Obtaining of high quality talc from talcose rocks: a case study from the Sinec and Kokava deposits (Slovakia)

JÁN DERCO; ZOLTÁN NÉMETH

Geological Survey of Slovak Republic, Jesenského 8, 040 01 Košice,
Slovak Republic, nemeth@gssr-ke.sk

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Abstract

The talcose rocks of lower quality and rarely exploited rock varieties accompanying talc occurrences were tested aiming to obtain talc products of high quality. The main goal was to contribute to wasteless technology of processing, because these rocks are usually stored in dumps and cause environmental threat.

The talc extraction and benefication from carbonatic talcose rocks - talc-magnesite, talc-dolomite and talc-magnesite-dolomite was done using flotation method in case study from Sinec deposit. The talc flakes, present in sericite-chlorite schistose rocks in Kokava deposit, were successfully tested for special use in paperboard for roof's covering. Both deposits belong to the strip of talcose occurrences in Veporic unit of Central Slovakia.

Key words: talcose rocks, high quality talc, talc flakes, flotation, benefication, wasteless technology, Sinec, Kokava, Veporic unit, Slovakia

Introduction

The study is targetted to obtain the talc of required industrial quality from talcose rocks accompanying the talc deposits. In the Sinec deposit these were (1) talc-magnesite, (2) talc-dolomite and (3) talc-magnesite-dolomite rock types. The goal was to obtain the high quality talc for pharmaceutical and electrotechnical industry using flotation method. The Kokava deposit with high content of accompanying flaky talcose schists served for obtaining suitable talc flakes for building industry. Studied there were (1) sericite-chlorite schists, (2) steatitized sericite-chlorite schists and (3) strongly steatitized chlorite schists.

Geological and tectonic settings of the Sinec and Kokava deposits

Talc-magnesite deposits are located in distinct strip of mylonitic muscovite-chlorite schists interlayered with metacarbonates and metabasic rocks (Sinec Complex of Lower Carboniferous? age; Bezák ed. 1999). This strip is sandwitched between Precambrian?-Lower Paleozoic crystalline rocks of Veporic tectonic unit of Western Carpathians (Fig. 1). The garnet-biotite-plagioclase paragneisses, mica schists and large bodies of biotite granodiorites to tonalites prevail northward of the strip. To the south of the strip the older outcropped tectonic étage is built up by biotite-albite gneisses and leucocratic, locally aplitic granites. These in distinct strip trending NE-SW and crossing through the town Hnúšt'a penetrate the beds of biotite hornfels phyllites. This Pre-Alpine crystalline basement is covered by Carboniferous phyllites and metasandstones as well as Permian arcosic sandstones and conglomerates.

The Pre-Alpine basement and its cover is burried beneath the flat lying body of low-grade muscovite-quartz schists, locally with carbonatic matter and interlayers of metacarbonates and metabasics (Sinec Complex, l.c.). Due to observed regional tectonic discordance and tectonization at the base of the complex there is a vivid discussion that it represents the Alpine overthrusted nappe of Carboniferous Ochtiná Formation of neighbouring south-eastward located Alpine Gemeric

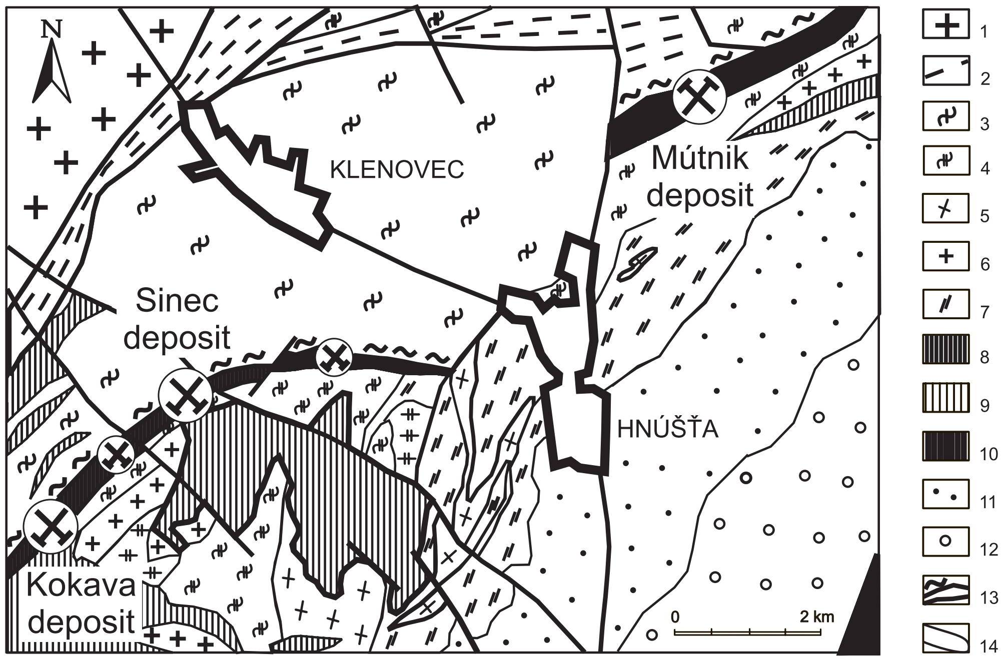

Fig. 1. Position of Sinec and Kokava talc-magnesite deposit in schematic geologic map of south-eastern part of Veporic tectonic unit (simplified after Bezák et al., 1999). 1 - biotite granodiorites to tonalites, locally with bodies of migmatites, orthogneisses of hybridic complex and leucocratic aplitic granitoids and aplites, 2 - mica schists, 3 - garnet-biotite-plagioclase paragneisses, locally amphibolic, 4 - biotite-albite gneisses, locally with bodies of light-coloured fine-grained quartz-feldspar orthogneisses, 5 - migmatites, orthogneisses, granitoids and layers of paragneisses (hybridic complex), local small bodies of leucocratic granites, 6 - leucocratic, locally porphyric granites, granite-porphyries and aplitic granites, 7 - beds of biotite hornfels phyllites to gneisses penetrated with leucocratic to aplitic granites, 1-7 - Proterozoic?-Lower Paleozoic, 8 - muscovite-chlorite schists interlayered with metacarbonates and metabasic rocks, the host rocks of talc-magnesite mineralization, 9 - muscovite-quartz schists locally with carbonatic matter, several small bodies of diorites. 8-9 - Sinec Complex, Lower Carboniferous? representing the nappe outlier? of Gemeric Ochtiná Fm., the main magnesite bearer in the Western Carpathians, 10 - the Gemeric Octiná Fm. - schists, metasandstones - it is spread eastward of described area. 11 - phyllites and metasandstones, 12 - arcosic sandstones and conglomerates, 11-12 - Upper Paleozoic cover of Veporic crystalline core. 13 - tectonic boundaries, 14 - lithological transitions.

