Table 2 Martian volatile inventory derived by degassing from ordinary chondrites (g cm^{-2})

	H	C	N	^{20}Ne	^{36}A	^{84}Kr	^{132}Xe
Mars atmosphere observed	—	5.0	0.50	$< 10^{-4}$	1.0×10^{-4}	$\sim 6\times10^{-6}$	$\sim 1\times10^{-6}$
Ordinary chondrite (LL)	66	145	8.3	10^{-5}	1.0×10^{-4}	2×10^{-6}	$\sim 3\times10^{-6}$
Volatiles escaped or on surface	66	140	7.8	–	–	–	–

allow a thickness of up to 40 m, if escape of water from Mars can be ignored. If not[11], the polar cap thickness would be accordingly smaller.

(5) Major volatiles deduced from Table 2, H_2O, CO_2, N_2, add up to $\sim$1,100 g cm^{-2}. It has been suggested[12] that Mars goes through major climatic fluctuations and at times all volatiles could be in the atmosphere. According to our inventory the total mass of the atmosphere in such a case would be $\sim$1,100 g cm^{-2} which, for Martian gravity, corresponds to $\sim$400 mbar; an atmosphere composed of $\sim$50% CO_2 and $\sim$50% H_2O with traces of nitrogen.

The ^{40}A degassing problem is a very different question than that of general outgassing of the planet (such as CO_2, H_2O, rare gases and N_2). ^{40}A is a radiogenic product of ^{40}K and was nearly completely absent in the earlier stage of planetary formation (its degassing should be a function of its production and could be continuing at the present time (compare the Moon))[13].

Viking measurements showed an ^{40}A/^{36}A ratio in the Martian atmosphere 10 times greater than the ratio in the Earth's atmosphere[2]. Soil sample analyses[14] give an upper limit for the potassium concentration at the surface of 0.25% (compared with the potassium concentration of 1.6% (ref. 1) in the Earth's crust).

We calculated the necessary thickness of a layer to account for the observed quantity of ^{40}Ar in the Martian atmosphere assuming two different values for the potassium concentration: 0.25% which is upper limit from Viking experiments and 0.08% which is the concentration in ordinary chondrites (LL). We find that layers of 2.5 km and 8 km respectively can account for the results of Viking measurements. These thicknesses are to be compared to the half-kilometre thickness calculated by us previously to account for the other volatiles (Table 2). This difference implies a different mechanism for outgassing of ^{40}A compared with the rest of Martian atmosphere.

The fact that the absolute amount of ^{40}A in the atmosphere of Mars could be explained by $\sim$10 times less K in the upper layers of Mars than on the Earth, is interesting. It implies that the upper layers of Mars have not been substantially enriched in K and other radioactive elements perhaps because of the absence of extensive melting in the interior of Mars during its formation.

S. I. Rasool
National Aeronautics and Space Administration, Washington, DC 20546, and Collège de France, Paris 6e, France

L. Le Sergeant
Laboratoire d'Astronomie Spatiale, Les Trois Lucs, 13012 Marseille

Received 14 January; accepted 7 March 1977.

1 Turekian, K. K. & Clark, Jr S. P. *J. Astron. Soc.* **32**, 1257 (1975).
2 Owen, T. & Biemann, K. *Science* **193**, 801 (1976).
3 Biemann, K., Owen, T., Rushneck, D. R., Lafleur, A. L. & Howarth, D. W. *Science* **194**, 76 (1976).
4 Owen, T. *et al. Science* **194**, 1293 (1976).
5 Anders, E. *A. Rev. Astr. Astrophys.* **9**, 1 (1971).
6 Grossman, L. & Larimer, J. W. *Rev. Geophys. in Space Phys.* **12**, 71 (1974).
7 Huguenin, R. L. *Icarus* **28**, 203 (1976).
8 McElroy, M. B., Yuk Ling Yu & Nier, A. O. *Science* **194**, 70 (1976).
9 Biemann, K. *et al. Science* **194**, 72 (1976).
10 Kieffer, H. H., Chase, S. C., Martin, T. Z., Miner, E. D. & Palluconi, F. D. *Science* **194**, 1341 (1976).
11 McElroy, M. B. *Science* **175**, 443 (1972).
12 Ward, W. R. *Science* **181**, 260 (1973).
13 Hodges, R. R. Jr, Hoffmann, J. H. & Johnson, F. S. *Icarus* **21**, 415 (1974).
14 Clark, B. C. *et al. Science* **194**, 1283 (1976).
15 *Handbook of Elemental Abundances in Meteorites* (ed. Mason) (1971).

