worn and corroded, with prisms of enstatite and augite, in a groundmass of labradorite laths, augite, and iron-ore granules. The base, which may represent a devitrified glass, now consists of an ill-defined, turbid, untwinned, felspathic substance and quartz, which carries numerous microlites of iron-ores. The rock is fully described in the above-cited paper. A N.N.W. dyke with similar characters occurs in the Church Burn at Corrie.

The dykes of the cumbraite facies, therefore, are distributed in a narrow band running S.S.E. from the Cowal peninsula, through the Great Cumbrae, down into central Ayrshire; and thence with a more south-easterly trend through the Muirkirk district towards the Scottish border. South of the border they give place to dykes which are regarded as basic varieties of inninmorite (Cleveland dyke) and the Brunton type of tholeiite (Anderson & Radley, 1916, p. 209). The cumbraites appear to belong to the regional or solitary dykes of Sir A. Geikie; and this may be the reason for their non-appearance in Arran, where the dykes are local and connected with the Arran centre of Tertiary eruption.

(*To be concluded in the August Number.*)

NOTICES OF MEMOIRS.

I.—The Oilfields of Egypt.[1]

BETWEEN the Sinai Mountains and the Red Sea Hills lies a depressed area bounded by faults and traversed by three hill-ranges, the Esh Mellaha, Zeit, and Araba Hills, which are separated from each other and from the main ranges by three plains and the Gulf of Suez. All these features trend approximately north-west and south-east. The breadth of the sunken tract is on the average 100 kilometres, of which the Gulf occupies about one-fourth.

Although petroleum has only been found in quantity in the peninsula of Jemsa, near the entrance to the Gulf, and at Rarquada[2] about 50 kilometres to the south-east of Jemsa, near the shore of the Red Sea, the whole of the area, together with a narrow strip on the shore of the Red Sea, extending as far as Ras Benas, is characterized by great geological similarity, and may be referred to as the oilfield region; but the district more especially dealt with in this report lies between 27° 10′ and 28° 10′ North lat., and 33° and 33° 50′ East long. A coloured geological map of this area and a plate of ten horizontal sections accompany the Report. During the progress of the work, extending over several years, the author examined some of the Roumanian oilfields under the guidance of Professor Mrazec, who subsequently visited Egypt and to whom we are mainly indebted for the horizontal sections.

Those portions of the Report which deal with the tectonic features of the oilfield region have recently been summarized by the author

[1] Report on the Oilfields Region of Egypt, by W. F. Hume, D.Sc., A.R.S.M., F.R.S.E., Director Geological Survey of Egypt. pp. viii and 103, with a geological map (1 : 150,000) from surveys by John Ball, Ph.D., D.Sc., F.G.S., 23 plates, and 9 text-figures. Cairo: Government Press, 1916. Price 30 P.T.

[2] Rarquada is opposite Gefatin Island

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himself in the GEOLOGICAL MAGAZINE,[1] so that it will be unnecessary in this notice to go into that branch of the subject in any detail.

In dealing with the succession of deposits the author follows the Lyellian method, beginning with the most recent. In this brief summary we will reverse the process, though we do not wish to suggest that this method should have been followed in the Report. The oldest rocks consist of granite and of ancient volcanic and sedimentary rocks, similar to those of the Red Sea Hills and the Sinai Mountains, probably of Archæan, certainly of pre-Carboniferous age. They form the cores of the asymmetric anticlines of the Esh Mellaha, Zeit, and Araba Hills as described by Dr. Hume in the paper already referred to. On the old floor formed of these rocks were deposited Nubian Sandstone, Cretaceous and Eocene strata. The succession is the same as that occurring on the western side of the Red Sea Hills and in Sinai, except that in the latter locality flat-bedded Carboniferous strata intervene between the old floor and the Nubian Sandstone.[2] The Cretaceous and Eocene rocks are seen only in the hill ranges where their thickness is often greatly reduced by folding. Their presence confirms the view generally held that these rocks were originally continuous over the whole area.

The Miocene rocks which follow rest on any of the underlying series. Thus on Shadwan Island they rest on granite and in the Zeit range on Lower Cretaceous strata. In the Esh Mellaha range, some 20 kilometres to the west of the Zeit range, both the uppermost Cretaceous and the Eocene rocks are present. It follows, therefore, that the Gulf of Suez marks the position of the axis of a post-Eocene and pre-Miocene anticline from which the sediment overlying the granite must have been wholly or partially removed by denudation before the Miocene rocks were deposited. We may remark in passing that in other parts of Egypt this interval is represented, to some extent at least, by the so-called petrified forests, the fluvio-marine series of the Fayum, and other deposits of a continental type.

