

SELECTIVE PRESERVATION OF ORGANIC MATTER IN TEPHRA LAYERS

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Introduction

Volcanic eruptions eject large amounts of fine-grained material, known as tephra, into the atmosphere. Tephra forms distinct layers when it falls to the surface (Lowe 2011) and is highly reactive when it comes into contact with sea water. In the marine environment, coupled electron transfer reactions lead to oxidation of Fe^{II} on the tephra surface and rapid depletion of sediment pore waters in dissolved O₂, and surface-bound Fe^{II} induces chemical catalysis of nitrate reduction (Haeckel et al. 2012; Hembury et al. 2012; Ottley et al. 1997). Diagenesis of tephra also generates reactive Fe-oxyhydroxide colloids, which disperse into the surrounding environment (Homoky et al. 2011). Thus, the chemical and redox gradients generated by tephra diagenesis may serve as energy sources for autotrophic microbiological communities, and/or an overlooked sink for organic carbon preservation. Current work being undertaken at the Universities of Southampton and Plymouth suggests that tephra layers up to 4 million years old, collected offshore from the volcanic island of Montserrat, contain a unique organic chemical signature, in the form of preserved amide and sulphonamide compounds. These compounds may either be indicative of microbial community activity, and/or demonstrate the potential for enhanced preservation of such organic compounds in tephra layers, which are currently overlooked in carbon cycle dynamics.

Results and Discussion

Downcore sediment profile data from cores collected from near Montserrat (IODP Exp.340, Site U1396C) and the Aleutian Islands (IODP Exp.323, Site U1339D) suggest that concentrations of amides and other nitrogen-based compounds are consistently higher in tephra than surrounding sediments (Figure 1). The source of these compounds is unclear, although it is noted that one of the abundant amide compounds, 13-docosenamide is found in plastic core liner and as such may be a contaminant. However, other studies have suggested that this and other similar compounds may result from various bacteria (Kim et al. 2000; Knicker et al. 1996). We cannot unequivocally exclude the potential for contamination, but all the samples in this study were treated in an identical fashion, from shipboard sampling to laboratory analysis and the amide compounds were only detected in quantifiable amounts in the tephra-rich samples at both sites. Regardless of the source, the fact that these compounds are found in significantly higher concentrations within the tephra compared to the sediments suggests tephra exhibit unique properties in the marine realm. Either tephra are a habitat for distinct microbial species, or they represent an environment with the potential for enhanced organic matter preservation. Lalonde et al. (2012) linked enhanced organic nitrogen preservation to reactive iron species, most likely via complexation. It is known that >20% of organic carbon in non-volcanogenic marine sediments is bound to reactive iron species, which aids in preservation of organic matter in the marine realm (Kaiser & Guggenberger 2000, Lalonde et al. 2012). This observation is consistent with organic carbon and reactive metal data from our study which suggests that tephra is indeed aiding the preservation of organic carbon, with lipid data potentially indicating this may be occurring through amide-iron complexation.

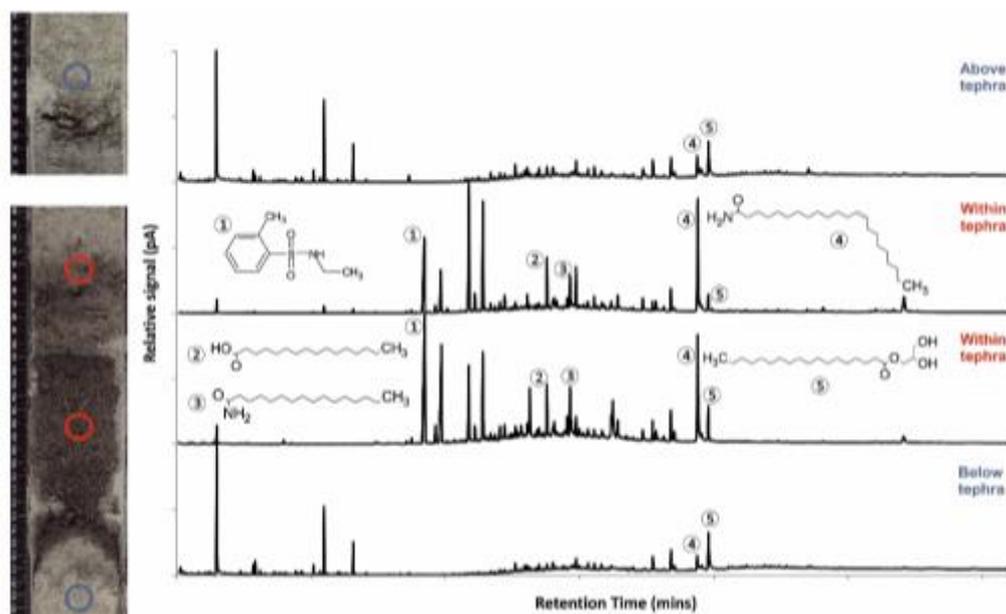


Figure 1 Example total ion chromatograms from Site U1396C showing the total organic extracts for sediments above, within and below a tephra layer dated as 2.4Ma

Conclusions

Results suggest that tephra represent a unique environment in the marine realm, either as an enhanced preservation of labile organic compounds. In either case, this observation demonstrates the utility of tephra layers in the marine environment and their likely contribution to carbon cycle dynamics.

References

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