non-insectan arthropods of the Palaeozoic. The most spectacular of these were the 6-foot long arthropleurids of the Carboniferous of Euramerica, which seem to have lived within the leaf litter, splitting it apart with their flattened heads and bodies—and their gut contents suggest that they fed on lycopod material. The Palaeozoic mites seem to be related to living forms which feed on fungi.

The biology of Upper Palaeozoic insects was discussed by R. J. Wootton (University of Exeter). Insects were almost unknown before the Upper Carboniferous and, even then, knowledge of them is almost exclusively limited to the Euramerica coal swamp fauna. The modern herbivorous groups of insect were almost unknown in the Palaeozoic and holometaboly, which enables totally different adaptations of larva and adult, did not appear until the Permian. Such forms as *Stenodictya* may have been a sap sucker or have picked up spores from sporangia.

Finally, two contributors dealt specifically with the theme of this symposium. W. G. Chaloner (Birkbeck College, London) produced some possible (if contentious) examples of possible plant-animal interaction. These included some plants from the Rhynie Chert which appear to have been damaged during life, and the strong coats of some Devonian spores which may have been adjusted to resist chewing or digestion. P. D. W. Barnard (University of Reading) categorised the ways in which animals could have used plants as food, and the types of evidence of this activity that might have survived. The instances that he had been able to gather together, however, were few. Plumstead has described leaves of *Glossopteris* with ragged edges which could well have been caused by browsing arthropods. Holes in the seeds of *Samaropsis* have been described by Sharon, and Barnard himself has described holes in the nut-like megaspore of *Trigonocarpus*; both of these could well have been due to attack by insects. Finally, some coprolites contain spores, and a specimen of the reptile *Protorosaurus* contains conifer seeds in its abdominal region.

Despite Barnard's best efforts, one's prevailing impression of the symposium was of a production of Hamlet in which the Prince made only fleeting appearances, and indeed there seems little chance of any great variety of unequivocal evidence of the interaction between Palaeozoic plants and arthropods. The meeting also served to demonstrate what a high proportion of knowledge of Carboniferous life is derived from one single (and possibly unusual) environment—the swamplands of Euramerica.

Why do pions eject 'alpha particles' from nuclei?

from Peter E. Hodgson
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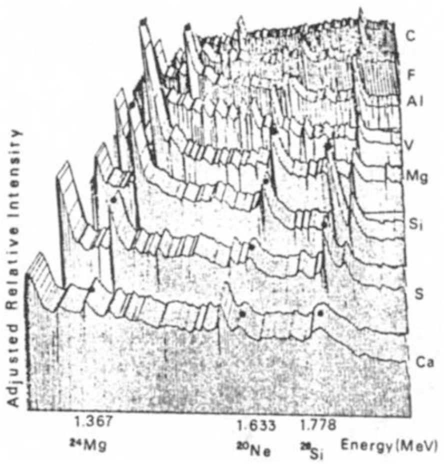
SEVERAL recent investigations have shown that when slow pions or kaons are captured by nuclei, the particles emitted promptly are very often such that the residual nucleus is an excited state of the target less one, two or more α particles or the equivalent numbers of neutrons and protons. The most plausible explanation is that somehow the pions or kaons eject α particles but this has not yet been established because the residual nucleus is identified only by the γ rays it emits, and the particles emitted previously are not detected.

A further important result has been obtained by V. G. Lind and colleagues working in the United States (*Phys. Rev. Lett.*, **32**, 479; 1974), who looked at the results of interactions of fast negative pions (220 MeV) with a range of light nuclei from carbon to vanadium. It is very difficult to detect directly the particles emitted from these intersections so, as in the previous work, the prompt γ rays were studied instead. These are emitted immediately after the particles resulting from the initial interaction. Some of the γ-ray spectra are shown in the figure, and it is notable that there are several peaks common to the spectra from different nuclei.

The energies of these γ rays identify the nucleus from which they were emitted, and it is then found that in the case of even–even targets the most likely residual nuclei correspond to removing one, two or several α particles (or the equivalent numbers of nucleons) from the target. In the case of the odd-*A* nuclei the γ rays correspond to the removal of a triton or an α particle or a triton plus an α particle from the target nucleus. The cross sections for these processes are comparable to the inelastic scattering cross sections. It is found that the proportion of multiple emissions of α particles compared with single emissions increases with nuclear size.



Some of the prompt γ-ray spectra emitted after interaction of 220 MeV negative pions with a range of nuclei. The lines marked with a solid dot appear in many spectra and correspond to the multiple removal of α particles.

The experimental technique does not distinguish between the emission of an α particle and the emission of two neutrons and two protons, since only the residual nucleus is identified. The relative likelihood of the two processes, and indeed of all possible processes and hence residual nuclei, can be calculated from statistical theory. It is found that this gives results completely different from those found experimentally so that multiple 'α' emission cannot be explained by the statistical theory.

These results have now been confirmed by studies of the interactions of both positive and negative pions with ^{27}Al and ^{28}Si by Ashery and colleagues (*Phys. Rev. Lett.*, **32**, 943; 1974) from Tel Aviv. The negative pions had an energy of 70 MeV and the positive pions energies of 25, 70 and 100 MeV.

Using essentially the same method as the United States group, they also found that there is a large cross section for removing an 'α particle' and leaving the nucleus in its first excited state. This occurs even below 25 MeV, which is the threshold for the emission of two protons and two neutrons, and this strongly supports the hypothesis of cluster emission.

It is found that at 70 MeV the cross section for 'α' emission is very similar to that for the elastic scattering of pions by free α particles, thus suggesting that the pions are simply knocking out pre-existing α particles from the target nuclei. Substantial cross sections are also found for reactions corresponding to the emission of deuteron clusters.

These experiments on the interaction of fast pions with nuclei thus give results similar to those found in studies of the interaction of slow pions or kaons. There seems to be some process that takes place in the initial stages of the interaction that leads to the preferential emission of α particles. This in turn suggests that there are α particles in the nuclear surface, a hypothesis for which there is already much evidence.

It is important to continue this work, and in particular to try to detect and identify directly the particles emitted in the early stages of the interaction. This is a difficult experimental problem but if it can be solved it will shed new light on the problem of α particles on the nuclear surface.