TL STRATIGRAPHY OF LOESSES: QUARTZ AND FELDSPAR DOSEMETERS WITHIN LOESSIC DEPOSITS FROM NORMANDY, FRANCE

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INTRODUCTION.

In a previous paper (Balescu et al., 1986a), we reported on the TL properties of detrital quartz grains from pure aeolian loesses of NW Europe, using the 40-50 μm grain size fraction, which is representative of the loessic sediment. We studied both the quartz natural TL (NTL) properties, related to the amount of environmental radiation to which the minerals had been exposed since deposition of the loess, and the quartz artificial TL (ATL) signals induced by laboratory irradiation with a Co60 γ source. We demonstrated that the quartz NTL intensity can successfully discriminate between Wiechselian loesses (deposited around 20ka) and Saalian loesses (older than 120 ka). However, this quartz TL technique did not allow any further stratigraphical discrimination since Saalian quartzes were found to be close to saturation.

In this paper, we further investigate loess TL properties of K-feldspar grains from the same grain size fraction (40-50 μm), in an attempt to establish a chronological discrimination between these Saalian loesses.
We present results of a comparative investigation of quartz and feldspar TL characteristics of loesses from Normandy (France). In contrast with most of the existing literature on TL of NW European loesses (e.g. Debenham, Mejdahl, Wintle), we use both quartz and feldspar TL methods as relative dating techniques, without any attempt to estimate absolute ages.

SAMPLES AND PREPARATION

The samples were taken from the loessic sections within Normandy shown in figure 1. Following Lautridou's chronostratigraphical scheme (1985), we sampled:

- Upper Wiechselian loesses deposited around 20 ka;
- Upper Saalian loesses lying below the Eemian soil (Elbeuf 1 or Saint Romain soil) which were deposited between 120ka and 200ka;
- Middle Saalian loesses older than 200 ka which underlie an intrasaalian soil (Elbeuf II).

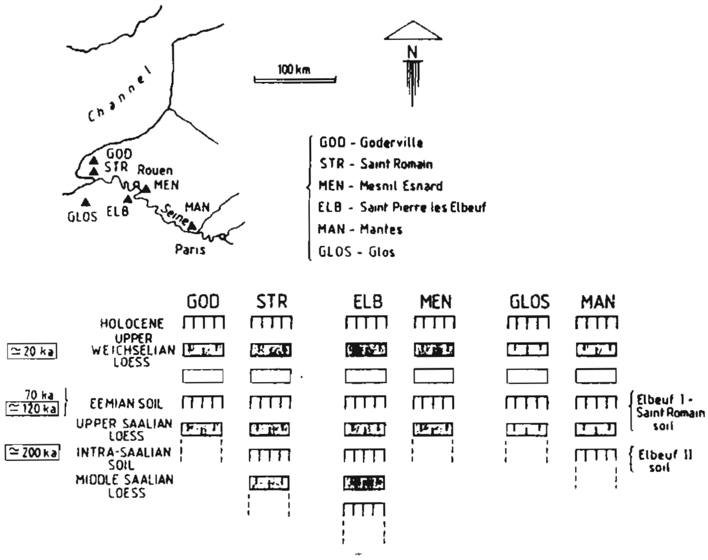

Figure 1: *Location of sampling sites in Normandy and schematic representation of the investigated loessic sections.*

Note that this chronology relies mostly on regional stratigraphical correlations (Lautridou, 1985) with some references to absolute dates reported by Stremme (1985).

Sample treatments comprised:
- wet-sieving for extraction of the 40-50 µm grains;
- etching with HCl;
- removal of iron oxides by use of the citrate-bicarbonate-dithionite method (Mehra and Jackson, 1960);
- quartz-feldspar separation using heavy liquids ($\rho = 2.60$), in order to obtain two fractions; 1) K-feldspar dominated material and 2) a pure quartz sample after treatment with 40% HF.

