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The reason behind source and cause of whitening of rocks at crater lake, Lonar, Maharashtra, India – A report.

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ABSTRACT

Basaltic rocks existing at Crater Lake in contact with water or submerged in water were found to be covered by a white layer on their surface. The authors of this paper, while studying Lonar Crater Lake formation came across these rocks covered by a white layer. A search was conducted to understand the true nature of this phenomena. They discovered the reason, why these rocks or stones became white and what is the material or component that deposits white layer on the rocks existing in the lake periphery and whether this phenomenon is of biological, chemical or physical in nature, has been reported through this paper.

Keywords: *Lonar crater lake, basaltic rocks, white layer deposition, biological phenomena.*

1. INTRODUCTION

Lonar, a small town in Buldhana District of Maharashtra is known for a crater, the formation of which is not yet fully understood, though a tremendous work has been carried out by various researchers to search its origin. The coordinates of the crater are 19º58'N and 76º30'E. The crater diameter is 1.83km approximately and the depth of it is approximately 150m.

The crater is of circular nature, has a raised rim. Below at the bottom of the crater, a lake exists having water of highly saline and highly alkaline. The colour of the lake water seems to be green due to a certain type of algae known as spirulina. Other microorganisms who have adapted the extreme conditions of the lake water are also found.

The civilization and empires of different rulers observed this area as a geological heritage and they built temples using rocks which may have been brought from outside or may be of local ones. The temples existing at the lake periphery are of Hindus.

After many years later, that empire ship was ended up due to unknown circumstances. No maintenance of these temples was carried out and no regulations or control were on tourist or visitors, visiting the crater, so that basaltic rocks and their debris spread over Lonar crater Lake periphery and submerged into crater lake.

2. OBSERVATION

These rocks which have been submerged in the lake water or in contact with water for many years or decades show white layer on its surface. (fig. 8).

(a) There is no relation of whatsoever to the formation of the crater and rise of civilization and the constructions of the temples here.

(b) There is no relation of whatsoever between formation of the crater and white layer deposition on basaltic rocks. These two events are of entirely different nature.

3. METHODOLOGY, EXPERIMENTS AND EXPERIMENTAL RESULTS

Methodology, Experiments and Experimental results have been discussed in detail in the papers[1], [2].

4. RESULTS AND DISCUSSIONS

In general, white layer deposition takes place on the rocks which come in contact with fresh water bodies including rivers, lakes, streams etc., for a long period of time. Fresh water bodies frequently show depositions of white layer on rocks. This is a type of biological process or phenomena. Some microorganisms deposit their metabolic products or their organic dead debris/dead remains results in white layer depositions on the rocks surface. It may be deposition of silica (SiO_2) layer. (fig. 1,4,5,7,8,9,16a,16b and 18). It may be deposition of calcium carbonate ($CaCO_3$) layer on the rocks. (fig. 3,6,15a,b).

In any water body once the chemistry of fresh water changes due to pollution or any other reason, this aquatic habitat is not suitable to living community at that point, calcium depositions or silica depositions stops. For example Lonar crater is one of them. Previously, Lonar Crater lake was a fresh water body and pollution free water body, where many organisms and aquatic life existed and thrived there and it became a part of healthy ecosystem of fresh water body e.g. micro organisms like diatoms, coral related micro organisms responsible for deposition of calcium carbonate ($CaCO_3$), etc. During this period, depositions of white layer appeared on the objects of Lonar crater. But after a long period of time, population, development and tourism spread over around Lonar crater and pollutant got concentrated over in stagnant fresh water body and the lake slowly started to become highly polluted and eutrophied. Due to this, healthy ecosystem was damaged and water turned into highly saline and highly alkaline, without living micro organisms and aquatic life. In absence of microorganisms, depositions of white layer process on rocks stopped at Lonar crater. No further depositions takes place because causative organisms are not there. So white layer depositions on objects of Lonar Crater lake and water colour changes from green to pink red is nothing but a biological phenomena.[1], [3].

This phenomenon is of historical nature because whitening of rocks took place many years ago. That time there was no water pollution and today is reflected that historical phenomena. The whitening of rocks is not unique, it happens in any fresh water body because diatoms and related micro organisms or the species of diatoms is responsible for deposition of amorphous silica, their dead debris on the rock surface. And this whitening of basaltic rocks, it is not only due to silica, but it is also due to calcium carbonate, because it depends upon the species existing in that water body.

