Sedimentary structures formed under water-surface-waves: examples from a sediment-laden flash flood observed by remote camera

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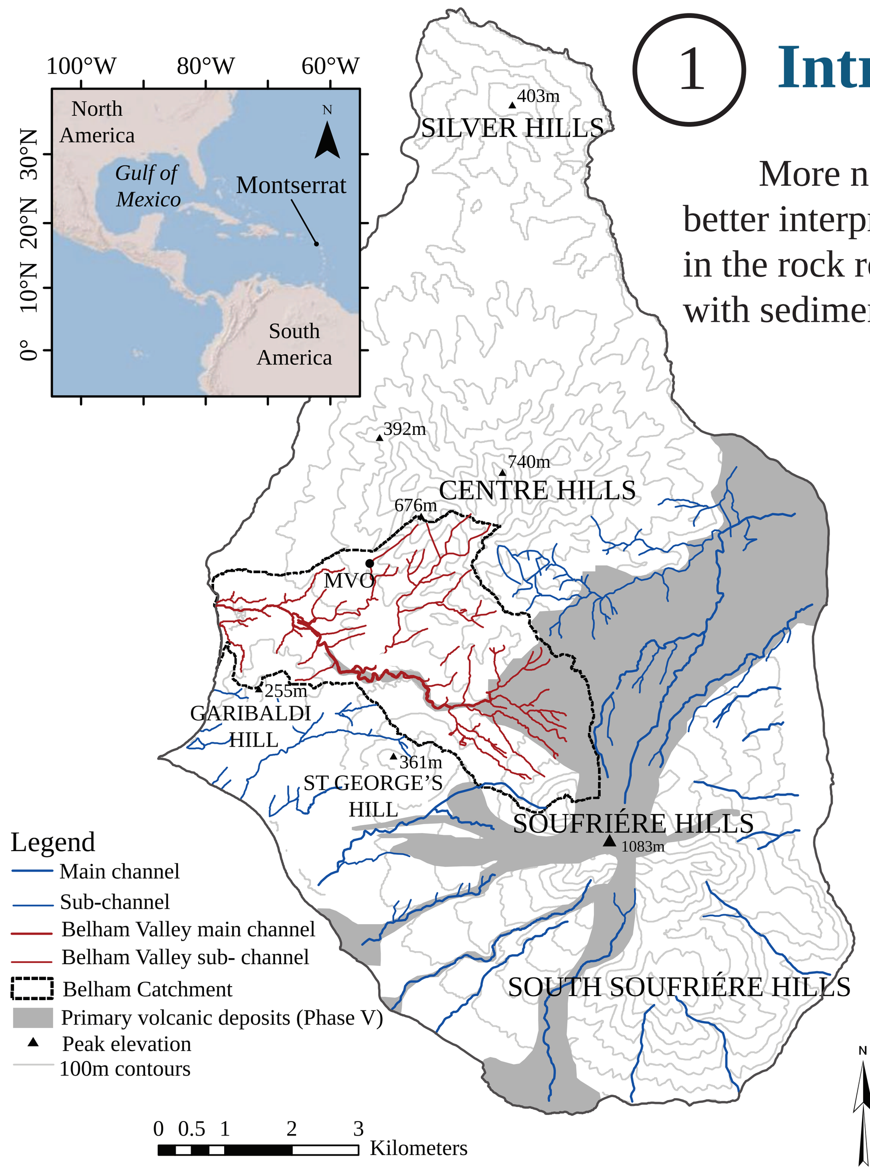
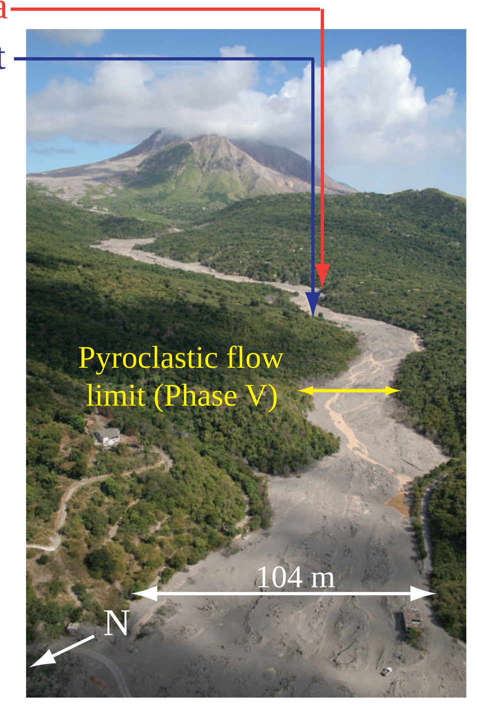


