ON THE INTERACTION BETWEEN TECTONIC PROCESSES OF THE EARTH AND THE MOON

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Abstract. At present seismographs are operating on the Moon as well, installed there owing to the successful Apollo missions. However these data are insufficient for detailed statistic investigations. That is why in case of the Moon we are to use indirect indications of its activity, such as the data on transient light phenomena from the catalogues by Miss B. Middlehurst. Among the great number of earthquakes there were chosen only the strong earthquakes (magnitude 6.5) with focuses deeper than 70 km. According to these characteristics 630 earthquakes were selected from 1904 to 1967. In the Middlehurst catalogue during the same period about 370 transient events on the Moon are registrated. A distribution of lunar events on the days of an anomalistic month gives evidence of the influence of the Earth's tidal forces (the Middlehurst effect). It appears that the distribution of earthquakes gives a similar curve. Thus the tidal interaction of the Earth and the Moon establishes certain synchronism in tectonic activity of these planets. The further statistic analysis reveals some more causal relation between the processes of the Earth and the Moon. Strongly pronounced maximum of lunar events is observed with the interval of 2–3 days after the earthquakes and the maximum of earthquakes – with quite the same interval after the lunar events. The peaks of these maxima exceed the mean number of events by a factor 3. The Moon Earth system is the astronomical example of a direct interaction of the processes in the neighbouring celestial bodies.

The corresponding experiments, made at the Pulkovo Observatory, confirm the possibility of immediate interactions of irreversible processes due to the change of physical properties of time. Thus we can form a chronology of orogenesis on the Moon judging from the data on the history of the Earth. Tectonic processes of the Earth and the Moon seem to be in such a close interaction as if the Moon were in direct contact with the Earth, i.e. in other words, were its seventh continent. These conclusions give evidence of the extreme importance of regular seismic observations on the Moon.

Seismic phenomena can serve as the direct, quantitative indication of tectonic activity of the planets. On the Moon such phenomena are being registered at present by seismographs installed there. However the data obtained embrace too short a period and are insufficient for statistic investigations. Therefore we are to use such an indirect indication of lunar activity as the transient luminous events on the Moon surface are observable from time to time. The vast catalogue of such events was compiled by Middlehurst *et al.* (1968). A certain number of erroneous information which could penetrate in the catalogue are not dangerous for the results of statistical investigations. However it is very important to account for extra-selectivity of the data in this catalogue, which can be explained by the specific conditions of lunar observations such as the Moon phases, height over the horizon, weather and even the heightened interest of astronomers towards the studies of the Moon surface. That is why the quantity of lunar events may not be compared directly with the quantity of simultaneous earthquakes.

Unlike to the lunar events, observed selectively, the total registration of earthquakes all over the Earth are being made regularly since 1904. It was necessary to choose from the great number of registered earthquakes those ones which gave evidence of tectonic processes of planetary scale. Therefore from the Gutenberg and Richter catalogue

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(Gutenberg and Richter, 1949) containing the list of earthquakes with the magnitude $\geqslant 7$ for the period from 1904 to 1946 the earthquakes with deep focus ($h > 300$ km) and intermediate ones ($70 < h < 300$ km) were selected. The data for the latest years, including 1967, and identical types of earthquakes (with the magnitude $\geqslant 6.5$) were selected from the International Seismic Bulletins. As a result the list of 630 earthquakes was compiled. In the Middlehurst catalogue about 370 transient events on the Moon were registered during the same period (from 1904 to 1967).

