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# COMPARISON OF THE MINERALOGICAL COMPOSITION OF THE CLAY FRACTION OF SOILS DEVELOPED ON DIFFERENT PARENT ROCKS

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**Abstract:** Samples for the comparative study were taken from the Žiar Basin and Košice Basin. They represent soil horizons A, B, C, D. The basic substrata of the soils are volcanites and Neogene sediments. On the basis of X-ray diffraction, we found differences in the mineralogical composition of the clay fraction of the soils studied. These differences appeared above all in the presence of vermiculite or chlorite-vermiculite, which was identified as the dominant clay mineral in horizon A of two profiles on volcanite rocks. Smectite is dominant in the lower horizons of these soils. Illite, chlorite, kaolinite and illite/smectite are the other identified minerals. Smectite or illite/smectite is the dominant mineral in the clay fraction of the soils developed on underlying Neogene sediments.

**Key words:** soil, parent rock, clay minerals, XRD.

## Introduction

Clay minerals represent one of the most important components of soils. They condition and influence many soil properties (physical, chemical), among which the most important is the sorption capacity. From the physical point of view, clay minerals represent very finely dispersed particles with a large specific surface, which actively participates in the physico-chemical processes in soils. They help to solve the relations between the properties of soils and the composition of the clay fraction, and from this point of view, it is necessary to see their irreplaceable importance in practice.

Clay minerals in soils may be inherited from the basic substratum, or be the result of a Quarternary or older climatico-sedimentary cycle, or correspond to special processes of change (Wilson et al. 1984, Němeček et al. 1990).

There are three main factors, which have a decisive influence on the origin, distribution and relocation of clay minerals in the soil profile. They are the basic substratum, relief and climate (above all the quantity of precipitation and drainage conditions). In this article we decided to establish the differences in the qualitative distribution of clay minerals in soils developed on different types of Neogene volcanic rocks as well as comparison with soils developed on Neogene sediments.

## Material and methods

The samples used for comparison were taken from the area of the Žiar Basin and some from the Košice Basin. They correspond to horizons A, B, C, D. Here we understand horizon D as weathered parent rock. The samples were first freed from plant remains, mechanically broken up and then sieved for the grains under 1 mm. The next step was the preparation of samples according to Jackson (1975). The carbonates were removed using sodium acetate buffer with increased temperature, then organic matter using $H_2O_2$, and finally Fe oxides and hydroxides were removed by the addition of sodium dithionite mixed with citric buffer. Before the treatment the samples were disintegrated in ultrasonic bath for 5 minutes. The aim of the preparation is to obtain good quality material for further analysis.

After removal of the cements, the clay fraction $<2\,\mu m$, and $<1\,\mu m$ were separated by the sedimentation method. We coagulated the separated fraction by adding of NaCl. Excess salts were removed by dialysis. The course of the dialysis was controlled by the addition of $AgNO_3$ solution.

### *X-ray diffraction analysis*

To identify the clay minerals, we used powder X-ray diffraction (XRD), which, especially for the identification of mixed layered minerals of the type I/S, has a basic importance (Šucha et al. 1991). Apart from maintenance of the correct approach to the removal of cements and correct separation, good quality diffraction results are also conditional on a well prepared oriented preparation. In preparation, it is necessary to pay attention to putting at least 10 mg of sample on 1 $cm^2$ of glass slide (Brindley & Brown 1980), and obtaining a sufficiently thick preparation for XRD. Samples were analyzed in the air dried state, and saturated with ethylene glycol

(8 hours at a temperature of 60 °C). We used a Philips diffractometer PW 1050, Cu K$\alpha$ radiation, a speed of the goniometer of 2 degrees 2$\Theta$/min and a range from 3 to 50 degrees 2$\Theta$, for taking the XRD patterns. In the interval of 30 - 50 degrees 2$\Theta$ we increased the sensitivity of the instrument.

*The Green-Kelly test*

After saturation with Li using a 3 M LiCl solution, the samples were heated at a temperature of 300 °C. Prepared oriented preparations were subsequently treated with ethylene glycol.

## Results

***Soils developed on andesites***

*Lúčky profile*

In horizon A, 14 Å mineral is dominant (Fig. 1). The diffraction peaks with values of 14.02 Å and 12.10 Å belong to vermiculite or chlorite-vermiculite. These results could also be interpreted as discrete vermiculite occurring together with biotite-vermiculite (hydrobiotite), which could create the peak around 12 Å (Reynolds 1980; April et al. 1986).

The origin of the vermiculite in the clay fraction usually reveals weathered biotite, which was inherited by the soil from the parent rock. This process plays a key role in forming the composition of the clay fraction in soils (Wilson 1984). Since a small quantity of biotite and amphibole were also identified in the clay fraction of horizon A, the process of vermiculization is also present. Chlorite, kaolinite and plagioclase are other minerals present in the clay fraction. In horizon C chlorite is dominant.

