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Establishing chronologies for loess records within 40 ka by AMS ^{14}C-dating of small mollusc shells

Gabor Ujvari (1), Mihaly Molnar (2), Agnes Novothny (3), Janos Kovacs (4,5)

(1) Geodetic and Geophysical Institute, Research Centre for Astronomy and Earth Sciences, HAS, Sopron, Hungary (ujvari.gabor@csfk.mta.hu), (2) Hertelendi Laboratory of Environmental Studies, Institute for Nuclear Research, HAS, Debrecen, Hungary, (3) Department of Physical Geography, Eötvös Loránd University, Budapest, Hungary, (4) Department of Geology and Meteorology, University of Pécs, Pécs, Hungary, (5) Environmental Analytical and Geoanalytical Research Group, Szentágothai Research Centre, University of Pécs, Pécs, Hungary

The key objective of the INTIMATE project is to determine whether abrupt climatic changes during the period of 60 to 8 ka, as reflected in a range of proxy records, were regionally synchronous or whether there were significant 'leads' and 'lags' between the atmospheric, marine, terrestrial and cryospheric realms. Such goals require precisely dated records of paleoenvironmental change for this period. Although wind-blown loess deposits are regarded as key terrestrial archives of millennial or even centennial scale environmental changes, these records are mostly poorly dated and/or their age-depth models have uncertainties of millennial magnitude. This prevents us from addressing issues like synchroneity of abrupt climatic/environmental events on millennial time scales.

Two different means of dating are commonly applied for loess sequences: luminescence and radiocarbon dating. Major problems are low precision of luminescence ages and the general lack of organic macrofossils (e.g. charcoal) in loess that can reliably be dated using ^{14}C. Other datable phases in loess are mollusc shells, rhizoliths and organic matter. While organic matter ^{14}C ages are often seriously compromised by rejuvenation in loess sequences, rhizolites consistently yield very young ages as first demonstrated in German loess profiles. Indeed, hypocatings (rhizolites) gave Holocene ages from three different depths (4.00 m: 9744-10156 2σ age range in cal yr BP, 5.00 m: 8013-8167 cal yr BP and 6.00 m: 9534-9686 cal yr BP) in the Dunaszekcső loess record we investigated. Mollusc shells are the only remaining phases for dating, but these are usually regarded as unreliable material for ^{14}C-dating, as they may incorporate ^{14}C-deficient (or dead) carbon from the local carbonate-rich substrate during shell formation, thereby producing anomalously old ages by up to 3000 years. Recent studies, however, indicated that reliable ages can be obtained by radiocarbon dating of molluscs having comparatively small ($<$10 mm) shells.

In the Dunaszekcső loess profile in Hungary (mentioned above), samples for AMS ^{14}C-dating of charcoals and molluscs, and also for OSL-IRSL dating of quartz and K-feldspar were taken. Plant macrofossils are widely accepted as phases yielding very reliable ^{14}C ages, so charcoals from the studied profile provided the opportunity to test ^{14}C ages of small molluscs against the charcoal ages. Likewise, ^{14}C ages of molluscs were compared with OSL-IRSL ages.

Results of this dating framework demonstrate that *Succinella oblonga* and *Vitrea crystallina* yield statistically almost indistinguishable ages (2σ age ranges: 29990-30830 and 29600-30530 cal yr BP) when compared with charcoal ^{14}C ages (29960-30780 cal yr BP), and others like Clausilia sp. and *Chondrula tridens* give slightly older ages than the charcoals and show larger age anomalies (500-900 ^{14}C yr). Further, OSL, post-IR OSL and pIRIR@290 ages are consistently older than the calibrated ^{14}C ages by several thousands of years. At the same time, pIRIR@225 ages appear to match well the ^{14}C ages. Precision of ^{14}C ages are an order of magnitude better (calibrated 2σ age ranges 500-800 yr) than the luminescence ages (2σ age ranges: 3700-7900 yr).

Thus, AMS radiocarbon dating of some species of small molluscs (e.g. *Succinella oblonga*) may form the basis of establishing reliable chronologies for loess records within 40 ka in the future that are both accurate and precise enough to address issues like synchroneity of millennial-scale paleoenvironmental events across regions around the North Atlantic and mainland Europe.

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