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Did the AD 853 Mount Churchill eruption trigger societal and climatic impacts in the northern mid-latitudes?

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1. Introduction

The eruption of Mount Churchill, Alaska, was one of the largest volcanic events in the Northern Hemisphere in the later first millennium AD. Ash from the eruption was dispersed eastwards, forming a visible lobe (WRAe) covering >250,000 km^2 in Alaska and NW Canada, and a cryptotephra horizon (AD860B) as far as Greenland and NW Europe (Fig. 1). The considerable ash fallout is thought to have impacted ecosystems[1] and human populations, possibly leading to the displacement of Athapaskan-speaking peoples from the Yukon to the American South-West[2]. But did the event have wider climate and societal repercussions? The tephra provides a precise isochron with which to examine palaeoenvironmental records in the North Atlantic region in order to evaluate the eruption's impact.

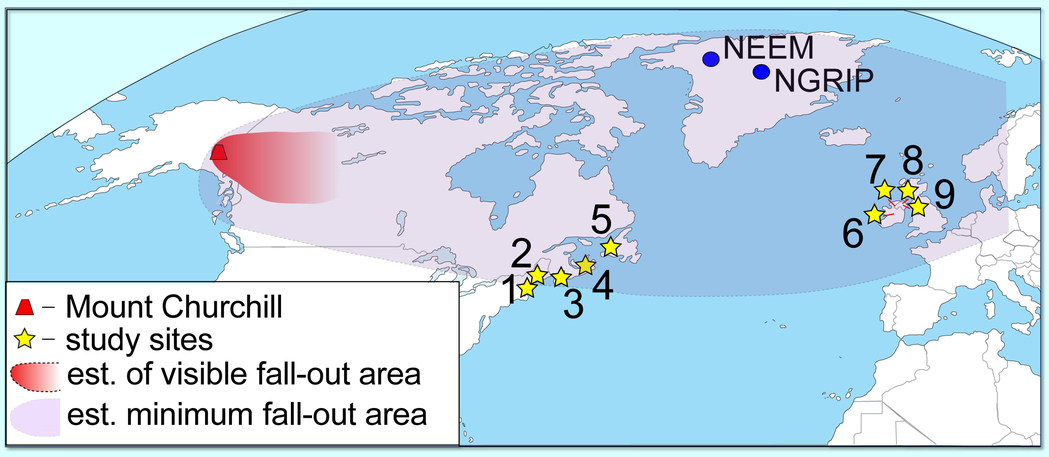


Fig. 1. Known distribution of the WRAe/AD860B tephra and the location of the palaeoenvironmental sites considered in this paper. 1. Saco Heath[3]; 2. Sidney Bog[4]; 3. Villagedale Bog[3]; 4. Framboise Bog[3]; 5. Jeffrey's Bog[3]; 6. Cloonoolish Bog[5]; 7. Glen West Bog[6]; 8. Dead Island Bog[6]; 9; Ballyscullion East Bog[7]. The locations of the NEEM and NGRIP ice cores are also shown.

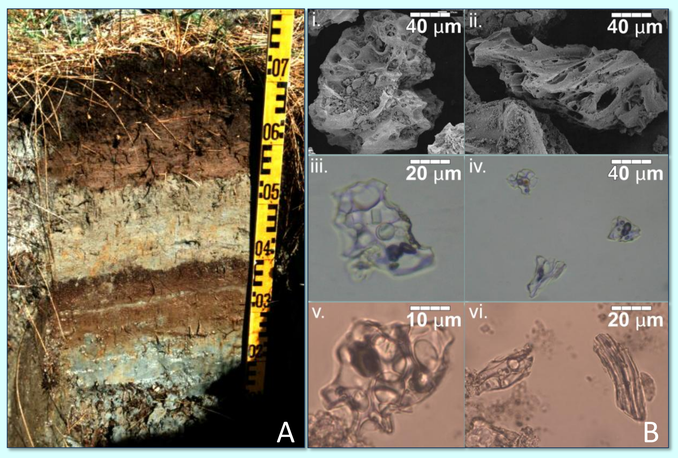
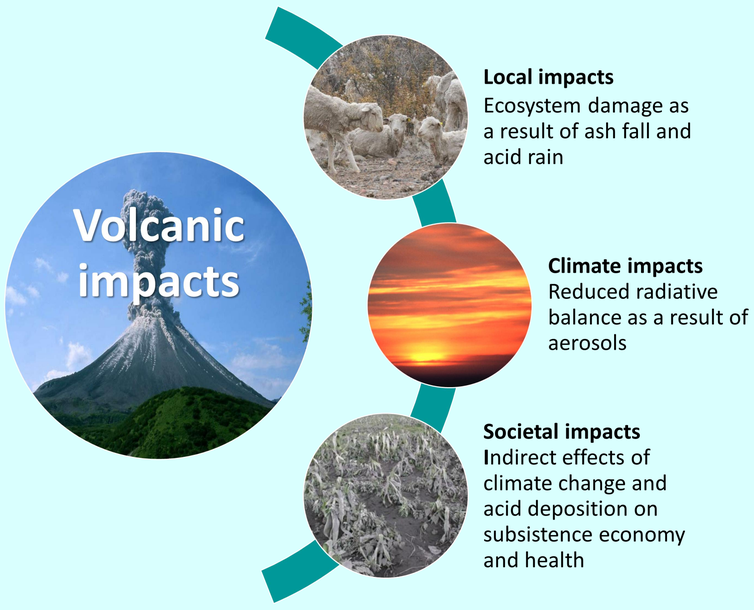


