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Challenges in interpreting orogen-scale dynamics from conflicting erosion rates and geomorphic analyses: an example from the Northern Apennines

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The Northern Apennines are an active orogen, with moderate rates of rock uplift and erosion that are often used to suggest a near steady topography. However, important contrasts in morphology and long-term erosion rate exist across the main divide between the prowedge (Adriatic) and retrowedge (Tyrrhenian) of the orogen, which invoke both tectonic and geomorphic processes. These contrasts are consistent with the kinematics of an orogen growing by accretion of Adriatic crust, and destruction by extension and erosion dominantly on the side facing the Tyrrhenian Sea. Evidence for steady state is based on prowedge river profile analysis, the distribution of erosion rates, sediment yield, coastal uplift rates, and river incision rates. Modern catchment-averaged erosion rates from ^{10}Be range from $\sim$0.2 – 0.7 mm/yr in the prowedge; there are currently no comparable data from the retrowedge. However, estimates of long-term exhumation yield rates of $\sim$1 mm/yr in the prowedge and $\sim$0.3 mm/yr in the retrowedge from 3-5 Ma, suggesting a long-term erosional asymmetry across the main divide. This hypothesis is not supported by fluvial geomorphology where normalized channel steepness index (k_{sn}) is on average higher for retrowedge rivers than for rivers that drain the prowedge. In addition, χ plots and χ maps illustrate a moderate contrast between most prowedge and retrowedge rivers. All else being equal, the conventional interpretation of these geomorphic analyses predicts higher erosion rates in the retrowedge and migration of the main divide towards the northeast. However, χ plots show kinked rivers, illustrating possible spatial variations in lithology and/or uplift along the river profile, which precludes the conventional migrating divide interpretation of the χ map. Here we present the first ^{10}Be derived basin-averaged erosion rates for retrowedge rivers. Erosion rates are $\sim$0.1-0.3 mm/yr, consistent with the thermochronometry rates, but not with the geomorphic metrics. These data reveal a disconnect between topographic form (e.g. steepness) and measured modern and long-term erosion rates in the Northern Apennines. These observations can be reconciled if we re-interpret the ^{10}Be flux in terms of a horizontal erosion rate for each catchment, consistent with the tectonic kinematics which carries material towards the fixed Tyrrhennian coastline. This method is consistent with spatially variable vertical erosion, reflecting the distribution of surface slope. We also recognize that substrate erodibility, and tectonic deformation and uplift across the divide may also play important roles in landscape morphology. We explore this interpretation to reconcile the different measured and modeled datasets, in order to understand whether topographic steady state exists across the Northern Apennines.