NEWS AND VIEWS

Chemistry in Unfamiliar Places

SINCE the first lunar samples were returned by the flight of Apollo 11, it has been clear that the microchemistry of the lunar surface would turn out to be well worth the trouble of mastering the intricate techniques now being deployed in dozens of laboratories. The report on page 29 of this issue of the analysis of dust from the lunar surface for methane and other carbon compounds is a striking example of how revealing this work can be. What Cadogan *et al.* have done is to show that some of the carbon in their lunar material is in all probability present as methane. In all the circumstances, the amounts of this gas are quite considerable—a few parts per million by weight. As earlier investigations have shown, there is a positive correlation between the amount of methane in the dust and the total carbon content. On this occasion, it also turns out that the amounts of the various carbonaceous materials in the different samples are correlated with the degree of exposure to particle radiation as measured by the proportion of grains with ionization tracks in the outer skin of 100 Å or so. All this ties in neatly with the hypothesis that the samples most heavily laden with carbon are those which have been exposed for longest to the solar wind. The assumption is that carbon atoms are deposited individually at the points at which they are brought to rest in the crystal lattices on which they impinge. Given the likelihood that the solar wind will saturate the exposed dust on the lunar surface with atoms of hydrogen, 10,000 times as abundant as carbon atoms, it is not difficult to see how molecules of methane might arise from the products of the solar wind. The interest of the work now reported is that it has been possible to demonstrate that there is also methane, perhaps in concentrations very much smaller than in the dust, in the indigenous rocks on the surface of the Moon. Is this, as Cadogan *et al.* suggest, the remnant of the primordial gas from which the Moon was formed ? That, no doubt, is a question that will preoccupy lunar microchemists for a long time to come. This, luckily, is only part of an absorbing problem.

The flux of hydrogen atoms in the solar wind is probably about 10^8 per square centimetre per second at the surface of the Moon and the flux of carbon atoms is probably 10^4 per square centimetre per second. What this implies is that the deposition of carbon is such that six micrograms of carbon would be deposited on each square centimetre in a million years. If the inference of Cadogan *et al.* and that of similar groups elsewhere is more or less correct, the concentrations of carbon found in the lunar dust imply that the surface material has been exposed for periods of time of the order of a thousand years or more. At the same time, it is clear that the accumulation of carbon is not so great that the dust must be thought to have been exposed for millions of years. In other words, what Cadogan *et al.* have to say about methane fits in well with other observations of the properties of the lunar surface and in particular with the evidence that the surface material in the dusty areas is frequently turned over—the garden effect, as it is called.

Where does the rest of the carbon from the solar wind reside ? A treatment of this lunar dust with acids suggests that carbon atoms embedded in crystal lattices are for practical purposes the functional groups of carbides. Much of the interest in the years ahead will turn around questions such as the rate at which such carbon atoms are converted into methane groups by reaction with hydrogen. There are echoes here of the kind of chemistry now familiar in some parts of solid state physics—the effects of radiation damage, for example. But the new observations of methane and carbon in lunar dust, like earlier analyses of the isotopic composition of materials in the lunar surface, suggest important new avenues of investigation of the interaction between particles in the solar wind and the materials of which the surface is made. For one thing, the outer parts of grains of lunar dust must be eroded away by the continuing bombardment of charged particles. For another, there must be nuclear reactions between the particles of the solar wind and the atomic nuclei of the lunar material, and there will be great interest in the way in which the new observations of the lunar fines suggest that the heavier isotopes of carbon—and of sulphur, oxygen and silicon—are enriched in the lunar surface by means of what are called stripping reactions. What happens is that the lighter isotopes are preferentially removed by conversion to volatile compounds. But differentiation among the isotopes also occurs by the fractionation of repeated absorption and evaporation. To be sure, nothing in the new observations is quite as spectacular as the way in which the isotope argon-40 appears to be enriched in all kinds of materials on the lunar surface by the absorption of large quantities of the isotope released by radioactivity near the surface of the Moon in the accumulation of dust actually on the surface, but that has been a special case ever since the study of lunar samples began.

What does all this imply ? To begin with, there is plainly a rich harvest to be won from further study of the microchemistry of the lunar surface. This in turn may yield a better understanding of the comparatively recent history of the lunar surface than can be obtained by other methods. In this connexion, it is especially important that the microquantities of compounds or isotopes which have now become detectable can serve as tracers to distinguish between, say, older and more recent material on the surface. But in the long run, there is also a chance that studies of the kind that have now been mounted may help to throw light on a quite different class of recent problems—that of accounting for the occurrence of comparatively exotic chemicals in interstellar space. These too are situations in which chemical compounds appear to be formed out of unlikely combinations of atoms in unlikely circumstances.