Annotated Bibliography and Index Map of Salt Deposits in the United States

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Annotated Bibliography and Index Map of Salt Deposits in the United States

By WALTER B. LANG

CONTRIBUTIONS TO BIBLIOGRAPHY OF MINERAL RESOURCES

G E O L O G I C A L S U R V E Y B U L L E T I N 1 0 1 9 - J

Contains references, to June 1956, on distribution of salt deposits, geologic occurrences, geophysical exploration, technology, experimental research, and historical accounts

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Plate 4. Index map of salt occurrences in the United States.... In pocket
CONTRIBUTIONS TO BIBLIOGRAPHY OF MINERAL RESOURCES.

ANNOTATED BIBLIOGRAPHY AND INDEX MAP OF SALT DEPOSITS IN THE UNITED STATES

By Walter B. Lang

ABSTRACT

Salt is abundant in the United States. Though of vital importance for domestic purposes in historic times, it has now become one of the most important commodities in industry and the demand for large tonnages of raw salt for industry is steadily increasing. The purpose of the bibliography is to serve as a ready reference to a wide range of subjects on salt which include the geographic distribution of salt deposits, geologic description of occurrences, geophysical exploration, technology, experimental research, and historical accounts.

INTRODUCTION

Common salt, the mineral halite, is of vital importance in the life of man. It was one of the first commodities to enter the arts and crafts of early man and in modern times has become one of the most essential commodities in industry. Where in the past, production of salt was for domestic use, an increasing demand now comes from the chemical industries, for food packing, refrigeration, weed and ice control, water conditioning, and many other technical applications.

The salt resources of the United States are enormous. In late years as prospecting to greater depth has been conducted for various commodities, large bodies of salt previously unknown have been discovered. These discoveries have not only added to the already large volume of known salt but also has widened our knowledge of its geographic distribution in sedimentary formations. Thus the question of adequate salt resources is not a present-day problem; but the coordination and adjustment of these natural occurrences of salt to the ever-changing requirements of economic industrial and chemical production, will be the chief concern for the future.

The great reservoir for salt is the sea. From this source, under certain conditions, concentrations of salt are made in shallow enclosed
basins upon the land where they may later become buried and so preserved along with other sediments. Where ground water encounters buried salt, the latter is dissolved and returns to the surface through springs. The salt either accumulates again in internal drainage basins or is returned to the sea by streams. Where tectonic forces have pressed upon deep-seated salt beds, the salt is squeezed upward and in some places comes out at the surface. Here erosion or ground water depending upon the climatic environment, soon removes it, and the salt ultimately returns to the sea. Some of the sources of commercial salt and the methods of production are listed in the following table.

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EXPLANATION OF THE ANNOTATED BIBLIOGRAPHY

This is an annotated bibliography about salt and, as such, contains information imparted or implied by the authors of the articles. It is intended to provide the reader with a general review of the variety of salt occurrences in the United States. Some references to the Canadian literature are also included because of the rapid recent developments in North Dakota and Montana and the contiguous areas of Canada. The selection covers a wide range of subjects: salt occurrences, geologic description, geophysical exploration, technology, experimental research, and historical accounts. The reader may pursue the subject of his special interest by use of the citations included in most of these references. Geologic names used in the references are those of the various authors and do not necessarily follow the usage of the U. S. Geological Survey.

To facilitate use of the bibliography, the entries are arranged in alphabetical order by the name of the author. The index provides subclassifications of the geologic and technologic subject matter. There is also a geographic classification of the references by their distribution in the States, and a map (pl. 4) which shows the distribution of the various occurrences of salt.
BIBLIOGRAPHY


Outlines the origin and the formations of the upper Permian evaporites that contain the major salt bodies in the Permian basin.

Adams, T. C., 1938, Recent deposition of salt from Great Salt Lake: Jour. Geology, v. 46, p. 637–646.

Great Salt Lake precipitates sodium sulphate each winter and redissolves this salt during the early spring. However, within the last 4 years (1934–38) summer precipitation of sodium chloride has also taken place as an accompaniment of the unprecedented low level of the lake. The sodium chloride returns to solution during the early winter, completing a spectacular annual cycle of salt precipitation and resolution. Winter precipitation of sodium sulphate is caused by the cooling of the water; summer precipitation of the chloride is caused by the annual reduction in volume of the lake, a result of heavy summer evaporation and reduced inflow during the season. A large tabular deposit of almost pure sodium sulphate is buried in the beach sands along the southeast shore of the lake and may be related in its formation to past winter precipitation of this salt similar to that now being observed.


Describes certain structural features found in the potash beds of the Salado formation in the mines of the United States Potash Co. and the Potash Co. of America, east of Carlsbad, N. Mex. Gives an interpretation of the manner of formation of the three identified variant types that depart from the normal seam; the depositional, erosional, and structural salt horses.


With respect to exploratory drilling for petroleum in Wilcox County, Ala.: “This test, abandoned at a total depth of 8,250 feet, penetrated 100 feet of Eagle Mills salt, from 8,150 feet to bottom of the hole, extending the salt basin well beyond the previous considered limits. The known presence of salt at this point will be of value as related to geophysical interpretation.”


Discusses at length the stratigraphy of the Silurian in western New York and gives possible explanations for the origin of the salt.


Reviews briefly the occurrence, distribution, and future trends in salt production in Ohio, West Virginia, Pennsylvania, and New York.

Gives a review of the stratigraphy of the extensive Devonian system of rocks in western Canada and the contiguous part of the United States east of the Rocky Mountains. Exploration for petroleum in recent years has made possible correlation of the salines of the Middle Devonian.


In the deepest well (20,450 feet) east of the Mississippi River anhydrite and rock salt were penetrated below the base of the Smackover formation of Late Jurassic age.


Lists U. S. Uranium Corp. as a producer of salt in Montrose County for 1941. Subsequent annual reports do not mention salt.


Gives a comprehensive and well-illustrated description of the geology of the great basin area of southern California, including chapters on the occurrence of borates, carbonates, chlorides, and nitrates contained within the area. It is particularly valuable for one desiring a perspective of California 50 years ago. Maps are included.


Describes by use of subsurface maps and cross sections, the stratigraphy and structural setting of the Devonian in Manitoba, Saskatchewan, Montana, North Dakota, and contiguous areas. Defines the salt-bearing Prairie and Davidson evaporites.


An amplification of the author's paper on the same subject contained in the Manitoba Department of Mines and Natural Resources, Mines Branch Publication 52-5.


Gives the original description and definition of the Paradox formation which contains the largest body of salt of Pennsylvanian age in North America.


Compares accounts of the geology of the Paradox formation and gives a section of the Hermosa and Paradox formations. Indicates the trend and marginal boundary of the saline basin and suggests a southeastward connection to the open sea.


This detailed study describes the structure of the salt in a part of the Grand Saline salt dome exposed by mining operations. The layered salt is steeply folded but shows no fractures, faults, cross cutting salt layers, foreign inclusions,
or brine. Anhydrite inclusions display a linear alinement with the salt grain, and in places halite crystals are elongated. Deformation has been by mass molding of the salt. A structure map of the mined area and diagrams of salt doming are included.

1953, Salt structure on Jefferson Island salt dome, Iberia and Vermilion Parishes, La.: Am. Assoc. Petroleum Geologists Bull., v. 37, p. 2455-2474. Describes the structure and characteristics of the salt. The origin and dimensions of the salt dome are presented along with a structure map of the mined area.

