Review of Barbante et al Greenland ice-core evidence of the 79 AD Vesuvius eruption

General comments

This paper outlines new evidence that suggests particles originating from the 79 AD Vesuvius eruption are preserved within a Greenland ice-core. A distinct acid peak dated to 80 AD in Dye-3 has been previously suggested to relate to the Vesuvius eruption (Clausen *et al*. 1997) and this distinct peak is also seen in GRIP and has been given a revised age of 79 AD in the GICC05 chronology (Vinther *et al.* 2006). This is the only major volcanic signal observed in the ice between 60 and 90 AD and so it is reasonable to relate this acid peak to the high-magnitude Vesuvius eruption of 79 AD. To test this, the authors investigate the geochemical composition of particles extracted from the ice in association with this acidity peak – a key approach that allows the source volcano to be determined. Six volcanic glass particles are identified and analysed by SEM-EDS technique and although there is scatter within the major element dataset, the authors believe that the geochemical signatures shows affinity to the Vesuvius AD 79 eruption. The particles are found within ice that is thought to equate to the summer of AD 79, whereas the acid peak and sulphate peak falls within the summer of AD 80. The authors believe that this offset reflects the differential deposition pathways of volcanic particles and volcanic aerosols. They suggest that volcanic particles are likely to be deposited first and then followed by the volcanic aerosols. This is a key observation that leads the authors to conclude that the acid and sulphate peaks are indeed dated to 80AD.

The paper is well-presented, but I feel that further consideration is required of the geochemical composition of the volcanic particles. These data are critical to the overall conclusions: 1. assigning the acid peak and particulate material to the Vesuvius AD 79 eruption and 2. relating the acid peak to AD 80 rather than AD 79. Thus, a geochemical consideration of all possible volcanic correlatives is required. I believe that the authors need to provide further description and discussion of the geochemical data in order to demonstrate their correlation to Vesuvius AD 79. The approach to test the origin of a volcanic aerosol peak, utilised within the ice-core chronological framework, via investigation of the associated particulate material is commendable and I believe that it should be published following minor revision. These revisions should particularly focus on strengthening and elaborating the discussion on the geochemical correlation to Vesuvius 79 AD.

Specific comments

Tephra geochemistry

A key consideration of this paper is whether the major element data presented supports a correlation to Vesuvius AD79. To explore this, my comments relate to the analytical approach adopted, the presentation and interpretation of the data.

1. The authors recognise the problems that can arise with the use of SEM-EDS technique, especially on samples that are not polished and not embedded within a mounting media (5436, line 20). As such I feel that the authors need to provide further information on the quality of the data, particularly in relation to the certified mineral and glasses used as reference standards. Ideally, these should be presented alongside the analyses presented in

Table 1. I also agree with the comments of Kurbatov requesting information on the SEM operating conditions and analyses of reference material from Vesuvius.

2. An assessment of the data presented in Table 1, clearly shows that there is scatter within the data-set. In particular Particle 1 and 2 seem to be offset from particles 3-6. To explore this, I quickly plotted the data in Table 1 on biplots relative to the data presented by Santacroce *et al.* 2008 (see below). These plots emphasise the compositional heterogeneity of Vesuvian products, but also highlights some offsets between the new data and the reference data-set. This is most clearly seen in the TiO_2 values, and SiO_2 and FeO values on Particle 1 and 2. Particles 1 and 2 in particular seem to be offset from the other analyses with low FeO values and slightly higher SiO_2 values. It would be useful if the authors could explore this by using such graphical plots and consider the likely reasons for the offsets shown. Other plots do show consistency between the data-sets e.g. Ca vs K_2O, total alkali silica plot (for 4 of the particles), Ca vs SiO_2 (for 4 of the particles) which in most instance shows a correlation to the white pumice component of the Vesuvian proximal deposits. However, a discussion of the offsets is required. Do all particles relate to the Vesuvius 79 AD eruption?
3. The box plots as shown are not easy to interpret and it is unclear what the different boxes represent - mean, median, minimum and maximum values? What do the blue, green and orange boxes represent? Also there are faint circles plotted above and below each box – what do these represent? This is an all-inclusive way of observing possible matches within 6 key major elements but I would prefer to see the authors also presenting these data on biplots (see above) so that the compositional heterogeneity that they mention is schematically shown. I would also urge the authors to plot the geochemical composition of other major eruptions between 50-100 AD. Although other volcanic candidates are listed in Table 2, their geochemical compositions are not shown. The authors state that the tephra composition is consistent with K-phonolitic composition of the Vesuvius juvenile ejecta and differs from the chemical composition of other major eruptions between 50-100 AD. It would be helpful to see this observation on the geochemical figures.
4. The authors recognise the compositional heterogeneity of Vesuvius AD79 products which is thought to be related to the presence of microlites. It is stated that there are no microlites within the analysed particles but I would like the authors to elaborate on this. How was this assessed?
5. It would be useful to provide information on the shard size and morphology (see also comments by Andrei Kurbatov). Inclusion of SEM images would also be beneficial.
6. Sanidine fragments were also recovered with the volcanic glass particles. Is it also possible to include these data in Table 1?
7. I am intrigued by the second peak in microparticles which falls before the acid and sulphate peak (Figure 2). Elemental compositions reflect the input of continental crust, but can the authors offer an explanation of what may have cause a sharp and sudden peak in particulate material? Are such events common during the Late Holocene?
8. Page 5434 paragraph 1. I would like the authors to comment on the dispersal of this tephra to Greenland. As stated on page 5433 the main eruptive products were dispersed in SSE/SE dispersal trajectory and I think it would useful for the author's to elaborate on the most likely transport pathway to Greenland.

