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Karst Morphology and Geotourism Potential of The Mfamosing Limestone Calabar Flank, South Eastern Nigeria

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Abstract
The mid-Albian Mfamosing Limestone located within the Calabar Flank S.E. Nigeria is a carbonate platform with significant karst. This carbonate buildup as typified by the Etankpini, Abung and Mfamosing Karst lands has evolved significant karst features. Surficial expressions of these include: towers, pinnacles and karrens. Subterranean caves, spelcotherms. phreatic tubes, dolines, uva1as and corrosion plains (swamp notches) form characteristic landforms. The intense karstification of this limestone unit is related to its burial history, especially the late Cenezoic (Pliocene) uplift associated with the adjacent Cameroon volcanic zone. Mfamosing karst field is an excellent field laboratory for carbonate and anthropological studies. It also provides captivating recreational sites for tourism (Geotourism).

Keywords: *Mfamosing Limestone, Etankpini, Etankpini karstlands, Karstification, Geotourism*

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I. Introduction

Karst is a comprehensive term applied to limestone or dolomite and gypsum areas that possess a topography peculiar to and dependent upon underground solution and diversion of surface waters to underground drainage systems with sinkholes and caves in a wide variety of climate and tectonic settings (Thonbury, 199I). Limestone is abundant in nature but full development of karst features is restricted to relatively small number of localities. Globally, significant karsts are found in the following localities: Causse de sauveterre region of southern France, Spanish Andalusia, Northern Yucatan and Tabasco in Mexico, Jamaica, northern Puerto Rico, western Cuba, central New Guinea, New South Wales, and Western Australia. Also major karst development is found in the Great Valley region of Pennsylvania, Maryland, Virginia and Tennessee, a belt extending from south-central Indiana into west central Kentucky; central Florida, and the Salem-Springfield Plateaus area of Missouri all in the United States, south China and The Tham Luang Nang cave system in northern Thailand made famous by the 2018 rescue of a junior football team.

In Africa, significant limestone karst features have been found in kasai and Mount Hoyo areas of Zaire, Tanga in Tanzania, and Ankara plateau in Madagascar, Petters and Reijers, 1996 (fig. 1). Major west African carbonates include the late Precam brian Devonian dolomitic and Stromatolitic limestone of the Taoulein Intracratonic basin in Mali, Guinea, Senegal and Burkina Faso, others are the thick Jurassic - lower Cretaceous carbonate found in the subsurface of North-West African coastal basins from Morocco to Senegal. Cretaceous- Tertiary carbonates, hardly exceeding 20m in thickness, are commonly intercalated within predominantly siliciclastic sequences in Nigerian basins. The Albian Mfamosing Limestone (fig. 2) is the only West African carbonate platform with significant karst features although similar carbonates are found in the coastal basins of Gabon to Angola (Petters and Reijers, 1996). Mfamosing limestone karst field covers Abung, Etankpini and Mfamosing areas of Calabar Flank, southeastern Nigeria. The aim of this study is to identify the various Karst Landforms of the Mfamosing Limestone Karstfield,Clabar Flank, southeastern Nigeria and access their economic viability in terms of their geotourism potential.

