CHAPTER I

INTRODUCTION

Salt is one of the most important nonmetallic minerals. It probably has been in the world from the beginning of the geological time and is neccessary either directly or indirectly through all stages of the evolution of the living things. The earliest recorded history tells of salt and its uses in a manner that it was obviously old long before. Salt seems to have been used almost universally in all times and all places. The word 'salt' comes from the Latin word 'sal' which is derived from the Greek 'hals' (αλs = sea)(1). Before any knowledge of chemistry, the word salt was applied to any solid, soluble, non-inflamable substance. Today there are two principal chemical meanings of salt. One is the specific chemical sodium chloride and the other is a generic term applied to a chemical formed by partially or wholly replacement of hydrogen atom in acid by metal or metal equivalent.

Source

Salt is widely distributed throughout the world. It occurs in solution in sea water and other saline waters. Among those, the oceans are the greatest sources. It is also present in large quantity in dry deposits as rock salt. Other sources of salt are from chemical reactions, salt containing substances such as shrubs, plants, grasses and salt-impregnated substances such as peat and muds.

Mineralogy of Salt

The mineralogical name for sodium chloride is halite. Halite is a common mineral, occurring often in extensive beds and irregular masses, precipitated by evaporation with gypsum, sylvite, anhydrite, calcite, clay and sand. Halite is dissolved in water of salt springs, salt lakes and the oceans. In dry deposits, it occurs as rock salt and is also found in the playas.

Playas are shallow basins found in desert plains where deposit forming is resulted from leaching the surrounding sediments, followed by evaporation. Halite is the major salt in playas but it is not an important source of salt.

The bedded deposits are refered to as rock salt. Bedded deposits were formed by the evaporation of large inland seas. The salt beds formed may have been covered by other sedimentary deposits and gradually buried beneath the rock strata formed by them. Rock salt commonly occurs in layered strata of the relatively pure salt seperated by thin layers of calcium sulphate or may be interleaved with insoluble dolomite or shale. The thickness of salt strata is generally between 20 to 100 feet or more. The deposits commonly occur at the depth of 500 to 4000 feet. The geological time for rock salt deposits are very old, dating back to cambrian and perhaps pre-combrian period. (2)

Salt is also produced from salt dome. A salt dome is a large vertical column of salt which has been formed from bedded deposits by salt flowage due to geologic forcing pressure.

Properties of Salt

Pure salt is composed of 39.34 percent sodium and 60.66 percent chlorine by weight. Natural salt (halite) contains some impurities. The most common insoluble impurities are anhydrite ($CaSO_4$) dolomite ($CaMg(CO_3)_2$) calcite ($CaCO_3$) pyrite (FeS_2) quartz (SiO_2) and iron oxides. The most common insoluble impurities are the following ions : Ca^{2+}, Mg^{2+}, K^+, Cl^-, CO_3^{2-}, and SO_4^{2-}. Ba, Sr, B and Br may be present in minor amounts.

Pure sodium chloride is colorless. The natural mineral may be either white, yellowish, brown, orange, red, green, purple or blue due to the nature and various amount of impurities present. It is luster transparent to translucent.

The crystallographic structure of salt is isometric. It is normally in the form of cubical crystals, other forms are very rare.

The specific gravety of pure salt is 2.165. Specific gravety of selected natural salt appears to be varied from 2.12 to 2.204. The hardness of pure sodium chloride is 2.5. (The hardness as used by mineralogists means the resistance to scratching and is expressed as a series of ten minerals arranged in order of increasing hardness.) Halite is harder than gypsum (number 2 on scale) and is softer than calcite (number 3). The designation of hardness of Halite is therefore is 2.5 but this does not imply that the hardness is exactly half- way between gypsum and calcite (1). Salt is quite brittle and under certain condition the plasticity deformation can occurs readily.

Methods of Production

There are three methods of producing salt commercially which are popular and used at the present time (4) One of these involves direct mining of rock salt and the other two involve evaporation of brine by applying heat or using the heat of the sun.

Types of Salt

In commercial production, salt may be classified in the following types.

1. Solar Salt is the salt produced by evaporation of saline water in a shallow pond (3) or in a large open pan.(4) The principal source of saline water is the sea but saline lake water and subterranean brine can also be used. Solar evaporation is basically a fractional cryztallization process (1) using the sun as a source of energy.

2. Evaporated Salt is fine crystal of sodium chloride which is produced by evaporating brines in large, covered, steam-heated kettles or pans under vacuum condition. (1,3) The most common source of brine is obtained from solution mining.

Brine may be sea water that has been particularly concentrated by solar evaporation. Solar evaporation is normally taken for completion of crystalline product.

3. Rock Salt is the salt that occurs in extensive deposits. Recovery of the salt of this type may be accomplished by two methods. One is the solution mining method and the other is the conventional mining method namely room and pillar method.