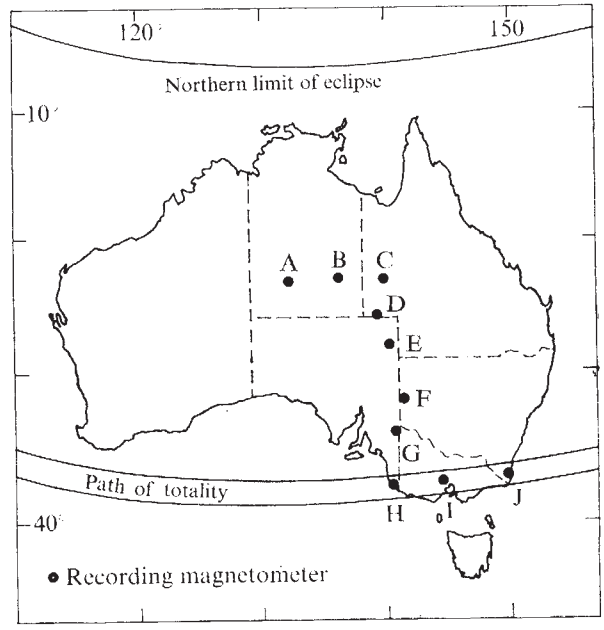
Magnetic observations of the solar eclipse of 23 October 1976 in Australia

Solar eclipses may cause geomagnetic effects by disturbing the flow of electric currents in the ionosphere[1,2], and a number of observations of this phenomenon have been made in recent years[3,4]. To monitor any magnetic effects of the eclipse of 23 October 1976, we operated recording magnetometers at 10 sites in central and eastern Australia (Fig. 1); these instruments were in addition to the regular observatories of the Bureau of Mineral Resources near Perth and Melbourne. We present here a preliminary analysis of the declination variations recorded in the path of totality at stations H (Millicent, S.A.) and J (Merimbula, N.S.W.).

The recording instruments were Gough-Reitzel variometers[5], set to take readings at intervals of 10 s. Because any eclipse effect was expected, on elementary grounds, to be mainly in the declination component, the declination sensors of the instruments were increased in sensitivity by a factor of four above their normal level. Timing of the 10-s readings (on film) was estimated to be accurate to within a few seconds.

The day of 23 October 1976 proved to be magnetically quiet in the declination component. Minor activity occurred at 0711 h Universal Time (UT), about 30 min after eclipse totality had passed. The declination records for stations H and J have been digitised at 10-s intervals for a 4-h period centred on the eclipse, normalised by calibration factors, and are shown plotted in Fig. 2.

Fig. 1 Sites of recording magnetometers operated to monitor the 23 October 1976 eclipse. Site H is Millicent Airfield (lat. 37°35′S, long. 140°22′E). Site J is Merimbula Airfield (lat. 36 55′S, long. 149°53′E).



Also shown in Fig. 2 is the difference between them, subtracting trace J from trace H.

Natural electromagnetic induction in south-east Australia has been well studied by two previous magnetometer array experiments[6,7], which showed the coast effect to be strong in the vertical component of magnetic fluctuations, but to be negligible in the declination component. Thus, stations H and J were placed at opposite coastlines to achieve the greatest time difference between them for the passage of eclipse totality. The previous array studies have also shown that magnetic substorms and similar events occur near-simultaneously across the area, but that the quiet daily variation moves across with local solar time.

Thus, in Figs 2*a* and 2*b* one may expect to see: a background quiet daily variation, with station H lagging behind station J by 38 min; possibly some substorm activity occurring simultaneously at H and J; and an eclipse signal moving rapidly from H to J. In Fig. 2*c*, where the traces are subtracted, the effect of the substorm activity should disappear to first order, and one may expect to see the daily variation subtracted from itself 38 min out of phase to give a smooth curve of amplitude approximately 5 nT, and some interference effect between the eclipse signals at H and J. It is significant that the activity starting at 0711 UT has indeed largely cancelled itself out in Fig. 2*c*.

The signal causing a depression in the declination traces at about 0638 UT is of interest as a possible eclipse effect, because: (1) it occurs at the time of the eclipse; (2) it does not cancel itself out in Fig. 2*c* as does the activity of 0711 UT; to be so strongly non-uniform it must be of local origin; and (3) it is of the correct sign, and order of magnitude, to be expected for the effect of an eclipse[2]. Several aspects inconsistent with a simple eclipse model should be pointed out, however: (1) the signal at 0638 UT is not of the same strength at stations H and J; (2) it has not moved from west to east at the known rate of the centre of eclipse totality on the ground; and (3) it starts gradually but ends abruptly.

Digitisation of the records obtained at the other stations will be undertaken and a more comprehensive report is planned.

We thank J. Styles for assistance with the field-work, and M. N. Sloane for assistance with the data reduction.

