The Origins of the Russian Chernozem Soil (Black Earth): Franz Joseph Ruprecht's 'Geo-Botanical Researches into the Chernozem' of 1866[1]

ANASTASIA A. FEDOTOVA

St Petersburg branch of the Institute for the History of Science and Technology
Russian Academy of Sciences
St Petersburg
Email: f-anastasia@yandex.ru

ABSTRACT

This article analyses the contribution of the Austrian-born Russian scientist, Franz Joseph Ruprecht (1814–70) to the development of geobotany in general and to the controversial issue of the origins of the very fertile chernozem (Black Earth) of the steppe region of the Russian Empire. On the basis of careful field work and microscopic analysis of samples of chernozem, Ruprecht argued, in an important article published in St Petersburg in 1866, that the organic matter in the soil was decomposed steppe grasses. Thus, the chernozem was of steppe origins, not forest or peat as had been assumed by most scientists prior to his researches. Ruprecht's work laid the basis for the later, and better known, work on the chernozem by pioneering soil scientist Vasilii Dokuchaev (1846–1903). The article places Ruprecht's researches in the context of contemporary social, economic, and political as well as scientific developments.

KEYWORDS

Geobotany, soil, chernozem, black earth, steppe, history of science, Russia

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INTRODUCTION

Franz Joseph Ruprecht (1814–70),[2] an Austrian subject, moved to St. Petersburg on the invitation of academician Karl Bernhard Trinius in 1839 to take up a position as curator of the Botanical Museum of the Imperial Academy of Sciences. His work was successful in several branches of botany: in floristics, taxonomic botany, algology and plant geography. In 1848, he became a scientific researcher (*ad'yunkt*) of the Imperial Academy of Sciences, in 1853 an extraordinary (candidate) and in 1857 an ordinary (full) academician. He did a great deal for the Botanical Museum (he was the director from 1855), sorting out its old and new collections and archives.[3] He also managed to travel while fulfilling his varied duties. Besides his work at the Museum, Ruprecht was assistant director of the St Petersburg Imperial Botanical Garden (1851–5), then a member of its council (from 1867), and professor of botany in the Pedagogical Institute (1854–9). In 1841, he became acquainted with the Malozemel'skaya tundra[4] (spending the proceeds of his share of the Demidov prize[5], which he had been awarded in 1840 for his work on Pacific algae). Ruprecht made excursions in St. Petersburg province and spent a year and a half in the Caucasus in 1860–1. In 1863–4, he travelled around the chernozem region, the result of which was his 'Geo-Botanical Researches into the Chernozem'[6] – a work which played a very large role in the development of Russian plant geography.

Ruprecht's interest in the steppe region can be explained in the contexts of both scientific curiosity, and its importance to Russian society. On account of settlement and the development of agriculture in southern Russia, it was not only scientists but also 'educated society' who were interested in the chernozem. In the nineteenth century, legends of the fabled fertility of the chernozem and the ease of cultivating it were widespread. It was described as an exclusively peculiar soil, the origins of which and the reasons for its fertility were still unexplained.[7] Many authors wrote about this soil as a source of Russia's wealth, including Grigorii E. Shchurovskii, a professor at Moscow University, and an anonymous author of an article entitled 'Researches into the chernozem'.[8] Professor Nikifor D. Borisyak, a researcher of the geological formations of southern Russia, chose the chernozem as the subject of his commencement address at Khar'kov University, and explained his choice because this soil was so important for the economy of the country. He asserted that 'chernozem … without any fertilisation, with very little labour, gives grain yields of 1:15 or 1:20'.[9] The publicist Gustav G. Veidenbaum compared 'chernozem' with 'gold or diamond mines'.[10] There was another point of view. When he described the 'chernozem', the Scottish geologist Sir Roderick Murchison (who visited Russia in 1840–2), was amazed not at its fertility, but at the unartful way in which it was cultivated. Farmers looked at manure as if it were an encumbrance, and took no measures against the spread of ravines etc.[11] Ivan F. Shtukenberg, who visited the Don region in the 1840s, wrote that agriculture 'in all branches is carried out ... in a very unsophisticated and primitive manner and has not been subject to any changes'.[12] In the words of an Englishman who lived in Samara province for two years, even in years with good harvests on large estates where farming is carried out 'relatively correctly', 'an English farmer would not be satisfied at all'.[13]

FIGURE 1. F.I. Ruprekht's portrait, from K.I. Maximovich, *Ocherki zhizni i trudov Frantsa Iosefovicha Ruprekhta*, Zapiski imp. Akademii Nauk, vol.20 (1872).

Soviet historian Ivan D. Koval'chenko, on the basis of his analysis of data in provincial governors' reports, calculated an average figure for grain yields in the southern steppe region for the first decade of the nineteenth century of 1:4.6, when for the European Russia as a whole, the figure was 1:3.1.[14] I have deliberately presented data for the start of the century, a period when the steppes were still sparsely populated and the harvests were from virgin, fertile lands. In later decades, the difference between the steppes and European Russia as a whole were less marked. However, the Department of Agriculture of the Ministry of State Domains[15] was complacent, and the department considered that 'there are poor harvests in only a small area of Russia and, on the contrary, abundant harvests in the largest area'.[16] The ministry evaluated grain yields in the middle of the century in various regions of the chernozem zone at between 1:4 and 1:8.[17]

Labour inputs on the steppes were in reality lower. According to the estimates of historian Alexander V. Dulov, in regions 'with favourable conditions' they were in some places twice and in others 4–5 times lower than in non-chernozem regions.[18] In fact, the relatively high productivity of labour signified a catastrophically low level of agricultural technology and, in consequence, unstable yields. There was an objective reason for this: the majority of farmers in this region were recent migrants – state peasants from the central provinces. Their agricultural and everyday experiences were of little relevance to the dry climate and 'treelessness' of the steppes.[19] The peasants had little opportunity to improve the level of their agriculture. The government, which did not have anything against the idea of converting backward and half-starved peasants into cultured and solid farmers, did not have any long-term policy on this issue. To many, given the abundance of fertile lands, improving the level of agricultural technology did not seem to be a pressing issue. Even after the terrible harvest failure of 1833, which affected the southern provinces particularly badly, the Minister of Finance Georg von Kankrin did not consider it necessary to implement a plan to develop agricultural education.[20]

As reserves of uncultivated fertile land became exhausted, views on the necessity of paying more attention to agriculture in general, and in the chernozem region in particular, were expressed more and more frequently. By the 1860s, a fairly large literature had accumulated devoted to the origins of the chernozem, its geographical extent, the causes of its fertility, and describing its cultivation. However, this literature, as Ivan F. Levakovskii, professor of geology at Khar'kov University, wrote in 1871 was affected by 'a remarkable disproportion of positive material in comparison with theories derived on this basis.'[21] 'Positive material' was accumulated by geologists (chernozem was considered to be a geological formation) and by chemists (owing to the development of agricultural chemistry in the middle of the century, discussions of the reasons for the fertility of chernozem moved beyond the realms of metaphysical speculation).

Hypotheses on the origins of chernozem were many and varied.[22] In the eighteenth century, the idea that chernozem originated from the remnants of decayed vegetation was put forward in general form by the Comte de Buffon, John Woodward, and also by Russian academicians Georg Richmann, Johann Christian Hebenstreit and Mikhail Lomonosov.[23] A connection was made between the origins of chernozem and herbaceous, or grassy, vegetation by Johann Anton Güldenstädt, who participated in the Academy of Sciences expeditions of the eighteenth century.[24] Güldenstädt's idea can be found in a school textbook written by his travelling companion Johann Friedrich Hackmann.[25] In the middle of the nineteenth century, however, other explanations of the origin of the chernozem were more widely known. Murchison put forward two theories of maritime origins: from black Jurassic shale or from marine silt.[26] Wangenheim von Qualen, who researched the geology and palaeontology of the southeast of European Russia, considered that an ancient flood displaced peaty northern soils, which were rich with humus, to the south. In the north, due to the cold and wet, they had remained infertile, but due to the warm southern climate, they had acquired their remarkable properties.[27] The geologist Karl Eduard von Eichwald, who worked at Dorpat University in Russian Livonia, connected the origins of chernozem with lake sediments and peat deposits.[28] And, there were other explanations which need not detain us here: almost every naturalist, even if only just passing through the southern Russian steppes, put forward his own explanations for why there were no trees on the steppes and how the chernozem had formed.