Uses of Salt

Salt has a greater number and a wider variety of uses than any other mineral substance. The first use of salt was as food and food supplement. The second use was as a preservative for salting fish and meat. Technologically, the most important reactions of salt are those in which are used as starting materials for the production of many other materials which are used to produce still other chemicals. The major chemicals produced by using sodium chloride as the raw material are listed in the Table 1.1

Table 1.1 Chemicals Produced by Reaction Using Sodium Chloride as Raw Material

Process	Product
1. Solvay process $2NaCl + CaCO_3 \longrightarrow Na_2CO_3 + CaCl_2$	Na_2CO_3 , $CaCl_2$
2. AC process $2\ NaCl + 2NH_3 + CO_2 + H_2O \longrightarrow Na_2CO_3 + 2NH_4Cl$	Na_2CO_3 , NH_4Cl
3. NA process	Na_2CO_3 , $CaCl_2$ NH_4Cl
4. Chlorine-caustic electrolytic cell $2NaCl + 2H_2O \longrightarrow 2NaOH + H_2 + Cl_2$	Cl_2 , NaOH
5. Downs sodium eletrolytic cell $2NaCl \longrightarrow 2Na + Cl_2$	Cl_2 , Na
6. Salt-suiphuric acid process (Mannheim Furnace) $2NaCl + H_2SO_4 \longrightarrow Na_2SO_4 + 2HCl$	Na_2SO_4 , HCl

Apart from the chemical industry, the other major uses are in the food industry. Salt has been used as a preservative throughout history and is still an excellent preserving agent. Meat, fish, butter and cheese are still produced as salted products. (5) Although the use of refrigeration seems that salt is not necessary in such cases. Canned foods, biscuits and baked product also use salt with no replacement. (5) Salt is essensial in human nutrition. It is one of the basic tastes possesed by human beings and is essential for their servival. It has been shown that daily ingestion of only 250-375 mg. of sodium chloride by adults can be maintained without any apparent sign of abnormalities (6). Certain disease conditions for years have been treated by salt restriction. The most common of such diseases is hypertension or high blood pressure (6). It has been stated that one-fourth to one-third of hypertensive patients respond to a reduction in blood pressure when they are put on a salt-restricted diet. Various other diseases also give response to salt restriction, for example, edematous heart disease, and congestive heart failure.

In the field of agriculture, salt is a supply of minerals and trace elements in the diet of animals. It is used for preserving green fodder for cattle feed, and to improve the sodium deficiency in the soil.

The other uses of salt in industries are in a variety. In soap making, it is used, for seperating soap from water and glycerine. The soap is separated as soft floating curds as it is practically insoluble in a solution containing salt. In leather tanning, salt is used for preventing bacterial decomposition in hide. As soon as the animal has been killed, the hide which is subject to decomposing by bacterial action may become worthless for tanning into leather. In textile dyeing, it is used for setting the dye on to the fiber. In pulp and paper manufacturing, it is used as a precipitant for water proofing compositions and for electrolytic generation of chlorine bleach. In metallurgy, it is used for descaling and as fluxes and in fused-salt baths. In refrigeration, it is employed in salt-ice mixtures for direct cooling. The other uses are in rubber manufacturing, in petrolium industry, etc. Salt is effective as a de-icing agent because the salt solution formed freeze at -21.1 °c with no indication of harmful effects on the environment. In water treatment, salt is used for the regeneration of ion-exchange resins which is used in the production of soft water.

The recent technological development of underground storage such as salt cavern is the important advantage. (7,9) It is superior to surface installations in many important respects. Firstly, it is more economical, because in the underground storage, the high cost of land and conventional construction and also many safety precaution required for large storage tank can be avoided. Secondly, such underground storge is safely located at several hundreds of meters underground. The danger of fires and explosions is vertually eliminated. Thirdly, in the aspect of environmental advantages, surface tankage requires a valuable land area that can better serve other purposes. Salt caverns can be used for fluid and gases storages such as crude oil, mineral oil products, natural gas, liquefied gas, compressed air, chemical products and special waste.

Salt domes are potentially valuable elements in new developments to meet future energy needs.(8) They offer an opportunity for cheaply developed safe underground space for construction of harzardous plants such as nuclear power plant and also suitable for the storage of radioactive wastes from nuclear power production. Salt domes might be utilized in various uses for environmental purposes (8) including space for ultimate disposal of noxious liquid and solid wastes, space for chemical and biological degradation of liquid and solid wastes, the use of man - made solution cavities in salt domes as chemical reaction chambers for industrial operation.

Historical Survey of Rock Salt in Thailand

Rock salt was first discovered in many localities on Khorat Plateau in the northeast of Thailand. This area has been known since the 1950's (13) to be underlined with thick deposits of halite or rock salt. The knowledge was resulted from drilling for ground water in an intensive ground water resources development program conducted by Department of Mineral Resources, Ministry of Industry. The salt program was derived in the early 1960's. The selection of an area for evaluation of the resource of Khorat Plateau was based on the geological data from Ground Water Division, Department of Mineral Resources and specifications in the UN Special Fund Plan of Operation (11) (UN.Special Fund Survey of Minerals and Mineral Processing Industries in the lower Mekong River Basin) It is limited to an area west of the general line Udorn-Chaiyaphum where drilling has been carried out for shallow rock salt.

