

**2017**

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# **China Mineral Resources**

**Ministry of Land and Resources  
People's Republic of China**

**GEOLOGICAL PUBLISHING HOUSE  
BEIJING**

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## Foreword

Since 2016, the Chinese government has made great efforts to push forward the supply-side structural reform in the field of mineral resources, implemented five priority tasks, namely, ‘cutting overcapacity, reducing excess inventory, deleveraging, lowering costs, and strengthening areas of weakness’, issued a series of policies and measures to solve excess capacity of coal and steel, deepened the reforms to streamline administration, delegate powers, and improve regulation and services, included mineral resources with proved reserves into the pilot work of unified confirmation and registration of rights to natural resources, promoted the reform of mineral rights’ transfer system and mineral resources royalty system, and comprehensively implemented the publication system for exploration and exploitation information of mineral rights’ holders to continuously improve the mineral resource management ability to serve the economic and social development.

Green (environmentally responsible) exploration has been fully advocated, and great progress has been made in the strategic mineral exploration. A new batch of important discoveries of oil, natural gas, tungsten, gold and graphite, etc. has been made, achieved a good start of the third stage in *National Exploration and Development Planning*. With the implementation of scientific and technological innovation strategy of ‘deep exploration, deep-sea exploration, deep space-to-earth observation and land science & technology innovation’, a historical breakthrough has been made in the exploration and exploitation of natural gas hydrate (NGH), and the independent innovation in theories, techniques, engineering and equipment for exploration and exploitation of marine NGH has been achieved.

The Ministry of Land and Resources (MLR) has formulated the *China Mineral Resources (CMR)* since 2011, in order to enhance the capacity of public services, promote the disclosure of government information and make the public better understand the situation of exploration, exploitation and utilization of mineral resources in China and the latest policies and regulations.

The *CMR 2017* focuses on introducing relevant information since 2016, including new progress in China's exploration, exploitation and utilization of mineral resources, protection of geological environment in mines, geological and mineral survey and assessment, new measures in policies and regulations regarding mineral resource planning, exploration, exploitation and supervision, taxes reform, ecological civilization construction, new trends in scientific and technological innovation in exploration, exploitation and utilization, geosciences theories, as well as the new achievements in international cooperation in 'the Belt and Road' mining industry development.

The statistical data of this report are mainly from the Ministry of Land and Resources and the National Bureau of Statistics of the People's Republic of China. The statistical 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.

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# Abstract

**The newly discovered resources & reserves of most strategic minerals increased and the potential of mineral resources enlarged further.** By the end of 2016, the remaining technologically recoverable reserves of oil was 3.5 billion tons, up by 0.1% year-to-year; the natural gas 5.4 trillion cubic meters, up by 4.7%. The resources & reserves of coal was 1,598 billion tons, up by 2.0%; iron ores 84.1 billion tons, down by 1.2%; copper 101.11 million tons, up by 2.0%; tungsten 10.16 million tons, up by 6.0%; gold 12,167 tons, up by 5.2%.

**The investment in geological exploration kept declining but important progress was made in strategic mineral exploration.** In 2016, RMB 77.479 billion was invested in geological exploration, with a year-on-year decrease of 16.6%, and the investment continued declining for the fourth year. The newly discovered reserve of oil amounted to more than 0.9 billion tons and natural gas more than 700 billion cubic meters. There were two new oil fields with the newly discovered geological reserves over a hundred million tons and two new gas fields with the newly discovered geological reserves over a hundred billion cubic meters. The newly discovered reserve of coal was more than 60 billion tons; tungsten 603,100 tons; gold 824.50 tons; graphite 36.663 million tons.

**The effects of supply-side structural reform policies were achieved and the supply of minerals was stable.** In 2016, the output of primary energy totaled 3.46 billion tons of standard coal equivalents, down by 4.2% on a year-on-year basis; 4.36 billion tons of standard coal equivalents were consumed, up by 1.4%; the proportion of raw coal witnessed continuous declining. The output of raw coal was 3.36 billion tons, down by 3.0%; crude oil 200 million tons, down by 7.7%; natural gas 136.83 billion cubic meters, up by 1.7%; iron 1.28 billion tons, down by 3.0%; cement 2.4 billion tons, up by 2.5%.

**The protection of geological environment of mines continuously was strengthened and the development of green mining industry proceeded smoothly.** Green exploration was included in the *Outline of the '13<sup>th</sup> Five-year' Plan for Land and Resources* and green and environmental technologies and methods were popularized proactively to vigorously develop green mining industry. Nine centralized exploitation areas for vital mineral resources were selected. RMB 60.69 million was invested to carry out a survey of geological environment for mines with areas totaled 6,150 square kilometers and scale at 1:50,000. 590 square kilometers of geological environment governance of mines were achieved nationwide.

**The strategy of ruling by law was deeply promoted and policies and regulations regarding mineral resources were improved continuously.** Since 2016, four regulations of geological and mineral management department have been modified, and 315 normative documents have been abolished. The administrative approval items for geological mineral have been continuously streamlined. The reform of mineral right transfer system was promoted. The reform of mineral resource royalty was carried out, and the price-based collection of resource tax was comprehensively implemented. The reform of oil and natural gas system was promoted steadily.

**The reform in mineral resource management was further promoted, with an attempt to reduce the cost of mining enterprises.** The package exploration layout of mineral resources was further optimized and the pilot work of unified confirmation and registration of rights to mineral resources with proved reserves was carried out. The construction of standard system for mineral reserves was promoted. The *National Plan of Mineral Resources (2016-2020)* was formally put into effect.

**The geological data management was improved increasingly and the ability of serving the society was raised continuously.** The competent departments of land and resources and geological data collection institutions enhanced the collection and management of geological data, strengthened the information service, further perfected the geological data management system and technical standard specification, and highlighted the networked service and special service. In 2016, the National Geological Archives, Cores and Samples Center of Land and Resources and 31 provincial geological archives received totally 30,400 person-times on site and provided 118,000 set-times of data services.

**The basic geological work was further improved and abundant achievements were made in geological survey and assessment of mineral resources.** By the end of 2016, the area of regional geological survey achieved was 3.7306 million square kilometers at 1:50,000, accounting for 38.9% of national land area. Twenty oil & gas prospects were delineated in the periphery of Songliao Basin, the periphery of Tarim and Junggar Basin in Xinjiang and Yin'e Basin, etc. Besides, there were great discoveries of manganese, copper, graphite and potash, etc. in the western China.

**The 'Three Deeps and One Land' innovation on land & resources science and technology were implemented to improve the science and technology innovation ability.** The independent innovation in exploration & exploitation theory, technology, engineering and equipment of marine gas hydrate were achieved. The mineralization model and exploration model of lead-zinc polymetallic deposit in 'Three Rivers' (Jinsha river, Lancang river and Nujiang river) orogenic belt were innovated. Three national standards and 45 industrial standards for geology and mineral resources were issued and implemented. The minimum indicator requirements for mining recovery rate, beneficiation recovery rate and comprehensive utilization rate of six minerals (including lithium, strontium, etc.) were issued, and 62 advanced and applicable technologies were selected for popularization.

**The international cooperation was expanded continuously and significant effects were achieved on geology and mineral resources in 'the Belt and Road'.** Bilateral and multilateral cooperation in the mining industry was promoted actively. The exchange and cooperation with ASEAN, UN-related organizations, World Bank and other international organizations were further expanded through international exchange platforms and project cooperation, such as China Mining Congress & Expo, China-ASEAN Mining Cooperation Forum and geological surveys, so as to promote the development of the mining industry.

# Chapter I

## Mineral Resources

36 major minerals, such as coal and manganese, witnessed various growths of discovered reserves, and evident growth of strategic minerals such as tungsten and graphite. The newly-discovered reserves of oil, natural gas and zinc etc., were significant with two oil fields of reserve more than one hundred million tons, two natural gas fields more than one hundred billion cubic meters, and one lead-zinc deposit more than ten million tons.

### I. Resources & Reserves

#### 1. Growth in the remaining reserves & resources

In 2016, the remaining reserves & resources of 36 major minerals increased, and which of 12 decreased. The remaining technologically recoverable reserves of oil, natural gas and coal-bed methane rose by 0.1%, 4.7% and 9.2% respectively, shale gas decreased by 6.0%. The remaining reserves & resources of coal rose by 2.0% while that of iron ore decreased by 1.2%, copper rose by 2.0%, bauxite 3.1%, tungsten 6.0%, tin 6.5%, gold 5.2%, crystalloid graphite 13.3%, phosphate rock 5.6%, while that of potash decreased by 1.9% (Table 1-1).

#### 2. Newly-discovered reserves & resources

In 2016, the newly-discovered geological reserves of oil and natural gas were 914 million tons, and 726.56 billion cubic meters respectively. The newly-discovered reserve & resources was 60.68 billion tons for coal, 518 million tons for iron ore, 3.63 million tons for copper, 156 million tons for bauxite, 603,000 tons for tungsten ore, 824.5 tons for gold, and 36.66 million tons for crystalloid graphite (Table 1-2).

Table 1-1 Remaining Reserves & Resources of Major Minerals

No.	Mineral	Unit	2015	2016	Growth rate/%
1	Coal	Billion tons	1566.31	1598.00	2.0
2	Oil	Billion tons	3.50	3.501	0.1
3	Natural gas	Billion cubic meters	5193.95	5436.55	4.7
4	Coal-bed methane	Billion cubic meters	306.25	334.40	9.2
5	Shale gas	Billion cubic meters	130.18	122.41	-6.0
6	Iron ore	Billion tons of ores	85.08	84.06	-1.2
7	Manganese ore	Billion tons of ores	1.38	1.55	12.6
8	Chromite	Thousand tons of ores	12458	12332	-1.0
9	Vanadium	Thousand tons of V <sub>2</sub> O <sub>5</sub>	61257	64018	4.5
10	Titanium	Million tons of TiO <sub>2</sub>	764	786	2.9
11	Copper	Million tons of metal	99.10	101.11	2.0
12	Lead	Million tons of metal	77.67	85.47	10.0
13	Zinc	Million tons of metal	149.85	177.99	18.8
14	Bauxite	Billion tons of ores	4.71	4.85	3.1
15	Nickel	Million tons of metal	11.17	11.18	0.2
16	Cobalt	Thousand tons of metal	680.0	672.5	-1.2
17	Tungsten	Thousand tons of WO <sub>3</sub>	9588.0	10159.5	6.0
18	Tin	Thousand tons of metal	4180.0	4453.2	6.5
19	Molybdenum	Million tons of metal	29.18	28.82	-1.2
20	Antimony	Thousand tons of metal	2926.0	3072.4	5.0
21	Gold	Tons of metal	11563.5	12166.98	5.2
22	Silver	Thousand tons of metal	254	275	8.4
23	Platinum group metal	Tons of metal	369.2	365.5	-1.0
24	Strontium	Million tons of celestite	55.83	55.16	-1.2
25	Lithium	Thousand tons of oxide	9708.4	9614.6	-1.0

## China Mineral Resources 2017

Continued

No.	Mineral	Unit	2015	2016	Growth rate/%
26	Magnesite	Billion tons of ores	2.97	3.09	3.9
27	Fluorite	Million tons of minerals	221	222	0.4
28	Refractory clay	Billion tons of ores	2.56	2.58	0.8
29	Pyrites	Billion tons of ores	5.88	6.04	2.7
30	Phosphate rock	Billion tons of ores	23.11	24.41	5.6
31	Potash	Billion tons of KCl	1.08	1.06	-1.9
32	Boron ore	Million tons of B <sub>2</sub> O <sub>3</sub>	75.76	76.48	0.9
33	Sodium salt	Billion tons of NaCl	1368.00	1412.86	3.3
34	Mirabilite	Billion tons of Na <sub>2</sub> SO <sub>4</sub>	117.07	117.11	0.1
35	Barite	Million tons of ores	330	350	6.4
36	Cement limestone	Billion tons of ores	128.23	134.33	4.8
37	Glass-making siliceous-rock	Billion tons of ores	7.90	8.32	5.3
38	Gypsum	Billion tons of ores	100.42	97.26	-3.1
39	Kaolin	Billion tons of ores	2.71	3.39	25.4
40	Bentonite	Billion tons of ores	2.89	2.97	2.8
41	Diatomite	Million tons of ores	480	490	2.1
42	Veneer granite	Billion cubic meters of ores	3.43	4.64	35.1
43	Veneer marble	Billion cubic meters of ores	1.61	1.63	1.2
44	Diamond	Kg of minerals	3396.5	3124.6	-8.0
45	Crystalloid graphite	Million tons of minerals	260	300	15.4
46	Asbestos	Million tons of minerals	91.57	95.66	4.5
47	Talc	Million tons of ores	275	286	4.1
48	Wollastonite	Million tons of ores	170	166	-2.4

Note: Data of oil, natural gas, coal-bed methane and shale gas are remaining technologically recoverable reserves.

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

No.	Mineral	Unit	2015	2016
1	Coal	Billion tons	39.03	60.68
2	Oil	Million tons	1118	914
3	Natural gas	Billion cubic meters	677.22	726.56
4	Coal-bed methane	Billion cubic meters	2.63	57.61
5	Shale gas	Billion cubic meters	437.38	0.00
6	Iron ore	Million tons of ores	1200	518
7	Manganese ore	Million tons of ores	110	172
8	Copper	Million tons of metal	3.92	3.63
9	Lead	Million tons of metal	4.37	6.31
10	Zinc	Million tons of metal	5.73	22.40
11	Bauxite	Million tons of ores	491	156
12	Nickel	Thousand tons of nickel	1129	128
13	Tungsten	Thousand tons of WO <sub>3</sub>	2484	603
14	Tin	Thousand tons of metal	44	41
15	Molybdenum	Thousand tons of metal	1023	226
16	Antimony	Thousand tons of metal	147	52
17	Gold	Tons of metal	1720.4	824.5
18	Silver	Thousand tons of metal	18	16
19	Pyrite	Million tons of ores	114.48	189.76
20	Phosphate rock	Billion tons of ores	1.74	1.34
21	Potash	Million tons of KCl	0	-6.92
22	Crystalloid graphite	Million tons of minerals	41.38	36.66

Note: Data of oil, natural gas, coal-bed methane and shale gas are the newly-discovered geological reserves.

## II. Review and Filing of the Report of Mineral Resources & Reserves

In 2016, 2,568 reports of mineral resources & reserves were reviewed and filed nationwide including the Ministry of Land and Resources and provincial departments of land and resources, down by 15.3% on a year-on-year basis, in which 108 reports of reserves of oil & gas and 2,460 reports of non-oil & gas minerals (Table 1-3). The Ministry of Land and Resources reviewed and filed 204 reports, down by 19.0%; provincial departments of land and resources reviewed and filed 2,364 reports, down by 15.0%. The first five minerals ranked by the quantity of reports reviewed and filed were coal (653 reports, representing 25.4%), gold (263 reports, representing 10.2%), iron ore (221 reports, representing 8.6%), geothermal resources (145 reports, representing 5.6%) and cement limestone (96 reports, representing 3.7%).

