A pedogeomorphic comparison of two granitic areas in the Kruger National Park

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Munnik, M.C. 1990. A pedogeomorphic comparison of two granitic areas in the Kruger National Park. *Koedoe* 33(2): 61-72. Pretoria. ISSN 0075-6458.

Two climatically different areas on granitic materials near Phalaborwa and Pretoriuskop in the Kruger National Park were pedogeomorphologically compared and the influence of climatic factors on soil and hillslope development in the two areas was assessed. The examination of 18 hillslopes and their soils showed that while the two areas have many broad similarities, there are specific soil and hillslope differences between them with the result that each area has its own distinctive pedogeomorphic character. While comparable parent material, situation and age appear to be responsible for similarities between the areas, the differences could in most cases be accounted for by the disparity in rainfall between the two areas. It was, however, also necessary to note the role of past (and possibly current) cycles of erosion and deposition in the creation of the two types of simple hillslopes occurring in the areas.

Keywords: simple hillslope, pedogeomorphic aspects, spatial variability, convex-convex and convex-concave hillslopes, transects, catenary sequence, intergrades.

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Introduction

The study of two areas in the Kruger National Park originally formed part of a larger pedogeomorphic research (Munnik 1988) involving hillslope profiles on granitic materials in five climatically different areas in the Transvaal. The main objective of the research was to determine the influence of climate on soil-hillslope relationships and development, hence areas, somewhat similar geologically (comparable parent material) but differing as regards temperature, rainfall and evaporation, were selected. The Pretoriuskop and Phalaborwa areas proved eminently suitable in this respect as the first-named area has daily maximum and minimum air temperature averages of 27,6 °C and 14,6 °C and an average annual rainfall of 688 mm, while the figures for the latter area are 28,3 °C and 16,2 °C and 570 mm per annum respectively (Weather Bureau 1986). Furthermore, both areas are predominantly underlain by granite and gneiss (Geological Survey 1984, 1987), and belong to the same time period (Partridge & Maud 1987).

The necessity for examining soil and landform together has received increasing prominence during the past decade, with the result that there is a tendency for more research to be pedogeomorphic in character. This is illustrated by studies, such as those by Munnik, Verster & Van Rooyen (1984, 1986), Carter & Pearen (1985), Oliver & Webster (1986), Ovalles & Collins (1986), and Verster (1987, 1989), which have been directed at examining the spatial variability of soils and determining among others, the relationship between soil properties and landscape position. In keeping with this trend and to achieve the main objective of the research, hillslopes were selected in the Pretoriuskop and Phalaborwa areas in order to (i) compare the soil and hillslope aspects of the two areas, and (ii) account for any pedogeomorphological similarities and differences between the areas with particular reference to the role of climate (rainfall). Since various aspects (especially those relating to the soils) of the Pretoriuskop and the Phalaborwa areas are discussed in two articles by Munnik, Verster

& Van Rooyen (1990; and in preparation), the emphasis in this article is essentially on the pedogeomorphic comparison of the two areas.

Methods and Materials

The hillslopes (nine in each area) and the soils on them were studied by means of a transect design extending from the crest to the valley bottom. In the Pretoriuskop area, hillslopes were selected within a 16 km radius of the camp, and in the Phalaborwa area, hillslopes situated from one to 25 km east of the Park entrance were chosen. Only simple hillslopes were used, that is, hillslopes with fairly smooth slopes which are uninterrupted by major facets causing a repetition of hillslope units and/or soil sequences.

Hillslope units (crest, midslope, footslope and valley bottom) were demarcated in the field by using a combination of form, shape, processes and soils criteria which was varied whenever necessary in order to assess every hillslope according to its own particular pedogeomorphic characteristics. The lengths of the hillslopes and hillslope units were measured with a measuring tape, and an Abney level was used to determine the slope.

In total, 123 soil profiles were examined in the two areas by means of excavation pits and augered holes at intervals not exceeding 100 m, and at closer intervals where changes of soil form occurred. The positions of the observations on the hillslopes were recorded for the determination of soil-hillslope relationships, and the soil profiles were examined and described as set out by MacVicar, De Villiers, Loxton, Verster, Lambrechts, Merryweather, Le Roux, Van Rooyen & Harmse (1977). Soil samples (356 in total) of every diagnostic horizon (and saprolite) were analysed in the laboratory to determine particle size distribution and pH.

