Clays and Clay Minerals, Vol. 28, No. 5, 388–390, 1980.

NOTES

STRUCTURE OF A TALC/SAPONITE MIXED-LAYER MINERAL

Key Words—Crystal structure, Mixed layer, Saponite, Talc, X-ray powder diffraction.

A talc/saponite mixed-layer mineral was first described by Alietti (1956, 1958a, 1958b) in serpentinized rocks of the Taro Valley, Parma Province, Italy, associated with minerals of the serpentine and talc groups. The mixed-layer mineral occurs as aggregates of small, soft, green plates which can easily be separated under the microscope. The mineral also occurs in the clay-size fraction of marly deposits. Subsequently, a similar mineral was recognized by Veniale and Van der Marel (1968) in serpentinite rocks of the Nure Valley, Piacenza Province, Italy. This material, however, was contaminated with orthochrysotile. The talc/saponite mineral was also found in the dolomites of the "Schisto-Calcaire" of the Congo Kinsasha by Guenot (1970) who suggested a sedimentary origin.

RESULTS

X-ray powder diffraction of the unoriented sample gave an almost complete series of (00ℓ) reflections up to the eighth order (Figure 1). The mineral swelled with glycerol, and when heated to 550°C, it gave the diffraction pattern of talc. The air-dried mineral had d(001) = 24.80 Å which increased to 27.10 Å with glycerol saturation. The 001 spacing decreased to 9.3 Å when the material was heated to 600°C. These results are typical of a regular interlayering of a smectite (d(001) = 15 Å) and a non-swelling phyllosilicate (d(001) = 9 Å).

A chemical analysis was made by a combination of atomic absorption and X-ray fluorescence techniques. The results shown in Table 1 indicate that talc and saponite are the main constituents of this mineral. Differential thermal and thermal gravimetric analyses (Figure 2) showed endothermic peaks at 150° and 220°C, characteristic of saponite, as well as a large endothermic peak at 905°C which appears to be a superposition of peaks of these two minerals. The infrared spectroscopic pattern (Figure 3) shows mainly overlapping peaks, but saponite and talc can be distinguished by bands at 614 cm^{-1} and 668 cm^{-1}, respectively.

STRUCTURE ANALYSIS

To establish the structure of the talc/saponite, as accurately as possible, X-ray diffraction intensities were measured from an oriented sample of the <0.5-μm fraction. The intensities were corrected for Lorentz-polarization effects and are listed along with d(001) values and structure factors in Table 1.

The stacking sequence, z coordinates of the atomic planes, and site occupancies were determined by trial and error. The F_{obs} values are consistent with a series of structures whose end members are illustrated in Figures 4 and 5. These structures differ principally in the placement of the iron and aluminum atoms in the two talc-like layers of the unit cell. The changes in the F_{talc} values in going from one end member to the other are not sufficiently large to permit one to characterize the structure more specifically.

In one end member (Figure 4), both talc-like layers are identical in chemistry. The octahedral magnesium is partially replaced by iron, and tetrahedral silicon is partially replaced by aluminum. The interlayer space is occupied by water and exchangeable cations. The stacking sequence is TBTTBT, where B is the expandable interlayer space and T is the talc-like layer.

In the other end member (Figure 5), all substitution is in one layer while the other layer remains ideally talc-like. The sequence is TBT'TBT'. Here, T' indicates a nonequivalent talc-like layer.

A plot of the electron density of the air-dried sample calculated using the F_{obs} and the phases of the corresponding F_{calc} is shown in Figure 6 (see also Mejsner, 1979). A similar plot for the glycerol-treated material is given in Figure 7. These are idealizations, because a center of symmetry was assumed in the calculations.

