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A search for the source of high content of sodium chloride (NaCl) at Crater Lake Lonar, Maharashtra, India

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ABSTRACT

Highly saline and highly alkaline nature of lake water is observed at Lonar Crater from ancient time till today. The formation of this lake is related to the formation of the crater by the impact of a meteorite forming Soda Lake. The existence of NaCl (Sea salt/common salt) in such a large quantity at Lonar, where the source is unknown because the formation of NaCl salt is a natural process and it may have started before the sea came into existence after the formation of the earth. The surrounding basaltic rocks have no NaCl salt or Chlorides content. A search was conducted to find the source of NaCl, which constantly maintained high salinity and at the same time high alkalinity from ancient time. Three edible salts i.e., Halite rock salt (the mineral form of NaCl), Kala namak (Black salt) and Sea salt (common salt) having similar physical properties as representative samples were taken for comparison with respect to Lonar salt. After analysis of the three salts namely Halite (rock salt), Kala Namak and Sea Salt, the major component found was NaCl in various amounts. It was found that the major component NaCl was also present in Lonar Salt which suggested that the source of high salinity may be from the remains of an ancient dried up sea which existed before volcanic eruption of 65ma, or there may be storehouse of NaCl salts beneath the basaltic rocks which reflects the primitive ecosystem lying under primitive basaltic rock, totally unknown and have not been excavated. This paper reports the findings and the work carried out to search for the source of high content of NaCl (sea salt also known as common salt) existing at the Crater Lake, Lonar on a preliminary basis.

Keywords— *Lonar Crater Lake, High salinity, High chloride content, Sea salt, Primitive ecosystem*

1. INTRODUCTION

Maharashtra is known for volcanic rocks known as basalts. The whole area is composed of basalts commonly known as Deccan plateau. This event might have taken place some 65ma ago. On this Deccan plateau, some thousands of years back, a crater was formed due to meteorite impact as per latest studies, but as per earlier workers opinion, this crater was formed by volcanic eruption. This crater is known by the name Lonar crater situated in village Lonar, Taluka Lonar, Buldhana District of Maharashtra, India, GPS positions are 19°58'N and 76°30'East. The crater has a diameter of approximate 1.83km and the depth is 150 meters. At the bottom of the crater, a lake exists with highly saline and highly alkaline nature of water. The water of the lake is greenish in color due to a type of algae known as spirulina or photosynthetic micro plants. No aquatic life exists in the lake water except some microorganisms and bacteria who have adapted themselves to the extreme conditions of saline and alkaline nature of Lake. The surrounding thick vegetation is not due to saline lake water but is due to surrounding percolating water. The soil around the saline lake is the sandy type with grayish and black appearance. The crater has a well preserved circular rim. There are gorges on the rim, the largest one being in the northeastern side of the crater, known as Dharatirtha where a continuous flow of water from below the temple is observed. Some authors suggest that this part seems to be the entry point of a meteorite impact. On the outskirts of the rim, a yellowish powdered dusty soil is observed which is known as ejecta blanket.

1.1 Previous work carried on Lonar Crater

Stroube et al. carried out analyses of impact glasses and basalts from Lonar Crater by determining 29 elements through INAA and concluded that a saline nature of lake exists at Lonar Crater, where due to post-impact alteration, the basalts related to it may have wiped out the original rock-glass relation[1]. Borul studied physicochemical analysis of lake water and concluded that the smell of the lake water is ill-smelling[2]. Antony et al. carried out physicochemical analyses and microbiological characteristic studies and concluded that microbial diversity in the lake of alkaline nature is very important in understanding the limits of life at extreme conditions; it will also help us to search for new kinds of biomolecules of useful nature[3]. Murali et al. studied tektite like bodies and concluded that it is considered that for the formation of tektites due to impact, free silica must be available in target rocks[4]. Sarkar et al. studied quartz grains through petrographic and SEM and concluded that planar deformation features developed on grains of cavity filled quartz, can be used as supportive evidence for an impact by a meteorite[5]. Morgan through RCNAA analyzed basalts, pumice and impact glasses and drew the conclusion that Lonar glasses did not show any promising component

