DRAFT--IN REVIEW...subject to revision!

Re-assessing the arrival of humans in the Faroe Islands and their impacts on the environment based on a lake sediment record from Eiðisvatn

Gregory de Wet[1,2], Raymond S. Bradley[2], William J. D'Andrea[3], Nicholas L. Balascio[4], Isla Castañeda[2], Lorelei Curtin[3], Dana MacDonald[2], and Jostein Bakke[5]

1. Smith College, Northampton, MA
2. University of Massachusetts, Amherst, MA
3. Lamont Earth Observatory, Columbia University, Palisades, NY
4. The College of William and Mary, Williamsburg, VA
5. University of Bergen, Norway

Abstract

Tradition holds that the Faroe Islands, a remote archipelago located in the North Atlantic between Iceland and Scotland, were first settled by Norse colonizers in the early-mid 9th century. This conclusion has been supported by the majority of archaeological investigations carried out on the islands to date. There are, however, a number of indirect lines of evidence that suggest an earlier phase of settlement, perhaps by Celtic peoples from Britain and Ireland. Here we present a lacustrine sediment record from Eiðisvatn, a lake adjacent to a known area of settlement on the island of Eysturoy in the northern Faroe Islands. Our results show that a major environmental "disturbance" occurred in the catchment of Eiðisvatn beginning ~420 CE (1530 cal yr BP). We characterize this signal based on organic matter concentration, macro-charcoal counts, and organic biomarker proxies including branched glycerol dialkyl glycerol tetraethers (brGDGTs) and leaf wax *n*-alkanes. Our results suggest that this disturbance interval was characterized by an increase in the delivery of terrestrially-sourced organic material to the lake, and that the most likely cause of this disturbance was the introduction of grazing animals to the landscape. Taken with increased charcoal concentrations during this interval, we conclude that the Eiðisvatn record provides strong evidence for anthropogenic influence on the landscape prior to the traditional arrival of the Norse in the 800s CE.

Introduction

It has long been considered that the Faroe Islands (or Færoes), situated between the Shetland Islands and Iceland (Figure 1), were first occupied by Norse (Viking) settlers from Norway, as described in various texts, collectively known as the *Færeyinga Saga*. Indeed, almost all of the archeological evidence supports the view that settlers first arrived on the islands and established farms ("*landnám*") around 850 ±50 CE (Arge et al. 2005). Although there are some artifacts indicating Celtic links (e.g stone tablets inscribed with a cross) it seems plausible that earlier Norse contacts with Christians in the British Isles could simply be reflected in these symbols, or that the Norse settlers arrived by way of the British Isles, where contacts had been established prior to AD 850 (Arge, 1991). However, many authors have drawn attention to the earliest manuscript that mentions the Faroes -- that of Dicuil, who described islands some distance north of Shetland, that were settled by Irish monks centuries before the generally accepted date of Norse settlement. He wrote,

> "*There are many other islands in the North British sea. They can be reached from the northern islands of Britain by sailing for two days and two nights on a straight course under full sail if the wind is favourable the whole time. A devout priest has told me that he navigated this route in two summer days and the intervening night, in a small boat with two thwarts, and landed on one of the islands. These islands are for the most part small, and there are mostly narrow sounds between them, and in these islands hermits, come from Ireland by boat, have lived for almost a hundred years. But as they have always been uninhabited from the beginning of the world, so have Norwegian Vikings caused them to be devoid of monks, but sheep are abundant and there are different kinds of seabirds. I have never seen these islands mentioned in the books of other authors"*
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> Dicuil (Irish Clergyman) A.D. 825: *De Mensuris Orbis Terrae* (*The Dimensions of the Earth*) *[translation by Tierney, 1967].*

Because Dicuil mentions that he had actually spoken to somebody who had visited the islands, that hermits had lived there for "almost a hundred years", and that his manuscript dates from AD 825, it is commonly assumed that this points to settlement by at least the 8th century AD, and perhaps earlier. However, this paragraph has generated much debate (e.g. Arge, 1991, 1993; Debes, 1993). Some dispute whether the text even refers to the Faroes, others question Dicuil's sources, and most importantly there is considerable skepticism about the inferred date of settlement. Nevertheless, some have pointed to intriguing symbols of a pre-Viking period of occupancy, with many place names on the islands having Celtic roots. In turn, others argue that this only reflects the fact that Viking settlers were strongly immersed in Celtic culture by the time they arrived, and indeed many are thought to have arrived with women from the British Isles, a fact seen today in the genetic make-up of the male vs. female population of the Faroes (Als et al., 2006). Perhaps the only thing that is clear from these limited historical archives is that they provide no definitive proof for a pre-Viking phase of settlement, only an intriguing possibility that requires confirmation by physical evidence (Arge, 1993).

The Signature of Settlement in Natural Archives

The arrival of settlers in a region is often reflected in their impact on the natural vegetation. They may burn the local vegetation to allow for agriculture, or they may bring grazing animals with them, or both. And they may introduce new species, either deliberately (as with crops) or inadvertently (as weeds carried in cargo or animal feedstocks, bedding etc). These impacts are often detectable in pollen profiles. Much work on this aspect of settlement in the Faroes was carried out by Jóhansen (1971, 1979, 1985) who argued strongly that the pollen record provides clear evidence for two phases of settlement—one in the early 600s (AD), and a later phase that occurred centuries later. Jóhansen found pollen of *Cerealia* (cultivated grasses) principally *Leymus* (lyme grass), *Avena* (oats) and (later) *Hordeum* (barley). At the same time as these indicator species became apparent, *Juniperus* and *Betula pubescens* pollen declined, as did spores from *Filicales* (ferns). He interpreted these changes as due to burning of juniper and birch, and trampling or cutting of ferns to clear areas for agriculture. At the same time, several taxa that he considered to be diagnostic anthropochors, such as *Montia fontana* (miner's lettuce) *Rumex obustifolia, R. longifolius* (dock plants) and *Plantago lanceolata* (ribwort plantain) made their first appearances. Jóhansen interpreted these findings as clear evidence of human impacts on the natural vegetation, superimposed on the on-going changes in vegetation, in response to Holocene climate changes (Jóhansen, 1982) and he argued that that the earliest settlers began by cultivating oats, which was later replaced by barley. Following the later settlement period, the disappearance of *Caltha* spp (buttercup) and *Filipendula ulmaria* (meadowsweet) indicated selective grazing by cattle. Jóhansen's conclusions about a "Pre-Viking" period of settlement was supported by Hannon et al. (1998, 2001) and Edwards et al. (2005) who also found multiple indicators suggesting there had been anthropogenic impacts on the local vegetation, including the occurrence of charcoal, dating from ~AD 650-850 (~1300 B.P).

Jóhansen (referring to Dicuil) argued that the early phase of human impact recorded by the pollen spectra reflected the arrival of the Irish monks, and the later phase indicated the arrival of the Vikings. Much more controversially, Jóhansen also claimed that there was evidence for an even earlier period of settlement, around 4300 years B.P. (Jóhansen, 1989). This was when *Plantago lanceolata* (ribwort plantain) made its first appearance in the pollen record. Jóhansen considered this species as a "pasture indicator" noting, "*P. lanceolata can be considered an indicator of human settlement. It followed Neolithic man, and all later palynological investigations in NW Europe have confirmed the early conclusion of Iverson…*" (Jóhansen, 1985, 1989). Jóhansen associated the increase in pollen from this plant with a decline in tall grasses, which he ascribed to the presence of grazing animals. Perhaps recognizing the controversial nature of this argument, Jóhansen pointed to the long history of settlement in the Shetlands, dating back over 5,000 years, and pondered whether it was conceivable that nobody had ever settled on the islands to the north. Hansom and Briggs (1990) argued that this claim was a misinterpretation of the pollen record, noting that pollen of *Plantago lanceolata* is found in Iceland much earlier than the accepted time of human settlement there. Also, Arge (1991) pointed to the chronological uncertainties associated with Jóhansen's pollen diagrams in some areas, which (in his view) rendered the "two-step" hypothesis of settlement inconclusive, at best. Arge emphasized the need for direct archeological evidence rather than inferences from pollen, but noted that such evidence was sadly lacking. In fact, the archeological evidence is quite definitive: the preponderance of physical evidence is of Viking or later Medieval age. There are numerous structures in many locations on the islands, of both year-round farmsteads and seasonal dwellings. Most importantly, so far, no building or structural evidence has been found that dates from the pre-Viking period. However, the discovery of charred barley grains from beneath a Viking structure re-opened the debate about the timing of settlement history (Church et al. 2013). The weighted mean date for the barley is AD 351-543, well before the conventional date for Viking settlement. Indeed, the range of dates on material found at this site, and their associated uncertainties, could be interpreted as indicating continuous settlement there since the 3rd or 4th century A.D. Church et al. proposed that the charred grains were strewn on the ground with other burnt material (as ash from hearths) to improve the fertility of the soil and to limit erosion. They suggest that the primary fuel burned was peat.

Arguably, whatever structures that earlier settlers may have constructed, could have been appropriated and reconstructed by the Vikings for their own purposes, essentially eliminating physical evidence of the earlier phase of settlement. Given the rugged terrain that characterizes much of the Faroe Islands, opportunities for agriculture and settlement are fairly limited, so it is likely that later arrivals also settled in locations where the early colonizers first came ashore to establish their farms (Arge et al. 2005). The actual dwelling sites may thus be a complex palimpsest of construction, destruction and rebuilding, extending over many centuries in a fairly limited area. However, settlement inevitably leaves other markers in the environment --unique geochemical fingerprints that provide diagnostic indicators of the former presence of humans, grazing animals and their associated impacts on the environment. With this in mind, we recovered sediment cores from several lakes in the Faroe Islands to try to identify an anthropogenic signal that would be diagnostic of the first arrival of humans in the islands.

Study area

We focused research on Eiðisvatn (62.2861N, 7.05761W, 129 m a.s.l.), on the island of Esturoy (Figure 1). This was a natural lake with a surface area of 0.47 km^2 before it was enlarged into a reservoir (by the construction of a dam on the western side of the lake) in 1980. Runoff enters the lake from the surrounding slopes and several small inlets but there is no main river discharging into the lake. Prior to the dam construction, there was one main outlet stream where the dam is today. On the eastern slope of the watershed there was a Viking age sheiling (summer farm) known as Argisbrekka, which was excavated and thoroughly documented by Mahler (1997). Currently the landscape around the lake is entirely devoid of trees and even shrubs are rare; the predominant vegetation cover is grass and sedge meadow overlying peaty soil.

Methods

Three sediment cores were recovered from the deepest area of the lake (32 m): two gravity/surface cores (EI-D-01-15; 83.7cm in length, and EI-D-02-15; 100.7cm), and one percussion-piston core (EI-P-01-15; 281.5 cm). The upper 10cm of EI-D-01-15 was sub-sampled in the field at 0.5cm intervals before being packed for shipment.

Cores were split and imaged at the University of Massachusetts, Amherst prior to analysis. EI-D-01-15 and EI-P-01-15 were analyzed using an ITRAX X-ray fluorescence (XRF) core scanner to determine elemental abundances. Scans were carried out using a molybdenum (Mo) tube with a downcore resolution of 200 μm. The voltage and current were set to 30kV and 55mA respectively, with an XRF count time of 10 seconds.

