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EVOLUTION OF THE ENUGU CUESTA: A TECTONICALLY DRIVEN EROSIONAL PROCESS

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ABSTRACT

The Enugu Cuesta is a curvilinear asymmetrical ridge dominating the landscape of the south-eastern Nigeria. It stretches in a laterally transposed sigmoid curve for over 500km from Idah on the Niger River to Arochukwu on the Cross River. Based on a review of the geomorphologic implications of the Santonian- Eocene tectonic movements in the Abakaliki Basin, a 3-stage evolution model for the cuesta landscape is presented.

The Santonian movement created the Abakaliki Anticlinorium and laterally translated the depocenter westward and southwestward to form the Anambra and the Afikpo Basins respectively. Thereafter the Abakaliki Anticlinorium became a dispersal center from which clastics were transported into the new basins by a drainage network comprising systems that flowed southwesterly along a valley occupying the site of the Benue rift, and a westerly-directed system headed to the Abakaliki uplift. Spasmodic uplifts of the Abakaliki source region during the Campanian-Maastrichtian period generated gently-dipping stratigraphic offlaps in the Anambra Basin. The progressive emergence of these units represents the early stage in the development of the Enugu Cuesta.

The second stage in the cuesta development began at the close of the Eocene, with the axial subsidence of the Abakaliki Basin and development of flexural zones at the margins of the Anambra Basin. The flexures beheaded the hitherto west-flowing drainage lines that transported clastics from the Abakaliki uplift into the Anambra Basin. New springs emerged at the flexural zones and flowed into the zone of subsidence. Through headward erosion and various mass movements, stream channels expanded, coalesced across the interfluves and facilitated westward slope retreat that soon defined a scarp face.

The final stage in the cuesta evolution is represented by the progressive retreat of the scarp slope. A slope retreat rate of 9cm per century has been estimated, which implies that, barring any further tectonic upheaval, the cuesta may level out into the Niger River valley in some 90 million years time.

KEY WORDS: Yo-yo tectonics, marginal flexures,drainage reversal,scarp retreat

INTRODUCTION

The Enugu Cuesta is the most prominent geomorphic feature in the landscape of southeastern Nigeria.It is an asymmetric ridge with a long and gentle dip slope, and a short steep, mostly east facing scarp slope. It extends northeastward from Idah at the left bank of the Niger River, to Okaba from where it turns southward, passing through Enugu and Okigwe. At Okigwe it turns sharply southeastwards to Arochukwu, flattening out towards the Cross River (Fig.1). Its elevation ranges from over 500m above sea level in the area north of Enugu, to less than 100m in the vicinity of Arochukwu. The scarp-slope is best developed between Otukpa and Leru, and is characterized by waterfalls and plunge pools (produced by differential erosion), as well as V-shaped steep-sided gullies and ravines created by mass movements. Whereas the scarp-slope shows the Enugu Cuesta as generally rising over 200m above the adjoining plain, the dip-slope shows no appreciable relief. The latter only rises gently toward the crest, and encompasses from less than 10km (in its southern reaches), to over 30km (in the northern areas) of rolling country strewn with smooth, rounded flat-topped residual hills and ridges.

The Enugu Cuesta forms a divide between the Anambra-Imo River systems and the Benue and the Cross River systems (Fig. 1). Drainage on the dip-slope is essentially pinnate or trellised. Here the main trunk rivers, the Anambra, Imo, and the Enyong Creek, have flowed southward since Tertiary times, keeping pace with the retreating Atlantic Ocean (Iloeje, 1980). These consequent streams collect numerous tributaries which by