Flint conglomerates and coral reefs occur at the base of the Miocene. In the Zeit range conglomerates, resting on Cretaceous strata, are immediately followed by a dark limestone containing fossils which M. Fourtau has identified with forms "typical of the Lower Miocene (Burdigalian) and of the Lower Helvetian (Lower Middle Miocene)". The limestone is succeeded by an important series of *Globigerina* marls with *Aturia aturi*, *Terebratula miocenica*, and a delicate Pecten fauna. Similar marls have been met with in a boring at Rarquada between 1,169 and 1,181 feet where they are underlaid by a limestone and a flint conglomerate, as in the Zeit range. This boring terminated in sands which Dr. Hume identifies with the Nubian Sandstone. The sands yielded oil. These fossiliferous strata are succeeded by deposits of clay, gypsum often calcareous, dolomitic limestones and salt; their total thickness cannot

[1] "Some Notes on the Post-Eocene and Post-Miocene Movements in the Oilfield Region of Egypt": GEOL. MAG., January, 1917, pp. 5–9. The map illustrating this paper should be referred to.

[2] See review of Dr. Ball's memoir on *The Geography and Geology of West-Central Sinai*, GEOL. MAG., February, 1917.

be less than 3,000 and may be as much as 6,000 feet. Above this great saliferous formation, which is generally unfossiliferous, occur oyster beds containing *Ostræa virleti* and an oyster of the *crassissima* type. Pending a more detailed examination of the palæontological evidence the beds from the flint-conglomerate up to and including the oyster beds are grouped together as being of Plio-Miocene age. They all belong to the Mediterranean area and can be connected up to the north with the Miocene deposits which occur between Suez and Cairo.

The oyster-beds are followed by strata containing the remains of sea-urchins and Pectens now living in the Red Sea and Indian Ocean, together with some forms which are apparently extinct. These deposits are referred to as Plio-Pleistocene. They mark the invasion of what had hitherto been a southward extension of the Mediterranean province by Erythræan forms of life. The plains are largely covered by thick deposits of gravel, derived from the waste of the hills. These are classed as recent, together with a raised beach of corals and molluscs now living in the Red Sea. The beach forms a marked feature on the Zeit and Jemsa coast at an average height of 15 metres.

Let us now consider the great saliferous formation, with which the oil appears to be associated, in greater detail. Gypsum is the most prominent rock at the surface. Salt in thick beds is only known from the borings. The gypsum is interbedded with clays or marls, and in some places, as in the Jemsa peninsula, with dolomitic limestone. Vertical sections of four borings are given. They show remarkable changes within short distances. Bore 11 passed through alternations of gypsum and clays to a depth of about 500 feet; then through thick beds of salt, separated by thin beds of clay, limestone, and gypsum, to a depth of 2,650 feet, where it ended in salt. The total thickness of salt in this section was found to be about 1,900 feet, or 600 metres. Bore 1, which was apparently situated about one kilometre from Bore 11, is represented as being entirely in limestone. It reached a depth of 1,300 feet. The other two bores, less than 300 metres from Bore 1, were in gypsum, with thin beds of clay and limestone. Speaking of the Jemsa oilfield, Dr. Hume says: "Sections have been made of the area so as to include the bore-profiles, but efforts to explain the present conditions either as simple anticlines or synclines have ended in complete failure. There is a provoking horizontality in the strata of the eastern hill of Jemsa, immediately above the oil-belt on the east coast. . . . What we do know is that the Jemsa borings which have yielded profitable oil occupy a long thin band close to the sea, parallel to the general fold movement of the country."

The oil at Jemsa appears to have been obtained from the dolomitic limestone which is porous, and therefore likely to form a good reservoir rock. Fragments of a similar limestone are common on the surface of the gypsum throughout the oilfield region. Dr. Hume suggests that this feature, and also the great thickness of limestone met with in some of the borings, may be due to the removal of gypsum in solution from beds containing both carbonate and sulphate of lime. Mr. Lucas contributes a chapter on the solubilities of these two substances in water and saline solutions, in which he shows that the relative solubility of gypsum increases up to a certain point as the salinity increases; and Dr. Hume points out that the underground waters at Jemsa have approximately the composition most favourable for the solution of gypsum. There appears to be strong reason for believing that the circulation of water in the saliferous formation has brought about great changes in the nature and distribution of the original materials.

