17th International Mining Congress and Exhibition of Turkey- IMCET2001, ©2001, ISBN 975-395-417-4

The History of the Evolution of Salt Working Methods in Romania, from Antiquity to the Present

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ABSTRACT: The presence of many salt massifs has favoured the appearance and development in the area of continuous mining activity. This has generated an evolution in exploitation methods in the following order: exploitation of the wood civilisation from the Dacian-Roman period, the bell type, systematic exploitation in rooms and small pillars and exploitation in solution.

1 INTRODUCTION

A review of documents and old works, as well as the study of many salt exploitations, some of which are very old, allow any attentive researcher to come up with new ideas regarding salt exploitation in this region from ancient times to the present. In this study, we focus on the development of exploitation methods used over thousands of years. Salt exploitation in the Romanian Carpathian area has been possible due to the presence of about 200 salt massifs with special characteristics: some are in outcrop or are very close to the surface, and the majority have superior resources of NaCl, > 97-98%, some of them with large reserves: Ocnele Man (Bozasca), 9,200 mil t; Reghiu-Andreiasu, 13,250 mil t; Sic, 18,300 mil t; Ocna Mures, 23,500 mil t; Turda, 38,750 mil t; Praid, 50,000 mil t; Ocna Sibiului, 61,000 mil t; and Sarmasel, 100,000 mil t. As a result of our studies, we have managed to identify for the first time 46 salt massifs under exploitation (Fig. 1), out of 200 which exist, and as part" of the massifs we have found traces of documents which certify the existence of many former exploitations, from antiquity to the present

2 METHODS OF EXPLOITATION

We ordered the methods of salt exploitation as follows: the wood civilization exploitations from the Dacian-Roman period, bell exploitations, systematic exploitations, and exploitations with rooms and small pillars and in solution.

2.1 *Methods of wood civilization exploitation*

In valleys and ravines, through the washing of salt massifs by aquifers, areas of waterlogging with salty efflorescence often appeared. Through ordinary evaporation, either in situ or in clay or wooden pots, different quantities of salt were obtained. Near Ocnele Mari in citadel 1 (Cotofeni Culture), thousands of tronconic "glasses" specially made for the evaporation of brine were discovered. In salt valleys, salt outcrops often appeared, especially due to landslides and the erosion due to rain. When they could not break salt rocks on the surface, people had to dig through rudimentary holes using wooden wedges and hammers. Depending on the digging depth, the salt was carried on the back to the surface, or a human chain was formed and the salt blocks were passed from hand to hand. As the salt was very heavy, sometimes a sort of sledge pulled by men or horses was used. The main problem was water infiltration, against which they used linings of animal skins and sticks with clay on walls and ceilings. Some researchers have revealed very useful information about this. From Wollmann (1996), we have Figures 2, 3 and 4; after Berciu, from the Verbicioara culture (1800-1300 BC), heavy axes used for mining exploitation and the breaking of salt blocks in the area of Dacian Buridavei (near Ocnele Mari) have been preserved. Parvan reported that a hammer, a pickaxe (Pickel) with a polygonal profile and gathering "ailerons" (together with more chisels in the form of axes) were found at Gusterita, which Goos compared with an analogous object found in a salt mine from Hallstatt to which he attributed the same usage. It was dated as being from 900-500 BC. In the area of the salt massifs, native tombs with cremation urns were found. At Uioara de Sus (globated at Ocna Mures), seven clearly outlined tombs were found - cremation "in the urn" from the VI-V centuries BC belonging to the Agatarsi Scythians. At Ocnita-Teaca, Bistrita Nasaud, a bronze mirror was found with the head of a ram at the end of the

handle and six more arrows. In 1871, 1846 and 1847, at Ocna Slatina in "the King's Valley", traces of Dacian exploitations (Bronze Age, probably die 2nd Iron Age) were found. These had irregular outlines with a depth of 10-13 ra, a diameter of approximately 13 m and a height of excavation which rarely exceeded 5 m. It is interesting that such exploitation was equipped with a "tank" dug in the salt used to collect waters from infiltration. Some wooden tools and jude ropes have been found, which leads to the conclusion that salt was brought up through a system of levers and pulleys. At Valea Florilor, some hand mills and other household objecte have been found. At Dacic Ocnita-Buridava feathers of a hammer and some tools specific to salt exploitation dating from the 1st century BC have been found.

