

Bleaching characteristics of some optically stimulated luminescence signals

Frank Preusser

Geologisches Institut, Universität zu Köln, Zùlpicher Strasse 49a, 50674 Köln, Germany
Present address: Geologisches Institut, Universität Bern, Baltzerstrasse 1, 3012 Bern, Switzerland

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Introduction

When dating sediments by luminescence, zeroing of the signal prior to deposition is essential since incomplete bleaching will result in age overestimation. Therefore when dating sediments undergoing rapid transportation like fluvial deposits, resetting of the luminescence signal prior to deposition needs to be verified. One possibility to do so is the comparison of luminescence emissions with different bleaching characteristics. As demonstrated by Godfrey-Smith et al. (1988), optically stimulated luminescence (OSL) is more rapidly bleached in comparison to thermoluminescence (TL). Hence, obtaining similar OSL and TL ages indicates zeroing of both signals prior to deposition (Duller 1994). However, for many sediments from fluvial environments complete bleaching of the TL signal is not very likely. Thus, the approach of comparing OSL and TL ages will be limited to well bleached sediments and negates the advantage of OSL, the easy-to-bleach nature of the signal. It has been suggested that the comparison of OSL from quartz and feldspars should be an appropriate method to confirm complete bleaching prior to deposition (Fuller et al. 1994). Furthermore, different IRSL emissions have been used for verifying the zeroing of feldspars gathered from lake deposits from Antarctica (Krause et al. 1997). However, only a few studies focusing on the bleaching characteristics of different OSL signals have been published so far. Therefore, it was the aim of this study to investigate whether these methods are indeed suitable for testing complete bleaching of the OSL signal prior to deposition.

Experimental details

Experiments were carried out to define the bleaching characteristics of different OSL emissions from polymineral fine grains (4-11 μm) and coarse grained (100-200 μm) potassium rich feldspar and quartz samples. The fine grained fraction was enriched using

the technique described by Frechen et al. (1996). Coarse grains were separated by wet sieving and heavy liquids (Mejdahl 1985). The quartz fraction was furthermore etched in concentrated HF for 60 minutes. The etched and dried samples were subsequently sieved again to remove remaining feldspar grains. Purity of the quartz samples was verified by the lack of luminescence under infrared stimulation (Smith et al. 1990).

Bleaching was carried out using an Osram Ultra-Vitalux UV lamp (300 W) and a Schott GG475 filter. The filter cuts off any light with wavelengths < 475 nm (UV - blue) and thus will give a rough simulation of shallow water conditions. However, an authentic simulation of a natural fluvial transport is nearly impossible because of the complexity of the environment. Former work has shown that turbidity and turbulence within the water column will severely decrease the light intensity (Ditlefsen 1992), yet turbidity and turbulence are highly variable both spatially and temporally.

The samples were taken from sections at Gossau (GOS) and Zell (ZEL), Switzerland. The delta sediments at Gossau (GOS1, GOS2) and the fluvial deposits at Zell (ZEL5) have OSL ages of approximately 100 ka. Sample GOS3 was gathered from an overbank deposit with an age of approximately 50 ka (Preusser 1999 a, b).

A Risø reader DA 12 has been used for the OSL measurements (Bøtter-Jensen et al. 1991). GLSL was measured using the apparatus described by Bøtter-Jensen & Duller (1992) with a Hoya U340 detection filter. The IRSL signal was detected in the broad band (Schott BG39), yellow (Schott BG39, Schott OG530), blue (Schott BG39, Corning 7-79, Schott GG400) and UV (Hoya U340) emission bands.

The multiple aliquot technique was applied for the fine grained samples GOS2 and GOS3 recording the emitted luminescence during a 60 second measurement with IR diodes. Five aliquots were

measured for each step without any normalisation and the integral 50-60 seconds was subtracted as late light (Aitken and Xie 1992). All other measurements were carried out using a single aliquot protocol. Here, the natural luminescence intensity was measured by a 0.5 sec exposure to infrared stimulation (IRSL) or green light stimulation (GLSL), respectively. The aliquots were then bleached for 60 seconds using the filtered light of the UV lamp and measured again. Subsequently, the samples were bleached for a further 240 seconds resulting in an entire bleaching time of 300 seconds. This procedure was repeated using different bleaching intervals up to the maximum entire bleaching time of 7200 seconds when no further depletion of the OSL signal has been recognised.

