Several speakers dealt with the role of wave phenomena, their generation and their relation to particle precipitation. Both micropulsations (fluctuations in magnetic field strength in the frequency range 0.1 to 1 Hz) and very low frequency electromagnetic waves in mid-latitude seem to be equatorially generated and observations generally seem to support wave growth associated with anisotropy in the particle pitch angle distribution as suggested by Kennel and Petschek. High latitude v.l.f. emissions, however, occur on open field lines in longitudinal zones which seem to be related to the plasma sheet in the magnetospheric tail and to the neutral points on the solar side. A possible mechanism may be Čerenkov radiation from particles entering the polar ionosphere with velocity greater than the local phase velocity of the electromagnetic waves.

CHANDLER WOBBLE

## Earthquake Correlations

from our Geomagnetism Correspondent

THE origin of the Chandler wobble, the precession of the Earth's axis of figure about its axis of rotation, has taxed the ingenuity of scientists ever since the phenomenon was discovered in 1891. But very little real progress has been made during the intervening eighty years. The most recent suggestion is that the random oscillations are maintained by the energy from earthquakes. Mansinha and Smylie (*J. Geophys. Res.*, **72**, 4731; 1967), for example, showed that very large earthquakes (magnitude greater than 7.5) correlate quite well with sudden changes in the centre of wobble during the period 1957–1967; and they took this to be an indication of a physical connexion between Chandler wobble and earthquakes. Hopes of this faded somewhat, however, when Ben-Menahem and Israel (*Geophys. J.*, **19**, 367; 1970) claimed that although, under favourable conditions, a single earthquake of magnitude 8.5 could maintain the Chandler wobble for about a year, all the real earthquakes taken together could only account for about 30 per cent of the observed wobble amplitude.

New evidence from Myerson (*J. Geophys. Res.*, **75**, 6612; 1970) has now modified the area of disagreement considerably by reaffirming the wobble–earthquake correlation (albeit in a different form), but at the same time suggesting that there may not, after all, be a direct causal connexion between the two phenomena. What Myerson has attempted is not a correlation between specific polar breaks and specific earthquakes, but a more general correlation between yearly means of the Chandler amplitude and yearly earthquake counts since about the beginning of the century. His technique is, of course, statistical; but—to cut a long development short—Myerson treats the build-up of Chandler wobble as a random walk problem on the assumption that the excitation is by sudden, random breaks in the centre of wobble. Such breaks could, of course, be caused by earthquakes; but there is nothing in Myerson's development which presupposes this to be so.

What emerges at the other end is a good correlation between a function of the Chandler amplitude (actually the rate of change in the Chandler amplitude squared) and the yearly count of earthquakes with magnitudes greater than 7.0. There is thus no doubt that earthquakes are associated with wobble excitation. Indeed, this demonstration is more convincing than Mansinha and Smylie's simply because it is more general. There is, on the other hand, a very poor correlation between the same function of Chandler amplitude and yearly counts of earthquakes with Richter magnitudes greater than 7.5. Clearly therefore the relationship between earthquakes and wobble cannot be a simple cause and effect.

But finally, and perhaps most significantly, Myerson demonstrates a good correlation between the function of Chandler amplitude and the yearly count of deep and intermediate earthquakes (magnitude greater than 7.0, depth greater than 70 km). This is likely to be a clue to the whole affair. It suggests that there may well be a deeper mechanism which both triggers earthquakes and maintains the Chandler wobble.

TRIBOLOGY

## Interacting Surfaces

from a Correspondent

TRIBOLOGY, the study of the interactions between surfaces in relative motion, has become an international subject of great interest to chemists, physicists, and metallurgists, as well as to the mechanical engineers who started it all. This was evident from the wide-ranging interests and nationalities of more than a hundred participants at a conference on the chemistry of bearing surfaces held in the Swansea Tribology Centre on January 5 and 6.

In his introductory address, Dr D. Tabor (University of Cambridge), reviewing the present "state of the art" in tribology, pointed out that wear, which is more important than friction, can only take place when actual contact occurs between the sliding surfaces. The role of a lubricant, whether it be a gas or a liquid, is to prevent this contact. What happens when contact does occur ? This

## Do Earthquakes depend on Rock Type ?

FROM an analysis of the worldwide distribution of earthquakes, Scholz (*Nature*, **221**, 165; 1969) concluded recently that although high differential motion is a necessary condition for the occurrence of earthquakes, it is not sufficient in itself. His argument was that there are many places in the world where the deviatoric stresses directly responsible for earthquakes are present but where no seismic activity results. In California, for example, no earthquakes have been observed below about 20 km and yet the necessary stresses must exist below this depth. Indeed, almost all seismic energy is released in the crust. To be sure, intermediate and deep earthquakes do occur; but they are almost always concentrated in narrow planar zones which dip at angles of about 45° below island arcs. It is clear that much of the mantle flows aseismically.

What, then, is the basic difference between the seismic and aseismic stressed regions which makes them one or the other? According to Scholz, seismic activity only occurs generally where the rocks are relatively acidic—a suggestion which seems to agree pretty well with both terrestrial and laboratory data. It has been found experimentally, for example, that the ease with which plastic flow occurs increases with decreasing silica content—that is, with decreasing acidity. And it is a fact that the primary difference between crustal and mantle materials is the smaller proportion of silica in the latter. Scholz's hypothesis thus seems to be in general accord with what is known of the Earth's composition.

In next Monday's *Nature Physical Science*, T. Hatherton offers more specific evidence for the validity of Scholz's idea with data from New Zealand and the adjoining Tonga and Kermadec island arcs. It is a particularly convenient region to choose because of the contrasts involved. In the Tonga and Kermadec areas the axis of the arc neatly separates the oceanic crust to the east and the continental-type crust to the west. In accordance with Scholz's hypothesis it also neatly separates the seismic from the aseismic region. And if this were not evidence enough, in the New Zealand area where continental crust occurs on each side of the arc axis, so do the shallow earthquakes. The point is, of course, that plate tectonic theory implies that the deviatoric stresses in the lithosphere are symmetrical about island arc axes. Hatherton demonstrates that this symmetry only applies to earthquakes when all the rocks concerned are acidic.