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Hydrothermal breakdown of chevkinite-(Ce) – evidence from experiments

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During hydrothermal alteration, the REE-bearing minerals of the chevkinite group (CGM) have the potential to release, not only REE but also high field-strength elements and the actinides. A commonly observed alteration sequence in natural rocks is chevkinite → titanite plus a REE phase, such as allanite and bastnäsite. To provide quantitative information on such reactions, we have experimentally subjected a natural chevkinite-(Ce) from the Diamer District, Pakistan to fluid-induced alteration involving a Ca(OH)2-bearing hydrous fluid. The experimental conditions were: temperature 600°C; pressure 400 MPa; duration 21 days. Small amounts of natural albite and quartz were added to the charge to simulate natural rock-forming conditions more closely.

Significant reaction between the chevkinite-(Ce) and fluid occurred, with the formation of titanite and britholite-(Ce), plus minor hedenbergite. The nature of the reaction zones was very variable. Commonly, the rims of chevkinite-(Ce) were replaced by thin zones comprised first of britholite-(Ce) followed by titanite. Such a structure is similar to that experimentally produced by dissolution-reprecipitation in monazite and apatite by Harlov and colleagues. In the present case, chevkinite-(Ce) was dissolved by the fluid until it became saturated with britholite-(Ce) and then with titanite. With time, the reaction proceeded inwards into the chevkinite via a coupled dissolution reprecipitation process.

A second type of alteration is seen along cracks. Here britholite-(Ce) formes along the walls with titanite crystallizing centrally, often as beautifully euhedral crystals. The titanite occasionally formed "veinlets" away from the cracks, which cut across the chevkinite-(Ce). This attests to a remarkable mobility of the titanite component.

A puzzling result of the experiment is that we are so far unaware of any natural example where a CGM has broken down to titanite and britholite. Ongoing experiments using different combinations of ligands in the fluids and P-T-time conditions are aimed at creating a full record of the mechanisms and products of CGM alteration.

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