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SOIL MAP OF AFRICA

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I. Explanation of the Soil Map

The Soil Map of Africa on the scale of 1/18,000,000 has been compiled based on the data obtained from our survey and investigation in Africa and the soil maps on small scales have been published abroad. The aim for compilation of this map is to give expression of the major soil types in Africa and their distribution regularities.

Africa is the second continent of the world with a total area of more than thirty million km². With its unique geographical position and landscape features, Africa covers the area from 37° north latitude to more than 35° south latitude. Three fourth of the continent are situated between Tropic of Capricorn and Tropic of Cancer, which forms the only big tropical continent in the world.

With the equator going across its middle part, the continent stretches both northwards and southwards at approximately equal distance. At the sametime, due to its flatter relief with marked tablelands and straight coastal line and without any high mountains, the continent is characterized by its symmetric bioclimate zonality of soils in both the Southern and Northern Hemispheres.

The horizontal distribution of soils from the equator both northwards and southwards in the continent is in the sequence of latosols — lateritic red earths — red earths — weakly allitic soils — tropical semiarid red brown soils — tropical semidesert arid soils — tropical and subtropical desert soils — subtropical semidesert arid soils — mediterranean semiarid red brown soils — mediterranean red brown earths. However, owing to the difference of soil forming factors, the regular zonal distribution of soils is often wrenched, diverted or discontinued. The remarkable examples can be found at Somalian Peninsula in the east section of the continent where tropical desert soils and semidesert arid soils are dominated due to the influence of very hot and arid climate under interference of ocean, and Ethiopean Plateau in northwest section of the continent where tropical brown soils are dominated due to uplifted relief and mild climate. Although the two plateaus are all near the equator, the main soil types distributed on them are not latosols. Another example is Kalahari Basin in the south part of the continent, although it is situated at the

symmetrically similar latitude of Saharian Desert in the north part of the continent, it is mainly covered by arenosols rather than desert and semidesert soils which draw back to the coastal region in southwest part of the continent, because it is not influenced by the northeastern trade-wind coming from the arid region of Asian Continent.

Vertical distribution of soils is the result of bioclimatic variation induced by the uplift of mountain land. Vertical soil sequences occur with the rising altitute above sea level, e.g. the vertical sequence of the Atlas Mts. in northwest part and Drakensberg Mts. in southeast part of the continent is mediterranean red brown soils (mediterranean red brown soils, weakly allitic soils) — mountain brown earths and the vertical sequence of Kenya Mts. and Kilomanjaro Mts. is lateritic red earths — weakly allitic soils — tropical brown soils — andosols — tropical mountain dystric humus soils.

Some exception for soil distribution in Africa have resulted from the influence of paleographical and paleoclimatic conditions, e.g. Ethiopean Plateau with an altitude of 2500–3000 m on which lateritic red earths are spread.

In the desert or semidesert regions, e.g. the Sahara Desert, due to arid climate, saline and alkaline soils are distributed; while in the semiarid regions at the outter margin of the desert, arenosols and regosols are usually spread.

In the valley plains with the parent materials derived from basic rocks such as basalt or those around which there have been volcanic activity, vertisols (tropical black soils) are widespread under semiarid and semihumid conditions, it can be seen that the greater area of these soils are distributed in the valleys of Blue and White Nile. While gley soils are mainly distributed on the wetlands in the valleys such as Congo Basin under humid climatic conditions.

Owing to its smaller scale (1/18,000,000), the Soil Map of Africa can only illustrate the general aspect of the soil distribution in the continent. The soils in the map are classified into 26 basic soil units. Many of the delineations are expressed by soil complexes, and the phases (surface gravel, ferruginous concretion, petrocalcic, petrogypsic, petroferric duripan, saline, alkaline) are expressed by symbols.

The brief descriptions of the soil units are as follows:

1. **Latosols** They are mainly distributed from the central and north parts of Congo Basin, coastal region of Atlantic Ocean, Gambia to east part of Madagascar. The soils are formed under the climate of high temperature and humidity without dry season and with an annual mean temperature of $>25°C$ and a precipitation of 1400–2500 mm. The vegetative covers on the soils include tropical rain forests, low forests, secondary forests and savanna. Allitization proceeds intensely in the soils. The solum is dark brown reddish, sometimes, yellow or dark red in color. When the

