Correlation of late Holocene terrestrial and marine tephra markers, north Iceland: implications for reservoir age changes

Gudrún Larsen, Jón Eiríksson, Karen Luise Knudsen & Jan Heinemeier

The tephrochronology of the last 3000 years has been investigated in soil sections in north Iceland and in a marine sediment core from the north Icelandic shelf, 50 km offshore. Tephra markers, identified with major element geochemical analysis of volcanic glass shards, serve to correlate the marine and terrestrial records. Hekla 3, the largest Holocene tephra marker from the volcano Hekla, in south Iceland, dated to 2980 years BP, is used as the basal unit in the tephra stratigraphy. AMS ^{14}C dating of molluscs in the sediment core shows variable deviation from the tephrochronological age model, indicating that the reservoir age of the seawater mass at the coring site has varied with time. A standard marine reservoir correction of 400 ^{14}C years appears to be reasonable at the present day in the coastal and shelf waters around Iceland, which are dominated by the Irminger Current. However, values over 500 years are observed during the last 3000 years. We suggest that the intervals with increased and variable marine reservoir correction reflect incursions of Arctic water masses derived from the East Greenland Current to the area north of Iceland.

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Palaeoclimatic studies that extend beyond historical and instrumental records must rely on dating techniques which enable reconstruction of time series for climate variability related proxies. The purpose of the present study is to obtain independent control on ^{14}C dating of a high resolution sediment core obtained from an oceanographic boundary region between Atlantic and Arctic water masses. The study is a part of the European Union HOLSMEER project, which focuses on climatic variability in shallow marine and coastal settings during the last 2000 years.

The study area on the north Icelandic shelf has the advantage of being close to the source volcanoes of Holocene tephras, and it is located in an oceanographically sensitive boundary region between the relatively warm, saline Irminger Current and the East Icelandic Current, which forms a cold, low salinity tongue of surface water (Fig. 1). The shallow north Iceland shelf seabed is strongly affected by surface circulation in the area (Eiríksson et al. 2000a). Tephra markers that can be traced from volcanic source regions into the marine depositional environment provide independent control on radiocarbon dates from that environment. The age of the tephra markers are based on historical records from Iceland for the last 900 years, correlation to the Greenland ice core chronology, and radiocarbon dates of terrestrial material (see e.g. Thorarinsson 1958, 1967, 1974; Larsen & Thorarinsson 1977; Larsen 1982, 1984, 2000; Sæmundsson 1991; Grönvold et al. 1995; Zielinski et al. 1997; Haflidason et al. 2000).

In this paper we demonstrate that a high resolution tephra stratigraphy can be used to link chronologies in the terrestrial and marine

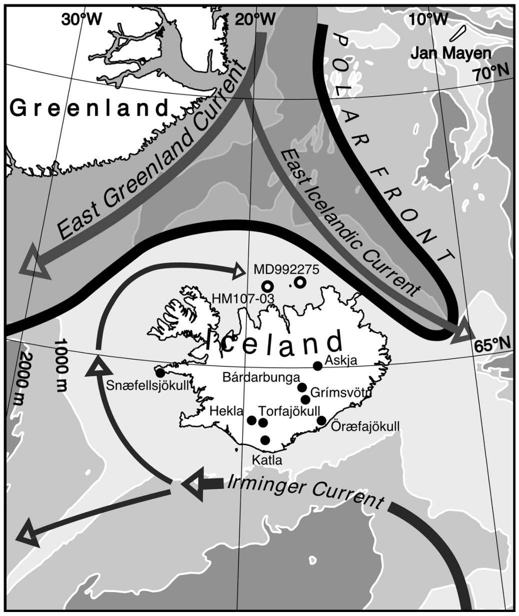

Fig. 1. Location map showing the study area and the present-day surface ocean circulation in the northern North Atlantic (based on Hurdle 1986). Depth contour interval 1000 m. Also shown are the central volcanoes of the most relevant volcanic systems. Location of core MD992275 is 66° 33.06' N, 17° 41.59' W.

environments. The investigation represents the first detailed high resolution land–sea correlation of the regional terrestrial tephrochronology with the marine record, although several previous studies have demonstrated the importance of single tephra markers (e.g. Lacasse et al. 1995, 1996; Eiríksson et al. 2000a, 2000b; Jennings et al. 2000). This allows us to compare two age models for a 3000 year sediment record from a marine shelf core north of Iceland. One model is based on tephrochronological data, the other on accelerator mass spectrometry (AMS) radiocarbon dating of the marine record. It is suggested that discrepancies between the two age models are related to palaeoceanographic changes in the region and resulting changes in the reservoir age of the water masses on the north Icelandic shelf.

