station and data		period	III	IV	A	WA
BUDAPEST	orig.	1780-1900	0.395	0.516	0.598	0.613
BUDAPEST	orig.	1780-1998	0.178	0.447	0.405	0.466
VIENNA	orig.	1775-1998	0.186	0.393	0.378	0.422
PRAGUE	orig.	1775-1998	0.221	0.371	0.367	0.394
PRAGUE G	orig.	1775-1998		0.422	0.403	0.437
BUDAPEST	corr.	1780-1998	0.338	0.441	0.528	0.551
VIENNA	corr.	1775-1998	0.333	0.423	0.508	0.525
PRAGUE	corr.	1775-1998	0.350	0.440	0.510	0.494
PRAGUE G	corr.	1775-1998		0.494	0.534	0.554
BUDAPEST	corr. sq.	1780-1998	0.376	0.498	0.592	0.619
VIENNA	corr. sq.	1775-1998	0.375	0.467	0.566	0.584
PRAGUE	corr. sq.	1775-1998	0.411	0.490	0.569	0.577
PRAGUE G	corr. sq.	1775-1998		0.539	0.601	0.617

Tab. 1. Correlation of lengths of grapevine sprouts with mean air temperatures.

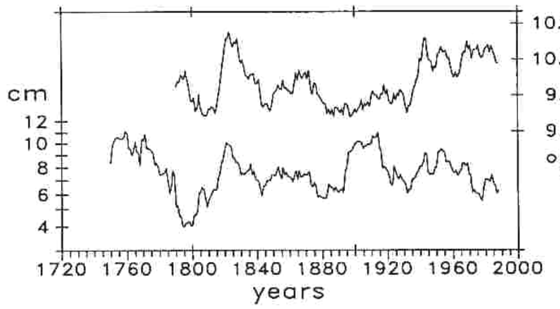

Fig. 2. The course of spring temperatures in Budapest, weighted average (March+ 2×April)/3.0 - upper curve, right-hand scale, and lengths of grapevine sprouts in Köszeg - lower curve, left-hand scale, both smoothed using running averages in the 21-yr interval.

to multiply all values after 1900 by different factors. The multiplication by 3 results in the highest coefficients and it seems therefore to be the most suitable. The correlations with the original data are marked "orig.", with the corrected data "corr." in Table 1. This correction improves the correlation by about 0.1 in columns A and WA. The highest correlations appear for Budapest, lower for Vienna and for Prague (but still significant). Using the averages till the 24th April only the correlation increases by about 0.05.

Using correlation coefficients one silently supposes that the relation between correlated quantities is linear. But the growth at the beginning is very slow and only later the sprouts grow more rapidly. It is therefore better to correlate the temperature with e.g. the logarithm or square root of the sprouts length. Using this transform differences between long sprouts (20, 30, 40 cm) decrease. Correlation coefficients between square roots of grapevine sprouts and temperatures are given in Table 1 in rows marked by "sq.". They increase by about 0.05.

Conclusion

We represented graphically the course of the air temperature in Budapest (weighted averages WA used in Table 1) together with the length of grapevine sprouts in square-root scale (this combination exhibits the best correlation), both smoothed by running averages in 21 year interval (Fig. 2). The picture shows a good agreement between both curves. Both curves display similar periods with higher or lower values lasting several decades, with the exception of the most recent decades (after 1960). This point confirms other observed and indirect data. The sprouts are relatively long even in decades before 1780 (see Figs 1 and 2), where no instrumental observation in the region in question is available. We may claim that spring temperatures between 1740–1780 were approximately on the same level as they were between 1780–1790, and surely higher than those in the middle of the 19th century were.

References

BERKES Z., 1942. Éghajlatingadozások tükröződése a Köszegi szőlőhajtások hoszában - Spiegelung der Klimaschwankungen in dem Längenwachstum der Weinreben-Triebe in Köszeg. A Magyar kir. földmivelésügyi miniszt. fennhatósága alatt álló M. kir. orsz. meteor. és földmágnességi intézet kisebb kiadv., új sor. 15. szám, *Kl. Veröff. der Kgl. Ung. Reichsanstalt für Meteorologie und Erdmagnetismus, Neue Reihe*, 15: 3-17.

