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WHITENESS IN COLOUR OF TALC

by

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(with 2 tables and 6 text-figures)

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Abstract

Whiteness in colour of talc is one of the most useful property in commercial uses, and it is used in ceramics and as a filler in paint, paper, and rubber. The present writer has carried out some quantitative studies on the whiteness as one of physical properties with the automatic photo-electric spectrometer.

Consequently, whiteness value being calculated by the Hunter equation amounts to 88.9% for the maximum. In general, however, the talc contains the other minerals as impurities, therefore the whiteness in colour of talc decreases from 88.9% to 72.3% with the increase of impurities.

Introduction

Talc has many commercial uses; the most familiar, talc is the major constituent of rocks known as soapstone or steatite, blocks of which can be used for thermal and electrical insulating purposes. Other uses of talc are as a filler for paints, paper and rubber, in soaps, cosmetics and other toilet preparations, and as a lubricant.

There appears to be little variation in the chemical composition of talc, sometimes of aluminium or titanium substitute for silica, and a small amount of iron, manganese or aluminum may substitute for magnesium. The relatively minor contents of calcium and alkalis also may substitute for magnesium, but more likely to be present as interlayer ions or in impurities.

Several studies on the thermal decomposition of talc have shown that the end products are clinoenstatite and cristobalite (Haraldsen, 1930), but the formation of an intermediate phase before clinoenstatite has been also reported. Thus Thilo (1937) calls the intermediate produced at 950°C meta-talc and states that it has composition $MgSiO_3$ and a crystal structure different from enstatite, whereas Eitel and Kedesdy (1943) describe the product of heating at 700 – 1,000°C as protoenstatite. Both enstatite and protoenstatite have different stability fields from clinoenstatite (Foster, 1951; Atlas, 1952).

Talc occurs in low and medium grade metamorphic rocks rich in magnesium, especially in ultrabasic igneous rocks made up of enstatite and olivine. Two common types of occurrence of talc are known; 1) the hydrothermal alteration product of ultrabasic rocks, and 2) the product of the low grade thermal metamorphism of siliceous dolomites.

From the viewpoint mentioned above, the present writer has carried out some experimental studies, especially on physical properties determined with the microscope and automatic photo-electric spectrometer.

Experimental methods and description of samples

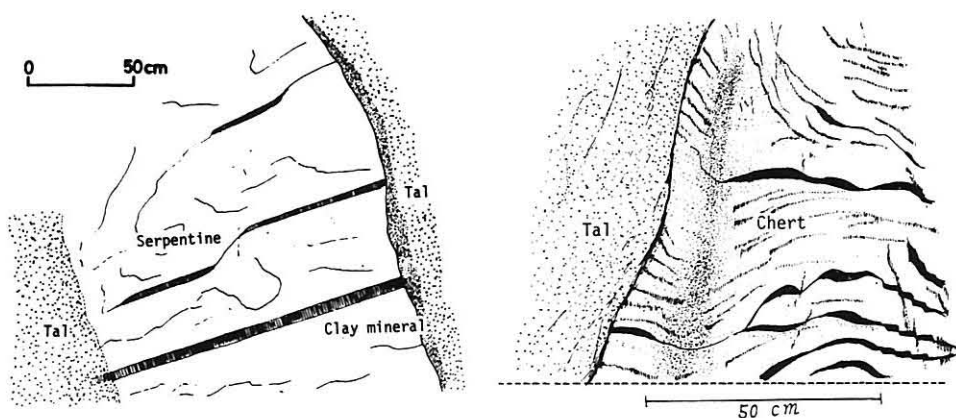
The talc from Hokkaido is pale green or nearly white in colour and is generally spotted with magnetite and chromite, rarely with hematite. Three subordinate properties in colour consist of lightness, hue and saturation, which vary independently to each other. Therefore, the quantitative analysis of talc colour was made by means of a photo-electric spectro-reflectometer and trichromatic specification was determined by the CIE (Commission Internationale de l'Eclairage) chromaticity diagram.