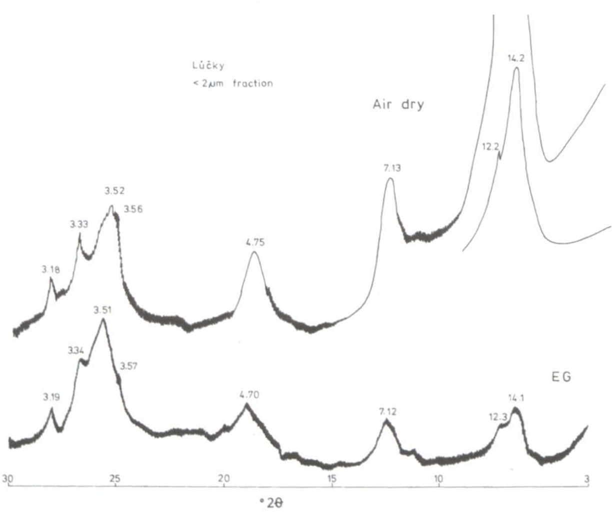


**Fig. 1.** XRD patterns of the fraction < 2$\mu$m from Lúčky profile (horizon A) in air dry state and after saturation with EG.

*Jánova Lehota profile*

It is very interesting to compare this profile with the preceding, since the composition of the clay fraction is significantly different. It can be seen from Fig. 2 that the dominant mineral of the clay fraction, in the whole profile, is smectite. Apart from smectite, vermiculite (chlorite?) is also present in horizon A in significant quantity. We also identified kaolinite, illite and feldspar. Smectite also clearly predominated in horizons B and C. Vermiculite with chlorite is probably also present in the clay fraction. Such a dominant position for smectite is in harmony with the statement of Srodon (1987), that volcanic rocks, acidic as well as basic, to a great extent weather into smectite, and much less frequently into kaolinite.

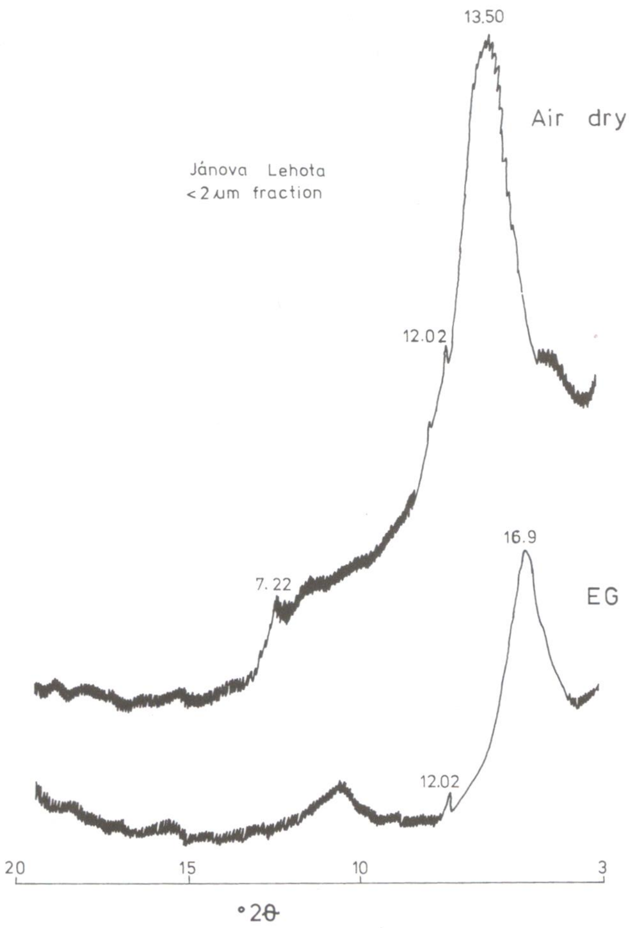


**Fig. 2.** XRD patterns of the fraction < 2$\mu$m from Jánova Lehota profile in air dry state and after saturation with EG.

***A soil on rhyolite and rhyolitic tuffs***

*The Lutilský Potok profile*

The prevailing mineral in horizon A is illite, but a smaller quantity of kaolinite is present. In horizon B, the situation is similar, but small amount of smectite is present as well. In horizons C and D, the situation is completely different. Smectite clearly prevails and illite is a minor phase. A small quantity of kaolinite is also present.

*Jastrabá profile*

We identified kaolinite, together with illite, chlorite and illite/smectite containing less than 40 % smectite layers, in the clay fraction of horizons A and B. Quartz and feldspar from the non clay minerals also are present in the clay fraction. In horizon C, kaolinite is dominant. Illite, a small quantity of chlorite, and traces of smectite are also present. Smectite is dominant in horizon D. We also identified kaolinite, illite, and feldspar with quartz.