THE EMERGENCE OF RUPRECHT'S HYPOTHESIS AND THE COURSE OF HIS RESEARCH

Franz Ruprecht became interested in the steppe region, in the words of his colleague and biographer Carl Johan Maximowicz, in 1860–1, 'while travelling across the chernozem zone on his journey to the Caucasus'.[29] In 1863, Ruprecht was assigned by the Ministry of Public Education to inspect the botanical departments of Khar'kov and Kazan' universities.[30] In the course of the trip, he became more closely acquainted with the vegetation of the steppes, and with the botanical and geological collections of the universities of the region. In Ruprecht's words, he succeeded in completing 'in addition to my main task, also in resolving in general terms the question of the origin of chernozem and in elucidating various particular aspects of the subject'. During the trip it is likely that he already had some ideas on the subject, because Ruprecht wrote that he had deliberately deviated from the main route in order to study the northern boundary of the chernozem, for example, he 'travelled up the Oka River for this purpose'.[31]

In May 1864 he set forth his hypothesis in two papers presented to meetings of the Physics and Mathematics section of the Imperial Academy of Sciences entitled: 'On the origins of the chernozem' and 'On the scientific importance of the chernozem'. After presenting his papers, Ruprecht asked for support from the Academy for a special research trip to clarify 'a few phenomena that required research in the chernozem region'.[32] He planned the route of his proposed trip very carefully.[33] Ruprecht's proposal found sympathy in the Physics and Mathematics section and with the president of the Academy, Fyodor P. Litke, but his estimate for expenses was cut in half. Litke wrote to the Ministry of Public Education that 'studying the chernozem, which is Russia's wealth, could bring significant benefit to science, and equally lead to results which would be important in a practical context'. However, the Ministry replied that its limited resources for scientific trips were already exhausted. Nevertheless, at the end of June, the money for the trip was forthcoming from the Imperial Academy of Sciences, and the Ministry of Internal Affairs provided a 'blank cheque'.[34] Ruprecht travelled for two and half months along the 'northern boundary of the chernozem', but this was insufficient time for the research, and he had to fill many gaps by studying the scientific literature.[35] In 1865, Ruprecht completed one more short trip to Novgorod province,[36] and completed a paper entitled: 'New researches on the chernozem'. At the same time, he prepared two further short works on related questions – on the rate of accumulation of peat (this question helped Ruprecht reject conclusively the 'bog hypothesis' on the origins of the chernozem),[37] and on fossil algae in 'marl strata', which had been found in Vyatka province, that were 'younger than the red diluvial clay and older than chernozem'.[38]

Ruprecht's hypothesis can be divided into two parts. The first part was the substantiation of the steppe origins of the chernozem. The second part was the explanation for the boundaries of the extent of the chernozem – the hypothesis of 'the chernozem mainland (*materik*)'.

THE STEPPE ORIGINS OF THE CHERNOZEM

Ruprecht's article was the most important study of the steppes before Vasilii Dokuchaev's works. What is the value of this work? First, the very title of the article coined a new term – 'geo-botantical'. Ruprecht used it in the same year as the prominent German plant geographer August Grisebach. His German counterpart, however, used the term as an abbreviation of the expression 'geographische Botanik',[39] while what Ruprecht called geobotany should properly be called 'geological plant geography'.[40] The term 'geobotany' was used, and it continues to be used with various nuances of meaning, which are considered in detail elsewhere.[41] Second, it was an innovation to have the very idea which opens the sentence: 'The chernozem embodies a botanical question, but it has not been studied from this perspective.'[42] The majority of existing works on the chernozem were written by geologists, chemists, 'farmers' and publicists, but from the end of the nineteenth century, the study of the soil would be included in the compulsory programme for most Russian plant geographers.

Third, Ruprecht reached new conclusions from his observations with a microscope. After studying samples of chernozem, he announced that the phytoliths (silicon corpuscles, which form in the cells of some higher plants and diatomic algae), were the remains of steppe grasses: 'It is very easy to demonstrate by experiment that burned *Stipa* [the prevailing genus of grass in the chernozem region] has the same phytoliths as in chernozem'.[43] Ruprecht was by no means the first to put samples of chernozem under a microscope, and not even the first to see phytoliths. Prior to Ruprecht's observations, phytoliths had been studied by a number of scholars, including the greatest specialist of that time on the protists of geological sediments, Christian Gottfried Ehrenberg.[44] However, every naturalist, in accordance with the prevailing idea of the history of the surface of the Earth at that time, looked for the remnants of marine organisms in chernozem. When they did not find them, they renounced the marine hypothesis on the origins of the chernozem in favour of the bog or forest hypotheses, and identified the fragments they observed as the remains of grasses or micro-organisms that had lived in bog or forest soils. Ruprecht knew grasses in general (family Poaceae) very well, and the genus *Stipa*[45] in particular. In 1842, jointly with Karl Bernhard Trinius, he published work on the subject entitled: '*Species graminum*

FIGURE 2. Black-soil steppe landscape with white 'feathers' of *Stipa pennata*. Photo by Olga N. Demina, a steppe researcher from Rostov-on-the Don..

stipaceorum'. In the opinion of a later researcher, P. Krutitskii, however, it is not possible to determine the genus of grass from phytoliths.[46] Perhaps it was not the genus of the phytoliths that convinced Ruprecht of the steppe origins of the chernozem but, on the contrary, it was a conviction in the steppe origins of the chernozem that made him identify the phytoliths as the remains of *Stipa*.

Fourth, in addition to microscopic investigations, Ruprecht used data from chemical analyses, which were carried out for him by Il'ya G. Borshchov.[47] At that time, statistical information about soils in many cases was provided by people who did not have special scientific training, and did not use accurate methodology. For example, materials for the soil maps of the 'Economic and Statistical Atlases' of the Department of Agriculture[48] were collected by officials with the assistance of local inhabitants. The collection of soil samples and their laboratory analysis became essential methods in the work of V.V. Dokuchaev and his followers – soil scientists and plant geographers.[49] Present-day Russian vegetation scientists have continued these practices.

Fifth, and this was a very bold conclusion: if there were remains of *Stipa* in the soil, then it meant that chernozem was formed, and continued to be formed, involving the same steppe vegetation and the same dry climate that existed at the time Ruprecht was writing. As I have already pointed out, by the 1860s, a whole array of hypotheses on the formation of the chernozem had been put forward, and almost all assumed that the process took place in conditions that were completely different from those at that time. However, in spite of this innovation, Ruprecht presented his conclusion as completely obvious and wrote that 'not one phenomenon contradicts it',[50] that this view had long been current among the peasantry, and had been put forward by Johann Anton Güldenstädt[51] and J.J.N. Huot.[52]

Finally, the causal connection between the chernozem and steppe flora was established: the northern boundary of the chernozem was also the boundary of steppe flora. This observation is not as trite as it might seem today to Russian scientists. Chernozem was considered to be a type of geological formation, and it was usual to write, for example, that 'steppe lands occupy a huge part of the chernozem',[53] or 'in the south the extent of the chernozem juts out into the southern Russian steppes'.[54]

'THE CHERNOZEM MAINLAND'

Ruprecht's colleague Ernst Rudolph Trautvetter had established that the southern boundary of the distribution of fir trees is an important floristic border, and one which many northern species do not go beyond.[55] This boundary also attracted the attention of the forester Adolf Bode,[56] and the researcher into the flora of south-eastern European Russia, Karl Claus. Claus connected the richness of the flora of the Volga region with the 'unusual characteristics of the soil', but he called 'the soil', 'greyish-brown marl' and 'light-red clay' – i.e. sub-soils according to modern terminology.[57] Ruprecht explained that the floristic border which restricted the movement of fir trees to the south and southern grasses to the north was connected with the boundary of the chernozem, but he wanted to find reasons for the sharp, simultaneous change in the species composition and, at the same time, in the character of the soils, and not simply to state the changes.

