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MADRAS RECORD OFFICE

GOVERNMENT OF MADRAS

Revenue DEPARTMENT

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Dated	<u>30 Jan</u>	<u>18/4</u> <u>1966</u>

Not to be folded or roughly handled

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1

In reply to your letter, No. 1,400, dated 12th ultimo, requesting information in regard to earth-salt said to be manufactured in His Highness the Nizam's dominions, I am directed to state that a species of edible salt known as Bhooski was formerly manufactured for local consumption from certain saline wells in the Oomraotee District of East Berar; but as it could not compete with the far superior produce of Bombay and Rajpootana, after the opening of the railway, its manufacture was put a stop to under orders of the Government of India in 1868; so that this description of salt has now practically disappeared from the local markets.

2. There are, however, several species of indigenous products, partly saline and partly composed of carbonate of soda, obtained from the Lonar Lake in the Buldanah District of West Berar, and applied to various purposes. Full particulars in regard to this lake, its saline products, their values and distribution, will be found embodied in the accompanying printed report, especially on pages 33—36, 46, and 47.

3. It may be mentioned, in conclusion, that the lake in question was formerly worked by contractors on leases for limited periods, the last of which expired in November 1871, and that the work is now being carried on under the direct management of district officers as an experimental measure.

(True Copy.)

(Signed) D. F. CARMICHAEL,
Secretary to Government

Rajpootana, after the opening of the

No. 269.

To

THE RESIDENT AT HYDERABAD.

Separate Revenue, No. 20.

Salt.

SIR,—In acknowledging your Secretary's letter, No. 3,211, dated 20th January, instant, I am directed to state that the information more par-

ticularly desired regarding the manufacture of "earth-salt" in the territories of His Highness the Nizam has reference not to the assigned districts administered by British officers, but to the area under the Minister's management, and herein especially to the districts lying immediately on the left bank of the Toongabudra and the Kistna, (viz., Moodgul, Raichore, Pangull, Amrabad, Daverconda,) and the Nelgoondah and Kummummett districts between the Kistna and Godavery rivers: all contiguous to portions of the Bellary, Kurnool, Kistna, and Godavery districts of this Presidency.

2. In some of these Madras districts, the salt monopoly has long been injured by the manufacture of very fair salt by a rough process from certain soils where it effloresces. The Governor in Council has passed orders providing for the gradual extinction of this practice; and, if a similar manufacture prevails in the neighbouring districts of Hyderabad, he is prepared, when full information is before him, to propose preventive measures against the entry of Hyderabad earth-salt into Madras territory for the concurrence of His Highness the Nizam's Government, with reference to the Treaty of 1802, Article III.

3. Soliciting the favour of an early reply,

I have the honour to be,

Sir,

Your most obedient servant,

(Signed) D. F. CARMICHAEL,
Secretary to Government.

Vol. of 1874

REVENUE.

To

THE RESIDENT AT MADDURAI.

Field Journey Bill.

Recd.

Recd.

Letter, 20th January 1974, No. 138.

JANUARY.
265
No. 208.

Reference to letter, No. 211, states that the information wanted is as to the manufacture of cartridges in certain specified districts, and that if such articles therein, proposals for preventive measures against its entry into Madras territory will be submitted.

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N^o 3211 - of 1873-74.

From

The Offg. 1st Assistant Resident
Hyderabad

To

The Secretary to the Government of
Fort St. George

Dated Hyderabad Residency 20 January 1874

Sir

In reply to your letter N^o 1400

of 12th ultimo, requesting information in
regard to earth-salt said to be manu-
factured in His Highness the Nizam's
Dominions, I am directed to state that a

species of edible salt known as Bhoske
was formerly manufactured for local con-
sumption from certain saline wells in
the Comraotee District of East Berar;

but as it could not compete with the far
superior produce of Bombay and
Rajpootana, after the opening of the

7/5
and that, the work is now being carried
on under the direct management of
District Officers as an experimental
measure.

I have the honor to be,

Yours most obedient servant

W. H. Jones
Offg. Asst. Resident

Railway, its manufacture was put a stop to under orders of the Government of India in 1868; so that this description of salt has now practically disappeared from the local markets.

2 There are however several species of indigenous products partly saline and partly composed of Carbonate of Soda obtained from the Lonar Lake in the Buldana District of West Berar and applied to various purposes. Full particulars in regard to this lake, its saline products, their values and distribution will be found embodied in the accompanying printed Report, especially at pages 33-36, 46 and 47.

3 It may be mentioned in conclusion that the lake in question was formerly worked by Contractors on leases for limited periods the last of which expired in 1871.

Rev. Sept 25/4
 No 138 30 Jan 1874
 To Resident, Hyderabad

Sir,
 In acknowledging Mr. Lee's
 letter No 3211 of 20th Inst. I am directed to state that the
 information more particularly
 desired regarding the manufacture
 of "Earth Salt" in the territories of H. H.
 the Nizam, has reference not to
 the Assigned districts administered by
 British Officers, but to the area under
 the Minister's management, and more
 especially to the districts lying
 immediately on the left bank of
 the Tungabhadra & the Krishna,
 viz., Moodgal, Raichur, Pangul,
 Anurath, Saverconda; and the
 Nalgonda & Kurnool districts
 between the Krishna &
 Godavari rivers: - all contiguous to
 portions of the Bellary, Kurnool, Krishna
 & Godavari districts of this Presidency.
 2. In some of these Madras districts, the
 Salt monopoly has long been injured
 by the manufacture of very fair salt
 by a rough process from certain soils

LD

25/1

Revenue 1874 Sept 25

From

The Officer in Charge
 Residents
 Hyderabad.

Date 20th January 1874
 No 3211

Referring to letter No 3211
 of 20th Inst. on the subject
 of the manufacture of salt.
 I call on His Highness the
 Nizam's Dominions

1. & No 1382 30 Jan 74

26 Jan 74 Rev. Sept 25/4

where it effloresces. The Govt.
has passed orders providing
for the gradual extinction of this
practice; and if a similar new
facture prevails in the neighbouring
district of Hyderabad, he is prepared,
when full information is before him,
to propose preventive measures against
the entry of Hyderabad East Salt
into Mirdra territory, for the
concurrence of H. H. the Nizam's
Exlt, in reference to the Treaty of
1802, Article III.

3. Soliciting the *26/1-74*
favor of an early reply.

3- Decr 30 Jan'y 74

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General
to the

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Library

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To/Res: Hyderabad

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REPORT ON SALT LAKE AT LONAR.

From Mr. S. A. READE, C. E., Assistant Engineer in charge Bassim Sub-division, to Captain JOHN HILLS, Executive Engineer, West Berar Division, dated 11th September 1871, No. 398:—

In reply to your No. 1,451 of 1871, I have the honor to submit the following Report on the Lonar Lake.

I purpose to divide my Report into three heads:—

(1st.)—A general account of my observations taken at the lake, and of information obtained from the natives.

(2nd.)—Deductions from the above observations.

(3rd.)—Recommendations as to the best thing to be done with the lake.

I shall also compare my observations, as I go along, with the account of the lake and its deposits, given by Dr. George Smith in a Pamphlet published in the *Journal of the Madras Literary Society*; and with the statements of other visitors.

General account of Proceedings at Lonar Lake from June 1st to June 4th 1871.

(1.)—The first thing I did on arriving at the lake was to collect the divers and ask them questions. I had the report of Mr. Laidlaw before me, and the suggestions of Messrs. Reid and Mitchell.

In reply to my questions they stated that in the rainy season the divers always went down to the bottoms of the holes; that no "dulla" was found there; but that it was obtained from the mud which is deposited in the holes either lying on the top, or mixed up with it; that the bottom of the holes consisted of a hard clay of which they had frequently brought up specimens by the orders of their masters; that some portions of the clay contained glistening crystals, but no "dulla."

The most intelligent of the divers, "Ballorecoli," asked me if I considered there was a deposit of salt at the bottom of the holes? and assured me that his ex-

perience had led him to adopt quite the opposite conclusion; he stated that the crystals were brought up by hand, and that no implement was used.

The divers unanimously refused to take me out in the boat on the lake, asserting that the boat was so leaky, I should certainly come to grief if I attempted it. I however subsequently ordered them to take me out, as will appear afterwards.

Trial holes sunk.

On the evening of my arrival I directed Corporal Bayliss (who accompanied me) to set men on to dig a large hole as close as possible to the hollows from which the crystals are obtained, and as the water in the lake was very low, the hole was excavated at a distance of about 200 feet from the centre of the larger of the two hollows.

Second day's Proceedings.

Survey commenced.

On the 2nd day I commenced the survey of the lake, to deduce the quantity of water evaporated per annum, the result is given in Part 2 of this report; I also chained round the upper lip of the crater as near as possible to the edge.

On the third day I obtained the specific gravity of water from different parts of the lake to test the statement that the water near the hollows was more dense than that taken from the other parts of the lake. I levelled from the upper edge of the crater to the level of high water mark. I examined the divers again, and elicited the following items of information from them.

Further examination of the Divers.

"Nimmuck dulla" is found just above the good dulla, and in contact with it. The whole of the dulla is never abstract. In one year, if taken out every year it is found in thin pieces, if left for two or three years the pieces are found thicker. Dulla is sometimes found outside the area of the holes, but is of inferior quality. "Kuppol" is often found outside the hollows; it is a thin kind of dulla, and principally of a red colour.

No movement of the water about the openings has ever been noticed, either upward or downward; the water is colder at the bottom than near the top; the dulla has been found on the sides as well as on the bottom of the holes; hard clay is found on the bottom into which the feet do not sink; the lake has been known to be dry with the exception of the holes in which, however, there was only one foot of clean water above the mud, which latter is seven or eight feet deep.

The natives are most decided in the opinion that the hollows never dry up nor can dry up.

General account of Proceedings at Lonar Lake from June 1st to June 4th 1871.

Third day's Proceedings. Survey continued.

I measured the contents of the deposit of salts round the margin of the lake, it was thickly entrusted with "bhooski" on the north, north-west, and west sides for a distance of 200 or 300 feet from the water's edge. On the east and south sides there is some "papree," which the natives said was not worth gathering; they had been gathering the papree the day before I arrived, but on my arrival ceased, and gave as a reason that a shower of rain had fallen and injured the papree washing it into the soil. I procured some specimens of it, however, which seemed very pure, and were of a white colour, with little admixture of impurities.

The excavation of the whole was continued day and night.

Fourth day's Proceedings.

Examination of the deep hollows in Lake.

On the 4th the men seemed much more willing to assist me, and after some persuasion I got them to launch the boat, having first stopped all holes and cracks with clay; the water in the hole was only an inch or two in depth over the soft slimy mud; the men walked in, and were covered a little above the waists in water and mud until they got the boat into the larger of the two holes when they were obliged to swim; by guaging the depth with an iron rod I found it to be 13 feet, the rod went down easily through the mud to that depth. As far as I could judge by moving the rod up and down, and striking it against the bottom, it seemed to be of clay, and certainly was not of rock. The men easily swam through the mud and water. Large pieces of dulla were found in this mud, the men's feet striking against them, as they swam they picked up several specimens with their hands. One of the men whom I brought with me from Bassim came into the hole at my request, and his feet and legs were cut by striking against the fragments of dulla as he swam, he drew up several large pieces between his feet, some of them upwards of two feet square. I could not induce any of the men to dive, as they thought the mud near the bottom of the hole too thick; but abundance of dulla and nimmuck dulla was obtainable between the depths of two and five feet below the surface of clear water: in fact half a dozen men could have filled the boat with it in quarter of an hour.

Description of Dulla.

The dulla consisted of a close collection of acicular crystals between two compact surfaces; the natives called these crystals teeth.

Description of Nimmuck Dulla.

The nimmuck dulla consisted of the characteristic cubical crystals of common salt of large size arranged mostly in pyramidal forms on a compact mass of the common dulla. These crystals are pure salt.

I remained about ten minutes on the lake while Overseer Bayliss took some levels connecting the bottom of the hole with bench marks on shore.

The quantity of sulphide of hydrogen which issued from the surface of the water when the mud was disturbed, nearly suffocate me, and as the boat was by this time quarter full of water, I was obliged to hasten on shore without examining the second hole. I observed large patches of white flocculent substances on the surface of the shallow water which I conjectured to be papree, and this was confirmed by the natives.

Excavation of hole on margin of Lake.

The excavation on the margin of the lake was carried down to a depth of 12 feet, equal to a depth of 10½ feet below the surface of the water in the lake. The soil was a stiff clay, with an admixture of decayed vegetable substance, which gives it a black colour when first excavated, but by exposure this disappears.

Examination of Substrata.

Iron rods screwed together were driven down to the depth of 18½ feet below the bottom of the hole, at this depth a hard substance was encountered which scraped the point of the iron rod; an artesian spring was tapped. A quantity of gas-bubbles issued from the hole directly the bed of rock was touched, and not before. I collected this gas in a drinking cup, inverted in a basket lined with clay, and examined it afterwards, it was without smell, on applying a lighted taper it burned rapidly with a light blue flame leaving no deposit on the sides of the jar, mixed with an equal quantity of air and fired, it still burned with a blue flame, and without explosion.

Artesian Spring.

Gas.

(4)

Spring Water Well.

I measured the depth of the spring water well near the temple on the margin of the lake, and found it to be 24 feet below the surface of the ground, and by levelling found it to be 18 feet below the surface water in the lake. I brought away a bottle of water from the artesian spring for future examination.

Survey—(Continued.)

I took several measurements and levels about the bed of the lake and across the delta of the principal feeder.

Departure from Lonar.

On the 5th I visited a spring in the town of Lonar which I had been informed was brackish, and took away a specimen of the water. I left Lonar on this day, taking with me specimens of all the salts, of several different waters, and some rocks, &c. I paid all the men employed by me, and left them very well satisfied.

I asked the principal diver to remove the clay from the edge of the excavation to prevent the floods from washing it in and re-filling the hole; and paid him one rupee in advance to do so.

Examination of Lake Water.

The specific gravity of the different waters were taken and found to be as under:—

Description of Water.	Specific gravity registered to 60° Fahrt.
Water taken from large hole	1083
Do. taken from lake at greatest distance from large hole.	1083
A specimen of spring water saturated with a mixture of the different salts taken from the lake	1083
Water taken from artesian spring at a depth of 30½ feet below surface, near large hollow	1010
Spring water 2½ to saturated solution of salt 1	1010
Spring water	1001

Proceedings at and near Lonar concluded.

I examined several old bunds that had been erected to intercept the surface drainage and prevent it entering the lake, all of which had given way.

PART 2.

General deductions.

Lonar Lake is situated at the bottom of a depression which is evidently the crater of an extinct volcano; the nearly circular form, the regular and uniform, and steep inclination of the slopes of the basin, and the character of the surrounding rocks, point to this conclusion.

(5)

Depth of water.

The level of ordinary flood mark is 407 feet below the average level of the lip of the crater,* which is almost exactly 3½ miles in circumference. The inclination of the slope cannot exceed 50°.

Circumference.

The circumference of the lake at high water mark is 1.9 miles, the circumference at the level of the water on the 2nd June 1871, (which may be taken as the lowest level for that year,) was almost exactly one mile. The difference of level between high and low water in 1876-71 was 4 feet, the difference of level between the highest flood and the lowest ebb ever obtained would be about 7 feet. In the first instance the water reached beyond the fresh water well, and in the second it dried up as far as the hollows, these two events have not been known to occur in one season. When Mr. Smith visited Lonar the water had extended round the bowrie of sweet water, and from this he concludes that the lake had extended its boundaries a good deal lately. I do not think this conclusion well founded, for there must have been exceptionally high floods in that year, as it is the only year in which the oldest inhabitant recollects the water of the well having been contaminated by the salt water of the lake, and the natives state it has not reached within about 50 feet of the well since that year; it is clear, however, that as the lake becomes silted up year by year, the area covered by the flood water must extend, as is shown by the marginal figure. The lake is filled from the surface drainage of the land on the north and north-east sides, and principally through a large feeder on the north side. For about three-fourth of the circumference of the lip of the crater the ground slopes back, so that by far the greater part of the yearly water supply passes down the principal feeder, and is derived from the drainage of the country to the north of the lake. There are a few other water courses on the sloping sides, but they are not fed by any considerable drainage area. The perennial spring of fresh water passes down towards the lake through the principal feeder, but as the land situated on what may be called the delta of this inlet is under cultivation, the whole of this water is absorbed and utilized in the hot months, and never actually reaches the lake; this spring and the bowrie on the south side are the only fresh water springs on the margin of the lake that I could see, although Dr. Smith states that there are several.

