South Florida Geological Site Guide series
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OVERVIEW OF SOUTH FLORIDA GEOLOGY

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South Florida lies within the "Southern Zone" of the coastal lowlands of the Coastal Plain physiographic province of the eastern United States. Most of this province originated from a combination of depositional and erosional processes associated with fluctuations in sea level during the late Pleistocene.

Figure 1 shows the main physiographic provinces in South Florida. The most prominent feature of the southeast, and in Miami-Dade County in particular, is the Atlantic Coastal Ridge. It is the major topographic feature in the area east of the Palmetto Expressway and is most obvious in the Coconut Grove area. West and southwest of Lake Okeechobee the Sandy Flatlands and the Big Cypress Swamp also form raised areas. The Everglades is thus a shallow broad river that flows south from Lake Okeechobee between the Atlantic Coastal Ridge and the Big Cypress Swamp. The Mangrove and Coastal Glades is a brackish estuarine environment where the fresh water from the Everglades meets the marine waters of the Gulf of Mexico.

The physigraphy of South is largely controlled by by its geology (Figure 2). The geology of the region South of lake Okeechobee is composed of 5 major sedimentary sequences known as formations. The oldest of these, the Tamiami Formation, is Miocene in age and underlies the Big Cypress Swamp and Sandy Flatlands. The area south and southeast of Lake Okeechobee is composed of four formations deposited during the Pleistocene interglacial stages. The Fort Thompson Formation is the oldest of these, but its upper part interfingers with the lower parts of the generally overlying Anastasia, Miami Formation and Key Largo Formations. These last three deposits are contemporaneous and formed Sangamon Interglacial Stage of the Pleistocene epoch - about 100,000-130,000 years ago (Figure 3). These are the formations that underlie the high areas of southeastern Florida (the Central Keys and Atlantic Coastal Ridge.

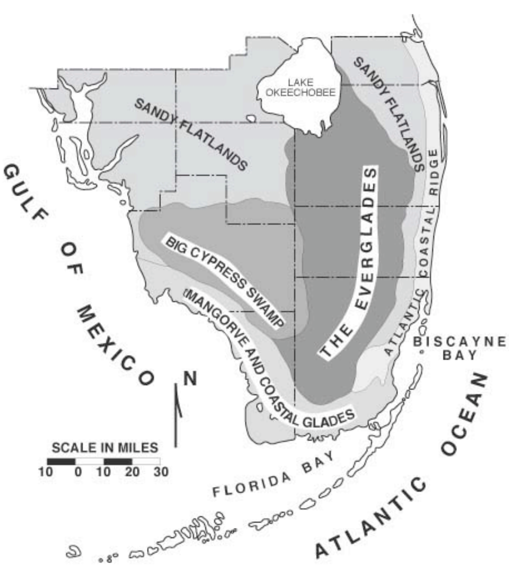

Figure 1 Physiographic provinces of South Florida

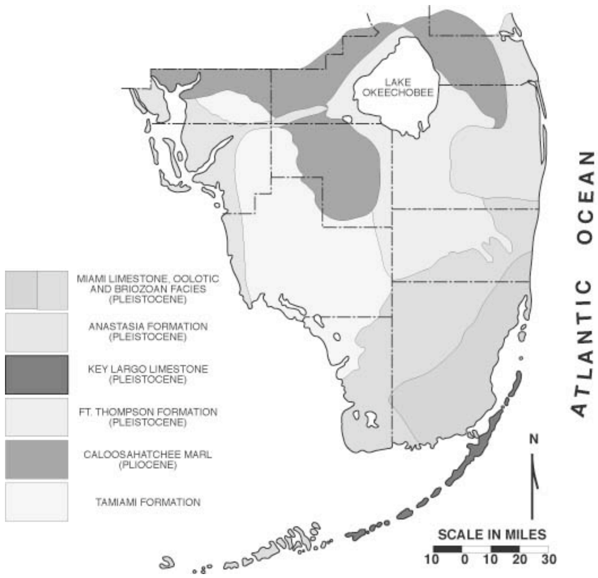

Figure 2 Geologic formations in South Florida

Fort Thompson Formation

The Forth Thompson Formation is composed of intercalated fresh and marine limestones that formed in an enviroment very similar to that which exists today in the Coastal Glades and Florida Bay. the limestones are generally marly (contain a significant amount of clay) and mangrove root fossils are not unusual.

