



REPORT
ON A
PRELIMINARY SURVEY
OF THE
**SALT INDUSTRY IN THE SHWEBO AND
SAGAING DISTRICTS**

BY
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REPORT

ON A

PRELIMINARY SURVEY OF THE SALT INDUSTRY IN THE SHWEBO AND SAGAING DISTRICTS

By Mr. E. G. Robertson, Superintendent of Excise (Salt).

CHAPTER I.

INTRODUCTION.

For convenience of reference this report is divided into three parts. Part 1 deals with the salt centres situated in the Shwebo District, Part 2 with the Sagaing District centres, and Part 3 consists of general observations.

2. My inspection of the various centres was somewhat hurried, as the advent of the monsoons seemed imminent and I was perturbed lest a heavy downpour of rain might create abnormal conditions with regard to the density and consequent value of brines to be tested.

3. This report therefore cannot claim to be final, but is limited in scope to a preliminary survey of the two districts with a view to ascertaining whether it should be worth while to seriously consider the question of developing the local salt industry on the lines indicated.

4. That there is scope for the expansion of the salt industry in Burma is evident from the fact that nearly 50 per cent. of the salt consumed in the province is at present being imported from foreign countries, principally the United Kingdom, Port Said, Aden and Germany.

Part I.

CHAPTER II.

5. The principal salt-works of the Shwebo District are situated at Halin and Thakuttaw in the Wetlet Township. A third centre, of some importance in the past, but now closed down, is at Kodaungbo, on the railway line, 529 miles from Rangoon.

HALIN.

6. The salt-works are situated here in two main areas, Myomakwin and Taungbo-yat, quite close to a Government rest-house.

7. In the Myomakwin area are four hot-springs which are associated with the local industry, but proved rather disappointing as a source of a permanent brine supply. Samples of this brine on analysis were found to contain 0.68 per cent. of salt in addition to the following constituents:—

Magnesium chloride	...	...	0.02
Calcium chloride	...	...	0.09
Calcium sulphate	...	...	0.01
Water	...	...	99.20

8. For purposes of comparison with sea-brine a table of the constituents of Bay of Bengal brine will be found in column 6 of Appendix 1.

9. The soil of Halin is highly saline in character, on the surface, and the local salt-boilers tell me that a shower of rain increases the proportion of salt. It should therefore be explained that my visit occurred at the end of three successive particularly dry years,

10. About two furlongs from the salt area the soil is impregnated with soda which the local folk say is abundant, and appears in the form of a fine white efflorescence in the cold weather but vanishes as the weather gets hot. The level where this soda (locally known as *sapya*) is found is somewhat lower than the surrounding country. This deposit may be due to the weathering of sodium sulphate taken up in solution during the rains and washed down to the lower levels.

11. The occurrence of the common salt (sodium chloride) is interesting. It appears in the form of a grey fine-powdered earth under the surface of a soft pellicle or mould which is cracked, by solar heat, into small pieces and curled up at the edges.

12. The oldest salt boiler I could find, aged about 65, stated that his ancestors had worked the same area before him and, in his opinion, the salt obtained, per given area of soil, has not diminished. The actual output of salt is said, however, to have decreased considerably as a direct result of taxation and consequent restrictions in the number and size of vessels used.

13. There is every indication of an extensive industry having been carried on from time immemorial. The headman, and others, state that the area produced salt during the reign of a local king who apparently reigned long before the rise of the Alaung-paya dynasty. Several mounds in the vicinity, containing fragments of pottery, appeared to me to look remarkably like the heaped up remains of important lixiviation operations such as one might expect to find near old salt factory sites where the local methods have been practised on a large scale.

14. However, it seems clear that this area has been producing salt sufficiently long to dispose of the argument that the deposits may be superficial and liable to exhaustion with intensive working.

15. The brine of the hot-springs, mentioned in paragraph 7, contains 68 per cent. of salt and the soil 17.75 per cent. The excess in the soil may be due to successive overflowing of the hot springs and consequent accretion of salt. My personal opinion of the manner in which the soil is impregnated with salt is that it is brought to the surface as described below, and that the hot-spring brine does little more than supplement this natural supply.

METHOD OF SALT MANUFACTURE.

16. According to one method, the salt-boilers collect the "salt-earth" and place it in bowl-shaped filters, lined with straw and clay, into the bottom of which a bamboo pipe is inserted. A gentle stream of weak brine, from the hot-springs, or individual wells, is then poured over it, and as the weak brine soaks into the soil it dissolves the salt and carries it off in solution, through the bamboo pipe, to an earthenware pot below. The first lixiviation yields a solution containing from 18 to 22 per cent. of salt, and this is taken away to the boiling shed. Other charges of spring, or well, brine of the initial density available, are then passed repeatedly through the filter until the density of the brine discharge is about 7.5° B_é. The early or stronger of this discharge is in most cases mixed with the brine of the first lixiviation and results in the brine, as finally boiled, being reduced to a density (average) of 16° B_é. The weak remains of the solution are reserved for the next operation.

17. The washed out soil is scraped from the filter and, in due course, spread out over the place from which it was collected. The salt boiler then waits for a shower of rain which apparently soaks into the soil and is drawn up again to the surface, by capillary attraction, bringing with it a fresh supply of salt in solution, and after the moisture has evaporated this 're-impregnated' soil is again collected and the whole process repeated. The boilers state that from 35 viss of soil they obtain 6 viss of brine and one-and-a-half viss of salt. They also explain that they return the washed-out soil to the fields in order to maintain the original level of the land, which is in very small holdings, approximately 25 of an acre, with weak brine within 10 feet of the surface, in the dry weather.

18. In the boiling-shed a seven-gallon iron pan is used and the brine is boiled until all the salts crystallize out. The product is then drawn into a basket which is drained over a glazed jar. The drainage or 'mother-liquor,' consisting of magnesium compounds, of highly soluble and deliquescent salts, is poured over the fields when they are levelled before the rains, where it probably does more harm than good. Surplus brine not being actually boiled, is stored in large glazed jars.

19. The result of this method is a very impure product containing 76.57 per cent. of salt and the following other constituents:—

Magnesium chloride	...	0.46
Calcium chloride	...	3.26
Calcium sulphate	...	1.71
Ferric oxide and alumina	...	0.17
Insoluble inorganic matter	...	0.19
Water	...	17.64
Total	...	23.43

CHAPTER III.

THAKUTTAW.

20. At Thakuttaw the process is somewhat varied in the initial stage. The salt does not appear incorporated with the soil in the first instance, as at Halin. But the initial brine, obtained from wells, is stronger and contains from 1.302 per cent. to 1.635 per cent. of sodium chloride (salt). This brine is irrigated over fields prepared by a thorough harrowing. After the soil has been well broken up a number of furrows, or brine channels, are formed about 4 feet apart and brine, up to the full capacity of the well, is gravitated into half of these channels and allowed to evaporate until dry. This brine permeates the soil between the channels and on evaporating deposits its salt therein. The following day the remaining half of the channels are irrigated in similar manner and this irrigation is continued in rotation. Each half being attended to when perfectly dry. After three successive irrigations the impregnated soil is collected and the remainder, or boiling down portion, of the process is the same as at Halin. The average area of land worked per factory is 5 of an acre.

21. I should like to point out here, that all this practically amounts to a somewhat laborious form of solar evaporation manufacture as practised on the Government Experimental Solar Salterne. A great deal of time is lost by the successive irrigations which must result in the salt, which has already been deposited in the soil, in minute crystals, being taken up in solution again at each irrigation with weak brine. And after all the salt to be manufactured had completely crystallized out it is again dissolved to go through the process of lixiviation before a final boiling down. On the other hand, this process breaks up the brine and exposes a very much larger area of surface than would be the case were it exposed in solid sheets on flat land. So what the boiler loses on the swings he gains on the roundabouts and in the end his process amounts to solar-evaporation, lixiviation and subsequent boiling down. The last two being quite unnecessary if simple solar evaporation were to be introduced.

22. It seems to me that the local system has evolved from many years' experience and it may possess some original merit or cogent advantages which I have been unable to trace. I am therefore unwilling to condemn it out of hand, but certainly think that it could be vastly improved upon. As a small family undertaking it may yield a living, but as a commercial proposition the labour involved would render this system of manufacture impracticable.

23. The maximum output of the average existing factory amounts to approximately 3,000 viss per annum, and in view of its inferior quality the producer cannot hope to sell it all for more than Rs. 300. Incidentally, the price of a good class German salt is now Rs. 100 per 1,000 viss. Paying, as he does at present, from Rs. 30 to Rs. 40 per annum, as a composition fee in lieu

of duty, the local manufacturer can hope for a sufficient return to compensate him for the labour he has put into the business. But under the direct-duty system his position would be as follows :—

Receipts.	Rs. A. P.	Expenditure.	Rs. A. P.
Sale of 3,000 viss of salt at Rs. 100 per 1,000 viss	300 0 0	Duty on 3,000 viss of salt at Rs. 54-11-0 per 1,000 viss	163 1 0
		Cost of pans, etc.	5 0 0
		Cost of fuel	24 0 0
		Labour, two persons, at Rs. 15 (minimum) for four months	180 0 0
		Total	372 1 0
		Less: Rs. 12-1-0 loss	12 1 0
Total	300 0 0		300 0 0

24. It consequently follows that the introduction of the direct-duty system, under existing conditions, cannot be contemplated unless it is for the express purpose of putting an end to the industry, for the purpose of benefiting the other parts of the province which are in a position to pay a higher rate of duty, and this course I would not recommend because natural conditions are such, that if no provision is made to legalize the manufacture of salt, a very large number of factories are bound to spring up and measures to suppress the illicit traffic are likely to prove so unpopular and costly as to be scarcely worth while.

25. On the other hand, I believe, that a great deal can be done, with the natural resources available, towards establishing an important industry; if the matter is taken in hand and thoroughly investigated, with a view to the encouragement of expansion and the introduction of improved and less costly methods.