plinthite occurs in the solum, there are red, lightly grey, lightly yellow or whitish mottles. The solum and the weathering crust are commonly in a depth from several to tens meters. Below A horizon is the oxic B horizon being highly weathered almost without any minerals that can be further weathered, the bases and silica have been mostly leached off, iron and aluminum are accumulated in this horizon, sometimes there occurs ferruginous cement from which iron rock is formed by alternation of wetting and drying when it is exposed. The clay fraction is dominated by 1:1 clay minerals and a large amount of iron oxide and aluminum oxide (commonly gibbsite), its SiO_2 /Al_2O_3 ratio is lower than 2, retention of cations is lower than 10 me/100g clay (1 N NH_4Cl), base saturation is often lower than 50%, clay content is higher than 15% without plasticity. When the soils are reclaimed for cultivation, organic matter content decreases, and the soils are deficient in nitrogen and other mineral nutrients. Latosols are suitable for multiple types of agriculture such as cultivation of tuber crops, cassava, corn, sorghum, millet, peanut, bean, cotton, banana, cocoa, coffee, rubber tree, tea, etc. The soils can be subdivided into Orthic latosols, Xanthic latosols, Rhodic latosols, Humic latosols and Plinthic latosols.

2. **Lateritic red earths** They are mainly distributed in Senegal, Mali, Ghana, Togo, Nigeria, Cameroon, Central Africa, Sudan, Ethiopia, Kenya, Uganda, Burundi, Tanzania, Angola, Zaire, Congo, Gabon and Madagascar. The soils are formed under the climate of high temperature and humidity, with a short drought season. The vegetative cover on the soils consists of rain forests or savanna. Owing to the influence of erosion, their allitization is weaker than that of latosols but stronger than that of red earths. Below A horizon, there is the argillic B horizon; the activity of clays is lower; the upper and lower boundaries change gradually; the structures have a bright surface that is not necessarily the clay coating but possibly the gel of aluminum oxide and silica. The content of weatherable minerals is lower, clay minerals consist mostly of kaolinite, free iron oxide, amorphous gel sometimes with a small amount of 2:1 clay minerals and gibbsite. SiO_2 / Al_2O_3 ratio is about 2, mostly below 2. CEC is more than 15 me/100g; being between those of latosols and red earths. Lateritic red earths, especially those derived from basic rocks, often with good physical properties and high fertility are suitable for planting various tropical crops such as rubber tree, oil palm, coffee, cocoa, tea, tung oil tree, cinchona, etc. under favorable climate, relief and altitude. Lateritic red earths can be subdivided into eutric lateritic red earths, dystric lateritic red earths and humic lateritic red earths.

3. **Red earths** They are mainly distributed in Guinea, Ivory Coast, Ghana, Benin (Dahomey), Togo, Mali, Nigeria, Tanzania and Angola. The soils are formed under the climate of high temperature and humidity with alternate humid and arid seasons, a yearly mean temperature of 24–30°C and a yearly precipitation of

800–1200 mm. The vegetative cover is rain forest or savanna. The allitization is stronger, but it is weaker than that of latosols and lateritic red earths. Below A horizon is the argillic B horizon with red color, the clay content in the horizon is increased significantly than that in A horizon, there is clay coating on the structure surface and in pores, and oriented clays can be seen on thin section. The weathering process in the soils is weaker than that in latosols and lateritic red earths, the soils contain a considerable amount of weatherable minerals, however, the leaching of bases and silica is intensive, iron and aluminum are accumulated in a considerable amount, the clay minerals are dominated by kaolinite associated with some hematite and goethite, or a small amount gibbsite and 2:1 clay minerals, SiO_2/Al_2O_3 ratio is about 2 or slightly higher, but SiO_2/R_2O_3 ratio is always lower than 2, retention of cation is higher than that of latosols and lateritic red earths, being 24 me/100g clay (1 N NH_4Cl), base saturation percentage is lower than 50% (NH_4OAc method). Sometimes there are dark red mottlings and concretions of free iron oxide. The soils with plasticity is weaker in resistance of erosion, but higher in fertility than latosols. The depletion of organic matter is accelerated after reclamation, at sometime, nutrients such as N, P, K and Ca are decreased rapidly. The suitability for crops is similar to that of latosols. Red earths can be further classified into orthic red earths, ferric red earths, plinthic red earths and surface gleyic red earths.