Figure 1: Limestone occurrences in Africa

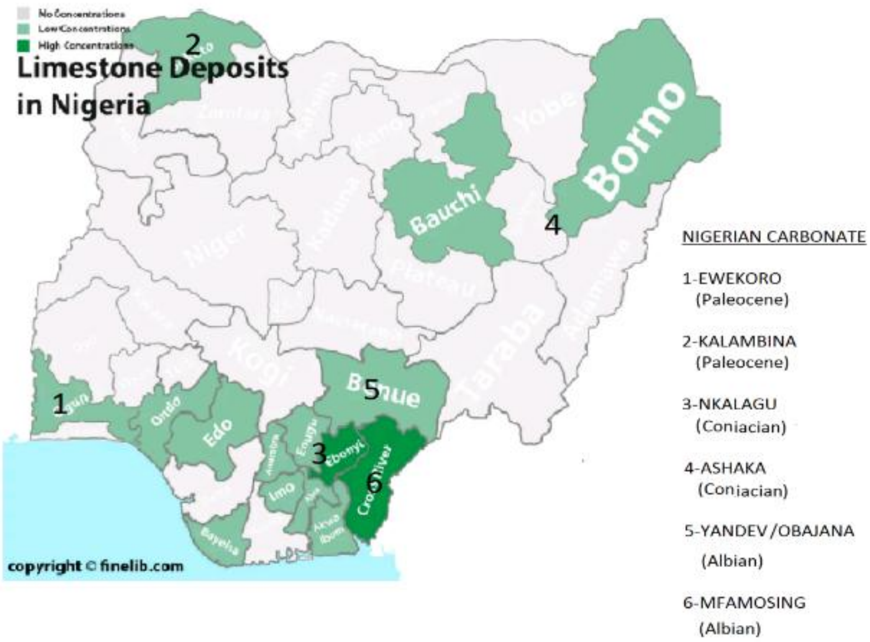

Figure 2: Major Limestone occurrence in Nigeria

Geological setting

The Mfamosing limestone extends over a distance of 135kms from the Nigerian-Cameroun boundary in the south-east, and along the northern margins of the Oban Massif, it interfingers with the sandstones of the eastern parts of Abakiliki trough. The carbonate which previously was 50m thick in the type section and 450m in the subsurface has been reduced drastically probably due to indiscriminate quarrying and continuous weathering. Mfamosing limestone is the thickest limestone section in Nigeria (Reijers and Petters, I987). The expansive Mfamosing limestone karst field has best outcrops with extensive karst development at Utuma village near the bank of Cross River across Ikot Okpora, Etankpini village, Abung and Mfamosing village (fig. 3).

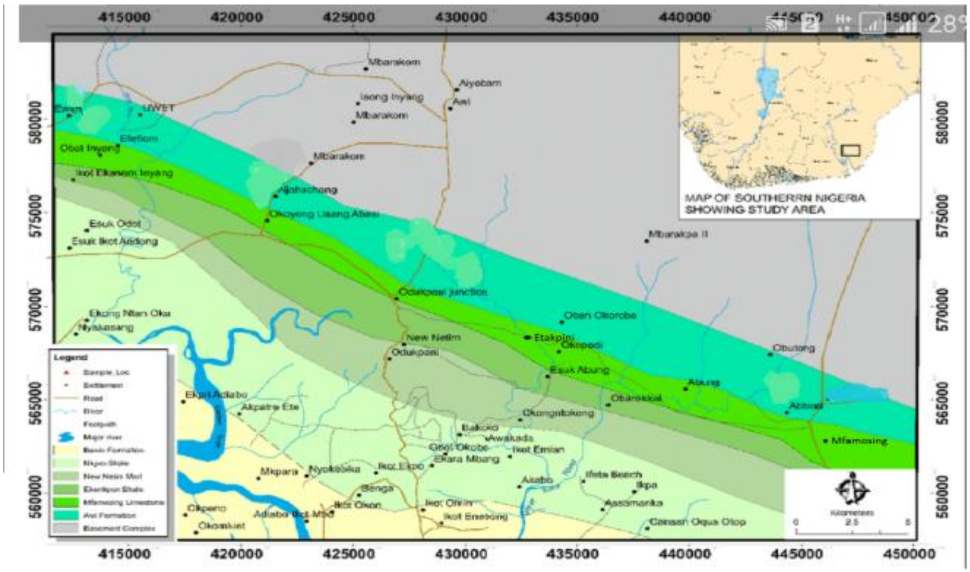

Figure 3: Outline Geological map of the Calabar Flank showing locations of Karst lands in the Mfamosing Karst field, S.E. Nigeria

The karst sites proper are not easily accessible as most of them are covered by thick virgin forest and highly flooded mostly during rainy season. The Mfamosing Karst field, the area under study is situated between longtitudes 8°00' and 8°45' East and latitudes 5°05' and 5°25' North. Favourable climatic and weathering conditions of tropical rainforest which include copious rainfall (over300mm/ yr), luxuriant vegetation and warm temperature. The origin of the Calabar Flank is intimately associated with the development of the Benue rift system. These events are related to opening of the South Atlantic and existence of a RRR triple junction which was active in Early Cretaceous (Burke et al., 1970).

Two principal sets of faults were produced by the initial rifting of Nigerian margin: NE-SW and NW-SE systems. The NE-SW bound the Benue depression while NW -SE bound the Calabar Flank. The major tectonic elements of the Calabar Flank include the Ikang Trough, which for most part of the depositional history was a mobile submarine ridge (Fig 4). Vertical movement of faulted blocks dominated the tectonics of the Calabar Flank. Also folding of the sedimentary strata is observable at the type section of Awi Formation and between 25 and 32 kilometer stones along the Calabar - Itu road. This observation is in line with an earlier report of a minor folding activity towards the close of the Cenomanian in the Benue Trough (Nwachukwu, 1972).

Lithostratigraphic development of the Calabar Flank appears to have been controlled by vertical movements of faulted crustal blocks, notably the Ituk High and Ikang Trough. The stratigraphic evolution of the Calabar Flank has been proposed and revised by several authors (PettersReijers, 1996*)*, (Fig.4). Sedimentation in the Calabar Flank started with the deposition of Awi Formation (Ade1eye and Fayose, 1978), consisting of fluviode1taic grits, shales, mudstones and arkosic sandstones of probably Aptian age. This unit uncomfortably overlies the Precambrian basement complex of Oban Massif. The Awi Formation is overlain by Mfamosing limestone which was deposited in a wide variety of environmental settings during the first marine transgression in the Gulf of Guinea in mid Albian times.

