# Landscape stability over 1100 years of pastoral farming in North Iceland


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## Introduction:

From the time when Iceland was colonised in the late 9th century CE, large scale degradation of vegetation and soils have left the country as one of the most eroded in Europe. Deforestation and exposure of soils to erosion by wind and water continue. The process of soil erosion may have undergone three stages of increase over the historical period: 1) destabilisation of land surfaces soon after the settlement; 2) increased soil erosion during the Little Ice Age (LIA); 3) significantly increased numbers of sheep and change in emphasis from dairy to meat from the mid 19th century CE resulted in large-scale desertification, particularly in highland areas. However, many of the studies come from the volcanic zones of the island, where the bedrock is the most porous and erosion-susceptible volcanic soils are thickest. Here we examine landscape stability in Svarfaðardalur in North Iceland (Figs. 1 and 2) over the last c. 3000 years, out of which anthropogenic activity features as a contributing factor over the last c. 1100 years. Our examination works along the hypotheses that 1) the impact of settlement was swift and pronounced, 2) that the LIA facilitated enhanced levels of erosion and 3) that the levels of soil erosion escalated further from c. 1800 CE (see Figure 3).

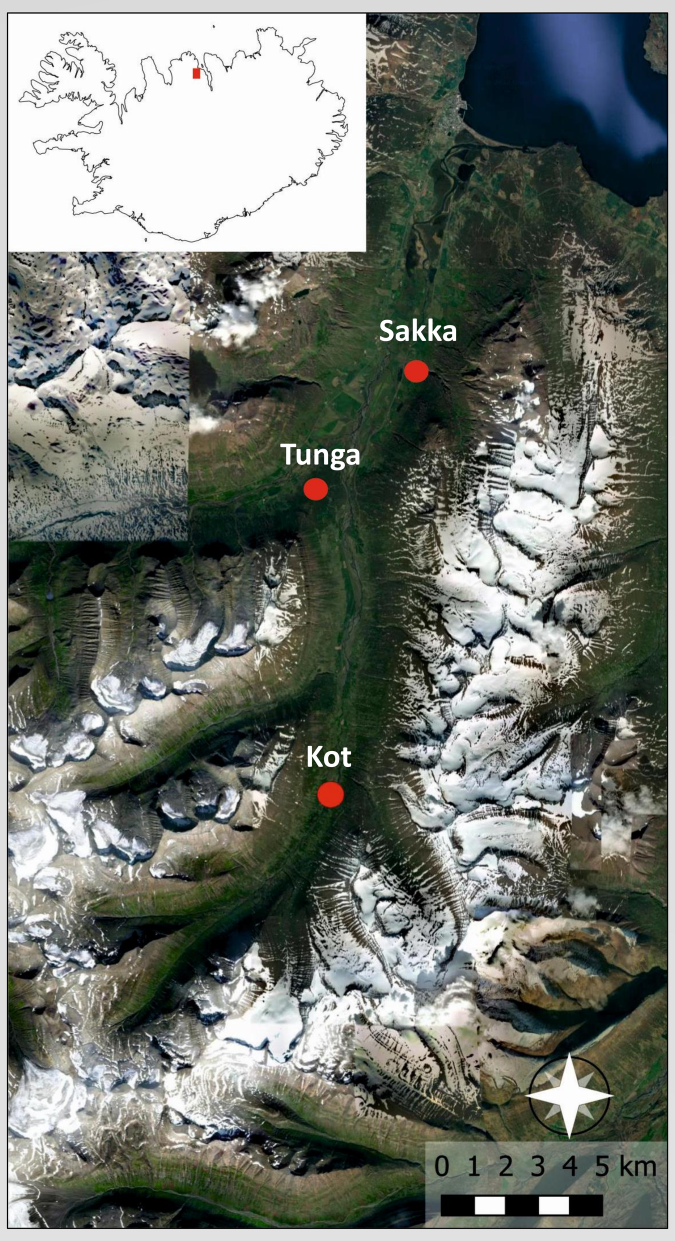


**Figure 1.** Svarfaðardalur and the three study sites. Map made by EÁE.

**Figure 2.** Svarfaðardalur, looking southwards.

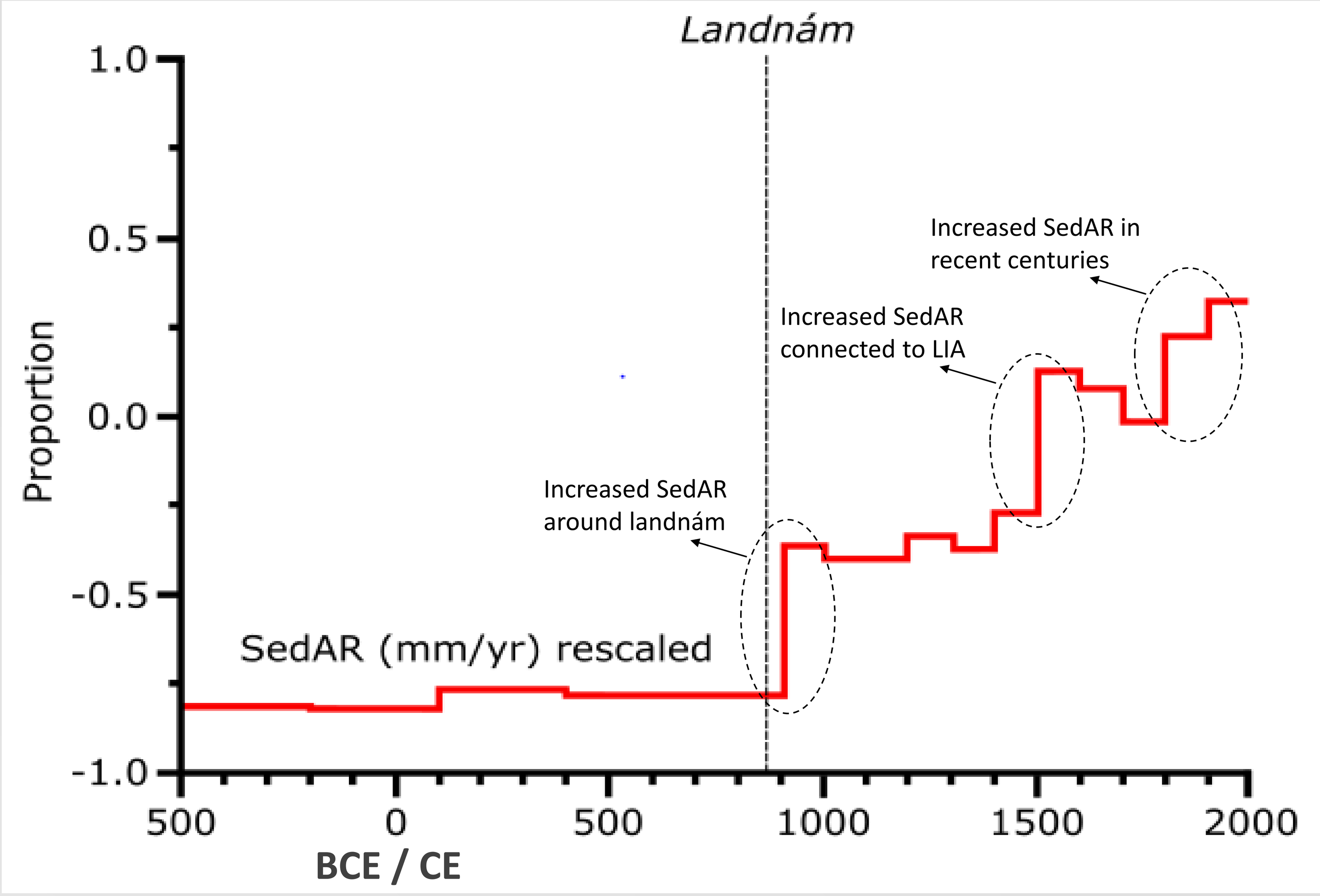


**Figure 3.** Combined records of sediment accumulation rates (mm/yr) from 36 sites in Iceland, rescaled to fit to between -1 and 1. Redrawn and simplified (by EE) from Streeter et al. (2015).

## Methods:

We employ XRF scanning and measurement of magnetic susceptibility (MS) from three terrestrial sites that form an altitudinal transect along the valley. Tephrochronological framework allows us to accurately isolate specific periods and landscape destabilisation therein. XRF scanning and MS measurements were undertaken at the Copenhagen University, Globe Institute. The analyses used Itrax CS37 scanner, at 30 kV and 50 mA. Analyses of tephra geochemistry (not shown here) were performed at the Institute of Earth Sciences, University of Iceland, using JEOL JXA-8230 electron probe micro-analyser.

## Results:

**Sakka (Fig. 4):** Low values for all erosion proxies before *landnám* (877 CE) are interrupted by the onset of settlement but do not increase in later centuries until around 1766 CE, after which the highest values are reached. Values for the selected erosion proxies remain low throughout, except for where tephra layers are encountered.

