Planetary science

Brimstone on Mars

Harry Y. McSween Jr

We normally think of the Red Planet as having a veneer of rust, but its ruddy surface is also abnormally rich in sulphur. Where did all this sulphur come from, and what might it tell us about sulphur cycling between different geochemical reservoirs on Mars? On page 50 of this issue, Farquhar and co-workers[1] provide the first unambiguous evidence that sulphur in martian rocks once resided in the atmosphere.

The Viking and Mars Pathfinder landers analysed the chemistry of the martian soil and found high concentrations of sulphur[2] (Fig. 1). Because of the high oxidation state inferred for the rusty surface, and spectroscopic evidence for the presence of sulphate, the sulphur in the soil is thought to occur mostly in the form of sulphates. No martian soil samples are available for analysis on Earth, but so-called SNC meteorites, which are thought to be igneous rocks from Mars[3], can be analysed. Until now, only the sulphides in these meteorites had been studied[4,5].

Sulphur is an unusual light element in that it has four stable isotopes and can exist in several oxidation states. Geological and biological processes separate isotopes according to their masses, and these 'fractionations' are often most pronounced when the oxidation state is changed. For example, sulphate-respiring bacteria on Earth reduce sulphur and, in the process, produce relatively huge fractionations between ^{32}S and ^{34}S (ref. 6).

Farquhar *et al.*[1] have separated both oxidized and reduced sulphur from SNC meteorites and analysed the isotopic composition. The results are surprising: sulphur isotopes have been fractionated independently of their masses. Mass-independent fractionation is known to occur during only a few processes, and it seems that the only mechanism that could have been applicable to these meteorites is chemical reactions in the atmosphere[7].

To substantiate this surmise, Farquhar *et al.* performed laboratory experiments to quantify the isotopic effects of gas-phase reactions on the main sulphur species thought to be present in the martian atmosphere. The distinctive fingerprint of atmospheric chemistry contained in these meteorites indicates that the martian sulphur cycle includes movement of sulphur from the atmosphere, perhaps introduced by volcanic eruptions, back into surface materials (the authors' scheme is shown in their Fig. 3 on page 52). It is not clear how atmospheric sulphur was incorporated into solid rocks, but an apparent correlation with oxygen isotopes suggests hydrothermal activity as one possibility.

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Figure 1 **The surface of Mars, which is rich in sulphur. From isotope studies of meteorites, Farquhar and colleagues[1] conclude that the sulphur came from the martian atmosphere after originating, perhaps, from volcanic eruptions.**

This work has another implication: chemical reactions in the atmosphere provide a way of bringing about large changes in the $^{34}S/^{32}S$ ratio without involving biological processes. Many scientists expect that the most likely evidence for past or present life on Mars might be found in the large isotopic fractionations produced by organisms. But the new results show that the $^{34}S/^{32}S$ biomarker must be used with caution on any samples returned from Mars. Moreover, fractionation of $^{33}S/^{32}S$ and $^{36}S/^{32}S$ should also be taken into account to ensure that the results of atmospheric processes are not confused with biological effects. ■

Harry Y. McSween Jr is in the Department of Geological Sciences, University of Tennessee, Knoxville, Tennessee 37996, USA.
e-mail: mcsween@utk.edu

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Daedalus

Brief lives

'A dog is for life — not just for Christmas!' This slogan is intended to warn potential purchasers of the long-term consequences of pet ownership: not merely dogs, and not merely at Christmas. Yet thousands of households buy pets to amuse the children, and are stuck with them when the children are no longer amused. Now Daedalus has the answer. He is inventing the short-life pet.

In principle, no mammal can live for ever. At every cell division, one unit is lost from the telomere sequence on each of its chromosomes. When the entire telomere sequence has gone, the cell can no longer divide. Its vital reserve is exhausted. So Daedalus plans to shorten the telomere sequence in pet animals. His biologists are taking fertilized dog, cat and hamster ova, and cultivating them *in vitro* by standard methods.

Every animal, of course, arises from a single fertilized ovum. It divides into two cells, then into four, and ultimately into a complete fetus. If at the two-cell stage the cells are separated, they go on to develop into identical twins. The DREADCO team members are encouraging this process. Each time an ovum divides into two, they separate the two cells. When these reach the two-cell stage, these are separated again, and so on. At each cell-division, one telomere unit is lost from the cells' chromosome termination. After many such divisions, Daedalus will have millions of identical telomere-depleted ova of the chosen pet species. They will be implanted into surrogate mothers of the same species, and brought to term.

The resulting identical youngsters will command vast prices in the pet market. Children will adore their fluffy appeal. Canny parents will appreciate their brevity. Almost as soon as their appeal has waned, their telomere sequences will be exhausted, and they will drop dead.

Daedalus is not sure what they will die of. It won't be senility; brain cells hardly divide at all. Gut cells divide very fast, so it may be indigestion. But one standard feature of old age, in Man as in animals, is the increasing embrittlement and fragility of connective tissue. So their fibroblast telomeres may give out first. Like other toys, Daedalus's short-life pets may just fall to pieces.

David Jones

***The Further Inventions of Daedalus* (Oxford University Press), 148 past Daedalus columns expanded and illustrated, is now on sale. Special *Nature* offer: m.curtis@nature.com**