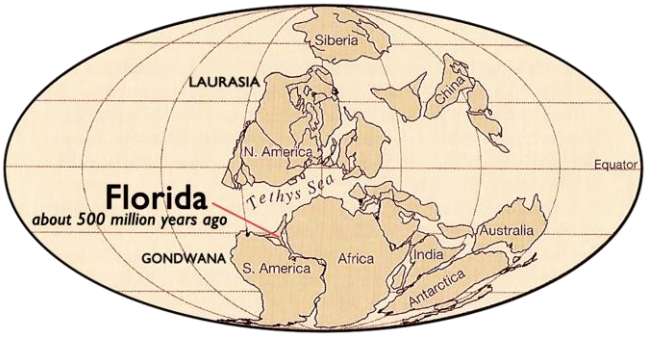
Florida Formations:
Shifting Seas and Sediments

The Florida We are all So Familiar With is a relatively new phenomenon, geologically speaking. This distinctive peninsula of land we live on, and the gently sloping, sandy shorelines we're drawn to for recreation and renewal, have not always existed as they appear today. In fact, Florida was a very different-looking place not so long ago, and over the past 500 million years it has had quite a unique and surprising geological history.



(Kosche, Bryan, Scott, Means)

African Origins

Believe it or not, the deep bedrock that underlies Florida was originally a part of Africa. Florida's oldest rocks formed about 500 million years ago on the "megacontinent" Gondwana. They were wedged between other masses of rock that would eventually separate—through the activity of plate tectonics—into the modern continents of Africa and South America. About 250 million years ago, Gondwana (containing the geologic beginnings of Florida) collided with another megacontinent called Laurasia (which contained the rest of future North America). The result was the *super*continent Pangea. When Pangea eventually broke up, about 230 million years ago, that special wedge of African bedrock that would be Florida, rifted apart from its tectonic plate of origin, and remained sutured instead to what we've come to know as the continent of North America.

200 Million Years of Calcium Carbonate Deposition

It is upon these very old, African-born igneous and metamorphic basement rocks that the sedimentary rocks of the Florida Platform would start to accumulate. Thick layers of carbonate rock—predominantly limestones and dolostones composed of the mineral *calcium carbonate*—built up over the next 200 million years to create Florida's flat-topped, "carbonate platform" structure. These rock layers, two to three miles thick in some places, are a result of the near-constant deposition of calcium carbonate ($CaCO_3$) that occurred in the warm ocean shallows that surrounded and very often completely submerged ancient Florida. As marine organisms lived and died in the shallow seas, their skeletal remains became concentrated, compacted, and gradually hardened (lithified) into a complex subsurface stratigraphy of sedimentary rock formations, whose differences in depth, location, and composition reflect Florida's fascinating formational history.


North America & the submerged Florida Platform in Eocene time—50 million years ago (Blakey)

FLORIDA GEOLOGICAL FORMATIONS:
Distinctive rock units—typically in the form of thick, extensive layers, continuous across a considerable distance—deposited on the Florida Platform over its geological history.

Beauty is in the Eye of the Informed

So beyond its deep African foundation rocks, and its thin cover of sand (which entered the state's geological picture relatively recently—only within the past 15 million years), this point of land we know as Florida was constructed primarily underwater. The resultant array of ocean-formed carbonate rocks, making up the subsurface structure of Florida, has an enthralling story to tell us about past environments and past climates. The allure of these Florida Formations may not be readily obvious—particularly when compared to some of the other

specimens in the museum—but upon closer inspection, subtle, even revealing distinctions emerge. Florida's geological formations are a physical representation of dynamic regional and global changes in oceanic, climatic, ecological, and geological conditions over the past several hundred million years. The unassuming rocks you see in this exhibit help us better understand how global atmospheric shifts, massive sea level fluctuations, and ongoing geological processes, have yielded our current landscapes and impacted life on earth and in Florida.