The overlying Ekenkpon shale is separated from the Mfamosing limestone by a hard ground. This thick sequence of black, highly fissile shale with minor intercalations of marls, calcareous mudstones and shale beds spans late Albian -Cenomanian Turonian age.Coniacian New Netim marl overlies the Ekenkpon shale. Santonian and early Campanian sediments have not been reported in the Flank, representing a period of non-deposition and/or erosion. Late Campanian to Maastrichtian sediments are characterized by dark grey carbonaceous friable shales with intercalations of mudstones and gypsiferous beds of the Nkporo Formation deposited in a variety of environment settings which included shallow, open marine, parallic and continental regimes. Tertiary to Recent sediments in the Calabar Flank are represented predominantly by the continental sands and gravel beds of the Benin Formation represented predominantly by the continental sands and gravel beds of the Benin Formation.

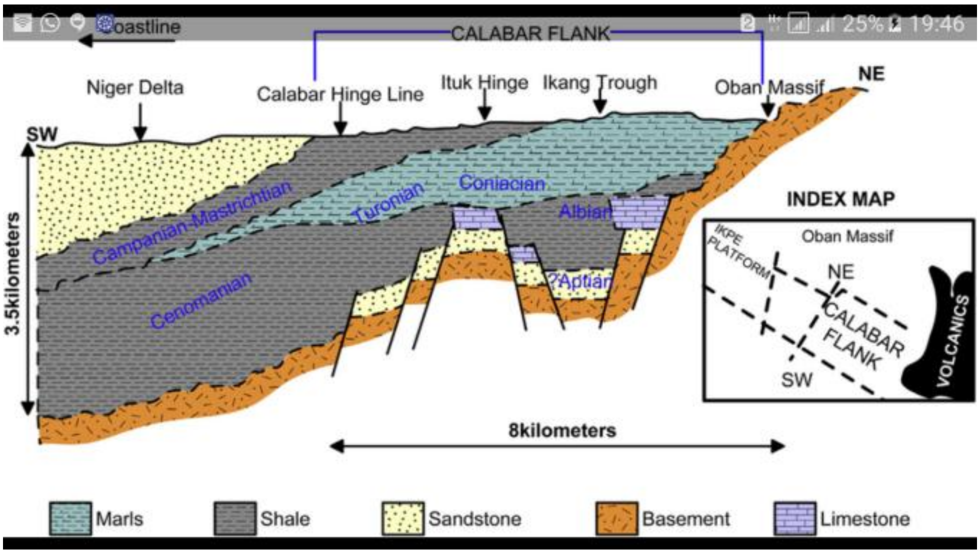

Figure 4: Structural elements and conceptual subsurface distribution of Creteceous sediments in the Calabar Flank (After Nyong and Ramanathan, 198S).

II. Methodology

The study involved field mapping of the Mfamosing Limestone Karstfield. Photographic documentations of the various features of the Mfamosing Karstfield was done using 13MP digital camera.Description of the Mfamosing Karst Landforms obtained from the field study were presented following the classification of Esteban and klappan (1983).

III. Result/Dicussion

Description of karst morphology

The description of karst features in Mfamosing karst field will be classified into three broad classes:

1. Subterranean landforms
2. Surficial landforms
3. Collapsed structures

Subterranean landforms

Caves

A karst cave is defined as a natural opening in a rock that is large enough for human to enter.

Within the Mfamosing karst field, caves are prominent in Etankpini area, where they are located beneath small, low conical limestone hills locally known as "ltiat Emiang" because of the large number of bats that inhabit the cave (Fig. 5-16). The cave has two main joints controlled chambers of about4 I.5m long and I.86m wide on the left chamber (plate. I) while the right chamber is about 30m long and I.3m wide. The diameter of the cave decreases from the entry point as one progresses into the cave chambers. The main entrance of the cave before the bifurcation has a width of 4.25m. The cave entrance progressively expands with time.

Petters and Reijers (I996) postulated that the cave once had a second opening to the outside at one of its far ends. However, what remains today is a day light hole that serves as a vadose shaft through which a small waterfall drops from a height of over 70m into the cave. The interior of the caves is completely dark and one can only access the cave interiors with the help of lamps. Eastward of "Itiat Emiang" cave, a proto cave is developing. The entrance of this cave is big enough for human entry but its horizontal dimension is about I0.5m long with no interconnectivity.This particular cave is rich in stalactites (fig. 5-10). Caves are not well developed in Mfamosing karst land but proto caves are developing around "Nasarawa" area ofMfamosing karst land.

Most of the caves in the study area are always flooded at the peak of the rainy season during which period the nearby rivers overflow their banks.Stromatolitic structures are prominently displayed on cave walls along the base of the limestone exposure at Etankpini (fig. 11). Also dissolution (erosional) scallops are prominent on cave walls both at Etankpini and Mfamosing karstlands (fig. 12)

Figure 5: Solid and Crystalline elongated stalactite at the left chamber of "Itiat Emiang" Cave. Note dissolution scallops on the cave wall.

