Charcoal in soils of the Allerød-Younger Dryas transition were the result of natural fires and not necessarily the effect of an extra-terrestrial impact

van der Hammen, T.; van Geel, B.

Published in:
Geologie & Mijnbouw

DOI:
10.1017/S0016774600023416

Netherlands Journal of Geosciences — Geologie en Mijnbouw | **87 – 4** | **359 - 361** | **2008**

Geo(Im)pulse

Charcoal in soils of the Allerød-Younger Dryas transition were the result of natural fires and not necessarily the effect of an extra-terrestrial impact

T. van der Hammen[1] & B. van Geel[2]

1 Apartado 090, CHIA (Cundinamarca), Colombia.

2 Corresponding author. Institute for Biodiversity and Ecosystem Dynamics, University of Amsterdam, Kruislaan 318, 1098 SM Amsterdam, the Netherlands. Email: B.vanGeel@uva.nl

Manuscript received: October 2008; accepted: November 2008

Abstract

During the warm Bølling-Allerød interstadial, tree species migrated from their refugia in southern Europe northwards into the area within the present temperate climatic zone. It is evident from high levels of charcoal in fossil records in this region that, especially during the later part of the Bølling-Allerød interstadial, many fires occurred. The start of the Younger Dryas was characterised by rapid and intense cooling and rising water tables, with catastrophic effects on the vegetation. Thermophilous pine trees could not survive the cold Younger Dryas climate. Dead wood provided an abundant source of fuel for intense, large-scale fires seen in many records as a concentration of charcoal particles in so-called 'Usselo-soils' dated to ca 10,950 ^{14}C BP. A similar trend in increased charcoal indicating increased burning is seen at many sites across North America at this time and it has been suggested by Firestone et al. (2007) that this was caused by an explosion of extra-terrestrial material over northern North America, causing the Younger Dryas climate cooling and Megafaunal extinction. We argue that there is no need to invoke an extraterrestrial cause to explain the charcoal in the fossilized soils. The volume of forest trees that died as a result of the cold Younger Dryas climate would easily have supplied sufficient fuel for intense, large-scale fires and can be used to account for the concentration of charcoal particles. As soils were no longer covered by dense vegetation, much erosion occurred during the Younger Dryas and therefore, at many places, Usselo soils, rich in charcoal, were preserved under aeolian sand dunes.

Charcoal in soils of the Lateglacial interstadial

The rapid climatic shifts during the so-called Lateglacial period (ca 12,500 - 10,150 radiocarbon yr BP) were first discovered, and have been most intensively studied, in the northern hemisphere, especially in northwestern Europe (Iversen, 1947; van der Hammen, 1951; van Geel et al., 1989; Bohncke, 1993; Björck et al., 1998; Yu & Eicher, 1998; Walker et al., 2001; Lowe et al., 2008; Steffensen et al., 2008; Hoek, 1997, 2008; Brauer et al., 2008). According to van der Hammen (1951, p. 120) forest fires occurred after the shift from relatively warm interstadial climatic conditions to much colder conditions at the Allerød-Younger Dryas transition:

"At the end of the Allerød-time there were, at first, nearly closed forests of pine and birch. Forest fires are reflected in the pollen diagrams, while also especially the charcoal and the half carbonized tree trunks point in that direction. Forest-fires must have occurred rather often and over larger regions since, also in many other places in the eastern and northern provinces (of the Netherlands) a fair amount of charcoal of Pinus was found in the 'Usselo-layer' (soil formed during Allerød period). At any rate it seems likely that towards the end of the Allerød-time the possibility of originating and expansion of forest-fires had increased. In the first place, because the pine-forest must then have been much more extensive than at the beginning of the time. Later, an increasing number of trees and amongst them possibly especially the pine must have died under the influence of the approaching cold of the Late (= Younger) Dryas-time."

Later the Usselo soil layer formed during the Allerød period was found in many parts of Europe, from the Netherlands (Kasse, 1999) to Germany (Schlaak, 1997) and Poland (Manikovska, 1994; Kasse, 2002). Radiocarbon dating of charcoal from pine found in these soils at many sites consistently produced ages of around ca. 10,950 ^{14}C BP (Hoek, 1997). The sudden onset of the cold conditions of the Younger Dryas caused the death of many trees, bringing about the demise of pine forests.