RESULTS AND DISCUSSION

Quartz TL properties

In Balescu et al. (1986b), using both the quartz ATL and NTL methods, we proposed a new stratigraphical marker defined as the ratio of the NTL intensity of the highest temperature peak to the intensity of the corresponding ATL peak (termed MQ).
Applying this technique to loesses from Normandy, we obtain the results shown in figure 2. The corresponding MQ values are given on the vertical axis, and the loessic sections on the horizontal axis. All Weichselian loesses taken at the same chronostratigraphical position - but from different sites - show similar ratios ranging between 0.45 and 0.55, within the limits (marked error bars) of experimental reproducibility using this method. Their ratios are systematically lower than those of the Saalian loesses which range between 0.9 and 1.2. As discussed previously, this marker does not allow stratigraphical differentiation between Upper and Middle Saalian loessic deposits since they have reached saturation.

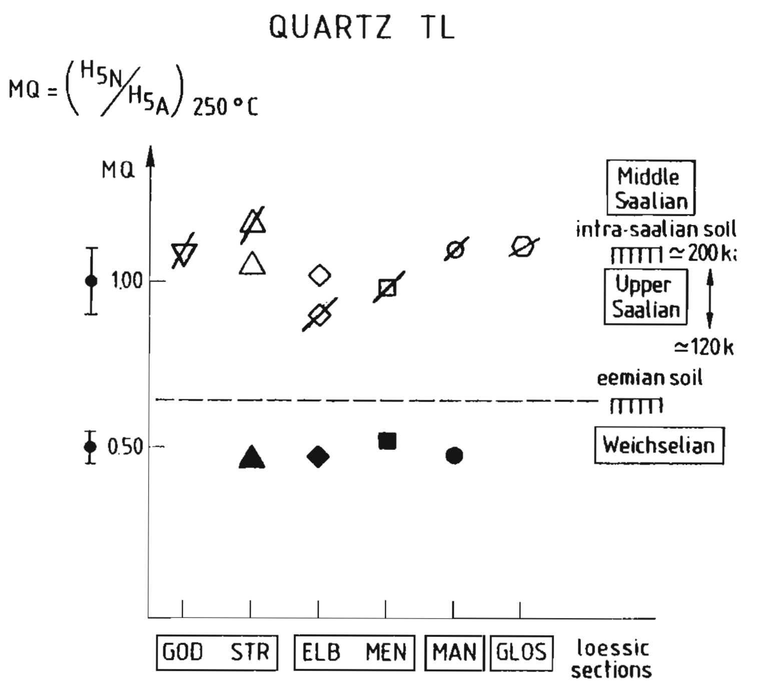

Figure 2: *MQ values, on the vertical axis, associated with different loesses from distinct loessic sections, plotted on the horizontal axis. MQ is defined as the ratio of the NTL intensity of the highest temperature peak ($H5_N$; 250°C) vs the corresponding ATL glow peak ($H5_A$).*

• *Weichselian loess* ø *Upper Saalian loess* o *Middle Saalian loess*

ϕ *error bars (1σ)*

Feldspar TL properties

Typical feldspar ATL glow curves obtained after γ irradiation (Co60 γ), shown in figure 3, contain three overlapping peaks lying between 130 and 320°C (1°C/s heating-rate). The double peaked NTL glow curves are also shown in this figure.