Gravitational interaction of the Earth and the Moon gives rise to the tides which can turn into a trigger mechanism responsible for a certain synchronousity in tectonic processes of these bodies. A potential of tidal forces on the Moon is 5 times as large as that on the Earth whereas the gravitation on the Moon surface is 6 times as small. Therefore deformations of the Moon surface can be larger than those of the Earth surface by a factor 30. In the same relations will be the variations of tidal deformations occurred due to a considerable eccentricity of the lunar orbit. A significance of these variations for processes on the Moon gives evidence of the dependence of the number of transient luminous phenomena on the days of an anomalistic month, i.e. a position of the Moon on the orbit. For the first time this dependence was discovered by Middlehurst (1967) on the base of her first catalogue (Middlehurst and Burley, 1966). The curve of distribution of the earthquakes shows a certain similarity of this dependence. The upper curve (Figure 1) gives the dependence of the number of selected earthquakes upon a position of the Moon on the orbit. The lower curve gives the number of lunar events taken from the second Middlehurst's catalogue for the same time. Unlike to the results of Miss Middlehurst the maxima were detected not only in perigee and apogee, but also near the moments of the highest speed of changing the geocentric distances. The upper curve of the number of earthquakes has also the similar peculiarities. Thus really the tides increase somewhat the probability of simultaneous events on the Moon and the Earth. This increase of probability can be

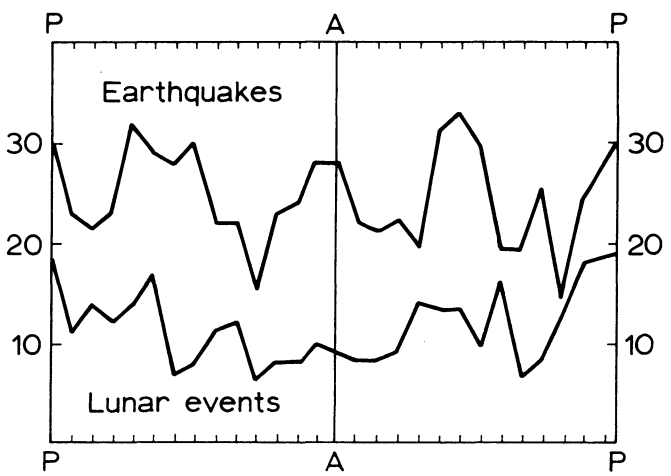

Fig. 1.

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TABLE I

1897

⊕	☾I	☾II
12 VI	–	14 VI
5 VIII	–	–
20 IX	–	–
21 IX	21 IX	21 IX
–	–	(8–15 X)
–	–	9 XII

revealed only by superposition of the great number of anomalistic periods, while individual events occur often without any connection with tides. And indeed it is seen from the given curves that the number of events in the minima is no less than $\frac{1}{2}$ of those in maxima. Let us consider only these extremum values instead of the curves and assume them to agree precisely in time. The probability of agreement between lunar and terrestrial events will be proportional to $(1+\frac{1}{2}\,\frac{1}{2})$ while a disagreement to $(\frac{1}{2}+\frac{1}{2})$. Thus according to the obtained curves the probability of coincidence of the events might increase not more than by 25% (rather – less). Therefore some occasional events must occur independently in practice. At the same time the direct comparison of the days, when the transient events were observed on the Moon, with the days of deep earthquakes shows remarkable coincidence. On April 1, 1969 the author obtained the spectrum of a transient red spot inside Aristarchus. The day before, on March 31 in the morning a deep earthquake took place in Egypt, and in the evening – at the seashore of Japan. In 1897 four deepest earthquakes (magnitude 8.5) occurred. In the table a comparison of the dates of these earthquakes with those of lunar events according to the first and second catalogues by B. Middlehurst is given. The first earthquake of the table is the great Indian earthquake. Via two days after it the volcanism in the Shröter Valley on the Moon was observed. The earthquakes on 20 and 21 of September were followed by the glow in Aristarchus. These astonishing coincidences give evidence of the direct causal relation between the events on the Earth and the Moon. Existence of this relation is confirmed by statistical reduction of the whole obtained data. There was calculated the number of lunar events N_i, removed by i days from the closest earthquake. However in order to make the removal by i days possible, the length of an interval between earthquakes is to be $d \geqslant 2i$. Thus for deriving the true distribution n_i it is necessary to reduce the N_i to one and the same number of intervals, for instance to their total number. It means that the number of N_i are to be divided by the calculated number of permissible intervals and multiplied by their total number. The results of such calculations are shown on Figure 2. The upper curve gives the corrected distribution of the number of lunar events, obtained from all the data. The lower curve gives the number of only those events which were observed with the intervals between neighbouring earthquakes being more than 30 days. Therefore this curve within the limit of 15 days can be constructed without any reduction, which is very important for

