

PATTERNS AND CONTROLS ON FLUVIAL INCISION IN THE LOWER DOURO RIVER (WESTERN IBERIA) FOLLOWING ENDORHEIC-EXORHEIC DRAINAGE REORGANIZATION

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The Douro River, is ~900 km long and has a drainage basin of ~97,600 km², crossing most of the Iberian Peninsula from east to west (Fig. 1). The study area of the present work comprises the Lower Douro River (LDR), limited upstream by a pronounced knickzone called the Arribas do Douro developed into resistant basement bedrock. The evolution of the Douro system documents an outstanding example of a continental-scale drainage reorganization, reflecting a transition from endorheic to exorheic conditions. The LDR study area documents the ongoing fluvial incision stage developed after the endorheic-exorheic transition.

By the middle Cretaceous, the passive Western Iberian Margin was tectonically reactivated by an increasing N-S to NW-SE compression, leading to intraplate deformation. This deformation peaked at ~9.5 Ma (middle Tortonian) resulting in differential uplift of crustal blocks [1, 2]. Until ~3.7 Ma (middle Pliocene) the regional drainage was routed east into the endorheic Douro Cenozoic Basin (DCB) (Fig. 1). The transition from endorheic to exorheic conditions is debated. Recent work has indicated that capture-related re-organization via headwards erosion of a small Atlantic draining system was unlikely due to the high resistance of the basement bedrock and instead overspill is a more plausible explanation [3, 4]. Although the endorheic-exorheic reorganization leading to an Atlantic system, has recently been investigated [2, 3, 4, 5, 6], the fluvial incisional stage of the main river and tributaries is less understood along the LDR, which will be characterized and discussed here (Fig. 1).

Along the LDR, the Douro incises into hard granitic and metamorphic rocks crossed by active fault zones, before reaching the Atlantic coast. The main valley displays a fluvial staircase configuration of 11 levels, with the upper levels occurring as erosional bedrock straths and the 3 lowest levels as straths with a fluvial sediment cover.

In this work, we characterize the transient landscape relief of four distinct sectors along the LDR (Figs. 2, 3, and 4), in terms of: valley width-floor ratio, degree and rates of incision, uplift rates, migration of successive erosion waves and knickpoint propagation, preservation of old plateaus of the regional planation surface, influence of lithology on the relief evolution, and the staircase arrangement along the main course considering the presence/absence of aggradational levels. The four sectors are separated by two major NNE-SSW strike-slip fault zones, namely the Penacova-Régua-Vérin fault zone (PRVfz) and the Manteigas-Vilariça-Bragança fault zone (MVBfz), which are represented morphologically as river gorges along the uplifted blocks between pull-apart basins (e.g., Régua and Vilariça-Pocinho). The less uplifted areas are also where the aggradational strath terraces are well expressed.

The 4 sectors of the LDR are: I) from the river mouth till the confluence of the main northern tributary, the Tâmega River – adjacent to a wide littoral platform with inland hills (top surface <500 m); II) from the Tâmega confluence to the Mesão Frio-Régua tectonic corridor, corresponding to the uplifted relief of the Occidental Mountain Range; III) from Régua to the Pocinho-Vilariça pull-apart basin, corresponding to the High Plateaus region of Northern Portugal; IV) from Pocinho to the river elbow that marks the DCB margin, the old erosion surface of the Iberian Meseta.