CHAPTER IV.

KODAUNGBO.

26. Kodaungbo railway station and village are situated, in the Shewbo District, on the 529th mile from Rangoon. The abandoned salt area in Sagyin *kwin* is about 5 miles to the west of the village. The salt land, formerly worked, is a depression, about 30 acres in area and circular in form. Two dry stream beds take off from this basin: one on the east being apparently a drain into the Daung-yu creek, a perennial stream, and the other, on the north, an inlet into the basin for the drainage of the surrounding country.

27. The whole of this salt-land is annually submerged by the overflow of the Daung-yu creek. This water takes up in solution the salt which has come to the surface during the preceding dry season and thus forms a natural reservoir of weak brine. The salt boilers used to combine at the end of the rains and put up a small dam to retain this brine. They would then allow it to concentrate and from 80 to 100 families would camp on the banks of the reservoir and boil down the brines as soon as it was sufficiently concentrated. As no arrangements were made to replenish supplies the concentrated brine soon got exhausted and then five or six wells were cleared out and drawn on by those of the boilers who remained in camp. As a rough estimate, based on the number of persons employed, the number of cauldrons used and the reputed output per cauldron, I should say that some 120,000 viss of salt was produced annually from this area. The old method of boiling proves that a very weak solution must have been used. Two cauldrons were placed over the fire place, and filled, and when the volume of the contents were reduced sufficiently the contents of one cauldron were emptied into the other. I arrived here after several heavy showers of rain and found the old well silted up and only just traceable. No signs of the former dam exist and the recent rain

must have drained off into the Daung-yu creek. The old well sites contained a weak solution of brine, about 6 inches in depth, and on analysis this brine proved to contain only 99 per cent. of salt. The brine that used to be obtained here is reputed to have been the best in the Shwebo District, and the present test cannot be said to have been a fair one. In fact it seems to me surprising that any salt was found at all, and I have little doubt that if the wells were opened up again a good brine would be found.

28. It should be noted that this area is further north than Halin or Thakuttaw and is not nearly so dry, but an abundant supply of fuel exists. On the whole I do not consider this area so suitable for the manufacture of solar salt unless brine of at least 7° Bé can be found. But as a boiling centre conditions are favourable provided a suitable supply of brine is obtained.

29. It seems to me that there is some possibility of a stratum of rock-salt existing below the surface. If this can be found, the fresh water available from the Daung-yu creek, one mile away, might be pumped down and a saturated solution of brine pumped up again and under these conditions the area could be worked under both the 'solar' and 'boiled' systems.

30. I understand that two capitalists of the district, Maung Nge of Wetlet and Maung Yôn of Kodaungbo, are anxious to exploit this area and applied some months ago for a salt license, which was refused. Perhaps it would be as well to permit these applicants to sink a well on the distinct understanding that they would be granted a direct-duty license, provided they find an abundant supply of brine, not below 7° Bé which is a perfectly safe working density.

Part 2.

CHAPTER V.

SADAUNG SAGAING DISTRICT.

31. Sadaung is situated 14 miles north-west of the Padu railway station and is the hub of the salt industry in the Sagaing District.

32. Salt manufacture is carried on in three quarters of the village, namely, Taungbo, Ywa-Zeit and Thin-dwe and the methods of manufacture are very much the same as elsewhere in the dry-zone, consisting of (i) irrigation of small plots of land with brine drawn from brine wells, (ii) lixiviation of salt-earth collected from the surface of the irrigated soil and (iii) crystallization in seven gallon iron pan, or cauldrons, over a mud fireplace.

33. The outstanding features of this centre are (a) the methodical manner in which the saline earth is scraped, and gathered together into a central heap by the use of cattle instead of manual labour (*vide* photograph in Appendix 12) and (b) the superior quality of the lixiviated brine.

34. Taungbo quarter is on a higher level than the remainder of the village and it is here that the best initial brine is found, and the best salt produced. The brine from two wells proved to contain 1.421 per cent. and 1.619 per cent. of NaCl at an average depth of 58.5 feet, from the ground level; the depth of the brine in the well being 18 feet. At lower levels the depth and density of the brine decreases and the quality of salt produced is very much inferior.

35. Sadaung village is about 7 miles from the north-west corner of the Ye-Myit-Kyi or Kadu Lake, which was almost dry at the time of my visit. This lake has an area of approximately 40 square miles and has not been brought under cultivation on account of the salt in the soil, and scarcity of fresh water. It is however periodically submerged and after each inundation a fresh supply of salt appears to be drawn to the surface.

36. During my visit the lake had the appearance of a large prairie, with patches of grass on the margin, but entirely destitute of vegetation in some parts. The surface brine of the lake proved on analysis to contain 1.24 per cent. of NaCl. The lake would be an excellent area to develop in order that this otherwise almost barren land may be made use of.

37. I was informed that a scheme to connect the lake up with the existing irrigation works has been under consideration, and understand that it is a costly proposal. This would no doubt secure a plentiful supply of fresh water but if the matter is brought up again I would strongly recommend that a careful boring test be conducted to ascertain definitely whether rock-salt exists, beneath the surface, or not. There is undoubtedly a vast quantity of salt in this locality, and if as I imagine to be the case, this salt is a deposit of a dried up inland sea then this lake is naturally indicated as the spot where the deposits are likely to be most abundant because it is on a lower level than the surrounding contry, and would be the centre towards which the remains of a shrinking sea would gravitate and deposit the bulk of its salt. If then, such is the case and an expensive irrigation scheme be adopted, it may so happen that salt, brought to the surface by capillary attraction each season, may possibly render the lake area uncultivable, as it is at present, notwithstanding the fresh water-supply, except perhaps for wet crops such as paddy which might possibly exist, in a superimposed layer of fresh water, but are likely to be affected during the ripening season when the soil is comparatively dry.

38. Near Taungbo quarter of Sadaung village, there is also about 50 acres of waste land, suitable for solar-salt works, on an experimental scale, and the brine wells as they stand contain 16.19 parts of salt per 1,000 as compared with 26.06 parts in the case of sea-water. With precautions taken to cut off fresh water, I feel convinced that the brine is sufficiently rich, at an average depth of 50 feet from the ground level, to make solar-salt manufacture a practical proposition.

39. A system worth consideration, in parts where a weak brine is available near the surface, is the pit or trench system, as worked in parts of Rajputana. In this system a pit or trench is dug with the banks sloping at an angle of about 45° and sufficiently protected to prevent any percolation of fresh water from the surface, or above the brine level. The total annual evaporation is in excess of precipitation, due to rain dew or fog, and a steady evaporation takes place. The brine, in the trench maintains its level and gradually increases in density as the evaporated water is replaced by a weak brine solution, until finally the salt crystallizes out and the trench is filled with salt to a level approximating the original level of the brine. The time taken to form these deposit depends entirely on the depth of brine, and rate of evaporation, and it may be noted that the latter is remarkably favourable in this locality.

40. The local salt boilers divide their land into two equal plots and irrigate each plot alternately. Two irrigations per day, at 6 a.m. and 6 p.m., suffice and each plot is scraped after 24 hours exposure in the hot weather, and 48 hours in the winter. This method of irrigation over loose, broken up, earth, exposes a maximum of surface and consequently speeds up evaporation, but, notwithstanding this, the heat and strong dry winds the locality is subjected to, place it in a very advantageous position.

41. In the low lying parts of Sadaung, a very inferior salt is being produced, the percentage of NaCl being 68.95 as compared with 83.84 and 81.85 at Taungbo less than a mile away. The principal impurities are sodium sulphate and sodium carbonate, and I believe that this may be due to the fact that the mother-liquor of generations of manufacture, has gravitated to the lower levels and is contaminating the supply wells. The mother-liquor, it may be noted, is not drawn off, or finally disposed of in any way, but is mixed with weak brine and poured over the fields, in the mistaken belief that it increases the output of salt. It must therefore re-appear in some form or other, and it seems to me, that a large portion of it, which does not move round in a circle from field to cauldron and cauldron to field, must drain down to the lower level with the effect described above. This would account for the excess of sodium sulphate which at ordinary temperatures is very much more soluble than salt. The presence of the sodium carbonate may be due to calcareous soil in the vicinity of the well, and to the fact that under certain circumstances salt in contact with lime is replaced by sodium carbonate, and the resultant calcium chloride drains away. The following is probably the equation:—



42. Other salt works are to be found at Baukthauk and Lenyin about five miles from Sadaung, in the direction of the Ye-mvit-kyi lake, and some small factories exist on the margin of the lake. These, however, are all worked on similar lines to the Sadaung factories and do not require a separate description.

CHAPTER VI.

YE-GA, SAGAING DISTRICT.

43. About seven miles due north of Sagaing is the Ye-ga (bitter-water) lake approximately one mile in length and half a mile across. The lake has the appearance of an extinct volcano crater, lying as it does, in a hollow surrounded by hills. It is above the level of the surrounding country and on the east a low range of hills (674 feet, trigonometrical height) separates it from the Irrawaddy River which is about two miles distant, as the crow flies.

44. The industry here has been temporarily abandoned as the persons who formerly engaged in it found that they could not afford to pay the duty imposed and sell their produce at a profit. The principal cause of this is that the article produced was to all intents and purposes not salt at all. It was purchased in 15 and 20 viss lots at prices ranging from at Rs. 2-8 to Rs. 5 per 100 viss and the purchasers are said to have retailed it at Re. 1 per viss. Its principal uses are for medical purposes and also, it is said, for 'loading' *ngapi*, probably with the intention of making use of its hygroscopic properties to increase the weight of this article. In any case it is quite certain that it cannot be used to any great extent as a condiment. The lake brine smells strongly of sulphuretted hydrogen and a sample of this salt was found to contain only 19.72 per cent. of salt and 55.81 per cent. of sodium sulphate, in addition to other constituents, *vide* Appendix 8. This product, then, is an impure form of Glauber salt.

