PUBLIC HEALTH AND SALT ENVIRONMENT IN SOME SALT MINES IN TRANSYLVANIA (ROMANIA)

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ABSTRACT: Salt exploitation in Transylvania (Romania) is an ancient activity, having more than 2000 years old (from the Roman Dacia). Since the 19th century the interest for the salt mine environment as a therapy tool has increased considerably. In the therapeutic methods used for this purpose, the salt mine microclimate has an important role. The curative effects of the underground cavities (former salt exploitation chambers) are given by an ensemble of physical, chemical and biological conditions, which together manifest a complex action upon the human organism. We exemplify this by the benefits provided by the Praid (Eastern border of Transylvania) and Turda (Western border of Transylvania) salt mines. The Praid salt mine represents an underground treatment centre, having a high therapeutic potential and Turda salt mine may be used successfully with therapeutic purpose. Another therapeutic component related to the salt ores in Transylvania is represented by the salt waters in the lakes developed within the site of some ancient mining exploitations and the sapropelic mud at the bottom of these lakes.

KEY WORDS: salt mine; salt therapy, microclimate, Romania

INTRODUCTION

The salt represents a major rock in the Earth's crust (lithosphere) and also a component of the hydrosphere and of the biosphere. It is one of the main raw materials on Earth and is available for human use in large amounts. This is why the salt was used and prized by humans since millennia.

The salt is composed of sodium chloride (NaCl) and is known mineralogically as halite. It is colourless, it cleaves into cubes, it crystallizes in the isometric (cubic) crystal system, is soluble in water.

In the Transylvania Basin (Romania) the salt is one of the mineral resources widely spread, known and used for a very long time. From the geological point of view, the salt rocks in Transylvanian Basin form a continuous level that has an average width of 200 m. In all Transylvania Basin, from litostratigraphycal point of view, the salt belongs to the Ocna Dejului Formation (Mészáros, 1991).

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The age of the salt was established through complex studies: nanoplankton (Mészáros et al., 1989; Chira, 2001), microfauna (Filipescu, 1994; 2001), microflora (Petrescu & Bican-Brişan, 1997; Petrescu et al., 2000), tectonica (Balintoni & Petrescu, 2002). It was determined that the genesis of the salt took place in the Middle Badenian (Wielician) – 13.6 million years ago.

Two of the most important salt massifs of Transylvania are located on its western and eastern borders (Praid and Turda) *(Fig. 1)*.

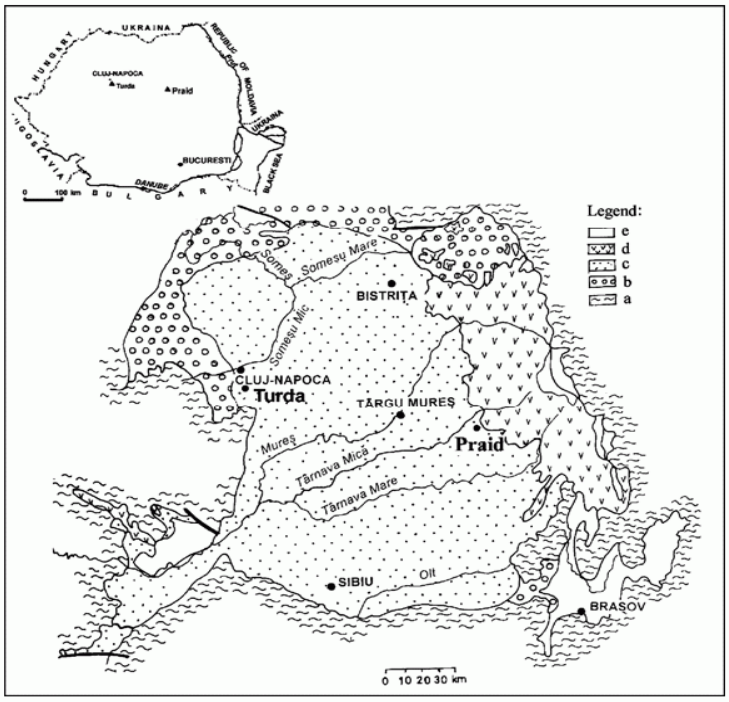

Fig. 1. Location of the salt mines studied (after Popescu et al., 1995, modified): a. fundament; b. Paleogene deposits; c. Neogene deposits; d. Neogene volcanic rocks; e. Quaternary deposits

The Turda region belongs to the western area of Transylvania that, unlike the central part where a dome-structure is typical, shows a specific structure consisting of a closely-grouped succession of symmetrically arranged anticlines and synclines usually having a N – S development.