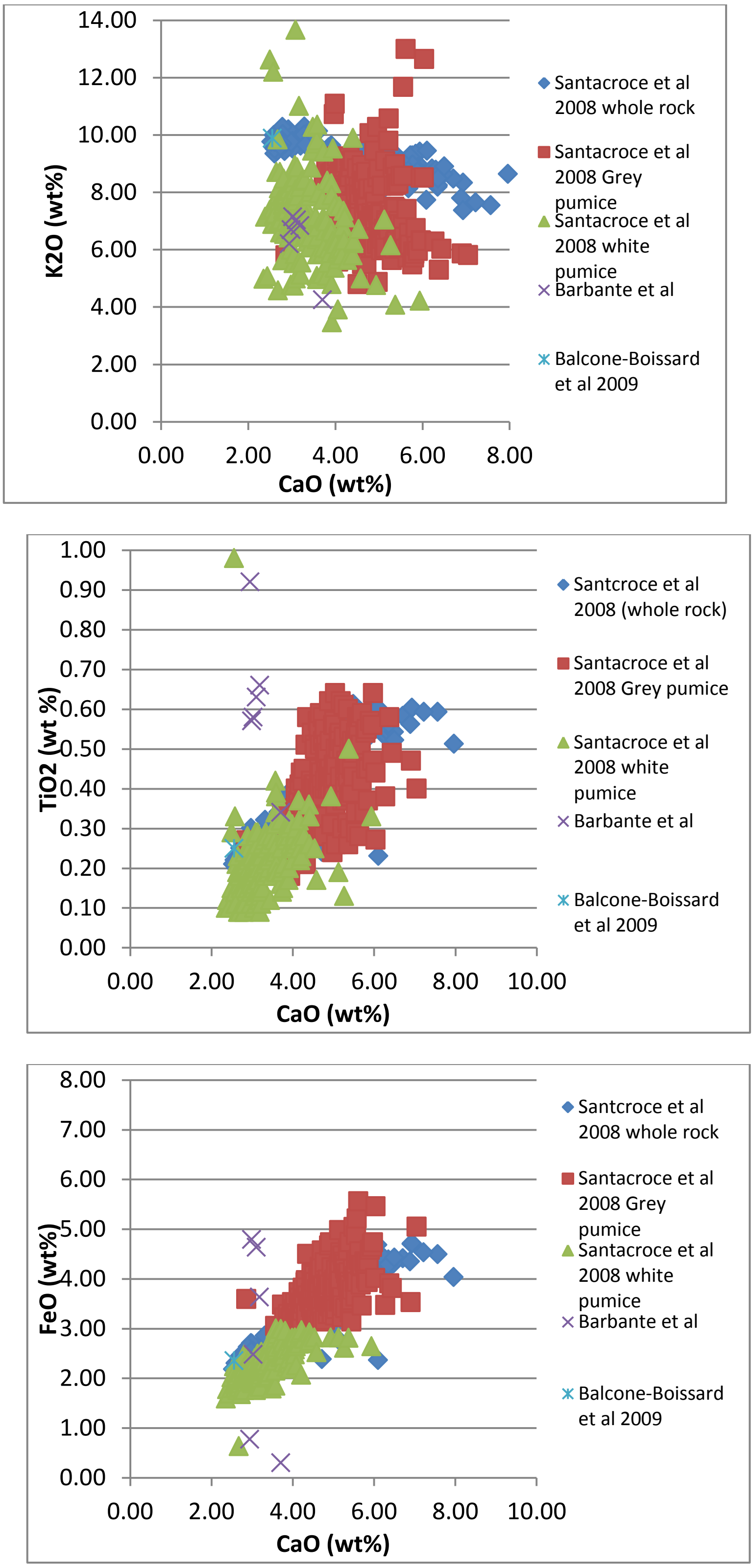
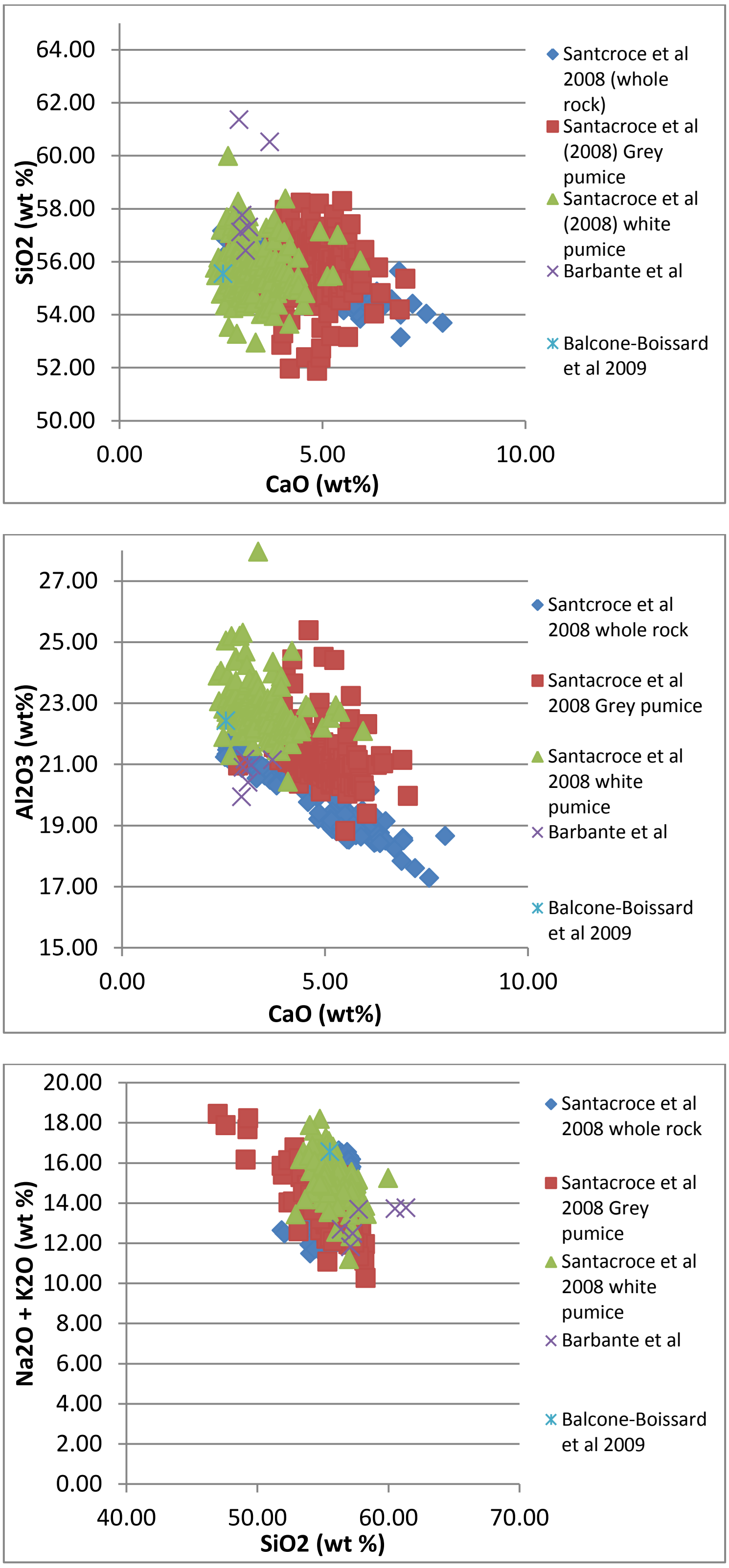


