Mars Atmospheric Chemistry and Astrobiology Workshop
California Institute of Technology
December, 2001

# Sampling of Trace Atmospheric Constituents Above the Surface of Mars from a Montgolfiere Balloons


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We suggest that use of an aerially deployed, solar-heated balloon, or Montgolfiere, during a Martian polar summer could provide an optimal platform for atmospheric measurements near the surface. Solar Montgolfieres are empty balloons with a hole in the bottom that fill with (Reference 1) ambient atmosphere while falling and are rapidly heated in by the sun, thus providing buoyancy (Reference 1). Such a balloon (Figure 1) would be driven by the Martian

Figure 1. Mars Montgolfiere Balloon

winds, in the constant sunlight of a high latitude entry and could provide a traverse of thousands of kilometers. It would encircle the Martian north polar region over a period likely lasting over one Earth month (Figure 2), and its altitude could be controlled as low as 100 meters to as high as 4000 meters above the surface.

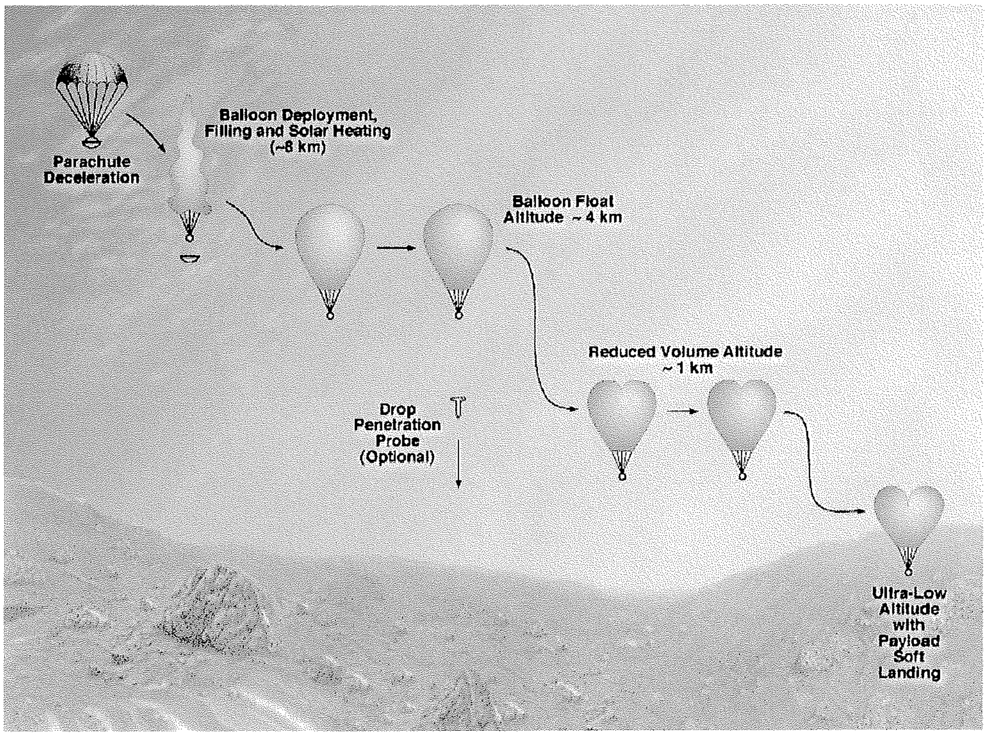


Figure 2. Solar Polar Montgolfiere Mission Scenario

A mission schematic is shown in (Figure 3) and consists of an atmospheric entry, followed by deployment of the balloon beneath a falling parachute. An open hoop in the bottoms of the balloon allows the balloon to fill by a ramjet effect in about two minutes, and solar heating provides buoyancy after about another minute (confirmed by JPL tests). The balloon can

