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I.—*An Outline of the Geology of Russia.*

By the Hon. WILLIAM T. H. F. STRANGWAYS, M. G. S.

[Read March 2, 1821.]

BEFORE I enter on a subject of such magnitude as the Geology of Russia, I shall state in few words the plan I mean to pursue in treating it. The vast extent of the country, the little natural connexion of its different parts, and the impossibility of examining with sufficient minuteness the true geological relations of so great a variety of strata in any moderate period of time, prevent my being able to throw into any general system even those formations whose existence, extent, and characters are known to me. The country, however, is very naturally divided into districts, the geological features of which are so distinct, and their actual distance from each other at the same time so considerable, as to allow of their being described separately: were they not politically united, they would have little claim to be considered as the same country. After a short general view, therefore, I shall proceed to examine the details, each under its particular head.

The two great divisions of the empire, Russia properly so called, and Siberia, must be considered, geologically, as perfectly independent of each other; the same boundary dividing the two countries and the two tracts of secondary country belonging to them.

The empire, taken altogether, contains five principal mining districts; two in Europe, two in Asia, and one on the confines of Russia and Siberia. Those in European Russia are the northern or Finnish district, and the central: the former reaching from the Gulf of Bothnia to the Lake Onega; the latter stretching in an oblique direction across the country, from the government of Kalouga to that of Nishegorod*:—the metal principally worked is

* The correct name of this government, and of the town from which it derives its name, is Nishney Novgorod, familiarly abbreviated into the simple word Nishney, and frequently written Nishegorod. In each of these words the letters *sh* are pronounced hard, as the English *s* in the word *leisure*.

iron. The border or Oural district comprehends all the Oural mountains as far as they have been explored; in other words, the greatest part of the governments of Perm, Orenburg, and Viatka; that part of the chain which lies in the governments of Vologda and Archangel being scarcely known*.

The two mining districts which lie entirely within the frontier of Siberia are those of Kolyvan and Nerchinsk. That of Kolyvan is situated on the west frontier of China and of the Steppe of the Kirghis: that of Nerchinsk, beyond the Lake Baical, on the frontier of Siberia and China towards the Pacific Ocean.

The three last-mentioned districts afford almost every metal.

FINLAND†.

In traversing Russia from north to south, we find first a vast extent of primitive country, comprehending Russian Lapland, Finland, the northern parts of Carelia, and part of the government of Olonetz. Its boundary on the south may be taken as follows: The Gulf of Finland; from which we may suppose a line drawn from the Berezovsky Isles, and passing within forty versts of Wyborg quite across the Isthmus to the north shore of the Lake Ladoga above Kexholm: this line may be continued in the same direction across the lake to the north-eastern shore, whence it crosses another isthmus to the northern shore of the Lake Onega above Petrozavodsk: whence being continued still in the same direction, it terminates in the White Sea‡. It is evident that this primitive country is only a prolongation of that of Sweden, which it much resembles, and its connexion with which may be traced by the Isles of Åland in the south, by those in the centre of the Gulf of Bothnia, and by the Lapland chain of mountains into Norway on the north: it probably extends also by Nova Zemlia and the islands in the Icy Sea, to the northern extremity of

* See the Map. Plate II.

† *Finland.*—Under this title I comprehend the whole country of Old and New Finland and Carelia, which is still the popular name for those districts east of Wyborg: as far as the Carelian, a Finnish dialect is spoken. Under the Russian division this tract comprises the government of Abo, and the north parts of those of Wyborg and Olonetz.

‡ The southern outline of the granite takes a regular direction from south-east to north-west, from the south of Sweden to the north of Russia. The Pleta formation, as traced across the Baltic, is apparently parallel to the primitive, and co-extensive with it. The northern salt district and the Valday Hills also run in a parallel direction for nearly the same distance. The escarpments are regularly towards the north; rolled masses of each rock are found south of its native bed, but not to the north of it. Primitive boulders are found as far south as Moscow, but are rare in the eastern governments.

the Oural mountains. The northern parts* of this district are said to consist principally of trap rocks, the central of gneiss and other varieties of schistose rocks, while the southern border is entirely composed of granite. Even these subdivisions have their respective analogies with the different primitive formations of Norway and Sweden, and they affect a line of bearing nearly parallel to that of the whole district, as pointed out above. This will be better understood by a reference to the map. I will now mention some of the most remarkable places, beginning from the westward.

Pargas.—This name is given to a parish comprehending several considerable islands in the Gulf of Bothnia, about ten miles south of Abo. These islands present, in general, the same features as the main land; being usually long steep ridges of gneiss, crowned with fir trees and birch. In fact, they are but continuations of the hills of the continent, the valleys between which are above the level of the sea; while the channels between the islands may be considered as similar valleys below that level. The scenery is much more picturesque than it usually is in the inland parts of Finland, not only from the additional beauty of the water, and numerous vessels continually passing between Abo and the Baltic, but from the absence of those boggy plains which abound on the continent. The rocks, for the most part, are cut down perpendicularly, or nearly so, to the water's edge, leaving little or no strand at their foot. The soil on some of the larger islands is reckoned of a quality superior to that on the main land; those near the coast are generally inhabited; and the villages, farms, churches, and counting-houses of some of the wealthier inhabitants of Abo contribute not a little to embellish and enliven the scene.

On one of the principal islands of the parish of Pargas, but not that where the church and village are situated, from which the groupe derives its name, is found the mineral which has been called pargasite from its locality. It occurs in one or more large veins of milk-white primitive limestone, which traverse the whole island from side to side. This limestone, though rather too fragile and coarse-grained to deserve the name of marble, is nevertheless possessed of considerable beauty, both from the purity of its own texture and the brightness of colour of the various minerals it contains. It is sometimes clouded with a delicate yellow, sometimes with a bluish grey, (owing to the

* On the shores of the White Sea are found bunches of crystals of a sandstone resembling that of Fontainebleau, but of a browner colour. They usually appear to spring from a central ball, which is probably only the remains of a softer mass that once filled the space between the crystals, but is now washed out.

admixture of felspar,) and contains many large irregular veins of augite and of hornblende rock*, also the same substances disseminated through its mass in great abundance. Bright purple spots, supposed to be fluor, are common in some varieties; also moroxite, scapolite, coccolite, and Romantzovite: tourmaline occurs, but rarely. One of the most remarkable minerals of this rock is chondrolite; it is also one of the most plentiful. It possesses a much greater degree of hardness than the limestone, which is usually washed out of the surface of the weathered blocks, leaving only the yellow or orange-coloured mass of chondrolite behind. By this it appears, that in many cases where the chondrolite is thickly sown in the limestone, the grains, which on the fresh fracture appear to be insulated, do in fact touch one another in some point within, and are sufficiently connected to form a rugged but firm mass. This may be the case also with the other minerals. Chondrolite is found in many other parts of Finland, uniformly in primitive limestone. The pargasite itself has been so long known to mineralogists, and is described in so many periodical works, that a particular account of it here would be unnecessary; especially as the Society is in possession of the detailed memoir on pargasite published by Dr. Bonstorff of the university of Abo†.

The country through which the limestone vein passes is gneiss; the fissures of which are in a direction parallel to the course of the vein. Sometimes long narrow ridges or plates of gneiss are seen in the body of the limestone itself: these are easily detected, even on the surface, from the difference of colour and superior hardness to the mass in which they are imbedded, which causes them to project considerably above its level. The vein may be traced along the ground, where in many places it serves as a road, by its colour alone: its breadth varies from twenty to a hundred feet, and is quarried in five or six different places. Perhaps it should not, strictly speaking, be termed a vein; but as it seems to descend perpendicularly, and extends in an unbroken line with little or no change of direction, I adopt the name for want of a better ‡.

Passing hence to the main land§, we observe that a gneiss, more or less

* One of these hornblende veins in one of the quarries near the western extremity of the Island, is represented in Plate I. fig 1. It is singularly interrupted.

† *Dissertatio Chemica, nova experimenta naturam Pargasitæ illustrantia proponens.* PP. I & II. Aboæ 1817—1818. This limestone of Pargas, both with respect to its geological situation and external character, seems to bear some analogy to that of the Hebrides, especially of the Isle of Tiree.

‡ At Abo it is called a Gang.

§ Another small island on this coast nearly opposite Bjorneborg is remarkable for rolled blocks of a fine-grained siliceous sandstone, of a yellowish colour, used for polishing glass. It is remarkable that a similar stone is found in the environs of Jönköping in Sweden, especially at Barnarp near the Taberg.

distinctly foliated, forms the most common rock of the country. To this, however, the stone of which consists the Rock of Abo, on which the observatory is placed, seems at first sight an exception. If viewed in hand specimens, or even large blocks detached from the rock, it appears to be rather a compact small-grained granite, of great hardness, abounding in garnets. But when viewed on the large scale, we see that the entire rock, as well as all the hills in the neighbourhood, is divided into layers, of great thickness indeed, but with a mutual parallelism and uniform dip. In this circumstance it agrees, not only with the nearest islands on the one hand, but on the other with the dip of some considerable hills up the valley on the road to Tavastchus.

To those who believe in the stratification of granite, few spots can offer so much satisfaction as the Rock of Abo *. Besides the regular lines which divide the beds, the beds themselves are readily distinguishable by their different colour, some being whiter, others of a redder or of a browner hue, but all equally studded with small garnets. The magnificent columns which adorn the interior of the public hall of the University of Abo, are single shafts cut from this rock; they bear a most brilliant polish.

The hills in this part of Finland are higher and more abrupt, and the valleys more fertile and infinitely better cultivated than those of the eastern districts. The hills are usually perpendicular where sections of the beds of rock are exposed to view, while on the opposite side, the back of the upper bed forms the gradual slope which conducts you to the bottom. Many are the secondary rocks whose inclination and escarpment are much less regular.

Near Tavastchus the granitic slates abound, frequently waved in the most singular and irregular manner. This is every where evident, owing to the absence of soil, which leaves patches of many square yards perfectly bare, on the top and sides of every hill. This circumstance is connected with another, namely, the peculiar roundness of all the hills and rocks, of which I shall say more hereafter. At Tamala, between this town and Abo, are glass-works supplied with flint from the rose quartz rocks of the neighbourhood; there is also found there a tabular variety of felspar.

At Orijerwy, near Helsingfors, is a copper mine, in which is found the blue quartz called steinhilite, also garnets, and primitive limestone. The latter is too valuable a material to be neglected in such a country as this.

* Near the summit of this rock I found a block of rose quartz and yellowish felspar; also a block of a blacker rock of the same composition as the rock of the hill, but which occurs *in situ* in a hill on the right bank of the river. This black variety was traversed by very thin white veins; the substance of the rock being turned red to a small distance on each side the vein throughout its entire length.

