The internal dose rate in quartz grains: implications for luminescence dating

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Introduction
This work presents how the internal alpha and beta dose rates in quartz grains obtained from sandy sediments impacts luminescence dating. In order to determine the internal dose rates, the innovative μDose systems were used. Our findings clearly indicate and confirm that etched quartz grains contain radioactive isotopes, hence the assumption that the only source of radioactivity is radioisotopes from outside is an erroneous approximation.

Presented results show that the internal radioactivity has a relevant influence on determining the age of the tested samples. Ignoring the internal alpha and beta components during the total dose rate assessing can overestimate the luminescence age. The internal dose rate to total dose rate ratio in our measurements often exceeds 10%. This means that the correction for internal dose rates should always be applied, otherwise the final dose rates will be underestimated, and the final results overestimated.

Research methodology and description of samples (Fig. 1):
Forty-two samples were selected from several different dating projects carried out at the Gliwice Luminescence Dating Laboratory. Most of the analysed samples were dune sediments, with a low concentration of natural radionuclides and, therefore, low external dose rates of about 1 Gy·ka⁻¹ or less. Comprehensive preparation of samples for measurements was performed along two paths, namely for internal and external dose rate determinations.

• Extracted quartz measurements
• Chemical procedure
• Measurement using the μDose system
• Bulk sediment measurements
• Internal, external and cosmic dose rates calculation

Results
Fig. 2. Internal dose rate and external dose rate measured for all investigated samples.
Fig. 3. Internal dose rate and external dose rate histogram from 42 measured samples and data derived from values reported in the literature.
Fig. 4. Distribution of the quotient of internal and dose rates (external and cosmic dose rate) expressed as a percentage.
Fig. 5. External dose rate versus internal dose rate for all investigated samples.

Conclusions:
• For low radioactivity sediments, it may be necessary to assess the internal dose rate in pure quartz grains. This requires the labour-intensive extraction of quartz grains. Our findings clearly indicate and confirm that etched quartz grains contain radioactive isotopes, hence the assumption that the only source of radioactivity is radioisotopes from outside is an erroneous approximation.
• Presented results show that the internal radioactivity has a relevant influence on determining the age of the tested samples. Ignoring the internal alpha and internal beta components during the total dose rate assessing can overestimate the luminescence age.
• The greatest ratio of internal dose rate to the total dose rate is noted for samples that have a low natural concentration of radionuclides, which translates to a low external dose rate (usually lower than 1 Gy·ka⁻¹). This means that for these types of sediments, correction for internal dose rates should always be applied, otherwise the final dose rates will be underestimated, and the final results overestimated.
• We cannot be sure what upper limitations we can obtain for other samples subjected to future experiments. Establishing the internal dose rate fixed correction for all types of sediments might not be possible because even for similar dune samples, the internal to external dose rate measurements are characterised by a lack of correlation.

References: