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Identification and Geochemical Characterisation of Cryptotephra Horizons within North Atlantic Marine Sediments

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The potential for the correlation and synchronisation of disparate palaeoclimatic archives using time-synchronous layers of volcanic material has dramatically increased recently. As a consequence of the recognition of tephra horizons that cannot be observed during visual inspection of core sequences due to the low concentration and/or small size of tephra shards deposited. These so called cryptotephra horizons have enabled the geographical range over which key horizons can be traced to be expanded and also led to the identification of numerous horizons that do not have visual equivalents in proximal settings. Their identification has resulted from the development of various techniques that aim to extract tephra shards from host sediments. One of the most widely utilised procedures is the isolation of tephra shards using heavy liquids, such as sodium polytungstate, prepared to specific densities. Density separation has been widely used to isolate cryptotephra horizons within terrestrial sequences, however, its application to the identification of horizons in marine sediments is limited. The majority of previous investigations of marine sequences have focused on coarse material >150 μm in diameter rather than the fine-grained material, down to particles 25 μm in diameter, investigated within this study.

Here we report on the application of the density separation technique for the study of cryptotephra horizons within the MD04-2822 core, a piston core retrieved from the deep water margins of the Barra Fan in the Rockall Trough area of the North Atlantic Ocean. Through the creation of a high-resolution record of tephra content within a 1.8 m section of the core, related to the MIS 4 and 5a periods, two cryptotephra horizons were identified. Major element geochemical analysis of individual tephra shards within these two horizons, 2327-2328 cm and 2359-2366 cm, demonstrates that they were both sourced from Iceland and display geochemical similarities to the transitional alkali and tholeiitic rock suites respectively. However, comparisons to proximal whole rock deposits do not allow specific Icelandic volcanic systems to be defined as sources. In addition, correlative horizons cannot be identified through an inspection of other tephrostratigraphical records for this period, implying that these horizons are the products of two volcanic eruptions previously unidentified within geological archives. The trace element composition of individual tephra shards was determined using a new laser ablation inductively coupled plasma mass spectrometry system and average rare earth element profiles for the horizons display strong similarities to proximal Icelandic material. The maximum size of the shards present within the horizons and their relative stratigraphic integrity suggests that they were deposited via primary airfall processes.

The search for cryptotephra horizons in MD04-2822 is being extended beyond the MIS 4 and 5a periods and we also report on early work to identify further horizons within the record back to MIS 6 as part of the SMART project (Synchronising Marine and ice-core Records using Tephrochronology). This project aims to define volcanic tie-lines between North Atlantic marine records and the new NEEM ice-core over this key climatic interval, which includes the Eemian interglacial, to overcome uncertainties regarding the timing of climatic variations.