Final report

ECORD Research Grant

Pantelleria volcano proximal-distal tephra correlations using site 964 of ODP leg 160

Introduction

Pantelleria is a volcanic island between Africa and Sicily and is known for being the only recently active peralkaline volcano in the Mediterranean region. It has been active since ~324 ka and has produced several caldera-forming ignimbrites after 200 ka (e.g. Mahood & Hildreth, 1986). Due to the unique composition of its eruptive products it is ideally suited to contribute marker horizons to the tephrostratigraphy framework of the Mediterranean region. This framework is used for dating palaeo-environmental records which help understand the timing and rates of environmental transitions such as palaeo-atmospheric circulation patterns (e.g. Lane et al., 2012). Further afield, tephrochronology has been used to date activities and movements of early hominins in Africa, Asia and Oceania (Lowe, 2011). In the Mediterranean Region, tephra layers have also been used to assess potential ecological and global climatic impacts produced by large explosive eruptions and a better estimation of their eruption volumes (e.g. Narcisi & Vezzoli, 1999).

Tephra layers thought to derive from Pantelleria have been found in several sites and drill cores, the furthest of which is in Greece, circa 1100 km east of the island (Margari et al., 2007). While some distal tephra samples have been correlated with the proximal eruption record (e.g. the 46 ka Green Tuff Formation), many proximal-distal correlations have been hampered by a lack of stratigraphic and geochemical control of both the proximal and distal records. For example, the 46 ka Green Tuff Formation is well established in the distal realm and is found in eight different archives, indicating an ENE dispersal direction (Jordan, 2014). However, further back in time correlations become more scarce and tentative. The second most widespread tephra layer is thought to correlate to the 123 ka Cinque Denti Formation, however both the distal and proximal ages are poorly constrained and there is some mismatch in the chemical data (Jordan, 2014). New data from a nearby core should help clarify these relations; site 964 (ODP leg 160) has been chosen for this as it is situated at a suitable distance (400 km) downwind from Pantelleria (Figure 1).

