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COMMENT ON "GROWTH AND PROPERTIES OF COLORED QUARTZ"

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The interesting results of Ballman (preceding article) on the differences in concentration of various ions in the different crystallographic zones suggest the following explanations which supplement or modify the author's conclusions.

(1) Keith and Tuttle (*Am. J. Sci.*, **Bowen Volume**, 1952, p. 203) found a similar zoning of alternate "segments" of different color in natural quartz (after irradiation). It is interesting to note that such crystals as well as those grown by Ballman provide examples of the chemical inhomogeneity of a "single phase" which still qualifies as a phase in the context of the Phase Rule.

(2) Ballman suggests that a "carrier ion must be used for charge balance" in order for ferrous or ferric ion to be included in the quartz structure. Since their valence is also lower than Si^{4+}, it is obvious that the elements suggested (Be^{2+}, Mn^{2+}) cannot form half-breed derivatives

such as (for example) P^{5+} serving as a 'carrier' for Al^{3+} and together proxying for $2Si^{4+}$. It may be implied that Be^{2+} could accept interstitial sites, which is feasible, but it would be much less likely that Mn^{2+} would do so.

Energetically, what appears to be most likely is that a stuffed derivative is formed rather than adding ions in interstitial sites. Thus, $Be^{2+^{IV}}$ replaces $Si^{4+^{IV}}$ with Mn^{2+}, Fe^{2+} and Fe^{3+} being added in the stuffing site to balance the loss of charge.

Alternatively, Fe^{3+}, Be^{2+} for Si^{4+} with Mn^{2+}, Fe^{2+} (and remaining Fe^{3+} if any) in the stuffing site.

If Fe^{2+} were in lattice sites rather than Fe^{3+} it would require that twice as many total charges be realized by the stuffing ions. In fact, the analysis of Fig. 5 cannot be quantitatively explained on the basis of any of these schemes, since the atomic concentration of Be is too high to be compensated for by putting all the iron and manganese in the stuffing site. If this amount of Be^{2+} is actually incorporated, almost certainly one should detect by infra-red spectroscopy appreciable $(OH)^-$ proxying for O^{2-}.

The absorption due to Fe^{3+}, Fe^{2+} or Mn^{2+} in the stuffing site will, of course, not be the same as the absorption in other commoner crystal fields and hence one cannot extrapolate from the color of known compounds to the 'color' of an ion in an interstitial or stuffing site.

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THERMOLUMINESCENCE MEASUREMENTS WITH RAPID HEATING

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Recent papers in the *American Mineralogist* have described refined thermoluminescence measuring apparatus for minerals (Ashby and Kellagher, 1958; Lewis, *et al.*, 1959). The heating rate used for these is about 2° C. per second or less. Slow heating rates were first used in this laboratory (Saunders, 1953), but a fast heating instrument has been found to be more sensitive to low levels of thermoluminescence and increases the number of determinations which can be made per hour. A consequence of the fast-heat feature, however, is a decrease in temperature control and precision. Houtermans, *et al.* (1957) has also described a fast heating thermoluminescence instrument and discusses its relative advantages.

The apparatus described here normally employs a heating rate of 20