The boundary of the lake has not extended greatly of late.

But has probably been extending slowly for ages.

The area of the surface of the lake at high water is about 160 acres, at low water on June 2nd 1871 the surface area was 40 acres. The two hollows could not be accurately measured, but judging from the other measurements, the larger of the two hollows cannot be more than 250 feet in mean diameter, and the small one not more than 100 feet; the distance between them from centre to centre is about 500 feet. The whole of the bed of the lake is covered by a deposit of clay, which, judging from the only excavation I had time to make, is about 30 feet in depth; it is a highly argillaceous stiff clay, and if properly worked up, would be impermeable to water; the admixture of some carbonaceous matter derived from vegetable decomposition, would not render it unfit to be used in the manufacture of bricks or tiles, as this matter would disappear in burning leaving a minute quantity of ash.

The deposits of the lake which are at present obtained are four in number, viz., dulla, mimnuck dulla, papree, and bhooski; several analyses have been taken of these salts, and it may be well to give a table comparing those which I have been furnished with, as they differ in many respects, about which difference I have a word to say.

* The depth of the crater is stated by Dr. Smith to be 510 feet, and the outer circumference 5 miles. These dimensions are erroneous.

TABLE I.

Number.	CONSTITUENTS.	DULLA.			NIMMUCK DULLA.			KHOPAL.			PAPREE.			DULLA CHOURA.			BHOOSKI.		
		Mayer.	Lyons.	Reynolds.	Mayer.	Lyons.	Reynolds.	Mayer.	Lyons.	Reynolds.	Mayer.	Lyons.	Reynolds.	Mayer.	Lyons.	Reynolds.	Mayer.	Lyons.	Reynolds.
1	Soda	45.82	29.43	32.8	0.0	29.8	...	40.6	...	...	43.5	11.5	...	27.3	...	...	15.4	4.8	...
2	Carbonic acid	38.00	29.64	34.2	0.0	27.5	...	32.0	...	...	29.1	11.2	...	2.6	...	...	10.6	4.6	...
3	Chloride of sodium	0.61	9.34	2.0	92.9	12.5	...	0.5	...	...	0.4	29.3	...	7.9	...	...	2.6	24.3	...
4	Water and organic matter	13.57	28.45	31.0	7.1	26.2	...	25.1	...	...	26.3	24.0	...	31.9	...	...	15.4	23.4	...
5	Insoluble residue	2.00	3.14	...	...	3.9	...	1.8	...	...	0.8	24.0	...	6.2	...	...	58.0	42.8	...
6	Equivalent of neutral carbonate	77.3	50.3	56.0	0.0	50.9	...	68.5	...	52	71.1	19.6	...	46.7	...	...	26.0	8.3	...
7	Amount of useless matter (columns 4 and 5)	15.57	31.59	31.0	7.1	30.1	...	26.9	...	...	26.1	48.0	...	38.1	...	...	73.4	66.2	...

The analyses of the lake water are two in number, one by a Mr. Malcomson, and the other by Doctor Lyons, the divergence here is very considerable as shown below :—

TABLE II.

Analyses of Lake Water.

	Lyons's	Malcomson's.*
Chloride of sodium	...	...
Sulphate of soda	...	...
Carbonate of soda	405.4	2,030.0
Sesqui-carbonate of soda	6.2	7.0
Carbonate of magnesia	118.37	0.0
Silica	0.00	294.0
Alumina	1.57	...
Volatile and organic	1.40	...
Soda combined as carbonate or sesqui-carbonate	96.20	Trace
Carbonic acid combined as do.	69	142
Total grains of solid matter in 1 gallon	49	151
Specific gravity	559.14	2331.0
		1,000.0

It will be seen in Table (I) that the difference in the results obtained from the analyses is so great in the case of all the salts examined that were the value of the salts to be deduced from the analyses the results would differ very widely.

The important columns in Table (I) are (3), (6), (7); (3) is the proportion of chloride of sodium or common salt; (6) is the equivalent of Na O, C O₂ (neutral

* Malcomson's analyses is given in grains per 1,000 grains of water. Lyons in the usual proportion of grains per gallon. I have reduced them both to the same standard for comparison.

carbonate of soda) on which the value of the salt depends, if it be solely for the manufacture of carbonate of soda; and (7) is percentage of useless ingredients obtained by adding together columns (4) and (5).

I believe the lake deposits have hitherto been purchased solely for the sake of the carbonate of soda they contain, and Doctor Lyons bases the commercial value of the specimens on the percentage of neutral carbonate contained in them.

Taking this view I append a table showing the various values per cwt. on each salt as deduced from the analyses in Table (I). I take as a basis the statement of Doctor Lyons that the value in Bombay of the alkali in 1 cwt. of a specimen containing 50 per cent. of the neutral carbonate is Rupees 12.

TABLE III.

Values of carbonate of soda contained in 1 cwt. of the different lake deposits according to three different analyses.

DESCRIPTION.	Value of Na O, C O ₂ in 1 cwt.					
	Mayer.		Lyons.		Reynolds.	
	Rs.	A. P.	Rs.	A. P.	Rs.	A. P.
Dulla	18	8 0	12	0 0	13	5 0
Nimmuck dulla	...	...	12	0 0	...	...
Khoppal	16	4 0	...	...	12	8 0
Papree	17	0 0	4	11 0	...	...
Bhooski	6	4 0	2	0 0	...	...

In endeavouring to account for the important differences in results of an analyses by Drs. Mayer and Lyons, involving, as it does, the great question of the real value of the lake deposits, I must conclude that fair samples of each particular kind of salt could not have been sent to the latter gentleman; at least in the case of the specimen analysed by him under the name "*nimmuck dulla*," which it is clear was really a specimen of "*dulla*." A glance at Table (I) will show that it scarcely differs at all from dulla except in containing 3 per cent. more of common salt; whereas the nimmuck dulla of Dr. Mayer is common salt (pure and simple) without any admixture of carbonate of soda; and, that such is its undoubted composition, I can confirm myself; the specimens handed to me out of the lake by the divers as nimmuck dulla, were, as I have already shown in the first part of the Report, common salt crystals.

The difference in the case of papree is more difficult to account for, it is so different in appearance from the other salts that the samples could not be confounded, and we are driven to the conclusion that the chemical constitution of the deposit must vary in different years. The same remark applies to bhooski, and as these form by far the greater part of the lake products as at present worked, it would be necessary in future transactions to have these deposits roughly analysed year by year in order to arrive at their correct commercial value. Table (III) shows that papree had diminished in intrinsic value four fold, and bhooski three folds in the interval that elapsed between Dr. Mayer's and Dr. Lyons' analyses, and the corresponding changes in the chemical composition of both substances are no less striking, especially as the nature of the changes has been the same in each, viz., (1) an increase in the percentage of common salt from next to nothing to 25 per cent.; (2) a corresponding diminution in the percentage of carbonate of soda; and (3) the change in the combining proportion of the soda and carbonic acid; the

alkali having changed from the neutral carbonate to the sesqui-carbonate, in both cases supposing the analyses accurate and the same substance (as far as appearance went) examined in both cases, these changes are curious, and if it be true (as a view of Table I would indicate) that there has been generally a large increase in the quantity of chloride of sodium in all the lake deposits, the fact would tend to corroborate a theory of the formation of these salts which I shall give further on, and might be of practical importance in considering the future working of the lake deposits, and the purposes for which the salt is extracted. It is not improbable, however, that the conditions under which the deposition of salt takes place, varying as they must in different years both as regards the rapidity of evaporation, amount of matter in mechanical suspension in the water, temperature, &c., may produce chemical differences in the composition of salts deposited, though the deposits themselves preserve the same or nearly the same mechanical constitution and outward appearance, and I would be far from basing a theory solely on the difference of two analyses taken at different times.

It is enough to point out that no estimate can be made of the theoretical value of the outturn of the lake from data differing so widely.

Table No. II.

Table II shows the difference between Lyons and Malcomson in their analyses of the lake water; it is taken, as of course the total quantity of solid matter per gallon depends on the degree of concentration of the solution, and in this case varies directly as the quantity of water in lake when bottle was filled, so that unless the analyses were taken on the same day, they could not be expected to agree in this point, but the other differences are quite irreconcilable, passing by the fact that one man sets down the soda as combined in the form of neutral carbonate, while the other shows it as sesqui-carbonate, the enormous preponderance of chloride of sodium over carbonate of soda in Malcomson's analysis is inexplicable, as I should expect to find the proportion of chloride of sodium diminish as the concentration of the water increased, as salt crystallizes out before carbonate of soda: he does not seem, either to have burned off his volatile matter while his setting down the soda as sesqui-carbonate was probably mere guess work. I feel quite sure from the look of his analysis that he never undertook the troublesome and delicate operation of estimating the carbonic acid, and I think I may safely dismiss his results as untrustworthy.

I shall use Dr. Lyons' analysis to endeavour to arrive at an approximate determination of the total quantity of the salts (papree and bhooski) deposited on the margin of the lake in an average year.

Estimate of total quantity of salts annually deposited.

The total weight in grains, of chloride of sodium, a gallon of water at the average temperature of Lonar Lake would dissolve, would be about 2,500 grains; as carbonate of soda is more soluble than chloride of sodium, the total weight in each gallon MUST EXCEED this amount, the specific gravity of the water is then 1,083, the specific gravity when Malcomson's analysis was taken was 1,060, the corresponding solid matter in one gallon being 2,300. The total solid matter when Dr. Lyons' analysis was taken was 559 grains, it is therefore probable that the water was taken when the lake was nearly full, and the water considerably below its average degree of concentration. The quantity of the annual deposit, calculated from this datum, will, therefore, be under the mark.

Taking then the carbonate of soda at 118 grains per gallon, and the chloride of sodium at 405 grains per gallon, I deduce the quantities annually deposited as under. The area of the surface of high water and low water in 1870-71 were—

High water ... 160 acres.
Low water ... 40 "

TABLE IV.

Probable quantity and value of salts deposited on margin of Lonar Lake from June 1870 to June 1871.

	QUANTITY.		VALUE.		Total value.
	Tons.	Cwt.	Rs.	A.	
Water evaporated	4,86,160	...	...	...	...
Anhydrous neutral carbonate of soda (NaO, CO ₂) deposited	819	10	24	0	393,360
Anhydrous chloride of sodium Na Cl, deposited	2,863	16	14	0	801,864
Total deposits...	3,683	6	...	...	11,95,224

In the above table I fear I have undervalued the chloride of sodium very considerably, and I have certainly not ventured over the mark in estimating the quantity of salts deposited.

It will be observed that I have made no deductions for the quantity of the salt necessary to raise the residue of the water in the lake from the assumed average point of concentration to complete saturation; but I did not think it necessary to complicate the calculation by introducing this, as my data were not sufficiently accurate, and the difference in the result would be very inconsiderable.

What the table is meant to show is, the approximate quantity of salt deposited on the shore of the lake. But what it shows still more accurately, is the quantity of salt actually procurable if the evaporation can be artificially expedited to such a degree that the same quantity of water which is now annually evaporated may be abstracted from the lake, and evaporated before the natural evaporation from the surface of the lake has had time to raise the solution above the degree of concentration it has acquired when the level of the water is at a maximum. Judging from the appearance of the margin of the lake, I consider it very probable that the deposition of the salt does not begin to take place to any extent until the level has sunk about two feet, which would probably be about the middle of February, under a proper system the four months which have elapsed since the former rains would be utilized in extracting the salt which is now entirely wasted, and when the water in the lake had reached the point of saturation, the greater part of it would have been pumped out and evaporated. Afterwards the process of natural deposition of salt would go on simultaneously with the artificial. But it is obvious to get the greatest advantage out of the lake, the period of natural deposition must be reduced to a minimum, or in other words the water must be pumped out, and deprived of its solid contents as quickly as possible after the rainy season; and none of the salts to be allowed to settle on the margin and bed of the lake.

Papri and bhooski would then be things of the past, and a salt obtained free from sediment, containing only carbonate of soda and chloride of sodium.

The next thing to be considered is the question to which so much importance has been attached, are there inexhaustible deposits of carbonate of soda lying at the bottom of the two hollows at an accessible and easily workable depth?

The question resolves itself into two parts, one of purely scientific, the other of purely practical and commercial interest. They are these: (1) are the saline properties of the lake derived from extensive saline deposits beneath the bed of the lake? (2) are these deposits sufficiently near the surface to be profitably worked? I am sorry I cannot give direct categorical answers to either of these questions; the more so as I gather from the Commissioner's letter that this was the chief point on which he required information.

Theories of the saline properties of the lake.

I could not be expected to see through 13 feet of black mud and water, but I will state briefly what I consider to be the probabilities of the case.

Ordinary theory of a salt lake.

First I must state a fact which has been apparently forgotten by people who have visited the lake, and that is, that the theory of saline springs, or deposits, is not required to satisfy the phenomenon of a salt lake.

Any body of water supplied by inlets draining the surrounding district, and not having any natural outlet *must* in course of time become saline; and the nature of the salts might be expected to depend on the nature of the *soluble constituents* of the surrounding soil and rocks.

In all lakes of this kind, the bulk of saline matter is chloride of sodium, and the lakes are salt for the same reason that the sea is salt, *viz.*, that the water comes in charged with solid matter, and goes out only in the form of vapour, leaving its solid matter behind; this vapour falls again as rain and washes down more soluble salts, and so on until the solution becomes concentrated enough to be called salt water.

A lake situated as Lonar Lake is *must be saline* from the mere drainage of the surrounding land; the presence, however, of such large quantities of carbonate of soda, which seems to have been collected year after year without apparent diminution in the form of dulla, and the fact of its only being found in two hollows in the lake leads me to conclude that the carbonate of soda, and probably a certain proportion of the chloride of sodium, has not been derived from the soluble constituents of surrounding rocks washed down in the course of ages, but is due to saline springs situated in the hollows of the lake.

Dr. Smith's theory of the formation of the carbonate of soda.

The theory of Dr. Smith is as follows: carbonate of lime is washed down from the rocks, and is also derived from numerous springs in the bed of the lake, this meets chloride of sodium issuing from the springs in the hollows of the lake, and the two together form carbonate of soda.

Rejected for three reasons.

This theory I reject—first, because no carbonate of lime is found in the lake water; second, because I cannot see how bi-carbonate of lime and chloride of sodium in solution in water can re-act on each other; and thirdly, because supposing them to do so the only rational formula, according to which the re-action could be supposed to take place would be something like the following $2(\text{CaO}_2, \text{CO}_2) + 2\text{NaCl} = 2\text{NaO}, 3\text{CO}_2 + \text{CaCl} + \text{CO}_2$ because the lime can only be in solution as bi-carbonate, and the resulting salt is a sesqui-carbonate.

According to this theory there ought to be a constant escape of carbonic acid gas from the surface of the lake and the salt, *chloride of calcium* ought to be found in the same quantity nearly as carbonate of soda, (for every 100 lbs. of neutral car-

bonate about 97 lbs. of chloride of calcium ought to be obtained,) but not a particle of this salt has been found either in the lake water, or in the deposits. Further I have seen none of the "*numerous springs charged with carbonate of lime*" in the bed of the lake which is covered by a deposit of impermeable clay 30 feet thick.

Laidlaw's hypothesis.

The next theory is that propounded by Mr. W. Laidlaw, C. E., of Akolah. He supposes the saline properties of the water to be derived solely from the action of the water on "mines" of saline deposits, situated at the bottom of the hollows, and that the top of the mine is in fact the bottom of the hollow. By the word mine he no doubt intends to express a solid layer of considerable thickness.

Now there is no antecedent improbability in supposing that there is a layer of salts, deposited somewhere beneath the hollows, and it is certainly good news, if true.

