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Geochemical and geochronological constraints for tectonic, thermal and thermodynamic modelling

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Modelling at different scales, from tectonic processes to mineral reactions requires constraints from natural and experimental studies. Geochemical studies document variations in elements and isotopes from the mineral to the regional scale that are translated into information that is fundamental to models, such as age, mineral reactivity and inheritance, sample provenance and chemical exchanges. This contribution will review some of the geochemical constraints that challenge and inform tectonic and petrological models.

Geochronological constraints on a regional or global scale are fundamental information for tectonic models. Not only absolute ages, but most importantly rates and duration of processes can refine and challenge tectonic models. The fast rate of subduction and exhumation recorded in some eclogitic units remains a challenge for tectonic models. Diachroneity of metamorphism across orogenic belts (e.g. subduction in the Alps and partial melting in the High Himalayan Crystalline) demands complex tectonics that can account for localized exhumation during convergence. Duration of melting over tens of millions of years, followed by fast cooling is recorded by geochronometers in collisional orogenies: this requires thermal models that maintain high temperatures and low melt production, and are coupled with fast tectonics.
Chemical and isotopic zoning in robust minerals such as garnet and zircon indicate that dissolution-precipitation is a common process in metamorphic rocks. Oxygen isotopes additionally inform that mineral dissolution is related to fluids that can either be internally equilibrated or externally sourced. Strong heterogeneities in chemical zoning and fluid influx are documented at the sample and unit scale. This information has bearings on the assumption of thermodynamic equilibrium at the micro scale, as well as consistency across rock types and geological units.