**Tunga (Fig. 5):** Low values for all erosion proxies before *landnám* (877 CE) are interrupted by the onset of settlement. This initial disturbance signal tapers off between 1104 CE and 1300 CE remains stable. Subtle increases in the density proxy and magnetic susceptibility from c. 130 mm (c. 1900 CE) are apparent. Overall, the selected erosion proxies remain low throughout.

**Kot (Fig. 6):** Low values for all erosion proxies before *landnám* (877 CE) continue into the settlement period. The values remain low until reaching the 1766 CE tephra layer (c. 130 mm), after which a clear rise in all proxies is found. The selected proxies all display low values throughout the study period.

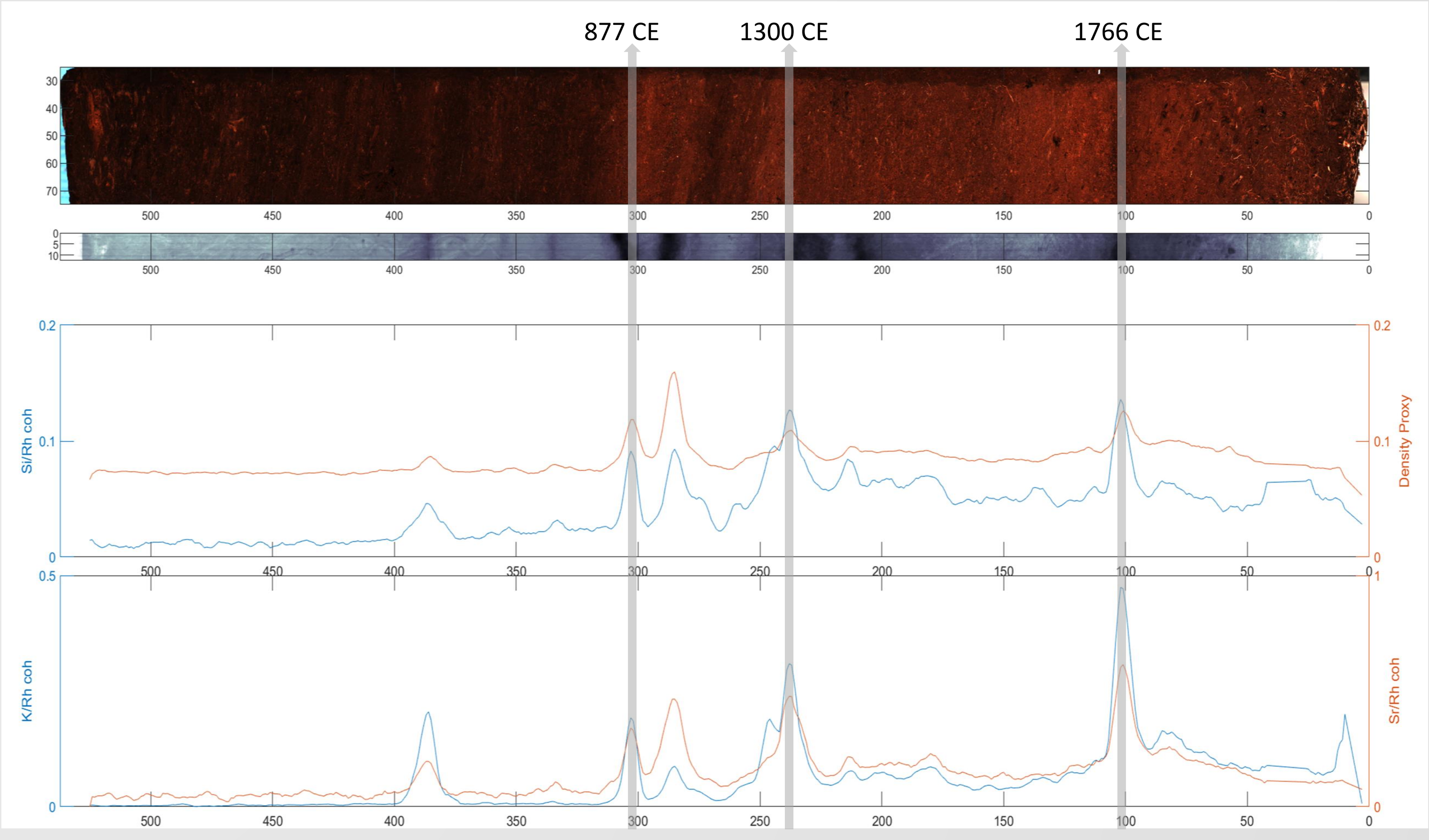


**Figure 4. Sakka**. Selected results from XRF scanning. Also shown are ages of the tephra layers within the peat. Depth measurements are in mm. Values are arbitrary.