Mr. Laidlaw indeed does not advance it as a probable theory, but asserts it as an ascertained fact, though he does not give any reason amounting to a demonstration. But we may well forgive him for want of caution if it turns out that he is in the main correct in his statement, and that a workable stratum exists at so moderate a depth.

My own deductions.

I myself guided by my observations and the rough survey I was able to take will give my own theory, which includes part of both of the above. I adhere to the idea of a sodariferous (if I may coin a word) spring, and I think it probable that large quantities of soda salts have been deposited near the site of the springs, most probably in large detached crystals and crystalline masses.

I think that the greater part of the chloride of sodium has been derived from such a spring, but that a considerable portion has also been derived from the surrounding soil and rocks, dissolved out by the action of rain water in the course of ages. I believe the hollows in the lake to have been partly caused by the action of these springs in a way which I shall endeavour to explain immediately.

The facts from which I derive my theory are: *first*, the general inclination of the bottom of the lake towards the site of the hollows; *second*, the depth and impermeable nature of the clay deposit; and *thirdly*, the appearance of an artesian spring of considerable hydrostatic pressure when I bored through the clay deposit to the rock below: the water of which contained a considerable proportion of NaO, CO_2 . I wish I had time to sink a few more trial holes, and probe the depth of the clay deposit in order to come at the slope of the rock below, which would have thrown more light on the subject.

The marginal sketch will give a rough idea of a section across the lake from east to west. It will be seen that the gradient of the bottom of the lake is much sharper on the west than on the east side, if the lines of the shore on both sides were imagined produced below low-water mark, they would meet at the point O, and that point would be nearly the position of the centre of one of the hollows. The same would be approximately true of any other section taken in any other direction, and passing through either of the hollows, both of which are near each other towards the western shore of the lake.

If these hollows were the original vents of the volcano, we might expect the edges to be raised, and the subsequent deposits would follow the contour of the ground, but if we suppose that numerous springs existed along the steep slopes, and at the bottom of the crater form depression, and that these springs were gradually

choked up by the clay carried down from the attrition of the surrounding rocks, the water of these springs would continue to creep along underneath the impermeable stratum of clay *under pressure*, and would all tend towards the lowest points of the depression as centres, whereby uniting their forces, and under an increased hydrostatic pressure, they would exert sufficient force to prevent the deposition of clay in their immediate vicinity, while they themselves would be continually overflowing the clay stratum and depositing their saline constituents.

The deposition of clay would however go on uninterrupted round these centres of greatest depression, effectually shutting out the springs from all other parts of the bed of the lake, except the lowest points, and in this manner large hollows would be formed in the course of time round these points. This is the way in which I conceive the two hollows in Lonar Lake to have been formed.

That numerous springs more or less saline must have issued from various points on all sides of the lake before the thick stratum of clay was deposited, is certain, as the neighbourhood abounds in springs, (the water of one well in the town of Lonar is undrinkable from the quantity of saline matter contained in it,) and the discovery of an artesian spring under the clay still further confirms this.

Further the debris brought down year by year, must have been incomparably greater at first than now, and the depth of clay deposited annually still greater both because the water had further to fall, and because it had a greater length of rock to traverse, and also because it was not retarded by the thick forests that now cover the margin of the lake which now lessen (if they do not altogether stop) the deposition of silt, in the bed of the lake.

A glance at the figure will explain this. While the clay was being deposited between A and B annual increase of depth must have diminished every year, and ceased altogether when the level reached B, and the trees grew up it can be easily understood how the rapid deposition of clay would soon dam up the springs

that formerly issued from the points (b) (c) (d) and (e), driving them down to the point (a) where they united and formed the hollows, as explained above.

These hollows would then be lined by crystals deposited from the solution, which would in their turn be partially dissolved by the water of the lake and disposed all over it, being again deposited in very minute crystals where the water was shallow, (and the concentration and evaporation consequently more rapid,) and in larger crystals where the water was deep and the concentration slow; this explains why *dulla* is found in the hollows of the lake, and *papree* in the other parts.

Again, the first deposition after the rains would take place while the water was turbid, consequently the salts found near the outer margin of the lake might be expected to contain a greater percentage of insoluble residue, than the salts deposited at a lower level, after the water had time to clear itself, and this explains why "bhooski," which is found outside "papree", is so much more impure. Again, as chloride of sodium is less soluble than carbonate of soda, we might expect to find a greater percentage of it in the salts first deposited, and this is confirmed by Mayer's analysis which gives 0.4 chloride of sodium in "papree," and 2.6 in "bhooski."

Lyons' analyses, however, gives rather more chloride of sodium in 'papree' than in 'bhooski,' but then he also gives 24 per cent. insoluble residue in 'papree' against Mayer's 0.8 per cent., so that I think the specimens must have been mixed.

Papree is pure white and first appears in the form of froth on the edge of the lake, where it is afterwards deposited. A specimen I dissolved left no visible sediment in the bottom of the glass.*

I shall now recapitulate the conclusions which I consider the balance of probabilities of the case tend to establish—

(1.)—That the saline properties of the lake are derived, conjointly from surface drainage and from deep seated springs, and from the latter in two ways—directly and indirectly.

(2.)—That the hollows in the bed of the lake are the result of the joint action of several springs, united under pressure in two great centres of action; and of the rapid and continuous deposition of an impermeable stratum by the action of surface drainage in past ages.

(3.)—That the power and hydrostatic pressure of these springs, and consequently the quantity of water supplied to the lake by them has been diminishing year by year for ages, in proportion to the corresponding increase of the thickness of the clay deposit, that these springs are still in action, though the quantity of water supplied by them must be small, owing to the hydrostatic column having nearly reached the height to produce equilibrium.

(4.)—That deposits of valuable soda salts may be expected to be found beneath the bottom of these hollows, *not* perhaps in a continuous mass, but in detached crystalline masses, intermixed with, and alternating with sedimental deposits, and that these deposits do not exceed from 20 to 25 feet to the surface of the solid rock.

(5.)—That it is not proved that the top of a valuable stratum actually coincides with the bottom of the hollows, (13 feet below low water mark,) but that it is possible it may.

(6.)—That the great value of the lake at present consists in the enormous real value of the salts procurable from the lake water by an expeditious system of evaporation, and not in the possible value of deposits beneath the bed of the hollows.

I shall go into this proposition more in detail in Part III. of the Report.

PART III.

Three classes of operations to be considered.

The operations at the lake I shall divide into three principal heads: (1st) Those which have for their object the extraction of the salts contained in solution in the lake water; (2nd) Those relating to the recovery of the *dulla* crystals from the hollows; and (3rd) Those relating to experimental operations to as-

* I may state here that it would be advisable to re-submit the different specimens of the salts to Dr. Lyons for analyses; they should be selected by a competent person at the lake and placed in wide necked bottles, sealed and labelled; and different specimens should be selected from different parts of the lake.

The large accession of chloride of sodium in 'papree' and 'bhooski,' and its preponderance over the neutral carbonate, reduces the value of these salts so materially, that confirmation is required of the analyses.

Indeed it is incredible that a substance containing 29 salt to eight soda would be bought up by dhobis for washing, but if its true composition is 6.04 salt to 71.1 soda, we can understand its value to the dhobi.

certain if there be valuable deposits beneath these hollows and to the subsequent working of them, should the experiments prove that such deposits really exist.

Importance of 1st Class of operations.

Now at the outset I give as it my decided opinion, that (No. 1) and (2), but especially (No. 1) are the operations which should first and foremost engage the attention of whosoever undertakes the working of the lake. No. 3 may turn out a source of profit, which may eventually eclipse (No. 1) and (2), but it is easy to show that to start at once with expensive operations for an uncertain return to the neglect of measures which are sure to pay handsomely for the labour, would be simply to let go our bird in the hand to go after the pair in the bush. When we have safely caged the former, we shall be better prepared (from the knowledge we have acquired by experience) to adopt the most effectual measures for the successful capture of the other two.

If the measures which I shall propose for (No. 2) be undertaken, the recovery of the dulla crystals and the experiment to ascertain the existence of a soda stratum will be conducted at the same time, while the experience we are gaining in carrying out (No. 1) will enable the Engineer in charge of the works to form an estimate of the probable cost of (No. 3) which he would otherwise be utterly unable to do; and lastly, the enormous profits which will be derived from the successful working of (No. 1) and (No. 2) will supply the funds to carry out (No. 3.) Other reasons will crop up as I go along, which will show the unadvisability of carrying out the three operations together (even supposing there were funds available). In order to carry out successfully the first of these operations

For the success of the first operation two things are primarily necessary.

two things are principally necessary (1) sufficient evaporating space; (2) sufficient pumping power.

(1.) Evaporating space.

I have already shown that our great object is to anticipate the natural deposition of the salts in the bed of the lake as much as possible. This can only be done by conducting the water into artificial evaporating beds and depriving it of its salts as quickly as possible, and it is further obvious that our pumping power must be calculated by the quantity of water we are able to evaporate in a given time.

To determine this quantity accurately would be impossible, but we can arrive at an approximate estimate of the minimum, below which our pumping power must not go.

Reid and Mitchell's Evaporating Flat.

Before going into this I shall glance at Messrs. Reid and Mitchell's suggestions on the evaporation of the lake, and unfold the sketch of the system I would recommend for adoption.

Messrs. Reid and Mitchell propose to construct evaporating flats all round the lake and pump the water into them.

The sketch is copied from their Report, the principle is all right, and my proposal is only a modification of it; but in stating that this could be done for a trifling expense, they do not seem to have been in possession of all this proposal involves.

I have no doubt that the sketch in the margin was merely sent as a rough indication of the general plan of their operations, and that they purposely abstained from swelling their Report by going into even the broadest details.

Difficulties to be overcome in conducting Evaporation on the margin of the Lake.

The difficulty in conducting the evaporating operation on the margin of the lake is that the margin is covered at high water, so that the flats could not be constructed until the water had subsided sufficiently to leave a space large enough for the purpose.

This is not likely to take place in ordinary years till the commencement of the hot season, and by that time a large quantity of the salts are ready deposited. Again, if this operation is continued the flats would have to be re-constructed (or at least extensively repaired) every year as they would be covered at high water.

Trees ought not to be cut down.

There is certainly sufficient space above high water mark, between it and the foot of the slope, but this space is covered with a thick forest of trees, which would have to be cut down and removed or burnt. To remove them would be no easy matter, the lake lying on one side and a slope 40° or 50° covered with thick forest and brush-wood on the other, the average height of the slope being 400 feet. To utilize part of the wood on works on the lake would be impossible, as it would be quite unfit for timber structures of any considerable dimensions, nor would it answer for piles for coffer-dams, being too short and too crooked; but supposing the 200 acres of forest cleared away for our evaporating beds, we should find the soil quite unfit for the purpose, being porous and penetrated by roots, whereas the margin of the lake is below high water mark, covered by a thick impermeable stratum of clay, *the very thing we want.*

And lastly (as I have shown before) the effect of clearing away so much forest and underwood, would be to bring down five times as much mud into the bed of the lake, which we decidedly do *not* want there.

Our plan then is not to place our evaporating beds above the present flood line, but to keep back the water from our evaporating beds, if we would avoid their annual destruction.

To do this, two methods may be adopted, and these two methods may be combined. I shall recommend the first method, but do not mean thereby to exclude all considerations of the other, though it would require a careful survey of the country surrounding Lonar and of the lake and a residence of some months at the lake to decide on the best method; I can only in this report indicate the outlines of both.

The marginal sketch is a rough plan of Lonar Lake (A A A) is the steep surrounding slope covered with thick forest; (B B B) the space above flood mark and below the foot of the steep slope, also covered with trees and underwood; (C C C) is the space between ordinary floods and ebbs; (D) the area covered at ordinary low-water; (B B) has an area of about 250 acres; (C C) 120 acres; and (D) 40 acres. By far the greatest part of the water which annually fills the lake comes in by the principal feeder (N.)

First method.

There are two or three minor feeders somewhere about (n) or (u.)

Now if we can shut out sufficient water from the Lake to reduce the area (C C) to say, half of its present dimensions, we have a new space between (C) and (B)

clear of both trees and water where we can construct our evaporating beds, and while we have the same evaporating area, *we have a less amount of water to dispose of*, but that which we have *must be disposed of by pumping*. This is the first method.

Second method.

Secondly, if we allow the water to come in, but confine it by banking all round the area (D), and up the principal feeder (N), and the minor feeders (n) (u) to a sufficient height; and further, if these banks can be formed by material excavated at (D) (D) so as to lower the level of our evaporating beds, then although we should have less evaporating area for the same quantity of water, yet by making our banks high enough, and our evaporating flats low enough, we could dispose of a great part of our water by gravitation. This is the second method.

The letters refer to the plan on page (29); the dotted lines at (C) (C) indicate evaporating beds; b b the embankment; (e) (h) and (h') low water, high water, and new high water marks.

Height of embankment.

The height to which the water will rise can be calculated from the area of present high and low water and the present annual rise. When we have determined the new area to be enclosed by our banks, if we decide upon enclosing the water at the average low water mark, the new area enclosed would be about 70 acres. The average annual rise of the water would be $7\frac{1}{2}$ feet, the required height of the bank about 10 feet, and its length about 10,000 feet. The depth to which the excavation would have to be carried, if we excavate the whole of the available space between the part of the embankment and the trees (e) (c) would be only about 6 inches, so that we could not dispose of the whole of the water by gravitation unless we excavated more material than would be necessary, to form the embankment which would be inadmissible.

Practically we could only dispose of the water between (II) and (h) by gravitation, and pumping must be resorted to, to get rid of the rest, masonry over falls would have to be constructed, and the whole of the embankment would have to be protected on both sides by the pitching; large pipes with high pressure, sluice valves, and other apparatus must be furnished for the escape of the water to the evaporating beds.

The area at present under cultivation at the mouth of the nullah would be covered at high water, and compensation would have to be given to the owners. The material also, though well adapted for puddle, is not adapted for a high embankment unless protected from the weather.

See Appendix.

These and other considerations make me exceedingly doubtful as to the advisability of adopting any plan which involves the construction of large embankments in the bed of the lake.

I have given in the Appendix of this Report, the algebraic solution of the problem involved in the calculation of the earthwork and excavation.

Two operations involved in first method.

The operations involved in first method are principally two.

(1.)

(1.)—Diverting the greater part of the water that comes down the larger nullah N, and excavating a catch water drain along the foot of the slope for such length as may be necessary for the purpose of intercepting any considerable quantity that comes down by the minor inlet, and conveying them to one point where a drain will be provided through the evaporating bed to the lake.

It will not be necessary to construct this drain all round the lake, as I am convinced that except at two or three main inlets, the water which comes down the slopes is sufficiently intercepted by the trees and underwood.

(a) (a) represents the intercepting drain in the marginal sketch; (E) (E) being the evaporating beds; (N) the principal feeder; (L) the water in the lake while the arrow heads denote the diversion and points of ingress of the surrounding drainage water.

The diversion of the main feeder may turn out a matter of some little difficulty and expense. The damming back of the water has been attempted before, and the remains of some well constructed solid looking masonry dams are still to be seen.

The dams were constructed near the edge of the steep incline down which the water rushes to the lake. They gave way, not by yielding to the hydrostatic pressure, but because the water first made its way through the porous stratum. This is evident by the appearance of hollows, a short distance behind the dam caused by circular movements of the water above the vent.

This space to be obtained by diverting some of the drainage.

end in failure, what we must do is to seek other natural outfalls for the drainage, and conduct the water there. Not the whole of the water that finds its way into the lake, but part of it.

But not the whole of it.

Even were it possible.

Why?

It is quite clear that to attempt to dam back a large quantity of water, after it has reached the edge of the lake, is wrong in principle, and would end in failure, what we must do is to seek other natural outfalls for the drainage, and conduct the water there. Not the whole of the water that finds its way into the lake, but part of it.

I would take this opportunity of observing that I disagree with the principle laid down by Messrs. Reid and Mitchell, that our first object is to get rid of the water, and that since we cannot do it by drainage, we must do it by evaporation as a kind of "*dernier ressort*."

