Using ground penetrating radar to map soil thickness and quantify weathering rates on the island of Hawai’i

Ground penetrating radar (GPR) and electrical resistivity tomography (ERT) were combined with sediment coring near Mountain View, Hawai’i, in January of 2023 to test how well these methods could effectively be used to create soil and regolith thickness maps. The island of Hawai’i is a young landscape, has a consistent temperature, is composed entirely of basalt, and has been populated by humans for very short time, making it an ideal natural laboratory to study how vegetation, rainfall, and weathering affect hillslope processes such as sediment erosion and landsliding, soil development, and the production of regolith. These are important factors in agriculture on the island, which represents a significant portion of the state’s GDP and plays a crucial role in the livelihoods of many residents on the island, both economically and culturally.

A preliminary analysis of data from a 160 MHz GPR antenna shows that it was able to easily distinguish the layer of weathered soil and regolith from competent bedrock. In many places, internal structures of lava flows could be distinguished, and in several locations the antenna appeared to identify soil or weathered regolith layers that had been covered by a younger lava flow. The 160 MHz antenna did not show a clear difference between the developed soil and regolith. Data from a 450 MHz GPR antenna showed a clear separation between weathered material and competent bedrock, like the 160 MHz GPR, but the data also showed multiple horizontal zones within the developed soil layer, suggesting the GPR was able to identify individual soil horizons in some places. Like the 160 MHz antenna, the 450 MHz antenna did not appear to be able to distinguish a clear separation between the developed soil and the regolith in most places, but it could in others. This is not surprising because the transition from the B soil horizon to regolith should be gradational. However, why the GPR antenna could discern between the soil and regolith in some locations is unclear but could indicate there was a perturbation, such as significant soil erosion, a fire, or a change in vegetative cover. Two ERT profiles with 24 electrodes were acquired for comparisons to GPR data and showed similar results; weathered soil and regolith were clearly distinguishable from the competent bedrock. ERT profiling appears to be unnecessary where the depth of investigation is shallower than 20 m.

Though preliminary, these results indicate that GPR is highly effective in mapping soil and regolith thicknesses in Hawai’i and can possibly reveal or highlight locations that have been affected by past environmental changes. Since the ages of many of the lava flows have been determined using radiometric age dating methods, mapping soil and regolith thicknesses with GPR makes it possible to quantify and analyze bedrock weathering and erosion rates at scales not possible using coring alone.