Figure 6: Porous and tuffaceous Stalactites at Etankpini

Figure 7: Highly porous and tuffaceous stalactites at Abung

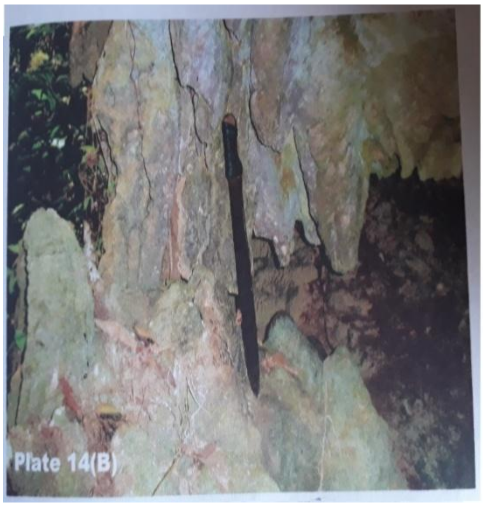

Figure 8: Porous and Tuffaceous Stalactites and Stalagmites growing syncronously at Etankpini

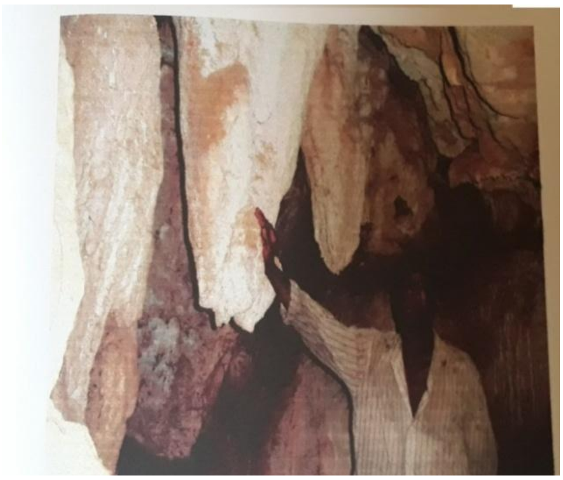

Figure 9: Solid and pseudo-crystalline stalactites in a proto-cave

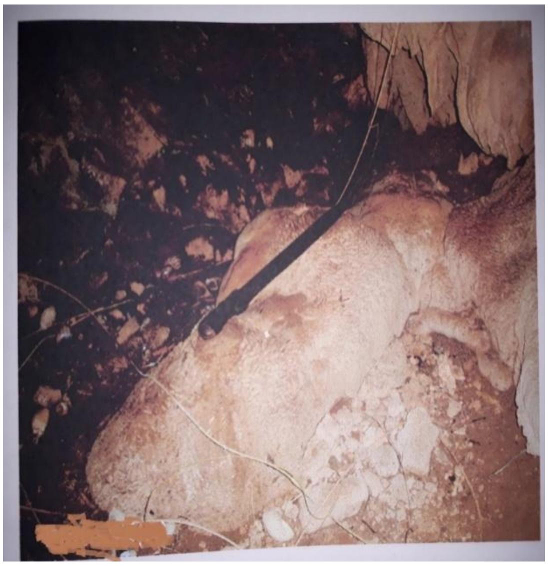

Figure 10: Mound of very solid stalagmite at Etankpini

Figure 11: Highly Stromatolitic cave wall at Etankpini

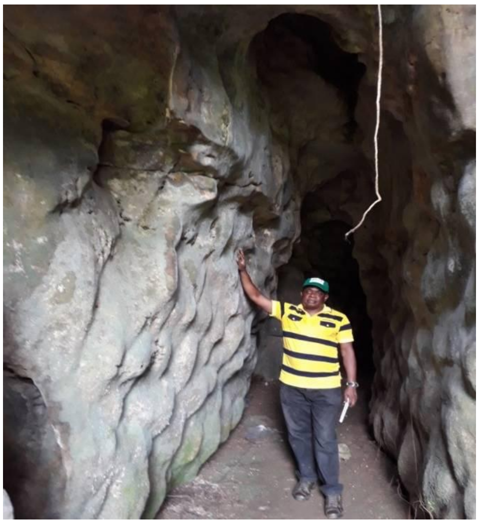

Figure 12: Dissolution scallops on cave wall at Mfamosing

Figure 13: Swamp slot at the base of a limestone tower at Etankpini

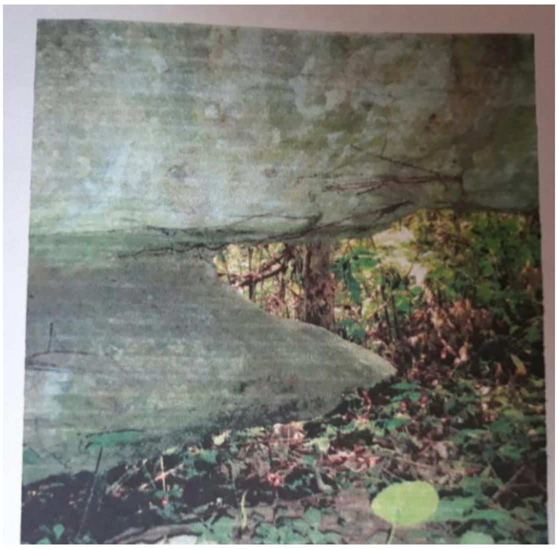

Figure 14: Two swamp notches, one above another at the base of an isolated Karst Tower at Etankpini