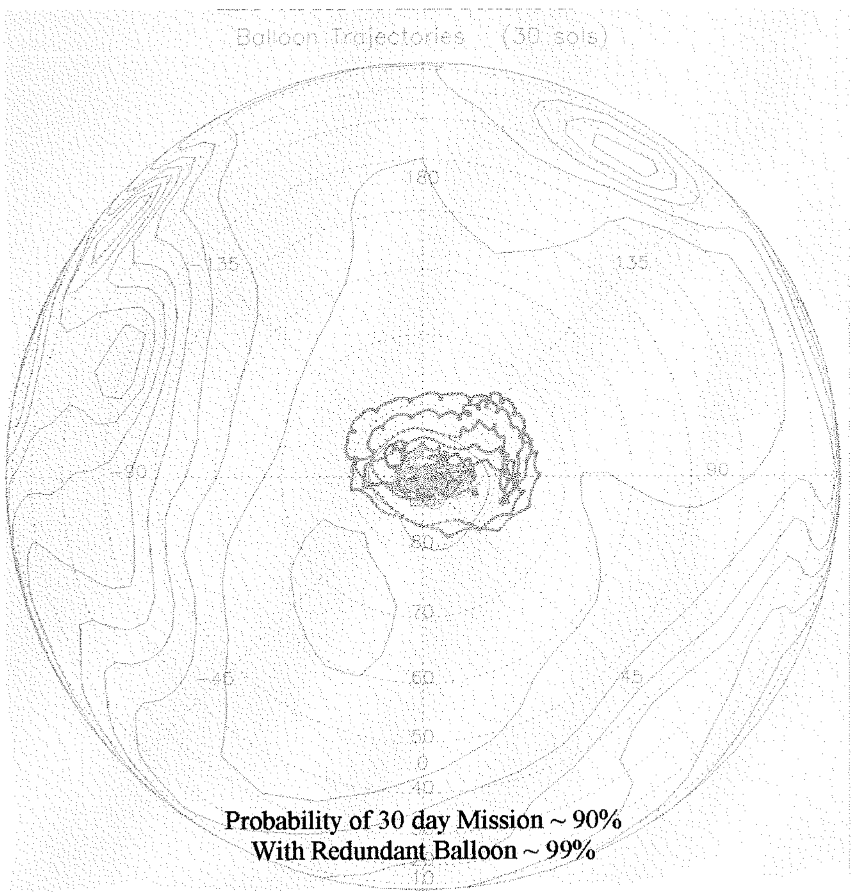


Figure 3. Balloon Trajectories (30 sols)

potentially drop deep penetration devices and can vary altitude by reducing its volume. Ultimately, it can fly at extremely low altitude and softland its payload on the Martian surface.

In order to float a 20-kg payload at altitudes between 100 m and 3000 m above the Martian north polar surface, an aluminized polyethylene Montgolfiere would be approximately 27 meters in diameter and have a mass of 27 kg. JPL has successfully deployed three polyethylene Montgolfieres at 4-6 mbar pressure in the Earth's stratosphere and will be deploying a 20 m diameter and a 27-m diameter polyethylene Montgolfiere in 2002.

The significant payload of tens of kilograms allowed by this technology could readily accommodate the mass of instrumentation and the power source needed for a sensitive search for disequilibrium species that might provide the atmospheric signature of localized subsurface biological or geological activity. Measurement of biogenic gases and their isotope ratios may be made using either optical or mass spectroscopic techniques. Both spectroscopic and mass spectrometric approaches have a long history of air-/space-borne operation, and in this experiment would be very complementary. Both techniques have extraordinary sensitivity, readily detecting sub-parts-per-billion mixing ratios. Tunable laser spectroscopy has the advantage over mass spectroscopy of specificity to distinguish different isotopomers of the same mass that would otherwise need extensive sample preparation. While mass spectrometers offer survey capability, for specific target gases, tunable laser spectrometers provide fast response (~ 1 sec), non-invasive, very sensitive measurements that are easy to calibrate through Beer's Law or calibration gases, and are very light.

