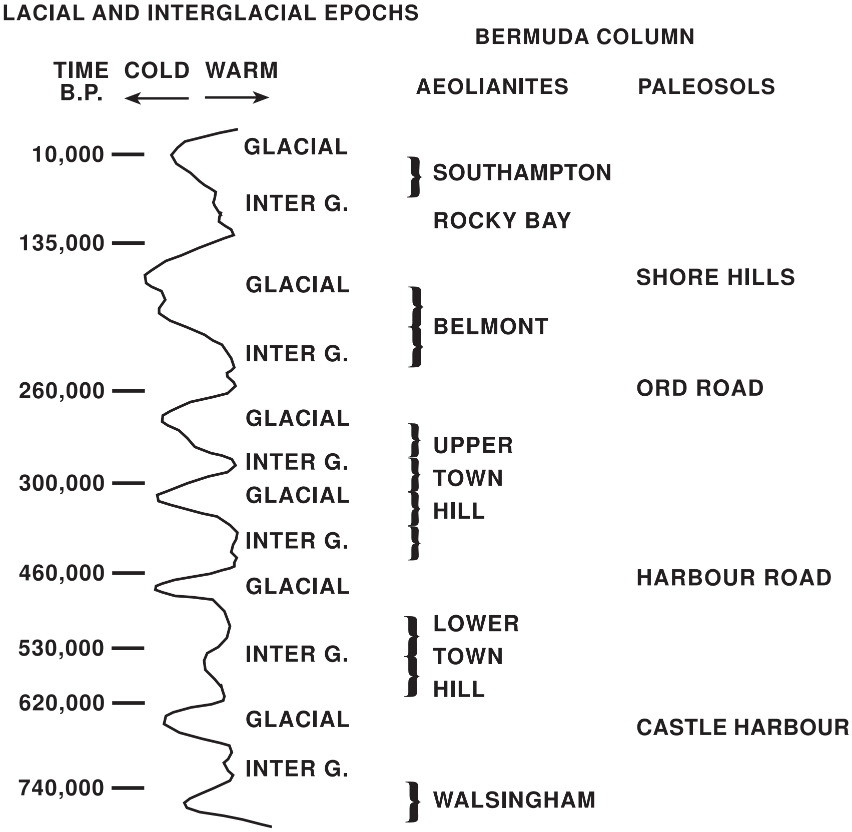



**Diagram 17**

## Since the Ice Age

There was a rapid rise in world sea level as inter-glacial conditions returned about 10, - 20,000 years ago; but this has gradually slowed down sea level has remained stable over the past 4,000 years. Bermuda is constantly being affected by modern processes:

### Constructive Processes

1. **Sedimentation.** Sediment production is taking place and in many areas the bioclastic material is accumulating in sedimentary layers e.g. in deeper, quiet waters of the sounds or lagoon, and in mangrove areas where silts and muds are trapped.
2. **Beach Formation.** Sediments transported by waves, currents and tides and accumulating in coastal bays.
3. **Dune Building.** Occurring on some south shore beaches but in this manner Bermuda grows outwards in successive glacials and inter-glacials.
4. **Development of Surface Soils.** The result of weathering processes and vegetation inputs.

### Desctructive Processes

1. **Weathering.** (i) Porous limestones subjected to chemical weathering, such as Bermuda's aeolianites since their deposition, undergo karsification. The term karst refers to the modified topography of limestone regions by chemical solution. In Bermuda, this is an island-wide weathering process which eventually lowers the landscape. As diagenisis continues aeolianites lose their primary porosity (gaps between grains fill in with calcium deposits) but increase their permeability (they develope joints, caves and caverns). Thus, most caves occur in the Walsingham Formation,
(ii) Biological weathering through soil microbes, enhance chemical breakdown of aeolianite and plant or tree roots break up the sub-soil layers.

2. **Erosion**. (i) Deflation of beaches by wind removes loose particles and may deposit them elsewhere as dunes,
(ii) Waves erode the cliffs, especially during stormy weather. Caves and cliffs are evidence of seashore erosional processes.

3. **Man's Activities.** Can you outline some of the ways in which man has altered (destroyed) Bermuda's Natural Environment?

## GEOLOGICAL TIME SCALE

| Era | Period or System | Epoch or Series | Important Physical Events and Fauna | Time in Millions of Years |
|---|---|---|---|---|
| CENOZOIC | QUATERNARY | RECENT | Glaciers melted; many mammals disappeared; warmer climates. | |
| | | PLEISTOCENE | Glaciation. Invertebrates; large mammals and Man. | 1 |
| | TERTIARY | PLIOCENE | Mountain building. Large mammals. | 10 |
| | | MIOCENE | Uplift of Rockies. Grazing animals. | 25 |
| | | OLIGOCENE | Lands generally low: Alps and Himalayan Systems develop; Rockies area had volcanoes. Sabre-toothed cats appeared. | 40 |
| | | EOCENE | Erosion, lakes in North America. Tropical/mild climate. All modern mammals. | 60 |
| | | PALAEOCENE | High mountains; cool climates. Birds and primitive mammals. | 70 |
| MESOZOIC | CRETACEOUS | | Lowlands widespread. Mild climates. Flowering plants and insects; extinction of giant reptiles. | 135 |
| | JURASSIC | | Lowlands widespread; Europe under seas; mild climates. Mountains rise in W. North America and eruptions widespread. Dinosaurs. | 180 |
| | TRIASSIC | | Continents mountainous; deserts widespread. Eruptions in W. North America | 220 |
| PALAEOZOIC | PERMIAN | | First mammal-like reptiles. Appalachians formed | 270 |
| | CARBONIFEROUS | | Lowlands emerged from seas; tropical coal swamps formed. Large reptiles and amphibians. Mountain building in North America. | 350 |
| | DEVONIAN | | N. America low and flat but mountains and volcanoes in E. North America; Europe arid and mountainous. Fishes dominant. | 400 |
| | SILURIAN | | Flat continents; mild climates; slate deposits. | 440 |
| | ORDOVICIAN | | Low continents; mild climates; shallow seas. Some mountains. | 500 |
| | CAMBRIAN | | Seas in Geosynclines. Mild climates. Algae and trilobites. | 600 |
| PRE-CAMBRIAN | PROTEROZOIC (Algonician) | | Seas in Geosynclines. Mild to cold. Few Fossils. Lake Superior iron deposits formed. | 1000 |
| | ARCHAEOZOIC (Primitive life) | | Extensive mountain building. Graphite and carbon. Earliest known life. | 3000 |
| | AZOIC (Without life) | | Formation of the Earth's crust. No rocks have been found. | 4500 – 6000 |