Magma dynamics from temporal and spatial compositional variations within and between eruptions

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Understanding the relationships between volcanic eruptions (style, duration, size, intensity) and the magmatic processes that lead to them (source composition, melting style and extent, magma transport, crustal processes and magma storage) is a long term goal of volcanology. Over the past decade, geochemists and petrologists have played increasing roles in such studies, using petrological and compositional variations in space and time in erupted products to decipher how and when magma is formed and delivered to active volcanoes. Here we discuss recent and ongoing work uniting high-spatial-resolution sampling of modern/recent volcanic products, compositional analyses, and deposit mapping to link spatiotemporal patterns of composition to variations in magma formation, supply, and eruption style within single eruptions and between successive eruptions. Examples from several different mafic magmatic systems will be discussed, primarily submarine volcanoes, where we use deep submergence methods for geological observations/sampling coupled to high-resolution temporal records from disequilibria amongst short-lived U-series daughters. Our observations span a range of magma supply rate, eruption style and eruption duration. These include short-duration/high-effusion-rate eruptions (2005-2006 East Pacific Rise 9°50'N eruption and 2009 Puipui eruption of the NE Lau Spreading Center), a longer-lived/effusive-explosive example (2008-2011 West Mata eruption), low-to-moderate effusion rate historical Juan de Fuca ridge eruptions, and examples from terrestrial volcanoes. We also consider successive deposits erupted over the past 50 years at sites on the southern and northern East Pacific Rise. We generally find larger spatial variations in erupted compositions at higher effusion rate, suggesting eruptions from multiple discontinuous, poorly mixed crustal magma reservoirs. Longer duration eruptions display greater temporal variations in parent magma composition that appear to require either magma recharge during the eruption or a temporal shift between the proportion of magma drawn from several different crustal reservoirs. These include cases of coerupted parent melts having distinct sources and melting conditions.