

DARTMOUTH UN.  
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TO: Mr. R. N. Miller, Windsor Minerals Inc.

SUBJECT: X-ray and Optical Examination of Talc Products

## INTRODUCTION

Studies were performed by x-ray diffraction and optical methods on talc concentrates and talc products. Samples were supplied by Mr. R. N. Miller, of the Windsor Minerals Inc. The purpose of the study was to examine differences in talc products that were produced by various milling procedures. Specifically, studies were made of ground products, delaminated products, and products prepared by techniques designed to simulate the effects of the delaminator. In addition very pure natural talc, and "flexible mica" were examined.

## LABORATORY PROCEDURES

X-ray diffraction studies were performed utilizing a General Electric XRD-5 Diffractometer equipped with a copper-anode tube and Ni filter. All samples were run over the angular range of 2 to 40°2 $\theta$ . The source unit was operated at 48 KVP and 16 Ma, and the diffractometer geometry included a 1° beam slit, medium resolution Soller slit, and 0.2° detector slit. The diffraction pattern was recorded at 2°2 $\theta$ /min. with a scale factor of 2000 c/s and a time constant of 2 seconds. Samples were packed into a rectangular-milled sample holder whose cavity dimensions are 14 x 25 x 1 mm. This procedure produced very intense diffraction patterns. Talc peaks were allowed to run off-scale in order to produce maximum sensitivity for the detection of small amounts of impurities.

Optical studies were carried out with a polarizing microscope at magnifications of 40 and 400 x. A calibrated ocular micrometer was used to measure grain size. Samples were studied in oil whose refractive index is 1.540. This index is close to the main index observed normal to the talc basal plane, hence talc was almost invisible under plane light. This technique provides maximum resolution for observing impurities such as carbonates and amphiboles that have significantly higher refractive indices.

X-ray and optical studies were made on bulk samples, that is, on samples that were not treated in any way. In addition, most of the samples were fractionated into >10 and <10 $\mu$  fractions. Talc is hydrophobic, and in order to wet the sample for size fractionation, it was found necessary to add a surfactant. An optimum

mixture for this purpose was found to be 10 grams of talc, 3 grams of cetyltrimethylammonium bromide, and 600 ml of water. The suspensions were allowed to settle for 34 minutes through a column length of 20 cm, and the supernatant was pipetted off. This provides material whose Stokes law diameter (equivalent spherical diameter) is  $<10\mu$ . It should be noted that not all of the  $<10\mu$  material was recovered by this procedure; some remained in the coarser sediments at the bottom of the column. Hence data presented here on %  $<10\mu$  are minimum values which probably represent about 2/3 of the correct values.

Suspensions  $<10\mu$  in diameter were recovered by centrifugation at 2000 rpm in a size 2 International Centrifuge, and were centrifuged several times from ethanol suspension in order to remove the amine reagent. They were dried and weighed in order to obtain data on the %  $<10\mu$  fraction.

Similar techniques were used to obtain  $<40$ ,  $<20$ , and  $<2\mu$  fractions for a few samples. In addition, studies of line broadening were performed in order to detect differences in crystallinity among the various talc products. These experiments provided no additional information, and they will not be described further.

## RESULTS

Chlorite, magnesite, and dolomite were identified by x-ray methods; optical methods disclosed the presence of carbonate minerals. Careful search for amphiboles (tremolite) failed to disclose any. Table 1 summarizes data on the various talc products for bulk and  $<10\mu$  fractions. Figure 1 shows a typical diffraction pattern with contaminant minerals identified; all peaks not labelled on Figure 1 are due to talc.

Optical studies showed the typical talc grain to be a sheet surrounded by sharply crumpled edges. Sheets average about  $60\mu$  in diameter and two to four microns thick. Some sheets show a small number of tiny ( $2\mu$ ), highly birefringent, equant crystals which cannot be identified with certainty, but which probably are carbonate minerals.