I look upon the water as our great ally and auxiliary, it gathers up all the valuable salts from the soil at the bed of the lake, and also from the hollows, and will lay the burden wherever we require it, and will then vanish into thin air.

If we could only construct a drain to carry the salt water to the nearest salt market, and there evaporate it, we would find it to be the cheapest carrier we could employ, I believe that the bed of the Lonar Lake is so rich in salts (that even supposing no supply came from the hollows) the water which annually comes in will take up and deposit in our evaporating beds untold wealth for years to come, and in

Water is the cheapest carrier.

The difficulties of mining in the present state of affairs.

fact it is a question which only experience in the working of the lake can solve whether it would now be worth our while in the event of our discovering Mr. Laidlaw's mine, to attempt to gather the riches ourselves, forcibly ejecting our supposed enemy water? or whether we would not act more wisely in welcoming aquarius as a faithful friend, employing him to extract the salts from the depths of the mine, and to deposit them clean and pure in our evaporating beds.

The expense and labour, and constant watching to keep back the water, from a mine in the bottom of a lake, without an outlet; the probability (and I have already shown it to be no slight one) of tapping strong artesian springs in excavating the clay; the difficulty of the conveyance of elaborate and costly machinery, would make the working of a mine a herculean labour in such a situation.

The question, however, is not to be hastily decided.

It is a grand engineering principle never to fight against nature, if we can see a chance of working with her, and although it would be the height of folly to speak dogmatically on a subject of which we have at present so imperfect a knowledge, I cannot help thinking that to commence working a deep deposit of salt now, supposing we find one in the bottom of those hollows, would be in effect to kill the goose for the sake of the golden eggs.

Difficulties of mining.

I lay stress on the adverb *now*, for as time advances, roads, railways, and canals open up the resources of the country.

Because the advance of time changes the conditions under which we work. May aid us to grapple with greater difficulties.

Lonar Lake, coming every year more renowned for the extensive yield and large profits of its salt works (conducted on the evaporating system) the conditions of the problem will be altered altogether. The easy transit of machinery and the European Lines, the cheapness of coal, owing to the proximity of the coal mines in the Nizam's territory, (just discovered,) and other things too numerous to mention, would then render it advisable to commence the working of the salt and soda mines at Lonar on an extensive scale.

We have, in fact, a case almost completely parallel in the workings of some of the Cheshire salt mines in the early part of the 17th century. The salt was obtained from the brine springs above, but when coal began to be worked, and mining operations were better understood, the salt deposits from which these springs were derived, were discovered and worked, and the evaporation from the brine springs discarded.

Division of some of the drainage.

I would, therefore, advise as much water to be diverted from the lake as will give us room enough to construct our evaporating beds round the margin AND NO MORE.

I regret I had no opportunity when at the lake of examining the lie of the ground up the nullah, which forms the principal feeder of the lake. I had intended including this in my survey, but the monsoon broke on the 4th of June, and I was obliged to return to Bassim as quickly as possible, without exploring the matter.

There cannot possibly be any engineering difficulty in diverting the water; at least none of any magnitude. For the lake is situated on the ridge which divides the water shed of the Paen Ganga from that of the Poorna, and the water can be carried down at either side of this ridge. Messrs. Reid and Mitchell state that the

lake is situated at the lowest point of the surrounding country, which is a curious mistake. Of course if it were, such a diversion of water would be impossible.

I have stated before that this might be a matter of some difficulty and expense, not arising, however, from the relative levels of the country about, but from the hard rocky nature of the ground in the neighbourhood of the lake. The cutting, however, would not require to be of any great length; and I do not anticipate that the expense of the work would be disproportionate to the advantages gained.

I cannot give any probable estimate of the cost without again visiting the lake, but I would suggest that a competent Engineer be sent as soon as possible to take a series of contour levels about the lake, especially on the north and north-east sides, with a view to determine the least expensive and readiest mode of diverting the water.

Once the channel for diverting the nullah was excavated, we could regulate the quantity to divert by sluices if necessary, but it is probable that the whole quantity we should be able to divert would not be in excess of our requirements, as we should certainly have to commence the point of diversion some distance up the nullah, and the whole of the drainage between that point and the lake would find its way to the latter; for I am entirely against any scheme for constructing reservoirs at the upper edge of the crater without any natural outlet.

I again repeat that the sooner an estimate is made out for this part of the scheme the better, as it is the first and most important thing to be done.

Details of system of evaporation.

Having thus laid dry the space to be occupied by our evaporating beds, we may next proceed to consider the principal features of their construction and their probable cost.

Description of plan.

The plan furnished with this Report (No. 1) will give a general idea of the scheme.

My proposal for evaporating the lake water at Lonar consists of ten principal parts: (1st) Settling tanks and filling tanks for the purpose of separating all matter mechanically suspended in the water; (2nd) Two main feeding channels running in opposite directions round the margin of the lake with a slight fall (C) (C); (3rd) The evaporating ponds (D) (D) (D); (4th) The crystalizing ponds (E) (E) (E) where the salts will be separated; (5th) The distributing channel (G) which collects the water from the evaporating ponds and distributes it to the crystalizing ponds; (6th) (H) The drying ground on to which the crystals of common salt are to be raked out of the crystalizing ponds; (7th) The road on to which the crystals of carbonate of soda are to be collected, after the solution in the crystalizing ponds is evaporated to dryness, and over which the products of the lake are to be conveyed to market; (8th) The pumping engines (K) of which more hereafter; (9th) The low embankment (L) constructed at the probable future level of high water, when part of the drainage shall have been diverted, to be about three to four feet high, for the purpose of guarding against unusual floods; (10th) The main intercepting drain which takes the drainage from the minor inlets and conveys it to the main feeder; (F) (F) (F) are the sites of certain mechanical means (involving the employment of animal power) to effect a more rapid evaporation of the water if necessary, of which more hereafter.

Details of system of evaporation.

The plan is not meant to give anything more than a general outline of the principal features of the scheme I propose. The dimensions of the channels, area of evaporating and crystalizing ponds, &c., are only roughly indicated.

The embankment at L L will be carried round the probable future high water level of the lake, and must end off where the natural ground is of the same level as the top of the bank.

Something in the way shown in the plan, the main intercepting channel (M) will discharge at this point.

The pumping station will be fixed at (B) both because the inclination of the shore is here steepest, (and therefore the horizontal distance over which the water is to be conveyed least,) and also because it is nearest to the deep hollows in the lake. The water will pass from the lake to the pumping wells, and from thence will be raised to the settling tank (A) which will be about 200 feet long by 50' wide by 40' deep, and will be constructed partly in embankment to give a sufficient fall to the filtering tanks (B) (B), whose dimensions may be 100 x 20 x 6. The outlet of B B

will be fixed at a lower level than the inlet to allow sufficient head of water in the hinder compartment to drive the water upwards through the filtering bed, which will be filled loosely with ballast made by burning the clay of the lake; from (B) (B) the water will pass along (C), then backwards, forwards, and again backwards through (D) (D) (D), each of whose beds are at different levels to suit the inclination of the ground, the water being compelled by the partitions to take the circuitous route indicated by the arrows.

From the lowest tier of the evaporating beds, the water will pass to the distributing channel (G) (G), from whence it can be let into all the crystalizing ponds simultaneously by opening the plugs in the orifices, as shown in the plan.

Here the water is supposed to have arrived at its greatest degree of concentration, and to be on the point of depositing its crystals, this will take place in the ponds (E) (E) (E).

The solid matter in solution being a compound of common salt and carbonate of soda, the crystals of the former will separate first and appear on the surface of the water. They must immediately be fished out and deposited in small heaps on (H) (H) (H). The instrument with which this is to be effected will be some kind of rake or perforated hoe with a long handle.

After all the common salt has crystalized out, the mother-liquor will be left undisturbed until it is nearly all evaporated when the carbonate of soda will be collected pure.

Certain thick lines drawn right across the three tiers of bed D D will be observed in the plan—these are small banks intended to divide the evaporating beds into separate compartments, so that if the water is sufficiently evaporated before passing through the whole length of the beds (D) (D), means will be provided of letting it direct into the crystalizing ponds E E.

The degree of saturation of the solution will be determined by hydrometers, a few of which will be furnished to the foreman of the works.

To guard against any unusual rush of water down the steep slopes, where an intercepting drain is not provided (which might happen after an unusually heavy fall of rain), the feeding channel (C) (C) will be connected with the lake by underground pipes or drains shown by the dotted lines (N) (N).

The degree of saturation of the solution as it issues from the filtering beds will always be noted, and the foreman will be able to determine through what length of evaporating beds the water must pass. This will of course vary according to the season, and as it might happen that the water might not have reached a sufficient degree of saturation on arrival at the crystalizing ponds, additional means of evaporating the water with rapidity may occasionally have to be adopted.

I have provided space for this purpose at F F F.

I shall notice three methods of accelerating evaporation any of which may be adopted, but I should recommend the third.

The first is the "Maison d' Epines" employed in Saxony for the evaporation of the weak brine springs, which are only slightly impregnated with salt; second is the "Maison de Cordes" also employed in Saxony for the same purpose; and third is a method of my own, not yet employed at any salt works.

For the first method, the brine is pumped into a reservoir, from whence it flows into the troughs of the thorn house. A number of horizontal pipes convey the brine from these troughs in a thin stream from which it slowly drops upon the wall of black-thorn fagots. A sloping board prevents the wind which passes through the thorns from giving a wrong direction to the falling drops, and the whole is covered with a roof to prevent rain water from mixing with the brine. The water can be carried to the opposite sides of the thorn-wall by moving a lever, whereby certain channels are closed and others opened.

The brine thus slowly trickly through the thorns exposes a large surface to a constant current of air which carries off a large portion of the pure water and leaves the brine which falls into a lower tank much stronger than before.

The pumps which serve to raise the brine are situated in the central part of the works, and in Saxony are usually worked by a hydraulic wheel.

"Maison de Cordes."

The second method is conducted on the same principle. The "Maison de Cordes" is much stronger than the "Maison d' Epines," the roof being supported on a number of arches of masonry, the intermediate spaces on the sides being left open.

In each of the divisions there are 1,200 cords in rows of 24 each, suspended from the roof and fixed tight at the bottom. The cords are about 16 feet in length. The water is raised to a reservoir at top of the building, and distributed by a number of small transverse canals, each row of 24 cords, having one of these canals over it, which is so pierced as to admit the water to trickle down it, drop by drop on each separate cord.

This contrivance may be used in two ways; first, for concentrating the brine as in the "Maison d' Epines;" and second, for crystalizing the salt itself upon the ropes.

In the Saxon salt works it was first used to crystalize the salt from the water which had been previously boiled in the pans. The residue water after the first boiling by repeatedly passing over the cords deposited its salts in 45 days, and the cords were encrusted with a cylinder of pure salt, which was broken off by an instrument adapted for the purpose.

Objections to both these methods.

It is obvious that the great objection to either of these methods is the repeated pumping of the water from the troughs underneath, to those above the cords and thorns, but it also necessitates a somewhat elaborate timber structure, which is also objectionable, and especially in this climate where wood is so apt to warp and crack, when alternately wetted and dried.

No. 2, however, is worth a trial.

Of the two methods, the second seems to be better adapted to our purpose at Lonar, and might be used to finish the deposition of the soda, after the salt had been abstracted in the crystallizing beds.

It would certainly be a very convenient form to get our soda in solid cylinders the thickness of a man's wrist.

It would be entirely a question as to whether it would pay for the repeated pumping or not, whether or not we should adopt it. It would be well, however, to make a trial of it, for the purpose I have mentioned on a small scale, viz., as a final operation for the deposition of the crystals, not as an intermediate one.

And under certain conditions would prove most effective.

For the concentration of the liquid in the event of a continued high wind blowing steadily for several days, this would be a most effective mode of operation.

New method of accelerating evaporation proposed.

The third method involves the use of that invaluable material, for the introduction of which into this country, Engineers should be ever thankful, I mean *corrugated iron*, and would be employed principally both for the rapid concentration of the liquid and the final deposition of the salts.

The construction of the apparatus would be simple, and its operation effective, as it would utilize a much larger proportion of solar heat than either of the two former methods.

It would also possess the great advantage of not requiring the water to be pumped, although mechanical power is used in working it.

The skeleton drawing in the margin will give an idea of the apparatus.

A sheet of any convenient length or breadth formed by rivetting corrugated iron sheets together, works on a pivot at (O), between two channels (A) (A).

As the sheet alternately rises and falls by a force applied to the rope (S), passing over 1 or 2 pulleys (P) (P); (1) if it is worked by men, 2 if it is worked by bullocks, a certain quantity of water is taken up from one channel and allowed to run down the inclined plane into the other.

By repeating the operation the water in the channels would soon become highly concentrated, especially if two sets of these apparatus were provided, No. 1 being worked, while No. 2 was being heated by the sun, and when it was being cooled by the passage of water along its surface, and its constant evaporation therefrom, No. 1 would be getting heated.

Two modifications of the new method.

(W) indicates that a counterpoise at one end is necessary. This would be used in concentrating the solution, but it could easily be adapted for the final operation of crystallization on the principle of the "Maison de Cordes," by attaching ropes along each valley of the corrugated iron.

New method of accelerating evaporation.

Two modifications of it.

The working of it then would be slightly different. Instead of a continual oscillation, a man would pass along a row of sheets tipping them up as he went.

Method of working it.

The water would then trickle down each of the ropes, which would take a certain time to dry. By the time the man arrived at the last sheet of this row, the ropes on the first sheet would be dry, and he would then recommence, tipping them up the other way, and in a very short time the salt would crystallize on the ropes.

The great heat absorbed by iron sheets from the sun would soon dry the ropes, and if the corrugated iron was blackened, the heat would be almost sufficient to boil the water as it trickled down the ropes.

Compared with the "Maison de Cordes."

This contrivance would possess all the advantage of the "Maison de Cordes;" would be much more effective (especially in the hot season,) and requires no expensive apparatus to work it. It could be erected for a fraction of the cost of the "Maison de Cordes."

When the cords were encrusted with a cylinder of the carbonate of soda they could be easily removed and fresh cords attached. If the sheets were completely level, each cord would be wetted by the water passing down the nullah, while it would be placed in a kind of reverberatory furnace, exposed to the action of the sun.

Used for crystallizing the carbonate of soda after the common salt has been extracted.

This apparatus would probably be used most advantageously for completing the evaporation of the mother liquor, after the crystals of common salt had been separated in the ponds (F) (E).

The rope deposit would be nearly pure carbonate, and would probably be known in the market as "sootli ka dulla," and ought to fetch a higher price than the present dulla.

System of evaporation concluded.

Recapitulation ten heads.

I shall now recapitulate the principal parts of the evaporation scheme—

- (1st.)—The greater part of the water which comes down the principal feeder to be directed at some distance from the upper edge of the lake.
- (2nd.)—A low bank to be constructed round the probable line of high water to guard against floods.
- (3rd.)—An intercepting drain to collect the water from the minor inlets, and convey it to the north of the large inlet.
- (4th.)—Settlement and filtering tanks.
- (5th.)—Evaporating ponds in which the water is always in motion in one shallow sheet.
- (6th.)—Crystallizing ponds in which the common salt is first collected and afterwards the carbonate of soda.
- (7th.)—Special means of accelerating evaporation.
- (8th.)—Special means of collecting the soda.
- (9th.)—Main feeding channels.
- (10th.)—Distributing channels.

Three great objects are to be obtained by this system—

(1st.)—The operations to be constantly going on during the season, the water being evaporated in the crystallizing beds as fast as it is supplied from the filtering tanks in order to effect the complete evaporation of the water in the lake.

(2nd.)—The salts to be obtained free from insoluble impurities,* which is the object of the settling and filtering tanks.

(3rd.)—The carbonate of soda to be separated from the chloride of sodium, so that neither will require any further purification for the market.

As regards the cost of this system, I am not in a position to make an estimate, which would be accurate enough to serve as a guide.

The point of greatest uncertainty (as I have before shown) is the extent and cost of the diversion of the drainage.