With a long heritage in Earth measurements from balloon and aircraft platforms, tunable laser absorption spectroscopy is widely recognized as a direct, non-invasive, simple measurement technique that is known for its high sensitivity (sub-parts-per-billion) and specificity. Using wavelength-modulation techniques, minimum-detectable-absorptions as small as 2 parts in $10^6$ are possible, with 2 parts in $10^5$ readily achieved in flight experiments. For pathlengths of up to 2 km achievable with the balloon experiment, this translates to parts-per-trillion sensitivities for numerous species in the mid-infrared, and ppb in the near-IR region.

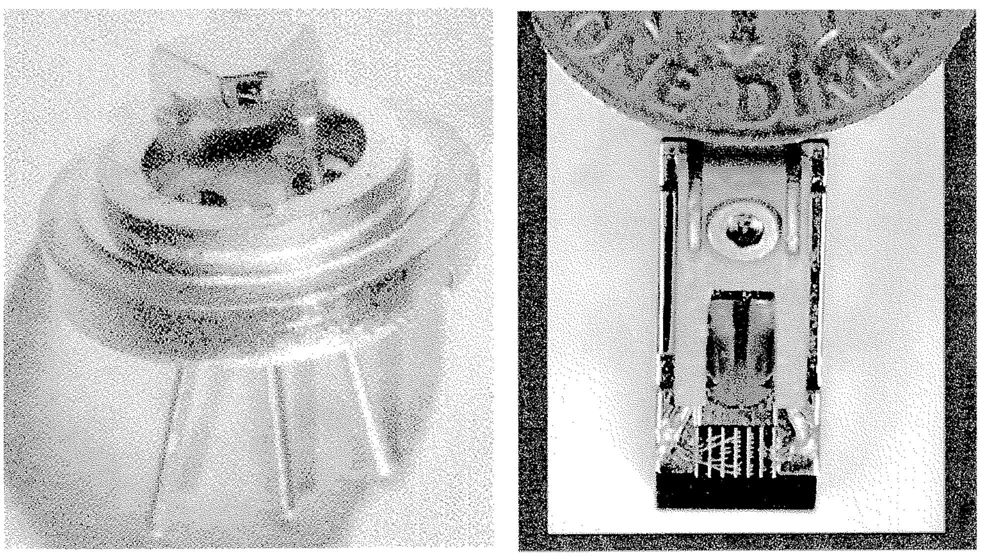

Figure 4. A near-IR DFB TDL at 1.43 microns, made at JPL, and 8 individual room-temp QC lasers single chip of dimensions 3 mm x 2 mm.

**MARS BALLOON EXPERIMENT:** ***CANDIDATE SPECTRAL REGIONS***

Pressure = 7 mbar (surface), T = 220 K, path = 2000 m, $A_{min} = 1x10^{-5}$, 95%$CO_2$

| Molecule | Wavenumber ($cm^{-1}$) | Wavelength ($\mu m$) | Expected mixing ratio | Minimum-detectable mixing ratio **(parts-per-trillion)** |
|---|---|---|---|---|
| CO | 2165.6 | 4.6 | 0.1-0.3% | 2 pptv |
| $H_2O$ | 1616.7 | 6.2 | 300 ppmv | 5 pptv |
| **$CH_4$** | **3067.3** | **3.3** | **??** | **5 pptv** |
| $H_2O_2$ | 1256.7 | 8 | <20 ppbv | 25 pptv |
| OCS | 2070.9 | 4.8 | <600 ppbv | 1 pptv |
| NH3 | 1046.2 | 9.6 | ?? | 50 pptv |
| $SO_2$ | 1373 | 7.3 | ?? | 10 pptv |

In particular, the balloon experiment offers the unique opportunity of providing long enough pathlengths to allow a search for atmospheric $CH_4$ and possible local sources at the unprecedented sensitivity of a few parts-per-trillion level.

Other measurements that can be made from the balloon include imaging, magnetometry, weather measurements, and subsurface sounding for water deposits. After a month of operation, the balloon could softland the payload and possibly continue imaging, spectrometry, and weather measurements.