Anastasia Formation

The Anastasia Formation underlies most of eastern Palm Beach county and extends north to St Augustine. It is composed of cemented shell fragments that sedimentologists call a *shelly grainstone*, but which is commonly known as *coquina*.

Miami Formation

The Miami Formation (also known as the Miami Oolite) crops out in many areas of Dade County, notably along U.S.1, north of Bird Road. along the Coral Gables waterway at Coco and, most spectacularly, along the cliffs on Bayshore Drive and Alice Wainwright Park in Coconut Grove. The Miami Formation is divided into two different "facies" which represent different depositional environments: the oolitic facies and the bryosoan facies

Oolitic Facies

This particular type of limestone, composed of grains cemented together, is referred to by sedimentologists as a *grainstone*. The majority of fragments are nearly spherical sand grains called *ooids*. Such grainstone composed predominantly of ooids is termed an *oolite*. Microscopic examination shows that these sand grains are made up of concentric l ayers around a small central nucleus of either shell fragments or small quartz grains. Mapping of the oolitic facies shows that it made up a continuous *oolite bank* that now underlies in the eastern parts of Miami-Dade county.

Oolitic sand banks are forming at the present time in the shallow waters of the Bahama Banks. Calcite is more soluble in cold water than warm water, so the warm conditions in tropical to sub-tropical seas encourages the precipitation of calcite from dissolved calcium bicarbonate in seawater. The reaction is:

$$Ca(HCO_3)_2 \rightarrow CaCO_3 + H_2O + CO_2$$

It is also possible that this reaction is not entirely inorganic and algae may play an important role in the precipitation of calcite in ooids. The agitation caused by the Atlantic oceanic swell rolls the grains around during calcite precipitation producing the concentric pattern observed in the ooids.

Thus, the Miami Formation is considered to have formed in conditions very similar to the present day Bahamas. At the time of deposition of the Miami Formation, however sea level would have been about 10m (~30 ft.) higher at present

Bryozoan facies

The western part of Miami-Dade is underlain by the Bryozoan facies. This facies formed in a lagoonal environment west of the oolite banks of the Atlantic Coastal Ridge. Bryozoans are colonial encrusting organisms that cover sea grass blades and rocks in the shallow marine environments. Ooids are present having been washed off the oolite banks, but make up a much smaller component of the limestone.

The differences in the contemporaneous oolitic and Bryozoan facies of the Miami Formation an various, and variable, environments of deposition throughout the area during the Pleistocene. The geologic interpretation of the Miami Formation is that it represents, essentially, a high energy wave zone (oolites and reefs) with a quiet lagoon to the west (Bryozoan facies). This environment is similar to that which exists in the Bahamas at the present day.

Subsequent modification

The oolitic facies of the Miami Formation is characterized by cross bedding, a sedimentary structure produced by flowing currents, in this case produced by water flowing out od and into the lagoon behind the banks. In many locations, this cross bedding was disturbed and severely modified by burrowing organisms living in the sediment, a process known as *bioturbation*. The burrows produces in this process are fossilized and superficially resemble the skeletons of stag horn coral. As a result the bioturbated facies of the Miami oolite is often erroneously referred to as "coral rock" (as in Coral Castle touris attraction).

Key Largo Formation

The Key Largo Formation crops out on the Florida Keys between Key Largo and Big Pine Key. It is a true coralline limestone and is a *framestone* made up of various species of corals and associated organisms. The central Keys are, in essence , a fossil reef tract, similar to the living reef that lies offshore at the present time.

The Florida Keys from Big Pine to Key West are underlain by oolite.

Later, superficial formations

Two other late formations are also notable.