In 2016, 2,460 reports of resources & reserves of non-oil & gas mineral resources were reviewed and filed, including 1167 reserve verification reports (47.5%), 947 exploration reports (38.5%), 180 reports of overlaid mineral resources (7%), 84 geological reports for mining (3.5%), 71 mine-closure reports (3%) and 11 reports of others (0.5%) (Table 1-4).

## III. Potential of Mineral Resources

### 1. Oil & gas

Up to the end of 2016, the geological resources of oil were 125.7 billion tons, including 30.1 billion tons recoverable. The geological resources of natural gas were 90 trillion cubic meters, including 50 trillion cubic meters recoverable. The geological resources of shale gas shallower than 4,500 meters were 122 trillion cubic meters, including 22 trillion cubic meters recoverable. The geological resources of coal-bed methane shallower than 2,000 meters were 30 trillion cubic meters, including 12.5 trillion cubic meters recoverable.

### 2. Non-oil & gas minerals

China boasts a huge prospecting potential, as shown in the evaluation on the potential of 24 major mineral resources, including coal, iron, manganese, chromite, copper, lead, zinc, bauxite, tungsten, tin, molybdenum, antimony, nickel, gold, silver, lithium, pyrite, sulphurite, phosphate rock, potash, magnesite, fluorite, boron and barite (Table 1-5).

Table 1-3 Review and Filing of Reports on Mineral Resources & Reserves

Reviewed & Filed by		2015	2016	Growth rate/%
Ministry of Land and Resources	Solid minerals	77	96	24.7
	Oil & Gas	175	108	-38.3
	Total	252	204	-19.0
Provincial departments of land and resources		2781	2364	-15.0
Total		3033	2568	-15.3

Table 1-4 Review and Filing of Reports of Reserves of Non-oil & gas Minerals

Report Type	2016		2015	
	Number of Reports	Proportion/%	Number of Reports	Proportion/%
Exploration	947	38.5	1118	39.1
Verification	1167	47.5	1329	46.5
Overlaid mineral resources	180	7.3	199	7.0
Mining	84	3.4	81	2.8
Mine-closure	71	2.9	102	3.6
Others	11	0.4	29	1.0

Table 1-5 Potential of Major Mineral Resources in China

Mineral	Unit	Predicted Resources	Discovery Rate <sup>1</sup> %
Coal	Trillion tons	3.88	30.3
Iron ore	Billion tons of ores	196	33.2
Manganese	Billion tons of ores	3.52	35.6
Chromite	Million tons of ores	56	24.5
Copper	Million tons of metal	304	30.5
Lead	Million tons of metal	235	33.1
Zinc	Million tons of metal	511	32.3
Bauxite	Billion tons of ores	13	29.1
Nickel	Million tons of metal	25	36.7
Tungsten	Million tons of WO <sub>3</sub>	30	30.1
Tin	Million tons of metal	19	31.7
Molybdenum	Million tons of metal	90	25.4
Antimony	Million tons of metal	15	30.2
Gold	Thousand tons of metal	33	36.1
Silver	thousand tons of metal	726	35.1
Lithium	Million tons of spodumene	6	37.7
	Million tons of LiCl	92	18.9
Pyrites	Billion tons of ores	18	26.6
Natural sulfur	Million tons of sulfur	230	60.3
Phosphate rock	Billion tons of ores	56	31.9
Potash	Billion tons of KCl	2	39.4
Barite	Billion tons of ores	1.4	27.6
Boron	Million tons of B <sub>2</sub> O <sub>3</sub>	189	38.2
Magnesite	Billion tons of ores	13	20.1
Fluorite	Million tons of minerals	953	25.9

Note: the burial depth is less than 2000 meters.

# Chapter II

## Exploration

In 2016, more than RMB 77 billion was invested in geological exploration. The proportion of investment in public-welfare geological survey was growing continuously and the governmental investment played a more important role in mineral exploration. Remarkable ore-prospecting achievements were made in such strategic minerals as oil, natural gas, copper, tungsten and graphite.

### I. Exploration Investment

#### 1. The exploration investment decreasing for four consecutive years

In 2016, the exploration investment totaled RMB 77.479 billion, down by 16.6% year-on-year, and the decrease for four consecutive years. The exploration investment of oil & gas was RMB 52.75 billion, down by 12.1%, and that of non-oil & gas minerals was RMB 24.729 billion, down by 24.8% (Fig. 2-1).

In 2016, 2,715 wells were drilled in oil & gas exploration, with a decrease of 10.2%, involving 52,869.80 km of two-dimensional seismic exploration and 26,452.09 km<sup>2</sup> of three-dimensional seismic exploration, down by 37.4% and 20.0% respectively.

#### 2. Exploration investment matrix of non-oil & gas minerals optimized continuously

Since 2011, among the exploration investment of non-oil & gas minerals, the proportion of public-welfare geological survey has been increasing continuously while that of exploration has been in decline. In 2016, among the exploration investment non-oil & gas minerals, the

mineral exploration accounted for 68.7%, decreasing by 11.4 percentage points than 2011; the basic geological exploration accounted for 14.1%, increasing by 4.6 percentage points; the geological survey of hydrology, engineering and environment accounted for 10.2%, increasing by 3.8 percentage points; the geosciences & technology accounted for 5.7%, increasing by 2.2 percentage points; the data service and informatization accounted for 1.3%, increasing by 0.8 percentage point (Fig. 2-2).

### 3. Governmental investment playing an important role

In 2016, for the exploration investment of non-oil & gas minerals, the financial investment by the central government accounted for 13.4%, increasing by 6.4 percentage points than 2011; the financial investment by local governments accounted for 31.2%, increasing by 10.4 percentage points; the total financial investment accounted for 44.6%, increasing by 16.8 percentage points; the social fund investment accounted for 55.4%, decreasing by 16.8 percentage points (Fig. 2-3).

## II. Oil & gas Exploration

In 2016, the newly-discovered geological reserves of oil and natural gas were 914 million tons and 726.56 billion cubic meters respectively, mainly in the Erdos, Sichuan, Junggar, Tarim, other mid-west and marine basins. Ordos Basin continuously witnessed high growth in geological reserves. Two oil fields, namely, Nanliang Oil Field and Huanjiang with geological reserves more than 100 million tons, were newly explored in eastern Gansu. The newly-discovered geological reserve of natural gas in Sulige was 311.1 billion cubic meters, representing nearly half of the national newly-discovered reserves of natural gas. With the newly-proved reserves of natural gas of 152.8 billion cubic meters, Anyue Gas Field in Sichuan is gradually becoming a giant gas field with a geological reserves of trillion cubic meters. A great breakthrough was made in oil exploration in the Shunbei Area of Tarim Basin, and a great discovery was made by No. 58 Zhonggu Well in buried-hill exploration in the Cambrian system in the eastern region of central Tarim. There were important discoveries in oil exploration in the Permian and Triassic systems on the eastern slope of Mahu in Junggar Basin, with the hundred-million-ton reserve scale. The newly-discovered geological reserves of oil in Bohai Gulf was over 100 million tons.

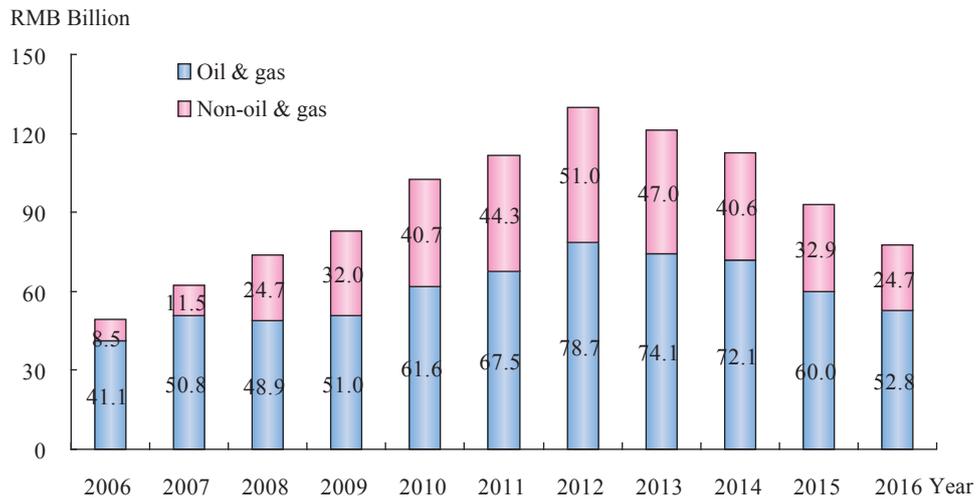


Fig. 2-1 Exploration Investment

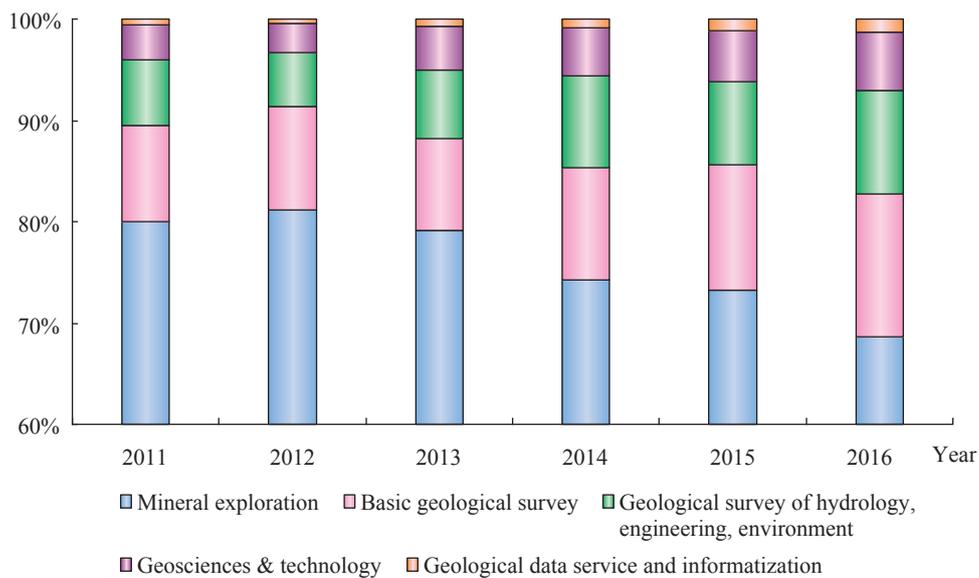


Fig. 2-2 Structure of Investment in Geological Survey of Non-oil & gas Minerals

### III. Non-oil & gas Exploration

In 2016, 10 coal fields were discovered in Xinjiang, Inner Mongolia, Shaanxi and Guizhou, etc., with the newly-discovered resources & reserves totaling 60.68 billion tons.

8 iron ore deposits were discovered mainly in Anhui, Xinjiang and Liaoning, etc., with the newly-discovered reserves totaling 518 million tons. 2 manganese deposits were found in Guizhou and Guangxi, with the newly-discovered resources & reserves totaling 172 million tons.

7 copper deposits were discovered, mainly in Jiangxi, Xinjiang and Tibet, etc., with the newly-discovered resources & reserves totaling 3.63 million tons, 11 lead and zinc deposits were discovered, mainly in Xinjiang, Tibet and Inner Mongolia, etc., with the newly-discovered resources & reserves totaling 6.308 million tons and 22.304 million tons respectively. 2 bauxite deposits were discovered in Guizhou and Henan with the newly discovered resources & reserves totaling 156 million tons. The newly-discovered resources & reserves of nickel was 128,000 tons mainly in Qinghai. 2 tungsten deposits were discovered in Hunan and Jiangxi, with the newly-discovered resources & reserves totaling 603,000 tons. 3 tin deposits were discovered in Hunan, Qinghai and Yunnan, with the newly-discovered resources & reserves totaling 41,000 tons. The newly-discovered resources & reserves of molybdenum was 226,000 tons, mainly in Henan, Gansu and Tibet.

12 gold deposits were discovered mainly in Guizhou, Shandong and Inner Mongolia, etc., with the newly-discovered resources & reserves totaling 824.5 tons. 2 silver deposits were discovered in Jiangxi, Inner Mongolia and Guangdong, with the newly-discovered resources & reserves totaling 16,000 tons.

The newly-discovered resources & reserves of phosphate rock was 1.34 billion tons mainly in Guizhou, Hubei and Yunnan. 5 graphite deposits were discovered mainly in Inner Mongolia and Heilongjiang, etc., with the newly-discovered resources & reserves totaling 36.66 million tons

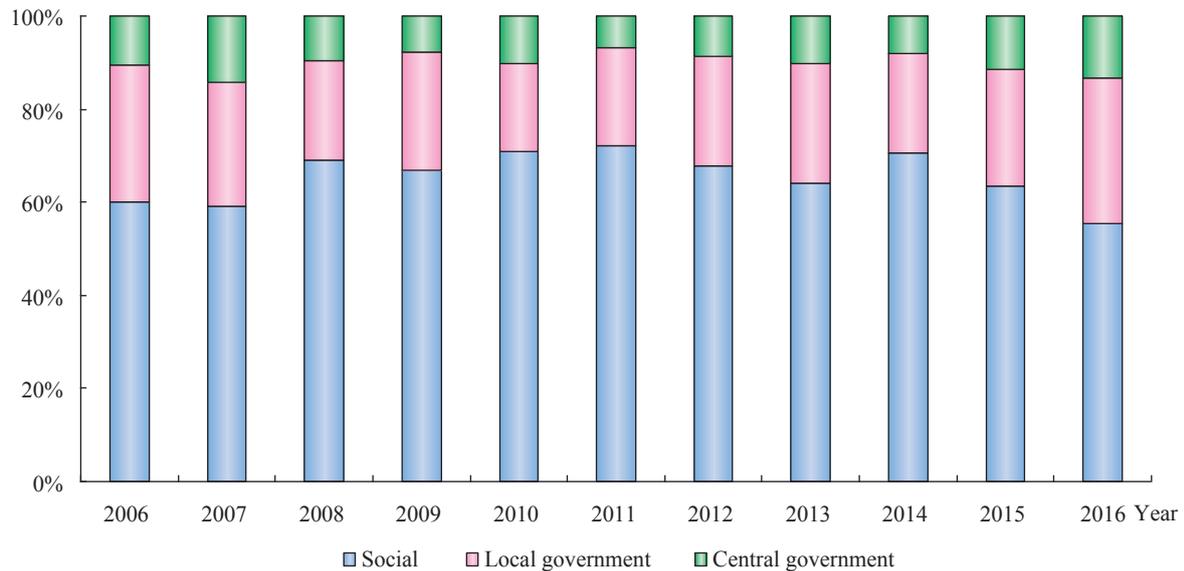


Fig. 2-3 Investment source in Geological Exploration of Non-oil & gas Minerals

### Column 2-1 New Progress in mineral exploration with Geological Exploration Fund

In 2016, the Central Geological Exploration Fund invested RMB 120 million, completed drilling of 27,000 meters and discovered 17 new ore fields; the provincial geological exploration funds invested RMB 4.885 billion and carried out 1,148 projects. The newly-discovered resources & reserves of tungsten trioxide resources was 578,500 tons in the 'General Investigation of Jiangxi Fuliang Cooper-Tungsten—Leping Baishu Tungsten-Copper Polymetallic Ore' carried out cooperatively by the Central Geological Exploration Fund and the Geological Exploration Fund of Jiangxi Province. Besides, in the project, the accumulative newly-discovered tungsten trioxide resources were 3.4433 million tons, and the paragenetic copper resources were 112,600 tons.