Materials and methods

The CALYPSO piston core MD992275 (66° 33.06' N, 17° 41.59' W; 440 m water depth) was collected from the north Icelandic shelf during the 1999 IMAGES cruise (Fig. 1). The research methods used for the core material presented here have been described by Eiríksson et al. (2000a) and by Knudsen & Eiríksson (2002). Tephra horizons, observed during visual and X-ray inspection of the cores, were subsampled and sieved on a 63 µm sieve for the preparation of polished thin sections. Major element geochemical analysis of volcanic glass shards (Table 1) were carried out by standard wavelength dispersal technique on an ARL-SEMQ microprobe at the Geological Institute, University of Bergen, Norway, with an accelerating voltage of 15 kV, a beam current of 10 nA, and a defocused beam diameter of 6 - 12 µm. Natural and synthetic minerals and glasses were used as standards.

Soil sections with tephra layers at six localities in north Iceland (Figs. 2, 3) provide detailed land-based tephrochronology for comparison with the marine records. Subsamples of the terrestrial tephras were prepared in the same way as the marine samples. Samples from three sections have been analysed for major elements on the ARL-SEMQ microprobe at the University of Bergen.

The ^{14}C datings of marine samples (Table 2) were carried out at the AMS ^{14}C Dating Laboratory at the University of Aarhus, Denmark. The dates have been corrected for natural isotopic fractionation by normalization to $\delta^{13}C = -25‰$ VPDB, and calibrated with CALIB4 (Stuiver et al. 1998a), using the marine model calibration curve (Stuiver et al. 1998b). A standard reservoir correction of about 400 ^{14}C years ($\Delta R = 0$) is built into this model (see also Andersen et al. 1989). In this paper we simply refer to calibrated years BP as years.

Tephra markers in north Iceland and the north Icelandic shelf

The number of late Holocene tephra layers from the last 3000 years in our soil sections in north Iceland ranges from about 50 in the eastern part to about 25 in the western part. Many of these tephra layers are probably too thin to form off-shore deposits, while others are regional markers with high potential as offshore markers. Tephra sections on land that are relevant for the present study are briefly described below, and only the tephra layers detected so far in core MD992275 will be treated.

The Svartárvatn lake lies about 90 km inland (1x on Fig. 2i), north of the volcanic areas where

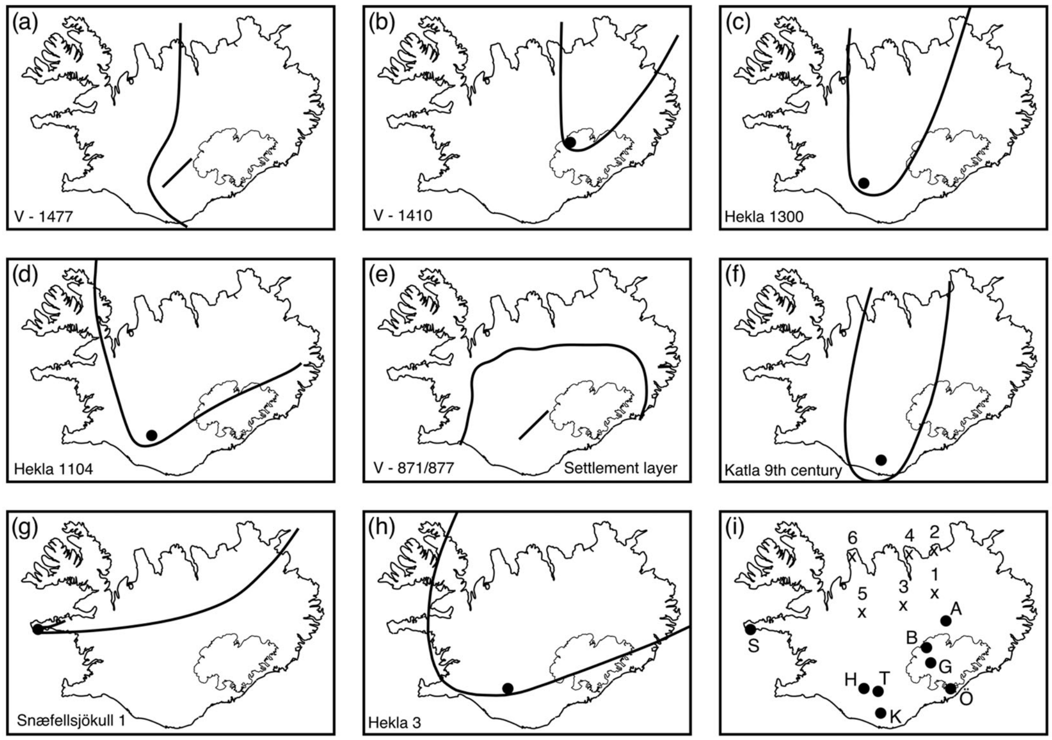

Fig. 2. (a–h) Dispersal of eight of the tephra layers relevant for this study. The lines show the outermost isopach of each layer as known at present. This isopach is 0.5 cm for the V-1477 and V-871/877 tephra layers, 0.2 cm for Hekla 1104 and 0.1 cm for the others. The central volcanoes of the relevant volcanic systems are indicated by capitals letters in 2i (full names on Fig. 1). Note that V-1477 and V-871/877 were erupted on long volcanic fissures belonging to the Veidivötn–Bárdarbunga system. Key sections in north Iceland are indicated by an X and a number. Relevant for this study are 1: Svartárvatn section; 2: Breidavík section; 3: Eyjafjördur section.