The Pamlico Sand is of late Pleistocene age and is widespread from the Hollywood area northward. It overlies the Miami in these areas. It is a fine beach sand deposit composed of both quartz and carbonate grains.

The Fossil Root Reef is an unusual deposit, about 5-10,000 years old, that if found only at the north end of Key Biscayne in the nature reserve of Crandon Park. It consists of vertical rods that give rise to an intricate interwoven lattice. Many of these rods can be observed with their lower ends attached to a layer of horizontal rods. All rods are made up of calcareous sand grains. The origin of this deposit is controversial and unresolved. One hypotheses is that it is a fossilized root system of black mangrove (*Avicennia germinans*). The other hypothesis is that they are the fossilized root system of a seagrass mat.

Either way such root reefs are not easily preserved and this deposit is considered very rare. Unfortunately, because of the rapid erosion of sediment on Key Biscayne, the sand deposits that used to protect the reef have now been removed.

Late Pleistocene to Recent modification of Pleistocene deposits

The late Pleistocene climate remained stable until about 75,000 years ago, when it began to cool. As more of the world's oceans became locked up in the expanding ice caps sea level fell. However, it did so episodically and may have remained stationary for several hundred, if not thousands of years. As sea level fell it eroded away the older oolite bank and produces the cliffs and wave-cut notches currentlky observed on Bayshore Drive in Coconut Grove.

Eventually, at the leak of the last glaciation some 18,000 years ago, sea level fell to about 100m (~300ft) below present sea level. At this time the Florida peninsula was both higher standing and areally more expansive. Than at present.

Rainfall is slightly acidic, and so slowly dissolves limestone. The modification of the bedrock by solution is known as *karstification*. During the late Pleistocene, solution produced caves, vertical solution pipes and a general enhancement of the porosity of the Miami and Fort Thompson Formations.

Since 18,000 years ago sea level has risen and many of the solution caves became flooded (the same happened in the Bahamas resulting in the flooding of the vertical solution pipes known as "Blue Holes").

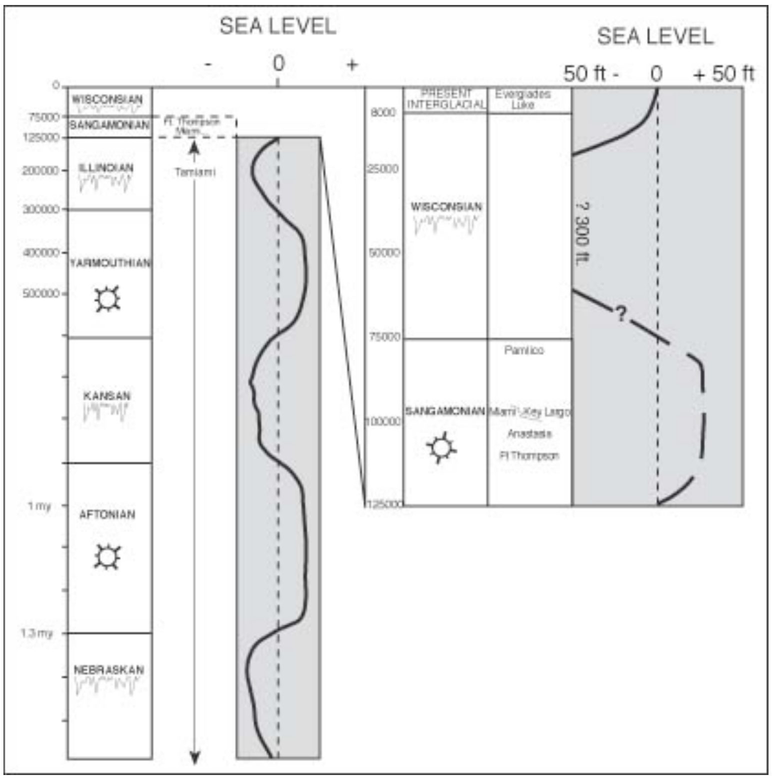

Figure 3 Changes in sea level during the Pleistocene epoch