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Testing models of slab-to-mantle transfer in subduction zones

EMMANUEL A. CODILLO[1] AND VÉRONIQUE LE ROUX[2]

[1]Carnegie Institution for Science
[2]Woods Hole Oceanographic Institution
Presenting Author: ecodillo@carnegiescience.edu

The physical transfer of subducted slab components into the mantle wedge is recorded in the composition of arc magmas worldwide. Whether the slab-to-mantle transfer process is facilitated by fluids and/or melts sourced from discrete subducted slab components (e.g., sediments, basalt, ultramafic mantle) or from mixed, hybridized mélange zones along the subduction interface remains debated. Here, we assess how the elemental and isotopic compositions of volcanic rocks in global arcs have changed over time. Meta-analyses of published geochemical data combined with comprehensive melting and mixing calculations reveal that the geochemical characteristics of volcanic rocks formed right after subduction initiation are best reproduced by slab-to-mantle transfer that is facilitated by hydrous melts from discrete slab components. However, a temporal transition in the transfer mechanism is observed where the geochemical characteristics of younger volcanic rocks are best reproduced by a process whereby hydrous melts originate from mélange zones. We discuss how this geochemical transition can be linked to the physical and chemical processes and conditions prevalent along the slab-mantle interface over time. These observations help to reconcile the long-standing debate on the relative importance of the two contrasting models of slab-to-mantle transfer in subduction zones worldwide.