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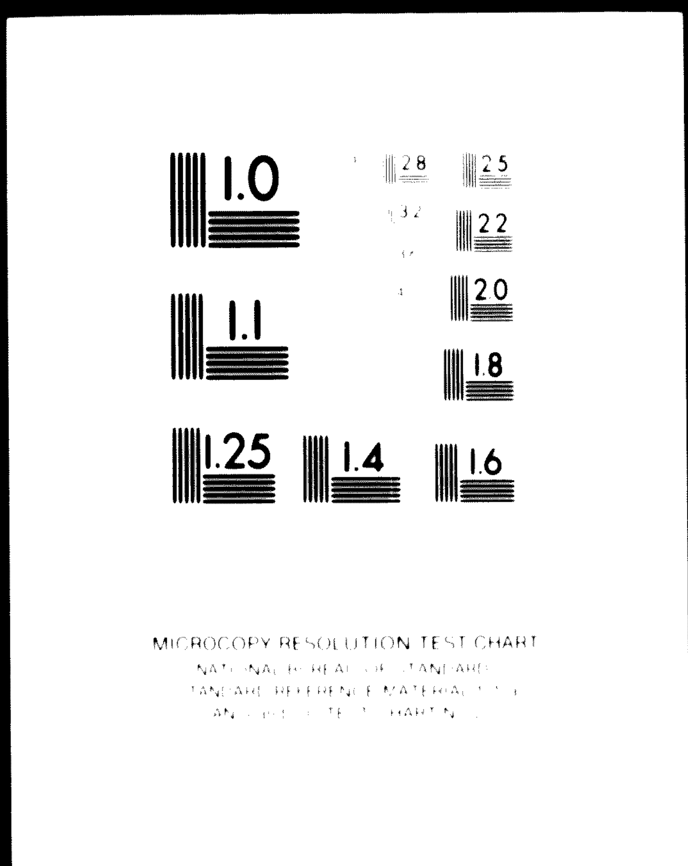
1 OF 2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The Development of SALT RESOURCES AND SALT BASED INDUSTRIES in the COUNTRIES OF THE MAGHREB

1973

DP/REM/66/572

prepared for

THE CENTRE D'ETUDES INDUSTRIELLES DU MAGHREB

on behalf of

THE UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANISATION

L. H. MANDERSTAM AND PARTNERS LIMITED

Consulting Engineers

38 GROSVENOR GARDENS

LONDON, S.W.1

GENEVA BRUSSELS

L.H. Manderstam and Partners Ltd. have the honour to submit their techno-economic study on the possibilities for using rock and sea salt as raw material for the production of basic chemicals in the countries of the Maghreb (Algeria, Morocco, Tunisia). Project No. DP/REM/66/572, Contract 72/52, commissioned by UNIDO on 12 January, 1973.

The terms of reference are set out in Appendix 1, as amended by agreement with UNIDO to take account of work done by the Centre d'Etudes Industrielles du Maghreb (CEIM). The emphasis has accordingly been placed on examining possibilities for Maghreb cooperation in the field of salt derivatives, rather than on salt and salt resources. The division of time between these two areas has followed that laid down in clause V (e) of Amendment 1 to the contract.

Visits to the Maghreb were made by members of the team from 7 February to 1 March, and from 14 March to 1st April 1973. Appendix 2 lists organisations visited and names of those with whom discussions were held.

Two counterparts from the CEIM worked with the team in London from 25 April to 11 May, during which period visits to salt, chlor-alkali and PVC plants took place. From 7 to 11 May the Director of CEIM also visited the London office, to discuss the main lines of the report.

The team would like to acknowledge in particular the helpful cooperation given by all organisations and individuals visited in the Maghreb, and for the valuable assistance extended by CEIM.

The Development of SALT RESOURCES AND SALT BASED INDUSTRIES in the COUNTRIES OF THE MAGHREB

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THE CENTRE D'ETUDES INDUSTRIELLES DU MAGHREB

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THE UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANISATION

BY

L.H. MANDERSTAM AND PARTNERS LTD

CONSULTING ENGINEERS

LONDON

JUNE 1973

CONTENTS

TABLES

TABLES Continued

DIAGRAMS

INTRODUCTION

L.H. Manderstam and Partners Ltd. were engaged by the United Nations Industrial Development Organisation to undertake a techno-economic study on salt and salt-derived products on behalf of the Centre d'Etudes Industrielles du Maghreb.

The object of the study is to establish possibilities of cooperation in the production and sale of salt and salt-derived products between the three countries of the Maghreb. Salt is defined as sodium chloride. Proposals include suggestions for cooperation between two or more countries of the Maghreb. The terms of reference are given in Appendix I.

The study shows that there is scope for cooperation between the Maghreb countries, particularly in the development of selected salt-derived industries, notably the manufacture of polyvinyl chloride and possibly chlorinated pesticides at an appropriate time.

The report consists of three main parts. The first examines the Maghreb markets for important salt derivatives and, in the light of these, analyses the demand for salt and its availability. The second puts forward recommendations for cooperation within the Maghreb, and at the same time states the individual implications for each country. The third part gives costings and brief process descriptions of each proposal. When dealing with the resources and industry of the Maghreb, the sequence adopted throughout the report is invariably from West to East, that is to say Morocco, Algeria, Tunisia.

As the report was prepared during 1973, all 1973 data has had to be estimated. The majority of production figures have been provided by the appropriate Ministries and Societes. Import figures have been estimated from past years customs data, in the light of comments from Ministries and Societes and other authorities on developments in 1973.

CONCLUSIONS AND RECOMMENDATIONS

By 1980 PVC will be the most important single product utilising salt derivatives in the Maghreb, and all recommendations in this report centre directly or indirectly on the proposals for the development of PVC manufacture. The principal conclusions of the report are as follows :

1. The demand for PVC in Morocco in 1980 justifies investment in a 20,000 t/a polymerisation plant, but manufacture of vinyl chloride monomer (VCM) is only economic at a much higher level (80,000 t/a). Moroccan requirements of VCM should be largely met from the Algerian unit at Skikda (Eastern Algeria). Tunisia, whose 1980 demand for PVC (8,000 t/a) is too small to justify manufacture, should import her requirements from Algeria and this would help the Skikda PVC/VCM complex to operate more economically.

2. Algerian demand for PVC in 1980 is expected to exceed the capacity of the PVC/VCM complex now under construction at Skikda (40,000 t/a VCM, 35,000 t/a PVC), and it is accepted that this complex will be uneconomic at full capacity. Doubling VCM capacity would improve the economics, and a high level of utilisation could be ensured by monomer sales to Morocco for local polymerisation. All sales of VCM will make a positive contribution to the economics of Skikda.

3. The Algerian Skikda complex will require 60,000t/a of salt when the PVC plant comes on stream. The proposed expansion will eventually double these requirements. There are strong arguments in favour of Tunisia as the source of supply of this salt. Tunisia is already exporting low-price, high-quality, salt, in quantities which exceed total Maghreb demand. The Algerian authority responsible, SONAREM, is proposing to supply Skikda with salt from the El Outaya deposit, which is at present under study. Without pre-judging the results of this study, it can be said that the price of Tunisian salt delivered at Skikda is very likely to be competitive with that from El Outaya, and of better quality.

4. The production of sodium tripolyphosphate (TPP) for the manufacture of powder detergents will not be economic in the Maghreb using locally produced soda ash or caustic soda at their anticipated future prices. But in 1980 it is anticipated that the expansion of PVC manufacture at

Skikda could lead to Algeria producing 27,000 t/a excess caustic soda over domestic demand, and that a sharp decrease in the caustic soda price could result. If then a decision is made to manufacture TPP, it could provide an outlet for this surplus caustic soda.

5. Demand for soda ash in the Maghreb is not sufficient to justify profitable manufacture from salt. Should a decision be taken at a later date to build a soda ash plant using salt as raw material, consideration should be given to locating it in Tunisia, as this is the only Maghreb country with large-scale supplies of cheap good salt near existing limestone quarries. Part of the soda ash demand might be manufactured from some of the excess caustic soda expected in eastern Algeria by 1980.

6. It is recognised in all three countries that a higher level of application of pesticides would benefit agricultural development. In addition DDT provides effective control against malaria and the World Health Organisation estimate potential West African demand at 5,000 t/a. Maghreb demand in 1980 plus DDT exports could be 4,600 t/a DDT and 1,500 t/a BHC.

At current price levels this investment would not be profitable but prices should rise by 1980. Bearing in mind the location of these markets for pesticides, Morocco is the preferred location for such an investment.

7. Opportunities for cooperation between all three countries at all levels are considerable. The expertise of the major producers of solar salt could benefit all producers. Meetings between staff of the various chlor-alkali units would allow a regular interchange of experience, to help improve performance. All three countries need educational and research services for their plastics industries. A Maghreb plastics institute would provide the most effective use of available staff, and the most effective solution of problems common to the plastics industry in the Maghreb.

8. Cooperative proposals could be implemented in several forms as described in Chapter Three. None of these precluded some participation by the private sector, though this must take the individual investment laws of each country into account.

CHAPTER ONE

MAGHREB MARKETS FOR THE DERIVATIVES OF SALT

This chapter describes the essential features of a salt-based industry, analyses Maghreb markets for important salt derivatives, and lays the basis for the discussion of the salt market and resources in Chapter Two. Assessment of the future of the market has been based on first hand study in all three countries. The maximum use has also been made of the informed views of Ministries and Government Departments, of public and private industry, of existing and previous studies and of other published sources.

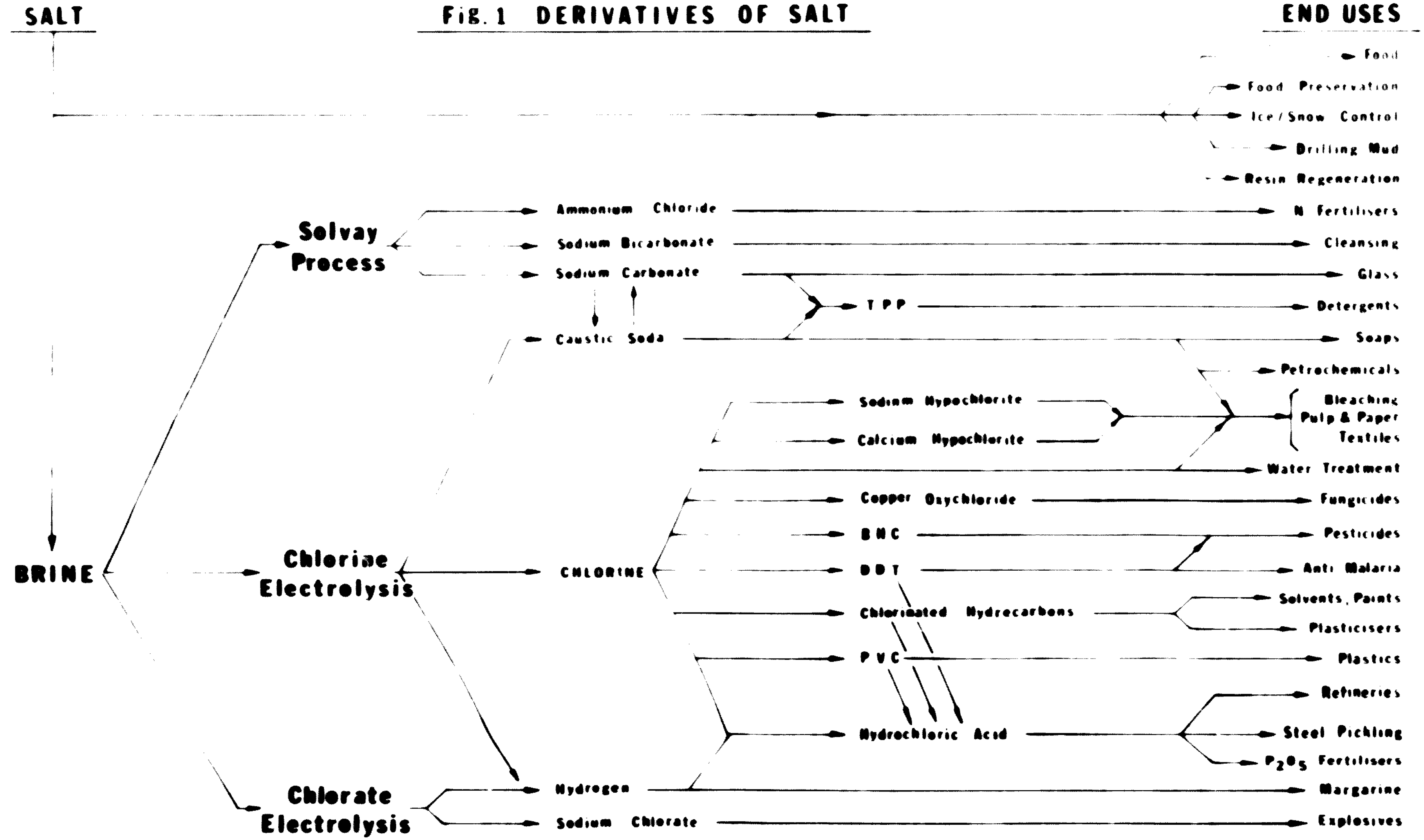
All three countries are at the last stages of their current national plans; in none of them were the new four-year plans published at the time of writing. All three countries, however, gave guidance about their expectations for relevant industries. In some cases this was related to the next four year period and in others (particularly in Algeria) to 1980. In all cases however thinking was often directed to 1980 which was therefore chosen as the forecast year.

I.1 The Derivatives of Salt

Although salt is an essential constituent of human life and one of the most prized commodities of human civilisation for many thousands of years, today less than 5% of the total production of salt is destined either directly or indirectly in the preparation of food.

In the more industrialised nations salt is extensively used for the production of its primary derivatives, chlorine and caustic soda. The manufacture of PVC provides by far the largest share of the market for chlorine, whilst the outlets for caustic soda are more varied. Some of the many products and outlets of the chlor-alkali industry are illustrated in Figure 1. The list of end uses indicates the widely ranging significance of salt to an industrialised society. Maghreb imports of varous salt derivatives are shown in Table 18 at the end of this Chapter.

Fig. 1 DERIVATIVES OF SALT



Primary processes

Salt used for the production of caustic soda, chlorine and soda ash is consumed as brine. The greater part is taken directly from underground salt deposits, and for this reason, these manufacturing units are usually located near to the salines. Where brine supplies are not available, solid salt has to be dissolved. The most important processes are the Solvay process, chlorine electrolysis and chlorate electrolysis, illustrated in Figure 1.

The main industrial uses for solid salt are in the direct electrolytic decomposition of salt to sodium metal and chlorine and the salt cake process for the mannufacture of hydrochloric acid and salt cake (sodium sulphate) through the reaction with sulphuric acid. Because of their lesser importance in the Maghreb, sodium and sodium sulphate have been omitted from Figure 1. The market for sodium chlorate is likewise very limited and the two processes of most immediate relevance are salt electrolysis (in chlor-alkali plants, of which there are already several in the area)and the Solvay process for the manufacture of soda ash.

Economic Factors

The manufacture of salt derivatives differs from many other industries which use solid raw materials, in that salt is normally available locally. There are few countries in the world which do not have access to rock or marine salt. It is one of the few commodities for which small-scale manual methods can still compete with sophisticated mechanised techniques, because transport costs are usually high in relation to the intrinsic value of salt. The costs of mining or quarrying or evaporating salt can be below $3 per tonne; the delivered price of salt to an industrial plant however can exceed $18 per tonne. This fact encourages the location of industrial plants close to the sources of salt. On the other hand, for chlor-alakli units the problems of chlorine transport are often more critical in determining location. The usual situation is for the chlorine to be fully consumed in other production units located in the same plant area. The choice of location for a chlor-alkali unit therefore is influenced not only by the location of the source of salt but also by the chlorine outlets.

The Chlorine/Caustic Soda Ratio

In contrast to the petroleum industry where by controlling processing conditions, it is possible to vary the ratio between various hydrocarbon products to some extent, the ratio of production between chlorine and caustic soda is fixed immutably by the laws of chemistry. For every ten tonnes of chlorine, eleven tonnes of caustic soda must be produced. One of the major problems of this industry is to ensure that there is a balance between the two products (and their derivatives). However attractive the market for one product may be , it can only be utilised in proportion to the outlets for the other.

Both products are difficult to export. The technical difficulties and dangers of transport prevent large sales of chlorine. The market for caustic soda is extremely variable because of the perennial difficulties of over-production in the industrialised countries.

Soda Ash/Caustic Soda

Soda ash is currently produced from salt, limestone and ammonia, and can also be made from caustic soda; conversely, and more commonly, soda ash can be used to make caustic soda. Before the widespread use of the electrolysis route, caustic soda was invariably manufactured from soda ash. In most industrialised countries the demand for chlorine for PVC manufacture has caused excess production of caustic soda and so soda ash is now sometimes made from caustic soda. There is also an element of competition between caustic soda and soda ash for certain uses. For example, caustic soda can partially replace soda ash in glass manufacture (a major outlet) and in the production of inorganic sodium compounds.

The Maghreb countries have not reached the stage of overproduction of caustic soda so it is still possible to consider producing soda ash directly from salt. A variant of the Solvay process is the production of ammonium chloride fertilizer as a co-product of soda ash (the "dual" process, which has been of great success in Japan). Unfortunately, in none of the three Maghreb countries have there yet been field trials to test the suitability of ammonium chloride for selected crops in North African conditions. Until such tests have been conducted and the market for ammonium chloride established, it is not possible to recommend this process route. Export prospects are not encouraging as most of the ammonium chloride produced in the world is consumed in the Far East, mainly China and India.

Chlorine/Caustic Soda imbalance

Because of the character of the chlor-alkali industry the first object of a survey must be to establish whether there will be a production surplus of chlorine or caustic soda after ascertainable demands have been satisfied.

During the last twenty years, the demand for chlorine for PVC manufacture has provided the greatest single stimulus for the chlor-alkali industry. In countries where there is no PVC manufacture, demand for caustic soda normally exceeds demand for chlorine, and it may be necessary to restrict caustic soda production to prevent over-production of chlorine where there is no outlet. In such countries, there is a strong incentive to examine closely the potential for chlorinated compounds, such as chlorinated pesticides instead of organophosphorous substitutes. Similarly, hydrochloric acid could be promoted as a substitute for sulphuric acid in certain applications (e.g. metal pickling). Soda ash production could be initiated using a variant of the Solvay process, since caustic soda and soda ash from this process route do not produce chlorine as a co-product.

I.2 PVC (Polyvinyl Chloride)

As explained in the last paragraphs, PVC is the most important world outlet for chlorine. The world PVC market is cyclical and is now moving into a period of slight shortage and firmer prices. World capacity is estimated at over 6 million t/a. Many European producers hope that manufacturers have learned from the recent period of profitless over-supply, and that they will be more cautious in the next round of expansion. Expansion is however, already starting, for example in the United States, which alone accounts for about a quarter of world production. There is also the threat from substitution by other plastics. Several of these such as polyethylene and polypropylene, are strongly competitive with many PVC applications. However it would be unrealistic to expect the present stability in the PVC market to contitue unbroken and over-supply is likely to return before 1980.

General purpose grade PVC is now selling in Europe at $270-300 tonne, roughly the same level of price as low density polyethylene. Polypropylene is nearer $400/tonne. However, the specific gravity of PVC is about 1.4, that of low density polyethylene is 0.92 and that of polypropylene 0.91. In terms of volume of material, therefore, PVC and polypropylene are about the same price; low density polyethylene is 35% cheaper. These and other materials are now taking many of PVC's potential new markets in many parts of the world.

There is a considerable world trade in Vinyl Chloride Monomer (VCM), the material fnom which PVC is polymerised. Large quantities have been imported into Europe from the USA in recent years, at prices around $135-150/tonne cif Mediterranean ports. Prices hardened abruptly to about $175/tonne at the end of 1972 as shortages began to be felt. These prices are expected to reach $190-200/tonne by the end of the decade. By 1980 however, new capacity is likely to ease the supply position.

I.2.1 PVC : Morocco

Moroccan consumption of all plastics materials is now estimated to be running at 40,000 t/a, all imported. The two most important materials are Low Density Polyethylene (approximately 12,000 t/a) and PVC (approximately 10,000 t/a). 60% of the PVC is used for manufacturing shoes and 20% of these are exported. About 80 firms in Morocco covert plastics raw materials into finished or semi-finished products and the industry is modern and well-equipped. Virtually all specialist plastics machinery (such as extruders) is imported, but the larger firms have good engineering facilities, make their own moulds, and have printing equipment and skills.

The industry has recently been the subject of a detailed 6-month study by two UNIDO experts working in conjunction with BEPI (Bureau d'Etudes et de Participations Industrielles). At the time of writing their report had not been finalised and could not be made available to the team, though an opportunity was given to discuss some general points.

The present outlets for PVC are as shown below.

Table 1

Morocco: Outlets for PVC in 1972 (% by weight).

Shoes	61.2
Imitation leather	10.1
Pipes & profiles	9.5
Bottles	7.5
Sheet & calendered	6.7
Other	5.0
	100.0

The proportion in shoes is very high. This is a notoriously volatile fashion market. It is one for which many leather substitutes are now being developed all over the world, some much more satisfactory than PVC. The export market for shoes, which is important to Morocco, is particularly susceptible to changes in fashion, and developments in leather-substitutes are advancing rapidly. While there will be periods of rapid expansion, these are not likely to be sustained, and a below average rate of growth is probable. Growing demand for the other end-uses, such as pipes and bottles is likely to be steadier though even this will be subject to strong competition from other synthetics and conventional materials. In the United Kingdom, for example, alternative materials are now taking a great many of PVC's potential markets.

Table 2

Morocco: Imports of PVC 1967-71 (tonnes).

	Imports	Increase over previous year
1967	3,180	
1968	4,972	1,792 (57.5%)
1969	5,750	788 (15.9%)
1970	6,537	787 (13.7%)
1971	6,819	282 (4.3%)

The rate of increase is declining rapidly both in terms of absolute tonnage and of percentage growth. It is rare for the high rates of growth normal in the early stages of a plastics industry's development to continue unbroken and Morocco is no exception. Local estimates of future growth range between 7-9% and 12-13% per year. Taking a middle figure of 10%, demand for PVC in Morocco,would increase from the present 10,000 t/a to 20,000 t/a in 1980.

I.2.2 PVC : Algeria

Algerian consumption of all plastics in 1969, including imported finished and semi-finished products, totalled 30,000 tonnes. 18,000 tonnes were in the form of resins imported into the country and processed locally. Of this nearly 8,000 tonnes were PVC.

Algeria has established a national plan for the development of plastics, with the object of raising consumption per head rapidly to an international level of 9.5 kg per head; a total consumption of about 150,000 tonnes per year. The plan covers every aspect of the future of the industry from raw materials through to markets, including training and the establishment of a large and modern processing industry.

Priority in market development of the Algerian economy is in the following order : i) agricultural applications, ii) the construction industry, iii) packaging, iv) industrial components, v) various other uses.

After careful study Algeria decided to concentrate at first on the manufacture and processing of a limited number of plastics materials from the wide range possible. The two most important of these are PVC and Low Density Polyethylene (LDPE). Units for manufacturing 35,000 t/a PVC and about 40,000 t/a LDPE are now under construction as part of a large petrochemical complex at Skikda in Eastern Algeria. The PVC plant consists of a 40,000 t/a VCM plant and a 35,000 t/a polymerisation plant, due to come on-stream by the end of 1975. Output is intended for the home market, at prices that are not necessarily expected to be competitive with international levels. The operation of the PVC plant is reported as likely to break even only at a high level of utilisation; it is planned to be in operation at full capacity in 1976, within six months of start-up. The site is designed to allow at least a doubling of PVC capacity, and this is being contemplated.