The granulometric properties of the sand and gravel fractions of the soil samples from two hillslopes in each area were also determined with a set of 18 sieves diminishing in size from 16 to 0,045 mm. In addition, selected samples from every observation on one hillslope in each area were chemically analysed to ascertain the percentage of organic carbon (using the Walkley & Black method), the exchangeable base content (by means of an 1N ammonium acetate solution at pH 7 and cations determined by atomic absorption) and the CEC (by measuring the amount of K absorbed by the soil using the ammonium acetate extraction method). An X-Ray Diffraction Analysis (XRD) of selected sand samples of reddish and yellowish soils in both areas was also conducted according to the standard procedures followed by the Geological Survey Laboratory, Pretoria.

The weighted averages of certain soil properties were calculated (using the method described by Ovalles & Collins (1986)) in order to present the data in a more comparable form. Pearson's Deviation Formula was used to compute the correlation coefficient r for the relationship between the clay fraction and the other fractions in the soil. A granulometric parameter (mean grain size) was calculated by using the method of moments according to the statistical analysis program system, version 5.16 (SAS Institute Inc. 1986).

Results and Discussion

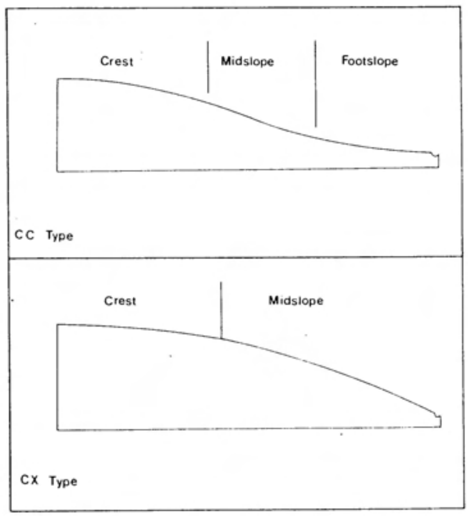

Fig. 1. Two types of hillslope based on curvature.

1. *Hillslopes*

In order to accommodate the different types of hillslopes occurring in the study areas, a system of hillslope classification based on form (profile curvature) was devised. The fact that the curvature pattern of a hillslope profile depends on the way the hillslope units curve, forms the basis of this classification. However, while all four the hillslope units contribute to the overall curvature pattern,

Table 1
Characteristics of the 18 Pretoriuskop and Phalaborwa hillslopes

Aspects		Extremes Min.	Max.	Average	Mean deviation	Coefficient of relative variability
		m	m	m	m	%
a)	Hillslope length	410 317	1125 590	709 393	181 57	26 15
	Hillslope height	22 6	47 17	34 12	9 4	26 33
		%	%	%	%	%
b)	Hillslope units as % of hillslope length					
	Crest	32 26	54 41	41 37	4 3	10 8
	Midslope	21 16	67 57	42 34	14 12	33 35
	Footslope	0 0	35 42	15 25	6 12	40 48
	Valley bottom	2 1	5 9	3 5	1 2	33 40
		°	°	°	°	%
c)	Average slope	2,3 1,1	3,5 2,4	2,8 1,8	0,4 0,3	14 17

Top rows of figures = Pretoriuskop; bottom rows of figures =Phalborwa.

only the midslope and footslope can cause variations of form as the crest in granitic areas is always convex and the valley bottom is always concave. Hence, if the valley bottom is omitted because it occupies a very small portion of the hillslope profile, three combinations of curvature with the crestal convexity is possible, that is convex-convex, convex-straight and convex-concave. The latter two combinations can, however, be grouped together because of similarities, so two types of hillslope can be identified, and these are referred to as CX and CC hillslopes (Figure 1). The CX type has no footslope since its slope increases from the crest to the valley bottom, and by definition the footslope cannot be steeper than the midslope. This hillslope type therefore differs fundamentally from the CC type.

