2016

# China Mineral Resources

Ministry of Land and Resources
People's Republic of China

GEOLOGICAL PUBLISHING HOUSE
BEIJING

# Editorial Committee

# Foreword

During the 12th Five-Year-Plan (FYP) period, the Chinese government has made great efforts in streamlining administration, delegating power to the lower levels proactively, promoting the reform with all its strength in the administrative approval system and the mineral resources taxation system. Great progress has also been achieved by intensifying supervision, improving service level constantly, and attaching equal importance to exploitation and protection, which gives full play to the decisive effect of the market in the allocation of resources. Administration complied with law and performed transparently has stimulated the vitality of the mining market, guided and regulated the business behavior in mining market, and made the management of mineral resources more regulated and orderly.

The Chinese government pays high attention to *National Exploration and Development Planning* which started in 2011.With positive responses, geological exploration agencies, mining industries and scientific research institutes had successfully completed the targets of the first 2 phases—making major progress in 3 years and significant prospecting breakthrough in 5 years. Shale gas exploration made historic breakthrough, natural gas hydrates (NGHs) survey witnessed major progresses, and a bunch of resources bases had been formed in terms of natural gas, copper, lead, zinc, tungsten, molybdenum and gold. All these had set strong basis for the rebuilding of further mineral exploration and development in the 3rd phase (2016~2020).

The Ministry of Land and Resources (MLR) has formulated *China Mineral Resources (CMR)* since 2011, in order to make the public better understand the situation of exploration and exploitation of mineral resources and the policies regarding the management of mineral resources, enhance the capacity of public services and impel the disclosure of administrative information. *CMR 2016* focuses on introducing major progresses during the 12th FYP period, including the exploration, exploitation and utilization of mineral resources, the protection of the geological environment of mines and the geological and mineral survey and assessment. This

report also elaborates the dynamics of mineral resource management from the perspectives of mineral resource planning, prospecting, development and monitoring, expounds on the progress of reform and policy highlights from the perspectives of the construction of laws and regulations for mineral resources and related taxation system. It demonstrates the latest achievements in scientific and technological innovations of geological theory and technology for exploration, exploitation and utilization of mineral resources. Finally, it summarizes the situation of international cooperation in the mineral resources sector.

We hope that this report would be helpful for the readers who are interested in the general situation of China's mineral resources.

The statistical data of this report are mainly from the Ministry of Land and Resources, the National Bureau of Statistics, and the General Administration of Customs of the People's Republic of China. The data of Hong Kong Special Administrative Region, Macau Special Administrative Region and Taiwan Province of the People's Republic of China are not included in this report.

# Contents

# Abstract

Faced with the complicated and changing situation of mineral resources at home and abroad during the 12th FYP period, the Chinese government stuck to focusing on internal conditions, carried forward *National Exploration and Development Planning* in an all-round way, strengthened the conservation and comprehensive utilization of mineral resources, enhanced the guarantee capacity of mineral resources, promoted vigorously the streamlining of administration and the delegation of power to the lower levels and improved constantly the service capacity of geological work for the economy and society.

**Mineral resource conditions were further ascertained.** During the 12th FYP period, China spent RMB 568.18 billion on geological exploration, with significant progress achieved. The newly-discovered reserves of oil amounted to 6.13 billion tons and natural gas 3.92 trillion cubic meters; shale gas was approved as a new kind of mineral resources, whose discovered reserves totaled 544.1 billion cubic meters. At the end of the 12th FYP period, the remaining technically recoverable reserves of oil were 3.5 billion tons, up by 10.4% over the end of the 11th FYP period; and natural gas 5.2 trillion cubic meters, up by 37.4%; newly discovered reserves of coal amounted to 1.57 trillion tons, up by 16.8%; iron ores 85.08 billion tons, up by 17.0%; copper 99.10 million tons, up by 23.3%; tungsten 9.588 million tons, up by 62.2%; gold 11,600 tons, up by 68.4%; and potash 1.08 billion tons, up by 16.1%.

**Mineral resources supply capacity was further improved.** During the 12th FYP period, the output of primary energies totaled 17.72 billion tons of standard coal equivalent, up by 28.0% over the 11th FYP period; their consumption amounted to 20.62 billion tons of standard coal equivalent, up by 27.7%. Raw coal output was 19.2 billion tons, up by 30.2%; crude oil 1.05 billion tons, up by 9.7%; and natural gas 594.1 billion cubic meters, up by 52.7%. The output of iron ores was 6.80 billion tons, up by 67.0%; crude steel 3.85 billion tons, up by 46.8%; ten kinds of nonferrous metals 210 million tons, up by 69.5%; gold 2,100 tons, up by 45.1%;

cement 11.57 billion tons, up by 53.3%. Total volume of mineral products trade was USD 4.99 trillion, with an increase of 81.4%. 1.33 billion tons of coal was imported, up by 195.7%; oil 1.63 billion tons, up by 46.3%; iron ores 4.14 billion tons, up by 71.2%.

**Conservation and comprehensive utilization of resources were further strengthened.** During the 12$^{th}$ FYP period, we formulated and released evaluation indexes for the comprehensive utilization of mineral resources, presented index requirements for the mining recovery rate, dressing recovery rate and comprehensive utilization rate of 27 minerals, with the evaluation index system for the conservation and comprehensive utilization of major mineral resources taking initial shape, popularized 210 selected advanced and applicable technologies, and promoted the construction of demonstration bases for the comprehensive utilization of mineral resources.

**Geological environment of mines was further improved.** During the 12$^{th}$ FYP period, the central finance spent RMB 18.07 billion on the improvement of the geological environment of mines, up by 39.9% over the 11$^{th}$ FYP period. Since the implementation of Mine Recovery, local governments have spent RMB 14.6 billion completing the improvement of 3,310 mines, covering an area of 103,000 hectares. By the end of 2015, the geological environment of about 810,000 hectares of mines had been recovered, at a rate of 26.7%. Active efforts had been made to propel the development of green mining and the construction of green mines, and 661 mine enterprises had been selected as national pilot units for green mines, of which 191 pilot enterprises passed the evaluation.

**The reform in mineral resources management was further promoted.** The government canceled 25 examinations and approvals pertaining to geology and mineral resources, and amended 14 administrative laws and regulations and departmental rules regarding mineral resources. Following the principle of advalorem supplemented by quantity-based collection, resource tax's collection mode was up to provincial governments.

**Geological service level was further improved.** At the end of 2015, the area covered by regional geological survey for 1:50,000 had accounted for 37.0% of the land area of China. Hydrogeological survey for 1:250,000 reached 45,000 km$^2$ and that for 1:50,000 reached 370,000 km$^2$. The government released publicly the serial map data of hydrological-engineering-environmental geology surveys for 1:500,000, and important geological drilling data and geosciences literature service products of package exploration areas, published the data on 400,000 geological openings, 110,000 provincial-level geological data service catalogues for nationwide mineral resource potential assessment achievements, 93 latest

geological maps for marine geologic surveys and more than 1,000 regional geological maps with the scale of 1 : 50,000.

**Technological innovation and international cooperation were further improved.** The new-generation table of strata of China was issued formally, new progress was achieved in the research of deep geology and structure, and the carstification-based mineralization pattern was proposed. 13 national standards and 91 industrial standards for geology and minerals were released and implemented. Such international cooperation platforms as China Mining Congress & Expo were utilized thoroughly to strengthen China's cooperation with U.S., Russia, Mongolia, ASEAN, Africa and UNESCO in geology and minerals.

As geological prospecting and mineral resources management are confronted with new challenges and opportunities, efforts should be made to adapt actively to the new conditions, deepen constantly the reform in the mineral resources management system according to the requirements of ecological civilization construction, further energize the market, attach particular importance to scientific and technological support and accelerate the improvement of geological data services.

# Chapter I
# Situation of Mineral Resources

During the 12th FYP period, an evident growth was witnessed in the newly discovered reserves & resources of such important minerals as coal, natural gas, manganese, bauxite, nickel, tungsten, molybdenum, gold and phosphate rock, etc. The cumulative discovered geological reserves of shale gas had amounted to 544.1 billion cubic meters since it was approved by the State Council as a new kind of mineral resource in 2011. China has a great prospecting potential according to the potential assessment of 23 important kinds of mineral resources.

## I. Reserves & Resources

### 1. Changes in reserves & resources

During the 12th FYP period, among the major mineral resources, the reserves & resources of 41 minerals increased, and those of 5 decreased, while the discovered geological reserves of shale gas, a new kind of minerals approved, witnessed a rapid growth. Compared with the end of the 11th FYP period, the remaining technically recoverable reserves of oil increased by 10.4% at the end of the 12th FYP period, natural gas grew by 37.4% and coal-bed methane rose by 132.3%. The reserves & resources of coal increased by 16.8%, iron ore 17.0%, manganese ore 55.8%, copper 23.3%, bauxite 25.6%, tungsten 62.2%, molybdenum 108.1%, gold 68.4%, phosphate rock 24.0%, potash 16.1%, and crystalloid graphite 40.5% (Table 1-1).

### 2. Newly discovered reserves & resources

Remarkable achievements were made in mineral exploration during the 12th FYP period,

Table 1-1 Reserves & Resources of Major Minerals

| Mineral | Unit | 2010 | 2015 | Increase or Decrease / % |
|---|---|---|---|---|
| Coal | billion tons | 1340.83 | 1566.31 | 16.8 |
| Oil | billion tons | 3.17 | 3.50 | 10.4 |
| Natural gas | billion cubic meters | 3779.32 | 5193.95 | 37.4 |
| Coal-bed methane | billion cubic meters | 131.84 | 306.25 | 132.3 |
| Shale gas | billion cubic meters | * | 130.18 | * |
| Iron ore | billion tons of ores | 72.70 | 85.08 | 17.0 |
| Manganese ore | billion tons of ores | 0.886 | 1.38 | 55.8 |
| Chromite | thousand tons of ores | 14905 | 12458 | -16.4 |
| Vanadium | thousand tons of $V_2O_5$ | 43819 | 61257 | 39.8 |
| Titanium | billion tons of $TiO_2$ | 0.720 | 0.764 | 6.1 |
| Copper | thousand tons of metals | 80407 | 99102 | 23.3 |
| Lead | thousand tons of metals | 55091 | 77669 | 41.0 |
| Zinc | thousand tons of metals | 115962 | 149852 | 29.2 |
| Bauxite | billion tons of ores | 3.75 | 4.71 | 25.6 |
| Nickel | thousand tons of metals | 9380 | 11166 | 19.0 |
| Cobalt | thousand tons of metals | 682 | 680 | -0.3 |
| Tungsten | thousand tons of $WO_3$ | 5910 | 9588 | 62.2 |
| Tin | thousand tons of metals | 4319 | 4180 | -3.2 |
| Molybdenum | thousand tons of metals | 14018 | 29176 | 108.1 |
| Antimony | thousand tons of metals | 2550 | 2926 | 14.7 |
| Gold | tons of metals | 6864.8 | 11563.5 | 68.4 |
| Silver | thousand tons of metals | 172 | 254 | 47.7 |
| Platinum group metal | tons of metals | 334.6 | 369.2 | 10.3 |
| Strontium | thousand tons of celestite | 43754 | 55833 | 27.6 |
| Magnesite | billion tons of ores | 3.64 | 2.97 | -18.4 |

Continued

| Mineral | Unit | 2010 | 2015 | Increase or Decrease / % |
|---|---|---|---|---|
| Fluorite | billion tons of ores | 0.18 | 0.221 | 22.8 |
| Refractory clay | billion tons of ores | 2.46 | 2.56 | 4.1 |
| Pyrites | billion tons of ores | 5.69 | 5.88 | 3.3 |
| Phosphate rock | billion tons of ores | 18.63 | 23.11 | 24.0 |
| Potash | billion tons of KCl | 0.93 | 1.08 | 16.1 |
| Boron | thousand tons of $B_2O_3$ | 73092 | 75757 | 3.6 |
| Sodium salt | billion tons of NaCl | 1333.77 | 1368.00 | 2.6 |
| Mirabilite | billion tons of $Na_2SO_4$ | 93.42 | 117.07 | 25.3 |
| Barite | billion tons of ores | 0.29 | 0.33 | 13.8 |
| Cement-producing limestone | billion tons of ores | 102.10 | 128.23 | 25.6 |
| Glass-making siliceous-rock | billion tons of ores | 6.47 | 7.90 | 22.1 |
| Gypsum | billion tons of ores | 76.91 | 100.42 | 30.6 |
| Kaolin | billion tons of ores | 2.10 | 2.71 | 29.0 |
| Bentonite | billion tons of ores | 2.80 | 2.89 | 3.2 |
| Diatomite | billion tons of ores | 0.43 | 0.48 | 11.6 |
| Veneer granite | billion cubic meters | 2.32 | 3.43 | 47.8 |
| Veneer marble | billion cubic meters | 1.53 | 1.61 | 5.2 |
| Diamond | Mineral kg | 3702.1 | 3396.5 | -8.3 |
| Crystalloid graphite | billion tons of ores | 0.185 | 0.260 | 40.5 |
| Asbestos | thousand tons of ores | 89753 | 91574 | 2.0 |
| Talc | billion tons of ores | 0.267 | 0.275 | 3.0 |
| Wollastonite | billion tons of ores | 0.155 | 0.170 | 9.7 |

Note: Data of oil, natural gas, coal-bed methane and shale gas are remaining technologically recoverable reserves; * represents a new kind of minerals approved.

with the newly discovered reserves & resources of natural gas, coal-bed methane, shale gas, manganese ore, tungsten and molybdenum accounting for more than 30% of the cumulative discovered reserves & resources. Compared with the 11th FYP period, China achieved an apparent growth in the newly discovered reserves of major minerals during the 12th FYP period. The newly discovered geological reserves of oil increased by 6.6%, natural gas 25.6% and coal-bed methane 111.1%; the newly discovered reserves & resources of manganese grew by 256.5%, tungsten 598.9%, molybdenum 250.6%, and phosphate rock 171.5%. In 2015, newly increased geological reserves of oil amounted to 1.118 billion tons, natural gas 677.22 billion cubic meters and shale gas 437.379 billion cubic meters; newly discovered reserves & resources of coal were 39.03 billion tons, iron ore 1.20 billion tons, copper 3.922 million tons, bauxite 490.87 million tons, tungsten 2.484 million tons, gold 1720.4 tons and phosphate rock 1.74 billion tons (Table 1-2).

