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C. F. Clarke's
Notes
on
tropical soils

CLASSIFICATION OF TROPICAL SOILS.

C. F. Marbut

1. Proposed Classifications: Marbut, Milne, Roberts, Vageler, Haraaasowitz ? Mohi ?
2. What is soil and what is parent material
3. Vagueness of definition
4. Limited experience and little data
5. Only way of getting good classification is following survey method as in States — (series; local Groups; World Groups etc)
6. Economic need for surveys in Colonies at the present moment.

Classification

I Eluvial
- Red Sallitic Earths
- Red Allitic Earths (less frequent on the whole)
- Mottled Sallitic Earths - (Concretionary type)
- Mottled Allitic Earths - (Conc. type) (Very much less frequent)

II Incompletely leached earths — Eluvial Earths with $CaCO_3$ deposits in lower part of the column or in the upper parts of the parent material.
- (a) due to climate
- (b) due to parent material

III Lithosols (includes desert Earths) Skeletal Earths

IV Limestone Earths

Illuvial

1. Mottled Earths
2. Semi mottled earths.
3. Grey earths. - Including Mangrove swamp earths
4. Illuvial calcerous earths
5. Saline earths

1. Gross Morphology of profile
2. Color of horizons
3. Texture of horizons
4. Consistency of horizons
5. Structure of horizons
6. Content and location of O.M.
7. Content and location of secondary minerals of pedogenic origin (MnO_2, Fe_2O_3 Al_2O_3, $CaCO_3$, $MgCO_3$)
8. Presence of soluble salts NaCl, Na_2SO_4 $CaSO_4$ etc.

TROPICAL EARTHS

1. Setting up of groups must be done on the basis of Macroscopic characteristics and simple field Tests (a) Use of HCl - for detecting carbonates, (b) Use of colorimetric methods for measuring pH. (c) Use of $Ag(NO_3)_2$ for detecting chlorides and $BaCl_2$ for detecting sulphates. Major earth groups must not be erected on the basis of chemical analyses - although these may be used to further characterize them. [This is aimed at Dayne's laterite with mol. ratio $\frac{SiO_2}{Al_2O_3} < 1.33$ and laterite soils with $\frac{SiO_2}{Al_2O_3}$ 1.33-2 (NB. Kaolin has $\frac{SiO_2}{Al_2O_3}$ ratio of 2 exactly)]

Podzols, Brown Earths, Rendzinas, Terra rossa, chernozem etc. all have set up on the basis of Microscopic Features.

Characteristics

a) Somewhat stiky character of clay present
b) Shrinkage of clay
c) Parent rock.
   - Mostly of Orthoclase feldspars
   - limestones and acid metamorphic rocks
   - Previously weakened clays and shales
d) Topographical position?

Concretions typically absent.

Local Soil Groups

Common features due to local rather than environmental conditions.

Main Earth-types of Tropics.

I Eluvial

Red Scallitic Earths.

Largely concolorous - not mottled or streaked in lower layers.

1. Sedentary over parent rock
2. Developed from transported materials.

Yellow Earths.

1. Sedentary over parent material
   a) Due to nature of iron compounds present
   b) Due to high rainfall
2. Developed from transported materials.

As a group probably immature
a) due to recent development.
b) Mostly to topographical factors - hindering the further development.

Possibly on way to development of
a) Red allitic Earths
b) Red mottled Earths.

Comprises the Red loams of Vageler, Marbut and others.

II 'Red' allitic Earths - Features

1. Largely concolorous
2. Concretionary
3. Developed from basic and intermediate igneous rocks never from acid crystalline rocks or previously weathered sediments. (Exception where allitic materials have been included in limestones
4. Topographical position?

Developed from rocks with mixtures of minerals some giving rise to Allitic products of weathering others to Scallitic - Kaolin removed in colloidal form by leaching

Procedure

(1) Define Group and (2) Take a typical example to illustrate features
(3) Similar earths from different parent materials (actual profile)

Relationship to Vegetation
Cropping - and Agriculture generally.

Is this the solution of the tropical pedozolic business

Black Soils of temperate regions due to
a) Calcerous nature of parent material
(Calc. loess or calc. glacial Till)
b) How temperatures concerning O.M.

Real black earths in dry regions of tropics
due to influence of parent material
of Region in India – hot rainfall
Topography also influences the colour

The greater part of Eluvial Tropical Earths
are of the red type without lime - Pedalfers
although in base rich rocks lime may
appear in rock cracks – e.g Antigua-Hawaii

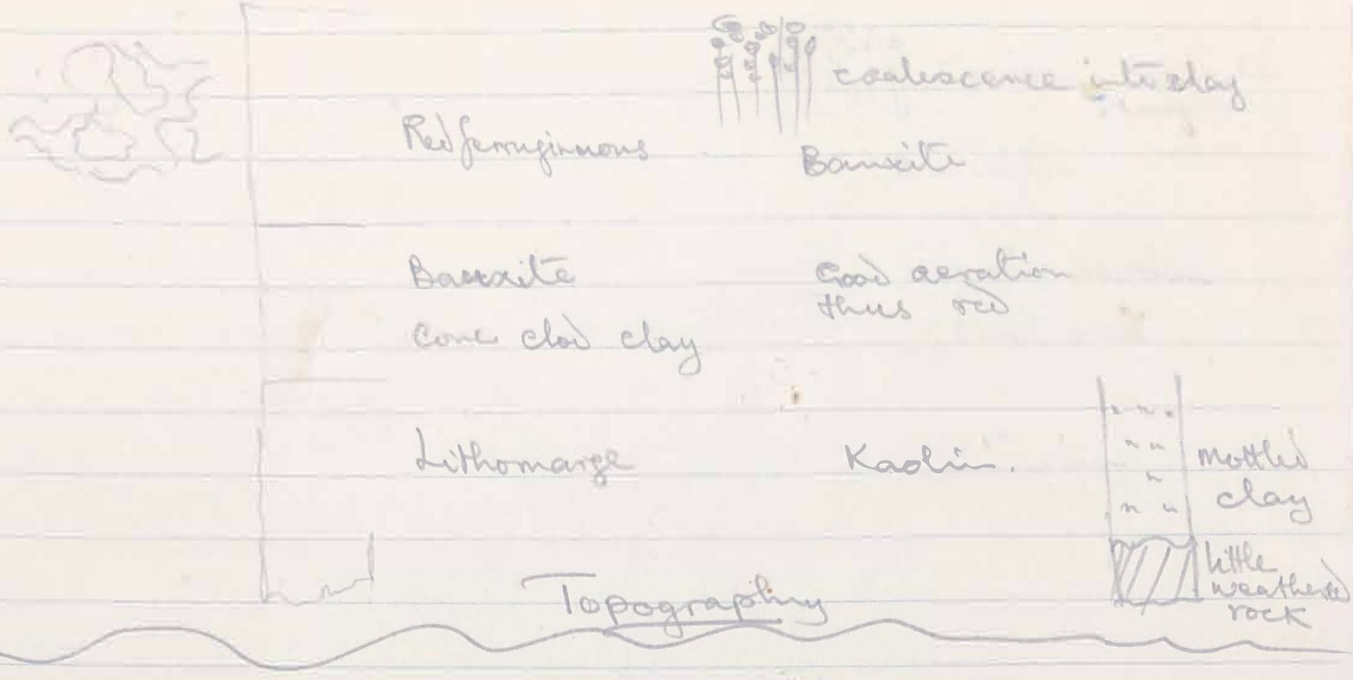
Grey brown or red brown
medium acid to
slightly acid to
neutral.
Red brown
May even be alitic!
Rock + $CaCO_3$ in crevices often
also with Mn and Fe deposits

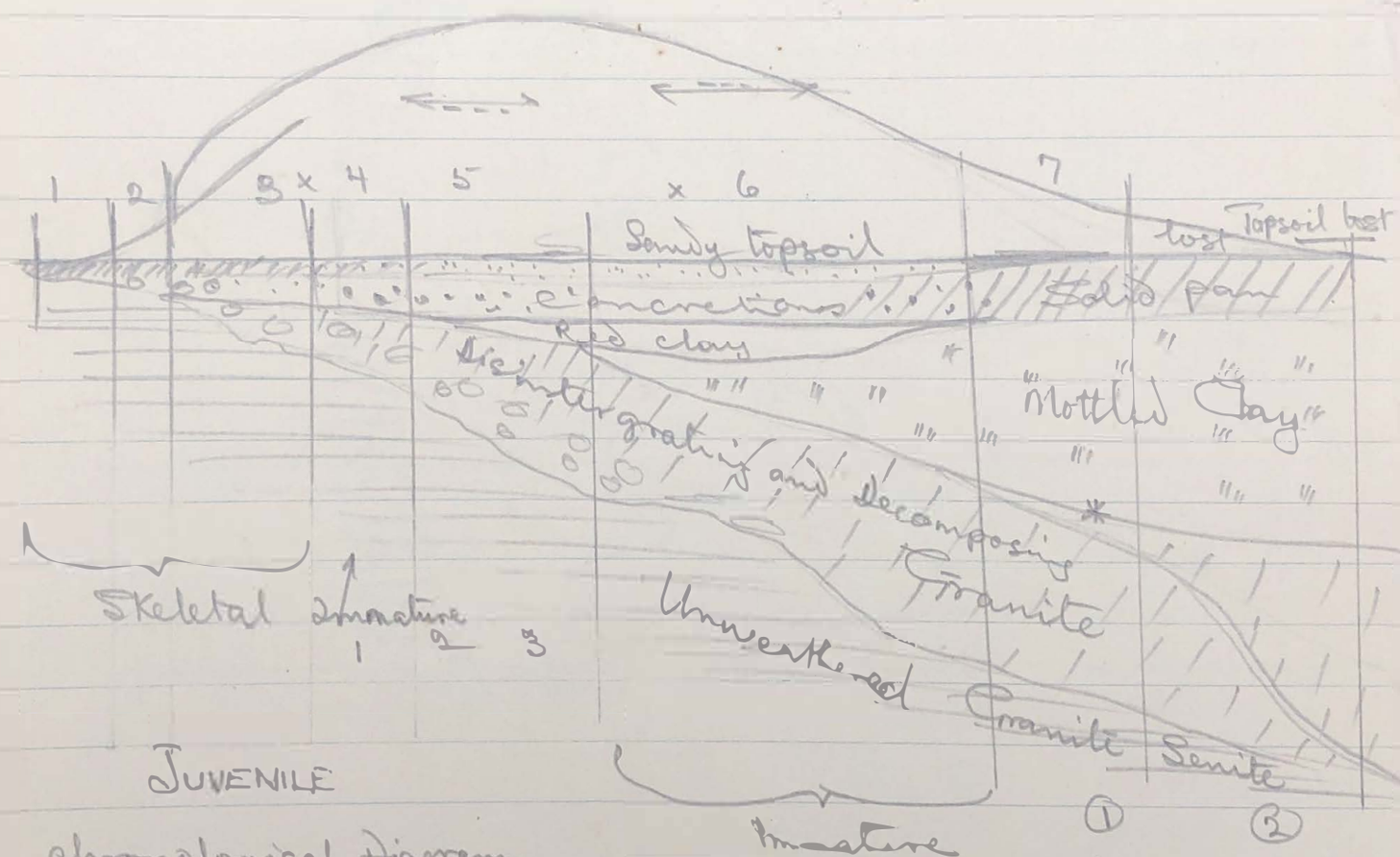
This resembles the 'pedozolic'
brown earths of England (of Kay and Clarke
Robison etc).

Several Antigua Sedentary earths

In less consolidated materials
or easily disintegrated rock
(ash, transported deposits)
Concretions may occur

Typical forms however are loose powdery
deposits (on Calcite) (Colour depends on P.M.)





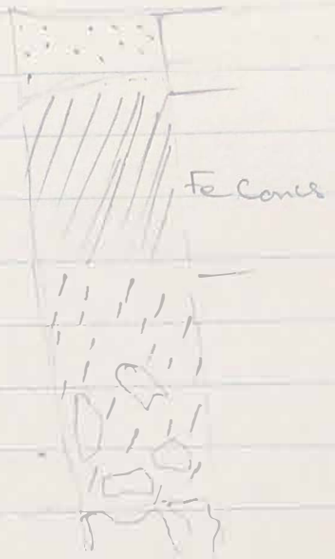
chronological Diagram showing development and ageing of the mottled earths over granite

* How does this affect the weathering of the underlying rock? Does it have a protective effect?

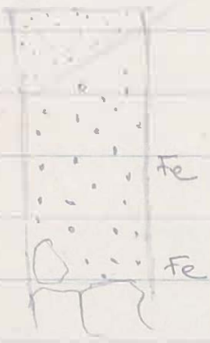
① Probably Sandy, to, heavy showers + runoff

② Somewhat heavier

③ Beginning of Separation.

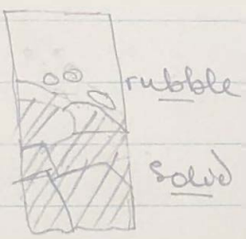


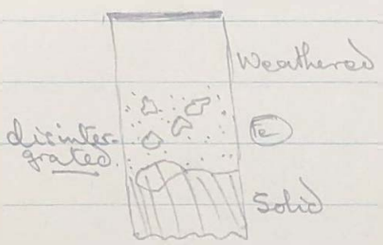
Reddish brown Sand/ desert.

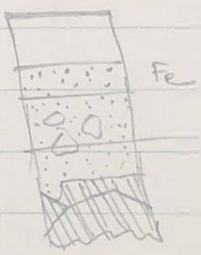


Reddish Sand/Rock

Variation with climate.





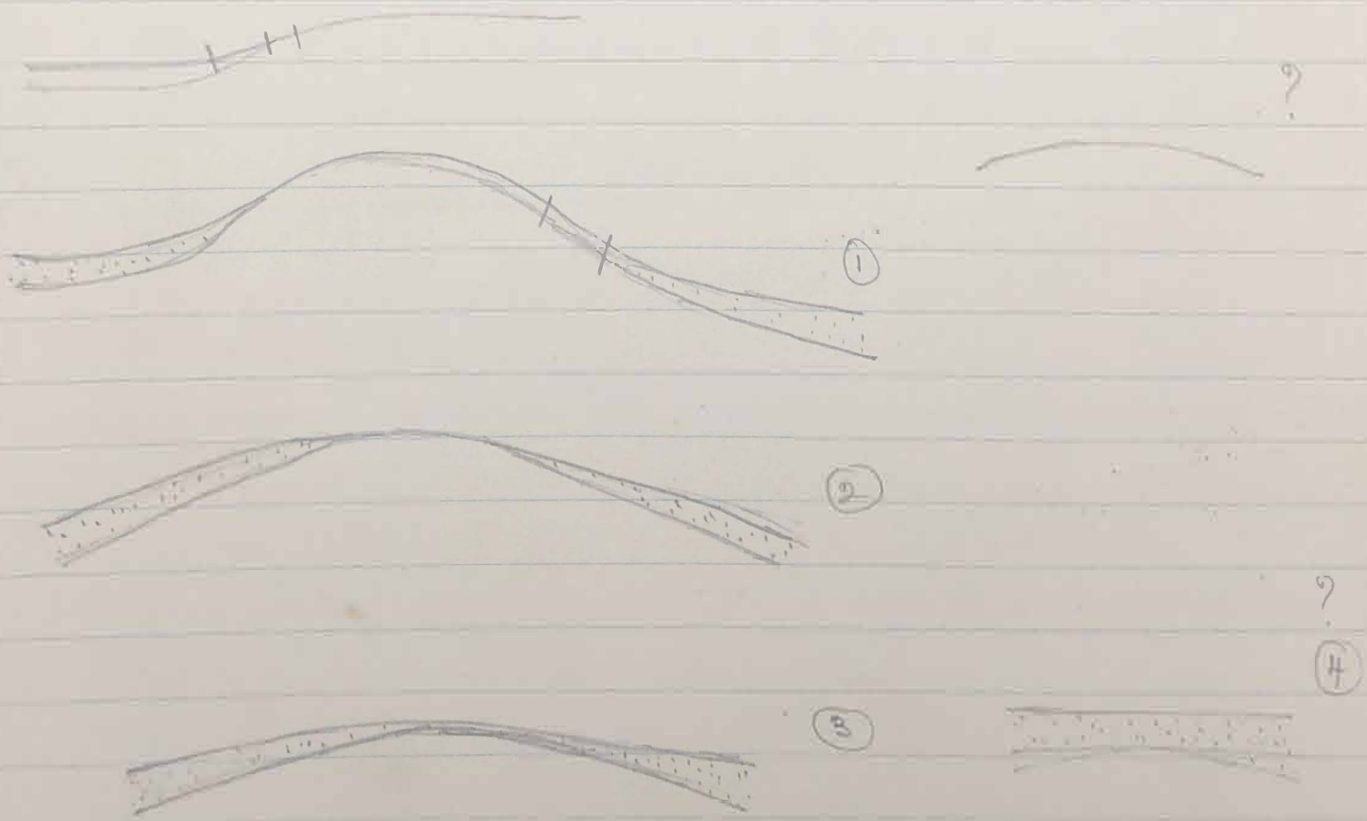


Dark Concretions

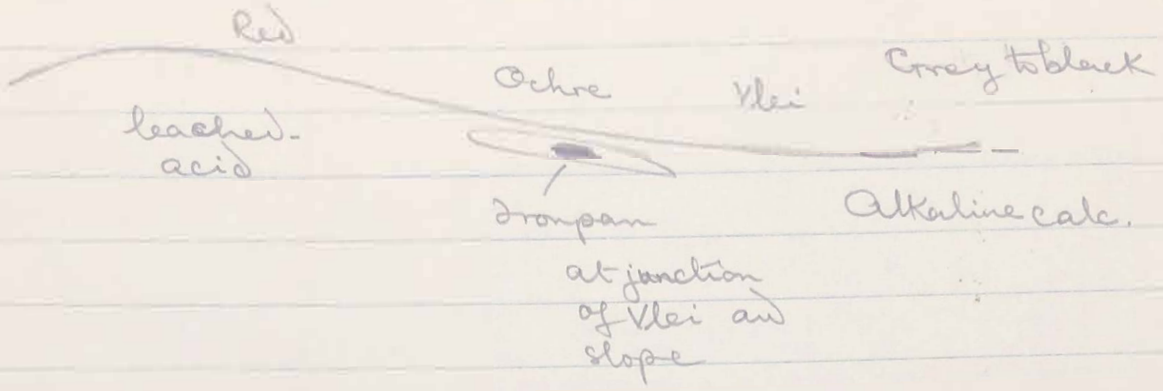
Is this dark, polished varnish similar to desert varnish?

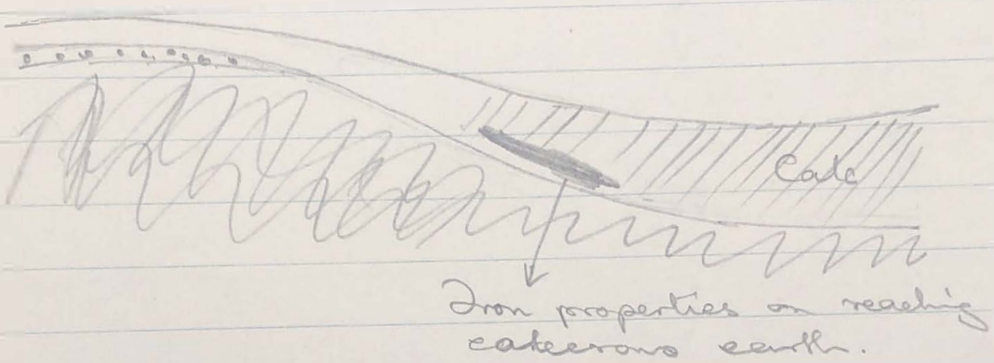
NB Joffe writes as though stones of the desert pavement had been covered with earth (during which time the varnish had been deposited on them) and checkens later removed by wind.

This would possibly explain the black stones and cones being in the upper part of the 'B' horizon? That is where drying out is greatest.



D.S. Grace Kenya





Similarly Milne's - Bukalasa catena of Uganda.

In Marten's Case - Murrain is freed concs - could the latter be transported? Is the obs accurate?
In Vine's Case - Murrain is not freed concs.

In all cases murrain appears to occur at the foot of slopes just above the calcerous clays. - Marten, Vine, Self, Milne.

Milne. Nature 1936. Vol 138 p 548.
Robenson. Nature 1936 Vol 137 p 550 (Lat. elviation and Transport of clay via Water Table.

Sedentary.

Dark grey or black pedocalic earths only occur where the parent material gives rise to clays high in Ca and Mg or both.

e.g. Trinidad – Marls, Main clays
Gold Coast – Hornblende Gneiss
Antigua, Barbados, British Honduras

What about the Tropical rocks of India? and Madagascar? Java?

Basalt.

Is there something to do with the topography here? or the minerals in the rock.

Does topography exclude the carrying astray of the products of hydrolysis, $CaCO_3$ and $MgCO_3$? So does weathering go on in an alkaline medium producing heavy clays of a black colour? ie Are red soils only formed where loss of $CaCO_3$ by drainage can take place?

(1) Special rocks
(2) Special topographical forms
(3) 1 × 2

Succession of soils in Tropical Africa from very dry to very wet regions.

Rainfall less than 15 ins Say less than 25 ?

Shallow skeletal earths red, sandy (where quartzose rocks are concerned. Earth probably sesquioxidic where basic rocks are concerned (cf dry areas of Hawaiian Is.) $CaCO_3$ as seams in the parent rock, in crevices, joints and fissures.

Kaolinitic otherwise

Owing to low rainfall presumably few introzonal earths - lack of rivers etc probably small basin with dark earths + $CaCO_3$ - material probably little decomposed.

Rainfall between 25-45" or 40?

Red earths with ironstone concretions in profile Neutral to alkaline basin and alluvial earths dark coloured *

Rainfall > 45"

Sedentary earths similar but basin and alluvial earths acid as a rule *

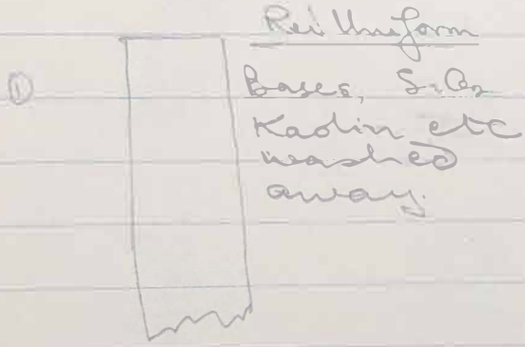
* Principal difference.

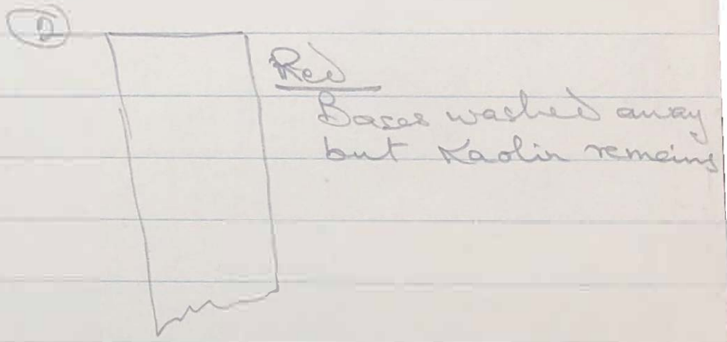
1. Different basalt soils in Gt British to Ceylon difference in leaching - less though in GB.
2. Ditto in in Deccan - but more so.

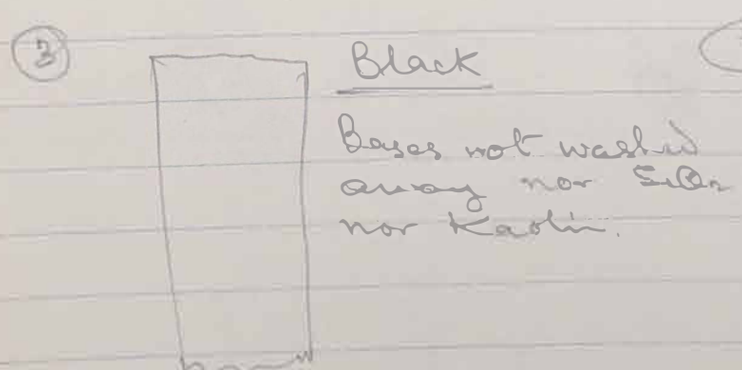
Initial weathering may be the same - but soil products of weathering not removed and resynthesis takes place.

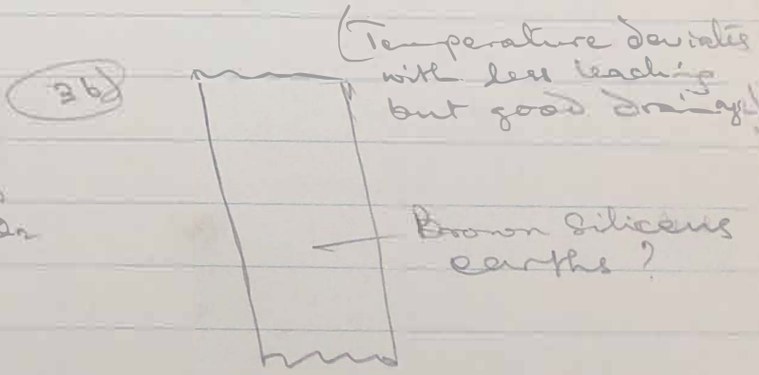
TOPOGRAPHY - Basic igneous rocks.

③









Compare Black Turf soils of S. Africa - Merwe.

Peat Deposits

Marine swamps earths
Lacustrine swamp earths

Limestone Soils { Black clays derived from limestone
Red clays derived from limestone

Increased leaching illuvial
Illuviate devoid of Ca & Mg Carbonates. Humid Sub humid

1. Groundwater Podzols
2. Mottled Earths (So-called Groundwater Laterites)
3. Semi mottled Earths?

Illuvial containing Carbonates Arid Sub humic Arid?

Saline and Alkaline Earths

SOILS OF TROPICS — Completely leached

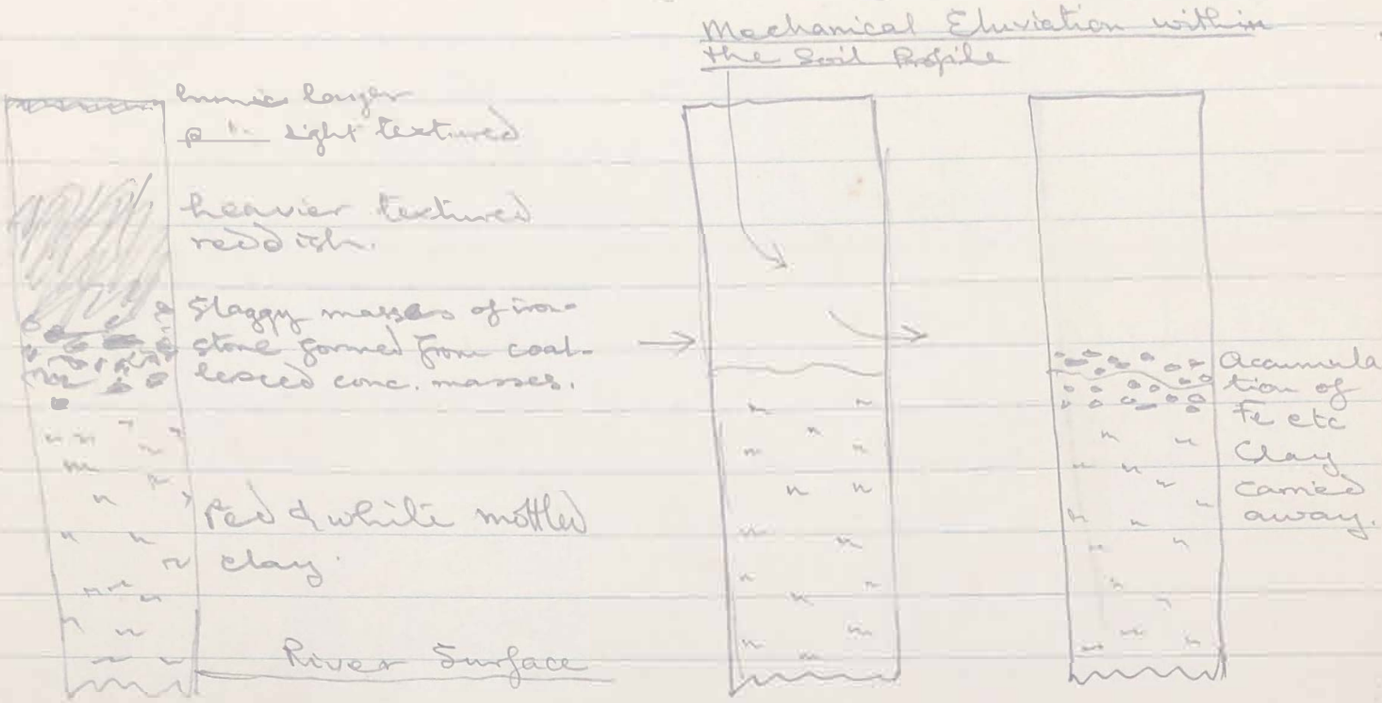
1. Eluvial Mottled Earths (Siallitic)
2. Eluvial Mottled Earths (Allitic)
3. Red and yellow Siallitic Earths
4. Red and yellow Allitic Earths
5. Podzolic Earths

Arid — Incompletely leached

1. Desert Earths
2. Red earths with lime conc
3. Crusts without $CaCO_3$ because previously leached
4. Soils of incomplete leaching in the Humid Zone. due to P.M.
5. Soils of incomplete leaching in the Humid Zone due to P.M. & Topography (Alkaline seem to be removed)

Lithological Types - Sands, Volcanic Ash etc.