45. I believe the daily quantity of salt necessary for a human being is estimated to be 10 grammes. To consume this amount in the form of the Ye-Ga product would involve the consumption of 28.30 grammes of sodium sulphate as well. What the physiological effect of habitually consuming this amount of sodium sulphate may be I do not know, but I feel sure that no one is likely to do it as a matter of choice. And the difference in price between the Ye-Ga article and a fair class of common salt is likely to be so infinitesimal that anyone would require to be poor indeed to substitute the cathartic on grounds of economy.

46. This is a form of impurity not noticed in Burma Bay-salt, due to the difference of conditions under which the brine occurs near the coast. But magnesium sulphate is an important constituent of sea-brine and as at low temperatures, near freezing point, magnesium sulphate and sodium chloride in strong solutions, break up, and their molecules re-form as sodium sulphate and magnesium chloride, according to the equation $\text{MgSO}_4 + 2\text{NaCl} = \text{Na}_2\text{SO}_4 + \text{MgCl}_2$. We may take it that probably this re-grouping took place in some bygone age when the lake contained a concentrated solution of brine, and probably resulted in the formation of sodium sulphate deposits similar to those found associated with the rock-salt at Strassfurth, in Prussia. Incidentally it may be mentioned that the discovery of these deposits in Prussia so reduced the value of sodium sulphate that it put an end to the manufacture of this salt from the mother-liquor of brine, which used, prior to the discovery, to be an important by-product feature of the salt industry on the coast of France. That this salt occurs here seems to me, another indication that rock-salt may also exist.

47. Manufacture was carried on here as recently as last year in very much the same manner as the manufacture of salt at Halin, which has been described elsewhere. The manufacturers state that their output was one viss of salt to every 20 viss of salt-earth used. This earth was scraped from the dried exposed margin of the lake left annually by the water contracting towards the centre due to evaporation in the dry weather. A photograph is attached to this report (Appendix 14) which conveys a good idea of the manner in which the water recedes. After collecting this soil some manufacturers used to obtain a fresh supply by irrigating a small portion of the exposed margin of the lake. The mud

is black, soft, tenacious and foetid, and in order to avoid walking into it, some manufacturers dug narrow channels and sank wells in the centre of the plot they irrigated, and with this connection between their land and the water of the lake they also saved the labour of walking to the water-line for their supplies.

48. The filter used was of a type somewhat different to the ordinary. A photograph will be found in Appendix 13. Boiling was conducted in three iron cauldrons, of which two were used as crystallizers and one as a reservoir. I was unfortunately not able to secure a photograph of these, but I have furnished a rough sketch in Appendix 15.

49. The lake brine was during my visit 3° Beaumé, lixiviated brine was 21° and the saturation point of the product obtained was 34°4' Bé. At this density little or no salt remains in solution, it should therefore be possible by taking advantage of the higher solubility of this salt, to obtain a fairly pure product.

50. Recent workers state that their average output was 15 viss per 24 hours for six months in the year. Fuel consumption was approximately 27 cubic feet per day of 24 hours and wastage due to deliquation was said to be about 29 per cent. per annum, but I should imagine it would be very much greater in other parts of Burma, where the humidity of the atmosphere is greater.

51. Whether the industry can be opened up on a large and profitable scale is a matter for the future to decide, in the meanwhile the fact remains that a number of people have been making a living out of it for many years. Last year ten families were employed. The product is decidedly not an edible salt such as was contemplated by the Salt Law and I am of opinion that this industry should be treated as entirely separate from that of salt manufacture. I do not think it should be subjected to taxation any more than the various chemicals produced in other parts of the province. The composition salt-tax, imposed as it is on the capacity of the vessels employed, does not permit of expansion, and although it may be necessary to protect the salt revenue, in the present instance, I feel convinced that it is handicapping an industry with which the salt revenue has no concern. This matter, I understand, was represented once before, but apparently the position was not clearly explained, and a misinterpretation resulted. I would recommend that it may be reconsidered in the light of the facilities we now possess for obtaining correct analytical reports on the products obtained, and, the improbability of any advantage being taken of any concession, with regard to the manufacture of chemicals, to deprive the Government of revenue by producing common salt.

52. This lake deserves the attention of capitalists interested in the production of chemicals on a commercial scale. It may be possible to build up an important industry and a thorough investigation by an industrial chemist is indicated. From a mere sodium chloride point of view, I would suggest the erection of a circular embankment round the circumference of the lake, to prevent the brine from receding during the hot weather. The space between this embankment and the natural bank of the lake would thus form a concentrating pond. As the brine evaporates and that beyond the embankment recedes towards the centre of the lake, the concentrating pond might be refilled by means of a pump. The contents of the concentrating pond might be solar evaporated until saturation point is reached, and since this is approximately 34°5 Beaumé all the less soluble salts, such as sodium chloride or calcium sulphate, will be deposited in the beds. It would probably be most economical to draw off the saturated solution at this stage and store it until the cold weather, when the low temperatures during the winter nights would be most favourable for crystallization.

Part 3.

CHAPTER VII.

WELLS AND BRINE SUPPLY.

53. The average existing brine well is about 3 feet in diameter, and is sunk through salt soil and other strata to a depth of 30 or 40 feet. In some half a dozen wells, I actually measured, I found that, irrespective of the depth of the

well itself, the brine rose fairly uniformly to within about 27 feet of the ground level at Thakuttaw.

54. There were traces of comparatively fresh water percolating through the sides of the wells. In some cases the salt-boilers have attempted to cut this off by means of a plaster of clay, but notwithstanding this effort, there can be little doubt that the brine is being considerably reduced in density by this contamination.

55. If, as I believe is probably the case, rock-salt exists below the surface, then water coming into contact with it would take the salt up in solution. The specific gravity of a saturated solution of salt would be about 1.208 and being heavier than fresh water there would be a tendency for the latter to lie on the top of the brine. Diffusion under such circumstances is a very slow process. Strong brine is invariably stored, without appreciable deterioration, in the open, during the rains, in the Amherst District, under several inches, and in some cases 2 or 3 feet of rain water. In the present instance capillary action would be somewhat assisted by contact with the soil, and it seems to me that possibly there may be a layer of rock salt beneath the surface capped by a stratum of gypsum, or marl which are fairly impervious to water, consequently the supply of saturated brine is limited and as in rising to the surface it has to pass through a cushion of fresh water its density must be greatly reduced in the process. It will therefore be understood that a really strong brine cannot be expected anywhere near the surface unless and until all fresh water is cut off.

56. I was not able to test the actual capacity on any of the wells inspected, but the boilers told me that they run dry when drawn on continuously by a single bucket, and fill fairly rapidly again when at rest. On the other hand, they explain that they are unable to dig the wells deeper because they fill more rapidly than they can be bailed out. As a rough guess based on the area and depth, I should place the maximum output, per well, per day of 24 hours, at 5,000 gallons.

57. The quantity of brine required to replace that lost by evaporation, drainage and leakage, etc., would be about half an inch per day, or 21,264 gallons per acre per day, and based on results obtained at Panga, I would estimate the probable crop to be as follows according to the initial density of brine available:—

Initial density in degrees Be.	Brine consumption in gallons per acre per day of 24 hours.	Estimated crop per acre of evaporating area per month.
25	21,264	243
50	21,264	426
75	21,264	729
100	21,264	972
125	21,264	1,215
150	21,264	1,458
175	21,264	1,701
200	21,264	1,944
250	21,264	2,430
300*	21,264	2,916
700	21,264	5,832
2500†	21,264	29,160

viss.

These calculations are necessarily approximate owing to the unknown local factors of temperature and humidity, but I believe them to be absolutely on the safe side.

58. It will be seen from the above that in order to work a 100 acre saltern (i.e. the economic minimum area) roughly some 400 wells of the existing type will be necessary, and the crop with a six month working season, should be from 7,29,000 in the case of Halin with its weak brine supply and shallow wells to 16,03,800 viss at Thakuttaw where deeper wells and a stronger brine are available.

59. In all wells inspected by me there were indications of the brine increasing in density in proportion to the depth of the well. The local boilers

* Minimum density recommended, † Saturated brine.

also agree that a more copious supply, and a stronger brine, is probable at a lower depth, but they have not been able to reach a lower depth than about 50 feet owing to the unstable nature of the soil, lack of funds to board in the well as they progress, and want of means to pump out the brine while working.

60. At Halin and Thakuttaw I conducted some actual tests and arrived at the following results :—

	At the surface.		At the bottom of the well.
Halin ...	1'25° Bé	...	2'00° Bé
Thakuttaw ...	2'25° Bé	...	2'50° Bé

Average depth of brine in the wells, 13·5 feet.

61. After careful consideration of the local conditions I am of opinion that a geological survey of this area and test borings may reveal valuable deposits of rock-salt, and with an assured supply of brine, of say, 5° Bé, in density, all other conditions are extremely favourable for the establishment of an important solar salt industry. The minimum density laid down for Madras, by Dr. Ratton was 2° Beaumé, and brine of this density is already available, but not in assured quantities.

62. Attached to this report will be found a rough plan of the stratification of the existing brine-wells (Appendix 16), and I have based my opinion regarding the existence of rock-salt on the observed conditions described above, as well as on the following well established characteristics of rock-salt formations.

63. The salt springs of Cheshire were known, and salt was manufactured from them, for about twenty centuries before the beds of rock-salt, which was the source of this brine, were discovered, and this discovery only took place within the last two hundred and fifty years. This was apparently due to the fact that over the bed of rock-salt there is often a stratum of marlstone which is very hard and impervious to water. On this stratum being drilled through the brine frequently rushes into the shaft so copiously that the sinking of these wells involves a certain amount of danger. The Thakuttaw boilers described a somewhat similar experience, met with in sinking their wells. They apparently drill through a thin stratum of marlstone and refer to the subsequent rush of brine by the term '*Bon-pauk*' which signifies the bursting of a roof. But in this case the brine is a very weak solution, due, probably to the well not being deep enough to pierce the real protective layer which is probably lower down.

