

Internally consistent database for oxygen isotope fractionation in minerals: theory and application to HP metamorphic rocks

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Oxygen isotope fractionation between minerals has been used for thermometry, but also to investigate samples that experienced fluid-rock interactions. Its petrological interpretation requires the knowledge of equilibrium fractionation between phases and its evolution with temperature. Available compilations of fractionation factors are either restricted to small chemical systems or based on different methods, making the data not consistent with each other. We report the first internally consistent database of oxygen fractionation factors for most major and accessory phases and a H₂O fluid phase. The database is based on a large compilation of literature experimental, theoretical and natural data. All the constraints for a given phase contributed to the refinement of its fractionation properties making the final database internally consistent.

This database can be applied in a thermodynamic framework to model the evolution of $\delta^{18}\text{O}$ in minerals through their metamorphic history. For a given a bulk rock composition, mineral assemblage, modes and compositions can be predicted along any P-T path by Gibbs free energy minimization. If the $\delta^{18}\text{O}$ bulk is known, the $\delta^{18}\text{O}$ values of each phase at the given T can be predicted. If the $\delta^{18}\text{O}$ of one phase is known, the $\delta^{18}\text{O}$ of the other phases in equilibrium and the $\delta^{18}\text{O}$ bulk can be calculated. This strategy enhances our ability to investigate samples that experienced complex thermal histories and/or fluid-rock interactions.

This approach was applied to HP rocks from the Sesia Zone (Western Alps). The continental fragments of this zone record different pre-Alpine histories and different P-T-t path during Alpine subduction. Several observations support the presence of fluid at HP. Relics of pre-Alpine garnet in metasediments show systematically higher $\delta^{18}\text{O}$ values with respect to Alpine rims, suggesting a significant input of external fluids between the Permian HT stage and the HP evolution. In situ $\delta^{18}\text{O}$ analysis allows the isotopic composition of mineral zones to be resolved and related to mineral textures reconcilable with growth zoning, but also resorption and replacement.