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Variable dehydration behaviors of slab serpentinite beneath the Mariana subduction zone

MS. SI-YU ZHAO, PHD[1], ALEXANDRA YANG YANG[1], ZHIYUAN ZHOU[2], YOSHI TAMURA[3], JINLONG MA[1], YIGANG XU[1], SHAOWEI ZHANG[1] AND TAI-PING ZHAO[1]

[1]Guangzhou Institute of Geochemistry, Chinese Academy of Sciences

[2]Southern University of Science and Technology

[3]IMG, JAMSTEC

Presenting Author: zhaosiyu@gig.ac.cn

The water cycle between the surface and interior of the Earth controls the long-term stability of the sea level. The discovery of ~24-km thick serpentinized mantle in the western Pacific plate outside of the Mariana Trench suggests water influx by plate subduction can be three times more than previous estimates [1]. However, it is unclear to what extent water hosted in the slab serpentinite has been released by subduction zone magmatism, and whether it would hydrate the mantle outside of the subduction zone. In this study, we conducted new B isotopic analyses on Mariana frontal- (Pagan) and rear-arc (NW Rota-1) volcanics, combining with literature $d^{11}B$, halogen and water data for other Mariana arc and back-arc basin basalts (BABB) to evaluate the role of possible serpentinite dehydration in the Mariana arc-basin magmatism. $\delta^{11}B$, Cl/Nb, and Cl/F all increase from BABB to arc volcanics for most Mariana arcs and correlate positively with Ba/Nb and Cs/Nb ratios (Fig. 1), tracers of water-rich flux from the slab crust. Such a coupled enrichment suggests the dominant role of slab crust for most Mariana arc-basin magmatism. However, $\delta^{11}B$, Cl/F and Cl/Nb of NW Rota-1 arc volcanics decouple with Ba enrichments, indicating that boron and chlorine are mainly from the serpentinized mantle instead of the crust of the subducted slab. Thus, along-arc chemical variations suggest the contributions of slab serpentinite occur in NW Rota-1, but mostly invisible in other arc volcanos and BABB, which seems inconsistent with extensive slab serpentinization inferred from well-developed bending faults along the entire Mariana arc systems in the subducting plate.

Thermodynamic modeling suggests that slab serpentinite beneath the Mariana subduction zone would start to dehydrate from sub-rear-arc depth of ~200km, to BABB depth of ~350km for slab serpentinite extending to 4-km-thick beneath Moho. The absence of characteristic geochemical index for serpentinite dehydration in BABB and most arc volcanics, however, suggests that slab serpentinite might be less than 4km thick at sub-BABB depth, and that water hosted in the 24-km-thick slab serpentinite near the trench might thus have been released at forearc region.

Reference

[1] Cai et al. *Nature* **563**, 389-392 (2018).

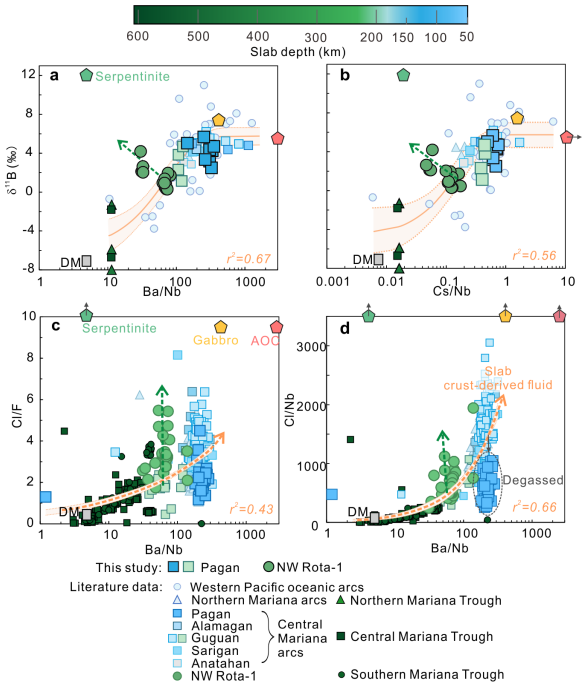

Figure 1.Variations of chemical compositions for volcanics from the Mariana subduction zone

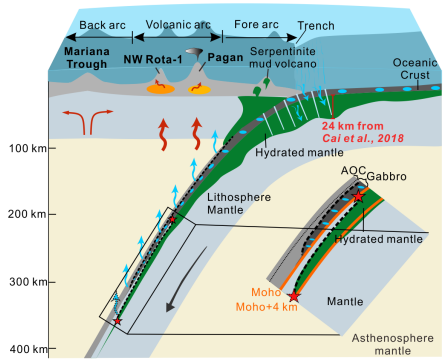

Figure 2. Schematic figure shows progressive dehydration of the subducting slab in Mariana subduction zone