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THE PERUVIAN SALT-INDUSTRY 1/

by

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1/ The views and opinions expressed in this paper are those of the author and do not necessarily reflect the views of the secretariat of UNIDO.

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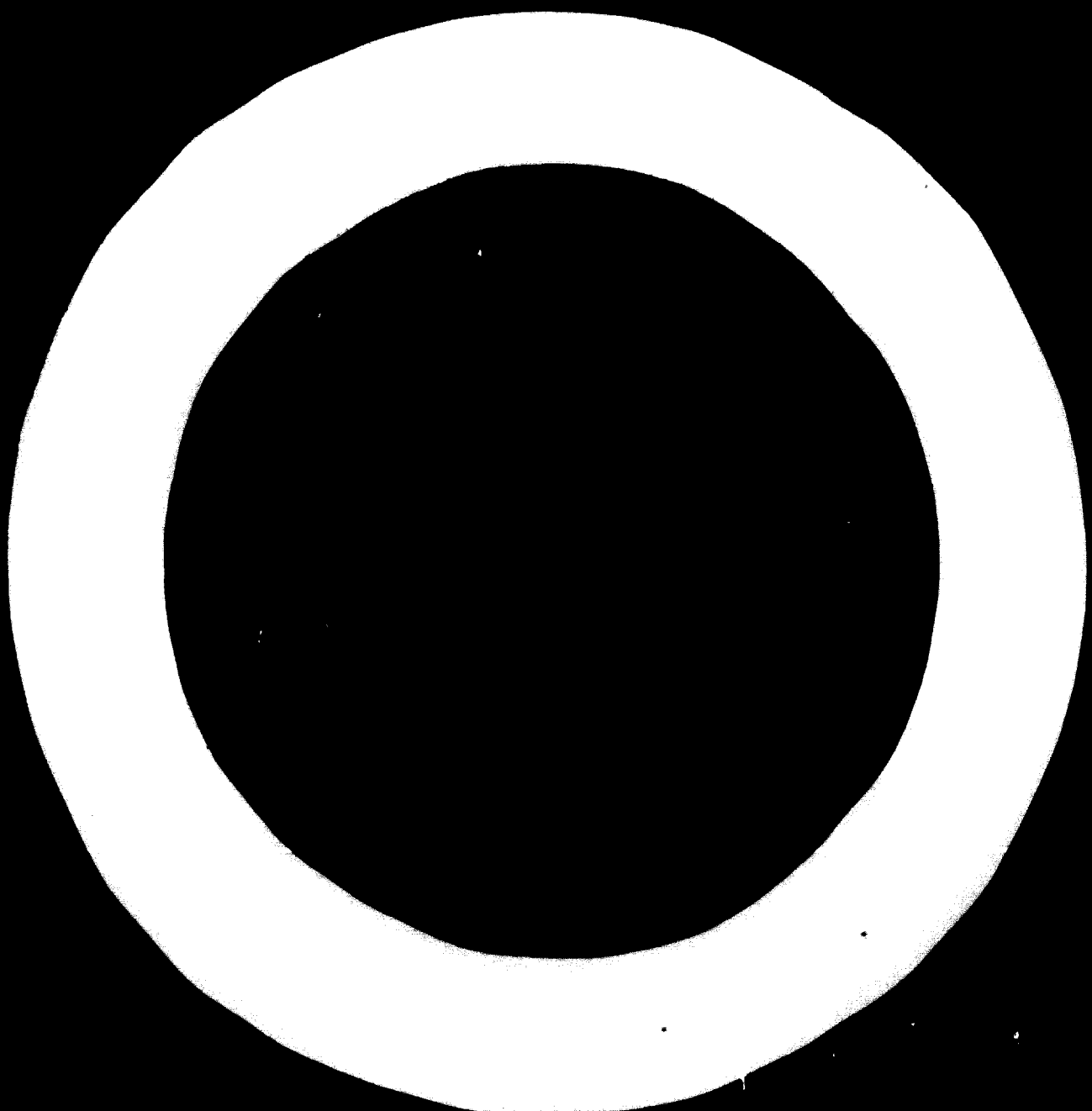

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I. INTRODUCTION

This report has been drawn up in accordance with the invitation made by the UNIDO Industrial Technology Division through the United Nations mission in Peru; it gives a brief outline of the present situation and future prospects of the Peruvian salt industry.

As suggested in the Aide-Mémoire prepared by the Expert Group which is to participate in the forthcoming round-table discussion, the report deals mainly with the seaside saltfields and certain "brine springs", whose combined production caters for more than 90 per cent of the country's salt consumption. Deposits of rock salt, situated chiefly in the mountain and forest areas of Peru, are also large potential sources of supply, but owing to their remoteness from large population centres, the lack of adequate means of communication and transport and the steadily rising cost of extraction, many of these rock salt mines which were worked in the past have now been closed down, at least for the time being. In view of these factors, it is doubtful whether the modernization and expansion of these and similar mines will be practicable in the foreseeable future.

The outlook for the expansion of the salt industry on the Peruvian coast is a different matter, however. The existence of large deposits in natural conditions favouring salt extraction by the solar process, the proximity of large urban centres, and the presence of transport and communication networks which ensure low freight rates, together with State planning to improve port facilities, indicate that this sector will shortly provide reliable sources of salt where modern refineries can be installed: it should then be possible to meet the entire Peruvian domestic and industrial demand and also develop the export side of the industry.

As will be seen later, the production of coarse salt in Peru has met consumption needs but it does not produce refined salt of the standard required for human consumption, and furthermore it does not satisfy the requirements for various types of salt used by the chemical industry, whose demands have increased so fast recently that the figure for industrial consumption has risen from 10 per cent of total consumption (i.e. domestic and industrial) to more than 38 per cent. It is now noted that as matters stand at present, future production is not likely to be sufficient to meet demand - a situation which must be avoided.

Peru therefore welcomes any recommendations that may emerge from the meeting of the UNIDO Expert Working Group, especially as the Peruvian Government has approved the installation of three modern salt-refining plants, two on the coast and one in the mountains, to be financed from this year's operational budget. It is not sufficient, of course, simply to plan these three plants: they must be an integral part of an overall development scheme for the mechanization and modernization of the salt extraction processes at the various deposits.

The Salt Monopoly ("Estanco de la Sal"), a State body which is now a subsidiary of the Peruvian National Bank, at present controls the whole of Peruvian salt production. It is responsible for ensuring an adequate supply of salt of appropriate quality at a fair price, both for human consumption and as a raw material for basic and small-scale industries, and any help it receives in drawing up its plans for the effective discharge of this function will be highly appreciated.

The Salt Monopoly's tables and statistical data only go as far as 1966; figures for 1967 could not be included as the last financial year only ended on 31 March 1968.

II. HISTORY OF THE PERUVIAN SALT INDUSTRY

LEGISLATION

The Peruvian salt industry has been controlled by the Government in a variety of ways and by different public or State-controlled bodies, but since its establishment in 1896 the Salt Monopoly has directly administered production in almost all the salt-producing areas.

Annex No.1 to this report (History of Salt Production in Peru) is a brief account of the production, distribution and marketing of salt under the State monopoly. Although, when the Salt Monopoly was set up in 1896, some salt deposits belonged to and were operated by private individuals or local indigenous communities, the Salt Monopoly has always bought all the salt they have produced and been responsible for marketing it.

As salt is an essential food product, its distribution has been a social problem since colonial times. The Peruvian Government has tackled this problem by exercising control and fixing moderate prices in order to avoid the cost of salt rising too high in areas lacking good communications and/or transport facilities.

Nevertheless, realizing the need to promote industrial development, aware of the growing demand for chemical products and derivatives based on salt, and anxious also to promote the growth of industry in general, in 1957 the Peruvian Government enacted Law No.12712 authorizing industrialists to obtain concessions in respect of salt deposits when the salt is to be used in basic industries considered to be of national importance. This Law has been amended several times, and recently, on 19 March 1968, a new set of regulations was enacted as Supreme Decree No.057-68-HC.

Under the Law referred to, there are now two concessions (in the Huacho and Otuma saltfields) which are being worked by "Alcalis Peruanos S.A." and "Química del Pacífico S.A." in connexion with the manufacture of caustic soda.

III. SALT CONSUMPTION IN PERU

Table 1 shows salt consumption figures since the establishment of the Salt Monopoly in 1896, under two headings: domestic salt and industrial salt. Until a few years ago (1959), all the salt consumed in Peru was marketed under the Salt Monopoly's control, and therefore the accuracy of the annual sales figures can be vouched for. The only data omitted relate to the production and consumption of industrial salt by private firms which since 1959 have been entitled, under Laws 12712 and 14776, to hold concessions in saltfields and extract salt for industrial and export purposes.

The consumption figures below, which are for the last ten years and are taken from the previously mentioned table, provide a basis for assessing the present position of the industry.

SALT CONSUMPTION

(Tonnes)

YEAR	DOMESTIC	INDUSTRIAL	TOTAL
1957	69,701	18,105	87,806
1958	71,629	18,925	90,554
1959	76,409	20,951	97,360
1960	81,441	21,358	102,799
1961	83,782	18,589	102,371
1962	92,357	17,537	109,894
1963	93,262	16,812	110,074
1964	95,517	15,217	110,734
1965	93,699	13,286	106,985
1966	101,541	7,167	108,708

In 1965, there was a drop in the consumption figures recorded by the Salt Monopoly: this is explained by the fact that a private firm sold more than 10 million kg of salt to private individuals and factories.

Furthermore, in 1964 and 1965 respectively, 3.3 and 4.3 million kg of salt meeting special specifications were imported for various industrial purposes but principally by the Southern Peru Copper Corporation for the treatment of copper ore in Southern Peru (Department of Moquegua).

Since 1960, there has been a noticeable decline in the consumption of industrial salt: this trend, which has become more marked in recent years, began in 1960, when concessionnaires started to extract for themselves salt previously supplied by the Salt Monopoly. It should also be realized that consumption figures for domestic salt include a certain amount which is really used for industrial purposes by firms which prefer this type of salt, despite its slightly higher price, because its quality is better or because it is crushed. Consequently, although internal salt consumption (domestic and industrial) remains approximately the same each year, industrial salt consumption figures are dropping sharply.

1. Salt Classification

It should be noted that in its statistics the Salt Monopoly currently classifies salt only as domestic salt or industrial salt, depending on the use to which it is to be put. There is not at present any standard specification which salt must meet, mainly because almost all salt is supplied in its natural form as rock salt or granular salt, depending on whether it is extracted from rock salt mines or collected from evaporation ponds: it is not processed in any way because of the absence of washing and refining plants, despite the fact that the Institute for Technical Standards and Certification (Instituto de Normas Técnicas y Certificación: INANTIC) laid down in June 1966 a system of specifications and grades for domestic and industrial salt (see Annex 2). These specifications provide for the compulsory iodization of salt for domestic consumption (table salt), as prescribed by the Government in Law No.9188(1/x/1940) in support of the endemic goitre campaign sponsored by the Ministry of Public Health and Social Insurance (Institute of Nutrition).

An increasing proportion of solar salt is given a modicum of processing in the form of milling or grinding. This salt is used as cooking (domestic salt), and small quantities of it are iodized for distribution to areas where endemic goitre is prevalent.

To summarize, salt in Peru is sold under the following appelations within the two categories previously mentioned (consumption figures are for 1966):

Domestic salt				
Granular (solar salt) or rock salt	67,450	tonnes		
Crushed (granular)	30,610	"		
Improved (iodized)	1,617	"		
Refined (table salt)	1,862	"	101,541	tonnes
Industrial salt			7,167	"
Total:			108,708	tonnes

2. Present consumption of domestic and industrial salt

(a) Domestic salt Table 2 shows the per capita consumption of domestic salt in each Department, average consumption being 7.69 kg per year. It should be noted that the actual total consumption of domestic salt in 1966 was 92,372 tonnes, but 9,169 tonnes of this type of salt should be deducted because it was used for industrial purposes; this explains why the figure of 101,541 tonnes is shown in Table 1.