Holocene eruption frequency has been highest. Several soil sections were studied in the vicinity of the lake, and were merged to form a composite soil section showing the regional tephra stratigraphy, in which nearly 50 tephra layers younger than Hekla 3 have been identified (Fig. 3). Forty of these tephras have been analysed by electron microprobe. The tephra layers originate from at least six volcanic systems, but the great majority has the chemical characteristics of the Veidivötn–Bárdarbunga system. The other volcanic systems include the Grímsvötn, Hekla, Katla and Snæfellsjökull systems (Fig. 1). Identification of tephra layers from the last 11 centuries was partly based on previous work (Thorarinsson 1958, 1967, 1974; Larsen 1982, 1984; Haflidason et al. 2000), but work on the older tephra layers is still in progress.

Analyses of nine tephra layers tephra from the terrestrial sections in north Iceland (Svartárvatn, Figs. 2, 3; and Eyjafjördur, Fig. 2) are presented in Table 1a. The V-1477, V-1410, Hekla 1300, Hekla 1104, Settlement (V-871/877) and Katla 9th century tephras have all been described earlier (Thorarinsson 1967; Larsen 1982, 1984; Ólafsson 1985). The Settlement tephra was dated to 871 ± 2 and 877 ± 4 AD in the GRIP and GISP 2 ice cores, respectively (Grönvold et al. 1995; Zielinski et al. 1997). We report for the first time the presence in north Iceland of the white acid tephra from an eruption in Snæfellsjökull volcano radiocarbon dated to 1750 ± 150 BP (Steinthorsson 1967), previously reported only in west and north-west Iceland (Jóhannesson et al. 1981; Roth 2000). Peaty soil collected 0.6 - 2 cm below this tephra at Svartárvatn yielded a date of 1855 ± 25 BP. Analyses of the Snæfellsjökull 1 tephra in the Svartárvatn section are presented in Table 1a as S-Svart and those of a sample from a section 10 km west–north-west of the volcano

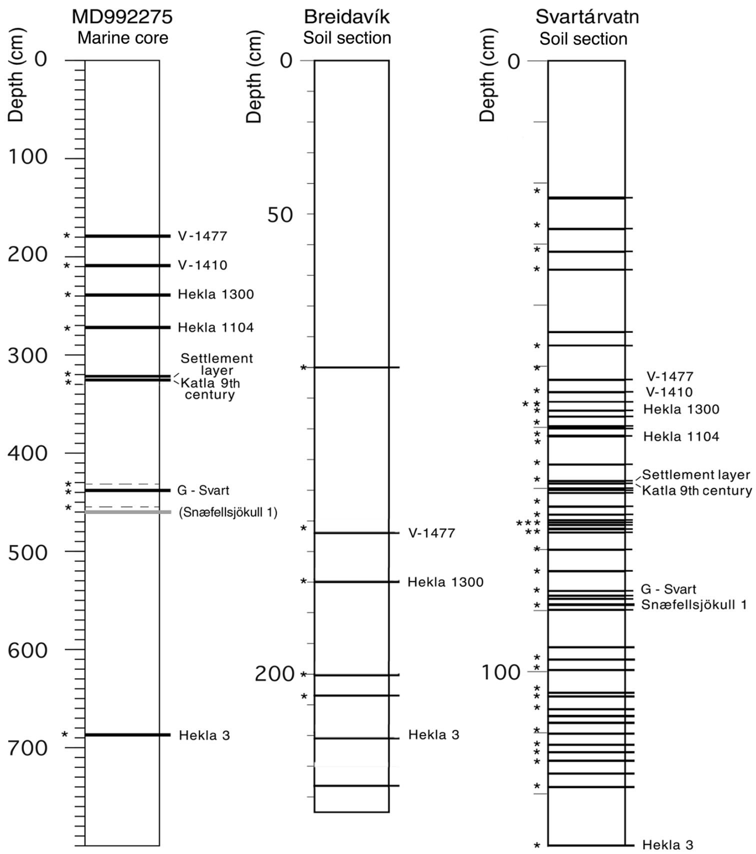

Fig. 3. Tephra stratigraphy of core MD992275 and the key sections Breidavík and Svartárvatn. All the tephra layers are shown as black lines without specific thickness. Asterisks indicate that glass from the tephra layer or horizon has been analysed for major element composition. Grey line shows inferred position of Snæfellsjökull 1 in core MD992275. Stippled line indicates tephra enriched horizons of mixed origin but containing Snæfellsjökull grains. Tephra layers relevant to this study are labelled with source (volcanic system) and eruption year. The volcanic systems are: Veidivötn–Bárdarbunga (V), Grímsvötn (G), Hekla, Katla and Snæfellsjökull.

