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Tracing Marine Cryptotephras in the North Atlantic during the Last Glacial Period

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Tephrochronology is a powerful technique that can be utilised for the independent correlation and synchronisation of disparate palaeoclimatic records from different depositional environments. There is a high potential to utilise this technique to integrate ice, marine and terrestrial records to study climatic phasing within the North Atlantic region due to the high eruptive frequency of Icelandic volcanic systems. However, until now North Atlantic marine records have been relatively understudied. Here we report on investigations to define a tephra framework integrating new studies of cryptotephra horizons within a wide network of North Atlantic marine cores with horizons identified in prior work. This framework has the potential to underpin the correlation of the marine records to the Greenland ice-core records and European terrestrial sequences.

Tephrochronological investigations were conducted on 13 marine sequences from a range of locations and depositional settings using cryptotephra extraction techniques, including density and magnetic separation, to gain high resolution glass shard concentration profiles and rigorous single-shard major element geochemical analysis to characterise identified deposits. Cryptotephras with an Icelandic source were identified in many records and displayed diversity in shard concentration profiles and the geochemical homo/heterogeneity of shards within the deposits. These differences reflect spatial and temporal variability in the operation of a range of transport processes, e.g. airfall, sea-ice and iceberg rafting, and post-depositional processes, e.g. bioturbation and secondary redeposition. The operation of these processes within the marine environment can potentially impart a temporal delay on tephra deposition and hamper the placement of the isochron, therefore, it is crucial to assess their influence. To aid this assessment a range of deposit types with common transport and depositional histories have been defined. Spatial patterns in the occurrence of these deposit types have been detected, the dominant controls at different sites explored and key regions of the North Atlantic with a greater likelihood for preserving isochronous deposits identified.

Overall, these investigations have allowed a framework of isochronous marine cryptotephras to be defined for the last glacial period. The most widespread deposit is the rhyolitic phase of North Atlantic Ash Zone II, identified in 9 of the marine sequences and providing a direct tie-line to the Greenland ice-cores records. The framework is dominated by horizons with a basaltic composition, predominantly sourced from the Icelandic Grímsvötn volcanic system but horizons with Katla, Hekla, Kverkfjöll, Veidivötn and Vestmannaeyjar like compositions have also been isolated. Correlations to horizons in the Greenland ice-core tephra framework are being explored, however, this is a challenging process due to the large number of horizons with similar geochemical signatures in the records and the difference in temporal resolution and stratigraphic control between the ice and marine sequences.