
THE MINERALOGICAL COMPOSITION OF SOME CEYLON DRY ZONE CLAYS

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ABSTRACT

THE mineralogical composition of some dry zone clays have been determined by modern physical methods (X-Ray and D. T. A.). Clays of the dry zone contain appreciable amounts of montmorillonite. However, kaolinite is the dominant clay mineral present. Gibbsite is not present in any of the clays examined. Minor amounts of interstratified minerals are present in some clays. Other minerals present include quartz, mica, feldspar and iron oxides. These clays differ considerably from those examined from the wet zone areas where montmorillonite is rare but gibbsite, in appreciable amounts, is commonly present.

INTRODUCTION

Since clay may be formed from rocks of diverse characters, it is natural, that they should differ considerably themselves, both as regards their mineral constituents and their other properties. All, however, are alike in having as their basis some form of hydrated silicate of aluminium.

Clays generally are composed of extremely small crystalline particles of one or more members of a small group of minerals which are known as clay minerals together with quartz, mica feldspar and other mineral substances.

Clays are the characteristic materials of soils and play a fundamental part in the physical and chemical properties of soils and soil fertility.

In this paper no attempt has been made to systematically examine the clays of the dry zone areas of Ceylon. In recent years valuable contributions have been made on various aspects of Ceylon soils by officers of the Land Use Division, Department of Agriculture (Panabokke 1959, Moormann and Panabokke 1961).

During the course of reconnaissance surveys a number of samples of dry zone clays have been collected by the writer and in recent years these clays have been subjected to examination by modern physical methods. The clay materials examined from the northern parts of the dry zone of Ceylon are sufficiently alike and differ considerably from those examined from the wet zone areas. It is therefore considered of value to present an account of the mineralogy of these clays as determined by X-ray and differential thermal analysis (D. T. A.) methods.

CLAY MINERALS

Clay minerals have been studied by scientists for a great many years, but within the last 40 years, as a result of the rapid growth of modern scientific knowledge there has been a tremendous expansion of clay mineral investigations.

The clay minerals are the essential constituents of all soils and shales. They fall into three distinct groups that is, as kaolinite and halloysite (kaolin minerals group or kandites), members of the montmorillonite group (smectite group) and members of the group of hydrous micas including bravaisite (Grim 1953).

Kaolinite characteristically develops in an acid environment. Minerals of the montmorillonite group are characteristic of the weathering of many types of parent material, particularly those of a basic nature which are rich in lime and ferromagnesian minerals. Where the material is less basic they are formed where low moisture conditions prevail, leaching is practically absent and protracted periods of drought occur. Montmorillonite characteristically develops in an alkaline environment.

The intense chemical weathering of rocks in Ceylon has produced soils that are rich in their content of iron and aluminium oxides. The final product of weathering is the result of the degree of influence of climate, vegetation and time of exposure to weathering and topography as it influences drainage conditions on the parent rock. The degree of influence of these factors has given rise to Ceylon soils that have montmorillonite, kaolinite and free oxide types of clay.

Herath (1959) concluded that ferruginous types of lateritic material is extensively developed in the south west sector of the Island and that the aluminous varieties are rare.

GEOLOGICAL SETTING

The whole of Ceylon with the exception of the Jaffna Peninsula and the north west coast, the Jurassic of Tabbowa and small coastal strips elsewhere, consists of Pre-Cambrian crystalline rocks.

The Pre-Cambrian rocks contain essential quantities of amphiboles, pyroxenes and other ferromagnesian minerals. These rocks would normally tend to give rise to soils with montmorillonite as a clay mineral but due to the prevailing physical and chemical environments they have undergone a lateritic type of weathering.

In the northern dry zone area rocks of the Miocene age represented by limestones occur in the north west coastal belt. The limestones extend from the Jaffna Peninsula in the north to about Puttalam on the west coast. This area is confined to the dry zone where the annual rainfall is less than 70 inches. Secondary clay deposits occur in the area. They are rich in lime and are confined to low lying areas and they also occur in beds of ancient tanks.

SAMPLES EXAMINED

A number of samples have been examined from secondary clay deposits formed in areas occupied by the Miocene Jaffna limestone. Differentiation of the face into sections for sampling was based as far as possible on the changing stages of the weathering profile. However sampling was not carried out in a detailed manner and weathering sequences were not always taken to study mineral transformations with depth.

A description of representative samples is given below—Sample No. 3 and No. 4 were collected from near Mankulam and they represent a plastic and a sandy clay. This material contains numerous dark brown to black spots. The plastic clay No. 3 is extremely hard when dry and was taken from about 2 feet from the surface. Sample No. 4 which was more sandy was taken from about 3 feet from the surface.