Both EI-D-01-15 and EI-P-01-15 were sub-sampled with a 1 cm^3 syringe at 1 cm intervals for weight loss-on-ignition (LOI), dry bulk density (DBD), and water content (WC) (n=335) (after Dean, 1974; Heiri et al., 2001). Macrofossils for radiocarbon dating were sampled from both the piston and EI-D-01-15 cores. Analyses were carried out at the Woods Hole NOSAMS facility and the University of California, Irvine (Keck) AMS facilities. Four tephra were identified by visual inspection, and/or by the presence of anomalously high K and Ca counts in the XRF elemental profiles (Supplementary Figure S1). As reported by Curtin et al. (2019), microprobe analysis indicated that three of these were Hekla-Selsund, Hekla 4, and Saksunarvatn with associated ages of ~3,750, ~4,260, and ~10,200 cal. years B.P., respectively (red symbols, Figure 2). Here we also identify the Mjáuvøtn Tephra (~6,600 ± 68 cal year B.P.; Olsen et al., 2010), and two cryptotephra that were possibly associated with the Tjørnuvík and Landnám Tephras (~1150s cal yr B.P. [800s CE] and ~1073 cal yr B.P. [877 CE], respectively) (as reviewed by Wastegård et al., 2018). Cryptotephra horizons were identified by digesting 1 cm^3 samples in 10% H_2O_2 to remove organics, washing over a 20 μm sieve, and then subjecting them to heavy-liquid density separations to isolate material with two density ranges, 2.3-2.5 g/cm^3 and 2.5-2.85 g/cm^3 (Turney et al., 1997; Blockley et al., 2005).

The basaltic Mjáuvøtn Tephra was found as a dark ~1 mm-thick layer at 223 cm and the geochemistry resembles tephra found at other sites in the Faroe Islands attributed to this eruption of the Icelandic Katla volcanic system (Wastegård et al., 2001; Olsen et al., 2010) (Figure S1). A sharp peak in dark green to brown shards up to 1600 shards/cm^3 was found from 34.4-35.4 cm in the heavier density range, and a lower and more diffuse peak in colorless, vesicular shards was found from 26-32 cm in the lighter density range (Figure S1). The geochemistry of shards from 34.4-35.4 cm is similar to the basaltic phase of the Landnám Tephra, however TiO values of all of the shards analyzed (n=35) are at the upper end of the typical range for this tephra (Table S1, Figure S1). Tephra found from 26-32 cm resemble the Tjørnuvík Tephra with an intermediate to rhyolitic composition. The Tjørnuvík Tephra has previously been found mixed with tephra correlated with the Landnám Tephra (Wastegård et al., 2001; Wastegård, 2002) and here we find peaks in concentration dispersed just above the likely Landnám Tephra. Based on our radiocarbon chronology and the four visible tephra layers, these deposits are within the correct age range that has been ascribed to these tephras. However, as we can only make a tentative correlation to the Landnám Tephra geochemistry, and the suggestions by others that the Tjørnuvík Tephra may not be a primary deposit (Wastegård et al., 2018) we did not use them as age-control points. Nevertheless, both cryptotephras are consistent with the age model that we have adopted (see Results and Discussion).

Apart from the four visible tephra layers discussed above, the sedimentary record from Eidisvatn does not display marked visual stratigraphy and is composed of light to dark brown organic-rich gytjja (Figure 3). A total of 54 samples were chosen for biomarker extraction and analysis. 34 samples were selected from the EI-D-01-15 surface core and 20 from the EI-P-01-15 piston core. Sampling was concentrated around high LOI values seen in Figure 2 (composite depth ~29-55 cm) and the deepest sample was extracted from a composite depth of 302 cm. The sediment was freeze-dried and homogenized before lipid extraction.

A total lipid extract (TLE) was obtained using a Dionex accelerated solvent extractor (ASE 200). Samples were extracted with a dichloromethane (DCM)/methanol (9:1, v/v) mixture at 100^{0}C. The TLE was then saponified to separate the lipid extract into a neutral and fatty acid fraction (after Birk et al., 2012). The neutral fraction was then further separated into three fractions, apolar (9:1 DCM:hexane, v/v), ketone (1:1 DCM:Hexane, v/v) and polar (1:1 DCM:methanol, v/v), using alumina oxide column chromatography.

One half of the polar fraction was filtered in 99:1 hexane:isopropanol using a 0.45μm PTFE syringe filter prior to analysis by high performance liquid chromatography (HPLC) to identify and quantify bacterial branched glycerol dialkyl glycerol tetraethers (brGDGTs). A C_{46} GDGT internal standard was added to all polar fractions prior to analysis. BrGDGTs were identified and quantified via high performance liquid chromatography-mass spectrometry using an Agilent 1260 HPLC coupled to an Agilent 6120 MSD following the methods of Hopmans et al. (2016). For compound separation two Waters BEH HILIC columns were used in series (150 mm x 2.1 mm, 1.7 μm). Two solvent mixtures were used as eluents: mixture A) 100% hexane; mixture B) 90% hexane, 10% isopropanol (v/v). Samples were eluted with 18% mixture B for 25 minutes, which was then linearly increased to 35% mixture B from minutes (25 minutes), and finally increased to 100% mixture B for 30 minutes. Scanning was performed in selected ion monitoring (SIM) mode. Concentrations were calculated by comparing brGDGT HPLC-MS chromatogram peak areas with peak areas of a known concentration (C_{46} GDGT standard added to every sample run).

For *n*-alkane analyses, apolar fractions were identified by a Hewlett Packard 6890 gas chromatograph coupled to an Agilent 5973 Mass Selective Detector equipped with a 5% phenyl methyl siloxane column (HP-5MS, 60 m ×0.25 mm×0.25 μm). The oven program ramped from 70°C to 130°C at a rate of 10°C min^{-1}, then from 130°C to 320°C at a rate of 4°C min^{-1}, and then held at the final temperature for 10 min. The *n*-alkanes were quantified using an Agilent 7890A dual gas chromatograph-flame ionization detector (GC-FID) with an Agilent 7693 autosampler equipped with a 5% phenyl methyl siloxane column (HP-5, 60 m ×0.32 mm×0.25 μm) with an identical oven program to the GC-FID. Quantification was achieved by an external calibration curve of squalane ranging in concentration from 1 ng/μl to 100 ng/μl.

Six biomarker-related indices were calculated for the purposes of this study. In the following equations the roman numerals and letters denote the different brGDGT structures as shown in Figure 1, De Jonge et al. (2014b). 1) The MBT'_{5ME} Index (De Jonge et al., 2014b) is an updated version of the original Methylation of Branched Tetraethers (MBT) Index of Weijers et al. (2007), which characterized the presence of methyl branches at the C-5 and C-5' positions and was found to be positively correlated to mean annual air temperature (MAAT).

Eq. 1: $MBT'_{5ME} = ([I + Ib + Ic])/[I + Ib + Ic + IIa + IIb + IIc + IIIa]$ (De Jonge et al., 2014b)

2) The CBT_{5ME} equation of De Jonge et al. (2014b) reflects the number of cyclopentyl moieties in the brGDGT structure and has been shown to relate to pH in some settings (e.g. Weijers et al., 2007). Paleo-pH was calculated using the calibration of De Jonge et al. (2014b).

Eq. 2: $CBT_{5ME} = {}^{-10}\log([Ib + IIb])/([Ia + IIa])$ (De Jonge et al., 2014b)

3) Paleo-pH was calculated using the CBT_{5ME} index and the calibration of De Jonge et al. (2014b).

Eq. 3: $pH = 7.84 - 1.73 \times CBT_{5ME}$ (De Jonge et al., 2014b)

4) The Branched and Isoprenoid Tetraether (BIT) index reflects the relative contributions of certain bacterial brGDGTs against archaea-derived crenarchaeol and was originally conceived as a proxy for soil (brGDGTs) vs. aquatic (crenarchaeol) organic matter source, with values with values closer to one representing a purely branched source, and values closer to 0 representing purely isoprenoid (marine-based) production (Hopmans et al., 2004). Subsequent research has demonstrated that brGDGTs are produced in both terrestrial and marine environments (e.g. Tierney et al., 2009; Buckles et al., 2014; Loomis et al., 2014), complicating interpretation of the BIT Index, but we suggest it is relevant is this setting (see below).

Eq. 4: BIT = ([Ia+IIa+IIIa] / [Crenarchaeol+Ia+IIa+IIIa]) (Hopmans et al., 2004)

5) The brGDGT IIIa/IIa ratio (Xiao et al., 2016), has been interpreted to reflect terrestrial vs. aquatic brGDGT sources, with values below 0.6 reflecting predominantly soil input and values above 0.9 reflecting predominantly aquatic input (Xiao et al., 2016, Martin et al., 2020).

Eq. 5: IIIa/IIa ratio = [IIIa] / [IIa] (Xiao et al., 2016)

6) Leaf wax *n*-alkanes are long chain carbon compounds that make up the waxy outer coating of plant leaves and stems. Short chain lengths (e.g. C_{17}-C_{21}) are broadly characteristic of aquatic plants, while longer chain lengths (C_{27}-C_{33}) are thought to be generally sourced from terrestrial higher plants (Eglinton and Hamilton, 1967). Here, we use the average chain length of *n*-alkanes equation of Poynter and Eglinton (1990).

$$\mathbf{Eq.\,6}\text{: } \mathrm{ACL} = \sum_{n=21}^{33} n * f(C_n)$$

Results and Discussion

Sediment stratigraphy and chronology

A composite sediment record was created based on aligning proxy data and visual stratigraphy from the EI-D-01-15 surface core with the EI-P-01-15 core (because the upper 10cm of the EI-D-01-15 core was sub-sampled in the field, core scanning and LOI data were not available from that section of the core). Based on these comparisons, it is apparent that ~20cm of sediment was lost from the upper part of EI-P-01-15 during coring (Figure S3). We assigned an offset of 20.36 cm between EI-P-01-15 and EI-D-01-15 (including the 10cm that was sub-sampled) based on a comparison of elemental counts from Itrax data. This results in a ~302 cm composite record from both cores. As noted above, Eiðisvatn was dammed and expanded in the 1980s. This operation likely caused the elemental anomaly at ~18cm depth in EI-D-01-15 (Figure S4). A 'modern' (post-1950) radiocarbon date was obtained on a sample from just below this disturbance, at a depth of 18.5cm; we assigned a radiocarbon age of zero (1950) to that depth in our age depth model (see below).

Figure 2 shows the BACON-derived age model derived from 12 AMS radiocarbon macrofossil samples and 4 independently dated tephras. Initially, the chronology was confusing due to the presence of old material that dated out of stratigraphic order, but with the identification of tephras and the acquisition of additional (non-bulk) dates it became apparent that there was an interval within which all dated samples were anomalously old.