Turda salt massif is related to the Măhăceni-Ploscoş anticline and it has an elongated shape (4 km length, 200–700 m transversal sizes). The thickness of the massif in the anticline axis varies from 750 m to over 1000 m. It is surrounded by Neogene (Badenian, Sarmatian) deposits and Quaternary deposits.

The Praid area is located at the contact of the Transylvanian Depression with the Neogene volcanic chain of the Eastern Carpathians, at the limit of the Târnavelor Highland with the Gurghiu-Harghita Mountains alignment (Eastern border).

Praid salt massif is a component of the diapiric anticline Sovata – Corund. The body of salt has a quasi-circular, slightly ellipsoidal shape in horizontal cross-section with 1.2 and 1.4 km. The base of the salt massif is situated at a depth of 2.6–2 km. It is the most developed and compact diapiric structure in Romania.

The salt was taken from the nature by people since the ancient times and one of the methods used was the extraction from the salt mine. A salt mine is the result of the underground salt exploitation. Salt mines have different shapes, depending on the historical moment in which the exploitation was made (conical shape, trapezoidal shape etc.). Besides the economical and industrial purpose, the salt mines also have been attractive due to some characteristics that made them suitable for therapeutical purposes. A very good example is the salt exploitation in Transylvania that is a very ancient activity, being older than 2,000 years (since the time of Roman Dacia). However, even if known since Antiquity, the interest for the salt mine environment as a disease treatment expanded considerably only in the 19th century.

EVALUATION OF THE CURATIVE POTENTIAL OF THE SALT MINE

It is likely that miners and others knew about the beneficial health effects of the microclimate of salt mines for centuries before they were first described in a book published by Polish physician Bochkowsky in 1843. Since then, the practice of bringing patients with respiratory diseases down into salt mines for cures gradually spread throughout Eastern Europe, and it has become a standard feature of spa treatment there. This method is called speleotherapy (from Greek speleos=cave).

The curative effects of the underground cavities (former salt exploitation chambers) are given by an ensemble of physical, chemical and biological conditions, which interact and have a complex effect on the human organism.

The measurements made in Turda and Praid salt mines revealed the curative effect of several parameters *(Table 1)*.

Parameters

Aeroionisation (the total concentration of small ions)

Inside Turda salt mine, the aeroionisation is similar to the outside environment. The small ions (10^{-4} to 10^{-3} μm) are found in variable quantities and the majority of them are positive (Anonym, 1989).

The negative aeroionisation in Praid has very high values. This reduces the intensity and the number of asthma crises and increases the elimination speed of bacteria and allergens from the respiratory system. The average aeroionisation of 495.5 in Praid salt mine makes it very useful for the asthma patients. Unlike Turda salt mine, in Praid, positive values of the aeroionisation can be found only during summer.

TABLE 1. The average data of the physical, environmental and chemical parameters in the Turda and Praid Salt Mines (measurements were made by the authors and by experts from Turda and Praid salt mines)

Salt Mine	Physical Parameters		Salt Mine	Chemical Parameters	
	Aeroionization (ions/cm^3)	Aerosol (partic./ cm^3)		CO_2 Concentr. (mg/m^3)	Air pH
Turda	640	180	Turda	733.3	7.2
Praid	495.5	–	Praid	705	6.7

Salt Mine	Environment Parameters		
	Air Temp. (°C)	Relative Humidity (%)	Draught Speed (m/s)
Turda	10.8	76.3	0.16
Praid	17.6	71.3	0.25

Aerosols (the concentration of aerosol particles bigger than 0.5 μm)

Aerosol microparticles larger than 10 microns in diameter are caught in the upper airways and transported up and out of the respiratory tract by the mucociliary system. In the range of 5–10 microns, they penetrate into the trachea and central bronchial area, but no farther. Only the microparticles smaller than 5 microns can penetrate deep into the lungs. However, the larger microparticles have useful effects in the upper respiratory tract. In the range of 0.1–2.5 microns – the same size as the most damaging microparticles from auto and industrial pollution, and invisible to the human eye – the microparticles of salt penetrate into every corner of the bronchi, bronchioles, and alveoli and deposit upon the surface. Even though the salt microparticles spread over an area in the alveoli roughly the size of a tennis court, only a few milligrams of salt are needed. The hygroscopic characteristics of moist particles make them grow significantly during transit and therefore to deposit mainly in the upper respiratory tract and in the central area of the trachea and bronchi. Still, studies have shown that moist particles of salt from hypertonic saline have beneficial effects in cystic fibrosis, for instance, at least in the short term (Wark & McDonald, 2004).