The two hillslope types are well-represented in the Pretoriuskop area, for, although the curvature is fairly gentle and does not vary greatly in most cases, the nine hillslopes are comprised of five CC and four CX hillslopes. The hillslopes moreover differ in length from 410 m to 1 125 m and in height from 22 m to 47 m (Table 1) so variation is a feature of the Pretoriuskop hillslopes. In contrast, the nine Phalaborwa hillslopes are more noted for their similarities than for their differences, since they are all relatively short (317 m to 590 m) and (irrespective of form) flattish with a curvature that is often so minimal that it is

Table 2
Soil forms and series on the 18 Pretoriuskop and Phalaborwa hillslopes

	Pretoriuskop		Phalaborwa	
Soil groups	Form	Series	Form	Series
Reddish	Hutton	Portsmouth Moriah	Hutton	Portsmouth Moriah Shorrocks
Yellowish	Clovelly	Denhere Paleisheuwel	Clovelly	Denhere
	Avalon	Middelpos		
Duplex and paraduplex	Kroonstad	Uitspan Slangkop Katarra	Kroonstad	Slangkop
	Estcourt	Balfour Estcourt	Estcourt	Balfour
	Sterkspruit	Sterkspruit	Sterkspruit	Sterkspruit
	Valsrivier	Herschel	Valsrivier	Herschel Valsrivier
			Swartland	Swartland Rosehill
Non-duplex	Longlands	Tayside Vaalsand		
	Cartref	Kusasa	Cartref	Kusasa Cartref
Valley bottom	Oakleaf	Jozini	Oakleaf	Jozini Venda
	Dundee	Dundee	Dundee	Dundee
	Swartland	Rosehill		
			Valsrivier	Valsrivier Herschel
Litholic	Glenrosa	Glenrosa	Glenrosa	Glenrosa

almost straight. Furthermore, only two of the nine hillslopes are of the CX type. Thus, while it requires two models as shown by Munnik *et al.* (1990) to depict the hillslopes in the Pretoriuskop area, it is possible to represent the Phalaborwa hillslopes by means of one model.

Regarding the hillslope units, both areas exhibit a reasonable uniformity of crest length, but as indicated by CRV (coefficient of relative variability) values of over 30 % (Table 1), there is a lively variation in the lengths of the other hillslope units. The Pretoriuskop footslopes and valley bottoms are, moreover, notable for their collective shortness (Table 1) which is in accord with Gertenbach's (1983) reference to narrow and relatively inconspicuous bottomlands in the Pretoriuskop area.

2. *Soils*

For comparative purposes, the soils are grouped into reddish, yellowish, greyish and litholic soils. The greyish soils are furthermore subdivided into duplex/paraduplex, non-duplex and valley bottom soils. The lith="olic group comprises soils of the Mispah and Glenrosa forms, while the soils in the other groups are placed according to the dominant colour of their sub-surface horizons.

Some 13 soil forms, comprising 19 soil series, were identified on the nine Pretoriuskop hillslopes (Table 2) and although there is some diversity among the hillslopes regarding a soil pattern, certain trends are nevertheless observable and fairly representative of the area.

Thus on most of the hillslopes, the extensive occurrence of sandy, reddish soils (Hutton form) on the crests is followed by sandy, yellowish soils (Clovelly form) which gradually change downslope into non-duplex soils with leached, greyish subsurface horizons (Longlands, Longlands/Fernwood intergrades and Cartref forms) reflecting an increasing soil wetness. The soils on the narrow remaining section of the hillslope to the valley bottom are however less predictable, for non-duplex soils (Longlands and Cartref forms) occur nearly as frequently as duplex and paraduplex soils (Estcourt, Sterkspruit, Kroonstad and Valsrivier forms). In addition, this section is characterised on the CX hillslopes by the dominance of Longlands, Kroonstad and Glenrosa forms. The valley bottoms on the other hand do not vary much among the hillslopes as regards soils, for they are occupied in most cases by stratified sands of the Dundee form.

The Phalaborwa soils exhibit certain broad similarities with those of the Pretoriuskop area. For instance, the 11 soil forms and 17 soil series present on the nine Phalaborwa hillslopes are very nearly the same as those identified in the Pretoriuskop area (Table 2) — the main point of difference being the absence of Longlands form soils in Phalaborwa. Furthermore, reddish, yellowish and greyish soils also follow each other in a catenary sequence on most of the hillslopes in this area.

