9. COAL- and PETROLEUM-DEPOSITS in EUROPEAN TURKEY. By
Lieut.-Colonel THOMAS ENGLISH, F.G.S. (Read December 18th,
1901.)

[PLATE IV—Map.]

IN the following paper I have attempted to give an account of the general succession, so far as at present known, of the formations which include some recently-discovered coal-seams and naphtha-bearing sands of Tertiary age, in the little-visited stretch of country lying to the north of the Gulf of Xeros in the Mediterranean and of the western portion of the Sea of Marmora.

The absence of any map sufficiently detailed for geological purposes renders it somewhat difficult to interpret various interesting features, and I feel that apology is due beforehand for many errors and omissions arising from this cause.

By far the best map is that compiled by the Russian military staff, on the scale of about half an inch to a mile, and the geological sketch-map which accompanies my paper is reduced from this. The Russian map is furnished with approximate contour-lines, apparently 10 sagues (=70 feet) apart; but these are only sketched in, and though amply sufficient for military purposes, do not give much geological information in so broken a country. I have therefore only transferred sufficient heights in feet to the sketch-map to give a general idea of the relief.

There is but little written description accessible of the geological features of the district. The only original information that I have been able to find is contained in Ami Boué's '*La Turquie d'Europe*,' 1840, and in Viquesnel's '*Voyage dans la Turquie d'Europe*,' 1868. The former² gives a short general summary of the composition of the Tertiary formation in Thrace. Viquesnel, in the atlas accompanying his book, shows a traverse-sketch of his itinerary, and also furnishes short descriptions of the rocks and fossils met with on the road. Some of the fossils were subsequently identified by Vicomte d'Archiac, and are described in an appendix to Viquesnel's second volume.

There is also a paper by F. von Hochstetter in the *Jahrbuch der k.-k. Geologischen Reichsanstalt*, 1870,³ but he states definitely (on p. 387) that he is dependent for his information, as to the district here dealt with, on Viquesnel, and that he had not himself visited the neighbourhood. Probably as a consequence, dependence cannot be placed in all points upon the geological map which accompanies his paper, so far as it relates to the localities which I propose to describe.

¹ Paris 1840, 4 vols. 8vo, with map.

² *Op. cit.* vol. i, pp. 319 *et seqq.*

³ '*Die geologischen Verhältnisse des östlichen Theiles der europäischen Türkei*' pp. 365-461 & pl. xviii (geological map).

These are included in a tract of country about 24 miles wide in a north-and-south direction, bounded on the west by the alluvial valley of the River Maritza, and on the south by the northern shore of the Gulf of Xeros; and in a littoral strip about 4 miles wide skirting the northern coast of the Sea of Marmora for about 32 miles, from abreast the head of the Gulf of Xeros to Ganos, opposite the western end of Marmora Island.

Hochstetter remarks (*op. cit.* p. 387) that

'this much, at any rate, can safely be derived from Viquesnel's account, that the core of this coastal chain of mountains is formed of old crystalline rocks (Viquesnel indeed generally mentions "terrain de transition") and chiefly of rocks of the "phyllite-zone" which are enveloped and overlain by Eocene Nummulitic limestones and sandstones, and by late Tertiary sandstones, limestones, clays, and marls.'

His map accordingly shows a large extent of 'pro-zoic' clay-slate (phyllite) which, so far as I can ascertain, has no existence, the area being occupied by Eocene strata and contemporaneous or younger volcanic rocks. It is true that Viquesnel often suggests 'terrains de transition,' but always with considerable reserve, and Vicomte d'Archiac, at the commencement of the description of fossils ('Voyage dans la Turquie d'Europe' vol. ii, 1868, p. 450) says:—

'We have not found, in the collection made by Viquesnel of fossils from Thrace, a single specimen belonging to transitional or even to old Secondary faunas. The only ones that denote the existence of late Secondary rocks are very few in number and come from two different localities.'

The lowest beds that I have seen are thinly-bedded hard blue coralline and softer brown Nummulitic limestones of Lutetian age. These crop out at the village of Vernitza (about 9 miles north-east of Ibridji on the Gulf of Xeros), where they show a north-westerly dip of about 15°, and are overlain conformably by blue shales. The junction-beds are one mass of nummulites, closely allied to *Nummulites complanata* and *N. biarrizensis*, of all sizes up to 2 inches in diameter, weathering into a gravel entirely composed of these fossils.