PÉCZELY G., 1982. A Köszegi "Szölö Jövések Könyve", *Légkör*, 27: 24-27.

Evidence of Climatic Variations in Loess and Cave Palaeolithic Sites of Southern Poland and Western Ukraine

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ABSTRACT. An outline of the Upper Pleistocene environmental changes reconstructed with the use of data gathered in Palaeolithic cave and loess sites from Southern Poland and Western Ukraine is presented. Lithological composition of cave sediments, mainly the weathering degree of limestone rubble as well as fossil fauna composition show a succession in landscape diversity from deciduous and coniferous forest to open vegetation and tundra. This succession is compared with loess sedimentation succession, interrupted several times by soil development under steppe or forest vegetation. Archaeological finds help with stratigraphical correlation.

KEY WORDS: Upper Pleistocene environments, Palaeolithic, loess, cave sediments.

Precisely documented profiles of cave and loess archaeological sites of Southern Poland and western Ukraine cover the time from the decline of the penultimate glaciation (Warthanian), through the Eemian to the end of Vistulian, which means 5–2 oxygen isotope stages. Traces of older cultural layers were found recently, probably corresponding to the penultimate interglacial - stage 7 and the beginning of stage 6. Human occupation of Lower, Middle and Upper Palaeolithic developed during periods of warm or cool climatic conditions and disappeared from this region in extremely cold ones. The presence of similar archaeological material in loess profiles and cave fillings helps with chronostratigraphical correlation of both types of sites. The profiles of cave and loess sites complement each other, because warmer periods are represented by comparatively thick series of cave deposits, whilst cold ones are better represented by series of loess. Intensive aeolian sedimentation, development of cryogenic structures in loesses and the accumulation of cryoclastic material in caves as well as the presence of rich tundra animals evidence cold, arctic environment. The presence of steppe animals and steppe-type fossil soils show dry, continental conditions. On the contrary, development of forest fossil soils on loesses, accumulation of chemically weathered rubble with residual loam in caves and the presence of forest animals are the evidence of humid, temperate environments (Madeyska, 1881).

Most of the cave sites in the Polish Jura Chain represent the Vistulian, some of them the Eemian Interglacial and the Warthanian. The oldest archaeological assemblages were found in sediments corresponding to the Warthanian and to the Eemian. In Early Vistulian sediments, the Levallois-Mousterian and Micoquo-Prondnikian assemblages were present (Chmielewski, 1975, 1988; Kozłowski and Kozłowski, 1977). The existence of deciduous forest during the Eemian is documented by fauna composition, charcoal of trees and lithological character of the sediments. This forest was transformed into coniferous forest with patches of steppe-tundra landscape during the Early Vistulian.

Upper Palaeolithic cultural layers were found in deposits correlated with a cool, bipartite period named Interplenivistulian (oxygen isotope stage 3) characteristic by the presence of a mosaic of open biotopes with patches of mainly coniferous forest. Two periods of severe, cold and dry climate characteristic by the dominance of tundra environment (4 and 2 stages), corresponding to the Lower and Upper Plenivistulian, are almost devoid of traces of human presence in caves. These periods are related to the main periods of the Vistulian loess sedimentation.

Loess Palaeolithic sites are rare in Poland (Chmielewski et al., 1977; Kozłowski, 1996), but rather frequent in western Ukraine (Chernysh, 1973; Ivanova, 1977; Sytnik et al., 1998). All sites are situated in loess profiles with pedocomplexes and cryogenic levels. Several stratigraphic horizons in the loess profiles of Podolia were distinguished by Boguckij (1986): recent soil, upper part of the Upper Pleistocene loess, Dubno fossil soil, lower part of Upper Pleistocene loess, Horokhov fossil pedocomplex, upper part of the Middle Pleistocene loess, Korshov fossil pedocomplex. Late Acheulian-type material was present in the upper part of the Korshevo pedocomplex correlated with early period of the Warthanian glaciation. Most of the Mousterian material can be correlated with the development of the upper part of the Horokhov pedocomplex - steppe soil originated during the Early Vistulian Interstadials. The older Mousterian layers were found in the lower part of this pedocomplex - forest soil, and, therefore, can be dated to the Eemian Interglacial. Stratigraphy is often complicated by the presence of bipartite levels of cryogenic deformations with