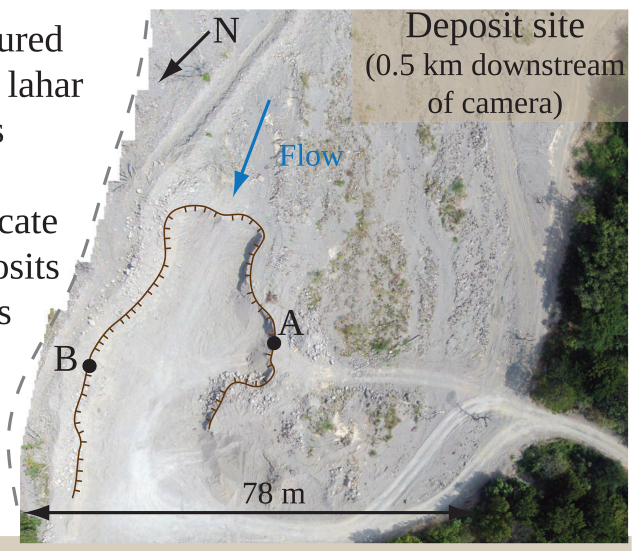
1 Introduction

More natural environment studies are required to better interpret sedimentary structures from flash floods in the rock record. This study links flow observations with sedimentary structures in the deposit.

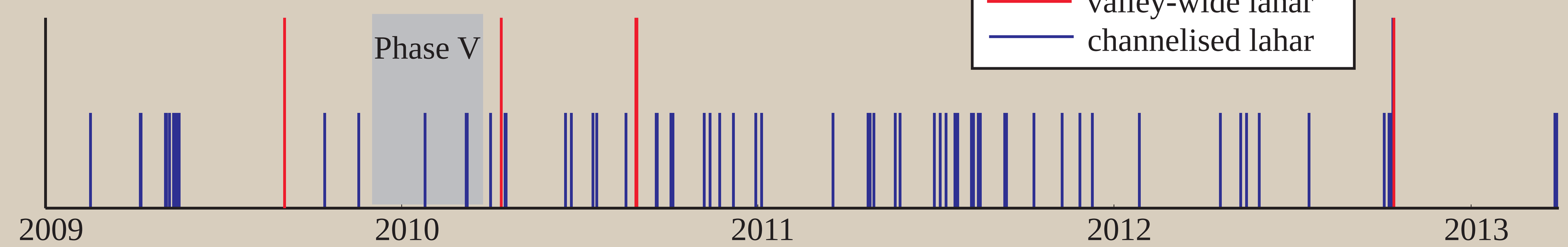
Since 1995, the Soufrière Hills volcano has undergone five phases of explosive activity, depositing ~37 million m³ of tephra within the 15.35 km² Belham catchment. Volcanic sediments have been remobilised by rainfall triggered lahars; these flows persist outside phases of primary activity [1].

A remote monitoring camera captured time-lapse images of a single lahar on 13-14 October 2012. Flow was strongly unsteady, turbulent. Suspended sediment samples indicate dilute streamflow. Upstream deposits and camera data indicate periods of hyperconcentrated flow.

