Identifying slab-derived volatile contributions and mantle source heterogeneity beneath the Washington Cascades

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November 24, 2022

Abstract

Fluid-flux melting is commonly attributed as the primary driver of magmatism in arcs; however, decompression melting, mantle heterogeneity, and the amount and compositions of slab-derived materials (fluids vs. melts; crust vs. sediments), have all been suggested to play a role in producing the compositional diversity of primary arc basalts. In this contribution, we present the volatile, major, and trace element compositions of melt inclusions from basaltic magmas erupted at three volcanic centers in the Washington Cascades: Mount St. Helens (two basaltic tephras from the Castle Creek period, 2.0–1.7 ka), Indian Heaven Volcanic Field (two <600 ka basaltic hyaloclastitic tuffs), and Glacier Peak (basaltic tephra from Whitechuck and Indian Pass cinder cones). Melt inclusions have H_2O and Cl contents that range from 0.3-2.2 wt% and 97-1011 ppm, respectively, and are hosted in olivine with compositions of Fo_{74}-Fo_{85} (Mt St. Helens), Fo_{80}-Fo_{87} (Indian Heaven) and Fo_{86}-Fo_{89} (Glacier Peak). We find that trace element ratios such as Nb/Y demonstrate that the variability between samples is likely related to differences in mantle source compositions. Impressively, these ratios span nearly the entire range of arc magmas globally, from high Nb/Y compositions at Mount St. Helens that are similar to ocean island basalts, to low-K tholeiites from Indian Heaven and Glacier Peak that have Nb/Y ratios similar to N-MORB. Interestingly, a calc-alkaline basalt from Glacier Peak displays S/Y ratios that overlap with the highest values measured in arcs globally (Ruscitto et al., 2012). While all magma types, including calc-alkaline magmas from Indian Heaven and Glacier Peak, have H_2O and Cl contributions from the downgoing plate (inferred from H_2O/Y and Cl/Y ratios) that overlap with other Cascade Arc segments, the maxima measured in the Washington Cascades are markedly lower than those from other segments, including central Oregon, northern California, and the northern Garibaldi belt, consistent with Venugopal et al. (2020). This dataset adds to the growing inventory of primitive magma volatile concentrations along the Cascade Arc and provides insight into spatial distributions of mantle heterogeneity and the variable role of slab processes in the petrogenesis of arc magmas.

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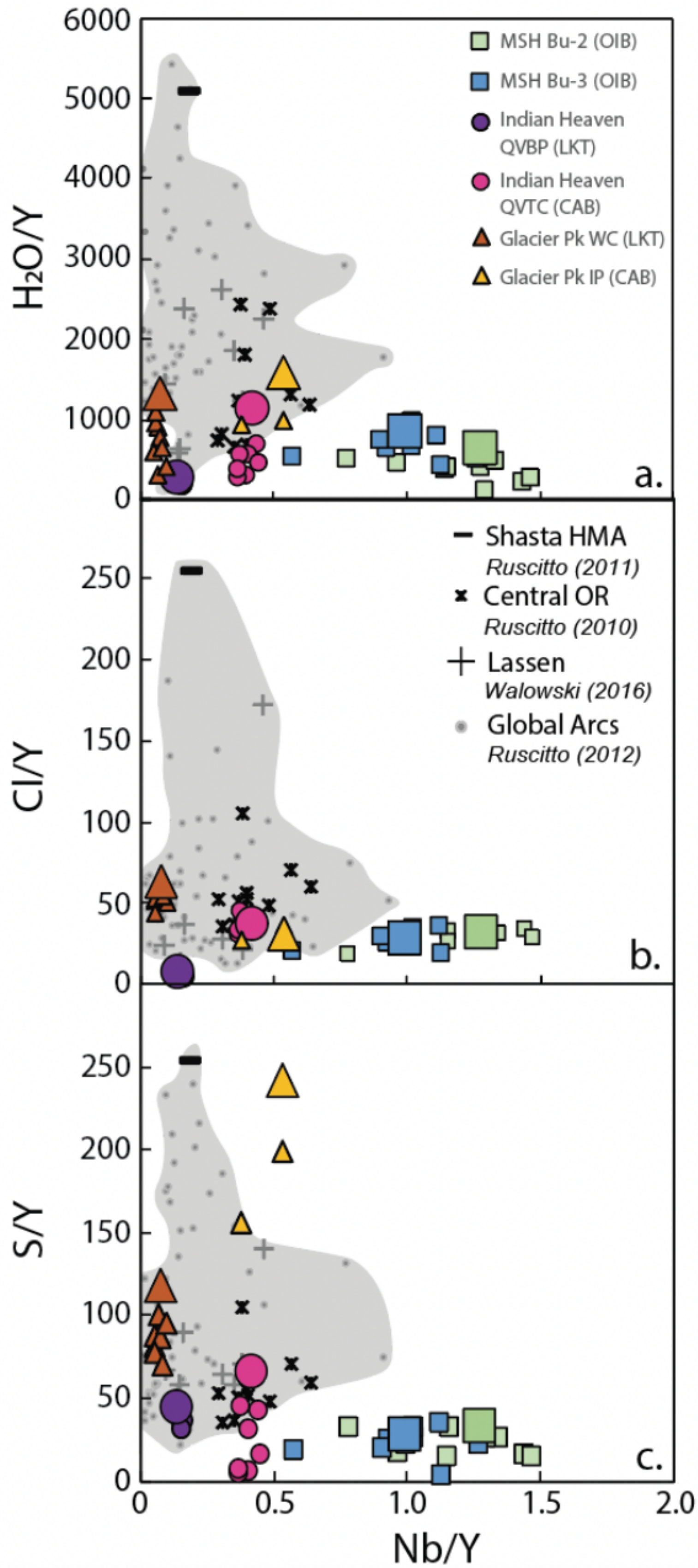
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MSH Bu-3 (OIB)
Indian Heaven QVBP (LKT)
Indian Heaven QVTC (CAB)
Glacier Pk WC (LKT)
Glacier Pk IP (CAB)
H2O/Y
a.
Shasta HMA
Ruscitto (2011)
Central OR
Ruscitto (2010)
Lassen
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Ruscitto (2012)
Cl/Y
b.
S/Y
c.
Nb/Y