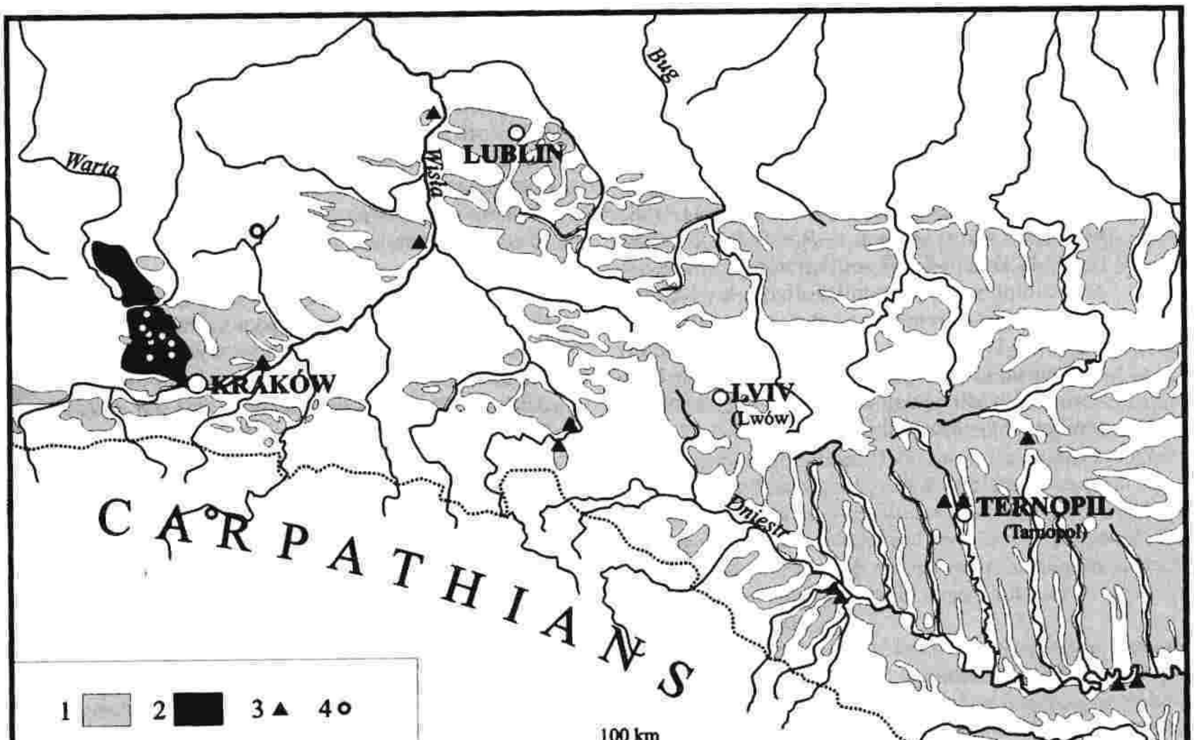

Fig. 1. Distribution of main cave and loess Palaeolithic sites in southern Poland and western Ukraine. 1 - loess covers, 2 - Polish Jura Chain, 3 - loess sites, 4 - cave sites.