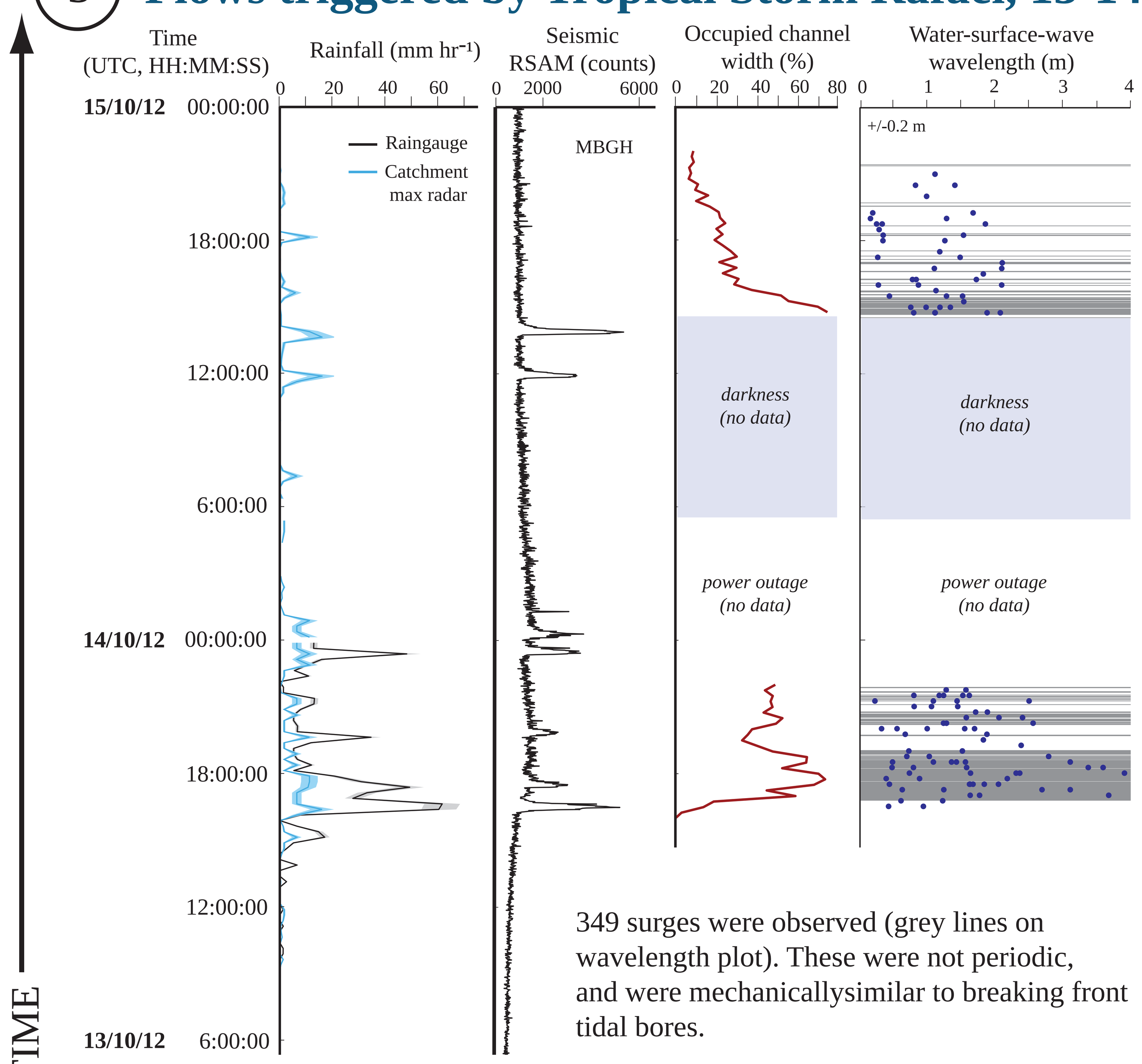




2 Lahars January 2009 to March 2013



3 Flows triggered by Tropical Storm Rafael, 13-14 October 2012



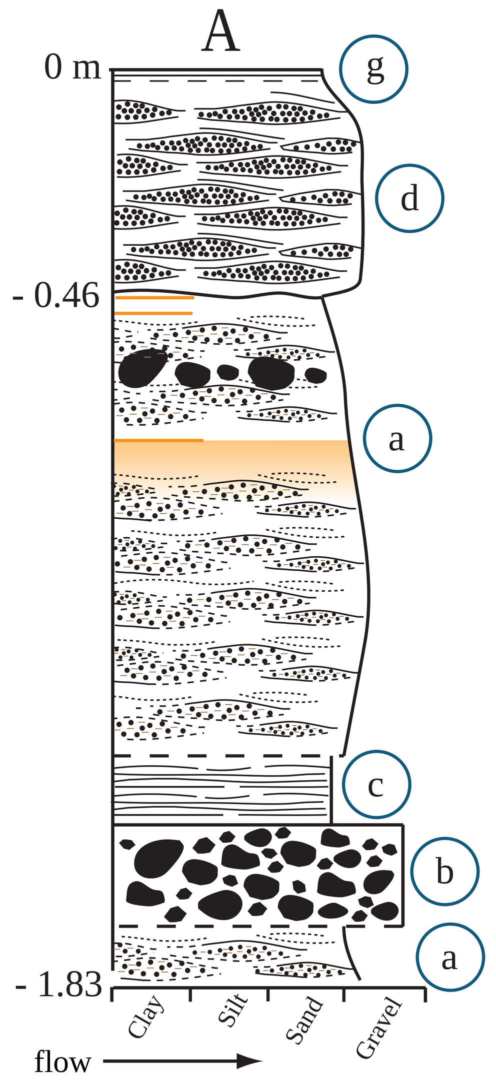
Seven peaks in seismicity were registered, corresponding to peaks in particle load and flow turbulence [2]. Peaks in seismicity did not correspond to visual peaks in flow vigour; a ~15 minute time lag existed. Peak discharge occurred 1 hr 18 minutes after the first seismic peak, and 1 hr 10 minutes after peak rainfall.

