American Mineralogist, Volume 92, pages 1695–1703, 2007

The system Al_2O_3-P_2O_5-H_2O at temperatures below 200 °C: Experimental data on the stability of variscite and metavariscite $AlPO_4 \cdot 2H_2O$

Kirsten Drüppel,[1,*] Andreas Hösch,[2] and Gerhard Franz[1]

[1]Technical University Berlin, Institute for Applied Geosciences, Department of Mineralogy, Sekr. ACK9, Ackerstrasse 71-76, D-13355 Berlin, Germany
[2]Röntgenstrasse 7a, D-10587 Berlin, Germany

Abstract

The system Al_2O_3-P_2O_5-H_2O contains many phosphate minerals that occur in various geologic environments. The natural occurrence of variscite ($AlPO_4 \cdot 2H_2O$, orthorhombic), including its monoclinic polymorph metavariscite, is largely restricted to soils and aluminous rocks like Al-rich igneous rocks and shales, which interacted with P-rich hydrothermal solutions or groundwater. Variscite dehydrates to berlinite ($AlPO_4$) and a hydrous P-Al-rich fluid. This dehydration reaction $AlPO_4 \cdot 2H_2O = AlPO_4 + 2H_2O$ is, however, metastable, at low concentrations of P in the fluid, because berlinite breaks down at lower temperature to augelite $[Al_2PO_4(OH)_3] + H_3PO_4 + H_2O$ and trolleite $[Al_4(PO_4)_3(OH)_3] + H_3PO_4 + H_2O$. The variscite/metavariscite = berlinite equilibrium has been investigated by synthesis experiments from mixtures of γ-Al_2O_3 and excess phosphoric acid at pressures between 1 and 5 kbar and temperatures of 100–200 °C using standard cold-seal vessels. The hydration-dehydration equilibrium is mainly controlled by temperature and only weakly by pressure. At 4 and 5 kbar, variscite/metavariscite were found at temperatures of ~150 °C, at lower pressure at 115–125 °C in accordance with their natural mode of occurrence. In this *T* range, however, variscite/metavariscite is not the sole phase but is always accompanied by variable but generally minor amounts of wavellite and trolleite $Al_4(PO_4)_3(OH)_3$. Secondary wavellite $Al_3(PO_4)_2(OH)_3 \cdot 5H_2O$, hydrated Al-phosphate $AlPO_4 \cdot xH_2O$ ($1.1 \leq x \leq 1.3$) and Al-metaphosphate hexahydrate $Al(H_2PO_4)_3$ formed during quenching and/or drying of the runs. Berlinite is the reaction product at temperatures 200 °C/4–5 kbar and 150 °C/1–3 kbar and may be associated with augelite and trolleite.

Keywords: Al-orthophosphates, berlinite, hydrothermal experiments, metavariscite, stability, variscite