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High frequency palaeoenvironmental variability in Last Glacial loess from Nussloch (Germany) dated by radiocarbon of earthworm calcite granules

Olivier Moine (1), Pierre Antoine (1), Christine Hatté (2), Amaëlle Landais (2), Jérôme Mathieu (3), Charlotte Prud'homme (4,1), Denis-Didier Rousseau (5,6)

(1) Centre National de la Recherche Scientifique, Laboratoire de Géographie Physique : Environnements Quaternaires et Actuels, France (olivier.moine@lgp.cnrs.fr), (2) Laboratoire des Sciences du Climat et de l'Environnement, CEA/CNRS/UVSQ, Gif-sur-Yvette, France, (3) Institut d'Ecologie et des Sciences de l'Environnement de Paris, CNRS/Université Paris 6/IRD/UPEC/INRA, Paris, France, (4) Max-Planck-Institut für Chemie, Mainz, Deutschland, (5) Laboratoire de Météorologie Dynamique, CNRS/Ecole Polytechnique/Université Paris 6/ENS Paris, Paris, France, (6) Lamont-Doherty Earth Observatory, Columbia University, Palisades, USA

The climate of the last glacial period (~110-15 ka ago) is characterized by the occurrence of numerous centennial-to-millennial milder phases known as interstadials and triggered by phases of enhancement of the Atlantic meridional overturning circulation (AMOC). According to modelling outputs, contemporaneous atmospheric circulation changes and temperature and precipitation increases impacted Europe. In the Mediterranean domain, this is in agreement with vegetation changes reconstructed from marine and lacustrine pollen records and with isotopic speleothem records, which all benefit from precise chronologies based on radiocarbon and U/Th dating methods.
Further north, in the Great European Plain, the reconstruction of palaeoenvironmental and palaeoclimatic dynamics relies for a long time on the study of periglacial aeolian deposits (loess) in which terrestrial mollusc shells overcome the absence of pollen. Their communities highlight higher humidity and temperatures during the formation of hydromorphic (tundra gleys) or pedogenic (arctic to boreal brown soils) horizons than during the deposition of alternating loess units whose higher grain size values reveal an increased wind dynamics. Comparisons between loess grain size records and Greenland dust records led to correlate these two types of soil horizons with Greenland interstadials (GI) owing to their lower dust content compared to stadials (GS). Nevertheless, luminescence-based chronologies available in Western Europe were still not precise/accurate enough to define an undisputable correlation scheme.
In West-European loess, organic remains such as wood, charcoals and bones are scarce. We thus developed a protocol to obtain radiocarbon ages from a new material: earthworm calcite granules. These granules are indeed present, as well as terrestrial mollusc shells, in large amounts in both types of soil horizons. This protocol has been tested on 46 samples taken from all soil horizons of the loess sequences of Nussloch (Rhine Valley, Germany), which present one of the most comprehensive records of the last glacial period in Western Europe.
The resulting chronology supports the general scheme linking phases of soil horizon development under milder conditions with Greenland interstadials, and phases of loess unit deposition during windier, drier and colder conditions with Greenland stadials. Each of the soils, formed between 47 and 20 ka ago, is reliably correlated with a unique Greenland interstadial. Furthermore, minor cryogenic horizons formed between 27 and 20 ka and characterized by changes in grain size and in the molluscan fauna composition comparable to those of the main soils have also been dated. Though the absence of synchronous isotopic excursions, their correlation with dust concentration minimums in Greenland ice cores and with several other marine and continental proxy records reflects the high sensibility of loess environment to climate changes and a more complex climate variability at mid-latitude than in Greenland during the Last Glacial Maximum (LGM).
As a perspective, this new dating protocol let us expect precise correlations between distant loess sequences and, combined with other proxies, the mapping of palaeoenvironmental and palaeoclimatic conditions associated with each interstadial phase across Europe and possibly farther East for the Middle and Upper Weichselian.