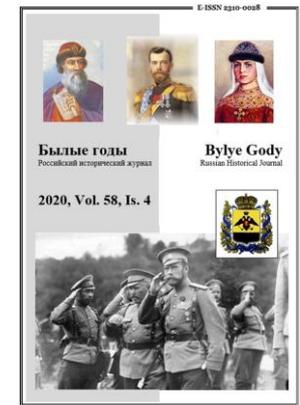


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## Russian and Western European Mining Schools in the first half of the 19th century: A Comparative Analysis of Educational Process Organization

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### Abstract

In the first half of the 19th century, an industrial advance began in the leading countries of Europe, as well as in the Russian Empire. The mining and processing industry, which formed the fuel and energy complex of national economies, developed intensively. New deposits of natural resources were discovered and old ones were actively used. The need for qualified specialists led to much attention being paid to the system of mining education.

The main mining educational institution in Western Europe was the famous Freiberg Academy, which has always been distinguished by a high level of teaching in technical subjects, as well as its excellent material base. Productive cooperation with this mining academy was supported by representatives of the St Petersburg mining institute – the main technical educational institution of the Russian Empire. These relationships laid the foundation for international cooperation on this issue for many years to come.

The European system of mining education in the first half of the 19th century was represented by a large number of national mining schools, but these educational institutions worked most seriously and productively in Germany and France. Ural academies are a good example of Russian regional mining schools of this period.

This article is devoted to the history of the creation and functioning of Russian and Western European mining schools in the first half of the 19th century. The features of the administrative structures of these educational institutions, such as their admission requirements, how their courses were structured, and what the graduation requirements were considered. A comparative analysis is offered of the organization of the educational process in German and French mining schools, as well as in domestic mining engineering schools. The main historical sources for this article are materials from the Russian State Historical Archive (RGIA).

**Keywords:** Russian Empire, Germany, France, schools of mining, mining engineering education, training of specialists.

### 1. Introduction

The beginning of the 19th century in Europe was characterized by intensive development of science and technology. The industrial revolution in the leading countries led to improvements in the education system. Particular attention was paid to training engineers. There were many technical schools founded at that time, included those that trained professionals for specific fields, including the mining industry. Natural resources began to play an important part in the national economy of various countries, so the correct planning of education systems was crucial for the development and use of those resources. The study of how Russian and foreign mining schools of mining emerged and developed remains an important issue of historical science. This, on one side, gives

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an overview of how mining engineering education developed abroad. On another side, it provides excellent documentation to compare the way mining industry professionals are trained in Russia and abroad.

## 2. Materials and methods

The research is based on materials from the Russian State Historical Archive (RGIA). Documents from fund №37 (“Mining Department”) and fund №44 (“Headquarters of Mining Engineers Corps”) were analyzed. These archival funds contain materials related to the history of the mining educational institutions of the Russian Empire in the 19th century, as well as analytical reviews of domestic mining specialists who visited foreign mining schools. The memoirs of famous Russian mining engineers such as D.M. Brillkin (Brilkin, 1892: 118-130; Brillkin, 1893: 130-138) and K.L. Latyshev (Latyshev, 1863: 32-38) were published in the Mining Journal. This historical source was also used. The authors applied the comparative historical method. The documents of the archival funds related to the process of organizing mining education in the Russian Empire and abroad were compared. As a result, it was possible to reliably establish general facts and particular details of the work of mining schools, as well as trace the development of this issue and the attitude of the state authorities towards it.

## 3. Discussion

The source documents, written before 1917, laid the foundation for studying the history of education of mining professionals. There were mainly analytical reviews by mining engineers who had gone to Europe for work. It was during those trips when the foreign approach to mining education was, for the first time, taken into consideration. D.M. Brillkin, a graduate from Saint-Petersburg Mining Institute, contributed a great deal in terms of collecting and analyzing that information. Brillkin is the author of several surveys about schools of mining in France and Germany in the 19th century (Brilkin, 1892: 118-130; Brillkin, 1893: 130-138). It is important to note that the experience he gained abroad was used to contribute to the education program in the Dombrowsky School of Mining in the Polish Kingdom (Brilkin became head of that school in 1889). Mining engineer K.L. Latyshev should also be mentioned here. Latyshev prepared a detailed study on foreign schools of mining in the 19th century (Latyshev, 1863: 32-38).