In Turda salt mine the concentration of aerosol is of 180 particles/cm^3, in Praid salt mine the concentration was not determined during this study.

Air temperature

The relatively low temperature from the salt chambers has a stimulating action on the coughing receptors. The temperature difference between Turda and Praid is relatively high: in Turda salt mine the temperature is 10,8 °C and in Praid is 17,3 °C. Nevertheless, not the level, but the constancy of the temperature is the most impor-

tant factor related to the therapy: the temperature in the salt mines is constant along the year (the variations summer-winter are insignificant).

Relative humidity of the air

The relative high humidity in the salt mines can lead to better treatment outcomes, because it helps to the dilution of the tracheal secretion. The level of the air humidity in Turda and Praid is similar: 76,3% and 71,3%.

Draught Speed

The draught speed is independent from the outside meteorological conditions and is very low: 0,16 m/s in Turda salt mine and 0,25 m/s in Praid salt mine. This is the reason why the human organism does not perceive the sensation of cold.

CO_2 concentration

The high concentration of CO_2 in the air stimulates the respiration, increasing the aeration of the lungs. The values for this parameter in Turda salt mine reach the value of 733,3 and in Praid salt mine that of 705.

Air pH

The acid pH of the air contributes to the disinfection of the air and reduction of the bacterial flora. This way pH level has a significant contribution to the curative effect of the salt mines.

Air purity

The relative absence of allergens and microbes in the air breathed by patients during therapy presumably also contributes to the improved status via desensibilization.

Discussions

The microclimate conditions in Praid and Turda allow the treatment and prophylaxis of various diseases. A treatment base is organized in Praid; for Turda a big project of arrangement with turistical and therapeutical purpose has started.

Two more well organized salt mines have been functioning for disease treatment for a long time: Slanic-Prahova and Targu-Ocna (extra-Carpathian area).

The average values for some parameters in Turda, Praid, Slanic-Prahova and Targu-Ocna are compared in the following graphics *(Fig. 2)*.

Analyzing all these characteristics we can conclude that the four salt mines have different microclimate, which are generated by the geological features, specific for each salt ore, and by other factors. Some of the parameters vary considerably from one salt mine to another. This variety might offer the possibility to adapt the therapy for different diseases and patients, according to their particular needs.

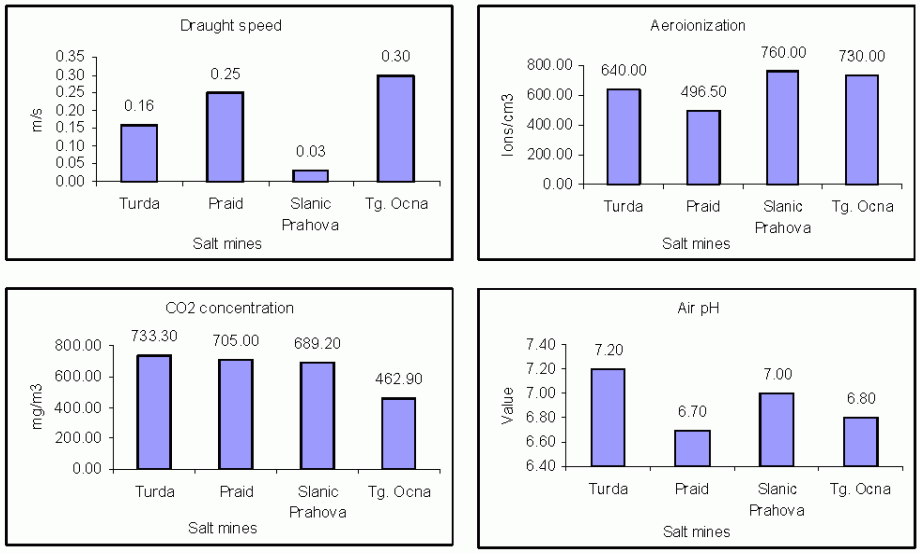

Fig. 2. Comparative analysis of average parameters in the salt mines treatment base in use (Praid, Slănic Prahova, Târgu Ocna) and under construction (Turda)

The salt therapy was found to be beneficial in the treatment of various diseases, such as: asthma and chronic bronchitis (may be improved through gradual and increasing exposure combined with sessions of breathing reeducation – breathing gymnastics), chronic obstructive pulmonary disease, allergic rhinopathy, cystic fibrosis, sinusitis, ear infections, smoking cough and various acute or chronic respiratory diseases.