The outcrops of Eocene strata apparently form a belt stretching in an easterly-and-westerly direction for about 40 miles, as Viquesnel notes similar fossils at Margarice, 3 miles south of Vernitza; and Vicomte d'Archiac identifies *Nummulites Ramondi* and *Orbitoides sub-media* in yellowish compact limestone, subcrystalline, with splintery fracture, from Bournar Oren near Examil, on the isthmus between the Gulf of Xeros and the Sea of Marmora.¹ He also notes *Nummulites biarrizensis* and *N. Ramondi* in brownish-grey limestone from Mount Serian, 2 leagues north-east of Kavak, and again *N. Ramondi* in yellowish-grey compact limestone with waxy fracture from Mount St. Elias, near Sterna.²

At the last-named locality, the conical summit of the mountain, 2300 feet above the sea, is a mass of coarse marble dipping 20° south-eastward, with seams of calcite weathering into distinct crystals about a quarter of an inch along their edges. The eastern and

¹ *Op. cit.* pp. 324, 466, 467.

² *Ibid.* p. 457.

south-western slopes of Mount St. Elias are also formed of thickly-bedded limestone.

At Vernitza, the blue shales overlying the Nummulitic limestone, which are about 70 feet thick, are covered conformably by brownish-grey calcareous sandstones with rectangular partings. These strata, with occasional volcanic interruptions, form the principal features of the country, and apparently stretch continuously nearly 50 miles to the eastward, to Ganos and Combos on the Marmora coast.

A fault, or series of faults, running north-east and south-west, with a south-easterly downthrow, marks out the course of the Deli Osman River for about 5 miles north-east of Mount St. Elias, and no Eocene limestones or sandstones are visible south-east of this line. North-west of it, the sandstones, with a northerly and north-westerly dip of 20° to 30° , form a continuous ridge from near Mount St. Elias for 10 miles, until they reach the sea at Ganos. Eastward from this point they form high cliffs along the coast, dipping 30° inland, and rise quickly into the mountain-mass of the Tekfur Dag (Holy Mountain) about 3000 feet high, 3 miles inland from Ganos, which is the highest ground in the district.

The sandstones are generally fine-grained, grey or greenish in fresh fractures, weathering to a dark brown, and breaking into rectangular fragments, often with calcite-partings; they contain thin subordinate beds of clay and shale, and few, if any, recognizable fossils. With occasional interruptions of basalt and rhyolite, they extend over a large area, perhaps three-quarters of the whole extent of country described, and form a belt with several parallel folds and a general east-north-easterly and west-south-westerly strike. They skirt both sides of the upper portion of the Gulf of Xeros, and probably extend across its bed.

Like all the other formations seen, they are concealed at intervals under a mantle of reddish, unstratified, sandy clay unconformably overlying them, and containing small angular fragments of sandstone which generally do not exceed a few cubic inches in volume.

The sandstones and associated beds are at least 3000 feet thick, both on the coast-section east of Ganos and in the western portion, along a south-easterly and north-westerly section following the road from Examil to the town of Keshan, a distance of 24 miles, approximately at right angles to the line of strike.

On this section, at the southernmost point exposed, near the village of Examil, the strata dip 30° to 15° northward for 2 miles. The head of the Gulf of Xeros, 6 miles wide, is covered by alluvium and stony clay, through which some small basaltic knolls appear. Near the village of Kodja-chesme the sandstones reappear with a south-easterly dip of 60° to 30° ; and the ground rises rapidly to a well-marked anticlinal 3 miles beyond this point, with a north-easterly and south-westerly strike, which forms the ridge of the Kuru Dag range of hills, about 1400 feet high, skirting the northern shore of the Gulf of Xeros.

North-west of this point the dip is generally north-north-westerly 10° to 30° where it can be seen, for about 3 miles, when the sequence of the sandstones is interrupted for 2 miles by a mass of scoriaceous olivine-basalt with palagonite. The sandstones are then covered by stony clay and alluvium for 4 miles, as far as the village of Teke-keui (about 4 miles from Keshan), where they reappear dipping 20° northward, and the road skirts another large mass of basaltic rock (melaphyre) as far as Keshan.

I have not been able to determine satisfactorily whether these masses of basalt are intrusive or interbedded with the sandstones, but the general dip of the strata does not seem to be affected by them. Several similar basaltic masses appear among the sandstones and higher strata to the south-west in a chain stretching eastward from the large volcanic mass forming the Enos mountain.