# Chapter III

## Development and Utilization

The production and consumption of minerals such as primary energy, crude steel, gold and cement ranked the forefront of the world. The excess capacity of coal and steel was solved effectively and the energy consumption structure was optimized constantly. The minimum index requirements for the mining recovery rate, dressing recovery rate and comprehensive utilization rate of 6 minerals (including lithium, strontium, etc.) were issued. 62 recommended technologies were selected for popularization.

### I. Mining Fixed Assets Investment

In 2016, mining fixed assets investment in China totaled RMB 1.0 trillion, down by 20.4% year-on-year. In which, coal mining & dressing was RMB 303.8 billion, down by 24.2%; oil & gas extraction was RMB 233.1 billion, down by 31.9%; ferrous metal mining & dressing was RMB 97.8 billion, down by 28.4%; non-ferrous metal mining & dressing was RMB 142.9 billion, down by 10.0%; nonmetal mining & dressing was RMB 212.6 billion, up by 1.6% (Fig. 3-1).

### II. Production and Consumption

#### 1. Energy

China is the largest producer and consumer of energy in the world. In 2016, the total output of primary energy was 3.46 billion tons of standard coal equivalents, down by 4.2% a year-on-year (Fig. 3-2); the energy consumption totaled 4.36 billion tons of standard coal

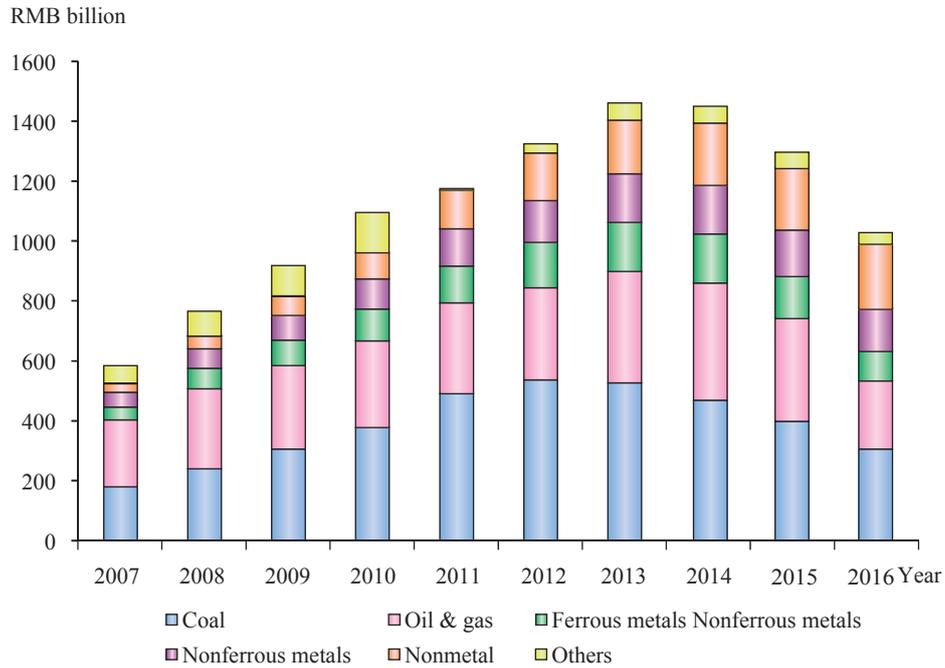


Fig. 3-1 Mining Fixed Assets Investment

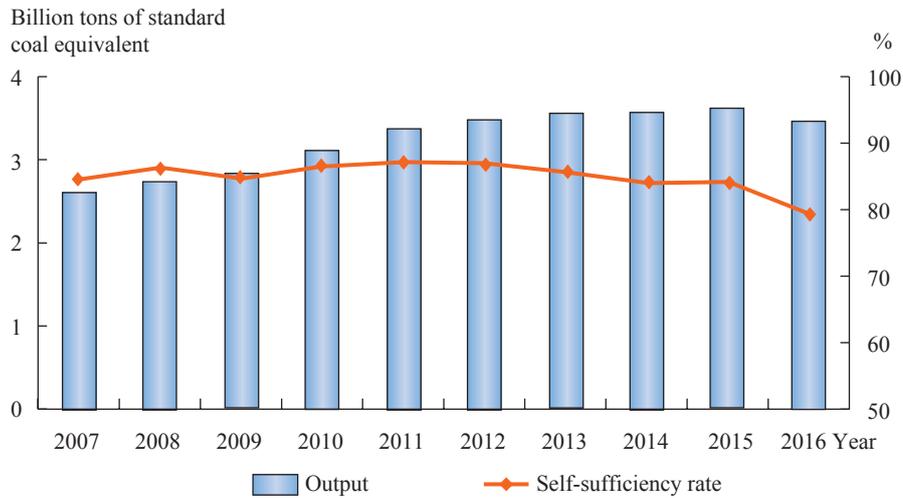


Fig. 3-2 Primary Energy Production

equivalents, up by 1.4%; the self-sufficiency rate for energy was 79.4%. In 2016 energy consumption matrix, coal and oil accounted for 62.0% and 18.3% respectively, and clean energy resources such as hydropower, wind power, nuclear power and natural gas accounted for 19.7%.

With the continuous improvement of China's energy consumption matrix, the proportion of coal declined continuously while the proportion of natural gas and other clean energy resources kept rising. The proportion of total coal consumption in 2016 decreased by 0.2 percentage points compared with that in 2015, and decreased by 10.5 percentage points compared with that in 2007. The hydropower, wind power, nuclear power and natural gas, etc. grew by 1.8 percentage points, compared with that in 2015 (Fig. 3-3).

Coal output has continuously ranked first in the world for many years. In 2016, coal output reached 3.36 billion tons, with a year-on-year decrease of 3.0%; annual coal capacity cut exceeded 290 million tons; coal consumption amounted to 3.78 billion tons. Ranking sixth in the world, oil output was 200 million tons, down by 7.7% (Fig. 3-4), and oil consumption totaled 579 million tons. Ranking sixth in the world, natural gas output was 136.83 billion cubic meters, up by 1.7%, and natural gas consumption totaled 210.34 billion cubic meters.

## 2. Metals

In 2016, productions and consumptions of crude steel, ten kinds of nonferrous metals and gold ranked first in the world. Iron ore output was 1.28 billion tons, with a year-on-year decrease of 3.0%, and iron ore consumption was 1.69 billion tons. Output of crude steel totaled 810 million tons, up by 1.2% (Fig. 3-5), and annual steel capacity cut exceeded 65 million tons. Output of ten kinds of nonferrous metals reached 52.83 million tons, up by 2.5%, including refined copper of 8.44 million tons and electrolytic aluminum of 31.87 million tons, up by 6.0% and 1.3% respectively. Gold production was 453.5 tons, up by 0.8%, and consumption 975.4 tons, down by 6.7%.

## 3. Non-metals

In 2016, phosphate rock production (30% of  $P_2O_5$ ) was 140 million tons, with a year-on-year growth of 1.0%; plate glass output was 770 million weight cases, up by 5.8%; cement output was 2.4 billion tons, up by 2.5% (Fig. 3-6).

### Column 3-1 Pilot extraction of marine NGH in China Succeeded

On July 29, 2017, the offshore operation for the pilot extraction of NGH in the Shenhu area, South China Sea, implemented by China Geological Survey, was comprehensively completed, indicating that China first pilot extraction of marine NGH ended. By July 9, 2017, the pilot extraction of NGH in the Shenhu area, South China Sea had continuously extracted NGH for 60 days and accumulatively obtained 309,000 cubic meters, with the average daily output of over 5,000 cubic meters and the maximum output of 35,000 cubic meters per day; the maximum methane content was up to 99.5%. 6.47 million sets of scientific experimental data provided reliable support for the subsequent scientific research. Breakthroughs, such as the longest continuous NGH extraction duration, maximum total NGH output, steady NGH flow and safe environment, were achieved, in which NGH extraction duration and total output set a world record.

