MINERALOGISCHE ONDERZOEKINGEN AAN KLEIEN EN KLEIMINERALEN

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The study of the clay fraction of soil has for years experienced great difficulties. This fraction, of which the particle size is less than 2 μ, is as a rule not a simple substance but a mixture of various constituents which cannot at all or only partly be distinguished by means of the usual physical and chemical methods. For this we refer to the first publication of this series [EDELMAN, VAN BAREN and FAVEJEE (1)].

The X-ray examination according to the Debije-Scherrer-Hull method has made it possible, since about 1930, to obtain a better conception of the mineralogical composition of the clay fractions. From numerous investigations, many of which are mentioned in the aforesaid publication, it has appeared that only a limited number of minerals occur in clay fractions, i.e. besides quartz and muscovite the clay minerals in a narrower sense, viz. kaolinite, halloysite (metahalloysite), and the minerals of the montmorillonite group (montmorillonite, beidellite and nontronite).

The clay fractions of which X-ray photographs have hitherto been made concerned, in the main, soils from the temperate areas. Only JACOB, HOFMANN, LOOFMANN and MAEGDEFRAU (6) mention in their publication the results of an examination of some soil samples, not further defined, from West-Africa, the Philippines and Java. In the soil sample from the first mentioned area kaolinite was chiefly found, while the samples from the two other tropical areas proved to contain mainly montmorillonite. With this as yet slight and not very systematically obtained knowledge of the clay minerals of tropical soils there was every reason to examine a number of soil samples from Java by X-rays and this time according to the soil type. Not only in order that the fundamental knowledge of the composition of the clay fraction might be enriched, but also as a help in classifying the various soils the X-ray investigation may make an important contribution.

This examination, made by the present writers during the European leave of the former in the Geological Institute at Wageningen in 1938 [for the method used we refer to: FAVEJEE (2)] bears the character of a general orientation and is to be considered as a forerunner of the more systematical examination of Indian soils, which will shortly be taken up in the Soil Science Institute at Buitenzorg.

Of the principal soil types found on *Java*, viz. lateritic soil, „mergelgronden" (Regur), limestone soils, mountain soils and the white and grey earths, one or more samples were examined. In the table below these samples are indicated by the consecutive numbers under which they are preserved in the collection of the Soil Science Institute at Buitenzorg, and arranged according the soil type to which they were reckoned in the soil survey of Java, while at the same time the origin is given.

TABLE

Number of the soil sample	Soil type	Origin
Lateritic soils		
12441/449	Red old lateritic soil derived from andesitic tuff	Res. Batavia
12647	Red old lateritic soil derived from tefritic tuff	Res. Semarang
28363	Red old lateritic soil derived from dacitic tuff	Res. Batavia
28486	Yellow old lateritic soil derived from dacitic tuff	Res. Bantam
31991	Yellow fine quartz-sandy old lateritic loam	Res. Batavia
30280	Red lateritic quartz-sandy soil	Res. Japara-Rembang
„Mergelgronden" (Regur)		
11863	Yellow young marl soil	Res. Pekalongan
12853	Black old heavy soil derived from calcareous tuff	Res. Madioen
12461/523	Black old marl soil	Res. Soerakarta
30277	Grey old quartziferous soil derived from calcareous tuff	Res. Japara-Rembang
33193	Black old marl soil	Res. Soerakarta
Limestone soils		
9170	Reddish brown limestone soil	Res. Soerakarta
19208	Reddish brown limestone soil	Res. Djocjakarta
27009	Blackish brown limestone soil	Res. Soerakarta
27028	Black limestone soil	Res. Soerakarta
Mountain soils		
30283	Yellow mountain soil derived from andesitic tuff	Res. Buitenzorg
White and grey earths		
28283	White earth derived from dacitic tuff	Res. Bantam
28531	White earth derived from dacitic tuff	Res. Bantam
32328	Quartz silty grey earth	Res. Batavia

Of the above samples the fraction with a particle size smaller than 2 μ was used for the examination.

The separation of this clay fraction took place in Buitenzorg according to the method used in the Soil Science Institute. Preliminary treatment with hydrogen peroxide and hydrochloric acid is not applied. The clay preparations were moistened before the examination and dried at room-temperature above a saturated potassium carbonate solution. As the spacing of the (001) interference characteristic for montmorillonite, is strongly dependent on the water-content, drying is desirable under these circumstances [FAVEJEE (3)].