4. **Tropical and subtropical weakly allitic soils** The soils are mainly spread in Mauritius, Senegal, Mali, Upper Volta, Benin (Dahomey), Niger, Nigeria, Chad, Central Africa, Sudan, Uganda, Kenya, Tanzania, Malawi, Mozambique, Rhodesia, Zambia, Angola and Madagascar (malagasy). The soils are formed under tropical semihumid climate which has humid summer and arid winter, yearly mean temperature of more than 23 °C, yearly precipitation of 500–800 mm, and the vegetative cover of the soils is savanna. With weaker allitization, there is the argillic B horizon below A horizon. Weathering intensity of minerals in the soils is weaker than that in red earths. Bases and silica leaching is also weaker than those in red earths, in addition to kaolinte, hematite and goethite, there are a small amount of 2:1 clay minerals in the clay fraction, but there is no gibbsite in general, SiO_2/Al_2O_3 ratio is slightly higher than 2, base saturation percentage is higher than 50%, there are often dark red free iron oxide mottlings and concretions, there occurs calcic layer or soft powdery lime accumulation or both of them in B or C horizon. The soils are higher in fertility than red earth, but weaker in erosion resistance. The weakly allitic soils can be further classified into ferric weakly allitic soils, plinthic weakly allitic soils, surface gleyic weakly allitic soils, rhodic weakly allitic soils and calcic weakly allitic soils.

5. **Tropical and subtropical brown soils** The soils are mainly distributed in

Guinea, Ivory Coast, Liberia, Mali, Upper Volta, Ghana, Gabon, Zaire, Sudan, Uganda, Ethiopia, Madagascar (malagasy). The soils are formed under tropical humid or semihumid climate, however, due to the influence of parent material, relief, etc, there is not yet the stage of allitization, and no migration and illuviation of clay in the profile have been found. Below the A horizon is the cambic B horizon with yellow brown color, a clay content more than that in the soil layer below it, and blocky structure. The soils contain a large amount of weatherable minerals, clay fraction is dominated by 2:1 clay minerals, CEC is about more than 16 me/100g, with higher content of nutrients, the soils are higher in fertility than the latosols and red earths. Tropical and subtropical brown soils can be subdivided into eutric brown soils, dystric brown soils, humic brown soils and ferrallic brown soils.

6. **Tropical and subtropical semiarid red brown soils** The soils are mainly spread in Senegal, Mauritania, Ethiopia, Kenya, Somalia, Mozambique, Botswana, Tanzania, Malawi, Swaziland, Rhodesia, Southwest Africa and Madagascar (Malagasy). The soils are formed under tropical semiarid climate with the distinct alternation of humid and arid seasons and a precipitation of about 500 mm. The vegetative cover is shrubby dry steppe. There is no distinct allitization and clay migration and illuviation in the soils. Below A horizon is a cambic B horizon with dark brown to dark red color, a clay content higher than the lower horizon and indistinctly blocky structures. There is a large amount of weatherable minerals in the soils, and a considerable amount of 2:1 clay minerals in the clay fraction. With the medium to high CEC, the soils have a base saturation percentage of 50%, and a weakly acid to neutral reaction, no calcareous horizon, but the soils have distinct calcium accumulation under the influence of parent materials that are rich in bases or in some areas transiting toward desert with a precipitation of less than 500 mm. Except the light-colored A horizon and cambic B horizon, there is calcic or gypsic horizon or a horizon of soft powdery lime accumulation, or at least there exists a calcareous horizon within a depth of 20–50 cm below surface. The red brown soils are generally used as pasture. However, owing to their higher content of nutrients, the soils can be used for planting millet and cotton under the condition of irrigation. Some of the soils are clayey in texture and liable to crack when dry, and poor in water retention. The soils can be subdivided into tropical and subtropical semiarid red brown soils and tropical and subtropical semiarid calcic red brown soils.

7. **Tropical mountainous dystric humic shallow soils (Rankers)** The soils are widespread on the upper part of the mountains in Tanzania, Kenya, Uganda, Zaire and Zambia. The soils are developed under high mountain climate with low temperature and abundant rainfall. The vegetative cover is meadow shrubs. The parent rocks are usually hard with very weak weathering. There are distinct organic

matter accumulation and base eluviation in the soils. The soils have only a dark dystric A horizon with a thickness of no more than 25 cm.