Execution of the plan is the responsibility of a specially established division of SONATRACH (Societe Nationale de Transportet de Commercialisation des Hydrocarbures) Projet Plastique. To develop the processing industry, SONATRACH will construct factories as necessary, some of which could be later transferred to other appropriate Societes Nationales for operation. For example a factory making building components could in due course be managed by SNMC (Societe Nationale des Materiaux de Construction). Balanced regional development is very important and three centres (West, Central and East) have been chosen in which most of the processing industry, will be concentrated. Training at management, supervisory and operative levels is planned. An American institute is at present studying the longer term problems of training, and the possibility of setting up technical schools and a system of qualifications in Plastics technology. Great stress is placed on education in all sectors of the economy about the best uses of plastics.

There is little doubt that this approach should lead to rapid growth in the consumption of plastics in Algeria. However, it has been common experience in many countries that the biggest difficulties met by an expanding plastics industry are those of the processors, converters and users of plastics products. Even using limited number of raw materials, the range of products made and the continual evolution of processing techniques places a very heavy burden on skills in this sector and on capital requirements.

Certain products needed in Algeria, such as pipes, use relatively large tonnages of material. Other plastics products such as packaging materials and film are very light and huge quantities need to be consumed to reach significant tonnages. End-users need reliable high speed packaging machinery to achieve this. Furthermore pipes, construction materials, and other heavier products have to be made to stringent standards. Many countries have been through disappointing periods of product failure before reaching satisfactory acceptance of these types of material.

To increase the tonnage of PVC converted in Algeria from about 8,500 t/a in 1970 to the planned output of 35,000 t/a in 1976, an increase of over 300% or 27% per year, requires a major effort. If this rate of growth is maintained, demand in 1980 would be 90,000 tonnes necessitating production of at least an additional 55,000 tonnes. For the reasons given above it is thought unlikely that this rate of growth could be sustained.

It is a reasonable conclusion that to achieve a 40,000 t/a consumption for PVC resins in Algeria by 1980, or an increase of about 20% per annum from 1973, would represent considerable success. Small quantities for export (say 2,000 tonnes per year) may also be possible in addition to inter-Maghreb trade as proposed later in this report.

I.2.3 PVC: Tunisia

Tunisian consumption of all plastics in 1973 is estimated at 10,000 tonnes, of which about 4,000 tonnes are PVC and 4,000 tonnes are polyethylene. The estimates suppose a very large increase over recent years. Imports of polymer in 1971 were 5,708 tonnes, of which less than one third was PVC.

There are about 40 plastics processers in Tunisian, mostly private companies, situated in Tunis, with a few at Sousse and Sfax. Most firms make specialised products; three or four make a wider range. The most important of the larger firms is at Sousse. There is no local centre for plastics development, nor is there any system of education in plastics technology. Some thought has been given to the possiblity of constructing a 10,000 t/a PVC polymerisation plant using imported monomer, but no studies have been made.

As in Morocco, it is unlikely that the apparently high rates of the last two years will continue. It is true that there are many untapped markets, for instance PVC bottles for Tunisia's important olive oil and wine production. Replacing traditional materials with plastics normally offers the customer advantages. It has been a common experience, however that this needs entensive development over time.

For these reasons demand for PVC in Tunisia over the next decade is forecast to grow at a rate not far different from that in Morocco, that is to say at about 10% per annum on average, though this does not rule out short periods of much faster growth during this time. On this basis demand for PVC would total about 8,000 tonnes in 1980.

1.3 Pulp for Paper

The manufacture of chemical pulp uses substantial quantities of caustic soda for the pulping operation and of chlorine for bleaching. The amounts used per tonne of finished pulp vary according to the process, the type of raw material (alfa, eucalyptus, pine etc.) and the degree of bleaching required.

As far as possible in this report, locally compiled data on consumption of chlorine and caustic soda, based on full knowledge of individual projects, have been used. Estimates have been made only where local data were unavailable.

1.3.1 Pulp : Morocco

Morocco is a large exporter of pulp (40,018 tonnes in 1970). but also imports considerable quantities of conifer-based long fibre pulp (24,258 tons in 1970). The sole manufacturer, at Sidi-Yahia du Gharb near Kenitra, La Cellulose du Maroc (CDM), produces about 45,000 t/a of pulp from eucalyptus. There are proposals to expand output in two phases, first to 60,000 t/a and then to 100,000 t/a all also based on eucalyptus, and at the same site. Changes in the process will mean a drop from the present caustic soda consumption of 4,500 t/a to 3,000 t/a on completion of the second phase.

Two other projects are under examination. One is for 30,000 t/a of semi-chemical pulp from eucalyptus. The other is for 60,000 t/a of pulp from alfa in Eastern Morocco. The next table illustrates Morocco's potential requirements for chlorine and caustic soda, if these new units were to be installed. The CDM figures were provided by the Moroccan authorities, and the others estimated.

Table 3

Morocco : Proposals for Expansion of Pulp Production (t/a)

Producer	Capacity Pulp.	Consumption Chlorine	Consumption Caustic Soda
CDM (eucalyptus)	100,000*	8,500*	3,000*
Semi-chemical project	30,000*	2,300	3,000
Alfa project	60,000*	5,400	6,300
		16,200	12,300

* Figures provided by Ministere du Commerce.

At present nearly 90% of pulp produced in Morocco is exported and demand is strong. However, one vital factor limiting output is availability of raw materials and the first phase of expansion of CDM is already well behind schedule For this reason, it has been decided that the forecasts of output for 1980 should include the two CDM projects, but exclude the two other projects which are still being studied. This puts 1980 requirements at 8,500 tonnes of chlorine and 3,000 tonnes of caustic soda.

1.3.2 Pulp : Algeria

Algerian exports of pulp are small and some quantities of conifer-based pulp are imported (4,996 tons in 1970). At present the only manufacture of pulp is at the factory at Baba Ali, near Algiers. This factory and the neighboring chlor-alkali plant are managed by the Societe Nationale des Industries de Cellulose, (SONIC).

SONIC has a major programme for the expansion of pulp production by 1980. The table below summarises Algeria's potential major requirements for chlorine and caustic soda for pulp manufacture if SONIC's plans are implemented. These figures were provided by the Algerian authorities.

Table 4

Algeria : Chlorine and Caustic Soda Requirements for Pulp Manufacture in 1980 (t/a)

Site	Raw Materials	Capacity Pulp	Consumption Chlorine	Consumption Caustic Soda
Rachgoune	(Rayon Complex)		90	14,000
Mostaganem	Alfa	46,000	5,500	5,580
Saida	Straw	35,000		1,900
Baba Ali	Alfa	50,000	7,000	7,300
			12,590	28,780

This table assumes that the proposed doubling of Baba Ali capacity takes place. It is also possible that a unit of 100,000 t/a eucalyptus pulp may be established at El Kala after 1980, requiring a further 4,500 t/a chlorine and 8,100 t/a caustic soda.

1.3.3 Pulp : Tunisia

Tunisia is a large exporter of pulp (18,537 tons in 1970) and also imports significant quantities of conifer-based pulp (8,887 tons in 1970). The only manufacturer is the Societe Nationale Tunisienne de Cellulose (SNTC) which at present is producing 22,000 t/a of alfa pulp at its factory at Kasserine, not far from the Algerian border. Until the end of 1972 SNTC has the monopoly for importing all basic chemical products. There is now no monopoly, but SNTC still handle a significant volume of imports as a service to its customers.

SNTC has plans for expansion in two phases : in Phase I to production of 30,000 t/a of alfa pulp, and Phase II to 35,000 t/a. As well as supplying the home market, SNTC is developing an important export business and demand for pulp is increasing.

Consumption of chlorine and caustic soda at Kasserine at different levels of output are illustrated below. These estimates are based on data provided by SNTC.

Table 5

SNTC : Chlorine and Caustic Soda Requirements for Pulp (t/a)

	Output Pulp	Consumption Chlorine	Consumption Caustic Soda
Present	22,000	2,000	2,300
Phase I	30,000	2,700	3,100
Phase II	35,000	3,200	3,700

Preliminary data in the next four year plan for Tunisia show no provision for increasing pulp capacity but, taking account of the pressure of demand it is reasonable to expect that Phase I at least will be implemented by 1980.

1.4. Glass

By far the most important single use for soda ash is glass manufacture. The quantity used varies with the type of glass. It is usually up to about 20% of the weight of glass produced. It is also possible to use caustic soda as a replacement for 8-20% of the soda ash required. This is done, for example by some manufacturers in the United States, but the practice is not widespread. All three countries of the Maghreb import considerable quantities of glass to supplement their present production, and each has a small export.

Production of glass in Morocco is estimated at about 25,000 t/a. Imports in 1970 totalled about 7,000 tons. If demand increased at about 5% per annum to 1980, consumption would reach about 45,000 t/a. This would be sufficient to justify consideration of installing at least 15,000 t/a additional capacity.

Algeria at present manufactures about 15,000 t/a of bottles, containers and glasses at the Oran factory of Societe Nationale des Industries du Verre (SNIV). This factory has a capacity of about 18,000 t/a. SNIV has major plans for expansion (Table 6).

Table 6

SNIV : Expansion Plans for Glass Production in 1980 (t/a)

Location	Glass	
	Type	Output
Oran	Flat	10-12,000
Oran	Bottles, etc.	56,000
East Algeria (possibility)	Bottles, etc.	30,000
		96-98,000.
Plus existing capacity at Oran	Bottles, etc.	18,000
		114-116,000

Tunisia produces about 12,000 t/a of glass at present. Imports were over 6,000 tons in 1970. It is proposed to extend glass production to 20,000 t/a by about 1976. If demand increased at 5% per annum up to 1980, consumption would total over 25,000 t/a, suggesting that further expansion might be justified.

Table 7

Maghreb : Estimated Soda Ash Requirement for Glass (t/a)

	1973		1980	
	Glass Production	Soda Ash requirement	Glass Production	Soda Ash requirement
Morocco	25,000	5,000	40,000	8,000
Algeria	18,000	3,500	115,000	23,000
Tunisia	12,000	2,400	25,000	5,000
Maghreb	55,000	10,900	180,000	36,000

There is also the possibility that soda ash could be replaced by caustic soda up to a maximum of 7,000 tonnes of the total requirement (36,000) in 1980.

1.5 Soap and Detergents

The markets for soap and detergents are closely related, and in many countries detergent consumption has been growing at the expense of soap for some years. Both products are large users of sodium alkali.

In Western Europe, for example, production of detergents in OECD countries increased by 35% between 1964 and 1968, while soap production fell by 17% over the same period.

The Maghreb market has not reached this stage. Consumption per capita of soaps and detergents is about 3.5 kg compared with 10 kg in 1968 in West European OECD countries. There is still plenty of scope for expansion in consumption of both products, and it is assumed that both will continue to grow for some years.

1.5.1 Soaps

Soap manufacture is a large user of caustic soda, as shown in Table 8.

Table 8

Maghreb : Caustic Soda for Soap Making in 1973 (t/a)

	Soap				Caustic Soda
	Production	Exports	Imports	Consumption	Consumption
Morocco	27,000	-	4,000	31,000	4,000
Algeria	30,000	-	1,000	31,000	4,500
Tunisia	17,000	500	500	17,000	2,500
Maghreb	74,000	500	5,500	79,000	11,000

The Societe Nationale des Corps Gras (SNCG) in Algeria plans to expand production of soap to 58,800 tons in 1980. If the same percentage growth rate is applied to consumption in Morocco and Tunisia and it is assumed that there are neither exports nor imports by 1980, production of soap and related demand for caustic soda in the Maghreb would be as follows :

Table 9

Maghreb : Caustic Soda for Soap Making in 1980 (t/a)

	Soap Production	Caustic Soda Consumption
Morocco	61,000	9,200
Algeria	59,000	8,800
Tunisia	33,000	5,000
Maghreb	153,000	23,000

1.5.2 Synthetic Detergents

Most of the household powder detergents throughout the world contain 30-40% by weight of polyphosphates as builders or synergists, to boost the cleaning power of the base detergent. Tetrasodium pyrophosphate and sodium tripolyphosphate are the cheapest and most effective detergent builders. Tripolyphosphate now sells in the U.S.A. at about $190-$200 per ton.

There have been arguments against the use of polyphosphates in detergents on ground of pollution, particularly in rivers and lakes in North America. Research in the United Kingdom has concluded that less than half of this type of pollution is caused by polyphosphates in detergents, and that a combination of other causes including sewage are primarily responsible. American Government research concluded in 1971 that polyphosphates were less harmful than any other possible alternatives, for example caustic soda or nitrilotriacetic acid (NTA). NTA was in fact withdrawn in the USA. The consensus of opinion is that polyphosphates will continue to occupy their important position in the synthetic detergent world.

Table 10

Maghreb : Powder Detergent Production and TPP Imports - 1973

	Production Powder Detergent	Imports TPP
Morocco	17,000	5,000
Algeria	22,000	6,500
Tunisia	2,500	900
Maghreb	41,500	12,400

SNIC has ambitious proposals for powder detergent consumption to reach 100,000 t/a by 1980, but a target of 60,000 t/a is more likely to be accepted. Tunisian plans projected to 1980 show a growth rate of about 10% per year, and the same rate has been assumed for Morocco in the calculation for Table 11.

Table 11

Maghreb : Demand for Powder Detergent and TPP in 1980 (tonnes)

	Detergent	TPP
Morocco	33,000	12,000
Algeria	60,000	21,000
Tunisia	5,000	2,000
Maghreb	98,000	35,000

1.6 Pesticides

Agriculture has high priority in all three countries of the Maghreb, and the importance of improving skills and increasing output is fully recognised. Discussions with government authorities revealed in all three countries that present levels of application are well below desirable levels and that much higher application rates would be beneficial.

Each country is making plans to encourage the use of pesticides. These include credit, subsidies, distribution, formulation and programmes to educate farmers in the benefits to be gained from their use.

Table 12

Maghreb : Estimated Imports in 1973 of DDT, BHC and Parathion (t/a)

	DDT	BHC	Parathion (1%)
Morocco	25	200	-
Algeria	1,500	400	120
Tunisia	-	50	1,000 (or BHC 8%)

(Note: Imports vary considerably from year to year.)

The figures correspond to average application rates well below those judged safe. Higher rates could be safely considered, with of course the reservation that the correct rates for specific pests or conditions need to be established.

In addition to the local market, there is also a potential market for DDT for malaria control in West Africa. At present about 1,000 t/a of DDT are used, but in the opinion of the World Health Organisation some 5,000 t/a are required for effective malaria control.

Table 13

Maghreb : Potential for DDT and BHC in 1980 (t/a)

	DDT	BHC
Morocco	800	600
Algeria	1,000	700
Tunisia	300	200
Maghreb	2,100	1,500

1.7 Soda Ash

Table 7 summarised soda ash requirements for glass. Table 14 below includes applications in a wide range of other industries such as laundries, cleaning and miscellaneous chemical uses. These applications are assumed to grow at 5% per year.

Table 14

Maghreb : Demand for Soda Ash in 1973 and 1980 (t/a)

	1973 (reported)			1980 (estimated)		
	Glass	Others	Total	Glass	Others	Total
Morocco	5,000	2,500	7,500	8,000	3,500	11,500
Algeria	3,500	3,500	7,000	23,000	5,000	28,000
Tunisia	2,400	2,600	5,000	5,000	3,500	8,500
Maghreb	10,900	8,600	19,500	36,000	12,000	48,000

I.8 Hydrochloric Acid

Hydrochloric acid consumption in the Maghreb totals about 2,000 t/a, made up as follows :

Table 15

Maghreb : Estimated Consumption of Hydrochloric Acid in 1973 (tonnes)

	Production	Imports	Consumption
Morocco	1,200	30	1,230
Algeria	100	10	110
Tunisia	50	700	750
Maghreb	1,350	740	2,090

The main current outlets are for the manufacture of cleaning products, water-treatment and textiles.

Future demand depends very much on the policy adopted towards the choice of hydrochloric acid or sulphuric acid in uses where they can be alternatives.

An important potential use is for pickling steel products such as hot-rolled coil or tinplate, where hydrochloric acid can be more economic than sulphuric acid and is now often favoured. To pickle one ton of steel, 4 kg of hydrochloric acid is typically required. 75% of this can be recycled, giving a net usage of 1 kg per ton.

Algeria is now planning construction of a 120,000 t/a cold-rolling mill including 40,000 t/a galvanising and 40,000 t/a tinning. Proposals for the future include expansion of this mill to 600,000 t/a. This and other possible developments in the Maghreb steel industry could create an additional annual demand for hydrochloric acid of about 1,000 tonnes.

1.9 Chlorine and Caustic Soda

Table 16 summarises estimated consumption and production of chlorine and caustic soda in the Maghreb in 1973. As well as the major outlets described earlier in this Chapter, chlorine is used for water treatment, textiles, hygiene, cleaning products and the manufacture of small quantities of hydrochloric acid and hypochlorites. Other outlets for caustic soda include cleaning products, oil refining and oil drilling.

Assuming that these other uses grow at about 5% per annum, Table 17 summarises Maghreb demand for chlorine and caustic soda in 1980 on the basis of the data used in this Chapter. The summary includes chlorine requirements for the Skikda PVC plant before further expansion, but excludes the proposals in Chapter Three.

Table 16

Maghreb : Estimated Chlorine and Caustic Soda Consumption and Production in 1973 (tonnes)

End-use	Chlorine			Caustic Soda		
	Morocco	Algeria	Tunisia	Morocco	Algeria	Tunisia
Pulp	3,500	3,500	2,000	4,500	3,700	2,300
Soap	-	-	-	4,000	4,500	2,500
Other	2,350	1,000*	850	5,300	6,800	2,200
Consumption	5,850	4,500	2,850	13,800	15,000	7,000
Imports	50	-	450	7,500	10,000	4,500
Production	5,800	4,500	2,400	6,300	5,000	2,500

* includes small exports.

Table 17

Maghreb : Forecast Demand for Chlorine and Caustic Soda in 1980 (tonnes)

(Excluding effects of the proposals of Chapter Three of this report)

End-use	Chlorine			Caustic Soda		
	Morocco	Algeria	Tunisia	Morocco	Algeria	Tunisia
VCM	-	27,000	-	-	-	-
Pulp	8,500	12,600	2,700	3,000	28,000	3,100
Soap	-	-	-	9,200	8,800	5,000
Other	3,300	1,400	1,200	7,400	9,500	3,100
Maghreb	11,800	41,000	3,900	19,600	47,100	11,200

Table 18

Maghreb : Imports of Salt Derivatives in 1970 (tonnes)

	Morocco	Algeria	Tunisia
PVC	6,537	10,796	1,320
Chlorine	65	-	400 (est)
Caustic Soda	10,400	10,306	3,989
Soda Ash	7,496	6,961	3,379
Chlorites & Hypochlorites	-	-	10
Hydrochloric Acid	32	8	875
Calcium chloride	337	1,852	-
Ferric chloride	387	427	-
Copper chloride	-	375	-
Ammonium chloride	251	11	-
Potassium chloride	147	153	-
Sodium chlorate	532	8	-
Carbon tetrachloride	15	243	6
Tri-and tetrachlorethylene	569	1,272	-
BHC	232	286	18
DDT	191	1,048	475
Sodium sulphate	4,706	1,742	-

CHAPTER TWO

SALT

II.1 The World Market

In 1971, world production of salt was estimated at nearly 150 million tonnes and was growing at about 3-5% per year. Comprehensive figures for trade in salt are not available, but exports were probably about 10% of this total, or about 15 million tonnes. Detailed figures given in Table 20 confirm that most salt-using countries who are subtantial consumers of salt have ample resources of their own, with the major exception of Japan, who account for about one half of world imports.

The market is competitive and prices vary considerably with availability of salt. A small quantity of the salt traded is high-purity table salt. The largest amount is crude salt used for such purposes as snow clearance or, after local purification, for industrial use or food manufacture. The best indication of typical price levels is given by average import prices, taken from the customs statistics of selected countries

Table 19

Average Import Prices of Salt in Selected Countries in 1970 & 1971 ($/tonne)

Importing country	Grades	Price
Belgium/Lux.	All	7 - 12
Canada	"	3 - 6
Denmark	"	14 - 15
Finland	"	8 - 10
West Germany	"	7 - 13
Japan	"	10 - 12
Nigeria	Mainly food	30 - 60
Norway	All	10 - 13
Sweden	"	10 - 11
USA	"	5 - 6
Yugoslavia	"	5 - 8

