Icelandic Tephra in Late-glacial Sediments of Scotland (14 - 9,000 ^{14}C BP)

Íslendsk tefra í seinglasialum áløgum í Skotlandi (14 - 9.000 ^{14}C BP)

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Úrtak

Vedde-ósku- og borrobol-tefrusetløg eru funnin í seinglasialum setløgum á seks støðum tvørtur um Skotland. Hesi kunnu verða nýtt til at útvega neyv og óheft prógv, ið lýsa lagskipanina í tíðarrøð, og sum sýna broytingar í fornumhvørvinum í teirri seinastu avglasiatiónini, og sum benda á beinleiðis samsvar millum støð í norðuratlantsøkinum. Føroyar liggja stak væl fyri landafrøðiliga, tá ið hypotesurnar um spjaðing av íslendskari tefru verða royndar.

Abstract

Vedde Ash and Borrobol Tephra deposits have been found in Lateglacial deposits at six sites across Scotland. These can be used to provide accurate and independent chronostratigraphic markers for palaeoenvironmental change during the last deglaciation and allow direct correlation between sites in the North Atlantic region. The Faroe Islands are ideally located to test hypotheses of Icelandic tephra dispersal.

We present summary results of analyses of micro-tephra layers within Late-glacial lake sediments in several sites in Scotland and discuss their potential for providing chrono-stratigraphic markers for Late Weichselian climate change in the Faroe Islands. Detailed descriptions of the laboratory methods employed can be found in Lowe and Turney (1997), Turney *et al.*, (1997), Roberts (1997), Turney (1998a,b). The full suite of geochemical analyses can be viewed on Tephrabase (http//: www.geo.ed.ac.uk/tephra/tbasehom.html) (Newton, 1996).

The ages of the micro-tephra layers have been determined using radiocarbon dating. Well-dated tephra layers provide chrono-stratigraphic markers for the accurate dating and correlation of Late Quaternary successions, and underpin models of palaeoenvironmental change. The widespread occurrence of rapidly – formed tephra horizons allows direct inter – site comparisons

Tephra Deposit	*Locations Discovered*	*^{14}C age (years BP)*
Saksunarvatn Tephra	Iceland[b,e], NAMC[t], Faroe Islands[c, g], Shetland[e, u], Orkney[e, v], Germany[a], Greenland[s]	8700[a], 8900[b], 9000 - 9100[c], 9140[d]
1-Thol-1	Iceland[b]	9200[b]
Vedde Ash	Iceland (Skogar Tephra)[b,c, q], NAMC[h-o], Norway[e,p], Sweden[r], Greenland[s]	10,300[e]
1-Thol-2	Iceland[b]	10,800[b]
Borrobol Tephra	Scotland[f]	12,500[f]

Table 1: *Components and radiocarbon ages of North Atlantic Ash Zone One (NAAZO). NAMC - North Atlantic Marine Cores.*

Talva 1: Tilfar og kolevni 14-aldur á norðuratlantsøskuumráði eitt (NAAZO = North Atlantic Ash Zone One). NAMC - North Atlantic Marine Cores, t.e. norðuratlantshavskjarnar.

Source information: [a] Merkt et al. (1993); [b] Björck et al. (1992); [c] Mangerud et al., (1986); [d] Jóhansen (1975); [e] Birks et al. (1996); [f] Turney et al., (1998); [g] Jóhansen (1985); [h] Bard et al. (1994); [i] Serjup et al. (1989); [j] Kvamme et al. (1989); [k] Sigurdsson and Loebner (1981); [l] Fillon et al. (1981); [m] Ruddiman and Glover (1972); [n] Long et al. (1986); [o] Austin et al. (1995) and (1996); [p] Mangerud et al. (1984); [q] Nordaahl and Haflidson (1992); [r] Wastegård et al. (1998) and Wastegård et al. (submitted); [s] Grønvold et al. (1995); [t] Sjøholm et al.(1991); [u] Bennett et al. (1992); [v] Bunting (1994).

of the accuracy and consistency of radiocarbon dates associated with time-equivalent horizons. However, tephra deposition is somewhat irregular at sites distal from the volcanic system and evidence from several sites is required when attempting to establish a reliable tephrochronological framework in such areas.

By applying a density-separation technique to remove unwanted minerogenic particles, two horizons of measurable concentrations of volcanic ash have been detected in deposits of Late Devensian Late-glacial age (13 - 10,000 ^{14}C BP) at six sites from in Scotland (Turney, 1998a). On the basis of major element shard geochemistry, an upper micro-tephra layer is equated with the well-known Vedde Ash, the principle component of North Atlantic Ash Zone One (NAAZO) (Table 1). It has also been found in a variety of oceanic, cryogenic and terrestrial repositories of the North Atlantic region and has been dated to 10,300 ^{14}C BP (Birks *et al.,* 1996). The lowermost tephra horizon, the Borrobol Tephra (~12,500 ^{14}C BP; Turney *et al.,* 1997) has only been detected so far at sites in Scotland, for few sites elsewhere have been investigated to determine whether an equivalent ash horizon can be detected at around this time. No source has yet been identified for the Borrobol Tephra, but its geochemical composition also indicates an Icelandic origin.