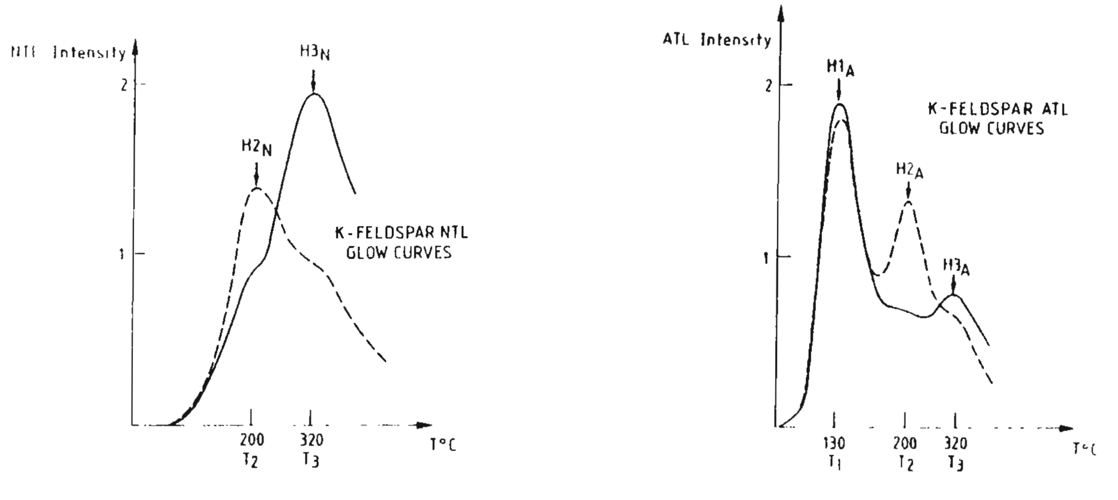

Figure 3. *Typical NTL and ATL K-Feldspar glow curves. TL intensity in arbitrary units and normalized by weight as a function of temperature (°C). The intensities (H_1, H_2, H_3) are measured from the height of the glow peaks. The intensity values are in the same units on both figures.*

a) Equivalent dose (ED) methodology:
For the relative ED determination, an additive γ dose method is used. Giving additional γ doses to a suite of identical specimens of the same natural sample, we build up first-glow growth curves, using the highest temperature peak, as shown in figure 4. The TL response is linear to approximately 6 or 8 hours of γ irradiation after which it curves, and in some cases approaches saturation.

The ED is obtained by linear extrapolation to zero TL of the first part of the growth curve (from 0 to 6 hours of γ irradiation). This yields values of relative ED, defined as EDL, which are given in table 1 (column 2). Very low values of EDL are obtained for Weichselian loesses (~2 hours of γ irradiation) and higher values are obtained in Saalian loesses, ranging between 5 and 18 hours of γ irradiation.

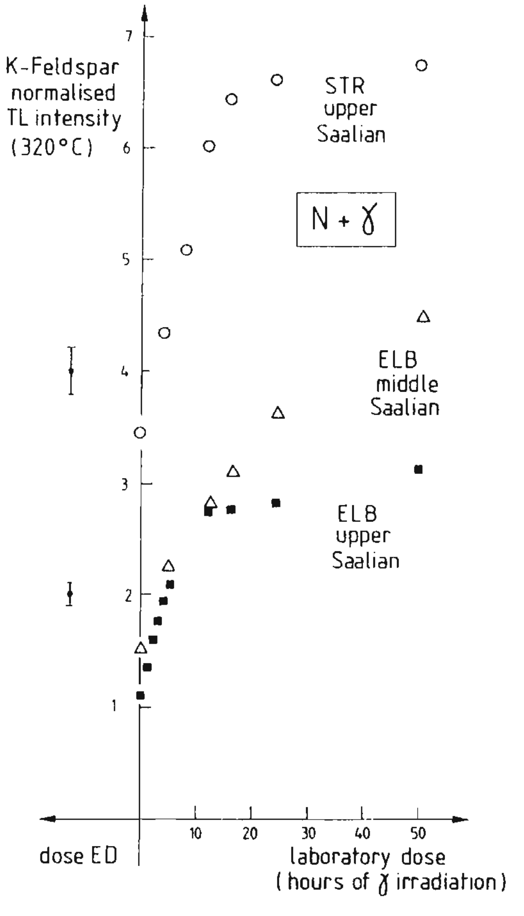

Figure 4.
Feldspar first glow curves, using the additive γ dose method.
K-Feldspar intensity of the highest temperature peak (320°C) versus laboratory γ dose (hours).

