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Rootless cones as a consequence of Martian volcanism- numerical kinetic simulation.

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Cones on Acidalia in the image THEMIS V55617012, (Figure 1,2) which are arranged parallel to the lava tongue and its are probably rootless cones. Lava had to flow on the area covered with ice or saturated with water (Figure 3). These cones on Acidalia are much smaller (50 m at the base) than for exmple on Amazonis (300-500 m at the base). We have created a numerical simulation showing the formation process of such cones. [1]

The simulation of magma-water ice interaction was performed using the EMMA Particle-In-Cell code. Particle-In-Cell (PIC) [2] is a technique commonly used to simulate motion of charged particles, or plasma. In our problem we applied mass density and the pressure of matter. We assumed that the analysis of electric charges of magma, ice, water or the atmosphere is not necessary. In other words we assumed that 100% of particles in our model are neutral particles. Characteristics of the model: dimensions: 2,000 m x 2,000 m x 1,000 m, cell size: 10 m x 10 m x 10 m, time step 10 s. The following molecules were introduced representing the mater: magma, water ice, atmosphere (CO2). We assumed following characteristics of particular molecules in the model: magma density: 2800 kg / m³ (comatite), initial magma temperature: 1700 K, initial magma layer thickness: 50 m, initial horizontal magma velocity: 50 km / h, the possibility of magma particle phase transition: true, initial temperature of water ice particle: 210 K, the possibility of water ice phase transition: true, we assumed that atmosphere particles are simply CO2 particles and the possibility of CO2 particle phase transition is false. We assumed in our PIC model that in each iteration a thermodynamic equilibrium will be achieved in a single cell of the model. In addition, phase transformations of magma and water ice have been implemented in the model and they were applied after each iteration. There are three forces operating on model cell nodes: general gravity of Mars with additional assumption of additional force and velocities compensating for the effect of gravity at reaching the minimum height of changes (position of the component r = 0.000), atmospheric pressure 636 Pa, pressure force dependent on the densities of the matter and general gravity force size and direction.

The Particle-In-Cell method consists of an initial setup, the main loop, and a final clean up / results output. All computation happens in the loop. The loop consists of the following steps:

1. Compute matter density: particle positions are scattered to the grid,
2. Compute gravity potential: performed by solving the equilibrium equations,
3. Compute gravity and pressure fields: from the gradient of potential,
4. Move particles: update velocity and position from Newton's second law.
5. Generate particles: sample sources to add new particles
6. Output: optional, save information on the state of simulation
7. Repeat: loop iterates until maximum number of time steps is achieved or until simulation reaches steady state. (Figure 4)

The outbreaks of pseudo-craters created on Mars 5 to 10 times larger cones than on Earth. 4 to 16 times less gas is required for each explosion to create craters despite their larger size. This is consistent with the view that propably water was less available in the Martian regolith than in Iceland. [3]

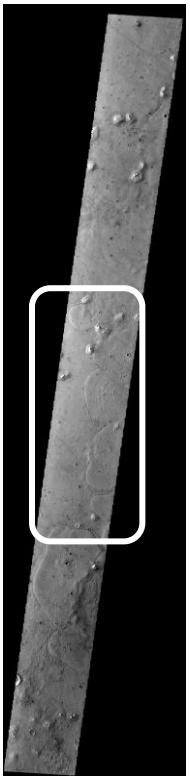

Figure 1: Acidalia Planitia. Rootless cones on lava tongue. THEMIS V55617012. Center Latitude 38.257454°, Center Longitude 319.3534°

Figure 2. Rootless cones on lava tongue. Acidalia Planitia. THEMIS V55617012. White arrows indicate the direction of lava flow. Selected fragment from Figure 1.

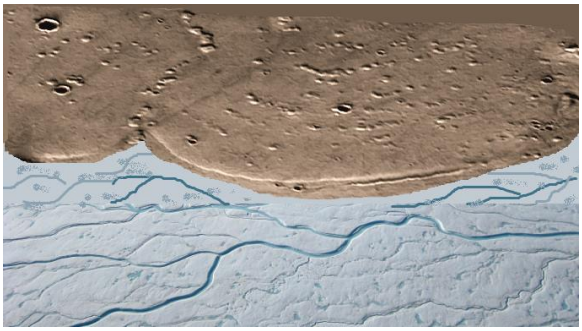

Fig.3 Acidalia Planitia. The process of creating rootless cones. Visualization of lava (V55617012) entering on the ice surface.

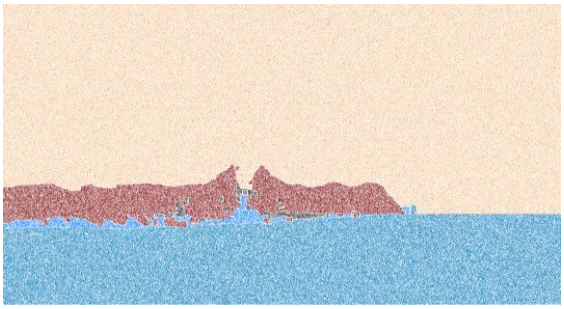

Figure 4. Modeling of the process of creating rootless cones. The simulation was prepared using a Particle-In-Cell code.

References

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