Using cluster analysis of salt mines, we can see that the most similarities are between Turda and Targu Ocna Salt Mines *(Fig. 3)*.

The most frequent positive effects of the speleotherapy observed over time are the following: through exposure to the salt mine microclimate beneficial effects on the breathing tracks at persons with professional or environmental risk factors (noxa, gas, tobacco and so on) are obtained, reducing the morbidity; children, young people and teenagers benefit from the improvement of breathing function, supporting growth and development with a better use of oxygen; physical effort is done in optimum conditions, with availability to individual or group sports; reduces snoring and activates better sleep by cleaning the airway passages in the oropharyngeal region; increases resistance to cold and flu by opening and clearing the nasal airway and improving the drainage of the sinuses; humidifies the bronchial secretions, reducing broncho-spasm and facilitating elimination of the smoke residual tar, phlegm expel and other allergens etc.

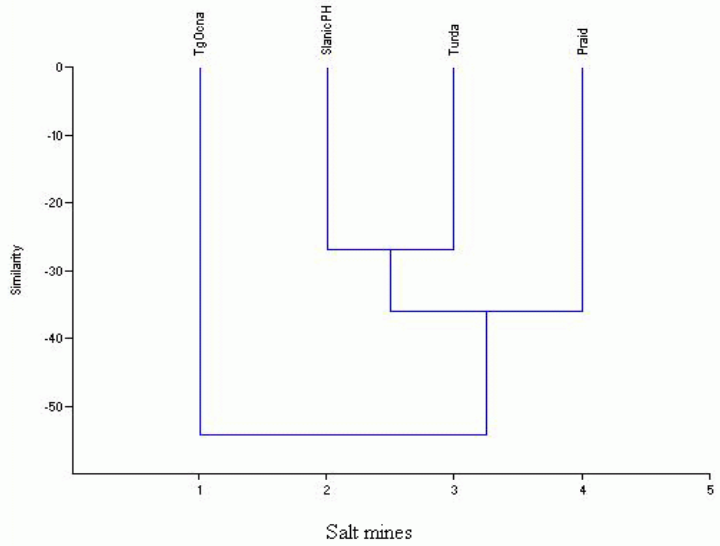

Fig. 3. Cluster analyses of parameters into Turda, Praid, Slanic Prahova and Targu Ocna Salt Mines

The benefits of the salt are found outside the salt mines, too, and the salt lakes are an excellent example. Some of the most frequent therapeutical recommendations for the salt water and sapropel mud (the mud from the bottom of salt lakes, rich in organic matter and other elements) are: rheumatic diseases, arthrosis, spondylosis, degenerative rheumatism, remnants of the locomotor apparatus' traumatism (recovery after fractures, sprains, dislocations), gynaecological affections (inflammatory affections, primary-secondary sterility), affections of the central and peripheral nervous system (paralysis, paresis, neuralgia, poly-neuropathy, psychomotor retardation), paediatric affections (rickets, growth and development disorders), recurred breathing affections, immunity depressions.

The general mechanism of action of the salt therapy is considered to be the following: it dehydrates the microbial cells and impairs the albuminous structure (Chervinskaya and Zilber, 1995). American researchers found that two of the main pathogens present in the respiratory tracts of chronic bronchitis patients are very sensitive to hypertonic salt (Rein and Mandell, 1973). In turn, the body's normal microflora repopulates the area, and the removal of the pathogens leads to a reduction in inflammation from the immune response. The numbers of immune cells are normalized, while both numbers and activation of the alveolar macrophages increase. The normalization of the immune response explains much of the salt therapy's action in treating asthma. The deposition of microparticles of salt reduces the viscosity of the mucus and restores the normal mucociliary transport that removes mucus, pathogens, and debris from the airways. In some chronic bronchitis patients, coughing becomes more frequent during the first seven days of daily treatment.

