

# NLMK GROUP

CORPORATE MAGAZINE

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OPERATIONS

## STOILENSKY'S ECOLOGY LAB

KEEPING THE ATMOSPHERE  
UNDER CONTROL

SVETLANA MINEEVA'S  
PARENTING EXCELLENCE

# MODERNIZATION IN ACTION

**RUSSIAN PRESIDENT DMITRY MEDVEDEV  
VISITS NLMK STEEL**

# Modernization In Action

**January 20th 2010.** Russian President Dmitry Medvedev chaired this year's first meeting of the Presidential Commission for Russian Economy's Modernization and Technological Advancement in Lipetsk. Discussion revolved around the issue of technical regulations which must lay the groundwork for industrial progress.



**T**he President's visit began with a tour of Novolipetsk Steel which has made substantial progress in technical upgrading and innovation. Here modernization results become tangible. Mr. Medvedev was hosted by Vladimir Lisin, NLMK's Chairman of the Board of Directors. They began by inspecting

*The President had a chance to see specific examples of how procrastination over reforming technical regulations is hindering the modernization of Russian industry*

Blast Furnace #6. In terms of specific capacity and fuel consumption efficiency it surpasses most European blast furnaces. BF-6 production capacity is 2.8 mln tons of pig iron per year or 8,000 tons per day. It is distinguished by its upgraded management system providing control of the entire cycle. At BF-6 all the production processes are automated and conservation technologies are in place allowing it to function with practically no damage to the environment.

The President talked to a number of cast house workers about their working conditions, wages and general mindset after the holidays. Sharing his impressions, Mr. Medvedev confessed to have never seen a blast furnace before. He was wowed by its size, as well as the overall dimensions of the site, "it's the size of a city," he said.

The President was even more impressed with WIP BF-7. It's a unique asset being constructed on an area



**Anatoly Alenin,  
furnace operator:**

– Mr. President greeted everyone with a handshake and told us it was his first time at a production site like this and that he had never seen a blast furnace before. He said he was amazed at the dimensions of NLMK, almost the size of a city. And he is right. Then he asked us how we were getting back into the work rhythm after the holidays, how we felt about our wages. Viktor Zagorsky replied about the wages, and I told the President that blast furnace processes are continuous, for this reason our work is not impacted by weekends and holidays.



**Viktor Zagorsky,  
furnace operator:**

– We were standing at a distance and watching Vladimir Lisin explain to Dmitry Medvedev how the blast furnace works. About 15 of us. It was really exciting to see the President so close. Then he walked along the cinder runner towards us. He asked us about the wages, so I told him what my pay slip says.





**Alexey Zolotarev,  
furnace operator:**

– The President's visit is a big event for everyone, not just us. When I came home that day, my 6-year-old grandson asked me right off the bat, "So, did you meet the President?" "Yes," I said, "He even shook my hand." "Really?!" he jumped with excitement. He only believed it when he saw the news on TV.



**Alexey Dykin, electrician:**

– "So, guys, feel free to ask the President some questions," Vladimir Lisin told us. And it's not that we were shy or anything, we just weren't prepared to ask something, I guess. It all happened so suddenly. But it's really great that the President himself came up to talk to us. And no one instructed us in advance, no one told us what to say. It was a very memorable moment.



of 78 ha. Some structures are up to 105 meters high. BF-7 is the first of its kind in modern Russia. Project investments are estimated at RUR 39 billion (appr. USD 1.3 billion). With capacity of 3.4 million tons of hot pig iron per year, the furnace will be operated by only 280 peo-

ple, resulting in good European-level labor efficiency rates. At the same time, increased pig iron production and by-product (blast furnace gas and slag) reprocessing will create over 1300 new qualified jobs at NLMK. Once launched, BF-7 will vividly exemplify the results of modernization.

The President had a chance to see specific examples of how procrastination over reforming technical regulations is hindering the modernization of Russian industry.

Mr. Medvedev asked Vladimir Lisin about all aspects of the situation at hand, conferring at the same time with Viktor Khristenko, Russian Industry and Trade Minis-

ter, Igor Sechin and Sergey Ivanov, Vice PMs, who accompanied him.

The issue is long overdue, so let us examine it in detail. At the end of last year, the president solved the problem of technical regulations and signed a corresponding law allowing the use of both Russian and foreign standards for manufacturing modern products. However, this law applies only to finished goods. Besides technical regulations, there are numerous production safety requirements which have not been reviewed for 30-40 years and apply to obsolete technologies. For example, some gas pipe sections have to be equipped with back-up valves, which increas-



### **Evgeny Dushenin, electric and gas welder:**

– Medvedev is very easy-going. The guys are teasing us, “Don’t stick your noses up in the air now that you’ve shaken hands with the President himself!” But I don’t see anything wrong with being proud.



es the BF-7 project costs by RUR 120 mln, whereas modern equipment does not require additional stop valving. Such situations are common for all industries. In other words, a lot of Russian regulations do not imply the use of best global practices and cutting-edge technologies, simply ignoring progress.

NLMK's Chairman of the Board of Directors pointed out another bottleneck to the President. Currently, seven government bodies are simultaneously charged with production safety control, from RosTekhNadzor (RF Service for Ecological, Technical and Atomic Supervision) to Glavgosexpertiza (RF State Expert Evaluation Department), with vaguely delimited areas of responsibility, resulting in severe overlapping and oftentimes mutually exclusive instructions. NLMK Steel annually goes through up to 85 audits. With restrictions being imposed on each regulating body individually, the total amount of inspections is limitless.

Meanwhile, in the EU countries these functions are performed by one or two regulating agencies, which are not directly involved in inspecting technologies, but carry out just the documentary audits.

European businesses declare their compliance with the set safety requirements themselves. Independent auditing companies are responsible for assessing and evaluating their degree of compliance. At the same time, businesses insure their operating risks.

Another obstacle hindering innovation is the lengthy construction permit procedure. It takes at least two years to obtain a permit, even though the time can be reduced to 6 months just by simplifying the procedure itself.

Coming back to Mr. Medvedev's visit, the tour concluded at the Dynamo Steel Mill, where unique HVA production facilities are currently being installed. For instance, nanostructured Hi-B grade transformer steel with especially low

specific magnetic losses. Its use in power transformers will reduce specific power losses by 10-15% and allow saving up to 2-3 billion kW/h per year (in terms of Russia's energy production).

gregative regulations. The President suggested that the Companies enter their standardization expenses as "production and service costs" because "standardization should lead to cost cuts." He reminded the



The President applauded NLMK efforts on implementing a large scale Technical Upgrade Program and strengthening the Company's position in the global market place.

...It looks like this visit to NLMK Steel confirmed the President's determination to eliminate all the obstacles in the way of modernizing the Russian economy. This became clear during the Commission meeting. Mr. Medvedev reminded the other participants that technical regulations and standards are "key tools determining our economy's competitive capacity and innovative appeal." The Cabinet must report back on the "amount of approved documents" in two months.