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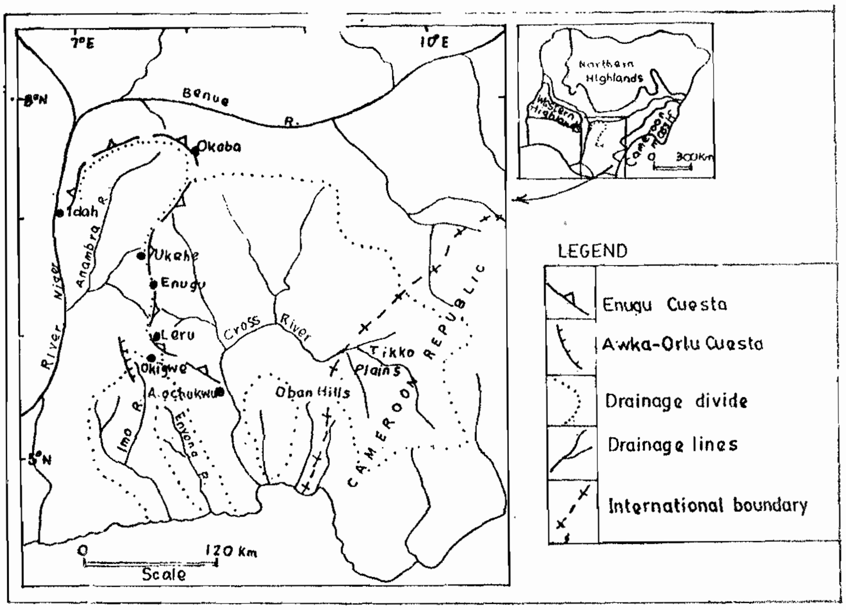

Fig.1 The major interfluves and drainage basins of southeastern Nigeria (after Wigwe, 1975)

rapid headward erosion lengthen their courses both by normal growth and by successive river captures.

Drainage on the scarp-slope is dominated by the Benue and the Cross River systems. The Cross River (main trunk) itself rises from the Cameroon Mountain, some 1800m above sea level and flows northwestward to the vicinity of Obubra, descending 1200m within a distance of 30-60km (Iloeje 1980). From there, the river progressively shifted its course to its present southward trend, the overall course mimicking a giant horseshoe, with the Oban Hills on the inner concave side of the bend (Fig.1).

The main tributaries of the Cross River in the study area are the Aboine and Asu Rivers. These trunk streams are fed by springs issuing from the scarp slope of the Enugu Cuesta. In the Okigwe area, the Asu River and its tributaries have carved a semi-circular notch that is rimmed by the southern loop of the cuesta.

In the northern area, the scarp-slope demarcates a tableland (the Ankpa Plateau). From this tableland several short streams emerge and flow northward into the Benue River. The erosional activity of these rivers is evidently responsible for the rounded profile of the cuesta in this region.

The imposing scarp-slope of the cuesta has exposed and allowed access for the study of the Campanian-Maastrichtian succession in southern Nigeria. Understanding the origin and evolutionary history of the landform is considered a key to the reconstruction of the tectono-sedimentological evolution of the Anambra basin.

Previous Studies

The earliest attempt to explain the origin of the Enugu Cuesta was by Grove (1951) who attributed it to denudation of a land surface uplifted in the Tertiary times. Subsequent workers (e.g. Simpson, 1954; Iloeje, 1980; Ofomata, 1973; Umeji, 1980; Egboka *et al.*, 1990) have presented various accounts of the landform. These scholars largely subscribe to Grove's thesis that subaerial erosion following uplift played a dominant role in the genesis of the cuesta. Umeji (1980) distinguished Paleocene, Eocene, and Oligo-Miocene planation surfaces along the longitudinal profile of the cuesta and ascribed them to sporadic uplifts separated by long periods of tectonic stability, erosion and lateritization. Iloeje (1980), and Egboka *et al.* (1990) suggested that the cuesta formed by erosion following compression associated with Tertiary tectonic movements that folded the post-Santonian succession in the Anambra Basin.

The major problem with these theories of origin of the Enugu Cuesta is that they resort to Tertiary tectonics and denudational processes without regard to the well-known tectonics of the Cretaceous times. The contribution, or indeed the relevance of the often mentioned Tertiary tectonics is however not clear. The Tertiary compressive folding in the Anambra basin invoked by Iloeje (1980) and Egboka *et al.* (1990) seems difficult to be substantiated. For example, the gently-dipping stratigraphic components of the cuesta (Obi, 2000), are rather associated with normal faults and other related microstructures (Benkhelil, 1982) consistent with the tensional tectonic regime that characterized the southern portion of the Benue Trough during the terminal part of the Eocene (Murat, 1972; Benkhelil, 1982; Maluski *et al.*, 1995). It is noteworthy that there are hardly any