The unique natural of this interval relative to the rest of the record is supported by loss-on-ignition (%) data over the Holocene (Figures 2, 3). The lowest % LOI values are recorded at the base of the core (~10,200 cal yr B.P.), with <5% organic matter content; this is related to the presence of a tephra (Saksunarvatn) at that depth. LOI concentration generally increased over the next few thousand years reaching nearly 20% by ~3500 cal yr B.P. Organic matter concentrations increased abruptly at ~1530 cal yr B.P. and remained high for ~550 years, reaching a maximum of over 44%. We consider that this section of the sedimentary record represents a "*disturbance interval*" containing old material that was exhumed from the landscape and redeposited in the lake. Though this high %LOI interval could be the result of increased preservation of organic matter, we suggest that the abrupt nature of the change, along with the signal recorded by numerous proxies presented both below and in Curtin et al. (2020) precludes this possibility. We define the disturbance interval as the period when LOI values exceeded and remained above 20% for a continuous period. The onset of the disturbance interval is at a composite depth of ~53 cm (below the sediment-water interface) with a mean date of 1530 cal yr BP (420 CE; 95% confidence interval, 265-521 CE). LOI values returned to pre-disturbance levels at a composite depth of ~29cm, which roughly constrains the upper level of disturbance. This is dated at ~980 cal yr B.P. in the age model (970 CE). The total duration of the disturbance period, so defined, was thus ~550 years, from ~1530-980 cal yr B.P. (420-970 CE, with a 95% confidence interval of 265 CE to 1025 CE). Dry bulk density variations are generally the inverse of the % LOI record, with the highest values recorded at the base of the core and the lowest values in both EI-D-01-15 and EI-P-01-15 in the ~1530-1000 cal yr B.P. interval.

As noted earlier, we attempted to further constrain the timing of the disturbance interval using cryptotephra. Tephra with intermediate geochemistry were found dispersed in samples within the upper portion of the disturbance interval from 27-32 cm (830-1050 cal yr B.P.; CE 1120-900). The geochemical composition of these tephras are similar to glass shards derived from the Hekla volcano and possibly represent the presence of the Tjørnuvík Tephra. The Tjørnuvík Tephra has been identified as a distinct cryptotephra horizon at Tjørnuvík on Streymoy (Hannon et al., 1998), in a bog at Eiði on Esturoy (Wastegård et al. 2001), and in a peat core from Suduroy (Wastegård, 2002). At two of these sites it has been found with tephra shards from the basaltic phase of the Landnám Tephra and tentatively ascribed to a Hekla eruption in the 9th century. This is roughly consistent with the modeled age of this interval in our record. However, it has also been suggested that the Tjørnuvík Tephra may not be a primary deposit but rather reworked from earlier, more significant, deposits of Hekla 4 and Hekla S eruptions mobilized due to soil erosion during initial human settlement of the Faroe Islands (Wastegård et al., 2018). This may be the case at our site considering the range of anomalously old radiocarbon ages across this interval. We were also unable to identify a distinct peak in shard concentrations or any tephra geochemically similar to the Landnám Tephra and so did not include this as a control point in our age model.

For the purposes of this investigation, where we wish to examine the first indicators of human activity in the landscape, we focus further discussion mainly on the upper half of the composite record (the last ~4000 years). However, other aspects of the climate record at Eiðisvatn over the entire Holocene, and a comparison with samples from nearby Klaksvik (which are of Eemian age) have been reported by Curtin et al. (2019).

Elemental data from XRF scanning

Selected elemental counts from Itrax core scanning are presented in Figures S2 and S3-S5. Of particular significance are the peaks in K and Ca which indicate tephras from the Hekla-Selsund, Hekla 4, Mjauvatn and Saksunarvatn eruptions (Figure S2). Ca and Ti both vary in phase throughout the record (Figure S4), largely reflecting minerogenic input from erosion and weathering of rocks within the lake catchment (cf. Balascio et al., 2015; Kylander et al., 2011) but Ca is especially high in the Saksunarvatn tephra layer (Figure S2). The lowest Ti and Ca counts of the entire Holocene were recorded during the disturbance interval, corresponding to the highest input of organic matter, as shown by the % LOI (also inc/coh ratio, not shown) (Figures 3 and S4). The Mn/Fe ratio fell to its lowest values post-disturbance, suggesting increased oxygenation of the sediments during this time (Figure S5).

Organic biomarkers

brGDGTs

The biomarker data presented here provides support for a distinct and abrupt shift in the nature of organic matter deposition in the lake at ~1530 cal yr B.P. Three distinct intervals were identified in the sediments based on distributions of brGDGTs: pre-disturbance (n = 23) (start of record – 1530 cal yr BP), disturbance (n = 21) (1530 – 980 cal yr BP), and post-disturbance (n =11) (980 – 0 cal yr BP). Non-cyclized 5-methyl brGDGTs are dominant in Eiðisvatn sediments throughout the record, though distribution patterns changed markedly across the disturbance transition (Figure 4). Pentamethylated brGDGTs are most abundant (38%, 45%, and 44% in each interval respectively) throughout the record (Figure 5a). Tetramethylated brGDGTs are the next most abundant in the disturbance (37%) and post-disturbance (35%) intervals, while they are the least abundant in the pre-disturbance interval (30%). Hexamethylated brGDGTs are least abundant in the disturbance (18%) and post-disturbance (21%) intervals, while making up 32% of brGDGTs in pre-disturbance sediments (Figure 4a). 5-methyl brGDGTs are more common than 6-methyl isomers in all intervals, though slightly more-so in the disturbance (95%) and post-disturbance (96%) periods relative to the earlier part of the record (89% in pre-disturbance) (Figure 4b). As can be seen in Figure 4c, brGDGT distributions from the three intervals are generally distinct from each other with sediments from the pre-disturbance period similar to published data from lake sediments (e.g. Russell et al., 2018; Feng et al., 2019; Harning et al., 2020), while samples from the disturbance have more similarity to soils (Naafs et al., 2017; Feng et al., 2019; Harning et al., 2020) (Figure 4c). The post-disturbance interval is more similar to the disturbance itself, but does seem to reflect a slight shift back towards pre-disturbance distributions. The brGDGT data presented here display a marked and rapid shift in the nature of tetraether distributions at the time of the disturbance interval. Based on a comparison with published data and other proxies/indices outlined below, we suggest that this shift represents a change from more aquatic/lacustrine production of lipids during the pre-disturbance interval to more soil/terrestrial delivery to the lake during the disturbance itself.

Relevant downcore brGDGT related indices and proxies are plotted in Figure 5. The MBT'$_{5ME}$ index varies from a maximum of 0.4 within the disturbance interval to a minimum of 0.3 in the pre-disturbance interval. MBT'$_{5ME}$ values are relatively low but variable (~0.32 – 0.35) during the pre-disturbance interval, with a trend towards higher values from ~3700 cal yr B.P. to the start of the disturbance at ~1500 cal yr B.P. Values are highest within the disturbance interval (~0.38-0.40) and then fluctuate between ~0.34 – 0.39 for the rest of the record (Figure 5a).

brGDGTs are known to be produced in both terrestrial and aquatic environments (Schouten et al., 2013 and references therein) and though relationships with temperature have been found in both environments (e.g. Weijers et al., 2007; Naafs et al., 2017; Russell et al., 2018), specific calibrations are necessary for each setting. The application of a single lake- or soil-specific temperature calibration to a sedimentary record with mixed brGDGT sources should be treated with caution, particularly when the relative contributions of brGDGTs sources has likely changed over time. We therefore refrain from applying a temperature calibration to our brGDGT data from Eiðisvatn, and do not interpret the MBT'$_{5ME}$ index as a temperature record. Rather, we note that the disturbance interval is characterized by an abrupt shift to higher MBT'$_{5ME}$ values at ~1530 cal yr B.P. (albeit within the context of slowing increasing, but variable, trend from ~3600 cal yr B.P.) (Figure 5a). This trend could be the result of increasing environmental temperature, however, existing paleoenvironmental reconstructions from the Faroes suggest that conditions in the islands became progressively colder through the Holocene (e.g. Andresen et al., 2006; Gathorne-Hardy et al., 2007; Lawson et al., 2005; McGowan et al., 2008; Olsen et al., 2010), with no suggestion of an abrupt warming event at the time of the disturbance in Eidisvatn (~1530 cal yr B.P.). We do not attempt to specifically disentangle the influence of temperature on the MBT'$_{5ME}$ signal, and rather suggest the major changes in brGDGT distribution are emblematic of a larger landscape shift at this time.

Many of the same caveats and uncertainties must be taken into account when interpreting the CBT$_{5ME}$ ratio and pH influences on brGDGT distributions, and in some studies the relationship between cyclized brGDGTs and pH seems tenuous at best (e.g. Russell et al., 2018). We therefore place little emphasis on the absolute values of pH in the record, and rather focus on the general trend in the data. Reconstructed pH presented here is based on the CBT$_{5ME}$ soil calibration of De Jonge et al. (2014b). The application of different lake and soil-specific pH calibrations produce variable absolute values, but show similar trends. Reconstructed pH is highest (~6 – 6.4) during the pre-disturbance interval and decline sharply at the disturbance boundary, from ~ 6.0 to a minimum of 5.5 by 1370 cal yr B.P. Reconstructed pH then increases towards the end of the disturbance interval to ~6.0 before declining again to ~5.9 in the uppermost part of the record. We suggest that the change in the distribution of cyclized brGDGTs across the disturbance reflects a meaningful change in the nature of the Eiðisvatn catchment and lake system. As noted, we do not place a great deal of weight on the absolute values of reconstructed pH, or even necessarily the interpretation of a shift to a more acidic environment, though that would fit well within a paradigm of increased transport of relatively acidic peat material into the lake at this time. Rather, we suggest the MBT'_{5ME} and CBT_{5ME} indices are robust indicators of a period of landscape/environmental change beginning ~1530 cal yr BP.

Though interpretation of the BIT Index has been complicated by well-documented brGDGT production in both terrestrial and aquatic environments, there does appear to be meaningful changes in BIT values downcore at Eiðisvatn. We find average BIT index values for the pre-disturbance interval of ~0.983, while values for the disturbance itself average closer to one (0.995). The post-disturbance values are similarly high, averaging 0.994. Though we acknowledge the BIT index proxy cannot be interpreted exactly as originally intended, the values from Eiðisvatn point to a relative increase in brGDGT contributions at the time of the disturbance interval, which fit within the paradigm of increasing terrestrial/soil input.

The brGDGT IIIa/IIa ratio was first proposed as a proxy for brGDGT source changes by Xiao et al. (2016). To date, this proxy has not been rigorously tested across multiple settings (the Xiao et al. study was conducted in a near-shore marine environment, though global datasets were considered), but it has proved useful in relatively small lake settings similar to Eiðisvatn (Martin et al., 2019; Martin et al., 2020). Xiao et al. (2016) proposed that IIIa/IIa ratio values above 0.9 reflect a predominantly aquatic brGDGT source, while values below 0.6 reflect a predominantly soil-derived brGDGT source. In Eiðisvatn sediments, the IIIa/IIa ratio is variable but rarely dips below 0.9 in the early part of the record until ~2300 cal yr B.P. (Figure 5d). From 2300 cal yr B.P. to the start of the disturbance (~1530 cal yr B.P.) values fluctuate between 0.9 and 0.6, suggesting a mixed source of brGDGTs. The IIIa/IIa ratio declines sharply at the start of the disturbance interval, from ~0.85 to a minimum of 0.34 by 1370 cal yr B.P., with the ratio remaining below 0.45 for the duration of this period, suggesting soil was the predominant source of brGDGTs. The ratio increases in the post-disturbance interval, but remains near or below 0.6 for the remainder of the record (Figure 5d). Though this proxy has not been tested in the Eiðisvatn catchment, the signal of increased soil-derived organic matter delivery during the disturbance interval fits well with other lines of evidence from the lake during this time.

