THE WEATHERING OF GRANITE ON THE SOUTH COAST OF NATAL

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The survey of the soils of the Natal sugar belt reveals a preponderance of granitic soils on the South Coast, frequently in close proximity to the shoreline. Amongst features observed is the considerable depth to which weathering proceeds in the granites, a feature which does not appear to have been studied a great deal in this area.

Sites selected for sampling were as follows:

Roadside cutting between Port Shepstone and Paddock (Bomela Site).

Quarry near Umzinto town (Umzinto Site).

Quarry near Adams Mission (Illovo Site).

Samples were taken from each site of the overlying soil together with selected channel samples at various distances down the face. At the same time, adjoining samples of fresh rock and slightly weathered rock were also taken for comparative study.

All samples were crushed in an agate mortar after sub-division, and passed through a 70 I.M.M. sieve in preparation for total chemical analysis by fusion with sodium carbonate. Thin sections of the fresh and partly weathered rock samples were kindly prepared by the Department of Geology, University of Natal.

Bomela Site

Granite occurring in this locality is of a comparatively rare type, namely charnockite or hypersthene granite. Overlying soil was taken to a depth of 18 inches, succeeded by samples of weathering granite at the depths indicated in the accompanying table. Rainfall in the locality is 40 to 45 ins. (1080 mm.) per annum and the altitude 1500 feet.

MINERALOGY

(a) Fresh and slightly weathered rock

The fresh material is a dark greenish, coarse grained rock composed of large orthoclase crystals (up to 20 mm. in length), some plagioclase together with patches of hypersthene and biotite; also a little quartz. Some of the large feldspar crystals are greenish in colour, often cracked, and sometimes exhibit Carlsbad twinning visible to the naked eye.

Under the petrological microscope the rock is found to be hypidiomorphic-allotriomorphic in texture with no signs of foliation. There are small patches of granulation composed of small crystals of quartz, microcline and pyroxene, otherwise the section is free from alteration.

The dominant mineral is the alkali-feldspar-orthoclase, occurring as large subhedral crystals, often twinned.

Smallish subhedral crystals of labradorite occur. These are twinned Carlsbad and albite.

The orthopyroxene hypersthene, often in association with a little hornblende, biotite and iron oxide, occurs as fairly large patches.

The pyroxene mineral in some instances occurs as large anhedral crystals enclosing small feldspars and ferromagnesians as well as quartz, mica and iron oxide crystals. On the whole the rock contains little free quartz.

The weathered rock is heavily iron stained, especially on surfaces exposed to the atmosphere. Even deep within the rock, weathering has taken place, and in cracks in the large orthoclase crystals a brown iron oxide is clearly seen with the naked eye. Around some of the ferromagnesian minerals, coronas of brown iron stain are fairly evident.

On microscopic examination, the feldspars are seen to be in a state of fair decay. All are cracked with the development of secondary minerals along the cracks and composition planes as well as around the edges of individual crystals.

In the section studied, the proportion of ferromagnesian mineral was not as great as in the fresh rock, but showed signs of decomposition, possibly with the formation of limonite.

(b) Weathering profile

The sample taken at 43-45 feet was found to be a yellowish brown mixture of largish quartz fragments and small pieces of well weathered charnockite in a fine matrix composed of well weathered feldspar fragments and clay minerals. Clay content 9 per cent.

The 17-20 feet sample was yellowish white with a "soapy" feel, composed of quartz fragments and a matrix of small highly weathered feldspars and clay minerals, which D.T.A. analysis proved to be kaolinitic in nature. Clay content was 16 per cent.

The 5-8 feet sample, soapy to the touch and yellowish in colour, is essentially the same as the 17-20 feet zone, although the feldspar fragments were so highly weathered that on being rubbed between the fingers they crumbled to a relatively fine powder. D.T.A. analysis showed the 36 per cent clay present to be kaolinitic.

The soil was a dark greyish black, gritty loam containing largish angular quartz fragments, the fine fractions being composed of clay minerals and possibly hydrous micas. Due to the fair proportion of ferromagnesian minerals present in the parent material, some montmorillonite is probably present. Clay content was 15 per cent.

Chemical composition

The decrease in silica up to the soil zone is accompanied by a corresponding increase in the alumina content, indicating a build up of hydrous alumino-silicate, also borne out by the increase in loss of combined water.

