European Planetary Science Congress, 19 – 24 September 2010, Rome, Italy; Angelicum Centre – Pontifical University of Saint Thomas Aquinas

Main directions of studies in dynamics of planets and satellites

Barkin Yu.V.

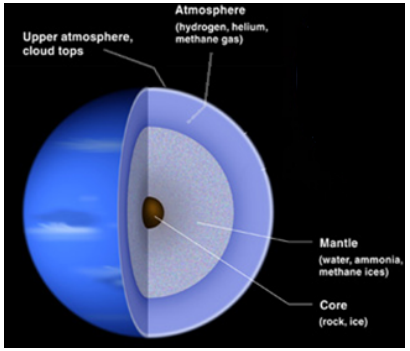
Sternberg Astronomical Institute, MSU, Moscow

Rotation, inner dynamics and natural processes of Solar system bodies

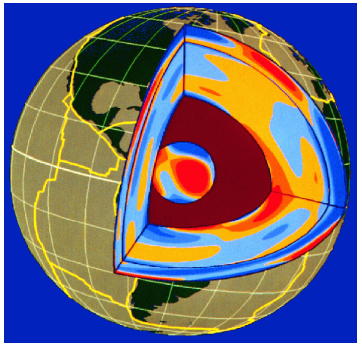
Convener: Dr. Barkin; Co-Conveners: J.M. Ferrandiz , N. Petrova , J. Souchay