Ruprecht rejected climatic explanations: no sharp climatic changes on the boundary of the 'forest' and 'steppe' flora had been observed. In addition, meteorological data were in very short supply at that time and their ecological implications had not been worked out.[58] Meanwhile, every botanist knew that 'une espèce peut ordinairement vivre et reproduire loin de son lieu natal' ('a species could live and reproduce far from its place of origin').[59] The differences in the characteristics of the soil of the steppe and forest zones, in the opinion of many botanists, could not, moreover, explain such a sharp difference in the flora. 'The physical and chemical characteristics of the chernozem', Ruprecht wrote, 'could not cause such a difference in flora, because all the species typical of the two zones ... grow in various botanical gardens without special admixtures to the soil.'[60] Thus, based on what today would be termed the potential ecological niche, botanists of that time evaluated actual ecological niches; therefore, the conditions of a habitat were not considered by all botanists to be a sufficient cause determining the boundary of the distribution of a species.

Not finding explanations in the conditions that existed at that time, Ruprecht turned to explanations in the geological past, all the more so since geology at that time was a very attractive branch of science for botanists. The significance of the history of the earth's surface for the phytogeography had been especially graphically demonstrated by Alphonse de Candolle. In the introduction to his work *Geographie botanique raisonée* (1855), he proclaimed the opening of new branch of research to the intellectual arena, declaring:

> A ce point de vue nouveau, la géographie botanique cesse d'être une simple accumulation de faits. Elle prend au contraire une belle position dans le centre des sciences. Elle doit avoir pour but principal de montrer ce qui, dans la distribution actuelle des végétaux, peut s'expliquer par les conditions actuelles des climats et ce qui dépend des conditions antérieures. En lui assignant ce but élevé, elle concourt, avec l'histoire des êtres organisés fossiles (paleontology) et avec la géologie proprement dite à la recherche de l'un des plus grands problèmes des sciences naturelles … des sciences en général et de toute philosophie. Ce problème et celui de la succession des êtres organisés sur le globe.[61]
>
> ('From this new moment, plant geography ceases being the simple accumulation of facts. It occupies a position impressing itself at the centre of knowledge. It must have as its main aim the striving to show that the distribution of plants at the present time can now be explained by existing climatic conditions, and that it is a consequence of previously existing conditions. Setting itself such a high

> aim, plant geography competes with the history of fossil organisms (paleontology) and with geology, ... in striving to solve one of the most important question in the natural sciences ... knowledge in general and philosophy as a whole. This question is the succession of organisms on the Earth.')

On the basis of his own observations and analysis of geological literature, Ruprecht concluded that the northern boundary of the chernozem coincided with the southern boundary of the distribution of 'erratic boulders'.[62] Therefore, he proposed that the region of the distribution of the chernozem, which Ruprecht called the 'chernozem mainland', dried out earlier than neighbouring regions. By the time of the transportation of the boulders, 'the chernozem mainland was sufficiently high, the northern sea became shallow at its borders, and the blocks of ice and hummocks, on which the boulders drifted, ran aground near its shores.'[63] Chernozem was considered a geological formation, and scholars sought geological laws for its distribution. Thus, at one time it was considered that the northern boundary of the chernozem constituted the 'Devonian zone'.[64] Drawing on geological data to explain the boundaries of the spread of species of plants was a response to the declaration by Alphonse de Candolle, Edward Forbes and other European plant geographers.

The 'chernozem mainland' as an older dry land, in the opinion of Ruprecht, was occupied by a certain flora, and as younger territories appeared with the retreat of the sea, they were occupied by other, younger flora. At that time, a flora was not just a list of species which inhabited a given region, but was a unified whole, which to a certain extent was consistent with some natural laws and harmonious. Conforming with this idea, the notion of migration of plants took shape. One region could be occupied by one flora, and a neighbouring region by another, and the merging of these entities could not start without serious justification.[65]

If the chernozem region ceased to be covered by sea water earlier than neighbouring territories, then it must have been an upland. Looking at the map of European Russia, we cannot see any upland which has even a remote conformance with the distribution of chernozem. In the middle of the nineteenth century, however, knowledge of absolute heights in European Russia was quite approximate. The scheme of the French geographer Philippe Buache, was still very influential on the ideas of natural scientists concerning the orography of European Russia. Buache proposed that all mountain systems on the Earth were interconnected, and their 'branches' radiated across the Earth's surface from certain points. The 'branches' of each mountain system met other 'branches'. According to this scheme, the Carpathians were connected with the Urals by a low ridge or plateau exactly in the region of the chernozem. This upland was represented in different variants (with a few exceptions) until the appearance of Aleksei Tillo's map in 1889.[66]

Ruprecht construed his 'chernozem mainland' without data on absolute heights of the territory. However, none of Ruprecht's critics used this as an argument against his theory. For all their indeterminate nature, hypotheses rooted in catastrophism, vulcanism and neptunism, including that of Ruprecht, persisted stubbornly. In his eyes, 'geological' arguments (which in reality were little more than guesswork) were considered more important than orographical ones: 'The thicker the land in identical circumstances [the layer of untouched chernozem]', he wrote, 'the older the land; the absence of chernozem indicates a younger age, although the land may be a considerable height above sea level.'[67] If there were boulders on the Valdai upland, then consequently it was formed after the retreat of the waters of the shallow northern sea and the deposition of the 'erratic boulders'.[68] The 'Tertiary' period was characterised in various ways by different geologists in the middle of the nineteenth century, but usually as extremely dynamic. This was a time when 'mighty floods, either eroding or depositing material on the dry land of that time, entire mountains were destroyed by gigantic waves and sunk below the level of the sea, mountain ridges were raised, suddenly changing the climate of adjoining lands, and immense glaciers spread…'[69] The speed at which geological processes acted and the duration of geological periods were also unclear to scientists at this time. Although the history of the Earth was no longer packed into the biblical seven thousand years, it was still a long way from reaching four and half billion years. Ruprecht made his contribution to increasing the duration of the post-tertiary period: the age of the chernozem, as calculated by Ruprecht (no less than 2.5–4 thousand years),[70] was longer than his predecessors considered, many of whom thought it to be a product of the last one or two thousand years.[71]

The idea that the thickness of the soil layer could serve as a measure of the age of the land, and that there must be a dependence between the age of the surface of the earth, its absolute height, and the thickness of the stratum of the chernozem, conformed to earlier conceptualisations by natural scientists concerning the 'evolution of landscapes'. It was probably connected with the ideas of Abraham Werner and his neptunist followers about the retreat of the global ocean. The retreat of the sea left behind saline infertile earth, but with the leaching of the soil, grassy vegetation replaced the desert. Then, after the grass had 'improved' the soil, forests could develop. The earlier a territory was freed from seawater (and, consequently, the higher it was above sea level), then the longer plant life and fertile soils had existed on it. This opinion was frequently expressed in the works of Russian writers until the early 20th century, for example, by the naturalist and traveller Eduard Friedrich von Eversmann,[72] the zoologist Modest N. Bogdanov,[73] the climatologist Alexander I. Voeikov,[74] the plant geographers Andrei N. Beketov,[75] Jozef K. Paczoski,[76] and others.

