

# **The role of coupled dissolution-precipitation in fluid-mineral reactions: silicates, oxides, and phosphates.**

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In order for silicate, oxide, and phosphate minerals to equilibrate with each other during metamorphism in the crust or lithospheric mantle in a melt-absent system, fluids are required to be present along grain boundaries in order to aid in the necessary mass transfer. Fluid-absent, solid-state diffusion exchange of elements within and between minerals, whether for a single element or coupled elements because of charge balance, is generally too slow in silicate, oxide, and phosphate minerals to effect equilibration, even under high-grade conditions over long periods of time. However, whether or not fluids will effect equilibration between minerals or re-equilibration of a single mineral phase is not so much a function of P-T but rather a function of the reactivity of the fluid with the mineral phase or phases. If reactive, fluid-aided re-equilibration between minerals or between a mineral and a fluid is generally accomplished via the process of a coupled dissolution-precipitation reaction involving the mineral phase (Putnis, 2009, *Rev Mineral Geochem* 70, 87-124), which is driven by a minimization in the chemical potentials between the mineral phase or phases and the fluid phase.

Examples of silicate, oxide, and phosphate minerals experimentally re-equilibrated via the aid of fluids over a broad P-T range include garnet (Pollok et al., 2008, *Chemie der Erde*, 68, 177-191), zircon (Harlov and Dunkley, 2010, V41D-2301, Fall AGU Meeting), feldspars (Norberg et al., 2011, *Contrib Mineral Petrol* 162, 531-546), uraninite (Harlov et al., 2021, EMPG XVII Conf Abst, 103), magnetite (Hu et al., 2017, *Goldschmidt Conf Abs* 1711), ilmenite (Angiboust and Harlov, 2017, *Am Mineral* 102, 1696-1708), apatite (Harlov, 2015, *Elements* 11-3, 171-176), monazite (Harlov et al., 2011, *Contrib Mineral Petrol* 162, 329-348), and xenotime (Harlov and Wirth, 2012, *Am Mineral* 97, 641-652). For mineral geochronometers, re-equilibration can serve to reset the clock such that metasomatic events can be dated. Comparisons between minerals and the fluids involved in their partial or total re-equilibration via a coupled dissolution-precipitation process allows for insight into how fluids interact chemically with rocks over a broad range in P-T-X-t in the crust and lithospheric mantle over time.