Flow persisted for >29 hrs, occupying 6 to 74 % of the valley width in 2 to 4 transient sub-channels.

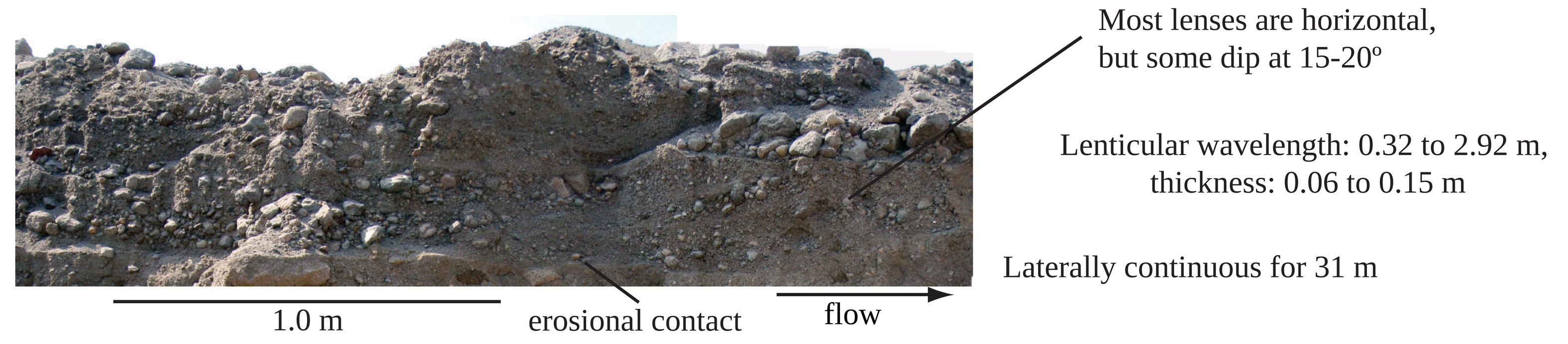
The longest water-surface-waves were measured in the widest sub-channel (48 m wide). Trains persisted for up to 5 minutes before breaking or diminishing in height.

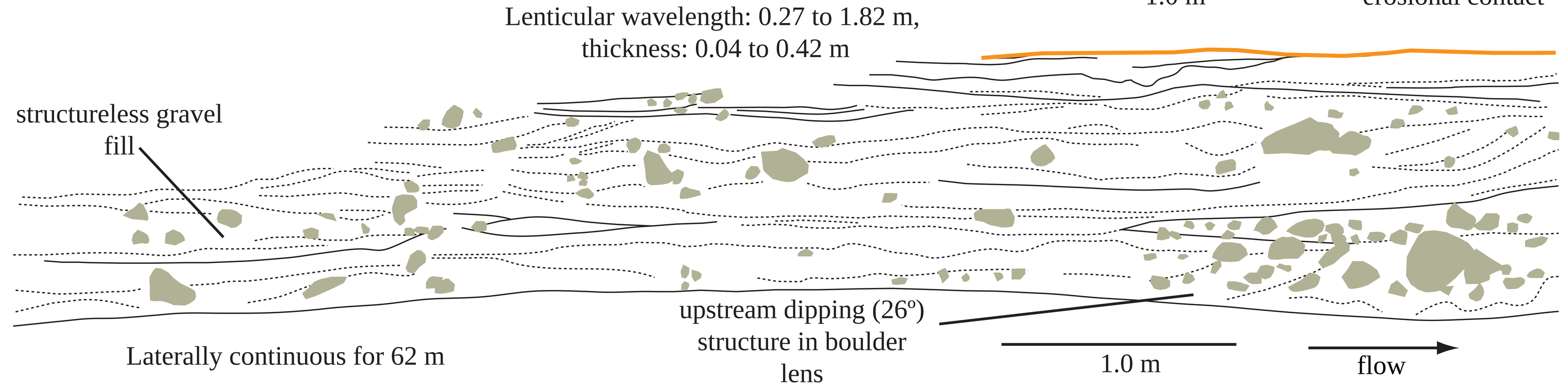
349 surges were observed (grey lines on wavelength plot). These were not periodic, and were mechanicallysimilar to breaking front tidal bores.

