Goldschmidt 2022 Abstract
https://doi.org/10.46427/gold2022.10716

How much water is recycled to the deep mantle by crust subduction?

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Subduction of oceanic crust introduces water into Earth's interior. However, it remains unclear how much water is recycled into the deep mantle. This arises due to the challenge in directly sampling, and analyzing the water content of, a deep subducting crust. Electrical conductivity is sensitive to water in Earth's interior, and the water recycling can be constrained by combining electromagnetic imaginings of subducting crust with mineral physics on the conductivity of typical crustal materials.

The subducting crust below 40 km depth is dominated by omphacite and garnet in eclogites. We measured the conductivity of omphacite and garnet in subduction-related eclogites, each with varying contents of Fe and H_2O that are key in electrical conduction. Combining the conductivity data, the eclogite chemistry by geochemical studies and the highly resistive property of subducting crust by geophysical surveys, we demonstrate that, at 70-120 km depth in the subducting crust, the H_2O contents of omphacite and garnet are strikingly small, with the maximum <400 and <80 ppm in the former and latter, respectively. The very low water contents indicate extremely water-poor conditions, or very low water activity, during the eclogite-facies metamorphism and in the system. This further implies the absence of appreciated amounts of hydrous phases (e.g., amphibole/chlorite) in the matrix, because of the strong ability of omphacite and garnet in hosting water. The water recycling to the deep mantle by crust subduction is probably very limited, and the water exchange between Earth's exterior and interior may be inefficient (Liu et al., 2021). This fits well with the high dehydration efficiency (>92%) of subducting crusts at shallow depths, estimated from H_2O/Ce ratios of mid-ocean ridge basalts (Dixon et al., 2002), and the preservation of protosolar nebular water in the deep mantle over Earth's history, constrained by D/H ratios of plume-related lavas (Hallis et al., 2015).

References

Dixon, J.E., Leist, L., Langmuir, C.H., Schilling, J.G., 2002. Nature 420, 385–389.

Hallis, L.J., Huss, G.R., Nagashima, K., Taylor, G.J., et al., 2015. Science 350, 795–797.

Liu, H., Zhang K., Jannick I., Yang X., 2021. Earth Planet. Sci. Lett. 559, 116784.