Figure 1 Biplots showing comparison of the new data presented in Table 1 (Barbante *et al*) and whole-rock and pumice data for proximal deposits of Vesuvius AD 79 (Santacroce *et al.* 2008 – see Figure 8 of this reference). Also shown is the mean value for Vesuvius white pumice deposits from Balcone-Boissard *et al.* 2009.



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Technical comments

1. Introduction. A comprehensive reference for recent tephrochronological work is Lowe *et al.* (2011).
2. Page 5432 line 9 & 20 correct spelling of volcanoes.
3. Page 5432 line 1 insert hyphen in ice-core stratigraphy
4. Page 5432 paragraph 2, page 5438 line 18-20, page 5439, line 11. The use of Davies *et al.* (2010) as a reference here is not quite correct. Although an offset between the tephra position and a sulphate peak was shown in this paper, these were thought to be unrelated as the differential age of the tephra and sulphate peak was around 12 years. Davies *et al.* (2010) mostly emphasised that tephra horizons can be present within the ice without a large sulphate signal, rather than showing high resolution offsets between tephra and sulphate aerosols.
5. Page 5432 paragraph 2 – you may want to consider including some additional more recent references e.g. Lane *et al*. 2011; Abbott *et al*. 2012.
6. Page 5434 line 6 correct spelling of stratigraphic.
7. Page 5438 line 22 correct spelling of Vesuvius.
8. Page 5439 line 12 correct spelling of stratigraphically
9. Page 5439 line 20 correct spelling of references within.
10. Page 5440 line 25 spelling of neighbouring.
11. Page 5441 line 16 correct spelling of plinian.

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