Dmitry Medvedev also asked to determine the amount of mandatory technical regulations, whether it is in the range of 40-50 or 400, stressing the necessity to avoid excessive detailization (with regulations covering every single item, like it was done in the GOST State Standards), but rather develop ag-

Government that alongside developing technical regulations, it is also necessary to resolve the issue of safety standards and identify the responsible agency.

The President retained the idea of self-regulating businesses in terms of occupational health and safety. He suggested looking into the possibility of creating community organizations charged with developing technical standards. Medvedev thinks that the new regulations will liberate manufacturers by breaking down excessive barriers, thus improving product quality and creating new opportunities for entering global markets. And the primary goal of these regulatory reforms is of course to boost Russia's economic modernization. 🇷🇺

*The President applauded NLMK efforts on implementing a large scale Technical Upgrade Program and strengthening the Company's position in the global market place*

# Natasha, Natasha, Natasha...

**The bright blue car labeled “Atmospheric Control” always catches my eye.** It’s the Stoilensky’s (NLMK subsidiary) Mobile Lab charged with safeguarding one of the most important things on Earth, clean air. It truly deserves a more detailed presentation.

STOILENSKY  
MOBILE LAB TEAM



**A**s it turns out, atmospheric monitoring is but the tip of the iceberg in the Company’s diverse environmental activities. The Technical Control and Lab Analysis Department’s Ecological Lab has been working for over 20 years. It employs three expert groups. One of them assesses working conditions, measuring illumination, vibration, noise, gas and dust levels. The other takes care of water and soil, and the third acts as the “atmospheric guardian”. It is responsible for air sampling along the Buffer Zone borders, in waste storage and disposal areas, as well as monitoring the Plant’s Gas and

Dust Collectors. The last group owns the Mobile Lab that I mentioned earlier.

“Sampling must be done in the direction of the wind,” Nina Khramchenkova, Group lead and lab engineer, explains. “For instance, if the wind is blowing South-East, we have a fixed sampling location near the neighboring Company’s Buffer Zone. The same goes for the other wind directions. Plus we have mandatory weekly sampling in villages closest to the quarry.”

We decided to accompany the Mobile Lab team to one of these villages. Sergey Skorobrekha, the driver, told us about the equipment,

“There are two compartments, one with a table, lockers and shelves for storing devices and materials, and the other with a meteorological station and a free-running generator of electricity.”

Sergey has been working on this car for a long time and knows it in and out. He says he even upgraded it somewhat. Sergey is also in charge of setting up the weather station which determines the speed and direction of the wind, pressure, temperature and humidity, as well as starting up the generator.

Two Natashas, Natasha Trofimenko and Natasha Bragina, are responsible for the measuring and



AT THE QUARRY

sampling. “The first atmospheric air sample is taken 100 m away from the quarry bank. We are going to make three stops altogether, at 100, 300 and 1000 m. We need to measure the content of several contaminants, like NO<sub>2</sub>, SO<sub>2</sub>, NO, CO, CH<sub>2</sub>O, C<sub>6</sub>H<sub>5</sub>OH, H<sub>2</sub>S and dust,” Nina says.

The car is equipped with four aspirators which suck in air through retractable probes. One measures the level of dust. The other three are connected with vessels containing chemical agents that absorb a specific element. For instance, one of them collects NO<sub>2</sub> only. The procedure takes 20-30 minutes for every contaminant. Everything is repeated at the next measuring location, so one trip could take an entire day. Nina explains that it all depends on the weather and wind direction. Rainy days are not suitable for sampling, so the team has to watch out for sunny days. “In late fall, winter and early spring, as well as after rain and snow the air is much cleaner,” Nina confirms.

After the sampling is done, the team goes back to the Lab to analyze the measures and calculate the contaminant ratios. Nowa-

days, most of the processing (ratios, charts) is done by computers. The girls only need to input the data. In the past these operations were performed manually and could take several days.

The obtained results are recorded and published in Corporate Newsletters. Some of the records go as far back as 1988 and they all confirm that Stoilensky has never exceeded the maximum allowable concentration of contaminants.

And it's not surprising taking into account the enthusiasm of the ladies working here. “Everything is in the hands of our three Natashas,” they say at the Lab because besides the two Natashas we have already had the chance to meet, there is another Natasha, Ms. Poliakova. “We are convinced that environmental protection is crucial. We can't afford to relax. We need to safeguard the planet,” she says.

“Our team is very professional,” confirms Elena Stepanova, laboratory lead, “Working conditions are good. We have all the modern equipment needed to perform accurate analysis. We also have special training programs for our employees organized in Saint-Petersburg.”

Every five years the Environmental Protection Department issues a report, indicating the type of contaminants, their maximum allowable concentration and sampling frequencies. It is also responsible for developing an annual Sustainability Action Plan. 2010 plan includes repair activities on balanced ventilation systems in the Crushing Plant, air ducts at the



Crushing-and-Sorting Mill, sprinkling quarry faces and roads, etc.

Needless to say how important ecological awareness is today. The Government is becoming increasingly involved in sustainability programs, and we must keep pace with the times. 🌱

NATALIA TROFIMENKO  
AND NATALIA BRAGINA  
AT THE LAB

Irina Tkacheva





## REDUCING EMISSIONS

**Novolipetsk Steel begins a new sustainability project at the Sinter Plant, aiming to reduce the environmental impact of its main production facility in Lipetsk.**

Environmental pollution will be reduced as a result of improving the sintering process and installing extra equipment for sintered layer treatment. Equipment for all four machines will reduce the Sinter Plant's carbon monoxide emissions by 10%.

In accordance with NLMK's policy to control and reduce its environmental impact, the Company will begin to revamp the central dedusting systems of its sinter machines and gas cleaning plants, generating an 80% reduction in sinter dust emissions. NLMK has already concluded an agreement with Alstom Power. Equipment is currently being delivered.

It 2009 NLMK introduced an automatic monitoring system for two sinter machines' emissions. This system enabled the Company to evaluate the efficiency of its emission reduction activities. This year a similar system will be implemented for the other two sinter machines. ■



## ON SCHEDULE

**New Blast Furnace #7 (with capacity of 3.4 million tpy) construction project is currently under way at Company's main production site in Lipetsk.**

Over 40% of all activities have been completed, including the in-

stallation of the furnace shell using hoisting equipment, the BLT and gas cleaning system, as well as coker stoves.

Ore and coke belt-conveyor trestles and refractories are being constructed according to plan. In 2010 we intend to install the main technological equipment. Automated proc-

ess management system set-up and hot tests are schedule for mid-2011.

The new BF complex and related facilities are going to take up an area of 78 ha in the Southern part of the Lipetsk production site. 75,000 tons of steel structures, 25,000 tons of refractories, 40,000 tons of equipment, as well as 50 km of new railway tracks and roads will be installed. ■

## FOR REFERENCE

BF-7 constructions started in 2008. Similar industrial complexes have not been constructed in Russia for over 20 years, since the Soviet era. This project is being implemented by NLMK in cooperation with Paul Wurth (Luxemburg) and UZTM (Yekaterinburg) as part of the second stage of the Technical Upgrading Program. The facility incorporates cutting-edge technical solutions providing for high efficiency, resource saving and highly automated hot metal production. The new furnace will be commissioned in 2012 and will increase the Company's main production site steelmaking capacity to 12.4 mln tons (+40%).