Experimental study on the subordinate properties of colour of talc has never been made so far. The trichromatic specification with the photo-electric spectrometer is the best method for such studies (Hunter, 1958). In the present experiment an automatic photo-electric spectro-reflectometer for colorimetry was used.

Spectroscopic reflective curve of talc samples arranged in the order of grain size from 0.1 mm to 0.25 mm, was obtained. Then the tristimulus values are calculated from the curve with the trichromatic integrator by selected ordinate method (Togari, 1978). Based on the trichromatic coefficients calculated from those values, the trichromatic subordinate properties (lightness, hue, and saturation) are determined by CIE chromaticity diagram.

The lightness and saturation values are shown in percentage, whereas the hue is given in dominant wavelength. Whiteness is calculated by the Hunter equation, $W=100 - \sqrt{(100-Y)^2 + Pe^2}$ %, where W is the whiteness, Y is the lightness, and Pe is the saturation (Hunter, 1958). Therefore whiteness value is always smaller than lightness except colourless sample. X-ray powder data for determination of talc was obtained by using X-ray diffractometer with $CuK\alpha$ radiation and silicon metal was used as an internal standard.

Differential thermal analysis was carried out to study thermal transition. Alumina powder was used as standard. Forty mg of pure talc was used for the determination of DTA and TGA data from 0° to 1,000°C in air with an automatic thermal analyser with Pt -



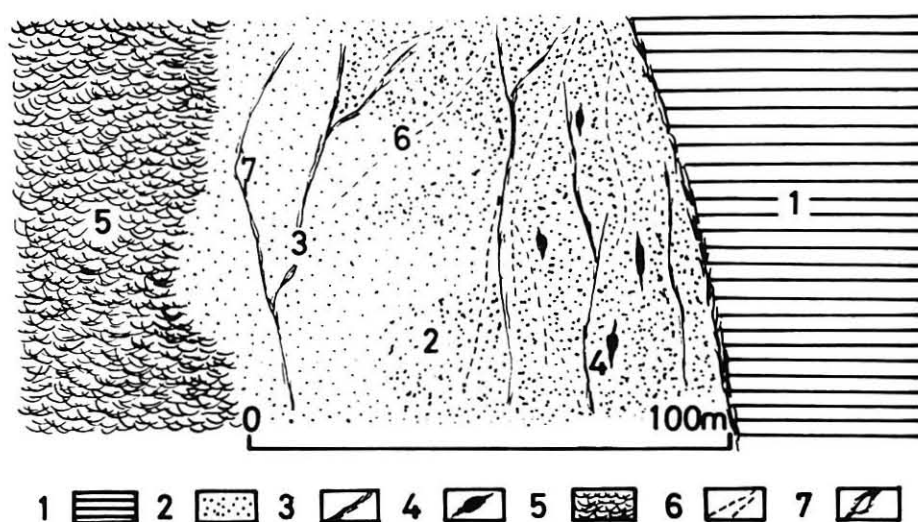
Text-Fig. 1 Detailed sketches of talc deposits

(Left) This talc bearing serpentinite is called "Same".

(Right) The high quality talc was formed along the boundary of the serpentinite mass and chert.

Pt/13% Rh thermocouple at the heating rate of 10°C/min.

The talc samples were collected from the Era-Kiyobe district along the down stream of Okamoto and Kokamoto rivers, Matsumae town, southwestern Hokkaido. This district is known as main resources of talc in Japan. There develop thick geosynclinal sediments of slate intercalated with limestone, dolomite, chert and some kinds of green rock of the Paleo-Mesozoic era. Small lenticular tremolite-bearing serpentinites forming host rock of talc deposits are observed in this formation. Detailed sketches of talc deposits are shown in Fig. 1. Talc deposits of small scale but high quality occur in the serpentinite lens associated with chlorite vein, while the crystals of talc and calcite are found to be enclosed widely in the serpentinite mass. This talc-bearing serpentinite is called "Same", and has been worked in recent years as low grade talc ore. The relation between occurrence of high quality talc and of low grade talc is shown in a schematic representation (Fig. 2).