In Marbut's observations of the Amazon Soils would be found this sort of thing:-



In the development of laterites with slaggy crust he postulated (Mosim Conf. Volume 5) erosion followed by redevelopment of profile:-

I have done same thing -
Also Mohi - 1st book and 2nd book

NB slaggy masses only harden on exposure! In cuttings they get soft behind surface.

This obviously must mean that mottled material must contain free Al_2O_3 or that Kaolin must be decomposed!

Could this sort of thing happen with detrital laterite? Which is usually full of iron anyhow?

Should Alluvial Soils be divided up into 2 Groups
1. Surface water types over impervious material?
2. Groundwater type

Clarke Study of Soil in the Field.

Meadow :- ? Trees?

Wet Forest Soils
Forest Swamp Soils
Forest Peats
Grasses and Sedge Peat?
Swamp Soils

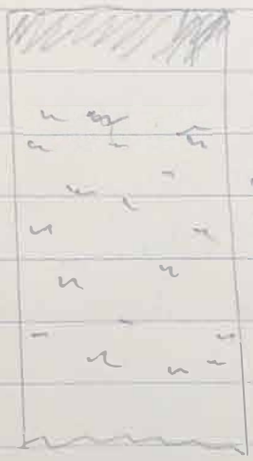
Wet woodland Soils
Wet woodland scarp
Woodland Peat
Grasses and Sedgeland Peat

Alluvial Soils - Acid Type

①

Thickness due to texture
Grey brown
Ochre
Ochre mottled rusty
Ochre-grey mottled
Ochre grey & grey mottled damp
Ochre-brown and bluish grey mottled Wet

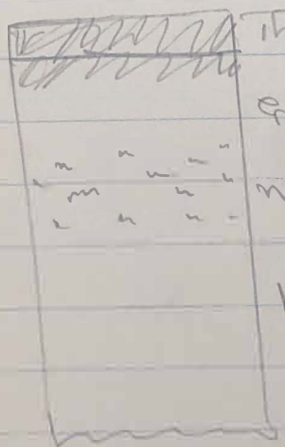
e.g. Granger Grove
Washington Series
etc



Grey-black - perhaps slight accumulation of O.M.
Grey (bleached layer)
mottled brown and bluegrey
This flooded too?

Half swamp

Swamp Type



Thick O.M.
Grey bleached
Mottled - Coarse.
blue grey.

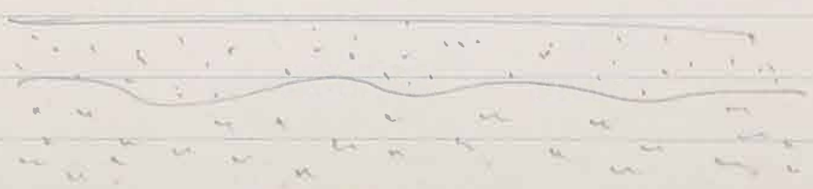
Acid Peat Type

Accumulation of O.M.

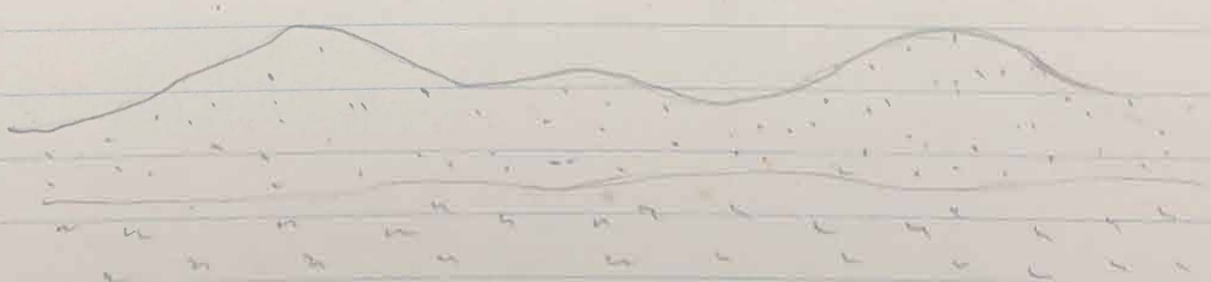
M | little above Normal
HB | high
B | Deep peat deposit.

Note on distinction between a uniform widespread pedological effect and a localised variable geological occurrence.

In the case of a sandy top soil of uniform depth directly overlying impermeable clay or of rock gravel occuring at a more or less fixed depth below the surface, these things ~~cannot~~ be explained as distinct geological deposits in the 1st Case or of surface gravel covered by creep or colluvial material in the second. Were this so it is quite improbable that evenness of depth would be maintained.
In the Sand/Clay one has



Were the sand and clay separate unrelated deposits one would expect



cf Nikiforoff the Genesis of a Solonetz-like soil also when one has a similar morphology appearing not only over large expanses of country in one region and a similar state of affairs in a region hundreds or thousands of miles removed it points to some mineral factor at work not to

some local geological occurrence, in the cases quoted to lateral elviation by surface water derived from rainfall and to the well known burying activities of the soil fauna.

0. Introduction. The Tropics Defined
1. Soil defined - Morphology and Methods of studying (based on field evidence)
2. Soil Genesis - Weathering - P.M.
3. Soil Genesis - Soil forming
4. Soil Genesis - Soil forming processes - groundwater
5. Soil classification.

Passive	P.M. Relief. Age.
Active	Climate. Organisms

The Origin of Soils

The Morphology of Soils.

Human Culture in the Tropics
Malay Sea. S. China (Peru Mayan) India (Egypt

of Climate and Man

(West Indies, India, Java, Hawaii
Mauritius - recent developments

Preface:-

Soils of the Tropics

I Introduction -

1. The Tropics defined - Herbertson's Map and Natural Regions.
2. The Soil defined - discuss question of whether the whole zone of weathering is to be considered soil.

Part I.

II Soil Forming Factors

(a) Topography } Passive?
(b) Geology (lithology) }
(c) Climate } Active
(d) Vegetation - organisms }
(e) Pedogenic Processes - Age
(f) Classification of Soils

} Should this go under O. in previous page?

Part II

Descriptions of the Morphology and Genesis of Soils

Soils of the Tropics
Their Origin and Structure.

Nikiforoff doubts much of the commonly accepted views concerning vertical Eluviation. ~~Differential weathering~~ giving rise to different horizons.

In case of Mn-Fe Concs - lateral mobilization within the same horizon

Segregation - (Concentration in one horizon)

Migration (movement from one horizon to another)

Lateral Elluviation - especially of Kaolin surface or of water table

1. The lysimeter results at Aberdeen
2. Merve in two soils in S. Africa
3. Self at Jafo

All the above on granite.

Presumably gneiss is the same?

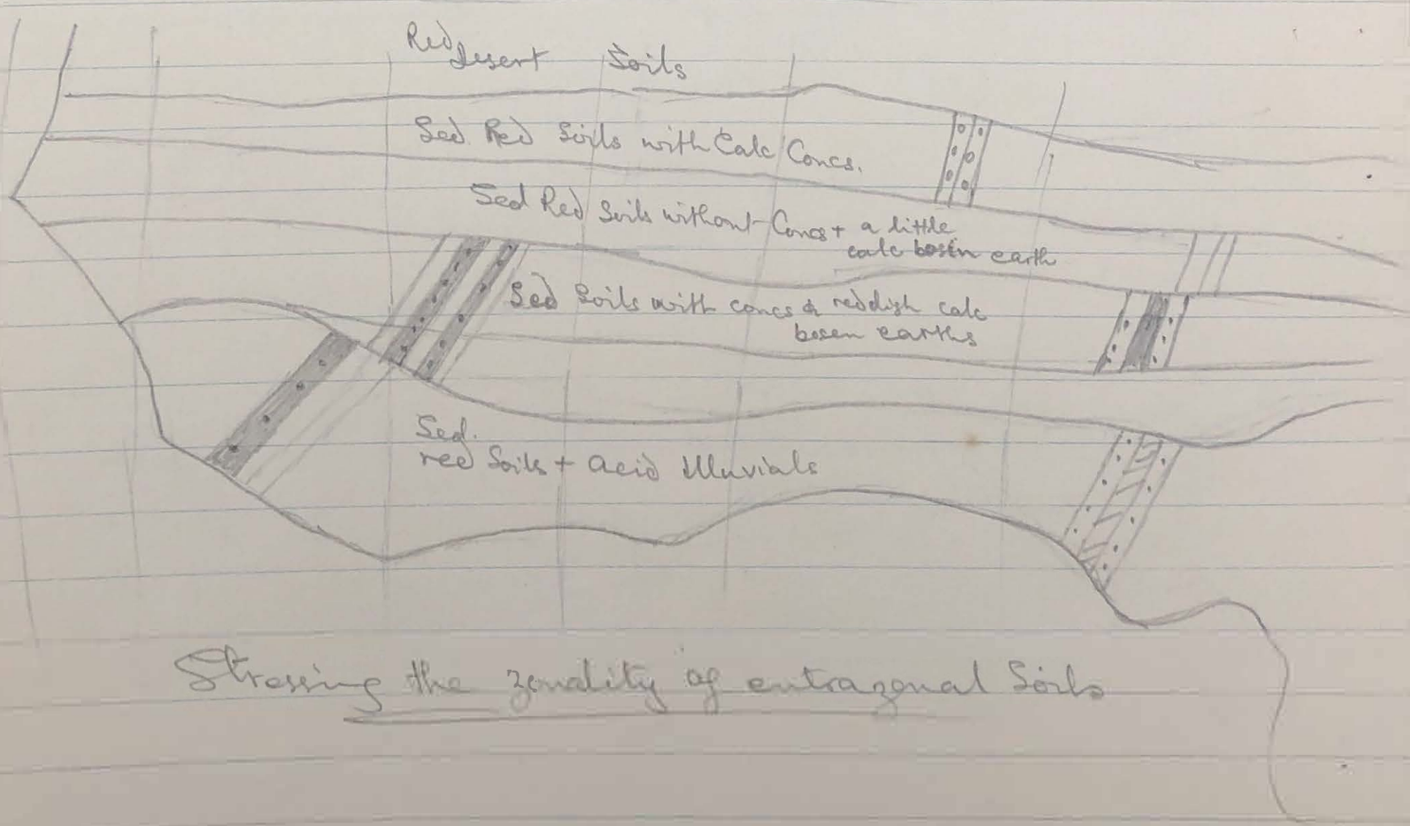
and Movement of Kaolin in Soils

What about other rocks?

Tens of Morocco - Red earths on slopes and black earths in hollows according to Del Villar

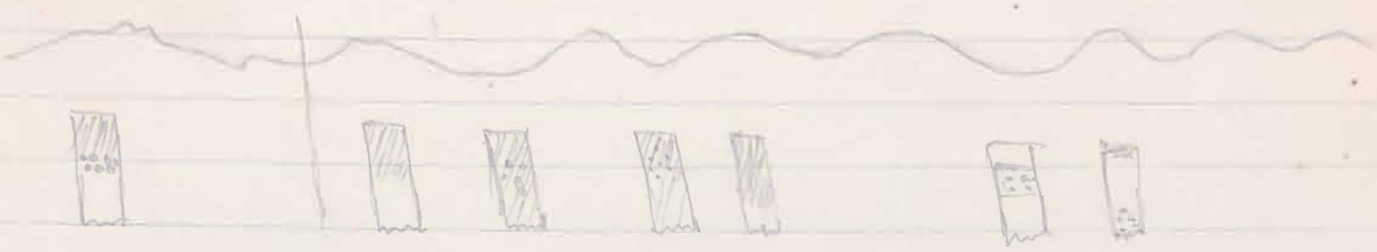
Hydrogenic earths - he assumes same about refer. (some Australian paper on this)

Soils of West Africa



Stressing the zonality of entrazonal Soils

Section N – South

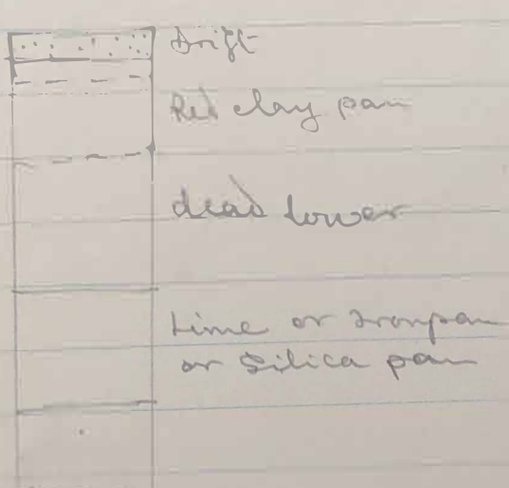


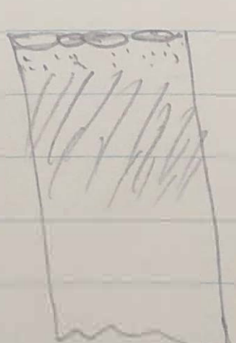
Savannah-Soils-eroded soils
mostly with iron pan
exposed

Ordinary Red Earths + thick dry forest + heavy rains + Very dry season – Biotic → Man's interference → eroded sed. earths + development of massive iron pan.

Points to be settled

1. Morphology of Desert Soils – residual
2. Morphology of calc. red earths (like Hawaii)
3. Morphology of red earths without calc. or iron. concs.
4. Morphology of red earths + iron concs in their dry zone
5. Morphology of red earths + iron concs in their Wet Zone.





Wrong assumptions based on
(a) Climate
(b) Vegetation
(c) inferences from North temperate conditions.

• An important point about Pan formation.

If pan formation were due to rise from water table it would not occur in the same position in the profile all the time - due to differences in the height of the water table from the surface.

W.T.

cf Nikiforoff. Characteristics of Desert Soils

Use this for Iron Pans
Lime Pans.

Dismiss the assumption that all these informations took place in past time – This is merely evasion. Not an argument since no proof is adduced that cone formation cannot and does not take place today.

Important :- If cone formation occurs to-day it gives important information on the 'Metabolism' of the soil not only from the point of view of profile development itself but also from the point of view of the plant life supported by the soil – For these processes leading to the formation of limestone and secondary minerals cannot be without these effect on the vegetation occupying the soil.

Where most layers dry out Fe_2O_3 & MnO_2 are deposited in this actual site. They do not rise in capillary water and become properties at the surface

NB Lower Hillslope earths } Tafo
Alluvial earths }
Devenish and Lowland Series – Trinidad.
Various Sand and heavy loams over clays etc.

Question of P.M. { Practically all Parent Materials in Temperate Zone. Secondary rocks or unconsolidated deposits. In tropics for greater proportion of primary or crystalline rocks

Prevalence of Black earths over Basic Igneous rocks.
Red earths/hard limestone Black clays/Marls
Red or brown earths over crystalline rocks?

NB The newest soils to the African are those of the Piedmont Plateau - from granite and gneiss.

Africa chiefly old crystalline and metamorphic rocks with derivatives from - In East Africa much basic igneous material.

Red Soils of Pacific Coast from Basalt and other basic rocks.
Non-calcic Brown earths of Pacific Coast (Group of Brown Soils) from Granite and Arkose - granite alluvial fan material.
Placentia, Ramona Soils. Central and Southern California (P.M. Granite alluvial fan material)
Vista-Holland, Fallbrook, Sierra Soils
Lower Sierra Nevada Foothill belt and upland mountain areas in California and Central Southern Arizona.
(P.M. Granite rocks: gneiss, granodiorite and similar rocks
See also Marbut-Soils of the U.S.A.

NB Shantung Peninsular is under basic igneous rocks.

Grey-Brown Podzolic

Chester-Manor Soils gneiss, granite, schist N. Piedmont.

Natalito soils – basalt.

Helmer-Santa Benevash Soils Calif.

granite, schist quartzite, basalt.

Olympic - Melbrine areas Calif.

(Recorded by Roberts for Puerto Rico go into differences between these and the Red and Yellow Podzolic at altitudes).

Regions with crystalline rocks –

California and adjacent states

Piedmont area of E. USA.

Shanting peninsular china

Asia Minor, Greece, Palestine

South Africa

Southern Australia.

Shanting Soils are Forest Soils (or Forest and Grass)

Prairie Soils are grass soils (discussion as to whether there occur now in Africa)

↖ What about mountain grassland?

↙ Bunda?

Red Earths of Piedmont

" " " California

Non Calcic Brown of Calif.

Grey Brown Podzolic of Cal and Pied.

Marbut marks

Jos Plateau as

Tropical Prairie

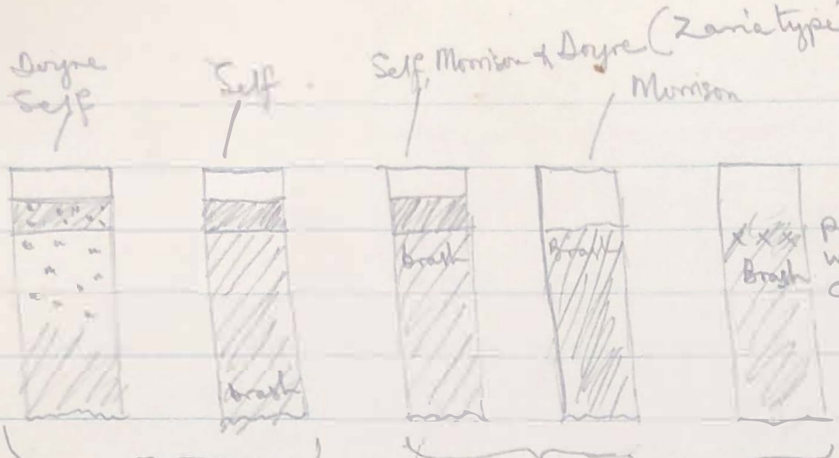
1. Red desert Soils - Alkaline
2. Reddish chestnut Soils? - Alkaline
3. Non-Calcic Brown earths - Forest-Prairie-Neutral
4. Red Paizotic earths - Acid
   Grey-brown Paizotic (mountain)
   (Mountain Prairie Soils?
   Mountain Meadow Soils?)
   Red and yellow ferrugino Paizotic Earths?

Bibliography of Tropical Soils and Useful Associated papers.

Parent Material

1. Acid Igneous rocks
2. Basic Igneous rocks
3. Clay shales
4. Sands & Quartzite. Deep structureless sands Ha.
5. Phyllites ?
6. Limestones and Marls

1. Basic Igneous and metamorphic	Sandstones-loose Sands
2. Acid Igneous " "	different diffi-
3. Phyllites	cult.
4. Clay shales	
5. Felspathic Sandstones	
6. Argillaceous Sandstones	



Succession from S to N

Apparently Morrison considered in his soils the iron pan rested on the rotten rock to be did no explore below the iron-pan

1. Get not topo map
2. " " Geological Map. (Parent Mat. Map)
3. " " Soil Map.
4. Rainfall Map

Soil Types Recognised

1. Marine Swamp alluvial — Mangrove
2. Structureless Sands — Nigeria. — (Forest - Savannah)
3. Concretionary red earths scallite
   a) Forest (Take forest boundary)
   b) Savannah (Take Savannah boundary)
4. Acid bottom Soils — Swamp forest.
5. Calcareous bottom Soils — Savannah grass
6. Allitic red earths (Basic igneous rocks) forest
7. Black Calcareous earths (or basic igneous rocks over hornblende gneiss) Savannah.
8. (Recent Volcanic Ash Soils of Cameroons — not mappable) forest.
9. Leached Red earths without iron concretions? — Savannah Scrub
10. Red earths with calcareous concs? Scrub desert.
11. Desert Soils
12. Saline and Alkaline Soils.

Such minerals would be commonest in alluvium derived from crystalline rocks and less common or absent? from secondary rocks.

In Hydromorphic Soils.

Clay can be derived in the following ways:-

1. Leaching from above - followed by erosion until the whole Profile becomes clayey.
2. Transport by groundwaters gradually building up clay from below.
3. Weathering of unweathered minerals in situ in the presence of groundwaters (Nikiforoff's reasoning).

Investigate the possibilities of 3. especially as regards the fine sand and silt fractions of recent alluvium.

Whilst perhaps most of the coarse sand may consist of quartz, much of the fine sand may comprise weatherable minerals, and still more of the silt.

The coarser fractions of the clay may also contain unweathered minerals

Weatherable minerals =

Felspars - Potash, Soda, Soda-lime, lime soda etc.
Micas - Muscovite, biotite
Amphiboles and pyroxenes
Chlorite
Talc?

- Where does alluvium come from?
  1. Wholly weathered (if such exists) topsoil?
  2. Subsoil where exposed by
     a) uprooted trees
     b) burrowing of animals
     c) accelerated, normal erosion such as exists on steep slopes
     d) Areas of mainly physical weathering
     e) Natural gullays - produced by cutting emanation of streams.

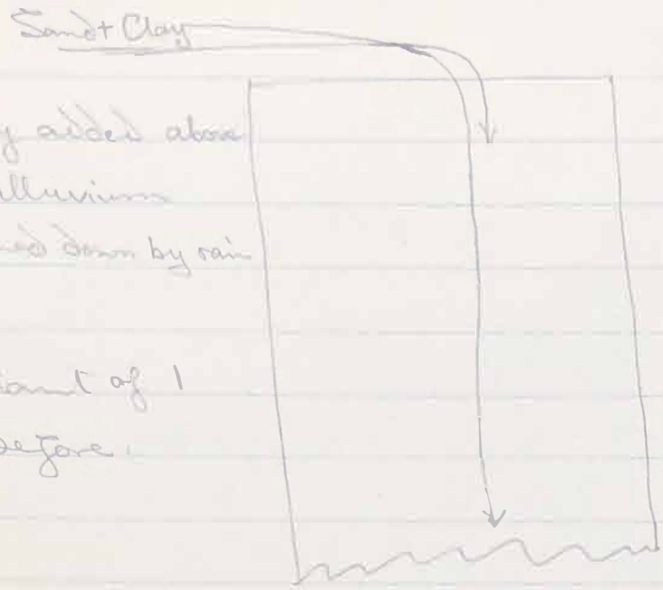
All this means that alluvium is not only unweatherable minerals - quartz and clay but consists to a great extent of weatherable minerals that weather to clay in situ when transported.

NB. Sands and quartzites that I have met with felspars and micas in them

After coarse alluvium consists not only of separate bits of minerals but bits of rock as well (eg Schists in Trinidad Ok Series) especially in areas of rapid ~~de~~ dation - or in areas where physical weathering prevails.

Were clay transported in considerable amount one would expect more to appear in drainage waters (investigate), wells, rivers etc. artesian supplies. Turbidity occurs ① After digging of wells, ② after heavy rains

Continued on next Page



of Analyses of Sedentary rocks

Actual minerals maybe disguised by stains of Fe_2O_3, clay and organic matter.

All of this of course can be subjected to proof ie by carrying out a mineralogical analysis of fresh alluvium and weathered alluvium.

Concretionary Savannah Earths.

Ferruginous { Forest Earths, Sands. / Savannah Earths, Alluvium / Calc. Black Earths } Desert Drift / Sesquioxidic earths.

Characteristics

1. Shallower depth of weathering. Absence of mottled clay zone. The solum properties over brash or rotten, disintegrated rock (characteristic present under forest)
2. Concretionary layer directly overlies the rotten rock, is very prominently developed - frequently forms a massive iron-pan (characteristic absent under forest

3. Organic matter content?
4. Clay complex siallitic - more so than the forest earths?
5. Surface horizon characteristically coarse textured

Suggested that these earths are distinct from those of the evergreen forest in the same way as the Chestnut Cal. Earths are from the chernozem.

Some of these characteristics are undoubtedly due to destruction of the original vegetation and consequent erosion, but it is considered that there were characteristic differences between these and forest soils even when under mountain vegetation of open? Savannah Woodland.

(Use of Savannah by Bennett and Allison also remarks of Ramann.)

Concretionary Forest Soils - Ferruginous Savannah Earths. Distinction based solely on profile characters.

Climate - different. Vegetation - different.
Profile - different.

- CFC & Doyle.

Vegetation to day is in part determined by climatic conditions - otherwise things could go back

(NB - Savannah regions appear to have been settled previously to forest (This has only been exploited since the advent of Europeans demanding oil, slaves and cacao; possibly also connected with possibilities of stock rearing). (Possibly nearness of unweathered rock to the surface has influenced this?)

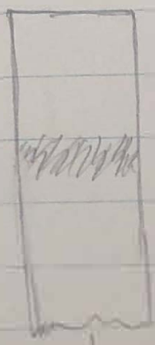
- CFC Morrison and many Authors

Tropical forest generally unsuited to human settlement.

One really wants this examined under natural vegetation. Less thoroughly leached but still acid (mobilisation of iron)
of Greenwood & Doyne.

NB. Bauxite deposits in Gold Coast.
Voltaian Sandstones
Phyllites - depend what these phyllites are made of

In case of superficial iron-crusts = erosion as suggested by Marbut.



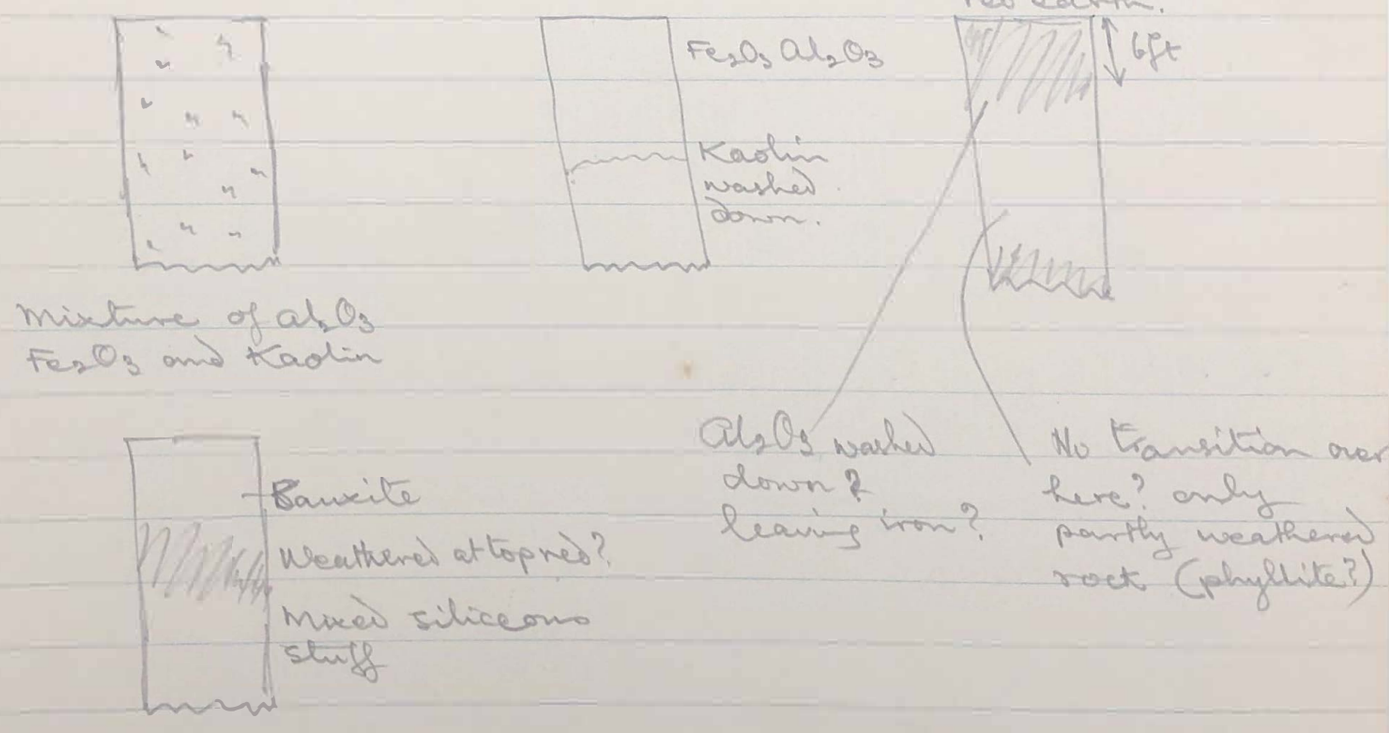
loss by erosion
segregation of iron due to high water table
sesquioxidic

↓ then this layer develops as — <u>see foll. diagrams</u>

<u>NB.</u> Martin and Doyne give examples of transported or detrital laterite.