Calcium decreases fairly rapidly from the fresh rock and is present in very small quantity in the highly weathered sample. Sodium shows a similar marked tendency.

Potassium mobilisation is of extreme interest as, for example, the inexplicable sharp increase in the slightly weathered granite. The retention of this element throughout weathering is also of extreme interest.

Umzinto Site

The granite in this locality is of a medium grained texture, with some indication of foliation. Overlying soil was sampled to a depth of 18 inches, and quarry face samples were taken at the depths indicated in the table. Rainfall is 40 to 45 inches (1080 mm.) per annum and the altitude 620 feet.

Mineralogy

(*a*) *Fresh and slightly weathered rock*

In hand specimens the fresh rock is seen to be composed of orthoclase and quartz, with a little biotite and epidote.

In thin section the rock is found to be medium to coarse grained and of allotriomorphic texture. Orthoclase, as anhedral crystals, some microcline and plagioclase (albite-oligoclase) are the feldspars present. Quartz occurs as smallish anhedral grains whilst biotite, in association with epidote, augite and hornblende, occurs in small quantities. Small iron oxide crystals, as well as a little muscovite and a few somewhat rounded zircons, are present.

The slightly weathered rock shows considerable decomposition. Freshly broken faces are often covered with a layer of powdery clay mineral, and the feldspars can be seen to be fairly well weathered. The biotite, too, appears somewhat altered.

In thin section, the feldspars are seen to be decomposed, alteration taking place throughout the crystals and not just along cracks or twin planes. Alteration products are to be observed around most crystals.

(*b*) *Weathering Profile*

The 34-54 feet zone, brownish yellow and fairly hard, shows a considerable breakdown of the structure of the rock. Feldspar crystals and quartz fragments are abundant. The clay content is 4 per cent.

The 23-34 feet zone, much more weathered than the lower zone, is whitish yellow and shows a greater decomposition of the rock structure. The clay content is 12 per cent.

Pinkish in colour, with a clay content of 8 per cent, the 18-23 feet zone appears to have had considerably less iron bearing minerals present, evidenced by the lower proportion of iron oxide in the sample.

The 10-18 feet zone, with 14 per cent clay, shows a further stage of decomposition.

The 18 inch to 10 feet zone is well weathered, and although some grains of feldspar are fairly hard, others can be crushed by rolling between the fingers. The clay content is 20 per cent, which D.T.A. analysis shows to be kaolinitic.

The soil, a dark grey black gritty loam with 14 per cent clay, contains angular quartz fragments and some feldspar grains.

Chemical Composition

Silica maintains its tendency to decrease up the profile, though erratically, and there is the usual apparent percentage increase in the soil largely accounted for by the removal of alumina.

Calcium and sodium as previously, tend to be removed fairly markedly towards the surface.

Potassium once again, while unaccountably low in the slightly weathered rock, shows the noteworthy tendency to accumulate throughout the weathering material.

Certain anomalous features observed between fresh rock and weathering samples, may be due to the fact that the rock was not found directly in the line of sampling.

Illovo Site

The granite in this locality appears to be mainly magmatic in origin. Schistosity was not observed and crystals generally were large. Overlying soil was sampled to a depth of two feet and once again quarry face sample depths are indicated in the accompanying table. The mean annual rainfall of the locality is 35-40 inches (950 mm.) and the altitude is 430 feet.

Mineralogy

(*a*) *Fresh and slightly weathered rock*

In hand specimens, the fresh rock is coarse grained, composed of large crystals of orthoclase which at times show good crystalline shape. Also noticed were smaller plagioclase and microcline crystals, flakes of biotite, quartz and small crystals of an iron oxide.

Under the microscope the rock appears holocrystalline and coarse grained with a hyp diomorphic texture. Small patches of granulation occur wherein a little perthite and graphic inter-growths of quartz and feldspar were observed.

Orthoclase occurs as large subhedral crystals and as smaller crystals in association with quartz, microcline, plagioclase (albite-oligoclase) and biotite of approximately the same dimensions. Quartz also occurs as fairly large anhedral crystals.

Small anhedral crystals of augite, a little hornblende, together with a highly refractive mineral, possibly muscovite, occur between the larger grains.

