Goldschmidt 2022 Abstract
https://doi.org/10.46427/gold2022.11434

Converting K-feldspar to Potassium Fertilizer with a Green Chemistry Approach

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Here I review recent developments for converting K-feldspar-rich rocks into a ready-to-use potassium fertilizer via hydrothermal alteration. Recent experiments[1,2] were based on the hydrothermal alteration of K-feldspar at 190 °C in pH 12 $Ca(OH)_2$ solutions for 24h in batch reactors. The secondary minerals that formed were predominantly calcium carbonates (calcium, vaterite) and Ca(Al)-silicates, such as tobermorite and hydrogrossular. In addition to these phases, we found that a K-rich amorphous phase formed at the interfaces of the original K-feldspar grains. To test the performance of the hydrothermal product, we carried out simple lab bench leaching experiments in pure water and quantified the leaching behavior based on 3 indices. By comparing leaching of K, Al, and Si at ambient temperature, it was shown that K is both enriched in the product, and also very labile. The second index was based on the mass of each element (K,Al,Si) in the leachate compared to its mass in the unaltered K-feldspar. The degree of conversion of K was highly elevated, and 1-2 orders of magnitude greater than for Al and Si. This result revealed that K release must be occurring from soluble secondary phases, rather than more slowly dissolving (alumino)silicates. The third index was based on the leaching behavior of the product and the original feldspar- here again the product released 1-2 orders of magnitude greater amounts of K, Al and Si. Overall these leaching results indicate that the hydrothermal product has potential for use as an “as-is” fertilizer that would readily release K to a soil. The presence of the in situ-formed amorphous surface altered layer may play a key role in the high degrees of K release that we measured.

1. Zhai, R. Hellmann et al., 2021, Fertilizer derived from alkaline hydrothermal alteration of K-feldspar: a micrometer to nanometer-scale investigation of K in secondary reaction products and the feldspar interface. *Applied Geochemistry* 126, 104828.
2. Hellmann, Y. Zhai et al., 2021. The hydrothermal alkaline alteration of potassium feldspar: a nanometer-scale investigation of the orthoclase interface. *Chemical Geology* 569, 120133.