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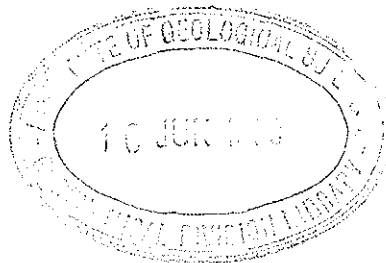
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GEOMORPHOLOGY

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EROSION SURFACES IN MALAWI

by

L. A. LISTER*

(PLATES I AND II)

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ABSTRACT

Landscapes throughout Malawi, with the exception of the northern and southern tips of the country, have been studied and interpreted in the light of the most recent geological knowledge. The overall distribution and inter-relationship of erosion surfaces in Malawi is described and these are classified according to the five major cycles of erosion recognised elsewhere in southern Africa.

I. INTRODUCTION

Five principal erosion surfaces occur in Malawi (King, 1963, pp. 271-274):

<i>Gondwana</i>	Jurassic
<i>Post-Gondwana</i>	early- and mid-Cretaceous
<i>African</i>	late-Cretaceous to early-Miocene
<i>Post-African</i>	late-Miocene and Pliocene
<i>Quaternary</i>	end-Pliocene to present day.

On the outline map of the erosion surfaces of Malawi (Plate II) the areas of the Gondwana and post-Gondwana surfaces have been combined.

Because of their considerable age the Gondwana and post-Gondwana surfaces, which often occur in close proximity to one another, are either limited to the highest regions of the country or occur as resurrected (fossil) landsurfaces at the basal contacts of Karroo and Cretaceous formations. As these younger sediments are of only restricted development in Malawi, the corresponding resurrected landsurfaces form an insignificant part of the geomorphology of the country.

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The African and post-African surfaces are widely developed and in certain areas both of these cycles occur, merging indistinctly to give rise to a composite landsurface.

The Quaternary erosion cycle is limited in distribution to the larger and deeper river valleys. It is still characteristically youthful and has not, therefore, reached any degree of planation.

II. EROSION SURFACES

(a) Gondwana

The Gondwana surface, the oldest landsurface in Africa which has survived to the present day without burial, is best displayed on the Nyika Plateau in the Northern Region of Malawi. (A localities map of Malawi, Figure 1, accompanies this article). The surface rises from an altitude of just over 6,000 feet on the southern Nyika, near the Katumbi escarpment, to a height of over 8,000 feet on the highest peaks, *e.g.*, Vitumbi (8,291 ft.), Kasaramba (8,434 ft.) and, in the extreme north, Nganda (8,551 ft.). This rise is most probably caused by post-Jurassic tilting. Even at these high levels the original planation has been dissected by younger cycles of erosion, mainly by the post-Gondwana cycle, and the Gondwana surface is therefore limited to the undulating crestlines and uplands (Plate I, A).

On the Vipya Plateau, further to the south, the general planation is of post-Gondwana age. At the northern end of the plateau, however, some peaks (Chimaliro, Kanje and Mtunje) stand above this planation and carry the merest remnants of the Gondwana surface at or near an altitude of 7,000 feet.

(b) Post-Gondwana

The post-Gondwana landsurface is far more extensively developed in Malawi than the older Gondwana surface.

The Gondwana surface forms the rolling uplands on the Nyika Plateau and is haphazardly dissected by steeper valleys, usually a few hundred feet in depth, which belong to the post-Gondwana cycle of erosion. These two erosion surfaces can be clearly distinguished on the eastern edge of the plateau where the post-Gondwana cycle forms the broad saddles which cut into the higher Gondwana portions of the skyline seen to the west of the Rumpi-Livingstonia road.

The Vipya Plateau, further south, stands at an elevation of between 5,000 and 7,000 feet, a gentle overall decrease in altitude being apparent from north to south. The highest points bear the Gondwana surface but elsewhere a broad post-Gondwana planation is exhibited at an average elevation of 5,700 feet. This is dissected by valleys formed by the African cycle of erosion which, in the northern part of the plateau around Mwimbo Hill (6,146 ft.), are of a shallow dendritic nature. Further south, in the area around Luwawa Dam, this African incision is more pronounced and deep, steep-sided valleys result.

The summit levels of the inselbergs which rise above the African surface of the Lilongwe Plain can be largely attributed to the post-Gondwana erosion cycle (Plate I, B). These residuals are particularly noticeable to the north and north-west of Lilongwe township although Mkhoma (5,854 ft.), which lies to the east, can also be assigned to this erosion level. The variation in relief between the surface of the plain and the summits of these residuals is not constant, indicating that, even where allowance is made for the fact that some of the remnants are in their last stages of removal, the post-Gondwana surface must here have been distinctly uneven.

At the southern end of the Lilongwe Plain, around Dedza, the post-Gondwana cycle is marked by the usually well-planed surface of the numerous hills which rise