## II. Potential of Mineral Resources

### 1. Oil and gas

China's oil and gas resources are mainly distributed in large petroliferous basins, 84% of oil resources are distributed in such major basins as Songliao, Bohai Bay, Ordos, Tarim, Junggar, Pearl River Estuary, Qaidam and Beibu Gulf. The nationwide evaluation on oil and gas resources for 2015 indicates that by the end of 2015, the geological resources of oil were 125.7 billion tons, of which 30.1 billion tons were recoverable; natural gas 90 trillion cubic meters, with 50 trillion cubic meters recoverable; shale gas at a burial depth of 4,500 or fewer meters, 122 trillion cubic meters, with 22 trillion cubic meters recoverable; and coal-bed methane at a burial depth of 2,000 or fewer meters, 30 trillion cubic meters, with 12.5 trillion cubic meters recoverable.

### 2. Solid minerals

China boasts a huge prospecting potential, as indicated by the evaluation on the potential of 23 major minerals, including coal, iron ore, manganese, chromite, copper, lead, zinc, bauxite, tungsten, tin, molybdenum, antimony, nickel, gold, silver, lithium, pyrites, phosphate rock, potash, magnesite, fluorite, boron and barite (Table 1-3).

Table 1-2 Newly Discovered Reserves & Resources of Major Minerals

| Mineral | Unit | 2015 | 12th FYP period | Change over the 11th FYP period/% | Newly Increased Reserves during the 12th FYP period -to-Cumulative Discovered Reserves at the End of 2015/% |
|---|---|---|---|---|---|
| Coal | billion tons | 39.03 | 298.96 | -26.9 | 18.1 |
| Oil | billion tons | 1.118 | 6.130 | 6.6 | 16.5 |
| Natural gas | billion cubic meters | 677.22 | 3922.40 | 25.6 | 30.1 |
| Coal-bed methane | billion cubic meters | 2.634 | 350.490 | 111.1 | 55.7 |
| Shale gas | billion cubic meters | 437.379 | 544.130 | * | 100 |
| Iron ore | billion tons of ores | 1.20 | 13.27 | -19.1 | 13.5 |
| Manganese ore | thousand tons of ores | 113124 | 619067 | 256.5 | 34.7 |
| Copper | thousand tons of metals | 3922 | 23410 | 10.6 | 17.9 |
| Lead | thousand tons of metals | 4372 | 23302 | 21.4 | 21.6 |
| Zinc | thousand tons of metals | 5732 | 37832 | 21.3 | 17.7 |
| Bauxite | million tons of ores | 490.87 | 957.81 | 47.3 | 18.6 |
| Nickel | thousand tons of metals | 1129 | 2792 | 56.2 | 19.9 |
| Tungsten | thousand tons of $WO_3$ | 2484 | 4599 | 598.9 | 37.8 |
| Tin | thousand tons of metals | 44 | 787 | 16.2 | 9.5 |
| Molybdenum | thousand tons of metals | 1023 | 15595 | 250.6 | 50.6 |
| Antimony | thousand tons of metals | 147 | 962 | 45.5 | 15.1 |
| Gold | tons of metals | 1720.4 | 4949.4 | 66.3 | 27.9 |
| Silver | tons of metals | 18050 | 81852 | 64 | 19.7 |
| Pyrite | million tons of ores | 114.481 | 481.621 | -0.5 | 7.4 |
| Phosphate rock | billion tons of ores | 1.74 | 5.81 | 171.5 | 23.3 |
| Potash | million tons of KCl | -0.367 | 92.37 | -30.1 | 7.1 |

Note: Data of oil, natural gas, coal-bed methane and shale gas are discovered geological reserves; * represents a new kind of minerals approved.

Table 1-3 Potential of Major Mineral Resources in China

| Mineral | Unit | Predicted Resources | Discovery Rate[1]/% |
|---|---|---|---|
| Coal | billion tons | 3879.6 | 30.0 |
| Iron ore | billion tons of ores | 196.02 | 33.5 |
| Manganese | billion tons of ores | 3.52 | 34.6 |
| Chromite | million tons | 55.56 | 24.8 |
| Copper | million tons | 304.45 | 30.4 |
| Lead | million tons | 235.03 | 31.9 |
| Zink | million tons | 511.25 | 29.8 |
| Bauxite | billion tons of ores | 12.97 | 29.3 |
| Nickel | million tons | 24.514 | 37.5 |
| Tungsten | million tons of $WO_3$ | 29.731 | 30.8 |
| Tin | million tons | 18.612 | 30.9 |
| Molybdenum | million tons | 89.603 | 25.8 |
| Antimony | million tons | 15.181 | 29.8 |
| Gold | tons | 32668 | 36.8 |
| Silver | thousand tons | 726 | 36.5 |
| Lithium | million tons of spodumene | 5.937 | 37.7 |
| | million tons of LiCl | 92.481 | 19.0 |
| Pyrites | billion tons of ores | 18.4 | 26.1 |
| Natural sulfur | billion tons | 0.23 | 61.0 |
| Phosphate rock | billion tons of ores | 56 | 31.4 |
| Potash | billion tons of KCl | 2 | 39.1 |
| Barite | billion tons of ores | 1.44 | 26.9 |
| Boron | million tons of $B_2O_3$ | 188.591 | 33.5 |
| Magnesite | billion tons of ores | 13.14 | 19.5 |
| Fluorite | million tons | 952.76 | 26.9 |

[1] Data by the end of 2015.

## III. Registration of Exploration and Mining Rights

### 1. Energy minerals

By the end of 2015, there had been 1,000 oil and gas exploration rights involving a registered area of 3.7066 million $km^2$, down by 4.3% and 12.3% respectively compared to the end of the 11th FYP period; and 720 exploitation rights involving a registered area of 148,600 $km^2$, up by 9.6% and 29.0% respectively compared to the end of the 11th FYP period.

During the 12th FYP period, there were another 116 oil and gas exploration rights approved, involving a newly registered area of 274,800 $km^2$; and 75 exploitation rights, involving a newly registered area of 24,200 $km^2$. Among them, 12 oil and gas exploration rights involving a registered area of 9,000 $km^2$ and 16 exploitation rights involving a registered area of 1,900 $km^2$ were approved in 2015 (Table 1-4).

By the end of 2015, there had been 1,770 coal exploration rights in China, involving a registered area of 97,600 $km^2$; and 9,480 coal exploitation rights involving a registered area of 58,100 $km^2$. During the 12th FYP period, 199 coal exploration rights and 283 coal exploitation rights were approved, involving a registered area of 27,300 $km^2$ and 6,600 $km^2$ respectively (Table 1-5).

### 2. Metallic and non-metallic minerals

By the end of 2015, there had been 26.6 thousand exploration rights for metallic and non-metallic minerals in China, involving a registered area of 451.9 thousand $km^2$, down by 16.1% and 22.63% respectively compared to the end of the 11th FYP period; and 64.5 thousand exploitation rights, involving a registered area of 46 thousand $km^2$ and a designed production scale of 10.582 billion tons/year, down by 29.4% and up by 4.8% and 8.1% respectively.

During the 12th FYP period, another 6,203 exploration rights for metallic and non-metallic minerals were approved, involving a newly registered area of 156.5 thousand $km^2$; 15,070 exploitation rights were approved, involving a newly registered area of 8,500 $km^2$ and a newly designed production scale of 2.715 billion tons/year. In 2015, 924 exploration rights for metallic and non-metallic minerals were approved, involving a newly registered area of 23.4 thousand $km^2$; 2,487 exploitation rights were approved, involving a newly registered area of 1,500 $km^2$ and a newly designed production scale of 285 million tons/year(Table 1-6).

Table 1-4 Oil & Gas Exploration and Exploitation Rights Newly Approved in China

| Year | Exploration Rights | | Exploitation Rights | |
|---|---|---|---|---|
| | Number | Area / thousand km$^2$ | Number | Area / thousand km$^2$ |
| 2011 | 22 | 31.9 | 4 | 1.0 |
| 2012 | 25 | 69.7 | 14 | 1.9 |
| 2013 | 55 | 163.4 | 11 | 12.8 |
| 2014 | 2 | 0.7 | 30 | 6.5 |
| 2015 | 12 | 9.0 | 16 | 1.9 |
| Total | 116 | 274.8 | 75 | 24.2 |

Table 1-5 Coal Exploration and Exploitation Rights Newly Approved in China

| Year | Exploration Rights | | Exploitation Rights | |
|---|---|---|---|---|
| | Number | Area / thousand km$^2$ | Number | Area / thousand km$^2$ |
| 2011 | 54 | 6.9 | 125 | 1.8 |
| 2012 | 66 | 12.2 | 57 | 1.4 |
| 2013 | 30 | 3.1 | 40 | 0.9 |
| 2014 | 25 | 2.9 | 26 | 0.7 |
| 2015 | 24 | 2.2 | 35 | 1.6 |
| Total | 199 | 27.3 | 283 | 6.6 |

Table 1-6 Certificating of Exploration and Exploitation Rights for Metallic & Non-metallic Minerals in China

| Year | Exploration Rights | | Exploitation Rights | |
|---|---|---|---|---|
| | Number | Area / thousand km$^2$ | Number | Area / thousand km$^2$ |
| 2011 | 1284 | 29.3 | 5826 | 2.9 |
| 2012 | 967 | 23.2 | 1788 | 1.2 |
| 2013 | 1543 | 42.9 | 2350 | 1.7 |
| 2014 | 1485 | 37.7 | 2619 | 1.2 |
| 2015 | 924 | 23.4 | 2487 | 1.5 |
| Total | 6203 | 156.5 | 15070 | 8.5 |

# Chapter II Exploration

During the 12th FYP period, China comprehensively carried forward *National Exploration and Development Planning* by implementing the central government's major decisions and arrangements thoroughly for ecological civilization construction and insisting on source protection and green exploration in order to promote coordinative development between geological exploration and eco-environmental protection. With more than RMB 560 billion investment, China had discovered a batch of world-class deposits, including copper, tungsten and molybdenum.

## I. Exploration Investment

During the 12th FYP period, national exploration investment amounted to RMB 568.18 billion, with an increase of 53.2% over the 11th FYP period (Figure 2-1), among which RMB 100.53 billion was from governmental investment, accounting for 17.7% of the national exploration investment, up by 108.4%; and RMB 467.65 billion was from social investment, accounting for 82.3%, and up by 44.9%. The exploration investment on oil & gas was RMB 352.34 billion (Figure 2-2), up by 39.0%, accounting for 62.0%.

During the 12th FYP period, 18.6 thousand wells were drilled for oil & gas, with 441 thousand kilometers for two-dimensional seismic exploration and 226.3 thousand $km^2$ for three-dimensional seismic exploration, up by 16.1%, 5.7% and 40.4% respectively over the 11th FYP period. Total drillings for coal, metallic and non-metallic minerals were 105.35 million meters, with an increase of 42.6%.

1,235 ore fields were newly discovered during the 12th FYP period.

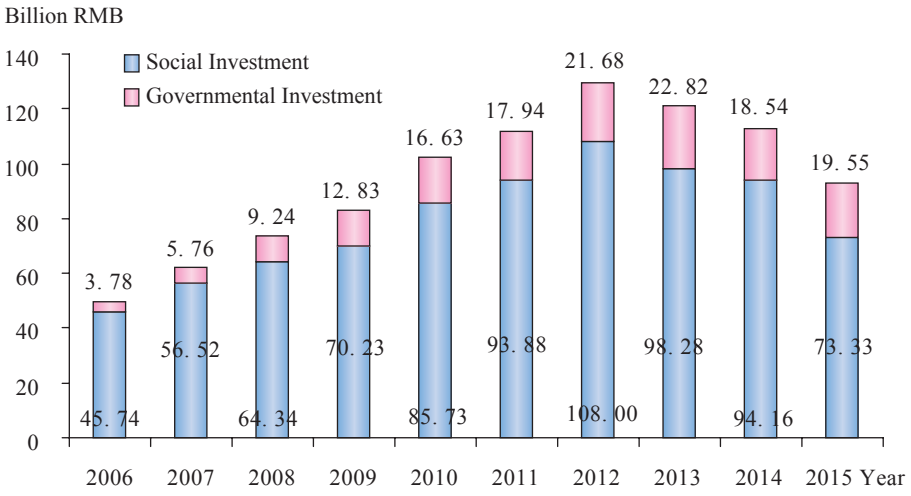


Figure 2-1 Exploration Investment

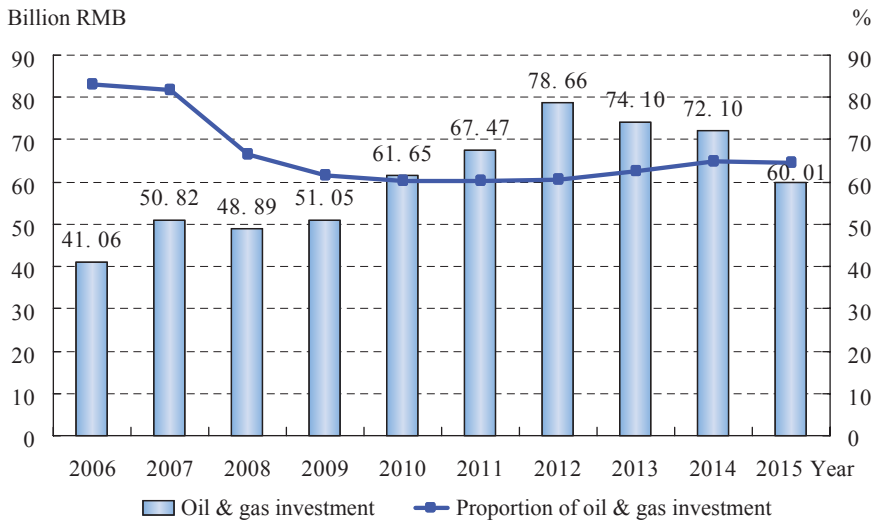


Figure 2-2 Oil & Gas Exploration Investment

## II. Energy Mineral Exploration

Significant progress was achieved in the exploration of energy minerals during the 12th FYP period. 218 coal fields, of which 169 were large & medium-sized, were newly discovered, for which newly discovered reserves & resources amounted to 298.96 billion tons, mainly concentrated in Inner Mongolia, Shanxi, Gansu, Sichuan, Heilongjiang and Xinjiang. Newly proven geological reserves of oil were 6.13 billion tons and natural gas 3.92 trillion cubic meters, mainly concentrated in such basins as Ordos, Tarim, Sichuan, Qiongdongnan and East China Sea.

