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Tracing subduction zone processes using light stable isotopes (Li, B, N)

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Subduction zones are fundamental for material exchange between the Earth's surface, including atmosphere and hydrosphere, and the deep reservoirs of the solid Earth (crust, mantle and core). Elemental concentrations and isotopic compositions of pre-subduction lithologies, subduction-related metamorphic rocks and igneous rocks from the arcs are key for an accurate assessment of the subduction zone cycling of elements. They are used to balance subduction zone inputs versus outputs at volcanic arcs, to understand subduction-related metamorphic processes and to interpret the geochemical signatures of mantle-derived magmas. In the last decades, the isotopes of the light elements lithium (Li), boron (B) and nitrogen (N) have increasingly been used to detect and quantify exchange processes during subduction. This contribution will provide a brief overview of fundamental aspects and will highlight some relevant findings pertinent to subduction zone processes.

All 3 light element stable isotope systems have relatively large isotopic differences between the various terrestrial reservoirs due to large relative mass differences. Two key issues for the interpretation of the isotope data have emerged: (a) The variability in isotopic compositions of the subduction input material, and (b) the distinction between isotopic signatures that derive from sources and those that derive from processes. For lithium, data that do not conform to those predicted for equilibrium Li isotope fractionation and lack of correspondence between Li isotopes and indicators of slab fluid involvement and have hindered unequivocal interpretations [1,2]. In contrast, boron has shown systematic concentration and isotopic changes in convergent margin settings that have successfully been used to track water cycling and fluid-rock interaction [3,4]. Data for nitrogen are still relatively scarce, but it seems particularly well-suited for the tracing of sediment-derived material because N is largely fixed by organic processes in sedimentary environments [5].

References:

[1] Tomascak, Magna & Dohmen (2016), *Advances in Lithium Isotope Geochemistry*.

[2] Penniston-Dorland, Liu & Rudnick (2017), *Reviews in Mineralogy & Geochemistry* 82, 165-217.

[3] De Hoog & Savov (2018), in: *Boron Isotopes*, pp. 218-247.

[4] Konrad-Schmolke & Halama (2014), *Lithos* 208-209, 393-414.

[5] Halama & Bebout (2021), *Space Science Reviews* 217, 45.