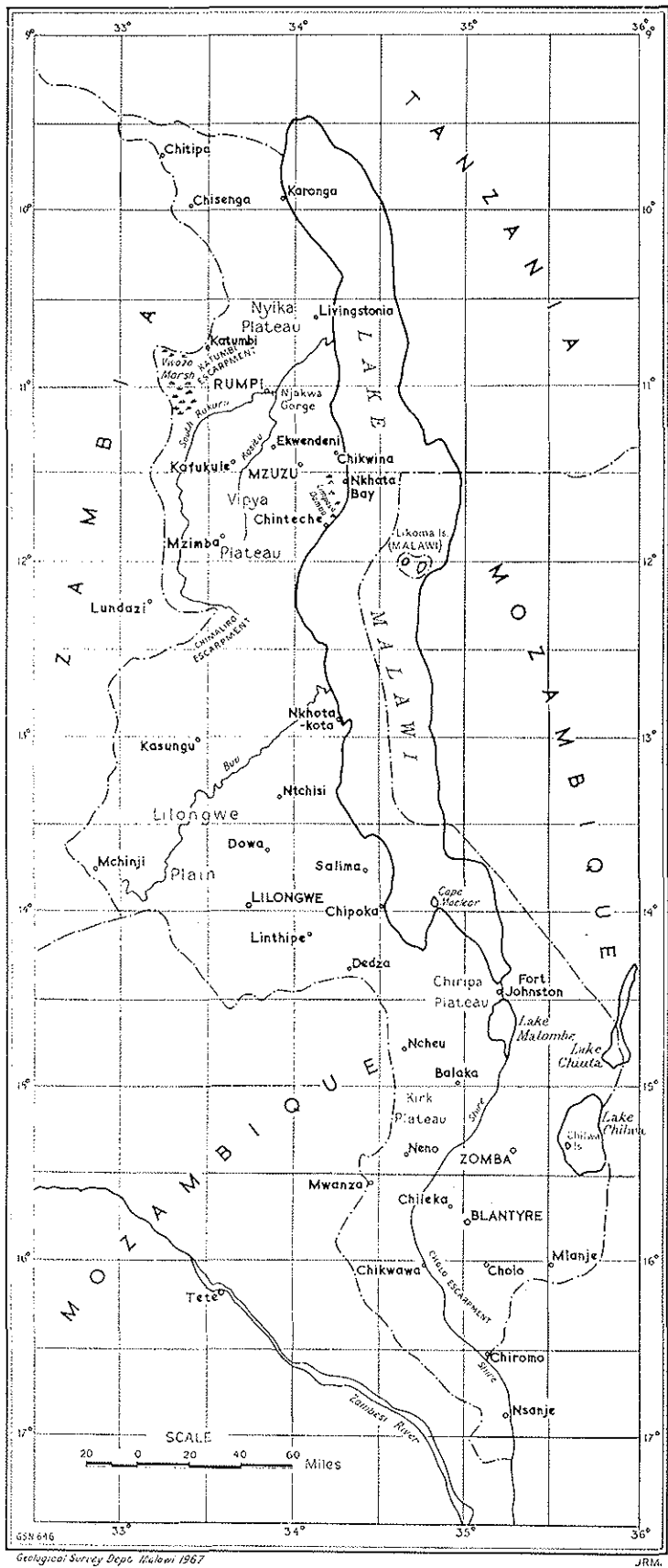


Figure 1. LOCALITIES MAP OF MALAWI

above the African surface. Immediately to the north of Dedza Mountains is an area of irregular terrain in which the highest points, Mlunduni (6,746 ft.), Dzenza (5,558 ft.), Makungwa (6,114 ft.) and Mnanda (5,897 ft.), exhibit the post-Gondwana surface. To the south of Dedza vestiges of the post-Gondwana surface are found at an elevation of approximately 6,000 feet in the Mvai and Dzonze Forest Reserves at the northern end of the Kirk Plateau. This landscape extends westwards into Mozambique.

Dedza Mountain itself clearly shows a twofold crestline and is thus geomorphologically similar to the Zomba and Mlanje Plateaux discussed below.

East of the Shire River, in the Southern Region of Malawi, the Zomba and Mlanje massifs rise to heights of between 6,000 and almost 10,000 feet above sea level. Dixey (1937) has attributed the crests on both mountains to the Gondwana (Jurassic) erosion cycle but recent radioactive dating of the syenites which compose these massifs has shown that the rocks are of early- to mid-Cretaceous age.

Each of these mountains carries distinct planations at levels of between 6,000 and 7,000 feet (the Malosa and Zomba plateaux in the Zomba area and the Lichenya and Tuchila plateaux on the Mlanje massif). It is therefore suggested that these planations below the summit levels belong to the post-Gondwana cycle of erosion, being pediplains formed immediately after the intrusion of the syenite masses, while the peaks which rise above them reflect the initial surface of the newly-intruded material.

Similarly, Dedza Mountain, which rises to a height of over 7,000 feet, shows a planation surface above 5,500 feet which is more or less continuous with the post-Gondwana crests of the nearby monadnocks.

On these mountains the highest summits will have been to some extent modified since Cretaceous times and any initial chilled surface removed by erosion but, nevertheless, they still *reflect* the original sub-aerial heights of the syenite intrusions.

(c) African

When undeformed the African landsurface is the most distinctive of all the erosion surfaces. It reached a state of extreme old age before the post-African erosion cycle was initiated and therefore shows a characteristically flat surface. This is clearly recognisable on the Lilongwe Plain where the monotonously flat African landsurface stretches for tens of miles in every direction.

The surface occurs elsewhere in Malawi in less characteristic form. Where the African cycle is immediately adjacent to the older post-Gondwana cycle, as on the Vipya Plateau, it cannot maintain its normal senile appearance but becomes much more youthful. It therefore gives rise to valleys of varied width and depth which dissect the older Vipya planations (*see p. 16*).

