Salt Extraction Industry in the Romanian Socialist Republic

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ABSTRACT

Over 2,000 indications of salt deposits are present in Romania in and outside of the Carpathian fold belt, especially in the sub-Carpathian region between Maramures and Oltenia. Salt mining in Romania dates from the first century A.D. and currently is done by both dry mining and brine wells. The salt deposits occur both as bedded salt and in diapiric folds with accessible deposits having thicknesses exceeding 100 meters. Many deposits which are dry-mined have a NaCl content of over 98% and do not require enrichment for market. Others require beneficiation owing to foreign substances such as anhydrite, other chlorides and clay.

The demand for salt in Romania is rising. Over 50% is used in industry, 25% is exported and the rest goes to the home market. The grades for various uses are described. It is anticipated that demand for salt products by the chlorine and sodium industry will rise 100% by 1980 with the demand being met largely from brining operations.

INTRODUCTION

Rumania is rich in rock salt (sodium chloride) deposits located inside and outside of the Carpathian bend and especially in the sub-Carpathian region between Maramures and Meridional Carpathés (Oltenia). Most of deposits are to be found in the folded Mediterranian solid phases and some of them are present diapiric structures.

As a result of tectonic movements of the Carpathian folding, some deposits occur in lenticular form (Tg.Ocna, Slănic—Prahova, Ocnele Mari etc.) and others are in diapiric folds (Ocna-Mures, Praid etc.). The large majority of such deposits were identified by direct investigation or discovered as a result of oil prospecting.

At present there are important reserves and approximately 2000 indications of saline deposits. A series of the more accessible ones have been put in operation both inside and outside of the Carpathian fold belt.

Due to the important developments in the chlorine and sodium industry, beginning in 1958, dry and wet extraction of salt were analyzed with a view toward increasing production, improving quality and stepping up exploitability. As a result, only the Ocna-Mures, Dej and Praid salt mines (in the inside of the Carpathian fold belt) and Cacica, Tg.Ocna, Slănic and Ocnele Mari salt mines (outside of the same belt) remained in operation.

USUAL DRY MINING METHODS

Due to the fact that recovery of salt in this part of Europe began long before the Roman occupation (first century A.D.), recovery methods were adapted to the specific features of deposits and to transportation arrangements.

In the 17th and 18th century they used the "bell" (dome) recovery method, known in Europe and especially in Austria and Germany. The vertical transport was performed by hoists driven by men or draft animals. At the beginning of the 19th century, a working method using ogival rooms was introduced. This gradually developed into trapezoidal rooms, between which pillars of different thickness were left depending on salt's resistance to caving.

After the First World War, mining methods were systematized and reduced to three: 1) trapezoidal rooms with a central pillar (where the hoisting shaft was located), 2) trapezoidal rooms with rectangular pillars and 3) small rooms with long pillars. In the first and second methods using trapezoidal rooms, the extraction is carried out by flat block underhand stopes. The rooms have the following dimensions: height 30–35 m, roof width 10 m and floor width 30–35 m. The side walls slope 60° at their upper part, until they reach a width of 30–35 m where they

become vertical. The worked slices have a thickness of 2–4 m. The floor and side walls are worked by means of cutting machines.

In the central pillar method, the lift shaft has walls located in the pillar and communicates on one side with principal transport room. The pillars between rooms have a square section with sides equal to the room opening (30–35 m).

In the rectangular pillars method, the trapezoidal rooms have the same dimensions as above. Between rooms, 20 m broad and 50 m long pillars are left. If possible, the shaft is located in one of the pillars. Otherwise, the access is provided by a crosscut tunnel with the ground surface and an inclined shaft.

These methods led to extraction of up to 73% of useful substance existing in a lift. In the case of the Dej-salt mine, which consists of a single lift in an up to 105 m thick deposit, the overall extraction is 50% because protective masses are left in the floor and the roof is of salt. When working by several levels (three levels at Slonic-Prahova salt mine), extraction drops to 30–35% because of the about 20 m thick floors left between levels.

The small-rooms-and-long-pillars method was employed on three levels in the Ocna Mures salt mine. The rooms have a crosssection of 20 X 12 m and a length of 120 m. Between rooms, 12 m pillars are left on each level and between levels there are 8 m thick floors. This method leads to an extraction of 35% on each level and of about 23–25% where there are safety pillars.

Whereas by the trapezoidal rooms method extraction is performed by underhand stoping (horizontal slices), with 2–4 m steps, the room-and-rectangular-pillars method extraction is performed by overhand working with remanent ore. All three methods lead to a high productivity at faces.

NEW METHODS OF DRY EXTRACTION

Due to the fact that many deposits have a thickness exceeding 100 m and attaining 600 m or more (Slanic Prahova, Praid, Ocna-Mures, Tg.Ocna etc. salt mines), the mining methods had to be adapted for working at depth by taking into consideration the mechanical characteristics of salt and by maintaining an acceptable exploitability factor (over 25% for the entire area) and an adequate productivity per post and mine.