The widespread idea that the in the recent past a significant part of European Russia had been covered by sea waters was also supported by the following 'misunderstandings'. In physical geography, the correlation between the quantity of precipitation and evaporation had not yet been introduced. Therefore, the abundance of lakes and mires in the north of European Russia could be

FIGURE 3. The map 'The spread of black soil and thermal lines, according to Konstantin I. Veselovsky and recent observations', from F.I. Ruprekht's paper. 'According to Veselovsky' refers to *Khozyaistvenno-statisticheskii atlas Evropeiskoi Rossii* (St. Petersburg: Departament Sel'skogo Khozyaistva Ministerstva Gosudarstvennykh imushchestv, 1857), edited by K.I. Veselovsky; 'recent observations' stands for the data furnished by Ruprekht himself.

explained by arguing that in the recent past the territory was a sea (shallow and fresh water), which had not yet dried up. Ruprecht considered the sea to have been shallow due to the low height of the chernozem mainland. He believed it to have been fresh on account of the absence of salts in the northern soils. The high content of soluble salts in the soils of south-eastern European Russia was accepted, not as a consequence of the salt solutions rising up through the soil due to the excess of evaporation over precipitation, but as the salt waters of a sea that had retreated not so long ago.

* * *

Ruprecht's theory received recognition rather slowly. It is probable that the strained interpretations that were required by the 'chernozem mainland' caused irritation among geologists and prevented them from seeing the core of the argument. It was also discovered quite quickly, moreover, that his view on the coincidence of the boundaries of the 'erratic boulders' and the chernozem was

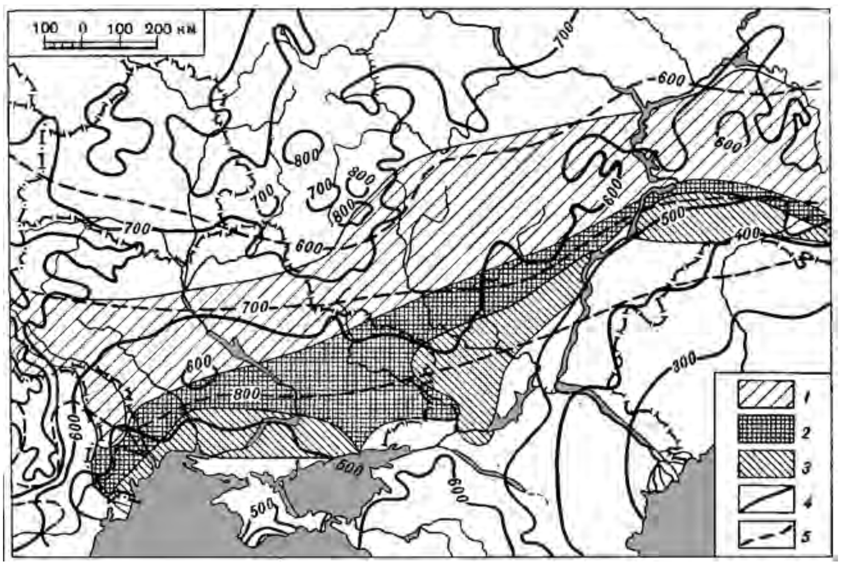

FIGURE 4. The scheme of black soil zone on the territory of the Russian Plain, from: T.P. Kokovina (Vodniy rezhim chernozemov in: *Russkiy chernozem. 100 let posle Dokuchaeva*. M.: Nauka, 1983. P. 51).

Legend: 1 – the forest-steppe zone of the typical and leached black-soils; the steppe zone; 2 – the regular black-soil subzone; 3 – the southern black-soils subzone; 4 – average annual amount of snow- and rainfall, in mm; 5 – average annual evaporation, in mm.

mistaken. Sharp criticisms followed Ruprecht's death in 1870. In 1871, Ivan F. Levakovskii criticised him for his poor knowledge of geology, discussed all the shortcomings of his 'chernozem mainland', and found flaws in his hypothesis on the steppe origins of chernozem.[77] In 1872, the chemist Pavel A. Il'enkov, a professor at the Petrovskaya Academy of Agriculture and Forestry, referred to Ruprecht's theory as a view that was not fully proven.[78] In the same year, in the introduction to his work on the flora of Kherson Province, Eduard von Lindemann set forth both Ruprecht's steppe hypothesis and Eichwald's peat hypothesis, and was more inclined towards the latter.[79] In addition, the German plant geographer August Grisebach did not accept Ruprecht's hypothesis.[80]

I did not succeed in finding any immediate responses to Ruprecht's theory, with the exception of a short review published by the director of the Imperial Botanical Garden in St. Petersburg, Eduard August von Regel, in his journal 'Gartenflora'.[81] There is no mention of any discussion of Ruprecht's work in the minutes of the sessions of the Physics and Mathematics section of the Imperial Academy of Sciences, and he was probably disappointed at the cool reception of his research. This made the letter he received from Nikolai A. Golovkinskii, who at that time was a privat-docent of Kazan' University and went on to become a major geologist, all the more pleasant. Golovkinskii informed Ruprecht that he was researching 'post-tertiary formations and the geography of Russia in that period' and had come to conclusions that were similar to Ruprecht's, but by a different route.[82] Ruprecht informed the permanent secretary of the Academy, Konstantin Veselovskii, about this letter, which was 'a pleasant occurrence in contrast to the recent actions of certain gentlemen'. He intended also to inform Fedor Litke, the president of Academy, and the Physics and Mathematics section of the Academy, 'so that colleagues will know how geologists working on similar questions judge my research'.[83] He published the letter in the Russian journal *The Naturalist* after a popular exposition of his work.[84] Other scholars who agreed with Ruprecht's opinions included his long-time correspondent, the botanist Il'ya G. Borshchov,[85] Ivan I. Vil'son, who compiled the 'Explanations' for the forth edition of the 'Economic and Statistical Atlas of European Russia',[86] and Nikolai A. Maev, who was a traveller and public figure in Russian Turkestan.[87]

Nevertheless the theory was gradually accepted. In botanical and geographical works on southern Russia which appeared in the 1870s, the expression 'black-earth steppe' began to mean 'typical' steppe with a particular floristic composition.[88] In deciding whether a species belonged to 'steppe flora', before long botanists began to cite Ruprecht's list of plant species that were indicative of chernozem as the most decisive argument. Moreover, within two decades, botanists had to explain why these 'chernozem' species could be found on other types of soil. It would not be an exaggeration to state that Ruprecht's work marked the start of the development of a scientific conception of steppe as a specific type of landscape with particular flora, vegetation and soil. It can also be considered that the theme of Ruprecht's research – the study of the interdependence between vegetation and soil – anticipated the direction of the work in Russian plant geography over the following decades.

