nightmare; but some movement in that direction I believe to be inevitable, and, with nationalisation of the land, it might well come more speedily than one would venture to contemplate. None will question, at any rate, that, should such a day arrive, education in the principles underlying the calling will loom as largely as practical training in determining the standards of admission to the use of the land.

The Structure of the Great Rift Valley.

By Prof. J. W. GREGORY, F.R.S.

THE explanation that the lake chains of East Africa lie in a system of tectonic valleys which are a continuation of the basin of the Red Sea was due to Suess (1891) in his contribution to the geological results of Teleki's expedition. Suess regarded the Great Rift Valley as made by a sudden rupture of the crust of the earth owing to contraction, as preceded by no upheaval, its age as Pliocene and Pleistocene, and the height of the land beside it as due to an uplift[1] in consequence of the rupture; and he considered that as the East African Rift Valley is bounded by block mountains and not by parallel horsts, it is different in structure from that of the Rhine. The present writer, after a visit in 1892–3 to the highest part of the Rift Valley, supported Suess's view of its formation by earth-movements due to lateral tension, but he considered that the valley had a much longer and more complex history than Suess recognised; for the Rift Valley was made by faulting repeated at intervals from at least the Oligocene to the Pleistocene, it was initiated by an uplift of a broad arch in the Upper Cretaceous, and the infall of the top of that arch was probably a consequence of the foundering of the floor of the Indian Ocean.

The Great Rift Valley in its course from Syria to Mozambique varies greatly in structure. In some places it consists of a single trench, and at others of several branches. Its structure is geographically most complex in Tanganyika Territory, where it was studied with especial care when that area was part of German East Africa. A valuable discussion of the combined topographic, geological, and geodetic researches in that region has now been prepared by Prof. Krenkel, of the University of Leipzig.[2] He shows that between the Congo and the eastern coast of Africa three great tectonic belts are now well established. That nearest the coast forms the eastern front of the main African plateau. As it is the oldest, and in the most exposed position, its structures have been obscured by denudation. Hence the determination that this mountain rampart was formed by faulting required close examination of its geology. The evidence available shows that the central part of Tanganyika Territory is traversed by a zone of fractures, which extends from Lake Nyasa to the plateau front west of Mombasa. This eastern zone consists in places of a series of step faults, but includes, as in Uluguru, some rift valleys.

The second belt is the continuation of the main trunk of the Great Rift Valley southward from Kenya Colony. It includes Lake Magadi, and forks at Lake Natron; one branch goes south-westward, and includes Lake Eyasi, and disappears near the town of Tabora. The main trunk continues southward; it is repeatedly deflected south-westward by faults parallel to those of the eastern fracture belt; it becomes indefinite after passing Kilimatinde on the railway from Dar-es-Salam to Tanganyika. There is some evidence of the extension of this fracture belt through the Ruaha valley to Lake Nyasa. The only gap still uncertain in the course of the Great Rift Valley is from the lower part of the Ruaha to near Kilimatinde.

The westernmost tectonic belt follows the western branch of the Rift Valley, and includes the Albert Nyanza and Lake Tanganyika. It forks near its southern end: one branch breaks into splinters on the southern coast of Tanganyika; the longer branch goes south-eastward past Lake Rukwa, joins the main trunk at the Ruaha valley, and continues through Lake Nyasa to south of the Zambezi, where it has been traced by Teale and Wilson. The evidence of the tectonic origin of the valley is especially clear around Lake Tanganyika, the coasts of which show complex series of faults, fault blocks, and secondary rift valleys. Many of the faults are quite modern, as some of them have dislocated recent conglomerates and have tilted some of the lake beaches. The walls of this valley, from the features noted in the original graphical description of it by Burton, are young, and, as Prof. Krenkel holds, the westernmost of the three tectonic belts is probably the youngest.