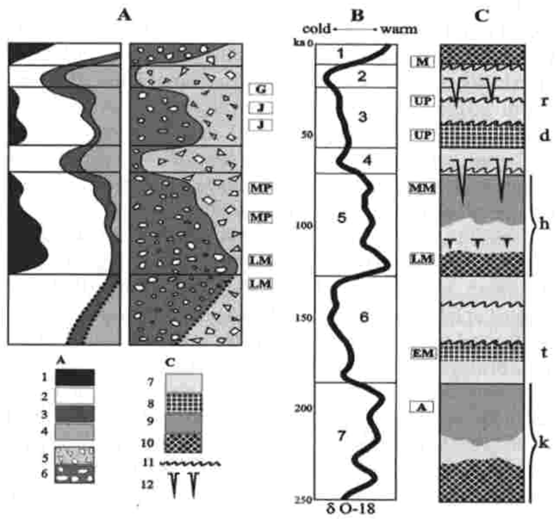

Fig. 2. Comparison of stratigraphy of cave deposits with loess stratigraphy and temperature changes.
A - A scheme of stratigraphy of cave deposits based on data from about 20 caves situated in the Polish Jura. 1–4: proportions of mammalian fauna according to ecological requirements in percent: 1 - forest animals, 2 - eurytopic animals, 3 - steppe animals, 4 - tundra animals; 5 - angular limestone rubble, 6 - rounded and chemically weathered limestone rubble. Archaeological cultures (after Chmielewski, 1975): LM = Levallois-Mousterian, MP = Micoquo-Prondnikian, J = Jerzmanowician, G = Eastern Gravettian.
B - Relative temperature changes (from SPECMAP curve) C - A scheme of loess stratigraphy of western Ukraine (after Bogucki, 1986): 7 - loess, 8 - tundra soil, 9 - steppe soil, 10 - forest soil, 11 - solifluction, 12 - frost wedges, r - Rovne fossil soil horizon, d - Dubno fossil soil horizon, h - Horohov pedocomplex, t - Ternopil horizon, k - Korshev pedocomplex. Archaeological cultures (after Sytnik et al., 1998): A = Late Acheulian, EM = Early Mousterian, LM = Levallois-Mousterian, MM = Mousterian with Micoquian elements, UP = Upper Palaeolithic, M = Mesolithic.

ice wedges and by solifluction. The Upper Palaeolithic material was found mainly in the Dubno fossil soil horizon. Environmental changes reconstructed from fossil soil typology are in good agreement with the data from cave fillings in relation to the main climatostratigraphic units. More detailed records are regionally and locally differentiated.

References

BOGUCKIJ A.B., 1986. Antropogenovye pokrovnye otlozhenia Volyno - Podolii. *Antropogenovye otlozhenija Ukrainy*: 121-132.

CHMIELEWSKI W., 1975. Paleolit środkowy i górny. In: Prahistoria Ziem Polskich. T. I. Paleolit i mezolit, Ossolineum. Wrocław, Warszawa, Kraków, Gdańsk, pp. 1-158.

CHMIELEWSKI W. (Editor), 1988. Jaskinie Doliny Sąspowskiej. Tło przyrodnicze osadnictwa pradziejowego. Prace Instytutu Archeologii UW, Warszawa.

CHMIELEWSKI W., KONECKA-BETLEY K. and MADEYSKA T., 1977. Paleolithic site Kraków – Zwierzyniec I in the light of investigations in 1972-1974. *Biul. Inst. Geol.*, 305: 13-30.

CHERNYSH A.P., 1973. Paleolit i Mezolit Pridnestovija. Izd. Nauka. Moskva.

IVANOVA I.K., 1977. Prirodnye uslovija obitanija ludei kamennogo veka v basseine reki Dniestr. *Paleoekologija Drevnego Cheloveka*: 7-19.

KOZŁOWSKI J.K. and KOZŁOWSKI S.K., 1977. Epoka kamienia na Ziemiach Polskich (Stone Age in Poland). PWN. Warszawa.

KOZŁOWSKI J.K., 1996. The Upper Palaeolithic site Kraków-Spadzista: units D, E and F (Excavations 1986-1989). *Folia Quaternaria*, 67: 1-127.

MADEYSKA T., 1881. Środowisko człowieka w środkowym i górnym paleolicie na ziemiach polskich w świetle badań geologicznych. (Res.: Le milieu naturel de l'homme du Paleolithique moyen et superieur en Pologne a la lumiere des recherches geologiques). *Studia Geol. Polon.*, 69: 1-124.

SYTNIK A., BOGUCKI A., WOŁOSZYN P. and MADEYSKA T., 1998. Wstępne wyniki badań środkowopaleolitycznych stanowisk lessowych Podola. (Sum.: Middle Palaeolithic loess sites in Podole (Western Ukraine - preliminary study). *Studia Geol. Polon.*, 113: 121-136.