Salt which has been met with in several bores does not occur in one central core as in the Roumanian fields, but is interstratified with shales and gypsum. It is best developed in the minor anticlines, and "Professor Mrazec was strongly impressed with the idea that these strata [the salt-beds] were derived by a leading action from salty clays, similar to those well developed at the surface, whereas beds of salt have never been noted on the large scale in the above ground observations". Dr. Hume suggests that the saliferous deposits were formed in a slowly sinking area into which sea-water could gain access, that the evaporation over this area was sufficient to cause the precipitation of gypsum and salt, and that while this was going on streams were bringing down clay and calcareous matter from the surrounding land.

The similarity in many respects of this formation to that of the Roumanian oilfields is referred to. May we not extend the correlation? *Aturia aturi* is a characteristic fossil of the "Schlier" which, according to Suess[1] and others, includes the Carpathian salt-beds, and probably also those of Armenia and Azerbigan, of the Iranian tableland as far as Khorasan, of the valley of the Tigris, and of the coast of the Persian Gulf. Doubt may exist as to the precise correlation of all these saliferous formations which, as Suess says, "afford us the spectacle of a great expiring sea"; but it seems clear that, both as regards age and mode of formation, the deposits of the Egyptian oilfield are closely allied to them; and it is with them that some of the most important oilfields of the world are intimately associated.

No definite opinion is expressed as to the origin of the petroleum, but the porous limestone (Jemsa) and the Nubian Sandstone (Rarquada) are regarded as reservoir rocks. Indications of oil are most conspicuous on both sides of the Gulf of Suez, and as the overfolding of the anticlines is directed towards the Gulf, it is suggested that the post-Miocene stresses probably reached their greatest intensity in this region, and may therefore have forced the oil into any rocks in the neighbourhood capable of containing it.

No detailed records of bores are given, except the four at Jemsa, and no statistics of production. It is to be regretted that so much secrecy should be considered necessary by those engaged in controlling and developing the economical resources of a country, and very doubtful whether it is not carried much further than is required for commercial purposes. Rivals generally find out sufficient for their purpose, and the progress of science is, therefore, often unnecessarily

[1] *Face of the Earth*, vol. i, p. 309, English translation.

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retarded. Moreover, valuable information may be, and often is, lost. Wherever Governments grant facilities for exploration by deep bores they should see that accurate records are kept and made public after a reasonable lapse of time.

The two outstanding features which sharply differentiate the oil-field region from the plateau regions of Sinai and Egypt are the presence (1) of a thick series of Miocene rocks belonging to the Mediterranean area, and (2) of sharp folding due to tangential pressure. We repeat the question that we put in reviewing Dr. Ball's memoir on West Central Sinai. Did the Miocene sea advance over a planed down surface of the older rocks? It was at one time supposed that some at least of the faulting in the region between Suez and Cairo was of post-Eocene and pre-Miocene date, and that Miocene rocks had been deposited against "horsts" of Eocene limestone. That view was disproved by Barron,[1] who showed that they were superposed upon, not apposed against, the Eocene strata, and that no evidence of pre-Miocene faulting was to be found in that district. Now Dr. Hume comes forward with evidence that the Miocene rocks of the oilfield region were formed over the denuded arch of the great post-Eocene fold whose axis coincided approximately with what is now the Gulf of Suez. Although we are not able to define with precision the boundaries of this southward extension of the Miocene sea there is some evidence to show that it did not extend far beyond the faults which bound the sunken tract on the east and on the west, and, therefore, as Dr. Hume points out, that it found a gulf agreeing approximately in position and direction with this tract and its continuation in the Red Sea trough. But in any case there must have been a considerable geocratic movement in post-Miocene times, for Dr. Ball has shown that Miocene rocks occur at a height of 642 metres on Sarbut el Gamal[2] in West Central Sinai, and has estimated the throw of the post-Miocene faults in that region at about 2,000 metres. Even allowing for the possibility that this may be an over-estimate, there seems no escape from the conclusion that the oilfield region owes its position largely to subsidence along faults of later date than the Miocene rocks of the district. But we must await the more precise determination of the palæontological horizons before attempting to correlate the physical history of the oilfield region with that of the Mediterranean area to which it belonged until it was invaded by the Erythræan fauna in comparatively recent times.