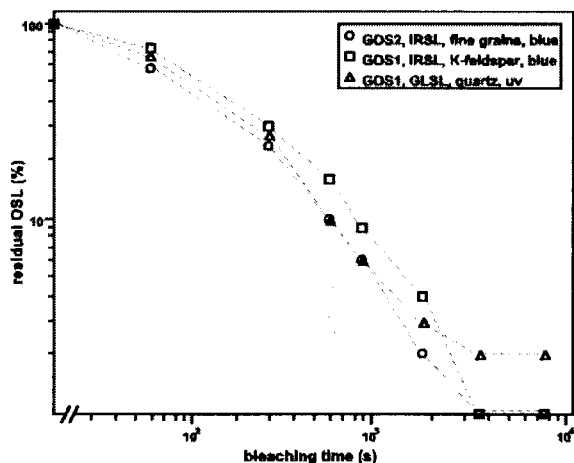


Figure 1.
Comparison of the bleaching characteristics of GLSL from quartz and blue IRSL emissions from polymineral fine grains and feldspar samples gathered from early weichselian delta sediments at Gossau, Switzerland.

Results

The results of the bleaching experiments are presented in figures 1-5. For comparison the remaining OSL after bleaching is stated as the percentage of the original signal intensity. Typical scatter within the single bleaching steps is about 5-10 % for the multiple aliquot and about 2-3 % for the single aliquot measurements. After 60 seconds of bleaching the signal depleted to about two-thirds of the original level. 300 seconds bleaching resulted in residual levels of about 20-30 %. After 3600 seconds the remaining IRSL intensity was about 1-2 %.

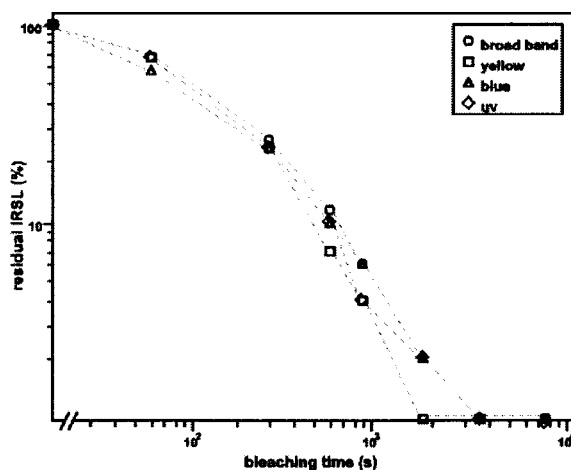


Figure 2.
Comparison of the bleaching characteristics of different IRSL emissions from polymineral fine grains (sample GOS2).

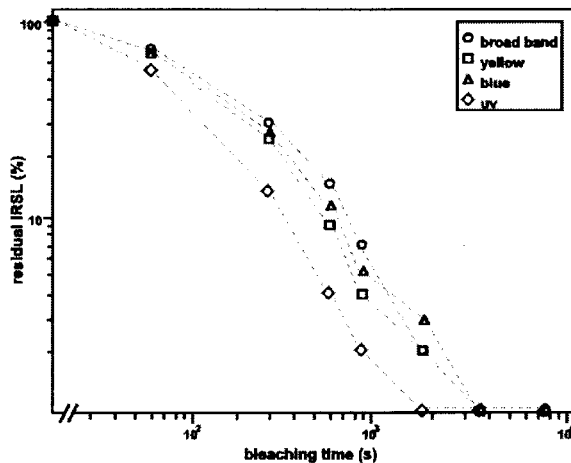


Figure 3.
Comparison of the bleaching characteristics of different IRSL emissions from polymineral fine grains (sample GOS3).

