Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

PPS002-P04 Room:Convention Hall Time:May 25 16:15-18:45

Numerical analysis of impact-induced tsunami and geological implications for paleo-ocean and paleo-crate lakes on Mars

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Since 1980s, presence of the paleo-ocean on Mars has been proposed (e.g., Brandenburg et al. 1987). Although some morphological features are suggested to be possible paleo-shorelines (e.g., Head et al. 1999), it is highly controversial because of the lack of confidential geological and sedimentological evidence. On the other hand, crater lakes highly likely existed in the past with abundant lake water (Fassett et al. 2007). This in turn suggests that surface of Mars was rich in liquid water during a certain periods in the past.

If there were large meteorites impact into the paleo-ocean or crater lakes on Mars, they must have generated huge tsunami and left some geomorphological and sedimentological features around the shorelines. Considering the fact that tidal and tectonic activities are very weak on Mars, the traces of impact-induced tsunami may habe been preserved until today. In this study, we conducted numerical simulations on the paleo-ocean and crater lakes on Mars, assuming that there were meteorite impacts into the water bodies, and examined the behavior of the tsunami at around the shorelines. Furthermore, we examined satellite imageries around the presumable shorelines to find traces of the tsunamis induced by the impacts.

We firstly conducted numerical simulations of impact-induced tsunami with a one-dimension model based on the shallow water theory. There are three types of tsunamis generated by the impact (Matsui et al. 2002). Among them, we focused on the behavior of the rim wave and receding-rushing waves, which might have been large enough to leave geomorphological and sedimentological features along the shorelines. We then examined the relationship between the crater diameter and the magnitude of the tsunami. As a result, we found that the crater diameter and the magnitude of the tsunami are in the direct proportion. In addition, we found that the tsunami on Mars is around 1.5 times larger than that on the Earth because of the difference in gravity.

We also conducted the two-dimensional calculation using the topography of a real crater, which is a possible candidate of paleo-crater lakes. The tsunami might have been affected the shoreline and left some geomorphological and sedimentological features when the wave overflow the crater rim.