Sesquioxidic Earths

1. Assume that due to decomposition of various minerals a mixture of sesquioxides (Al_2O_3+Fe_2O_3) and of alumino silicates are formed. The latter in regions of good drainage are removed leaving a sesquioxidic earth. Hence decrease in SiO_2/Al_2O_3 ratio in regions of high rainfall.
2. Transported products of above
   a) would have the level surface of many laterite deposits
   b) would probably be mixed with kaolinitic products.



Laterite Never appears to have been investigated by pedologists only geologists and chemists (Hardly unable to form opinions of his own-relied on Harrison's explanations) Erhart?

Sesquioxidic earths, however, have Cuba, Puerto Rico, Sierra Leone, Hawaii, Mauritius etc

Grenada U.S.A. B. Guiana Topography of the latter appears to be irregular. Not regular as in the former.

. Aluminous earths in process of forming to day in situ apparently occur only over basic rocks (examples)

.. 'Laterites' apparently occur over most types of rocks, clay shales, sandstones, phyllites, granodiorites, granites, limestones? etc. This in itself is suggestive. (No possibility of error) Acid gneiss.

Absolutely no evidence to suggest that kaolinite etc can be split up into SiO_2 & Al_2O_3.

'Laterite' may therefore be in many cases deposits of geological significance only although they may act as soils, ie media for plant growth. (This at least appears to agree with the geologists. Much bauxite mined is fossil)

Two types - Residual Bauxitic earths
Transported Bauxitic earths -
In these it seems bauxite may be further concentrated - hence it is possible these are mined

Occurrences on elevated peneplains and dissected plateaux only
Occurrence overlying a particular rock formation does not mean that it was derived therefrom.

Probably a continuous sequence of earths from wholly sialitic to almost wholly allitic occurs.

Effects of climate. Climate may not affect the formation of Al_2O_3 but may affect the case and rate of removal of the impurities such as Kaolin etc.
Goldsmit - in Tumbora - also Polynov.

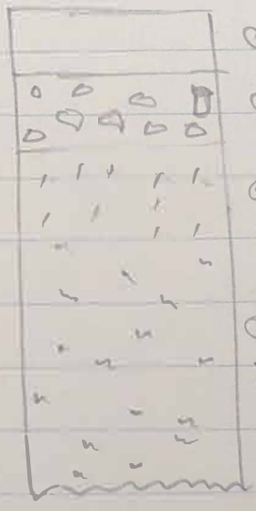
Fossil Laterites associated either with limestone (Europe and America) or Basalts
Fox suggests that bauxitic impurities are responsible for this - regards it as a type of terra rossa formation.
In Ayrshire lacustrine clays contain bauxite (see Petrology of the Igneous rocks)

Apparently (Fox 1936) the Malabar 'laterite' of Budaaan was developed over acid? gneiss and was mottled clay - Kaolin + Fe_2O_3. Presumably this was an eluvial mottled earth + iron concs overlying mottled clay over gneiss - One of the usual types of red soallitic earth?

1. Even very wet climate of the Tropical forest - rainfall 100"+ Cameroons. —

(Can one argue from the concretionless red earths of S.E. U.S.A to the mod. conc. earths of the Guinea forest — the heavily conc. earths of the Savannah)

1. Even climate
2. More extreme climate
3. Very extreme climatic conditions.



Orange brown earth (text?)

Orange earth + quartz gravel (text?) no concs.

Orange - obscurely mottled ochre with semi soft remains of concs - brownish?

Grading into red ochre & white mottled clay and this (presumably) into deeply weathered gneiss.

Red earths were rare or absent over gneiss which seemed to have plenty of biotite in it

Autogenic

1 & 2. Allitic earths – do but overlying mottled zone? do with cone zone.

3 & 4. Sallitic earths – red and homogeneous.

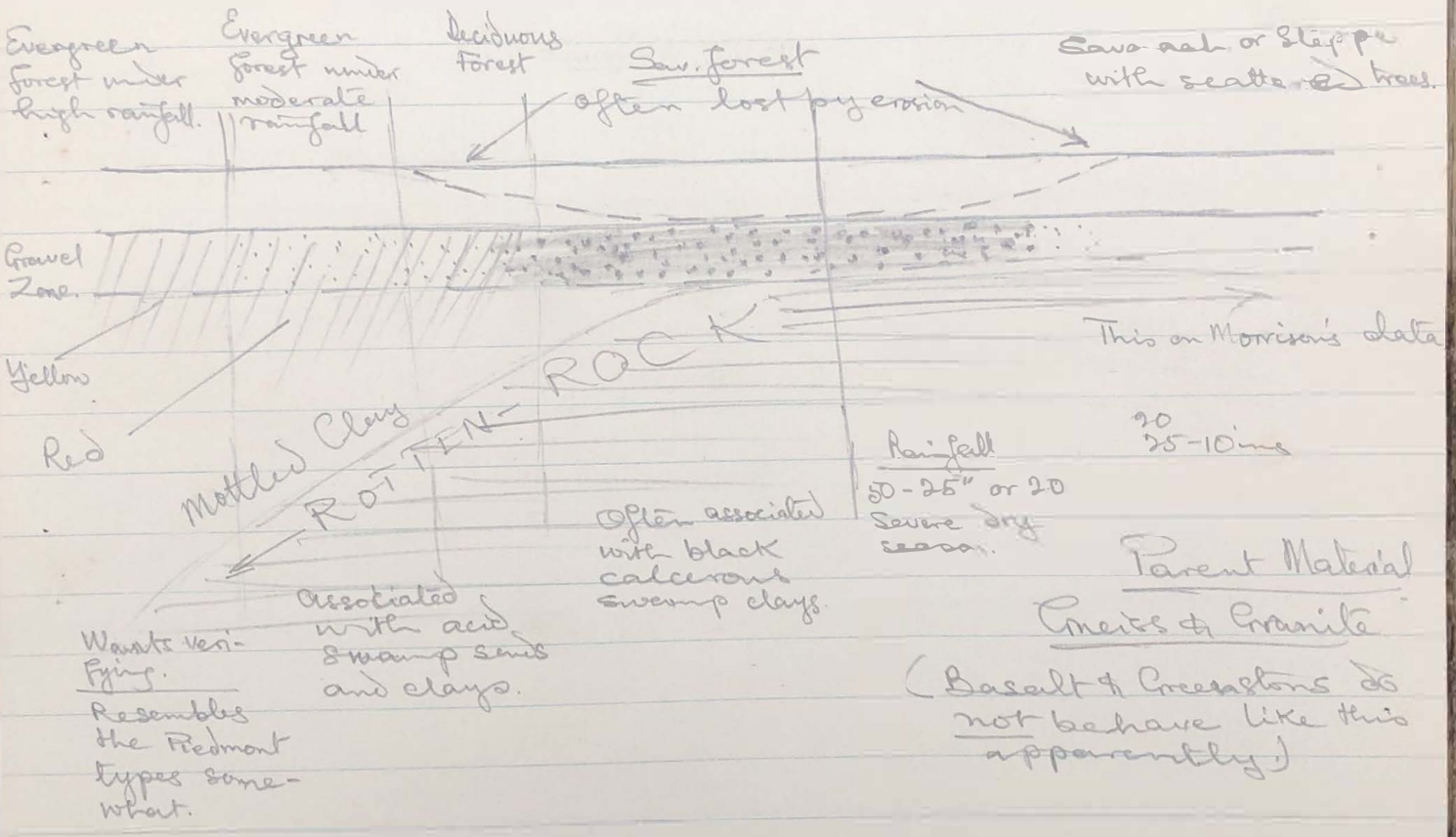
5. do with red mottled inferior zone.

6. do do with cone zone.

7. Red neutral earths with no cones?

8. do with $CaCO_3$ deposits in P.M.

9. Red full of O.M. – Mountain pastures?

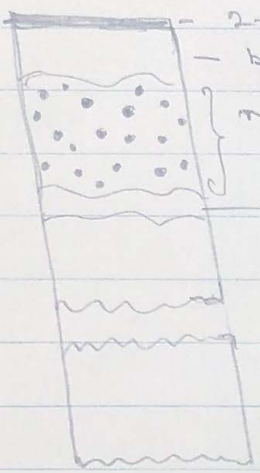


Wet practically all the year little or no drying out in dry season	Wet most of year. Moderate to little drying out in dry season	Dry at least half of the year (one rainy period concentrated) long and severe dry season.	Dry most of the year, low rainfall. Severe drying out for long periods.
Probably very high leaches of nutrients.	Cacao mostly on hill tops and slopes.	Forest confined to fringes of streams and rivers. Cacao in forested bottoms.	

has plenty of rotten rock got something to do with the great development of cone zone?

1. The important soil in the Tropics – the real characteristic 'Zonal' soil is the concretionary Red Forest Soil. This as far as extent is concerned out classes all others.

2. It has the following 'Profile':-



3. This is the Tropical Analogue of the warm, humid temperate red 'podzolic' earth as found in the S.E. U.S.A.

4. It has been observed developing over the following rocks. Granites (several) granodiorites, syenite (?) Basalt, Diorite, Anderite?
Phyllites, greywackes(?) Clayshales of various sorts felspathic sandstones and felspathic quartzites, slates. Mottled sandy clays. Silty shales. limestones? Schists of various sorts (Barbados?)

5. Variants include types in which the concretionary zone also contains quartz stones - from intrusive quartz veins and bits of rotten rock being haematized. This type of profile cannot develop on sands that are neither argillaceous nor felspathic.
On sandstones a related but quite dissimilar profile arises.

6. The following climatic and vegetative? types occur
a) Concretionary Red Forest Earth (with moderate numbers of concretions and very deep).
b) Concretionary Red Savannah Earth
Large numbers of concretions often forming a pan. Frequently profile is shallow-rotten rock occurring just under the concretionary layer.
c) Red (yellow) Forest Earth. Occurring under very heavy rainfall with a moist 'dry season'. Very deeply weathered, no concretions and yellowish brown colours to the upper part of the profile although the mottled clay exhibits red colours.

7. Ceylon, Malagascar, South Africa(?) India, Siam, South China, West Africa, Central Africa? East Africa?, Brazil-Guianas, Cuba, Puerto Rico, Trinidad.

8. Take as a type the concretionary red earth over phyllite! (Granite and gneiss exhibit a few mineral features - quartz sand content, quartz vains etc.)

9 Occur on somewhat flat, and undulating relief; do not occur in broken topography.
In this case uniform red earths occur.

10. Apparently - Buchanan's type of latosile was really this soil!

Note on Effects of Topography in regions of medium to low rainfall.
(of Ellis)

Sedentary Soils in all situations.

Rainfall insufficient to cause much transport or to flood hollows. But uplands suffer from run-off and decreased effectiveness of the properties — whilst the hollows enjoy a master climate and deeper leaching and therefore have deeper profiles than the more elevated areas. In chestnut soil areas one may therefore have chestnut soils on the ridges and chernozems in the hollows (Marbut - Texas). This type of thing can only occur in regions of low rainfall and gentle rainfall — not in regions of heavy even if 'low' rainfall of the tropics

Note on the Soils of Hawaii.

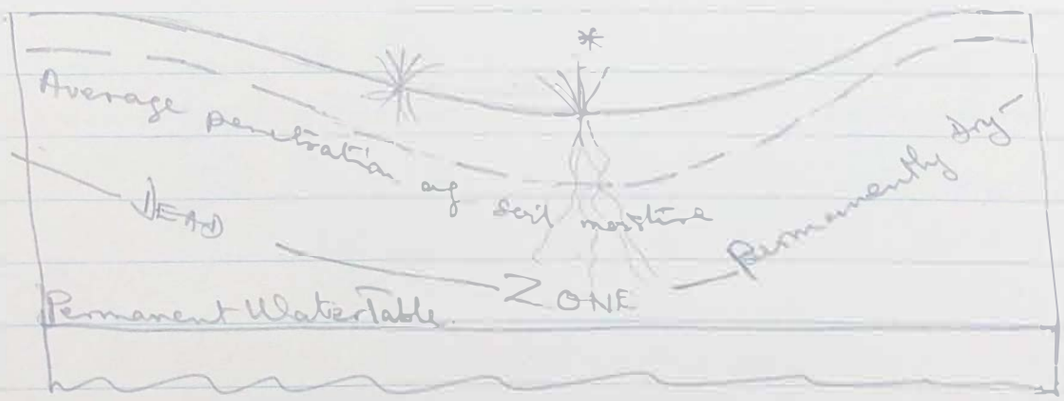
These are as stated in 'Soils & Men' inclined to be shallow and, in places, rocky. Occuring over recent ashes and lavas most are immature and there is little pronounced profile development. The adverse local feeling towards Soil Surveys based on the morphology of the Soil is therefore explained. Had these Soils had distinct morphological features they would have undoubtedly been investigated from this angle by the numerous chemists etc employed by the Sugar and Pineapple estates. As it is, much of the islands consists of shallow Soils with rocks that form a more or less uniform covering to the

land - differing mostly in chemical and mineralogical attributes such as content of Mn, titanium etc. There are differences in colour too, due to rainfall and altitude. Most of the lavas seem to be of the same or very similar composition so that no varying soils occur due to differences in parent material.

To some extent this must be characteristic of islands of small size. They are not the ideal places to study soil morphology!

Further note on Effect of Topography on Soils with low rainfall (page 40)

In the hollows one would get :-



* In occasional years properties and run off would be sufficient for percolation to reach the Water Table and deep rooted phreato phytes (perennials) would be able to get established. This must be an occasional and very tricky business - cf Meinger's papers and the remarks of Maximov - The Plant in relation to moisture.

World Distribution of Soil Parent Materials.

I Consolidated Deposits.

Other than limestones

A. Crystalline, Acid, Igneous and Metamorphic rocks
B. Crystalline, Basic, Igneous and Metamorphic rocks.
C. Sandstones (a) Non calcerous (b) Calcerous.
D. Clay Shales & Slates (a) Non calcerous (b) Calcerous.
E. Limestones and Dolomites

II Unconsolidated Deposits.

A. Alluvium - chiefly river, Lacustrine, Estuarine and marine.
B. Glacial Till and Clay (a) Non Calcerous (b) Calcerous.
C. Glacial outwash sands etc. Inter glacial periods
D. Loess
E. Wind blown sands (chiefly desert and littoral dunes)
F. Rock waste and valley filling materials

of Polynox on this Reference?

Key - I A. Pink B. Red.

Sandstones :::: non calc. pale yellow
Calc. pale blue.

Shales /// Pale yellow Blue

Limestones - deep blue

Glacial Till ooo Pale yellow
Pale blue.

Alluvium - Pale yellow
Pale blue

In case of Preliminary geological Surveys - especially of new or little known countries - Maps probably mostly represent actual surface exposures and conditions.

No first 'country rocks'?

What about Rechthoven's work?

CARD INDEX OF TROPICAL SOILS

Author (date) Title. details of publication on back.
Types of Soil dealt with:- method of dealing

(a) Profile Diagrams PD
(b) Profile Photos PP
(c) Profile descriptions (Ventale) PV. (g.f.p)
good fair poor.
(d) Profile chemical data PC
(e) Analysis of surface soil
chiefly nutritive A-N.
or general A-g.

Also list under following:- U.S.A, CENTRAL AMERICA, SOUTH AMERICA, WEST INDIES
NORTH AFRICA, TROPICAL AFRICA (West. Cent. East) - SOUTH AFRICA - Natal
INDIA. BURMA - MALAYA - SIAM. CHINA - FORMOSA. JAPAN
MAURITIUS. Madagascar
EAST INDIES (- Java, Sumatra, Borneo). AUSTRALIA.

Author, Title, Reference on back - details as above.

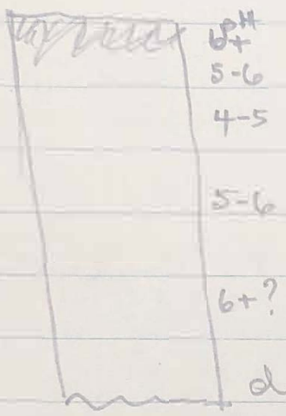
Base status and Vegetation of Swamp Soils
Mottled clays - only grass where thoroughly flooded
Acid nutrient defined.
Alkaline Soils - trees always - Alkaline - excellent base status. (Grass on this type result of clearing)
but where always thoroughly flooded deep sav. grass (peat)

of Soils of Cuba and S.E. U.S.A (Florida)
Java & Sumatra, British Guiana - Pegasse, British Honduras. Burma. Mataya.

HYDROMORPHIC

TROPICAL SWAMP SOILS. Lowland.

1. Organic matter (does not form a distinct layer) distributed in surface of mineral soil (comparable to the Temperate Meadow Soil - Weisenboden) may occur under grass or trees.
   Not always thoroughly wet.
   Has nutrient status got anything to do here? ie N.S. x Water relations?



2. Organic matter occurring as a distinct peaty layer overlying the mineral soil and affecting its profile ~~structure~~. Plants rooted in both surface peat and mineral soil below (comparable to Temperate Half-bog soil) May occur under grass or trees?

3. Organic matter deep - plants entirely rooted within it. Grass or trees.
   (Comparable to Bog soils of Temperate Zone)

Forest muck soils
Forest Peaty Soils - Swamp?
Forest/Peat Soils
Half peat? or Bog?

Continued on next page.

Mountain half peats - eg. such as occur on misty mountains etc.

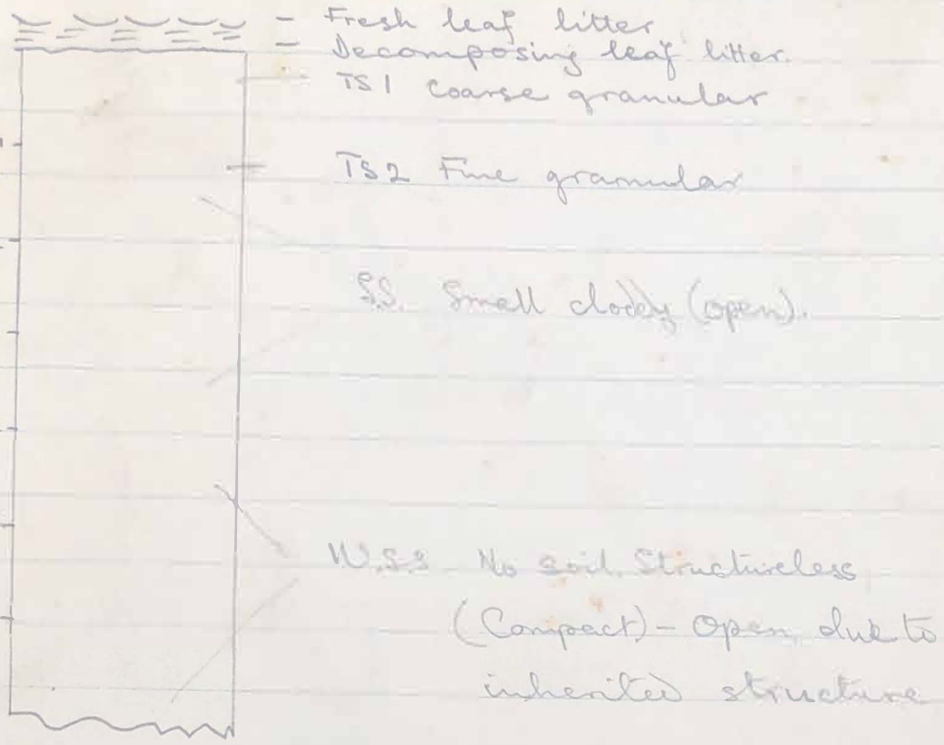
Mountain peats ? like above but very deep.

Mountain mucks ? highly organic always wet?
(Tropical mountain grassland)

Forest Soils

Forest soils have the following structure:-

(Fig 1)

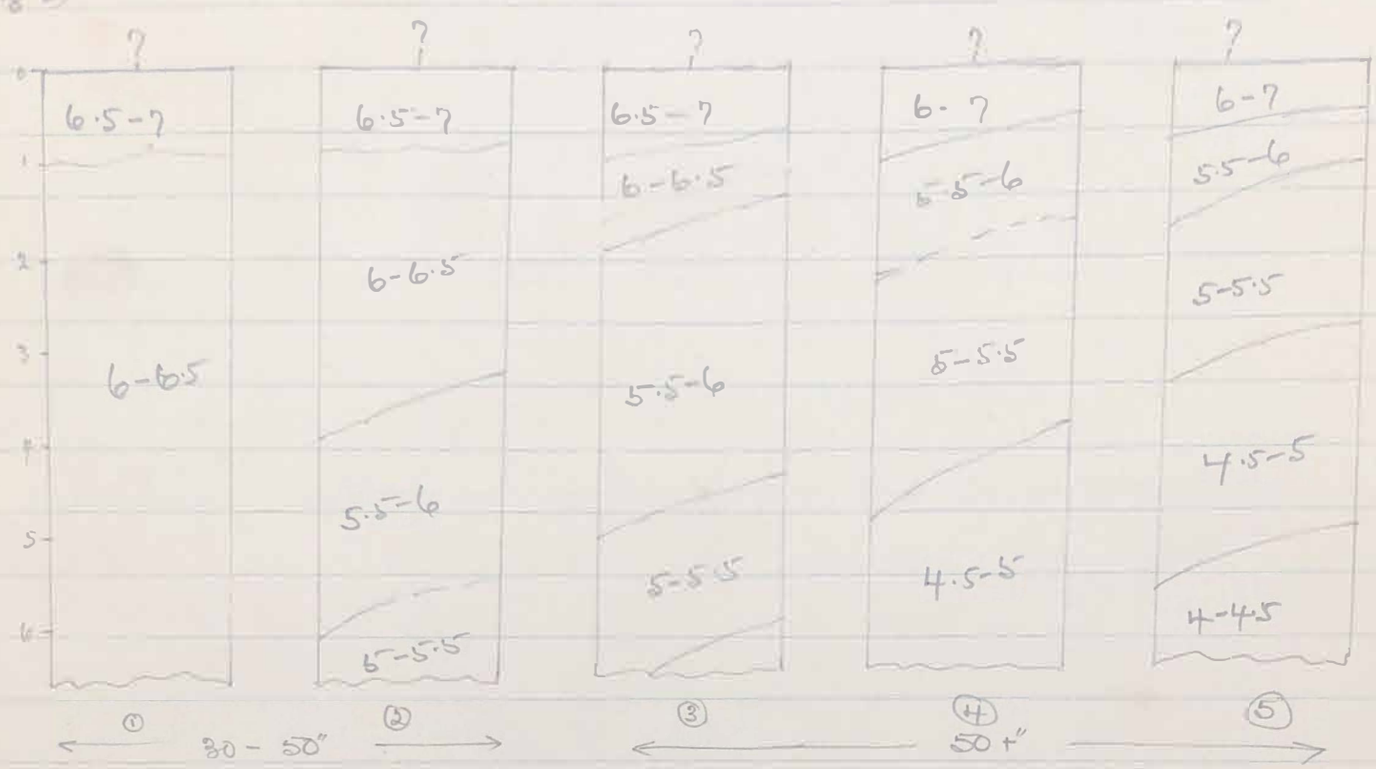


Is this more typical of the neutral forest soils than the acid forest soils?

A structural 'B' might occur in 'Sedentary' soils but not in Podzols. There might in Wambeke's nomenclature be latosolic regosols with A/C horizons only.

Forest soils can be divided into two groups:-
1. With neutral humus
2. With acid humus.

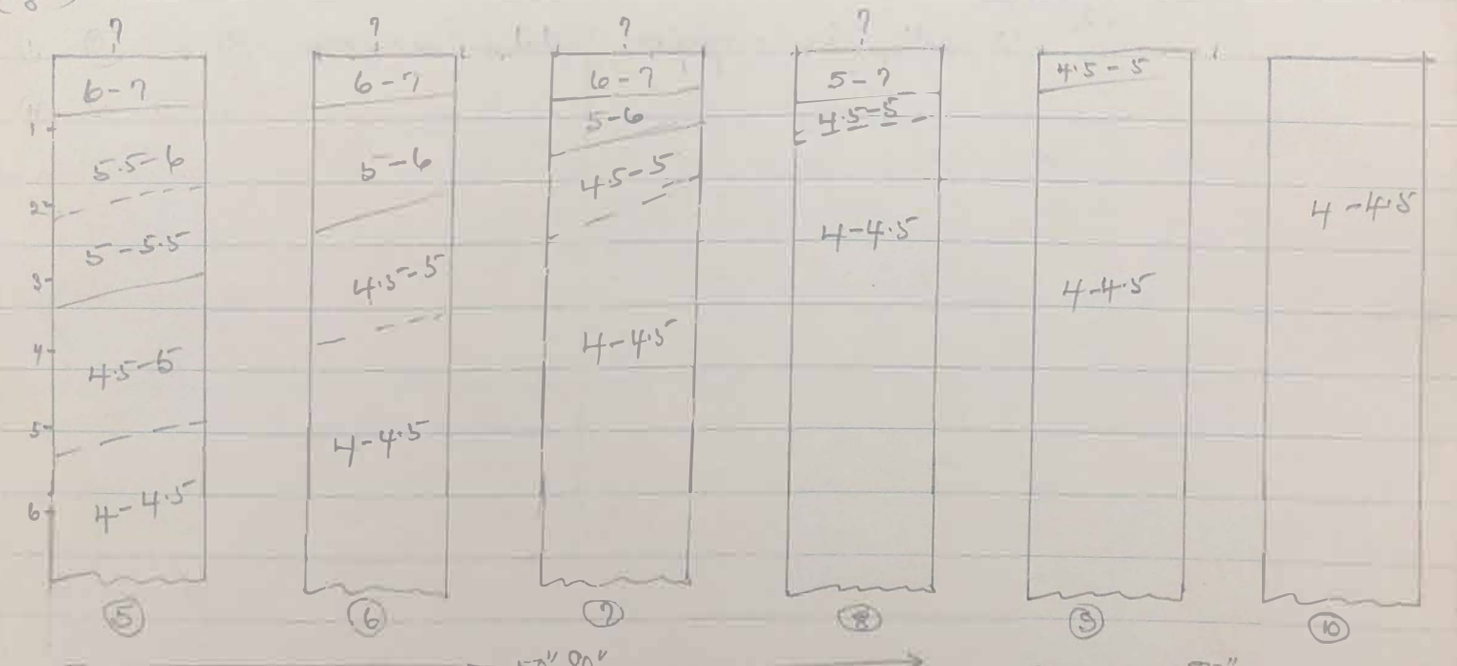
(Fig 2)



Antigua
Keta

Forest zones
Gold Coast

(Fig 3)



Yongambi
Nigeria

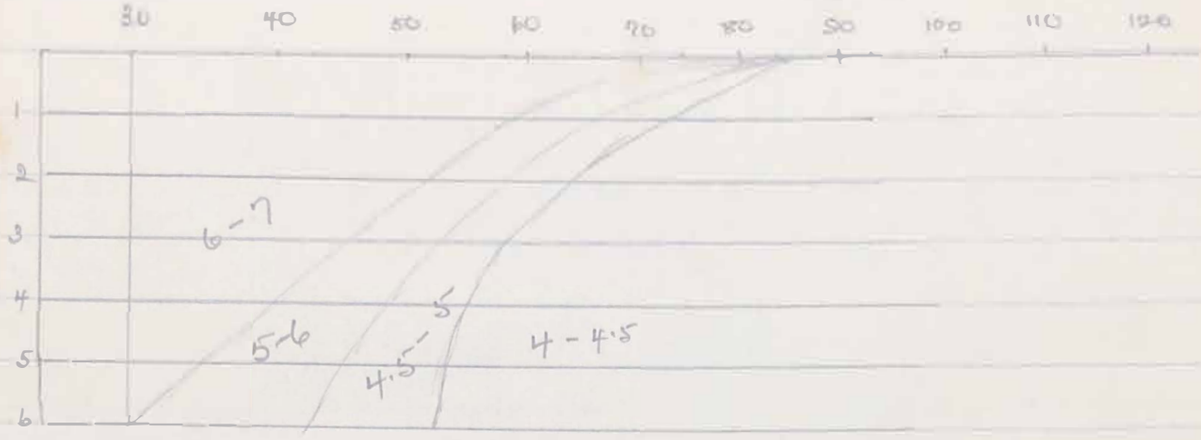
①②④③ presumably approach the U.S. 'Red Prairie'

④ to ⑧ Compared with the old U.S. 'Red & yellow Podzolic soils'

① to ③ represented in Antigua would merge into Pedocalic red soils.