These slaty kinds of primitive rock, which may all be comprehended under the term granitic slate, seem to be continued in a north-easterly direction across the country to the neighbourhood of Wilmanstrand, not far from which, the river Voxa, flowing between banks of this substance, forms the rapids of Imatra, one of the grandest spectacles of the North, and which merit a particular description. I have, therefore, made it the subject of a separate paper*.

Still further to the eastward, is a finer slate, which is quarried in the hills which extend at a short distance from the north-west shore of the Lake Ladoga. Its colour is a deep black, and its texture is of the very finest quality. Although not yet in the general use which it merits, it is sometimes carried to Petersburg in large slabs for writing-tables.

In the same neighbourhood is also a garnet rock, said to resemble that of which boulders are found at Strelna. Higher up the country, near Cuopio, is found a species of potstone which is turned for bowls of pipes and other purposes; and also a black mica slate containing staurolite, boulders of which are found near Petersburg. At Nyslot is found rose quartz.

South of the tract above described, the primitive rocks lose entirely their schistose structure, and a true granite, perfectly free from any symptom of lamellar arrangement, prevails. Their general character may be described as glandular, better than by any other name, and is most conspicuous in the rocks around Wyborg †.

On a hill situated on the right bank of the river which runs by Borgo, and nearly opposite the town, is a tor of granite, in which red felspar predominates, spotted with small crystals of hornblende and black mica. Rolled masses of this rock are by no means uncommon in the neighbourhood of Petersburg. Between Borgo and Louisa are found boulders of jet black mica slate, both with and without garnets; the former variety is by far the hardest: also fragments

* Imatra is not the only remarkable waterfall on the Voxa: Turus or Turu Nemy is celebrated for the fall of Turoun kosky, immediately below which is the passage of the river. It is only fifteen versts from the post station of Kevy nemy, on the great road from Petersburg to Kexholm; and is close to the spot where the Voxa is crossed on the road from Kevy nemy to Raizela. Many other parts of this river, or chain of lakes, present interesting and picturesque scenery, especially in the neighbourhood of St. Peter and St. Andrus; the road by which villages, though only a cross road, is far superior to the best of the great roads of Russia.

There are two rapids at Imatra: the upper, where the Voxa issues from the Lake Saima; the lower, which is the most remarkable, a few versts further down the river. The latter I have described in another place.—*Geological Transactions*, vol. v. page 340.

† This granite may be well examined in the quarries belonging to Baron Nicolai, in an island in the Gulf of Wyborg, which furnished the great columns now seen in the Cazan Church at Petersburg.

of a yellowish or reddish hornstone, somewhat like a large rolled block of the same substance now on the shore of the Gulf of Finland, at Becova.

From Fredericshamn towards Wyborg *, and from Wyborg to the southward, as far as the granite can be traced *in situ*, it is distinguished by round or oval masses of reddish felspar of very regular appearance. Hornblende, which is plentiful, not only occurs mixed with the quartz between these portions of felspar, but is also disseminated through the felspar in small black spots. The felspar is sometimes dark red, sometimes pale pink or flesh-coloured, sometimes white or ash-coloured.

This, as is usual with most of the large-grained granites, is very liable to decomposition : instances of which may be seen frequently in Finland; where a great tor or boulder has often a hole cut in it large enough to admit a cart and horse; and the stone, though at a small distance it seems calculated to last for ages, is cut down and shaped away with the same ease and much in the same manner as a hayrick.

This granite is subject also to a different kind of decay, where large masses are separated by the winter frosts, in directions regulated by their prevailing fissures. These fissures are usually perpendicular, with horizontal ones crossing them at right angles, and at considerable distances, producing a sort of columnar arrangement on a large scale; not irregular, though ill defined. This structure may be traced every where on the surface of the rock, and affords bold and picturesque façades wherever the hill rises to a considerable elevation. North of Wyborg the country rises considerably, and in general, even in the flattest parts of Finland, are to be seen some of these abrupt rocks. They are too large perhaps to be called tors, but yet bear a considerable likeness to them. I will instance only a spot about three versts from Ehandola, on the road to St. Andrus, by the side of a small lake, as one of the best and most picturesque examples; and the perpendicular rocks which surround the beautiful cove called the Fins Haven, in the pleasure-ground of Monplaisir, the country house of Baron Nicolai, on an island in the Gulf of Wyborg.

I have before stated that towards the south the granite sinks beneath its own rubbish, and its ending is not known. It appears, however, in rocks on the Voxa between Imatra and St. Peter, and again between St. Peter and

* Between Fredericshamn and Wyborg is found a clay of a pale purplish colour, lying in the bottom of the valleys, and probably formed from the decomposition of the felspar after the disintegration of the granite. The great scarcity of lime in this part of Finland, makes this clay a valuable substitute for mortar to the peasantry, who use it as such, in the few buildings which they construct of stone.

St. Andrus. Its most southern known point is near Suvenoya, twenty versts from Wyborg.

The northern shore of the Ladoga is much broken and indented; its rocks present several varieties of red and grey veined marble, formerly much used at Petersburg: that of Reuscola was the most celebrated. Further eastward, near Cerdopol *, were formerly worked veins of sulphuret of copper, but I know not in what rock; of late some attempts have been made at working both copper and iron ores, higher up the country near Eno, but with indifferent success.

Nearly opposite Cerdopol, and at a considerable distance in the lake, is the Island of Valaam, famous for its monastery, and for a magnetic sand used in Petersburg for writing-sand; it is the largest island in the lake. North-east of Cerdopol is the Lake Shuya, near which was formerly worked a rich iron ore in veins, which has since been abandoned on account of the superior cheapness of the iron worked at Petrozavodsk, or procured in the same manner as at that place †.

The Lake Onega is bounded on its north-western shore by rocks of dark green jasper-breccia, on the north by a veined marble sometimes resembling that of Reuscola, sometimes greenish and full of tremolite, much like the marble of Glen Tilt. It is crystalline in its texture, and seems undoubtedly a primitive limestone. The western coast consists of a red sandstone of great hardness and solidity: this, as well as the breccia and marble above mentioned, is used in Petersburg as an ornamental stone. Blocks of the red sandstone are found over a large tract of country to the southward, comprehended between the Lake Onega, Petersburg, Moscow, and Kostroma ‡.

A striking resemblance may be traced in the features of the two lakes and of the Gulf of Finland. In each case, the northern shore is formed of the older rocks, is much broken and indented, and skirted with islands; and in each case the deep waters are found along those coasts. Sand or sandstone forms the east and west sides, and the necks of land which divide the respective basins. The southern boundary of each is a marsh, behind which, at a small distance, is a chain of hills of secondary limestone, of one and the same formation. The outlet of each is similarly situated; the Svir connecting the Lakes Onega and

* In the Swedish maps Sordivala.

† See hereafter, p. 10.

‡ I give these as the extreme known localities: of course there is no prescribing absolute limits to the rolling of a boulder. The red sandstone boulders of Uryavetz are studded with pebbles of white quartz, and are used as paving-stone at Nishne Novgorod. They are also found on the Oca.

Ladoga, in the same manner as the Neva connects the Lake Ladoga with the Gulf of Finland. The south shore is an even line, in both cases unaccompanied by islands, and the water for several miles out remarkably shallow; so much so, as in each instance to have made a canal necessary for the navigation.

There is probably a still greater difference of level between the Lakes Onega and Ladoga, than between the latter and the Gulf.

In a deep bay at the north-east extremity of the Lake Onega, is a small cluster of islands, one of which, called Volk Ostrof, or the Isle of Wolves, is celebrated for the beautiful minerals it affords*. Loose on the soil are found numerous blocks of a dark brown or black argillaceous ironstone, which, when broken, are seen to contain irregular cavities, lined with crystals of quartz, and oxyd of iron, of great variety and beauty. Sometimes the quartz becomes amethyst, and is at the same time penetrated by delicate tufts or pencils of oxyd of iron in radiating capillary crystals; sometimes the quartz itself is coated with yellow or red oxyd of iron; in the latter case it resembles in appearance the Hyacinth of Compostella. The yellow oxyd is often seen in small cubes; the black in fine acicular crystals. Some large blocks present cavities, each of which is lined with a different variety; others show all the varieties crystallized in the same group.

A glance at the map will suffice to throw together all I have said respecting this extensive tract of country. One circumstance, however, I must not omit. Throughout the whole of Finland, the evident traces of diluvian action are on the most astonishing scale. Without dwelling on the stupendous size and universal distribution of primitive boulders, it is impossible not to perceive, that the top of every rock *in situ*, every tor, every hill and knoll of granite, or primitive rock, from its first appearance in Carelia, till it sinks beneath the Gulf of Bothnia, presents a surface as much rounded, and as visibly waterworn, as the boulders or colossal pebbles that lie round their bases. Where the rock *in situ* does not rise high above the soil, and where the boulders are at the same time thickly scattered and of vast size, it is scarcely possible to distinguish one from the other. This is particularly the case between Wyborg and Fredericshamn, where they totally prevent the culture of the earth, and

* Some of these specimens are not unlike the nests of quartz crystals found in the neighbourhood of Bristol, often tinged red by iron. The acicular oxyd of iron is often found lining cavities in the ironstone of Mendip.

The blocks found on Volk Ostrof are evidently foreign to the island: their parent rock may perhaps be discovered hereafter in the almost trackless wilderness which extends north of the Lake Onega.

barely allow the passage of a carriage over a most tortuous and narrow road*. The islands off Abo possess the same rounded character: of course I do not mean those rocks whose summits are within reach of the sea which now surrounds them.

Another fact connected with this subject, and well worthy of remark, is, that in the south of Finland, where we recognise *in situ* the parent rocks of the commonest boulders of the neighbourhood of Petersburg, we find new varieties occurring in rolled masses, probably brought from rocks existing still further north. This circumstance much increases the interest attached to the primitive rocks in the north of Europe; since from this cause every rolled stone merits a certain degree of attention.

It remains only to mention the iron works of Petrozavodsk, by far the largest establishment of the kind in the north of Russia. The only sort of iron ore now smelted there is the bog iron ore, which abounds in its vicinity. The usual way of procuring it is to drag the small lakes, especially those north-west of Petrozavodsk, which yield vast quantites of the ore. It is not found equally spread over the bottom of all the lakes; often different points under the same sheet of water will afford ore of various degrees of purity. There are two great zavodes or manufactories of this iron; one four versts from Petersburg, on the Riga road; the other at Petrozavodsk; which place derives its name partly from that circumstance, partly from having been established by Peter the Great.

Specimens of plumbago have often been brought from different parts of Finland; but they are too coarse and too much mixed with grit to be serviceable.

PLETA DISTRICT†.

South of this primitive range follows a very strong and regular formation of secondary rocks; the lowest of which is a pale greenish blue clay, which, it is probable, reposes immediately upon the granite or some

* This road however, in itself, is excellent, as are both the cross and great roads throughout all Finland.

