Reviewed research article

The bedrock and tephra layer topography within the glacier filled Katla caldera, Iceland, deduced from dense RES-survey

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Abstract — *We present results from recent low frequency radio echo-sounding (RES) campaigns over the ice-covered caldera of Katla central volcano, beneath the Mýrdalsjökull ice cap, southern Iceland. The current RES-survey both partly repeats and enhances the RES-profile grid of a previous survey in 1991 with denser sounding lines and improved instruments. The RES-data, obtained in 2012–2021, include ∼760 km of 2D migrated RES-profiles covering an area of 116 km^2. Around 14 km^2 subsections of this area were surveyed with RES-profiles 20 m apart allowing 3D migration of the RES-data. Our study confirms findings from previously published bedrock mapping, including main topographic features, ice volume stored within the 100 km^2 caldera (45±2 km^3, in autumn 2019) and maximum ice thickness (740±40 m). However, the significantly expanded level of detail and features observed in the new bedrock map reveals further evidence of a complex and eventful formation history of the caldera interior. This bedrock map is unprecedented in terms of detail for an ice-covered volcano. The new RES-data allows for a unique comparison of bedrock maps obtained from RES-data with 2D and 3D migration, demonstrating the limitations of 2D migrated RES-data in areas of high topographic variability. Reflections from the 1918 Katla eruption tephra layer within the ice were detected in a much wider area within the caldera than in the 1991 RES-data. We also observe a second internal layer at 420–580 m depth within the northern part of the caldera, identified here as the tephra from the 1755 Katla eruption. The 1918 tephra layer is typically observed at 200–300 m below the glacier surface. However, the layer depth varies from ∼100 m depth at the western rim of the caldera down to 460 m depth, where geothermal activity beneath ice cauldrons melts ice from below. At the most prominent geothermal areas all ice beneath the 1918 tephra has been melted leaving the tephra at the bed. Furthermore, the obtained tephra layer maps reveal footprints of some previously unidentified geothermal areas.*

INTRODUCTION

Many of the most active volcanoes in Iceland are ice-covered. The high elevations, found at many central volcanoes, produce an environment where more snow accumulates in winter than melts during summer, favouring glacier formation. An eruption within a glacier is usually accompanied by jökulhlaups and tephra fall (e.g. Gudmundsson *et al.*, 2008) and can be a serious threat, causing death of people and livestock and damage of agricultural land and infrastructure including houses, roads, bridges, dams, and hydropower stations. The interaction of ice and volcanism is also of broader scientific interest, with meltwater-magma interactions causing explosive fragmentation that can result in widespread airborne tephra. A sub-