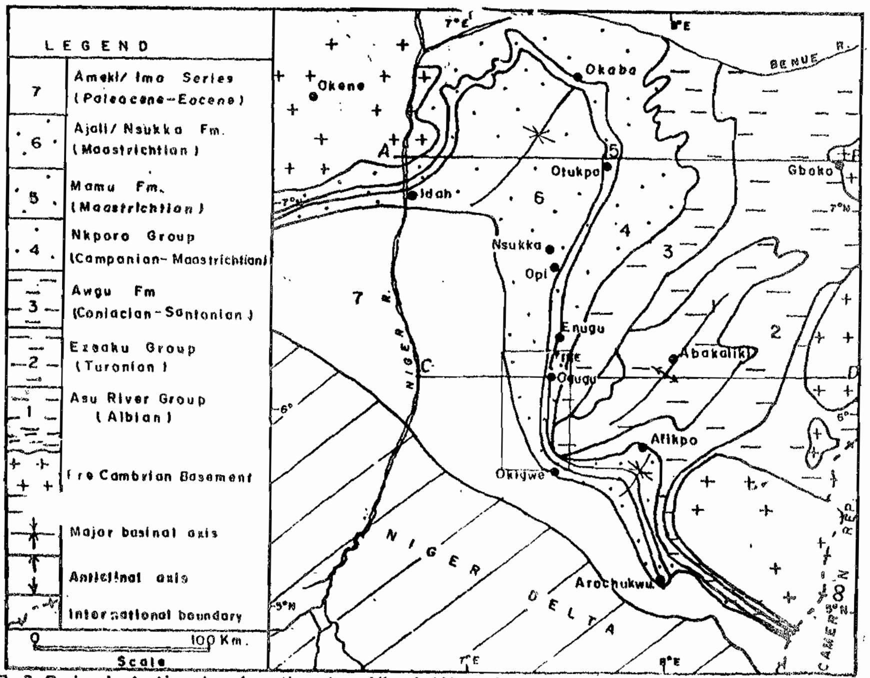

Fig.2 Regional stratigraphy of southeastern Nigeria (Nwajide,1990) AB & CD are lines of section.

easterly dipping strata within the Anambra basin. The gentle dip of strata to the west and southwest is explicable in terms of asymmetrical subsidence towards the west and southwest (Obi, 2000). Besides, no reverse faults or thrusts, critical earmarks of compressive tectonics, have been unequivocally reported in Tertiary strata of southeastern Nigeria.

The objective of the present study is to show that though the cuesta is an erosional feature, its spectacular presence has evolved from the accelerated subsidence of the Abakaliki region about 30Ma ago. The study largely involved a review of the geomorphologic implications of palaeotectonic movements in the Abakaliki Basin between the Santonian and late Eocene. A close inspection of watersheds, stream patterns, channel forms and drainage densities, to evaluate tectonic imprints preserved in the drainage systems, was carried out using aerial photographs and satellite imageries.

STRATIGRAPHIC SETTING

Figure 2 provides an overview of the stratigraphic setting of the Abakaliki and Anambra basins. The oldest sedimentary rocks in the Abakaliki basin consist of scarcely outcropping unnamed deltaic and non-marine sediments of Late Jurassic to Neocomian age (Freeth, 1990, p.22). These strata rest unconformably on the Precambrian Basement Complex, and are overlain by strongly deformed Albian-Coniacian marine succession. The latter comprises the Asu River Group (Albian), Ezeaku Group (Turonian), which unconformably overlies the Asu River Group, and the Coniacian Awgu Group (Reyment, 1965; Zaborski, 1982). The Cenomanian strata are missing in the region. Similarly, the Awgu Group is exposed only on the western flank of the Abakaliki basin, and has not been reported on the eastern flank/Afikpo basin.