Beyond Keshan to the north-west and north, the sandstones continue to dip in a northerly direction at moderate angles into a synclinal basin, 8 miles across from south to north, along the edges of which the outcrops of several seams of coal have been traced.

One seam in particular crops out for a distance of at least 3 miles along the southern edge of the basin, at about 400 to 500 feet above sea-level, from a point 1 mile north-east of Keshan; and the same seam, to all appearance, occurs again at Boztepe, 6 miles west of Keshan. Along the north-western edge of the basin, following a curved line passing through the villages of Boztepe, Beyendikeui, and Mousali, the sandstone-strata generally dip steeply south-eastward.

A considerable fault, with a downthrow to the north of at least 90 feet, dislocates the coal-seam at Boztepe; but the general features of the basin are so much concealed by stony clay, that the extent of this, and of other probable faults can only be ascertained by future underground workings.

The coal is now being worked near Keshan, where it is from 3 to $3\frac{1}{2}$ feet thick, and consists of a bituminous hard coal with the characteristic features of cannel, burning with a long flame and little smoke. The coal is non-coking, does not soil the fingers, and breaks with a cubical, occasionally a conchoidal fracture. The specific gravity is about 1.37, and good samples yield about 2 per cent. of grey ash. Near the outcrop, so far as the workings have as yet gone, the coal is deposited directly on the sandstone and has a hard clay-roof about 2 feet thick, in which many impressions of dicotyledonous leaves occur.

A remarkable feature in connection with this deposit is the occurrence above the coal, and generally separated from it by about 40 feet of shales, clays, and sandstones, of a thick layer (usually 40 to 50 feet) of brecciated rhyolite. This layer is very persistent, and has possibly had some influence in the conversion of lignite into true coal. Overlying the coal near Mousali, on the northern edge of the basin, there is a layer of decomposed andesite, with much biotite. Near the centre of the basin, 4 miles north of Bulgarkeui,

is an outcrop of augite-syenite forming a large knoll; and outside the basin, at Kurujekeui on the north-west, there is a considerable outcrop of mica-basalt, with biotite and augite.

A section of a trial-boring, striking the coal at 122 feet from the surface, is appended; and I consider that this may be taken as a fair sample of the average formation immediately above the coal, so far as yet known:—

Section of borehole above the coal between Keshan and Bulgarkewi.

	Dip N. 25° E. at 33°.		Vertical thickness.	
			Feet.	Inches.
Red stony clay			34	0
Volcanic ash and conglomerate (Rhyolite)			48	7
Sandstone with black layers			6	7
Coaly mixture			1	6
Shale and clay			5	4
Sandstone			1	6
Shale and clay			5	4
Coaly mixture			0	11
Shale and clay			11	4
Sandstone			0	6
Shale and clay			5	6
Chocolate-coloured ground			0	10
COAL			3	4
Sandstone			1	6

There are many indistinct leaf-impressions in the sandstone-beds above and below the coal, but no other fossils have yet been discovered in the sandstones, which in this neighbourhood, especially below the coal, are very thickly-bedded and free from joints, greenish-grey in colour, and form admirable building-stones. Some of the cores produced by diamond-drilling have been brought to the surface in lengths of 4 or 5 feet, and some of the beds are sufficiently tenacious and gritty to be worked for grindstones.

A boring 225 feet deep, immediately below the coal, yielded the following section:—

Section of borehole below the coal between Keshan and Bulgarkewi.

	Dip N. 25° E. at 15°.		Vertical thickness.	
			Feet.	Inches.
Grey sandstone			7	6
Blue shale			5	0
Grey sandstone			5	6
Blue shale			20	0
Grey sandstones intermixed with blue shales			17	0
Grey sandstone			12	0
Grey sandstone with shale			4	0
Grey sandstone			3	0
Dark blue shale (rough-grained)			20	0
Blue shale (lower 3 in. clay)			16	3
Blue shale intermixed with grey sandstone			14	9
Grey sandstone, with layers of blue shale			27	6
Blue shale, with layers of sandstone			45	0
Grey sandstone, with layers of shale			8	6
Blue shale, with layers of sandstone			22	0

As I have not been able to find a complete section of the sandstones free from interruption by basalt or stony clay, I cannot say definitely whereabouts in the series the coal occurs, but I am inclined to place it not far from the middle; there are more shale-beds interstratified with the sandstones near the coal-horizon than far above or below it.

