NUCLEAR PHYSICS

Symmetric Fission

THE continuing competition to produce new nuclear species is providing more material for studies of the properties of fissioning nuclei, even though the pace in this branch of nuclear research is perceptibly slower than in the 1940s. Elements up to 104 or maybe 105 have been synthesized and there is talk that element 112 may have been produced (Marinov *et al.*, *Nature*, **229**, 464; 1971). In 1963 it was noted in studies of spontaneous fission of artificially synthesized elements that the average mass of the heaviest fragment remained constant at $A = 142 \pm 1$, while the mass of the light fragment increased when a range of nuclei from curium 248 (${}_{96}\mathrm{Cm}^{248}$) to fermium 254 (${}_{100}\mathrm{Fm}^{254}$) was considered (R. Brandt *et al.*, *Phys. Rev.*, **131**, 2617; 1963). If this trend were to continue a truly symmetric fission would not be obtained until the nuclear mass approached $A = 284$. There has been speculation, however, that symmetry would be obtained at some lower mass where the characteristic strong binding energy associated with the nuclear magic numbers 50 and 82 manifests itself. Briefly, this arises from the fact that some nuclei with certain numbers of neutrons and protons are particularly stable. These are found experimentally to be 2, 8, 20, 28, 50, 82, and 126. A nucleus which has a magic number of neutrons and of protons, but not necessarily the same number, is termed doubly magic and is an even more energetically bound species. The values of the magic numbers are understood theoretically in terms of a neutron or proton moving in an average potential well formed by the other particles in the nucleus with the inclusion of a strong spin-orbit interaction. The resulting solution which gives the quantum levels of the particle in the potential well has well defined energy gaps at the magic numbers.

The fission fragments should therefore show some trend towards symmetry as the fissioning nucleus approaches ${}_{100}\mathrm{Fm}^{264}$, which is composed of exactly two tin 132 (${}_{50}\mathrm{Sn}^{132}$) nuclei, a particular isotope of tin that has a doubly magic structure. Such a trend has now been reported by a group from Los Alamos (J. P. Balagna *et al.*, *Phys. Rev. Lett.*, **26**, 145; 1971). They have studied the spontaneous fission of ${}_{100}\mathrm{Fm}^{257}$ and observe a much greater degree of mass symmetry than for ${}_{98}\mathrm{Cf}^{252}$ and ${}_{98}\mathrm{Cf}^{254}$ which they also studied.

The results from Los Alamos constitute the first piece of evidence for symmetric fission in this mass region. There is one fact, however, that makes the generalization of this result a dubious matter. The isotope ${}_{100}\mathrm{Fm}^{257}$ has an odd number of neutrons, so the properties of the fission are affected by the angular momentum and parity of the nucleus which is different from nuclei which have an even number of neutrons and protons.

The fission of one other nucleus with an odd number of particles has been studied in this mass region, einsteinium 253 (${}_{99}\mathrm{Es}^{253}$), and the results obtained for this nucleus are consistent with those of its neighbours which have an even number of neutrons and protons. This, of course, does not imply that the fission of ${}_{100}\mathrm{Fm}^{257}$ is characteristic of its neighbours. A much better test, as suggested by the Los Alamos group, would be to study the spontaneous fission of some other heavy nucleus such as ${}_{100}\mathrm{Fm}^{256}$ or mendelevium 258 (${}_{101}\mathrm{Md}^{258}$), or any heavier nucleus that may be available.

OCEAN FLOORS

More Nodules

from our Geomagnetism Correspondent

MANGANESE is not a particularly abundant element in the Earth, either within the crust or, if chondritic meteorites are any guide, within the deep interior. On average it forms only about 0.1 per cent of igneous rocks, compared with several per cent of iron; and because the manganese in oceanic sediments is ultimately derived from continental igneous rocks, concentrations there are not much different. All of which accounts for the great interest aroused by the discovery of manganese-rich nodules and slabs on the ocean floor. A typical nodule contains between 6 and 24 per cent manganese, about the same concentration as iron. Clearly, such nodules cannot be derived from continents unless some remarkable concentration process has occurred. Their origin is not actually known, though because of a close association with volcanic rocks it is likely that the manganese-rich material was derived from lava as it extruded into the seawater.

Not surprisingly, manganese nodules and slabs have often been viewed in economic terms. But there is one snag. Most deposits lie at depths of 18,000–20,000 feet or more and far from land—a situation guaranteed to turn businessmen, economists and mineral prospectors off. But deposits newly discovered in the Kauai Channel, Hawaii, by Maury Morgenstein of the University of Hawaii are likely to make an altogether different economic story. For manganese nodules and crusts have been found at depths of only 5,000–8,000 feet and lying only 5–8 miles offshore. Moreover, they cover at least an area of 150 square miles to a thickness of over 10 inches in places. In short, Morgenstein has discovered an economically important reserve which is relatively easy to get at and which is likely to have a profound effect on Hawaii's economy in the longer term.

In fact, the story may not end there. It is possible, of course, that Morgenstein has by accident hit on the only manganese deposits in the area. On the other hand, in the vicinity of Hawaii there is a total of 3,750 square miles of shallow seafloor with the same geological conditions as the Kauai Channel, all within ten miles of land.

London Ash Revealed in Harwich

NATURE is full of mysteries; but few are so mysterious as those which science could in principle have solved at any time during the past hundred years or so but did not. Nobody would pretend that the minor mystery unearthed and solved by G. F. Elliott, of the British Museum (Natural History), and reported in next Monday's *Nature Physical Science*, is likely to change the face of geology. But all the same Elliott must have obtained a peculiar satisfaction from it; and for that he can be envied.

The problem which Elliott has solved is the relationship between the so-called London Clay of southern England and the similar deposits in continental Europe. The continental clay is marked by a thin ash layer near the base; but, in spite of the many petrological studies, no comparable layer has ever been discovered in England. As a result some geologists have suggested that the ash fall never in fact reached England and others have taken the view that the two clay deposits were not at the same period of time.

It turns out that neither of these two assumptions are necessary. The London Clay which is exposed on the foreshore at Harwich contains a conspicuous stone band near its base. Indeed, this band has been known for more than two centuries, for in 1730 one Dale described it and noted that Harwich was paved with it. Elliott's studies now reveal that the missing ash is contained in this very stone band. Preliminary petrological examination of the ash suggests that it is very similar to that reported from the so-called London Clay in Denmark. It seems therefore that the English and continental ash layers are, after all, contemporaneous. The mystery is laid to rest. The English ash contains angular brown glass shards, some of which are streaky and resemble pumice, crystal fragments (often plagioclase) and lithic fragments full of opaque granules and containing minute, elongate feldspar crystals.