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Understanding bias in provenance studies

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Innumerable pieces of information are stored in the sedimentary archive. Each single sediment layer contains billions of detrital grains, and every grain preserves imprints of its geological story. If we learn to read, compare, and combine these messages properly, through a deeper understanding of physical and chemical processes that modify sediment composition during the sedimentary cycle, provenance analysis may eventually enable us to reconstruct more accurately the geological processes that shaped the Earth's crust in the past.
Interpreting detrital modes is not straightforward because provenance signals issued from source rocks become progressively blurred by multiple noises in the sedimentary environment ("environmental bias"; Komar, 2007), and finally during post-depositional history ("diagenetic bias"; Morton and Hallsworth, 2007). During transport and deposition, detrital minerals are segregated in different size fractions and environments according to their size, density and shape (Rubey, 1933; Garzanti et al., 2008). Heavy-mineral concentration can increase by an order of magnitude due to selective-entrainment effects, with potentially overwhelming impact on chemical composition and provenance estimates based on detrital-geochronology data (Garzanti et al., 2009). Conversely, heavy-mineral concentration is typically reduced by an order of magnitude in Alpine and Himalayan foreland-basin deposits older than the Pleistocene (Garzanti and Andò, 2007). Extensive chemical dissolution can occur even prior to deposition during weathering in hot humid climates (Velbel, 2007).
Primary provenance signals can be isolated and assessed by studying first modern sediments in hyperarid settings (i.e., free from diagenetic and weathering bias). Next, weathering, hydraulic-sorting, and diagenetic effects can be singled out by analysing sediments of similar provenance produced in contrasting climatic conditions, sediments transported in diverse modes and deposited in different subenvironments within a same system, and sediments of approximately constant provenance and progressively older age. Detangling the various interacting factors controlling mineralogical and chemical compositional variability is a fundamental pre-requisite to improve decisively not only on our ability to unravel provenance, but also to understand much about climatic, hydraulic, and diagenetic processes.

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