Moon-Earth gravitational variation force connection with earthquakes near Oceans.

Marilia Hagen, Department of Geological Sciences, Bloomington, Indiana, USA - Anibal Azevedo, Faculdade de Ciências Aplicadas da Unicamp, Limeira, São Paulo.

Abstract

In this paper, we investigated the possible interactions of the moon and Earth, mainly in the period 1996-2016. Initially, we considered the gravitational force of Moon vs. Earth by Newton's equation. The Moon has an elliptical orbit around the planet that reaches two points of maximum. One is the closest, the Perigee, and other the farthest is the Apogee. The Apogee and Perigee have distinct values monthly. We calculated the perigee force variation during the period, for every month to all years. This result creates an oscillation, which in, 13 – 14 months, completes a whole cycle. The wave period is 5400 hours as calculated. The energy generated by Moon on Earth from this closest position reaches a maximum during the Full or New Moon. An unusual result found in November 2016 when the Perigee force reached the highest magnitude of all period. We observed during these phases; there is an enhancement of earthquakes near the shorelines of the Pacific. On the other hand, the perigee minimum matches with the First or Third Quarter, but in this case, the effects on seismological events are smaller than the ones observed for New or Full Moon. The outcomes indicated that external forces created by Moon- Earth system allied with ones beneath the earth's surface are responsible for increase earthquakes in the pointed out areas. Also, the oscillating movement of Moon-Earth system provides a tool for predicting the next enhancement on earthquakes cycles.

Introduction

Relatively little research has been done so far about the connection between the gravitational interaction of moon-Earth system and earthquakes. [1], [2], [3].

Investigators have doubts as to an accurate approximation of the problem. However, the evidence of an interaction between the moon and Earth are clear in studies of the ocean waves and tides, and it is well known and reviewed [4], [5], and [6], [7], [8], [9]. The Moon is the satellite orbiting around the Earth, in an elliptical trajectory. Its mass is eighty times less than Earth, has 27% of the earth's volume, and has no external magnetic field. The moon has a small paleomagnetic field with a magnitude of 2.5 nT. Moon's orbital movement around the Earth creates a gravitational force at the surface of the Earth, which varies every month in the extreme positions, as Perigee (closest) and Apogee (farthest). The satellite depending on its position around Sun- Earth system assumes different phases. If the moon is aligned with the Sun-Earth system, the phase is designated as the New or Full Moon. At the New Moon, it is facing the magnetic dayside of Earth, at the full Moon is on the night side of magnetosphere into the plasmasphere. [10],[11], [12], [13]. When the Moon position is 90 degrees about the Sun- Earth, the phase is 1st or 3rd Quarter. These variants on the Moon position related to Earth mold different effects of the Earth as the spring and neap tides. Spring tides are the strongest tides of the moon cycle month, and the neap tides the weakest. The first step in this investigation was to calculate the variations in the gravity field of Moon- Earth system as per Newton's universal law as we see later. The result found is a gravity wave generated between the two bodies with specific values of oscillation, period, and wavelength. Then, we repeated this procedure for a complete Solar Cycle (1996- 2016) to investigate how the force between Moon-Earth system varies. The moon wave produced maximum peaks, which coincided with the Full or New Moon. The same was true for the minimum days were always, in the 1st or 3rdQuarter. After we had obtained the days for the maximum and minimum we search in the earthquakes catalog for the location of the earthquake in those days, the magnitude of the earthquakes were M ≥4.0. Those data were discussed as the result of our calculations.

THE PERIGEE FORCE VARIATION

The following picture Figure (1) shows the position of the sun, Earth and the moon and the moon phases for spring tides. At the new moon and full moon, the sun, Earth, and moon arrange themselves more or less along a straight line in space. The pull on the Earth, consequently on the tides increases, since the gravity of the sun, reinforces the moon's gravity. Then, at these phases, the tide's range is at its maximum and is the definition of spring tide: the highest (and lowest) tide. The weaker forces happen at the 1st or 3rd Quarter named neap tides. It is when the sun and moon are at right angles as seen from Earth. Therefore the sun's gravity works against the moon's gravity. Therefore the moon's effect on the tides is smaller, defining a neap tide; the range of those tides is at its minimum.