There is, moreover, little difference between the two areas as regards soil textural properties (Table 3), and in both cases the soils of the upper part of the hillslope are, on the average, low in clay content (below 10 %) which contrasts markedly with most of the lower-lying soils. However, despite the simi-

Table 3
Textural properties of the soils of the Pretoriuskop and Phalaborwa areas (values are weighted averages of the whole soil)

	Particle size distribution				
Soil group	Clay %	Silt %	Fine sand %	Medium sand %	Coarse sand %
Reddish	7,7	5,1	23,9	23,6	39,6
	8,2	5,6	30,6	24,6	31,3
Yellowish	7,1	5,5	26,5	24,4	36,8
	6,7	5,0	29,2	26,6	32,5
Non-duplex	7,9	5,5	24,2	22,9	39,8
	7,4	4,0	30,3	25,2	33,2
Duplex and paraduplex	18,9	6,3	20,2	17,2	37,4
	22,9	6,2	24,0	17,1	29,8
Valley bottom	13,9	4,5	13,0	18,7	49,8
	15,9	4,6	13,9	18,5	47,0
Litholic	7,9	7,3	26,2	20,7	38,0
	8,5	6,4	30,4	25,7	29,3

Top rows of figures = Pretoriuskop; bottom rows of figures = Phalaborwa

Table 4

Selected granulometric properties of the soils on a Pretoriuskop hillslope and on a Phalaborwa hillslope

Hillslope unit	Observation	Mean grain size in mm Above the stoneline	 Below the stoneline
(a) **Pretoriuskop**			
Crest	A	0,56	0,79
	B	0,55	1,13
	C	0,57	1,27
Midslope	D	0,60	1,27
(upper)	E	0,47	2,27
	F	0,52	0,74
(lower)	G	0,52	2,04
	H	0,35	2,99
	I	(Shallow Glenrosa form soil)	
Valley bottom	J✝	0,81	1,37
(b) **Phalaborwa**			
Crest	A	0,51	1,04
	B	0,54	1,42
Midslope	C	0,56	0,74
	D	0,55	0,97
Footslope	E	0,42	1,65
	F	0,46	1,05
	G✝	0,44	1,37
	H	(Shallow Glenrosa form soil)	
Valley bottom	I✝	0,72	0,84

✝ no stoneline — top and bottom soils used

larity in texture and in sand grade (coarse sand dominant) the increases in the clay fraction downslope, occur at the expense of the medium sand fraction (r = -0,68) in the Pretoriuskop area, and at the expense of the medium and fine sand (r = -0,91 and r = -0,84) in the Phalaborwa area. This disparity could be due to a difference in weathering, but it is more likely that it is of parent material origin. This is also the case regarding the difference between the two areas in mean grain size of the sand and coarse particles (>2 mm) below the stoneline (Table 4). It is interesting, however, to note that while this material is coarser in the Pretoriuskop area, the material above the stoneline does not differ very much granulometrically between the two areas. The resultantly greater disparity between grain size above and below the stoneline in the Pretoriuskop area could possibly be as a result of more intensive weathering in this area. However, while it is assumed that (because of higher rainfall) the soil moisture conditions in the Pretoriuskop area is more conducive to the chemical weathering of soil particles than in the Phalaborwa area, this could not be determined in the research. For instance, an XRD analysis of the sand particles of selected soil samples merely revealed a fairly substantial and almost equal sodic feldspar presence in both areas, which, judging by a weathering sequence list of coarse-grained minerals (Goldich 1938, cited by Jackson & Sherman 1953), is an indication that weathering is not far advanced (intermediate stage) — sodic feldspar, being less stable than most of the other minerals, is among the first to be weathered.

The Phalaborwa soils on the other hand differ in several other respects from those of the Pretoriuskop area, and possibly the most distinctive diffentiating feature is the general shallowness of the soils in the Phalaborwa area (Table 5). In fact, most of the reddish and yellowish soils have B horizons which are so

Table 5
Soil extent and depth on the 18 Pretoriuskop and Phalaborwa hillslopes

Soil groups	Extremes Minimum	Extremes Maximum	Average	Mean Deviation	Coefficient of relative variability
a) **Extent** (% of hillslope length)	%	%	%	%	%
Reddish	32	67	43	6	14
	26	51	40	8	20
Yellowish	0	48	19	13	68
	0	27	14	5	36
Non-duplex	0	54	18	13	72
	0	43	13	6	46
Duplex and paraduplex	0	27	8	7	88
	0	37	15	6	40
Valley bottom	2	5	3	1	33
	1	9	5	2	40
Litholic	0	41	9	9	100
	0	35	14	7	50
b) **Average soil depth**	mm	mm	mm	mm	%
Reddish	630	950	810	13	16
	400	650	500	7	14
Yellowish	620	880	670	11	16
	450	700	530	9	17
Non-duplex	600	1 000+	930	20	22
	530	800	620	9	15
Duplex and paraduplex	1 000	1 000+	1 000+	7	6
	640	850	730	9	12
Valley bottom	850	1 000+	1 000+	6	5
	550	850	720	11	15
Litholic	250	430	360	6	17
	350	450	430	3	7