which characterizes a meteorite component, but they did show abundance changes which were found to co-relate with impact process[6]. Kumar studied impact deformational features in massive basalt exposed on the upper crater wall and concluded that since Lonar Crater is unusual meteorite impact structure, excavated in basalt, it will be useful to understand such craters on other planetary bodies and their satellites[7]. Chakrabarti and Basu analyzed trace elements and Nd, Sr, Pb-isotopes of impact breccia rocks and target basalts gathered from Lonar Crater, and stated that craters as simple as Lonar combination of Archean basement rocks which lie below Deccan in breccias rocks can give us new understanding regarding formation of crater in basalts, being above granites [8]. Hagerty and Newsom analyzed samples from cores drilled under crater floor, Lonar and suggested that changes had taken place only after the event occurred[9]. Komatsu et al. through studies carried on drainage systems of Lonar Crater, stated that the lake water art Lonar Crater as it appears is affected by surface runoff being active in a rainy season, the groundwater input being effective in both the seasons, i.e., rainy and dry [10]. Badve et al. studied silt samples of lake sediment, which were collected from different parts of the lake, some meters away, found that activity through anaerobic is going on[11]. Nayak studied glassy objects (impactites) from Lonar Crater and came to the conclusion that, it can be said that Lonar Crater formation by giant meteorite or meteorite-comet must be accepted, though there is no direct proof for such assumption[12]. Nandy and Deo carried out analyses of salt and water of Lonar Crater and concluded that their results did not show any occurrence of limestone in this region, also their bore samples of silt did not show any occurrence of high % of CaO[13]. Shinde and More carried out physicochemical analyses of Lake Water and according to their results stated that the water quality shows a high content of chlorides, hardness, and salinity, for which alkalinity of the lake water is found to be too high[14]. Son and Koeberl collected a set of samples of Lonar impactites and impact glasses, the analyses of these through chemical and petrographic studies shows that the age of original rock basalt of Deccan traps is 65ma[15]. Maloof et al. studied geologic and topographic maps taken from field studies, describing ejecta features and concludes that ejecta blanket shows or depicts important radial mass movement which resembles similarity to Martian layered ejecta forms[16]. Rao and Bhalla carried out investigation on Paleomagnetic and rock magnetic on rocks collected from Lonar Crater and stated that the shock features with respect to the age of the crater, depth to diameter ratio, unique regional geomorphology, no trace of any recent volcanic activity in Indian subcontinent, points that Lonar Lake may have been formed by meteorite impact in quaternary periods[17]. Pawar carried out physicochemical analysis of Lonar Lake water for seasonal variation and concluded that chlorides and salinity were found to increase before monsoon and found to decrease in monsoon and after monsoon[18]. Gaikwad and Sasane carried out an assessment of groundwater quality in and around Lonar, through their analysis concluded that water supplied to rural areas should be treated and also to be protected from the danger of contaminations[19]. Lafond carried field survey of Lonar Crater and states that the findings of meteorite fragments have not been detected at an impact site of the ancient crater, it should be searched for[20].

2. METHODOLOGY

Three edible salts as representative samples having similar properties were taken to search for the source of high content of NaCl with respect to Lonar lake salt. 1) Halite (Rock salt mineral form of NaCl), 2) Kala Namak (Black salt) and 3) NaCl Sea salt (common salt). 3 liters of Lonar lake water was collected in a plastic can with GPS position $19^0$5818.1N and $76^0$3021.5E. Sealed properly and brought for analysis purpose. Sea salt was brought from saltpans, Halite rock salt and Kala namak were purchased from a grocery shop and Lonar lake water collected and brought was kept in the sun for evaporation until the water was completely evaporated and the salts left behind. Figure 1 and 2. The salt was collected for further analysis with other three salts. Before sending these salts for chemical analysis their characteristic features were noted down 1) Halite-(rock salt) appearance white in powdered form, but in the crystalline form its color is white with some orange shade, transparent pure glassy type, purely of crystalline nature, nonhygroscopic. (Halite-rock salt is the mineral form of NaCl), 2) Kala namak (black salt) - appearance similar to dark chocolate, somewhat dark brownish in color, crystalline in nature similar to rock salt halite, non-hygroscopic, 3) Sea salt (common salt) appearance white, small crystals formed after evaporation, hygroscopic in nature, opaque, and 4) Lonar lake salt appearance muddy white may be due to impurities in it, amorphous (non-crystalline), opaque. After evaporation, a thin paper like formation was observed, nonhygroscopic.

