Progress in luminescence dosimetry in contaminated settlements

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Introduction

Previous studies have shown that luminescence techniques can be successfully applied to ceramic building materials such as bricks and tiles to determine the external gamma dose in radioactively contaminated settlements [1]. In this study, luminescence dosimetry is applied to bricks from a former mill of the village of Muslyumovo in the Techa River Valley, Southern Urals, Russia, which was contaminated by the release of radionuclides from the Mayak PA during 1949-1956.

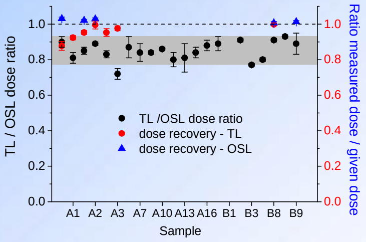
Material and Methods

Sampling strategy:
- bricks for measurement of height profile and dose depth profile
- four adjacent bricks from the same spot for analysis of variability
- bricks from well-shielded locations for assessment of firing age of bricks

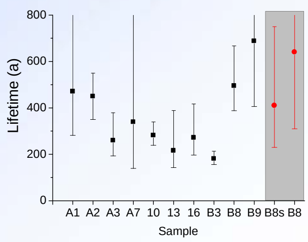
Luminescence measurements on quartz grains (140-200 µm) extracted from bricks (at depths of 10 and 20 mm from brick surface):
- OSL using a single-aliquot-regeneration protocol with test-dose normalization [2]: preheat at 190°C for 10 s, cutheat at 160°C
- TL (up to 280°C) using the 210°C peak and a single-aliquot-regeneration protocol [3]: preheat at 160-170°C for 100 s
- Measurement of present gamma-dose rate at sample location averaged over one year using Al_2O_3:C dosimeters (corrected for energy response)

Luminescence results

- Cumulative doses measured with TL are systematically lower (10-20%) than the ones measured with OSL (range 400-600 mGy)
- Dose recovery tests for both methods reveal that in general the dose discrepancy cannot be explained by the measurement protocols alone
- Estimation of mean lifetime of 210°C TL peak by laboratory measurements and from modeling of TL/OSL dose ratio yields similar range of values: approx. 200-700 years
- Thermal fading of 210° TL peak is the most likely reason for dose discrepancies. Only OSL values should be used in dose reconstruction.



TL/OSL dose ratio (left axis) and dose recovery tests (right axis)

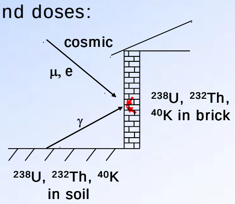


Lifetime from TL/OSL dose ratio (black) and from laboratory measurements (red)

Assessment of background dose

- Measurement of natural radionuclides in soil and brick
- Dose conversion coefficients considering irradiation geometry, obtained from Monte Carlo methods [4]
- Separate estimation of 'soft' and 'hard' component of cosmic dose rate
- Measured age of bricks: (130 ± 5) a
- Range of background doses:

  240-300 mGy

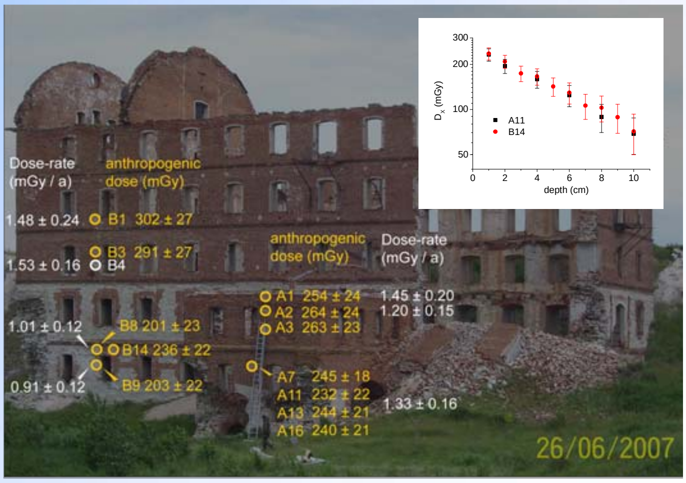


irradiation geometry for background dose

In-situ gamma spectrometry for measurement of natural radionuclides in soil

Anthropogenic dose (OSL) in brick samples

- Assessed after subtraction of background dose from cumulative dose
- Doses for samples A7-A16 show variability within statistical errors (3%). Dose for sample B14 is 20% higher than for B8 (reasons not known)
- Doses for higher located samples (B1, B3) are 50% higher than for lower located samples (B8, B9) ⇒ indications for extended source geometry
- Dose depth profiles are compatible with ^{137}Cs distributed on the ground
- Samples from the same height but from different walls (A7-A16, B8-B9) show expected decrease in dose with increasing distance from the source
- Present gamma-dose rates show similar characteristics as anthropogenic dose



Conclusions

- Luminescence dosimetry provides valuable information for dose reconstruction with computational modeling [5]
- In the case of small anthropogenic doses, the background dose needs to be carefully assessed
- In regions of continental climate, the 210°C TL peak should only be applied for samples of the last 50-60 years

References:
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