Top rows of figures = Pretoriuskop; bottom rows of figures = Phalaborwa

thin that the soils are actually borderline litholic soils (Glenrosa intergrades). The litholic group is moreover more prominent in this area, and on a number of hillslopes the shallow reddish crestal soils of the Hutton form merge downslope into Glenrosa form soils instead of the shallow Clovelly form soils present on the other hillslopes. The midslope soils in the Phalaborwa area are consequently more predictable and uniform than is the case in the Pretoriuskop area. However, while also less varied than in the Pretoriuskop area, the footslope soils show some variation, although the Sterkspruit form occurs somewhat more frequently than the other soils present on this hillslope unit, namely, Kroonstad, Valsrivier, Swartland, Estcourt and Cartref forms. The valley bottoms again, are dominated by the Oakleaf form with a few occurrences of Valsrivier and Dundee form soils.

Other significant soil features of the two areas are:

(i) An exchangeable base content that is generally fairly low, but which increases markedly in the footslope and some valley bottom soils in the Phalaborwa area, but only slightly in the Pretoriuskop area (Table 6).

(ii) A lowish organic carbon percentage (0,22 to 0,69) in the A horizons in the Phalaborwa area, compared to a moderate percent-

Table 6
Selected soil chemical properties (averages) on two Pretoriuskop and Phalaborwa hillslopes

Properties (% C = A horizon rest = B horizon)	Soil groups					
	Reddish	Yellowish	Non duplex	Duplex and Para-duplex	Valley bottom	Litholic
K	0,11	0,07	0,05	0,14	—	0,12
me/100g	0,14	0,14	0,15	0,32	0,30	0,38
Ca	0,82	0,81	1,13	3,08	—	1,32
me/100	0,23	0,40	0,35	7,04	10,70	2,87
Mg	0,63	0,64	0,81	2,89	—	0,97
me/100g	0,31	0,57	0,73	6,52	6,30	4,83
Na	0,02	0,04	0,14	0,57	—	0,26
me/100g	0,36	0,51	0,57	4,59	1,37	0,73
Organic C	0,90	0,91	0,87	1,13	—	0,91
%	0,34	0,39	0,22	0,38	0,69	0,42
pH (four hillslopes)	5,7	5,5	5,9	6,8	6,4	6,0
	5,7	5,6	6,5	6,7	7,2	6,2
S-value	1,58	1,56	2,13	6,68		
me/100g soil	1,04	1,62	1,80	28,27		
CEC	2,02	1,77	1,98	6,09		
me/100g soil	1,61	1,94	2,01	13,24		
S-value	17,70	15,60	19,40	25,70		
me/100g clay	13,60	23,10	20,00	85,20		
CEC	22,50	17,70	18,00	23,00		
me/100g clay	21,70	27,70	22,30	40,60		

Top rows of figures = Pretoriuskop; bottom rows of figures = Phalaborwa.

age (0,87 to 1,13) in the Pretoriuskop area (Table 6).

(iii) A pH reading that is generally moderately acid, changing gradually downslope to neutral or alkaline (Table 6).

(iv) A very limited occurrence of soils with E horizons and no Longlands form soils in the Phalaborwa area, in contrast to the Pretoriuskop area where the occurrence of these soils are fairly common.

(v) The presence of some poorly developed hard plinthite resulting in a Cartref/Wasbank integrade type of soil in the Pretoriuskop area. It is significant that the hard plinthite occurs mainly on the lower midslope/upper footslope where there is generally an accumulation of lateral moving water in the soils of the hillslopes concerned. No such accumulation of water was observable on any of the nine Phalaborwa hillslopes and the absence of hard plinthite in this area is therefore not unexpected.

(vi) An average me/100 g clay of the exchangeable bases in some of the reddish and yellowish soils of 16,4 in the Phalaborwa area and 16,8 in the Pretoriuskop area which indicates that these soils are eutrophic (i.e. very little leaching has occurred) in both areas. Although one would have expected a greater degree of leaching in the Pretoriuskop area because of the higher rainfall, the area has, like the Phalaborwa area, a Typic Tempustic soil moisture regime (according to the Newhall model by Van Wambeke 1982) which is only conducive to minimal leaching of the soils due to its marked seasonal moisture variation.

