South Florida Geological Site Guide series
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FLORIDA INTERNATIONAL UNIVERSITY
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No.

Montgomery Botanical Center

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Location and access
The Montgomery Botanical Center is located at 11901 Old Cutler Road, Miami, FL 33156-4242 and is just east of where Red Road meets Old Cutler Road. The Center is a privately run botanical institute specializing in the botany of palms. For access to the grounds permission should be obtained from the Director. Patrick Griffith, who can be reached at 305-667-3800 ext 105.

What there is to see
Excellent exposures of the Miami Oolite and its sedimentary structures; wave cut cliff and basal notch. Some karst features such as case hardening of the limestone and solution pipes.

Backround
The oolitic facies of the Miami Formation is exposed in an extensive small cliff, Silver Bluff, that runs at lest 200m in the Center's gounds. The cliff is cut into one of a series of oolite sandbanks that extend from Coconut Grove to Cutler ridge. In addition, there are artificial exposures made in a cut that was excavated to improve the view of the grounds from the house.

Rock type(s)

Observations
The rock is a white to cream-colored rock composed mainly of spherical grains and shell fragments. It effervesces when acid is applied, indicating that the grains are composed of calcite (calcium carbonate – $CaCO_3$), and therefore the rock is a limestone. 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 *ooid s*. A grainstone composed predominantly of ooids is termed an *oolite*. Microscopic examination shows that these sand grains are made up of concentric layers around a small central nucleus of either shell fragments or small quartz grains. Mapping of the oolite shows that it made up a continuous *oolite bank* that forms the Atlantic Coastal Ridge which is in the eastern parts of Miami-Dade and the southern part of Broward county.

Fossil studies and uranium-lead dating indicated that the limestones of the Miami Formation were produced in the Pleistocene epoch, about 125,000 years ago – very young by geological standards.

Three macro fossils can be found at this locality. Two sand dollar fossils, one about 10 cm in diameter, the other about 3 cm diameter can be found at locality SD. Part of a possil conch is seen nearby at locality C.

Interpretation
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. If this is the case, then sea level at the time of the deposition of the Miami Formation would have been about 10m (~30 ft.) higher relative to the land than a present. As Florida is tectonically very stable it is more likely that this higher level was the result of global sea level rise rather than uplift of South Florida. This view is supported by many other studies that indicate that the Miami Formation was deposited in the last interglacial stage (Sangamon) when sea level was indeed about 10m above the present sea level.

Sedimentary structures
Observation
The main bedding surfaces are horizontal and about 20-30cm thick. These surfaces define "packets" within which are subsidiary laminations which dip at an angle of about 25^0 to the main bedding surfaces. These subsidiary strata are known as cross beds. Note that the majority of the cross beds dip toward the E or SE, but that a few cross beds dip W to NW. These are best seen in the cut, or in in the doline at locality **D**.

Interpretation
Cross bedding has been shown to result from deposition by horizontally moving water or air. The cross laminations dip in the direction of the movement of the currents. In this case, this suggests that the majority of the currents were roughly perpendicular to the trend of the oolite bank and the ancient coastline.

The detailed topography supports this view. The generally N-S trending Atlantic Coastal Ridge is transected erosional channels (Figure 1) that formed due to currents draining the lagoonal area on the landward side of the ridge. Similar topography is seen on the actively forming oolite sand banks in the Bahamas at the present day.

The cause of these currents is uncertain. One possibility is that they are caused by tides, allowing water to drain from the lagoon behind the oolite bank during low tide, and for ocean water to drain into the lagoon during high tide.

This author thinks that it is more likely that the cross-bedded packets were deposited after seasonal, or extreme weather events. High summer rainfall, or tropical storms, would fill up the lagoon and produce land-to-ocean currents lasting many days. Storm surges could cause ocean-to-land currents, but these would probably be much more short-lived than the lagoon draining events.

The rubbly layer is probably the result of a storm event in which coarse material from the coastline was moved inland by high energy oceans waves.