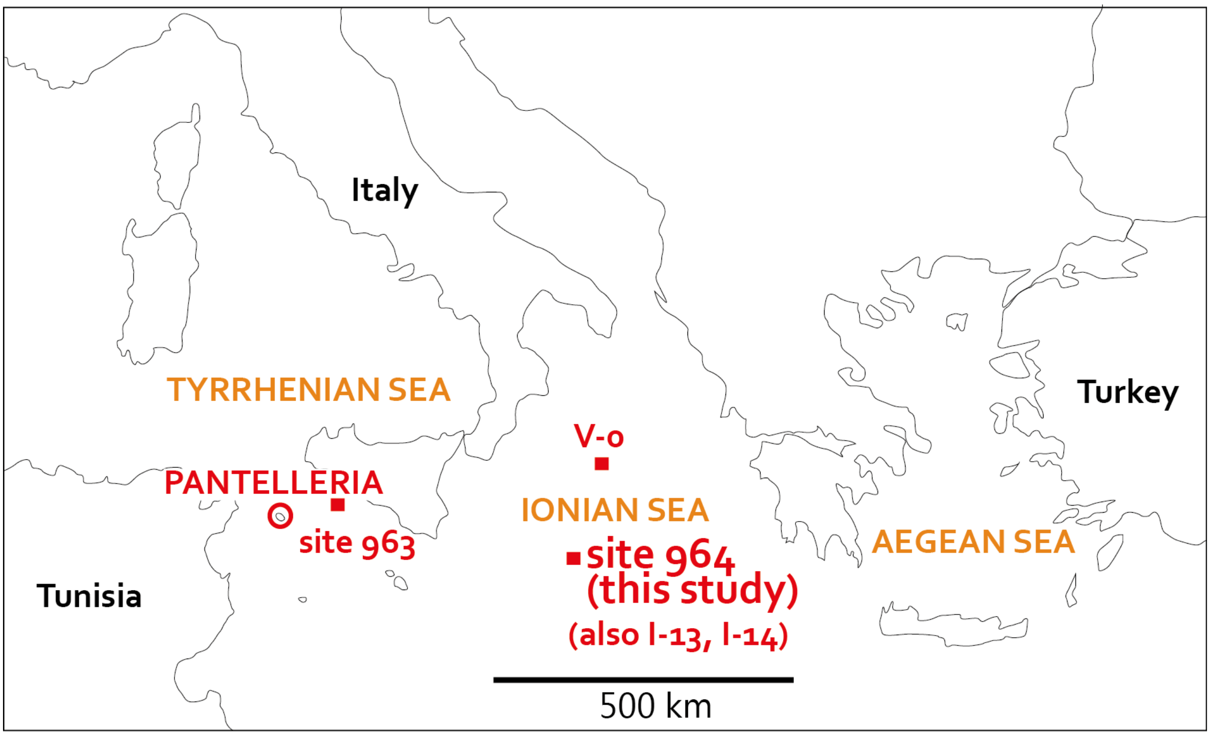

Figure 1. Location of ODP Leg 160 Site 964 (sampled in this study) in the Mediterranean Sea. Also shown are core locations from selected published tephra thought to relate to Pantelleria activity.

Sampling & results

Visible tephra layers were identified in the age range 46 to 200 ka following the revised composite depth section of Sakamoto et al. (1998), to overlap with the onshore ignimbrite ages. Sapropel ages of Lourens (2004) were used to bracket the appropriate sediment ages and depths, and unpublished XRF data were consulted to help guide sampling (Yulong Zhao, pers. comm.). A total of 29 samples were taken from 17 visible ash layers. These were rinsed, sieved and mounted in epoxy. After pre-screening with SEM-EDS, only the Pantelleria glass shards were analysed by EMPA at RWTH Aachen University, Germany.

Of the 29 samples, only two turned out to have the typical chemical signature from Pantelleria. These were from the top and bottom of a layer at 75-80 cm in hole A, core 2, section 3, directly overlying sapropel S6. This had been dated at 172 ka (Lourens, 2004) and has recently been re-dated to between 133 and 163 ka (Bourne et al., 2015).

Discussion & further work

A single tephra layer from Pantelleria in this composite section is unusual, when up to nine layers were expected. This raises important problems about the non-uniform distribution of tephra layers on the seafloor, in line with results elsewhere (e.g. Allan et al., 2008).

The ODP tephra has chemical affinities with both the 123 ka Cinque Denti and the 181 ka Polacca Formation (Figure 2). Chemically, the match is better with the Cinque Denti Formation. However, in terms of other distal tephras, the match is better with distal equivalents of older tephras (Figure 3), making the Polacca Formation a possible match. The age of S6 is therefore crucial to resolving which proximal eruption this tephra originated from: an older age of S6 (>170 ka) would mean this tephra could be the equivalent of the Polacca Formation, whereas a younger age (140-150 ka) would make it more likely a distal equivalent of the Cinque Denti Formation.

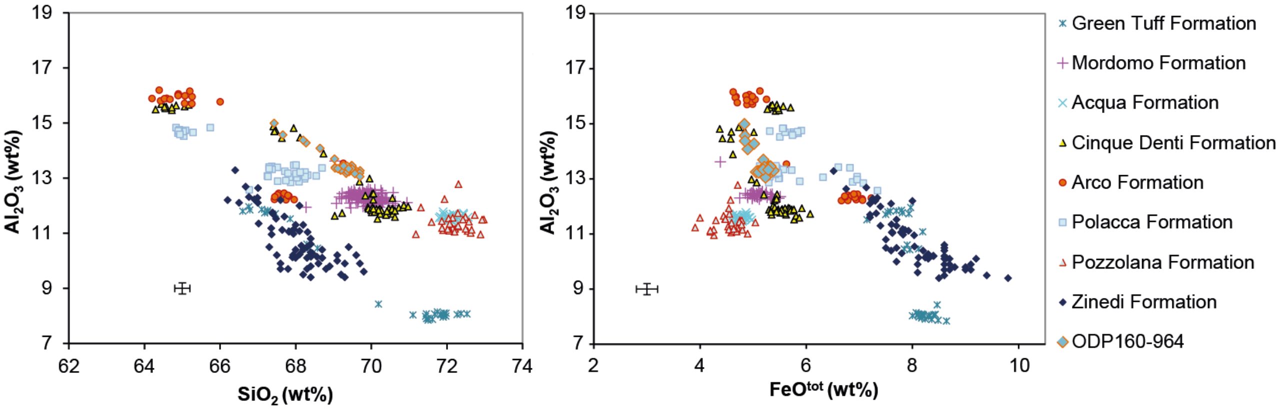

Figure 2. Comparing the composition of tephra in core ODP160-964 to proximal explosive eruptions from Pantelleria (Jordan, 2014). The closest match is with the ~130 ka Cinque Denti Formation and the ~180 ka Polacca Formation.