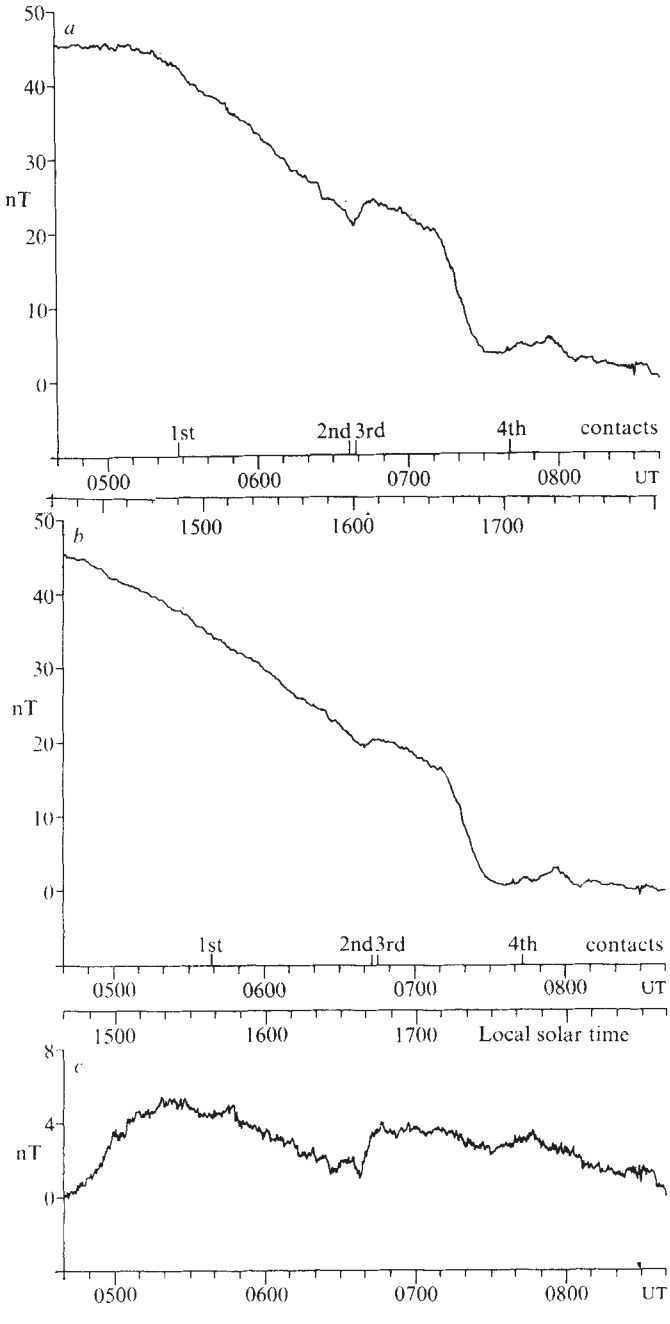
F. E. M. Lilley
D. V. Woods

Research School of Earth Sciences, Australian National University, Canberra, A.C.T., Australia

Received 21 December 1976; accepted 22 February 1977.

1 Chapman, S. *Terrest. Magn. Atmosph. Elec.* **38**, 175 (1933).
2 Matsushita, S. in Matsushita, S. & Campbell, W. H. *Physics of Geomagnetic Phenomena* 348 (Academic, New York, 1967).
3 Bomke, H. A. *et al. J. geophys. Res.* **72**, 5913 (1967).
4 Stening, R. J., Gupta, J. C. & van Beek, G. J. *Nature phys. Sci.* **230**, 22 (1971).
5 Lilley, F. E. M., Burden, F. R., Boyd, G. W. & Sloane, M. N. *J. Geomagn. Geoelectr.* **27**, 75 (1975).
6 Lilley, F. E. M. & Bennett, D. J. *Geophys. J.* **29**, 49 (1972).
7 Lilley, F. E. M. *Geophys. J.* **46**, 165 (1976).

Fig. 2 *a*, The declination record for site H. *b*, The declination record for site J. *c*, H-record minus J-record. All records are plotted relative to arbitrary zeros. Amplitude conversion factors are 6.4 nT per minute of arc for station H, and 6.8 nT per minute of arc for station J.



Magnetic superleaks

Two new natural materials which behave as superleaks to superfluid ^{4}He and also have magnetic properties are described here. In the search for magnetic superleaks the first choice was, obviously, a highly magnetic material such as a manufactured ferrite which has the advantage that its porosity is very uniform. We tested such a material but apparently not at a low enough temperature to be able to detect any onset point for the superfluid ^{4}He. The pores or gap distances must be extremely small[1]. Second, natural magnetic materials, among which the most obvious were different types of the so-called magnetites, were tested. Two magnetites of apparently quite different origin have been tested with superfluid ^{4}He. One from the south-east of Argentina, Province of Rio Negro about 41°S latitude and about 30 km from the Atlantic Ocean (sample A) and another of unknown origin taken at random from the Mining Department of the University of Delft (sample B). An X-ray diffraction analysis of these two samples gave the following components: For sample A, haematite (Fe_2O_3) (ferromagnetic), magnetite (Fe_3O_4) (ferrimagnetic), mica and garnet [$(Mg,Fe)_3Al_2(SiO_4)_3$] (paramagnetic) and for sample B, mainly magnetite (Fe_3O_4) (ferrimagnetic) and chlorite, a sheet silicate [$(Mg,Fe)_5AlSi_3O_{10}$](OH)$_8$ (paramagnetic). Both samples are anisotropic aggregates and the magnetic characteristics are given at room temperature.

The method already described[2] to determine the onset temperatures of superleaks was used. A carbon sensor as a detector of the superfluid rests on the surface of a flat superleak inside a cell. When the superfluid through the superleak finally reaches the sensor, a noticeable jump in its resistance value is noted. This method has the advantage