The works I have described in the bed of the lake ought to be carried out, very cheaply, there is no essentially expensive item in them, and almost all the materials required are found on the spot. What brickwork is required will be constructed of bricks made from the clay of the lake and burnt at site, and I have no doubt that after a little time, glazed earthenware drain pipes of first rate quality could also be manufactured there. A few of these will be required. The clay is of first rate quality, and there are in abundance the very materials we require to make a good permanent glazed pipe, salt, and soda.

The levelling and laying out the evaporating beds can be done for a trifling cost, and the wood that may be required for sluices can be cut from the trees that grow on the edge of the lake.

The corrugated iron for the apparatus I have proposed, would be the only expensive item, and I am convinced it would well repay the money laid out on it.

Pumping power

I shall now pass on to the consideration of sufficient pumping power.

This subject resolves itself into two independent problems: (1st) The magnitude of the power required. (2nd) The agency employed to produce it.

The magnitude of the power required depends on the resistance to be overcome, which in this instance depends on four independent quantities, viz:—

(1st.)—The weight of water to be raised.

(2nd.)—The average height through which it is to be raised.

(3rd.)—The time in which it must be raised.

(4th.)—The duty of the machine employed.

By the duty I mean the percentage of the effect produced to the power applied.

Now we can easily get numbers, sufficiently near the truth for our purpose to determine the magnitude of our pumping power.

* A layer of charcoal might be laid over the burnt ballast in the filtering beds to promote the oxidation of the saline organic matter.

I take the total quantity of water in the lake after the rains to be 600,000 tons (exclusive of deep holes). We must divert at least one-fourth of this, (probably a much larger proportion), the quantity to be disposed of will then be for the future 450,000 tons, which is about the quantity annually raised by evaporation in six months at present. The exposed surface being reduced by diverting the water and constructing a small embankment to about half its former area, the quantity which the sun will take up annually will be reduced to 225,000 tons in six months.

Further, formerly the water was saturated when 225,000 tons had been abstracted, but now as 150,000 are kept out of the lake altogether, the water will be saturated when 75,000 tons have been abstracted; and at the rate of 225,000 in six months, the sun would accomplish this in two months.

Now I have before shown, that to make the most of the lake, we must have got rid of all the water, by the time it has become saturated. That is we must pump out $450,000 - 75,000 = 375,000$ tons of water in two months. We have thus disposed of questions (1) and (3).

The average height to which the water will have to be raised will be only four feet, but let us take it at five feet.

Then 375,000 tons raised five feet in two months, equals
 1,875,000 do. raised one foot do., which equals
 31,250 do. raised one foot in one day, which equals
 1,302 do. raised one foot in one hour, which equals
 21½ do. raised one foot in one minute, which equals
 48,720 lbs., which equals one and-a-half horse power.

Allowing the power applied to be double the effect produced we should require a three-horse power engine working 24 hours a day; or say a 10 horse-power engine working eight hours a day for two months.

Agency to be employed.

Now I should not think of recommending such an engine to be erected at Lonar Lake.

I need not go into the details of such an undertaking including carriage of steam engine, boiler, pumps, air vessel, steam exhaust, suction, and delivery pipes, girders', filters', and stokers' tools, &c., erection of engine house and fitters' cottages, cost of coal, fitters' wages, engineers' and stokers' pay.

Nothing less than the discovery of a gold or diamond mine would justify such expenditure in an out-of-the-way place like Lonar.

Pumping Power Agency to be employed.

From my own experience of pumping engines at home, I am of opinion that the most suitable engine, and the most economical for pumping continuously a moderate quantity of water is the double acting rotative beam engine working expansively (a first-rate example of which may be seen at the Warwick Sewage Irrigation Works designed by Mr. Latham, and erected under my superintendence), but the difficulty of carriage precludes us from erecting such engines in this country.

In the event of discovering large and valuable deposits in the hollows of Lonar Lake steam pumping power might be requisite, and I shall describe further on the kind of engine I should recommend for that purpose. But in the mean time I should use animal power to supply the water to our evaporating beds.

In looking about for the best means of raising water in use in this country, I was shown by Captain Mackenzie an article in the *Economist*, describing the bucket pump used in the Government Experimental Farm near Madras, and it seems to me to be just the thing for our purpose. It is worked by bullocks, and is very simple, effective, and not liable to go out of order.

The pump I allude to is Messrs. Burgess and Key's bucket pump, as improved by the Honorary Secretary to the Government Experimental Garden near Madras.

By this pump a pair of bullocks raise 61,500 gallons of water 18 feet high in eight hours. We will compare this with our requirements at Lonar Lake—

61,500 gallons 18 feet in eight hours, equals	do.	which equals
615,000 lbs.	1 foot	do.
11,070,000 do.	1 do.	one minute.
23,662 do.	1 do.	do.

This result is equal to about half the power needed, so that two of these pumps working continually for two months would give us the required power.

It will be recollected that the rate of pumping will be limited by the rate of evaporation, and that the above calculation supposes that our evaporating bed will enable us to get rid in two months of three-quarters of the quantity of water that the area at present abstracts in six. I have every expectation that they will be equal to the task; and if so, we shall have four months to explore the hollows.

Taken of the lake being dry all round them, add another month, and it will give sufficient margin for all contingencies, and we can safely assert that we shall have finished our evaporating operations by the end of March at the furthest.

I append in a note an extract from the *Economist*, describing the bucket pump, and giving the details of its cost.*

We have come to the consideration of the two hollows, the recovery of the dulla, and examination of stratum. These hollows are 17 feet deep in the rain—about 7 feet clear water and 10 feet loose mud.

When the lake is laid dry all round them they will be found to be ten feet deep and filled with slimy slush of the consistence of custard for five feet deep, increasing in thickness with the depth.

Mr. Laidlaw reports a crust of dulla one and half inches thick overlying the sticky mud, from my own observation and personal examination of one of the holes, I conclude that there is no such continuous layer, but that the dulla exists in large pieces in different depths, mixed all through the loose mud.

The original bucket pump was sent from England by Messrs. Burgess and Key, it raised 20,723 from 17 to 20 feet in eight hours, the cost per ton of water raised is—

	Rs.	A.	P.
Original cost of pump	700	0	0
Bullocks, labour	700	0	0
Interest, wear and tear at 15 per cent on 700 Rupees	8	12	0
Price of bullocks and drivers	21	0	0
Total monthly cost	30	12	0

The Honorary Secretary to the Government Experimental Farm improved the bucket pump, and 61,500 gallons were raised 18 feet high in 8 hours at the same cost, viz., for 1 Rupee.

Captain Mackenzie, in his report published in the *Deccan Gazetteer*, and after him, Mr. Laidlaw asserts that if the dulla is not recovered before the water of the lake dries up to a depth of four feet it cannot be recovered at all that season: (1st) because the mud becomes too thick for the men to dive into it; (2nd) and because the water is not sufficiently buoyant at that depth.

Now the first proposition is correct, the second erroneous, and the conclusion erroneous.

When the water is deep, the men must dive to reach the dulla, when the water is shallow the men cannot dive, because the mud is too thick, and the water too buoyant; but then they can reach the dulla without diving, and as may be supposed, recover it much more readily.

Dulla Fishery.

There may be other reasons and weighty ones for the dulla fishery being stopped in the hot weather, probably the alternate basting in saturated brine and roasting in the sun is not agreeable, and I can myself bear witness that the inhalation of sulphide of hydrogen is rather unpleasant, both of which evils must be greatly mitigated in the cold weather. Nevertheless the fact remains that the dulla can be recovered in large quantities in the hot weather, as also appears from Part 1 of this Report.

Now what method shall we take for the better obtaining of the dulla—a dredging machine is inadmissible—so is a diving bell. To construct a coffer dam round the holes and lay them dry by pumping merely for the recovery of the dulla would never pay.

If we had a good barge moved over the holes some species of landing net might be contrived, or better still the spoon and bag contrivance which is sometimes used in small dredging operations, but I think I shall recommend the system at present adopted to be continued, providing the divers wear diving dress and helmet. A barge of sufficient dimensions would be constructed to collect the dulla on which would be fixed the small pump or bellows necessary to supply the divers with air. This apparatus ought to be easily procurable; it is in common use at home for moderate depths. With it one diver could do the work of a dozen, and could at the same time examine the bottoms of the hollows and excavate specimens of stratum.

A barge sufficient for the purpose or even a common raft could be made at the site of the lake.

Mr. Laidlaw's experimental tube for examining bottom of hollows.

Mr. Laidlaw's suggestion of a sinking a ten foot square box 18' long of two inch planks, open at both ends, might be adopted for the examination of the bottom. There would probably be some difficulty in preventing the water from coming up underneath the sides of the box—bags of clay placed by the divers all round the lower edge of the box would prevent this.

Proposed improvement on it.

Instead of a wooden box, however, I should recommend a cylinder of corrugated iron 4' diameter 16' long, formed by rivetting together sheets bent to the proper camber—18 sheets only would be required—3 wrought iron hoops bolted inside, would make it rigid enough for any thing, and we then have a light strong portable structure easily sunk, and not liable to warp, shrink, or crack.

The recovery of the dulla crystals would of course be carried on the same time as the evaporating operation.

The last point to be considered is the working out of the mineral deposit.

Mining operations.

Having got down our corrugated iron cylinder, removed the water and mud from the interior and revealed to view the glittering surface of the solid deposit of dulla crystals, (always, supposing we are fortunate enough to find it there,) the next thing to ascertain is its *depth*, and the nature of the substratum.

Trial boring.

If we find the depth very considerable, and an *impermeable* stratum underneath, the circumstances will be most favourable; but if we, on the other hand, find the depth inconsiderable, and an artesian spring underneath, the circumstances would be least favourable to the success of working the mine.

This must be ascertained by *boring*, boring apparatus is very simple and easily procured.

In this case I would proceed as indicated by the sketch in the margin.

Two strong rafts (B) and (C) moored at each side of the shaft, and further secured by being fastened together by *chains* and planks, and also by ropes to opposite sides of the shore. The sheer legs A B C are supported on the rafts, a double pulley is attached at A. The boring rod D is turned by men at the bottom of the shaft (i. e., the corrugated iron cylinder,) and is raised by two winches fixed on the rafts, the third leg of the sheer legs rests on a plank supported between the two rafts or barges, the boring rods are of course attached in separate lengths as the boring proceeds.

In a soft stratum like dulla the boring could be carried to a considerable depth without the use of the winch.

Should the experiments warrant us to proceed further, the next thing to be done is to construct a coffer dam* *round* the hollows, and apply steam power to clear the interior of mud and water.

I fear the coffer dam recommended by Mr. Laidlaw, although easily constructed and admirably adapted where small spaces have to be enclosed, would not be strong enough to enclose such a large area as is here required, the dam would yield by the sliding of the boxes on the bottom, and the water would find its way underneath. We should then have to resort to strutting and propping, and in the end it would be no cheaper than the ordinary dam.

My experience in dams has taught me that too much money, labour, and care, cannot be expended in making them tight and strong in the beginning; it will save no end of expence afterwards in stopping leaks and adding props and supports, &c.

* *Coffin Dam*.—Whatever kind of dam is constructed must extend the full depth of the hollows, and a space must be dredged, or otherwise cleared out to effect a water tight juncture between the puddle wall and the bottom of the hole.

I shall only add that a coffer dam for Lonar Lake must be constructed on the best principles, and must be a very expensive structure.

Pumping Engine.

I shall now consider briefly the kind of engine we want to pump* out the water. I have before shown the kind of engine we do not want.

We cannot erect a large stationary engine in Lonar Lake, and carry on the business profitably, of that I am firmly convinced.

It is true that under ordinary circumstances a large engine is more economical than several small ones aggregating the same horse-power, but (1) the conditions under which we work at Lonar are extraordinary; and (2) it is probable that a very moderate pumping power will be sufficient, and in the not unlikely event of strong artesian springs being tapped, in the course of our mining operations, I should recommend the operation to be abandoned, or at any rate postponed, until the march of civilization in this country should enable future Engineers to start the work under more favourable conditions.

The kind of engine I would recommend then would be one that (1st) could be brought out entire and not in pieces; (2nd) one that could convey itself and all its appurtenances at a good speed from the nearest railway station to Lonar along the present native roads; (3rd) one light enough to work on such a timber staging as we could erect for it at the lake; (4th) one adapted to work a centrifugal pump; if one engine of this kind was found not to be sufficient, then I should recommend two, and if two were not sufficient three, and so on.

Now there is a kind of engine which I have seen at home, which I think with some slight modification could be made to fulfil all these conditions.

It is true that an ordinary agricultural engine would answer our purpose if it could be brought along the roads without injury, but such would not be the case, besides the expense of bringing it would be dead loss.

I would therefore, if possible, choose a *traction engine* which could be applied also for working a centrifugal pump.

Boydell's Traction Engine.

The traction engine which I consider the thing for our purpose is *Boydell's*, it is the best known machine for ploughing by steam by drawing plough after it, and it is also well adapted for travelling over soft and rough roads, it is also able to draw a very heavy load and to prevent the wheels sinking into the ground, the driving wheel has a number of flat boards hung upon it by links one of which comes down in advance of the wheel by the time the wheel has passed over that already on the ground; pieces of rail are fixed on these boards upon which rail the engine runs, and a travelling railway for the wheel to run over is thus obtained.

Boydell's Traction Engine might be modified.

Boydell's engine is capable of passing over very bad roads, large stones, and ploughed fields: it has been used to draw guns, boats, and other heavy weights, besides ploughs, and has been found to work in an efficient and satisfactory manner.

Now the only thing required to make this engine suitable for our purpose, is means of detaching the connecting gear from the driving wheel, and of having the

* It may turn out that the water would be sufficiently kept out by animal power, but in case of steam being required, the engine described in the text is recommended.
† Even in so unfavourable a case our operations would not be unprofitable, as an artesian spring would bring up an additional quantity of salts which would be afterwards deposited in the evaporating beds.

fly wheel, (or other pulley fixed in the crank shaft.) fitted with a strap to work on centrifugal pump, which modification could be easily arranged by the maker.

I need dwell no further on the great advantage of combining an efficient traction engine with a pumping engine.

When pumping operations were suspended, it could be employed to draw a train of waggons, filled with the products of the lake to market. I do not know the cost of the engine, nor its duty, but I should say it could not exceed £300 or £400 at Home, and if we put the duty at 6 to 8 lbs. of coal per horse-power per hour when pumping we shall, I think, be well over the mark.

I may observe "en passant" that if one of these engines were once seen drawing its load over bad Indian roads, in the way it runs over a ploughed field at Home, I am persuaded hundreds of them would be imported into this country in the course of one year.

A little levelling of the banks of nullahs, and a few Irish bridges, and they could go any where, and draw any thing in the fine weather.

Centrifugal Pump recommended.

I need not waste space in advocating a centrifugal pump for such a situation as Lonar, its small size, compactness and efficiency compared with a double or treble through suction pump, and the great facility with which it can be fixed in its place and removed at pleasure; settle the question.

Conclusion.

In conclusion, I can't help expressing my surprise that the Government of India should have had possession of Berar for so long a time without turning their attention to this most valuable source of revenue, that it should have been left for years to be worked in so primitive, unprofitable, and slovenly a manner, by a lazy native contractor; and that so little information regarding it should be forthcoming, and that little, partial, imperfect, incorrect, and in some instances contradictory, that the very value of the salts should be unknown, and their composition undetermined.

In the short visit I was able to pay Lonar, I was not able to discover much, but I have seen enough to warrant me in recommending that no further time be lost in developing the resources of this valuable lake.

I would therefore suggest—

(1st.)—That a competent and energetic Engineer be put in charge of the lake, with a European subordinate, and a sufficient staff of skilled workmen under him, and as few accounts as possible.

(2nd.)—That the general recommendations contained in this Report be adopted, subject to such modifications and alterations as the Engineer in charge may suggest from a further examination, and more particular survey of the lake and its vicinity.

(3rd.)—That such further examination and particular survey be at once undertaken.

(4th.)—That when the present contract has expired, the working of the lake be undertaken directly by Government.

I have the honor to be,

Sir,

Your most obedient Servant,

(Signed) S. A. READE, Assistant Engineer,

In charge Basing Sub-Division.

September 16th 1871.