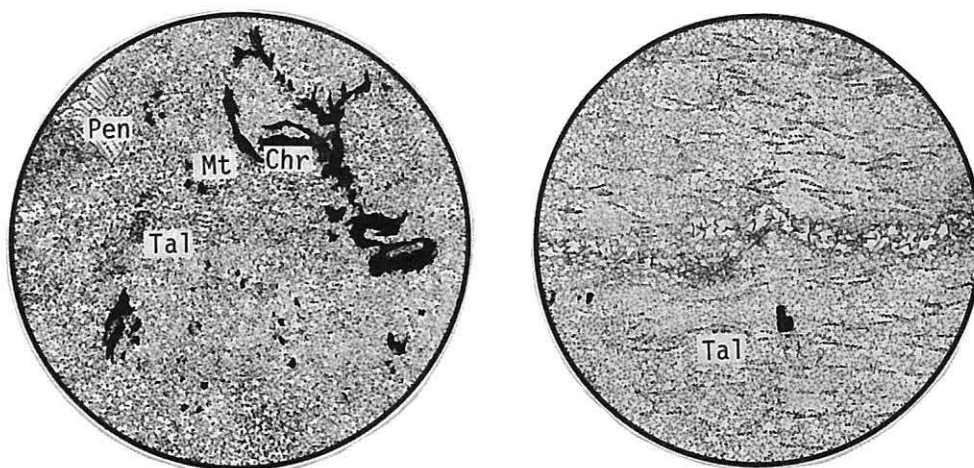
Text-Fig. 2 A schematic representation of talc deposits
 1: chert 2: talc 3: dolomite 4: lenticular chlorite (penninite) 5: serpentine (antigorite)
 6: talc vein 7: dolomite druse

Results and discussions

Microscopic study

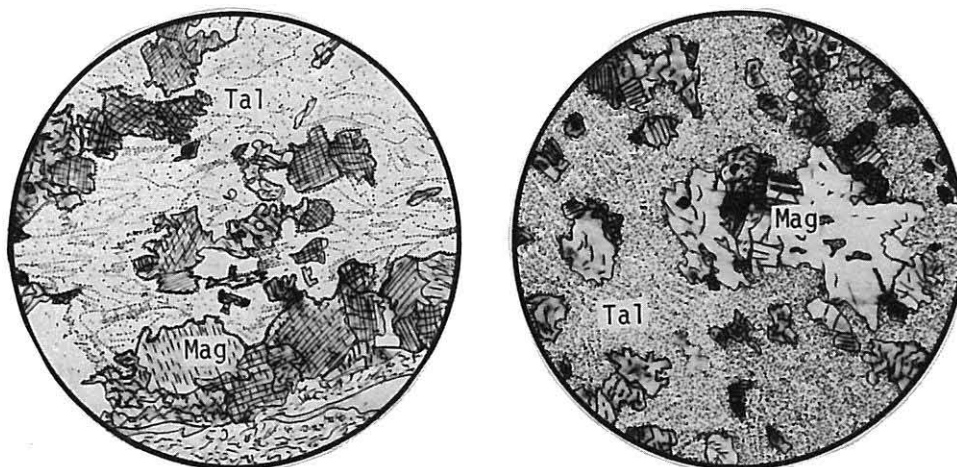
Microscopic sketches of talc ores are shown in Figs. 3 – 5. Figure 3 illustrates the high quality talc ore containing a small amount of impurity minerals. These consist of magnetite, chromite, penninite (Fig. 3, left), and sometimes hematite, but almost pure talc ore is found in places.