Figure (1) displays the moon positions related to sun and Earth. The moon trajectory around the Earth is elliptical, with one side closer to the Earth is the perigee and the other farthest from the Earth are the apogees. Both happen once by month in one year, but in some months there can be 2 perigees or 2 apogees, [15], [16], [17].

As the Figure (1) shows, at the "new moon," the moon is between the Earth and Sun, so that the side of the moon facing toward us receives no direct sunlight, and is lit only by dim sunlight reflected from the Earth. As it moves around the Earth, the side gradually becomes more illuminated by direct sunlight. At the "full moon," the moon is 180 degrees away from the sun, so that the Sun, Earth, and the Moon form a line. The moon is fully illuminated by the sun, so this is called "full moon." Full or New Moon have some unusual characteristics at the "new moon," the body receives radiation, ionized and energetic particles from the Sun, which intensifies, during solar storms. During the "full moon," earth's plasmasphere located at the magnetotail charges the satellite with electrons, therefore negatively. Our first procedure in this study has been to calculate the change in gravitational force of the moon and the Earth, evident in the little

difference in the perigee locations, [13], [14], [15], [16], and [17].

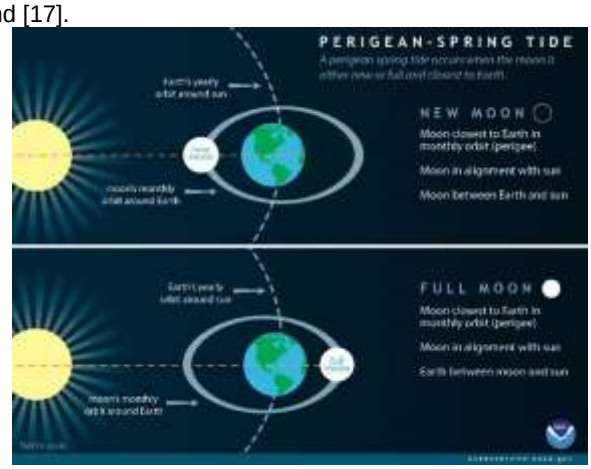

Figure 1 The perigee and the moon phases relation to Earth and Sun

The calculations refer to the period 1996-2008, which is a complete Solar Cycle; the objective was to observe any alteration in the moon cycle connected to the maximum or minimum of Cycle 23. The period we chose 1996-2016 detected in our calculations a gravitational variation changing in an oscillatory mode among Moon –Earth when the satellite is reaching the Perigee position. This location happens most of the time once by month, but some months are occurring twice. Earthquakes M6 or beyond enhances during those periods most near the shorelines. [11] The exact moon position for Perigee and Apogee during centuries displayed in the Tables [18]

For example, on Jan15, 2016 the perigee was 369618 km. On Feb 11, 2016, it was 364357km, creating a gap between the two values of 5261 km. Therefore, an oscillation was apparent after ten months, set up by the small differences in the perigee values. Figure (2) displays the maximum and minimum of the moon cycles against the days observed.

At the apogee locations, although the moon is further apart from earth, we followed the same method.

For the apogee locations, in this case, Jan 2, 2016, the apogee was 404,277 km, on Jan 30, 2016, was 404,552 km; the difference was only 275 km, meaning it creates a straight line if all results are considered. Therefore, we disregarded the Apogee locations in our calculations, (18) and (19).

Overall, the perigee position varied 3.5% during a year and the apogee position only 0.5% in the same period. The universal gravitational force is given by,

$$F = G\,\frac{mM}{r^2} \quad \textbf{(1)}$$

In the equation (1), the moon mass (m), earth mass (M) and G= 6, 67 x10^{-11}N.m^2 kg^{-2} are all constants; the only variable is being r, the distance between the moon and the Earth describing an elliptical path around the earth.

