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The long-term evolution of the Douro River as evidenced by strath terrace staircases located at NE Portugal (western Iberia)

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Abstract

In western Iberia, mechanisms that explain the transition from endorheic to exorheic continental-scale drainage reorganisation are foreland basin overspill, headwards erosion and capture by an Atlantic river, or a combination of both. To explore these controls we have investigated the Portuguese sector of the Douro River, the site of drainage re-organsation. The Douro River routes downstream through weak sedimentary infill of the Douro Cenozoic Basin (Spain), after which the river cuts down through granitic and metamorphic rocks cut by active fault zones (NE Portugal), before reaching the Atlantic coast. We investigated the drainage reorganisation using an integrated remote sensing, field survey and geochronological approach applied to Pliocene-Quaternary fluvial sediments and landforms. The older drainage record is documented by a series of high and intermediate landform levels comprising 1) a high level (1000-600 m) faulted regional fluvial erosion surface, the North Iberian Meseta Planation Surface (NIMPS); 2) an inset level (650-600 m altitude) comprising a broad fluvial surface formed onto a large ENE-WSW depression that overlies resistant Proterozoic and Paleozoic bedrock and 3) an inset (500-450 m) fluvial surface. The

Proterozoic and Palaeozoic bedrock and 3) an inset (500-450 m) fluvial surface. The younger drainage record comprises an entrenched fluvial strath terrace sequence of up to 9 levels (T9 = oldest positioned at 246-242 m above the modern river base (a.r.b); T1 = youngest positioned at 17-13 m a.r.b.). Levels T1 and T3 display fault offsets where the cross active NNE-SSW fault zones.

The three lowest terrace levels (T1-T3) were dated using optically stimulated luminescence (OSL) techniques using Quartz-OSL and post infra-red stimulated luminescence (pIRIR). Results ranged from 39-12ka (T1), 57ka (T2) and >360ka (minimum) (T3). Fluvial incision rates of the younger (terrace) drainage record were quantified and temporally exptrapolated to model the ages of the high to intermediate elevation levels of the early drainage record. Integration of incision data with fault zone derived crustal uplift values informs on the timing of the endorheic to exhoreic drainage reorganization.

We interpret the NIMPS to be part of the endorehic Douro Cenozoic Basin drainage divide erosion. The inset wide fluvial surface at 650-600 m altitude represents the overspill level in the area of the Mesão Frio ridges (drainage divide with the Atlantic drainage). Development of the exhoreic ancestral Douro valley is documented in the 500-450 m fluvial surface with our age and uplift modelling suggesting this became established during the upper Pleistocene (3.6 Ma) through to the Early Pleistocene (1.8 Ma). The entrenched river terrace sequence spans the Pleistocene, developing via spatial and temporal variations in rock strength, uplift and cyclic cool climate variability as the river adjusts to the Atlantic base level.