Paleographical and stratigraphical inferences from TL properties of Saalian & Weichselian loess of NW Europe

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Introduction

In this paper we report on stratigraphical and paleogeographical inferences from a comparative TL investigation of Saalian and Weichselian loess of Northwestern Europe. The aim of the research, carried out at the Laboratory of Mineralogy of the FAPOM in Mons, Belgium, is to study the stratigraphical and spatial variations of the loess TL characteristics. Evidence of such variations would provide new promising means for loess identification, stratigraphical correlation and paleographical reconstitution.

Materials and methods

We have selected several reference loess sequences under stratigraphical control, from northern Belgium to Normandy (France), as shown in figure 1. We confined ourselves to the analysis of truly aeolian loessic deposits as they can be assumed to be optically bleached under sunlight during aeolian transportation, prior to their deposition (Wintle and Huntley, 1982). The different loess sections investigated are schematically presented in figure 2. On one hand, we sampled the Late Glacial

FIG 1

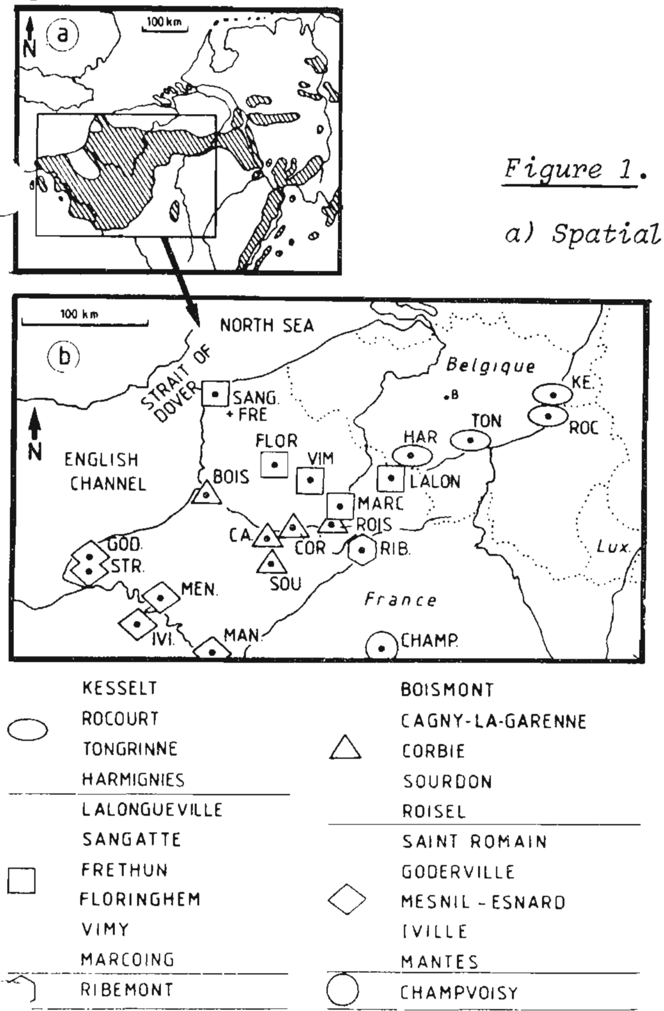


Figure 1.

a) Spatial distribution of NW European loesses.

b) Locality map.

References:

TON (Paepe and Vanhoornem, 1967)
HAR KE ROC (Haesaerts et al., 1981)
CA, SANG (Balescu and Haesaerts, 1984)
FLOR (Tuffreau, 1975)
VIM MARC LALON (Sommé and Tuffreau, 1976)
BOIS (Devismes et al., 1977)
STR GOD MEN (Lautridou, 1968)
IVI (Dewolf Y. et al., 1981)
MAN (Vazart, 1983).

