

ALTERATION OF TREMOLITE TO TALC IN THE DOLOMITE MARBLES OF YELLANDU WARANGAL DISTRICT (HYDERABAD, DN.)

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It was noticed while working on the tremolite specimens gathered from the Munditok (Yellandu) marble quarries that some of them had a higher silica and magnesia content and an unusually low calcium content. This led the author to suspect the presence of talc in the mineral most probably as an alteration product and it was indeed found to be so. The alteration of tremolite to talc seemed to be due to meteoric solutions, and to the atmosphere, because the alteration was found to be always a surface phenomenon. Generally speaking the alteration was noticeable only till a depth of about six feet. Instances of alteration at lower depths could be ascribed to the vicinity of yawning cracks in the marble. The gradual conversion of ferrous iron to the ferric state observed in the samples of the mineral in progressive stages of alteration also lends support to this view. Further, it was found that some of the larger altered samples had unaltered cores although their shells showed complete alteration.

Though the alteration of tremolite to talc was observed previously, the exact mechanism of alteration is still a matter of doubt. To get a clear picture of the process of alteration it is necessary to collect numerous data obtained from a systematic work on specimens of secondary talc derived from tremolite and also on the various intermediate products of alteration. With this idea in view the present work was undertaken and it is hoped that the results of this investigation would throw some light on this matter.

A microscopic examination of such samples of tremolite revealed the presence of large patches of talc which bore a pseudomorphic replacement relation to its tremolite host. A careful examination of the locality showed that there were numerous samples of almost pure talc derived from the alteration of tremolite. Specimens of tremolite which had been acted upon by meteoric solutions and by long exposure to atmosphere were found to be

completely altered to the fibrous variety of talc. Unexposed portions of tremolite were found to show no alteration. One large crystal which was completely altered to talc had a thickness of about nine inches and a length of about eighteen inches. Though the talc derived from the alteration of tremolite generally retained the original shape and size and was also rather rigid, this particularly large specimen showed signs of crushing and corrosion and was found to be very soft and somewhat pliable.

The material derived from the alteration of tremolite, *viz.*, the secondary talc, has the following properties : It has a pale-white to pale-green colour, a fibrous appearance and pearly lustre. The white variety seems to be more abundant than the greenish type. In this work only the white variety was studied in detail as the green coloured one was found to be admixed with serpentine and chlorite and so had a large alumina and iron content. Perhaps, the green variety of talc is derived mostly from the actinolite bands in the marble which provide iron, the alumina being taken up at the same time from the circulating underground meteoric solutions. The white variety has the characteristic soapy feel of talc and a hardness of about 1.5. The pure altered substance (talc) has a specific gravity of 2.7165 while the unaltered tremolite has a specific gravity of 2.9962. The mean index of refraction of the secondary talc is found to be 1.5743 while that of the unaltered tremolite from which it is derived is 1.6241. This altered end-product shows a stronger birefringence than the unaltered tremolite. This secondary talc was found to be insoluble in acids.

The intermediate products of alteration (Table I) excepting specimen No. 4, were found to be heterogeneous mixtures of the two end-members in varying proportions and their indices of refraction were found to be very variable. But they showed a gradual decrease in the value of their specific gravities from the tremolite end to the talc end. Specimen No. 4, though it showed the presence of a very few minute unaltered tremolite needles, is rather homogeneous and seems to denote a definite intermediate stage in the alteration of tremolite to talc. It has a specific gravity of 2.8261 and a mean refractive index of 1.6023. A similar intermediate product was noticed by Pelisek¹ while working on the alteration of tremolite to talc in a crystalline limestone at Petrov. Various other specimens collected from different quarries and having the same characteristics as specimen No. 4 showed approximately the same density and refractive index. Of all the intermediate products specimen No. 4 was the most definite and widespread. It is found to be more abundant than the final product of alteration and is always found wherever alteration has proceeded. As for the general physical

properties, its resemblance to the end-product of alteration is very striking. However, it differs from talc in still retaining to some extent the platy habit of tremolite. It shows incipient development of the fibrous texture of the secondary talc and the soapy feel also is well pronounced. Specimen No. 5 was found to be a mixture of specimens Nos. 4 and 6 the final product of alteration. This was deduced by a heavy-liquid separation of this specimen, viz., No. 5, when two fractions were obtained one of which resembled specimen No. 4, in specific gravity and chemical composition, and the other which was the lighter fraction, resembled specimen No. 6.