are included for comparison as Sn-1. Analyses of a basaltic tephra a few centimetres above the Snæfellsjökull 1 tephra are presented in Table 1a as G-Svart. This tephra is characterized by TiO_2 in the range 2.1 - 2.4 weight% and is the older of two tephra layers in the key sections having these TiO_2 values (the other is 12th century AD). Finally we present analyses of Hekla 3 from the Svartárvatn section.

Eight tephra horizons of homogeneous glass composition have been found in the uppermost 7 m of core MD992275 (Fig. 3, Table 1b). Several horizons with abundant glass grains have also been analysed, but as the glass composition was heterogeneous the analyses are not included here except for a few grains with Snæfellsjökull 1 composition from two such horizons (Table 1c).

The four youngest horizons in core MD992275, at depths of 179, 209, 239 and 271 cm (Table 1b), are correlated to the V-1477, V-1410, Hekla 1300 and Hekla 1104 AD tephra layers in the key sections (Fig. 3). The 1477, 1410 and 1300 AD tephras are reported in an offshore deposit for the first time, but Hekla 1104 has also been found in other cores in the area (Eiríksson et al. 2000a, 2000b). The two tephra horizons at 322 and 324 cm form a pair where the upper tephra has the chemical

Table 1 (opposite page). (a) Representative microprobe glass analyses of tephra layers relevant to this study from key sections in north Iceland. Eight of the tephra samples are from the Svartárvatn key section; the exceptions are the Katla 9th century tephra (sampled in the Eyjafjördur key section) and the Sn-1 sample (from a section on the Snæfellsnes peninsula). The analyses do not show the complete composition range of each tephra layer. (b) Representative microprobe glass analyses of tephra horizons in the core MD992275. Five horizons with basaltic glass grains of homogeneous composition occur at depths of 179, 209, 322, 324 and 438 cm. Three horizons with silicic glass grains of limited compositional range occur at depths of 239, 271 and 687 cm. (c) Snæfellsjökull 1 composition shards in MD992275: selected analyses from two horizons (depths 431 cm and 455 cm) of glass grains with a variety of compositions. Low totals are due to the small shard size of the tephra and the few analyses available. They are nevertheless strong indications of the grains' origin.

(a)