***Soils developed on Neogene sediments***

*Rozhanovce profile I*

The dominant mineral in horizon A is mixed layered I/S with a content of expanding structures around 75 %. A large quantity of illite is present, but there is less kaolinite and chlorite. We also have a similar picture of the distribution of clay minerals in horizons B and C, where I/S with 80 % expanding structures was identified. Quartz and feldspar are represented.

*Peder profile*

In horizon A, illite is dominant, and kaolinite with I/S containing less than 40 % smectite layers is also present. In horizons B and C, smectite prevails, while illite, kaolinite and chlorite are also present.

*Jasov profile*

The diffraction record of samples coming from horizons A and C gives interesting information about the presence of mixed layered chlorite/smectite (Fig. 3). When we compare the modeled X-ray diffraction patterns of mixed layered chlorite minerals (Reynolds 1988)

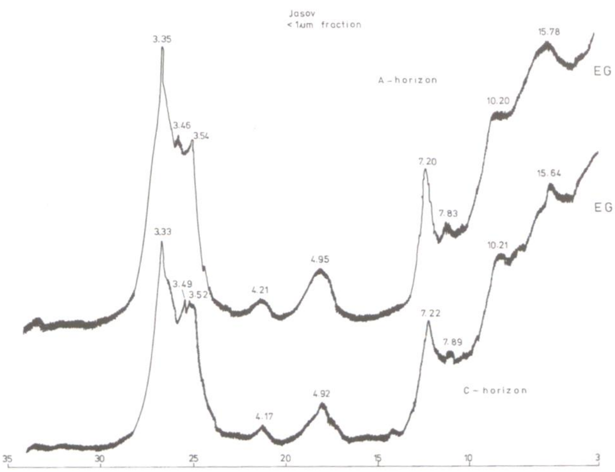


**Fig. 3.** XRD patterns of the fraction <1 $\mu$m from Jasov profile (A and C horizons). Both patterns are after EG saturation.

with the records of our samples, we see that there is a very close similarity. The occurrences of reflexes 15.64, 7.89, 3.49 Å (horizon C), and 15.78, 7.83, 3.46 Å (horizon A) indicates the presence of such a Ch/S structure.

All samples containing smectite were subjected to Green-Kelly test, to distinguish montmorillonite and beidellite. In all studied samples only smectites of montmorillonite type were identified.

## Discussion and conclusion

Our results show that the mineralogical composition of the clay fraction of soils developed on different substrata is different, especially when we compare soils on volcanic rocks and soils on Neogene sediments. It appears that the soil type is note the decisive factor in forming the mineralogical composition of soils. When we compare these two groups of soils, the most significant difference between them is the presence of vermiculite, or vermiculite of a similar phase, in the clay fraction of soils developed on volcanites.

We identified vermiculite or chlorite/vermiculite as the dominant mineral in the clay fraction in the Lúčky profile and in the Hodruša-Raková profile. The diffraction peaks 14.02 Å and 12.44 Å , and also 14.02 Å and 12.19 Å could be interpreted as discrete vermiculite occurring together with biotite vermiculite or hydrobiotite (Reynolds 1988; April et al. 1986).

The origin of vermiculite in the soils is explained by the weathering of biotite, which was inherited from the basic rock. However not all soil vermiculites show a genetic relationship to biotite. According to Huang (1977), chlorite is a typical product of the weathering of amphibole and pyroxene in soil conditions. In an aggressive weathering regime, it may be transformed further into vermiculite, generally via mixed layered chlorite-vermiculite (Ross & Kodama 1976; Basham 1974). Mixed layered chlorite minerals in soils are often described (Reynolds 1988; Wilson & Nadeau 1985). Chlorite-smectite was identified in the Jasov profile by comparison of the model X-ray diffraction patterns described by Reynolds (1988) with the experimental patterns. We can assign almost all examples of mixed layered chlorite minerals, described by authors, to two types (Reynolds 1988):

- regularly ordered (R=1)
- randomly ordered (R=0)

Soil chlorites are more varied. Structural arrangements with more than two components have been described. In this article, we are not concerned with a closer description of chlorite/smectite.

The dominant possition of smectite or mixed layered illite/smectite in the clay fraction is a characteristic feature of soils developed on Neogene sediments. This is in harmony with views of the majority of authors, who are concerned with soil smectites (Wilson 1987). There is a generally accepted view that the smectites and illite-smectites present in soils on Neogene sediments are inherited from the parent rock (Wilson 1987). The character of identified illite/smectite is in harmony with those characterized by Franců et al. (1991) in parent shales from the Neogene sediments of the studied area. On the basis of the results obtained from the Green-Kelly test all samples correspond to montmorillonite. This is in contradiction with generally accepted beidellitic character of soil smectites. We did not devote attention to other differences between soil smectite and bentonitic smectite.

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