† I have given this name to this extensive district from the principal bed contained in it; which also happens to be very centrally situated with respect to the whole formation, as far as it is contained within the Russian territory.

A suite of specimens of the strata constituting this formation is in the Museum at Oxford: some are also in the collection of the Geological Society; as are likewise similar specimens from the transition limestone of Plymouth, and from North America.

I have seen specimens of organic remains from the limestone of Shropshire, which are nearly identical in all their characters with those of the strata here described.

one of the older rocks last described. Upon this lies a sand or sandstone, of which, it has been imagined, the hard red grit of the west coasts of the Onega Lake is only a more compact form. In the neighbourhood of Petersburg this sand alternates with beds of shale, above which occurs a thick bed of limestone characterized by the same fossils which mark the limestones of Sweden and Norway, according to Von Buch. The clay and sand only have yet been found north of the Neva and Svir; the limestone follows the southern outline of the lakes, and skirts the two rivers above named. The sand and shale, together with the limestone, are distinctly stratified; the latter, with the sand, contains organic remains; both which characters are wanting in the clay.

These three strata, which I shall consider as making one formation, extend from the Baltic isles, which connect it with Sweden, through Esthonia*, the north of Livonia and Ingria, up to Vitegra, at the south-east corner of the Lake Onega. As I have given a more detailed account of it in another memoir, it will be unnecessary to enlarge upon it in this place.—*Vide Geological Transactions,* Vol. v. p. 293, &c.

NORTHERN SALT DISTRICT.

This formation, characterized in all parts of the globe by its striking features of red marl and sand, containing subordinate beds of sulphate of lime in every possible variety, as well as rock salt or saline springs, abounds in the central and southern parts of Russia. The northern salt district stretches in a line parallel to the Petersburg limestone mentioned above for one thousand versts; it makes its first appearance in the Isle of Osel, and is worked in several parts of the south of Livonia.

Gypsum is quarried at Dünahof, Uexhüll, and Kirchkolm. It is frequently of a dark brown colour, veined with white, and in that state takes a fine polish and is extremely beautiful, much resembling that called oriental alabaster.

* The limestone of Reval contains pyrites, which is uncommon in that of Petersburg. At Arrosaar, near Fellin, it contains sulphuret of lead, together with blende, in nests. These minerals were worked there under the Swedish Government; but an attempt to reopen the mines in 1806 was unsuccessful. The same minerals have been found also in veins traversing the limestone of Reval.

This limestone exists also on the very edge of the salt district next described, at Seltza Posad, a village and post on the road from Novgorod to Pscov, and just within the border of the latter government; also, according to Güldenstädt, at Sukhlova, not far from Porkhof. Both localities are on the river Shelon.

True alabaster, however, has only yet been found in Osel. The sand which constitutes the greatest part of Livonia has more consistence, and is more properly called a sandstone, than that of the government of Novgorod, with which it is naturally connected, both as accompanying the gypsum formation, and as bounding the northern limestone on this side: it is therefore much better adapted for geological examination, and is shown to great advantage in the rocky valleys of the rivers Salis, Raune, Ruje, Ammat, and Aa. Near Treyden, on the latter river, it contains a cavern called the Gutmann's Höhle; another in the same rock is called the Teufel's Höhle. The gypsum of Livonia is exported in large quantities from Riga to Petersburg*.

The red ground, in a state varying between sand and marl, is continued through the government of Novgorod, and forms the valley or basin in which the lake Ilmen lies. On the west side of this lake salt springs occur in many places, of which it is necessary to mention only the principal, Starry Russ, or Staraia Rus, which gives name to the manufactory and district. The same formation extends across the lower part of the Msta, and across the Volkhof, where it is in a more sandy state. In the government of Vologda, it occurs in many places; the most distant of which towards the east is Cisolsk. Whether the Vologda salt district communicates with those of Perm on the east and of Costroma on the south, is not yet determined.

This may, perhaps, be the proper place to mention, that in this government, at about 700 versts from the town of Vologda there is found near the mouth of the Vim, district of Yarensk, a black bituminous slate called by the Russians Domanite. It resembles the Kimmeridge coal of Dorsetshire.

* Livonia may be considered as a flat country, although some few hills attain a considerable elevation. It is remarkable that none of the principal eminences belong to the calcareous ranges by which the flat or sandy part of the country is bounded on the north and south; but rise insulated from the plain, and consist of the same sand and sandstone as the country below them. The best information respecting this country is to be found in Bray's *Hist. de Livonia*, vol. iii. also in two little works published at Riga,—*Livona*, and *Livona's Blumenkranz*.

Below are some measurements of the principal hills (from Bray's work).

Teufelsberg, near Laitzen, . .	860 French feet	above Riga.
Sestu Kaln, near Aselhof, . .	650	
Plain of Serben	539	
Munna Meggi (Egg-hill) . .	806 Rhenish feet above the lake of Werro, probably 1000 above the Baltic.	
Wölla Meggi	766	
Blauberg, a single hill, . . .	544 French feet.	
Gaysekaln (Himmelsberg or Fehsenberg), supposed to be higher than all.		

In the languages of the country, *Berg* in German, *Kaln* in Lettonian, *Meggi* in Esthonian, signify Hill.

Valday Hills.

The valley of Novgorod is bounded on the south by the ridge of the Valday Hills, the most considerable regular chain between the Baltic and the Black Sea. It is possible that they may yield, in point of elevation, to the hills which accompany the right bank of the Volga during the middle part of its course; but as the Valday Hills form the ridge which throws off the waters, on the one side into the southern, and on the other into the northern basins, they make a more important feature in the physical map of Russia. They probably do not exceed eight or nine hundred feet in height; an inconsiderable elevation for the centre of so vast a country, and which will seem the more remarkable if we observe the magnitude of the streams which flow on either side from this nucleus. From the western extremity the Düna flows into the Baltic, and the Dniepr into the Black Sea: at a short distance to the eastward rises the Volga, which conveys all the waters of eastern and central Russia into the Caspian. Many inferior rivers flow from the northern slope into the three lakes, Ilmen, Ladoga, and Onega, all which empty themselves by the Neva into the Gulf of Finland. Towards the eastern extremity of the ridge the river Dina* collects all the smaller streams of the northern basin, and flowing to Archangel throws itself into the White Sea.

The escarpment of the Valday Hills is greatest towards the north. Though sandy, the soil is tolerably good, and the country is generally cleared and cultivated. These hills derive their name from the town and monastery of Valday, on the road from Moscow to Petersburg, and nearly midway between the two cities. The situation of the monastery on an island in the middle of a lake, and surrounded with wood, is wild and picturesque, particularly when viewed from a steep hill on the Borovichy road. Between Valday and Borovichy the hills are steep; but it is not till the deep channel of the Msta lays open their internal formation, that any trace of the limestone or coal, reputed to exist in this tract, makes its appearance. The clean and thriving town of Borovichy is situated on the Msta, just where that river quits the Valday Hills to enter into the plain of Novgorod. It is noted for the falls or rapids, which in this

* This river, and that which flows by Riga, are both spelt and pronounced in Russian *Dina*. The Livonian river I have written above Düna, according to the spelling adopted in the language of the country (German). That which flows into the White Sea I must therefore spell as I have done in the text. Both rivers are often incorrectly spelt Dwina or Dvina. Güldenstädt, though a German, seems to prefer *Dina* to *Düna*, yet by a strange inconsistency calls the lake, which is its source, *Dwinez*. vol. i. p. 19.

place impede the navigation of one of the principal channels of communication between the northern and central governments of Russia. Immediately above the town the hills rise to a very considerable height, and are much more varied in their forms than in the neighbourhood of Valday. As the river, for nine or ten versts above the town, runs between lofty and precipitous cliffs, excellent sections of the strata are exposed, more particularly in three spots; the Upper Fall, the Lower Fall, and a sort of gorge in the hills between the lower fall and the town. This gorge I shall describe first, as it occurs first on quitting Borovichy. It is proper to say, that the only rock seen *in situ* on the banks of the river at Borovichy is a red and grey marbled clay; it resembles both the red marl of central Russia, and some of the coloured varieties of the Esthonian clay: its situation with regard to the vale of Novgorod would connect it apparently with the former. Unfortunately, where the sandstone and calcareous rocks begin, their point of contact with this clay was so completely obscured, at the time I was there, by fragments of chert and other stones in great quantity, that their relative situation was not distinguishable. On following up the banks of the river, only limestone or sandstone is seen forming its bed, where that becomes free from the accumulations of chert and gravel. In the town of Borovichy, a little below the church nearest to the bridge, and on the right bank, is a deposit of calcareous matter of a snowy whiteness (*Lac Lunæ*) at a considerable height above the level of the river.

A little above the town, where the first ridge of hills abuts against the stream, is a lofty perpendicular cliff, of which the upper part is a pale reddish sand, which, some feet lower down, presents large patches of a bright yellow and white loose siliceous sand, resembling that on the Ishora near Petersburg. This sand appears to contain sulphur. Below this is a black sandy clay, intimately mingled with pyrites, which accompanies a bituminous clay bed that has long passed in the neighbourhood for a sure indication of coal. Connected with this pyrites and coaly clay, is a rugged ironstone containing charred wood; a fossil which also occurs in small fragments entangled in white calcareous spar lining cavities in the rock. There appear to be two thin beds of the bituminous clay in this place, one above the fine white sand, the other but little above the water's edge. Flint, though not seen here *in situ*, is plentiful in detached pieces under the cliffs.

No good sections are seen for some distance above this spot; but as we approach what is called the lower fall, about six versts above Borovichy, the left bank presents a long perpendicular face to the river. Opposite the lower part of this cliff is a small flat, covered with rolled masses of rocks brought down by the river in its floods. The hills on the right bank sweep round this little

plain, and, meeting the river opposite the upper end of the long cliff on the left bank, form a sort of gorge; which being much filled up with ledges of strata that cross from side to side, together with great accumulations of primitive boulders and fragments of the surrounding rocks, constitutes what is called the lower fall*.