Tuesday, 21 Sep 2010 Room: Workshop Room 1

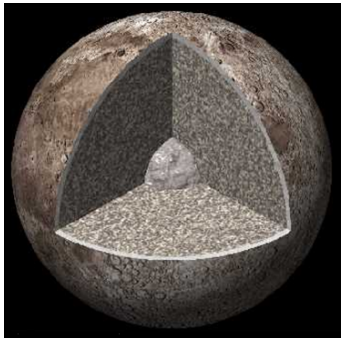
Neptune



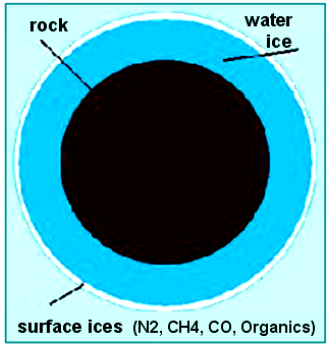
The Earth



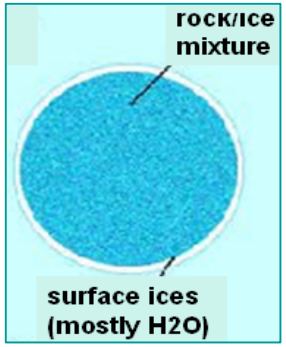
The Moon



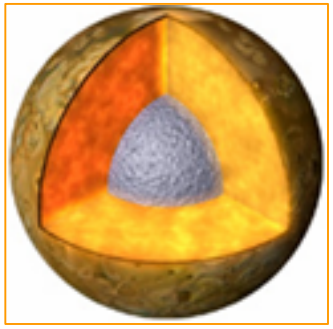
Pluto



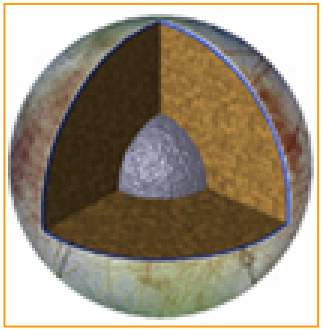
Charon



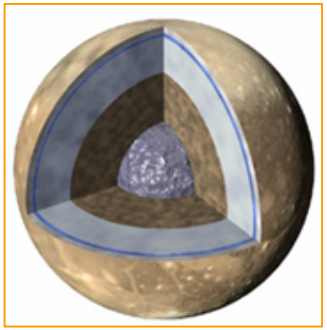
Io



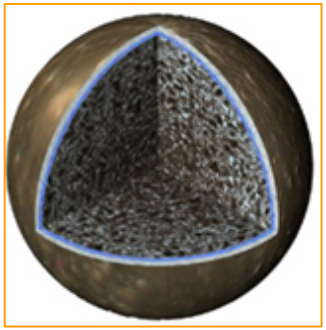
Europa



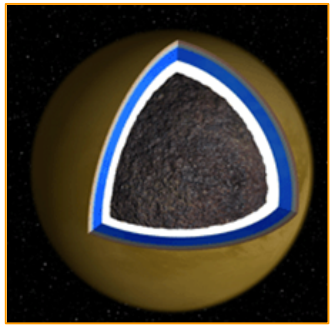
Ganimede

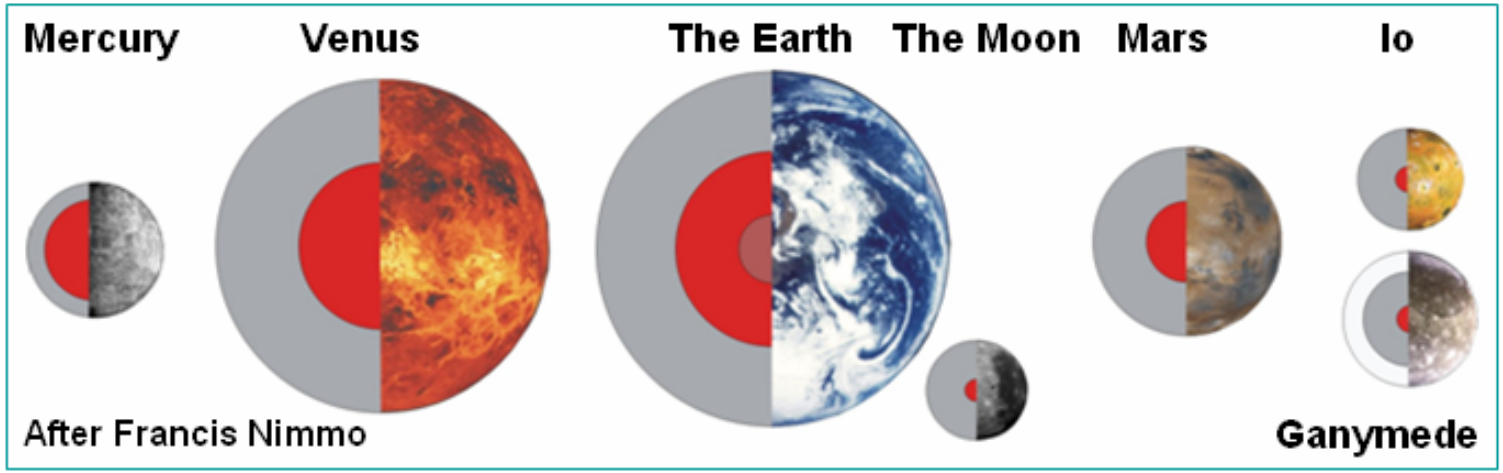


Callisto

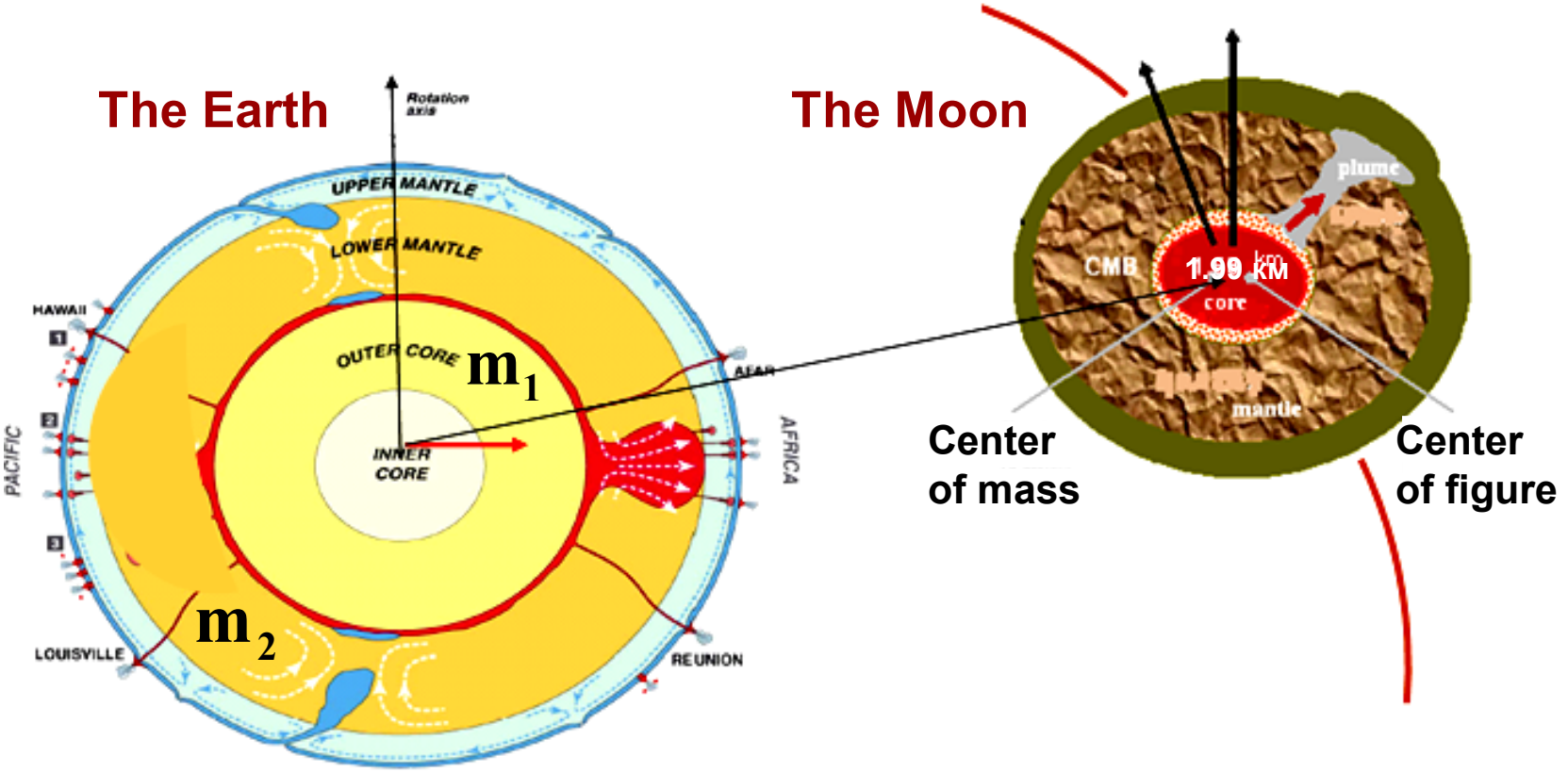


Titan





Earth-Moon system: the mutual gravitational influence and stimulation of endogenous activity (Barkin, 1996, 2002)



The case of the spherical core

$$U_{M2} = f\frac{m_2 m_M}{r_2}$$

$$U_{M1} = f\frac{m_1 m_M}{r_1} + f\frac{m_M (C_1 - A_1)}{2r_1^3}(1 - 3\gamma_1^2)$$

$$U_{M2} = f\frac{m_2 m_M}{r_2} + f\frac{m_M (C_2 - A_2)}{2r_2^3}(1 - 3\gamma_2^2)$$

Forced relative dynamics of the core and mantle of the Earth, planets and satellites

Barkin Yu.V. Explanation of the endogenous activity of planets and satellites and the mechanism of its cyclicity. pp. 45 - 97. In Russian.

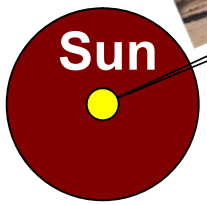
The mechanism of the relative excitation of buildup, oscillations, displacements, wobble and turns and excitation of the planet by external celestial bodies.

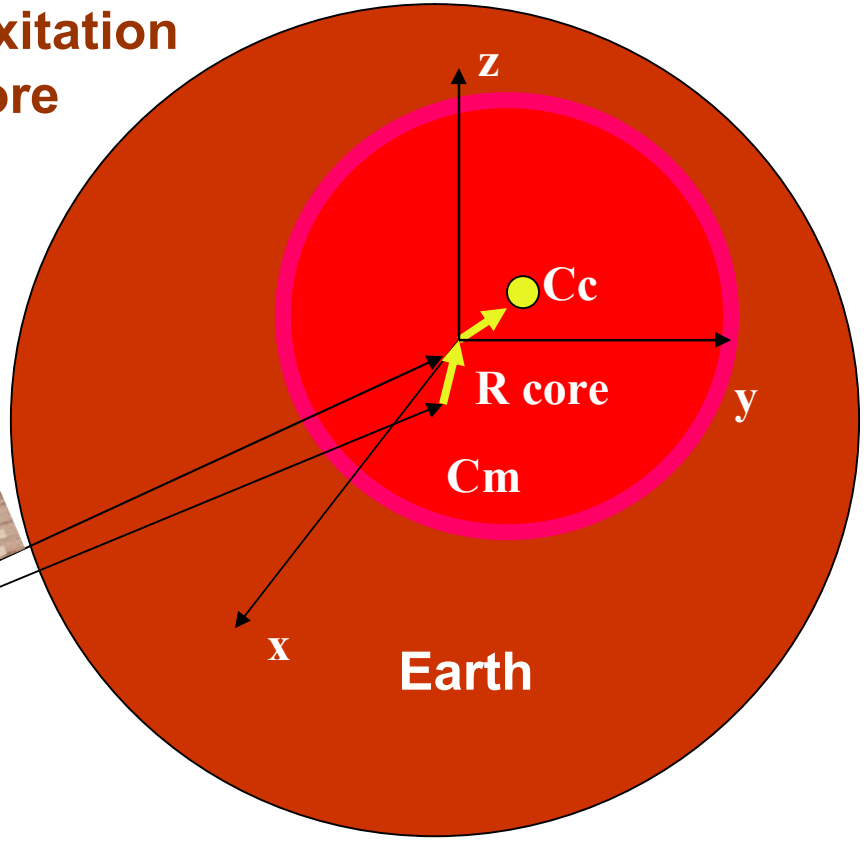
Factor of asphericity of the shells (their ellipsoidality)

The factor of eccentricity in the relative positions of the centers of gravity of the core and mantle and noninertial.

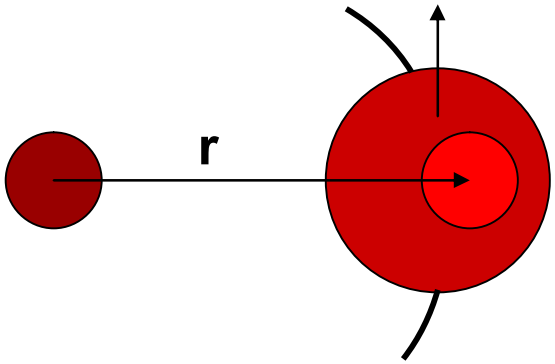
Gravitational mechanism of exitation of oscillations of eccentric core

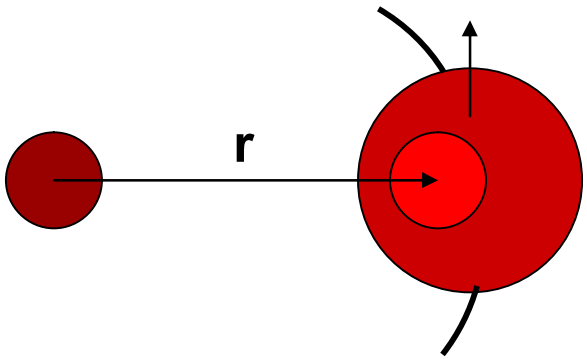
Barkin, 1996, 2001



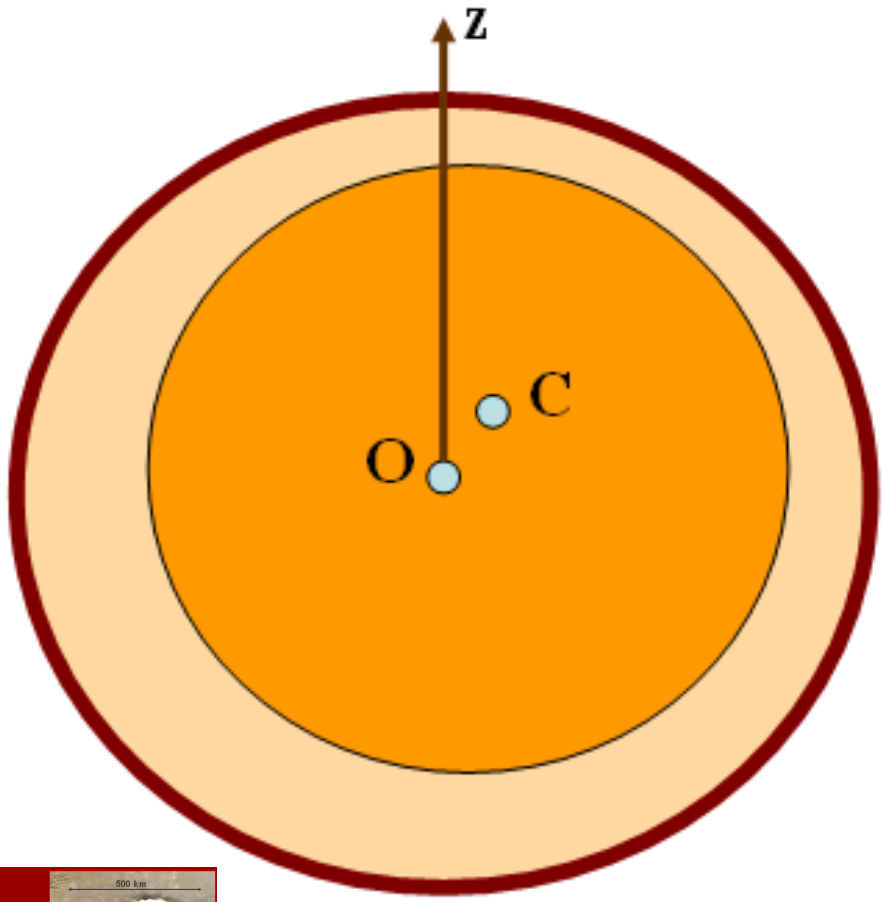


The nature of the diurnal and semidiurnal oscillations of the core-mantle





Large displacements of the centers of mass of the Moon, Mars, Venus, Earth, Titan, the Sun relatively to their geometric centers



