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Numerical approach to the study of coastal boulders: The case of Martigues, Marseille, France

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ABSTRACT

The coastal area extending east of the city of Martigues, between the bays of Bonnieu and that of Chariot, is characterized by an alternation of gently sloping rocky coast and 5 m high cliffs composed of Miocene limestone. The foot of the cliff is marked by a well developed notch and a discontinuous wave-cut platform; at its base, the sea bottom reaches a maximum depth of about 4.5–6 m. The emerged area shows boulders placed up to 10 m inland of the coastline at around 2 m above s.l. and, weighing as much as 35 tonnes. A geomorphological survey was conducted by means of a Terrestrial Laser Scanner to estimate boulder sizes. The particular focus of the proposed study was to estimate the minimum wave height required to detach and transport two boulders, originally joined together as one bigger one and weighing approximately 25 tonnes, from the wave-cut platform onto the surf bench. Hydrodynamic models developed by various authors were used to calculate the minimum wave height necessary to move them. The data obtained from the resulting hydrodynamic equations were compared to wave-climate data collected over the last 15 years by the buoy off the coast of Marseille, in the Gulf of Lion. The present study seems to confirm that it would not have been necessary to have a tsunami impact (among other things, never recorded in the last 20 years) to move a 25 tonnes boulder. Indeed, hydrodynamic equations suggest that the boulder might have been broken and only subsequently moved due to the impact of waves generated by an extreme storm which would have occurred prior to December 2003. This hypothesis seems to be in agreement with the morphology of the sea bottom, hydrodynamic features of the area as well as eyewitnesses.

1. Introduction

In recent years, scientific debate on coastal dynamics has focused also on the effects of extreme wave impact on coastal areas, thus increasing the awareness of the high risks these impacts pose on all human settlements as well as on the environment. Indeed, examples of hurricane impacts which have occurred in the last fifteen years, inducing exceptional waves and devastating tsunamis, underline the fact that morphological effects cannot be underestimated neither in purely scientific terms nor in application to the Integrated Coastal Zone Management (ICZM) (i.e.: Mastronuzzi et al., 2013). In particular, an important field of science dealing with coastal morphodynamics studies large boulder accumulations distributed along the coastline of the Mediterranean basin as an attempt to reconstruct the sequence of the high energy event that distribute boulders along the coast using historical or chronological data (i.e.: Mastronuzzi and Sansò, 2000, 2004; Morhange et al., 2006; Mastronuzzi et al., 2006, 2007; Scicchitano et al., 2007; Maouche et al., 2009; Vött et al., 2010; Mastronuzzi and Pignatelli, 2012; Shah-Hosseini et al., 2013; Anzidei et al., 2014; Biolchi et al., 2016). The study of extreme waves impacting all along the coasts of the world over the past 25 years suggested that boulder accumulations are the consequence of impacts of both storm surges and tsunamis (Mastronuzzi and Sansò, 2004; Goto et al., 2007; Barbano et al., 2010; Bourgeois and MacInnes, 2010; Regnauld et al., 2010; Paris et al., 2010; Richmond et al., 2011;

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