Landform Development (geomorphology)

Silver Bluff
The outcrop has the form of a small bluff, or cliffcliff, At locality **N**, the cliff is undercut, with a distict notch at the base. At the top of the outcrop, there are small spoon-shaped pits, attributes to solution by rainfall (*solution pits*).

Interpretation
The undercutting of the oolite bank was produced by wave action to produce the cliff and the *wave-cut notch* at its base. After the formation of the oolite banks at about 125,000 years, seal level was stable until about 75,000 years ago, after which the climate became colder as the Earth entered into another glacial period. As a result, sea level dropped, and at one point stood a little above present sea level. Wave action was strong enough to erode the oolitic sand ridge, and produced the wave cut notch that can be seen at the base of the cliff at Alice Wainwright, and also at Silver Bluff in Coconut Grove.

Sea level continued to fall, and rainfall on the exposed sand banks both dissolved and precipitated calcium carbonate within the banks. The precipitation lithified the sand banks into solid rock, and the solution created cavities of the order of a few centimeters in the formation. This karstification process continues to the present day. In fact, the *karstification* of the Miami and Ft. Thompson Formations in the Late Pleistocene has resulted in a high permeability and porosity in the Biscayne Aquifer, which makes it one of the most productive aquifers in the U.S. You owe every glass of water and every shower to the Late Pleistocene drop in sea level!

Case hardening
At several places on the cliff, detail of the cross bedding is obscured by a layers that seems to cover the outcrop. This is the result of solution of the limestone by rainwater and then the re-precipitation the calcite in the pores in the outer centimeter layer of the outcrop. This is very common in limestones in the tropics and is known as *case hardening*.

Doline
The closed, conical depression at locality **D** is typical of karst weathering and is known as a doline. As dolines are closed depressions, rainfall drains through the bottom of the doline and goes directly to the water table. Ford and Williams (1989) note that there are several types of dolines, and this author interpretsa this one as being a solution doline. The rock pinnacles within the doline are typical of karren (ie limestone surface features) formed under sub-soil conditions.

Solution pipes
To the west of the Smiley Center Meeting Room by Palm Walk B East, there are a series of solution pipes and pits in the limestone. Such vertical, cylindrical pipes are thought to be due to solution by rainwater. However, there may also be some upward solution from the water table. Such solution pipes may eventually coalesce to form larger doline structures.

