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Research Article

FORMATION AND FEATURES OF MFAMOSING KARST TOPOGRAPHY SOUTH-EASTERN NIGERIA

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ABSTRACT

Karst geographical regions are characterized by the presence of carbonate rocks (limestone) and where drainage mainly occurs through an underground flow system. A mild carbonic acid produced from carbon dioxide (CO_2) in the atmosphere is responsible for the solvent nature of groundwater on carbonate rocks. Over a period of time, groundwater dissolves limestone and enlarges drainage routes. This creates a topography dominated by caves, *sinkholes or dolines, speleothem*, underground water channels, as characterized by Mfamosing limestone. New information about distribution of karst features of the Mfamosing limestone has been obtained by an extensive surface and subsurface geological exploration carried out within the area from since 2010. A point is where a core drilling rig was swallowed by an underground water channel during limestone exploration for Offshore Calabar International Cement (OCIC) in Etankpini community. It became pertinent for an extensive study of the Mfamosing karst topography. This study is significant because, if not properly understood, these features that may serve as a threat to human activities especially while exploration and exploitation is going on, as well as when engineering works are being carried out can be controlled. Future events such as swallow homes, cattle, earth moving equipment, cars, and farm machinery can be guided as well as caution in plant/quarry design to reduce structural failures.

Keywords: Karst regions, carbonate rocks, subsurface features, caves, drainage, Mfamosing area, Southeastern Nigeria.

INTRODUCTION

The Mfamosing Limestone is the northernmost carbonate deposit in the south Atlantic. Its deposition took place during the initial marine transgression into the south Atlantic in Mid – Albian times (Essien and Edet, 2008). Karst topography is used to describe areas similar to that found in Kras, which is a German name for an unusual and distinct limestone terrain in Slovenia, located just north of the Adriatic Sea, is an area of barren, white, fretted rock. The most remarkable feature of karst regions is the formation of caves (Gun, 2004). Karst geographical regions are characterized by the presence of carbonate rock (limestone), and where drainage mainly occurs through an underground river system (Gams, 2003). A mild carbonic acid produced from carbon dioxide (CO_2) in the atmosphere is responsible for the solvent nature of groundwater on carbonate rocks (Galdenzi et al, 2008). Over a period of millions of years, groundwater dissolves limestone and enlarges drainage routes. This creates a topography dominated by caves, sinkholes or dolines and disappearing streams/underground water channels characterized by Mfamosing limestone. A case of a core drilling rig that was swallowed by an underground water channel during limestone exploration for Offshore Calabar International Cement (OCIC) at Etankpini community. It became pertinent for the research report on Mfamosing karst topography as a threat for human activities on carrying out exploitation preliminary and engineering work. Future events such as swallowed homes, cattle, earth moving equipment, cars, and farm machinery can be guided as well as caution in plant/quarry designing. This research work is an attempt to evaluate the impacts of karst features on human and mineral resources development.

REGIONALGEOLOGY AND STRATIGRAPHY

According to Essien and Edet, 2008, the Mfamosing limestone was deposited in the Calabar Flank. Structurally, the Calabar Flank represents that part of the foundered Southern Nigerian Continental margin. It is dominated by a system of NW – SE trending step fault system that resulted in the formation of a horst (Itu high) and a trough (Ikang low) within the area. The horst became the site for carbonate sedimentation while the clastic deposition took place in the graben. The Ikang trough for most part of its depositional history was the site of active clastic sedimentation while the Itu high was a stable carbonate platform where about 450m of the Mfamosing Limestone accumulated (Reijer and Petters, 1987).

Sedimentation started in the Calabar Flank with deposition of fluvio-deltaic clastics of probably Aptian age on the Precambrian crystalline basement complex, the Oban Massif. These sediments belong the Awi Formation (Adeleye and Fayose, 1978). The earliest marine transgression into the Calabar Flank occurred in the Mid –Albian times with deposition of platform carbonate of Mfamosing limestone. This carbonate body was deposited in a variety of depositional environments. The Mfamosing Limestone is overlain by a thick sequence of black to gray shale unit, the Ekenkpon Formation. This formation is characterized by minor intercalation of marls, calcareous mudstone and oyster beds. This shale unit was deposited during the late Cenomanian – Turonian times.