Large amounts of mobilized mucus that had been blocking the bronchioles are expelled, whereupon the patient experiences general improvement.

The salt therapy is useful in the treatment of many diseases and for the general health condition; however, there are opinions, according to which some contraindications should be taken into account: the acute stage of respiratory diseases, the third stage of chronic obstructive pulmonary disorder (bronchitis and/or emphysema), intoxication, cardiac insufficiency, bleeding and spitting of blood, advanced hypertension (Speleotherapy Clinic, 2004). As there is not a clear common opinion related to the contraindications among the researchers, there is still a great need for further investigations in this area.

Speleotherapy makes a great demand on patients' time. Beside the time spent inside the mines, they have to go to the salt mine, which is not conveniently located for most people, implying a cost in time and money. The patients who do not live nearby must bear the transportation and accommodation fees and all patients (and visitors) have to pay the entrance ticket. The tariffs for patients per day and for a 12 days treatment session are listed below:

	Age	Price for 1 day (Euro)	Price for 12 days (Euro)
Turda	Adults	2.3	18
	Children	1.2	11
Praid	Adults	3.5	25
	Children	1.8	9

Taking into account that the treatment session should be of at least 12 days and that the average income of a person in Romania is (in 2007) around 230 Euro, the price is relatively high. Nevertheless, if we compare the price with the cost of conventional treatments in a hospital, the price become very low. Besides this and most important of all, the efficiency of the treatments and the lack of the side effects (which have not been clearly established so far) sustain the use of speleotherapy. This is why the speleotherapy can bring important economic advantages to the patients and to the society in general.

Due to the difficulty of reaching the salt mine that many patients face, a solution was searched. The answer found was the halotherapy (from Greek halos=salt). Halotherapy is a mode of treatment in a controlled air medium that simulates a natural salt cave microclimate and uses dry aerosol microparticles of salt to treat respiratory diseases. Halotherapy uses halochambers that recreated in clinics the microclimate of salt mines, tubes for breathing in the aerosol salt, ceramic salt pipe, rock crystal lamp or salt lamp.

Serious clinical studies have been done of the first two methods, where the number of microparticles per cubic meter is monitored, and permitting accurate dose measurement. For instance, some studies concluded that it should be no concern about the possibility of excessive salt intake from halotherapy in the case of hypertensive patients. The extremely small size, relatively low amount, and slow dosing of the microparticles also make them much less likely to provoke a hyperreactive

response in asthma patients than moist hypertonic saline (Wark & McDonald, 2004). The ability to deliver a specified dose represents a major advantage of halotherapy over speleotherapy. Still, speleotherapy retains importance as a source of scientific evidence regarding the as-yet not well-characterized, multiple factors that deliver the therapeutic effect. Depending on the conditions of a certain salt mine or cave, speleotherapy might also prove more effective than halotherapy in a given cases.

CONCLUSIONS

The efficacy of speleotherapy is associated with the unique cave microclimate. The reported healing and invigorating effects of the microclimate of salt mines are variously ascribed to the microparticles of salt floating in the air, the temperature, the relative humidity, the low concentration or total absence of pathogens and allergens, the effects of radiation from minerals, and the tranquility of the setting. Nevertheless, it is difficult to determine the relative influence of these factors, and most probably some synergy exists. In addition, each chamber in each mine has a distinct microclimate. Conducting clinical trials in such conditions is not easy. Often speleotherapy has been combined with other therapies.

The numerous favourable clinical trial reports and positive outcomes for many individual patients in different countries over the world, have led to growing scientific attention and increasing interest of the patients for speleotherapy (Horvath, 1986).

As nowadays respiratory diseases are a major cause of morbidity and mortality worldwide, the importance of speleotherapy increases. Asthma has become ever more prevalent in industrialized societies, with special impact on children. Meanwhile, cigarette smoking has spread chronic bronchitis and emphysema everywhere; in developing countries biomass cooking smoke has a similar devastating impact on women and children. The situation is especially bad in China, with its 350 million smokers and terrible air pollution.

Most drug therapies of respiratory diseases have only palliative effects, and many have significant side effects. So, a physical therapy like salt therapy is much needed. Its excellent action and modest cost make it a very attractive kind of medicine.

Under these circumstances the salt therapy should be understood as a valuable resource whose properties must be carefully researched and wisely exploited. Romania has several salt mines that could be suitable for treatment purposes (and also for tourism) due to their microclimate proper for prophylaxis and treatment of many diseases. This is why is especially important the continuation of the research that will establish the relation between the salt mine environment and the human health.

