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Dehydration processes in the meta-autunite group minerals meta-autunite, metasaléeite, and metatorbernite

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ABSTRACT

We investigated dehydration processes in uranyl phosphate minerals of the meta-autunite group that consist of uranyl phosphate sheets and interlayer cations, and water molecules. Meta-autunite [$Ca(UO_2PO_4)_2{\cdot}6H_2O$], metasaléeite [$Mg(UO_2PO_4)_2{\cdot}8H_2O$], and metatorbernite [$Cu(UO_2PO_4)_2{\cdot}8H_2O$] were selected for our study. The change in basal spacing between two adjacent uranyl phosphate sheets with temperature was examined by temperature-controlled X-ray diffraction (XRD) analysis from room temperature (RT) to 300 °C to determine structurally distinct, dehydrated phases. Thermogravimetric and differential thermal analyses (TG/DTA) were also performed under conditions similar to those used for the XRD analysis to clarify the hydration states of the dehydrated phases. Retention of the structure of the uranyl phosphate sheets under a high vacuum, equivalent to 300 °C, was confirmed by transmission electron microscopy. Meta-autunite, metasaléeite, and metatorbernite decreased their basal spacings by losing water molecules. Comparison of the TG/DTA and XRD results indicates that the changes in basal spacings of the dehydrated phases with temperature are as follows: 8.32 Å (6 H_2O per unit formula) at RT, 7.31 (? H_2O) and 6.68 Å (? H_2O) at 75 °C, 6.34 Å (2 H_2O) at 120 °C, and 5.81 Å (1 H_2O) at 300 °C for meta-autunite; 8.29 (8 H_2O) and 7.73 Å (? H_2O) at RT, 6.62 Å (probably, 2 H_2O) at 40 °C, 6.54 Å (2 H_2O) at 160 °C, and 5.52 Å (1 H_2O) at 300 °C for metasaléeite; and 8.61 Å (8 H_2O) at RT, 8.07 Å (4 H_2O) at 100 °C, 6.58 Å (2 H_2O) at 200 °C, and 5.60 Å (1 H_2O) at 300 °C for metatorbernite. The dehydration processes revealed by XRD and TG/DTA under similar experimental conditions are slightly different from those obtained by previous studies. Our results clearly demonstrate the presence of previously unknown dehydrated phases of the meta-autunite group minerals with basal spacings less than 6 Å that may have distinct thermodynamic properties.