A clear spatial pattern of maximum shard concentration is evident for both tephras. The highest number of shards per cm^3 occur in sites in the North and West, but this pattern is not simply related to location (Figure 1; Table 2). Atmospheric and post-depositional sedimentation processes appear to be the most important factors controlling the stratigraphic distribution of tephra shards in lake sediments. Single peaks tend to reflect air-fall, though in

most cases a 'tail' is observed in sediments directly above the peak consistent with deposition of reworked material within the catchment. Multiple tephra peaks generally reflect post depositional disturbance, and the interpretation of such features can be complex.

The discovery of Late-glacial tephra horizons on the British mainland represents a significant advance. It allows precise correlation with other high resolution sequences in the North Atlantic region, *e.g.* Greenland ice cores, avoiding the complexities inherent in correlations attempted on the basis of radiocarbon dating (*e.g.* radiocarbon plateaux and contamination.

The Faroe Islands lie in an ideal location (in the North Atlantic, midway between Iceland and mainland northwest Europe) for searching for new Late-glacial tephras. If equivalent tephras, marked by sulphate peaks, can be traced in the GISP2 ice core then theories of tephra dispersal can be tested (Zielinski *et al.*, 1996). The type site of the earliest of the four main components of NAAZO, the Saksunarvatn Tephra (~9140 ± 160 and 9180 ± 140; Jóhansen, 1975), is

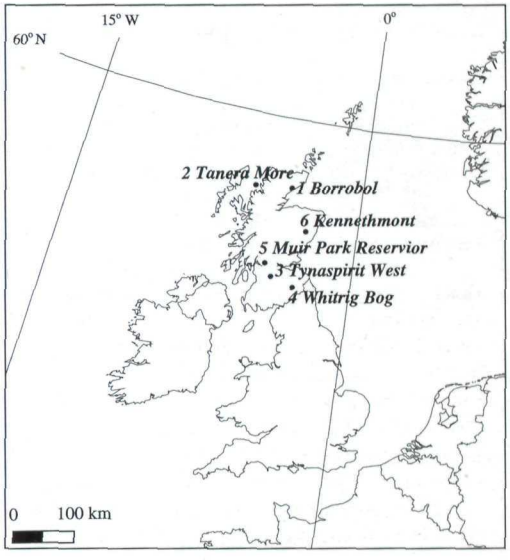

Fig. 1: Location of six sites investigated.
Mynd 1: Støðukort, ið vísir seks støð, sum eru kannað.

Site Name	*Lat. (°)*	*Long. (°)*	*Depositional Environment*	*Maximum Depth (m)*	*Maximum shard concentration (number shards per cm³ wet sediment)*	
					Vedde Ash	*Borrobol Tephra*
1 Borrobol	*58° 09' 30'' N*	*03° 50' 00'' W*	*infilled lake basin*	*5*	*6222*	*373*
2 Tanera More	*58° 00' 24'' N*	*05° 23' 36'' W*	*infilled isolation basin*	*8*	*259*	*17*
3 Tynaspirit West	*56° 13' 10'' N*	*04° 10' 00'' W*	*infilled kettle hole*	*9.5*	*128*	*9*
4 Whitrig Bog	*55° 36' 02'' N*	*02° 36' 00'' W*	*infilled lake basin in inter drumlin hollow*	*2.95*	*743*	*65*
5 Muir Park Reservoir	*56° 05' 11'' N*	*04° 16' 58'' W*	*infilled lake basin*	*8*	*52*	*-*
6 Kennethmont	*57° 21' 03'' N*	*02° 46' 25'' W*	*infilled hollow (non-lacustrine)*	*2.5*	*22*	*-*

***Table 2:** Site locations, associated information and maximum concentration of Vedde Ash and Borrobol Tephra shards found at each site. For Muir Park Reservoir and Kennethmont organic Late-glacial Interstadial deposits, which the Borrobol Tephra was found in at the other four sites, were not available for examination.*
Talva 2: Staðsetingar og upplýsingar í sambandi við tær og hámarkskonsentratión av brotum úr Vedde-ösku og Borrobol-tefru, sum eru funnin á hvørjum stað. Í Muir Park Reservoir og Kennethmont bar ikki til at kanna lívrunnin seinglasial millumstøðusetløg, sum Borrobol-tefran var funnin í á hinum fýra støðunum.