Moon: OC=1.9 km

Venus: OC=1.5 km

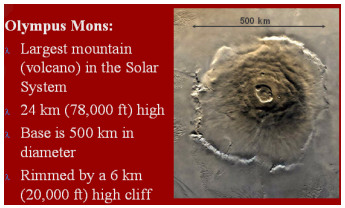
Mars: OC=3.3 km

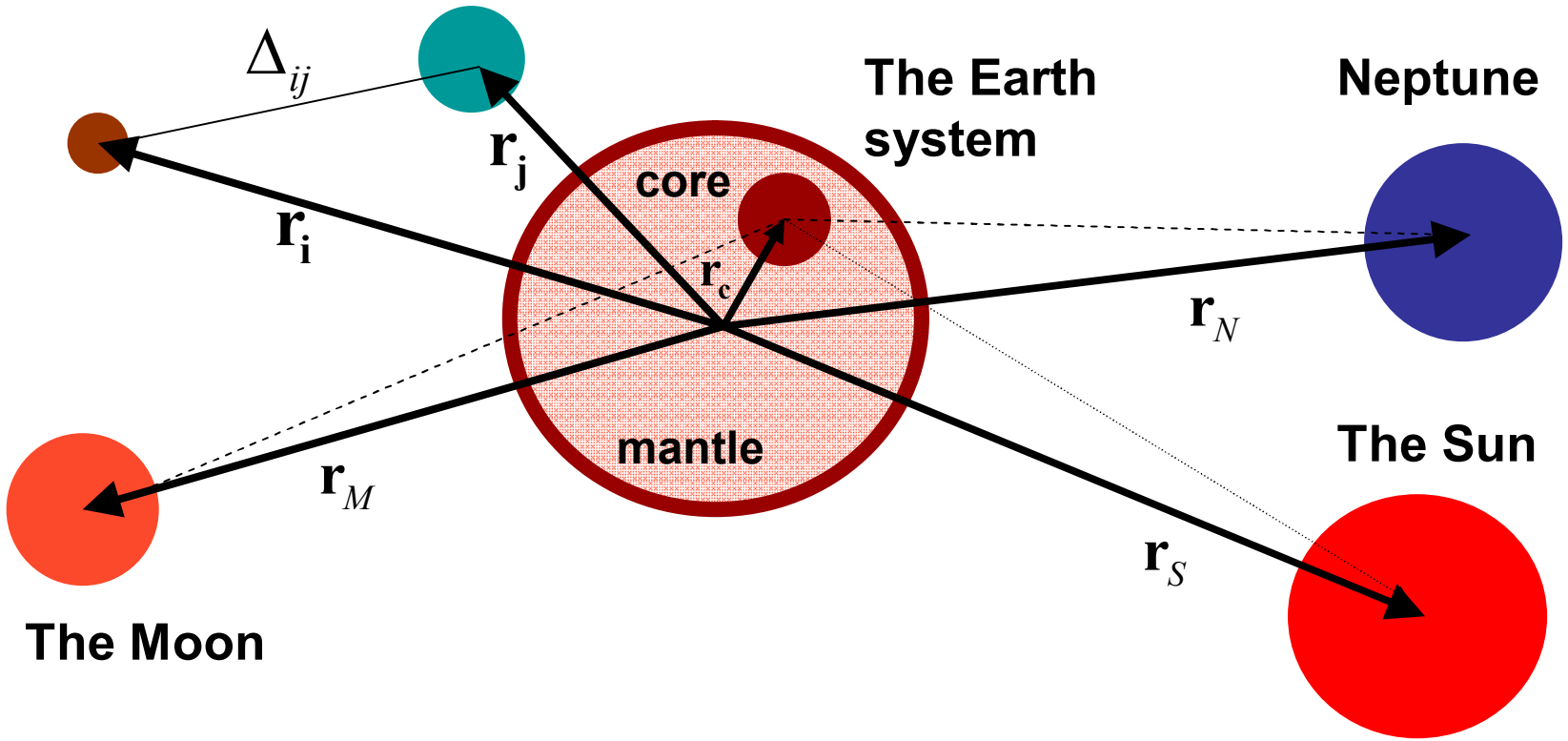
Mercury: OC=0.6 km

Earth: OC=1.1 km

Titan: OC=0.27 km

Sun: OC~ 300 km?





The mechanism of excitation of eccentric core of the Earth (Barkin, 2001)

Differential equations of motion of the nucleus relative to the mantle

$$\ddot{x}_c = 3f\sum_{j=1}^{N} m_j r_j^{-5}\left(x_j x_c + y_j y_c + z_j z_c\right)x_j - f\sum_{j=1}^{N} m_j r_j^{-3} x_c + F_x(t, x_c, y_c, z_c)$$

$$\ddot{y}_c = 3f\sum_{j=1}^{N} m_j r_j^{-5}\left(x_j x_c + y_j y_c + z_j z_c\right)y_j - f\sum_{j=1}^{N} m_j r_j^{-3} y_c + F_y(t, x_c, y_c, z_c)$$

$$\ddot{z}_c = 3f\sum_{j=1}^{N} m_j r_j^{-5}\left(x_j x_c + y_j y_c + z_j z_c\right)z_j - f\sum_{j=1}^{N} m_j r_j^{-3} z_c + F_x(t, x_c, y_c, z_c)$$

The solution of the problem of the relative translational oscillations of the core and mantle, due to eccentricity of the core and the lunar-solar gravitational attraction (Barkin, 2001)

$$x = \sum_{\nu} x_\nu \cos(\Theta_\nu + \lambda) + y_\nu \cos(-\Theta_\nu + \lambda) + \sum_{\tau}\sum_{\nu} X_\nu(\tau)\cos(\tau\Theta_\nu - 2S - \lambda) + Y_\nu(\tau)\sin(\tau\Theta_\nu - S),$$

$$y = \sum_{\nu} x_\nu \sin(\Theta_\nu + \lambda) + y_\nu \sin(-\Theta_\nu + \lambda) + \sum_{\tau}\sum_{\nu} X_\nu(\tau)\sin(\tau\Theta_\nu - 2S - \lambda) - Y_\nu(\tau)\cos(\tau\Theta_\nu - S),$$

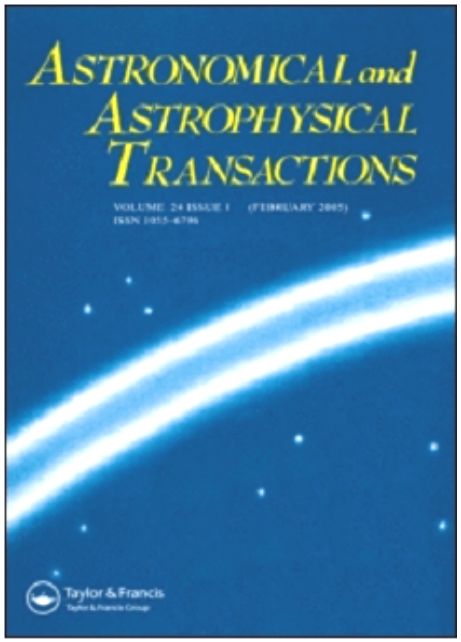
$$z = \sum_{\nu} z_\nu \cos(\Theta_\nu) + \sum_{\tau}\sum_{\nu} Z_\nu(\tau)\sin(-\tau\Theta_\nu + S + \lambda),$$

where

$$x_\nu = \frac{3\rho_0 B_\nu N^2}{2[(\Omega_\nu + \omega)^2 - k^2]}, \quad y_\nu = \frac{3\rho_0 B_\nu N^2}{2[(\Omega_\nu - \omega)^2 - k^2]}, \quad z_\nu = -\frac{6z_0 B_\nu N^2}{\Omega_\nu^2 - k^2},$$

$$X_\nu = \frac{3\rho_0 D_\nu(\tau) N^2}{2[(\tau\Omega_\nu - \omega)^2 - k^2]}, \quad Y_\nu = \frac{3z_0 C_\nu(\tau) N^2}{2[\Omega_\nu^2 - k^2]}, \quad Z_\nu = -\frac{3\rho_0 C_\nu(\tau) N^2}{(\tau\Omega_\nu - \omega)^2 - k^2}$$

$$\Theta_\nu = \nu_1 l_M + \nu_2 l_S + \nu_3 F + \nu_4 D + \nu_5 \Omega, \quad \Omega_\nu = \nu_1 n_M + \nu_2 n_S + \nu_3 n_F + \nu_4 n_D + \nu_5 n_\Omega$$