A seam of coal of similar quality, also interbedded with these sandstones, and 2 feet 4 inches thick, crops out at Capoudjidere, 3 miles north-east of Examil, at the head of the Gulf of Xeros. The sandstones and coal are here dipping 50° south-eastward, directly into the hill which forms the southern slope of the Kavak river-valley, at about 400 feet above sea-level.

A layer of brecciated rhyolite is interstratified with the sandstone-beds between the villages of Kiskapan and Grabuna, and may probably be the same as that at Keshan, but no coal has yet been found in connection with it.

Much-disturbed beds of doubtful age occur to the south-west of this, apparently overlying the sandstones. Among them are several outcrops of palagonite-tuff, interstratified with thinly-bedded shales, which come to the surface near the village of Geltic. In one specimen microscopic foraminifera (*Globigerina*) are included in the tuff. A sample of fragmental, possibly reconstructed limestone from near Bekeui contains a few small *Nummulites biarritzensis* and other foraminifera:—*Carpenteria*, *Operculina complanata*, *Orbitoides papyracea*, and *O. sumatrensis*; also angular quartz-granules, pieces of dolomite, and probably palagonite.

In apparent connection with these beds is a series of variegated clays and sands. Similar clays appear to the east of Mount St. Elias, where they are tilted to very steep angles, and are of considerable thickness, perhaps 500 feet. The upper tributaries of the Deli Osman River have cut deep gorges through these beds, in which mineral springs occur.

A large expanse of hard limestones overlying the above-mentioned tuffs includes the sea-cliffs near Ibridji, on the Gulf of Xeros. These strata are generally grey, very hard, semi-crystalline, and sometimes thickly-bedded. A specimen from Ibridji was largely composed of foraminifera, *Lithothamnion*, polyzoa, and ostracoda. The recognizable foraminifera belong to the genera *Spiroloculina*, *Planispirina*, *Textularia*, *Anomalina*, and *Heterostegina*. Another specimen from about 3 miles north of Ibridji, of fragmental limestone with much calcitic cement, was also composed largely of foraminifera, *Lithothamnion*, and polyzoa, containing *Miliolina*, *Globigerina*, *Pulvinulina*, *Amphistegina*, and *Heterostegina*.

Near Erekli, on the coast 4 miles west of Ibridji, and at Fakirma village north of this, a capping of soft friable limestone-beds of Miocene (Helvetian) age occurs, containing *Pecten subbenedictus*, *Ostrea*, and *Cardium*. These Miocene rocks apparently extend westward along the coast as far as Cape Gremia at the

mouth of the Gulf of Xeros, occupying all the country to the south of the Enos Mountain.

In the north and north-west the Eocene sandstones are occasionally overlain by soft sandy strata, probably Pliocene, containing *Melanopsis* allied to *M. Martiniana*, at a point $1\frac{1}{2}$ miles north of Boztepe, and numerous casts of *Corbula Sauleyi*, *Cardium*, and *Dreissensia* near Ghonue and Malgara; also *Cardium Paulini* and *Corbula Sauleyi* at Maltepe.

In the district south-east of the fault which stretches from Mount St. Elias to Ganos a series of sands, marls, and clays occur, with which naphtha-bearing beds are interstratified. The lowest beds visible are clays containing indeterminate Unioniform shell-remains, probably Pliocene; the beds above are generally light-coloured and very variable in composition.

From the junction of the Deli Osman River with the Milos Brook, 320 feet above the sea, the river runs 3 miles eastward to the village of Hora, where it falls into the Sea of Marmora. At this junction naphtha in fair quantity, and under considerable gas-pressure, has been obtained from borings about 300 feet deep. Appended is the section of a borehole, $1\frac{1}{2}$ inches in diameter, which has yielded at the rate of 2 tons in 24 hours.

