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Geochemistry of Shallow Artesian Salt Water
Near Sabetha, Nemaha County

by

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GEOCHEMISTRY OF SHALLOW ARTESIAN SALT WATER NEAR SABETHA, NEMAHA COUNTY

A Report for the
Kansas Department of Health and Environment

by

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INTRODUCTION

Salt water has been encountered at shallow depths (130 to 150 feet below ground surface) during the drilling of boreholes for oil in an area about 1-2 miles south of Sabetha, Nemaha County. The salt water is under artesian head and in some instances has flowed at the surface. The dissolved solids concentration of the brine is much higher than in the water accompanying oil in the Sabetha field, thus the source does not appear to be pollution from produced oilfield brine. The shallow formations in which the salt water is first encountered are probably the Johnson Shale and the Long Creek Limestone Member of the Foraker Limestone, Council Grove Group, Lower Permian Series, based on formation thicknesses from Mudge et al. (1959), surface elevation, and depth to salt water. These rocks, especially the Long Creek Limestone Member, contain thin gypsum beds elsewhere in northeastern Kansas. Solution of the gypsum can produce permeable zones in the limestone such as have been observed in Pottawatomie County (Whittemore and Switek, 1977).

Where the gypsum has not been completely dissolved, groundwaters in the Long Creek Limestone are usually of calcium sulfate type. However, chloride concentrations in groundwaters of this type are typically less than a couple hundred mg/L. Therefore, the shallow salt waters (containing 80,000 to 100,000 mg/L dissolved chloride) encountered south of Sabetha are anomalous. Three initial hypotheses describing possible saltwater sources were as follows:

(1) The saltwater has been naturally derived from the solution of previously unknown thin beds of halite accompanying the gypsum in the Permian formations present.

(2) The salt water has naturally flowed from deeper formations up through permeable zones along faults associated with the Nemaha anticline.

(3) The salt water has been introduced into the shallow horizons from deeper formations by oilfield activities.

This report discusses the probable source type of the shallow salt water based on the geochemistry of water samples from some of the flowing wells.

PROCEDURE

Major dissolved constituents for most samples were determined by the Kansas Department of Health and Environment laboratories. Concentrations of chloride, sulfate, bromide, and iodide were measured in a few samples at the Kansas Geological Survey by automated methods on a Technicon Auto-Analyzer, except for one sample in which sulfate was determined by manual turbidimetry. A phenol red method was used for bromide (Basel et al., 1982) and ceric-arsenious acid oxidation for iodide measurements.

RESULTS AND DISCUSSION

Chemical analyses of the flowing well samples are given in Table 1 and chemical weight ratios in Table 2. Chloride concentrations of the shallow salt water range from about 80,000 to 100,000 mg/L. The sodium/chloride, bromide/chloride, and iodide/chloride ratios all indicate that the salt water is similar to oilfield brine and is not halite-solution

TABLE 1. Dissolved Constituent Concentrations in Samples from Flowing Wells near Sabetha. Analyses for the Pyle wells were made by the Kansas Geological Survey; other analyses are from the Kansas Department of Health and Environment. All concentrations are in mg/L.

Sample Description	Location	Date Collected	KDHE No.	Ca	Mg	Na	HCO_3	Cl	SO_4	Br	I
Aberle #2 flowing oil well water from 150 ft depth	NW 13-2S-14E	3-1-83	1632	4820	1800	42,900	<20	80,600	245	-	-
Flowing oil well water from 130 ft depth	W/2 NW 13-2S-14E	6-22-83	2338	5780	2110	44,800	<50	86,000	203	-	-
Pyle #4 drilling water	W/2 NW 13-2S-14E	9-22-83	-	-	-	-	-	1,295	1720	5.1	0.092
Pyle #4 flow water diluted by drilling water	W/2 NW 13-2S-14E	9-22-83	-	-	-	-	-	14,150	2300	62	1.47
Pyle #1-A flowing oil well water from 130 ft depth	NW 13-2S-14E	11-3-83	-	-	-	-	-	79,900	1780	356	8.8
Moorhead #1 flowing oil well water	NE SW 13-2S-14E	11-15-83	1044	5500	2040	56,600 (50,000)[a]	-	91,500	1670	-	-
Creek #1 below Moorhead #1 flowing water	SW 13-2S-14E	11-15-83	1045	777	260	6,750 (5,860)	-	10,900	372	-	-
Moorhead #1 flowing oil well water	NE SW 13-2S-14E	11-18-83	1193	5440	2380	54,100	<30	100,000	1350	-	-
Flow to stream from Moorhead #1 flowing well	SW 13-2S-14E	11-18-83	1194	5440	2500	54,100	<30	98,600	1350	-	-

[a] Values in parentheses are calculated and are estimated to be more correct than values immediately above based on charge balance errors of 5.2 and 5.8 percent for Moorhead and Creek samples, respectively, collected on 11-15-83. The sodium determination was believed to be the constituent in error based on ratios of other constituents.

