The Florida Everglades: A Buried Pseudoatoll?

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ABSTRACT


Based on biostratigraphic data, the Everglades region of southern Florida is shown to contain a number of problematical geomorphological features, including an elongated, lagoon-like central basin surrounded by a large, atoll-like ring of fossil coral bank reefs. The youngest and largest reef tract is of Pliocene age, and underlies the Atlantic Coastal Ridge and the other topographic highs that surround the Everglades. Since both the distinctive atoll-like feature and the lagoon-like central basin are not associated with any known volcanic or tectonic process, the term pseudoatoll is used for this type of ring-shaped reef tract. It is hypothesized that the Pliocene pseudoatoll possibly represents an enlarged version of several older, increasingly-smaller, pseudoatolls that had built northward up the carbonate platform. The existence of an initial, smallest pseudoatoll of Oligocene age is hypothesized, and this may have formed around a small, collapse feature under the southern part of the Everglades. It is here proposed that the collapse feature represents the remnants of a simple astrobleme that was produced by a meteorite impact in the late Eocene. The existence of a Floridian astrobleme is supported by several lines of geological and geophysical evidence, some of which include: the absence of late Eocene (Ocala) sediments, and the presence of abundant fracture zones and gravity lows (~5 milliGals) under the southern Everglades; a valley-like depression in the middle Eocene limestones (Avon Park) below the missing late Eocene; the existence of a strong magnetic anomaly (100-250 nannoTeslas) in the deepest part of the basin; and the fact that the missing Eocene sediments are contemporaneous with an iridium anomaly on Barbados. The iridium anomaly is not associated with microtektites, as would be expected of a meteorite impact on a carbonate platform. The carbonate astrobleme acted as a template for coral reef growth, producing a pseudoatoll. As sea levels rose in the Neogene, the original pseudoatoll enlarged and infilled to become the Everglades.

ADDITIONAL INDEX WORDS: Everglades, Florida, pseudoatoll, astrobleme, tombolo, iridium anomaly, collapse basin, Atlantic Coastal Ridge, Eocene.

INTRODUCTION

The southern third of the Floridian Peninsula of the United States has long been considered by geologists to be a thick (approximately 5-6 kilometers) stable, carbonate platform, analogous to the Yucatan Peninsula of Mexico and the Bahamas Platform. The southern tip of Florida, in particular, contains an unusual geomorphological feature, comprising a marsh-filled, shallow, elongated to oval-shaped depression with a raised rim, that is referred to as the Everglades (Figure 1). Traditionally, the Everglades were defined as a simple, surficial basin that had formed on top of the carbonate platform as the result of late Pleistocene-Holocene dissolution by standing water (PARKER and COOKE, 1944; WHITE, 1970). The near-surface geology of this area was also presumed to be relatively simple, with planar orientation of formations (COOKE, 1945). Because of this supposed geologically uninteresting model, and because of the technical difficulties of both seismic studies and drilling in swampy areas, the late Paleogene and Neogene stratigraphy of the Everglades region had been largely ignored.

Instead of the simplistic layer cake near-surface geology for southern Florida that had been presented by earlier workers, a far more complex subsurface topographic pattern is now known to exist. Over the last ten years, the ecologically-questionable increase in building construction in southern Florida has actually proven to be a boon to surficial stratigraphers. The draining and channelization of many parts of the Everglades has allowed the first
large-scale sampling of Neogene formations. By analyzing molluscan paleontological and biostratigraphic data, assembled from collections made at canal dredgings and borrow pits around southern Florida, I found that the pattern of deposition of the Neogene formations indicated a deep subsurface depression with more relief than was previously reported. Together with data from well cores (PARKER et al., 1955; MILLER, 1980; MERRITT et al., 1983; USGS Water Resources division unpublished data), this paleontological evidence led to the discovery of an oval-shaped paleobasin beneath the present-day Everglades.