Sedimentary n-alkanes

Leaf wax *n*-alkanes are long chain carbon compounds that make up the waxy outer coating of plant leaves and stems. Short chain lengths (e.g. C_{17}-C_{21}) are broadly characteristic of aquatic plants, while longer chain lengths (C_{27}-C_{33}) are thought to be generally sourced from terrestrial higher plants (Eglinton and Hamilton, 1967). *n*-Alkane results from Eiðisvatn are presented in Figure 6. Average chain length values are based on the equation of Poynter and Eglinton (1990) (Eq 6.) ACL values are generally stable between 28 and 28.5 for the early part of the record until ~2225 cal yr B.P., when they start to decline, reaching a minimum of 27.0 by 1550 cal yr B.P. The index then increases rapidly over the next 10 cm through the base of the disturbance interval, to a maximum of ~29.2 by 1340 cal yr B.P. Chain lengths then broadly decrease, with some variability, through the end of the Holocene, with a value of ~27.4 by 100 cal yr B.P.

n-Alkane concentrations display relatively little variation over the early part of the record, with values below 500 ng/g organic matter (apart from C_{31} in two samples) until the beginning of the disturbance at ~1500 cal yr B.P. At this point concentrations of all chain lengths increase, in parallel with changes in LOI, with the most marked increases in longer chain lengths C_{29}, C_{31} and C_{33} (Figure 6). Concentrations remain relatively high until the end of the disturbance interval, when they decline to similar values seen in the early part of the record.

Interpretation of leaf wax *n*-alkane distributions is difficult in light of widespread variability in production between different plant types (e.g. Bush and McInerney, 2013), particularly in peatland environments (e.g. Naafs et al., 2019 and references therein), though it is worth noting that C_{31} has been shown to be highly abundant in plants growing in bog/peat settings (Nott et al., 2000; Nichols et al., 2006). We therefore refrain from attempting to disentangle specific vegetation changes from the Eiðisvatn *n*-alkane distributions and instead note the general trend of increasing concentrations of most n-alkanes, particularly longer chain lengths C_{29}, C_{31}, and C_{33}, across the disturbance interval (Figure 6b). This pattern is also reflected in the ACL values, which reach a maximum within the disturbance (Figure 6a). We interpret the *n*-alkane data presented here as another indicator of large-scale environmental change during the period of ~1530 cal yr B.P. through ~980 cal yr B.P. The relative increase in longer chain lengths during this interval may reflect increased delivery of terrestrial higher plant and/or non-sphagnum peat species to the lake.

In summary, the individual biomarkers data presented here suggests that the disturbance interval was a period of unique environmental change in the Holocene, likely related to an increase in the delivery of terrestrial material to the lake.

Charcoal

The record of macroscopic charcoal was determined for the upper 101.5cm of the sediment record (back to 3150 cal yr B.P.) (Figure 7). This shows that fire activity was extremely rare or absent in the area for most of the late Holocene, but increased at the onset, and continued during, the disturbance interval. We interpret this as a clear indicator of human-induced landscape modification, resulting from burning of the natural vegetation to clear the area for grazing animals. Along with the *seda*DNA data and other biomarker information presented in Curtin et al. (2020), the charcoal record from Eiðisvatn provides compelling evidence that the driver of the environmental disturbance was likely anthropogenic. We examine this conclusion further in the following section.

Possible Explanations for Disturbance

The evidence presented indicates that there was a unique late Holocene disturbance interval that involved a sustained period when anomalously old terrestrial organic matter was delivered to the lake. There are three possible explanations for the cause of this interval in the Eiðisvatn sediment record: 1) a natural instantaneous mass movement event (a slump or turbidite); 2) a climatically induced disturbance; or 3) the arrival of humans and/or grazing animals in the watershed. Each possibility will be discussed in turn below.

1. A slump or turbidite

The slopes around the lake are at a relatively low angle, which makes an instantaneous mass movement event into the lake very unlikely. A sediment slump or turbidite that carried such a large sediment load into the deepest part of the lake would be expected to produce a distinct erosive boundary, whereas none is seen. Rather, there is a relatively abrupt transition to darker brown gytjja/organic rich-sediment at the lower boundary of the disturbance interval (Figure 3). Furthermore, there is no visual evidence for a 'fining upward' grain size sequence in the sediments. The structure in many of the proxy records throughout this interval (e.g. pH and BIT Index) also suggest this interval was not deposited as an instantaneous event. We therefore conclude that the disturbance is not the result of a mass movement deposit.

2. A climatically-induced disturbance

It is clear that the disturbance interval represents a period that was unique in the Holocene record from Eiðisvatn. If the disturbance was related to a change in climate, there should be evidence of a contemporaneous episode in other locations in the Faroe Islands, with a similar date for the onset of the disturbance. There are many lake and peat studies from other locations in the Faroe Islands and a similar episode of increased organic matter input has been observed in several of these. In most cases, however, this increase has been attributed to the beginning of peat formation in the catchment/surrounding area (e.g. McGowan et al., 2008; Olsen et al., 2010). Lawson et al. (2007) addressed the timing of peat expansion in the Faroes explicitly in their 2007 study, which showed that the initiation of peat formation across the islands occurred at variable times throughout the Holocene, with perhaps some indication of higher activity from 6000 - 4000 cal yr B.P. (Figure 6 in Lawson et al., 2007). Based on more than 30 estimates for the initiation of peat lands across the archipelago, the authors conclude "*there is, at present, no strong evidence to suggest that climatic changes have played a role in the timing of peat initiation in the Faroes*". Furthermore, Johansen (1989) has suggested that peat initiation occurred at the Argisbrekka site ~6000-4000 cal yr B.P., much earlier than the date of the disturbance seen in the Eiðisvatn record. Although few of these records are well-dated, there is no evidence for a disturbance that is synchronous with that observed in Eiðisvatn (Table S3). Indeed, the evidence points to diachronous disturbance across the archipelago, which suggests a non-climatic factor caused the landscape changes.

3. Human activity

Several lines of evidence suggest that the disturbance was human-induced, either by direct human intervention in the watershed, or indirectly through grazing by animals brought to the site by humans. Malmros (1994) notes that there were trees of *Betula pubescens*

(European birch) and bushes of *Juniperus communis* (Common Juniper) growing in the Eiðisvatn watershed prior to human activity in the region. The charcoal record provides strong evidence of biomass burning by people; in this wet environment, naturally-induced fires are extremely unlikely, as shown by the virtual absence of charcoal in sediments prior to the disturbance interval (cores were examined for charcoal back to ~3150 cal yr B.P.). Furthermore, prior to the arrival of people in the Faroes, there were no mammals living on the islands, and new DNA evidence provides compelling confirmatory evidence that strongly links the disturbance interval to the arrival of sheep in the watershed (Curtin et al., 2020). Sheep would have rapidly degraded the vegetation cover (e.g. Austrheim et al., 2008) and increased erosion of terrestrial material into the lake, resulting in sedimentary changes that are entirely consistent with those presented here.

In the nearby town of Eiði, Hannon et al. (2005) recovered a ~3m sediment core from a small lake, Heimavatn (now filled in by the construction of a soccer pitch) and analyzed the record for pollen, charcoal, diatoms and magnetic susceptibility. Based mainly on the first appearance of macrofossil charcoal, as well as *Hordeum*-type cereal pollen [barley], they suggested that the first evidence for human activity (their "settlement horizon") was at 220 cm, which they dated at 1505 ±50 ^{14}C B.P. (2σ range of 470-600 CE) (Hannon and Bradshaw, 2000). This conforms with a (less reliable) bulk date from beneath a house foundation in Eiði that dated 1540 ±55 B.P. (Arge, 1991). However, an earlier disturbance (whether anthropogenic or climatic) occurred at ~270cm depth (at ~250 CE according to their age model), as recorded by an increase in magnetic susceptibility and nutrient-sensitive diatoms, as well as an increase in %LOI, all suggesting that vegetation and soil cover was disturbed at that time. Hannon et al. (2005) take the position that such disturbance was climate-related and pre-dated settlement, though they offer no strong evidence that the disturbance was not in fact a consequence of human activity. But they note that the development of heathland without anthropogenic influence "*could be unique in the European Holocene*". The argument that, because the only physical archeological evidence in the islands dates from the period of Viking settlement, any prior landscape disturbance must be due to climate is also made by Olsen et al. (2010). But in our view, it seems much more likely that major vegetation changes in Eiði were in fact the direct consequence of human activity and grazing by sheep, leading to the virtual elimination of woody vegetation and extensive disturbance of the landscape.

The only other paleoenvironmental record from this area is from the village of Tjørnuvík, across the fiord on the island of Streymoy. There, Hannon and Bradshaw (2000) obtained a sediment core from a marsh and examined plant macrofossils and microcharcoal fragments. Based on the first appearance of cereal *Hordeum*-type pollen [barley], as well as the first presence of charcoal, they dated the "palaeobotanical settlement horizon" at 1270 ±60 ^{14}C B.P. (2σ range of 690-830 CE), somewhat later than at Eiði.

As noted earlier, the only radiocarbon dates relating to pre-Viking era settlement in the entire Faroes archipelago (defined by Arge, 1991 as from ~825 to 1030 CE) are from charred barley grains excavated from beneath a Viking house at Á Sondum on the island of Sandoy, where the four oldest samples had ^{14}C ages of 1685-1555 ±40 B.P. (2σ range of 245-591CE) (Church et al., 2012). These are similar in age to the onset of the disturbance interval at Eiðisvatn. However, there is no direct archeological evidence that people were present in the Eiðisvatn watershed at such an early date. Excavations at Argisbrekka, within the Eiðisvatn watershed, revealed a Viking-era sheiling (seasonal farm) but no material that dated from an earlier period (Mahler, 1997). Reconciling the environmental and archeological evidence is thus problematical, leading to several possible explanations. It is possible that deteriorating climatic conditions in the late Holocene led to "threshold responses" at different times in watersheds across the archipelago, causing similar but diachronous changes in vegetation cover and increased input of organic matter into each lake. This argument is discounted by the charcoal, and DNA evidence from Eiðisvatn which clearly points to a human connection (Curtin et al., 2020). Dating of cereal-type pollen identifies the beginning of agriculture in settlements, but the evidence points to an earlier episode of landscape disturbance related to burning and disturbance of the vegetation cover, presumably by grazing sheep. It is possible that the absence of archeological evidence of the presence of people in the Eiðisvatn watershed is simply because such evidence has yet to be uncovered. But it may also be that there was never direct settlement in the area, and that sheep were introduced without any settlement activity in the immediate area, with the location only used as a grazing resource for other settlements nearby. Finally, it is possible that the age model we have adopted is inadequate to capture the exact timing of the onset of the disturbance. By definition, the disturbance interval mobilized old organic material that created a period of anomalous radiocarbon dates (Figure 2). It is therefore possible that the exact timing of the first arrival of people in the area fell within this period of disturbance but that the dating of that event is literally buried within the disturbance itself. Nevertheless, in the absence of evidence to the contrary, we interpret the data to show that there was anthropogenic activity in the Eiðisvatn watershed that began between 265-521CE, similar to the timing of human activity that has been identified on Sandoy (Church et al., 2000). Our results point to the need for further research (both archeological and paleoenvironmental) to determine the full extent of pre-Viking human landscape disturbance in the islands and the extent to which sheep may have modified the landscape on Esturoy as well as other islands in the Faroes archipelago.