TABLE 2. Weight Ratios of Dissolved Constituents in Samples from Flowing Wells near Sabetha.

Sample Description	Location	Date Collected	Na/Cl	Ca/Mg	Ca/Cl	Mg/Cl	SO_4/Cl	Br/Cl x 10^4	I/Cl x 10^6	Br/I
Aberle #2 flowing oil well water from 150 ft depth	NW 13-2S-14E	3-1-83	0.532	2.68	0.0598	0.0223	0.0030	-	-	-
Flowing oil well water from 130 ft depth	W/2 NW 13-2S-14E	6-22-83	0.521	2.74	0.0672	0.0245	0.0024	-	-	-
Pyle #4 drilling water	W/2 NW 13-2S-14E	9-22-83	-	-	-	-	1.33	39.4	71	55.4
Pyle #4 flow water diluted by drilling water	W/2 NW 13-2S-14E	9-22-83	-	-	-	-	0.163	43.8	104	42.2
Pyle #1-A flowing oil well water from 130 ft depth	NW 13-2S-14E	11-3-83	-	-	-	-	0.0223	44.6	110	40.7
Moorhead #1 flowing oil well water	NE SW 13-2S-14E	11-15-83	0.619 (0.546)[a]	2.70	0.0601	0.0223	0.0183	-	-	-
Creek #1 below Moorhead #1 flowing water	SW 13-2S-14E	11-15-83	0.619 (0.538)	2.99	0.0713	0.0239	0.0341	-	-	-
Moorhead #1 flowing oil well water	NE SW 13-2S-14E	11-18-83	0.541	2.29	0.0544	0.0238	0.0135	-	-	-
Flow to stream from Moorhead #1 flowing well	SW 13-2S-14E	11-18-83	0.549	2.18	0.0552	0.0254	0.0137	-	-	-

[a] Values in parentheses are estimated to be more correct than values immediately above based on charge balance errors of 5.2 and 5.8 percent for Moorhead and Creek samples, respectively, collected on 11-15-83. The sodium determination was believed to be the constituent in error based on ratios of other constituents.

brine. Sulfate/chloride ratios very widely for the waters, however, suggesting the dissolution of gypsum at the shallow depths in some locations.

A comparison of the analyses for the Pyle well samples shows increasing bromide/chloride and iodide/chloride ratios with increasing chloride concentration from the drilling water, to flow water diluted by drill water, to undiluted flow water. The drilling fluid supposedly contains water that was produced with oil from the Hunton Group or Viola Limestone. The bromide/chloride ratio is slightly higher and the iodide/chloride ratio is about the same as for average oilfield brines in Kansas. The values are not as high as for brines from the Lansing-Kansas City Groups in central Kansas.

Average chloride concentrations in brines studied by Dingman and Angino (1969) from central Kansas (Russell, Barton, Ellsworth, and Rice counties) were 86,900 mg/L for the Wabaunsee Group, 96,000 mg/L for the Shawnee Group, and 64,900 mg/L for the Lansing-Kansas City Groups. Three analyses of brines from the Shawnee and Douglas Groups in McPherson County (Kansas Geological Survey brine file) show that east of the counties studied by Dingman and Angino, these formations contain chloride contents greater than 100,000 mg/L. These concentrations also exceed those in salt waters from the Lansing-Kansas City Groups, although brines in the latter formations also contain more than 100,000 mg/L chloride. Thus, there is a possibility that the source of the shallow salt waters in the Sabetha area could be from the Virgilian Stage (Wabaunsee, Shawnee, and Douglas Groups) underlying the Permian strata.

CONCLUSION

The shallow salt water in the Sabetha area, Nemaha County, is geochemically similar to oilfield brine. If the avenue for the emplacement of brines in the shallow Permian strata is natural, there may be a possibility that the source is from Virgilian rocks (Wabaunsee, Shawnee, or Douglas Groups) of the Upper Pennsylvanian Series.

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