Rainfall in inches

(Fig 4)



Climatic sequence - affected by
(a) Nature of parent rock
(b) Age of soil.

That neutral and acid forest soils occur is a fact. The question is:
Is there a fairly sudden change from the neutral to the acid soils as hypothecated in the climatic sequence shown above?
My sketchy evidence to date suggests that the upper part of the top soil remains neutral as the highly acid horizon approaches nearer and nearer to the surface.
① to ② undoubtedly occur (Antigua)
③ to ⑥ undoubtedly occur (Gold Coast)
accord to Vine under undisturbed conditions the thin surface layer of the 'Acid Benin Sand' is neutral.
(These would be represented by ② and ⑧)

But the U.S. descriptions seem to indicate that their red and yellow podzolic soils had distinctly acid humus horizons (but not highly acid) [disturbance?].

With ① to ③ on uplands neutral to calcareous valley soils would occur.

With ④ to ⑧ neutral valley soils would occur.

With ⑨+ acid valley soils would occur (sedge grass and forest peats).

In the past, writers on and investigators of red forest soils have been mainly - if not entirely - concerned with the supposed effects of climate on the mineral weathering complex - ie. whether this is sallitic or allitic and not upon the soil proper - ie. the organic, and organo-mineral complex. It is now known that the mineral weathering complex is dependent for its nature mainly on the mineralogical composition of the parent rock.

Neutral and Acid Forest Soils

Can develop over any type of mineral weathering complex - depending on the rainfall - though the precipitation at which neutral soils change over to acid soils and the rapidity (i.e length of weathering necessary) with which this process take place will depend to some extent upon the nature of the parent rock.

The following types of mineral complex occur :-

1. Siliceous sand
2. Kaolinitic clay
3. Illitic clay.
4. Montmorillonitic clay?
5. Sesquioxidic earth (allite or ferrallite)

Colour of the organo-mineral layers will vary according to the nature of the mineral complex.

Difference between soils with neutral and soils with acid humus seems a fundamental one.

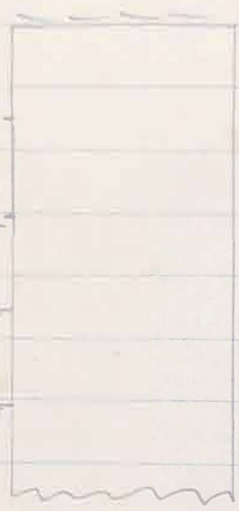
Neutral and acid forest soils can develop over parent material that has arisen in situ or over parent material representing various forms of drift.

Reaction profile in old drifts may be different from that in sedentary earths.

Also reaction profile in sedentary earths may be affected by the portion of the earth the soil is developed in.

Acid Forest Soils (cf page 1)

(Fig 5)



← Accumulation of peaty layer?

No real differentiation into top soils 1 and 2?
gradual diminution of humus staining
downwards the profile.

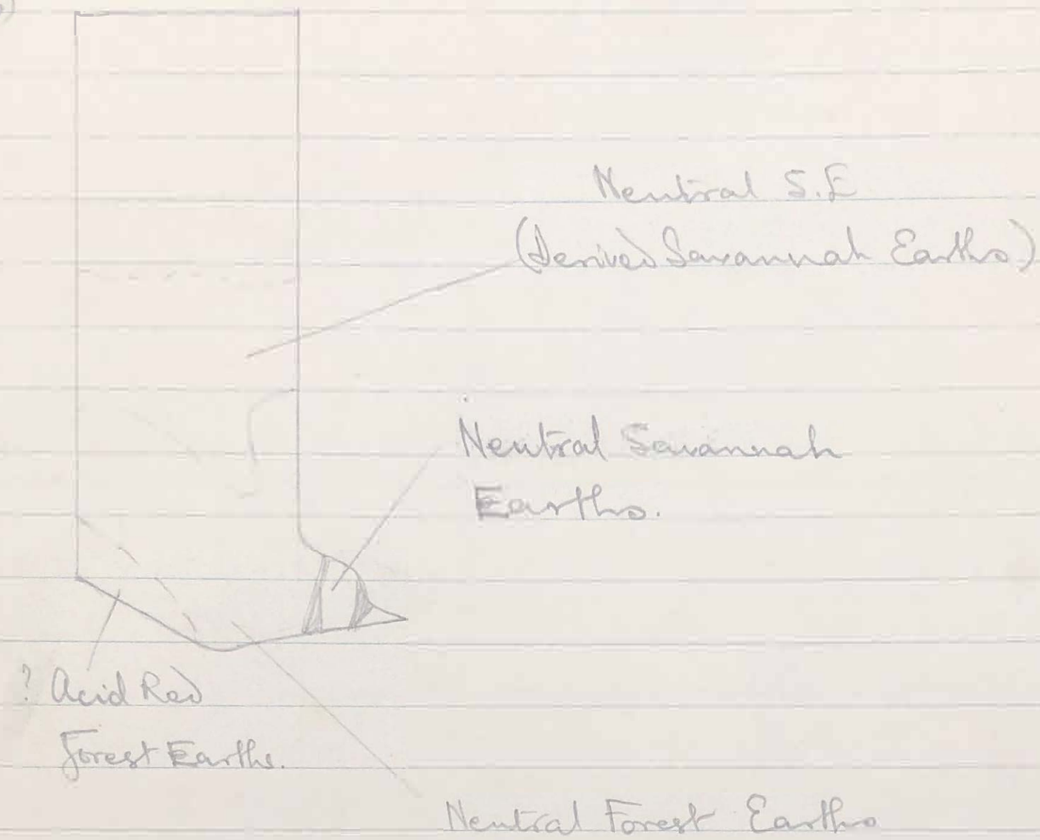
1. Absence of bases to form crumb.
2. Absence of crumb forming fauna.

Presence or absence of a root mat?

British Guiana 1. Alluvial Profile?
2. Basaltic? Profile } Red
1. Dolerite Profile }
1. Quartzite Profile Yellow
1. Sandstone Profile

Climatic Soil Zones: Gold Coast.

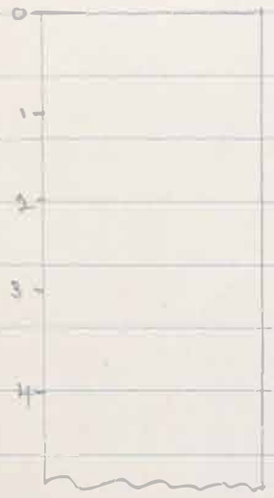
(Fig 6)



Savannah Woodland Earths

Savannah Woodland Earths have the following structure:-

(Fig 7)



(a) No litter layers

(b) Gradual decrease of humus throughout the topsoil *

(c) Top soil neutral over acid parent material.

(d) Large areas of these earths (by far the majority) are developed over peneplane drift.

(* Usually, if not always grey-brown possibly due to fires - Nipe soils, however?)

(e) Associated with either neutral or calcerous valley soils - also with grey ironstone swamp soils.

These are the soils mainly associated with ironstone sheets - (laterite) [BOVALS]

Savannah Woodland Earths are typically associated with inselberg landscape (Savannah landscape of Cotton) cover an extremely large area in africa.
Tall perennial grasses (Andropogons, Hyparrhenias) with scattered trees or thin woodland (open) - abundant game. Trees predominately of the Caesalpinneaceae

Shuld be neutral at the surface - though analyses of the O.F.C. show them to be slightly to moderately acid - possibly poor sampling - for note frequency of Grant-Snail and abundance of game.

NB Surface 2-3" may be neutral - lower layers somewhat acid - if a foot thickness, inches sampled, the whole sample would tend to be acid.
Many samples must have been taken after deep ploughing, too.

Note on Acid Savannah Woodland and Thicket Soils:-
(surface acidity)

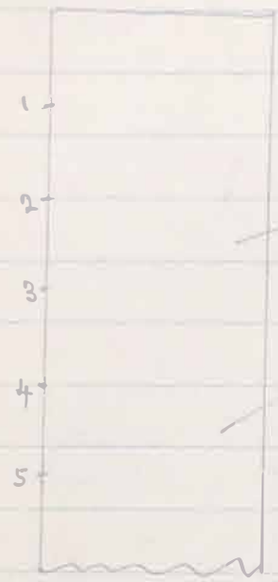
But see page 25

Even if savannah Woodland or thicket have developed over leached or acid parent materials - produced under a previous humid climate - the top soil should become neutral in course of time by surface additions of bases from various sources:-

1. Volcanic ash:- This is deposited all over the world - of Oceanic deposits (should be some data or amounts)
2. Aeolian dust:- either from deserts or dried up river flats (local).
3. Animal transported bases due animals feeding in valley bottoms and later depositing their dung on uplands.

Desert drift Colours due to Doyne, Hartley and Watson

(Fig 8)

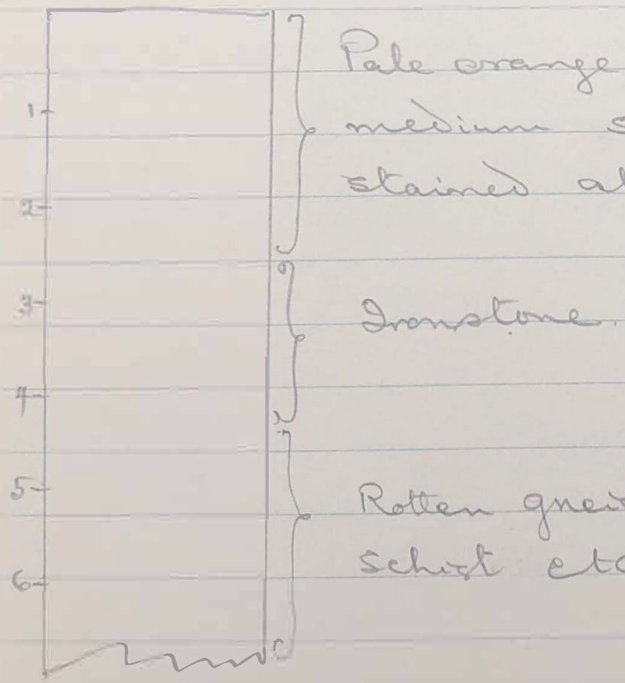


Aeolian Sands in West Africa

Fine to medium desert sands laid down over peneplanes often surfaced with ironstone.

Profile:-

(Fig 9)



(Fig 10)

These have been observed at Kano and Dakar - i.e. to the South of the Sahara. Presumably occur elsewhere in West Africa - cf. French literature.

* See page 13

Are there those sandy deposits the tropical analogues of the Temperate loess? Note that loess itself does not occur in Africa South of the Sahara - ie loamy calcerous material giving rise to black earths.

Aeolian Sands of West Africa

What happens to the finer material - clay and silt - of tropical dust? (Harmattan dust)

These soils are sands with less than 10% perhaps mainly with less than 5% clay. Little exchange complex.

In reaction they must - therefore be only slightly acid to neutral throughout the profile and presumably neutral to slightly calcerous in surface (note calcerous character of harmattan dust.)

Extent of these soils:-

Desert exists in Sahara land and stretches across the Sudan to the Atlantic. With the N.E. Trades there should, therefore, occur in a belt extending across africa south of the Sahara.

Vegetation: Acacia thicket (and other thicket) with Boababs? (N.B characteristic Boobabs of the vicinity of Dakar). Short annual grasses. Similar soils should occur north of the South African deserts.

Soils of this character should not occur in the neotropics - due to absence of deserts nor in India and Malaysia (N.W. India?)

Might occur in tropical Australia (Predominately africand).

These Desert sand soils are a lithological variant of the thicket soils.

Thicket Soils developed over red peneplane drifts in East Africa (Mainly Kingwa)

Vegetation here was thorn thicket characteristic species belonged to the Burseraceae with scattered Boababs through it.

Soils were red to the surface and seen from the air in the dry season, the landscape resembled red morocco leather with patches of grey mould

Soils at Kangwa (even red ones on acid soils even at surface? sampling? should be neutral (?) See page 25

In many areas soils developed in drifts.

Associated soils:—

Dark grey to black over lake travertine.

Red soils with $CaCO_3$ conc in subsoil on pediments and pan slopes

Grey acid sands on certain upland areas with impeded drainage.

Great game country

With thicket one has short annual grasses

What are morphological differences between thicket and Savannah Woodland soils?

Thicket soils usually devoid of ironstone i.e. ironstone is little or not at all developed in the drifts from which they here developed (But may occur in underlying drifts — desert sand areas) This suggests that the ironstone of the Savannah Woodland is a contemporaneous phenomenon?

Rain Forest Flora.

Families important:-

1. Papilionaceae (+Mimasaceae and Caesalpeniaceae)
2. Moraceae
3. Combretaceae (Terminalia)
4. Meliaceae (Mubaijonies)

Composed of numerous species none dominant — only occasional exceptions to this.

List of upland obvious Tropical Soils

1. Neutral Red Earths
2. Acid Red Earths
3. Savannah Woodland Earths (Red)
   Savannah Woodland Earths (Grey) *
4. Red calcerous pedimont soils
5. Mountain Red Earths (of Rift Region)
6. Black calcerous earths (Mont) *
7. Red limestone soils
8. Black limestone soils
9. Pale orange desert sands
10. Thicket soils ?

* Under Savannah or Thicket.

List of obvious Tropical Soils - Lowland.

1. Neutral valley soils (Meadow type) +
2. Dark grey to black Vlei soils
3. Sedge etc peat (acid) Regosol
4. ? Tree swamp peat acid *'
5. Ironstone swamps
6. Neutral sedge or grass peat swamp *2
   (* do papyrus peat swamps come in 1 or 2?)
7. Mangrove swamp soils
8. Saline inland soils — (Solonitz - Solontshak)

+ Forest and Grass

Can use Spanish - Trinidad Team for this vega soils as distinct from meadow soils (= with grass)

Quartz sand Savannah Soils - occurrence:-

× 1. Cuba - see Bennett and Alaron × (d)
2. Trinidad (d)
3. British Honduras:
   a) Coastal Pine Ridge (d)
   b) Mountain Pine Ridge (?)
4. Kenya (d)
5. Southern Province (d)
6. Gold Coast ? (d)
7. cf also Llanos of British Guiana, Venezuela, Brazil. (d?)
8. Patana soils of Ceylon ?

For East African Forms see
Milne - Provisional Soil Maps of E.A and other papers

Similarities

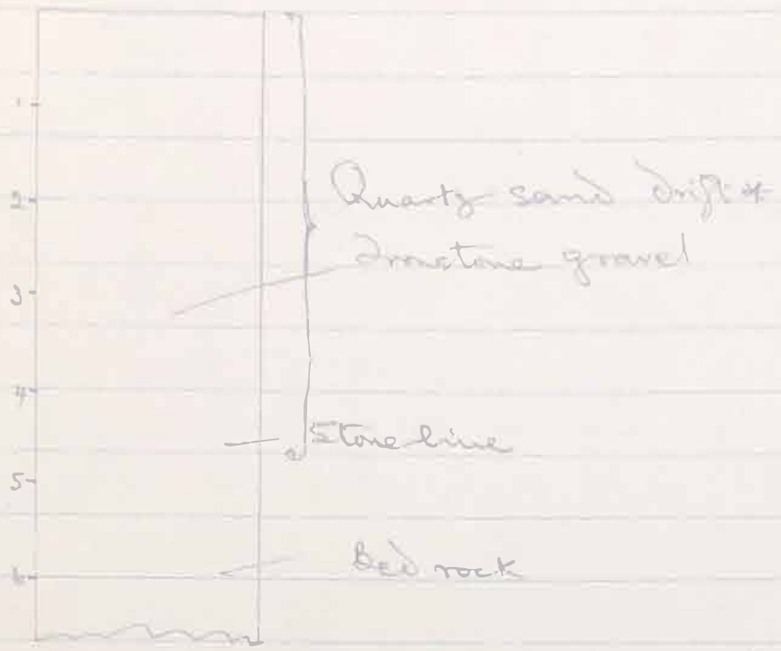
a) Nature of parent material quartz sand + ironstone gravel
b) Impeded drainage
c) Acid character - even of topsoil ?
d) Peneplane or plateau land form
e) Type of vegetation - grass or Sedgeland + scattered bush or trees.
f) Climate: pronounced wet and dry [illegible]

How many of these similarities are superficial?

Are these largely lithologically determined soils on a poor with Alitre red earths, black marilonitic clays + red and black limestone soils?

Siliceous Savannal Soils
(= Milne's Plateau Earths)

(Fig II)



* May be deposited as such or developed in situ from a clayey sand - drift includes alluvium. (Relict drifts of this nature may be incorporated in sedentary soils of later origin)

What connection have these grey acid sands with the Valeca sands of Trinidad and the soils over the white sands of B.G.?

Presumably one can have neutral and acid siliceous sand soils. Different rainfall regime may follow the formation of peneplane drifts.

Hill and Mountain Slip Earths of the Tropics.

cf: Cotton on the concave slopes hill topography of the Tropics in both "landscape" and "climatic accidents".

This type of landscape observed in

Trinidad: Miocene Marine clays and Marls:
mica schists

St. Lucia: Andesitic rocks

~~Kanda Uramdi~~ Uganda: schists

Has rainfall anything to do with this form? Obviously — say round about 80" penaplane? Also parent rock.)

Really belong to neutral and acid Forest groups.

Principles of Tropical Soil Classification

1. Must be based on the soil itself not on the soil parent material. By the soil is meant the organic and organic-mineral-surface complex which is developed as a result of the growth of vegetation at the surface of the parent material.

2. Firstly

Is the Organic and Organic mineral complex base saturated — neutral — is the humus more or less base saturated? and water-stable? or is it so unsaturated that it is easily dispersed?

A. Stable humus.
   (a) Neutral
   (b) Acid

B. Unstable humus (Readily impure water dispersed) [apparently only occurs with siliceous earths?]

Secondly

Vegetation and structure of soil layers.

See page 28 and 30

What happens with
Kaolinitic,
Illitic,
Sesquioxidic earths
when humus is of the exceeding acid dispersable type - does this occur with sesquioxidic earths - (eg. Mohr's allescivium? white mountain top soils of Hawaii?)

Climatic Vegetation Succession

1. Evergreen Forest:

Rainfall from 60-80" upwards (by evergreen is meant that few or no distinct seasonally deciduous trees occur

2. Semi-deciduous Forest:

Rainfall from 40-80" (by deciduous is meant seasonally deciduous)

3. Deciduous Forest

Rainfall From 30-50"

4. Evergreen Thicket } < 20-30" closed
5. Semi-deciduous thicket
6. Deciduous thicket
7. Open thicket < 10"
8. Savannah Woodland 30-50"

Besides amount of annual rainfall- distribution is important.

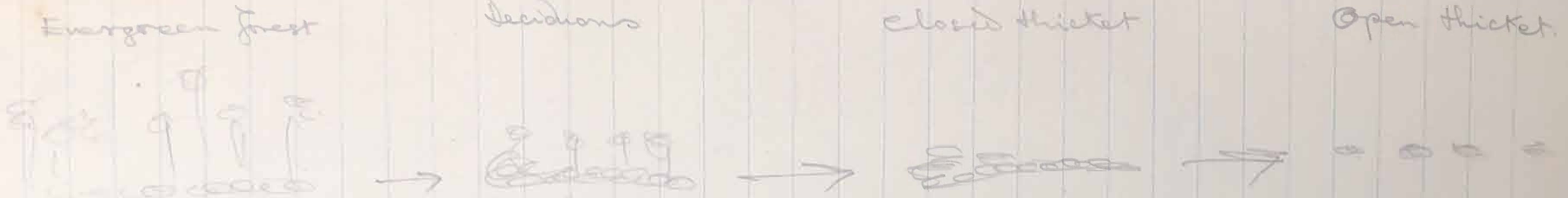
Climates: { Equatorial, Monsoon } Tropical Forest

Derived Savannah Woodland. (Savannah Woodland, Thicket.)

Tropical Climate.

1. Long dry season - of about 6 or more months
2. Single maximum rainy season.

(Fig 12)



Notice how easily Evergreen or partially evergreen forest is converted to derived savannah woodland

Succeeded by closed thicket when peneplane or edaphic condition become less favourable.

(biotic conditions + climatic and edaphic conditions)

both trees and under shrubs sparse.

The above suggests that savannah woodland is derived from deciduous forest? or semi deciduous forest.

Leaching under tropical conditions

Leaching would be effective with only short periods of rain capable of percolating through the soil. Under semi-arid tropical conditions much of the rain is in short periods of heavy fall. Such falls will wash out bases - but the soil will be dry too long to support vegetation able to return bases to the surface (scanty leaf fall of thicket vegetation).

This sort of thing is very different from the chernozem climate where brief, gentle showers occur throughout the growing season and penetrate only a short distance into the soil.

Thicket:

. A few heavy rainfalls that flush out the soil.

.. Spare leaf fall from thicket returning few bases to the soil - sparse foliage also accounts for red colour to the surface and lack of fires.

Result: Acid soil.

N.B. Thicket soils at Kongwa and Southern Province were acid.

Rainfall for thicket country and Steppe + short-grass plains want confirming.

No harmattan dust on the soils in East Africa.

N.B. Meinzer's Pheatophytes that top ground-water below the 'dead' zone get their roots down during periods of exceptional rain.

Effect of sparse leaf fall + occasional leaching rain when parent material is already well leached as a result of a former wet rainfall.

How do these compare with Terra Rossas of Mediterranean Zones? and chaparral soils of Pacific States.

In thicket regions is game actually typical of the actual thickets? or of the valley soils? What game besides rhinoceros can get through thicket? except small antelope etc. which can graze beneath thicket? Upland Game mainly typical of Woodland Savannah?

1. Acid forest Earths
2. Neutral forest Earths
3. Neutral Savannah Woodland Earths
4. Acid thicket earths?
5. Desert earths (presumably unleached)

All of the above typically quartzose Kaolinitic clays (normal bedrock granite or granite derivatives)

A. Sesquioxidic earths (allites and ferrallates)
B. Quartzose earths
C. Montmorillonitic earths
D. Limestone earths

largely lithologically determined variants

(Continued on next page)

Three main types in this respect similar to Podzols - Brown Earths
- Chernozems of temperate zone
This does not equate thickest soils with chernozems.

When considering Tropical soils it is necessary to remember that

a) Closed Forest
b) Savannah Woodland and
c) Thorn thicket

are the three main upland vegetation forms and that if soil characteristics are mainly determined by vegetation — major soil groups will be associated with these vegetation forms.

These facts do not appear to have been given due consideration before.

Literature to look up.

Milne
Trapnell
French Sudan Authors
Belgian Congo Authors
Morrison, Hope-Simpson and Hoyle.
(Also ecological Authors.

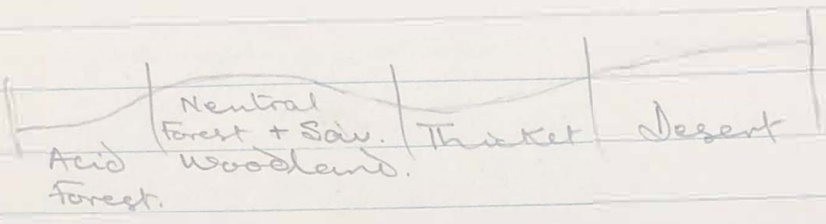
Correct evaluation of Savannah Woodland Environment.

N.B. Cotton has nothing to say about Savannah landscape being a fossil form. He assumes it to be a form undergoing development at the present time under the control of the prevailing climate.

Hence the ironstone content of Savannah Woodland drifts should be related to present day processes and is not fossil material (except of course where ironstone mesas occur.)

1. Acid forest soils + acid swamp Peats.
2. Neutral forest soils + neutral Vega soils.
3. Neutral Savannah Woodland Soils + neutral (to calceous) tropical meadow soils.
4. Mildly Acid thicket soils + calceous Vlei soils.

(Fig 13)



Types of Parent Material as characteristic of certain climatic soil zones

1. Forest regions

Parent Material formed in situ as a result of deep chemical weathering + river alluvium

2. Savannah Woodland and Thicket Regions.

Except on inselbergs - weathering of these climatic regions produces drifts of some sort.

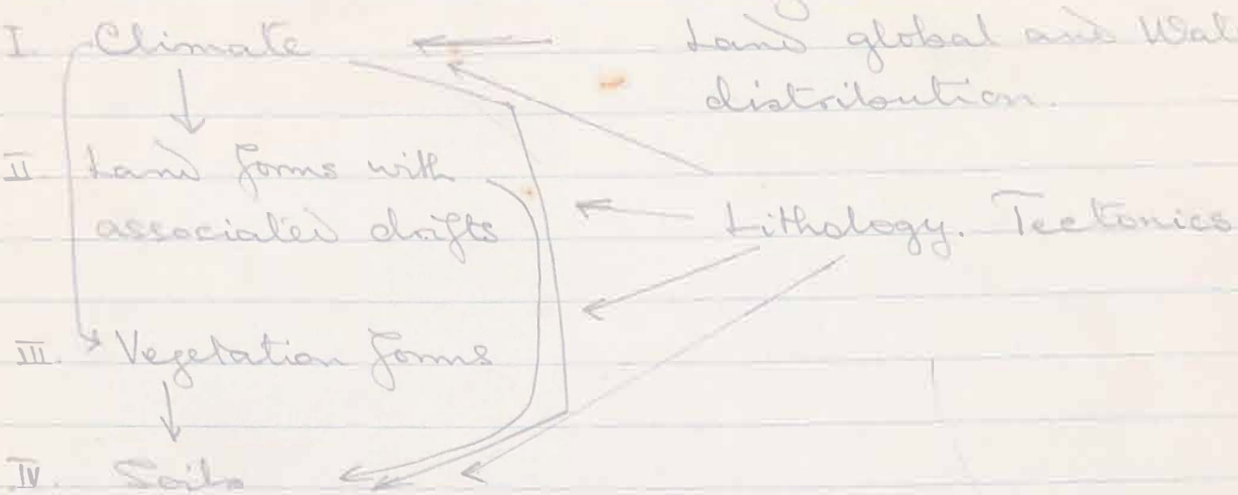
(a) Peneplane drifts

(b) River alluvium.

Catton makes this clear with his diagrams illustrating characteristic land forms of arid, semi-arid, savannah and humid regions. (semi humid) in climatic accidents

N.B This is a most important principle.