The sand here appears in horizontal strata, containing thick and regular beds of an argillaceous ironstone, which is an agglomerate of charred wood and every sort of geode; it is mammillated on the surface, in which character and in colour it resembles the sandstone of the Popovca, and other streams near Petersburg, and in its whole appearance is like that near Helsingborg in Sweden; which, it is remarkable, is in a true coal country. Some of its concretions are coloured much like Egyptian pebbles, and appear to be siliceous. Above this is a reddish sand, which forms the most projecting point of the rock; below it a yellow sand, presenting a pseudo-stratified structure or cleavage, which forms a considerable angle with the true lines of its beds, when viewed in the mass. The next beds are a blue limestone, which continues to near the water's edge, containing madrepores like those of the mountain-lime in Northumberland. Still more abundant is a very peculiar sort of Briarean Pentacrinite, the joints of which are very minute, and at first scarcely perceptible to the eye of one who does not suspect their existence. Its manner of growth seems to have been panicled, not unlike that of millet, with an inclination to droop on one side. Impressions of large tufts of this pentacrinite cover the greatest part of the surface of these limestone strata, bending sometimes in one direction, sometimes in another. In the bed of the river, the ledges of rock show a yellower and more sandy variety of this limestone, in which I could not discover the madrepores, though the pentacrinites were as abundant as in the blue beds. The latter contain also quantities of fragments of large encrini, minute corallines, and other marine fossils, in which it resembles the limestones of Dudley in England and some of the varieties of the Pleta formation in Russia, before described. This blue limestone also contains those large terebratulites with very thick shells, so common in certain limestones of the neighbourhood of Moscow, but which I have never yet seen in the northern limestone district. Although the bituminous and pyritical clays do not appear in this place, yet I suspect this dark limestone to be very near them.

* Most of what are called Falls in the rivers of the north of Russia, are merely rapids, owing to a combination of obstacles such as are here described. In Russian, the word *paroghee* is applied to waterfalls of every description.

Immediately above this spot the river widens, and then contracts itself between wooded banks which afford no geological sections. About three versts above the lower fall is placed the village of Ouglova, probably so called from the coal, such as it is, which re-appears in the bank of the upper fall situated just below it *.

At the upper fall, the banks of the river are not so high as at the lower; nevertheless, as they afford sections of the limestone containing chert *in situ*, a circumstance of rare occurrence in general in Russia, they cannot fail to be interesting. Both the limestone and chert are varied with yellow and red patches, and pass gradually into each other. The limestone contains here not only the large terebratulites which I have before mentioned, but also fragments of encrini &c. like those of the limestone of the rivers Sas and Shelon. These also occur in the chert; but I could see no large or perfect fossils in the beds of that substance at this spot, although they are so common in the loose masses south of the Valday Hills. Below these beds the coal shale and pyrites re-appear at the water's edge. I found one flint in the bed of the river, slightly rolled, much resembling those of the English chalk, and containing a finger-shaped alcyonite.

The Msta is a river very important in the inland navigation of Russia, as it is not only the largest stream of these parts, but also cuts through the greatest part of the whole breadth of the Valday Hills, in the line where their height is greatest, and where it would have been extremely difficult to form a canal. It is also fortunate, that the Tvertza, which flows southward, and joins the Volga at Tver, rises not far from the source of the Msta; so that by a short canal which passes through Vishney Volochok, the communication between the Baltic and Caspian Seas has been easily effected. This is the principal line of water communication: but as the Msta is extremely shallow and much obstructed by rocks, and the Tvertza, though less impeded in its course, does not at all times of the year contain sufficient water for barks, it was necessary to supply it by artificial means. Locks, in the time of Peter the Great, to whom the opening of this navigation is due, were too expensive; especially as the declivity of the Tvertza is so rapid, that it would have required a vast number of them to keep up the water of that river between Vishney Volochok and Tver. This rapidity of the Tvertza is probably owing to its source being so near to the southern slope of the hills; although their slope on this side is less than on the north. The Msta, on the contrary, by its long course through a deep valley, is less rapid than might have been expected: and although the

* See Plate 1. fig. 2.

plain of Tver is probably at a higher level than that of Novgorod, there is reason to believe that the level of the Volga, even in this early part of its course, is extremely low. Since the rivers did not contain water enough, the simplest and most obvious remedy was to fill them, at least at stated times, for the passage of vessels towards Petersburg from the countries on the Volga: and it happens fortunately for this object, that this part of the Valday Hills abounds in small lakes; every one of which, within a district of about 200 versts in circumference, that either communicates naturally or can be made to communicate with the Tvertza or the Msta, is laid under contribution, and compelled to furnish, at certain periods, a known and regulated quantity of its waters for the supply of one or the other river during the seasons of navigation. For this purpose, all the water-courses within the district have been dammed up, and at each sluice is stationed a guard, whose duty it is to give daily notice of the increase of the waters at his post, to a superior officer, who is commonly placed in one of the three towns along the line of navigation. This information being regularly transmitted from every station within the two systems of waters of the Tvertza and the Msta, the officer can easily calculate whether the total bulk of all the waters collected will be sufficient to float the vessels that are ready to pass, and which usually wait for the intelligence at Tver. As soon as he has information that the waters have risen at each station to the necessary height, orders are sent to the vessels that are waiting, to be prepared to mount the river, and to each of the guards at their respective posts to open the sluices at a particular hour. The hours specified in the orders sent to each guard at the sluices are so calculated, that the water shall not all be let off at the same moment, but that the more distant ponds being opened at an earlier, and those nearer to the navigable river at a later hour, the great body of water shall be brought into the bed of the river at the same moment, if required; or, that, if more of it than is necessary should be ready, the full stream may be continued at a certain height as long as it will last.

The immense rush of water which on these occasions passes down the Tvertza renders it, of course, very difficult to ascend; but the bottom and sides being free from rocks, the barks pass without much danger. On the other hand, the passage down the Msta is reckoned extremely dangerous, and they never attempt to remount the stream. The impetuosity of the current in so deep and uneven a bed,—sometimes abruptly turning rocky points, or confined within narrow gorges, which often suddenly expand it to wide basins, and as suddenly contract again,—is yearly the cause of the wreck of a great number of these vessels, although built on a peculiar plan for the passage of the rapids. They are extremely flexible, and narrow in proportion to their

length ; and the merchandize is arranged in rows placed across the vessel, so as to leave a certain interval between each row. This, together with the flexibility of the bottom, enables them so far to yield to the current, that the greatest waves barely cause the tops of the rows of sacks, casks, or other merchandize, to touch each other. Were they set close together, the boats would probably break, or be upset. Signal staffs on the most conspicuous points give notice of the approach of the water and boats ; when men, women, and children, flock from the neighbouring villages, to give any necessary assistance to those engaged in this perilous navigation. When the waters have subsided, the passage is stopped for the next three weeks or month, according to the dryness or wetness of the season, till sufficient water is collected to fill the rivers as before. And this is repeated at intervals during the whole summer.

Although the Msta, at these moments of its being enlivened by a sudden and as it were miraculous navigation, presents a most curious and interesting spectacle ; yet it is at low water that it is best adapted for geological investigation, as its rocks are then more exposed. By going a day before the waters are let off, it may be observed at high and low water within a short space of time. Among the artificial parts of this communication, the canal and sluices of Vishney Volochok, which are on a very large scale, and lined with gray granite supplied by the boulders of the neighbourhood, must be particularly noticed.

From Borovichy the high country stretches in a north-easterly direction between Tikhvin and Oustioushna, where there exists a second water communication across it, by means of the rivers Sas and Mologa and their affluents, which approach within a short distance of each other and are joined by a canal. This line of junction between the districts on the Volga and those on the Lake Ladoga, as well as the road which accompanies it, is now under a system of progressive amelioration. The face of the country is hilly, but sandy ; I could not discover the limestone any where *in situ*, although some loose blocks of it, together with pieces of chert, are to be seen in small quantities south of Choudzi *.

There is yet a third system of navigation at present in progress across this

* One of the most remarkable facts with regard to the central parts of Russia, is the quantity of siliceous boulders which are scattered over the governments of Moscow, Vladimir, Tver, and the neighbouring countries. They are found on the Valday Hills, but rarely north of them, although they occur there *in situ* : a strong proof of the direction of the diluvian current from north to south. They resemble in general the chert of the mountain lime, and contain terebratulites, caryophyllites, entrochites, astroites, meandrites, and many other marine fossils, beautifully preserved and frequently agatized. They are rarely found north of the town of Valday, or east of Kostroma. Their boundary on the south and west is unknown.

high level, to the east of those I have already mentioned. It is designed to connect the lakes Onega and Bieloe Ozero (or White Lake) by means of the river Vitegra, which flows into the former. The latter lake empties itself by the Shexna into the Volga at Ribinsk. In this case two canals are required; it being necessary not only to connect the Vitegra with the river that runs into the Bieloe Ozero, but also to avoid that lake, by cutting a canal round one half of its circumference to join the feeding with the emptying stream. For the Bieloe Ozero is merely a shallow pool in the sand, of a regular oval figure; and, like most of the lakes of northern Russia, would be considered as rather a faulty spot in an improved system of navigation, though it may probably have been very useful in an incipient one.

Still further to the eastward, between Vologda and Kostroma, about sixty versts from the former town, is quarried a dark hard limestone of very good quality. Not being able to describe either the stone or the quarry from personal inspection, I mention it only to hazard the conjecture, that it may be a continuation or re-appearance of that of Borovichy*.

Here my acquaintance with the Valday chain terminates; but I believe it to be prolonged to some distance further in the same direction. This eastern portion of it is thickly wooded, and supplies a great part of the timber used in the interior of Russia, where its want is becoming daily more and more sensible, and also of that demanded by the northern export trade.

A branch of the Oural Mountains is described as projecting into the government of Vologda, with which it is possible the Valday chain may be connected on the east.

CENTRAL SALT DISTRICT.

The very extensive tract of country which I designate under this name will scarcely admit of any precise geographical boundary. I shall however endeavour to give an idea of it, by following the course of the Volga from Tver to Cazan, in a direction nearly east and west; and by giving such a

* According to Gmelin, some limestones, much of the same character as those of Borovichy, and, like it, containing a sort of coal, are found at Uryefskoy and Coudroszovo in the government of Tver. This government is celebrated for the beauty of its siliceous fossils, found in loose boulders of chert scattered over the surface of the country. As chert has been found *in situ* at Borovichy accompanying limestone, and containing fragments of the same organic remains, may not these limestones of the government of Tver, which are characterized by the same encrinites, &c. as those of Borovichy, be connected with the chert boulders, to which no place has yet been assigned, and whose organic remains, shells, &c. agree with those of the limestone of Borovichy, though not yet found in the chert of that place?

description as I am able of the country on its banks, and of some remarkable spots in the interior.

At Tver the Volga receives the Tvertza, and with it the first line of central water communication. The whole country presents nothing but a reddish sand, extremely loose, and bare of herbage: in many places the surface is furrowed in waving ridges by the action of the wind, in the same manner as the sand of the sea-shore is by that of the water. Widely different from the sand of the northern districts, it is not a poor soil; but produces rye, wheat, and flax in abundance. The Volga is here shallow in proportion to the width of its bed, which is strewed with boulders, partly primitive, partly siliceous.

At Mologa the Volga receives the river of that name, and with it the second line of central water communication. The country in every respect resembles the environs of Tver, and siliceous boulders, containing their usual organic remains, are plentiful. This is nearly the most northern point of the course of the Volga.