Figure 15: Corrosion bridge at the base of a bluff at as Abung

Figure 16: Cliff foot formed at the base of a cave wall

TABLE 1: CAVE INTERIOR DEPOSITS/STRUCTURES IN THE MFAMOSING KARST FIELD.

CLASTICS SEDIMENTS	SPELEOT-HERMS	CORROSION PLAIN	EORSIONAL SCALLOPS
Fragments and Boulders of collapsed blocks where the channel is armoured with heavy breccias load moved only during heavy flood. Encouraging channel widening and cave walls dissolution	1. Stalactites four types: * Porous and tufaceous *Elongated crystalline * Pseudo-crystalline * Solid gold-like crystalline Varies in length 4.5cm-12cm (max dimension of stalactites depend on strength of attachment to roof, strength of roof rock or dimension of cave- (Curl, 1973 a)	Corrosion plantation: are extensive and create characteristic flat roof: * Swamp slots or notches (at the base of towers) * Cliff-foot cave * Corrosion Bridge	Spoon-shaped scallops in caves of Mfanosing and Etankpini Karst land. Erosional scallops occur in packed patterns on the walls of the caves so that individuals are overlapping and incomplete. Range in length between 10 - 30cm. Asymmetrical in the direction of flow, perimeter being steeper at upstream. Scallops are important indicators of both direction and velocity of paleo-flow in relict caves
Allochthonous sands, silts and clays as cave sediments (cave earth). Sources: Fluvial and alluvial and also filtrates from overhead soils.	2. Stalagmites (are rare) Solid and Crystalline (diameter ranges between 20-65cm).		
Autogenic components from the weathering of walls or the winnowing and decomposition of older sediments. Generally, the floor sediments are mixed allogenic and autogenic fines referred to as cave earths.			

Phreatic tubes

There are common occurrences of phreatic tubes in carbonate exposures of the Calabar Flank. The tubes normally open along a major joint system through which ground water probably flowed horizontally below the water table. The phreatic tubes with circular, semicircular or quasi-elliptical outlines could have been caused by solution attack delivered uniformly around the perimeters of the subterranean drainage passages. Lange (I968) and Susteric (1979) attributed the forms of phreatic passage globally as a function of the interactions between passive variables (lithologic and structural) and active mass transfer variables (fluid velocity, solution potential, type and abundance of clastic load). Within the Mfamosing Karst field, Phreatic tubes diameters vary between 0.7m- 2.0m. Figure 17-20 show different morphologies of phreatic tubes encountered within the Mfamosing karst field.

Figure 17: Phreatic tube

Figure 18: Phreatic tube

Figure 19: Phreatic tube

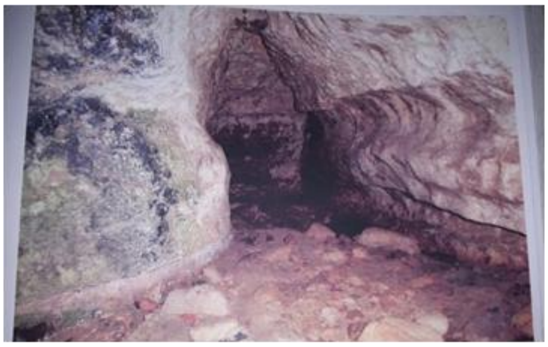

Figure 20: Phreatic tube

Surficial landforms
Towersand Pinnacles:

Mfamosing karst landscape is characterized by isolated towers and pinnacles of between 2.5m - 25m high. The tallest towers and pinnacles are found in Abung area where they are standing in muddy pond waters (fig. 21). The towers display a variety of shapes from tall shear steep sided towers to cones. Most of the towers occurs in groups rising from a common base (fig. 22-23) showing vertical walls with indentations along former joints or bedding plains. The pinnacles do not show any indentations but are steep sided (fig. 24). Towers and pinnacles are relief landforms that result from collapse and weathering of limestone outcrops. The surrounding mushy soil with dense forest litter at Mfamosing karst field is part of the karst alluvial plains.


Figure 21: Isolated Karst tower at Abung


Figure 22: Cluster of towers at Etakpini karstland


Figure 23: cluster of towers at Etakpini karstland


Figure 24: A cluster of pinnacles at Etankpini.