Between Suess's simple theory that the Rift Valley was formed from a single series of fractures in the uppermost Kainozoic and my more complex classification with its three different series of fractures separated by four volcanic periods, Prof. Krenkel adopts an intermediate position. He accepts two periods of faulting and three of volcanic activity for the Nyasa basin; so that his sequence of events is nearly as long as mine; but he regards all the volcanic rocks as Miocene or later. The evidence on which I referred the lava of the plains near Nairobi to the Upper Cretaceous was admittedly scanty; but that age fitted in best with the general history of that part of the world. Later a promising clue to the age of the earlier volcanic eruptions was offered by Dr. Oswald's work on the Victoria Nyanza; but the volcanic pebbles he collected in the pre-Miocene conglomerates cannot be certainly identified. It is to be hoped that some visitor to that area will make a further collection of the volcanic pebbles from these conglomerates, so that their position in the East African volcanic sequence may be determined.

The view that the Kapitian lava plains are Pliocene has been held persistently; but that view has now been conclusively disproved by fossils collected by Mr. Sikes from beds deposited in depressions in the surface of these lavas. The fossils have been identified by Mr. R. B. Newton as Pliocene, so that the lavas themselves must be Miocene or older. Their Cretaceous age

[1] [In 1891 he referred to the uprise as an *Aufwölbung*; later as an *Aufwulstung*.]

[2] Die Bruchzonen Ostafrikas: Tektonik, Vulkanismus, Erdbeben und Schwereanomalien. Von Prof. E. Krenkel. Pp. viii+184. (Berlin: Gebrüder Borntraeger, 1922.) 7s. 4d.

has recently been supported by the work of E. O. Teale and W. Campbell Smith from the Zambezi. Some lavas which these authors correlate with the Kapitian are shown to be Cretaceous; they remark (*Geol. Mag.*, May 1923, p. 228), " . . . the close similarity between the specimens from the Lupata Gorge just described, and the Kapitian phonolites, seems to afford very striking confirmation of Prof. Gregory's view that the latter are of Cretaceous age."

This evidence establishes the suggested date for the beginning of the East African part of the Rift Valley by fixing the age of the oldest associated lavas as Cretaceous. That the Rift Valley faults had begun by the Oligocene has now received further confirmation from the Gulf of Suez. In a lecture to the Royal Geographical Society in 1921 (*Geog. Journ.* vol. lviii. pp. 267-271) Dr. Hume threw doubt on the fault origin of the Gulf of Suez, and attributed it to folding. This conclusion would have been difficult to reconcile with the successive maps of the area issued by the Geological Survey of Egypt had not that Survey also published a diagram of one of its folds (Petrol. Research Bull. No. 6, 1920, before p. 1). The structure represented is what in ordinary geological nomenclature is termed a fault. In answer to Dr. Hume's view that the Gulf of Suez was formed by folding, it is only necessary to refer to the two last publications on the area by the Survey of which he is director. The valuable account of the geology of the Gulf of Suez in No. 10 of the Petroleum Research Bulletins, by Messrs. Moon and Sadek, includes two sections which illustrate the structure of the Gulf. The essential parts of these sections are here reproduced (Figs. 1 and 2). They both represent the Gulf of Suez as in a typical fault-formed valley. The second figure (after Pl. IX. D) is especially instructive, as it shows that the faults which formed the Gulf of Suez were post-Eocene and pre-Miocene. It therefore shows that the conclusion that the Rift Valley faulting began in the Oligocene, which was first based on evidence from Lake Nyasa, holds for the Gulf of Suez. A further Petroleum Research Bulletin, No. 12, has just been issued, in which part of the eastern shore of the Gulf of Suez is described. The authors, Messrs. Moon and Sadek, conclude that the position of the shore is determined by "a very important fault," and they show that the faults in this area were in part pre-Miocene and partly post-Miocene. One of the sections, Pl. I. D-H, shows a series of vertical and steeply inclined fracture planes which are marked as faults and not as folds.

Suess's view that the Great Rift Valley is tectonic in origin has been supported by an overwhelming balance of opinion; but his view that it was a sudden rupture due to the contraction of the crust has been less widely adopted than the writer's hypothesis that it was due to a series of infalls along an upraised belt. That preliminary uplift has been accepted under various names—arch, anticline, or mountain ridge along the axis of the valley—and it is consistent with the gravity survey by Kohlschütter, of the results of which an excellent summary is given by Prof. Krenkel. Tanganyika Territory is under three different conditions. Along the coast gravity is in excess. The central area, along the south-western branch from the Great Rift Valley through Lake Eyasi to Tabora, includes a broad basin, with gravity less than the normal. Along the western branch of the Rift Valley is a long narrow band in which the gravity is also less than normal; Krenkel describes it as a *Dichterinne* or density-trough.

