assemblages are predicted to contain abundant Fe-, Mn-, and Al-hydroxides in addition to the dolomite, chalcedony, and kaolinite. Subsequent evaporation of the groundwaters after reaction with basalt is predicted to form, with progressive evaporation, dolomite, $MgCO_3*3H_2O$, apatite (or other phosphate minerals), calcite, dawsonite, and gypsum. Halite and sylvite are not predicted to form, even with extensive evaporation. Reactions of the regolith with groundwaters near 0°C are predicted to result in acidic waters and alteration assemblages containing abundant Fe- and Al-hydroxides (or smectites), Mn-hydroxides, and kaolinite.

The portion of the project in which we model sub-zero brine-regolith interactions has required extensive modifications to the computer programs that carry out the reaction-path calculations and the thermodynamic database that serves as the basis for the calculations. Modeling calculations below 0°C are still in progress.

Summary: Although the chemical reaction-path calculations carried out to date do not define the exact mineralogical evolution of the martian surface over time, they do place valuable geochemical constraints on the types of minerals that formed from an aqueous phase under various surficial and geochemically complex conditions. Based on these results, we believe that further chemical reaction-path modeling efforts are needed as new remote sensing data and other lines of evidence are acquired on possible surficial mineralogies. By integrating such geochemical modeling calculations with remote sensing studies, more realistic and geochemically valid models for the evolution of the martian surface through time can be developed.

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P-1

CONTROLS ON THE CO_2 SEASONAL CYCLE.

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The meteorology experiment on the Viking landers carried out accurate measurements of the surface pressure over the course of several martian years [1]. These data show substantial variations in pressure on seasonal timescales that are characterized by two local minima and two local maxima. These variations have widely been attributed to the seasonal condensation and sublimation of CO_2 in the two polar regions. It has been somewhat of a surprise that the amplitude of the minimum and maximum that is dominated by the CO_2 cycle in the north was much weaker than the corresponding amplitude of the south-dominated extrema. Another surprise was that the seasonal pressure cycle during years 2 and 3 of the Viking mission was so similar to that for year 1, despite the occurrence of two global dust storms during year 1 and none during years 2 and 3.

We have attempted to model the observed seasonal pressure variations with an energy balance model that incorporates dynamical factors from a large number of general circulation model runs in which the atmospheric dust opacity and seasonal date were systematically varied [2,3]. The energy balance model takes account of the following processes in determining the rates of CO_2 condensation and sublimation at each longitudinal and latitudinal grid point: solar radiation, infrared radiation from the atmosphere and surface, subsurface heat conduction, and atmospheric heat advection. Condensation rates are calculated both at the surface and in the atmosphere. In addition, the energy balance model also incorporates information from the GCM runs on seasonal redistribution of surface pressure across the globe, a process that has very little effect on CO_2 condensation and sublimation per se, but which can alias surface pressure measurements at local sites.

Numerical experiments with the energy balance model show that the following factors make important contributions to the seasonal pressure variations measured at local sites: albedo and emissivity of the seasonal CO_2 polar caps, topography of the polar regions, atmospheric heat advection, and seasonal redistribution of the surface pressure. The last factor contains contributions from seasonal variations in atmospheric dynamics and from scale height changes in the presence of topography. The model-derived values of cap emissivity may contain an influence from CO_2 ice clouds that are particularly prevalent in the north during its fall and winter seasons [4]. Atmospheric dust influences each of the above factors, albeit in different ways. For example, atmospheric heat transport to the poles rapidly increases as the dust opacity increases from 0 to 1, but then tends to approach an asymptotic value. We suggest that the similarity of the seasonal CO_2 cycle between years with and without global dust storms may reflect this type of saturation effect. Indeed, runs with the energy balance model performed using Viking-lander-measured opacities during years 1 and 2 [5] tend to substantiate this hypothesis.

We have used estimates of the surface temperature of the seasonal CO_2 caps [4] to define the infrared radiative losses from the seasonal polar caps. This information implicitly incorporates surface topography, a quantity that is poorly known in the polar regions. We have been able to closely reproduce the seasonal pressure variations measured at the Viking lander sites. Our best models are characterized by a lower cap emissivity in the north than in the south. We attribute this difference to the influence of CO_2 ice clouds [4]. According to our calculations the reduced amplitude of the north-cap-influenced pressure extrema, when compared to that of the south-cap-influenced extrema, are due to the following: lower cap emissivity in the north (due to a greater frequency of CO_2 ice clouds in the north), greater heat advection during northern winter when the dust opacity is elevated, and a larger amplitude to the seasonal pressure redistribution during northern winter when the dust opacity is higher. Opposing these factors is a lower CO_2 ice temperature in the south due to its higher elevation.

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