CHEMICAL CHARACTERZATION OF SURFACE SALTS IN QAIDAM BASIN: IMPLICATIONS FOR CLIMATES OF PLANET EARTH AND MARS

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Introduction: The Qaidam Basin has been considered as a good terrestrial analogue for Mars [1], as recent explorations and studies revealed that the Martian crustal compositions are similar to that of Earth. It has been hypothesized that about 1/3 of Martian surface was covered by oceans and lakes in the early stage of Mars development [2]. The ocean and lake water bodies should have dissolved a large quantity of minerals from surrounding rocks, and during Martian drought periods the dissolved mineral ions precipitated and formed evaporites and salt deposits. Sulfates and chlorides are the common salt composition deposited in the Qaidam Basin and on Mars [3-4]. Given these similarities, the studies of Qaidam salts could shed lights on the physiochemical factors influencing the Martian ancient climate, and in turn from the Martian history we can better understand the future of saline lakes and playas on Earth. Furthermore, the detailed study on Martian analogous samples may enable us to be prepared for better analysis of future Martian samples.

Figure 1 Four sampling saline lakes in the Qaidam Basin.

Methodology: Motivated by these aspects, we study and compare the physical and chemical properties of salt samples from four saline lake areas (Chaka, Keke, Qarhan and Mang'ai) of the Qaidam Basin (Figure 1). The experiments characterize the chemical compositions and the hygroscopic properties of the solid salts. Four types of salt samples (brines, crystalized brines, lakebed salts and crust salts) collected at and near the four saline lakes in the Qaidam Basin are studied for their physicochemical characteristics. The common cations (Na^+, K^+, Mg^{2+} and Ca^{2+}) and anions (Cl^-, SO_4^{2-}, and NO_3^-) are determined by ion chromatography (IC), and the elemental compositions are measured by energy dispersive X-ray fluorescence (EDXRF) spectrometry. The chemical composition results are analyzed by positive matrix factorization (PMF). The pH of sample brines and solutions are measured, and the governing factors are discussed. A vapor sorption analyzer is used to measure the hygroscopic properties. To thoroughly understand the hygroscopic behaviors, the AIOMFAC model [5] is used to predict the deliquescence RH (DRH) based on the chemical matrix of each sample. The results present various physiochemical properties of the playa surface salts and explain the main components driving the hygroscopic behaviors that potentially influence the climate. The connections between the salts in the Qaidam Basin and on Mars are discussed.

Results and Discussions: The common elements detected by EDXRF and IC have excellent consistency. Notably, the crystalized brines exhibit similar ionic compositions with brines, suggesting that the crystalized brines well reflect the complex mineral composition of brines and evaporative crystallization can be used for brine preservation. However, the natural solid salts (lakebed salts and crust salts) present obvious composition differences. Mg^{2+} and SO_4^{2-} are primarily found in brines, while the natural solid salts are dominated by NaCl and KCl. The pH of the brines and salt solutions are found to correlate to Mg^{2+} concentrations and potentially affected by ambient CO_2 uptake. The electrical conductivities of sample solutions are linearly scaled by the dilution factors, indicating that balanced reactions and buffer systems exist in the salt textures. Three interpretable factors are identified by the PMF analysis, and the differences of samples types and sampling sites are clearly reflected by the three factors. The lakebed salts (except for the Qarhan lakebed salt) present excellent correlations with the crust salts, and the crystalized salts are greatly correlated with the brines. The hygroscopicity experimental results are well

described by the AIOMFAC model, based on the ionic composition. The results show that the water uptake by crystalized salts is initialized by $MgCl_2$ at RH 30-40%. For natural salts, the hygroscopic behavior is similar to NaCl except for the QH lakebed salt, which is co-influenced by both NaCl and KCl. The findings presented in this study improve our understandings of the physical and chemical properties of surface salts spread across the Qaidam Basin, and the implications to climate systems on Planet Earth and Mars are discussed.

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References:

[1] Angles, A. and Li, Y. L. (2017) *J. Geophys. Res-Planet, 122,* 856-888.

[2] Di Achille, G. and Hynek, B. M. (2010) *Nat. Geosci., 3,* 459-463.

[3] Wang, A. et al. (2006), *Geochim. Cosmochim. Ac., 70,* 6118-6135.

[4] Wang, A. et al., (2020) *J. Geophys. Res-Planet*, 125, e2019JE006283.

[5] Zuend, A.et al., (2011) *Atmos. Chem. Phys*., 11, 9155-9206.