Baltimore and Ohio Railroad Company, Baltimore, Md., 1949, Salt report for the Baltimore and Ohio Railroad area: Manager Indus. Devel., Traffic Dept., 56 p. Contains a compilation of rock salt and brine resources of parts of the States of New York, Pennsylvania, West Virginia, and Ohio within the area served by the Baltimore and Ohio Railroad. The book, in looseleaf binding, is well illustrated with simple maps and diagrams, showing the areas underlain by salt and the location, depth, and thickness of brine sands in producing wells. Brines are found from the Ordovician to the Pennsylvanian and at increasing depth from west to east. Analyses of the more representative brines are given. The information provided is sufficiently comprehensive to give the reader an excellent and concise preview of the saline resources of the region.

Bangston, R. J., Moore, D. D., Ramsey, R. H., and Lund, R. J., 1950, Mineral Resources of southeastern Ohio: Ohio Dept. Nat. Res., Div. Geol. Survey, p. 79-88. Presents a compilation of data on salt brines in southeastern Ohio, including maps showing areas of strong bromine and calcium concentrations and a geologic column indicating the brine-producing horizons. Seven companies produce salt in Ohio; 5 from rock salt and 2 from brines. Gives a list of salt producers and chlorine plants, with costs and the uses of the products.

Barksdale, Jelks, 1929, Possible salt deposits in the vicinity of the Jackson fault Alabama: Ala. Geol. Survey Circ. 10, 23 p. Salt seeps in Clarke County apparently are related to the Jackson fault and the Hatchetigbee anticline. The regional dip is to the southwest, and it is believed that ground water descends to a source of salt and from there rises to the surface along fractures. The salinity and flow of the springs have remained constant for more than 70 years. These brines were a source of salt during the Civil War. Many shallow wells have been drilled for salt but none has so far encountered rock salt.

Barnes, R. B., 1933, Plasticity of rock salt and its dependence on water: Phys. Rev., v. 44, p. 898-902. Measurements indicate that water actually penetrates the interior of a salt crystal when wetted. Wetting causes a high degree of plasticity and tensile strength (Joffe effect) as measured by infrared radiation. See also Phys. Rev., v. 43, p. 82-83.


Contains a long description and graphic illustration of the representative forms of salt structures found in Roumania and north Germany. In Roumania, salt domes are commonly related to overthrusting in border-mountain areas. In Germany, compressive forces caused linear ruptures along which, and at the intersections of which, salt domes formed, but some apparently were caused by local influences. The roots of American salt domes have not been studied, but it is assumed they have a similar origin in depth. The anhydrite-gypsum-calcite cap rock is a typical feature of American salt domes. This type of cap rock is seldom present in Roumanian salt domes. In Germany the cap is commonly composed of gypsum; sulphur and oil are common associates in American domes.


The article is chiefly concerned with prospecting for petroleum but mentions the occurrence in Louisiana of massive salt at a depth of only 500 feet under a thick cap rock of limestone and gypsum.


Describes 3 major (Palangana, Piedras Pintos, and Falfurias), 3 minor (Sal del Rey, Sal Vieja, and Chapeño), and 2 probable (Smith Corkill and La Lomita) salt domes in the tip of Texas. It also gives a comparison of their indicated forms with better explored salt structures in Germany.


The salt in salt domes is believed to be of sedimentary origin and to have come from salt beds at depth. Gulf Coast salt domes were formed by static thrust and by downbuilding, a term used for differential compaction of the surrounding sediments. Salt domes may be formed along the crests of folds, zones of faulting, convexities in the top of the salt bed, or over deep canyons. Rim synclines, the limit of upthrust, and isotatic compensation are discussed. A map of the distribution of salt domes and other structural features of the Gulf Coast is included. The volume of salt contained in Gulf Coast salt domes of Texas and Louisiana is calculated as 520 cubic miles and the age of the source bed is considered as Early Cretaceous or older. A table of compaction figures is also given. In the absence of evidence of dynamic thrust which might explain salt-dome formation, emphasis is placed on the relative merits of static thrust and downbuilding.


The report gives little useful information on salt, but contains descriptive data on a salt dome now famous for its early exploitation and prolific production of oil.


The Lion Oil Refining Co. drilled a well 7,255 feet deep in Union County, Ark. Rock salt was drilled into at a depth of 5,960 feet which continued to the
bottom of the hole. The salt is placed in the Trinity group of the Lower Cre­
taceous.

Mines Bull. 327, 530 p.

Many of the 3,967 entries of world literature on potash contain information about salt.

Blake, W. P., 1857, Geological Report, in Reports of Explorations and Sur­
veys * * * from the Mississippi River to the Pacific Ocean: 33d Cong.,

Mentions Casteca (Castaic) Lake in Tejon Pass as containing a thick crust of salt formerly used by the Indians, also a similar occurrence on the eastern side of the elevated plain of Taheechaypah. Briefly describes the saline bed of dry lake of the Colorado Desert (Salton Sea) and the occurrence of salts in Cajon Pass and the Mojave Desert.


Gives a sketch of the early records of Salton Sink; Emory, 1848; Williamson, 1853, and the changes made by New River. The New Liverpool Salt Co. bored a well 3 miles west of the tracks of the Southern Pacific where a 7-inch crust of salt (sodium chloride and magnesium chloride) was penetrated. The flood of 1891 is mentioned.

Brownocker, J. A., 1906, Salt deposits and the salt industry in Ohio: Ohio Geol.
Survey, 4th ser., Bull. 8, 42 p.

Presents the occurrences of salt by county and the methods of production and preparation as practiced before 1906.


Lists the areas of salt production from dry lakes and locations of plants where salt is extracted by solar evaporation from sea water in California. Gives tonnage and value of salt production in California since 1887, markets, prices, and estimated reserves.


Brine springs and rock salt occur in the area of Star Valley near Afton, Wyo. The brines are saturated and served in the early years as a source of salt for many mining camps of the region and for domestic use. The article contains a review of regional geology; considers the salt originally disseminated in the Beckwith formation, later accumulated in anticlines when folding took place, and subsequently transferred to Tertiary or Quaternary lake deposits when the latter were formed. Estimates of the quantity are given.

Browdesh, F. W., 1951, Beneficiation of Kansas number four salt: Kans. Geol.

Discusses the methods of improving the quality of crude salt for market.


The author contends that a basin must be isolated from the sea before halite beds form and that no large basin can be isolated from land drainage. From
Usiglio's succession the postulated sequence of deposition, in ascending order, is limestone, anhydrite, and halite. Salt deposits are not found throughout the Coastal Plain, but at Smackover, Ark., in Texas and Louisiana interior areas, and in the Gulf Coast proper. They are shown to be of different ages. The Comanche rocks occur upon the Pennsylvanian without intervening Permian, Triassic, or Jurassic. The salt at Smackover is said to be in the lowest lower Comanche, and the Louisiana-Texas salt to be of Glen Rose age.


Gives annual production figures, estimate of reserves, and a map showing the subsurface distribution of salt in Kansas.


An outline of the production of salt by the Leslie Salt Co. from sea water in San Francisco Bay. Explains preparation of vats, evaporation process, and harvesting of salt. The production months are April to October when rainfall is slight. Rainfall is 10 to 18 inches per year; the evaporational differential is 31 to 43 inches per year for salt production. The bittern removed after salt crystallization contains 16.0 percent NaCl; 6.0 percent MgCl₂; 4.2 percent MgSO₄; 1.4 percent KCl; and 0.121 percent Br at 28° Be°. The ratio of K to Br is 11.5 to 1.


Gives an account of salt formed at low water, caused by tide and wind, along the Gulf Coast west of Corpus Christi. At Grand Saline, brine seeps and a well made available during the Civil War, 1,000 sacks of salt of 200 pounds each per day. Near Graham, Young County, salt was obtained from seeps along the banks of the Salt Fork. Also in Wise and Lampasas Counties, along the Red River, and at the crossing of the Pecos there were sources of salt.


Salt "Abounds in the country along the upper Pecos above the road from Fort Concho to Fort Stockton. Near the Horse Head crossing of the Pecos are large deposits of salt in the bed of what is called Salt Lake. To this place wagons resort for supplies of salt for El Paso, Presidio and other counties."