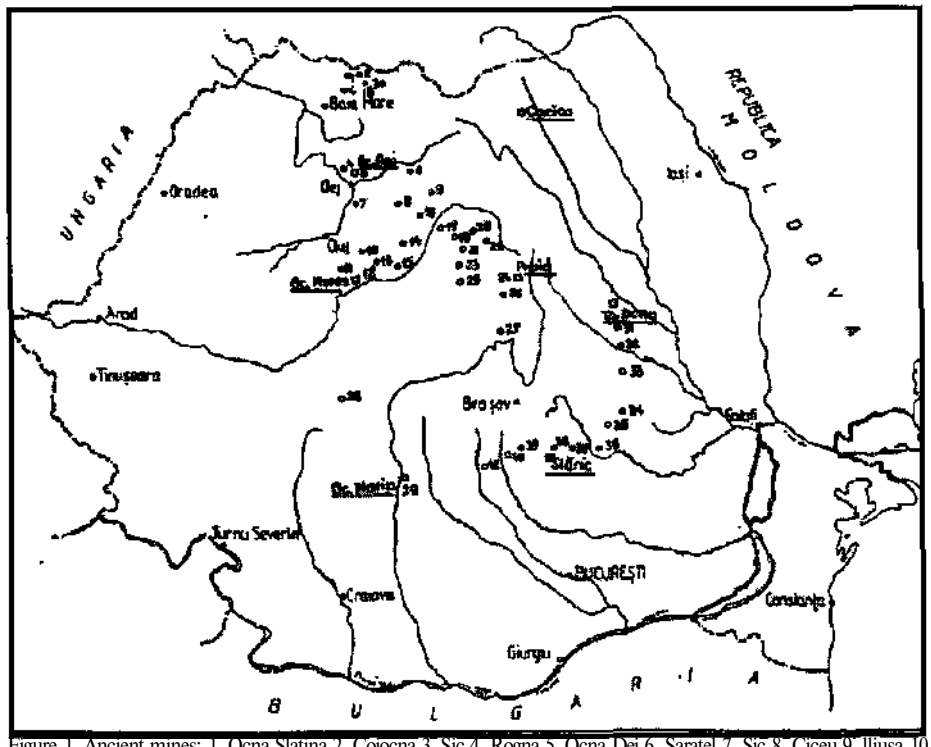

Figure 1. Ancient mines: 1. Ocna Slatina 2. Cojocna 3. Sic 4. Rogna 5. Ocna Dej 6. Saratel 7. Sic 8. Ciceu 9. Iliusa 10. Manastur II. Turda 12. Ocna Mures B.Domnesti 14. CaianuMare 15. Cuzdioara 16. Vireag 17. Releag 18. OcnaSugatag 19. Sintereag20. Chiua 21. Tau 22.Beclean 23, Sovala 24. Mogosmat 25. Martinis 26. Sanpaul 27. Rupea 28. Ocna Sibiului 29. Boizasca 30. Rcma de Sus Middle Ape mines: 31. Grozesti 32. Nord Vaiea Sarii - Sud Valea Sarii 33. Reghiu - Andreiasu 34. Bisoca(Picineaza)35. Rusavat (Sarea lui Buzau)36. Aricesti 37. GhitIoara (AnInisul-Saranu) 38. Teisani 39. Telega 40. Doftana41. Baicoi Actual mines: Cacica, Tg. Ocna, Slanic Prahova. Ocnele Mari, Ocna Mures, Ocna Dej, Praid.