Furthermore, and most importantly, an anomalous atoll-like feature, composed of a ring of Pliocene zonated coral reefs and scattered bank reefs, has been discovered to surround the paleobasin (PETUCH, 1986). Since the southern part of the Floridian Peninsula has been tectonically inactive since the Jurassic (KLITGORD, et al., 1984) the discovery of a large basin-like feature on the carbonate platform, surrounded by a large coral atoll-feature, is quite problematical. In this paper, I present the evidence for the existence of the deep paleobasin and the atoll-feature. Based on geological, geophysical, and geomorphological data, I also propose a possible extraterrestrially-influenced mechanism for the creation of the atoll-feature and the subsequent Everglades.

Evidence For A Paleobasin And Geological Anomalies Beneath the Everglades

When the surficial regions of the Everglades are analyzed biostratigraphically, a basal pattern of deposition is easily recognizable. For example, in the Everglades region of Collier County, Pliocene marine limestone (the Tamiami Formation) is present at or just below the surface, while slightly farther north, in Broward and Palm Beach Counties, Pleistocene marine deposits are found at the surface and range to depths of over 40 meters (McGINTY, 1970; PARKER et al., 1955). Conversely near the western coast of Florida, at Estero and Lehigh, Lee County, and Mule Pen Quarry near Naples, Collier County (MEEDER, 1979), and at Sarasota (PETUCH, 1982), richly fossiliferous early Pliocene marine beds have been uncovered only 5 meters below surface. I also have encountered Pliocene coral reef deposits from shallow (15 meters) construction digs in Miami (PETUCH, 1986). These indicate that the eastern and western coasts of Florida are composed primarily of ridges of older deposits covered by only very thin veneers (5-15 meters) of Pleistocene-Holocene material (quartz sand and oolitic limestone) (PETUCH, 1986; GLEASON et al., 1984; MISSIMER, 1984). This near-surface basinal pattern of deposition within the Everglades region is shown, in a series of stratigraphic columns, in Figure 2. In this figure, the stratigraphy of two locations in the center of the Everglades basin is shown, along with one location on the western side and one on the eastern side.

Judging from the biostratigraphic data, the surficial basin of the Everglades region, then, reflects a deeper subsurface, large geomorphological feature. In being roughly oval-shaped, and with the deepest part in the extreme southern end, this large, caldera-like basin is unique, with no counterpart known from any other carbonate platform, and has a decidedly non-karstic appearance when viewed on a large scale. Stratigraphic data from cores and well logs show that the structural basement of this
Figure 2. Correlation of stratigraphic columns from locations within the Everglades region. The columns were assembled from biostratigraphic data collected by dredging operations at Mule Pen Quarry (MP) near Naples (MERDER, 1979; 1980), the Griffin Brothers Quarry (G) and along the North New River Canal (N) in central Palm Beach County, and at Bird Road in Miami (M) (PETUCH, 1986). Pleistocene formations include the Fort Thompson (FT), Miami Limestone (M), Bermont (Be), and Caloosahatchee (C); the Pliocene is represented by the Buckingham Formation (=Pinecrest Beds) (Bu); stippling represents unfossiliferous, undifferentiated sands; P=Everglades Peat.

feature lies in the Eocene formations and that the uppermost Eocene group of formations, the Ocala Group (Jackson age), is completely missing in the southern and southeastern parts of the state (MERRIT et al., 1983; MISSIMER, 1984) (Figure 3). Here, late Oligocene sediments (the Suwannee Formation) unconformably overlie a middle Eocene formation (the Avon Park). Judging from this disconformity, the event that initiated the formation of the Everglades basin can be dated as having taken place in the late Eocene.

The underlying early Eocene formations (Lake City and Oldsmar) characteristically contain gypsiferous limestones and anhydrite beds, and these are well developed under the central and northern parts of the peninsula. The anhydrite beds, however, are missing under the Everglades (Figure 4). Here, there is a shift in lithofacies and the anhydrite beds are replaced with a dolostone-limestone facies and the problematical “boulder zones” (drillers term), "high transmissivity zones," or "cavity zones" that are found in the southern end of the state (MERRITT et al., 1983; PURI and WINSTON, 1974). These labyrinthine vugs and interconnected cavities may have formed by subsequent dissolution enlargement of fractured limestone. The two large gravity lows of less than −5 milliGals, shown by KLITGORD et al., (1984) in the Everglades region (reproduced here in Figure 5), may be related to these cavity zones. Unfortunately, these boulder zones make seismic interpretation difficult and have limited the amount of oil exploration along the southwestern part of the Everglades (APPLEGATE, 1986).

