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KENYA SOIL SURVEY

The sand mineralogy of some soils of the Kisii area

by

W. Siderius

Kenya Soil Survey, Internal Communication No. 20,
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1. Introduction

The reconnaissance soil survey of the Kisii area at scale 1:100,000 was carried out by the Training Project in Pedology from the University of Wageningen, The Netherlands. At the request of the teamleader, Ir. W.G.M. Wielemaker, 31 soil samples from 16 soil pits were submitted to the Kenya Soil Survey for sand mineralogical analysis. Special attention was asked to be given to the possible influence of volcanic ash on the soils in the area. Because of lack of soil material mineralogical slides could not be prepared from all the samples submitted. For the same reason fractionated sand mineralogical research was only carried out on a limited number of samples.

2. Materials and methods

A total of 31 soil samples were received from 16 sites (see fig. 1). The samples were taken from the topsoil (0-20cm) and from the subsoil (in general 80-100cm). From 24 samples the very fine sand fraction (0.05-0.10mm) was examined; from 26 samples the fine sand fraction (0.10-0.25mm) and from 16 samples the medium sand fraction (0.25-0.50mm) were examined. To prevent disintegration of the finer mineral particles no pretreatment of the very fine and fine sand fractions was carried out. However for the medium sand fraction the materials were "cleaned" with H_2O_2 and 0.2N HCl.

The separation of the minerals into light (s.g. $<$ 2.89) and heavy minerals (s.g. $>$ 2.89) was carried out by means of bromoform (s.g. = 2.89). Grains were mounted on glass slides with Canada balsam and subsequently counted with a petrographic microscope. Only those grains touching the cross-line on the eye piece were considered. For both the light and heavy minerals 100 mineral grains were identified. The number of opaque minerals was subsequently recounted for transparent grains.

The heavy mineral fraction of the very fine and fine sand fractions appeared to be 100% opaque and was therefore not considered any more. For the medium sand fraction only a few slides contained transparent mineral grains.

It is assumed that a number of minerals (for example feldspars) have not been identified because they have been coated by mineral or organic matter, which because of the "soft" pretreatment was not removed, and as such were seen as opaque minerals.

3. Results

3.1. Parent material and soils

The majority of the area is underlain by some of the oldest rocks known in Kenya dating back to the lower Pre-Cambrian. Only a small area in the northwestern corner of the map sheet has rocks of younger age (Tv-Tertiary). Figure 1 shows the simplified geology and the sampling sites. The geological data are extracted from Huddleston (1951) and Schoeman(1959). Detailed information on age of rock, rock type, major constituent of the rock and soil classification is given in Table 1.

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Table 1. Geology and soils of the sites

Era	System	Rock & type map symbol(1)	Major constituents	Soil classification (profile no.
Mesozoicum	Upper Tertiary	nepheline basalt(Tv)x	nepheline,quartz, alk.feldspar,iron ores	pellic Vertisol (XII)
Upper Pre-Cambrian	Upper Bukoban	rhyolites and tuffs, intercalated with sediments (Bar)x	rutile,zircon, tourmaline,iron ores,orthoclase, oligoclase, biotite,chlorite	luvic Phaeozems (I and VI)
Upper Pre-Cambrian	Upper Bukoban	felsites and andesites (Ba)x	quartz,andesine, epidote, biotite, orthoclase,iron ores	Nitosols (II & III), Planosol (IV) and Histosol(V)
Upper Pre-Cambrian	Lower Bukoban	basalts with Kisii soapstone(Bb)	quartz,olivine, plagioclase	Nitosol(VII)
Pre-Cambrian	Post Kavirondian	granite intrusives(G3)	plagioclase, augite, olivine, magnetite,quartz	Phaeozems (XV & XVI) Nitosol (XIV)
Pre-Cambrian	Kavirondian (post Nyanzian)	granite intrusives(G2)x	feldspars, quartz,epidote, muscovite	Cambisol (VIII) Nitosol(IX) Planosol(X) Alluvium(XI)
Pre-Cambrian	Nyanzian	rhyolites and rhyolitic tuffs (Nr)	tourmaline, sphene,epidote, orthoclase, oligoclase,quartz	Phaeozem (XIII)

x= possible influence by volcanic ash according to Kisii Soil Survey parties
(1) see fig.1
(2) according to FAO/Unesco, 1974

