Geophysical Research Abstracts, Vol. 7, 09249, 2005
SRef-ID: 1607-7962/gra/EGU05-A-09249

The effects of glacier size and thickness on the relief of glaciated landscapes in the western United States

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The development of relief in glaciated landscapes plays a crucial role in hypotheses relating climate change and tectonic processes. Enhanced erosion rates and relief production, principally through more widespread glacial erosion, have been proposed to explain the apparent worldwide uplift of mountain ranges in the late Cenozoic. However, glaciers can only be responsible for peak uplift if they are capable of generating significant relief in formerly nonglaciated landscapes. Prior theoretical work has suggested that relief production in glaciated landscapes should scale with the thickness of the ice. Here we summarise a field-based test of this hypothesis in two mountain ranges in the western United States, the Sierra Nevada, California, and the Sangre de Cristo Range, Colorado. Our previous work in these ranges has indicated that glaciers have had a profound impact on the landscape. However, even where glacier termini were at approximately the same elevation at the last glacial maximum (LGM), glacier size appears to have had a major influence on landscape evolution. Incision has been focussed at high elevations in the case of smaller glaciers, but extended to much lower elevations in the case of the largest glaciers. We combined field surveys with aerial photograph interpretation to map LGM trimlines, and used these to reconstruct glaciers and estimate LGM ice thicknesses. A comparison of various quantitative measures of relief (hillslope, hanging valley and geophysical) with our ice thickness estimates indicates that relief production in glaciated mountain belts does indeed scale with ice thickness. Given that ice thickness is inversely related to ice surface slope for temperate glaciers, this suggests a key relationship between downvalley gradient, basin size (and potentially pre-glacial topography) and relief production. In our field sites, only the largest glaciers have generated enough relief to have had a significant

impact on peak elevations.