# A World-wide Look at Salt

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**ABSTRACT**

The Fifth Symposium on Salt volumes contain papers. The participants at the Hamburg meeting heard from authors residing on five continents. The papers cover a broad spectrum of science, engineering, technology and the art of understanding the occurrence, origin, properties, significance and uses of salt and related minerals.

## INTRODUCTION

The Fifth International Symposium on Salt contains one of the broadest summaries of the science, technology and state of the art regarding the origin, location, production, use and significance of salt and related minerals and rocks available at this time. Included in the May–June meeting in Hamburg, Germany, and in these two volumes are papers of global, regional and local import on subjects of geology, engineering, mining, environmental and varied industrial and governmental concerns.

## FIFTH SYMPOSIUM TOPICS

This international meeting, involving over 600 participants from 42 countries in North, South and Central America, Europe, Africa, the Near and Far East, heard papers presented in five concurrent sessions or sections. Publication of the papers in these volumes follows that organization. Section 1 contains papers on the geology, mineralogy, geochemistry and tectonics of salt. Section 2 covers dry mining, geophysics, and rock mechanics of dry mines. Section 3 has papers on solution mining, cavity construction, utilization and underground storage. Section 4 covers solar evaporation, thermo-evaporation, salt production, and technology, seawater desalination and by-products. Section 5 includes salt markets, nutritional and other uses, environmental problems and other topics of interest.

We believe that the highlights of the meeting and the papers in these volumes can be summarized very briefly by saying that new concepts regarding the occurrence, origin, properties, technology and uses of salt and related evaporates are evolving. In addition to the traditional harvesting and mining of salt, there is continued expansion of solution mined cavities for the production of salt and the storage of petroleum products. Both the technology used here and in deep mining, together with the basic scientific and engineering studies of the origin, geological history and stability of salt masses is of critical importance to the question of permanent disposal of radioactive wastes in bedded and domal salts and economic storage of other products. A half-dozen papers directly address nuclear waste storage and others in sections 2 and 3 are of critical importance. Let us look at some of these topics in more detail.

## SECTION 1. GEOLOGY, MINERALOGY, GEOCHEMISTRY AND TECTONICS

The twenty authors in this section, convened by Dr. G. Lüttig, Vice President of the Bundesanstalt für Geowissenschaften und Rohstoffe, presented papers on topics of continuing practical concern to scientists and engineers.

The papers address many problems concerning the origin of salt deposits. The main focus in regional geology was the sequence and extent of the Permian Zechstein and related Triassic Muschelkalk salts. Reports on specific occurrences reemphasize the high solubility of salt, the commonly observed signs of recrystallization, and the processes resulting in diagenetic and metamorphic overprint which obscures the primary depositional structure of salt deposits. To these, of course, must be added the factor of high mobility of salt rock and salt deformation. Consequently, geochemical studies on rocks and modern evaporite deposits are neces-

sary to help reconstruct the sedimentary and chemical conditions of the formation of salt deposits.

Especially noteworthy are the descriptions of salt features in Louisiana, Germany and Holland. These areas are important not only as tremendous sources of salt products, but also because the industry is increasingly active in drilling and dissolving caverns in salt domes there for storage of petroleum products. Scientific and engineering studies continue to explore the feasibility of storing radioactive wastes in salt deposits. Any such disposal requires a clear understanding of the effects of hot wastes on the stability of the salt container and its surrounding environment. Papers on finite-element modeling, stability modeling and investigations of anomalies in salt domes as well as gypsum cap rock formation speak to these stability problems.

New salt deposits continue to be discovered, and extended especially as the result of deep drilling, as shown in reports on the Netherlands, Denmark, Poland, Switzerland and Turkey.

## SECTION 2. MINING, ROCK MECHANICS AND GEOPHYSICS

This section, convened under the leadership of Dipl.-Ing. W. Heim of the Kali u. Salz AG, Kassel, West Germany heard some 29 papers.