## NLMK RAISES FUNDS TO FINANCE CAPEX PROGRAM

**Novolipetsk Steel has successfully closed a credit agreement to finance the purchase of imported equipment guaranteed by leading export credit agencies.**

The EUR524million facility will be used to finance the purchase of equipment upon 19 commercial agreements from 7 leading European engineering companies. The facility, which bears a weighted average interest rate of EURIBOR + 1.53, has a maturity of 7 - 10 years. The funds raised by the Company will be used to finance projects that are part of NLMK's Technical Upgrade Program. This facility will allow the Company to carry forward the financing load of the Capex program. The funds will be provided by a range of major international banks including Société Générale Corporate & Investment Banking, Bayerische Landesbank, Deutsche Bank, and ING Wholesale Banking under guarantee from the Export Credit Agencies (ECA), Hermes, OeKB, ODL and ONDD. ■



## BOFS CATCH A SECOND WIND

**New dedusting facilities installed as part of an extensive campaign currently underway at Novolipetsk Steel. BOF-2 resumes operation in Steelmaking plant No.1**

Within 107 days NLMK experts assembled 1500 tons of steel structures. BOF-1 was upgraded earlier in the year. Dust content in the gas exiting the dedusting system was reduced by 38%. Final stage BOF-3 upgrade is scheduled for March 2010. Upgrading activities are carried out

by NLMK together with Siemens VAI as part of the Group's Technical Upgrade Program. The project is aimed at equipping NLMK's main Steelmaking Plants with modern dedusting systems to meet the most demanding environmental regulations. Modernizing all three LD converters in Steelmaking Plant No.1 will reduce dust emissions by 59% improving both the overall air quality in Lipetsk and the working conditions at the plant. ■

## FOR REFERENCE

Novolipetsk invested a total of around RUR 4 billion into environmental programs, 1.5 times more than in 2008. Key projects included ceasing water discharge into the Voronezh River and decommissioning 4 obsolete coke batteries. In 2009 VIZ-Stal allocated RUR 140 million to sustainability projects, including circulating water system re-equipment, industrial water purification methods, reduced emissions, etc. Another subsidiary, Altai-Koks, also implemented a number of en-

vironmental projects, for instance dust collector, NH3 pipe and coking chamber door repairs in Coke Plant No.3, oven rebricking, liquid fuel pump assembly at CHP, further site landscaping, etc. Altai-Koks invested RUR 42 million and was able to reduce overall emission levels by 5%. Nizhniye Sergi plant upgraded the existing drying stations with PF and other harmful substance reburning system thus improving health KPI. HHC recycling issue was completely resolved.

## SOMETHING TO BE PROUD OF!

**1st stage of Stoilenky's new Concentration Mill commissioned.**

Celebrations were of course in order, with ceremonial signing of



the Acceptance Act, cutting the red ribbon and breaking a champagne bottle over the drum of the new Ore Crushing Mill. This is definitely something for the Company to be proud of. The most complicated construction stage coincided with the economic crisis but Stoilenky made an effort to complete it continuing to stay on course towards modernization and development. Project CAPEX budget is around RUR 3 billion, with 2.6 billion developed so far. The facility is almost ready for full-scale operations, with an estimated capacity of 3.5 mln tpy (68.3% iron content). Cutting-edge ferrous metal ore processing technologies, as well as state-of-the-art energy and resource-saving methods were used for the first time in Russia. In this sense, Stoilenky miners are the pioneers of the industry. ■

## EXPLORING IT POTENTIAL

**NLMK Steel is implementing a specialized computer training system based on cutting-edge IT technologies to stimulate professional development.**

The first stage of the project will allow the Company to annually train over 300 employees directly involved in production. The new system provides a means of simulating production processes by recreating actual working conditions and assisting the team with perfect-

ing operating procedures in both routine and emergency situations, including via simulating various equipment failures. Trainings will allow improving the skills of new workers, as well as testing the qualification of operational personnel. The new system is currently used to train pourers and continuous casting operators at BOF Shop #1. A specialized computer class has been set up. Similar classes will be equipped at BOF Shop #2 and the



Hot-Rolling Mill in the nearest future. Next year, the new system will be used to train mill operators, cold-rolled and coated steel production supervisors. ■



## EXPANDING PRODUCT MIX

**NSMMZ, a Maxi-Group production facility, launches a new grade of hot-rolled wire rod, At800, used for concrete-reinforcement, as well as for manufacturing dynamically loaded complex components.**

At800 wire rod is made from high-resistance steel and is char-

acterized by improved plasticity and viscosity. It is fully compliant with all the Russian and international standards and has enhanced mechanical properties ( $\geq 1000\text{N/mm}^2$  strength,  $\geq 800\text{N/mm}^2$  yield point). New wire rod production expands the Company's product mix, strengthening its positions on the long product market. ■





## LIBRARY FINDS NEW HOME

**NSMMZ scientific library reopened in January at the spacious Demidov Centre. It used to be confined to a tiny room in the Plant Management Area**

The library was created in 1949. Over the years, its collection grew to 29 thousand books, all carefully selected on relevant steel production topics.

Ekaterina Chashchina, lead engineer, is in charge of the library. Technical Division workers are the most regular readers, she says. Others come here from time to time. For example, when mechanics had to pass the end-of-year upgrading exam, they signed



out all the EGW books. The library has a wide selection of periodicals, as well as some old rare

editions. It's free of charge, the employees only have to pay in case of loss or damage. ■

## FAULTLESS MANAGEMENT

**NSMMZ completes first stage of Human Capital Management system implementation based on SAP ERP HCM.**

Employee administration and personal data management functions have already been automated. The project is part of the Company's performance improvement activi-

ties. It involves developing a new management model while concurrently outsourcing a number of production support processes. "The new system will allow making management decisions based on actual real-time personnel data," says Denis Samsikov, NSMMZ Director General. The system provided the

tools needed to unify and standardize document flow and HR management. According to Vadim Uryas, NLMK IT Vice President, the Human Capital Management project is part of a comprehensive system which will be implemented at all the Group's companies over the next few years. ■

# Corporate Services – NLMK North American Manufacturing Divisions



SEATED L TO R: ARLENE BARNEY, CORINN GROSSETTI

STANDING L TO R: JASON ADAMS, ROBERT MILLER, TIMOTHY JACKSON

## Corporate Services USA

**Robert Miller,**

*Executive Vice President*

In mid-2009, the Corporate Service Group was commissioned in order to leverage off of the experiences within the service providing organizations at the US divisions of Duferco Farrell Corporation and Sharon Coating, LLC. The group is committed to and currently focused on integrating systems, developing formalized processes, and instituting controls at all levels of the organization at Beta Steel. While we are undertaking a full Oracle system implementation at Beta Steel and look to complete this in calendar year 2010, we continue to look for opportunities to create synergies and cost savings throughout all three operating divisions. Improved reporting, expanded access to data and overhaul of processes and protocol, will ultimately yield improvements in speed, accuracy, and consistency of business decisions. We are excited about the progress that has been made in all areas to date, and have set up an aggressive developmental schedule for 2010. Both progress and future plans are highlighted below by area. ■

