GEOCHEMICAL SURVEY ROCKS AND QUARRIES AROUND KISUMU, KENYA

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Introduction

In the framework of the project "Women Food Entrepreneurs in Kenya and Burkina Faso: Building inclusive business models for food security in the city slums of Kisumu and Ouagadougou" a geochemical survey was carried out in order to find rocks suitable for producing powder for soil conditioning. The survey was carried out in the period August 30th to September 7th by Prof JB Okeyo-Owuor, Gilbert Modi and Huig Bergsma. Considering that transport of the rocks should be kept at a minimum the survey was concentrated in a zone 100 km around Kisumu. A total of two larger mechanized quarries (KCP/Ndugu, Homa Lime) were visited as well as six smaller active or deserted artisanal quarries (Lake Quarry, Raroki, Samanga, Adhiambo, Got Okii, Kedowa). Besides this several samples were taken along the road to get an impression of the potential of the surrounding area (Fort Ternan, Chepseon, Londiani). The sample areas can be roughly divided geographically into three zones: one zone near Kisumu (Ndugu, Lake Quarry), one near Homa Hill (Adhiambo, Raroki, Samanga, Adhiambo, Got Okii) and one zone stretching from Legetet Hill to Londiani (Homa Lime, Kedowa, Fort Ternan, Chepseon, Londiani).

In terms of geology the sampled area can also be divided in three groups:

- Phonolitic rocks (found in all three geographical zones)
- Basanite rocks (Tinderet Mountain)
- Rocks in the contact zone of carbonatites (Homa Hill, Legetet Hill)

Samples were analysed using a Niton Goldd+ Portable XRF and compared to commercially available rock sand and powder in Europe (Eifelgold, Vulkamin, Vulkatec). K and Ca were used to discriminate potential useful rocks from less useful rocks.

Locations visited

Kisumu Concrete Products/Ndugu

Large mechanized mine with a large production capacity of 1,000 tonnes per day in the outskirts of Kisumu. Fine-grained grey phonolite with a low amount of very small, thin, elongated phenocrysts. The mine produces raw materials for road construction and building materials. They produce a 0–3 grade rock sand with a high amount of fines. As far as we know, no waste stream of fines was kept apart or disposed of. Despite the low levels of nutrients, this rock could be used for experimental plot soil conditioning as the 0–3 grade sand is available and only needs sieving to produce a rock flour of acceptable grain size.

http://www.kcpquarry.com/

Lake Quarry

Small artisanal mine of low production capacity located W/SW of Ndugu. Rock is similar in appearance and chemistry to the Ndugu rocks. This site has apparently been investigated for large production mining as drilling marks for explosives were visible.

Homa Hill

Complex of chemically widely varying rocks situated around a carbonatite dome. The former production site of Homa Lime at the Westside of the volcano near the coastline was visited but no samples were taken there. Carbonatite rocks and Ca-rich silicate rocks were found on the western slope of the volcano.

Raroki

On the way back from Homa Hill a pile of volcanic rocks for construction purposes was found. The lava was dark, brittle and contained larger off-white phenocrysts (feldspathoids?). Local inhabitants redirected us to the quarries of Raroki. At Raroki two types of rocks were found: yellow to red 'sedimentary rocks' and the dark grey phenocryst-bearing volcanics as found along the road. Both volcanic and 'sedimentary' rock contain quite high amounts of K and Ca. Ca content is very variable. It is uncertain if the red and yellow rocks are 100% sedimentary – it is likely to be closely related to the volcanic rock in different stages of oxidation.

Adhiambo

Small artisanal quarry halfway along the road from Kendu Bay to Homa Bay. The quarry contains a light grey phonolitic lava, shifting in colour from green to blueish. There are small, elongated phenocrysts reminiscent of the phonolite found in Kisumu. A 10–20mm rock aggregate is produced by hand all around the slope of the dome-like hill. People in the quarry were very helpful showing which varieties of rocks could be found. A set of four bench hammers was donated to the female workers in the quarry.