Salt (domestic salt) is an essential element in the human diet, whether ingested directly or indirectly (preserved foodstuffs, etc.). Its consumption is, however, more or less invariable: that is to say, per capita consumption of salt runs at a fixed level, so that national consumption is more or less restricted by the size of population, showing a direct increase only with growth of the latter. It has therefore been possible to establish statistically that per capita consumption is 7-8 kgs per annum.

Consequently, as the population of Peru is about 12 million inhabitants, the supply of domestic salt required for human consumption will not at present exceed 84-96 million kg per year, excluding normal growth of the population at an annual rate of approximately 2.8 per cent.

The importance of this inflexibility or fixed per capita level of domestic salt consumption is essentially that whatever the Salt Monopoly or private firms may do

to produce salt conforming to current specifications by refining processes, the limits of production imposed by the size of population cannot be exceeded unless the salt industry is developed in such a way as to be able to export salt.

The Salt Monopoly sells domestic salt intended primarily for culinary use under the name of ground salt. Consumption of this type of salt is constantly growing, although its quality is very similar to that of common salt (solar salt) in its natural state: it is merely ground in small crushing plants equipped with hammer-mills. The resulting product has a small but uneven grain size not having even been dried or screened, but is certainly more suitable for domestic consumption in the absence of refined or washed salt.

The only type of salt which meets the requirements for table use and which is indeed also being used temporarily by some firms in the food-processing industry is the refined salt produced at the small thermo-compression plant constructed in Lima in 1954 which has an average output of only 6 tonnes per day. The consumption figures below do not really show the true capacity for the sale of this type of salt, because production is at present totally inadequate to meet demand. It is generally agreed that all salt for domestic consumption, which is at present supplied in the form of granular or ground salt, can and should be replaced by refined or, at any rate, washed and screened salt. Consumption of this kind of salt could then rise to the estimated total demand for domestic salt of 90,000 tonnes per year.

SALES OF EXTRA-REFINED SALT IN PERU

(in tonnes)

YEAR	LIMA AND CALLAO	REST OF PERU	TOTAL
1958	1,522	424	1,946
1959	1,358	34	1,392
1960	1,419	113	1,532
1961	1,869	193	2,062
1962	1,686	24	1,710
1963	1,743	4	1,747
1964	1,965	-	1,965
1965	1,173	-	1,173

The low output of this type of salt is consumed entirely in Lima, a city with a population of more than 2 million; recently, therefore, the deficit has been met to some extent by salt imported from various other countries, purchased for the most part by commercial firms or supermarkets, but even so the demand for this grade of salt remains enormous.

(b) Industrial salt Whereas in European countries and the United States far more salt is consumed by the industrial sector than is used directly in the human diet (90 per cent as aginst 10 per cent), in Peru most salt is consumed domestically. Between 1896 and 1900 the ratio was 59 per cent for domestic salt and 41 per cent for industrial salt. In 1966, however, it was 85 per cent for domestic salt and only 15 per cent for the industrial salt sold by the Salt Monopoly, indicating that although the increase in total consumption had been considerable, growth in the industrial use of salt had not risen proportionally, as it is hoped that it will in future through the establishment of new industry. One of the industries of growing importance in Peru which is dependent upon salt is caustic soda manufacturing for paper and P.V.C. production. Private firms have made capital investments of some $15 to 16 million in this industry, while some $6 to 7 million is also being invested in a new project for manufacturing paper in the forest region.

About 40,000 tonnes of industrial salt are produced annually by the two concessionaire firms mentioned previously for their own use, primarily in the manufacture of caustic soda and its derivatives. As the Salt Monopoly sold a further 16,336 tonnes (Table 3), the total consumption of industrial salt amounts to 56,336 tonnes, therefore, giving a ratio of 38 per cent for this type of salt to 62 per cent for domestic salt.

There is also a project for the refining and flotation processing of minerals which is designed to replace all imports in this category. This project will cost $16 million and will require each year approximately 30,000 tonnes of high-purity salt at a very low price, together with hydrochloric acid produced from salt by electro-chemical plants.

There is another project for the manufacture of sodium carbonate which is intended to replace 30,000 tonnes of imports every year: the cost will be approximately $10 million for a plant with a capacity of 100 tonnes per day, and the saving of foreign exchange will be about $2 million.

A special use of salt which has not yet been introduced in Peru is in road building through the stabilization of soil with a mixture of gravel, sand, gypsum or lime. The arid areas on the Peruvian coast with their lack of rain and frequent salt deposits would be very suitable for the application of this process because salt is cheap, easy to use and readily available, unlike other materials such as asphalt and cement. However, the process has yet to be tried out.

It will be readily appreciated that the consumption of domestic salt and the problem of supplying it in the required quality and quantity are insignificant problems compared with the importance and implications of the salt industry's expansion to complement the general economic growth previously mentioned. Besides the benefits which the country would receive from these investments, there is the equally important factor of the additional employment created by the building, equipping and operation of these industrial plants.

3. Consumption projections for 1972

On the basis of the 3.66 per cent growth rate actually recorded for the period 1956-1962, it can be estimated that the volume of internal consumption of different types of salt will reach 223,000 tonnes, broken down as follows:

Domestic salt	124,800	tonnes
Industrial salt produced by the Salt Monopoly	40,200	"
Industrial salt produced by concessionaires	58,000	"
Total:	223,000	tonnes

Additional consumption of 180,000 tonnes is expected from the projects previously referred to, giving a total projected demand in 1972 of 403,000 tonnes of salt.

The breakdown of the projected demand for 1972 by areas and by types of salt is as follows:

	Southern Area (1)	Central Area (2)	Northern Area (3)	Total
Domestic salt	26,300	59,000	39,200	124,500
Industrial salt produced by the Salt Monopoly	14,300	98,800	6,400	119,500
Industrial salt produced by concessionaires		134,000		134,000
Industrial salt for special uses (including animal husbandry and poultry-keeping)	4,500	17,000	3,500	25,000
Total:	45,100	308,800	49,100	403,000

These figures are conservative estimates of the amounts of salt required in each area; it would be technioally advisable to establish three salt production centres, each comprising salt extraction facilities and a refining plant.

IV. RESOURCES FOR SALT PRODUCTION

The salt resources of Peru can be classified according to their origin into three main categories:

(1) Sea saltfields
(2) Rock salt deposits
(3) Brine springs

Since the State took over salt production, the Salt Monopoly has in one way or another controlled more than 166 saltfields situated throughout the country. The location and present state of these fields are shown in Table 4. Many deposits have never been recorded, however, because they are, for the most part, so remote from any civilized centre that it is still virtually impossible to work or even to explore them; most of these deposits are in the Peruvian desert.

The construction of roads and new means of access in the interior have made it possible for many areas to be supplied with salt from the coast or at any rate from the larger saltfields, so that some fields which were active in the past because they were close to centres of salt consumption are now disregarded because .

their scanty yield makes them uneconomic. The Salt Monopoly has therefore had to reduce the number of saltfields operated by it, closing about 134 of them and limiting its operations to fields whose output is sizeable and whose location enables them to supply certain areas. The map of Peru (Annex 3) and Table 5 show the twenty-five saltfields at present in operation, eight of which are sea saltfields, eleven rock salt deposits, and six brine springs; four other saltfields operate during the summer months only, while another three are leased to private individuals for the supply of salt to small communities as their proximity to the latter might lay them open to clandestine exploitation.

1. Sea saltfields

These consist of deposits formed by brine and sea-water and salt beds formed in the surface of beaches.

The sub-surface brine retained by sandstone and other porous rocks is thought to derive from captive sea water, but much brine is formed by the dissolution of salt layers dating from pervious eras. Almost all the saltfields on the Peruvian coast have salt beds of this type, except for the Puite saltfield, where rock salt is extracted.

The sea saltfields are of prime interest at present both because they can be exploited with greater ease and because they afford larger potential reserves. The sea saltfields provide 83 per cent of the Salt Monopoly's present output of domestic salt: in 1966, 89,153 tonnes were produced and another 4,177 tonnes were bought from the firm Alcalis Peruana S.A. making a total of 93,330 tonnes out of the total of 111,721 tonnes of domestic salt produced. The sea saltfields also produce some 50 per cent of Peru's industrial salt (Table 5).

In the northern area of Peru are situated the Colán, Negritos and Las Garzas saltfields, those of the Sechura Group (Zapayal, García and El Cerro), and the Cañacmac, Casma and Guadalupito fields. There are also some small fields in the Department of Tumbes, such as those at Palo Santo, Bocapán and El Abejal, which operate seasonally and comprise small lagoons where the salt crystallizes during the summer months; their output is low and only serves to meet a small proportion of local needs when a salt harvest takes place.

The Colán saltfield (in the Department of Piura) is a standard example of a "barrier-type" saltfield, being situated 100-120 metres from the shore, parallel

to which there extends for approximately 1½ km a natural sandbank or dyke which creates a small lagoon where salt crystallizes. There is an opening in the sandbank through which sea-water enters the lagoon. Present production at Colán is not very large, but the site would lend itself to the construction of artificial ponds giving a much higher yield of solar salt.

The "Las Garzas" saltfields (Province of Sullana, Department of Piura) comprises four ponds lying in a hollow below sea-level into which brine filters. Salt is formed during nearly every month of the year, but principally in summer. As the saltfields are a long way from the sea, however, it would be difficult to effect improvements that would be economic.

The Negritos saltfield has several ponds of varying sizes; it is five kilometres to the south of the International Petroleum Company's oil refinery, at Talara, where there are also oil wells, so it is probable that the formation of salt deposits was linked with the presence of oil in this area. The main difficulty arises in connexion with the evaporation process, as sand blown into the ponds is a constant nuisance. Nevertheless, a feasibility study could be made to establish whether production should be increased.

The Sechura Group at present comprises the Zapayal, García and El Cerro saltfields, although previously many other saltfields in the Sechura desert were worked (see Table 4). The Sechura Group and the Cañacmac saltfields (Department of Lambayeque) constitute together the largest potential salt reserves in the northern area and in the whole of Peru. This group of saltfields is located within the Sechura desert area between the Departments of Piura and Lambayeque, covering more than a million hectares and extending from the District of Sechura (Piura) to the District of Mórrope (Lambayeque). The "Cía. Bayovar S.A." which holds concessions for phosphate production in the Sechura desert, believes that the process for obtaining potassium chloride by the solar evaporation of subterranean brines or deposits which in potassium and sodium chloride would also yield a 70 per cent proportion of common salt, or an output of the order of 4 million tonnes a year - 30 times the total national salt consumption of Peru. At present, the Salt Monopoly only produces enought salt from these fields to supply the Northern Departments: in 1966, the output of the Sechura Group was 7,913 tonnes and that of the Cañacmac fields 16,241 tonnes (Table 5). Were the Bayovar project brought to fruition, the

extraction of salt as a by-product would mean that large-scale exports of the commodity could be effected, provided that the desert roads were improved, docks were constructed and inexpensive marine transportation made available.

Even if the Bayovar project did not materialize, the Virrillá Estuary near the García and Zapayal saltfields has an area of 1,400 hectares and offers an ideal site for solar evaporation plants. Factors such as natural canals permitting the inflow of sea water and the desert climate of constant sunshine and heat in every season, together with the absence of rain and strong winds, are particularly favourable to pond crystallization. Another advantageous feature is the presence of stratified salt deposits, which facilitates saturation of the brine.

