the surface of Mars. Modeling of nonaqueous, diffusion-limited growth of carbonate rinds [6] has established that, if long-term kinetics are anywhere near the laboratory rates implied by Booth and now by us, then the growth rate will decrease rapidly after a few 100 m.y. and we may require times approaching 3–4 b.y. to store 1 bar of CO_2 on Mars.

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GEOLOGIC CONTROLS OF EROSION AND SEDIMENTATION ON MARS.

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Because Mars has had a history of diverse erosional and depositional styles, an array of erosional landforms and sedimentary deposits can be seen on Viking orbiter images. Here we review how geologic processes involving rock, water, and structure have controlled erosion and sedimentation on Mars, and how further studies will help refine our understanding of these processes.

Impacts: The early geologic record is dominated by large impacts, including dozens of circular basins that exceed 200 km in diameter [1,2]. Large impact events have strongly influenced erosional and sedimentary processes throughout Mars' geologic history by (1) comminuting crustal rocks into very poorly sorted debris [3]; (2) forming large topographic basins whose rims have been eroded and whose interiors have accumulated sediment (and, in some cases, temporary lakes) [4,5]; and (3) seismically disrupting [6] and driving hydrothermal circulation [7] in aquifers. Large volumes of sediment are contained in Argyre and Hellas Basins and the northern plains, which include several large impact basins and one proposed mega-impact, the 7700-km-diameter Borealis Basin [1,8].

Tectonism: For Earth, sedimentologists have said that "the major control of all sedimentation is tectonics" [9]. For Mars, tectonism has also been a major sedimentological control in that it has (1) produced topographic relief, (2) provided fractures that have served as zones of enhanced surface erosion, as well as subsurface conduits for the flow of water, and (3) produced seismicity. Possible tectonic lowering of the northern lowlands at the end of the Noachian Period may have caused the extensive erosion observed there and along the highland/lowland boundary [10,11]. This erosion formed vast areas of knobby terrain in the lowlands and fretted terrain and channels along the lowland boundary. In addition, the increased surficial activity appears to have been associated with a climate change that resulted in waning highland erosion [11,12]. Also, contemporaneous deformation of the Thaumasia highlands by folding and faulting led to local channel formation [e.g., 13].

The growth of Tharsis and Valles Marineris, which may have peaked in Late Hesperian time, resulted in high local to regional relief, as well as possible changes in axial orientation of the planet [14] and high obliquities [15]. In addition, this tectonism led to catastrophic flooding of the Chryse region [16] and of Mangala Valles [17] and possibly to the formation of small channels along the edge of the Thaumasia plateau [18]. This flooding also may have led to temporary climate change [19] that caused glaciation in the southern high latitudes [20].

Volcanism: Mars is renowned for its huge volcanic shields and extensive lava fields. Volcanism (and intrusion) apparently occurred throughout geologic time [21,22]. Their influences on erosion include (1) formation of topographic highs, (2) local production of easily erodible pyroclastic material [23], (3) local rises in crustal temperature, leading to increased hydrothermal circulation, and (4) local disruption of near-surface rocks. In the Tharsis region, many of these effects were associated with tectonism.

Crustal Ground Water and Ground Ice: The presence of large volumes of water and ice in the martian crust has been the major factor in producing the large-scale erosion evidenced by various landforms. At present, interstitial or massive ice may be common in the upper kilometer or so of the crust where freezing temperatures exist, particularly at high latitudes [24]. Steep slopes in ice-rich material may lead to the formation of debris aprons and rock glaciers. Perched subpermafrost aquifers (that may have provided pore water for sapping and catastrophic discharges) and ice-laden permafrost zones could have been charged from the water table by thermal liquid or vapor transport and by seismic pumping [25].

Eolian Activity: The transport by wind of dust and sand-sized particles on the martian surface is shown by extensive dune fields in the the north polar region and within local topographic traps [26] and by polar layered deposits and mantle material [27]. Moreover, winds can erode friable materials, producing the yardangs and deflation pits that are common in extensive equatorial deposits in the Medusae Fossae region. Ephemeral wind streaks all over Mars attest to the ongoing eolian transport of fine particles.

