tered in Spitzbergen, that south-west winds are usually accompanied by rain and thaw even in December and January.

A paper was then read, "On the Tertiary Formations and their connexion with the Chalk in Virginia and other parts of the United States," by Charles Lyell, Esq., V.P.G.S.

Having examined the most important cretaceous deposits in New Jersey, Mr. Lyell proceeded, in the autumn of 1841, to investigate the tertiary strata of Virginia, the Carolinas and Georgia, with a view to satisfy himself, first, how far the leading divisions of the tertiary strata along the Atlantic border of the United States agree in aspect and organic contents with those of Europe; and, secondly, to ascertain whether any rocks containing fossils of a character intermediate between those of the cretaceous or the eocene beds really exist. The conclusions at which he arrived, from his extensive survey, are given briefly as follows:—1. The only tertiary formations, which the author saw, agree well in their zoological types with the eocene and miocene beds of England and France; 2. he found no secondary fossils in those rocks which have been called upper secondary, and supposed to constitute a link between the cretaceous and tertiary formations.

1. *Virginia.*—The tertiary strata bordering the James River, Mr. Lyell says, have been well described by Prof. H. D. Rogers and Dr. Rogers*; and, he adds, they are also noticed in Mr. Conrad's excellent work on the tertiary strata of the United States. At Richmond, Mr. Lyell examined the remarkable bed of infusorial clay described by Prof. Rogers†, consisting of an impalpable siliceous powder derived from cases of microscopic animalcules. It varies in thickness from twelve to twenty-five feet, and is interposed between eocene greensands and miocene clays; but Mr. Lyell agrees with Prof. Rogers in considering it as probably belonging to the former epoch.

Similar eocene greensands, very much resembling the cretaceous greensand of New Jersey, occur at Petersburg, thirty miles south of Richmond, and are overlaid by a large deposit of miocene marls abounding in testacea different from those of the subjacent sands. Among the fossils of the latter deposit are a Venericardia scarcely distinguishable from *V. planicosta* of the London clay, also an Ostrea almost equally near to the *Ostrea bellovacina* and the *O. sellæformis*, so widely disseminated through the eocene formations of South Carolina and Georgia, is found in the uppermost beds of the formation at Coggin's Point, on the James River. The part of Virginia to which these remarks refer, is a flat region, forty or fifty feet above the level of the sea. The miocene strata which compose the upper beds consist sometimes almost exclusively of shells, and in the neighbourhood of Williamsburg Mr. Lyell collected eighty species, which bear a great resemblance generically, and in their relative numerical force, to collections from the Suffolk crag and the Faluns of Touraine.

* American Phil. Trans., New Series, vol. v. p. 319 *et seq.* 1835, and vol. vi. p. 347 *et seq.* 1839. † States' Report, 1840.

Among these Testacea are several species of Astarte, some very analogous to those of Suffolk, the *Voluta mutabilis*, which resembles the *V. Lamberti*, also *Conus diluvianus*, *Lucina squamosa*, and *L. divaricata*. Mr. Lyell says there are many other analogies among the Mollusca, besides the occurrence of several corals, Echinodermata, fishes' teeth and bones of Cetacea; but he shows that the most important point of comparison is in the proportion of recent to extinct Testacea. Out of eighty-two species which he collected at Williamsburg, sixteen are considered by Mr. Conrad to be recent, and found for the greater part living on the coasts of the United States. The existing species, therefore, are in the proportion of one-fifth of the whole, which agrees well, says the author, with the average per-centage in the shells obtained by him in 1840 from the Faluns of Touraine. The entire number of American miocene shells known to Mr. Conrad is 238, of which thirty-eight have been identified with recent species.