At present, the Salt Monopoly's operations are limited to harvesting granular salt which crystallizes naturally in lagoons formed by the Virrillá Estuary. In the Zapayal and El Cerro saltfields, brick-salt is cut out with axes from the beds or strata of crystallized rock salt. This type of industrial salt is popular in animal husbandry, where it is used instead of manufactured blocks, especially in areas bordering on Ecuador, with which trade is conducted.

The main difficulties which arise in connexion with production from these deposits are the lack of good communication facilities and the distance from consumer centres. The Zapayal saltfield is about 100 km from the city of Piura, and 60 km of this distance is over desert tracks, so that a lorry takes more than four hours to reach Piura. The El Cerro saltfield is even further away and travelling-time is six hours. Similarly, the Cañacmac saltfield is 70 km from the District of Mórrope and transportation by lorry takes more than seven hours by road and sand-track. These disadvantages which make the product considerably more expensive, since the freight rate from Cañacmac to Lambayeque is more than S/100 per tonne and from Zapayal to Piura S/76 per tonne, are offset, however, by the ease with which salt is produced, for as the salt occurs in strata of 15 to 20 cm thick covered by a layer of sand approximately 30 cm thick, extraction consists simply of removing the sand, breaking the salt with picks and crowbars, and packing the pieces of salt for dispatch. The relatively low cost of this simple operation counterbalances the high transport costs.

Finally, the Northern area's salt resources include the Guadalupito and Casma saltfields. The Guadalupito field has been a private concern since before 1896 when the Salt Monopoly was established, and belongs to the "Negociación Agrícola Guadalupito S.A."; until 1965 the Salt Monopoly purchased the entire output and marketed it, but recently, under Law 12712, the company has been selling salt directly, principally to the fishing industry around Chimbote, which explains why its production does not figure in the Salt Monopoly's statistical tables.

The Casma saltfield, situated at the port of the same name and practically within the town of Casma, comprises three sectors where there is infiltration from the sea. The sea water which infiltrates thus collects in small ponds 10 to 20 square metres in area where the salt crystallizes in over six months. The salt is of poor quality because its extraction stirs up mud from the pond-bed; and is therefore mainly used industrially by the fish-flour works at the port of Casma. A tidal wave flooded the ponds in October 1966, putting them out of action, and they were closed down by the Salt Monopoly. It would seem that the commercial potentialities here do not justify repair work or the opening of new ponds, especially as production, even in a good year, does not amount to more than about 2,000 tonnes.

The Central Area of the country, comprising the Departments of Ancash, Huánuco, Junín, Cerro de Pasco, Ayacucho, Huancavelica, Ica and Lima, has the highest salt consumption rate in Peru. In 1966, the Salt Monopoly sold 56,917 tonnes of salt (Table 6) - 56 per cent of total domestic consumption - in this area, with a proportional financial yield. These figures do not include the production of private industrial firms, which in 1966 [illegible] 40,000 tonnes. From Table 2 it can be seen that this area is not only the most densely populated, but also has the highest per capita salt consumption rate, which exceeds 10 kg per annum in Lima and Callao.

Fortunately, the Central Area has two large sources of supply, the Huacho and the Otuma saltfields, situated near Lima, and the main Peruvian road transport route, the Pan-American Highway, runs down the coast, while in the interior there is another first-class road and the Peruvian Central Railway.

The Huacho and Otuma saltfields have also supplied Departments in the Northern and Southern areas as well as the Central area. Out of a total of 88,625 tonnes of salt produced by sea saltfields, 51,785 tonnes have come from Huacho (Table 9).

The Huacho saltfield has two slight advantages over Otuma: the cost of transportation to Lima and Callao is S/60.00 per tonne, whereas for Otuma, a journey of 285 km, the cost is S/120.00, and Huacho can market its products directly in the large consumption centres.

Annex 4 comprises a detailed report on the Huacho saltfields, prepared by Dr. Georg Petersen G. for the firm "Alcalis Peruanos S.A.", in which it is stated that these saltfields have sizeable potential reserves and that conditions and facilities are favourable for immediate development with a view to increased production. According to the report, there are 45 million cubic metres of concentrated brine, 12 million metric tonnes of dissolved salt, and 45,265,500 tonnes of rock salt, amounting to total reserves of more than 100 million tonnes.

The Otuma saltfield, for its part, has a high output of as much as 900 kg per annum, helped by the dry, warm climate which prevails almost all the year round. The harvesting of each pond takes place at 30-day intervals and the yield is on average 50 to 60 kg per square metre. The present ponds are only 20 by 30 metres in size.

Otuma had the third largest production figure in 1966 with a yield of 9,117 tonnes (Table 5) distributed mainly in the Southern area of the country; consignments are occasionally sent to Lima too.

The firm "Química del Pacifico S.A." also operates here, holding a concession of 54 hectares where 3 ponds, each of 4,000 square metres, have been constructed. The production or extraction cycle resembles that of the Salt Monopoly but is performed mechanically with a tractor and rake which scrapes up the salt and deposits it in heaps on the pond-edge; later it is taken to the caustic soda plant in Callao where it is given a light washing process.

The potential reserves at Otuma indicate that more than 100,000 tonnes could be extracted annually and that it would be an economic proposition to introduce pond evaporation systems supplied with deep brine by pumps and to install washing plants. Perhaps the only problem is that sand particles, blown into the ponds by the wind, are present in the salt crystals.

In the Southern area, there are virtually no sea saltfields and local consumption, which in 1966 was 10,836 tonnes (Table 6), is met by consignments from Otuma, the Pichu-Pichu brine springs and production from minor rock-salt deposits.

2. Rock salt deposits

Almost all the rock-salt deposits in Peru are sedimentary in origin. None is of the dome type except perhaps the formations at the Pilluana and Callanayacu saltfields on the banks of the river Huallaga in the Northern area, where the thickness of the salt layers might be due to such an origin. The sedimentary layers in almost all the salt deposits are interspersed with strata of gypsum, anhydrite and potash minerals. The thickness of the salt layers varies from a few centimetres to several tens of metres. Usually many layers of salt are superimposed one above the other. Some of the salt strata display repeated expansion and contraction in thickness ("rosary"-type strata), and the angle of inclination of most strata is irregular, varying between 0° and 90°. In view of these features, and chiefly because none of the salt strata, except at the Pilluana salt-mines, is sufficiently thick, it is impracticable to introduce conventional mechanized mining methods, and extraction costs would therefore be high.

A considerable number of the rock-salt deposits in Peru belong to this category; for the most part, they are situated in the Sierra and forest areas, (Table 4). For the reasons previously outlined, many of these deposits have been closed or have never been properly worked, chiefly because their operation would now be uneconomic. In all, only eleven rock-salt deposits are worked at present; they produced 8,377 tonnes of domestic salt and 765 tonnes of industrial salt (Tables 5 and 9), or barely 9 per cent of national consumption.

No practical solution yet seems to exist which would enable these rock-salt deposits to supply adequately the Sierra and forest areas. High extraction costs, long distances to consumer centres, poor-quality mineral (only 70 to 80 per cent sodium chloride) and the physical features of the deposits militate against economic production; only enough rock-salt is now mined to supply population centres in the immediate neighbourhood of rock-salt mines, as this involves relatively low transport costs by comparison with the freight charges which must be paid for salt brought from the coast (Huacho and Otuma saltfields in the South and Centre). However, a feasibility study could be made to ascertain whether such rock-salt deposits could be worked by installing facilities for pumping fresh water into bore-holes, extracting saturated brine and supplying it to evaporators or drying ponds.

Table 5 shows production figures for the eleven rock salt deposits mentioned, which are as follows:

In the Northern area, the Yurumarca saltfield in the Department of Amazonas produces salt of very poor quality and lacks suitable means of communication. The salt is consumed only by the nearest villages, to which it is transported by beasts of burden.

In view of its potential output and quality of salt, perhaps the most important rock-salt deposits is that at Pilluana on the banks of the River Huallaga in the Department of San Martín. At present, the Salt Monopoly is not working this deposit, however; it did so previously, but because of difficulties in transporting the salt by river to the city of Iquitos and other towns in the Amazon basin, local inhabitants have been allowed to exploit the deposit freely for their own needs. However, there is now a secondary road linking the mine with the town of Yurimaguas, from which consignments by steamship can pass along the river Amazon. Furthermore, this mine has the advantage of being open-cast, so that extraction costs are relatively low by comparison with other deposits of this type. A grinding plant with drying and screening facilities could make this mine into a flourishing industrial concern producing table salt for the whole forest area of Amazonas (Department of Loreto). The salt is of high quality, and might not require any washing or refining.

The Central area is perhaps the richest in rock salt deposits, but their formation and potential output are such that they would not be economic to exploit and many are becoming exhausted.

Mines of this type in the Central area which are being worked on a regular basis are Cachi-Cuyao in the Department of Huancavelica, with a production of 2,592 tonnes in 1966, and Atacocha and Urancancha in the Department of Ayacucho. Atacocha could be converted into an open-cast mine but this would involve complete mechanization whose cost is not at present justified. There are no roads yet and the transfer of salt to sales depots is still effected partly by beasts of burden.

In the Southern area the largest deposits of rock salt are at Cachihuancaray and Carqueque in the Department of Apurimac, Occopata and Pichuimarca in the Department of Cuzco, Huarhua in the Department of Arequipa and Puite in the Department of Moquega. The salt at Occopata is of optimum quality (98 to 99 per cent of sodium

chloride) but unfortunately, owing to the depth of the veins and their regular structure, extraction costs are excessively high and production is low, not even meeting the local needs of the town of Cuzco. This salt has, however, been ground and used as table salt and could continue to serve this purpose, if their were a complete crushing-plant, including facilities for sizing, mixing of iodine additives and packing.

The Huarhua saltfield is equally ill-suited for profitable development, on account of its geological formation, its location and its poor-quality salt.

The Puite saltfield on the Southern coast in the Department of Moquega, a few kilometres from the sea and ten kilometres by cart-track from the Pan-American highway, has at present the best-quality salt, analyses of which show it to be of 99.1 per cent to 99.6 per cent purity. The salt occurs in crystallized form in layers from 0.30 metres to 0.80 metres thick, which are almost horizontal and barely 2 to 6 metres below the ground surface. The mining process used is the "bord-and-pillar" method with faces approximately 10 metres wide and 2 metres high.

In 1966, 1,388 tonnes of salt were produced from this mine, but output was increased to more than 2,500 tonnes in 1967, of which 2,245 tonnes were delivered to Lima as crushed salt, since the saltfield has its own crushing plant. This salt was packed and distributed in Lima as table salt in view of the shortage of refined salt.

The nature of the veins, the filiform crystallization and the geological characteristics of the area would appear to indicate that this deposit was volcanic in origin or at least that its formation was considerably influenced by volcanic action. This theory is supported by the fact that in the neighbourhood only rocks of volcanic or intrusive origin similar to those in the Southern Copper Corporation's copper deposits at Toquepala are found. The quality and purity of this salt are outstanding and its crystals are considered unique in the world. It would seem that crystallization occurred under great pressure and at high temperatures.

The potential reserves of salt in the area which is at present being worked at Puite are no more than 20,000 tonnes; however, the existence of surface layers 20,000 cms thick near this area has been confirmed, and these layers may serve as an additional source of supply. It is certain, at any rate, that the existing workings could supply the needs of the Departments of Tacna and Moquegua in the South for about five years more.

3. Brine springs

There are many springs in the Sierra and forest areas which provide brine of 20° Be, and small amounts of brine were at one time taken from them and evaporated in copper pans over wood fires, as was the practice in the Department of San Martin, in the Northern forest area. These springs are no longer operated commercially, but even now in remote villages brine is taken directly from such springs and used in cooking.