At Ribinsk, a handsome and flourishing town, the Volga receives the Shexna, the third and last branch of the central water communications. After these accessions of strength, the Volga visibly increases in size, and some slight difference is perceivable in the country through which it flows. The banks attain a much greater elevation, and are frequently intersected by deep and precipitous ravines, which begin to form a striking feature in the scenery, and are common throughout all this eastern part of central Russia. This may be partly owing to the nature of the red rock, which here quits its sandy character to acquire that argillaceous one, which so commonly distinguishes the salt formation in every corner of Europe where it occurs. The original sandy appearance, however, recurs at frequent intervals; but the marl usually discovers itself at the depth of a few feet. It is of a deep red colour, and often contains thin beds of the same substance, coloured greenish gray or white. This soil produces the finest pastures and most brilliant verdure found in Russia.

The next considerable town is Yaroslaf or Yarollart, capital of the government of the same name, and situated in a rich and cultivated country. In several parts of this government exist salt springs, especially in that part of it south of the Volga. In this and the neighbouring governments of Tver and Kostroma, the soil is remarkably favourable to the culture of flax, the principal manufactures for which are in the governments of Kostroma and Yaroslaf: and it is remarkable, that a similar soil produces also the finest quality of that which is exported from the northern ports, which is grown in the governments of Pscov and Novgorod.

The same rock continuing, the country improves in riches and beauty towards the town of Kostroma, which is deservedly reckoned one of the most beautiful on the Volga, as well in architecture as in situation. It would perhaps be difficult to prove that the climate of this part of Russia is at all superior to that of the provinces I have been hitherto describing; but it is certain that from the neighbourhood of Kostroma oaks are frequent, and continue to be so along the remaining course of the Volga as far as the woods continue. The scenery on the banks of the river becomes much more varied, and is enlivened by towns and villages, among which should be particularly mentioned the picturesque town of Kineshma, situated on the southern bank. In a ravine in the middle of the town, opposite the great monastery, is a sand-pit, the sand of which is partly red, like that common throughout the country, and partly white and yellow, and of that clear glassy appearance which characterizes the sand of Borovichy and of the Ishora near Petersburg. In the ravines between Kostroma and Kineshma the red marl and sand are well seen *in situ*. On the south bank, between Kineshma and Uryavetz Pavolskoy (or Uryavetz on the Volga), more commonly contracted into Uryetz, the ravines occur at every two or three versts, and at the town of Uryetz are of the depth of 150 feet, if not more. Two or three of these ravines unite just at the spot where the town is built, between their opening and the Volga. There is no water in them in summer: and in fact, they owe their origin not to the waters of the soil, but to the melting of the snows in spring. The surface of the hill is horizontal to their very edge, and the upper part of their cliffs absolutely perpendicular to the depth of thirty or forty feet, before it begins to slope towards the centre of the hollow. On the side of one part of the ravine, where the rock is no longer liable to slip, is a wood of firs; but in general the sides are perfectly bare, on account of the very regular annual decay which takes place after the thawing of the snows. The substance of the rock being very tender, yields readily to the impetuosity of the annual *débâcle*. It is the ordinary red marl, containing small calcareous concretions. In the ravines are some large boulders of ancient rocks. Near the head of one of the ravines is a large square tower, the remains of an ancient fortress, erected when this part of Russia was exposed to the incursions of the Tartars; which, together with the steep road which descends into the town, accompanied on each side by a yawning chasm, will probably be at some future period precipitated into the gulf. Some grotesque chapels, which are placed on projecting knolls round the town, are in danger of sharing the same fate.

In the government of Kostroma, salt is made in many places from brine, especially at Solyi Galich*, on the borders of the government of Vologda, where it is accompanied by gypsum.

The next considerable salt manufacture near the Volga is at Balakhna, where there are several brine-springs situated in a plain between the hills and the river. One opened in 1818 affords 13° of salt.

The plain extends from Balakhna to the mouth of the Oca, the hills turning off abruptly to the south. The ground is low and marshy, being often flooded by the two rivers. Some part of this plain is probably of alluvial formation; but how much of it owes its existence to recent depositions would be difficult to determine.

Opposite to this plain, which is triangular (being bounded by the two rivers and the ridge of hills above mentioned, on the left of the Oca), stands the town of Nishney Novgorod, on the point of a triangular elevation, which fills the angle on the right of the mouth of the Oca, as the plain just described fills up the left. The hill is extremely steep, rising almost from the water's edge: the apex, on which is placed the ancient Kreml or fortress, is stated by the engineers to be above 400 feet in height above the river. This high ground is intersected by numerous ravines of great depth, even in the middle of the town. One of these extends so far into the body of the hill, as nearly to join one that begins on the other side of the town, and opens to the valley of a small river flowing to the eastward. This stream does not join the Volga for ten miles below the town.

But the most remarkable chasms are to be seen on the Oca, just above the town, under the walls of the convent which stands between the Moscow road and the river. They cannot be less than 350 feet in depth; but show nothing but horizontal strata of red and white marl. Still higher up the river, near the fifth verst on the same road, is a beautiful view over the whole valley of the Oca: a little to the right of this spot, a path leads to the head of a romantic dell, which descends towards the river, and which far surpasses in picturesque beauty any thing in the neighbourhood of Nishney Novgorod. The path winds down among broken hills, here and there exposing perpendicular cliffs of red rock-marl, which, when seen between the tufted woods of oak and ash in which they are embosomed, and through which is caught from time to time a view of the winding Oca studded with sails, cannot fail to recall the smiling landscapes of the western counties of England. In the deepest part of the

* Solyé Galich, or Sol Galitzkoy.

valley a stream makes its way down to the river, which it enters near the salt magazines*.

The Volga too, below the town, has no less claim to notice than the Oca. About two versts from the fortress, on the left side of the road to Cazan, are seen ravines and chasms of the same nature as those so often described. But a little further on, the lofty bank of the Volga becomes wooded and cultivated. On a knoll considerably lower than these banks, but yet raised high above the river, is placed the monastery of Pechersk, and not far from it a large village of the same name. Beyond it is seen, in a situation somewhat similar, the white steeple of the church of Podnolyé, another considerable village, which, as well as Pechersk, is built close to the water's edge. The roads down to these villages, winding among the large trees and orchards with which they are surrounded, are no less remarkable for beauty of scenery than for some geological circumstances which may there be examined. We here see for the first time beds of pale red sandstone alternating with the marl. The colour of this sandstone sometimes varies to a dusky green, and is marked by irregular concretions and a sort of globular structure, like those of Borovichy and the Poporca. The red variety sometimes presents a singular appearance, when, with the fracture and aspect of a very ill made brick, it discovers, on breaking, a number of flattened cells or cavities, in which are loose concretions of marl, usually of some shade of red, which easily fall out of their receptacles. At the bottom of the cliff along the shore is seen a thick bed of a remarkably hard and compact tuf, the cavities of which are often lined with brown sulphate of lime, deposited stalactitically; it sometimes nearly resembles that found among the solid alabasters, and is capable of taking a fine polish. Fresh-water shells are found in this tuf, though rarely. A similar formation exists on the Oca near the salt magazine.

From the summit of these heights may sometimes be seen a phenomenon similar to what has been observed in other places. The blue waters of the Volga, on receiving those of the Oca, which are by no means of an equal degree of purity, are seen to flow uniformly along the left side of the channel; while the other stream on the contrary keeps as regularly along the right. From their point of junction, the difference of colour is too striking to be overlooked by the most casual observer; and it appears but little abated where they pass out of sight. The explanation of the phenomenon is simply this:—The Volga above

* These magazines are not stored with the salt of the neighbouring districts, but with that of the Steppes of the south-eastern parts of Russia, which is supplied at a cheaper rate for the consumption of the interior.

Nishney Novgorod, as well as the greatest part of its tributary streams, (which it is remarkable are much more numerous and considerable on the north side than on the south,) flows through a tract of country almost universally covered with sand. The Oca on the contrary flows through a country of rich red marl, in its strongest and most argillaceous form: neither of the two rivers being sufficiently rapid to disturb immediately the new body of water with which it comes in contact, the effect above described is naturally produced.

The situation of Nishney Novgorod at the confluence of the two principal rivers of central Russia, and which thus connect the two richest and most populous districts of the empire, the provinces immediately south of Moscow and those on the upper Volga, is singularly adapted for commerce, independent of its more distant connexions. Here naturally centres not only the greatest internal trade of the empire, but by the lines of navigation I have before detailed, this town has a three-fold communication with the provinces of the north and with the Baltic; and, by means of the Oca and Moskva, with Moscow itself. The Kama, which meets the Volga a little lower down, brings all the produce of Siberia, the iron and copper of the Ourals, the gold and silver of Kolyvan, and the beryls, amethysts, and topazes of Nerchinsk. The trade with China is also carried on by means of this river. The commerce of central Asia, to which we owe the introduction or the recovery of the true Turquoise or Calaïte*, as well as that of the south of Russia and Persia, comes partly from Astracan and the Caspian Sea by the navigation of the lower Volga, partly by caravans, which arrive on the banks of that river in different parts of its course. The supply of European commodities is furnished chiefly from Petersburg. These commercial advantages, added to the circumstance of its being placed in the centre of one of the most fertile districts in Russia†, in most of which particulars it has greatly the advantage

* By far the clearest and most accurate account of this stone, and of the difference between it and the coloured bones which have been mistaken for it, (and for which it has itself been also mistaken,) is to be found in Professor Fischer's treatise on this subject.—Moscow. 1818.

† When the science of geology shall have made men thoroughly acquainted with the history of the substrata, their attention will probably be directed to the nature and formation of the vegetable soils which cover them; nor will this be the least useful object of their labours. The government of N. Novgorod contains the three soils most common in Russia; the sand, red marl, and black earth. The sand found in the western parts is the poorest, the other two are remarkably fertile. The red marl is chiefly found along the Volga and on the northern side of the government. Besides corn, it produces the finest grass and oaks, as may be seen in one of the finest forests of Russia, near Vasil Soursk, entirely composed of oaks planted by Peter the Great at a time when wood was much more plentiful than it is at present. The black earth makes fine corn land, but seems less adapted to the growth of oak timber, or for fine herbage,

both over Petersburg and Moscow, are believed to have inspired Peter the Great with the idea of ultimately fixing in this spot the capital of the empire. As this design was neglected after his death, this important situation had been overlooked till within a few years past, when the great bazaars and buildings at Makarief having been destroyed by fire, the government determined on removing the seat of the fair annually held there, to Nishney Novgorod; both on account of its situation, and from its being nearly an hundred versts higher up the Volga than the original place of Makarief; while the additional journey to the eastern trade is insignificant.