tectonic unit. The Ochtiná Fm. includes the main occurrences of magnesite mineralization in the Western Carpathians (cf. Grecula et al. 2000 and Radvanec & Prochaska 2001).

The recent geologic setting of the area is a product of at least two-stadial evolution. The result of tectogenesis of Upper Paleozoic Hercynian era was south-vergent tectonic piling of several crustal units of various lithology and metamorphic evolution (Bezák 1994, Bezák ed. 1999). The origin of first transpressional steeply dipping shear zones is dated back to Hercynian era. It is still unknown whether the former high-temperature metamorphic overprint belongs to Cadomian or old Hercynian tectogenesis (l.c.).

The Alpine (Cretaceous) evolution is characterized by pervasive compression of the territory from the south-lying units. There originated the Alpine zonal setting inside the Veporic and Gemeric tectonic units, as well as the Alpine overthrusting of Gemeric unit on Veporic one. In schematic section it is generalized by overthrusting of rocks of the Gemeric Ochtiná Fm. (in low right corner of Fig. 1) on cover sequences of Veporic crystalline basement. The very probable (being still in the state of detail observation) is continuation of this body to outliers of the Sinec Complex west of Hnúšt'a town. Part of Sinec complex was later sandwitched between Veporic crystalline blocks during younger north-vergent transpressional imbrication of the area. This very distinct generally SW-NE driven transpressional strip of so-called Sinec shear zone contains numerous magnesite lenses with partial or full reworking to talc. The only deposit being recently exploited in this strip is the Mútnik deposit located in its NE segment. In other magnesite-talc occurrences, also with abandoned Kokava and Sinec deposits in its SW segment, the exploitation already ceased.

Talcose rocks from Sinec deposit

The rock types tested for obtaining of high quality talc can be divided into (1) talc-magnesite, (2) talc-dolomite and (3) talc-magnesite-dolomite types.

The rocks were subject of mineralogical and chemical methods of study (Derco 1986). In single rock types participates following minerals: talc, magnesite, chlorite (sheridanite), dolomite, quartz, felspars, muscovite, pyrite and apatite. The distribution of the main rock-forming minerals in the deposit points to a clear decrease of muscovite, quartz and chlorite contents with growing content of talc (Figs. 2 and 3).

Laboratory tests aimed the gaining of high quality talc for electroceramic or pharmaceutical uses. Single samples were prepared by crushing, grinding, homogenization and quartation. The results of subsequent flotation treatment are expressed in Tables 1-4. The best results were obtained using emulsion-kerosene-pineoil (500 g.t^{-1}), Na_2CO_3 (200 g.t^{-1}), water-glass (2,000 g.t^{-1}), pH-6. The tables state also the sampling intervals.

Obtained results confirm that the flotation of talc-magnesite rock type gave a product fulfilling the requirements for pharmaceutical type. In the case of electroceramic technological type the main drawback was the higher content of Fe_2O_3 (1.38 %). Therefore additional dressing using polygradient electromagnetic mud separator was necessary and the Fe_2O_3 content was lowered to 1.0-1.16 %.

During the flotation of talc from talc-dolomite rock type the natrium hexametaphosphate was used to inhibit dolomite. It depressed dolomite, but lowered the yield of talc product (29.28 %). This product fulfils the criteria for pharmaceutical talc (Table 2).

Dressing of talc-magnesite-dolomite rock type produced talc, which after refining flotation fulfils the norm criteria for electroceramic talc. The talc yield is 50.73 % (Table 3).

Using of refining flotation for the talc-magnesite cell product (Table 4) there was obtained high quality

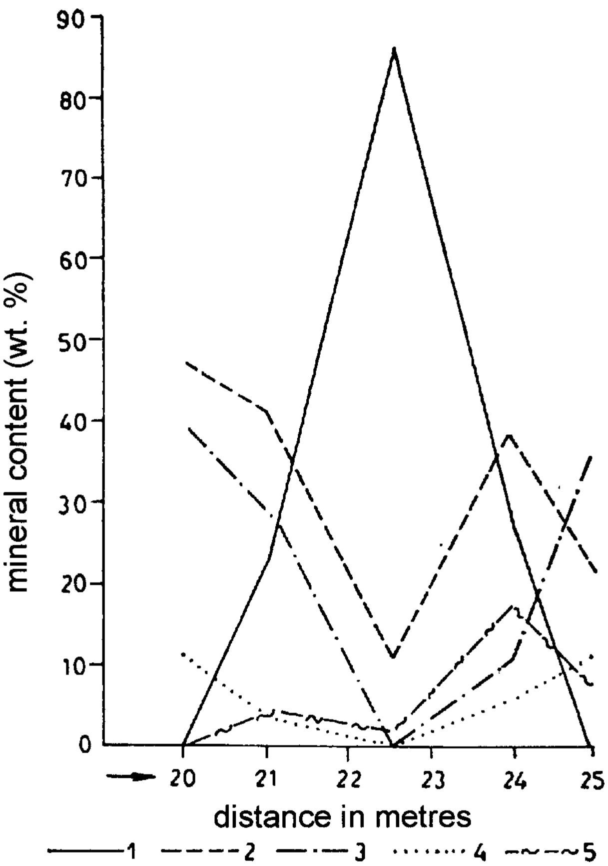

Fig. 2. Distribution of the main mineral components of the deposit in relation to the rock type in the profile from talc-chlorite schist, chlorite-talc schist to talc-chlorite schist. 1 - talc, 2 - chlorite, 3 - quartz, 4 - muscovite, 5 - dolomite.