In the Anambra basin the strongly folded Albian-Coniacian succession is overlain by nearly flat-lying Campanian-Eocene succession. The latter comprises the Nkporo Group (comprising the late Campanian Nkporo Shale, the Oweli Sandstone and the Campano-Maastrichtian Enugu Shale), the Mamu Formation, Ajali Sandstone and the diachronous Nsukka Formation (Maastrichtian to Danian), the Paleocene Imo Shale and the Eocene Ameki Formation. These strata dip gently to the west and the younger units, which tend to offlap successively to the southwest (Fig. 3), are topographically expressed as the Enugu Cuesta. The E-W section at the northern loop of the Cuesta (Fig. 3) shows that the stratigraphic units underlying the cuesta are virtually horizontal. This is consistent with the layer-cake stratigraphy of the Ankpa Plateau. In this region the cuesta is composed of the Mamu Formation, Ajali and the Nsukka Formations. South of Enugu elements of the Nkporo Group progressively become incorporated in the scarp slope. This is well illustrated at Ogugu where the Nkporo Group is a major cliff-forming lithology, and only gives way to the Mamu Formation a substantial height up the scarp slope (Fig. 3b).

The characteristics of the cuesta components are summarized in Table 1.

Table 1. Lithofacies and topographic characteristics of the stratigraphic components of the Enugu Cuesta (Obi, 2000)

Lithofacies Unit	Characteristics	Topographic expression
Ajali - Nsukka series (Maastrichtian-Paleocene	Unconsolidated to poorly cemented, coarse to fine grained sandstones, siltstones and carbonaceous mudrocks, lateritic on the surface. Mainly fluvial to marginal marine facies	Mostly the dip slope of the Enugu Cuesta characterized by gullies/canyons and laterite-capped residual hills.
Mamu Formation (Maastrichtian)	Tidal estuarine facies dominated by poorly consolidated carbonaceous sandstones, siltstone and mudrocks with coal seams	Scarp slope of the Enugu Cuesta characterized by gullies, crags and waterfalls
Nkporo Group (Campanian-Maastrichtian)	Marine-tidal flat facies comprising carbonaceous shales, siltstones and poorly consolidatded coarse -medium grained sandstones.	Undulating lowland flanking the scarp face of the Enugu Cuesta. Southward it becomes part of the scarp slope

EVOLUTIONARY PERSPECTIVES

The development of the Enugu Cuesta may be appreciated by studying the tectonic and geomorphic evolution of the Abakaliki Basin of the southern Benue Trough.

Tectonic Perspective

The tectonic history of the Abakaliki-Benue trough is well documented. The trough originated from the initiation on land of the equatorial oceanic fracture zones during the early stage of the separation of Africa and South America (Benkhelil, 1982; Burke 1996;). Repeated vertical movements along these fracture zones, particularly the Chain and Charcot is widely believed to be the major factor controlling the evolution of the Abakaliki Benue trough. The vertical movements generated successive tensional and compressional stresses on the overlying sedimentary succession (Murat, 1972; Benkhelil, 1982). Major recorded movements along these fracture zones occurred in the Neocomian, Cenomanian, Santonian and the Paleogene (Murat, 1972; Nwachukwu, 1972; Benkhelil, 1982; Nwajide 1990; Burke 1996). Of these episodes, the Santonian movement which was accompanied by wide spread magmatism, folding and faulting, created the Abakaliki Anticlinorium and laterally translated the depocentre westward and southeastward, forming the Anambra and Afikpo Basins respectively (Nwachukwu, 1972; Benkhelil, 1982). Thereafter, the Abakaliki Anticlinorium became a sediment dispersal centre from which mineralogically mature detritus was shed into the new Anambra and Afikpo basins during the Campanian-Eocene (Hoque, 1977; Amajor 1987).

The Paleogene movement which spanned 65Ma-30Ma (Burke 1996), was a subsidence (Murat, 1972; Nwajide, 1980; Benkhelil, 1982) that marked the end of sediment derivation from