Predominantly basaltic rocks are much affected by white layer depositions, which are in vicinity or submerged in water of the crater lake. On the river banks, depositions of white layered rocks are observed, because the river water is a fresh water body and diatoms are found in fresh water body (Manish et al.)[4] The white colour on rocks surface is nothing but a deposition of white layer of amorphous silica, which are solely due to presence of diatoms. But if the river passes through urban area, no white layered rocks are observed due to pollution of water body.

Interaction of abiotic and biotic components i.e., basaltic rocks of Lonar crater and water organisms like diatoms (silica) and coral (calcium), their exo skeletal organic material deposits on the basaltic rocks and become white in colour, all the metabolic products or their dead debris of such organisms deposit on the rocks, which get deposited permanently on the rock surface and the black surface of the rock appears white in colour.

Diatoms microorganism shell contains silica. Diatoms are mainly responsible for white layer deposition on the rock surface. That deposition is mainly of silica origin and this silica is amorphous in nature (fig.11), because the source of silica is microorganisms diatoms, similar to the rocks of coral reefs or coral islands caused by related microorganisms. Those rocks which are in contact with coral organisms deposit calcium carbonate and show calcium deposition on the boulders or big rocks are observed, which have been submerged in the waters for many years or decades. (fig.3,6,15a,b)

Silica (SiO_2) in the silt has been reported by Nandi and Deo[5]. Existence of diatoms in the lake water has been reported by Badve et al.[6]. On the basis of these information, a search was conducted, what is the source, abundance and cause of silica depositions on the rocks existing at crater lake and submerged rocks in the lake water and to understand the relation between diatoms, silica and depositions of white layer on basaltic rock surface.

As has been mentioned earlier, diatoms came into existence because the lake was previously of fresh water nature as diatoms are found in fresh water bodies[4], and marine environment. The water table of Lonar crater is of potable nature. If one digs a hole, few feet away from the lake, potable water is available. Earlier Banana plantations were carried out at the eastern part of the crater lake, using potable water for the plantations , by using a diesel pump to draw potable water from a hole dug in the ground few feet away from the lake. (fig. 13). This practice has been stopped completely long back, Now the hole is used for animals and birds living nearby, which proves that the water Table is of fresh water nature. Pawar reported that the pH of the lake water is minimum or neutral during the rainy season and reaches its maximum during summer season[7]. This infers that the lake water prior to the earlier era was of fresh water body ecosystem.

Lonar crater eco system functions as dual in nature, in rainy season it shows freshwater ecosystem and forms fresh water flora and fauna because of water pollutant get dispersed and dilute. In summer season freshwater ecosystem turns into saline and alkaline ecosystem, that all freshwater biota and life killed, on that dead remains, fungus grows and evaporation rate is fast, water pollutant get concentrated in small quantity of water and ecosystem changes into eutrophite and maintains anaerobic condition. Therefore nature of Lonar Crater dual in nature, operating fresh water and saline and alkaline ecosystem simultaneously ultimately fresh water and saline and alkaline nature of water is governed by climatic condition and meteorological and weather condition. High rainfall and high temperature responsible for Lonar Crater exhibiting dual in nature ecosystem.

(Fig 17 & 18). A frog was found to jump in the lake water (Fig 14a,b,c), which shows that the lake water dilution factor was maximum even after the rains i.e. pollution free. This also shows that the crater lake contains a reach biodiversity of freshwater ecosystem.

Relation between diatoms and silicified ecology exists at crater lake, the process of silica deposition (process of silicification) seems to operate only in the lake and not beyond that, has been reported[2]. It is assumed that debris of diatoms is recycling of silica (SiO_2)[2]. These indicates that the only source available for the deposition of white layer on basaltic rocks (silicification) is due to diatoms, which are also indicators of silica (SiO_2). Presence of diatoms in the lake water and their existence itself points to the water to be of fresh water nature. There is no doubt that the lake water was of fresh water nature, when it formed. Besides diatoms, there is no other source available or abundance for amorphous silica, which can be the cause for deposition of white layer of amorphous nature. Maximum percentage of silica in the silt at the bottom most part of the lake has been reported by Nandi and Deo[5]

