

on which to calculate the total cubic contents of the sea, and of the supposed glaciers, it is difficult to form any good estimate of the change of level that would result from such a cause. If there was an ice-cap at both poles at the same time, the centre of the gravity of the earth would remain much as it is, and the cause of submergence invoked by Dr. Croll and M. Adhemar would not come into operation.

(*To be concluded in our next Number.*)

IV.—NOTES ON THE GEOLOGY OF THE COUNTRY AT THE BASE OF THE S.W. SLOPES OF THE URALS.

By W. H. TWELVETREES, F.G.S.

THE country at the base of and forming the south-western slope of the Urals has been little visited by geologists from Western Europe, and deserves more attention than it has received. Several years' residence in it form my excuse for recording a few notes thereon. The area I have travelled over extends from Samara on the Volga in the W. to Preobrajensky and Bieloretzky in the E., and from Orenburg in the S. to the town of Ufa in the N. The formations met with within these limits are the Silurian, Devonian, Carboniferous, Permian, and Jurassic. The three former are the crystalline rocks of the Urals, the western edge or front range being composed of Carboniferous grits and limestones. The foot hills are Lower Permian, made up of gypsum, red sandstones and marls, conglomerates, and different varieties of rather homogeneous, compact limestone. This division of the Permian, which only in places yields *Unios* or *Anodons* and plant-remains, gives way further west to the highly fossiliferous Magnesian Limestone, upon which repose the copper-bearing marls and sandstone of the great Permian steppe.

A journey due E. from Kargalinsk over the Lower Permian country to the Carboniferous mountain rocks showed the conglomerates and sandstones undulating in gentle flexures to within five miles of the front range, and then they dip to the W. The lowest of the Permians was a band of massive gypsum. Five miles further N. the same band was met with, and eighty miles still further to the N.W. the gypsum preserved the same relative position. The outlying conical Carboniferous Limestone hills at Sterlitamak in the Ufa government, which have burst through the Lower Permian rocks, bring the same gypsum up, which is to be seen at their eastern and southern bases. The band of gypsum first referred to lay on the W. side of the Ik, and the alluvium of the valley obscured any succeeding rocks. Those on the other side of the river were the grits and sandstones of the Carboniferous dipping E. towards the mountains. These were succeeded by the grey crystalline Carboniferous Limestone also dipping uniformly in the same direction. Here then the Permian and Carboniferous would appear to be unconformable. Further N.W., near Voskresensk, the Carboniferous Limestone dips W., and is succeeded by overlying sandstones and coaly flags with plant-remains thinly developed, and these, which are apparently here the uppermost members of that formation, are

conformably overlain by Lower Permian sandstones and conglomerates with gypsum. A succession of marls of various colours, almost unfossiliferous limestones, pebble-beds and sandstones then occupy the country till the Magnesian Limestone is reached. I have repeatedly searched the lower limestones for fossils, but the only traces of anything are obscure tubular branching substances, which I could not with certainty identify as organic. Besides these, were faint markings which might be fucoidal. From the grits and mud-like shales of a copper mine at Darghina, fifteen miles S.W. of Voskresensk, I obtained several species of *Unio* and many ferns. With the identification of these I have only proceeded thus far :—

Odontopteris Permianensis (Brongn.)
Cyathea Schlotheimi, var. *latifolia* (Göpp.)
Callipteris (Brongn.) sp.
Neuropteris salicifolia (Fischer).
Neuropteris tenuifolia (Sternb.)

The conglomerate of the Krasnaia Gora, W. of Voskresensk, which reposes on the compact limestone, contains many rolled fragments of the fossiliferous Carboniferous Limestone, which, in spite of the apparent conformity, would suggest a Post-Carboniferous movement taking place in Lower Permian times.

Near Voskresensk some of the conglomerates are cupriferous, but the pebbles render the ore intractable in the furnaces. The ore averages 4 to 5 per cent. fine copper. Experiments are being made with a view to gain the copper by the humid process, and have proved successful when conducted on a laboratory scale.

These lower rocks of the Permian form a very distinct division of the formation, and are, I suppose, the equivalent of the Rothliegende. I have not seen any vertebrate remains from this division.

The limestone with Zechstein fossils may be seen in the country to the W. of the Ufa and Orenburg post road, but is most fossiliferous in the Grebeni peaks near Orenburg. It forms two anticlinals near Jemangoolova, and is seen all through this part of the country to pass under the upper copper-bearing sandstones. The superior contact rock is generally a light-coloured or yellow sandstone. In the Kargalinsk district the limestone has a persistent character, and gives place definitively to the cupriferous sands.

The mines are small, but very numerous, and the few fossils found in this upper series are derived from the ore beds. It is to be regretted that many specimens are scattered all over the world, and are lost to science. I know an instance of a perfect reptilian jaw (I suspect of the rare genus *Rhopalodon*) having found its way to England in the possession of an agent at these mines, and on making inquiries I learn that it has been presented to a relative in Australia. These rocks consist of alternating sandstones and marls, with much irregular bedding, and are characterized by great want of constancy even in limited areas. This may be exemplified by the following sections of four mines in this field in descending order.¹

Ordinsky Mine.—1. A few inches of black earth. 2. Eighteen feet of red clay. 3. Twenty feet of red sandstone and clay.

¹ The sections were taken by a resident agent, Count dal Verme.

