Объединение независимых экспертов в области минеральных ресурсов, металлургии и химической промышленности

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# Molybdenum
## Production, Market and Forecast in the CIS

**11th edition**

**Sample PDF**

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## LIST OF ACRONYMS

| | |
|---|---|
| CJSC | Closed Joint Stock Company |
| PJSC / JSC | Public Joint Stock Company |
| JV | Joint Venture |
| NPO | Research, Development and Production Facility |
| CMC | Copper and Molybdenum Complex |
| MMC | Mining and Metallurgical Complex |
| MPC | Mining and Processing Complex |
| GKZ | the State Committee for Mineral Reserves |
| Rosnedra | Federal Agency for Subsoil Use (Russia) |
| RF | The Russia Federation / Russia |
| SGKhC | Stepnogorsk GKhC, Stepnogorsk Mining and Chemical Complex |
| GMZ | Hydrometallurgical Plant |
| FMP | Ferromolybdenum Plant |
| PGKhO | Priargunskoe Mining and Chemical Production Concern |
| ChEMC | Chelyabinsk Integrated Iron-and-Steel Works |
| OEMC | Oskol Electrometallurgical Complex |
| | Chelyabinsk Integrated Iron-and-Steel Works |
| UzKTZhM | Uzbek Refractory and High-Temperature Metal Complex |
| RDF | Fund for Reconstruction and Development of Uzbekistan |
| AMP | Armenian Molybdenum Production |

# EXECUTIVE SUMMARY

This report is the **11th edition** of the CIS Molybdenum Market Review.

**The study purpose** is analyzing the molybdenum market.

**The study subject** is molybdenum concentrate; the report also provides a brief description of the producers of other molybdenum products, ferromolybdenum, molybdenum metal, etc.

This is **a desk study**. As the sources of information, data of the Federal Government Statistical Service of the Russian Federation (Rosstat), JSC Russian Railways (railage statistics), the Federal Customs Service of the Russian Federation (FCS), the InfoMine database were used. Besides, the materials of the sectoral and regional mass-media, annual and quarterly reports of securities issuers, websites of producers and consumers of molybdenum concentrate were used.

**The study chronological scope:** 1998-2016; forecast until 2025.

**The study geography:** Russian Federation, comprehensive detailed market analysis; Armenia, Uzbekistan, Kazakhstan, general market analysis; the rest of the world, general information on the market trends and characteristics.

**The study scope:** the report consists of **6** chapters, contains **171** pages, including **51** Tables, **50** Figures, **2** Appendices.

**The first chapter** of the report provides information on mineral resource base of molybdenum and production of molybdenum-bearing ores abroad. The main applications of molybdenum concentrates, as well as world prices for molybdenum products are covered.

**The second chapter** of the report is devoted to analysis of mineral resource base of molybdenum-bearing ores of Russia and other CIS countries.

**The third chapter** provides information on trends and pattern of molybdenum concentrate production in 1998-2016, description and characteristics of major producers of molybdenum concentrate in the CIS. Sales markets and consumers, export activity are considered.

**The fourth chapter** is devoted to analysis of foreign trade operations of Russia, Kazakhstan, Armenia and Ukraine with molybdenum concentrates in 1998-2016. It provides information on the delivery destinations, exporters and importers of molybdenum concentrate.

**The fifth chapter** provides review of molybdenum concentrate consumption in the CIS. The chapter presents balance of production and consumption of the product in Russia (1998-2016), as well as description of the main company-end-users. In

addition, the chapter provides description of manufacturers of ferromolybdenum and other molybdenum products in Russia and other CIS countries.

The final, **sixth chapter** of the report provides forecast for development of Russian molybdenum raw materials market up to 2025.

The **appendices** present mail addresses and other contact details of the major producers of molybdenum concentrates and consumers of molybdenum raw materials.

**The study target audience:**

- players in the molybdenum resources market: producers, consumers, traders;
- potential investors.

The proposed review aspires to become a reference tool for marketing services and specialists who make managerial decisions on the market of molybdenum raw materials.

# INTRODUCTION

Molybdenum was discovered in 1778, but received industrial application relatively recently. Until the twentieth century only some molybdenum compounds were used, mainly as chemicals and dyes. In the end of the nineteenth century, the effect of molybdenum on steel properties was discovered, that resulted in expansion of its application. At present, molybdenum is one of the most important alloying metals. More than 90% of the molybdenum produced in the world in the form of ferromolybdenum are consumed in special steels metallurgy. In addition, molybdenum, due to its refractoriness and low coefficient of thermal expansion, is widely used in electrical engineering, radio electronics, high temperature technology.