The survey for rock salt in northeastern Thailand began in 1965 with Mekong Committee Minerals Survey in the area of Chaiyaphum. There have been consideration for detailed rock salt drilling survey. in areas nearest to the proposed site of a deep sea port and those near the already existing railways, railway stations, roadways, water and electricity sources. Department of Mineral Resources has estimated that the area of Bamnet Narong District, Chaiyaphum will be most suitable for salt mining as beds of rock salt in the thickness of 200 - 1000 feet have been found in the drilled holes in this area. And from the results of the surveys, it has been confirmed that this particular site has more favorable geological condition than the Khorat site.

Regional of the Khorat Plateau and Salt Deposit at Chaiyaphum

The Khorat Plateau is an area of about 170,000 square kilometers in northeastern Thailand. It is devided into two subsidiary basins by the northwest-southwest ridge of the Phu Phan mountains. (Map no.1.1) The northern basin is the Sakhon Nakhon Basin, an area of approximately 21,000 square kilometers.

The southern basin is the Khorat Basin with an area of approximately 36,000 square kilometers (10, 13). The deposits of the Khorat Plateau are in the Maha Sarakham Formation (named by Gardner and others) of the Cretaceous Age. The Maha Sarakham Formation is characterised by a composition of sandstone, siltstone, shale, salt and anhydrite gypsum. (10)

The rock formation at Bamnet Narong site consists of four major rock units(12) as follows

(a) Unconsolidated overburden consisting of interbedded clay, sand and gravel of the recent age.

(b) Consolidated claystone/mudstone and siltstone of Maha Sarakham Formation of Createceous Age.

(c) A thick sequence of rock salt with a zone of interbedded anhydrite, carnallite, potash, tachyanhydrite and salt. The salt sequence is a number of the Maha Sarakham Formation of Cretaceous Age.

(d) Underlying the rock salt is a thin member of siltstone followed by a sandstone unit which is probably the Khok Kruat Formation of Jurassic Age.

The location of drilled holes of rock salt at Bamnet Narong are shown in Map No. 1.2 Bore holes No. RS. 2.4 is reserved for sylvite and Nos. RS. 1.1, RS. 1.2, RS. 1.4, RS. 1.5 RS. 2.0 RS. 2.3 RS. 2.7, RS. 2.11 and RS. 2.12 are reserved for carnallite in development of potash mining. The descriptions of core logs of the drilled holes are in Table Nos. 1.2, 1.3, 1.4, 1.5, 1.6 with the coresponding diagramatic columnar sections of each core log in Figure 3.1, 3.2, 3.3, 3.4, 3.5, respectively. The cross-section of five drill holes are illustrated in Figure 1.6

Reason For Undertaking This Work

In order to utilize the discovered rock salt, one of the important mineral resources of Thailand, the Thai Government proposed The Rock Salt Soda Ash Project as Regional Project for Thailand at the Asean Summit Conference held in Bali, Indonesia in February 1976.

Rock salt can be produced by mining method. The purpose of rock salt mine is to supply rock salt for the soda ash plant as well as for export. Before mining design can be commenced, one of the essential information required is the chemical analyses of mineral resources around the interested area. It is obvious that the result of chemical analysis obtained from this study would certainly give an excellent guideline for the selection of the potential minable rock salt zone for rock salt mining. Furthermore, it is hoped that the finding from this research would be used for indicating the suitability and feasibility of the rock salt deposits for being a good quality commercial reserves.

Table 1.2 Description of core log of drill hole NO. RS 1.3

Location : Wat Hua Bung

Ban Hua Bung, Bamnet Narong District

Chaiyaphum

Intervals	Thickness	Description
0 - 110'4"	110'4"	Clay & sand
110'4" - 197'10"	87'6"	Anhydrite
197'10"- 1079'8"	881'10"	Rock salt
1079'8"- 1083'6"	3'10"	Anhydrite
1083'6"- 1090'	6'6"	Sandstone

Table 1.3 Description of core log of drill hole NO. RS 1.6

Location : Wat Sarika

Ban Wang Ka-Am, Bamnet Narong District

Chaiyaphum

Intervals	Thickness	Description
0 - 65'	65'	Sand & clay
65' - 102'	37'	Mudstone
102' - 147'5"	45'5"	Clay
147'5" - 153'7"	6'2"	Gypsum
153'7" - 170'2"	16'7"	Clay
170'2" - 191'11"	21'9"	Anhydrite & gypsum
191'11"- 926'1"	734'2"	Rock salt
926'1" - 931'2"	5'1"	Anhydrite
931'2" - 945'	13'10"	Sandstone

