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Simulated Dynamic Evaporation of Yiliping Salt Lake Brine

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1 Introduction

There are numerous salt lakes in western China (Zheng Mianping, et al., 2011). Yiliping playa on the western Qaidam Basin is a magnesium sulfate subtype dry salt lake with high concentrations of potassium, boron and lithium. The intercrystalline brine (shallow underground brine) bears LiCl reserve of 410.9 kt and B₂O₃ reserve of 214.5 kt, both of which are attributable to large-scale deposits, and also KCl reserve of 4084.9 kt, which corresponds to a medium-sized deposit (Cao Wenhui, et al., 2004).

The simulated dynamic evaporation of salt brine is necessary because its experimental conditions are much closer to the real salt pan area, providing salt precipitation results close to the actual.

2 Experimental and Results

An experimental simulation of the dynamic evaporation of the Yiliping intercrystalline brine was conducted by performing indoor evaporation at 294.15±6K.

The calculation and the evaluation of the water evaporated rate, the salt precipitation rate and the brine forming rate indicated that the whole evaporation kept a very well material balance (Table 1).

According to our experimental results, the whole evaporation might be divided into four stages: halite stage, mixed potassium salts stage, potassium-magnesium mixed salts stage and bischofite stage. And the salt precipitation sequence is halite, gypsum, sylvite, carnallite, pentahydrate, epsomite and bischofite (Table 2).

Li⁺ and B₂O₃ continually concentrated in the liquid phases during the complete evaporation without any precipitation but with an unknown way of loss. Figure 1 interpreted the degree of loss by defining (Tang Na, et al., 2012) the concentrated times of the salt brine (equals to a

Table 1 Material balance of each solid-liquid separation

S-L No.	Brine In Kg	Water Evaporated Kg	Salt Precipitated Kg	Mother Liquid Kg	Loss Kg
0	20.00	0.00	0.00	20.00	0.00
1	20.00	2.90	1.10	16.00	0.00
2	16.00	4.40	1.72	9.84	0.04
3	9.74	1.74	0.66	7.32	0.02
4	7.12	1.72	0.66	4.70	0.04
5	4.60	1.05	0.40	3.12	0.03
6	3.00	0.30	0.46	2.24	0.00
7	2.12	0.22	0.16	1.68	0.06
8	1.58	0.16	0.18	1.22	0.02
9	1.12	0.12	0.22	0.72	0.06

S-L No.	Water Evaporation Rate %	Salt Precipitation Rate %	Brine Formation Rate %	Total* %	Process %
0	0.00	0.00	100	100.00	0.00
1	14.50	5.50	80.00	100.00	20.75
2	27.50	10.75	61.50	99.75	52.70
3	17.86	6.78	75.15	99.79	65.77
4	24.16	9.27	66.01	99.44	79.36
5	22.83	8.70	67.83	99.36	87.55
6	10.00	15.33	74.67	100.00	92.12
7	10.38	7.55	79.25	97.18	95.02
8	10.13	11.39	77.22	98.74	97.41
9	10.71	19.64	64.29	94.64	100.00

Note: "S-L No." refers to the serial number of solid-liquid separation; "Total" refers to the sum of the water evaporation rate, the salt precipitation rate and the brine formation rate.

Table 2 XRD patterns of the solid phases precipitated at each S-L separation and the salt precipitation sequence

Standard PDF card NO.	1S	2S	3S	4S	5S	6S	7S	8S	9S
\ sample NO.									
NaCl (01-075-0306)	√	√	√	√	√	√	√		
CaSO ₄ ·2H ₂ O (00-036-0432)		√		√		√			
KCl (00-004-0587)					√			√	
KCl·MgCl ₂ ·6H ₂ O (01-071-0727)					√	√	√		
MgSO ₄ ·5H ₂ O (01-070-1445)							√		
MgSO ₄ ·7H ₂ O (01-072-1112)						√			
MgCl ₂ ·6H ₂ O (01-077-1268)								√	√

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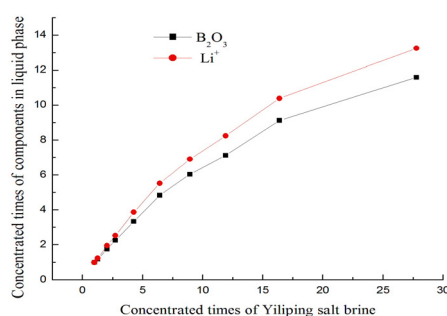


Fig. 1. Relationship between concentrated times of salt brine and that of boron and lithium in liquid phases.

ratio that the raw brine weight divided by the brine weight after each S-L separation) and the concentrated times of Li^+ or B_2O_3 (equals to the ratio that the concentration of Li^+ or B_2O_3 in each separated brine divided by Li^+ or B_2O_3 concentration in the raw brine) in all the liquid phases.

As shown in Figure 1, the concentrated times of Li^+ and B_2O_3 were 13.24 and 11.59 respectively while that of the brine climbed to 27.78 at the end of the process, i.e. the concentration of lithium and boron was unsynchronized with that of the brine, indicating the existing of the unknown ways of loss of Li^+ and B_2O_3 . It might relate to the complexity of borate anions and the isomorphism replacement of lithium with potassium, which need further investigation.

The calcium concentrations both in brine and the precipitates showed a variable fluctuation, most probably resulting from the salting-in and salting-out effects of magnesium chloride on gypsum respectively at its lower and higher concentrations; another factor influencing gypsum precipitation is that the solubility changing trend of gypsum with temperature at the experimental

conditions.

The concentration of Cl^- and SO_4^{2-} exhibited a negative correlation in the liquid phases and their salts precipitated at the potassium-magnesium mixed salts stage showed the following rules: the salts at lower temperatures showed relatively higher ratio of sulfate but lower ratio of carnallite, while the salts at higher temperatures showed relatively lower ratio of sulfate. In particular, the precipitates are deficient in gypsum at a higher temperature of 26.8°C , but richer in gypsum at a lower temperature of 17.7°C .

The results of this study can provide an important case for the comprehensive utilization of the intercrystalline brine in Yiliping playa.

Key words: Yiliping, playa, salt brine, underground brine, simulated dynamic evaporation

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