It is interesting to compare the views of Suess as to the structure of the district with those set forth in this memoir and in other publications of the Egyptian Geological Survey. In his chapter on the Great Desert Plateau Suess shows that flat-bedding in the Cretaceous and Tertiary rocks is the characteristic feature of large portions of North Africa south of the Atlas range, of the Sinai peninsula, of North and South Arabia, of Palestine and Syria, and that the same feature probably extends as far east as the Persian

[1] *The Topography and Geology of the District between Cairo and Suez*, Cairo, 1907, p. 55.
[2] See GEOL. MAG., February, 1917, p. 83.

Gulf. The only post-Tertiary movements that he recognizes over this vast area, extending eastwards from the Atlantic Ocean for some 3,000 miles, are "in the form of subsidence, particularly as great trough-subsidences, which are here and there associated with flexure of the edges. On the other hand, tangential movement and folding are entirely absent, at least as far as we can judge at present". This view can no longer be maintained if we are to understand by "subsidence" movements along normal faults. Flat-bedding, so far as the eye can judge, certainly is the dominant feature in the Egyptian portion of the Nile Valley, in the Oases, and in Sinai. But, as Dr. Hume has pointed out,[1] the V-shaped outcrops on the geological map of Egypt require the assumption of a broad syncline whose axis dips slightly to the north, while the relations of the Cretaceous and Eocene rocks to the Red Sea Hills and Sinai Mountains indicate the presence of a complementary anticline to the east. Thus folds of great amplitude certainly occur in this portion of the desert plateau, reminding one of the swell of the ocean which is often felt far away from the storm centre which produces it. Now Dr. Hume shows us that sharp folding due to tangential pressure is also present. But this alone would probably not have led Suess to modify his general view. He would doubtless have regarded it as connected with a trough subsidence and therefore of only local importance.

The Report is well illustrated by photographs of scenery and figures of the more characteristic fossils which are briefly described by M. Fourtau in a special chapter. It does not profess to be final. The map is said to be provisional and research is still going on. We await with interest the communications which are to follow, and conclude by wishing success to those who are engaged in developing the Egyptian oilfield, to whom we are indebted, both directly and indirectly, for so much geological information about this most interesting region.

J. J. H. T.

II.—The Conchological Features of the Lenham Sandstones of Kent, and their Stratigraphical Importance. By R. Bullen Newton, F.G.S., of the British Museum (Natural History).

Part II.

Conclusions.

We gather from the previous literature on this subject that the majority of investigators have agreed that the Lenham Beds are equivalent to the Diestian deposits of Belgium, which have been generally recognized by geologists as belonging to the base of the Pliocene system, on account of the shell remains exhibiting a marked Miocene facies with many species identical or related to southern or Mediterranean forms. The Miocene aspect of the Lenham fauna is very pronounced, as out of the seventy-seven conchological species that have been determined in the present work, forty-seven, or sixty per cent, date their origin from the Vindobonian

[1] Explanatory notes to accompany the geological map of Egypt.

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(Helvetian–Tortonian) stage, which represents the middle part of that epoch in such countries as Germany, Italy, France (S.), Holland, Denmark, and Austria (Vienna Basin). Again, twenty-six of the Lenham species occur as well in the Redonian beds of Gourbesville, Normandy, which are either of Vindobonian or Messinian age, and therefore Miocene. These Gourbesville deposits are of peculiar interest. They were originally discovered by Vasseur,[1] and ascribed to Pliocene or Red Crag times, having been more critically studied since by M. G. F. Dollfus,[2] who in 1880 regarded them as of similar age, although subsequently determining them as belonging to his[3] "Etage, Rédonien", which in explanation was stated to be neither Helvetian nor Plaisancian, but equivalent in time to the Tortonian stage of the Miocene, notwithstanding that he had previously paralleled this new horizon with the Anversian Beds of Belgium.[4] The Redonian fauna was considered to be related to the Gedgravian (Coralline Crag) of England.