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APPENDIX I.

A = Area of surface of high water in square feet.
 A' = do. low water in do.
 l = Horizontal distance between high and low water.
 k = Present annual rise.
 k' = Future annual rise.
 k'' = Increase in annual rise.
 a = Area enclosed by embankments.

Then

$$\frac{1}{2} (A - A') l = a k'' + k' = \left(\frac{A - A'}{2} \right) k$$

$$k = k' + k''$$

$$k' = k \left(1 + \frac{A - A'}{2} \right)$$

To determine approximately the depth and length of excavation to form a bankment without waste.

L = Circumference of lake at high water.
 L' = do. low water.
 H = Height of embankment determined by equation (1).
 h = Width at bottom, b = width at top = ratio of slopes.
 l = Horizontal distance between high and low water embankment.
 C = Length of excavation supposed carried round the lake.
 z = Required width of do.
 y = Required depth of do.
 Z = Distance from toe of bank to object.

1stly.—Neglecting Z , we can easily prove that—

(2)

$$C = (L-l) \frac{B+l}{2l} + L$$

and $X = (l - L)$

Then $C (l - B) y = \frac{(B+b)}{2} H L'$

(3)

$$\therefore y = \frac{(B+b) H L'}{2c (l-B)}$$

2ndly.—Including Z . We get two unknown quantities, and therefore two equations—

(4)

$$C x y = \frac{(B+b) H L'}{2}$$

and since

$$B + Z + x = l$$

and $Z = \frac{y}{r}$

We have

(5)

$$y + r x = r (l - B)$$

Eliminate x from equations (4) and (5.)

$$C y \left\{ (l - B) - \frac{y}{r} \right\} = \frac{(B+b) H L'}{2}$$

Equate to Zero and

$$y^2 r (l - B) y + \frac{r L' H (B+b)}{2c} = 0$$

Whence

$$(6) \quad y = \frac{1}{2} r (l - B) - \sqrt{\left\{ \frac{1}{2} r (l - B) \right\}^2 - \frac{r H L' (B+b)}{2c}}$$

The value of c is obtained from equation (2) and $B = (b + 2 r H)$

I did not make these substitutions to avoid complications in the Formula.

When Z is small, equations (3) and (6) are equal.

(Signed) S. A. READE, Assistant Engineer,

In charge Bassim Sub-Division.

BASSIM,
10th September 1871. }

APPENDIX II.

Previous correspondence and papers regarding the Lonar Lake.

1. Account of the Lonar Lake by Dr. G. Smith, in the Madras Journal of Literature and Science October—December 1856, with Appendices A—E. Reprinted.
2. Note on the Lonar Lake by Captain K. Mackenzie No. 2529 dated 15th December 1869. Reprinted.
3. Extract from a letter No. 376 dated 16th February 1870 from Deputy Commissioner Booldana to Commissioner, West Berar. Reprinted.
4. Report by Dr. Lyon, Chemical Analyser to Government Bombay; No. 35 dated March 12th 1870. Reprinted.
5. Letter from Deputy Commissioner, Booldanah No. 656 dated 21st March 1870, to Commissioner West Berar, forwarding No. 4. Reprinted.
6. Covering docket to No. 5, from Commissioner West Berar, No. 965 dated March 30th 1870, to Secretary to Resident P. W. D. Not printed.

Forwards Nos. 4 and 5 of this collection and mentions that by desire of H. E. the Viceroy, who had seen them at Akola, certain samples of the produce of the Lake had been sent to Calcutta.

7. From Secretary to Resident P. W. D. to Secretary to Government of India P. W. D. No. $\frac{870}{55}$ dated 7th April 1870. Reprinted.

Forwards Nos. 1, 2, 3, 4 and 6 of this collection and submits a summary of deductions from the correspondence.

8. From the Government of India, P. W. Department to the Secretary to the Government of India, Foreign Department, No. 796 R dated 7th May 1870. Not printed.

Forwards copy of No. 7 and remarks that while there is no present probability of any railway being made near Lonar, or of the Khamgaon Railway being extended in that direction, the value and weight of the produce of the Lake are not such as to produce a traffic of any consequence to a Railway.

9. Copy of No. 8 forwarded for the information of the Resident, with reference to No. 7. Not printed.
10. From Messrs. Reid and Mitchell, Contractors, to the Commissioner, West Berar, dated May 2nd, 1871. Not printed.

Submits certain proposals for working the Lonar Lake under an agreement with Government.

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11. From Commissioner West Berar to Secretary to Resident P. W. D. No. 1419 dated 12th May 1871. Not printed.

Forwards No. 10, and also a report on the Lonar Lake by Mr. Laidlaw Local Funds Engineer (not printed) and states that he has, in anticipation of sanction, requested Mr. S. A. Reade, Assistant Engineer, to examine and report on the Lake.

12. From Secretary to Resident to Commissioner of West Berar No. 1637 dated 23rd May 1871. Not printed.

Approves of Mr. Reade's deputation and of the postponement of a reply to Messrs. Reid and Mitchell till his report is received.

13. From Commissioner West Berar to Secretary to Resident P. W. D. No. 2953 dated September 21st 1871. Reprinted.

Forwards Mr. Reade's report, and a table (printed) shewing the Revenue derived from the Lake since the cession, and requests orders on the offer of Messrs. Reid and Mitchell.

APPENDIX II.

(From the Madras Journal of Literature and Science,
No. 1, New Series—Oct.—Dec. 1856.)

I. Description and plan of the Natron Lake of Loonar, with an analysis of the Salt. By GEORGE SMITH, M. D., Residency Surgeon, Hyderabad.

[The following interesting description of the Loonar Lake of Berar was communicated by Dr. SMITH to the Committee for the Madras Exhibition for 1857, and placed by them at the disposal of the Madras Society, for insertion in their Journal.]

Description of the Lake of Loonar.

In the Circle of Meiner Soubah of Berar, about 45 miles N. W. of Hingolli in Lat. 20° N., lies the curious Natron Lake of Loonar. It is situated at the bottom of a crateriform depression, which forms a singular and unexpected interruption to the general gentle undulatory character of the district. The Lake is 510 feet below the level of the surrounding ground*—has a rounded outline and is about 3 miles in circumference. The sharp edge of the great excavation is about 5 miles round and the inner surface of the bowl rises abruptly at an angle of from 75° to 80°. The surface of this sharp slope is covered with luxuriant vegetation, in the shape of trees and thick, vigorous underwood, tenanted by the tiger, hog, panther, deer and peacock. Between the sloping bottom of the abrupt dip and edge of the still green lake, the ground especially to the N. and N. E., is under cultivation, and the luxuriance of the crops shews the excellence of the soil and the abundance of the irrigation. Water is supplied freely from springs of sweet, soft water, close to the edge of the lake, and near the surface of the ground as well as from the streams which in the rainy season, come from the surrounding water shed, and which have left their vertical trace upon the walls of the crateriform hollow. Here and there in the thick recesses of the wood, are observed small deserted and ruined Hindoo temples, built of the common compact Trap of the district. Many years ago, an officer, upon entering one of them, was seized and seriously injured by a tiger. The lake, a still sheet of water, emitting an intolerable stench of sulphuretted hydrogen (especially during the heat of the day, when the gas rises in millions of bubbles to the surface of the water), has a bright green color owing to the abundance of confervæ on portions of its surface, especially near the edges. The mud close to the margin of the lake, is thick, black, salt and tenacious, from the mixture of regur, salt and alum—when dry, fan shaped, black, glassy crystals of carbonate of soda are seen. The lake has evidently lately extended its bounds a good deal, as proved by this, that numerous dead trees are standing within its margin (for every tree touched by the lake dies) and also by the fact, that a bowrie of sweet water, protected by a low wall is now completely surrounded by the water of the lake. Reptiles, fish, and insects are never found in the lake, but flocks of teal and duck not its surface. The water has a salt and nauseous taste, and its emanations are said to give rise to fevers of intermittent and remittent types.

At two points, near the centre of the lake, distant from each other about $\frac{1}{2}$ a mile (judging by sight) are two saline springs which have never been known even in seasons of extreme drought, to become dry. It is supposed that the muriate of soda from this source, coming in contact with the carbonate of lime found abundantly in the other springs of the lake, and in the surrounding rocks whence it is washed down by the feeders of the lake, causes the deposition of the carbonate of soda or natron salt, in a state of greater or less purity. The purest varieties, containing upwards

* As calculated in January last by the aneroid, which during the descent from the brim of the crater to the level of the lake rose 6-10ths of an inch, nearly 510 feet.

+ For list—vide Appendix D extracted from Surgeon Bradley's Memoir.

of 50 per cent of the neutral carbonate being found close to the saline springs themselves—whence it is raised by diving. The depth of the lake near the springs, varies from 5 or 6 feet in the hot months, to 12 or 14 during the rains.

Description of Salt.

There are six principal varieties of salt to which the natives give the following names:—1 dulla, 2 nimuck dulla, 3 khuppul, 4 puppre, 5 bhooskee and 6 madkhar. Dulla and nimuck dulla are used for dyeing silks, fixing colors, and as medicine, and in the manufacture of bangles.* Of khuppul, there are two kinds, one of greater value than the other; this salt is used in fixing the red dyes of cloths. Puppre is used in the manufacture of bangles, in the baking of a cake called papur—and by the native hukéems as an anti-acid in dyspepsia. There is also an inferior description of puppre. Bhooskee is a white saline salt, left as a deposit on the margin of the lake, and is principally used in the manufacture of soap. Madkhar is an inferior kind of bhooskee, used by Dhobies in bleaching clothes. The purest salt is found close to the saline springs, and the other salts in their order, as entered above, are found on receding from that point towards the margin of the lake.

Salt how raised, transported and sold.

The salt is raised by divers who proceed towards the centre of the lake, in canoes (recently introduced by Major Johnston†) formed of single pieces of light wood, from 14 to 16 feet long and 2½ broad. The divers remain under water several seconds, and come up with their hands full of salt. When the lake was very shallow in 1836, the salt was scooped up by the iron pans or towas, on which natives bake their bread—no dredging instruments are used. The process of raising the salt is rude, tedious and insufficient. The salt thus raised is much prized, and finds a ready sale, in both Berars, in Nagpore, Candesh and Poonah. It is purchased at the lake by dealers, who carry it to considerable distances in bamboo baskets, and retail it.

History of the Loonar Salt Trade.

The lake has not been worked regularly since 1836, twenty years ago. A detailed statement‡ of the results then obtained, is appended for the information of the General Committee. From this carefully prepared table, it will be seen, that 2,136 candies of the several kinds of salt were raised, each candy being equal to 210 seers. The aggregate value of the whole being Rupees 60,081, of which sum, the Government (Native) share amounted nominally to 45,000. Since then, Major Johnston informs me, the lake has not been worked, and the salts are consequently in great demand, so much so, that inferior substitutes for the salts, supposed to be obtained from vegetable products§ are procured from Bombay and sold in both Berars. Last year (1855) Major Johnston, as an experiment, raised from the lake 35 candies of the several descriptions of salt, the value of which amounted to Hyderabad Rupees 1,461-4, the expense of raising, &c., to Rupees 522-9-9 leaving a profit to Government of Rupees 938-10-3 equal to about Rupees 26 per candy.

* There are two manufactories near the lake. When these are in full operation, bangles are manufactured in large quantities, each man being able to manufacture from 6 to 700 daily. The eye-sight of these men fails soon, owing to the entire want of protection from the glare of the glass furnaces. Crystallized Quartz is abundant.

† For much of my information, I am indebted to the kindness of Major Johnston, Deputy Commissioner of Southern Berar.

‡ Vide Appendix A.

§ Impure carbonates of potass from burnt wood probably.

¶ Vide Appendix A.

Suggestions under consideration for enhancing the revenue of the Lake.

The suggestions which have been proposed for increasing the productiveness and revenue of the lake, and which are at present under consideration may be stated briefly to consist of

- 1.—Contrivances for preventing the flushing of the lake with water, supplied by the main-feeder, and by the several streams from the surrounding water shed—such as bunds and channels.
- 2.—Means for raising the salt with facility, and in due quantity—such as dredging machines.
- 3.—Means for procuring the salts in greater purity—such as evaporating pans.
- 4.—Means for protecting and preserving the salt raised—such as sheds, store-rooms, &c., with careful supervision by trustworthy Government officials.

Remarks on the Geology of the Loonar Lake.

In an able statistical memoir of the Circular of Meikher, drawn up by Surgeon Bradley of the Contingent, then on special duty, the opinion is re-advanced and supported by Geological facts, that this singular and wild looking excavation, is the crater of an extinct volcano. On this point, however, there exists amongst Geologists, I believe, some difference of opinion, so that the question may be regarded as still "sub judice." A jagged and picturesque rent exists in the N. E. wall of the supposed crater, down which runs the little stream which passes through a stone channel called the cow's mouth, forming part of a Hindoo temple, which is perched romantically upon a spot near the top of the ravine. Since the destruction of a weir too, during the rains, a large and deep nullah is filled with water which rushes down the ravine. The water as it passes over the almost vertical face of a Trap wall deposits travertine in considerable quantity. Through this great rent, the lava current is supposed by Surgeon Bradley to have found an exit, whence he supposed it to have spread over the surrounding country. Whilst descending the ravine, the rough natural section thus exposed, shows Trap rocks of various kinds, vesicular, compact and amygdaloidal. Masses also of ferruginous trap, weathering red, are seen with seams of chalk, reddish ochre, clay and disintegrated trap having all more or less of a stratiform aspect. During the Resident's recent tour to Hingolee, Loonar, Mominabad, Oodoghcer and Beder back to Hyderabad, the whole route with the exception of the syenite and green stone near Hyderabad, and the laterite plateau of Beder lay over an uninteresting country of Trap to the entire exclusion of rock of greater Geological and Palaeontological character. In many places, the Trap bears features precisely similar to those observed in the walls and rent of the Natron Lake; at times, the Trap was in solid blocks with vertical seams and irregular horizontal rents—often seen in bowries—again, it was amygdaloidal the nodules being imbedded in concentric laminæ of disintegrated trap and argillaceous shale, the beds being laid over chalk, argillaceous schists, marls, red ochre and green earth—again, it appeared in rude, but distinct strata, almost as regular as the layers of stones in a wall—again, it appeared disorganized with seams, thick or thin, of chlorite, calcspar, quartz and calcedony, in contact with marl—again, it was seen in vertical shells containing triangular fragments easily separable—again, as vesicular, trap cavities being some times distant and empty, at others close and filled with adventitious minerals—again, it was solid, compact, and of a leaden black hue—again, it was reddish and ferruginous—again, where it underlies the laterite, it was mingled with that deposit, and where it slopes over the syenite, boulders of that rock were imbedded in its mass—these the Committee should be informed, are merely the personal remarks of an inexperienced Geologist. The same appearances with a few exceptions were observed at Loonar and in its neighbourhood. It appears to me, as if the rocks constituting the supposed crater were too compact, to have issued from a sub-aërial volcano, though it is more than probable that this

was one of the vents of the great eruption of the Trap of the Deccan, which was at first effused, it is supposed, under the pressure of water.

The points, to which the attention of the General Committee is respectfully solicited in this reference, are the following:—

a.—What is the exact chemical composition of the several salts?

b.—What is their commercial value, as now sent?

c.—Are the suggestions alluded to as under consideration, correct in their general principles? and

d.—Can the salts at Loonar be profitably separated from each other, and if so, by what process or processes?

—The following specimens are forwarded for examination—

- 1.—Dulla.
- 2.—Nimuck Dulla.
- 3.—Khuppul.
- 4.—Puppre.
- 5.—Malkhar.
- 6.—Dhooskee.
- 7.—Travertin.
- 8.—Quartz used in glass-making.
- 9.—Glass prepared for the manufacture of Langles.
- 10.—3 Bottles of water.

[Further communication from Dr. Smith, accompanied by a plan and section of the Lake.]

In the plan now submitted, the crateriform shape of the hollow is well seen, and if the opinion of some Geologists be correct, namely, that this hollow is the crater of an extinct volcano, the interest felt in it must be deepened by the fact, that in all probability it is the only one in southern India.