The Ekenkpon shales are overlain by a thick marl unit, the New Netim Marl. This unit is nodular and shally at the base and is interbedded with thin layer of shales in up – section. Foraminiferal (Nyong, 1995) and Coccolith evidence (Perch – Neilson and Petters, 1981) suggest Early Conciacian age for this marl unit. The New Netim Marl is unconformably overlain by a carbonaceous dark gray shale, the Nkporo Formation (Reyment, 1955). This shale unit was deposited during the Late Campanian – Maastrichtian times and caps the Cretaceous sequence in the Calabar Flank. It is overlain by a pebbly sandstones unit of the Tertiary Benin Formation. There is also presence of unmapable intrusions of hyperbyssal rocks dolerites at New Netim.

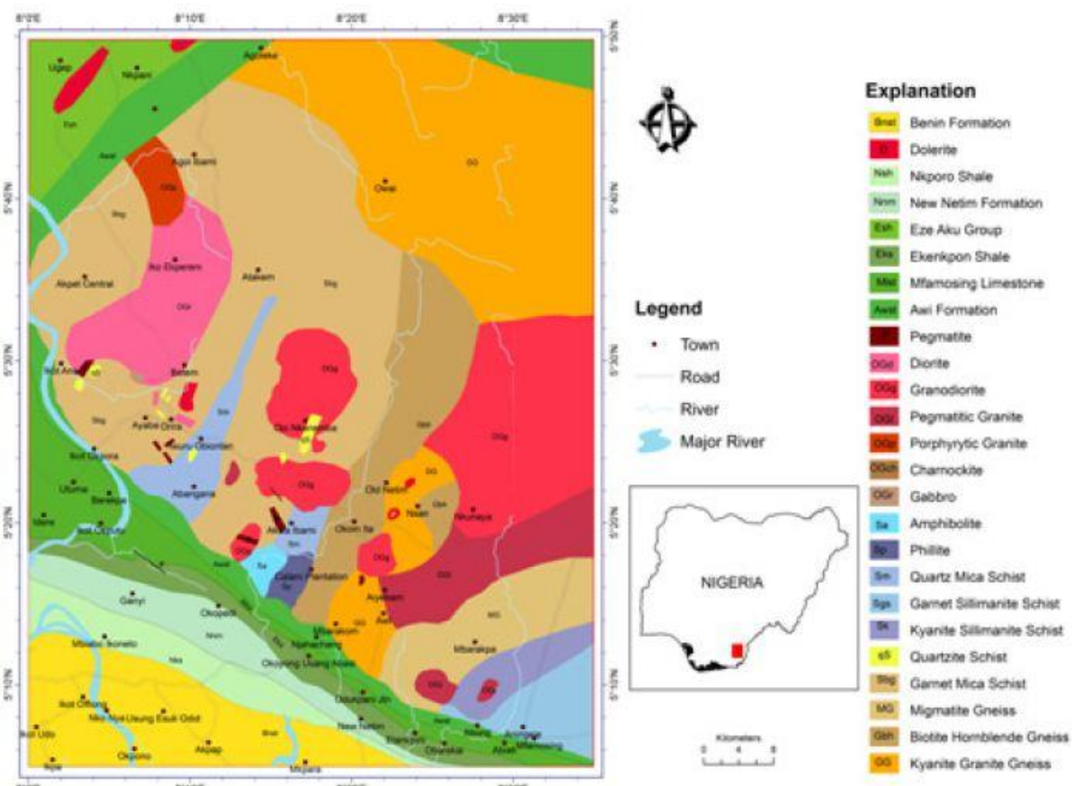

Figure 1: Geologic map of part of Cross River State showing the Mfamosing Karst topography in Southeastern Nigeria (NGSA, 2010).