Lapies

The commonest forms of karren structures are rillenkarren and the circuar platform. Rillenkarren structures (fig. 25-26) display small parallel solution furrows and alternate ridges developed on a bare surface sloped limestone. They ranged from few millemeters to a few centimeters. Karren structures also developed as small dissolution micropits and etched surface with honey combed structures on surfaces of some limestones called microkarren (fig. 27). Rillenkarren develops well upon fine grained and homogeneous limestone. At many sites it appears that setting aside textural factors, the length of rillenkarren increases with an increase of gradient.

Many apparently bare carbonate surfaces are partly or entirely covered by bacteria, fungi, green algae or lichen which contributes to the preferential etching and bioerossion of weaker grains and to the development of microkarren structures. Generally, lapies show, perhaps better than any other karst feature, how minute differences in rock solubility, permeability, jointing, bedding and other physical and chemical attributes influence the rate and localization of solution by descending meteoric waters (Thornbury, 1991).

Figure 25: Rillenkarren Structures with small parallel solution furrows and ridges (hydraulically controlled) developed on a bare surface sloped limestone.

Figure 26: Rillenkarren structures with deeper parallel solution furrows and broader ridges (hydraulically controlled) developed on a bare surface sloped limestone.

Figure 27: Micropits and etched surface (honey combed) karren structures

Collapsed Structures (Karst depressions)

Two types of superficial karst depressions have developed in the Mfamosing karst field. These are dolines and uvalas Their origins are either due to the collapse (fracture and rupture) of the rock roof and soil or subsidence (sagging and settling) of the surface without obvious breaking of the soil.

Dolines (Sinkholes)

Doline derived from "dolina", a Slovenian expression for any depression in the landscape is called "Sinkhole" in North American literatures (Beck, 1984). Within the Mfamosing karst field, dolines occur with circular perimeters of up to 3-5 meters in diameter and several meters deep. The actual depth of these dolines cannot be ascertained since in most cases their top appears very hostile but estimated depths vary from 20 - 70m. Sometimes the sides of dolines are widened by robust roots of trees which wedge and dislodge limestone blocks giving them sub circular planar configuration Platewhile some occur as simple sinkholes cylindrical blind pits (fig. 28-29).

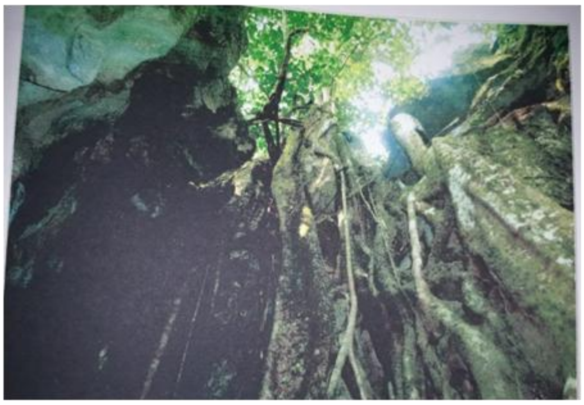

Figure 28: shaft-like doline with robust tree and roots wedging and dislodging limestone boulders

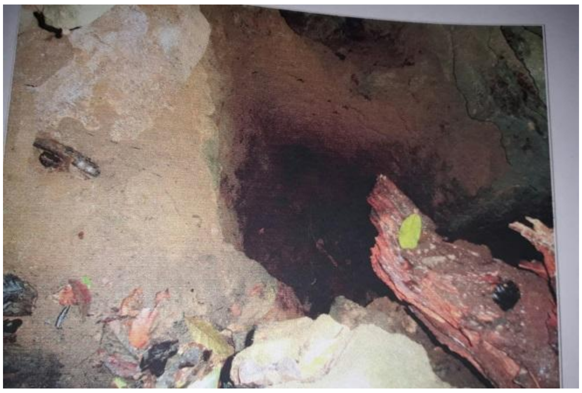

Figure 29: A simple sinkhole common in Etankpini Karstland

Uvala

The Bosnian term uvala has been applied to large depressions resulting from collapse of extensive roof sections over underground water course (Thonbury, 199I).

Uvalas are prominent in Etankpini at "ltiat Emiang" where it exits as a collapsed structure, probably a cave that now forms a deep karst valley with highly stromatolitic vertical walls and a hanging roof (fig. 30-31). It is very likely that uvalas at Etankpini were caused by the roof collapse of caves or some underground tunnel resulting in the formation of narrow chasms, up to 70m deep and about 3.5m across with an inverted funnel shaped configuration. The floors of the uvalas are filled with organic debris, gravels, sands, sedimentary silts, limestone breccias and boulders. The development of uvalas in a karst terrain represents a significant stage in the evolution of karst topography (Thonbury, 199I).