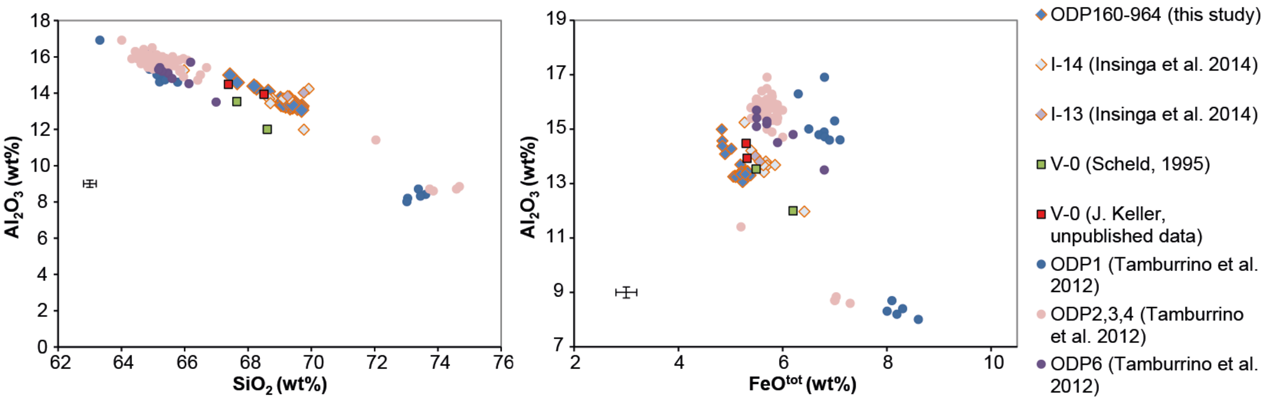

Figure 3. Comparing the composition of tephra in core ODP160-964 to distal Pantelleria tephras from the literature. Both plots show a good match with V-0, I-13 and I-14, also from the Ionian Sea. Tephras ODP1-6 from Tamburrino et al. (2012) are from a core in the Strait of Sicily, 100 km NE of Pantelleria.

Further work could undertake trace element analysis to allow better separation and proximal-distal correlation of layers. Also, it would be interesting to resolve which eruptions the 27 other samples may derive from; likely candidate volcanoes include Etna, Vesuvius & the Aeolian Islands.

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Appendix 1: Cost breakdown

Travel to Bremen Core Repository (incl. accommodation): GBP 377.61
Travel to RWTH Aachen microprobe lab: GBP 221.50
Laboratory expenses, University of Leicester (SEM-EDX, thin sections): GBP 822.00

Appendix 2: Poster presented at EGU Vienna, 17-22 April 2016

Marine-continental tephra correlations (Pantelleria (Italy) and Ionian Basin): the potential for Mediterranean marker horizons

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Introduction & aims

Explosive volcanic eruptions may disperse tephra over large areas, leading to its deposition in various distal archives such as seafloor sediment, lakes or cave deposits. Since they represent isochrons (horizons of the same age) they have been used to date palaeo-environmental and archaeological records and to understand the timing and rates of environmental and climate transitions. There is, thus, a need for widespread chemically distinctive tephras that can link several archives, in particular for the time >50 ka.
Pantelleria is ideally suited to this end as its eruptions are chemically unique in the Mediterranean Region and occur >1000 km away from source. It is located in the central Mediterranean Sea to the SW of Sicily.
Two of its explosive eruptions are already well-known in the distal sediment record: the 46 ka Green Tuff Formation (e.g. Scaillet et al., 2013) and the ~130 ka Cinque Denti Formation (Jordan, 2014).
Here, I present new data from a previously un-analysed core to extend the tephra record further back in time.