*Section of naphtha-borehole, at the junction of the Deli
Osman River and the Milos Brook.*

	Feet.	Inches.
Yellow loam and boulders	35	6
Grey marls.....	4	6
Grey sandy limestone	1	0
Blue and red marls	12	0
Hard grey limestone.....	0	6
Grey marls.....	4	6
Limestone (chalky)	0	6
Clay	0	6
Limestone	0	6
Marls	11	6
Soft calcareous conglomerate	2	0
Marls	18	0
Sandy marls	4	0
Hard limestone	0	4
Sandy marls	11	8
Blue and red marls	32	0
Running sand with brackish water.....	3	0
Yellow clay.....	4	0
Blue, red, and yellow marls.....	30	3
Cream-coloured limestone	0	3
Blue and yellow marls	47	0
NAPHTHA.		
Limestone	0	6
Marls	15	6
Hard limestone	0	9
Marls	15	0
Sandy marls	28	0
NAPHTHA.		
Yellow clays	0	6
Grey marls.....		

The naphtha has a specific gravity of about 0·825, and contains about 10 per cent. of paraffin; it is accompanied as usual by a flow of bitter-salt water.

The naphtha-sands and marls, with a thickness of perhaps 1000 feet, occupy the surface from Sarkeui eastward as far as Ganos, for a length of about 15 miles along the coast, and extend inland for an average breadth of about 3 miles. The strata are very much disturbed over the whole area, and are nearly vertical in places. The only fossil that I have seen from them is a specimen of a small variety of *Melanopsis*. West of Sarkeui the naphtha-sands are hidden by red stony clay, but show in many of the gorges.

Indications of naphtha, in the shape of sands with a strong smell of petroleum and surface-oozings of bitumen, occur at many points between Ganos and Sarkeui. Several beds of lignite, 12 to 18 inches thick, are intercalated. North-eastward from the naphtha-borings, these sands and marls can be traced for about $1\frac{1}{2}$ miles, nearly as far as the village of Milos, where they have a conglomerate-capping containing *Planorbis* and *Cyrena*, and dipping 30° northward.

It has hitherto proved impracticable to determine from the surface whether the Eocene sandstones and limestones exist under the Pliocene strata; but a deep boring now proposed will probably settle this point, and also the presence or absence of the coal-horizon in this part of the country.

The stony clay, which has several times been referred to, is spread unconformably over all the formations already described. In general it occupies the lower grounds, but has no apparent connection with the present drainage-system. At Ibridji it covers a limestone-saddle about 420 feet above the sea-level. In many places it is of considerable thickness, and a shaft sunk in it to a depth of 170 feet near Boztepe has not reached the bottom. At the eastern end of the district, it abuts against the flanks of the sandstone-mountains of the Tekfur Dagħ to a height of about 1000 feet, and forms a considerable mass, covering a saddleback which forms the water-parting of the Ganos and Milos Brooks, and stretching down both valleys towards the sea, with a thickness, where exposed in a ravine leading to the Ganos Brook, of at least 100 feet, and a surface-slope of about 4° from the mountain.

Many scratched and striated sandstone-boulders (see figure, p. 158) occur in the clay near Milos village, at 900 to 1000 feet above the sea-level. Lower down the Milos Valley near the naphtha-borings, the mass changes in character, and becomes much more stony and full of subangular and faceted sandstone-boulders, which fill up the valleys through which the Deli Osman River and Milos Brook run. The existing streams have cut their way through this deposit, rearranging the boulders and carrying them down the valley towards the beach at Hora. Neither the upper nor the under surface of the stony mass agrees at all in slope with the existing river. One of the borings for naphtha, starting from the river-level, passed

through 60 feet of clay and boulders; while half a mile above the naphtha-borings, in the Deli Osman Valley, there is a cliff-section

Scratched sandstone-boulder, Milos. (Length=about 2 feet.)

[From a photograph.]

60 feet high from the river-level, composed of 40 feet of boulders and clay, with a capping of sand slipped down from the naphtha-bearing strata.

At the naphtha-borings, the upper surface of the stones is about 12 to 17 feet above the river-level, and presents a series of parallel ridges, about 5 feet high, curving diagonally, with a downstream convexity, across the Milos Valley. These ridges are full of boulders up to 3 tons in weight, and have a general surface-slope down the valley of 3° . The river-slope is 1° , and no boulders of more than 5 cwt. are visible in the channel.

The stony clay merges similarly into a mass of stones in the Ganos Valley, as the sea is approached. This valley is prolonged into the Sea of Marmora to a very remarkable depth, rivalling the deepest fiords of Norway: soundings of 533 fathoms being shown on the Admiralty Chart about 4 miles east-north-east of Ganos and within $1\frac{1}{2}$ miles of the coast, which at this point is formed by the steep sandstone-cliffs of the Tekfur Dagh, dipping 30° inland. Farther west there are scarcely any soundings of 50 fathoms for more than 100 miles towards and through the Dardanelles.