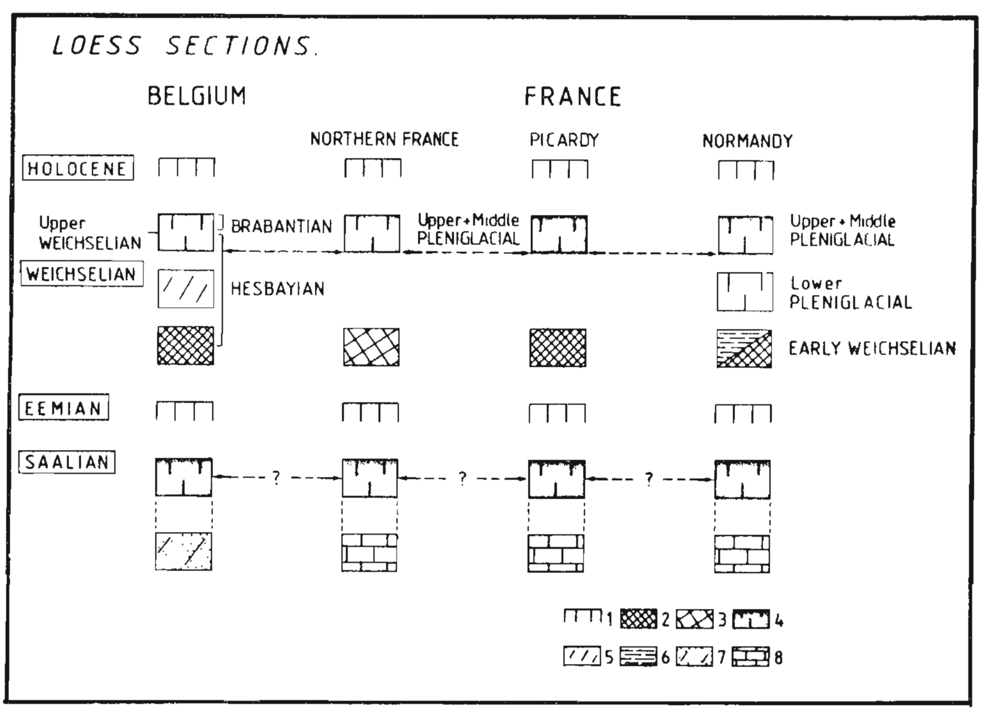


Figure 2. Loess sections.
Key 1. illuviated soil (brown forest soil); 2. grey loam (steppe soil); 3. grey hydromorphic loam; 4. loess; 5. loams; 6. clayey loam; 7. sandy substrate; 8. chalky substrate.

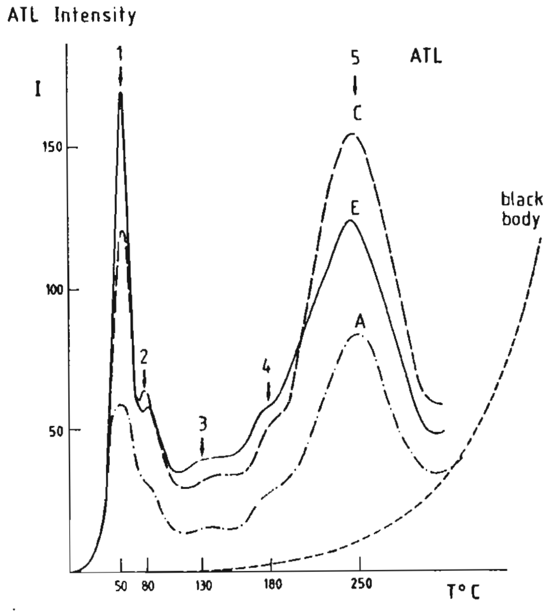


Figure 3a. Examples of quartz ATL glow curves, corresponding to types A, C and E shown in figure 3b.