8. **Mediterranean red brown earths** The soils are mainly spread coastal region of the Mediterranean Sea in northwest Africa including Morocco and Algeria and South Africa. The soils are developed under the mediterranean climate that is mild and humid in winter and hot and arid in summer, with an annual mean temperature of 16–20°C, annual precipitation of 500–900 mm. The vegetative cover consists of Mediterranean evergreen and semi-deciduous forests or shrubby forests. The parent materials are mostly weathering materials of limestone. The allitization is weak. Below A horizon is the argillic B horizon, in which the leaching process of bases is delayed due to the parent materials rich in calcium carbonate, but iron oxide has been accumulated. The soils are dark brown to dark red in color. The clay fraction consists of 2:1 clay minerals associated with 1:1 clay minerals. The soils have a clay texture, a CEC being higher than that of red earths and a base saturation of more than 50%. They are deficient in organic matter and nitrogen and liable to suffer from drought, but with higher potential fertility and thus can be used for planting cereal crops and subtropical fruit trees such as grapes, citrus, etc.

9. **Subtropical and mediterranean mountain brown earths** The soils are mainly distributed in the Drakensberg Mts. in South Africa and the Atlas Mts. in North Africa. The soils are developed under subtropic mountainous mild and humid climate with an annual mean temperature of 15°C and annual precipitation of 1000 mm. The vegetative cover consists of deciduous broad-leaved forests, coniferous-broad leaved forests or steppe and shrubs. There is no allitization, but distinct migration and illuviation of clay exist. Below A horizon is argillic B horizon that is brown in color and blocky in structure, sometimes, albic horizon E or rusty streaks occur on B horizon. Base saturation is higher than 50%. The soils is higher in fertility, suitable for various cereal crops. However, the soils are liable to suffer from erosion, soil conservation should be stressed.

10. **Mediterranean mountain chestnut soils** The soils are mainly spread on the plateaus in the Atlas Mts. such as Morocco. The soils are developed under mediterranean semiarid climate with stronger continental characteristics being hot in summer and cold in winter, with an annual precipitation of only 200–300 mm. The vegetative cover consists of shrubby steppe. The calcification is very distinct. The soils have a dark A horizon rich in bases, chestnut color, base saturation of more than 50%. Below A horizon is the calcic or gypsic horizon, or soft powdery lime accumulation horizon. The soils are suitable used for pasture, however, most of them are reclaimed for farming fields of cereal and cotton.

11. **Mediterranean semiarid red brown soils.** The soils are mainly spread

in Algeria, Morocco, Tunisia and Niger, and developed under mediterranean semiarid climate with stronger continental characteristics being hot in summer and cold in winter, with an annual precipitation of 500 mm or less. The vegetative cover consists of xerophytic forests or shrubby steppe. There are no allitization and distinct migration and illuviation of clay in the soils. Organic matter content is higher in A horizon, amounting up to 3%. Below A horizon is the cinnamon cambic B horizon with nutty or blocky structures, weak weathering process and abundant minerals that are liable to be weathered. There are a considerable content of 2:1 clay minerals and a small content of free iron oxide in clay fraction, with the medium and high CEC, a base saturation of more than 50%, a weakly acid to neutral reaction. No calcareous reaction is found, but calcification often occurs when the parent materials are derived from basic igneous rocks or limestone. There is calcic horizon or soft powdery lime accumulated in the profile, with calcareous reaction at least within the soil layer of 20 to 50 cm below the surface. In the soil complexes,exchangeable calcium and magnesium are dominant, with a base saturation of about 80%. The soils are more fertile, suitable for planting various crops. Those with calcic pan are often suitable for pasture. The soils may be subdivided into Mediterranean red brown soils and Mediterranean calcic red brown soils.

12. **Tropical and subtropical semidesert arid soils** The soils mainly distributed in the transitional regions from desert to shrubby steppe such as Algeria, Morocco, Tunisia, Egypt, Libya, Chad, Sudan, Ethiopia, Kenya, Somalia, Angola, Southwest Africa and South Africa. The soils are developed under temperate arid climate, with an annual precipitation of less than 150 mm. The vegetative cover consists of semidesert shrubby steppe. The soils are dominated by physical weathering, with distinct calcification. Semidesert soils are characterized by the moisture regime of arid soils according to the measurement in the period when the temperature of the soil of 50 cm from soil surface is higher than 5°C in half of the period (days). the soils deficient in available water, while according to the measurement in the period when the temperature of the soil of 50 cm is higher than 8°C, the time in which there is available water in the soil is no more than 90 days, in the areas where the difference of mean temperature between summer and winter is 5°C or more and the annual mean temperature is 22°C, in the 3 months after winter solstice, the period when there is not any moisture in soil control section amounting to 60 days. The surface soil is the weakly developed A horizon with the organic matter content of lower than 1%. Below A horizon is the cambic B horizon, with a calcic or gypsic horizon. Sermidesert arid soils generally provide forage grasses of poor quality or trees which produce rosin, perfume and gum arabic. However, the soils are of potential fertility, and can be used to plant cotton or other crops under irrigation, in this condition, the secondary salinization

should be controlled. The soils can be subdivided into Haplic semidesert arid soils, Calcic semidesert arid soils and Gypsic semidesert arid soils.