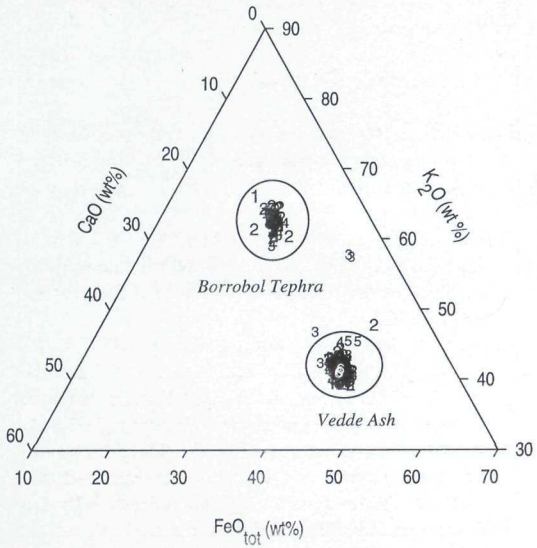

Figure 2: *Ternary plot of Fe_2, K_2O and CaO composition of tephra shards analysed from all six sites illustrating the geochemical distinction between the Vedde Ash and the Borrobol Tephra.*
Mynd 2: Trískift strikumynd av Fe_2, K_2O og CaO samansetingum av tefrubrotum, sum eru greinað úr øllum seks støðum og vísa tann jarðevnafrøðiliga munin millum Vedde-øskuna og Borrobol-tefruna.

Sites: *1 Borrobol* *4 Whitrig Bog*
2 Tanera More *5 Muir Park Reservoir*
3 Tynaspirit West *6 Kennethmont*

at Saksunarvatn, Streymoy. It appears that the Faroe Isles had a parochial ice cap during the Last (Weichselian) Glaciation and only small corrie glaciers existed during the cold periods that interrupted the general warming that led to deglaciation (*e.g.* Younger Dryas Chronozone of NW Europe) (Geike, 1880; Humlum *et al.*, 1996). It is therefore likely that some sediment sequences have developed on parts of the Faroes which extend through the Late-glacial period, and these may contain traceable quantities of the three main tephras referred to above: Vedde, Borrobol and Saksunarvatn. Other, as yet undiscovered tephra layers, some of which may equate with other components of the NAAZO, could also be found on the Faroe Islands.

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Heitið á greinini, tekstir til myndir og tabellir skulu standa á føroyskum og enskum.

Heitið og navnið á høvundanum eiga at standa á fyrstu síðu, síðani kemur samandráttur av ritgerðini, ið ikki má vera meiri enn 175 orð, ið víðka um heitið uttan at endurtaka tað. Samandrátturin vísir í stórum á endamálið við ritgerðini, greiðir frá arbeiðinum, staklutum og týdningarmiklum úrslitum og niðurstøðum. Umframt eigur enn eitt úrtak at vera tøkt til at týða annaðhvørt til føroyskt ella enskt alt eftir, hvørjum máli ritgerðin er á. Fult navn og bústaður hjá høvundanum/unum eiga at standa aftan á tilvísingarlistan, somuleiðis telefon- og faksnummar og hvagar snarpostur kann sendast.

Best var, um hetta stóð í tekstinum: Inngangur, tilfar og mannagongd, úrslit, kjak og niðurstøður, men onnur hugtøk munnu fara at verða góðkend. Í tekstinum verða altjóða skipanir og eindir nýttar (SI-Units, sum til dømis metur skrivaður m; Celcius-stig skrivað °C). Myndir: Talvur og myndir (eisini fotomyndir) eiga at standa aftan á tekstin, og frágreiðing um tær eigur at standa í myndatekstinum (ikki sum: ...sí tekst). Í talvunum eigur teigari at verða nýttur, **ongantíð** glopp. Myndir eiga at verða sendar sum ein EPS ella TIFF fíla ella prentaðar á hvítt pappír. Allir stavir og øll tøl verða sett við telduni hjá prentaranum. Svart/hvítar fotomyndir ella litmyndatalvur mugu sendast sum diasmyndir (6cm x 6cm) ella sum glansprent, ikki størri enn A4 til støddar.

Í tekstinum eiga tilvísingar ikki at verða talmerktar, men navngivnar sum Joensen (1963) ella tá ið tað liggur betur fyri sum (Joensen, 1963). Er meiri enn ein tilvísing, eigur at verða skrivað soleiðis: Joensen (1963; 1970), ella: (Joensen, 1963; 1970), ella: (Svabo, 1783; Joensen, 1963). Soleiðis eigur at verða víst til ávísar síður: (Joensen, 1963: 123-134). Soleiðis eigur at verða víst til tveir høvundar: (Joensen og Táning, 1970) og soleiðis til meiri enn tveir høvundar: (Enckell *et al.*, 1986). Longri niðri stendur tilvísing í fullum orðaljóði. Tilvísingarlistin eigur ikki at verða settur í nummarrøð, men skrivaður í bókstavarøð, heiti á bókum í fullum líki, tíðarrit við teimum styttingum, sum tíðarritið nýtir í løtuni, so sum:

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Svabo, J.C. 1783 (1959). *Indberetninger fra en Reise i Færøe 1781 og 1782.* Selskabet til Udgivelse af Færøske Kildeskrifter og Studier. København.

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