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Global mass balance of volatile element recycling: a tug-of-war between volcanism and subduction

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Volatile elements are essential ingredients for life on Earth and key modulators of the rheological properties of the mantle. Their distribution across terrestrial reservoirs reflects the combined effects of heterogeneous planetary accretion and exchanges between Earth's surface and interior, via volcanism and subduction, over geological times **[1]**. While subduction initially occurred at relatively high temperatures, implying limited transfer of volatiles into the solid Earth, the onset of modern-style subduction **[2]** marked a fundamental change in the nature of Earth's mantle-surface interactions. Despite the important role volatiles play in controlling Earth's Habitability and geodynamic evolution, the global cycling of volatile elements between Earth's mantle and surface reservoirs remains shrouded in uncertainty due to the critical paucity of quantitative and globally representative constraints on volatile fluxes across Earth's lithosphere. This talk aims to provide a comprehensive overview of the history and present-day state of the global volatile element cycle between Earth's mantle and surface **[3]**.

The presentation will summarize our current understanding of Earth's volatile inventories, and describe the mechanisms through which volatiles were first acquired **[4]** and subsequently conveyed between terrestrial reservoirs **[3]**. Then, I will show how literature data can be combined together to build an internally balanced assessment of modern global volatile recycling, delineating the present-day global fluxes of volatile elements in-and-out of the mantle via subduction and volcanism, respectively. I will outline the limitations of this approach, as well as the outstanding questions that remain to be resolved before a holistic view of terrestrial volatile recycling history can be reached. Finally, I will discuss promising avenues of future investigation that will allow for a better quantification of how volatile recycling has evolved since the onset of modern-style subduction, and how subduction has variably affected the budget of volatile elements across solid Earth's reservoirs.

[1] Hilton, D. R., Fischer, T. P., & Marty, B. (2002). *Rev. min. geoch.*, *47*(1), 319-370. **[2]** Brown, M. (2006) *Geology*, *34*(11), 961-964. **[3]** Bekaert et al. (2021). *Ann. Rev. Earth & Plan. Sci.*, *49*, 37-70. **[4]** Broadley et al. (2022) *Nature, 611*(7935), 245-255.