13. **Tropical and subtropical desert soils** The soils are mainly spread in the Sahara Desert, Namib Desert and Somalia Desert including Morcco, Algeria, Liberia, Spanish Sahara, Mauritania, Mali, Niger, Chad, Sudan, Somalia, Ethiopia, Kenya, Angola and Southwest Africa. The soils are developed under warm and extremely arid climate, with an annual precipitation of only several tens mm, even without any rainfall year round. The vegetative cover consists of semidesert sparse shrubby steppe or without any vegetation. The soils are dominated by physical weathering with distinct calcification. The soil mositure regime is similar to semidesert arid soils, with an even more arid condition. Surface soil is the very weakly developed light colored A horizon, with an organic matter content of less than 0.5%. Below A horizon is the cambic B horizon, with a calcic or gypsic horizon. The soils can be further distinguished into Haplic desert soils, Calcic desert soils and Gypsic desert soils.

14. **Limestone soils** The soils are mainly spread in Morocco, Algeria and Tunisia. The soils are developed on limstone under more arid climate. The vegetative cover is predominated by herbaceous plants. The soils have a marked humus accumulation, in the dark A horizon, the carbonate content is more than 40%, or the eutric dark A horizon is directly developed on the parent material with a carbonate content of more than 40%. The soils can be used for various crops under irrigation condition.

15. **Saline soils** The soils are mainly spread in Algeria, Tunisia, Libya, Mauritania, Nigeria, Ethiopia, Kenya, Botswana and Southwest Africa. The soils are developed in the areas of poor drainage under arid or semiarid climate. There is marked salinization, electric conductivity of the saturated extract of soil is higher than 15 mΩ/cm (25°C), if the soil pH (H_2O, 1:1) is higher than 8.5, the electric conductivity of saturated extract of soil is 4mΩ/cm. Plant growth on these soils is severely inhibited. The properties of the soils differ due to different genetic conditions. The soils are subdivided into orthic saline soils, takyric saline soils, gleyic saline soils. The soils can be used for planting rice, cotton, sugarcane, etc. if irrigation–drainage system is provided.

16. **Alkaline soils** The soils are mainly spread in Chad, Kenya, Somalia, Angola and Southwest Africa. The soils developed in the areas of poor drainge under arid or semiarid climate. There is marked alkalization. Below A horizon is the natric B horizon with alkaline reaction, prismatic structure or block structure with tongue–like mottlings. In exchangeable complexes, sodium saturation percentage is more than 15%, or exchangeable Mg plus exchangeable Na is higher than exchangeable Ca plus exchangeable acid (during pH 8.2). The soils are strong in alkalinity and

poor in physical properties. Plant growth on the soils is severely inhibited. However, through improvement of salt-leaching in combination with application of chemicals, the soils can be used to plant rice, cotton, sugarcane, etc.

17. **Planosols** The soils are mainly spread in Lesotho, South Africa, Morocco, Chad, Tanzania, etc. They are developed under humid or semihumid climate with a precipitation of 500–1000 mm. The vegetative cover consists of high grass savanna. The relief is flat. Parent materials are clayey weathering materials of sedimentary rocks covered by aeolian deposits or colluvial deposits. With distinct marked side bleaching or reducing iron in profile. A horizon has a brown or dark grey color, light texture and a clay content of less than 20%. Below A horizon is the albic E horizon with a whitish grey color, and pseudogley mottles or Fe–Mn concretions in the lower part. Below E horizon is the argillic horizon of which the texture becomes clayey markedly, with a clay content being 2 times that of A horizon, a poor permeability of water, a yellow brown color and the blocky or prismatic structures. A horizon and E horizon are neutral to weakly acid in reaction, While B horizon is weakly alkaline in reaction. Planosols also solodic soils that are developed through solodization process. Sodium saturation in exchangeable complexes in B horizon is more than 6%. Planosols can be used for pasture, or planting cereal crops under the conditions of mechanized cultivation and fertilization.