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Astronomical & Astrophysical Transactions
The Journal of the Eurasian Astronomical Society
Astronomical and Astrophysical Transactions
2004, Vol. 23, No. 6, pp. 533–553

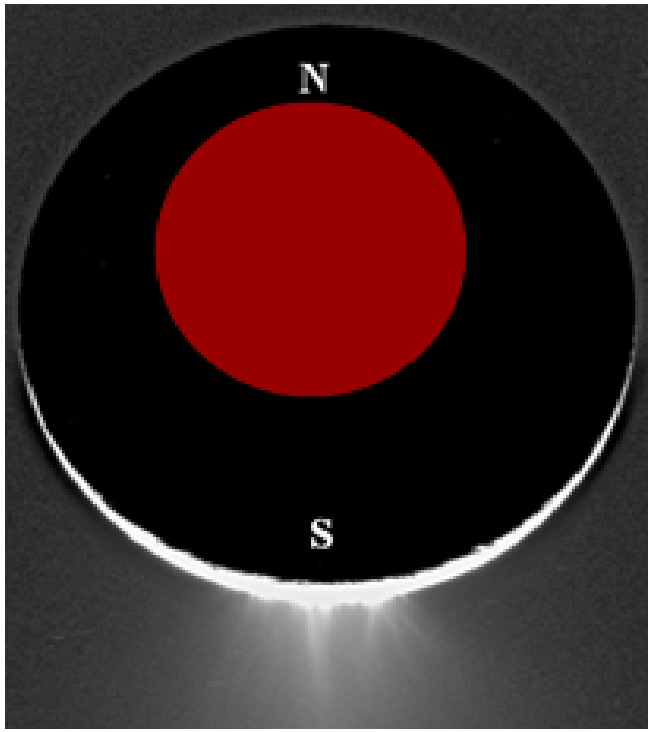
CELESTIAL MECHANICS OF PLANET SHELLS

Yu. V. BARKIN[a,b,*] and V. G. VILKE[c]

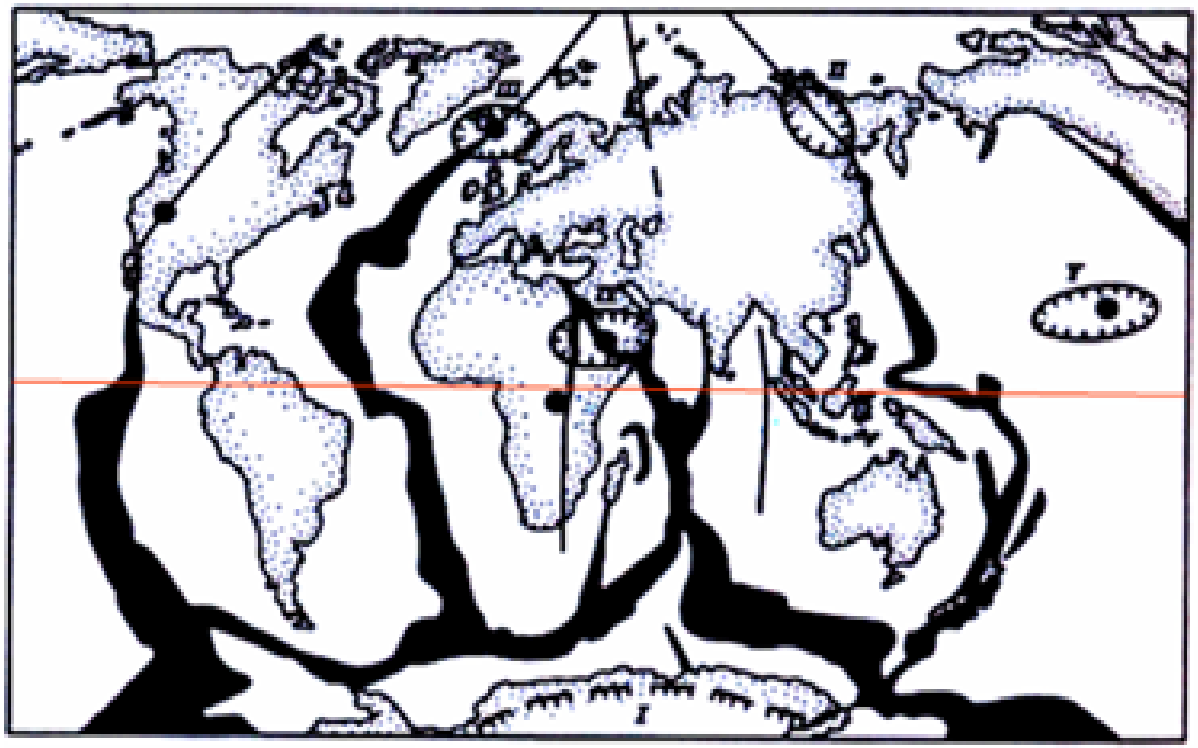
The gravitational attraction of the moon, sun and planets primarily contributes to the relative polar oscillations of the centers of mass of the core and mantle, separated by a visco- elastic (or fluid) layer.

The relative oscillations of the centers of mass of the core and mantle are characterized by a wide spectrum of frequencies and in different scales of time, not just seasonal fluctuations. They are reflected in the observed oscillations of the center of mass of the Earth.

The unity of the mechanisms of degassing on the Earth and Enceladus

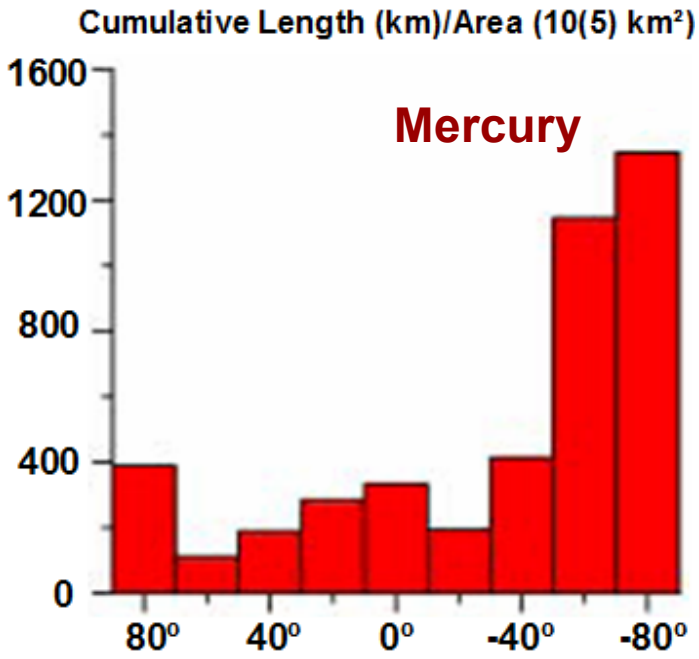


Geysers on Enceladus

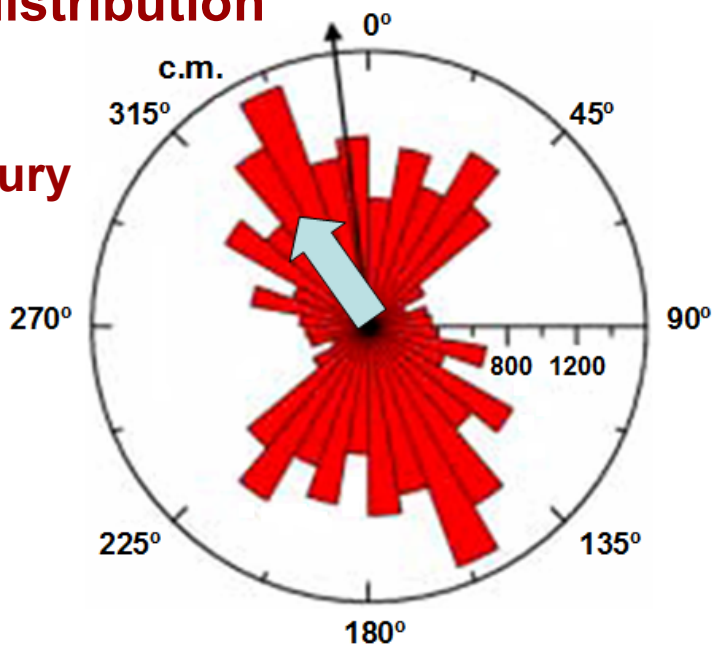


Planetary structure of spreading zones and active zones of degassing of the Earth

