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Terrestrial Laser Scanner techniques in the assessment of tsunami impact on the Maddalena peninsula (south-eastern Sicily, Italy)

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The coastline of the Maddalena peninsula (south-eastern Sicily, Italy) is characterised by the occurrence of a boulder field associated to an extended soil stripping area and by a gravel/sandy berm. The accumulation of the boulders has been mostly correlated to the impact of the December 28, 1908 tsunami wave. The use of Terrestrial Laser Scanner survey techniques, associated to Differential Global Position System determinations, permits to obtain new data for the assessment of tsunami impact on this coastal area. The computing of the surveyed data using the most recent equations is a useful tool in order to estimate the theoretic inundation limit and to reconstruct its variability in function of the boulders size and of the coastal topography. Moreover, the entire new data set allows to confirm that the hypothesis of the tsunami impact is the most reasonable to explain the occurrence of boulders weighing up to 50 tons on the Maddalena peninsula.
Key words: Tsunami, hydrodynamic model, Laser Scanner Techniques, Sicily, Italy.

1. Introduction

One of the most impressive evidence of extreme wave impact on the rocky coasts is represented by the presence of mega-boulders, sparse or accumulated in field or berms (Mastronuzzi and Sansò, 2000, 2004; Williams and Hall, 2004; Hall *et al.*, 2006, 2008; Scheffers and Scheffers, 2006; Mastronuzzi *et al.*, 2007; Scicchitano *et al.*, 2007; Goto *et al.*, 2009a, b, 2010a). The post-event surveys performed after the impact of the Indian Ocean Tsunami (IOT), occurred on December 26, 2004, have permitted to recognise morphological/sedimentological effects of its impact and, in the same time, to extend all obtained results on coastal sectors where similar evidences were recognised (e.g. Szczuciski *et al.*, 2005; Kelletat *et al.*, 2006, 2007; Lavigne *et al.*, 2006; Richmond *et al.*, 2006; Paris *et al.*, 2007, 2009, 2010; Srinivasalu *et al.*, 2007; Umitsu *et al.*, 2007). In particular, it has been demonstrated that frequently the wave flow has been able to detach and scatter inland boulders of significant size and weight (Goto *et al.*, 2009a, b). Notwithstanding the immense number of data derived by the surveys performed all along the coast hit by the IOT, the debate about the correlation of these landforms/sediments with the extreme event responsible of their genesis/deposit is still open. In fact, since the absence of eyewitness, at present, no undisputable signatures allow to discriminate between the boulders accumulated by a sea storm from those accumulated by tsunami. The reply to this scientific question was the increase of the number of papers examining the nature of these landforms/sediments, focusing their attention on the wave forces necessary to detach, transport and deposit boulders of different size and weight (e.g. Nott, 1997, 2003; Noormets *et al.*, 2004; Scheffers and Kelletat, 2005; Kelletat *et al.*, 2006, 2007; Mastronuzzi *et al.*, 2006; Scheffers, 2006, 2008; Goto *et al.*, 2007, 2010b; Scicchitano *et al.*, 2007; Imamura *et al.*, 2008; Kelletat, 2008; Benner *et al.*, 2010; Goff *et al.*, 2010; Regnauld *et al.*, 2010).

The occurrence of boulders eradicated from the infralittoral/adlittoral zones is considered evidence of the past impact of extreme waves. Starting from the presence of boulders and from their size, some authors consider really possible to evaluate the features of the impacting waves. An important degree of uncertainty regards the methodology aiming to the definition of the origin of the wave responsible for their deposition. In the boulder accumulation process, is the impacting wave height more important compared to the wave length and to the wave period? Different theories have been proposed in the recent time, but the final reply is still far away (Nott, 2003; Goto *et al.*, 2007, 2009b, 2010b; Hansom *et al.*, 2008; Imamura *et al.*, 2008; Pignatelli *et al.*, 2009; Barbano *et al.*, 2010). The more easy reply is that if a wave can be described by height, length and period, the best way to evaluate its impact on a rocky coast should consider these parameters all together.

The aim of this paper is to estimate the inland penetration limit of tsunami waves responsible for boulder deposition applying the Pignatelli *et al.* (2009) method. In particular,

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