The brine springs at present worked by the Salt Monopoly are: Maras and San Sebastián in the Department of Cuzco, Napa, Tiquillaca, Muni and Azángaro in the Department of Puno, and Pichu-Pichu in the Department of Arequipa. All these springs are in the Southern area, and only Maras, Azángaro and Pichu-Pichu have a large output.

The Maras salt field, which is at a height of 2,750 metres above sea-level in the Province of Urubamba, Department of Cuzco and is 45 kilometres from Cuzco by a first-class road, comprises about 5,000 small ponds of varying sizes, but averaging more or less 4 sq. metres, which were built by the local inhabitants. It has a production of approximately 2,000 tonnes per annum (in 1966 1,523 tonnes of domestic and industrial salt combined were extracted). Production is by solar evaporation during the months when there is no rainfall, from June to November; the 20° Be brine which emerges in the upper part of a small ravine is collected in small canals or ditches and channelled to the tiered ponds. The brine flows out at the rate of approximately 100 litres a minute at all times and throughout the year. About 40 metres below the first brine outflow point there is a second one a few metres from the stream bed; it has a flow of 120 litres a minute which at present is not used because the ground does not slope and is unsuitable for building evaporation ponds. One solution would of course be to pump the brine up to join that from the upper outflow point, but the Salt Monopoly has not deemed it advantageous to do this yet. Since the flow even from only a few outlet points amounts to 6 cubic metres a minute of 20 per cent concentration brine, it can be estimated that even with a simple evaporator an output of 30 tonnes in 24 hours or approximately 9,000 tonnes a year could be obtained. This production would amply meet present consumption in the Departments of Apurimac, Cuzco, Puno and even Arequipa, although the first three towns alone have a potential market for 12,000 tonnes a year.

In fact, the salt which could be produced at Maras by forced evaporation would replace the granular salt now used: it would be of better quality, provided that it were refined, and would in fact be table salt. At the moment the granular or coarse salt produced at Maras is of poor quality because some clay from the pond bottoms is taken up when the salt is harvested.

The Salt Monopoly has a project for installing a 20,000 tonnes/year plant using the two existing outflow points of the springs. Consideration was also given to the possibility of working some of the rock salt layers which give rise to the brine springs, but as the strata are very deep and irregular it has been decided that the mining process would be too expensive.

In the Southern area, the saltfield with the largest output is that at Azángaro, situated in the Province of the same name in the Department of Puno, 3,800 metres above sea-level. The saltfield comprises a lagoon on whose edge the local inhabitants have built small ponds 10 to 18 square in area. The waves of the lagoon drive the brine up communicating channels into the ponds where it dries by evaporation until the salt crystallizes out. The method is utterly haphazard and labour-consuming. Crystallization only occurs during about six months of the year. The salt is stacked in conical piles called locally "Cumanas", on the pampa and encased in mud so that it is not affected by the rain. It is then packed in 60 or 80 kg jute sacks and sent by lorry to the various depots.

A survey of this saltfield written in 1950 may be found in Annex 5. At that time the salinity of the lagoon was only 8 to 10° Be and production was no more than about 300 tonnes per annum. Once a six- or seven-year cycle of heavy rainfall was over, however, the salinity of the lagoon increased and the present concentration of 15° Be gives a harvest of some 10,000 tonnes a year, although purchases by the Salt Monopoly from local extractors who have their own ponds amounted to only 7,640 tonnes in 1966: the difference is accounted for by stock-piling.

This saltfield, which supplies the whole of the Department of Puno and part of the Departments of Cuzco and Apurimac, could well be the subject of a feasibility study to see whether it might not be possible to stabilize production by mechanical means and avoid the drop in output which occurs during years of heavy rainfall.

The Pichu-Pichu saltfield is located 4,300 metres above sea-level in the Department of Arequipa. It is similar to the "beach-type" deposits. The salt, which is combined with borax, potash and other chemical substances, occurs in a dried-out lake-bed in the form of surface deposits which are dissolved each year when the rains come. Until a short while ago, the company "Borax Consolidated S.A." was the concessionaire for the whole lake on account of the borax deposits, although it only worked them sporadically, but the Salt Monopoly kept the salt rights.

In some sectors of the lake crystallized borax predominates, whilst in others there are greater quantities of salt. The salt is swept up between June and October when there is no rain and piled in small heaps prior to being transported by mule to the storage depots and by lorry to the city of Arequipa.

The output of this saltfield is naturally determined by climatic conditions, and in years of scanty rainfall output has been as high as 3,000 tonnes or more. In 1966, however, production was only 318 tonnes. The salt layers are relatively few centimetres thick, but they extend over the whole of the lake-bed; underneath them is a layer of mud which prevents the use of motor vehicles.

As there is no possibility of improving the brine saturation process by installing a source of supply and thus ensuring continuous production throughout the year, and as the salt contains borax and potash impurities which detract from its quality, it hardly seems logical to consider carrying out improvements designed to increase productivity or installing refining facilities. The most practical solution might be to install a washing plant, provided that the cost was not out of proportion to the potential production.

V. METHODS OF SALT PRODUCTION

1. The present situation

In view of the advantages which the State Monopoly enjoys in the production and marketing of salt and the great scope offered by many of the salt producing areas for the modernization of extraction techniques and the introduction of new methods of refining, the Salt Monopoly has undoubtedly lagged behind in this respect, particularly in the production of "domestic table salt". For Government budgetary reasons the Salt Monopoly, in spite of innumerable efforts to obtain the allocation of development funds, which would be amply justified from the Exchequer's point of view by the increased productivity they could be expected to bring about, has been unable so far even to think of modernizing its production methods. The annual budget estimates for the Salt Monopoly have only contained the regular items covering the cost of maintaining its personnel and acquiring materials and tools: they contain nothing permitting an effective expansion programme for the industry, which is still operating with primitive and antiquated methods. Of the 25 saltfields operating under the administration of the Salt Monopoly, only the Huacho saltfields have a modicum of mechanization, and in all the other fields picks, shovels and wheelbarrows are still used for the extraction of salt. The partial use of mechanical equipment for extraction, loading and transport in the larger saltfields would make it possible to reduce the present labour force by 75 per cent, however, and consequently achieve a substantial reduction in production costs.

Until 1930, all refined table salt was imported from England and Germany at considerable cost and with a consequent drain on the country's foreign exchange resources. In 1930, a refining plant with an approximate daily output of 4 tonnes was established in order to help meet demand, and it continued to function until 1954. This plant operated on the vacuum evaporation system, being equipped with a small-capacity vacuum pan not adapted for continuous operation. At the time, the salt produced in this plant, although not of very good quality, supplied the requirements of the city of Lima.

In 1928, a small mill was installed at the Huacho saltfield, where it is still in operation. This plant has been extended by the installation of two further mills and provides "ground salt" mainly for the city of Lima and neighbouring towns, but the salt produced is not of good quality because of its irregular grain size, which is due to the fact that it is neither screened nor previously washed or dried.

In 1956, the Ministry of Health installed 7 salt iodization plants in various cities or saltfields as part of its campaign against endemic goitre, which is prevalent in certain areas of the country. These plants, which consist basically of a hammer mill driven by a Lister 24 hp engine and a hand-operated mixer, were installed at the Yurumarca and Huacho saltfields and in the cities of Ayacucho, Chimbote, Huaraz, Cuzco and Rodriguez de Mendoza. The salt from the various saltfields of each Department where these plants were installed was ground and mixed with a certain proportion of potassium iodate and bicarbonate of soda. As some of the saltfields which provided the raw materials supplied only a limited area, however, and as most of the rock salt contained a considerable amount of clay impurities, the ground salt resulting from these activities was not very suitable for domestic consumption. It was therefore decided to transfer those plants and iodize only salt from the coast, i.e., from the sea saltfields. In 1963, these plants came under the authority and control of the Salt Monopoly, and iodized salt is now only produced at the Huacho and Cañacmac saltfields and in the city of Cuzco, from where it is supplied to goitre-prone areas.

In 1962 and 1963 respectively, the Salt Monopoly installed two complete milling plants at the Puite and Cañacmac saltfields. These plants are of $1\frac{1}{2}$ and 2 tonnes capacity, respectively, and were made by the German firm Standar-Messe. They consist of a hammer-type crusher, a "Condux" prong-type mill, and an elevator and hoppers. The milling achieved is quite good, particularly with the salt produced at the Puite saltfields, which is at present used as "table salt".

In 1954, a new salt refining plant was set up in Lima. This plant, which represented the first step in modernizing the salt industry, was constructed by the New York firm "Salt Chemical, Inc." and has a rated capacity of 24 short tons per 24 hours of operation. It operates on the thermocompression system, whereby the vapour coming from a single-action evaporating vessel is recompressed in a closed circuit, in this case by a blower driven by a Caterpillar diesel engine which raises the pressure from one to two atmospheres. The plant is automatically controlled, using electric motors, from a single central control panel. The plant is also provided with the mechanical equipment required for the introduction of measured quantities of additives, such as iodine, magnesium carbonate, etc., and for packing the salt in cartons. Initially the plant was equipped with two 60kW Murphy electric generating sets, which were operated alternatively, but later these sets were superseded when industrial electric power was supplied from the State network.

Due to some mechanical shortcomings in its installation, lack of experience in its operation, and above all failure to take account of the raw material supplies available, the output of this plant has only averaged six to seven tonnes per day, which is far below its rated capacity. Its output has consequently been insufficient to satisfy the demands for which it was established, and at the present time, 14 years after its establishment, it is operating on a precarious basis.

Generally speaking, the above developments constitute the only attempts to mechanize some aspects of the salt industry, and in substance the operating methods used in the saltfields remain old-fashioned.

2. Present production methods

Because of the geological conditions of the deposits of sea salt and rock salt, the operating conditions of saltworks concerned with the extraction of these two types of salt are naturally different. The operations of saltworks concerned with the extraction of salt from brine springs are to a certain extent similar to those works concerned with the extraction of sea salt.

(i) Operating methods of saltworks concerned with the extraction of sea salt

The operating methods of sea salt extraction works are generally speaking similar in all cases, the only difference being connected with the extraction of salt at the Cañacmac and Sechura works, where existing salt banks are worked and no attempt is made to crystallize salt in ponds. Only the Huacho saltworks has any form of mechanization. At this works, the salt is transported from the ponds to the storage areas in small wagons hauled by small diesel locomotives on a Decauville-type narrow-gauge railway line.

The three salt deposits of greatest present potential are those at Otuma, Huacho and at the saltfields of the Sechura group. In view of the importance of these deposits and the fact that they are of different types, reference will be made below to the operations carried on at them.

The salt resources at the Otuma saltfields in the Department of Ica consist of saturated brine which keeps at a constant level less than 30 centimeters below the surface of the ground. The salt ponds are excavated in the lowest-lying places below the permanent level of the brine, and natural infiltration keeps the ponds

constantly full of brine, so that the production of salt by solar evaporation is constant throughout the year. At the Huacho saltfields, which are situated in the centre of the country, the brine table is at a lower level and is subject to seasonal variations of level. Water from the seasonal rains flows down from the surrounding high mountains, through the permeable ground, into the basin where the Huacho saltfields are located. This water becomes mixed with the residual brine of the basin and becomes partially saturated, rising to a level some little distance below the ground.

The salt ponds at Huacho are excavated to approximately 1.20 metres below normal ground level. Infiltration during the period of heavy rains, which usually occur during the months of January to March, fills the ponds with weak brine to a depth of 50-70 centimetres. Solar evaporation brings the brine to saturation point, whereupon salt begins to be precipitated out, and this process continues until the evaporation has reduced the depth of brine to 5-10 centimetres. This variation in the brine level gives the operation an intermittent nature, and consequently a lower volume of production than when the level of the brine is kept constant. The inflow of fresh water results in a fall in the specific gravity of the brine, so that production is low in years of very heavy rains.