North Carolina.—In the neighbourhood of South Washington, on the north-east branch of Cape Fear river, Mr. Lyell found the dark, bluish marls of the cretaceous series, to which his attention had been directed by Mr. Hodge's paper in Silliman's Journal*. They closely resemble, in composition and organic contents, those in New Jersey, and abound with *Belemnites mucronatus*, *Exogyra costata*, and a species of Gryphæa resembling *G. columba*; Mr. Lyell also found in them *Ostrea vesicularis* and *O. pusilla* of Nillson, likewise *Anomia tellinoides*, a species of Plagiostoma, and several new shells. These marls extend to the south of Lewis Creek, for several miles along the banks of the north-east branch of Cape Fear river, nearly to Rocky Point, where they are covered by the Wilmington limestone and conglomerate. This formation, which is overlaid by miocene strata, and ranges to Wilmington, as well as along the coast to Cape Fear river, has been considered by Mr. Hodge, and other geologists, to be an upper secondary deposit, or interposed between the eocene and cretaceous series; but Mr. Lyell could find in it no organic forms which supported this opinion, nor could he learn that any had been discovered. On the contrary, the only determinable species apparently agree with the *Lucina pendata*, an Alabama shell, and *Pecten membranosus*, both eocene fossils. The organic remains at Wilmington are only casts, but are referable to the genera Cardium, Nucula, Corbula, Cardita, Venus, Arca, Natica, Oliva, Cypræa, Conus, Calyptræa, and Siliquaria. Associated with these remains of Testacea are a species of Lunulites and several other corals, the claws of Crustacea, and teeth of the Lamna family. Many of these fossils occur at Rocky Point, including *Pecten membranosus*, with a Lunulite and a Vermetus subsequently found by the author in the limestone of the Santee canal in South Carolina.

South Carolina and Georgia.—Charleston stands on a yellow sand, beneath which is a blue clay containing the remains of Testacea that inhabit the adjacent seas; and Dr. Ravenel informed Mr. Lyell that he had found in it the *Gnathodon cyrenoides*, not now known to occur in a living state nearer than the Gulf of Mexico. The author

* Vol. xli. p. 332, 1841.

could not ascertain whether this post-pliocene formation rises above high-water mark; but he states that, on the Cooper river thirty miles north of Charleston, there occurs beneath the superficial sand and mottled clay a freshwater formation, in which Dr. Ravenel has found the remains of the Cypress, Hiccory and Cedar, which must have grown in a freshwater swamp, although the formation is now six feet below the level of high water. No shells have been noticed in the deposit, but they are also commonly wanting in the marsh accumulations of that region. As the salt water of Cooper river must now cover much of this deposit, a very modern subsidence, Mr. Lyell says, must have taken place along the coast. At Dr. Ravenel's plantation in the low country near the mouth of Cooper river is a pulverulent limestone, artificially exposed, which Mr. Lyell thinks may be an eocene formation, though its fossils differ from those of other deposit of that epoch.

Between this point and Vance's Ferry, on the Santee river, is a continuous formation of white limestone, which Mr. Lyell examined with Dr. Ravenel at Strawberry Ferry, Mulberry Landing, the banks of the Santee canal, Wantout and Eutaw. It varies in hardness, and consists of comminuted shells; but it very rarely exhibits any laminæ of deposition, and even where it attains a thickness of twenty or thirty feet there would be a difficulty in determining whether it were horizontal, if a bed of oysters, like that at Vance's Ferry, did not occasionally occur. At the Rock bridge near Eutaw springs, the limestone composed of comminuted shells, corals, the spines of Echini, &c., resemble so precisely the upper cretaceous formation at Timber Creek in New Jersey, that Mr. Lyell at first felt no doubt of the identity of the two formations, although the organic contents of the limestone prove that it belongs to the tertiary series. This resemblance has led to the admission into Dr. Morton's excellent work on the fossils of the cretaceous group, of the *Balanus peregrinus, Pecten calvatus, P. membranosus, Terebratula lachryma, Conus gyratus, Scutella Lyelli,* and *Echinus infulatus**, though they do not really belong to the chalk series; and to several other similar mistakes whereby, Mr. Lyell observes, beds of passage have been erroneously supposed to exist. Among the most widely distributed of the limestone fossils is the *Ostrea sellæformis*; and he searched in vain at various points throughout a distance of forty miles for an admixture of characteristic cretaceous and tertiary organic remains, though the chalk formation, containing Belemnites and Exogyræ, occurs between Vance's Ferry and Camden. The Santee limestone, he is of opinion, cannot be less than 120 feet thick at Strawberry Ferry, being vertically exposed to the extent of seventy feet in the banks and bottom of Cooper river, and to the height of fifty feet in the neighbouring hills. Its upper surface is very irregular, and is usually covered with sand in which no shells have been found. Mr. Lyell followed the limestone north-westwardly for twelve miles by Cave Hall and Struble's Mill to near Half-way Swamp. At Stoudenmire or Stout Creek, a tributary of the Santee, it has disappeared beneath a newer

* See pl. 10. of Morton's Synopsis.

