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Ineffective contribution of copper from subducted Pacific oceanic slabs to mantle wedge with progressive subduction

ZAICONG WANG[1], PINGYANG ZHANG[1], YIBING LI[2], TERUAKI ISHII[3], WEI LI[4], STEPHEN F. FOLEY[5] AND XIANG WANG[1]

[1]China University of Geosciences (Wuhan)
[2]Institute of Geology, Chinese Academy of Geological Sciences
[3]Center for Integrated Research and Education of Natural Hazards, Sizuoka University
[4]Second Institute of Oceanography, Ministry of Natural Resources
[5]Macquarie University

Presenting Author: wzc231@163.com

Addition of subducted materials from slab to mantle wedge is often thought to elevate the oxygen fugacity of arc magmas and also to fertilize the mantle wedge in metals for subduction-related Cu-Au deposits. However, it remains controversial if slab-driven metal addition is effective and whether it occurs at all stages of subduction. Here we study the ore-forming and redox-sensitive Cu and its isotopes (δ^{65}Cu) in type-locality forearc basalts, boninites and high-Mg adakites from the Izu-Bonin-Mariana (IBM) forearc, which represent magmatic products from subduction initiation, through transitional stages to mature arc magmatism [1]. Beginning with the boninites, the magma products from the IBM display strong slab signals, high water contents and high fO_2 as typical arc basalts [2]. Importantly, boninites are formed by melting of highly depleted mantle wedge, which was fluxed by hydrous components released from the subducted Pacific oceanic slabs that are rich in sulfides and Cu. However, the boninites and subsequent high-Mg andesites display low Cu contents, and mantle-like Cu/Sc ratios and δ^{65}Cu, with no clear slab addition of Cu. Combined with available data from boninites, arc basalts and arc peridotites worldwide, our results lead to a general conclusion that subducted slabs from initial to mature subduction contribute little Cu to mantle wedge [3]. Adding Cu-poor, water-rich slab materials to mantle wedge during Pacific oceanic subduction causes limited release of Cu, which remains trapped mainly by reduced sulfides in the subducting slab. This likely reflects the overall reducing nature of the slab materials added to mantle wedge; otherwise, oxidative leaching of sulfide-bearing, Cu-rich Pacific oceanic crusts by infiltrating oxidized slab fluids or melts would noticeably elevate Cu contents or δ^{65}Cu of the derivative arc magmas [4]. Instead, hydrous melt-peridotite reaction as suggested recently [5] may be the key process to form oxidized primitive arc magmas, promoting sulfide dissolution and metal release from the mantle wedge to arc magmas.

[1] Li et al (2019) EPSL, 518, 197-210; [2] Brounce et al (2021) G3, 22, e2021GC009823; [3] Wang et al (2021) EPSL, 574, 117178; [4] Fernandez and Borrok (2009) CG, 264, 1-12; [5] Tollan and Hermann (2019) NG 12, 667-671.