Firestone et al. (2007; see also Kloosterman, 2007) interpreted a carbon-rich black layer, contemporaneous with the onset of the Younger Dryas and extinction of the Pleistocene megafauna, which is present at approximately 50 sites across North America as resulting from an explosion of one or more extraterrestrial objects over the northern part of that continent and subsequent extensive biomass burning. The supposed extraterrestrial impact should have triggered Younger Dryas cooling and megafaunal extinctions. Haynes (2008) interpreted 'black mats' of mollic paleosols, aquolla, diatomites or algae radiocarbon dated to the Allerød-Younger Dryas transition as 'stratigraphic manifestations' of the cooler Younger Dryas climate which resulted from a rise in local water tables caused by more effective recharge. He also questioned the evidence presented by Firestone et al. (2007) for an extraterrestrial impact, noting that the microspherules and micrometeorites they cite are components of cosmic dust that constantly fall to earth making an 'impact' difficult to distinguish on this basis alone. Marlon et al. (in press) linked heightened fire activity to abrupt climate changes in the past. Fire regime changes during the Last Glacial-Interglacial transition appeared to be strongly associated with changes in climate and fuels. They concluded that rapid climate change may impose widespread stress on ecosystems that increases disturbance and synchroneity in fire episodes.

Fig. 1. Usselo soil in Weelde, Belgium (photo C. Kasse).

We suppose that the evidence for forest fires contemporaneous with the onset of the Younger Dryas in North America should be recognised as resulting from the same phenomenon that was discovered sixty years ago in Europe; that is, sudden cooling producing a large quantity of dead, dry biomass which was in turn consumed by natural large-scale forest fires. Given the fact that natural fires in boreal forests at present take place with a frequency of 50 - 200 years, charcoal particles present in deposits formed during the Allerød period should not be regarded as peculiar. It is highly questionable that an extraterrestrial impact over North America could have caused large-scale forest fires in northwest Europe. Studies of Greenland ice cores, of very high temporal resolution, show that climate change during the Lateglacial period occurred very rapidly (Steffensen et al., 2008). Brauer et al. (2008) presented sub-annual records of varve microfacies and geochemistry from Lake Meerfelder Maar in western Germany, providing one of the best dated records of the Allerød-Younger Dryas climate transition. Their data indicate an abrupt increase in storminess during the autumn and spring seasons, interpreted as an abrupt change in North Atlantic westerlies towards a stronger and more zonal jet, in combination with a change in the North Atlantic Ocean overturning circulation and reduced transport of heat to western Europe, and a southward advance in sea ice.

Conclusion

Rapid climate change from interstadial to cold climatic conditions at the start of the Younger Dryas caused enormous quantities of dead biomass that supplied sufficient fuel for intense, large-scale fires. The charcoal formed during forest fires was deposited on soil surfaces of that time. After the fires, wind erosion of soils – not longer covered with vegetation – occurred and elsewhere soils with charcoal were covered and archived after deposition of aeolian sand. There is no need to interpret the evidence for large-scale fires at the Allerød-Younger Dryas transition as the effect of an extraterrestrial impact.

Acknowledgements

The authors thank Wim Hoek, Kees Kasse and Pierre Richard for comments.

References

Björck, S., Walker, M.J.C., Cwynar, L., Johnsen, S.J., Knudsen, K-L., Lowe, J.J., Wohlfarth, B. & INTIMATE Members, 1998. An event stratigraphy for the Last Termination in the North Atlantic region based on the Greenland Ice Core record: a proposal by the INTIMATE group. Journal of Quaternary Science 13: 283-292.

Bohncke, S.J.P., 1993. Lateglacial environmental changes in the Netherlands: spatial and temporal patterns. Quaternary Science reviews 12: 707-712.

Brauer, A., Haug, G.H., Dulski, P., Sigman, D.M. & Negendank, J.F.W., 2008. An abrupt wind shift in western Europe at the onset of the Younger Dryas cold period. Nature Geoscience 1: 520-523.

