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Dissolution of Kansas Evaporites, The Radioactive Waste Disposal Problem

Barbara J. Smith

DISSOLUTION OF KANSAS EVAPORITES

THE RADIOACTIVE WASTE DISPOSAL PROBLEM

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Abstract

The radioactive waste repository at Lyons, Kansas, focused attention on the problem of evaporite dissolution. More study is needed in the determination of the mechanisms responsible for deterioration. Also recent water use policies have been questioned with the need pointed out for increased effectiveness in planning. Good water planning has to take into account the role of evaporite dissolution in water quality.

1. INTRODUCTION

The consideration of using salt deposits for radioactive waste disposal sites dates from 1955. Many things can be said in favor of bedded salt for disposal purposes. It is abundant, often located in seismically stable regions of the United States. Mining technology had been developed previously and excavation shown to be inexpensive. Salt has physical properties to commend it for nuclear waste disposal such as good heat transfer qualities and plasticity to heal fractures. Its one disqualifying feature, that of solubility in water undersaturated with respect to it, was discounted because of the usual occurences of impermeable shale deposits isolating the salt from circulating groundwaters. Lyons, Kansas, was selected as an experimental repository and from this experiment much has been published (3). The site was abandoned, however, because of unexplained losses of water in the repository area by a local salt extracting company and a long record of oil well drilling close to the site (4)(14). What has Kansas learned from this experiment? Are there changes needed? How will these affect land or water uses, energy production or nuclear waste disposal prospects for Kansas in the future? To understand these concerns a look at Kansas geology, geography, and water uses is in order.

2. GEOLOGY AND GEOGRAPHY OF KANSAS

2.1 BACKGROUND INFORMATION

The western two thirds of Kansas is underlain by gently dipping evaporite-bearing rocks of Permian age. The general dip is to the south and west but the elevation of the land rises to the west. Descriptions of the stratigraphic units can be found in the literature (15)(23). Many bedded evaporites are present but salt zones suitable for radioactive waste disposal are described by Bayne (1). The most extensive salt unit is the Hutchinson salt in the Wellington Formation. Figure 1 summarizes important information.

Above the Permian evaporites are the fresh groundwater aquifers yeilding water for domestic, industrial, and agricultural uses, irrigation being the major use of water in the western counties. Waters in most of the Permian and lower strata are highly mineralized and have limited uses. Waters having high dissolved solids but not contaminated by oil brine are shown in Figure 2.

Under the Permian evaporites are the petroleum production zones accounting for 78.5 million barrels of crude oil and over 894,000,000 M.C.F. of natural gas produced in 1971 (2). Density of petroleum-related boreholes is shown in Figure 3.

2.2 EVAPORITE DISSOLUTION

The problem is one of evaporite dissolution. There is fresh or undersaturated water above the evaporites and extensive drilling through the evaporites to the petroleum production zones below. Evidence for dissolution is found in the sinkholes, salt marshes, salt springs and seeps, and subsurface erosional truncations of evaporite beds. Comparison of Figures 2 and 3 shows the coinsidences of dense drilling operations and higher dissolved solids content of waters not attributed to oil field brine from the surface. Deteriorated casings or boreholes not adequately plugged allow water from above to enter the salt units, dissolve the salt, and set up new hydrodynamic systems which adversely affect the ground water supply. Petroleum drilling is not the only means of water access to salt. Others present in Kansas include salt solution extraction mining and natural geologic factors such as faults. Any of these accelerate the normal deterioration of the salt beds by providing the hydraulic communications for water.

The drive for new hydrodynamic systems is provided by sufficient height of water and the increased density of the water as it dissolves the salt. An additional factor in the mobility of the brine is the extensive irrigation in western Kansas. Many areas are mining the groundwater. Over pumpage of fresh water can allow lower, denser water to move upward when there is hydraulic communication provided. More complete discussions of the mechanisms, contributing factors or extent of dissolution are found in Fader (5), Smith (19), Walters (21), and Leonard and Kleinschmidt (11). There is disagreement about the extent of salt dissolution but more research is needed to determine which combinations of possible mechanisms are responsible and what to expect in the future.

