

Volcanism, Clouds, and the Climate of Early Mars

M.A. Bullock, D.H. Grinspoon and R.J. Phillips
Fall 2001 AGU Meeting
Wednesday, December 12, P31B-03

Two recent developments in the study of ancient Mars have led to new theoretical avenues for investigating the nature of its early climate. The first involves modeling of cloud processes and the greenhouse effect in the early martian atmosphere [Colaprete, 2000; Forget and Pierrehumbert, 1997; Mischna *et al.*, 2000], and the second is an emerging view that the immense Tharsis province is an igneous construct that formed during the Noachian epoch [Phillips *et al.*, 2001].

Whether the formation of infrared-scattering CO₂ clouds could have warmed the surface sufficiently in a CO₂-H₂O atmosphere under a faint young sun to allow water to flow is unclear. As pointed out by Mischna *et al.* [2000], CO₂ clouds in the ancient martian atmosphere may have had either a cooling or a warming effect, depending upon cloud location, altitudes, and optical depth. Colaprete [2000] found with a 1-D CO₂ cloud model that as the atmosphere warms due to latent heating and radiative forcing by the clouds, the clouds dissipate, losing their radiative influence. Both investigations point to the necessity of 2 or 3-D cloud/climate models in order to address the net effect that clouds could have had on early Mars surface temperatures.

The Phillips *et al.* [2001] picture of Tharsis, derived from MGS MOLA and gravity data, is that its emplacement must have been nearly complete while the largely Noachian valley networks were still forming. The volcanic magma from which Tharsis formed probably contained substantial quantities of water, CO₂, and sulfur gases that would have been released, providing input of gases to the atmosphere and possibly contributing to an early, thicker atmosphere and cloud formation. This circumstantial connection provides some important constraints on climate and cloud models for Noachian Mars.

We have begun a program to couple models of volatile outgassing due to the formation of Tharsis with atmospheric radiative-convective models that include parameterized cloud formation. We will discuss some results from 1 and 2-D models that bear on the effects that large injections of water, CO₂ and sulfur gases may have had on cloud formation and surface temperatures of early Mars.

Colaprete, A., *Eos Trans. AGU*, 81, 2000.
Forget, F., and R.T. Pierrehumbert, *Science*, 278, 1273, 1997.
Mischna, M.A., *et al.*, *Icarus*, 145, 546, 2000.
Phillips, R.J., *et al.*, *Science*, 291, 2587, 2001.