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Fibrous nanoinclusions in massive rose quartz: HRTEM and AEM investigations

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ABSTRACT

Pink fibrous crystals within massive rose quartz from localities in California, South Dakota, Brazil, Madagascar, and Namibia were examined with high-resolution transmission electron microscopy (HRTEM) and analytical electron microscopy (AEM). This study reveals that the nanofibers in all samples are related to dumortierite. Selected-area electron diffraction (SAED) patterns and HRTEM images indicate that the dumortierite-related fibers have a superstructure with a doubled periodicity along the **a** and **b** axes of dumortierite, giving cell parameters $a = 2a_{dum} = 2.36$ nm, $b = 2b_{dum} = 4.05$ nm, $c = c_{dum} = 0.47$ nm. Computer simulations suggest that periodic arrangements of two different M1 site occupancies in the octahedral face-sharing chains give rise to the superstructure. One type of M1 site is occupied mainly by Al, whereas the other type is dominated by Ti and Fe. Simulated HRTEM images based on our proposed model match the experimental images. Most of the fibers, elongated along the **c** axis, are free of defects. AEM analysis shows that the dumortierite-related fibers have a composition similar to well-characterized dumortierite, but that they contain a greater amount of Fe substituting for Al in the M1 sites. Boron was detected in all fibers examined by electron energy loss spectroscopy as well as in sillimanite crystals found as a minor component in one rose quartz from Brazil.