Future Work: Through geologic mapping of Mars at local (1:500,000) and regional (1:2,000,000 and 1:5,000,000) scales and by topical studies, workers have continued to assess the geologic settings and processes that have caused erosion and sedimentation on Mars. Detailed maps have been made of the Tharsis volcano-tectonic region, the Elysium volcanics and channels, the Chryse channels and basin, the Hellas and Argyre basins, the Valles Marineris, Lunae Planum, Mangala Valles, and other regions. These maps provide the basis for more rigorous semiquantitative analyses of Mars' sedimentological history. To achieve this, we plan to augment the mapping studies with further research and compilation. Our objectives include (1) statistical studies of martian channels, including their morphology (lengths, type, drainage pattern, junction angles, etc.) and their distribution by age, elevation, slope, and geologic setting, and (2) determination of the intensities of erosional events along the highland/lowland boundary and their relation to infilling of the northern plains.

We have recently completed a digitized, vector-format, graphical database of channels on Mars as observed on the 1:2,000,000-scale photomosaic series. We plan to implement GIS software and merge other Mars databases (e.g., geology and topography) to accomplish our objectives. This approach will permit evaluation of channel genesis as a function of channel type and morphology, slope, elevation, age, latitude, type of material dissected, and proximity to specific geologic features. In turn, the influence on channel origin by possible global or local anomalous climates may be assessed.

Although some work has been done to assess the timing of erosion and crater obliteration along the highland/lowland boundary [e.g., 28,29], we still know little about the volume of material eroded. We intend to measure depths of dissection by using photoclinometry, which will enable us to estimate these volumes of eroded material (and, consequently, volumes deposited in the northern plains).

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POLAR SEDIMENT ACCUMULATION: ROLE OF SURFACE WINDS AT THE TWO POLES.

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The accumulation of the large deposits of volatile and nonvolatile sediments at both martian poles has occurred through periods of likely climate change. Most data on wind directions near the martian poles and seasonal activity relate to a very short period of time, at one point in climate cycles. It is still uncertain what the net budgets to the poles are and how this budget (if known) would fit into longer climate/sediment cycles. Pending further data we examined the full suite of Viking high-resolution, high-latitude images for wind markers of all sizes and types. These probably represent timescales of formation from days to several tens of thousands of years. The goal is to estimate the effectiveness, and possible drivers, of wind systems that bring materials near the surface to the regions of polar sediments, and also remove materials from the polar areas.

The simple polar vortex model of French and Gierasch [1] accounts for only a part of the observed features; most particularly it lacks the poleward flow seen near 75–80 latitude in both polar regions, but especially the north. Observations of crescentic dunes, framing dunes, and some wind streaks show confinement of the north polar erg by off-pole winds near the margins of the layered deposits and prograde, on-pole winds slightly farther south. The on-pole winds have formed features as transitory as wind streaks and as long lived as large framing dune complexes. Exceptions to the pattern of confining, on-pole wind directions occur in some longitudes and might be due to topographic control. The present topographic data are inadequate to model these effects. In the south, intracrater dune fields are imaged well enough to show field orientations, and thus very-long-term winds, but the bedforms are largely transverse with 180° ambiguities in wind directions. Streaks show some on-pole flow, but in a retrograde sense.

It is desirable to discriminate between feedback effects, such as the dunes' low albedos, that might confine the winds to a narrow belt, and causes that are independent of the dune presence, which would allow poleward transport of the sand and some dust at the surface, for inclusion in the polar deposits. Surface transport of the saltating materials to the polar regions would remove the dilemma of saltating materials being present in deposits thought to be made up of suspension load and condensed volatiles.

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S44-91 ABS. ON

THE MARTIAN SOURCES OF THE SNC METEORITES (TWO, NOT ONE), AND WHAT CAN AND CAN'T BE LEARNED FROM THE SNC METEORITES.

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The SNC meteorites almost certainly from the martian crust, have been inferred to come from a single impact crater site, but no known crater fits all criteria. Formation at two separate sites (S from one, NC from the other) is more consistent with the sum of petrologic, geochronologic, and cosmochronologic data, and eases crater selection criteria. If the source craters for the SNC meteorites can be located, Mars science will advance considerably. However, many significant questions cannot be answered by the SNC meteorites, and await a returned sample.

Introduction: The SNC meteorites are rocks of basaltic parentage, inferred to be samples of the martian crust, and have been important in providing "ground truth" to other observations of Mars throughout the MSATT and predecessor programs. Although the SNCs have provided essential information on mantle and magmatic processes, the hydrosphere, and the composition of the atmosphere, their utility is limited because their source site(s) on Mars are not known. The most comprehensive effort at determining a source impact crater for the SNC meteorites [1] was not entirely successful, as no martian crater met all the criteria for an SNC source. However, it seems likely that the SNC meteorites came from two separate sources on the martian surface, and a number of craters fit this relaxed criterion.