During the Soviet era, the history of foreign schools of mining in the 19th century was not studied at all, due to Cold War ideology. For this reason, there is no research comparing Russian and foreign mining education. There are, however, several important surveys on Russian engineering schools which should be mentioned. Those works give an overview of the education of professionals in the mining industry in the 19th century. In 1926, an anniversary issue called “Leningrad Mining Institute in 1773–1923” was published. A whole chapter of the issue was dedicated to the education of mining engineers in the Russian Empire in the 19th century (Leningrad Mining Institute, 1926). Another issue, which came out in 1973, also describes pre-revolutionary times (Leningrad Mining Institute. 1773–1973, 1973). The role of Saint-Petersburg Mining Institute in training professionals for the factories in the Ural area and Siberia in the 19th century is shown in the surveys by T.A. Boyarkina (Boyarkina, 1981: 145-156) and P.P. Kostenkov (Kostenkov, Shestakov, 1987: 92-97), while schools of mining in the Ural area are described in the research by N.V. Nechaev (Nechaev, 1956).

The history of the education of mining factory workers in the Altai region in the 19th century is described in the studies by A.V. Smolin (Smolin, 1959: 125-157). His PhD thesis in pedagogy, defended in 1956, is still a relevant work on the history of education of mining factory workers in Western Siberia (Smolin, 1956).

It is noteworthy that there were a lot of fundamental works on the history of pedagogy and professional education in Russia written during the Soviet era. Those surveys contain interesting facts on the history of schools of mining in Russia in the first half of the 19th century. They include works by N.N. Kuzmin (Kuzmin, 1971: 41-53) and A.D. Chirkov and Z.S. Aladisheva (Chirkov, Aladisheva, 1970).

The recent period of studying the history of education of mining industry workers is characterized by numerous articles which give an overview and summarize the facts collected both in Soviet and recent times. This variety of topics and cross-disciplinary research has become the new trend. After the Cold War there was a renewed focus on the education of mining engineers.

There are two fundamental multiauthor historical works, edited by V.G. Afanas'ev, to be noted. Based on archival materials, these surveys reveal important aspects of the education of mining industry workers in Russia, based on the example of the Mining University (Afanas'ev et al., 2010; Afanas'ev et al., 2019), which is also the topic of several of Afanas'ev's other studies (Afanas'ev, 2016: 36-42; Afanas'ev, Voloshinova, 2017: 140-166).

The Russian program of education for mining engineers in the 19th and 20th centuries, along with that adopted abroad, is revealed in studies by I.V. Voloshinova and A.B. Mokeev (Voloshinova, Mokeev, 2016: 5177-5181).

The social and cultural aspects of education in technical schools in Russia and Europe are revealed by D.A. Schukina (Schukina, Egorenkova, 2017: 198-206), S.A. Rassadina (Rassadina, 2016: 498-503), V.V. Sharok (Sharok, 2016: 604-607; Sharok, 2018: 281-296) and Y.M. Sishchuk (Sishchuk et al., 2018: 631-637). Questions relating to the physical and ethical education of students of technical schools are explored in the

works by E.A. Izotov ([Izotov et al., 2018a: 43-45](#); [Izotov et al., 2018b: 14-16](#)) and I.A. Kuvanov ([Kuvanov et al., 2019: 12-14](#)).

Regional schools of mining are described by L.N. Mukaeva ([Mukaeva, 2008](#)) and E.A. Chernoukhov ([Chernoukhov, 1998](#)).

#### 4. Results

Germany. In the 19th century, the German economy made considerable progress, especially in the fast-growing mining industry. The exploitation of iron, copper and silver ore was of high importance. The extraction of coal increased several times. Significant growth of the mining industry started in 1835 and was to last until the revolution of 1848–49. This was the time when the Ruhr coal basin was actively developed and coal coking was introduced. The share of population employed in the mining industry tripled in the first fifty years of the 19th century ([Mining Encyclopedia, 1985: 273](#)).