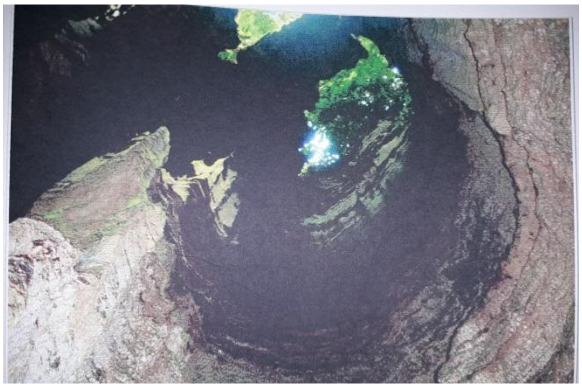

Figure 30:A uvula at Etankpini karstland showing a hanging roof.

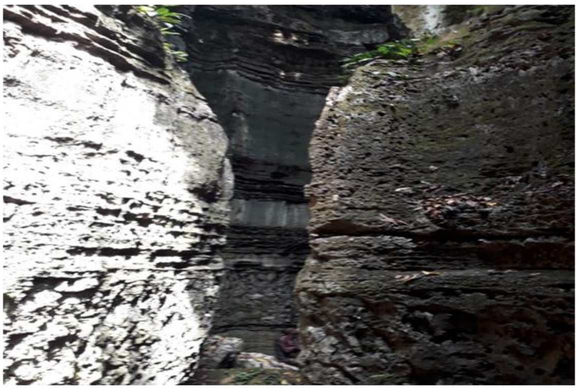

Figure 31: Highly stromatolitic uvala at Ekankpini.

Karsification/karst geomorphic cycle

The Mfamosing Limestone that developed between the Albian and Pliocene, was uplifted and subjected to karstification process in the field of weathering. Both microscopic and macrospic karst imprints were formed in the formation. Collectively these processes have modified the original depositional facies into the present day karstified Mfamosing Limestone. Whether there exists a distinct cycle of landform evolution in limestone terrains which may be designated as karst cycle or whether what has been designated is better considered as the karst phase of a fluvial cycle is a disputed question. Infact, there is probably no type of landscape to which the concept of cyclic evolution can be applied with less complication than a karst landscape. Solution is the dominant geomorphic process. The concept of karst cycle was developed byCvijic (1893) as referred by Thonbury (1991) who recognized four stages in the evolution of karst, which he designated as: youth, maturity, late maturity and old age. Table 2 summarizes Cvijic karst cycle concept.

Each of the karst geomorphic cycle has its peculiar characteristics as well as its unique features. These peculiar characteristics as well as its unique features defined the boundaries of the karst evolution. Deducing from Table 2, it is evident that with the complete dissolution and disappearance of Limestone pillars at Odukpani, collapse of the Etankpini caves forming uvalas and the presence of collapsed breccias, complete dissection by dissolution of limestone bluffs into multiple blocks, the formation of speleotherms, relic towers, natural bridges and limestone boulders, the Etankpini and Abung karst terrains can be said to have reached the mature and late maturity stages of the karst geomorphic cycle respectively.It should be noted that, just as a region undergoing dissection by stream erosion may exhibit the characteristics of youth in one section, maturity in another, and old age in another, so in a karst region, the various stages of the karst cycle may be present. Much as in the fluvial cycle, the various stages move progressively into a region accompanying and following entrenchment of major drainage lines across the terrain. Areas remote from entrenched streams are likely to be less advanced in the cycle than those adjacent to them. Relating this to Mfamosing karst field, it appears that areas with near disappearance of limestone towers, formation of caves "ltiat Emiang" and uvalas (Odukpani, Etankpini and Abung areas) are more advanced in the karst geomorphic cycle than the Mfamosing karstland and adjoining karst terrains towards the Nigerian Cameroun boundary.

TABLE 2. STAGES OF KARST GEOMORPHIC CYCLE (MODIFIED AFTER THONBURY, 1991)

STAGE	CHARACTERISTICS	FEATURES
Youth	Begins with surface drainage on either an initial limestone surface or one that has been laid bare and is marked by progressive expansion of underground drainage.	Lapies and scattered dolines are features dominant in this stage. No large caverns.
Maturity	There is maximum underground drainage. Surface drainage is limited to short sinking creeks ending in swallow holes or blind valleys.	Cavern network are characteristic of this stage. Time of maximum karst development.
Late Maturity	Marks the beginning of the decline of Karst features. Portions of cavern streams are exposed through what is called 'Karst windows'.	Expansion of Karst windows result in the formation of uvalas, and detached areas of the original limestone upland begins to stand out as hums.
Old Age	Marked by return to surface drainage.	Few isolated hums remaining as remnants of the original limestone terrian.

Geotourism

Tourism potentials of Limestone karstlands have been one of the most captivating recreational sites for tourists. There are about 650 documented tourist caves in the world, with those in the "eastern hemisphere" alone being visited by over 15million tourists a year (Maksimovich, 1979). The tourism potentials of the Mfamosing karstfield were earlier highlighted by Nicklin (1980) in his archaeological reports on cave sites in Cross River region of Nigeria. Further investigation by Petters (1981) also corroborated the findings of Nicklin (1980). Nations of the world are earning millions of dollars in the tourism industry as a result of their economic decisions to develop their caves for tourism purposes. The Federal Government of Nigeria through the Federal Tourism Board in collaboration with the Cross River State government should focus its searchlight on the beautiful caves and its galleries, the dolines, breathtaking uvalas of Etankpini, the intimidating towers of Abung and complex Aguagune caves located within the adjoining New Netim Marl which are crying for development.