2.3 RADIOACTIVE WASTE DISPOSAL

How does nuclear waste disposal fit into the picture? Nuclear wastes must be isolated from the biosphere for 100 to 200 thousand years (7). The long-term hazards of the wastes are the actinides needing storage for thousands of years, a short time geologically but a long one in human terms. The short-term effects, those of thermal expansion of stratigraphic units above and below the salt beds and possible changes in the hydrodynamics of the area, have questionable safety in Kansas (10) (3). In situ testing of the effects of thermal energy on the rock salt and enclosing strata may take many years (22). Gera and Jacobs (9) discuss the possible mechanisms for exposure of wastes to the biosphere. Groundwater leaching is a possibility in short geologic time in an originally watertight salt bed used for disposal. When past and present salt extraction and petroleum exploration and production in Kansas are added to the uncertainties of thermal effects the problem is compounded. There is great difficulty in finding and permanently plugging every borehole through the salt to insure the integrity of the salt bed. Kansas has difficulties finding sites to meet criteria for safe, long-term disposal. That much has been learned by the industry after the experiment at Lyons. The question now is what Kansas has learned from the experiment. What effects will or should there be from the knowledge gained? Where do we go from here?

3. RESPONSES TO THE PROBLEM

Individuals, public and private, questioned the use of the Lyons site because of the possible presence of water in the disposal zone (4)(20). Increased recognition of salt bed deterioration has been after the radioactive waste repository experiment. The publication of several studies of evaporite deterioration have very recent dates. The recognition of possible salt brine contamination of ground water as a result of water use in Kansas is also recent (16). The recognition of ground water depletion now encountered in western Kansas has called for reassessment of our water planning and policies. Some studies question the

present policies in managing water resources in the best interest of the state(17)(18).

Leuhring (12)(13) has summarized many problems encountered in effective water planning. Problems include the number of agencies involved, the difficulty of coordinating the present agencies and the effectiveness of voluntary cooperation plans. She presents the Kansas Water Resources Board (KWRB) as the logical agency to coordinate water planning as does Smith. Coordinated planning is necessary to provide water of good quantity and quality.

Additional studies are needed on the extent and mechanisms responsible for evaporite dissolution because of the harm possible to water quality. These could be coordinated through the Kansas Geologgic Survey and the results and recommendations made available to KWRB. Results important to regulation of the petroleum and salt extration industries should be available to the responsible agencies. Petroleum and natural gas production has a long history in Kansas and is forcast to continue. Kansas has laws with good intentions but part of the problem lies in the effective uses of the laws. This can be seen in the problems encountered in water planning pointed out by Leuhring. Coordination of research activities and policy planning can help make the laws more effective or show the need for changes.

4. SUMMARY

The radioactive waste repository at Lyons, Kansas, focused attention on the problem of evaporite dissolution. More study is needed in the determination or the mechanisms responsible for deterioration. Also recent water use policies are questioned with the need for increased effectiveness in planning. Good water planning has to take into account the role of evaporite dissolution in determining water quality.

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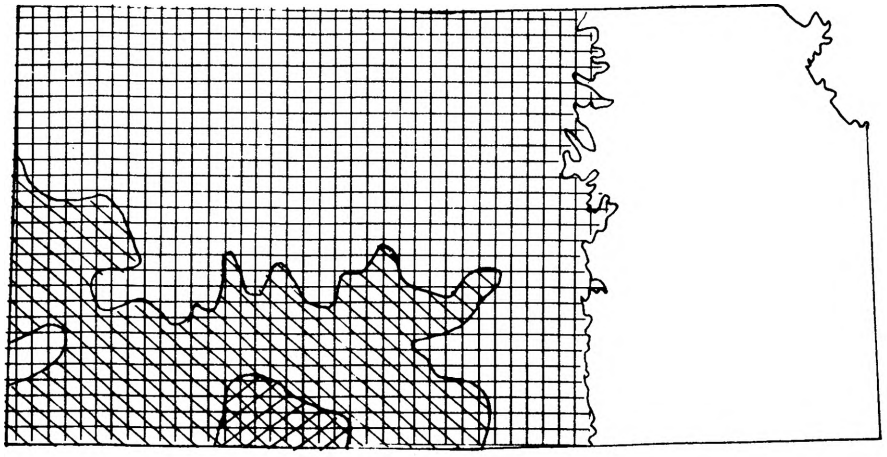
6. BIOGRAPHY

Barbara J. Smith received B.S. degrees in secondary education and geology in 1969 and 1975. She received her M.S. degree in geology in 1976 from Kansas State University. Currently she is a consultant.