2.2 *Methods of exploitation from the Daco-Roman period*

It is generally considered that salt mining developed during this period through the appearance of new exploitations, through the enlargement of die resulting gaps and through the memods used. There were two methods of salt exploitation: the semi-dried method and the dried method.

2.2.1 *The semi-dried method*

In this memod, salt was obtained through a procedure which allowed the rocks to be separated from the salt blocks by hitting with a hammer in tracks created as a result of dissolution by water brought through a system of eaves from the surface. In the free Dacians from Ocna Slatina as well as in the area occupied by the Romans at Valea Florilor and Ocna Dej, similar wooden eaves have been found. These were assembled at 0.3 m from the surface up to a

maximum of 10 m in depth on wooden supports and had the role of ensuring water transport from the surface to the working front. For the assurance of the water flow or for raising it, the Dacian Romans used "hydraulic wheels". The eaves were preserved from place to place with pearces plugs, through which there were unlignified wires of lime-tree trunks. By moving these eaves and by closing or opening the plugs, the water spurt could by led to somewhere away from the exploitation. At the head of the eaves. Hat eaves provided with plugs of water distribution were often used. Through dissolution, the water created a ditch in the desired direction. As matter of fact, this was a vertical and horizontal undercutting. The water was collected in a concave area and was evacuated. Through hitting with hammers in the feathers and with the help of crowbars, the salt was detached in blocks. In 1902. some wooden tools, which could even originate from before the Romans arrived in Dacia, were found at an ancient exploitation at Turda. Among them, a shovel with a short handle of 46x 13 cm used in the scraping of salt obtained through evaporation was found.

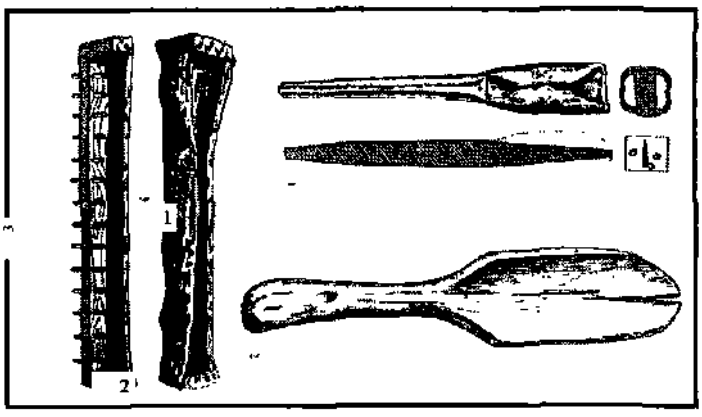

Figure 2. Tools and installation dating from the wood civilization. 1. Sharp pickaxe of the "Lappeinbein"-Spalnaca (Ocna Mures) 2. Wooden shovel - Turda 3. Trough with orifices for undercutting salt in fresh water.

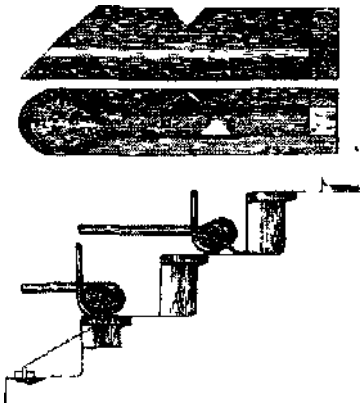

Figure 3-The component parts of on instulliition of conducting fresh water tor undercutting salt - Ocna Slutina.

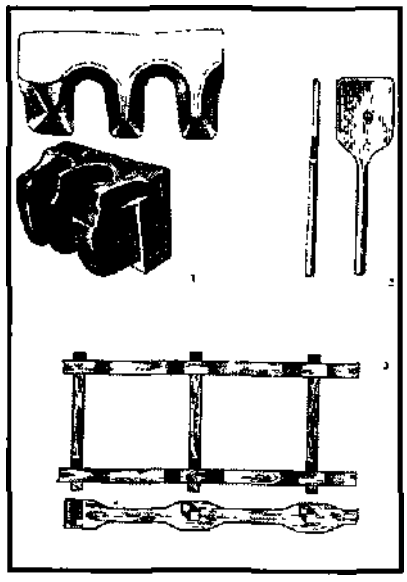

Figure 4. The component parts of on installation of conducting fresh water for undercutting salt - Ocna Slatina.