At the Hora Lighthouse, about 1 mile to the south-west of the river-mouth, a very well-marked 'raised beach' occurs at 130 feet

above the present sea-level. The remains consist of rounded sandstone-pebbles up to 2 inches in diameter, cemented into a strong concrete by a calcareous matrix. Where the underlying sands, which dip about 10° north-eastward, are weathered out, large tabular masses of concrete, 3 and 4 feet thick, have tumbled down the slope; but the upper surface, where preserved, is singularly level, and can be traced for $\frac{3}{4}$ mile along the coast.

The lighthouse is built on the most salient remaining knoll. The natural concrete contains, between the pebbles, abundant specimens of the recent fluviatile shell *Dreissensia polymorpha*, and a *Neritina* (probably *N. danubialis*), showing that, at the time of the formation of this beach, the Dardanelles Channel could not have been open to its present depth. The fresh water within the Sea of Marmora must, at that epoch, have stood at a sufficient height to collect the drainage of the whole of South-eastern Europe and Western Asia, an area of at least 2,000,000 square miles, into a freshwater sea, from which the volume of water discharged would, even with the present small rainfall, not be less than twice that of Niagara.

The Dardanelles Channel is itself a gorge cut back through soft horizontal Miocene strata, with every appearance of rapid erosion by falling water.

At Myriophyto, 6 miles west of Hora, there are obscure traces of a pebble-conglomerate at about 330 feet above sea-level; but I could not find enough material *in situ* to enable me to speak with confidence as to whether the remains are those of another 'raised beach.'

Along the Anatolian coast of the Black Sea, terraces occur at several points, at various heights up to about 700 or 800 feet, as judged from the sea. Prof. Wright, in his paper read before the Society on March 6th, 1901,¹ described one of these at Trebizond at the 650-foot level, as a deposit of fresh-looking beach-gravel. I think that the freshwater beach at Hora affords a strong presumption that the water, when standing at these higher levels, was also fresh, and not brought in from the Mediterranean.

A high level of fresh water, gradually collected by rainfall or ice-drainage, and released by rapid erosion of the drainage-channel from the levels indicated by these beaches, may account for a number of perplexing problems in these regions, without invoking a series of inland continental subsidences and subsequent re-elevations.

I have to thank Mr. R. B. Newton, F.G.S., for very kindly identifying many of the fossils collected.

EXPLANATION OF PLATE IV.

Geological sketch-map of a portion of Turkey-in-Europe, bordering the Gulf of Xeros and the Sea of Marmora, on the scale of one quarter of an inch to the mile.

¹ Quart. Journ. Geol. Soc. vol. lvii, p. 249.

DISCUSSION.

Prof. SOLLAS remarked on the great interest of the observations contributed by the Author to the history of a district which would always be associated in the minds of geologists with the genius of Neumayr. That Eocene beds were involved in the structure of the Aegean 'island' was a new and hitherto unsuspected fact, which would render necessary some corrections in its outlines, if not a fundamental change in our conceptions concerning it. Hitherto the oldest post-Palæozoic beds recognized in the district were the Sarmatian, and curiosity was naturally aroused as to the nature of the succession intervening between these deposits and the Eocene. It was to be hoped that the Author would be able to furnish sections in illustration of this question.

As regards the origin of the Dardanelles, Neumayr had supposed that they had been produced probably as a valley along a line of fracture, and at a time so recent as the Pleistocene. Prof. Andrussov, however, had given reasons to show that they were probably already in existence during the Upper Pliocene, since the Cháuda Beds of Kerch occur, according to him, near Gallipoli, where they contain *Didacna crassa* and *Dreissena Tschaudæ*. Besides this, *Dreissena rostriformis* is found both at the bottom of the Pontus and of the Sea of Marmora, thus proving the existence of Pontic conditions in that Sea during late Pliocene times. In view of these facts, the age of the 'raised beach' becomes a matter of extreme importance; if it is not on the horizon of the Cháuda Beds, fresh difficulties arise in our study of this problem, which may be welcomed as likely to lead to a more complete solution.