4 Deposit characteristics



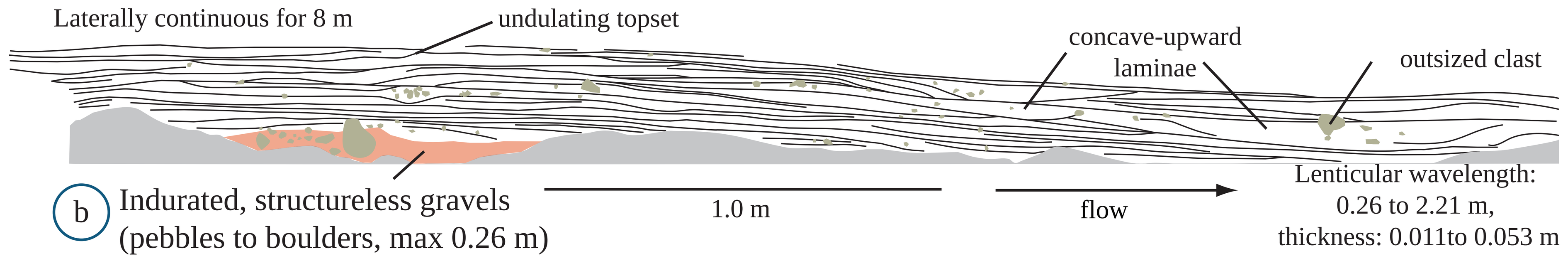
d Clast-supported gravel lenses, varying in character laterally and vertically. Some lenticular fills contain concave-up or upstream-dipping structures and normal grading. Most are delineated by a topset of sands.