Reviews the sources and methods of salt production in California and gives a supporting list of references.


The first salt furnace in Kanawha Valley was erected in 1797 at the Great Buffalo Lick. In 1808 the first salt well west of the Alleghany Mountains was drilled here. By 1844-54 salt production varied from 400,000 to 600,000 barrels annually and rivaled the output from New York State. It was found later that the salt water was coming from the Pottsville series at depths of 600 to 1,000 feet.

Brine issuing from the Pocono sandstone was used in the early days to make salt, and gave name to Saltsburg, on the Conemaugh River. The salt works which stand by the old canal, and were fired with Freeport coal, ceased operations long ago.


Discusses in particular the characteristics and form of the continental shelf off the coast of Texas and Louisiana. Gives a stratigraphic cross section of the coast and shelf area in central Louisiana. The Eagle Mills formation is shown as the source of salt that has been squeezed into salt stocks to heights of 35,000 feet.


Contains a review of the Gulf Coast salt domes and maps and tables indicating their distribution, geologic characteristics, stratigraphy, structure, and the methods and time of discovery.


Contains geochemical data on the ocean, waters of enclosed basins, mineral wells and springs, and saline residues.


Gives a brief statement of early salt production and the possible development of a future salt industry under more favorable economic conditions.


In Wyoming, salt water issues from the Spearfish formation (Triassic) 9 miles north of Newcastle, near Cambria and the head of Salt Creek. During 1878 and later, salt was produced in wood-fired evaporating pans also used for chloridizing gold and silver ores from the Black Hills. The estimated spring flow is 60 gallons per minute. The water contains 3 percent of NaCl and minor amounts of CaSO₄, MgSO₄, MgCO₃, FeCO₃, SiO₂ but no Br or I.


The Darron salt dome, believed to have been formed by faulting, is the first one found east of the Mississippi River from which there has been sustained oil production. Oil is from Miocene sands above salt or from the same sands faulted up from depth. The top of the salt is 4,627 feet below the surface. A minor deflection of the river suggests recent movement of the dome. There is no gypsum or anhydrite cap on the salt.


Presents at length the history of development, processes of manufacturing, and marketing of salt, with a table of the geologic occurrence of salt in the United States as known at the time.
Discusses the theories of salt formation and the geology of the southern peninsula, with maps and sections. Each formation is treated separately and analyses are given.


A spring of salty water on the north side of Lake Kerr, Marion County, has the composition of dilute sea water. Fissures in the limestone from which the spring issues are 30 feet deep and extend below the fresh-water horizon and sea level. The salt water may be siphoning out of the limestone.


Mentions the occurrence of flowing salt wells at Waldrip and San Angelo and of salt at Colorado City, Salt Flat, and Salt Croton Creek. Describes Hanna and Hancock Springs at Lampasas.


Describes the early known occurrences of salt springs, flats, and wells along the eastern exposures of the Permian and drained by the Red, Wichita, and Brazos Rivers. Also mentions salt production at Colorado, Tex.


Discusses the occurrence of polyhalite in the Permian salt deposits of West Texas, including its mineralogic characteristics, geologic associations, and economic possibilities.


Gives a description of the Paradox formation (salt bearing) and related geology. Salt is not exposed at the surface but occurs at depth.


Map shows location of a salt spring at the head of Salt Creek in Wyoming. Considers source of salt to be in the Spearfish formation and gives an analysis and estimate of flow of the spring.


Twenty miles northwest of Quemado in central-western New Mexico is an elliptical depression about 1 mile wide that holds a shallow salt lake. This lake is spring fed near its southern border and the shallow margins are salt encrusted. Indians and Mexicans have gathered salt here for centuries.


Includes a list and a discussion of logs of wells drilled in the Permian basin of Kansas, Oklahoma, Texas, and New Mexico which have penetrated notable thicknesses of salt in association with potash.

Contains logs and records of wells drilled into Permian salt in the Pecos Valley of southeastern New Mexico.


Presents an excellent historical review of the evolution of opinions and concepts on the origin of salt domes in the United States. The review of the literature is grouped into periods. The theoretical concepts are classified under four headings. Domes are regarded as formed (1) from old erosional outliers, (2) as salts deposited from rising solutions, (3) from volcanic sources, and (4) as a consequence of tectonic forces applied to sedimentary beds of salt at depth. De Goyler concludes that he favors the tectonic origin for salt domes, although he admits he cannot fully document his beliefs.


Gives a brief review of the concept of the origin of salt domes as of 1930. Also states that evidence of potash was found in the Bayou Bouillon dome of Louisiana as well as the Markham dome of Texas.


Compares the salt of the Salina formation with marine solar salt and concludes that as they have similar characteristics, they were formed under similar conditions. Believes seasonal or temperature changes are indicated by banding. Temperatures of deposition as indicated by liquid inclusions suggest lower temperatures of formation than previously considered.


Hockley salt dome, one of the largest known, has been prospected by many oil companies since 1905 with no discoveries of commercial oil or sulphur. Fifty wells have been drilled, ranging in depth from 200 to 4,600 feet.


An analysis of salt-dome formation made by the use of working models simulating geologic conditions. Viscous liquids assume movement comparable to salt under pressure. It is believed that plasticity is an essential for the intruded as well as the intruding rock. Movement is accelerated until a domal shape is well established, after which growth continues at a constant rate. Continued growth indicates a plentiful supply of salt, and, where the height of the dome is more than 10 times the thickness of the salt bed, additional salt is pressed from the marginal area.


The playa is estimated to contain 15 million tons of high-grade salt at depths of less than 40 feet. There were no promising indications of associated potash. The sediments to a depth of 50 feet were tested by drill and the results are presented graphically.

Gives a chronological record of prospecting the Bayou Bouillon salt dome before 1925. It is an asymmetrical salt dome with steep south and west flanks.


Although this paper deals primarily with the occurrence of potash, the article also presents data on wells drilled into the salt of the Paradox formation in the Moab-Thompson area of Utah.


Thomas Jefferson, in his Notes on Virginia in 1781, mentions the occurrence of salt springs in southwestern Virginia, but rock salt was not discovered until 1840. Eckel considered the salt and gypsum to be an integral part of the Greenbrier formation. Logs of wells drilled for gypsum and possible rock salt on the Robertson property between 1815 and 1857 are given. Concludes that the salt aggregates 175 feet in thickness.


Describes salt production from Great Salt Lake, Utah, where salt is produced by solar evaporation. In the summer season 2 inches of water is evaporated per day from the salt ponds and about 3 inches of salt is formed in an average season, although 6-inch crops have been reported. Analyses of the water and a brief history of the salt industry are given. Comments on salt production in California at San Diego and San Francisco Bay are added.


This book although of mainly commercial interest, offers the reader a comprehensive review of the nontechnical and historic phase of salt production.


Consists of descriptions of sample cuttings from wells drilled in western Pennsylvania, with a discussion of the correlation of formations from the St. Peter sandstone (Ordovician) to the Pennsylvanian. A map of the location of the wells and a table of formation thicknesses accompany the article. Salt is indicated in some of the Salina sections.


Gives a graphic presentation, by columnar sections and depth and thickness contours, of the distribution of Salina salt in northwestern Pennsylvania. Also shown are the limits of salt occurrence and the position of the outcrops of rocks of the Salina group.

On this map are indicated the following salt licks and rivers of importance as sources of supply to the early travellers migrating westward.

- Bigbone Lick
- Blue Lick
- Blue Licks
- Blue Spring
- Boonsboro Lick
- Bryans Lick
- Bulletts Lick
- Flat Lick
- Flat Licks
- Knob Lick
- Muddy Creek Lick
- Upper Blue Licks
- Licking River
- Salt River

Foshag, W. F., 1926, Saline lakes of the Mojave desert region: Econ. Geology, v. 21, p. 56-64.