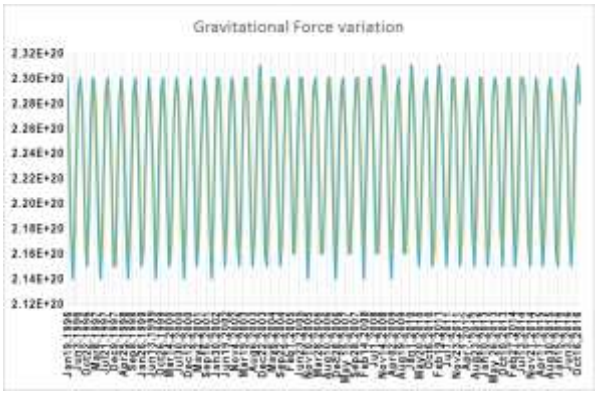

Figure 2- Gravitational Force Variation 1996-2016- it shows how the perigee force varied during twenty years, the maximum force reached during the New or Full Moon. The minimum power in the First or Third quarter. These calculations based on the data from [17]

The Figure (2) displays the results for the oscillating force during Cycle 23; the period 1996-2008 was a time scale to limit our lunar wave with known data. It is also an answer to the question what happen with the variation of gravitational Moon- Earth during a solar cycle. Moreover, established how many lunar cycles are in a solar cycle. We found that the there were 11 lunar cycles between the period 1996- 2008 that comprehends the Solar cycle 23. The variation and the possible connections solar cycles and moon cycles demand more calculations that we did not develop in this paper.For the moon we found a perigee force variation, with a maximum at F = 2.31 ×10^{20}N and minimum at F= 2.14 ×10^{20} N. Maximum values of F occurred at the Full or New moon and the Minimum; happened at the First or Third Quarter. The period falls in the range of 52080 hours – 5400 hours. The moon's speed around Earth is 3683 km/h generating a wavelength that is between $1,94 \times 10^7 km$ - $2,05 \times 10^7 km$. The results in the Figure (2) found a wave between the moon and the Earth, which depended on their distance variations when the satellite reaches the Perigee. The Cycle 23 took 11 moon cycles to accomplish; we took the Cycle 24 (2008-) and are in the eighth year for the possible total cycle. The Figure (2) shows the wave with the Maximum and Minimum of the gravitational forces and the date corresponded at the horizontal axis. Figure (3), shows the percentage of the moon phases during the maxima or minima of the gravitational force. The Full and New moon, reach the Maxima in equal percentages 25% and the minima of the force is 30 % during the First Quarter, and 20% at the Third Quarter. This result obtained between 1996- 2008.

Results

In a previous article, we calculated a gravitational force change between Moon and Earth has an oscillatory behavior. We considered the period 1996-2016 the result showed the change of the Perigee force which maxima values corresponded to the New or Full moon (spring tides) and the minima for the 1st or 3rd Quarter (neap tides). Perigee is the nearest position the Moon reaches in its elliptical orbit around the Earth. The only variable is r – distance between Moon- Earth at Perigee, it varies about 3.5% by year. We established this date based that the solar cycle did not change the moon –earth force, therefore it was a steady relationship. To update the information and results in the last paper, we searched for moon phase connection for all megathrust earthquakes recorded since the one in Japan on July 9, 869. This earthquake mainly happened in a moon phase 4 days after the Third quarter and four days before the New Moon. Those historical earthquakes showed they occurred more at the New Moon, and another similar amount in the other three phases. Figure (3)

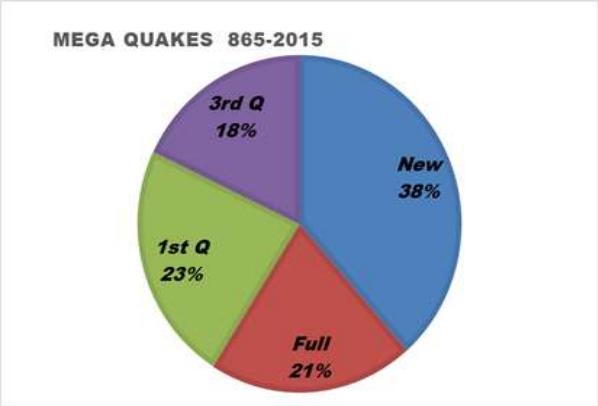

Figure 3 Mega quakes distribution 869 - 2015 and the percentage by moon phases when occurred mega earthquakes. Magnitude M≥8.5.

