CHAPTER ONE

THE DEEP PAST

1.3 BILLION TO 18,000 YEARS AGO

MAJOR DEVELOPMENTS

- ☐ Precambrian era, 3.5 to one billion years ago
- ☐ Paleozoic era, 600 to 230 million years ago
- ☐ Mesozoic era, 230 to sixty-five million years ago
- ☐ Cenozoic era, sixty-five million years ago to the present

SIGNIFICANT EVENTS

- ☐ One-celled organisms evolve during Precambrian times, 3.5 to one billion years ago.
- ☐ The Grenville Orogeny mountain-building episode, 1.3 to one billion years ago.
- ☐ The Iapetus Ocean covers the region, one billion to 500 million years ago.
- ☐ The Pangean supercontinent forms, 500 million years ago.
- ☐ Plants, insects, and amphibians emerge during the Paleozoic era, 600 to 230 million years ago.
- ☐ The Appalachian Orogeny mountain-building episode, 350 to 250 million years ago.
- ☐ Dinosaurs, birds, and the first mammals appear during the Mesozoic era, 230 to sixty-five million years ago.
- ☐ North America goes with Laurasia when Pangaea splits up 200 million years ago.

- ☐ Lying on the shores of Laurasia, parts of the region are periodically flooded by Atlantic Ocean waters between 200 million and 12,000 years ago.
- ☐ Mammals begin to emerge as dominant land animals, sixty-five million years ago.
- ☐ North America begins to split off from Laurasia fifty million years ago.
- ☐ The most recent series of Pleistocene Ice-Ages begin two million years ago.
- ☐ The most recent glacial ice-sheets begin to retreat 18,000 years ago.

CHANGING ECOLOGIES

Both Chesapeake Bay and the communities of plants and animals living in and around it may appear ageless, but the Bay environment we see today only began to emerge 12,000 years ago. Going further back in time, the region has been a place of tropical rainforests, arid grasslands, teeming swamps, dense pine lands, and bleak arctic tundra. Over time, a restless earth has shifted Chesapeake lands across portions of the face of the earth, moving them through polar, temperate, and equatorial latitudes. Deep ocean waters, vast lakes, glacial ice-sheets, layers of sand, and streams of molten lava covered these lands in their season. Colliding continents, earthquakes, volcanoes, and, perhaps even an ancient meteor strike have raised, lowered, and fractured the part of the earth's crust that undergirds the region today. Chesapeake lands have sunk under the weight of rock, water, and ice, only to rise - at least twice during the past billion years - into mountains rivaling the Himalayas, when the massive forces released by colliding continents pushed huge blocks of land many thousands of feet into the air.

These changes occurred at different rates over vast stretches of time. Sometimes they occurred very quickly, even by the immense expanses of time used to measure geological change.

Catastrophic events - such as the meteor strike believed to have gouged a crater hole into the crust beneath the present Chesapeake basin many millions of years ago - could transform the entire landscape in an instant. Other changes took time. Over the course of millennia, wind, water, and ice cut through the mountains, wore away rocks, and ground stone into gravels, silts, clays, and sands. Continents drifted apart and slammed together along fault lines running through the region, triggering earthquakes and sometimes causing deeply buried rock melted by the heat of these collisions to ooze from great cracks and craters to bury the land beneath layers of magma, lava, and ash. Today, the routes of many Chesapeake waterways mark these faults where earthquakes cracked and shifted vast wedges of the earth's crust.

This history is written, too, in the region's waterways, rocks, soils, and sediments. For instance, we can see the sands, sediments, and gravels laid down by ancient oceans, bays, and rivers in today's limestones, dolomites, sandstones and other sedimentary rocks. Deposits of these rocks can now be seen on cliff sides, mountain slopes, in quarry pits, and deeply buried in caves and mines. We can also find clues to the past in the slates, serpentines, marbles, and other metamorphic rocks exposed along Piedmont uplands and buried beneath the coastal plain. Transformed by heat and pressure, these rocks preserve a record of the enormous forces released during earthquakes and continental collisions. Unique locales, such as Maryland's Pilot Serpentine Barren Preserve and Soldier's Delight Serpentine Barren, provide distinctive Piedmont habitats for plant communities including red cedar, blackjack oak, post oak, and a unique form of chickweed that only thrives on soils derived from deposits of serpentine metamorphic rocks. And igneous rocks, such as granite, basalt, and diabase often found exposed along Piedmont cliffs, recall times when lava and magma welled up from vents, fissures, and volcanic craters.