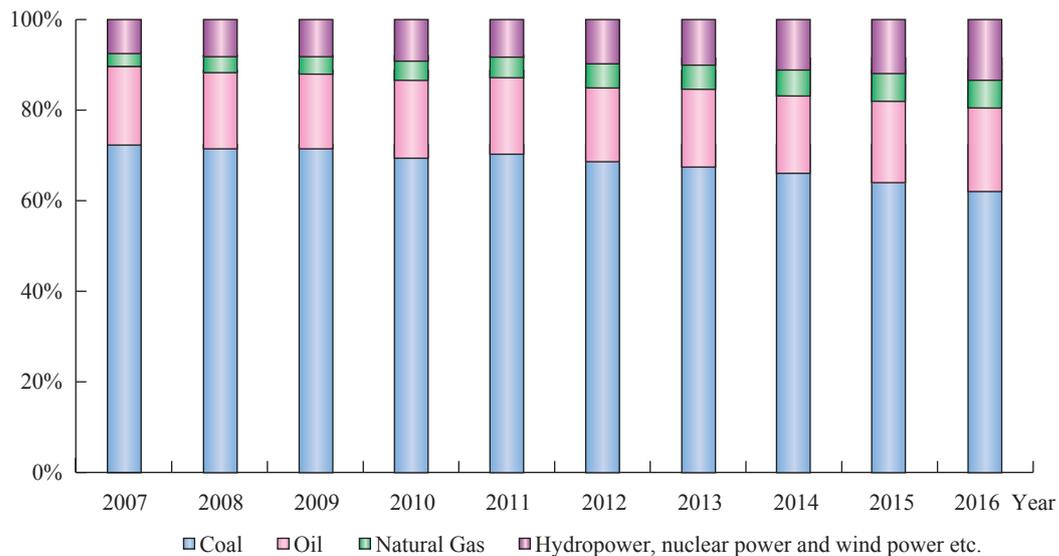


Fig. 3-3 Primary Energy Consumption Matrix

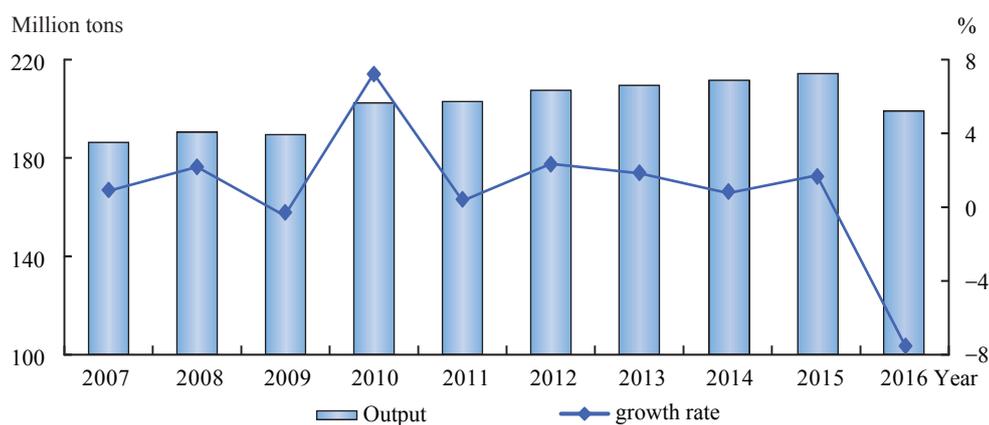


Fig. 3-4 Crude Oil Output

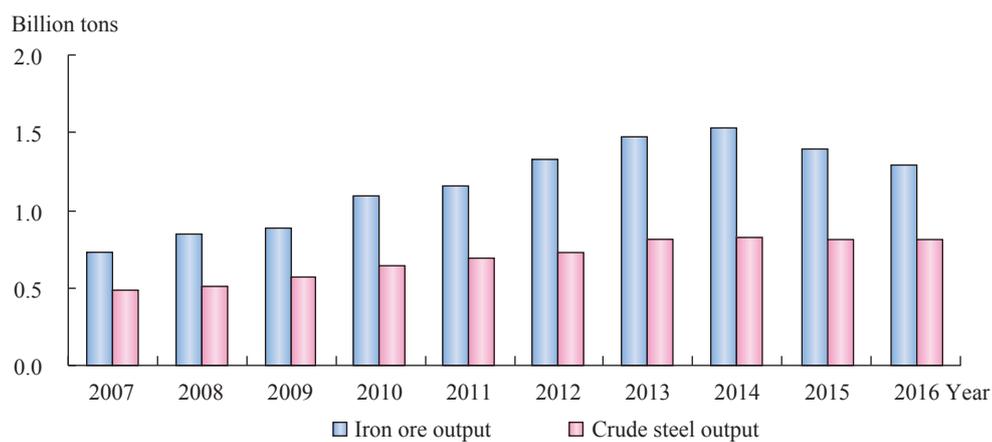


Fig. 3-5 Outputs of Iron Ore and Crude Steel

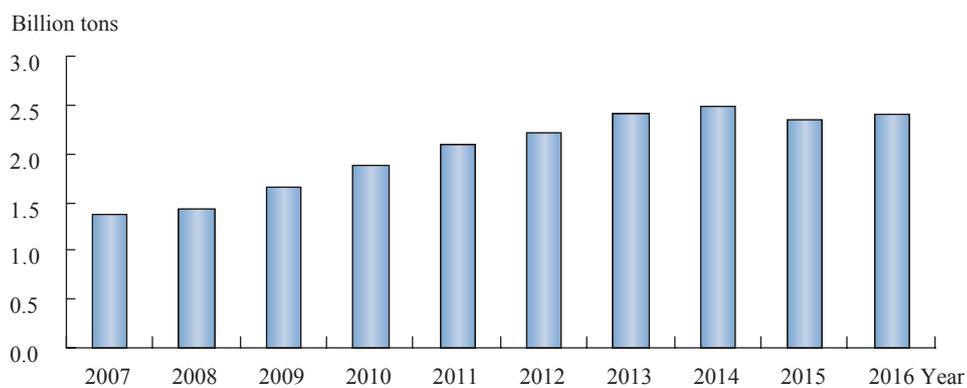


Fig. 3-6 Cement Output

**Table 3-1 Promotion List of Recommended Technologies for Comprehensive Utilization of Mineral Resources (V)**

Minerals	SN	Efficient Mining and Dressing & Comprehensive Utilization Technologies
Coal (6)	1	Microbial remediation technology with mycorrhiza etc. for land reclamation in arid and semiarid coal mines in western china
	2	Coal extraction technology by overburden strata isolating- grouting without village relocation
	3	Non-pillar and self-tunneling 110-method technology for thick coal bed
	4	Key technology and equipment for heavy-medium fluid-bed coal dressing with modular dry method
	5	Technology of information collection and intelligent identification and control of coal production system
	6	Key technology for coal extraction by grouting to floor and water preservation in deep-buried seam of coal mine
Oil & natural gas (13)	7	Safe and efficient extraction technology of gas fields with high sulfur content
	8	Technology for meticulous description and efficient extraction of super-deep organic reef gas reservoirs
	9	Intensive extraction technology of large well groups in super tight gas reservoirs
	10	Efficient and energy-saving design technology of sucker-rod pumping system
	11	Purification and upgrading technology of high hydrogen sulfide-bearing crude oil
	12	Utilization technology of contaminated crude oil by ultrasonic and high frequency electric treatment
	13	Anti-eccentric wear technology for sucker rod of directional wells
	14	Integrated technology for water injection, testing and adjustment
	15	An automatic system for sewage recycling and reusing
	16	CO <sub>2</sub> fracturing technology for tight oil and gas reservoirs with low-permeability
	17	Technology for non-excavation replacement of buried oil and gas pipes in situ
	18	Key technology of high-efficient utilization of rock chips in shale gas drillings
	19	Technology of drilling machines powered by electricity replacing oil

Continued

Minerals	SN	Efficient Mining and Dressing & Comprehensive Utilization Technologies
Metal (31)	20	technology of deep coning with full tailings without power and preparation & filling of dense paste
	21	Efficient exploitation technology for super open pits
	22	CFP series of magnetic flotation column and flotation technology
	23	Dressing technology of vanadium titano-magnetite with low-titanium
	24	High intensity mining technology for super panel in slightly inclined-inclined medium-thick ore body
	25	Integrated technology for dry grinding and separation
	26	Technology for gradient utilization of high-sulfur and low-silicon iron ore tailings
	27	Software for digital evaluation and exploitation of mineral resources
	28	Bio-safety identification technology of cooper mines by biological extraction
	29	Key technology for horizontal pillars which are super, complicated and difficult to be extracted
	30	Flotation technology for porphyry copper and associated elements
	31	Key technology for large-scale, safe and efficient exploitation of open metal mines
	32	Beneficiation technology by intelligent imaging
	33	Integrated informatization technology for mining and dressing process
	34	Full tailings paste filling technology
	35	New mining technology by cementation and filling of classified tailings
	36	Technology for sewage treatment and recycling of lead and zinc flotation factory
	37	Technology of controlled blasting in slope and ore rock in extremely-hard rock
	38	Technology for digitalized mining and dressing of nonferrous metal mines
	39	Technology for low-cost and harmless treatment of low-concentration and acid wastewater in mines
40	Technology for efficient flocculation and recycling of dressing wastewater containing suspended solids	

Continued

Minerals	SN	Efficient Mining and Dressing & Comprehensive Utilization Technologies
Metal (31)	41	Key technology for clean and efficient dressing of high sulfur copper–cobalt polymetallic ores hard to dress
	42	Technology for gold extraction by CCGRI biological oxidation
	43	Engineering technology and equipment for high purification and comprehensive utilization of carbon slurry tailings
	44	Mining method of waste rock backfilling in–situ and enhancing recovery rate
	45	Key technology for large–scale development of low–grade resources in gold mines
	46	New technology for low–carbon and efficient utilization of light rare earth hard to dress
	47	Efficient gravity–flotation dressing technology of strontium (celestite)
	48	Technology for supervision, forcing filling and collaborative governance of goaf
	49	Continuously efficient mining technology without pillar in medium–thick ore body
	50	Regeneration Technology of activated carbon by wet process under room temperature and atmospheric pressure
Nonmetal (12)	51	Technology of neutral recovery of complex kyanite and comprehensive utilization of associated minerals
	52	Key technology for selective milling of fluorite
	53	Stone cutting technology with rail–wheel saw
	54	Dressing technology of colophonite by heavy–medium cyclone
	55	Technology for safe and efficient mining of medium–thick broken phosphate rock body
	56	Technology for recovery of residual pillars of vein ore body
	57	Technology for digital intelligent blasting of open pits
	58	Technology for regrinding and flotation of low–grade crude fluorite concentrate
	59	Automatic control system for crystalloid graphite dressing
	60	Technology for efficient utilization of shale with sound absorption and noise reduction
	61	Technology and equipment for comprehensive utilization of low–grade pyrite
	62	Technology for mining and blending of inter–bedded limestone and dolomite ores

### III. Conservation and Comprehensive Utilization

#### 1. Investigation and evaluation system for development and utilization level of mineral resources established

The minimum index requirements for mining recovery rate, dressing recovery rate and comprehensive utilization rate of six minerals, i.e. lithium, strontium, barite, limestone, magnesite and boron, were issued in 2016. The *Work Program for the Investigation and Evaluation System for Development and Utilization Level of Mineral Resources* was published in December, 2016. It is expected to establish a normal, scientific and standard investigation and evaluation system for development and utilization level with different incentives and constraints, develop the basic ‘three-rate’ index system for major minerals, and continuously raise the development and utilization level of mineral resources by 2020.

#### 2. Popularization of recommended technologies for conservation and comprehensive utilization of mineral resources accelerated

The promotion list of advanced and applicable technologies (V), including 6 technologies for coal, 13 for oil & gas, 31 for metals and 12 for nonmetals (Table 3-1) was published. At present, the promotion list of selected 272 recommended technologies was released.

# Chapter IV

## Geological Environment Protection and Green Mines

Policy and system innovations were further explored, and the governance, restoration and protection of geological environment of mines were carried forward proactively. The concept of green exploration was upheld to energetically develop and popularize the green exploration technology. Supportive policies, such as mineral use policy, land use policy, fiscal policy and financial policy, were expressly specified, in order to comprehensively facilitate the development of green mining.

### I. Protection, Governance and Restoration of Geological Environment of Mines

#### 1. Policy and regulation innovations further explored

The *Guiding Opinions of the Ministry of Land and Resources, Ministry of Industry and Information Technology, Ministry of Finance, Ministry of Environmental Protection and National Energy Administration on Strengthening the Geological Environmental Restoration and Integrated Renovation of Mines* was promulgated and enforced, in order to promote the policy and regulation innovations in restoration and comprehensive treatment of geological environment of mines. Tightening of admittance requirements, intensification of supervision, implementation of corporate responsibility and other measures were adopted to strictly prevent the emergence or accumulation of new environmental problems of mines. Solving of problems left over by history was accelerated by taking such measures as land and mineral utilization policy innovation, public-private partnership (PPP) mode and the third-party governance.

### 2. The regulation reform deepened to enhance protection and prevention

In 2016, the *Notice of the General Office of Ministry of Land and Resources on Finishing Work Related to Preparation and Presentation of Scheme on Geological Environment Protection and Land Reclamation of Mines*, and the *Guide for Preparation of Scheme on Geological Environment Protection and Land Reclamation of Mines* were promulgated, and the combined preparation and presentation system for scheme on protection, governance and restoration of geological environment of mines, and scheme on land reclamation of mine enterprises was implemented, streamlining the administrative approval process, raising the work efficiency, easing mine enterprises' burden, promoting the comprehensive treatment of environmental problems and enhancing land utilization within mine fields.

### 3. Investigation and governance of geological environment of mines carried out actively

In 2016, nine different centralized exploitation regions for mineral resources were selected group by major mineral resources development zones, an investigation of geological environment of mines for 6,150 square kilometers at 1:50,000 was carried out with an investment of RMB 60.69 million. The investigation focused on the ecological damage arising from water & soil environment pollution and mine drainage, and the characteristics of impacts that mineral resource development activities have on regional geological environment were preliminarily researched and delineated. Besides, the area of geological environment restoration of mines completed reached 590 square kilometers.

### 4. Great efforts to promote the construction of mine parks

32 national mine parks were officially named, and 41 provincial mine parks were established. Accumulatively, RMB 2.294 billion was spent on the construction of mine parks.

## II. Green Exploration

### 1. The concept of green exploration initiated

Under the leadership of the concept of green development, for the purpose of creating environmental and economic benefits simultaneously, green exploration was implemented to minimize the environmental impact in the whole process by means of scientific management

and advanced technology. Green exploration initiative was adopted into the *Outline of the '13<sup>th</sup> Five-year' Plan for Land and Resources* in April 2016. Later, on May 10, 2016, the *Declaration of Green Exploration Actions* was published.

### Column 4-1 Qinghai Province firstly started green exploration

With the implementation of provincial government's 'ecological province' strategy, the Land and Resources Department of Qinghai Province published the *Notice on Carrying out the Activity of Green Exploration and Development Year*, and implemented 10 green exploration projects. By integrating geological exploration, ecological protection, herdsmen's interest, Tibetan harmonization, and others during the package exploration in Duocai Region, Qinghai Provincial Bureau of Nonferrous Metal and Geological Exploration put forward the 'Duocai mode' of green exploration in ecologically vulnerable areas, minority areas and prospecting areas, so it led the way nationwide.

## 2. Technology of green exploration developed and promoted

Based on the environmental carrying capacity evaluation, exploration methods, such as trenching, which seriously impacted the surface environment, were properly adjusted and replaced. A green exploration supervision system was established, and all measures for ecological protection of exploration and construction were strictly adopted. Great efforts were made to develop and popularize new technologies and methods, such as airborne geophysical prospecting and remote sensing, in an attempt to reduce the impact of geological exploration on ecological environment.

## III. Green Mines

### 1. *Implementation Opinions on Accelerating Construction of Green Mines* promulgated

In March 2017, the Ministry of Land and Resources, Ministry of Finance, Ministry of Environmental Protection, General Administration of Quality Supervision, Inspection and Quarantine, China Banking Regulatory Commission and China Securities Regulatory

Commission jointly released the *Implementation Opinions on Accelerating Construction of Green Mines*. Three goals were specified as follows: Firstly, preliminarily establishing the new pattern of the construction of green mines, all newly constructed mines meeting the requirements for the construction of green mines, accelerating the transformation and upgrading of mines in production, carrying out 100 demonstrative exploration projects, and establishing more than 50 demonstrative mining areas; Secondly, researching the new path for transformation in mining development mode, the new mode for resource industry and new path for mining economy, promoting mining industry to a higher level; Thirdly, establishing a new mechanism of green mining, strengthening the standardization system of green exploration and green mine construction, and improving the related incentive policies.

### 2. Incentive policies and measures promoted

As for incentive policies of mineral resources, the construction of green mines and green mining development areas were supported preferentially according to laws by means of regulation of total exploitation quantity index, assignment and transfer of mineral rights, etc.

As for the secure of land use, the land demand could be supported and secured in terms of planned scale, annual plan target, acquisition of newly increased land for mine construction and use of inventory land.

As for the fiscal and taxation policies, the support for green mines should be enhanced by overall planning of various financial funds from the central and local governments and implementation of preferential taxation policies for hi-tech enterprises, etc.

As for financial policies, the support with respect to implementation of supportive green credit, listing & financing and construction of credit system, etc. should be intensified.

### 3. A group of advanced models established, and reproducible and applicable experiences obtained

A group of advanced green mine construction models were established, which promoted the efficient utilization, comprehensive utilization and recycling of resources, strengthened the ecological environment protection of mines, led the green development and harmonious development of mines by scientific and technological innovation, and shared the benefits from resource development, and experiences worthy of learning were obtained.

# Chapter V

## Policies and Regulations on Mineral Resources

Since 2016, 4 regulations of geological and mineral management have been modified, and 315 regulations have been abolished. The administrative approval processes for geological and mineral issues have been continuously streamlined. The reform of mineral rights transfer system, mineral resources royalty system was put through, and the price-based collection of resource tax was comprehensively implemented. The reform of oil and natural gas system was promoted steadily.

### I. Regulations on Mineral Resources

#### 1. Streamlining the administrative approval processes

In 2016, the *Decision of the State Council on Cancelling 13 Administrative Approval Items of the Departments of State Council* cancelled ‘geological data protective registration’, an administrative approval item. The *Decision of the State Council on Cancelling the Second Group of 152 Administrative Approval Items Designated by the Central Government for Implementation by Local Governments* cancelled ‘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’, an administrative approval item implemented by the provincial department of land and resources.

### 2. Modification of multiple administrative regulations and policies regarding mineral resources

(1) In February 2016, in the *Decision of the State Council on Amending Some Administrative Regulations*, Article 11 in the *Measures for the Administration of Geological Data* was revised as: ‘When failing to submit geological data within the prescribed deadline in Article 10 hereof due to force majeure, a geological data submitter should inform the geological and mineral management department, which receives geological data, of the fact of force majeure resulting in such a delay in written form.’ In March, in the *Decision of the State Council on Amending and Abolishing Some Administrative Regulations*, Clause 2 of Article 15 in the *Measures for the Administration of Geological Data* was revised as: ‘Geological data except for those specified in preceding clauses should, within 90 days from the submission date, be disclosed to the public by the National Geological Archives or the department safekeeping such geological data. If applicable, the department receiving these geological data should protect them in accordance with the provisions raised by the geological and mineral management department of the State Council.’

In March 2017, the Ministry of Land and Resources, Ministry of Finance, Ministry of Environmental Protection, General Administration of Quality Supervision, Inspection and Quarantine, China Banking Regulatory Commission and China Securities Regulatory Commission jointly released the *Implementation on Accelerating Construction of Green Mines*.