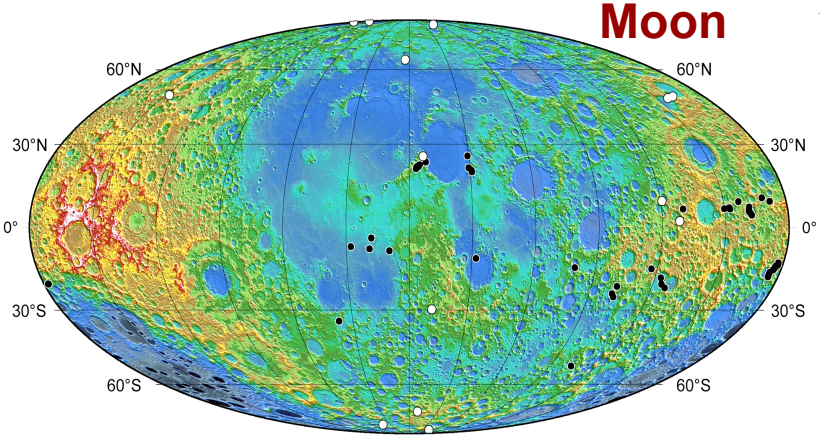
Lobate scarps distribution



Mercury

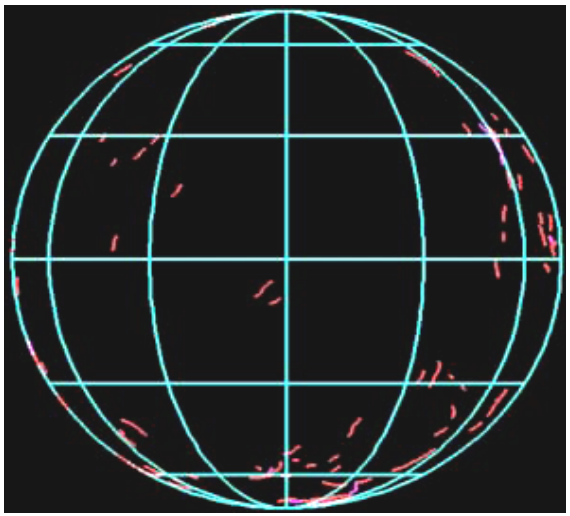


Mercury

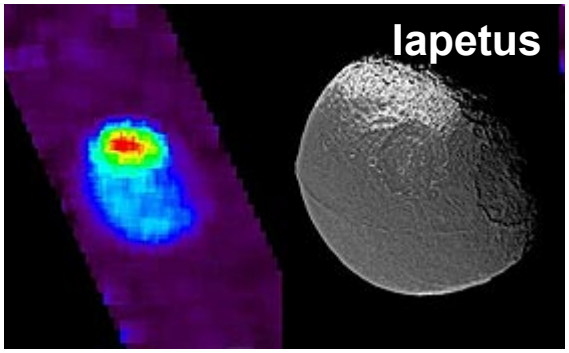


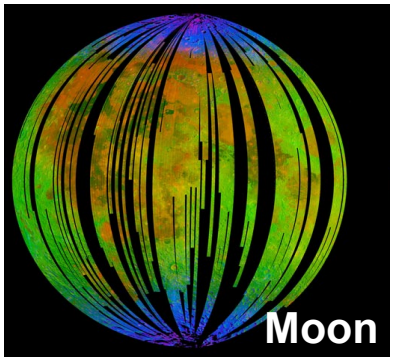
Moon

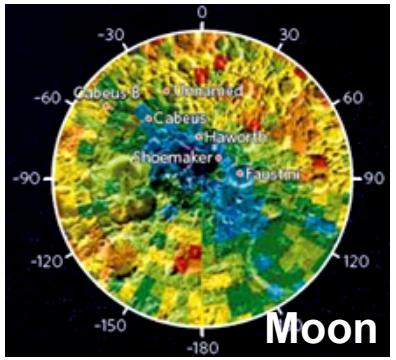
Mercury

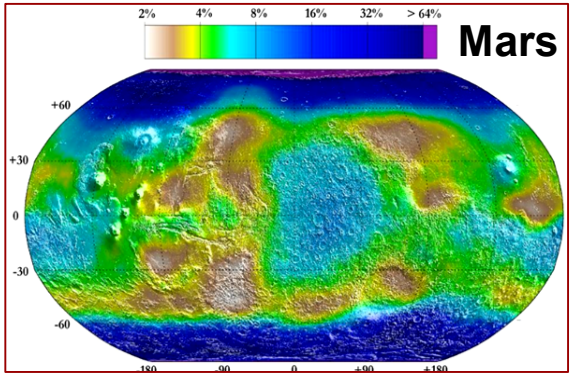


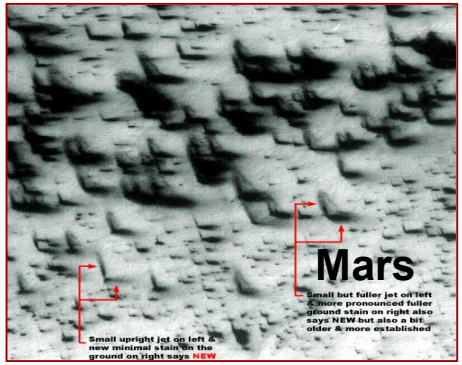
Distribution of orientations of lobate scarps and high-relief ridges on Mercury and Moon. Non-global contraction. Watters et al., 2004.

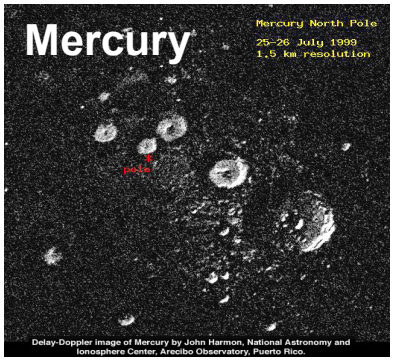


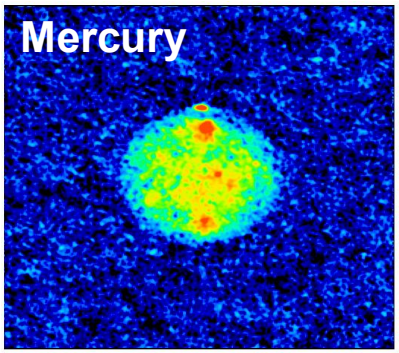


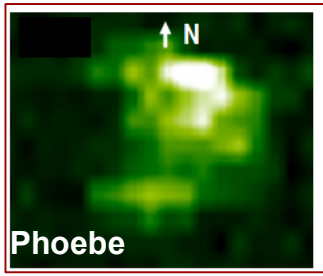


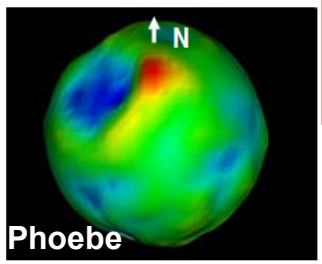


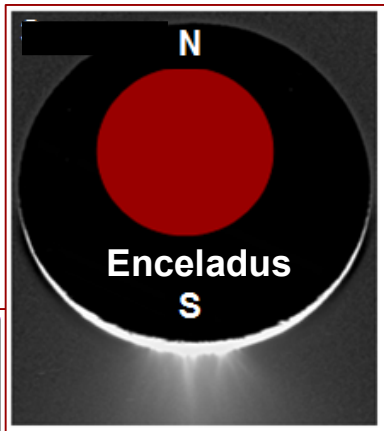


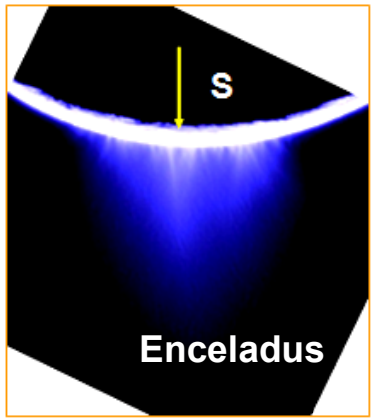






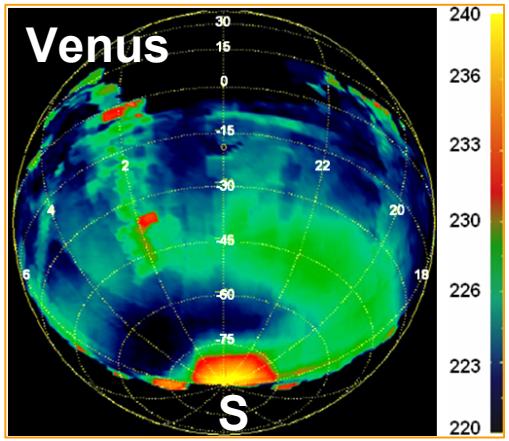


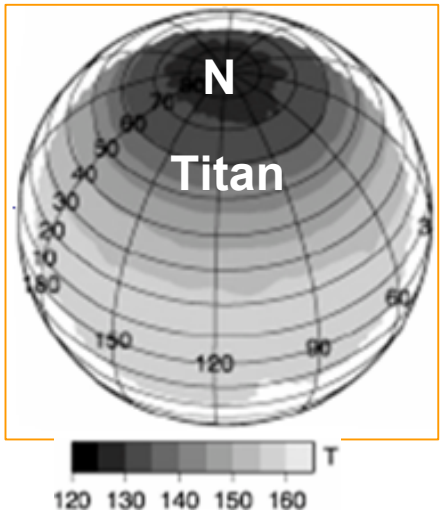




Geysers: Mars, Enceladus, Triton

Ice, water: Mars, Moon, Mercury, Iapetus, Phoebe, and others.