In the first half of the 19th century, a great number of permanent schools of mining were founded. Those schools had their own educational program and statutes. Almost all trained mine workers. Graduates from Eisleben and Clausthal Mining Schools could be employed as both mining and factory workers, while those from the Rhine-Westphalian Mining School were trained only to work in factories.

Freiberg Mining Academy, founded in 1765, is also worth mentioning. The school is notable for its rich history, as well as its brilliant lecturing staff of world-renowned professors. It is nowadays considered the oldest mining engineering institution. The academy's forerunners were the so-called scholarship fund established in 1702 to train mining professionals, as well as I.F. Genkel's chemical laboratory, founded in 1733 for students and researchers. This laboratory was a training ground for many foreign students, including Mikhail V. Lomonosov, who studied there in 1739–1740. The academy was founded thanks to the activities of three German scholars: H.E. Hellert, head of the scholarship fund from 1753; I.G. Kern, author of the first textbook for students (1740); and K.F. Zimmermann, who developed the structure of the future educational institution. Until 1871, when Dresden Technical University was founded, Freiberg Academy remained the highest-ranked educational institution in Saxony. It was only in 1899 that the academy was declared a higher education institution ([Mining Encyclopedia, 1985: 280-282](#)).

The town of Freiberg is located in the center of Saxony, between Dresden and Hemnitz, at the foot of ore-bearing mountains. Back in 1168, silver ore was discovered there. Its mines remained a source of wealth for the monarchs of Saxony for many generations. Even today, Freiberg has retained its role as a strategically important place for Germany. Until 1969, it was the leading town for the mining industry, though in recent decades it has been turned into a center of high-tech manufacturing (semiconductors and solar panels), becoming part of the so-called Silicon Saxony region.

Freiberg Mining Academy was founded by Prince Franz of Saxony, following the plan of Friedrich Wilhelm von Opper. It was conceived of as a professional school for miners, originally called the Kurfurst Saxon Academy of Freiberg but renamed as the Royal Saxon Mining Academy in 1806. The academy statute was approved in 1766, after which classes began. It was noteworthy for its high-quality teaching from the very first days of its foundation. This not only distinguished the Academy among the other mining schools in Germany, but also made it a model for other countries in terms of how to set up the educational systems for their own school of mining. Even today, the Freiberg Academy has retained its excellent reputation and remains attractive to trainee professionals from all over the world ([Eberhard Wächtler, Friedrich Radzei, 1965: 55](#)).

Let us look through the main features of study at the Freiberg Mining Academy in the first half of the 19th century. First, there were certain admission requirements. Applicants had to be older than 16 and younger than 23 years old and healthy, as confirmed by a medical certificate. In addition, applicants had to provide a baptismal certificate and references from their previous school. Basic knowledge and skills were also required, including legible handwriting, a good command of German and Latin (applicants had to translate "Caesar's Commentaries"), geography, arithmetic and geometry, drawing and general history (due to the grammar school program). Fluency in French and English was considered an advantage. Applicants were examined on these subjects and those who showed knowledge in all subjects were admitted; those who failed could try again next year. No matter how well-prepared the applicants were, they all started education from the first (lowest) step. The King of Saxony was advised of the list of applicants to be admitted and approved it in person.

Students were divided into several categories. The first group attended academic courses without paying any fees and received grants from the state. They were trained for the Saxon Mining Service and were called "royal interns". These students could not quit the school or, subsequently, the royal service without special permission from the authorities, unless they refunded the entire sum invested in their education. There was also a group of students who attended only some of the courses, in order to gain some sort of professional training. The third group consisted of foreign students, who were granted special conditions and studied to improve their knowledge for the service of their homeland. There was no campus, only rooms for lectures and practicing ([Mining Journal, 1834: 120-121](#)).

Freiberg Academy was governed by a curator (director). Students were taught by leading professionals in geology, mining and metallurgy such as A.G. Werrner, F.A. Greithaupt, J.L. Weisbach and F. Reich. There

were three departments: mining, factory and land surveying. The course initially lasted three years, but in 1829 it was extended to four years. The academic year lasted nine-and-a-half months. Practice and annual exams were mandatory. The number of students grew consistently, from 50 students at the beginning of the 19th century to 150 in by mid-century.