Table 20

Productions, Importations et Exportations Mondiales de Sel

World Production Imports and Exports of Salt

Pays Principaux - Selected Countries

milliers de tonnes - thousands of tonnes

	1968			1969			1970		
	Prod	Imports	Exports	Prod	Imports	Exports	Prod.	Imports	Exports
Austria	402	6.5	0.1	418	12.9	0.1	266	2.0	0.1
Bulgaria	117	(b)	(b)	117	(b)	(b)	120	(b)	(b)
Czechoslovakia	207	37	28	205	(b)	(b)	304	(b)	(b)
Denmark	150	190	11	246	245	3	341	454	6.0
Finland	None	435	None	None	421	None	None	490	None
France (total)	4 442	71	84	4 791	65	133	5.502	51	284
Rock	987	(a)	(a)	1 158	(a)	(a)	1.222	(a)	(a)
Brine	3 455	(a)	(a)	2.667	(a)	(a)	2.884	(a)	(a)
Marine	1 000	(a)	(a)	966	(a)	(a)	1 296	(a)	(a)
German Dem Rep	1.970	(b)	763	1.975	(b)	(b)	2 130	(b)	(b)
Germany Fed Rep (total)	8.820	146	1.150	9 71.	174	1 217	10.447	338	1 595
Rock	8 900	(a)	(a)	7 640	(a)	(a)	8.325	(a)	(a)
Other	1.920	(a)	(a)	2.070	(a)	(a)	2 122	(a)	(a)
Greece (Sea Salt)	99	(b)	(b)	75	47.5	(b)	82	(b)	(b)
Hungary	None	291	(b)	None	320	(b)	(b)	(b)	(b)
Italy (Total)	3 925	0.3	20	3.910	0.3	29	4.365	7.5	227
Rock	2 625	(a)	(a)	2 800	(a)	(a)	2.870	(a)	(a)
Marine	1 300	(a)	(a)	1.110	(a)	(a)	1.495	(a)	(a)
Netherlands	2 380	34	1.422	2 670	62	1 603	2 870	417	2 065
Norway	None	323	8	None	304	3	None	340	1.7
Poland (Total)	2 633	(b)	177	2 815	(b)	197	2.905	(b)	209
Rock	970	(a)	(a)	1.165	(a)	(a)	1.225	(a)	(a)
Other	1.663	(a)	(a)	1.650	(a)	(a)	1.680	(a)	(a)
Portugal (Total)	415	4	0.1	466	1	0.2	401	3.1	5.0
Rock	152	(a)	(a)	166	(a)	(a)	194	(a)	(a)
Marine	263	(a)	(a)	300	(a)	(a)	207	(a)	(a)
Rumania	2 365	(b)	485	2 355	(b)	516	2.862	(b)	604
Spain (Total)	1 820	0.9	322	1 845	2	269	1 890	1.2	177
Rock	910	(a)	(a)	1.075	(a)	(a)	1 090	(a)	(a)
Marine	910	(a)	(a)	770	(a)	(a)	800	(a)	(a)
Sweden	None	937	0.2	None	978	0.2	None	1 102	0.3
Switzerland	255	2	None	268	1	1	333	3.0	1.5
U.S.S.R.	11 000	(b)	222	12 000	(b)	218	13.000	(b)	294
United Kingdom (Total)	7 710	33	483	8 610	52	510	9.188	141	583
Rock	1 110	(a)	(a)	1.410	(a)	(a)	1.757	(a)	(a)
Other	6.600	(a)	(a)	7 200	(a)	(a)	7.431	(a)	(a)
Yugoslavia	179	137	(b)	212	171	(b)	209	145	(b)
Canada	4 410	584	(b)	4.200	631	(b)	4.580	561	(b)
Mexico	3 600	0.1	2.993	[illegible]	0.5	3.582	4.150	0.3	3 407
United States (Total)	37 440	3 130	660	40.150	3.000	650	41.550	3.208	384
Rock	11 300	(a)	(a)	12.150	(a)	(a)	12.850	(a)	(a)
Other	26 140	(a)	(a)	28.000	(a)	(a)	28.700	(a)	(a)
Argentina	738	None	48	750	None	62	498	None	84
Brazil	1 450	(b)	(b)	1 640	(b)	(b)	1.820	(b)	(b)
Chile	852	None	681	1.330	None	(b)	516	None	(b)
Colombia (Total)	506	0.1	(b)	677	(b)	(b)	775	(b)	(b)
Rock	318	(a)	(a)	343	(a)	(a)	541	(a)	(a)
Other	188	(a)	(a)	334	(a)	(a)	234	(a)	(a)
Peru	172	3	0.2	166	3	0.5	95	(b)	(b)
Venezuela	126	None	63	170	None	(b)	265	None	(b)
Algeria	120	(b)	40	150	(b)	35	100	(b)	(b)
Angola	72	(b)	19	81	(b)	20	88	(b)	33
Ethiopia	233	(b)	159	233	(b)	178	260	(b)	141
Kenya	61	7	1.5	42	4	0.2	39	2.4	0.7
Libya	16	(b)	(b)	16	(b)	(b)	16	(b)	(b)
Morocco	40	0.1	0.1	67	(b)	0.1	57	-	2.1
Mozambique	19	(b)	(b)	10	3.0	5.6	29	0.7	5.0
Senegal	72	0.1	22	80	(b)	(b)	118	(b)	107
South Africa	342	(b)	43	378	2.6	28	420	2.7	29
Namibia	110	(b)	(b)	110	(b)	(b)	110	(b)	(b)
Sudan	51	0.1	0.4	51	0.1	0.4	53	0.1	0.8
Tunisia	380	(b)	323	283	(b)	265	300	(b)	234
United Arab Republic	620	(b)	49	384	(b)	(b)	500	(b)	(b)
Congo (Republic of)	(b)	3.7	(b)	(b)	2	(b)	(b)	(b)	(b)
Gabon	(b)	2.7	(b)	(b)	2.5	(b)	(b)	(b)	(b)
Ghana	29	0.1	None	36	1.6	None	16	2.6	(b)
Liberia	(b)	3.4	0.1	(b)	2	0.1	(b)	(b)	(b)
Nigeria	1	128	(b)	1	138	(b)	(b)	144	(b)
Sierra Leone	(b)	9	(b)	(b)	7.0	(b)	(b)	(b)	(b)
Cameroon	(b)	(b)	(b)	13.0	(b)	(b)	(b)	(b)	(b)
Dahomey	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)
Gambia	(b)	0.1	(b)	(b)	0.1	(b)	(b)	0.1	(b)
Ivory Coast	(b)	23	1.9	(b)	18	(b)	(b)	25	(b)
Mauritania	0.8	(b)	(b)	0.6	4.8	(b)	(b)	(b)	(b)
Niger	4	6	(b)	4	6	(b)	(b)	13	(b)
Bahamas	629	(b)	630	450	(b)	450	788	(b)	769
Egypt	811	(b)	48	370	(b)	40	(b)	(b)	48
Pakistan	880	(b)	83	[illegible]	(b)	126	757	(b)	103
Burma	130	0.1	(b)	180	(b)	(b)	160	(b)	(b)
China Main and	15 000	(b)	(b)	15.000	-	-	18.000	-	-
India	5 040	0.1	202	6.380	0.1	365	5.600	0.2	104
Indonesia	79	(b)	(b)	177	-	-	181	-	-
Iran	275	0.1	4.7	310	(b)	(b)	350	0.1	4.2
Japan	966	5 023	0.4	980	5.857	1	960	6.490	0.3
Korea North	500	-	-	540	-	-	549	-	-
Korea South	552	-	-	284	-	-	405	-	-
Taiwan	302	-	(b)	285	-	(b)	535	-	(b)
Thailand	150	-	95	200	-	109	200	-	93
Turkey	568	-	(b)	570	-	33	600	-	(b)
Australia	914	9	169	1 680	6	294	3.071	8.2	1.389
Formosa	306	-	(b)	377	-	7.7	535	-	(b)
Totals		11.581.5	11 597.4		12.358.7	10.857.9		13.953.0	12 9[illegible].4

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Search: Non-Metallic Minerals 1970-71

(a) Totaux seulement / Totals only

(b) Donnees inexistantes / Data not available

Shipping of salt exports from North Africa is usually arranged by the buyer. As a rule, it will only be economical to ship either on a return basis, or on a ship already engaged on general tramping business. Table 21 lists some typical freight rates and indicated the maximum fob prices from the Maghreb at which exports from these countries can take place.

Table 21

Costs and Prices for Maghreb Salt Exports ($/tonne)

Destination	Import price (cif)	Insurance & Freight	fob Price indication
USA	5 - 6	4 - 7	max. 2
Scandinavia	10 - 12	5 - 7	3 - 7
Japan	10 - 12	7 - 9	1 - 5

It is clear that freight is a major element in the price of exported bulk salt. Additional exports may be possible but large increases, for example to the USA and Japan, will prove extremely difficult to achieve. In any event it is clear that large-scale exports are possible only from cheap sources of salt located close to major ports.

II.2 Maghreb Salt

All three Maghreb countries possess ample salt deposits yet, unfortunately, few can be exploited economically. Most rock salt deposits and salt lakes are a long way from potential salt users and with a few exceptions, the chemical compositions are unsuitable for industrial use without substantial reprocessing. The resources of salt are examined in the sections that follow.

II.2.1 Resources

Three basic sources of salt are available, salt from the sea, salt from salt mines, and rock salt. The last - rock salt - is conveniently considered in two categories. The potential and existing Maghreb saltworks (salines) are listed on Table 22 (next page) and have been coded as shown on pages 31 and 32.

Table 22

Sources of Salt

(The list is not exhaustive and includes some resources which are not yet being exploited)

MOROCCO			
Sidi Massa	40 kms S	Agadir	A, J
Ait Ourir	30 kms E	Marrakech	C
Lac Zima	57 kms SE	Safi	B, J
Ifni N'Tissint	25 kms N	Skoura	C, G
Oualidia to Sidi Moussa	40-100 kms N	Safi	A, J
Berrechid	14 kms SE	Mohammedia	C
Souk el Arba	106 kms NE	Rabat	C, F/J
Larache	73 kms S	Tanger	A, J
Ammassene (Oued Mikkes)	50 kms NE	Meknes	C, F
El Ayasma	30 kms E	Sidi-Kacem	C, H/J
Tissa	40 kms NE	Fez	C, F
Taza	90 kms E	Fez	C, G, H/J
Nador	13 kms S	Melilla	A, J
ALGERIA			
Grande Sebkha D'Oran	10 kms S	Oran	B, J
Arzew	20 kms SE	Arzew	B, J
Bouziane (Ferry)	15 kms SE	Relizane	B, J
Chott Ech Chergui	125 kms SE	Oran	B
Khanguet El Melah	85 kms E	Gerryville	D
Zahrez Rharbi	200 kms S	Alger	B, J
Zahrez Chergui	10 kms E	Zahrez Rharbi	B
Rang El Melah	27 kms N	Djelfa	D, E
Djebel Metlili	5 kms E	Chott El Hodna	D
El Outaya	32 kms N	Biskra	D, E
Guemel	25 kms S	Setif	B, J
M'Zouri et Timsilt	50 kms NE	Batna	B, J
Ouled Kebbeb	10 kms E	Constantine	C
Hippone	5 kms SE	Annaba	A, J
TUNISIA			
Rades	3 kms SE	Tunis	A, J
Soliman	60 kms SE	Tunis	A, J
Megrine	4 kms SE	Tunis	A, J
Sahline	9 kms S	Sousse	A, J
Sidi Salem	1 km S	Sfax	A, J
Zarzis	50 kms SE	Gabes	B
Chott El Djerid	Near	Gabes	B
Djebel Hadifa	20 kms N	Chott El Djerid	D, E

A. Salt from the sea (sel marine). The sea contains most of the world's resources of salt. Given suitable climatic and geological conditions, sea-salt may be recovered by solar evaporation (see code J below) with purities exceeding 98% NaCl (dry basis). Appropriate conditions exist in the Maghreb (particularly along the southern coastlines of Morocco and Tunisia) although generally in areas that are not close to ports or to centres of industrial development.

B. Salt from salt lakes (sebkhas). Throughout the Maghreb there are numerous salt lakes fed by streams which have leached salt from rocks. The chemical composition of each salt-lake is different and so the quality of the recovered salt from sebkhas varies greatly. However, salt-lakes can be a valuable source of salt, especially when located near to potential salt users.

C. Rock salt beds (gisements de sel gemme). These originate from the evaporation of seas of former geological ages. The hinterland of the Maghreb, especially Algeria, contains vast reserves of rock salt. In general these are too deep to be easily exploited or, with the exception of the Berrechid deposit in Morocco which has sectors exceeding 98% NaCl, appear to be of poor quality.

D. Salt-domes (diapirs). It is a fairly common geological occurence for beds of rock salt to have been subjected to intense pressure so that the salt moves upwards through weaknesses in adjoining strata, forming diapirs. There are many examples, particularly in Algeria, of salt-domes which now stand above the surface of the land as "rochers de sel". Examples are Range El Melah which is 100 metres high and 1½ Kms in diameter and Khanguet El Melah which is 250 metres high and nearly 1 Kilometer in diameter. Although these can yield good quality NaCl layers of other salt will usually also be present which have to be quarried, thus adding to costs.

II.2.2 Extraction

Methods of extracting salt vary with the character of the resources. Codes E to H (below) apply solely to the recovery of rock salt (C and D above). But combinations of techniques also are possible.

E. Small-scale production (exploitations artisanales). The salt deposits of Algeria are known to have been exploited by primitive methods of collection and digging for thousands of years.

F. Quarrying (en carriere) using explosives. In instances observed in the Maghreb the crudity of the quarrying techniques used necessitated additional processing to remove the impurities which mix with the salt. However this criticism does not apply generally to quarrying and, given suitable conditions, good quality salt may be extracted economically.

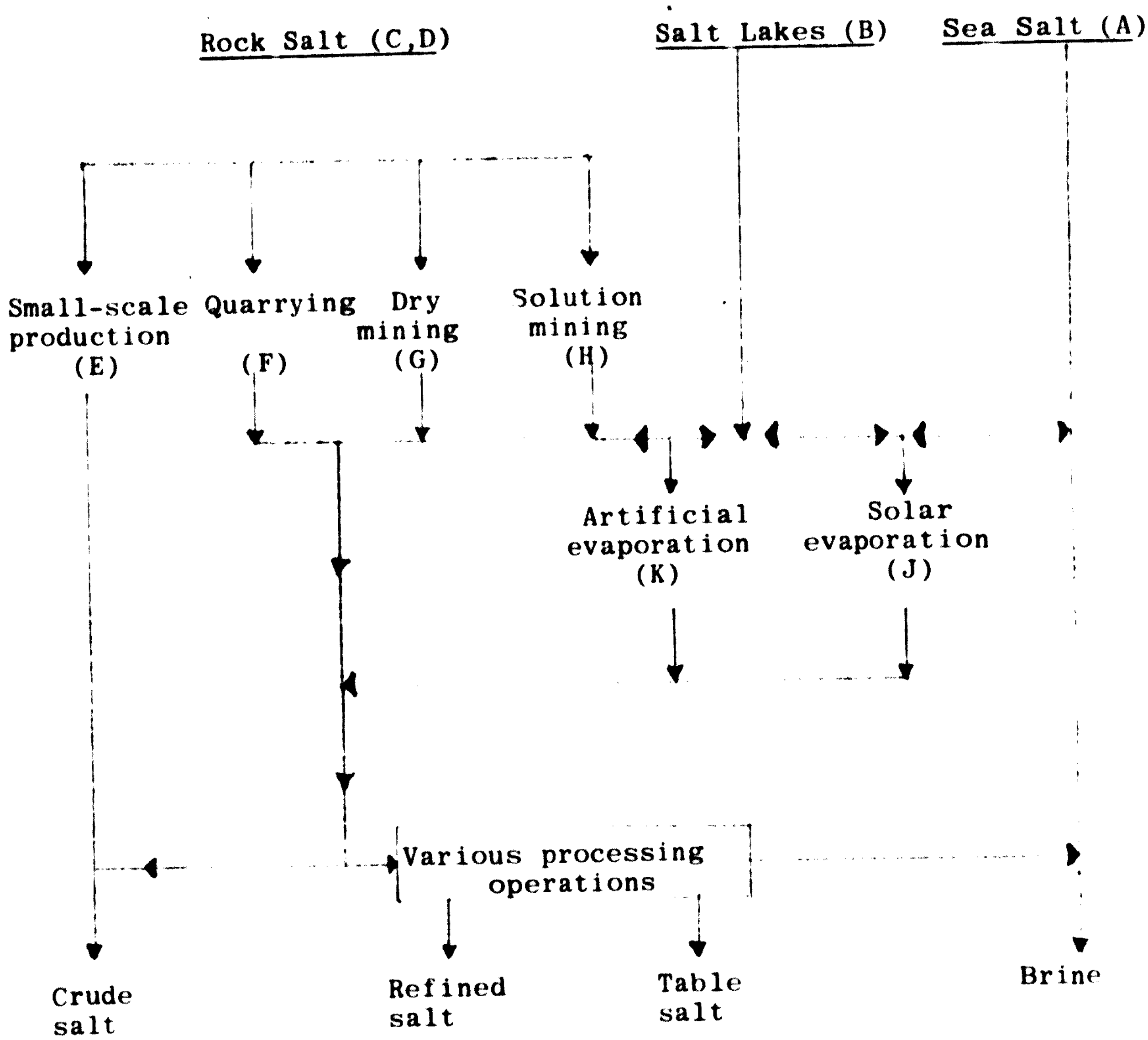
G. Dry mining underground ("chambre et piliers"). This technique is usually employed to recover rock salt found at depth. "Chambers" of salt are removed leaving large "pillars" to prevent the overlaying strata from collapsing. However, salt does "creep" - especially when under pressure at great depth, and there can be no guarantees against subsidence into salt mines.

H. Solution mining is commonly used in countries which have ample water resources, especially when the salt is to be used as brine. Water is pumped underground to dissolve the salt and brine is brought back to the surface. Subsidence is a hazard although the technique is normally employed only for relatively small-scale production.

In the case of salt from the sea (A), salt from salt-lakes (B) and solution mining (H), and also in most purification processes, brine has to be evaporated to obtain dry salt. Two basic techniques can be employed.

J. Solar evaporation (evaporation naturelle) is the more obvious technique in the Maghreb countries where land is available and climatic conditions are favorable. By making use of the differing solubilities of $CaSO_4$, $MgCl_2$ and other common impurities of salt, it is possible to obtain purities exceeding 98% NaCl without chemical treatment (dry basis).

K. Fuel- fired and spray evaporation (evaporation artificielle) has to be employed in temperate and humid climates. This process is usually integrated with any necessary chemical treatment and size grading for the resultant solid salt product.



II.2.3 Processing

Additional processing may also be necessary to obtain salt of a marketable quality, because the chemical purity of the salt obtained from the extraction techniques described may vary from 90% to 99% NaCl according to the initial chemical purity and the technology employed. A variety of processing techniques may be used, either in sequence or simultaneously. The most common combinations of processes are chemical treatment, washing and fuel-fired evaporation in conjunction with solution mining.

The chemical purity of salt may be improved by dissolution followed by "recrystallisation" or by the addition of precipitation agents to the brine and decantation - i.e. "chemical treatment". The salt crystals are usually "washed" to remove dirt and the more soluble impurities. The physical character of the salt product may be altered by a variety of actions such as crushing, grinding and size separation. Finally, according to the end use required, the salt may be packed with or without additives, compressed or caked or sold in bulk.

Table 22 used the codes A to K to indicate the Maghreb's more significant salt resources and the nature of the recovery and processing techniques currently in use. To meet the objectives of the present study it was appropriate to visit selected Maghreb salt producers. The study was made during the 'wet' season and opportunity was not available for direct observation of production at the evaporative salines. Nevertheless a few points can still be made about the adequacy of the techniques currently employed in the Maghreb.

It is evident that, technically, the COTUSAL (Compagnie Generale des Salines de Tunisie) salines of Tunisia and the SCS (Société Cherifienne des Sels) salines of Morocco operate efficiently and produce salt of the quality desired by their present consumers. In all probability product quality could be improved further should this prove necessary to satisfy other consumer demands. By contrast, improvements in production techniques appear to be desirable at other salines. Technical service provided to these salines appears to be insufficient, and knowledge of modern salt extraction techniques is lacking. The basic minimum requirements for a saline supplying salt for industrial uses include (i) a laboratory equipped to analyse the Na^{+}, Cl^{-}, Mg^{++}, Ca^{++} and SO_4^{--} contents of salt, (ii) technical literature and books relating to the production of salt, (iii) provision for the training and development of technical staff. The absence of such facilities at, for example, the Saline D'Arzew, is most noticeable and must have an adverse effect upon production rates and product purity.

A very brief description of the underlying scientific principles is necessary in discussing the production of salt by solar evaporation from sea-water. The principles apply equally to solar evaporation from salt lakes or evaporative purification at salt mines although the actual figures for composition and quantities will be different.

When sea-water evaporates, the salt constituents do not all crystallise at the same time. The first salts to crystallise are iron salts and calcium carbonate. By the time the brine reaches a concentration of 16° Baumé, almost three quarters of the original water will have been evaporated and the gypsum is starting to crystallise.

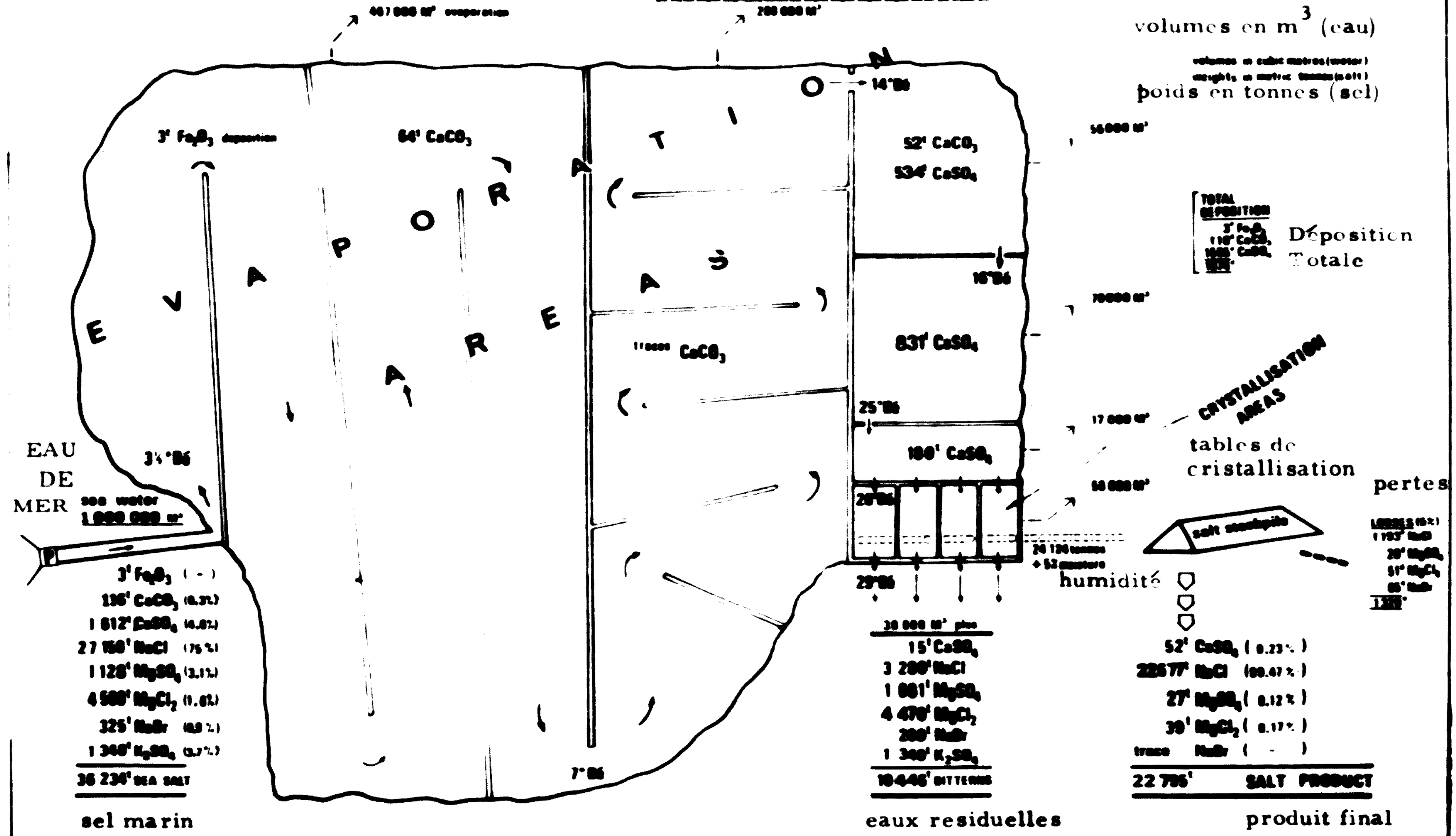
SCHEMA 2

PRODUCTION DU SEL MARIN PAR EVAPORATION NATURELLE

FIG 2 PRODUCTION OF SALT FROM SEA WATER BY SOLAR EVAPORATION

TYPICAL MASS BALANCE

MASSE PONDERALE TYPE



In order to prevent this gypsum and the earlier salts contaminating the NaCl product, these stages in the process take place in evaporating ponds separated from the crystallisation pans where the NaCl crystals are harvested. The typical mass balance for the entire operation illustrates the sequence of crystallisation, areas of ponds, volumes of water evaporated, etc. (Fig.2).

In order to maximise the concentration of NaCl in the product salt, the crystallisation pans must operate within a narrow concentration range close to 27^{o} Baumé, the concentration at which NaCl preferentially crystallises. The ancient process of "total crystallisation" used for many thousands of years yielded salt of only 75% NaCl purity (the proportion present in the original sea water) compared with up to 98% obtained by the more modern techniques.

Similarly, at the salt lake salines, gypsum impurity could be reduced if prevaporation to around 25^{o} Baumé took place before the brine entered the crystallation ponds. (Although this would involve a drop in production per hectare, the improvements in produce quality are normally considered to compensate for the lost production). But there seems to be little comprehension of the mechanics of this process - which may be the reason why proposals for expansions at certain salines are unnecessarily expensive and incorporate very ancient production techniques.

Improvements in harvesting techniques should be possible at all solar evaporation salines, particularly with respect to reducing the insolubles and magnesium impurities. Various new techniques which involve simultaneous washing, chemical treatment and harvesting are now available in countries such as Greece, France and Italy.

Transport and handling costs for salt often exceed production costs and these operations demand special attention. At Bouziane, for example, the construction of only 1½ kilometres of railway would eliminate the need for lorries, a stockpile and an entire cycle of loading and unloading. This is one of several cases where possible economies in transport and handling do not appear to have been fully appreciated or examined.