Table 1.4 Description of core log of drill hole NO. RS 2.2

Location : Ban Hua Bung, Bamnet Narong Destrict

Chaiyaphum

Intervals	Thickness	Description
0 - 37'7"	37'7"	Sandy clay
37'7" - 135'	97'5"	Mudstone
135' - 139'9"	4'9"	Gypsum
139'9" - 198'2"	58'5"	Clay
198'2" - 210'	11'10"	Anhydrite
210' - 1133'1"	923'1"	Rock salt
1133'1" - 1136'10"	3'9"	Anhydrite
1136'10"- 1145'	8'2"	Sandstone

Table 1.5 Description of core log of drill hole NO. RS 2.5

Location : Ban Kloi-Ban Tan, Bamnet Narong District

Chaiyaphum

Intervals	Thickness	Description
0 - 120"	120'	Sand & clay
120' - 202'10"	82'10"	Clay
202'10" - 220'5"	17'7"	Anhydrite
220'5" - 730'	509'7"	Rock salt

(Stopped drilling in rock salt)

Table 1.6 Description of core log of drill hole NO. RS 2.9

Location : Ban Wang Ka Am-Ban Hin Tang

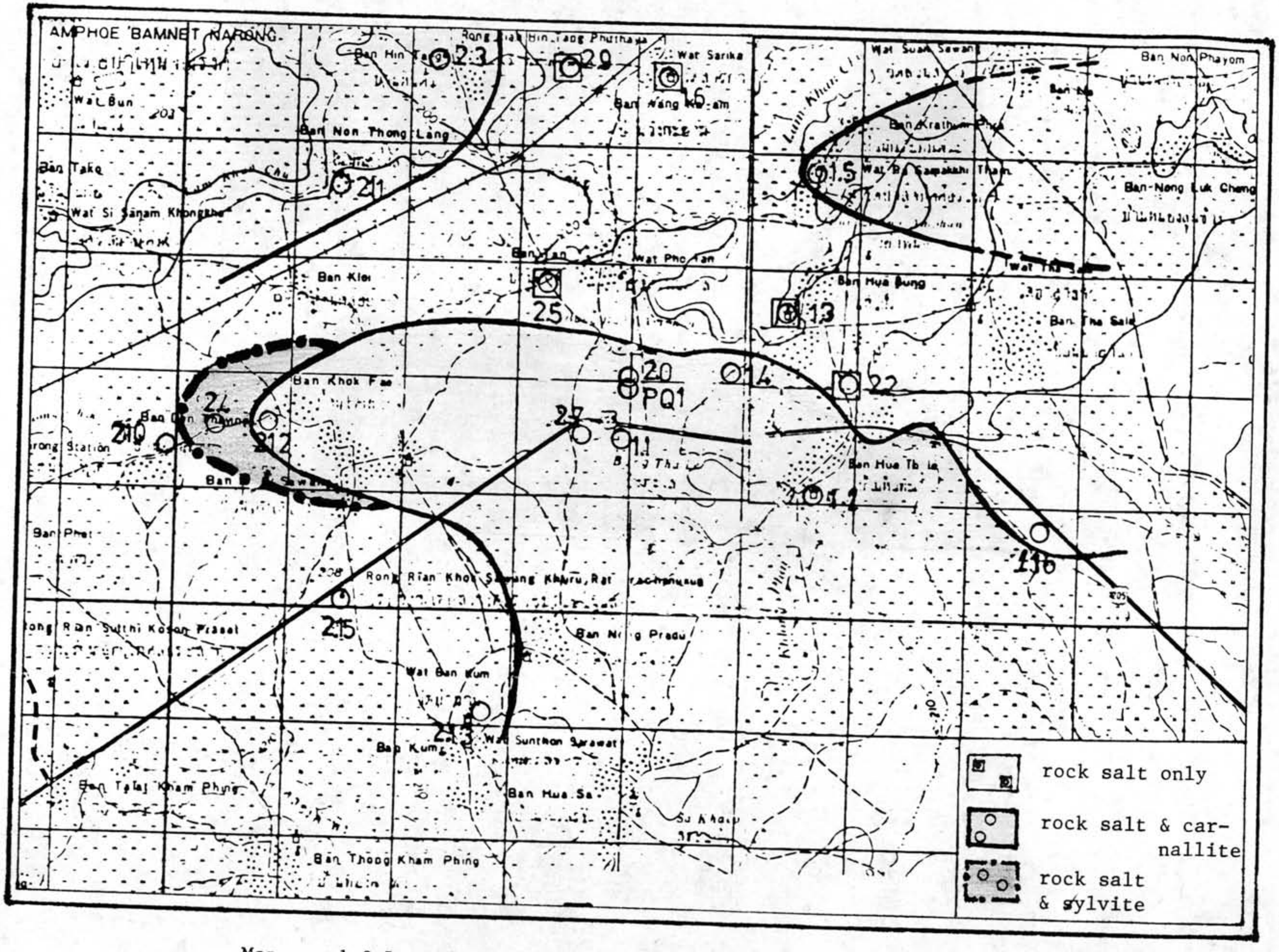
Bamnet Narong District

Chaiyaphum

Intervals	Thickness	Description
0 - 183'6"	183'6"	Sand & Clay
183'6" - 277'10"	94'4"	Gypsum & anhydrite
277'10"- 606'	328'2"	Rock Salt

(Stopped drilling in rock salt)

Map no.1.1 Map of Thailand showing area of the salt bearing formation, Khorat and Sakon Nakhon basins.