About twenty of the Lenham shells, including *Anadara diluvii*, occur in the Upper and Middle Miocene of Holland, and a rather smaller number of species in the same horizons of Denmark, as determined by Molengraaff and Van Waterschoot Van der Gracht[5] for Holland and by Ravn[6] for Denmark. The Pelecypod, *Anadara diluvii*, is of frequent occurrence in the Lenham Beds, and although unknown in the Diestian of Belgium, it is found in the Bolderian (= Tortonian) and Anversian (= Messinian) of that country, as well as in the Vindobonian of Germany, France, Austria, and Italy, and in the Plaisancian deposits of Italy and France; its only British occurrence from the Lenham sandstones was first recorded by Mr. Reid. The Lenham fauna presents an interesting resemblance to that of the Upper Miocene of North Germany (Reinbeck and Holstein), described by Zimmermann[7] and Gottsche,[8] and regarded as Messinian or the latest stage of the Miocene period, a formation-term introduced by Mayer-Eymar,[9] to include Pontian–Sarmatian, Zanclean, and Miocene of other authors. The North German Miocene deposits contain twenty-five species of Mollusca which are also found in the Lenham Beds, among them being *Streptochetus sexcostatus*, *Zaria subangulata*, *Tellina benedeni*, *Papillicardium papillosum*, etc.

Speaking further of this Miocene facies of the fauna, it may be observed that *Drillia obeliscus* and *Clavatula jouanneti* are first known in Burdigalian times, whereas *Margaritifera phalænacea* commenced its career in the Aquitanian stage, which forms the basal or oldest

[1] Bull. Soc. Géol. France, ser. III, vol. vii, p. 741, 1879.
[2] Bull. Soc. Géol. Normandie, 1880.
[3] Assoc. Française-Cherbourg, 1905, published 1906, pp. 358–70.
[4] Bull. Soc. Géol. France, ser. IV, vol. iii, p. 258, 1903.
[5] "Niederlande": Handb. Region. Geol., vol. i, pt. iii, p. 53, 1913.
[6] "Molluskfaunaen I Jyllands Tertiaeraflejringer, etc.": Mus. Min. Géol. Univ. Copenhague: Paléontologiques, No. 7, 1907 (plates and text).
[7] "Ueber der Schichten der Tertiärformation welche bei Reinbeck durch die Hamburg, etc.": Amtl. Ber. Deutsch. Nat. Aerz. Kiel (1846), 1847, pp. 232–4.
[8] Die Mollusken-Fauna des Holsteiner Gesteins": Abhandl. Geb. Nat. Ver. Hamburg, vol. x, No. 8, pp. 14, 1887.
[9] *Cat. Syst. Foss. Tert. Mus. Zurich*, 1867, pt. ii, p. 13.

division of the Miocene formation. The following Gastropods may also be referred to as dating from the Vindobonian stage of the Miocene; *Streptochetus sexcostatus*, also Messinian and Anversian; *Bonellitia serrata*, ranging into the Italian Plaisancian; *Terebra acuminata*, occurring also in the Messinian of North Germany, the Anversian of Belgium, and in the Plaisancian and Astian beds of Italy; *Maculopeplum lamberti*, recorded as well from the Redonian of France, the Diestian and Scaldisian of Belgium, the Box-stones and the Coralline and Red Crags of England; and *Ficus reticulata* known also from the Redonian of France, the Messinian of North Germany, the Bolderian, Anversian, and Diestian of Belgium, Box-stones, Lenham Beds, and Coralline Crag of Britain, Plaisancian and Astian of France and Italy, and belonging also to recent seas. Among the chief Pelecypods similarly originating in Vindobonian times are: *Glans senilis*, known also in the Redonian, Scaldisian, and Coralline Crag; *Arcopagia ventricosa*, also Plaisancian and Astian; *Tellina benedeni*, Messinian and from Bolderian to Scaldisian; *Plagiocardium hirsutum*, Plaisancian and Astian; *Astarte basteroti*, Redonian, Diestian, and Scaldisian; *Papillicardium papillosum*, Messinian, Redonian, St. Erth Beds, Plaisancian and Astian to recent seas; *Cyprina rustica*, Messinian, Anversian to Scaldisian, Box-stones, and Coralline Crag; *Cyrtodaria angusta*, Messinian, Bolderian to Scaldisian, Box-stones, and Coralline Crag; and *Panopæa menardi*, Anversian, Messinian, Box-stones, Coralline and Red Crags.