Large fractures and fracture zones are also abundantly present in the missing anhydrite and dolos-
Figure 3. Contours, in meters below present surface, of the top of the southern Floridian Eocene. Stippled area delineates the region where the late Eocene Ocala group of formations is missing, and where the middle Eocene Avon Park formation is unconformably overlain by Oligocene sediments. (Taken from MERRETT et al., 1988, with depths converted from English system to metric system.)

The deepest part of the basin is located in the southern end of the Everglades, under Everglades National Park. This deep depression is best seen by following the contours of the upper surface of the Oligocene Suwannee Formation, the first formation to be deposited after the late Eocene event. Below the Atlantic Coastal Ridge, upon which the cities of Miami, Fort Lauderdale, and Palm Beach are built, and around the edges of the Everglades, the Suwannee can be found at depths of 200-250 meters. In a small area below the southern Everglades (Figure 5), however, the Suwannee plunges to depths of over 400 meters (PURI and WINSTON, 1974). This depression in the Oligocene corresponds to a northwest-southeast trending valley, averaging 100 meters depth, that is carved into the underlying middle Eocene limestone (Figure 3). This valley-feature may have originally been a crater-like feature in which the western rim had eroded away.

A strong magnetic anomaly surrounded by a steep magnetic gradient, corresponding exactly to the valley-like depression in the middle Eocene Avon Park Formation, has recently been detected in the Everglades (KLITGORD et al., 1984) (Figure 5). This geographically small anomaly, with a field of between 100-250 nannoTeslas, stands out strikingly from the surrounding low magnetic area of only 0-10 nannoTeslas, that extends for over 300 kilometers to the north, south and west, and for over 100 kilometers to the north and east. The characteristic low magnetism of the surrounding areas of the Florida Platform relates directly to the predominance of undeformed carbonate rocks, which are over 5 kilometers thick below the Everglades region. Considering, that this is the thickest accumulation of carbonates on the entire peninsula, the Everglades is the least likely place to expect to encounter a magnetic high. The presence of a lone, very high magnetic anomaly, coincident with the Eocene valley-like depression, therefore, is a most intriguing feature.

**Geomorphology and Paleontology of the Everglades Pseudoatoll**

The previously-mentioned atoll-feature that surrounds the Everglades basin is structurally complex and may represent several increasingly-larger oval coral reef tracts, one built upon the other. As far as is presently known, this unusual biogenic geomorphological feature, like the central Everglades depression, is unique, with no other similar symmetrical reef complex being found on other carbonate platforms around the world. Structurally, this coralline feature is not a true atoll, since it is not derived from a subsiding volcanic island or caldera and is apparently not related to any tectonic mechanism.

I here use the geomorphological term pseudo-
Florida Everglades Pseudoatoll

Figure 4. Schematic cross-section of southern Florida, on a transect from Haines City (H), across Lake Okeechobee (OK) and the Everglades (E), to Key Largo (KL). Depth in meters. Eocene formations include the Ocala Group (Oc), Avon Park (A), Lake City (L), and Oldsmar (Ol). The Oligocene is represented by the Suwannee Formation (S). The fracture (brecciated?) zone (F) and the cavity ("boulder") zone (Z) are present below depression. Stippling represents amount of anhydrite present in limestones. (Adapted from F. MEYER, USGS, unpublished map and data, and PURI and WINSTON, 1974.) Vertical exaggerated approximately 70,000/1.

The Everglades pseudoatoll is composed of two main sections: (1) the southern distal section, which corresponds to the southern rim of the depression in the Paleogene formations, and (2) the northern proximal section that has expanded northward up the slope of the carbonate platform. During the time of maximal growth in the Pliocene, the distal section comprised roughly the southern one-third of the pseudoatoll, while the proximal section made up the expansive northern two-thirds. In the Recent this maximal distal section underlies the topographic highs of the Big Cypress Spur, the Everglades Keys, the Silver Bluff Scarp, and the southern end of the Atlantic Coastal Ridge (Figure 1). The maximal proximal section, in turn, underlies the Immokalee Rise, the Atlantic Coastal Ridge, and some of the low ridges north of Lake Okeechobee along the Okeechobee Scarp.