Molybdenum is light gray metal with cubic volume-centered lattice of a-Fe type, $a$ = 0.314 nm. The density is 10.2 g/cm$^3$; the melting point is 2623°C, the boiling point is 4800°C. The specific heat capacity at 20-100°C is 0.272 kJ/(kg×K). The thermal conductivity at 20 C is 146.65 W/(cm×K). The thermal coefficient of linear expansion is (5.8-6.2)×10-6 at 25-700°C. The specific electrical resistance is $5.2\times10^{-8}$ Ω×m; the electronic work function is 4.37 eV. Molybdenum is paramagnetic; the atomic magnetic susceptibility is $90\times10^{-6}$ (20°C). The mechanical properties are determined by purity of the metal and the preceding mechanical and thermal treatment.

Molybdenum is used as alloying addition to various alloys, including high-quality steels. Molybdenum addition significantly increases hardenability of steel. Small additions of Mo (0.15-0.8%) in structural steels increase their strength, viscosity and corrosion resistance so much that they are may be used in manufacture of the most critical parts and products. Molybdenum and molybdenum alloys are used in parts for long time work in vacuum at temperatures up to 1800°C (in rocket nozzles and vacuum tubes), as well as structural material in nuclear power reactors, for manufacture of equipment operating in corrosive environments.

In pure form, molybdenum is used in the form of narrow strip or wire as heating element of electric furnaces operating under hydrogen atmosphere at temperatures up to 1600°C. Molybdenum wire and lamina are widely used in radio electronic industry and X-ray technology for manufacture of various parts of electronic tubes, X-ray tubes and other vacuum devices.

Molybdenum is used in manufacture of missile skins and elements of structure, honeycomb panels of spacecraft, heat exchangers, envelops of rockets and capsules returning to the earth, heat shields, wing edge skins, and stabilizers in supersonic aircrafts. Some parts of straight-jet and turbojet engines (turbine blades, tail skirts, jet shutters, rocket engine nozzles, control surfaces in solid fuel rockets) operate in severe conditions.

Molybdenum compounds - sulphide, oxides, molybdates - are catalysts of chemical reactions, pigments of dyes, glaze components. Molybdenum hexafluoride is used in application of molybdenum metal to various materials. $MoSi_2$ is used as a solid high-temperature lubricant. Molybdenum trioxide (molybdenum anhydride) is widely used as the positive electrode in lithium current sources.

# 1. BRIEF DESCRIPTION OF MOLYBDENUM WORLD MARKET CONDITIONS (RESERVES, PRODUCTION, PRICES)

Molybdenum resources have been identified in 35 countries across the world, and the total proved reserves of molybdenum, according to the US Geological Survey (USGS) as of 2016 amounted to about 14 million t.

The largest molybdenum mineral resource base is belonged to China. Among other leading countries in molybdenum reserves are Chile, USA, Peru, Mexico and Russia (Table 1).

Resources of molybdenum are sufficient to satisfy, in the foreseeable future, the world's demand for this metal.

**Table 1. Molybdenum Reserves of the Leading Countries, kt**

| Country | Reserves category | Molybdenum reserves, kt |
|---|---|---|
| China | Ensured Reserves | |
| Chile | Proved + Probable Reserves | |
| USA | Proved + Probable Reserves | |
| Peru | Proved + Probable Reserves | |
| Mexico | Proved + Probable Reserves | |
| Russia | Reserves of being exploited and under developing deposits in categories $A+B+C_1+C_2$ | |

*Source: review of specialist literature*

The ***China***'s resources base is mainly presented by deposits of molybdenum-porphyry (more than half of the country's resources) and skarn types. Total number of the Mo deposits exceeds 220, among which there are many large ones. Most of the deposits is suitable for open-pit mining. The China's resources base is of mixed quality: about two-thirds of the country's Mo reserves belong to ordinary and low-grade ores, and the residual third is characterized by high grade (more than 0.1% Mo in the ores).

In ***Chile***, all resources and reserves of molybdenum belong to sulfide ores of molybdenum-copper-porphyry deposits. There are about 15 large deposits of this type in the country, including El-Teniente, Chukikamata, Andina, Kolyauasi and others.

In the ores, Mo occurs as minor component; its average grade in the ores across the country estimates at 0.013%.

