From the Neolithic to the Anthropocene: Humans and depositional processes in Iberian Mountain watersheds

Blas L. Valero Garcés*, Fernando Barreiro-Lostres, Ana Moreno, Penélope González-Sampériz and Graciela Gil-Romera

Instituto Pirenaico de Ecología, Consejo Superior de Investigaciones Científicas, Avda Montañana 1005, 50059 Zaragoza, Spain, blas@ipe.csic.es

Large changes in the hydrological and biogeochemical cycles and surface processes dynamic have been documented in mountain watersheds during the last centuries, greatly affecting landscapes structure and surface processes. In Mediterranean regions, the summer drought and the variability in water availability are primary forcing controls for hydrological regimes, vegetation cover changes and depositional dynamics. Through changes in land uses, natural resources exploitation and an intense urbanization, humans have become significant agents shaping the mountain landscapes during the last millennia.

The mountain watersheds in the Iberian Peninsula showcase how humans have interacted with the landscape and contributed to change the depositional dynamics. Transformations from natural to rural and finally urban landscapes have left a strong signature in watersheds, slopes, rivers and lakes during the last millennia. Although first impacts could be traced to the Neolithic, fluvial and lacustrine environments were largely unaltered. Iberian and Roman imprint in the landscape resulted in the main first large-scale soil erosion and sediment accumulation phase and heavy metals atmospheric deposition, both documented with varied intensity all over the Iberian Peninsula. Fluvial deposits and lake sequences show large depositional transitions during the last millennia related to hydroclimate variability (e.g., mid Holocene transition, Iberian Roman – Humid period, Medieval Climate Anomaly, Little Ice Age) and to intense anthropogenic impact in the watersheds (Iberian- Roman, Middle Ages, the 19th-20th century). Most watersheds - even those located in remote areas and considered more "pristine" - have been transformed during previous centuries of intense land use and climate change. Intensification of soil erosion and sediment fluxes occurred both during more humid periods (stronger rainfall and higher frequency) and more arid periods (increased storminess, higher soil erodibility when vegetation cover was reduced). Synergetic effects between phases of increased human pressure and rapid climate change occurred during the onset and demise of the Little Ice Age and caused increased sediment fluxes in watersheds and changes in flood intensity and frequency.

Recent changes, both in the mountains and in the lowlands, have been even more dramatic. Climate and anthropogenic activities are responsible for some trends starting in the mid 1970s: diffuse contamination due to industrial development of intensive agriculture; recent eutrophication in aquatic systems in more touristic areas; lower sediment fluxes from watersheds where significant land abandonment occurred since the 1950s, changes in erosion patterns in slopes and channels in mountain rivers. Recent climate change has a global impact, already seen in flood and drought dynamics, with important implications in small-scale watersheds.

Anthropocene signatures in Iberian mountain depositional systems are varied, as the watersheds during the last centuries have witnessed phases with strong human impact (Medieval times, late 19th century and early 20th century) and periods with decreased human

activities (Little Ice Age, economic and social crises during Medieval times, rural exodus after mid 20th century). Past human activities have to be considered to understand current depositional systems and landscapes dynamics in the Mediterranean mountains with a long history of human activities. Climate variability, particularly in rainfall amount and seasonal distribution, has also played a determinant role. Synergies, resilience and hysteresis interactions have occurred in the past and should be expected in the near future. Evaluation of hazards and risks (floods and droughts, slope activity, landslides, soil erosion, sediment and geochemical fluxes) and adaptation strategies should include humans as active agents of change, not only as passive receptors.