Reviews the geologic and mineralogic conditions in the areas of Mojave saline lakes. Concludes with four premises: (1) The chief sources of playa salts are Tertiary saline sediments, rock decay, volcanic emanations, and hot springs. (2) Concentration of saline is largely confined to the surface layers. (3) The occurrence of crystals in playa muds is due to the downward diffusion of saturated solutions. (4) The concentration of large bodies of salts are the result of special conditions seldom duplicated.


Contains a group of papers on stratigraphy of the four contiguous corners of Utah, Colorado, New Mexico, and Arizona, and a description of the saline deposits of the Paradox formation.


Gives geologic descriptions of the basins, their history, composition of dissolved salts, sediments, and character of the minerals contained.


Gives a description of the geologic setting for Bristol Dry Lake near Amboy, San Bernardino County; the deposits, and a review of exploration and production operations. On the north side of the present playa, salt is mined at shallow depth below the surface. Calcium chloride and sodium chloride brines are drained off from the top clay bed by ditches. Where the brine is concentrated, sodium chloride crystallizes out leaving a concentrate of calcium chloride which is shipped in tank cars to Los Angeles. Gypsum was mined 2 miles southeast of Amboy. Concentrations of celestite occur in the top muds of the playa.


Lists seven salt producers. Diamond Alkali Co., at Painesville, and Pittsburgh Plate Glass Co., at Barberton, are the two largest, employing 90 percent of the salt workers. Includes brief data arranged by county on rock salt and brine production with tables. Two maps show areas underlain by rock salt or containing brines.

Gives a detailed petrographic description of cap-rock core specimens from the Gulf Coast salt dome region. The specimens are composed mainly of anhydrite, gypsum, calcite, and sulfur. From the evidence, an attempt is made to ascertain the origin of cap rock.


Contains a detailed study of cores obtained by the Union Sulphur Co. from its test 194, drilled through 628 feet in the cap rock of Sulphur Salt Dome. Presents an identification of the minerals and an interpretation of their relation in the cap-rock formation.


A modern compilation of geochemical data. Ten pages of data on sodium appear in group IA of the alkali metals along with a statement of its place in the cycle of sedimentation. Chlorine appears in Group VIIB, requiring 14 pages to cover the subject.


This salt dome was one of the first discovered by geophysical methods (torsion balance). Oil was found in 1928. The salt mass was thrust up at a slight angle to the north. The Beaumont clay, which occurs at the surface, does not indicate the presence of a dome.


Presents an early description of the Big and Little Salt Plains of the Cimarron in Oklahoma just south of the Kansas boundary.


This textbook covers rather completely the essentials of saline deposition and the geologic processes related to it. Abundant references are given.


Briefly mentions the geology of the Pottsville series in relation to brines. Of a hundred or more companies that began production of salt products in West Virginia, only two remain, the Hartford Salt Co. and the Westvaco Chemical Division of Food Machinery and Chemical Corp. Diamond Alkali Co. is in process of building a plant on the Kanawha River. Reviews the many products that are derived in part from brines.


Postulates that in western North Dakota (1) where ground water drains along preglacial channels into kettle depressions with impervious bottoms, concentration of mineral matter occurs, (2) but where lakes drain through their bottoms or overflow into other lakes at lower levels during flood periods, they remain fresh.

Includes diagrams and a discussion of an interpretation of thrust faulting along the expanded head of a salt dome. Such an explanation gives a new concept for consideration in future exploration for oil in domes of this type.


The authors consider the Louann salt of the Gulf Coast to be the same age as the Castile formation (Permian) of the Delaware Basin, postulating that the Louann salt is the equivalent of the anhydrite of this basin. A connection between the two basins is proposed north of the central mineral region. Salt plugs are formed from the Louann salt by differential pressure of the overlying sediments on the lighter salt.


Lists 28 minerals found in a study of cap rocks. Contains illustrations of 47 specimens and a bibliography of related subjects.


Reviews the world production and trade in salt: world occurrences, production methods, preparatory processes, annual production by countries, and its various uses in the United States. Maps show distribution of major world deposits, world production, also salt deposits and producing plants in the United States.


Gives the origin, geologic occurrences, and economic importance of rock salt in the State of Louisiana together with brief notes and references to all known salt deposits and industries of the world.


The earliest salt production by settlers was in 1797 in Jackson County where Indians had evaporated brines. In Gallia County, 1809, the first brine well was drilled 100 feet deep. Rock salt was first found in the Salina formation by the Cleveland Rolling Mill Co. at Newberg, and thus began a new era in salt production. Data on later developments are given. Salt production as an industry began in Muskingum Valley in 1817 with production rising to 400,000 bushels by 1833. (A bushel equals 80 pounds.)


The discovery and investigation of saline-bearing anticlines in southwestern Colorado and southeastern Utah has led to their classification into 4 groups, namely; saline anticlines bearing plugs, saline anticlines that bear no plugs, domes
not associated with anticlines, and structural anticlines. The regional geology and stratigraphy are presented along with maps, diagrams, and many illustrations.


Includes a geographic description of the lake, the early historical events, and analyses of the waters taken at various times. Gives the probable combination of the ions in solution, $\text{NaCl}$, $\text{Na}_2\text{SO}_4$, $\text{MgCl}_2$, $\text{CaSO}_4$, $\text{K}_2\text{SO}_4$. Estimates, as of 1942, the total worth of the salts in Great Salt Lake as $44.5$ billion as compared with $3$ billion for total value of mineral production in Utah since 1869. Briefly outlines the uses of the salines. Contains a bibliography.

Hazzard, R. T., Spooner, W. C., Blampied, B. W., 1945, Notes on the stratigraphy of the formations which underlie the Smackover limestone in south Arkansas, northeast Texas, and north Louisiana: Shreveport Geol. Soc., v. 1–2, p. 483–503.

Presents data for the depth to, and thickness of, the Louann salt and the underlying Werner anhydrite. Attempts to correlate these formations with the Permian of West Texas and to reconcile their thickness with the proportional volumes of salts contained in sea water. Invokes the Branson theory as a means of explaining deficiencies. Contains correlation charts and well records for the area.


Lake-bed deposits of the Verde formation crop out along the Verde River valley near Camp Verde, Ariz. Some salt occurs along with thenardite in these beds. Salt crops out in the Virgin Valley.


This is a reprint of a paper published in 1838 and presents the conditions and sources of salt supply (salt springs or salines) from about 1800 to 1835.


Presents an interpretation of seismograph data obtained from a traverse of Moss Bluff dome. Reflections yield figures of 36,000, 26,000, and 16,000 feet as the base of the salt column. Reasons are given for preferring the multiple reflection interpretation of 16,000 feet.


Gives tables of analyses of brines found in wells drilled into brine-producing formations of western West Virginia with information on the owner, location, depth to production, and the flow of the wells sampled.

Reviews the developments and experiences resultant from the operation of two reservoirs formed in salt for storage of propane: one in Winkler County and the other in Upton County, Tex. [LPG, low-pressure gas.]


“In southwest Alabama, 108 feet of the salt facies of the Eagle Mills formation was penetrated in the Union Producing Companies M. M. Waite No. 1, sec. 27, T. 8 N., R. 1 W., Clarke County, Alabama.”


Summarizes information on the occurrence and production of salt in the United States and Kansas. Outlines methods of mining and refining, uses, markets, and chemical products requiring salt for their manufacture; costs of plant construction and operation.


A map covering an area of the Gulf Coast between Sabine Pass and Grand Cheniere, La., and extending out 75 miles from shore, records the gravity variations made within depths of 20 fathoms (120 feet). Within the area mapped, numerous salt domes have been discovered and the presence of others are suggested by anomalous gravity variations.


