Comparative Study of the Mineral Composition of Red Clays in Hungary

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Introduction

Red clays in Hungary are the products of soil forming processes of earlier geological times. They are generally situated in areas that were mainlands in the Tertiary period and so were not covered by marine sediments.

Our contemporary knowledge on the conditions and characteristics of red clays, red and yellow soil formations in Hungary and in other countries was summarized by BALLENEGGER (1917) and 'SIGMOND (1934). Their major characteristic features are: they do not contain lime, they are sticky and soft and have the ability of swelling and rapid drying. They contain iron compounds. Red clays are rocks featuring unique characteristics and are not to be mixed up with other types of rock.

Different ideas have developed about the distribution and characteristics of red clays and loamy formations (VADÁSZ, 1956; BIDLÓ, 1974; BORSY & SZŐŐR, 1981; JÁMBOR, 1980; KRETZOI, 1969; SCHWEITZER, 1993). STEFANOVITS (1959) showed that the red clays of Hungary are genetically diverse formations.

Some authors draw parallels between red clay formation and the process of bauxite formation, or consider bauxitic formations to be red clays (BÁRDOSSY & ALEVA, 1990).

KUBIENA (1956) thoroughly studied the formation of red clays. In his opinion red clay soils are the products of different processes. He called the two main processes of formation laterization and rubefication.

The FAO World Soil Map also makes difference between different types of red soils. As indicated in the book of DRIESSEN and DUDAL (1991), Plinthosols and Ferralsols can be characterized by a great amount of mobilizable iron and aluminum compounds, and the red Cambisols (Chromic Cambisols) too went through a relatively moderate weathering process.

There is a fundamental difference between these two directions of soil formation with respect to clay mineral composition as well (FEKETE, 1988).

Materials and Methods

Samples were collected from 61 soil profiles all over Hungary. From these, results of 8 red clay samples are presented in this paper. Samples were selected to represent the most important sites of occurrence and types of red clays, as follows:

108.	Mád	40 - 60	cm
2.	Aggtelek - I.	7 - 20	cm
100.	Jósvafő	20 - 55	cm
65.	Vörösberény	20 - 40	cm
68.	Balatonalmádi	80 - 100	cm
75.	Máriagyűd	100 - 130	cm
120.	Kakasd	60 - 80	cm
88.	Nagygombos	115 - 130	cm

Basic soil examinations and mechanical analysis were carried out on the red clay samples. X-ray diffraction and (derivatographic) thermal analysis were applied to determine the mineral composition of the samples.

Table 1
Basic analysis data of red clay samples

Sample	K_A	hy_1	pH		$CaCO_3$, %	Humus, %
			KCl	H_2O		
Mád	41	5.73	6.12	6.78	-	0.92
Aggtelek - I.	64	3.62	6.74	6.89	0.12	0.61
Jósvafő	62	9.72	5.91	6.75	-	0.19
Vörösberény	60	3.33	7.59	8.15	5.80	3.29
Balatonalmádi	46	1.31	7.11	7.37	0.12	1.31
Máriagyűd	42	1.85	7.89	8.50	39.77	-
Kakasd	51	3.73	7.47	7.74	-	0.18
Nagygombos	54	6.56	8,00	8.14	1.32	0.22

Table 2
Mechanical composition of red clays (in percentage)

Sample	>0.25	0.25-0.05	0.05-0.01	0.01-0.005	0.005-0.001	<0.001
	mm					
Mád	0.87	8.71	31.07	2.00	12.2	45.15
Aggtelek - I.	0.26	0.33	7.42	3.95	8.06	79.98
Jósvafő	0.64	0.00	20.17	6.76	13.29	59.14
Vörösberény	3.41	9.85	19.09	5.65	21.91	40.09
Balatonalmádi	2.74	34.74	21.28	6.33	11.35	23.56
Máriagyűd	5.36	34.37	7.35	7.35	11.21	34.36
Kakasd	1.17	41.10	5.48	1.57	3.89	46.79
Nagygombos	5.22	12.58	13.78	4.31	8.52	55.59

Results

Data of basic soil analysis and mechanical composition are shown in Table 1 and Table 2, respectively. Derivatograms are presented in Figure 1 (A and B). Data on the mineral composition from X-ray diffraction and thermal analysis are summarized in Table 3.

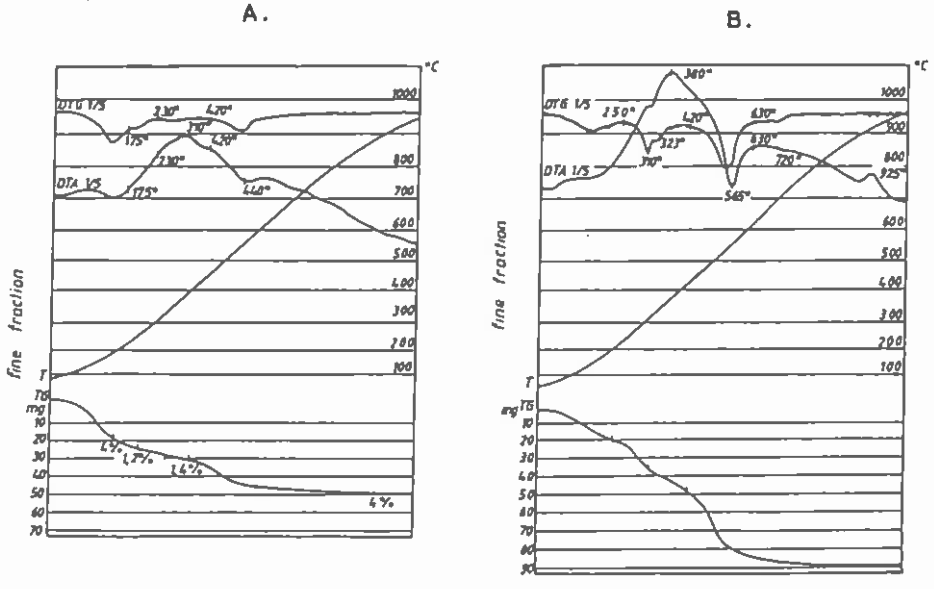

Figure 1
Derivatogram of red clay samples.
A. Sample No. 108, Mád (40-60 cm). B. Sample No. 65, Vörösberény (20-40 cm)

Hungarian red clays can be divided into several groups.

