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REPLY TO: COMMENTS ON AN EXPANSIBLE MINERAL HAVING HIGH REHYDRATION ABILITY

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In his Comments, Cole has pointed out that heating time of 1 hr was short. In this regard, the influence of particle size should be considered. Our experiments used a sample particle size $<2\ \mu m$ and the heating was done on a very thin film on the glass slide. We thought that 1 hr was long enough to expel all interlayer water. We have reexamined the sample and have found that it has high capacity for rehydration even after heating to at least 830°C for 5 hr.

Cole states that certain vermiculites have a high capacity to rehydrate so long as they contain some hydroxyl water. I agree with him, but certain other vermiculites will not rehydrate. I wonder if it is certain that there is a relation between existence of hydroxyl water and rehydration. Recent studies have confirmed that certain regularly interstratified minerals have high rehydration ability. However, despite this high rehydration capacity the dehydroxylation peaks in their DTA curves do not occur at high temperature (Cole and Hosking, 1957; Brindley and Sandalaki, 1963; Tomita *et al.*, 1969; Tomita and Dozono, 1973; Tomita *et al.*, 1974). Many montmorillonites and all hydrated halloysites do not rehydrate after heating to certain temperatures despite retaining some hydroxyl water. Is vermiculite the only mineral which will rehydrate after heating until all hydroxyl water is lost?

Walker and Cole (1957) and Walker (1961) reported that Batavite does not lose the last trace of interlayer water until about 800°C. In his Comments, Cole explains that it might be expected that Batavite would rehydrate after heating to 800°C. Although in their former publications it was not clearly mentioned that Batavite possessed such capacity, in the Comments it is stated that Batavite does possess a high rehydration capacity. When the mineral was allowed to rehydrate in air after heating to 800°C, a 14·2 Å reflection typical of the unheated mineral was partially recovered. An interstratified mineral from Iwato investigated by Tomita and Dozono (1973) completely rehydrated after heating to 800°C.

Some reasons are considered for high rehydration capacity. As pointed out by Granquist and Kennedy (1967), fluoride in hydroxyl sites enhances the water sorption capacity. Wright *et al.* (1972) suggested, for the same clay studied by Granquist and Kennedy, that the thermally activated substance had protons in the tetrahedral vacancies of the octahedral layer. In his Comments, Cole concluded that the greater rehydration capacity of Batavite and Llano vermiculite over the material from West Chester might be due to the fact that the former contain no iron in the octahedral layer. I think this lack of iron is one of the reasons. For example, the dehydroxylation peak of nontronite occurs at a lower temperature than in the case of iron-free analogs.

The rehydration of montmorillonite after heating to temperatures up to 1000°C has been investigated by Grim and Bradley (1948) and by Hill (1953). They concluded that after preheating to 800°C dioctahedral smectites do not show appreciable rehydration. DTA curves of some trioctahedral smectites give dehydroxylation peaks at high temperatures. Saponite from Krugersdorp, Transvaal, South Africa dehydroxylates between 800 and 900°C, and California hectorite at about 800°C (Schmidt and Heystek, 1953). Some smectites having high amounts of Mg ions in the octahedral layer might be expected therefore to have high rehydration capacity. Unfortunately, I could not obtain pure specimens of such kinds, and could not investigate their capacity to rehydrate. The problems are left for future study.

I suppose that one of the main reasons for high rehydration capacity may be due to the mineral structure. Batavite has an Al:Si ratio of 1:3 in its tetrahedral layer (Weiss and Hofmann, 1951); Llano vermiculite a corresponding Al:Si ratio of 1:2 (van Olphen, 1965). Certain interstratified minerals with high rehydration ability have fairly high substitution of Al for Si tetrahedrally (Tomita *et al.*, 1969; Tomita and Dozono, 1973; Tomita and Dozono, 1974). I have found that a Tosudite investigated by Kanaoka (1968) has a high rehydration capacity and also has a fairly high substitution of Al for Si. Thus, specimens having high tetrahedral substitution of Al for Si seem to have this rehydration ability.

According to Tomita and Sudo (1968a, b), a $2M_1$ sericite, which had been heated to dehydroxylation temperatures (650–950°C), was converted into a regularly interstratified structure by boiling in acid solution for a few minutes. Rehydration and rehydoxylation therefore occurred in the heated sericite under relatively mild conditions. Why is it that rehydration and rehydroxylation occur so easily in heated sericite? Tomita and Dozono (1972) succeeded in forming a regularly interstratified mineral from dehydroxylated $2M_1$ sericite by extraction of K^+ ion with sodium tetraphenylboron at room temperature and pressure. Here, rehydration and rehydroxylation again occurred in the dehydroxylated sericite, this time during extraction of K^+ ion from interlayers.

Weissenberg photographs of some vermiculites give diffuse spots, which can be considered evidence that these vermiculites have distorted structures. This distortion may be due partly to tetrahedral substitution of Al for Si. Heated sericites also have distorted structures (Tomita and Sudo, 1968b). These distorted structures seem to play an important role in rehydration and rehydroxylation.

Recently, Tomita (1974) reported that the rehydration and rehydroxylation properties of rectorite are similar to those of $2M$ sericites. Why are these properties of $2M$ sericites different from $1M$ sericites? We reported an interstratified mineral having high rehydration ability. We thought the phenomenon would be helpful for interpretation of the origin of interstratified minerals; it seems to be equally pertinent to discussion of the problems of high rehydration capacity.

Pure specimens having high rehydration ability should be found in the near future. Studies on such specimens should

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establish the reasons for the observed high rehydration and rehydroxylation capacity.

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