SEISMOLOGY

Nocturnal Earthquakes

from our Geomagnetism Correspondent

THE suggestion that seismic activity fluctuates with the seasons or the time of day has been made on numerous occasions in the past; but as Bullen (*Introduction to the Theory of Seismology*, Cambridge University Press; 1963) pointed out some years ago, claims for such periodicities have never been substantiated. Not, that is, until last year when Shimshoni (*Geophys. J.*, **24**, 97; 1971) produced evidence which seemed to show that seismic activity is significantly higher during the night than during the day. At first sight such a correlation appears inherently unlikely, except that it is never possible to ignore completely the idea of trigger forces. In other words, although there can be no suggestion that minor forces, such as, for example, temperature effects, tidal effects and abnormal changes in barometric pressure, produce the elastic strain which is ultimately released in earthquakes, it is just conceivable that minor forces act as the "last straw" (Bullen) leading to the actual release of strain.

But whatever the cause may be, a correlation is a correlation; and that is just what Shimshoni seemed to have from a statistical analysis of the 15,325 seismic events reported by the US National Oceanic and Atmospheric Administration for 1968 to 1970. If seismic events occur randomly with local time throughout the twenty-four hour period, the number of events within each hourly period over the three years should be 638.5 (that is, 15,325/24). In practice, however, χ^2 for the randomness hypothesis turned out to be 80.1137, the probability of obtaining a figure as high as this for a truly random process being less than 10^{-7} . Shimshoni thus concluded that seismic events do not occur randomly throughout the twenty-four hours, and went on to show that within the daily cycle there is a peak of seismic activity around midnight and a minimum around noon.

Three authors or groups of authors have now descended upon Shimshoni to point out that, although there may indeed be a correlation of the sort he demonstrates, it represents a data deficiency rather than a real variation in seismicity. Davies (*Geophys. J.*, **28**, 305; 1972), for example, notes that the number of earthquakes recorded over any given period of time will reflect not only the number of earthquakes actually occurring over that period, but also the detection capability of the recording network, and that it is the latter which varies between night and day.

To see how this effect works, he considers an earthquake occurring on the equator at the equinox. The location of

such an event will be determined from observations made within epicentral distances of 100° ; and so if the shock occurs at midday it will be observed (P waves) at most of the relevant stations in daylight, and if it occurs at midnight it will mostly be observed in darkness. Seismic background noise—most of it probably local cultural noise—correlates strongly with light and dark, however, the detection threshold at many stations being significantly higher during the day. According to Davies, it is possible to observe at many stations a dawn noise level rise of 10 to 20 db.

The result of all this is that more of the earthquakes occurring at night will actually be detected—a circumstance which is bound to bias the data in any published list of earthquakes. On the other hand, this situation will not obtain for events occurring far from the equator. At high latitudes, P waves from midnight earthquakes will be observed at many stations during daylight. Under these circumstances no day/night correlation would be expected; nor is it found. Events occurring at middle and lower latitude will, however, be sufficient to give an overall bias.

Flinn *et al.* (*Geophys. J.*, **28**, 307; 1972) raise the same basic objection as Davies, but they also present data to make explicit the point that it is the detection rate of the low magnitude earthquakes that will increase as the detection threshold lowers at night. Moreover, this will have a particularly significant effect in giving the Shimshoni correlation simply because most events are of low magnitude anyway (only 4 per cent have body wave magnitudes greater than 5.5). In a very satisfying series of graphs of earthquake frequency against the time of occurrence, Flinn and his colleagues are able to show that the

diurnal effect is definitely not present for events in the body wave magnitude range 5.5 to 6.5, is possibly present in the range 4.5 to 5.5, and is certainly present below 4.5.

Knopoff and Gardner (*Geophys. J.*, **28**, 311; 1972) again raise the question of bias introduced by the higher daytime noise, but they also add two other possible sources of bias. First, they claim that there is bound to be a bias against reporting small shocks because of a "finite and variable density of mesh of seismic stations". In addition, they propose a bias caused by aftershocks. The argument here seems to be that if one of the relatively few earthquakes of magnitude 8 or higher happens to occur at night the large number of associated aftershocks will give a false impression of nocturnal seismicity. Knopoff and Gardner then go on to describe an elaborate technique for the identification of aftershocks and their elimination from the record. When the three sources of bias are removed from the original record (actually for the period March 24, 1963, to December 31, 1968, rather than 1968 to 1970), no day/night correlation is evident. The conclusion then is that Shimshoni's correlation must be produced by one or more of the three biases.

As Shimshoni (*Geophys. J.*, **28**, 315; 1972) points out in his reply to the critics, the elimination of aftershocks by Knopoff and Gardner is rather "drastic", not least because the process will also remove many events not related to the principal shock. On the other hand, he accepts the basic point about variation in detection capability. But this is not necessarily the last word on the matter. The question still remains as to whether the detection threshold effect can explain all of the day/night correlation.

A New DNA Base

IN *Nature New Biology* next Wednesday (September 20) Marmur and his several colleagues report the identification of a new DNA pyrimidine 5-(4',5'-dihydroxypentyl)-uracil, or DHPU, which is present in the altogether unusual DNA of bacteriophage SP-15, a generalized transducing phage of *B. subtilis* and *B. licheniformis*.

DNA from SP-15 phages has an anomalously low melting temperature (61.5°C) but a very high buoyant density (1.761 g cm^{-3}). From past experience with the DNAs of other phages Marmur and his colleagues suspected that these unusual properties of SP-15 DNA might well result from the presence of modified bases, and their suspicions proved to be well founded. After SP-15 DNA is hydrolysed with 90 per cent formic acid, five rather than four bases can be separated by thin layer chromatography. The

new fifth base partially replaces thymine to the extent that it comprises 12 moles per cent of all bases. Marmur's group and collaborators isolated this base, DHPU, on a preparative scale and determined its structure by spectroscopic and nuclear magnetic resonance measurements.

The substitution of thymine by DHPU probably accounts for the low melting temperature of SP-15 DNA, but it does not account in any obvious way for the very high buoyant density of this DNA. That apparently results from a compound which is covalently linked to both strands of the DNA and reacts as a pentose. This pentose compound may be in the phosphodiester backbone of the molecule, but it might rather occur attached to the side chain of DHPU. Finally SP-15 has one other unusual feature: it includes covalently bound glucose residues.