References and further reading

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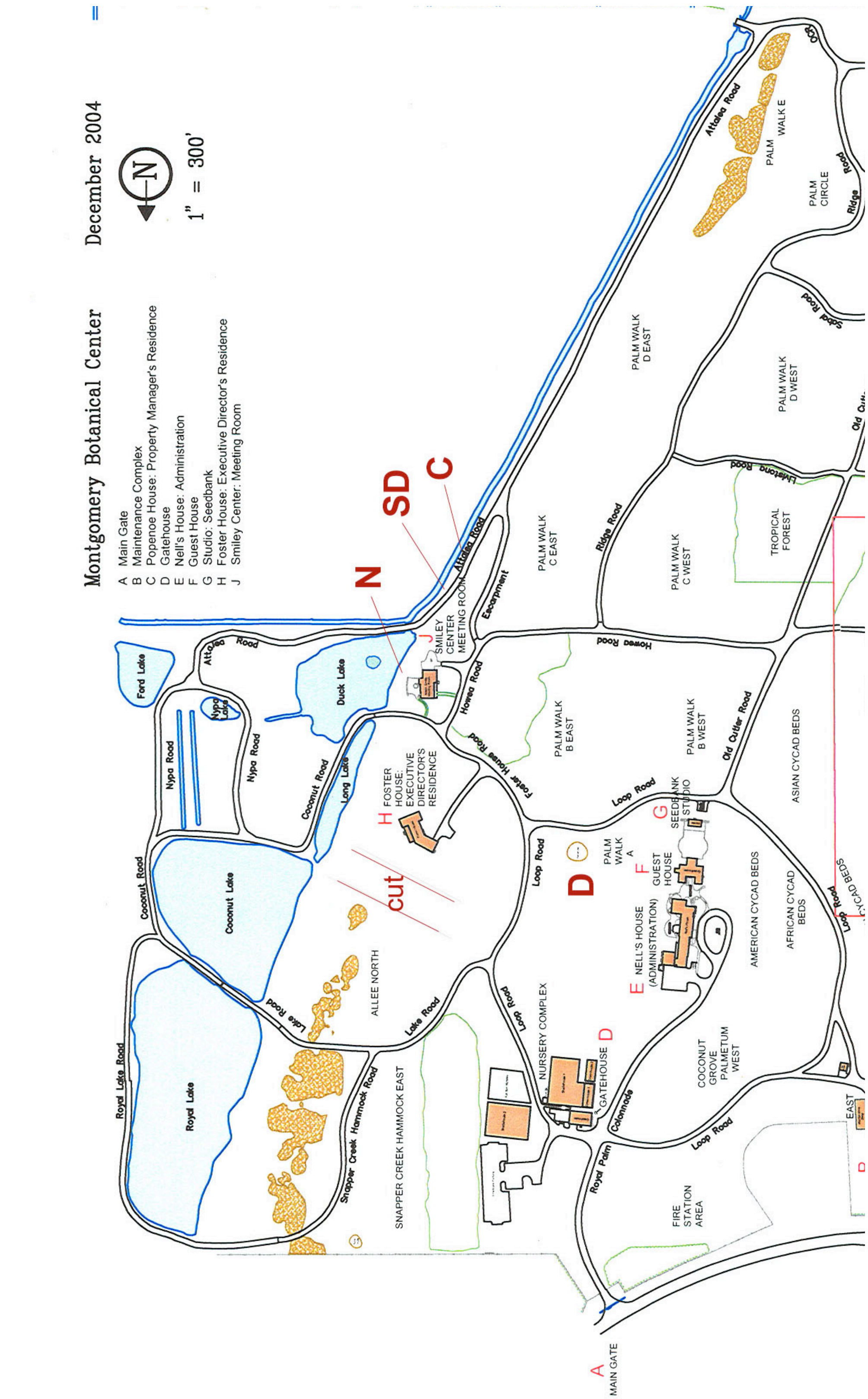
Montgomery Botanical Center
A Main Gate
B Maintenance Complex
C Popenoe House: Property Manager's Residence
D Gatehouse
E Nell's House: Administration
F Guest House
G Studio: Seedbank
H Foster House: Executive Director's Residence
J Smiley Center: Meeting Room
December 2004
N
1" = 300'
N
SD
C
cut
D
Royal Lake
Coconut Lake
Duck Lake
Ford Lake
Long Lake
Nypa Lake
Royal Lake Road
Coconut Road
Nypa Road
Attalea Road
Lake Road
Loop Road
Snapper Creek Hammock Road
Howea Road
Foster House Road
Escarpment
Ridge Road
Old Cutler Road
Livistona Road
Sabal Road
Royal Palm
Colonnade
SNAPPER CREEK HAMMOCK EAST
ALLEE NORTH
FOSTER HOUSE: EXECUTIVE DIRECTOR'S RESIDENCE
SMILEY CENTER MEETING ROOM
PALM WALK B EAST
PALM WALK B WEST
PALM WALK C EAST
PALM WALK C WEST
PALM WALK D EAST
PALM WALK D WEST
PALM WALK E
PALM CIRCLE
TROPICAL FOREST
ASIAN CYCAD BEDS
AMERICAN CYCAD BEDS
AFRICAN CYCAD BEDS
CYCAD BEDS
PALM WALK A
SEEDBANK STUDIO
GUEST HOUSE
NELL'S HOUSE (ADMINISTRATION)
NURSERY COMPLEX
GATEHOUSE
COCONUT GROVE PALMETUM WEST
FIRE STATION AREA
EAST
MAIN GATE