Samanga

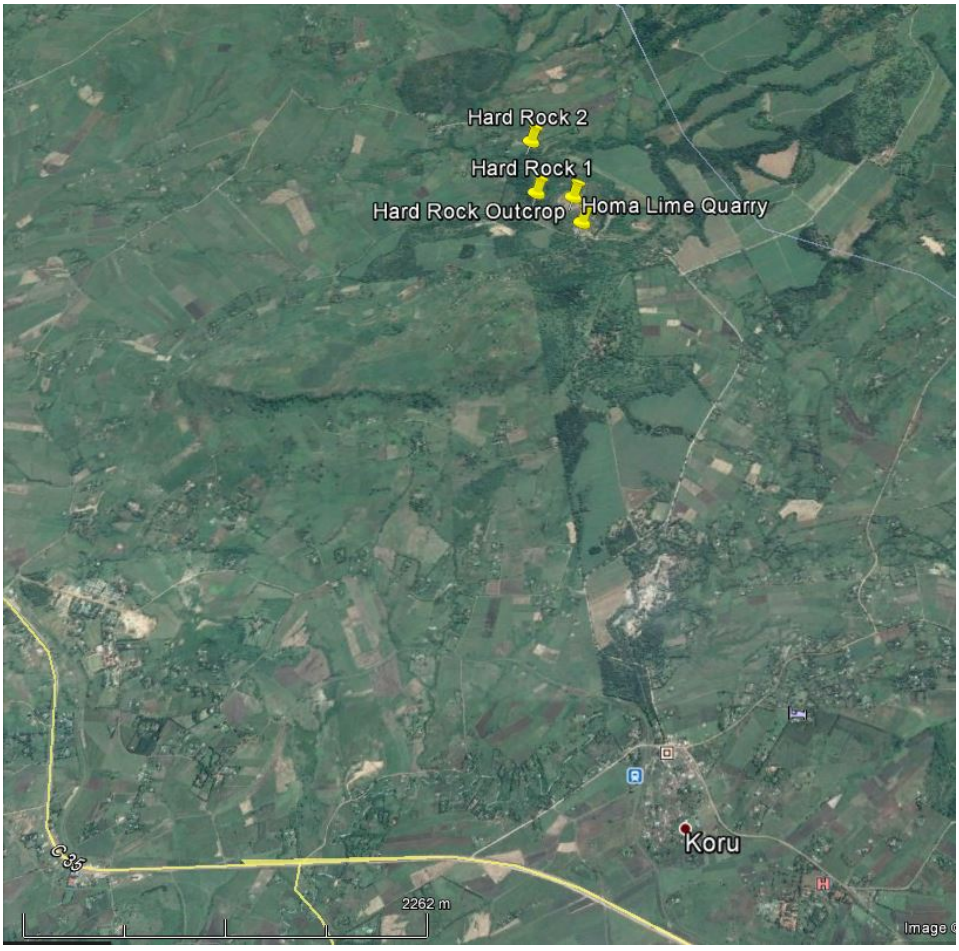
Deserted softstone (sedimentary rock) quarry on the opposite side of the road from Adhiambo with a small part of lava outcrop at the edge. The quarry is around a dome-like hill, more pronounced in shape than the Adhiambo hill. The lava rock is considerably tougher and darker than the phonolites from Adhiambo and Got Okii.

Got Okii

Small artisanal quarry between Kendu Bay and Adhiambo/Samanga. Rock comparable to Adhiambo, KCP/Lake and Kedowa.

Legetet Hill/Homa Lime

Homa Lime is a mixed mining/farming company situated on Legetet Hill near Koru. In earlier times the quarry was located at Kowuor near Homa Hill, hence its name. The quarry produces almost 100 tonnes per day of carbonatite limestone in two grades: grade one, a dark and crystalline variety for high end applications, and grade two, a dusty white carbonatite for agricultural purposes. At the north side of the quarry a silicate rock can be found with a high percentage of large phenocrysts, probably nepheline and augite. Surrounding the quarry west and south a very tough fine grained dark pyroxene bearing rock was found.