SiO_2	TiO_2	Al_2O_3	FeO	MgO	CaO	Na_2O	K_2O	P_2O_5
V-1477								
50.84	1.84	13.23	12.94	6.80	11.46	2.60	0.28	0.07
50.66	1.84	13.32	12.72	6.75	11.60	2.32	0.22	0.25
50.06	1.90	13.26	12.78	7.07	11.78	2.31	0.29	0.22
51.06	1.96	13.05	13.38	6.55	11.42	2.01	0.21	0.17
49.70	2.02	13.88	12.85	6.87	12.12	2.31	0.18	0.22
50.17	2.06	13.19	13.15	6.62	11.51	2.53	0.23	0.24
V-1410								
49.54	1.91	13.86	12.31	7.07	11.82	2.53	0.28	0.06
49.81	1.96	13.99	12.35	7.21	12.04	2.35	0.25	0.02
48.65	1.85	14.00	12.48	6.81	11.78	2.33	0.27	0.20
49.47	1.92	13.72	12.40	7.04	11.85	2.35	0.25	0.11
49.09	1.84	14.13	12.26	6.92	11.64	2.33	0.18	0.28
49.33	1.83	14.19	12.44	6.95	11.76	2.29	0.25	0.25
Hekla 1300								
62.43	0.84	15.50	7.69	0.79	4.28	4.59	2.00	0.36
62.23	0.92	14.85	8.15	0.92	4.13	4.51	2.04	0.48
61.61	1.10	15.22	8.74	1.19	4.71	4.11	1.77	0.37
61.30	1.02	14.99	9.59	1.51	4.68	4.28	2.03	0.26
60.29	1.34	14.66	9.97	1.68	4.94	4.04	1.81	0.57
58.47	1.26	15.90	10.10	2.08	5.57	4.23	1.56	0.48
Hekla 1104								
73.76	0.26	13.67	2.62	0.03	1.75	4.41	2.89	0.06
72.82	0.21	14.21	3.00	0.05	1.88	4.53	2.70	0.00
72.69	0.25	14.08	3.26	0.11	1.92	4.23	2.58	0.00
72.41	0.27	14.20	3.31	0.12	2.01	4.33	2.66	0.00
71.69	0.29	14.47	3.24	0.01	1.90	4.52	2.84	0.00
70.68	0.32	14.40	3.34	0.09	1.91	4.36	2.89	0.13
V-871/877								
48.47	1.94	13.58	12.65	6.74	11.45	2.55	0.22	0.22
49.38	1.92	13.68	13.05	6.36	11.03	2.47	0.29	0.09
49.33	1.86	13.71	12.70	6.30	11.35	2.43	0.21	0.27
48.85	1.86	13.70	12.85	6.79	11.39	2.34	0.17	0.20
49.93	1.82	13.56	12.81	6.51	11.19	2.20	0.26	0.22
49.59	1.77	13.58	12.94	6.39	11.22	2.36	0.30	0.19
K 9th century								
49.53	4.61	13.17	15.13	4.45	9.37	2.42	0.82	0.55
48.83	4.43	13.46	15.75	4.44	9.40	2.96	0.77	0.46
48.55	4.83	13.28	14.88	5.27	10.42	2.59	0.86	0.47
48.04	4.74	13.12	15.55	4.87	9.80	3.00	0.86	0.64
47.75	4.56	12.94	15.55	4.90	9.46	2.59	0.90	0.60
47.52	4.35	13.09	15.02	4.91	9.74	2.64	0.81	0.49
G-Svart								
49.68	2.42	13.92	12.31	6.32	11.02	2.39	0.43	0.20
49.36	2.34	14.60	12.12	6.70	11.35	2.64	0.38	0.31
49.43	2.29	14.12	12.04	6.63	11.45	2.38	0.44	0.31
48.95	2.27	14.24	12.26	6.40	11.20	2.51	0.42	0.16
49.57	2.26	14.38	12.12	7.03	11.52	2.58	0.35	0.23
50.12	2.17	14.16	11.94	6.76	11.37	2.53	0.40	0.15
S-Svart								
67.48	0.38	15.63	4.11	0.21	1.81	4.77	4.19	0.05
67.42	0.48	15.80	4.25	0.35	1.72	5.62	4.49	0.09
66.08	0.41	15.98	4.00	0.28	2.00	5.61	4.01	0.00
65.46	0.51	15.99	4.62	0.33	2.08	5.39	4.04	0.00
65.42	0.45	15.96	4.39	0.34	2.03	5.64	4.02	0.02
64.96	0.47	15.74	4.40	0.30	1.94	5.21	4.05	0.01
Sn-1								
69.32	0.33	15.54	3.37	0.16	1.30	5.12	4.59	0.02
67.63	0.41	15.61	3.83	0.30	1.61	5.14	4.51	0.08
67.32	0.42	15.70	4.29	0.49	1.94	5.06	4.38	0.04
67.16	0.36	15.22	4.36	0.24	1.57	4.70	4.41	0.00
66.36	0.40	15.71	4.40	0.32	1.61	5.25	4.34	0.25
65.81	0.36	16.34	4.20	0.44	2.31	5.17	3.93	0.02
Hekla 3								
71.76	0.22	14.48	3.04	0.12	1.98	4.43	2.66	0.01
71.45	0.25	14.20	3.13	0.14	2.07	4.59	2.52	0.06
71.12	0.28	14.26	3.04	0.10	1.96	4.69	2.66	0.11
71.11	0.26	14.07	3.05	0.16	1.97	4.63	2.47	0.00
70.43	0.19	14.31	3.16	0.14	2.04	4.48	2.67	0.02
69.30	0.14	14.31	3.12	0.03	2.05	4.62	2.54	0.03

(b)