Figure 1 compares the results of the bleaching experiments for GLSL from quartz and the blue IRSL emissions from K-feldspars and polymineral fine grains of two samples (GOS1 and GOS2) from the delta sediments at Gossau. All dosimeters show nearly identical bleaching characteristics except for a higher residual level for the quartz measurements caused by scattered light from the stimulation source. The results of the bleaching experiments on different IRSL emissions for fine grains are plotted in figure 2 and figure 3. Both samples show nearly corresponding bleaching characteristics of the single IRSL emissions but a more rapid zeroing of the yellow emission (GOS2; Fig. 2) and UV emissions (GOS3; Fig. 3), respectively. The K-feldspar samples (Fig. 4 and Fig. 5) show also only small differences

in the resetting of the IRSL. However, for both samples the broad band emissions seem to be bleached less rapidly. The apparent higher residual level for the yellow emissions of sample ZEL5 (Fig. 5) is due to the weak IRSL signal emitted in that range and, hence, caused by a low signal/background ratio.

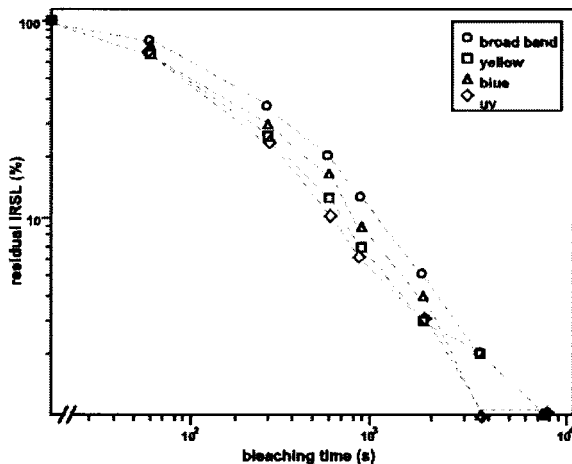


Figure 4.
Comparison of the bleaching characteristics of different IRSL emissions from coarse grained potassium rich feldspars (sample GOS1).

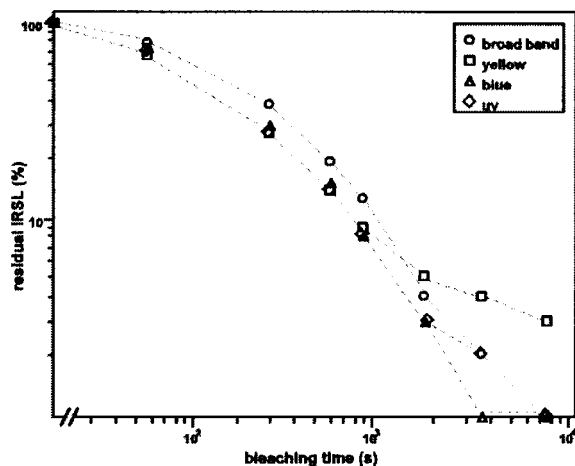


Figure 5.
Comparison of the bleaching characteristics of different IRSL emissions from coarse grained potassium rich feldspars (sample ZEL5).

Discussion

Considering scatter and reproducibility, only trifling differences in the resetting characteristics of the single OSL signals have been recognised in the recent

study. Furthermore, these small differences seem to show no systematic pattern.

The bleaching experiments by Krause et al. (1997) were performed under similar experimental conditions but on a different mineral (plagioclase). In contrast to the original interpretation by the authors, these experiments show actually also only small differences in the bleachability between the single IRSL emissions (see Krause et al. 1997: Fig. 7; consider the logarithmic scale). Consequently, it has to be questioned if the higher IRSL ages obtained for the emissions at 330 nm and 410 nm are really caused by differences in the resetting characteristics of the single emissions, as suggested by the authors.

Conclusions

No significant differences in the bleachability of the single OSL signals have been found so far. Therefore, comparing different OSL emissions is no appropriate method for verifying zeroing of the OSL prior to deposition until clear evidence for variations in the resetting characteristics is given. However, even if some systematic patterns could be confirmed, the differences in resetting of the single OSL emissions are likely too small to give a reliable verification considering the reproducibility of multiple aliquot dating.

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Reviewer

G. Duller