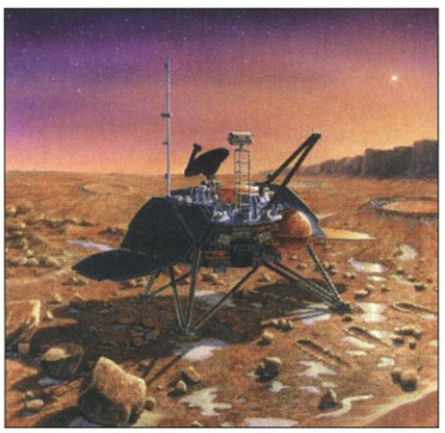
In response to an earlier letter, details of the abundance and characteristics of CO_2 clathrate-hydrates under martian conditions are presented to explain why such clathrates could not have been involved in the loss of the Mars Polar Lander mission. Whether the current epidemic of human *Salmonella enteritidis* infections, particularly in the United Kingdom, began in the 1960s or 1980s is debated. And a hypothesis about the origins of this epidemic, "that eradication of [*Salmonella*] *gallinarum*... opened an ecological niche that allowed... *S. enteritidis* strains to be introduced into poultry flocks from their rodent animal reservoir," is discussed, including whether sources other than poultry might be to blame.

Clathrates Are Not the Culprit

A. F. Koster van Groos and S. Guggenheim suggest in their letter that clathrates might have played a role in the loss of the Mars Polar Lander mission (*Science*'s Compass, 11 Feb., p. 973). However, no significant amount of clathrates could exist near the surface of Mars. The average annual surface temperature at the landing site is about 205 kelvin, in comparison with an upper limit of about 151 kelvin for CO_2 clathrate-hydrate stability (*1*) at martian surface pressures [~450 pascal at the landing site elevation of about +2 km (*2*)]. Also, this average temperature will increase with depth. Thus, the only clathrate possible (relevant to the landing) would have to have formed during the prior winter, when surface temperatures are buffered by seasonal CO_2 condensation at 143 kelvin (at these elevations).



Had the Mars landing gone as planned... (an artist's rendition).

CREDIT: PHOTO COURTESY LOCKHEED MARTIN

The atmosphere at south polar latitudes is relatively dry, even for Mars (*3*), and the proportion of H_2O present in the seasonal CO_2 deposit is almost certainly no more than its global annual average in the atmosphere, about 0.0001 by mass (*4*). The seasonal CO_2 accumulation at the landing region is about 1000 kg/m^2 (*5*). Carbon dioxide in a clathrate-hydrate is present in a ratio of 1/6 with the H_2O molecules. This yields an upper limit on clathrate abundance of 0.1 kg/m^2 and no more than about 0.03 kg/m^2 of the trapped-gas release. This amount of volatile material could not have disrupted the landing process.

In addition, the forecast of surface conditions based on Mars Global Surveyor (MGS) and historical observations (*6*) was that the seasonal CO_2 deposit would be gone by 7 November 1999, a month before the landing; this was confirmed by continuing MGS monitoring activities. Once the pure CO_2 deposit was gone, the residue seasonal H_2O frost, clathrate or not, would sublime in less than 30 minutes of natural sunlight.

Hugh H. Kieffer
U.S. Geological Survey, 2255 North Gemini Drive, Flagstaff, AZ 86001, USA. E-mail: hkieffer@usgs.gov

References

1. S. L. Miller and W. D. Smythe, *Science* **170**, 531 (1970).
2. D. E. Smith *et al.*, *Science* **284**, 1495 (1999).
3. B. M. Jakosky and C. B. Farmer, *J. Geophys. Res.* **87**, 2999 (1982).
4. H. H. Kieffer, *J. Geophys. Res.* **95**, 1481 (1990).
5. R. B. Leighton and B. C. Murray, *Science* **153**, 136 (1966).
6. http://wwwflag.wr.usgs.gov/USGSFlag/Space/MGS_TES/.

Salmonella enteritidis Epidemic

A. J. Bäumler, B. M. Hargis, and R. M. Tsolis suggest in their Perspective "Tracing the origins of *Salmonella* outbreaks" (*Science*'s Compass, 7 Jan., p. 50) that the current worldwide epidemic of *S. enteritidis* might have started in the late 1960s rather than in the 1980s. They cite three publications from the Public Health Laboratory Service of England and Wales (*1*); however, they do not provide information about the annual incidence of infections nor data on individual phage types of *S. enteritidis*. This information is vital to an understanding of the epidemic of *S. enteritidis* infection in the United Kingdom.

The current U.K. epidemic of *S. enteritidis* has been caused predominantly by a strain of phage type 4 (PT4). Infections have been associated with poultry and poultry products, particularly the contents of whole-shell eggs. The latter vehicle has provided a new dimension for *S. enteritidis*, and many large outbreaks have been linked to eggs rather than poultry meat (*2*).

From 1961 to 1970 the total number of people infected in the United Kingdom with *S. enteritidis* increased from 151 to 913 per annum. However, the most common phage type isolated was PT8, which was responsible for several substantial turkey-associated outbreaks in the late 1960s. Isolations of PT4 increased only moderately during this period, from 18 in 1961 to 109 in 1970. Although there was a doubling in the incidence of PT4 from 1969 to 1970, many infections were associated with foreign travel. From 1971 to 1980, isolations of *S. enteritidis* ranged from 651 to 879 per annum, with PT8 remaining the most common phage type. In 1983, PT4 became predominant, comprising 46% of 1774 isolations that year. The most dramatic increase was seen in 1987–88, when isolations of *S. enteritidis* increased from 6858 to 15,427, with PT4 comprising 81% of strains isolated (*3, 4*).

If these data are plotted on a logarithmic scale, a steady increase in isolations from the mid-1960s to 1981 is apparent. The epidemic of PT4 most likely commenced in 1982–83. Subsequent epidemiological investigations have indicated that poultry breeding lines infected with PT4 were introduced into the United Kingdom around this time, probably originating in elite flocks in continental Europe. We therefore conclude that the epidemic of *S. enteritidis* PT4 in the United Kingdom started in the early 1980s, and not in the late 1960s.

The largest number of isolations of PT4 was recorded in 1993, when 17,371 infections were identified (*4*). There has been a dramatic decline since 1997, with around 6700 isolations of PT4 identified in 1999 (*5*). The reasons for this decline are multifactoral, including that several codes of practice for the control of salmonellas in chickens have been in operation in the United Kingdom since 1993; there have been many improvements in the poultry industry in infection control and hygiene at breeding sites; and in 1994, vaccination against *S. enteritidis* started in breeder flocks and in 1998 in layer flocks.

Linda R. Ward
John Threlfall
Henry R. Smith
Public Health Laboratory Service, Laboratory of Enteric Pathogens, Central Public Health Laboratory, 61 Colindale Avenue, London NW9 5HT, UK
Sarah J. O'Brien
Public Health Laboratory Service, Communicable Disease Surveillance Centre, 61 Colindale Avenue, London NW9 5EQ, UK