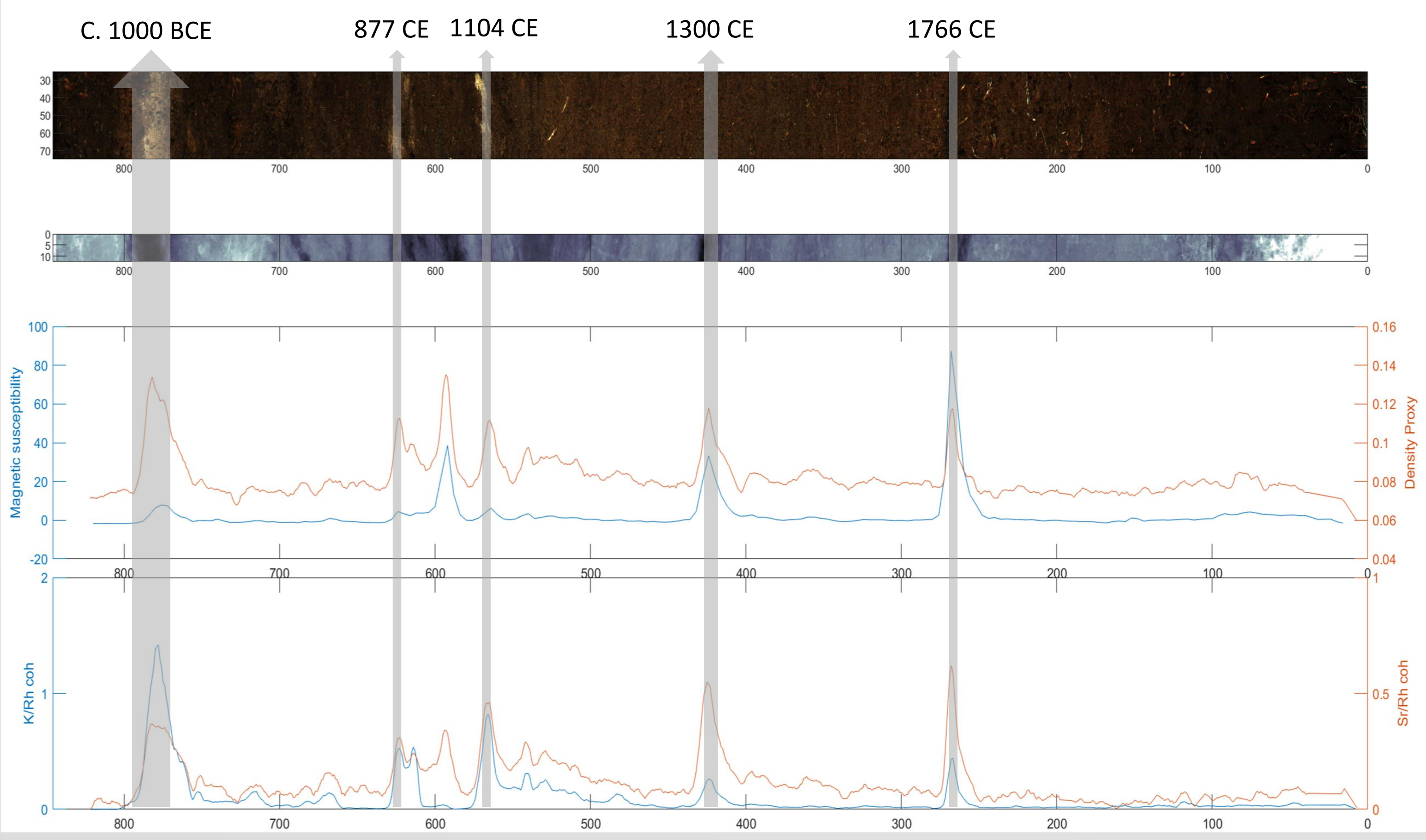


**Figure 5. Tunga**. Results from XRF scanning and magnetic susceptibility measurement. Also shown are ages of the tephra layers within the peat. Depth measurements are in mm. Values are arbitrary.