Interestingly, not all of the past events documented in the region's rock records occurred locally. Some rocks originated on other continents were left behind after colliding landmasses drifted apart. Others from locales closer to the Chesapeake provide evidence of past events not yet found or no longer present in the region.

Deeply buried granites discovered in layers of rock (rock layers are known to geologists as strata) in Piedmont deposits 500 miles away in Alabama, for example, preserve the earliest evidence of the region's geological history. They represent the remains of what geologists call the Grenville Orogeny. The term orogeny refers to geological processes that occur when mountains are formed. The Grenville Orogeny raised up a lofty mountain chain across the present day Piedmont, between 1.3 and one billion years ago. Made up of relatively soft rocks, this mountain chain eroded away within the comparatively brief span of 150 million years, and the Grenville terrain was flooded by the in-rushing waters of the Iapetus Ocean. The Iapetus Ocean was first formed about four billion years ago. It separated the continents of Laurentia (today's North America), Baltica (today's northern Europe), and Gondwanaland (today's Africa, South America, and Southwest Asia).

Today we can see the clean white sands from the floor of the Iapetus Ocean in the hard quartzites that lie atop distinctly shaped Piedmont hills known as monadnocks, such as northern Virginia's Bull Run Mountain, and on exposed sides of cliffs in places that include Pennsylvania's Otter Creek Gorge and Urey Overlook. About this time, the slates and marbles of the present day Catoctin Ridge and the fall line hills of Maryland and Virginia were formed from lava and ash spewed from submarine volcanoes and vents at the floor of the Iapetus Ocean, between 750 and 410 million years ago. And the thick sheets of limestone that form much of the Piedmont's bedrock today were formed by a rain of tiny dead microrganisms, coral skeletons, and dissolved minerals that drifted to the ocean bottom over the span of many millions of years.

The earliest of these microscopic lifeforms evolved in the Iapetus Ocean waters between 3.5 and one billion years ago. More complex, multicellular organisms, such as corals, emerged as Laurentia, Baltica, and Gondwanaland began drifting closer toward one another at the beginning of Paleozoic times. As these continents drifted closer, the Iapetus Ocean narrowed into a body of water known as the Tethys Sea. The waters of this sea gradually drained away as the continents collided to form Pangaea, a single supercontinent, around 500 million years ago. The force of this collision pushed together vast chunks of the earth's crust, and the heat it generated caused rocks to melt into magma. This magma issued then from great volcanoes, fissures, and vents and flowed across the land. Many of the gneisses, marbles, schists, granites, and slates comprising the Chesapeake region's bedrock were forged in this underground furnace. And most of the asbestos, mica, iron, nickel, gold, silver, and other minerals extracted from the historic mines and quarries of the region came from rocks pressed and heated by these events. In Pennsylvania, Piedmont sites that preserve historic mines include the Delta slate quarries, the Codorus iron furnace, the Gap nickel mine, Wood's chrome works, and the Pequea silver mine.

Pressures built up as masses of ancient sediments and younger volcanic rocks piled into one another. These pressures produced the Appalachian Orogeny, the second great mountain building episode in the region, between 450 and 250 million years ago. The highest peaks of the chain that this orogeny created soared more than four miles into Late Paleozoic skies. Today's Appalachian uplands are the much eroded remnant of this ancient mountain chain.

When the vast Pangaean land mass existed, this mountain chain lay at its center, near the earth's equator. All but the westernmost portions of the present day Chesapeake region sat astride this range. Little is known about the region's environment at the time. Rocks telling this story have either eroded away, been buried deeply, or transformed beyond recognition by heat and pressure beneath younger sediments.

Evidence of the earliest plant life exists in rocks found in sediments lying astride today's western Piedmont uplands. These preserve a record of great swamps of seed ferns, club mosses, and other primitive plants - some as tall as modern trees - that thrived in the warm, wet climate of the Late Paleozoic era. Horsetails flourishing in soils far too poor for other plants are a living representative of these early species in this region. Late Paleozoic swamps lined the shores of a long, narrow sea that jutted into the center of Pangaea. Dead plants - preserved in acidic, stagnant swamp waters - formed thick peat sediments. These sediments gradually hardened into the vast coal seams that extend today in a broad arc across the Appalachian uplands from Pennsylvania to Alabama. Mollusks, insects, bony fishes, and, eventually, amphibians swam in these ancient swamps and rivers, beneath the wings of six-inch dragonflies and four-inch cockroaches. Pennsylvania's Hopeland Coal Deposit is one of the few locales in the Chesapeake region that preserves geological evidence from this era.