The only representative of the Brachiopod group of shells is *Terebratula perforata*, which ranges through the Redonian of France, Bolderian to Scaldisian of Belgium, and the Coralline and Red Crags of Britain. With the exception of *Ficus reticulata* and *Papillicardium papillosum*, which exist in present seas, the species thus enumerated are extinct. Several of the Lenham species occur in the Bolderian and Anversian beds of Belgium, the latter according to M. Dollfus[1] being Vindobonian, and equivalent to his Redonian stage, although attributed by Renevier[2] to the later Pontian (= Messinian) division of the Miocene. The Anversian and Diestian occurrences represent 34 and 30 species respectively, Box-stones 12, St. Erth 15, and the Coralline Crag 50. It has been urged by Mr. Harmer that the Coralline Crag fauna is younger than that occurring in the Lenham deposits because several of the older shells found there and that have been previously alluded to are absent in the Coralline Crag beds, a fact more or less accurate, although some important forms do occur in those deposits, such, for instance, as *Margaritifera phalænacea*, *Glans senilis*, *Cyrtodaria angusta*, *Panopæa menardi*, *Terebratula perforata*, etc.

All these facts seem to suggest that the Lenham and Coralline Crag faunas, although showing certain differences of detail, are, nevertheless, to be regarded as presenting a close relationship, and therefore to be considered as of approximately the same age. Marked affinities are also noticeable in the molluscan faunas of the Coralline

[1] Bull. Soc. Géol. France, ser. IV, vol. iii, pp. 256–60, 1903.

[2] "Chronographie Géol.—Text Explicatif": Comp. Rend. Cong. Géol. Internat. (1894), 1897, p. 597.

Crag and the Diestian beds of Belgium. This is apparent from Mr. Harmer's list of the Diestian species (Quart. Journ. Geol. Soc., 1898, vol. liv, p. 317), in which, out of rather more than seventy forms enumerated, nearly all are stated to occur in the Coralline Crag.

A considerable proportion of the Anversian species of Belgium, as listed by M. Van den Broeck (Ann. Soc. Mal. Belgique, 1874, vol. ix, pp. 118–121), likewise occur in the Coralline Crag, as out of a list of 175 species 80 are recognized as being found in that formation.

The following table shows the numerical representation of the seventy-seven Lenham species occurring in the principal formations:—

Recent	40	species.
Post-Pliocene	23	,,
Astian	36	,,
Plaisancian	40	,,
Scaldisian	44	,,
Norwich Crag	12	,,
Red Crag (probably derived from Coralline Crag).	48	,,
Coralline Crag	51	,,
St. Erth	16	,,
Box-stones	13	,,
Diestian	30	,,
Anversian	34	,,
Messinian	25	,,
Bolderian	17	,,
Redonian (Tortonian)	26	,,
Vindobonian (Helvetian–Tortonian)	47	,,

The so-called Older Pliocene beds of Mr. Reid's memoir are characterized by shells with a southern facies indicating warmer climatic conditions than prevailed in the Red Crag period, when boreal and Arctic species were largely predominant. The East Anglian Box-stone deposits have been regarded by Mr. Harmer[1] as the probable equivalent in time of the Waenrode Beds of Belgium, which Van den Broeck[2] has considered to be of Bolderian age and therefore Miocene. In this connexion it is interesting to note that the Box-stone beds have been quite recently regarded as Miocene by Mr. Reid.[3]

Sir Ray Lankester[4] determined some Proboscidean remains from those beds as a new species of *Mastodon*, although subsequently recognizing them as a variety of *M. angustidens* of Cuvier,[5] being further of opinion that they were older than the Diestian of Belgium. It is well known that Cuvier's species characterizes the older Vindobonian beds of France, and is frequently found in the ossiferous deposits of Sansan. When the Box-stone Mollusca are more studied, such an age as is here indicated will probably be more conclusively proved; in the meantime the evidence is in favour of those deposits being older than the Lenham Sandstones. The St. Erth deposits of Cornwall were originally described by Searles Wood[6] as

[1] Quart. Journ. Geol. Soc., vol. lvi, p. 708, 1900.
[2] Ann. Soc. R. Mal. Belgique, vol. xix, pp. lvi–lxvi, 1884.
[3] Mededeel. Rijks. Delfst., 1915, No. 6, p. 9.
[4] Quart. Journ. Geol. Soc., vol. xxvi, pp. 507–9, 1870.
[5] GEOL. MAG., 1899, p. 292.
[6] Quart. Journ. Geol. Soc., vol. xli, pp. 65–73, 1885.