2.2.2 *The dried method*

In the second method, rooms of well-defined dimensions, lengths of 15-30 m and widths of 4-8 m, were obtained. One piece of proof is the exploitation from the surface with square sections (7 x 7 m) provided with reinforcements of moulded beech or oak. Salt exploitation was carried out by descending from the surface, detaching being done only in the sole. For üuis, iron hammers were used for the creation of tracks in the exploitation sole, after which through the utilisation of feathers and crowbars salt blocks were cleaved. The access to the exploitation sole, as well as the bringing of the salt to the surface, was accomplished with stairs and ropes. Aeration was through natural circulation, and the lighting was also natural, creating a semi-dark atmosphere. At the surface, a roof was made for protection from rain and snowfall. Around this, a system of drainage was built with ditches. When they could not evacuate the water infiltrating the exploitation, it was abandoned and another one was opened in the nearby area, at a distance of 15-20 m. In order to support what has been said before, we can turn to ancient texts, and to epigraphic and archeological sources. From ancient text, it follows that near Potaissa (Turda) was the city of Salinea, where "the Salt Headquarters-Collegium salinariorum" was, and at Sarateni was the "castrum salis". Of the epigraphic sources, only the epigraph from Domnesti dedicated to the health of Aelius Marus can be mentioned - "conductor pascui et saünarum", the inscription, near Sanpaul, from the village of Martinis, dedicated to the health of C. Iul. Valentinus c(onducator) sahnar(um). Soldiers were stationed at Micia-Vetel with P. Ael. Euforus - salinary agent. Of the archaeological sources, there are roman coins, die votive altar worshipping Jupiter and Terra Mater from Domnesti, and bricks with cohort signs from Ocnele Mari, Buridava, etc.

2.3 *The bell-type exploitation method*

Up to the 17th century, the exploitation technique for salt in Romania did not progress significantly. The first attempt at standardization of the exploitation and administration of salt mines was to be completed by the Austrian mountain forum, by the detachment from the metalliferous exploitation of some topographers, who drew the first mining maps. These present the geometrical form of the intracarpatic mines - conical excavation - regularly called the bell-type exploitation (Figure 5). It seems that this system dates back to the 14th century, but the information is not conclusive. However, the last exploitation in which the digging system of simple surface holes was abandoned and the use of the bell-type exploitation was abandoned was at Praid in 1780. The mining technique consists at first of the making of some fairly primitive boreholes with depths of 10-15 m. If salt was found, the next step was the making of two wells wim a section of approximately 1.8 x 2 ra, up to 4-5-m depths in the salt layer. From this level, they were enlarged to 4-6 m at a depth of 2-3 m. In order to prevent water from entering, the back of die key signature was filled with buffalo skin, clay, wool or chaff. After arrangement of these wells, the excavation continued in a conical shape, up to approximately 8 m in depth, where the junction with the other well occurred and the exploitation was given a conical shape. From the second part of the 18th century, the use of four wells for the mine opening began. In the exploitation process, the purpose was to detach the salt in blocks which could be transported over long distances and for which a lot of money was paid. They did not have much use for small salt. In diese exploitations, pointed-end hammers were used to separate tracks and detach beds. The beds were 2-5 m in length, 0.6-1.5 m in width and 0.3-0.5m İn depth. This size varied according to the bed inclination, the thickness of the white or black salt bed and the bed's position İn the required outline. After die creation of a track 15-20 cm in widtii with an approximate small-base trapezoidal outline, the hammer edge was introduced at a distance of 5-10 cm from one another for detachment of the bed. For detachment of a bed approximately 2 m in length, 40-50 hammer edges were used. After detachment of the bed, which was sometimes difficult, breaking again occurred with hammer edges and throygh lulling 20-30 kg balls were obtained. The salt balls were transported by hand, or by barrow up to a farding bag moved up and down by a pulley called a 'crivac', as used at the exploitations of Slanic Prahova, Telega, Doftana, Ocnele Man, Turda, Ocna Dej, and Ocna Sibiului. It was made of a rope at the end of which a platform from bar guzly buffalo skin, solid nets on which the salt was put. The rope wrapped a cylindric tambour fixed on a principal vertical axis, in such a way tiiat during the rotation of the tambour axis, one end of the rope to rose and the other descended into the mine. The tambour was put in more with the help of four or six 'tovele\ at die end of which a pair of horses were usually harnessed. Following white salt zones, most of the time steps of 4-6-m exploitations remained on which people climbed and descended on planks equipped with transversal laths in order to prevent slipping. These exploitations reached 96 ra in depth in Ocna from Slanic Hill Prahova, 145m in depth in Ocna from Slanic Valley Prahova, 147.5 m in Ocna Cojocna, 152 m in Ocna Superioara, Turda, and 160 m Ocna Mare and Sibiu. Aeration occurred by natural circulation, and sometimes fresh air was also introduced in buffalo skins. When the air was no longer breathable, that is, when the candles that provided the light went out, straw was burnt at the opening of the salt mine. In 1739, a manual air hole was introduced; it was a kind of turbine introduced in a wooden frame that was used at the exploitation.