The saltfields at Cañacmac and Sechura in the north of the country are called sea salt workings: the salt is not extracted by the normal system of solar evaporation, however, but is extracted from beds in the sub-soil consisting of deposits of solid salt on the site of ancient lagoons or estuaries.

A thin overlying layer of sand is removed and the compact bed of salt is then cut up into blocks or lumps which are milled into ground salt or else sold in the form of lump or rock salt.

The operations of salt extraction proper are carried out at the Otuma, Huacho and Sechura saltfields, as already stated, manually with the aid of crowbars, picks and shovels. The workers generally work standing in the salt ponds during the extraction and primary washing of the granular salt, wearing rubber boots to protect themselves against the effects of the brine in the ponds. In most of the sea salt workings, the workers operate under the "piece work" system, whereby they are paid a pre-arranged amount for a given quantity or unit of measurement (wagonloads or wooden skip loads) of previously established weight. For other operation, such as transport and milling operations, workers are paid a daily wage.

(a) The Salt Monopoly's operations at the Otuma saltfields

At the Salt Monopoly's Otuma saltworks, evaporation is continuous throughout the year, the salt produced being collected once a month during the dry season and every 30-50 days during the rainy season in winter. The only reason for this continuous collection of the salt appears to be that if a longer period were allowed to elapse between collections of salt, this would result in the salt building up above the surface level of the brine, whereupon the upper crust of the salt would then dry out and make the salt collection operation more difficult.

Two types of salt are produced: domestic salt and industrial salt. Domestic salt is given a primary washing in the natural brine pond when it is collected. This first washing of the crude salt gives a clear white product. Industrial salt is produced in ponds which are contaminated to a high degree with sand as a result of the windy season, and it consequently contains a considerable amount of sand and dust. This sand cannot easily be extracted by means of the method of single washing used at present. Of the 10,133 tonnes produced by the Salt Monopoly at Otuma in 1966, approximately 10 per cent was of industrial class. The crude salt produced at Otuma is of a fine crystal structure, with an average grain size of approximately $\frac{1}{2}$ cm. Since there are no facilities for processing at Otuma, all the salt is bagged in its crude form and loaded for transport to the stockpiles. The salt ponds are approximately 60 to 80 metres long, from seven to nine metres wide, and are spaced about twenty metres apart in order to facilitate heaping up, storage and access. The narrowness of the ponds enables the workers to collect the salt from the pond bottoms, where it accumulates, directly by means of shovels. The area where the Otuma saltfields are located is approximately 45 kilometres from the Pan-American highway, with which it communicates, at a point five kilometres north of Pisco, by a road consisting of 28 kilometres of asphalted roadway and 17 kilometres of improvised dirt road accross the Pampa.

(b) The Salt Monopoly's operations at the Huacho saltfields

The production of sea salt at the Huacho saltfields is seasonal because the brine resources are subject to annual fluctuation in level, being increased in winter through the seepage of rain water and diminishing through evaporation during the dry season in summer. The brine level in the saltfields and salt ponds rises in the period from January to March, and the seepage of brine into the ponds is supplemented by the admission of brine through channels from adjacent lagoons.

In the early part of the season, the brine which has been diluted by rainwater seepage has a low salt content, and it is not possible to produce salt until evaporation has concentrated the brine to saturation point and the precipitation of salt has begun. As soon as the brine level has gone down as a result of evaporation, the ponds dry out and the work of salt collection is begun. The salt is in the form of a hard crust whose thickness varies depending on the period of seasonal evaporation. This crust is broken up with picks and crowbars into crystals or small clods, piled up into heaps, and then thrown into skips from which it is emptied out into stockpiles around the ponds, or else thrown into 750 kilogramme capacity mine trucks and transported over a Decauville-type narrow-guage railway by diesel locomotive to the storage centre to be used as stock material for ground salt. All the work of extraction, loading, unloading and piling up is carried out by contractual labour.

The salt ponds are irregular in shape and of varying area, many of them are located in separate scattered groups, and the possibility of modernizing this saltfield is limited at the moment to the two largest groups of existing ponds. It does not appear feasible to integrate the many scattered separate ponds into a properly controlled and regulated system of solar evaporation ponds where maximum output and purity could be obtained.

Because there are periods when the ponds contain brine of low salt content, and because of the dependence between the production of salt and the varying levels of the natural brine, production is not steady, and amounts to an average of only some 50 per cent of the possible yield of salt. The pumping of saturated brine from drilled brine wells to supply brine during the year, however, should double the present production of salt. The salt is collected annually, or in some areas twice a year, depending on the depth of the deposits in the various sections. The salt produced is in the form of crystals 2 cm. in size and is known as granular salt.

Two categories of crude salt are produced, the purest product being classified as domestic salt and the salt with the highest contamination with sand being classified as industrial salt. Approximately three per cent of the 54,871 tonnes produced at the Salt Monopoly's Huacho saltfields were of the industrial type. A small section of the deepest deposits adjacent to the perimeter of the ponds is cut up into square pieces and sold as block salt or as salt blocks for livestock.

Most of the output, whether of industrial salt or domestic granular salt, is bagged and packed for transport and distribution to the various stockpiles located around the salt ponds. The central stockpiles are used to supply the salt milling plant where fine-grain ground salt is produced. Domestic and industrial granular salt is sold in 80 kilogramme jute sacks, while ground salt is sold in 50 kilogramme calico sacks.

(c) The operations of "Alcalis Peruanos S.A." ("Peruvian Alkalis") at the Huacho saltfields

The "Alcalis Peruanos S.A." concessions at Huacho comprise a very well designed system of ponds. There is a total of twelve ponds, laid out in four series of three, with interconnected channels for the movement of the brine and a system of channels for filling and emptying. Salt wells and pumps provide a constant supply of brine, so that the level of brine in the ponds is maintained constant throughout the year. The ponds can be emptied for collection of the salt at any time. Transport is by means of trucks which drive in between the ponds for easier loading, which is carried out with a minimum of manual labour. Mechanized salt collection and loading will be used as soon as the appropriate methods are decided upon. The output of the salt ponds is 270 kilogrammes per square metre, which is approximately double the average 150 kilogrammes per square metre achieved at the adjacent ponds belonging to the Salt Monopoly.

This system is an example of what can be achieved by appropriate study and investigation. Work is at present being carried out to double the existing area of the salt ponds.

(d) The operations of the Salt Monopoly at the Sechura Saltfields

The salt deposits of the Sechura fields, which are situated in the North Coast area of Peru, cover a considerable area extending some 50 kilometres from the estuary of the Virrilla in Sechura Bay (Department of Piura) to the beginning of the Department of Lambayeque. These salt deposits were probably formed by the evaporation of salt lakes which were once upon a time connected with the Pacific Ocean by the estuary of the Virrilla, and they appear to cover an area of several hundred square kilometres, containing an enormous reserve of salt. Chemical analyses made by the Salt Monopoly show, however, that the salt is of low purity, containing less than 94 per cent of sodium chloride and some 4 per cent of calcium sulphate. The salt is found in strata separated by thin strata of sand and gypsum.

All the deposits of salt are covered by a surface layer of sand from 25 to 50 centimetres thick.

The Salt Monopoly at present operates two saltfields in the Sechura area, namely, the Cañacmac saltfield situated about 100 kilometres north of the city of Lambayeque, and the Zapayal saltfield about 100 kilometres south-west of the city of Piura.

The salt produced at Cañacmac is mainly granular salt, a small crushing plant being operated intermittently to produce ground salt. The Salt Monopoly has an office and a store at Cañacmac, but most of the salt produced is distributed directly from the storage area of the saltfield.

At Zapayal the salt is produced mainly in the form of blocks or bricks, but also sometimes in the form of granular salt.

Operations are carried on in a very primitive manner, and only hand tools are used.

A 4 to 5 metre wide section of the overlying deposit of sand is removed with mattocks and thrown into the excavation to the left of the place where it is proposed to extract salt, and the hard crust of salt is then broken into lumps approximately ½ metre square and piled up on the adjacent area, where it is broken down manually with hammers into irregular shapes or cut with hatchets into small square blocks or bricks. All the types of salt produced, including the bricks, are packed in 80 kilogramme jute sacks. The area of Sechura is lashed by sandstorms which make contamination with sand a difficult problem. The transport routes throughout the area run through the desert, making transport difficult and expensive.

The use of a tractor and scraper to remove the sand and the use of pneumatic drills could greatly facilitate the present difficult operations and lower the costs of extracting salt. In view of the relatively large amount of salt produced at Cañacmac, it would also be easy to demonstrate the economic advantages of using a gasoline-engine-driven jaw crusher.

The salt at present distributed by the Salt Monopoly varies in type from large-grain granular salt with grains 2-10 cm. in size produced in the mines and the deposits of sea salt, to finer crystallized salt produced by solar evaporation at the seaside saltworks and the brine springs. There are at present only two crushing mills for producing granular salt.

(ii). Methods of operation in the rock salt mines

Until some three years ago, operations in almost all deposits of rock salt were carried out under the contract labour system, whereby the worker extracted in each week or each fortnight such amounts of salt as his labours enabled him to, and this salt was then delivered to the Salt Monopoly stores at a fixed price. The Salt Monopoly provided the explosives, tools, containers and some protective items such as helmets and boots. This system, particularly in isolated areas where most of the workers were peasants following agricultural pursuits, gave the workers the advantages of flexible employment which fitted in with their system of life, since it did not call for strict hours nor even for daily presence at the mine, while the Salt Monopoly benefited in that it could keep its salt extraction costs almost fixed, without any risk of sudden substantial increases. In the long run, however, this system, which had been in existence almost since the establishment of the Salt Monopoly itself, came to be discarded in favour of the usual system of day labour, whereby the worker completes a normal 8-hour working day six days a week. This change was brought about by the fact that under the previous "contract" system the work of prospection and excavation, before the extraction of the salt, had to be carried out by the workers without any remuneration but that received for the salt extracted. With the diminution of the richness of the seams or strata of salt in the mines and the continual trend towards salt workings deeper underground, which increased the distance the salt had to be hauled and the time and labour needed to bring it up to the surface, this system became a source of injustice. Moreover, the work done by the salt miners at their own expense or on their own account was not always in keeping with the best requirements of the upkeep and safety of the mine, so it was finally decided that the work of exploration and preparation, like the actual work of extracting salt, should be carried out at the expense of the Salt Monopoly. This naturally increased the cost of the overall mining operations, as did the continual rise in the daily wages and social benefits of the workers, but it did promote better planning and development of the mine galleries, thus making eventual mechanization easier. Two mines which operate under a rather special system are the small salt mines at Carqueque (Department of Apurimac) and Pichuimarca (Department of Cuzco), which are operated on their own account by buyers of industrial salt, without any extraction costs being payable by the Salt Monopoly. These two open-cast mines produce only industrial salt of low quality, the price of which does not

warrant intensive exploitation of the deposits. The salt buyers are therefore permitted to extract salt themselves and are only charges a very low price, under the supervision of a Salt Monopoly employee.

The present mining operations in the rock salt deposits do not hold out great prospects for expansion. These deposits, which are of the sedimentary type, are mostly made up of seams or strata of small thickness which are often located very deep below the ground, and the small percentage of salt extracted from the rock excavated in the operation of a mine does not at the present time justify the cost of the equipment required for normal mining operations. It is therefore safe to hazard the forecast that the production from rock salt deposits will probably decline from its present share of 9 per cent of total national production and will continue to serve only local demand, where the degree of purity is not important, for salt to be used as a substitute for salt licks (bricks) specially manufactured for livestock.

Nevertheless, as already stated in previous chapters, there are considerable reserves of rock salt in deposits which are either not yet exploited or are at present closed down because they are located in remote areas which do not at present offer any economic advantages to encourage their exploitation. Examples of such salt deposits, which constitute considerable potential reserves for the future, are those at Atacocha (Department of Ayacucho) and Pilluana (Department of San Martín).

