Development of the Salt Deposits of North East Thailand

*By Kevin Rolfe**

Summary

North East Thailand has massive deposits of rock salt. They haven ot been developed on a large scale because the processes considered to date do not produce chemical products of particular value.

In this paper the desirability of utilising the salt deposits is analysed with regard to the industrial development of the area. The various possibilities for doing so are also considered.

The writer concludes that a little-known process called the Monocycle Process, which has the nitrogenous fertiliser Ammonium Chloride as a co-product, has the greatest potential for development.

Inroduction

North East Thailand (or, the Thai name for it, Pak Isan) is generally considered to be an area with infertile land, of relative poverty and supporting a rather high (by Thai standards) population density. In some provinces of Pak Isan the peasant holdings arc too small to allow families to have a standard of living comparable to that in other parts of Thailand. This causes workers from the North East to migrate to Bangkok and to other provinces where areas are being opened up to agriculture after the construction of new roads.

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The potash find is exciting news for industrial development in the future. An article in the magazine The Investor stated that i is "the shallowest, thickest layer of potash in the world and quite possibly, the most extensive too. It consists of a 146 feet-thick layer of 90-95 percent carnallite, a mineral containing 17 percent potash, at a depth of only 280 feet. A minimum deposit of 60 million tonnes of high grade carnallite is indicated." (2)

However, there is some doubt about the usefulness of the deposit. In Laos, close to Vientianne, a significant deposit of sylvite has been found. Lhis is a much more valuable mineral than carnallite because its potash content is over three times greater - 63 percent. If the sylvie is commercially exploited then it would undercut prcduction from Udon Thani. Also, there are a number of technical difficulties involved in the mining of carnallite. For example, the potash found so far is mixed with magnesium chloride which is a toxic waste, unless it is used to make magnesium by electrolysis. The latter process requires an abundanec of cheap power (which is unlikely to be availabie in the near future) and it would prcduce vast and troublesome quantities of chlorine.

The base metals found aroud Loei make the area one of the richest and most diverse for mineral development in the country. A second article in The Investor magazine reports that "copper deposits arc the largest ever found in Thailand and are estimated to amount to one million tonnes of metal." (3) Apparently much of the reserves occurs in army controlled areas of the Loei district, but even so security will be a problem. Large scale mining is likely to be hazardous, although a road is being constructed to the Mekong. The discoveries are therefore both interesting and frustrating, reports The Investor. "On the one hand the fact that such large deposits have been found without very detailed or extensive ground reconnaissance indicates that the mineral potential is very great indeed, while the conditions which hamper exploration are likely to make the exploitation difficult." (3)

Because of the current difficulties with both the potash and base metal deposits, this paper will consider only industrial development to utilise the rock salt deposits.

The existence of salt resources in North East Thailand has been known for centuries, but, despite this fact, the extent of the resources has only recently been determined. In 1967, the Department of Mineral Resources published a report on preliminary investigations on the extent of the reserves. They drilled 48 wells and estimated total reserves of 1.3 billion (ie. 1.3 thousand million) tons, about 4.7 billion tons of indicated reserves and more than 2,700 billion tons, inferred. (4) More recent investigations, based on information gathered from over 1.000 wells, has the inferred reserves slightly less that the preliminary figure - 2,000 billion (ie. 2 million million) tonnes. (3)

No matter which figure is used, the reserves are clearly massive. When one considers that the world consumes 50 million tonnes of salt a year for all its various uses, the reserve is sufficient to supply the entire world for 40,000 years. (3)

Apart from the extent of the reserves, the factor determining the usefulness of a mineral deposit is its purity. The rock salt of North East Thailand is very pure-between 94% and 99%. Four typical chemical analyses of rock salt are given in Table 1. The first two sets of values are taken from the 1967 Department of Mineral Resoures report (4) while the seoond two are from a recent paper issued by the Department of Science. (5)

TABLE 1 : ANELYSES OF LOOK SALT CORES FROM WELLS IN NORTH EAST THAILAND

	Ban Chiang Phin	South Udon	Pimai	Borabu
Moisture	0.40	0.32	0.39	0.17
$Si\ O_2$	0.17	0.06		
CO_2	0.30	0.07	(insoluble	
Al	0.04	0.90	(1.11)	(0.67)
Fe	0.04	0.06	matter)	
Mn	0.05	0.03		
Ca	0.97	0.19	0.22	0.22
Mg	0.12	0.09	0.03	0.03
Na	37.23	38.43		
SO_4	1.62	0.28	0.60	0.49
Cl	58.58	60.25	58.60	58.50
% Na Cl	94.76	97.76	96.60	96.30

Chemicals from Salt

Salt is a vital basic commodity for life, but it has also become a source of many of the chemicals which are now the mainstay of our complex industrial civilisation. Chemical engineers say our present material civilisation is completely dependent upon five primary raw materials - salt, sulphur, limestone, coal, and petroleum - a strikingly small number. Among these, salt is unique in versatility and number of uses, due to application of a large number of its physical and chemical properties.

