The Sixth Salt Symposium: An Introduction

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ABSTRACT

These two volumes, covering the papers contributed by participants of the Sixth Salt Symposium held in Toronto, 24–28 May 1983, cover a diverse array of topics concerning salt and other evaporites. These range from the biology of solar salt ponds, their chemistry and management; the chemistry, engineering and design of electrodialic salt processing systems using ion exchange membranes; through the geology and the distribution of evaporites, both modern and ancient, to the physics and design of salt caverns and mines; and last but not least, problems associated with the exploitation of salt-related economic, safety and environmental considerations in its mining and use.

INTRODUCTION

All of the speakers at the Sixth Salt Symposium had the privilege of submitting written manuscripts for publication and most of the topics are presented in written form in these two volumes. The first covers the topics of geology, geophysics evaporites, geochemistry, tectonics and rock mechanics of evaporites and dry mining. The second volume covers solution mining, cavern development and utilization, solar evaporation, salt processing and technology, occupational safety and health, environmental considerations and economics. Because the papers were all written in the English language, which for many authors is not the native tongue, considerable rewriting has been required—but the original organization, intent and style of the papers has not been altered by the editor. In this way it is hoped that the inherent nature of the papers has not been changed. Both English and American spelling and usage is employed on a paper by paper basis, depending on the preference of the authors.

VOLUME I

SECTION 1. GEOLOGY, GEOPHYSICS, EVAPORITES, GEOCHEMISTRY AND TECTONICS

Geology and Geophysics (11 papers)

The subsection on geology covers a broad spectrum of topics. The volume begins with the problems encountered in distinguishing between primary and secondary features in evaporites (both chemically and physically). There are then a group of papers which address the geology and stratigraphy of a number of evaporate deposits. One paper, in particular, considers the depositional setting for two separate areas in a single evaporite deposit and offers some thoughts on the model appropriate to the sediment variations encountered. The final paper in this group is an estimate of the world's potash reserves, based on a technique of structural analysis.

Evaporites (6 papers)

These are a mix of papers that consider special aspects of evaporite formation. The first two deal with the manner in which particular physical features of calcium sulfate deposits are developed. The second two are ecological analyses of modern solar ponds, a feature we have begun to realize controls both the morphology and the rate of evaporite deposition. The last two papers treat the physical characteristics of two non-marine salt lakes in China, a most significant beginning for future knowledge from a region that has more evaporitic areas than any other region in the world.

Geochemistry (6 papers)

The geochemistry subsection begins with a thoughtful consideration of the amount of calcium sulfate found in the rock record (far more than might be anticipated from simple evaporation of seawater) and the possible mechanisms that have permitted this unbalanced accumula-

tion. The next papers address the significance of pore and crystal fluid inclusions in evaporitic minerals, and what can be learned concerning the formation and alteration history of these deposits through careful studies of these liquids. The final three papers deal with the geochemical considerations for the formation of specific minerals within evaporitic settings.

Tectonics (6 papers)

The first two papers address the regional geology of an area and how it relates to the formation of salt dome structures. The next two reveal microtextures and fabrics in salt that may be used as an aid to unravel salt tectonics. The final two papers deal with mechanisms and development of structural features caused by salt solution.

SECTION 2. ROCK MECHANICS AND DRY MINING

Rock Mechanics (15 papers)

In order to mine salts efficiently and safely and to utilize the subsequent caverns for storage, tests need be performed concerning the mechanical behavior of the salt under the stresses of unequal and changing loads. In addition, theoretical consideration of the salt deformation possible must be made as well. The application of theory to the design of the caverns is then made, utilizing the empirical measurements obtained in the tests. The first two papers in this series address the theoretical considerations of the deformational behavior of salt. The next seven papers deal directly with measurements of the mechanical behavior of salts under stress, particularly when the salt is in the form of pillars or contains hollow caverns.

The tenth paper in this series seeks to characterize various types of salt domes, as to their utility for storage and waste. The next two papers discuss the actual use of salt domes for just such storage purposes. Additionally, one of the problems in salt storage caverns is that models are usually built on consideration of reasonably pure salts, but gas-bearing salts may result in bursts with subsequent cavern damage and contamination as well as possible injury to personnel. This problem is discussed in the next paper of the series. The most pressing storage problem at the present time is that for radioactive wastes. The fourteenth paper in the series is directed to this facet of storage. The last paper deals with radar probes that are utilized within boreholes in order to locate irregularities and discontinuities in salt deposits—a marked aid in the design and modeling of future cavern construction.