A geologist who accepted the idea of the steppe origin of the chernozem (but not the idea of the 'chernozem mainland'), and began to study 'post-tertiary formations', was Vasilii Dokuchaev. In his main work on this subject, 'Russian Chernozem' (1883), Dokuchaev gave special attention to an exposition of Ruprecht's views, calling him 'the father of scientific investigation into the question'.[89]

The dual attitude to Ruprecht's theory persisted, however, into the early 1880s. Thus, the researcher of Eastern Siberia, Nikolai N. Agapitov, criticised his theory,[90] while Pavel A. Kostychev, who may be rightly considered to be the second founder of Russian soil science after Vasilii V. Dokuchaev, held Ruprecht's 'Geo-botanical researches' in very high regard and, criticising Dokuchaev, declared that 'there was nothing to be added' to the work of Ruprecht.[91] Ruprecht's 'Geo-botanical researches' had a major influence on the scientific interests of Sergey I. Korzhinskii,[92] who had begun his botanical work with cryptogams. His colleague, Andrei Ya. Godyagin, pointed out that it was precisely under the influence of Ruprecht's work that Korzhinskii changed his topic and directed his research to the vegetation of the northern boundary of the chernozem in eastern Russia.[93] Korzhinskii himself gave a high evaluation to the work of Ruprecht, stating directly in his works that it constituted 'an epoch in the question of the chernozem and steppe vegetation'.[94]

Although in its entirety the hypothesis on the 'chernozem mainland' was unsuccessful, it also had a certain, positive influence. The conception of the existence on the territory of European Russia of floras with different histories is considered important both for the historical geography of vegetation in general,[95] and for certain hypotheses, such as the conception of Dmitrii I. Litvinov on the relict highland pine forests in European Russia.[96] Moreover, Ruprecht pointed out the important distinction between the geological age of a formation and the age of the soil [97] – it is the last that provides data on the age of the vegetation.[98]

The work of Ruprecht differed fundamentally from other work on the chernozem of that time. This was not only because it was written by a botanist and not only because of its conclusions. Ruprecht utilised certain attributes of 'new' science, such as microscopic investigations and chemical analysis. His paper was not a speculative analysis of logical constructions: he advanced a hypothesis, went on a research trip to check it, and at the same time conducted research into in particular related questions. As a botanist, he completely dealt with his task: he proved the existence of a connection between the chernozem and steppe vegetation. Neither Ruprecht (who was above all a taxonomist and florist, and his main work in the 1860s was devoted to the Caucasus flora) nor natural science as a whole was ready, however, to explain the causes of this phenomenon at that time.[99]

Studying the history of such a narrowly-specialised and, it could seem, a tedious idea as the hypothesis of the steppe origins of the chernozem shows how convoluted the path of scientific thought can be. Analysis of Ruprecht's evidence demonstrates that theories which go on to become banal truths for the scientific community can initially have a fairly shaky basis.[100] The social background against which Ruprecht's researches took place was curious and contradictory. In the 1850s and 60s, scholars could declare that the natural sciences (or plant geography in particular) were very important for agriculture. Educated officials – supporters of the policy of bureaucratic paternalism – considered it useful to involve academic science in the vital questions facing the economy of the Russian Empire. But their good intentions got bogged down in the state's bureaucratic machine. Russian agriculture depended little on the successes of science, relying instead on the accumulated experience of fathers and grandfathers. The situation began to change in later decades as the steppes of European Russia did not remain free, fertile lands. The extensive development of agriculture and the destruction of the natural vegetation entailed massive soil erosion with its consequences – dust storms, falling levels of ground water, droughts and other disasters including the creation of favourable conditions for the multiplication of pests and weeds. It became clear that agriculture could not develop successfully without the help of natural science. As Olga Elina has shown, a change in the attitude to agriculture as an activity demanding not only common sense, but also specialist education and scientific research, occurred in the first instance as a result of the initiative of the public and the zemstvos,[101] and not the central authorities.[102] But that is another story.

NOTES

[1] This article is a revised and expanded version of an article that was first published in Russian as '"Geo-botanicheskie issledovaniya o chernozeme" F.I. Ruprekhta', *Voprosy istorii estestvoznaniya i tekhniki* (2008), no.1, pp. 22–34. It is published with the permission of the editorial board of *VIET*. The translation was prepared by David Moon with the assistance of the author.

[2] In Russian he was known as Franz Ivanovich Ruprekht. For details see biography: K.I. Maximovich, 'Ocherki zhizni i trudov Frantsa Iosefovicha Ruprekhta', *Zapiski imp. Akademii Nauk*, vol. 20 (1872), pp. 1–49 (Also published in German: Maximovicz C.J. Dr. Franz Josef Ruprecht, *Bulletin de l'Académie Impériale des Sciences de St.-Petersbourg*. 1871. T. XVI. № 1. Suppl. p. 1–21.) For a full bibliography of his works, see V.I. Lipskii, *Sankt-Peterburgskii imp. Botanticheskii sad za 200 let ego sushchestvovaniya* part 3 (St Petersburg, 1913–15), pp. 434–32. For a short biography, bibliography of taxonomical works, and the location of his herbaria and sources, see: F.A. Staffleu and R.S Cowan, *Taxonomic literature*, 2nd edn, Vol. 4 (Bohn et al, 1983), pp. 993–997.

[3] The result of his archival work was a history of the museum: J.F. Ruprecht, 'Das Botanische Museum', in zur Geschichte der Museen der Kaiserl. Acad. der Wissenschaften,

Bulletin de l'Académie Imp. des Sciences de St.-Pétersbourg, vol. 8 (1864), Suppl. 2; Russian translation: F.I. Ruprekht, 'Materialy dlya istorii imp. Akademii nauk po chasti botaniki', *Zapiski imp. Akademii nauk*, vol.7 (1865), Prilozhenie no.3, pp. 1–35.

[4] A low-lying tundra region in the northeast of the Russian plain.

[5] The Demidov prize, which was worth 20,000 roubles, was awarded annually by the Imperial Academy of Sciences from 1831 to 1865 for work in any branch of knowledge by non-academicians.

[6] J.F. Ruprecht, *Über den Ursprung und die wissenschafliche Bedeutung des Tschernosjom oder Schwarzerde Russlands. Geobotanische Untersuchungen* (St Petersburg, 1867); in Russian: F.I. Ruprekht, 'Geo-botanicheskie issledovaniya o chernozeme', *Zapiski imp. Akademii nauk*, vol.10 (1866), Prilozhenie No.6, pp. 1–131. The publications comprised three separate papers read by Ruprecht at sessions of the Academy on 6 and 20 May 1864 and 13 November 1865. Since the first two papers were written before his trip later in 1864 and prior to his 'detailed' verification of his earlier deductions, there are minor discrepancies between the different parts of the work.

[7] See, for example, A. Shmidt, *Khersonskaya guberniya. Materialy dlya geografii i statistiki Rossii sobrannye ofitserami General'nogo Shtaba*, vol. 24 (St Petersburg, 1863), part 1, pp. 111–25. Another 'puzzle' of the steppes was the question of the origins and reasons for the lack of trees. Similar questions emerged among researchers of grasslands in the western hemisphere – the American prairies. American geologists, geographers and botanists wrote on this subject: James Dwight Dana, Josiah Dwight Whitney, Andrew Thomas Drummond, Asa Gray, Léo Lesquereux, Newton Horace Winchell, etc.

[8] Anon, 'Issledovaniya o chernozeme', *Zhurnal Ministerstva Gosudarstvennykh imushchestv*, part 52, section 3 (1854), pp. 95–132. See also G.E. Shchurovskii, 'Chernozem', *Vestnik estestvennykh nauk*, 1854, no.12, pp. 177–83; no.14, pp. 209–15; no.15, pp. 232–8. The conception of 'chernozem' which modern natural scientists are accustomed to was formulated only at the end of the nineteenth century by V.V. Dokuchaev. Earlier, the term 'chernozem' was used for any dark-coloured fertile soil, its upper layer, humus, and such like. 'Chernozem' was seen as a geological formation or the ploughed layer. For accuracy, it is also necessary to distinguish between the modern term 'soil' and the use of this term in works written before the works of Dokuchaev.

[9] N. Borisyak, 'O chernozeme', *Otchet o sostoyanii Khar'kovskogo universiteta za 1851–2 gg.* (Khar'kov, 1852), Prilozhenie, pp. 7–8. Ratios of seed to harvest were the prevalent way of measuring crop yields in Russia in the eighteenth and nineteenth centuries. A ratio of 1:20 indicates that 20 measures of grain were harvested for every measure sown.

[10] G.G. Veidenbaum, 'O proiskhozhdenii chernozema', *Znanie*, 1870, no.3, p. 191.