Using experimental methods on a pilot-scale the 8 X 16-rooms method was selected, which has square pillars of 14 X 14 m and intermediate floors of about 8 m between levels. The extraction factor per level is in the order of 38%. By working on more of four levels, an extraction factor of about 25% can be achieved (by taking into account the safety pillars left in the roof and by partitioning perimeters with long masses).

For the time being, this method is applied in the Slanic Prahova and Tg.Ocna salt mines. For intensive production, the drilling was performed by Secoma machines, the loading was done by low scoop shovel with a 1.2 m^3 bucket and the salt transported by tippers with a 12 ton bucket. In both deposits, salt is transported through crosscutting tunnel and the communication between levels is through an inclined shaft built in a helix.

WET EXTRACTION

The wet extraction of salt began at the end of the 18th century at Cacica by diverting brine springs above the salt-mass, by accumulating the brine in basins and by crystallizing the salt by brine evaporation.

In 1896, at the Ocna-Mures salt mine, a chemical plant using the Solvay process was built. Its brine source was obtained by collecting water from protection drains of the salt mass. Later on, in the old excavations fresh water was fed into it to obtain a brine with a satisfactory concentration. Because of the increased brine demand for the chlorine and sodium industry, dissolution basins were built in underground from where the brine was pumped to the surface.

The development of the chlorine and sodium industry led to employment of the well extraction method. Such a well at the Ocna-Mures salt mine reached a depth up to 1750 m. In some mines (Cacica, Ocna-Mures etc.) which were exploited by dry extraction, wells were drilled in the cavities left by old excavations and the deep extraction of the salt mass is carried on by the wet method.

The extraction of useful substance increased together with the extension of mine diameter and depth but in individual wells it does not exceed 18% of the entire exploited perimeter. The wet extraction method gave the best results in deep deposits which contain many foreign substances (Cacica, Tg.Ocna, Ocna-Mures, Ocnele Mari, etc. salt mines) and especially in those places where brine can be directly used in chemical processes of recrystallization by evaporation.

PHYSICO-CHEMICAL PROPERTIES OF DEPOSITS

Most of exploited deposits have a NaCl content of over 98.5% and two of them (Dej and Slanic-Prahova) presently in production a NaCl content of 99%. Such deposits deliver by dry extraction a product which need not be enriched by mechanical reprocessing or by physical concentration (dissolution and evaporation). Salt produced by such enterprises is ground and delivered to the market in original state.

Some deposits or deposit zones have a foreign content (clay, sand etc.) of 5–15%. Such deposits are adequate for wet extraction (Cacica, Ocnele Mari, Tg.Ocna, Ocna-Mures salt mines) with good results. The extracted brine

is used in the chlorine and sodium industry or for obtaining salt by evaporation.

Foreign chemical substances, such as calcium sulphate, magnesium sulphate, calcium chloride and magnesium chloride are generally to be found in small quantities in exploited deposits. On the whole, such substances are present at about 1.5%, with the exception of some deposits at the Cacica, Praid and Ocna-Mures salt mines where they exceed 2%.

It is to be noted that almost all deposits located outside of the Carpathian fold belt, and particularly the southern ones, contain methane inclusions in the cleavage surfaces of crystals so that, in case of an intensive exploitation, methane formation raises problems of mine ventilation and gas protection.

The mechanical properties of exploited salt deposits are very different even within the same deposit. Compression strength, for instance, varies between 130 kgf/cm^2 and 340 kgf/cm^2 depending on contained foreign matter and soil tectonics.

Salt plasticity is a rather important factor and well known for its effects on the stability of mine supports. According to studies by the Romanian Central Institute for Mining Research about support safety, it is recommended that principal pillars be left with a height/width ratio between 0.5 and 1, taking into consideration a pillar subsidence under lithostatic load between 0.3% and at most 0.6%. In this way, a massive scaling in the stressed sections of pillars, outside of the central core, is avoided.

SALT USES FROM EXISTING MINES

Over 50% of salt produced at present by wet or dry extraction is used in Romania as raw material for the chlorine and sodium industry as well as for the synthetic resins, textile, leather and other industries. About 25% of rock-salt in different sizes is exported for industrial and nutritional uses and the rest is delivered to the home market.

Recrystallized salt is obtained from wet extracted salt by evaporation and recrystallization in grainer at the Cacica salt mine and by evaporators in direct contact with hot gas and brine at Ocna-Mures salt mine. Production of recrystallized salt covers the home market demand and is also delivered to foreign markets. Seventy percent of the grainer salt has a crystal size between 0.2 and 0.7 mm. Salt produced in the direct contact evaporator has a crystal size between 0.16 and 0.5 mm.

The following sorts are produced for the home and foreign market:

For nutritional uses:

1. recrystallized salt packed in 0.5, 1, 25 or 50 kg bags;
2. natural salt with a content of 98.5% NaCl in the following granulations:

a) 0.1 – 0.5 mm named first-quality
b) 0.1 – 1.0 mm named fine
c) 0 – 2.0 mm named granulated
d) 2 – 10 mm named grit
e) lumps of 3–50 kg

These sorts of natural salt with the exception of lumps may be delivered at request in other crystal sizes and in different packing, as desired.