Except for the deposits at Paita (Department of Tacna), the rock salt mines being operated at present work on the "cut and fill" method, which is best adapted to the geological characteristics of the seams. There is no uniform pattern in the application of this system, however. Frequently, galleries follow the direction of seams which outcrop on the surface and mining operations follow the same course as the gallery; there are no levels, so that even a minimum of mechanization, such as the utilization of Decauville-type light railways and mining skips, is a problem. Recently, however, there has been a trend towards the development of such mines according to preconceived plans, with galleries being cut to the seams at a single level so that railway lines and other equipment can be installed. Thus, the Cachi-Cuyao salt mine has a gallery some 180 metres long in which there is a 60-centimetre-guage Decauville-type line and two mining skips. Likewise, the excavation of a gallery 350 metres long in which a railway line is to be installed is being completed

in the Cachihuancaray salt mine, while the salt mine at Ococpata (Department of Cuzco) has just installed a 210 cubic foot capacity Worthington compressor which provides air for three pneumatic drills as well as for ventilation of the mine.

The only salt deposit which has been operated in a completely mechanized manner is that at San Blás (Department of Pasco), which is now closed. Many years ago, this mine was operated for the Pasco Mill Copper Corporation; later it was operated by the Vanadium Corporation of America, which extracted salt from it for the treatment of Vanadium until 1955. When the mine was in operation, pneumatic drills were used and the salt was hauled out from the main face along a Decauville-type narrow gauge railway line which ran along a gallery, the skips being then lifted to the surface by a jumper 30 metres high. Once on the surface, the skips were hauled up by a motor winch to the stockpile or store.

(iii). Operating methods at the "brine spring" saltworks

The seven brine spring saltworks at present in operation (i.e., those at Pichu-Pichu in the Department of Arequipa; Azángaro, Napo, Moni and Tiquillaca in the Department of Puno, and those at Maras and San Sebastián in the Department of Cuzco) have been operated on the "purchase" system since the establishment of the Salt Monopoly. The reason for this system is that the brine springs in question have been operated from time immemorial by the local natives, who were their de facto proprietors. The characteristics of the deposits and the production methods used have contributed to keep this system, for in all these saltfields except Pichu-Pichu the salt is crystallized in small prefabricated ponds rendered waterproof with clay; in Pichu-Pichu, however, crystallization is carried out in the bed of the lagoon when the lagoon dries out completely. The crystallization of salt takes place at various times of the year, but generally from April to October, when rain is scarcest. It is in order to be ready for these months that the natives of the communities in question prefabricate their ponds, which are lost during the period of heavy rains.

The small ponds, some of which are not even four square metres in area, are passed on from father to son in legendary inheritance, and it is impossible to count the number of disputes which have occurred over right of ownership and the amount of litigation that has taken place between the various families. At the Azángaro saltfield, each individual or family holding common ground rights is assigned a

strip of ground running from the edge or perimeter of the lagoon to a post in its centre, so that when the brine is saturating, the construction of ponds is begun as soon as the level of the brine permits.

As may be imagined, direct operation of these saltfields by the Salt Monopoly on the basis of day labour would at present be an extremely risky venture and there would be a risk of ineffective operation. It would be necessary, first of all, to maintain the whole labour force throughout the year, and extremely strict vigilance would be needed to obtain a good yield in the collection of the salt and to ensure the proper maintenance and preservation of the ponds. Moreover, the fact that the output is subject to seasonal variations and the limited production potential of the facilities would not permit mechanization of salt production to a sufficient extent to reduce costs. At Maras, the small ponds are constructed on a slope which makes it impossible to use any type of machinery, and it is not possible to construct large ponds. At Azángaro and Piohu-Pichu, even though the lagoons are of considerable size and the first has a considerable output of salt, the irregular layout of the basins of the lagoons would permit neither the construction of permanent ponds nor the meohanization of salt collection.

It will be appreciated from the above that the "purchase" system, whereby the holders of oommon land rights extract the salt on their own account and sell it to the Salt Monopoly at a fixed price is, although archaic, the most appropriate system, at any rate for satisfying local demand and for the production of salt for industrial purposes.

However, as stated in the previous chapter, if we leave aside the production of granular salt by solar evaporation, the Maras salt field does have the special feature of possessing a spring with two outlets from which brine of a speoific gravity of 20°Be emerges at the rate of over 200 litres per minute. This would enable refined salt to be produoed with vacuum evaporation plants at the rate of over 30 tonnes per day. This project, of which we have already spoken, is at present being studied. Thus, the only "brine spring" which presents any possibilities of modernization of salt production is that at Maras.

VI. PRODUCTION, DISTRIBUTION AND SALES COSTS

1. Products and Production Costs

The overall gross receipts from the operations of the Salt Monopoly in 1966 were S/73,794,625.35, resulting from the sale of 108,708 metric tonnes of domestic and industrial salt and jute packings, broken down as follows:

				Value
Domestic salt:				
Granular	67,450,390	Kgs.	S/	40,239,206.52
Ground	30,610,814	"	"	18,387,705.70
Iodized	1,617,496	"	"	1,206,325.00
Table salt	1,862,995	"	"	3,725,990.00
Industrial salt:	7,167,035	"	"	1,435,030.63
Packings (jute and calico sacks)	-		"	8,800,367.50
			S/	73,794,625.35

Total expenses amounted to S/65,913,362.39, so that at the end of the financial year there was a net profit of S/7,881,262.96.

It must be borne in mind that the figures for the consumption of "industrial salt" recorded by the Salt Monopoly do not reflect the actual national consumption of this type of salt, since there are private companies which hold concessions for the production of salt for their own and other industries. It is estimated that these concessionaires, who are not, of course, under the control of the Salt Monopoly, produce over 40,000 tonnes of salt a year.

The production costs are arrived at by adding together the cost of the labour (day labour) employed on the extraction of salt proper, the cost of materials and tools used in the salt extraction operations, and the extras in connexion with labour costs, such as social security costs. The table below shows the costs of extraction and production per hundred kilogrammes of salt for each saltfield. The great difference between the relatively low production costs at the sea salt works and the high costs at the rock salt mines will readily be appreciated.

SEA SALTWORKS	EXTRACTION COST PER 100 KILOGRAMMES, S/	TOTAL PRODUCTION COSTS PER 100 KILOGRAMMES, S/
Huacho	1.52	8.24
Cañacmac	4.77	8.15
Otuma	1.63	7.09
Grupo Sechura	5.10	8.59
Las Garzas	1.75	34.97
Colán	1.61	34.53
Casma	2.93	47.39
Grupo Negritos	7.75	35.89
ROCK SALT DEPOSITS		
Atacocha	20.99	63.44
Cachi-Cuyao	15.71	32.01
Cachihuancaray	15.84	57.21
Yurumarca	15.99	64.54
Huarhua	14.93	45.00
Occopata	28.27	79.94
Urancancha	12.99	82.87
Puite	18.00	39.99
BRINE SPRINGS		
Pichu-Pichu	10.00	61.70
Maras	11.31	31.63
Ñapa	15.00	43.41
San Sebastían	10.00	46.79
Tiquillaca	11.38	37.95
Azángaro	15.00	21.68
Muni	10.00	53.21

Table No.10 shows, in addition to the production costs for each saltfield, the transport costs and the administrative expenditures which, when added to the production costs, make up the total costs incurred in placing the salt on sale to the public at a given depot. These figures also show us the great incidence of

transport costs for each depot and the way in which the transport costs considerably exceed the value of the salt itself, particularly for depots in the interior of the country; for example, for the depots of Rodriguez de Mendoza, Puerto Maldonado and Iberia, the percentage of the total cost accounted for by transport costs is 87.13, 89.80 and 92.46 per cent respectively. The lowest incidence of transport costs is recorded at the Locumba depot, where only 5.16 per cent of the cost of the salt from Puite is accounted for by transport costs, due to the small distance between the saltfield in question and the depot. It is easy to see from Table 10 the enormous difference which exists at many depots between the sale price and the total cost of the salt. The Salt Monopoly tries to subsidize the most expensive salt from the higher profits obtained at saltfields with easy access, such as those on the coast, so as to avoid an unusually high sales price; it has therefore been the Salt Monopoly's policy so far to sell salt at less than its real cost in places which are difficult to supply, as a social service.

Generally speaking, the annual cost of the production, distribution and sales operations of the Salt Monopoly can be broken down as follows:

Pay and allowances of the staff	30 per cent
Day labourers' wages	16 "
Materials and raw materials (purchases of salt)	17 "
Transport costs	30 "
Other expenses	7 "
	100 per cent

2. Distribution and sales

Perhaps the most important work of the Salt Monopoly, and that which covers the social aspect of its activities most effectively, is the marketing of salt, which includes its transport, sale and distribution.

The production centres dispatch the salt to the main depots or stores which, in their turn, dispatch the salt to depots manned by personnel of the Salt Monopoly in the provinces and other lesser centres of population. As the Salt Monopoly has now been reconstituted as a sub-unit of the Tax Collection Department of the National Bank, the operation of the saltfields and the sale of salt at the depots

are supervised by each Main Area Office of the Bank and the money received from sales of salt is likewise paid into the Cashier's Department of each provincial or district branch of the Department of Tax Collection. Each saltfield and depot makes up its accounts monthly and submits them to the Main Area Office, where they are centralized and passed on to the Salt Monopoly's headquarters in Lima.

In 1966, salt was distributed and sold through 111 depots and over 4,400 retail outlets or agents operating under special contracts by which they were granted a commission varying between 5 and 10 per cent on the amount of sales, depending on the locality. Authorized agents were paid transport costs, depending on the distance from depot to sales point, for transporting the salt which they bought at given depots. In the main cities and Lima, distribution from the depots to the sales outlets was carried out at the Salt Monopoly's expense by contractors. Domestic salt is distributed in the following forms:

Granular salt: in 60-80 kg. jute sacks;
Ground salt: in 50 kg. packages or Polyclupack paper sacks;
Table salt: in 1 kg. cartons.

Industrial salt is sold either in jute sacks or else directly at the saltfields in bulk.

In 1966, the Salt Monopoly spent S/17,373,695.07 on these shipment and reshipment operations, using the following means of transport at an average cost S/13.75 per 100 kg:

Means of transport	Amount of salt moved	Average cost of transport
Road transport	108,707,357 Kls.	S/ 11.98
Rail transport	11,836,200 "	" 24.11
Beasts of burden	394,837 "	" 35.41
Water transport	2,078,059 "	" 36.44
Air transport	84,875 "	" 175.16
	123,101,328 Kls.	S/ 13.75

While considering the question of distribution by road transport, it is worth bringing out the fact that in some places, although distances are considerable, unit transport costs are low because there is heavy movement of freight which enables the transport contractors to bring back loads from the place to which the salt is being dispatched, while in other areas of lesser economic importance there is no return load and it is therefore logical that the transport costs should be higher. It should also be emphasized that most salt production centres are difficult of access, being served only by ill-kept minor roads.

In order to make up for losses during transport and sales, transporters are given an extra 1-5 per cent of salt by weight above the correct figure, depending on the distance to be covered and the means of transport used. In order to make up for losses of salt during storage, an allowance of up to 1 per cent is made when salt stays more than one year in store, the storekeeper being held responsible for losses above this figure, except in unforeseen circumstances.

Most of the losses take place during the sales process, due to the lack of adequate packing. There are also considerable losses during the refining process, and also during transport because of inadequate loading systems.

Except in special cases where transport is free, the road transport services to the various depots are provided by contractors selected annually on the basis of tenders.