Threats of Destruction

The Mfamosing Karstfield has been delineated into limestone mining leases for Dangote Cement Company, Larfarge Cement Company and Global Infrastructures for the exploitation of quality Limestone for the production of Portland cement. The quarrying activities of these companies when all of them come on stream in this area will pose serious threat to these captivating karst structures except they are marked out as National Geologic Sites for preservation. Also the destructive activities of local miners will soon obliterate these breathtaking geologic karst features in the Mfamosing karstfield if these interesting sites are not carved out for preservation.

IV. Conclusion

This work represents a documentation of the karst morphology of the Mfamosing limestone at Etankpini, Abung and Mfamosing localities. The karst features at the study locations represent typical tropical varieties and includetowers, pinnacles, karrens. Subterranean caves, spelcotherms. phreatic tubes, dolines, uvalas and corrosion plains.The impressive karst features definitely will provide excellent field laboratory for students of carbonate geology. The unique scenery of the humid tropical Mfamosing karst landforms are potential sites for tourism. Therefore, to safeguard these potential geotourism sites, it is recommended that the United Nations in collaboration with the Federal Government of Nigeria should mark out these areas as world heritage sites for preservation.

Acknowledgement

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References

[1]. Adeleye, D. R. and Fayose, E. A. (1978). Stratigraphy of the type section of Awi Formation. Odukpani Area, South Eastern Nigeria. *Nigeria Journal of Mining Geology*, 51 (1), 35 - 37.

[2]. Berk, B. F. (1984). Sinkhole: Their geology, engineering and environmental impact. Rotherdam, Beckema.

[3]. Burke, K. C., Dessavagie, J. F. J. and Whiteman, A. J. (1970). Geological history of the Benue Valley and adjacent area. In: Dessavagie, J. F. J. and whiteman, A. J. (Eds). *African geology*. (pp. 187 - 206). Ibadan, University of Ibadan Press.

[4]. Curl, R. L. (1973). Ninimum diameter statectites. *Bulletin of Natural Speleological Society*, B. A. 129 - 136.

[5]. Esteben, M. and Klappa, C. F. (1983). Subaerial exposure environments. In: Scholle, P. A., Bebout, D. G. and Moore, C. H. (eds.). Carbonate depositional environments (pp. 1-54), Oklahoma, American Association of Petroleum Geologists.

[6]. Lange, A. (1968). The changing geometry of cave structures. *Cave Notes*, 10, 1 - 32.

[7]. Maksimorich, G. A. (1977). Man's Utilization of caves throughout the ages. Procedure of the 7th *International Congress of Speleology*, sheltfeild, 305 - 310.

[8]. Nicklin, R. (1980). Archeological sites in the Cross River Region. *Nyame Akwa*, 16, 17, 23.

[9]. Nwachukwu, S. O. (1972). The tectonic evolution of the southern portion of the Benue Trough. Nigeria Geological Magazine 109, 411 - 419.

[10]. Nyong, E. E. and Ramanathan, R. M. (1985). A reward of oxygen - deficient paleo-environments in the cretaceous of the Calabar Flunk, South Eastern Nigeria. *Journal of African Earth Sciences*, 3(4), 455 - 460.

[11]. Petters, S. W. (1981). Caves and tower Karst near Calabar. Nigeria, *Nigerian field Society Bulletin*, 46, 9-20.

[12]. Petters, S. W. (1992). Economic limestone and gypsum deposits in Nigeria. *Tropical Journal of Applied Science*, 2, 136-148.

[13]. Petters, S. W. and Reijers, T. J. A. (1996). Karst in the Mfamosing Limestone, South Eastern Nigeria. *The Nigerian Association of Petroleum Explorations Bulletin*, 66, 84 - 99.

[14]. Reijers, T. J. and Petters S. W. (1987). Depositional environment of Albian carbonates in the Calabar Flank South Eastern Nigeria. *Nigeria Journal of Petroleum Geology*, 10.283 - 294.

[15]. Susteric, F. (1979). Some Principles of Cave Profile Simulation. Actors *Symposium International Survey of Corrosion Karst*, 125 - 131.

[16]. Thornburg, W. D. (1991). Principle of geomorphology. New Delhi, India, John Willey and Sons.

UDOFIA, P. A, et. al. "Karst Morphology and Geotourism Potential of The Mfamosing Limestone Calabar Flank, South Eastern Nigeria." *IOSR Journal of Applied Geology and Geophysics (IOSR-JAGG)*, 9(3), (2021): pp 15-30.