Sample No. 5 is from Murunkan taken at a depth of about 3 feet from the surface. The material is highly plastic, dark grey in colour and contains nodules of calcareous material. The clay records a high shrinkage and shows extreme cracking when dry. This soil type has been described by Moormann and Panabokke (1961) under the heading Grumasols.

Sample No. 6 was collected from a deep drill hole put down in the Puttalam area. The clay material is fairly consolidated, greasy looking

and has a distinct greenish tint with marked minor striations. This type of clay has not been observed by the writer to occur in any other part of the Island. The clay is interbedded with sandy and clayey material and may occur to depths of about 200 feet from the surface. There is a possibility that this type of clay may be encountered at depths in areas occupied by the Miocene Jaffna limestone.

MINERAL DETERMINATIONS

Clay mineral determinations have been made with X-ray diffraction units and with differential thermal equipment. Table 1 is presented to show the X-ray results of samples examined and the percentages of clay minerals and other minerals found in these soils. Table 2 is presented to show the most dominant and minor minerals identified. Figure 1 is presented to show the results of differential thermal analyses. Vertical calibrations indicate 100°C intervals of temperature to 1000°C.

Montmorillonite is present in appreciable amounts in the clays examined. Montmorillonite is associated with kaolinite in all the samples. Kaolinite is the dominant clay mineral present. Other minerals present are iron oxides, quartz, mica and feldspar. Minor amounts of interstratified minerals are present in sample No. 3. Gibbsite has not been identified in any of the samples examined and this mineral is absent in the dry zone clays.

In examining the dry zone clays by (D. T. A.) methods, samples were passed through a 72 mesh, .5g were used as the charge for each run and calcined alumina was used as a reference material.

Curves presented in Fig. 1 show a characteristic intense endothermic peak between 100 and 200°C. A slight deflection in the curve 5A is seen in the region 600 to 700°C. The final endothermic peak is broadened in all the samples examined. All these phenomena point to the presence of a member of the montmorillonite group of minerals. The endothermic peak in the region 500 to 600°C is due to the presence of kaolinite.

The large irregular exothermic reaction between 200 and 400°C (5 and 4) is due to organic matter and is a characteristic feature in these montmorillonite bearing soils. Most of the organic matter can be removed by treating the sample with hydrogen peroxide and its removal may be observed in the differential thermal curves of treated samples (Fig. 1 curve 5A is a treated sample of Murunkan clay).

DISCUSSION

Many of the clays deposited in the dry zone areas mainly occupied by the Miocene limestone have montmorillonite as a clay mineral. The dominant clay mineral present is kaolinite. From initial studies the montmorillonite group mineral has been identified as montmorillonite. The possibility of nontronite, the iron rich member of the group occurring in these clays must not be overlooked.

The well known physical properties of these clays such as swelling on wetting, high liquid limits, high shrinkage and cracking on drying and high cation exchange capacity also point out to the presence of a member of the montmorillonite group of minerals.

Other minerals present in these clays are minor amounts of interstratified minerals in sample 3. All samples contain varying amounts quartz, mica, feldspar and iron oxides.

Panabokke (1959) concluded that the deeper horizons of soil profiles (dry zone area) contain small amounts of montmorillonite and that the weathering zone is chiefly montmorillonite.

Herath (1959) concluded that gibbsite, goethite and kaolinite are invariably present in soils developed in the south west sector of the Island (wet zone). Montmorillonite is rare. Kaolinite is the common clay mineral (Herath 1963).

From these and other studies it is seen that montmorillonite is a common mineral in soils from the dry zone areas. Kaolinite is the predominant clay mineral. Gibbsite is absent in the soils so far examined. Goethite may be present.