Excavators working at locales such as Zion's View Dinosaur Site in the Pennsylvania Piedmont have given us glimpses of the kinds of animals that lived in the region during the Mesozoic era between 230 and sixty-five million years ago. Intriguing evidence unearthed by modern technology further fills out our picture of the world at this time. Crystalline rocks brought up from deep in the earth by drilling rigs indicate that the rocks now underlying the Chesapeake coastal plain originated in the part of Gondwanaland that today is East Africa. These rocks were left behind when Pangaea split apart during Triassic times, around 200 million years ago. Consisting of the present continents of Africa, South America, Australia, and Antarctica, Gondwanaland broke away and drifted south. The remaining part of Pangaea containing North America, Europe, and Asia became a new continent known as Laurasia.

Chesapeake lands lay at the edge of this new continent and were again submerged by in-rushing ocean waters. Sand, mud, and other sediments flowed into this ocean from Laurasian rivers. These sediments gradually formed a continental shelf consisting of new layers of limestone, sandstone, and shale beneath the shallow waters of the Laurasian coast. In these shallow, warm waters, succeeding generations of plankton, submerged aquatic vegetation, invertebrates, fish, and, lastly, aquatic dinosaurs made their homes.

Following the mass extinction of dinosaurs and many other forms of life around sixty-five million years ago, global sea levels dropped, and the portion of continental shelf containing modern day Chesapeake lands began rising above the waves. Discoveries of fossils of tropical rainforest plants, birds, and mammals indicate that this region was dry land when North America spilt from Europe and Asia around fifty million years ago. During the next twenty-five million years, the region's rainforests were gradually replaced by brushy grasslands as the earth evidently shifted somewhat on its axis at the same time the North American continent drifted farther north toward cooler latitudes. Because of changes in world sea level during these years, lands along what is now the Atlantic seaboard were periodically flooded and exposed.

The most complete known evidence showing how living things adapted to changes in the Chesapeake region between ten and twenty million years ago comes from fossils found in the

Pennsylvania Piedmont Bootlegger's Sink and the Maryland coastal plain's Calvert Cliffs preserve. These fossils show that a wide variety of animals, now long extinct or only alive in warmer or wetter parts of the world, inhabited the flat grasslands and shallow coastal waters of this ancient Chesapeake world. The bones of nearly two dozen kinds of whales, porpoises, seals, and sea cows have been identified in Calvert Cliffs deposits. Such now extinct species as mastodons, along with primitive types of horses, camels, rhinoceros, tapirs, deer, wolves, bears, beavers, dogs, cats, crocodiles, snakes, and turtles lived on the coastal plains. Aquatic birds, such as gannets, auks, loons, and shearwaters flew in Chesapeake skies. Various types of shark; a wide range of bony fish, including bluefish, weakfish, ocean catfish, sturgeon, black drum, cod, sailfish, and ocean sunfish; and dense colonies of corals, crabs, clams, oysters, and scallops made their homes in the waters that periodically covered coastal plain lands.

This world of dry grasslands and warm, shallow coastal waters gradually gave way to dense spruce forests and marshy tundra bordering on deep ocean waters as the much colder Pleistocene period began two million years ago. At least four major glacial advances, known as Ice-Ages, occurred during this period. Each lasted more than 100,000. Sea levels rose and fell as glacial ice-sheets advanced and retreated. At their maximum, the region's coastal plain extended eastward as far as a hundred miles beyond the present shoreline, as frozen ocean waters locked into glacial ice caused world sea levels to drop as much as 300 feet below current elevations. Whenever warmer conditions melted ice-sheets, rising ocean waters flooded continental shelf lands.

