

## NOTES AND NEWS

### THE SYSTEM $\text{Fe}_2\text{O}_3$ - $\text{Mn}_2\text{O}_3$ : SOME COMMENTS ON THE NAMES BIXBYITE, SITAPARITE, AND PARTRIDGEITE

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Early in 1942 I published a paper (1) in which I pointed out the structural identity and chemical similarity of bixbyite and sitaparite (both can be represented by the formula  $(\text{Mn,Fe})_2\text{O}_3$ ), and suggested that the name sitaparite be discarded in favor of bixbyite, which has priority. My attitude is summed up in a sentence from that paper: ". . . the mineral name bixbyite may be defined precisely as including all specimens with manganese, iron, and oxygen as principal components, and having the same crystal lattice as the original bixbyite from Utah." On the basis of this definition the name bixbyite would include all specimens from pure  $\text{Mn}_2\text{O}_3$  up to the limiting substitution of iron in place of manganese. Recently, however, de Villiers (2, 3) has disagreed with this scheme, and instead proposes to retain the name sitaparite, and in addition describes as a new species—partridgeite—natural  $\text{Mn}_2\text{O}_3$  with only small replacement of manganese by iron. In his words: ". . . I suggest that the name partridgeite be applied to those manganese-iron sesquioxides containing less than 10%  $\text{Fe}_2\text{O}_3$ , sitaparite to the sesquioxides containing between 10% and 30%  $\text{Fe}_2\text{O}_3$ , and bixbyite to the mineral with more than 30%  $\text{Fe}_2\text{O}_3$ ."

As Fleischer says in a commentary to de Villier's proposals (3), arguments can be advanced for both of the above views, and the interpretation preferred is chiefly a matter of convenience. From that point of view there is little reason to carry the discussion further. However, in order to obtain a more precise knowledge of the mutual relations of these minerals I spent some time in 1942 in working out the phase diagram for the  $\text{Fe}_2\text{O}_3$ - $\text{Mn}_2\text{O}_3$  system. This work and the discussion of the mineralogical aspects was recently published in full in the *Geologiska Föreningens i Stockholm Förhandlingar* (4). As, however, this publication is not at present available outside Europe, a summary of the results may be given here, as the phase diagram provides the only satisfactory basis for the discussion of the mineralogical aspects of this system.

The phase diagram (Fig. 1) was built up by the use of synthetic preparations covering systematically all compositions between  $\text{Fe}_2\text{O}_3$  and  $\text{Mn}_2\text{O}_3$  at intervals of 10 mol.% and occasionally also at 5 mol.%. These preparations were heated in air at different temperatures between 600° and 1000° until equilibrium was reached, and the phase composition of the products determined by means of powder photographs.

In the present discussion it is unnecessary to consider the  $\text{Fe}_2\text{O}$  side of the phase diagram. The feature which concerns us is the replacement in the  $\text{Mn}_2\text{O}_3$  structure of manganese by iron. The diagram shows that the maximum replacement of manganese by iron is nearly 30% at 600°