Outlines the technical factors and cost advantages for underground storage of propane in a salt-water sand as an alternative to reservoirs formed in rock salt or in steel tanks.


Presents a cross section of the Ochoa series in a part of the New Mexico Permian salt basin, the stratigraphic succession of beds, and their relation to potash accumulation.


Describes sources of salt supply in the early days, with analyses and production figures. Contains a picture of Crater Salt Lake.


The composition and environmental conditions of the salt-dome formations and the results of laboratory investigations of the S^{32} and S^{34} ratios of sulfate reduction to sulfide indicate that sulfate-reducing bacteria played an important part in the formation of sulfur. The bacteria probably reduced dissolved sulfate to hydrogen sulfide. The subsequent formation of sulfur was most likely due to a nonbiological process, such as a reaction between sulfide and sulfate.

Lists and describes the rocks of the Permian basin occurring in West Texas by systems and formations from the Precambrian to the Quaternary, including the salt-bearing formations of the Permian. An ample bibliography is given.

Keller, R. M., and Quirke, T. T., 1939, Mineral resources of the chemical industries: Econ. Geology, v. 34, p. 287-296.

Lists 150 chemicals essential to industry. For the manufacture of these chemicals, 34 raw materials are required. Salt is fifth in importance, being preceded by water, air, coal, and sulfur. Salt is essential to the production of 75 percent of the chemical products listed.


This article is of interest for its description of a salt dome of the typical small sulphur-bearing type, with a thick cap rock of the anhydrite-sulfur-limestone succession. It is also the place where the Frasch process was developed for the extraction of sulfur. A brief historical note, cross sections of the cap rock, and an outline of the Frasch process are included.


Rock salt was first found at Ithaca in 1885. The salt occurs in beds in the Salina from 5 to 50 feet thick and at depths of from 1,800 to 2,100 feet. The Cayuga Lake depression offers a 400-foot topographic advantage, with from 100 to 400 feet of easy drilling in the overlying glacial fill from Watkins Glen to Ithaca. Logs of wells drilled through the Salina at Watkins Glen and Ithaca are recorded; a brief sketch of the early salt development is given.


Gives an outline map of the saline lakes and descriptions and analyses of the salts in Brooklyn and Philadelphia lakes. The dominant salts are mirabilite and epsomite. Sodium chloride is present in negligible amount.


Attributes the close of Capitan reef building to excess of evaporation over inflow to the basin. Confines the lower Castile to the Delaware Basin, with a total thickness of 2,000 feet of banded and white anhydrite, white halite, without potash. The top of the lower Castile has a depositional relief of hundreds of feet which makes correlation from this base inaccurate. Potash is the important mineral of the upper part of the Castile (Salado) and is present in amounts sufficient to satisfy the future requirements of the country.


Presents by maps the geographic distribution of evaporite deposits in the systems of rocks from the Ordovician to the Tertiary and gives a discussion of the lithologic relations of the evaporites to other sediments and to the structural basins in which they are formed.
Salt is extracted from sea water by solar evaporation at Moss Landing for local use in fish curing, ice cream, dairy and cattle markets. It requires 2 months of evaporation for initial salt crystallization, ultimately producing a layer of salt 4 to 6 inches thick. The salt is said to be more uniform in composition than that from San Francisco Bay.

Laizure, C. M., 1925 [Salines in Monterey County, Calif.]: Calif. State Min. Bur., Mining in California, v. 21, no. 1, p. 53–54.

Salt is obtained by solar evaporation and marketed for many years as stock salt. There has been no production for about 10 years.


Illinois was at one time an important salt-producing State. Formerly, salt works were in operation at Equality, Central City, Murphysboro, St. John, Danville, and probably elsewhere. All were in central or southern Illinois. Ultimately these works were closed because of salt production from other sources. The St. Peter sandstone seems to yield the strongest brines. A table of 13 analyses accompanies the article.


Reviews the stratigraphy of Devonian rocks of the Detroit River group in the southern peninsula of Michigan. Contains a series of structure contour maps that are helpful in saline investigations.


Gives a description of the Salina formation and its stratigraphic position in the northern part of the southern peninsula. Near Saginaw Bay the Salina is 3,000 feet thick and the top of the section is at a depth of 5,000 feet. It is composed of dolomite, salt, and shale; 36 percent of the section is salt. The salt does not crop out; instead, breccia resulting from solution and collapse is found near the outcrop.

Contains an outline of the stratigraphic position and distribution of the salines of the Permian basin and a discussion of the factors controlling Permian sedimentation.


The economic depression in salt mining in 1895 brought most of the New York salt mining companies together under the Retsof Mining Co. banner. Retsof later became a subsidiary of the International Salt Co. Salt is mined by shaft at a depth of 1,063 feet. In 1926 a core test was drilled 784 feet below the mined salt bed. Logs of both mine shaft and core test are given, also a full description of the methods of mining and preparation of salt.


Brackish water of moderate salinity occurs in Bladen County, N. C. This salinity is apparently related to faulting associated with the great Carolina ridge. It is believed that the water entering Salt Marsh Creek is artesian and not invading sea water, which is likely true in Florida (Salt Spring and Warm Salt Spring, 86°F).


Refers briefly to the various mineral products recoverable from sea water, the world's greatest mine. Gives a table in pounds of the minerals in sea water and paragraphs on salt and on gold, bromine, magnesium, and other elements.


Lenses or beds of salt from 85 to 100 feet thick crop out in washes of Virgin Valley near St. Thomas.


Describes in general the uses of salt with special reference to the Lixate solution process, the making and use of eutectic salt ice, and the stabilization of clay roads by the application of salt.


Summarizes the geologic occurrences of salt and potash in the world, including many maps and diagrams.
Lists analyses of brines from oil wells in eastern and western Kentucky.

Lists analyses of brines from oil wells in eastern Kentucky.

Boggy Creek salt dome is near the axis of the East Texas geosyncline. Its large size and shape are uncommon for salt domes, for it has a low central area on top. Faulting has occurred in the south end of the uplift. Oil is produced from the southeast flank of the dome.

Describes briefly the economic extraction of salts from the brines of three California desert lakes: the American Potash and Chemical Co. and West End Chemical Co. at Searles Lake: the Natural Soda Products Co. of Keeler, and Pacific Alkali, both at Owens Lake: and the Desert Chemical Co. producing sodium sulphate and sodium chloride at Dale Lake, discovered by Irwin Bush in 1920 to be a source of salts. The Pacific Coast Borax Co. operations at Mojave and Death Valley Junction are mentioned.

In 1922 the Wallace-Wyoming Oil Co. drilled a well in Tygee Valley. Six beds of salt from 6 to 29 feet thick were penetrated in a section of 456 feet, from a depth of from 123 to 579 feet. The salt is in the Preuss sandstone of the Jurassic.

Briefly reviews occurrences of potash contained in salt deposits of the world. Gives an account of the search for potash in the United States with special reference to the Permian salt basin of the Southwest. Analyses of salt samples from Government and oil-well tests in percentages of potash present are given.

Reviews stratigraphy of the Ohio basin in West Virginia, Pennsylvania, Ohio, New York, and includes logs of salt sections of many important wells. Gives analyses of the salt, estimates of reserves, and considers the possibility of salt in eastern West Virginia. Outlines salt production and uses.

Outlines the problem of petroleum byproducts in seasonal demand the search for suitable storage in off-season periods. After a review of the situation, the conclusion is reached that a dissolved-out reservoir in salt is the most satisfactory and economical solution to the problem. Salt domes and salt beds are advantageously situated in or near many large oil-producing areas.