Dry Mining (4 papers)

Dry mining of salt has been practiced in Europe for more than one thousand years. Nevertheless, new mining techniques are still being developed and implemented. Entrance shafts, which need to cut through a number of poorly consolidated sedimentary layers above salt deposits, are commonly a great source of water flooding and pose a grave danger to a salt mine. Techniques for sinking new shafts and the relining of old shafts are discussed in the first two papers. Similarly, new equipment and techniques for the development of safe and adequately designed roofs for salt caverns is discussed in the third paper. Naturally, as in the development of any large-scale industrial production system, the use of computers to help model mine operation is essential. The last paper in this subsection details such a planning strategy, which attempts to direct mine operations in the most productive and utilitarian manner.

VOLUME II

SECTION 3. SOLUTION MINING, CAVERN DEVELOPMENT AND UTILIZATION

Solution Mining, Cavern Development and Utilization (22 papers)

After an introductory paper by the head of the Solution Mining Research Institute, a series of nine papers address the analytical and design problems of creating and maintaining solution caverns. Not only are the caverns themselves considered, but in the next paper the problems of maintaining the integrity of cavern-entering boreholes are also presented. Naturally, if solution caverns are created, then the attendant problem of subsidence need also be treated. The next three papers deal with subsidence and dissolution problems related to cavern creation and stabilization.

Once the salt has been removed and caverns exist, then the next point is what else may they be used for? Cavern used for storage of both hydrocarbon and waste is discussed in the next six papers. These papers deal with storage on the basis of the materials to be stored in the caverns and also on a national basis, with variations in storage application changing from country to country. The final two papers are rather more philosophical in their approach. The penultimate text discusses the degree to which energy storage programs have contributed to our knowledge of salt dome structure and behavior. The last paper in this subsection considers the legal aspects of cavern development—"who owns the hole when the salt is gone?"

SECTION 4. SOLAR EVAPORATION, EVAPORATION, SALT PROCESSING AND TECHNOLOGY, AND OCCUPATIONAL SAFETY AND HEALTH

Solar Evaporation (18 papers)

The utilization of solar evaporation techniques is literally as old as human history. In practice, simple tests of

the rate of evaporation in an area (before building of a facility is begun) have proven very important. The first four papers in this section deal with these tests and subsequent solar plant design. The fifth and sixth papers provide easily used computer models for controlling the performance of solar plants. One straightforward method to improve the production of a solar salt works is to cover it during rainfall, thus permitting solar production of salt even in marginally dry to rainy regions. This approach is presented in the next paper. The succeeding ten papers all address special design and recovery problems, each dealing with chemically different salts in solar processes. The final paper deals with a study of controlled solar ponds (ponds within enclosed, covered areas) in what is otherwise an area unsuited for them. The purpose of this study is to see if covered solar ponds are feasible as solar energy collectors, even in poor settings.

Evaporation, Salt Processing and Technology (15 papers)

Special techniques for the processing of salt are necessary in regions where mining or simple solar saltworks are not feasible. Unsuitable climate and lack of appropriate land areas commonly force alternative salt production. Compression evaporation, vacuum produced salt and electrodialysis processes (or a mix of these) may all be employed in salt concentration where nature doesn't provide the means. Eleven papers in this series deal with one or another of these processes, their development and their applications.

The electrostatic separation of different salts, after production processes that produce a mixed product, is a newly implemented idea discussed in the twelfth paper. The next paper in this series describes the production of K_2SO_4 through use of less desirable salts in the presence of a solvent, at ambient pressures and temperatures. The last two papers involve using solar energy for (1) electrical power production from solar ponds and (2) also in solar-driven, thermal energy systems using molten salts.

Occupational Safety and Health (4 papers)

The Salt Institute Safety and Health Committee has led the way in improving conditions in the salt industry. These four papers illustrate how proper monitoring of pollution contamination and safety hazards together with employee training can lead to improved working conditions.

SECTION 5. ENVIRONMENTAL CONSIDERATIONS AND PRESENT AND FUTURE MARKET DEMANDS

Environmental Considerations (6 papers)

The first three papers in this group deal with the use of road salt and the environment. They show that with correct application road salt poses little environmental hazard and has great potential for good. The fourth paper deals with salt removal from pulp mills by purification and drying of the salt produced. Much of this salt is then reused by the mills themselves. Similarly, in the fifth paper, the effluent produced from a vacuum salt plant is in part recycled and the remainder is utilized to make drilling brines for salt wells. The final paper in this series deals with the monitoring of ground movements over salt domes. In this case the data obtained may be used to determine the stability of the dome prior to creation of cavities in the subsurface and also after formation to monitor for continued stability.

Present and Future Market Demands (5 papers)

The final subsection of the second volume is actually a review of the motivation of the entire two-volume set—the economics of salt production. Evaluation of the continuing market for salt in North America, and an understanding of how much salt is wanted and in what forms it is needed, is vital for the continued health of the industry. The final paper, a case study of production of food grade salt in Portugal, is presented. It is a small but significant study and the implications are clear. Overproduction destroys the industry as surely as does underproduction.