During the 12th FYP period, the geological reserves of shale gas were proved for the first time, which were mainly from Fuling and Changning—Weiyuan fields in Sichuan Basin. Besides, major progress was also achieved in the exploration of shale gas of Meso-Cenozoic Erathem continental facies and Upper Paleozoic Erathem transitional facies. Newly proven geological reserves of coal-bed methane amounted to 350.49 billion cubic meters, mainly derived from Qinshui Basin and Ordos Basin. High-purity natural gas hydrates were discovered for the first time at the Pearl River Mouth Basin.

Great discoveries were obtained in the geological survey of marine oil and gas. Oil flows were obtained for the first time at the tight oil and gas reservoirs, ushering in a new frontier for oil and gas exploration. The scientific drilling wells were deployed on the upheaval of the central part of South Yellow Sea, which got the shows of oil and gas at marine facies Mesozoic-Paleozoic strata for the first time.

## III. Metallic and Non-metallic Minerals Exploration

Major progress was achieved in the exploration of metallic and non-metallic minerals during the 12th FYP period (Table 2-1), with a batch of large and super large mineral deposits discovered. 113 iron ore deposits were newly discovered, including 69 large & medium-sized ones, for which the newly discovered reserves & resources amounted to 13.27 billion tons, located mainly in Gulin-Lanling Mine Area, Cangshan County, Shandong province; Taihe V-Ti Magnetite Mine Area, Xichang City, Sichuan province; Pangang Lanjian-Zhujiabaobao

V-Ti Magnetite Mine Area, Panxi Region, Sichuan province; Baima V-Ti Magnetite Mine Area, Miyi County, Sichuan province; the periphery of Dataigou Mine area, Benxi City, Liaoning province. 18 manganese deposits were discovered, including 16 large & medium-sized ones, for which the newly discovered reserves & resources were 619 million tons, mainly concentrated in Tongren-Songtao Package Exploration Area, Guizhou province; the periphery of Fuwan Mine Area, Debao County and Dongping Mine area, Tiandeng County, Guangxi Autonomous Region.

52 copper deposits were discovered, including 11 large & medium-sized ones, for which the newly discovered reserves & resources were 23.41 million tons, with a batch of world-class copper ore areas discovered in Tibet, Jiangxi and Yunnan. 81 lead and zinc deposits were discovered, including 41 large & medium-sized ones, for which the newly discovered reserves & resources were 23.302 million tons and 37.832 million tons respectively, mainly distributed in Xinjiang, Hunan and Fujian. 6 nickel deposits were discovered, for which the newly discovered reserves & resources were 2.792 million tons, located mainly in Xinjiang, Inner Mongolia and Qinghai, with super large nickel deposits discovered in the North of Lop Nor, Ruoqiang County, Xinjiang Autonomous Region and Xiarihamu, Qinghai province. 25 tungsten deposits were discovered, including 23 large & medium-sized ones, for which the newly discovered reserves & resources were 4.599 million tons, mainly distributed in Jiangxi, Hunan, Gansu, Henan and Xinjiang, with exceeding 2 million tons world-class deposits discovered in the south of Jiangxi. 29 molybdenum deposits were discovered, for which the newly discovered reserves & resources were 15.595 million tons, mainly distributed in Anhui, Xinjiang, Inner Mongolia and Henan, with 3 deposits, each exceeding 1 million tons, including Shapinggou world-class molybdenum deposit, Jinzhai County, Anhui province.

131 gold deposits were discovered, including 51 large & medium-sized ones, for which the newly discovered reserves & resources were 4,949.4 tons, mainly located in Shandong and Inner Mongolia.

18 phosphate rock deposits were discovered, for which the newly discovered reserves & resources were 5.81 billion tons. 17 graphite deposits were discovered, including 12 large & medium-sized, in which one deposit's resources exceeds 10 million tons.

Table 2-1 Numbers of Newly Discovered Major Deposits during the 12th FYP Period

| Mineral | Newly Discovered Deposits | Large & Medium-Sized Deposits |
|---|---|---|
| Coal | 218 | 169 |
| Iron ore | 113 | 69 |
| Manganese | 18 | 16 |
| Copper | 52 | 11 |
| Lead-Zinc | 81 | 41 |
| Nickel | 6 | 4 |
| Tungsten | 25 | 23 |
| Molybdenum | 29 | 20 |
| Gold | 131 | 51 |
| Graphite | 17 | 12 |
| Phosphate | 18 | 10 |

## Column 2-1 Progress on Special Funds of Central Geological Exploration

From 2006 to 2015, the Central Geological Exploration Fund carried out 382 mineral exploration projects, with the investment of RMB 4.766 billion, completed the drilling of 2.25 million meters, discovered more than 100 large & medium-sized deposits, increased the reserves & resources for 23 minerals, such as coal, iron, manganese, copper, bauxite, nickel, gold and tungsten, and made achievements in the exploration of a batch of deposits, including Dongsheng and Jungar Coal fields, Inner Mongolia Autonomous Region; Panzhihua V-Ti magnetite deposit, Sichuan province; Wuzhengdao Bauxite field, Guizhou province; Zhuxi Mine Area Peripheral Tungsten-Copper deposit, Jiangxi province; Pobei nickel deposit, Xinjiang Autonomous Region; Qinghai Duocai Copper deposit and Qaidam Basin deepwater brine potash deposit.

# Chapter III
# Development and Utilization of Mineral Resources

During the 12th FYP period, the mining fixed assets investment increased by 70% compared to the 11th FYP period. The production of primary energy, crude steel, ten kinds of nonferrous metals and cement ranked first in the world. MLR published index requirements for the mining recovery rate, dressing recovery rate and comprehensive utilization rate of 27 minerals and popularized 210 recommended technologies.

## I. Mining Fixed Assets Investment

During the 12th FYP period, China's mining fixed assets investment totaled RMB 6.72 trillion, with an increase of 74.7% over the 11th FYP period. In 2015, mining fixed assets investment reached RMB 1.3 trillion, down by 8.8%. Among the mining fixed assets investment, that of coal mining and washing was RMB 400.8 billion, down by 14.4%; that of oil and natural gas extraction was RMB 342.5 billion, down by 5.7%; that of ferrous metals mining and processing was RMB 136.6 billion, down by 17.8%; that of nonferrous metals mining and processing was RMB 158.8 billion, down by 2.3%; and that of non-metallic minerals mining and processing was RMB 209.2 billion, up by 2.1% (Figure 3-1).

## II. Production and Consumption

### 1. Energy production and consumption

China is the largest producer and consumer of energy in the world. During the 12th FYP period,

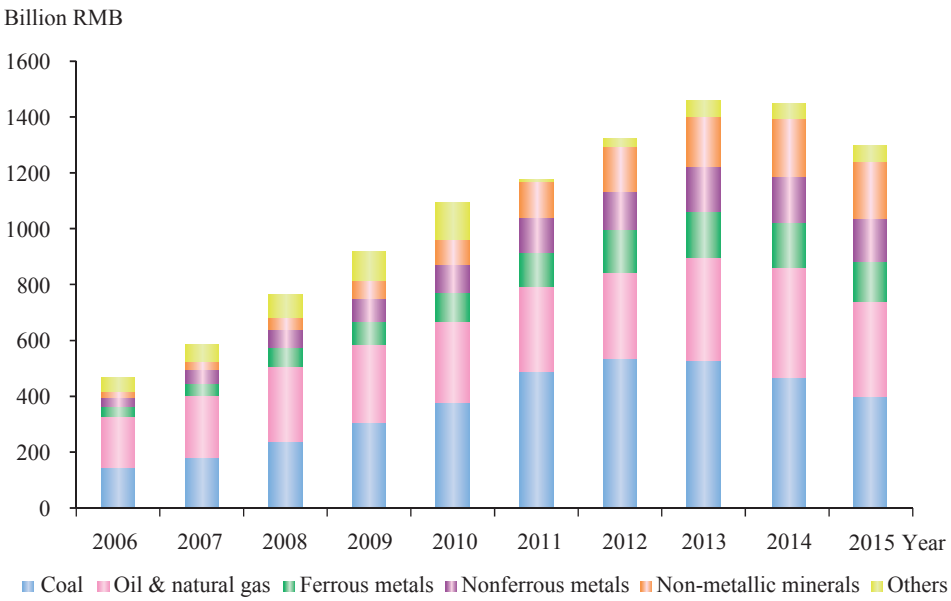


Figure 3-1 Mining Fixed Assets Investment

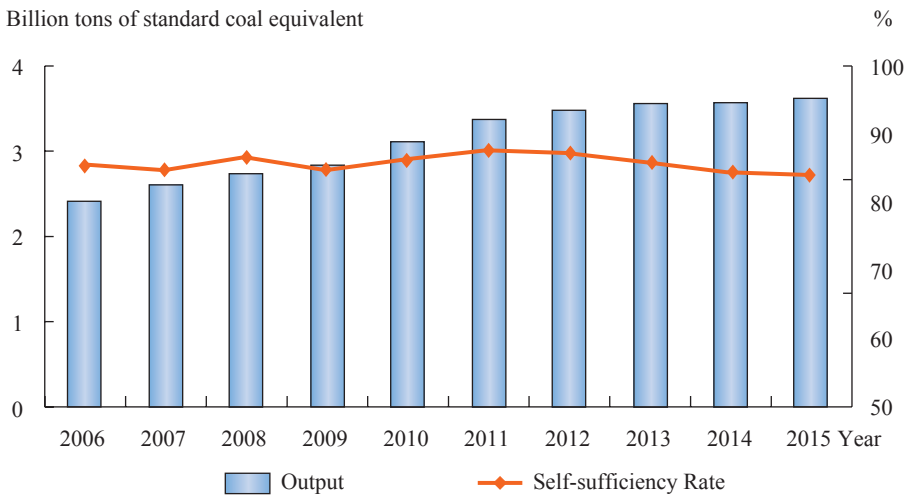


Figure 3-2 Primary Energy Production

primary energy output totaled 17.72 billion tons of standard coal equivalent, up by 28.0% over the 11th FYP period; its consumption amounted to 20.62 billion tons of standard coal equivalents, up by 27.7%. In 2015, primary energy output totaled 3.62 billion tons of standard coal equivalents (Figure 3-2) and its consumption amounted to 4.30 billion tons of standard coal equivalents, with an energy self-sufficiency rate of 84.2%.

During the 12th FYP period, the proportion of coal in energy consumption continued to decline, while that for natural gas and other clean energy resources witnessed an increase. Coal-to-energy consumption proportion decreased by 6.2 percentage points, while that of hydropower, wind power, nuclear power and natural gas rose by 4.9 percentage points. In 2015, coal accounted for 64.0% of the energy consumption matrix, oil 18.1%, natural gas 5.9%, and hydropower, wind power and nuclear power 12.0% (Figure 3-3).

During the 12th FYP period, raw coal output was 19.2 billion tons, up by 30.2% over the 11th FYP period; crude oil 1.05 billion tons, up by 9.7%; natural gas 594.1 billion cubic meters, up by 52.7%. In 2015, raw coal output was 3.68 billion tons, ranking top in the world; crude oil 215 million tons, ranking fifth (Figure 3-4); and natural gas 127.14 billion cubic meters, ranking sixth.

## 2. Metal minerals production and consumption

During the 12th FYP period, iron ore output was 6.80 billion tons, up by 67.0% over the 11th FYP period; crude steel 3.85 billion tons, up by 46.8%; ten kinds of nonferrous metals 210 million tons, up by 69.5%; and gold 2,100 tons, up by 45.1%. In 2015, the output of iron ore, crude steel, ten kinds of nonferrous metals and gold ranked first in the world. Iron ore output was 1.38 billion tons and crude steel 800 million tons (Figure 3-5). The output of ten kinds of nonferrous metals amounted to 50.90 million tons, including 7.964 million tons of refined copper and 31.413 million tons of electrolytic aluminum. In the year, the gold output was 450.1 tons and consumption 985.9 tons.

## 3. Non-metallic minerals production

During the 12th FYP period, the output of cement was 11.57 billion tons, up by 53.3% over the 11th FYP period; and plate glass 3.90 billion weight cases, up by 36.9%. In 2015, cement output was 2.35 billion tons (Figure 3-6), plate glass 740 million weight cases, and phosphate rock 140 million tons ($P_2O_5$ 30%).