REFERENCES

BALINTONI, I. and PETRESCU, I. (2002). "A hypothesis on the transylvanian halite genesis." Studia Univ. Babeş-Bolyai, Geologia, Special issue 1:51–61.

CHERVINSKAYA, A. V. and ZILBER, N. A. (1995). "Halotherapy for Treatment of Respiratory Diseases." Journal of Aerosol Medicine 8(3):221–232.

CHIRA, C. (2001). "The Badenian Calcareous Nannoplankton from Turda and Ocna Dej Salt Mines (Transylvanian Basin, Romania)." Studia Univ. Babeş-Bolyai, Geologia, XLVI (2):141–150.

FILIPESCU, S. (1994). "Microfauna in the Neogene Deposits close to the salt diapir of Turda – Valea Sărată (West Transylvanian Basin)." In: The Miocene from the Transylvanian Basin, pp. 139–145., Cluj-Napoca

FILIPESCU, S. (2001). "Wielician foraminiferal at the western border of Transylvanian Basin." Studia Univ. Babeş-Bolyai, Geol.-Geogr., XLVI (2):115–124., Cluj-Napoca

HAMMER, Ø., HARPER, D. A. T., and RYAN, P. D. (2001). "PAST: Paleontological Statistics Software Package for Education and Data Analysis." Palaeontologia Electronica 4(1):9 pp. http://palaeo-electronica.org/2001_1/past/issue1_01.htm

HORVATH, T. (1986). "Speleotherapy: a special kind of climatotherapy, its role in respiratory rehabilitation." Int. Rehabil. Med. 8:90–92.

HERNÁNDEZ, M. T., MENÉNDEZ, T. F., and CIDAD, L. F. (2002). "Documentación histórica de las Salinas Espartinas." In: SEHA. Sociedad Española de Historia de la Arqueología, Archaia no. 2, (Año 2002). http://www.seha.es

MÉSZÁROS, N. (1991). "Nannofossil Zones in the Paleogene and Miocene Deposits of the Transylvanian Basin." Proced. IV. INA Conf., Knihovnicka ZPN, Prague 14b (2):87–92.

MÉSZÁROS, N., NICORICI, E., and FILIPESCU, S. (1989). "Le nannoplancton des dépots néogenes saliféres traversés par les forages executés aux environs de la ville Turda." Studia Univ. Babeş-Bolyai, Geol.-Geogr., XXXIV (2):61–65.

PETRESCU, I. and BICAN-BRIŞAN, N. (1997). "Contributions to the study of microflora in the salt deposits from Turda." Studia Univ. Babeş-Bolyai, Geol., XLII (2):103–111.

PETRESCU, I., BICAN-BRIŞAN N., and MERA, O. (2000). "Paleoclimatic and environmental conditions during genesis of evaporitic formation from Turda – Cheia area (western Transylvanian Basin, Romania) based on palynological investigation." Acta Palaeontologica Romaniae 2:361–368.

POPESCU, G. H., MĂRUNŢEANU, M., and FILIPESCU, S. (1995). "Neogene from Transylvania Depression." Romanian Journal of Stratigraphy 76 (3):27 (Guide to excursion A1, X Congr. RCMNS)

REIN, M. F. and MANDELL, G. Z. (1973). "Bacterial killing by bacteriostatic saline solutions: potential for diagnostic error." New England Journal of Medicine 289(15):794–795.

WARK, P. A. B. and McDONALD, V. (2004). "Nebulised Hypertonic Saline for Cystic Fibrosis, Cochrane Review." (abstract), (August 3, 2004)
www.update-software.com/abstracts/AB001506.htm

WORMER, E. J. (1999). "A taste for salt in the history of medicine."
http://www.tribunes.com/tribune/sel/worm.htm

*** (1989). Studiul microclimatic al salinei Turda în vederea valorificării sale terapeutice

*** (2003). La sal en la vida, in Biologia. Org, El portal de Biología y Ciencias de la Salud, http://www.biologia.org/revista/pdfs/67.pdf

*** (2004). Speleotherapy Clinic, www.halotherapy.com

http://www.pravasolnajaskyna.sk

http://www.saltinstitute.org/28.html

http://www.scientiapress.com/findings/ht.htm

http://www.salinetherapy.com/