Core location & sample treatment

The core is from the Ionian Basin east of Sicily, ~400 km distance from Pantelleria (ODP leg 160, site 964; Fig. 1). All visible tephra layers in the appropriate age range (<300 ka) have been sampled in the revised composite depth section of site 964 (after Sakamoto et al., 1998). A total of 29 samples were rinsed, sieved and mounted in epoxy. After pre-screening with SEM-EDS, only the Pantelleria glass shards were analysed by EMPA at RWTH Aachen University, Germany.

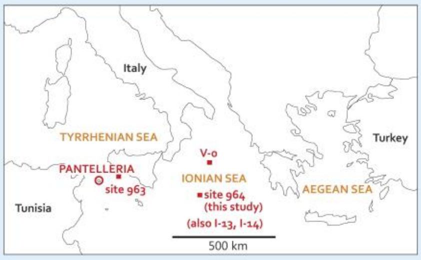

Fig. 1: Core location for ODP160, site 964 in the Mediterranean Sea, ~400 km downwind from Pantelleria. Also shown: core locations from selected published tephra thought to relate to Pantelleria activity (see Fig. 5).

Fig. 2: Geological context of the tephra layer from Pantelleria found in ODP leg 160, site 964. It overlies sapropel S6 which is thought to be 172 ka old (Lourens, 2004).

Results

Several tephras had been expected but only one tephra layer from Pantelleria (Fig. 2) was found in this core: hole A, core 2, section 3, 75-80 cm (at 10.65-10.70 revised meters composite depth). It directly overlies sapropel 4 (S6 of Lourens, 2004) which is dated at 172 ka. However, based on a new age model this was recently revised to between 163 and 133 ka by Bourne et al. (2015).

Chemically, the ODP964 tephra is unequivocally from Pantelleria (Fig. 3) and, more specifically, it matches with both the ~130 ka Cinque Denti Formation and the ~180 ka Polacca Formation (Figs. 4 & 5). The age of S6 is therefore crucial to resolving which proximal eruption this tephra originated from: an older age of S6 (>170 ka) would mean this tephra could be the equivalent of the Polacca Formation, whereas a younger age (140-150 ka) would make it more likely a distal equivalent of the Cinque Denti Formation.

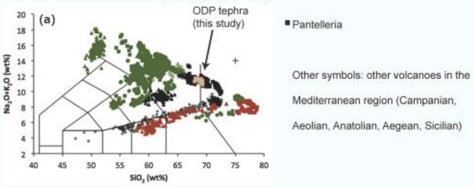

Fig 3. Classification diagram for volcanic rocks showing compositional affinity of the ODP tephra (36 analyses) with Pantelleria (other compositions from Tomlinson et al., 2015)

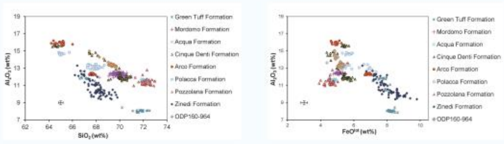

Fig 4. Comparing the composition of tephra in core ODP160-964 to proximal explosive eruptions from Pantelleria (Jordan, 2014). The closest match is with the ~130 ka Cinque Denti Formation and the ~180 ka Polacca Formation.

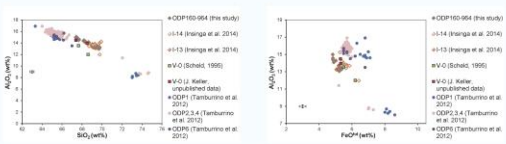

Fig 5. Comparing the composition of tephra in core ODP160-964 to distal Pantelleria tephras from the literature. Both plots show a good match with V-0, I-13 and I-14, also from the Ionian Sea. Tephras ODP1-6 from Tamburrino et al. (2012) are from a core in the Strait of Sicily, 100 km NE of Pantelleria.

How to contact me
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Conclusions

- Pantelleria tephras predominantly get dispersed to the E and NE
- Only one Pantelleria tephra found in Ionian Sea core (ODP160, site 964), in line with published studies from nearby cores
- More high quality chemical analyses and Ar-Ar dates are needed from distal tephras and sapropels to enable unequivocal proximal-distal correlation

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Acknowledgements
Sampling at the IODP core repository in Bremen was funded by a ECORD Research Grant.
Microprobe analyses were kindly provided by IML in Aachen for free.
This project follows on from my PhD with Mike Branney, Mike Norry and Rebecca Wiliams.

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