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Diatoms are microorganisms of phyto planktonic group[4]. Their skeletal body (i.e., the outer shell) is made up of silica (glassy nature). Diatoms are the source and cause for the amorphous nature of silica deposition on basaltic rocks at Lonar crater lake or silicification of rocks at Lonar crater. The deposition of white layer on basaltic rock surface is nothing, but a process of deposition of amorphous silica which may possibly be the metabolic product of diatoms or it may be the decomposed organic material i.e., their dead debris/dead remains of organic nature, which is released in the waters. When the diatoms die, their dead remains/dead debris goes into sediments at the bottom of the lake and get decompose. After a long time, the decomposed material being of organic nature forms into amorphous silica. The amorphous silica is a white powdered form of opaque nature (fig. 11), and later on settles on the surface of basaltic rocks when coming in contact with it and seen as deposition of white layer, also known as silicious material of organic nature. It is this silicious material, which is the amorphous silica, reflected in the form of white layer appearance or deposition of white layer on the rocks, when the rocks come in contact with water. In this way, the rocks existing at crater Lake periphery are affected by silica deposition. This is also termed as silicification of basaltic rocks. There seems to be no other source, other than diatoms, which can affect the basaltic rocks by way of deposition of white layer of silica origin on their surface.
It is surprising that such a high percentage of amorphous silica (SiO_2) is found at Lonar crater lake and that too in abundance, when there is no natural source available. Diatoms are the only biological source of silica (SiO_2), which is found at Lonar crater lake, which are the source for white layer deposition and high percentage of SiO_2 in basaltic rocks.

Every year from November to February migratory birds come here and also local birds are found in the waters of Lonar crater lake. (fig. 2). If no food is available in the lake, how are these birds found here? It is possible that the organic dead debris/dead remains or skeletal material of microorganisms like diatoms may serve as a source of food for these birds and hence come here. Otherwise without availability of food, these birds would not come here from faraway lands, unless and until food is available in any form for their survival, they would not be found here. Badve et al. mentioned that microscopic examination of silt samples revealed the presence of rich organic remains such as algal filements, fungi hyphe, and spores, diatoms etc.[6] This infers that the dead organic remains/dead debris/skeletal material of diatoms may be a rich source of food in the form of amorphous silica of organic nature.

Crystalline silica has also been found in the soil of Lonar Crater Lake periphery.(fig. 10). Due to pollution of the lake, it is possible that diatoms may have died long back. Their release of metabolic product or their dead debris accumulation of it in the waters and deposition of it into white layer may have stopped after their death. No further deposition of white layer may have taken place. Hence whatever is observed today as white layer deposition of amorphous silica, is the process which may have taken place long back, when the diatoms were alive. It is the biological product of diatoms. Diatoms are therefore the source for the phenomena of white layer deposition (silicification) to take place. If the source is not available silicification of rocks will not take place.

Due to abundance of silica or availability of silica in the form of crystalline (fig. 10), and amorphous (fig. 11) in large quantities, possibility of making of glass beads industry flourished here in ancient time[8]. The major component of oxides in basaltic rocks is SiO_2 (silica), which may be 50-60%. The coating of amorphous silica on the surface of basaltic rocks raises the percentage to around 95-98% SiO_2. When the basaltic rocks disintegrates due to weathering conditions, the silica present is released in the soil as crystalline silica and hence crystalline silica is also found in the soil of Lonar crater lake periphery. At north eastern part of the crater, at Shukracharya shala, temple stones and nearby stones and rocks, are found to be subjected to a very high temperature or tremendous heat phenomena, which infers some kind of work related to high temperature phenomena was carried out here. To melt silica (SiO_2) temperature of around 1600ºC is required, otherwise there was no reason whatsoever for the civilization to arise here in this remote area and build temples in the 12th Century or earlier than that[8], where the water is found to be highly saline and highly alkaline. But it arose and flourished here because the lake was of fresh water nature during that period.

From the above studies, it can be said that for the process of deposition of white layer of amorphous silica (silica coating) to take place on basaltic rocks (volcanic rocks), these factors are necessary. [1] Volcanic eruption and formation of basaltic rocks, [2] water and [3] diatoms, without which silicification of rocks (i.e., white layer deposition of amorphous silica) may not be possible. At Lonar crater lake, all these factors were present and hence silica deposition was possible on rock surface which came in contact with water or rocks submerged in water.

The Deccan Plateau was formed due to volcanic eruption some 64ma, due to which basaltic rocks (volcanic rocks) were formed. Volcanic activities ceased long back. If the crater lake originally was of saline and alkaline nature, when it formed, diatoms would not come into existence in the lake and the process of silica deposition (silicification) on the surface of rocks would not have taken place and been observed today.

