

## CHLORATE SALTS AND THE POTENTIAL FOR LIQUID WATER ON MARS. J. D. Toner<sup>1</sup> and D. C. Catling<sup>1</sup>

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**Introduction:** Perchlorates ( $\text{ClO}_4^-$ ) have been detected in Mars' soils [1-3]. Chlorates ( $\text{ClO}_3^-$ ) are also expected on Mars because perchlorate on Earth is associated with chlorate in roughly 1:1 ratios [4]. Highly soluble salts such as chlorides, chlorates, and perchlorates could form liquid water on Mars' surface by (1) deliquescing (absorbing water vapor) and (2) depressing the freezing point of ice (by up to  $-75^\circ\text{C}$ ). This could potentially explain putative aqueous flow features such as Recurring Slope Lineae (RSL).

Unlike perchlorates, the properties of chlorate solutions are poorly known, which makes it impossible to determine the potential for these salts to form liquid water on Mars. To address these issues, we have measured water activities in  $\text{NaClO}_3$ ,  $\text{Ca}(\text{ClO}_3)_2$ , and  $\text{Mg}(\text{ClO}_3)_2$  solutions at  $25^\circ\text{C}$ . Our results indicate that  $\text{Ca}(\text{ClO}_3)_2$  and  $\text{Mg}(\text{ClO}_3)_2$  have an even stronger tendency to form aqueous solutions than perchlorates.

**Methods:** We measured water activities using the highly accurate isopiestic method. In the isopiestic method, a reference solution is equilibrated over the water vapor phase with an unknown solution. To do this, we constructed ten novel glass isopiestic apparatus each consisting of (1) two sample vials, (2) a high vacuum stopcock, (3) a temperature bath, and (4) magnetic stir bars to agitate the solutions (Fig. 1).

For a typical experiment we first accurately weighed  $\sim 1$  g of solution into the reference/sample vials to 0.01 mg precision, and then fitted these vials to the apparatus using vacuum grease. Then, we removed all residual air from the apparatus, and equilibrated the solution for 1-3 days in the temperature bath. The final weights of the vials gives the sample/reference concentrations, from which water activity is calculated.

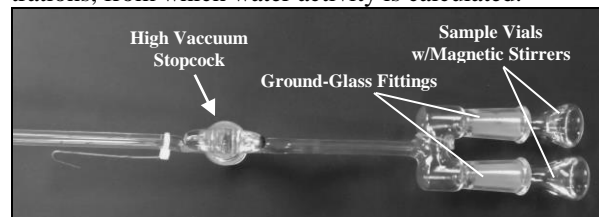


Fig. 1. An experimental isopiestic apparatus.

**Results/Discussion:** Water activities in chlorate solutions are higher than in perchlorate solutions of the same concentration, and osmotic coefficients are lower (Fig. 2). However, saturated Mg and Ca chlorate solutions are much more concentrated than perchlorate solutions; hence, extremely low water activities occur near saturation. A saturated solution of  $\text{Mg}(\text{ClO}_3)_2$  oc-

curs at  $7.3 \text{ mol kg}^{-1}$  with a water activity ( $a_w$ ) of 0.2, which compares with  $4.5 \text{ mol kg}^{-1}$  and  $a_w = 0.4$  for  $\text{Mg}(\text{ClO}_4)_2$ . More concentrated solutions also have greater potential to supersaturate, leading to even lower water activities. In general, solutions with lower water activity will be more stable on Mars' surface. In the future we will analyze chlorate-perchlorate mixtures, and use our data to develop geochemical models that can be used to predict water activities and solution compositions during freezing and evaporation.

**Conclusions:** Chlorate solutions have a strong affinity for water and could form liquid water in the cold and dry conditions on Mars. Deliquescence of chlorate salts could explain RSL, and could form widely dispersed brine droplets in Mars soils. The presence of water implies potentially habitable conditions.

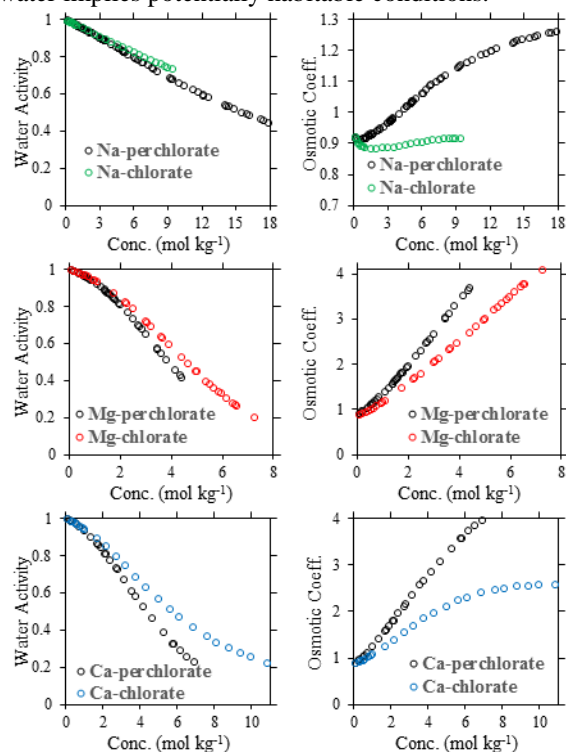


Fig. 2. Osmotic coefficients and water activities in Na, Mg, and Ca perchlorate (literature) and chlorate (measured here) solutions.

**References:** [1] Hecht et al. (2009) *Sci.*, 325, 64-67. [2] Navarro-González, R. et al. (2010), *JGR*, 115, 1-11. [3] Leshin, L. A. et al. (2013), *Sci.*, 341, 1-9. [4] Rao, B. et al. (2010), *En. Sci. Tech.*, 44, 8429-8434.

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