[11] R.I. Murchison, 'Issledovanie o chernozeme vnutrennikh gubernii Rossii', *Zhurnal Ministerstva Gosudarstvennykh imushchestv*, part 8 (1843), pp. 119–38.

[12] 'Opisanie Zemli Voiska Donskogo i Taganrogskogo gradnonachal'stva', *Statisticheskie trudy I.F. Shtukenberga* (St Petersburg, 1858), p. 48. Shtukenberg was an active member of the Russian Geographical Society and the author of a number of works on Russian geography, history and statistics.

[13] V.I. Kovalevskii, 'Zametki anglichanina o sel'skom khozyaistve Vostochnoi Rossii. Po knige Henry Ling Roth, "A Sketch of Agriculture and Peasantry of Eastern Russia"' [London: Baillière, Tindall & Cox, 1878], *Sel'skoe khozyaistvo i lesovodstvo*, part 128 (August, 1878), p. 437.

[14] I.D. Koval'chenko, *Russkoe krepostnoe krest'yanstvo v pervoi polovine XIX v.* (Moscow: Izd. MGU, 1967), pp. 77, 386.

[15] The Ministry, founded in 1837, that was responsible for the administration of the extensive land holdings of the state, and the peasants that lived on them.

[16] *Ob'yasneniya k khozyaistvenno-statisticheskomu atlasu Evropeiskoi Rossii* (St Petersburg: Departament Sel'skogo Khozyaistva Ministerstva Gosudarstvennykh imushchestv, 1857), p. 71.

[17] *Khozyaistvenno-statisticheskii atlas Evropeiskoi Rossii* (St Petersburg: Departament Sel'skogo Khozyaistva Ministerstva Gosudarstvennykh imushchestv, 1857), Karta no. 5.

[18] A.V. Dulov, *Geograficheskaya sreda i istoriya Rossii: konets XV–seredina XIX v.* (Moscow: Nauka, 1983), pp. 58–60.

[19] The contradictory course of the agricultural colonisation of the steppes has been described in Willard Sunderland, *Taming the Wild Field: Colonization and Empire on the Russian Steppe* (Ithaca, NY: Cornell University Press, 2004).

[20] B.A. Val'skaya, 'Zemledel'cheskaya gazeta i zemledel'cheskay geografiya v Rossii v 30-kh gg. XIX veka', *Izvestiya Russkogo geograficheskogo obshchestva*, vol. 125, part 5 (1993), pp. 41–7.

[21] I.F. Levakovskii, 'Materialy dlya izucheniya chernozema', *Trudy Obshchestva ispytatelei prirody pri Khar'kovskom universitete*, vol. 4 (1871), p. 17.

[22] Almost every nineteenth-century work devoted to this question had a more or less detailed historical essay on the study of chernozem and hypotheses put forward by previous specialists. Different authors evaluated the opinions of their predecessors in various ways. For example, Levakovskii considered that Ruprecht wrongly attributed to Wangenheim von Qualen the hypothesis on the peaty origins of chernozem and to Huot – on steppe origins. 'Materialy dlya izucheniya chernozema', p. 18.

[23] N.G. Sukhova, 'Fiziko-geograficheskie vozzreniya M.V. Lomonosova, *M.V. Lomonosov: Sbornik statei i materialov*, vol. 7 (Leningrad, 1977), pp. 119–21.

[24] Johann Anton Güldenstädt, *Reisen durch Russland und im Caucasischen Gebürge*, 2 vols (St Petersburg: Kayserl. Akademie, 1787–91), vol. 1, p. 33.

[25] [Johann Hackmann], *Prostrannoe zemleopisanie Rossiiskogo gosudarstva* (St Petersburg,1787), p. 55.

[26] R.I. Murchison, *Geologicheskoe opisanie Evropeiskoi Rossii i khrebta Ural'skogo*, 2 vols (St Petersburg, 1849), vol. 2, pp. 551, 556. (Originally published as Roderick Impey Murchison, *The Geology of Russia in Europe and the Ural Mountains*, 2 vols [London: John Murray, 1845].)

[27] F. Wangenheim von Qualen, 'Beitrage zur Kenntnis der Schwarzen Erde in Russland (Tschernozem)', *Bulletin de la Société des Naturalistes de Moscow*, vol. 26, no. 1 (1853), pp. 1–68.

[28] E. Eichwald, *Paleontologiya Rossii. Novyi Period* (St Petersburg, 1850).

[29] Maximovicz, 'Ocherk zhizni', p. 26. It is possible that Ruprecht became interested in the history of the vegetation of the steppes earlier. In 1859, he wrote an article on a fossilised tree-fern he had received from I.G. Borshchov, who researched the flora of the Aralo-Caspian region. See F.J. Ruprecht, 'Über einen verkieselten Baumfarn aus der Kirghisen-Steppe', *Bulletin de l'Académie Imp. des Sciences de St.-Pétersbourg*, vol. 1 (1860), pp. 147–153.

[30] F.I. Ruprekht, 'O nauchnykh posobiyakh universitetov Khar'kovskogo i Kazanskogo po chasti botaniki', *Zhurnal Ministerstva Narodnogo prosveshcheniya*, part 120, section 2 (1863), pp. 492–505.

[31] Peterburgskii filial Arkhiva Rossiiskoi akademii nauk (hereafter PFA RAN) [St. Petersburg Branch of the Archive of the Russian Academy of Sciences], fond [f.] 2, opis [op.] 1, 1864, delo [d.] 6, list [l.] 1.

[32] *Protokoly zasedanii Fiziko-matematicheskogo otdeleniya imp. Akademii nauk* (1864), paragraphs 90, 111, 127.

[33] PFA RAN, f. 2, op.1, 1864, d. 6, ll. 1–2.

[34] Ibid., ll. 8–18.

[35] Ruprekht, 'Geobotanicheskie', p. 25.

[36] *Protokoly zasedanii Fiziko-matematicheskogo otdeleniya imp. Akademii nauk* (1865), paragraph 128.

[37] F.J. Ruprecht, 'Ein Beitrag zur Frage über Zeitdauer, welche zur Sumpf- und Torfbildung nothwendig ist', *Bulletin de l'Académie Imp. des Sciences de St.-Pétersbourg*, vol. 7 (1864), pp. 148–58.

[38] F.J. Ruprecht, 'Über eine mikroskopische Süsswasser-Algae als Bestandteil gewisser Mergel des Gouvernements Wjatka', *Bulletin de l'Académie Imp. des Sciences de St.-Pétersbourg*, vol. 9 (1866), pp. 35–43.

[39] A. Grisebach, 'Der gegenwärtige Standpunkt der Geographie der Pflanzen', *Geographisches Jahrbuch von E. Behm*. vol. 1 (1866), p. 373.

[40] D.I. Litvinov, 'Ob okskoi flore v Moskovskoi gubernii', Materialy k poznaniyu fauny i flory Rossiiskoi imperii (Moscow, 1899), no. 3, pp. 16–17.

[41] On the history of the term see, for example, G.I. Dokhman, *Istoriya geobotaniki v Rossii* (Moscow, 1973), pp. 8–22; E. Rubel, 'Ecology, Plant Geography and Geobotany: Their History and Aim', *Botanical Gazette*, vol. 84, no.4 (1927), pp. 428–439.

[42] Ruprekht, 'Geo-botanicheskie', p. 1.

[43] Ibid., p. 3.

[44] C.G. Ehrenberg, who is considered the founder of micropaleontology, studied samples of chernozem which he had been sent by Eichwald. See Eichwald, *Paleontologiya Rossii*, pp. 245–6.

[45] The most well known species of the genus *Stipa* is *Stipa pennata,* which is usually translated into English as 'feather grass'.

[46] P. Krutitskii, 'Mikroskopicheskie issledovaniya o chernozeme', *Fiziko-khimicheskie issledovaniya pochvy i podpochvy chernozemnoi polosy Evropeiskoi Rossii*, part 2 (St Petersburg, 1881), pp. 29–32.