64. The ancient tradition of the Sambhar Lake is described by Ashton in his "Salt Industry of Rajputana" in the following words :—

"At one time a dense forest flourished on the plain now occupied by the lake. About the year 540 A.D. a Chohan Rajput, named Manik Rai, who lived in a village called Sirthulla on the margin of the depression, used to graze his cows in this forest, and observed one day that one of the animals returned home dry. Determined to discover the reason of this he watched the cow the next day and found that she proceeded to the cave temple of the Goddess mother Sakambri (the consort of Shiva) in a conical hill on the western edge of the plain, and there milked herself into the brass vessel of an ascetic who sat motionless at the shrine absorbed in contemplation of the Deity. Having conducted herself in this pious manner, the cow returned to the herd, but Manik Rai remained behind and stole up unperceived close to the holy man. After a while the ascetic removed a charm from his mouth, and placing it on the ground commenced drinking the milk. Manik Rai instantly picked up the amulet, and by its virtue visited in spirit the twenty-four sacred places of Hindi pilgrimage in a moment: and as soon as the ascetic had finished his draught, presented the charm. The holy man now observing the stranger for the first time, was surprised at his honesty in returning the priceless amulet, and desired him to keep it. Manik Rai, however, refused, on which the ascetic directed him to present himself before the goddess, who would be kind to him. Obeying the ascetic, Manik Rai reverently approached the shrine, on which the goddess, instantly creating a horse, bade him mount and ride, but warned him to abstain from looking backwards. In accordance with this injunction, Manik Rai mounted and rode, taking a somewhat circular course, and as he passed along, the forest disappeared and the plain became covered with solid silver. By evening he had proceeded about 50 miles, when the branch of a tree having caught his turban, he turned to disentangle it, forgetting for a moment the goddess's prohibition: the horse stopped instantly and refused to go further. Manik Rai had no choice but to return home. As the sun arose next morning and displayed a vast plain of glittering silver, the inhabitants of the village of Sirthulla were awe-struck, and collecting in knots, sought

fearfully from each other the meaning of the strange sight. Manik Rai then related his adventure of the previous day, on which the sages of the community determined that he should be deputed to the goddess to beg her to take back her gift, as it would assuredly be the cause of war and destruction of the village. Manik Rai accordingly approached the shrine and delivered the message. The goddess replied that from real silver the plain would be transformed into one of apparent silver, and it instantly became a vast sheet of water. The inhabitants of Sirthulla remained in ignorance of the value of the lake till some time after, when a native officer of position in passing the lake noticed the formation of crystals of salt, in the water, communicated its worth to them, and had himself placed in charge of the place in order that he might manufacture salt."

In a somewhat similar but cruder legend the Burmese attribute the salt deposits of Shwebo, Sagaing and Katha, to the natural action of a female 'Beloo.' However little truth there may be in the legends themselves they both indicate that the appearance of brine or salt, in places where it had not previously existed, was sudden, and it seems to me, that a possible explanation of this may be, that the appearance was caused by the sudden cracking or bursting of the protective strata of gypsum or marlstone providing an outlet for the brine stream. I would suggest that possibly in the present case cracks or volcanic fissures in the otherwise impervious marlstone have provided a means of access, for fresh water, to the rock-salt strata and a very slow process of diffusion is taking place with the superimposed fresh water, which probably accounts for the weak surface solution now being worked.

In this connection I would also quote Dr. Ratton's work on 'Common Salt' for easy reference, page 298 :—

"As strong brine is heavier than weak brine, and diffusion makes little progress as a general rule, the density of brine springs increases with the depth of the boring. This is well shown by the following observations taken during the boring at the Dunenberg Salt Works :—

Depth.		Sodium chloride.
At 37'0 feet the brine contained	4'38 per cent.	
55'0 do.	3'79 "	
74'5 do.	2'95 "	
91'0 do.	3'21 "	
280'0 do.	4'64 "	
285'0 do.	3'82 "	
305'0 do.	4'94 "	
463'0 do.	2'50 "	
502'0 do.	2'90 "	
588'0 do.	4'25 "	
706'0 do.	3'30 "	
815'0 do.	5'25 "	
965'0 do.	6'82 "	
986'0 do.	9'26 "	
994'0 do.	12'14 "	
1024'0 do.	17'00 "	
1026'6 do.	19'16 "	
1028'5 do.	17'06 "	
1055'0 do.	16'86 "	
1064'0 do.	16'57 "	
1133'0 do.	15'15 "	
1138'0 do.	14'08 "	
1158'0 do.	14'66 "	

Alterations of strength may be accounted for by supposing that the various plains of stratification bored through are traversed by brine solutions of different densities, according to their surface or contact with rock-salt, and abundance of fresh water."

* * * * *

"Borings directed with a view to tap the sources of natural springs at some considerable distance from their natural outlets, are often successful in obtaining a stronger brine. Thus at Rodenberg, a spring containing 0'0 per cent. of sodium chloride at its natural outlet, was found by judicious boring near its source, to yield brine holding in solution 5'1 per cent. of salt. Test borings of the nature described should always be undertaken under the guidance and direction of a practical Geologist, otherwise a great deal of money may be thrown away in useless labour. In many cases the brine, as in artesian wells, is forced to the surface by hydraulic pressure."

65. I would add that although I have quoted Dr. Ratton's instance of boring to over 1,000 feet in Germany. I do not associate the local deposits with such extreme depths. I am no Geologist and perhaps should not venture an opinion but, from the manner in which the various salts associated with Bay-salt are found in close association here, I believe that a portion of this country must in pre-historic times have been an inland sea. I should like, therefore, to invite attention to the fact that although I advocate deeper boring, I would carry this to the point at which the familiar soils associated with salt cease, and would not embark on expensive drilling without further knowledge.

66. I would mention here that deep, medium and shallow brine wells exist and have been worked continuously for many years in China. Some accounts place the commencement as far back as two thousand years. The shallow wells are at Kwei-Chow-Fu on the Yangtze River, just over the border of the province of Szechuen and are about 35 feet deep. They are, however, comparatively unimportant, but the deep wells, which are situated in the mountain province of Szechuen, are of special interest as the brine obtained is boiled down by means of a natural gas, the existence of which is indicated in the Shwebo District, *vide* paragraph 82 of Appendix 9. These brine and gas wells of Szechuen are situated along hillsides between longitude 104° and 110° East and latitude 29° and 31° 5' N. The following figures indicate the importance of the industry, notwithstanding the fact that extremely primitive methods of manufacture are followed, and the wells have to be drilled, in some cases through hard limestone formation, from 1,000 to over 3,000 feet:—

1915. Total consumption of salt in China	...	1,502,678 tons.
1915. Total salt produced in Szechuen	...	328,125 tons.

(Anyone interested in this digression will find very complete accounts of the Chinese industry in "The Scientific American" Supplement No. 2133 of 18th November 1916, and "Metallurgical and Chemical Engineering" of January 1, 1917, September 1, 1917, and September 15, 1917. I mention it here as it seems to me that conditions are somewhat similar and with salt deposits in China on the East and the Sambhar lake deposits about long. 75° East and latitude 27° North on the West, it does not seem unreasonable to assume, in view of the evidence already recorded, that equally valuable deposits may exist in between at Shwebo or Sagaing).

CHAPTER VIII.

CONCLUSION.

67. To sum up, the following factors are in favour of establishing a sound industry in the Shwebo and Sagaing Districts with particular reference to Halin, and Thakuttaw in Shwebo, and Sadaung in Sagaing.

68. Evaporation—

Shwebo.	Sagaing.
Average shade temperature	Details not definitely
90°F., hot-weather.	known, approximately
60°F., cold weather.	the same as Shwebo.

Strong dry winds prevail in both districts.

69. Precipitation—

Shwebo.	Sagaing.
Rainfall, 30" to 35"	Rainfall, average 32.5".

70. Soil.—As a general rule land suitable for paddy cultivation is sufficiently 'percolation-proof' to be used as concentrating ponds. Large areas of such land are to be found in both districts, shown on the maps as waste land due to drought and an insufficient supply of fresh water to enable it to be brought under cultivation. The so called black cotton-soil is apparently also suitable and is not unlike the Amherst District salt-soil.

71. Labour.—Average cost in both Sagaing and Shwebo, eight annas per day, as compared with 13 annas 4 pies in the Amherst District.

72. Market.—Upper Burma would in itself provide a good market for the produce obtained and, with some suitable provision for granting a rebate on salt exported, overland, a potential market exists in China, *via* Bhamo, Myitkyina and Lashio provided there is not any international convention prohibiting this trade. Large quantities of salt are, I understand, already being exported by these trade routes, notwithstanding the fact that it apparently has to pay duty, *equivalent to the rate levied on salt consumed in the province.*

73. Fuel.—At, and north of, Kodaungbo, in the Shwebo District, there are dense forests and an abundant supply of fuel could be arranged for by the reservation of a portion for salt fuel.

Full particulars regarding an abandoned coal mine, about 24 miles north-east of Shwebo, will be found in Appendix No. 9, and as salt boiling does not require fuel of a very high calorific value, it may probably be very useful, both here, and possibly also in the Amherst District where the fuel problem is acute.

74. As against these advantages, the possibility of occasional serious floods will require to be guarded against, and in this respect the areas reported on are apparently beyond the radius of the sphere notorious for periodical floods. With normal precautions, I would not anticipate any serious damage from this cause, but the matter should certainly be taken into consideration in selecting sites for important salt gardens.

75. From the foregoing I think it will be agreed that experimental borings are indicated in the vicinity of—

- (i) Sadaung, Sagaing District; preference being accorded to a suitable spot on the margin of the Ye-myt-kyi lake.
- (ii) Wetlet, Thakuttaw, Shwebo District.
- (iii) Halin, Shwebo District.
- (iv) Kodaungbo, Shwebo District.

