THE ACCRA EARTHQUAKE OF JUNE 22, 1939

THIS earthquake, which caused the deaths of seventeen people and injury to upwards of 135 others, besides doing damage to buildings to the extent of hundreds of thousands of pounds in Accra, the capital of the Gold Coast and the surrounding country (NATURE, **144**, 18; 1939), has recently been the subject of comprehensive research*. The Gold Coast as a whole is a relatively stable region and earthquakes are rare, though the Accra district and the coastal area to the east and west are subject to earthquakes. Major shocks occurred in 1862, when every stone building in Accra was razed to the ground and Christiansborg Castle and the forts at Accra taken over by the British from the Danes twelve years before, were rendered uninhabitable; in 1906 when on November 20 Government buildings in Accra were damaged though no casualties were reported; and in the present instance. Recorded minor shocks occurred in 1636, 1858, 1863, 1883, 1907, 1911, 1918–19, 1923, 1925, 1930 and 1933–35.

There are no records of any minor precursor shocks to the 1939 earthquake since the operation of the seismograph at Accra had been discontinued a few years previously on the grounds of economy; but between 1932 and 1935 cracks began to appear in substantial Government buildings in Accra and in the ground near the buildings. At the time Dr. Junner directed attention to the possibility of earthquakes occurring within the next 10–15 years. The earthquake of June 22, 1939, occurred at approximately 7.20 p.m. (G.M.T.) and was felt for about 20–30 seconds at Accra. There is no doubt that casualties were fewer than might have been expected from the severity of the shock since at the time many people were out of doors and there were no subsequent outbreaks of fire. The earthquake was felt by persons over an area of approximately 300,000 square miles and at places more than five hundred miles from Accra. As the epicentre was probably out to sea some twenty-five miles from Accra it is likely that it would have been felt over an area of 600,000 square miles if the whole of the area had been populated land.

According to a geological and engineering survey conducted immediately after the shock and a study of the answers to a questionnaire circulated in the area, it appears that the maximum intensity reached on the modified Mercalli scale was 9 (probably 10 at the epicentre). Accra experienced intensity 8. The villages within isoseismal 9 consisted almost entirely of swish buildings or of grass huts. In Aplaku, situated on Akwapimian quartzite near the Sakumo lagoon, ten houses were razed to the ground and most of the others lost walls facing north-west or south-east. Nyanyanu, similarly situated, was almost completely ruined, and in addition the north-west sides of all the cylindrical fish-drying kilns in the village were forced out. The small villages of Amanfro, Tokusè and Tetegbu, situated on alluvium, suffered much damage. A line of fissures in alluvium and earth with, in places, a downthrow to the south-east of 9–16 in. stretched from Fete to Weija, and another series of fissures was formed in the sand on the sand spit south of Sakumo lagoon. Near Tokuse the fissures were, in places, up to 15 ft. wide. Villages on the north-western side of the fissure were only slightly damaged while those on the south-east side of it were ruined. Small cracks also occurred in several places in made-up ground and rarely in weathered Akwapimian quartzite. Scores of vents and fissures from which water, sand and mud poured for several hours occurred along the western and southern sides of the Sakumo lagoon. The water works at Weija (intensity 8) were seriously damaged.

At Accra during the earthquake a loud and sustained rumbling was heard and some found it difficult to walk. The sea is said to have become rough and fishermen at Labadi and Teshi say their canoes shivered and that they lost control for a time. The earthquake was just short of world shaking according to the evidence of seismographs. As a result of the examination of the seismograms obtained at about sixty observatories throughout the world where the shock was recorded, a least squares solution using the P waves alone gave:

Initial time	= 19h. 19m. 25·8s. ± 1·0s. G.M.T.
Latitude	= 5·18° N. ± 0·03°
Longitude	= 0·13° W. ± 0·03°
Depth of focus	= 13 km. ± 2 km.,

probable errors being given. These results were checked by statistical methods, by readings of other pulses, and by the macroseismic evidence. The energy of the earthquake was of the order of 10^{19} ergs. From June 22, 1939, until July 11, 1940, ninety-four aftershocks have been recorded, these showing a distinct diminution in frequency as time progressed, with the possible exception of February 12, 1940, when eight occurred.

In view of the seismic history of the district, the geological evidence concerning the 1939 earthquake and the engineering aspects of the earthquake, which showed that failures in structures were often due to poor materials, poor construction or poor design, certain recommendations have been made for the rebuilding of Accra. It has been suggested that Government headquarters should be transferred to a more central and more suitable site than Accra. The advantages of such a transfer would probably outweigh the disadvantages except that the initial cost would be very great. If it is impracticable to move from Accra it is of the greatest importance that rebuilding and future building should be, so far as is possible, on sites favourable from the geological point of view to withstand earthquake shocks, and that buildings and other structures should be designed and constructed in such a way that the effects of earthquake shocks will be reduced to a minimum. It should not be necessary, however, to build special earthquake-proof structures except for large buildings on unfavourable sites, and for essential public works such as reservoirs and power stations. From the geological point of view the area east and north-east of a line from Christiansborg police station to Okplonglo is considered to be the most suitable for rebuilding and future building programmes. Stricter control and supervision of the design and construction of all buildings other than single-story, inferior-

* Gold Coast Geological Survey Bulletin 13: 'The Accra Earthquake of 22nd June 1939'. By Dr. N. R. Junner and other authors. Pp. 67. (Accra: Geological Survey; London: Crown Agents for the Colonies, 1941.) 3s.

type buildings is advocated, and the following facts, together with others, based largely on the experience gained in regions subject to severe earthquakes, should be taken into account when permanent re-building at Accra is being considered:

(a) A building should be of simple design and should be so constructed that it will move as a whole in an earthquake.

