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Climatically controlled increase in Quaternary erosion rates: An exploration of real and perceived biases from thermochronology data

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The potential increase of erosion rates over the last few million years in response to climate change and Quaternary glaciations remains controversial. Such an increase was initially inferred from the sedimentary record, but several authors have argued that this record is biased due to unresolved erosional hiatuses, and therefore the inferred increase in sedimentation rates is an artefact. More recently, the discussion has focused on erosional records from the source areas themselves; in particular records extracted from low-temperature thermochronology data. A global compilation of such data appears to show increasing erosion rates toward the present, but it has been argued that this increase may also be an artefact, for similar reasons that affect the sedimentary record.

Here we assess real and perceived biases in the thermochronological record that might affect the inference of temporal variations in erosion rates from such data. We argue that it is unlikely that erosional hiatuses affect thermochronology data because the temporal and spatial scales at which such hiatuses might occur are significantly smaller than those that are resolved by the data. Instead, we explore the potential bias introduced by the erosional response time of thermochronological systems (defined as the time required to exhume rocks that are fully reset for the thermochronological system considered, i.e. to attain exhumational steady state). These response times are typically longer than the timescale of Quaternary glacial-interglacial cycles, implying that thermochronological systems are insensitive to such variations. For thermochronological data to record an overall increase in erosion rates, the increase must occur over longer time periods, independent of superimposed shorter-term variations. However, because the erosional response times depend strongly on the final exhumation rate, it is much easier to detect increases in erosion rates with thermochronological data than to detect decreases, introducing a potential bias when examining a global database. Moreover, the integration time of thermochronological systems, i.e. the timescale over which a particular system averages the exhumational history, is equal to the response time and therefore also strongly dependent on the exhumation rate. This implies that rapid exhumation rates can only be resolved on relatively short timescales, again introducing potential bias toward high recent rates in global databases. We show that such a bias is real when attempting to reconstruct global average erosion histories from spatially uncorrelated thermochronological data, and it persists even when combining different thermochronometers. Therefore, confirmation of the inferred increase in erosion rates from the global database will require detailed regional studies combining multiple thermochronometers, in-situ and detrital thermochronology, and carefully designed sampling strategies.