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Isotopic Analysis of Hydrous Phenocrysts in Lava Flows of the Peruvian Altiplano Plateau: Testing for a Subduction Signature

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Motivation

The process of flat-slab subduction introduces fluids directly into the overlaying lithosphere, leaving behind a unique stable isotope and trace element signature to the surrounding crust/mantle. Fluid alteration of the deep lithosphere can help explain geologic processes that are observed at the surface, such as patterns of crustal deformation (mountain building) and volcanism. The young high-K mafic volcanic rocks found in the Altiplano region of Southern Peru are derived from the melting of an altered mantle source. By analyzing the hydrogen stable isotopes as well as the trace elements of these volcanic rocks we can locate the water source associated with these melts and relate that to fluid alteration of the mantle appertained to ancient shallow subduction.

- Hydrogen stable isotopes measuring between -15‰ to -35‰ are indicative of fluids transferred from the subducting oceanic lithosphere. Values of -80 ± 10‰ indicate primary mantle hydrogen [4, 9, 10].
- Relatively high concentrations of fluid mobile trace elements, such as light rare earth elements (LREEs) are indicators of fluid alterations of the mantle melt source [7, 8].

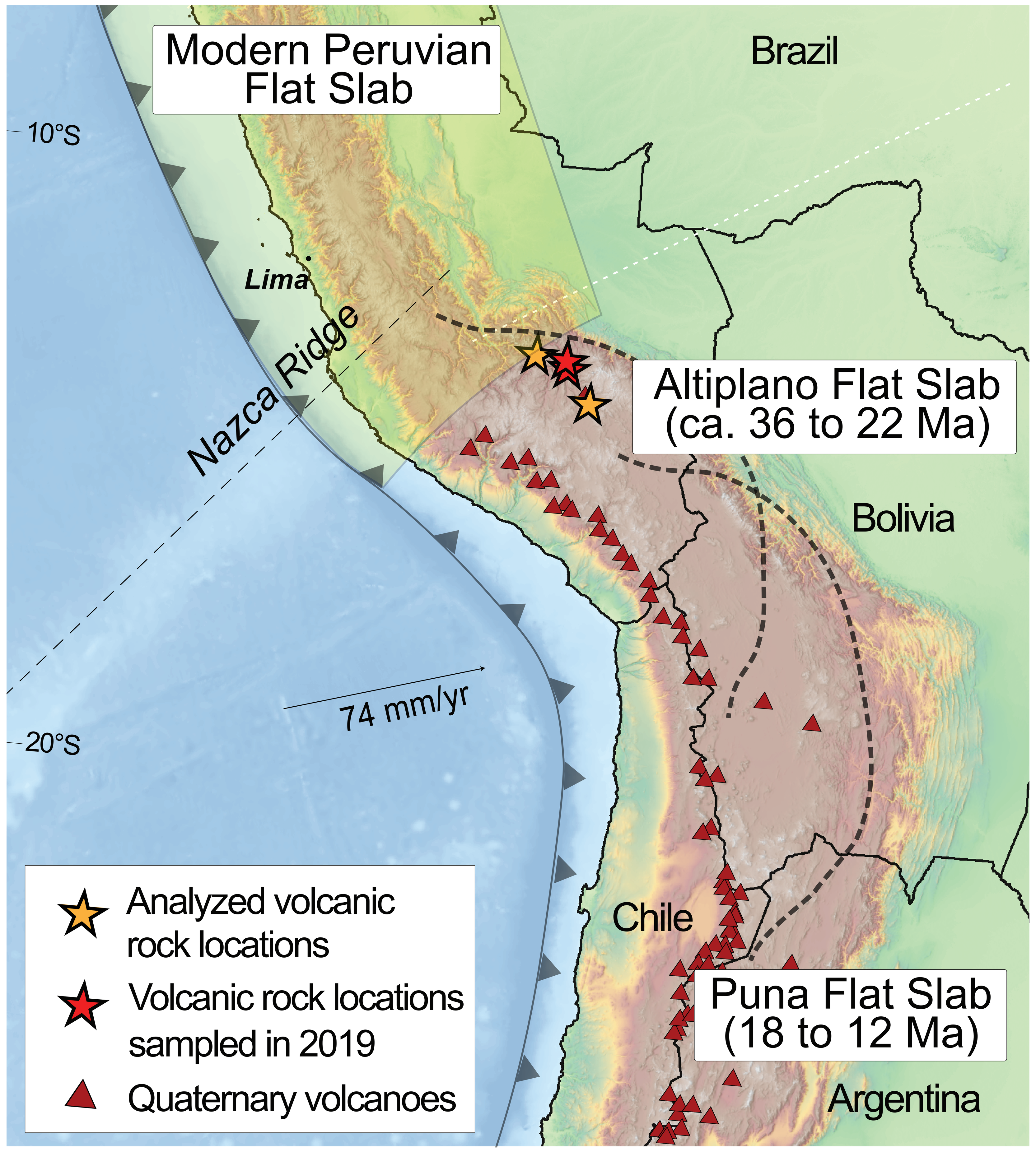
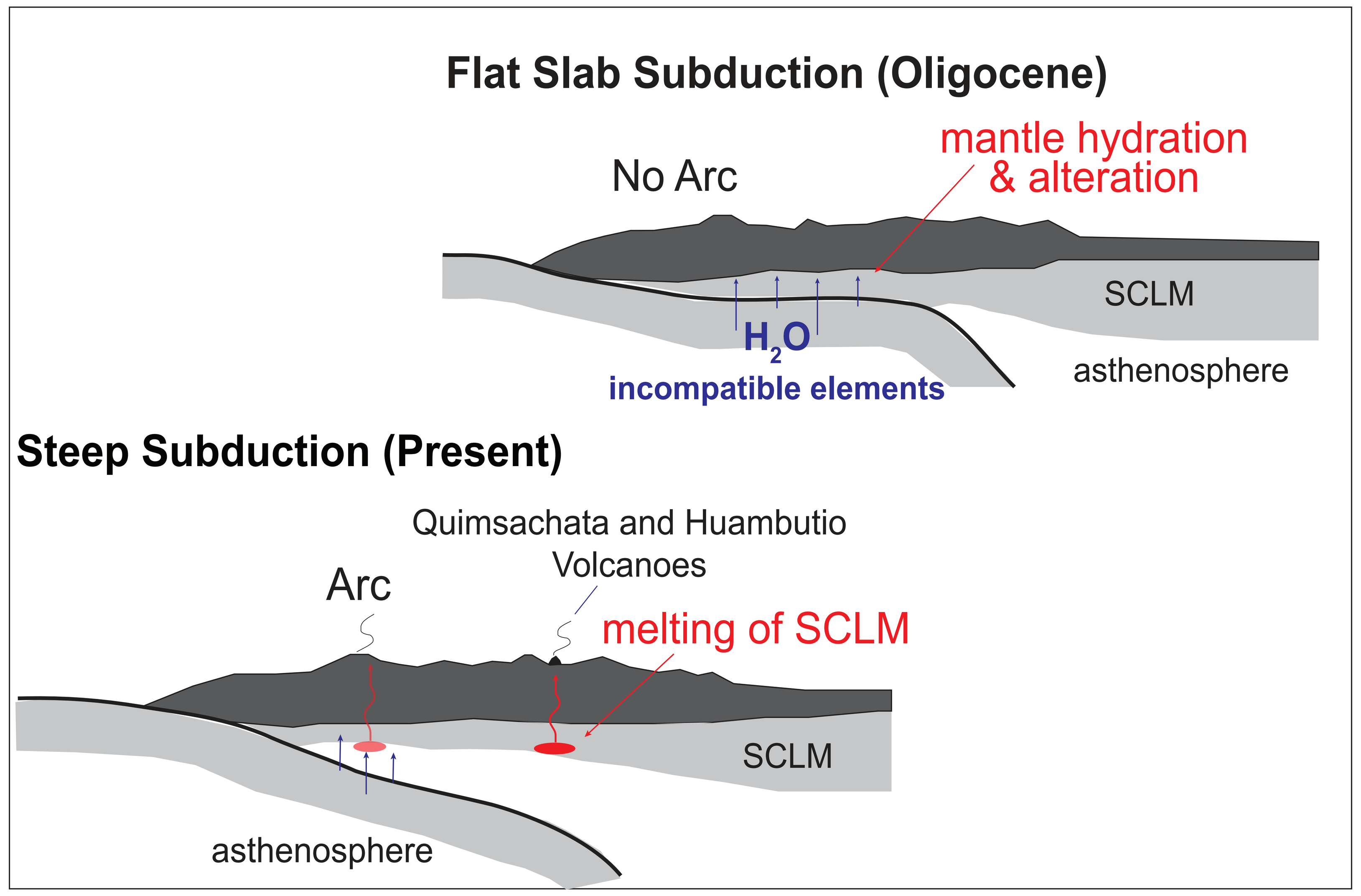