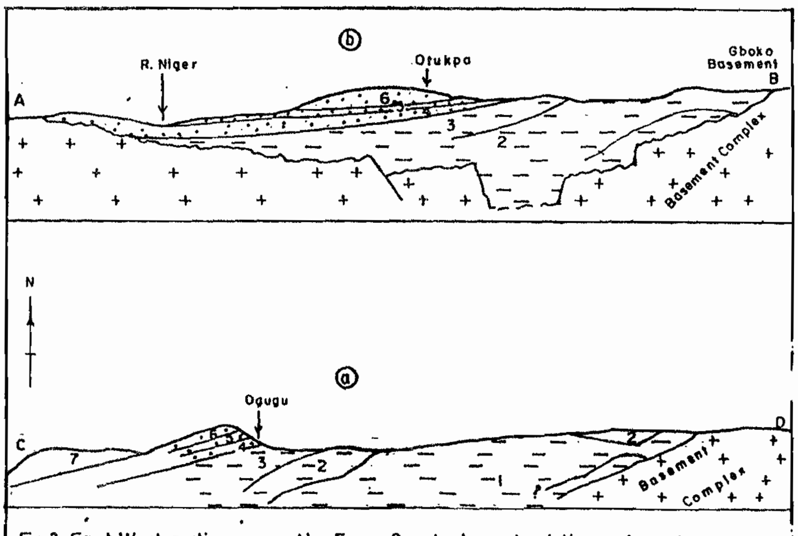

Fig.3 East-West section across the Enugu Cuesta. Legend and lines of section as indicated in Fig.2 (Obi, 2000).

e Abakaliki source region. Occurring at a period hen the Cameroon Volcanic line was initiated urke, 1996), this phase of vertical movement is nerally believed to be in isostatic response to e thermal relaxation of the lithosphere (Benkhelil, 982; Binks and Fairhead, 1992; Burke, 1996).

eomorphic Perspective

he yo-yo tectonics exhibited by the Abakaliki asin provided the diastrophic backdrop to the eomorphic aspects of the evolutionary processes.

ach stage of the vertical movements conceptulized in Figure 4 should produce a corresponding uite of geomorphic elements, especially topography and drainage. The actual disposition of each f these elements depends on the lithological characteristics. Thus the weathering products from he flanks of the first downwarp of the Benue rough were arkosic first cycle sandstones and kaolinitic mudrocks. These would conceivably be transported from the dispersal centres to the depocentres by first-order streams probably merging to form major tributaries of the proto-Benue River. Thus the drainage in the area might have been centripetal and most probably dendritic in pattern, especially in those areas underlain by granitic rocks.

The Santonian uplift resulted in westward translation of the depositional axis from the Abakaliki region to the Anambra basin, and in an emergent westward sloping topography . The drainage would comprise:

- a system that flowed southwestward along the western flank of the Abakaliki Anticlinorium, corresponding to the ancestral Benue system which according to Whiteman (1982) and Burke (1996), flowed southwesterly along a valley that occupied the site of the Benue rift; and
- westerly directed systems coming from the general area of the Abakaliki uplift and corresponding to the systems that transported clastics from the Abakaliki Anticlinorium into the Anambra Basin (Amajor, 1987).

The drainage was at least initially trellis in pattern given the trough-parallel folds. The detritus derived therefrom would tend to be arenitic rather than arkosic, having been recycled from uplifted pre-Santonian sources. To the east of the uplift the proto-Cross River heading in the Cameroon Mt. flowed northwestward to join the ancestral Benue system.

The axial subsidence of the Abakaliki basin at the close of the Eocene restored the initial graben structure of the basin, with the east and west bounding faults expressed as flexures. The flexures beheaded the hitherto west-flowing streams that transported clastics from the Abakaliki region to the Anambra basin, deflecting their waters into the zone of subsidence, as described by Goodrich (1898), Zernitz (1932) and Howard (1963). The effect on the northwest-directed proto-Cross River was also remarkable. The horseshoe like overall course of the Cross River, with the convex side towards the Anambra basin (Fig. 1), reflects a shift from an initial northwest direction to the present southeasterly trend. This indicates channel profile deformation as the rivers crossed into the zone of subsidence (Burnett and Schumm, 1983; Ouchi, 1985; Marple and Talwani, 1993; Schumm *et al.*, 1994). The overall course of the Cross River system thus reflects an effort to gravitate toward the general zone of subsidence. This is typical of low-gradient rivers that are affected by epeirogenic movements (Cox, 1994; Keller and Pinter, 1996). Subsidence of the Abakaliki region during the Paleogene thus marked a turning point in the evolution of the present Cross River system, and initiated the denudational complex that began to define the scarp side of the Enugu Cuesta.

The effect of the Paleogene subsidence was also remarkable in the Anambra basin. As the Campanian-Maastrichtian terrain became emergent, the area to the south progressively subsided. The Benue delta rapidly prograded toward the west and southwest, depositing abundant sediment eroded from the northern basement rocks, and from the newly elevated Anambra basin facies (Whiteman, 1982; Doust and Omatsola, 1990; Burke, 1996).

