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Inventory of Ice-Related Deposits on Mars: Evidence for Burial and Long-Term Sequestration of Ice in Non-Polar Regions

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We estimate the total water abundance on Mars and the nature and magnitude of sources and sinks throughout its history by starting with the present environment, when climate conditions are more well-known, and working backward in time, using the geologic record as a measure of the presence, location, and state of water. We identify elements of the current water cycle, assess their volumes, and then turn to the Amazonian geological record to trace the history of the climate and water cycle as recorded in non-polar ice deposits. This inventory permits us to assess the migration paths and behavior of water during long-term climate change and to document changes in the nature and volumetric significance of the water cycle in the past geologic history of Mars. We first assess the current polar caps and then identify non-polar ice deposits and assess their significance. The current hydrological cycle on Mars is horizontally stratified, separated from the subsurface by a global permafrost layer; seasonal variations and longer-term climate change result in migration between the largest reservoir (the polar caps), the atmosphere, vapor diffusion into and out of the regolith, and surface deposition in non-polar regions. Current polar layering is related to variations in spin-axis/orbital parameters. These variations cause changes in insolation and climate, and corresponding variations in dust and volatile stability, mobility, transport and deposition. Examples of non-polar ice-related deposits include: 1) The Latitude-dependent mantle emplaced during recent Ice Ages; 2) Northern high latitude cold-based glacial crater fill; 3) Mid-high latitude concentric crater fill (CCF); 4) Mid-latitude lineated valley fill (LVF) and plateau glaciation; 5) Mid-latitude lobate debris aprons (LDA); 6) Mid-latitude ice high-stands; 7) Low mid-latitude phantom LDAs; 8) Tropical mountain glaciers; 9) Near-equatorial outflow channel rim deposits; 10) Pedestal and excess-ejecta craters (EEC); 11) South circumpolar ice cap: the Hesperian Dorsa Argentea Formation. We use the characteristics of these deposits to assess: 1) Current volatile inventory; 2) Alternate volatile reservoirs during climate change evolution; 3) Relationship of climate change drivers and alternate volatile reservoirs; 4) Sequestration: Evidence for removal of ice from the active climate system; 5) Amazonian climate history; 6) Transition to the Hesperian-Noachian climate; 7) History of climate change. On the basis of the inventory of water-related deposits to date, the DAF appears to represent the sequestered record of a significantly different climate that characterized the early history of Mars. This was followed in the Amazonian by a hyperarid cold climate with a lower-volume water cycle dominated by mobilization and lateral migration of surface snow and ice in response to variations in spin-axis/orbital parameters; the active water inventory decreased with time due to progressive sequestration of snow and ice beneath sublimation lags.