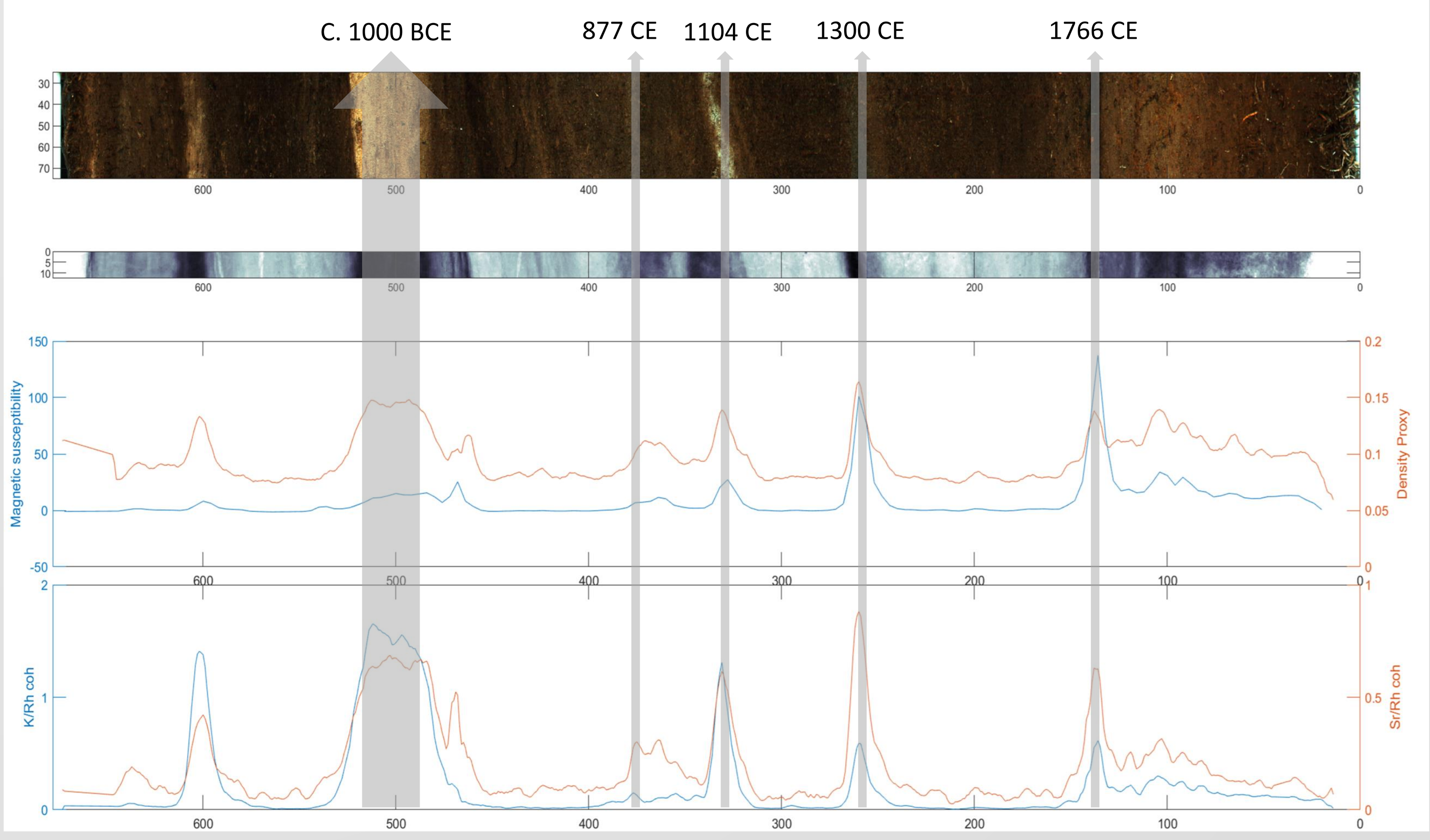


**Figure 6. Kot**. Results from XRF scanning and magnetic susceptibility measurement. Also shown are ages of the tephra layers within the peat. Depth measurements are in mm. Values are arbitrary.