Preparation of the Samples for Examination.—The specimens were initially obtained by picking from the crushed marble. They were then roughly powdered and carefully examined under a low-power microscope, and marble pieces, if present, were removed by picking. Part of this material was utilised for the specific gravity determination and the other part for the complete chemical analysis. Ferrous iron determination was made with a portion of the sample and the rest of the material was then treated with very dilute hot hydrochloric acid to remove traces of calcium carbonate derived from the marble. It was then washed well with distilled water and dried at 105° and then taken for analysis.

Method of Analysis.—As usual with other silicates, fusion with sodium carbonate was resorted to and silica, alumina, iron, magnesium and calcium were determined as usual. As fluorine was found to be present only in traces in specimen No. 1 no special precautions were taken for the estimation of silica. Ferrous iron was determined by heating the substance with a mixture of hydrofluoric and sulphuric acids in a platinum crucible in an atmosphere of carbon dioxide and steam and then taking the solution in a saturated solution of boric acid and titrating it against standard potassium permanganate. Water was determined by strong ignition of separate portions of the substance. Prolonged heating at about 900° was found to be necessary to drive off the water completely. The loss on ignition thus obtained gave the total water present in the tremolite. This water in the tremolite was found to be liberated in stages at three different temperatures, viz., 300°, 650° and 900°.

Six specimens showing a gradual transition from almost pure tremolite (Specimen No. 1) to a definite end-product, viz., the secondary talc (Specimen No. 6), were taken for chemical analysis, and the results obtained are given below in Table I.

TABLE I
Percentage Compositions of Various Specimens

Oxides	SPECIMENS*					
	1	2	3	4	5	6
SiO ₂ ..	% 57.98	% 58.56	% 58.92	% 59.61	% 60.59	% 61.07
Al ₂ O ₃ ..	0.16	0.38	0.55	1.85	2.23	2.42
Fe ₂ O ₃ ..	0.11	0.52	0.63	1.07	1.32	1.49
FeO ..	1.12	0.98	0.78	0.36	nil	nil
MgO ..	24.39	25.53	26.97	27.82	28.69	29.13
CaO ..	13.92	10.71	9.26	5.63	2.48	0.75
F ..	Trace
H ₂ O ..	1.85	2.14	2.59	3.99	4.55	4.82
TOTAL ..	99.53	98.82	99.70	100.33	99.87	99.68
Sp. Gr. ..	2.9962	2.9407	2.9114	2.8261	2.7495	2.7165

* Specimens 1, 2, 4 and 6 were taken from pit No. 1 and specimens Nos. 3 and 5 were taken from pit No. 3 of the Munditok (Yellandu) marble quarry.

Table I shows that all the constituents of the original mineral (Specimen No. 1) undergo changes during the alteration process. All the other constituents excepting calcium and ferrous iron show a definite increase during alteration. The increase shown by silica is only apparent and not real, as can be gathered later (Table II). Calcium and ferrous iron decrease in quantity and while the latter is completely absent in the altered mineral calcium is present only in traces. The changes of the major constituents during the alteration of 100 grams of original substance, involved a loss of 13 grams, (out of about 14 grams originally present) of CaO while 3 grams of SiO₂, 5 grams of MgO and 3 grams of combined water were gained.

It is clear that there is no volume change in the alteration of tremolite to talc in these marbles. Because, the dolomite crystals surrounding the inclusions of tremolite both in specimens wherein the tremolite is fresh and in specimens wherein it is completely altered to talc, have similar optical properties. They show no strain effect and therefore indicate that the volume of the mineral did not increase or decrease during its alteration.

Further, it is found that the process of alteration effected the porosity of the mineral only very slightly.

So now it would be instructive to calculate the weights of the constituents involved in the alteration. By comparing the amounts of the various constituents in 100 c.c. of the fresh mineral with those in an equal volume of the completely altered mineral, the gains and losses involved during the alteration can be obtained. The results of such comparison are given in Table II.

TABLE II

Gains and losses in grams due to the alteration of 100 c.c. of Tremolite to an equal volume of Talc

Oxides	Tremolite g.	Secondary talc g.	Change in weight g.
SiO ₂	173.8	165.9	- 7.9
Al ₂ O ₃	0.5	6.6	+ 6.1
Fe ₂ O ₃	0.3	4.0	+ 3.7
FeO	3.4	nil	- 3.4
MgO	73.1	79.1	+ 6.0
CaO	41.8	2.0	-39.8
H ₂ O	5.5	13.1	+ 7.6
TOTAL ..	298.4	270.7	-27.7

Table II shows that 39.8 grams of CaO, 3.4 grams of FeO and 7.9 grams of SiO₂ were lost, and 6.0 grams of MgO, 7.6 grams of combined water, 6.1 grams of Al₂O₃ and 3.7 grams of Fe₂O₃ were gained during the alteration of 100 c.c. of the mineral. Therefore, a total loss of 27.7 grams of matter results and the specific gravity falls from 2.9962 to 2.7165. This loss of 27.7 grams of matter, however, has not increased very much the porosity of the mineral.