(2) The *Decision of the Ministry of Land and Resources on Amending and Abolishing Some Regulations*, which was promulgated and enforced in 2016, amended 4 Ministerial regulations concerning management of mineral resources, including *Measures for the Implementation of the Regulation on the Administration of Geological Data*, *Provisions on the Protection of the Geologic Environment of Mines*, *Measures for the Implementation of the Regulation on the Protection of Fossil Specimens* and *Measures for the Implementation of the Regulations of the People’s Republic of China on the Administration of Environmental Protection for Offshore Oil Exploration and Development*. Besides, the *Proclamation of the Ministry of Land and Resources on Publishing the List of Abolished or Invalid Normative Documents*, was published, abolishing and invalidating 315 regulations.

(3) In May 2017, the MLR promulgated and enforced the *Regulations of the MLR on Administrative Responses to Lawsuits*, which mainly intensifies the implementation of

administrative organ lawsuit responding responsibility and clearly specifies that the land and resource management department's working body, which takes administrative acts under litigation, should serve as the lawsuit responder, which is required to respond to administrative lawsuits accordingly. The departmental chief and bureau director court-responding-system was established.

### 3. Formulation of new provisions on mineral resources in national laws

Article 79 of the *General Provisions of the Civil Law of the People's Republic of China* (adopted by voting at the 5<sup>th</sup> Session of the 12<sup>th</sup> National People's Congress), which was passed in March 2017, specifies that all unidentified owner of buried or concealed objects shall be owned by the State and that the receiver shall commend or grand a material reward to the unit or individual, which turns over such objects to the State. Article 81 specifies that all mineral resources of the State may be legally exploited either by a state-owned unit and a unit under collective ownership or by citizens. The State safeguards legitimate mineral rights. It is not allowed to buy, sell, lease, mortgage or illegally transfer(in any other ways) the mineral resources and rivers owned by the State and forests, mountains, grasslands, wastelands and intertidal zones owned by the State and owned collectively by law.

## II. Mineral Resource Regimes

### 1. Expanding mining opening-up

The *Notice of the State Council on Some Measures for Expanding the Opening-up and Actively Utilizing the Foreign Investment* promulgated in January 2017 requires loosening accessing restrictions for foreign investment with respect to oil shale, oil sand, shale gas and other unconventional oil & gas and mineral resources in mining industry, and changing the approval system into filing system for cooperative projects regarding oil & gas with foreign companies.

The *Catalogue of Industries for Guiding Foreign Investment (Revised in 2017)* was issued in June 2017 and enforced from July 28, 2017.

### Column 5-1 *Reform Program for Mineral rights Transfer System*

The mineral rights competitive transfer system has been improved. Except in special circumstances, all mineral rights should be transferred by bidding, auction and listing, and the transfer income could be paid in installments per year. The progressive dynamic adjustment mechanism for exploration license occupancy expenses has been established, and to adjust in time the mining license occupancy expense and minimum exploration input standard.

The transfer of mineral rights has been under strict control. The transfer-on-agreement mineral rights has been strictly controlled for specific subjects of exploration & mining, the approved key construction projects, and deep mining of the established large & medium size mines. Besides, the transfer-on-agreement benchmark price system has been developed.

The power of examination and approval has been delegated to lower administration. The MLR examines and approves the exploration and mining licenses of 6 group of minerals, i.e. oil, natural gas, shale gas, radioactive minerals, tungsten and rare earths and the exploration rights of 11 minerals, i.e. coal with resources & reserves of more than 1 billion tons, super-large coal-bed methane, gold, iron, copper, aluminum, tin, antimony, molybdenum, phosphate rock and potash. The MLR's other original power of examination and approval has been delegated to provincial land and resources management departments.

## 2. Reform on mineral rights transfer system

In February 2017, the General Office of the CPC Central Committee and General Office of the State Council issued the *Reform Program for Mineral rights Transfer System*. 6 provinces (regions), i.e. Shanxi, Fujian, Jiangxi, Hubei, Guizhou and Xinjiang, were selected for pilot work, mainly improving the mineral rights competitive transfer system, strictly restricting the transfer-on-agreements, delegating the power of examination and approval to lower levels and strengthening the supervision service, etc.

## 3. Deepening the reform of oil and natural gas system

The *Guidelines on Deepening the Reform of Oil and Natural Gas System*, issued by the Central Committee of the Communist Party of China and the State Council in May 2017, specifies 'deepening the oil & gas exploration & mining, import & export management, pipe network operation, production & processing, product pricing system reform and reform in state-owned

oil & gas enterprises, releasing the market vigor in competitive links and vigor of key oil & gas enterprises so as to improve the following abilities: continuous support of resources, utilizing international and domestic resources, market risk prevention, intensive transportation and fair service, producing and supplying high-quality oil & gas products, strategic safety assurance and supplying of oil & gas, safe and clean operation of full industrial chain, promoting the sustainable and healthy development of oil & gas industry through reform and greatly increasing the discovered resources & reserves to continuously enhance the resources allocation efficiency.’

### Column 5-2 Reform Tasks of *Guidelines on Deepening the Reform of Oil & Gas System*

1. Improve and orderly open up the oil & gas exploration & mining system.
2. Improve the oil & gas import & export management system.
3. Reform the oil & gas pipe network operation mechanism.
4. Deepen the reform in downstream competitive links.
5. Reform the oil & gas product pricing mechanism.
6. Deepen the reform in state-owned oil & gas enterprises.
7. Develop a perfect reserve system with organic combination and mutual complementation of governmental reserves, enterprise reserves for social responsibility and inventory for production & operation.
8. Establish and improve the safety and environmental protection system in oil & gas sector.

## III. Taxes and Fees for Mineral Resources

### 1. Full implementation of resource ad valorem tax

In May, 2016, the Ministry of Finance and the State Administration of Taxation issued the *Notice on Promoting Comprehensively the Resource Tax Reform* and the *List of Items and Rates of Resource Taxes*, proposing the implementation of pilot work for water resources tax reform and the implementation of ad valorem tax of mineral resources from July 1, 2017 (Table 5-1). The 2016 national resources tax income totaled RMB 95.1 billion, down by 8.1% year-on-year, accounting for 0.82% of total nationwide tax revenue.

Table 5-1 List of Items and Rates of Resources Taxes (starting from July 1, 2016)

Mineral Commodities			Tax Rate
Crude oil			6% of gross sales
Natural gas			6% of gross sales
Coal	Coking coal		2% ~ 10% of gross sales (determined by local government)
	Others		
Nonmetals	Graphite	Concentrate	3% ~ 10%
	Diatomite	Concentrate	1% ~ 6%
	Kaolin	Ore	1% ~ 6%
	Fluorite	Concentrate	1% ~ 6%
	Limestone	Ore	1% ~ 6%
	Pyrite	Concentrate	1% ~ 6%
	Phosphate rock	Ore	3% ~ 8%
	Potassium chloride	Concentrate	3% ~ 8%
	Potassium sulfate	Concentrate	6% ~ 12%
	Well and rock salt	Primary sodium chloride product	1% ~ 6%
	Lake salt	Primary sodium chloride product	1% ~ 6%
	Evaporated salt from underground brine	Primary sodium chloride product	3% ~ 15%

Continued

Mineral Commodities			Tax Rate
Nonmetals	Coal-bed methane		1% ~ 2%
	Clay and gravel	ore	RMB 0.1 ~ RMB 5 per ton or per cubic meter
	Others	Concentrate or ore	≤ RMB 30 (specific rate of duty); ≤ 20% (ad valorem rate of duty)
Metal ores	Iron	Concentrate	1% ~ 6% of gross sales
	Gold	bullion	1% ~ 4% of gross sales
	Copper	Concentrate	2% ~ 8% of gross sales
	Bauxite	Crude ore	3% ~ 9% of gross sales
	Lead and zinc	Concentrate	2% ~ 6% of gross sales
	Nickel	Concentrate	2% ~ 6% of gross sales
	Tin	Concentrate	2% ~ 6% of gross sales
	Others	Concentrate or ore	No more than 20% of gross sales
Sea salt		Primary sodium chloride product	1% ~ 5% of gross sales

Note: 1. Bauxite consists of refractory alumina, abrasive-grade alumina and high-alumina clay. 2. Primary sodium chloride products refer to well and rock salt, crude lake salt, evaporated salt from underground brine and crude sea salt, including solid and liquid primary products.

The resources tax reform reduces resources tax for two types of mines. In January 2017, the State Administration of Taxation and MLR jointly issued the *Announcement on Some Issues Regarding the Implementation of Preferential Policies for Resources Tax Reform*, deciding to reduce 50% and 30% of resources tax respectively for eligible mines with the cut-and-fill mining and in the exhaustion stage and to implement the record management system.

### 2. Reform in mineral resources royalty system

In April 2017, the State Council promulgated and implemented the *Reform in Mineral Resources Royalty System*. The exploration and mining licenses cost has been changed into the mineral rights transfer income, applicable to all transfers of mineral rights and manifesting the state ownership. Based on the fluctuation of mineral prices and the need of economic development, the exploration and mining licenses fees has been integrated into the dynamically adjusted mineral rights occupancy expense. The mine environmental restoration assurance (fund) has been changed into the Mining Rehabilitation Fund, with standard management, integration of power and responsibility and convenient use.

#### Column 5-3 Reform in Mineral Resource Royalty System

Firstly, the exploration and mining licenses cost was changed into the mineral rights transfer income. The mineral rights cost was changed into the transfer income showing the state ownership interests, and the sharing proportion between central and local governments were determined as 4:6.

Secondly, the cost of using the exploration and mining licenses was integrated into the mineral rights occupancy expense. The cost of using mineral rights was adjusted into the occupancy expense, and the sharing proportion between central and local governments were determined as 2:8.

Thirdly, the levy of resource tax was continued and the price-based taxation was implemented comprehensively.

Fourthly, the mine environmental restoration assurance (fund) was adjusted into the Mining Rehabilitation Fund.

# Chapter VI

## Mineral Resources Management

The reforms to streamline administration, delegate powers, and improve regulation and services was deepened, standards for approval of mineral rights were stricter, and the overcapacity was actively defused. Cleanup of mineral licenses in national nature reserves was conducted. The regional distribution of mineral resources exploration was further optimized. The unified registration of rights to mineral resources with resources & reserves was promoted, and the construction of mineral reserve standard system has being advanced. The new mineral resources planning was issued and implemented, and the mineral resources support capability to national economy was continuously improved.

### I. Mineral Resources Planning

The *National Mineral Resources Planning (2016-2020)*, issued in November 2016, generally aims to basically establish a safe, steady and economical resources guarantee system, basically form an economical, efficient, environment-friendly and harmonious green mining development mode, basically build an open and unified, orderly competitive and vigorous modern mining market system, significantly improve the quality and benefit of mining development and create the new pattern of resources security and mining development by 2020.

### Column 6-1 *Goals of National Mineral Resources Planning (2016-2020)*

Keeping steady growth in major mineral resources & reserves; discovering 5~8 hundred-million-tonnage oil fields and 5~10 hundred-billion-cubic-meter gas fields, building 103 energy and resource bases and delineating 267 planned national mining areas.

Fulfilling the task of restoration of geological environment for 500,000 hectares legacy mine land.

Heightening the productivity of large coal bases to be over 95% of that in nationwide, the capacity of graphite, rare earth and other resource bases to be over 80% and the tungsten, tin, antimony, phosphorus, potash and other resources bases to be around 50% by 2020.

Spending 3~5 years in cutting 500 million tons of capacity and reducing and restructuring 500 million tons of capacity. Restrict the national coal output to be 3.9 billion tons by 2020.

In order to safeguard the national economic security and the development need of emerging strategic industry, 24 minerals, such as oil, have been included into the List of Strategic Minerals and considered as the key points for macro-control, supervision and management of mineral resources. Guidance and differentiated management of resource allocation, financial investment, major project and mining occupied land, etc. were strengthened to improve the secure availability and productivity of mineral resources.

### Column 6-2 *List of Strategic Minerals*

Energy: oil, natural gas, shale gas, coal, coal-bed methane and uranium

Metals: iron ore, chromite, copper, bauxite, gold, nickel, tungsten, tin, molybdenum, antimony, cobalt, lithium, rare earths and zirconium

Nonmetals: phosphate rock, potash, crystalloid graphite and fluorite

## II. Geological Exploration Management

### 1. Geological exploration qualifications

By the end of 2016, there were totally 2,691 units with geological exploration qualifications nationwide, in which 1,190 units with the highest qualifications of Class-A, accounting for 44.2%; 762 units with the highest qualifications of Class-B, accounting for 28.3%; 739 units with the highest qualifications of Class-C, accounting for 27.5%. Besides, there were totally 7,778 geological exploration qualifications of all kinds and classes around China. Among them, there were 2,985 Class-A qualifications, 2,939 Class-B qualifications and 1,854 Class-B qualifications, accounting for 38.4%, 37.8% and 23.8% respectively.

Field types of geological exploration entities: 435 qualifications were for regional geological survey, accounting for 5.6%; 25 for marine geological survey, accounting for 0.3%; 4 for oil and natural gas exploration, accounting for 0.1%; 727 for liquid mineral exploration, accounting for 9.4%; 292 for gas exploration, accounting for 3.8%; 1,925 for solid mineral exploration, accounting for 24.8%; 1,109 for hydrogeological, engineering geological and environmental geological surveys, accounting for 14.3%; 804 for geophysical exploration, accounting for 10.3%; 415 for geochemical exploration, accounting for 5.3%; 5 for aero-geological survey, accounting for 0.1%; 96 for remote-sensing geological survey, accounting for 1.2%; 1,461 for geological drilling (pitting), accounting for 18.8%; 480 for geological experiment and testing, accounting for 6.2% (Fig. 6-1).

Economic types of geological exploration entities: 1,325 state-owned (49.2%), 22 collectively-owned ones (0.8%), 10 joint-stock (0.4%), 1,180 limited liability (43.9%), 71 entities limited by shares (2.6%), 55 private (2.0%), 2 joint-venture (funded by Hong Kong, Macau or Taiwan) (0.1%), 1 foreign-funded (0.04%) and 25 others (0.9%) (Fig. 6-2).

