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NaCl Solubility in NBT-6 and WIPP-A, 0-100°C

by

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ABSTRACT

Solubility of NaCl in complex bitterns NBT-6 and WIPP-A from near 0°C to near 100°C are reported. The experimental data and coefficients of an equation for a smoothed curve describing each system are listed in tables.

INTRODUCTION

The data presented here were obtained to help develop an improved model of fluid inclusion migration in domal and bedded rock salt. Present fluid inclusion migration models have used saturated NaCl solutions as the migrating fluid (Anthony and Cline, 1974; Bradshaw and Sanchez, 1969; Gaffney, 1978). However, fluid inclusions in domal and bedded salt are likely to be complex bitterns in the system Na,K,Ca,Mg//Cl, SO_4, (e. g. Roedder and Belkin, 1978; Stewart and Potter, 1978) and may have physical properties significantly different than saturated NaCl solutions. The brine migration models require many input parameters including density and $\partial NaCl/\partial T$. The solubility of NaCl in WIPP-A and NBT-6 (compositions in Table 1) presented here can be used to calculate $\partial NaCl/\partial T$ and the NaCl-saturated density of these two complex bitterns using the method of Potter and Haas (1978).

EXPERIMENTAL METHOD

The experimental technique used in this study is a modification of the commonly applied visual or synthetic method and has been discussed in detail in an earlier report (Potter and Clynne, 1978). To summarize: the method involves loading a Pyrex glass test tube with salt and solution at a precisely known bulk composition. A stirring mechanism is inserted into the tube and a layer of silicone oil added to prevent water gain or loss. The tube is then placed in a bath containing either water (2-85°C) or ethylene glycol (85-170°C) as a heating medium. The tube is brought to thermal equilibrium, and the solution plus salt crystal assemblage vigorously stirred until dissolution of salt ceases. The bath is heated incrementally, and the above procedure repeated. Heating increments are made progressively smaller as the amount of salt decreases. The temperature at which the last salt crystal dissolves is taken as the saturation point of the particular bulk composition of the tube. The temperature limits of this method are the freezing and boiling points of the saturated salt-water systems.

The experimental precision obtained by the modified visual method is quite good and, in addition, avoids many of the problems encountered by other methods (Potter and Clynne, 1978). Analyses of the possible sources of error for the method yield accuracies of 0.1 to 0.2 percent (Potter and Clynne, 1978).

EXPERIMENTAL RESULTS

The measured solubility of NaCl in NBT-6 and WIPP-A are listed in Table 2, along with smoothed values and the deviation of the measured values from the smoothed results. The smoothed values were obtained by a least-squares regression of the experimental values to an equation of the form:

$$S = \sum_{o}^{i} a_i t^i$$

where t is the temperature in degrees Celsius and S is the solubility of NaCl, over the original NaCl content of the solution, in grams per 100 g of saturated solution (g/100g). The coefficients for the regression equation are listed in Table 3 along with the mean deviations in g/100g and percent deviation.

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Table 1. Compositions of starting solutions.

Component	WIPP-A		NBT-6
	g/l solution*	g/100g solution	g/100g solution
NaCl	101.55	8.43	5.00
KCl	57.20	4.75	5.00
$MgCl_2$	137.08	11.37	10.00
$CaCl_2$	1.665	0.14	10.00
Na_2SO_4	5.175	0.43	0

* Density at 20°C = 1.2052 g/cm^3 (Chou and others, 1982).

Table 2. Solubility of NaCl in WIPP-A and NBT-6.

Temperature °C	Experimental solution wt.% NaCl*	Calculated solution wt.% NaCl	Difference wt.% NaCl
	WIPP-A		
0.37	2.80	2.82	-0.02
5.97	3.05	3.01	0.04
8.51	3.10	3.10	0.00
21.07	3.50	3.53	-0.03
32.79	3.98	3.95	0.03
47.71	4.47	4.49	-0.02
61.12	4.97	4.98	-0.01
74.26	5.50	5.49	0.01
89.16	6.07	6.07	0.00
98.86	6.45	6.45	0.00
	NBT-6		
25.66	0.78	0.78	0.00
38.42	1.25	1.24	0.01
52.31	1.70	1.71	-0.01
70.85	2.43	2.41	0.02
88.62	3.28	3.29	-0.01
99.36	3.98	3.98	0.00

* NaCl in addition to that in original solution.

Table 3. Regression coefficients and mean deviation for solubility equations.

Solution	Coefficients a_0	a_1	a_2	a_3	Mean deviation g/100g
WIPP-A	2.8118	0.03346	3.4244×10^{-5}	0	$\pm$0.016
NBT-6	0.4231	0.05829	-5.464×10^{-4}	4.079×10^{-6}	$\pm$0.008