The gradual change in chemical composition taking place during the alteration of fresh tremolite to secondary talc is shown graphically in Fig. 1 (relating to the percentage composition) and also in Fig. 2 (relating to the weights of the various constituents in 100 c.c. of the mineral during alteration).

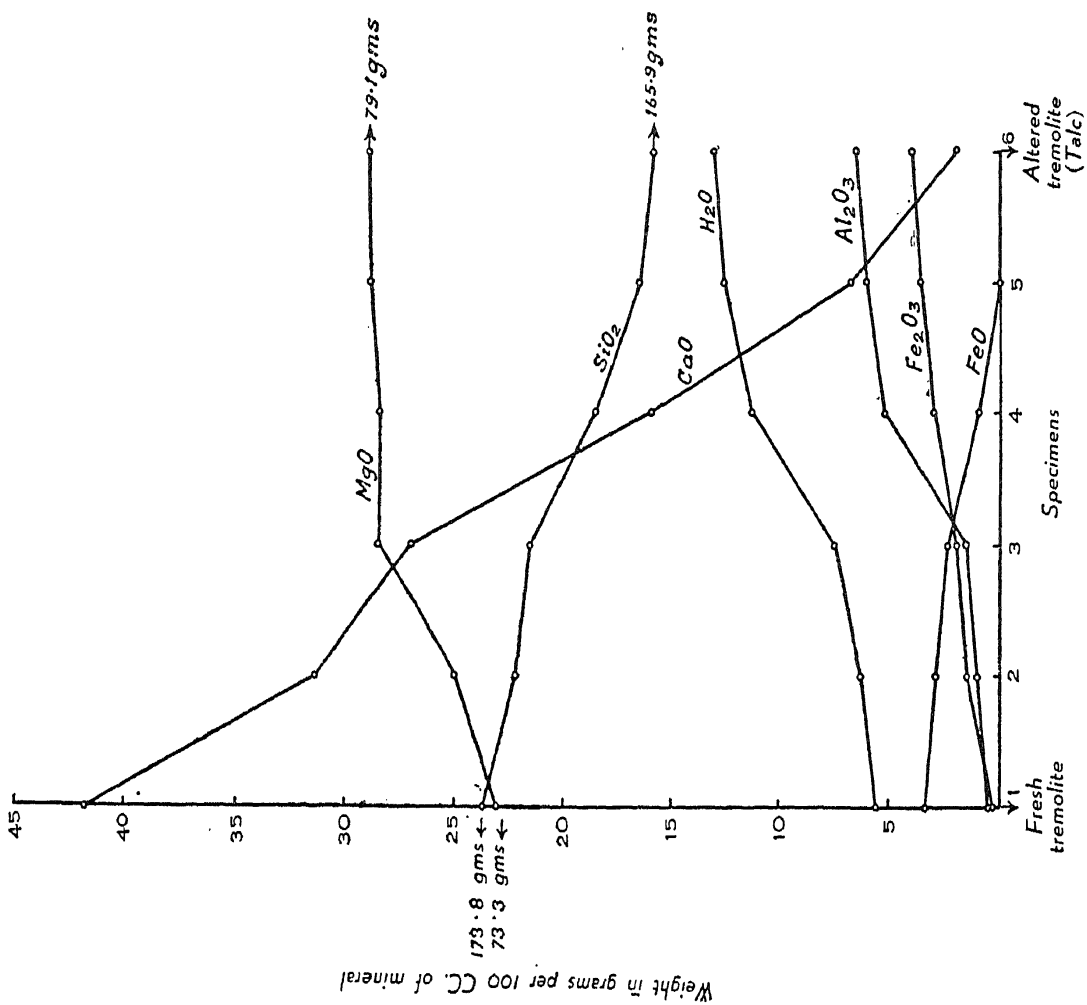


FIG. 2

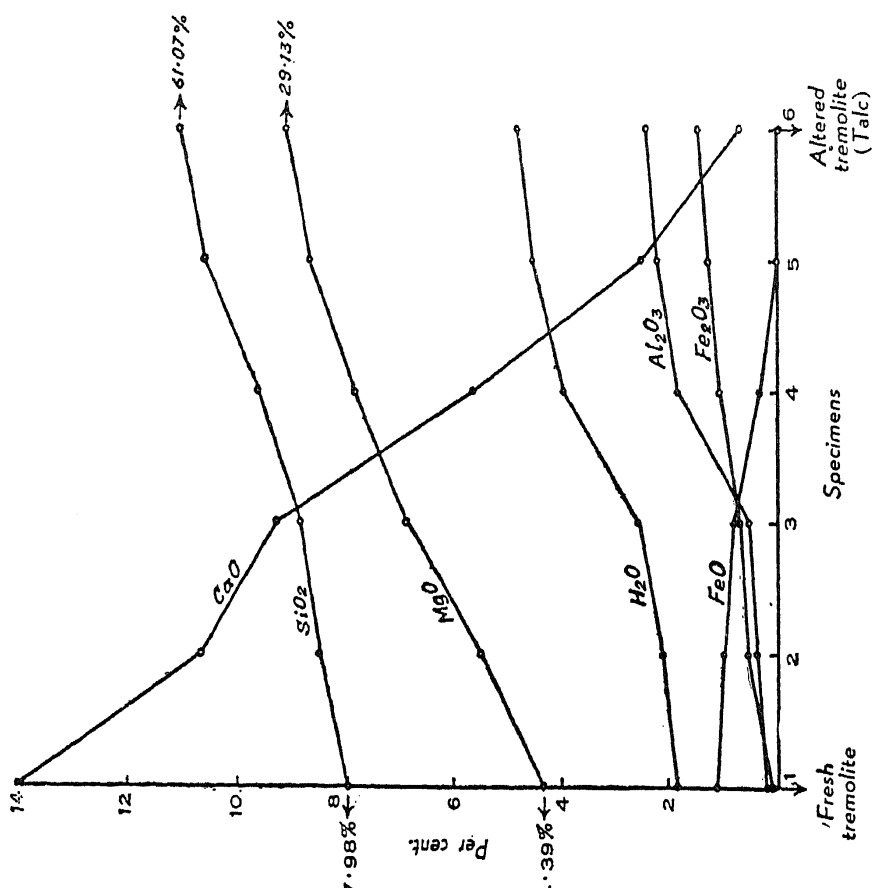


FIG. 1

Fig. 1 indicates a definite increase in weight of silica while Fig. 2 shows a definite decrease. This anomaly is brought about by the lowered density of the altered mineral. As the volume of the mineral remains constant during its alteration, Fig. 2 represents more correctly the various stages of alteration.

Summary

1. Specimens of tremolite from the dolomite marbles of Yellandu showed variations in composition indicating that they have undergone alteration.

2. The end-product of alteration was identified to be talc.

3. Six different specimens in varying stages of alteration were examined and they revealed a gradual change in specific gravity and chemical composition.

4. A definite intermediate stage of alteration was confirmed by examination of some specimens.

5. It was established by chemical analysis that during the progress of alteration the following changes take place: (a) almost all the calcium is lost, (b) water of constitution and alumina accumulate and (c) ferrous iron gets fully oxidised.

6. It is suggested that meteoric solutions and atmospheric action were mainly responsible for the alteration of tremolite to talc.

