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Subsidence of the South Polar Terrain and global tectonic of Enceladus

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Introduction: Enceladus is the smallest celestial body in the Solar System where volcanic and tectonic activities are observed. Every second, the mass of ~200 kg is ejected into space from the South Polar Terrain (SPT) – [1]. The loss of matter from the body's interior should lead to global compression of the crust (like on Mercury). Typical effects of compression are: thrust faults, folding and subduction. However, such forms are not dominant on Enceladus. We propose here special dynamical process that could explain this paradox. Our hypothesis states that the mass loss from SPT is the main driving mechanism of the following tectonic processes: subsidence of SPT, flow in the mantle and motion of adjacent tectonic plates. The hypothesis is presented in [2] and [3].

We suggest that the loss of the volatiles results in a void, an instability, and motion of solid matter to fill the void. The motion includes:

1. Subsidence of the 'lithosphere' of SPT.
2. Flow of the matter in the mantle.
3. Motion of plates adjacent to SPT towards the active region.

Methods and results: The numerical model of the subsidence process is developed. It is based on the model of thermal convection in the mantle. Special boundary conditions are applied, that could simulate subsidence of SPT.

If emerging void is being filled by the subsidence of SPT only, then the velocity of subsidence is ~0.05 mm·yr^{-1}. However, numerical calculations indicate that all three types of motion are usually important. The role of a given motion depends on the viscosity distribution. Generally, for most of the models the subsidence is ~0.02 mm·yr^{-1}, but mantle flow and plates' motion also play a role in filling the void. The preliminary results of the numerical model indicate also that the velocity of adjacent plates could be ~0.02 mm·yr^{-1} for the Newtonian rheology.

Note that in our model the reduction of the crust area is not a result of compression but it is a result of the plate sinking. Therefore the compressional surface features do not have to be dominant. The SPT is compressed, so "tiger stripes" could exist for long time. Only after significant subsidence (below 1200 m) the regime of stresses changes to compressional. We suppose that it means the end of activity in a given region.

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References

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