As this boring is likely to be an expensive business, it will require careful consideration and management. To drill artesian wells would cost approximately Rs. 12-8 per foot, and the introduction of this expensive method is probably not yet justifiable. I would therefore suggest that a test well be sunk first at Sadaung, Sagaing District, in a position central to the existing factories, and for this purpose I would not, at first, dig deeper than 200 feet. An open well would probably be the cheapest and most satisfactory for this purpose. As a lining I would suggest reinforced concrete for the purpose of cutting off fresh surface water. Diameter at top 6 to 8 feet. Inside of this well I would let down a 3 inch iron pipe (iron piping is sometimes used in Cheshire), or tree trunks bored out and tapered at the end to admit of each pipe fitting into the next lower one, to within 2 feet of the bottom of the well; in order that the lowest and densest layer of brine may be tapped. The pressure of the surface weak brine in the well will raise the brine inside this pipe so that probably no great lift will require to be provided for. A 3 inch, 60 feet lift, centrifugal pump with a capacity of 150 gallons per minute, together with a 13 horse power oil engine will cost approximately Rs. 5,500 new, in Rangoon. But as regards these details, I would first complete the well, and on knowing its capacity and the actual conditions necessary to be provided for, it will be a simple matter to select a suitable pump. Possibly the Disposals Board may see its way to provide a pump and engine from the surplus Government stores now lying at the Government Stores Depot, Haji Bunder, Sewree, Bombay. I notice a large number of pumps are being advertised and there does not seem to be any very great demand for them.

76. With the well and pump established I would recommend solar salt manufacturing experiments on a very small scale, having in view the following main factors:—

- (1) Density of brine at various depths.
- (2) Capacity of well.
- (3) Suitability of soil.
- (4) Ratio of precipitation and evaporation.
- (5) Quality of salt.

65. I would add that although I have quoted Dr. Ratton's instance of boring to over 1,000 feet in Germany. I do not associate the local deposits with such extreme depths. I am no Geologist and perhaps should not venture an opinion but, from the manner in which the various salts associated with Bay-salt are found in close association here, I believe that a portion of this country must in pre-historic times have been an inland sea. I should like, therefore, to invite attention to the fact that although I advocate deeper boring, I would carry this to the point at which the familiar soils associated with salt cease, and would not embark on expensive drilling without further knowledge.

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76. With the well and pump established I would recommend solar salt manufacturing experiments on a very small scale, having in view the following main factors:—

- (1) Density of brine at various depths.
- (2) Capacity of well.
- (3) Suitability of soil.
- (4) Ratio of precipitation and evaporation.
- (5) Quality of salt.

Some experiments may be necessary with the salt in order to secure a superior quality, but I anticipate no serious difficulty on account of impurities commonly associated with salt and those particularly likely to be met with can be disposed of by precipitation or retention in the mother-liquor. Organic impurities are more difficult to deal with, but I have no doubt that, if they are met with, they can be eliminated by careful treatment of the brine.

77. The total cost of this experiment I would limit to some definite amount governed by the cost of the well and plant. The well might be constructed by a Public Works Department Engineer from whom an estimate could be obtained if necessary, and the cost of the plant will, of course, depend upon where it is obtained. These capital charges *plus* Rs. 300 per mensem should be sufficient to start with and arrive at conclusive results.

78. It should be remembered that the minimum density considered essential for solar works, in Madras, was fixed by Dr. Ratton, at 2° Beaumé (*vide* page 233, Handbook of Common Salt, second edition, 1921 reprint). The brine now available, in this locality, is anything from 1.25° Bé to 2.5° Bé and contains 1.619 per cent of NaCl, as compared with 1.736 per cent. which is the approximate content which may be expected in 2° Bé, Madras brine. Conditions are therefore already favourable, notwithstanding the fact that no real effort has hitherto been made to effectually shut out fresh water from the brine wells now being worked. It is therefore as certain, as can be, in a venture of this nature, that brine obtained by the method now recommended will be much superior to the brine now used, and if at any time it is considered desirable to abandon the experiment, I have no doubt that a ready purchaser will be found for the well and pump which could be converted into a profitable business by the purchaser fitting up a system of bamboo aqueducts and supplying the surrounding factories with brine at certain fixed rates.

79. This would form a safe nucleus from which to extend the experiment to Halin, Thakuttaw and Kodaungbo, should it be desirable to do so. And the results would indicate beyond doubt whether deeper boring would be justifiable. Further experiments at these places would, in due course, indicate the best locality for the permanent establishment of a large scale factory. I would add that the loss in salt revenue alone, by the continuance of the composition-duty system, in these districts, must at present amount annually to probably as much as I propose to expend on the experiment. The scheme is a very modest one for Government to undertake; it might well be more ambitious, but I have endeavoured to reduce expenditure to the absolute minimum and at the same time suggest a scheme which, by the elimination of everything in the nature of precipitate speculation, is as safe as I can make it.

80. Any discovery of a rich and copious supply of brine, or a vein of rock-salt, might well be the means of transforming these areas into really important salt centres.

81. As regards Kodaungbo I would recommend that the persons who have already applied for licenses be permitted to prospect for brine, on the same lines, at their own risk, if they wish to do so.

82. Finally, I would suggest that ten tons of the Shwebø coal be obtained, if possible, and forwarded to the Government Experimental Salt Boiling Factory at Panga, for experiment. Suitable furnaces already exist, on this factory, and although it may not have been suitable for railway or steamship furnaces, it might prove an excellent fuel for salt manufacture. Incidentally I might mention that the ordinary fuel used in Cheshire is coal, slack, with 15 to 20 per cent. of ash. And while on the subject of fuel the possibilities of the 'Fire fountain' of Wethaw might be thoroughly investigated.

APPENDICES.

E. G. ROBERTSON,
Superintendent of Excise (Salt).

(17)

APPENDIX 1.

Report of Analysis, Shwabo District, BRINES.

Locality	Thakuttaw.		Kaoaungbo.		Halin Hot-spring.	Bay of Bengal.
	Well No. 1.	Well No. 2.	Surface brine 1.	Surface brine 2.		
Authority	Mr. Wischam, B.Sc. Asst. Supdt., Excise (Salt).					King.
<i>Constituents.</i>						
Sodium chloride	1'638	1'634	0'922	0'990	0'68	2'606
Magnesium chloride	...	...	...	...	0'02	0'281
Potassium chloride	...	...	...	...	...	0'120
Calcium chloride	...	...	...	...	0'09	...
Magnesium sulphate	0'278	0'177	0'061	0'021	...	0'182
Calcium sulphate	0'130	0'206	0'041	0'047	0'01	0'136
Sodium sulphate	...	...	0'028	0'007	...	...
Organic matter	0'001	...	0'009	0'002	Trace.	...
Insoluble inorganic matter	0'015	0'020	0'015	0'003	Trace.	...
Ferric oxide and alumina	0'008	0'004	...	...	Trace.	...
Water	97'930	97'959	98'924	98'930	99'20	98'675
Percentage of solid constituents	2'070	2'041	1'076	1'070	0'80	3'325

APPENDIX 2.

Report of Analysis, Sagaing District, BRINES.

Locality	...	...	Sadaung.				Ye-ga.	Yemyitkyi.
			Taungbo 1 Well brine.	Taungbo 2 Well brine.	Thin-dwe 1 Well brine.	Thin-dwe 2 Well brine.	Lake Brine.	Lake brine.
Authority	...	...	Mr. Q. Wischam, B.Sc., Asst. Supdt. of Excise (Salt).					
Constituents.								
Sodium chloride	...	...	1'619	1'421	1'117	1'013	0'69	1'24
Magnesium chloride	...	...	0'157	0'199	0'012	0'008	...	0'11
Magnesium sulphate	...	...	0'163	0'020	0'106	0'072	0'08	...
Calcium sulphate	...	...	0'068	0'214	0'024	0'020	0'05	0'02
Calcium chloride	...	...	...	...	...	...	...	0'02
Sodium sulphate	...	...	...	...	...	...	0'91	...
Organic matter	...	...	0'006	0'009	Trace	0'007	0'01	0'01
Insoluble inorganic matter	...	...	0'008	0'018	0'002	0'001	0'02	0'01
Ferric oxide and alumina	...	...	0'069	0'078	...	...	Trace	Trace
Water	...	...	97'910	98'041	98'739	98'874	98'24	98'59
Percentage of solid constituents	...	...	2'090	1'959	1'261	1'121	1'76	1'41

APPENDIX 3.

Report of Analysis, Shwabo District, LIXIVIATED BRINE.

Locality	Thakuttaw.	Locality.	Thin-dwe, Yega lake.	
Constituents.		Constituents.		
Sodium chloride	10.256	Sodium chloride	14.310	4.90
Magnesium chloride	0.560	Magnesium chloride ..	...	...
Magnesium sulphate	0.155	Magnesium sulphate ...	0.254	0.34
Calcium sulphate	0.388	Calcium sulphate	...	0.20
Organic matter	0.002	Sodium sulphate	1.751	12.82
Insoluble inorganic matter ...	0.013	Organic matter ..	Trace	0.02
Ferric oxide and alumina ...	0.239	Insoluble inorganic matter...	0.002	0.08
Water	88.387	Ferric oxide and alumina ...	...	0.04
		Water	83.683	81.60
Percentage of solid constituents ...	11.613	Percentage of solid constituents.	16.317	18.40

APPENDIX 5.

Report of Analysis, Shwabo District, SOILS.

Locality	Halim.		Kodaungbo.
	Well Soil.	Field Soil.	Marsh Soil.
Constituents.			
Sodium chloride	0.08	1.75	1.25
Magnesium chloride	0.05	2.48	...
Magnesium sulphate	...	0.50	0.54
Calcium sulphate	0.03	0.53	0.07
Sodium sulphate	...	...	0.07
Sodium carbonate	...	...	...
Calcium chloride	0.04	...	...
Organic matter	Trace	4.19	2.77
Insoluble inorganic matter ...	0.33	83.90	2.728
Ferric oxide and alumina ...	Trace	0.12	0.19
Water	0.27	6.53	67.83
Sand	99.20	...	...

