

Aqueous Pb sorption by hydroxylapatite: Applications of atomic force microscopy to dissolution, nucleation, and growth studies

STEVEN K. LOWER,^{1,*} PATRICIA A. MAURICE,¹ SAMUEL J. TRAINA,² AND ERNEST H. CARLSON¹

¹Department of Geology, Kent State University, Kent, Ohio 44242, U.S.A.

²School of Natural Resources, Ohio State University, Columbus, Ohio 43210, U.S.A.

ABSTRACT

A combination of atomic force microscopy, scanning electron microscopy, transmission electron microscopy, energy dispersive spectroscopy, electron diffraction, and X-ray diffraction were used to study reactions of 0.5–500 mg/L aqueous Pb with $\text{Ca}_5(\text{PO}_4)_3\text{OH}$, hydroxylapatite (HAP), at pH 6 and 22 °C. Following 2 h reaction time, concentrations of Pb_{aq} ($[\text{Pb}_{\text{aq}}]$) decreased from 500 mg/L to <100 mg/L, and from 0.5–100 mg/L to <15 $\mu\text{g/L}$. This loss of Pb_{aq} from solution (i.e., sorption) resulted partially from simultaneous dissolution of HAP and precipitation of $\text{Pb}_5(\text{PO}_4)_3\text{OH}$, hydroxypyromorphite (HPY), or another solid Pb phase.

The initial saturation state with respect to HPY (defined as the ratio of the ion activity product to equilibrium solubility product) influenced strongly precipitation processes. At a high degree of saturation (initial $[\text{Pb}_{\text{aq}}] > 100 \text{ mg/L}$), small nuclei or aggregates of poorly crystalline HPY precipitated homogeneously in solution. At intermediate saturation (initial $[\text{Pb}_{\text{aq}}] \sim 10\text{--}100 \text{ mg/L}$), large, euhedral needles of HPY precipitated homogeneously in solution. At a low degree of saturation (initial $[\text{Pb}_{\text{aq}}] < 10 \text{ mg/L}$), a needle-like Pb-containing phase grew heterogeneously on HAP. These results agree well with concepts derived from nucleation and growth theories and demonstrate that initial saturation state influences strongly the sorption process.