II.3 Salt : Morocco

Salt consumption in Morocco in 1972 was estimated at about 90,000 tonnes, compared with production of about 80,000 tonnes. For the last two years, which have been climatically bad for solar salt production, imports have been 6-10,000 tonnes.

1973 will also be a bad year because of lack of rain at the right time. For this reason, Morocco's largest saline, Lac Zima, is expected to yield nearly 20,000 tonnes less than its potential.

This situation is reflected in prices. In 1970 bulk salt was selling at 80 DM/tonne. In 1972, it was 130 DM/tonne and in 1973 it was 140 DM/tonne. The 1973 situation is aggravated by the situation in other countries such as France which normally export at cheap prices but which owing to temporary production set-backs are having to import. This situation is not however likely to continue indefinitely and prices should ease over the coming years.

Probably over 80% (70-75,000 tonnes) of Moroccan salt consumption is for direct human use. The balance of about 15,000 tonnes is used for canning, for the preservation of fish and other foods, for the chemical industry and a variety of industrial uses.

Consumption is greatest in the large towns and industrial areas, led by the Casablanca region with 30-40,000 t/a. Other than imports, all consumption is met as far as possible from nearby sources of supply because of the high cost of transporting salt. Safi's needs, for example, are supplied from Lac Zima and neighbouring sources. Fez is supplied from sources such as Taza.

Consumption of salt in Morocco is growing in line with world consumption at about 5% per annum. This increase is likely to continue as population and incomes grow, giving a demand of about 130,000 tonnes in 1980. To this should be added demand for any additional chlor-alkali capacity installed.

Morocco is fortunate in having a wide variety of salt resources. The largest single saline is the salt-lake of Lac Zima. Next in importance are the mines of Taza and Tissa where dry and solution mining are practised. There also are salines marines on the Atlantic and Mediterranean coastlines. Purification of quarried rock and brine is invariably effected by solar evaporation.

Table 23

The Salines of Morocco

	Production (t/a) Normal	Known Potential	Ownership
Sidi Brahim	5- 6,000	6,000	SCS
Sidi Moussa I	700	1,000	Private
Sidi Moussa II	800	1,000	SCS
Biar El Assora	2- 3,000	3,000	SCS
Others	5,000	10,000	Various
(Oualidia to Sidi Moussa	13-15,000	21,000)	
Lac Zima	20-33,000	33,000	SCS
Berrechid	-		
Souk el Arba	3- 4,000	5,000	Lamrani Mohamed
Larache	4- 5,000	12,000	Private
Tissa	10-12,000	30,000	SOMISEL
Taza	7- 9,000		Ste. Benchekroun
Nador	5- 6,000		Private
Others	10,000		
	72-104,500		

II.3.1 Lac Zima

In average years, about 30,000 tonnes of good quality salt are produced from the 600 hectare lake by the Societe Cherifienne des Sels (SCS). The yield in the crystallation area is around 2,000 tonnes per hectare, confirming the very favorable climatic conditions for evaporation. Salt handling is aided by mechanical equipment.

Salt production here can be adversely affected by too much rainfall (diluting the lake) or too little rainfall (reducing the salt inflow). In bad years production can drop below 15,000 t/a. For this reason SCS (50% state-owned) do not propose large-scale investment at Lac Zima and prefer to extend operations in the Oualidia to the Sidi Moussa region or, if allowed to develop, solution mining of the Berrechid gisement.

II.3.2 Oualidia to Sidi Moussa

Along the Atlantic coastline north of Safi there is a chain of lagoons, protected from the sea by sand dunes and occasionally by cliffs. The total output of these salines is listed in Table 23 and could be as high as 21,000 t/a. The largest is at Sidi Brahim (5,000 t/a) owned by SCS.

No doubt more efficient production would be possible if this multitude of lagoons were controlled by a single organisation and production was integrated, but even if this were brought about it is doubtful whether the character of the land and the communications are suitable for major expansion. Together with Lac Zima these salines can supply all the envisaged domestic needs of South Morocco but they do not appear suitable for more distant markets.

II.3.3 Berrechid Basin

The Berrechid Basin salt deposit was discovered in the course of the UNDP project "Potash Exploration in the Khemisset Basin (1967-1969) with BRPM (Bureau de Recherches et Participations Minieres) as the Moroccan counterpart agency. A preliminary study on the profitability of exploiting this salt, commissioned by the United Nations, suggested that production costs of less than $1/tonne would be possible for a throughput of 1 million tonnes per annum for export,but this calculation excluded the costs of providing suitable port facilities and a road to the port.

A subsequent study by the Battelle Institute in 1972, gave a much higher estimate of likely production costs. Present observations and analysis of the available data generally support the Batelle findings.

During the present study the port of Mohammedia was visited and discussions took place with the harbour authorities. It was learnt that the port cannot cater for ships exceeding 12,000 dwt, and the cost of providing facilities for bigger ships would be large - greater indeed than the probable cost of mine development. Unless the Moroccan government has reason to install the necessary facilities for trade in other commodities, these facts must rule out Mohammedia as a port for large-scale export of salt. Similarly, road transport costs to the next port (Casablanca) rule out Casablanca as an export terminal. It is just possible that rail transport to Casablanca would be economic, but this would necessitate revised thinking about the site to be exploited and the techniques to be used. However, Table 21 suggests that the prospects for large-scale exports are difficult even at $2/tonne fob.

The possibility that the annual production from the gisement is likely to be well below the one million tonnes previously projected would have a direct bearing upon the choice of techniques of recovery. The Batelle reports estimated dry mining costs as follows:

Table 24

Dry Mining Costs at Berrechid (Battelle estimate)

Production (t/a)	Capital Costs ($)	Operating Costs ($/tonne)
160,000	7,800,000	8.00
240,000	10,000,000	6.52
400,000	12,500,000	5.26
800,000	15,000,000	3.35
1,600,000	22,000,000	2.61
2,400,000	24,000,000	2.00

The technique of solution mining may prove more suitable than dry mining for production rates below ¼ to ½ million t/a. Batelle's estimates for solution mining indicate a range of production costs from $5.36/tonne at 450,000 t/a to $5.17/tonne at 90,000 t/a. Although the actual costs of exploitation may differ from the Batelle estimates, it can be safely accepted that they will exceed the $2/tonne needed for exports by a large margin and that below 100,000 t/a solution mining will be far less costly than dry mining.

The biggest technical difficulty with solution mining at Berrechid is the local shortage of water. This might be overcome by using sea water, despite the costs of pumping and the inevitable loss of product quality. If the salt were intended for a local chlor-alkali plant it might be possible to recycle the weak brine from the chlor-alkali electrolysis unit. But the technical problems are highly complex and a very detailed study of these questions would be needed before undertaking a major new capital investment.

Provided that sufficient water were available and the technical problems can be overcome, solution mining (possibly from a point in the Oued Mellah Valley) seems likely to be the most economical technique for supplying local markets. There is insufficient flat land suitable for solar evaporation close to Mohammedia for the production of around 30,000 t/a of high purity crystalline salt. There is also other, though less suitable, land higher up the Oued Mellah Valley. If BEPI's chlor-alkali plant is constructed near Mohammedia it might be supplied directly with brine from solution mining.

On the other hand, BEPI's plans to construct a chlor-alkali plant at Mohammedia depend on their PVC project and on the economics of large-scale exploitation of Berrechid salt. An alternative site might be considered. In such case, it might be better to postpone plans for exploiting the Berrechid deposit indefinitely, (whatever the results from the trial recovery of 500 tonnes planned as the next stage in its evaluation).

There appears to be assured local future domestic demand for around 30,000t/a salt in the Casablanca-Rabat region. Plans for exploitation of the Berrechid deposit could more reasonably be based on this figure rather than the wildly optimistic figures based upon the unsupported assumption that large-scale exports of salt are possible.

Whatever the eventual output of salt from Mohammedia, this in itself does not offer any significant basis for Maghreb co-operation. If exports should reach a high level, these would be competing against Tunisia, and some form of regulation might have to be contemplated.

II.3.4 Souk El Arba

Recovery of salt from this source is from an open quarry using explosives. The recovered rock is so mixed with clay and other impurities that, before washing, crushing and packaging, it has to be dissolved in brine and crystallised by solar evaporation. The nature of this deposit and the recovery techniques employed make it impossible to visualise this saline as a potential supplier of industrial salt and its production potential must be severely restricted.

II.3.5 Larache

The saline at Larache averages 6,000 t/a of salt by solar evaporation from sea water. The ultimate capacity of the saline is limited by the area available and it is not thought possible to exceed 12,000 t/a - more than sufficient to cater for the expected local markets but quite inadequate for any large industrial development.

II.3.6 Tissa

In 1971, this quarry produced around 12,000 tonnes of moderately good salt, nearly three times production in 1970. It is badly situated for transport and it is not likely that salt of industrial quality can be produced from it at an economic cost. On the other hand, it appears fairly easy to increase production rates and it might be worthwhile to encourage operations at this quarry as an insurance against poor seasons at Lac Zima and at other evaporative salines.

II.3.7 Taza

This mine is owned by the Societe Benchékroun. Production is usually around 7,000 to 10,000 t/a and is limited primarily by the lack of outlets. The salt quality is similar to that of Tissa although the top quality, which is selected by hand, is very good. About 20% of the production is by an unusal variant of solution mining, followed by solar evaporation on a few hectares of flat land at the foot of the hill.

Although the mining techniques are primitive and the salt quality variable, this gisement is interesting because of its location. Within a distance of two kilometres there is the main Casablanca-Oujda railway line and national highway, a major river, a 15 KV electricity supply line and suitable land for industrial development. The Moroccan government wants to develop the region and this location could be suitable for industrial development including a chlor-alkali plant supplying Kenitra (and the pesticides complex later discussed in Chapter Four).

II.3.8 Nador

Around 6,000 t/a are produced at this privately owned saline for the supply of local markets. There is limited scope for expansion and the Moroccan outlets are very restricted. There could be potential for small sales to West Algeria if Algerian demand outstrips supplies available in the Oran region. Climatic conditions at Nador are more favourable than at Oran, although the distance between is only 100 kms.

II.4 Salt : Algeria

Salt production in Algeria is currently about 130,000 t/a. In 1970 35,000 tonnes (or 30%) was exported, mostly to France. 8,000 tonnes have recently been exported to Morocco from the Saline d'Arzew, but so far this is an isolated case. Local consumption between 1967 and 1970 increased from about 48,000 t/a to 77,000 t/a.

The official selling price for average grade food salt at Arzew depot, is 145 DA/tonne. Industrial prices are known to be lower but are not generally disclosed.

Two-thirds of the local consumption of salt in Algeria (52,000 tonnes in 1970) is for direct human consumption. 7-10,000 tonnes of the remainder are used in the chemical industry, about 5,000 tonnes for various industrial purposes, some 500 tonnes for fish preservation and varying quantities up to about 3,000 t/a for oil-drilling.

Local consumption for present uses can be expected to grow in line with world growth rates for salt consumption, possibly at about 5% p.a., to 110,000 tonnes in 1980. Major new industrial developments (Table 25) would increase requirements.

Table 25

Algeria: Planned Chlor-alkali Capacity in 1980 (t/a)

	Chlorine Capacity	Potential Salt Requirements
Mostaganem, projected	13,000	26,000
Baba Ali, existing	4,700	18,000
projected	4,700	
Skikda, under construction	36,000	144,000
projected	36,000	

However, for the reasons given in Chapter Two, it is unlikely that the outlets for chlorine in 1980 will be sufficient to utilise all this capacity. The likely demands for salt in 1980 are summarised in Table 26, ignoring potential exports.

Table 26

Algeria : Chlor-alkali and Salt Consumption in 1980 (t/a)

	Chlorine	Caustic Soda	Soda Ash	Salt
Rachgoune (SONIC)	90	14,000		
Oran (SNIV)			23,000	
Saida (SONIC)		1,900		
Mostaganem (SONIC)	5,500	5,580	50	11,580
Others	200	4,325	350	27,500
Total, West Algeria	5,790	25,805	23,400	39,080
Algiers and others	200	8,650	3,000	55,000
Baba-Ali (SONIC)	7,000	7,300	100	14,400
Total, Central Algeria	7,200	15,950	3,100	69,400
Skikda (SONATRACH)	53,000	500	500	108,000
Annaba (SNS)	1,000			
Souk Ahras (SONIC)		24		
Others		4,325	1,000	27,000
Total, East Algeria	54,000	4,849	1,500	135,000
Grand total, all Algeria	66,990	46,604	28,000	233,000

Note: a) These figures assume that by 1980 the Skikda VCM production will be 80,000 t/a (for internal con sumption and exports) but that no TPP production is taking place.

b) There is a small potential export market for salt which has been assumed to remain around 35,000t/a. The overall potential demand for salt in 1980, including export, has thus been projected at 270,000t/a.

The hinterland of Algeria is well-endowed with salt deposits far from the main centres of industry. As a result of the leaching action of rivers which eventually drain into inland lakes, Algeria also is well-endowed with salt-lakes some of which are close to centres of population and industry. Unfortunately, Algeria has less favourable climatic conditions than Morocco and Tunisia for solar evaporation so that, despite superiority in salt resources, Algeria is least able to exploit her resources economically.

Table 27

The Salines of Algeria

	Production (t/a)	
	Normal	Known Potential
Grande Sebkha D'Oran	0	
Sebkha d'Arzew	80,000	160,000
Sebkha Bouziane (Ferry)	40,000	40,000
El Outaya (a hill of rock salt)	0	150,000
Sebkha El Guemel	10,000	20,000
Hippone (a sea-water saline)	6,000	0
	136,000	370,000

All salines are state-owned and are administered by SONAREM (Societe Nationale de Recherches et d'Exploitations Minieres). The table of potential production is taken from the plans of SONAREM for 1980.

It will be seen from a comparison of Tables 26 and 27 that large scale additional supplies of salt will be needed by 1980. If an additional source such as El Outaya is not exploited only 220,000t/a will be produced and 50,000t/a will have to be imported.

II.4.1 Grande Sebkha d'Oran

This sebkha is the largest in Algeria and is situated within 10 kilometres of the industrial centre of Oran. Previous attempts to recover salt from this sebkha have failed - but not for technical reasons. There will be an increasing demand for salt in this region even if not in the immediate future and, because of likely limitations on production at Arzew (II.4.2), this sebkha may be a suitable location for a new saline.

Previous reports have pointed out its apparent potential and have recommended programmes of hydrological and hydrochemical investigation to determine the extent of the salt reserves and to assess the best method of exploitation. It is suggested that, in addition, it would be valuable for any study to include consideration of land reclamation, communications and the possibilities for other industrial developments on this site.

II.4.2 Arzew

The Saline d'Arzew is at present the most important saline in Algeria and is scheduled for expansion in spite of some doubts about the water supply to the sebkha. A typical analysis of the impurities gave 0.36% $CaSO_4$ and 0.35% $MgCl_2$ which most industrial users consider poor. The cost of production is around 45 DA($9/tonne). Nevertheless the techniques of production currently employed effect an appreciable purification of the salt in the sebkha, as indicated by analyses conducted in the UK.

Table 28

Analyses of Salt at the Saline d'Arzew (wt %)

	For sale	Within the sebkha
Chlorides	92.20	75.00
Calcium	0.10	0.98
Magnesium	0.06	1.43
Sulphates	0.43	1.87
Insolubles	Trace	0.26

There appears to be considerable scope for improvements in production techniques at Arzew. But before embarking on any major additional investment the current studies of the hydrology of the basin should be evaluated. It is not yet clear what the ultimate production potential of this saline is and whether it will be limited by rainfall or salt reserves or the area of the lake.

Another problem is that the existing port of Arzew is being reserved for petrochemicals and so an alternative port is needed, possibly Mostagenem. The proposed Mostagenem chlor-alkali plant is expected to account for most of the extra demand for Arzew salt and it would be worthwhile to consider the economics of transporting the salt by pipeline to Mostaganem or a nearer port, in order to reduce transport and handling costs. The same pipeline might also be used to supplement the water supply to the sebkha by supplying sea-water at times during the wet season.

II.4.3 Bouziane

Available information suggests that many of the problems of Arzew may also apply to the Bouziane saline. Time was not available for a visit and it was not possible to find anyone with detailed knowledge of this saline in Algiers.

II.4.4 El Outaya

Early in 1973 SONAREM were arranging for a study to be made of the possibility of exploiting this hill of rock salt and transporting the salt to the proposed chlor-alkali plant of the Skikda complex. The salt appears to be of low quality ($CaSO_4$ from 2-6%, KCl up to 0.7% insolubles up to 2%, etc.) and discussion with representatives of SONAREM did not fully explain why El Outaya is favoured.

One factor mentioned was SNCF's offer to transport salt to Skikda at a special rate of 15 DA/t($3/t). Although this is attractive to SONAREM it could mean a loss to the railway and balanced against the overall cost of recovery and transport from El Outaya to Skikda the scheme hardly seems likely to be beneficial to the economy of Algeria as a whole. Without prejudging the results of the engineering study, the costs of quarrying and road construction at El Outaya, rail transport and chemical treatment may be substantial and the development of Arzew salt resources or even imports from Tunisia could prove at least as economic for Algeria as the exploitation of El Outaya.

II.4.5 El Guemel

The saline of the sebkha of Oum El Guemel currently produces between 5,000 to 10,000 t/a of reasonably good quality salt. The saline had been scheduled for extensions in spite of reservations expressed by previous investigators concerning the supply of water and the hydrological situation.

The saline is reasonably well-placed to supply the proposed Skikda industrial complex but it would be wise not to make any further plans unless the investigations proposed to SONAREM in April 1970 are first carried out.

II.4.6 Hippone

This is the only saline marine in Algeria and produces better quality salt than the others. SONAREM envisage discontinuing production in the near future, as the area will be developed for industrial purposes.

II.5 Salt : Tunisia

Domestic salt consumption in Tunisia is about 40,000 t/a. Consumption has grown steadily during the last seven years, at about 3-4% per annum. Exports in this period have ranged between 250-350,000 t/a except for a peak of 392,000 tonnes in 1965.

The selling price of industrial grade salt in Tunisia is controlled by the Government, at 2,80 DT/t for bulk lots. Prices for human consumption vary but are considerably higher. Export prices are determined by the international market and vary considerably from time to time. In 1972 exports to Morocco from Tunisia were costing about 2.8 DT/t fob. Tunisian port, and 12 DT/t cif Moroccan port. The average Tunisian fob price was however about 2 D/t.

Over 80% of the salt used locally is for direct human consumption, the food processing industry and similar end-uses. An important part of the market at present is in the North of Tunisia. About 6,000 t/a are used by the chlor-alkali unit of SNTC at Kasserine.

The destinations of exports show large variations from year to year. The United States of America however account for about one-third or about 100,000 t/a, and recently another third has gone to Scandinavia. Export salt has three major end-uses of approximately equal importance. It is used to clear snow from roads, mostly in the United States and Europe; for salting fish, particularly to Scandinavia for salting cod; and for various industrial uses. Destinations vary considerably according to competition and prices. Tunisian salt is not used for industrial purposes in Scandinavia. German and Dutch suppliers are cheaper for this market because of lower transport costs and they also offer a quality better suited to customer's requirements.

Export salt is always sold fob and the customer makes his own arrangements for freight. The method of shipping varies according to destination. Salt is always shipped as a return load to the United States, because of the distance. Shipment is also often on a return load basis for European destinations for instance in ships that have brought timber from Scandinavia. Alternatively, many vessels in the Mediterranean trade change cargoes at different points on their journeys and sometimes carry salt.

As industrial activity grows in Tunisia the domestic consumption of salt may be expected to increase more rapidly than in recent years. If an increase of 6% pa is assumed, domestic demand would be about 60,000 tonnes in 1980.

The future of salt exports will be much influenced by variations in climate, production and the movements of prices. Tunisia is however planning to increase exports to 383,000 t/a by 1976, an increase of about 80,000 t/a above the typical level of 300,000 t/a in recent years. In view of the highly variable nature of the world salt market, it has been thought wise to project a conservative rate of growth to 1980. Taking 5% pa for the average rate from 1973 to 1980, exports would reach 420,000 tons. Including the 60,000 t/a for the domestic market this gives a forecast of demand in 1980 at 480,000 t/a.

Table 29

The Salines of Tunisia

	Production (t/a)		Port
	Current	Known potential	
Soliman/Rades (SORASEL)	4,000	80,000	Tunis
Megrine (COTUSAL)	40,000		
Sahline (COTUSAL)	130,000	150,000	Sousse
Sidi Salem (COTUSAL)	240,000	400,000	Sfax
	414,000	630,000	

The three major Tunisian salines marines (near Tunis, Sousse and Sfax) are owned and operated by the French owned company COTUSAL. The company now exports over 300,000 t/a. A Tunisian company SORASEL (Societe de Raffinage du Sel) has recently been formed and owns a small saline marine at Rades close to the Megrine saline of COTUSAL and a second one at Soliman further to the East. The quality of Tunisian salt is above average for the Maghreb, largely because crystallisation takes place in the narrow range 26-30°Bé and because much care is taken in harvesting and handling.

About 160,000 t/a are exported from Sousse, a port which is capable of accepting 15,000 dwt ships. Sfax can receive vessels of 28,000 dwt and exports over 150,000 t/a. Plans are under way to increase salt charging rates from 200 t/h to 400 t/h and to dredge a channel so that 30,000-50,000 dwt ships can enter the port. The Tunis salines supply most of the 30-40,000 t/a taken by the domestic market.

CHAPTER THREE

MAGHREB COOPERATION

The problems and objectives of Maghreb cooperation were discussed in detail with authorities in all three countries during the course of the field investigations. The study team's conclusions about the approach to tbe adopted to such practical proposals as might emerge from their investigations were influenced by these discussions. The general principles adopted by the team are summarised below.

III.1 Principles

Five basic principles seem to be generally accepted as desirable in any proposal for Maghreb cooperation. Not all five have necessarily to be fully satisfied. Rather these are the preferred characteristics of any proposed projects.

III.1.1 Economic criteria

Criteria for judging the economic case for investments differ between the three countries, particularly with respect to the importance attached to profitability as compared with more general factors such as industrial development and social needs. The term "economically justified", when considering a potential Maghreb project, has to balance these factors. However desirable Maghreb cooperation might be as an aim, individual projects have to satisfy tests of economic justification and, moreover, should be more attractive as a cooperative effort than if undertaken as a separate independent project. In general this principle tends to suggest that cooperative projects ought to involve advanced technology and high-value products for which transport costs represent only a small proportion of total costs.

III.1.2 Mutual advantage

It is unlikely that a proposal will find universal acceptance if all or most of the benefits accrue to one party. So, in addition to the need for overall benefits, it also is necessary for a proposal to be advantageous for each of the parties concerned.

III.1.3 Balanced development

Financial benefit alone may not be a sufficent reason to justify a cooperative project. For example, a country may derive financial advantage from the sale of a basic commodity without necessarily stimulating the industrial development of its economy.

All the Maghreb countries need and wish to develop new industrial activities to increase self-reliance and to create and expand industrial skills. Cooperative projects also have to be judged according to their contribution towards such progress in all the countries concerned.

III.1.4 Complementary advantage

Individual specialisation within the Maghreb countries offers advantages, although it is advisable to avoid merely a supplier-consumer relationship. For example, the suggested specialisation in non-ferrous metals (copper-Morocco, zinc-Algeria, lead-Tunisia) would allow each country to benefit from the activities of the other whilst still enabling each to concentrate on perfecting expertise in its own important area of technology.