APPENDIX 6.

Report of Analysis, Sagaing District, SOILS.

Locality	Ye-ga Lake Soil.	Sadaung Thin-dwe Surface Soil.	Sadaung Ywa-zait Surface Soil.
Constituents.			
Sodium chloride	3.11	0.97	0.22
Magnesium chloride	...	0.49	1.05
Magnesium sulphate	2.22	0.50	0.34
Calcium sulphate	0.41	0.01	0.50
Sodium sulphate	11.18	...	...
Organic matter	0.09	0.07	0.06
Insoluble inorganic matter ..	65.16	26.56	24.74
Ferric oxide and alumina	Trace.	Trace	0.05
Water	7.02	4.86	4.03
Sand	10.81	66.54	69.01

APPENDIX 7.

Report of Analysis, Shwabo District, SALT.

Locality	Halim	Government factory.*	Government factory.*
	Boiled.	Boiled.	Solar.
Constituents.			
Sodium chloride	76.57	96.90	97.42
Magnesium chloride	0.46	...	...
Calcium chloride	3.26	...	...
Calcium sulphate	1.71	1.05	0.17
Magnesium sulphate	...	0.06	0.20
Sodium sulphate	...	...	...
Organic matter	Trace	...	...
Insoluble inorganic matter ...	0.09	0.08	0.07
Ferric oxide and alumina	0.17	0.09	0.10
Water	17.64	1.82	2.04

* Included for purposes of comparison.

APPENDIX 8.

Report o Analysis, Sagaing District, SALT.

Locality.	...	Taungbo 1st class.	Taungbo 2nd class.	Thin-dwe.	Ye-ga.
<i>Constituents.</i>					
Sodium chloride	...	83.84	81.85	68.95	19.72
Magnesium chloride	...	1.76	1.44	...	...
Calcium chloride	...	...	...	...	...
Calcium sulphate	...	2.30	3.22	...	0.31
Magnesium sulphate	...	0.91	1.20	0.07	3.91
Sodium sulphate	...	...	...	8.42	55.81
Sodium carbonate	...	...	...	10.51	...
Organic matter	...	0.04	0.05	0.12	0.08
Insoluble inorganic matter	...	0.09	0.56	0.73	0.70
Ferric oxide and alumina	...	...	...	0.25	0.07
Water	...	11.26	11.68	10.88	19.46

APPENDIX IX.

Extract from Report on the Settlement Operations in the Shwabo District, 1900-1906.

* * * * *

75. A still more important mineral product of the district is coal. There are coal mines situated at a place called Letkobin in the Kin-u Township, about five miles north-north-west of Kawbwet on the Irrawaddy. The coal is said to have been discovered in Mindon's reign by the Thon-myo-wun, Maung Po, who ruled over this part of the country. He reported the matter to the king, who ordered excavation. Work was started in the dry weather by digging a big hole of oblong shape, about 60 feet in length and about 40 feet in breadth. Coal was found at a depth of about 15 feet, and digging was continued to a depth of 25 feet. The king had an idea of burning this coal on his steamers in place of the timber fuel then in use, and advanced money for the excavation, but the ministers and other officials who had the handling of such money helped themselves to most of it and very little reached the workmen. The coal was carried in small baskets, woven for the purpose, on a pole between two men who had to ascend and descend by steps dug in the sides of the hole. From the pit's mouth the coal was taken to Kawbwet in solid-wheeled carts, the only kind then in existence. In those days there were no made roads, the carts soon fell to pieces with having to traverse the rough and rocky country, and the carters had a bad time generally. The labour was forced from the surrounding villages and the labourers were paid scanty wages according to the pleasure of the Thon-myo-wun who acted as paymaster. Work was carried on till the rains, when the pit was filled by rain-water and by the flooding of the surrounding country, after which it became impossible, and was never taken up again under Burmese supervision.

76. Sir W. B. Hudson, an indigo planter, had been asked by the Government of Bengal to interest himself in the question of emigration from the congested districts of Behar to Burma; in April 1889 therefore, he accompanied the Bengal Director of Agriculture to Burma. He found that the climate of Upper Burma was more suitable for Beharis than that of the Lower Province, but the country was still not fully settled and the information as to what land was available for the purpose of settling agricultural immigrants was not forthcoming. Accordingly Sir W. B. Hudson was requested by Government to visit Burma again in the ensuing winter. This he did, and was accompanied by Mr. Walker, of Calcutta to Rangoon, where they were joined by

Mr. Herrmann, who had already applied for coal mining concessions in the tract now under remark. Sir W. B. Hudson and Mr. Walker both joined the syndicate to work coal. Sir W. B. Hudson was offered by the Government a lease of 158 square miles or 101,120 acres under certain conditions. The idea was that the coal mines could not be entirely worked by Burmese labour that the employment of Indian labour would be inevitable, and that an agricultural settlement of Beharis would have helped to bring under the plough the waste land, of which the bulk of the lease offered consisted, as well as supply labour for the coal mines. But this scheme fell through. An offer was also made by this syndicate to undertake the manufacture of salt in this district on a large scale. They proposed to buy brine from the Burman workers, or to acquire the wells, and sink others where advisable. They proposed to use the refuse coal from their mines for boiling the brine, and to lay a tramway for the conveyance of coal refuse to the salt wells, and for the removal of the salt. As salt is manufactured chiefly at Halin, and southwards of it, the tramway would have had to be laid in the first instance for some thirty odd miles, the distance from Letkobin to Halin thence on to Thakkutaw and other salt boiling villages. This scheme also fell through, as Government declined to guarantee that the duty on salt would not, for a certain number of years asked for by the syndicate, be raised beyond what was then levied, namely, Rs. 2 per 100 viss.

77. In about January 1890, Messrs. Hudson, Walker and Herrmann came up and inspected the site of the mines and in December 1891 obtained a license, under the title of the Shwabo Mining Syndicate, to work them. They made all the necessary arrangements by building houses for the staff and labourers and establishing their working plant, etc. Work however does not seem to have been started till 1892, in which year the output was 3,670 tons of coal. When enough coal was obtained to tranship to the river, a small tramway, costing between two and three lakhs of rupees, was constructed from the mines to Kabwet. The laying of the tramway was rendered necessary by the refusal of Government to make a siding from the Mu Valley Railway to the site of the coal mines (a distance of about 25 miles from Kin-u) until sufficient quantities of coal were produced to give a return for the expenditure. A proposal was afterwards made to open out the coal area by a branch line from the Mu Valley Railway and preliminary surveys were made. But no railway line was ever constructed. It was not, however, till February 1893, when the mine changed hands and the Burma Coal Company obtained the lease of 84 square miles to prospect, that the work was started in earnest. In this year 9,038 tons of coal were obtained, of which some 900 tons turned out to be useless. The daily average of persons employed on the mines during that year were 176 men, 131 women and 13 children or a total of 320 souls. The Company are said to have lost on the year. In an inspection note, dated July 1896, the Deputy Commissioner says that:—

"A survey and examination of a useful and practical description has been carried out, which, until refuted, tends to prove that the extent of coal in the locality of Letkobin is large. The original theory by the late Manager that the mine is confined to a small area, probably containing not more than 70,000 tons has been upset. The present theory is that a very extensive area of coal exists. . . . At present there can be no doubt that only surface coal has been extracted and considerable expenditure is necessary to sink proper shafts and work out the superior quality which is believed to exist at a greater depth it having shown that the coal is improving as a greater depth is arrived at."

The great difficulty of supplying water in the dry season was met by bringing it up from the river in tanks on the tramway, until the Manager constructed a reservoir by bunding up ravines, and laid the water on to the village and works by pipes. The total amount of coal extracted from the mines from beginning to end was some 154,288 tons valued in the early days at Rs. 9-9 and latterly at Rs. 9-8-0 per ton of pure coal, or Rs. 6-8-0 per ton including dust. The coal was sold to the Burma Railways and to the steamers of Government and the Irrawaddy Flotilla Company. Towards the end the difficulty in finding labour reduced the output, and the deterioration of the quality of the coal found hastened to abandonment of the work in 1904. In the previous year Messrs. Begg, Dunlop & Co., Calcutta, the Managing Agents for the Burma Coal Company, had sold the engines and machinery to Messrs. Sevastopulo and Clifford of Rangoon, though the lease was not taken over by them. The latter extracted some 10,000 odd tons of coal and finding that the investment did not pay, stopped work. In September 1904 the lease was cancelled as the mines could not be worked without intermission, and to the satisfaction of Government.

78. All these companies were managed by Europeans, with European capital and were a source of income to the poor of the neighbourhood, some of whom were stranded on the cessation of the work without the means to return to their homes. These in many cases found their way to Thabeitkyin to work as coolies on the Mogôk road, while others settled down in Kabwet and the neighbourhood to work as agricultural coolies and boatmen. The 60 houses of which the colony consisted in 1891 had increased to 200 in 1904 when operations were suspended. On the death of the old Burmese *thungy*

there were many applicants for the vacant post, and as they could not come to terms to smooth matters over the European Manager of the mines was elected *thugyi* by the villagers. He was, after a time, replaced by another Manager who did not wish to do the work of a *thugyi* and a Burman cooly gaung was appointed. All the inhabitants of the colony were engaged by the mining Company and paid a privileged *thathameda* of Rs. 5 a household. If any one came and settled down there without work in the mines he had to pay the full Rs. 10 rate of *thathameda*, and was not encouraged by the Company to stay; in fact the Manager and the people took it that residence in the colony made one liable to be called upon to work in the mines. At first the number of people employed averaged over 300 souls daily for the year, it then fell to a little over 200 and finally, for the two years previous to the closing of the mines, the average number was reduced to under 100. The 18 households now left on the site pay the full *thathameda* rate; they cut fuel for the Irrawaddy Flotilla Company and also work *taungyas*. Amongst them is a native of India who is a cattle-trader and money-lender; he is said to own some 150 head of cattle, and to accept cattle as interest if the money is not forthcoming. There is still standing in very good repair, a large building on the plan of an English cottage, except that the top story is of wood, which was erected for the residence of the Manager of the mines. A wooden shanty built at the same time, also remains. These houses attract the attention of the traveller to Kabwet, as they are not far from the Public Works Department road, and act as melancholy land-marks of a decayed industry, which helped to develop the resources of the country, and with encouragement might have remained the maintenance of many poor families, both in this country and in India. Although deficiency of late years in the quantity and quality of the coal is said to have been the main cause of failure, the Burmans who have worked in the mines have an idea that the seam is far from exhausted, and that it is of good quality.

