Geophysical Research Abstracts
Vol. 13, EGU2011-6739, 2011
EGU General Assembly 2011


# Volcanic Tsunamis in the Mediterranean Sea: A Review

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Mediterranean Sea tsunami catalogues list more than 300 events. The majority of them were caused by earthquakes but only 18 were attributed to volcanism. In a reliability scale ranging from 0-improbable tsunami, to 4-definite tsunami, about 140 events were characterized as reliable ones, with reliability index 3 or 4, but only 8 were associated with volcanism. The intensity, K, of the 8 volcanic tsunamis, estimated in the 12-grade Papadopoulos-Imamura (2001) tsunami intensity scale, ranges from 3 to 10. Three were the largest volcanic tsunamis with estimated $K \geq 7$: (1) The local tsunami produced by landslides triggered during the eruption of Stromboli, 30 December 2002, was studied by several authors. From post-event field survey we estimated maximum K=7 at Ficogrande and Punta Lena. (2) The strong tsunami caused during the AD 1650 eruption of the submarine volcanic edifice Columbos, Thera island complex, South Aegean, is documented in several historical sources. From these sources we concluded that a series of tsunamis were produced from September to December 1650. The main event occurred after the paroxysmal phase of the eruption on 30 September (OS) very possibly because of the cone collapse; we estimated maximum wave height of 16-19 m in Ios island. Maximum intensity of K=9-10 was estimated in Kamari and Perissa, east Thera, where the wave caused extensive destruction and ground erosion. Tsunami sediment deposit was found in Kamari, about 85 m from the seashore at elevation of $\sim$3.8 m in a locality historically documented that inundated by the tsunami. The second important tsunami inundation was reported in Thera on 4 November 1650 (OS) caused possibly by further collapse of the cone. (3) The tsunami caused by the giant Late Bronge Age eruption of Thera is documented in publications reporting coastal and sea-bottom tsunami deposits in several localities of the East and Central Mediterranean. The elevation of the coastal tsunami sediment deposits ranges from -1.6 m to +9 m in relation to msl. Calibrating against a msl rise of about 1.5 m, which occurred in the Mediterranean in the last 4000 years, it comes out that the elevation of the LBA tsunami deposit localities at the time of deposition ranged from 0 to +10.5 m. Maximum elevation was observed in NE Crete. We simulated the tsunami with two mechanisms, caldera collapse and pyroclastic flows. For the wave propagation fully non-linear Boussinesq equations were adopted. Synthetic tsunami waveforms were produced in virtual tide-gauges situated at shallow water depths of about 20 m to reduce uncertainties due to shallow depth bathymetry. Caldera collapse produced one-peak wave amplitudes which fit well enough the elevations of deposit localities. For caldera collapse of 19 km3 and 34 km3 in volume wave amplitudes of $\sim$2.5 m and 7.5 m were found offshore NE Crete. Due to the strong energy directivity associated with the pyroclastic flow, tsunami amplitudes are consistent with deposit elevations only for localities where the wave energy is directed to. For pyroclastic flow of 55 m in thickness penetrating the sea at azimuth of 2000, that is towards NE Crete, wave amplitude of $\sim$9 m was found. The pyroclastic flow mechanism may account for small and moderate tsunami waves produced during the entire eruptive activity. Due to the energy directivity effect, however, the mechanism is considered uncapable to produce the minimum tsunami amplitudes required to deposit sediments in many different azimuths with respect to a preferred direction of penetration. On the contrary, the caldera collapse may account for significant wave amplitudes in different directions from the tsunami source. However, other tsunami mechanisms, e.g. large earthquake(s), associated with the LBA eruption should not ruled out.