### 2. Optimization of Regional Exploration

The *General Program on National Exploration and Development Planning (2016)* was issued. Firstly, it redefined 26 key metallogenic belts. Secondly, it optimized the package exploration layout, which was adjusted and completely withdrawn from national nature reserves. 13 were

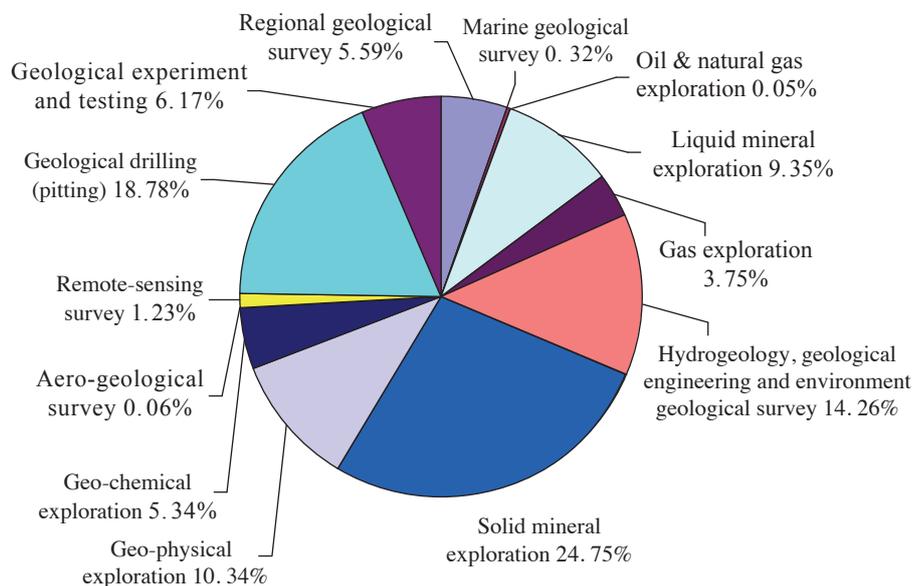


Figure 6-1 Field Types Involved by Geological Exploration Entities in 2016

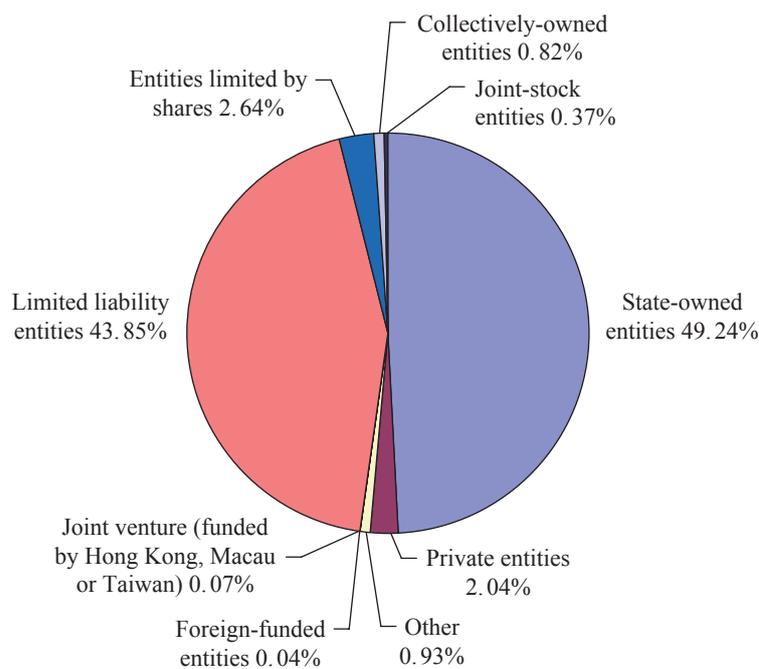


Figure 6-2 Economic Types of Geological Exploration Entities Nationwide in 2016

cancelled, 38 were adjusted, and 23 were newly added. The number of package exploration areas was increased from 107 to 117. Thirdly, it intensified the mineral exploration needed for emerging strategic industry, including the graphite, lithium, diatomite and other types of minerals into the list of major minerals for exploration.

### III. Mineral Resources & Reserves Management

#### 1. Unified registration of mineral rights with resources & reserves

The *Program for Including Mineral Resources with Resources & Reserves into the Pilot Work of Unified Registration and Cadastre of Natural Resource Assets*, issued in March 2017, states the comprehensive implementation of pilot work in Fujian and Guizhou to promote the standardized registration and cadastre of mineral rights, form a unified registration and cadastral system for mineral resources with well-defined power and responsibility and effective supervision, and strengthen the government's protection and supervision of mineral resources.

#### 2. Publicizing system for exploration and exploitation information of mineral licenses' holders

The MLR optimized the supervision mode for mineral resources exploration and exploitation by changing the annual inspection system to the information publicizing system. The publicizing system for exploration and exploitation information of mineral licenses' holders is a significant change in the supervision and management mode of mineral resources exploration and exploitation. It not only expressly defines the entity responsibility of mineral licenses' holders but also intensifies the social supervision, and can enhance the fairness, standardization and effectiveness of government's supervision. Since 2017, the system was put into full operation, 26,100 exploration projects have been publicized nationwide, with the publication rate of 94.0%, and 64,000 mines in production have been publicized, with the publicity rate of 90.0%.

#### 3. Construction of mineral resources & reserves standardization system

The MLR is organizing and implementing the construction of technical standardization

system for national mineral resources & reserves and systematically researching and building a new frame of technical standard system for mineral resources & reserves. Formulationally, revision and research of 21 standards were finished in 2016.

The creation of connection documents between China's standards for classification of mineral resources & reserves and *United Nations Framework Classification for Fossil Energy and Mineral Resources* (UNFC) was promoted, the research was conducted on disclosure rules and management systems for information on solid mineral resources & reserves in capital market to further internationalize China's standards for mineral resources & reserves.

#### 4. Establishment and improvement reservation system on mineral resources

The reservation of mineral resources was included in the national plan to actively explore the ore field protection and resource reservation operation mechanism and promote the reservation of dominant minerals, scarce minerals and staple minerals greatly affecting the national economic development. The reservation of important ore fields for tungsten, rare earths, crystalloid graphite and other strategic minerals were strengthened to explore the new mechanism combining exploitation with reservation.

#### 5. Streamlining of review process for important mineral resources overlain by construction projects

Relevant requirements were adjusted for mineral resources overlain by construction land in pre-review and approval stages. In the land pre-review stage, there is no need to review whether the construction project (subject to approval) at separately chosen site overlays the important mineral resources.

### IV. Mineral Rights Management

#### 1. Mineral licensing

**Oil & gas exploration:** By the end of 2016, 978 oil & gas exploration licenses involved a registered area of 3.54 million km<sup>2</sup>, down by 2.2% and 4.5% year-on-year, respectively.

In 2016, 13 new exploration licenses were newly approved, involving a registered area of 105,000 km<sup>2</sup> (Table 6-1).

**Oil & gas development:** By the end of 2016, 745 oil & gas exploitation licenses in total involved a registered area of 154,100 km<sup>2</sup>, up by 3.5% and 3.7%, respectively. In 2016, 25 new exploitation licenses were newly approved, involving a registered area of 5,176.74 km<sup>2</sup> (Table 6-1).

**Non-oil & gas exploration:** By the end of 2016, 25,500 non-oil & gas exploration licenses involved a registered area of 458,700 km<sup>2</sup>, down by 10.1% and 16.6%, respectively. In 2016, 1,165 non-oil & gas exploration licenses with a registered area of 27,400 km<sup>2</sup> were newly approved, up by 22.9% and 7.2%, respectively (Table 6-2).

**Non-oil & gas mining:** By the end of 2016, 65,600 non-oil & gas exploitation licenses involved a registered area of 100,600 km<sup>2</sup>, down by 11.4% and 3.3%, respectively. The designed annual capacity was 14.97 billion tons, up by 1.1%. The designed annual capacity of coal exploitation license was 4.11 billion tons, down by 2.7%. In 2016, 1,819 non-oil & gas exploitation licenses were newly approved, involved a registered area of 1,073 km<sup>2</sup> and a designed annual capacity of 594 million tons, down by 27.9%, 65.1% and 16.1%, respectively (Table 6-2).

## 2. Continuous deepening of reform of ‘simplifying administration and delegating power to the lower levels, combining power delegating and flexible regulation and optimizing service’ in mineral rights management

The *Notice of the Ministry of Land and Resources on Modifying Article 25 of the ‘Notice of the Ministry of Land and Resources on Further Improving Matters Regarding Registration and Management of Mining Rights’* requires that, from March 2017, the land and resources management departments should no longer examine and approve changes in capacity of mining licenses. The *Notice of the General Office of the Ministry of Land and Resources on Standardizing Requirements Concerning the Review of Exploration Implementation Programs* and the *Notice of the General Office of the Ministry of Land and Resources on Adjusting the Collection Way of Examination Fees for Development and Utilization Program of Mining licenses Certified by the Ministry of Land and Resources* issued respectively specify expressly that the review fee for exploration implementation program of exploration

Table 6-1 Newly Approved Oil & Gas Licenses

Year	Exploration		Development	
	Number	Area / thousand km <sup>2</sup>	Number	Area / thousand km <sup>2</sup>
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
2016	13	105	25	5.2

Table 6-2 Newly Approved Non-oil & Gas Mineral Licenses

Year	Exploration		Mining	
	Number	Area / thousand km <sup>2</sup>	Number	Area / thousand km <sup>2</sup>
2011	1338	36.2	5951	4.7
2012	1033	35.4	1845	2.6
2013	1329	40	1962	1.9
2014	1269	32.6	2306	1.2
2015	948	25.6	2522	3.1
2016	1165	27.4	1819	1.1

licenses and the review fee for development and utilization program of mining licenses approved and certified by the MLR shall be paid from the government's financial budget and be no longer paid by mineral licenses' applicants. The *Notice of the Ministry of Land and Resources on No Longer Including the Opinions by a Safety Supervision and Management Department into Key Preconditions for Granting a Mining Licenses* was promulgated and announced.

Mineral licenses' holders are no longer required to submit the Annual Report of Items for Mineral Resources Exploration or the Annual Development and Utilization Report during examination and approval of mineral licenses after the publicizing system for exploration and exploitation information of mineral rights' holders was implemented comprehensively in 2017. The *Notice of the Ministry of Land and Resources on Relevant Issues for Promoting the transfer of State-owned Land-use Rights and Mineral rights Being Included into the Uniform Public Resources Transaction Platform* issued requires incorporating the releasing, transaction and results of mineral rights transfer into the public resources transaction platform, so as to increase the supervision of examination and approval of mineral licenses. Meanwhile, keep implementing the one-stop service for application for mineral licenses, optimizing the approval procedure, strengthening the dynamic monitoring and postmortem supervision, filing the whole process for reference, providing the mineral licenses' holders with continuous reminding service, and publicizing the exploration and mining licenses with a period of validity of less than 120 days on the web portals of land and resources management departments in advance to timely give a warning for abnormal conditions.

### 3. Defusion of overcapacity

The *Opinions of the Ministry of Land and Resources on Resolving Overcapacity in Steel & Coal Industries to Propel Overcoming Difficulties and Upgrading* was promulgated, expressly stating that delimitation of mining areas should be terminated in 3 years, that the approved coal construction projects should be connected with the cutting overcapacity task, with the mining registration procedures handled after the announcement by the related provincial government department, and the registration and certificate granting for mineral licenses involving merger and acquisition of coal enterprises shall be fully delegated to provincial land and resources management departments.

### 4. Promotion of cleanup of mineral rights in nature reserves

In July 2017, the MLR issued the *Work Program for Cleanup of Mineral rights in Nature Reserves*, in order to fully carry out the cleanup of mineral rights in national nature reserves, thoroughly investigates, classifies, sorts and systematically analyzes the mineral rights within the prohibited areas of mineral resources exploration and exploitation in various nature reserves, and lay a foundation for the classification of mineral licenses in the nature reserves. Meanwhile, the mineral licenses approval mechanism was adjusted and improved to ensure that no new approved mineral licenses is in a nature reserves.

### 5. Orderly promotion of reform in oil & gas exploration and development

Xinjiang served as a pilot area to orderly promote the reform in oil & gas exploration and development system and mechanism. Exploration licenses were granted to the first group of bid-winners of oil & gas exploration zone. The technical exchange, cooperation between local governments and enterprises and guidance were organized and conducted.

### 6. New Mechanism for Shale Gas Exploration and Development

The construction of Experimental Area of Shale Gas Exploration and Development was formally started in southern Sichuan. The construction of Chongqing Fuling Shale Gas Exploration and Development Experimental Base and northern Guizhou Shale Gas Comprehensive Exploration Experimental Area continued. The new mechanism was explored intensively for jointly promoting shale gas exploration and development by ministries, provincial governments and enterprises. The Guizhou Provincial Government was entrusted to organize the auction and transfer of Zhengan block to explore the new model competitive offer of shale gas block. The Shanxi Provincial Government was entrusted to examine, approve and register exploration and development of partial coal-bed methane, effectively giving play to the local government's initiative, stimulating the market's vitality and helping Shanxi Province's economic transformation and development.

# Chapter VII

## Geological Survey and Mineral Resources Evaluation

The geological survey was further enhanced. Marine geological survey at 1:250,000 in key marine areas, oil & gas resources survey in key marine areas, NGH exploration and trial extraction were conducted. Fruitful achievements have been made in geological survey and mineral resources evaluation, and 20 oil & gas prospecting areas were delimited in the periphery of Songliao Basin, periphery of Tarim and Junggar Basin in Xinjiang and Yin'e Basin, etc. Furthermore, there were great discoveries of manganese, copper, graphite and potash, etc., in the western China.

### I. Geological Survey

#### 1. Regional geological survey

In 2016, China finished 202,000 km<sup>2</sup> of regional geological survey at 1:50,000. Accumulatively, 3,730,600 km<sup>2</sup> of regional geological survey was finished, accounting for 38.9% of onshore territorial area.

#### 2. Regional geophysical survey

China finished 15,000 km<sup>2</sup> of regional gravity survey at 1:250,000, 12,000 km<sup>2</sup> of gravity measurement at 1:50,000 and 495,000 km (measuring line) of airborne geophysical survey at 1:50,000.

### 3. Regional geochemical survey

China finished 27,000 km<sup>2</sup> of geochemical survey at 1:50,000, 20,000 km<sup>2</sup> of geochemical survey at 1:250,000 and 220,000 km<sup>2</sup> of geochemical survey for land quality at 1:250,000.

### 4. Airborne geophysical survey

Comprehensive surveys by airborne electromagnetic method, airborne gravity method, airborne electrical method, airborne radioactive method and other single or multiple were conducted in Qinling -Beishan Region and other important metallogenic belts, oil & gas basins like Songliao Basin and its periphery, the Key Coastal Zone of Bohai Bay and other areas, completing 495,000 km (measuring line) of airborne geophysical survey (scales measurements were mainly 1:50,000 and 1:100,000).

### 5. Mineral geological survey

In 2016, there were 169,000 km<sup>2</sup> of mineral geological survey (1:50,000) was completed and more than 500 prospecting targets were delimited during the mineral geological survey with respect to important metallogenic belts, package exploration areas, important prospecting areas of mineral resources and large mineral resources bases.

