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Climate of the Past Discussions



# *Interactive comment on* "Greenland ice core evidence of the 79 AD Vesuvius eruption" *by* C. Barbante et al.

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Comment on Barbante et al. 2012

Introduction In this new paper the results of the analysis of tephra shards from the alleged AD 79/80 layer in the GRIP ice core have been presented for discussion. The results presented are not in themselves sufficiently robust to definitively answer the question raised by Baillie (2008; 2010) as to whether, or not, the Danish ice core workers correctly attributed the acidity layers at depth 780.75 m in the Dye3 core and at depth 429.1 m in the GRIP core to AD 79/80 (Clausen et al. 1997). These decisions, on the dating of acid layers and their attribution to Vesuvius, were made originally without the benefit of tephra analysis and therefore must have formed something approaching an educated guess. This comment on the present paper relates to the chronological

trap the ice core workers may have set for themselves when they chose an acid layer (we can accept that the acid layers in Dye3 and GRIP are part of the same layer) and attributed it to Vesuvius; thus introducing a fixed date into their otherwise potentially flexible chronology. Discussion By choosing an acid layer and attributing it to Vesuvius AD 79 the ice workers made a decision that had to be either precisely correct, or wrong (Clausen et al. 1997; Vinther et al. 2006). To discuss this we have to imagine the consequences if they made the wrong decision, and had actually picked an innocent (unknown) acid layer some years (possibly not very many years) from AD 79. Obviously in this case the layer would not originate from Vesuvius, which is fixed in time historically. However, one consequence of designating an acid layer to Vesuvius was that the amount of acid output – estimated in this case to be 40 to 50 Mt – then became attributed to Vesuvius. This large acid peak, attributed to Vesuvius, in turn made it more likely that evidence for that eruption might have been expected to turn up in Greenland. Yet the circularity in this reasoning seems to have gone unnoticed. After all, in the absence of a major acid peak with identifiable tephra, definitively from Vesuvius, there was never any guarantee that a medium-scale mid-latitude eruption like Vesuvius would be represented in Greenland by either sulphur or tephra. Choosing an acidity and attributing it was underlain by an implicit, but unwarranted assumption that Vesuvius would have put acid into Greenland. It was a decision, once made, from which no retreat was possible. Let us turn to the current paper where acid and tephra have both been located across depth 428.4 to 429.6 m in the GRIP core. The sulphate spike attributed to Vesuvius is centred on 429.1m and is notably separate from the layer containing the tephra particles at 429.3m; a full year earlier. Indeed it is noted that these two layers are separated by a micro-particle layer from 429.25 to 429.15m. So there are three layers and they are presented in Figure 2 as separate, with the tephra occurring in the centre of the 18O profile for “summer AD 79”, while the sulphur peak occurs after the centre of the 18O peak for “summer AD 80”. It is at this point that forcing the event to be Vesuvius comes under serious stress. First, there can be no absolute guarantee that the tephra and the acid need to be from the same volcano.



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It is now known (Davies et al. 2010; Coulter et al 2012) that tephra can occur in the ice record without acid and vice versa. Thus any discussion, as we have here, of separate acid and tephra layers must include an acknowledgment that they could derive from different volcanoes. It is therefore special pleading to invoke these two GRIP layers, 20cm apart, as necessarily deriving from a single eruption. In particular, given that it is well accepted that the Vesuvius eruption took place over about two days in later AD 79 (current consensus September or October 79), how could a discrete pulse of tephra travel to Greenland and be deposited in the middle of the 18O summer of AD 79? It has to be remembered than in Figure 2 there is no chronological flexibility; the oxygen, micro-particle and acid measurements are all made on ice which is tightly constrained stratigraphically and hence chronologically. Indeed, how could Vesuvius tephra arrive as a discrete spike in the middle of a summer under any circumstances? We can therefore rule out Vesuvius as the source of the tephra analysed in this paper at 429.3m, which leaves us with a free standing acid spike at 429.1m, which, on its own, could not be definitively attributed to any volcano. Thus without even discussing the tephra analyses, but merely looking at chronological issues, Figure 2 tells an observer that the tephra at 429.3m in GRIP cannot be from Vesuvius, while the acid at 429.1m could be from anywhere and need not be from Vesuvius. The critical link between the ice core chronology and the Vesuvius eruption which has provided a key tie-down point for the whole chronology (Vinther et al. 2006) is therefore broken. Elsewhere I have shown evidence, involving links between ice acidities and bristlecone pine frost rings in the 6th century AD that would suggest that the GRIP chronology should be moved forward in time by around 7 years (Baillie 2008). Such a move would have the advantage of moving another large ice acidity around 50 BC (Clausen et al. 1997) down to around 44-43 BC where it would fall coincident with another bristlecone pine frost ring at 43 BC (Salzer and Hughes 2007) and with the dust veil associated with the death of Caesar in 44 BC. Until now the prospect of GRIP being absolutely tied at AD 79 has precluded acceptance of this suggested forward move. Now, with the weakness of the Vesuvius link to Greenland ice exposed, links to tree ring chronologies may be the only way to



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impose an absolute chronology on the ice cores.

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