(a)

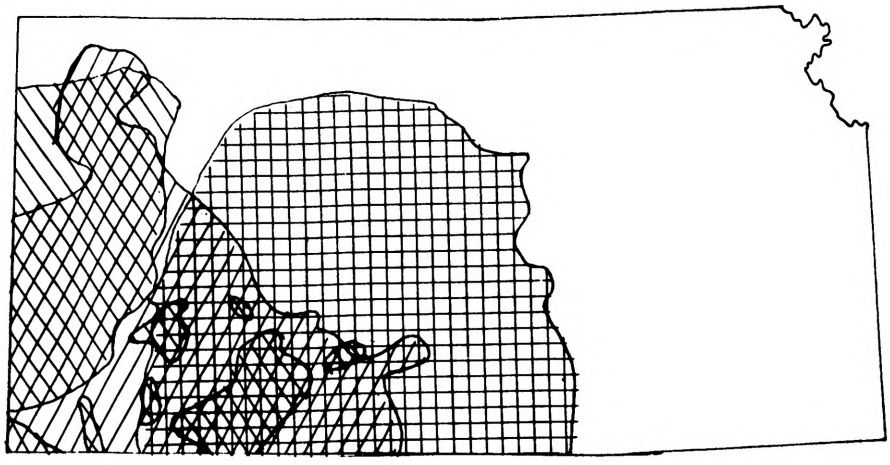


Less than 500 feet of evaporite deposits

500 to 1000 feet of evaporite deposits

More than 1000 feet of evaporite deposits

(b)



Cimarron salt

Hutchinson salt

Blaine salt

Figure 1.

(a) total thickness of evaporite deopsits in Permian redbeds (redrawn from Merriam, 1963).

(b) locations of bedded salt deposits (redrawn from Bayne, 1972).