In areas where the African surface is dominant, and the post-Gondwana surface forms vestigial hills standing at a higher level, the nature of the African pediplain depends upon the spacing of the older erosional features. In the Dedza area the post-Gondwana remnants are widely scattered and the African surface is therefore able to take on its characteristically flat appearance between them. Similarly, at the foot of the Mlanje Massif, the flat African plain stretches for many miles to the north and west forming the Shire Highlands which lie between 2,500 and 3,200 feet above sea level. Close to the Zomba-Blantyre road, however, numerous hills composed of very resistant syenites, *e.g.*, Chiradzulu (5,821 ft.), Ndirande (5,293 ft.), Malabvi (4,755 ft.) and Mikolongwe (3,980 ft.), rise above the level of the African surface and cause it to be distorted. These hills probably represent a reduced post-Gondwana level but, because of their limited lateral extent, they have not retained the planation as clearly as Dedza, Zomba and Mlanje mountains. In this region the African surface therefore becomes more youthful and irregular in appearance, this non-characteristic surface

extending at altitudes of between 3,000 and 4,500 feet to the base of Zomba Mountain.

The valleys which dissect the post-Gondwana planation on the Zomba and Mlanje plateaux are the extremely youthful head reaches of the African cycle, the dissection being similar to that noted on the Vipya Plateau.

The attitude of the African landsurface forming the Shire Highlands strongly reflects its proximity to the Rift Valley. There is a very gentle, but nevertheless distinct, rise of the surface westwards to the edge of the rift-valley scarp at approximately 3,500 feet and a fall eastwards towards Lake Chilwa which lies at approximately 2,000 feet above sea level. Recent deposits of alluvium and sand spits and bars around the lake and marshlands have locally buried the African surface by a few feet but the surface gradient has remained smooth.

Where the crest of the rifted scarp overlooks the Shire River in the south, the African surface is much dissected by younger erosion cycles which encroach from the Shire Valley. This is particularly noticeable along the Limbe-Cholo road.

The more stepped descent to the rift-valley floor described by Dixey (1941, A & B) occurs to the north of Blantyre. At Chileka Airport the African landsurface lies at an altitude of 2,550 feet but to the west and north of this point the incipient post-African cycle appears and the overall level of the *Chileka Step* drops to approximately 2,300 feet, the surface becoming considerably more broken within a distance of ten miles. The gentle descent of the Chileka Step to the floor of the Shire Valley near Matope would appear to indicate a fault splinter which varies the altitude of the dissected African surface along the step. Along the western side of this step the post-African cycle is dominant in a zone of composite African and post-African land-surfaces.

Bloomfield (1965A) records that the pediment between the western foot of Zomba Mountain and the Shire River is two-fold. The lower terrace, which is thickly covered by Cainozoic talus from the mountain, stands at between 12 feet and 300 feet above the Shire plain, while the higher *Chingale Step* is a fairly flat-lying area between 1,900 and 2,500 feet in height. The flat surface of this step is broken by hills of nepheline syenite, e.g., Chinduzi (4,264 ft.) and Junguni (3,030 ft.), just as the African surface of the Shire Highlands is broken by similar intrusions (see above). It is probable that the surface which underlies the younger talus and sediments is the African but of course the present sub-aerial surface on the step can only be Quaternary.

On the western side of the rift valley the Shire-Zambesi watershed, which marks the international boundary between Malawi and Mozambique, clearly shows the African surface which continues for many miles to the north and north-east into Mozambique. Along the border road the African surface rises from a height of approximately 3,900 feet near Mwanza to approximately 5,000 feet at the junction with the Neno road. These African border uplands merge with Dixey's *Mwanza Step* at its northern and southern ends and, as Dixey (1941B, p. 108) postulated, the step therefore appears to be a portion of the African surface which has sagged down against a fault.

The northern section of the valley of the Mwanza River, incised by approximately 250 feet, shows post-African dissection while further south on the step, where the Blantyre-Salisbury road crosses the valley, post-African dissection becomes more widespread and exfoliation of the country gneisses gives rise to a rugged bornhardt-type topography.

In the northern part of the Kirk Plateau a dominantly African landsurface is displayed. This surrounds post-Gondwana residuals and is itself dissected by broad,

rather shallow valleys of post-African age. This three-cyclic topography is clearly shown at the northern end of the plateau, in the border area to the west of Ncheu, where the African surface forms the minor ridges and accordant saddles between higher ridges which carry post-Gondwana summits, *e.g.*, Dzonze (6,086 ft.). The African landsurface continues northwards along the Malawi-Mozambique border to form the previously described widespread pediplain surrounding post-Gondwana residuals in the neighbourhood of Dedza.

To the east of Ncheu the African landsurface has been modified by post-Oligocene faulting to produce a very clear step-topography along the western side of the Bwanje-Liwawadzi Valley (Walshaw, 1965).

The very flat floor of the *Bwanje-Liwawadzi Valley* (see Fig. 2), which lies approximately 2,300 feet above sea level, is characteristically African. The watershed between the northwards-flowing Bwanje and the southwards-flowing Liwawadzi is insignificant and the whole area is liable to become swampy during the wet season. Despite the relatively low altitude the flatness of the valley floor is essentially an erosional feature. The land to the east of these rivers rises very gently for several miles and then steepens to form the *Chiripa Plateau* while the western side of the valley is limited by the *Bilila Fault*. On this western side the *Nsipe-Livelezi Shelf* shows a characteristically African surface at between 3,200 and 3,600 feet above sea level, this surface rising by about 100 feet eastwards to the edge of the shelf which is defined by the *Bilila Fault*. Post-African dissection is shallow and is confined to the courses of the Nsipe and Livelezi rivers.

The *Ncheu Step* (see Fig. 2), which stands above the Nsipe-Livelezi shelf at an approximate altitude of 3,800 feet, is far more uneven and shows considerable post-African dissection into the African surface. This step is therefore markedly two-cyclic.

