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Lanthanum Incorporation in Synthetic Pb–Vanadate and Pb–Arsenate Apatites: Implications for REE Recovery by Coprecipitation

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The increasing demand for rare earth elements (REE) in advanced technologies has intensified the search for alternative recovery methods. A recently proposed approach involves leaching REE in phosphoric acid followed by coprecipitation with lead apatite, pyromorphite ($Pb_5(PO_4)_3Cl$) [1]. This study evaluates the fate of REE during coprecipitation with structurally analogous lead arsenate (mimetite, $Pb_5(AsO_4)_3Cl$) and lead vanadate (vanadinite, $Pb_5(VO_4)_3Cl$), as well as their hydroxyl analogs.

A series of syntheses was conducted under ambient conditions at pH 3 and 9. Stoichiometric solutions of Pb^{2+}, Cl^-, and AsO_4^{3-} or VO_4^{3-}, were reacted in the presence of La^{3+}, used as a proxy for light REE. Hydroxyl analogs were prepared in the absence of Cl^-. Control experiments were performed without La.

All experiments yielded the targeted apatite-type phases, as confirmed by powder X-ray diffraction and SEM/EDS analyses. The precipitates formed hexagonal prismatic crystals or acicular aggregates ranging from 0.5 to 10 μm in length. In La-bearing systems, crystals were systematically longer, consistent with observations for phosphate analogs. Lanthanum incorporation varied among phases. Mimetite incorporated up to ~2.9 wt% La, whereas vanadinite incorporated ~1.4 wt% La. These values are significantly lower than the ~5 wt% reported for synthetic pyromorphite under comparable conditions [2].

The results indicate that substitution of PO_4^{3-} by AsO_4^{3-} or VO_4^{3-} reduces REE incorporation efficiency in lead apatite-type structures. Thus, arsenate and vanadate analogs are less favorable hosts for REE recovery via coprecipitation. To our knowledge, this study provides the first experimental evidence of REE incorporation into synthetic mimetite- and vanadinite-type phases. Further investigation is required to quantify partitioning mechanisms and structural controls on REE uptake within the apatite supergroup.

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[1] Manecki *et al.* (2026) patent PL248621B1, https://patents.google.com/patent/PL444079A1/ en?oq=PL444079A1

[2] Staszel *et al.* (2025) *Geochemistry,* 85, 126252. doi:10.1016/j.chemer.2025.126252.