2.1 Experiments

All the four salts were crushed to a powdered form in a motor pestle and then were sent for physicochemical analysis for the following parameters. Analyses were carried out as shown 1-5gm of each salt was taken diluted in 100ml distilled water. From this diluted prepared solution, according to parameters, the prepared solution was taken and analysis carried out. 1) pH, 2) Alkalinity, 3) Chloride, 4) Conductivity, 5) Hardness and 6) Sulfates. Later on the powdered form was observed under a stereo binocular microscope and finally, these samples were sent for XRF analysis to look for salts and oxides.

2.2 Experimental results

The results obtained by physicochemical analysis from table 1, it is observed that pH of Lonar salt is found to be the highest among the other three salts and the lowest pH is found in Halite rock salt. Alkalinity is found to be highest in Lonar salt and the least in Halite rock salt. Whereas chloride content is found to be highest in Lonar salt and the lowest is found to be in sea salt. Observation through a stereo binocular microscope shows the powdered samples of Halite rock salt and Kala Namak shows crystalline structure figure 6 and 7, whereas sea salt after keeping in the sun and when observed shows minute crystals of the salt figure 8 and 9, and Lonar lake salt also shows minute crystal structures, figure 10. Analysis through XRF shows that NaCl was found to be highest in Halite rock salt whereas it was lowest in Sea salt. Br content was found to be highest in Lonar salt and second highest was in sea salt but was absent in Halite rock salt, table 2 and 3.

3. RESULTS AND DISCUSSION

From the experimental results of physicochemical analyses, table 1, shows that pH, chloride content and alkalinity are found to be highest in Lonar salt amongst other salts. From XRF analyses, table 2, the values of Lonar salt is found to be close to the values of Sea salt (common salt) because Lonar salt and Sea salt is of water ecology or marine ecology, whereas the values of NaCl in

Halite (rock salt) is found to be close to the values of Kala Namak. This is because Halite rock salt and Kala namak are of desert arid ecosystem although in all the four salts analyzed to have the same elements in more or less percentage. Also, the values of Na, Cl, and NaCl of Lonar lake salt are close to the values of Sea salt rather than to the values of Kala Namak or Halite (rock salt). Br is found to be highest in Lonar salt and to a lesser amount in Sea salt (common salt) and Kala Namak but is absent in Halite (rock salt). Though Cl is found to be highest in Lonar lake salt, Br content in Lonar salt is noteworthy which is 5.5 mass %. The Dead Sea contains Cl and Br in large quantity[21]. Detection of Br in basalt has also been reported by Son, which is in trace quantity[15] i.e., at ppm level. From the analysis of the three salts namely halite (rock salt), Kala Namak and Sea Salt, the major component found was NaCl in various amounts. It is found that the major component NaCl is also present in Lonar Lake salt. When the four salts were compared, the major component was NaCl and it showed similarity.

