



# IJFANS

International Journal of Food  
And Nutritional Sciences

Volume 2, Issue 4, Oct-Dec-2013,

[www.ijfans.com](http://www.ijfans.com)

e-ISSN: 2320-7876



**Official Journal of IIFANS**

## A Geomorphic Evidence for an Impact origin of the Gagan Crater: A Smaller companion crater to the Ambar and Lonar Impact crater of Maharashtra, India.

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### Abstract

Lonar crater and its surrounding area is an important Geomorphic and Geological structure. It is the largest meteoritic crater in basaltic rock of India. It is one of the unique meteoritic features of the world. Therefore it is known as a natural wonder of the world. It is located at Buldhana district of Maharashtra, India. (19° 58'50'' N lat. and 76° 30'50'' E long.) In the present investigation simple, bowl-shaped, nearly circularly impact crater found near the 4.3 k.m from the Lonar crater. This relatively small crater is of particular interest because of its unique morphological and hydrological properties, which make it a valid analogue for similar craters. In the field observation glassy objects of impact origin have been found in the the crater for its unique ecosystem. a small crater 100 m. in dia-meter depression about 700m away from the rim of the Lonar crater, and suggested that it may be a recent field work

**Key Words:** Impact crater, Gagan crater, Ambar crater and Lonar crater, Impact glasses, ejected blanket.

Its diameter is 90 mts to the Lonar, the Gagan crater (20°00'36.86''N Lat. and 76° 28'8.6'' E Long.) structure is investigated by the author on the 12th November, 2010. It is 4750m. away from the rim of the Lonar crater. It is 350m away and N-W direction to the village Matmal. During the field work we find glass fragments, whitish gray colored soil and completely rounded ejected blanket. Gagan crater is very small depression, its diameter is approximately 90 meters and it rises 3 meters above the ground level. This crater also has a lake. Water is present only in rainy season. It becomes dry in summer season. It is having very small ejecta blanket. The shape of the crater is almost circular and surrounding area is occupied by basaltic rock. In the present paper I've focused mostly on the geomorphic evidence of impact

### Introduction

The Lonar crater is an inland saline lake. It is one of the unique meteoritic features of the

origin of the Gagan crater is as like as Ambar crater. Thus finally it may be pointed out that Gagan crater and Ambar crater are not secondary craters but they are formed at the same time as Lonar crater. Thus we can say that, these craters (Ambar and Gagan) are originated from the impact of smaller pieces of the meteor which spilt from the main body in the atmosphere, before the main meteor hit the ground and hence they were originated at the same time. Remote Sensing and GIS technique is used for the detailed investigation of the study area. Detail investigations have not yet done regarding this crater. Ambar crater and Gagan crater's study is required for detail understanding of the Lonar crater.



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unique way unusual geo-hydrological and climatic condition. (Ram malu et.al, 2007).

**A panoramic view of lonar crater)**

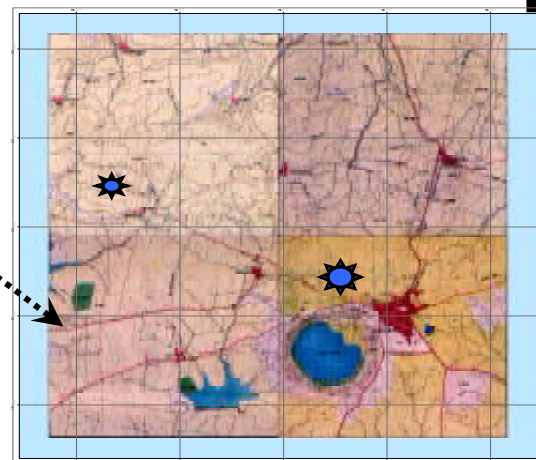
It is located in the Deccan traps .It is 570000 years old. This is the only crater in basaltic rock for-med by the meteoritic impact in India, ranking third largest in the world. It has an average dia-meter of 1830m and a depth of about 150m. The rim of the crater is raised about 20 m above the surrounding plain. It is almost circular, simple (bowl-shaped) impact crater.

Lonar crater is often described as the wonder of the world, because of its uniqueness. I.e. climate, vegetation, organisms are find unique inside of the crater.