The courses in Freiberg Mining Academy were divided into general and specialist ones. The general courses were mathematics (algebra, geometry, arithmetic, trigonometry); higher mathematics; applied mathematics; general chemistry; analytical chemistry; metallurgical chemistry; physics; drawing; civil architecture; mining mechanics; mining law; mining language; mining (which included the study of mining mechanisms, exploration and mineral processing); creating devices, models etc.; mineralogy; geognosy; crystallography; general metallurgy; and French. Special courses included land surveying techniques; mining accounting; petromatognosy (the study of fossils, also known as paleontology); laboratory practice and metallurgy.

From 1829, the general course became mandatory for all students. The first year was designed as a preparatory course for more complicated subjects. During their first year, students were taught the basics of mathematics, mineralogy, geognosy, physics and drawing. In their drawing classes students learned to create plans. The second year included subjects such as higher mathematics, general chemistry, crystallography, practical mineralogy, mining, drawing, civil architecture and physics. Subjects from the first year required 20 hours' study a week; second-year courses, 21 hours; third year courses, 19 hours; and fourth-year courses, seven hours a week. Students remained in the academy from 7 a.m. until noon, then from 2 p.m. to 6 p.m.

The following subjects were tested in mandatory exams: higher mathematics, theoretical mechanics, physics, mineralogy, geognosy, mining, ore enrichment, development of mineral deposits, land surveying techniques, applied mining mechanics and mining law (Eberhard Wächtler, Friedrich Radzei, 1965: 75).

There was strong cooperation between Freiberg Mining Academy and Russian scientists. In 1773, due to a law passed by Empress Catherine II, a professional school of mining was established in Saint-Petersburg. It was the first higher technical institution in Russia. Its foundation and development were supposedly influenced by I.M. Renovatz, one of its first lecturers. From 1768 to 1771, Renovatz attended various courses on factory mining at the Mining Academy in Germany. He then contributed to the development of the educational program for the Saint-Petersburg Professional School of Mining. He designed various mechanisms and devices applied in mining, and was also the author of practical manuals. He also created a so-called "training mine", which was considered one of the city's attractions.

It was clear to the founders of the school that it was impossible to become a professional without knowledge of foreign science and technology, so they sent their best graduates to the Academy in Germany for professional training. Thus in 1793, P.P. Meder and A.F. Deriabin went to Freiberg. These scholars then played an important part in developing mining in Russia. Deriabin had a rich collection of minerals collected abroad which, in 1801, he donated to the School. He is also known for having developed the basis for Russian mining law (RGIA. F. 44. Op. 3. D. 120. L. 15).

The intensive development of mining and industry in Russia in the first half of the 19th century required significant changes in the educational program at the School of Mining. The statute was substituted by a new one. Thus, the School was transformed into the Mining Cadet Corps.

The students of the Corps were mostly of noble origin. However, the children of chief officers and rich merchants could also be admitted. The age of admittance was between 14 and 23 years old. The entrance exams tested applicants on their prior school education. References played an important part as well. No practical mining experience was required.

The students were divided into cadets, state-financed interns, self-financed interns and half-time interns. Cadets' education was paid for by the State. Cadets were appointed by order of the Emperor, Minister of Finance or the director of the Corps. State-financed interns received funds from the State Treasury, various mining departments or factories. The others were financed by private benefactors.

Students were divided into three grades: lower, middle and two upper grades. They studied arithmetic, algebra, geometry, land surveying, hydraulics, physics, chemistry, mineralogy, metallurgy, drafting and drawing. In the lower grades they were taught general subjects, while in the upper grades they attended special courses such as civil and mining architecture, mining mechanics and mining administration. Courses were held from 8 a.m. till noon and then from 2 p.m. till 6 p.m. The remaining time students spent marching, cleaning and doing home tasks. Students thus gained a valid general boarding school education. The Corps provided lectures on civil and criminal law, political economy, general and Russian history, geography, biology, botany, logic, dancing, fencing, music, singing and acting. There were also special tutors who taught fluency in foreign languages. The Corps was famous as an educational institution and provided a level of training equivalent to university (RGIA. F. 44. Op. 3. D. 120. L.37).

