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The Earthquake Impact is the Most Probable Cause for the Formation of Lonar Crater, Maharashtra, India – A Report.

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***Abstract*: During many visits to Lonar crater to study its formation, there is a clear indication of elevation from Talni village towards Lonar village and there is a sudden decline of elevation towards Sultanpur. From the observation point, it seems that Lonar crater region is earthquake disturbed zone and structural disturbance in Land pattern. Earthquake impact result in sharp certain elevation and depression on the land and the land pattern is not uniform i.e., there are crests and troughs (ups and downs). Lonar crater formation is due to maximum depression on the land due to land sliding, land sinking (land collapse) which is due to effect of earthquake.**

This study being a preliminary investigation to understand and keep on records, how Lonar crater was formed considering all the possibilities for its formation, which has been reported through this paper.

Keywords: Earthquake impact, Lonar crater, land sinking, land sliding.

I. INTRODUCTION

Lonar crater is a depression (land collapse) formed on the basaltic rocks of volcanic origin, which erupted some 64 Ma and formed a plateau region known as Deccan Plateau. This crater is situated in Southern part of Buldhana District, Maharashtra, which have coordinates as 19º58′ N and 76º30′ E., with approximate diameter of 1.83 km and approximate depth of 150 meters. The age of the crater is found to be around 656 Ky (Jourdan F. et al. 2010). Surrounding the crater, raised rim is seen which is at some height from the surrounding area and it is well preserved. On the inner side there are gullies or ravines of which Dharatirtha as it is named is the largest, (fig. III and X), where continuous flow of water is observed. Visitors, devotees and pilgrims come to this place, have a bath and take this water from Dharatirtha for drinking purpose. Below at the base of the crater, a lake exists, since there is no outlet for water to drain out or migrate, being a stagnant water body. The entire base of the crater is a wetland.

The water is found to be green in color, due to a kind of green algae known as Spirulina. The nature of the water is eutrophied i.e., highly saline and highly alkaline. On the periphery of the crater lake, there are temples built in the 12th century, (Vyas 2000). Due to earthquake of 1803 on Deccan Plateau (Bugdane S. T.1990), the temples are found in ruins (Fig. XI and XII). A dense forest exists surrounding the crater lake (Fig. II and V).

In summer, when the water quality decreases due to high evaporation rate, the temperature being around 45ºC - 50ºC approximately, deposition of white layered salts are seen on the dry part of the crater lake periphery. Sandy type of soil is seen on the southern part of the crater lake periphery which has magnetic stony minerals, which shows attraction towards a magnet (Jadhav and Mali – 2024), and grey white type of soil is seen on the northern side of the crater lake (Fig. 8). Subsurface water which is natural sweet water found few feet away from crater lake (Fig. 9).

II. LITERATURE SURVEY

The present investigation was confined to the lake basin and as such, the observation made could not be conclusive about the origin of the lake (Nandy and Deo – 1961). Iridium is probably the most sensitive element for many types of Fe-rich meteoritic material (Morgan – 1978). The data present here suggest that this did not happened for Lonar materials (Stroube et al. – 1978). From all this, it is evident that there are various uncertainties and implications involved in high – temperature in an impact event (Nayak – 1993). It is suggested that the glassy objects in all probability are an impact product and represent an impactite strewn field around the Lonar crater (Nayak – 1999). Both types of glasses contain small grains of magnetite, titanomagnetite and ilmenite of basaltic origin, which are interpreted as remnants of

the respective inclusions in the target basalts (Son and Koeberl – 2007). Our conclusion from this assessment is that some type of chondrite may have been the most likely impactor for the Lonar crater (Misra et al. – 2009). It is considered that for the formation of tektites due to impact, free silica must be available in target rocks (Murali et al. – 1987). Yet the area of impact should have resulted in relatively greater concentrations of nickel, cobalt and other metals in which the iron meteorites are very rich (V. Venkatesh – 1965). The findings of meteorite fragments have not been detected at an impact site of the ancient crater, it should be searched for (Lafond and Diaz – 1964).