Map no. 1.2 Location of drill holes at Bamnet Narong

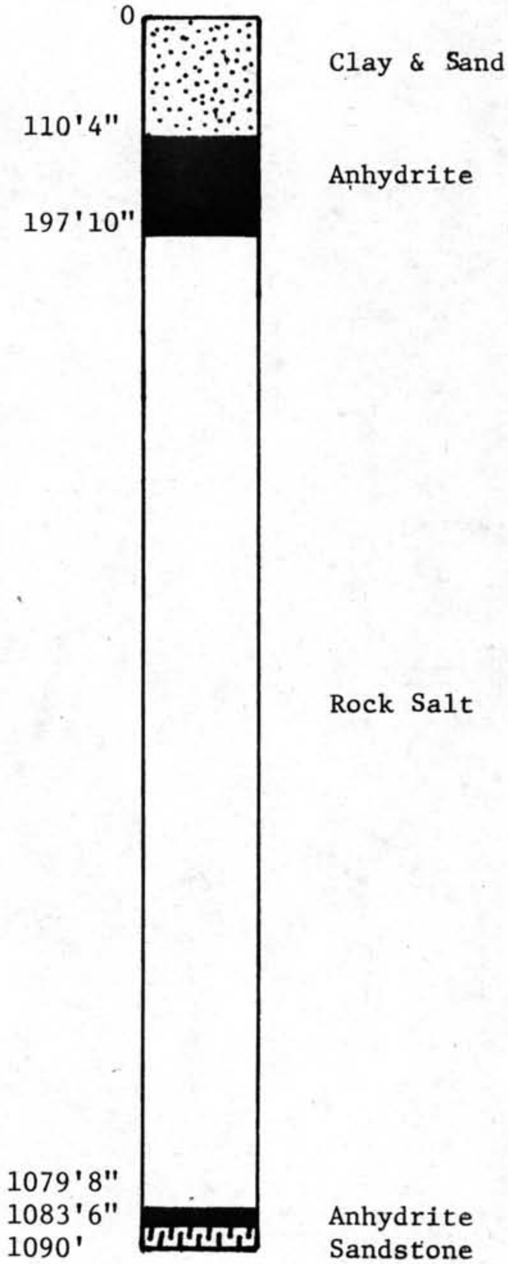


Figure 1.1 Diagrammatic columnar section of core log drill hole no. RS. 1.3