The presence of the crater is responsible for generating ecological variables within a small-localized system than could be expected in such semi-arid area. An important ecological principle is that, with greater complexity of ecological variables, greater is the potential and possibility of rare and unique forms being supported by that ecosystem. The most striking feature of the saline water ecosystem of Lonar lake is its blue-green alage and bacteria. These microscope forms have adapted to thrive in an extremely alkaline medium, where normally no life form can be hoped to survive. The mechanism of adaptation involves development of specialized cell wall that is capable of with-standing the



**STUDY AREA: MOSAC TOPOMAP**



5 2.5 0 5 Kilometers



**Ambar and Gagan crater**

(Location map of Lonar, Ambar and Gagan crater)

The average altitude of the crater lies in between 460 to 610 m where as the circumference of the lake basin among its outer rim is 6 Km, while along it's inner rim, it is 3.5 Km and the maximum depth of water is 5.5m. The lake water is of special quality with high salinity and alkalinity. The Lonar ecosystem has evolved in a

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alkali levels. The luxuriant growth of algae colonies with an inland lake with the water having a pH as high as (10.5) is not known anywhere except at Lonar.

According to scientists, about 50000 years back a massive meteorite entered into the Earth's gravitational forces with a range 60 meter long and weighing 20 lack ton. It was racing at a speed of 25 km. per second towards the planet. When it stuck the earth, the energy released was equivalent to that released by six-megaton atom bombs. The meteor is believed to have been buried 600 meters below the crater level. The impact was so severe that rocks from all sides came on the surface and reached the height of 20 meters. Lonar is the third natural salt water lake in the world. It comes after Bosmatvi Lake in Ghana, which has a diameter of 10000 meter and New Cubec in Canada with a diameter of 3500 meter. (Khagol Vishwa)

The ejected cover extending outward from the craters rim has progressively been brought under cultivation. Unfortunately this agricultural activity close to crater rim has destroyed many scientific evidences which are important for understanding the planet Mars.

Lonar crater is characterised by six morphological segments. The ejecta blanket, summital convexity, the rim, the rectilinear slopes of the crater, crater basin or floor and the saline water lake. The crater has now worldwide recognition, few years ago plans of building a hotel were made but they were rejected as they were considered to be harmful for the crater. Anyone can enter the lake and damage it; no security system is present. Farming is done near the crater causing considerable damage to the soil. Fertilizers mix with Lonar water as small streams meet in this lake. The city development taking place is approaching towards the lake. Plastic wastes are thrown in the lake by people visiting the temples. The main threat is possessed by a lake placed in the village near to Lonar. The water from the lake situated in village evaporates

and much of it goes in the crater, water seeps through soil and reaches Lonar crater. This results in increasing height of Lonar and losing its salinity.

(‘Bhabar’ deposited at the foot of the crater at N-E direction of the crater by the Dhar stream)



There are abundant evidences in support of an impact origin of this crater. The famous geologist G.K.Gilbert in 1896 showed its similarity with the Meteor crater (Barringer crater), Arizona (USA). The morphology of the crater, the presence of glasses around the crater, ejected melt breccias with shocked minerals and a sub-surface breccia identified in drill cores beneath crater. The ejecta blanket is spread over about 1350 m away from the crater rim and slopes away by 2-6 degrees. The uppermost region of ejecta contains the deposits that melted due

to the impact. (Nayak 1972; Fredriksson 1973, 1979, Fudali et.al.1980).

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(Dome inselberge in at foot of the crater)

**• Ambar Crater: (Little Lonar-I)**

Little Lonar-I is also known as Ambar lake (Master 1999).It is elliptical depression 700 meters away from the rim of Lonar crater. (19°59'25.4"N lat. to 76°30'38.7" E long.)



(A google image of Ambar crater)

It is currently used for agricultural activities. Unfortunately it is destroying various scientific evidences to understanding other planet.