III. OBSERVATIONS

From the figure XIII, table I and II, it is observed that Lonar region is an elevated land. The study conducted in the vicinity of Lonar region, showed that Lonar region is disturbed land pattern of sudden elevation and declination. The steady continuous elevation land pattern towards Lonar crater from Sultanpur and steady decline elevation away from Lonar crater towards Talni. The Lonar crater rim is situated on higher altitude i.e., 603 meters (spot height) and Lonar crater or Lonar village altitude is 590 meters with respect to its surroundings. This shows that there is a steep rise in elevation/altitude from Sultanpur to Lonar crater and from Lonar crater to Talni, there is a steep declination. The elevations of Lonar crater and its surrounding region was given by Department of Geography, University of Mumbai, on request using Survey of India, toposheets Sr. Nos. 56 A/5, 56 A/9, 55 D/8, 55 D/12, 56 A/6 and 56 A/8. The details of elevations/altitude given are all average altitudes, taken and calculated from the toposheets as mentioned above. The elevation points of Deulgaon Kundpal is taken from (Google net Wikipedia) and the elevation point of Tandulwadi was also taken from Google net (https://www.onefivenine.com).

Table I. The graph shows continuous elevation towards Lonar crater.

Sr. No.	Names of Places	Average elevation points in meters.
1	Deulgaonraja	540
2	Sindhkhedraja	550
3	Kingaonraja	520
4	Dusarbid	500
5	Bibi	540
6	Sultanpur	525
7	Tandulwadi	454
8	Lonar village	590
9	Lonar crater rim spot height	609

Table II. The graph shows declination from Lonar crater.

Sr. No.	Names of places	Average declination points in meters.
1	Lonar crater rim spot height	609
2	Lonar village	590
3	Deulgaon Kudpal	454
4	Talni	500
5	Mantha	560
6	Partur	520

Fig. 1. Topographical disturbed land pattern or deformative land pattern, Lonar Crater.

Fig. II. Ecological biodiversity flora high spot, Lonar crater.

Fig III. Continuous Flow of water from Dharatirtha, Lonar Crater. (Emergence of new spring due to earthquake impact, which never existed before earthquake impact).

Fig IV. Percolating or seepage of water from crater rim (Sitanahni). Emergence of new spring, Lonar crater.

Fig. V. Biological diversity high spot, Lonar crater.

Fig VI. Earthquake residual effect seen on the inner rim of the Crater wall, Lonar.

Fig VII. Land collapse effect of earthquake seen on the inner side of crater wall, Lonar.

Fig VIII. Weathering remains of surrounding rocks Lonar.

Fig IX. A hole dug near the crater lake having potable water (sweet water) for the animals and birds living in Lonar crater lake jungle. The water table of Lonar is of sweet water nature.

Fig. X. Dharatirtha ravine or gorge, being one of the largest among others ravine or gorge, Lonar crater. Topographical changemade on land pattern caused by earthquake impact.

Fig. XI. The temples at the crater lake periphery are found in ruins due to the earthquake on Deccan Plateau of 1803 (Bugdane S. T. 1990).

Fig. XII. Temples found in a dilapidated state due to earthquake impact of 1803 on Deccan Plateau (Bugdane S. T. 1990).

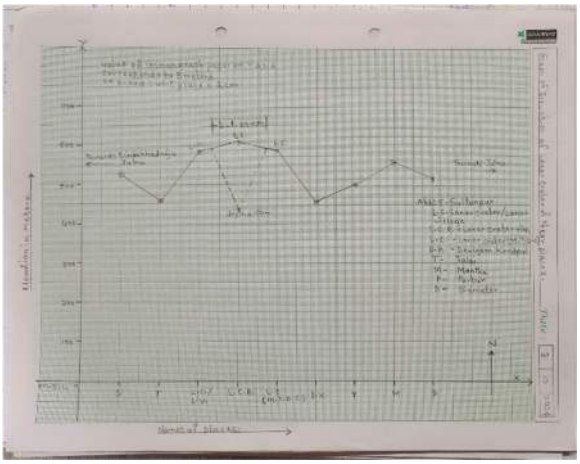

Fig. XIII. Graph of elevation of Lonar Crater and surrounding places.