Soil Forming factors



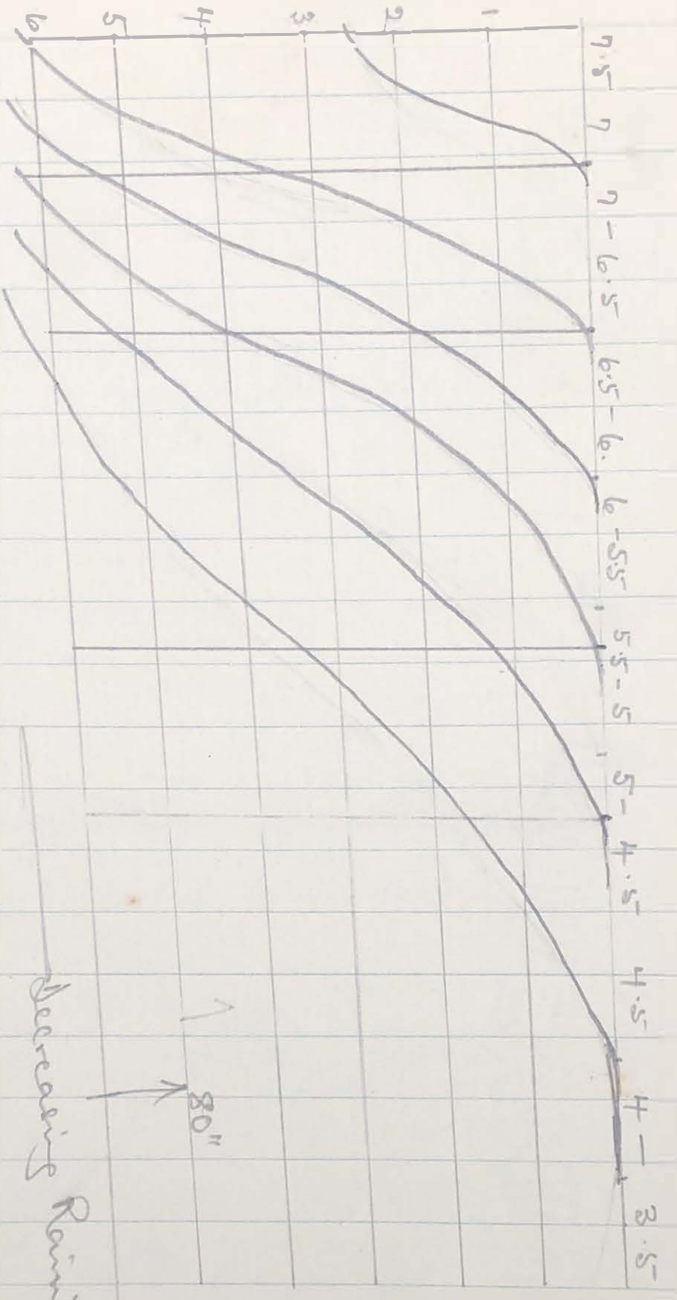
Lithological and geological variants superimposed on this scheme.

Assume the continental rock granite with its derivatives:- Schists, Gneisses, Sandstones, Kaolinitic clays (see Woolbridge and Morgan).

- 1st. Determination of the limits of Tropics.
- 2nd. Careful listing of all the relevant literature - including careful search for papers with possible information.

10 Oct

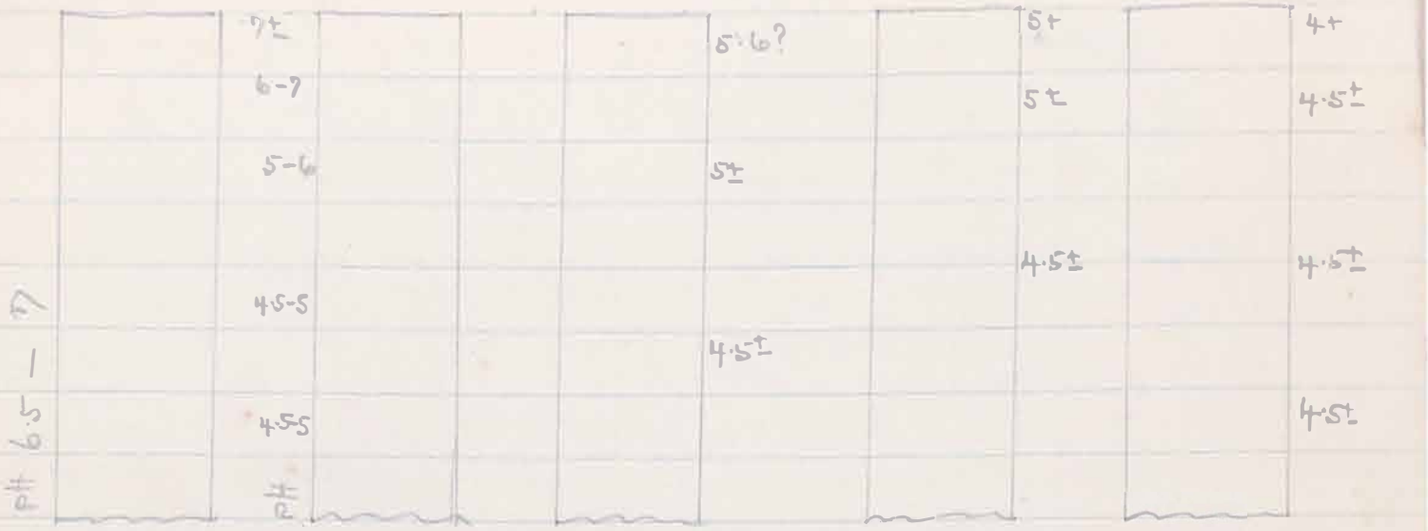
(Fig 14)



Antigua
Trinidad
Jamaica
Grenada
B. G.
Tobago
E. Africa
Nigeria
Gold Coast
Malaya
Ceylon
Australia?
Mauritius
Congo
Sierra Leone?
Sudan
Hawaii
Cuba
Puerto Rico
South Africa
India

High pH's in some Gold Coast forest top soils due to accidental shells - snail shells - Column cones and Millipede skeletons.

(Fig 15)



Sub soil looses bases and becomes acid more quickly than topsoil which eventually thus becomes more acid than below.

1. Black or brown weathering sediments
2. Black or brown weathering crystalline rocks.
3. Quartzose sands or Sandstones.
4. (Ultra basic rocks weathering to aluminous earths.)

Lithological Variants in Tropics
(Under free Drainage).

1. Black weathering limestones } Sediments
2. " " Shales
3. " " Tuffs
4. Black weathering igneous rocks
dioritos, hornblende schists etc.
5. Quartzose sands or Sandstones.
6. (Mottled clays?)

Occurrences of lithological variants under poor to no Drainage - sediments of course.

Rainfalls from 15" upwards.

Absences of Pedocals or very small areas of.
(absence of loess - calc. glacial till)

Importance of varieties of red loams

Question of Desert Soils. (C.C. Nikiforoff etc)
Where described?

Thoroughly well-developed red loams and earths.
= Sugarcane
Oil palm
Rubber
Robusta Coffee - Composition of Coffee beans
Pine-apples
Sisal

Soils of Tropics.

1. Predominant soils Red loams over Crystalline and Sedimentary rocks with yellow-brown loams where relief provides less perfect drainage — Relatively small areas of black to brown earths where lime-rich rocks (etc) occur — and pale yellow earths where sands and sandstones occur; also aluminous earths where basic and ultra basic rocks occur.

2. Considerable variation amongst sediments of poor drainage covering relatively small areas.

3. Great agricultural significance of well-drained lithological variants and of sediments with poor drainage — Agricultural development predominantly on certain of these and not on red loams and earths!

Sedimentary Soils

Jamaica
Barbados
Puerto Rico
Central America
Trinidad
Antigua
Cuba
Guadeloupe-Martinique
B. Guiana
Ceylon?
Java -
Sumatra
India?

Igneous Rocks

Recent ashes and Tuffs

St Kitts
Java
Central America
Cameroons
Rift Valley and
East Africa

Shallow juvenile volcanic rocks 'solid'

Relative Importance of various kinds of Tropical Earths. (Under Good drainage).

Red Earths occur over all but

1. Very siliceous rocks (i.e. sands) Sandstones and Quartzites.
2. Siliceous limestones and marls
3. Certain high lime rocks giving rise to montmorillonitic clay.
4. (Soils with imperfect drainage (and/or aeration) - brown and yellow earths rather than red)

('Sedentary' Black Earths
alluvial Black Earths.)

'Alluvial' soils of poor drainage.

1. Grey sands, loams and clays
   Grey sub-hydric.
2. A. Grey and brown mottled sands, loams and clays Gley
   B. Grey and red mottled sands loams and clays
3. A. Grey ironstone soils
   Groundwater laterite
   B. Groundwater Podsol
   Grey sand and transported humus as well as iron

} Alluvial Acid

4. Grey saline loams and clays.
5. Grey to brown loams and clays (calc) often Plano salic)
6. Grey to Black clays (calc)

} Alluvial Alkaline

Add also - neutral to Alkaline Peats
Acid Peats.

Calcification in Tropics.

1. Regions where rainfal is too high (i.e > 80inches?)
2. Regions where bases accumulate in ex form (30-80" ?)
3. Regions where sporadic intense rainfalls are sufficient to support only xerophytic small-leafed shrubs - bases lost (10-30?) (These earths could have no "ironstone")
4. [Regions where rainfall is insufficient for effective leaching and N.T. calcification takes place ? (> 10-15" ?)]

Effects of degradation due to interference with the vegetation.

1. ? little change?
2. development of acidity - due loss of humus and bases.
3. ? little change?
4. ? little change

Importance of lowland associates of red upland soils.

1. - Podzols - Peats ?
2. - 'Forest' meadow soils (mottled soils etc)
3. - Black calcerous earths.

Value of Gold Coast Soils.

Very Good	perhaps 1 or 2 %	
Good	10	10
Fair	30	33
Poor	30	33
Very Poor	20	20
	90	98

Principles - for direction of policy and research

Techniques - day to day work

Agrology ? (Pedology)
Agronomy - Agronomists
Agriculture - Agriculturalists (Farmers)

Experimental field work
- not broader principles -
- practically techniques -

Question of Agricultural Institutes
1. Millet - Sorghum - Groundnut Zone
2. Middle Zone
3. Forest Zone.

Crop Botany

1. Botany	Physical Geography
2. Zoology	Plant Ecology
3. Chemistry	Soils.
4 Physics	

Agricultural Systems

1. ? Agriculture x
2. ~~Land~~ rotation x
3. Exploiting organic accu—lations o
4. (Volcanic Ash – farming) } o
5. Exploiting – rich rocks or sediments }
6. Manuring – Organic } x
   Mineral }
7. Mixed husbandry – without importation of fresh foods. //
8. Chinese method. //

NB 0. Shifting Cultivation
= A form of gathering as does 3 and 5

(Fig 16)

Query ?

Is there a grain culture say on the thicket edge of the Savannah Woodland and the Savannah Woodlands edge of the thicket ?

1. Removal of competitors (weeds)
2. Maintenance of fertility

{ Exploitation Agric.
{ Conservation Agric.

Lesser importance of Annual animals have to feed on plants.

Looked at dispassionately the
Savannah Woodland (and thicket) areas
are stocklands (of Tryps. and rinderpest
are got rid of)
of great herds of wild game
of native cattle of grass cover

Cereals	Association of
Pulses	Auctisations with
Roots and Tubers	grain
Fruits	
(Nuts)	Sorghums
Leaf crops	
Accessory	
food subsistence	

Rice Cultures — Lowland Tropics
Tropics China, India, Burma, Indonesia, Siam
Indo china (Malaya?)
(Japan)

Cereals of to roots
1. Greater yield of dry matter per acre
2. Greater keeping power
3. Higher protein
4. Higher minerals
5. Transport.

Wheat 25 - 30 cwt per acre.
20 cwt @ 10% dry matter = 2 cwt
10 tons = 1 ton dry matter

Type of Carbohydrate too more starch less cellulose.
of also pulses in this way.

Cereal climate: low gentle rainfall
Cereal Soils: deep friable calcerous soils
Loess:
Rice:
(Very little below this in the tropics)

Principles of Agriculture

1. General - type of crop, type of agriculture
2. Water supply } Soils
3. Nutrient Supply }
4. Tillage and weed control }
5. Land form etc }
6. Pest and disease control
7. Breeding

Basic Information

1. Climate
2. Land forms
3. Vegetation
4. Soils
5. Present Use
6. Crops
   (a) Morphological characteristics etc
   (b) Climatic requirements
   (c) Soil requirements
7. Agricultural Systems

Maize in Tropics

Mostly a cereal of forest country cannot stand drought in early growing period - growth must be un-interrupted.

2 crops a year in 2 rainfal peak climates M.A.M.J.J.A // S.O.N.D.J.F //
low mineral content - high fat content (oil seed)
(Types grown?) (High yields poor keeping qualities)
What is the climate of the U.S. Grain belt?
? Prairie soils?

West Indies
Central America
South West Africa
Malaya
Ceylon
Java - Indonesia

Forest Regions
Savannah Woodland - No
? - Cereals, Cattle and Pulses

Limiting factors

(a) Climate
(b) Soil depth
(c) Topography
(d) Fertility - (a) Presence or absence of nutrients
(b) Presence or absence of harmful substance.

Grain Producing Areas Tropics

(a) Tropical climate
3-5 months growth
(roots etc mainly in Forest)

(b) Savannah Woodland and Thicket Areas.
Sorghums - Pennisetum
(guinea corn) (millet)
Low ratio grain to straw?
Very open crops - insufficiently dense.

1. Area with climate suitable for cultivated crops (lower limits only)
2. Area with soil depth suitable for cultivated crops (lower limits only)
3. Area topographically suitable for cultivated crops (soil and water conservation to be considered here)

3 consequetive months = minimum
= say 12" + growth water
say 12" + 3" = 15"

4 consequetive months - say 16" + 4" = 20"

Question of uncertainty of rain at lower limits 6 @ 0 2 @ 2 = 4 24"
5 @ 0 3 @ 2 = 6 26"

This is determinable

Question of subsoil moisture }
and run off water }

Cultivated Crops.

1. Crop Morphology
   including root systems (depth + working depth)
2. Growing period
3. Climatic requirements:- (a) Length (b) Rainfall distribution requirements.
4. Soil requirements: (a) Nutrients } (b) Cultural }
5. 'Landscape' requirements for Landform economic production.

Areas dependent upon overhead properties.
Areas " " subsoil moisture
Areas " " run off moisture
(irrigable areas)

General Principles -

(types of crop-storage etc)

1. Principles of water supply.
2. " " Weed control.
3. " " Nutrition
4. " " Tillage
5. " " Disease and pest control
6. " " Breeding
7. " " Land layout

Title Page Proof

A. MORPHOLOGY OF TROPICAL SOILS

(1952)

C. F. Charter.

3 copies

Capitals

I The Soil Series.

The Soil Series comprises soils with similar profiles developed over similar parent materials and usually with similar relief and similar conditions of drainage that under natural conditions support similar vegetation.

Divided into subseries on basis of variations in the inherent characteristics:

(a) texture of parent material } Question on
(b) relief } depth rooting medium?

- Texture of soil material – unalterable
- Relief – do
- General soil profile structure – do. (humic horizons alterable)

Alterable – Structure of top soil (2)
Drainage (3)
Vegetation covered (1)
Chemical nature of topsoil.

Soil Series / Normal subseries = the most extensive.
Subseries : American type / or phase
Phase : American phase in restricted sense.

Variant – A variation that occurs e.g either of a subseries or phase, character but insufficiently extensive to be mapped on any scale.

Subdivisions of series must be agriculturally significant.

Subseries: ① Must be mappable – at least by detailed surveys – e.g must cover a significant area.

② Differences from normal subseries must be definable

③ And based on inherent characters only.

Variants. ① Need not be mappable – recorded in individual soil pits.

② Differences due to inherent characters only e.g presence of stones etc – or transported zones

③ definable differences.

Soil Series:

Aim. General Form of Profile
. Relief – or Topo site
. Nature of soil material
. Depth of rooting medium

Soil Phases: Must be mappable on large scale surveys at least.

1. More or less ephemeral changes in soils produced. Mainly as a result of biotic, chiefly man's activities. If such activities ceased soil would return to its natural condition
   (a) Nature of vegetation.
   (b) Structure of topsoil – including erosion
   (c) Chemical character of topsoil (Reaction etc)
   (d) Drainage of upper horizons – at least.

NB If ~~eroded~~ eroded to subsoil – Soil sub-series.—

The Morphology of the Soil Profile.

This wants careful going into – especially subsoil.

Top soil 1 } Absence of cones and gravel, presence of
Top soil 2 } O.M., lighter texture than layer below.

Affected by creep or surface drift

Sub soil 1 No visible O.M. Rounded dark cones and quartz gravel.

?

Sub soil 2. As above, but unaffected by creep or drift.

Sub soil 3 ? earth without cones or gravel.

W.SS. Shows cheshire Cat's grin.

Soil Series.

1. Restricted colour range.
2. Restricted texture range. – sand, loam, clay
3. Restricted reaction range. —
   a) Very acid to acid 4.0 - 5.0
   b) Acid to slightly acid 5.0 - 6.5
   c) Slightly acid to slightly alkaline 6.5 - 7.5
   d) Slightly alkaline to alkaline 7.5 - 9.0
   e) Alkaline to Very alkaline > 9.0
4. Restricted drainage range.
5. Restricted relief range.
6. Restricted vegetation range.
7. Restricted parent material range.

Series Diff.

1. Same Profile type
2. Same colour.
3. Same parent material
4. Same relief
5. Same drainage
6. Same vegetation
7. Same texture.
8. Same reaction
9. Same Calc. Concs.
10. Same content of soluble salts
11. Same Fe Concs
12. Same MnO_2 Concs.
13. Same

1 2 3 4 5 6 7 8 ? × 9 × 10.

Subseries - part of the range (restricted) allowed in series.

Sandy Jaw Wulu?

Upper slope and bottom — Sege's

Is depth to bedrock different?

~~Colour & Texture of Ofin and Densu~~

Jaw Wulu Topsoil - colour & texture - cf. Ofin + Densu

Sege subsoil
+
Parent material

1. Ease of Surveying — Main rooting zone
   — Establishment zone
2. Crop growth — May be affected spectacularly by subsoil conditions.

Series and ~~Mp~~ Types

Jaw Wulu - Sandy clay subseries

Sandy subsoil variant
or Sandy sub~~soil~~ series.

Sedentary Soils

Pierce Type?

Drifts

	TS	Soil Series based on SS. and WSS.	Recent alluvium – Peneplane.
	SS		
	WSS	Sub Series based on topsoils	Soil Series based on TS. Sub-series based on subsoils.

Or is topsoil - typical - when combined with relief, drainage, texture colour and vegetation?

Sege.

Sege (II)? (Zenu?)

Sege I

Basis of Sege classifications.

Prampram

AKuse ?

Tano Wulu?

Shallow on steep slopes
Deep in flats and depressions?

II Soil Classification. Capitals

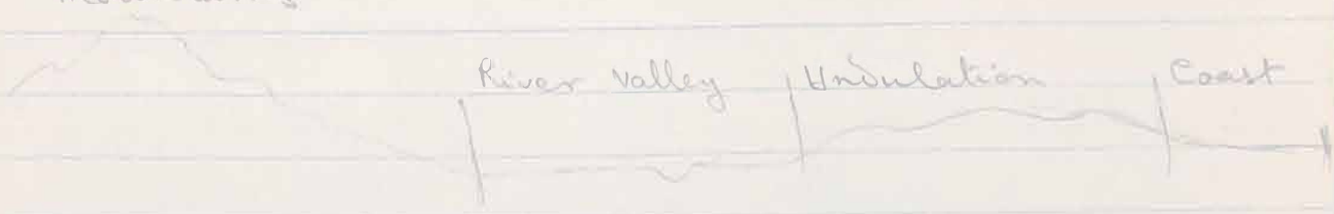
Soils are 3dimensional objects - (see Milne on this)
Hence Geomorphology comes in - especially drainage regime
N.B. Richards suggestion that vegetation of the tropics is normal and temperate zones abnormal and not the other way round.
N.B. Goldsmidth and - Laterization in Norway also Polynov?

Soils are integral parts of landscape (Relief & drainage)

1. Geomorphology
2. Climate
3. Lithology
4. Vegetation

Mapping Soils -
Mapping landscape units. (Age?)

Glacial - Volcanic - Aridity? Humid - Weathering.



Groups of minor land forms.

e.g.! Upland – Valley – Lowland – Coast

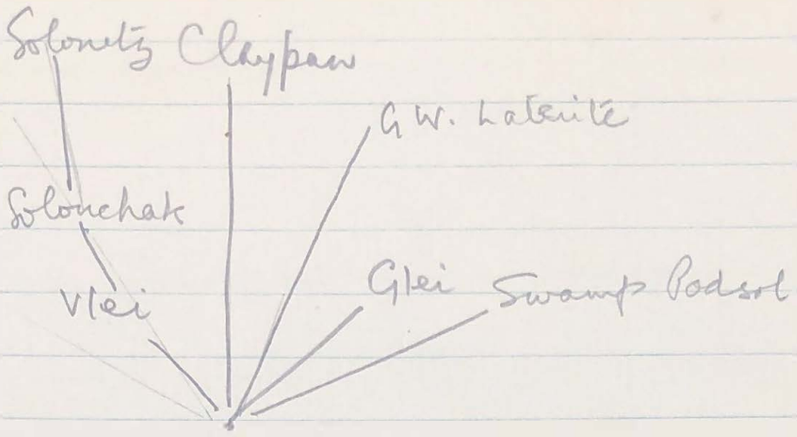
Temperate

Sub Tropical

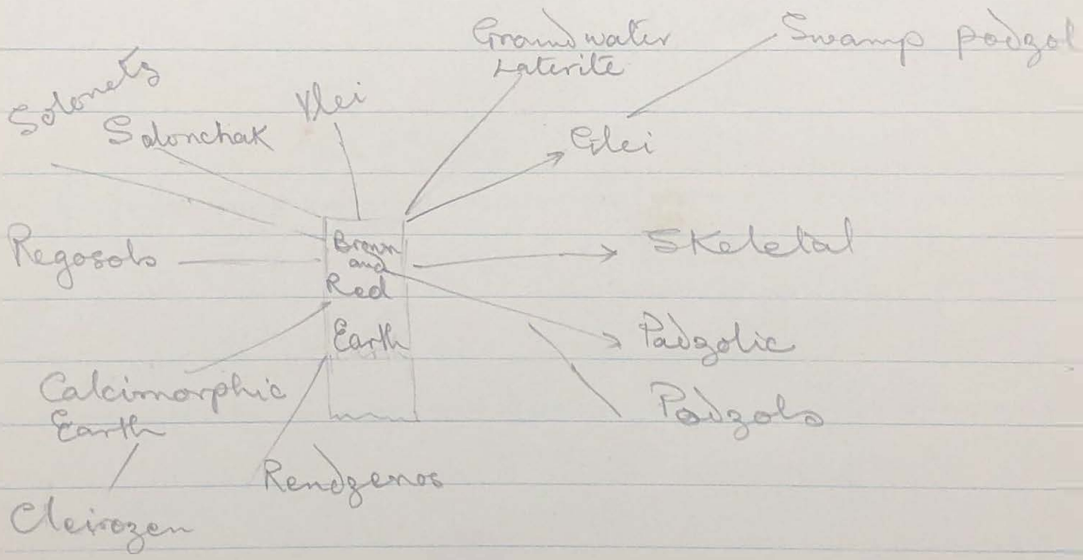
Tropical

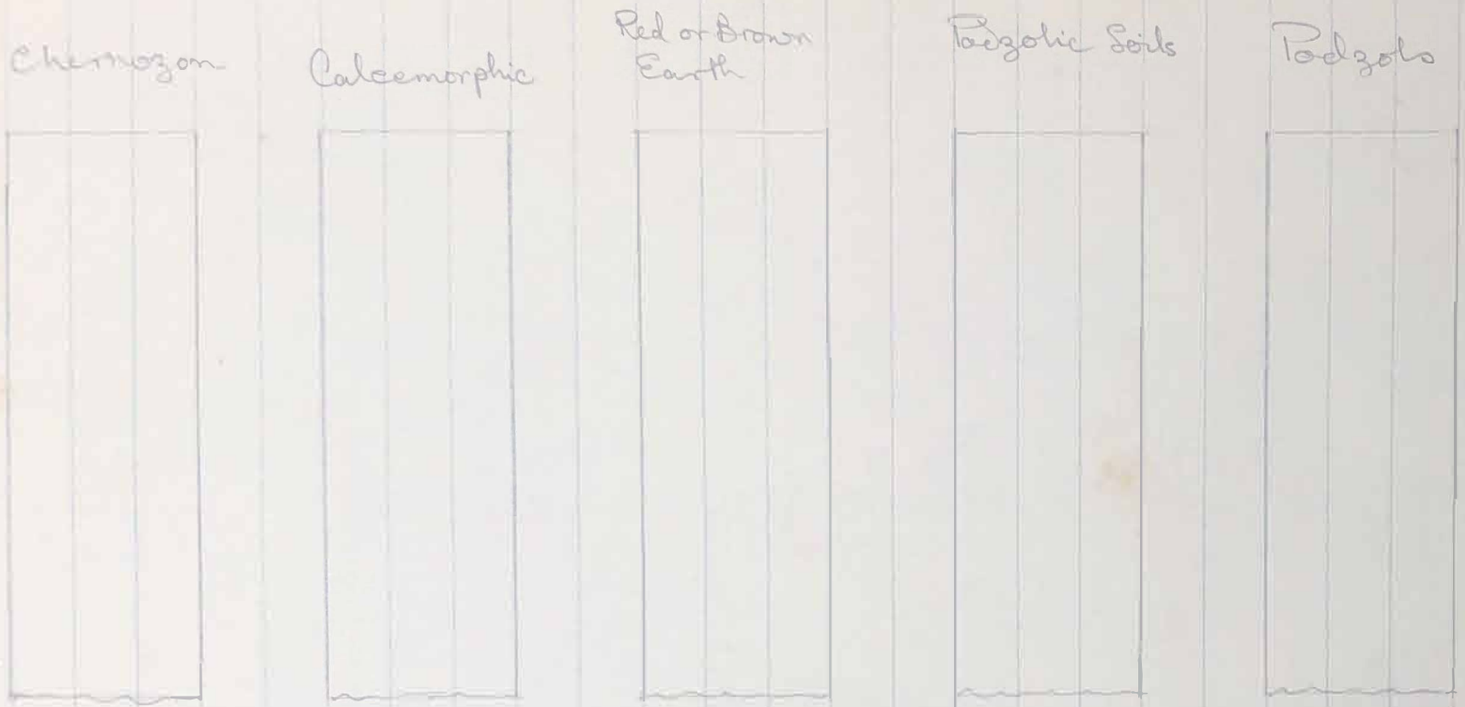
Similar

Similar



Red Earths as the Modal Soils.




Chernozom
Calcemorphic
Red or Brown Earth
Podzolic Soils
Podzolo

Capitals

Pedogenesis.

Surface agencies affecting soil formation (Profile form etc

Natural Erosive Agencies

(a) Creep.
(b) Slope solifluction + lateral eluviation (Slope wash)
(c) Sheet flow.
(d) Slip.

Vegetative Agencies (Biotic)

(a) Effect on morphology of topsoil.
(b) Effect on soil status

Catalèn

Great Soil Groups.

1. Red, brown to yellow earths developed from underlying rock and occuring on moderate steep to gently undulating territory (would include Terra Rossas)
2. Rendzinas (Black or grey residual clays).
3. Red-brown - pale yellow earths of pedeplanes (mottled Peneplane drifts).
4. Black Pedeplane clays.
5. Skeletal or Brash Earths.
6. Alluvial drifts (contemporary).
7. Aeolian Drifts ? (Dune soils)
8. Volcanic Ash deposits.

III Geomorphology: Landscapes and Soils. Capitals

~~Geomorphology and Soils - landscapes and Soils~~

(1) Each land form has its destructive mantle of unconsolidated material - either of transported or of residual origin.

(2) These mantles associated with different land forms have each a characteristic morphology.

(3) This destructive morphology may directly affect plant growth.

(4) Since landscapes are largely determined by climate - the distribution of the mantles (and soils developed on them) are largely climatically determined.

Mantles of well-dissected landscapes - sedentary + creep.

1. Topsoil over solid rock — TS/UR
2. Topsoil over brash — TS/brash/UR
3. Topsoil over partially-weathered rock — TS/WSS.
4. Topsoil/sub soil/weathered substration { shallow to very deep — TS/SS/WSS.

Although we have 1, 2 & 3 over granitic rocks in the forest region we should also get them over others.

Rock Types and Peneplanation

1. Basic igneous (e.g Basalt and Granite lava flows)
   - stepped topography and micas.
2. Granites - Domes of exfoliation and Inselbergs 'tors'
3. Sandstone
   Clay shale
4. Unconsolidated

Tropical Soils on a Geomorphological Basis. Cafilals

1. Hilly and Mountainous country
   - Residual upland soils — Non calc. rocks and
   - Transported valley soils — Calc. rocks.