Venus
S
240
236
233
230
226
223
220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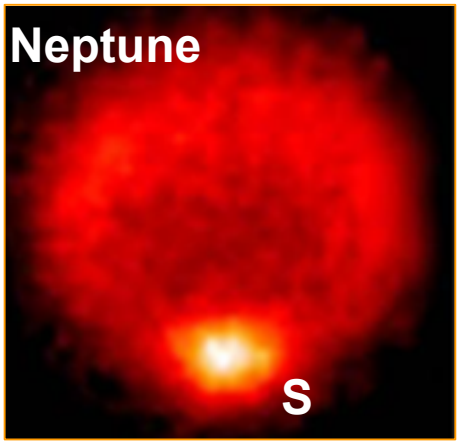
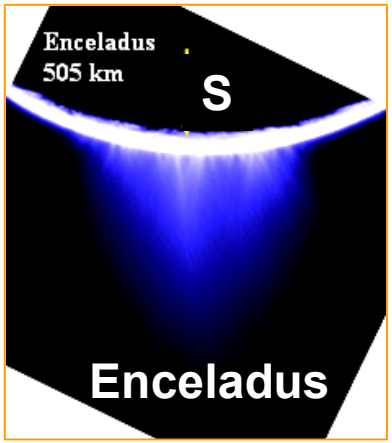
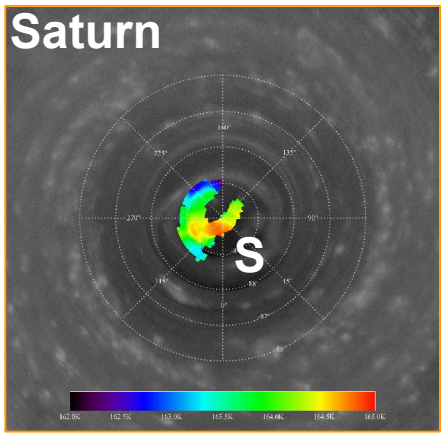
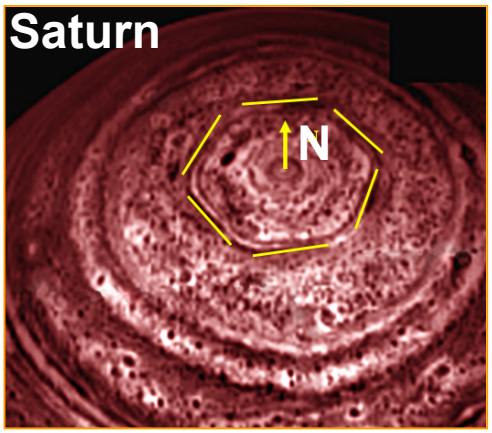
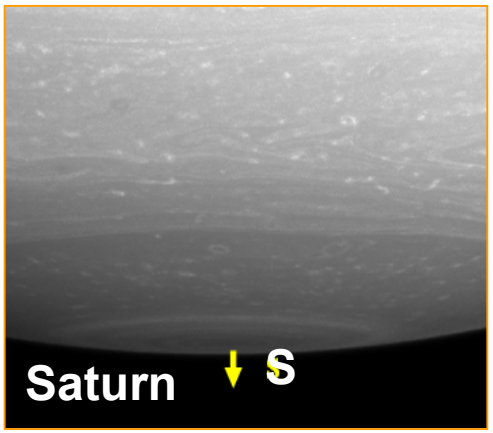
Titan
T
120 130 140 150 160

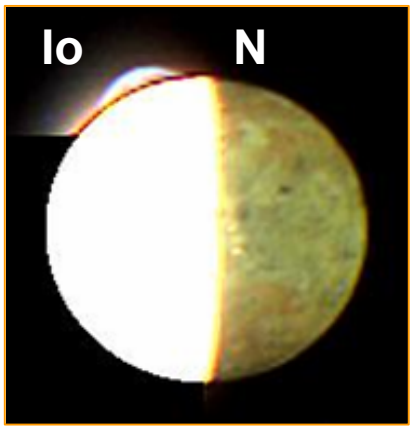

Neptune
S

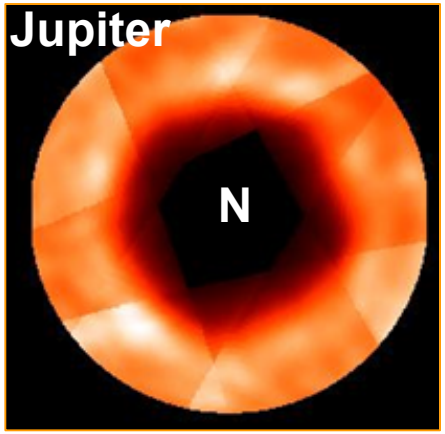

Enceladus
505 km
S
Enceladus

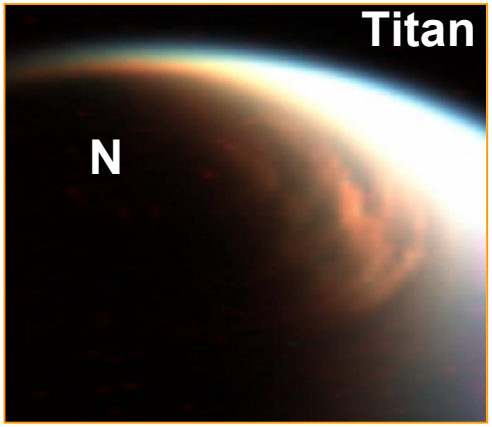

Saturn
S

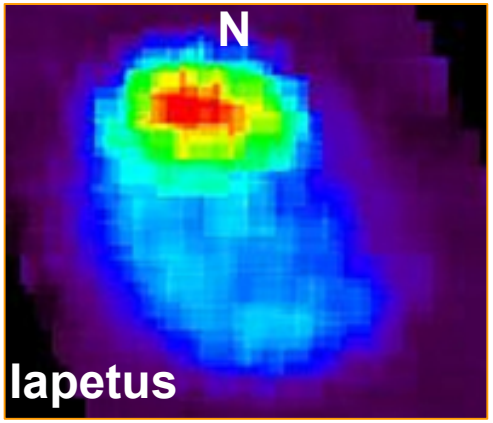

Saturn
N

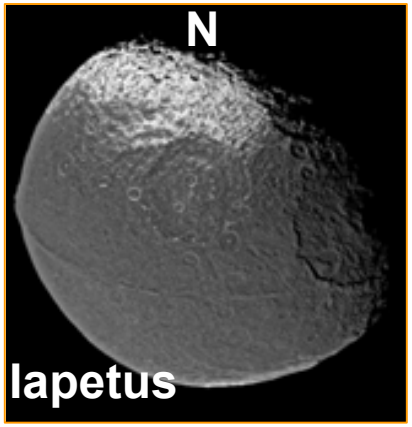

Saturn
S


Io
N


Jupiter
N

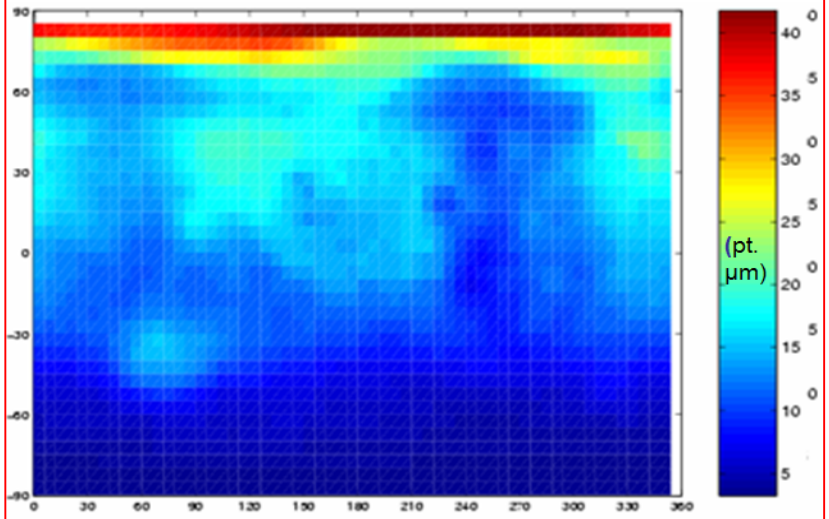

Titan
N


N
Iapetus


N
Iapetus

Mars

Inversion in distribution water column annual mean on Mars



It can be assumed that at present on Mars is global climate change, which planet's water resources are redeployed from south to north.