IV. RESULTS AND DISCUSSIONS

According to our study and research work, it is strongly suggested that Lonar crater is formed by earthquake impact. While studying altitudes i.e., elevation and topographical features of Lonar Taluka places.

From the elevation studies, it is found that Lonar crater (i.e., Lonar village) is at a higher altitude with respect to other places.

Volcanic eruptions and earthquakes have affected the whole of Maharashtra, for example formation of Deccan Plateau of 64Ma, earthquakes of 1803 on Deccan Plateau (Bugdane 1990), Koyna earthquake of 1967, Killari, Latur earthquake and Umarga (Osmanabad) earthquake of 1993. Killari, Latur District of Maharashtra, where a crater was formed after the earthquake which took place in the 1993 (https://en.wikipedia.org). It appears that the Latur earthquake was caused due to rupturing of the over pressured fault segment at the base of the seismogenic zone. The globally deadliest Latur earthquake of September 30th, 1993 points out that the Indian shield is seismically more active than hitherto to thought of (https://www.las.ac.in). The plate boundaries are made up of many faults and most of the earthquakes around the world occur on these faults (https://www.usgs.gov). Landslide scars and rubble piles are abundant on the crater wall (Maloof et al. 2010). (Fig 7 and 8). This suggest that formation of Lonar crater is related to earthquake impact (i.e., combined effect of earthquake, land sliding, land sinking (land collapse) process, rather than any other calamities.

Earthquake impacts cause changes in land topography, geological alterations or rearrangement of land formations, land patterns land sliding, land sinking (submergence), land folding, land shaking, elevations and depressions at high strength, impact of earthquake causes continental shift (land movement), formations of mountains or valleys etc. For example in history, it is found that some of the effects of earthquakes are: Submergence of Dwarka city under the sea, buried remains found of Mohenjo-Daro and Harappan civilizations, disappearance of Sarasvati river in the north, rising of Himalayan mountain ranges in the north of India, disappearance of Tethys sea under the Indian plate and Urasian plate (continental dislocation), rising of Sahyadri mountain ranges in the western part of Indian peninsula, similarly rising of Andes mountain ranges in the western part of South America and which is parallel to Sahyadri mountain ranges of Western India, submergence of Atlantis city in the sea. The impact of earthquake also give rise to Tsunamis in the sea. All these events or natural calamities are related to tectonic movement or tectonic activity i.e., earthquake impact or it is also termed as collective or combined effect of earthquake. In other words, it can be said that all these are due to tectonic movement or tectonic activities. The earthquakes and volcanic eruptions are the major tectonic activities. Similarly, formation of Lonar crater may also be related to one of the tectonic movement or tectonic activity i.e., earthquake impact because Lonar is located over a tectonic weak zone (Burra Subrahmanyam 1985) and or Lonar crater was lying in a structurally disturbed zone (Badve et al. 1993). Due to earthquake impact at Lonar, new springs came into existence like Dharatirtha (Fig. III and X), Sita Nahani (Fig. IV), and Ram gaya, which never existed before. This unusual continuous flow of water throughout the year from the time it came into existence, is not found anywhere in entire Marathwada and Vidarbha region of

Maharashtra. This unusual continuous flow of water without disturbance is an indicator of water courses change by impact of earthquake. The earthquake impact which gave rise to such a huge and maximum depression at Lonar, which changed the water course also, again if in future such kind of earthquake takes place, at that strength, then water course will again be changed.