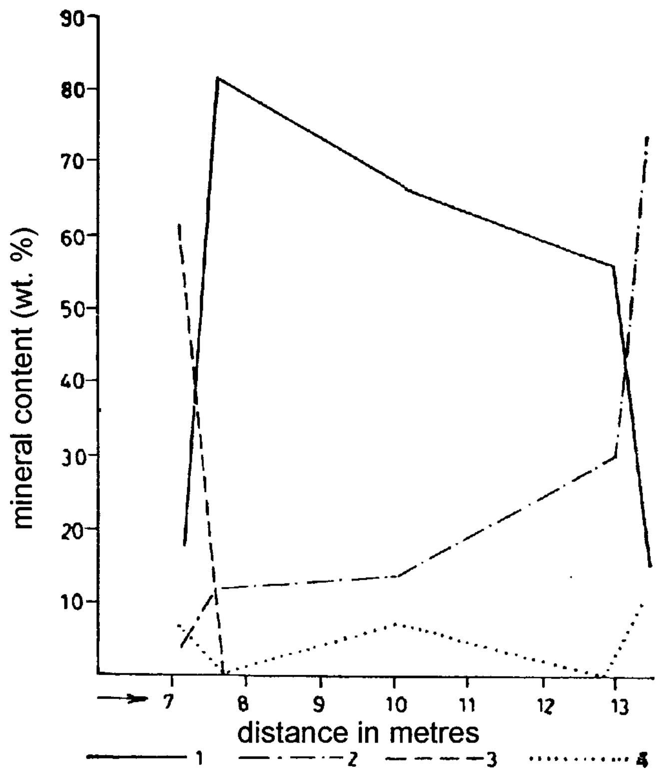

Fig. 3. Distribution of the main rock forming minerals in the deposit in relation to single rock varieties in the profile steatitized magnesite, talc schist, chlorite-talc schist and talc-chlorite schist. 1 - talc, 2 - chlorite, 3 - magnesite, 4 - dolomite.

Table 1: Flotation treatment of talc-magnesite type of raw material

Chemical and mineral composition (wt. %)	Primary flotation			Refining flotation of talc				TALC QUALITY 00/A (pharmac. talc)
	Flotation input	Foam product (talc)	Cell product (magnesite)	First sampling after 4 minutes	Second sampling after 14 minutes	Foam product	Cell product	
Weight yield (%)	100,00	10,35	89,65	4,37	2,39	6,76	3,59	100,00
SiO_2	5,88	44,64	1,40	61,06	57,22	60,05	16,27	-
Al_2O_3	0,93	4,10	0,56	0,73	1,00	0,83	10,26	-
Fe_2O_3 (t)	1,63	1,82	1,61	1,33	1,46	1,38	2,65	max 2.5
MgO	44,08	33,60	45,30	31,16	33,20	31,88	36,86	-
CaO	0,95	0,45	1,01	0,28	0,35	0,30	0,72	-
Na_2O	0,03	0,03	0,03	0,03	0,03	0,03	0,04	-
K_2O	0,02	0,02	0,02	0,02	0,02	0,02	0,02	-
loss by ignition	46,25	14,82	49,88	4,99	6,31	5,40	32,57	max 10
talc	7,50	63,10	1,10	96,00	89,50	93,70	5,50	-
chlorite	4,10	18,00	2,50	3,20	4,40	3,60	45,10	-
magnesite	85,30	17,50	93,10	-	5,10	1,80	47,00	-
dolomite	3,10	1,40	3,30	0,80	1,00	0,90	2,40	-

Table 2: Flotation treatment of talc-dolomite type of raw material

Chemical and mineral composition (wt. %)	Flotation input	Refining flotation of talc					TALC QUALITY 00/A (pharmac. talc)
		First sampling after 5 minutes	Second sampling after 13 minutes	Third sampling after 20 minutes	Foam product	Cell product	
Weight yield (%)	100,00	15,82	8,21	5,25	29,28	7,08	100,00
SiO_2	33,63	59,44	59,72	60,39	59,69	39,59	-
Al_2O_3	1,02	0,46	0,49	0,46	0,47	1,00	-
Fe_2O_3 (t)	1,79	1,48	1,67	1,46	1,53	1,82	max 2.5
MgO	26,30	30,53	29,97	29,49	29,64	27,88	-
CaO	12,75	1,46	1,60	1,78	1,56	9,40	-
Na_2O	0,02	0,01	0,02	0,02	0,01	0,03	-
K_2O	0,02	0,02	0,02	0,02	0,02	0,02	-
loss by ignition	24,09	6,29	6,30	6,21	6,28	19,89	max 10
talc	51,00	93,20	92,60	92,30	92,90	62,60	-
chlorite	4,50	2,00	2,20	2,00	2,10	4,50	-
dolomite	44,50	4,80	5,20	5,70	5,00	32,90	-

Table 3: Flotation treatment of talc-magnesite-dolomite type of raw material

Chemical and mineral composition (wt. %)	Flotation input	Refining flotation of talc				TALC QUALITY EK-I (electrotech. talc)
		First sampling after 5 minutes	Second sampling after 10 minutes	Foam product	Cell product	
Weight yield (%)	100,00	36,60	14,13	50,73	9,67	100,00
SiO_2	40,85	60,92	63,55	61,65	46,58	-
Al_2O_3	0,66	0,26	0,22	0,25	0,96	max 5.0
Fe_2O_3 (t)	0,82	0,55	0,57	0,56	0,74	max 0.7
MgO	31,93	31,76	31,56	31,70	31,03	min 28.0
CaO	5,41	0,80	0,60	0,75	3,94	-
Na_2O	0,02	0,02	0,02	0,02	0,02	-
K_2O	0,02	0,02	0,02	0,02	0,03	-
loss by ignition	19,85	5,24	5,27	4,75	17,15	max 6.0
talc	63,40	96,60	97,00	96,70	75,50	-
chlorite	2,80	1,10	1,00	1,10	2,50	-
magnesite	17,50	-	-	-	9,00	
dolomite	16,30	2,30	2,00	2,20	13,00	-

