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Detrital minerals from source to sink : tracing Orange River sand from Lesotho to Angola

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Quantitative provenance analysis based on high-resolution bulk-petrography and heavy-mineral data on beach and dune sands, integrated with detrital-zircon geochronology and chemical analyses of pyroxene, garnet and staurolite, demonstrates that sand carried by the Orange River and derived from Lesotho and South Africa is carried by powerful and persistent longshore currents as far as southern Angola (Garzanti et al., 2014a). This is the longest cell of littoral sand transport documented so far on Earth, and a great test case for investigating physical controls on sand texture and composition. We have monitored textural, mineralogical and geochemical variability of beach and eolian-dune sands along a 1750 km stretch of the Atlantic coast of southern Africa by using an integrated set of techniques, including image analysis, laser granulometry, optical microscopy, Raman spectroscopy and bulk-sediment geochemistry (Garzanti et al., 2014b).

Our results contrast with previous reports that feldspars and volcanic detritus break down during transport, that sand grains are rounded rapidly in shallow-marine environments, and that quartzose sands may be produced by physical processes alone. We demonstrate that basaltic rock fragments and pyroxenes, traditionally believed to be rapidly destroyed, survive healthily the 4000 km-long multistep hazardous journey from Lesotho volcanic highlands to Angola. Feldspar abundance remains remarkably constant from the Orange mouth to southern Angola, and quartz increases only very slightly, possibly as a result of local recycling. Among sedimentary and metasedimentary rock fragments, unconsolidated or strongly foliated types are readily comminuted when they enter the high-energy marine environment, but cemented sandstone/siltstone grains can survive the travel from the Karoo Basin of South Africa to northern Namibia and beyond.

No detrital mineral displays a significant increase in grain roundness after 300-350 km of longshore transport in high-energy littoral environments from the Orange mouth to south of the Namib Erg, but all minerals get rapidly rounded after passing into the Namib dunefield. Pyroxene and opaques get rounded faster than harder quartz and garnet, but sand mineralogy remains unchanged. Excepting strong transient selective-entrainment effects, physical processes are unable to modify sand composition significantly. Mechanical wear and selective mechanical breakdown can thus be largely neglected in provenance studies even in the case of ultra-long distance transport in high-energy environments dominated by waves or winds. This is particularly true for ancient sandstones, where chemical dissolution during diagenesis exerts an incomparably stronger control on mineralogical assemblages.

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