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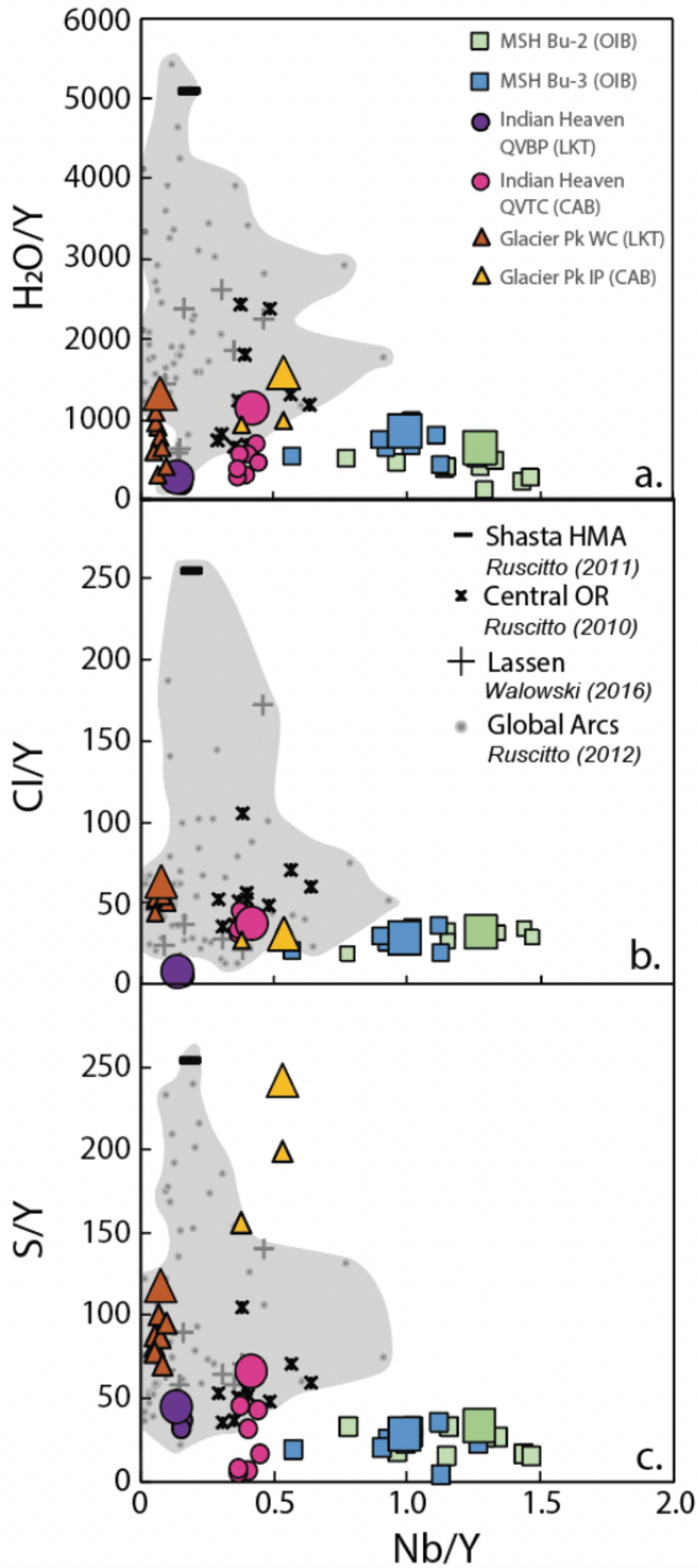

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