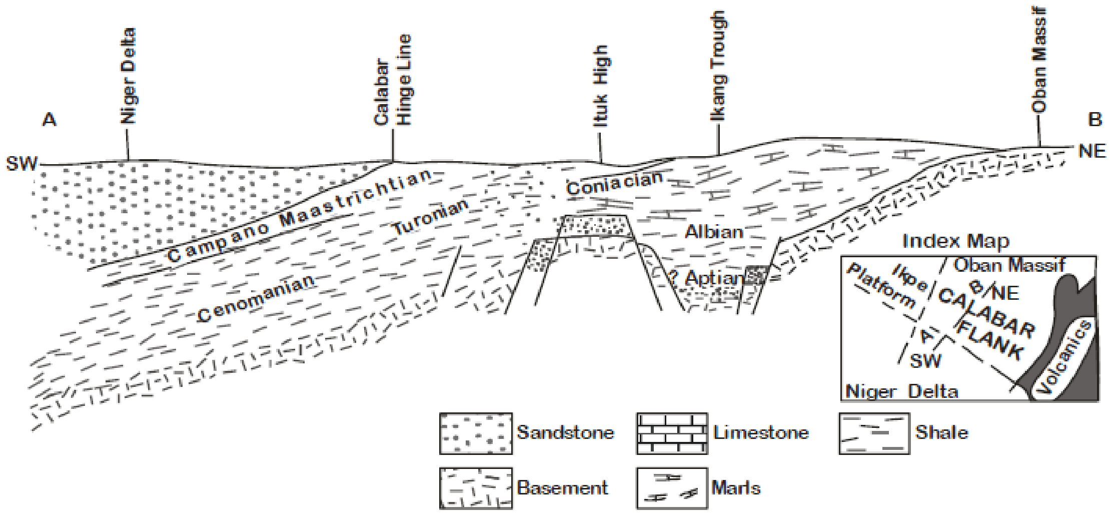

Figure 2: Structural elements and conceptual subsurface distribution of Cretaceous sediments in the Calabar Flank (After Nyong, 1995).

MATERIALS AND METHODS

Geological method adopted in this study involved surface and subsurface geological mapping using conventional instruments. Surface geological mapping here was done alongside with reconnaissance surveys for subsurface geological mapping (coring), karst topographical features were mapped through traversing the exploration licensed concession, global positioning system (GPS), compass clinometer, photographic camera and measuring tape were very valuable instruments. Subsurface geological mapping (coring) using a conventional rotary diamond drilling rig, as a detail exploration tool was employed in carrying out in-situ subsurface investigation to aid in ascertaining; the distribution of overburden, reserve estimation and geochemical composition for a cement plant factory. These work was carried out during the dry season to ease accessibility. The important and relevant karst surface and subsurface features of Mfamosing limestone were identified, described and photographed.

S/N	Location	Mfamosing limestone karst features
1.	**Etankpini**	**Caves, Speleothems, passages**
2.	**Ediganang**	**Doline, cavity**
3.	**Agbung I and II**	**Runnels, cavity**
4.	**Abiati**	**Cavity, Grikes, Clint**
5.	**Mfamosing**	**Clint, Kamenitzas, passages.**