The same search for large quakes (M>8.0) during centuries, first recorded event 9/7/869 and the period 1900-2015, indicated similar results to the New Moon, 35%,1st Quarter, 23%, 3rd Quarter,20% and Full Moon with 22%. Figure (4) shows the highest locations probabilities, most of the Pacific or the Indian Ocean where 92% of the events occurred. Intraplate larger events happened only 8% observe that all happened at the North, with 7% intraplate northern, and 1% at the Northern Atlantic. However, 62% of bigger quakes occurred in the Southern Hemisphere, and the rest of the Northern Hemisphere. During the New Moon, Sun-Moon –Earth aligned with each other and the Moon faces the Earth's dayside. The New or Full moon phases create the Spring Tides; they are the highest tides observed in the oceans. The regions are not affected by the tides in the same way the tectonics

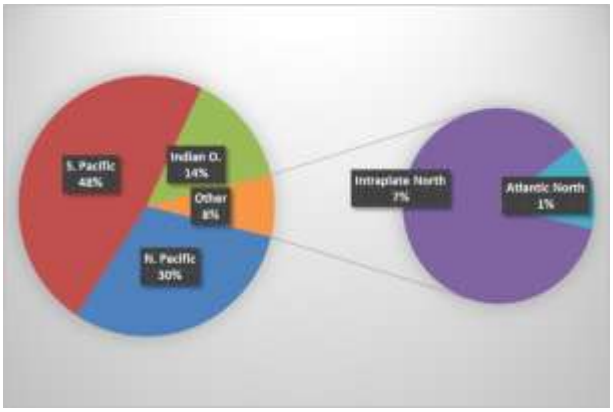

Figure 4- The events occurred in 78% in the Pacific, 14% in the Indian Ocean, and 8% in other places. It indicates the giant earthquakes tendency happened 92% in the Oceans, and subduction zones

of each area has different geometry and structure. Some allow better the waves interaction with the inner Earth below those regions. However, in subduction zones, the marine water may reach the internal level and lower crust beneath the platform. During the highest tides, the water faster spreading below the continent land in the subduction zones. Those places accumulating energy, stress, the water adding strain and pushing the older platform to the earth's center. The water running beneath the continent allows different processes as the serpentinization of rocks and the creation of convection currents that blow hot water to the cold surface. Therefore, the oceanic currents changed by tides had a solid rule on the accumulation of strain in such regions. A temporal dependence for earthquakes in those areas and connections with tides. There are several processes for the weaker rocks shifting their positions under the times and displaced to other locations triggering earthquakes. The water found in those places coming from the oceans waves and the dynamic of tides launching into the cavities, which reach the liquefaction temperatures releasing more water. The process is longer and more complicated, however; it is not in the precincts of this paper. The big earthquakes involve a longer process and depend on how is the endurance of each region to resist before it disrupts. In a megathrust earthquake, it takes years. Even though the syzygy tides happened during the New or Full Moon, our calculations demonstrated that the events occurred most close or at the New Moon. Appendix (A) If the tides are somehow, connected with the earthquakes, why not all the regions with high tides triggering giant quakes? In the Bay of Fundy, Canada has detected the highest tides in the world, and there are no outsized earthquakes. The explanation links the events as tides and ocean waves to the geology and tectonics of each region. The subduction zones make possible to trigger earthquakes instead of other seafloor formation as allied to Canada. Therefore, the Pacific floor structure is essential to understand how the oceanic waves

interacting in the subduction zones. There is a possibility that the smaller earthquakes as defined in the other paper M ≥4.5 increased in number in the locations as subduction during the New or Full Moon, and it is a possibility that the same phases can enhance the number of events with smaller magnitudes. Therefore would happen several foreshocks created by the higher intensity of the water, and later the 'big' one due to the increased pressure in the same region.

