Proto-Enceladus and Role of Its Activity for the Satellite and So-lar System

L. Czechowski[1].

[1]University of Warsaw, Faculty of Physics, Institute of Geophysics, ul. Pasteura 5, 02-093 Poland (lczech@op.pl).

Introduction: Enceladus, a satellite of Saturn, is the smallest celestial body in the Solar System where endogenic activity is observed in the form of cryovolcanism. We discuss here the role of this activity. This activity makes Enceladus a unique body in the Solar System. It is a base for hypotheses of proto-Enceladus [2] and suggestion about Enceladus as a cradle od life in Solar System.

Cryovolcanism: Cryovolcanism is concentrated in the South Polar Terrain (SPT). In this terrain the stream of mass is ejecting into space with the rate ~200 kg/s [e.g. 1, 2, 3]. We have suggested that this mass loss is a main driving mechanism of the Enceladus' tectonics [1, 2]. Usually the loss of matter from the body's interior (or thermal contraction) lead to global compression of the crust. Typical effects of compression are: thrust faults, folding and subduction [5]. However, such forms are not dominant on Enceladus. In previous presentations we proposed special tectonic model that could explain this paradox [1, 2, 5] and Fig. 1.

The volatiles escape from the hot region (through the fractures) forming plumes in the space. The loss of the volatiles results in a void and motion of matter into the hot region to fill the void *in statu nascendi*. The motion includes (see Fig. 1):
(i) subsidence of the 'lithosphere' of South Polar Terrain,
(ii) flow of the matter in the mantle,
(iii) motion of plates adjacent to SPT towards the active region.

The sinking of the STP plate reduces essentially compressive forces acting from the plates surrounding the STP region. Therefore, the thermal processes below tiger stripes are sufficient to keep open active fractures. Note that the present situation in STP is similar to situation of the Philippine Plate (and some other regions of terrestrial oceanic floor), where back-arc spreading is observed. Note that back arc spreading indicates extensive forces).

End of Cryovolcanis Activity: The continuous loss of mass will cause eventually an increase of compression forces, which will ultimately lead to closing fissures and stopping activity in the STP region.

Periodic Activity: We suggest that the activity of Enceladus is periodic. The activity in the present place are propbably decreasing now (some parts of 'tiger stripes' are not active now). A new center of activity should then to be formed as a result of high rate of tidal heating. We believe that ovoid-shaped depression down to 2 km deep, of size 200×140 km with the center at 200E, 15S is a good candidate for this future center. The depression indicates partial melting of the mantle. It indicates higher temperature of the mantle and moreover it could lead to an increase of tidal heating at that place (higher amplitude of tidal motion and higher dissipation of energy).

The heating will lead to the emergence of strong currents of hot water or steam which, acting on the shell, could lead to the formation of fissures similar to current tiger stripes. The reorientation of the satellite is also possible leading to situation where region of activity is close to the polar region.

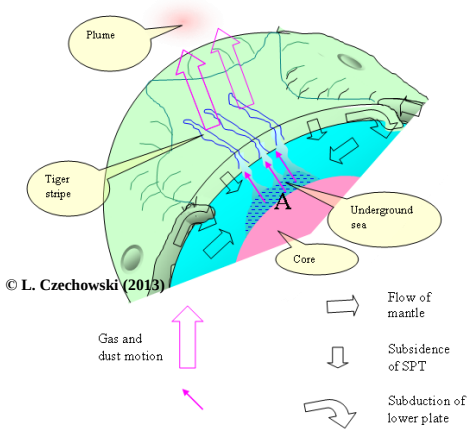

Figure 1: A scheme of suggested processes in the activity center (after [1]). Note that the present situation in STP is similar to situation of the Philippine Plate, where back-arc spreading is observed.

Proto-Enceladus hypotheses: The mass of matter ejected into space by volcanic activity of Enceladus is 200 kg s^{-1}. It means that just after the accretion, Enceladus could be substantially larger.

We refer here this larger body as proto-Enceladus [2]. Two assumptions could be used for calculation of the size of proto-Enceladus: (i) the present rate of mass out flow could be treated as the average or (ii) densities of proto-Enceladus and Mimas were the same because the satellites accreted in the same part of the nebula. Both approaches give similar size of proto-Enceladus [2].

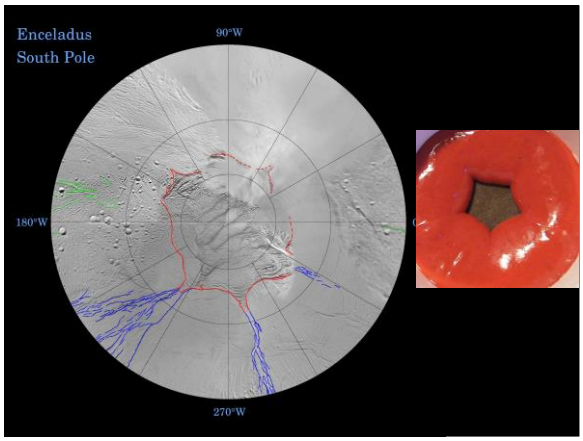

Figure 2. The image of STP (left hand side, after NASA). Laboratory model of subsidence is on the right part of the figure [5]. The subsidency of the central plate reduces significantly compressional forces resulting from interaction with surrounding plates.

There are some traces of past activity on the surface of Enceladus [4]. The traces could be interpreted as indication that the past activity was similar to the present one (similar features), but we do not know how old are these traces. Their age could be used for estimation of the period of changes of the activity.

Enceladus as cradle of life in Solar System:

The model of core origin and evolution [2] indicates that for hundreds of My there were conditions preferable origin of life. In [6] it was stated that Proto-Enceladus was the most appropriate body for a cradle of life in the Solar System. Simple organisms could be ejected in icy grains into space by volcanic jets. Several mechanisms could be responsible for later transport of the grains to the early Earth and other terrestrial planets.

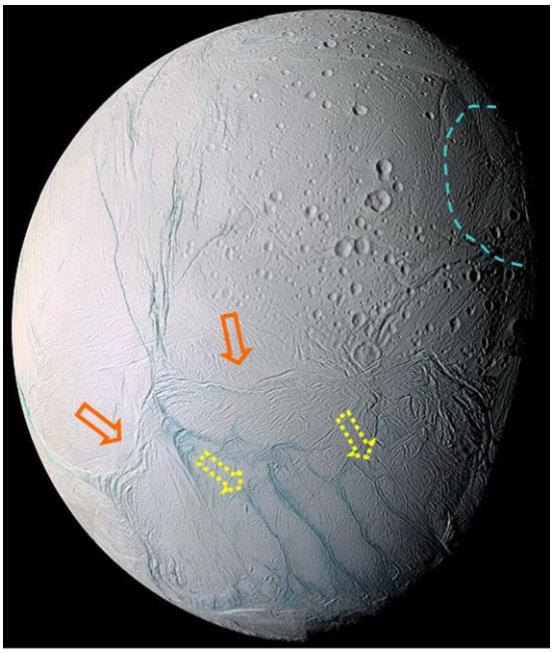

Figure 3. Surface features in the cryovolcanic center (SPT) of Enceladus (NASA, PIA06254). Solid arrows show the arcuate scarps convex southward. Analogy with terrestrial subduction zones suggests that the polar plate is there subducted- e.g. [1]. Dashed arrows indicate two tiger stripes. Blue dashed line shows an ovoid depression which may be an activity center in the future as suggested by [1].

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