(b) Buildings should be as nearly square and as low as is conveniently possible.

(c) Foundations should be strong and deep.

(d) All unnecessary ornamental work should be avoided.

(e) Walls should be light and strong. Arches and windows are a source of weakness.

(f) Roofs should be light and rigid and should not be steeply inclined.

(g) Piers may be a great source of weakness. Arched piers should not be used, and all piers should be constructed to withstand an acceleration of at least 3 ft. per second from any direction; in other words, the width at the base of the pier should be at least one tenth of the height of the pier. Tapered piers are advisable in seismic areas and stronger cement may be used near the base of a pier.

(h) Well-constructed wooden buildings will oscillate greatly but will withstand anything but very severe earthquakes unless the structures are built on unconsolidated materials.

(i) Good-quality building materials and workmanship are essential.

(j) Inferior-quality buildings should not be of more than one story.

RECENT RESEARCHES ON RUBBER

RUBBER FRACTIONS

PUBLICATIONS Nos. 3–6 of the British Rubber Producers' Research Association follow a well-beaten track with interesting new details. On the general principle that rubber is a mixture of molecules of different lengths, several previous investigations have attempted to sort the molecules out either by fractional precipitation from solution or by fractional dissolution. A division into 'sol' and 'gel' rubber on these lines has become more or less standard. G. F. Bloomfield and E. H. Farmer (*Inst. Rubber Ind. Trans.*, **16**, 69; 1940) have adopted fractional extraction as their mode of approach, using mixtures of petroleum ether and acetone as extractant, differentiating the fractions in relation to the increasing proportion of petrol in the extracting mixture. Oxygen was rigidly excluded at all stages, but it may have been unfortunate to add β-phenyl-naphthylamine to the extraction mass; this compound is an anti-oxidant for vulcanized rubber, but may act in some conditions as an oxidation promoter for raw rubber.

Four distinctive fractions were taken at arbitrary points—a first small one containing appreciable combined oxygen; a second fraction comprising a pure hydrocarbon of relatively low molecular weight; a third, also pure hydrocarbon, of higher molecular weight; and a fourth containing appreciable combined nitrogen. There was also an insoluble residue. Different types of raw rubber gave different proportions of extract, and at various compositions of the mixed solvent, so that there is little that can be said of a conclusive nature about the make-up of rubber in relation to this extractant.

However, G. Gee and L. R. G. Treloar (*Inst. Rubber Ind. Trans.*, **16**, 184; 1940) have examined several properties of some of these fractions with results of considerable interest. Using methods previously described (Gee, *Trans. Faraday Soc.*, **36**, 1162, 1171; 1940), the molecular weights of the four fractions, in a particular case and from viscosity data, were found as 63,000, 240,000, 350,000 and 360,000. Experimental technique is not yet available to decide whether these, or some of them, represent well-defined classes of uniform length molecules, or merely average 'cuts' in a continuous range of molecular lengths. Several of the properties measured varied in a systematic way with the molecular weight, as for example, the plastic flow, tensile behaviour, crystallization phenomena, and extensibility range. Properties independent of molecular weight seem to be the temperature at which retraction occurs after extension to produce crystallization, and the low-temperature elastic limit. It is particularly interesting to observe that the physical properties of the third fraction are remarkably similar to those of normal crêpe rubber, indicating clearly that the usual elastic properties of (raw) rubber are not dependent on the presence of either low-molecular constituents or 'gel-skeletons'.

PROTEINS IN HEVEA LATEX

Publication No. 2 of the British Rubber Producers' Research Association brings out a marked resemblance between rubber latex protein and typical leaf proteins. The following table, from G. R. Tristram (*Biochem J.*, **34**, 301; 1940), compares his analyses with leaf protein analyses by Chibnall:

	Amino-acids as percentage protein: Latex	Various leaves
Ammonia	1·46	0·97– 1·17
Arginine	6·90	7·1 – 8·2
Lysine	5·68	4·6 – 6·2
Histidine	0·63	1·0 – 1·6
Glutamic acid	13·68	11·4 –14·0
Aspartic acid	10·5	7·9 – 8·8
Tyrosine	7·24	4·8 – 6·1
Tryptophan	1·49	2·1 – 2·4
Methionine	1·12	2·2 – 2·7
Cystine	1·02	1·4 – 2·2
% Total nitrogen	14·95	12·8 –15·0

The similarity in the two sets of figures undoubtedly suggests some relationship between the proteins in the leaves and latex of *Hevea brasiliensis*, and the question is being pursued by way of analyses of proteins from Hevea leaves themselves.

J. McGavack and C. E. Rhines (*Ind. Eng. Chem.*, **32**, 1072; 1940) recently showed that the nitrogen content of "whole latex" is approximately constant at 0·25 per cent, the analyses being of 117 samples, collected in a single month (thus avoiding seasonal