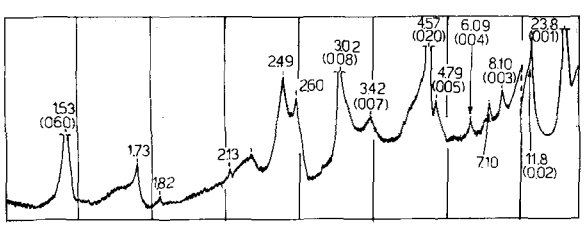


Figure 1. X-ray powder diffraction pattern of talc/saponite mineral (from Veniale and Van der Marel, 1969). (Spacings in Å.)

Table 1. X-ray powder diffraction data and F values of a talc/saponite mixed-layer mineral from the Taro Valley, Italy.

00ℓ	d(Å) natural	I_{obs} natural	F_{obs} natural	F_{calc} natural	F_{obs} glycerated
001	24.80	1000	344	−349	430
002	12.40	671	568	−577	540
003	8.27	60	253	289	822
004	—	—	—	−26	129
005	4.96	22	259	264	241
006	—	—	—	−5	410
007	3.54	23	381	366	200
008	3.10	120	1000	−1000	838
009	—	—	—	91	1000
0010	2.48	5	256	269	0

Table 2. Chemical analysis of talc/saponite mixed-layer mineral from the Taro Valley, Italy.

SiO_2	53.15
Al_2O_3	3.48
Fe_2O_3	3.48
MgO	27.40
MnO	0.03
CaO	1.10
Na_2O	1.18
H_2O	10.18
	100.00

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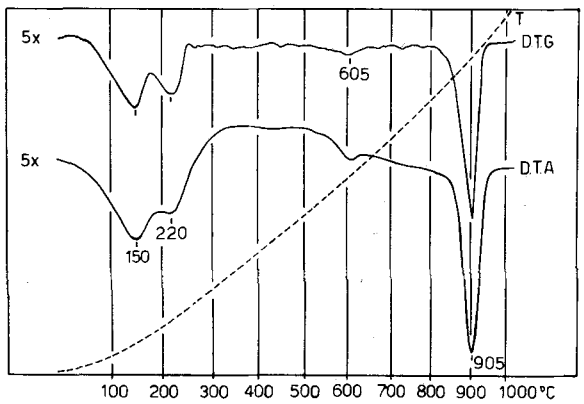


Figure 2. Differential thermal gravimetric and differential thermal analysis curves of talc/saponite mineral (from Veniale and Van der Marel, 1969).

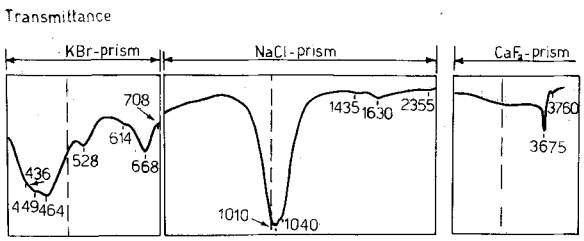


Figure 3. Infrared spectra of talc/saponite mineral (from Veniale and Van der Marel, 1969). (Horizontal axis in cm^{-1}.)

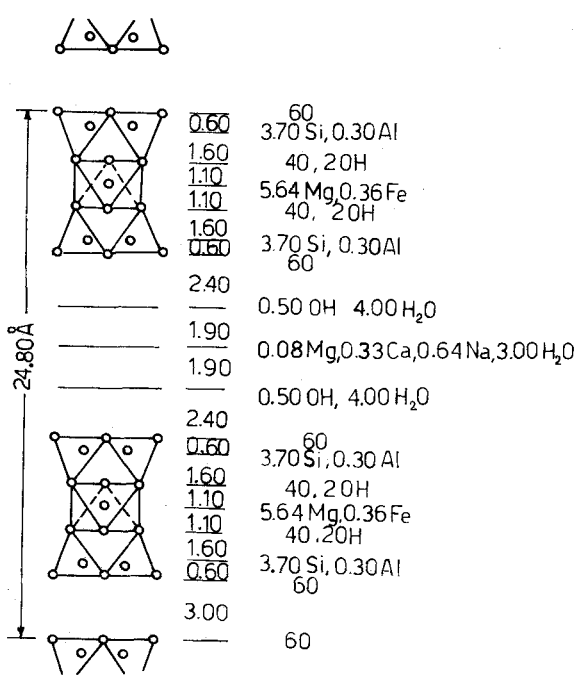


Figure 4. The structure of a talc/saponite mixed-layer mineral, involving two identical talc-like layers in the unit cell.