1.2-Lunar Variations connections with earthquakes

We obtained a gravitational force variant created when the moon reaches the Perigee. The maximum value is 2.31×1020 N, at these points, the moon phase was always new or full moon. During the solar cycle, 23 (1996-2008) occurred 11 moon cycles. Gravitational forces have peaks of gravitational force that showed earthquakes magnitude M4 or above happened mostly at the subduction zones. [Historical Mega earthquakes M ≥8.5 in the period 865- 2016 indicated events happening 36% at the New Moon and 20 % at the Full Moon as a figure (3). The results by region showed that 92 % of larger events happened at the subduction zones in the period of 1900-2015. In Figure (4) some significant earthquakes occurred intraplate but all in the Northern Hemisphere and the same for the Atlantic. The Appendix 1 and 2 showing several data for large quakes, Appendix 1 show the biggest shocks since the first recorded in 865, Japan and the Moon phases and locations. However, the moon phase and tides appeared to do alterations we observed that 35% of quakes happened during the New Moon, 25% in the Full Moon, in 60% of total geohazards. The locations are most at the Pacific side, from the 55 events only two happened in Europe. At this point, our analysis for moon-earth forces showed strong evidence that the moon is important to the large events at the subduction zones. Also, the evidence showed that the most significant quakes occurred one or two days after the primary phase happen. The events would link the variation of tides and the occurrences. Geohazard events occurred one or two days after or before the moon phase take place.

Conclusions-

The results pointed out that the enhancement of earthquakes near the shorelines with M6 or higher magnitude is strongly linked to the variation of tides during a moon cycle. This conclusion, coming from the several attempts with earthquakes M≥6. The majority of them happened at the subduction zones in the records since 865. This study makes part of other results for the three-body problem. The most important phases are New or Full moon when many M6 events happen near the coast. These locations called subduction zones are the places where most quakes M ≥6 happening. Somehow, the spring tides during the new or full moon can enhance the trigger of earthquakes in those regions. Next study is to develop the possible interactions between the external forces by Sun, Moon, and Earth to determine if it affects the earthquakes.

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APPENDIX A

The largest earthquakes recorded since 869 in Japan. Those earthquakes recorded most on the Pacific side.

The Lisbon earthquake is one of the exceptions in Appendix A . (did not happen in subduction zone)

Date	*Location*	*Magnitude*	*Moon*
22/5/1960	*Chile*	*9.5*	*New*
27/3/1964	*Alaska*	*9.2*	*Full*
26/12/2004	*Indonesia*	*9.3*	*Full*
11/3/2011	*Japan*	*9*	*1st Q*
4/11/1952	*Kamchatka*	*9*	*1st Q*
13/8/1868	*Chile*	*9*	*3rd Q*
26/1/1700	*Canada*	*9*	*1st Q*
9/7/869	*Japan*	*9*	*New*
2/12/1611	*Japan*	*8.9*	*New*
2/4/1762	*Bangladesh*	*8.8*	*1st Q*
25/11/1833	*Sumatra*	*8.8*	*Full*
31/1/1906	*Colombia*	*8.8*	*1st Q*
27/2/2010	*Chile*	*8.8*	*Full*
15/08/1950	*China*	*8.7*	*New*
28/9/1707	*Japan*	*8.7*	*New*
8/7/1730	*Chile*	*8.7*	*3rd Q*
1/11/1755	*Lisbon*	*8.7*	*New*
4/2/1965	*Alaska*	*8.7*	*New*
28/10/1746	*Peru*	*8.7*	*Full*
28/03/1787	*Mexico*	*8.6*	*1st Q*
28/3/1787	*Alaska*	*8.6*	*New*
28/3/2005	*Indonesia*	*8.6*	*Full*
11/4/2012	*Indonesia*	*8.6*	*3rd Q*
16/12/1575	*Chile*	*8.6*	*Full*
24/11/1604	*Chile*	*8.6*	*New*
13/05/1647	*Chile*	*8.6*	*1st Q*
24/05/1751	*Chile*	*8.5*	*New*
9/11/1822	*Chile*	*8.5*	*1st Q*
20/02/1835	*Chile*	*8.5*	*3rd Q*
16/02/1861	*Indonesia*	*8.5*	*1st Q*
9/05/1877	*Chile*	*8.5*	*3rd Q*
10/11/1922	*Chile*	*8.5*	*3rd Q*
1/2/1938	*Banda Sea*	*8.5*	*New*
13/10/1963	*Kuril Is*	*8.5*	*New*
12/9/2007	*Indonesia*	*8.5*	*New*
20/10/1687	*Peru*	*8.5*	*Full*
17/10/1737	*Kamchatka*	*8.5*	*3rd Q*
3/08/1361	*Japan*	*8.5*	*New*
15/06/1896	*Japan*	*8.5*	*New*