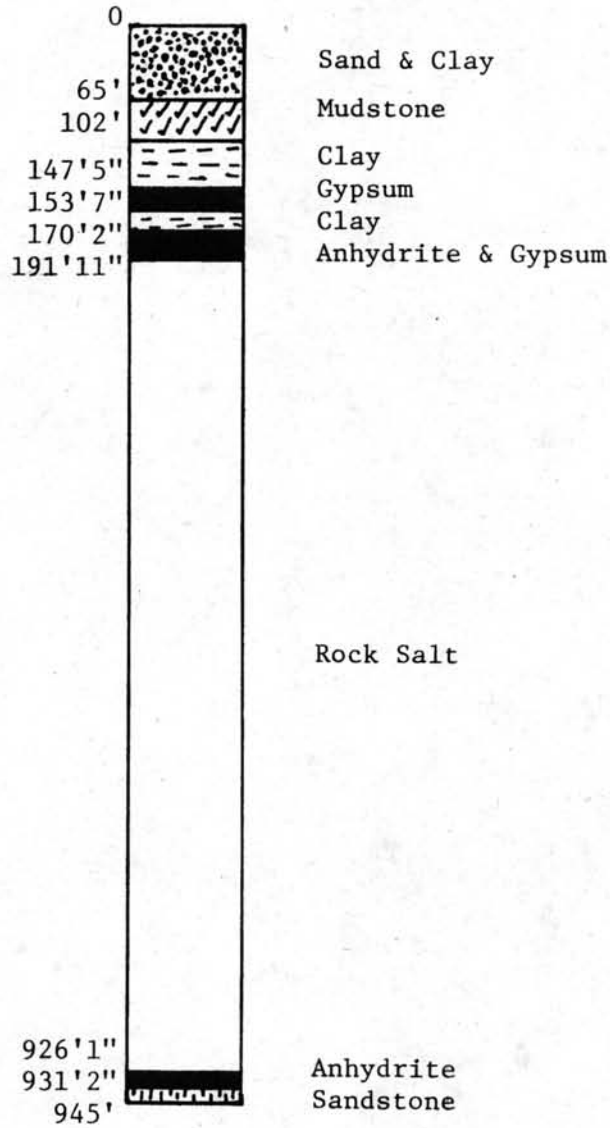


Figure 1.2 Diagrammatic columnar section of core log drill hole no. RS. 1.6

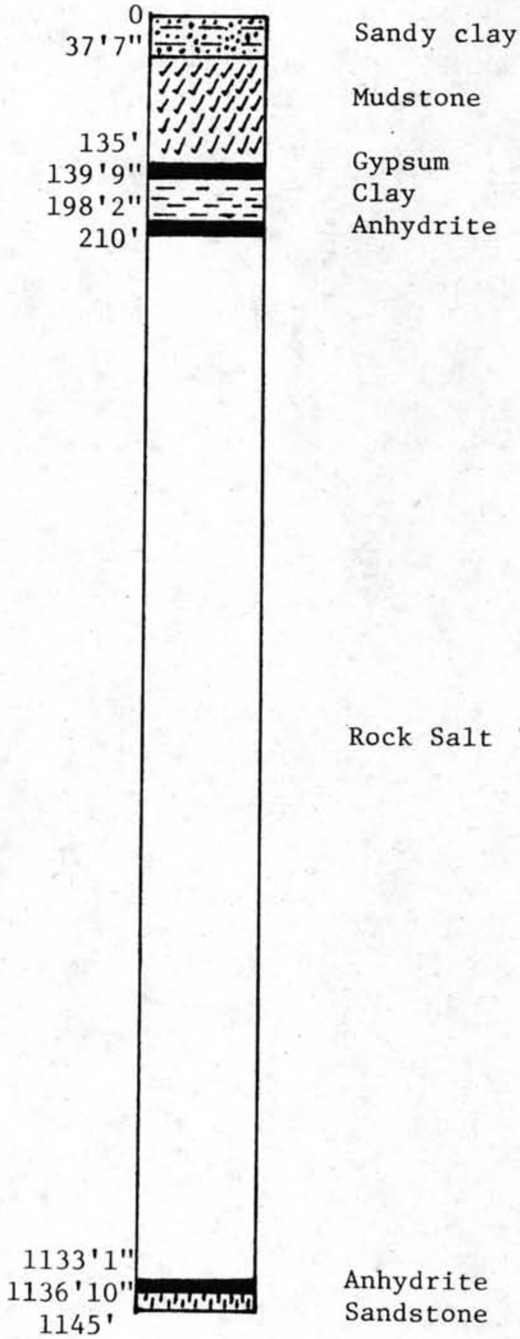


Figure 1.3 Diagrammatic columnar section of