Climatic and other influences

In order to account for the similarities and dissimilarities of the two areas it is necessary to note not only the present, but also the past landscape-shaping factors, namely the erosion cycles described by King (1963), Brook (1978), Partridge & Maud (1987) and others. There can be little doubt that these cycles had a considerable influence on the soil cover of the two areas, for the soils provide ample evidence of this. For instance, the presence of stonelines on most of the hillslopes in the two areas point to the existence of former erosion surfaces — the erosional break being indicated by the stoneline according to Gerrard (1981). This is substantiated by the granulometric analysis of the soils on a hillslope in each area, for in both cases the soil material below the stoneline differs quite markedly in mean grain size from the material above the stoneline (Table 4), which suggests a difference in origin. Thus, while the lower material appears in most cases to have developed *in situ* from the weathered rock since it repeats to a large extent the granulometric properties of the parent rock, the finer-grained upper material was probably colluvially deposited on the layer of rock fragments forming the stoneline. With reference to Verster (1989), the colluvial movement of material over the stoneline is also indicated by the overall decrease in mean grain size of the upper material from the crest to near the valley bottom (Table 4). The increase in coarseness of the valley bottom material on the other hand, can be ascribed to alluvial action. The soils therefore reflect to an extent the long and complex history of landscape development of the two areas — development during which successive cycles of erosion and deposition during the Tertiary and Quarternary carved and covered the underlying rock structure to form the present landsurface.

Furthermore, because both areas form part of the low-lying landsurface system between the escarpment and the sea, and are underlain by granite or related material, the erosion and deposition cycles have created landsurfaces with certain broad similarities, that is, rounded, fairly regular undulations with isolated, steeply sloped koppies. The fact that the soils of the two areas are somewhat similar in respects such as texture, degree of leaching, and pH, can also be attributed to the comparable parent material, location, and erosion and deposition cycles, as well as climates that do not differ too greatly.

However, within this broad soil and hillslope agreement there are the specific differences (discussed in the previous section) that give each area its own character and set it apart from the other. These differences, moreover, appear to be directly attributable to the difference in rainfall and (to a much lesser extent) temperatures between the two areas. For example, it is generally accepted that the rate and degree of weathering depends largely on the quantity of moisture, so the fact that the weathering of the underlying rock is observably more pronounced in the Pretoriuskop area than in the Phalaborwa area, is doubtlessly due to the wetter conditions there. Furthermore, there can be little doubt that the markedly thicker soil cover on the Pretoriuskop hillslopes is due to the greater source of weathered material, and the difference in soil depth between the two areas is therefore also rainfall relatable.

The disparity in rainfall can also be used to explain most of the other, in some cases more subtle, soil differences between the two areas. Thus the relative scarcity of soils with E horizons in the Phalaborwa area can be attributed to the moderate amount of water moving downslope in the soils. The limited and fairly infrequent lateral flow of water in the soils has, moreover, resulted in the pronounced accumulation of bases and clay in the lower-lying soils. Furthermore, the more extensive occurrence of duplex/paraduplex soils in this area (15 % of hillslope length) compared to the Pretoriuskop area (8 % of hillslope length) is undoubtedly partially due to the more pronounced wet and dry cycles resulting from the lower rainfall and higher temperatures.

In the Pretoriuskop area on the other hand, the seepage on the lower midslope/upper footslope of some of the hillslopes as well as the fairly common occurrence of soils with grey, leached subsurface horizons, is clearly the result of the higher rainfall. So also is the higher organic carbon content, the generally low base status of most of the soils and the very moderate accumulation of bases in some of the bottomland soils.

Rainfall differences are also largely responsible for the differences in hillslope features between the two areas. Thus, besides the role of the deeper soils and a higher degree of weathering in the formation of the Pretoriuskop hillslopes, the greater erosive (down-cutting) powers of the streams (through the higher input of water energy) have much to do with the creation of specific hillslope characteristics. The latter include more deeply incised valleys and consequently steeper hillslopes as well as a greater variation in hillslope length than in the Phalaborwa area.

