Ground Penetrating Radar (GPR) survey on volcanogenic outburst flood deposits, northeast Japan

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Volcanogenic outburst floods from volcanic lakes such as intra-caldera lakes or volcanically dammed river-valleys tend to be voluminous with discharges that are usually several orders of magnitude greater than normal river flow condition. Such a large flood can travel long distance, and cause enormous transport of unconsolidated sediments and eventually burials of downstream areas. Therefore, sedimentary architectures, depositional patterns, and bedforms are important to understand properties, processes and mechanisms of large-scale hazardous flows. In contrast to the extensiveness of sediments and bedforms/landforms left after the volcanogenic outburst floods, outcrop information obtained by classical geological and geomorphological field surveys is limited to the dissected/terraced parts, road cuts and/or large quarries. This study therefore uses Ground Penetrating Radar (GPR), using the properties of electromagnetic wave propagation, to obtain extensive images of subsurface sedimentary structures of volcanogenic outburst flood deposits.

The GPR survey was carried out over two volcanogenic flood fan/apron sediments in northeast Japan, at surrounding the Numazawa and Towada volcanoes. The 5 ka Numazawa flood deposits in the Tadami river catchment has been emplaced by a breakout flood from ignimbrite-dammed valley leaving pumiceous gravelly sediments with meter-sized boulders in the flow path (Kataoka et al., 2008). At Towada volcano, a comparable flood event originating from a breach in the caldera rim emplaced the 13-15 ka Sanbongi fan deposits in the Oirase river valley, which is characterized by a bouldery fan deposits (Kataoka, 2011).

The GPR data was collected following 200 to 500 m long lateral and longitudinal transects, using a GPR Pulse-Ekko-Pro mounted with 50 MHz and 100 MHz antennas. We obtained radargrams up to 13 m depth, where the dielectric properties of the material were allowing a good penetration of electromagnetic waves. GPR profiles show large internal cross structures with 2-5 m amplitude and 10s m wavelength indicating lateral/downstream accretion in flood fan deposits. Some of them are slightly inclined towards upstream (backsets) which may suggest upstream migration of bedforms. These cross stratifications revealed by the GPR profiles correspond with very low-angle cross-stratifications or parallel stratifications in outcrops. The GPR images also containing hyperbolic reflectors suggest 1-3 m diameter boulders scattered in the fan deposits. Both the 5 ka Numazawa flood deposits and 13-15 ka Sanbongi fan deposits have underlying ignimbrites emplaced by the eruptions. Boundaries between fan deposits and ignimbrites/buried terrace deposits can be detected as clear reflectors. Thus, GPR survey on volcaniclastic material is useful to understand not only sedimentary architectures of the flood deposit but also paleotopographies, volumes of buried ignimbrite and overlying breakout flood or lahar sediments.