All three surfaces merge at their southern ends near Balaka so it would appear that the African surface was formed normally and subsequently faulted and splintered to produce the present physiography. The degree of post-African dissection is markedly greater with each succeeding level: it therefore seems likely that the faulting is contemporaneous with, or only slightly later than, the initiation of the post-African cycle of erosion, *i.e.*, during the Miocene period.

On the eastern side of the Bwanje Valley the Chiripa Plateau stretches eastwards as far as Lake Malombe and the south-east arm of Lake Malawi. Structurally this plateau is formed by a fault-block downtilted to the west. The Cape Maclear peninsula is formed by a granitic complex of Lower Palaeozoic age (Bloomfield, 1965B) which occurs on the upraised eastern portion of the block. This peninsula separates the south-western and south-eastern arms of Lake Malawi.

The surface of the Chiripa Plateau shows both the African and the post-African cycles of erosion in varying proportions. In general, a progressive eastward decrease of the African and corresponding increase of the post-African is indicated, the surface becoming more highly dissected towards the eastern margin where it is truncated by the younger lakeshore plain. This latter feature lies at an altitude of 1,620 feet, *i.e.*, less than 100 feet above the present lake level, while the plateau, varying according to its two-cyclic and tilted form, lies at between 2,600 and 3,200 feet above sea level. A resistant mass of granite of Precambrian-Lower Palaeozoic age forms Piri-longwe Mountain which rises to an altitude of 5,098 feet in the centre of the plateau.

Further to the east, between the lake and the Mozambique border, the uplands around the Mangoche and Namizimu Forest Reserves show a similarly uplifted African landsurface which is highly dissected by the post-African, and probably also by the Quaternary, erosion cycle.

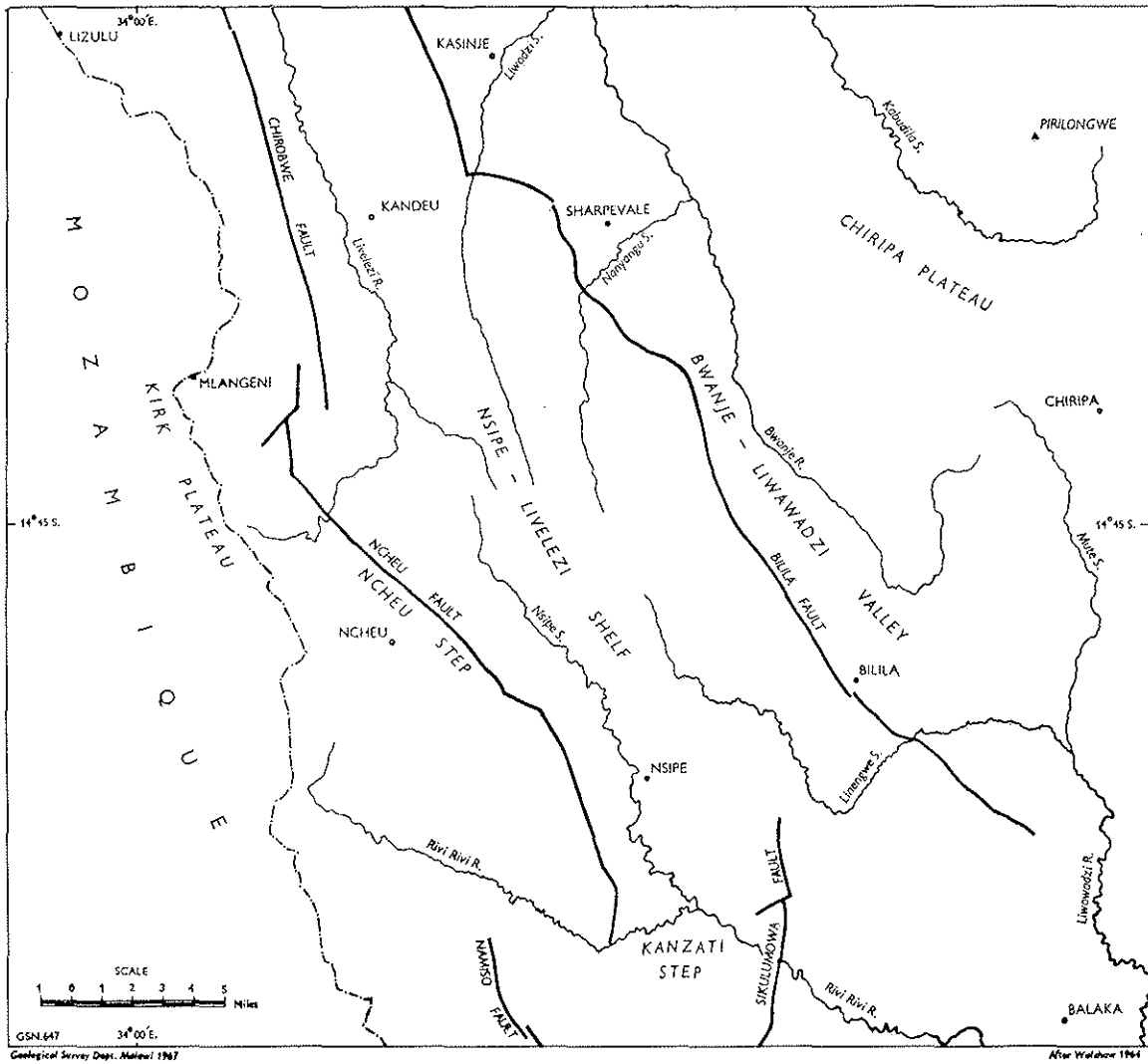


Figure 2. SIMPLIFIED STRUCTURAL MAP OF THE NCHEU-BALAKA AREA

The dissected area due north of Dedza, which can be seen clearly from the Lilongwe-Salima road, appears to be an African landsurface deeply incised by the younger post-African erosion cycle. The highest points, *e.g.*, Tuma (5,123 ft.), are probably post-Gondwana but most of this region to the west of Chipoka owes its ruggedness to the African and post-African cycles of erosion. As the western edge of the rift valley is approached the degree of younger dissection, and therefore the relief, increases. The eastern limit of this landscape is clearly marked by the fault-scarp where there is a steep descent to the lakeshore plain.