2. Alluvial and Coastal Plains

3. Coastal Soils.
   (Strand, Dune, Lagoons
   Deltas, Mangroove Swamps etc.)

4. Peneplane Soils
   a) "Red" loams to clays b) Mottled clays
   c) Quartzose sands
   d) Montmorillonitic clays
   e) Aluminous

5. Volcanic Soils (recent-ash, pumice deposits).

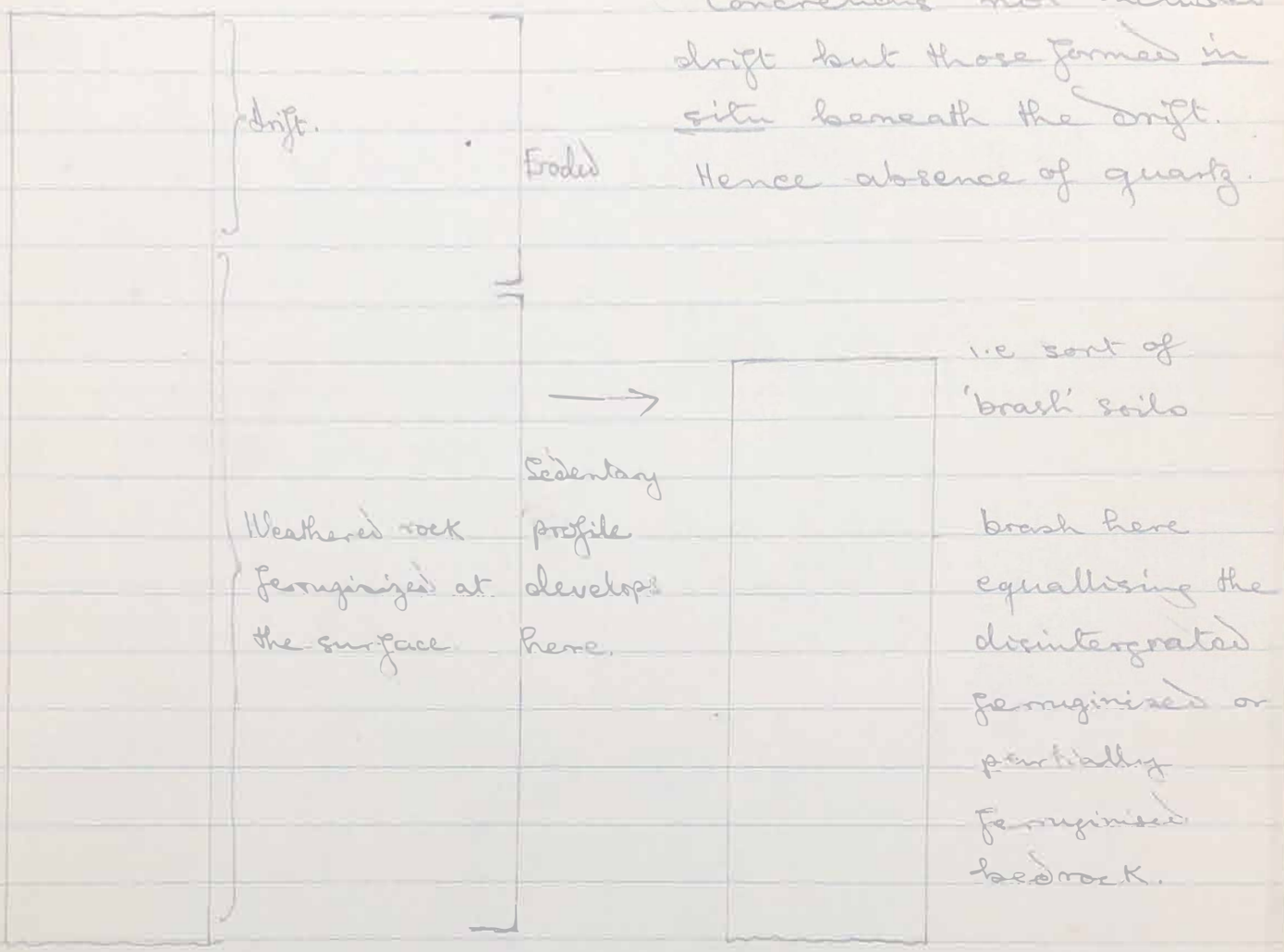
6. Karst Country
   - White sands of B.G.?
   - Coastal pearls?
     B.G, Malaya and Java

Missing ones.

1. Real desert soils — Sand & rock.
2. Interior Saline Soils
3. Mountainous Tundra Soils.

Answers to Hotson's Queries – (Also answers questions of development of cores in situ)

Concretions not included drift but those formed in situ beneath the drift. Hence absence of quartz.



This may provide the key to the typing of 'drift' soils to their parent rocks.

What about old Termitaria of forest?
Formed under peneplane conditions and
sank into their present positions?

N.B Gravel zone peices beneath them

Every termitaria in valleys - moved downhills?

Previous peneplane - covered with (cone) red drifts
these stripped.
Termite earths built up over weathered rock plain.

Objection etc.

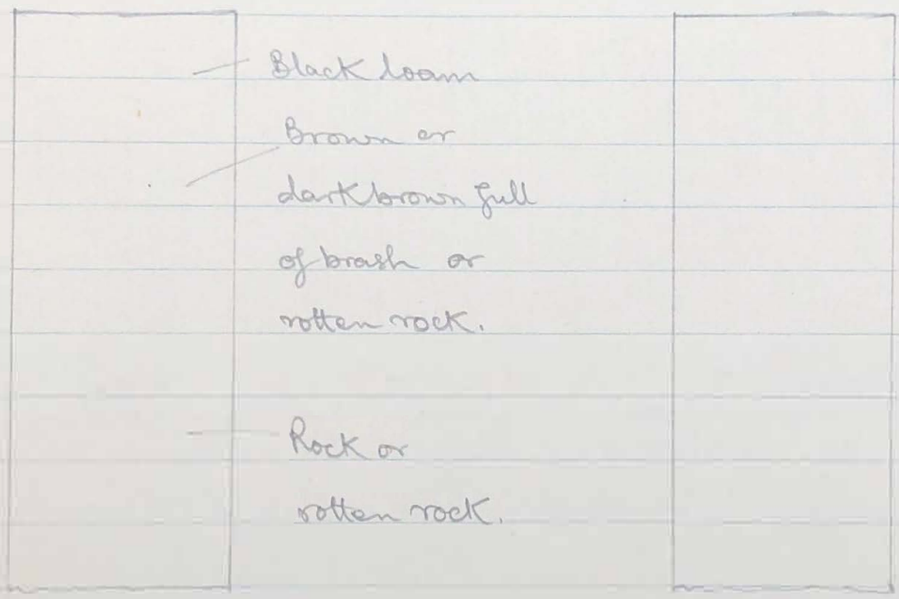
1. Idea not previously advanced - but compare Haracin and Alta cephalates in Brazil - quoted by Glinka.
2. Working depths of Termites.
3. Necessary to check the widespread occurrence of of a stoneline in such soils as

Agatawo	Fehe	Sege
Simpa	Agbosome	Tam Wulu
Kenya	Joyem	
Koni		

4. What about other areas? Eg Transvaal, Deccan etc?

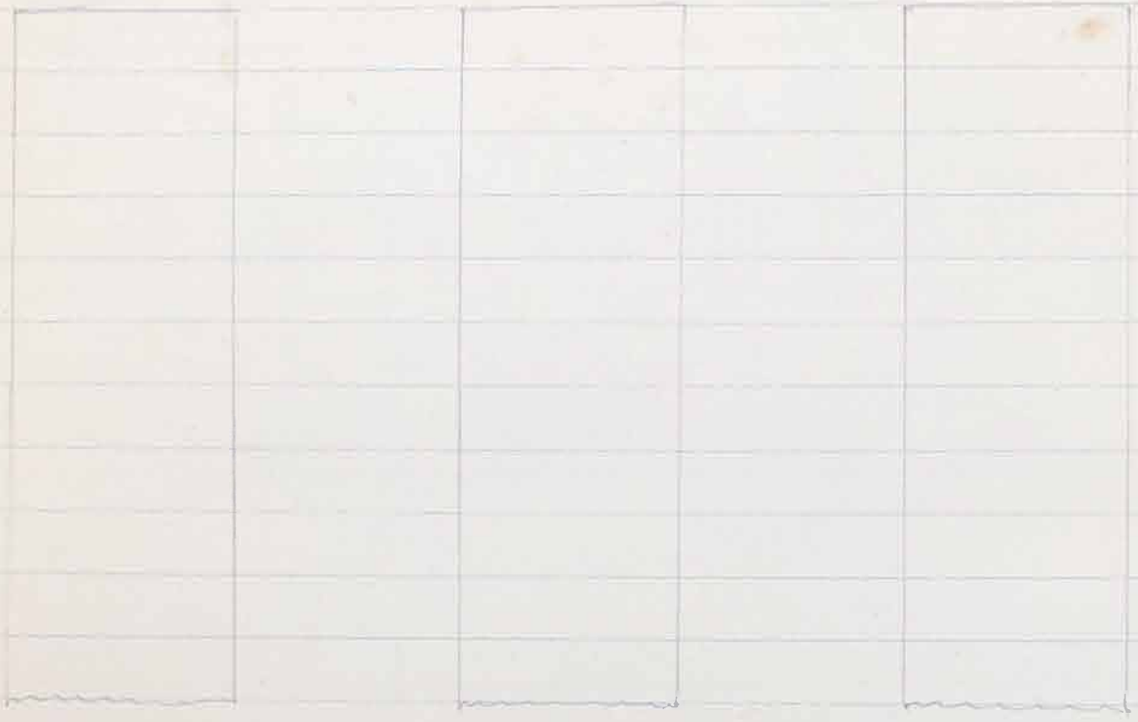
What would one expect?

Akuse Series
This is a typical
'alluvial type of profile.

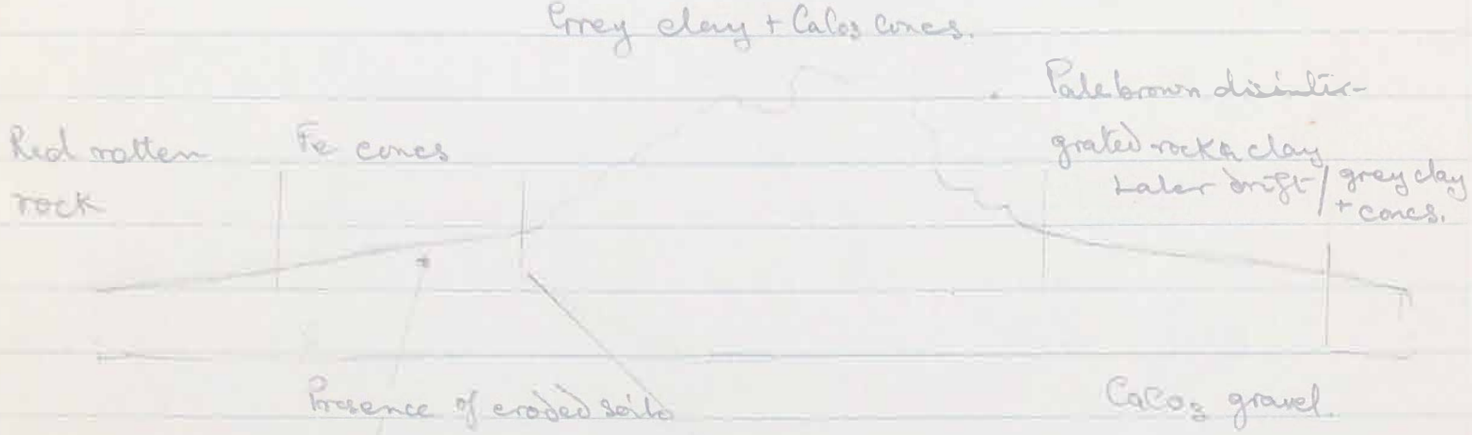


i.e low level Kloyo

TACHEM - BUMBI - AKUSE



Low level Kloyo + gravel sand.



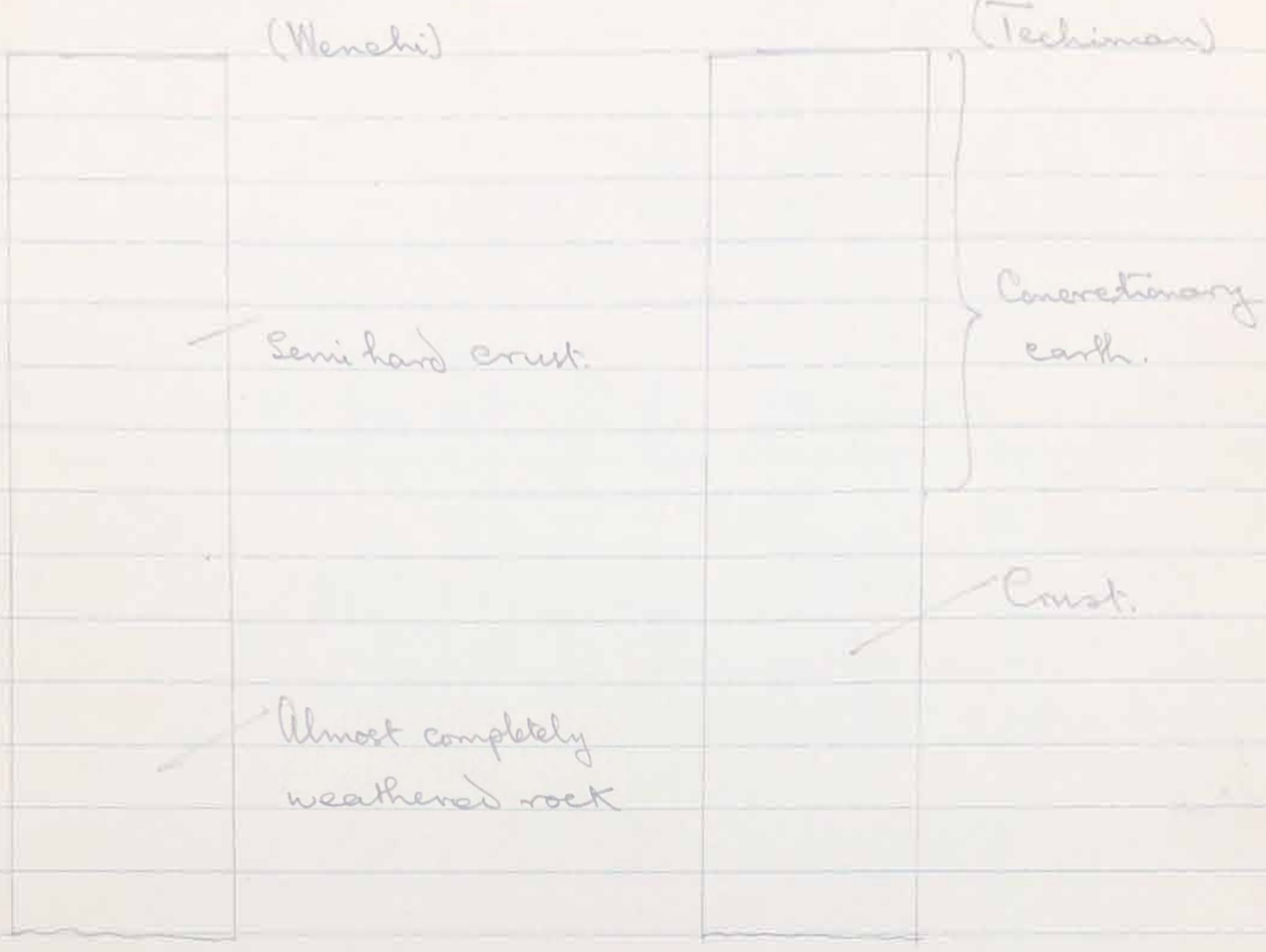
1. Shai hills.
2. Krobo
3. Tween Rocks?
4. Osudoku?

One can only imagine a deeper drift once covered the area and that this has been eroded exposing the calcerous zone

Residual soil here one would expect to be low level Kloyo

Subdrift.

— Crust Soils —

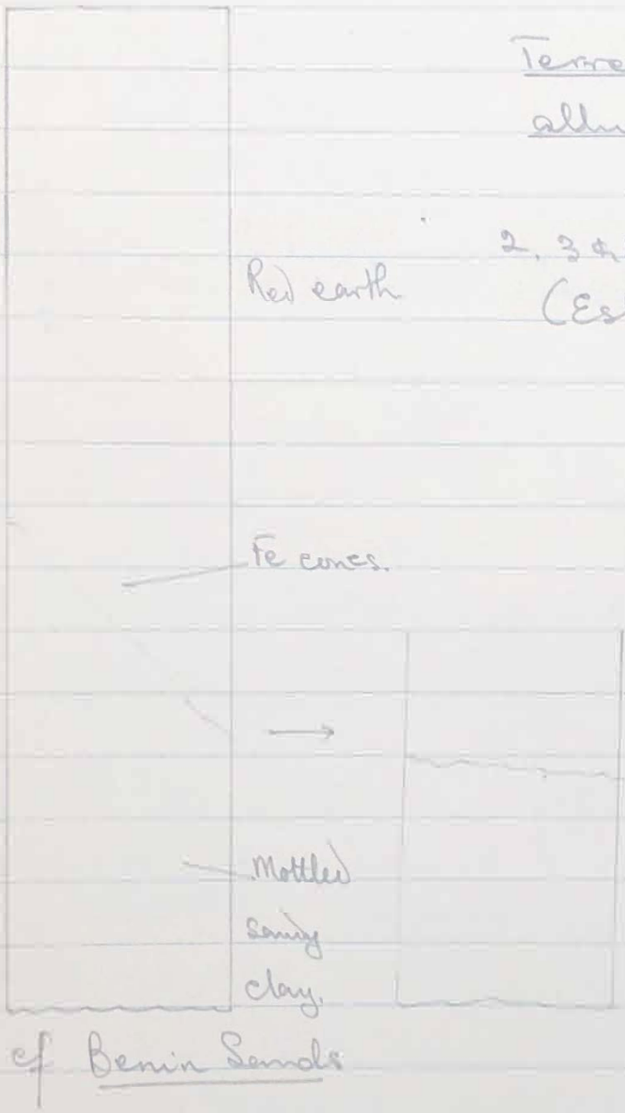


Crust Soils:

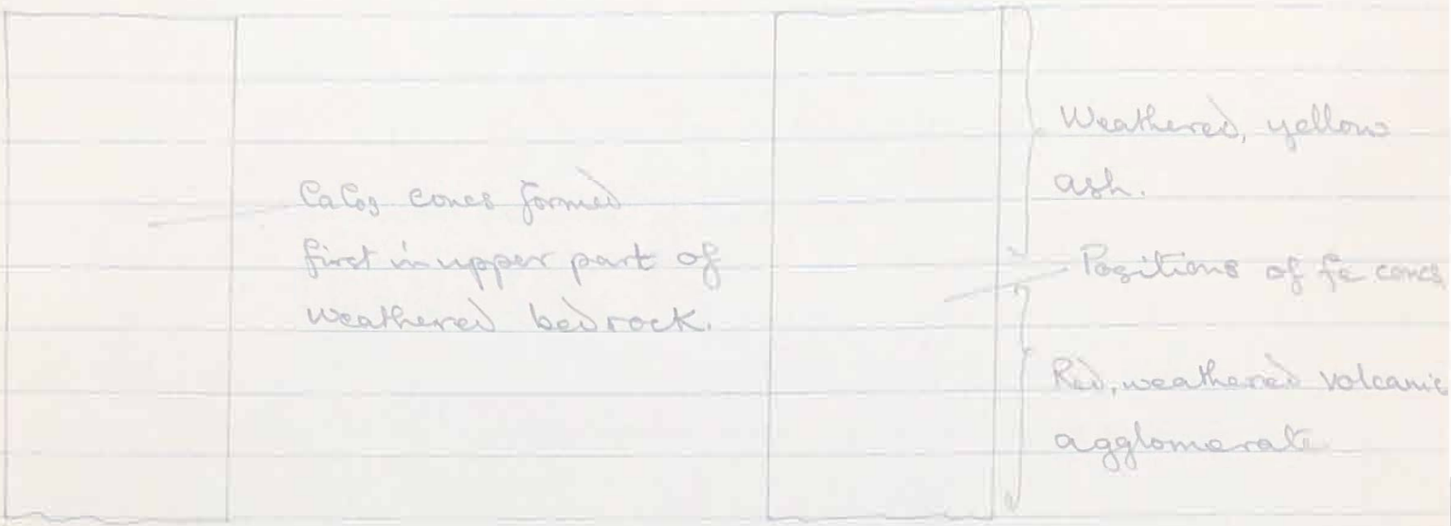
Wenchi - Techiman — Over massive ironstone {Gravelly over massive Ls.
Konongo — boulderey ironstone
Domenasi — gravelly ironstone
Swedru, Kumasi, Betwiaeta. — Fully developed profile

Need for information on Soils as distinct from crust soils!

1. Ashimata Fuelwood Reserve
2. Borkem - Red tertiary Sands.
3. Southern Nigeria.
4. Gambia.



Red Hillslope soils at Kongore Mountain of $CaCO_3$.



East Africa.

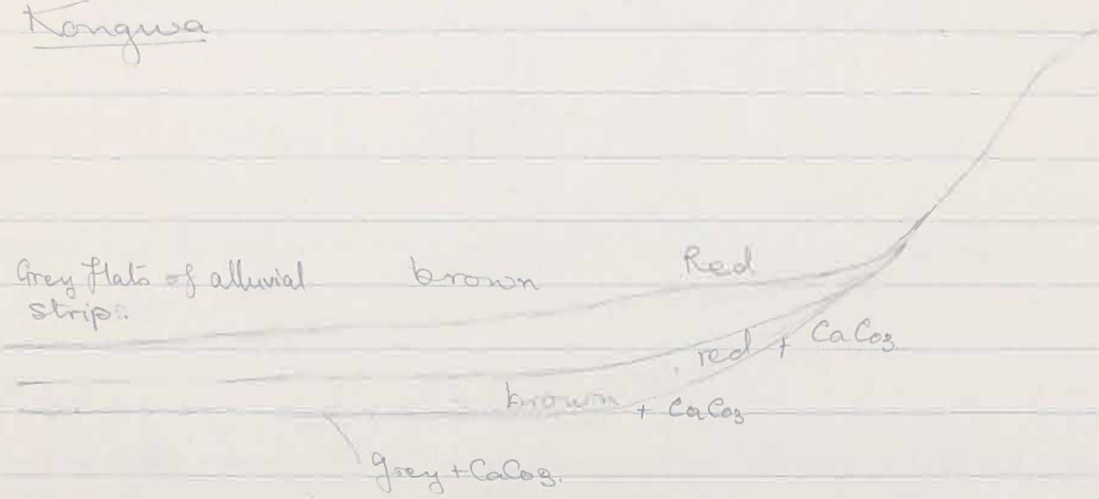
1st — Emphasis on development of concs, horizon in upper part of weathered bedrock.

Certain soils different e.g. horizontally bedded sand and silt and clay shales.

Important note ie - types of parent material.

Soils developed in parent material consisting of weathered bed rock previously overlain by drift. cf Osonko Series

Kongwa



Yenguva or Shai type of material.

Loam or light clay
+ much garnet sand

Non Calcerous.

← $CaCO_3$ concs here second / in some places Fe concs.

← $CaCO_3$ concs here first.

Were not sedentary earths consisting of grey clay + $CaCO_3$ concs found on upper part of peiment by side of road passing through Shai hills? (in gullies roadside ditch?)

Calcerous sub drift soils.

Profile in Achimota Firewood Plantation.

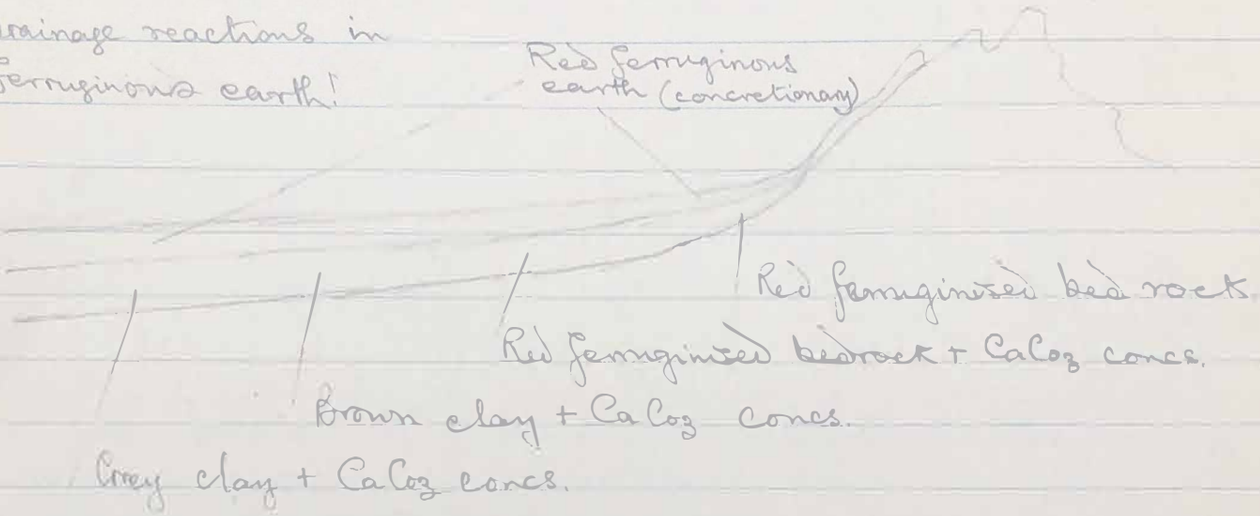
cf also soil near Ho with concretions over calcerous rotten clayey rock.

This would account for Black earths being tied to particular bedrock and

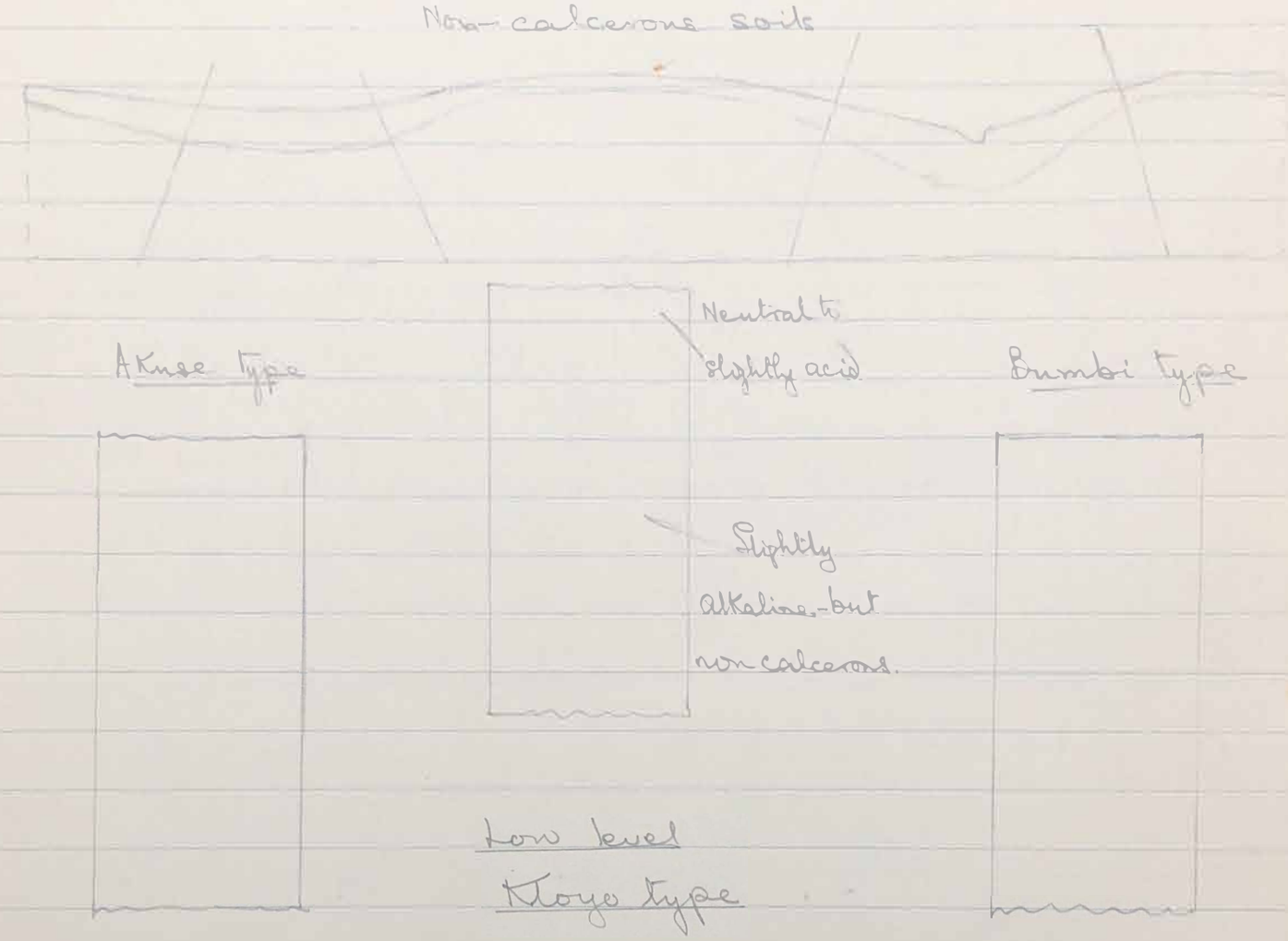
cf with Kongwa Succession.