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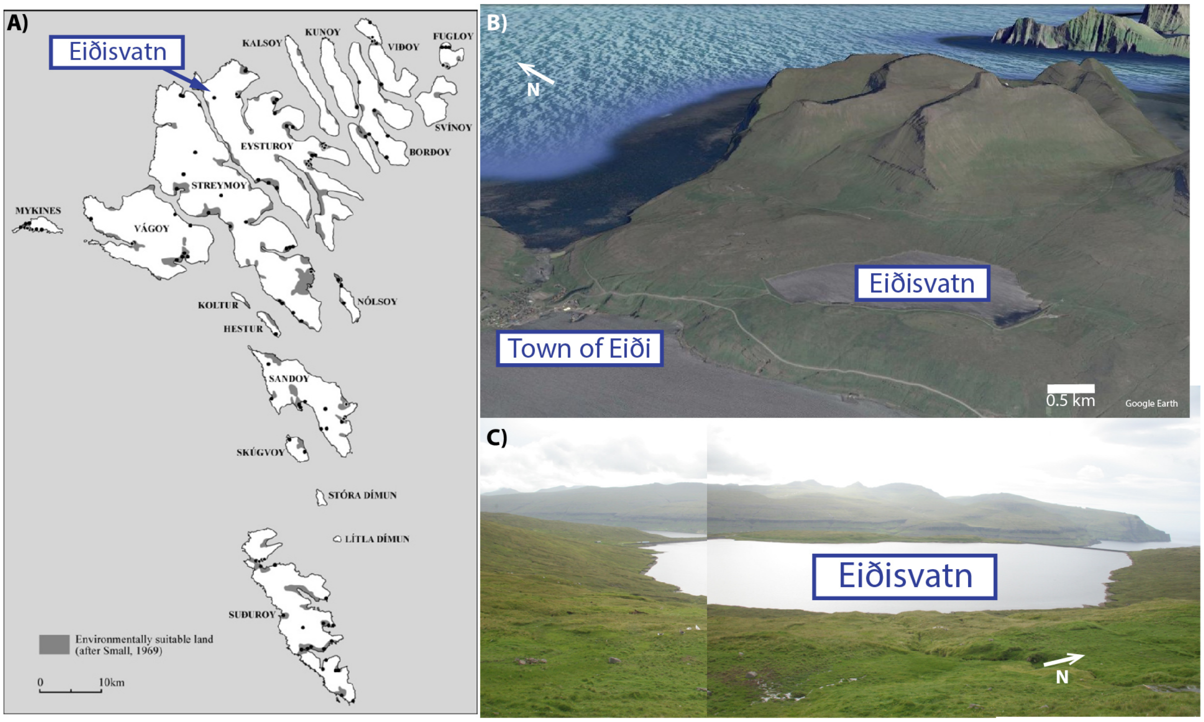

Figure 1. A) Location of Eiðisvatn at the northwestern end of the island of Eysturoy (modified from Arge et al., 2005), B) Eiðisvatn and town of Eiði (satellite imagery from Google Earth), C) composite photograph of Eiðisvatn from above eastern shore of the lake in 2015.

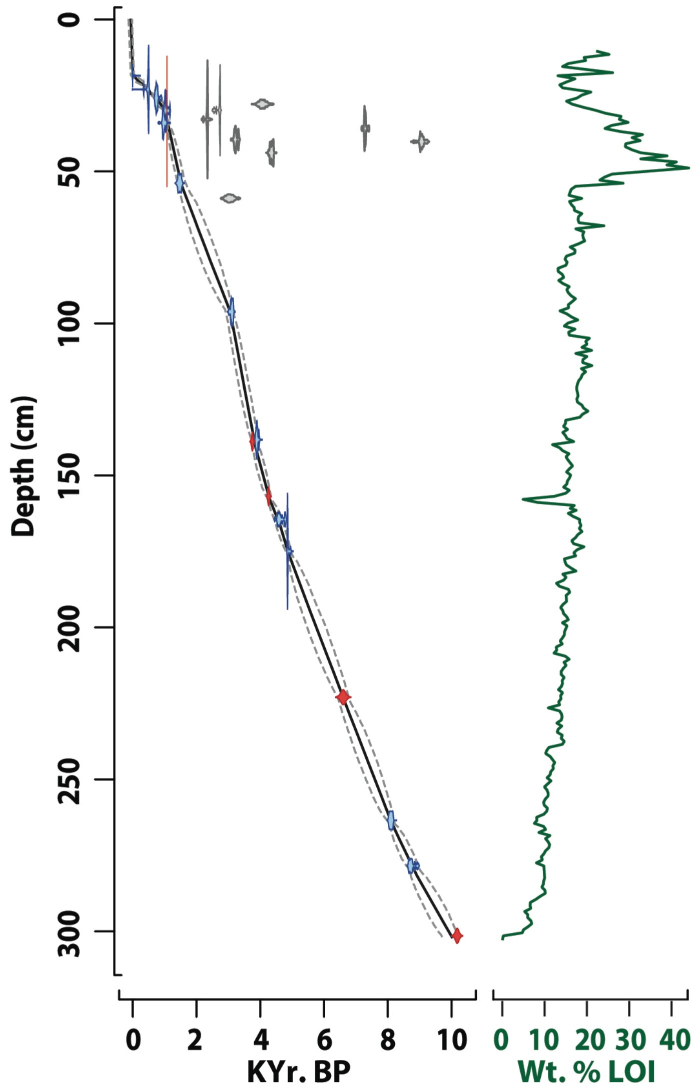

Figure 2: Eiðisvatn age model (left) and composite %Loss-on-ignition (%LOI) (right), created using 'Bacon' in R (Blaauw & Christen, 2011) using bulk sediment and macrofossil radiocarbon dates (blue symbols) and four identified tephra layers (red symbols).

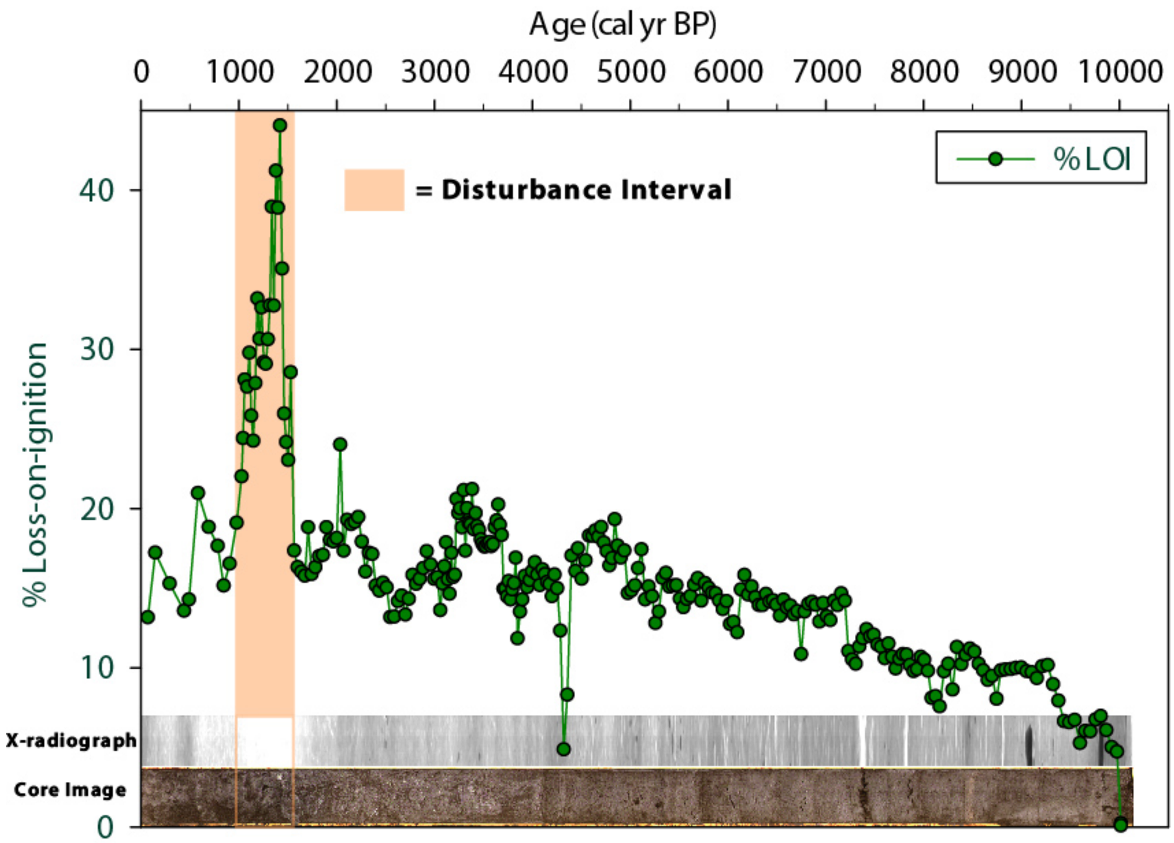

Figure 3. Composite loss-on-ignition (% LOI) (green) and EI-P-01-15 x-radiograph and core image. In x-radiograph, darker greyscale values = more dense material. The disturbance interval (~980 – 1530 cal yr BP) (orange) is defined here by sustained %LOI values above 20%.