## CSG Accounting & Finance

**Corinn Grossetti,**

*Corporate Vice President*

CSG Accounting and Finance has made significant progress at Beta. Successful installation of the Oracle receivable, payables, inventory, purchasing and general ledger modules have helped to facilitate a five day close process. Additionally, increased efficiencies from these system developments have helped to promote more reliable and timely flow of information. Internal management reports with relevant cost and spending data are available early in the month and on a consistent basis to support decision-making and planning. Concurrent with the upgraded software progress is the advancement of the underlying processes and procedures which promote good business flows and appropriate accounting controls. Strong team interactions between the locations have provided implementation training and documentation of the new Oracle processes coupled with on-going support after the implementation. The group is also in the process of consolidating select functions at a corporate level, including credit, treasury and financial modeling and analysis. This will help to provide uniform

and consistent methods within these areas. We will continue to seek areas and opportunities where synergies and efficiencies can improve the group's contribution to the company. ■

## CSG Quality & Metallurgical Engineering

**Jason Adams,**

*Corporate Vice President*

CSG Quality is a centralized body of resources designed to provide technical services and a formalized structure to all three business divisions. One key synergy created by the formation of this group is the manner in which we provided technical service and metallurgical expertise to the aggregate customer base. A Corporate Technical Services Group has been formed to serve as the technical liaison between the customer and the products they purchase from DFC, Sharon Coating, and now Beta Steel. The customer benefits from a singular contact to address all of their metallurgical / product needs. Another segment of the new corporate organization is a Quality Information Group. This team is focused on development and expansion of quality information reporting and serves as the leadership behind the development of new and existing quality and business level systems at Beta Steel, or any other future acquisition. Beta's baseline quality performance has been good historically, averaging a half-percent or less of shipped volume. Nonetheless, developmental efforts are underway to improve measurement of product characteristics, improve gauge and strip profile control, improve the resultant chemistry hit rate via Melt Shop scrap management and data trending, and improve steel baseline cleanliness through sulfur and nitrogen control practice implementation. We are also working to improve internal systems such as aged and



non-conforming inventory management. Under the CSG, Beta has also experienced a significant product development initiative. Beta is now a successful producer of specialty carbon and alloy slabs and hot bands for DFC and the open market. New product development has taken off for grades like SAE 1050 through 1074 High Carbon, SAE 5120H, SAE 4140, and SAE 4130 Alloy Steels, plus A414 Pressure Vessel Quality Steels (among others). Not only has Beta engaged in the production of a wide range of new, more highly value-added materials, but they are now producing this as hot band substrate for ultimate cold rolled applications – a first time event for Beta, and successful across the board. ■

### CSG Commercial

**James Banker,**

*Jr., Executive Vice President*

CSG Commercial has consolidated the sales activities of the three operating companies into one coordinated effort. Sales territories were redesigned for maximum efficiency allowing account managers to sell the full range of products inside their geographic territory with minimal overlap. Presenting a full product range has helped overcome a market perception of Beta / DFC / Sharon Coatings as mono-line or short-line companies and has resulted in increased sales. Working closely with Quality and Operations, the Commercial group has introduced new products and expanded product ranges to our customer base. The expansion of Beta's offerings in high carbon and alloy grades for subsequent sale to the DFC Specialty Products Division has been quite successful, and we are now expanding the sale of these grades to the broader re-rolling markets in the Midwest. ■

### CSG Information Technology

**Arlene Barney,**

*Corporate Vice President*

CSG ITS has consolidated the business information system and infrastructure support activities of the three operating companies. The focus is on integrating and leveraging best-practice business processes, systems and technology solutions across business units. The group has extensive experience in implementing, upgrading, customizing and supporting Oracle E-business Suite (EBIS) ERP software. In the past



L TO R: ALEXANDER TSEITLINE, JAMES BANKER JR.

year, CSG ITS has implemented the Beta Steel location as an additional operating unit within the existing Oracle EBIS instance, housed at the Farrell Site. Modules implemented included Oracle Financials (AR, AP, and GL), Purchasing, iProcurement, Raw Materials Costing and Inventory. Key business process improvements implemented in 2009 included raw material pay from receipt, automated scrap quality notification to suppliers and automated scrap inventory consumption. Major business system projects for 2010 include upgrading of Oracle EBIS to the latest release, implementation of the Beta Order to Cash process within the Oracle EBIS platform and Melt Shop production data collection automation. CSG ITS is focused on lowering total cost of ownership for ITS infrastructure while maintaining high levels of service. This can be done by standardization of platforms, leveraging of hardware/software purchases across companies and the application of a common IT focus in the execution of corporate strategies. ■

### CSG Research & Technology

**Alexander Tseitline,**

*Corporate Vice President*

CSG Technology & Research is focused on the following areas of responsibility – benchmarking North American mills within and beyond the NLMK group, identifying and implementing best practices, identifying opportunities for improvement through capital ex-

penditure programs, implementing cost reduction initiatives, developing technological improvements, and engaging in long-term technological planning. Recently, our efforts have been concentrated on the Beta Steel melt shop. The EAF operations require significant developmental work in order to reach good operational performance and to produce slabs with a measure of reliability and cost effectiveness. Another important area of improvement is an EAF fume evacuation system. Modernization of this system will allow Beta Steel to significantly improve work conditions in the melt shop, reduce long-term deterioration of the equipment and it will let us move forward with expansion of net liquid steel output. ■

### CSG Risk & Insurance

**Timothy Jackson,** *Director*

CSG Risk & Insurance has consolidated the insurance plans of the three operating companies into one coordinated group program. The objective of this approach was to identify synergistic opportunities across the companies that lead to cost savings and eliminate redundancies. Along with real cost savings, we have improved coverage terms, conditions, deductibles and started new relationships with best in class service providers. We are actively involved with Operations, Maintenance and Finance to assist in identifying potential sources of trouble, analyzing them, and taking the necessary actions to prevent losses. ■

# They've Got All the Cards

**NLMK Group is in the process of standardizing its operations.** As part of the project, in September VIZ-Stal started developing and implementing Technical Process Sequence Cards.

**T**he goal is to improve performance by enhancing discipline and skills. In the process of auditing the Company's Quality Management system in October 2009, BSI remarked on the importance of this project for improving production.

Implementing modern operating methodologies is one of the primary challenges VIZ-Stal HR is currently facing. Process sequence cards are being developed for all key professions in three units at the same time, i.e. Cold Rolling, Gas,

Water Supply and Waste Processing. The first stage has been completed, with cards developed for such professions as mill operator, cold metal cutter, instrumentation worker, etc.