Figures 4 and 5 show the low grade talc ore called "Same" including magnesite, magnetite and chromite, sometimes dolomite or quartz. In general, quartz and dolomite



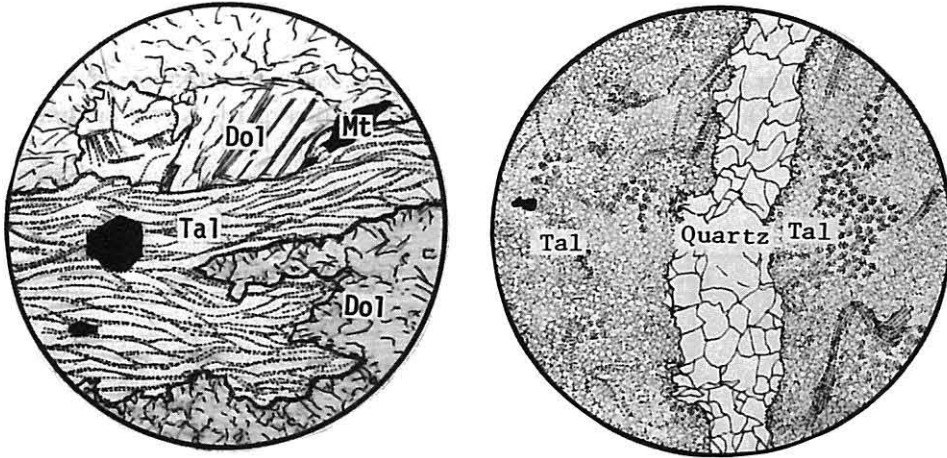
Text-Fig. 3 Microscopic sketches of high quality talc ore coexisting with a small amount of impurity minerals,
 Tal: talc Mt: magnetite Chr: chromite Pen: penninite $\times 20$

appear in scaly white talc vein which is formed in "Same". Though talc deposits and serpentinites are commonly foliated, chlorite is generally massive. Under low temperature and high pressure, talc deposits were formed in some parts of serpentinite through iso-chemical condition. Later a fault was formed along the boundary of the serpentinite mass and slate, and the serpentinite mass moved upwards along the fault, followed by the injection of hydrothermal solution under the environment of high temperature and low pressure (Bamba and Yajima, 1974). This explanation is also supported by the results of the



Text-Fig. 4 Microscopic sketches of the low grade talc ore called "Same" coexisting with magnesite
 Tal: talc Mag: magnesite $\times 20$

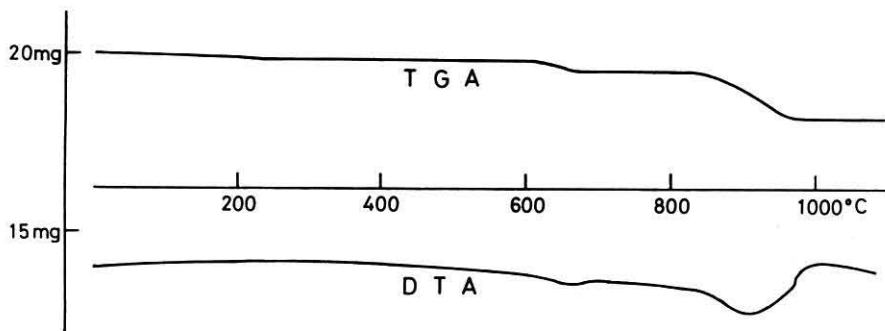
experiments on the systems $\text{MgO-SiO}_2\text{-H}_2\text{O}$ (Bowen and Tuttle, 1949) and $\text{MgO-Al}_2\text{O}_3\text{-SiO}_2\text{-H}_2\text{O}$ (Yoder, 1952). But magnesite scattering in talc ore is occasionally found. In this case, the view mentioned above is not applied.