Titan

S. Rodriguez et al., 2010 Roma Europlanet: Vol. 5, EPSC2010-142, 2010

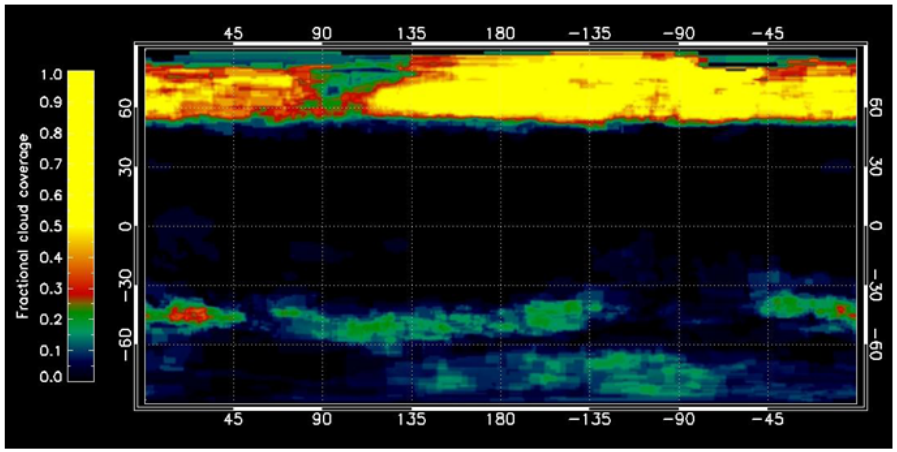


Figure 1: **Mean fractional cloud coverage in Titan's atmosphere between July 2004 and April 2010.**

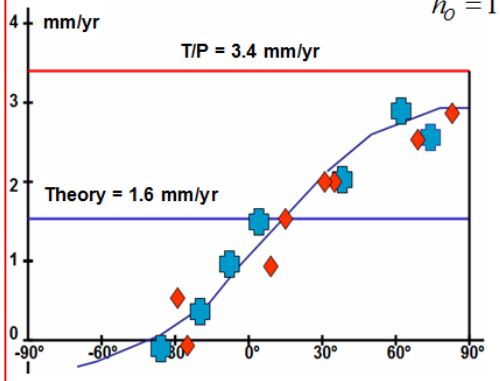
Earth

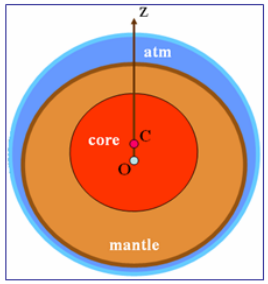
The rate of increase in sea level, depending on the latitude, the mean rates of increase in sea level in northern and southern hemispheres during the period of 1980-2000.

$$\dot{H}_o(\theta) = \dot{H}_o^{(0)} \sin\varphi + \dot{\bar{h}}_o$$

$$\dot{H}^{(0)} = 1.84 \pm 0.61 \text{ mm/yr}$$

$$\dot{\bar{h}}_o = 1.5 \pm 0.5 \text{ mm/yr}$$



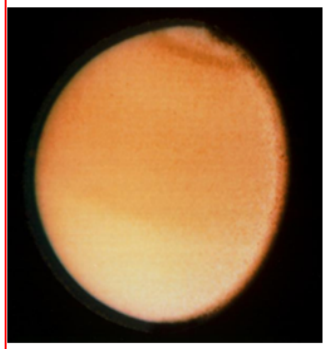


Barkin, 2005

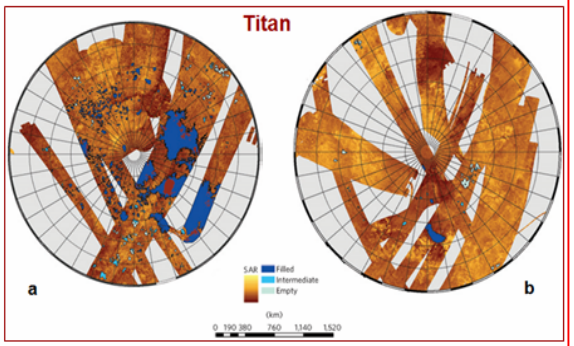
Prediction and discovery of the secular tide in the northern hemisphere

Titan

Titan from Voyager



Geographic distribution of lakes



http://photojournal.jpl.nasa.gov/

Fig. a,b, Maps of the northern (a) and southern (b) hemispheres. The lakes are colour coded according to their morphologic type (filled, intermediate, empty). Shades of brown indicate SAR backscatter brightness. Hayes, 2008.

Earth volcanism

Migration of volcanism between northern and southern hemispheres

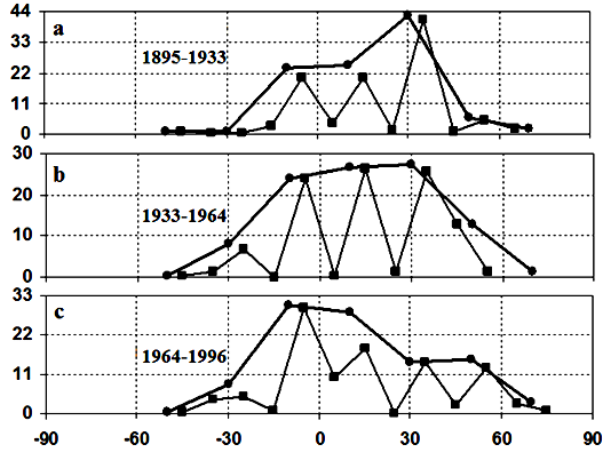


Fig. Latitudinal distribution of volcanic eruptions with known volume of lava, step 10 ° for the periods: a - 1900-1933 yrs., b - 1933 -1964 yrs., c - 1964-1996 yrs. The scale of ordinates is expressed as a percentage of the total number eruptions during the period.

Earth seismicity

The phenomenon of latitudinal migration of the zone of active seismic phenomena in 1900 - 1996 years

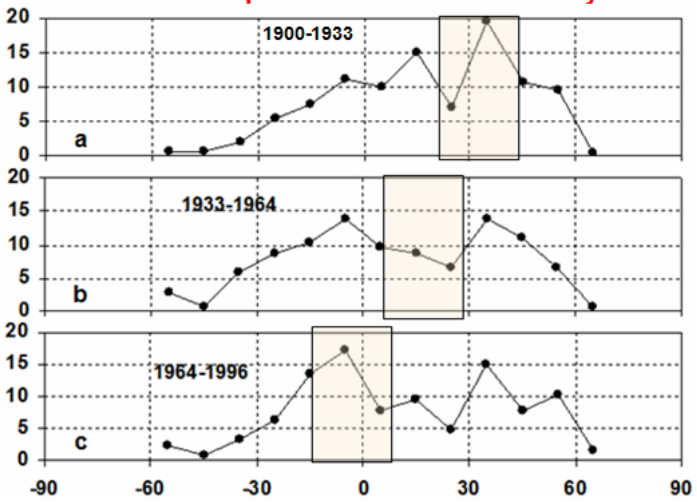
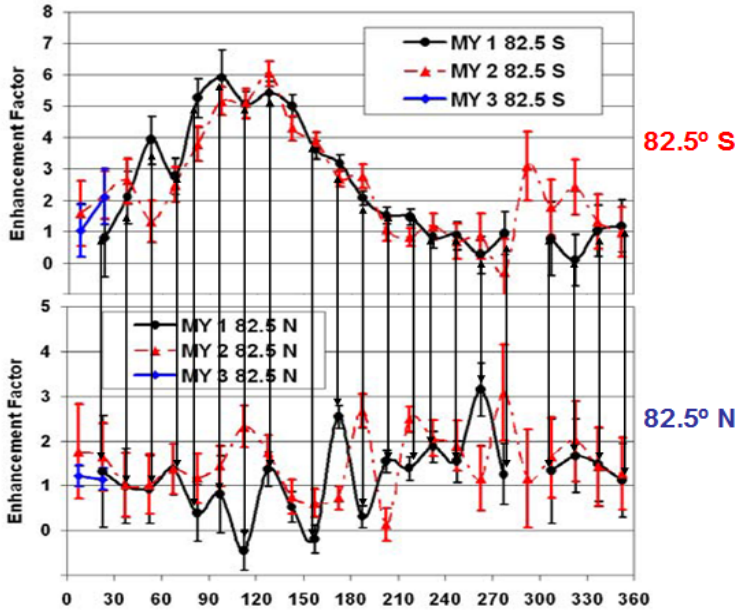


Fig.5. Distribution of large earthquakes (M> 7.6) on latitudes of the secular cycle with steps of 10 ° for the periods: a - 1900-1933 years, b - 1933-1964 years, c - 1964 -1996 years. The scale of ordinates is expressed as a percentage of the total number of earthquakes in specified period. Belov et al (2009); Barkin (2000), (2002).