Lonar crater formed in at least six 10-25m thick basalt layers[9]. But apart from crater lake this feature or phenomena (silica deposition) has not been observed or reported from any where on Deccan Plateau, suggesting that the source and the medium must be available for the process of silicification to take place and the source for the high percentage of silica (amorphous) can only be through diatoms, if silica coating on basaltic rocks has to take place as per the studies carried out through this paper.

Whatever thickness basaltic lava flows may be or may have come through volcanic eruptions; it cannot be a rich source for amorphous silica deposition.

Some researchers are of the opinion that Lonar crater was formed by meteorite impact. If such a high percentage of silica (SiO_2) has to come from meteorite impact, then iron meteorite contains negligible or no silicon (Si)[10], stony iron meteorite like Nantan and Morrocco contains 28.7% and 17.2% SiO_2 respectively[11] and stony meteorites like North West Africa (N.W.A.) contains 39.9% SiO_2[11] and Chelyabinsk meteorite contains 29.2% SiO_2 [10]. A.G.C. Nair et al. showed that Kobe meteorite (stony) and Czech meteorite (stony) contains Silicon (Si) 15.1% and 18.1%respectively.[12]. This shows that meteorite impact, if any at Lonar cannot be a high source of amorphous silica or cause of amorphous silica deposition on basaltic rocks at crater lake.

Other researchers are of the opinion that Lonar crater was formed by volcanic eruption of unknown nature or crypto type, where the source of high percentage of silica covered by white layer, must be through volcano. The volcanic activities took place some 64ma and ceased long back. No volcanic eruption is known to take place after this or if taken place is not recorded or documented. Hence, it is of the opinion that volcanic eruption cannot be a rich source for amorphous silica deposition on rocks. Meteorite impact or volcanic eruption therefore cannot produce amorphous silica, but can produce crystalline silica and crystalline silica is also found in abundance at Lonar crater. (fig. 10), which is derived from basaltic rocks when it disintegrates due to weathering. Since amorphous silica is a biological phenomena, question of meteorite impact or volcanic irruption does not arise.

At present in existing condition, the process of deposition of amorphous silica on rocks is going on or not? Obviously, it depends upon water quality or degree of pollution. At present Lonar crater lake is highly eutrophied water body and hence this process is stopped. This paper explains the process of silica deposition on basaltic rocks. If there exist any reverse process or mechanism to remove white layer deposition from basaltic rock surface in nature, and for how long white layer sustains on basaltic rocks, that have not been observed.

It has been considered all the possibilities of sources for amorphous silica deposition on basaltic rocks, except diatoms, there seems to be no other source available, which can be the source and cause of amorphous silica deposition on basaltic rocks.

5. 0 CONCLUSION

From the studies carried out through this paper, the conclusion drawn is:
There are two types of depositions on the rocks of Lonar crater lake.
(1) silica deposition, the source is diatoms.
(2) Calcium deposition, the source may be micro organisms related to the calcium deposition process.
(1) Diatoms organisms are responsible for the silica deposition of amorphous nature i.e., a type of white layer deposition on basaltic rocks. The metabolic product of diatoms or their dead debris /skeletal material/silicious material get decomposed. The decomposed organic material after a long period of time scale gets converted to amorphous silica, a white powdered form which sticks on the black surface of basaltic rocks and become white. (2) Big rocks and boulders in the water body submerged over a long period of time are affected by coral deposition/calcium deposition. The metabolic product of coral related micro organisms or their dead debris or calcious material stick over the big rocks or boulders of black surface and become white in colour.
Finally for silica sources of amorphous nature, micro organisms diatoms are the main culprit of silica deposition (white layer) on basaltic rocks.

5.1 IMPORTANCE OF WORK

30 years have passed when Badve et al. in 1993, first found the presence or existence of diatoms in the silt of crater lake[6]. It is to be checked now, whether diatoms are still alive or still exist, then the process of deposition of white layer on basaltic rocks (i.e., silicification) process continues. If they are dead, then no more white layer depositions take place. Hence it is of utmost important to find out their existence in such an extreme condition of lake water, where they are not likely to be found. This will help us to understand the mechanism of white layer deposition of amorphous silica or how the rocks are silicified or the process of silicification of basaltic rocks, coming in contact with water or submerged rocks, where diatoms are found to exist. If we are able to find out, the mechanism or process of silica depositions on rocks, it will be a major achievement in the history of man. But microorganisms who deposits $CaCO_3$ (calcium carbonate) on rocks or boulders observed at Lonar Crater Lake have not been reported or documented.