79. In March 1893 one Maung Po Hnet of Letpangon village, Wuntho, applied for a concession to prospect for coal in the country between the Minwuntaung and Zin *chaung*, east of the village of Yawgon in the Bawmyo; he was informed by the Deputy Commissioner that, before his application could be accepted, he must be approved by the Local Government, and submit the necessary certificate of approval and plan of land, etc., as required by the rules; this apparently he was unable to do, and nothing more was heard of him.

80. In 1904 a license to prospect for coal in *kuins* 3048 and 3049 of Nyaungbinyo and Thitcho villages in the Kyunhla Township of this district, was granted to Messrs. Stathacopulos and Echlin of Rangoon for one year, which terminated on the 1st October, 1905. Mr. Echlin, formerly Manager of the Letkabin coal mines, died, at the end of last year, of fever contracted in the northern jungles, and the license has not been renewed. Mr. Stathacopulos has asked that the matter be left in abeyance till he could make other arrangements to work the mines. It is believed that this coal is lignite and not anthracite or bituminous. Coal is said to exist also at Udaung in the same township.

81. In about August 1902 two inhabitants of Mandalay, Koola Ismail, Khan Bahadur, and ex-thandawsin Maung Kyaw E, each obtained a lease to prospect for petroleum at Naunggauk and Wethaw respectively, in Kyunhla Township. Experimental borings were made and one well was actually being made to yield (a set of appliances resembling a diver's apparatus with an air pump was in use), but the yield was, on the whole poor and not apparently likely to improve. Work on a large scale has not yet been started although the rents due to Government have been paid regularly up to date. Both lessees appear to be depending on the Burma Oil Company to help them, and have been allowed to remain in possession for another year from April 1905.

82. Near Wethaw is a natural fountain of fire in the side of the hill; gases issue and are ignited by the intense heat imparted to the rock by the sun's rays in March and April, and flames burst forth until quenched by the first rains.

* * * *

APPENDIX 10.

(b) Rainfall and Seasons.

140. The average rainfall over the greater part of the district is between 30 and 35 inches. Generally speaking, the rainfall is more regular as one proceeds northwards. It is also heavier, the average of twelve years at Kanbalu being nearly 40, and the average for eleven years at Kyunhla over 42 inches. There are no recording stations north of these, but the rainfall is probably heavier still near the Katha border. It is also heavier among the northern forests along the banks of the Mu and to the west of the river than in the thinner jungles near the railway line, as the recorded figures for Kyunhla and Kanbalu indicate. The Baw valley is probably as wet as any part of the district. The hilly

and partially wooded ground along the Irrawaddy seems to attract rain, for the average of twelve years' records at Letkokbin is 44 inches, and the total for the year 1899 was over 63. Sheinmaga, the other station on the river bank, has had as much as 52 in 1894, 47 in 1895 and 46 in 1905 though at times it has fallen very low, 22 in 1891 and 1901. Statements No. XI (a) to No. XI (b) of the appendices include a chart showing the curves of average rainfall for the nine stations at which records have been kept for any length of time, and separately for Shwebo town; tables of average monthly rainfall at the same nine stations, and of mean rainfall at all the recording stations, year by year; total annual rainfall at each recording station year by year; and details month by month for each station. It will be seen that there is practically no rain till the end of April. Between the middle of May and the middle of June there is usually a good fall, followed by a break which lasts till the middle of August. September is the wettest month in the year and after that the rainfall declines rapidly. A few light showers are almost always received during November, and one or two showers fall as a rule in December and again in February. These are useful to cold weather crops but rain in November or December may cause damage to *ya* crops that have not been harvested.

141. The lowest mean rainfall is for the famine year 1891, and the highest is for 1899, the good year preceding settlement. The settlement year comes next in order of total mean rainfall. But the quality of the season does not always follow the quantity of rainfall for the whole year. Though the total mean rainfall for 1895 was 37 inches, the season was bad, while 1893 with 33 inches was fair. The rainfall of August and September seems to be more valuable than that of other months, for 1898, with a total mean rainfall of 31.66 inches, of which nearly 7 fell in August, and over 8 in September, was a fair season, whereas 1892 with a total of 35.53 was poor; a good deal of the rain fell before the end of June, only four and half inches fell in August, and under 4 inches in September. As elsewhere in the dry zone the fall is patchy. For instance, the year 1903 was fair for the Ngayane tract but bad for the adjoining Myethe tract, but Myethe did moderately well in 1902, when the season was disastrous for Ngayane."

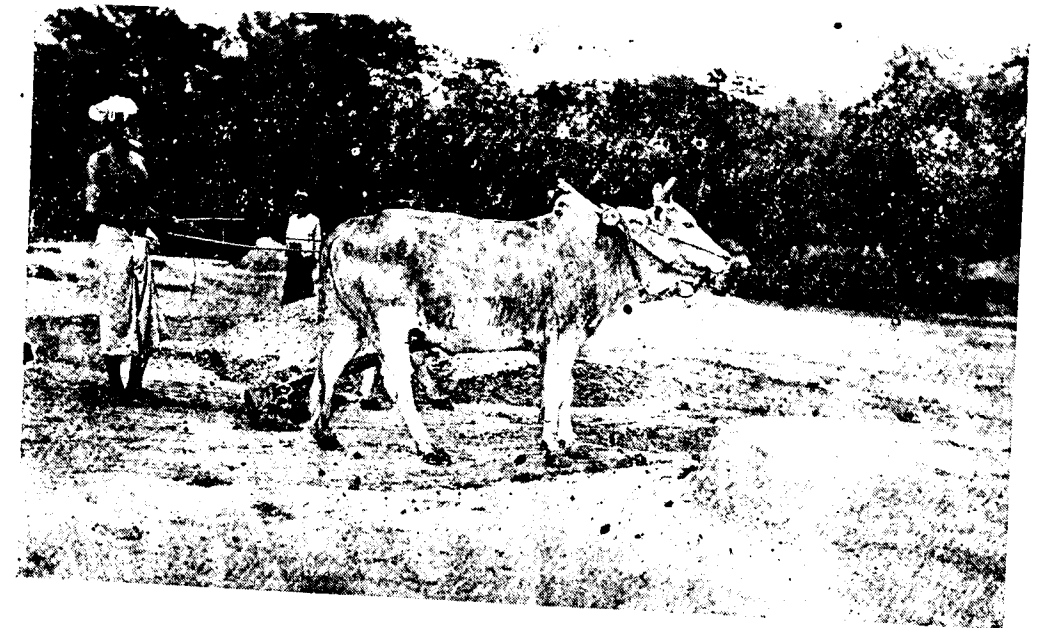
APPENDIX 11.

RAINFALL RECORD OF WETLET FOR THE YEARS 1918 to 1920.

NOTE.—Wetlet Railway Station is about 2 miles from the Thakuttaw Salt fields in the Shwebo District.

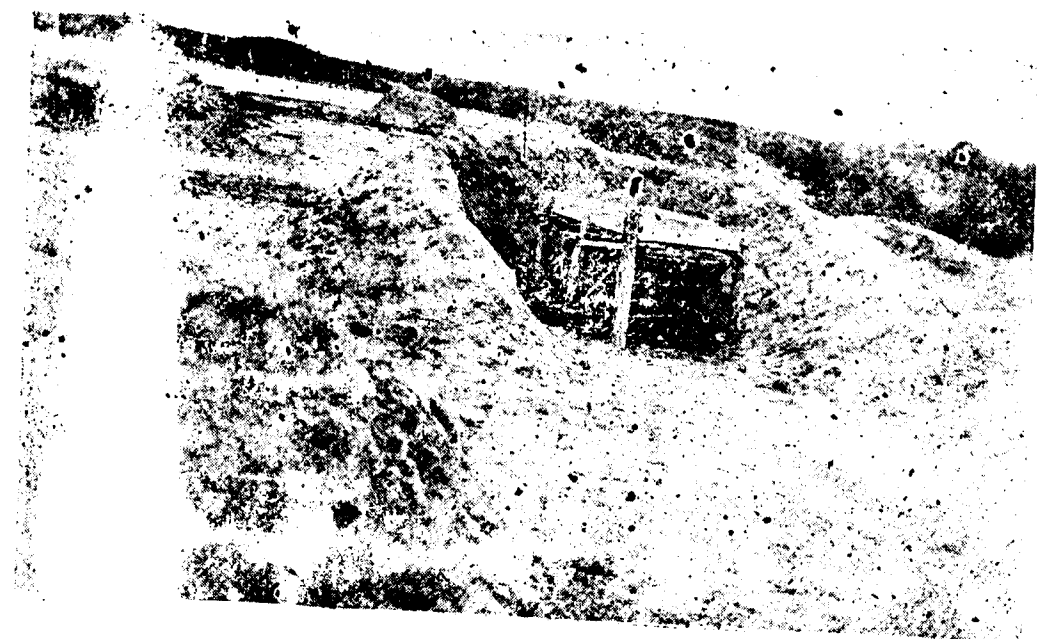
		1918.	1919.	1920.
January	...	...	...	...
February	...	...	...	...
March	...	1'11	...	...
April	...	0'11	0'35	...
May	...	3'44	2'98	3'32
June	...	3'56	5'41	1'20
July	...	1'04	3'74	4'65
August	...	3'94	5'85	5'17
September	...	7'06	1'40	5'61
October	...	4'71	0'80	1'23
November	...	...	1'30	...
December	...	...	0'10	...
Total ...		24'97	21'93	21'18

APPENDIX 12.



