IODP Expedition 340: Lesser Antilles Volcanism and Landslides

Site U1393 Summary

Background and Objectives

Integrated Ocean Drilling Program (IODP) Site U1393 (CARI-02C; 16°43.13'; 62°5.06'W; 914 m below sea level [mbsl]) is located close to the Soufrière Hills volcano (SHV) at Montserrat (13.7 km from point Shoerock, the SE tip of Montserrat).

The on-going eruption of the Soufrière Hills volcano at Montserrat started in 1995. Activity has included lava dome growth, pyroclastic flows from dome collapse, explosive activity with tephra fall and pumice flows, flank collapse with debris avalanches and volcanic blasts. More than >70% of erupted material from the on-going eruption has been transported to the sea (Le Friant et al., 2009, 2010; Trofimovs et al., 2006). The rapid entrance of volcanic material into the sea has caused smaller tsunamis.

The site survey data obtained for Site U1393 show that the distal parts of the pyroclastic flows as well as some underlying, older debris avalanches have been deposited at this site. The English's crater event, which occurred ~2000 years ago, produced deposit 1. The debris avalanche deposit 2 probably resulted from a combined submarine and subaerial flank collapse of the eastern flank of the volcano, as well as sediment failure. The site survey seismic data indicate that Site U1393 might penetrate through the erupted material from the on-going eruption and into the underlying debris avalanche deposits 1 and 2.

The objective of Site U1393 is to characterize the processes occurring during debris avalanche emplacement, associated erosional processes and tephra diagenesis. Analysis of 5 m piston cores taken in this area show that the pyroclastic material from the 2003 SHV dome collapse mixed with seawater and immediately deposited the coarse components out of the suspension (Trofimovs et al., 2006). The coarse debris avalanche deposit will enhance our understanding of the emplacement processes.

Comparing the geochemical signatures (pore waters and sediments) of cored material with surface sediments (from the 2007 cruise) will allow us to characterize the alteration rates of volcanic material in seawater. In addition, we will examine the dependency of alteration rate and style on grain size, layer thickness, admixture of sediments, etc.

Coring through both the smaller debris avalanche deposit 1 and the larger volume deposit 2 will allow comparing the emplacement processes of debris avalanches of different magnitudes. We will undertake a detailed lithological, sedimentological, and textural fabric analysis of the retrieved material at the macro- and microscopic scale to investigate the transport and deposition processes, the nature and magnitude of erosional processes and interaction with the substratum (e.g., bulking; Komorowski et al., 1991; Glicken, 1991, 1996). These data will provide valuable insights into the chronology (one or several pulses) and the debris avalanche mobility, which have implications for tsunamigenesis.

Scientific Results

It was planned to core two holes at Site U1393 and recover as much of the young debris avalanche deposit called deposit 1 of the Soufrière-Hills volcano on Montserrat as possible. However, due to the unfavorable drilling conditions encountered at this site only one hole was drilled. The hole was cored to a depth of 47.55 mbsf with an $11^{7}/_{16}$" diameter APC/XCB core bit and a 135.75 m long bottom hole assembly (BHA). A mud line core with the APC system established a water depth of 926 mbsl. The second APC core bounced off the formation and the APC system was changed over to the XCB coring system. Coring conditions proved to be very difficult and recovery was very poor. Coring was terminated when the XCB system failed, leaving part of the XCB core barrel in the hole. The depth objective at the site was 250 m and this appeared to be unreachable with the tools planned for the site. Overall core recovery for Site U1393 was 11.4% of the 47.5 m cored (5.42 m of material).