Firestone, R.B., West, A., Kennett, J.P., Becker, L., Bunch, T.E., Revay, Z.S., Schultz, P.H., Belgya, T., Kennett, D.J., Erlandson, J.M., Dickenson, O.J., Goodyear, A.C., Harris, R.S., Howard, G.A., Kloosterman, J.B., Lechler, P., Mayewski, P.A., Montgomery, J., Poreda, R., Darrah, T., Que Hee, S.S., Smith, A.R., Stich, A., Topping, W., Wittke, J.H. & Wolbach, W.S., 2007. Evidence for an extraterrestrial impact 12,900 years ago that contributed to the megafaunal extinctions and the Younger Dryas cooling. PNAS 104: 16016-16021.

Haynes, C.V., 2008. Younger Dryas 'black mats' and the Rancholabrean termination in North America. PNAS 105: 6520-6525.

Hoek, W.Z., 1997. Late-glacial and early Holocene climatic events and chronology of vegetation development in the Netherlands. Vegetation History and Archaeobotany 6: 197-213.

Hoek, W.Z., 2008. The Last Glacial-Interglacial Transition, Episodes 31: 226-229.

Iversen, J., 1947. Plantevækst, Dyreliv og Klima i det senglaciale Danmark. Geologiska Föreningens i Stockholm Förhandlingar 69: 67-78.

Kasse, C., 1999. Late Pleniglacial and Lateglacial aeolian phases in the Netherlands. *In:* W. Schirmer, editor, Dunes and fossil soils. GeoArchaeoRhein 3: 61-82.

Kasse, C., 2002. Sandy aeolian deposits and environments and their relation to climate during the Last Glacial Maximum and Lateglacial in northwest and central Europe. Progress in Physical Geography 26: 507-532.

Kloosterman, J.B., 2007. Correlation of the Late Pleistocene Usselo Horizon (Europe) and the Clovis Layer (North America). Eos Trans. AGU 88 (23), Jt. Assem. Suppl., Abstract PP43A-02.

Lowe, J.J., Rasmussen, S.O., Björck, S., Hoek, W.Z., Steffensen, J.P., Walker, M.J.C., Yu, Z. and the INTIMATE group, 2008. Synchronisation of palaeo-environmental events in the North Atlantic region during the Last Termination: a revised protocol recommended by the INTIMATE group. Quaternary Science Reviews 27: 6-17.

Manikowska, B., 1994. État des études des processus éoliens dans la région de Lódz (Pologne Centrale). Biuletyn Peryglacjalny 33, 107-131.

Marlon, J.R., Bartlein, P.J., Walsh, M.K., Harrison, S.P., Brown, K.J., Edwards, M.E., Higuera, P.E., Power, M.J., Anderson, R.S., Briles, C., Brunelle, A., Carcaillet, C., Daniels, M., Hu, F.S., Lavoie, M., Long, C., Minckley, T., Richard, P.J.H., Shafer, D.S., Tinner, W., Umbanhowar Jr., C.E. & Whitlock, C. Wildfire responses to abrupt climate change in North America. PNAS (in press).

Schlaak, N., 1997. Äolische Dynamik im brandenburgischen Tiefland seit dem Weichselspätglazial. Arbeitsberichte Geographisches Institut, Humboldt-Universität zu Berlin, Heft 24, 58 pp.

Steffensen, J.P., Andersen, K.K., Bigler, M., Clausen, H.B., Dahl-Jensen, D., Fischer, H., Goto-Azuma, K., Hansson, M., Johnsen, S.J., Jouzel, J., Masson-Delmotte, V., Popp, T., Rasmussen, S.O., Rothlisberger, R., Ruth, U., Stauffer, B., Siggaard-Andersen, M.-L., Sveinbjörnsdóttir, A.E., Svensson, A. & White, J.W.C., 2008. High-resolution Greenland ice core data show abrupt climate change happens in few years. Science 321: 680-684.

Van der Hammen, T., 1951. Late-glacial flora and periglacial phenomena in the Netherlands. Leidse Geologische Mededelingen 17: 71-183.

Van Geel, B., Coope, G.R & van der Hammen, T., 1989. Palaeoecology and stratigraphy of the Lateglacial type section at Usselo (the Netherlands). Review of Palaeobotany and Palynology 60: 25-129.

Walker, M.J.C., Björck, S. & Lowe, J.J., 2001. Integration of ice core, marine and terrestrial records (INTIMATE) from around the North Atlantic region: an introduction. Quaternary Science Reviews 20: 1169-1174.

Yu, Z.C. & Eicher, U., 1998. Abrupt climate oscillations during the last deglaciation in central North America. Science 282: 2235-2238.