Constraining Rates of Ocean Processes Using Tracers

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The marine environment is controlled by a complex interplay of physical, chemical, biological, and geological processes occuring over a vast array of time and space scales. Deconvoluting these processes is necessary to gain any quantitative understanding of how the ocean works and is a challenging task. Much of what we know about oceanic biogeochemical processes (and their rates) comes from the interpretation of the distributions of tracers combined with simple physical laws. Progress in measurement techniques have lead to numerous new tracer tools, including transient-, radioactive-, age-, and "steady state" tracers that have lead to remarkable insights into oceanic processes.

While we have advanced from the halcyon days of one-dimensional advection-diffusion models, we still struggle with some fundamental challenges arising from the nature of tracers and their observations. Among these are the fact that individual tracers, based on their *in situ* behavior and their boundary conditions in space and time, provide a specific, skewed measure of the ocean. Recognizing factoring in this bias is an important step forward for tracer oceanographers. Another important consideration is that the tracers' boundary conditions and/or *in situ* behavior may not be completely defined or understood, so inclusion of these uncertainties into the confidence assigned to the results of our interpretation. Finally, we have to deal with the reality that tracer observations are usually sparse in both space and time. Although all of the above conspire to make life difficult for tracer geochemists, valuable insights can still be gained, and advances in tracer diagnostic methodologies hold considerable promise. Among the relatively new methods include Optimum Multi-Parameter Analysis (and the related Total Matrix Inversion), Transit-Time Distribution Analysis, and Age Tracer Contour Inverse Method. In this overview, I will attempt to compare these methods and tracers and point to future directions where progress may be made.

The competing roles of sulfide saturation, magma mixing and degassing during the petrogenesis of convergent margin magmas

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The point at which the silicate melt becomes saturated with a sulfide phase in an evolving magmatic system depends on the initial S content and oxidation state of the parental melt. Because of their more oxidized character, evolving convergent margin magmas usually reach sulfide saturation at a more advanced stage of their evolution than mid-ocean ridge basalts (MORB). Sulfide saturation may be initiated by stabilization of magnetite: the so-called "Magnetite Crisis", identified in the near-arc, Manus Backarc Basin submarine volcanic systems. Here we report new major and trace element data for submarine volcanic glasses from the magma-starved southern Valu Fa Ridge (SVFR), the current location of the propagating tip of backarc basin spreading of the Eastern Lau Spreading Centre in the Lau Basin, SW Pacific. The change of Cu/Se, Ag/Se and Cu/Ag with indices of evolution also indicate a Magnetite Crisis, demonstrating this process is not a localized phenomenon. In contrast, chalcophile element contents of submarine glasses from the more active Central Valu Fa Ridge (CVFR) are more scattered, which may be due to magma chamber recharge, resulting in illusion of sulfide saturation prior to the appearance of magnetite as a crystallizing phase. The systematics of chalcophile and volatile element abundances of Valu Fa Ridge samples are inconsistent with partitioning of Cu, Ag and Au into an exsolved Cl-rich brine or vapor phase during differentiation or degassing. The occurrence of volcanogenic hydrothermal sulfide deposits along the Valu Fa Ridge indicate that Cu, Ag and Au were likely leached from the host rocks during circulation of hydrothermal fluids post dating magmatic solidification, and accounting for the similarity of hydrothermal sulfide deposits in both the Manus and the Lau backarc basins.

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