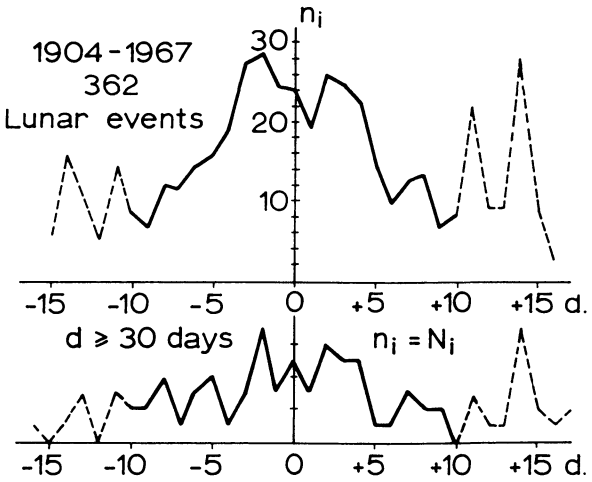

Fig. 2.

checking the results. The lunar events observed after the earthquakes are plotted to the right of the origin of coordinates whereas those observed before the earthquakes – to the left. The conditions of the Moon observations are independent on the earthquakes, unless the earthquake occurs just under the telescope. Therefore with the exception of such an unreal situation, incompleteness of the catalogue can only diminish the total number of data but cannot change their distribution. A lunar event being removed by more than 10 days from the nearest earthquakes, the reductional factor is more than 4. Then the obtained data becomes inaccurate and cannot be taken into account, that is why on the upper graph they are drawn by dotted lines. The spread of points on the lower graph is due to lack of data. Nevertheless this graph confirms that near to the earthquakes the number of lunar events increases by about a factor 3 as compared with the common background and that two peaks of maximum exist really. Any of the epochs detected from the whole data have also two peaks of maximum, which are nearly symmetric, at a distance of 2–3 days from the earthquakes. Even the small number group of events, taken for the short period (from 1948 to 1953) shows the analogous result (Figure 3).

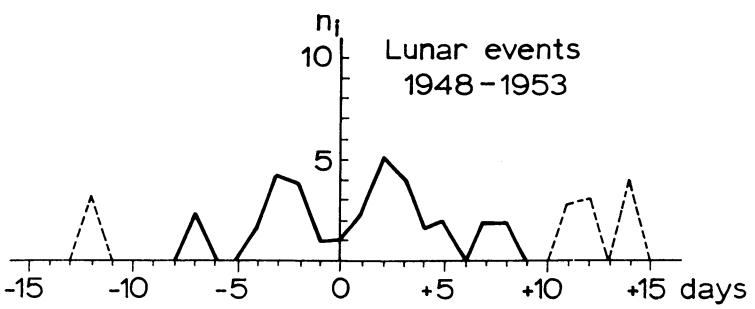

Fig. 3.

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The existence of two maxima (before and after the earthquake) shows that the grouping of lunar events near the earthquakes cannot be explained by a common reason which influences upon the Moon and the Earth (for example the high solar activity). Rather there is a direct double-connection when earthquakes cause a lunar event with a delay of 2–3 days and, vice versa, lunar events cause terrestrial events with the same delay. It is interesting that coincidence of lunar events with earthquakes takes place only when the lunar and terrestrial crust are weakened by tides. Indeed the middle graph in Figure 4 shows that the coincidence of events occurs only near the

