AOGS 2005

Recent Climate Change on Venus

MARK A. BULLOCK[1] and DAVID H. GRINSPOON[1]
[1]*Southwest Research Institute*

The atmosphere of Venus has almost certainly been perturbed by the injection of volatiles from large-scale volcanism in the past 1 Gy. Models of the greenhouse effect show that small changes in atmospheric H_2O or SO_2 abundance can alter the surface temperature [1]. This is because pressure-broadened CO_2 absorption bands dominate the infrared opacity of the Venus atmosphere, but H_2O absorbs infrared radiation where CO_2 does not. SO_2 has some absorption bands in the CO_2 windows, but more importantly, it, along with H_2O, are the chemical precursors of Venus' global cloud layer. Changes in SO_2 and H_2O in Venus' atmosphere would have changed the morphology and optical properties of the clouds [1].

Massive outgassing associated with the formation of vast basaltic plains 300-800 Mya must have influenced the evolution of Venus' atmosphere. The evidence from the impact cratering record on Venus implies that much of the volcanism that formed the plains should have taken place within 10-100 My [2]. Perturbations to the atmospheric inventories of radiatively important species constitute a potentially important climate forcing mechanism on Venus. Laboratory data on the rates of reaction of sulfur bearing gases [3] indicate that heterogeneous reactions with the surface also have significant climatic implications.

Curious surface features revealed by Magellan radar images may be indications of recent climate change. It has been shown that wrinkle ridges seen on Venus' vast plains may have been emplaced all at once, the product of stresses caused by a climate change-induced thermal wave propagating into the surface [2]. Ribbon terrain in the interior of the highly deformed tessera regions appear to have formed when the brittle-ductile transition in the crust was shallower than it is today [4]. Higher surface temperatures in the past could have caused these features.

We have modeled the climatic effects of volcanism in Venus' past by coupling detailed atmospheric radiative transfer calculations with models of volcanic outgassing, cloud formation, exospheric escape of hydrogen and reactions of SO_2 with surface minerals. We find that volcanic injections of radiatively active gases to the atmosphere initially cool the surface due to the build up of massive H_2SO_4/H_2O clouds and an increase in planetary albedo. In the absence of continuing volcanic outgassing, however, atmospheric SO_2 is rapidly lost to reactions with surface carbonates and clouds dissipate in approximately 50 million years. This implies that the clouds of Venus today are being supplied by recently active volcanism.

References

[1] Bullock, M.A., and D.H. Grinspoon, *Icarus*, *150*, 19-37, 2001.
[2] Solomon, S.C., M.A. Bullock, and D.H. Grinspoon, *Science*, *286*, 87-89, 1999.
[3] Fegley, B., and R.G. Prinn, *Nature*, *337*, 55-58, 1989.
[4] Phillips, R.J., and V.L. Hansen, *Science*, *279*, 1492-1497, 1998.