Almost all the units have finalized the descriptive part of the new regulations, i.e. determined process sequence, chronometered actual duration and photographed optimal implementation approaches. Ready-to-use cards are uploaded to the plant's IT network, as well as stored in electronic and printed

form at the sites. The new system has proved successful in stimulating performance because the most skilled workers were involved in developing it.

A lot has already been accomplished but this is just the beginning. The next stage is to proceed to practical implementation. This will of course take time. The process will, however, be facilitated by a number of factors. First of all, the cards were developed taking into account acting technological instructions (though the cards are more than just instructions, they provide a step-by-step description of the specific actions a worker needs to perform). Secondly, the new cards are somewhat similar to the labor organization cards that have existed at the plant since the Soviet era being at the same time a significant improvement on the latter which contained flow sheets but did not describe the action itself. The new sequence cards act as a visual aid for performing operations at optimum quality and speed making it possible not only to determine how many people are required to perform a certain amount of work but also to achieve maximum efficiency.

New regulations will be updated and adjusted throughout the implementation stage because as they say, practice makes perfect. In time, process sequence cards will become an invaluable reference for VIZ-Stal workers, an ABC of efficient labor algorithms. 🔄



**Natalia Kachmasheva**



# Cherish the Children

**Svetlana Mineeva, Atlai-Koks coke-screening forewoman and mother of seven, receives the Parent Excellence Award.**

**S**unday morning. As in many families, it starts with breakfast. And then everyone picks what they like best: computer games, books, TV. Relaxing is what Sundays are for, after all. But in the Mineev family everybody knows the drill: while some relax, it's always someone's turn to do the dishes. And they all understand why chores are so important. There are six kids in the family, not too long ago there were seven.

Svetlana Mineeva, their mum, grew up in a large family herself, with three siblings. Of course, in the Soviet times it wasn't all that unusual. But even then, Svetlana's family would have been an exception.

After school in the village of Bobrovka, Svetlana continued her studies at a cooking college in the city of Novosibirsk. Classes finished late and sometimes she found herself at the train station past the safe hour. Once she got picked on by a gang of bullies but luckily there was someone to stand up for her that night. That's how Svetlana met Mikhail Mineev, a river college student. They started dating and got married six months later.

The young couple moved to Zarinsk, closer to Mikhail's parents. At first, they had to rent an apartment. It wasn't till the birth of their daughter Natasha that they finally got a room of their own. Gradually they were able to expand to three rooms.



PHOTO  
FROM FAMILY ALBUM



This is where their big family lives today.

Svetlana started working as a cook at a primary school. Then the Mineev family started to grow and for over ten years Svetlana was on maternity leave.

In March 2005, when the youngest Elza was about two years old, Svetlana decided to go back to work. She found a job with Altai-Koks, an NLMK subsidiary, where she started off as a cleaning lady. Then she became a coke sorter in Coke-Oven Shop No. 3. Today she is the coke sorting control panel operator. She confesses having been a little intimidated by the challenge when she was offered this position. But once she tried it, she knew she would be ok. With the help of her colleagues, she gradually mastered all the necessary procedures. "The atmosphere in the team is amazing," she says.

The Mineevs are among those lucky people with a perfect work/life balance. They love their work and they are always happy to come home to their six kids, and now to their grandson, one-year-old Timur. When we ask Svetlana about the kids, her eyes light up.

"They are my joy. When I was a girl, I dreamed of having two or three, but now I have seven! And they are all so wanted and loved."

Natasha, their first child, has already moved out and started a family of her own. Timur is her son. Natasha has many talents, she taught herself to play the piano, and she is an excellent cook because she would always help mum in the kitchen.

Their oldest son, Mikhail, is in his last year at High School. When Mikhail Mineev Sr. is on a business trip, he is in charge of the family. He is very focused and

ambitious. After school, he wants to go to college. The entire family believes that he is going to be very successful.

Evgeny is 15. He loves computers and is just as persistent as his older brother. Daniil is two years younger. He is very inquisitive, loves to paint and read. In fact, everyone in the family is fond of reading. The Mineev boys were even awarded a prize by the city library as best readers.

Nadia is in Junior School. She plays the piano, draws well and participates in making the school paper. Evelina is 8. She is very active and brave. The boys adore her. Elza started school this year. She is an excellent dancer. Her other passion is origami. The youngest girls are very competitive, always trying to beat each other at puzzles and games.

"They are all different and they all have their special talents," Svetlana says. "But at the same time we are very close as a family. The kids share everything. They even bring fruit and juices back home from the school canteen to treat the toddlers."

#### FOR REFERENCE

The Parent Excellence Award was created in the Altai region in 2007. It is given to citizens of Russia who have been living in the Altai region for at least 15 years and have raised (or are raising) five and more children.





Svetlana herself is fond of knitting. She loves making jumpers, mittens and socks for her kids. And she has always been fond of painting, a passion which she was thrilled to discover in her children as well.

The Mineev's chose the children's names from the Bible. This book plays an important role in their family. They read it out loud, teaching the kids all the commandments. They also go to Church regularly. The parents try

to cultivate friendship and hard work in the family. All the kids, irrespective of age, have household chores. The older ones cook, the younger ones wash the dishes. The Mineevs have a plot of land in the country and every summer they used to plant their own vegetables and fruit. Not everyone was excited about this so last year they decided to take a break. And surprisingly enough, by the end of the summer even those who didn't

like it started to miss working on the land. In the winter, they all go skiing and ice-skating.

Another family tradition involves celebrating birthdays and holidays together. Their favorite one is New Year. Everyone gathers around the festive dinner table, including their eldest daughter's young family. And of course what they value most about such moments is not even the holiday, but the chance to be together. ❄️

# Underground Icon-Painting

**The Russian Orthodox Church split in the mid-17th century into those who accepted the reforms introduced by Patriarch Nikon and those who didn't, the so called Old Believers.** The Old Believers were persecuted and were forced to flee to the most remote regions of the country, including the Ural. They abided by the ancient rules: elected their priests, continued special liturgical practices and devotedly guarded their icon-painting traditions.

## ICONS

ACAPHISTUS TO THE MOTHER  
OF GOD AND NATIVITY OF  
CHRIST.  
BOGATYREV WORKSHOP.  
1800 - 1830



Gradually, an underground Old Believer painting school evolved around the city of Nevyansk. It existed for over two centuries in the very heart of the Ural mining industry, the two being intricately intertwined. Today, with a few enthusiasts at the helm, the Nevyansk icon is finally starting to get the attention it deserves.

Nevyansk has always been epicentric to both the industry and the Old Believer move-

ment. When the Demidovs, an influential Russian family at the time, started exploring the Ural region, they badly needed the support of honest, enterprising and serfdom-free locals. The schismatics possessed all these qualities and quickly earned the respect and trust of the entrepreneurs. It is therefore not surprising that the Old Believer culture, and icon-painting in particular, blossomed here in Nevyansk.

