Spatially resolved luminescence dating of sediments: First Steps.

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Introduction

Recent advances in optical dating allow the dating of sediments, which have not been completely zeroed prior to deposition. Coarse-grain single-aliquot (SAR) dating of insufficiently bleached sediments include amongst others protocols based on the analysis of small aliquots with a reduced number of grains per subsample and single-grain (SG) techniques (e.g. Olley et al. 1998, 1999, Clark et al. 1999). However, SG dose-determination requires the knowledge of possible spatial heterogeneities in dose rate. As a consequence spatially resolved information on both, paleodose and dose-rate distribution are needed. At the Forschungsstelle Archäometrie, Heidelberg, a new reader for spatially-resolved luminescence detection is being developed (Greilich 2004, Greilich et al. 2002) for (details of the LasLum OSL-reader cf. oral presentation of Greilich et al., this conference). First dating-results of the highly resolved optically stimulated luminescence (HR-OSL) dating of stone-surfaced have been presented (Greilich et al., in press). In the future, we would also like to use the potential of the new measurement instrument for sediment dating and especially for potentially poorly bleached sediments.

Strategies for HR-OSL-sediment dating

Basically, we follow two strategies: the analysis of big stones like pebbles or cobbles, which are treated like stone surfaces and coarse-grain, mainly sandy sediments, which are casted in resin, so that they too may be handled like stone surfaces. From the stones or hardened sediments we take small drilling cores (~Ø 5 - 8 mm) potassium content of the feldspar grains to be determined as a function of time. So far only preliminary low level gamma measurements were done on the LasLum reader. One example is given in fig. 9. While from the stones only the outer surface may be used for OSL-dating, from the sediment cores several slices (aliquots) may be cut off and/or better broken off - and used as ‘interior surfaces’.

Samples and HR-OSL measurements

We selected samples from two study areas, one of which is the Ica-Nazca depression in the northern Atacama desert in southern Peru (fig. 1), the other one is the place of founding of the famous lower jaw of the Homo heidelbergensis in Mauer near Heidelberg in southwestern Germany (Schoetensack 1908, Wagner & Beinhausner 1997).

Irrigation channel: Three types of sediments were taken from the Peruvian sites. At the locality of Jaime in the Santa Cruz valley (fig. 1) samples were collected from an anthropogenically heaped up sidewall of an irrigation channel (fig. 2). The sediment is mainly made up from the fine-grained loess covering the area and contains few pieces of stones from the underlying desert pavement. We tried several measurements on the hardened fine-grained material applying a resolution of 2x2 bins (50 µm). But as we could get hardly any signal from the silty fine grains and the small binning additionally worsened the low signal-to-noise-ratio, we changed the strategy and collected the contained stone fragments in a second field campaign. The difference in results for fine-grains and bright stone surfaces is demonstrated with two respective dose recovery tests (figs. 3).

From eight measured surfaces of stone pieces five were analyzable. Determining the paleodoses of the brightest areas ( roi of interest / ROIs) with >260 cts/first 60 s (dim sample) up to >600 cts/first 60 s (very bright sample) from ten ROIs of four samples, we gained Ds in the range of ~25.8 - 38.4 Gy. Assuming a dose rate of ~3.8 Gy/ka these would represent ages of ~7 - 10 ka. Apparently, the stones were not (sufficiently) bleached during the channel construction but preserved - (much of) what presumably is the paleodose corresponding to the desert pavement by loss deposition, which according to conventional OSL, fine-grain dating and C-dating in the area started at the onset of the Holocene and lasted until the middle of the Holocene (Eitel et al. 2005). However, one stone yielded two analyzable ROIs of ~1.4 and 3.7 Gy, respectively, which represented a core from sample HDS-1472 cored from an embedded stone in Mauer (fig. 7). We measured one slice of one core from sample HDS-1472 (fig. 8). From two ROIs (>250 cts/first 60 s per pixel) we determined Ds of 2.8 and 4.8 Gy. As from preliminary low level gamma measurements dose rates of ~3.5 Gy/ka are expected, corresponding OSL ages are about 0.9 and 1.4 ka.

Alluvial sand Peru: Alluvial sand deposits were sampled from an openwater into terrace sediments of the Rio Palpa / Rio Viscas at the Fundo Lauranga (fig. 1). In its lower part the profile contains artefacts dating to the Nazca period (pers. comm. Dr. Markus Reindel). Two samples from the upper part of the profile wall (fig. 7) were casted into resin. We measured one slice of one core from sample HDS-1472 (fig. 8). From two ROIs (>250 cts/first 60 s per pixel) we determined Ds of 2.8 and 4.8 Gy. As from preliminary low level gamma measurements dose rates of ~3.5 Gy/ka are expected, corresponding OSL ages are about 0.9 and 1.4 ka.

Alluvial sands Germany: The expected age for the alluvial sand, in which the lower jaw of the Homo heidelbergensis was found (fig. 9), lies beyond 500 ka (Zölller et al. 1997), which cannot reliably be determined using feldspar grains due to longterm fading. However, HR-OSL analyses may provide useful information on luminescence characteristics like e.g. the shape of the growth-curves of individual feldspar grains at high doses or longterm fading. The bright spots (ROIs with >500 cts/first 60 s per pixel) analyzed in this study provide Ds of ~170 - 300 Gy (fig. 10), which would yield ages of ~120 - 200 ka, if a dose rate of ~1.5 Gy/ka is assumed. Once UV-transmittant tests are available at the Forschungsstelle Archäometrie future studies will focus on green light stimulated HR-OSL on quartz in order to find ‘hot grains’ that do not saturate even at high doses.

Protocol: HRSL-SAR on yellow feldspar emission

For equivalent dose (D_E) determination we apply a SAR protocol (Murray & Wintle, 2000). With the presently available LasLum reader only OSL-readout is possible, irradiation is carried out at an external SEV 5’ELSC 5-bias (~3.6 Gy/min) while preheat and cutfront procedures are performed in an external oven at 150 °C. Before OSL-readout the sample is cooled for 500 °C (~16 °C on a watercooled metal plate. Stimulation of the feldspar component occurs with an IR-laserdiode (837 nm, ~15 mW/cm²) at the sample. As in the period of measurements it was not appropriate to change the measurement configuration, only the detection of the yellow feldspar component (~500 nm (Schott glass filter GG075 + BG3, 3 mm each) was possible. The OSL-signal is collected on a nitrogen-cooled CCD camera chip (Princeton Optics). We used a resolution of 50 µm (pixel of 2 x 2 bins) or 100 µm (pixel of 4 x 4 bins) and read out 15 consecutive frames of each. The background noise per pixel is ~150 - 200 counts/s (see dark- blue colours on figure 3, 6, 8 & 10). Data analysis was done with the program AgeoGlow (Greilich et al., sub. poster presentation of Afnasjap et al., this conference). The first frame (~160 s) was used for D_E determination, while the last frame (~811 - 900 s) was used for late light subtraction (Aktten & Xie 1992). Depending on the signal strength and expected equivalent dose of a sample, test doses of ~1.6 Gy, 6 Gy or 18 Gy were administered (mostly ~50% of paleodose).

Unfortunately no tests of anomalous fading could be done before the conference, nor could the internal potassium content of the feldspar grains be determined in time. So far only preliminary low level gamma measurements were done for rough dose rate estimates. However, the principal potential of the spatially resolved technology for sediment dating may still be demonstrated.

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