

Stability and transformation of (Al-)jarosite in acid-sulfate paddy soils: A field study

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Jarosite ($\text{KFe}_3(\text{SO}_4)_2(\text{OH})_6$) is a commonly occurring mineral in oxidised acid sulfate (AS) environments, where its stability influences soil acidity and the availability and mobility of trace elements (sorbed or incorporated), Al and Fe. Jarosite is formed under oxic conditions with $\text{pH} < 4$. However, under flooded conditions, increasing pH promotes rapid transformation of jarosite into other mineral phases by hydrolysis, and microbial reduction of Fe allows for Fe(II)-catalysed jarosite transformation. Despite the ubiquity of these reactions in AS systems, the transformation of jarosite has rarely been observed in situ where close contact with organic and inorganic soil components, complex chemical matrices, diverse biological communities, and advective or diffusive processes, may influence the jarosite transformation rate and pathway. Therefore, in this study, we explored the stability and transformation products of synthetic jarosite, with and without Al-for-Fe substitution, in anoxic redox-active AS topsoils and anoxic subsoils from Central Thailand. Using mesh bags made of PETE fabric (pore size of 52 μm), pure (Al-)jarosite and soil enriched with ⁵⁷Fe-labelled (Al-)jarosite were buried at 15 and 70 cm depth in a paddy that was flooded for rice cultivation. Products of mineral transformation were measured by ⁵⁷Fe-Mössbauer spectroscopy (mineral soil-mixes and selected pure minerals), and X-ray diffraction (pure minerals only). In topsoils, pure unsubstituted jarosite was completely transformed to goethite and minor amounts of ferrihydrite within twelve to sixteen weeks. In contrast, pure Al-jarosite in topsoil, and all samples in subsoil, were only partially transformed after sixteen weeks. In soil with ⁵⁷Fe-labelled (Al-)jarosite enrichment, near-complete dissolution of unsubstituted jarosite occurred in topsoil within sixteen weeks, and partial dissolution of the Al-jarosite in topsoils and (Al-)jarosite in subsoils was observed. Notably, in (Al-)jarosite-enriched soils, Fe(III) (oxyhydr)oxides such as ferrihydrite, goethite and lepidocrocite were minor products. Iron(II) dominated the products, as sorbed, complexed and disordered species. The results demonstrate that (Al-)jarosite is stable for several months in this AS topsoil and subsoil. However, the lack of ⁵⁷Fe (oxyhydr)oxide products in the (Al-)jarosite-enriched soil that could have immobilised trace elements, Al and Fe, suggest that these elements could remain mobile in flooded AS soils.