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Fluid origins, cycling, fluxes, and thermal regimes in subduction zone forearcs

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At subduction zones, fluid and volatile cycling between the major reservoirs is pervasive. Scientific ocean drilling has provided core and hydrologic borehole observatory data that illuminate fluid origins, thermal regimes, mass fluxes, and the role of fluids in earthquake cycles in this dynamic tectonic regime. Long-term records from sealed borehole observatories (CORKs) have provided both high-resolution background in-situ values of physical, chemical, and biological properties and transients at several subduction zones since the first installation in 1989.

A recent in-depth analysis and synthesis of data on the chemical and isotopic composition of forearc fluids, fluid fluxes, and the associated thermal regimes, in the most well-studied representative erosional and accretionary subduction zone forearcs [1] provides evidence for large-scale fluid flow, primarily focused, associated with faults. It is manifested by widespread seafloor venting, related biological communities, extensive authigenic carbonates, chemical and isotopic anomalies in pore-fluid depth-profiles, and thermal anomalies. The nature of fluid venting seems to differ at representative accretionary and erosive subduction zones; at both, however, fluid and gas venting sites are primarily associated with faults.

The measured fluid output fluxes at seeps are high, ~15-40 times the amount that can be produced through local steady-state compaction, suggesting that additional fluid sources, possibly recirculation of seawater, or non-steady-state fluid flow must be involved.

The newly extrapolated fluid reflux to the global ocean suggests that subduction zones are an important source and sink for several elements and isotope ratios, in particular an important sink for seawater Ca, Mg, and sulfate and an important source of B and Li. Specifically Li and B concentrations and their isotopic values are prominent tracers used for fluid recycling, the nature of the sediment input, and insight into the thermal regimes. These characteristics provide key insights on the source of the fluid and the temperature at the source. ^{3}He data also provide important insights into the interaction between Earth's interior and exterior reservoirs at subduction zones. For example, at the accretionary Nankai

Trough subduction zone there is a remarkable range of ^{3}He values from mostly crustal 0.47 R_A to 4.30 R_A which is ~55% of the MORB value of 8 R_A. Whereas at the erosional Costa Rica subduction zone, off-shore Osa Peninsula, the ratios range from 0.86 to 1.14 R_A, indicating the dominance of crustal radiogenic ^{4}He from U and Th decay.

[1] Kastner, M., Solomon, E.A., Harris, R.N., and Torres, M.E. (2014). *Developments in Mar. Geol., V.7, 671-733. Stein, R., Blackman, D.K., Inagaki, F. and Larsen, H.-C., Eds., Elsevier B.V.*