The most important role in molybdenum resources base of ***the United States*** is played by molybdenum-porphyry deposits, which contain more than 60% of the country's resources, including Climax, Questa, Henderson, and others. Mo grade in the deposits ores is at the level of 0.1-0.2%. The rest belongs to molybdenum-copper-porphyry, copper-porphyry and skarn deposits.

In ***Peru***, almost three quarters of molybdenum resources belong to five giant and large molybdenum-copper-porphyry deposits: Toquepala, Cuajone, Cerro Verde, Toromocho and Antamina.

In ***Mexico***, all molybdenum resources belong to molybdenum-porphyry deposits of various size, whose ores are of complex composition and contain minor copper, tungsten, gold and silver.

In the period of 2001-2014, positive trend of world molybdenum production was in force. Overall, the metal in concentrate output increased 2 times, from 125-141 ktpa in early 2000s up to XXX ktpa in 2011-2014.

For the latest 2 years, the world molybdenum production decreased: in 2015, the output dropped by 12% to XXX kt. In 2016, the decline rate slowed down to 3.4%; according to the USGS estimate, the molybdenum production amounted to XXX kt.

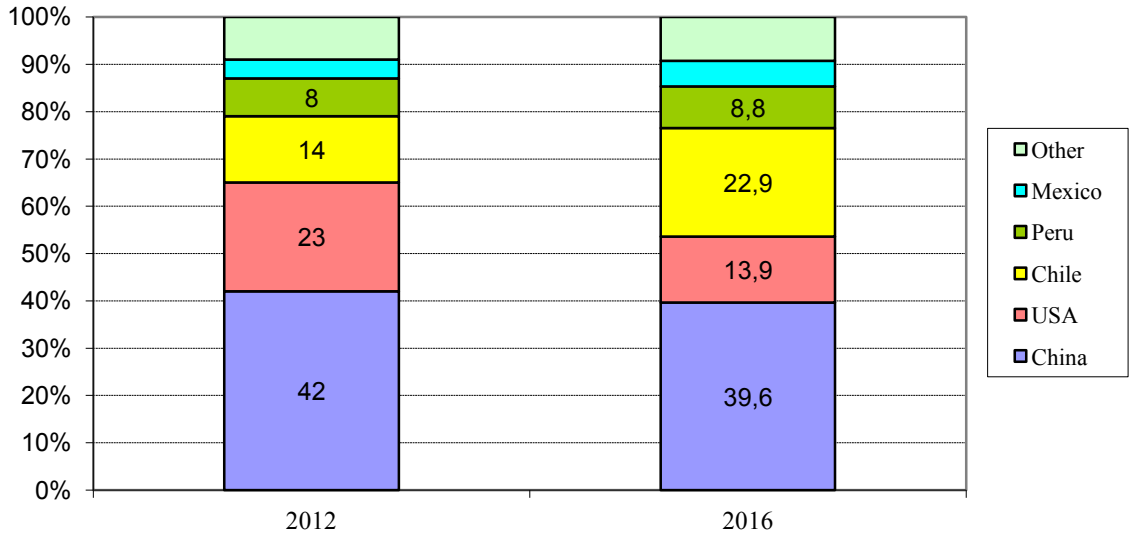
**Figure 1. Trends of Molybdenum in Concentrate World Production in 2001-2016, kt**

*Source: InfoMine based on USGS data*

About 60% of the world's output of molybdenum is obtained as the by-product in the course of processing of complex resources, mainly from copper mines, and the remaining 40%, from exclusively molybdenum ores. Copper ores from which molybdenum is extracted as by-product usually contain 0.5-1.5% copper and 0.01-0.05% molybdenum (contained in molybdenite $MoS_2$). The mines at annual capacity of approximately 50 million t of raw materials produce about 200 kt of copper and 5-15 kt of molybdenum per year.

The main country-producers of molybdenum are China, the United States, and Chile. These three countries produce together more than 75% of the total molybdenum in the world. In addition, top-five world producers of molybdenum includes Peru and Mexico. For the latest 4 years, pattern of world molybdenum production has changed somewhat: the share of the US has decreased noticeably with the simultaneous increase in the share of Chile (Fig. 2).

**Figure 2. Patterns of World Molybdenum Production in 2012, 2016, %**




*Source: InfoMine based on USGS data*

The world's largest producer of molybdenum, China, provides about 40% of the world's molybdenum output.

The most significant reduction in the output of molybdenum in kind occurred in the US, from above 60 ktpa in 2011-2014 to 31.6 kt in 2016. The decline in the US molybdenum production was mainly due to the closure of Thompson Creek Mine mine, as well as significant decrease in the production volumes of Bingham Canyon Mine (Utah).