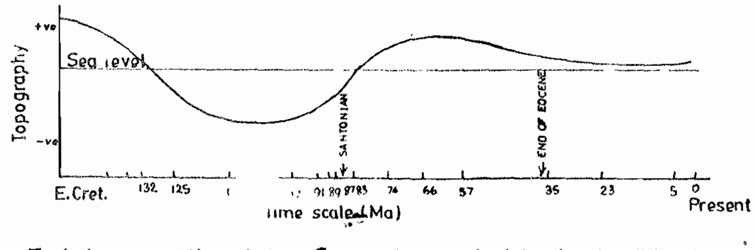

Fig.4 A representation of the relative relief conceived for the Abakaliki region since Early Cretaceous (after Nwajide and Reijers, 1996).

EVOLUTIONARY MODEL

In the light of the foregoing tectono-geomorphological history of the Abakaliki-Anambra basin complex, a model is here presented to explain the origin of the scarp slope, processes of the scarp retreat and the evolution of the dip slope. The major stages are sketched in Figure 5.

Origin of The Scarp Slope

The flexure at the margin of the Abakaliki basin proximal to the Anambra basin beheaded the drainage lines directed into the Anambra basin from the Abakaliki Anticlinorium. New springs emerged at the flexural zones and flowed into the zone of subsidence, following lines of weakness provided by faults and lithologic contacts.

Two of such consequent streams one to the north, and one to the south, represented the ancestral Aboine and Asu Rivers respectively. By headward erosion the headwaters of these streams began to etch into the topmost units of the post-Santonian strata at the margins of the down warp (i.e. the Nsukka and Ajali Formations). These streams had a particularly high cutting power as a result of the steadily increasing gradient consequent upon continued subsidence of the Abakaliki basin. Their erosive power would also be enhanced by the poor consolidation and friability of the post-Santonian sediments. Thus while headward erosion propagated the stream channels linearly, such mass movements as rock fall, sliding, slumping, debris flow, and mud flow widened them by hacking away at the interfluves. The northwesterly directed ancestral Cross River heading in the Cameroon Mt. would respond to the down-warp by shifting its course into the zone of subsidence. Lowering of the interfluves would eventually produce a drainage plain when the river valleys become amalgamated across the flattened interfluves. By this process a scarp slope appeared on the post-Santonian strata at the edge of the down-warped Abakaliki region and gradually migrated backward (Fig. 5). At first the scarp slope would be low, insignificant, and discontinuous in plan, with re-entrants marking the through passage of the previously west flowing drainage lines.

Scarp Retreat

From inception the scarp slope has continued to retreat westward under the combined action of rain-wash, spring sapping, and mass movement as determined by lithologic control. For example, at the southern and central areas of the escarpment, where gently dipping sandstones, siltstones, coal and the mudrocks of the Mamu Formation and the Nkporo Group dominate, differential erosion of the less resistant units produces crags resulting in water falls. Where undermining of the soft rock occurred beneath a waterfall (e.g. at Nike, near Enugu, and in the Ukehe and Obollo-Afor areas), a plunge pool is developed. Spring sapping, gullying and land sliding