To distinguish Lonar salt with other salts in chemical nature, table 6 showing ratios of different parameters carried out. The ratios of Cl: Alkalinity calculated for Lonar salt was 0.92, for Sea salt it was 125, for Kala Namak, it was 14, which shows that the ratio of Cl with respect to alkalinity is highest in sea salt and lowest in Lonar salt. The ratios of Cl : SO_4 of Lonar salt was found to be 17, for Sea salt it was 12, for Kala Namak, it was 17 and for Halite it was 18, which shows that the ratios of Cl with respect to SO_4 is highest in Halite salt, lowest in sea salt and equal in Lonar salt and Kala Namak. The ratios of Cl: Hardness for Lonar salt it was 43, for Sea salt it was 2, for Kala Namak it was 5 and for Halite it was 7, which shows that the ratios of Cl with respect to Hardness is highest in Lonar salt and lowest in sea salt. The elemental ratios of salts to elements, the ratios of NaCl: Br calculated for Lonar salt was 14, for Sea salt it was 104 and for Kala Namak it was 382, which shows that the ratios of NaCl with respect to Br was highest in Kala Namak and lowest in Lonar salt, whereas elemental ratios Cl : Br for Lonar salt it was 8, for Sea salt it was 63 and for Kala Namak it was 232, which shows that the ratios of Cl with respect to Br was highest in Kala Namak and lowest in Lonar salt.

Deccan Plateau was formed some 65Ma[15] in Maharashtra, through volcanic eruptions. From the studies carried out, it is found that the depth of basaltic lava flows at Lonar is around 700m[8, 22]. Chakrabarti mentioned that Archean basement rocks lies below the basaltic rocks[8]. Similarly, Fudali also stated that below the basaltic lava flows at 700 meters depth lies the rocks of Precambrian period[22]. When basaltic soil sample as a representative was taken near Ramgaya mandir to check for pH and Chlorides, it was found that pH of bathe saltic soil is 8.4 and Chloride content was found to be 51.5 mg/kg (5.15×10^{-3}) which is in trace quantity. Also analysis carried out by different researchers of basaltic rocks shows that Cl and NaCl are absent[1, 15]. But from the physicochemical analysis of ground water quality of surrounding area of Lonar Lake by Gaikwad and Sasane shows that Cl content is in trace quantities. These results suggest that the surrounding basaltic rocks cannot be the source of NaCl (sea salt) found at Lonar Crater.

The deepest drill core by TISCO to search for meteorite was 144 feet[13]. Even at this depth, NaCl was detected[13]. Rajasekhar also mentioned that 300– 400m five boreholes were made[23], in search of a meteorite. But further, no drilling work was undertaken below this depth. The groundwater or the surface water on Deccan Plateau does not show any NaCl salts (sea salt). The hardness of water is due to carbonates and bicarbonates. Findings of NaCl salts (sea salt) on Deccan Plateau has not been reported from the analyses of basaltic (volcanic rocks) by different research scholars, which suggests that except Lonar, there is no source of NaCl salt (sea salt) found anywhere on Deccan Plateau. NaCl (sea salt) at Lonar Crater Lake is related to the formation of the Crater, since Lonar Crater Lake is 150m below the surrounding region , it is possible that being the lowest part of that region, surrounding rocks during the rainy season may bring the salts through springs in the lake, thereby increasing the salinity of the lake water. Cl content found in the surrounding area is in trace quantities[19]. Therefore the source of NaCl cannot be attributed to basaltic rocks of Deccan Plateau. Also from the physicochemical analyses by A.L. Pawar, it was found that Cl content and salinity of lake water was found to be lower in monsoon rather than pre-monsoon and post-monsoon which shows that if Cl has to come from surrounding rocks, then Cl and salinity of the lake water in monsoon should be higher than the pre-monsoon or post-monsoon, which was not the case. Hence Cl coming from surrounding rocks cannot be the source of high content of Cl[18].

It is postulated that the possibility of NaCl salts at Lonar Crater Lake, therefore, can be from two sources either from the remains of an ancient dried up sea or storehouse of NaCl may be present below the basaltic lava flows which is unknown and from where the source may have been supplemented to lake water making it highly saline at the time the crater was formed. At present, there is no evidence to prove this postulation, but the remains of that ancient dried up sea reflect in the form of NaCl salts at Crater Lake, due to which high salinity is observed. It is commonly known that NaCl refers to sea salt or common salt. Sea salt or common salt is a natural formation and the sea being the storehouse of it, for which the process of its formation is unknown. Therefore at Lonar, there must be a source, without such a source with a large quantity of NaCl is not possible. Formation of NaCl being a natural process cannot be derived from any source other than the sea.

