Isotope Fractionation of Magnesium Chloride During Crystallization With Application to Mars

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INTRODUCTION

Isotope Fractionation:

◆ Ratio of abundances of different isotopes occurring in a compound

◆ Record of conditions under which a compound was formed

◆ Used to compile records of the formation of Earth [1]

◆ Affected by alteration and the precipitation of brines

Research Goals:

◆ To crystallize solutions of magnesium chloride at varying temperatures

◆ To determine relationship between fractionation and temperature, if any, for magnesium

◆ To use results to understand conditions under which magnesium salts formed on Mars once martian samples become available

BACKGROUND

Isotope fractionation occurs when different isotopes of a certain element are crystallized from solution at different rates.

Factors that cause variation in fractionation:

◆ Isotope masses

◆ Temperature at which crystals form

◆ Nature of chemical bonds

General Fractionation Theory:

◆ Low temperature: lighter isotopes react and crystallize faster than heavier isotopes

◆ High temperature: differences in reactions not as obvious – everything reacts and crystallizes faster

Magnesium Salts on Mars:

◆ Lower freezing point of water in a brine solution [2]

◆ Exist in high concentrations in some areas, like Juventae Chasma [3,4]

◆ May point to past or present existence of water

◆ Mg - 4th most abundant element on Mars

◆ Found in regolith and in combination with sulfates [4], perchlorates [5], and likely chlorides [6]

METHODS

Stock Solution:

◆ 35.5 wt% $MgCl_2$ in H_20

◆ Saturated at room temperature, oversaturated at lower temperatures

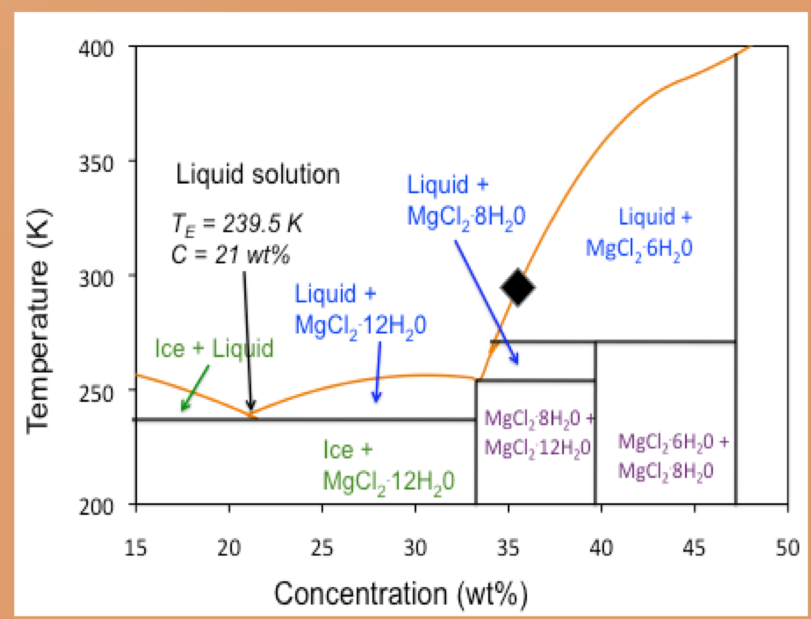

Figure 1. Stability diagram of $MgCl_2$ in solution with H_2O. Black diamond shows location of 35.5 wt%

Crystallization and Separation:

◆ Crystallize samples at 5 different temperatures - -22°C, -12°C, 16°C, 26°C, and 50°C

◆ Separate solution from crystals (Fig. 2) at temperature using filter

Figure 2. Crystallized $MgCl_2$ at -22°C

RESULTS

Crystallized Samples:

◆ Both at -22°C

◆ End concentration of 25.25 wt% (followed equilibrium line)

