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Why most "dry" rocks should cool "wet"

MATTHEW J. KOHN[1,*]

Lawrence Livermore National Laboratory, P.O. Box 808, Livermore, California 94550, U.S.A.

ABSTRACT

A new consideration of oxygen isotope resetting among metamorphic minerals is made accounting for (1) the possibility of f_{H_2O}-buffering by typical mineral assemblages during cooling and (2) experimental data that show that high f_{H_2O} correlates with high diffusion rates. Isotope closure temperatures in buffered rocks are intermediate between simpler predictions based on "wet" (1 kbar hydrothermal) and "dry" ($P \leq 1$ atm, H_2O-absent) diffusion experiments, but are typically within ~50 °C of closure temperature estimates that use "wet" diffusion rates, yet 200–300 °C different from "dry." Even though many rocks may be "dry" in that they lack a hydrous fluid that is physically present during cooling, buffering of f_{H_2O} results in quasi-"wet" diffusion rates. Re-evaluation of published data shows that most rocks indeed exhibit substantial isotope resetting that is best matched by predictions of f_{H_2O}-buffering models. Wet- and dry-diffusion models somewhat overestimate and greatly underestimate resetting respectively. Previous interpretations invoking "dry" diffusion rates may derive from erroneous fractionation factors or faster cooling rates than assumed. The rare preservation of isotope closure temperatures that are higher than predicted may reflect faster than expected cooling rates or extraordinarily low f_{H_2O} in conjunction with anhydrous assemblages.