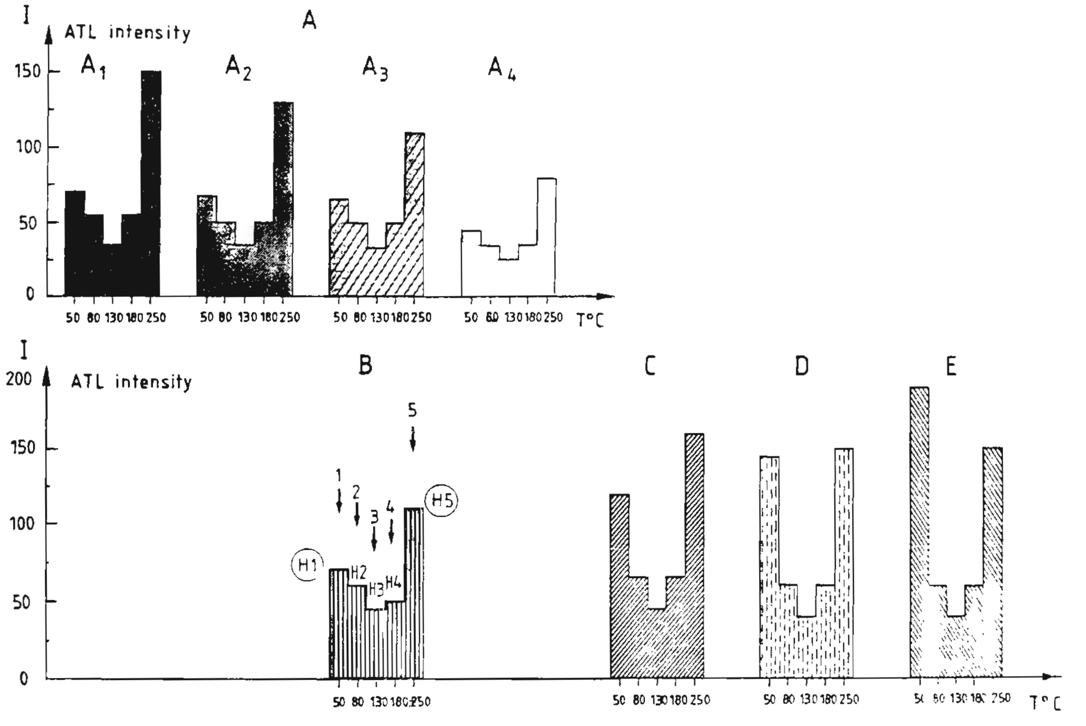


Figure 3b. Quartz ATL typology of NW European loesses from samples which have been γ irradiated for 12 h after being bleached by a 24 h exposure to the sunlamp. Schematic representation of ATL glow curves where mean peak intensities (related to the height of the peak, in arbitrary units) are plotted as a function of temperature (°C).

Representation of five distinct types of ATL glow curves, A,B,C,D and E according to variations in absolute and relative intensities of their first (50°C) and fifth (250°C) peaks (H1 and H5).

Mean intensities of the peaks were calculated using the results from several samples collected in different loessic deposits characterized by the same type of curve.

Weichselian loess on top of which is developed the surface soil, a remnant of the Holocene pedogenesis. On the other hand, we collected samples from the Saalian loess which are systematically underlying the Eemian illuviated soil.

We concentrated on the analysis of the pure detrital quartz grains of the 40-50 μm grain size fraction, using both artifical (ATL) and natural (NTL) TL glow curves. The quartz samples were irradiated for 12 hours with a Co60 γ source after being UV bleached by a 24 h exposure to a sunlamp. We refer to the papers of Charlet (1969) and Baleine (1973) for further technical details.

Results and discussion

The ATL curves from samples of both Weichselian and Saalian loess comprise five peaks lying between 50°C and 250°C and occuring, in all curves, at the same temperature, as shown in fig 3a (1 to 5). Variations in absolute and relative intensities of the lowest and the highest temperature peaks (50°C and 250°C), lead us to define five different types of curves (A,B,C,D and E), corresponding to distinct curve shapes, as shown in fig 3b. One can distinguish asymetrical curves with a dominant fifth peak (types A,B,C) or a dominant first peak (type E) and symmetric curves (type D).

The ATL glow curves were found to be similar within the whole individual loessic deposit, and thus allows us to use the ATL signal as a new sedimentological marker for loess identification. The finding of a variety of types demonstrates the existence of distinct quartz assemblages within northwestern European loess.

The NTL glow curve, obtained from the same quartz samples, comprises a double peaked glow curved. The two TL peaks occur at the same temperature as the two highest temperature peaks of the ATL glow curve. In figure 4a the intensity of the highest temperature peak of the NTL glow curve has been plotted versus intensity of the corresponding artifical peak. As is clear from the figure, the NTL intensity sucessfully discriminates between Saalian (unshaded symbols) and Weichselian (shaded symbols) loess. Indeed, all Weichselian loess show systematic and significantly lower NTL intensities (illustrated in the schematic insets to figure 4a). However, the NTL signal does not allow any further stratigraphical discrimination among Saalian loess since it has reached saturation (see figure 4b).