Figure 1: The modern peruvian flat slap (yellow region) and the the estimated boundries of the ancient Altiplano and Puna Flat slap (black dashed lines [6] . locations of our analyzed sites marked by the golden stars [5].

Hypothesis

We hypothesize the δD values of the hydrous phenocrysts will deviate from nominal mantle values (-80 ‰ vs VSMOW) towards that of derived fluids from the subducting Nazca Plate (15‰ to -35‰), indicative of a melt source being altered by slab-derived fluids.



Methods

Sample Collection and Preparation:

Samples collected from four quaternary lava flows in 2019 by Coleman Hiett and Dennis Newell. This study focused exclusively on samples obtained from the Huambutuio and Quimsichata Volcanoes. Petrographic thin sections were used to determine the size, quantity, and quality of the hydrous phenocrysts (mainly biotite). Chippings were chosen based on a lack of xenoliths and near surface alterations. To isolate biotite, samples where:

- Crushed to a grain size of >500 µm
- Hand washed to remove clay and other fine particles
- Minerals were magnetically separated with Franz electromagnet
- Sorted further by platy characteristics via paper-shake technique
- Hand picked under a binocular microscope

Stable Isotope Analysis:

Biotite was weighed to approximately 3 to 6 mg and packed into Ag capsules and then pyrolyzed in a glassy-carbon reactor at 1400°C using a Thermo Scientific high temperature conversion elemental analyzer (TC/EA). The δD of the produced H2 gas was analyzed on a Thermo Scientific Delta V Advantage Isotope Ratio Mass Spectrometer (IRMS)[1].