tertiary deposit of considerable thickness, consisting of slaty clays, quartzose sand, loam of a brick-red colour, and beds of siliceous burr-stone. Mr. Lyell is not aware of any published description of this formation, though he afterwards met with it on the Savannah river. In both localities some of the clays break with a conchoidal flinty fracture when dry, and even occasionally pass into a stone closely resembling menilite. The fossils which he found were in the state of casts. He does not determine whether this formation should be regarded as an upper division of the eocene group or not; but he has little doubt that it is of the same age as the burr-stone series of Georgia. In the notice of the cretaceous and tertiary strata of the Southern states, drawn up by Dr. Morton from the notes of Mr. Vanuxem, the tertiary limestone and the burr-stone sand and clay are included in the same group, and Mr. Vanuxem informed Mr. Lyell that he had not been able to determine their relative position; but from what Mr. Lyell saw on the Savannah river, he infers that the burr-stone formation is above the limestone. One of the strata at Stoudenmire is extremely light and of white colour and resembles calcareous tufa, but according to the analysis of Prof. Shepard it contains no carbonate of lime; Mr. Lyell, therefore, states it may probably be of infusorial origin.

At Aikin, sixty miles west of Orangeburg, and near the left bank of the Savannah, an inclined plane in a railway has been cut through strata 160 feet in thickness, consisting of earth and sand of a vermilion colour and containing much oxide of iron; also of mottled clays and white quartzose sand with masses of pure white kaolin. These strata are within ten miles of the junction of the tertiary formation and the great hypogene region of the Appalachian or Alleghany chain, and their materials, Mr. Lyell states, have evidently been derived from the decomposition of clay-slate and granitic rocks. No fossils were observed by him in the deposit at Aikin. A similar formation is extensively developed at Augusta, where the Savannah divides the states of South Carolina and Georgia, and it must, in some places, be more than 200 feet thick. Three miles above the town are the rapids, which descend over highly inclined clay-slate and chlorite schist, overlaid unconformably by tertiary beds. This point is the western boundary of the supracretaceous series; and Mr. Lyell observes, that on all the great rivers of the Atlantic border from Maryland to Georgia, and still further south, the first falls or rapids are along a line at which the granitic and hypogene rocks meet the tertiary, and which is nearly parallel to the Atlantic coast, but at the distance of 100 or 150 geographical miles. This great feature, Mr. Lyell states, was first pointed out by Maclure, but he adds that portions of the tertiary formations usually cover the hypogene rocks for a certain distance above the Falls, and that their outline is very irregular and sinuous. On Race's Creek near Augusta, the highly inclined clay slate, containing chloritic quartzose beds with subordinate strata much charged with iron, are decomposed to the depth of many yards into clays and sands which resemble so precisely a large portion of the horizontal tertiary strata of the neighbouring country, that the disintegrated ma-

terials might be mistaken for them, if the veins of quartz which often traverse the argillaceous beds at a considerable angle, did not continue unaltered. The only point at which Mr. Lyell saw any organic remains in beds associated with these upper tertiary red strata was at Richmond in Virginia, where he obtained casts of decidedly miocene fossils; but as he observed on the Savannah river thick beds of sandy-red earth beneath the burr-stone of Stony Buff, he concludes that the same mineral character may sometimes belong to the upper division of the eocene group. At the rocks six miles west of Augusta, the tertiary beds derived from the hypogene rocks have the appearance of granite, and have been called gneiss by some geologists. They exhibit occasionally a distinct cross-stratification, and include angular masses of pure kaolin.

Though the Savannah, in its course from Augusta to the sea, flows for the greater part in a wide alluvial plain, and has a fall of less than one foot in a mile, yet Mr. Lyell descended it to obtain information, by means of the Bluffs, respecting the superposition of the several masses, natural sections being otherwise difficult to obtain. After passing cliffs of horizontal strata in which the brick-red sand and loam prevail, the first exposure of a new deposit was observed at Shell Bluff, forty miles below Augusta. The height of the section was 120 feet, and its extent more than half a mile. The lowest exposed strata consisted of white, highly calcareous sand, derived chiefly from comminuted shells, but the beds passed upwards into a solid limestone, sometimes concretionary, and containing numerous casts of shells. In one place a layer of pale green clay showed the horizontal character of the formation. The upper part of this deposit is more sandy and clayey, and incloses a bed of huge oysters, *Ostrea Georgiana*, occupying evidently the position in which they lived. The total thickness of these lower strata is eighty feet. The upper portion of the cliff is composed of forty feet of the red loam which prevails at Aikin and Augusta, and yellow sand. Mr. Lyell did not find any fossils in this deposit, but he believes that it belongs to the burr-stone formation, and therefore to be an upper eocene accumulation. At his first inspection of the casts contained in the limestone, he inferred that they belonged to eocene species, without any intermixture of cretaceous or miocene forms; but it was not till he had the advantage of Mr. Conrad's assistance that he was able to determine the following twelve species which are well known to be characteristic fossils of the eocene beds of Claiborne and Alabama:—

Oliva Alabamiensis.	Corbula nasuta.
Calyptræa trochiformis.	——— oniscus.
Dentalium alternans.	Nucula magnifica.
Venericardia planicosta.	Crassatella prætexta.
Cytherea Poulsoni.	Ostrea sellæformis.
——— perovata.	——— Alabamiensis.