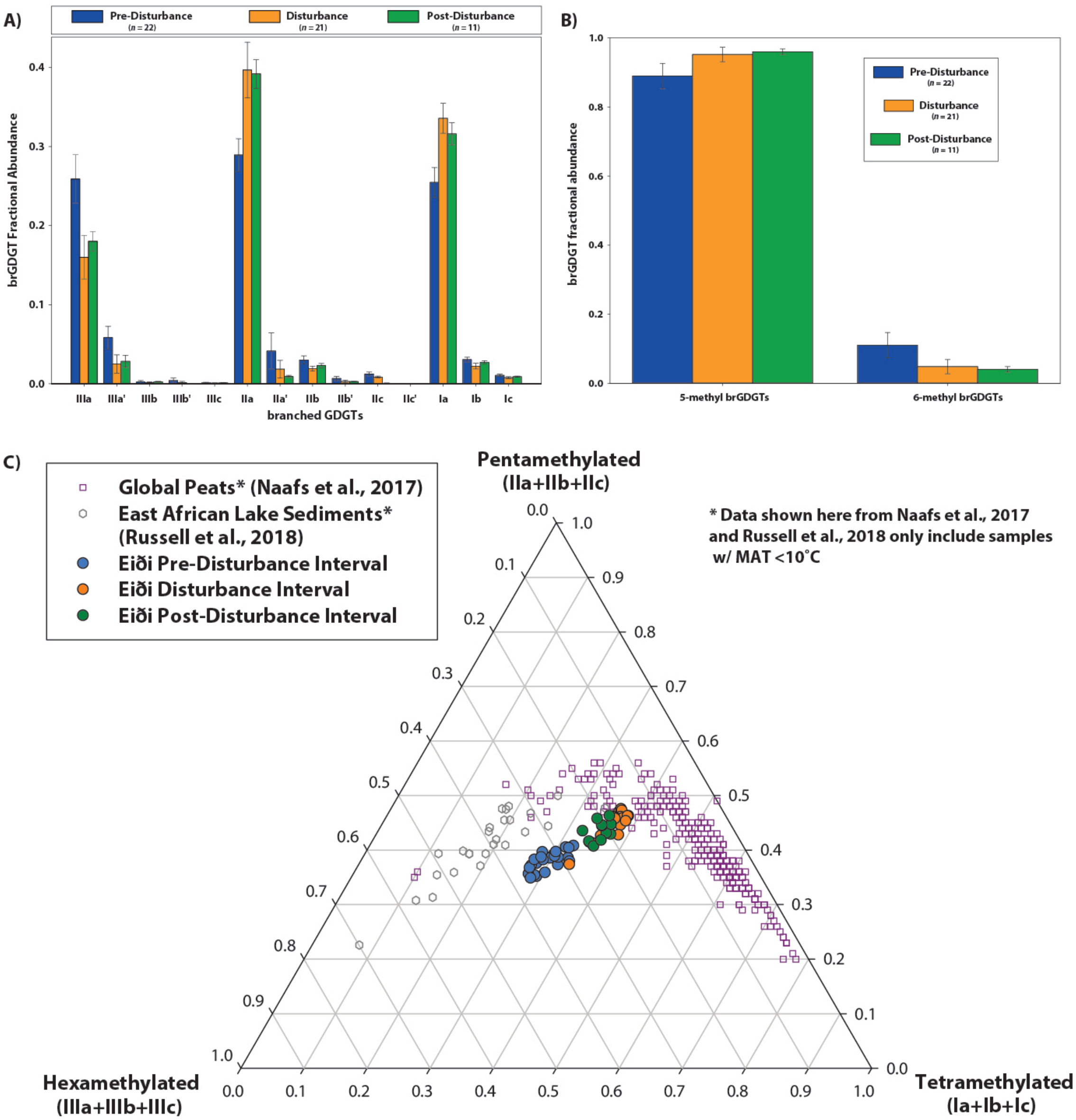

Figure 4 – A) Fractional abundances of specific brGDGTs from Eiðisvatn sediments binned by depositional interval. B) Same as A), but comparing 5-methyl vs. 6 methyl brGDGTs. C) Ternary diagram depicting summed brGDGT fractional abundances from Eidisvatn depositional intervals (blue, orange, green filled circles) along with lake surface sediment samples from East Africa (unfilled gray hexagons, Russell et al., 2018) and peat samples (purple unfilled squares, Naafs et al., 2017). NB: For better comparison to local conditions in the Faroe Islands, the Russell et al. (2018) and Naafs et al. (2017) data have been filtered to only include samples from sites with a mean annual air temperature (MAT) of less than 10ºC.

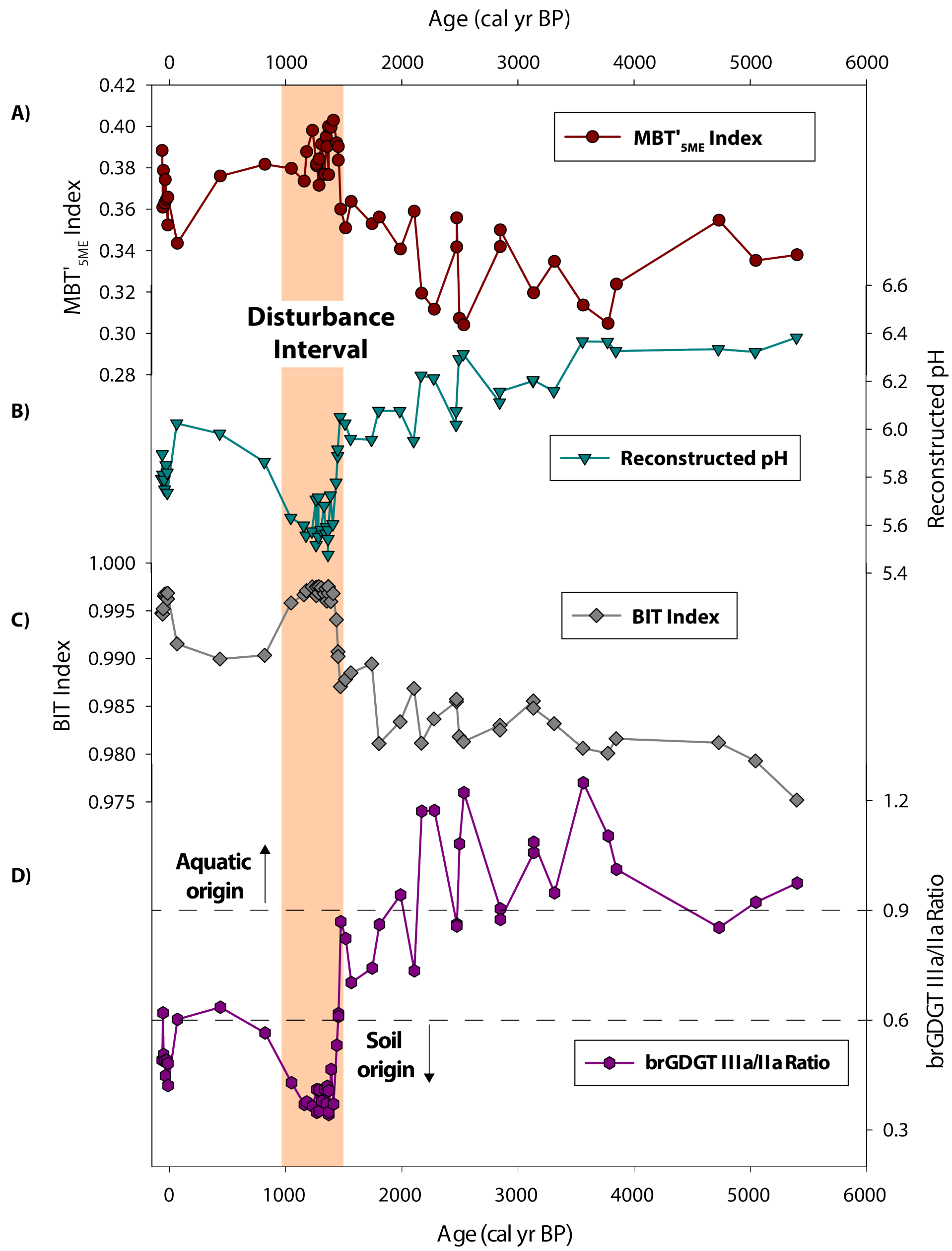

Figure 5. Downcore brGDGT results from Eiðisvatn, with disturbance interval is outlined in orange (~420 – 970 CE). A) MBT'$_{5ME}$ index, B) reconstructed pH using CBT$_{5ME}$ equation of De Jonge et al., 2014b, C) BIT Index (after Hopmans et al., 2004), and D) brGDGT IIIa/IIa ratio (after Xiao et al., 2016). Dashed lines in D) represent index values associated dominant sources of brGDGTs as defined by Martin et al. (2019).

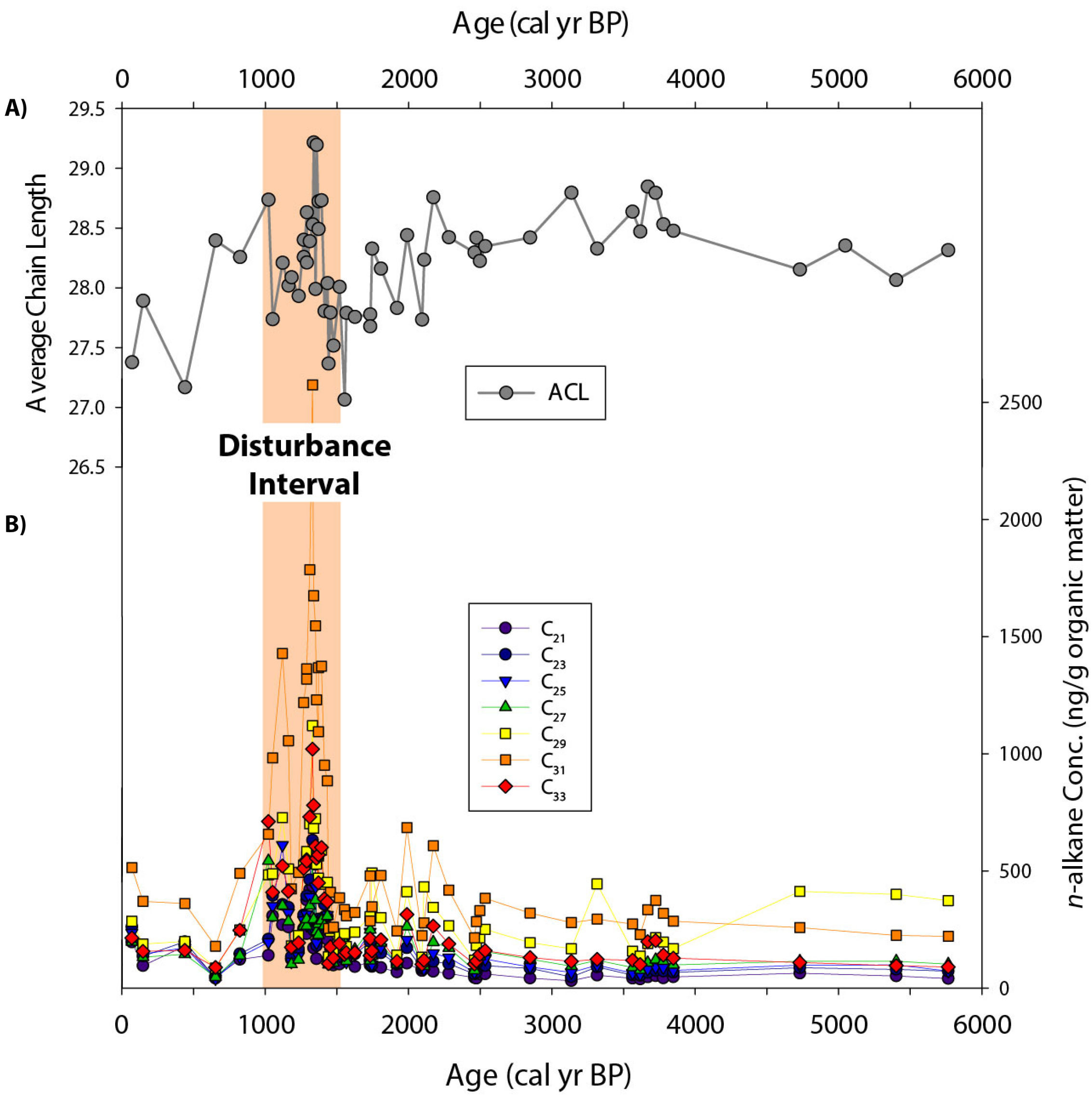

Figure 6. Leaf wax n-alkane results from Eiðisvatn, with disturbance interval outlined in orange (~420 – 970 CE). A) Average *n*-alkane chain length values and B) concentrations of selected individual *n*-alkanes downcore.