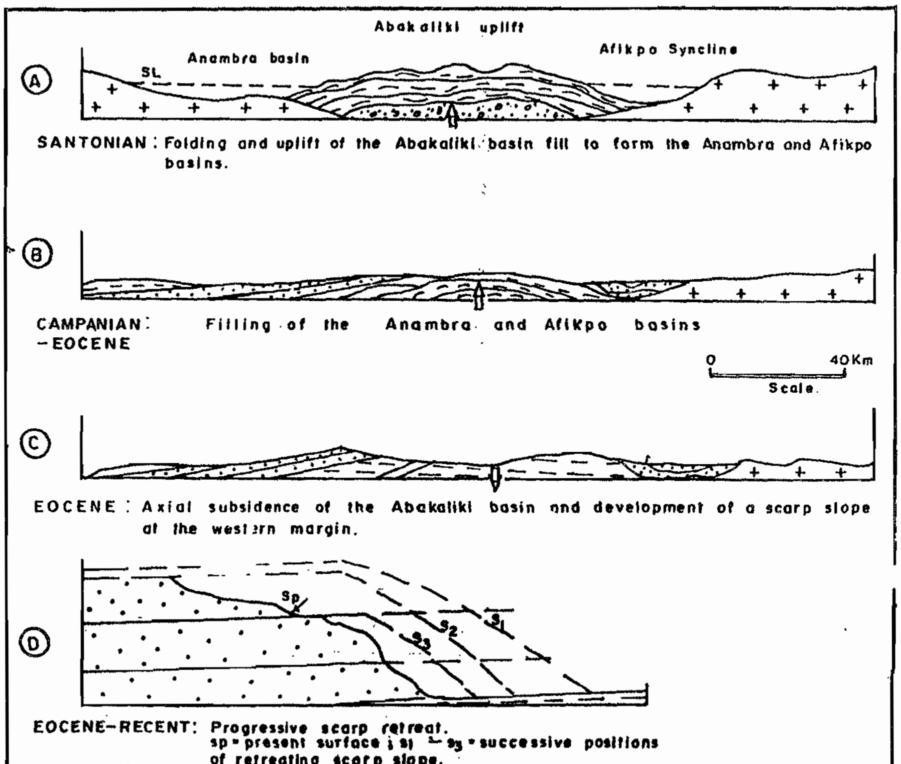

Fig.5 The major stages in the tectono-geomorphologic evolution of the Enugu Cuesta. Arrows point in the direction of the prevailing tectonic movement.

dominate the upper slopes where the unconsolidated units of the Ajali Sandstone occur. Wherever exposed (e.g. at Nsude) the Ajali Sandstone remains heavily gullied. Its erodibility is attributed to its extreme friability, and this seams to dictate the pace of scarp-slope retreat. It is evident that headward erosion by the network of scarp-foot springs is the main force driving the watershed migration.

Origin and Evolution of the Dip Slope

Spasmodic uplifts of the Abakaliki source region during the Campanian-Maastrichtian period generated gently dipping (4-10 degrees) stratigraphic offlaps in the Anambra Basin. These units became progressively emergent during the Paleogene as the dip slope of the evolving cuesta landscape. Drainage on the emergent slope was dominated by the beheaded systems (e.g. the ancestral Anambra and Imo systems). As base level dropped during the Oligocene in response to global marine regression, the drainage systems progressively penetrated the dip slope, tapping groundwater percolating through the formations. In this way they increased their discharge and erosive power.

Sculpturing of the dip slope was largely controlled by lithologic contrasts between the topmost Nsukka Formation and the Ajali Formation. The Ajali is highly porous and friable whereas the Nsukka Formation is heterolithic and readily lateritized into an impervious erosion-resistant residuum (Reyment, 1965) that promotes run-off. Thus the network of valleys which characterize the dip slope of the cuesta could be attributed to extensive run-off. Initially the valleys would be V-shaped, with sharp-crested slopes. With time they gradually transformed into U-shaped valleys bottomed on the porous Ajali Formation. The interfluves also gradually smoothened out into rounded, laterite-capped, residual hills which today dot the dip slope.

DISCUSSION

The main purpose of this exercise has been to demonstrate that the Enugu Cuesta is basically the result of the tectonic history of southeastern Nigeria. Being essentially a surficial feature, earlier workers on the Anambra basin geohistory considered denudation as the only factor forming the feature. It is accepted that while the shaping of the landscape was essentially erosional, some basic endogenic factors predetermined the course of erosion. Therefore tracing the causal connection between tectonics, sedimentation and denudation has been found desirable in order to establish the real sequence of events leading to the present physiography of the area.

Palynological studies (Ojoh 1992) have shown that the western half of the Cross River drainage basin was once covered by the Coal Measures, i.e. the Mamu, the Ajali and the Nsukka Formations. It is now clear that by the erosional stripping of the whole area, the Nkporo Group has been exposed. This is a continuing process taking place as a gradual westward slope retreat.

By inspection of the appropriate maps of both southeastern Nigeria and western Cameroon it is evident how extensive the Cross River drainage basin is. It obviously exploited a slope advantage created during the latest subsidence of its general catchment area centred in the Abakaliki area. It has obviously been expanding at the expense of the adjacent terrains. The expansion is thought to have begun at the end of the Eocene (ca 35Ma BP). This point in geological time marked the:

1. emergence of the dip slope,
2. cessation of sedimentation in the Anambra basin,
3. inception of a westward slope retreat from the western edge of the newly formed Cross River drainage basin.