The unmodified African landsurface is most extensively developed in the Central Region of Malawi where it forms the Lilongwe Plain. With increasing distance northwards from Dedza the post-Gondwana residuals, which are a prominent feature

in this area, are reduced until a virtually unbroken African surface is formed which stretches for the best part of a hundred miles from Linthipe Village (30 miles south of Lilongwe) to the southern end of the Vipya Plateau. This surface lies at between 3,500 and 4,500 feet and is gently tilted away from the rift so that towards the west the rivers periodically spread into marshlands. This is particularly marked along the course of the Bua River.

Towards the east the uptilted African surface becomes increasingly dissected by the post-African cycle and the topography around Ntchisi and Dowa is fairly rugged. The gentle westward fall of the African planation surface from an altitude of approximately 4,500 feet along the main road to about 3,500 feet along the Bua River can clearly be seen near Ntchisi. The heights of the few post-Gondwana residuals show a similar westward fall from Mandevu (5,430 ft.), Chungwe (5,382 ft.) and Ntandazuga (5,569 ft.), to Mponda (4,720 ft.), Chalundu (4,697 ft.) and Mpudza (4,249 ft.), and finally to Sendwe (4,028 ft.) and Chirobwe (3,879 ft.), the latter lying within eight miles of the Bua River marshes. The tilting movement is therefore younger than early Miocene.

Incipient post-African erosion has penetrated along the floors of the shallow streams and rivers which cross the Lilongwe Plain and the two cycles merge gently and indiscernibly into each other instead of being separated by scarps and nickpoints. The surface in the immediate vicinity of watercourses is therefore of a composite nature, comprising both the African and the post-African cycles which are separated by a vertical interval of approximately 200 feet.

The African planation stretches westwards into Zambian territory along the entire Malawi-Zambia border as far north as the Nyika Plateau, interrupted only by a post-Gondwana residual mass which rises to a height of over 5,500 feet immediately to the north of Mchinji. The political boundary follows the Lake Malawi-Luangwa River divide.

The Lilongwe Plain extends to a point approximately 40 miles north of Kasungu where an almost continuous scarp marks the southern margin of the Vipya Plateau. Above this scarp, however, the landsurface appears to exhibit characteristics similar to those of the Lilongwe Plain (*i.e.*, dominantly African but carrying reasonably accordant post-Gondwana residuals and showing incipient post-African erosion along valley floors) although the general level of the surface is approximately 500 feet above that of the plain. Instead of assigning the surfaces on the Lilongwe Plain and those on the southern Vipya to different ages because of their different altitudes it is suggested that regional warping or tilting has occurred, thereby lifting the same Lilongwe Plain surfaces to the higher level of the southern Vipya. The small continuous scarp which separates the two occurrences or *berms* would simply reflect the critical height and degree of tilting of the basement rocks of this region.

The slight northward rise of the post-Gondwana planation on the Vipya previously described (*see* p. 16) is probably the result of such tilting movement and berm formation on the southern Vipya. A steady but gentle drop, by 500 feet or more, of the African surface of the Lilongwe Plain southwards towards Kasungu, such as occurs along the Mzimba road, emphasises the probability of this movement. Thus the lower berm forms the Lilongwe Plain and the upper berm forms the southern Vipya in the Chimaliro-Lodjwa-Champira region where the dominant African landsurface occurs at an altitude of between 4,500 and 4,800 feet. Hills rising above this level, *e.g.*, Kalungusi (5,369 ft.) and Champila (5,969 ft.), carry the vestigial post-Gondwana erosion cycle while the larger valleys, such as that of the Luviri River, can be attributed to the post-African cycle of erosion.

Further to the north, towards and beyond Luwawa Dam, the dominant plateau surface of post-Gondwana age has already been described. The steep dendritic valleys