Although the pseudoatoll may have begun to form in the Oligocene, as proposed later in this paper, only the uppermost, near-surface, Pliocene portion has been sampled in any quantity. On the topographic highs surrounding the present-day Everglades, large quantities of Pliocene index...
Bird Road, Miami (PETUCH, 1986). Zonation of patterns within some of these coral assemblages, as found on modern atolls, were also described by Meeder and myself. High energy, surf-loving coral genera such as Acropora, Stylophora, Montastrea, and the hydrocoral Millepora (Figure 6A) were found along the western edge of the distal section, while the eastern edge of the distal section contained a rich fauna of solitary, lagoonal genera such as Placocyathus and Manicina and also lagoonal ecophenotypic morphs of the hydrocoral Millepora.

The molluscan fauna of the Pliocene pseudoatoll is equally as rich and characteristic as the coralline fauna. The best samples to date have been taken at Bird Road, Miami, and these collections yielded over three hundred species of reef-associated gastropod mollusks (PETUCH, 1986). Typical coral reef-loving gastropod genera that were most commonly collected included the muricids Vitularia (Figure 6J) and Muricopsis (Figure 6L), the coralliophagous magilid Babelomurex (Figure 6K), the gorgonian ectocommensal ovulid Cyphoma (Figure 6G), the mitrid Scabricola (Figure 6E), the columbellid Parametaria (Figure 6F), the turbinellid Hystrivasum (Figure 6M), and the conid Virgiconus (Figure 6D). All of these genera, with the exception of the extinct Hystrivasum, are common reef or hard substrate-associated organisms in the Recent, and can be considered to be good indicators of Neogene coral reef environments.

Of special interest, as an index fossil for the Pliocene pseudoatoll, is the calyptraeid genus Trochita (Figure 6B), which is extinct in the Recent Atlantic but is found in rocky areas of the Recent Eastern Pacific that are pounded by heavy surf (KEEN, 1971). This genus has been collected at the Brighton Indian Reservation (OLSSON and PETIT, 1964) along the northern proximal section, and has been found to be abundant at Miami along the distal section (PETUCH, 1986), indicating that these areas were exposed to surf. Trochita, and many of the other Pliocene reef gastropods, have not been found elsewhere in the United States outside of southern Florida, and these must have been confined to the pseudoatoll and its associated bank reefs. Besides the gastropods, reef-associated pelecypod mollusks, including the genera Spondylus, Chama, Lima, Rupellaria, Coralliophaga, Barbatia, and Gastrochaena, have also been collected at the Bird Road site (PETUCH, 1986; STANLEY, 1986). Similar pelecypod faunas have been found at the other reef locations shown in Figure 7.

Specimens of Pliocene coral reef index fossils, primarily mollusks, have also been taken along the distal section of the pseudoatoll in well cores at Krome.
Avenue, Miami (PARKER et al., 1955) and from along the proximal section at Palm Beach (SWAYZE and MILLER, 1984) (as reefal limestones and shells), and from canal digs at Fish Eating Creek (OLSSON and PETTIT, 1964; OLSSON, 1967) and Olga on the Caloosahatchee River (MANSFIELD, 1939). Quarries at Acline (TUCKER and WILSON, 1932; 1933), Buckingham (type locality of the Buckingham Formation) (MANSFIELD, 1939), and Pine-crest (type locality of the "Pinecrest Beds") (OLSSON and PETTIT, 1964; OLSSON, 1967), have all yielded similar reefal or reef-associated faunas.