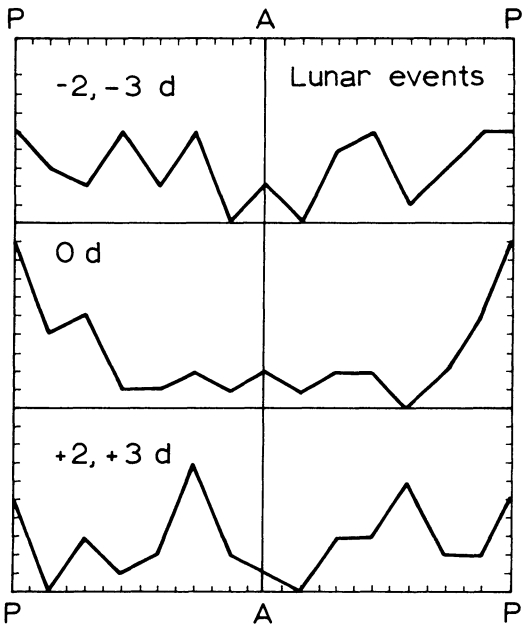

Fig. 4.

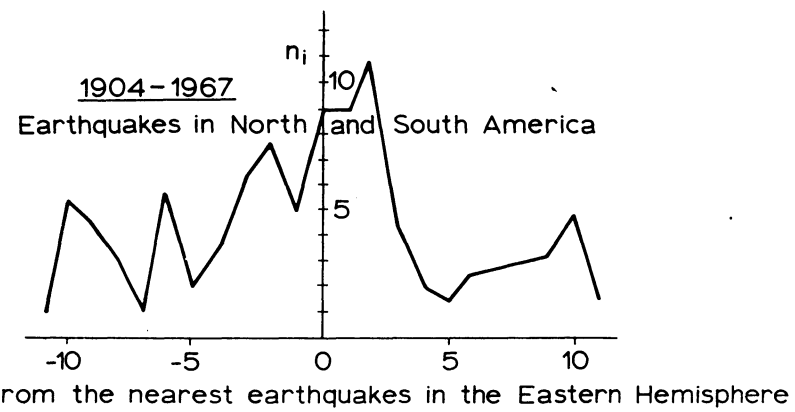

Fig. 5.

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perigee. The preceding and following maxima, as it is seen from the lower and upper graphs, are quite independent on tidal effects. This result shows once more that the obtained interaction between earthquakes and lunar events cannot be explained by synchronism of tides. Most probably we have received an astronomical example of direct interactions between the processes occurred in the neighbouring systems. The indications of such interaction are present not only in the Earth-Moon system but also the double star systems (Kozyrev, 1967). Connections between processes could be established by current time, if its course is the physical property existing objectively. The corresponding experiments, made at Pulkovo, give evidence of the physical properties of time, varying in the vicinity of any irreversible process. These variations of time properties can be influenced by the other system. Thus the connections of systems in nature can be realized not only through space by means of fields but also through time by means of its physical properties. It is probable that by the same way the interaction between tectonic processes on the remote continents of the Earth is realized. Figure 5 gives an example of such interactions. It represents the distribution in time of the earthquakes in the America with respect to those in the eastern hemisphere (Eurasia). Most earthquakes of the 630 ones, considered by the author, occurred in the Eurasia and only 96 – in the America (Northern and Southern). This graph was plotted by the same method as that used in the analysis of the lunar events. The similarity of the obtained relations appears to be remarkable: the reaction of the Moon and the America on the earthquakes in the Eurasia is near the same. In both cases there was a marked delay of the maxima by two days and their heights were about 3 times as large as the background. Thus tectonic processes on the Earth and the Moon are in such interaction as if the Moon were the seventh continent of the Earth. Hence it means that the cycles of the Moon orogenesis must be synchronous with those of the Earth orogenesis. In this case we can construct the chronology of tectonic processes on the Moon from the data on the Earth history. For example it is quite possible that the recent Kopernic period of the Moon history coincides chronologically with the period of the Alpine orogenesis on the Earth.

The above investigations show that regular seismic observations on the Moon is very important for the study of its physical properties and also for solving the problems which are of a great scientific interest in principle. It is necessary to make every effort for making the permanent network of seismic stations on the Moon.

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