Table1: Location and karst features of Mfamosing limestone

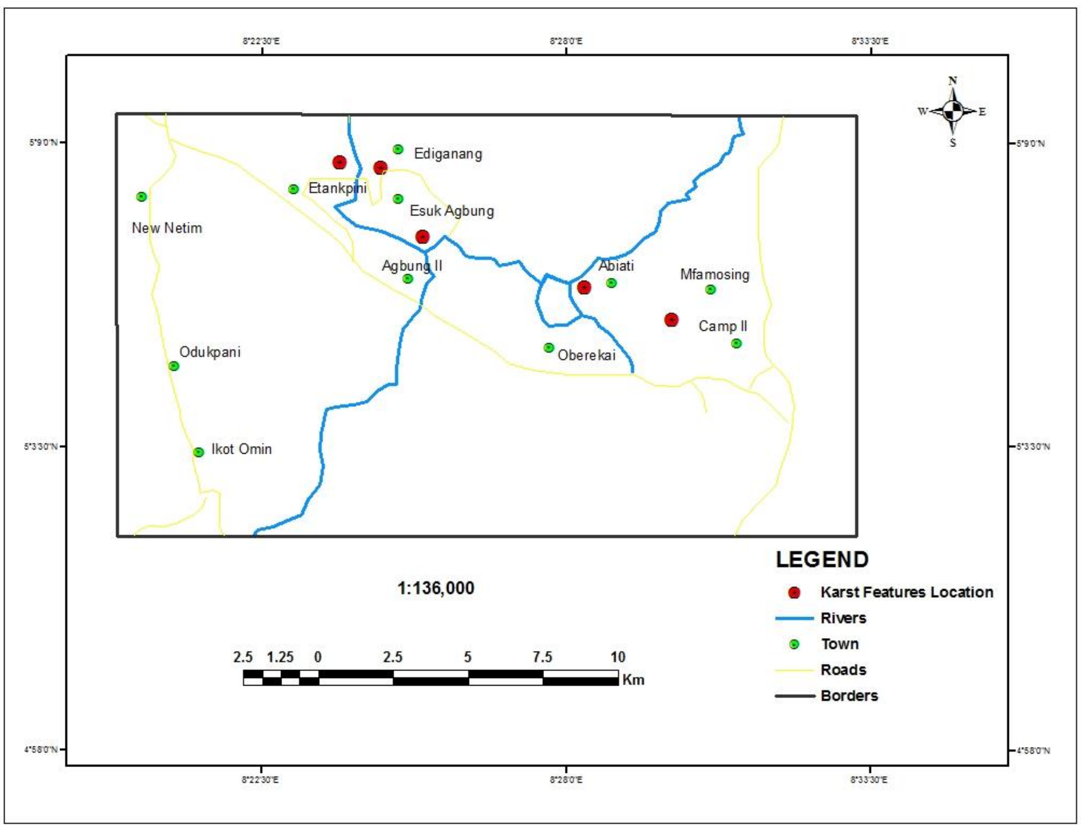

Figure 3: Study Area Map showing the Karst Features Locations

RESULT AND DISCUSSIONS

The karst topography is generally the same anywhere in the world and as such that of Mfamosing is not in exception. The carbonic acid that causes these features is formed as rain passes through the atmosphere picking up carbon dioxide (CO_2), which dissolves in the water (Galdenzi et al, 2008). Once the rain reaches the ground, it may pass through soil that can provide much more CO_2 to form a weak carbonic acid solution, which dissolves calcium carbonate. The primary reaction sequence in limestone dissolution is the following:

$H_2O + CO_2 \rightarrow H_2CO_3$

$CaCO_3 \rightarrow Ca^{2+} + CO_3^{2-}$

$CO_3^{2-} + H_2CO_3 \rightarrow 2\ HCO_3^-$

$CaCO_3 + H_2CO_3 \rightarrow Ca^{2+} + 2\ HCO_3^-$

This mildly acidic water begins to dissolve any fractures and bedding planes in the limestone bedrock. Over time these fractures enlarge as the bedrock continues to dissolve. Openings in the rock increase in size, and an underground drainage system begins to develop, allowing more water to pass through and accelerating the formation of underground karst features. The process of subsurface rock dissolution results in a topography with distinctive features, including sinkholes or dolines (closed basins), vertical shafts, disappearing streams, and springs.

KARST FEATURES

According to University of Texas at Austin, karstification of a landscape may result in a variety of large- or small-scale features both on the surface and beneath. On exposed surfaces, small features may include flutes, runnels, clints and grikes, collectively called Karren or lapiez. Medium-sized surface features may include sinkholes or cenotes (closed basins), vertical shafts, foibe (inverted funnel shaped sinkholes), disappearing streams, and reappearing springs. Large-scale features may include limestone pavements, poljes, and karst valleys. Mature karst landscapes, where more bedrock has been removed than remains, may result in karst towers, or haystack/eggbox landscapes. Beneath the surface, complex underground drainage systems (such as karst aquifers) and extensive caves and cavern systems may form. The Speleology of Mfamosing karst features are explored, discussed and presented as follows:

CAVE:

Cave is a natural cavity within the earth's crust that is connected to the surface, is penetrable by a human, and includes a zone of permanent and total darkness" (B.C. Ministry of Forests 2003a:72). Most people correctly associate caves with karst, although in the context of karst systems, caves tend to acquire a disproportionate amount of public attention. Caves are undeniably very important features and can contain a range of significant values and resources, including the geomorphological, paleontological, archaeological, and biological. A number of references are available that provide a more extensive discussion of these values and resources, plus the related cave management issues (Griffith et al, 2009). However, caves as karst features should also be placed into the perspective of other subsurface openings in the karst system, as the vast majority of these openings or voids are not large enough for humans to enter but are, nevertheless, important biospaces with their associated eco-hydrological functions (Griffith et al, 2005). As such, caves typically make up only a small portion of the cavities within a karst system (e.g., less than 0.01%; Ford and Williams 2007). Caves may appear as complex or random patterns when displayed in maps or as cross-sections, but these features typically exhibit three basic components: (1) passages, (2) chambers, and (3) one or more entrances. In most cases, geological or hydrological factors dictate the location of a cave by defining its shape, extent, and dimensions. A cave's significance is not necessarily related to its size; even a very small cave can contain significant resource contents or values.

Etankpini cave is sitting on Mfamosing Limestone, spanning about 10 – 40m with passages, chambers and two entrances with speleothems - A deposit, usually calcium carbonate, formed in caves by chemical precipitation from drips or thin films of water. Common speleothem forms are: Stalactite: which hangs downwards from a roof or wall of a cave and Stalagmite: which projects vertically upwards from a cave floor.

Plate 1a: Etankpini Cave

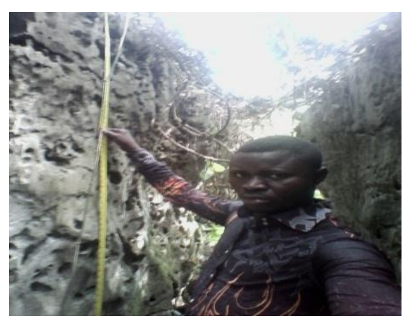

Plate 1c: Passages at Etankpini

Plate 1b: Cave Close view.