An Astrobleme Analogue to the Everglades and a Contemporaneous Iridium Layer

A similar, although much smaller, analogue to the basinal structure in the southern part of the

Figure 6. Some characteristic reef-associated invertebrates collected from the Pliocene pseudoatoll of southern Florida. Gastropods include *Trochita floridana* (B), *Scabricola lindae* (D), *Parametaria lindae* (F), *Cyphoma finkii* (G), *Vitularia linguabison* (J), *Babelomurex* sp. (K), *Muricopsis lyonsi* (L), and *Hystrixovum olssonii* (M); coelenterates include the hydrocoral *Millepora* sp. (A), and the scleractinians *Sextastrea crassa* (E), *Diploria sarasotana* (H), and *Phyllogia floridana* (I).
Figure 7. Schematic diagram showing the possible configuration of the Floridian pseudoatoll during its maximum development in the Pliocene. Black areas denote land above mean sea level, stippled areas denote coral reefs; contours show depth in meters below mean Pliocene sea level. The last and largest pseudoatoll shallowly underlies the Recent ridge system that surrounds the Everglades. Pliocene coral reef index fossils have been collected, in well cores and dredging operations, at Fish Eating Creek (F), Brighton Indian Reservation (BR), West Palm Beach (P), Bird Road Miami (B), Krome Avenue, Miami (K), Pinecrest, Tamiami Trail (PC), Mule Pen Quarry, Naples (M), Estero (E), Buckingham (stratotype of Buckingham Formation) (T), and at Olga (O).

Everglades can be seen in the buried Viewfield Crater of the Williston Basin in Saskatchewan, Canada (SAWATZKY, 1975; LEVIE, 1986). There, a large subterranean depression had been detected and, like the Everglades, had been found to overlie areas of missing evaporite beds and brecciated sedimentary rocks. The Viewfield Crater was further shown to have formed as the result of a Triassic-Jurassic meteorite impact on an area that was underlain by anhydrite beds. This impact produced a simple astrobleme, one without a central uplifted area (SAWATZKY, 1975; LEVIE, 1986).

Although all surficial features had been obliterated by subsequent erosion, deeper radial fracture patterns were discovered below the Viewfield astrobleme. These fractures had become the focal point for the accelerated dissolution of the evaporites below the impact area and, subsequently, led to the formation of a symmetrical collapse basin. Taking into account the caldera-like geomorphology of the Viewfield Crater and the similar geological setting in southern Florida, the basin below the southern third of the Everglades may have resulted from a similar situation involving an asteroid impact. Since astroblemes are known to be excellent sedimentary traps that result in localized petroleum reservoirs (LEVIE, 1986), it is also interesting to note that the only producing oil field on peninsular Florida (Corkscrew field) corresponds to deep fractures and faults below the western and southwestern sides of the Everglades (APPLEGATE, 1986; McCASLIN, 1986).

The possibility of a Floridan astrobleme is further supported by the discovery of a contemporaneous iridium anomaly in sediments in the Caribbean region. Dated as being of late Eocene age (GANAPATHY, 1982), this iridium layer appears to be of meteoric origin, and was originally thought to be mixed with a supposedly co-occurring microtektite layer that was linked to the late Eocene North American Tektite Strewn Field (GLASS and ZWART, 1979). Recent studies by SANFILIPPO et al., (1985) on Eocene-Oligocene boundary rocks in Barbados, however, have shown that the iridium anomaly and the microtektites actually occur in separate layers, with the tektites immediately above the iridium in the stratigraphic column. Furthermore, the iridium layer, and not the microtektite layer, coincided with the radiolarian extinction that is generally thought to represent the Eocene-Oligocene boundary (MAURRASSE and GLASS, 1976).

The missing layer of Ocala-aged sediments and the corresponding valley-feature in the Avon Park Formation in Florida, together, date the inception of the Everglades as being of late Eocene age. The removal of the Floridian sediments, then, would also have been contemporaneous with the production of the Barbados iridium layer. Taking into account the probable results of shock metamorphism of biogenic carbonates, a meteorite impact on a carbonate platform such as Eocene Florida would produce mostly calcium oxide and carbon dioxide. Due to the high solubility of calcium oxide in water, the remains of the vaporized meteorite would be deposited, alone, as an iridium-rich dust layer in surrounding areas. The two layers preserved in the Eocene-Oligocene rocks on Barbados, then, may have recorded the evidence of two
separate impacts; one having taken place on a carbonate platform, producing the lower iridium layer without tektites, and the second having been terrestrial, possibly hitting siliceous crystalline rocks somewhere in North America and producing the upper glassy microtektite layer. While looking over all of this data, the tantalizing question arises: are the missing Eocene sediments in Florida, their associated geological anomalies, and the contemporaneous iridium layer on Barbados causally related?

