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学 位 論 文 要 旨

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題目: Soil Development and Fertility Characteristics in West African Lowlands
西アフリカの低地における土壌生成と肥沃度特性

Physicochemical, mineralogical and morphological characteristics of soils were investigated intensively in inland valleys of Southeast Nigeria as well as extensively in lowlands (inland valleys and flood plains) of West Africa to gain basic information towards the sustainable rice production in the region.

First of all, mineralogical composition in the clay fraction (< 2 μm) of 87 topsoil (0–15 cm) samples from inland valleys and flood plains in seven West African countries, namely Cote d'Ivoire, Ghana, Guinea, Mali, Niger, Nigeria and Sierra Leone, was examined using X-ray diffraction analysis (Chapter 2). The clay fraction of these samples consisted of 68.4% of 7 Å minerals (low-activity clays such as kaolin minerals), 26.6% of 14 Å minerals (relatively high-activity clays such as smectite and vermiculite) and 5.1% of 10 Å minerals (illite or clay micas), and showed a high variability in the composition. With respect to the soil material classification based on the relative abundance of these three types of minerals, Type 7 (rich in 7 Å minerals) accounted for 42.5% of the total samples, while 39.7% of all the samples were Type 7-10 and 7-14 with a predominance of 7 Å minerals and with negligible amounts of 10 and/or 14 Å minerals, respectively. Type 14-7 accounted for 17.2% of the total samples and was only recorded in Nigeria. The other clay mineral types (i.e. Types 7-10-14, 14, 10, 10-7, 10-14 and 14-10) that were composed mainly of 10 and/or 14 Å minerals, were hardly found in the West African lowland soils, whereas Types 14 and 7-10-14 were observed in a vertic soil of Southeast Ghana and in northern Ghana, respectively. In contrast, no significant differences in the clay mineralogical composition were found between the IV and FP soils. Geographical distribution of the soil types showed that the soils in the eastern part of West Africa contained more 14 Å and 10 Å minerals than those in the western part. Although the effect of agro-climatological differences was not conspicuous, soils in the Sahel and Sudan savanna zones showed a higher percentage of 14 Å clay minerals than those in the Guinea savanna and equatorial forest zones. The findings were as follows: (1) the low fertility status of the lowland soils in the region was closely associated with their poor mineralogical characteristics (i.e. predominance of 1:1 type clay minerals and a lower amount of 2:1 type clay minerals), (2) no significant differences in the mean clay mineralogical composition were observed between the IV and FP soils, indicating that the lower fertility of the IV soils mainly resulted from lower clay content, (3) the clay mineralogy of the West African lowland soils was more strongly influenced by the nature of the parent materials than by the climatic conditions and relief.

Secondary, the fine-sand fraction (20-212 μm) of the samples used in Chapter 2 was examined by the x-ray diffraction analysis and petrographic investigation so as to elucidate their primary mineral composition (Chapter 3). The mineralogical composition in the fine-sand fraction was predominantly consisted of quartz. A small amount of feldspars was also usually observed but other weatherable minerals were almost or completely absent in these samples. These findings suggested that quartz, a highly resistant mineral to the weathering, predominantly remained in the lowland soils of West Africa resulting from severe weathering over a long period.

Subsequently, physicochemical and morphological properties of the soils were investigated in two inland valleys from Abakaliki and Bende, Southeast Nigeria, where the soils derived from shale materials (Chapter 4). The result of particle size analysis suggested that the soils at both sites were fine-silty, fine-loamy or clayey and thus would have the ability of retaining high amount of water. On the other hand, the higher content of the clay and silt in the Abakaliki soils would enhance much more water retention than the Bende ones. The soils in Abakaliki, except for some subsoil horizons, generally had acidic reactions, low contents of exchangeable bases (Ca, Mg, K and Na) and high amounts of exchangeable acidity (Al and H) for which leaching effects under high precipitation in the area would be implicated. Bray-1 P values of these soils were generally low under such acidic conditions, while organic C and total N were found at relatively high levels in particular at the surface horizons reflecting large biomass production under humid climate. The Bende soils showed similar chemical properties to Abakaliki except for relative accumulation of exchangeable bases throughout the profile on the downslope possibly due to the rolling topography. This suggested that geological fertilization, i.e. afflux of nutrients released during the soil formation in the upland into the lowland, was more beneficial in Bende than Abakaliki. From the findings of the present study, we concluded that the soils both in Abakaliki and Bende had good texture for the *sawah* development but their poor chemical properties would be constraints for the agricultural production.

Finally, clay mineralogy and parent material nature were investigated in the study sites of Chapter 4 (Chapter 5). The clay-free size analysis in collaboration with the field morphological observation indicated lithologic discontinuities at subsurface horizons in a couple of pedons in Abakaliki. In contrast, all the pedons in Bende could consist of a homogenous parent material. Petrographic analysis revealed that quartz predominantly comprised the fine-sand fraction, while relatively weatherable minerals such as biotite, muscovite and feldspars hardly coexisted in these soils. This could reflect intensive and prolonged weathering processes under the humid climate in the region. The clay mineralogy of the soils was a mixture of kaolinite, vermiculite, smectite, smectite-illite interstratified (S/I), hydroxyl-Al interlayered 2:1 clays (HICs) and illite along with fine-sized quartz in Abakaliki. Vertical distribution of these minerals in the soils of Abakaliki showed that the mineralogical composition was little affected by the lithologic discontinuity. In contrast, smectite, which was interlayered with hydroxyl-Al to a minor extent, and kaolinite were predominant in the soils of Bende. The content of HICs remarkably decreased with depth in the soil profile at both sites suggesting natural occurrence of HICs. This could be due to interlayering of hydroxyl Al in 2:1 phyllosilicates such as smectite and vermiculite under hydromorphic conditions, which was involved in the *ferrolysis* process. Lessivage was not significant at both sites, whereas high water table and/or saturated moisture conditions have slowed the in situ weathering of minerals so that weatherable minerals still persist in the soils. On the other hand, clay lattice destruction under the *ferrolysis* would reduce a nutrient holding capacity of these soils regardless of their relatively high contents of 2:1 type phyllosilicates which was originated from shale as the parent material in the region.