Already in 2015, the United States lost the second place in the world ranking of molybdenum producers. This place was achieved by Chile, which increased output of molybdenum to 52 ktpa in the latest 2 years. Among the world producers of molybdenum, the most significant reduction in the production volumes, besides the United States, happened in Canada, where, in 2005-2014, production of molybdenum in concentrate varied within the range of 7.2-9.4 ktpa, but dropped to 1.7 kt in 2016 (Table 2).

## Table 2. Confirmed Reserves and Production of Molybdenum in the World in 2001-2016, kt

| Country | Reserves, kt | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| China | 4300 | 28.2 | | | | | | | | | | | | | | | |
| Chile | 2300 | 33.5 | | | | | | | | | | | | | | | |
| USA | 2700 | 37.6 | | | | | | | | | | | | | | | |
| Peru | 450 | 8.35 | | | | | | | | | | | | | | | |
| Mexico | 130 | 5.52 | | | | | | | | | | | | | | | |
| Canada | 220 | 8.56 | | | | | | | | | | | | | | | |
| Armenia | 150 | 3.4 | | | | | | | | | | | | | | | |
| Iran | 50 | 2.6 | | | | | | | | | | | | | | | |
| Russia | 250 | 3.93 | | | | | | | | | | | | | | | |
| Mongolia | 160 | 1.42 | | | | | | | | | | | | | | | |
| Uzbekistan | 60 | 0.58 | | | | | | | | | | | | | | | |
| Kazakhstan | 130 | 0.09 | | | | | | | | | | | | | | | |
| Kyrgyzstan | 100 | 0.25 | | | | | | | | | | | | | | | |
| Turkey | - | - | | | | | | | | | | | | | | | |
| Other | 55 | - | | | | | | | | | | | | | | | |
| **Total** | **11,050** | **134** | | | | | | | | | | | | | | | |

*The data are given in molybdenum equivalent*
*Source: INFOMINE based on USGS data*

The world's largest company-producers of molybdenum are Jinduicheng Molybdenum Group (China), Freeport-McMoran Copper&Gold (USA), Codelco (Chile), China Molybdenum Co (China), Zhongxi Mining (China), Rio Tinto (Great Britain), Antofagasta plc (Great Britain).

By the end of the 1990s, at the world market, the supply exceeded demand, that resulted in falling prices for molybdenum products. The market oversupply and low prices forced the main producers to reduce production volumes. As a result, in early 2000s, the demand exceeded supply, that, in turn, resulted in increase of the prices in the end of 2002 and their further growth later.

The steady rise in the prices for molybdenum products in 2002-2007, when they increased by about 11 times compared to 2001, caused expansion of exploration, creation of new mining and processing facilities, modernization of operating enterprises and restoration of previously abandoned production facilities.

In the first half of 2008, the producers of molybdenum products strove for making profit of rapidly developing market of molybdenum: many large producers announced expansion plans and presented new projects. However, since October 2008, against a backdrop of the global financial and economic crisis, world demand for finished molybdenum-containing products, such as automotive steel, LCD panels for displays and tools from superhard alloys, has begun to decline. As a result, in 2008-2009, the demand for molybdenum also fell. Molybdenum producers quickly reacted to the recession in the world economy, bringing the volumes of supplies in line with the level of demand for the metal. A number of projects to expand existing and build new facilities were postponed. With such sudden changes on the market, molybdenum prices quickly fell below the production costs of many producers.

Producers of molybdenum as the basic product were the first to respond to demand recovery in 2010, but in 2011 the growth in production of molybdenum as by-product of copper production outstripped the production growth at the exclusively molybdenum-producing facilities. Producers of by-product molybdenum reported the increase of almost 13%. The reason for this growth was high prices for copper. In the meantime, the volume of molybdenum produced by the exclusively molybdenum producers has increased by more than 2%.

World demand for molybdenum in 2012 grew by almost 5%. The change in demand for molybdenum was different in different regions of the world. After positive trend in the first 2 months of the year and a short period of replenishment of stocks by producers in April, sentiment at the Chinese market was pessimistic.

In the US, the demand for molybdenum in 2012 remained high. The increase in steel production has positively affected the demand for molybdenum, since more than 70% of the metal consumption belong to steelmaking sector.

In 2013, the slowdown in economic growth in China led to slowdown in the growth of molybdenum demand. Overall, the molybdenum consumption remained at the level of the previous year.

At the same time, the growth in demand for steel (the main molybdenum end-use) in China and Japan was offset by weak demand in the US and Europe. Due to