**Astrobleme Template Model for the Evolution of the Pseudoatoll and the Everglades**

Based upon the data given in this paper, I here propose a five-step model, that, I feel, best explains the problematical geomorphology and geology of the Everglades. This is an expansion of a simpler model that I had proposed previously (Petuch, 1985).

**Meteorite Impact In A Shallow Sea**

At the end of the late Eocene, a meteorite or bolide hit the extreme southeastern edge of the then-submerged Floridian Peninsula (Figure 8). Judging from the contours of the Floridian Eocene Formations, and considering that Florida has undergone subsequent isostatic adjustment, the meteorite would have struck in open oceanic conditions along the continental shelf-slope break, in about 200-250 meters of water. Upon impact, 100 to 150 meters of middle Eocene sediment were blasted off the southward-sloping platform. This exposed and shattered the underlying Avon Park Formation. Subsequent tsunamis would have further removed any unconsolidated material and would have also obliterated any ejecta rim or overturned strata that may have formed around the point of impact. At this time, a cloud of residual meteoric dust would have spread over the Caribbean region, possibly becoming the source of the Barbados iridium anomaly.

Fracture zones produced by the impact, however, extended throughout all of the underlying Eocene rocks, specifically the gypsiferous limestones of the Lake City and Oldsmar Formations, and into the Paleocene Cedar Keys Formation and underlying Cretaceous limestones. Judging from the dimensions of the remnant valley-depression in the Avon Park and the corresponding depression in the Oligocene Suwannee Formation, and from the size of the surrounding fracture zone, the original impact structure may have been only two or two and one-half times larger than the Barringer Crater in Arizona and would have been classified as a simple astrobleme. The magnetic anomaly below the Recent southern Everglades may possibly be caused by a concentration of iron-nickel condensate microspherules mixed with limestone.

**Subaerial Exposure and the Collapse Feature**

Following this latest Eocene event, a major sea level drop took place in the Oligocene (Vail et al., 1977). The lowered sea level would have increased the gradient of the Floridan Aquifer system at that time, increasing its potentiometric head, and producing an upwelling of the aquifer into the brecciated area under the center of impact. Along with surface water infiltration into the fractures, the increased dissolution potential of the aquifer upwelling would have selectively removed all of the evaporite material in an oval-circular area, producing a collapse feature in a manner analogous to the Viewfield Crater of the Williston Basin. During this subaerial exposure, the undisturbed late Eocene sediments farther north lithified into the Ocala Group of formations.
Also during this time, the fractures in the early Eocene formations may have begun to enlarge, producing the cavities of the "boulder zones."

The Astrobleme Template

In the late Oligocene, sea levels began to rise (VAIL et al., 1977), flooding southern Florida with a shallow tropical sea. The flooded collapse feature at the southern end of the peninsula now acted as a template for subsequent coral reef growth, with the corals growing around the topographically higher rim. This reef growth around the astrobleme template produced the first, small pseudoatoll, which occupied only the southern third of what would later become the Everglades Basin. These Suwannee-aged reefs and reef-associated carbonates were deposited unconformably upon the Avon Park Formation in the central and southeastern areas of the basin. The eastern edge of the Oligocene reef tract is exposed today, offshore, in the deeper waters of the Straits of Florida, as the Miami Terrace (F. MEYER, USGS, personal communication; USGS, unpublished data on Oligocene reefal limestones).

Northward Enlargement Of The Pseudoatoll

During the Miocene and Pliocene, extended periods of higher sea levels and warmer temperatures allowed the proximal section of the pseudoatoll to expand northward, stepwise, up the increasingly-flooded southward-sloping peninsula. Each consecutive pseudoatoll, from the Miocene to Pliocene, became increasingly larger, until the entire structure was three or four times larger than the original astrobleme and collapse basin. The northern two-thirds of the Everglades basin, then, formed as a lagoon inside the pseudoatoll, while the southern third of the Everglades basin represents the collapse basin. The stepwise northward expansion of the pseudoatoll is shown, schematically, in Figure 9.

