Mars Polar Mission Concept Study for the 2013 Visions and Voyages Decadal Survey. W. M. Calvin, Geological Sciences and Engineering, University of Nevada, Reno, wcalvin@unr.edu.

Introduction: While Mars Sample Return emerged as the highest priority mission for the decade from 2013 to 2022 in the Visions and Voyages decadal survey [1], it was also recognized by the Mars Panel and the Steering Committee that much high priority Mars Science would not be accomplished along the path to sample return. Two additional studies emerged including the Mars Geophysical Network (whose science is captured by the Insight mission) and Mars Polar Climate Concepts including both orbiter and lander options [2].

Following up on scientific results from the Phoenix (PHX) mission and other high-latitude ice studies, there was strong community support behind a mission to the exposed polar-layered deposits (PLDs). The purpose behind the decadal study [2] was to understand what types of mission architectures could best achieve the primary science goals articulated by the Mars polar community at that time [3], including several white papers submitted to Decadal Survey. Drilling, roving, and specific orbital observations have been proposed as methods to access the stratigraphy and climate history locked in these deposits. The prioritized science questions defined at that time [3]:

1. What is the mechanism of climate change on Mars? How has it shaped the physical characteristics of the PLDs? How does climate change on Mars relate to climate change on Earth? What chronology, compositional variability, and record of climatic change are expressed in the PLDs?

2. How old are the PLDs and how do they evolve? What are their glacial, fluvial, depositional, and erosional histories, and how are they affected by planetary-scale cycles of water, dust, and CO_2?

3. What is the astrobiological potential of the observable water ice deposits? Where is ice sequestered outside the polar regions, and what disequilibrium processes allow it to persist there?

4. What is the mass and energy budget of the PLDs? How have volatiles and dust been exchanged between polar and non-polar reservoirs, and how has this exchange affected the past and present distribution of surface and subsurface ice?

Orbiter Concepts: The study consider two orbiter concepts, one likely to fit in the Discovery cost cap with two possible science options and a more capable New Frontiers class orbiter mission. For Discovery, Option 1 would study current climate and weather and seasonal cap properties, the second option was focused on the polar energy balance and composition of the residual ice deposits. The New Frontiers class orbiter would accomplish all of the science objectives of the two Discovery class options. Since that time, an additional orbital concept study was undertaken by MEPAG [4] with several science themes that built on the decadal survey study and new discoveries including the distribution and origin of ice reservoirs and dynamic processes in the current martian atmosphere.

Landed Concepts: The decadal polar mission study considered three landed missions, two stationary landers and a rover. The simplest lander system would land within a large chasma, make high priority atmospheric measurements and remotely image stratigraphy and composition of the residual ice. However sub-surface access at the poles via sampling or drilling has been widely proposed as the only way to constrain recent Martian climate history [5,6], understand the stratigraphic record preserved in the polar layered deposits [7], and search for potential biomarkers in buried ground ice - one of the most habitable places on Mars [8]. Hence the second stationary lander included a meter-scale drill and the rover would traverse and collect small cores, similar to MSL, to sample lateral compositional variations as well as current accumulation/ablation rates. These latter two concepts are likely to be New Frontiers class and similar concepts were reiterated at a recent Keck Institute Workshop [9]. Detailed mission concepts for landed polar science would benefit from additional study and engineering development.

References: [1] National Research Council. 2011. *Vision and Voyages for Planetary Science in the Decade 2013-2022*. Washington, DC: The National Academies Press. doi: 10.17226/13117. [2] Mission Concept Study, Planetary Science Decadal Survey, Mars Polar Climate Concepts, available at http://sites.nationalacademies.org/ssb/ssb_059331. [3] Fishbaugh, K., et al. Icarus, 196, 305–317, 2008. [4] NEX-SAG, 2015, available at https://mepag.jpl.nasa.gov/reports.cfm [5] M. H. Hecht, et al. *Concepts and Approaches for Mars Exploration (2012), Abstract #4330*. [6] W. M. Calvin, C. L. Kahn, *Concepts and Approaches for Mars Exploration (2012), Abstract #4298.* [7] M. H. Hecht, Chronos Team *Fourth International Conference on Mars Polar Science and Exploration (2006), Abstract #8096.* [8] C. P. McKay, et al. *Concepts and Approaches for Mars Exploration (2012), Abstract #4091.* [9] Keck Institute Workshop, "Unlocking the Climate Record Stored Within Mars' Polar Layered Deposits (I and II)" http://kiss.caltech.edu/workshops/polar/polar2.html