Optical and radiocarbon dating of loessic hillslope sediments in New Zealand’s South Island is used to constrain the timing of prehistoric rockfalls and associated seismic events, and quantify spatial and temporal patterns of hillslope sedimentation including responses to seismic and anthropogenic forcing. Trenches adjacent to prehistoric boulders enable stratigraphic analysis of loess and loess-colluvium pre- and post-dating boulder emplacement, respectively. Luminescence ages from loessic sediments constrain the timing of boulder emplacement to between 3.0 and 12.5 ka, well before the arrival of Polynesians (ca. AD 1280) and Europeans (ca. AD 1800) in New Zealand, and suggest loess accumulation was continuing at the study site until 12–13 ka. Large (>5m³) prehistoric rockfall boulders preserve an important record of Holocene hillslope sedimentation by creating local traps (i.e. accommodation space) for sediment aggradation (i.e. colluvial wedges) and upbuilding soil formation. Sediment accumulation rates increased considerably (>10 factor increase) following human arrival and associated anthropogenic burning of hillslope vegetation. Our study presents new numerical ages to place the evolution of loess-mantled hillslopes in New Zealand’s South Island into a longer temporal framework and highlights the roles of earthquakes and humans on hillslope surface process.