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New insights into composition and source, single or multistage emplacement, and relationship to eruption cycles from first drilling of volcanic island landslides, offshore Montserrat

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Volcanic island landslides include the largest mass flows on our planet. They can pose a significant hazard due to the landslide itself, and through generation of far-travelling tsunamis. The potential tsunami magnitude is highly controversial, and depends on where material originates, and how the landslide is emplaced. It is also important to know whether landslides are preceded or post-dated by major eruptions, and whether landslides play a role in initiation of new volcanic centres.

IODP Expedition 340 recovered the first cores through volcanic island landslides, located offshore Montserrat and Martinique. Here we analyse two landslides offshore Montserrat, where we also have unusually comprehensive seismic data and shallow cores. The younger Deposit 1 (∼1.8 cubic km) contains chaotically distributed blocks and was emplaced as a granular avalanche. The older and larger volume (∼9 cubic km) Deposit 2 contains blocks in its proximal part, but generally has a smoother surface.

Cores from IODP Site U1395 (∼25 km from the volcano) contain a spectacular ∼7 m thick stack of massive, graded turbidite sands associated with Deposit 2. For comparison, the 1995-recent eruption on Montserrat only produced a ∼20 cm thick deposit at this location. The stacked turbidites lack intervening mud suggesting emplacement by pulses in a single event. Deposit 2 is ∼100 m thick at Site 1394, where it comprises flat-lying turbidite sands and hemipelagic mud, and thin intervals of homogenised muddy sand. Most turbidites contain a significant (20-90%) bioclastic component. The surprising composition of Deposit 2 can be explained by two hypotheses. First, the flat-lying turbidites and hemipelagic muds are in-situ and record episodic failure over a prolonged period of time. Second, emplacement of material from the volcano caused failure of sea floor sediment, and the turbidite sand and hemipelagic muds are flat-lying blocks of seafloor sediment incorporated into the landslide. Shear was concentrated on the homogenised muddy sand. The latter hypothesis is most likely, as it is corroborated by IODP site U1399 offshore Martinique, where flat-lying strata with thin zones of muddy sand occur within landslide deposits.

Deposit 2 is directly overlain by a basaltic fallout deposit at Site U1394 suggesting it was followed by a major eruption, which could represent the start of the basaltic South Soufriere Hills centre.

Although drilling of Deposit 1 was unsuccessful, run-out deposits associated with Deposit 1 were recovered at Sites U1394 and U1395. The most powerful event since Deposit 2 produced a mixed bioclastic-volcaniclastic turbidite at 14 ka, suggesting that Deposit 1 includes carbonate platform material. Mud intervals in the 14 ka turbidite indicate 5 stages of emplacement. Alternatively, emplacement of Deposit 1 is recorded by turbidites at ∼2 ka and/or 6ka, coeval with formation of English's Crater on land. However, the magnitude of Deposit 1 favours correlation with the larger 14 ka turbidite.
This unique data set suggest that volcanic island landslides can incorporate large amounts of sea floor sediment, and involve failure of submerged carbonate platforms as well as the volcanic edifice. They may occur in a single or in a series of stages, and be followed by major eruptions.