As far as storage is concerned, the Salt Monopoly as a general rule uses rented premises, many of which are inadequate and of very limited capacity; the premises at the saltfields, however, are constructed by and belong to the Salt Monopoly. This system enables an annual stock to be maintained for initial supplies: thus, on 31 December 1966 the saltfields and depots held stocks of 34,768 tonnes of domestic salt and 236 tonnes of industrial salt, together with 1,178,462 empty jute sacks. The salt is stored at the depots in jute sacks or calico bags, which eliminates storage losses on the one hand, but on the other hand leads to losses of sacks and bags through the effects of humidity when the salt is kept for a considerable time. For the last three years or so, four-ply polyethylene-lined Polyclupak paper sacks have been used for packing ground salt with marked success; these sacks are not returnable by the buyer, as their cost is included in the sales price of the salt contained in them.

The average sales price per kilogramme of salt [illegible] Peru was S/0.63 for domestic salt and S/0.[illegible] for industrial salt.

The maximum price was S/1.50 per kilogramme of domestic salt at the depots at Iberia (Department of Madre de Dios) and Rodriguez de Mendoza (Department of Amazonas) and S/0.50 per kilogramme of industrial salt at the depot at Cajamarca.

VII. THE POSSIBILITY OF DEVELOPING AND MODERNIZING THE PERUVIAN SALT INDUSTRY

With respect to the problem of satisfying the estimated requirements for 1972 and the present requirements shown in Chapter III, the potential resources of the northern part of the country, the exploitation of which could be linked with the exploitation of phosphate and potash deposits in the same area, offer tremendous prospects for the extraction as a by-product of enormous amounts of salt of a high level of purity - higher than that of the salt at present being produced - not only for satisfying domestic needs but also, and indeed particularly, for export to foreign markets. The 1,400 hectare natural dam of the estuary of the Virrilla contains enough brine for a potential production of 1,500 tonnes of salt per square decametre. The salt beds in the southern part of the estuary of the Virrilla, which are even greater than those being exploited at the Cañacmac saltfields and which belong to the same mineral deposits as the saltfields of the Sechura group, could be used either for immediate extraction or else to saturate sea water and provide brine for crystallization ponds without needing to wait the five or six years required under the normal system of salt production.

There are various problems which must be dealt with in order to expand the exploitation and industrialization of this area economically and quickly. One of these problems is the lack of good means of communication or highways which would reduce transport costs, for there is a considerable distance between these deposits and the consumption areas at Piura or Lambayeque. Another problem is contamination with sand, which is a problem encountered in all the sea salt production operations carried on by the Salt Monopoly, but which is more apparent and more difficult to solve at the saltfields of the Sechura group and Cañacmac, because of the strong winds from the desert. Perhaps the economic feasibility of providing coverings for the salt being worked could be considered. Another problem, although it

is admittedly a remote possibility and a rare natural occurrence, is the flooding of deposits located below sea level: the dissolving of the concentrated brine in the estuary and in the sedimentary deposits of Chilcamac would not represent a great loss, however, but simply a delay in crystallization, as the underground reserves of salt would bring the brine up to the degree of saturation needed for salt production.

From the economic and commercial point of view, an important problem, which is perhaps a matter for long term solution, is the lack of loading ports in the immediate vicinity of the salt production areas. The solution to this problem must lie in the Government's projects for new ports and for the modernization of the port installations at Paita in order to permit bulk loading, which is at present only possible in the northern area at the port of Salaverry. The phosphates project for Bayovar also provides for the construction of a port in Bayovar Bay.

If the project for producing salt as a by-product of potassium chloride or phosphate production or for the production of salt by solar evaporation were not feasible at Virrilla, development work at these saltfields would be concentrated on the exploitation of the sedimentary deposits of rock salt, which do not call for large investment for the construction of salt pans or for the operating equipment normally required for rock salt deposits.

The development of salt production in the central area must be limited for the moment to the saltfields at Huacho and Otuma, where the climatic conditions and the availability of saturated brine under highly favourable conditions give grounds for envisaging large scale production. At these saltfields the transport problem practically does not exist, as there are highways connecting with the Pan-American highway system which shorten the distance to Lima and other centres of consumption. It is true that there is the problem of the presence of sand in the crystallizing salt in the ponds and the salt in the storage heaps, but this problem is less serious than at Sechura. Likewise, salt could not be exported through the ports of Callao and Ilo at the moment, because these ports do not have the requisite installations for loading large tonnages of salt at low costs, but this problem will disappear if the Government carries out its project for equipping Ilo with all the necessary installations for the loading of minerals.

Leaving aside the rock salt mines or deposits and also the rest of the "brine springs" it would appear that the only possibility in the Department of Cuzco for expansion and industrialization with a view to supplying salt to related or derivative industries is at the Maras saltfields, where refined salt could be obtained by feeding the brine into a vacuum evaporation plant. There are no major transport or climatic problems in the way of this project, and its output alone would be sufficient to take care of the local requirements of the area (made up of the Department of Apurimac, Cuzco and Puno), which are estimated to amount to 12,000 tonnes.

A quick recapitulation of this chapter will show that the conclusions are that the projects for the extension and/or modernization of the Peruvian salt industry in the areas and saltfields referred to should be put into effect immediately, without prejudice to any subsequent revision by which it might be decided to extend this development also to other deposits of rock salt or brine springs in other areas.

While this order of priority should be followed, for the reasons set out in each specific case, however, it is also true that studies, technical assistance, advice and instructions from persons and organizations with special experience in the salt industry, to be provided in this particular case through the co-operation of UNIDO, could be of very definite help in solving the technical and economic problems mentioned in this report, which can be summarized as follows:

1. Production of solar salt

A review of this aspect of the industry would be limited to the operations of solar evaporation in sea salt works and the extraction of solid salt from existing sedimentary beds or both operations together, particularly in the saltfields of the Sechura group and Cañamarca.

The study would include the adaptation of the method of fractional evaporation and the primary washing of the salt with brine to the brines of the various sea salt fields of Peru, which are of different compositions depending on the depth from which they come. The brines found both in the saltfields of the north and in those of Huacho and Otuma in the South differ from the brine normally obtained from seawater to produce highly purified salt. The salt extracted at Sechura, like that extracted at Huacho and Otuma, has an approximate sodium chloride content

of between 96 and 97 per cent - much less than that of salt produced by primary washing, which attains an average of 99.2 to 99.5 per cent. A series of experiments is therefore necessary to decide on the best extraction processes, the selection of brines, the construction of ponds, the crystallization process, and finally the materials and equipment to be used to improve the operations carried on.

Table 11 shows the composition of brine from the Huacho and Otuma saltfields and the composition and accumulation of salt at different degrees of specific gravity, with an indication also of the degree of specific gravity at which pure sea salt is produced. Table 12 gives analyses of various types of salt from the main deposits which are placed on the market in their natural state.

In accordance with the desired objective of aiding the drafting of such projects as, for example, the determination of the techniques and factors necessary for the improvement of the operations at Huacho and Otuma, it must be borne in mind that the brines from these salt fields, and indeed those from the Peruvian coast saltfields in general, contain a higher percentage of sulphates and carbonates than marine brine in the natural form and therefore not only produce a salt which is less pure, but also have a tendency to form harder and more permeable deposits of crystalline gypsum which are difficult to break up and to separate from the individual natural salt crystals, as is easily done when dealing with sea salt. Such deposits of salt are formed at the Huacho and Otuma saltfields when an annual or semi-annual salt harvest allows the deposits of hard salt to thicken, and it is probable that this is the reason why harvesting is carried out monthly at Otuma. The breaking up and extraction of these deposits would be difficult with the standard machinery used for extraction in small marine salt facilities, and the heavier and more costly equipment required would be too heavy for the bottoms of the ponds and would call for the construction and maintenance of a permanent floor of salt in the pond bottoms, which would, in its turn, make it necessary for the ponds to be excavated very deep. All these factors show that the breaking up and extraction of the salt can most economically be carried out by the present manual methods, and economies in this phase of the salt harvesting could only be achieved after analysis of the particular operations in question, upon whose scale they would in any case depend to a considerable degree.

Mechanical loading into trucks by means of light equipment working in the bed of the salt ponds would be quite feasible and less costly than the present system

of using wheelbarrows or skips and light railway lines, and the greater flexibility and rapidity of these operations would have the result of permitting more evaporation time and hence greater output, while the use of a conveyor and trucks would also pay dividends because of the small investments required.

Crushing and initial washing are essential to produce a good quality of salt. These operations must be carried out as soon as the salt is extracted, before it becomes hard and the impurities from the brine residues adhere to the salt crystals. The present manual crushing methods are strenuous and labour consuming, and moreover they do not break up the crystal conglomerate sufficiently to give good results in the washing process.

2. Modernization of the systems of extraction, transport, loading and packing

The salt harvesting, transport and loading methods used should be the subject of an economic and engineering study both in connexion with the expansion of salt production at the saltfields already referred to and in connexion with the possible development of new saltfields; such a study should determine the methods best adapted to each case and the appropriate equipment for the particular conditions of each salt deposit.

In the case of the saltfields in the north, for example, such as those in the Sechura group and at Cañacmac, the fact that there are beds of rock salt from 20 to 40 centimetres thick covered with a layer of sand some 20 centimetres thick would permit the use of a bulldozer to clean off the layer of sand and of rakes or scarifiers to break up and harvest the salt beds. The methods used at present by the Salt Monopoly at these saltfields are not only labour consuming and prejudicial to the health of the workers, who have to work in brine through most of the salt harvesting process, but also have a considerable adverse effect on production costs, and the use of suitable machinery could mean a saving of over 25 per cent on these operations and much more if the scale of the operations were extended as a result of the possibility of exporting salt on a large scale. Mechanical loading and transport by means of light equipment working in the bed of the salt ponds would be perfectly feasible, especially in the saltfields of Central Peru, such as those

at Huacho and Otuma, and it would cost less than the present method used by the Salt Monopoly, which involves the use of wheelbarrows or mining skips running on a Decauville-type light railway line, filled manually with shovels. The use of loading machines and adequate transport vehicles would soon repay the investments needed to introduce it, in view of the fact that it would permit a substantial reduction in the labour force. It is sufficient to point out that for the extraction of approximately 55,000 tonnes of salt per year the Salt Monopoly employs an average of 100 men on a permanent basis, while "Alcalis Peruanos S.A." employs no more than ten men for an average annual production of 40,000 tonnes, thanks to mechanization of the salt extraction process.

The use of hoppers or some other type of storage which would permit automatic packing would be another source of saving in handling operations. The packing operations now carried on by the Salt Monopoly take place in the open-air at the stockpiles, where jute sacks are filled with salt with shovels and weighed on small platform scales.

It is very important in such mechanization projects to take into account the materials which are to be used, for the high corrosiveness of the salt and the humid climate are factors which make it necessary to renew components continually, thus adding to the maintenance expenses.

3. Processing of the salt

Apart from the very small-scale production of refined salt at the thermo-compression plant in Lima which has already been described, the Salt Monopoly does not carry out any processing of salt to improve its quality other than the straightforward milling, without drying or screening, of crude salt. The increase in sales of ground salt in preference to granular or crude salt gives grounds for believing that the present salt could, if washed, screened and dried, attain a quality and average grain size which would be adequate for the needs of the industrial and domestic market. Very few chemical or food products call for refined salt of high purity, but there are just a few which can use crude salt which has simply been crushed, as it is supplied today. Peru has no experience of plants for washing, screening and drying crude salt, but a slight acquaintance with the subject gained

mainly from reading gives grounds for supposing that the relatively small investment capital needed for plants of 10,000 to 30,000 tonnes output per year and the potential market for a product of better quality and smaller grain size than the crude granular or milled salt now on sale would present an opportunity for increasing profits.