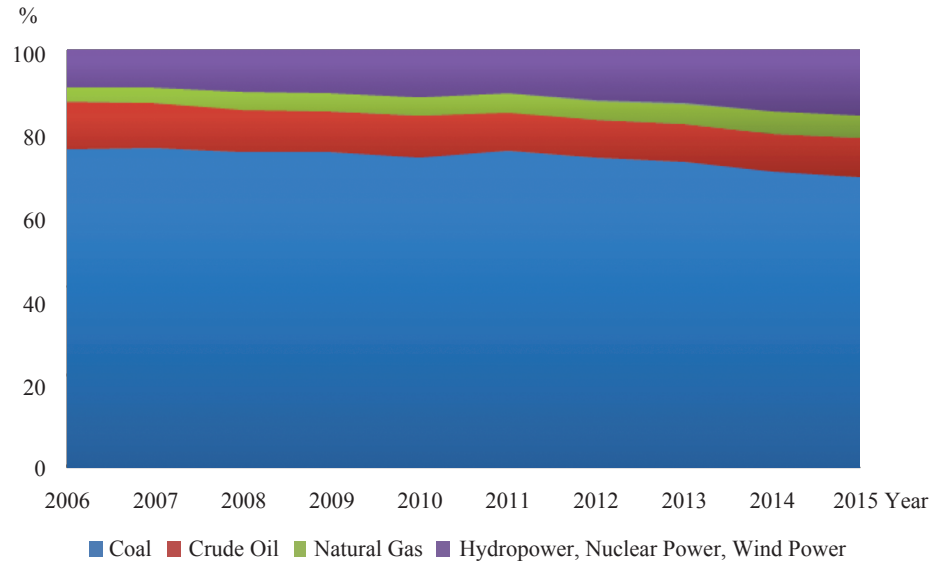


Figure 3-3 Primary Energy Consumption Structure

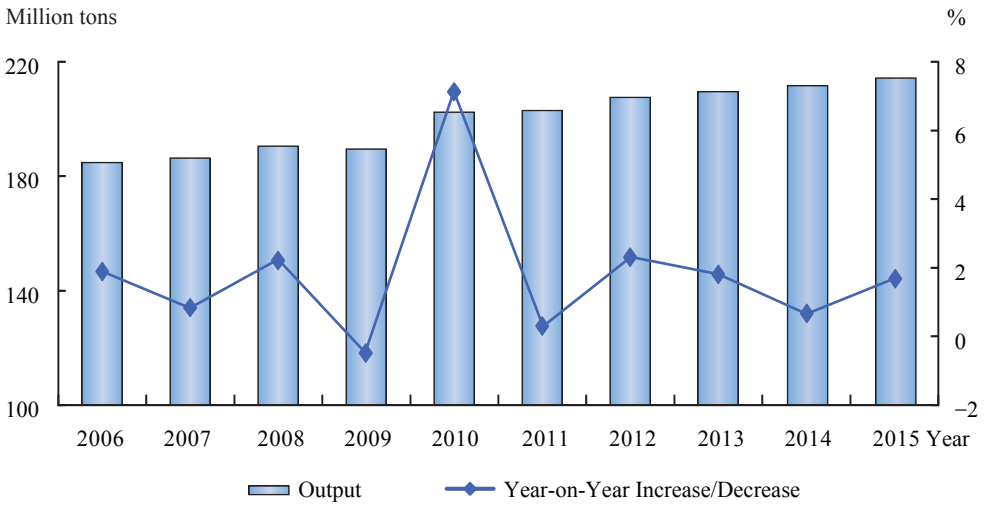


Figure 3-4 Crude Oil Production

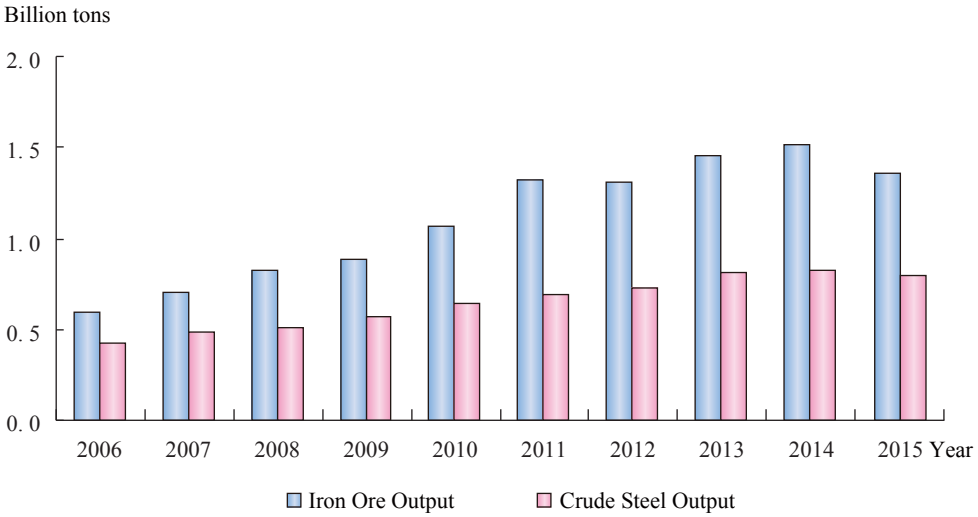


Figure 3-5 Iron Ore and Crude Steel Production

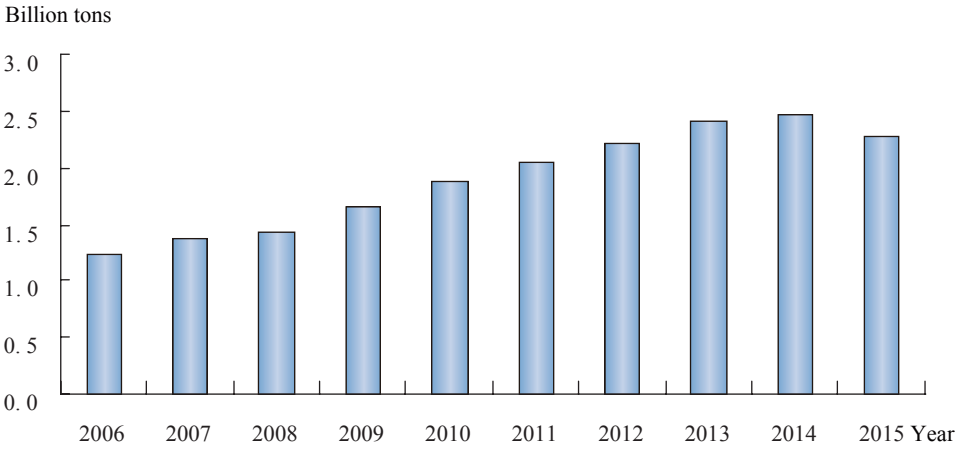


Figure 3-6 Cement Production

## III. Conservation and Comprehensive Utilization

### 1. Mining recovery rate, dressing recovery rate and comprehensive utilization rate of mineral resources were ascertained basically.

During the 12th FYP period, mining recovery rate, dressing recovery rate and comprehensive utilization rate of mineral resources were ascertained basically through the survey on 22 important minerals such as coal, oil and iron ore. Compared with the results of the sampling survey conducted in 1999, working section recovery and selected rate of coal increased by more than 15 percentage points; mining recovery rate of ferrous metals rose by more than 5 percentage points; and mining recovery rate of nonferrous metals witnessed a general growth.

### 2. Indexes evaluation system for the mining recovery rate, dressing recovery rate and comprehensive utilization rate of major minerals was established preliminarily.

MLR formulated the *Technical Indexes for the Comprehensive Utilization of Mineral Resources and Their Computing Methods*, standardizing and unifying that the mining recovery rate, dressing recovery rate and comprehensive utilization rate should be the mining evaluation indexes. It also released the indexes requirements for the mining recovery rate, dressing recovery rate and comprehensive utilization rate of 27 kinds/categories of minerals, covering energy such as coal, oil and natural gas, ferrous metals such as V-Ti magnetite, iron ore, manganese ore and chromite, nonferrous and precious metals such as copper, lead, zinc, bauxite, tungsten, molybdenum, nickel, tin, antimony and gold, as well as rare earth and nonmetallic minerals such as phosphate rock, potash, pyrite, kaolin, fluorite, graphite, asbestos, gypsum and talc. A conservation and comprehensive utilization evaluation indexes system for major minerals was formed initially and the conservation and comprehensive utilization of mineral resources was assessed objectively and managed regularly.

### 3. Recommended technologies of conservation and comprehensive utilization were selected and popularized.

Since 2012, MLR selected and then popularized 210 recommended technologies, including 30 for oil and gas, 45 for coal, 94 for metallic minerals and 41 for non-metallic minerals. In 2015, MLR published 51 recommended technologies, including 8 for oil and gas, 11 for coal, 24 for metallic minerals and 8 for non-metallic minerals (Table 3-1).

Table 3-1 Recommended Technologies for the Comprehensive Utilization of Mineral Resources Generalized in 2015

| Minerals | SN | Efficient Mining and Dressing & Comprehensive Utilization Technologies |
|---|---|---|
| Coal (11) | 1 | Technique for electricity generation by ventilation methane of coal mines |
| | 2 | Technique for collection of coal-bed methane from "low-abundance, low-permeability and low-output" fields and its application |
| | 3 | Research on the technique for long-wall fully mechanized top coal caving along heavy-pitch high-gas super-high seam strike |
| | 4 | Technique for underground filling of super-high water materials for mining |
| | 5 | Research on the technique for the comprehensive treatment of high-pressure water at deep areas of mines |
| | 6 | Research on the technique for the long-wall slant comprehensive mining at heavy-pitch extremely-thick inflammable seams |
| | 7 | Research on the key technique for the information construction of outburst mines and process demonstration |
| | 8 | Technique for safe mining under the "dormant window" at extremely-thick water-rich sand seams of Dongrong No. 1 Mine |
| | 9 | Technique for hydro-fracturing weakening of full-mechanized top coal caving at thick seams |
| | 10 | Intelligent unmanned mining technique |
| | 11 | Configuration for the drainage and comprehensive utilization of deep karst geothermal water based on multiple information searching |
| Oil & Gas (8) | 12 | Technique for the carving, exploration and development of complicated carbonate crannies and caves |
| | 13 | Technique for the development of "well factory" of Fuling Shale Gas Field |
| | 14 | Technique for well-simulating water-flooding development of low-permeability oil reservoirs |
| | 15 | Technique for the comprehensive utilization of wastes of gas fields |
| | 16 | Technique for the anti-sand development of loose sandstone gas reservoirs |
| | 17 | Research and application of automatics at coal-bed methane fields in mountainous areas |

Continued

| Minerals | SN | Efficient Mining and Dressing & Comprehensive Utilization Technologies |
|---|---|---|
| Oil & Gas (8) | 18 | Technique for natural gas-driven enhanced oil recovery rate of abnormal-high-pressure ultra-low-permeability oil reservoirs |
| | 19 | Technique for the development and industrial application of sludge-filling gel pellets |
| Metallic Minerals (24) | 20 | Key technique for energy conservation and emission reduction of electrolytic manganese metal production |
| | 21 | New technique for the efficient forward selection of ferrous metal ores |
| | 22 | Technique for the recycling of cemented full-tailing backfilling of metal mines |
| | 23 | Mineral separation process of lean magnetite ores and new-type dry magnetic separator |
| | 24 | Ground remote-control underground trolley haulage transportation system |
| | 25 | New process for comprehensive recovery and separation of iron, rare earth, niobium and fluorite in Bayan Obo |
| | 26 | Key technique for open underground coordinated exploitation and risk control of large iron mines and its application |
| | 27 | Technique for recovery and utilization regarding hematite-floatation-tailing |
| | 28 | Technique for the comprehensive utilization of phosphorous in low-grade phosphorus-containing iron ores |
| | 29 | Application of floated dry magnetic separators to the separation of ultra lean magnetite |
| | 30 | Key technique of activate micro powder for high-temperature controllable desulfurizing production of electrolytic manganese residue |
| | 31 | Technique for the dry separation of manganese carbonate and its industrial demonstrative application |
| | 32 | Underground LED energy-efficient lighting equipment for non-coal mines |
| | 33 | Technique for the recycling of solid wastes of the iron and steel industry |
| | 34 | 3R-O new technique of high-concentration cyanide-containing wastewater and complete equipment |

Continued

| Minerals | SN | Efficient Mining and Dressing & Comprehensive Utilization Technologies |
|---|---|---|
| Metallic Minerals (24) | 35 | New technique for the efficient utilization of skarn-type low-grade scheelite |
| | 36 | Technique for heap leaching-based recovery of oxidized resources of low-grade gold |
| | 37 | Technique for high-concentration large-upscaling self-flow cemented filling |
| | 38 | Technique for recycling low-grade molybdenum from iron and molybdenum ores |
| | 39 | Technique of column-and-machine combined separation of low-grade copper and molybdenum ores |
| | 40 | Energy-saving and environmental-protection technique of segmented concentrated grading of lead-zinc poly-metallic ores |
| | 41 | Comprehensive new technique of efficient extraction of gold from complicated and refractory arsenic-and-antimony containing gold ores |
| | 42 | Technique for popularization and application of environment-friendly gold leaching agent |
| | 43 | Technique for in-situ leaching of uranium by $CO_2$ and $O_2$ |
| Non-metallic Minerals (8) | 44 | Technique for yellow phosphorus production from low-grade phosphate rocks |
| | 45 | Technique for machine-made sand production |
| | 46 | Green technique for comprehensive utilization of mid and low-grade phosphate rock without discharge of ardealite |
| | 47 | Technique fir digital and information technology-based application of optimized utilization of cement mine resources |
| | 48 | Technique for separation, quality improvement and upgrading of pyrites |
| | 49 | Technique for optimization and automatic monitoring of cement clinker and ingredients of admixture and comprehensive utilization of barren rock |
| | 50 | Technique for manufacturing and drying of bentonite cat litter |
| | 51 | Application of new-type calcium sulfate inhibitor to potash production |

MLR employed various approaches to establish an information exchange platform so as to "make the enterprises in need get applicable technologies and advanced technologies reach applicable enterprises" and raise the conversion rate and popularizing rate of recommended technologies.

## 4. Construction of demonstrative bases for the comprehensive utilization of mineral resources showed notable effects

MLR and Ministry of Finance launched the construction of demonstrative bases for the comprehensive utilization of mineral resources (hereinafter referred to as "demonstrative bases"). The central finance invested RMB 20 billion and enterprises planned to invest RMB 174.2 billion in the first group of 40 demonstrative bases, covering 7 fields such as oil & gas, coal and nonferrous metals. Progress was achieved in three respects: Firstly, breakthroughs were achieved in the development of a group of industrial technologies for the comprehensive utilization of low-grade, symbiotic and associated, and difficult-to-use resources, vitalizing plenty of resources with the emphasis on the country's urgent need for comprehensive utilization of bulk minerals and strategic emerging minerals. Secondly, a group of new modes for green exploitation and industrial development of resources were formed and a new path for the transformation and upgrading of the mining industry was explored successfully, which was quite helpful in demonstration and leading. Thirdly, the formulation and implementation of plans, policies and standards was speeded up. Efforts were made to promote the establishment of a system of regulations and policies for the conservation and comprehensive utilization of resources, and a group of industry-university-institute cooperation platforms were built up.

