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Numerical modeling of impact-induced tsunami on Mars and possible sedimentological traces of an ancient Martian ocean.

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The ancient ocean hypothesis on Mars was first proposed in the late 1980s based on geomorphological evidence interpreted in Viking orbiter images (Parker et al., 1989), which had too low spatial resolution to discuss detail geomorphology. Since then, resolution of satellite images has improved, and now 30-cm resolution HiRISE (High Resolution Imaging Science Experiment) images enable us much more detail sedimentological observations (e. g. McEwen et al., 2007). Comparison of sedimentological features of Mars and the Earth may provide new clues for the past existence of Martian ocean(s).

However, on Mars, sedimentological features of the oceans and shorelines may differ from those on the Earth because of lack of a tidal activity, which is a large factor characterizing terrestrial shorelines (Dohm et al., 2009). One phenomenon that is in common on Mars and the Earth as well and that can leave sedimentological traces on the surface of the planets is meteorite impact into oceans and consequent generation of large tsunami waves. In order to propose candidate localities to find sedimentological evidence of the impact-generated tsunami, we conducted numerical modeling for tsunami propagation and inundation on the surface of Mars.

We conducted numerical simulation using the MOLA (Mars Orbiter Laser Altimeter) topographic data. Simulations are based on the nonlinear long wave theory, and a leap-frog scheme was used. According to the simulation, velocities are low at the deep sea region (0 to 2 m/s) but are high at around the impact-produced crater and the shoreline (4 to 12 m/s) if we assume 50 km for the crater diameter. Velocities along the shoreline differ depending on the regions because of the differences in geomorphological features or of the presence of various craters. The numerical simulation indicates that the tsunami effects are strong mostly around the crater and the shoreline, which should be the candidate places to explore the sedimentological traces of the tsunami.

Erosion and sedimentation is the main sedimentological process of tsunami that leaves possible trace of the tsunami. Tsunami sedimentation is divided into sedimentation of sand deposit, and transport and sedimentation of boulders. In these features, movement of boulders is the most adequate candidate as a trace of tsunami on Mars, because erosional and depositional features preserved in sedimentary layers are difficult to find on Mars with satellite images, whereas boulders placed on the surfaces of Mars are visible with high resolution satellite images such as HiRISE. Furthermore, the current velocity calculated along the shoreline (˜12 m/s) is high enough to move meters-scale long boulders (˜4 m/s for movement of 4 to 5 m long boulders) on Mars. Therefore, although boulders may be originally deposited concentrically around impact craters, they might have been reworked by tsunami wave currents if an ocean existed in the past. Thus, we propose that the reworked boulder deposits may be the best candidates as the sedimentological trace of ancient oceans on Mars.

Keywords: Mars, Satellite images, Boulder