6. ACKNOWLEDGEMENT

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Fig. 1. Rocks covered by deposition of white Layer found at crater lake, Lonar.

Fig. 2. Local birds found at crater lake, Lonar.

Fig. 3 Big boulders covered by White layer deposition observed at Lonar Crater lake.

Fig. 4. Rock covered by layer of White deposition found at. At Lonar crater lake periphery.

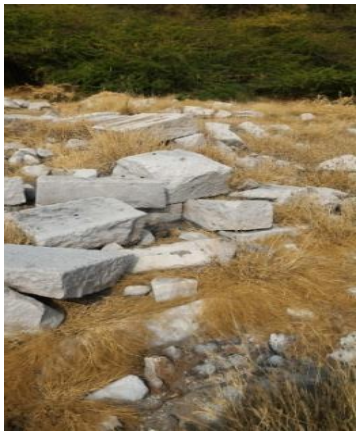

Fig. 5. Rocks spread over northern Side of the crater, covered by deposition of white layer.

Fig. 6. Big boulder covered by white layer deposition observed at Lonar crater lake Periphery.

Fig. 7

Fig. 8.

Fig. 7. White layered rocks found at the northern side of the crater and Fig. 8 White coloured rock submerged in the lake water.

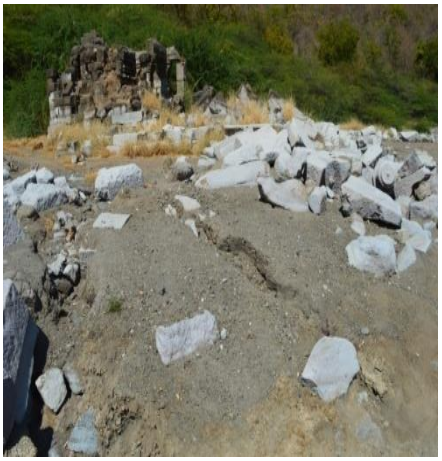

Fig 9 Rocks found in front of the Temple covered by white layer of amorphous silica.

Fig. 10 Glassy objects i.e. crystalline silica found in the Soil of Lonar crater lake.

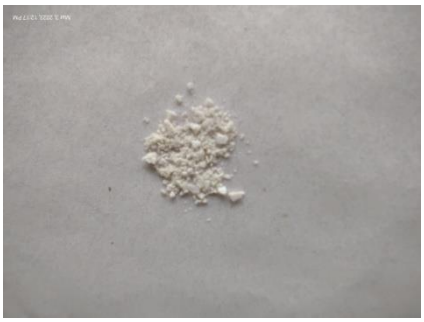

Fig. 11. Powdered amorphous silica, the root cause of white layer deposition on basaltic rock surface, being the dead debris/dead remains of diatoms.

(a) (b) (c)

Fig. 12. (a), (b) and (c) Sands collected from different river banks in India, showing glassy nature objects i.e., crystalline silica. The sea and the deserts being the store house of silica. The glassy objects i.e., crystalline silica in fig 10 shows similarity to river bank sands.

Fig. 13. A hole dug few feet away from crater lake for the animals and birds living nearby. This water is of potable nature.


Fig. 14 (a)


Fig. 14 (b)


Fig 14(c)

Fig. 14 (a) A frog is seen to jump in the lake water, Lonar, Fig. 14(b) The frog went in the waters and Fig. 14(c) the frog nearly disappeared in the lake water. These images were taken in the year 2007 in the month of January. The authors along with Dr. Pramod Salaskar visited this lake in the year 2007. The images shows that the pH of the lake water seems to be norma,l i.e., pollution free.
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Fig. 15. (a)


Fig. 15 (b)

Fig. 15 (a) and (b) White layered boulders seen on the lake periphery, Lonar crater.


Fig. 16(a)


Fig. 16(b)

Fig. 16(a) and (b) Shows white powder depositions on the rock surface and also on the dead insect found at Lonar crater lake periphery. This image was taken in the year 2007, when the authors visited Lonar crater in the year 2007.

Fig.17 Lonar crater lake during monsoon season the image is taken in the month of August 2023. The image was taken by S. S. Bugdane, near Jain Mandir, Lonar. This shows that during rainy season dilution factor is maximum and hence lake becomes pollution free.

Fig. 18 Lonar crater lake during monsoon season the image is taken in the month of August 2023. The submerged temples and white coloured rocks are seen. The image was taken by S.S. Bugdane, near Jain Mandir, Lonar.