Describes a test of underground storage of petroleum where, by dissolving the salt, a reservoir of 50,000 barrel capacity was formed between the depths of 1,167 to 1,750 feet. Five tests were made by filling and removing the petroleum from the reservoir. The first test recovered 95 percent of oil; the last 4 tests returned 99 percent of it to the tanks. The only noticeable effect on the oil was a slight exclusion of moisture. The maximum cost of storage per barrel is $2.50 or about one-seventh that of steel-tank storage on the surface. The test was made in Winkler County, Tex.

Meinzer, O. E., 1911, Geology and water resources of Estancia Valley, N. Mex., with notes on ground-water conditions in adjacent parts of central New Mexico: U. S. Geol. Survey Water-Supply Paper 275, p. 7-86.

Describes the geologic setting for the saline lakes of central New Mexico, from which salt has been produced over the centuries.


Deposits of sodium chloride and sodium sulphate occur in certain low places. Thin crusts of sodium chloride occur on small northern alkali flats along Salt Creek and in arroyos and small flats east of the White Sands. Sodium sulphate in considerable quantities underlies Lake Lucero in the southern part.


States that the Salton depression was covered by a salt marsh with salt crusts 6 inches to 1 foot thick before flooding by the Colorado River in 1904. The New Liverpool Salt Co. had developed a profitable salt industry before 1904. As much as nine-sixteenths of an inch of water was reported to have evaporated from salt pans in 24 hours when temperatures reached a maximum of 140°F.


Reviews the salt industry with respect to its trade practices, sales, marketing, price maintenance, discounts, price discriminations, and freight equalization as it affects customer classification. Lists members of the Salt Producers Assoc. and their division of sales territory.


A brief review of the geology of the Gulf Coast salt domes, with maps and diagrams.


Appendix 1 presents data on salt deposits suitable for the storage of petroleum products in various areas in the United States as a means of saving steel for
storage tanks. Appendix 2 deals with some chemical aspects of underground storage and appendix 3 with the engineering aspects of underground storage. Comparative costs are presented.


The prime cause for salt dome formation is ascribed to density difference and plasticity of the sediments. The peripheral sink formed about the base of a salt stock may cut off the supply of salt. Expressions for volume relations and relative dimensions are given in terms of thickness of salt and radius of peripheral sink. The differential behavior of two liquids of different viscosities and densities is given by experiments. Diagrams are presented to show the effects of contemporaneous sedimentation and salt doming as an explanation for many of the geologic features of salt domes. A list of related references is included.


Gives a comparison of the factual data to experimental evidence in formulating a concept of salt dome evolution. It is concluded that salt domes are the consequence of fluid mechanics where pressure and plasticity are the motivating factors. Recent evidence for the existence of rim synclines favor this postulation.

—— 1947, Geophysical history of typical Mississippi piercement salt domes: Geophysics, v. 12, no. 1, p. 30–42.

Describes the discovery and exploration of the New Home and D’Lo salt domes by geophysical methods. They were indicated by gravity surveys, checked by the refraction seismograph, and their depth and position confirmed by drilling. Gives examples of how strong, but local gravity expressions, may be missed by reconnaissance surveys.


A comparison is made of the earlier concepts of salt-dome formation with those of today. It seems evident that salt domes are due to a fluid adjustment of salt to density differences. A study of the quantitative relations involved in salt doming and of increasing evidence of the occurrence of rim synclines are impressive; assurances of a displacement origin for the domes.


In part presents some results of experiments with dry powders as model materials to simulate salt-dome formation.


A symposium of 19 papers which describes the geologic setting of the Permian salt basin in southeastern New Mexico.


Gives a brief review of the salt industry in the State, a block diagram, a map of the salt area and a list of companies producing salt in the State.

Presents a comprehensive review of early history and development of the salt industry of New York State; also the mining, manufacture, and production of salt. Lists the plants, producers, and grades of salt marketed.


Reviews the information accumulated on the Salina formation. Compares the sedimentary characteristics of the Vernon, Camillus, and Bertie beds. States the Camillus problem and concludes that the Salina sea was of marine origin, that the volume of salt present could not have been derived from erosional leachings, and that the cause of saline accumulation varied from place to place. Because there is no trustworthy evidence, concedes the point that the Silurian sea may not have had the same composition as the sea today has.


Jefferson Island is the only one of the Five Islands in southern Louisiana from which sulfur is produced. It is a flat-topped dome, capped by sulfur-bearing limestone and anhydrite. A salt spine rises 850 feet above the cap on the east side. Salt was discovered in 1894. Sulfur was accidentally drilled into in the late twenties. By 1935 more than 2,225,000 long tons of salt had been produced and 500,000 long tons of sulfur. The author believes that the spine and cap were initially formed and were later thrust up from the source of the salt. Salt is produced by conventional mining and sulfur by the Frasch process. The sulfur wells are in Lake Peigneur and are connected by pipeline to the plant on shore.


Most of the saline deposits of Wyoming are of the sodium sulphate-sodium carbonate types. Sodium chloride occurrences in brines or in deposits associated with other salines are given by counties.


Describes various experiments using asphalt and semifluid muds of greater density to simulate salt-dome formation.


From a study of the records of 3,555 wells, contour maps of the total thickness of salt, position of the top of the salt, and the variation in thickness of rocks between the top of the Big Lime and the top of the uppermost salt bed were constructed. The first salts were deposited in local basins; subsequent deposition occupied enlarged basins which later coalesced to form continuous beds of salt. Salt beds, 100 feet thick, approach to within 1,300 feet of the surface southwest of Cleveland (Lorain and Cuyahoga Counties) and descend southeastward to 6,734 feet (Monroe County) below surface. The western limit of the salt is defined.

"Many years ago salt was obtained from wells sunk on Big Sandy River near Zelda. The old salt works have long since disappeared. South of Zelda, near Catalpa, some of the wells drilled for oil and gas have struck salt water, which is still running."


This comprehensive study includes descriptions of salt deposits by States. History of production, extent of deposits, geology of the deposits, and a bibliography of literature available for each State are included. Maps indicate locations of deposits. The origin and formation of saline deposits, chemical composition of saline materials, and tables on production are also given.


Summarizes most of the essential factors of salt: its properties, composition, mode of occurrence, origin, and world distribution. Operations relating to production, consumption, processing, marketing, with tests and specifications of salt for human consumption, uses and prices are described. A bibliography is given.


Gives data on the salt beds of Michigan. In Ogemaw County a well was drilled through 1,066 feet of the Detroit River formation containing 300 feet of rock salt in 12 beds from 6 to 78 feet thick. Also in this well, 3,144 feet of Salina was penetrated, which contained 38 rock salt beds from 2 to 463 feet thick, totaling 1,260 feet of rock salt. A deep well in Bay County penetrated 2,790 feet of Salina with 1,700 feet of rock salt in beds of from 30 to more than 400 feet thick. The top of the Salina formation varies from 5,393 to 8,547 feet below the surface in Ogemaw County; from 5,480 to 8,270 feet in Bay County; and from 1,000 to 2,000 feet below the surface in Wayne County where 550 feet of salt occurs in 17 beds 20 to 90 feet thick.

Rock salt is mined from a depth of 1,100 feet below Detroit. Elsewhere at Midland, Taganau, Bay City, St. Clair, Port Huron, and also in Detroit, salt is manufactured from natural and artificial brines.


Discusses the characteristic features of six salt domes located in the interior of eastern Texas—Grand Saline, Steen, Brooks, Keechi, Palestine, and Butler—and compares them with the interior domes of Louisiana. Contains an introductory outline of the history, exploitation, and stratigraphy of the salt-dome area.


Gives geologic descriptions of the salt domes with logs of wells, maps, and gas analyses. Also gives a general description of the origin of salt domes.

Outlines the stratigraphy of the Sacramento Mountains, covering the complete section of rocks of Paleozoic age which include or are related to the salt beds of the Permian salt basin to the east of the mountains. Maps, illustrations, and a bibliography are included.