Scraping salt earth at Sa-daung, Sagaing District.

APPENDIX 13.



Filters, Y-sa, Sagaing District (Note the lake in the back ground.)

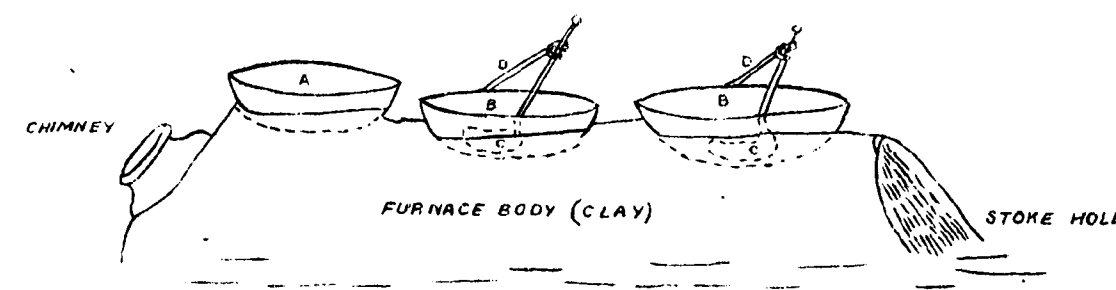
APPENDIX 14.



Ye-ga Brine Lake, Sagaing District.

APPENDIX 15

Rough Sketch of Salt Pans at YE-GA, SAGAING DISTRICT.



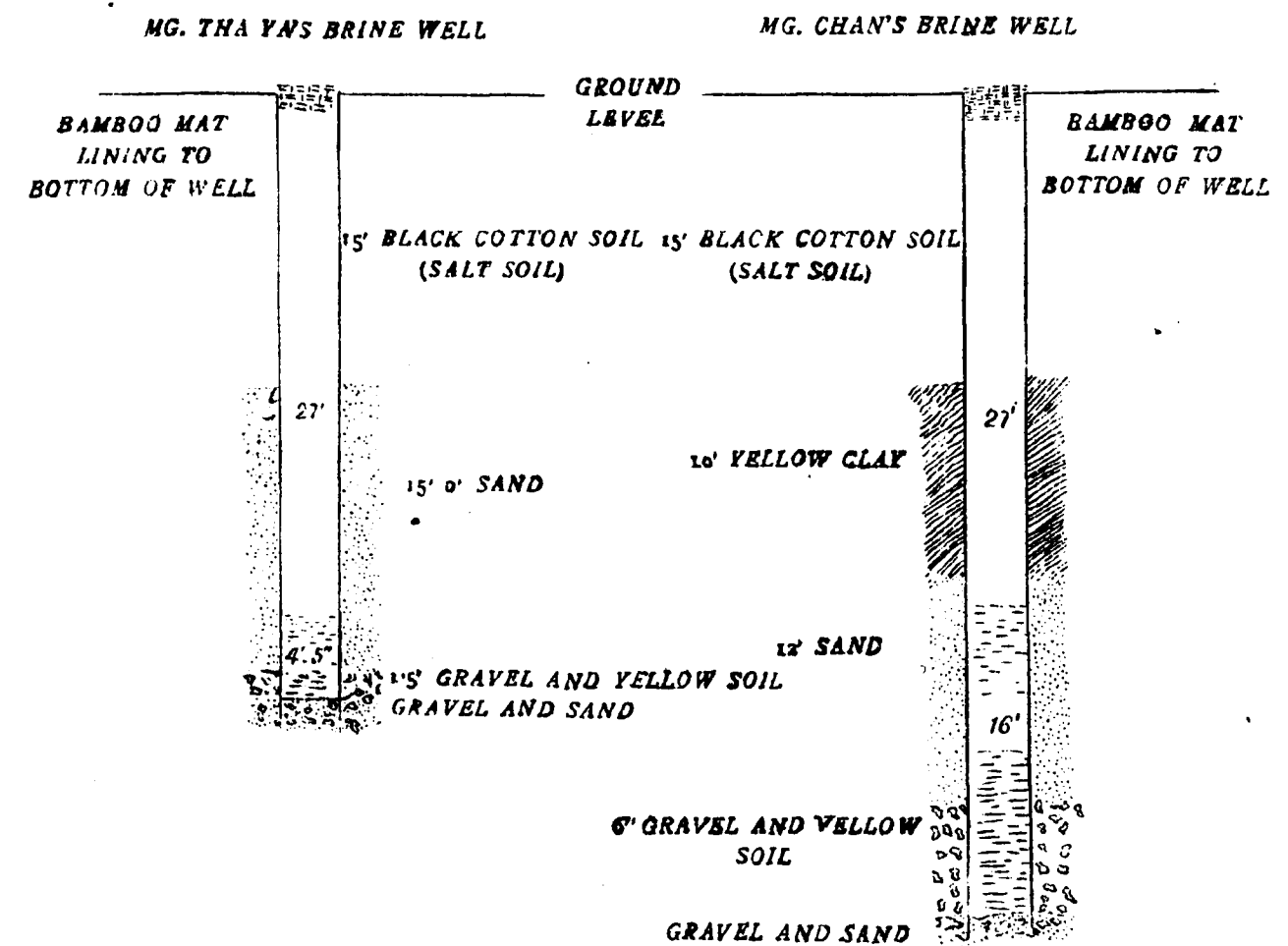
- A. Reservoir (1 gallon, cast iron)
- B.B. Crystallizing Pans (1 gallon, cast iron)
- G.G. Ladles (Copper or shell)
- D.D. Ladle Props

E. G. ROBERTSON,
Superintendent of Exoise (Salt),
 18th July 1921.

APPENDIX 16

Rough Plan of Stratification at THAKUTTAW, SHWEDO DISTRICT

Scale: 1 inch = 10 feet.



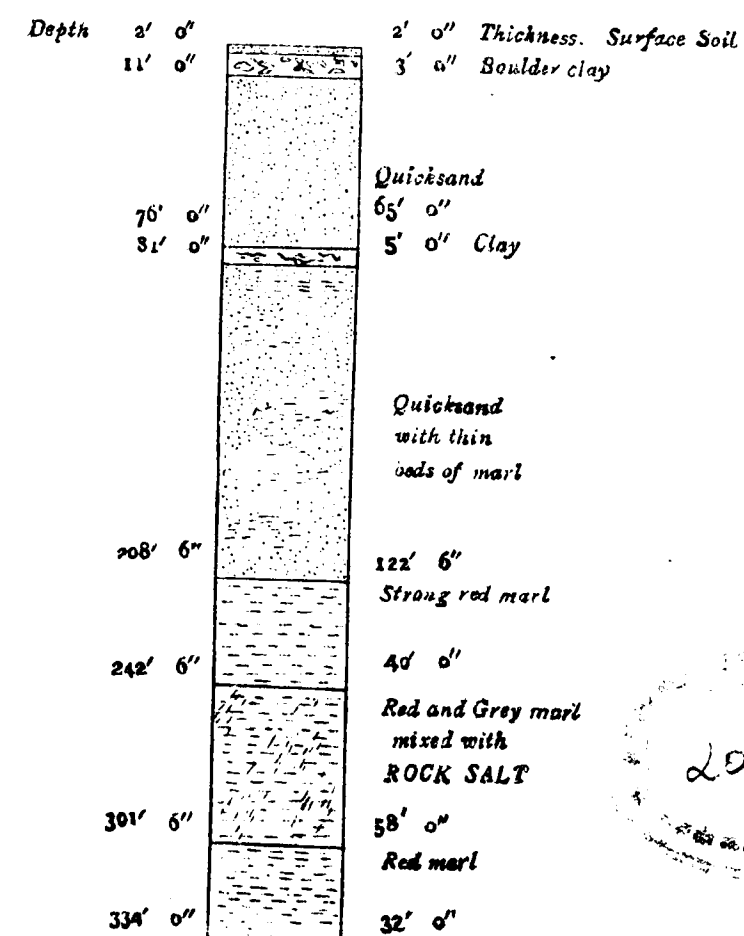
E. C. ROBERTSON,
Superintendent of Excise (Salt).
18th July 1921.

APPENDIX 17

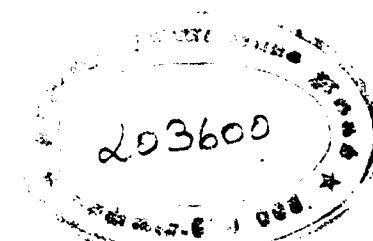
Print giving details of a Boring in Cheshire

Reproduced from 'SALT IN CHESHIRE' by Calvert.

Boring at Pimblott's Boiler Yard, Leftwich Cheshire



Level of surface 43' above Ordnance Datum. Some weak brine got at 255' 0" but a flow of brine registering from 37 to 41 oz. to the gallon at 301' 6" from surface.



203600

N 23

Map of Ye-Myit-Kyi Lake Area.

To Sadaung
14 Miles
from Padu

33 Miles to
Ketka Ry. Sta.

7 Miles to
Irrawaddy R.
Over low Hills 387

Ketka Ry. Sta.

Noniyo

Padu

B.N. 28288

Rest House
Padu Ry. Sta.

Yedwingaung

PERIODICALLY

SUBMERGED

YEMYITKYI OR KADU
LAKE

Permanently Submerged area

REFERENCES.

- Lake area
- Cart track
- Pagoda

Miles from Rangoon 406

Scale: 1 inch = 1 mile

10 Miles from
Sadaung
Ry. Sta.