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Determination of palaeo-water content for OSL-dating of shallow lacustrine sediment sequences – a limnological approach

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Water content is an important variable in optically-stimulated luminescence (OSL) dating as it affects dose rate by attenuating radioactive energy received by a sample. The fluctuation of water content with time is usually considered negligible in terrestrial environments, where the range of values does usually not vary greatly. However, correctly estimating or closely approximating the water content in lacustrine or water-logged settings is more problematic since water content (and hence dose rate attenuation) in these settings is one order of magnitude higher than in terrestrial settings. An estimation of palaeo-water content is especially necessary if the cores to be dated by OSL have been sampled without an immediate laboratory measurement of actual water content.

We here present a data set derived from modern limnological investigations where water content is routinely measured in cores ranging from 1-10 m below lake bottom with the aim of arriving at a robust method of estimating palaeo-water content. In particular, the range of sediment properties allows an empirical relationship between these variables and water content to be established and statistically tested. In groundwater-saturated settings all pores are filled with water, and, depending on particle density, pore space can make up more than 50% of the wet bulk density (denoting the total mass of water and solid matter per unit of volume) and hence very large water

contents are the norm (over 120% in terms of the gravimetric water content required as input for OSL-dating applications). The empirical relationship (R^2 = 0.865) derived from aforementioned data set allows pore space (and hence water content) to be determined based on measurable sediment properties as sampling depth and particle density.

We test the reliability of this data set and the value of the derived empirical relationship for OSL-dating on three cores containing lateglacial to Holocene sediment sequences from high-alpine lacustrine settings. A detailed radiocarbon chronology and pollen stratigraphy exists for all three cores, but water content had not been measured when the cores were taken (Tinner et al., 1996; Tinner & Theurillat, 2003). Application of the single-aliquot regenerative protocol for equivalent-dose determination on fine-grain polymineral and quartz separates (4-11 μm) reveals good luminescence behaviour throughout. Water content was calculated empirically using sampling depth and particle density for these three samples as input data. The resulting values were then used to calculate ages for the three samples, which were then compared with independent age control. All three polymineral samples match the independent age control, while the quartz samples consistently underestimate ages by about 2-3 ka. Further work, including fading tests, is currently being carried out to assess potential reasons for this, but the preliminary results are highly encouraging.

References

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