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Tracing erosion patterns in Taiwan by quantitative provenance and geomorphological analysis

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Taiwan is one of the world's foremost natural laboratories for studies of orogenesis. After only a few Ma of ongoing collision between the Chinese continental margin and the Luzon Arc, the associated orogen has reached nearly 4 km in height and 100-150 km in width. High rates of convergence leading to rapid rock uplift combine with the wet stormy climate of the sub-tropical typhoon belt to deliver annually an average detrital mass of 9500 t/km2. The doubly-vergent thrust belt is composed of more than 85% of sedimentary rocks dominant in the pro-wedge, but metamorphic rocks as young as < 10 Ma are exposed in the retro-wedge, where zircon fission-track, apatite fission-track and (U-Th)/He ages are all reset and as young as 1 Ma or younger, indicating very recent fast exhumation. There is hardly another region where rock-uplift, unroofing and sediment production are of equal intensity.

Quantitative analyses of tectonic and erosional processes around Taiwan have been carried out following diverse independent ways, including estimates of fluvial discharge of suspended solids, thermochronological techniques, cosmogenic measurements, and morphometry of river profiles (Dadson et al., 2003; Willett et al., 2003; Fox et al., 2014). Also the appearance and relative abundance of diagnostic rock fragments and other detrital minerals in Plio-Pleistocene sedimentary successions has been used to constrain unroofing rates, but a systematic description of compositional signatures of sediments shed by distinct tectonic domains has not been carried out so far. In this study we combine high-resolution petrographic and heavy-mineral analyses of modern sands carried by rivers all around Taiwan with their estimated sediment loads to calculate the detrital volumes generated from different lithologic assemblages within the orogen. River sediments are potent integrators of information that efficiently mediate provenance signals from different parts of the entire watershed, thus offering a great advantage relative to techniques analysing bedrock. This strategy allows us to calculate the sediment mass shed by each tectonic unit within each sub-catchment, and thus to trace erosion rates with continuity in space both along and across the orogenic belt. The results obtained were compared with the spatial pattern of estimated fluvial erosion rates calculated across the island by applying the stream power analysis relating river incision to basal shear stress (Finlayson and Montgomery, 2003). Initial investigation of sources of discrepancies between provenance analysis and morphometric analysis points toward the importance of lithological control on fluvial incision within the stream power model framework.

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