First icons appeared in the Demidov "capital" as far back as Peter the Great. However, it is impossible to establish the exact dates, as well as the authors, because Old Believers were strictly prohibited from practicing the art and had to do it secretly and on a by-order basis only. Nonetheless, we do know a few names of the Nevyansk school's founding fathers. Among them was Father Gregory Koskin who lived a secluded life not too far





ICONS  
OLD TESTAMENT TRINITY  
AND NATIVITY OF THE  
BLESSED VIRGIN.  
SECOND HALF OF THE 18TH  
CENTURY



ICONS  
THE FIERY ASCENSION OF  
ELIJAH THE PROPHET.  
SECOND QUARTER – MID-  
19TH CENTURY  
AND ALEXANDER NEVSKY, HIS  
LIFE AND TIMES.  
BEGINNING OF THE 19TH  
CENTURY.

from the factories. His grave is a shrine still zealously revered by the Old Believers. His icons, on the other hand, have unfortunately been lost. However, one of the first Ural Old Believer culture researchers, Suchel Dulong, a French missionary who was lucky enough to see some of Koskin's works at the beginning of the 20th century, said they were "remarkable".

The earliest dated icon is the *Egyptian Godmother* (1734).

Looking at it, one can already notice the specific painting techniques which later developed into a unique recognizable style. It's easy to remark the stereotypical depiction of the Saints and the way their markedly "withdrawn" images stand out against a perfectly "mundane" background.

White-painted faces barely depict emotions, rather than "live" them. Painting manner is very calm, almost austere. Multiple

shades of one color prevail (usually, red or yellow). Inscriptions (paleography) are perfectly executed and often abundantly ornamented. 18th century Old Believer icon painters followed a very strict canon which appeared long before the schism.

At the same time, despite the rigid iconographic rules, they demonstrated extreme boldness and a remarkable sense of style which is revealed through their unique color treatment. A viv-





ICONS  
ST NICHOLAS THE  
WONDERWORKER  
AND EXALTATION OF THE HOLY  
CROSS. 1830S.

id example of this is the Nativity of the Blessed Virgin. The artist used around twenty different shades of red painting it!

At the turn of the 18th century, the Nevsky school boomed together with the mining Ural, the region's Golden Age coinciding with that of icon painting. This period, scientifically referred to



as the High Nevsky, sees the emergence of the most interesting and original icons, like the *Holy Martyrs Florus and Laurus Praying to Christ Pantocrator*, *Apostles Peter and Paul (Their Life and Times)*, *St Nicholas the Wonderworker*. They are all remarkably strict in style and executed on a very high level of mastery.

And it could not have been otherwise. Old Believers, mostly successful manufacturers and rich merchants, were well-educated and strongly devoted to their ancestors' religious traditions. They were willing to pay huge sums of money for a good icon. An icon could sometimes cost several times more than a

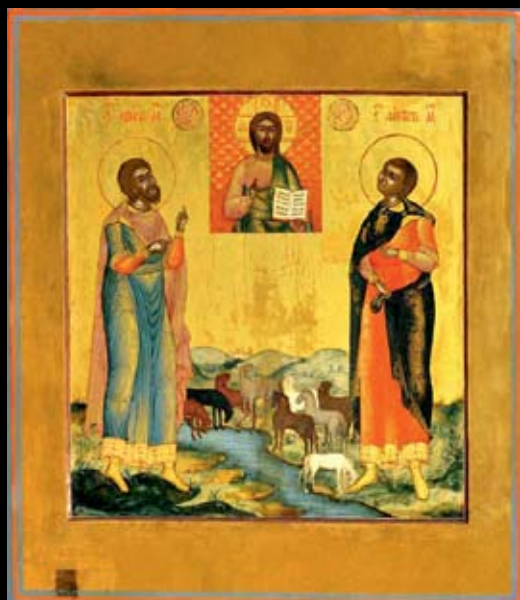


### Secluded World

The first to discover the remarkable artistic value of the Ural Old Believer icon-painting to the scientific community was a French missionary, Suchel Dulong, in his report in 1923. Forced conspiracy in the Soviet times, authoritarian attempts to wipe out all traces of the Old Believer culture concealed the Nevsky treasures from the public eye for many years.

First publications on the subject started appearing only in the late 1980s, during the Perestroika. Evgeny Roizman, State Duma deputy, historian, poet, writer and collector, made an enormous effort to rediscover the Nevsky icon. He gathered a vast collection of Old Believer icons. In 1997 he used it to publish a beautiful Nevsky Icon Painting album. Two years later he created a museum in Yekaterinburg. The museum is still open today. Its exposition is displayed regularly in different cities around Russia. In December 2009 an exhibition was held in Moscow with great success.





ICONS  
 HOLY MARTYRS FLORUS AND  
 LAURUS PRAYING TO CHRIST  
 PANTOCRATOR AND THE  
 EGYPTIAN GODMOTHER.  
 18TH CENTURY.

house. Only the best masters would paint Saints for the Old Believers, including such isographic dynasties as the Chernobovins, the Anisimovs, and later the Filatovs and the Romanovs.

Perhaps the most important influence on the development of the Nevyansk icon in the 1790s through to the first quarter of the 19th century came from the Bogatyrev dynasty and its founder, Ivan Bogatyrev. According to historians, almost all Ural icon-painters copied their work. Bogatyrev icons' typical features include multi-figure groups, dynamic angles, stately gestures, a lot of gilded details, baroque and classic elements, as well as the actual Ural mountain landscape in the background. In fact, local grayish blue mountains appeared on the Nevyansk icons long before the Bogatyrevs (for instance, *St Nikita the Warrior* dating back to the end of the 18th century). What rendered them innovative, on the other hand, was the impact of secular art they introduced to Old Believer iconography.

