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A New Approach for Estimating Background Rates of Erosion Using Concentration of Meteoric 10-Be Adhered to River Sediment: Application to the Rapidly Eroding Waipaoa Basin, New Zealand

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New and existing data suggest that the concentration of atmospherically- produced, meteoric 10-Be adhered to river sediment provides a proxy for basin-scale erosion rates. Although the widely applied method of analyzing in situ produced 10-Be in river sediments has proven useful for estimating pre-anthropogenic rates of erosion in a variety of environments, there are lithologic limitation. In contrast, measuring the concentration of meteoric 10-Be adhered to river sediment allows erosion rate analysis in landscapes underlain by quartz-deficient or fine-grained lithologies, as well as in basins where the concentration of quartz varies spatially. By assuming that basins are in an overall isotopic steady-state, that erosion is rapid enough that decay is negligible, and that the integrated delivery rate of 10-Be from the atmosphere (D10-Be) can be estimated, basin-scale mass loss rates (Ms) can be solved by equating the 10-Be flux in from the atmosphere with the flux of 10-Be out of the basin on sediment (C10-Be) and expressed as sediment yield per unit area (Ys). Fin = Fout D10-Be * A = Ms * C10-Be Ms = (D10-Be * A)/ C10-Be Ys = D10-Be / C10-Be To validate this new approach, we examined the limited data that do exist and found reasonable correspondence between erosion rates estimated from meteoric 10-Be concentrations and estimated by other means. As a first application, we use meteoric 10-Be in river sediment to estimate basin-scale erosion rates from catchments within and near the mud-stone dominated Waipaoa River Basin draining the tectonically active east coast of New Zealand's North Island. Near total conversion of indigenous forest to pasture over the past century in the Waipaoa Basin has resulted in some of the most dramatic and widespread erosional features on the planet, and

contemporary sediment yields that rank among the highest in the world (~7 million kg/(km2 * yr)). The amount of meteoric 10-Be adhered to eight river sediment samples suggests that modern-day sediment yields are at least seven times higher than natural rates of sediment generation. This finding is in tight agreement with other estimates of pre-settlement sediment discharge from the Waipaoa Basin derived from middle shelf and nearby lake cores (Kettner et al., 2007; Page and Trustrum, 1997). Tributary basins (n=4) draining portions of the Waipaoa Basin dominated by landsliding in shallow soils yield an average background sediment generation rate of 106 ± 105 kg/(km2 * yr), assuming a deposition rate of 1.3 million atoms 10-Be/(cm2 * yr). Conversely, sediment shed from a basin dominated by severe gullying contains ~four times less 10-Be due to the contribution of deeply sourced material containing little or no meteoric 10-Be. Large basins to the north and south of the Waipaoa (n=3) yield similar background rates of sediment generation ranging from 0.25 to 1.6 million kg/(km2 * yr). Meteoric analysis of an additional 40 samples, as well as cross-calibration between in situ produced and meteoric 10-Be in 19 quartz-bearing samples will further test the robustness of this new approach for estimating natural rates of sediment generation and erosion.