SiO_2	TiO_2	Al_2O_3	FeO	MgO	CaO	Na_2O	K_2O	P_2O_5
MD992275/179								
49.66	1.90	13.94	13.36	6.65	11.49	2.44	0.30	0.12
49.47	1.94	13.32	13.46	6.30	11.50	2.51	0.23	0.24
48.86	1.94	14.21	12.88	6.49	11.65	2.23	0.23	0.31
48.15	2.01	13.41	12.66	7.56	12.48	2.14	0.25	0.11
49.25	2.02	13.18	13.67	6.26	11.56	2.40	0.31	0.16
50.65	2.09	12.96	13.71	6.60	11.43	2.21	0.23	0.15
MD992275/209								
51.53	1.83	13.25	13.10	6.10	11.81	2.21	0.25	0.12
51.05	1.93	13.26	12.68	6.57	12.04	2.15	0.23	0.15
50.94	1.96	14.61	12.53	7.32	11.05	2.39	0.19	0.24
50.62	1.76	14.13	12.85	6.87	11.49	2.26	0.21	0.19
50.31	1.91	14.38	13.11	6.55	10.98	2.38	0.24	0.21
49.36	1.83	14.19	12.68	7.01	11.59	2.30	0.23	0.17
MD992275/239								
61.73	1.22	15.64	9.13	1.63	4.95	4.29	1.76	0.41
61.20	1.02	15.21	8.95	1.55	4.95	4.08	1.80	0.33
61.11	1.15	15.73	9.34	1.49	5.00	4.33	1.76	0.58
60.05	1.32	15.31	8.76	1.58	4.49	4.32	1.67	0.39
58.74	1.12	15.53	9.30	1.38	5.06	4.08	1.77	0.52
57.59	1.15	15.72	9.44	1.62	5.34	4.38	1.67	0.23
MD992275/271								
74.19	0.20	14.39	3.13	0.08	2.13	4.11	2.81	0.01
72.69	0.25	13.38	3.24	0.11	2.05	4.50	2.65	0.03
72.65	0.22	14.46	3.17	0.00	2.08	4.67	2.84	0.00
72.04	0.30	14.24	3.24	0.14	2.06	4.61	2.77	0.11
70.74	0.31	13.68	3.29	0.08	1.99	4.30	2.62	0.07
69.36	0.24	13.94	4.73	0.06	4.40	5.16	1.62	0.04
MD992275/322								
48.61	1.75	14.26	12.51	6.76	11.27	2.39	0.26	0.15
50.54	1.88	13.89	12.85	6.88	11.59	2.11	0.23	0.31
48.82	1.97	13.61	13.22	6.37	10.83	1.77	0.20	0.11
49.89	2.03	13.67	12.92	6.69	11.27	2.46	0.18	0.07
49.49	2.06	14.04	11.85	7.37	12.32	2.42	0.22	0.18
49.49	2.09	13.67	12.53	6.91	11.26	2.46	0.23	0.07
MD992275/324								
48.12	4.48	13.59	15.32	4.89	10.02	2.91	0.94	0.55
47.66	4.40	12.89	15.04	4.83	10.02	2.99	0.72	0.62
47.59	4.96	13.15	15.17	4.59	9.92	3.06	0.88	0.43
47.45	4.70	13.38	14.71	4.78	9.86	3.14	0.92	0.53
47.40	4.72	12.74	14.71	4.55	9.94	2.98	0.86	0.67
46.32	4.50	13.45	14.81	4.77	9.99	3.12	0.76	0.43
MD992275/438								
49.68	2.35	14.18	12.34	6.32	11.31	2.66	0.29	0.34
49.68	2.30	14.38	12.41	7.17	11.34	2.46	0.32	0.14
49.58	2.18	14.67	12.24	6.74	11.04	2.35	0.41	0.28
49.16	2.20	14.52	12.16	6.77	11.25	2.49	0.43	0.20
49.13	2.26	14.35	12.26	6.88	11.18	2.40	0.34	0.23
49.12	2.33	14.47	12.15	6.54	10.95	2.56	0.30	0.26
MD992275/687								
71.45	0.18	14.37	3.19	0.00	2.00	5.02	2.46	0.00
71.16	0.26	14.29	3.18	0.04	1.98	4.92	2.38	0.00
70.21	0.03	14.21	3.20	0.09	1.97	4.39	2.36	0.00
69.66	0.19	14.05	3.18	0.22	2.15	4.48	2.39	0.11
67.28	0.33	15.06	5.34	0.30	3.08	4.59	2.17	0.07
65.42	0.45	15.18	6.12	0.38	3.51	4.64	2.04	0.12

(c)

SiO_2	TiO_2	Al_2O_3	FeO	MgO	CaO	Na_2O	K_2O	P_2O_5
431								
65.44	0.49	15.60	3.91	0.29	1.75	5.16	4.46	0.10
63.70	0.38	15.19	3.95	0.32	1.66	5.20	4.00	0.00
455								
64.46	0.47	15.93	4.86	0.52	2.31	5.05	3.95	0.03
60.82	0.59	15.81	4.74	0.44	2.08	4.49	3.80	0.12

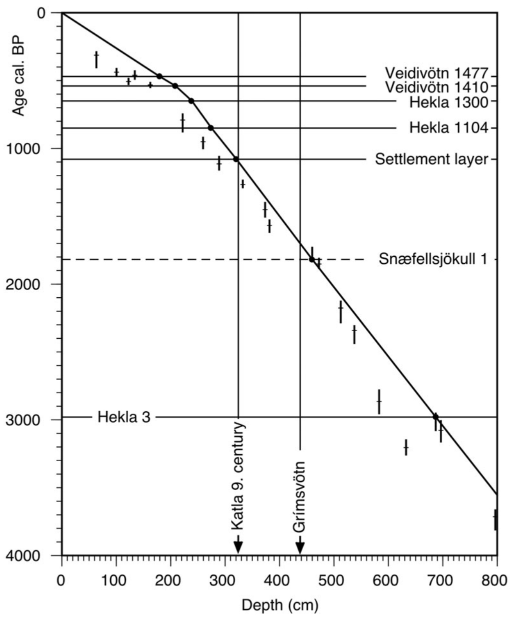

Fig. 4. Age–depth diagram for core MD992275. Two possible age models are shown. The solid line indicates an age model based only on tephra markers (tephrochronological age model). The AMS ^{14}C dates are shown with ± one standard deviation (see also Table 2).