Fig. 2. Near and far. A. Visible bed of WRAe as seen in the Yukon. B. Microscopic glass shards of proximal WRAe (i, ii) and AD860B cryptotephra in eastern Canada (iii, iv) and Ireland (v, vi). The fine particles form invisible horizons as much as 7,000 km from source.



2. Distal impact?

On the basis of the NS1-2011 ice core chronology[8], the Mount Churchill eruption can now be dated to the winter of 852-3 (M. Sigl, pers. comm.). Could the Mount Churchill eruption have therefore been responsible for summer snow and frosts in AD 855 and the harsh winter of 855-6, recorded in the Irish Annals? WRAe/AD860B tephra in Greenland ice cores is associated with a modest sulphate deposition at the time of the event[9] (Fig. 2). Palaeohydrological records from the Atlantic seaboard (Figs 1, 4) reveal that

i. the eruption occurred during a wet/cold phase in eastern N. America, when a trend towards drier/warmer conditions had already begun
ii. in Ireland, a shift towards wetter/colder climate was underway before the eruption, and continued after the event.

Pollen records indicate that a decline in farming in Ireland in 10th century is time-transgressive (Fig. 5). Despite its close timing to the event, this decline cannot be attributed to the Mount Churchill eruption.

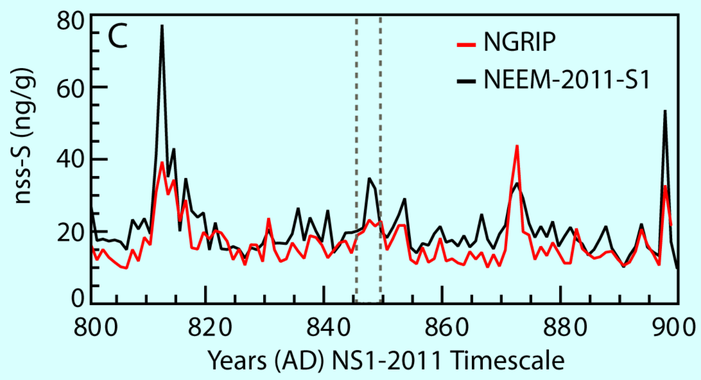


Fig. 3. Non-sea salt sulphur (nss-S) concentrations in the NGRIP and NEEM-2011-S1 ice cores (based on ref. 9, timescale adjusted to NS1-2011[8]). The position of the ice core sample containing AD860B tephra is indicated by the dashed lines.