Table 4: Flotation treatment of talc-magnesite type of raw material

Chemical and mineral composition (wt. %)	Cell product (input)	Primary flotation		Refining flotation		TALC QUALITY Ia - Ib (rubbery industry)
		Foam product	Cell product	Foam product	Cell product	
Weight yield (%)	89,65	64,48	25,17	56,23	8,25	100,00
SiO_2	1,40	0,95	2,57	0,51	3,95	max 1.5
Al_2O_3	0,56	0,34	1,13	0,14	1,74	-
Fe_2O_3 (t)	1,61	1,56	1,71	1,56	1,51	max 2.42
MgO	45,30	45,78	44,10	46,09	43,66	min 44.4
CaO	1,01	0,94	1,18	0,92	1,08	max 0.90
Na_2O	0,03	0,03	0,03	0,02	0,04	-
K_2O	0,02	0,02	0,02	0,02	0,02	-
loss by ignition	49,88	50,26	48,90	50,65	47,59	-
talc	1,10	0,80	1,90	0,50	2,80	-
chlorite	2,50	1,50	5,10	0,60	7,80	-
magnesite	93,10	94,60	89,10	95,90	85,90	-
dolomite	3,30	3,10	3,90	3,00	3,50	-

magnesite product. The yield of magnesite is 56.23 %. This type magnesite was successfully tested as an additive for wall-plaster substances.

Beside the yield of talc, the primary flotation of talc-magnesite raw material also allows to gain magnesite concentrate of technological type usable in rubbery industry with 89.65 % yield of magnesite concentrate (Table 4).

Talcose rocks from Kokava deposit

Three talcose rock types were studied from the viewpoint of flake industrial use:

The first type is represented by ***sericite-chlorite schist*** with predominance of tabular mineral grains in foliation. The orientation of tabular minerals is either parallel or irregular. The chemical and mineral compositions are displayed in Table 5.

The second rock type, ***steatitized sericite-chlorite schist***, and third rock type, ***strongly steatitized chlorite schist***, consist of combination of mosaic of equidimensional and tabular minerals of irregular orientation.

The evaluation of the quality of obtained products was made using quantitative shape analysis of particles. Grains have been assigned as flakes in the cases where the elongation/thickness ratio was 3 : 1 or higher. Qualitative analysis of flakes was made under microscope in thin section (Table 5), as well as by chemical and X-ray analysis (Derco & Vlasák 1984; Table 6).The relation of weight yield to granularity was studied in the case of the first rock type (sericite-chlorite schist; Fig. 4).

Table 5: Partial chemical composition, calculated mineralogical composition and average flake content in principal samples of three investigated rock types.

Rock type	Sample number	Average flakeness %	Partial chemical analysis wt. % SiO_2	Al_2O_3	MgO	K_2O	Al_2O_3+ MgO + K2O	K+	Mineral composition (wt. %) chlorite	sericite	talc	quartz	chlorite+ sericite+ talc
Type 1 Sericite-chlorite schist	3	27,16	59,93	15,93	9,74	2,11	27,78	2,16	38,58	21,10	-	40,32	59,62
	5	11,85	70,91	10,74	7,42	1,37	19,53	3,63	26,84	13,70	-	59,46	40,54
	6	22,55	67,27	13,74	7,65	2,17	23,56	2,86	27,86	21,70	-	50,44	49,56
	17	18,15	70,81	13,18	5,60	2,50	21,28	3,33	20,27	25,00	-	54,73	45,27
	18	24,03	66,88	14,23	7,70	2,35	24,28	2,75	27,28	23,50	-	49,22	50,78
Type 2 Steatitized sericite-chlorite schist	7	19,76	62,97	10,49	12,17	0,66	23,32	2,70	36,66	6,60	7,37	49,37	50,63
	9	45,88	59,13	12,40	16,93	0,68	30,01	1,97	44,88	6,80	15,58	34,03	67,26
	12	31,87	60,05	13,43	12,91	1,01	27,35	2,20	44,39	10,10	3,00	42,51	57,40
	13		60,08	12,79	13,39	0,81	26,99	2,23	44,61	8,10	4,36	42,93	57,07
	14	37,67	58,96	11,86	17,84	0,02	29,72	1,98	52,70	0,20	11,70	35,40	64,60
	15		56,17	12,94	18,62	0,08	31,61	1,78	56,58	0,80	10,83	31,79	68,21
Type 3 Strongly steatitiz.chlorite schist	8	24,37	53,14	9,82	22,67	0,19	32,68	1,63	40,95	1,90	37,56	19,59	80,41
	16		37,49	17,84	27,71	0,02	45,57	0,82	79,41	0,20	20,27	0,12	99,88

K+ = SiO_2 / (Al_2O_3 + MgO + K_2O)

Table 6: X-ray diffraction records of principal samples representing individual rock types.

Measured values in nm: **Type 1** Sample No. 5 d	I	**Type 2** Sample No. 9 d	I	**Type 3** Sample No. 8 d	I	Table values in nm: chlorite d	I	muscovite (sericite) d	I	talc d	I	quartz d	I
1,410	6	1,410	6	1,410	7	1,410	7	-		-		-	
0,992	3	0,992	1	-		-		0,999	95	-		-	
-		0,930	1	0,930	9	-		-		0,930		-	
0,708	10	0,709	10	0,710	10	0,707	9	-		-		-	
0,497	1	-		-		-		0,498	30	-		-	
0,472	6	0,473	7	0,473	7	0,472	8	-		-		-	
0,425	2	0,425	1	0,425	0,5	0,354	10	-		-		0,426	35
0,353	9	0,353	9	0,354	9	-		-		-		-	
0,334	9	0,334	5	0,333	3	-		0,332	100	-		0,334	100
-		0,311	1	0,311	10	-		-		0,310	70	-	
0,284	2	-		-		0,284	5	-		-		-	