Table No.1 The major habitat of Lonar Lake

Sr.No.	Area coverage	%ge
1.	Lake (sheet of water)	<b>45.60</b>
2.	Forest (Moist deciduous+ semi evergreen)	<b>07.64</b>
3.	Forest (open and degraded).	<b>16.61</b>
4.	Grass and scrub	<b>23.27</b>
5.	Farmland	<b>06.33</b>
6.	<b>Ruins,etc.</b>	<b>00.50</b>

(Source: Forest department)



(Ambar crater's ejected blanket occupied by agricultural patches)



(A part of ejected blanket at N- E side of the Lonar crater)

The depression diameter of 300m and wall deposits upto 12m thick (Fredriksson et al.1973). The structure is roughly oval shaped. It is believed to have originated from the impact of a smaller piece of the meteor which spilt from the main body, before it hit the ground. This crater also has a lake, fed by three streams which through the years have eroded the surrounding area causing the exposure of basaltic bressia. It's Ejected blanket rises 6 m above the ground level.

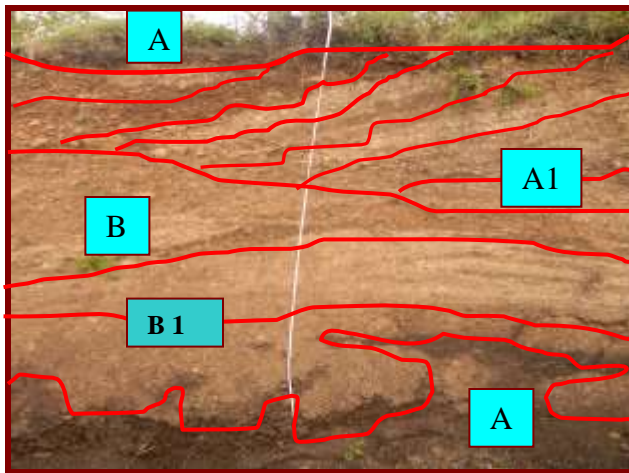
The estimated rim to rim major and minor axis are about 290m and 250 m respectively. The

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major axis is oriented along an approximate strike of  $120^{\circ}/300^{\circ}$ . The rims breached in three places, where streams arising in the surrounding flat basaltic plains have cut narrow channels draining into the central lake. The largest of these channels to the north, has built out a small delta which protrudes tongue-like into the lake.

In 1973, Fredriksson suggested that, Ambar lake Crater was formed by a fragment ejected from Lonar crater, where as S. Master who surveyed the Ambar crater in 1999, concluded that it was not a secondary crater but it was formed at the same time as the Lonar crater. Following in situ profile to the S-W shows the evidences crater formation.



(A Profile to the S-W of ejecta of Ambar crater shows an impact origin (A1 layers) of the crater.)

• **Gagan Crater: (Little Lonar-II)**

Little Lonar-II is also known as Gagan crater. (Found by Atul Jethi, on 12 th Nov, 2010.) It is a small circular depression, about 4750m away from the rim of the Lonar crater. (N-W). It is situated 350 m away and N-W direction to the Matmal Village. (Tahsil-Lonar Dist-Buld-hana of Maharashtra). Its GPS location is as  $20^{\circ}00'36.86''$ N lat. to  $76^{\circ}28'07.98''$  E long.



(A view of Gagan crater: Little Lonar-II)

It is bowl-shape in structure. Ejected blanket of the crater rises 3 meters above the ground level. Outer slope of the ejected blanket is gentle in nature, while inner slope is steep in nature. It is totally circular in shape unfortunately ejected blanket is breached by local farmers at the S-W direction of the crater for the road of bull carts. It is very important scientific evidence to understand the formation of Ambar, Lonar crater formation. It is also important scientific evidence to understand Moon and Mars crater formation.

There is no inlet and outlet for this lake. Its length is 90m to N-S direction while 110 m at E-W direction. Its total circumference with ejected blanket is 150m, while depth is less than 5 meters. We found impact induced evidences from the Gagan crater, i.e. we collected glass material from the soil sample. Soil sample is collected from the ejected blanket of the Gagan crater. An ancient temple of Lord Shiva is one of the evidences to show the relation of the Gagan crater with the Lonar crater. Its Geo-morphic structure and flora-fauna are also indicates the relation of impact origin of the crater. Colour of the Soil is whitish-gray, while outer side from the blanket it is black in colour.