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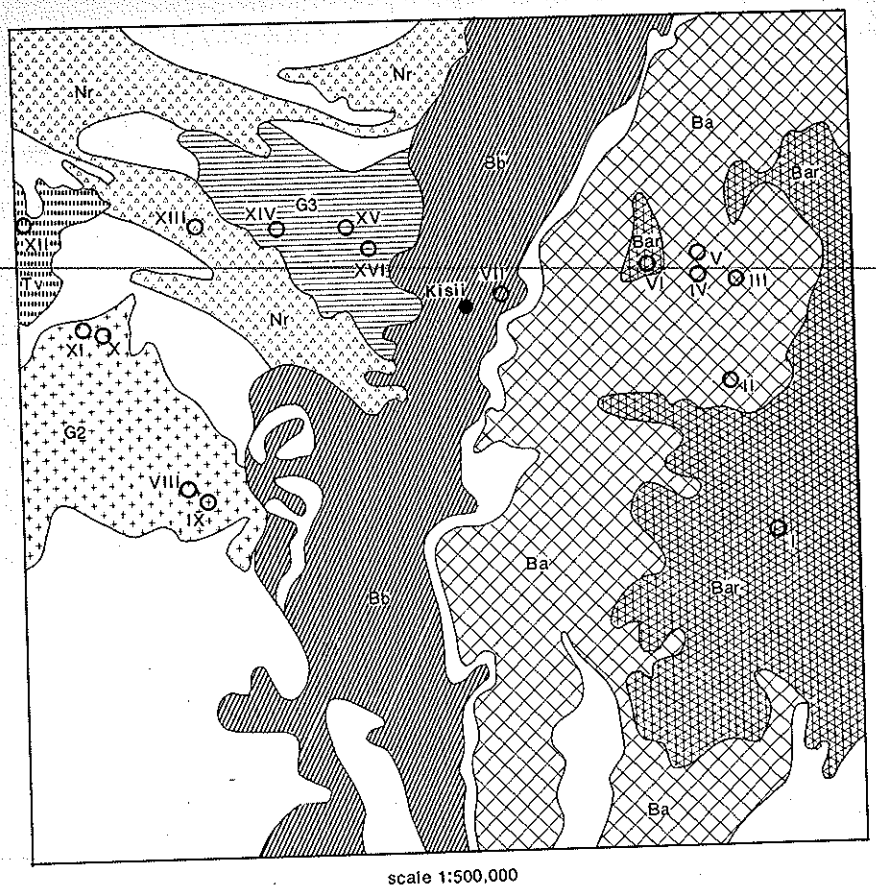
Fig. 1 **Simplified geology in relation to sampling sites**



scale 1:500,000

Pit no.	Sample no. 0-20cm	Sample no. 80-100cm
I	1	2
II	3	4
III	5	6
IV	7	8
V	9	10
VI	11	12
VII	13	14
VIII	15	–
IX	16	17
X	18	19
XI	20	21
XII	22	23
XIII	24	25
XIV	26	27
XV	28	29
XVI	30	31

Geology

Bar – rhyolites and tuffs
Ba – felsites and andesites
Ba – felsites and andesites
Ba – felsites and andesites
Bar – rhyolites and tuffs
Bb – basalts
G2 – granites
G2 – granites
G2 – granites
G2 – granites
Tv – nepheline basalts
Nr – rhyolites
G3 – granites and quartz diorites
G3 – granites and quartz diorites
G3 – granites and quartz diorites

Drawing No. 79049

The light mineral composition of the sand fractions is presented in Appendix I a,b & c. From the data it is evident that most of the weatherable minerals are not present in the soils sampled, quartz being the dominant light mineral constituent. However a number of other light minerals occur in the sand fractions of the sampled soils which are not mentioned in Table 1. They concern volcanic glass, phytolite and some plagioclase feldspars. Their presence points to an allochthone influence (volcanic ash) of the original parent material and is evident in all profiles, except X, XI.

Data on heavy minerals are only available for some of the medium sand fractions. Opaque minerals are dominant in these sand fractions. They consist of iron ores, as commonly reported present in the rocks, but may also consist of other minerals which are coated by authigenic matter, viz a metalcutan or organan, which as such prevents their disintegration. No further research on their composition has been carried out. The presence of olivine conforms with the parent rock composition (profile XV). The occurrence of the various minerals was also plotted against the rock types. The following remarks can be made. Very fine sand fraction (0.05-0.10mm). It appears that the highest number of opaque minerals occur on soil samples derived from felsites and andesites (Ba). The highest amount of quartz in this fraction was observed in soils derived from the younger and older granite intrusives (respectively G3 and G2), but high percentages occur also on soils derived from rhyolites and felsites and andesites (Bar and Ba). Most of the volcanic glass determined in this fraction is confined to soils developed on unit Ba, but also on units G3, Bb and Bar. Phytolite is found in largest percentage in soils derived from unit Ba.