It may be added to this that if the equipment chosen were less complex and specialized, and if it were similar to other equipment of the same kind used in many other industries which, moreover, could be manufactured in Peru, it would give the advantages of greater economic flexibility in the expansion and diversification of the product specifications of the salt industry, together with a low consumption of fuel, electric power, water, etc., in contrast to the more complex installations used in large salt refineries.

Because of the special natural and other conditions at each saltfield, which mean that there are fundamental differences between the saltfields of the North and those at Huacho and Otuma, however, a complete study of the washing process to be applied should be made in order to determine, for example, if it is feasible to eliminate the encrusted or superficial sand from the salt crystals in order to obtain salt of 99 per cent sodium chloride content or, alternatively, to determine the limit of purity which could be obtained. It should also be determined up to what point it is advisable to use brine from the same saltfield in the washing process, bearing in mind the variations in its concentration and possible sulphate and carbonate impurities which are frequent in the brines of Peruvian coastal saltfields. Likewise, it is necessary to determine if this washing process can best function in conjunction with the processes of a refining plant or if it is completely independent of such processes. Finally, it is important to determine the most convenient and least expensive methods of primary washing to be carried out at the time of extraction and the most appropriate types of mills, screens, dryers, etc. for this type of plant.

The design of the washing, milling and drying plants for the projects referred to above, that is to say, as a first step towards the modernization of salt processing, for a plant of 30,000 metric tonnes annual capacity in the Northern area and another of 75,000 metric tonnes capacity in the Central area, must also fulfill the

fundamental requirement of being suited to the location of the plants: if processing requires continuity of operation with the solar salt extraction work, the plants must naturally be adapted to the climatic and local conditions, taking into consideration such factors as working conditions, transport, water, electric power, etc. If, in the areas in question, these factors are not such as to ensure smooth functioning of the plants and the achievement of low operating costs, it may be considered that the plants should be located in cities, where many of the negative factors, such as the lack of drinking or fresh water in the saltfields, lack of motive power installations, absence of suitable facilities for the personnel, and other factors which adversely affect costs could be eliminated. In the first project, for example, if it proved impossible to install or operate the plant at the actual saltfields of the Sechura group or Cañacmac in such a way that the washing process took place, without any unnecessary movement of the material, at the logical point between production of the crude salt and its packing and loading, then the plant in question could more advantageously be located in the cities of Piura or Lambayeque, even though this alternative would break the logical line of continuity between the extraction process and the washing or refining processes, since the plant could fairly easily be supplied with raw material drawn from one of the salt deposits mentioned. In the case of the plant which is envisaged to set up in the Central area at the Huacho saltfields, it is not believed that the factors referred to earlier would weigh so heavily that the plant could not be erected on the actual salt workings, thus preserving the desired continuity of operations, since it is only a very short distance to centres of population, and this factor eliminates the other negative factors. Consideration could however, also be given to the possibility of establishing the plant in the town of Huacho Pueblo, which is scarcely 17 kilometres from the saltfields, with which it is connected by a good highway.

When considering the modernization projects for the salt industry, particularly those concerning the processing of crude salt dealt with in this chapter, we cannot leave out from our consideration the question of setting up refining plants for the production of refined "table" salt.

The market for this type of salt, according to consumption forecasts already investigated and established, would be subject to competition from low-priced salt

that was simply washed, ground and dried, so that the quality and the system of distribution, packing and sales of refined table salt would determine its sales prospects in competition with the other type of salt. At the present time, there is a potential market for not less than 20,000 tonnes of refined table salt in the Lima and Callao area and some 15,000 tonnes in the Northern and Southern areas: i.e. a total of 35,000 tonnes per year for the whole Republic. Thus, when this potential consumption is projected for a five-year period, taking into account increases in consumption for other uses connected with the food industry, it would appear that any plants to be installed in the near future should have a production capacity of 50,000 tonnes per year.

The production of the three salt processing projects already referred to, which have a capacity of 30,000 tonnes for the Northern area (Piura and Lambayeque), 75,000 tonnes for the Central area (Huacho) and 9,000 tonnes for the Southern area (Maras), should be broken down as follows: 10,000 tonnes of refined salt and 20,000 tonnes of washed salt per year for the Northern project; 30,000 tonnes of refined salt and 45,000 tonnes of washed salt for the Central project (Huacho), and 9,000 tonnes of refined salt, supplemented by washed salt from the Azángaro saltfields, for the Southern project (Maras).

In addition, the washing plants should include a section provided with appropriate equipment for the manufacture of salt licks containing suitable additives for the various kinds of livestock. The proportion or quantity of such bricks to be manufactured could be determined by a simple subsequent study.

The usual vacuum evaporation systems, with one or more thermo-compression or vacuum pan stages, could be used in the proposed refining plants, but it is desirable that certain automation equipment and instrumentation should be eliminated in order to reduce investment costs and keep down depreciation and operating expenses of the plant. The local manufacture of some parts of the equipment could be envisaged. It is naturally very important to study the question of the supply of electric power or the possibility of installing a steam plant, always bearing in mind that the installation of these plants in the saltfields themselves would involve the need for a source of supply of fresh water.

An important factor in the marketing of refined table salt is the type of packing and the packaging equipment used for this purpose.

One of the reasons for the low output achieved at the refining plant now being operated by the Salt Monopoly is the difficulty of maintaining the packaging machines and other final processing equipment, which are subject to premature wear and require expensive maintenance and upkeep because of the corrosiveness and the humidity of the salt; the infiltration of the dust produced in the packaging rooms and around transporters and elevators is particularly serious because of the deterioration it causes in electric circuits, motors, pipework, etc. The use of suitable equipment for eliminating this dust and the corrosive action of the salt is therefore very important.

The Salt Monopoly's refining plant at present packs its refined salt in 1-kilogramme-capacity duplex cartons, which are packed in their turn in corrugated cardboard boxes holding 25 cartons. Both the duplex cartons and the corrugated cardboard boxes in which they are packed are expensive in Peru, however, and the manufacture of these packings is uneconomic; it may be observed that the S/0.80 which each 1-kilogramme carton at present costs represents more than 30 per cent of the price of S/2.00 at which the refined table salt is placed on the market. When the other packing costs for labour and materials are added to the cost of this packing, it can be seen that the type of packing used is a determining factor in the marketing of the product. Experiments have been made in the use of polyethylene bags packed on a [illegible] 1-2P" Hesser machine, which gives an approximate cost of S/0.18 per bag, with less use of additional materials and less consumption of labour, but the automatic mechanism of this electronically controlled machine calls for very careful operation and constant maintenance, which militates against the continuous operation of the machine to obtain satisfactory output. Moreover, the polyethylene sheet used is not of the uniform quality essential for the smooth operation of the packing and sealing machine.

It would appear that there is at present no type of packing on the national market which costs less than polyethylene or some similar product, and polyethylene is also very suitable in that it protects the salt packed in it from humidity. Duplex cartons or other thicker packings are not only more costly, but also fail to protect the salt from humidity, particularly in the climate of the Peruvian coast. For this reason, a machine for sealing polyethylene bags which has already been used with success for packing salt, or else has been manufactured especially

for this purpose so as to be proof against the adverse effects of the salt on its operation, and which is also relatively simple to operate as far as the synchronization of its various components are concerned, would be the most appropriate and advantageous for our purposes.

Consideration must be given, however, to the utilization, although to a lesser extent, of other types of packing such as plastic, tin, cardboard, etc. in different shapes and sizes to hold quantities from 250 grammes to one kilogramme for retail sale and from 5 kilogrammes to 50 kilogrammes for wholesale sale. Such packing would have to be by automatic or semi-automatic machines, as the projects already referred to will require the daily packaging of an average of 100 tonnes of salt in a single plant (Huacho). In the same line of thought, it must be kept in mind that the whole packing system and equipment, from the conveyor belts and railway tracks to the packaging machines and stores, must be located in a direct line and involve the least possible use of labour.

All the above calls for the more advanced knowledge which has been built up from experience in other countries where the salt industry has already advanced past the stage which Peru wishes to reach. Recommendations and actual experiments on the spot would therefore constitute most valuable assistance.

FOR FURTHER INFORMATION CONTACT

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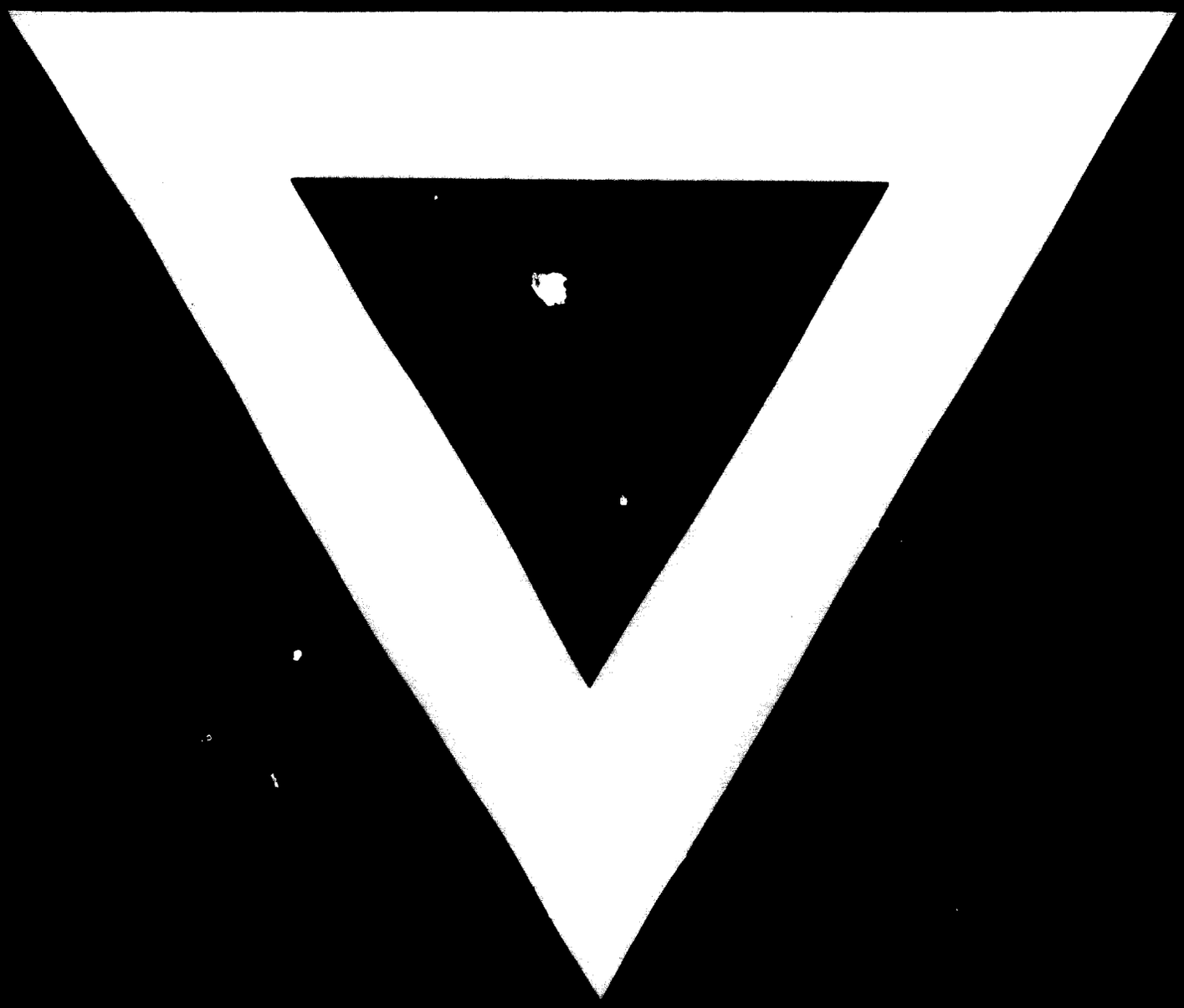

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