## 5. The revised directory of encouraged, limited and eliminated technologies for the conservation and comprehensive utilization of mineral resources was issued

Policy-based guidance for technology development was enhanced, and the *Directory of Encouraged, Limited and Eliminated Technologies for the Conservation and Comprehensive Utilization of Mineral Resources (Revised)* was modified and issued. The revised directory includes 262 technologies to be encouraged, limited and eliminated for such as exploitation, separation and pre-separation of minerals and comprehensive utilization of tailings, which provided important reference and basis for land and mineral resources departments at all levels to intensify the access management for the development and utilization of mineral resources.

# Chapter IV
# Geological Environment Protection of Mines

The geological environment of mines is an important part of the eco-environment. During the 12th FYP period, MLR paid high attention to the geological environment restoration and integrated renovation of mines. For one thing, it carried out the geological environment restoration and renovation for mines left over from history; for another, it built the geological environment protection system for newly built and productive mines and formed preliminarily a new situation that 'the geological environment problems of new and old mines' were solved as a whole. Also, it completed comprehensively the periodic goal for the construction of green mines, and formed typical patterns, which promoted the in-depth development of green mining.

## I. Geological Environment Restoration and Renovation

Governmental fund guarantee for the geological environment renovation of mines has been intensified constantly. During the 12th FYP period, the central finance assigned RMB 18.07 billion subsidies for geological environment renovation projects, with an increase of 39.9% compared with the 11th FYP period. The subsidies amounted to RMB 3.27 billion in 2015. These funds were spent mainly on supporting the geological environment renovation and demonstrative projects of mines in resource-exhausted cities, while promoting the involvement of local governments and enterprises.

The geological environment restoration and renovation of mines achieved notable results. By

the end of 2015, about 810 thousand hectares of the land damaged by mining development had been restored across China, with the renovation rate of 26.7%.

The payable cash deposit system for the geological environment restoration and renovation of mines was implemented comprehensively. 31 provinces (autonomous regions and municipalities directly under the central government) enacted administrative regulations. Upholding the principle of 'owned by enterprises, supervised by governments, stored in special accounts and a fund for a fixed purpose', the cash deposit payment was smoothly promoted on the whole and was used to supervise and restrain mining enterprises in geological environment protection and integrated renovation in combination with cash deposit, mining rights approval, annual inspection or plans for renovation and restoration. During the 12$^{th}$ FYP period, about 85.9 thousand mines paid RMB 86.77 billion cash deposit for geological environment restoration and renovation. RMB 30.74 billion was returned to the mining right holders who had fulfilled the obligation of renovation. RMB 2.52 billion of the closed mines which failed to fulfill the obligation was preserved in the account.

Construction of national mine parks was carried forward steadily, with evident improvements seen in the quality and management of construction. During the 12$^{th}$ FYP period, the construction of 11 mine parks was approved, of which 9 mine parks were built up and opened. Thanks to the construction of national mine parks, a group of mines with long history became demonstrative areas for the geological environment restoration of mines, protected areas of relics and culture of mining, and bases for geological and mining science popularization and education. Turning the passive restoration-based environmental improvement into the active development-based protection and development of the environment, the construction of mine parks is of great importance for the construction of resources and environment and the economic transition and development of mines or mining cities.

In July, 2016, MLR, together with the Ministry of Industry and Information Technology, the Ministry of Finance, the Ministry of Environmental Protection and National Energy Administration, issued the *Guiding Opinions on Strengthening the Geological Environment Restoration and Integrated Renovation of Mines*, presenting general requirements, main tasks and safeguard measures for the next stage of the geological environment protection, restoration and integrated renovation of mines, with the aim to implement the *Opinions of the Central Committee of the CPC and the State Council on Accelerating the Promotion of Ecological Civilization Construction*, enhance the resource management's source protection

effect for the natural ecology, intensify the geological environment protection of mines, speed up the geological environment restoration and integrated renovation of mines, and build a new pattern of mineral exploitation where development and protection are well coordinated as early as possible. Firstly, it states that by the year 2025, a dynamic monitoring system should be established to grasp and monitor comprehensively the dynamic changes in the geological environment of mines across China; a stricter constraint mechanism for mining rights holders' performance of the statutory obligations for the geological environment protection of mines should be established so as to effectively protect and timely control the geological environment of newly built and productive mines, accelerate the resolution of issues left over from history, and further consolidate the new situation where the resolution of existing geological environmental problems is accelerated and no new problem is left unsolved. Secondly, it specifies that governments at all levels should be responsible for the overall planning and integrated renovation of the issues left over from the past, for which the central finance should provide necessary support. Thirdly, it puts forward that efforts should be made to control strictly the approval of mine development, strengthen the formulation and implementation of protection, improvement and restoration plans as well as the development and process monitoring, and perform the monitoring throughout the process. Fourthly, through the integration and improvement of land utilization and mineral development policies, social investment is encouraged to build a new mechanism based on 'government guidance, policy support, social participation, development-oriented treatment and market-oriented operation'. Finally, efforts should be made to raise the scientific and technological level of the geological environment protection of mines by accelerating the construction of the legal system, enhancing scientific and technological support, strengthening publicity and education, and further improving related laws and regulations.

## II. Green Mining Development

During the 12$^{th}$ FYP period, MLR selected 661 mines for the pilot program of national green mines construction to advance the efficient development of oil & gas minerals, green exploitation of coal, efficient comprehensive utilization of associated resources of metallic minerals and environment protection of chemical and non-metallic mines. A group of typical patterns were formed and imposed positive influence on the society and became an important

platform for transforming mining development mode, improving mining image and livelihood, strengthening ecological protection and promoting social harmony as well as a green label for the standard operation, transition and upgrading, financing and listing and overseas development of mining enterprises. In the meantime, MLR has been considering to build a sound region & industry-specific green mine standards system, improve supportive policies and pay more attention to the land utilization, mineral utilization and advance drawing and returning of the cash deposit for mine environment restoration and renovation of green mine construction. As a result, a policy system in favor of the green mining development was taking shape gradually and a long-standing mechanism was under construction.

**Pilot construction goals were achieved.** By the end of 2015, 661 mines were selected as pilot national-level green mines, achieving the goal of establishing over 600 national-level pilot mines by the end of the 12th FYP period. Distributed in 29 provinces (autonomous regions and municipalities directly under the central government), these mines were involved in such industries as energy, ferrous metals, nonferrous metals, gold, chemical industry, non-metallic minerals and building materials (Figure 4-1).

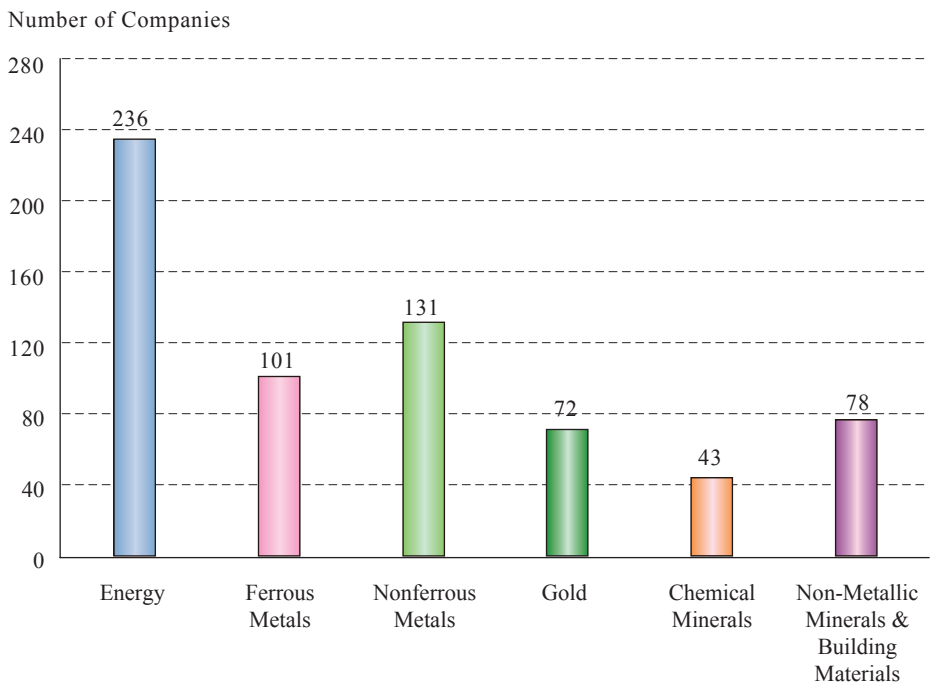


Figure 4-1 Distribution of National-level Green Pilot Mines by Industry

**Assessment of pilot construction was developed steadily.** 220 pilot national-level green mines were assessed in 2014 and 2015, of which 191 passed the assessment, including 60 mines engaged in the energy industry (59 for coal and 1 for oil), 29 in ferrous metals, 44 in nonferrous metals, 23 in gold, 22 in chemical industry and 13 in non-metallic minerals and building materials.

**Typical models of pilot construction took initial shape.** Typical models that could be publicized and popularized, such as green mining, mine site reclamation and land conservation, mines-community harmony, multi-purpose development of mine relics and innovation in green management technology, were summarized preliminarily.

**Pilot construction witnessed outstanding effects.** Firstly, digital and modern construction of mines was intensified and enterprise image improved gradually. The assessment indicated that over 90% of the pilot mines realized the digital management of mines and the application of advanced technologies and equipment, raised the production efficiency, reduced the cost of production and operation and established a good image of modern mines. Secondly, key technologies were transformed vigorously and the comprehensive utilization of resources was improved constantly. Each pilot mine spent more than 1% of its annual sales revenue on technology development. Thirdly, eco-environmental restoration and renovation of mines showed outstanding effects and the concept of environmental rebuilding through mining projects was established. Mining companies arranged special funds generally for land reclamation, mine re-greening, tailings pond treatment, vegetation recovery and other eco-environmental improvement and rebuilding projects. Finally, social responsibilities were performed to promote the harmonious development of mines. Mines performed actively the obligation of payment of taxes and fees, making contribution to the local economy, and provided jobs as many as possible and held employment skill trainings to promote social harmony and stability, and supported local communities through project cooperation to develop the planting industry and improved their production and living environment, bringing actual benefits to people.

# Chapter V
# Mineral Resources Management and Policies

During the 12th FYP period, through simplifying administration and delegating power to the lower levels, combining power delegating and flexible regulation, optimizing service and innovating management modes, the Chinese government standardized interim and afterward supervision and management and created a fair competitive environment. Meanwhile, China eliminated 25 items with regard to geology and mineral resources approval, cleared up all non-administrative approval issues, and modified 14 items concerning administrative regulations and departmental rules. Furthermore, the Chinese government vigorously enhanced taxes and fees reform, carried forward reform on the regime of oil & gas exploration and development, and reform on examination and approval of geological exploration qualification.

## I. Management System of Mineral Resources

### 1. Examination and approval system reform

By the end of June 2016, the State Council had specified that MLR would reserve 9 items in its implementation concerning geology and mineral resources administrative approval, adjust 2 items to internal examination and maintain 3 others which needs to be reformed and standardized further (Table 5-1).

MLR cancelled 25 items of examinations and approvals concerning geology and mineral resources and cleared up all non-administrative examinations and approvals since 2013 (Table 5-2).

### 2. Amendment of administrative regulations and departmental rules

The Chinese government amended 5 groups of 14 administrative regulations and departmental rules concerning mineral resources since 2011.

Table 5-1 List of Administrative Examination and Approval Reform for Geology and Mineral Resources

| Category | SN | Item |
|---|---|---|
| Reserved administrative approvals | 1 | Preliminary review of land used by construction projects and examination and approval of important ore deposits covered by construction projects |
| | 2 | Examination and approval of mineral resources exploration |
| | 3 | Examination and approval of mineral resources exploitation |
| | 4 | Examination and approval of geological exploration qualifications |
| | 5 | Examination and approval of grade A qualification of geological disaster prevention and control entities |
| | 6 | Examination and approval of paleontological fossils protecting |
| | 7 | Examination and approval of transfer, exchange and donation of the paleontological fossils among collection agencies |
| | 8 | Examination and approval of exit & entry of the paleontological fossils key protected |
| | 9 | Certification by the Quality Supervision and Testing Center, MLR (to perform newly established procedures of administrative approval) |
| Items shifted to internal approval of government | 1 | Examination and approval of mineral resources planning |
| | 2 | Examination of specific minerals for protective exploitation |
| Other items to be further reformed and standardized | 1 | Examination and approval of filing of mineral reserve assessment and registration |
| | 2 | Examination and approval of naming of national geological parks |
| | 3 | Examination and approval of national mine parks |

Table 5-2 Abolished Examinations and Approvals Concerning Geology and Mineral Resources since 2013

| SN | Items | Categories | Regulations |
|---|---|---|---|
| 1 | Examination and approval suspended acceptance filing of new exploration right in the areas where regional mineral geological surveys are financed by the central government | Non-administrative examination and approval | GF (2013) No. 44 |
| 2 | Examination and approval of packaged exploration implementation plans | Non-administrative examination and approval | |
| 3 | Pre-examination of China-foreign cooperative exploration and exploitation of mineral resources | Administrative approval | GF [2014] No. 5 |
| 4 | Examination and approval of geological survey filing | Administrative approval | |
| 5 | Examination and approval of exploration and development of mineral resources and engineering construction in the areas beyond the relics protection zone of national geological parks | Non-administrative examination and approval | |
| 6 | Examination and approval of distribution plans of mining rights | Non-administrative examination and approval | |
| 7 | Examination and approval of naming of the towns (cities, capitals) of hot spring of China | Non-administrative examination and approval | |
| 8 | Check of filing of coal exploration and mining rights examination and approval projects in pilot provinces for the reform in the management of coal mining rights examination and approval | Non-administrative examination and approval | |
| 9 | Registration of mineral water sold across provinces, autonomous regions and municipalities directly under the central government | Non-administrative examination and approval | GF [2014] No. 27 |
| 10 | Examination and approval of postponed collection of geological data | Administrative approval | GF [2015] No. 11 |
| 11 | Examination and approval of the development and utilization of mineral resources in reserved areas of mineral deposits | Non-administrative approval | |
| 12 | Examination of consulting of geological data within the protection period by related departments of governments above county level | Non-administrative approval | |
| 13 | Examination of geological environment protection planning of mines in provinces, autonomous regions and municipalities directly under the central government | Non-administrative approval | |