Salt miners currently are operating at depths in excess of 1,000 meters. The deep conditions require intensive investigation of the mechanical properties and specific stress and stability conditions of the salt in rooms, pillars, roofs and at the mine face. Rheological properties of salt are especially important.

Modern computational methods provide a means for more accurately describing the conditions of the subsurface cavern stability. The safety of deep caverns is threatened, however, by salt creep, water flood and gas explosions. New geophysical methods including the use of reflection seismic tools, sonic and radar waves, and acoustic emmission are a few methods being used and developed to predict and avoid such dangerous conditions. It is possible, for example, to "see through salt" using radar and sonar waves to detect and locate discontinuities in salt masses at centimeter size and at distances up to 30 meters.

Among the less favorable occurrences, but one with a "happy ending" is the report of a water flood at the rate of 67 l/min in a deep potash mine in Saskatchewan in 1970 which flooded 20 miles of mine. The flood was subsequently contained, grouted off, the mine dewatered and production resumed after two years.

Of special interest to American readers is the Dutch Approach to feasibility studies for radioactive waste disposal in salt.

## SECTION 3. SOLUTION MINING, CAVERN DEVELOPMENT, CAVERN UTILIZATION AND STORAGE

Of the 20 participants presenting papers in this section, arranged by Dr. Hans-Günter Haddenhorst, KKB Kavernen Bau und Betriebs Gmbh, Hannover, 15 were from West Germany and the USA, in addition to France and the UK. Clearly the scientists and engineers in these countries have the greatest interest, expertise and technology in this area. Problems of rock mechanics, cavern stability and solution processes occupy half the section, but again radioactive waste disposal problems are addressed in papers from the USA.

The principal ideas evident in the presentations in this section are that the rock mechanics laboratory testing procedures must be field tested with careful attention given to viscoelastic and viscoplastic forces, and that long-term creep tests are absolutely necessary to predict the life of solution caverns. In addition, the development and application of computer programs for finite-element analysis more and more provide a basis for understanding the mechanical stability of subsurface caverns in salt. Nevertheless, prediction of cavern stability to the desired degree is still a long way off in situations where the geological conditions are complex.

## SECTION 4. SOLAR EVAPORATION, THERMO-EVAPORATION, SALT PRODUCTION AND TECHNOLOGY, SEAWATER DESALINATION AND BY-PRODUCTS

About twenty papers were presented in this section assembled under the direction of Dipl.-Ing. G. Jungk of the Bayerische Berg-, Hütten und Salzwerk AG, Munich, West Germany.

Certainly the oldest, simplest and theoretically least expensive method of salt production is solar evaporation. It is, of course, the engine for the origin of natural salt deposits and of compelling interest on that account alone.

The continued economic life of solar evaporation facilities is dependent on the state of national economic and technological development, the fine tuning and control of field conditions in the face of varied meterological conditions and the interplay of biological forces with the water conditions in evaporating pans.

Pollution resulting from salt use is matched by the difficulties of controlling salt grade and removing impurities in saltworks operating under open conditions. The demand for high quality salt and refined by-products for the chemical industry leads naturally to other salt refining processes such as thermo-evaporation, use of high capacity evaporators and

electrodialysis using ion-exchange membrane technology, a process well-developed in Japan.

## SECTION 5. SALT MARKETS, NUTRITION AND OTHER USES, ENVIRONMENTAL PROBLEMS AND MISCELLANEOUS

The section convened by Dipl.-Ing. K. Schmidt of the Deutsche Solvay-Werke Gmbh, Solingen, West Germany heard 21 papers addressing salt quality in the broadest sense including topics such as salt for alkali-electrolysis, the quality of sea salt and its inorganic constituents, quality of salt from solar and vacuum processes, and uses of salt in fluidized bed combustors.

The articles range from market trends in Europe and North America, especially in deicing salts, to regulations on salt quality for human nutritional purposes, especially in developed countries where regulation of purity is heavy, compared to problems of initially introducing socially acceptable additives to salt for basic health maintenance in underdeveloped countries. The latter provides an interesting contrast in the shifting nature of governmental goals in the use of salt and its regulation.

## REFERENCES

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