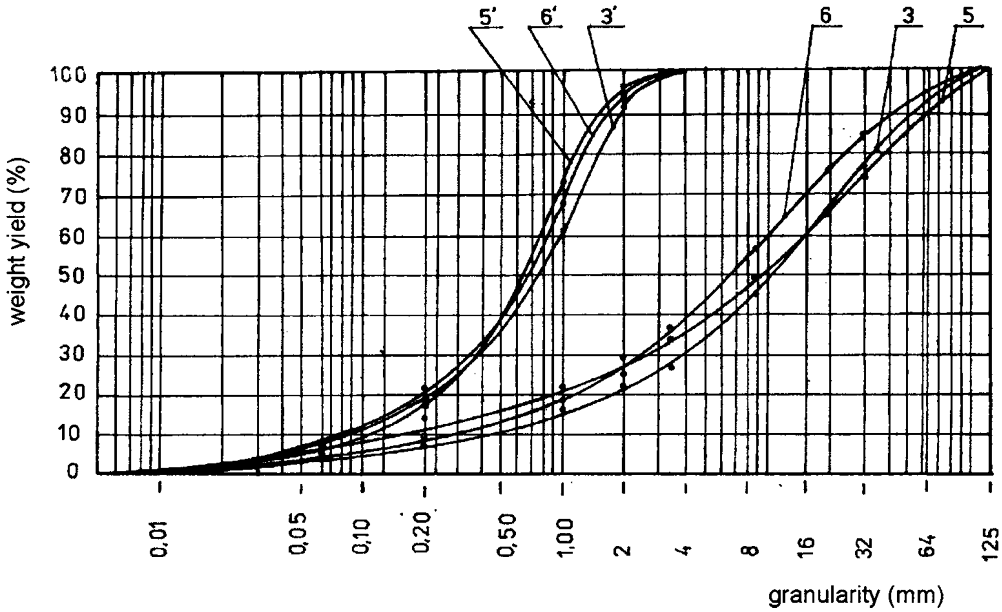

Fig. 4. Granularity curves of the first rock type samples (sericite-chlorite schist, samples 3, 5, 6) expressed in the polarographic net. 3, 5, 6 - primary samples after 1st grinding, 3‘, 5‘, 6‘ - the same samples after 2nd grinding.

Technological properties of the raw material

The specific gravity of rock fluctuates between 2.70 and 2.74 g.cm^{-3}. In the course of primary crushing of samples with higher moisture (over 5 wt. %) problems arised during sizing due to its adhesive power. Considerable amounts of dust particles (under 0.1 mm size) originated during the drying of the crushed material.

Characteristics of flakes and granules

Flakes from ***sericite-chlorite schist*** reveal the following mineral composition: chlorite (47 %), sericite (28 %) and quartz (25 %). The share of flakes in the sample is fluctuating between 11 and 27 wt. %. The granules consist of quartz (55-58 %), chlorite (28 %) and sericite (17 %) and their amount fluctuates between 73 and 89 % (Tab. 5)

Flakes of the ***steatitized sericite-chlorite schist*** consist of chlorite (75 %), quartz (10 %), sericite (8 %) and talc (7 %), the amount of flakes is 19-46 wt. %. The rest of the rock represent quartz (55 %), chlorite (36 %), sericite (6 %) and talc (2.8 %).

Mineral composition of the flakes of the ***strongly steatitized chlorite schist*** consists of chlorite (67 %), talc (17.5 %), quartz (9.5 %) and sericite (6 %). The average content of flakes is roughly 24 % and the rest of rock consists of quartz (34 %), chlorite (36 %), talc (29 %) and sericite (1 %) and the average yield of granule is around 76 % (Tab. 5).

As follows from the previous, *the second rock type, **the steatitized sericite-chlorite schist,** is the most suitable for flake production*. The flake material has low quartz contents and the best shape indices. *Unsuitable for the flake production is the third rock type* because the content of flakes is low. The high talc content assigns this type prevailingly as raw material for the rubber industry.

Relations between the amount of flakes, mineralogy and chemical composition

According to the analytical results, higher content of quartz in the rock results in lower amounts of flakes whereas higher chlorite and sericite content is reflected by higher flake production. *Steatitizations beneficates the flake content only in amounts up to 10-15 %*. This finding has been proved on artificial samples of the 0.56-1.00 mm size fraction representing the composition of average primary sample. The flake content in sample prepared was 0-50-100 % as indicated in Table 7 and Figs. 5, 6 and 7.

Table 7: Partial chemical composition and calculated mineralogical composition of artificial samples with 0-50-100 % of flakes from the 0.56-1.00 mm size fraction.

Rock type	Flake content (%)	Partial chemical composition (wt. %)						Mineral composition (wt. %)				
		SiO_2	Al_2O_3	MgO	K_2O	Al_2O_3 + MgO + K_2O	K+	chlorite	sericite	talc	quartz	chlor.+ seric.+ talc
Type 1	0	72,07	12,25	6,19	1,70	20,14	3,58	28,45	17,00	-	54,55	45,45
	50	59,80	15,24	11,31	1,40	27,95	2,14	46,44	14,00	-	39,56	60,44
	100	50,89	21,26	11,40	2,80	35,46	1,44	47,50	28,00	-	24,50	75,50
Type 2	0	65,94	10,06	10,67	0,56	21,29	3,10	36,31	5,60	2,81	55,28	44,72
	50	51,61	14,94	18,19	0,58	33,71	1,53	57,79	5,80	8,37	28,04	71,96
	100	41,66	19,43	22,29	0,79	42,51	0,98	74,58	7,90	6,98	10,54	89,46
Type 3	0	56,81	8,66	18,70	0,15	27,51	2,07	36,40	1,50	28,70	33,40	66,60
	50	49,98	14,29	22,02	0,36	36,67	1,36	58,28	3,60	20,93	17,19	82,81
	100	44,52	17,04	23,58	0,57	41,19	1,08	67,30	5,70	17,49	9,51	90,49

K+ = SiO_2 / (Al_2O_3 + MgO + K_2O)