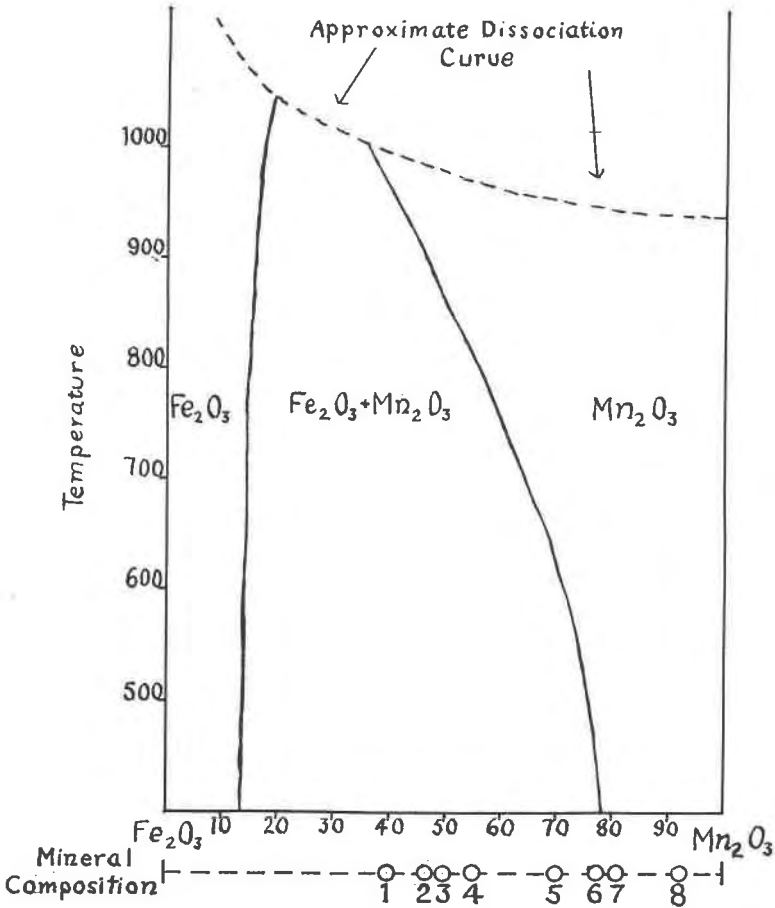


FIG. 1. The system  $\text{Fe}_2\text{O}_3$ - $\text{Mn}_2\text{O}_3$ . Mineral localities: 1 and 2, Rio Chubut, Patagonia; 3, Thomas Range, Utah; 4, Black Range, New Mexico; 5, Sitapar, India; 6, Långban, Sweden; 7 and 8, Postmasburg, South Africa.

and increases rapidly with temperature, reaching somewhat over 60% at 1000°. At temperatures greater than 1000° the sesquioxides dissociate.

The chemical composition of recorded minerals of this group are also plotted in Fig. 1. According to my proposals all these should be referred to the one species, bixbyite. According to de Villiers specimens 1-4 are

bixbyite, specimens 5, 6, and 7 are sitaparite, and specimen 8 is partridgeite.

On a paragenetic basis it is possible to arrange these specimens in two groups, the one group—specimens 1–4—being those of fumarolic or pneumatolytic origin, the other group—specimens 5–8—being of metamorphic origin. The specimens of the first group are all associated with acid extrusives, generally rhyolites, and occur together with such minerals as quartz, feldspar, topaz, and hematite (specularite). The specimens of the second group all come from metamorphosed manganese ores.

The noteworthy feature is that these two groups do not overlap in composition. The specimens of fumarolic or pneumatolytic origin group in the interval 45–60%  $\text{Fe}_2\text{O}_3$ , those of metamorphic origin between 0–30%  $\text{Fe}_2\text{O}_3$ . The explanation is contained in the phase diagram. Specimens containing more than 45%  $\text{Fe}_2\text{O}_3$  can only be formed at temperatures of about 800° or higher, whereas specimens with 0–30%  $\text{Fe}_2\text{O}_3$  can be formed at temperatures of about 650° and less.

It is evidently unlikely that specimens of  $(\text{Mn,Fe})_2\text{O}_3$  with more than 30%  $\text{Fe}_2\text{O}_3$  will be found in metamorphosed ores, unless the temperature of metamorphism has been unusually high. Thus the composition range of the specimens of metamorphic origin is not likely to overlap that of the specimens of pneumatolytic and fumarolic origin. It is evident that the latter have been formed at temperatures of about 800°–1000°, and the almost constant association of hematite with them shows that they were formed in a medium rich in  $\text{Fe}_2\text{O}_3$ . Thus they probably contain the maximum amount of  $\text{Fe}_2\text{O}_3$  possible at the temperature and pressure of formation.<sup>1</sup>

This discussion reveals that the homogeneous mineral  $(\text{Mn,Fe})_2\text{O}_3$  can be subdivided into two groups, falling into two composition ranges:

1. Those of pneumatolytic or fumarolic origin, with  $\text{Fe}_2\text{O}_3$  content from 40–60%.
2. Those occurring in metamorphosed manganese ores, with  $\text{Fe}_2\text{O}_3$  content from 0–30%.

It might appear that I have made a good case for the division of the  $(\text{Mn,Fe})_2\text{O}_3$  group of minerals into two species—bixbyite for all specimens of pneumatolytic origin, the original bixbyite having been of this type, and sitaparite for all specimens of metamorphic origin, the original sitaparite having been of this type. However, I still do not think that

<sup>1</sup> From the phase diagram it can be seen that specimens of  $(\text{Mn,Fe})_2\text{O}_3$  of fumarolic and pneumatolytic origin should be in a metastable state at normal temperatures, tending to disintegrate into an intergrowth of a hematite phase and a  $(\text{Mn,Fe})_2\text{O}_3$  phase with a much lower content of  $\text{Fe}_2\text{O}_3$ . Specimens from Utah which I have examined show, however, no trace of any such disintegration. Evidently the rate of cooling was too great for re-adjustment.

such a subdivision is necessary. Mode of origin is no principle on which to base mineralogical systematics, any more than age is a basis for petrological systematics. The specific name bixbyite, as I defined it above, covers the  $(\text{Mn,Fe})_2\text{O}_3$  group satisfactorily. However, if it is desired to subdivide the group, then subdivide rationally, into bixbyite and sitaparite. The introduction of the name partridgeite is an unnecessary complication, serving no useful purpose.

## REFERENCES

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4. MASON, B., Mineralogical aspects of the system  $\text{FeO-Fe}_2\text{O}_3\text{-MnO-Mn}_2\text{O}_3$ : *Geol. Fören. Förh.*, **65**, 97-180 (1943).