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Connecting the Surface and the Deep: Evolving Role of Subduction Zone Fluids Through Time

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The speciation of aqueous fluids controls the transport and exchange of metals and volatile elements on Earth. Subduction zones are the most important geodynamic setting for this fluid-mediated chemical exchange. Characterizing the ionic speciation and pH of fluids equilibrated with rocks at subduction zone conditions has been a major challenge in Earth science. I will first present thermodynamic predictions of fluid-rock equilibria that tie together models of mineralogy and fluid speciation along a range of model P-T paths. The pH of fluids in subducted crustal lithologies is uniform and confined to a mildly alkaline range, controlled by rock volatile and chlorine contents. In contrast, the pH of mantle wedge fluids exhibits marked sensitivity to minor variations in rock chemistry. These variations may be caused by intramantle differentiation, or by infiltration of fluids enriched in alkali components extracted from the subducted crust. The sensitivity of pH to carbon, alkali and halogens illustrates a top-down control of Earth's atmosphere – ocean chemistry on the speciation of subduction zone fluids via the hydrothermally altered oceanic lithosphere. These results provide a perspective on the physicochemical mechanisms that have coupled metal and volatile cycles in subduction zones for over 2.5 billion years.