The Indian Earthquake (1934) Area

By DR. J. DE. GRAAFF HUNTER, C.I.E.

MUCH attention has been recently focused on Bihar and Orissa Province as a result of the disastrous earthquake of January 15, and some facts about the condition of the earth's crust in that region have an enhanced interest. It is, of course, no consolation to those who have suffered by the earthquake to be told that there were good reasons for it. These reasons have been in existence for a long time and yet, so far as I am aware, no earthquake of any magnitude has occurred there during the previous century.

The area roughly bounded on the north by the Himalayan foothills, on the south by the Ganges River and stretching from Meerut to beyond

overloading of the two outer regions is roughly equal to the underloading of the Ganges valley. Both the underload and overloads are reckoned from a state of isostatic compensation; so the northerly area of overload is not to be thought of as the weight of the Himalaya but something much smaller, as a considerable degree of compensation of the Himalaya is existent.

These regions of great loading anomaly must cause very great stress-differences in the earth's crust which supports them. The region of underload and the amount of underloading are very much of the order which has been estimated by Dr. H. Jeffreys to be sufficient to cause fracture

in the lithosphere. Now these stresses have no doubt been in existence for a long time. In so far as the land level has been rising from sedimentation, known to have been in progress, some measure of relief has been afforded; but this has not been more than a small palliative. Meanwhile, evidence of another kind has recently come to light—again from the measurements of the Survey of India.

In 1858, spirit-levelling operations on a comprehensive scale were begun in India by General Walker. In 1862 work was carried out in Bengal, and since then measurements of this kind have accumulated. This accumulation gave rise to some embarrassment a few years ago, in that the newer lines of levelling gave results at variance with those of the older lines. After the whole system of lines had been carefully scrutinised, it

was found that the apparent discrepancies would all be accounted for on the hypothesis that the land level had been rising so much each year, the rate of rise varying from place to place in a nearly uniform manner. Thus along a line passing a little north of Benares and directed towards east-north-east an annual increase of elevation of 0.06 ft. was found; and other lines, approximately evenly spaced and roughly parallel to the first, showed rates of increase of 0.05, 0.04, 0.03, 0.02, 0.01, 0.00, the last being some fifty miles from Calcutta.

It will be seen that this rising of the land is occurring in the south-east quadrant of this area of excessive underloading in the earth's crust. It is not necessarily confined to that quadrant. Evidence of change of level from spirit levelling results elsewhere has not yet been so carefully analysed, being not sufficiently complete. None

FIG. 1. Sketch map showing main region of underload in Bengal, Bihar, etc. and secular changes of level in Bengal.

—, contours of underload in feet of equivalent thickness of rock, density 2.67.
---, generalised contours of secular change of crustal level in feet per century.

Darjeeling, between longitudes 78° and 89° is one of excessive underloading in the earth's crust (Fig. 1). The average underloading of this area of about 100,000 square miles is on the average equivalent to a thickness of rock of more than 3,000 ft.; or, put otherwise, the deficiency of pressure in the crust is above 200 tons per square foot. This underloading arises from abnormally low densities in the crust. It is in part accounted for by the low density of the alluvium of the Ganges valley; but unless this alluvium extends to a greater depth than most geologists would believe, the explanation is not wholly there.

The presence of this region of underloading is revealed by measurements of the shape of the earth which have been accumulated during the past century by the Survey of India. The area of underload is flanked both on the north and on the south by regions of overload; and the total

the less, revision levelling in the present century shows a persistent rise from Dhulia (lat. 20.9° , long. 74.7°) to Cawnpore (which also shows a small rise from Benares); and this, so far as it goes, confirms the Bengal results, which in turn are closely in sympathy with the underloading of which they are a natural consequence.

Before the earthquake occurred, the relevant facts accordingly were (a) that there was a large area of serious underloading, flanked by areas of overloading; (b) that in the part of this region where spirit levelled heights had been determined in sufficient detail at sufficient time intervals, the results indicated that the land has been rising steadily where the underload occurs, the rate of rise increasing as the centre of that region is approached.

A slow but continuous yielding of the crust has been in progress. When a material is stressed beyond its elastic limit, it yields in a non-elastic way and eventually fractures. In the present case, the earthquake gives evidence of fracture having occurred; and the floods which have followed the earthquake indicate the resulting rising of some portions of the area.

In the case of such a large area, fracture is not likely to extend throughout the entire region of stress, but it occurs at the position where the relation of stress to strength is most severe, and leads to a modification of the general stress distribution. There is no question of one earthquake of the magnitude of that which has recently occurred entirely relieving the stress differences.

To do that an uplift amounting to thousands of feet would be necessary. I have little doubt that spirit levelling will show that there has been some sudden rising of the land. Were this of the order of tens of feet, it would immediately be made apparent by a wholesale change in the courses of the local rivers; and indeed, a recent report in the Press states that one of the most impressive features of the disaster has been such changes in river courses.

As stated earlier, the area from Meerut to Darjeeling is one of excessive underloading. A smaller amount of underload exists over a much larger area—a strip skirting the Himalaya from the Punjab to Bengal of width varying from 150 miles to twice that amount. We have so far discussed the eastern portion which provides the area of most acute underloading; but there is another region, roughly centred on Lahore (31.6° , 74.3°) where underloading of very considerable amount—about 2,000 ft. of rock-equivalent—exists. This region is not completely defined, as in the north-west it passes out of the area for which the necessary geodetic observations have been made. It is just in this neighbourhood that the last serious Indian earthquake—Kangra (32° , 77°)—occurred in 1905. Eight years previously, in 1897, there was the Shillong earthquake, with epicentre at 26° , 91° . Unfortunately, this is outside the area of full geodetic survey, and spirit levelling was not commenced in that region until 1900, so as yet we have no knowledge of what anomalies of loading exist there or of the secular changes of ground height.

Recent Developments of Sterol Chemistry in Relation to Biological Problems

By JOHN PRYDE

ONCE again there has been demonstrated in striking fashion the impetus which organic chemistry gains from biology, and how a field of organic research, formerly of purely academic interest, enters on a fresh phase of development in virtue of a new correlation with biological problems. The field in question is that of the sterols and the polycyclic aromatic hydrocarbons.

It is well known that the fundamental researches of Wieland, Windaus, Mauthner, Borsche, Diels and others on the sterols and bile acids received a new interest on the isolation of calciferol (vitamin D) from the products of irradiation of ergosterol, $C_{28}H_{44}O$, with which the vitamin is isomeric, and that our conceptions of the structure of these, and of other members of the cholane series to which

they belong, have been re-oriented by the new formulæ advanced by Rosenheim and King¹. The structures below show the old (I) and the now accepted representation (II) of the cholane nucleus. The new, and at the time somewhat revolutionary, formulæ conferred a great stimulus on the investi-

gation of the whole series of compounds. They are based upon evidence which cannot be detailed here, but some of the more salient of the recent observations can be summarised.

Thus, on drastic dehydrogenation with palladium-charcoal or zinc, cholesterol and cholic acid yield the fully aromatic hydrocarbon chrysene (III)², whilst less drastic dehydrogenation of these