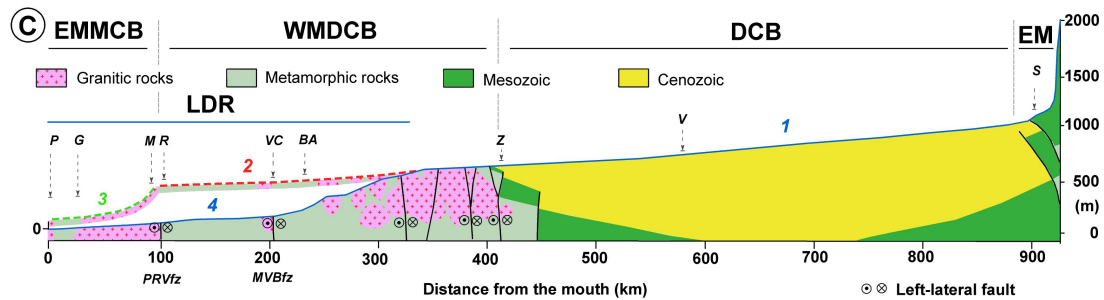
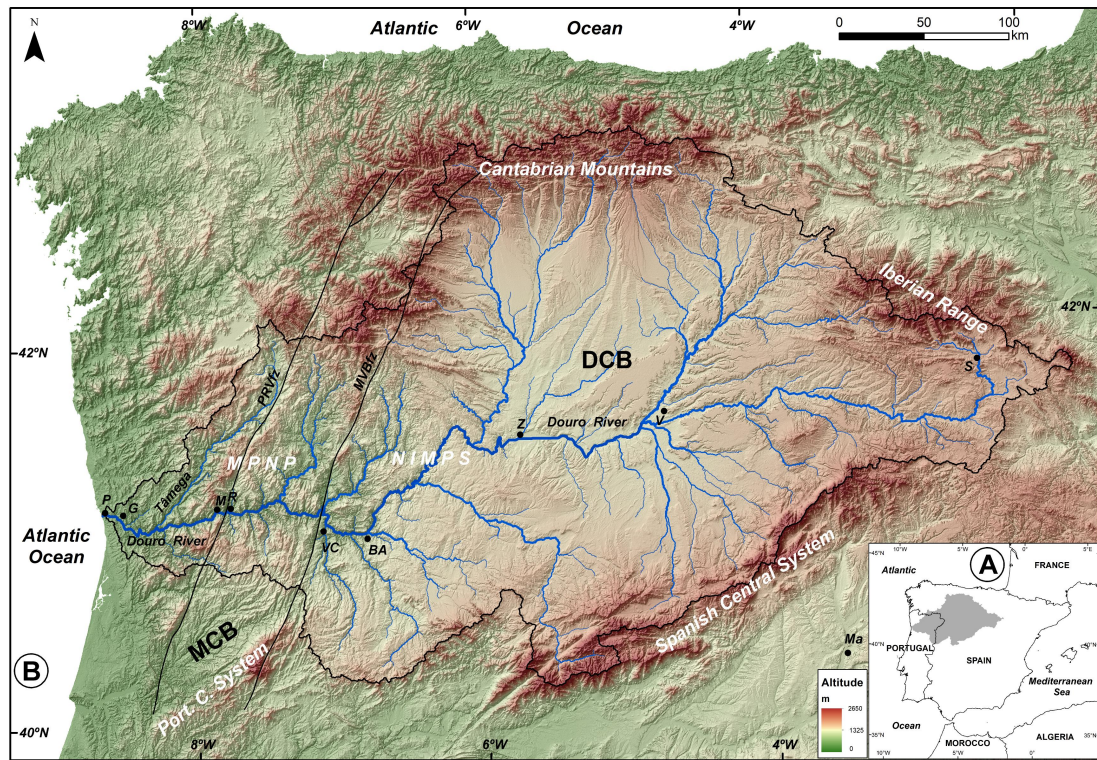


Fig. 1 - The Douro catchment (drainage divide=black line) and its drainage network (blue lines) (B), inset showing location in Iberia (A) and longitudinal profile (C) with bedrock geology. 1 - long profile of Douro River in the Douro Cenozoic Basin (DCB); 2 - long profile of the ancestral Douro in the study area; 3 - long profile of an ancestral coastal Atlantic river; 4 - long profile of the modern Douro downstream of the DCB; LD - Lower Douro.



Fig. 2 - Panoramic view of sector III from the Occidental Mountain Range (Alvão Mountain). High Plateau (MPNP) well preserved contrasting with the entrenched valley of Corgo River, a tributary of Douro of the right margin. Upstream of the minor bridge at left, there is the migration of the erosion wave and the transient knickpoint locate at the city of Vila Real.



Fig. 3 – Panoramic view of sector III upstream the village of Pinhão, where we observe the alternance of incision vs dynamic equilibrium marked by the staircase of strath terraces, highlighted by the location of the settlements and the bedrock terraces on the slopes.



Fig. 4 – Panoramic view of sector IV showing the transient landscape on the Côa River valley, a left margin tributary of Douro. On first plan, the spread of the incision upstream on the metamorphic soft basement, and the flattened erosion surface (NIMPS) that extends over the horizon to the residual quartzite relief of the Marofo Mountain (976 m).

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