7. The gains and losses of the various constituents when 100 c.c. of tremolite undergo alteration to an equal volume of talc can be calculated because no change in volume occurs during the alteration of the mineral. The results of such are tabulated in this paper.

In conclusion, the author wishes to express his indebtedness to Dr. K. R. Krishnaswami, D.Sc. (Lond.), F.I.C., for his keen interest and advice and also for much helpful criticism.

REFERENCE

1. Pelisek .. "Priroda", Brno, 1935, 28, pp. 115.; *Mineralog. Abts.*, 6, p. 510.

EXPLANATION OF FIGURES

- FIG. 1.—Dolomite marble from Yellandu with the characteristic inclusions of tremolite—actual size.
- FIG. 2.—Four specimens of tremolite in various stages of alteration—actual size.
 (a) Original unaltered tremolite
 (b) and (c) Intermediate products of alteration
 (d) Final product of alteration—talc.
- FIG. 3.—The dolomite marble with the definite intermediate product of alteration present as streaks— $\frac{1}{2}$ natural size.
- FIG. 4. The marble with the final product of alteration—the fibrous talc.—Actual size.
M—Marble, *Tc*—Talc.

MICROPHOTOGRAPHS

- FIG. 5.—Unaltered tremolite in the dolomite marble.
M—Marble, *Tr*—Tremolite. $\times 30$. Between + nicols.
- FIG. 6.—The definite intermediate product of alteration.
I—Intermediate product, *Tr*—Tremolite. $\times 30$. Between + nicols.
- FIG. 7.—Shows the intermediate product of alteration and the secondary talc in an original tremolite.
Tr—Tremolite, *I*—Intermediate product and *Tc*—Talc. $\times 30$. Between + nicols.
- FIG. 8.—Shows the final stage of alteration.
I—Intermediate product, *Tc*—Talc. $\times 30$. Between + nicols.