The same shelly, white, calcareous beds, overlaid by red clay and loam, are exhibited at London Bluff, nine miles below Shell Bluff, and a horizontal bed of the large oysters is exposed in a cliff two miles farther

down the river. At Stony Bluff, on the borders of Scriven county, the calcareous deposit is no longer visible, the cliff being composed of siliceous beds of the burr-stone and millstone series, resting upon brick-red and vermilion-coloured loam. This section, Mr. Lyell states, is of great importance, as it concurs in proving that the millstone of this region, with its eocene fossils, is an integral part of the great red loam and sand formation usually devoid of organic remains. The burr-rock of Stony Bluff abounds with cavities and geodes partially filled with crystals of quartz and agates. In the fragments scattered over the adjacent fields Mr. Lyell observed casts of univalves. At Millhaven, eight miles from Stony Bluff and five from the Savannah river, these siliceous beds again crop out and afford casts of the genera Pecten, Eulima or Bonellia, and a Cidaris. It had been pierced through to the depth of twenty-six feet, and was associated with red loam, white sand and kaolin, affording further evidence of these deposits belonging to one formation.

One mile west of Jacksonborough, in the ford of Briar and Beaver Dam Creeks, is a limestone passing upwards into white marl which appears to have been deeply denudated, and is overlaid by sand that belongs to a formation of sand, loam, and ferruginous sand-rock, referred by Mr. Lyell to the red loam and burr-stone series. The limestone and marl, although rarely exposed in sections, are considered to constitute very generally the fundamental strata of the region on account of the not unfrequent occurrence of lime-sinks or circular depressions, formed in the beds of loam and sand by subterranean drainage. The fossils procured from the limestone of Jacksonborough by Mr. Lyell, as well as those presented to him by Col. Jones of Millhaven, were for the greater part well-defined casts, and were specifically new to American palæontologists; nevertheless he has no hesitation, from their general aspect, to regard them as belonging to the eocene period. The genera enumerated in the paper are, Conus, Oliva, Bulla, Voluta, Buccinum, Fusus, Cerithium ?, Trochus, Calyptræa, Dentalium, Crassatella, Chama, Cardium, Cytherea, Lithodomus, Lucina, Pecten, and Ostrea. The Trochus is considered identical with the *T. agglutinans* which occurs in the Paris basin; and the Lithodomus to be undistinguishable from the *L. dactylus* of the West Indies, one of the few eocene Parisian fossils identified by Deshayes.

All the Bluffs examined by Mr. Lyell on the Savannah river below Briar Creek belong to the beds above the limestone, and are referable chiefly, if not entirely, to the burr-stone formation. In white clays exposed a few hundred yards below Tiger Leap in Hudson's Reach, the author found impressions of Mactra, Pecten and Cardita, also fragments of fishes' teeth, particularly of the genus Myliobates, likewise several teeth of the genus Lamna, and one belonging to a Notidamus or a nearly allied genus. At Sisters Ferry he observed not only the brick-red loam, with the red and grey clay and sand, but a highly siliceous clay, which though soft when moist, exhibits a conchoidal fracture when dry, and resembles flint; in some spots the clay also passes into a kind of menilite.

In conclusion, Mr. Lyell offers the following general observations. The part of South Carolina and Georgia which lies between the mountains and the Atlantic, and of which he examined a portion near the Santee and Savannah rivers, has a foundation of cretaceous rocks containing Belemnites, Exogyræ, &c., overlaid first by the eocene limestone and marls, and secondly by the burr-stone formation with the associated red loam, mottled clay, and yellow sand. According to Mr. Vanuxem's observations, a tertiary lignite deposit sometimes intervenes between the cretaceous and eocene series. The remarkable difference in the fossils of the eocene strata at different points, as the Grove on Cooper river, the Santee canal, Vance's Ferry, Shell Bluff, Jacksonborough, and Wilmington, might lead, Mr. Lyell states, to the suspicion of a considerable succession of minor divisions of the eocene period. That the whole are not precisely of the same age he is willing to believe, but he is inclined to ascribe the difference principally to two causes: 1st, that the number procured at each place is small and therefore represents only a fractional portion of the entire fauna of the period, so that variations in each locality may have arisen from original geographical circumstances; and 2ndly, no great eocene collection has been made from any part of the United States.

