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Solid-liquid Equilibria for the Quaternary NaCl–Na_2SO_4–$Na_2B_4O_7$–H_2O System at 348 K

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1 Introduction

China has very abundant liquid mineral resources. Especially, the brine resources in the west of Sichuan Basin are pushed into the first place in China, whose K and B contents are unusually high. These rare liquid mineral resources have very good exploitation prospect (Lin, 2001; 2006). Generally speaking, phase equilibrium and phase diagrams are the theoretical basis of the exploitation and utilization of underground brine resources (Niu et al., 2002). The main components in the underground brines in Western Sichuan Basin can be approximately described with the Na–K–Cl–Br–SO_4–B_4O_7–H_2O system. The quaternary system NaCl–Na_2SO_4–$Na_2B_4O_7$–H_2O is a subsystem of the brines (Table 1).

2 Results

The phase equilibria in the quaternary system NaCl–Na_2SO_4–$Na_2B_4O_7$–H_2O was investigated at 348 K using the isothermal dissolution equilibrium method. The phase diagram in Figure 1 has an invariant point , three univariant curves and three crystallization fields corresponding to NaCl, $Na_2B_4O_7{\cdot}5H_2O$ and Na_2SO_4. The crystallization field of $Na_2B_4O_7{\cdot}5H_2O$ is slightly larger than that of other two slats. Double salts or solid solutions have not been found in the quaternary system at 348 K. Point E is the invariant point of the quaternary system, whose liquid composition is at w(NaCl) = 0.2329, w($Na_2B_4O_7$) = 0.0453 and w(Na_2SO_4) = 0.0422.

Table 1 Experimental solubility values of the quaternary system NaCl–Na_2SO_4–$Na_2B_4O_7$–H_2O at 348 K

No.	Composition of solution w(B)×100			Jänecke index J/g·100 g^{-1}		Equilibrium solids
	NaCl	Na_2SO_4	$Na_2B_4O_7$	Na_2SO_4	$Na_2B_4O_7$	
$1E_1$	0.00	22.15	7.63	74.38	25.62	NC+NS
2	4.44	20.34	7.64	62.74	23.57	NC+NS
3	8.01	15.77	7.85	49.86	24.82	NC+NS
4	11.37	12.53	7.28	40.19	23.35	NC+NS
5	12.25	11.84	6.81	38.32	22.04	NC+NS
6	14.46	9.95	6.45	32.24	20.90	NC+NS
7	22.32	4.93	4.7	15.43	14.71	NC+NS
8	23.03	4.91	4.89	14.96	14.89	NC+NS
$9E_2$	25.73	0.00	4.12	0.00	13.80	NC+NB
10	23.25	2.57	4.66	8.43	15.29	NC+NB
11	22.6	4.57	4.76	14.31	14.91	NC+NB
12	22.37	4.93	4.75	15.38	14.82	NC+NB
13	22.77	4.73	4.99	14.56	15.36	NC+NB
$14E_3$	25.05	4.7	0.00	15.80	0.00	NB+NS
15	23.85	4.77	2.82	15.17	8.97	NB+NS
16	23.33	4.75	4.05	14.78	12.61	NB+NS
17	23.4	4.73	4.21	14.63	13.02	NB+NS
18	23.21	4.86	4.3	15.01	13.28	NB+NS
19E	23.29	4.22	4.53	13.17	14.14	NC+NB+NS

Note：NC: NaCl，NB:$Na_2B_4O_7{\cdot}5H_2O$，NS:Na_2SO_4.

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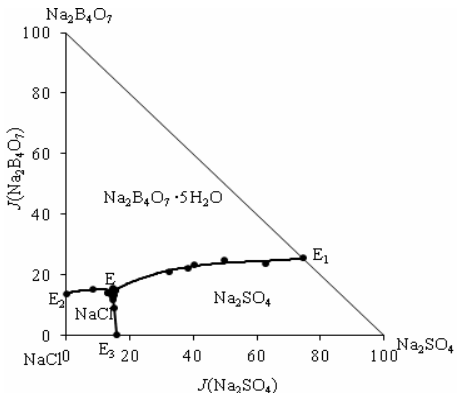

Fig. 1. Equilibrium phase diagram of the quaternary system NaCl–Na_2SO_4–$Na_2B_4O_7$–H_2O at 348 K.