A. B. Orlebar in 1839, suggested that the hollow might have been originated by the subsidence of an upheaved portion which went down when the force of upheaval was withdrawn (Nandy & Deo 1961). Whatever earlier attempt was made by the respected research scientist A.B. Orlebar in 1839 to explain the reason for the formation of Lonar crater, it is a kind of force that has been explained in his research paper subsidence (i.e., sinking of the ground because of underground movement (https://oceanservice.noaa.gov), upheaved (i.e. uplifted, up risen), upheaval (temblor i.e., earthquake) (https: www.thesaurus.com). These are the hyper dynamic effect of earthquake or disaster, which was explained by Sir Orlebar in 1839. The research workers of this paper are also trying to explain the same facts i.e., earthquake impact and volcanic eruptions are natural calamities, responsible for formation of Lonar crater. The age of the crater may probably be the age of earthquake impact, taking place and forming a hollow depression. It is seen that geophysical and structural features of Lonar crater region is influenced under the earthquake impact.

Hence from this, it can be said that there is every possibility to suggest or infer that formation of Lonar crater must be from earthquake impact i.e., the earthquake impact must be the cause for the formation of Lonar crater (depression).

If considered that Lonar crater formation is of meteorite impact, then the following elements are looked for: Meteorites show high enrichment of elements such as Iron (Fe), Nickel (Ni) and Cobalt (Co), compared to crustal elemental abundances (Nair et al. 2004). The elemental abundances of Platinum Group Elements (PGEs), such as Iridium (Ir), Osmium (Os), Platinum (Pt) along with Gold (Au) play an important role in the study of meteorites. In impact craters, these elements occur in concentrations that are 20 – 100 thousand times greater than those on the earth's crust. Such abnormal concentrations are also used as evidence for meteor impact (Nair et al. 2004).

From the studies and analysis of geological samples (i.e., rocks and soil) from Lonar crater and its surroundings, research scientist/geologist did not come across any such abnormal concentrations or abundances. Even after drilling work carried out up to 400 meters depth, below the crater lake, no meteorite of any nature or meteoritic material or fragments were recovered from such a depth. Cores, however indicate that the rocks at the floor are fragmentary and appear to be highly crushed (Nandy & Deo 1961). This may possibly be due to earthquake. It seems that no meteoritic material of any nature has either been reflected in any of the geological samples studied so far from Lonar crater and its surroundings. Unlike at Barringer crater, no significant vertical displacement of the basalt flows in the crater walls was observed along identifiable tear zones (Maloof et al. 2010). The elemental compositions of geological samples collected from different locations in and around Lonar crater region shows similarity to basaltic compositions. The rocks at the floor of the lake, as found from bore-holes cores, are similar in composition to those exposed in the cliff sections (Nandy & Deo 1961). From all these evidences, it suggests or infers that meteorite impact is not the reason or cause for the formation of Lonar crater.

Most earthquakes associated with volcanoes occur at a comparatively shallow depths normally of less than 10 km (https://www.cambridge.org). Both volcanoes and earthquake occur due to movement of the earth's tectonic plates. They are both caused by the heat and energy releasing from the earth's core. Earthquakes can trigger volcanic eruptions through severe movement of tectonic plates (https://australian.museum).

One of the peculiar features of earthquake impact observed at Lonar crater is the emergence of new springs and the other is the formation of gullies, the largest one of them being Dharatirtha, which never existed before. Earthquake impact i.e., the whole crater was a huge hump (i.e., formed on a higher elevation with respect to its surroundings).

What is observed today of Lonar crater is the visual form or remains of earthquake impact (Fig. I, VI and VII). Today's existence of hollow structure or Lonar depression or Lonar crater is the resemblance of earthquake impact and associated effect of earthquake impact.

V. CONCLUSION

From the above studies, observations, results and discussions, the conclusion drawn is: Elevation and depression in earthquake impact process, and after stabilization of land may have given hollow huge crater i.e., formation of Lonar crater, which is observed till date. In short formation of Lonar crater is the collective effect of earthquake impact i.e., the earthquake impact is the cause for the formation of Lonar crater.

It seems that earthquake impact not only created a big huge depression such as Lonar crater, but it also created a new water courses where rainfall is scanty and arid land. The continuous flow of water in the Lonar region, one of the unusual phenomena i.e., continuous flow of water throughout the year of Dharatirtha, Sita Nahani and Ramgaya, is a positive discrimination to reoriginate water resources for local villagers of Lonar.

VI. REFERENCES

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