## II. Survey and Evaluation of Energy Minerals

### 1. Conventional oil & gas

20 oil & gas prospecting areas were delimited in the periphery of Songliao Basin, the periphery of Tarim and Junggar Basin in Xinjiang and Yin'e Basin, etc. It was verified through drilling that oil & gas were discovered in 4 blocks in Yin'e Basin. Additionally, two big traps, both of which were greater than 100 km<sup>2</sup>, were identified in the new exploration area in Qiangtang Basin.

## 2. Unconventional oil & gas

Anye-1 Well in Zunyi City, Guizhou Province, which uncovered a ‘four-floored’ pattern of oil & gas reservoir, has a guiding significance for the oil & gas exploration in areas with complicated geological structures in South China. Zhenjia-1 Well in Mizhi County, Shaanxi Province, first uncovered shale gas in transitional facies in the Carboniferous System. Shale gas flows were discovered when Eyiye-1 Well and Eyangye-1 Well in Yichang, Hubei and Huadi-1 Well in Dazhou, Sichuan were drilled. ‘One oil and three gases’ were discovered in Gangdi-1 Well in Xuancheng, Anhui.

27 exploratory wells were drilled in Shenhu Area, northern South China Sea, where 12 km<sup>2</sup> of ore body area were delimited. Besides, the geophysical survey, engineering geological survey and environmental survey were carried out at the well sites. Wells for trial extraction and production were selected through comprehensive analysis, and a perfect safety type of guarantee and environmental monitoring system was built.

### Column 7-1 NGH Survey and Evaluation in China

6 NGH prospecting areas, 19 metallogenic belts, 25 favorable blocks and 24 drilling targets were delineated in northern South China Sea. 9 favorable metallogenic blocks were selected in the cryolithozone in southern Qinghai and northern Tibet.

Surveys by drilling have proved 2 hydrate mineral deposits more than 100 billion cubic meters and made significant breakthroughs in marine prospecting. 55 km<sup>2</sup> and 128 km<sup>2</sup> of NGH distribution areas have been controlled by drilling in the eastern marine area of Pearl River Mouth Basin and Shenhu Area, respectively.

## 3. Geothermal resources

Shallow geothermal energy and hydrothermal geothermal resources surveys were conducted in key areas of Beijing-Tianjin-Hebei Collaborative Development Zone, and hot dry rock resources survey was carried out in the southeast coastal region and Qinghai Xining-Guinan

Region. Meanwhile, 5,500 km<sup>2</sup> of geothermal survey was completed. 12,000 m was drilled and 2600 sets of water samples were collected and analyzed. Besides, the zoning planning for development and utilization of shallow geothermal energy in Beijing-Tianjin-Hebei Region was completed.

### III. Survey and Evaluation of Metal and Nonmetal Minerals

The resources of manganese in Maerkansu, West Kunlun, Xinjiang exceeded 30 million tons (with the average grade above 30%); the estimated super-large crystalloid graphite resources in Huangyang Mountain, Qitai County, was predicted to be totaled 20 million tons. 8 manganese prospecting targets were delimited in the Central Hunan-Central Guangxi Region, with the estimated resources of 127 million tons. The uncovered Luerma Copper Mine in Tibet extended the Gangdese Copper Belt for 200 km westward. 20 million tons of potassium chloride resources were newly discovered in Dalangtan-Heibei Valley, Qaidam, Qinghai.

### IV. Groundwater Survey and Evaluation

National groundwater monitoring points of 31 provinces (regions and municipality) have been collected since 2013 and an integrated evaluation was made for the last 10 years' information on national groundwater pollution, with the survey area of 4.4 million km<sup>2</sup>; regional quality distribution and pollution status of nationwide groundwater were known well basically.

Poverty-reduction water exploration for well drilling was implemented in Wumeng Mountainous Area, Yimeng Mountainous Area, Karst Mountainous Area in Southwest China and ecological vulnerable areas in south Jiangxi and northwest China, involving 46,000 km<sup>2</sup> of 1:50,000 hydro-geological survey and 45,000 m of hydro-geological drilling. Besides, a group of water-rich sections were delimited, and over 140 wells combining exploration and exploitation were built. High-quality natural mineral water was found in south Jiangxi, providing people in water-lacking areas with sources of drinking water.

## V. Marine Geological Survey and Evaluation

### 1. Marine geological survey

The geographical base map for 1:1,000,000 marine regional geological survey in jurisdictional marine areas was prepared to determine the regional contrast relationship among key structural interfaces in major basins. It was the first time to systematically name 245 large and medium-sized geographic entities at the bottom of South China Sea systematically. Field surveys for 4 maps, i.e. maps of Rizhao, Lianyungang, Xiamen and Ledong (1:250,000) were completed, and geological information was acquired systematically so as to serve the construction of infrastructure such as the new Sanya airport. The task of 2800 m of scientific drilling (CSDP-2 Well) in South Yellow Sea Continental Shelf was achieved, the South Yellow Sea Cenozoic stratigraphic sequence was established, and the sedimentary strata lithology and sedimentary facies sequence of the uplift region of South Yellow Sea from Late Ordovician to Triassic period was determined preliminarily.

### 2. Survey and evaluation of marine oil & gas

Oil & gas surveys for new areas and new horizons were continued in important sea areas such as the Yellow Sea and deep-water continental slope area in the northern South China Sea. 2 important targets in the Laoshan Uplift in South Yellow Sea were evaluated. Mesozoic-Palaeozoic marine oil & gas shows were first discovered in the central uplift of South Yellow Sea, which was proven to be a favorable oil & gas prospecting area. 5 important exploration targets were selected in the midwest of Xisha Trough Basin. Chaoshan Depression in Dongsha, northern South China Sea was delineated as the Mesozoic oil & gas prospecting areas.

## Chapter VIII

# Management and Service of Geological Data

The competent departments of land and resources and geological data collection institutions enhanced the collection and management of geological data, strengthened the information service, further perfected the geological data management system and technical standard specification, and highlighted the networked service and thematic service. The geological data management level and service capability grew constantly.

### I. Geological Data Management

In 2016, 16 regulations, such as the *Notice of the Ministry of Land and Resources on Strengthening Geological Data Collection and Management*, were canceled and integrated and regulations including the *Notice of the Ministry of Land and Resources on Issuing the 'Management Measures for Physical Geological Data'* and the *Notice of the Ministry of Land and Resources on Strengthening Geological Data Management* were issued, which further strengthened the collection and management of resultant, original and geological material data, standardized the collection procedure, simplified the workflow, enhanced the services and supervision and specified the sorting and storage principles of geological material data. In order to satisfy the new management demands, the geological data management system was improved.

## II. Geological Data Status

### 1. Resultant and original geological data increasingly enriched

By the end of 2016, totally 492,500 varieties of resultant geological data had been collected in the National Geological Archives and provincial geological data collection institutions, up by 3.6% year-on-year; nearly 700,000 varieties of original geological data had been collected, up by 13.0%.

In 2016, the National Geological Archives and provincial geological data collection institutions received totally 10,659 varieties of resultant geological data. Geological data collection institutions at all levels throughout the country received totally 2,725 varieties of original geological data, in which mineral exploration data accounted for 72.4%.

### 2. Geological material data constantly increased

By the end of 2016, the Cores and Samples Center of Land and Resources and 20 provincial geological archives had safe-kept cumulative 940,000 meters of cores. The Cores and Samples Center of Land and Resources had safe-kept cumulative 380,000 meters of cores, 24,000 samples, 285 large-size samples, 46,000 slices, etc.

In 2016, the Cores and Samples Center of Land and Resources and 20 provincial geological archives received totally 77,600 meters of cores, 10,900 samples, 31,100 slices and 222,800 bags/bottles of samples. The Cores and Samples Center of Land and Resources newly collected 40,000 meters of cores, 4,000 samples and 4,000 slices.

### 3. The informatization of geological data steadily promoted

By the end of 2016, the centralized sharing service platform of geological data and information had provided the online directory service for 412,000 pieces of data, increasing by 11% year-on-year; and the digital-file service for 15,000 pieces of geological data; there were 200,000 digital files, increasing by 4%. Up to June, 2017, the National Geological Archives and provincial geological data collection institutions had collected 497,200 varieties of digital documents, accounting for 99.0%.

## III. Geological Data Services

### 1. Service products increasingly enriched

By the end of 2016, important image data for cumulative 240,000 meters of cores, nearly 2,000 decrypted geological maps with the scale of 1:50,000 and data information about 600,000 important geological drill holes had been released.

In 2016, image data for 40,000 meters of cores and data for 200,000 drill holes were newly released, and 156,000 directories of geological material data were collected. Thematic and customized services were actively carried out, and over 30 thematic geological maps including the 1:4,000,000 geochemical series maps, geological material data and other typical service products were completed. The products matrix of geological data was further improved.

### 2. Socialized services of geological data steadily promoted

In 2016, the National Geological Archives, the Cores and Samples Center of Land and Resources and 31 provincial geological data collection institutions received totally 30,400 person-times on site and provided 118,000 set-times (4,693,100 piece-times) of data services. The Cores and Samples Center of Land and Resources received totally 6,660 person-times on site and provided 14,600 meters of core observation samples. The website hits of the National Geological Archives, the Cores and Samples Center of Land and Resources and provincial geological data collection institutions reached totally 1.9562 million times, and the website hits of the National Geological Archives and the Cores and Samples Center of Land and Resources reached 352,100 times and 82,300 times respectively. The visits of the centralized sharing service platform of geological data and information exceeded 680,000 times.

### 3. Important geological survey results published

A series of geological survey results were published, including *One Hundred Achievements in China Geological Survey*, *Annual Report on China Geological Survey (2016)*, *Geological Survey Implementation Scheme for Supporting and Serving the Beijing-Tianjin-Hebei Collaborative Development (2016-2020)*, *Report on Phased Achievements in Geological Survey in the Middle Reaches of the Yangtze River*, *Report on International Cooperation*

*Achievements in Geological Survey, Report on Geological Survey of China Coastal Zone, Atlas of Chinese Natural Resources (2016), etc.*

#### 4. Marine geological data services fully carried out

In 2016, the Marine Geology Information website was officially launched, and it released, in public and for the first time. A number of marine geological survey achievements and original data, including 224 data directories in such fields as marine regional geology, coastal zone environmental geology and marine mineral resources, 460 metadata, 133 online resultant maps, 64 resultant reports, 68 technical standards for marine geological survey, etc., were published. The *Detailed Rules of China Geological Survey for Sharing the Marine Geological Data Resources (Trial)*, the *Specification for Classification of Marine Geological Information Resources* and the *Service Interface Specification for Marine Geological Information Resources* were compiled, which standardized the data sharing procedure and unblocked the data sharing channels. The comprehensive information atlas for marine geological survey was compiled to enhance the achievement service level.

## Chapter IX

# Scientific and Technological Innovation

Science and technology innovation strategy of the DDDL(deep exploration, deep-sea exploration, deep space-to-earth observation and land science & technology innovation) for land & mineral resources were implemented. Some innovations were made in metallogenic theories, prospecting models and exploration methods. A number of geological exploration techniques and instruments were developed or integrated. Mineral resources exploration and development techniques were applied deeply, and obvious progress was made in standardization system in mineral industry.

### I. Research on Basic Geology and Mineral Theories

#### 1. Innovations of metallogenic theories

The research on geodynamic model for intra-plate Yanshanian large-scale mineralization in eastern China shows that intra-plate mineralization is controlled by interaction of multiple blocks in plate margins. The large-scale metal-enrichment special space was discovered. A total of 8 concentration areas of mineral resources were built, and the geodynamic model for the eastern Yanshanian intra-plate mineralization was also established. The mineralization theory of northern sandstone-type uranium deposit was studied further, and the new understanding of uranium mineralization being controlled by 'rise edge in basin' structure was put forward which led the uranium prospecting to move towards 'basin center' from 'basin edge'. The metallogenic model and exploration model of lead-zinc polymetallic deposit in the

‘Three Rivers’(Nujiang, Lancangjiang and Jinshajiang) orogenic belt were proposed, which provided guidance for breakthrough in mineral prospecting in Tuotuo River Duocaima, Yushu Mohailaheng and Dongmozhazhua. The Mengyejing potash ‘two-floored’ mineralization model was established, and the sylvinite-containing stratum with a vertical thickness of 70m was explored in the deep formation. The close relation between the huge vanadium-titanium magnetite enrichment in Panzihua-Xichang area and the existence of early subduction-caused eclogite in lithospheric mantle was defined. The marine volcanic-type iron deposit was founded to be related to high-angle subduction under the background of hot mantle and cold crust.

## 2. Innovation theory in forming of natural gas hydrate

The ‘two-stage and three-type’ mineralization theory was established, which guided the accurate delineation of prospecting targets in South China Sea. The reservoir-forming system theory of natural gas hydrate was built, which guided the scientific formulation of pilot production implementation scheme. The ‘three-phase control’ extraction theory was established, which guided the accurate determination of depressurization range and path for pilot production.

## 3. New progress in deep exploration

Significant breakthroughs, were made for deep exploration techniques, deep mineralization-controlling factors and their application in deep prospecting, etc. of deep exploration and prospecting in the eastern Dabieshan Mountain. The deep gold mine exploration technology reached the international advanced level. The 4,006.17m drill hole in gold exploration in Laizhou, which is the first ultra-deep drill hole in gold exploration throughout the country, and other projects had been successfully constructed in Shandong Province, indicating the great potential in deep prospecting. The late Devonian early carboniferous volcanic rock was discovered in the Longmucuo-Shuanghu junction zone and the new understanding of Longmucuo-Shuanghu Paleo-Tethys Ocean Basin having northward subduction in the Late Paleozoic Era and northern Qiangtang block being the active continental margin in the Late Devonian-Early Carboniferous was put forward. In-situ diamond and deep mantle mineral group were discovered in the Neo-Tethys ophiolite, the Himalaya three-dimensional collision orogenic mechanism and whole-process inversion model were established, and the new mechanism of ‘bending and crust decoupling’ for material escape from southeastern margin of Qinghai-Tibet Plateau was put forward. The technical difficulties in deep-sea seismic detection below the strong-wave impedance interface shielding layer were overcome, and the ‘high

coverage, rich low-frequency component and strong source energy' seismic detection technique applicable to deep marine-phase Mesozoic-Paleozoic oil & gas survey and evaluation in South Yellow Sea basin was developed.