All samples show larger carbonate grains. These average between 5 and  $15\mu$  in dimension. Careful studies were performed in order to ascertain the presence of any attached talc. This was accomplished by pressing the cover glass with a pencil tip while observing the character of the grain as it rolled over in the immersion media. This test showed the grains to be free, independent, crystals, unattached to any other mineral fragments. The carbonate grains were much less abundant in acid treated,

delaminated, and delaminator-simulated products. There seems to be little doubt that this is the carbonate which shows up in x-ray studies and in acid dissolution studies performed at the Windsor Talc Company laboratories.

Chlorite and amphibole were not found, by optical methods, in any of the samples. Small, black, opaque, specks were observed which could be pyrite, magnetite, or metal contaminants from the milling equipment.

It should be noted parenthetically here, that the "flexible mica" sample consists of talc plus large amounts of chlorite, and that the pure talc crystal shows no detectable impurities.

#### DISCUSSION

The data in Table 1 show that chlorite is less abundant in the  $<10\mu$  than in the bulk samples. This observation, plus the lack of evidence of discrete chlorite grains from the optical studies, suggests that chlorite occurs as interlaminated domains in the talc. The data from Table 1 show that minimum chlorite concentrations occur in the delaminated products. The reason for the delaminators effectiveness in removing chlorite is not known.

Table 1 shows that dolomite and magnesite are most abundant in the  $<10\mu$  fractions. Figure 2 shows a plot of magnesite peak height (for  $<10\mu$  fractions) versus carbonate contents determined by acid dissolution methods. The relationship indicates that the destruction of magnesite by acid is the reaction that occurs during the acid treatment. Also, it should be noted that dolomite is absent or nearly so in the acid-treated products. Dolomite is much more soluble than magnesite, hence it is suggested that the steep, early portion of the dissolution-time curve may be due to dolomite destruction. Optical studies showed that free carbonate grains are extremely rare in acid treated products. Micron or submicron inclusions in talc crystals are still apparent. Therefore, acid treatment removes the free, unattached carbonate grains.

Table 1 shows that products obtained by simply removing the delaminator from the milling procedure produces materials that are much higher in carbonate than are the products from the simulated-delaminator or the delaminator. The simulated product seems to have carbonate levels equivalent to those from the delaminator.

Carbonate contaminants degrade the quality of the talc products, and these are apparently effectively removed by flotation

procedures following the operation of the delaminator or the simulated-delaminator. It is perplexing that the flotation procedures apparently float free carbonate in fairly coarse (10 $\mu$ ) sizes if the sample has not passed through the delaminator or its simulator. This suggests that the delaminator does something to the carbonate surfaces that renders them not susceptible to flotation, and the answer does not lie in rafting by attached talc because optical studies show the carbonate grains to be free, monomineralic entities. If carbonate problems are considered as solved by present milling procedures, then this argument becomes academic. However, if further purification of products is required, it might be useful to concentrate further research on the character of the carbonate surfaces produced by various milling procedures, and to supplement these studies by examination of the behaviour of carbonate grains in the flotation agents.

#### CONCLUSIONS

1. Cetyltrimethylammonium bromide acts as an effective wetting agent for talc.
2. Chlorite is concentrated in the coarser size fractions of the talc products, probably as an interlaminated phase.
3. Dolomite and magnesite are more abundant in the <10 $\mu$  than in the bulk fraction of the products,
4. Acid dissolution removes dolomite and much of the magnetite.
5. Minor amounts of probable carbonate occur as 1-2 $\mu$  inclusions in talc, but the bulk of the carbonate removed by acid dissolution consists of free particles about 10 $\mu$  in dimension.
6. For some reason, the delaminated and simulated delaminated products contain carbonate that does not float in the flotation process, whereas material that does not pass through these procedures contains carbonate that does float and causes contamination of the product. The reason for this behaviour does not lie in the degree of liberation of carbonate from talc.
7. Delaminator and simulated delaminator products are significantly lower in carbonate than products produced without these milling procedures.

8. The simulated delaminator produces material that is as low in carbonate as is the material produced by the delaminator.
9. The delaminator products are lower in chlorite than the products from the simulated delaminator.
10. No amphibole, garnet, or asbestos impurities were observed during optical studies of the products.
11. Future attempts to refine the products further should include studies of the nature of the carbonate crystals produced by various milling procedures.

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