signature of the Veidivötn–Bárdarbunga system and the lower one has that of the Katla system. Three such pairs have been identified in the key sections Svartárvatn and Eyjafjördur. The youngest pair is the Settlement tephra and the 9th century Katla tephra, the second youngest pair is from the early 9th/late 8th century AD and the third is much older. The chemical signature fits best with the late 9th century tephras. The Settlement tephra has not yet been traced to the north coast of Iceland (Fig. 2e shows the 0.5 cm isopach) despite its volume of 5 km^3 as freshly fallen tephra (recalculated from Larsen 1984), but offshore deposition is likely considering the magnitude of the eruption.

Below 3.3 m the core has only partly been searched for tephra horizons. One distinct tephra horizon has been detected at 438 cm in the core (Fig. 3). It consists of homogeneous basaltic glass and has TiO_2 values in the 2.1 - 2.4 weight% range that allow it to be correlated to the G-Svart tephra in the Svartárvatn section. Chemically identical grains to those of Snæfellsjökull 1 have been found in two of the glass-rich horizons at depths of 431 and 455 cm in core MD992275 (shown as stippled lines in Fig. 3), together with a variety of acid, intermediate and basaltic glass grains. Examples of glass grains with Snæfellsjökull 1 composition are presented in Table 1c. A tephra horizon consisting entirely of acid glass with the chemical characteristics of the Hekla system occurs at 687 cm. The composition and range is consistent with the Hekla 3 tephra in the Svartárvatn section as well as the Hekla 3 tephra identified in core HM107-03 by Eiríksson et al. (2000a).

Radiocarbon dates of molluscs from core MD992275 are listed in Table 2 as well as the age of dated tephra markers. The results are plotted against core depth in Fig. 4, which shows an age model based on tephrochronology as well as the calibrated radiocarbon dates. Above the Hekla 3 tephra marker, over 100 years need to be subtracted from the radiocarbon dates to bring them to the tephra age model level.

Discussion

The tephrochronological age model for core MD992275 (Fig. 4) is at present based on five well-constrained dates of tephra layers younger than 1130 years (the time span of Iceland's recorded history) and on terrestrial radiocarbon dates on two older tephra layers: Snæfellsjökull 1 and Hekla 3. A straight-line fit age model between the tephra layers is presented, and slight adjustments can be expected as more terrestrial dates become available. The date of the Hekla 3 marker tephra is well-constrained (Dugmore et al. 1995). The two dates on the Snæfellsjökull 1 tephra are in reasonable agreement, considering that the 1855 ± 25 date is on a soil slice separated from the tephra by 0.6 cm and the 1750 ± 150 date is on soil immediately below. The presence of the Snæfellsjökull 1 tephra in the core is manifested by the occurrence of glass grains in the sediment below and above the G-Svart tephra. The lowest level of identified glass grains with Snæfellsjökull 1 composition is at 455 cm in core MD992275 and such grains are also found above the G-Svart tephra. These grains are considered redeposited, and the level of the primary Snæfellsjökull 1 tephra is tentatively estimated at 460 cm depth (Fig. 3), slightly below the level of their first appearance.

Previous age model investigations on the north Icelandic shelf have shown discrepancies between 400 year reservoir age corrected radiocarbon age models and tephrochronological age models, both for the upper Holocene and the Late glacial (Eiríksson et al. 2000a, 2000b; Knudsen & Eiríksson 2002). They concluded that a southward shift of the Polar Front ca. 3000 years ago, indicated by benthic and planktonic foraminifera, coincided with an increase of about 130 years in the reservoir age correction needed to fit their radiocarbon and tephrochronological age models. This value corresponds approximately to the reservoir age of ca. 550 ^{14}C years reported by Tauber & Funder (1975). Before 3000 years BP, a 400 year correction was sufficient back to ca. 4500 years BP. The results presented here show that core site MD992275 has been extensively affected by Arctic water for the past 3000 years. At present, the site is closer to the Polar Front than site HM107-03 studied by Eiríksson et al (2000a) and Knudsen & Eiríksson (2002).