III.1.5 Coordination

It is unreasonable to expect any country to delay its own projects indefinitely when these have been thoroughly investigated and proved to be feasible. Projects need to be undertaken at the appropriate time for those concerned, with consultation among all parties from the earliest stage.

III.2 Forms of cooperation

Three forms for cooperative effort seem possible.

III.2.1. Agreement to accept a country's leading role

Sometimes one country may have advantages over others with respect to particular forms of industrial activities because of its natural or other resources or by the accidents of history. In this situation, it might be beneficial to the other two countries to look favourable on the development of such activities and agree to purchase solely from this source at favourable rates. The first country can thus concentrate fully on these activities with the added security of guaranteed markets.

III.2.2 Accord d'entreprises

Arrangements can be made between the three countries to manufacture and trade in certain commodities as in the suggested copper-zinc-lead cooperation mentioned earlier. Here the benefits are complementary and provide a better basis for balanced development.

This form of cooperation does not necessarily require joint investment; it offers the advantage of guaranteed markets without unnecessary competition and enables the manufacturing units to be established more economically.

III.2.3 Joint Venture (Enterprise conjointe Maghrebine)

In this form of cooperation two or more countries participate directly, as in the case of the Algerian-Moroccan cement venture in Morocco. This is an ideal form of cooperation although it raises various problems related to legal arrangements, taxation, remittance of funds and management.

III.3 Recommendations

Salt is a low value product and is readily available throughout North Africa. Consequently it is to be expected that each of the three countries would prefer to develop its own resources rather than to exploit one or two major salines jointly.

The prospects for Maghreb cooperation improve for products derived from salt, because of their higher value after several processing stages. We are then dealing with more costly products which might be distributed throughout the Maghreb without adding a significant amount to the base cost, and there is the further advantage that resources and advanced technological skills could be concentrated in a limited number of locations.

In Chapter One the demand in 1980 for various high-value salt derivatives was assessed. It was seen that several of the products listed on Figure 1 are unlikely to be consumed at significant levels by 1980. Table 30 summarises the conclusions of Chapter One for the more significant chlor-alkali derivatives.

SCHEMA 3

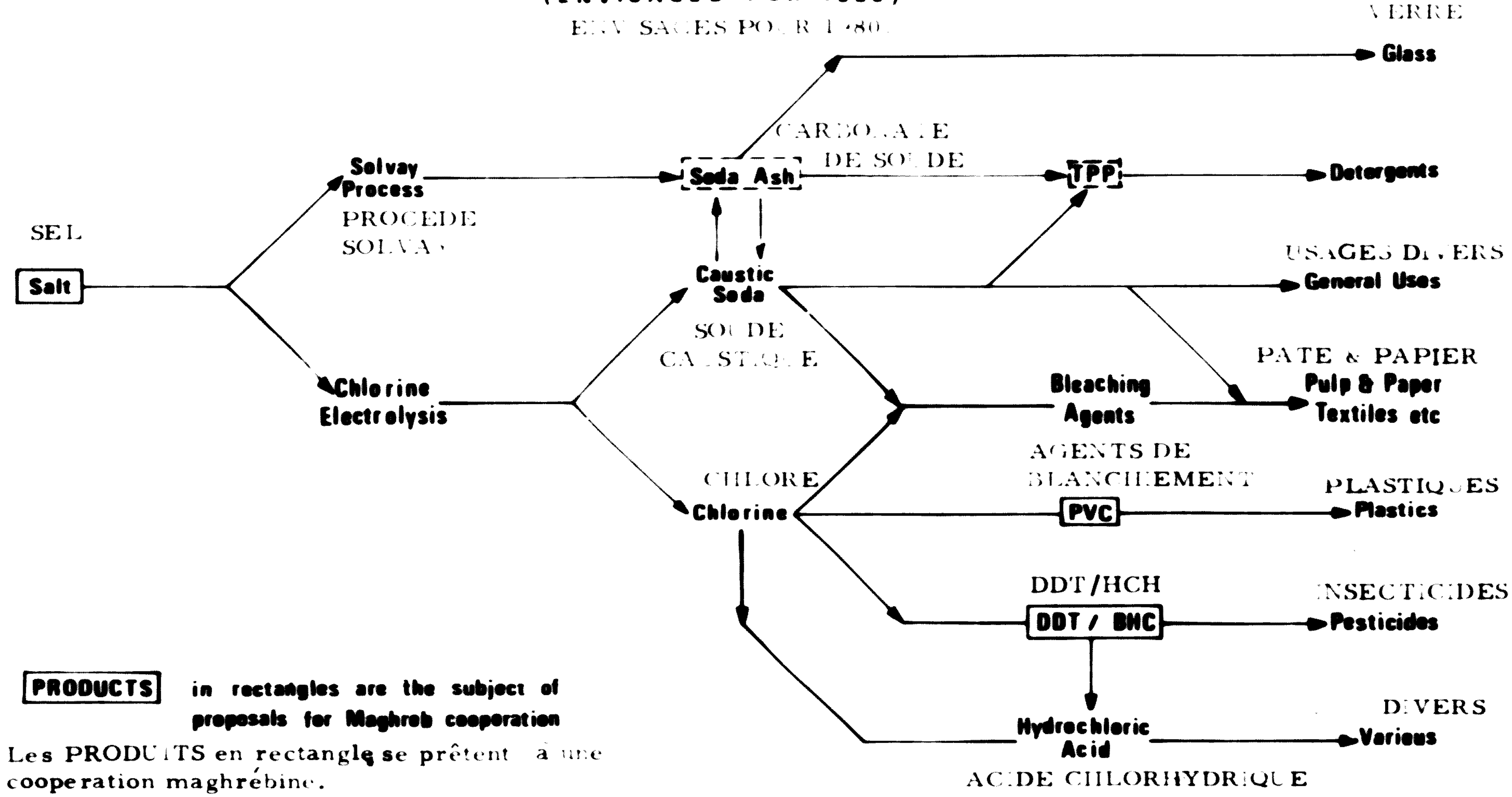
DEBOUCHES INDUSTRIELS IMPORTANTS DU SEL

Fig 3

MAJOR INDUSTRIAL OUTLETS FOR SALT

(ENVISAGED FOR 1980)

ENVISAGES POUR 1980



PRODUCTS in rectangles are the subject of proposals for Maghreb cooperation

Les PRODUITS en rectangle se prêtent à une cooperation maghrébine.

Table 30

Estimated Demand for selected Salt Derivatives in 1980 (t/a)

	PVC	DDT	BHC	Soda ash (a)
Morocco	20,000	800	600	11,500
Algeria	40,000	1,000	700	28,000
Tunisia	8,000	300	200	8,500
All Maghreb	68,000	2,100	1,500	48,000
Potential exports	2,000	2,500	-	12,000
Total demand	70,000	4,600	1,500	60,000
Minimum economic plant capacity (b) (VCM)	80,000	5,000	3,000	>100,000
(PVC)	20,000			

Notes : (a) Excludes soda ash for TPP and caustic soda.
(b) Calculated in Chapter Seven.

Table 30 demonstrates that there are few immediately commercially viable opportunities for Maghreb cooperation with respect to investments in manufacturing facilities for these products. On the other hand price trends in organo-chlorine pesticides may make an investment in DDT and BHC economic in the future and other considerations may dictate that soda ash should be manufactured locally. The next question is whether the provision of centralised manufacturing facilities for any of these products would be advantageous to the Maghreb countries.

This Chapter considers the following products groupings: PVC, soda ash and pesticides; The special issue of TPP is next considered. Following this analysis, further cooperative ventures suggest themselves, such as the supply of salt, transport of chemicals and joint measures for technical training. Subsequent chapters consider these proposals in separate detail for Morocco, Algeria and Tunisia.

III.3.1 PVC

Because of its low capacity, the 35,000 t/a PVC plant being constructed at Skikda, Algeria is unlikely to be profitable. This fact is fully appreciated by the Algerian authorities and that is why they plan to double capacity as soon as possible. As a matter of Maghreb cooperation it would be inappropriate for Morocco to invest in a separate plant which would have even smaller capacity when they could take advantage of the opportunities offered by availability of supplies from Algeria.

The calculations in section VII.3.4 show that the suggested second phase expansion at Skikda is unlikely to show a commercial return and would not meet the criteria for investment generally adopted in Morocco and Tunisia.

It is generally agreed that 80,000 t/a is the minimum plant size (see section VII.3.4 for calculations) needed for the economic manufacture of Vinyl Chloride Monomer (VCM). The final stage of PVC polymerisation from VCM, however, can be profitable at much lower throughputs (section VII.3.5). Consequently there is a considerable world trade in VCM. An ideal timing for investments in polymerisation and VCM is illustrated schematically in Fig. 4.

Probably Morocco could reasonably make an initial PVC investment solely in polymerisation since PVC demand in 1980 is forecast at around 20,000 t/a. Moroccan investment in polymerisation would provide an excellent opportunity for mutually beneficial cooperation between Algeria and Morocco through the supply of Algerian VCM to the Moroccan PVC polymerisation plant. The calculations at sections VII.3.4 and VII.3.5 indicate that this arrangement would be financially beneficial to both countries. A 20,000 t/a polymerisation plant would employ a total staff of about 50.

It could be argued that Morocco should make a joint investment with Algeria in PVC polymerisation at Skikda and import polymer rather than monomer. Against this, the volume of PVC is greater than the equivalent amount of VCM, and the need to store, transport and record several different PVC grades would add further costs. The main argument for locating the polymerisation unit in Morocco is however not financial. Such a plant would provide a basis for the development of industrial expertise in PVC and provide a solid foundation for future developments of plastics technology. It is a step in the creation of a fully-integrated self-sufficient Moroccan plastics industry.

The Tunisian forecast demand for PVC at 8,000 t/a in 1980 is too low to justify investment even in a polymerisation plant. There is still a case for cooperation, with Algeria supplying Tunisia with PVC polymer.

Thus all three countries would benefit from cooperation. Algeria would have a increased outlet for her PVC investment. Morocco and Tunisia would avoid premature investment in VCM manufacture and would have an opportunity to develop their PVC markets. As explained in Chapter One the biggest problem is likely to be the marketing of the tonnages produced.

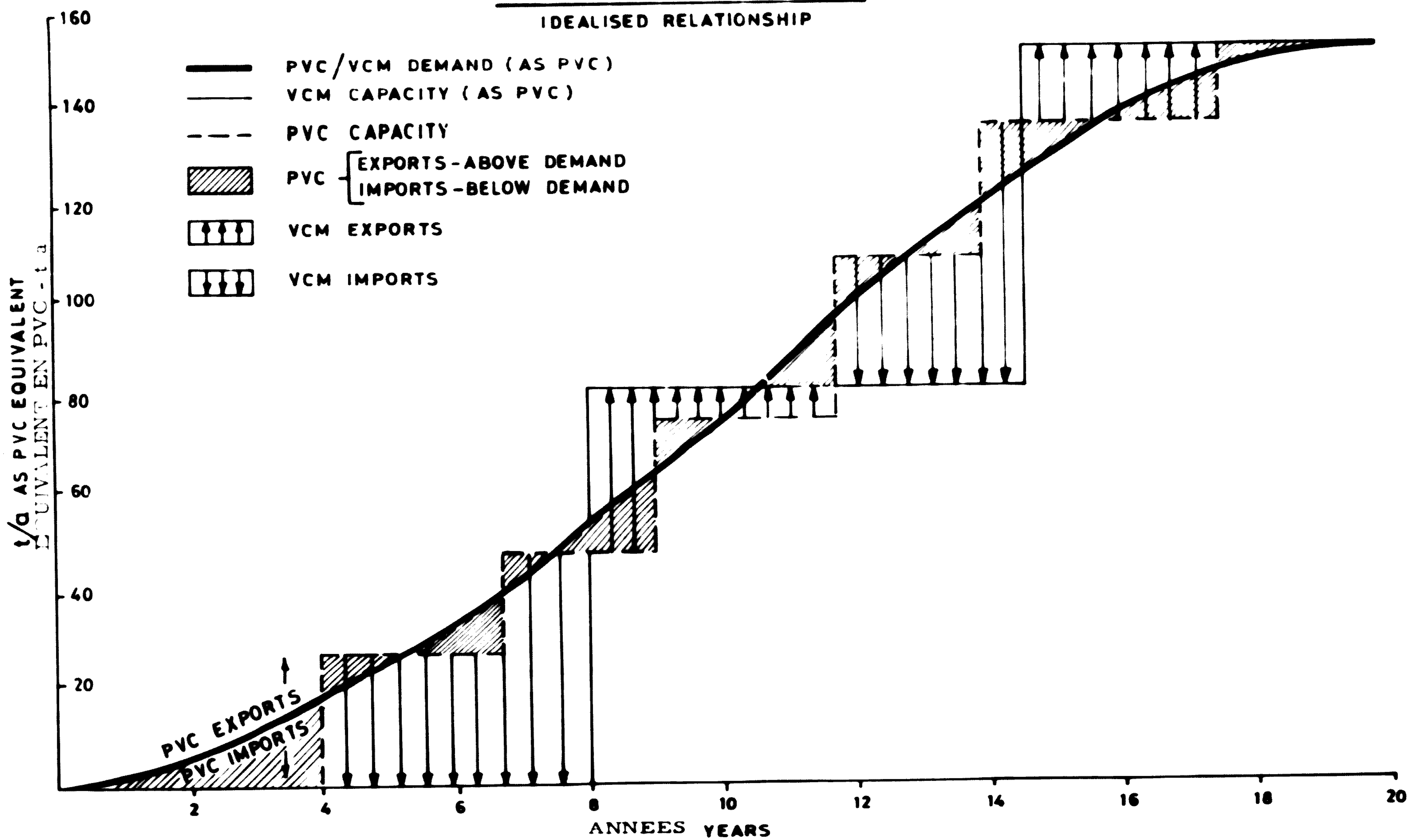
SCHEMA 4 — CAPACITE EN PVC EN FONCTION DES BESOINS (Relation Parfaite)

FIG. 4.

PVC

DEMAND VS CAPACITY

IDEALISED RELATIONSHIP



III.3.2 Soda Ash

The demand in the Maghreb for soda ash as such is not sufficient to ensure its profitable manufacture (sections VII.3.1 and VII.3.2). The possibility of soda ash production has been considered in order to clarify the prospects for the future manufacture of this chemical. But even if the demand for sodium tripolyphosphate (TPP) is stimulated greatly and caustic soda is also manufactured from soda ash in Tunisia, it will not be possible to make soda ash profitably for less than about $90/tonne. The current import price is $50-60/t.

It should be explained why soda ash is available at such low prices and why Maghreb countries are unable to compete. It is now many years since a new soda ash plant was built in Western Europe or North America, the main reason being competition from the increased production of caustic soda. The plants which still produce soda ash are largely depreciated and free from initial financial charges and are thus able to sell at a profit only a little above the marginal (variable) costs of production.

In addition there is some competition from the natural deposits of soda ash in Kenya. Kenya is exporting soda ash at $37/tonne fob and it seems unlikely that the Maghreb price of soda ash will rise to $90/tonne in the foreseeable future. Moreover, the calculations of section VII.3.2 show that at this price soda ash can be manufactured at a profit from caustic soda at $95/ton, the price at which the excess 27,000 tonnes of Algerian caustic soda could be available.

Morocco and Algeria are both developing markets for chlorine, and hence additional production of caustic soda, but this is not happening to the same extent in Tunisia. A deficit of about 7,000 t/a caustic soda is expected in Tunisia by 1980 and may be expected to continue., If the deficit were to be met from soda ash conversion, the total Maghreb demand for soda ash would be raised by about 11,000 t/a to around 60,000 t/a.

Tunisia's close neighbour, Libya, has a similar demand for soda ash to those of Algeria and Morocco, so Tunisia would be centrally located in a relatively evenly distributed North African market. Tunisia, alone of the three Maghreb countries, has ready large-scale supplies of good quality salt adjacent to existing limestone quarries and thus appears to be the preferred location of the three Maghreb countries.

This does not mean that a demand of 75,000 t/a, (or even of 100,000 t/a if possible TPP demands are included) justifies investment in soda ash. On a world scale, the demand for this product is declining because of its partial replacement by caustic soda. This recommendation merely suggests that, should an investment in soda ash be undertaken, the location of the plant should be in Tunisia. The calculations of section VII.3.1 are based on this assumption : at any other location the costs of production would be even higher.

III.3.3 Pesticides

The future requirements of DDT and BHC (or Lindane) in the Maghreb countries together with possible exports could justify local investment in DDT and BHC manufacture if the prices of those commodities were to rise by 10-20% - a not unlikely prospect. However, there are doubts about the use of the products, particularly in view of the decisions of several advanced industrial nations to place greater emphasis on more expensive pesticides such as the organo-phosphorous compounds.

As with soda ash, it is many years now since new DDT and BHC plants were constructed. Most producers have largely depreciated their plants and paid off the financial charges and so are able to sell these products at low prices. But the analogy with soda ash is not exact for there are no 'natural' deposits of DDT and BHC nor are there other pesticides capable of replacing DDT and BHC for every application.

The consequence of this situation could be a sharp rise in prices for DDT and BHC as the old plants cease production. A world shortage of these products may arise in a few years and so a new investment, if correctly timed, could prove commercially justified.

An indication of the continuing potential for DDT is a recent recommendation of the World Health Organisation (WHO) that about 5,000 t/a DDT should be used in West Africa for malaria control. The present consumption is only 1,000 t/a and UNIDO has proposed that a DDT manufacturing unit should be constructed in West Africa to satisfy the needs of this region.

Fears have been expressed concerning the long-term effect of DDT and BHC but it should be emphasised that, even at the much higher levels of application suggested in this report, the use of these organo-chlorine compounds would be well below the levels which have caused concern in the USA and elsewhere. Similar arguments apply to other organo-chlorine compounds such as chlordane which could be manufactured at the same location as DDT and BHC.

If steps are taken to stimulate the application of pesticides in the Maghreb it will also be necessary to improve the efficiency of the formulation factories and give greater consideration to the problems of ensuring efficient application.

Resources are limited and qualified personnel scarce in this field and it could be advantageous to pool national resources for manufacturing capacity, formulation manufacture, equipment for application and advisory services. Although there would be scope for several privately owned formulation units, it would be appropriate for such a Maghreb centre to be located alongside a centralised manufacturing unit for BHC and DDT.

Both DDT and BHC, like PVC require chlorine as a raw material. One consequence of an Algerian concentration of PVC manufacture (discussed later in Chapter Five) will be that Algeria will have a potential 'shortage' of chlorine in 1980 (in practice, a surplus of caustic soda). In these circumstances, and mindful of the need to stimulate industrial development in all three countries, Algeria does not seem a suitable location for a pesticides complex. Either Morocco or Tunisia appear to be more suitable as locations for a pesticide complex which would contribute towards a more balanced industrial development in the Maghreb countries.

However, Morocco is closer to the West African outlets for DDT and thus more centrally placed in relation to the outlets of the complex. Morocco has local sources of sulphuric acid (used for DDT production) and is more likely to be able to dispose of the by-products. Moreover, there is currently some opposition to the use of organo-chlorine pesticides in Tunisia. Although this attitude could be overcome with a greater understanding of the facts involved it could make implementation of the project more difficult.

Should it be agreed that an all-Maghreb pesticides complex is justified and should be constructed, we recommend that it should be located in Morocco. Such a complex would employ 120-150 people.

III.3.4 TPP

Sodium tripolyphosphate (TPP) is made by reacting chemical grade phosphoric acid (normally obtained through the purification of fertiliser acid) with either soda ash or caustic soda. The preferred alkali is soda ash as in most countries it is cheaper than caustic soda on an Na_2O basis.

The raw material costs of these chemicals show that in present conditions TPP cannot be produced economically. Chemical grade phosphoric acid might cost \$150/tonne (100% basis, as 54% P_2O_5). Caustic soda may be priced at \$95/tonne so the raw material costs alone would be around \$177/ton (0.82 x \$150 + 0.57 x \$95). Since TPP is currently priced at \$200/ton this calculation clearly leaves too little margin for the payment of loan charges, depreciation and other fixed costs.

At the maximum throughputs envisaged for soda ash production in the Maghreb, the cost of soda ash would still exceed $90/tonne if locally produced. This is a similar raw materials cost to that calculated for caustic soda and so would make TPP production uneconomic.

TPP production could be economic if soda ash were to be imported at $40/ton or less. In such case, the raw materials cost for TPP would be only $133/ton (0.82 x $150 + 0.75 x $40) but it is outside the scope of this report to investigate the manufacture of TPP from imported soda ash since this soda ash would not be derived from Maghreb salt. Our conclusion is that, at present prices, the manufacture of TPP does not provide a suitable outlet for chemicals derived from the salt resources of the Maghreb countries, although, if a project were to be considered, it should be as a cooperative effort rather than as an individual project. On the other hand, should Algeria be faced with a problem of disposal of excess caustic soda, TPP could provide a suitable outlet for this surplus, (see Table 33, page 73). In this case the price of caustic soda will tend to drop, and the economics of TPP manufacture would improve.

It would be premature at this stage to suggest a location for TPP manufacture should this prove to be viable in due course. Both Tunisia and Morocco are in the process of developing export markets for phosphoric acid and the choice of location will depend primarily on the relative prices of caustic soda and phosphoric acid. It might be advantageous for the three countries to agree on manufacturing TPP in either Morocco or Tunisia, using caustic soda from Algeria. Or alternatively it might be more economical to import phosphoric acid into Algeria from either country.

III.3.5 Effects of these proposals

At this stage it is appropriate to look at the overall picture of production and demand in the Maghreb countries and to see how the recommendations above affect the position. Table 31 has been drawn up assuming that these were followed. If any of our proposals were not acceptd, or if any of the existing plans of SNIC, BEPI and SONAREM (ignored in Table 31) were to be implemented, then the imbalances would be much greater.

Table 31

Maghreb : Potential Imbalances in Supply of Salt and Major Derivatives in 1980 (t/a)

	Morocco	Algeria	Tunisia	Maghreb
Salt	=	-50,000	+450,000	+400,000
Soda Ash	-11,500	-28,000	- 8,500	- 48,000
Caustic Soda	+ 4,400	+27,000	- 6,900	+ 24,500
PVC	-20,000	+30,000	- 8,000	+ 2,000
DDT	+ 3,800	- 1,000	- 300	+ 2,500
BHC	+ 900	- 700	- 200	=

Note : Excludes the plans for soda ash (SNIC), El Outaya salt (SONAREM), PVC (BEPI), TPP. Assumes implementation of recommendations of this report concerning VCM/PVC and BHC/DDT.

In considering Table 31 it will be appreciated that whereas a deficit can usually be made good by imports, it does not follow that surpluses can be eliminated through exports. On the contrary, since the products we are considering are unlikely to be exported (except in the special cases of DDT from Morocco and salt from Tunisia) it is more than likely that production would have to be curtailed with consequential effects upon related products and upon profitability.

As a general principle, it may be assumed that each chlorine plant will produce as much chlorine as can be locally consumed. As a result, there will be deficits and surpluses in caustic soda. This is illustrated in Table 33 (Section V.2) in the calculation of Algeria's 27,000 t/a surplus of caustic soda. For other products the imbalances are calculated simply as production minus local consumption. These figures suggest further cooperative projects covering salt and inter-Maghreb transport.

III.3.6 Salt supplies

Chapter Two explained that, although all three countries have vast reserves of salt, only Tunisia is able to at the moment to exploit her resources economically on a large-scale. The possibility that Tunisia could supply the other two countries therefore be considered, since this could save the cost of investments in Morocco and Algeria and make available a cheaper and better raw material for industrial development in those countries.