Virchow had described undulating ridges stretching across the alluvial plains of Troy, containing large blocks of stone derived from the mountains behind; and Neumayr commented on the interest of this discovery, in view of the fact that no signs of extended glacial action had been furnished by the Balkan Peninsula. The present Author's observations confirmed and extended the conclusions of Virchow, even if the evidence as to the existence of glacial striæ were of a very doubtful character, as to him (the speaker) it seemed to be.

Prof. HULL considered the paper of great interest, as bearing on the view that the Mediterranean Sea consisted in Pleistocene times of a series of freshwater lakes connected with the Black Sea by the Straits of the Dardanelles, and by channels now submerged, one of which had been traced by soundings by Admiral Spratt. When elephants and hippopotami inhabited Malta—as shown by Leith Adams—the surrounding waters were unquestionably fresh, the outlet into the ocean being closed. The Author's description of the great boulder-clay formation suggested the agency of glaciers in Asia Minor during Pleistocene times; and this was by no means improbable, when we recollected that glaciers had descended from the Lebanon, and had left their terminal moraines at a level of 4000 feet above the sea, from which the cedars were now rising, as described by Sir Joseph Hooker.

Prof. SEELEY desired that the Author should state the physical evidence on which he inferred the former great development of the freshwater lake assumed to be represented by the Sea of Marmora. The genus *Dreissena* was met with in the marine Miocene of France, and *Neritina* was separated by so uncertain a boundary from the marine *Nerita*, that the palæontological evidence was not conclusive that freshwater conditions had given place to marine in the way stated. The change was not improbable, but it needed demonstration. It did not appear evident to the speaker that the rhyolitic outbursts could be determined as of definite geological age: they pierce indeed the Nummulitic Series, but there was need of local evidence to fix their age.

Mr. H. W. BURROWS remarked that the assemblage of fossils was not very convincing, as to either exclusively marine or exclusively freshwater conditions; and they might well be of fluvio-marine origin. The presence of foraminifera, however, would be distinctive, and he therefore recommended microscopic examination of the specimens.

The AUTHOR replied that he thought that the occurrence of marine Miocene (Helvetian) shell-beds at Erekli on the Gulf of Xeros required a much greater change in the position of the coastline of the Miocene Ægean land, than Prof. Sollas seemed inclined to admit. The displacement would not be less than 100 miles from the line shown in Lapparent's 'Traité de Géologie.'

The Author had quite recently examined the Quaternary shell-beds at Gallipoli, referred to by Prof. Sollas, of which a sketch-section was given in Calvert & Neumayr's paper.¹ This section is described in their paper as composed of eroded remains of Tertiary beds, tilted and dipping inland, overlain by the horizontal shell-beds to a depth of 30 or 40 feet, the latter forming steep cliffs towards the Hellespont.

The Quaternary beds examined by the Author form a very solid shell-conglomerate, with horizontal partings, split vertically in many places into columnar masses, and protected from further erosion by a talus of their own material in large tabular blocks, extending in places for 100 feet into the water. These blocks are generally tilted, so as to present the appearance of an inland dip, but no older material is at present visible. In any case, the Author did not think that these shell-beds materially affected the question of the erosion of the Dardanelles, as they did not make up more than a twentieth part of the height of the cliff-sections visible in the channel. He also thought that the deposition of these shell-beds was subsequent to the erosion of the channel, as Calvert & Neumayr stated that out of 33 species of shells occurring in them, 29 were still living in the Mediterranean, generally widely spread.

The Author quite admitted the fact pointed out by Prof. Seeley,

¹ 'Die jungen Ablagerungen am Hellespont' Denkschr. k. Akad. Wissensch. Wien, vol. xl (1880) pp. 357-78 & 2 plates.

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that the presence of *Neritina* in the raised beach at Hora did not necessarily imply absolutely fresh water (though the identification of *Neritina danubialis* was confirmed by Vicomte d'Archiac on a specimen from the same place)¹; but he submitted that this was not necessary to his argument, which was that the presence of these shells did show that at the time of this deposit there was no influx, as there was at present, of Mediterranean salt-water to the locality. The only way, as it appeared to him, by which it could be kept out, would be by a difference of level between the Mediterranean and the Sea of Marmora, the latter being the higher. If this were granted, the Author saw no reason to prevent the fresh or brackish water from having stood at one period at the level indicated by this beach, or at any other level required to effect the erosion of the Dardanelles Channel.

¹ Viquessel's 'Voyage dans la Turquie d'Europe' vol. ii (1868) pp. 480, 481.