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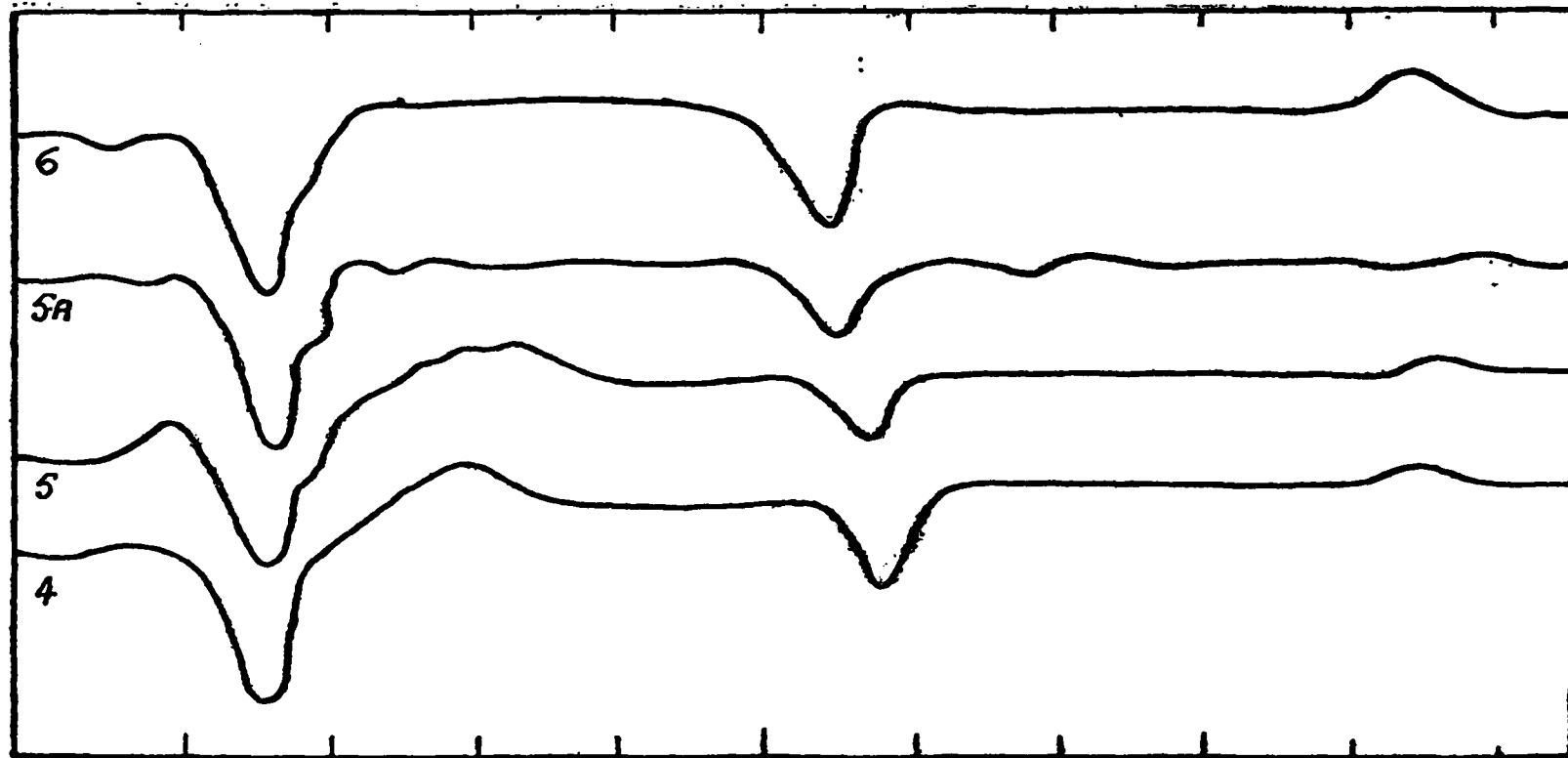


Fig. 1—Differential Thermal curves for Dry Zone Clays

TABLE I
Mineralogical Composition of Dry Zone Clays

<i>Designation</i>			<i>Mankulam</i>		<i>Murunkan</i>		<i>Puttalam</i>	
			3	4	5		6	
Kaolinite	..	..	.. 40	25 ..	40 ..		40	
Gibbsite	..	..	.. —	— ..	— ..		—	
Iron oxides	..	..	.. 5	5 ..	5 ..		5	
Goethite	..	..	.. —	— ..	— ..		—	
Quartz	..	..	.. 10	25 ..	30 ..		35	
Mica	..	..	.. 5	5 ..	— ..		—	
Felspar	..	..	.. 15	25 ..	20 ..		trace	
Montmorillonite		..	.. 10	10 ..	20 ..		20	
Interstratified minerals		..	.. 5	— ..	— ..		—	

TABLE II
Minerals Identified in Dry Zone Clays

<i>Sample</i>		<i>Clay Minerals</i>		<i>Other Minerals</i>
		<i>Predominant</i>	<i>Other</i>	
3	..	Kaolinite	.. Montmorillonite Inter-stratified minerals	Quartz, Mica, Felspar, Iron oxides
4	..	Kaolinite	.. Montmorillonite	.. Quartz, Mica, Felspar, Iron oxides
5	..	Kaolinite	.. Montmorillonite	.. Quartz, Felspar, Iron oxides
6	..	Kaolinite	.. Montmorillonite	.. Quartz, Iron Oxides