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BARON TOLL ON NEW SIBERIA AND THE CIRCUMPOLAR TERTIARY FLORA.*

By P. KROPOTKIN.

THIS new paper of the well-known arctic explorer is of exceptional interest. After a few historical remarks relative to the exploration of arctic Siberia, Baron Toll briefly sketches the geology of the Verkhoyansk ridge and the plateau in the west of it. The ridge, in the upper course of the Yara, Dulgulakh, and Bytantai rivers, consists of black slates, of Devonian age, and sandstones—partly glauconite sandstones—belonging to the Mesozoic age, and specially to the so-called "Volga deposits." Both are considerably metamorphosed. In the upper and the middle courses of these rivers, Triassic slates (containing *Pseudomonotis ochotica*, Keyserling) prevail. They alternate with sandstones, and were traced up to 70° N. lat. Between Verkhoyansk (67° 32′ N.) and the junction of the Adicha with the Yana, Bunge found slates containing the *Gryphœa cf. dilatata*, which indicates the Liassic age of these slates. Liassic deposits were also found in 1893 on the Anábar.

Under 70° N., the Yana pierces the Kullar branch of the Verkhoyansk ridge, which branch shoots east-north-east, and consists of lower Triassic slates (*Hungarites triformis*, Mojs., and *Meecoceras affine*, Mojs.). Quartz porphyries pierce the Triassic slates, and granites constitute isolated heights, such as the Yngnakhkaya mountain (4297 feet) and the Kikhilyakh (3528 feet).

The Lena, from Bulun to its delta, flows in a valley between the Verkhoyansk ridge and the plateau which lies to the west of this ridge. Middle carboniferous limestones were found on the right bank of the Lena, opposite Stolbovyi island; and Upper Devonian slates, similar to the Dulgulakh slates, were found on the bank under 67° N. Palæozoic limestones appear at Kumaksurki, and are covered further down by limestones and slates, containing beds of coal. Lower Triassic slates were found on the Tas-ary island.

As to the plateau, which is watered by the Vilui, Olenek, and Anábar rivers, and probably also by the Khatanga, it stretches as far as the Yenisei, reaching the lowlands of West Siberia. Baron Toll gives it the name of "Central Siberian plateau," instead of which it would, perhaps, be better to retain the name of "High Plains of Siberia," proposed by the present writer, reserving the names of plateaus for the high plateaus of East Asia.

The average altitude of these "high plains" is about 1000 feet, and they are mainly composed of Cambrian and Silurian deposits. A little above Yakutsk the Cambrian deposits are followed by carboniferous sandstones of the "Volga deposits." These deposits appear also along the Lena up to 71° N., and westwards to the mouth of the Olenek, where they cover Triassic deposits. The "Czekanowski ridge," running west-north-west and west along the coast, is composed of them. As to the "Pronchischeff ridge," which runs further, from the Olenek to the Anabar, it consists exclusively of Mesozoic deposits—Lias, Volgian, Neocomian, and Oxford. The names of Czekanowski and Pronchischeff, which Baron Toll gives to these two ridges, are sure to be gladly accepted by geographers. At one spot at the mouth of the Chirima (64° N.), Tertiary deposits, of which more will be said presently, were found by Czekanowski.

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* "Sketch of the Geology of the New Siberian Islands, and the Main Problems in the Exploration of Arctic Regions," by Baron E. Toll, with two maps (*Memoirs of the St. Petersburg Academy of Sciences*, 8th Series, vol. lx., 1899. Russian).

The New Siberian islands occupy, as is known, the space from 73° to 76° 6′ N. and 136° to 160° E. long. The most northern and highest island is Kotelni. Its northern portions consist of Upper Silurian limestones, rich in corals. Similar deposits are known on the continent, especially on the upper Olenek. On Kotelni they form a series of folds running north-north-west, and Toll proposes for them the name of "Schmidt's ridge," thus rendering a well-deserved homage to the geologist and explorer of Siberia, Friedrich Schmidt. The southern part of the same island consists of Middle Devonian limestones and slates. At Bear cape Triassic deposits were found.* Diabases pierce the former, and olivine rocks shoot as dykes through the latter. The highest summit, Malakatyn-tas, 1200 feet high, consists of trapp. The New Siberia island, in the part explored by Toll, does not reach more than from 200 to 300 feet above the sea. The so-called "wood mountains" proved to be an excellent cutting through Miocene deposits, containing brown coal, and not deposits of modern driftwood. To the ridge formed by these Tertiary deposits Toll gives the name of "Hedenstrom's ridge." Only post-Tertiary deposits were found during a cursory visit to Fadeevski island.