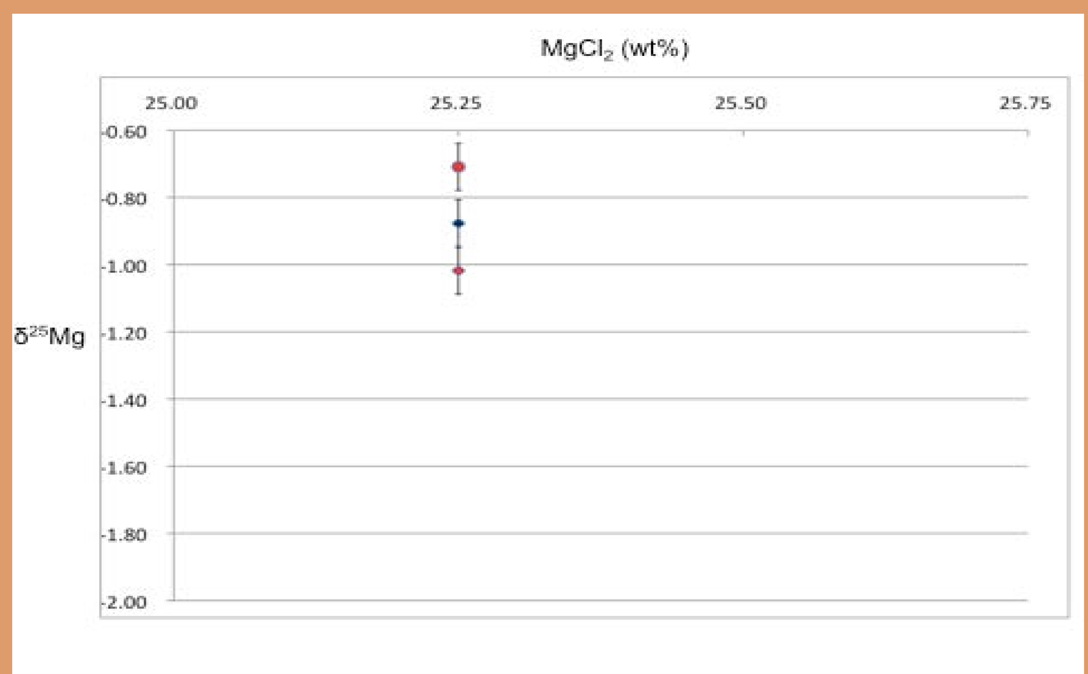

Fig. 3. δ^{25}Mg fractionation. Red points are sample 1 and blue point is sample 2. Diamonds are crystals, circle is solution.

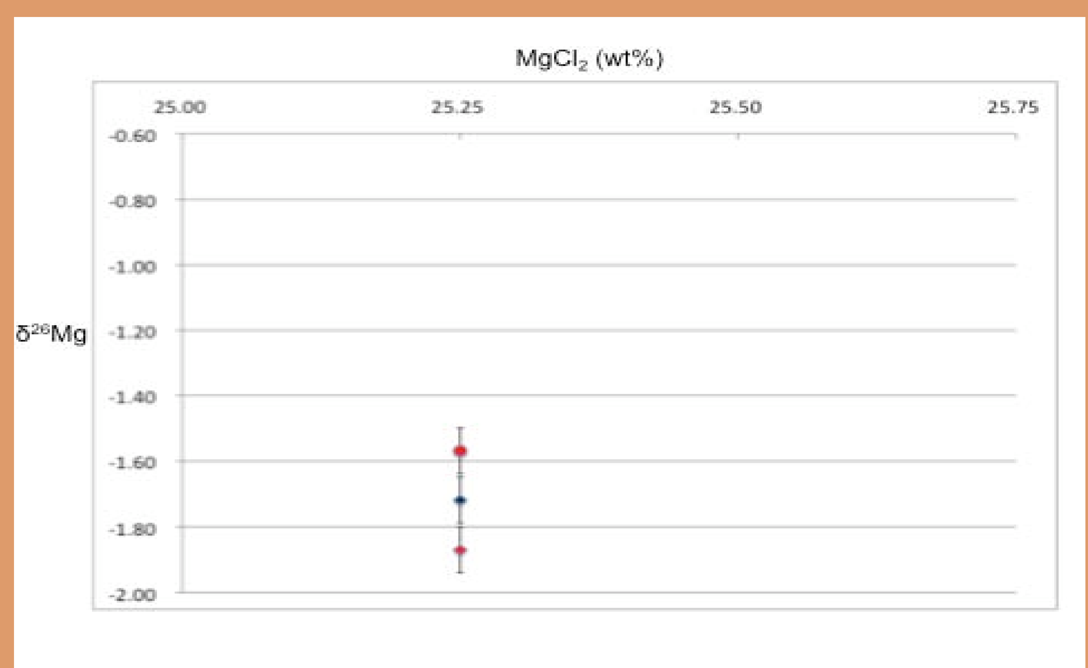

Fig. 4. δ26Mg fractionation. Red points are sample 1 and blue point is sample 2. Diamonds are crystals, circle is solution.

DISCUSSION

Insignificance of data due to:

◆ Systematic error in MC-ICP-MS

◆ Difference in separation method for samples

Sample Differences:

◆ 1: Separated days after crystallization

◆ 2: Separated minutes after crystallization

◆ Samples approach equilibrium (complete precipitation) as they crystallize, fractionation changes

CONCLUSIONS

Fractionation vs. Temperature:

◆ Not enough data to show correlation

◆ Plot data as samples crystallize

Comparison to Previous Study:

◆ Magnesium fractionation through magma cooling: insignificant fractionation [1]

Expected Results:

Fractionation will be more significant than the magnesium fractionation at higher temperatures based on fractionation theory.

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