ments on returned Apollo 11 material. Moreover, the distance–travel time curves for the laboratory samples up to pressures equivalent to a depth of 20 km in the Moon (the limit of refraction for seismic waves from LM and S–IVB) had no sharp changes in slope, a property with which the spot body wave data from Latham's experiment are consistent. In other words, the limited evidence suggests that the distance–time curves for the upper 20 km of the Moon are also smooth up to about 6 km s^{-1}, which must mean that within that distance there is no major lunar boundary.

The other important result obtained by Latham *et al.* is confirmation that lunar signals have extremely long decay times—about an hour for LM and more than four hours for S–IVB. A comparable signal on Earth would die away in a few minutes. This suggests that lunar material has a Q (quality) factor as high as 3,000 (compared with 10–300 for the Earth's crust), possibly because of the lack of fluids in the Moon's outer shell. It seems likely, however, that other causes of the long reverberation times are also required. The two possibilities suggested are dispersion of the seismic waves, by which coherent waves propagate at different group velocities depending on their wavelength, or scattering, by which the path lengths of the waves are effectively increased by repeated reflexions at acoustic discontinuities.

Dispersion of surface waves requires the presence of a surface layer with a low velocity, which has been shown to exist. Scattering, on the other hand, implies the presence of heterogeneities in the outer shell of the Moon on a scale ranging from a few hundreds of metres to several kilometres, although surface irregularities may also be important. The existence of such heterogeneities has not been proved directly; but in view of the age of the Moon, the likely effects of meteoroid bombardment and the known low viscosity and high thermal expansion coefficient of at least some of the lunar material, such irregularities are not unlikely. At present it is quite impossible to decide between dispersion and scattering.

Latham's approach to the interior of the Moon is essentially experimental. Turcotte and Oxburgh (*J. Geophys. Res.*, **75**, 6549; 1970), on the other hand, take a more theoretical and speculative view. Their object is simply to deduce whether or not convection, such as that which is thought to take place in the Earth's mantle, can occur in the Moon. The difficulty is, of course, that convection probably depends on the heat produced by radioactive decay; and because the distribution of radioactive elements within the Earth is still a matter of disagreement, it is not very easy to make a reliable assessment of concentrations of lunar radioactivity.

Not to be deterred by this, however, Turcotte and Oxburgh have calculated the uniform mantle concentration of radioactive elements which would produce the Earth's observed surface heat flow and then proceed to apply this figure to the Moon as a whole. They then use a reasonable theoretical model to show that under these conditions—that is, with an undifferentiated Moon—convection can occur even within a Moon having a thick rigid outer shell.

The problem is, of course, that the Moon cannot now be completely undifferentiated—the concentrations of radioactive minerals in the Apollo 11 rocks are almost certainly too high to be typical of the Moon as a whole. The question thus arises: is convection still going on in the Moon or has differentiation proceeded far enough to stop it? This, Turcotte and Oxburgh are not prepared to answer. According to their model, convective velocities would have to be two orders of magnitude higher than those in the Earth's mantle; and thus lunar differentiation would be complete in a few billion years. But it is difficult to tell what stage the process has reached.

ORIGIN OF LIFE

Chemical Evolution

from a Correspondent

THE chemical origin and early evolution of life was the theme of a timely Nobel workshop at the Botanical Institute, University of Stockholm, on December 7 and 8, 1970. The timeliness results from recent publications and theories propounded by the four eminent speakers who delivered the invited public lectures which preceded round-table discussions.

Dr C. Ponnamperuma (NASA, Ames) introduced the subject with a survey of the geochemical history of the Earth and the theories advanced to account for the origin of life, culminating in the classic writings of Oparin (1924) and Haldane (1928) which set the stage for all modern research on primordial organic chemistry. The range of compounds which can be synthesized under simulated conditions of the primaeval Earth, using varying sources of energy, is impressive—these include, for example, most of the proteinoid amino-acids, simple peptides,

Interstellar Silicate Extinction

THE demonstration by D. R. Huffman and J. L. Stapp in next Monday's issue of *Nature Physical Science* (**229**, 45; 1971) that the predominant feature in the ultraviolet region of the interstellar extinction curve, the peak near 2200 Å, could be an indicator of a silicate component of the interstellar grains rather than the "signature of graphite" should be a timely reminder to others searching for the chemical identification of the grains. The absence until now of an alternative identification can be traced chiefly to the lack of knowledge of the complex optical constants, over a wide spectral range, of commonly occurring materials. (Both the refractive index and the absorption coefficient are needed to carry out extinction calculations in which scattering and true absorption are included.) Extensive and precise spectral observations in the ultraviolet and in the infrared promise progress towards a unique identification; present indicators, such as the shape of the interstellar extinction curve, are too ambiguous, placing only rather broad limits on particle sizes and refractive indices. These opportunities will be largely wasted, however, unless sufficient research on the optical constants is carried out.

The 2200 Å feature is related to the lack of fundamental data. Following the discovery of this peak by T. P. Stecher in 1965 (*Astrophys. J.*, **142**, 1683) using rocket-borne detectors, Stecher and B. Donn noted (*Astrophys. J.*, **142**, 1681; 1965) that graphite had optical constants which could reproduce this detail in the extinction curve. Subsequent rocket flights and observations from the Orbiting Astronomical Observatory have confirmed the existence of the feature and, in addition, have defined its wavelength more precisely. K. Nandy and H. Seddon (*Nature*, **226**, 63; 1971) have found from the most recent evidence that the match of the observed and predicted peaks is not good, the difference being outside the present errors of observation. Nevertheless, since 1965 considerable importance has been attached to the original identification and the feature has been accepted as the "signature of graphite". It should be pointed out, however, that in 1965 graphite was already a candidate for the grain material; theoretical arguments had suggested the possibility of condensing graphite particles in the cool atmospheres of relatively carbon-rich stars. The confirmation of the ultraviolet peak was therefore important.

Huffman and Strapp have now shown that silicates can also produce this peak. Their interest in the silicates was prompted by other spectral evidence in the infrared (where optical constants are again needed) and by theoretical calculations of the condensation of silicates in cool stellar atmospheres. They had to measure the complex optical constants, as none previously had been determined. Further laboratory observations of many materials in the infrared and ultraviolet will be needed to strengthen this identification and to determine whether it is unique. It is to be hoped that this work by Huffman and Strapp will stimulate greater efforts to determine the optical constants of the wide variety of materials.