The popularity of the Mining Corps grew continuously, with the number of students increasing every year. In 1924 the number of students reached 500. Nevertheless, Russian professionals continued to be aware of foreign educational programs and scholars from the Mining Institute were still sent for training to Western Europe. They mainly focused on mining engineering institutions in Germany and France.

Apart from Freiberg, there were other early 19<sup>th</sup>-century German mining schools which are worth mentioning. Those schools provide a good illustrate of the level of basic and advanced technical education in mining.

Let us consider the example of the School of Mining in Claustahl, founded in 1811. Before attending, students enrolled in preparatory schools, whose number varied depending on demand. Students had to be older than 18 and have two years of mining work experience. They also had to be able to read and write correctly and know the four arithmetic rules. There was just one grade and the course lasted one year. Students attended classes three times a week; the rest of the time they gained practical experience in mines or factories.

After completing preparatory school, students could enroll in the main School of Mining in Claustahl. On request, one additional grade on land surveying could be added. For admission to the main school, students had to be older than 18, have at least six months' experience working in mining and have completed a one-year course at the preparatory school. There was just one grade, the course lasted two years. Students attended the course three times a week, and spent the rest of the time gaining practical experience in the mines. On average, there were 26 students in any year in the main school.

The School of Mining received half its funding from the city of Claustahl (Mining Treasury), and the other half from the state and private factories. Students were taught free of charge. However, the students could be asked by the school council to pay a 3 taler fee for preparatory school and a 6 taler fee for the main school. Students from other districts could also study in the Claustahl School of Mining, but they had to pay more: 6 talers for preparatory school and 12 talers for the main school. The graduates could be hired as employees in mines, factories or salt-works (Brilkin, 1892: 1118-120).

In 1839, Tarnowitz School of Mining was founded in the Upper Silesia. It was the only school in Prussia where mining practice was not mandatory. The lack of practice gave students a chance to dedicate all their time to studies. For this reason, Tarnowitz graduates displayed much better knowledge of theory than those from other schools.

Tarnowitz School of Mining consisted of two basic grades, each one lasting a year. The first grade was the preparatory course for the second grade, giving a complete education. The graduates who studied that far had enough training to cover lower-level mining posts. Besides the two basic grades, there was also a third level, which also lasted for a year. This was a specialized course, divided into two sections, aimed at training land surveyors and mine managers respectively. This course did not have much practical use, therefore, it was not so popular. In fact, it barely even existed; however, it could be launched on request due to the school's statute.

To enter Tarnowitz School of Mining, students had to be older than 17 (no upper age limit), have two years' mining experience (confirmed by the mine's manager), be able to read, write, and apply the four rules of arithmetic for integers and fractions and to solve trigonometric tasks.

At the beginning of every year, the director of Tarnowitz School of Mining asked the mine managers in the Upper Silesia to send him a list of workers worth admitting to the school. 1 March was the application deadline, and applicants had to send their autobiography (compiled and written by the applicant) together with their educational certificate. Those admitted to the entrance exams were chosen according to their results, depending on the number of vacant places.

Tarnowitz School of Mining was funded by the Upper Silesia Mining Fund, which also provided scholarships for the best students. Applications for scholarships had to be sent no earlier than three months before admission. School education was free of charge.

At the end of every school year there were final written and oral examinations. Based on their results, students were either admitted to the next grade or just given a certificate for having completed one or both grades. In order to pass to the next grade, the student had to obtain "good" or "good enough" results. A student with a "satisfactory" result would rarely be admitted to the next grade. Besides the exam score, the School also considered students' general abilities, behavior and references from their teachers. Thus, only the best students were admitted to the upper grade, the others received the certificate of the grade they had finished.

It is important to note that final and annual exams were in fact just a formality. The students were carefully supervised during the whole school year and scored for their activities in class, thus the end-of-year score was simply the sum of those intermediate results. The exams lasted from eight to ten days. Written exams were held on all subjects, while oral exams were only given on the subjects selected by the examination board, which was composed of teachers and a member of the Upper Silesia Mining Fund. The latter was also the head of the examination board (Brilkin, 1892: 126-128).