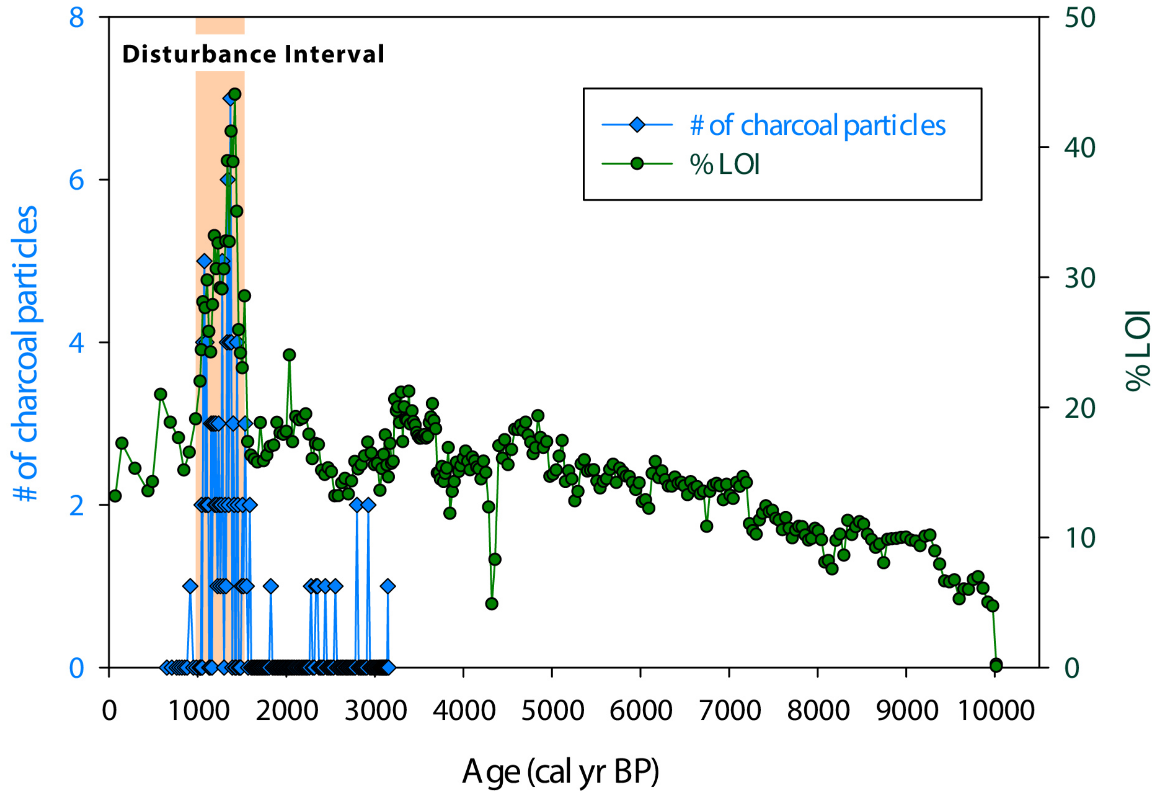

Figure 7. Loss-on-ignition (%) (green) and number of macro-charcoal particles (blue) in the composite core record. The disturbance interval (orange) is defined as the period when %LOI values continuously exceeded 20% and spans the interval from 980-1530 cal. yr B.P. (420 – 970 CE). Note: charcoal counts extend back to ~3200 cal yr B.P.

SUPPLEMENTARY FIGURES and TABLES

Tephra geochemical data

Curtin et al. (2019) documented the geochemistry of three tephra from the Eiðisvatn record attributed to Hekla-Selsund, Hekla 4, and the Saksunarvatn Ash. Here we also present data from tephra attributed to the Mjáuvøtn Tephra and two cryptotephra that are possibly associated with the Tjørnuvík and Landnám Tephras (Table S1). We also provide individual glass shard geochemical compositions for all analyses from the Eiðisvatn record.

Table S1. Geochemical composition of glass shards isolated from the Eiðisvatn record compared to tephra identified at other Faroe Islands sites.

Sample		SiO_2	TiO_2	Al_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	Cl	BaO	Total
Eidi 26-32 cm (n=54)	*Mean*	70.96	0.23	13.41	3.06	0.11	0.17	1.99	4.68	2.51	0.05	0.07	0.08	97.30
	1 σ	3.04	0.17	0.98	1.53	0.04	0.22	0.87	0.43	0.41	0.05	0.04	0.03	2.41
Tjørnuvík (n=39)[1]	*Mean*	69.80	0.27	13.64	3.93	0.14	0.26	2.32	4.01	2.41	-	-	-	96.77
	1 σ	4.19	0.21	0.85	2.44	0.07	0.24	1.11	0.33	0.46	-	-	-	1.336
Eidi 33 cm (n=35)	*Mean*	49.09	2.55	13.47	12.38	0.21	6.20	10.70	2.58	0.37	0.27	0.02	0.01	97.84
	1 σ	0.45	0.08	0.15	0.16	0.01	0.20	0.36	0.11	0.02	0.01	0.01	0.01	0.61
Landnám (n=15)[2]	*Mean*	49.11	2.02	13.36	12.47	0.21	6.37	10.97	2.59	0.27	-	-	-	97.37
	1 σ	0.83	0.43	0.37	0.62	0.04	0.53	0.66	0.24	0.11	-	-	-	1.05
Eidi 223 cm (n=28)	*Mean*	47.33	4.17	12.95	14.30	0.23	5.10	9.59	2.99	0.80	0.50	0.04	0.02	98.02
	1 σ	0.42	0.09	0.15	0.36	0.01	0.09	0.32	0.13	0.03	0.03	0.00	0.01	0.77
Mjáuvøtn (n=19)[3]	*Mean*	46.70	4.19	12.88	14.46	0.28	4.90	10.05	3.07	0.77	-	-	-	97.31
	1 σ	0.46	0.15	0.45	0.41	0.10	0.35	0.53	0.30	0.09	-	-	-	0.91

1. Tjørnuvík A geochemical data from Tephrabase as reported by: Hannon et al. (1998), Wastegård et al. (2001), and Wastegård (2002).
2. Basaltic phase of the Landnám tephra from Tephrabase as reported by: Boygle (1994), Larsen et al. (1999), Wastegård et al. (2001), and Wastegård (2002).
3. Mjáuvøtn geochemical data from Wastegård et al. (2001).

The basaltic Mjáuvøtn Tephra was found as a dark ~1 mm-thick layer at 223 cm and geochemical data closely resemble those identified from Lake Mjáuvøtn on Streymoy (Wastegård et al., 2001) (Figure S1). Cryptotephra were found after searching the upper ~20 cm of the piston core EI-P-01-15. Colorless shards were found in the lighter density range, 2.3-2.5 g/cm^3 and green to brown shards attributed to basaltic tephra were counted in the heavier density range, 2.5-2.85 g/cm^3 (Figure S1D.) A sharp peak in basaltic grains at 34.4-35.4 cm have tephra that are similar to the Landnám Tephra, however TiO values of all of the shards analyzed (n=35) are at the upper end of the typical range for this tephra. A broad peak in colorless shards contains tephra that resemble the Tjørnuvík Tephra with an intermediate to rhyolitic composition (Table S1, Figure S1).

Table S2. Radiocarbon dates on bulk sediment and macrofossils, and identified tephra (orange) from Eiðisvatn sediment record.

Lab ID	age	error (yrs)	depth (cm)	Type	In age model?
surface	-65	1	0	surface	yes
EI-D-01-15	-10		18.5	macro	yes
EI-D-01-15: 13	410	15	23	macro	yes
EI-P-01-15 1 of 2	840	30	25.86	macro	yes
EI-P-01-15 1 of 2	3720	70	27.86	macro	no
EI-P-01-15 1 of 2	2575	20	29.86	macro	no
EI-D-01-15: 20	1145	15	30	macro	yes
EI-P-01-15 1 of 2	2320	20	32.86	macro	no
EI-P-01-15: 13 Landnam	1073	1	33	tephra	yes
EI-D-01-15: 24	1055	35	34	macro	yes
EI-P-01-15 1 of 2	6355	20	35.86	macro	no
EI-D-01-15	3030	20	39.5	macro	no
EI-D-01-15: 30.2	8110	45	40.2	macro	no
EI-P-01-15 1 of 2	3915	20	43.86	macro	no
EI-P-01-15 33.5	1580	35	53.86	macro	yes
EI-D-01-15	2450	15	57	bulk	no
EI-P-01-15 38.5	2900	80	58.86	macro	no
EI-P-01-15 1 of 2	2330	20	60.36	bulk	no
EI-D-01-15	3300	15	82	bulk	no
EI-P-01-15 1 of 2	2945	15	96.16	macro	yes
EI-P-01-15 [1/2]: 117.9	3595	15	138.26	macro	yes
EI-P-01-15 1/2-Hekla Selsund	3750	20	138.86	tephra	yes
EI-P-01-15 1/2-Hekla 4	4260	20	156.86	tephra	yes
EI-P-01-15 [2/2]:4.5	4100	30	164.46	macro	yes
EI-P-01-15 [2/2]:15	4310	15	174.96	macro	yes
EI-P-01-15 2/2 63 Mjauvatn	6600	68	222.96	tephra	yes
EI-P-01-15 2 of 2	7290	30	263.46	macro	yes
EI-P-01-15 [2/2]: 118.5	7925	20	278.46	macro	yes
EI-P-01-15 [2/2]-Saks	10176	49	301.46	tephra	yes

Table S3. First major increase in organic matter &/or increase in magnetic susceptibility in sediment records from the Faroe Islands

Location		**cal yr B.P.**	**Reference**
Eiðisvatn, Eysturoy	%LOI	~1530	This study
Eidi, Eysturoy	MS [peak]	~1550 or later	Hannon et al. 2005
Starvatn, Eysturoy	% org	~2050+	Andresen et al. 2006
Saksunarvatn, Streymoy	^{14}C	~2300	Edwards & Whittington 2001
Mjáavötn, Streymoy	PCA (↑ minerogenic)	~1360	Olsen et al. 2010
Millum Vatna, Sandoy*	MS	~1480	Lawson et al. 2005
Litlavatn, Sandoy	%LOI	~2114?	Lawson et al. 2005
Grothusvatn, Sandoy	MS & %LOI	~2625?	Lawson et al. 2005
Lykkjuvatn, Sandoy	% org	~2800 +	Andresen et al. 2006
Heygsvatn, Suduroy	MS & %LOI	~1750 (or earlier)	McGowan et al. 2008