The time lag between the tephra age model and the calibrated radiocarbon dates in core MD992275 increases sharply to at least 400 years after the deposition of Hekla 3, decreasing to nearly zero at ca. 1900 years BP. Above that there is a lag of 100 - 200 years with broad maxima at around 1400, 600 and 300 years BP. More radiocarbon dates and a tighter control on the tephrochronology above Hekla 3 is necessary for the quantification of these age deviations and their frequency, as well as high resolution studies of palaeoceanographic proxies throughout the core. This work is currently in progress within the HOLSMEER project.

Conclusions

1) Nearly 50 tephra layers from the last 3000 years have been documented in key sections in north Iceland, providing a basis for high resolution terrestrial tephra stratigraphy to which marine records can be correlated.

2) Reliable correlations between terrestrial and marine tephra layers can be based on geochemical signatures and mapping of the distribution of these layers on land and on the sea floor.

3) Correlation of eight tephra horizons in marine core MD992275 to dated tephra layers in key sections on land allows the construction of a tephrochronological age model for core MD992275

Table 2. Radiocarbon dates and ages of dated tephra markers in core MD992275. All radiocarbon samples were calibrated with CALIB4 (Stuiver et al. 1998a, 1998b). The age of historical tephra layers is reported as calendar years BP (before 1950), rounded off to the nearest decade. Radiocarbon dates of the pre-settlement tephra layers are on terrestrial material below the tephras; for details on Hekla 3 see Dugmore et al. (1995). Tephra marker depths correspond to the base level of each unit. A standard reservoir correction of about 400 years for marine samples is built into the radiocarbon model. ° = assumed standard δ^{13}C value.

Depth cm. MD992275	Lab. no.	Material; **dated tephra layer**	^{14}C age (BP) $\pm 1\ \sigma$	Cal. age(s) BP R = 400	Cal. $\pm 1\ \sigma$ (BP)	δ^{13}C
63 - 64	AAR-7116	*Thyasira equalis*	695 ± 45	310	410 - 290	-7°
100 - 101	AAR-7117	*Thyasira* cf. *equalis*	785 ± 40	440	470 - 410	-6.85
122 - 123	AAR-6089	*Siphonodentalium lobatum*	895 ± 45	510	530 - 480	+0.70
133 - 135	AAR-7118	*Thyasira equalis*	815 ± 45	460	490 - 430	-8.98
162 - 163	AAR-7119	*Nuculana* sp.	945 ± 35	530	550 - 510	+0.51
179		**V-1477**		**470**		
209		**V-1410**		**540**		
220 - 224	AAR-7120	*Thyasira equalis, Thyasira* sp.	1265 ± 45	790	880 - 740	-8.69
239		**Hekla 1300**		**650**		
259 - 260	AAR-7121	*Thyasira equalis*	1420 ± 50	950	1000 - 920	-8.00
272		**Hekla 1104**		**850**		
287 - 291	AAR-6931	*Thyasira equalis*	1555 ± 35	1110	1160 - 1060	-6.84
321		**Settlement layer**		**1080**		
332 - 333	AAR-7122	*Siphonodentalium lobatum*	1710 ± 45	1270	1290 - 1230	+0.44
373 - 374	AAR-6932	*Siphonodentalium lobatum*	1905 ± 40	1450	1510 - 1400	+0.69
381 - 382	AAR-6933	*Bathyarca glacialis*	2020 ± 40	1570	1620 - 1530	+1.65
ca. 460	LL-1169A	Snæfellsjökull 1 (peat)	1750 ± 150	1690 - 1630	1860 - 1520	
ca. 460	**KIA17232**	**Snæfellsjökull 1 (peaty soil)**	**1855 ± 25**	**1820**	**1820 - 1730**	-24.6
472 - 473	AAR-6934	Cf. *Dentalium entalis*	2245 ± 40	1850	1890 - 1810	+0.72
512 - 513	AAR-6935	Cf. *Siphonodentalium lobatum*	2530 ± 45	2180	2290 - 2120	+0.91
537 - 538	AAR-7123	*Thyasira equalis*	2680 ± 65	2340	2440 - 2310	-6.80
582 - 584	AAR-6936	*Thyasira* sp.	3110 ± 70	2860	2960 - 2780	1°
632 - 633	AAR-7124	*Thyasira* cf. *equalis*	3345 ± 45	3200	3260 - 3150	-8.05
687		**Hekla 3 (peat)**	**2879 ± 34**	**2990 - 2970**	**3080 - 2950**	
696 - 697	AAR-6937	*Siphonodentalium lobatum*	3265 ± 50	3080	3160 - 3010	+0.96
796 - 797	AAR-6938	*Bathyarca glacialis*	3795 ± 50	3710	3810 - 3660	+2.11

and comparison between marine and terrestrial dates.

4) Discrepancies between reservoir corrected radiocarbon dates of molluscs and the tephrochronological age model vary from tens to hundreds of years.

5) The discrepancies between the radiocarbon and tephrochronological age models may be related to incursions of Arctic water masses into the northern North Atlantic to the north and east of Iceland.

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