Plate 1d: Speleothem at Etankpini

DOLINE:

Dolines (sinkholes) dolines are bowl – shaped, enclosed depression on landscape that can be several meters to several hundreds of meters wide (Bryant, 1998). They can form by the dissolution of limestone from surface downward, or by the collapse of overlying rock into a cave, or combination of both.

In Mfamosing karst there are about 10 dolines which a few photographs are as shown below:

Plate 2: Sinkhole at Ediganang

Grikes, Clints, Kamenitzas and Runnels:

Gikes are vertical or near vertical fissures in limestone pavement. Initially, the limestone contains only microscopic fractures or cracks. By the time you can see it with your naked eyes it is called grikes. Grikes can be up to 80cm wide and 2 meters deep (Stokes et al, 2008). The grikes divide up the limestone pavement into blocks called Clints. Most Clints are 1-5m^2 in area.

Kamenitzas are small, shallow, round flat bottomed depression or pools on the surface of limestone pavement (Burren connect project). They are usually a 5 -30cm wide. They form as the limestone is dissolved by standing water. The limestone does not contain any microscopic holes that let water drains through, and so any water from rainfall will sit in hollows on the limestone surface. This water dissolves the limestone underneath enlarging the hollows.

Runnels are channels formed where water drains from a Clint and dissolves the limestone (Burren connect project). Runnels occurs on the top surface of the limestone and along the sides of grikes. On the surface, the runnels can develop a branching patterns and often appears to start at a kamenitzas the grikes. As runnels and kamenitzas continue to become larger over time, the limestone pavement becomes more dissected or broken up.

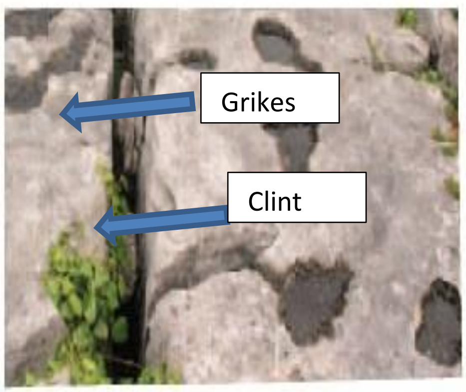

Plate 3a: Clint and Grike at Abiati

Plate 3b: Kamenitzas at Mfamosing

Plate 3c: Runnels at Agbung Area

Disappearing streams:

In karst areas, streams often disappear into the ground usually at a sinkhole forming underground water channels (Jennings, 1985).The swallowing of the drilling rig at Ediganang during exploration campaign for Offshore Calabar International Cement (OCIC) confirmed the underground water channels.

Plate 4: Disappearing stream swallowed a rig.

CAVITY:

A limestone cave or cavern is a natural cavity that is formed underneath the earth's surface that can range from a few meters to many kilometers in length and depth (Ford et al, 2007). Cavities were encountered in most of the exploratory wells drilled during the Offshore Calabar International cement exploration campaign, cavities here are multiples ranging between 2 – 15m down the hole.

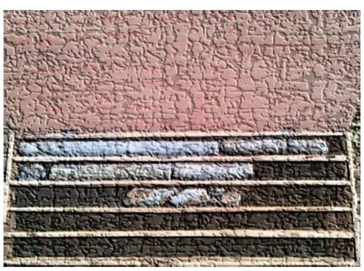

Plate 5a: 3m Cavity

Plate 5b: 5m cavity

Plate 5c: 3.2m cavity

CONCLUSION

Knowing where karst features are located could help city and town planners, as well as individual landowners, to make decisions on where to build houses and other structures. This information could save cities thousands of dollars in repairs to buildings that are built on unstable karst terrain. Karst springs supply drinking water to millions of people. Knowledge of karst terrain and the movement of water in underground drainage systems is important for maintaining good quality and safe drinking water. Pollution of ground water is a major problem in karst terrain as such areas tends to have pH > 7.

Caves provide a venue for recreation. Although most of the caves located in National Parks are protected, there are over 200 commercial caves nationwide which are open to the public. Recreational caving has become a popular hobby. The National Speleological Society has about 20,000 active affiliates nationwide. Deposits preserved in caves can tell geologists about past climates. Fossils and artifacts found in caves help geologists and archaeologists unravel the prehistory of an area.

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