PLATE I

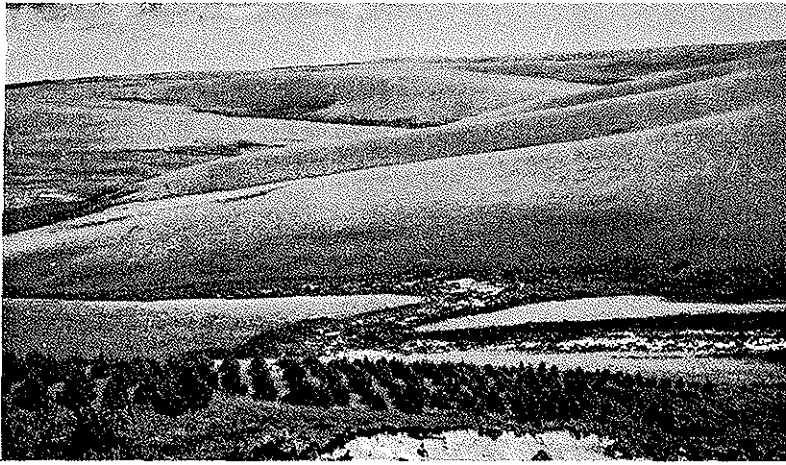


Photo: K. Bloomfield

A. Gondwana and post-Gondwana erosion cycles on the Nyika Plateau.



Photo: K. Bloomfield

B. Kasungu Mountain (4764 ft.) which stands above the African planation immediately south of the Vipya Plateau.

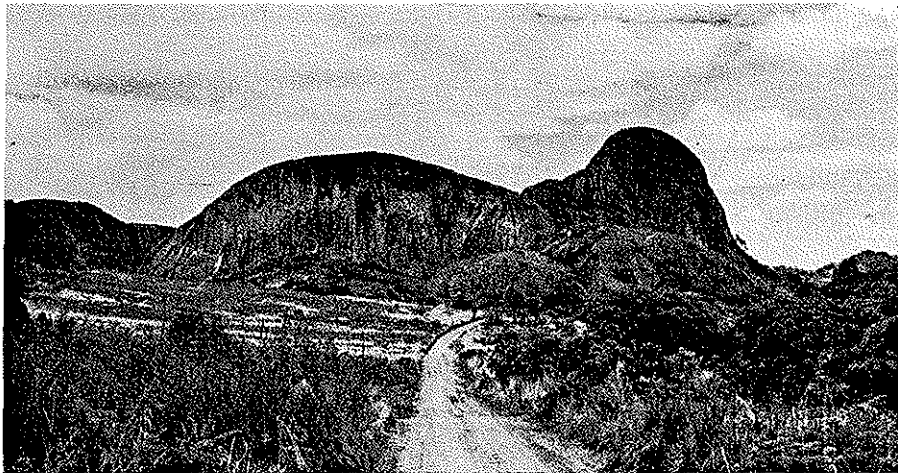


Photo: D. M. Arnall

C. "Elephant Rock," one of the bornhardtts which occur along the northern edge of the Vipya Plateau.

of the extreme head regions of the various drainage systems can, however, be assigned to the African erosion cycle although they are not characteristic of this cycle.

The Mzimba Plain to the west of the Vipya Plateau shows a marked planation standing at approximately 4,400 feet above sea level. Dixey (1941) described this as the *Mzimba Surface* and assigned to it a mid-Tertiary age. Its appearance is, however, characteristic of a composite African and post-African surface and the Mzimba Plain can therefore be classified within the erosion cycles already named. The African cycle is the dominant one but the two cycles are not sharply separated, merging gently into one another as on parts of the Lilongwe Plain. The post-African valleys of even the major rivers, such as the South Rukuru, are broad and shallow and often swampy.

This composite topography extends westwards to beyond the Zambian border, the almost unbroken African surface lying at an altitude of approximately 4,000 feet along the Lake Malawi-Luangwa divide.

To the north this geomorphic region stretches to far beyond Kafukule. The various inselbergs which rise above the Tertiary surface of the Mzimba Plain, particularly in the area around Mt. Hora which lies some 15 miles to the north of Mzimba, are of the *bornhardt* type and they are characteristically weathered by exfoliation (Plate I, C). It does, however, seem doubtful whether they carry the older post-Gondwana surface on their summits which are not very accordant and seldom reach the altitude of the post-Gondwana level shown on the Vipya Plateau. They probably did carry the post-Gondwana cycle in earlier geological time but now, during their last stages of removal, they occupy small areas and individual crests have been lowered at a differential rate to produce the present forms. This belt of *bornhardts* can be clearly seen from Ekwendeni.

In the northern Vipya area the African surface, which is occasionally broken by post-African erosion, changes from being the upper surface in the Kaningina Forest Reserve on the Mzuzu-Nkhata Bay road to being the dominant surface further west near the Chikwina turn-off and finally, to the north of Mzuzu, to being the single surface at an altitude of about 4,200 feet. Thereafter this surface is interrupted only by the younger Kasitu and South Rukuru valleys and, in the area between Kafukule and the South Rukuru River, by a few older residuals, *e.g.*, Kayozi, Ngonga and Nthumbi, in its westwards passage to beyond the Zambian border.

Slight post-Miocene warping has resulted in small variations (within 500 ft.) in the altitude of the African surface in this region. In general, this surface is at a higher level in the south and becomes lower northwards towards Rumpi so that tilting has apparently occurred, resulting in an uplift of the Vipya segment. Tilting of the southern Vipya to cause repetition of the African surface at different levels has been noted previously and so, with this surface evidence from the northern Vipya, it would appear that the Vipya Plateau forms a broad crest uparched by several hundred feet along an east-west line. When the degree of dissection is considered it would seem that this arching is fairly recent, possibly being contemporaneous with the other Plio-Pleistocene movements of Central Africa, *e.g.*, initiation of the Quaternary cycle.

To the north of Ekwendeni the main road follows the post-African valley of the Kasitu River. The African surface is marked by distinct bevel which occurs along both sides of the valley at a height of approximately 500 feet above the valley floor, this surface being surmounted by a number of residuals of various heights which are probably of post-Gondwana age, *e.g.*, Chimaliro (6,749 ft.) and Chona (6,050 ft.).

Below the Kasitu-South Rukuru confluence at Njakwa the South Rukuru valley has a similar morphology, the African surface clearly forming an intermediate bevel between the Gondwana and post-Gondwana surfaces of the Nyika Plateau and the post-African valley floor.