In pursuance of this object, a new and magnificent bazaar is building on a vast scale upon the plain, on the left bank of the Oca, opposite the town of Nishney Novgorod, to which it is joined by a light and elegant bridge of boats. This plain, however, being purely alluvial, or, in other words, a sort of Delta formed by the Oca, is subject to regular floods from the waters of both rivers. It happens, rather unfortunately, that the Volga and its affluents coming from the north, while the Oca flows directly from the south, the difference of climate between the tracts of country that are drained by these two rivers is sufficiently great to cause a difference in the time of their respective inundations. Thus the ice on the upper part of the Oca, and the snows of the country on its banks, break up sometimes a month earlier than those of the Volga and other northern rivers; and at the time when the waters of the former river would naturally subside, the flood is prolonged, increased, or renewed, by the melting of the ice on the former. In addition to these difficulties, the action of the two rivers on their banks presents an evil of considerable magnitude. At their confluence the two rivers are describing in their course the segment of a very large circle, the concavity of which is, in each case, on their right bank; on which side of course the destroying action takes place, whilst the left bank of each river becomes the deposit of whatever they leave behind. Now the right bank of the Oca is lofty and precipitous, and though it may require some ages for the action of the river to do material damage to the town, yet it has barely left room for one narrow street at the foot of the hill, which is regularly under water every year. But the right bank of the Volga, on the other hand, is a low and sandy accumulation of alluvial origin, being in fact only one side of that sort of Delta which

than the other, being overrun with wormwood. It is said to extend from the Kama to the Dniestr, and in all the governments between the two rivers forms a rich and productive soil. I have followed it 150 versts on each side the Volga, and found it covering red marl sand, white marl, in short every kind of substratum, with one uniform coating of black mould, from a foot to three feet in depth, and spread over hill and dale like a regular but unconformable bed.

the Oca has deposited at its mouth. Of this, large portions are carried away annually by the current, which throws it upon the left bank, where it has formed an extensive sandy plain, intersected by small branches of the river. The islands which they surround are covered with low brushwood, and are still flooded annually. This plain therefore is not cultivated; and as the land behind has but little elevation, it is not immediately perceived that it is as fertile and as much inhabited as the high grounds on the south bank of the river. The Oca in like manner deposits on its left bank all that it brings down from the right: so that this alluvial triangle is annually gaining on one side, while it is losing on the other; a considerable deposit being left also on the surface of the plain itself. It has been necessary however to raise the surface many feet, in order to keep the water out of the bazaar; the necessary quantity of earth being supplied from the excavation of a canal which is intended to surround the whole; and a protection is also required against the ravages on the side of the Volga. It may be asked why this weak and perishable angle between the two rivers was chosen, in preference to the more solid one on the opposite bank? The fact is, that there is not room at the foot of the hill to place any thing like requisite buildings for the merchandise accumulated at the fair: also, that the little space there is, is annually lessened or endangered by the action of the Volga on the north, and of the Oca on the west,—both rivers here conspiring to destroy the hill. On the summit of the hill the ground is too uneven to admit of regular buildings of such a size, without being endangered by the ravines, whose banks are nearly as insecure as those of the river; besides the labour and risk of bringing heavy goods up a steep of four hundred feet in height, which must all descend again to be trans-shipped. The only good situation is already occupied by the Kreml, which completely covers the lofty angle between the Volga and Oca.

The stone used in the new constructions, is partly the hard tuf of Pechersk, which is blasted by gunpowder,—a method newly introduced there; a white limestone from the upper Oca, which will hereafter be mentioned; and in part a red sandstone, containing numerous glassy concretions of sulphate of lime, which is quarried at Novinski, about sixteen versts up the Oca. This sandstone, though not much resembling the young red sandstone of England, is probably allied to it, as occurring in company with gypsum, interstratified with a saline red marl. There is also at Novinski another species of white limestone, much intersected with small veins of glassy gypsum, but containing shells, which are in general of rare occurrence in any form of sulphate of lime. Specimens are in the collection of the Geological Society, and in the Museum at Oxford.

Among the greatest natural curiosities of the government of Nishney Novgorod, must unquestionably be reckoned the rocks and cavern Barnoucova. They are situated near the western extremity of a ridge of hills that accompany the northern bank of the river Piana, which flowing first westward doubles the end of these hills, and then runs eastward, by the town of Cergach, till it reaches the Volga.

A round hill, covered with a wood of oaks to the very summit, is at this place hollowed on one side into a natural amphitheatre, accessible only by a rugged path, which follows a small stream issuing from a narrow opening between the hills. On pursuing this stream into the recess from which it flows, some lofty perpendicular rocks appear above the wood on the right hand; and a few steps further, on turning a sudden corner, the dell widens a little, but is suddenly barred across its upper end by a precipitous cliff of considerable height and snowy whiteness. A small lake lies in the hollow, fringed with oaks, and which has an outlet by the stream which accompanies the path. The white cliff rises abruptly from behind the lake, and a woody eminence above terminates the scene. But the beauty and repose which characterize this sequestered spot, are not the only features which distinguish it. On arriving at the foot of the cliff, it is discovered to be of the purest alabaster; and on passing the tangled brushwood which conceals it, is seen the mouth of a cavern formed in a rock, of which it is no exaggeration to say that it resembles the driven snow; for to no other object in nature does it bear any resemblance. On descending towards the mouth of this cave, although yet at a distance of several feet from it, a sudden and remarkable sensation of chill is strongly experienced: it seems at the moment as if the rock, which has all the appearance of snow, had also its coldness; and in ascending the rocks on either side, the return to perfect warmth is felt instantly on rising above the level of the cave. The interior soon contracts*, and is, as might be supposed, intensely cold; a quality remarkable even during the hottest weather. On the right hand, the tops of many of the flatter or larger masses which rise above the trees, not only glitter in the sun like drifts of snow, but the purity of their colour, their powdery texture, and even their furrowed surfaces, which are channelled and waved as if by the action of the wind, contribute to deceive the observer, and produce the most perfect resemblance. The rock is indistinctly stratified in large beds, and contains starry crystallizations of

* Pallas visited Barnoucova in 1768. For a minute description of the cavern, which makes it needless for me to say more upon this subject, see his Travels, vol. i.

selenite *. The neighbouring country is all red rock marl, in which the alabaster forms subordinate beds.

About eleven versts higher up the river Piana, is the village of Tzaitska, situated on the side of the ridge of hills that extends from Barnoucova. An ancient wooden church in the most grotesque style of Russian architecture stands on a bank, the structure of which is laid open in a cliff just below it. Regular horizontal strata of red marl are discovered alternating with grey and white beds, of the same nature as at Nishney Novgorod; and as at that place, the grey beds contain a substance which has been taken for the mineral called rock-leather†, but which on examination proves to be a coriaceous form of fibrous gypsum. It is interposed in continuous layers between the beds of marl, and might be pulled out with care in sheets of several square feet, as it is very tough. I have not found it anywhere in so perfect a state as at Troitska, though it occurs more or less in all the marls of this district. The only difference between the appearance of the cliff at Troitska and those at Nishney, is, that in the latter instance small beds of sandstone occur, which are wanting in the former. The vegetable soil which covers the cliffs on the Oca, is of a deep red, like the rock itself; while at Troitska it is a thick bed of jet black mould, although the rock below is exactly similar in colour and nature to that of Nishney.

The red marl continues to be seen along the banks of the Volga, and prevails in the governments of Cazan and Simbirsk: the most distant locality of it, that I can mention with certainty, is at Tetushy, which is built on the summit

* Where the beds of alabaster pass into the red marl, they form a pale-coloured compact limestone, containing selenite. This would naturally be the bed in which to look for gypseous shells like those of Novinski, but I was not lucky enough to discover any decided trace of organic remains.

† See Mém. de l'Université de Moscou, p. 253.—The mineral which Dr. Pansner is there said to have brought from Nishney Novgorod, is identical with that of Troitska here described, and is found in similar beds *in situ* in the red marl. It is quite evident that this cannot be an alluvial product, or have come out of a hill of alluvium (400 feet in height). That which is described by Professor Fischer, in a subsequent part of the same paper, as found near Mourom, is identical with what will be described hereafter under the head of Vixa; except that instead of occurring in ironstone, it is in a calcareous concretion like what I have found at Myavetz Pavolskoy; this concretion may have been in alluvial soil.

Having seen the specimens in both cases, in the possession of those who found them, and having visited the localities and found the minerals myself *in situ*, there and in other parts of the same district, I am enabled to speak positively upon this subject.

Coriaceous gypsum occurs also in the red marl of Devonshire.

of a high cliff of marl exactly resembling that of Nishney, except that its beds are undulating rather than horizontal. On the opposite bank of the Volga stand the ruins of Bolgary, the ancient capital of the Tartars; as is attested by an inscription in Tartar, and by the coins of silver and copper bearing the names of their princes in Mongol, which are frequently dug up there with various other pieces of antiquity. The remains of several baths and minarets are remarkable as being entirely built of stone, a sort of masonry hardly to be seen in Russia. The stone seems partly to come from the same beds which are used for foundations at Cazan, partly to be a species of tuf. No quarries are visible near the ruins. The Arabic, Armenian, and Tartar inscriptions (many of the Arabic, in Cufic characters) are well preserved and have been given by Lepekhin. These remains of antiquity were first ordered to be preserved by Peter the Great. Over the door of one of the buildings are some Arabesque figures and chain patterns carved in a sandy stone, probably from a bed alternating with the marl, which have resisted the ravages of time better than most of the external parts of the buildings. The hill on which they stand is of a loose sandy rock, probably a form of the red ground. The black soil which covers it is clothed with the yellow flowers of the Scabiosa Tatarica, and in the peasants' gardens produces magnificent hops, which in August were covered with bunches of three inches and a quarter in length, and broad in proportion; it bears also rich crops of corn and sunflowers.

The same sand rock extends northward to Cazan, and is seen on the south at Simbirsk. At the latter place, the upper part of the hills on the Volga contains great quantities of very white marl (kreide mergel of Pallas), which appears also at Tagay west of Simbirsk, and is seen along the brow of an escarpment of bare downs for several miles. At Chircovo, the ridge between the rivers Sara and Soura is composed of a variegated sandy clay, sparkling with selenites. At Ardatof (Simb.) the same strata appear, either marly or sandy, as at Nishney.

It will be necessary to mention here the limestone of Cazan, for although it has peculiar characters, yet it appears to belong to this formation. It is of a greyish yellow colour, usually very distinctly oolitic, and at the same time much harder and more compact than those rocks which form the oolite series in England. It contains terebratulites, and long stalks which appear to be of organic origin, although a regular termination is wanting at either end. It contains small milk-white concretions of radiated quartz. The only rock I have seen like it, is a hard oolite in Podolia *.

* This limestone appears in beds jutting through the sand, on the side of the hill going up to

Opposite to Cazan, near the town of Iviashsk, commences a high ridge of hills, which run due south between the Volga and Sviaga as far as Simbirsk. Thence it skirts the whole right bank of the Volga to near Sarepta, and forms the eastern part of the High Steppe of Pallas. The northern part is still wooded; but the remainder is more like the downs of the south and west of England than anything I have seen on the continent. The greatest part of what Pallas described in 1769 as open Steppe, is now brought into cultivation, some of the hills being left for cattle as in this country.

