Global Tsunamis from Impacts and Airbursts: is there a Paleo Record?

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One component of planetary defense research is risk assessment, which is informed by the geologic record in the form of impact craters. However, the vast majority of asteroids are too small to traverse the atmosphere, so they explode as airbursts. Most that do reach the surface land in the ocean. The rest form craters, most of which are erased by resurfacing. The cratering record is therefore a very sparse representation of the impact history of our planet.

The tsunami component of impact risk remains poorly understood but may be significant or even dominant. We have identified several possible mechanisms for impact and airburst-generated tsunamis: 1) coupling of the air blast to form tsunamis in deep water by a mechanism similar to that which drives meteotsunamis, 2) reaction force at the surface from the ballistic plume ejected into space, which carries significant momentum, 3) expanding toroidal vortices at the surface, which travel more slowly than the shock wave and can generate a Proudman resonance in relatively shallow ocean (such as continental shelf), 4) steam explosions from seawater ablation by a “Type II” (Libyan Desert Glass-type) contact airburst in which the hot vapor jet descends to the surface, and 5) pressure coupling to the ocean of compression waves driven by the collapse of the ballistic plume.

The 2022 explosion of the Hunga-Tonga Hunga-Ha’apai volcano and the resulting global tsunami pointed to another mechanism. Large atmospheric explosions generate global Lamb waves with larger amplitudes, longer periods, and slower speeds than the local and regional blast waves we modeled prior to that event, suggesting that impact tsunamis can be much stronger and more significant over much greater distance than anyone contemplated.

We will present models of global tsunamis generated by known impacts, as well as from known explosive volcanic eruptions, in an effort to predict the locations of paleotsunami deposits that might have resulted from these events. We suggest that a successful prediction or establishment of links between known deposits and known sources would provide useful data for assessing global tsunami risk from impacts, including airbursts and ocean strikes, as well as from large volcanic explosions.