core log drill hole no. RS. 2.2

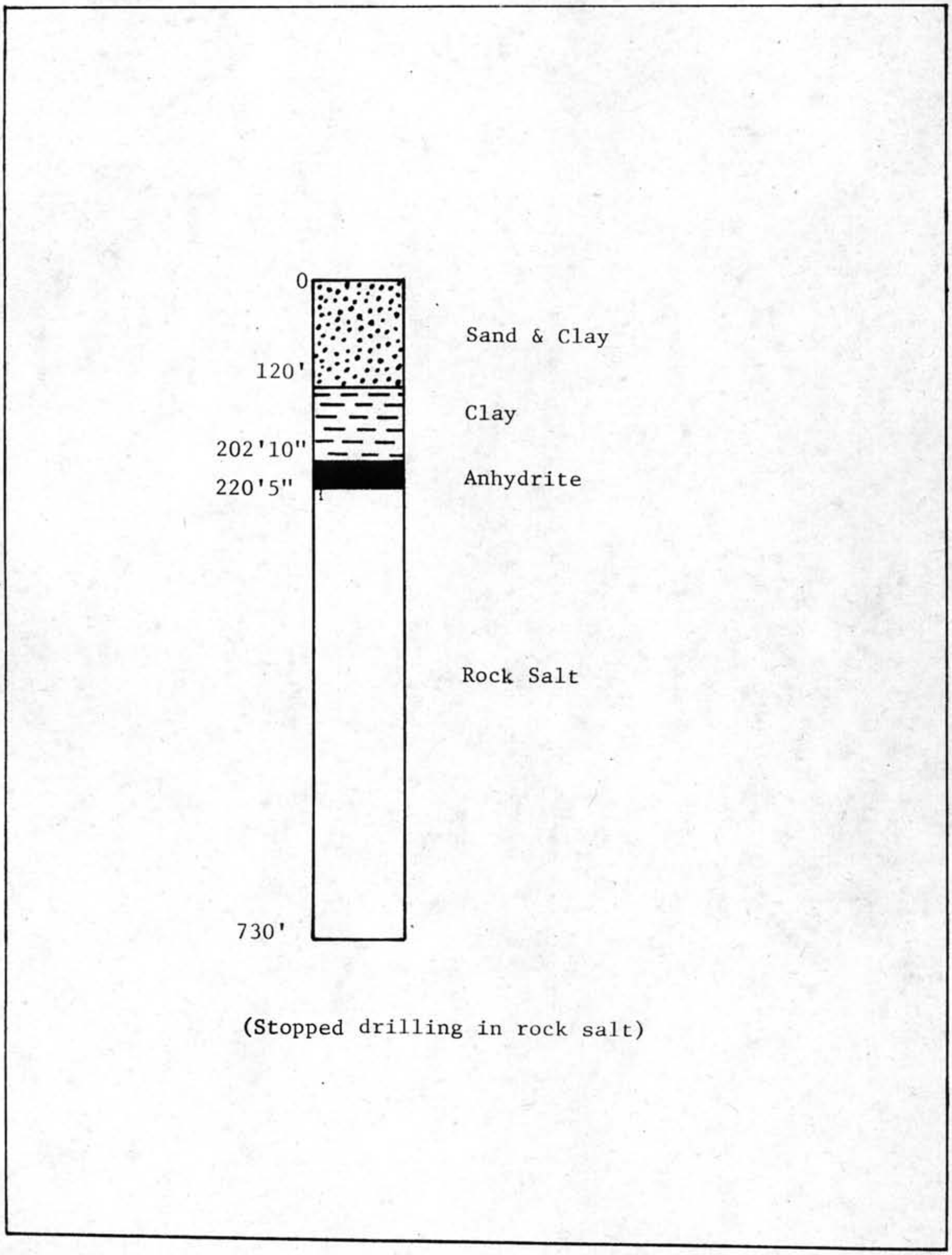


Figure 1.4 Diagrammatic columnar section of core log drill hole no. RS. 2.5

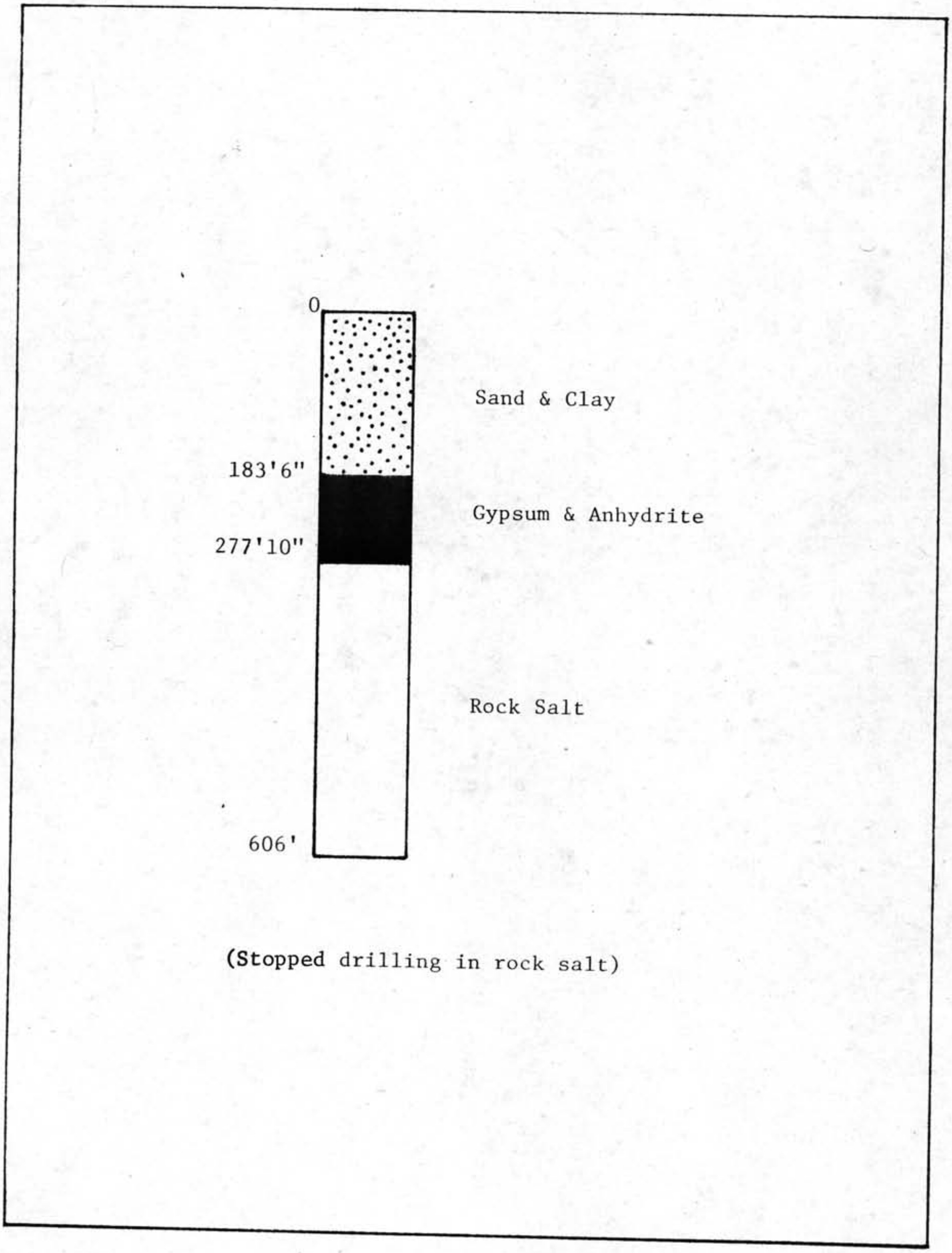