## Discussion:

Going back the hypotheses, we can find support for the ones relating to initial disturbance of the *landnám* at all sites and altered land use in recent centuries (see basis for hypotheses in Fig. 3). This is unsurprising. The former can find explanation in the colonisation of pristine land and implementation of pastoral agriculture, deforestation and opening of the landscape. The latter may be the result of increased sheep to cattle ratios and the increased number of free, roaming sheep in the landscape as the transhumance system was abandoned and the emphasis in production changed from dairy to meat. More surprising is the lack of response in erosion proxies around the onset of the LIA. In fact, both at Sakka (Fig. 4) and Tunga (Fig. 5) a reduced signal for soil erosion is suggested between 1300 CE and 1766 CE. One reason may lie in the extensive earthwall systems in the valley (Fig. 7). They suggest that control over the landscape with regard to land use was in place. A second explanation may be found the valley's climate. The area is known for its heavy snow cover in winter (Fig. 8) and this may have protected the soils from autumn to spring, when storms are the most frequent and violent. A third line of explanation may be found in a cull in population from the beginning of the 15th century when the black death is known to have reduced the human (and probably livestock) population significantly and reduced pressure on the land.

The low values displayed by the proxies for soil erosion throughout the study period may, in part, arise from considered land use, snowy conditions and the black death. In addition however, it must be noted that Svarfaðardalur is situated some distance from the main active volcanic zones (Fig. 9) and the deep, erosion-suspect andosols in these areas. Much of the studies of historical soil erosion have been performed in such areas and care should be taken in extrapolating data from volcanic areas over older, more "mature" areas of Iceland.

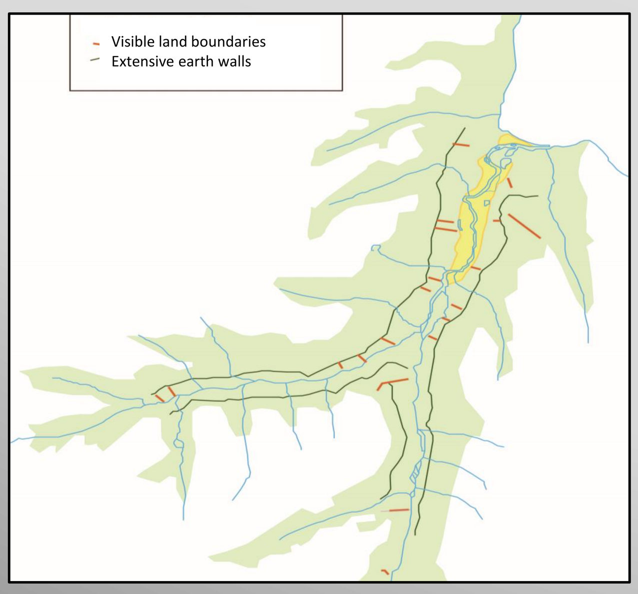


**Figure 7**. Earthwall systems in Svarfaðardalur. Map by Elín Ósk Hreiðarsdóttir.

**Figure 8**. Winter in Svarfaðardalur. (Web source: https://www.wikiwand.com/is/Svarfadardalur#).

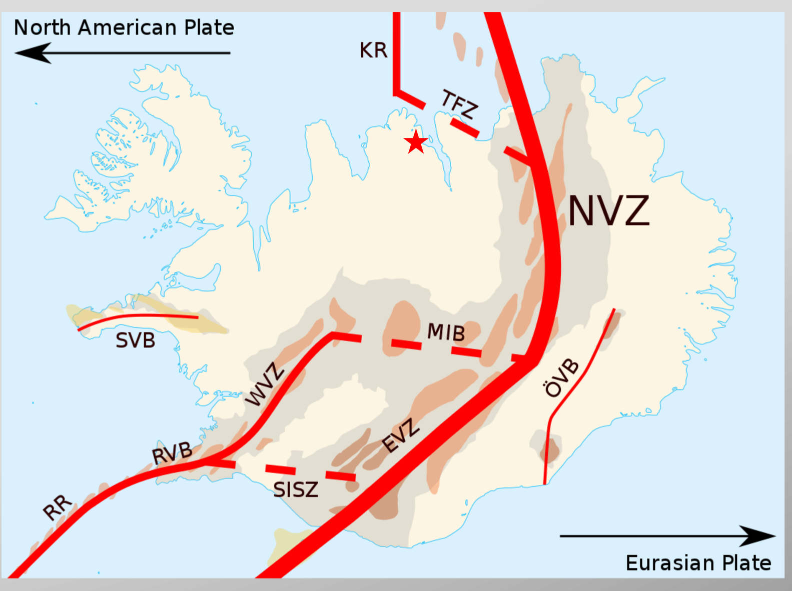


**Figure 9**. Volcanic zones of Iceland. The study area is marked by a red star. (Web source: https://www.wikiwand.com/en/Volcanism_of_Iceland).


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