Continued

| SN | Items | Categories | Regulations |
|---|---|---|---|
| 14 | Examination and approval of the catalogue of places of key protected fossil specimens | Non-administrative examination and approval | GF [2015] No. 11 |
| 15 | Examination and approval of construction of the scientific and technological platform of the MLR | Non-administrative examination and approval | |
| 16 | Examination and approval of setup of package exploration areas | Non-administrative examination and approval | |
| 17 | Examination and approval of adjustment of mineral exploration risk classification | Non-administrative examination and approval | |
| 18 | Examination and approval of the determination and overall construction planning of mineral resources comprehensive utilization demonstration bases | Non-administrative examination and approval | GF [2015] No. 27 |
| 19 | Examination and approval of application for the transfer of agreements of exploration rights and exploitation rights | Non-administrative examination and approval | |
| 20 | Examination and approval or registration approval of mining rights deployment | Non-administrative examination and approval | |
| 21 | Examination and approval of setup, alteration or cancellation of national planned mine areas and mine areas of important value to the national economy | Non-administrative examination and approval | |
| 22 | Examination and approval of registration of property value assessment for mining rights | Non-administrative examination and approval | |
| 23 | Examination of overall planning of development and construction of the towns of hot spring of China declared by the people's governments of municipalities directly under the central government | Non-administrative examination and approval | |
| 24 | Examination and approval of planning of national geological parks | Non-administrative examination and approval | |
| 25 | Registration of geological data protection | Administrative approval | GF [2016] No. 10 |

Group I: *Regulation of the People's Republic of China on the Exploitation of Offshore Petroleum Resources in Cooperation with Foreign Enterprises, Regulation of the People's Republic of China on Sino-Foreign Cooperation in the Exploitation of Continental Petroleum Resources and Regulation on the Management of Township Mines* were amended by the State Council in accordance with *Decision of the State Council on Repealing and Amending Some Administrative Regulations (Order No. 638 of the State Council)*.

Group II: *Regulation for Registering to Explore for Mineral Resources Using the Block System, Procedures for Administration of Registration of Mining of Mineral Resources and Measures for the Administration of Transfer of Mineral Exploration Right and Mining Right* were amended by the State Council in accordance with *Decision of the State Council on Amending Some Administrative Regulations (Order No. 653 of the State Council)*.

Group III: *Measures for the Administration of Qualifications of Evaluation Entities of Geological Disaster Hazard, Measures for the Administration of Qualifications of Survey Entities, Design Entities and Construction Entities of Geologic Disaster Control Projects, Measures for the Administration of the Qualification of Supervision Entities of Geologic Disaster Control Projects, Provisions on the Protection of the Geologic Environment of Miens and Measures for the Implementation of the Regulation on the Protection of Fossils* were amended by MLR.

Group IV: *Measures for the Implementation of the Regulation on the Administration of Geological Data and Measures for the Implementation of the Regulation of the People's Republic of China on the Administration of Environmental Protection for Offshore Oil Exploration and Exploitation* were amended by MLR.

Group V: Relevant provisions of *Measures for the Administration of Geological Data were amended by MLR in accordance with Decision of the State Council on Amending Some Administrative Regulations (Order No. 666 of the State Council)*.

## 3. Cleanup and standardization of relevant intermediary services involving administrative examination and approval of geology and mineral affairs

The *Decision of the State Council on Reviewing and Regulating the First Group of 89 Items of Intermediary Services for Administrative Approval of the Departments of the State Council (GF [2015] No. 58)*, released on October 15, 2015, presents 9 intermediary service matters involving the administrative examination and approval of geological and mineral affairs, including (1) attestation and public announcement of the transfer of mining rights (involving

the examination and approval of the exploration of mineral resources); (2) review of scope of exploitation right application; (3) formulation of implementation schemes for mineral resources exploration; (4) formulation of schemes and reports for land reclamation for mineral resources exploitation; (5) verification of mineral reserves; (6) formulation of schemes for exploitation and utilization of mineral resources; (7) formulation of annual reports on mine reserves; (8) formulation of reports on the geological environmental protection, renovation and restoration of mines; and (9) formulation of assessment reports for important mineral resources covered by construction projects. Each applicant may formulate such reports by its own or entrusting a relevant institution according to the requirements; examination and approval entities shall not require the applicants to entrust a specific intermediary organ to provide services in any form; existing technology assessments and reviews of examination and approval entities should be reserved. Attestation, public announcement and examination should be performed by relevant organs entrusted by local departments of land and resources.

The *Decision of the State Council on Reviewing and Regulating the Second Group of 192 Items of Intermediary Services for Administrative Approval of the Departments of the State Council (GF [2016] No. 11)*, issued on February 28, 2016, involves 2 items of intermediary services—attestation and public announcement of transfer of mining rights (involving the examination and approval of exploitation of mineral resources) and geological reports for exploitation of mineral resources. 1 item of intermediary service concerning geology and minerals, geological hazard assessment of construction projects, implemented by departments of land and resources, is reserved.

MLR abolished administrative approval items designated by central government for implementation by local governments according to the requirements of the Office of the Leading Group for the Reform in the Administrative Examination and Approval System of the State Council. 5 geological and mineral administrative approval items involving MLR designated by central government for implementation by local governments, as specified in the *Decision of the State Council on Cancelling the First Group of 62 Administrative Approval Items Designated by the Central Government for Implementation by Local Governments (GF [2015] No. 57) and the Decision of the State Council on Cancelling the Second Group of 152 Administrative Approval Items Designated by Central Government for Implementation by Local Governments (GF [2016] No. 9)*, were all abolished.

## 4. Strengthening of supervision and management

All administrative approval items of MLR were shifted to the central handling of the Government Affairs Hall. MLR formulated and implemented the new versions of the

Administrative *Approval Service Guidelines of the Ministry of Land and Resources and the Detailed Rules for the Review of Administrative Approval Items of the Ministry of Land and Resources (2015)*; provided red, yellow and green-light warning services in the examination and approval system, established and implemented the mechanism of early warning for handling time-limit, and built a 'green channel' for administrative examination and approval; opened the column of "simplifying administration and delegating power to the lower levels, combining power delegating and flexible regulation and optimizing service" on its web portal so as to hear extensive social opinions; advanced actively the online open inquiry of administrative examination and approval information, and established a dedicated information desk and a hotline so as to timely provide whole-process inquiry service and accept social supervision.

MLR implemented strictly the disclosure system for the sale and transfer of mining rights, and realized the public disclosure of related basic information. Since 2014, it announced and disclosed 14,600 pieces (cumulatively 60,200 pieces) of basic information on the web of the market of mining rights, automatically announced 54,000 pieces (cumulatively 241,000 pieces) of non-confidential information on the registration of mining rights, and provided through the web of MLR 134,000 times (cumulatively 386,000 times) of information inquiry services about the registration of mining rights for the society.

*MLR issued the Measures for the Publication of Information on Exploration and Exploitation by Mining Right Holders (Trial)*, stating that upon July 1, 2016, mining right holders shall publicize their exploration and exploitation information on the web portals of MLR or provincial-level departments of land and resources timely and actively accept supervision. Competent departments of land and resources will include all mining right holders who fail to publicize information according to regulations or fail to perform any statutory obligation by practicing fraud into the directory of abnormalities and the list of serious violators of law. Enterprises included in the 'blacklist' will be restricted or forbidden to participate in relevant activities organized by the departments of land and resources.

## II. Taxes and Fees

Since the 12$^{th}$ FYP period, the Chinese government promoted constantly the reform in the taxes and fees system of mineral resources under the principle of price-based collection supplemented by the quantity-based collection, with the compensation rate for mineral resources reduced to zero; it studied and established a premium system for mineral resources according to the requirements of the ecological civilization construction scheme.

### 1. Compensation

RMB 88.44 billion compensation fees for mineral resources were collected during the 12th FYP period, 71.3% higher than 11th FYP period (Table 5-3).

Table 5-3 Payment of Mineral Resource Compensation Fees

Unit: billion RMB

| | 2015 | 11th FYP | 12th FYP |
|---|---|---|---|
| Mineral Resource Compensation Fees | 8.88 | 51.63 | 88.44 |

### 2. Reform in resource taxes system

In October, 2014, Ministry of Finance and State Administration of Taxation released the *Notice on the Implementation of the Reform of Coal Resource Tax and the Notice on Adjusting the Relevant Policies for Resource Tax on Crude Oil and Natural Gas*, bringing the mineral resource compensation rates of crude oil and natural gas to zero and increasing their applicable tax rate from 5% to 6%. On April 30, 2015, Ministry of Finance and State Administration of Taxation issued the *Notice on Implementing the Reform of Price-based Collection of Rare Earth, Tungsten and Molybdenum Resource Taxes(CS [2015] No. 52)*, applying a region-oriented applicable tax rate to light rare earth, which is 11.5% for Inner Mongolia, 9.5% for Sichuan and 7.5% for Shandong; and the applicable tax rate is 27% for medium-heavy rare earth, 6.5% for tungsten and 11% for molybdenum.

On May 10, 2016, Ministry of Finance and State Administration of Taxation issued the *Notice on Promoting Comprehensively the Resource Tax Reform (CS [2016] No. 53)* and the *List of Items and Rates of Resource Taxes*, stating that the compensation rates of all mineral resources will be reduced to zero from July 1, 2016. Upholding the principle of price-based collection supplemented by the quantity-based collection, the collection mode of resource tax shall be determined by people's governments at provincial level.

## III. Mineral Resources Planning

### 1. The *National Plan of Mineral Resources* (2016~2020) was formulated

MLR completed the formulation of the *National Plan of Mineral Resources (2016~2020)* and submitted it to the State Council for examination and approval. The new round of planning gives overall consideration to the tasks concerning the exploration, development, utilization and

protection of mineral resources based on the development concept of being innovative, coordinated, green, open-up and shared by all. It defines: (1) the arrangements for the secured supply of resources for building up a moderately prosperous society in an all-round way; (2) major measures for promoting the sustainable, healthy development of mining economy in the New Normal situation; (3) main tasks for speeding up the promotion of the transformation and green development of the mining industry; (4) major policies for promoting the open-up and shared development of the mining industry proactively; and (5) the overall thinking for deepening the management reform comprehensively and enhancing the vitality and impetus of mining development.

## 2. Formulation of plans by local governments at all levels was directed and promoted

At first, MLR issued the *Notice of the Ministry of Land and Resources on Performing the Third Round of Formulation of Mineral Resources Plans (GRZF [2015] No. 35)*, presenting comprehensive arrangements for launching the third-round of formulation of mineral resources plans. Secondly, it formulated the *Technical Procedures for the Formulation of Overall Mineral Resources Plans at Provincial and County Levels and Guiding Opinions for the Formulation of Overall Mineral Resources Plans at Municipal Level* so as to direct the formulation by local governments at all levels. Thirdly, it formulated *Standard of Databases of Mineral Resources Plans (Trial) and the Guidelines for the Construction of Databases of Mineral Resources Plans*, with obvious requirements presented for the construction of such databases by local governments at all levels and guidance provided for the departments of land and resources construction at locals to build databases of plans simultaneously and improve the information-based development of management. Finally, it issued the *Notice on Performing Environmental Impact Assessment of Mineral Resources Plans* in cooperation with the Ministry of Environment Protection, defining the overall requirements for the environmental impact assessment of plans, and promoting the environmental impact assessment at all levels.

## 3. The system of division-based deployment of mining rights was implemented.

MLR abolished the examination and approval or filing approval of setup schemes of mining rights and implemented the division-based setup of mining rights in order to implement the spirit of the *Decision of the State Council on Cancelling Non-administrative Examinations and Approvals (GF [2015] No. 27)*, deepen the reform in mineral resource management and reduce examinations and approvals. Upholding the principle of delegating power to the lower levels, streamlining procedures and raising efficiency, it has integrated organically the setup schemes of mining rights and the exploration and exploitation planning in mineral resource plans into the 'division of setup of mining rights', prepared a 'specialized chapter' for it in overall

planning or special planning, made detailed arrangements for exploration and exploitation of mineral resources and took it as an important approach for optimizing the layout of mines.

## IV. Management of Exploration and Mining Rights

During the 12th FYP period, MLR implemented the comprehensively deepening reforms arranged by the central government, and advanced the reform in the exploration and exploitation system of oil & gas resources; changed the 'application-first' transfer mode into the competition mode for oil & gas exploration rights; conducted two competitive transfers for both conventional oil & gas and shale gas. In 2015, it launched a pilot reform in conventional oil & gas exploration rights in Xinjiang and transferred the exploration rights of 4 oil & gas reserve blocks through competition.

It also took shale gas as another kind of minerals under the approval of the State Council, released the *Notice on Strengthening the Work Concerning the Exploration, Exploitation, Supervision and Management of Shale Gas*, and opened the shale gas exploration and exploitation market. Besides, it joined hands with local governments and oil & gas enterprises to establish Fuling Shale Gas Exploration and Development Demonstration Base, Chongqing, Qianbei Shale Gas Comprehensive Exploration Pilot Zone, Guizhou Province.

