TSUNAMI GENERATION AND PROPAGATION IN POSSIBLE ANCIENT OCEAN ON MARS. T. Matsui[1], I. Takamiya[2], F. Imamura[3] and E. Tajika[2], [1]Dept. of Complexity Science and Engineering, Graduate School of Frontier Science, Univ. of Tokyo (7-3-1 Hongo, Bunkyo-ku, Tokyo 113-0031, Japan; matsui@k.u-tokyo.ac.jp), [2]Dept. of Earth and Planetary Sciences, Graduate School of Science, Univ. of Tokyo (7-3-1 Hongo, Bunkyo-ku, Tokyo 113-0031, Japan; takamy@sys.eps.s.u-tokyo.ac.jp, tajika@eps.s.u-tokyo.ac.jp), [3]Desaster Control Research Center, Graduate School of Engineering, Tohoku Univ. (Aoba 06, Sendai-shi, Miyagi 980-8579, Japan; imamura@tsunami2.civil.tohoku.ac.jp)

Introduction: It has been proposed that northern lowland of Mars had once covered by ocean [1]. Recent high-resolution altimetric data from the Mars Orbiter Laser Altimeter (MOLA) instrument on the Mars Global Surveyor (MGS) mission provides evidence for possible ancient oceans on Mars [2]. If there were oceans on Mars, we may expect a meteorite impact into the possible martian oceans, which results in the formation of marine target crater. Such a marine target crater on Mars was studied by Ormö and Muinonen [3]. According to their study there are a few candidates for such craters in Western Arabia Shelf located at the transition between the lowlands and highlands. Meteorite impact into martian ancient ocean generates tsunami and then there is a possibility that we may find some geological evidence of tsunami deposits around the possible shoreline of the ancient ocean (the contact 1 [2]). This will probably be one of the candidates for future landing site of the Mars mission. In this paper we study generation and propagation of impact-induced tsunami on Mars by using numerical models.

Impact frequency on martian ocean: Impact frequency on possible martian ocean is dependent on its area and duration. If the impact crater (38N, 13E) with the diameter of about 20 km proposed by Ormö and Muinonen [3] were really the marine target crater, this suggsts that the possible ocean is characterized by the contact 1. In Fig. 1 we show the formation frequency of 20 km sized crater for the possible ocean with the contact 1. The formation frequencies are calculated for three impact frequency models [4]. We used the low impact frequency after 2.5Ga, and this results suggest that formation of marine target crater requires about ten million years. For more ancient ocean it requires less period because of higher impact frequency.

Generation of tsunami: We assumed that impact-induced tsunami is generated by formation of the marine target crater proposed by Ormö and Muinonen [3] and that the possible ancient ocean is characterized by the contact 1 [2]. The depth of the ocean at the impact point is about 450m. We assumed that the crater cavity with diameter of 20 km was formed in the ocean with the ocean floor characterized by the present altimeter data. We can consider the three stages of impact-induced tsunami generations [5]; (1) the wave coupled with high air pressure and wind generated by the entry of meteorite into the martian atmosphere, (2) the rim wave formed at the front of the ejecta curtain, (3) the wave caused by movement of water to fill and flow out of the crater cavity. Mtasui et al. [5] showed that the receding and rushing waves generated by the third stage were the most devastating waves. We numerically simulated movement of water into and flow out of the crater cavity based on the non-linear shallow water theory with dispersion effect. In Fig. 2 we show the temporal variation of the water levels at the center and the rim of the crater. It is shown that the water that flowed into the crater cavity accumulates and the crater cavity overfilled, thus, generating the rushing wave outward.

Propagation of tsunami: We can obtain the wave amplitude and period of receding and rushing waves, and the water depth around the crater from the above numerical simulation. Using these results as the initial conditions we can simulate oceanic propagation of tsunami based on the linearized long-wave theory in the spherical coordinates [6]. Fig. 3 shows the temporal variations of water level at the coastal region. As seen in these figures there are two types of tsunamis that attacked the coast near the crater; one is the receding wave and the other is the rushing wave. No measurable wave was found ahead of the initial receding wave. Maximum tsunami height (more than 60 m) is observed at the location 2 [after 2.3 hours from the impact event] (Fig. 3). We may find some evidence of tsunami around this region if the above assumptions of numerical simulation are reasonable. The receding wave covers the entire ocean over about 30 hours after the impact. The maximum water level of the ocean during 30 hours after the impact is shown in Fig. 4. And dominant frequency of tsunami waves is estimated to be about 1.7 hours.

