D/H FRACTIONATION IN THE ATMOSPHERE-GROUND ICE SYSTEM ON MARS. M. D. Ellehøj, S. J. Johnsen and M. B. Madsen, Niels Bohr Institute, University of Copenhagen, Juliane Maries Vej 30, 2100 Copenhagen Ø, Denmark (ellehoj@gfy.ku.dk)

Introduction: The main objective for this work is to investigate the solid-vapor fractionation processes of Deuterium/Hydrogen (D/H) in the ground ice-atmosphere system on Mars.

The current water cycle on Mars consists of coupled interactions between the 3 major water reservoirs [1]: The polar layered deposits, the atmosphere and the ground ice.

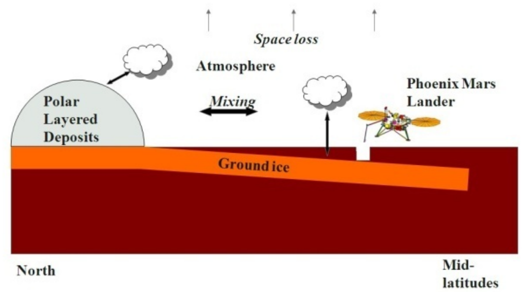
The Martian climate and the water cycle are strongly influenced by the obliquity cycle. This oscillation is very strong, and in the last 5 million years Mars' obliquity has varied between 15º and 45º [2]. These large insolation variations have a profound effect on the stability of the water ice deposits, and large amounts of water are being exchanged between the ground ice reservoirs and the polar layered deposits with time [3].

The polar layered deposits and the ground ice are archives of the climate history on Mars, just as the terrestrial ice caps in Greenland and Antarctica contain information about the past and present climates on Earth. Investigating the processes of the Martian water cycle is necessary for understanding these "climate history archives", and will lead to a better understanding of the present state and the evolution of the Martian climate.

One method of investigating the water cycle processes is by the fractionation of stable water isotopes. When water vapor condenses, there is a change in the stable isotope ratio D/H of the remaining vapor, since the condensate receives a higher proportion of D due to the differences in vapor pressure between H_2O and HDO. Similarly during sublimation, the stable isotope ratio D/H of the remaining solid is enhanced.

Investigating the stable isotope ratios in water vapor and ice (e.g. in the Greenland ice cores) have proved to be a valuable method for understanding the past climate on Earth. On Mars, the ongoing annual and long-term exchange between water vapor in the atmosphere, the polar layered deposits and the ground ice will lead to a fractionation of the stable isotopes as described above as well.

On the figure a sketch of the main processes governing the D/H fluxes in the Martian water cycle can be seen. The present D/H ratio is dependent on the exchange of vapor between the different reservoirs, the D/H ratio in the other reservoirs, and the space loss rate of the lighter molecules. By understanding the D/H fluxes in the Martian water cycle by in situ and orbital measurements and by theoretical modeling, one can gain information about the current and past water reservoir volumes on Mars and on how the Martian water cycle has changed with time.



A sketch of the main processes governing the D/H fluxes in the Martian water cycle.

The Phoenix Mars Lander arrived succesfully on the Martian surface on May 25th 2008. It landed in the north polar region of the planet, a place where there are substantial amounts of ice in the subsurface [4]. Phoenix performed in-situ measurements of soil, the ground ice and of the climate in the Martian arctic. Thus, data from the mission will be valuable in the understanding of the Martian water cycle.

Approach: Our work is divided into two parts, an experimental part and a modeling part.

Experiments. Due to the low temperature and pressure on the Martian surface, an important parameter for understanding the behavior of the stable isotopes under phase changes on Mars is the solid-vapor fractionation coefficient: $\boldsymbol{\alpha}$ = (D/H solid)/(D/H vapor). $\boldsymbol{\alpha}$ is temperature dependent and empirical measurements of $\boldsymbol{\alpha}$ (on Earth) only span 230K < T < 360K [5]. This means that the behavior of $\boldsymbol{\alpha}$ through much of the Mars temperature range is not known. Thus, when modeling the D/H fractionation on Mars, people have used extrapolation to evaluate $\boldsymbol{\alpha}$ for Martian temperatures. To increase the knowledge about solid-vapor fractionation under Martian conditions and to improve current and future models, we investigate $\boldsymbol{\alpha}$ for Martian conditions.

Model. To investigate the behavior of the stable isotopes in the water cycle on Mars, a time varying model for the D/H fractionation in the ground ice-atmosphere system is being developed. This model will be relevant for e.g. the environment of the Phoenix landing site, and parts of the input will be data from the TEGA (Thermal and Evolved Gas Analyzer) instrument and the MET meteorological station on board Phoenix. Supported by these and other datasets, the model will be designed such that it will provide information about the temporal and spatial behavior of the stable isotopes in the subsurface-atmosphere environment, based on knowledge of the present conditions. The results from the experimental work will be used in the model and comparisons with previous modeling results will be made.

Discussion: We will present preliminary results mainly from the experimental work. The results and their implications to the understanding of the processes of the Martian water cycle will be discussed.

References: [1] Clifford et al. (2000), Icarus, 144, 210-242. [2] Touma and Wisdom (1993), Science, 259, 1294 – 1297. [3] Mellon and Jakosky (1995), JGR, 100, 11781-11799. [4] Boynton et al. (2002), Science, 297, 81-85. [5] Merlivat and Nief (1967), Tellus, XIX, 122-127.

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