MLR strengthened the supervision and service of mining rights. At first, it upgraded and rebuilt the national uniform number assignment system of mining rights, enhanced dynamic and post monitoring, performed whole-process recording for examination, and gave timely warnings against abnormalities. Secondly, it published the *Service Guidelines of the Ministry of Land and Resources for the Examination, Approval and Registration of Non-Oil & Gas Mining Rights*, and further defined the conditions for the application for exploration and mining rights, requirements for data of application, time limits and procedures of examination and approval and servicing and inquiry of results. Finally, MLR provided postponement reminding services for exploration and mining right holders. Since April 1st 2015, 632 exploration rights and exploitation rights were published on MLR's website, with a validity of less than 120 days.

MLR reformed and innovated the management system of exploration and mining rights consistently. It issued the *Notice on Standardizing the Examination and Approval Management of Rare Earth and Tungsten Exploration and Exploitation Rights*, further standardized the management of rare earth and tungsten exploration and mining rights; enhanced the protection over advantageous minerals, and issued the *Notice on Issues Concerning the Mortgage Recordation of Mining Rights Provided by Mining Right Holders as Collateral for Others'*

*Debts*, allowing mining right holders to provide guarantee for others' debts, with mining rights they hold as the collateral, relieving the financing difficulties of mining enterprises.

## V. Management of Geological Survey Qualifications

MLR strengthened the management of geological survey qualifications, supported and served geological survey entities' reform and development and focused on promoting the reform and supervision of the examination and approval of geological survey qualifications and plans to issue institutional measures. The twice-a-year centralized handling was changed into daily handling and simple applications are dealt on site. In addition, it attempted to carry out online examination and approval, established a social publication system for important information of geological survey entities, and intensified interim and afterward management through social supervision and random check.

By the end of 2015, 2,640 geological survey entities nationwide had held totally 7,595 geological survey qualifications, including 2,819 Class A qualifications, 2,915 Class B qualifications and 1,861 Class C qualifications. There had been 1,157 entities whose highest level was Class A, 756 entities whose highest level was Class B and 727 entities whose highest level was Class C.

419 qualifications were for regional geological survey, 22 for marine geological survey, 4 for oil and natural gas exploration, 696 for liquid mineral exploration, 284 for gas mineral exploration, 1,936 for solid mineral exploration, 1,076 for hydrogeology, engineering geology and environment geology survey, 793 for geophysical exploration, 394 for geochemical exploration, 5 for aero-geological survey, 84 for remote geological survey, 1,411 for geological drilling (pitting) and 471 for geological experiment and testing (Figure 5-1). The number of geological survey qualifications by the end of the 12$^{th}$ FYP period was 29.7% higher than that by the end of the 11$^{th}$ FYP period.

In 2015, according to economic category, the geological exploration entities consisted of 1,291 state-owned entities, 19 collectively-owned entities, 12 joint-equity entities, 1,164 limited liability entities, 71 entities limited by shares, 57 private entities, 22 other entities, 1 joint venture (with funds from Hong Kong, Macau or Taiwan), 1 entity with entire funds from Hong Kong, Macau or Taiwan, 1 entity with entire funds from foreign countries and 1 foreign-funded shareholding company (Figure 5-2).

In 2015, MLR issued 438 geological survey qualification certificates, in which 165 newly established, 15 renewed, 257 altered and 1 reissued, and cancelled 7 geological survey qualifications.

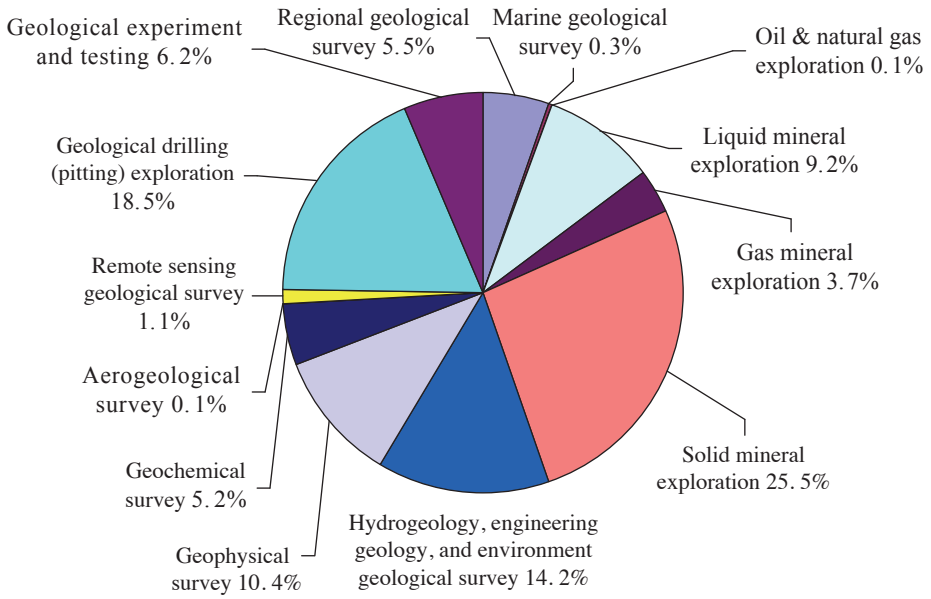


Figure 5-1 Categories of Qualifications of Geological Survey Entities in China, 2015

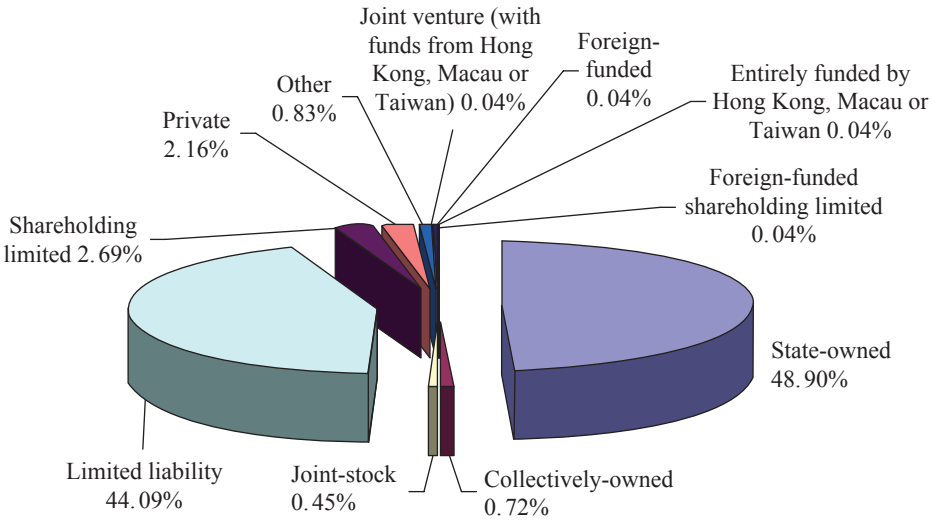


Figure 5-2 Economic Structure of Geological Survey Entities in China, 2015

# Chapter VI
# Geological Survey, Mineral Resources Assessment and Geological Data Services

During the 12th FYP period, geological survey, mineral resources assessment and geological data services played more prominent roles in the development of national economy, and essentially supported social development and ecological civilization construction. Geological survey and mineral resources assessment witnessed abundant achievements, and offered effective protection for China's mineral resources supply. Geological data products were increasingly enriched; and the capability and level of geological data services were further improved.

## I. Basic Geological Survey

### 1. Regional geological survey

By the end of 2015, China had accumulatively finished regional geological survey for an area of 3.52 million $km^2$ at 1:50,000, accounting for 37.0% of onshore territorial area. In the key metallogenic belts (areas), 2.017 million $km^2$ was totally explored, with the exploration coverage reaching 52.3%.The exploration area finished in 2015 reached 205 thousand $km^2$.

## 2. Remote sensing geological survey

In 2015, China analyzed satellites data from both domestic-sourced GF-1/GF-2 and ASTER/ETM, and completed remote sensing interpretations of lithology-structure, ore-controlling factors in the key areas, and alteration (mineralization) information extraction in Bangong Lake- Nujiang, A-er-jin and East Kunlun, the total areas of which reached 4,200 $km^2$. China also finished totally 107.6 thousand $km^2$ of remote sensing geological survey in all the terrestrial boundaries.

## 3. Mineral geological survey

By the end of 2015, 1.857 million $km^2$ of geological exploration in the key metallogenic belts had been completed, with the coverage raised to 46.0%. More than 3,300 comprehensive abnormalities were delimitated; 1,250 mineral (mineralizing) points were newly discovered; more than 500 prospecting targets were defined. Airborne gravity survey of 40 thousand $km^2$ at 1:50,000 in the key areas of Tarim Basin and Junggar Basin in Xinjiang Uygur Autonomous Region were finished.

In 2015, geological survey for mineral resources at 1:50,000 in an area of 97 thousand $km^2$ were finished.

## 4. Marine geological survey

The integration of the marine regional geological survey results at 1:1,000,000 in the marine areas under the jurisdiction of China was initiated; the eastern and southern China's marine stratigraphic frameworks was preliminarily established; 13 map-sheets of marine regional geological survey at 1:250,000 under key waters were carried out; 2,000 $km^2$ of pilot marine regional geological survey at 1:50,000 was completed; comprehensive geological survey and monitoring in key coastal zones was successively carried out; the integrated onshore/offshore pilot geological survey was initiated; marine oil & gas resources exploration in key sea areas was continued; oil & gas shows were found in the Mesozoic-Paleozoic marine beds in the Laoshan Uplift in the southern part of the Yellow

Sea; the exploration and pilot mining of natural gas hydrates as well as ocean scientific investigation were constantly carried out.

## II. Prospecting and Evaluation of Mineral Resources

### 1. Conventional oil & gas resources

Yican-1 well was drilled in the southeastern Ordos Basin; industrial gas flows were obtained at the new strata series of Ordovician weathering crust reservoir; a new exploration area as large as 1,000 $km^2$ was hence opened up. 2 large trap structures, each with more than 100 $km^2$, in favor of oil & gas entrapment, were identified in Peninsula Lake and Tuonamu of Qiangtang Basin.

### 2. Non-conventional oil & gas resources

Anye-1 Well, implemented in Zheng'an county, Zunyi City, Guizhou Province, uncovered a 'four-floored' pattern of oil & gas reservoir, a breakthrough of shale gas and natural gas exploration in the southern China's complicated tectonic areas outside the Sichuan Basin in the past 60 years, opening up a new area of oil & gas exploration and expected to be another industrial gas field.

Yidi-2 Well, implemented in Hubei province, obtained 70-meter-thick high-quality source rocks in the Shuijingtuo Formation, Cambrian with predicted shale gas resources above 500 billion $m^3$. Wenye-1 Well in Shandong Province discovered 93 beds of shale oil, with cumulative thickness of over 200 meters, proving good prospects of shale oil resources in the southwestern Shandong Province.

### 3. Geothermal resources

During the 12$^{th}$ FYP period, China Geological Survey (CGS) organized shallow geothermal resources survey and evaluation of 336 cities above prefectural level and geothermal water survey and evaluation of 31 provinces (autonomous regions, municipalities), launched survey on dry hot rock resources, implemented the first scientific drilling of dry hot rock of China,

cumulatively investigated 2,334 hot springs and 5,818 geothermal wells, drilled more than 70 thousand meters, basically found out the current distribution, development and utilization of geothermal resources in China, and preliminarily evaluated the quantity, development and utilization potential of geothermal resources. Results indicated that annual allowable exploitation of shallow geothermal resources was equivalent to 700 million tons of standard coal, which could heat or cool more than 32 billion $km^2$ of buildings. Annual allowable exploitation of geothermal water resources was equivalent to 1.9 billion tons of standard coal, mainly located in North China, Songnen, Fenwei, Jianghan, North Jiangsu and Xialiaohe Basins and Dianzang, Southeast Coastal, Jiaoliao Peninsula and Taiwan mountains. 205°C steam was obtained at the depth of 370 meters along Qinghai-Tibet Railway, the highest temperature at the same depth in China. Preliminary estimates showed that the quantity of dry hot rock resources at 3,000~10,000 meters underground was 856 trillion tons of standard coal. China Geological Survey implemented the first scientific drilling of dry hot rock of China in Zhangzhou, Fujian.

## 4. Solid mineral resources

In southern Tiegelong mining area, Duolong, Tibet, cumulatively more than 10 million tons of copper resources were measured. In the periphery of Jiajika area, a total increase of more than 800 thousand tons of lithium oxides resources was obtained, adding the total lithium resources volume up to more than 2 million tons. In Qaidam Basin, Qinghai Province, 2 new potash occurrences were defined, with an increase of over 100 million tons of potassium chlorides resources. In Haobintala area, Inner Mongolia, a super-large fluorite deposit was discovered, with the resource more than 20 million tons. In Xixia-Tongbai area, Henan Province, 2 new graphite deposits were discovered, with the resources potentials being of over 2 million tons.

## 5. Groundwater resources

During the $12^{th}$ FYP period, CGS organized an investigation on groundwater resources and environment of Hetao Plain, Jianghan Plain, Chengdu Plain and Badain Jaran Desert, and completed a hydrogeological survey for 1:250,000 covering 45 thousand $km^2$; performed

a hydrogeological survey on ecologically vulnerable areas and centralized contiguous exceptionally poor areas such as Wumeng Mountainous Area, Yimeng Mountainous Area, Taihang Mountainous Area, Shanganning Area and Qaidam Basin, and completed the hydrogeological survey for 1:50,000 covering 370 thousand $km^2$; obtained 4 super-huge groundwater-enriched areas and 8 medium-large sized water supply sources in Qaidam Basin; delimitated 9 high-quality deep groundwater sources, with the water yield of each well reaching 3,000~5,000 $m^3$/day, in East Gansu Energy Base; carried out the emergency action of combat-drought water exploration and well digging for the four provinces in North China, conducted more than 2,200 wells of combined exploration and exploitation, and solved drinking water difficulties for 2.2 million people; conducted the groundwater exploration in Central and Southern Ningxia Ecological Immigrants District, constructed 53 wells in the combination of exploration and exploitation, and solved drinking water difficulties for 120 thousand people; carried out the groundwater emergency exploration in the Wandashan Region of Heilongjiang, and provided groundwater resources security for 400 thousand urban residents.