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of Red Crag age, although he observed that "the character of the mollusca, as a whole, is essentially southern, no peculiarly Arctic shell having as yet occurred".

The fauna was more particularly described by Professor Kendall and R. G. Bell[1] in the following year and again referred to as contemporary with that of the Red Crag, a result contrary to the views of Mr. Reid, who claimed a greater age. Since that discussion Mr. Alfred Bell[2] has published a paper on the St. Erth Mollusca and regarded their age as Mio-Pliocene or Messinian, a somewhat similar horizon having already been partially suggested by Gwyn Jeffreys,[3] who stated: "He was not clear whether the St. Erth deposit was of Older Pliocene or possibly of Upper Miocene age." In the same paper Mr. A. Bell placed upon record an important opinion he had received from M. Dollfus, which reads as follows: "You have in St. Erth exactly the same Pliocene fauna as we have at Gourbesville in the Cotentin," a statement more or less confirming the previous researches of Mr. Reid (1890), who had acknowledged the necessity of a strict comparison between the molluscan species of Gourbesville and those of the St. Erth deposits, as the fossils from the former locality "point to conditions very similar to those indicated by the shells from St. Erth". The Gourbesville fauna, however, as previously mentioned, is now considered to be of Miocene age (Tortonian or Messinian). About fifty per cent of the Lenham shells are extinct species, a somewhat similar percentage marks the Boxstone fauna (according to a calculation made from Mr. A. Bell's memoir in Journ. Ipswich Field Club, vol. iii, pp. 7, 8, 1911), and Mr. Reid (Survey Memoir, 1900, p. 64) has stated that the Coralline Crag and St. Erth deposits contain each about forty per cent of extinct shells. It will be observed that there is a similarity running through these percentages of extinct forms, which appears to furnish satisfactory evidence for regarding the four stages of Mr. Reid's "Older Pliocene" group as of the same approximate geological age, although the Box-stones, as before explained, may be somewhat older.

From the foregoing details of the different faunas involved in this discussion, it is certain that many of the species had their origin in Miocene times. There is good reason for recognizing the St. Erth shells as of Miocene age, because of their relationship to species characterizing the French Redonian. Similarly, the Box-stone fossils would belong to the same period, as their affinities are with those of the Bolderian of Belgium, which is generally regarded as Tortonian or Upper Vindobonian.

Lastly, the Lenham fauna with its strong Vindobonian and Coralline Crag facies should also be placed in the Miocene, and in consideration of its relationship to that characterizing the Upper Miocene deposits of Northern Germany and the Anversian beds of Belgium, I would recognize it as belonging to the latest or Messinian stage of the Miocene, which is synonymous with the term Mio-Pliocene. The stratigraphical name of Mio-Pliocene was introduced into Belgian

[1] Quart. Journ. Geol. Soc., vol. xlii, pp. 201–14, 1886.
[2] Trans. Roy. Geol. Soc. Cornwall, vol. xii, p. 133, 1898.
[3] Quart. Journ. Geol. Soc., vol. xli, p. 72, 1885.

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geology by Mourlon,[1] who regarded it as including Lyell's "Upper Miocene" and Dumont's "Pliocène Diestien". It was recognized as comprising two divisions or zones, the first characterized by *Panopæa menardi*, and the second by *Glycymeris* [*Pectunculus*] *pilosa*, both of which are now included in the Anversian stage, or "Crag Noir", of the Belgian Miocene, which is developed at Edeghem and Antwerp. These two Pelecypods occur in the Vindobonian strata of Europe, *P. menardi* being found as well in the Lenham Beds, Box-stones, and Coralline Crag beds, whereas *Glycymeris pilosa* is found present in the same horizons, being likewise a member of the St. Erth fauna. Although acknowledging certain differences in the faunas of these Upper Tertiary horizons, which may be probably accounted for by different conditions of environment, no great disparity of time need be allowed for in considering their geological age. I am induced, therefore, from a knowledge of their conchology, to regard the Coralline Crag,[2] the St. Erth Beds, and the Lenham Beds of Britain, together with the Diestian and the Anversian of Belgium, as of Upper Miocene age, and belonging to the stage Messinian or Mio-Pliocene, while the Box-stones, or Nodule beds of East Anglia, I should consider as referable to the Vindobonian division of the Middle Miocene.

