Mega floods and giant landslides: extremes of the Atacama.

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Abstract

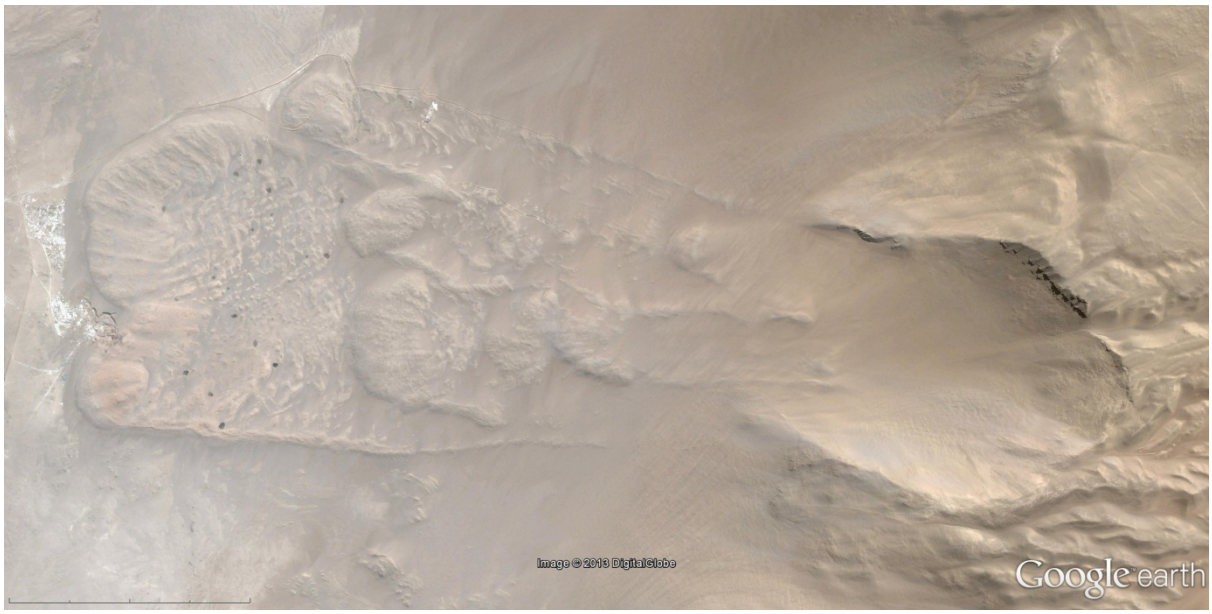
The Atacama Desert of Northern Chile is one of the oldest and driest deserts on Earth. As a result of its hyper-aridity it preserves some of the oldest geomorphology in the world in remarkable detail. Here we will examine the dominant terrestrial transport mechanisms for mobilizing sediment in this environment over Mio-Pliocene and Quaternary time scales: mass wasting and transport by water.

Firstly we will examine an extensive suite of late Neogene giant terrestrial coastal landslides along the classic convergent margin of western South America (18° to 24° south). These are remarkable in terms of their unusual abundance and atypical setting, such failures previously being linked with oceanic volcanic edifices or over-steepened glaciated coastlines. These landslides were emplaced as a combination of rock avalanches and multiple rotational failures. The majority terminated directly into the Pacific - likely generating significant tsunami hazard to the Chilean and south Peruvian coastline in a region which is today considered to be part of a notorious seismic gap. The proliferation and scale of these Late Neogene giant landslides in this actively uplifting, hyperarid terrain suggests they are the main geomorphic agent for relief reduction, probably triggered by megathrust earthquakes and potentially providing a unique palaeoseimic archive. The temporal and spatial distribution of these giant landslides corresponds with a period of surface steepening of the forearc wedge in the Central Andes and south to north differential uplift associated with factors such as aseismic ridge subduction. The resulting surface gradient increases, combined with the persistent climatic aridity of the region, have served to limit effective relief-reducing geomorphic processes in this oversteepened terrain to large-scale landsliding. The phenomena documented here geospatially link previously recognised large-scale slope failures from the off-shore environment and higher altitude areas of the Andean forearc, suggesting that large-scale landsliding is capable of transferring sediment on a regional scale to the off-shore Peru-Chile trench. This has implications for the friction of the subducting Nazca plate and associated seismicity and uplift.

Secondly we will examine extreme flood events recorded in Pliocene to Quaternary sedimentary and geomorphological records. In this transport limited environment the flows range from hyperconcentrated through to cohesive debris flow and extremely bimodal mudflows capable of transporting extreme outsize clasts ('debris flow erratics') large distances (>20 km) on low slopes (<4 degrees). Within channelized areas the hyperconcentrated flows represent extremely high discharges of water and sediment capable of generating anti-dune bedforms in conglomerates, reminiscent of the characteristics of jökulhlaup events (outburst floods) generated in proglacial environments. The palaeoflood events observed within the Pliocene-Recent sedimentary record of the Atacama strongly reflect 1) catchment size and relief and 2) catchment configuration (geomorphology and geology). Larger catchments typically generate flows with higher water to sediment ratios, leading to a dominance of hyperconcentrated flood events. Smaller steeper catchments are dominated by cohesive debris flows. However, in the largest, high relief catchments adjoining the Central Depression there remains the evidence of extreme flood events ('mega floods') which may be the result of Landslide Lake Outburst Floods (LLOF).

Dating of the above features is problematic, but Cosmogenic radionuclide (CRN) dating is currently being explored as a possibility.

Giant landslide ‘El Magnifico’ of the Coastal Cordillera. Image courtesy of Google Earth. View some 5 km across



‘Debris flow erratics’ of the Central Depression