The triangular shape of the great Lyakhovski island is due to granites (Bunge), while the Svyatoi Nos mountains on the mainland are either table-shaped or conical-shaped hills, made up of basalts. The Suruk-tas has well retained its volcanic form. These basalts are posterior to the Jurassic epoch. The glacial formations are represented on the southern coast of the Great Lyakhovski island by a lower bed, about 70 feet high, of ice, and an upper bed of clayey fresh-water deposits, always frozen, and containing tusks and pieces of the skin of the mammoth, as well as full frozen carcases of *Ovibos* and rhinoceros. Remains of horses, stags (the noble American stag), antelopes, *saigas*, and even of a tiger, were found in this bed. To prove that these animals lived and fed on the spot, a complete tree of *Alnus fruticosa*, 90 feet long, with all its roots, leaves, and fruits, was found. Similar deposits, as is known, are spread on the mainland. Speaking of the conditions of life of these animals we must remember, however—Toll remarks—the musk oxen of Greenland and the mammals of the high plateaus of Tibet.

Omitting a few remarks of Baron Toll concerning the structural origin of the ridges of the far north of Siberia, we shall dwell especially on what he has to say on the exploration of the Tertiary deposits *still further north, towards the pole*. Beds containing brown coal, and probably of the same age as those of the New Siberian islands, were found, as is known, by De Long on Bennett island. Besides, volcanic rocks were seen on this same island, and when Baron Toll sighted Sannikoff's Land from Kotelni island in 1886, he saw table-shaped mountains, the shape of which makes one believe that they must also have a volcanic origin, and that in the north of New Siberia there may be an archipelago, perhaps as big as that of Franz Josef Land. "Considering the geographical distribution of the Miocene plants in the arctic regions," Baron Toll writes, "we see that they appear in the shape of a complete ring around the pole, especially in Kung Karl's Land, on Spitsbergen, on the west and east coasts of Greenland, in Grinnel's Land, in Bank's Land, in Sitka, in Alaska, in Kamchatka, and finally on the Lena, at Kirimy-Phaya, in 67° N. The most northern spot where Miocene plants were found is 81° 45′, in Grinnell's Land. Captain Feilden, in 1876, during the British polar expedition, found there in the slates thirty species of plants, of which I shall only mention *Taxodium distichum*, or the marsh cypress, which now grows in the southern states of North America, a modern species of the pitch tree, and two fir trees; then the *Ulmus*

* List of fossils found are given in each case.

Corealis, a lime tree, two birch trees, two species of poplar, and so on. The yearly average temperature under which such a flora could grow must have been at least 46°·5 Fahr., while now the average temperature of this spot is only 6° below the Fahrenheit zero. How can we explain such a change of climate, and altogether the possibility of climatic conditions necessary for such a flora?

"Two probable hypotheses," Baron Toll continues, "were offered to explain the facts. One explains them by a different distribution of land and water, and the other by a change of position of the axis of rotation of the Earth, and consequently of the two poles and the equator. The renowned astronomer Schiaparelli has discussed the possibility of the latter hypothesis, and his conclusion was as follows: 'Astronomy does not deny the possibility of those considerable changes of latitudes which are claimed by geologists for the explanation of certain geographical facts.' Among the geologists, the late Dr. Neumayr expressed himself as follows: 'Let us imagine that the north pole has shifted, in the Ferro meridian, ten degrees in the direction of North-East Asia. The 70° of latitude would run then through Spitsbergen, Novaya Zemlya, the mouth of the Ob, and thence through Siberia to Irkutsk; it would pass then through the northern portion of the sea of Okhotsk and Kamchatka, cross the Pacific in the south of Behring strait, entering America at the mouth of the Copper river, and reach Greenland at the spot where the 78th degree of latitude issues now.' Nathorst, in 1888, accepting this idea, admitted that the pole must have been during the Tertiary period full 20° southward of its present position. Under this supposition, the Tertiary plants discovered by Czekanowski on the Lena at Pirimy-khaya, under 70° N. lat., would have been under the 78th degree of north latitude, and the small leaflets of a sickly aspect which he found would have been explained by the proximity of the spot to the pole. But how would this suggestion agree with our own finds in New Siberia? Perfectly well-developed and full-sized leaves of *Populus arctica* and *Populus Richardsoni*, Hr.; numerous fruits of the mammoth tree (*Sequoia Langsdorfii*, Brogt.); the leaves of several conifers (*Taxites tenuifolius*, Schm., *Taxodium distichum miocenum*, Heer), and so on, do not indicate at all a proximity to the pole, while under Neumayr's hypothesis this spot would be situated under 85° N. lat., and it would be near to this same degree of latitude under Nathorst's hypothesis. Consequently, then, the hypotheses are fully insufficient, and we must have *more* data than those which I could collect in 1886—not only from that spot, but also from the islands situated further north. As to the other rival hypothesis concerning the distribution of land and sea during the Tertiary period, still less can be said in its favour, *so long as all the globe, and especially the polar lands, have not been explored.*"

