and those lying very near the planary surface will survive unaltered by the ejection process.

The orbits of the ejected bodies have relatively low eccentricities and inclinations and can exist, on average, between 5×10^6 and 100×10^6 years (depending on aphelion distance) before being hit by another minor body in the Solar System and broken up. Calculations show that of all the material that will hit the Earth from a specific martian event, 36 per cent will do so within 10^7 years. In the favoured small-body model, Wetherill suggests that the cosmic-ray exposure ages of the meteorites are equivalent to the transit time between Mars and Earth. The much longer isotopic age represents the time interval between the present day and the time of production of the specific region of Mars' surface that suffered the impact.

Similar calculations were made for Mercury ejector and it was found that 100 times fewer Mercury meteorites would finally hit the Earth.

What remains to be explained is the ratio between martian and lunar meteorites. The shergottite–nakhlite–chassignite class of meteorites represent 8 of the 2,000 distinct recovered stony meteorites. Only one certain lunar meteorite has been found, a 31 g rock found in the Allan Hills region of Antarctica and known as ALHA 81005. (There are two other 'possibles', both found by the Japanese near the Yamato Mountains in Antarctica.) Other things being equal, theory predicts that the influx of lunar meteorites will be at least several hundred times greater than that from Mars. By contrast, observations indicate that it is smaller by a factor of around 3. A possible explanation is that the orbital dynamics mitigates against lunar meteorites. More unlikely is the suggestion that it is due to a statistical quirk, there having been no large lunar cratering events for the last 10^5 years or more. Another possibility is that there is some special characteristic of the martian surface, the presence of volatiles for example, that facilitates the acceleration of impact-generated fragments to very high velocity.

Whatever the outcome, the importance of meteorites is obvious. The museums of the world contain about 200 tonnes of meteoritic material, of which 90 g are thought to come from the Moon, 70 kg from Mars and the rest from asteroids. Unfortunately, it seems that the only rigorous way of checking the martian origin is to go there and see. ☐

David W. Hughes is Senior Lecturer in Astronomy and Physics at the University of Sheffield, Sheffield S3 7RH.

Ecology

Forest history from pollen

from Peter D. Moore

POLLEN analysis has proved a useful tool for documenting vegetational changes over thousands of years. Carried out on a regional scale, with information collected from sites, such as large lakes and mires that have been carefully selected such that local vegetational events have little impact and local noise is minimal, the technique has supplied important information on climatic history[1]. To the ecologist, however, it is often the very local events that are of interest. Thus he will tend to choose small ponds, peat deposits and even organic humus layers accumulating on forest floors which receive their pollen input from the local vegetation canopy and in which regional changes in vegetation may be masked by the local flora. Such sites can provide a valuable record of local vegetational history and have recently been exploited for this purpose in many parts of the world.

Bradshaw has shown that in a forest, most pollen does not travel more than 20-30 m (ref.2), and recently, with the help of Jacobson, he has constructed a model relating the origin of pollen components to the diameter of the receptor site[3]. In a small 50 m diameter site, for example, 60–70 per cent of the pollen input is immediately local in origin.

The use of mor humus layers was pioneered in Denmark by Iversen[4,5], who found it a particularly useful technique for the detection of the impact of man on woodlands. His conclusion that *Ilex aquifolium*, holly, had been greatly favoured by man's modification of the Danish forests received further support from work on mor humus layers in the Netherlands by Stockmar[6]. This type of deposit has also proved useful for tracing the history of species that have limited powers of pollen dispersion and that are poorly represented in larger sites. Birks has shown that lime, *Tilia*, a tree which is known to have very local pollen deposition[7], has been abundant in Cumbrian limestone woodland in northwest Britain from about 6,000 years ago[8], while in southern England[9] and in Denmark[10], it declined following man's modification of the forests in AD 600–800 and AD 1650, respectively.

Outside the temperate zone of the Northern Hemisphere, relatively little advantage has been taken so far of the opportunities offered by small sites and mor humus layers. Recently, however, Macphail has done some important work in the wet sclerophyll forests of Tasmania. These forests are dominated by *Eucalyptus* species, often reaching heights of 30–40 m, with a high (20 m) shrub layer, consisting of many species, beneath the canopy. They are found in eastern and south western Australia. Their history is uncertain because of their apparent dependence on fire as a containing factor in succession: in the absence of fire, they may be subject to invasion by temperate rain forest trees. This dependence suggests that they may be a product of human activity and maintained by it.

Macphail has now approached this question by analysing the sediments of a small (8 × 18 m) kettle hole in Tasmanian wet *Eucalyptus* woodland[11]. The sediments have been buried by a landslip and date from the early Holocene (9,000 to 7,000 BP). The changes in the pollen stratigraphy of the site are associated mainly with a sequence of understorey species which can in part be explained in terms of climatic trends. Superimposed, however, is a pattern induced by fires, as indicated by charcoal frequency. A marked increase in fire frequency at about 7,200 BP is associated with Aboriginal activity in the area and this produced a distinct shift in the woodland composition in which the rain forest species, such as *Nothofagus*, which had previously been expanding, were set into decline. The involvement of fire and of man in the persistence of the wet sclerophyll forest is thus confirmed.

One further line of evidence is desirable if such studies are to be exploited to the full, namely the study of modern pollen rain in present-day forest types. In this way the varying properties of pollen production and dispersion in the trees and shrubs of the forest can be compensated for in the interpretation of fossil pollen spectra. Studies of this type in the European forests by Andersen[12] and Bradshaw[2] have proved very informative and one must look forward to the outcome of similar work on small sites in other parts of the world. ☐

1. Berglund, B.E. in *Background to Palaeohydrology: A Perspective* (ed. Gregory, K.J.) 237 (Academic, London, 1983).
2. Bradshaw, R.H.W. *J. Ecol.* **69**, 45 (1981).
3. Jacobson, G.L. & Bradshaw, R.H.W. *Quat. Res.* **16**, 80 (1981).
4. Iversen, J. *J. Ecol.* (Suppl.) **52**, 59 (1964).
5. Iversen, J. *Oikos* (Suppl.) **12**, 35 (1969).
6. Stockmar, J. *Palaeohistoria* **17**, 38 (1975).
7. Keatinge, T.H. *Grana* **21**, 171 (1982).
8. Birks, H.J.B. *New Phytol.* **90**, 339 (1982).
9. Baker, C.A., Moxey, P.A. & Oxford, P.M. *Field Stud.* **4**, 645 (1978).
10. Aaby, B. *Dansk. geol. Unders.* IIR, no. 114 (1983).
11. Macphail, M.K. *New Phytol.* **96**, 131 (1984).
12. Andersen, S. Th. *Dansk. geol. Unders.* IIR, no. 96 (1970).

Peter D. Moore is Reader in Ecology in the Department of Plant Sciences, University of London King's College, 68 Half Moon Lane, London SE24 9JF.

Erratum

IN the course of editing the News and Views article by Malcolm Walter on 'Biased record of early life', (*Nature* **309**, 512; 1984), an incorrect reference was introduced. The correct citation for ref.1 should have been to Hofmann. H.J. *J. Paleontol.* **50**, 1040 (1976) and not to Schopf, J.W. (ed.) *Earth's Earliest Biosphere: Its Origin and Evolution*, 543 (Princeton University Press, 1983).