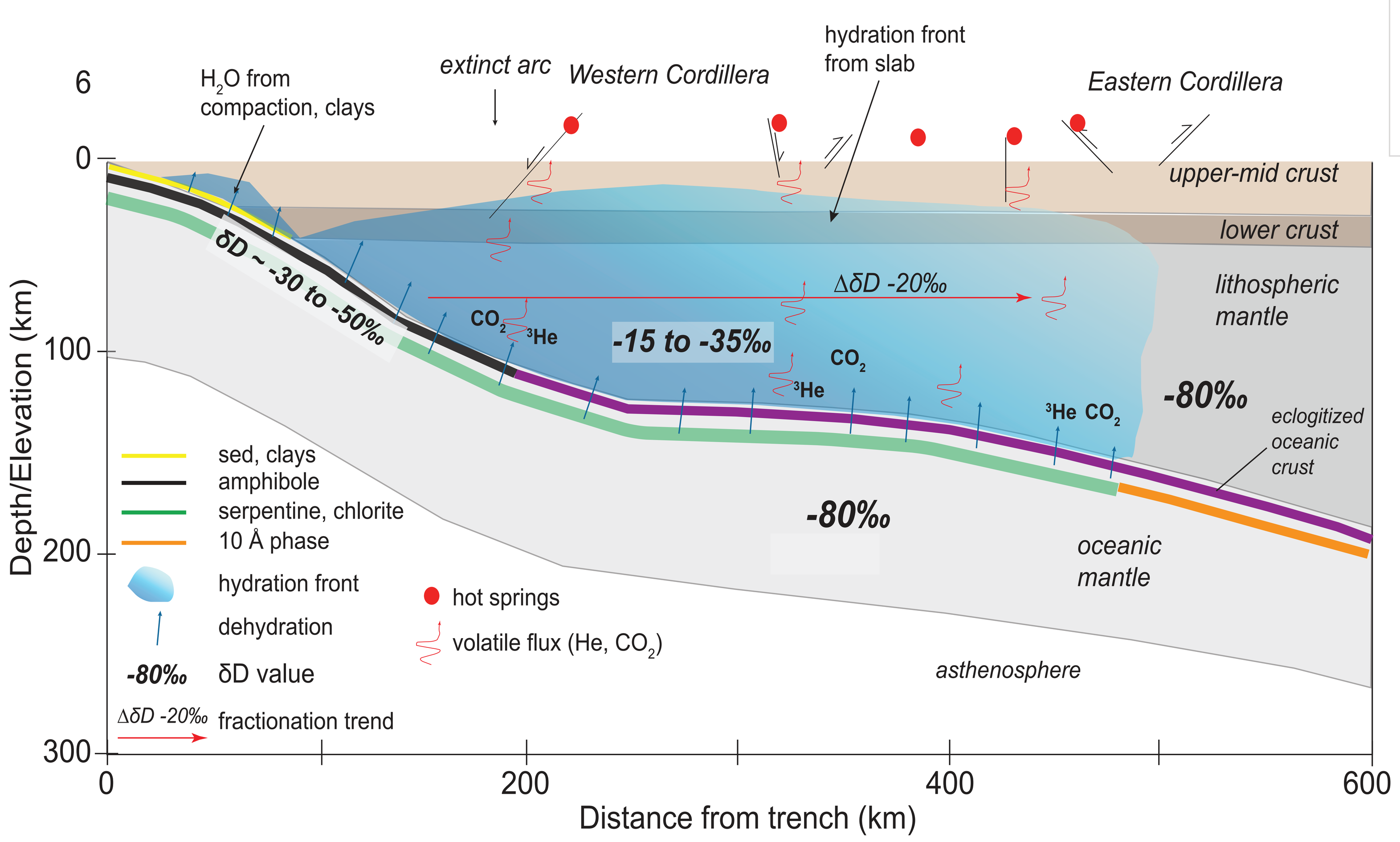


Figure 2: Hypothesised cross section showing the Hydrogen isotopic evolution of the flat slab below the Altiplano Plateau

Data

Identifier	δH
HUAM	-69.8
HUAM	-68.2
HUAM	-66.6
QUIM	-46.3
QUIM	-46.0
QUIM	-45.8

The δD values associated with the Huambutuio volcanoe average out to be -68.2‰ ± 1.33.

The δD values associated with the Quimsichata volcanoe average out to -46.03‰ ± 0.205.

