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Quartz microstructures in the Younger Dryas boundary layer ∼12.9 ka.

A. van Hoesel (1,2), W.Z. Hoek (2), G.M. Pennock (1), and M.R. Drury (1)

(1) Utrecht University, Department of Earth Sciences, Utrecht, Netherlands (a.vanhoesel@uu.nl), (2) Utrecht University, Department of Physical Geography, Utrecht, Netherlands

In 2007, Firestone et al. proposed that an extraterrestrial impact occurred at the end of the Allerød interstadial, destabilizing the North American ice sheet and initiating the colder Younger Dryas (YD) stadial. Up to now, the evidence for this proposed impact has been heavily debated (Pinter et al., 2011) and no one has been able to provide convincing evidence in favour of the hypothesis. Two years later, Mahaney et al. (2009) claimed that they had frequently found planar deformation features (PDFs) in quartz from a possible YD boundary layer in Venezuela. However, the data presented consisted of an SEM image of the surface of a quartz grain only, and in following work Mahaney et al. (2010) stated that they had found no irrefutable evidence of PDFs. Instead, they showed grains with oriented cracks along their edges, which they claimed to be related to the 'mass impact and extreme heat' from incoming ejecta material. However, oriented cracks are not accepted evidence for an impact (French, Koeberl, 2010).

We investigate the quartz fraction of samples from the European Usselo horizon, an Allerød-YD age soil, as well as one sample from the North American Black Mat, which marks the onset of the YD. Possible shocked quartz grains were isolated using density separation, mounted in epoxy and polished. No evidence for oriented cracks along grain edges, like those reported by Mahaney et al. (2010), has been found so far.
Transmitted light microscopy showed that a number of grains contained tectonic deformation lamellae. One grain from the Usselo horizon contains at least two sets of closely spaced, straight, and narrow lamellae, similar to PDFs. In SEM-CL imaging however, only some of these lamellae showed up as non-luminescent, while most had the same intensity as the host grain. This is not typical for PDFs (Hamers, Drury 2011). It is possible that these lamellae represent planar fractures, which also form by low pressure shock processes.

It must be noted that even if these closely spaced features are indeed shock related, one or two grains do not prove the YD impact hypothesis. Although, the quartz in the YD boundary layer is derived from regional aeolian activity, their source material was transported to the area by major rivers systems or the Scandinavian ice sheet. It is thus possible that these grains were eroded from an older crater or impact horizon. Furthermore, low shock level deformation might also occur during a large volcanic eruption. In that case, the planar features we find might possibly be related to the colossal Laacher See eruption (Van den Bogaard, Schminke, 1985), which occurred only two centuries before the onset of the YD.

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