In the Ouslonsky hills, that part of the chain immediately opposite Cazan, the cliffs on the right bank of the Volga show the usual alternations of red and white marl. There are also some beds of a limestone whiter than that of Cazan, and somewhat more like the white limestone of the interior; which is likewise quarried and brought to Cazan. It may be of the same kind with the white magnesian limestone of Roche Abbey near Doncaster.

I will mention here another deposit apparently not connected with the salt formation, but which appears in several patches along the central part of Russia. It is a black clay, containing pyrites and green sand in abundance, and usually full of organic remains. Its most eastern locality that I have seen, is at Simbirsk *, where it occurs at the foot of the hill under the town, on the bank of the Volga; it is probably continued on the other bank; and it appears also at Polymnia, a few versts higher up the river. It is well seen below the church nearest to the river, where large slabs containing ammonites of great size, beautifully iridescent, are lying at the surface of the ground. There are also seen in it mytilites, and a few large and coarse septaria. The apparent situation of this rock is *under* the sand.

A similar rock is found also at Mourzikha on the Soura near Courmish, where large multilocular shells, of a nature intermediate between the ammonite and nautilite (resembling the well-known fossil of Kelloway in Wiltshire), are frequent; they are covered with a beautiful pearly crust, and are sometimes carried down by the floods into the Volga at Vasil-Soursk. When cut, the interior of these shells is usually found in a delicate state of preservation †.

the Kreml or fortress, but is not distinctly seen on the other side in the cliffs on the Cazanka. Specimens of it are in the Museum at Oxford.

* The view from the hill of Simbirsk (Plate 1. fig. 3.) shows the relative situation of the white marl, sand, and black clay. The rocks in the distance are the white central limestone, forming the High Steppe of Pallas, which near Cinghylëy rises into the high hills which border the Reach of Samara.

† These appear to fall under the genus which Parkinson proposes to call Ammonautilus;—Organic Remains, vol. iii. p. 108.—They certainly are the same which Parkinson mentions at p. 140,

A deposit of the same kind has been met with at Vixa at a considerable depth, but the specimens I saw there may have belonged to rolled masses.

A black clay is seen on the left bank of the Oca at Mourom, also beneath the sand; but as it contains no organic remains, it is not yet identified with any other bed.

It is very common in some parts of the neighbourhood of Moscow, where it also seems to lie under the sand of that country, and may be well examined at Petrovsky and at Kharashova. It there contains pyritical ammonites, black siliceous wood, and belemnites*. Some specimens of it include dentalia, sometimes covered with pyrites, sometimes imbedded in masses of black chert.

About twenty-four versts west of Moscow, near the village of Tatarki, is quarried a white siliceous sandstone, used at Moscow for foundations, and sent to distant parts of the country for millstones; but which are inferior to those of Voronesh. The Tatarki stone is often of a pinkish hue, and lies in large slabs with irregularly waved surfaces.

CENTRAL MINING DISTRICT.

This tract includes parts of the governments of Nishney Novgorod, Vladimir, Tambof, Rezan, Toula, and Calouga; extending from a little above Mourom on the Oca, to near the town of Calouga. It is in general a very poor sandy district†, and probably belongs to the red-marl formation, although its connexions are not very distinct. Along it are situated several extensive iron works‡; for in general the iron is manufactured where the ore is raised. These supply the principal consumption of that metal in the interior of Russia. One of the most considerable is the establishment at Vixa and its dependencies, in the forest of Mourom, belonging to Mr. Bataskoff.

as being found near the river Moscva (Russ. Moscva Reca), about a league from Moscow,—probably at the places hereafter to be noticed, as showing the black clay.

* Pallas mentions a similar rock, as a probable indication of coal at Cashponr, lying under a hill of white marl like that of Simbirsk and Tagay, but mentions no sand between them.

† It is nevertheless more fertile than the sand of Petersburg, since, without manure, it lies fallow only every third year, and gives a return of eight for one. When properly treated, it bears tolerable crops, especially of lucerne, a plant which has almost naturalized itself where it has been introduced. Among the surface gravel, are rolled pieces of granite, limestone, and chert.

‡ The Crown works of Toula employ exclusively Siberian iron: this is the principal manufactory of arms in Russia. The manufactory at Calouga formerly attempted the finer kinds of cutlery, but failed.

The forest of Mourom* is a tract of more than fifty versts in length, which stretches along the right bank of the Oca above Mourom: its sandy soil and gloomy appearance resemble more the forests of Carelia, than those of the central governments in general. At the depth of sixty feet below the surface is found a series of beds of ironstone of variable quality; some of the beds are dark red and argillaceous; others are mere layers of large concretions, the outer crust of which is an argillaceous rusty earth, while the centre is solid, and of an ash-grey colour: there are also regular strata of pale yellowish-brown coloured ironstone, which is the ore principally worked. Of the two latter varieties, the lightest coloured ores produce the most iron. The mines, if they may be so called, are in several parts of the forest; the principal about two or three versts from the ferry over the Oca, on the road from Vixa to Mourom. Here the whole surface of the ground appears as if covered by large mole-hills: they are the heaps with which the old pits are covered up. The present system of working is, to sink a shaft, as if for a well, till it meets the bed of ore, and to raise what lies within the circumference, and perhaps a little more all round, and then to close the shaft, and sink another as near to the old one as convenient. In this manner the whole ground is perforated with small holes as near together as they can be placed: no gallery is driven, and all the ore is got out by a shaft immediately above the spot where it lies. The reasons given for this apparently expensive mode of working are, that the ore lying so near the surface, it is little more expensive to arrive at it through a soft bed of sand, in which it is easy to sink shafts, than to drive galleries, for which much timber and machinery might be necessary; since the sand, from its loose texture, would require a vast structure below to support it: yet there is a superabundance of timber in the immediate neighbourhood.

* The history of the foundation and progress of the iron works at Vixa is not devoid of interest. About fifty years since, the present owner, who with his brother had been engaged in the iron works at Toula, and who possessed a certain knowledge of this part of the country, imagined that the ironstone of the government of Toula was likely to extend into the Forest of Mourom. He followed therefore the course of the Oca; and finding pieces of iron ore on the banks of the river, was induced to try whether it existed *in situ* in the neighbourhood. He actually found that its strata were at an inconsiderable depth below the surface on the right bank. This was in the Forest of Mourom, then almost uninhabited, except by banditti, which were then in sufficient force to oblige him to take an escort of Cossacks in the researches which he made for ore. Being satisfied of the quality of what he found, he bought, at an extremely low rate, a vast parcel of the forest, then Crown land; and he now possesses, in the midst of the barren wilderness,—besides a large country-house, with English and Italian gardens, a theatre, a bazaar, and a market,—eleven separate iron works, at from four to twenty versts distance, handsome churches, villages, and 30,000 inhabitants, as his share in the adventure.

In some parts of the district are chalybeate, and in others sulphureous springs, at which buildings are erected as hospitals for the establishment. In digging for these were found the fragments of the black rock with ammonites, and also of the siliceous rocks containing shells.

CENTRAL LIMESTONE DISTRICT.

There extends across the middle of Russia a tract of limestone of a very well-defined character. It is generally of a very pure white, completely filled with broken encrinites, large terebratulites, caryophyllites, pectinites, and the exuviæ of other marine animals. Its extent may be taken from the reach of Samara on the Volga to the country between Smolensk and Moscow: it is easily recognised under the characters above stated. Near Moscow it is quarried at Machcova, where the earthy varieties nearly resemble chalk, and have sometimes a pale yellow colour. There are also in that part of Russia two species of marble, which should be noticed here, as they are probably members of the same formation. One is the yellow marble of Serponkhof and Colomna, both on the Oca, near which places it is quarried, to be used in Moscow for ornamental purposes. It contains fragments of encrini, and a very large species of terebratulite with a spiral hinge, found also in the mountain lime of Derbyshire. It is very frequently covered with dendrites. The other marble is found near Aleshina, between Moscow and Colomna, and is of a dull reddish-brown colour, and is sometimes used for tables. It contains large specimens of the Anomites productus, like those of Borovichy*.

This white limestone† occurs also in great quantity on that part of the Oca above Mourom, where the governments of Nishney Novgorod and Tambof join those of Vladimir and Rezan. At Ounsha near Yelatom, one of the iron works dependent on that of Vixa, and at Gelat in the same neighbourhood, it is quarried for the use of the smelting-houses. It contains its usual

* A mineral called Ratofkite is found lining the surface of siliceous layers in marl, on the river Ratofka near Moscow. Professor Fischer has published an account of it: *Mém. de l'Université de Moscou*, tom. 5.

† A limestone with flints is stated by Bray to occur on the Düna, where it enters Livonia; but it is doubtful whether it is a prolongation of the limestone of the Valday, or of that of Central Russia.

A white entrochal limestone occurs in Scania, but its exact geological relations are not known; it much resembles that of Machcova.

fossils in abundance and good preservation. Further eastward it appears in the south part of the government of Simbirsk, and it is seen on the banks of the Volga for a great distance both above and below the town of Cinghylëy: it forms the lofty ridge which diverts the course of the river between Stairopol and Syzran, and is called by the name of the Markvashky and Shigoulefsky Hills. These are the highest banks of the Volga. The hill called Tzaref Kourgan, or King's Barrow, at the mouth of the Sok near Samara, is not artificial, but is composed of strata of grey limestone, with minute madrepores, which in shape and size resemble grains of wheat*.

The limestone at Sernoi Gorodok contains sulphur mines, no longer worked; they are in the hills called Sokoly Gory. The banks of the Volga, in what is called the reach of Samaraarc, are wild, and possess an interesting character. I must refer to Pallas as an authority for the vultures, chalk, gypsum and sulphur, and other wonders of the place.

OURAL MOUNTAINS.

This primitive chain, running from the Icy Sea to the steppe north of the Caspian Sea, forms the natural boundary between Asiatic and European Russia: and I must include in this district a certain portion of country on each side the chain†.

A rich and extensive tract of red marl, salt, and gypsum, stretches down the course of the Kama, and is probably connected on the south with the salt district of the Volga, and on the north with that of Vologda. The principal salt works are in the neighbourhood of Solikamsk; and the alabaster grottos of Koungour, in the government of Perm, exceed in size and magnificence the cave of Barnoucova. At intervals along this line appear springs of naphtha, every where considered as a sign of coal, which however has only as yet been found on the Ousva, nine versts from Alexandrovsk, where it occurs with a rich argillaceous ironstone, manufactured at the latter place, the establishment of Mr. Vscvoloshsky.