A Story, and Shoreline, Still in the Making

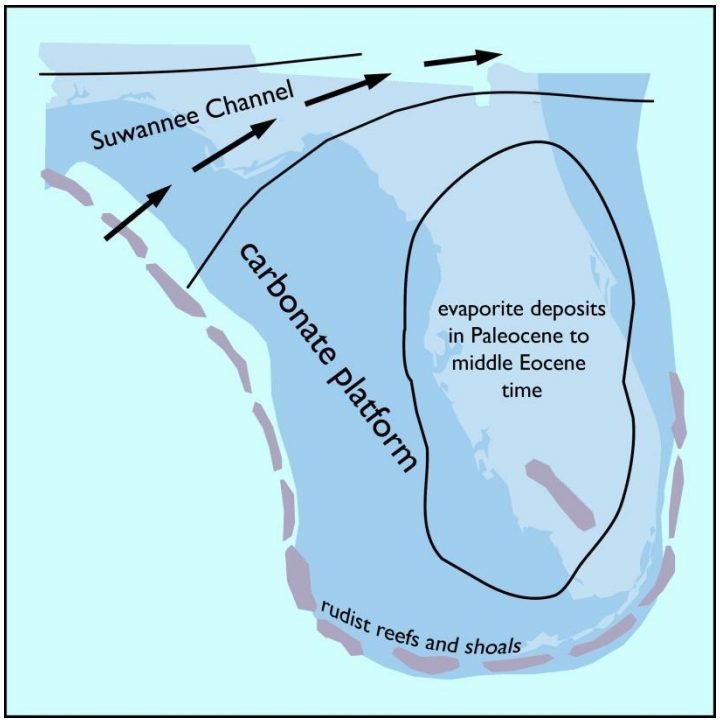
Fossilized crab, Historic Gillespie Collection

The information in these pieces of pale stone, supported and expounded by a wealth of science from around the world, convinces us that Florida was rarely the same for long, and is undoubtedly still continuing to change. Indeed, many scientists believe that we are entering a new period of much more rapid change (sometimes called the Anthropocene because of the increasing influence of humans) with accelerated sea level rise due to human-induced global warming. Though the present configuration and associated environments of this finger of land we know so well seem very permanent and stable, these most recent conditions constitute only about 0.001% of Florida's geological history. Let's now, with the help of some of Florida's formations, take a look at the rest of its still-unfolding story.

FLORIDA SUBMERGED

The Cretaceous, Paleocene, and Eocene (145 to 34 million years ago)

After the supercontinent Pangea broke up about 230 million years ago leaving Florida attached to the North American plate, the cooling of the crustal rock after the rift resulted in the continental plate margin gradually subsiding into the sea, taking the foundational bedrock of Florida with it. Florida would enter the carbonate-building phase of its geological story as a submerged peninsular projection off the southeastern end of the slowly drifting North American continent.



(Adapted from *Roadside Geology of Florida*; Bryan, Scott, & Means; 2008; Kosche)

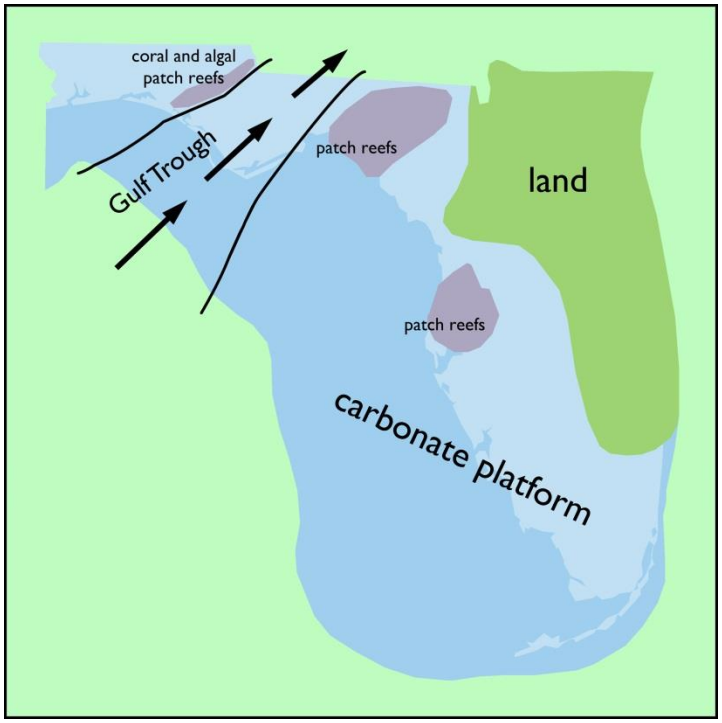
During this time period, earth was in a global "greenhouse" state, with warm climates and extremely high sea levels because of an absence of continental glaciers, and the Florida Platform was all or mostly submerged under a shallow sea. By the Late Cretaceous, a seafloor channel had developed across the top of underwater Florida (the Suwannee Channel), isolating most of the Platform from the siliciclastic sediments (quartz sand and silt, and clay, derived from the Appalachian Mountains) being discharged by mainland North American rivers. This protective current shielded Florida's underwater environment from introduced siliciclastics, and allowed for the formation and buildup of carbonate rock overtop the earlier African basement rocks.