An examination of a drainage map of the two areas will reveal that the Phalaborwa area has a higher drainage density than the Pretoriuskop area. This is in accord with the opinions and findings of researchers such as Gregory (1976), Gregory & Walling (1978), Knighton (1984), and others, namely that drier areas tend to have higher drainage densities than wetter areas. This landsurface feature is thus rainfall related, so it follows that hillslope length which is largely dependent on the distance between water courses can also be linked to rainfall. The very much longer hillslopes in the Pretoriuskop area are therefore due to the higher rainfall.

The occurrence of more CX type hillslopes and hillslope form variation in the Pretoriuskop area, compared to the Phalaborwa area, is in all probability also rainfall induced, but cannot be easily linked, for the study of other areas showed that additional factors could also be involved (Munnik 1988). The occurrence of CX and CC hillslopes in the two areas can nevertheless be explained by considering the role that cycles of deposition and erosion have played in the development of the present landscape. Consequently it is postulated that, prior to the most recent erosion cycle, the majority of hillslopes in the two areas probably had concave footslopes and valley bottoms because of thick colluvium deposits (Fig. 2). This is substantiated by a recent research in nearby Swaziland which indicated that colluviation could have occurred about 30 000 to 12 000 years ago (Watson, Price Williams & Goudie 1984).

The latest erosion cycle (or cycles as there may be one occurring at present) has, however, removed much of the soil on these two hillslope units on some of the hillslopes, while incising deeply into the valley bottom and creating a steepish convex transition to the valley bottom (Fig. 2). All the hillslopes are, of course, not affected in the same way by this erosion cycle for the valley bottom incision and the convex transition depend on the downcutting ability of the stream which varies according to its size, slope and catchment area. CC hillslopes therefore also occur in the two areas.

Furthermore, the erosional stripping of soil material by valley bottom incision and footslope erosion during a Quarternary erosion cycle could also account for the presence of shallow soils (mainly Cartref/Wasbank intergrade and Glenrosa forms) on the transitional convexity to the valley bottom on many of the CX hillslopes in the two Kruger Park areas and in the nearby Nsikazi area examined by Verster (1989).

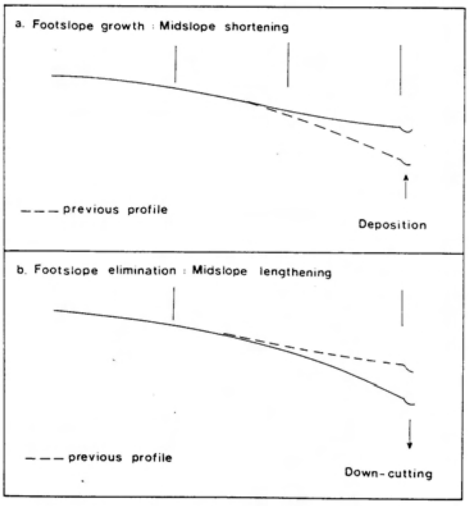

Fig. 2. Lower hillslope curvature created by deposition or incision.

Conclusion

It is evident from the foregoing pedogeomorphic comparison of the Pretoriuskop and Phalaborwa areas in the Kruger National Park, that while it is not possible to provide a simplistic explanation of their landsurface development because of the lengthy time period and the many variables involved, many of the soil/hillslope features are relatable to specific landsurface-shaping factors. Furthermore, since some of these factors are basically the same for both areas, the hillslopes and especially the soils of the two areas are similar in some respects. The equating influence of these factors is, however, modified by the difference in effective rainfall between the two areas. Thus, the greater input of energy (rainfall) in the Pretoriuskop area has resulted in a more deeply incised landscape, deeper soils, a more pronounced degree of spatial variability of soil and hillslope features, and longer and steeper hillslopes than in the drier Phalaborwa area.

As stated earlier, the rainfall difference between the two areas is significant but not extreme, hence the majority of soil and hillslope differences are not very marked. It is therefore logical to assume that a greater difference in rainfall would have resulted in more pronounced soil and hillslope dissimilarities between the two areas.

Lastly, it is also evident from the examination of the Pretoriuskop and Phalaborwa hillslopes, that simple hillslopes on granitic materials can be divided into two groups according to the presence or absence of footslopes. It is, moreover, probable that valley bottom incision or deposition, associated with past (and possibly present) cycles of erosion and deposition, is responsible for the two forms of curvature occurring in the lower sections of the hillslopes.

Acknowledgements

The National Parks Board is thanked for permission to work in the Kruger National Park and for providing assistance with the field work.

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