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Quantitative Estimations of the Holocene Erosion due to Seismically Induced Landslides in the SE Altai (Russia) Applying Detailed Profiling and Statistical Approaches

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Abstract: Earthquakes are some of the most disastrous natural hazards. Coseismic slope failures often significantly contribute to the global damage and may cause most of the casualties related to strong earthquakes. Seismically induced landslides are widespread phenomena within tectonically active mountain terrain. Their abundant occurrence and the large volumes of displaced slope material reveal their great influence on topographic changes. This paper presents new correlations between the earthquake magnitude and the total volume of displaced slope material and between earthquake magnitude and the volume of the largest triggered landslide. These relationships allow us to quantify erosion due to seismically triggered landslides. Calculation of the total volume of displaced slope material is based on the parameters of the largest landslides which could be preserved in the topography for thousands years. This approach was tested in the most seismically active southeastern part of Russian Altai, which is evidenced by numerous giant earthquake-induced paleo-landslides. The total volume of slope material displaced during ancient earthquakes within the Chagan-Uzun river basin, calculated on the basis of statistical correlations, is $(3.0\text{-}4.3)\times10^{-1}$ km^3, and the Holocene erosion rate due to seismically induced landslides $(1.1\text{-}3.0)\times10^{-5}$ m a^{-1}. The numerical estimates were verified by calculating the volumes of all detected earthquake-triggered landslides within the Chagan-Uzun river basin and the neighboring Kurai basin on the basis of detailed profiling approach, which are 1.33×10^{-1} and 2.25×10^{-1} km^3, respectively. The Holocene erosion rate due to seismically induced landslides in these basins could be estimated at 1.1×10^{-5} and 1.4×10^{-5} m a^{-1}, respectively. Thus the Holocene erosion rate of the SE Altai due to earthquake-triggered landslides obtained by applying different techniques can be estimated at $(1.1\text{-}3.0)\times10^{-5}$ m a^{-1}, which more precisely characterizes topography changes within the Chuya-Kurai system of intermountain depressions and framing ridges.

Keywords: seismicity, paleoseismogeology, earthquake-triggered landslides, erosion rate, detailed profiling, Russian Altai, Holocene

1 Introduction

Seismically triggered landslides accompanying strong earthquakes are one of the most dangerous natural hazards. Coseismic slope failures, which are widespread phenomena within tectonically active mountain terrain, represent a high risk to both human lives and construction. Numerous examples provide evidence for this. The well-known catastrophic Huascaran rock debris avalanche triggered by the 1970 Peru earthquake (M=7.7) killed more than 18,000 people (Plafker et al 1971); giant loess landslides induced by the 1920 Haiyuan earthquake, NW China, (M=8.5) caused about 100,000 casualties (Schuster and Highland 2001); and a long run out loess and rock

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