GEOPHYSICS

Mantle Plumes Get Cool Reception

"I DON'T believe them either, Harold," was how Professor Keith Runcorn comforted an incredulous Sir Harold Jeffreys at last week's meeting of the Royal Astronomical Society devoted to mantle plumes. Their scepticism was endorsed by almost all the attendance. The consensus was that there is little evidence for any of the mantle plumes which have been postulated to account for geological features on various parts of the Earth's surface, with the possible exception of the plumes held responsible for the Hawaiian islands and chains of seamounts in the Pacific.

Only one of the participants was more venturesome. Dr N. Petersen (Institute of Applied Geophysics, Munich) described work carried out with colleagues at Princeton University (see R. A. Duncan, N. Petersen and R. B. Hargraves, *Nature*, **239**, 82; 1972) as a result of which they identify two plumes at work on the European plate. The basic notion is of course that there are hotspots in the mantle which give rise to volcanic effects on the Earth's surface as the lithosphere moves over them, and it is an essential part of the hypothesis that the hotspots are comparatively narrow convection plumes. Apart from being a convenient way of accounting for the chains of volcanic features that litter the Earth's surface, these mantle plumes could conceivably initiate rifting and provide a mechanism for driving the plates. And if the hotspots can be considered fixed in the mantle—a qualification that may be difficult to sustain—then it ought to be possible to chart the movement of the plates by following the paths of the plume traces.

The two volcanic chains in the European plate which Dr Petersen and his colleagues suggest may be plume traces run in one case from the western part of the Eifel region in Germany through central Germany and Czechoslovakia to volcanic areas near Wroclaw in Poland, and in the other case from Iceland to the Faeroe Islands, the islands of the west coast of Scotland, the Antrim plateau and the Mourne mountains of Ireland. The youngest ends of the two traces are at Iceland and the Eifel region, and Dr Petersen and his colleagues claim that the motions of the European plate deduced from each trace are consistent.

Criticism of this work centred on the Iceland plume, possibly because a decreasing age of the igneous activity from east to west in the central European chain is demonstrated only when the times of the most abundant and intense eruptions are considered. When the total duration of activity at volcanic centres along the chain is examined the evidence for a migration of activity along the chain looks much less secure.

The chief point was that the evidence for migration of the Iceland plume along the section from the Mourne mountains to the Faeroes depends heavily on ages for the Mourne mountains and Antrim plateau which have recently been revised downwards so that they more nearly match the ages of Arran, Mull, Ardnamurchan, Skye, St Kilda and the Faeroes. This age problem becomes more serious if the island of Lundy in the Bristol Channel is considered to be the end point of the chain. There is also the problem of explaining several igneous regions further out in the Atlantic such as Rockall which are well away from the postulated trace.

Dr Petersen's reply was to admit that the age relationships are not as good as he would have liked, but he continued to remain faithful to the Faeroes–Iceland sector of the Iceland plume and to the central European plume.

Having devoured Dr Petersen, the meeting turned to a consideration of how the required hotspots might arise. Professor B. A. Bolt (University of California, Berkeley) described how seismologists are beginning to be able to study the nature of the boundary between the mantle and the core, the interest here being the possibility mentioned earlier in the meeting by Professor R. Hide (Meteorological Office) that bumps on the boundary could give rise to localized convective motions. Professor J. A. Jacobs (University of Alberta) described recordings by arrays of seismometers in Canada of earthquakes in the Tonga arc, the recordings suggesting the presence of inhomogeneities in the mantle beneath the Hawaiian islands. But Professor Runcorn (University of Newcastle upon Tyne) argued that the convection pattern from a hotspot on the boundary between the mantle and the core would not remain narrow but would spread out well before it reaches the surface. He felt that many people were imagining mantle plumes to be analogous to the narrow plumes of smoke which can develop in the atmosphere, whereas in fact the atmosphere is not a good model for behaviour in the mantle.

All the same, the meeting seemed prepared to concede that some kind of hotspot is responsible for the Hawaiian chain, even though there seems to be no firm evidence of mantle plumes at work on continental plates. But Professor D. L. Turcotte (Cornell University) cast doubt even on that. He suggested that the Hawaiian islands may be explicable in terms of a tensional fracture propagating in the lithosphere, causing volcanic activity as it migrates. The meeting on mantle plumes ended with Professor Jacobs's comment "We may be worrying about something that doesn't exist".

From Quantum Crystals to Neutron Stars

IT is now generally accepted that pulsars —or at least most pulsars—are rotating magnetic neutron stars. It is therefore of interest to study the structure of neutron stars, and this raises problems in several completely different fields of physics. First of all, nuclear physics should ideally provide an equation of state, but nuclear forces are as yet not understood with sufficient accuracy to lead to a really reliable equation of state. Second, elementary particle physics should reveal something about the state of matter at densities which are so high that apart from neutrons, protons and electrons, other particles such as hyperons will appear. Again present knowledge about elementary particles is still far from complete, so that part of the theory of neutron star interiors is still chiefly a speculation. Finally, there are several problems which fall in what is broadly called solid state physics.

In early studies of the interior or neutron stars it was generally assumed that it would be a fluid—which might be both superfluid and superconducting. Recently several authors have suggested that the interior of a neutron star may be solid. One such calculation is reported by Canuto and Chitre in *Nature Physical Science* next Monday (May 28). These authors apply a method, successfully used in describing quantum crystals such as ^3He and ^4He, and find that for densities above about 1.5×10^{15} g cm^{-3} the stable configuration is a face-centred cubic one in which the neutron spins show an "antiferromagnetic" ordering.

It is interesting to note that there is possibly some observational evidence in favour of a solid core. This evidence is provided by so-called glitches, the speedups of the Crab and the Vela pulsars, and the subsequent healing. These glitches have been explained in terms of star-quakes in which the interior of the neutron stars adjusts itself to the lower rotational velocity. Calculations by Pines, Shaham, and Ruderman (*Nature*, **237**, 83; 1972) have shown that to explain the magnitude and the frequency of the Vela glitches, it seems necessary to assume the existence of a solid core; this lends some degree of credibility to the results of calculations such as the one reported by Canuto and Chitre.