Evidence to support that NaCl found at Lonar Crater Lake is due to the existence of remains of an ancient dried up sea or presence of storehouse of NaCl below basaltic lava flows. 1) Presence of NaCl salt, 2) Sandy type of soil with high % of SiO_2 detected in the form of white rusting of rocks and silica pebbles on the periphery of the lake[24, 25], 3) Arid type of climate similar to desert type, throughout Marathwada i.e., hot summers, cold dry winters, scanty rainfall, 4) Flora- Short and stunted bushes like xerophytes and thorny bushes, e.g. being cacti plants which are usually found in desert, seen throughout Marathwada. 5) Fauna– rattlesnake found at Crater, away from the lake, which is usually found only in the arid type of climates like desert type, peacocks and other fowls found at Lonar and throughout Marathwada, which are found in the arid type of climates like Gujarat and Rajasthan, animals like lizards. 6) Findings of silica pebbles/white pebbles/Lonar pebbles in large quantities at Crater. White pebbles are usually found near river beds or near the seashores. These pebbles contain a high % of SiO_2 i.e., 98% mass[25]. Findings of silica pebbles in volcanic eruption sites or meteorite impact sites have not been reported from anywhere on earth. Hence it is possible that findings of silica pebbles at Lonar Crater may be some indication of the existence of an ancient dried up sea, but due to high salinity, higher than the sea, it is likely that aquatic life or sea flora or fauna is not found. It is also likely that high alkaline

nature of salts like carbonates and bicarbonates present aquatic life is not found in the lake. 7) Halite rocks and calcified sedimentary rocks like Kadappa, Marble, Granite, Shahbadi Ladi, which are alkaline in origin. Rock salt like halite rock salt and black salt (Kala namak) are chlorides in nature.

Though the high salinity is due to a source of NaCl related to an ancient dried up sea, as postulated above, yet no sea animals or sea plants in fossilized form has ever been found nor has any sea related flora and fauna been detected to prove the existence of an ancient dried up sea, the source of NaCl at Lonar. Nandy and Deo also stated that no fossil was detected in the silts in spite of their great antiquity[13]. It is possible that the hot lava flows might have burnt the flora and fauna and sea animals existing at that time into ashes leaving no traces for its detection. The formation of crater gave rise to the lake along with saline and alkaline nature of water. The supplemented salt incorporated from that time persists till date. Addition of water and evaporation takes place year after year, but the salt remains as it is.

The observation through the stereo binocular microscope of all the four salts shows that Lonar salt and sea salt are found to be similar or shows close resemblance, whereas Halite (rock salt) and Kala Namak are found to be similar which shows that there is some similarity or relation between Lonar lake salt and Sea salt. In other words, it can be stated that Lonar salt is nothing but sea salt NaCl, which has also been stated by other workers. Hence from the above results and discussion, it shows that sea salt is the only source of high content of NaCl which exist at Crater Lake and which was supplemented at the time the crater was formed. Hence from that time till date, the salts remained at Lonar. The water comes to the lake through springs near Ram Gaya temple, Sita Nahni, Dhara Tirtha and rainwater during the rainy season, the concentration of salinity decreases, yet it persists. In summers the evaporation of water takes place due to very high temperatures, yet the salts remain there as it is i.e., in other words, it can be stated, the water comes to the lake through springs underground and rainwater and evaporates, but the existence of salt remains. Finally, it can be stated that NaCl salt found at Lonar must be a part of the concentrated sea.

The above sedimentary rocks and rock salts like Kala Namak and Halite rock salt are originated from the arid ecosystem, which is buried under the primitive lava flows. And after meteorite impact on this, have opened that arid ecosystem, which is buried under lava flows and maintained atmospheric pressure or exchange of components with environment to balance the system and due to exchange mechanism caused, a continuous supply of salinity and alkalinity takes place, that's why the water of the lake is having high salinity and high alkalinity.