4. Seven feet of grey sandstone. 5. Two feet of grey marl and white sandstone, with poor copper ore. 6. Two feet of white sandstone with cupriferous beds. 7. Red marl.

Troitsky Mine.—1. Twenty-five feet red clay. 2. Forty feet of red sandstone and marl. 3. Six feet of brown sandstone. 4. Eight feet of yellow sandstone. 5. Ore bed four feet. 6. Yellow and grey sandstones.

Vichy Nikolsky Mine.—1. Twenty-five feet of red clay and marls. 2. Twelve feet of grey marl. 3. Ore bed three feet. 4. Yellow sandstone three feet. 5. Red marl.

Droojelobny Mine.—1. Twenty feet red marl. 2. Three feet of yellow sandstone. 3. Ore bed three feet. 4. Yellow sandstone. 5. Red clay or marl.

All over this area there are no repetitions of the limestone. The Government of Orenburg affords a truly typical display of the Permian rocks. In the eastern part are the lower limestones and sandstones, in the central part is the band of Zechstein limestone, while the Kargalinsk area is occupied by the upper series of sands and marls.

The conglomerates of the lower division are more powerful than those of the upper, which are very thin and local. No gypsum has been observed in the Kargalinsk series. The homogeneous limestones so prevalent near the base of the system are here absent from the upper beds. The copper ore is more irregularly distributed in the lower beds than in the Kargalinsk steppe. A combination of these characters, apart from stratigraphical considerations, will generally enable a practised local observer to ascertain whether he is on Lower or Upper Permian ground, though of course there are localities which may fairly puzzle one. I should therefore be disposed to dissent from the Rev. A. Irving's view that the "limestones and dolomites of the Russian series are repeated over and over again through nearly its whole range."¹ In the Bielebee district, in addition to the supra-Zechstein marls and sandstones, intercalated marls to a small extent and thin developments of sandstones occur in the Zechstein Limestone, and that district (though not the intercalated marls) having yielded to Sir R. Murchison most of his Permian plants, was much emphasized by him, and has become a kind of typical ground for students of the Russian Permian, while I should rather insist on the rocks of the Orenburg government being taken as the type. The Zechstein Limestone of Bielebee is below the marls, sandstones, and grits containing bones of Saurians. That some data are needed for an appreciation of the correct age of the Kargalinsk cupriferous beds may be seen from the uncertain tone of Ludwig's treatise on the Dyas in Russia.² He says, "It is not clear from Murchison's description whether the cupriferous sand ores of Kargalinsk, in which silicified wood, impressions of plants, *Palaeoniscus* and bones of Saurians have been found, belong to the Rothliegende or to the beds which at Nijni Troitsk [Bielebee dis-

¹ GEOL. MAG. April, 1882, p. 161.

² Geinitz, Dyas, vol. i. p. 300.

trict] overlies the Upper Zechstein." He comes to the conclusion¹ that the upper (fluvial or lacustrine) group with *Uniones*, plants and Saurian bones, must for the present be placed somewhere between the Palæozoic and Mesozoic rocks, or equivalent to the Vogesen Sandstone of Subzbach (Lower Trias). This is just the point requiring settlement, and every scrap of information bearing upon it is valuable.

To avoid confusion it may be mentioned that the present government of Ufa, in which the Bielebee district is situate, was formerly part of the government of Orenburg, and that the mines of Kargala or Kargalinsk, to which I have been referring, are not those of Kargala in the Bielebee district.

M. Möller believes that certain portions of the Permian field were deposited synchronously. I do not know to what extent he applies this theory; but when there are on this parallel such plain evidences of superposition, I cannot bring myself to believe that the three divisions of the system or any two of them were laid down at one and the same time.

A few miles S.E. of the village of Jemangoolova, on the Orenburg-Ufa post road, and 20 miles east of the Voskresensky mines office on the Kargalinsk steppe, is the hill of Saragul, the base of which consists of the Upper Permian beds. The upper part of the hill is composed of a horizontal or nearly horizontal bed of Jurassic sandstone crowded with shells, according to Murchison, of the Oxfordian division, but in the opinion of Dr. Trautschold, who is *par excellence* the historian of the Russian Jura, characteristic of a superior horizon in the system.

In a subsequent communication I hope to furnish a list of the Mollusca found in this patch of Mesozoic rocks. Von Qualen asserted that he discovered chalk with fossils on the eastern side of this hill, but Mr. Rickard and I have more than once made a fruitless search for it. The nearest Jurassic strata are about 80 or 100 miles to the south, and the position of this isolated cap is suggestive of great denudation over the intervening area, which is occupied by the Permian beds.

Apart from points of local or special interest, the whole surface of the steppe from here to the Volga, with its comparatively loose materials arranged in more or less horizontal layers, opens up some questions of general importance. Is it possible that this immense plain was raised in its entirety to its present elevation by plutonic force? Were the organic remains now found in the beds of copper ore restricted to those sinuous channels, which may mark the courses of streams which during various changes of level flowed through land surfaces? Or were they originally scattered also through the red rocks which are now destitute of them? Mr. Rickard has noted that the latter rocks lose their colour and much of their iron when in contact with the ore beds. The theory which will explain the formation of the copper ore and the preservation of the organic remains in it will have also to account for the sterility of the red sands.

¹ *Op cit.* p. 304.