[47] Ruprekht, 'Geo-botanicheskie', pp. 117–19.

[48] *Khozyaistvenno-statisticheskii atlas Evropeiskoi Rossii*, Eds. 1–4 (St Petersburg, 1851–1869).

[49] Dokuchaev repeatedly wrote that even an experienced researcher who relied only on organoleptic evaluations could make serious mistakes. See, for example, *Russkii chernozem*, *Sochineniya*, vol. 3 (Moscow-Leningrad: Nauka, 1949), pp. 40–3.

[50] Ruprekht, 'Geo-botanicheskie', p. 10.

[51] Ibid., p. 43.

[52] Ibid., p. 9. The French geologist J.J.N. Huot was a participant in the expedition directed by Anatoliy N. Demidov across southern Russia. See: *Voyage dans la Russie meridionale et la Crimée par la Hongrie, la Valachie et la Moldavie, exécuté en 1837 sous la direction de M. Anatole de Demidoff par M.M. de Saison, le Play, Huot, Leveilé, Rousseau, de Nordmann et du Ponceau*, 4 vols (Paris, 1840–1843). A few years later, the chemist P.A. Il'enkov named among the founders of the theory, in first place the common people and in second place – F.I. Ruprecht. See P. Il'enkov, O khimicheskom sostave chernozemnykh pochv', *Godichnyi ak Petrovskoi Zemledel'cheskoi i Lesnoi akademii*, 1872, p. 5. Plant geographer Andrei N. Beketov also wrote that Ruprecht acknowledged that the 'general Russian popular opinion' was correct. A.N. Beketov, 'Yuzhnorusskie stepi v sravnenii s vengerskimi i ispanskimi', *Trudy S-Peterburgskogo obshchestva estestvoispitatelei* (1885), vol.16 (1885), protokoly, p.47.

[53] L.V. Tengoborskii, *O proizvoditel'nykh silakh Rossii*, part 1 (Moscow, 1854), p. 48.

[54] N.A. Maev, 'Orografiya Evropeiskoi Rossii', *Zhurnal Ministerstva narodnogo pros-veshcheniya*, part 148, no.4, otdel nauk (1870), p. 421.

[55] R.E. Trautfetter, *O rastitel'no-geograficheskikh okrugakh Evropeiskoi Rossii* (Kiev, 1851); also published in German as: E.R. von Trautvetter, *Die Pflanzengeographishen Verhältnisse des Europaeischen Russlands*, 3 parts (Riga, 1849–1951).

[56] A. Bode, 'Beitrag zur Würdigung der Forstwirtschaft in Russland. Verbreitungsgränzen der wichtigsten Holzgewüsche des europäischen Russlands', *Beiträge zur Kenntniss der Russischen Reiches und der angränzenden Länder Asiens*, vol.18 (1856), pp. 1–107.

[57] K. Claus, *Flory mestnye privol'zhskikh stran* (St Petersburg, 1852), pp. 12–13; also published in German as: Karl Ernst Claus, *Lokalfloren der Wolgagend, Beitrage zur Pflanzenkunde des Russischen Reichs*, Lief., vol.8. (1851), pp. 1–312. Claus was Professor of Chemistry at Kazan' University, a specialist on the platinum metals and the discoverer of the element Ruthenium.

[58] To refute the view that the formation of chernozem depended on the climate, Ruprecht inserted a map on which isotherms were in no way connected with outlines of the boundaries of the chernozem region. In the text he pointed out that the northern boundary of the chernozem 'coincides with the isotherm 14–15 degrees Celcius, but in western Europe, this isotherm has no significance.' The reason why there was no chernozem in western Europe, in his opinion, was 'the large quantity of forests', and not in any way the high level of precipitation. Ruprecht, 'Geo-botanicheskie', p.11.

[59] Alphonse de Candolle, '*Géographie botanique raisonée ou exposition des faits principaux et des lois concernant la distribution géographie des plantes de l'époque actuelle'* (Geneva, 1855), p. xi.

[60] Ruprekht, 'Geo-botanicheskie', pp. 15–16.

[61] Candolle, '*Géographie botanique*', p. xii.

[62] 'Erratic boulders … cover almost the entire northern half of European Russia, and ... were brought from ... Finland, ... Sweden. The transportation of erratic boulders dates from a special geological period, which preceded historical times ... and which ... is called the diluvial .... It is thought that at this time the entire northern part ... of Europe was the bottom of a vast sea, which washed foothills of Finland and Scandinavia. Both ... countries emerged from the sea in the form of islands, ... and were covered in glaciers, which carried a large quantity of rock fragments and brought them down to the sea, then tore them away from the general mass and together with fragments of rock drifted to the

south, where they were stopped by some obstruction, or having thawed, deposited their burden on the bottom of the sea.' G.E. Shchurovskii, 'Chernozem', *Vestnik estestvennykh nauk* (1854), no. 12, pp. 179–80. The 'erratic' hypothesis of the origin of the boulders in Russia persisted among Russian geologists and geographers, while at the same time they accepted the idea of an Ice Age in central and western Europe. See N.G. Sukhova, 'Istoriya izucheniya lednikogo perioda na territorii Rossii v XIX – nachale XX stoletiya', *Izvestiya Russkogo geograficheskogo obshchestva*, vol. 132, no. 6 (2000), pp. 66–80.

[63] Ruprekht, 'Geo-botanicheskie', pp. 26–7.

[64] This view was refuted by the researches of Gregor von Helmersen. See G.P. Gel'mersen, 'Geognosticheskoe issledovanie Devonskoi polosy Srednei Rossii ot reki Zapadnoi Dviny do r. Voronezha', *Zapiski Russkogo geograficheskogo obshchestva* (1856), book 11, pp. 3–63.

[65] On nineteenth-century notions of floras and their migration, see J. Browne, *The Secular Ark: Studies in History of Biogeography* (New Haven/London: Yale University Press, 1983), pp. 32–57.

[66] For more detail, see D.N. Anuchin, 'Rel'ef poverkhnosti Evropeiskoi Rossii v posledovatel'nom razvitii o nem predstavlenii', *Zemlevedenie* (1895), book 1, pp. 77–126; book 4, pp. 65–124.

[67] Ruprekht, 'Geo-botanicheskie', p. 26.

[68] Ibid., pp. 75–6.

[69] Nikolai A. Golovkinskii, *O posletretichnykh obrazovaniyakh po Volge v ee srednem techenii* (Kazan', 1865), p. 4.

[70] Ruprecht calculated the age of the chernozem by comparing the thickness of the layer of chernozem which had formed on the top of *kurgany* (burial mounds), which were built no later than the time of Batu Khan [the 13th century], with that of chernozem on unploughed steppe. Ruprekht, 'Geo-botanicheskie', p. 9. Modern radio-carbon dating techniques have put the age of the humus in the lower horizons of chernozem at no less than 6–8 thousand years and in the upper layers at 1–2 thousand years. E.M. Samoilova, 'Proizkhozhdenie chernozemov', in V.A. Kovda and E.M. Samoilova (eds.), *Russkii chernozem: 100 let posle Dokuchaeva* (Moscow: Nauka, 1983), pp. 28–37.

[71] The basis for this assertion was the evidence of Herodotus, who allegedly described Scythia as a forested and well-watered land. Later, its lakes and marshes dried out (probably the territory experienced geological uplift), the forests were destroyed, and for these reasons the climate became drier. Such a view was shared, with some variations, by, for example, Eikhwald, *Paleontologiya Rossii*; Wangeheim von Qualen, 'Beitrage zur Kenntnis'; and Borisyak, 'O chernozeme'.

[72] E. Eversman, *Estestvennaya istoriya Orenburgskogo kraya* (Orenburg, 1840).

