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Subducted H_2O budget of nominally anhydrous minerals – the importance of clinopyroxenes in mafic rocks and their contribution to the deep water cycle

NILS BENJAMIN GIES AND JÖRG HERMANN
University of Bern

In the subducting slab formation of nominally anhydrous minerals (NAMs) such as clinopyroxene and olivine commonly takes place during the break down of hydrous phases, in the presence of a fluid phase. NAMs equilibrating in the presence of fluid can incorporate hydrogen into their crystal structure. Thus, NAMs have the potential to transport significant amount of H_2O in subduction zones beyond the stability field of hydrous phases into the deep mantle and contribute to the deep volatile cycle. Especially clinopyroxenes are stable over a wide pressure, temperature and composition range in meta-sedimentary, mafic and ultramafic rocks, can incorporate several hundreds of ppm H_2O by weight and are important for the deep water cycle budget.

FTIR spectroscopy on eclogites was used to estimate the H_2O content of subducted mafic crust and enabled to establish an average and maximum H_2O content of eclogites along typical subduction geotherms. Gradients or homogeneity in the H_2O content of the investigated samples, was tested using spatially resolved H_2O absorbance maps. In combination with literature data, the average H_2O concentration in NAMs in different units of the subducting plate was constrained. In a second step, partitioning of H_2O into NAMs was added to the numerical petrogeological model of Gies et al. (2024) [1], to estimate the modern global subduction transport capacity of NAMs.

The results indicate that olivine is dominating the H_2O budged of ultramafic rocks whereas clinopyroxene is the most important carrier of H_2O in mafic rocks. In intermediate and cold subduction zones H_2O transport of NAMs is neglectable compared to the H_2O transport in hydrous phases. However, in hot subduction zones depending, on the chosen maximum H_2O concentration in NAMs H_2O transport capacity of NAMs is exceeding the transport in hydrous phases by a factor up to 1 to 4.5. Consequently, when the Earth was hotter and subduction faster, NAMs dominated the deep water cycle. On a global scale the modern ingassing in NAMs is in the range of 0.5-2 times to the global H_2O MORB outgassing (25 km^3 with 0.1 wt.% H_2O).

[1] Gies, N. B., Konrad-Schmolke, M., & Hermann, J. (2024). *Geochemistry,Geophysics,Geosystems*, https://doi.org/10.1029/2024GC011507