Florida was as an underwater home to a diversity of marine flora and fauna at this time, and its main geological formations from this age are a direct result of the millions of years of cycling life represented in the calcium carbonate depositions which accumulated across the ancient seabed. Reefs and shoals formed around the margins of the submerged Florida Platform during this period, restricting water circulation and creating an evaporative lagoon which left behind evaporite minerals. Sands, clays, shales, and conglomerates were deposited across northern Florida at the outflows of the mainland rivers, but the carbonate rocks (limestones and dolostones), which formed in the protected waters of the warm shallow seas, constituted most of the rocks from this era.

(MAJOR FLORIDA FORMATIONS: Avon Park Formation, Ocala Limestone)

PARADISE ISLAND
The Oligocene
(34 to 23 million years ago)

The start of the Oligocene Epoch was marked by a significant global cooling event, in which the warm, high carbon dioxide, high sea level "greenhouse" conditions of the prior 250 million years gave way to the variable "icehouse" conditions which still prevail today. When in an "icehouse" state, the earth has continental ice sheets present, and these glaciers advance (grow) and retreat (melt) in recurring intervals that scientists call "glacial" and "interglacial" periods. The cooling temperatures, growing Antarctic ice sheets, and falling sea level (the late Oligocene saw sea level drop over 300 feet) had profound effects on the developing Florida Platform.



(Adapted from *Roadside Geology of Florida*; Bryan, Scott, & Means; 2008; Kosche)

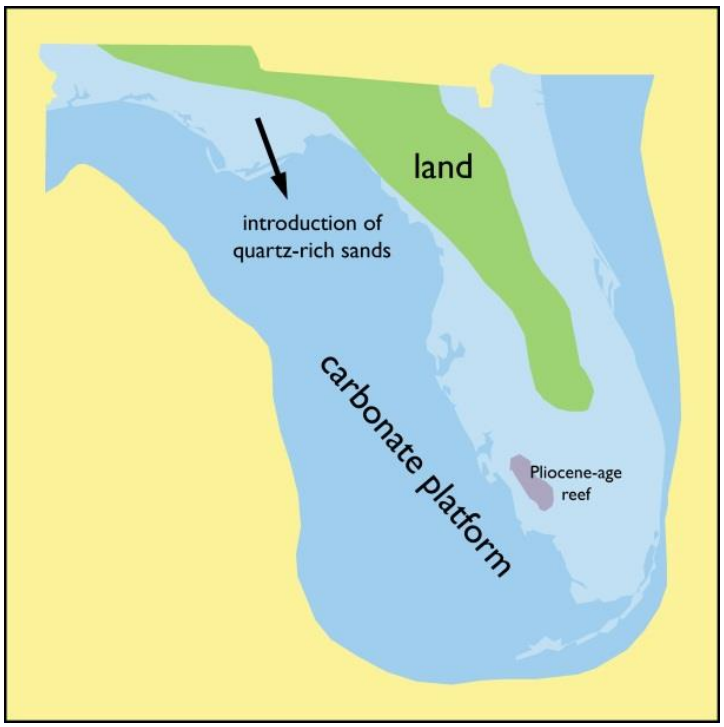
It was during this time that parts of Florida emerged from the sea and became land, with much of the Florida Platform exposed as a large island or islands. By the late Oligocene, while the surrounding shallow seas continued to diversify with life, the first land animals appeared in Florida's fossil record. Saber-toothed cats, oreodonts, primitive horses, and other large and small land-dwelling mammal species roamed ancient Florida now, and their presence represented the onset of a new chapter in our geological story, with the introduction of terrestrial processes to the ongoing evolution of the Florida Platform.

