EARTH, MOON, MERCURY AND TITAN SEISMICITY: OBSERVED AND EXPECTED PHENOMENA

[1]Yu.V. Barkin, [2]J.M. Ferrandiz, [2]M. Garcia Ferrandez,
[1]Sternberg Astronomical Institute, Moscow, Russia, e-mail: barkin@inbox..ru
[2]Alicante University, Spain

Tidal and shell-dynamics interactions of the given celestial body with external celestial bodies lead to variations of their tensional state and as consequence to variations of different planetary processes including variations of seismic activity. It is clearly observed that variations of lunar seismicity have the celestial mechanical nature and depend from the Moon perturbed orbital motion. Using dynamical analogy in translatory-rotary motions of synchronous satellites and Mercury we have obtained evaluations of periods of variations of seismic activity of the Titan and Mercury. The high level of endogenous activity of Titan was predicted earlier [1].

The full elastic energy of luni-solar tides superposition is not an additive sum of elastic energies of separated tides and contains additional terms of the mutual character, which play a significant role in the geodynamical life of the Earth [2], [3]. The tensional state of the Earth is characterized by the elastic energy stored in superposition of tides. Some part of elastic energy dissipates and goes to the warm energy and to an energization of different geodynamical processes in definite rhythms. Correlation of the extreme variations of the elastic tidal energy of the Earth with earthquakes and moonquakes events (in period 1971-1976 years) has been studied in [2] - [4]. This potential regularity of seismic process we have used for prediction of the dates of biggest earthquakes in 2003 and 2004 years.
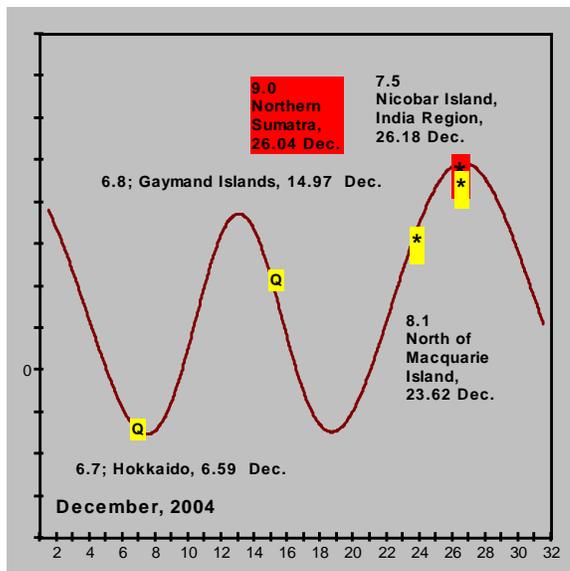

Fig.1. Variations of elastic energy and biggest quakes.

In particular the date of phenomenal Hokkaido quake of 25.83 September 2003 with magnitude

M=8.3 and date of catastrophic Sumatraquake of 26.04 Dec., 2004 (M=9.0) with awful consequences and Nicobarquake of 26.18 Dec., 2004 (M=7.5) have been predicted with high accuracy in [2], [3]. Corresponding predicted dates are 26.3 Sep., 2003 and 26.10 Dec., 2004 ([2], [3]). Fig. 1 illustrates behavior of elastic energy curve (in conditional units) in December of 2004 and positions of biggest quake events. The mechanism of the differential and cyclic gravitational action of the Moon and Sun on the Earth shells and on interacting plates is suggested (as a trigger mechanism) for explanation of discovered regularity.

Cyclicities of the Moon seismicity. The relative orbital motions of the Moon and the Earth are identical. Periodicities in their orbital motions in same style influence on the tidal processes on both celestial bodies and, consequently, rhythms at identical periods can be expected in seismic processes for the Moon and for the Earth. A first confirmation of mentioned correlations has been obtained for shallow earthquakes (with magnitude >7.3) and shallow moonquakes in period 1971-1976 [4]. Tidal nature of moonquakes has been discussed by an interpretation of results of their spectral analysis [5], [6]. In mentioned papers the periods of the Moon orbital perturbations in 27.4, 13.6, 206 days and some others have been determined.

Our spectral-temporal analysis of the full series of the deep moonquakes from catalogue which has been kindly presented us by Y. Nakamura (7344 events, [7]) have been let us to confirm mentioned periods and to establish some new cyclicities in the quake activity of the Moon and to describe a fine structure of some from orbital periodicities. So variations of Moon seismicity with another periods multiple to orbital draconic (T_{drac}), anomalistic (T_{anom}) and synodic (T_{synod}) periods were determined.

Table 1. Periods of seismic variations.

Moon		Titan	Mercury
$T_{drac}/2$=13.611	(13.608; 2371);	7.9722	
T_{anom}= 27.54	(27.570; 1214);	15.9455	87.969
$T_{syn}/2$= 14.766	(14.765; 1042);	7.9846	
$T_{drac}/4$= 6.805	(6.804; 815);	3.9861	
T_{drac}= 27.22	(27.18; 680);	15.9444	
T_{syn}= 29.53	(29.56; 495);	15.9661	
$T_{syn}/3$= 9.844	(9.840; 373);	5.3230	
$T_{drac}/6$= 4.537	(4.535; 354);	2.6574	
$T_{syn}/4$= 7.383	(7.380; 348);	3.9923	
$T_{drac}/3$= 9.074	(9.071; 314);	5.3148	
$T_{anom}/4$= 6.884	(6.871; 289);	3.9864	21.992
$T_{drac}/8$= 3.403	(3.395; 285);	1.9961	
$T_{anom}/5$ = 5.508	(5.500; 261);	3.1891	17.594