18. **Tropical lowland humic podzols** The soils are mainly spread in Angola and Zambia. They are developed under tropical humid and semihumid climate, in the areas with flat relief, on sandy parent materials, with a groundwater table of 200 cm below surface. The vegetative cover consists of sparse forest grassland and shrubs or forest swamp. Podzolization process in the soils is remarkable. Surface soil is a raw humus horizon under which there is a whitish grey albic horizon and a dark brown spodic B horizon (humic Fe, Al illuvial horizon). Sometimes, rusting mottles can be seen in the lower part of B horizon. The soils are strongly acid in reaction, deficient in nutrients and unfavorable for plant growth. The soils can be used to plant crops or develop forest after improvement.

19. **Gley soils** The soils are mainly distributed in depressions of Zaire, Angola, Zambia, Nigeria, Mali, etc. The soils are influenced by ground water, with marked gleyization process and hydromorphic properties within a depth of –050 cm below surface. The soils are developed on unconsolidated parent materials except alluvial materials. Below A or H horizon is the cambic B horizon manifesting reducing process or with the evidence of reduction and segregation of iron. The fertility of the soils, especially the periodical waterlogged gley soils, is higher. Most of the soils are used for planting rice, or sugarcane and banana when they are improved by drainage. Gley soils can be subdivided into orthic gley soils, humic gley soils and plinthic gley

soils.

20. **Histosols** The soils are mostly spread in depressions or swampy lands of Zaire and Zambia, and part of them can also be found on the top of mountains. The vegetative cover consists of swampy sward or swampy forests and bryophyte. Owing to long term submergence and uncomplete decomposition, a large amount of organic matter is accumulated, even formed into peat. In the upper soil of 50 cm (or the soil of 30 cm by artificial drainage), The organic matter content is more than 20% (on sandy parent material) or 30% (on clayey parent materials). Histosols are suitable for planting vegetables and banana after reclamation. However, in the process of drainage, the soils are liable to become acidification and oxidation, which often results in the irreversible changes of physical properties of organic colloids, especially the water retention ability of the soils. Decomposition of organic matter in soil may also bring about subsidense and building break.

21. **Vertisols** The soils are mostly spread in Morocco, Algeria Tunisia. Mali, Niger, Chad, Sudan, Ethiopia, Somalia, Upper Volta, Nigeria, Togo, Ghana, Cameroon, Central Africa, Uganda, Kenya, Tanzania, Mozambique and Angola. The soils are formed under distinct alternation of arid and humid seasons, with an annual mean temperature of 15.5–26.5°C and annual precipitation of 300–1000 mm. The vegetative cover consists of scrub and high grass savanna. The parent materials are mostly Holocene transported deposits or colluvial deposits of basic rocks weathered in situ. The soils are mainly developed on the depressions with an altitude lower than 300 m and lower part of surrounding slopelands. A horizon is more than 20 cm, with a lower organic matter content and a dark color. In the upper part of the profile (0–50 cm), clay content is more than 30%. In dry season of most years, the cracks of the soil can extend from the soil surface downwards to the depth of 50 cm, with a width of more than 1 cm, except on the soil being irrigated. The region of vertisols is characterized by the galgai microrelief. The whole profile is of prismatic or coarse blocky structure, sometimes, with fine structures on the surface soil. the soils contain more minerals that are liable to be weathered. The clay fraction consists of 2:1 clay minerals, especially montmorillonite and mixed-layer minerals. The soils have a greater swelling, higher CEC, a base saturation percentage of more than 50% and a neutral or slightly alkaline reaction, some of them have calcic concretions. The soils of which part is the major farming soils are suitable for cereal crops (corn, wheat, sorghum, rice), tobacco and forage crops. Vertisols can be subdivided into orthic vertisols and hydromorphic vertisols.

22. **Andosols** The soils derived from volcanic ash are mainly spread in Zaire, Kenya, Tanzania, Uganda, Rwanda, Cameron, Madagascar, Mascaren Is., Verde Is., Canary Is., Princepe I., Sao Tome, Comoros, which are mountain lands or

islands influenced by volcanic activity. The soils have a medium silty texture in its upper 35 cm, sandy and gravelly fractions contain more than 60% of glassy volcanic ash, volcanic cider or other glassy volcanic detritus, clay fraction is dominated by amorphous materials (allophone). The soils have a very high CEC, OM content, porosity and water retention ability, but a low bulk density, and weak genetic process. There are only a A horizon and a cambic B horizon in the profile. The use pattern of the soils varies with their altitudes, those with highest altitude are generally used for pasture or forestry, those with higher altitude for cereal crops, while those with medium and lower altitude for planting banana and coffee.