In 2015, 50 thousand $km^2$ of hydrogeological survey for 1:50,000 was completed in key areas, 300 exploration & exploitation wells were constructed, and drinking water difficulties were solved for 330 thousand people. The national groundwater monitoring project was launched, and the construction of the first group of 350 national groundwater monitoring wells was drilled.

## III. Geological Data Services

### 1. Service products increased constantly

During the 12$^{th}$ FYP period, series map data of the hydraulic, engineering and environmental survey results for 1:500,000, data on important geological drilling of mineral resources package exploration areas and geosciences literature service products of mineral resources package exploration areas were disclosed to the public; data on 400 thousand geological drills and provincial-level geological data service catalogue of 110 thousand maps of national mineral resources potential evaluation results were published, 93 latest basic geological

maps of marine geological survey were provided to the society for the first time, *China Annual Report on Geological Survey (2015)* and more than 1,000 regional geological maps for 1:50,000 were published. By the end of 2015, the centralized sharing service platform of geological data and information provided catalogue services for 373 thousand pieces of data, electronic files services for 13 thousand pieces of geological data and had 197 thousand online electronic files.

## 2. A group of major geological survey results published

Conversion, application and service of survey results were promoted, a group of first-class geological survey results were brought out, and *Report on Geological Survey for Supporting and Serving the Concerted Development of Beijing, Tianjin and Hebei (2015), Atlas of Land, Resources, Environment and Geology of the Beijing-Tianjin-Hebei Region, Report on Geological Survey for Supporting the Development of the Yangtze River Economic Zone, China Geochemical Survey Report and China Report on the Survey of Shale Gas Resources* were published, with a vigorous push for economic and social development.

## 3. Socialized services of geological data advanced constantly

In 2015, National Geological Archives of China and geological data collection institutions of 31 provinces (autonomous regions, municipalities) received totally 23.3 thousand person-times on site and provided 104.4 thousand piece-times of data services. Entities entrusted to hold oil & gas and other geological data received 9,093 person-times on site, including 5,744 person-times of original geological data services and 3,349 person-times of in-kind geological data services and provided 22.4 thousand piece-times of original geological data services.

# Chapter VII
# Scientific and Technological Innovations and International Cooperation

During the 12th FYP period, innovations were made in the theories of mineralization, modes of mineral prospecting and methods of mineral exploration. Several national and industrial technical standards on mineral resources exploration and geological environment and survey were published and implemented, and new progress has been achieved in the international cooperation of geology and mineral resources.

## I. Basic Geological and Mineralization Theory Researches

### 1. A new generation of stratigraphic chart published formally

An accurate correlation between China and international chronostratigraphic systems was established, and the *Stratigraphic Chart of China 2014 and the Stratigraphic Guide of China and its Specifications (Version 2014)* were published formally.

### 2. New progress achieved in the research of deep geotectonics

The lithospheric structure based on the crashing of the Paleo-Pacific Plate and the Okhotsk Plate beneath the Songliao Basin was revealed for the first time, the ancient subduction zone inside Yangtze Craton was discovered under the Sichuan Basin, and the insidious ancient orogenic belt was discovered under the Xuefeng Mountain. 3 old continental plates, aged over 2.6 billion years old, were marked off in North China Craton for the first time.

Deep probing technology and experimental study were completed successfully, which provided technological and team support for carrying out deep earth probing comprehensively across China and made important achievements in four aspects. Firstly, a three-dimensional probing technique system consistent with China's deep earth characteristics was established in a systematic way, and the independently-developed key instruments and equipment of deep probing were internationally advanced. Secondly, deep probing drove major scientific discoveries and China edged itself into the great powers of deep probing. Thirdly, a group of major prospecting clues with strategic importance were discovered, providing powerful support for the *National Exploration and Development Planning*. Finally, the law of global activity was grasped, providing strong support for improving early warning capability against natural disasters.

## 3. Innovations made in the theories of mineralization, models of mineral prospecting and methods of mineral exploration

A first system of ore-body prediction theories and methods for exploration areas centering on the research of geologic body of mineralization, ore-forming structure and structural surface and characteristic indexes of mineralization was established, and geologic models for the prospecting of China's 25 important types of deposits were built in an integrated manner. They were applied widely to the prospecting in old mines and integrated exploration areas and raised the success rate of prospecting significantly.

A new type of ophiolite diamond enrichment and a new kind of gold deposits, one magma-type gold deposit, were discovered, and its genetic model was established. Through studies on the theories of landmass marine potash formation in China, the coupling mechanism for the 'structure, provenance and climate' of small landmass marine potash formation in China was unveiled, the small-landmass marine potash formation model of the East Tethyan domain was advanced, the absolute age of the Menyejing Formation of Simao Basin and the potash formation age were obtained, and it was confirmed that Triassic Paleo-Salt Lake Brine had the conditions for potash formation. The special geodynamics background that marine volcanic-based iron ores were formed by 'steep subduction against cold earth crust and hot mantle' was advanced, through the modes of 'desiliconization & iron-enrichment' and 'iron activation-enrichment' in the later hydrothermal overlapping transformation of Anshan-type magnet-

rich ores, with marine volcanic-based iron ores and sedimentary metamorphic-type iron ores being the main goals of the high-grade iron ore deposits prospecting in China. Studies were conducted on the uranium-bearing rock series sedimentary environment, super-genetic fluid, coal and other organic matter of continental basins and their structure's restrictions on the formation of uranium ores, a framework of theories for the formation of uranium ores was established, and new understandings about large-scale mineralization of uranium at continental basins were advanced. Theoretical understanding about shale gas reservoir forming of the southern complicated tectonic regions based on the development of organic matters-rich shale, steady structure storage and stratum overpressure was advanced, on the basis of the systematic summarization of the southern shale gas enrichment theories and reservoir forming rules of China.

## II. Techniques of Mineral Exploration and Exploitation

### 1. A group of geological exploration techniques and instruments developed or integrated

A set of full-hydraulic geological core drilling equipment for 2,000m deep and key apparatus were developed successfully, honored with the Second Prize of the National Scientific and Technological Progress Award 2015. Aeromagnetic three-component magnetometer, magnetic compensation apparatus and data collection system, Φ140 turbodrills for high-temperature drilling of dry hot rock and high-pressure drilling fluid rheometer prototype, and JW-1 portable geological disaster emergency survey toolbox were developed. Groundwater hierarchy remote monitoring system and small-size groundwater dynamic monitor were developed, realizing one-drill multi-layer management of monitoring wells. Small-trace-interval high-resolution multi-channel digital seismic detection system was developed and a web-based dual-cable multi-channel acquisition and recording system was completed.

### 2. The methods and techniques system for geological exploration further improved

Helicopter pod-type time-domain airborne electromagnetic exploration denoising and data correction methods were developed. Research on key techniques for seamless splicing of 02C satellites, color balancing and different fusion methods of 02C HR and MUX data were

completed and application service modes of the co-ordination, receiving and distribution of data from 02C satellites were established preliminarily. Dynamics and PRB repairing technology of organic chloride, cadmium and chromium-contaminated soil as well as measurement of rare and dispersed elements by LA-HR-ICP-MS method for melting samples were developed.

### 3. Application demonstration promoted the practical application of techniques and equipment effectively

The independently-developed 'Sea Horse' 4,500-meters deep-sea unmanned remote-operated vehicle (ROV) was successfully used for geological exploration, and high-definition video records and physical samples with the mark of active 'cold spring' were obtained for the first time. Big-caliber same-diameter long-drilling-distance coring technology was developed, making a world record for the continuous coring of ϕ311mm and the drilling with a single-roundtrip footage over 30 meters and realizing for the first time 'same-diameter coring and one-diameter completion' and 'three-tube-coordinated long-roundtrip drilling'. The helicopter rigid-frame-type airborne magnetic survey system was integrated, with breakthroughs of application achieved in the west Kunlun High-Altitude Area of Xinjiang.

### 4. Comprehensive utilization techniques of mineral resources applied better

Important progress was made in the new technology of ore grinding-selective dissociation-compounding force field magnetic separation and selection, and high-efficiency iron separation and selection equipment with compounding force field were developed successfully. Breakthroughs were achieved in the high-intensity magnetic tailings discarding-regrinding of rough concentrate-centrifuge separation-flotation combined titanium concentration technology, and efficient utilization of titanic iron ores was realized. The two stage roasting process was developed, realizing the comprehensive recovery and utilization of gold, silver, copper, lead, zinc and iron in gold smelting slag. A new process of recovering associated metal elements in iron ore by microbial leaching was developed, which greatly increased the recovery rate of associated metals.

## III. Technical Standards for Geology and Mineral Resources

China established a standardized work pattern based on unified management, coordination

and distribution of responsibilities, expert counseling, entities' support and security and industrial coordination and promotion and thereby, making geological and mineral standards as a complement to the mineral resources law and auxiliary regulations, with positive effects in promoting the law-based administration of government in the geological and mineral sectors and standardizing the mining order.

During the 12th FYP period, a total of 13 national standards and 91 industrial standards for geology and mineral resources had been issued and implemented, which provided technical support for the exploration, development, protection and management of mineral resources. In 2015, China released and implemented 1 national standard—*Geological Legends Used for Regional Geological Maps* and 60 suggestive industrial standards, including *Procedures for Original Geological Record of Solid Mineral Exploration, Technical Requirements of Integrated Compilation and Study on Geological Data about Solid Mineral Exploration, Technical Regulation for Mining Geo-environment Monitoring, Specification for Survey and Monitoring of Land Subsidence, Specification of Dynamic Survey on Geological Hazards, Specification of Risk Assessment for Geological Hazard, Standard for Groundwater Quality, The Technical Specification for Gravity Survey(1:50 000),Technical Regulation for Controlled Source Audio Magnetotelluric Method, Technical Regulation for Phase Induced Polarization Method, Specification of Geochemical Reconnaissance Survey(1:50 000), Specification of Regional Eco-geochemistry Assessment, Specification of Remote Sensing Technique in Regional Geological Survey(1:50 000), Specification of Remote Sensing Technology for Regional Environment Geological Exploration(1:50 000), Codes for Comprehensive Utilization of Mineral Resources, Specification Identification of Rocks and Minerals, Geological Data Concurrent Specification and Structure and Drafting for Specification of Geological Database Construction, etc.*

In addition, China opened and operated the standard information service platform of land and resources, involving dynamics of standardization, operation and management of technical committees, formulation and amendment of standards, knowledge about standards, inquiry of standards, information consulting services for standards, forums of standards and etc., which helped improve the informatization level of standardization of land and resources and effectively promoted the openness of government affairs.

## IV. International Cooperation

### 1. International exchange in the field of mining expanded

During the 12th FYP period, the land and resources system carried forward in-depth international cooperation, and a lot of works were done in terms of participating in the country's overall diplomacy, expanding the network of international cooperation, supporting the business of land and resources, improving the international cooperation platform, enhancing international cooperation in science and technology, promoting talent recruitment and training and improving foreign affairs management, making positive contribution to supporting the overall situation of national open cooperation and the development of land and mineral resources.

In 2015, China Mining Congress & Expo was held successfully, which strengthened the cooperation with great mining powers such as Australia, Canada, Chile, Peru and other major mining countries. Besides, relevant conferences in the geological and mineral sectors were held under the general framework of China-ASEAN Exposition, Silk Road International Expo, China-Russia Expo and China-Mongolia Expo. Achievements of the Johannesburg Summit of Forum on China-Africa Cooperation were expanded and geological and mineral cooperation was included in *China's African Policy*. Geological and mineral cooperation with Ethiopia, Ghana and Angola was enhanced. Cooperation in geology, minerals and spatial planning was included in the *Medium-Term Plan for Cooperation between China and Central and Eastern European Countries*, and the cooperation with Poland in shale gas exploration and exploitation technology and management was promoted.

During the 12th FYP period, trainings were provided for more than 500 persons from nearly 80 countries. In 2015, 252 persons engaged in geology and minerals from over 40 countries received trainings in China, and a training on digital mapping and geochemical mapping technology and application was held in Laos in cooperation with its Ministry of Natural Resources and Environment for the first time.

### 2. International science and technology cooperation in mining strengthened

During the 12th FYP period, international geosciences cooperation obtained a series of pioneering achievements with great influence and thereby, effectively promoted the

construction of the global mining community with a common future and played an important role in supporting international mining investment, promoting ecological civilization, facilitating geosciences advancement, cultivating talents and improving the international right of speech.

115 memorandums of cooperation and understanding were signed with geological survey institutions and international geosciences organizations from 51 countries and regions, and geological and geochemical surveys were conducted in cooperation with more than 20 countries such as Laos. More than 40 experts took office at International Union of Geological Sciences (IUGS), Commission for the Geological Map of the World (CGMW), International Consortium on Landslides (ICL), Coordinating Committee for Geo-science Programs in East and Southeast Asia (CCOP) and other inter-governmental international geo-science organizations. The International Research Center on Karst under the Auspices of UNESCO, China-Shanghai Cooperation Organization Cooperative Center for Geo-science Research and other international geo-science research centers were established, further improving the level of geological science and technology.

The UNESCO-sponsored International Center on Global-Scale Geochemistry was approved. IUGS Secretariat worked well to promote the implementation of the RFG initiative. Such important international conferences as the 51st CCOP Annual Session were hosted successfully. By China-Shanghai Cooperation Organization Cooperative Center for Geo-science Research, the cooperation with Central Asian countries in geo-science studies was strengthened, and two geo-science cooperation forums were held. UNESCO and the World Geopark Network Office were used to hold several international seminars on geoparks and geological environment of karst.

New progress was made in the international cooperation in geological survey. In 2015, China conducted cooperative regional geological and geophysical survey with 16 other countries for the first time. Cooperation on groundwater survey was performed with US Geological Survey (USGS) and China-US Groundwater Quality Monitoring Seminar was held for two sessions. In the areas of hydrogeology, karst and mine environment, a series of hydrogeological maps for Southeast Asian Region were compiled, and 'China-Vietnam Joint Study on Comparison of Holocene Sedimentary Evolution of the Yangtze River Delta and the Red River Delta' was launched.