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GPR-derived architecture of jökulhlaup sediments, Gígjökull, Iceland

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A warming global climate has implications for glacial retreat and meltwater generation. In Iceland, the potential frequency and magnitude of jökulhlaup (glacial outburst flood) hazards from ice-dammed and moraine-dammed lakes may be increased by: (i) increased glacial meltwater production; and (ii) the glacio-isostatic response of the mantle driven by deglaciation, which is hypothesised to increase volcanic activity. The high peak-discharges of volcanically-induced jökulhlaups in Iceland have the ability to deposit significant volumes of sediment, causing major geomorphic change and societal impacts. Understanding geomorphological process associated with jökulhlaups can assist in predicting and evaluating future jökulhlaup behaviour and impacts.

The 2010 Eyjafjallajökull eruption produced multiple jökulhlaups resulting in major sediment deposition and proglacial aggradation. Observations of the timing, scale and hydraulic properties of these jökulhlaups during the eruption have provided a unique opportunity to investigate the impact of ice-rich meltwater flows on the proglacial environment. Using low-frequency (40 MHz) ground penetrating radar (GPR) and differential GPS (dGPS) surveys of the Gígjökull basin, this study has: (1) geophysically characterised the thick sequence of sedimentary deposits associated with the Eyjafjallajökull eruption, to test conceptual models of jökulhlaup deposition; and (2) quantified post-depositional (2010-2016) elevation change, to evaluate the role of buried ice on post-jökulhlaup landscape response and recovery.

The jökulhlaup deposits are characterised by three prominent sediment sub-units, delimited by strong continuous reflectors, and displaying discontinuous undulating reflections (indicating the presence of dunes or anti-dunes). The structures within these sub-units provide insight into the fluvial processes associated with multiple high-magnitude flood events and their relation to the hydraulic properties and rheology. Our geodetic observations demonstrate significant lowering of the surface of the jökulhlaup sediments over six years since deposition (i.e. 0.456 ma-1 between 2010 and 2015; increasing to 1.926 ma-1 between 2015 and 2016), which we interpret to be the result of the meltout of buried ice within these sediments.

Our findings will quantify the hazard potential of ice-rich jökulhlaup flows, by constraining sub-surface properties and their spatial relation to the highest rates of elevation change. The association of geomorphological processes of the Eyjafjallajökull jökulhlaups in relation to hydrograph shape will provide useful information for future mitigation and constraints for jökulhlaup propagation modelling. The integration of hydraulic observation and sedimentary products of the Eyjafjallajökull jökulhlaups can also provide process-insight into Quaternary megafloods (e.g. outburst floods from the Laurentide ice-sheet) and megafloods on other planets (e.g. Mars).