Environmental impacts of the Hekla 3 and Hekla 4 eruptions in Iceland

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Project rationale
Icelandic volcanic eruptions occur on average at 3-4 year intervals and the impact of frequent, yet relatively small, eruptions was evident in both 2010 and 2011. In the past, large plinian eruptions have occurred which have covered much of Iceland in thick tephra (volcanic ash) deposits, but the long-term impact of these on the environment is poorly understood. The aim of this project is thus to establish the impact of two large prehistoric eruptions from Hekla (Hekla 3 and Hekla 4, from around 3100 and 4200 years ago) on environments across Iceland. It is important that we improve our currently poor understanding of the consequences of such eruptions, in order to mitigate the impacts of future eruptions.

Research Questions
1. What was the impact of the Hekla 3 and Hekla 4 tephras across different depositional environments across Iceland?
2. How long did it take similar environments at different distances from the eruption to recover from the impact of the Hekla 3 and Hekla 4 tephra layers?
3. What would be the impact of similar eruptions be on Iceland today?

Methodology
This project will involve fieldwork at a number of locations in Iceland. Recent remapping of the extents of both Hekla 3 and Hekla 4 tephra layers (Stevenson) has been used to identify suitable sites. Together with the other supervisors' experience in Iceland, we have already identified potential sites on the Skagi Peninsula (Figure 1), Aðaldalur area, SW of Husavík, the Mývatn area in northeast Iceland and other areas will also be investigated during the project. These areas are distal, but more proximal sites, including Búrfell, only about 10 km from the Hekla, provide an excellent opportunity to study the impact of a thick tephra fall on a well-forested landscape. Tephrochronology will be employed to establish changes in aeolian sediment accumulation rates before and after deposition of tephra and a variety of other analysis including particle size analyses, palaeoenvironmental and ecological analyses will be used to establish the impact of the tephra falls. Different techniques will need to be applied to the wide range of environments to be considered, which will range from soil profiles, peat bogs and lake sediments. Geochemical microanalysis (major, minor and trace elements) will identify and correlate tephra layers and radiocarbon dating will also be used where appropriate. This project will be carried out with the collaboration of colleagues at the University of Iceland, exploiting long running research links. Computer-modelling of tephra (Tephra2) will allow potential areas that could be affected by future eruptions to be investigated and to study reworking of thick tephra layers over time (centuries).

Timeline
- Year 1: Literature review, analysis of samples already held in Edinburgh, computer modelling training, fieldwork in Iceland (summer 2016)
- Year 2: Geochemical analysis of the tephra layers, particle size and analyses of sediment/soil samples, modelling, paper writing, fieldwork in Iceland (summer 2017)
- Year 3: Further analysis (as Year 2), modelling, interpretation of results, thesis writing and conference presentations.
- Year 4: Completion and further papers.

Figure 1
Soil profile just over 1 m thick on the Skagi peninsula, North Iceland, 200 km north of Hekla. The three visible white tephra layers (up to 2 cm thick) were produced in the most recent large rhyolite eruptions of Hekla: H1 (1104 AD, top of ruler); H3 (c. 3100 BP, around 75 cm up, faint) and H4 (c. 4200 BP, around 45 cm up). Note the colour change from dark clay into orange, oxidised clay that takes place at the time of H4. Such changes in oxidation state or grain size are common in soil profiles in this part of Iceland at the time of H4, indicating that it was a cause of major environmental change.

Research Training
A comprehensive training programme will be provided comprising both specialist scientific training and generic transferable and professional skills. The student will have training in Edinburgh from the supervisors so that they are able to carry out the fieldwork, computer modelling, tephrochronology and other palaeoenvironmental studies, as well as geochemical microanalysis (in Edinburgh), particle size analysis and other laboratory work, data analysis, as well as transferable skills training.

Requirements
Ideally the student should have a geography, geology, Quaternary or environmental science and/or soils background and ideally would have some experience of tephras or tephrochronology. Computer modelling will be a component of this PhD and although not essential, some experience of this would be helpful.

Further Reading

Dugmore A.J., Larsen G. and Newton A.J. (1995) Seven tephra isochrones in Scotland. *The Holocene* **5**, 257–266.
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Guðmundsdóttir, E.R., Eiríksson, J. and Larsen, G. (2011) Identification and definition of primary and reworked tephra in Late Glacial and Holocene marine shelf sediments off North Iceland. *Journal of Quaternary Science* **26(6)**, 589–602.
Larsen, G., and Thorarinsson, S. (1977) H4 and other acidic Hekla tephra layers. *Jökull* **27**, 28-46.
Larsen, G. and Eiriksson, J. (2008) Late Quaternary terrestrial tephrochronology of Iceland - frequency of explosive eruptions, type and volume of tephra deposits. *Journal of Quaternary Science* **23**, 109-120.
Lowe, DJ (2011) Tephrochronology and its application: a review. *Quaternary Geochronology* **6**, 107-153.