The rock does not appear to be weathered at all, though the larger feldspar crystals are a little cracked.

The exterior of the slightly weathered rock is covered by a coating of brown iron oxide, whilst fresh fractures across the rock are found to be stained. Large feldspar crystals are badly cracked and stained. To the naked eye, no decomposition of the biotite is observable, though in thin section there appears to be a fair amount of alteration to chlorite.

(b) Weathering Profile

The 25-40 feet zone is yellowish grey, fairly hard weathering granite. Decomposition is reasonably advanced and the mass consists of individual grains of feldspar and quartz as well as small fragments of unbroken granite. Most fragments are covered with a fine clay mineral, the clay content of the zone being 3 per cent.

The 15-25 feet zone is little different to the lower, though a slightly greater degree of decomposition was detected on sampling. Clay content is 4 per cent.

Considerably more decomposition of the granite is found in the 2-10 feet zone, though most minerals present in the parent rock can still be detected. The clay content is 9 per cent.

The soil is a greyish black gritty loam with a clay content of 15 per cent. Quartz occurs as angular fragments, and smaller amounts of altered microcline and orthoclase are present. The finest fractions consist of secondary alteration products.

Chemical composition

As before, the decrease in silica up the profile to just below the soil is accompanied by the apparent proportionate increase in alumina.

Calcium appears to increase up the profile in this case, whereas in the previous two instances there was a tendency for it to decrease. The drier conditions prevailing at this site might possibly account for the lower rate of migration of the element.

Sodium decreases up the profile, but once again potassium has shown its tendency to remain in the weathering complex. In this instance the pronounced retention of the element extends into the surface soil.

Summary

Samples of granite and various stages of weathering granite (including the derived soil) were taken from three widely separated sites on the South Coast of Natal.

These were subjected to mineralogical and chemical analyses. Observations were made on the alteration of the minerals, and changes in the chemical composition were discussed. A noticeable feature was the high potassium content of the weathering complex, which in many cases was higher than that in the original rock.

Dr. Saggerson: Examination of the various chemical analyses reveals that the greatest significant factor is the concentration of potassium during weathering of certain rocks along the Natal coast. This concentration is not unusual, however, and substantiates the work done in other parts of the world.

In cold climates like Norway the potassium in feldspar, even if finely crushed, is unavailable to plants though the potassium from biotite is readily utilised. That biotite is the main source of potassium has been substantiated by the Norwegian College of Agriculture, and it has been found that biotite will supply potassium for years. Evidently the biotite is not lost in drainage, which is the case if potash salts are used as fertilizers. In warm climates the feldspar becomes progressively weathered and the two factors of climate and time are involved. Under humid conditions the formation of clay minerals is favoured and there is a strong adsorption of potassium by the clay minerals in the soils. Geochemistry of potassium ions is dominated by equilibria of cation adsorption and exchange between the soil solutions and the various clay minerals. Sodium on the other hand tends to form soluble salts during weathering and accumulation is therefore prevented.

I feel that the analytical approach initiated by the authors is valuable and should be continued. In my own experience sampling is an extremely important feature, but I have no doubt that the authors have attended to that. It is often difficult to distinguish between soil and soil containing comminuted rock particles. I take it the authors refer to a pure soil in their tables.

In continuing this study, I would recommend that closer attention be given, for example, to differences occurring in various rock bodies, e.g. the various granites. Differences, if any, of pattern and distribution of the clay minerals in Natal, bearing in mind the differences that already exist, could well be noted.

Weathering of rocks in Natal is closely associated with cyclical weathering processes, and it is important to note whether particular profiles represent re-weathering of ancient soils preserved on erosion surfaces. I notice the authors in one of the papers refer to pre-weathering, but I feel greater stress should be placed on this important aspect when carrying out analytical studies on weathering.

Today's proceedings have stressed the need for the interdependence of all disciplines, pedology, geomorphology and geology. An example of where this might be put into effect would be the study of weathering on isolated mountains and hills, where the effects of external contamination are a minimum. I feel these studies could profitably be continued and recognised as having a role to play in the scientific research of the South African sugar industry.