Fort Ternan

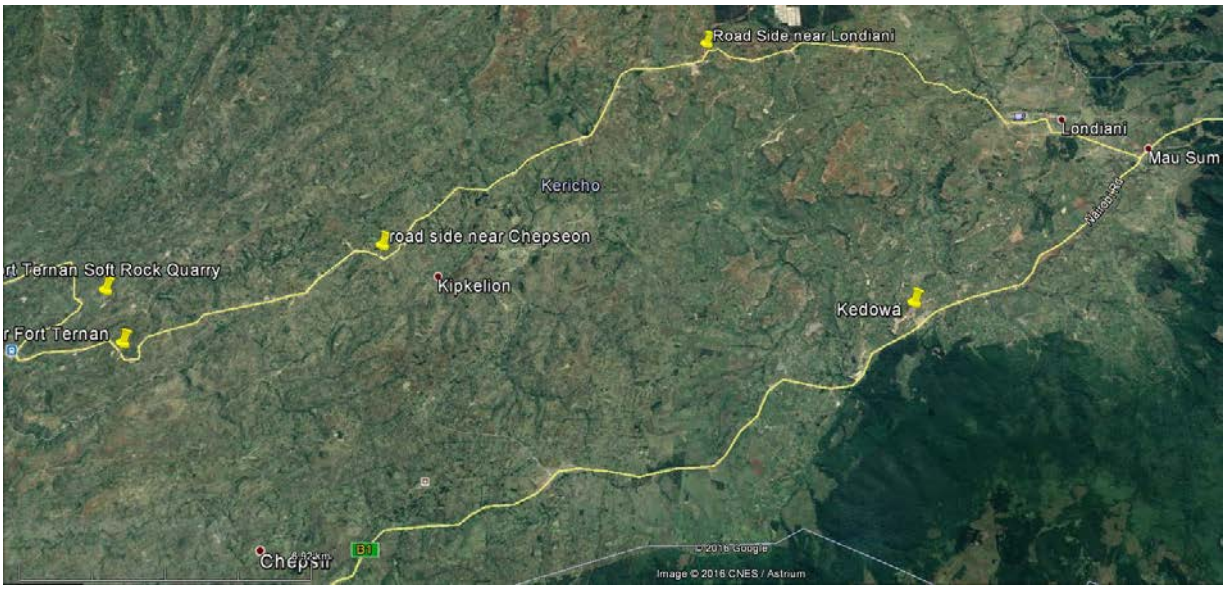
About six kilometres east of Fort Ternan, a road leads up to a sandstone quarry where bricks are being cut. Halfway along this road, outcrops of a very hard and dark pyroxene and olivine-bearing lava were found. Unfortunately the quarry itself was pure sedimentary rock.

Fort Ternan – Chepseon – Londiani roadside

Along the newly constructed C35 road from Muhuroni to Londiani several fresh outcrops of volcanic rocks were found, probably because the rock could serve as raw material for road construction or because some rock had to be removed in order to smooth the course of the road. Several samples were measured, which showed that the rocks were gradually becoming poorer in Ca and K when travelling eastwards.

Kedowa

At the very end of the Ternan–Londiani track is the Kedowa quarry. This has a rock resembling that of Adhiambo, Got Okii and Lake Quarry/Ndugu/KCP.

