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Study on the Isothermal Evaporation Process at 5℃ with the Brine of Laguocuo Salt Lake

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1 Introduction

Tibet has nurmerous salt lakes. Laguocuo is one of the salt lakes, which is located to the sorthern of Ali Plateau, 31°59′02″N-32°04′08″N, 84°02′03″E -84°12′ 03″E. Its lake water is rich in potassium, magnesium, lithium, boron, rubidium, cesium and other resources. The study of evaporation and precipi -tating salt law of the brine is the basis for developing and utilizing of chemical resource of any salt lake. So far, the study of evaporation and precipitating salt law of Laguocuo brine has not been reported, it was thus necessary that we run the experiment of evaporation and precipitating salt law of Laguocuo brine. The authors first run the experiment of 5℃-isothermal evaporation–precipita -tion salt law for the lake water. Considering the carbonate (include bicarbonate) in the lake water is higher, not conducive to concentrate Li, and addition of Mg can drops carbonate, thus the authors also studied the lake water after added Mg evaporation process and their precipitation salt law.

2 Material and Method

The chemical type of Laguocuo lake water belong to sodium sulphate subtype. The brine this study used is made up according to the chemical compostion of the lake water. The chemical compo -sition of the brine preparated is shown in Table 1.

The condrete way is: directly adding $MgCl_2 \cdot 6H_2O$ into the above preparated brine (LGC00), by the mole -proportion of Mg/DIC=1, 1.5 and 2, then continuous stirring a few minuyes and letting stand for 72 hours, filtering the brine. In this way we respectively obtained brine sample LGC10, LGC15, and LGC20. In the process, we found that the bigger proportion of add Mg, the more deposit appear. But there is not any deposit in the mother liquor of LGC10. The chemical compo -sition of the brine by treatment added Mg is also shown in Table 1.

The evaporation-precipitation salt experiment took the way boilling-evaporating-cooling-equili -brating: First, the experiment brine was boiling by heating to evaporate to a predeterminate concentra -tion; then, equilibrate the brine (may be include some salt) by water bath at 5℃ for 6 hours at least; final, sampling the liquid sample (for no precipiting salt) or separating solid and liquid sample (for precipitating salt).

3 Result and Discuss

For the soild and liquid samples, the compositions , K^+, Ca^{2+}, Mg^{2+}, Li^+, Cl^-, SO_4^{2-}, CO_3^{2-}, HCO_3^-, B_2O_3, H_2O, were determined by chemical analyses method, but calculated Na^+ by subtraction method. And we also determined the pH, density, and relative viscosity of liquid samples. In addition, we used the XRD analysed the solid samples.

The evaporation ratio e（wt%）is given by $e = (w_e/w_0) \times 100\%$, where w_0 is the mass of the origin brine for evaporation and w_e is the mass of water loss in evaporation process.

3.1 The change of pH of the liquid phases

The determined result of the pH is shown in Figure 1.

Table 1 Chemical composition of Laguocuo brine at before and after added Mg（wt%）

Code	Adding Mg or not	K^+	Na^+	Ca^{2+}	Mg^{2+}	Cl^-	SO_4^{2-}	CO_3^{2-}	HCO_3^-	Li^+	B_2O_3	ρ/(g/cm^3)	pH
LGC00	Original brine	0.242	1.595	0.003	0.000	1.350	1.895	0.249	0.063	0.027	0.249	1.048	9.55
LGC10	Add 1 time Mg	0.239	1.752	0.002	0.104	1.653	1.893	0.248	0.004	0.024	0.249	1.051	9.42
LGC15	Add 1.5 times Mg	0.242	1.784	0.008	0.131	1.791	1.940	0.229	0.000	0.025	0.253	1.051	9.17
LGC20	Add 2 times Mg	0.247	1.753	0.007	0.181	2.029	2.033	0.018	0.076	0.025	0.254	1.054	9.09

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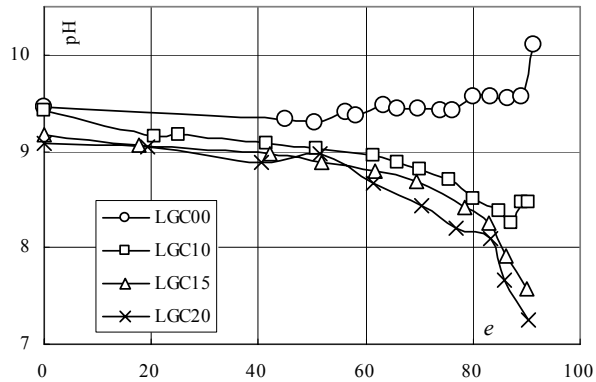

Fig. 1. The function of pH of brines as evaporation ratio (e).

