Geophysical Research Abstracts, Vol. 8, 01526, 2006
SRef-ID: 1607-7962/gra/EGU06-A-01526

A Late Glacial Submarine Landslide in the Sea of Marmara and the Mathematical Modelling of its Associated Tsunami

M. Sinan Özeren, Namik Cagatay, Nazmi Postacioglu, Kadir Eris
Istanbul Technical University, Turkey(ozerens@itu.edu.tr)

The Sea of Marmara Basin (SMB) is tectonically active basin formed between the branches of the North Anatolian Fault (NAF). It has a relatively broad shelf (max. 45 km) in the south and a narrow one (max. 20 km) in the north with the shelf break located at a depth of about -100 m (Fig. 3). Between the shelves are three rhomboidal or wedge-shaped, NE-SW trending basins with a maximum depth of 1280 m. They are the Tekirdag, Central and Çinarcik basins that are separated by tranpressional ridges rising about 600 m above the basins' floor. This morphology of the SMB is determined by the interaction of the dextral strike-slip tectonics of the NAF and the north-south extensional Aegean regime prevailing in the northwestern Anatolia.

The SMB basins are bounded in the north and south by the branches of NAF (boundary faults). The basin slopes are steep, especially in the north (up to 29˚), and marked by several submarine canyons and land slides. The most significant land slide is the one located on northeastern slope of the Çı narcı k Basin, south of Tuzla. It has a total area of about 32.5 km^2 and thickness of about 30 m. The area affected by mass movement consists of two parts. The western part is of semi-elliptical shape with 15 km^2, and appears to be large-scale slump rather than a mass movement that is reminiscent of a sliding block. The eastern part covers an area of about 17.5 km^2 on the slope and is characterized by a folded, undulatory topography on the slope. This topography strongly suggests that this part has moved by creep. A core taken on the toe of the western land-slide area at –988 m depth, has revealed a late glacial-Holocene stratigraphic sequence typical of the Marmara Sea. The sequence consists of 1 m-thick marine Unit I and and a 0.50 m-thick lacustrine Unit 2 above a chaotic mixture at the base of mud clasts, and angular pebbles, and a sandstone block in a sandy matrix. It is clear from this observation that the late Quaternary sequence has been deposited after the submarine landslide. Considering that the age of the Unit 1/Unit 2 boundary at 1 m below sea floor is 12 kyr BP and assuming a typical sedimentation rate of 10 cm for Unit 2 on the slop areas, the age of the slide is calculated to be about 17 kyr BP. Radiocarbon analysis of “total” carbonate in a sample from 148-149 cm core depth has yielded an age of 23.4 kyr BP that is probably too old because such a sample would include “radiogenically dead” carbon.

We attempted to mathematically model the tsunami that could have been generated by the submarine landslide in the Sea of Marmara. Unlike the Tsunamis created directly by faulting, the water waves generated by the landslides have a very dispersive nature. The fact that the disturbance on the sea bottom is very localized makes it impossible to use shallow water equations to model landslide Tsunamis. Thus we approached the problem using a linearized 3-D algorithm and calculated the gravity wave field created by the landslide.

We use a semi-spectral algorithm to model the Tsunami generation and propagation. We apply a series of virtual sources and sinks on the sea bottom to simulate the landslide (or slump) motion. A second collection of sources and sinks are used to satisfy the kinematic condition on the flat part of the sea bottom. To satisfy the same condition for the slump-dominated part of the sea bottom we make use of an integral equation. Once the amplitudes of the sources and sinks are calculated, we finally calculate the surface shape while satisfying both the kinematic and dynamic conditions on the free surface. Since the virtual volume injections by the sources (and the suctions by the sinks) are impulsive, the whole solution process is carried out using a Green’s function formalism. The time-domain propagation itself is calculated using a Runge-Kutta algorithm to solve a system of ordinary differential equation to obtain the wave amplitudes. The method is tested against a series of laboratory data and gives satisfactory results for the first order characteristics of the dispersive surface wave field. During and after the slumping motion the dispersive wave field is scattered by the bathimetric irregularities, in this work we calculate the entire wavefield including the part that propagates towards the shelf on the north of the landslide area. We used two slumping scenarios, differing slightly from each other, and calculated the wave field. Apart from the surf zone where the non-linear effects dominate, we obtain a realistic approximation for the spatio-temporal evolution of the wave field including the effects of geometrical spreading. In our calculations there is a linear scaling between the average thickness of the sliding mass and the wave amplitudes, our modelling shows that the maximum wave height reaches 0.65 times the block thickness when the width of the slump reaches around 5 km. This inditates that the local maxima of the wave amplitudes for our case might have been in excess of 15 metres.

keywords: Marmara Sea, submarine slump, late glacial, tsunami, water waves, mathematical modelling, Green's function