Salt, with the chemical name sodium chloride (Na Cl) is the most common and cheapest source of source of sodium or chlorine for all the chemicals containing these elements. There are five processes commonly used for the production of chemicals directly from salt. These are listed in Table 2. taken from a roport prepared by the writer for the New Zealand governmment, (6) with a list of the other chemicals repuirred and the sodium and chlorine products.

TABLE 2 : MAIN CHEMICAL PROCESSES BASES ON SALT

Process	Other Chemicals required	Sodium product	Chlorine product
Brine Electrolysis (Mercury and Diaphragm Cells)	–	Caustic Soda	Chlorine
Electrolysis of Fused Salt (Downs Cell)	–	Sodium	Chlorine
Solvry Psocess	Limestone Ammonia (Make-up)	Soda Ash Caustic Soda	Calcium Chlorice
Monocycie Process	Limestone Ammonia	Soda Ash Caustic Soda	Ammonia Chloride
Salt - Sulphuric Acid Process (Mannheim Furnace)	Sulphuric Acid	Sodium Sulphate	Hydrochloric Acid

The table gives a total of eight chemical products made directly from salt. Calcium Chloride and Ammonium Chloride have their end uses mostly in that form, but the largest quanlities of the other six are in turn used to make an increasingly larger number of secondary, ternary, etc., chemicals which are used as such or else used up in manufacturing processes. Salt as a primary raw material will therefore often appear many generations back in the ancestry of a particular chemical. Furthermore, salt or salt derivatives, particelarly caustic soda and chlorine, are often a necessary part of a chemical process even when neitner Na or Cl appear in the final product.

Table 3 lists the common uses of the eight chemical products. Most of the information for this table is taken from Shreve's book, (7)

TABL 3 : USES OF CHEMICAL PRODUCTS MADE DIRECTLY FROM SALT

Chemical	Used in the manufacture of...............
Caustic Soda	Chemicals
	Soap
	Petroleum Refining
	Cleaning agents
	Textiles
	Pulp and Paper
Chlorine	Pulp and Paper
	Plastics (eg. PVC)
	Pesticides
	Solvents
	Water Treatment
	Chemicals
Sodium	Tetraethyl and Tetramethyl Lead
	Sodium Oxide
	Descaling of Hydrides
	Metals (eg. Potassium)
Soda Ash	Glass
	Soaps and Detergents
	Chemicals (eg. Sodium salts)
	Pulp and Paper
	Water Treatment
	Nonferrous Metallurgy
Calcium Chloride	Lay dust on highways
	Low–temperature refrigeration
Ammonium Chloride	Nitrogenous sertiliser
Sodiun Sulphate	Kraft pulp
	Glass and Ceramics
	Detergents
	Dyes
	Bleaches
	Photography
Hydrochloric Acid	Petroleum exploration
	Metals
	Food industry (eg. Monosodium Glutamate)
	Cleaning agents

A RESEARCH PROPOSAL

The writer has initiated an investigation in the Industrial Engineering Dapartment of Khon Kaen University of the feasibility of estabishing a chemical industry based on the rock salt in North East Thailand. Two groups of people are involved–a research committee of six lecturers in the Department and a group of four students supervised by the writer for their final year B.E. (Industrial) degree project assignment.

The plan of the research in to study each of the five processes commonly used to make chemicals directly from salt and decide which, if any is feasible. Also, if a chemical plant appears good proposition then it is hoped that a pilot plant installation will be designed.

The research will involve a great deal of work, However, the writer is impressed with the enthusiasm for the project shown by some members of both groups that will work on it and he is hopeful that the investigation will be completec in a reasonable time,

ASSESSMENT OF THE VARIOUS PROCESSES

Becauss the investigations have barely commenced, it is too early at this stage to state which of the various processes are going to be feasible. Before that decision can be made, the quantities and prices of all the raw materials and chemical products must be considered and the capital cost of the required process equipment must be estimated. However, for the purpose of this paper, the writer will give his opinion on which of the proceses is the most likely to be feasible.

The subjective assessment of the various processes that follows is based on the premise that if a plant is to be built then, to be worthwhile, it will need to be a large one. Therefore, large quantities of both desirable and undesirable chemical products for the chosen processes will be produced.

If either of the electrolysis prosesses are to be feasible then a market would need to be found for vast quantities of chlorine. Only a PVC plant or otner petrochemical plants producing chlorinated hydrocarbons would require this quantity of chlorine. It is unlikely that such a maket would be available in Thailand until oil and natural gas deposits in the Gulf of Thailand are utilised. Also, for the electrolysis processes large quantities of cheap electricity are needed. In the near future this will not be available.