error bars (2σ)

b) Relative age estimation:
We next measure the ß count-rate from the bulk sample, using Geiger-Muller counters (Intertechnique type RA 12, France). The analytical results are given in col.3 of table 1. They range from 5.6 to 8.5 counts/g/min (σ = 0.5).
The relative ages of these loesses are estimated by the ratio, EDL /ß count-rate, defined as the MF ratio. The MF ratio is plotted on the vertical axis of figure 5. It lies between 0.2 for Weichselian loesses and 2.14 for older ones. We see that it clearly discriminates between Weichselian and Saalian loesses, thus confirming the results of the quartz investigation of the previous section. Furthermore, the MF ratio leads to good chronological differentiation between Upper and Middle Saalian loesses and reveals the existence of two distinct loessic generations within the Upper Saalian, which we define as S1 and S2.

TABLE 1.

SECTIONS	MQ	ED	ß COUNT-RATE	$MF=(ED_L/ß)$
GOD_{us}	1.01	11.14	8.00	1.39
STR_w	0.46	1.94	8.10	0.24
STR_{us}	1.16	15.43	7.80	1.98
STR_{ms}	1.05	17.75	8.30	2.14
MEN_w	0.52	-	-	-
MEN_{us}	0.99	4.56	7.97	0.57
ELB_w	0.47	-	-	-
ELB_{us}	0.90	5.95	7.97	0.57
ELB_{ms}	1.01	10.38	6.10	1.70
MAN_w	0.48	2.67	6.80	0.39
MAN_{us}	1.10	10.43	5.50	1.90
$GLOS_{us}$	1.09	9.85	8.20	1.20

Notes: TL results and radioactivity data for loesses from Normandy.
w: Weichselian; us: Upper Saalian; ms: Middle Saalian.
Units.- ED: hours of γ irradiation;
- ß count-rate: counts/g /minute.

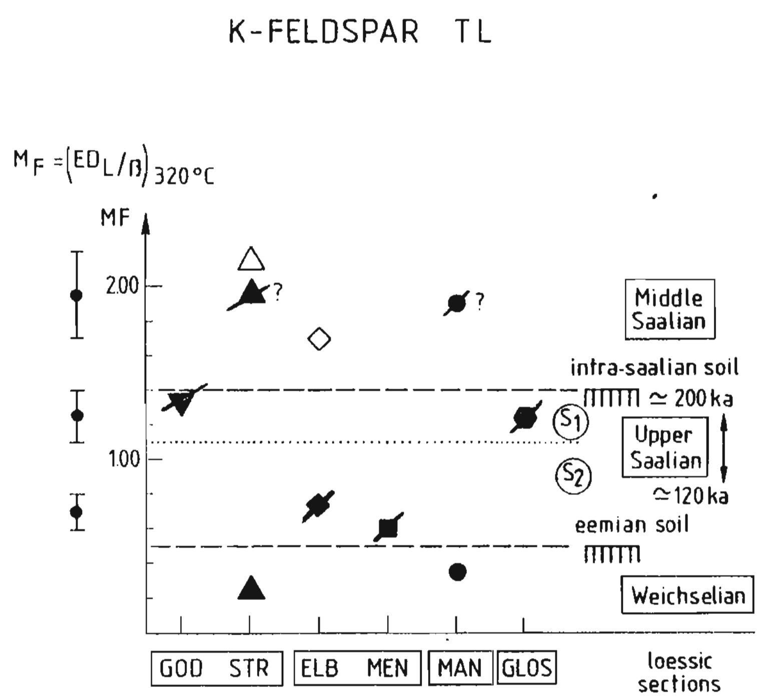

Figure 5.
MF values, on the vertical axis, associated with loess from different loessic sections, on the horizontal axis. MF is defined as the ratio of the ED_L obtained by linear extrapolation to ß count-rate from the bulk sample.