Fine sand fraction (0.10-0.25mm) Opaque minerals are dominant in soils from unit Ba, while high quartz percentages occur in soils of unit G2, G3, and also on soils of units Ba and Bar. Highest counts of volcanic glass are found on sand fractions of soils of units Bar and Ba. These decrease in number on other formations. If easterly winds are assumed during the ash deposition one would expect the finest particles to be carried further West (unit Ba etc) and the coarser particles to be settled closer to the source, which seems to be the case. Phytolite is most common in soils on unit Ba, followed by those on units Bar, Bb, G2 and G3. A trace is found in material from Tv.

Medium sand fraction (0.25-0.50 mm)

Opaque minerals are abundant on soils derived from granites (G2 and G3) Quartz, which is also very common on soils derived from rhyolites is also abundant. The amount of volcanic glass in this fraction is very small, and is mainly restricted in occurrence to soils from units G2, G3, Bb and Tv. For phytolite the same applies. The presence of the exotic constituents in the sand fraction has enriched the soils. Evidence of their occurrence in the subsoil may point to considerable homogenization of the soil material since their deposition. The presence of volcanic glass and the accessory minerals sanidine and anorthite confirm the presence of volcanic ash. The latter two minerals have been observed in the sand fractions of soils from the Kinangop Plateau (personal communication Siderius to Nyandat). There is no clear evidence as to the origin of the volcanic ash, although it has been postulated that it was brought with easterly winds from a source or sources in the Rift Valley (Wielemaker, 1979). In addition it is not known how much ash has been deposited in the (recent ?) past.

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Table 2. The percentage volcanic glass, phytolite, anorthite and sanidine in the sand fraction of the soils

mineral	percentage	sample no's in fractions		soil and profile no's
		0.05-0.10mm	0.10-0.25mm	
volcanic glass	0-5	1,2,11,13 29,30 3,4 7,8	2,13,30 7,8 10	Phaeozems(I,VI,VII,XV,XVI) Nitosol (II) Planosol (IV) Histosol (V)
	6-10	12 5 10	1,11 3,4,5 9	Phaeozems (I,VI) Nitosols (II,III) Histosols (V)
	>10	6 9	6	Nitosol (III) Histosol (V)
phytolite	0-10	2,12 7	2,11,12,25,30 3,4,14,26,27 7,18 9,10 22	Phaeozems(I,VI,VIII,XVI) Nitosols(II,VII,XIV) Planosols(IV,X) Histosol(V) Vertisol(XII)
	11-20	1, 3,4,13 11	1,29 5 8 15	Phaeozems (I,XV) Nitosols(II,III,VII) Planosol(IV) Cambisol (VIII)
	>20	5,6 8 9	6	Nitosol (II) Planosol (IV) Histosol (V)
anorthite	0-5	 3 7 10	11,12 4,5,6,13 7,8	Phaeozem(VI) Nitosols (III,VII) Planosols (IV) Histosol (V)
	6-10	 6	1 3	Phaeozem (I) Nitosols (II,III)
	> 10	 4 8	2	Phaeozem (I) Nitosol (II) Planosol (IV)
sanidine	0-5	2,12, 4,5,6 8		Phaeozems (I, VI) Nitosols (II,III) Planosol (IV)
	6-10	11 7		Phaeozem (VI) Planosol (IV)

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The occurrence of consolidated ash or tuff has been reported in the Geological Survey Reports. These depositions are however of a much older age than the ash deposits referred to above (units Bar and Nr). Table 2 summarizes the occurrence of various light minerals in the various soils. It appears that the volcanic ash influence is evident in most soils of the area and is not restricted only to a few particular ones. In addition this influence is decreasing from East to the West. The highest amount of volcanic glass occurs in the Nitosols (III), the subsoil of a Planosol (IV-8) and a subsoil of a Nitosol (II-4). Percentages in orther soils are variable. Sanidine occurs mainly in Nitosols, Planosols and Phaeozems. Thus the occurrence of the various light minerals is not closely related to soil classification.