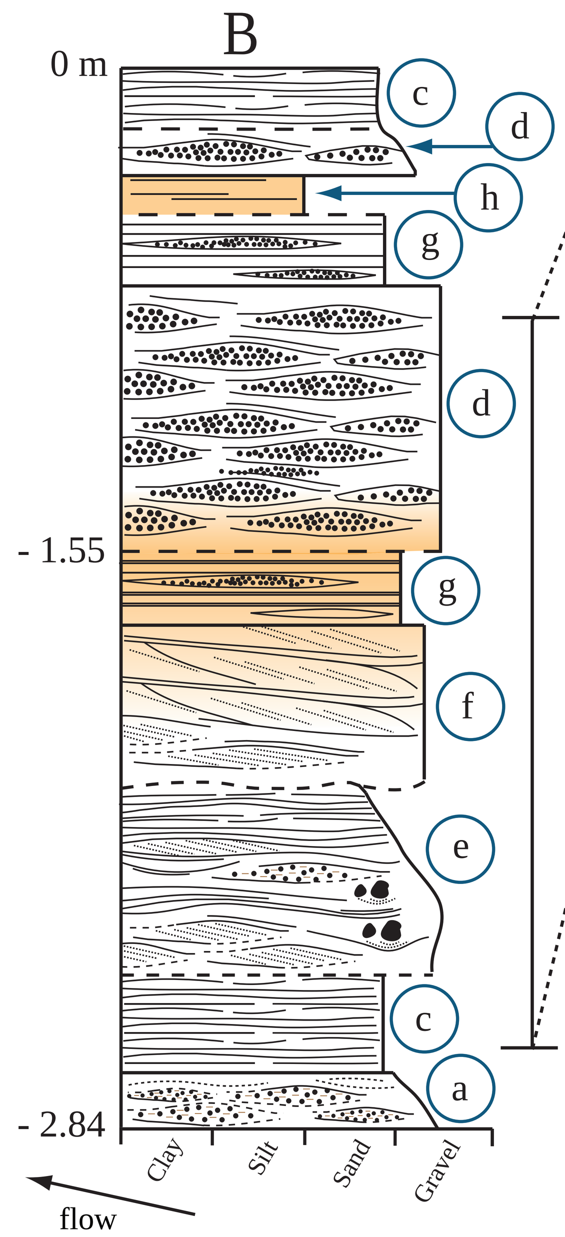


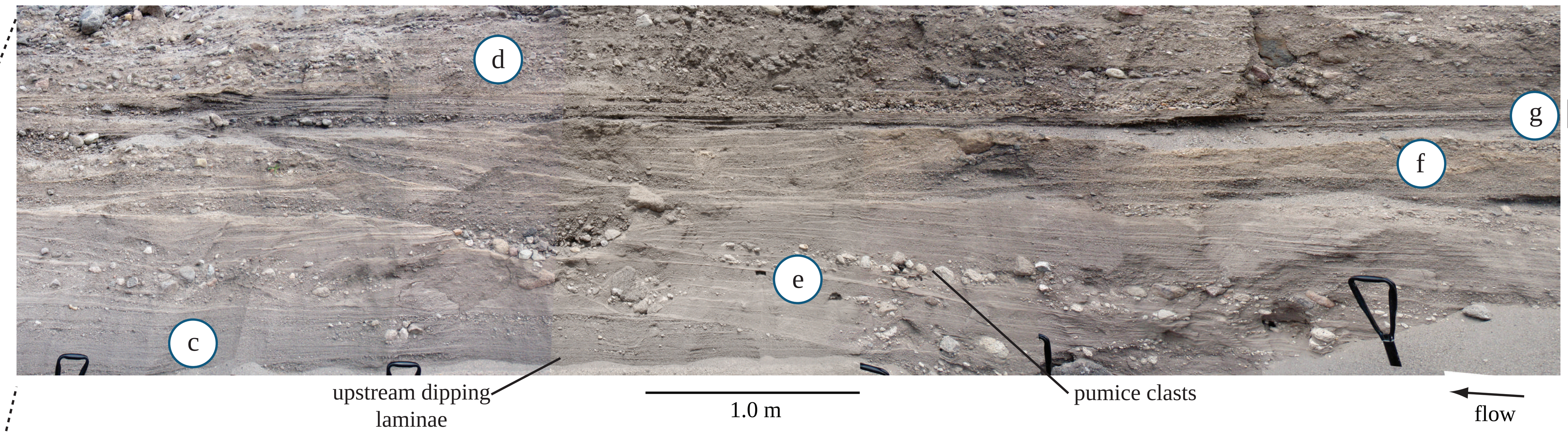
a Diffusive gravel lenses within a sand matrix. Lenses contain variable weak internal architecture, but most show reverse-grading in the bottomsets, and normal-grading in the topsets.

c Sub-horizontal planar sand beds interlaminated with discontinuous, undulating lenses containing granule-pebble sized clasts in a sand matrix

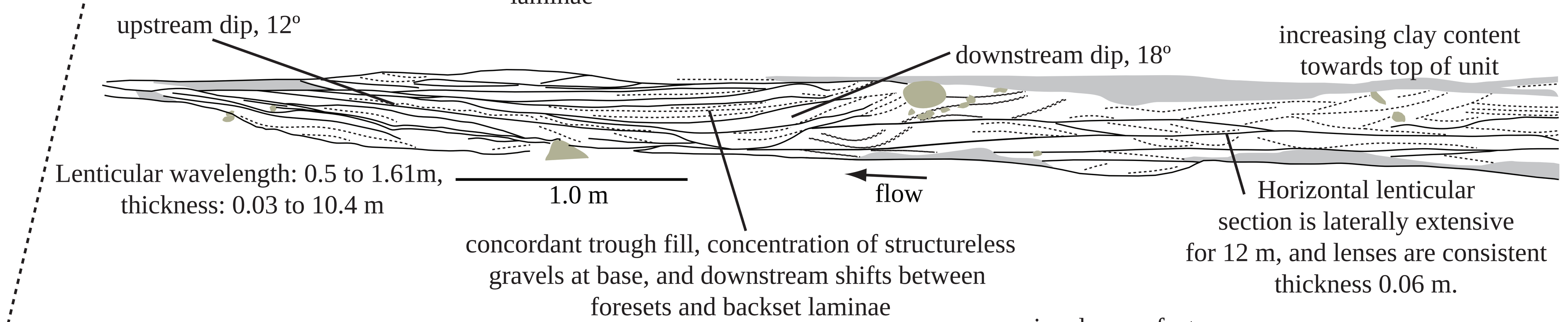


b Indurated, structureless gravels (pebbles to boulders, max 0.26 m)