- *Weichselian loess*
- *Upper Saalian loess*
- o *Middle Saalian loess*

S1 and S2: *two upper Saalian loessic generations identified by the TL relative dating technique.*

error bars (2σ)

The feldspar relative dates show stratigraphic consistency both within individual sections and laterally. Indeed, our age estimates are in a correct chronological sequence in each section. Also, adjacent loessic deposits, such as MEN and ELB which are at the same chronostratigraphical position (Upper Saalian), have similar ratios.

There are, however, two "TL anomalies" within the Upper Saalian loesses of Mantes (MAN) and Saint Romain (STR). Their relative ages are higher than would be expected and indistinguishable from those of the Middle Saalian loesses. Note that the relative age estimate of the Saint Romain Upper Saalian loess is nevertheless consistent with the corresponding absolute dates obtained by Wintle (Wintle et al.,1984), which are also abnormally high (as mentioned by Singhvi and Mejdahl, 1984). As the Upper Saalian loesses of Saint Romain and Mantes are generally attributed to the same loessic generation as the loess from Goderville (GOD) using stratigraphical evidence (Lautridou,1985), further TL and sedimentological investigations are required to identify the origin of these TL anomalies.

The loess chronological discrimination by the MF ratio is in agreement with independent mineralogical results (Balescu et al., 1986a). Also, loesses belonging to different generations also have a distinct heavy mineral content and quartz ATL characteristics.

Finally, we note that these feldspar TL results are consistent with other relative dates we have estimated in loesses from Northern France and Belgium (Balescu et al., in preparation).

CONCLUSION

In this paper we have demonstrated that both quartz and feldspar TL characteristics of loessic deposits from Normandy can provide good chronological differentiation between Weichselian and Saalian loesses. Moreover, we have shown that the feldspar TL properties allow chronological discrimination among Saalian loesses. The agreement of our new feldspar TL data with the stratigraphy suggests that it can be used as a relative dating technique for loesses older than 120 ka. However, some further work is needed to understand the reason for the anomalously "old" values obtained for the Saint Roman and Mantes loesses discussed above.

By contrast with absolute dating methods which provide point date estimates, our technique is more adapted to rapid, comprehensive studies of loess chronology within large areas. It enables definition and comparison of regional relative TL chronologies and therefore can be used for preliminary chronological investigations. This approach, which we have termed "TL stratigraphy", allows a better control of the chronological and regional coherence of the TL results.

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[PR] Reviewers Comments (A.G. Wintle)

The empirical use of TL measurements on separated 40-50 μm potassium feldspar grains described in this paper is interesting since it throws light on the current discussions of TL dates obtained for fine grain loessic sediments from north west Europe as well as providing a relative dating method for these sediments.

In the first study using the regeneration method, geologically acceptable ages were obtained at Saint Romain (Wintle et al, 1984) for samples taken down to the loess immediately beneath the soil thought to result from the last interglacial (Eemian). However, Debenham's study on a variety of loessic sediments from several sites in north west Europe (Debenham, 1985) showed that deviation of the apparent TL age from the geological age occurred for samples as young as 50 ka. Wintle (1985) subsequently found underestimation of ages for deeper samples at Saint Romain. The implication of those studies is that the uppermost interglacial soil, thought to be the Eemian (Lautridou, 1985), is in fact considerably older than this. At other sites the TL age for loess immediately beneath the last interglacial soil is about 85 ± 10 ka (Proszynska-Bordas, 1985). This discrepancy is also shown up in this paper by Balescu et al (1986) and with this further evidence, the geological evidence for interpreting the uppermost soil at Saint Romain as being from the last interglacial should now be re-examined. The use of 40-50 μm K-feldspar grains also seems to give much clearer separation of the Saalian loesses than can be achieved using the regeneration method to obtain TL ages on fine grains (e.g. Debenham, 1985; Wintle, 1985).

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