The African surface forms the flat crestline along the Livingstonia Escarpment at an altitude of approximately 4,500 feet. This surface is particularly well displayed on Mount Waller and at the Livingstonia Mission, the eastern margin being marked by a sharp rifted drop to the shores of Lake Malawi. Post-African dissection is fairly deep and widespread on the Livingstonia Plateau but the older remnants of the African surface continue, with occasional breaks along the crest of the rift valley scarp, to far south of the South Rukuru River and eventually link up with the African planation in the Kaningina Forest Reserve area.

North-west of Rumpi the African surface can be traced at an altitude of more than 4,500 feet on the accordant summits of the hills around Katowo Court (N. A. Katumbi). On the margins of the Nyika Plateau north of these hills the African cycle loses its characteristic planation and, as on the Vipya Plateau, forms river valleys of more youthful appearance which are eroded into the older, higher landsurfaces.

(d) Post-African

The late-Tertiary, post-African erosion cycle is widespread in Malawi, particularly at lower altitudes. As well as being evident as an individual landsurface it also occurs in close association with the older African surface, forming the valley floors of the composite surfaces described in the preceding section. Wherever the African surface extends to the edge of the rift valley scarp it becomes heavily dissected by the younger erosion cycle and, in areas such as Cholo, Dowa and Ntchisi where the African surface has been tilted away from the rift, this dissection is particularly marked.

In the Cholo area the degree of post-African dissection into the African surface increases southwards along the Limbe-Cholo road. This zone of deeper dissection extends approximately ten miles back from the floor of the Shire Valley but is of course most marked along the actual edge of the rift scarp. Towards the east, away from the rift, the degree of post-African dissection decreases and is eventually limited to incipient erosion into the African surface of the Shire Highlands.

The post-African dissection into the African surface of the Chileka Step has been described earlier. The lower of the two terraces described by Bloomfield (1965A) is broadly covered by Quaternary deposits but it is possible that these rest upon a post-African surface, the small scarp which separates this terrace from the higher level of the Chingale Step marking the nick between the buried post-African and African surfaces.

To the west of the Shire River the *Neno Step* stretches parallel to, and approximately 500 feet below, the Mwanza Step from which it is separated by a pre-Cretaceous fault scarp. On the western side of the Wamkurumadzi River this lower step appears to exhibit a fairly smooth post-African surface in the small area between the river and the foot of the scarp. To the east of the river, however, the same step clearly shows the characteristic undulating surface of the post-African erosion cycle. The height of the post-African surface on the Neno Step varies considerably between approximately 3,000 and 1,300 feet above sea level, a general drop southwards being apparent.

The post-African landsurface can be recognised near Balaka where it emerges from beneath a blanket of Quaternary river deposits at an altitude of 2,100 feet and rises northwards to become the subsidiary cycle at an altitude of more than 3,000 feet on the Ncheu Step. The repetition of the African surface with varying degrees of post-African incision on the steps to the east of Ncheu has been discussed more fully in the previous section, as has the incipient post-African erosion into the African surface of the Kirk Plateau.

The African and post-African surfaces on the Chiripa Plateau to the west of Lake Malombe can be clearly recognised from the lakeshore road which lies on the lower Quaternary level.

The composite nature of the river valleys which cross the Lilongwe Plain, that of the Bua River for example, and the increased degree of post-African dissection along the upwarped African surface as the edge of the rift is approached, *e.g.*, around Dowa and Ntchisi, was discussed earlier (*see p. 22*). Further south this increased dissection is even more marked and deep post-African valleys are a prominent feature of the rugged area to the south of the Lilongwe-Salima road and west of Chipoka and also around the Tuma Forest Reserve.

The very broad shallow valleys of the southern Vipya show incipient post-African erosion while the larger, deeper valleys, such as the headregions of the South Rukuru River, are clearly due to post-African incision. The South Rukuru valley retains its post-African characteristics throughout its entire length although these are somewhat ill-defined in the middle reaches, the valley being very broad and shallow at the point where it is crossed by the Mzimba-Lundazi road.

The post-African surface becomes the dominant landsurfaces eastwards towards Nkhata Bay and marks the main crestline of the Kandoli Mountains at an altitude of more than 3,000 feet. The highest peaks on this range, *e.g.*, Mtogama (5,314 ft.) and Kandoli (4,056 ft.), probably reach the African and perhaps even the post-Gondwana erosion levels.

In the vicinity of Chikwina the post-African surface forms the crests of several parallel ridges at an altitude of approximately 3,000 feet. These ridges trend north-south and are separated from each other by deep youthful Quaternary valleys; the surface marks a distinct bevel which has been slightly downwarped to the east towards the rift. The landscape rises to the African surface at an approximate altitude of 4,300 feet in the Kaningina Forest Reserve. In this region the occurrences of three erosion cycles—the African on the highest points, the post-African on the lower hills and ridges, and the Quaternary in the steep-sided valleys—has resulted in the formation of a very complex topography.

The broad northward-trending valley of the Kasitu River is a post-African feature, as is the narrow Njakwa Gorge which occurs immediately above the Kasitu-South Rukuru confluence. Below this confluence the South Rukuru valley remains within the post-African cycle at an altitude of 3,500 feet; here the river bed is remarkably flat and meandering and a considerable amount of alluvium has probably been deposited within it during the Quaternary period.

From a point some 25 miles north-east of Rumpi, the post-African surface of the Rukuru valley becomes increasingly dissected by small streams of Quaternary origin, this being particularly marked where the older surface rises to altitudes of 3,800 feet or more. The post-African surface takes on more youthful characteristics and west of the Rumpi-Livingstonia road its headreaches bound against the intermediate bevels of the African surface on the eastern margins of the Nyika Plateau. Deep Quaternary incision into the uneven post-African surface between the Livingstonia Escarpment on the east and the Nyika Plateau on the west has resulted in the extremely rugged terrain traversed by the road as Livingstonia is approached.