Based on the lithological characteristics the sediments recovered at Site U1393 only one lithostratigraphic unit was defined. This unit is termed Unit 1. Unit 1 extends from the seafloor to a depth of 4.24 mbsf, however, the lower stratigraphic boundary of this unit cannot be defined due to the poor core recovery. The upper part of Unit 1 consists of mud clasts embedded in a sandy matrix. This is followed by dark brownish gray-black sand consisting of volcaniclastic material containing medium to very coarse sand-sized grains. The grains are mainly composed of andesite and rarely of carbonate. Occasionally larger clasts of amphibole-rich andesite are present. The unit is moderately well to well sorted, massive and normally graded. The lowest part of Unit 1 consists of andesite clasts up to 3 cm in size embedded in a coarse sand matrix. Below Unit 1 the material recovered consists mainly of andesite clasts. The clasts show variable signs of hydrothermal alteration and subaerial oxidation. These clasts probably are derived from the deposit 1 debris avalanche deposit. The upper 4.24 m of the material cored are a product of the most recent eruption of the Soufrière-Hills volcano.

Generally, the cores retrieved at this site contain only very few micro- and nannofossil remains, which is consistent with the lithostratigraphic information we have for this site. Due to the small number of fossil remains an age determination of the cored material was not possible. The majority of the observed foraminifers are typical for a reef environment shallower than 30 m water depth, suggesting a re-deposition caused by the debris flow.

The physical property data obtained on the cored material, display the behavior expected coring moderately to well-sorted sands with an andesitic bulk composition. The measured grain density of 2.80 g/cm^3 and the measured bulk porosity of 41% are consistent with an andesitic composition and medium to well-sorted sand that has undergone little consolidation, respectively. The magnetic susceptibility (maximum value of 3.75×10^{-2} at a depth of 1.07 m) as well as the natural gamma radiation (NGR, 13 counts/second) is much higher than for pelagic sediment, consistent with sediments dominated by volcaniclastic particles. Meaningful paleomagnetic directions for the interpretation of the geomagnetic field at Site U1393 could not be obtained. This is mainly due to the grain size and the consolidation stage of the material recovered. Sand sized grains are usually comprised of multi-domain size magnetic grains, which are inefficient at recording paleomagnetic directions and unconsolidated sands are usually highly sensitive to disturbances. The grains themselves are often too large to orientate the Earth's magnetic field.

References

Glicken, H.X. (1991) Sedimentary architecture of large volcanic-debris avalanches, in Fisher R.V., and Smith G.A., eds, Sedimentation in volcanic settings: SEPM (Society for Sedimentary Geology) Special Publication, 45, 99-106.

Glicken, H.X. (1996) Rockslide-debris avalanche of May 18, 1980, Mount St. Helens Volcano, Washington. US Geol. Surv. Open File Rept. US Geol Surv., Washington, DC, 98pp.

Komorowski, J-C, Glicken, H, Sheridan, M.F. (1991) Secondary electron imagery of microcracks and hackly fracture surfaces in sand-size clasts from the 1980 Mount St. Helens debris-avalanche deposit: Implications for particle-particle interactions. Geology 19, 261-264.

Le Friant, A., Deplus, C., Boudon, G., Feuillet, N., Trofimovs, J., Komorowski, J-C., Sparks, R.S.J., Talling, P., Loughlin, S., Palmer, M., Ryan, G. (2010) Eruption of Soufrière Hills (1995-2009) from an offshore perspective: Insights from repeated swath bathymetry surveys. Geophysical Research Letters 37, L11307, doi: 10.1029/2010GL043580.

Le Friant, A., Deplus, C., Boudon, G., Sparks, R. S. J., Trofimovs, J., Talling, P., (2009) Submarine deposition of volcaniclastic material from the 1995–2005 eruptions of Soufrière Hills volcano, Montserrat. Journal of the Geological Society 166, 171-182: doi: 10.1144/0016-76492008-047.

Trofimovs, J., Amy, L., G. Boudon, C. Deplus, E. Doyle, N. Fournier, M.M.B. Hart, J-C Komorowski, A. Le Friant, E. Lock, C. Pudsey, G. Ryan, R.S.J Sparks, P.J. Talling (2006) What happens when pyroclastic flows enter the ocean? Geology 34, 549-552.