At present there are no salt brine industries in Wayne, Cabell, or Lincoln Counties. Brines from the Salt Sand of Pottsville age and the Big Injun of Mississippian age have a specific gravity of 1.08 or more. The Big Injun sand always yields large flows of salt water when penetrated by drill holes.


Gives a descriptive and historic sketch of the brine industry, the geology and chemistry of production, and many tables of analyses of brine samples from wells.


Reviews history of salt production from brines that are believed to be connate waters in marine sediments. The Middle and Lower Pennsylvanian and the Mississippian rocks are the most important containers of brine. The Salt Sand yielded a heavy brine of 1.1243 specific gravity; Big Lime, 1.1299; Big Injun, 1.1449; Brown Shale, 1.1617, and the Oriskany a brine of 1.2246 specific gravity. Calcium saturates the lower horizons. The brine section is calculated to contain 800 million tons of salt. Rock salt is available only from the Salina (Silurian). The northern part of the State is underlain by a bed of salt about 100 feet thick. Production is by solution only. A table of depths to the Salina salt is given.


Presents explanations of the relation of subsurface saline formations to anticlinal structures and the stratigraphy of the region. Maps, cross sections, and other illustrations accompany the article.


Contains a list of 600 analyses of oilfield waters in which, with other elements, the amounts of sodium and chlorine are given.


This is a voluminous compilation of data on geochemistry containing many items having particular reference to both sodium and chlorine and to their combined form, salt. Subjects such as sea water, evaporation, chemical differentiation during sedimentation, the alkali metals and the halogens which are of importance in problems concerning salt are discussed.
Reidel, J. C., 1951, Ninety percent propane recovery from 50,000-bbl salt reservoir: Oil and Gas Jour. v. 49, p. 167–168, 236–237.

Describes a reservoir dissolved out of salt for the storage of propane at the Texas Gasoline Corp. plant in the Benedum field, Upton County, Tex. The top of the 1,000-foot section of salt is at a depth of 1,290 feet. The first test showed a recovery of 93.79 percent of the propane stored in the reservoir.


Presents data on the salt lakes in Salt Basin west of the Guadalupe Mountains, with analyses of some of the salts. Traces of strontium, lithium, and potassium have been identified, also borax. Mexicans for centuries have come from as far as Chihuahua to gather salt from these lake flats. Denial of their use without payment caused the Salt War of 1877.


The Jurassic rocks exposed in Sevier Valley contain lenses of salt and gypsum.


Presents data and explanations for the behavior of salt as a road binder for clay and soil surfaces.


Gives a critical review of the mechanics of salt-dome formation as evident from data known at the time. It assumes that salt from unknown depth is pressed through the overloading sediments toward the surface as opposed to a contemporary view held by most geologists that the salt was deposited by ascending waters.


Describes briefly the mining method and equipment used in the Retsof salt mine of the International Salt Co., Retsof, N. Y. The article is well illustrated.


Describes briefly the occurrence of salt in the Preuss sandstone in southern Caribou County. Gives citations to salt, items 110, 406, 457, 565, 625, 726 in part 2, the Bibliography, volume 2 of this report. Also lists U. S. Geological Survey Mineral Resources 1882 to 1915 as references to information on salt.


Spectrochemical examination of mined salts, brines, and processed salts from Kansas revealed the presence of celestite, iron, and possibly polyhalite. Elements identified as present in minute quantity are Si, Al, V, Ti, Mn, Cr, Ca, Sn, Pb, Zn, and Ag.

Contains a descriptive list of the minerals found in an examination of the salt cores obtained in wells drilled into the Permian salt beds of western Texas and southeastern New Mexico.


Describes the San Mateo plant of the Leslie-California Salt Refining Co. on the west side of San Francisco Bay where salt is produced from sea water by solar evaporation. The San Francisco Salt Refining Co. also produces salt on the marsh flats east of Redwood City.


Gives geographic distribution of oilfield brines and their analyses by stratigraphic position. Although the emphasis is on magnesium, data on sodium chloride are adequately presented.


Presents largely a speculative view of an origin of salt domes with particular reference to their possible mode of occurrence in offshore locations.


Describes the operations and developments at Salduro for the extraction of potash from brines drained from the marsh. Gives representative analyses of the brine and a review of the economic factors involved. The very superabundance of salt in the intermountain region where industrial requirements are small makes production of sodium chloride for other than immediate local use uneconomic.


The Middle Devonian in western Montana is reported to contain large deposits of anhydrite and salt.


"Several large salt springs exist in South Park, some 15 miles southeast of Fairplay, and some years since works were erected there capable of turning out 10,000 pounds of salt per day. Saline springs of various degrees of strength also exist at several other points in the State, some of which could be made profitable, but none of them have been improved, and many are not even claimed. Among the best of these are springs near the head of Salt Creek, a tributary of the Rio Dolores, which are so strongly saline as to render the waters of the creek quite briny."
Outlines the salt industry of the time. The record shows that most of the salt-producing areas of the present were then known. Along the shores of Lake Huron and Saginaw Bay, lumber mills in the early days engaged in salt production by burning waste sawdust to evaporate the brine obtained from wells. The decline in lumbering curtailed much of this production.


Describes the Alfalfa County salt plain, the salt plains of the Cimarron, known as Big and Little salt plains in Harper, Woods, and Woodward Counties; also those in Blaine, Beckham, Harmon, and Jackson Counties. The salt plains of the Cimarron are of historic interest because their salt was widely drawn upon by explorers and early settlers.


Gives a general survey of the geology of northwestern Louisiana, including a note on exploitation of salt, and a comprehensive description of the Vacherie, Prothro, Bistineau, King’s, Rayburn’s, Price’s, Drake’s, Winnfield, Cedar Creek, and Cochee Beake salt domes.


Salt was discovered at a depth of 5,974 feet in the Hayes well A–9, sec. 4, T. 16 S., R. 15 W., Union County, Ark., and the drill continued in salt and thin lenses of anhydrite to 7,255 feet. On the basis of this and other data it is believed that the Smackover oilfield is on a salt-dome structure.


The Abert, Summer, and Alkali dry lakes of south-central Oregon contain sodium chloride, sodium sulphate, sodium carbonate, potassium chloride, and borax. Production and delivery of salt from these lakes to markets along the Columbia River in competition with imports of solar salt from San Francisco is not considered likely. The economic production of sodium carbonate and the other salts from these lakes depends on successful research and better facilities to meet the competitive market.


Although salt is not produced from deposits in Pennsylvania, large quantities are available. Fifteen deep wells drilled in 9 counties of western and northwestern Pennsylvania penetrated beds of salt in the Salina formation at depths of from 2,300 to 7,000 feet. Single salt beds are from 5 to 70 feet thick; one bed in Erie County is 15 feet thick; 4 beds in Washington County total 100 feet. Another test penetrated 22 beds from 6 to 55 feet thick which, with intercalated shale, represents a 407-foot section.


Describes the Holston River valley, giving an outline of the stratigraphy and structure of the rocks. The Maccrady formation, of the Mississippian, contains salt and gypsum. The gypsum occurs irregularly along an overthrust fault; the
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Salt is produced by solution from a depth of 2,000 feet on the east side of valley; it is shallower on the west. Natural brine seeps indicated the presence of salt below, which formed the only source of salt for the South during the Civil War. The author considers the salt and gypsum to be replacement deposits in relation to the fault.


Covers the history, origin, and stratigraphic succession of the occurrences of brines and their utilization and distribution by county and formation.


Rock salt occurs in association with gypsum in the valley of the North Fork of the Holston River. The valley extends 30 miles northeastward. No rock salt is mined in Virginia, but brine is produced by the Olin Mathieson Chemical Corp. at Saltville. It is believed that exploratory drilling might uncover additional deposits of salt.