Measurements on the 1:2 million geological map of Nigeria (Geological Survey of Nigeria, 1974) can be used to estimate the rate of slope retreat. A line parallel to, and just below Latitude 7°N, traversing Opi town south of Nsukka (Fig. 1) may be assumed to pass through the midpoint of the cuesta. If we further assume that the scarp slope has retreated over the past 35 million years, from its initial position marked by the Awgu Shale-Nkporo Group boundary, to the present position at Opi (approximately 30km, Fig. 2) the rate of scarp retreat can be approximated to 9cm per century. Thus, provided no tectonic upheaval occurs, the estimated rate of slope retreat will drive the Cuesta into the Niger valley (some 78km away) in about 90 million years, which in human terms is no cause for alarm. However, the prognosis implies that those mass movements associated with scarp retreat will continue unabated, human interference notwithstanding.

The above projection is nevertheless highly speculative and simplistic. In the southern parts the progress will be complicated by the set of similar processes affecting the Awka-Orlu Cuesta (Fig.1) which is also being driven towards the Niger River. However, the processes here appear much faster than for the Enugu Cuesta. This is perhaps because, while only one extremely erodible unit, the Eocene Nanka Formation, is involved in the reduction of the Awka-Orlu Cuesta, the Enugu Cuesta encompasses three to four formations, all but one of them considerably consolidated. This will therefore reduce the life span of the southern portion of the Enugu Cuesta to about half of the estimated value. It will also imply that the flattening out of the interfluve is quickened, occasioning the widening of the Cross River plain.

A similar modification is expected to apply to the rate of scarp retreat when it approaches the Anambra River valley. Since the approaching scarp slope will be lower than the plain of the Anambra River valley, a series of river captures will be the major signs of the impending topographic re-ordering that will plane out the area and end up in the Niger River.

CONCLUSION

The Enugu Cuesta is the most imposing geomorphic feature in the Anambra basin. It is a laterally inverse sigmoid-shaped asymmetrical ridge stretching for over 500km from Idah in the northwest through Enugu to Arochukwu in the southeast. Its dip slope is a gentle, almost imperceptible incline to the south and southwest, while the scarp slope is a rugged steep descent into the Cross River plain mainly to the east. The northern loop of the sigmoid encloses a tableland, the Ankpa Plateau, with a gentle incline to the south defined by the Anambra River catchment area.The crest of the cuesta is the longest water divide in southeastern Nigeria and demarcates such major river systems as the Cross River from the Imo and Anambra, and the Benue system from the Anambra.

The genesis of the cuesta had been attributed entirely to denudational processes. The present study has attempted to anchor these processes in the appropriate endogenous antecedents.

This implies the integration of the stages of cuesta evolution into the fairly well known tectonic history of the southern Benue trough. The various vertical movements undergone by the Abakaliki region of the southern Benue trough occurred partly in response to the generalized extensional regime accompanying the opening of the Atlantic Ocean, changes in the African plate motion, and as a response to the Early Cretaceous crustal thinning and post-rift thermal relaxation of the lithosphere. They caused the topographic elevation and folding of the Abakaliki region and the simultaneous formation of the Anambra and Afikpo Basins.

The topographically positive area had served as a sediment dispersal centre for the lithic fill of the Anambra Basin. The implication of this is that west-flowing drainage transported detritus to the newly formed basin. The eventual decay of the mantle plume about the close of Eocene resulted in thermal contraction consequent upon which the overlying topography became depressed. This reversed the drainage at the boundary between the Anambra basin and the former Abakaliki high from west-flowing to east- flowing. The resultant drainage was a centripetal system centred in the Abakaliki region which became the present Cross River system. As the streams at the western and southern edge of the newly formed drainage basin began to etch into the loose-to partially consolidated post-Santonian facies of the Anambra and Afikpo basins, a scarp slope was defined which progressively retreated at an average rate of 9cm per century. The slope has in the 35Ma from the end of Eocene to the present traversed some 30km; the ca 78km to its natural graveyard, the River Niger, is estimated to take the next 90Ma.

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