3.2. Sand mineralogy of the topsoils and the subsoils

No sand mineralogical analyses of complete profiles could be prepared since only samples from the topsoils and the subsoils were submitted. However the analysed samples enable an interesting comparison between the mineralogical composition of the top soils and the subsoils. The result of the computations, which are based on the data given in the Appendices, is presented in Tables 3, 4 and 5.

These tables are shown on page 6, 7 and 8.

note

According to Alvarado(1974) and Mohr et al. (1972) the occurrence of phytolite or plant opal is closely associated with volcanic ash soils.

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Table 3. Light mineral composition of the very fine (0.05-0.10mm) sand fraction

mineral	topsoil (t)			subsoil(s)			
	total counts	no's of samples	mean	total counts	no's of samples	mean	ratio t/s
quartz	878	11	79.8	783	11	71.2	1.1
opaque	586	12	48.8	465	11	42.3	1.2
phytolite	238	11	21.6	169	10	16.9	1.3
volcanic glass	53	10	5.3	47	10	4.7	1.1
anorthite	13	3	4.3	34	4	8.5	0.5
total	1768			1498			

mineral percentages

quartz	:49.7%	:52.3%
opaque	:33.1%	:31.0%
phytolite	:13.5%	:11.3%
volcanic glass	: 3.0%	3.1%
anorthite	: 0.7%	: 2.3%
	100.0%	100.0%

combined mineral composition of the topsoil and the subsoil

quartz	:50.9%
opaque	:32.2%
phytolite	: 2.5%
volcanic glass	: 3.1%
anorthite	: 1.4%
	100.0%

Differences in light mineral composition of this sand fraction are small concerning quartz and opaque minerals and volcanic glass. The percentage of phytolite is slightly higher in the topsoil than in the subsoil, the reverse is the case for anorthite.

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Table 4. Light mineral composition of the fine (0.10-0.25 mm) sand fraction

mineral	topsoil (t)			subsoil (s)			
	total counts	no.of samples	mean	total counts	no.of samples	mean	ratio t/s
quartz	858	11	78.0	750	10	75.0	1.0
opaque	662	11	60.2	533	10	53.3	1.1
phytolite	61	8	7.6	82	7	11.7	0.7
volcanic glass	57	9	6.3	34	6	5.7	1.1
anorthite	29	6	4.8	25	5	5.0	1.0
total	1667			1424			

mineral percentages

quartz	:51.5%	52.6 %
opaque	:39.7%	37.4 %
phytolite	: 3.7%	5.8 %
volcanic glass	: 3.4%	2.4 %
anorthite	: 1.7%	1.8 %
	100.0%	100.0 %

combined mineralogical composition of topsoil and subsoil

quartz	:52.0%
opaque	:38.7%
phytolite	: 4.6%
volcanic glass	: 2.9%
anorthite	: 1.8%
	100.0%

The percentages quartz, opaque minerals and anorthite are fairly constant, however there is a slight increase in phytolite and a definite decrease in volcanic glass with depth.

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Table 5. Light mineral composition of the medium (0.25-0.50mm) sand fraction

mineral	topsoil (t)			subsoil (s)			
	total counts	no.of samples	mean	total counts	no.of samples	mean	ratio t/s
quartz	986	10	98.6	582	6	97.0	1.0
opaque	460	10	46.0	322	6	53.7	0.9
phytolite	8	5	1.6	12	2	6.0	0.3
volc.glass	4	3	1.3	4	2	2.0	0.7
total	1458			920			

mineral percentages

quartz	:67.6%	63.3%
opaque	:31.5%	35.0%
phytolite	: 0.6%	1.3%
volcanic glass	: 0.3%	0.4%
	100.0%	100.0%

combined mineralogical composition of the topsoil and the subsoil

quartz	:65.8%
opaque	:32.9%
phytolite	: 0.8%
volcanic glass	: 0.3%
	100.0%

The ratios of quartz and opaque between topsoil and subsoil indicate comparable percentages. There is an increase of phytolite and volcanic glass with depth.

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If all the sand fractions are considered it appears that the light minerals occur in the following sequence of dominancy: quartz, opaque, phytolite, volcanic glass, anorthite (i.e. for all samples respectively 56.3%, 34.6%, 2.6%, 2.1% and 1.6%).

Quartz occurs more frequently as the sand fraction becomes coarser. There is little variation in the occurrence of the mineral in the topsoil and the subsoil (ratio t/s=1.0)

Opaque minerals are most abundant in the fine sand fractions. There is little difference between their percentage in the topsoil and the subsoil (ratio t/s=1.1).