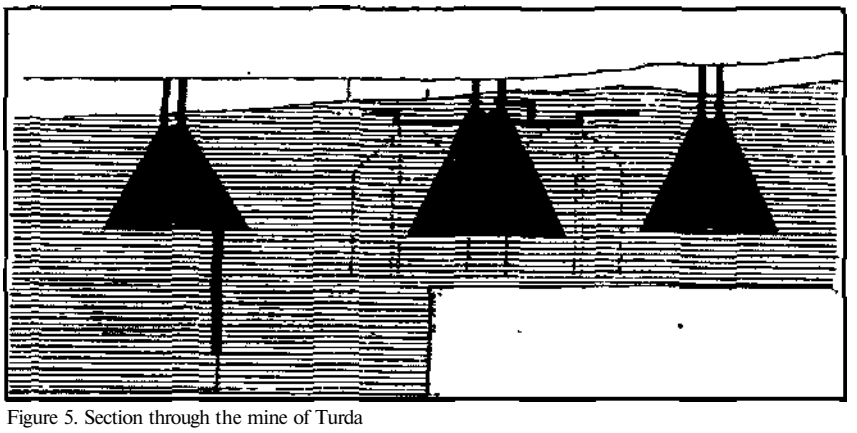

Figure 5. Section through the mine of Turda

2.4 *The systematic exploitation method*

The exploitation methods developed from the conical excavation type, with a single room, to a system with several connected rooms, called systematic rooms. Using the information found, the following chronology of the development of this method can be-made: from Vielicyka (Poland), this method passed to mines in Maramures Costiui, Sugatag, Ocna Slatina (1777, at the proposal of the engineer Iosef Grosychimed), then to Ocna Sibiului, then to Ocnele Mar (1845, by the Austrian engineer Foit) Slanic (I860), Doftana (1865), and Targu Ocna (1870). The advantage of this method was that an exploitation field with a larger surface could be created, and a larger quantity of salt could be extracted through work of the same extension. Within this method, two variants can be distinguished: the first one retains the transversal section with a bell appearance, and the second one has a trapezoidal aspect of the upper part of the exploitation rooms.