For industrial purposes

Salt is available with at least 97% NaCl, currently 98.5% NaCl, in the following crystal sizes:

– 0 – 2 mm industrial type A
– 0 – 4 mm industrial type A
– 0 – 10 mm industrial type A
– 0 – 16 mm industrial type A
– 0 – 20 mm industrial type A
– 16 – 200 mm lumps or industrial type B

Besides these, the plants produce salt briquettes for cattle and sheep in dimensions requested by users containing various stimulators and anthelmintic substances.

For the chlorine and sodium industry, salt mines deliver brine extracted by wells with a content of 308–312 g salt per liter, respectively with a 1.20 density.

FUTURE SALT PRODUCTION IN ROMANIA

Improvement of production quality

The forecast for the chlorine and sodium industry for the near future implies an increase over present production of 50% by 1975 and of 100% by 1980. The most important increase will be that of wet-extracted salt. Salt extracted from the Dej and Slanic-Prahova salt mines, with a content of 99% NaCl, satisfies the required quality for covering the long-term demand of the home food industry, provided the sorts fine and granulated are dusted off. Fine particles resulting from dedusting (under 0.3 mm) are to be used by briquetting for animals. This kind of process is to be applied by 1975 at the Slanic-Prahova, Tg.Ocna and Praid salt mines.

With regard to recrystallized salt, the problems to be solved are improvement in crystal size, reduction of particles under 0.3 mm, change in salt hydrophobic quality for increasing its flow and avoiding agglomeration, and diversifying the packings of small capacity (under 1 kg).

Improvement of dry mining methods

The dry mining methods used up to the present did not permit working at depths greater than 200 m below the ground surface. Studies in the past by M. Stamatiu, (Institute of Mining, Bucharest) and the recent studies carried out by the Romanian Central Institute for Mining Research, Bucharest on testing supports in the Tg.Ocna pi-

lot-mine and in the new mines at Slanic-Prahova and Tg.Ocna led for the time being to the conclusion that pillars must as a rule have a height/width ratio less than 1. A pillar subsidence in time of more than 3% no longer offers any safety.

Tests performed in exploited salt mines showed that at a pillar subsidence of 0.3%, the stress did not exceed 100 kgf/cm (uniaxial effort). In the case of the Moldova Veche salt mine (Tg.Ocna) the abandoned pillars resisted in the above mentioned mechanical conditions for 85 years.

Calculations made by taking into consideration the current conditions in these salt mines show that dry extraction may be performed, with satisfactory support conditions, up to a depth of 450-500 mm if the height/width ratio remains subunitary. At such depths salt, however, enters the range of its plastic flow so that the width of rectangular rooms must not exceed 20 m. However, the pillar length is unlimited. At depths greater than 300 m, trapezoidal rooms are no longer adequate because of the increase of the instability of the pillars.

By taking these conclusions into consideration as well as the desirability of optimum exploitability, one may conclude that adequate dry extraction methods for the known deposits are the following:

1. For 100–200 m thick layers: the method of trapezoidal rooms and long or square pillars is satisfactory. A room must have an opening of 30–35 m at floor and of 10 m at roof. On the part, side walls must have an inclination of 60°. This method leads to an exploitability factor up to 50%.

2. For layers whose thickness does not exceed 300 m, workings may be made with trapezoidal rooms, small rooms and square pillars (Slanic-Prahova and Tg.Ocna salt mines) or by rectangular rooms and long pillars (Ocna-Mures salt mine). For depths up to 500 m, a safer working method is one which employs rectangular rooms and long pillars (it is also applied at Borth, F.R.G.).

3. For layers with a thickness over 120 m, it is especially recommended that the working perimeters be partitioned by long pillars and that a perimeter should not exceed 500 × 500 m in order to locate possible faults.

Such systems lead to an intensive working. They imply mechanization of drilling, loading and transport operations. The dimension of salt blocks must be reduced below 300 mm in the proximity of faces.

If conditions permit, the access to salt mines is made by adits (Dej, Slanic-Prahova and Tg.Ocna salt mines). In case of deep deposits, the access is by a hoisting shaft equipped with heavy duty skips.

WET EXTRACTION

The prospects for development of further salt extraction in Romania are determined by the ever increasing demand for raw materials by the chlorine and sodium industry which will absorb about 63% of the whole salt production in 1975 in the form of brine and in 1980 about 68–70%. On the other hand, the deep deposits or deposits with many foreign substances are easier and cheaper to exploit by wet extraction. In as much as the Ocna-Mures, Praid, Tg.Ocna, Cacica, etc. salt mines are in deep deposits and have many foreign substances, future prospects will lead to an important development of wet extraction in those mines.

The wet extraction method by individual wells is well established in Romania. In the last few years, in the Ocna-Mures salt mine a working depth of 1750 m was reached. To increase the extraction factor of useful substance, batteries of wells will be extended. The same may be said for increasing stability by vertical multistage dissolution of salt. In Romanian well fields, dissolution control is attained by using a petroleum pad. To reduce the consumption of petroleum products in the future, we intend to try dissolution control by use of an air cushion or by controlled dissolution between two or more wells, without using an isolating layer.