Red earths around Inselbergs.
Fe concs soil over
calcareous soils uphill and down dale.

? Drainage reactions in ferruginous earth!



Expected straight forward residual + transported soils in depressions – No Fe Cones!

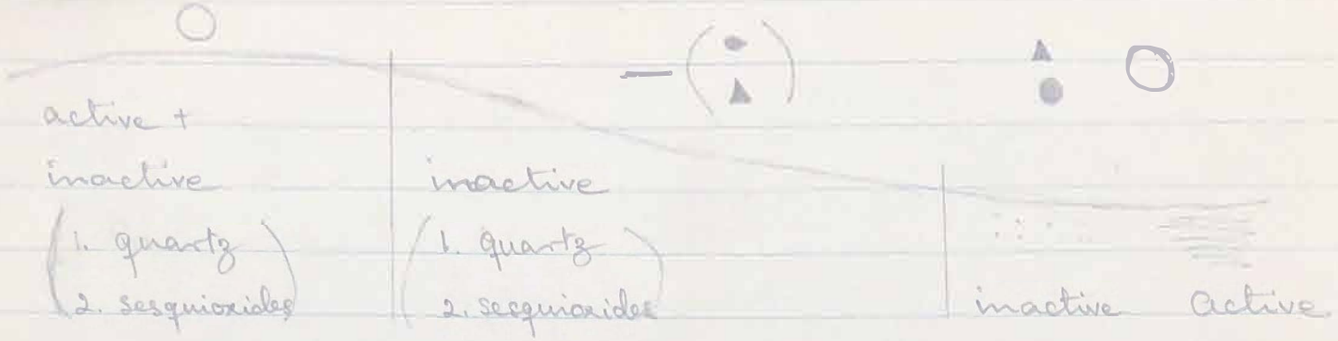


1. General character of bottom soil - but over all - and depressions.
2. Attachment to specific rock.
3. Red soils around inselbergs (weathered ferruginised rock)
4. Fe concs distributed all over area - concentrated in spots.

Red drifts + concs over uplands
Black calc drifts in depressions?
If present, proportions?

- Erosional factors responsible for Earth formation
  formation of present material
  (drifts - mattes etc)

Biotic factors — responsible for soil formation within earths.



Kaolinite
+
Sesquioxides

Sesquioxides
+
Kaolinite

Kaolinite
±
Sesquioxides

Kaolin removed → Kaolin deposited here

Ansum
Akroso Types

A

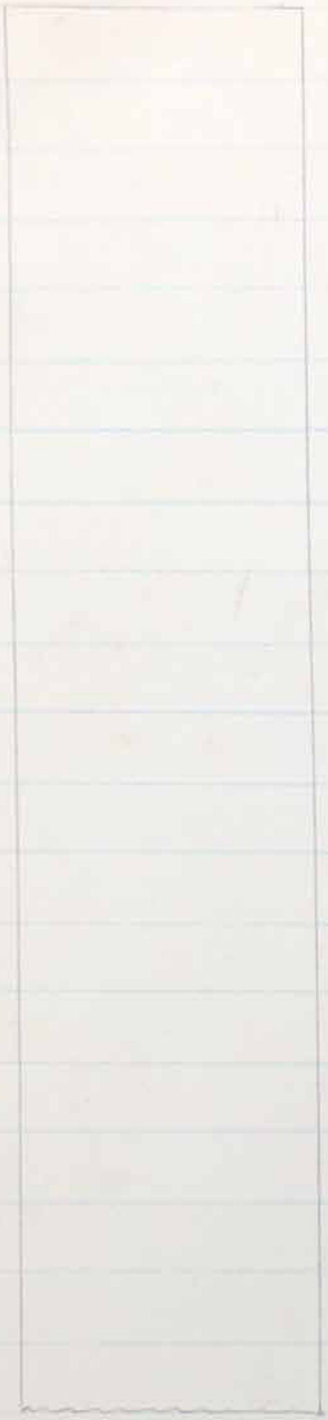
Types of Pediplain Drifts. Capilds

Types of Drift

1. Primary. Non concretionary red earth (or brown)
   Concretionary red earth (or brown)
   Quartzose and concretionary sand (upland pallid
   (Quartzose gravel ?)
   Bauxitic earths
   Kaolinitic red & white mottled clays & sandy clays
   (Caribbean)
   Montmarillonitic earths.

2. Secondary Red or brown concretionary Red-earths
   Black, Montmarillonitic earths.

Schematic Pediplain Drift Profile (ferruginous type).



Drift:

Homogeneous red earth

Red earth + ironstone concretions.

Vermicular ironstone

STONE LINE - Subangular gravel.

Ferruginised weathered bedrock:

Ironstone

Concretionary red clay

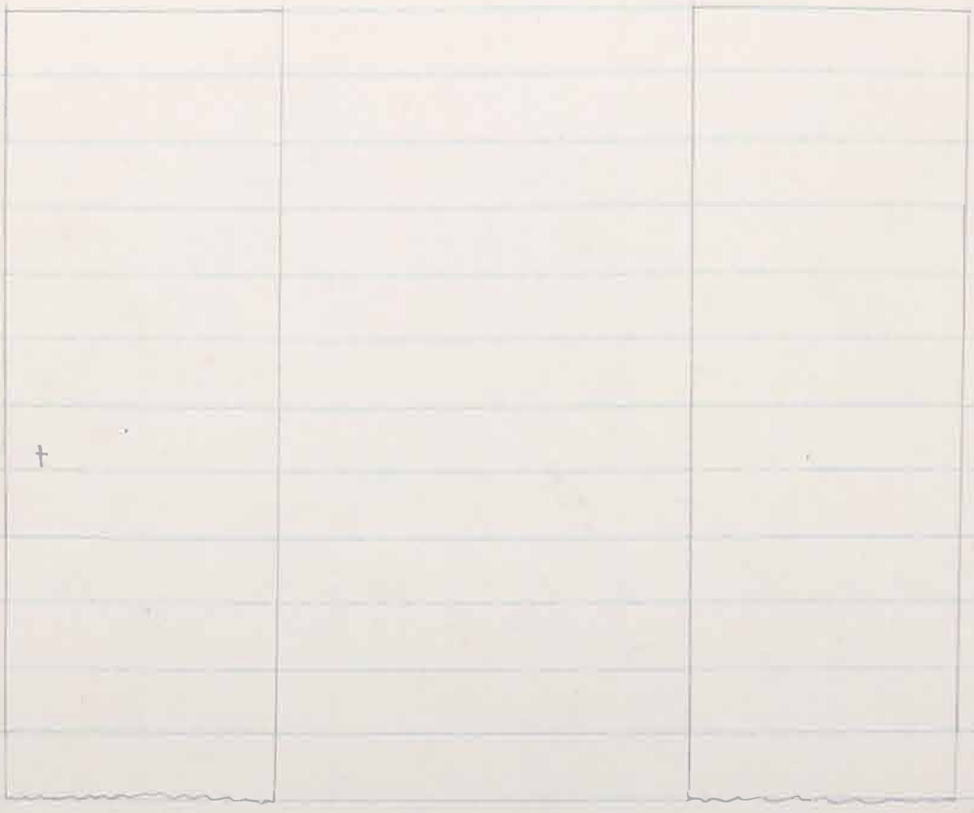
Clay and rotten rock - perhaps mottled.

Partially weathered rock.

~~Insert this page after heading in capitals on page 97~~

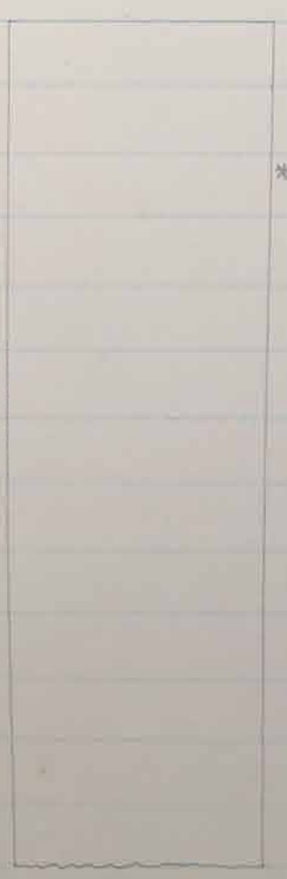
Soils developed in drift. Capilals.

Damongo Type.

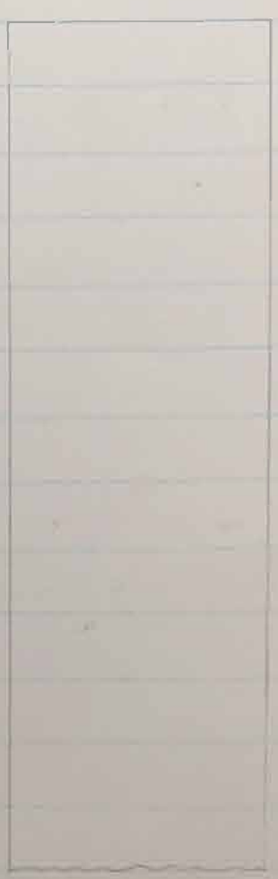


+ Irregular rough concretions formed and remaining in site.

Techiman Type



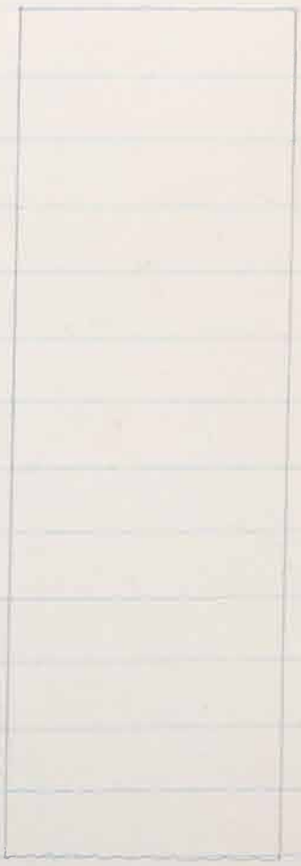
Wenchi Type.



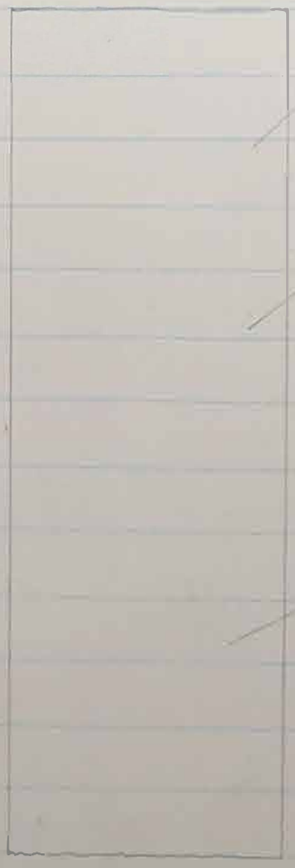
* Smooth rounded concretions formed from + by local surface drift.

Soils derived from Ferruginized Weathered bedrock after drift has been lost by Erosion.

Wenchi Type



'Konongo' Type.



'Osanko Type (a'Domenasi.)

The Ferruginized Weathered Bedrock.

Ferruginization of the weathered bedrock, resulting in the formation of ironstone and manganese concretions (or even of massive iron pan) is a result of iron-bearing water accumulating in the lower part of the drift and seeping into the weathered material below where in comes general ferruginization or separates out as concretions.

This sort of thing has been observed in Martinique where volcanic ashes overlie weathered basaltic or andesitic rock.

Concretions do not develop in normal soils derived from weathering in situ.

Soils of the Asonko type are probably very common. The Banku granite soils are probably of this type.

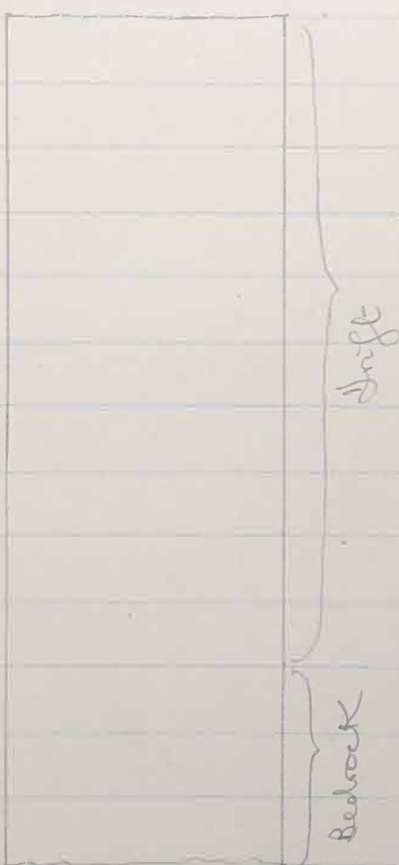
It is the Asonko type which eventually develops into the Koforidua type. This means that the concretions and quartz gravel have largely developed in situ and are not necessarily remnants of a former overlying drift — though there concretions owe their origin in situ to the fact that previously a drift did cover the area where Koforidua type soils now exist.

This explains why concretion zones are occasionally very deep. In this case the quartz gravel layer may consist of drift material.

1. Secondary Drifts.

These have been derived from materials that include previous drifts of the ferruginized type.

Tabular inselbergs

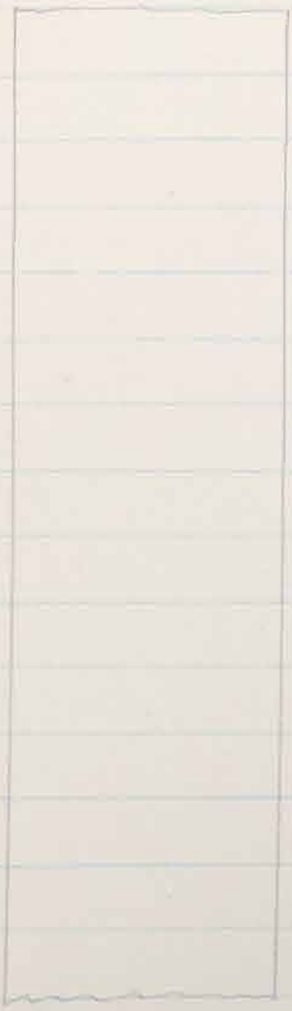


Concretions besides being formed in situ have been washed in. Contains rolled and rounded masses of ironstone varnished over with a layer of lenionic (Pendleton 'cauliflower heads') also contains rounded fragments of rock other than that forming the bed rock. Such drifts closely resemble local superficial drift of recent date overlying drifts ferruginized in situ.

~~Types of Peat and Drift.~~

2. Concretionless-drift – overlying layered bedrock more or less on end and therefore good under-drainage.

No impedance at the junction of drift and bed rock, no accumulation of iron-bearing drainage water and no formation of concretions or ironstone.



— Stone line may be present.

~~Types of Peneplain Drift.~~

3. Quartzose drifts

These drifts are presumed to have developed under the influence of perched groundwater held up by the horizontally-bedded or horizontally foliated bedrock. This has led to the concentration of the clay and iron into concretions leaving sand or pale clayey sand behind as a matrix. Possibly some of the clay and iron have actually been washed out.

These are the upland pallids of Kongwa and Nachingwea; the Dogum and Teke series of the Accra plains. Possibly the quartzose sands of the mountain Pine Ridge, British Honduras, are similar.

~~Types of Tenaplain drift.~~

4. Montmarillonitic drifts.

Contemporary drift + rolled. hard $CaCO_3$ concs. — Similar to rolled fe concs. — Local surface drift.

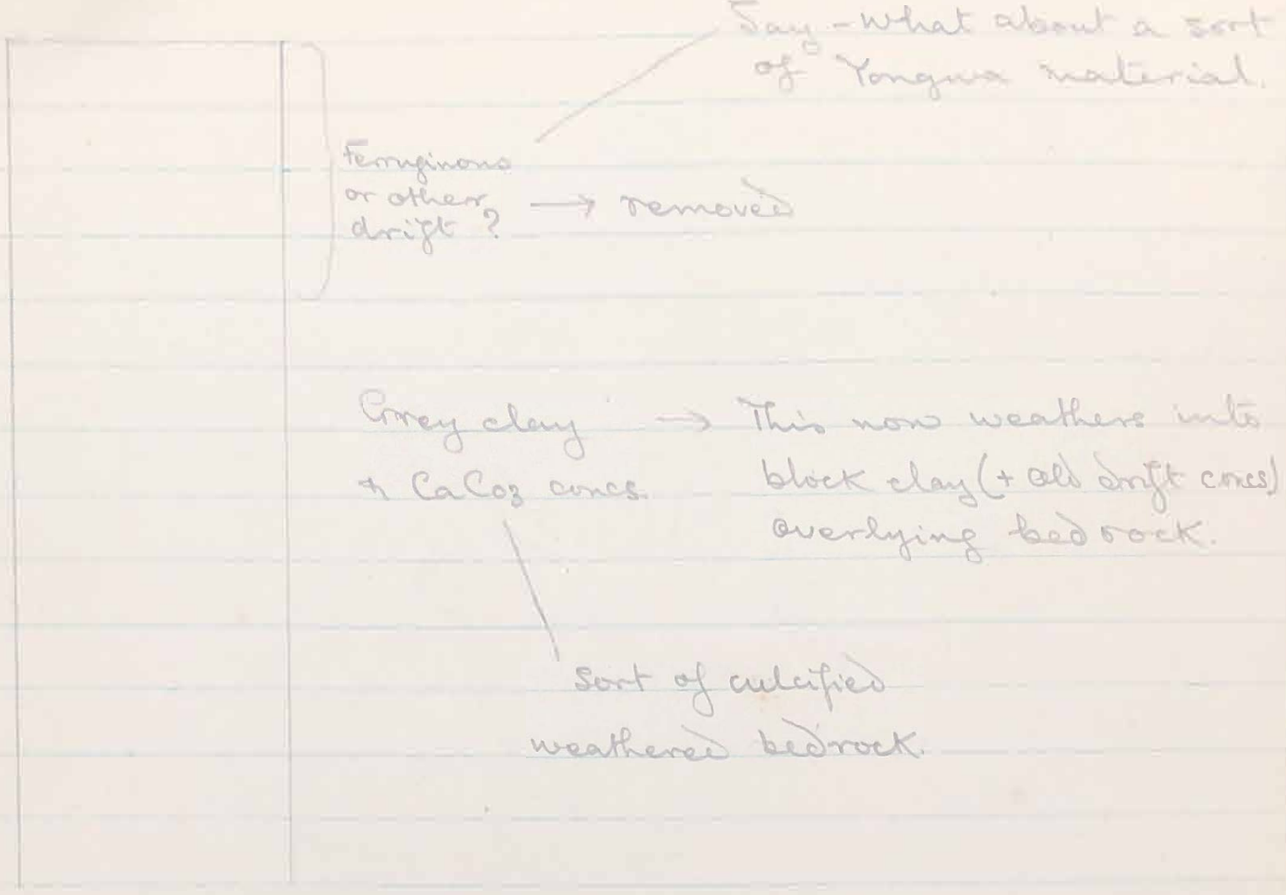
Grey Calc. clay, soft irregular concs to off white 'Marl' — Similar to rough irregular fe concs formed in situ.

Similar to massive ironstone

better never seen indurated as yet.

STONE LINE (sometimes) sometimes fe concs.

Weathered rock Calc. or mottled.

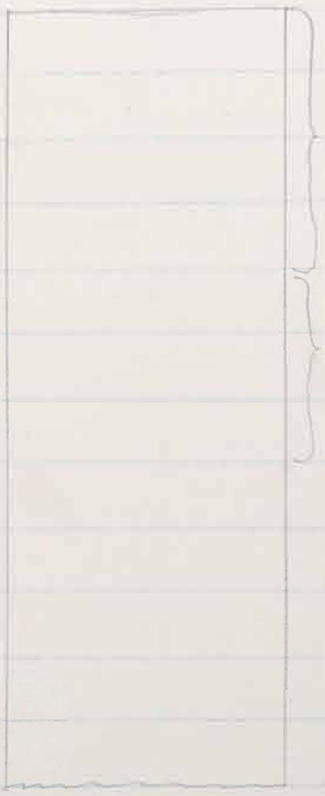

Say - What about a sort of Yongwa material.
Ferruginous or other drift ? → removed
Grey clay → This now weathers into block clay (+ old drift cncs) overlying bedrock.
+ CaCO3 cncs.
Sort of calcified weathered bedrock.

~~Types of Pediplane Drifts~~

4. Montmarillonitic drifts – continued.

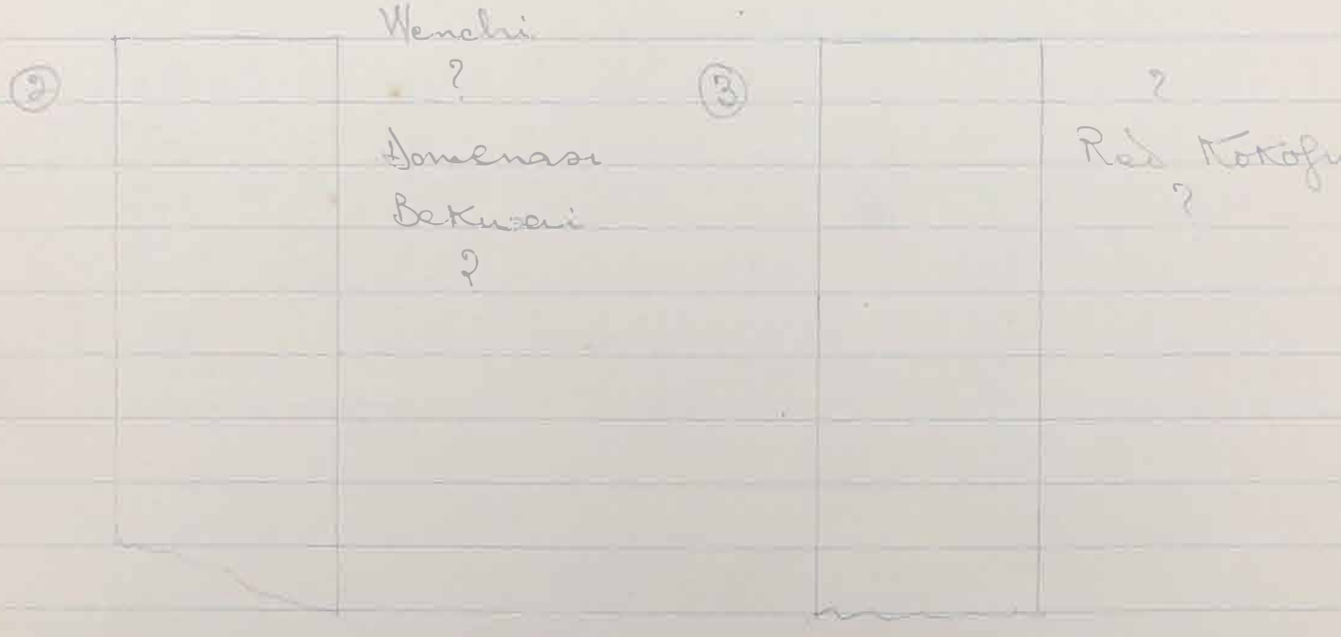
Some of these may be secondary drifts and resemble true in Morphology ①

NB. No grey calc. clay.

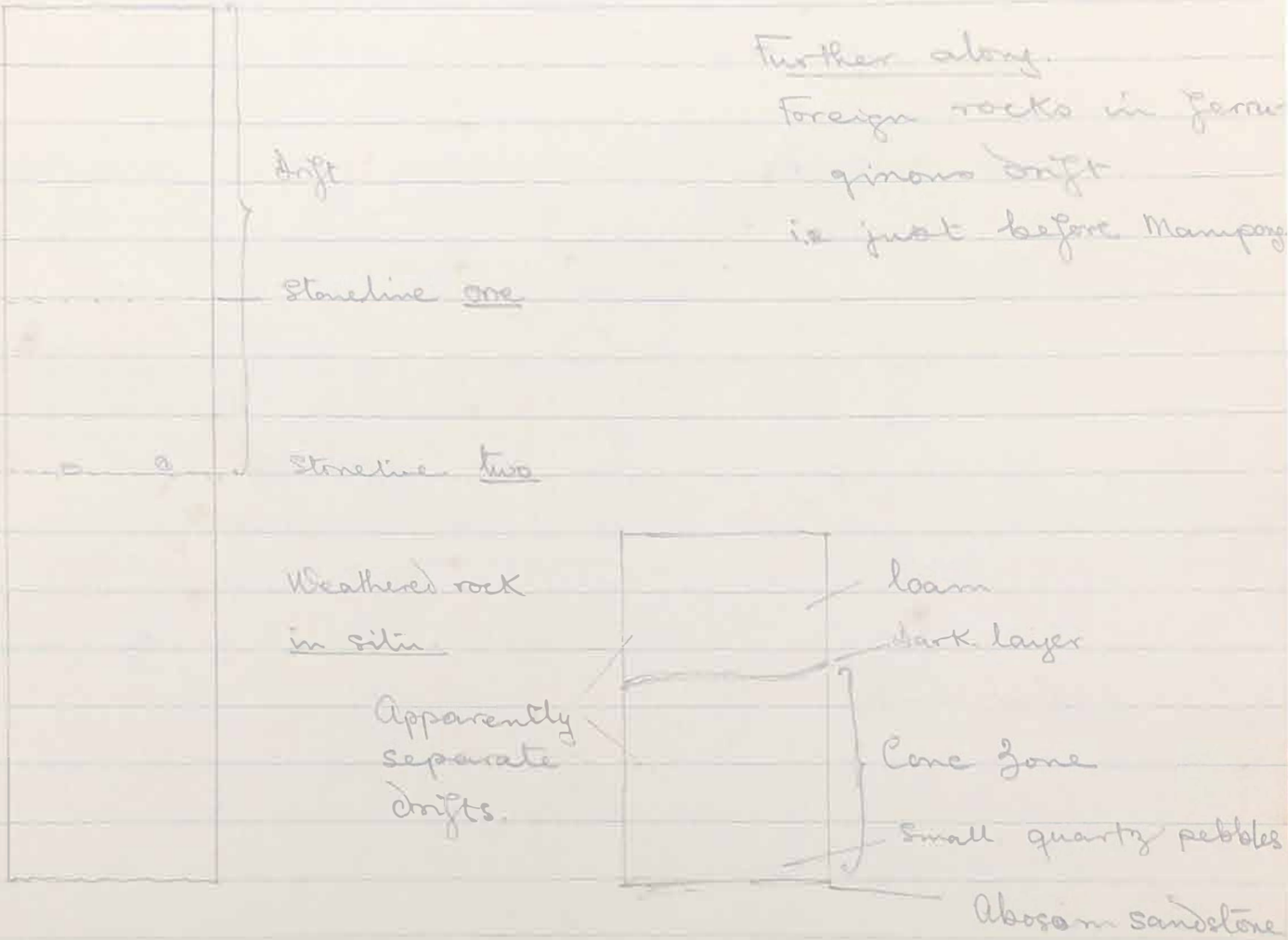


Perhaps it is in these types of drift that the stone line is absent.

Direction of Aeroplane AKUMADAN



Top of Mampong Scarp (Voltaian)



Types of Pediplain Soils.