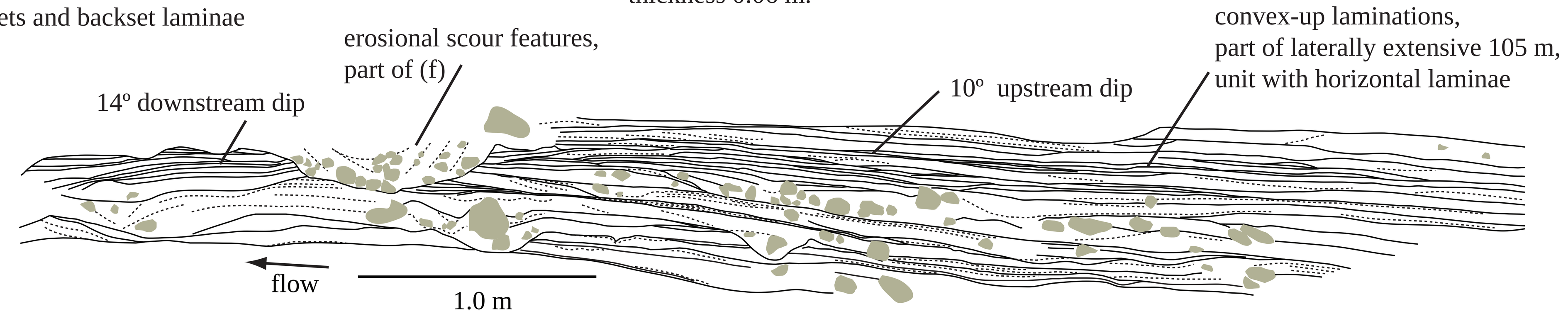


g Planar bedding, inter-laminations of coarse sands-pebbles (35 mm thick), and vf sands-silts (3 mm thick). Laterally extensive for 100+ m.



f Lenticular structures containing clast-supported v.coarse sands and gravels with predominant upstream low inclination dip. Structures are delineated by 20-30 mm thick layers of m-v.coarse sands. Erosional basal contact.

e Interlaminated sands and silts, with planar boulder structures and scour features. High content of pumice clasts. Coarser laminations show undular form and convergence.



5 Discussion

- Atleast **90%** of the deposit is interpreted as upper flow regime origin.
- Structures characteristic of those formed under water-surface-waves in the flume e.g. [3] and [4], are present in Facies (a), (c), (d), (e) and (f).
- Geometries of lenticular structures are within the range of water-surface-wave wavelengths measured from camera images of flows on 13-14 October 2012. However, only the **upper ~0.5 m of the deposit is linked with the 2012 event** and includes:
  - Facies (d) intepreted to have formed from breaking water-surface-waves
  - Facies (c) deposited during waning flow
- The frequency of surges limits the preservation of bedforms, mobilising boulders **up to 40cm**
- Deposits beneath Facies (h) in log B are attributed to lahars in 2010.
- The regularity of horizontal lenticular structures in Facies (f) is suggestive of antidunes formed under persistent water-surface-waves.
- Preservation of fine interlaminations in Facies (e) indicates a less turbulent flow regime (than the 2012 event).
- Facies (b) in log A is associated with deposition by a 'hot' lahar. Gravel-sized material indicates mobilisation by valley-wide large flow event.
- Shift from **depositional** to **erosional** regime in reponse to sediment availability from Phase V volcanic deposits.
- **Water-surface-waves characteristic of both regimes.**
- Downstream **surges unlikely to be dominant feature of flows immediately proceeding Phase V,** based on facies associated to 2012 flow.

6 References

[1] Alexander, J. et al. (2010) Sediment-charged flash floods on Montserrat:...,J.Volc.Geothermal. R., 194. [2] Doyle, E. et al. (2011) Defining conditions for bulking and debulking in lahars. Geol.Soc.Am.Bull., 123 (7). [3] Alexander, J.et al. (2001) Bedforms and associated sedimentary structures formed under water flows over aggrading sand beds. Sediment., 48. [4] Cartigny, M. et al. (2013) Morphodynamics and sedimentary structures of bedforms under supercritical-flow conditions: New insights from flume experiments, Sediment., 61(3)

7 Acknowledgements

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