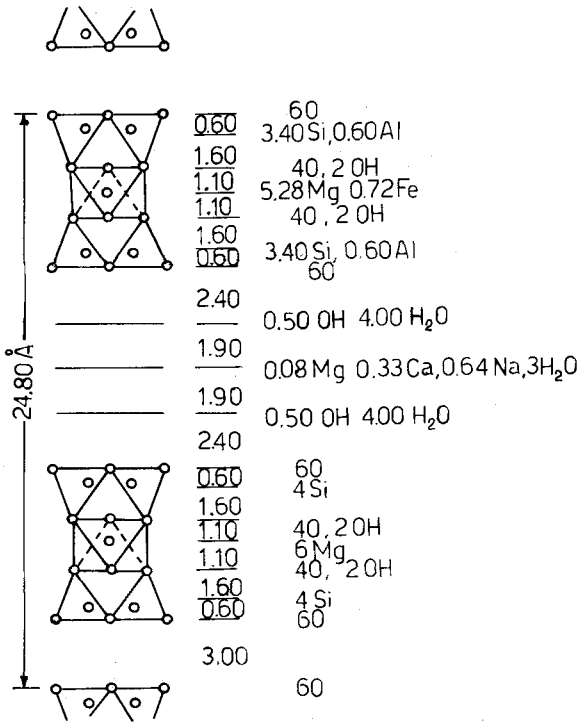


Figure 5. The structure of a talc/saponite mixed-layer mineral, involving the maximum difference between the talc-like layers in the unit cell.

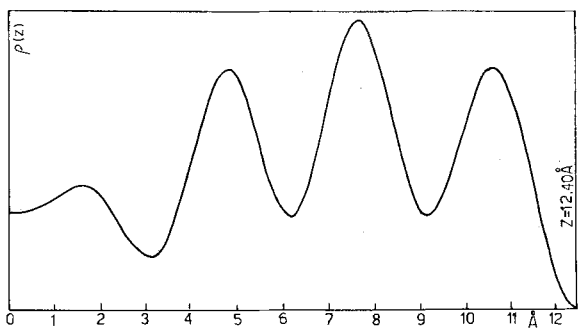


Figure 6. Electron density plots $\rho(z)$ normal to the (001) plane of talc/saponite mineral.

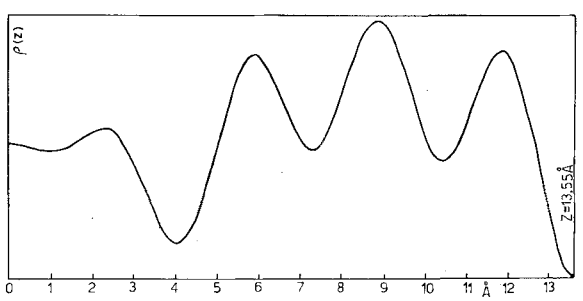


Figure 7. Electron density plot $\rho(z)$ normal to the plane of talc/saponite mineral saturated with glycerol.

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CONCLUSIONS

A regularly interstratified phyllosilicate has been investigated by X-ray powder diffraction, thermal, infrared, and chemical analyses. The crystal structure has been studied using the (00ℓ) intensities. All data are consistent with a talc/saponite mixed-layer mineral which lies between two end members. In one end member, all talc layers are identical in ionic substitution, whereas in the other end member, one type of talc layer has the ideal composition, while the other contains all of the substitution. The former has the stacking sequence TBTTBT, and the latter is TBT′TBT′.

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(Received 11 July 1978, accepted 7 March 1980)

https://doi.org/10.1346/CCMN.1980.0280509 Published online by Cambridge University Press