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Behavior of halogens (F, Cl, Br, and I) during medium- to high-grade metamorphism: evidence from the Ivrea-Verbano Zone, Italian Alps

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Previous findings from Han et al., 2023 (GCA) indicate a significant fractionation of Br/Cl and I/Cl ratios between glacial diamictite composites and pelagic sediments, where diamictite composites have distinctively lower I/Cl (or higher Br/Cl) than the sea-floor sediments. Several hypotheses could explain these differences, including metamorphic dehydration and/or chemical weathering (affecting the diamictites), or biological enrichment (affecting the pelagic sediments). To determine whether the fractionation is controlled by metamorphic dehydration, amphibolite- to granulite-facies metapelites, associated leucosomes, and metabasites from the Ivrea-Verbano Zone, NW, Italy were analyzed for F, Cl, Br, and I. In the metapelites, increasing grade from amphibolite-facies kinzigites to granulite-facies stronalites shows a decrease in the average [F] (764 ± 153 to 346 ± 69 ppm), an increase in [Cl] (49 ± 26 to 87 ± 35 ppm), fairly constant [Br] (0.82 ± 0.20 to 0.61 ± 0.15, and a slight decrease in [I] (0.09 ± 0.02 to 0.01 ± 0.00 ppm). The leucosomes in the kinzigites and stronalites, where the former formed from precipitation from hydrothermal fluids and the latter by dehydration melting, yield similar results to the metapelites for [F] (430 to 29 ppm) and [Cl] (67 to 131 ppm) but contrasting relationships for Br and I, where [Br] increases (0.56 ± 0.14 to 1.49 ± 37 ppm), and [I] instead remains constant (0.08 ± 0.02 to 0.10 ± 0.03 ppm). The resultant halogen ratios for Br/Cl and I/Cl for the metapelites and associated leucosomes generally plot within the field of the glacial diamictites with no distinction between amphibolite or granulite samples. The metabasites similarly display no fractionation but fall within the realm of arc/backarc lavas due to their igneous origin. The lack of halogen (I/Cl and Br/Cl) fractionation between metamorphic grades indicates that metamorphism does not have a significant effect on I/Cl and Br/Cl halogen ratios and cannot account for the fractionation between the glacial diamictite composites and pelagic sediments. Further analysis is recommended to determine the possible effects of chemical weathering or biological enrichment.