$T_{syn}/11$= 2.685　(2.685; 253);　1.4517
$T_{drac}/5$= 5.444　(5.455; 249);　3.1889
$T_{anom}/8$= 3.442　(3.470; 249);　1.9932　10.996
$T_{synod}/8$= 3.692　(3.735; 236);　1.9961
$T_{synod}/7$= 4.219　(4.205; 234);　2.2813

From other the more remarkable and observed periodicities of the Moon activity are (in days): 441.800 [436.9 ± 8.7], (819); 366.9 [347.5 ± 11.3], (661); 206.6 (847); 441.8 [436.9 ± 8.7], (819); 227.9 (564); 299.5 (515); 258.5 [250.2 ± 3.6], (393); 148.9 (484); 81.73 [81.8 ± 0.4], (360); 61.13 (324); 106.8 [107.5 ± 0.9], (305); 101.3 (295); 68.13 (291); 138.1 (280); 178.3 [178.1 ± 2.3] (274); 161.1 (271); 117.3 (256); 58.78 (242); 34.300 [34.5 ± 0.1], (311); 33.575, [33.6 ± 0.1] (268); 32.75 (500); 31.950 [32.0 ± 0.1], (424); 14.05 (462); 30.024 [30.6 ± 0.1], (344); 25.20 (440); 25.91 (420); 16.495 [17.9 ± 0.1], (240); 13.13 (348); 6.561, [6.5 ± 0.1] (263), 5.710 [5.7 ± 0.1] (250); and others.

Here in square brackets are given values of periods obtained independently by Dr. Kaftan V.I. (ZNIIGAIK, Moscow) and in parentheses are given conditional amplitudes of corresponding seismic variations. Obtained results were analyzed and compared with similar results obtained for a random temporal distribution of quakes. The main conclusion is: the seismic rhythms on the Moon have the celestial - mechanical nature and are dictated by gravitational influence of the external celestial bodies. Though , the spectral-temporal analysis has revealed some temporal instability of observed rhythms [6]. As known the many from the Earth processes are characterized by a similar behavior. To explain observed cyclicities in the moon seismicity we study a possible role of the orbital and rotational tides and a role of mechanical interaction between non-spherical mantle layers and core of the Moon induced by gravitational action of the Earth and the Sun.

Variations of the Earth seismic activity. We have been fulfilled statistical analysis of differences of dates of big earthquakes (in last 30 years, [9]) and close dates of extremes of tidal elastic energy. Obtained results in general have been confirmed the correlation of these dates and a new phenomenon of displacements of dates of the big quakes on 1.5-2.0 days with respect to the dates of extremes of elastic energy has been observed. These phenomena of the quake activization are not very clear and in reality illustrate only some general tendencies of concentration of the dates of big quakes closely to the dates of the more perturbed states of the Earth.

We can dear to suggest that variations of elastic tidal energy exert some control on seismic processes. It is important to note that the crossed terms of the elastic energy plays a relevant role in the observed correlation with seismic events. It seems natural: a part of the elastic energy accumulated with every orbital cycle of Moon (and Sun) dissipates to inner geodynamical processes that its variation drives.

For an explanation of observed regularity of the seismic process we have been suggested a mechanism of differential and cyclic action of the Moon and Sun on the interacting plates. This mechanism is a trigger mechanism which control the big seismic events in different time-scales.

Cyclicities of Titan seismicity. Titan is a synchronous Saturn satellite with parameters of orbital motion similar to the Moon motion. In the assumption that mechanisms of the endogenous activity of Titan and their displays are identical with the Moon we can give some first evaluations of periods of variations of Titan processes including its seismic activity. These periods are given in analogy with observed lunar variations of seismicity (in Table 1). Here we have used known model of the Titan orbital motion [8].

Cyclicities of Mercury seismicity. The translatory – rotary motion of Mercury is also resonant. In assumption that the mechanisms of endogenous activity of Mercury and their displays are identical with the Moon we can remark on the possible variations of Mercury processes including. So variations of the seismic activity of Mercury with periods multiple to period of its orbital motion 87.969 days must be observed (some from them are given in Table 1).

References

[1]. Barkin, Yu.V.: 2002. Explanation of endogenous activity of planets and satellites and its cyclicity. Izvestia sekzii nauk o Zemle RANS, N9, M., VINITI, pp. 45-97. In Russian.

[2]. Barkin, Yu.V., Ferrandiz, J.M. and J. F. Navarro: 2003. Variations of elastic energy in Earth-Moon system and their correlations with earthquakes and moonquakes. Abst. of Microsimpos. 37 on Comparative Planetology (October 27-29, 2003), Moscow, Russia. CD-rom: Topics in Compar. Planetol. Vernadsky Institute – Brown University.

[3]. Barkin, Yu.V.; Ferrandiz, J.M. (2004) Tidal elastic energy in planetary systems and its dynamic role. Astronomical and Astrophysical Transactions, v. 23, Issue 4 (August 2004), pp. 369-384.

[4]. Shirley, J.H.: 1985/1986. Shallow moonquakes and large shallow earthquakes: a temporal correlation. Earth and Planetary Science Letters, 76, pp. 241-253.

[5]. Lammlein D.R.: 1977. Phys. Earth. and Planet Inter., 14, pp. 224-273.

[6]. Oleinic O.V., Galkin I.N., & Gamburtsev A.G.: 2000. LPS XXXI.

[7]. Nakamura Y.: 2003. Base data on moonquakes. Private communication.

[8]. Sinclair A.T.: 1977. The orbits of Tethys, Dione, Rhea, Titan and Iapetus. Mon. Not. R. Astr. Soc. , 180, 447-459.

[9]. Seismosurfing the Internet for Earthquakes Data: http: //www. geophys. washington.edu/ seismosurfing. html.