## II. Exploration Techniques

### 1. A batch of geological exploration techniques and instruments developed

The first set of aeromagnetic three-component exploration system based on Y-12 aircraft and the fixed-wing time-domain airborne electromagnetic system based on domestic Y12IV aircraft were successfully developed in China, the helicopter TEM system (CHTEM-II) reached the practical level, which integrated the airborne geophysical exploration (gravity/magnetic) and remote sensing comprehensive measurement system. The precise cold-drawn seamless steel pipe for XJY950 steel cable coring drilling rod was successfully developed. The assembling and commissioning of complete experimental prototype of the wave spectrum-energy spectrum composite X-ray fluorescence spectrometer was achieved. The first thermogravimetric analyzer suitable for high/over-maturity source rock and high-pyrolysis temperature rock in China was successfully developed, which enhanced the capability of shale gas test and analysis.

### 2. Application and transformation achieved remarkable effect

The self-developed airborne geophysical prospecting system was widely used in oil & gas survey, solid mineral exploration and environmental survey, and the abnormal polymetallic mineralization in Hami, Xinjiang were discovered by the helicopter TEM system (CHTEM-II). The 3D multi-function electromagnetic detecting instrument was used in Liuyuan, and many other places. The  $\phi 108\text{mm}$ ,  $\phi 127\text{mm}$ ,  $\phi 140\text{mm}$ ,  $\phi 178\text{mm}$  and  $\phi 194\text{mm}$  (hollow) series turbine drills were directly used in hot dry rock drilling engineering and 'Songke-2 Well' ultra-deep high-temperature core drilling.

### 3. A varieties of analytical methods or technical systems for geological exploration developed

The technical guide for geochemical mapping suitable for landscape characteristics of countries was compiled, and the eco-geochemical evaluation methodology for the beneficial element Selenium was preliminarily established. The technical system of satellite remote

sensing for geological survey and integrated natural resources survey was initially formed. The supplementary method for the field EDXRF rapid analysis of over 10 elements including copper, lead and zinc, the supplementary methods for analysis of ‘rare, dispersed and rare-earth’ elements with 23 modern brand-new instruments, the LA-ICPMS analysis method for 17 elements in rare-earth minerals, etc. were established.

### III. Development and Utilization Techniques

#### 1. Significant progress in pilot extraction technology of natural gas hydrate

The ‘Stratum fluid extraction’ new method of pilot production was established, and self-dependent innovations were realized in sand control techniques, reservoir stimulation techniques, drilling and completion techniques, exploration techniques, testing and simulation experiment techniques, environmental monitoring techniques, etc. The first 4,500-meter deep-sea unmanned remote-operated submersible ‘Sea Horse’ and other equipment were developed, and pilot extraction techniques and equipment systems suitable for natural gas hydrate in silty reservoir in the northern South China Sea were initially established in China.

#### 2. Comprehensive utilization techniques

Associated tungsten resources were comprehensively utilized in gold deposit in the western Henan Province, the ‘magnetite ultrafine crushing – classification and separation – magnetic dressing’ new process was put forward, which achieved energy saving and consumption reduction effectively. Qualified iron ore concentrate with 58.5% TFe grade and 56.5% recovery rate was produced with the ‘stage grinding - selective separation – efficient grinding and dressing’–new iron dressing technology for the deep vanadium-titanium magnetite in the Panzhihua, Xichang. The environment-friendly weatherproof expanded perlite insulation plates were developed. The optimal process flow for ‘classification–gravity separation–magnetic separation–reverse flotation – electric separation’ of eclogite-type rutile utilization was determined, which could produce the rutile concentrates with the  $\text{TiO}_2$  more than 90% as well as the garnet concentrates and omphacite concentrates with the mineral content more than 85%. Technological breakthroughs were made in efficient utilization of lithium, rubidium and cesium from lepidolite concentrates, Yichun, Jiangxi province (a typical rare metal mineral resources), which achieved effective extraction of lithium, rubidium and cesium, with the leaching efficiency of 89.7%, 93.3% and 93.9% respectively.

### IV. Planning of Scientific and Technological Innovations

In September 2016, the *Development Planning of 'the 13<sup>th</sup> Five-Year Plan' Scientific and Technological Innovations in Land and Resources* was released, in which the 'Three Deeps and One Land' strategy for land and resources science and technology was put forward and the scientific and technological innovation in geology and mineral resources was systematically deployed. In May 2017, the Ministry of Science and Technology, the Ministry of Land and Resources and the Ministry of Water Resources jointly issued the *Special Planning of 'the 13<sup>th</sup> Five-Year Plan' Scientific and Technological Innovations in Resources*, seeking breakthroughs in a number of basic theories and key techniques, research and development of a number of major equipment, establishment of theoretical and technical systems for resources exploration, development and comprehensive utilization, and realization of economical and efficient resources utilization.

#### Column 9-1 *Development Goals of Special Planning of 'the 13<sup>th</sup> Five-Year Plan' Scientific and Technological Innovations in Resources*

Research and develop a number of equipment urgently needed for deep exploration, with the market share of major equipment being over 80%; achieve the capability in 3,000m deep exploration and 5,000 m deep survey and evaluation, and form the deep exploration technology system with independent intellectual property rights; research and develop a number of high-efficiency automated drilling, logging and oil production techniques and equipment, with major equipment replacing over 60% of foreign products; make breakthroughs in 1,500m deep extraction and other key techniques and equipment; achieve clean and efficient development as well as higher-value utilization of bulk, paragenetic and associated nonmetallic mineral resources and salt-lake resources; make breakthroughs in recycling utilization techniques of bulk industrial solid wastes, establish the mining and metallurgical solid waste resources recycling utilization technology system, and achieve the ratio of comprehensive resources utilization rate of beyond 50%; construct international cooperation and exchange platforms for talent, technology, resources and others, rely on domestic market and expand overseas market, and establish the 'two markets, two resources' optimizing and complementary system.

## V. Technical Standards for Geology and Mineral Resources

The standardization reform of land and resources was deepened, and the integration of standards and geology & mineral was promoted. In December 2016, the *Implementation Scheme of the Ministry of Land and Resources for Deepening the Reform of Standardization* was issued, in which the standardization was deployed for supporting, serving and guiding the development of geology and mineral industry during ‘the 13<sup>th</sup> Five-Year Plan’ period.

In 2016, 3 national standards, namely *Specification for Exploration of Solid Mineral Resources*, *Code of Geological Exploration of Natural Mineral Water Resources*, and *Code for Geological Investigation of Landslide Prevention*, were issued and implemented, and 45 recommended industrial standards for the geology and mineral industry were released, including *Specification of land quality geochemical assessment*, *Requirements of Remote Sensing Monitoring Technology for Geological Environment (1:250,000)*, *Technical Specifications for Shale Gas Ground Time-frequency Electromagnetic Method*, *Technical Specifications for Seismic Data Collection and Processing for Shale Gas Survey*, *Code for Coal Seismic Exploration*, *Code for Geophysical Logging of Metal Deposit*, *Technical Regulation for Magnetic Logging*, *Technical Specifications for Resistivity Profiling Method*, *Technical Specifications for Time Domain Induced Polarization Method*, *Technical Specification for Ground Magnetic Source Transient Electromagnetic Method*, *Analysis Methods for Regional Geochemical Sample (34 parts in total)*, *Colorless Synthetic Single-crystal Diamond Grown by Chemical Vapor Deposition Method—Screening and Identifying*, etc. The issuance of such standards provided technical support for mineral resources exploration, development and management, ecological environment protection and other related work, pushed application of new techniques and methods in geology and mineral, and promoted scientific and technological innovation of geology and mineral.

# Chapter X

## International Cooperation

A positive response was given to the ‘the Belt and Road’ initiative, and the bilateral and multilateral cooperation in the field of geology and mineral resources was promoted. With the China Mining Congress & Expo, China-ASEAN Mining Cooperation Forum and other international exchange platforms as well as geological survey projects, the exchange and cooperation with ASEAN, Africa, South America and other mining countries was further expanded.

### I. Bilateral and Multilateral Cooperation Mechanism

#### 1. Bilateral cooperation increasingly enhanced

Memoranda of understanding on cooperation in the fields of geology and mining was signed with Moroccan ministries of energy, mining, water resources and environment as well as Saudi Arabian ministries of energy, industry and mineral resources, which promoted the position of mineral resources in bilateral cooperation.

The 6<sup>th</sup> meeting between mineral resources cooperation sub-committees of China-Mongolia committees of foreign trade, the China-Mexico mining workgroup meeting and the 8<sup>th</sup> meeting between geology and mineral sub-committees of China-Kazakhstan cooperation committees have been held successfully. The friendly cooperation with major mining countries such as Australia, Canada and South Africa was further consolidated, and the

cooperation with developed countries such as UK and Holland was developed in oil & gas management, shale gas exploration and development, geological environment protection and other fields. Close cooperation with Laos, Cambodia, Papua New Guinea, Ethiopia, Namibia, Nigeria, Argentina, Peru, Mexico and other Asian, African and Latin American countries with important resources were carried out in geo-scientific research, geological survey, mining management and other fields.

Memoranda of understanding and agreements on cooperation were signed with geological survey agencies of 15 countries such as America, Russia and Switzerland. The seminar on China-Canada international geological sci-tech cooperation, seminar on China-Australia international geological sci-tech cooperation, Nigeria-China mining investment cooperation forum, and bilateral meeting between Chinese and American departments of geological survey were held, which promoted the scientific and technological innovation cooperation with developed countries in the field of geological survey and the cooperation with developing countries in mining investment.

## 2. Multilateral cooperation platforms actively established

China actively participated actively in multilateral meetings in the field of mineral resources. By taking part in the 22<sup>nd</sup> meeting of the International Seabed Authority, China was successfully elected as a member of the Legal and Technical Committee, International Seabed Authority, and by joining the 10<sup>th</sup> meeting of the mining workgroup of APEC, the Kimberley Process, the 35<sup>th</sup> International Geological Congress in South Africa, the 69<sup>th</sup> executive committee meeting of the International Union of Geological Sciences (IUGS) and other multilateral organization conferences. Chinese scientists were successfully elected as the chairman of IUGS and for other important positions in international organizations.

The international scientific and technological cooperation on land and resources was boosted according to the ‘Three Deeps and One Land’ strategy. The MLR and United Nations Educational, Scientific and Cultural Organization (UNESCO) had developed productive cooperation for a long period. In 2016, they signed the *Agreement between the Government of the People’s Republic of China and UNESCO on Establishing an UNESCO-supported*

*International Global-scale Geochemical Research Center (Type 2) in Langfang, People's Republic of China and the Agreement between the Government of the People's Republic of China and UNESCO on Establishing an UNESCO-supported International Karst Center (Type 2) in Guilin, China, established the 'UNESCO-supported International Global-scale Geochemical Research Center', and started the 'International Big Science Project for Chemical Earth' and the 'International Big Science Project for Resource-environment Effect of Global Karst Dynamics System'.*

## II. Opening-up and Cooperation

### 1. Promotion of resources cooperation with 'the Belt and Road' countries

The formulation of *Planning for 'the Belt and Road' Geological Survey (2016-2030)*, *Maritime Cooperation Plan for Construction of 'the Belt and Road'* and *Framework Program for International Cooperation between South China Sea and its Surrounding Seas (2016-2020)* and the overall design of '21st-century Maritime Silk Road' were completed, and dialogues and communications with surrounding countries, maritime powers and great maritime powers were strengthened. The *Law of Exploration and Development of Deep-seabed Resources* was promulgated and enforced, promoting the exploration and development of deep-seabed resources.

The joint investigation on field study on the open sea outside the mouth of Beibu Gulf of China and Vietnam was completed smoothly. The cooperation with ASEAN countries was promoted. 11 seminars or training classes in geology and mineral fields were held, such as 'China-ASEAN Maritime Geosciences Capacity Building and Disaster Reduction & Prevention Seminar'.

### 2. International cooperation in geological survey

38 international cooperation projects for joint geological survey with 32 countries has been established, mainly including geological mapping, geochemical mapping, technical training, research on methods and technical cooperation, research on metallogenic rules

and cooperative mapping etc. Geological and geochemical mapping at various scales was conducted with 27 countries, such as Uzbekistan, Russia, Pakistan, Laos, Ethiopia, Australia and Peru, covering the area of 3.64 million km<sup>2</sup>.

117 maps of geological minerals at various scales were prepared cooperatively in 2016, involving the 1:25,000,000 map of world oceanic mineral resource, 1:10,000,000 Asian metallogenic map, 1:2,500,000 series maps of geological minerals for Central and East Asia and adjacent regions, Northeast Africa, West Africa, Mideast Africa and other regions, 1:1,000,000 geological, mineral, structural and metallogenic maps of such key metallogenic belts as China-Mongolia Cross-border Metallogenic Belt, China-Kirgizstan-Uzbekistan Tianshan Orogenic Belt, China-Kazakhstan Cross-border Metallogenic Belt, areas along China-Pakistan Railway and Andes in South Peru, 1:5,000,000 3 dimensional remote-sensing maps of areas along 'the Belt and Road', and remote-sensing maps of 35 countries at 1:1,000,000.

### 3. Foreign training classes on geology and minerals

In 2016, a total of 18 foreign training classes on geology and minerals were organized and more than 400 geology and mineral experts from over 50 countries have been trained. A total of three overseas international training classes were held in Malaysia, Cambodia and Thailand, promoting the international cooperation of Chinese methods and technologies for geological survey and strongly supporting the implementation of China's 'the Belt and Road' co-construction initiative and international mining capacity cooperation.

## III. International Mining Cooperation Platform

### 1. China Mining 2016

The China Mining 2016, where more than 7,000 representatives from 53 countries and regions attended, proposed the 'innovation-driven, reform-led, green & safe, inclusive & sharing and open & mutually beneficial' mining development concept, manifested and propagandized China's mining reform and development direction in the new situation,

expanded the government cooperation platform to cooperatively create the common destiny of global mining industry, and deeply analyzed the development trend of global mining industry to boost the confidence in mining development.

### 2. China-ASEAN Mining Cooperation Forum

Themed by ‘Information Sharing and Win-win Corporation’, co-organized with the Guangxi Zhuang Autonomous Region People’s Government and MLR, the 7<sup>th</sup> China-ASEAN Mining Cooperation Forum played a positive role in deepening the cooperation between Chinese and ASEAN governments, promoting the signing of mining cooperation agreements, strengthening the mineral rights management and talent training cooperation, construction of green mines and others, and promoted the pragmatic cooperation regarding geology and minerals with Malaysia, Cambodia, Thailand and other ASEAN countries.

### 3. Establishment of multiple geosciences cooperative research centers

The year 2016 witnessed the successive establishment of China-Southeast Asia Geosciences Cooperative Research Center, China-Latin America Oceania Geosciences Cooperative Research Center, China-Northeast Asia Geosciences Cooperative Research Center and China-West and North Africa Geosciences Cooperative Research Center. The international platform for geosciences cooperation has been built and consolidating the basis for geosciences cooperation has been consolidated.