1. Red clays of the foothills of the Tokaj mountains (Mád).

This soil contains about 60% <0.01 mm particles. Besides quartz it consists of feldspars, illite, montmorillonite and a small amount of kaolinite. It was formed on rhiolite or rhiolite tuff, and is covered by loess in some areas. It is older than loess, formed under the warm climate of the Tertiary. Relic soil.

2. Red soils of the Northern-Borsod karst region (Aggtelek and Jósvafő).

Both are very heavy soils with 70-80% clay content. The dominant clay mineral is kaolinite, but a significant amount of smectite is also present. Their hematite and goethite content varies in the area. They are Tertiary relic soils formed on Mesozoic limestone. Laterite and bauxite formations can be detected in some places. The frequency of their occurrence varies.

Table 3

Mineral composition of the red clay samples (in percentage)

Minerals	Sample															
	Mád		Aggtelek-I		Jósvafő		Vörös-berény		Balaton-almádi		Máriagyűd		Kakasd		Nagy-gombos	
	orig.	f.f.*	orig.	f.f.*	orig.	f.f.*	orig.	f.f.*	orig.	f.f.*	orig.	f.f.*	orig.	f.f.*	orig.	f.f.*
Quartz	32,3	28,1	3,3	4.1	59.5	37.2	3.4	31.8	27.6	39.8	16.9	15.6	29.8	13	43.2	28.6
Calcit	-	1.3	-	-	2.7	-	5.4	3.6	-	-	23.6	21.2	1.1	-	2.7	1.5
Dolomite	-	-	-	-	-	-	-	-	-	-	14.5	8.8	-	-	-	-
Feldspars	1.5	13.1	-	-	2	2	-	-	-	-	6.2	32	10.2	6.3	-	-
Kaolinite	2	8.1	68	65	28.5	14.9	35.6	32.3	20.9	25.3	25.2	1.8	26	19.4	4.8	10.9
Chlorite	-	-	-	-	-	-	-	-	-		-	-	10.6	4	-	-
Illite or muscovite	32.8	-	-	-	-	-	-	-		4.6	6.8	2.4	-	-	-	-
Montmorillonite + amorphous	25	42.8	-	-	-	39	14.4	-	47.1	20	-	12.7	16.4	48.9	42.3	50
Boehmite	-	-	-	-			-	16.1	-	-	-	-	-	-	-	-
Gibbsite	-	-	-	-			1.8	5.4	-	-	4.2	2.2	-	-	-	-
Hematite	-	-	2.1	7.9	0.8	0.5	5	8	2.3	6.3	-	-	-	0.8	-	-
Goethite	-	-	20	19	-	-	-	-	-	-	-	-	-	-	-	-
Humus	1.4	1.4	2.2	2	2.1	2	4	2.8	0.8	1.4	0.4	1.6	0.8	1	0.4	0.8
H_2O-	4.4	4	2.8	2	3.2	3.6	2	3.8	1	1.8	1.8	1.3	4.7	5.4	6	7
H_2O+	0.6	1.2	0.6		1.2	0.8	-	-	0.3	0.8	0.4	0.4	0.4	1.2	0.6	1.2

* fine fraction

3. Bauxitic formations of the Transdanubian mountain range (Vörösberény).

In Hungary bauxite formation is the result of tropical weathering of the surface of inland limestone and dolomite. However, the red clays in the upper layer of the eroded bauxitic areas are relics of tropical and subtropical soils. Their kaolinite, gibbsite, boehmite and hematite content is characteristic.

4. Red soils formed on Permian sandstones of the Balaton highlands (Balatonalmádi).

The signs of the oldest soil formation in Hungary can probably be found in the Permian red sandstones. They are red, sporadically coloured with a purple nuance. These are rocks formed from the mixture of sediments and tropical red soils. Naturally, the soils formed on the Permian bedrock are not a Paleozoic remnant of a soil, but are relic soils and originate from the end of the Tertiary period. Their kaolinite, illite, montmorillonite and hematite contents are characteristic.

5. Red clays of the Transdanubian hilly region.

a) Red clays formed by the weathering of the Pannonian surface (Kakasd). – These red clays have a medium clay content. They contain kaolinite, illite, chlorite and a small amount of hematite. They were formed between the end of the Miocene and the lower Pleistocene.

b) Red clays of the Mecsek and Villányi mountains (Máriagyűd). – These red clays are on the surface, in suppressions and fissures of limestone. Occurring clay minerals are kaolinite, montmorillonite and illite. Gibbsite can also be present and the iron content is amorphous. These are terra-rosa formations, formed under Mediterranean conditions.

6. Soils of the border region of the Hungarian Great Plain (Nagygombos).

These soils have medium clay content. They contain a lot of montmorillonite and a small amount of kaolinite. The iron content is often amorphous. They are situated on clay, silt and sand layers of different origin or between loess depositions. They were formed in the Pliocene and at the turn of Pliocene and Pleistocene.

Summary

The red clays of Hungary are the products of soil forming processes in earlier geological times. Their range of occurrence coincides with the tropical and subtropical mainlands from the Tertiary period. At present they are covered by forests and are used for viticulture and arable farming.

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