The exposed carbonate rocks of the newly-drained land portions of the Platform began to weather and erode in a process called *karstification*. In this process, acidic rain and groundwater percolate into the rock and dissolve the porous limestones and dolostones, enlarging holes and fractures in the stone, weakening the crystal structure, and creating cavities and fissures in the surface and underlying rock layers. Karst landscapes are those formed of this eroded limestone, and here in Florida they are often characterized by sinkholes, depressions, springs, caves, and underground streams. Though the dry land parts of Florida began to dissolve and erode during Oligocene time, new carbonate rock formation still continued offshore. The Suwannee Channel became a narrower inlet called the "Gulf Trough," and its intercepting currents still kept the majority of the Florida peninsula protected from mainland North America's sediment discharge, allowing carbonates to develop among patch reefs and in other underwater marine environments.

(MAJOR FLORIDA FORMATIONS: Suwannee Limestone, Marianna Limestone, Bridgeboro Limestone)

FLORIDA CONNECTED
The Miocene and Pliocene
(23 to 2.6 million years ago)

In the early Miocene Epoch, tectonic uplift occurring in the southern Appalachian Mountains had a tremendous impact on the remainder of Florida's geological history. Increased erosion as a result of the uplift produced exceptionally high levels of sediment influx in areas downstream of the mountains, and these quartz-rich sediments (siliciclastics) being deposited with renewed intensity above Florida would eventually fill and overtop the Gulf Trough. When this insulating ocean cut finally infilled, fully merging Florida with the rest of North America, the result was the arrival of large volumes of quartz-rich sediments onto the Florida Platform for the first time.



(Adapted from *Roadside Geology of Florida*; Bryan, Scott, & Means; 2008; Kosche)

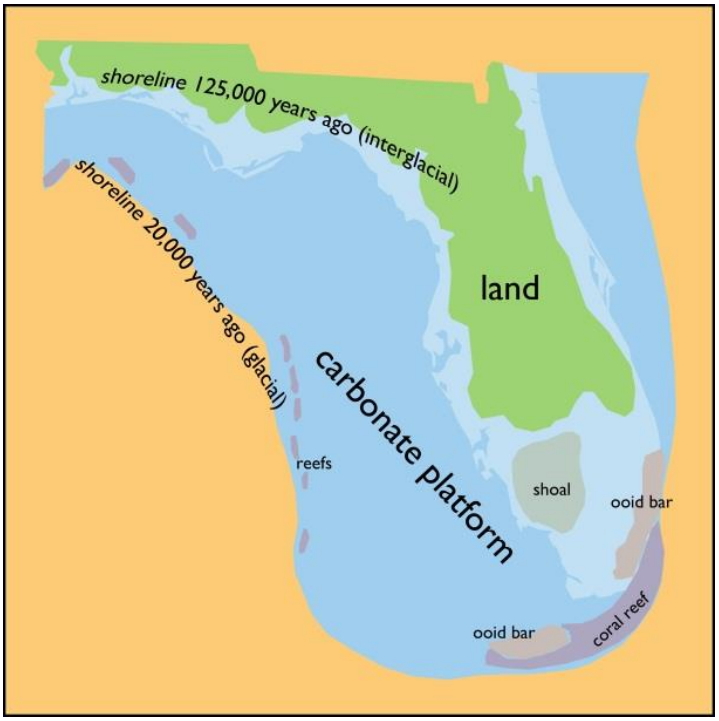
The earth remained in a global "icehouse" state throughout this period, with climates continuing to cool, sea level still low, though fluctuating, and continental glaciers generally advancing. The Florida Platform's exposed land area varied in size with sea level changes (entirely submerging at times in the early and middle Miocene), but by the late Miocene a significant fall in sea level left much of Florida exposed as land, and it would remain a sizable, if at times narrow, peninsula throughout the Pliocene Epoch. Another significant event of this time was the uplift of the Panamanian Land Bridge, which joined North and South America for the first time. This new connection set off a major biotic exchange that brought South American land animals to Florida, while at the same time isolating and altering Atlantic and Pacific Ocean marine communities.

Where and when the Florida Platform was underwater, carbonate rock continued to form, but the formations tended to be of mixed composition, containing quartz-rich clastic sediments such as clay, sand, silt, and gravel, introduced by rivers flowing down from the north. In the Pliocene, when only the flanks and southern peninsula of Florida were submerged, some reef formation occurred, but more notably, the extensive shell beds of South Florida's Tamiami and Caloosahatchee formations were deposited. By the end of the Pliocene, the quartz-rich siliciclastics arriving from the north became the dominant sediment type across Florida, and sandy beaches and barrier islands, similar to those we see along the coast today, began amassing along Florida's fringes.