2.4.1 *The systematic exploitation method with the aspect of a bell*

The first systematic mine were realized by separating directional and transversal galleries through salt massifs. After some short soundings, descending digging of the exploitation rooms took place through the same system of carving and detaching of the furrow, except that the walls of the rooms had had a tilted and plain aspect. Through this exploitation system, working conditions were improved, aeration could be ensured through natural circulation, and through galleries and wells over long distances. More workers were used. At Slanic there were 160-220 'ciocanasi', that is, those who cut the salt, and there were 180-220 'maglasi' those who worked by

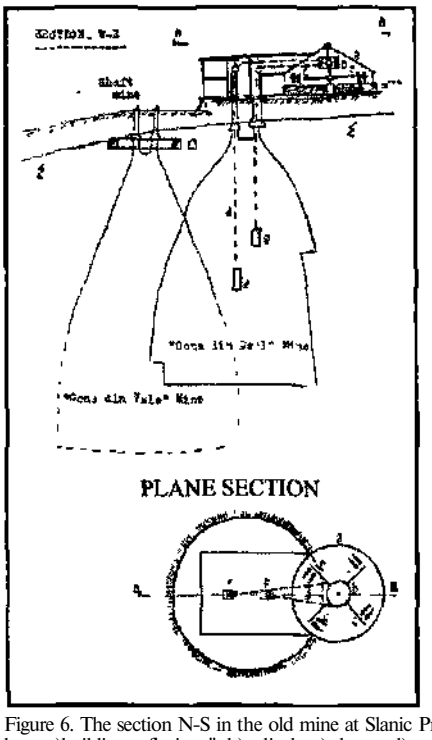

Figure 6. The section N-S in the old mine at Slanic Prahova.a)building of'crivac" b)cylinderc) hors, d) cable, e) hamper ,0 shaft

hand. At the salt mines free men were used as well as prisoners. Mechanical ventilation was introduced for the first time in a salt mine in Slanic, at the Systematica mine by the engineer Carol Craciunul (Caracioni) İn 1854. Electric current Was introduced in Slanic İn 1883, and was used on a large scale from 1910.

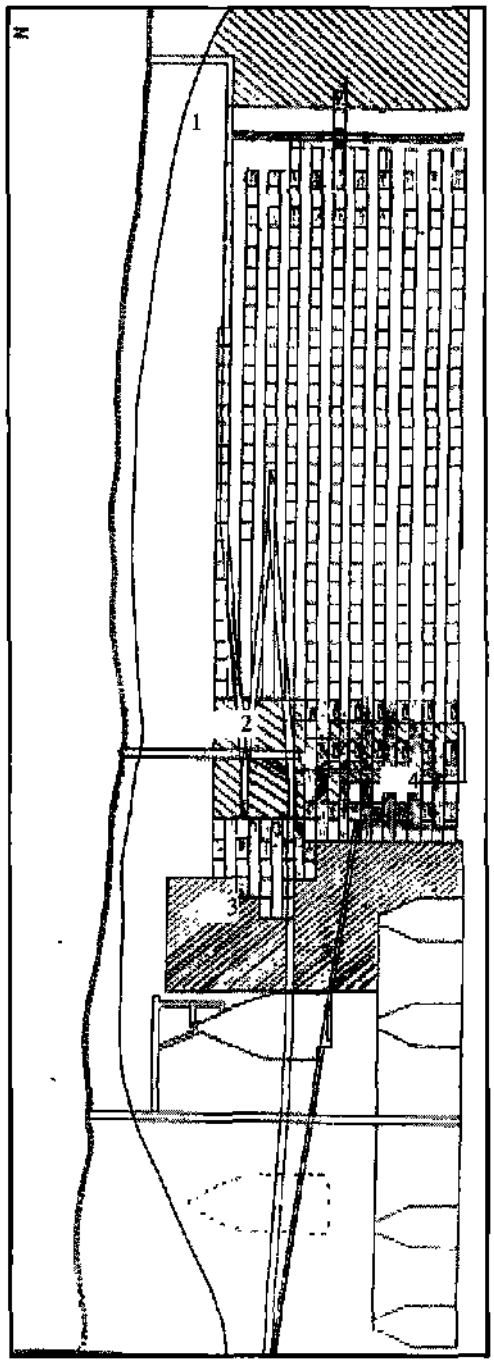

Figure 7. The section N-S in the old mines at Slanic Prahova (1-Victoria Mine ,2- Carol Mine. 3-Mihai Mine and 4-Unirea Mine).

