SEDIMENT RECYCLING AT SUBDUCTION ZONES: THE INS AND OUTS OF ARC VOLCANOES

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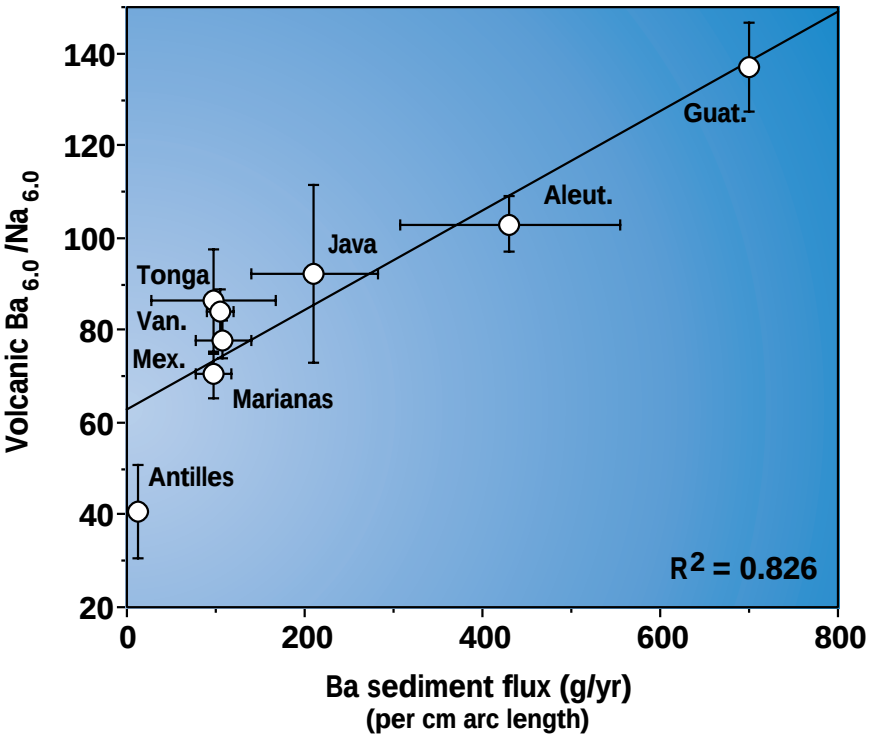
As the tune goes: "What goes up, must come down..." Deep-sea drilling at trenches, however, shows us that what goes down, must come up. That is, mud and ooze on the seafloor plunge more than 100 km into the mantle at subduction zones, before portions rise again in magmas that erupt around the Pacific, in the Ring of Fire. We can't see the sediment sink all the way into the deep mantle, but we can use chemical tracers to see where they end up. This technique requires drilling, because there are no remote ways to measure chemical tracers in deep-sea sediment. Few ODP or DSDP drill sites have been specifically targeted to address this issue, but many "holes of opportunity" exist near trenches, where sediments begin their descent into the mantle.

Some isotope tracers, such as ^{207}Pb and ^{10}Be, provide strong evidence that sediment components are "recycled" into volcanoes [*Woodhead*, 1989; *Tera et al.*, 1987]. Although volcanic lavas clearly preserve isotopic imprints of marine sediment, strong evidence linking the exact sediment in the trench to the nearby volcanoes has come to light more slowly. Analysis of many drill cores near trenches (ODP Legs 123 and 129 in particular) reveals large ranges in the flux of element tracers (e.g., Ba, Sr, Th), with each sediment column possessing its own geochemical fingerprints [*Plank and Ludden*, 1992; *Plank and Langmuir*, 1997]. For example, the figure shows an order of magnitude variation in the sediment Ba flux for different trenches around the globe [*Plank and Langmuir*, 1993]. By obtaining data for lavas from the nearby volcanoes for the same tracers, we find that the volcanoes are clearly influenced by the sediments. The correlation in the figure shows that where the subduction flux of sedimentary Ba is high, the volcanoes erupt Ba-enriched lavas. Thus some of the geochemical characteristics of arc volcanics are ultimately derived from sedimentological processes in the oceans, illustrating a remarkable linkage of processes across the hydrosphere and lithosphere.

What goes down doesn't all come back up; some keeps going down. A mass balance of the inputs and outputs at several convergent margins suggests that only 20-50% of the subducted sediments are recycled to the arc, with the remainder possibly continuing down into the deep mantle. Because sediments are ultimately derived from the continents, this downward flux is a net loss of mass from the continents, and through time, slows the growth of the continents. Current flux estimates are based on individual element or isotope tracers. We still have a poor understanding of what the sediments actually do when they subduct, how they separate into material that rises in magmas and sinks with the subducting plate [*Scholl et al.*, 1996]. Future drilling will help us move beyond mass balance of tracers, and learn much more about the rock recycling process, or how that spinning wheel goes round...



References:

Plank, T. and J.N. Ludden, Geochemistry of sediments in the Argo Abyssal plain at ODP Site 765: A continental margin reference section for sediment recycling in subduction zones, *Proc. ODP, Sci. Results, 123,* 167-189, 1992.

Plank, T. and C.H. Langmuir, Tracing trace elements from sediment input to volcanic output at subduction zones, *Nature, 362,* 739-743, 1993.

Plank, T. and Langmuir, C.H., The geochemical composition of subducting sediment: implications for the crust and mantle, *Chemical Geology*, in press, 1997.

Scholl, D.W., T. Plank, J. Morris, R. von Huene, and M. Mottl, *Scientific Opportunities in Ocean Drilling to Investigate Recycling Processes and Material Fluxes at Subduction Zones*, JOI/USSAC Workshop Report, 1996.

Tera, F., L. Brown, J. Morris, I.S. Sacks, J. Klein, and R. Middleton, Sediment incorporation in island-arc magmas: Inferences from ^{10}Be, *Geochim. Cosmochim. Acta, 50,* 535-550, 1986.

Woodhead, J.D., Geochemistry of the Mariana arc (western Pacific): source composition and processes. *Chemical Geology, 76,* 1-24, 1989.