From the figure, we can find that the pH of add Mg brines continuously drop during evaporation and after *e*≈50% tend to accelerrate, while from *e*≈50% the pH of LGC00 turn to rise after undergo slow dropping. LGC00's behavior is more like carbonate type brine. Obviously, adding Mg change the behavior of the pH of the brines during evaporating.

3.2 The change of the relative viscosity of the liquid phases

The determined result of the relative viscosity is shown in Figure 2.

From the figure, we can find that the relative viscosity of LGC15 and LGC20, after *e*≈50%, are obvious greater than LGC00 and LGC10. This is associated with adding Mg excess for thses brine.

3.3 The precipitation salt law of the brines during evaporated

By brines evaporate, the salts in order precipited out from brines. First is magnesium carbonate (except for LGC00), then is sodium sulfate, sodium chloride, and Gla

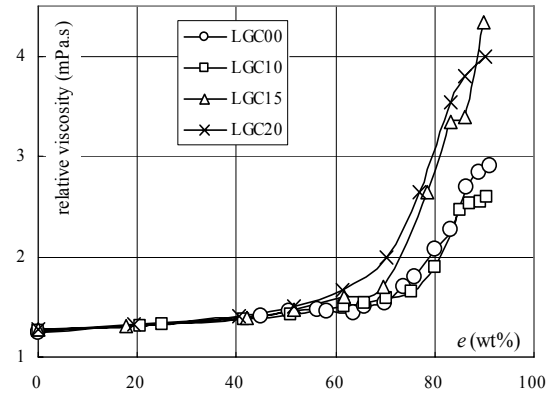

Fig. 2. The function of relative viscosity of brines as evaporation ratio (e).

($Na_2SO_4 \cdot 3K_2SO_4$).

Plotting the J index of thses brines on the phase diagram of quaternary system Na^+、$K^+//Cl^-$、SO_4^{2-}–H_2O at 25℃, we found, from LGC00 to LGC20, the $J(SO_4^{2-})$ when NaCl begin to precipitate was in turn increase. This is list in table 2.

4 Conclusion

The change of pH of brines added Mg in the process of evaporation were, continuued to decline, obviously different from the original brine which more like a carbonate type brine[1]. After *e*≈50%, the relative viscosity of the brines with Mg excess are obvious greater than without Mg excess. Adding Mg or not also leads to the change of precipitation salt path in phase diagram.

Table 2 The J when NaCl begin to precipitate

Code	LGC00	LGC10	LGC15	LGC20
$J(SO_4^{2-})$	16	18	32	34
		Increase in order →		
J(2K)	11.9	11.6	10.5	9.8
		Decrease in order →		

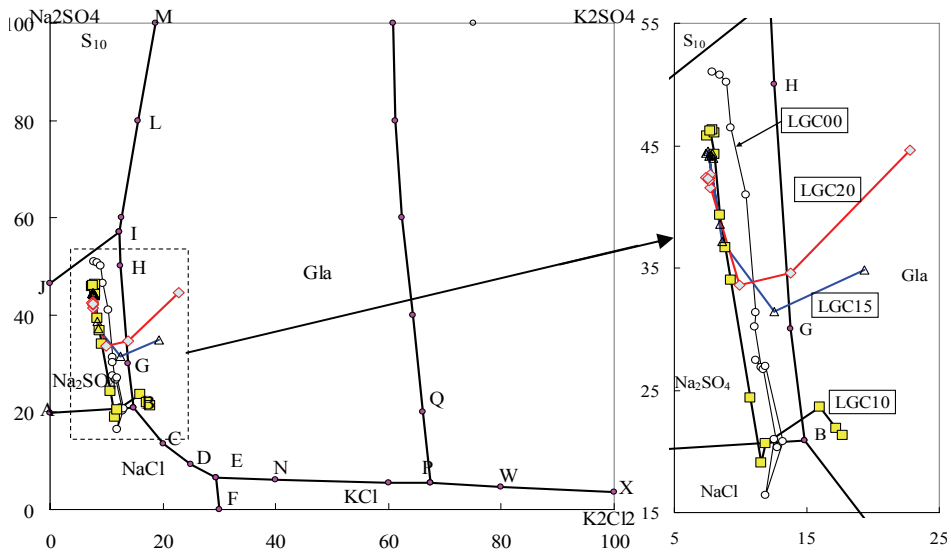

Fig. 3. The paths of the liquid composition on the phase diagram of quaternary system Na^+、$K^+//Cl^-$、SO_4^{2-}–H_2O at 25°C.