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The evolution of an island-arc volcanic system: records of volcanic processes at Montserrat, Lesser Antilles

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Among the islands of the Lesser Antilles arc, Montserrat is the most intensively studied, particularly since its present eruption began in 1995. Research at Montserrat has significantly advanced our understanding of andesitic island-arc volcanism. Nevertheless, the focus of most of this research has involved dome-forming volcanism and associated processes at the Soufriere Hills volcano. This does not capture the full spectrum of activity that has characterised volcanism on Montserrat over longer timescales. A range of results from offshore investigations, coupled with new on-land fieldwork, is being used to advance our understanding of the long-term evolution of this typical island-arc volcano. This history includes episodes of submarine volcanism, highly explosive eruptions, and major edifice collapses.

Here, we provide an overview of results from these studies.
Montserrat has developed via the growth of three successive composite-volcanic systems, over the past 3 Myr. Each is likely to have grown through both submarine and then subaerial volcanism, over cycles that produced volumetrically-comparable edifices. Recent sampling, including the collection of IODP cores from around the island, allows us to investigate the development of these three volcanic systems. The IODP samples span over 4 Myr, and record tephra deposits older than any dated terrestrial samples on the island. The samples can be used to explore variations in eruption frequency, style, magnitude and chemistry. While similarities exist between the volcanic systems, distinct isotopic signatures point to changes in the source magma conditions through time. A range of eruption styles is also apparent, with departures from the andesitic dome-forming eruptions that characterise present-day Soufriere Hills volcanism. Both Centre Hills, and possibly Soufriere Hills in its earlier history, produced multiple large Plinian eruptions. Additionally, volcanism away from the three main centres has occurred at different times. This includes southerly vents of Centre-Hills age, submerged seamounts off the island flanks, and the South Soufriere Hills basaltic volcanism.

Each volcano has also produced large-scale landslides during the mature stage of edifice growth. Such landslides transport substantial volumes of material offshore. Indeed, volcaniclastic sediment distribution, via processes operating across a range of scales, is a major process in growth of the island flanks and surrounding arc-crust. The largest landslides are relatively rare in the life cycle of an individual volcano, but appear to be ubiquitous in the Lesser Antilles and elsewhere. Our results point to complex landslide processes, involving multiple phases and incorporating seafloor material, all of which are significant for understanding their potential for tsunami generation. The largest collapse at Soufriere Hills coincides with an episode of mafic volcanism at South Soufriere Hills, and may have induced the ascent of these magmas following unloading of the magma storage system. Together, our records point to a complex range of eruption styles, which can be used to investigate how and why the style of volcanism, and associated hazards, vary as a volcano develops.