23. **Arenosols** The soils are mostly spread in Mali, Mauritania, Niger, Senegal, Chad, Nigeria, Kenya, Somalia, Sudan, Congo, Zaire, Angola, Botswana, Mozambique, South Africa, Southwest Africa and Madagascar. Arenosols are derived from unconsolidated parent materials containing sands (0.05–2) mm of more than 65%, clay (< 0.002 mm) of less than 18%, which are mostly aeolian materials partly with weathered materials of sandstone or ancient transported materials (excluding recent alluvium). They are developed under semihumid and semiarid climate with an annual precipitation of 200–600 mm. The vegetative cover consists of sparse grassland. Due to the parent materials with higher resistance to weathering, the soil forming process is very primary. Generally there is only a light colored A horizon, under which there are some characteristics of cambic B horizon or argillic B horizon in the profile, or the soil layer of 0–50 cm consists of albic materials. The soils of which the fertility varies with different parent materials are generally used for pasture, but they can also be used to plant millet or cotton when irrigation is provided. Arenosols can be subdivided into cambic arenosols, luvic arenosols, ferralic arenosols and albic arenosols.

24. **Lithosols** The soils are widespread in Morocco, Algeria, Tunisia, Libya, Sudan, Ethiopia, Chad, Niger, Mali, Mauritania, Sahara, senegal, Guinea, Sierra Leona, Togo, Nigeria, Kenya, Uganda, Somalia, Tanzania, Mozambique, Zambia, Angola, Southwest Africa, South Africa and Madagascar. The soils have a very shallow soil layer with a depth no more than 10 cm, due to the hard parent rocks.

25. **Regosols** The soils are mainly spread in Algeria, Mauritania, Mali, Guinea, Upper Volta, Benin (Dohomey), Nigeria, Niger, Chad, Sudan, Egypt, Ethiopia, Somalia, Henya, Uganda and Madagascar. The soils are developed on unconsolidated parent materials that are not recent alluvium. The soil forming process is very primary dur to arid and cold climate, slope relief, erosion and parent materials being stronger resistance to weathering. The soils have only a light colored A horizon. According to the difference of parent materials, the soils can be subdivided into eutric regosols, dystric regosols and calcaric regosols.

26. **Fluvisols** The soils are mostly spread in the valleys of the Nile, Niger, Sene-

gal and Volta Rivers and the lowlands in coastal region. The soils are developed on the parent materials that is still influenced by the recent alluvium including fluvial, marine, lacustrine and colluvial deposits. Due to continuous supplement of new deposits, the age of the soils is short and the soil forming process is primary. The soils have only a A horizon or H horizon, sometimes with a layer containing sulfur. The soils are commonly high in fertility, suitable for planting various crops. However, rice can be grown on the acid-sulfate fluvisols only after their improvement. According to the parent materials, the soils can be subdivided into eutric fluvisols, dystric fluvisols, calcaric fluvisols and thionic fluvisols.

In this soil map, the mapping units (delineations) are expressed with the dominant soil units, if necessary, also with soil complexes, and the soil units are represented by colors and big numerals, the subdivided soil units are expressed with the smaller numerals that follow the big numerals. The colors of delineations of soil complexes are expressed with the colors of dominant soil units, the soil complex dominated by lithosols, however, are expressed with color streaks.

There are various symbols in the map except color numerals, The symbols include two kinds: one indicates the soil characters in relation to agricultural production, which is designated as "soil phase". Another one indicates non-soil parts, which is designated miscellaneous lands. Soil phase is the subdivision of soil unit according to the valid characteristics in soil utilization and management; however, these characteristics are not used as diagnostic characteristics for the subdivision of soil unit in the map, (because there are not yet so enough data in this respects that these characteristics can not be taken as diagnostic charcteristics).

The soil phases in the map are as follows:

Surface gravel phase denotes that there are gravels, rocks, boulders or outcrops of rocks on the soil surface;

Litho-subsoil phase denotes that there are continuously consolidated and hard rocks in the soil layer of 0-50 cm;

Ferruginous concretion phase denotes that in the soil layer of 0-100 cm, there are concretions of iron oxides or plinthite or other coarse fragments with a thickness of more than 25 cm and a volume of more than 40%, but being not continuously consolidated as iron pan;

Petrocalcic phase denotes that there is calcic pan of which the upper part is in the soil layer of 0-100 cm, the calcic pan is a continuously cemented or consolidated layer of calcium carbonate or carcium and magnesium carbonates;