4. CONCLUSION

From the results obtained through physicochemical analysis of the four salts, the physical parameters, chemical parameters and finally chemical analysis through XRF, their observations through a stereo binocular microscope to study their characteristic features all these shows that there exist some relation between Lonar Lake and the remains of an ancient dried up sea in eons.

From the discussions above and the evidences put forward, it can be said that presence of NaCl salt (sea salt) at Lonar supports the theory or view that in eons before volcanic eruptions of 65Ma could take place, existence of an ancient dried up sea may be possible near or in the vicinity of Lonar or storehouse of NaCl may be present below the basaltic lava flows due to which high salinity is observed, the source of high salinity can be due to sea salt (Nacl salt), which is the only possibility. There is no other possible source to suggest for NaCl to be found in Lonar Crater Lake. This is the best explanation offered as to the source of high salinity of lake water which is due to the sea salt(common salt) NaCl, which was supplemented from below the ground at the time the crater was formed and the lake of saline nature came into existence, from thence onward till date the salts remained there, making the lake water highly saline, otherwise it is impossible for NaCl salts to be found at Lonar whereas on basaltic plateau findings of NaCl salts has not been reported or recorded, in spite of detail work carried out on basaltic rocks of Deccan Plateau, with respect to elemental compositions. It is also possible that rocks like Halite, Kala Namak, which contribute high salinity and sedimentary rocks Kadappa, Marble, Granite, Shahbadi Ladi, limestones that contribute high alkalinity, the same ecosystem which is buried under primitive basaltic lava and after meteorite impact; these basaltic rocks cracked and opened that original primitive ecosystem. In the exchange mechanism to balance environmental conditions, continuous supply or leakage of high salinity and high alkalinity takes place from beneath the primitive ecosystem which is under primitive basaltic rocks, which reflects the primitive ecosystem or existing ecosystem. The buried ecosystem is the only source of high salinity and high alkalinity which is concluded as per our above studies.

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APPENDIX

(a)

(b)

Fig. 1 (a) (b): Lonar lake water kept for evaporation

Fig. 2: Sample of Halite (Rock salt)

Fig. 3: A sample of Kala Namak (Black salt)

Fig. 4: A sample of Common salt (Sea salt)

(a)

(b)

Fig. 5 (a) (b): Salt Samples of Lonar Crater Lake (after evaporation) of lake water

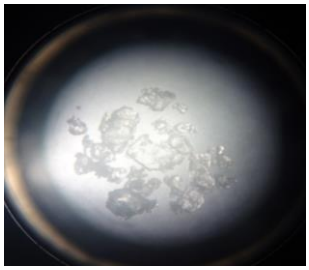

Fig. 6: Microscope observation of crystals of Halite (rock salt)

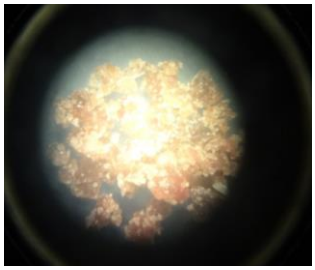

Fig. 7: Microscope observation of crystals of Kala Namak (black salt)

Fig. 8: Crystals of Sea Salt observed under binocular microscope (Lower magnification)

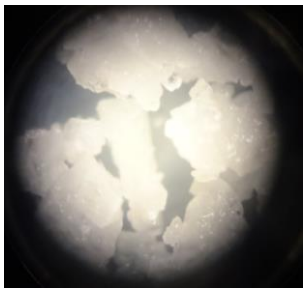

Fig. 9: Crystals of Sea Salt observed under binocular microscope (Higher magnification)