Presents a general review of the occurrence of salt, its production and marketing, with special reference to Kansas.


Gives a review of the geology, mineralogy, and literature of Louisiana salt domes. Describes the form and structure of cap rocks. Rejuvenated movement of the salt core in places may bypass the old cap, giving the impression, on insufficient exploration, that no cap rock is present. Concludes that the anhydrite of a cap is the same anhydrite as that found in the salt. Considers that ground water plays an important part in determining the size and composition of the cap rock.


Notes that 83 salt domes have been found in southern Louisiana: 27 in the northern part of the State, 50 in Mississippi, 1 in Alabama, 21 in east Texas, 51 along the Gulf Coast, and 5 in southwest Texas, making a total of 238 for the Gulf Coast region. Describes the general characteristics of salt domes, their size, depth, and mineral content, with more detailed data on Avery Island, Jefferson Island, and Weeks Island salt domes. Contains references and a map that shows the distribution of salt domes, both inland and offshore.


Gives a brief historical outline and the operational development of the chemical plant for the successful production of the various salts from the Searles Lake brine. The presentation of equilibria diagrams constitutes two-thirds of the book.


Saline waters and crusts are found in Salt Lake, Lord Lakes, and their vicinities. Some shallow wells also yield water too saline for domestic use. The salt is believed to be leachings from the Pierre shale.
Outlines the Tully and Detroit methods previously developed to dissolve bedded salt from depth by solution and shows by description and diagram the advantages gained in using the Trump plan. In the Trump plan air is forced down with the water which forms a protective blanket between the salt above and the water, thus forcing solution of the salt to advance radially from the base of the well along the floor of the salt bed. By periodically raising the water level more salt is dissolved, and any impurities contained in the salt falls to the floor where it is eliminated from subsequent mining and refining operations.


Before the flooding of Salton Sink in 1903 by the Colorado River, salt was produced from the dry bed by the New Liverpool Salt Co. The salt layer was reported to range from 10 to 20 inches thick. Salt is now produced by solar evaporation at the north end of Salton Sea, 6 miles southeast of Mecca. The present concentration of salt in the water is from 12 to 22 per cent: annual rainfall 1.48 inches, and an evaporation of 87 to 129 inches per year.


A brief note indicates that the Long Beach Salt Co. is producing salt from Dry Salt Lake, 6 miles northeast of Cantil. Industrial salt is recovered from lake brine by solar evaporation.


Relates some of the early beliefs, superstitions, and biblical customs of ancient times regarding salt and its place in war and peace. Describes briefly the present vacuum process of salt production and mentions some of the uses of salt.

United States Bureau of Mines, 1924-31: Mineral Resources of the United States. These annual reports are a continuation of those formerly issued by the Geological Survey and contain a chapter on salt, giving statistics on production, consumption, prices, uses, imports, exports, and any notable changes in the industry during the year.


These annual reports are a continuation of those previously appearing under the title of Mineral Resources of the United States. Each annual report contains statistics on the production, consumption, uses, prices, imports, exports, and any notable changes in the industry during the year.


Includes lucid descriptions and contour maps of each of the Five Islands, giving a general review of its history, geology, physiography, and paleontology.
The article is of value as an historical review of the geology of the Five Islands and the various interpretations of their origin before the salt-dome concept. Rock salt was first discovered here in the United States in 1862 (Avery Island). The salt masses were postulated to be upturned salt blocks.

Names by which the Five Islands have been known are as follows:

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<thead>
<tr>
<th>Early name</th>
<th>Later Names</th>
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<tr>
<td>Belle</td>
<td>Iberia dome</td>
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<td>Cote Blanche</td>
<td>Cote Blanche Island dome</td>
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<td>Cote Carline</td>
<td>Jefferson Island (Depuys, Millers, Orange)</td>
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<td>Grande Cote</td>
<td>Weeks Island</td>
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<tr>
<td>Petite Anse</td>
<td>Avery Island (Thomas, Salt, Marsh)</td>
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Four companies mine salt in Kansas: Morton Salt Co., American Salt Co., Carey Salt Co., Independent Salt Co. Salt is produced by both solution and mining from a bed 8½ feet thick and at a depth of 600 feet. Mining is done by the room-and-pillar method. A brief description is given of the solution process and vacuum refining.


The major production of salt in California is by solar evaporation. Favoring by climate and natural facilities this method remains economically competitive. By modernization of refining methods salt of high purity is produced along with bromine, potassium, and magnesium chlorides from the bittern, when the market will permit. The raw water is drawn from San Francisco Bay which is only slightly less salty than the open-sea water (3.40 in comparison with 3.72 percent).


Briefly mentions salt as one of the primary necessities of life as well as of industry, and broadly states the areas of salt production in the United States and the uses for salt.


Brines were early reported near Vale, Malheur County. To determine the facts, 9 hand-auger tests were drilled in the clay sediments of the area to a depth of 31 feet or less. Water samples taken in the wells gave salinities as much as 51,500 parts per million. Wells in the northwest sector of the group were strong in sulphates, those to the southeast high in sodium chloride. The origin of the brines remains uncertain. No bromine or iodine was found.


Gives a general review of the salt industry in Louisiana and southeastern Texas.

Reports on results of exploration in the last 20 years. Drilling on the south and southeast sides of the dome has revealed small individual accumulations of oil in sand with possibilities of finding many more on opposite sides of the dome. This drilling has made it possible to define the shape of the salt stock to a depth of 12,000 feet and has disclosed sharply upturned marginal sediments and radial faulting. The positions of the calcite-anhydrite cap and the sulfur pocket have been outlined.


Although some occurrences of rock salt have been reported, no economically important bed has been found. Drilled wells have encountered brines from the Ordovician to Mississippian. Counties from which brines have been produced are mentioned. Hawkins County, contiguous to Virginia, is suggested as the most likely place to prospect for salt in Tennessee.


Explains in simple terms that the mineralized lake waters of North Dakota are derived from leachings of Cretaceous rocks. The shallow wells generally yield hard, or alkali-bearing waters; the deep or artesian wells yield soft, or sodium waters.


Presents a lengthy discussion of what the author calls an artesian process of salt-dome formation in which it is postulated that saturated warm water rising from salt beds through fissures deposit salt and other minerals on cooling, and by the force of crystal growth enlarge the mass of the salt body.


A small tonnage of salt has been mined from the Camp Verde sulphate deposits in Yavapai County. Salt also is found in dry marshes along the Salt River, particularly in the brine seeps at Salt Banks. It is dispersed in the muds of dry lakes and playas.


There are salt springs in the Red River valley in the northwest corner of Minnesota and adjacent North Dakota and Manitoba. This fact was known as early as 1823. Wells drilled in the area for stock water gave an overflow of brine. It is suggested that the source of the salt is in the Devonian, although it may be in older rocks, or even the younger Carboniferous. The salt springs issue through openings in the covering sheet of clay.


Briefly mentions the salt and brine industry in Ohio, stating that salt production is both the oldest and newest mineral activity because of the rise in chemical
industries. Anticipates increased production of salt as a companion to abundant local sources of limestone and fuel which are required for the production of numerous chemicals.


Comments in general on the production and economic use of salt in the chemical industry.


Salt crops out over an area 1.5 miles by 0.5 mile, east of Salina, Utah. The method of mining by the Great Western Salt Co. is described, also the procedure followed in recovering salt from a strong brine (27 percent) formed by solution of exposed salt by rain water.


A cavern was formed in a 250-foot bed of salt at a depth of 3,798 feet by dissolving out the salt, requiring 6 barrels of water for each barrel of underground space formed. Propane from the Pampa, Tex., plant was injected at 1,200 pounds per square inch gage. Withdrawal of the propane will be made by water displacement at 200 gallons per minute.
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