Figure 1.5 Diagrammatic columnar section of core log drill hole no. RS. 2.9

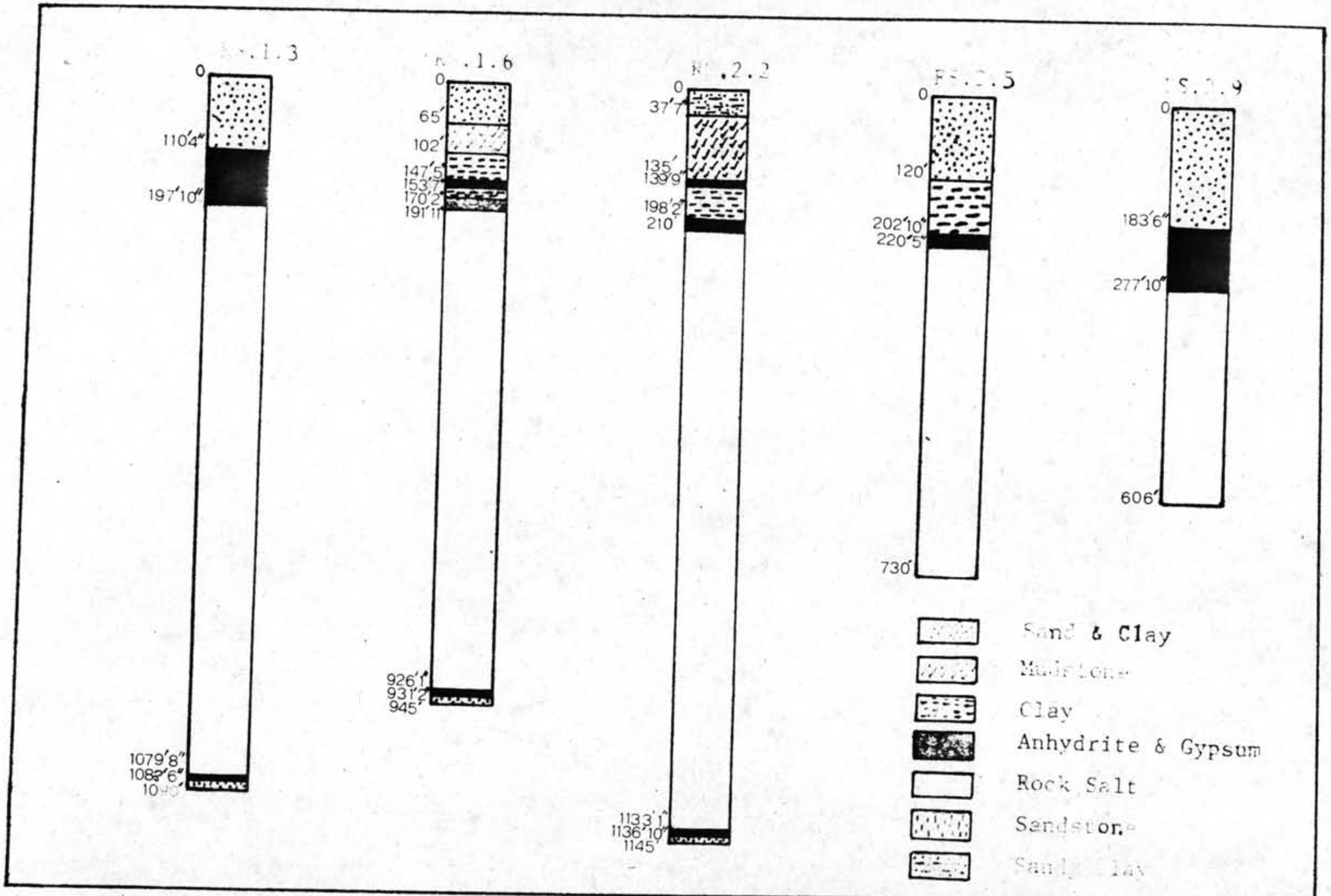


Figure 1.6 Cross - section of dirll holes at Bamnet Narong Area