High percentages of phytolite are observed in the very fine and particularly in the fine sand fraction, but they decrease sharply in the medium sand fraction. The ratios of phytolite are variable, in two out of the three fractions the percentage increases with depth (ratios 1.3, 0.7 and 0.3).

Volcanic glass is most abundant in the very fine sand fraction (3.1%), followed by the fine sand fraction (2.9%), but drops sharply in the medium sand fraction (0.3%). For the former two fractions the ratios of this mineral occurrence between the topsoil and the subsoil is fairly constant (ratio t/s=1.1).

Anorthite mainly occurs in the very fine and the fine sand fractions. In general the amount is higher in the subsoil than in the topsoil.

4. Conclusions

The conclusions drawn below should be/with care since not all /taken the samples considered received similar treatment with regard to pre-treatment and fractionated mineralogical identification. With this in mind the following conclusions can be made:-

- from the original parent material as provided by the "country" rock only the most resistant minerals are present in the sand fractions, viz. quartz and opaque minerals
- quartz is most commonly encountered in soils derived from the granitic intrusives and rhyolites
- the presence of volcanic glass, phytolite, anorthite and sanidine in the light mineral fraction points to an exotic source, that has contributed to the soil (parent) material
- the influence of volcanic ash is widely spread over the Kisii area and is concentrated in the eastern half
- ratio's of quartz and opaque minerals for topsoils and subsoils are fairly constant and percentages do not vary greatly;
- volcanic glass occurs frequently in the very fine and the fine sand fractions. The ratios of this mineral between the topsoils and the subsoils are fairly constant. This may indicate a favourable degree of homogenization of the soils
- phytolite is commonly associated with the finer sand fractions

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- the occurrence of the exotic minerals in the finer sand fractions may indicate that the wind is probably the transport agent for these particles; Their main occurrence in the eastern half of the survey area may further be indicative of an easterly wind direction during the time of deposition
- the admixture of volcanic ash with the soils has enhanced the percentage of weatherable minerals. This is considered to be highly beneficial with regard to soil fertility.

5. Acknowledgements

Acknowledgement is due to Drs. P. Riezenbos (University of Amsterdam) for the positive identification of phytolite or plant opal, to the staff of the KSS soil laboratory for the preparation of the sand mineralogical slides.

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Appendix Ia - Light mineral composition of the sand fractions 0.05-0.10mm and 0.10-0.25mm

Sample no.	Depth cm	opaque		volc.glass		phytolite		quartz		anorthite	
		0.05-0.10	0.10-0.25	0.05-0.10	0.10-0.25	0.05-0.10	0.10-0.25	0.05-0.10	0.10-0.25	0.05-0.10	0.10-0.25
I	0-20	14	92	2	9	20	11	78	73	-	7
2	80-100	5	70	2	1	12	7	84	76	-	13
3	0-20	31	100	5	8	18	7	74	67	3	10
4	80-100	18	56	5	6	15	9	64	78	12	5
5	0-20	94	87	8	7	80	18	10	70	-	5
6	80-100	73	62	13	15	35	41	40	4	8	1
7	0-20	39	67	3	2	5	5	79	91	5	2
8	80-100	21	55	4	5	55	14	25	72	12	3
9	0-20	66	82	28	11	72	7	-	3	-	-
10	100-120	79	93	7	5	7	3	35	34	2	-
11	0-20	69	82	3	13	20	6	64	78	5	2
12	80-100	71	86	7	-	10	6	79	91	tr	3
13	0-20	94	72	1	2	13	--	86	95	-	3
19	60-80	100	2	-	-	-	-	100	100	tr	-
20	0-20	30	-	-	-	-	-	100	-	-	-
29	80-100	24	58	2	-	15	-	83	100	-	-
30	0-20	58	4	1	1	3	tr	96	99	-	tr

Sanidine was detected only in the very fine sand fraction of sample 2(2%), 4(4%), 5(2%), 6(4%), 7(8%), 8(4%), 11(4%) and 12(4%).
Isotropic plant remains occurred in the fine sand fraction of sample 2(3%), 3(8%), 4(2%), 6(39%), 8(6%), 9(79%), 10(58%) and 11 (1%) and in the very fine sand fraction of sample 10(49%).

Note: tr = seen but not counted
-- = not seen
na = no slide

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