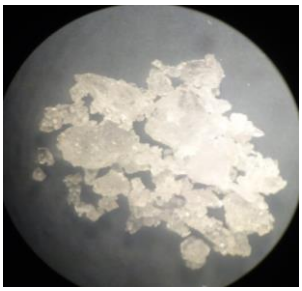

Fig. 10: Microscope observation of crystals of Lonar lake salt (Evaporated)

Table 1: Physico chemical analysis of different salts with respect to Lonar salt

↓Parameters/Salts→	**Halite (Rock salt)**		**Kala Namak**		**Sea salt (Common salt)**		**Lonar Salt**	
	Results	Unit	Results	Unit	Results	Unit	Results	Unit
pH (10% solution)	6.1		8.8		7.5		10	
Sulphate	3493	mg/kg	3639	mg/kg	5002	mg/kg	17676	mg/kg
Chloride	64324	mg/kg	62199	mg/kg	60904	mg/kg	298200	mg/kg
Conductivity	91.8	ms/cm	95.1	ms/cm	90.9	ms/cm	78.4	ms/cm
Salinity calculated from chloride value	116.1	g/L	112.27	g/L	109.93	g/L	538.25	g/L
TDS calculated from conductivity value	135000	mg/L	139852.94	mg/L	133676.47	mg/L	115294.1	mg/l
Hardness	9716	mg/kg	11957	mg/kg	39026	mg/kg	7006	mg/kg
Alkalinity	<1	mg/kg	4433	mg/kg	488	mg/kg	323529	mg/kg

Remarks: All the above results excluding pH are on a dry weight basis

Table 2: Oxide composition of salts by XRF in mass %

↓Formula/Salts→	**Halite (Rock salt)**	**Kala Namak**	**Sea salt (Common salt)**	**Lonar salt**
NaCl	88.403	85.123	70.695	75.138
Oxides				
SO_3	5.804	11.585	16.704	8.621
K_2O	2.656	0.588	2.203	3.687
CaO	2.501	0.613	9.168	3.72
Fe_2O_3	0.636	1.867	0.548	3.334
Br		0.223	0.683	5.5
Total	100	99.999	100.001	100

Table 3: Elemental composition of Different salts by XRF in mass %

↓Elements/Salts→ Formula	Halite (Rock salt)	Kala Namak	Sea salt (Common salt)	Lonar Salt
Na	34.777	33.487	27.811	29.559
S	2.324	4.639	6.689	3.452
K	2.205	0.488	1.829	3.061
Ca	1.788	0.438	6.552	2.659
Fe	0.445	1.306	0.383	2.332
Br		0.223	0.683	5.5
Cl	53.626	51.636	42.884	45.579
O	4.836	7.782	13.169	7.858
Total	100.001	99.999	100	100

Table 4: Physicochemical analysis of basaltic soil near Ramgaya, Lonar Crater

Test Parameters	Result	Unit	Test Method
pH	8.4		SW-846-9045-C
Chloride	51.5	mg/kg	IS:3025(P-32)1988

Table 5: Chemical analysis of basaltic soil near Ramgaya, Lonar Crater by XRF

Element	Mass %	Oxides	Oxide Content
Silicon	40.65	SiO_2	52.114
Iron	26.67	Fe_2O_3	16.847
Calcium	14.2	CaO	10.137
Aluminum	13.62	Al_2O_3	16.809
Titanium	3.03	TiO_2	2.431
Sulfur	0.75	SO_3	1.007
Potassium	0.64	K_2O	0.403
Manganese	0.35	MnO	0.202
Copper	0.05	CuO	0.026
Zirconium	0.04	ZrO_2	0.023
Total	100		99.999

Table 6: Ratios of salts and elemental compositions from analysis of salts and elements with respect to Lonar salt

Ratios	Lonar Salt	Sea Salt	Kala Namak	Halite rock Salt
NaCl: Br	13.66	104	382	
Cl: Br	8.29	63	232	
Cl: Alkalinity	0.92	125	14	
Cl: $S0_4$	17	12	17	18
Cl: Hardness	43	2	5	7
Alkalinity: Hardness	46	0.01	0.37	0.0001

