INVESTIGATING ALTERNATIVE CONCEPTIONS ABOUT WATER ON MARS HELD BY MIDDLE SCHOOL SCIENCE TEACHERS. K. J. Kolb[1], J. M. Keller[2], Ingrid Novodvorsky[3], [1]Lunar and Planetary Laboratory, University of Arizona, 1629 E. University Blvd., Tucson, AZ 85721; kkolb@LPL.arizona.edu, [2]California Polytechnic State University, San Luis Obispo, CA 93407, [3]College of Science Teacher Preparation Program, University of Arizona, 1118 E. 4th St., Tucson, AZ 85721.

Introduction: The current Mars Exploration strategy of the National Aeronautics and Space Administration (NASA) is to "follow the water" [1] in hopes of finding past or present life. NASA's education and public outreach (EPO) efforts reach large numbers of citizens each year and aid in the national goal of improving science literacy. It is important for the public to understand what science is being done and why it is being done so that they can see how science is relevant and directly applicable to every day life. The purpose of our mixed-methods study is to identify any alternative conceptions about water on Mars held by middle school science teachers in order to inform space science educators.

Definitions. Water on Mars: Water includes all phases (solid, liquid, gas) of the molecule dihydrogen monoxide, which contains two hydrogen atoms and one oxygen atom. Its phase depends on the temperature and pressure of its location.

Alternative Conceptions: Alternative conceptions are views and understandings that are different from those currently accepted by the expert community (scientists in this study) [2].

Held/hold: To hold a conception is to have a certain belief or understanding and to demonstrate that one has the belief or understanding by answering questions accordingly.

Previous Research. Middle school science teachers are responsible for teaching and engaging future generations of scientists and engineers, yet they often subscribe to the same alternative conceptions that their students do [3, 4]. Students often have alternative conceptions about phase changes [5], especially involving water [6-8] and earth science [9, 10], topics that are relevant to understanding water on Mars. It is important that the public understand the concept of water on Mars to understand the goals and rationale of the Mars Exploration Program. Also, space science is a topic that tends to fascinate people; incorporating space science into every day classroom lessons could increase interest and attract the attention of students, thus enhancing their learning experiences.

Research Questions: Three research questions are of interest: 1. Do middle school science teachers hold alternative conceptions about water on Mars? 2. If alternative conceptions are found, which are the most prevalent and where do respondents believe their ideas originated? 3. If alternative conceptions are found, is there any correlation between number of alternative conceptions and respondent characteristics (i.e. teaching experience, demographics)?

Population and Sample: The target population of this study is middle school science teachers in the United States of America. Past or present middle school science teachers in southern Arizona and California were chosen as the sample for this study because state standards in Arizona [11] and California [12] dictate that phase changes and earth science, topics related to water on Mars, are taught in middle school in these states and because, as science teachers, they are instrumental in educating the next generation of scientists. Participants were recruited through emails from district personnel and at teacher workshops held in 2008. Our sample consists of 20 teachers for the pilot study and 27 teachers for the main study.

Instrumentation: We designed a survey with ten content, twelve non-identifying demographic, and two informative questions. The content questions assess understanding of four main concepts:

1. carbon dioxide versus water ice,
2. recent versus ancient water,
3. the phases of water, and
4. how scientists know about water on Mars.

We administered the survey to a pilot group before a larger group to determine if there were any confusing questions and if the questions provide the data needed. All participants completed the online survey anonymously using QuestionPro software [13].

Data Analysis: The data from the pilot surveys have been analyzed using content analysis to look for frequency of alternative conceptions, self-reported origin of conceptions, and interest in classroom media (pilot and main). We are in the process of performing content analysis on the main study data. We plan to use inferential statistics to look for possible relationships between number of alternative conceptions and a variety of non-identifying demographics. This analysis will be limited by the demographics available in our non-random sample.

Results: A preliminary analysis of the data from the pilot study suggests that the teachers surveyed do not know about or understand that water vapor exists on Mars, the utility of Earth-based telescopes, and the status of the search for life on Mars.

Figure 1 shows the number of participants having a given number of alternative conceptions. These repre-

sent minimum values because all participants did not necessarily respond to all questions and each question relates to a varying number of alternative conceptions.

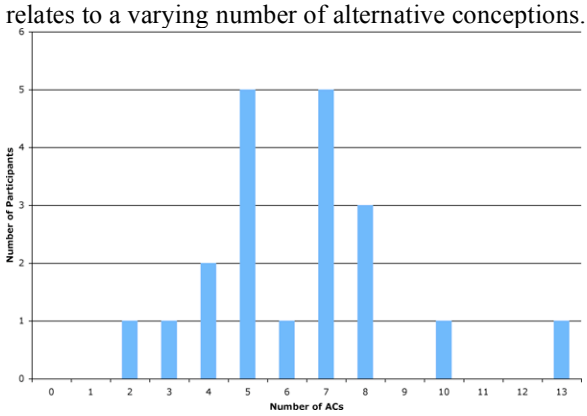

Figure 1. Number of participants having a given number of alternative conceptions.

Table 1 lists the most common alternative conceptions found in the pilot study and the percentages of participants responding to each question who ascribed to each conception. Table 2 lists the self-reported origins of conceptions from the pilot study. Table 3 contains the percentages of teachers, from the pilot and main studies, likely to use particular media in their classrooms. In all tables, topic numbers refer to content topic numbers designated in the Instrumentation section.

Table 1. Most Common Alternative Conceptions (Pilot)

Topic	Alternative Conception	%
3	There are no water clouds on Mars today.	100 (18)[+]
3	Spacecraft have not detected water vapor.	80 (15)
4	Scientists do not study water on Mars using Earth telescopes.	74 (19)
2	Water vapor was not common on Mars in the past.	60 (15)
2	Glaciers have not been possible on Mars.	56 (18)
4	Spacecraft have detected past life on Mars.	39 (18)

[+]Number of responses to relevant question

Discussion: This study is limited by a non-random sample and the fact that recruited participants self-selected to attend or receive information about space science teacher workshops. As such, the results most likely represent minimum alternative conceptions that a typical middle school science teacher might have.

The results of this study will have implications for how space science institutes could direct their education and public outreach efforts in order to be accessible to more people. Future expansion of this project could include surveying a larger number of teachers and using the results to develop and test an EPO activity.

Table 2. Self-Reported Reasoning for Responses (Pilot)

Response	Topic 1	Topic 2	Topic 3	Topic 4
Guess	4	5	0	2
Media	10	11	4	9
Mission	2	0	4	5
Fact	4	14	12	16
Other	0	10	3	4
No response	1	23	19	48

Table 3. Teacher Interest in Classroom Media (Pilot & Main, by % of respondents)

Media	Very Likely	Likely	Neu-tral	Not Likely	Very Un-likely
Classroom activities	70	27	2	0	0
Posters	78	20	2	0	0
Games	64	30	7	0	0
Lesson plans	62	31	7	0	0
Models	68	25	5	2	0
PPT pres.	51	38	11	0	0
Scientist visits	55	32	9	5	0
Fieldtrips	41	30	11	9	9
Overheads	37	33	14	12	5

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