The Solvay Process and the Monocycle Process produce the same "sodium" products-the useful industrial chemicals Soda Ash and Caustic Soda-but different "chlorine" procts. The Solvay process produces Calcium Chloride and the Monocycle Produce ss produces Ammonium Chloride. The only other significant difference in the two processes is that a Monocyele plant requires much more Ammonia than a Solvay plant. Limestone, the other chemical required by both processes, is in plentiful supply in the northern provinces of Thailand and in the Pakrsak valley in the central part of the country so its supply should not cause any problems.

Ammonia has been made from a wide range of fuels - wood, lignite, coal, hydrogen (elctrolytic), coke oven gas, natural gas, LP gas and refinery gas. Until the recent explosion at the plant, ammonia was produced in small quantities at the Mae Moh lignite deposit in Lampang province. The lignite deposit at Mae Moh is estimated to be at least 55 million tons and possibly ur to 100 million tons (8). The quality varies in rank from lignite to sub-bituminous coal. Much of it has calorific valves of sub-bituminous coal but it all has the important lignite characteristic of rapid slacking and is therefore generally called lignite. (9) Until natural gas deposits are utilised, lignite is the only source of ammonia available in Thailand. Ammonia can be prodiced from coal or lignite by two general methods - as a by - product of the coking process and from the synthetic production of ammonia directly from its elements (hydrogen and nitrogen). The former methd was the only one used prior to 1913, when the synthesis method was biscovered. However, it is unsuitable for large scale production because the yield of ammonia is very low–about 6 lbs of ammonia per ton of coaked coal. (10)

The second general method, in which the coal is used as the source of hydrogen in the synthetic production of ammonia, could be used at Mae Moh for large scale ammonia production. A detailed analysis of the chemical reactions involved is necessary before it can be decided whether or not sufficient lignite deposits are avaiable for large scale ammonia production - to the quantity required by a Monocycle Plant. Preliminary calculations by the writer indicate that there will be sufficient. Assuming this, the choice between the Solvay and the Monccycle plants rests on the relative usefulness of the Calcium Chlaride ank Ammonium Chloride products.

As Table 3 shows, Calcium Chloride is practically useless. The Calcium Chloride produced at most Solvay plants is the world is discarded. On the other hand, Ammonium Chloride is a nitrogenous fertiliser with potential uses in rice production and other tropical and sub-tropical agriculture. Therefore, the production of this useful co-product, Ammonium Chloride, makes the Momocycle plant a more likely proposition than the Solvay.

A Salt-Sulphuric Acid plant produces the useful produt Sodium Sulphate. Assuming sufficient Sulphuric Acid is available (careful investigation is needed to determine that,) the main problem with this process is the vast quantities of Hydrochloric Acid produced. It is unlikely that Thailand has mnch use for large quantities of this chemical and, as the world usage of it is very small, an export market is probably out of the question.

The writer believes, therefore, that the Monocycle Process has greatest potential for development. Detailed investigations will be needed to confirm this, but at this stage the proposal looks most promising.

Ammonium Chloride as a Fertiliser

Ammonium Chloride is a nitrogenous fertiliser. That is, it is a source of nitrogen - one of the four essential elements for soil vitality. The soils of Thailand are nitrogen deficient but very little nitrogenous fertiser is applied at present, mainly because most of the fertiliser is imported and is therefore very expensive. The Fertiliser Guide for the Tropics and Subtropics, discussing factors to consider when choosing between the various nitrogenous fertilisers, makes the following pertinet point: "The choice between the different N fertilisers depends as much on unit price as on their agronomic efficiency." (11)

A report on the salt industry in Indonesia prepared by L.H. Manderstam and partners (12) contains a section on the use of Ammonia Chloride as a fertiliser. Ammonium Chloride is used in large quantitiee in Japan, Indiaand China, applied mainly to rice and other cereals. The main advantage of the fertiliser is the price - it can be produced very cheaply - and the only disadvantage is that it has an acidifying effect on the soil.

The acidifying effect Ammonia Chloride has on soil is similar in many respects to that of Ammonium Sulphate. In experiments carried out by the Department of Soil Science, University of Michigan (referenced in the Indonesian report (12) it was found that the most acidifying nitrogenous fertiliser is Ammonium Sulphate followed by Ammonium Chloride. After application of 300 lbs. per acre per year five years, the soil ph reduced from its original 5.9 to 4.0 and 4.4 respectively. An increase in acidity causes an increase in the lime requirements of the soil.

The Fertiliser Guide (11) specifically states the acidifying effect of fertilisers such as Ammonium Sulphate on Thai soils, which tend to be slightly acidic in their original state, should not be usod as a reason for not applying these fertilisers. The soils need nitrogen and if more lime must be added then this is of little significance. Lime is plentiful in Thailand so is relatively inexpensive. Therefore, the writer believes that Ammonium Chloride is a useful fertiliser for use in rice growing areas of Thailand.

