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Luminescence dating of river terrace formation – methodological challenges and complexity of result interpretation: a case study from the headwaters of the River Main, Germany

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River terraces are widespread geomorphic features of Quaternary landscapes. Besides tectonics, their formation is predominantly controlled by climatic conditions. Changes in either conditions cause changes in fluvial discharge and sediment load. Therefore, fluvial terraces are widely used as important non-continuous sedimentary archives for paleotectonic and paleoenvironmental reconstruction.

The informative value of fluvial archives and their significance for paleoenvironmental research, however, strongly depend on a precise dating of the terrace formation. Over the last decades, various luminescence dating techniques have successfully been applied on fluvial deposits and were able to provide reliable age information. In contrast to radiocarbon dating, modern luminescence dating techniques provide an extended dating range, which enables the determination of age information for fluvial and other terrestrial archives far beyond the last glacial-interglacial cycle. Due to the general abundance of quartz and feldspar minerals, there is almost no limitation of dateable material, so that luminescence dating methods can be applied on a wide variety of deposits.

When using luminescence dating techniques, however, some methodological difficulties have to be considered. Due to the mechanism of fluvial transport, this is especially true for fluvial sediments, for which two major problems have been identified to be the main reasons of incorrect age estimations: (1) incomplete resetting of the luminescence signal during transport and (2) dosimetric inaccuracies as a result of the heterogeneity of terrace gravels. Thus, luminescence dating techniques are still far from being standard methods for dating fluvial archives and the calculated sedimentation ages always demand a careful interpretation.

This contribution reveals some of the difficulties that may occur when luminescence dating techniques are applied on river terraces and illustrates several strategies used for overcoming these problems and for determining correct sedimentation ages.

The presented results are based on a case study, located in the headwaters of the River Main, the longest right bank tributary of the Rhine drainage system. Here, within an oversized dry valley in Northern Bavaria (Germany), five Pleistocene terraces are distinguished. The terraces are interpreted as the result of a complex landscape evolution, which is characterized by multiple river deflections.

The need for a careful interpretation of luminescence results is illustrated by some optically stimulated luminescence (OSL) ages calculated for the youngest of these five Pleistocene terraces. These results show different sedimentation ages of samples originating from the same morphological unit. Thus, these ages may be interpreted as evidence for a diachronic character of river incision and, hence, point to the complexity of fluvial systems' response to climatically and/or tectonically forced changes in local and regional paleoenvironmental conditions.