[73] Modest N. Bogdanov, 'O chernozeme, ego praktichestkom i nauchnom znachenii', *Trudy imp. Vol'nogo ekonomicheskogo obshchestva* (1877), vol. 1, no. 2, pp. 149–62.

[74] [Vozrazdeniya A.I. Voeikova na doklad V.V. Dokuchaeva 'O zakonnosti izvestnogo geograficheskogo raspredeleniya nazemno-rastitel'nostykh pochv na territorii Evropeiskoi Rossii'], *Trudy S-Peterburgskogo obshchestva estestvoispitatelei*, vol. 12, no. 1 (1881), pp. 83–4.

[75] Beketov, 'Yuzhnorusskie stepi', p. 47.

[76] I.K. Pachovskii, 'Osnovnye cherty razvitiya flory yugo-zapadnoi Rossii', *Zapiski Novorossiiskogo obshchestva estestvoispitatelei*, vol. 34 (1910), Prilozhenie.

[77] Levakovskii, 'Materialy dlya izucheniya chernozema'.

[78] P.A. Il'enkov, 'O khimicheskom sostave chernozemnykh pochv', *Godichnyi akt Petrovskoi Zemledel'cheskoi I Lesnoi Akademii* (1872), Prilozhenie.

[79] E. Lindemann 'Ocherk flory Khersonskoi gubernii', *Zapiski novorossiiskogo obshchestva estectvoispitatelei* (1872), vol. 1, Prilozhenie 1, pp. xviii–xix. Military doctor Eduard von Lindemann (1825–1900) was a recognised florist and taxonomist, an honorary member of several Russian and European scientific societies, and a doctor of botany, honoris causa (1877).

[80] A. Grizebach, *Rastitel'nost' zemnogo shara soglasno klimaticheskomu ee raspredeleniyu*, vol. 1 (St Petersburg, 1874), pp. 363, 526. The German original is: A.N.R. Grisebach, *Die Vegetation der Erde nach ihrer klimatischen Anordnung*. *Ein Abriss der vergleichenden Geographie der Pflanzen*, 2 vols (Leipzig, 1872).

[81] *Gartenflora* (1866), vol. 15, pp. 88–9.

[82] PFA RAN, f. 61, op. 2, d. 45, l. 1.

[83] Ibid., l. 5.

[84] F.I. Ruprekht, 'Novye issledovaniya o chernozeme', Naturalist (July–October, 1867), No. 13–20, pp. 217–65.

[85] Borshchov informed Ruprecht about 'chernozem islands' in Chernigov province. Ruprekht, 'Geo-botanicheskie', p. 83.

[86] I. Vil'son, *Ob" yasneniya k khozyaistvenno-statisticheskomu atlasu Evropeiskoi Rossii*, 4th edn (St Petersburg, 1869), pp. 3–15.

[87] Maev, 'Orografiya Evropeiskoi Rossii', pp. 424–8.

[88] See, for example: D. Kozchevnikov, 'Beitrage zur Flora des Tambowschen Gouvernements', *Bulletin de la Societe imp. des Naturalistes de Moscou*, vol. 51, no. 4 (1876), p. 248.

[89] V.V. Dokuchaev, *Russkii chernozem* (St Petersburg, 1883), p. 297. Latest edition of this magnum opus – V.V. Dokuchaev, *Russkii chernozem*, ed. by B.F. Aparin (St Petersburg: Russkaya kollektsiya, 2008).

[90] N.K. Agapitov, 'K voprosu o proiskhozhdenii chernozema', *Izvestiya Voctochno-Sibirskogo otd. Russkogo geograficheskogo obshchestva* (1881), vol. 11, no. 3–4, pp. 16–28.

[91] P.A. Kostychev, 'K voprosu o proiskhozhdenii chernozema', *Sel'skoe khozyaistvo i lesovodstvo*, (December, 1884), p. 272.

[92] S.I. Korzhinskii (1861–1900) was one of the most influential and authoritative Russian plant geographers of the late-nineteenth century, the author of the hypothesis of the natural advance of the forest zone to the south (1888). He was also one of the authors of the mutation conception of evolution (1899). His brilliant work was cut short by his premature death. For a chapter analysing the work of Korzhinskii on the boundary of the steppe and also his conception of evolution, see Daniel P. Todes, *Darwin without Malthus*. *The Struggle for Existence in Russian Evolutionary Thought* (New York/Oxford: Oxford University Press, 1989), pp. 62–80.

[93] A.Ya. Gordyagin, 'Rastitel'nost' Tatarskoi respubliki', *Geograficheskoe opisanie Tatarskoi respubiki*, part 1 *Priroda kraya* (Kazan', 1922), p. 160.

[94] S.I. Korzhinskii, 'Severnaya granitsa chernozemno-stepnoi oblasti vostochnoi polosy Evropeiskoi Rossii v botaniko-geograficheskom i pochvennom otnoshenii. 1. Vvedenie.

Botaniko-geograficheskii ocherk Kazanskoi gubernii', *Trudy Obschestva estesvoispitateley pri Kazanskom Universitete*, vol. 18, no. 5 (1888), p. 18.

[95] S.Yu. Lipshits and I.T. Vasil'chenko, *Tsentral'nyi gerbarii SSSR* (Leningrad: Nauka, 1968), p. 25.

[96] D.I. Litvinov, 'Geobotanicheskie zametki o flore Evropeiskoi Rossii', *Byulleten' Moskovskogo obshchestva ispytatelei prirody*, new series, vol. 4, pp. 322–434.

[97] V.V. Dokuchaev, 'K voprosu o sootnosheniyakh mezhdu vozrastom i vysotoi mestnosti, s odnoi storony, kharakterom i raspredeleniyu chernozemov, lesnykh zemel' i solontsov s drugoi', *Vestnik estestvoznaniya* (1891), no. 3, pp. 113–15.

[98] Ruprecht, 'Geo-botanicheskie', p. 22.

[99] The climate of the steppe zone of the Russian plain with its unpredictable moisture regime and regular droughts (every 3–4 years) gives a competitive advantage to grasses over trees. This is ensured by the massive root systems of grasses (the ratio of underground to overground biomass is at least 8:1), and the ability to slow or stop vital functions in periods of drought. Trees, which require very large transpiration, lose out in these conditions. The peculiarities of the litter of herbaceous plants together with the peculiarities of the climate assist the accumulation of humus. The most northerly (meadow) steppes do not have an annual interruption in plant growth caused by summer drought. The main mass of animal life consists of earthworms (Lumbricidae). The decomposition of the remains of plants in these organisms ends at the stage of the formation of humus. Therefore, the soils of the meadow steppes contain more humus than any other soils in the world – up to 12–15%. In the more southerly steppes there is a pronounced period of summer rest caused by drought. The place of earthworms is taken by potworms or white worms (Enchytraeidae), which develop not for 2–3 years, like earthworms, but for 2–3 weeks. Thanks to the symbiotic microflora that live in its intestines, they break down vegetative mass into its microelements. Humus accumulates less intensively. For details see V.G. Mordkovich, A.M. Gilyarov, A.A. Tishkov and S.A. Balandin, *Sud'ba stepei* (Novosibirsk: Mangazeya, 1997).

[100] On contemporary views on the questions of the origins and evolution of chernozem and changes in these soils over the last century, see Kovda and Samoilova, *Russkii chernozem*. On the status and history of steppes as a biome, see Mordkovich et al, *Sud'ba stepei*.

[101] Elected district and provincial councils set up in many provinces of Russian Empire after 1864.

[102] O.Yu. Elina, *Ot tsarskikh sadov do sovetskikh polei: Istoriya sel'skokhozyaistvennykh opytnykh uchrezhdenii XVII–20-e gody XX v.*, 2 vols (Moscow, 2008).