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MORPHOLOGY AND DISTRIBUTION OF BROWN AND CHESTNUT SOILS IN SENEGAL, MAURITANIA AND SUDAN

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In 1923 H. L. Shantz and C. F. Marbut⁽¹⁾ reported that brown soils exist in Senegal. Since then, very few works have been published which throw any light on the typology of the soils of the sub-arid zone of French West Africa. The map of African soils prepared by the Russians does however show brown and chestnut soils. So far as the French Colonies are concerned, the distribution of the different soil types has been shown on this map only on the basis of climatic and geological data.

As regards Senegal, Mauritania and French Sudan, the brown and chestnut soils are situated in the Sahelian zone.

Their approximate limits are:

(1) *To the north* :

South of Tigent, north of Mederdra, Timbedra, Néma, Sokolo, Nampala, Néré, south of Niafouké.

(2) *To the south* :

Region of Bambey, Diourbel, Touba, Linguère, 50 km. to the north of Kayes, north of Mourdiah, Nioro, and of the Niger lacustrine zone.

These soils are succeeded to the north by grey sub-arid soils and to the south by leached ferruginous soils and fine savanna gravels.

From the climatic aspect they occur between the isohyets 200 and 550 mm., being found only exceptionally in more humid regions (up to 650 mm. per annum). The mean annual temperature varies from 27-29°C.

Table of rainfall and temperatures

1. *Rainfall in mm.*

<i>Mauritania</i>		<i>Senegal</i>		<i>Sudan</i>	
Boutilimit	192.1	Dagana	360.6	Goundam	286.9
Tamchakett	217.2	St. Louis	392.8	Niafouké	369.9
Méderdra	249.0	Louga	444.6	Mopti	520.4
Timbédra	282.8	Bakel	528.3	Yelimané	589.1
Néma	300.0	Bambey	653.7	Mourdiah	591.6
Rosso	320.6	Linguère	630.9	Nioro	599.1

2. *Temperature in °C.*

<i>Mauritania</i>		<i>Senegal</i>		<i>Sudan</i>	
Néma	29°95	St. Louis	24°8	Mopti	27°42
		Bambey	26°9	Nioro	28°61
		Linguère	28°3		

The climate is characterized by the alternation of a very short wet season (from July to October) with violent rainfall and a long dry season during which the wind is dry and burning and from the east. During the whole of this latter period, the humidity of the air is very low.

In the regions studied, the brown and the chestnut soils occur on very varied parent rocks. We have noticed them on quartz sands, silts, clays, marls, calcareous sands, schist alluvia, dolerites and fine granites.

The vegetation is essentially that of a grass steppe or an open thorny savanna, and corresponds to Trochain's⁽²⁾ Sahelo-Saharan and Sahelo-Sudanian domains.

The main species found are : in the bush and tree layer mainly some *Acacias* (*tortilis* and *verecha*), *Balanites* and some *Combretums* (*glutinosum* and *sculeatum*), and in the herbaceous layer *Schoenfeldia gracilis*, some Chlorideae, some Aristideae and some *Panicums*.

Sub-arid brown soils. These are situated in the more arid zones, generally on compact parent rocks. The vegetation is essentially steppe.

Normally, the soils exhibit :

- (1) A rather small depth for tropical soils, from 100-150 cm.
- (2) A dull brown colour, tending sometimes towards black, and very uniform throughout the profile.
- (3) Any differentiation between the horizons is solely one of structure.
- (4) A lamellar structure in the topmost mm. by reason of accumulation of organic matter, then a granular structure more or less developed in the upper part of the profile and degraded in the lower part.

The only sub-arid brown tropical soils of French West Africa which effervesce with acid are those above a calcareous parent rock. Effervescence occurs to the greatest extent in the horizons near the parent rock and where zones of carbonate accumulation can be noticed. These latter are very different from the calcareous nodules observed in the Sudan in the old Niger delta.

Thus, to the north of Coki (Senegal), half way to Lac de Guiers on the Yang-Yang road we observed the following profile above marls.

- 0-15 cm. grey brown horizon, humiferous, sandy silt, a beginning of granular structure, considerable root debris of *Schoenfeldia gracilis*.
- 15-70 cm. a lighter brownish horizon, rather more compact, slightly developed structure, at about 60 cm. beginning of effervescence with acid, horizon becomes paler, some small very friable concretions.
- 70 cm. and below : a very calcareous marl.

The vegetation is a degraded savanna of *Balanites aegyptiaca*, *Schoenfeldia gracilis* and *Chloris Prieurii*.

Again, at 12 km. west of Merinaghem (Senegal) in an old millet field at present covered with *Callotropis* the horizons are :

- 0-55 cm. very sandy, rather dull grey, humiferous, rather more black above 10 cm.
- 55-85 cm. more compact horizon, browner, without being reddish.
- 85-150 cm. the colour decreases towards 150 cm., the sand becoming yellowish-white.

As we travel further from the ocean towards Mauritania and the Sudan, the brown soils observed are more typical and developed on a large scale. Magnificent examples occur in the Néma region (Mauritania) 50 km. to the south of this village on the Naroh road in the centre of a grass steppe with some *Acacia tortilis* and *A. verecha*. The profile exhibits :

- 0-15 cm. brown silty-sand horizon, granular structure and slightly compacted, horizon looser and with a slightly lamellated structure in the surface cm.
- 15-50 cm. brown horizon, structure rather degraded with a tendency towards the prismatic, towards the lower part the horizon whitens and many crystals of weathered felspar occur.
- below 50 cm. weathered rock, whitish, then fine granite.