Ural art started evolving towards ornamentality as



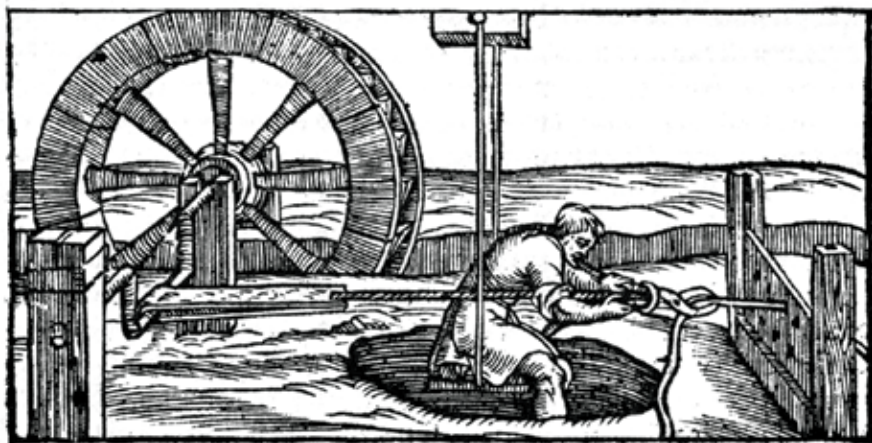
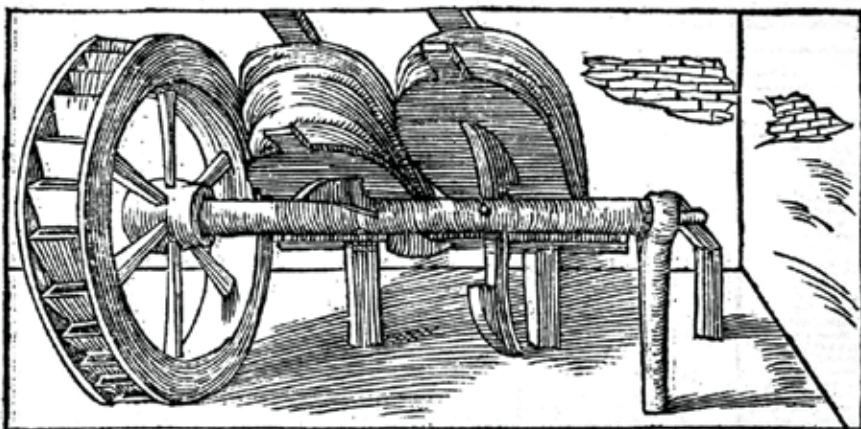
early as the turn of the century, i.e. in the most favorable conditions of economic prosperity and lack of authoritarian pressure.

However, in the 1830s Old Believer persecutions resumed. Old Believer icon-painting, always frowned upon by the officials, turned into a crime. To avoid arrests, a lot of industrialists and their isographers were forced to formally accept the New Faith. Icon-painting traditions, already strong at the time,

did not disappear. They merely became more ornamental. In this form icon-painting existed until the October Revolution in 1917. As a result of the Civil War and antireligious policies, Old Believer icon-painters had to go underground, just like 30 years before that. The last officially known Nevyansk icon, *Christ the Pantocrator*, appeared in 1919. However, scientists found traces of secret icon-painting in Nevyansk as late as the 1950s. ❄

# Renaissance Metallurgy

**Steelmaking today relies heavily on scientific progress which is the driving force behind operational innovation.** As a leading Russian company, NLMK Steel is successfully implementing state-of-the-art scientific achievements to master and improve its production processes. The centuries-old interrelation of theory and practice stemming from the Renaissance still plays a crucial role in the world today. In fact, we owe the existence of metallurgy as a separate science discipline to the researchers of the Renaissance.



OPERATION OF BELLOWS  
BY CAMS ON A SHAFT AND  
WIRE DRAWING FROM  
BIRINGUCCIO'S  
DE LA PIROTECHNIA. 1540.

**K**nowledge on mining and extracting metals from ore has been accumulated and systemized over many thousands of years. Ancient Indians, Chinese, Greeks and Romans composed tracts on the various aspects of mining. Their less literate con-

temporaries, the Celts and the Gaels, who mastered the craft of iron weapon-making, passed on their knowledge to the younger generation of blacksmiths by word of mouth. In the Middle Ages, European metallurgists made significant progress in the smelt-

ing and smithing of bloomery iron. Alchemists' experiments led to discovering multiple means of treating metals. As a result, entire regions specializing in mining sprung up in Germany, Italy, the Czech lands and Scandinavia. Gradually, a diverse pool of knowledge on the properties of ferrous and non-ferrous metals was accumulated. And at the beginning of the Renaissance it was systemized and even encyclopedized for the first time, thus forming metallurgy as a science. The works of Vannoccio Biringuccio and Georg Bauer (Agricola) played a crucial role in this process.

## The Father of the Foundry Industry

Renaissance started at the turn of the 13th century. In Italian city-states Medieval ideals (austerity, withdrawal for the vanity of the world) were being replaced by attention to the individual and his activity. At the same time, intellectuals started to revive the Antique culture, re-introducing the principles of harmony, natural beauty and hedonism to art. Researchers began to rely on scientific principles and methodologies as opposed to religious doctrines and scholastic dogmas of the past. These tendencies stimulated the develop-





ment of exact and natural sciences, which, in their turn, boosted the growth of mining, as well as other industries.

One of the most prominent figures of the Renaissance whose works became classics of metallurgical theory was Vannoccio Biringuccio. He was born into a noble family in Siena, an independent Italian city, around 1480. Although Siena was slightly economically and militarily inferior to the Northern Italian city-states (Venice, Milan, Florence), it was nonetheless a large trading, cultural and scientific center. The University of Siena was famous across Europe for its Faculty of Medicine. Moreover, the celebrated Siena school of painting, formed by the end of

the 13th century, was a significant influence on all of the Renaissance art. Emerged in such a culture-rich environment, Vannoccio had no choice but to take in its ideals.

Since early childhood he was fascinated by natural sciences, chemical experiments and drawing. His father, seeing Vannoccio's passion for science, decided to initiate him into the craft of mining. The family's prominent position in Siena allowed Vannoccio to supplement his already solid education by real-life observations acquired during his visits to German and Italian mines. Upon return, he embarked upon his own path in the mining industry. In the beginning of the 16th century, he

successively managed a mine, ironworks, silver ore processing company and the City armory.

However, an opposing clan soon seized power in Siena and Vannoccio was forced to flee his home city. He continued his studies in exile, travelled around Europe and gained invaluable experience. It was then that he started working on his main oeuvre, *De la pirotechnia*, translated as the "Fire method". By the time

**METHODS OF VENTILATING  
A MINE AND METAL  
SMELTING FROM AGRICOLA'S  
DE RE METALLICA. 1556.**

**VANNOCCIO BIRINGUCCIO  
AND GEORGIUS AGRICOLA**







METAL SMELTING

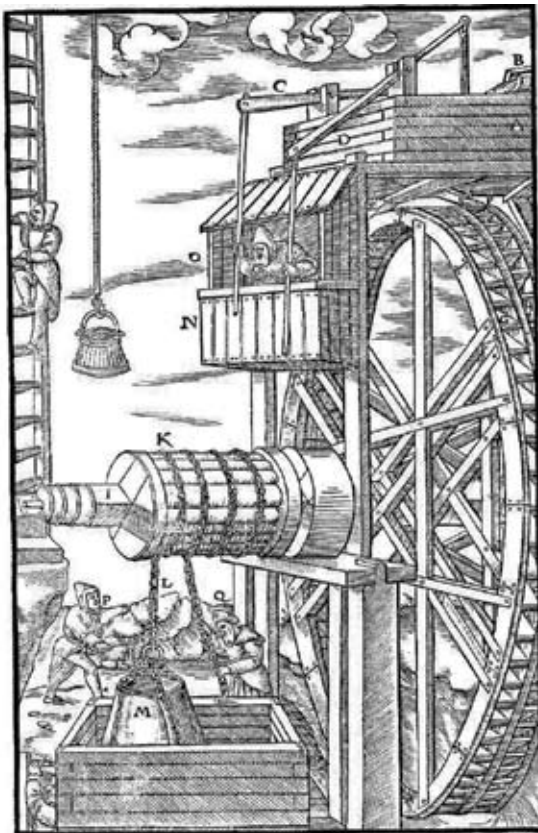
FROM AGRICOLA'S *DE RE METALLICA*, 1556.

in the official Latin) was a stunning success. In the 16th century alone it was reedited five times. In ten relatively brief chapters Vannoccio managed to summarize an impressive range of information on the history and current state of the mining industry. He described the best prospecting, mining and smelting techniques. *De la pirotechnia* incorporated details on furnace design and revealed some steel quenching secrets. Vannoccio also looked into various mineral processing methods. He was perhaps the first to tackle the term alloy, defining it as “a mixture of metals existing in friendly cooperation.” All the techniques and practices are meticulously illustrated by woodcuts. In fact, *De la pirotechnia* can be considered to be the first industrial encyclopedia in the world. Mining historians justly refer to Vannoccio Biringuccio as the “father of the foundry industry.”