In accordance with these views, therefore, the following synopsis of the various geological horizons referred to is now proposed:—

Recent	. . . .	British and Mediterranean Seas.
Post-Pliocene	Glacial, etc.	Britain.
Pliocene	Norwich Crag	Britain.
	Red Crag (= Astian of Italy and Scaldisian of Belgium)	Britain.
Upper Miocene or Messinian (= Pontian or Mio-Pliocene)	Coralline Crag	Britain.
	Diestian	Belgium.
	St. Erth Beds (Cornwall)	Britain.
	Lenham Sandstones	Britain.
	Anversian (= "Crag Noir" of Edeghem and Antwerp)	Belgium.
	Upper Miocene	Germany (N.).
Middle Miocene (=Vindobonian)	Redonian (=Tortonian or Anversian)	France (N.W.).
	Box-stones (=Bolderian of Belgium)	Britain.
	Helvetian-Tortonian	Italy, Vienna Basin, Holland, Denmark, etc.
Lower Miocene	Burdigalian	France (S.W.).
	Aquitanian	Italy.

[1] *Géologie de la Belgique*, vol. i, p. 261, 1880.

[2] The foraminiferal evidence, also, lends support to the view that the Coralline Crag is of older age than has yet been accepted. According to the Monograph on the Crag Foraminifera by Jones, Burrows, and others (Palæontographical Society, 1897, p. 369) the following species are recorded from the Coralline Crag of Sudbourne: *Nummulina planulata*, *Amphistegina vulgaris*, *Operculina complanata*, and *Orbitoides aspera*, formerly determined as *O. faujasi*. These are said to be "derived from earlier beds", although from a recent examination of the specimens, which are in the Geological Department of the British Museum, they present the appearance of having been found in situ. However, the so-called *Nummulina* might indicate an Eocene or Oligocene horizon, but the other organisms are characteristically Miocene, especially when it may be stated that in *Orbitoides aspera*, after

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Lastly, I may mention that in 1907 I was favoured with a visit from the late Professor Dr. Gottsche, Director of the Hamburg Museum, and one of the chief authorities on the molluscan fauna of the North German Miocene deposits, for the purpose of examining the Lenham Collection of the Museum of Practical Geology, which was then in my keeping at the British Museum; he was specially interested in some specimens referred to in Mr. Reid's memoir as an elongated variety of *Triton heptagonum* (?), being confident that they represented Beyrich's *Fusus sexcostatus*, a characteristic fossil of the Upper Miocene formation of North Germany. He was further of opinion that the Lenham Beds were older than had hitherto been supposed, and he considered that they should be referred to the Miocene period.

REVIEWS.

1.—Some Problems in South African Geology. By P. A. Wagner. Proc. Geol. Soc. South Africa, 1917, pp. xix–xxxix.

In his Presidential Address to the Geological Society of South Africa for 1917 Mr. P. A. Wagner dealt at some length with four outstanding problems of the geology of that country, namely, the origin of the gold-reefs of the Rand, the genesis of the diamond, alteration of diamonds after their formation, and the nature of the famous salt pan near Pretoria. On each of these he had something of interest to say. An excellent summary is given of recent views as to the source of the gold in the Banket. Dr. Mellor has recently brought forward evidence in favour of the "placer" theory, founded largely on the actual distribution of the gold in the conglomerates. It is found by assays that the gold is richest where the pebbles are largest, and it is therefore argued that the gold was deposited by the strong currents that brought the large pebbles, the weaker currents that could bring only the finer sand not being competent to carry the heavier grains of gold. Nevertheless, the actual character of the particles of gold indicates recrystallization in place. Mr. Wagner dissents from Dr. Mellor's view that the quartzites and conglomerates were deltaic deposits and regards them as having been formed on beaches in a subsiding area.

The author considers kimberlite as the hypabyssal or volcanic form of a peridotite magma which he believes to underlie the granitic and other rocks at a great depth, and he regards the diamonds as original constituents of this magma, brought up, often in a fragmental form, during extrusion. He also gives some facts of great interest as to the possible effect of radio-activity or other agencies on diamonds after they reached their present position. This subject, however, appears to be of a very speculative nature, and much work is obviously required.

The salt pan on the farm Zoutpan, 25 miles N.N.W. of Pretoria, now gives rise to a considerable industry. The pan itself is a most

careful rubbing down of the horizontal surface on the median plane of the figured example, there is exposed a series of minute chamberlets of squarish or hexagonal outline which can only belong to the Miocene genus *Lepidocyclina*.