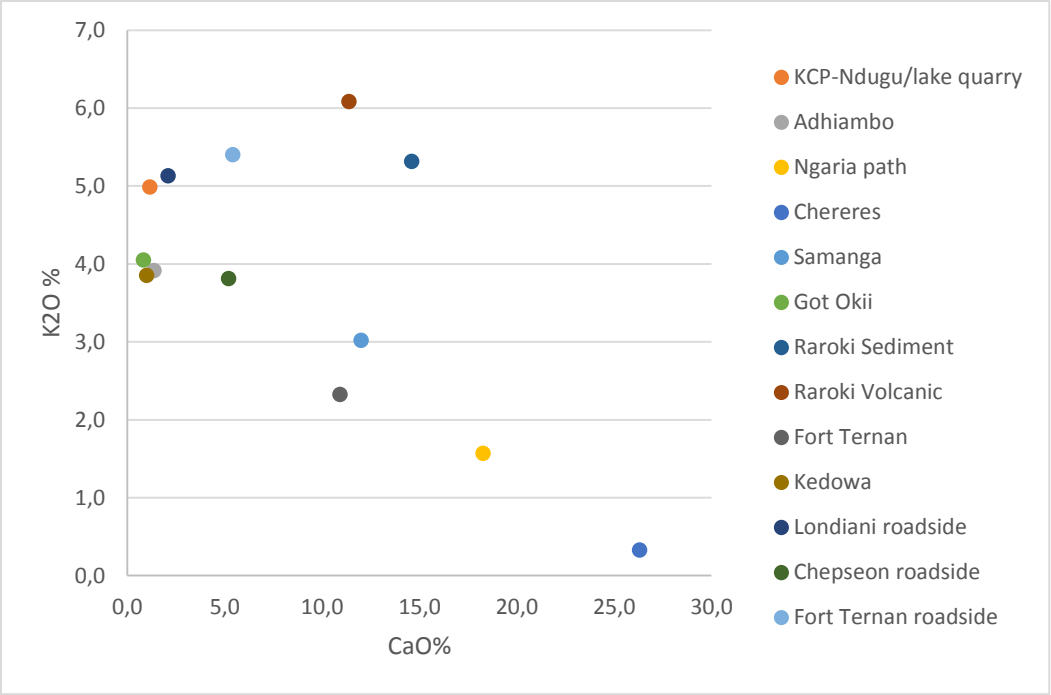


Analytical results

All samples were measured with a Niton Goldd+ Portable XRF. Filters for heavy metals (main range Zn, Fe, Cu, Ni etc) and K and Ca (low range) were set for 30 seconds each. The filter for light elements (light range Mg, Al and Si) was set for 60 seconds. Ca, K and Fe results are pretty accurate as well as those for Zn and Cu. Mg and Ni results are indicative. It should be kept in mind that the XRF only analyses 8mm of the surface and that, especially when large phenocrysts are present, the chemical composition may vary widely. In general, the phonolites contain a low quantity of phenocrysts and are very homogenous – for example, only two analyses were done to characterize Kedowa. For Raroki rocks on the other side, 25 measurements were done.

SAMPLE location	CaO (%)	K2O (%)	MgO (%)	Fe2O3 (%)	Zn (mg/kg)	Cu (mg/kg)	Ni (mg/kg)
KCP-Ndugu/lake quarry	1.2	5.0		5.4	183		
Adhiambo	1.4	3.9		3.7	132		
Ngaria path (hard rock)	18.3	1.6	++	9.6	49	207	
Chereres (HL quarry)	26.3	0.3	+++	10.1	85	135	196
Samanga	12.0	3.0	++	9.3	111	59	75
Got Okii	0.8	4.0		3.0	95		
Raroki Sediment	14.6	5.3	++	11.1	80	99	62
Raroki Volcanic	11.4	6.1	+	14.1	68	118	
Fort Ternan	10.9	2.3	+++	9.7	73	135	61
Kedowa	1.0	3.9	++	8.1	239		
Londiani roadside	2.1	5.1		5.4	168		
Chepseon roadside	5.2	3.8		7.0	60	42	
Fort Ternan roadside	5.4	5.4	++	6.5	116	57	56

In general, rocks that contain high levels of K, Ca, Mg and Na and low SiO2 (<52%) are suitable as a soil conditioner. Since Na was not measured and Mg results are only indicative, it is hard to say what the liming value of the rocks is. However, in terms of nutrients it is clear that the rocks found near Homa Hill and Legetet Hill/Fort Ternan are the most promising ones. Rocks near Homa Hill have a quite rare combination of high K and high Ca, which is likely the result of a geochemical alteration zone of carbonatite in contact with fresh phonolite lava. The rocks on Legetet Hill are richer in Ca and Mg. The sample taken in the quarry itself is extremely high in Ca, which is probably due to contact metamorphosis between the basanite lava from Tinderet (as found near Fort Ternan) and the carbonatite bodies.



Selection for pot greenhouse trials

Based on the nutrient content, larger samples (4–5kg) from Raroki (both volcanic and 'sedimentary') and Chereres/Ngaria were selected for pot experiments. Adhiambo was selected as an average phonolite. For the field experiment, it is most desirable to produce rock dust from Raroki as this is currently being mined. It might however be a challenge to produce enough fines. If grain size turns out to be a limiting issue, we could further investigate the 0–3mm product from KCP/Ndugu.

Soil issues

Soils in the Kisumu area are chemically a fine blend of all sediments transported from the surrounding hills and mountains. Therefore its cation content is well balanced and adding rock dust for this reason seems unnecessary at first glance. Rock dust addition for nutrients might be more effective on soils outside this area.

Structure

A more important issue to address is the physical properties of the soil. The high clay content of this soil makes it swell and become impermeable during heavy rainfall. On the other hand, during drought deep cracks develop and damage plant root systems. Addition of fly ash, nutshells, lime and sand have been tested to improve the mechanical characteristics of these soils. Accidentally in the Netherlands one big bag of rock dust was applied on clayey cropland. This did not improve yield but one year after application, during heavy rainfall, it turned out that survival of the plants on the lane where rock dust was added was significantly higher (see photo below).

Organic matter

Cow dung and other manure decomposes very fast under tropical conditions. Adding just organic matter therefore does not seem likely to improve soil structure. Perhaps mixing it with rock dust could provide some kind of stabilization.

Follow up

1. Samples from Kenya have to be broken, crushed and milled.
2. Milled and homogenized samples have to be analysed on XRD (mineralogy), XRF (whole rock) and ICP-MS HF/HCl/HCLO4/HNO3 (micronutrients).
3. Decision has to be made which rock to use for field tests. Raroki has the best quality but is less well equipped for large volume of fine material. KCP/Ndugu has low nutrient phonolite but produces material that comes closer to what we need.