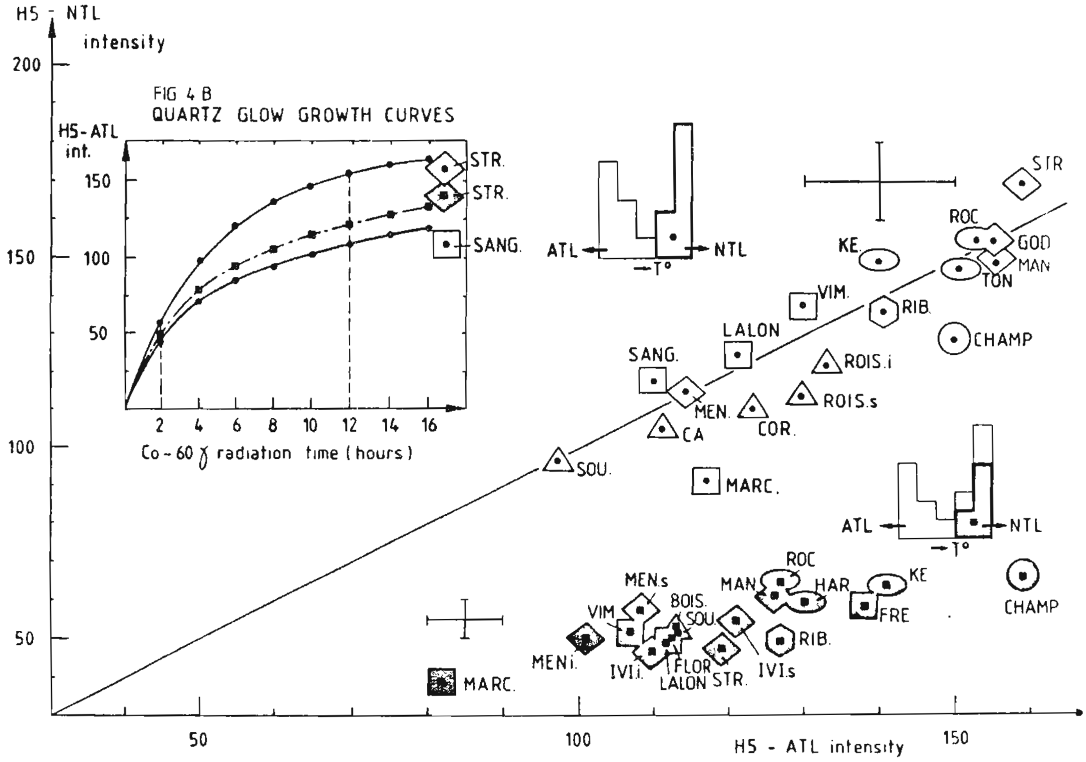
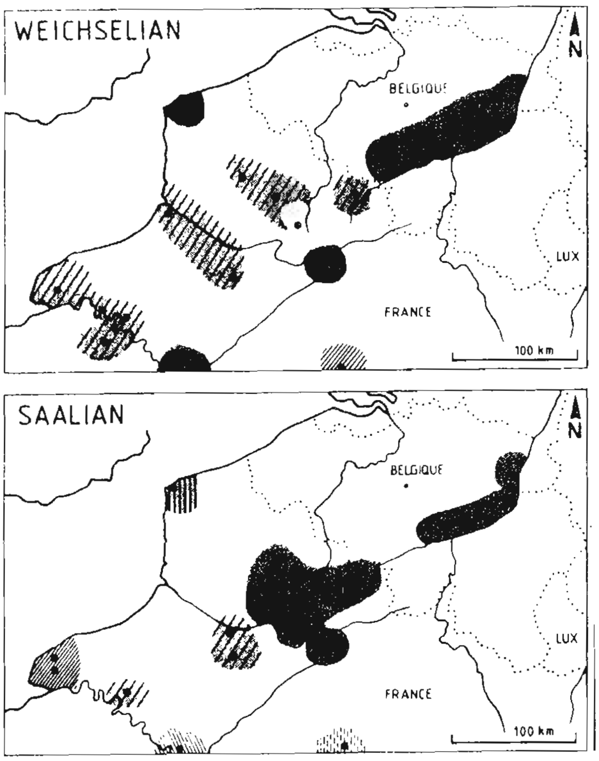


Figure 4. a) Quartz NTL-ATL diagram. Intensity of the highest temperature natural glow curve peak (250°C) versus intensity of the corresponding artifical peak; samples have been exposed for 24 h to uv radiation before being γ irradiated for 12 h (intensity in arbitrary units).

b) Quartz second growth glow curves at 250°C glow curve temperature, after samples have been uv bleached by sunlamp for 24 h (TL in arbitrary units versus γ irradiation time in hours).