During the period of this study, SONAREM initiated an engineering study for the quarrying of El Outaya rock salt. The intention is initially to deliver 60,000 t/a salt by rail to the Skikda chlor-alkali unit; the ultimate production level envisaged is 120,000 t/a. It would be wrong to pre-judge the results of the study on the basis of incomplete information, but attention should be drawn to some facts which might be taken into consideration in the engineering study, as it could affect cooperation in the Maghreb countries.

The decision to investigate El Outaya was taken because the other Algerian salines did not appear to SONAREM able to supply salt of suitable quality to Skikda at an economic price. The Arzew saline has the greatest potential but when the decision to concentrate attention on El Outaya was taken its ultimate capacity was thought to be limited. These matters were considered in Chapter Two. For the purpose of the immediate discussion, it suffices to say that a major argument used against Arzew has been the delivered price - around 73 DA/t ($15/t) - based upon transport by rail.

By contrast, the exploitation cost of El Outaya is not thought to be high (an investment with operating cost between $3/t and $8/t over the range of production rates envisaged.) When the railway authority offered to transport these quantities to Skikda for 15 DA/t ($3/t), SONAREM decided to undertake a detailed investigation into the El Outaya location.

Other alternative sources of supply within Algeria, Morocco and Tunisia must be considered. The price at Sousse for non-contractual customers is at present 2 DT/t ($5/t) and it is estimated that the shipping costs to Skikda without return loads would be around $3/t. On this basis Sousse salt would be competitive with El Outaya salt, even if the latter were of equally high quality. The calculations of section VII.3.9 also indicate that Arzew salt, transported by pipeline and sea, could be cheaper than thought at present.

Several other considerations also warrant attention.

a) Although the railway authority is now quoting $3/t for salt transportation, the costs to Algeria could well be increased - possibly around $8-$10/t. After the investment has been made to open up El Outaya there is always a risk that the price for salt transportation could be increased to such an extent that the original justification for the El Outaya decision could be invalidated.

b) The investment in El Outaya would have to be justified initially by the needs of the Skikda complex since transport to other industrial centres would be even more expensive. If salt were bought from Sousse (and there are many other countries also able to supply salt of the required quality at a comparable price should the need arise), the investment costs saved could be used for other purposes in the economy of Algeria.

c) There is also a real possibility that the existing salines elsewhere in the Maghreb, including Arzew could supply Skikda with better quality salt by coastal shipping at a lower cost.

d) It is questionable whether El Outaya could supply salt to Skikda in time for the expected commissioning date for the chlor-alkali unit.

These are some factors which should be considered together with the results of the El Outaya engineering study. But in addition, as a matter of Maghreb cooperation, there is a strong case for Algeria to obtain salt from Tunisia where reliable supplies are already available. It is recommended that, unless studies show that El Outaya salt can be delivered on time to the time to the Skikda complex at very low cost, Algeria should buy salt from Tunisia.

III.3.7 Shipping

The question of shipping has been mentioned in relation to salt. It is equally important with respect to trade in soda ash and VCM and other products outside the scope of this study.

An adequate transport system is essential for the future progress of Maghreb cooperation. The geography of the three countries is ideally suited to the existence of a fleet of small ships or barges calling in at the many ports along the coastline, yet at present only one ship is fulfilling this function.

Although it is possible to carry on the coastal trade through charter arrangements, and although for salt and VCM this could be economically more favourable than rail transport, substantial savings could be made if the local shipping problem were to be considered and developed further as a cooperative project among the three countries.

III.3.8 Training

The development of new industries in the Maghreb brings with it many problems of staff training. Countries which have expertise in certain industrial skills can help others through providing facilities for short-term work. Another point of cooperation could be regular consultations between the personnel of similar enterprises.

(a) Solar salt production.

The expert staff of SCS, SORASEL and COTUSAL could give valuable help to production staff at all the other evaporative salines of the Maghreb. It is recommended that a scheme for training be instituted at Lac Zima or a Tunisian saline. Regular meetings once or twice a year to discuss production and technical issues also could prove valuable.

(b) Chlor-alkali production.

An exchange of personnel between the projected half-dozen chlor-alkali plants could be useful to discuss many techno-economic issues such as power consumption, brine purification, anode replacement, etc.

(c) Pesticides Advisory Services.

This has been discussed earlier in relation to the proposed DDT/BHC manufacturing unit.

(d) Plastics Institute.

Morocco is considering establishing a plastics institute. In Algeria consultants are preparing recommendations for education in the plastics industry. In Tunisia, new entrants to the industry are very active. In all three countries the special problems of the industry are recognised.

The present stage of the plastics industry in the Maghreb offers the opportunity to establish a single plastics institute to serve the needs of all three countries. The Institute might provide the following facilities:

Education and training for management, supervisors, and operatives.

The establishment of qualifications and examinations in plastics technology.

A service of applied research;

- to enable buyers of plastics (e.g. the construction industry) to make the best use of materials,
- to enable processors to solve problems with materials and machines,
- to provide a service on special subjects such as die-making, printing techniques, use of coloured materials, and manufacturing standards.

Such an Institute would need to have a library, laboratory facilities, a small number of machines capable of the most important processes (e.g. injection-moulding, and film blowing) and staff to run the Institute and to teach.

Both staff and members would get great benefit from drawing on the experience of three countries, and a joint institute would make lower demands for qualified staff, equipment and premises than would three separate institutes.

CHAPTER FOUR

MOROCCO

The proposals for Maghreb cooperation outlined in the previous Chapter need detailed consideration as they relate to the interests of the individual countries. In this chapter the proposals are considered in more detail with relation to Morocco and possible locations for industrial development are explored. The nature of the raw materials and outlets of the proposed manufacturing units are very different so each proposal is discussed separately.

IV.1 PVC

In Chapter Three it is recommended that Morocco should invest in a 20,000 t/a PVC polymerisation unit but postpone the manufacture of Vinyl Chloride Monomer (VCM). It was proposed that much of the requirements of VCM be imported from Skikda, Algeria. VCM could be transported by rail or by sea though rail might be less safe. Containers must be kept below 50°C and this might be difficult in the event of an unexpected halt in a rail journey in summer. In either case storage and handling facilities are necessary, and indications of the costs of these and of sea freight are given in Chapter 7.

It would therefore appear reasonable to locate the polymerisation unit near a suitable port. This would be an added advantage if supplies have to be obtained from other countries. This safeguard is essential since there will be periods during which the expected spare capacity of the Algerian Skikda plant would not be sufficient for Moroccan needs.

The outlets for PVC produced in Morocco will be the local polymer processers, most of whom are operating near Casablanca, and probably will continue to do so. This factor points to the advisability of locating this unit near the port of Casablanca, possibly at the Mohammedia site presently envisaged by BEPI for an integrated chlor-alkali-PVC complex.

The prospect of a future proposal for an integrated VCM and chlor-alkali production should not influence choice of site for PVC polymerisation. Proximity to suitable sources of salt is of great importance when selecting the location of a chlor-alkali plant and since there are difficulties in obtaining salt near Casablanca (Chapter Two), it may prove more appropriate to locate any future VCM manufacturing capacity some way from that area.

At present there are about eighty processers who are coping well with the processing of imported PVC and other materials into saleable products. The projections for PVC demand suggest that these units will need to double their capacity involving substantial capital investment. Given the present state of efficiency in this sector and its rate of profitability, the level of investment required might be generated from within the industry, provided that control over the number of factories is maintained.

The economics of PVC polymerisation are examined in section VII 3.5 and indicate that polymer can be produced at a cost below its current import price of about $310/t. with VCM charged at the projected world market price of $200/t. Negotiations between Morocco and Algeria on the VCM price should establish a mutually beneficial trading agreement with guarantees for continuity of supply.

The main benefit to Morocco would be the opportunity to stimulate the use of plastics without the initial loss that otherwise would be inevitable, until the demand for VCM reaches an economic production level (see section VII 3.4).

IV.2 Soda Ash

The anticipated demand for soda ash in 1980 is 12,000 t/a - far below the level needed for profitable production (over 100,000 t/a). Although the demand for soda ash in the Maghreb as a whole could stimulate interest in an investment in soda ash, there does not appear to be a location in Morocco where more than 100,000 t/a of good quality cheap salt can be obtained together with a similar quantity of limestone for the Solvay process, or close to 25,000 t/a of ammonia if the "dual" process were to be used.

Rightly therefore Morocco is not considering an investment in soda ash. It would be preferable to continue importing and, if a soda ash plant were established in Tunisia, to import from that country.

IV.3 Pesticides

The relevant calculations in section VII.3.7 show that under present market conditions the manufacture of DDT in Morocco at the rate of 3-5,000 t/a would not be economic. It has been recommended in Chapter Three that the situation should be reviewed if the forecast decrease in world capacity of chlorinated pesticides takes place at some time in the future. Should this occur, prices will harden, and a DDT project in Morocco for the supply of the requirements of the Maghreb and of West Africa could then be viable.

Should the project be implemented, the consequences for the chlorine/caustic soda balance in Morocco are illustrated below.

The demand for caustic soda and chlorine in Morocco in 1980 was estimated in Chapter One (Table 17). The figures indicated a potential deficit of 6,600 t/a for caustic soda since demand for chlorine is not expected to exceed 11,800 t/a (equivalent to about 13,000 t/a caustic soda production) compared with an estimated demand for caustic soda of around 19,600 t/a.

If a chlor-alkali unit were constructed to produce 19,600 t/a caustic soda it would also produce 17,800 t/a chlorine-that is, about 6,000 t/a more than could be consumed in the local market. In practice production would have to be curtailed to the level of the demand for chlorine, thus necessitating caustic soda imports of about 6-7,000t/a unless some other use could be found for the surplus chlorine.

The installation of a pesticides unit could increase the anticipated demand for chlorine in Morocco by over 9,000 t/a as follows :

1,500 t/a BHC unit will use	1,100	t/a chlorine
4,600 t/a DDT unit will use	8,300	t/a chlorine
Total	9,400	

If this amount of chlorine were produced an additional 10,000 t/a of caustic soda would be available thus creating a potential surplus of c.4,000 t/a. Making due allowance in these estimates for the uncertainties of market forecasts and plant performances, Morocco would be virtually in balance with respect to chlorine and caustic soda.

The consequent production of excess caustic soda is not expected to cause difficulties. It would facilitate additional expansion in some type of paper pulp making and could be used as a substitute for some of the 12,000 t/a imports of soda ash.

The products of the proposed chlor-alkali pesticides complex include 33% HCl,83% H_2SO_4, DCB, DDT, BHC, Cl_2 and NaOH. The raw materials include ethanol, benzene and 98% H_2SO_4. Good communications would be essential for this complex and proximity to a salt supply (45,000 t/a) and to Kenitra for the Progharb pulp operation is most important. Another factor to consider is that the area between Fez and Kenitra is a major agricultural region and might be expected to use more pesticides than other areas.

The Fez/Taza regions would therefore deserve serious considerations because there are several underutilised salines in this region which are also central to the market area. Tissa, Taza or Ammasene could prove suitable and we recommend that these sites be investigated in detail before a decision is taken. We particularly suggest that the salt deposit at Taza presently exploited by Societe Benchekroun be investigated. There is suitable land for industrial development within 2 kms of the main Casablanca-Oujda railway and highway, the salt mine, a major river (water supply) and a 15 KV main power supply.

IV.4 Salt Supplies

Morocco has considerable reserves of salt and there should be little difficulty in remaining self-sufficient. However, there will be some difficulties in distribution because at the present time there is no working saline in the Casablanca-Rabat region. Demand from this region could exceed 30,000 t/a by 1980. Transport from El Jadida (from the South), Taza (from the East) or Larache (from the North) would be costly and is to be avoided.

For the Casablanca region, the investigations into the Berrechid Basin deposit should be pursued even though, for reasons explained in Chapter Two, the prospects for major exports are limited. Solution mining will be more economic than dry mining at this tonnage because of the 400 metres depth. The exact choice of location would therefore have to be determined primarily by the availability of water.

It is recommended that an organisation such as the Societe Cherifienne du Sel should establish a 30,000 t/a saline at this location to supply the regional market. Dividing Morocco into four regions future supplies might follow the pattern shown on the next page (Table 32).

Table 32

Morocco: Salt Supplies (t/a)

Central (Casablanca/Rabat)	Berrechid	30,000
South (El Jadida/Safi/ Essaouira)	Lac Zima Oualidia/Sidi Moussa	30,000
North (Tanger, Souk el Arba)	Larache Souk El Arba Nador	30,000
East (Fez/Taza)	Tissa Taza Ammassene	30,000

CHAPTER FIVE

ALGERIA

The proposals for Maghreb cooperation envisage that Algeria should supply Morocco with VCM until the demand for PVC in Morocco becomes large enough to justify investment by Morocco in all stages of PVC manufacture. Pesticides and soda ash would continue to be imported to Algeria and salt would be imported for some time from Tunisia. The first four sections of this chapter develop the reasons for these proposals as they affect Algeria. Other sections deal with problems specific to Algeria.

V.1 PVC

The market study in Chapter One suggested that by 1980, the demand for PVC in Algeria might exceed the 35,000 t/a capacity of the plant now under construction at Skikda. If this were so the provisional plans for doubling the Skikda capacity might have to be implemented by 1979 during the period ofthe 1977-80 Four Year Plan. If production capacity were increased at that rate, it would be considerably in excess of Algerian demand, and there would be a large amount of spare capacity except for short periods. In order to improve the economy of production, there is a strong case for maximising VCM production and selling VCM monomer.

The variable cost of producing VCM (in conditions of excess capacity) has been estimated at considerably less than $100/t. (VII.3.4.) World market prices for VCM are approaching $200/t. Although $200/t is below the full production cost, sales of VCM at this price would make a positive contribution to fixed costs and so it should be possible to negotiate a mutually advantageous arrangement with Morocco. (Morocco would find it profitable to invest in a 20,000 t/a polymerisation unit rather than continue PVC imports. Her needs for VCM in 1980 could reach 20,000 t/a). It should be noted however that there could be general overcapacity of PVC in Europe during the latter part of the 1970's and in such case it would be advantageous for Algeria to conclude long-term arrangements with Morocco for VCM sales rather than rely upon possible sales to other Mediterranean markets.

The potential demand for PVC in Tunisia seems insufficient, even by 1980, to justify Tunisian investment in even one polymerisation reactor, but arrangements to supply polymer to Tunisia should be worthwhile. The aim of any negotiations should be to enable Algeria to raise PVC production rates to an economic level in as short time as possible. The sales of VCM to Morocco and PVC to Tunisia should be encouraged in order to improve the economics of the Skikda investment.

V.2 Soda Ash

SNIC propose to construct a 100,000 t/a soda ash plant in the Oran region, near the present SNIV glass plant. The proposal raises several questions.

The first question is the justification for a production capacity of 100,000 t/a. The maximum need of SNIV for soda ash seems very unlikely to exceed 23,000 t/a in 1980 and, we estimated in Chapter One that no more than 5,000 t/a would be needed for other applications.

In order to boost the demand for soda ash, SNIC propose to build a 20,000 t/a TPP plant. This plant would be built at Skikda and would use chemical grade phosphoric acid obtained by purifying the fertiliser grade acid. But even at double that TPP capacity, the total overall Algerian demand would not reach 75,000 t/a of soda ash. At that capacity the production cost of soda ash would be too high to allow economic production of TPP (section III.3).

The assumptions supporting the proposal for a TPP plant also need exploration. In Chapter One it was pointed out that the market for detergents cannot be viewed in isolation from the market for soaps. It is doubtful that a demand for detergents as high as 100,000 t/a would develop by 1980. The potential demand for TPP in 1980 was estimated in Chapter One to be around 21,000 t/a requiring no more than 18,000 t/a soda ash.

But even assuming that TPP were to be produced economically and that demand at a profitable level were to be assured, more thought should perhaps be given to the choice of alkali as a raw material. TPP can be manufactured either from soda ash or from caustic soda. By 1979 Algeria may need to find outlets for excess caustic soda. At that stage, the manufacture of TPP from caustic soda (12,000 t/a for 21,000 t/a of TPP) could help solve a potential restriction on the growth of the plastics industry. (See also V.4 below).

Table 33

Algeria : Potential Chlor-alkali Imbalances in 1980 (t/a)*

Region	Chlorine Production (equals consumption)	Caustic Soda Production	Caustic Soda Consumption	Caustic Soda Imbalances
West (Mostaganem)	5,800	6,400	25,800	- 19.400
Central (Baba Ali)	7,200	7,900	15,950	- 8,050
East (Skikda)	54,000	59,400	4,850	+ 54,550
	67,000	73,700	46,600	+ 27,100

* Based upon the consumption figures of Table 26 which assumed VCM production at 80,000 t/a and no TPP production.

Table 33 summarises the probable demand for chlorine and caustic soda in 1980 in relation to production capacities and likely production rates. There are inevitably many unknown factors but the general uncertainty tends to reinforce the basic conclusion of the table ; that in 1980, Algeria will be self-sufficient in caustic soda and that further industrial developments would tend to create a caustic soda surplus.

Because of the need to maintain a balance between demand and production of caustic soda and chlorine, we recommend that if an investment in TPP manufacture is undertaken (section V.4), the plant should use caustic soda and not soda ash, as a raw material. On this basis, the Algerian demand for soda ash would not exceed 28,000 t/a in 1980. A soda ash plant could not be justified solely by the needs of the Algerian economy.

There could be a case for soda ash manufacture if this were based upon the overall needs of the Maghreb. However, as explained in Chapters Three and Six, Tunisia has better justification as a location for such a plant. In particular, the difficulties of supplying salt at an economic price to the proposed soda ash plant are considered insurmountable.

According to SONAREM, the maximum capacity proposed for the Arzew saline by 1980 will be 160,000 t/a. Production will be fully consumed by the Baba Ali and Mostaganem chlor-alkali plants and by existing domestic markets and exports. A 100,000 t/a soda ash plant needs 160,000 t/a salt and it is most improbable that this quantity could be supplied from the Oran region in the foreseeable future.

Because 1.6 tonnes of salt are needed for every tonne of soda ash produced, the plant must be located as close as possible to a large, cheap source of good quality salt. There is no such site now in Algeria. This is another fundamental reason for rejecting the idea of a 100,000 t/a soda ash plant located in Algeria.

V.3 Pesticides

The use of pesticides in the Maghreb was discussed in Chapter One. The reason for rejecting Algeria as the location of the proposed pesticides complex was stated briefly in Chapter Three. It is the potential shortage of chlorine (or more precisely a potential surplus of caustic soda). The problem of the chlorine/caustic soda balance, discussed above in relation to soda ash production, is again crucial to an understanding of the recommendations concerning pesticides.

If Algeria were to consider producing organo-chlorine pesticides, this would further aggravate the caustic soda surplus which could reach alarming proportions in the mid-1980's and restrict Algeria's ability to develop the PVC and plastics industries.

It would thus be much to Algeria's advantage not to embark upon the local production of organo-chlorine pesticides but to obtain DDT and BHC from Morocco on a negotiated basis if the Moroccan project is implemented.

V.4 TPP

In Chapter III, section III.3.4, it was shown that TPP cannot be manufactured economically with soda ash priced at $40/t or higher. Similarly, TPP cannot be manufactured economically from caustic soda unless the price of caustic soda is $60/t or less.

However, Algeria may find herself with a potential market for 80,000 t/a VCM (section V.1) and this may lead to an excess production of 27,000 t/a caustic soda (Tables 26 and 33). It could then be economically advantageous to use caustic soda at $60/t for TPP, at the same time enabling VCM manufacture to be expanded to satisfy this demand.

It is recommended that the possiblility of TPP manufacture be kept under constant review in the light of developments in the Maghreb markets for PVC/VCM, synthetic detergents, and caustic soda.

V.5 Salt Supplies

Algeria's demand for salt in 1980, excluding the requirements for Skikda, is expected to be substantially the same as the present level. Skikda's requirements would rise to 108,000t/a if this report's proposals for VCM were implemented.

SONAREM's plans for supply are to close the Hippone marine saline, expand the Arzew and Bouziane sebkha salines and to open up a new quarry at El Outaya to supply Skikda. The technical problems of the last proposals have been dealt with already in Chapter Three and need not be repeated here.

One aspect of this problem may be more appropriately dealt with as of concern to Algeria rather than as one of the general problems of salt production throughout the Maghreb. This is the special question of solar salt production which comes under the aegis of SONAREM which otherwise is concerned with mining and geology.

The technical support given to these salines is not adequate and this inadequacy may well result in production targets not being achieved. Greater understanding of all the essential scientific knowledge of the solar salt process would be beneficial. The sebkhas of Arzew, Bouziane, El Guemel and Oran are undoubted assets to the Algerian salt industry, but their full potential is not being realised. It is possible that the emphasis on mining in SONAREM may create a situation where new quarries are opened far from industrial centres whilst the sebkhas remain partially or wholly unused despite their greater potential.

V.6 Hydrogen

Hydrogen from chlorine electrolysis is of very high purity (minimum 99.99%) and is used in the manufacture of hydrogenated oils and fats (such as margarine). If such an outlet for hydrogen can be found it should be used for this purpose. As an example of the economic importance of this matter, it was learnt that SNCG are considering an investment in hydrogenation and that within this investment about 100,000 DA are needed for electrolysis of water to produce 99.99% pure hydrogen. Not more than 20 Kms away, at Baba Ali, SONIC is producing hydrogen of the required purity in quantities several times greater than needed by SNCG.

V.7 Coordination

The previous sections have drawn attention to matters about which coordination between Algeria's Societes Nationales would be helpful in obtaining the best results for the Algerian economy. The problems of coordination are complex because (as discussed in Chapter One) the chemical industry does not fall into any cearly defined administrative sector. In particular the chlor-alkali industry has an impact upon the activities of SONIC, SONATRACH, SNIC, SNCG and others at several different levels.

The necessary, but somewhat arbitrary divisions between different parts of the chemical and petrochemical industry necessitate close liaison. Subjects for liaison suggested by the present study are set out below. The links are suggested from the chart on the second page of Chapter One.

Soaps/Detergents/Washing materials - SNCG/SNIC/SONATRACH
Fertilisers - SONATRACH/SNIC/SNS

Coordination also would be valuable in such matters as purchasing. At present SNCG, SONITEX, SNIC and others import caustic soda separately at widely differing prices according to the quantities required and the effort expended in searching for supplies. It ought to be more economic to arrange for a single organisation (such as SNIC) to handle all caustic soda imports for the Societes as well as smaller users, thus securing better prices and eliminating duplication of effort. Similar arrangements should be equally useful for other chemicals.

CHAPTER SIX

TUNISIA

The implications for Tunisia of the major proposals for Maghreb cooperation (Chapter Three) are considered in this Chapter. In general industrial development in Tunisia is lagging behind that in the other two countries and greater emphasis could be placed upon industrial training. It could be valuable if the opportunity were given for selected technicians from Tunisia to be employed in the industries developing in Algeria and Morocco, where they could gain experience to be used later in their own country.

VI.1 PVC

The annual demand for PVC in Tunisia is not expected to exceed 8,000 tonnes by 1980 and, at this level, it would not be worth while investing in monomer manufacture, or even merely in polymerisation as proposed for Morocco (section VII.3.5).

Some degree of Maghreb cooperation is possible however if Tunisia were to purchase PVC polymer from Algeria on an agreed basis. Provided the PVC were sold at approximately the same price levels as obtained from the world market a secured supply should benefit Tunisia. In return for the PVC, Algeria would buy salt from Tunisia.

At present the processing section of the Tunisian plastics industry is growing vigorously, though some problems could arise if too many firms compete for too little total business. The Ministry of Economy is aiming to achieve a balanced development by controlling new entrants to the industry.