The majority of recent authors have adopted the view that the Great Rift Valley was due to lateral tension. That the faults which bound the valley might be due to compression has been several times suggested. The occurrence of reverse faults in the older rocks beside the Great Rift Valley appeared to support this possibility. This view was suggested by Uhlig in 1907, but he has abandoned it. An overthrust fault—which has since been rejected—was described from German East Africa, but Suess remarked that he knew of no other anywhere along the Great Rift Valley system. Dr. Hume inserted a reversed fault on the western shore of the Gulf of Suez. His section was reissued last year "slightly altered" (Petroleum Research Bulletin, Geological Survey Egypt, No. 10, Pl. VIII. Fig. 2); but the only noticeable modification, except in colouring, is that the fault is no longer drawn as a reverse fault.

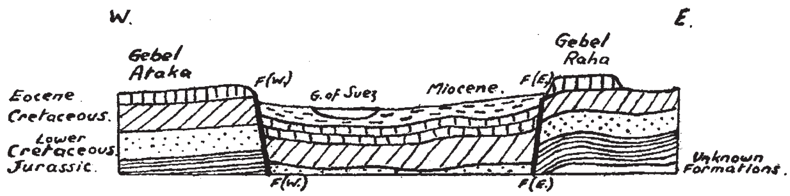

FIG. 1.—The structure of the Rift Valley of the Gulf of Suez according to the Egyptian Survey. From Petroleum Research Bull. No. 10. (Cairo, 1921.)

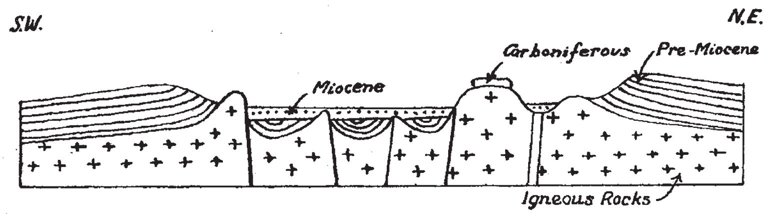

FIG. 2.—Another section by the Egyptian Survey of the valley of the Gulf of Suez. From Petroleum Research Bull. No. 10. (Cairo, 1921.)

The main advocate of the compression theory is Mr. E. J. Wayland, the director of the Geological Survey of Uganda, for the Great Rift Valley near the Albert Nyanza (*Geog. Journ.* vol. lviii., 1921, pp. 344-359). The suggestion is more probable for that area than for those places where the Rift Valley is associated with immense lava fields, and in Unyoro it has some abnormal features. Mr. Wayland's view is based on general considerations, and he does not appear to have seen any reversed fault along the Rift Valley. All the numerous faults that have been recognised in the Great Rift Valley series are normal. Any reversed faulting that may be found will probably prove to be exceptional. The geographical and geological features of the mountains beside the Great Rift Valley resemble those of normally faulted block-mountains, and not those of fold mountains due to corrugation of the crust by compression. The topography along the Great Rift Valley agrees with that of areas torn by tension clefts rather than with mountains raised by compression; for all the faults known are normal; beside the valley rise many block-mountains and horsts, and it is associated with vast lava fields. In mountains due to compression, on the other hand, the faulting is reversed; volcanic action is rare except for isolated volcanic groups some distance from the main chain, or where it is cut across by later faults. The mountains, moreover, occur in long sinuous chains and sheaves of chains which gradually dwindle in height through parallel foothills. That the Rift Valleys are due to tension is emphatically asserted by Prof. Krenkel. The fracture zones of East Africa, he says, are zones in which the crust has been torn asunder (*Zerreissungszonen der Kruste*, p. 169).