Text-Fig. 5 Microscopic sketches of the scaly white talc vein which is formed in "Same",
Tal: talc Dol: dolomite Mt: magnetite x20

Thermal analysis

Differential thermal analysis was performed with the heating ratio of $10^\circ\text{C}/\text{min}$ in order to determine the transformation point. The DTA curve is shown in Fig. 6. A weak and broad endothermic peak due to dehydration was observed near 950°C . The weight loss curve (TGA) was calculated and is shown in Fig. 6 together with DTA curve. The TGA data of the pure talc in air is well correlated with the DTA data, and a weight loss of 5.05% was confirmed. The product of the DTA experiment was cooled to room temperature in 2 hrs.



Text-Fig. 6 DTA and TGA curves of talc in air, Pt/Pt-13Rh thermocouple and heating rate of $10^\circ\text{C}/\text{min}$.

The nonquenchable material thus obtained was studied by the X-ray powder method. The product of the treatment in air shows the peaks of enstatite and quartz. These results support that on heating, talc gives off water and decomposes at 950°C into enstatite and quartz.

X-ray powder study

X-ray powder data for the talc from Matsumae are compared with those of ASTM card (13-558) (Table 1). These data support that the composition of talc is very uniform, there being little or no atomic substitution.

Table 1 X-ray powder data of talc

Talc (ASTM 13-558)			Present work	
d (Å)	I	hkl	d (Å)	I
9.34	100	002	9.39	100
4.66	90	004	4.67	40
4.55	30	020 11 $\bar{1}$	4.56	10
3.510	4	11 $\bar{4}$	3.51	3
3.430	1	113	3.43	3
3.116	100	006	3.12	100
2.892	1	025	2.89	2
2.629	12	20 $\bar{2}$	2.63	2
2.595	30	13 $\bar{2}$	2.60	3
2.476	65	132 20 $\bar{4}$	2.48	12
2.335	16	008	2.35	3
2.212	20	134	2.22	3
2.196	10	20 $\bar{6}$	2.20	2
2.122	8	204	2.13	3
2.103	20	13 $\bar{6}$	2.10	6
1.930	6	136	1.94	5
1.870	40	0010	1.87	16
1.725	—	24 $\bar{2}$	1.71	5
1.682	20	24 $\bar{4}$	1.58	1
1.557	20	0012	1.56	7

Whiteness

Though spectroscopic reflectivity measured with the automatic photoelectric spectro-reflectometer shows the constant value about 88% in high quality talc, the reflectivity of pale green talc in low grade ore decreases slightly toward short wave between 510 to 400 m μ . But the difference between these two reflective curves gives little influence to the whiteness value. Whiteness values calculated from the trichromatic subordinate properties by the Hunter equation, are summarized in Table 2.

Table 2 Whiteness in colour of talc and talc ore

Sample no.	Whiteness of talc ore (%)	Whiteness of talc (%)	Impurities separated by the isodynamic separator				
			Reductive weight (%)	Chlorite	Magnetite	Chromite	Magnesite
H ₁	88.9	—	—	—	tr	tr	—
H ₂	87.8	—	—	—	tr	tr	—
H ₃	87.6	—	—	—	tr	tr	—
S ₁	79.5	83.2	4.5	+	+	+	—
S ₂	79.1	82.6	4.1	tr	+	+	—
S ₃	77.1	84.1	9.6	—	+	+	—
L ₁	78.5	80.6	9.8	tr	+	+	+
L ₂	76.5	80.9	13.3	—	+	+	+
L ₃	72.3	77.5	10.0	—	+	+	+

H: High quality talc S: "Same" L: Low grade talc
 +: Abundance tr: Trace -: Absence

Whiteness value in colour of pure talc amounts 88.9% for the maximum, whereas this values of pale green talc amount to 79.5% for the maximum and to 72.3% for the minimum. The whiteness values of the pale green talc ores separated with the isodynamic separator increase by a few percent with decreasing impurities, but those values do not reach to the maximum in high quality talc.

These results suggest that first the whiteness of talc decreases linearly with increasing impurity minerals, and secondly the impurities in talc ore can not be separated perfectly with the isodynamic separator.

Acknowledgement

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