2.4.2 *The systematic exploitation method with ceiling for trapezoidal rooms*

The person who conceived this method was the engineer Stamatiu Mihai. He designed a system of exploitation at Slanic with a central pillar surrounded by rooms and pillars at 150m and under ancient bell-like exploitation and systematic with a bell aspect (Carol mine and Mihai mine, Figure 7); after constructing climbing parts with a compartment for stairs made of wood the ceiling galleries of future rooms were opened.

They initially had a section opening of 4 x 2.5 m, but were enlarged to 10 x 2.5 m. During digging, haveye were used, and wooden balconies were installed laterally in the salt. The exploitation of the work fronts was carried out in the order: undercutting, perforation, loading with explosives of the holes obtained after perforation, the blasting of the holes, either pyrotechnically or electrically, the loading of the salt in trolleys, transport underground and the extraction of the salt in the well to the surface. For lighting, bulbs of 300 W were used and in the 1960s these were replaced with fluorescent tubes. On the surface, exploitations gained an industrial aspect through the building of annexe maintenance workshops, pipe stations, the building of the modification of locomotives, warehouses of ground salt or clods, of packaging for coal, cement, and clay, cloakrooms, canteens and offices. Mine working has diversified, and new jobs such as havators, perforators, pyrotechnists, electricians, mine locksmith engineers, locomotive mechanics, undercutters, etc. have appeared- Durihg the operation of systematic exploitations, progress was made from obtaining a single type of salt balls to obtaining several other types of salt. The exploitation of subterranean surfaces has substantially expanded: only the Unirea mine in Slanic Prahova, closed down in 1970, had a room surface of 72,000 mp outlined by 15 rooms with a 35-m opening, a ceiling of 60 degrees, and 11 pillars with a 50-m side line. The height of the room was 55 m.

2.5 *The method of exploitation with rooms and small pillars*

After hundreds of years of exploitation by the bell-type system and after about 200 years of exploitation with the systematic type system, the exploitation of salt passed to a multi-flood system with rooms and smal pillars (Slanic Prahova, Tg. Ocna, Ocna dej, and Ocnele Man). The method was tested for the first time in Romania at a pilot mine in Tg. Ocna between the September 1966 and 1968, when two floors were opened. The sizes of the rooms and the pillars were adapted to each massif. The biggest mine opened in this system was the Victoria mine in Slanic Prahova (1971-1992), which comprised a

multi-floored structure of 11 floors. The sizes of the supporting pillars were 14 x 14 m, 15 x 15 m, 36 x 16 m, 17.5 x 17.5 m and the heights were 8 m. The ceilings between the floors were 7 and 8 m The opening of such an exploitation was accomplished creating two wells of ventilation, an auto-inclined plan and ventilation galleries. The exploitation of the rooms was İn the following order: undercutting, perforation, loading the holes with explosive, blasting of the ventilation fronts, loading the salt from stopes by means of transport, transport to the underground crusher equipped with a somersault, crushing of the salt underground and its transport an a relay of converger lanes to the surface.

2.6 *Methods of exploitation in solution*

For massifs which had tradition and prospects for the chlorine sodium industry and which had difficult geological conditions in the deposit, in the 20th century the derricks exploitation was used. One advantage of this method was the fact that areas of the massif with low qualitative parameters could be exploited, and sterile elements, most of them insoluble (calcium and sodium sulphates) remained as sediment in the dissolution rooms. Salt in solution İs exploited today at Ocna Mures, Ocnele Mari, Tg. Ocna and Cacica.

3 CONCLUSIONS

According to the study, it was found that 46 salt massifs had the geological, technical, economical and social conditions for mining activity. An untold history has built up around them over the years. The present study is the starting point for anyone wishing to broaden global salt research in this area.

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