Assuming a link among the three craters implies that the Gagan lake structure was formed at the same time as the Lonar crater and Ambar crater, for which an age estimate of  $570000 \pm 60000$  years.

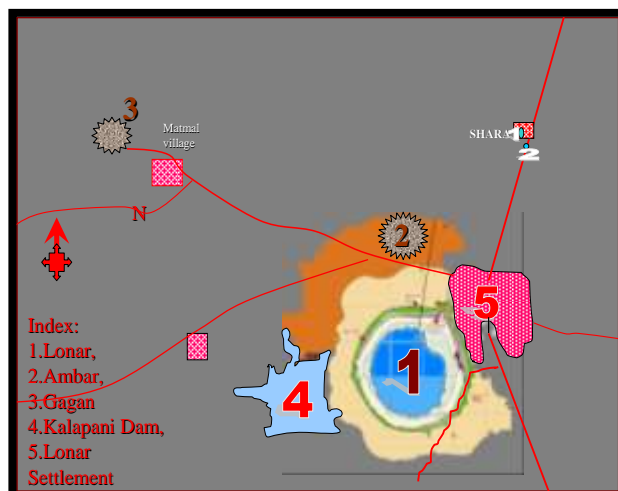
## • Methodology:

The paper is the result of a disciplinary three years study schedule from 2007 to 2010. The soil samples of Gagan crater, Ambar crater and Lonar crater were collected from the different locations of the three of craters. Recent field work detailed GPS survey of Lonar, Ambar and Gagan crater was conducted. Latitudinal and longitudinal measurements, as well as elevation from MSL were measured by the same instrument, while other important morphoclimatic and Envi-ronmental parameters were measured by using digital altimeter, Thermometer, Infiltrometer, Magnetic needle and magnetic Tape etc.

In this study I've examined impact material i.e. Soil sample and glass material collected from the different locations of the ejected blanket of the crater.

Digital photographic images, google earth images as well as maps were used for the spatial effectiveness and for the problem of identification.

SOI topographical sheets were used for terrain analysis i.e.1:25000 sheets (55D/8/SE, 55 D /12/SW, 56A/5/NE and 56A/9/NW) were used for morphometrical analysis. ERDAS and ARC-



GIS and GOOGLE EARTH soft wares of GIS were used for preparation of maps.

The present paper deals with the geo-morphic evidence of impact origin of Gagan crater. Therefore a comparative study of Gagan crater has been conducted with meteor crater of Lonar and Ambar lake crater.

The Geomorphic and Environmental regarding Gagan, Ambar and Lonar crater were identified in the present paper.

## • Result and Discussion:

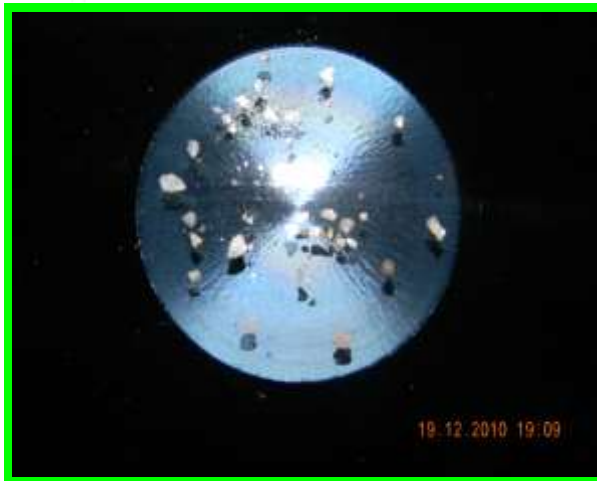
The composition of the soil sample collected from the Gagan crater shows that the ferrous and microbreccia and shock-produced glasses were found. At the surface of Gagan crater, most dramatic evidences for the impact shocks are the presence of impact spherules. Around the southern and South-Eastern rim of the Gagan crater we have identified sculpted, vesicular impact glasses with diameters of 0.1 to 1.2cm and with density of 1.0 to 1.32 g/cm<sup>3</sup>. Also founded the medium to small rounded like meteoritic parts at East side of the Gagan crater's rim. Glass fragments significantly enriched in silica and sodium in content.