Some of the burr-stone fossils occur in the limestone, and Mr. Lyell thinks the former may bear to the latter a relation analogous to that which the upper marine sands of the Paris basin bear to the calcaire grossier.

With respect to the conclusion stated in the beginning of the paper, that he had been unable to find any beds containing an intermixture of cretaceous and tertiary fossils, Mr. Lyell says, it would require far more extended investigations to enable a geologist to declare whether there exist in the Southern states any beds of passage, but he affirms that the facts at present ascertained will not bear out such a conclusion.

The generic affinity of the cretaceous fossils of the United States to those of Europe is stated to be most striking, and Mr. Lyell observed in Mr. Conrad's collection from Alabama a large Hippurite, a point of analogy not previously recorded.

The proportion of recent shells in the eocene strata of the United States appears to be as minute as in Europe, and the distinctness of the eocene and miocene testacea hitherto observed to be as great. Mr. Lyell says, it is also worthy of remark, that the recent shells found in the American miocene beds are not only in the same proportion to the extinct as those of the Suffolk crag, or the Faluns of Touraine, but that they also agree specifically in most cases with mollusca inhabiting the neighbouring sea; in the same manner as the recent miocene species of Touraine agree for the greater part with species now living on the western coast of France or in the Mediterranean, and as the recent testacea of the crag are identifiable with species belonging to the British seas. This result appears to Mr. Lyell to confirm the accuracy of conchological determinations; for if, on the contrary, it should be maintained, that the number of recent species is so enormous, and different species resemble each other so closely as

to have produced identifications from the mere difficulty of effecting discriminations, he would suggest that in that case, according to a fair calculation of chances, nine-tenths of the American miocene species hitherto identified ought to have been assimilated to exotic shells, instead of having been found to agree with some portions of the limited fauna at present known on the American shores. The same argument, he adds, is clearly applicable to the identifications which have been made of fossil and recent shells in the European tertiary formations.

May 18.—Joseph Colthurst, Esq., Parliament Street, was elected a Fellow of this Society.

A memoir "On the Geological Structure of the Ural Mountains," by Roderick Impey Murchison, F.R.S., Pres. G.S., M. E. de Verneuil, and Count A. von Keyserling, was read.

A short introduction explains, that although the true geological relations of the rocks which constitute these mountains were previously little known, the Russians had become well acquainted with their mineral wealth and lithological structure. The skill and energy with which the mines have been worked having been adverted to, the authors dwell with pleasure upon the facilities which the Imperial Government afforded them by the instructions conveyed to all the mining establishments by the orders of Count Cancrine and the arrangements of Gen. Tcheffkine. They also acknowledge the advantages they derived from the co-operation of many officers at the different stations or zavods, several of whom prepared maps for their use*. They further express their obligations to many individual proprietors, and notably to M. Anatole Demidof, and the Prince Butera, for their very hospitable reception at the zavods of Nijny Tagilsk and Bissersk. They then proceed to state, that without the small general map recently published by Baron A. von Humboldt and his associates, the objects of the journey could not have been so well attained. These objects were, to reunite the various fragments of the Ural chain, to show of what sedimentary masses it was originally composed, and to explain by what agency the strata have been dislocated and altered. In the latter respect they are aware that their labours have to a great extent been anticipated by the researches of Baron Humboldt, and his companions M. G. Rose and M. Ehrenberg, as well as by their predecessors Colonel Helmersen and M. Hoffmann †, and various officers of the Imperial School of Mines ‡.

Moving in two parties and upon separate but parallel lines of re-

* Among these officers allusion in this brief notice can only be made to those in command, viz. Gen. Glinka, Commander-in-chief at Ekaterinburg; Col. Völkner, formerly at Perm; Col. Protassof at Bogoslofsk, who first explored the districts north of that station; Col. Tchaikofski of Ekaterinburg, and Col. Galahofski of Turinsk.

† See various works on given districts of the Ural mountains by officers of the Imperial School of Mines.

‡ These works are referred to and ably condensed in a Russian work by Prof. Stshurofski of Moscow.