VI.2 Soda Ash

When considering the prospects for soda ash manufacture in Tunisia it is useful to recall the key estimates for chlorine and caustic soda demand and production for 1980 given in Chapter One, and that soda ash can be manufactured from caustic soda and caustic soda from soda ash.

Tunisian demand for chlorine (virtually all for SNTC) is estimated at around 4,000 t/a and caustic soda at around 11,000 t/a. SNTC may be expected to install sufficient capacity at Kasserine to satisfy their chlorine requirements thus reducing the potential deficit in caustic soda production to around 7,000 t/a.

There is little probability that the demand for chlorine in Tunisia could be stimulated sufficiently to employ electrolytic caustic soda production as a method of reaching the total demand level. PVC, DDT and BHC production facilities have been considered and ruled out because of the low market potential. The 7,000 t/a caustic soda deficit will presumably have to be met by imports or by local manufacture through a process which does not entail chlorine co-production. If, alternatively, the required quantity of caustic soda were to be produced from soda ash, the extra demand for soda ash would be approximately 11,000 t/a. Thus the total demands in the Maghreb upon a soda ash plant established in Tunisia would be some 59,000 t/a (see Tables 14 and 34). Allowing for the possibility of some export, the total demand from all sources might be about 71,000 t/a as shown in Table 34.

Table 34

Maghreb : Overall Demand for Soda Ash in 1980 (t/a)

	Internal (Table14)	For NaOH	Exports	Total
Morocco	11,500	-	-	11,500
Algeria	28,000	-	-	28,000
Tunisia	8,500	11,000	12,000	31,500
Maghreb	48,000	11,000	12,000	71,000

The calculations of section VII 3.1 indicate that a soda ash plant of 75,000 t/a could only be viable at a soda ash price of $100/tonne but at this price soda ash could be more economically manufactured from caustic soda(The current soda ash import price is $50-60/tonne). The process economics improve if the "dual process" (producing Ammonium Chloride fertiliser coproduct) were to be employed. However, no trials have been conducted on the efficacy of this fertiliser in any of the Maghreb countries. It is recommended that the possibility of organising a programme of trials for this fertiliser should be examined.

The possible location of the plant is to some extent affected by the choice of process route. In the "dual process" ammonia carbon dioxide and salt are the major raw materials, whereas for the traditional Solvay process limestone replaces ammonia in importance. If the Solvay route is chosen the location near Tunis may be preferred because of its proximity to a local limestone quarry. For the dual process Sousse has advantages.

VI.3 Pesticides

The demands for DDT and BHC in Tunisia are not expected to exceed 300 t/a and 200 t/a respecitively by 1980. This is clearly insufficient to warrant investment. Moreover at present opinion in Tunisia does not appear to favour the use of organo-chlorine pesticides.

Much of the difficulty in promoting the application of pesticides in Tunisia appears to stem from weaknesses in the 'formulation' sector of the industry. Decisions with respect to the chemicals employed seem to be taken primarily to resolve the problems of existing formulation plants. Clearly it is necessary for Tunisia to consider the structure of the industry as a whole from production of the basic materials, to improve the formulation section and to encourage a national appreciation of the value of pesticides to agriculture. If the needs of agriculture were given due importance, the demand for DDT and BHC could be increased several times.

VI.4 Salt

The proposal in Chapter Three that Tunisia should supply about 50,000 t/a of salt to the Skikda PVC complex would mean that productive capacity had to be increased by more than 15% over a 6-7 year period (assuming that the 350,000 t/a export level is maintained). There is no technical reason why this cannot be achieved, provided that investment is adequate. Indeed this is hardly more than the rate of increase envisaged in the 1973-1976 Four Year Plan.

It is not, however, ideal that over 90% of Tunisian salt is exported for an income less than the cost of the imports of the major derivatives of salt (caustic soda, soda ash, and PVC). Should a decision be made at some time in the future to manufacture soda ash from salt in Tunisia, it would go some way towards improving this situation and at the same time provide some insurance against world market fluctuations.

CHAPTER SEVEN

DATA AND COST ESTIMATIONS

VII.1 Data

Throughout this report local costs are given in local currencies. All other costs are given in U.S. Dollars.

Table 35

Currency Exchange Rates

Moroccan Dirham	:	1 DM = 1.097 Francs = $0.241
Algerian Dinar	:	1 DA = 1.125 Francs = $0.247
Tunisian Dinar	:	1 DT = 10.58 Francs = $2.32

The prices in Table 36 (over page) are either those prevailing currently in Maghreb countries or are based on West European levels with an allowance for transport costs - the latter for products which are not imported at present or only imported in small quantities.

Since all prices are subject to fluctuations, the levels chosen reflect some judgement with respect to future trends.

Table 36

Prices used in the Calculations ($/t)

Caustic Soda	100	$95/t transfer price (ex-works)
Soda Ash	75	Maximum price in the Maghreb
Salt (i)	5	Tunisia, industrial users
(ii)	12	Algeria, industrial users
(iii)	9	Morocco, industrial users
DDT	450	Could rise by 1980
BHC	200	Could rise by 1980
VCM	200	Could fall by 1980
PVC	310	Will move in step with VCM
Limestone	3	Tunisia only
Benzene	80	West European levels
Ethanol	135	West European levels
Ethylene	100	West European levels
Fuel Oil	20	West European levels
33% HCI	30	Commercial grade
98% H_2SO_4	30	Commercial grade
H_3PO_4	150	Commercial grade (100% basis)
TPP	200	West European levels

VII.2 Basis of Calculations

The calculations of the following section (VII.3) are taken to the degree of accuracy necessary for the conclusions of this report - that is, to identify projects requiring further consideration in depth, distinguishing them from those that can be eliminated. For such a level of accuracy it is not necessary to assess the relàtive merits of competing processes or to define the precise requirements for raw materials and utilities. The main items of the cost estimations and the assumptions used, are as follows:

VII.2.1 Capital investment ($ millions)

This item includes studies, design, equipment, construction, commissioning, inventory, spares, and off-sites - in other words, all items except land in the investment costs for a new plant. In the case of a manufacturing unit within a complex, it is assumed that the cost of off-sites is shared with other units.

VII.2.2 Capital dependent costs ($ millions)

This item includes depreciation (at 10%),maintenance (4-5%), insurance,plant ,overheads and other small items (3-4%). The annual cost thus is taken to be 18% of the fixed capital investment (except in the special case of pipeline costs). It is appreciated that the components of this item in reality will vary with each plant, process and site but the figure of 18% is considered a fair average for the purposes of these calculations. Note that financial charges are not included in this item.

VII.2.3 Labour and Related Costs ($ millions)

These costs include the wages of all employees, supervisors and salaried staff associated with the plant - and the costs of social benefits and other charges arising from their employment. Allowance is made for the fact that Algerian costs are higher than Moroccan and Tunisian costs for this item, approximate global figures per plant employee averaging $6,000/a (Algeria) and $4,000/a for the other two countries.

With respect to the number of plant employees needed, it is assumed that 50% more would be used under Maghreb conditions than would be normal under West European conditions. In no instance does this assumption critically affect the results of the cost calculations.

VII.2.4 Raw Materials and Utilities ($/tonne product)

In general it is assumed that the raw materials and utilities will be consumed at approximately the rates claimed by major licensors of the relevant processes. In certain instances (for example, salt and power in chlorine manufacture), the figures taken are somewhat higher. The higher figures reflect assessments of the quality of the raw materials required, the experience of the plant operators and also (of great significance), that the performance during a test run of a plant is rarely achieved on a continuous basis. To simplify presentation utility costs are grouped together except when a single item exceeds 30% of the total.

VII.2.5 Financial charges and return on investment

It is impossible to forecast with any certainty the terms for financing these capital projects or what rate of return is likely to be considered acceptable at any particular time in the future. To avoid making possibly invalid assumptions, most calculations merely estimate the available margin as an annual percentage of the capital investment. Wherever this method cannot be used (for example, in calculating the transfer price for chlorine manufactured in a chlor-alkali plant and used in VCM manufacture) a figure of 20% on the capital investment has been taken. When expressed in terms of unit output, this figure assumes that the production is at 100% capacity for the entire life of the project. In practice, this is rarely achieved and the capital dependent costs per tonne of product tend to be higher than the levels shown in the calculations (and hence the available margins to be lower).

VII.3 Cost Estimates

The presentation of each calculation is preceded by a brief process description and is followed by comments upon the implications of the results of each calculation.

VII.3.1 Soda Ash (from salt)

The economics of soda ash production at 75,000 t/a and 100,000 t/a are estimated for the Solvay and "Dual" processes.

In the "Dual" process, salt, ammonia and carbon dioxide are reacted to give sodium carbonate (soda ash) and ammonium chloride in equal quantities.

The traditional Solvay route includes all the stages of the "Dual" process, but, in addition, involves the recovery of ammonia from the ammonium chloride (by reaction with lime) and the re-cycling of the ammonia. The lime and the carbon dioxide are obtained from limestone and calcium chloride is a waste product.

	Solvay		Dual	
	75,000t/a	100,000t/a	75,000t/a	100,000t/a
Capital investment ($ millions)	21	25	19	23
Fixed Costs ($ millions)				
Capital-dependent	3.8	4.5	3.4	4.1
Labour etc.	0.3	0.4	0.4	0.5
Total	4.1	4.9	3.8	4.6
(as $/t)	55	49	51	46
Variable Costs ($/t)				
Salt @ $5/t	9.0		6.2	
Limestone @ $3/t	3.3		-	
Other items (not ammonia)	10.6		9.8	
Sub-total	22.9		16.0	
Credit for ammonium chloride over ammonia	+0.1		-3.0	
Total	23.0		13.0	
Overall production cost ($/t)	78	72	64	59

Since this calculation makes no allowance for loan charges and return on capital, and since the maximum price at present for soda ash is $75/t (usually much lower) it is clear that investments in soda ash manufacture at the above capacities would not be economic using the Solvay or Dual process.

VII.3.2 Soda Ash (from Caustic Soda)

The economics of soda ash production from caustic soda are estimated, on the assumption that carbon dioxide is available at negligible cost (for example, from a flue gas).

In this process a 50% caustic soda solution is reacted with waste flue gases in a spray type reactor. This evaporates most of the water simultaneously with the converstion to sodium carbonate. The product discharged from the spray reactor is further dehydrated in a drier.

	15.000t/a	30,000t/a	45,000t/a
Capital investment ($ millions)	0.28	0.33	0.37
Fixed Costs ($ millions)			
Capital dependent	0.05	0.06	0.07
Labour, etc.	0.02	0.02	0.02
Total	0.07	0.08	0.09
(as $/t)	4.7	2.7	2.0
Variable Costs ($/t)			
Caustic soda @ $95/t 0.71t/t		67.5	
All other conversion costs		3.7	
Total		71.2	
Overall production costs ($/t)	75.9	73.9	73.2

This calculation, which ignores financial charges and any return on investment, shows that with soda ash at $75/t or less it is not possible to manufacture it economically from caustic soda at $95/t by this process at the above capacities.

These figures can be used to calculate the relative prices of the two chemicals at which this process could become economic. With 20% on investment for loan charges and a satisfactory return on the investment, total conversion charges are $13.1/t for the 15,000 t/a plant. (Total conversion costs are $4.7/t fixed costs, $3.7/t 'other' conversion costs, $4.7/t for the 20% on investment, totalling $13.1/t). For example with soda ash at $70/t this leaves $56.9 available for caustic soda which, at 0.71 t/t usage, implies a caustic soda price of $80/t. The following table is derived from similar calculations for other price levels.

Table 37

Soda ash from caustic soda

Relative prices for economic production at various capacities ($/t)

	Maximum caustic soda price		
Soda ash price	15.000t/a	30,000t/a	45,000t/a
70	80	86	88
60	66	72	74
50	52	58	60
40	38	44	46

The excess caustic soda expected for 1980 in Algeria is 27,000 t/a which at $95/t would enable 36,000 t/a soda ash (the total Maghreb demand) to be manufactured at $77/t. This would still be greater than the expected 1980 soda ash price. In order for Algeria's excess caustic soda to be used in this manner, the price would have to drop to around $60/t giving a soda ash price of $50-$55/t.

VII.3.3 Chlorine (for VCM at Skikda)

Chlorine is manufactured by the electrolysis of brine, caustic soda and hydrogen being essential co-products. Very often significant quantities of chlorine are reacted with hydrogen (to give hydrochloric acid) or caustic soda (to give sodium hypochlorite) at the same location - these being optional co-products of a chlor-alkali unit. For the purpose of these calculations, only chlorine and caustic soda are considered.

The economics of chlorine production are considered for three cases, the figures corresponding to the various levels of VCM production considered in section VII.3.4.

(a) VCM production at 40,000 t/a would need 26,500 t/a chlorine. Allowing 4,000 t/a for other chlorine uses near Skikda this would mean 85% utilisation of the 36,000 t/a chlorine plant now under construction at Skikda.

(b) VCM production at 80,000 t/a would need 53,000 t/a chlorine Again allowing 4,000 t/a for other local chlorine consumption this would mean 57,000 t/a chlorine consumption. In case (b) this would be achieved by doubling the 36,000 t/a chlorine capacity and operating at 80% utilisation.

(c) Case (c) is the same as case (b) except that the plant capacity would be 57,000 t/a chlorine operating at 100% capacity.

These calculations coupled with those of section VII.3.4 show that:

(a) it would be economically beneficial to export VCM at world market prices in the event of Algerian VCM demand not reaching the Skikda plant capacity;

(b) the investment in VCM and chlorine production at Skikda will not show a sufficient economic return to attract Moroccan and Tunisian capital in a joint venture.

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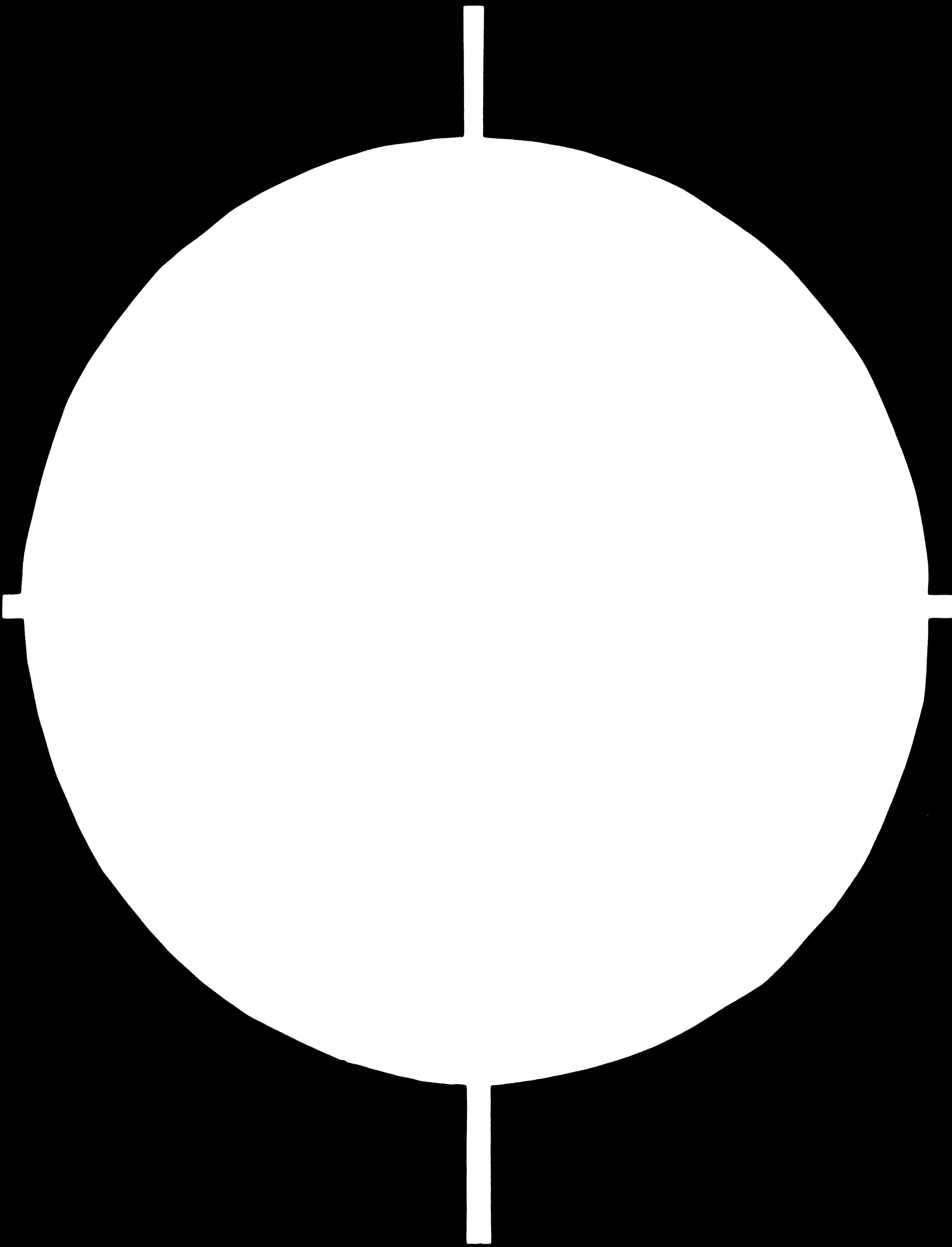

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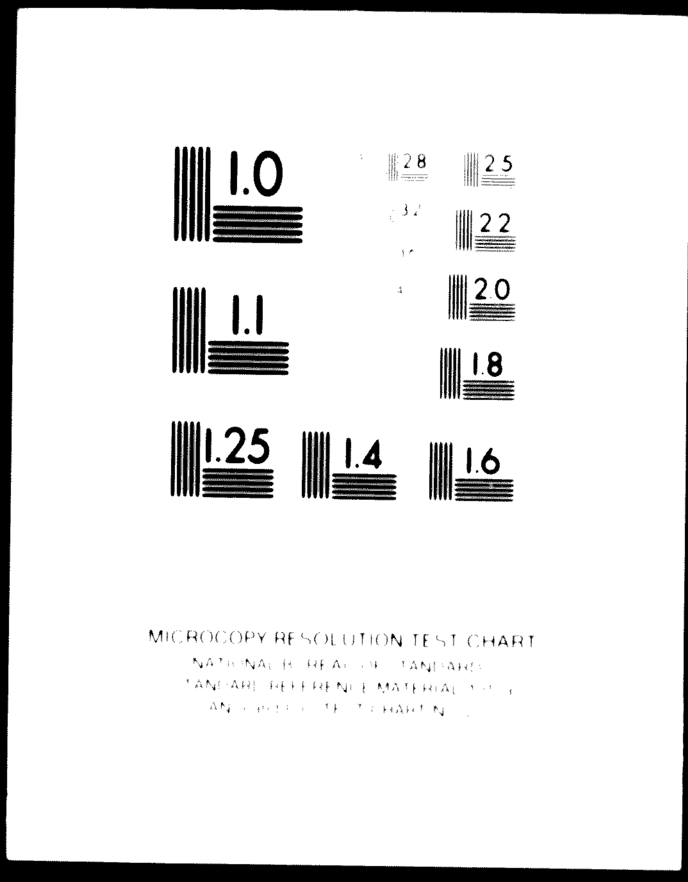

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	(a)	(b)	(c)
Plant capacities (chlorine)	36,000t/a	2x36,000t/a	36,000t/a + 21,000t/a
Chlorine production	30,500t/a	57,000t/a	57,000t/a
Capital investment ($ millions)	10.0	18.0	15.0
Fixed Costs ($ million)			
Capital dependent	1.8	3.3	2.7
Labour, etc.	0.2	0.3	0.3
Total	2.0	3.6	3.0
(as $/t)	67	63	53
Variable Costs ($/t)			
Salt @ $12/t, usage 2.0t/t	24	(licensors quote 1.8t/t)	
Power costs	46	(4,500 KWH/t overall)	
Brine treatment (for good Tunisian salt)	10		
Other variable costs	25		
Total	105		
Less credit on caustic soda @ $95/t 1.1t/t	105		
Net variable costs	Zero		
Overall production costs ($/t)	67	63	53
20% of investment as $/to)	67	63	53
Minimum selling price	134	126	106

It will be noted that these minimum economic prices are much higher than the $70/t chlorine price normally expected under West European conditions. The blame for this rests primarily with the size of the plants and their low loading. Over $20/t could be saved in cases (a) and (b) if the plants were to be operating at full capacity. By contrast, not more than $15/t would be saved if peak operating efficiency were to be achieved. Another useful saving of around $10/t would have been possible had the plant been located close to a cheap source of purer salt.

The implications of the "zero" net variable cost need to be fully understood. This figure is achieved by virtue of the income derived from the sale of the co-product caustic soda. It means that at this price, the caustic soda may be considered to pay for the cost of raw materials and utilities whereas income from sales of chlorine may be considered as available to pay for the fixed costs and financial charges. Since the latter costs have to be paid anyway (because they are "fixed" costs), it means that sales of chlorine, whatever the price, make a positive contribution to the fixed plant expenses even though the price has to exceed \$134/t, \$126/t and \$106/t for the capacities calculated in order for the investment to show an economic return.

On the other hand, if the price of caustic soda were to drop to (say) \$60/t the net variable cost would rise to around \$40/t. (Note: at \$60/t for caustic soda, the calculations of section VII.3.2 indicate that soda ash can be produced economically from caustic soda). From this stage onwards, the price of chlorine would need to exceed \$40/t for there to be a net positive income: below this figure the costs of raw materials and utilities would exceed the income that could be derived from the combined sales of chlorine and caustic soda.

VII.3.4 Manufacture of VCM

Vinyl Chloride Monomer (VCM) is manufactured by the reaction of ethylene and chlorine firstly to form ethylene dichloride (EDC) which is then cracked to form VCM with the evolution of HCl. A second reaction train produces EDC by the oxychlorination of ethylene and HCl. Thus there need not be any net production of by-product HCl - although in countries with a high demand for HCl this is quite common.

Cases (a), (b) and (c) below correspond to the three cases of chlorine production of section VII.3.3. Case (a) corresponds to a single 40,000t/a plant whilst cases (b) and (c) both correspond to a doubling of this VCM capacity but with different chlorine transfer prices as calculated in VII.3.3. For comparison a completely hypothetical case (d) also is calculated assuming that chlorine is available at \$70/t (West European level) for a single 80,000t/a VCM unit.

	(a)	(b)	(c)	(d)
Capacity VCM	40,000t/a	2x40,000t/a	2x40,000t/a	80,000t/a
Production VCM	40,000t/a	80,000t/a	80,000t/a	80,000t/a
Chlorine price ($/t)	134	126	106	70
Capital investment ($ millions)	6.5	11.5	11.5	10.0
Fixed Costs ($ millions)				
Capital dependent	1.17	2.06	2.06	1.80
Labour etc.	0.13	0.18	0.18	0.15
Total	1.30	2.24	2.24	1.95
(as $/t)	32	28	28	25
Variable costs ($/t)				
Ethylene @ $100/t 0.48t/t	48	48	48	48
Chlorine 0.66t/t	89	83	70	46
Other variable costs	15	15	15	15
Total	152	146	135	109
Overall production costs ($/t)	182	174	161	134
*Margin ($/t)	18	21	34	66
(as $ millions)	0.72	1.44	2.48	5.29
% on investment				
100% throughput	11%	13%	21%	53%
90% throughput	4%	7%	15%	52%

*Note: In cases (b) and (c) allowance is made for the $20/t transport costs to Morocco of a quarter of the VCM production since $200/t is the assumed cif price. In these two instances 20,000t/a VCM exports from Algeria would be necessary if 100% utilisation is to be achieved.