To the south of Sokolo (Sudan) around Kougui (Niger Office) the brown soils are developing on silty alluvia.

Sub-arid chestnut soils. These are distinguished from brown soils by :

- (1) a first beginning of colouration by free iron,
- (2) a more distinct differentiation into horizons,
- (3) an A₁ horizon with structure only slightly developed, often degraded.

They are situated in the less dry zones and on parent rocks which are generally of loose nature.

The vegetation is more typically savanna.

Their characteristics are:

- (1) A thickness of 150-200 cm. in most cases.
- (2) A distinct separating out of iron and the beginning of accumulation in B in a diffuse form.
- (3) A rapid disappearance of the organic matter in A₁ and thus a less clearly developed structure.

Such a soil, situated 29 km. south of M'pal on the road from Louga to St. Louis (Senegal) exhibited :

- 0-5 cm. horizon finely sandy, chestnut-grey, slightly humiferous.
- 5-25 cm. a more compact reddish-chestnut horizon.
- 25-140 cm. chestnut horizon, less compact, some reddish staining towards 150 cm.
- 140-200 cm. a beige sandy horizon, slightly silty, with greyish-white sand below.

A soil of this kind, in having reddish stainings towards 150 cm., exhibits quite an advanced degree of evolution. Again, 80 km. to the north of Niore du Sahel (Sudan) on the Timbedra road, in a region of dunes fixed by *Balanites aegyptiaca*, *Sclerocarya birrea*, *Combretum glutinosum*, the soils are much less leached and already tend towards sub-arid grey soils. The profile is :

- 0-15 cm. sandy, humiferous horizon, grey, rather compact, some vegetable debris.
- 15-70 cm. sandy, bright ochreous horizon, grey at the top, rather compact and slightly ferruginous.
- 70-170 cm. horizon of similar colour, slightly redder, in its lower part becoming lighter, approaching a light beige.
- below 170 cm. a very pure bright sand.

In a rather more humid zone, 104 km. to the north of Kayes (Sudan), on the Niore du Sahel road, a very typical chestnut soil can be seen above intrusive dolerites. Vegetation consists mainly of *Pterocarpus lucens*, *Anogeissus leiocarpus*, *Sterculia setigera*, some jujube trees and acacias (thus already Sudanian), but here the topography (plateau edge) renders the pedoclimate arid.

- 0-16 cm. greyish-black horizon apparently quite humiferous, lumpy structure.
- 16-30 cm. horizon brownish-red, same structure, some roots, dolerite debris.
- 30-100 cm. transition zone towards white weathered dolerite. Below this, dolerite.

Towards Sokolo (Sudan), in an old bush fallow of *Guiera senegalensis* where some *Acacia tortilis* and *Balanites aegyptiaca* occur, the profile shows :

- 0-15 cm. chestnut-brown horizon, wind-eroded, quite friable, slightly humiferous sandy silt.
- 15-90 cm. a redder more compact silty sand, becoming gradually brighter with depth.

In the more humid, more southerly regions, the leaching is accentuated and we come to leached ferruginous soils of the Dior type and even of the savanna fine-gravel

type. In the regions studied, there seems to be quite a clear relationship between the distribution of these two soil types and the physical and chemical nature of the parent rock :

- (1) in any one region the chestnut soils are always of a lighter texture than the brown ;
- (2) the chestnut soils usually occur over rocks richer in iron and more acid than those underlying the brown soils.

Thus, in Senegal, in the Louga region, chestnut soils occur only on silty sands between dunes, while the brown soils form essentially above marls and calcareous clayey sands and are more compact. Again, in the Néma region (Mauritania) the brown soils occur on fine granite and are much heavier than the chestnut soils which are always over sands.

The same holds good for the Sokolo region (old Niger delta) (Sudan) where the clayey or silty brown soils are generally at a lower level than that of the more sandy chestnut soils. The essential difference between brown and chestnut soils appears to be the presence of the first signs of leaching in these latter, a leaching which is still more distinct in the case of the exchange elements.

Chemical analyses of a chestnut soil between dunes in the Louga region (Senegal)
(per cent of dry soil at 105°)

depth	free iron	Ca	Mg. in milliequivalents
0—5	0.33	22.46	11.59
10—20	1.05	29.27	13.16
20—35	1.28	29.27	20.23
35—110	1.64	48.92	30.83
110—225	trace	28.87	22.98

Only the brown soils exhibit an equilibrium between ascent and descent, which explains their good organic-matter content, their granular structure, relative stability against wind erosion and the saturation of their absorbing complex.

In the Kougui area (Sudan) the pH of this soil is above 7, and, on irrigation, rise of salts may be observed. The distribution of these two types of soils depends

- (1) on the climate : the brown soils occur in a more arid region than the chestnut ;
- (2) on the parent rock, which by its texture facilitates drainage to a greater or lesser extent, and by its chemical nature facilitates the pseudo-solution of the elements, these two characters contributing to a more or less pronounced leaching of the soil.

In conclusion, and in spite of the insufficient number of analytical results which we possess, it appears to us that the brown and the chestnut soils constitute two great soil types, at least as regards Senegal, Mauritania and Sudan. The first corresponds to an equilibrium between the phenomenon of ascent and descent of the elements, and the second to an incipient leaching affecting the absorbing complex and to a more definite separating-out of iron.

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