*peat section: decrease in organic content + Lake transitions to bog

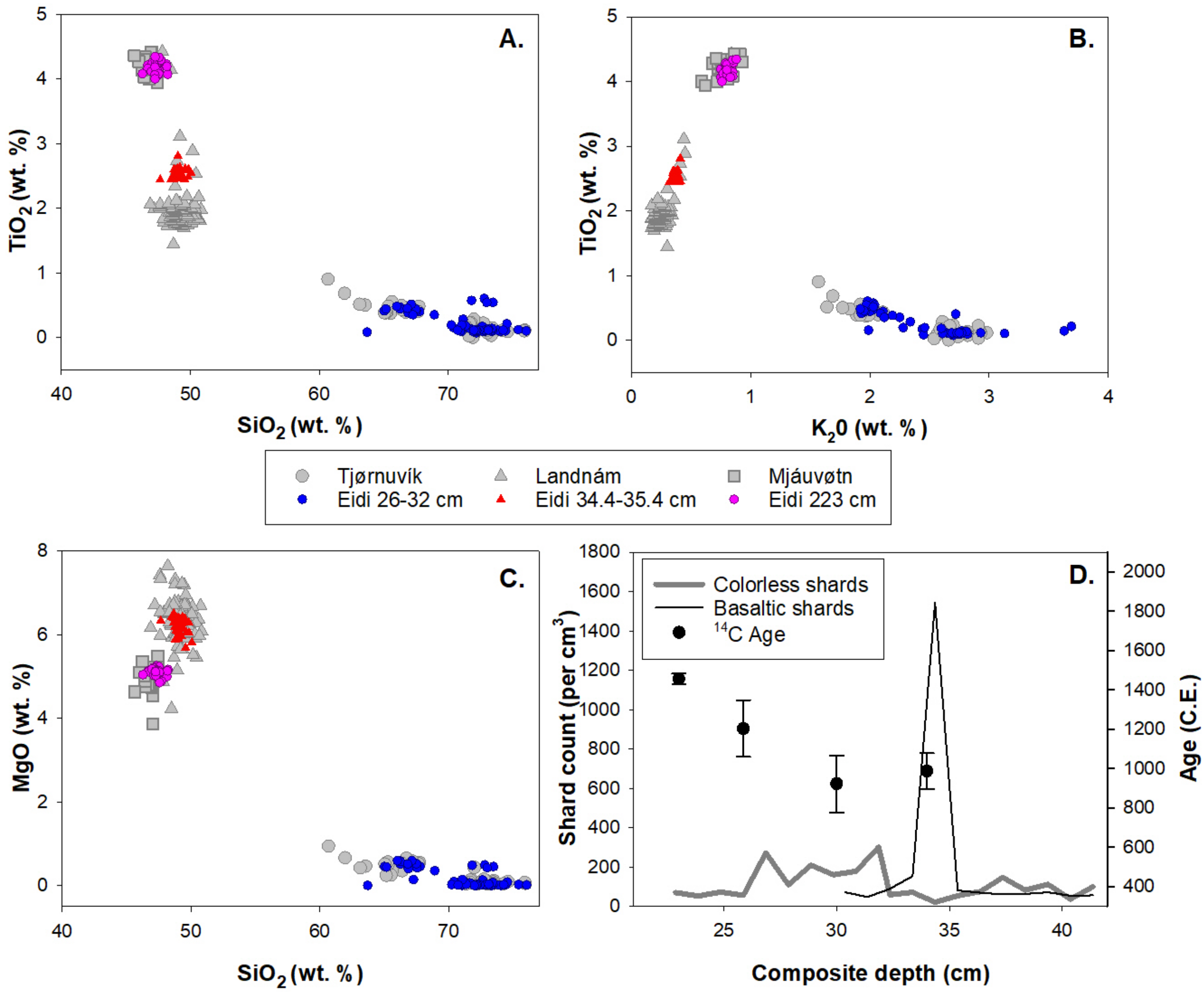

Figure S1. Geochemical data from tephra samples analyzed from the Eiðisvatn record compared to data from tephra attributed to the Tjørnuvík (Hannon et al., 1998; Wastegård et al., 2001; Wastegård, 2002), Landnám (Boygle, 1994; Hannon et al., 1998; Larsen et al., 1999; Wastegård et al., 2001; Wastegård, 2002), and Mjáuvøtn (Wastegård, 2001) Tephras. Shard counts and radiocarbon dates also shown across the interval searched for cryptotephra (D.).

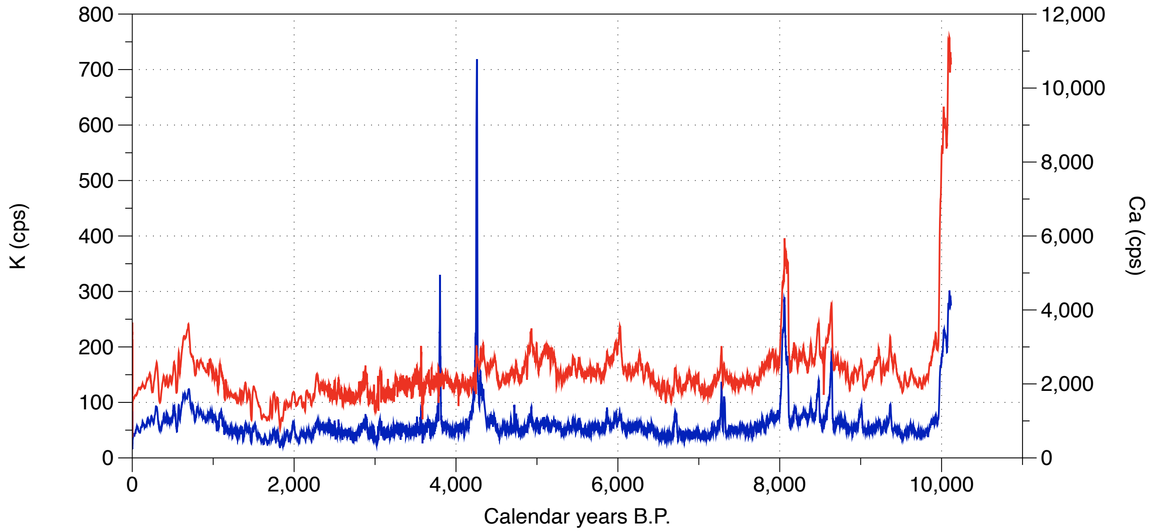

Figure S2. K (blue) and Ca (red) (cps) from XRF scanning on EI-P-01-15, which revealed the presence of tephras, subsequently identified as Hekla-Selsund, Hekla 4, Mjauvatn and Saksunarvatn (see Curtin et al., 2019 for the geochemical analysis of each tephra). The other anomalies were not associated with (detectable) tephras.

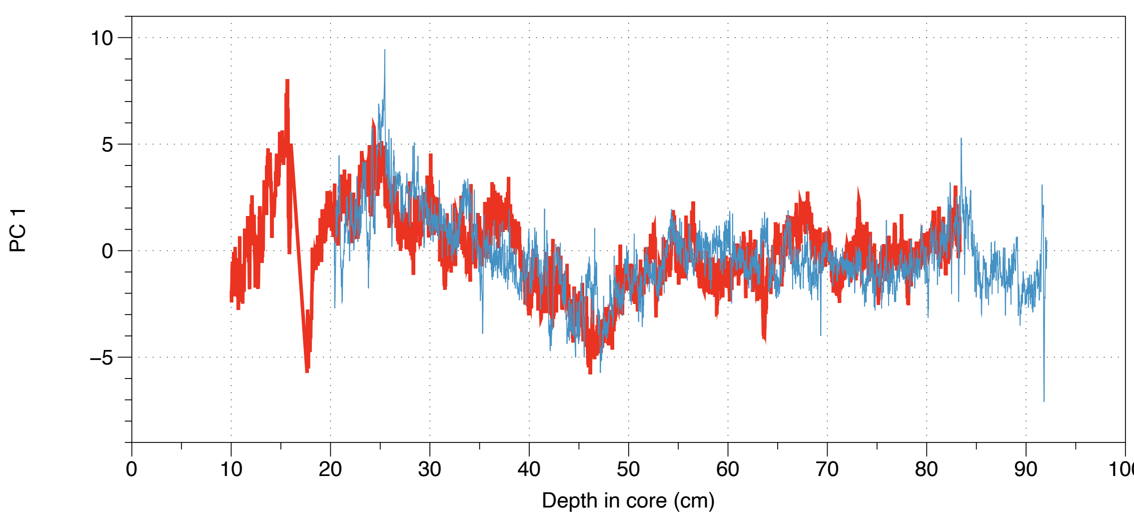

Figure S3. PC1 of major elements (K, Ca, Ti, Mn, Fe, Cu, Sr and Zr) of sediment cores EI-D-01-15 (red) and EI-P-01-15 (blue) to show that the offset of the top of the piston core EI-P-01-15 from the top of the surface gravity core EI-D-01-15 was estimated to be ~20.36cm Note that the upper 10cm of the gravity core was sub-sampled in the field and so is not plotted here.

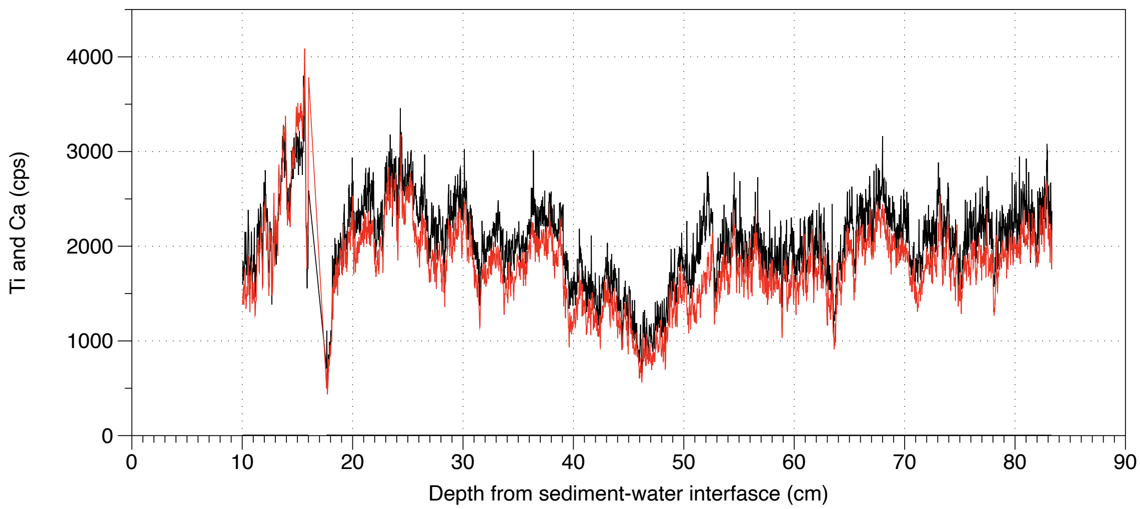

Figure S4. Ti (black) and Ca (red) counts in core EI-D-01-15 indicating disturbance at a depth of 18.5cm, associated with reservoir construction. The uppermost 10cm were sub-sampled at 1cm intervals and therefore not available for XRF core scanning.

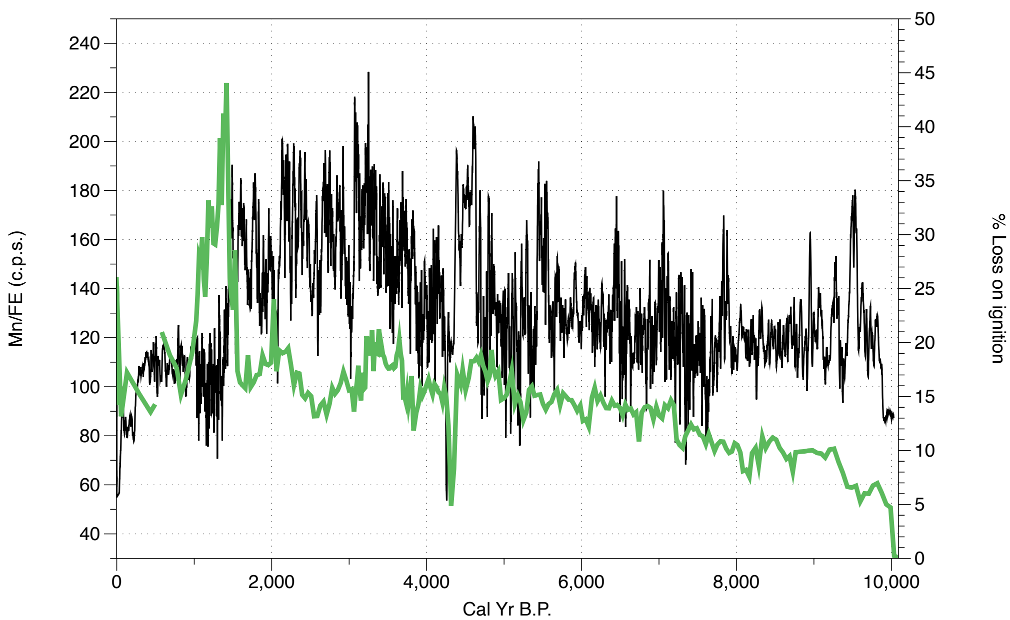

Figure S5. - % Loss-on-ignition (green) and Mn/Fe (black: 10 value running mean). Lower values of Mn/Fe indicate more oxygenation of the sediments during and after the disturbance interval.