The previous calculations confirm that the initial Skikda investment in chlorine and VCM (reflected by case (a) above) will not show a commercial return. Should PVC consumption rise as hoped, a doubling of VCM and chloralkali capacity will be possible. This (reflected by case (b) above) would improve the production economics. A further improvement would occur if chloralkali capacity were to be kept closer to demand as in case (c). Nevertheless the economic returns from case (b) and (c) are not very attractive particularly when the likelihood of periods of under-utilisation also are considered. The effect on profitability for 90% utilisation is given at the end of the calculations and indicate that on such a basis the margins would not be sufficient even to pay for the loan charges.

But in reality the doubling of VCM and chloralkali and VCM capacities at Skikda is not likely to produce the margins suggested by the calculations of case (b). The chlorine price used assumes a netback from the sales of caustic soda at $95/t (VII.3.3). But the manufacture of 80,000t/a VCM implies that the Algerian production of caustic soda will exceed demand by 27,000t/a (Table 33). In order for this excess to be sold or used for the manufacture of soda ash or TPP, the price may have to drop to around $60/t (VII.3.2) - equivalent to around $945,000 or $12/t for each of the 80,000 t/a VCM. This is 2/3 of the available margin calculated for case (b).

One aspect of these calculations which is of great importance concerns the variable costs of producing VCM. Supposing that consumption of VCM has not reached plant capacity, what are the marginal costs of producing extra VCM? In this instance the fixed costs will still have to be paid and the variable costs indicate at what VCM price additional sales would contribute a positive income to help pay for these fixed costs.

<u>Variable costs of VCM</u> ($/t)	
Ethylene @ $100/t 0.48 t/t	48
Chlorine @ zero variable cost (see VII.3.3)	-
Other variable costs	<u>15</u>
	63

This calculation shows that VCM sold at $200/t would make a considerable positive contribution towards payment of the fixed costs. Although this price is insufficient to make the investment economic, sales at this price level would help reduce the operating deficit. So, if Algerian demand for VCM is insufficient to utilise plant capacity fully, efforts should be made to export VCM. Moreover the arguments for this policy remain valid even if the caustic soda price were to drop to $60/t adding $30/t to the VCM marginal price.

<u>VII.3.5 Polymerisation of PVC</u>

Several different techniques are employed to polymerise Vinyl Chloride Monomer (VCM). The most common is bulk polymerisation as opposed to emulsion, suspension and solution polymerisation. The costs below are for bulk polymerisation.

	8,000t/a	14,000t/a	20,000t/a
Capital investment ($ millions)	1.9	2.7	3.3
Fixed Costs ($ millions)			
Capital dependent	0.34	0.49	0.59
Labour etc.	0.14	0.16	0.18
Total	0.48	0.65	0.77
(as $/t)	60	46	38
Variable costs ($/t)			
VCM @ $200/t.1.05t/t	210		
Other variable costs	20		
Total	230		
Overall production costs ($/t)	290	276	268
Margin on $310/t	20	34	44
(as $ millions)	0.16	0.48	0.88
% on capital investment	8%	18%	27%

These calculations show that a polymerisation unit with a capacity of 20,000t/a or more can be an economic investment and that this conclusion remains valid so long as the difference between VCM and PVC prices continues at about $110/t. In other words an investment in a 20,000t/a polymerisation unit would be reasonably secure against price fluctuations so long as PVC and VCM prices move in step.

VII.3.6 Chlorine (for DDT and BHC, Morocco)

The electrolysis process for chlorine production is the same as that envisaged in section VII.3.3 for Skikda. The different costs used take into account Moroccan conditions. Salt is expected to be cheaper, due to lower transport costs, but not of as high purity as the Tunisian salt envisaged for Skikda. As mentioned earlier, labour costs are not as high as in Algeria. Two cases are envisaged:

(a) 12,000t/a chlorine production to satisfy envisaged domestic demand for 1980 (mainly for Progharb);

(b) 22,000t/a chlorine production as for (a) above but also supplying around 10,000t/a chlorine to the proposed DDT and BHC units.

This calculation is used in order to estimate the unit cost of chlorine supplied to the BHC and DDT units and is based upon the market assessments of 4,600t/a DDT and 1,500t/a BHC estimated in 1980. In practice any variation in the output would affect chlorine throughput and hence chlorine costs. This factor is ignored in the calculations of sections VII.3.7 and VII.3.8 but does not critically affect the result of the conclusions.

	(a)		(b)
	12,000t/a		22,000t/a
Capital investment ($ millions)	5.0		7.0
Fixed costs ($ millions)			
Capital dependent	0.9		1.26
Labour etc.	0.1		0.15
Total	1.0		1.41
(as $/t)	83		64
Variable costs ($/t)			
Salt @ $9/t usage 2.0t/t		18	
Power costs		46	
Brine treatment		12	
Other variable costs		25	
Total		101	
Less Credit on caustic soda @ $95/t 1.1t/t		105	
Net variable costs		-4	
Overall production costs ($/t)	79		60
20% of investment as $/t	83		64
Minimum economic selling price ($/t)	162		124

The difference between these two represents a saving of $38/t due to the economies of scale. In effect the additional demand for chlorine for the DDT and BHC units has reduced the unit cost of chlorine by $38/t - a benefit of $38/t x 12,000t/a = $454,000. Thus each tonne of the 10,000t/a chlorine needed for pesticides can be considered to contribute $45.4 towards reducing the cost of the other chlorine outlets.

This saving must be taken into account when assessing the economic usefulness of the DDT and BHC investment. For the purposes of this report, this saving is contained within the transfer price of chlorine to the pesticides unit giving a transfer price of $79/t to the pesticides units and a selling price of $162/t to domestic users. In practice a different accounting procedure probably would be used to account for the relative economic contributions of the pesticides unit and the other chlorine consumers.

But, whatever accounting method is used this has no effect upon the calculations of overall financial benefit to Morocco as a whole, even though it may well affect the economic benefit received by each manufacturing enterprise.

VII.3.7 DDT (Morocco)

Pure DDT is 1,1,1 - trichloro - 2,2 - bis (p-chlorophenyl) ethane. It is synthesised from chloral and monochlorobenzene (MCB) by a condensation reaction in the presence of 98% sulphuric acid (which is discharged when diluted to 83%). Chloral and MCB are obtained from the chlorination of ethanol and benzene respectively, in both instances with the evolution of HCl gas and in the latter, instance with the co-production of dichlorobenzenes (mainly ortho- and para-)which normally can also be sold.

The economics of DDT production are thus heavily dependent upon the sales of by-products H_2SO_4, HCl, PDB and ODB.

	1,000t/a		3,000t/a		5,000t/a
Capital investment ($ millions)	1.1		2.2		3.3
Fixed Costs ($ millions)					
Capital Dependent	0.20		0.40		0.60
Labour, etc.	0.16		0.20		0.24
Total	0.36		0.60		0.84
as ($/t)	360		200		168
Variable costs ($/t)					
Chlorine @ $79/t, 1.8t/t		142			
Benzene @ $80/t, 0.75t/t		60			
Ethanol @ $135/t, 0.30t/t		40			
98% H_2SO_4 @ $30/t, 1.8t/t		54			
Other variable costs		25			
Total		321	....	321	
Less, 83% H_2SO_4 @ $24/t, 1.5t/t		36			
33% HCl @ $30/t, 2.5t/t		75			
ODB and PDB @ $700/t, 0.05t/t		35			
		146	....	146	
Net variable costs				175	
Overall Production Costs ($/t)	535		375		343
20% on capital investment ($/t)	220		150		133
Minimum Economic Selling Price ($/t)	755		525		476

These calculations show that investment in a 3,000-5,000 t/a DDT plant would not be economic with DDT priced at $450/t and that the economics of DDT manufacture are heavily dependent on outlets for NaOH, H_2SO_4, HCl, DCBs and the chlorine price. For 4,600 t/a DDT the minimum economic selling price would be around $500/t (if all assumptions used in the calculations prove valid).

VII.3.8 BHC (Morocco)

BHC is produced by the reaction of gaseous chlorine with benzene under ultra-violet radiation. The reaction product is neutralised and the excess benzene recycled. Molten BHC normally is flaked, dried and conditioned, before bagging.

		1,000 t/a		3,000 t/a	5,000 t/a
Capital investment ($ millions)		0.30		0.60	0.85
Fixed Costs ($ millions)					
Capital-dependent		0.054		0.108	0.155
Labour, etc.		0.060		0.100	0.140
	Total	0.114		0.208	0.295
	(as $/t)	114		69	59
Variable Costs ($/t)					
Chlorine @ $79/t, 0.77t/t			61		
Benzene @ $80/t, 0.36t/t			29		
NaOH @ $95/t, 0.04t/t			4		
Other variable costs			5		
	Total		89		
Overall Production Costs ($/t)		208		163	153
20% of capital investment ($/t)		60		40	34
Minimum Economic Selling Price ($/t)		263		198	182

This calculation shows that, at $200/t, BHC production is not economic below 3,000 t/a and that the costs are largely dependent upon the price of chlorine and sales of caustic soda. For 1,500 t/a BHC production the minimum economic selling price would be around $240/t if all assumptions prove valid.

VII.3.9 Salt Transport

Three forms are considered; rail, sea and pipeline. In all three cases actual costs would be critically dependent upon local conditions. The discussion is intended to indicate the circumstances under which each technique may be used.

(a) Rail

In West European conditions, with relatively fully utilised rail networks, salt transport costs by rail average \$0.02 to \$0.04 per tonne-kilometre plus about \$2 to \$4 at each end for loading and unloading. In Maghreb conditions rail costs will probably be higher (because of low utilisation) even though - through government policies - costs may not be fully reflected in higher prices. By contrast, loading and unloading costs could be lower because of lower labour costs. Taking these factors into account, the costs of transporting salt from El Outaya to Skikda probably would be in the range \$8 to \$12 per tonne. From Arzew to Skikda the equivalent costs could be \$11 - \$16 per tonne.

(b) Sea

The costs of sea transport depend primarily upon the availability of suitable ships. For example the large scale exports of Tunisian salt are dependent upon the Scandinavian trade in wood and other commodities to Italy and nearby countries. After the wood is unloaded, these ships are available to take salt back to Scandinavia and countries en route.

When ships are available (and port loading and unloading facilities exist) shipping costs from Tunisia to Western Europe vary between \$2 and \$5 per tonne. Assuming ships are available the costs of salt transport by sea between the Maghreb countries could be around \$3/tonne.

The price would be similar or lower if ships or barges were bought or constructed to transport Maghreb salt, providing that return loads for the salt shipments could be found.

(c) Pipeline

In several countries salt is transported by pipeline in a slurry using saturated brine as a carrier. (With minor dilution this brine has the average strength of cell feed brine to a diaphragm cell electrolysis installation). The costs of pumping over a distance of more than 30 kms can range between $0.005 and $0.01 per tonne-kilometre.

It may be appropriate to consider constructing a pipeline between the Saline d'Arzew and Mostaganem. This pipeline could have three purposes :

to transport salt (as a slurry) to the port for exports and possible shipments to Skikda, following the closure of the salt jetty at the port of Arzew in 1975.

to deliver 25% brine to the proposed Mostaganem chlor-alkali plant.

to pump sea-water from Mostaganem to the saline, during the wet season, to supplement the rainfall and thus increase the potential salt production.

The construction of a 150 mm pipeline between Mostaganem and the Saline d'Arzew might cost around $0.5 million and have operating costs of about $50,000 t/a (including the capital-dependent charges, maintenance, labour, pumping costs, loan repayments and return on investment). Such a pipeline would be capable of delivering more than 50,000 t/a salt (as brine and salt)to Mostaganem (at around $1/tonne salt equivalent) and supplementing the potential annual production at the saline by up to 10,000 t/a.

VII.3.10 VCM Storage and Transport

To transport VCM from Skikda to Morocco, loading and reception facilities would be necessary. An indication of the estimated cost of these facilities is given below, assuming shipment of 22,000 t/a of VCM.

	$
Skikda loading station	300,000
Moroccan reception terminal (assuming polymerisation plant next door)	250,000
	550,000

10% depreciation $ 55,000

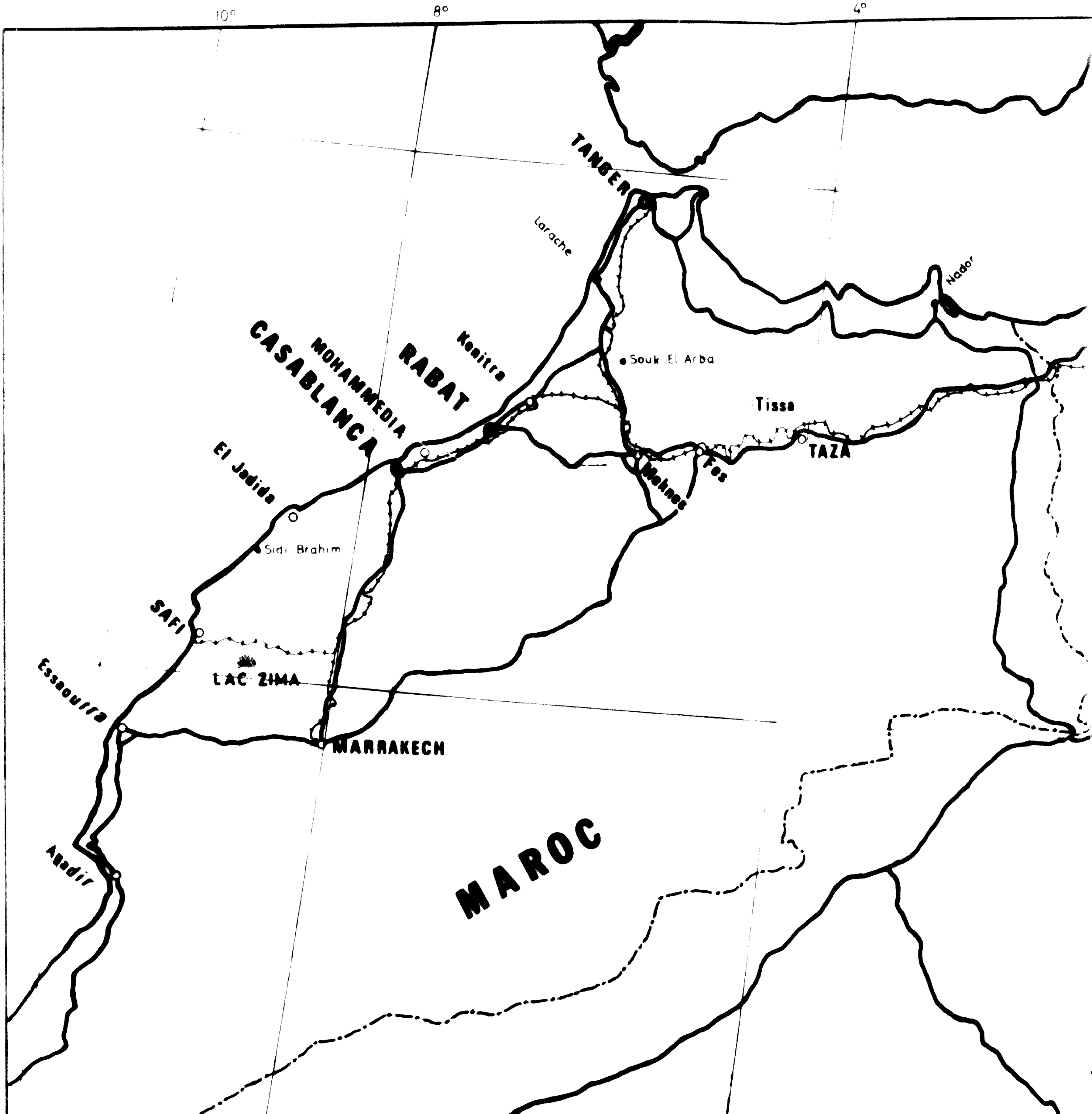
or $\frac{\$55,000}{22,000}$ = $ 2.50/t VCM

Shipping costs are estimated at about $17.50/t on current charter freight levels. This is based on 6/900 tonne lots, for 20-25,000 t/a, at a rate of about one shipment per week.

On the above basis, the total costs for storage and transport of VCM by sea from Skikda to Morocco would be as follows.

	$/t
Storage	2.50
Shipping	17.50
	20.00

Operating costs at both terminals are excluded; these are however relatively small and would be absorbed by the Skikda complex and the Moroccan PVC plant.



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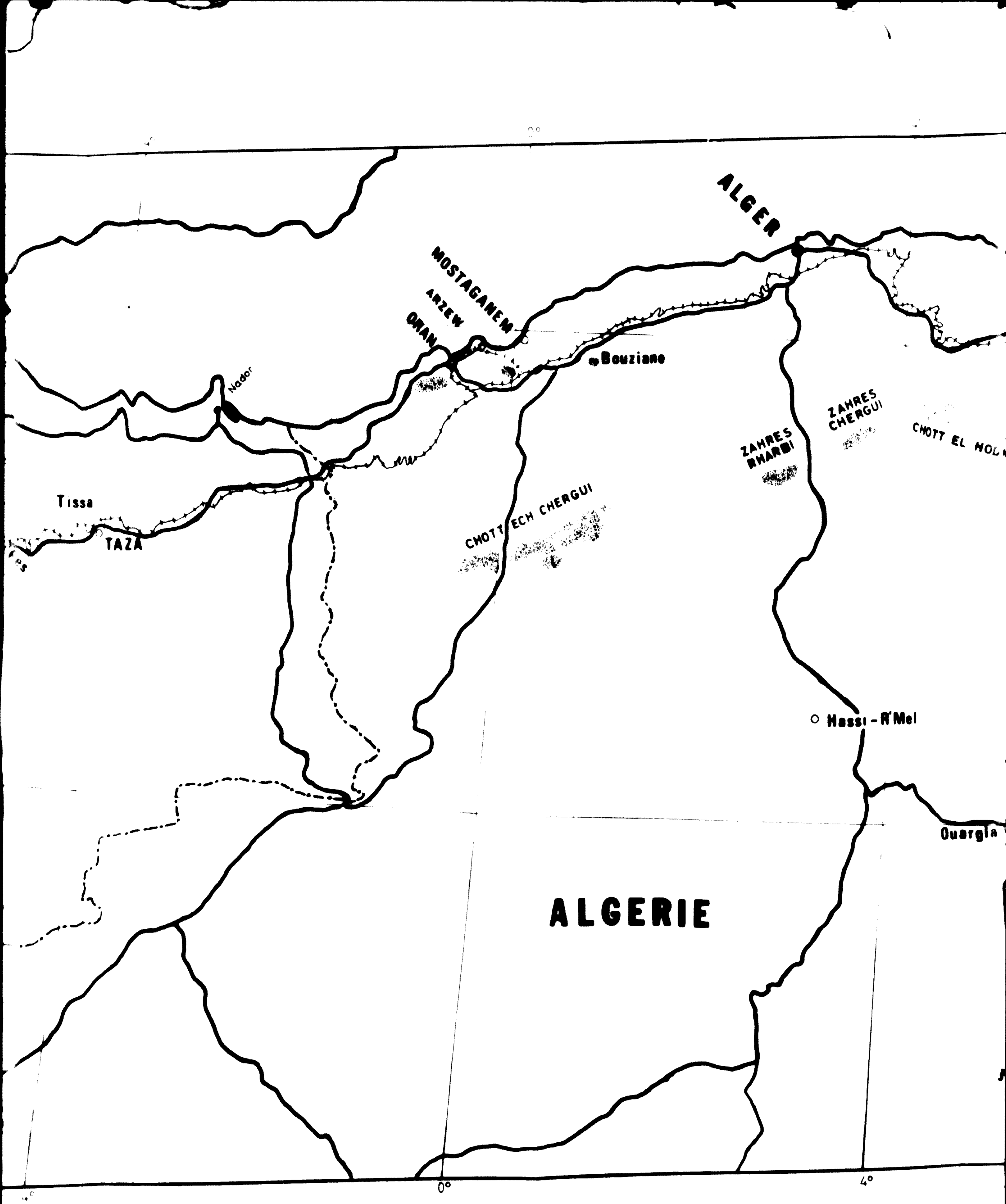
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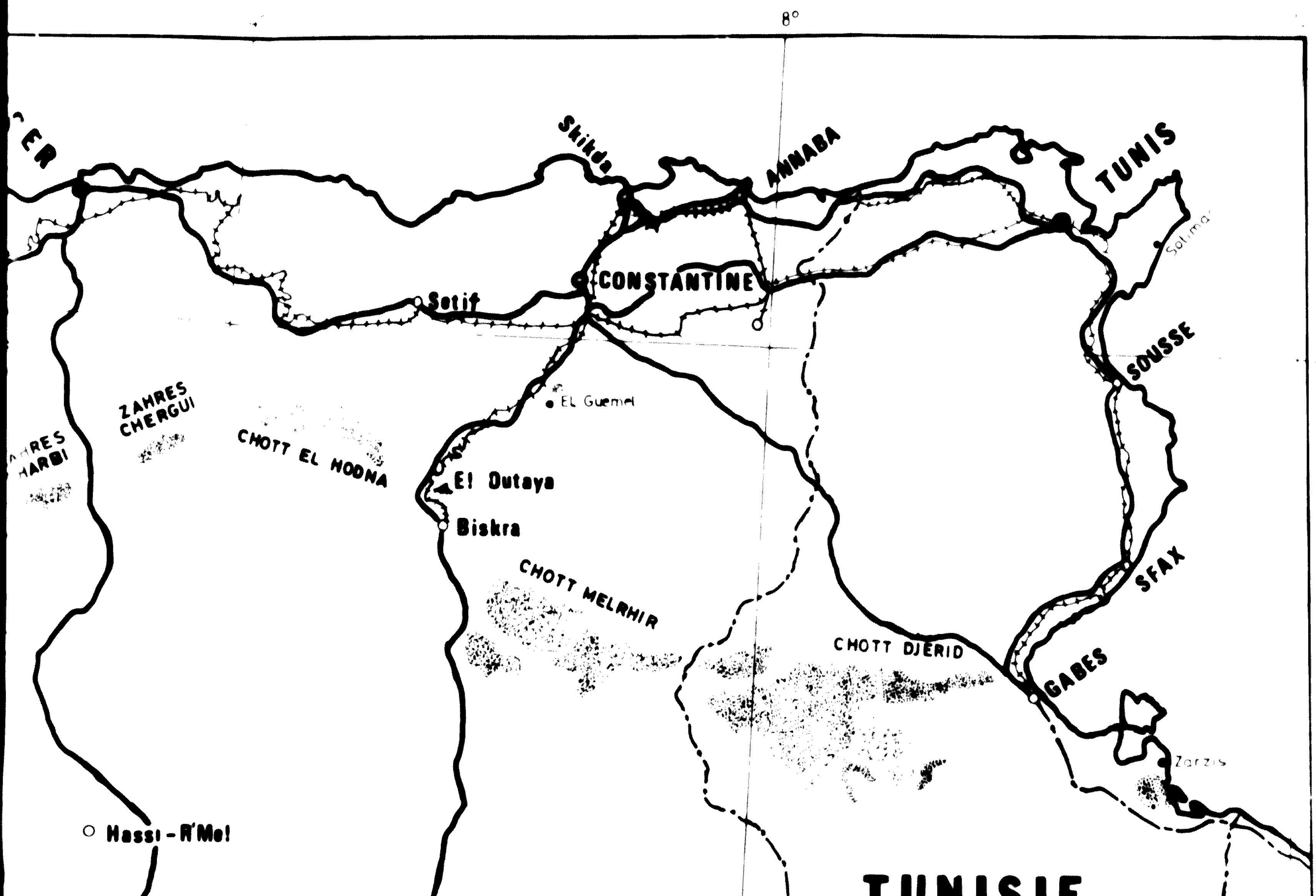
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