The action, however, even of a large crater like this must have been comparatively limited, other vents and fissures, which have left no permanent mark of their existence must have given exit to those vast sheeted masses of porous and solid rocks constituting the trappean plateau of the Deccan. This plateau over lying primary and secondary rocks to depths varying from a few feet to 300 probably, covered with a rich mantle of inexhaustible black soil, and capped here and there along its eastern indented edge with laterite patches, extends from 17° to 27° N. L. and from 72° 30' to 79° E. L.

It may be interesting to remark, that at the South East angle of the plateau, the existence of numerous hot springs seems to indicate the persistence of igneous action. Taking Loonar as a centre, and with a radius of 150 or 200 miles, the quarter circle extending from the North East to the South East, will be found to include (a) the tepid spring of Beder, rising from the base of a laterite cliff; (b) the hot springs at Kair on the Pain Gunga (87° Bradley) and (c) the hot springs near Labundee (102° Bradley) lying in a North Easterly direction.

APPENDIX A.

STATEMENT of Salt Extracted from Loonar Lake from Fuslee 1252 to A. D. 1836-1837, under the Nizam's Government.

	Dulla per Candy 57 Rupees.		Nimuck Dulla at 45 Rs. 4 As. per Candy.		Choorah at 59 Rupees 8 Annas per Candy.		Kuppul at 35 Rupees per Candy.		Pepper at 22 Rupees 4 Annas per Candy.	
	Quantity	Value.	Quantity	Value.	Quantity	Value.	Quantity	Value.	Quantity	Value.
1252 Fuslee.	3 130	17515	3 2 710	10914	6 81 8	3215	40 177 1116	6,214 110	62129	1,401 30
1253 Fuslee.	7 1035	42915	6 5 3204	234 8	9 41 2 64	1,023 119	67 3 0	2,350 40	60 8121	1,311 40
1254 Fuslee.	3 7 0	13015	3 18 16	85011	3 67 15	2,676	20 105 16204	3,704	26 131 4321	2,920 19
1255 Fuslee.	2 16 30	15814	6 9 11 0	43814	9 54 16	0	2,164 106	46 13 0	1,032 120 145	7 0
1256 Fuslee.	15 18 381	909 1	6 20 14 204	93812	0 26 3 123	1,033	86 37 2 0	1,298	80 195 2 0	2,338 76
Total.	32 14 131	1,564 14	0 56 15 221	2,569 13	3271	4181	107 13	43434	5361	15,209
1256 Fuslee.	0 0 0	0 0	0 20 13 10	93415	6 8 2 0	319 150	31530	132 90	71 14 10	1,535 99
1257 Fuslee.	36 510	1,724 15	6 9 15 0	441 3	6 29 3 0	1,155	60 16 4 0	567 00	227 10 0	5,068 90
1258 Fuslee.	8 8 0	478 13	0 213 64	120 4	9 9 5341	367 10	3 7121	117 129 127	0 264	2,828 40
1259 Fuslee.	0 0 0	0 0	0 0 0 0	0 0	0 0 0 0	0 0	0 0 0 0	0 00	0 0 0	0 00
1260 Fuslee.	0 0 0	0 0	0 0 0 0	0 0	0 0 0 0	0 0	0 0 0 0	0 00	0 0 0	0 00
Total.	38 15 10	2,203 12	6 33 1 164	1,496	7 3 46 12 341	1,842	60 23 7 21	817	59 426 10 361	9,462 69
Grand Total.	71 7 234	4,068 10	6 89 16 381	4,066	4 6 317 17 13	12,555	10 345 7 12 381	16,017	11 393 1 12 214	20,730 79

Under Rate Pul
Mookadur
Taloorkar.
Under Meer Mohib Ali
Khan Taloorkar.

Mixed Ammuns Pup- price at Rs. 17-1-0 per Candy.										Bhooskoo.										Madkhar.									
Quantity.		Value.		Quantity.		Value at Rs. 7-10-0 per Candy.		Value at Rs. 10-14-0 per Candy.		Value at Rs. 11-14-0 per Candy.		Value at Rs. 20-14-0 per Candy.		Total Value.		Quantity.		Value at Rs. 3-15-0 per Candy.		Value at Rs. 8-5-0 per Candy.		Total Value.							
Rs.	P.	Rs.	P.	Rs.	P.	Rs.	P.	Rs.	P.	Rs.	P.	Rs.	P.	Rs.	P.	Rs.	P.	Rs.	P.	Rs.	P.	Rs.	P.						
0	0	0	0	60	1	10	457	15	9	0	0	0	0	0	0	457	15	9	0	0	0	0	0						
0	8	64	7	0	0	2914	64	226	8	6	0	0	0	0	0	226	8	6	0	0	0	0	0						
9	13	35	167	4	3	43	6	0	0	0	0	0	0	0	0	330	3	0	0	0	0	0	0						
2	18	10	50	3	6	2319	10	148	12	9	81	5	9	0	0	230	2	6	0	0	0	0	0						
4	12	0	79	6	3	21	4	0	0	0	0	231	12	0	0	231	12	0	0	0	0	0	0						
17	12	11	303	14	0	181	4	201	1,163	8	0	81	5	9	231	12	0	0	0	0	0	0	0						
1	2	0	18	15	6	6	7	0	0	0	0	73	6	6	0	73	6	6	0	0	0	0	0						
8	2	25	140	4	0	15	1	39	0	0	0	179	2	6	0	179	2	6	0	0	0	0	0						
0	16	127	14	1	3	25	12	0	0	0	0	304	0	0	0	304	0	0	0	0	0	0	0						
0	0	0	0	0	0	0	18	20	0	0	0	0	0	0	0	19	5	3	0	0	0	0	0						
0	0	0	0	0	0	0	3	30	0	0	0	68	10	9	0	68	10	9	0	0	0	0	0						
10	0	37	173	4	9	54	5	0	0	0	0	646	3	6	0	646	3	6	0	0	0	0	0						
27	17	8	477	2	9	235	9	201	1,163	8	0	150	0	6	810	5	6	12	5	3	2,113	2	3	4					

Grand Total.				Deduct Char- run or Share to parties employed in extracting the Salt.				Government Share.				Remarks.
Quantity of Salt.		Value.		Quantity of Salt.		Value.		Quantity of Salt.		Value.		
387	9	0	11,571	13	6	2,892	15	9	8,668	15	9	210 Seers to the Candy or 12 Seers to the Maund.
211	10	129	0,916	4	6	1,554	1	3	4,662	8	9	
379	19	137	10,839	8	0	2,769	11	0	8,129	10	0	
289	3	10	7,009	10	6	1,977	6	6	5,932	4	0	
230	16	371	6,849	7	3	1,712	6	9	5,137	1	6	
1,098	18	337	43,861	9	10,846	11	3	32,540	2	6		
101	14	10	3,077	7	3	769	6	9	2,308	1	6	
300	12	10	9,292	12	3	2,332	3	0	6,969	9	8	
170	3	114	4,230	4	9	1,057	9	3	3,172	1	6	
018	20		19	5	3	4	13	3	14	8	0	
619	20		74	6	0	18	9	6	53	12	6	
637	7	317	16,694	3	6	4,173	8	9	12,520	10	9	
2,136	6	251	60,081	1	3	15,920	4	0	45,060	13	3	

APPENDIX E.

Report on the Chemical Examination of several specimens of Salt from the Loonar Lake in the Deccan, by J. E. MAYER, Professor of Chemistry, Madras.

Qualitative Examination of Salt No. 1 "Dulla."

A portion, not weighed, treated by dilute sulphuric acid gave off a very large quantity of carbonic acid, leaving a notable portion of impurities undissolved, consisting of dirt, earth and some organic matters; these were separated by filtration. A portion of the filtrate ascertained to be acid, was then treated by solution of nitrate of silver, a copious white precipitate was deposited, showing the presence of chlorine. A second portion of the filtered solution was neutralized by solution of ammonia, iron and alumina were thrown down in small quantity: the precipitate was separated by filtration; to the filtrate, solution of oxalate of ammonia were added, white precipitate took place; this was separated by filtration, and to the filtered solution, phosphate of soda was added, a small crystalline precipitate occurred.

A fresh portion of salt taken and tested by the blow pipe for the presence of soda, gave the characteristic flame; the only base that could be left being potash, it was passed over (as if present it could only be in small quantity) till the quantitative examination was carried out.

A fresh portion of salt was dissolved, and treated by a little nitric acid; after effervescence and filtration, solution of nitrate of baryta was added—no reaction—absent sulphuric acid. Phosphoric acid being evidently in small quantity, if present at all, was not looked for. The preliminary examination of each sample of salt was conducted in a similar manner.

Guided by the qualitative examination above shown, the quantitative determinations were carried out. The usual methods adopted by chemists were employed throughout in these determinations. To ascertain the constitution of the salt, some special experiments were required. Fresenius and Will's method for the determination of the carbonic acid was made use of, to ascertain whether it was really a sesquicarbonate with the formula $2 \text{NaO}, 3 \text{CO}_2$, like the natural compounds of soda and carbonic acid in Africa, or whether it had the more ordinary formula of the neutral or bicarbonate. These experiments showed in the case of the "Dulla" salt, that there is a mixture of carbonate and sesquicarbonate, in the proportion of 54 per cent. of the neutral carbonate and 30 per cent. of the sesquicarbonate; but in the others, a neutral constitution was found to exist, as exhibited by the formula NaO, CO_2 . The point of interest connected with the constitution of the Dulla salt is purely a scientific one, since natural sesquicarbonates are very rare, having hitherto been found only in Pezzan in Africa, in the soda lakes of Hungary, and in Venezuela, Nizami's country. An artificial sesquicarbonate can only be obtained with difficulty, and under certain conditions involving a very careful employment of temperature.

The following is a statement of the composition of the several specimens of salts from the Loonar lake, calculated on 100 parts.

No. 1. "Dulla."

Carbonic acid.....	35.00	} 83.82; equal to 77.30 of neutral carbonate consisting of—
Soda.....	45.82	
		31.48 of carbonic acid
		45.82 of soda.
		77.30 neutral carbonate anhydrous.

Chlorides of sodium and calcium.....	0.61
Insoluble matter, trace of iron, alumina, and organic matter....	2.00
Water.....	13.57
	<hr/>
	100.00

No. 2. "Nimuck Dulla."

Nearly pure common salt, containing 92.88 per cent. of chloride of sodium.

No. 3. "Khuppul."*

Carbonic acid.....	32.0	} 72.58; equal to 68.47 of neutral carbonate consisting of— 27.89 of carbonic acid 40.58 of soda. <hr/> 68.47 of carbonate of soda.
Soda.....	40.58	

Chloride of sodium.....	0.53
Water.....	25.09
Insoluble matter.....	1.80
	<hr/>
	100.00

No. 4. "Puppree."

Carbonic acid.....	29.00	} 72.46; equal to 71.1 of neutral carbonate consisting of— 29. of CO ₂ . 42.1 of soda. <hr/> 71.1 of neutral carbonate.
Soda.....	43.46	

Chloride of sodium.....	0.10
Insoluble matter.....	0.80
Water.....	26.34
	<hr/>
	100.00

No. 5. "Madkhar."

Neutral carbonate of soda.....	27.0	{ Carbonic acid...11 Soda.....16 <hr/> 27

Insoluble matter, consisting of clay, sand, &c.....	30.4	} Mean of 2 experiments.
Water.....	16.4	
* Common salt.....	25.4	
	<hr/>	
	99.2	

* The common salt in the sample is not uniform in quantity

(44)

No. 6. "Dhooskee."

Neutral carbonate of soda.....	26.0	{ Carbonic acid...10.6
		{ Soda.....15.4
		<hr/>
	26.0	

Insoluble matter, consisting of	
sand, clay, &c.....	58.0
Water.....	15.4
Soluble impurities, chloride of sodium chiefly.....	2.6
	<hr/>
	100.

No. 7. "Travertin."

Carbonate of lime.....	78.00
Do. of magnesia.....	4.53
Insoluble matter, oxide of iron, &c	9.00
Chloride of sodium.....	2.60
Water.....	3.80
	<hr/>
	97.93

No. 8. Quartz.

No. 9. Greenish brown glass, very fusible.

No. 1. This salt appears to be formed in crystalline masses, and is but slightly contaminated by chloride of sodium, or by any other insoluble impurities; these, exclusive of the water present, will amount to about 4 per cent.

No. 2. Fine cubical crystals, forming masses, in which the peculiar structure may easily be traced; this salt contains something more than 92 per cent. of common salt, or chloride of sodium.

No. 3. Has less crystalline structure than No. 1; is efflorescent and white in appearance. Chemical constitution shows a larger amount of water, while the soda and carbonic acid are nearly in the proportions required to form neutral carbonate.

No. 4 is formed by the aggregation of numerous small crystals, is whiter than No. 1, but has almost the same chemical constitution as No. 3.

No. 5 appears in larger dirty looking masses, is not homogeneous in its composition; in parts, it possesses a beautiful structure, seen in crystals radiating from a centre: contains 16 per cent. of water, 25 per cent. of common salt and 30 per cent. of insoluble impurities.

No. 6. A greyish looking earth, containing 58 per cent. of insoluble impurities, 15 per cent. of water, 2½ of common salt, leaving 26 per cent. of carbonate of soda.

No. 7. A salt varying from all the other specimens, being composed of earthy (not alkaline) carbonates chiefly, some insoluble impurities, a little common salt.

No. 8 not examined, it evidently consists of crystallized silicic acid, known as quartz.

No. 9. A readily fusible glass, most probably chiefly a silicate of soda, not examined chemically, scratches window glass.

I have made no remarks respecting commercial value, as this must necessarily depend on various circumstances, concerning which I am but partially informed; these will chiefly embrace 1st, the present quantity available for the market: 2nd, constancy of the supply: 3rd, local demands for the salts, which can only be known to those residing near the lake: 4th, means of transit, should a demand exist or arise elsewhere: 5th, the small probability of bringing any natural carbonate from a distance to compete in Europe, with the carbonate of soda made from common salt by Lablanc's process: 6th, the want of any extensive Indian manufactories of glass or soap, for which in Europe alkaline carbonates are principally employed.

The foregoing observations apply more or less strongly to all the samples containing carbonate of soda. The sample No. 2, which is essentially a pure rock salt, deserves more consideration, as it might, supposing it to exist in quantity, be turned to account as a source of revenue; there being always, from the large consumption and high price of the article, a ready market for good common salt in India. Sample No. 7 is worth a trial for building purposes, provided that the common salt present could be eliminated by washing.

The purification of the salts Nos. 1, 3 and 4 is easily effected by simple solution in hot soft drinking water, decanting or syphoning off the supernatant clear fluid to separate insoluble impurities, and evaporating in cast iron or sheet iron pans by means of furnace heat. As to whether the purification would prove profitable or not will depend on the expense incurred for fuel and cooly hire, and the price of the evaporating pans, together with that of the purified article; the latter is a main point to be considered, and cannot be seen before hand.

No. 2 requires little or no purification.

No. 5 might be purified in the same manner as Nos. 1, 3 and 4. There will exist in solution, a mixture of common salt and carbonate of soda, the former averaging about 25 per cent.; by concentration of the solution, (which should also be effected in iron pans), the common salt, from its less solubility compared with the carbonate of soda, and its equal solubility in both hot and cold water, will subside to the bottom of the evaporating vessel; it can be removed by means of a colander, drained, subsequently washed and dried; the solution will then contain carbonate of soda chiefly; by further concentration it will crystallize. A second solution of the carbonate in a limited quantity of water, and evaporation, will give crystals in a pretty pure state.

If it be considered worth while to purify salt No. 5, it must be chiefly for the purpose of extracting the common salt it contains, for which a ready market exists in this country; in doing so, however, the price of the article so obtained should be weighed against the selling value of this article obtained by solar evaporation from sea water or brine springs.

4. The manner in which these are obtained and the process have been described in my predecessor's letter No. 2529 of the 15th December 1869.