The African surface prominent in the Livingstonia-Mount Waller area is abruptly truncated to the east by a faulted scarp. Both post-African and Quaternary erosion has occurred along the edge of the escarpment, the post-African valley floors being generally about 300 feet lower than the African planation.

The road leading north from Rumpi to Chisenga passes over a slightly undulating post-African landsurface which shows a gentle northwestward rise from an altitude of 3,400 feet to approximately 3,700 feet.

The Vwaza Marsh, to the south-west of Katowo Court (Katumbi), occupies a poorly-drained basin on this post-African landsurface which becomes more and more irregular as the Katumbi Escarpment is approached, the cycle being eventually cut out completely in the valleys along the escarpment. The crest of the escarpment is marked by the African landsurface.

(e) Quaternary

Quaternary surfaces of both an erosional and a depositional origin are found in Malawi although these are generally of only limited extent, being largely confined to the floor and sides of the rift valley. Quaternary deposits have in places overlain, and thereby fossilised, the older African and post-African erosion surfaces while Quaternary erosion has penetrated northwards from the Zambezi Valley at least as far as the middle section of the Shire Valley.

In its lower reaches the Shire Valley flows in a broad, flat-floored valley in which alluvium and other recent deposits mask any Pleistocene erosion that might have occurred. The middle Shire Valley is, however, characterised by active youthful Quaternary erosion: the river bed is marked by numerous sets of rapids and the valley is narrow and steep-sided, features which are clearly visible at the Murchison Falls (Matope Bridge) and the Mpatamanga Gorge, both localities where the Shire is crossed by main roads. The river course in this section is largely superimposed.

The upper Shire Valley is typically broad and flat-floored and is largely covered by recent deposits of alluvium which extend westwards as far as Balaka. The only evidence of Quaternary erosion is undercutting of the river banks, a feature which can clearly be seen at Liwonde. Further to the north the shoreline of Lake Malombe is marked by a belt of erosion, but elsewhere the lakeshore plain exhibits Quaternary deposition.

A thin blanket of Quaternary sediments masks the downwarped African surface in the Lake Chilwa area but elsewhere in the Shire Highlands the Quaternary cycle is marked by erosional features. Certain rivers, *e.g.*, the Luchenza, have incised their course below the African surface, marking their passage by two or more terraces above the present river course to give a total micro-relief of approximately 30 feet. The upper features of these irregularities are probably due to the post-African cycle of erosion but the lower terraces and banks are undoubtedly Quaternary.

The width of the Quaternary lakeshore plain which surrounds Lake Malawi varies considerably between less than one and more than ten miles. In the wider parts this plain is generally covered by Recent sands and alluvium which therefore represent Quaternary deposition. Erosion is, however, manifest along the immediate shoreline which cuts across pre-Quaternary formations such as the Cretaceous Beds which occur at the foot of the Livingstonia escarpment. The small beach at Nkhata Bay shows no less than six shelves, each less than ten feet wide, which probably represent various recent lake levels although the lower one or two would be storm shelves.

Youthful Quaternary erosion occurs along the crest of the rift valley escarpment wherever streams and rivers notch the crest and face of the scarp. This erosion sometimes continues headwards for several miles from the edge of the escarpment in the valleys of the larger rivers, *e.g.*, the Bua and the South Rukuru.

West of Nkhata Bay the depression between the Kandoli Mountains and the northern end of the Vipya Plateau is occupied by the Limpasa *Dambo**. This swampy area occupies a north-south trough rejuvenated by Quaternary erosion which is now largely carpeted by Recent sediments. Towards the southern end of the depression, the barrier of the Kandoli Mountains, which separates the trough from the lake, dies

* Chinyanja—broad, grass-covered swampy valley.

away and the Limpasa-Majinene *Dambo* extends eastwards to the shores of Lake Malawi. The Quaternary deposits in this area therefore represent a tongue of the lakeshore plain which extends northwards along the valley for a distance of some twenty miles from Chinteche. The undulations which occur on the floor of the valley, at heights of between 1,600 and 1,900 feet above sea level, are due to uneven deposition.

At the northern end of the Limpasa Valley, towards Chikwina, the Quaternary erosion cycle has encroached upon the margins of the post-African surface to produce a series of parallel, deeply incised, north-south valleys separated by ridges which carry the post-African level. Interlocking spurs are a common feature in this area.

Quaternary dissection is very marked on the eastern slopes of the Kandoli Mountains, this being well displayed in the vicinity of Nkhata Bay township.

III. CONCLUSIONS

The scenery of Malawi can be classified into the five principal cycles of erosion recognised elsewhere in southern Africa which are, in fact, dispersed across the entire continent. Certain landsurfaces which, for various reasons, were regarded by previous workers as being distinctly separated from this classification, *e.g.*, the Mzimba Plain and the Vipya Plateau, can be shown to possess characteristics which enable a re-classification to be made within the above framework.

Cretaceous igneous intrusions have caused local complexities in the development of the erosion surfaces and proximity to the rift valley has further complicated the erosion pattern in certain areas. Localised movements, such as faulting and warping, which have occurred between pre-Cretaceous and Pleistocene times, have also added to the diversity of the landscape and, as a result, the geomorphology of some areas in Malawi is undoubtedly more complex than the text of the above broad survey indicates.

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