



# Halogen (F, Cl, Br, I) behaviour in subducting slabs: A study of lawsonite blueschists in western Turkey



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## ABSTRACT

We examined the F, Cl, Br and I abundance of minimally retrogressed lawsonite blueschists from the Tavsanli Zone in northwest Turkey to evaluate the behaviour of halogens in subduction zones, and to determine the role coexisting high pressure minerals may play in transporting the halogens to the Earth's mantle. The blueschists contain sodic amphibole and lawsonite, with variable amounts of phengite and chlorite, and minor apatite. A positive correlation between Cl, Br and I contents in bulk rocks suggests their overall coherent behaviour in subduction zones, although high ratios of I/Cl and Br/Cl compared to altered oceanic crust indicate that Cl is preferentially lost relative to Br and I before or during blueschist metamorphism. Iodine and F are enriched relative to altered oceanic crust, suggesting incorporation from marine sediments. *In situ* analyses of minerals in thin sections reveal F preferentially concentrates in apatite (avg. 3.13 wt%), over phengite (482 ppm), lawsonite (avg. 413 ppm) and Na-amphibole (257 ppm). Chlorine also preferentially resides in apatite (138 ppm), followed by equal partitioning between phengite (59 ppm) and Na-amphibole (56 ppm), and lower concentrations in lawsonite (27 ppm). Upon apatite decomposition at a depth of ~200 km, F may redistribute into lawsonite and phengite in slabs, whilst Cl is likely expelled to the overlying mantle wedge. Given the stability of lawsonite and phengite to a depth of 280–300 km in cold subduction zones, they may transport F beyond subarc depths, contributing to the high F in magmas derived from the deep mantle.

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## 1. Introduction

Halogens are predominantly concentrated in the Earth's surface reservoirs, including seawater and sediments. Their concentrations are low in the primitive mantle, with current estimates of 18 ppm F, 1.4 ppm Cl, 0.0036 ppm Br and 0.001 ppm I (Lyubetskaya and Korenaga, 2007). As halogens are not compatible with mantle minerals, they are preferentially removed from the mantle during partial melting, and as such their concentrations are even lower in the depleted MORB mantle (DMM). Despite having low concentrations in the mantle, halogens are abundant in mantle-derived magmas, and are continuously discharged from volcanoes of a variety of settings. For example, F and Cl are the most abundant constituents of volcanic gases discharged from arc volcanoes after H<sub>2</sub>O, CO<sub>2</sub> and S species (Symonds et al., 1994). The key mechanism responsible for volcanic outputs is the recycling of elements from surface reservoirs to the mantle through sub-

duction. Many studies have primarily focused on Cl in subduction zones, using it as a proxy for the other halogens (e.g. Scambelluri et al., 2004; Marschall et al., 2009).

During subduction, aqueous fluids released from the slab move upward to the overlying mantle wedge, which leads to partial melting of the interior of the hot mantle wedge for arc magmatism. The depth of fluid release is related to the geothermal gradient of the subduction zone and the stability of hydrous minerals. As halogens are soluble in aqueous fluids, their behaviour is expected to follow that of water, but the stability of hydrous minerals differs widely, and hydrous minerals have varying ability to accommodate fluid-mobile elements, including halogens. Therefore, the composition of fluids released from slabs is likely to change with increasing depth. Furthermore, some hydrous minerals, such as serpentine (~13 wt% H<sub>2</sub>O), lawsonite (~ 11 wt% H<sub>2</sub>O) and phengite (~4 wt% H<sub>2</sub>O), are stable to depths of 200–300 km in cold subduction zones (Schmidt and Poli, 1998), far beyond the depths beneath arcs. This suggests that these minerals are able to transport not only water, but also fluid-mobile elements, to the deeper mantle.

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