5. The means of communication now available for the distribution of the products are as follows.

Lonar is sixty miles distant from Khamgaon, which will shortly be a railway station. This is the nearest railway point to the Lake. In other directions, there is the high road leading to Jaulna, which place is 50 miles off, and to Karinja and Omraottee, in a north easterly direction. Omraottee is about 118 miles by road, but the products would reach Omraottee more easily by rail via Khamgaon.

6. Lonar being on the boundary of this District on the south, numbers of traders from the Nizam's Country come in the hot season to Lonar for the Soda, and convey it to different places, chiefly on bullocks; these places are Asundah, Kotun and Paiton in His Highness's Territories. It is also taken to Boorhampoor, to Bokur in Khandesh, and to Nagpoor, and even to these more distant places the usual mode of carriage is by bullock.

7. The average yearly out turn I am unable to state. We have no records of past years, for the farm has been in the hands of Contractors whom we have never called upon to furnish particulars of the out turn. But the out turn of the past year, which owing to the very scanty rain fall of the previous monsoon was a most favourable one for working the Lake, was as nearly as possible as follows;

No. 1 and 2 Dulla.

60 Kunderes of 20 maunds each at 17 seers per maund or 40, 800 lbs. this is of both the 1st and 2nd descriptions and the value is given at 100 Rupees per Kunder or 6,000 Rupees.

No. 3 Dulla ka choora.

70 Kunderes at 75 Rupees per Kunder, Rupees 5,250.

No. 4 Papree.

500 Kunderes at 20 Rupees per Kunder Rupees 10,000.

No. 5 Bhoskie.

1200 Kunderes at 10 Rupees per Kunder, Rs. 12,000.

8. In answer to the query as to the demand being in excess of the supply, I find that of the quantity extracted from the Lake last year, Rupees 20,000 in value was carried away before the rains set in, leaving Rs. 14,000 to Rs. 15,000 on the ground; this is accounted for by the fact that much more was procured from the lake last year than usual, and as soon as the rains set in no traders bring their bullocks to the lake. The surplus from last year is now being carried off, and the supply will not be more than the demand this season.

Chemical Analyser's Office,
Bombay 12th March 1870.

(4)

No. 25.

From THE CHEMICAL ANALYSER to Government.

To THE COMMISSIONER, West Berar, Akola.

Sir,

I have the honor to forward herewith a tabular statement of the results of my examination of the water of the Lonar Lake and of the 5 samples of salt forwarded with letter No. 259 of the 24th ultimo from the Deputy Commissioner Booldana District. The samples arrived here on the 16th ultimo.

(2) NOTE ON THE LONAR LAKE BY CAPTAIN K. MACKENZIE, BOOLDANA
No. 2529 of 15th December 1869.

I learnt on the spot that the crater, if crater it be, has towards the western side (rather than the centre) two openings, hitherto unfathomed, and which in the hot season, for the water else where around them completely dries up, hold a very thick and slimy solution, a kind of blackish clay and water; the mouth of one opening is said to have an area of from 2 to 2½ acres; the mouth of the other opening from 1½ to 1¾ acres, and it is in these openings, so the Natives assert, that the impregnation of the accumulation of the rains, which fill the lake, takes place. The water in fact day by day during the monsoon, getting thoroughly saturated, spreads and fills the lake to the extent we see. As the hot season approaches, the water evaporates and recedes to the openings before mentioned, when the whole bed of the lake, to the openings, is found encrusted with a thin layer of crystalized deposit, called by the Natives "Papree," and which is carefully collected and stored. Below this crusting of "Papree," the earth which is also to some depth full of a similar deposit, is dug up and stored away, and this goes by the name of "Bhooskee." The "Papree" and "Bhooskie," you will observe, can only be got in the hot weather and after the bed of the lake has, with the exceptions mentioned, been left completely dry. But it is otherwise with the "Dulla" or the large blocks of pure crystal, which can only be got by the divers when the lake is full of water and then only at the sides of the openings before mentioned, Bamboos being set up in the dry season round the margin, to be a guide to the divers when the waters rush in and fill the bed of the lake. The divers have no doubt that these crystals could be found in the hot weather also, but they dare not then enter the thick slimy mud which fills the openings, for to dive into it at that season, is to dive to certain death. The Native account of the source of impregnation is further, it seems to me, borne out by the presence of a well at the margin, near the temple of "Bowance," which contains the purest and sweetest water; and their belief on account of this well is, but this is of course an untested belief, that any shaft sunk, unless carried to a depth we could never think of, will result in nothing.

It may be of interest further to record that the "Dulla" crystals fetch from 85 to 100 Rupees per Kundy. The "Papree" from Rupees 18 to Rupees 25 per Kundy, while the "Bhooskie" is worth only Rupees 8 to Rupees 10 the Kundy. The divers' families number, I am told, about 150 chiefly "Malies" and "Kolies," all wuttundars, sharing amongst themselves, in certain proportions 1/4th the out turn of the year, be it little or great, for one fourth is what the contractors allow them. They hold lands which they cultivate, and in the diving season they go to work, I believe, in gangs by turns. For the collection of the "Papree" and "Bhooskie" they all go to work and call in besides a number of coolies, who are paid at their expense.

(3) Extract from a letter No. 376 dated 10th February 1870;
From the DEPUTY COMMISSIONER, BOOLDANA DISTRICT,
To the COMMISSIONER WEST BERAR.

Para 3. The several products of the Lake of Lonar are named by the Natives as under:—

- No. 1 Dulla.
- No. 2 Nummuck Dulla.
- No. 3 Dulla ka choora.
- No. 4 Papree.
- No. 5 Bhooskie.

Result of the analysis of the Lonar Lake Deposits.

	Dulla	Nimuck Dulla.	Dulla ka Choora.	Paprec.	Bhooskie.
Insoluble Residue.....	3.41	3.91	6.19	21.04	42.84
Water and organic matter.....	28.45	26.21	31.95	23.96	23.40
Chloride of Sodium.....	9.84	12.55	7.89	29.50	21.28
Soda.....	29.13	29.79	27.34	11.49	4.84
Carbonic acid.....	29.61	27.54	26.63	11.21	4.64
	102.00	100.00	100.00	100.00	100.00
The soda is equal to neutral carbonate.	50.31	50.93	46.74	19.64	8.27

(5)

No. 656 of 1870.

From DEPUTY COMMISSIONER Booldana District, West Berar Division,
To THE COMMISSIONER, West Berar Division.

Dated Booldana 21st March 1870.

Sir,

I have the honor to forward copy of letter from the Chemical Analyser to the Bombay Government giving his analysis of the products of the Lonar Lake.

2. The specimens sent were 2 gallons of water taken from that part of the Lake where the best dulla is found, and a quantity of each of the five solid products, viz: "dulla" "nimuck dulla" "dulla ka choora" "paprec" and bhoski."

3. Dr. Lyon estimates the value of the three first named products at about 1 anna 9 pias per pound, considerably less than what it fetches at the Lake.

7th April 1870.

(7)

No. 870 of 1870.

To

THE SECRETARY TO THE GOVERNMENT OF INDIA,
P. W. Department.

Sir,

Railway.

* 1 Extract from Madras Journal of Literature and Science.

1 Booldana Note.

1 Extract from a letter No. 376 dated 14th February 1870 from Deputy Commissioner Booldana District to Commissioner West Berar.

1 Letter from Chemical Analyser to Government Bombay.

1 Letter from Commissioner West Berar No. 965, dated 20th May 1870.

is by means of bullocks. The nearest Railway Station now will be Khaungaon, 60 miles distant; Jaulna is 60 miles off. By the Deputy Commissioner's report (attached) the soda is carried away in all directions.

With reference to your letter No. 1663R dated 16th October last, I have now the honor under instructions from the Resident to submit copies of papers as per margin* giving the information required on the subject of the manufacture &c., of Soda at the Lonar Lake, West Berar.

The lake is situated in Latitude North 19°58' Longitude East 76°34' vile Trigonometrical Maps. There is no made road to or even near it, and apparently the only means of communication adapted for the purpose of carrying away the produce of the lake

On referring to the analysis it will be noticed that chloride of sodium and soda and carbonic acid (combined together as carbonate of soda) from the principal constituents of 561.92 grains of solid matter contained in each Gallon of the water, and that Dulla, Nimuck Dulla, and Dulla ka choora, as well as the soluble portion of Papree and Bhoskie consist chiefly of these two substances, viz: common salt and carbonate of soda.

On comparing the relative proportion of the soda and carbonic acid contained in the 5 samples of salt, it appears that these are united with one another, for the most part at any rate, in the form of sesquicarbonate of soda, the usual form in which these substances are found combined together in similar deposits in other parts of the world.

The commercial value of the various salts under report is evidently due to the carbonate of soda they contain, and the last line of Table B shows the amount of anhydrous carbonate of soda equivalent to the soda present in each sample.

Ordinary crystallized carbonate of soda contains 27.66 per cent of soda equal to 47.31 per cent of anhydrous carbonate, but owing to efflorescence the carbonate of soda of commerce generally contains a larger percentage of anhydrous carbonate than this.

On enquiry at the Bombay Custom House, I find that the price in the Bombay Market of the carbonate of soda of commerce averages about Rupees 15 per cwt: and judging from this and from the percentage of soda present in the deposits under report I should say that about Rupees 12 might be taken to represent the value in Bombay of the Alkali contained in 1 cwt., of Dulla, Nimuck Dulla or Dulla ka choora.

With regard to the purification of the carbonate of soda I think that this might be effected at any rate to an extent sufficient for most commercial purposes, by dissolving the deposit in water, allowing the solution to settle, drawing off the clear fluid and crystallizing out the carbonate of soda by evaporation.—It might perhaps be found of advantage to incinerate at a low heat the deposits before dissolving them in water. This would have one effect of destroying the organic matter, and enabling a clear solution of the salts to be more readily obtained.

Lastly as bearing on the subject under report I may mention that in addition to the carbonate of soda imported from England, carbonate of soda is to be found in the Bombay market in two impure forms, one of these known by the name of Suji khar is said to sell at Rupees 1½ per maund 28 lbs., and a specimen I examined contained Alkali=29.71 per cent of anhydrous carbonate of soda; the other is said to be worth Rupees 4 per maund 28 lbs., and on examination I found that a sample of it contained Alkali=42.16 per cent of anhydrous carbonate.

TABLE A.

Results of the analysis of a sample of water from the Lonar Lake labelled "water taken from that portion of the lake whence the best Dulla is procurable."

	Grains per Gallon.
Chloride of sodium.....	405.40
Sulphate of soda.....	6.18
Carbonate of Soda.....	118.37
Carbonate of Lime.....	2.80
Carbonate of Magnesia.....	1.57
Silica.....	1.40
Volatile matter chiefly organic.....	26.20
Total...	561.92

A description of the Lake with an account of the salts &c., communicated by Dr. George Smith M. D., Residency Surgeon Hyderabad was published by the Madras Literary Society in their Journal for October—December 1856, copy of which is attached. This account gives a very clear and interesting description of the lake and the process of collecting the different kinds of salts. A second account is now furnished by Captain Mackenzie, Deputy Commissioner, Booldana District.

No calculation as to the annual supply that might be obtained can be made. By Dr. Smith's account it appears that in 1856 the quantity of all kinds of salts obtained was 2136 candies (each 240 seers) the value of the same being Rupees 60,031, of which 1/4th only went to the people who collected it, the cost of collecting thus being about Rupees 7 per candy.

In Major Johnstone's experiment in 1855, 35 candies were raised at a cost of Rupees 522 or about Rupees 15 per candy. In both cases the market value was about the same. In 1869 from the Deputy Commissioner's report it appears that salts to the value of only Rupees 20,000 were collected and this was considered a very favorable year. The kind named Khuppel which in 1856 realized Rupees 16,017 does not shew in the return of 1869. The prices of the superior kinds seem to have increased (whilst that of the inferior have decreased) very considerably, for instance

	1856.	1869.
Dulla.....	Rs. 57 per candy	
Nimuck Dulla.....	45/4 do.	Rs. 100 average.
Choora.....	39	75
Papree.....	22	20
Bhooskie.....	11/14	10

The two district analyses will not bear comparison. It is possible that in one case or other the different kinds of salts may have become mixed. The price in Bombay that may be expected from Mr. Lyon's report, is not very encouraging. It is suggested that boxes of samples of a few seers of each kind be collected and sent to the Chambers of commerce at Calcutta and Bombay, and their opinion on them sought.

No. 2953 of 1871.

(13)

From THE OFFG. COMMISSIONER, West Berar.
To THE SECRETARY TO RESIDENT, Hyderabad D. P. Works.

Dated Akola 21st September 1871.

Sir,

The correspondence in the Resident's Civil Office shows the great interest that is attached by the Secretary of State, the Government of India, the Resident and the several Officers who have from time to time been connected with the administration of this Province, to the proper and efficient working of the Lonar Lake, which is believed to contain a mine of wealth which only requires developing to give the Government an enormous return. In First Assistant Resident's letter No. 850 of March 1869, the Resident desired that before the expiration of the current lease measures should be taken to assume, departmentally, the working to the best advantage of the saline products of this Lake through competent European Agency. Subsequently you were addressed on the subject of deputing Mr. Reade Assistant Engineer to visit the Lake and make as close an investigation as his leisure and his other regular duties would permit, and at the same time a copy of Mr. Laidlaw's report, and an original tender from Messrs. Reid and Mitchell for the working of the Lake, were sent to you.

2. I now beg to send you Mr. Reade's report in original. He has evidently taken the greatest interest in his subject and has spared no pains to make his report as full and complete as possible, but I have not sufficient knowledge of either Engineering or Chemistry to enable me to test its value in any way. I would only remark that if, as Mr. Laidlaw states, the impregnation is thicker above the supposed craters and becomes gradually lighter towards the sides of the Lake, it will probably account for the different results arrived at by the analysers, for unless the specimens of earth and water sent to them were taken from the same locality, there would probably, if Mr. Laidlaw is right, be the difference reported.

3. I beg to append a statement showing the Lonar Lake receipts since the Cession. There is an idea that the Native Contractors for the working of the Lake have at times made enormous profits. If this is the case I can only say that the chances of such must be very remote, for it has not been found that the Contractor of one year, or term of years, has been anxious to obtain the contract for the next. Indeed, experience goes fully to prove that only a precarious and uncertain return can be hoped for so long as the present plan of working the lake is continued.

4. There are three ways in which it appears to me the Lake might be worked. Either to make it over to the Customs Department which is willing to undertake it, on the understanding that the best Engineering skill shall be employed in developing its resources, and at the same time arranging that the revenue should be secured to Berar—or making the Lake over to the Contractors Messrs. Reid and Mitchell on the very equitable terms which they propose—or that we should hold and work the lake ourselves. The last mentioned is the course I would recommend, but in the event of its being adopted we must be prepared for a considerable outlay, and there should be, I am of opinion, a special Engineer of ability and experience appointed to carry out the work and remain in charge till such time as it is considered it might be entrusted to a less responsible person.

5. Meanwhile there are two points on which early orders are requested. 1st. the present three years contract expires in November. 2nd. Messrs. Reid and Mitchell are awaiting a reply to their offer.

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6. Owing to the scant fall of rain this year, more particularly in the Mehkar Taluq, it is probable that the next season will be a particularly good one for operations at Lonar, and if the works are sanctioned and an Engineer placed in charge, he could in addition to superintending the work watch the operations according to the present system of working for extracting the Soda from the bed of the lake. If we have not heavy rain before the hot weather sets in, it seems to me that the season will be just one of those where the largest returns from the lake may be expected.

7. I would not recommend our working the lake ourselves unless under European supervision.

8. I would suggest all the reports connected with the Lonar lake being printed. I shall be happy to get it done if the Resident desires it—but I have kept no copy of Mr. Reade's report.

Statement showing the Receipts from Lonar Lake since the Cession.

	Amount.	
1853/54...	1,500	
1854/55...		
1855/56...		
1856/57.....	750	
1857/58.....	245	
1858/59.....	"	
1859/60...	3,000	Lease for 3 years.
1860/61...		
1861/62...		
1862/63...	18,105	Do.
1863/64...		
1864/65...		
1865/66...	11,593	Do.
1866/67...		
1867/68...		
1868/69...	22,000	Do.
1869/70...		
1870/71...		