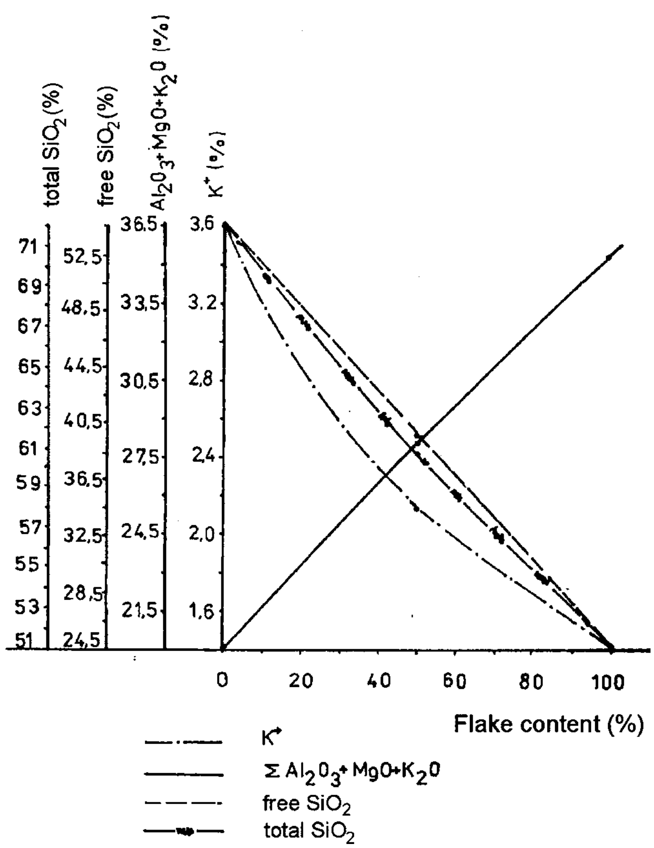

Fig. 5. Relation between the flake content and K+ coefficient, total SiO_2, free SiO_2, Al_2O_3 + MgO + K_2O of the first rock type (sericite-chlorite schist; 0.56-1.00 mm size fraction).

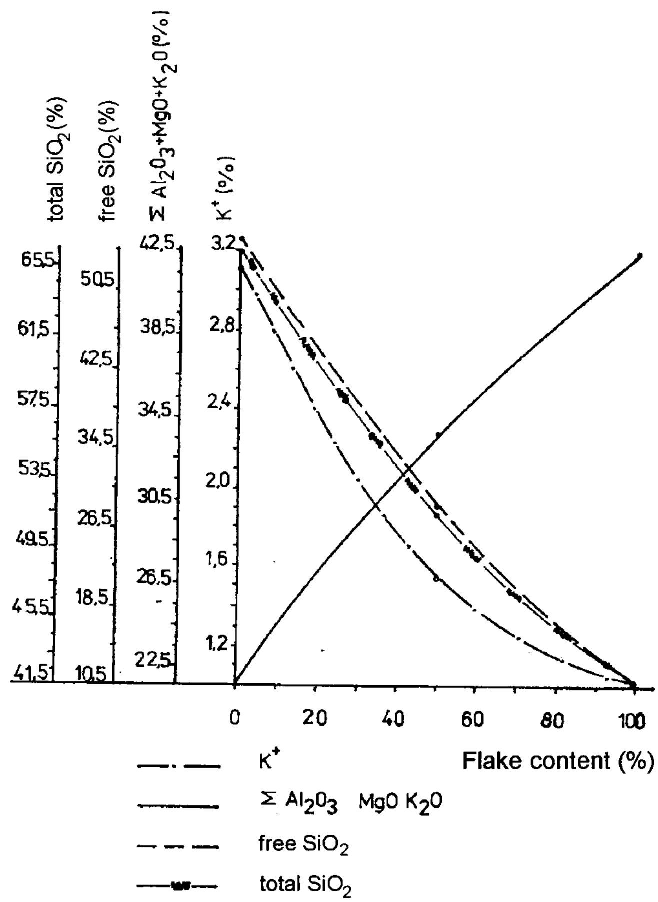

Fig. 6. Relation between the flake content and K+ coefficient, total SiO_2, free SiO_2, Al_2O_3 + MgO + K_2O of the second rock type (steatitized sericite-chlorite schist; 0.56-1.00 mm size fraction).

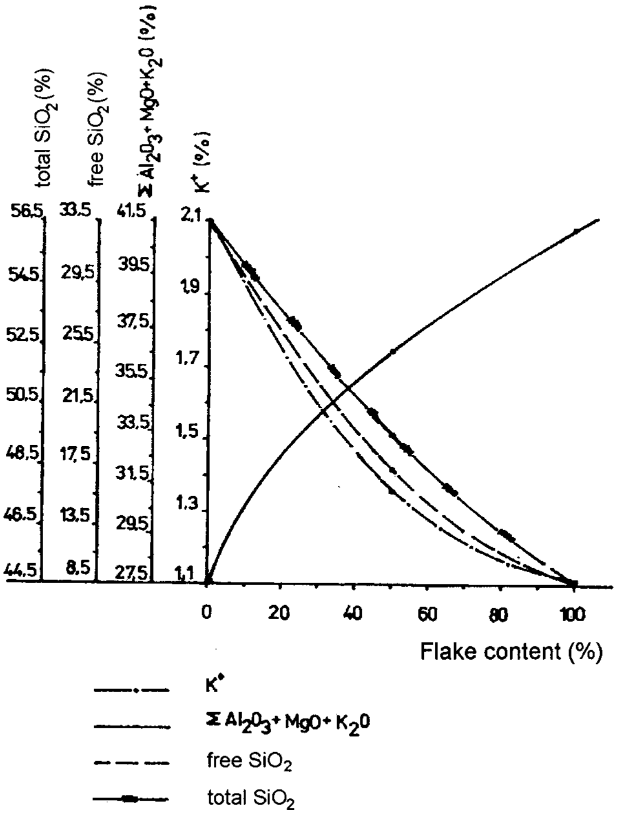

Fig. 7. Relation between the flake content and K+ coefficient, total SiO_2, free SiO_2, Al_2O_3 + MgO + K_2O of the third rock type (strongly steatitized chlorite schist; 0.56-1.00 mm size fraction).