Baron Toll does not deny, of course, the usefulness of such hypotheses. On the contrary, they stimulate research; but the researches must necessarily be made. Besides, he points out that there are on the New Siberia islands distinct traces of glaciation, as also of elongated hills similar to the eskers of Courland, and of erratic boulders, brought perhaps from the Sannikoff archipelago, and he concludes for the necessity of exploring this archipelago in order to settle this question as well.

This paper is accompanied by two maps. One of these shows the position of both the pole and the 70th degree of north latitude, under the hypotheses of Neumayr and Nathorst. The other map is a large-scale geological map of the New Siberia islands, as well as those parts of the Yana, the Lena, the Olenek, and the Anabar, which were explored by Baron Toll's expedition.

A few words may be added to the important paper of Baron Toll. The necessity of exploring the Tertiary deposits in the far north, and especially in Sannikoff Land, as also in the land that was supposed to exist to the north-west of Novaya

Zemlya (Franz Josef's Land was not yet discovered at that time), and the far-reaching geological results which could be attained in this way, were indicated already as one of the main points of scientific interest in the report issued in 1871 by the Arctic Committee of the Russian Geographical Society, of which the present writer was the secretary. The discoveries of Czekanowski and Baron Toll have only added immensely to the interest of this question, by rendering the explanation still more difficult.

The whole question of the changes of climate on the Earth since the end of the Tertiary period—warm climate, even in high latitudes, at the end of the Tertiary period, immediately followed by glaciation, spreading to nearly equally low latitudes in North America and East Europe—continues to remain a puzzle for the geologist. And this question will remain unsolved until more data are supplied by the explorers of the globe in two different directions. Data of direct observation are of absolute necessity before any step can be made in the way of explanation, and these data must be of two distinct sorts. First of all, we must know how far north did the Tertiary vegetation spread, and in what direction it gradually lost its warm-climate character in proportion as it spread northwards. In this respect the exploration of Sannikoff's Land is *of the utmost value*, inasmuch as this problematic land is supposed to be situated almost on the opposite side of the globe (140° E. long.) to the spot of the Grinnel's Land (70° W. long.) where the Tertiary plants were found.

The other series of exploration must be directed to ascertain in how far *the glaciation of the southern hemisphere* was contemporary with the glaciation of our hemisphere, and *what was the climate in the equatorial regions during the same period.* So long as we do not possess reliable data in these two directions, all our hypotheses relative to changes of climate on the Earth, or of the Earth's axis, will possibly remain more than problematic.

One probable hypothesis relative to the possible cause of the Glacial period has been pointed out by the great physicist, Arrhenius; it is the increase of carbonic acid in our atmosphere, which would be sufficient to explain the cold period which our Earth lived through in the Post-Pliocene period. The numerous and large-scale volcanic eruptions towards the end of the Tertiary period, the traces of which have lately been discovered in immense quantities by the explorers of Siberia and Asia altogether, have brought a new argument in favour of the hypothesis of Arrhenius. These eruptions, which took place all over the immense border-ridges of the great plateau and on the plateau itself, certainly *must* have thrown masses of carbonic acid into our atmosphere. However, the hypothesis of Arrhenius, while giving a most valuable hint for the exploration of the Glacial period, leaves still the presence of Tertiary floras within 8° 15′ from the pole in Grinnel's Land and 16° in New Siberia quite unexplained. Only a full knowledge of this extraordinary flora and of its full extension in arctic regions—*in the American archipelagos as well as in the Siberian ones*—will permit physicists and astronomers to make a further step in the proper direction, and to suggest to the geologists a possible cause of such changes of climate as took place since the end of the Tertiary period.

THE MONTHLY RECORD.

THE SOCIETY.

The National Antarctic Expedition.—Since the President delivered his address, considerable progress has been made in the preparations for the National Antarctic Expedition. The commander and one of the