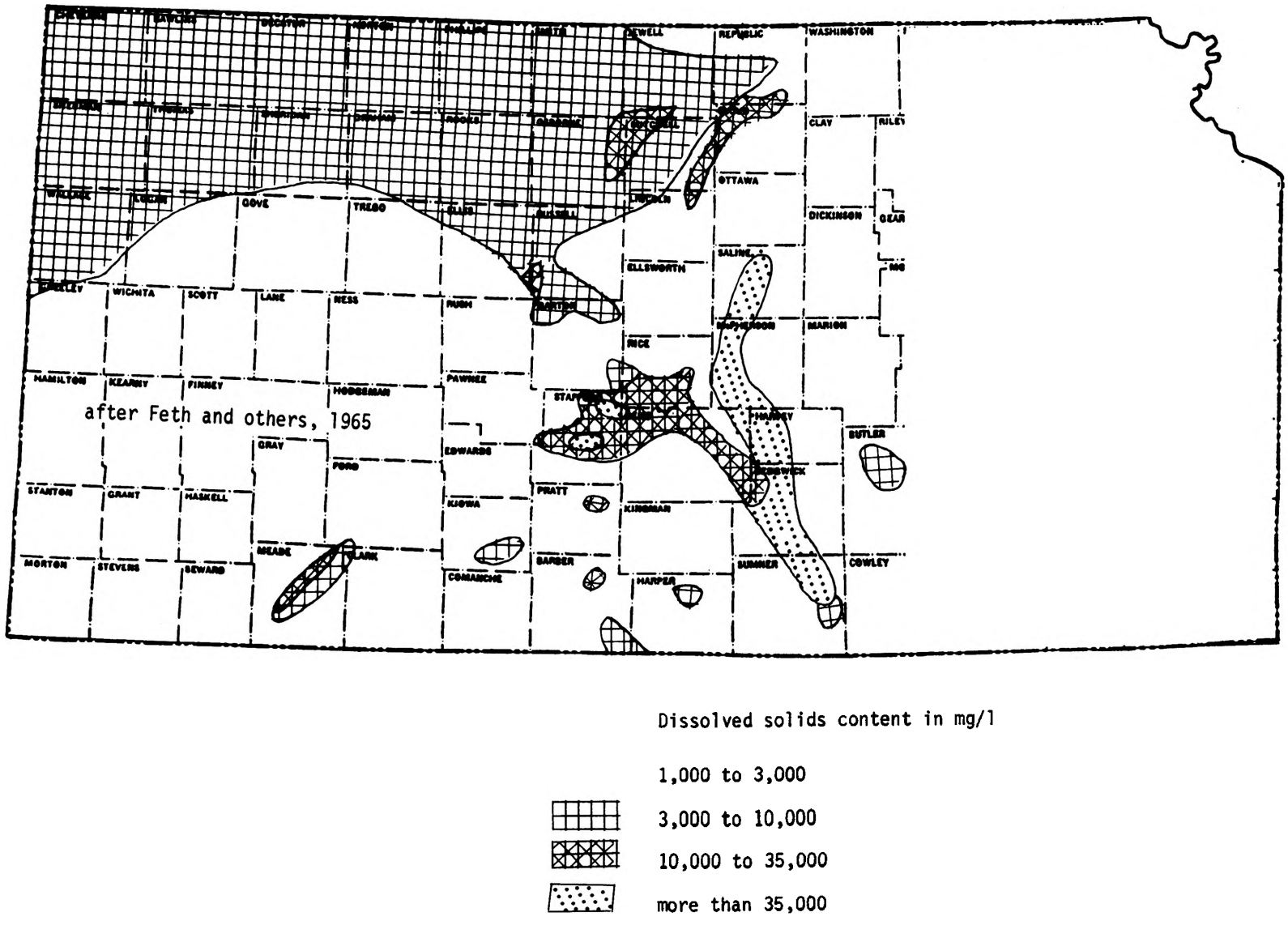
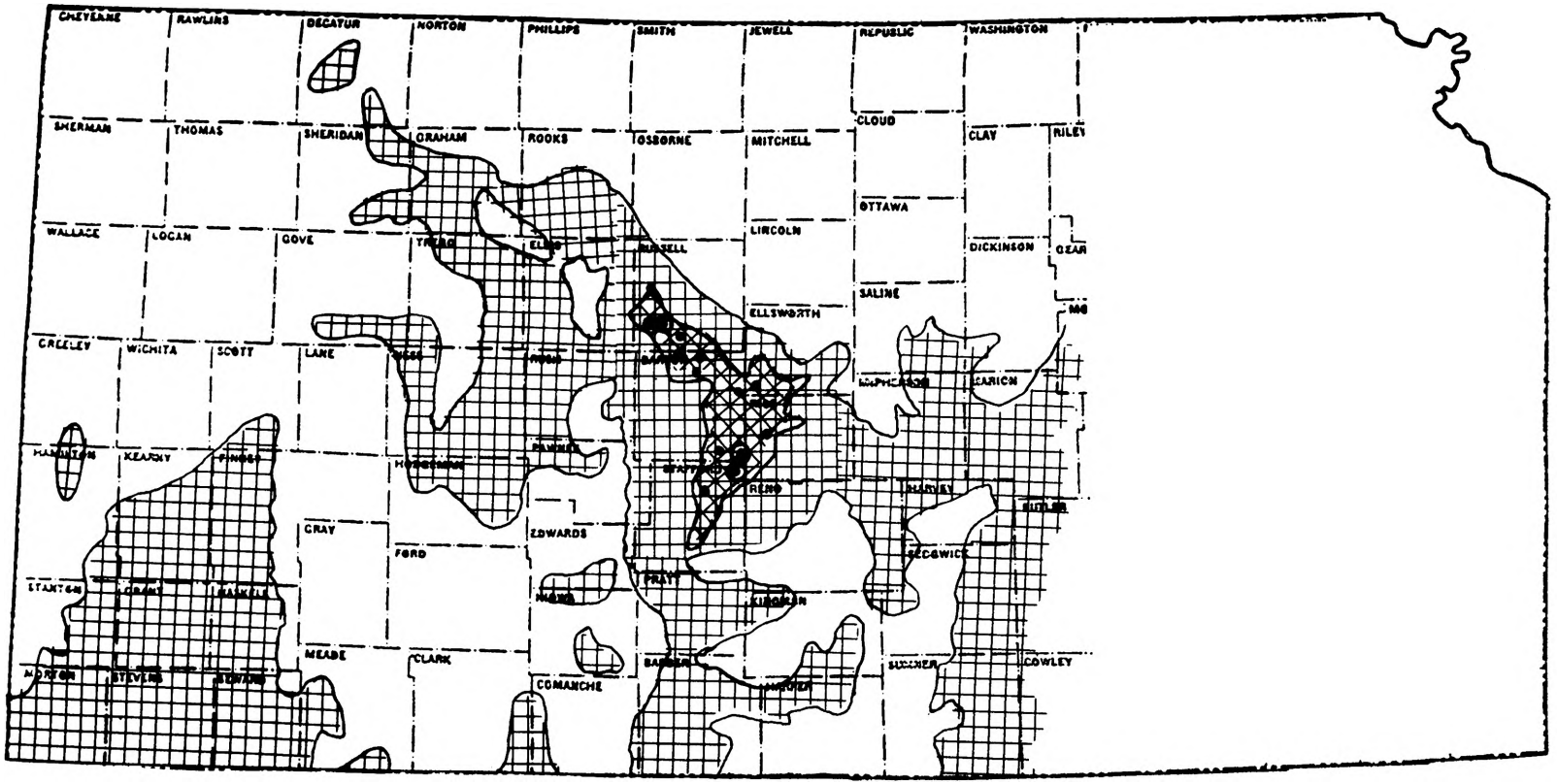


Figure 2. Ground waters having concentrations of 1000 mg/l dissolved solids (excluding oilfield brines)(Redrawn from Feth and others, 1965).



Boreholes per square mile

0 to less than 1

1 to 10

more than 10

more than 15

more than 20

Figure 3. Average number of boreholes per square mile.