Relation between the flake content of prepared products and bulk weight

The higher is the share of flaky grains in the single preparation products the greater is their volume in the case of loose pouring. Hence the bulk weight may be used to control the amount of flakes produced. For the sake of reproduceability, the routing indicated schematically in Fig. 6 has been applied. Results are in Tab. 8.

Because the weight of a loosely poured material was necessary to measure, the important size of the 5 slot has been designed 5 x 50 mm and the grain filling height into the calibrated vessel was 200 mm.

For the assessment of the relation between the bulk weight and the flake content, the artificial samples containing various amounts of flakes have been prepared. It was proved that the relation between the bulk weight and amount of flakes may be expressed by an exponential function of

$$\beta = k.z^n$$

where β = maximal - expected flake content in wt. %, z = 0-1, where 0 means minimal and 1 maximal bulk weight, k = maximal-minimal flake content.

The comparison of curves obtained from artificial samples with the calculated values is in Fig. 8. The

Table 8: Relation between bulk weight and flake content

Rock type	Sample type	Grain size (mm)					
		1 mm - 2 mm		0.56 mm - 1 mm		0.2 mm - 0.56 mm	
		Bulk weight ($g.l^{-1}$)	Flake content (%)	Bulk weight ($g.l^{-1}$)	Flake content (%)	Bulk weight ($g.l^{-1}$)	Flake content (%)
Type 1	T	1160	37,00	1087	38,24	957	39,10
	T	1180	27,79	1140	20,63	1020	20,15
	N	1182	26,20	1104	29,36	975	31,61
	T	1187	26,00	1122	23,50	970	34,13
	N	1203	20,35	1125	24,33	984	26,25
	N	1208	18,55	1150	20,18	1018	20,90
	N	1219	14,56	1190	13,84	1049	17,50
	N	1225	14,00	1178	15,35	1028	19,42
	N	1235	13,50	1183	15,15	1031	18,87
	T	1240	11,50	1296	3,37	1258	6,53
Type 2	N	1030	43,40	975	44,19	857	55,60
	N	1072	35,15	1010	37,90	893	40,00
	N	1109	28,70	1039	31,54	917	35,37
	N	1239	14,19	1198	19,08	1075	21,25
Type 3	N	1199	25,60	1146	24,09	1018	28,57

T - artificially prepared technological sample, N - natural sample

Table 9. Relative flake content and partial chemical composition of weight fraction in the 1-2 mm size class.

Rock type	Bulk spec. gravity (g.cm-3)	Flake content (%)	Chemical composition (%)				
			SiO_2	Al_2O_3	MgO	K_2O	Loss by ignition
Type 1	-2,67	10,04	75,77	6,33	8,24	-	4,04
	2.67-2.72	16,50	72,60	10,37	7,24	-	4,02
	2.72-2.75	50,03	55,89	18,67	9,65	-	5,80
	2,75	45,50	58,34	15,94	8,46	-	6,07
Type 2	-2,67	17,50	54,42	13,23	20,41	0,26	7,97
	2.67-2.72	40,87	52,64	15,81	19,77	0,89	7,10
	2.72-2.75	60,13	45,52	18,90	21,41	1,54	8,61
	2,75	55,22	46,76	17,38	20,69	2,30	8,42
Type 3	-2,67	12,63	72,22	8,35	12,03	0,13	5,03
	2.67-2.72	43,00	61,80	12,09	16,17	0,41	6,91
	2.72-2.75	31,51	44,89	15,04	8,84	0,56	9,04
	2,75	12,60	38,99	6,51	28,41	0,51	16,78

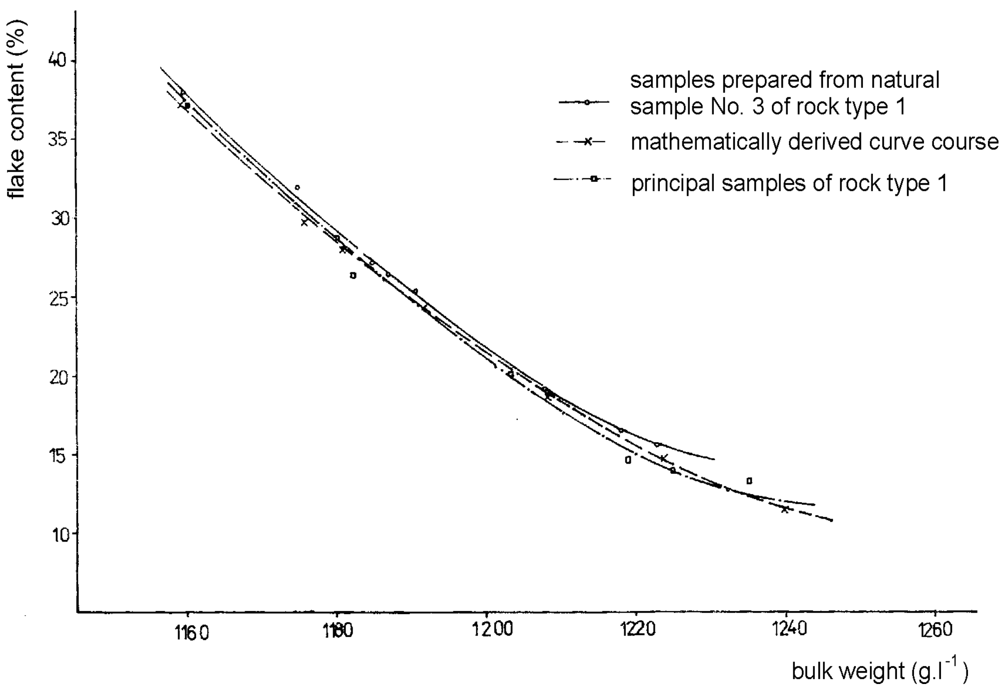

Fig. 8. Relation between the bulk weight and flake content of the first rock type, 1-2 mm size fraction.