The clay fractions of the soils, which, as has been said, were classified as *lateritic soils* in the soil survey turned out to contain mainly kaolinite ($Al_2O_3.2\ SiO_2.2\ H_2O$), except number 31991. The clay preparations of the samples 28363, 28486, and 30280 showed at the same time admixture of quartz, if only in a small degree. On the X-ray pattern of the clay fractions of the two dacitic soils, the numbers 28363 and 28486, the diffraction line d = $\pm$ 14 Å characteristic for montmorillonite ($Al_2O_3.4SiO_2.H_2O.nH_2O$), was still visible, which points to traces of this clay mineral being present.

The clay preparation of number 31991, from a yellow fine quartz-sandy old lateritic loam, from the Krawang-area, showed a different image. Besides much kaolinite, much montmorillonite was here also present, with at the same time an admixture of some quartz. The high content of montmorillonite is possibly caused by the sediment of the water of the Tjitaroem, with which the soil, from which the examined sample derives, is regularly irrigated. The high value of adsorption capacity of the clay fraction agrees with this content. This value, usually for the clay fraction of lateritic soils below 20 milli equivalents per 100 grams, is for this clay fraction 45 milli equivalents.

The clay fractions of the examined „*mergelgronden*" (Regur) all show in their X-ray photographs chiefly the lines of montmorillonite. The residual black old heavy soil derived from calcareous tuff, number 12853 (from the surroundings of Ngawi), appeared to contain exclusively this clay mineral. In the other preparations there occurred a slight admixture with kaolinite (or metahalloysite), while in the pattern of the clay fraction of the grey, old quartziferous soil derived from calcareous tuff, number 30277 (from the surroundings of Blora) also the lines of calcite and quartz were visible.

The X-ray photographs of the clay fractions of three of the four examined limestone soils, i.e. of those which react more or less acidly, chiefly show the lines of metahalloysite ($Al_2O_3.2SiO_2.2H_2O$). The sample of the blackish brown limestone soil (number 27009), which has an alkaline reaction, contains on the other hand chiefly montmorillonite as clay mineral, while, besides, some kaolinite (or metahalloysite) still occurs.

The clay preparation of the mountain soil, number 30283 (from Patjet in the neighbourhood of Tjiandjoer) only contained metahalloysite.

In the sample of quartz silty grey earth (Nr. 32328), kaolinite as well as montmorillonite occurred as clay constituent; at the same time a fairly large admixture of quartz was established.

The two samples of white earth derived from dacitic tuff from the residency of Bantam showed a typical difference as compared with the other samples examined. Besides much metahalloysite and little montmorillonite α-cristobalite could be identified in number 28283 little, in number 28531 even rather much.

From the *results* obtained it appears that in the samples, at present examined, three known clay minerals were found as well as a mineral, that was not yet with any degree of certainty detected in clay fractions, viz. α-cristobalite [only HOFMANN, ENDELL and WILM (5) have clearly observed the interferences of β-cristobalite and faintly those of α-cristobalite, besides those of montmorillonite, on the X-ray photograph of a bentonite from Rumania]. In contrast with soils from the temperate areas, e.g. from the Netherlands [see FAVEJEE (2), EDELMAN, VAN BAREN and FAVEJEE (1)], the clay fraction of the Indian soils, as far as they belong to one type, is chiefly composed of one clay mineral. The occurrence side by side of more types and the mixture with detrital minerals are of little importance in the examined cases, except in the lateritic loam from Krawang and the white earths derived from dacitic tuff from Bantam.

It is remarkable, that the three main soil types of Java, the lateritic soil, the ,,mergelgrond'' (Regur) and the limestone soil, which mutually show great differences as regards manner of origin and appearance as well as in physical and chemical properties, are each characterized by one clay mineral, respectively kaolinite, montmorillonite and metahalloysite. It is not to be expected that in an examination of more material from these soil groups a similar homogeneity will be found in the composition of the clay fraction, because the samples examined must be considered as typical representatives.

In this X-ray examination it has appeared that there is a relation between the type of the soil and the mineralogical composition of the clay fraction, which was to be expected on the strength of former chemical examinations in the Soil Science Institute in Buitenzorg (HARDON (4)). For the classification of soils and in solving soil problems this method of investigation has therefore proved to be of valuable help.

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