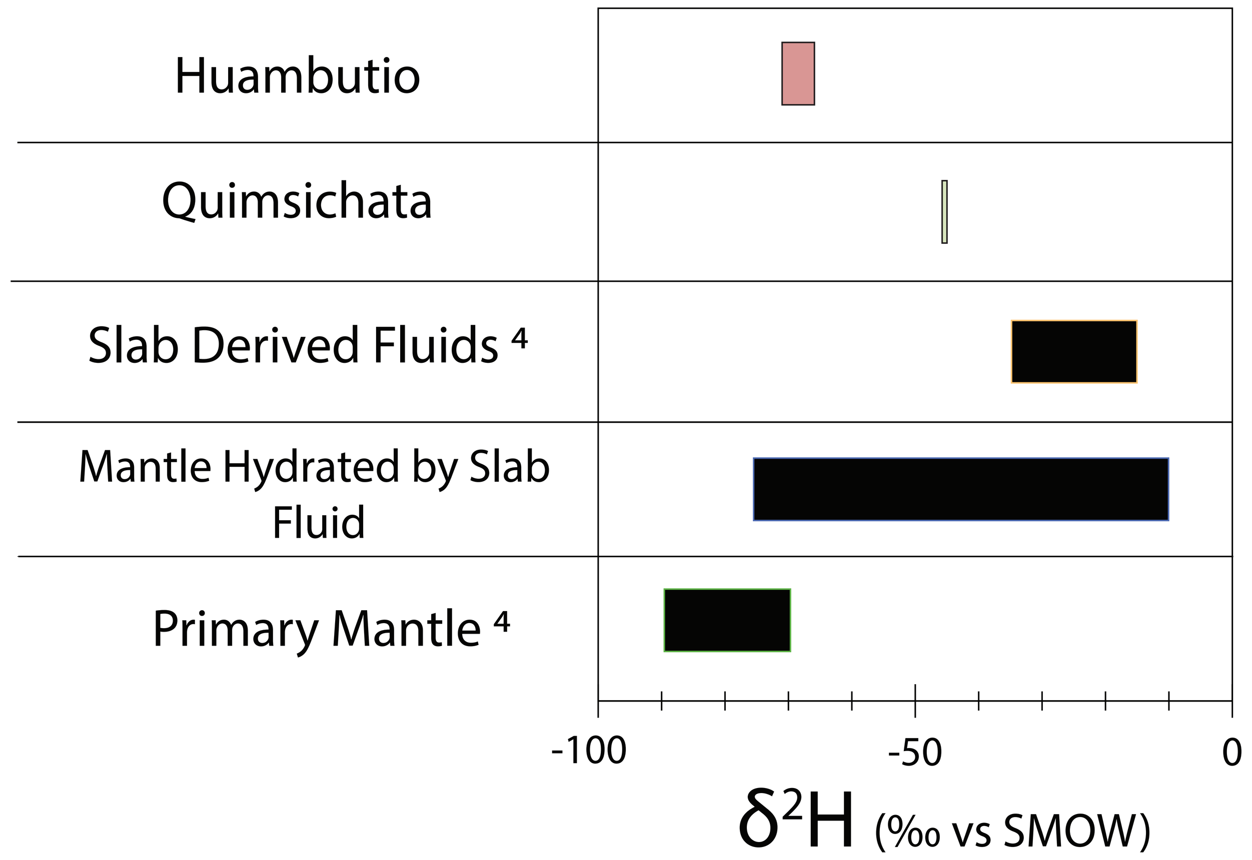
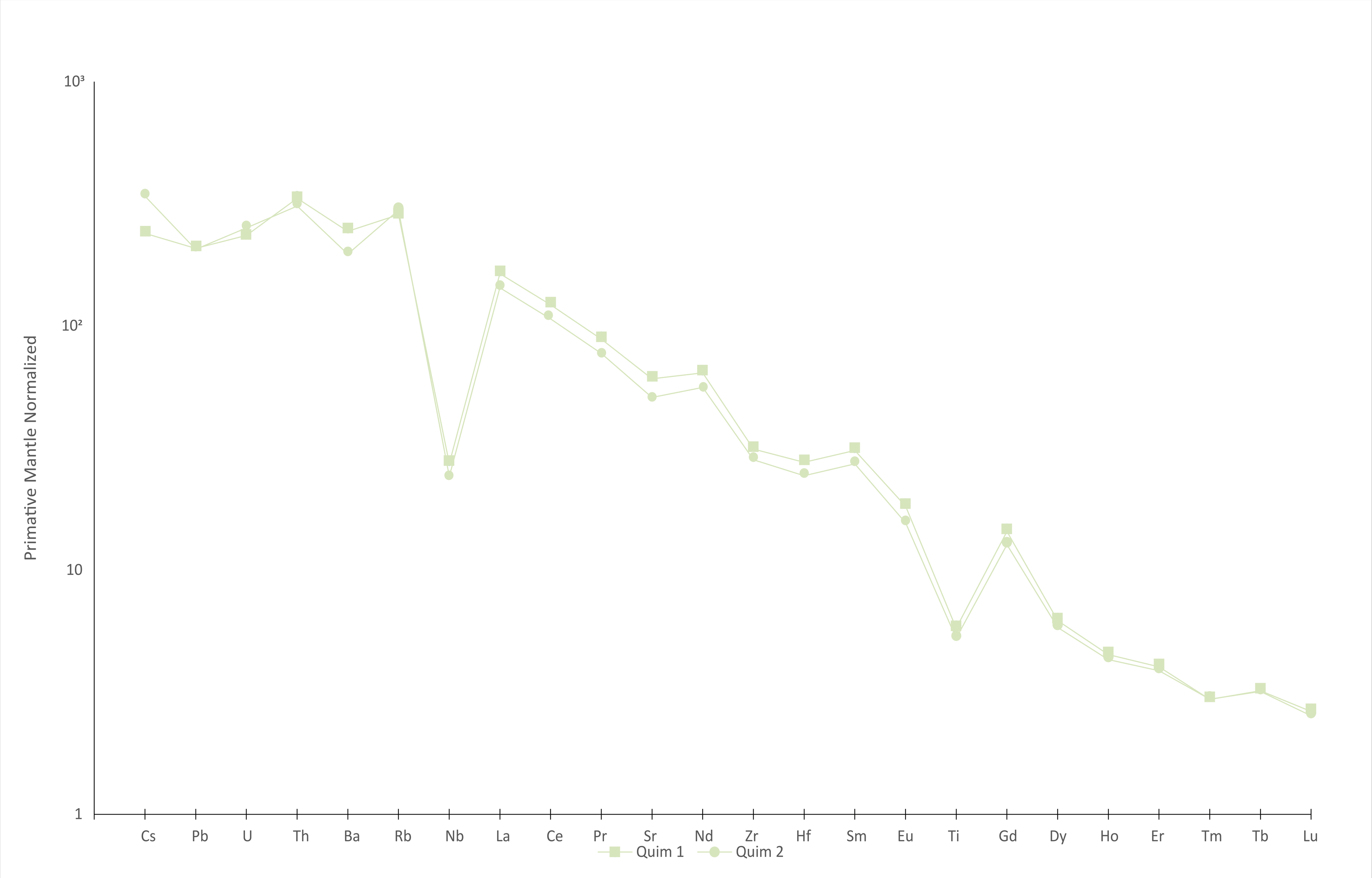


Figure 3: Visualizes the competeing δH values of the anydrous lower crust, anydrous mantle with the predicted values of the lower crust hydrated by subducting fluids, and lower crust hydrated by mantle fluids.



Conclusion

1) We dermined the δD values associated with the Huambutuio volcanoe average out to be -68.2‰ ± 1.33. While the δD values associated with the Quimsichata volcanoe average out to -46.03‰ ± 0.205.

2) Previous LREE analysis of the Quimisichata volcanoe positivly reflect the mantle presence We can confirm the δD values of the vocanic rocks will deviate from nominal mantle values (-80 ‰ vs VSMOW) towards that of derived fluids from the subducting Nazca Plate (15‰ to -35‰), indicative of a melt source being altered by slab-derived fluids.

It can be determined that the hydrous pheoncrysts collected from the Huambutuio and Quimsichata are the product of mantle hydration from slab derived fluids.

References

[1] Sharp, (2017) [2] Boettcher & O'Neil, (1980) [3] Deines, (2002), [4] Shaw et al., 2008; [5] Heitt (2019); [6] Ramos and Folgura et al., 2009; [7] Mamani et al., 2010; [8] Chapman et al., 2015; [9] Marshall et al., 2017; [10] Kyser and O'Neil, 1984