The training lasted 36 hours per week. The school year started immediately after Easter. There was also a four-week holiday from mid-July to mid-August.

The educational program in Tarnowitz School of Mining was designed primarily to meet the needs of the district. Upper Silesia district stood out mostly for its coal industry, so the training in coal mining was extremely detailed. The topic of developing metallurgical mines was dealt with superficially, while the development of salt and gold mines was not considered at all.

The graduates from Tarnowitz School of Mining could be employed in entry level mining jobs, as mine managers or foremen, as land surveyors or as supervisors (Brilkin, 1892: 128-130).

D.M. Brilkin, the head of Dombrovsky School of Mining, visited the Tarnowitz school in the 1890s. Among the advantages of the school program, he noted that the students were taught not only general facts, such as methods for developing deposits, but also received practical knowledge. For example, students were trained in which method to apply, how to lay cord, how to install door frames, and how to lay new rails in the

mine and fix old ones. In other words, students were instructed in all the important details often missed in other institutions. D.M. Brilkin noted: “that preliminary practice is useful as it gave students clear ideas and helped their understanding of the subject. Thus, the applicants already had a first view of the profession they were being taught for” (RGIA. F. 37. Op. 53. D. 3067. L. 171).

Among the weak points Brilkin mentioned were that the mechanics course objective was only to use machinery, not to create it. In Tarnowitz School of Mining, they taught, for example, how to calculate the power of a machine and how to run it, without mentioning how to draft its detailed plans or implement them. Furthermore, when teaching construction as subject, it was presumed that future managers should have practical skills, so they were taught in detail how to make a brick, how to make a wall or an arch, how to make calcimine or put together wooden parts of a building, but all without teaching drafting at all (RGIA. F. 37. Op. 53. D. 3067. L. 170).

In the first half of the 19th century, the situation in France was quite unstable, which influenced both industry and the development of the economy in general. However, the mining industry in France was growing rapidly and mining schools provided professionals with the required training.

From this period in France, there was one particular school of mining that must be mentioned. It was founded in 1848 and was located in the south of the country, in the town of Alais. The school trained future mine managers and land surveyors.

The course lasted two years, with half of the time spent in the classroom and the other half working in the mines. In order to be admitted, students had to be older than 18 and have a year-and-a-half experience as miner or land surveyor’s assistant. Applicants sent a request to the prefecture in which the school was located, no later than 1 August, attaching a metric certificate, a certificate of good conduct, a smallpox vaccination certificate and a document proving they had practical work experience in a mine. The student (or his parent or tutor if he was not yet of legal age) had to sign an obligation that, if admitted, his tuition fee would be paid regularly.

After the documents were collected and sent to the prefectural office, an examiner was appointed, usually from among the teachers of the local schools. To pass the exam, the applicant had to be able to read both typed and handwritten text, solve basic arithmetic tasks and answer some easy questions about volume, weight and length. If the applicant showed more knowledge than required on arithmetic, geometry and so on, he could insist that the information was registered on his exam answer sheet. After having checked the applicants’ knowledge of these subjects, the examiner compiled the exam sheet with the completed exam papers attached. The answer sheet was sent, together with the exam papers, to the prefect who, in turn, forwarded them to the director of the school before the end of August. After that, the school examination board checked the documents and selected the applicants who would be admitted to the final exam. The final exam and the preliminary one covered the same subjects, but the latter was harder to pass. It was the last exam used to select the future students of the school of mining. The final exam took place in October; the academic year started the following month (Brilkin, 1893: 130-135).

The school in Alais was a boarding school, which students left only for holidays. Every school year was divided in four terms. The winter term lasted from November to February and students spent their time in the classroom. The spring term ran from March to May, and students spent this time in practical learning in the mines. Students spent the summer term, through June and July, revising the school’s program, land surveying and drafting. This was also the term when the annual or final exams took place. In the autumn, from August to October, students spent another term doing practical work in the mines.

During the school terms students lived on campus. While students were paid for their practical work in the mines, they had to pay their local expenses and accommodation on their own.

Students had to do all the household work at school, apart from cooking. They were in charge of, for example, cleaning the rooms, filling and fixing the lamps, and taking care of the heating. For this reason, the only non-teaching staff were a cook and a guard.