Recent evidence, therefore, from the Zambezi and the Gulf of Suez, Mr. Sikes's fossils from the Kapiti Plains, and Prof. Krenkel's valuable monograph, combine to confirm the conclusions that the Great Rift Valley was initiated by an upbulging of the crust; that its fractures were connected with vast volcanic eruptions which began in East Africa in the late Cretaceous, and were contemporary with the Deccan Traps of India; and that one set of the fractures that made the Rift Valley happened in the Oligocene. These conclusions render it probable that the African Rift Valleys are due to the secondary consequences of the movements that made the basin of the Indian Ocean.

Obituary.

Mr. F. J. H. Jenkinson, Hon. D.Litt. (Oxon.).

In Mr. Francis Jenkinson, University Librarian at Cambridge, who died on September 21, has passed away one of the most versatile and distinguished of Cambridge scholars. Of his profound knowledge of classics, of bibliography and antiquarian matters, and of music, this is not the place to write. This notice must be restricted to his activities in natural science, in one branch of which, entomology, he was an expert. Nor is it possible here to give more than the briefest outline of his life. Born in 1853, he entered Marlborough at the age of twelve, and in 1872 began a distinguished career at Trinity College, remaining for the rest of his days at Cambridge. He became University Librarian in 1889, and held this post until his death, a period of more than thirty years.

Jenkinson was Curator in Zoology in the University Museum for a few months in 1878 (the same year in which he gained his Fellowship at Trinity by his classical attainments). He was the second occupant of this position, the first having been Mr. J. F. Bullar, and during his tenure he worked chiefly at insects. The same curatorship was afterwards filled (in 1890) by the late Dr. David Sharp. But though Jenkinson's official connexion with the Museum of Zoology was short, he was its valued helper to the end.

From boyhood a keen naturalist, and especially a lepidopterist, Jenkinson was much associated in early years with his lifelong friend Mr. Edward Meyrick, as a student of the smallest and most delicate forms. Some time after the coming to Cambridge of Dr. Sharp, with whom he formed a lasting friendship, Jenkinson turned his attention to Diptera. These were henceforth his special study until the last, and it is as a dipterist that he will be remembered in entomological circles.

It is true of Jenkinson's entomological side, as perhaps of all his interests, that his published works are little in comparison with the greatness of his knowledge. His writings comprise some twenty-seven short notes and papers, contributed to the *Entomologist's Monthly Magazine* between 1886 and 1922. The first four, up to 1900, deal with Lepidoptera, the remainder almost entirely with Diptera. In his longest paper (1908) he recorded a number of fungus-gnats new to Britain and described one new to science. The short notes contain records of captures and observations of the habits of various flies. His last entomological writing (1922) was an obituary notice of his old friend A. B. Farn.

But these publications are only a small part of Jenkinson's dipterological work. None could be more generous than he in aiding other workers. He had a wonderful faculty for distinguishing obscure species in the field, and very great deftness in capturing minute insects, even without a net. He was a very skilful manipulator, and collected a vast amount of material in several parts of Great Britain, but especially in his own garden at Cambridge. The pick of these captures was always at the disposal of the University Museum, to which he gave hundreds of specimens, and he was one of the makers of the Cambridge collection of British Diptera, now one of the largest extant. The national collection at South Kensington has also been enriched by many of his specimens. His miscellaneous captures in other orders were frequently interesting: a minute Copeognathe found in a house at Crowborough, and described by Dr. Enderlein in 1922 as a new genus and species (*Pteroxanium*), is the first Psocid (*sens. lat.*) with scale-covered wings to be discovered in Great Britain, the forms related to it being tropical.

Jenkinson's faculties for observing were extended to plants, birds, and even, at one time, to mollusca. He applied his classical and bibliographical knowledge also to entomological matters. The former was often called into play in questions relating to scientific names. What he wrote of Farn was true also of himself: "he disliked slovenliness" and "was the most scholarly of naturalists." As Librarian he was always sympathetic to the needs of entomology, and contributed to the result that the University Library and departmental libraries together now contain a body of entomological literature (especially periodicals) probably unsurpassed in any centre in Great Britain outside London. In person he was tall but of almost fragile build, and he was always hindered by poor health. The kindest-hearted of men, his personality exercised a singular charm over his many friends.

H. S.