But on both sides of this salt country is a vast tract of what is commonly called copper sand, which extends through a great part of the governments of Viatka, Perm and Oufa, and completely skirts the south and west sides of the

* A specimen is in the Museum at Oxford.

† A secondary tract appears on the side of the Oural Mountains, forming the western or low division of Siberia; but I am not able to state with certainty whether its rocks resemble the formations on the European side.

Oural mountains. This sand is of a dull red or green, and is commonly worked for copper. It contains fossil wood impregnated with copper, and what are supposed to be casts of cacti, resembling the fossil vegetables of the English coal formation. It sometimes occurs also in the state of a conglomerate.

In the neighbourhood of Orenburg, where this copper sand is extensively worked, is, according to Falk, a limestone which contains shells, and lies immediately on the granite of the Obschey Sirt, the southern projection of the Oural chain. (See Falk, vol. i. p. 182.) The alabaster rock seems to belong to the salt formation; which, as will be seen, forms islands in the centre of the desert steppe. A salt district, full of saline lakes, exists on the south-east corner of the Ourals, and seems to connect Siberia with European Russia and the steppe of the Kirghis.

There seems to be no continuous primitive ridge connecting the Oural and Altay mountains. Insulated granitic hills, surrounded by the salt district and partially wooded, are described as existing near the frontier. The mountains in the steppe opposite Orenburg and Orsk, resemble those within the Russian frontier: they contain copper and salt, which latter is worked by the Russians under protection of a fort at Iletsk.

The Oural chain consists of various primitive rocks, remarkable for being finely and distinctly characterized. Primitive marble exists in many places, but is now little worked; and the southern and eastern parts are celebrated for the beauty of their ornamental jaspers, which occur in large rock masses. The iron and copper mines, and other mineral treasures of the Ourals, are too well known, and have been too often described, to require mention in this place.

SOUTHERN RUSSIA.

The secondary rocks, of which I cannot give any detail, are continued across the whole of this country till we arrive at the primitive steppe. Good coal has been found near Toula, where it is worked; but the quantity is so small, and the difficulty of working it beneath a loose and half-liquid bed of quicksand is so great, that it seems unlikely to be of much utility. Coal has also been worked at Bakhmout, in the government of Katerinoslaf, where it is accompanied by hills of schist, which border the Donetz, as described by Pallas in his Second Voyage.

Steppes*.

Primitive Steppe.—The first part of the steppe district with the geological features of which I am in some degree acquainted, is that primitive tract which stretches in a direction E.S.E. from the upper part of the river Bug to the Berda. It occasions the rapids of the Dniepr, and passing to the south along the Bug, terminates within a short distance of the Black Sea. The rock in this tract is a coarse-grained granite, containing garnets, but sometimes passing into trap or syenite. It forms a level country, intersected by deep ravines, and is without woods. In Volhynia, near the borders of Gallicia, it affords a fine white earthy felspar, fit for making porcelain. It occurs at Croupetz on the road to Lemberg.

Calcareous Steppe.—A series of calcareous rocks accompanies the southern border of the primitive steppe, following the line of the Dniestr and the coasts of the Black Sea. Some large-grained oolites appear near the frontier of Gallicia, as also between the Bug and Dniestr near Tomaspol, where they are very hard and compact; and again, of a very fine grain, between Bender and Odessa. A shelly limestone, much resembling those of Purbeck and Portland, occupies a large tract between the two rivers before named.

The only new formation is that of bitumen in the peninsula of Kerch, at the entrance of the sea of Azof, which appears also in the opposite peninsula of Taman, and at the other end of the Caucasian chain, in the promontory of Bacou, on the Caspian Sea. Limestones of secondary formation form a high steppe, in the intermediate space, around the northern edge of the Caucasus, and compose the first ridge of elevated land which appears south of the steppe of the Courna. It appears that the bituminous formation of Bacou, in the peninsula of Abkharon, is comprehended in a ridge of argillaceous shale,

* The etymology of the word *Steppe* is a disputed point, even among the Russians; it may possibly be of Tartar origin. The word steppe is applied generally to any waste land whatever, provided it is not covered with forests. Thus we hear of the high, the low, the rich, the poor, the salt, the sandy, the icy, the stony, and other steppes: districts differing in almost every character, except in that of being desert. The high steppe is like the Downs of England, but without their fine herbage, being much covered with wormwood. The low steppe, formed by the sinking of the waters of the Euxine, is *sui generis*. Some of the small grassy valleys among the Ourals are called steppes: but the term is applied to no mountainous country within the territory of Russia. Part however of what is generally called the steppe of the Kirghis is mountainous. Some of the tracts lately reclaimed from the waste are still, incorrectly, known by their former name of steppes. In the Russian language, the desert of Africa is called the *Africansky step*.

which forms the bulk of the country of Shirvan. The hills of Dagestan and Shirvan nearest the sea on the north of Bacou, are composed of a shelly limestone. The bituminous formation re-appears in the Isles of Naphtha, on the eastern shore of the Caspian, and, it is said, also in Georgia.

Salt Steppe.—The most remarkable of all the steppes is that which, lying at an extremely low and generally uniform level, extends between the Black Sea and the Caspian, and of which Pallas has partly traced the ancient boundaries. It is marked by an extreme want of fresh water, and is covered with sand and recent shells, such as are now found in the neighbouring seas. The lakes and pools which it contains are mostly salt *, and the scanty vegetation of the steppe consists of such plants only as are found with us on the sea-coast, or which are of a like nature. The rock under the superficial sand is a hard clay, sometimes left bare. It may easily be imagined that this district is of an extreme sterility, and is consequently scarcely inhabited.

The origin of this steppe is usually attributed to a change of level in the waters of the Black Sea, which, having burst a passage through the straits of Constantinople, left dry the shallow tract between it and the Caspian. The extent which this sea is supposed to have occupied formerly is loosely traced upon the map ; according to which there must formerly have been either two inland seas, separated by land in the neighbourhood of the Bosphorus, or the Mediterranean must have extended to the interior of Asia, as far as the low steppe continues ; and in that case its eastern shore would have been the high land which, in the steppe of the Kirghis, connects the Altay with the Himalaya mountains. Many considerable islands and peninsulas would have thus been formed, such as the Crimea †, Kharizm, the Beshtan, &c. : for the bed of a strait is said to be traced across the isthmus of Perecop, including the steppe of the Dniepr on the north, and a part of that of the Crimea on the south ; the Lake Aral would have been joined by narrow seas with the Caspian on the north-west, and perhaps also on the south-west. And among the smaller islands would have been those insulated hills, which now rise in the steppe between the Volga and Oural rivers, and which consist of alternating strata of limestone, and red and yellow sand, and clay, with salt, gyps, and alabaster, like those which accompany the salt formation in the south of Russia.

* The salt contained in the ground is frequently said to form an efflorescence on the surface resembling hoar-frost. Salt rain also is said to fall in the neighbourhood of the Caspian Sea, although its waters are much less salt than those of the British Channel, where that sort of rain is not known.

† See Pliny, Hist. Nat. lib. 4.

Of these the rock or mount Bogdo is the most remarkable, being eight versts round and nearly five hundred feet high (in part perpendicular) above the plain. The hills of Chapchachy *, Minggan, Khonggor, Arsagar†, and that of Inderskoy ‡, beyond the Oural river, are of a similar character, and generally contain salt lakes: Yelton and other considerable salt lakes occur at a distance from them.

Although this theory of an extension of the Mediterranean Sea may be on the whole correct, it would obviously be vain to attempt any detailed account of the former condition of this tract of country, till accurate levels and surveys shall have been taken of the entire steppe §. The traditionary idea among the ancients that there was a communication between the two seas by means of the river Phasis, though false in itself, may have been founded on the existence of a strait at no greater distance from the Phasis than the Manych, which is the most likely situation for it ||. Indeed the communication between the two seas could never have been much more than a strait; and the term river would hardly be an objection to this idea. The actual enlargement of the Caspian towards the north, and its communication at that end with the lake Aral, formerly much larger, may also account in some degree for the ancient notion of its opening into a northern ocean; especially if we consider that in the oriental geography of the ancients, the north-east seems commonly to have been mistaken for the north, and thus to have occasioned the erroneous disposition of the Caspian in their maps with regard to the cardinal points.

The Caucasus is a primitive chain, containing in many places columnar trap **. The older secondary rocks on its northern border, are a continuation of those which form the highest mountains on the south coast of the Crimea, where primitive rocks are wholly wanting. These mountains are principally composed of slate, with a conglomerate, and older limestones, in which the hard oolite is apparently insulated. Behind these are chalk and flint, with pyritical

* Gmelin, vol. ii. p. 8; also Pallas 1st Voy. vol. iii. p. 667; and 2d Voy. chap. 7.

† Pallas 2d Voyage. ‡ Pallas 1st Voyage.

§ The Survey by Engelhardt and Parrot, from the mouth of Couban to that of the Terek, crosses an interesting line of country, and makes the Caspian Sea to lie in a hollow; its level being, according to their measurement, 54.2 toises lower than that of the Black Sea. This sufficiently proves the steppe, though comparatively even, to be by no means level.

|| See Strabo; and Pliny, who speaks more directly to the point. Hist. Nat. lib. vi.

** See Reineggs' Travels in the Caucasus, in German.—It is much to be regretted that no translation exists of the greater part of the travels in Russia. Pallas alone of the older travellers has appeared in English, and with Gmelin and Biberstein has been translated into French; but Reineggs, Krasheninikof, Güldenstädt, Falk, Lipekhin, Renovanz, Georgi, Hermann, Engelhardt, and Parrot, are still to be read only in German or Russian.

balls, exactly as is seen in England and France: chalk is seen also on the Dniestr near Moghilef*, and on the Gallician frontier between Brody and Radzivilof; the sandstone of Lemberg intervening between the chalk and the Carpathian mountains. The most southern part of this secondary tract is composed of a soft yellow shelly limestone, extending along the shore of the Black Sea from the heights of the Dniestr and Odessa, across the mouth of the Bug and the Dniepr towards Cherson: and similar strata, especially the oolites, are found in Moldavia and Valachia. The country, though bare of wood, is fertile.

Secondary strata, which I suspect to be partly a continuation of these limestones, form the High Steppe of Pallas, along the Don and lower Volga, and probably stretch further north.

The greatest part of the interior of the Crimea, as described by Pallas, Engelhardt, and Parrot, appears to consist of strata of similar character to those above mentioned; but gradually rising towards the mountains of the south. These strata form what is called the steppe of the Crimea, and are continued on the eastern side of the Sea of Azof, along the northern edge of the Caucasus towards the Caspian. The descriptions and maps of the Crimea represent it as affording a most perfect example of a regular series of diluvian escarpments.

* In the ravines communicating with the Dniestr near Moghilef, is found siliceous wood, in considerable quantity: it much resembles that of Portland. Siliceous wood resembling that of the Palm tree has been found near Tomaspol.