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# A multiple dating approach (luminescence and electron spin resonance) to assess rates of crustal deformation using Quaternary fluvial terraces of the lower Moulouya River (NE Morocco)

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The Moulouya River, the largest catchment in Morocco, drains an area characterized by active crustal deformation during the Late Cenozoic due to the convergence between the African and Eurasian plates. Our study focuses on the lowermost reach of the river in NE Morocco, where a thrust zone associated with N–S compressive shortening in this region was identified (Barcos et al., 2014; Rixhon et al., 2017). New geomorphological results demonstrate contrasting fluvial environments on each side of the thrust: long-lasting fluvial aggradation, materialized by >37 m-thick stacked fill terraces, and the development of a well-preserved terrace staircase, with three Pleistocene terrace levels, occurred in the footwall and the hanging wall, respectively (Rixhon et al., 2017). Here, we present a preliminary geochronological background for these contrasting terrace systems based on a multiple dating approach. Samples for (i) luminescence (pIRIR225 and pIRIR290 dating of coarse-grained K-feldspars) and (ii) electron spin resonance (ESR dating of coarse-grained quartz) from four different profiles were collected.
(i) Due to the application of the athermal detrapping model by Huntley (2006) (modified after Kars et al., 2008), it appears that the feldspar signals are in sample specific field saturation. Our results yielded minimum ages of 0.9 Ma and 0.7 Ma for the footwall and hanging wall, respectively.
(ii) Using the multiple centre approach with ESR dating (Duval et al., 2015), we measured both the aluminium (Al) and the titanium (Ti) centres in order to evaluate whether they would provide consistent results. Results indicate that De values of the Al centre are either slightly higher compared to those of the Ti centre or they agree within a $1\sigma$-error range, which may simply be due to the slower bleaching kinetics of the Al centre. Thus, the ESR ages were inferred from the Ti centre. Ages between $1.35\pm0.10$ and $1.17\pm0.10$ Ma in the footwall show sediment aggradation between MIS 40 and MIS 32, whilst the last terrace formation in the hanging wall is dated between $1.19\pm0.11$ and $1.61\pm0.15$ Ma, indicating even older fluvial deposition.
This study shows the high potential of the multiple centre approach in ESR dating, especially when dealing with samples beyond the dating range of luminescence techniques. Nevertheless, independent age control is still required to evaluate the reliability of the ESR dating results; this will be achieved in the near future using palaeomagnetism (CENIEH, Burgos) and isochron burial dating (26Al/10Be) on the same deposits. The acquisition of a reliable chronological framework based on different techniques will eventually give new insights into the rate of Quaternary crustal deformation in this region of Morocco.

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