During the time of the Buckingham and Tamiami Formations (Pliocene), the pseudoatoll had grown above sea level by detrital build-up, producing a ring of coral islands around an oval, inland sea. By this time, the mainland of Florida had grown southward by longshore transport, connecting with the proximal section of the pseudoatoll to produce a giant tombolo. If this is the case, then, the emergent part of the Florida peninsula that rests on the carbonate platform represents the largest known tombolo. The peninsula would also be the only tombolo known to have formed by the fusion of an offshore atoll reef with a continental mainland.

The Proto-Everglades

By the end of the Pleistocene, the pseudoatoll

Figure 9. Schematic cross-section of southern Florida, on a transect from the Brighton Indian Reservation (B) across Lake Okeechobee (O) and the Everglades (E), to Miami (M) and Key Largo (KL), showing the probable arrangement of successive pseudoatolls. Depth in meters. Stippling represents areas of coral bank reef build-up, showing the eustatically-controlled, stepwise, northward expansion of the pseudoatoll. Eocene formations include the Ocala Group (Oc), Avon Park (A), and Lake City (L), and the Oligocene is represented by the Suwannee Formation (S). Neogene formations include the Miocene Tampa and Hawthorn (T-H), the Pliocene Buckingham (=Pinecrest Beds) (B), and several thin Pleistocene units, grouped collectively as PL. Vertical exaggerated.

lagoon had infilled with carbonate sediment, causing it to retain only a remnant of its original morphology. During the Sangamon Interglacial, ultrahigh sea levels permitted thin layers of sediments to be deposited on top of the island chain. These sediments include the oolitic limestones (Halley and Evans, 1983) and quartz sands that characterize the surficial sediments of the Recent Atlantic Coastal Ridge and other rim areas.

A large freshwater lake filled the basin in the latest Pleistocene (Brooks, 1984), laying down the peats and freshwater marls that characterize the thin surficial sediments of the central Everglades. The last remnant of this proto-Everglades precursor lake is found in Lake Okeechobee, which still retains the basinal oval-circular shape of the pseudoatoll lagoon.

CONCLUSIONS

As outlined in this paper, three mechanisms, working synergistically, are probably responsible for the creation of geomorphological features such as the Everglades and the pseudoatoll. The first, and most important, is an initial meteorite impact, which produced the structural framework for subsequent deformation. The second is the formation of a simple astrobleme-collapse basin, resulting from increased dissolution of brecciated material during a time of subaerial exposure. The third represents a biogenic component, in the form of coral reef growth put down during eustatic highs, which consolidated, preserved, and enlarged the original astrobleme template.

The Everglades possibly may represent a new category of astrobleme: one that initially forms on a thick carbonate platform in shallow water, and later results in the formation of a pseudoatoll of bank reefs. These carbonate astroblemes would be associated with contemporaneous iridium anomalies, alone, and not with tektite layers.

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Lage ein "Pseudoatoll" genannt. Die Hypothese wird entwickelt, dass das Plioz anpseudoatoll repriisentiert
in the Surficial Aquifer of
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RESUMEN

Basándose en datos bioestratigráficos, se describe una problemática geomorfológica de la región Everglades, al Sur de
Florida. En ella aparecen sistemas lagunares y arrecifes coralinos. Se denomina "seudoatolones" a las formaciones
analísmicas que se desarrollaron en la plataforma. Finalmente, la elevación de nivel del mar en el Neogene el
seudoatolón original se extendió y relleno constituye 10 que hoy en día constituye la región
Everglades.--Miguel A. Losada,
Universidad de Santander, Santander, Spain

ZUSAMMENFASSUNG

Auf dem Grund biostratigraphischer Daten wird es demonstriert, dass viele fragliche geomorphologische Merkmale im
Evergladesgebiet des südlichen Floridas zu finden werden. Unter sich gibt es eine verlangerte, lagunenförmi­
gene Zone, die von einem atollformigen Ring der Korallienriffe umringt ist. Das eigenartige atollformige Merkmal und die
pseudoatolones que se desarrollaron el Norte de la plataforma. Finalmente, la elevacion de nivel del mar en el Neogeno el
uesto que hoy en día constituye la región
Everglades.--Stephen A. Murdock, CERF, Charlottesville, Virginia, USA