Mars atmosphere Argon

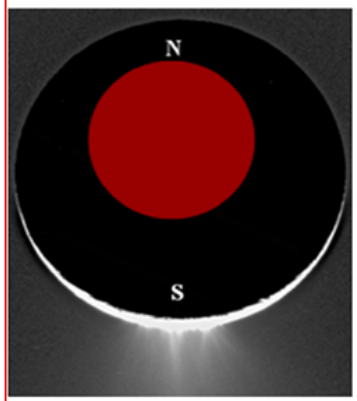
Argon in Mars' atmosphere in Northern & Southern hemispheres



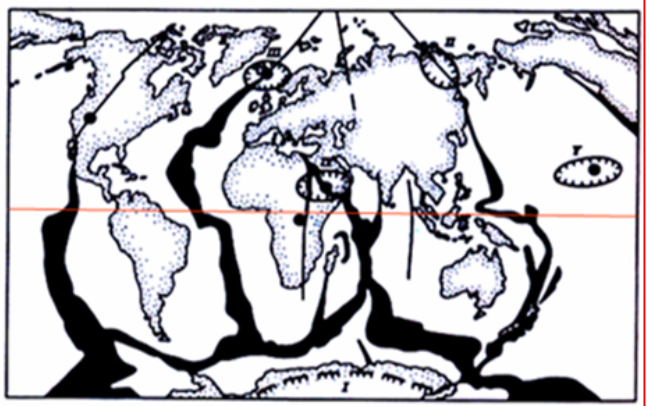
A.L. Sprague et al., 2007; L_s (degrees) LPS XXXVIII (2007)

Enceladus, Earth

The unity of the mechanisms of degassing on the Earth and Enceladus



Geysers on Enceladus

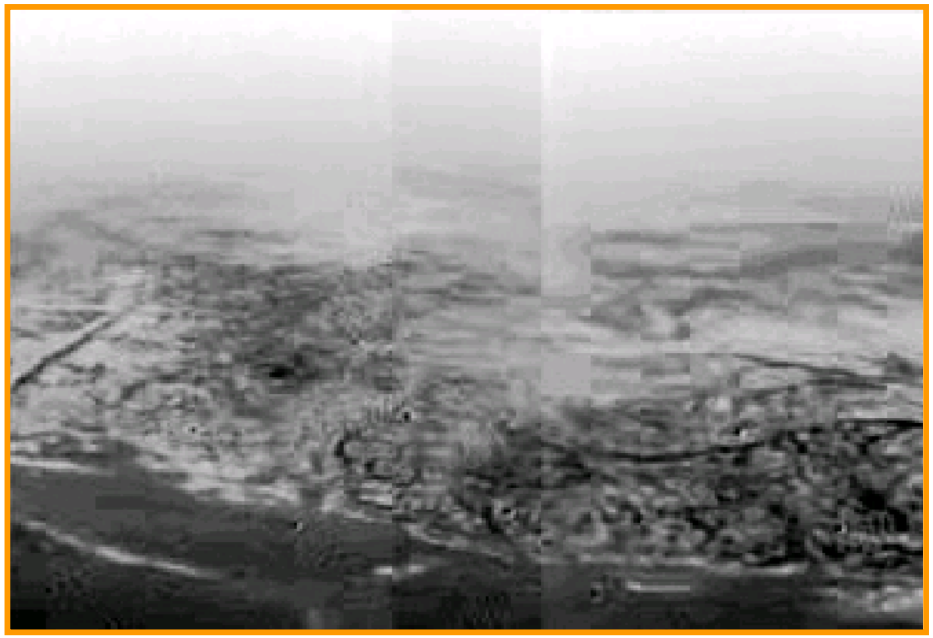


Planetary structure of spreading zones and active zones of degassing of the Earth

Barkin Yu.V. Explanation of the endogenous activity of planets and satellites and the mechanism of its cyclicity. pp. 45 - 97. In Russian.

Cyclic recurrence
Energetics
Unity
Synchronism
Inversion
Polar Activity
Spasmodic
Sawtooth
Order
Twisting
Versatility

Thanks for your attention!

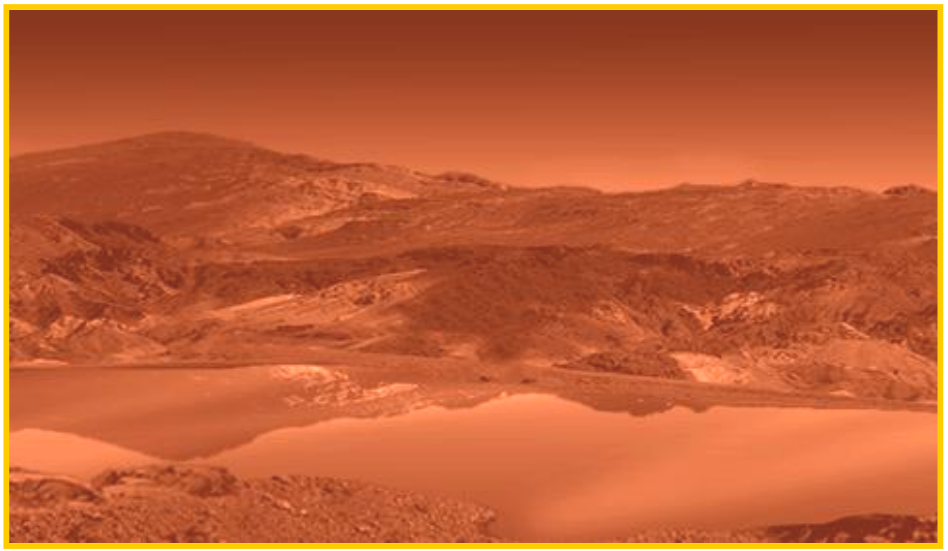


Prediction of high endogenous activity of Titan (Barkin, 2002):

"Titan is a second world in Solar system, on own activity similar to the planet Earth".

"Costa Blanca" on Titan

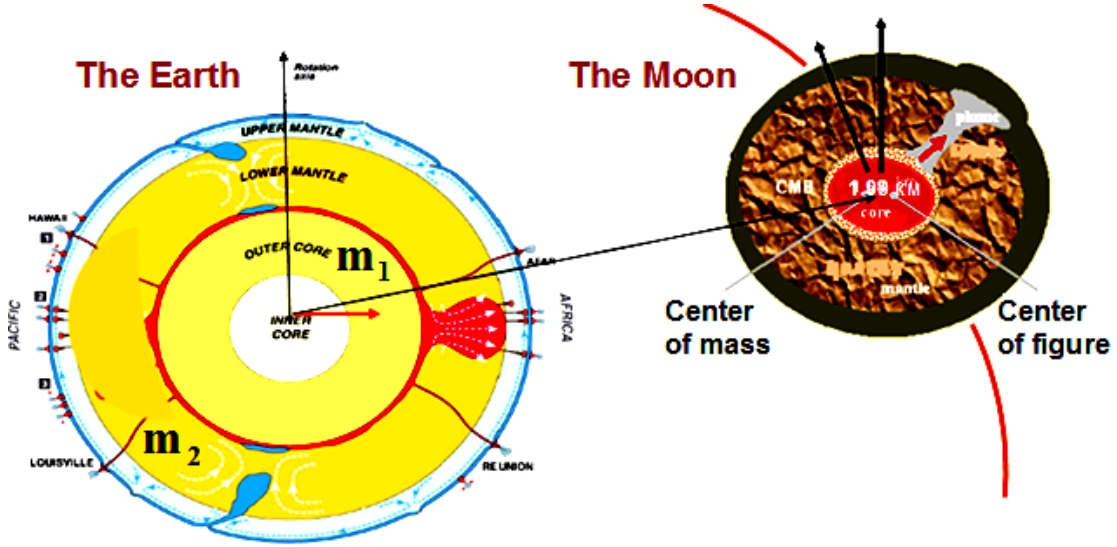
$$U_{\substack{\text{shell}\\\text{forced}\\\text{interactions}}} >> U_{\text{tidal}}$$



Main geodynamical models in geodynamics and geology

Expanding Earth
Contracting Earth
Pulsing Earth

External gravitational excitation of the shells



Thanks for your attention!