(MAJOR FLORIDA FORMATIONS: Alum Bluff Group, Hawthorn Group, Miccosukee Formation, Intracoastal Formation, Tamiami Limestone)

ICELESS ICE AGE
The Pleistocene
(2.6 million to 11,700 years ago)

Though the earth had been in a global "icehouse" state for the past 30 million years since the Oligocene, the Pleistocene Epoch was characterized by a dramatic intensification of these cooler climatic conditions, and is sometimes even called "The Great Ice Age." Average global temperatures became even colder during this time, precipitating substantial advances of continental ice sheets, and as a result global sea levels reached new lows. In North America, a massive continental glacier stretched from Canada to as far south as present-day Kentucky, and record-setting low sea levels would drain the breadth of the Florida Platform, exposing twice as much land as is uncovered today. Florida itself was never glaciated, but it grew cooler and drier with the rest of the world, developing greater expanses of semiarid savannah amongst thinning woodlands.



(Adapted from *Roadside Geology of Florida*; Bryan, Scott, & Means; 2008; Kosche)

During this time Florida was home to a wide array of ice age mammals such as horses, mastodons, mammoths, saber-toothed cats, bison, wolves, bears, and giant beavers. During the low sea levels resulting from the extensive glaciation of the late Pleistocene, a land connection was created between present-day Russian Siberia and northern Canada. This Bering Land Bridge in combination with an ice-free corridor down western North America, and perhaps progress by boats along the coasts, brought another remarkable mammal, *Homo sapiens*, from Asia into the Americas, and eventually to Florida, by around 15,000 years ago.

Most of the Florida Platform in the Pleistocene was still under the influence of the now-dominant, quartz-rich clastic sedimentation patterns established in the Miocene, which brought quartz sand and other imported sediments onto the Platform from the north. Still there were some areas that were conducive to carbonate formation. When sea level was higher during Pleistocene interglacial periods, southernmost Florida was under water, and remained warm enough and protected enough from introduced clastics, to build carbonate rock. The fossilized reef that we know as the upper Florida Keys formed during this time. Coral reefs, oolitic shoals (made of spherical, egglike, calcium carbonate ooid grains), and deposits of shells and bryozoans all contributed to Florida's Pleistocene-age carbonate formations.

(MAJOR FLORIDA FORMATIONS: Anastasia Formation, Miami Limestone, Key Largo Limestone, Fort Thompson Formation)

If You Want to Discover More

about Florida's unique geology, unusual rock formations, and fascinating fossils, you will find much to explore with these excellent sources.

Books and Publications

Roadside Geology of Florida, Jonathan R. Bryan, Thomas M. Scott, & Guy H. Means, Mountain Press, 2008

A Brief Geologic History of Volusia County, Florida, Edward German, USGS, 2009 (https://pubs.usgs.gov/fs/2009/3101/)

Florida's Geological Treasures, Iris Tracy Comfort, Gem Guides Books, 1998

Geological History of Florida: Major Events That Formed the Sunshine State, Albert Hine, University Press of Florida, 2013

Guide to Rocks and Minerals of Florida, Ernest Bishop, & Lawrence Dee, Jr., Special Publication No. 8, Florida Bureau of Geology, 1961, *out of print—available in pdf version online* (http://www.dep.state.fl.us/geology/geologictopics/rocks/rock_minerals.pdf)

Exhibits

Florida Fossils: Evolution of Life and Land, Florida Museum of Natural History, Gainesville

Prehistory of Florida Gallery, Museum of Arts and Sciences, Daytona (http://www.moas.org)

Walter Schmidt Museum, Florida Geological Survey, Tallahassee (http://www.dep.state.fl.us/geology)

Websites

United States Geological Survey, Florida— https://www.usgs.gov/science/regions/southeast/florida

Florida's Rocks and Minerals, identification & photos (Florida Geological Survey) http://www.dep.state.fl.us/geology/geologictopics/rocks/florida_rocks.htm#Rocks of Florida

Florida Geological Survey— http://www.dep.state.fl.us/geology

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