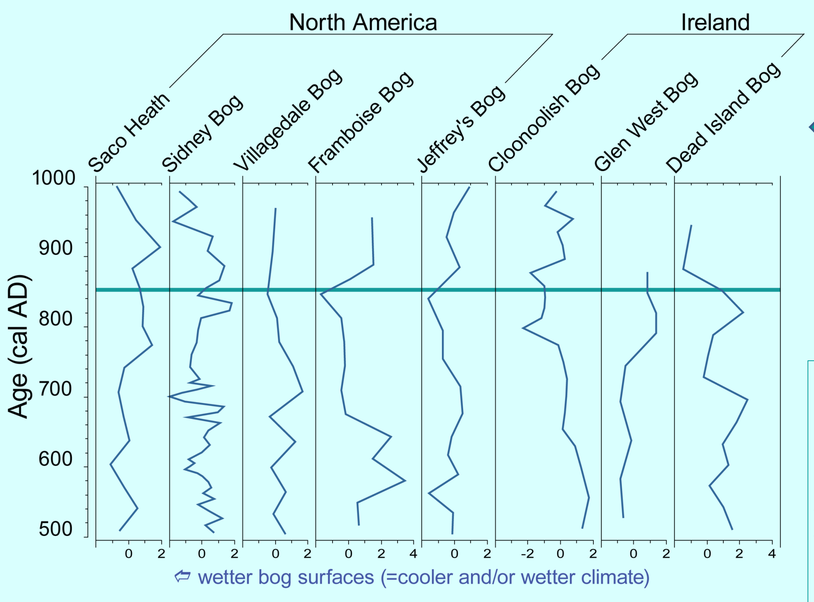
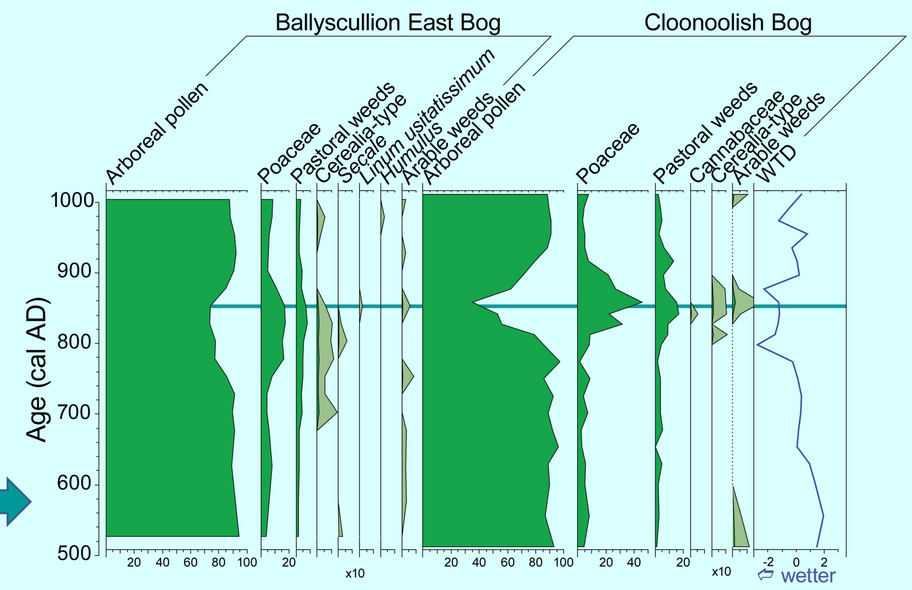


Fig. 4. Palaeohydrological records inferred from testate amoebae assemblages from ombrotrophic bogs in eastern North America and Ireland (standardised data). The blue band indicates the position of the WRAe/AD860B tephra in each record. At the time of the eruption, opposing trends towards increased dryness in N. American sites and increased wetness in Irish sites can be observed, but the event does not appear to alter these patterns.

Fig. 5. Pollen records from Ireland showing arboreal pollen and cultural indicators. The blue band indicates the position of the WRAe/AD860B tephra in each record. Arable agriculture was in decline at Ballyscullion East by the time of the eruption. Mixed farming continued to be well-represented at Cloonoolish after the event, but declined some decades afterwards. Here, the decline coincides with a shift towards drier/warmer conditions.



3. Evaluation

Distal impact?

- No palaeoenvironmental evidence that the eruption had any lasting impact on climatic conditions in the N. Atlantic region.
- Despite its large magnitude, modest aerosols emissions, the high latitude of the event and its occurrence in winter will have diminished the eruption's climate impact.

Conclusion

- Despite its close temporal correlation with extreme weather events and a downturn in farming in Ireland, the eruption is unlikely to have impacted climate or society at an extra-regional level.

Implications

- Palaeoenvironmental proxy records from sedimentary archives may lack the temporal resolution to identify short-lived volcanic impacts.
- But not all large volcanic eruptions are climatically effective, and caution must be exercised to avoid mistaking correlation with causation.

Acknowledgments

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References

[1]Bunbury, J. & Gajewski, K., 2013 *Arctic* 17-31.
[2]Hare, P.G. *et al*. 2004 *Arctic* 57, 260-272.
[3]Mackay, H. et al. 2016 *Quaternary Science Reviews* 132, 101-113.
[4]Clifford, M.J. & Booth, R.K. 2013 *Climatic Change* 119, 693-704.
[5]Blundell, A. *et al*. 2008 *Journal of Quaternary Science* 23, 59-71.
[6]Swindles, G.T. *et al*. 2010 *Quaternary Science Reviews* 29, 1577-1589.
[7]Hall, V.A. *et al*. 1993 *New Phytologist* 125, 193-202.
[8]Sigl, M. *et al*. 2015 *Nature* 523, 543-549.
[9]Jensen, B.J. *et al*. 2014 *Geology* 42, 875-878.