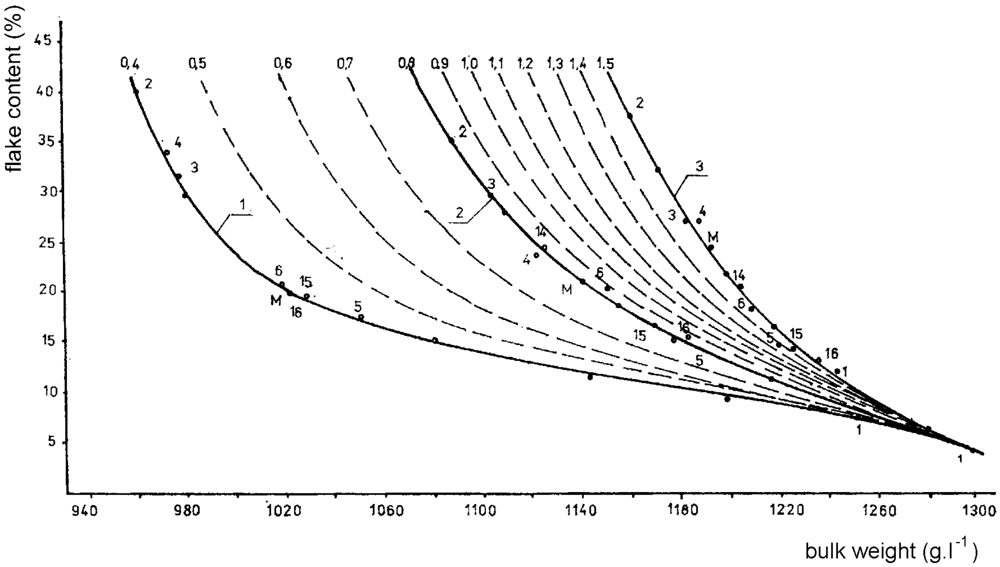

Fig. 9. Relation between bulk weight and flake content of samples 1 - 0.2-0.56 mm size fraction, 2 - 0.56-1.00 mm size fraction, 3 - 1.00-2.00 size fraction, M - artificial sample prepared for the calculation of the curve, 3, 5, 6 - principal samples of the first type of rock, 1, 2, M, 4 - artificial samples, 14, 15, 16 - further samples of the first type of rock prepared for testing of methodics, ... - points without designation were calculated mathematically.

relation between bulk weight and flake content of samples of individual grain size fractions of the first rock type is demonstrated in Fig. 9.

The information about the change of flakeness and chemical composition of products in relation to their bulk specific gravity was obtained using heavy fluid separation (tetrabrometane; Tab. 9). The decrease of amount of flake material in weight fractions as well as increase of the number of granules in the third rock type above value 2.73 g.cm^{-3} was caused by presence of carbonates (dolomite).

Laboratory tests of further upgrading

Obtained flaky products may be further upgraded with the aim to increase the flake content and to suppress the amount of dust particles under 0.1 mm size.

Upgrading tests were performed using the following laboratory devices

- fixed slot grate
- concentrating table operating moisture-free, rubber lined
- electromagnetic vibration screen operating with triboadhesion effect

Table 10: Results obtained during upgrading of grinding and sizing products.

Used devices	Inputted raw material			Assorting after additional upgrading			
	Grain size (mm)	Flake content (%)	Dust particles content %	Weight yield %	Flake content (%)	Dust particles content %	Efficiency E + (%)
Steady grillage	0.2-0.7	29,6	21	80,00	36,20	12	97,84
	0.7-2.0	26,0	4	72,00	33,50	-	92,80
Concentration sluice with dry operation	0.2-0.7	29,6	21	78,10	36,50	10	96,30
	0.7-2.0	26,0	4	72,00	33,00	-	91,40
Electromagnetic vibrational sieve	0.2-0.7	29,6	21	78,12	36,30	6,7	95,80
	0.7-2.0	26,0	4	71,85	32,40	-	89,50
Rebound drum separator	0.2-0.7	29,6	21	70,65	35,50	-	84,70
	0.7-2.0	26,0	4	68,45	30,50	-	80,30

E + = $\beta.\gamma/\alpha$, where α - flake content of inputted raw material (%), β - flake content of upgraded concentrate, γ - weight yield of concentrate (%); dust particles are below dimensions of 0.2 mm

- drum-type rebound separator

From the reason of simplicity and plainness of equipment together with the necessary output, the most suitable results were obtained using the fixed slot grate or eventually its combination with the electromagnetic vibration screen. The results obtained are in Tab. 10. Accordingly, in the 0.2-0.7 mm size fraction, the amount of flakes increased from 29.6 to 36.2 % at a 80 % yeld and 97.8 % efficiency. The amount of dust particles decreased from 21 to 12 %. The efficiency in the 0.5-2 mm size fraction is somewhat lower.

Conclusion

The talcose rocks of lower quality and rarely exploited rock varieties accompanying talc occurrences were tested for obtaining the high quality talc products.

The talc extraction and beneficiation from carbonatic talcose rocks was done using flotation method. The principal characteristicts of flotation and its products are tabled. The obtained products have practical use in pharmaceutical, electroceramic and rubbery industry.

The talc flakes, present in sericite-chlorite schistose rocks were tested for special use in paperboard for relatively untraditional roof's covering. According to the results indicated, the quality of rock suitable for flake production, applying grinding and sizing in dry state, was postulated. After the determination of the rock type, the relation between the sum of Al_2O_3 + MgO + K_2O (in wt. %) and the flake content is as follows (see table).

The magnesite concentrate, the by-product of talcose raw material dressing, was successfully used as an additive for wall-plaster substances. By this way all components of parent rock were used by human community and this approach fulfils the demand of environmentally friendly wasteless technology.

Al_2O_3 + MgO + K_2O (wt. %)	flake content in wt. %	
	Type 1 - sericite-chlorite schist (chlorite, sericite, resp. muscovite, quartz)	Type 2 - steatitized sericite-chlorite schist (chlorite,sericite, resp. muscovite, quartz, talc to 10 %)
under 15	0	0
15-20	0-13	0-15
20-25	13-28	15-34
25-30	28-45	34-60
30-35	45-65	60-90

Note: The rock type 3 - strongly steatitized chlorite schist is for the flakes production unsuitable.

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