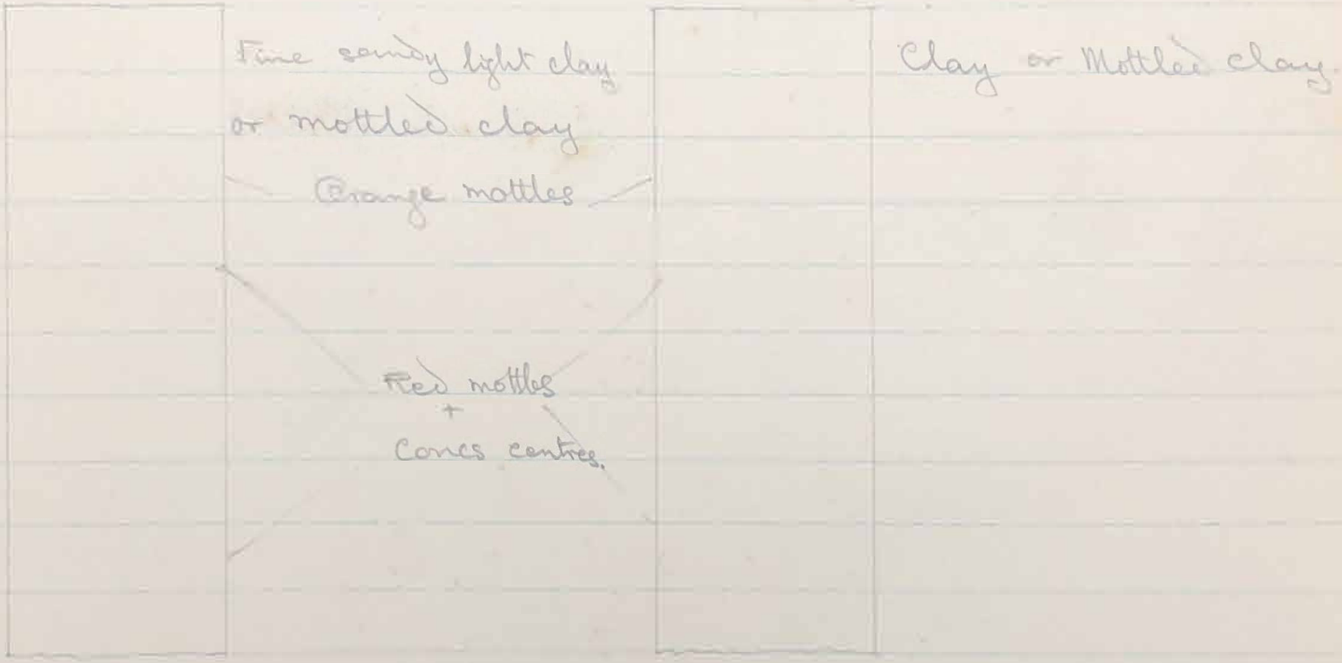
Peneplain Clays – Kaolinitic – non calc (also on coast-planes (e.g. coastlines) then Coastal Plains.)

e.g. Trinidad – Mottled Clays.

Derived from clay shales (Miocene and pliocene) mica schists etc.

Aripo Savannah

e.g. Erin Savannah – Pearco Savannahetc



Types of Pediplain Drift

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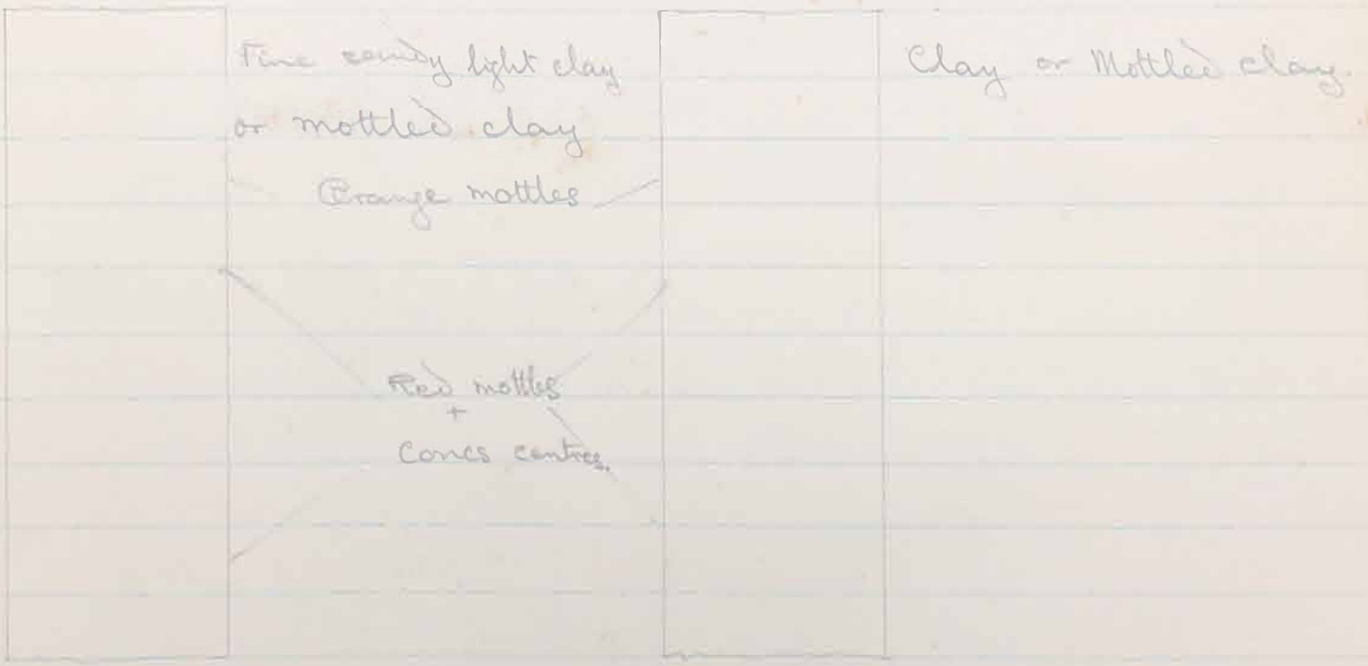
Aripo Savannah

e.g Erin Savannah – Pearco Savannahete



Coastal Peneplanes: Coastal Plains or Coastplanes (e.g. Coastlines)

Eg Trinidad

Gold Coast

Small Knolls emerging from a then cover of alluvium.

Bearing residual soils.

Cape Coast region

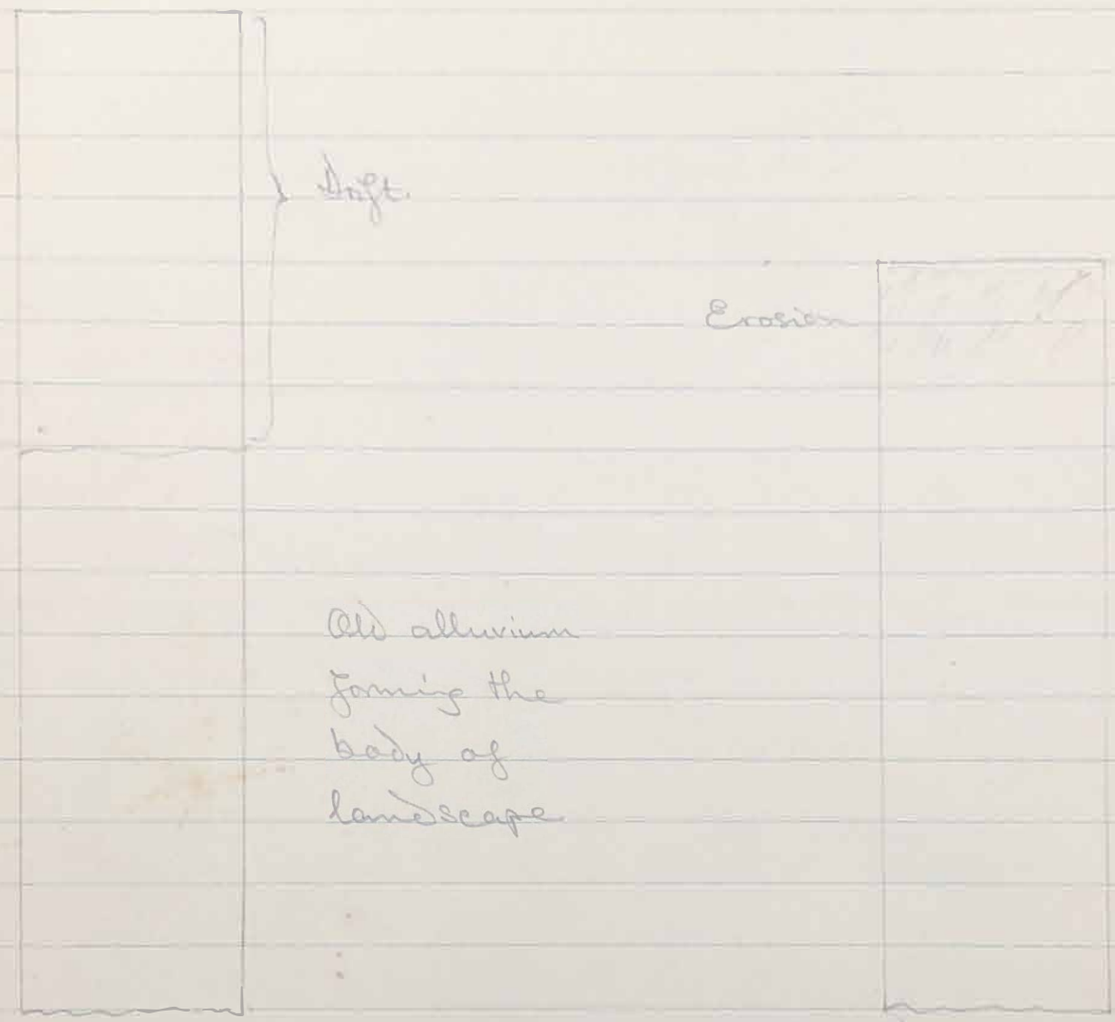
Esperanza

actually rock plains in the WM Davis scale.

Capitals

B. Peneplain deposits over unconsolidated deposits
e.g. estuarine sands (cf also Gambia & S Nigeria)

Adu's Eastern Tertiary Sands
profile



Bleached Swamp Sands - (Related to Agbotsone Series).

Dark grey to black sand

— White Sand may be thicker

— Rich brown sand

Mottled yellow-brown and pale grey sand (may be white again?)

or deeper

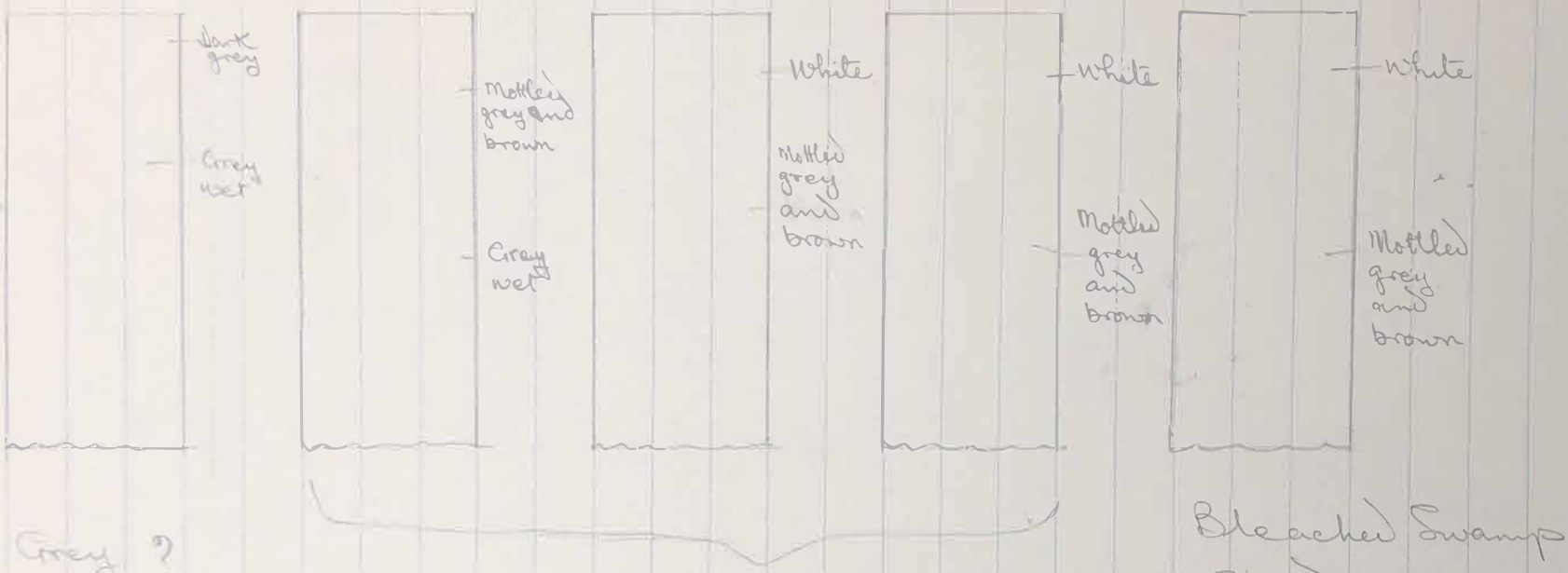
? Water table?
(white or grey)

① Eviama Savannah
② Grand Popo to Cotonou
③ Near Leopoldville and elsewhere in Belgian Congo.

Not an acid podzol-bleaching effect due to reduction only.

Some suggestion of this in S. Province Tanganyika.

Bleached Swamp Sands. (cf. also Keta at Keta).



Grey clay ⟶ Analogous brown mottled clay ||

Water Works, Kumasi

Flat Topography C. 950?

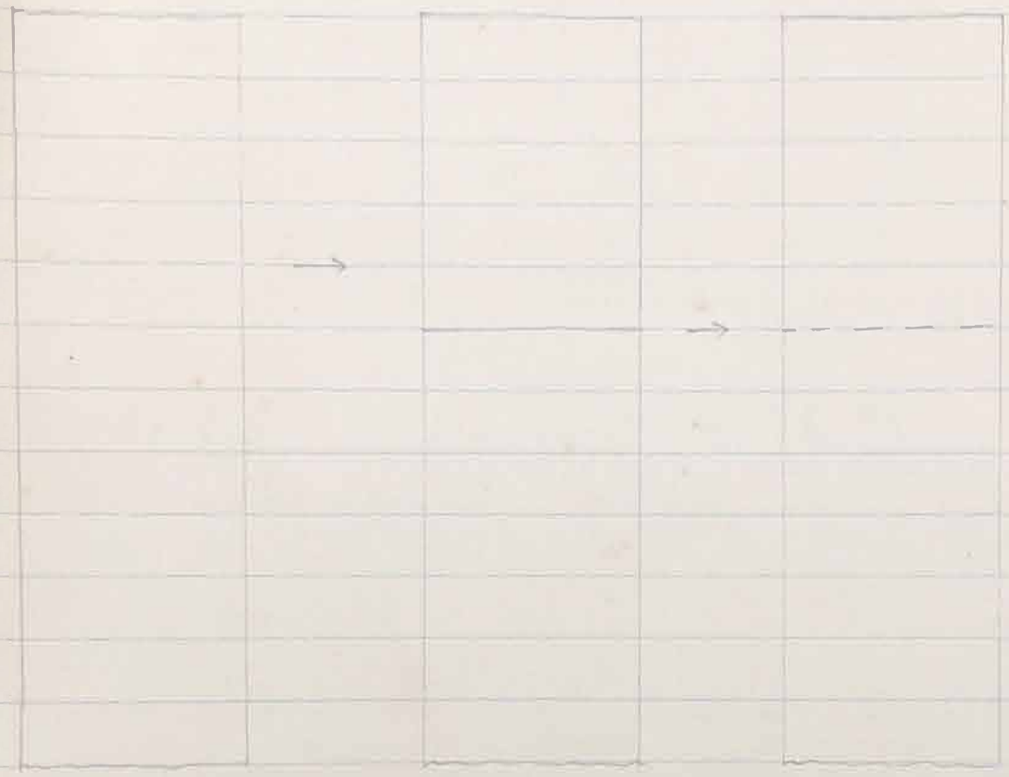
- Orange brown clay
- Stoneline + Fe concs.
- Mottled clay (Buchanamite) + concs.
- Rotten phyllite.

Mottled Sedentary clay. (Peneplanes)
Colepa – Nigeria
Erin Savannah mottled clay Trinidad
Ste Madeleine Trinidad
Talpan
Pine Ridge B. Honduras
also Terrace alluvial clay.
Trinidad British Honduras.

Ironpan Sheet erosion
and then hardening of surface?
due to impervious nature of
substratum?

Drift soils over Red unconsolidated Tertiary Materials.

① Development of mottled clay. ② Erosion of overlying earth ③ Deposition of fresh material over mottled earth.



May even here. Impedence - result in the formation of ironstone.

Colony Series
W. Nigeria

Sierra Leone.

Capitāla blose

C. ← Valley Soil Associations

	Nta	Ofin	Denon	Chichiwen

	Nta	
		Drainage groove ascending upland.

	Nta	
		Edge of Valley with stream.

Nta
Drainage groove

NTA. SERIES

Ofin — Loamy Sand.

Denon. — Stoneline + Seepage here

— Rotten rock

~~Valley Soil Association (Contd)~~

NTA

Red upland Soil

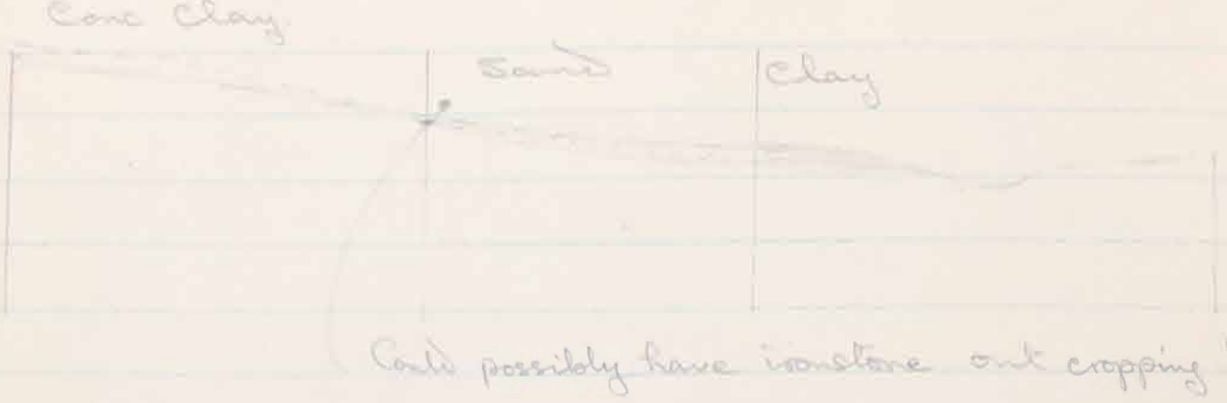
Chichiveri

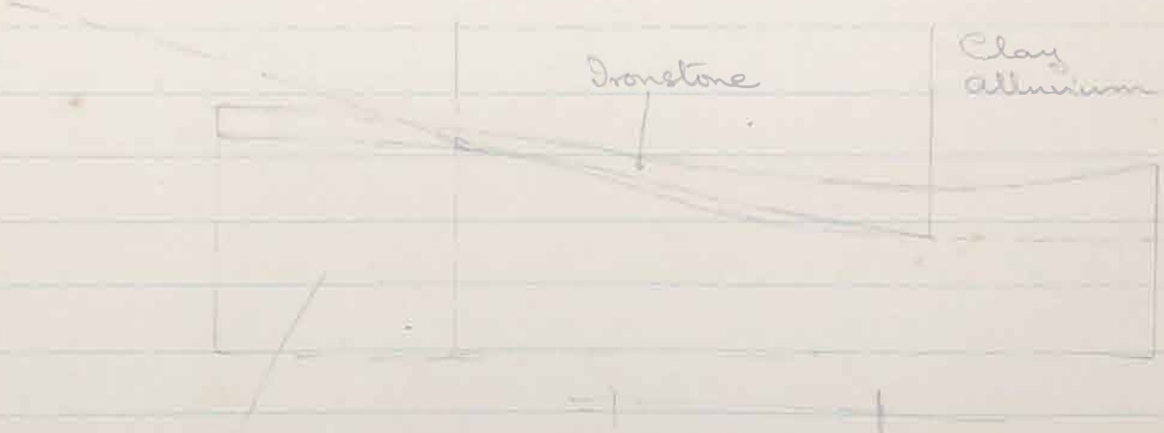
Torrential Stream.

Suggestion ① Nta = Tropical Solifluction

" ② Nta = Filled in torrent channel ie that NTA etc. fossil valley with sand.

Bauchi Sequence: Upland soils developed in ferruginized bedrock-drift cover eroded.





Sand/indurated and conc. clay of sedentary origin. Drift eroded.

Drift here preserved (ironstone = drift remnant).

Nyankpala Sequence: Ferruginized drift over siltstone.

Nyankpala	Kapelaugu	Chongnalilli	Volta.

Is this a pediment?
(equivalent to Plarco or Tripo Series)
and are uplands remains of a
previous peneplane — now rounded
residual hills?

i.e Sand/Mottled clay is equivalent to
sand/ironstone.

The ~~Valley Soil Associations~~ (Cont):

The Valley-alluvium Association has been more or less taken for granted to-date!

Points to Note:-

1. The Association is similar in both forest and Savannah Regions.
   (This in itself is remarkable? - Does this mean that the same causes had the same result?)
2. N.B. Greene had doubts about the verity of the succession Swedru-Nta-Ofin-Densu when he was there!
3. ? Nta-Ofin-Densu in the forest region is a relict of the time the forest region was a Savannah area covered with drift. Fossil drift-remnants occur in the quartz gravel and ferricrete zone of upland soils - why not fossil remnants in the valleys?

~~Valley Soil Associations (cont.)~~

Can Tropical humid solifluction or sub-surface erosion carve valleys or grooves?

1. Evidence of movement of the sand in the groove
2. Evidence that this movement causes scouring (or removal of clay, leaving sand of 'sedentary' origin behind which itself starts to flow.)

observable		
	heavier	
	lighter	Path of water removing clay both above and below ?
	heavier	
?	heavier still	Certainly accumulation of water at this level
?		

N.B. Drainage Grooves ascending hills practically undecernable by eye (at least under forest)
(a) My own experience – Tukua, Koranzang etc
(b) Experience of soil conservation units in grandnut regions of Tanganyika country

Bruey Radwanski and his ferns?

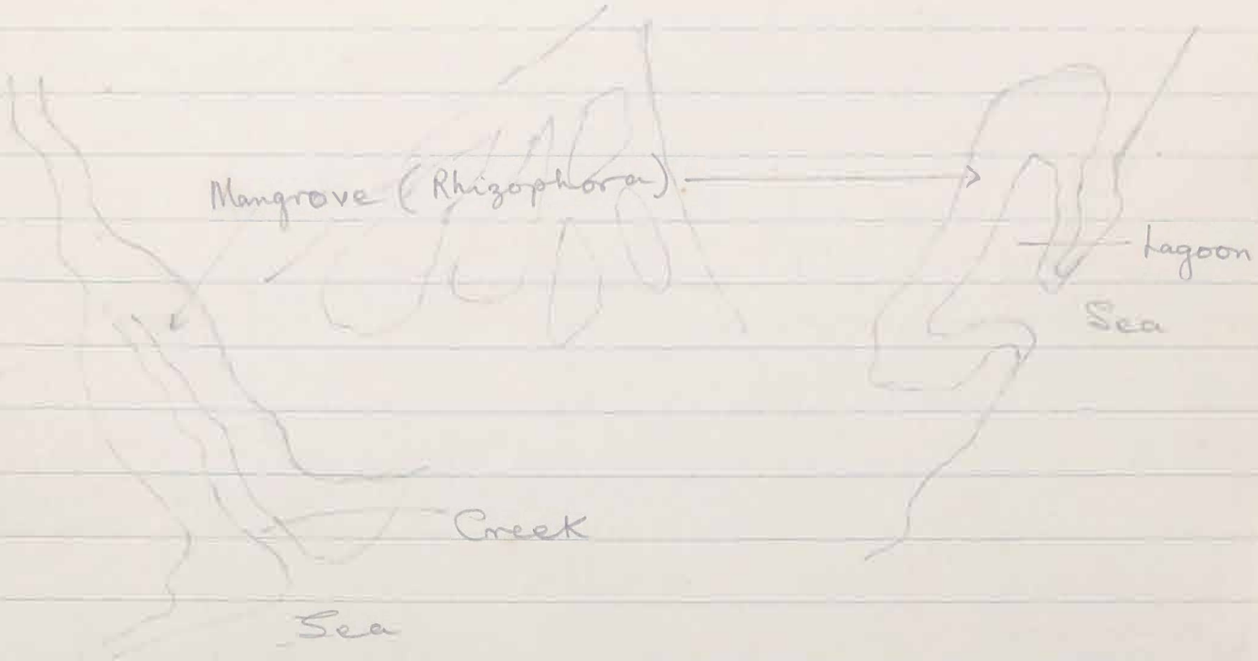
Bryan — Gulley Gravine

Nothing like this in West Indies!
Otherwise seen in Gold Coast, Nigeria, Cameroons

D. Mangrove Swamp Soils Capitals

Rhizophora mangle (or racemosa)

Found in shallow water of estuaries and deltas, or in lagoons open to the sea.



~~Mangrove Swamp Soils~~ -

Rhizophora

Surface soft - one sinks in it.

Mangrove Forest or Thicket

— Mangrove Mat.

Dark bluish grey clay or black clay

+ scattered mollusc shells

Alkaline (pH 8.2)

If Mangrove merely cut comes up to Acrostichum aureum.

Typically usually submerged.

On artificial draining gives rise to Katteclei, streaked yellow, whitish and grey (mixed alluviums) - extreme acidity

Avicennia nitida - Avicennia mud flats

Found (a) back of Rhizophora.

(b) in closed lagoons

(sea breaks over bar occasionally)

Very high salinities zones occur (salt deposited as Hallow cubes).

Sometimes inundated with fresh water - run off from adjacent land.

Typically dry from surface.

When cut Sesuvium comes up

or Philloxera verimiformis.

Alternating reducing and oxidizing conditions?

(N.B. Many lagoon beds here, no vegetation when dry, colonised by Sesuvium - Philloxera if dry long enough.

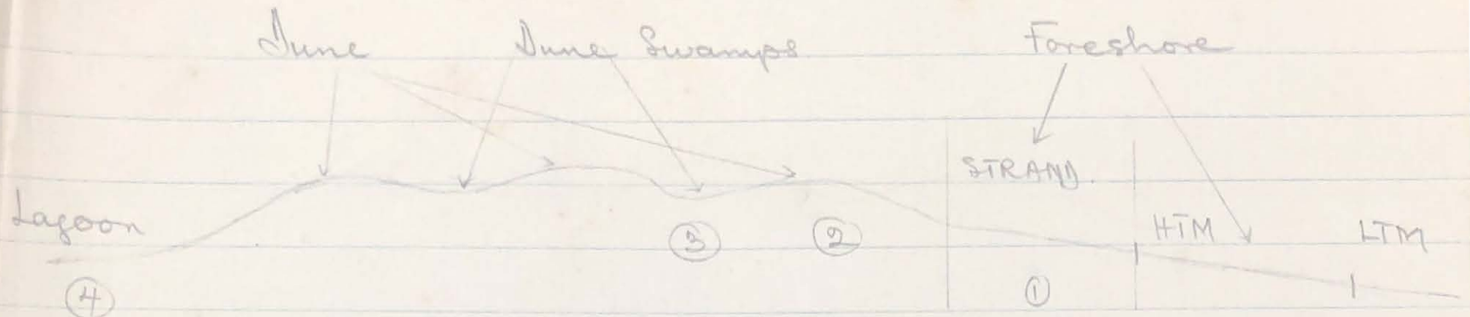
Lagunularia racemosa — Streams running
Where stream enters lagoon — with lagoon and
also Cyperus articulatus — deltas so built up.
Typha australis?
also Phragmites?
Paspalum vaginatum
also Hydrophila sp.

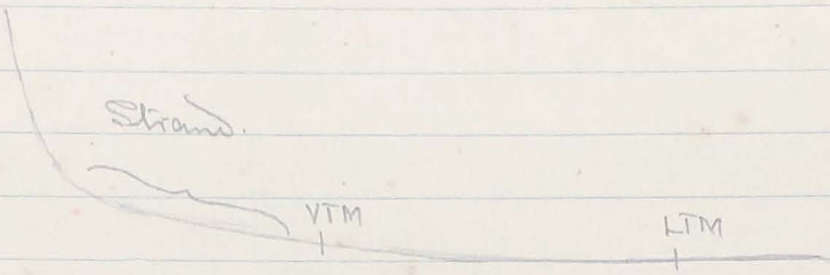
Grass swamp
or Marsh

Perennially moist
acid clays ± gypsum.
with conocarpus erectus
on drier parts
also Phoenix reclinata.
Possibly Pandanus spp in
wet areas.

Ada Series - raised lagoon deposit?
Hence differs from the Lagunclaria type which is leached with water containing gases or is built up over deltaic deposits. Fresh water.

- Chlorides driven off by
H_2SO_4 - sodium sulphate remaining?





Scarp-foot Soils.


Red earth