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Physical stratigraphic model for the Eocene Escanilla sediment routing system, Spanish Pyrenees: Inverting for climate and tectonic change

John Armitage (1), Philip Allen (2), Peter Burgess (1), and Gary Hampsen (2)

(1) Department of Earth Science, Royal Holloway, University of London, Egham, UK, (2) Department of Earth Science and Engineering, Imperial College London, London, UK

Sedimentary architectures are fundamentally controlled by the interplay at different temporal and spatial scales of the volume and grain-size distribution of the sediment supply to a depositional setting. Yet, the sediment source is a function of both climate and tectonics, and unravelling the forcing mechanism from the observed stratigraphic architecture remains a key research challenge, particularly if we wish to understand the interactions between tectonics and surface processes. The Escanilla palaeo-sediment routing system has its source region in the south-central Pyrenean orogen in the Mid to Late Eocene, and transported sediment from wedge-top basins along tectonic strike to marine depocentres in the west. From constructing a volumetric budget of the sedimentary system, it is observed that during this period there is a marked change in the source distribution of grains and a movement of the gravel front, across three $\sim$2.6 Myr time intervals from 41.6 to 33.9 Ma. Classic sequence stratigraphy would relate the movement of depositional fronts to changes of base level. However, given the variability of source grain size distributions, we explore the possibility that the position of the gravel front is primarily driven by catchment uplift rate and/or surface run-off.

Using a simple model of sediment transport that captures first order processes, we can re-create the lateral movement in gravel deposition within the Escanilla sedimentary system. Movement of the gravel front is both a function of accommodation space and the transport capacity of the sediment routing system. We assume that the transport capacity is a linear function of the local slope and the water flux. By assuming that the observed thickness of deposits is the equivalent to the accommodation space generated, we can then use the stratigraphic architecture to constrain the change in upland catchment size and water flux. We find that during the Mid Eocene there was an increase in catchment length and sediment flux, likely driven by uplift within the Pyrenean orogen. However, a marked progradation of the gravel front during the Late Eocene is the consequence of reduced transport capacity due to a reduction in surface run-off. Such a scenario is in agreement with pollen taxa records that indicate a transition to more open vegetation in the Late Eocene.

Sediment transport is likely too diffusive to allow for a true inversion for basin uplift and subsidence, but the running of multiple scenarios with a simple forward model allows the sedimentary record to be used to find the most plausible tectonic and climatic history. The combination of a sediment transport model with a full sediment budget makes the inversion and deconvolution of tectonic and climatic changes in the past possible.