Petrogypsic phase denotes that there is a gypsic pan of which the upper part is in the soil layer of 0-100 cm, the gypsic pan is the layer cemented by gypsum;

Petroferric phase denotes that there iron pan of which the upper part is in the

soil layer of 0–100 cm, the iron pan is a layer of continuous consolidated soil particles cemented by ron without any organic matter;

Duripan phase denotes that there is a hard pan of which the upper surface is in the soil layer of 0–100 cm, the hard pan is the subsurface layer of soil cemented by silicon, thus it is not dissolved in hydrochloric acid;

Saline phase denotes that in the soil layer of 0–100 cm, the electric conductivity of the saturated soil extract is higher than 4/cm;

Alkaline phase denotes that in the soil layer of 0–100 cm, the ESP of the soil is higher than 6%.

II. Legends of the Map

Soil Units

1. Latosols
   - 1_1 Orthic latosols
   - 1_2 Xanthic latosols
   - 1_3 Rhodic latosols
   - 1_4 Humic latosols
   - 1_5 Plinthic latosols
2. Lateritic Red Earths
   - 2_1 Eutric lateritic red earths
   - 2_2 Dystric lateritic red earths
   - 2_3 Humic lateritic red earths
3. Red Earths
   - 3_1 Orthic red earths
   - 3_2 Ferric red earths
   - 3_3 Plinthic red earths
   - 3_4 Surface gleyic red earths
4. Tropical and Subtropical Weakly Allitic Soils
   - 4_1 Tropical and subtropical ferric weakly allitic soils
   - 4_2 Tropical and subtropical plinthic weakly allitic soils
   - 4_3 Tropical and subtropical surface–gleyic weakly allitic soils
   - 4_4 Tropical and subtropical rhodic weakly allitic soils
   - 4_5 Tropical and subtropical calcic weakly allitic soils
5. Tropical and Subtropical Brown Soils
   - 5_1 Tropical and subtropical eutric brown soils
   - 5_2 Tropical and subtropical dystric brown soils
   - 5_3 Tropical and subtropical humic brown soils
   - 5_4 Tropical and subtropical ferrallic brown soils
6. Tropical and Subtropical Semiarid Red Brown Soils

6_1 Tropical and subtropical semiarid red brown soils

6_2 Tropical and subtropical semiarid calcic red brown soils

7. Tropical Mountainous Dystric Humic Shallow Soils (Rankers)
8. Mediteranean Red Brown Earths
9. Subtropical and Mediterranean Mountainous Brown Earths
10. Mediterranean Mountainous Chestnut Soils
11. Mediterranean Semiarid Red Brown Soils

11_1 Mediterranean semiarid red brown soils

11_2 Mediterranean semiarid calcic red brown soils

12. Tropical and Subtropical Semidesert Arid Soils

12_1 Tropical and subtropical semidesert haplic arid soils

12_2 Tropical and subtropical semidesert calcic arid soils

12_3 Tropical and subtropical semidesert gypsic arid soils

13. Tropical and Subtropical Desert Soils

13_1 Tropical and subtropical haplic desert soils

13_2 Tropical and subtropical calcic desert soils

13_3 Tropical and subtropical gypsic desert soils

14. Limestone Soils
15. Saline Soils

15_1 Orthic saline soils

15_2 Takyric saline soils

15_3 Gleyic saline soils

16. Alkaline Soils
17. Planosols

17_1 Planosols

17_2 Solodic planosols

18. Tropical Lowland Humic Spodosols
19. Gley Soils

19_1 Orthic gley soils

19_2 Humic gley soils

19_3 Plinthic gley soils

20. Histosols
21. Vertisols (Black Clay Soils)

21_1 Orthic vertisols

21_2 Hydromorphic vertisols

22. Andosols
23. Arenosols

23_1 Cambic arenosols

23_2 Luvic arenosols

23_3 Ferralic arenosols

23_4 Albic arenosols

24. Lithosols

25. Regosols

25_1 Calcic regosols

25_2 Eutric regosols

25_3 Dystric regosols

26. Fluvisols

26_1 Calcaric fluvisols

26_2 Eutric fluvisols

26_3 Dystric fluvisols

26_4 Thionic fluvisols

Soil Phases


Surface gravel


Litho subsoil


Ferruginous concretion

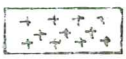

Petrocalcic


Petrogypsic


Petroferric


Duripan


Saline


Alkaline

Miscellaneous Lands


Sand dunes or mobile sand dunes


Rock debris accumulation or desert debris


Salt flats

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