A simultaneous use of both ATL and NTL glow curves leads us to define distinct Weichselian and Saalian loessic provinces and to establish paleographical maps, as shown in figure 5a. The inter-province heterogeneity of the quartzose material could involve a diversity in the sediment provenance and source areas of the northwestern European loess. A comparison of the Saalian and Weichselian loessic provinces reveals either a similarity or a difference in their quartz ATL characteristics, reflecting either a constancy or a time change in their sediment provenance.

The results of heavy mineral analysis have supported our TL investigation and allows definition of specific Weichselian and Saalian loessic provinces on the basis of their green hornblende and garnet content, as shown in figure 5b. Information gathered by both heavy material and TL analysis are generally in good agreement. There are, however, some significant discordances, as can be seen by comparing the respective paleogeographical maps (figs. 5a and 5b). This makes both methods complementary. Consequently, a concurrent use of the loess NTL properties - for time control - together with their ATL characteristics and heavy mineral content - for better paleogeographical control - provides a new stratigraphical marker for loess.



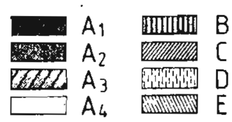
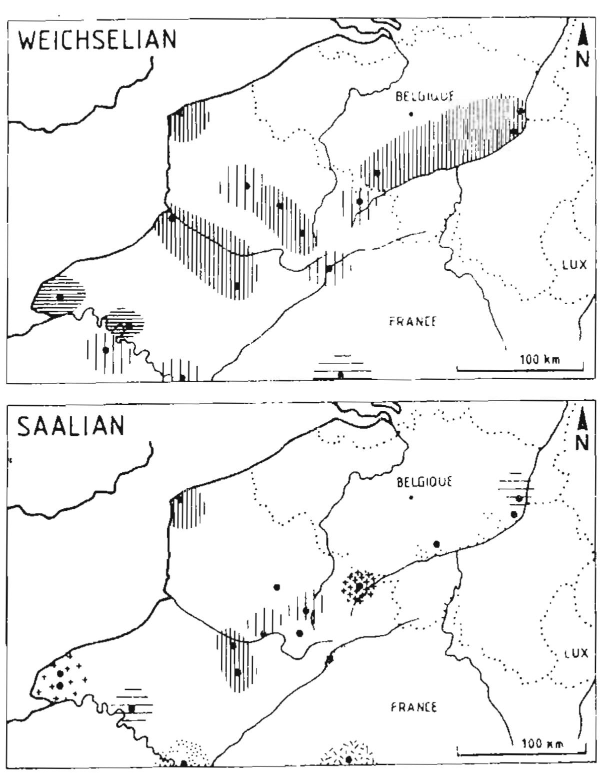


Figure 5a. Spatial distribution of ATL quartz assemblages within Saalian and Weichselian loesses. Quartz ATL assemblages referring to the quartz ATL typology defined in figure 3



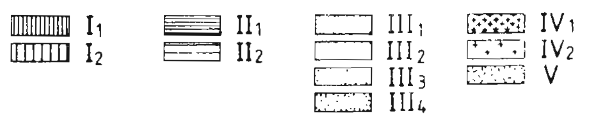


Figure 5b. Spatial distribution of green hornblende and garnet associations within Saalian and Weichselian loesses. Average green hornblende (GH) and garner (G) content (in %) estimated on total count of 300 transparent heavy mineral grains per sample: H ≈ 20%, M ≈ 10%, L ≈ 5%, VL ≈ 1-2%, A ≈ 0%.

$-I_{1-2} = \underline{H.(GH)} + M\text{-}L.(G);$

$-II_{1-2} = \underline{M.(GH)} + VL.(G);$

$-III_{1-2-3-4} = \underline{L\text{-}VL.(GH)} + L\text{-}VL.(G);$

$-IV_{1-2} = L\text{-}VL.(GH) + \underline{A.(G)};$

$-V = \underline{A.(GH)} + VL.(G).$

Conclusion

Our results clearly demonstrate the important potential of the quartz TL method for identification, stratigraphical correlation and relative age determination of these isolated and discontinuous aeolian deposits. Furthermore, the remarkable stratigraphical and spatial coherence of these TL results show great promise for the identification of source areas of these loesses and to establish a reference loess stratigraphical scheme for NW Europe.