Also during Pleistocene times, vast sheets of glacial ice scraped their ways across the northern hemisphere. During warmer intervals, torrents of water rushing from melting glaciers deposited vast sheets of sand, silt, gravel, and clay across the coastal plain. Although causes for these episodes remain unknown, plant pollen recovered from cores drilled into Pleistocene age deposits reveal something of environmental conditions during these times. Pollen from aquatic plants indicates that ocean temperatures averaged from 3.5 to 5.5 degrees Fahrenheit (F) cooler than those at present, and analysis of land plant pollen suggests that continental air temperatures averaged almost ten degrees F cooler than today. As for temperatures during periods when glaciers were in retreat, discoveries of pollen from plants adapted to warmer conditions in core levels dating to these periods suggest prevailing temperatures that were on average as much as fifteen to twenty-five degrees F warmer than those measured today.

These new sediments sluiced through and buried earlier coastal plain deposits. Newly deposited glacial sediments gradually weathered into deep layers of generally acidic, sandy or silty soils of light to medium texture. Today, miners quarry iron ores, mineral earth pigments, greensand marl, diatomite, clay, sand, and gravel from these sediments. During Pleistocene times, cold adapted spruce and pine forests grew on these newly deposited soils. Easily penetrated by rain, river, and sea water, these soils filtered water into vast underground aquifers of fresh and brackish water. This water was locked within layers of sand and gravel, which lay atop deeply buried impermeable bedrock strata. Today, freshwater is generally found in aquifers that lie from several hundred to more than a thousand feet deep along the western and upper eastern shores of Chesapeake Bay. Brackish waters, which percolate downward into the earth from saltwater sources, lie from 200 to 300 feet below the surface in the lower Eastern Shore and are as deep as 2,500 feet near the present mouth of the Bay.

Farther inland during the Pleistocene period, windswept tundra marshlands (similar to those in northern sections of present day Siberia, Canada, and Alaska) covered all but the southernmost reaches of the Piedmont uplands. We can see evidence of this in several stretches of coniferous forest in the southern Virginian Piedmont that are dominated by Canadian hemlock, white pine, and, in one locale, arbor vitae. As these plant communities are commonly found today only in far more northerly latitudes, the Virginian forests are believed to be remnants of late Pleistocene woodlands. Foremost among these are the Tye River Hemlock-Beech Slopes, the James River Arborvitae Bluff, and the Big Otter River Hemlock Slope. Other evidence of the Pleistocene environment is preserved in places like Pennsylvania's Falmouth Potholes, where the power of glacial meltwaters is dramatically exhibited in the forms of perfectly round holes cut in rocks scoured smooth by careening cascades of rocks and gravels carried by rushing waters. Sediments scoured from rocks by glacial meltwaters collected as medium textured, easily tilled, and highly fertile, clayey soils in broad Piedmont valleys. Enriched by organic deposits laid down by successive generations of plant and animal life, some of these soils are now as much as a hundred feet thick. Rains and rivers provide most water in the Piedmont; the presence of bedrock close to the surface prevents the formation of extensive underground aquifers.

Bones, teeth, and horns found in Piedmont and coastal plain soils dating to Pleistocene times indicate that present day Chesapeake region residents, such as white-tailed deer, beaver, and black bear, lived side by side with now extinct species such as the mammoth, mastodon, giant beaver, and Eastern short-faced bear. Other finds dredged from beneath the modern continental shelf show that walruses, seals, and other sea mammals that are now found only in more northerly latitudes thrived in the waters that periodically covered the coastal plain when melting glaciers retreated northward.

The earliest identifiable geological evidence of the Susquehanna, James, and other rivers that now flow into Chesapeake Bay dates to Pleistocene times. Melting glacial waters, coursing down the rivers of the ancestral Chesapeake region, cut new channels across the mid-Atlantic coastal plain at least four times during periods of major glaciation. Drilling core evidence indicates that all but the most recent of these channels now lie buried beneath layers of sand, silt, and gravel deposited by successive episodes of flooding by glacial waters.

The modern day Chesapeake region drainage was first formed during the most recent glacial episode. During what is known as the Wisconsin glaciation, ice-sheets up to a mile thick covered northern Pennsylvania by the time they advanced to their maximum extent about 18,000 years ago. Today's Chesapeake region was then a widely branching network of narrow upland river channels wending their way across gently rolling terrain. Rising more than 300 feet above present sea level, these streams joined in a single tidal river somewhere along a now submerged section of the continental shelf. This river snaked its way across the level, continental shelf lowlands to its mouth, nearly a hundred miles east of the present day shoreline.

FURTHER INFORMATION

Useful sources containing information needed to more fully understand the deep past in the Chesapeake region include;

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