References: [1]Parker T. J. et al. (1993) *JGR, 98,* 11016-11078. [2] Head J. W. et al. (1999) *Scence., 286,* 2134-2137. [3] Ormö J. and Muinonen P. (2000) *LPS XXI,* 1344–1345. [4] Tanaka K. L. (1986) *JGR, 91,* E139-E158. [5] Matsui T. et al. (2001) submitted to GSA special paper for Catastrophic Events and Mass Extinctions. [6] Imamura F. and Shuto N. (1990) *Proc. Of Int. Sym. Comp. Fluid Dynamics, Nagoya, 390.*

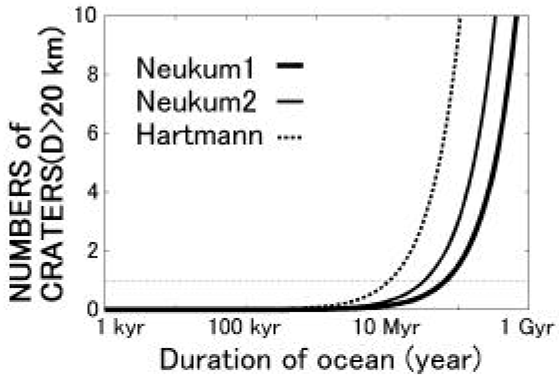

Figure 1. Formation frequencies of the 20 km sized crater in possible ancient ocean on Mars. The thick and thin solid, broken curves represent the results for the impact frequency models [4] by Neukum1, Neukum2 and Hartmann, respectively.

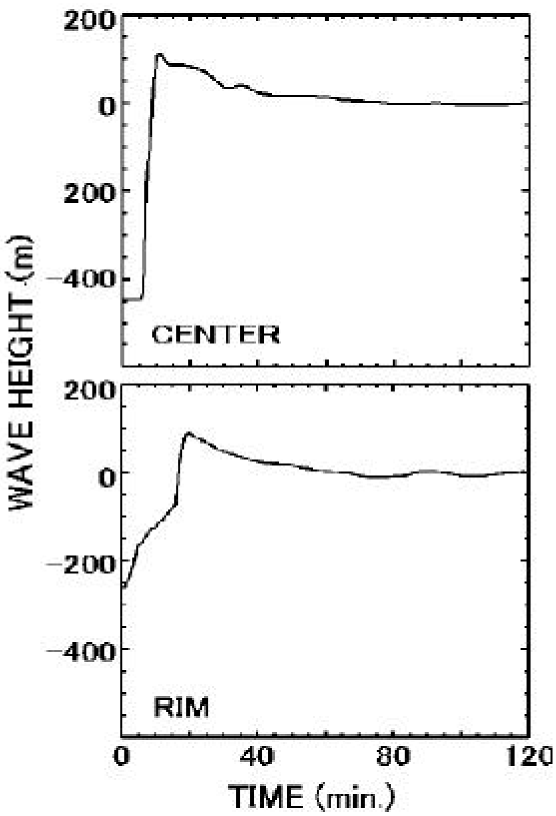

Figure 2. Temporal variations of water height from the still water at the center and the rim of the assumed marine target crater on Mars.

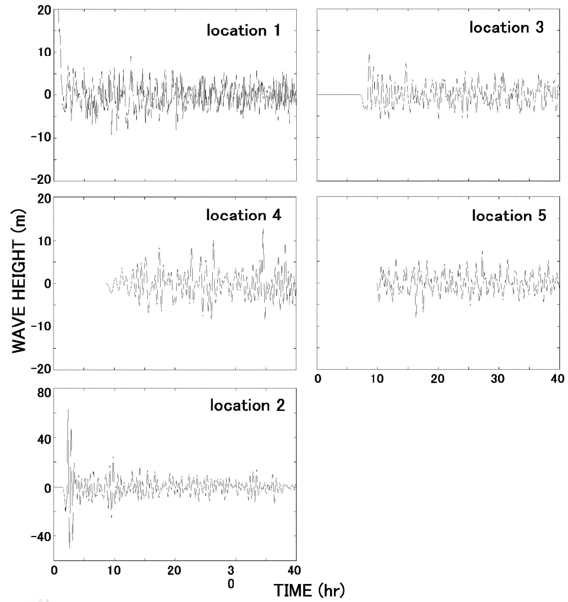

Figure 3. Temporal variations of water hight from the still surface at some coastal regions of possible ancient ocean with the contact 1. The locations are shown in Fig. 4.

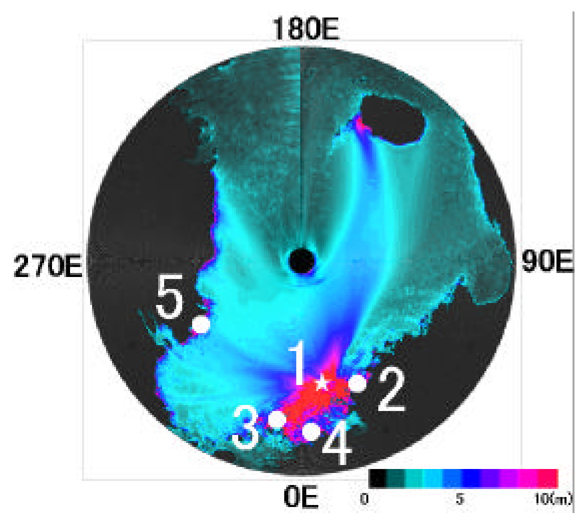

Figure 4. Maximum water hight from the still surface of the possible ancient ocean with the contact 1 during 30 hours after the impact. Possible impact crater (star) and some specific locations (1-5) are also shown.