B- and Li-rich fluid pulses in the Mariana mantle wedge

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Serpentinized subarc mantle peridotites act as an important sink for Li and B. These mobile light elements are carried by H_2O-rich fluids released from the downgoing Pacific slab during subduction. We studied variably serpentinized harzburgite clasts recovered after drilling in the forearc region of the Mariana arc-basin system (ODP Leg 195, Site 1200). Our goal was to determine the course of serpentinization by studying various textural features and their B and Li signatures.

Slab dehydration and the resulting serpentinization of the overlaying mantle wedge is not a sudden process but rather a series of stepwise reaction fronts fed by separate fluid pulses through the rock. These fluid pulses have changing, constantly evolving composition and thus form different serpentine types and could even react with already serpentinized rock.

We measured the Li and B concentration in different textural types (e.g. veins, mesh rims and centers) of serpentine on a 5 µm scale by SIMS and identified the specific serpentine polymorphs of these textures by Raman spectroscopy. Lizardite appears to be the dominant serpentine polymorph in all textural types.

The textures in serpentinite clasts with relict primary minerals (e.g. OL and PX) can be correlated with distinct Li and B concentrations. Serpentinization begins with fracture-filling veins and the formation of mesh rims replacing olivine. For instance, an early broad vein shows an evolution from high B (up to 90µg/g) and Li (>10µg/g) content in the rim zone towards lower B (~55µg/g) and Li (>0.4µg/g) values in the veins central part. Thus, the initial slab fluids were highly enriched in light elements that were incorporated into the first generation serpentines. The first generation mesh rims have variable B concentrations, but also high Li (>10µg/g) contents. To the contrary, late-stage mesh centers and late (often brucite-rich) thin veins record the lowest Li contents (down to ~0.1µg/g) and low B contents (<10µg/g).

Our data reveal that serpentinizing fluids in the mantle wedge change their composition. Such changes may have a massive influence on the style and extent of the Li and B forearc outfluxes. We conclude that serpentinization of the mantle wedge is very heterogeneous on all scales.

Weathering rates: A hydrological approach

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A set of springs in the Vila Pouca de Aguiar region (N.Portugal), where granites and metassediments occur, was monitored for discharge rate and sampled for major inorganic composition Using GIS software, the study area was divided into very small (40±20 ha) and small (300±170 ha) watersheds and the springs positioned within their boundaries. The GIS software also characterized the basins for perimeter (P), area (A), volume (V) and length of drainage lines (L), from which average flow paths ($F = 2A/P$) and aquifer depths ($D = V/A$) could be estimated. These variables were coupled with the average discharge rate (Q) to estimate the hydraulic conductivity $K=0.57\sqrt{}(a_3/a_1)(A^3/L^2V^2)$ and effective porosity $n_e = 1.98/(V\sqrt{}(a_1a_3))$ of the fractured massifs, where a_1 and a_3 are intercept-y values of Brutsaert graph lines [1], and hydraulic travel times $t = (n_e/K)(F^2/D)$. With additional information on rock mineralogy and mineral properties, fracture and BET surface areas of plagioclase (A_{Pl}) could be estimated: $A_{Pl} = 2\alpha_{Pl}Q\sqrt{}(\rho_w g n_e/12\mu_w K)$ and $A_{Pl} = (Q/n_e)\ \alpha_{Pl}\rho_{Pl}S_{Pl}$, where α_{Pl}, ρ_{Pl} and S_{Pl} are the proportion of plagioclase in the rock and the specific weight and surface of plagioclase, ρ_w and μ_w are the specific weight and dynamic viscosity of water, and g is the acceleration of gravity. Finally, weathering rates of plagioclase (W_{Pl}) were calculated by $W_{Pl} = ([Pl]/t)(Q/A_{Pl})$. The mole fractions of plagioclase, [Pl], were determined by the SiB algorithm [2] assuming two weathering scenarios compatible with the regional range of annual precipitations (1000–1600 mm/yr): maximization of kaolinite and gibbsite productions. Average log rates of plagioclase are shown in Table 1. The log rates are higer in the first scenario. Changing the reference basin does not affect the fracture rates but lowers the BET rates. Fracture rates compare favourably with reported laboratory measurements whereas BET rates of very small watersheds are similar to reported field estimates [3].

		Weathering scenario			
		1 - Maximization of kaolinite production		2 - Maximization of gibbsite production	
		Fracture area	BET area	Fracture area	BET area
Reference basin for springs	Very small watersheds	-12.2	-15.3	-12.5	-15.5
	Small watersheds	-12.3	-16.7	-12.4	-16.8
Literature results at room temeratures		Laboratory log rates = -12.1			
		Field studies log rates = - 15.1			

Table 1: Average log rates of plagioclase.

[1] Brutsaert & Lopez (1998) *Water Resour. Res.* **34**(2) 233–240. [2] Pacheco & Van der Weijden (1996) *Water Resource. Res.* **32**, 3553-3570. [3] White & Brantley (2003) *Chem. Geol.* **202**, 479-506.