There was only one 90-minute lecture per day. Later, the same lecturer, from 4 to 5.30 p.m., checked the material learned and answered students’ questions. Thus, there were just three hours of classroom time a day. There were special rooms for preparing homework.

The time spent in the mines was for applying classroom knowledge. During their practical sessions, students were basically ordinary workers, supervised by their teachers, in order to make the practice more useful.

Students were employed for the work which best served the subject they were learning. And what they learned in one practical field was transferred to another. At the end of these practical placements, students had to show the school a certificate from the manager of the mine, consisting of a detailed report about what they had seen and learned. The certificate had to also show the time worked, the work section and the results obtained.

Besides that, students also had to report on their placement, including what they found useful. Students’ reports were preliminarily discussed in class and revised by their professors. As students were sent to different mines, they had a chance to share their experiences. This kind of exchange of experience was of a great use for students in French mining schools, as an addition to their theoretical experience in the classroom.

The classroom hours in Alais School of Mining were arranged as follows:

I grade: arithmetic (16 hours), geometry (20 hours), physics (14 hours), chemistry (13 hours), mineralogy (9 hours), geology (9 hours), land surveying (18 hours). II grade: arithmetic (8 hours), geometry (8 hours), geology (6 hours), land surveying (18 hours), mining (34 hours), mechanics (20 hours).

It is important to note that education in French schools of mining was primarily intended to develop practical knowledge. The French believed that comprehensive development is the goal of general schools, while the purpose of mining school was to prepare professionals for the specific industry. For this reason, there were next to no courses on general subjects (Brilkin, 1893: 135-138).

Let us turn to the Ural region mining engineering schools in the first half of the 19th century, to compare them with those from abroad. The specific types of schools for that region were as follows: primary schools were associated with all factories; there were regional schools for every factory-centered region; and the Ural Mining School covered all the Ural districts.

Preparatory schools were for the children of all mine workers, and there were two grades. In the lower grade, pupils were taught reading, writing and basic arithmetic, while in the upper grade, they learned subjects such as religion, reading, arithmetic and mining (e.g. learning to distinguish ore and rocks).

Regional schools admitted children with primary-school knowledge. Pupils were taught religion, arithmetic, algebra, geometry, history, Russian, drafting, drawing and German. Besides that, students were trained to work in the mining industry: they received a basic education in geology, geodesy, ore development and land surveying. Graduates worked as draftsmen, supervisors, laboratory workers, or sometimes mine specialists and managers. As the Ural school did not have its own practical training ground, one weak point was the lack of practice for students. There was also a shortage of qualified teachers and shortage of specific textbooks and manuals. Due to lack of funds, there was not enough summer practice for students. It was only in the second half of the 19th century that the situation improved. This was because with the growth of capitalism and the rise of industry, demand for mine workers increased drastically, and it was the Ural School of Mining where such professionals were trained (Voloshinova, 2012: 36).

#### 4. Conclusion

Comparing the principles of education in the schools of mining in Germany and France to those in Russia in the first half of the 19th century, we can see the following differences. The admission age for European schools of mining was not less than 17-18 years old, with no upper limit. Schools of mining in Russia always had an age limit, such as from 14 years old or until 20. The upper age limit in Russian schools of mining was particularly unfair, as it excluded large numbers of workers who were willing to seek greater theoretical knowledge.

Practical experience in a mine or factory was among the essential requirements for applicants to the German or French schools. The duration of work experience required might vary from six months to four years. However, for Russian school entrants, practical experience was not mandatory.

French schools of mining modeled better ways to organize practice, while in Germany students had to combine classroom hours and practice in a single day in a way that was quite complicated. It would have been more comfortable for students if the practical and theoretical sections of their course ran in different months, as in France. Russian schools focused mostly on classroom studies, with little time for practice.

While the German schools of mining were open to everyone, in France there were limits on admissions. The training in foreign schools lasted two or three years, while in Russia it mostly took four years. In Russia students had to pay for their education, while in most of the foreign schools, training was free of charge. One separate course abroad could already provide complete training, while in Russia the education was considered finished only after all the courses had been completed.

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