(A soil sample collected from the Gagan crater)

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(Glass material is founded from the soil sample)

It may be pointed out that looking to the ejected blanket around the crater's rim as well as the circularity of the crater's rim and continuous extension of the ejecta blanket around the crater's rim we can say that the Gagan crater is a impact crater like Ambar and Lonar craters. Slope is also one of the important parameters to identify the impact crater. The ejected blanket's slope is uneven i.e. inner side slope is steep where as outer side slope is gentle. So on the basis of slope parameter we can say that Gagan crater is also impact crater.

We have conducted GPS survey of Lonar, Ambar and Gagan crater, closed traversing type of methods were used. The GPS locations of important places are as fallows;

• **GPS Survey of Lonar, Ambar and Gagan crater**

Sr. No.	Name of the point	Latitudinal location	Longitudinal point
1.	Dhar temple	19°59'08.3" North	76°30'58.7"E east
2.	Gutter Bund	19°59'03.2" North	76°30'50.1" East
3.	Kumareshwar temple	19°59'04.4" North	76°30'50.1" East
4.	Yadneshwar temple	19°58'58.1" North	76°30'44.3" East

5.	Banana farm on alluvial fan	19°58'57.3" North	76°30'36.3"E east
6.	Darga	19°58'49.1" North	76°30'45.7"E east
7.	Wagh mahadeo temple	19°58'.36.5" North	76°30'50.0" East
8.	Ramgaya temple	19°58'35.2" North	76°30'56.2" East
9.	Ramshwar Temple	19°58'35.2" North	76°30'56.2" East
10.	Kamalja Mata temple	19°58'17.5" North	76°30'21.6" East
11.	Alluvial cone	19°58'45.5" North	76°30'10.6" East
12.	Chopda mahadeo temple	19°58'57.0" North	76°30'27.9" East
13.	A little spring	19°59'4.8" North	76°30'50.1" East
14.	Ganesh crater	19°58'10.7" North	76°30'53.6" East
15.	Mahadeo temple	19°58'06.7" North	76°30'53.7" East
16.	Magnetic maruti temple	19°59'24.00" North	76°30'37.4" East
17.	Ambar crater	19°59'31.0" North	76°30'43.6" East
18.	Gagan crater	20°00'36.6" North	76°28'08.6" East
19.	Lord Shiva temple	20°00'36.6" North	76°28'08.6" East
20.	Kundpal talav dam wall	19°57'55.83" North	76°29'20.45" East
21.	Umbarzire	20°00'5.2" North	76°30'54.1" East
22.	Junna	19°58'47.1" North	76°31'49.5" East

(GPS survey conducted by Atul Zete on 11 to 14 nov,2010)

Due to shape, size and structure of the crater, it may be pointed out that there is a relation of the Gagan crater with Ambar lake crater and Lonar crater. Ancient vegetation and ancient Archeo-logical evidence on ejected blanket (Lord Shiva temple) indicates the relation of the crater is with the meteoritic craters like the Ambar and Lonar craters.

At the ejected blanket of Gagan crater we found a variety of Impact melt rocks and glasses at the rim and inside of the crater. It may have occurred due to very high heat of the meteorite part.



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So comparison of the small impact crater is essential to recognize whether any deformation features are common to all of them.

• **Conclusion:**

Finally we can say that during the formation of Lonar crater the meteor broken into the three pieces that's why three craters are formed. Meteor may be broken in the layer of Ionosphere or Ozonosphere of the atmosphere. Therefore from the main biggest part of the meteor Lonar crater was formed, where as Ambar crater formed next number sized piece of the meteor, while smallest piece of meteor was thrown near to the N-w side of the Matmal village, there-fore Gagan crater is came into existence.

As Lonar, Ambar and Gagan craters are a rare meteorite impact structure formed entirely in basaltic part of Deccan plateau. It is helpful to understand similar craters on other terrestrial planets as like Mars and its natural satellites.

• **Acknowledgement:**

I'm very thankful to Dr. Rajat Subhra Chatterjee. He has given me a opportunity to organize various field works at Lonar crater as well as encouraged me a lot and also provided well laboratory facilities to me in IIRS Dehradun.

I'm also thankful to Dr.Sunil Gaikwad for providing me knowledge as well as latest surveying instruments.

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