The Social Desirability of a Monocycle Plant

Thailand, in particular Pak Isan, is currently experiencing the beginnings of the phenomenon that political scientists call "rural revolt". This is a demand by the countryside to sharl in the development of the Kingdom and in the running of its affairs." (13) Enough is known about why these revolts occur to know what to do to prevent them. "Thus, as with most hnman problems, the difficulty lies not in the lack of information but in the will." (13)

By any economic indicator one can think of - per capita income, telephones installed, power consumption, etc. - North East Thailand is the poorest region of Thailand. In Table 4, per capita incomes (1972) and farm household incomes (1970) are given. The per capita incomes are taken from "Incomes of Thailand, 1972-73", Volume 6, of the National Economic and Social Development Board, and reproduced in an article in The Investor magazine. (13) The The farm income figures are from "An Income Study of Agricultural Sector in Thailand, 1970" by the Division of Agricul tural Economics, Ministry of Agricul ture, and reproduced in a book published by The Voice of the Nation. (14)

Table 4: Regional Dispsrities in income

		Per capita incomes 1972	Farm Household Incomes 1970 Farm 1/	Total 2/	%Farm 3/ Total
Central			1,739	7,154	24
	Bangkok	12,750			
	Rest	5,453			
North		2,707	2,168	3,761	58
South		3,681	1,783	5,954	30
North East		1,927	927	1,986	47
Kingdom		3,986	1,486	3,531	42

Notes :

1/ Net Farm Income

2/ Includes Net Farm Income plus Non - farm Income

3/ The writers own calculations

The figures given in Table 4 could be made to show a very good correlation with the amount of rural unrest, Obviously, the central govenmlnt in Bangkok must implement policies to raise the standard of living in areas such as Pak Isan. Two methods for achieving this are increasing agricultural production and introducing desirable industrial development. The writer believes that the establishment of a Monocybce plant in North East Thailand would improve the general standard of living in the area and it would achieve this by both these methods.

The soils of North East Thailandare nitrogen deficient and, providing the Ammonium Chloride can be produced at a reasonable price, the application of large quantities of fertiliser should improve the real income of the farmers. Much has been written lately about the introduction of either eommunes or co - operatives to improve the real income of farmers. However, although co - operatives may be desirable for crops such as soyabeans, maize, suger cane, etc., for rice production the evidence is clear that small rice - holdings are successful and can be made more so. Table 5, from the 1963 Census of Agriculture and reproduced in an article in The Investor magazine (15), shows there is a perfect inverse relation - ship between rice production and size of holding.

TABLE 5 : RELATIONSHIP BETWEEN SIZE OT RICE HOLDING AVD YIELD

Size of holding (rai)	Yietd (buckets/rai)
2 to 5.9	29.5
6 to 14.9	26.2
15 to 29.9	23.0
30 to 49.9	21.6
45 to 59.9	21.2
60 to 139.9	20.8
140 and over	19.2

The small - holding rice farmer cannot afford expensive fertiliser. Because locally produced Ammonium Chloride will be very much cheaper than imported fertiliser, the social desirability of a Monocycle plant is obvious.

In Table 4, the writer has calculatd that the percentage farm incomes to the total farm household incomes are greater in the North East than the average for the entire Kingdom. (The area is second to the North in this respect.) Non-farm incomes should be raised. A Monocycle plant will bring some employment and thus help to do this.

Therefore, the establishment of a Monocycle plant should achieve some desirable socio-economic development in Pak Isan. The only questions yet to be answered about the proposal are concerned with the economic feasibility of censtructing a plant. If these are answered in the affirmative then the writer is confident about the social desirability of the project.

CCNCLUSIONS

The establishment of a Monocycle plant in North East Thailand would utilise the only mineral resource in the area currently suitable for large scale indus trial development, rock salt, for the greatest benefit of the people living in Pak Isan. It would provide some employment, produce the useful industrial chemicals Soda Ash and Caustic Soda and, most importantly, produce as a co-product a nitrogenous fertilise suitable for rice production, Ammonium Chloride.

Possible site locations are Ban Phai and Chai Ba Dan. The former could receive the salt from deposits at Borabu in brine form by pipeline, the coal or ammonia from Lampang by rail transport and the limestone from the Loei district by bulk road transport. The Bangkok markets for Soda Ash and Caustic Soda could be supplied by either rail or road transport.

A plant located of Chai Ba Dan could receive the salt from deposits near Chaiyaphum by brine pipeline, the coal or ammonia from Lampang by rail and the limestone from deposits in the nearby Par Sak valley. The Bangkok markets conld be supplied by rail, road or water transport.

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