### The Father of Mineralogy

Another celebrated name in Renaissance metallurgy is that of Vannoccio Biringuccio's contemporary, Georg Bauer (1494 – 1555), a German scholar and scientist. He was born in the small town of Glauchau in Saxony but dazzled by the brightness of the Renaissance he Latinized his name, turning the coarse German “peasant” Bauer into the honorable Roman “farmer” Agricola and went on to become famous under this pseudonym.

Metallurgy wasn't in fact his first passion. In his youth, Agricola studied philology and earned a degree in Linguistics from the famous University of Leipzig. Later he devoted himself to the study of medicine. After becoming a physician, he moved to Italy to master the art



his returned to Siena in 1523, he was already famous in Italian cities and in Germany as a scientist and one of the best metallurgists. Highly valued in both Siena and Rome, he received numerous invitations to work on the most important production facilities in Italy. For instance, in 1529 in Florence he supervised the casting of one of the most impressive weapons of his time, a 6-ton 6.7 m long bronze cannon.

Vannoccio's manual on metalworking, *De la pirotechnia*, was published in 1540, a year after his death, in Rome, where he managed the production of bells, cannons and cannon balls. Although he didn't come up with any innovative methods of mining and processing ore, his book, written in Italian (rather than

A WATER-POWERED MINE HOIST

USED FOR RAISING ORE FROM AGRICOLA'S

*DE RE METALLICA*, 1556.



of healing. There he discovered the curative properties of many minerals used to treat miners that were described by Antique authors. Minerals and miners alike were in abundance in Italy at the time but to practice medicine Agricola needed a formal appointment. Finding a vacant position at the Apennines proved extremely difficult for a German and Agricola moved to the Czech Jachymov whose newly opened mines attracted thousands of workers. Here he could freely practice his profession, as well as study geology, mining and metallurgy. Agricola summarized the knowledge won by three years of practical work in a book with a peculiar title, *Bermannus, sive de re metallica dialogus*, published in 1530. The text of this work is in the form of a dialogue between Bermannus, a learned miner, and three physicians on the most important issues in the fields of geology and mineralogy, accompanied by the author's ethical commentary.

Agricola's diverse interests and his "multiple-track" path into metallurgy are characteristic of his time. Renaissance scholars, just like the Ancient Greeks and Romans, devoted themselves to many sciences at once, with primary focus on philosophy. Therefore, they started all of their theoretical works with a



discussion of universal topics. In his most famous book, *De Re Metallica* (1556), Agricola points out the importance of philosophy, astronomy and many other sciences for a miner.

However, none of this would make sense, Agricola says, if the metallurgist fails to master all the field-specific disciplines.

Then he devotes a number of pages to protecting the mining profession from the prevalent Renaissance stereotypes of it being a dirty and unworthy business. In the following passage he summons metallurgists to honor God, to cultivate high morals, to be economical and not to tempt fate. Only then Agrico-

**FIRE-SETTING  
UNDERGROUND**  
FROM AGRICOLA'S *DE RE  
METALLICA*, 1556.

### Primary Source

Georg Agricola and Vannoccio Biringuccio relied not only on their personal mining experience but drew from an extensive theoretical base as well. Like many Renaissance scientists, they were inspired by the works of Antique authors which they were the first to discover among neglected volumes in dusty monastery libraries. They were captivated by Strato of Lamsacus's (340 – 268 BC)



writings *On Metallic Works*, as well as those of Herodotus on the art of processing metal and the travelling accounts of Strabo.

The most significant influence, however, came from the theories of Aristotle (384 – 322 BC) and Vitruvius, a Roman engineer and architect who lived in the 1st century BC. The former provided knowledge on the system of substances in the world, which caused a lot of con-

trovery. The latter engaged in mine construction and his works proved to be an invaluable source of architectural information for the 15th-16th century metallurgists. Another one of Vitruvius's inventions adopted by the Renaissance men was the system of canonical proportions (correlation of ideal human proportions and architectural geometry) widely known today from a drawing by Leonardo da Vinci called *Vitruvian Man*.



TITLE PAGE  
OF SEBASTIAN MUNSTER'S  
COSMOGRAPHIA.

la proceeds to the scientific and technical aspects. The first six chapters summarize knowledge on mineralogy and mining, as well as provide an original classification of minerals, which was used by many generations of geologists and metallurgists. Chapter Seven covers the basics of fire assay testing. In the following chapters Agricola talks about ore beneficiation, smelting, separating and processing metals. He describes melting equipment, as well as salt, niter and glass production processes. Surprisingly enough, the book ends with an annex entitled *De Animantibus Subterraneis* (on animals known to exist in the subsurface), completing, in the author's vision, a well-rounded depiction of the mining world.

Besides those already mentioned, Agricola published several more works (*De ortu et causis subterraneorum*, *De veteribus et novis metallicis* and others) which also contributed to his fame. Contemplating Agricola's role in history, Johann von Goethe, a remarkable poet, natural scientist and philosopher, wrote: "He unraveled the mysteries of the mountains... We are still captivated by his works which aggregate all the ancient and new knowledge on mining and metallurgy. They are a precious gift to us."

Of course, Biringuccio and



Agricola were not the only ones driving mining science in the Renaissance. Sebastian Münster (1489 – 1552) describes the state of the German mining industry and metallurgy in his extensive *Cosmographia*, providing a lot of information on the various machines and beneficiation processes that existed at the time. Münster makes an effort to inscribe metallurgy into the overall picture of the Universe.

Inventions of the Renaissance genius Leonardo da Vinci also played an important role in developing mining. Some of his drilling and dewatering mechanisms are still used today.

And finally, we have to mention Vavřinec Kříčka, a Czech

metallurgist who authored a manuscript in the beginning of the 16th century sharing invaluable information on casting techniques and mine dewatering methods.

A lot of researchers from all over Europe contributed to metallurgical advancement. Not all of them can be referred to as men of the Renaissance because European states were much more heterogeneous than they are today, and whilst in some Renaissance was at its peak, in others it was yet to start or was unfolding in a very specific way. However, all the scientist of the time shared an urge to fuse theory and practice paving the way for science in metallurgy.