PROGRESSIVE WEATHERING OF GRANITE WITH DEPTH

(RESULTS EXPRESSED ON OVEN-DRY BASIS)

	1 BOMELA, SOUTH COAST						2 UMZINTO, SOUTH COAST								3 ILLOVO, SOUTH COAST					
SAMPLE NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
DEPTH FROM SURFACE IN FEET	0″-18″	5′-8′	17′-20′	43′-45,	At 50′		0″-18″	18″-10′	10′-18′	18′-23′	23′-34′	34′-54′	At 60′		0″-24″	2′-10′	15′-25′	25′-40′	At 45′	
Description of sample	Dark greyish black gritty loam	Yellowish well weathered charnockite granite	Yellowish white well weathered charnockite granite	Yellowish brown well weathered charnockite granite	Slightly weathered charnockite granite	Fresh charnockite granite	Dark greyish gritty loam	Yellowish well weathered granite	Yellowish well weathered granite	Pinkish well weathered granite	Whitish yellow weathering granite	Brownish yellow weathering granite (Hard)	Slightly weathered granite	Fresh granite	Greyish black gritty loam	Yellowish highly weathered granite	Yellowish grey weathering granite	Yellowish grey partly weathered granite	Slightly weathered granite	Fresh granite
SiO_2 % . .	74.77	55.12	63.35	68.21	69.47	63.67	74.19	57.43	60.02	73.64	62.01	63.36	76.98	73.59	78.44	69.07	72.54	71.08	72.58	73.51
TiO_2 . .	1.09	0.52	0.52	0.41	0.24	0.62	0.29	0.56	0.54	0.11	0.69	0.68	0.19	0.08	0.35	0.39	0.28	0.28	0.23	0.26
Al_2O_3 . .	3.65	21.17	18.93	10.20	15.04	15.36	11.92	21.56	20.21	13.76	18.57	17.26	12.84	13.99	5.63	16.98	14.25	14.84	15.39	14.78
Fe_2O_3 . .	8.92	9.28	4.78	9.24	2.42	3.25	3.71	5.04	5.23	2.48	4.73	4.87	1.72	1.09	4.92	3.25	3.69	3.50	2.07	1.55
FeO . .	0.56	0.18	0.28	0.25	0.41	3.66	0.32	0.36	0.42	0.24	0.46	0.33	0.25	1.33	0.34	0.16	0.15	0.15	0.12	1.42
MnO . .	0.01	0.01	0.01	0.01	0.01	0.06	0.01	0.03	0 01	0.05	0.05	0.05	0.08	0.03	0.02	0.01	0.01	0.02	0.01	0.05
MgO . .	0.05	0.10	0.15	0.05	0.15	0.20	0.06	0.46	0.46	0.04	0.25	0.30	0.30	0.01	0.02	0.03	0.02	0.02	0.01	0.01
CaO. . .	0.25	0.05	0.70	0.60	1.47	3.95	0.24	0.18	0.34	0.26	0.37	0.59	0.55	0.89	2.74	2.40	1.88	1.85	2.78	1.58
Na_2O . .	0.26	0.30	0.56	0.37	2.36	3.41	0.44	1.07	1.55	1.32	2.00	2.34	2.40	2.30	0.66	1.68	1.49	2.45	2.37	2.10
K_2O . .	0.70	3.00	7.00	5.47	8.05	4.31	3.05	7.73	7.77	6.43	6.98	6.99	3.44	7.50	3.65	3.50	3.17	4.25	3.87	3.52
P_2O_5 . .	0.08	0.17	0.08	0.07	0.07	0.22	0.04	0.05	0.05	0.04	0.07	0.06	0.06	0.03	0.19	0.08	0.10	0.10	0.09	0.10
Loss on Ignition .	7.44	8.43	4.31	3.79	0.42	0.66	4.50	5.47	3.98	2.15	3.36	2.27	0.60	0.28	3.11	3.03	1.90	1.58	0.58	0.53
Moisture .	1.46	1.90	0.64	0.64	0.24	0.08	0.92	0.91	0.64	0.26	0 42	0.32	0.18	0.13	0.88	0.70	0.45	0.34	0.13	0.10
TOTAL . .	99.24	100.23	101.31	99.31	100.35	99.45	99.69	100.85	101.22	100.78	99.96	99.42	99.59	101.25	100.95	101.28	99.93	100.46	100.23	99.51