References

Baleine, O., Charlet, J.M. and Dupuis, C. (1973) Les techniques utilisées pour l'étude de la thermoluminescence au laboratoire de minéralogie de la F.P.Ms; 10 années d'expérience. Ann. Scientifiques du Department des Mines-Géologie, 1, 34-48.

Balescu, S. and Haesaerts, P. (1984) The Sangatte raised beach and the age of the opening of the Strait of Dover. Geol. en Mijnbouw, 63, 355-362.

Charlet, J.M. (1969) La thermoluminescence des roches quartzofeldspathiques. Applications á l'étude des séries sédimentaires détritiques; intérét dans la datation des granities Bull. B.R.G.M., 2e série, 2, 51-97, and 3, 11-60.

Devismes, R., Dupuis, C., Haesaerts P. and de Heinzelin, J. (1977) Fouilles de 1975 á la carriére est du chemin des Salines, Boismont, Somme, France. Cahiers Archéologiques de Picardie, 4, 31-42.

Dewolf, Y., Helluin, M., Lautridou, J.P. and Vazart, M. (1981) Les loess d'Iville (Eure). Faciés régional de transition entre deux provinces loessiques majeures du Bassin de Paris . Bull. A.F.E.Q., 3-4, 159-172.

Haesaerts, P., Juvigne, E., Kuyl, O., Mucher, H. and Roebroeks, W. (1981) Compte rendu de l'excursion du 13 juin 1981, en Hesbaye et au Limbourg néer landais, consacrée á la chronostratigraphie des loess du Pléistocèe supérieur. Annales de la Société Géologique de Belgique, 104, 223-240.

Lautridou, J.P. (1968) Les loess de Saint Romain et de Mesnil-Esnard. Bull. Centre Géom., 2, 55.

Paepe, R., Vanhoorne, R. (1967) The stratigraphy and paleobotany of the Late Pleistocene in Belgium. Mém. Expl. Cartes Géol. et Min. Belg., 8.

Somme, J., Tuffreau, A. (1976) Vimy (Pas-de-Calais): 191-194; Marcoing (Nord France): 205-209; La Longueville (Nord France): 214-217. Livret guide Préhistoriques et Protohistoriques.

Tuffreau, A. (1975) Acheuléen dans les limons anciens de Floringhem (Pas-de-Calais). Septentrion, 5, 37-39.

Vazart, M. (1983) Paléodynamiques weichséliennes des provinces normandes, vexinienne et séquanienne (Analyse micrographique). Travaux du laboratoire de géographie physique, 11, 81 p.

Wintle, A.G. and Huntley, D.J. (1982) Thermoluminescence dating of sediments. Quaternary Science Reviews, V. 1, 31-53.

P.R. Reviewers Comments (A.M.D. Gemmell)

The use of NTL and ATL curves to distinguish detrital sediments of different provenances has been known for several years (Charlet, 1971). The present study takes this approach a stage further by applying the technique to loessic sediments, and using it not only to distinguish palaeographic provinces, but as a tool for stratigraphic correlation.

In respect of the latter use, a number of questions arise. As no bleaching curves are presented, overbleaching may have occurred. Wintle (1985) has suggested that dose-dependent sensitivity changes may occur when a sample is exposed to light, but whether such dose dependent changes would survive significant changes in the samples in the present study might provide an answer to this question.

Closer examination of figure 4a shows clearly that ATL characteristics fail to separate Saalian and Weichselian sediments, and it is the NTL which is the discriminating factor. As the NTL of the Saalian loesses has reached saturation level (Balescu, Dupuis and Quinif, this issue), then the technique is unlikely to be useful for the stratigraphic correlation of older deposits.

If the various quartz assemblages identified in this study represent differences in the composition of loess due to changes in wind direction, some of the sediment may not have been transported far enough from its source for complete bleaching to have taken place prior to deposition. if the sources can be identified, and assuming that the loesses are securely dated by other techniques, than the significance of transport distance as a possible influence on the TL-age of loessic sediments can be investigated.

References

Balescu, S., Dupuis, C. and Quinif, Y. (This volume). Paleogeographical and stratigraphical inferences from thermoluminescence properties of Saalian and Weichselian loesses of northwestern Europe.

Charlet, J.M. (1971) Thermoluminescence of detrital rocks used in paleogeographical problems. Modern Geology, 2, 265-274.

Wintle, A.G. (1985) Sensitization of TL signal by exposure to light. Ancient TL, 3 (3), 16-21.

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