

2019

China Mineral Resources

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Foreword

China's mining industry has developed by leaps and bounds since the founding of the PRC thanks to the intimate care of the CPC Party and state leaders. A total of 173 kinds of minerals have been discovered in China. The kinds of minerals with identified reserves have increased from less than twenty to 162, and the reserves of mineral resources has increased significantly, making China become one of the few large countries in the world with complete mineral species and abundant mineral resources. The output of major mineral products such as coal, iron and steel, ten kinds of non-ferrous metals, cement and glass has ranked top among the world, making China become the world's largest producer of mineral products. With the active implementation of the strategy of opening to the outside world, China has become the world's largest trading country for mineral products, and has made great contributions to the development of the world's mining industry.

The organization and preparation of the annual report *China Mineral Resources* (hereinafter "CMR") have been started from 2011 onwards, with the purpose to effectively improve the public service capacity of mineral resources management departments and promote the disclosure of government information so that the public can know better about China's exploration, exploitation and utilization of mineral resources and the latest policies and regulations.

Since the establishment of the Ministry of Natural Resources (MNR) in 2018, MNR has actively carried out green mineral exploration and ecological restoration of mines, vigorously promoted the reform of mineral resources management system, continued to put more efforts into the strategic mineral investigation and evaluation, continuously improved the theory of mineral geology and the level of comprehensive development and utilization, and further expanded the "Belt and Road Initiative" international cooperation in geology and mineral resources.

The *CMR* 2019 focuses on such information since 2018 as the new progress made in China's

exploration, exploitation and utilization of mineral resources, construction of green mine mine, and geological and mineral surveys and evaluations; the new measures taken in policies and regulations related to mineral resources planning, supervision and management, mining industry taxation system reforms and ecological protection and restoration; the new developments made in scientific and technological innovation in mineral resources exploration, exploitation and utilization, as well as geoscience theoretical studies; and the new achievements obtained in international geological and mineral resources cooperation with countries participating in the “Belt and Road Initiative”.

In 2018, the identified reserves of important minerals in China such as natural gas, copper, nickel, tungsten, lithium, fluorite, crystalline graphite, etc. increased. A total of 153 new deposits were discovered throughout the country, including 51 large-scale, 57 medium-scale and 45 small-scale deposits. Among them, there were three oil fields with proved geological reserves more than 100 million tons, and one gas field with proved geological reserves more than 300 billion m³. In terms of natural gas hydrate exploration, the construction of a pilot test area for natural gas hydrate exploration and trial production was started in the preferred key sea area in the northern South China Sea. For the first time, natural gas hydrate deposits with large thickness, high purity, multiple types and multiple layers were revealed by drilling.

The investment in oil and gas exploration across the country rebounded to some extent, whilst the investment in non-oil and gas mineral exploration continued to decline. The demand for mineral products kept growing, and the energy consumption structure was continuously optimized. The fixed asset investment in the mining industry began to rebound, and the supply capacity of major mineral products was continuously strengthened. In particular, the output and consumption of primary energy, crude steel, ten kinds of non-ferrous metals, gold and cement continued to rank first in the world.

Guided by Xi Jinping’s Thought of Ecological Civilization, active efforts were made to promote the ecological restoration of mines, reform and improve the various management systems, and carry out the ecological restoration of abandoned open-pit mines in key areas. It is required to accelerate the demonstration of green exploration and the construction of green mines to promote the transformation and upgrading of mining industry.

Efforts were made to continue pushing forward the revision of laws and regulations on mineral resources and promoting the reform of the administrative examination and approval system in the field of mineral resources. A number of administrative approvals were canceled and decentralized. The *Regulations on the Protection of Paleontological Fossils* was amended. The reform of the property rights system of natural resources assets was actively promoted as a whole, and the reform of the mineral resources management system and the resources taxes and fees was further deepened.

A new round of preliminary research on the national mineral resources planning was carried out. The mid-term evaluation of the implementation of the *National Mineral Resources Plan* (2016-2020) was completed. A pilot project for unified mineral rights registration of mineral resources and reserves was initiated, a sound mineral resources inventory system was established. Supervision and protection of mineral resources were strengthened, and consistent good job was done in the disclosure of basic information on mineral rights management.

The level of basic geological survey was further improved. The areas of regional geological survey, remote sensing comprehensive survey and aeromagnetic survey were further expanded. In the aspect of mineral resources survey, hydrocarbon basic investigation and strategic zoning were carried out with priority given to “new areas, new strata, new fields and new types”. Mineral geological surveys were carried out along key metallogenic belts, packaged exploration areas, important ore-rich areas and large-scale resource bases. The geological data management system was further improved and was able to provide services with continuously improved capacity and quality.

Significant achievements were made in basic geological research. Innovative metallogenic theories, prospecting models and prospecting methods were innovated, and a number of geological prospecting instruments and equipment were developed or integrated. Advanced and applicable technologies for comprehensive utilization of mineral resources were applied and popularized more forcefully. The build-up of a scientific and technological innovation talents team in the field of geology and mineral resources was promoted as required in the series of national documents on the reform of the scientific and technological system.

The bilateral and multilateral cooperation in the field of geology and mineral resources was comprehensively promoted in active response to the “Belt and Road Initiative”. Through international exchange platforms such as China Mining and China - ASEAN Mining Cooperation Forum, geological survey cooperation projects were actively promoted, and the exchanges and cooperation with relevant countries were further expanded.

Statistics in the *CMR* are mainly from the Ministry of Natural Resources and the National Bureau of Statistics of the People’s Republic of China. Statistics from the Hong Kong Special Administrative Region (SAR), Macao SAR and Taiwan Province of the People’s Republic of China are not included in this report.

Contents

Foreword

Chapter I Mineral Resources	1
I. Reserves & Resources	1
II. Review and Filing of Reports on Reserves & Resources	4
III. Potential of Mineral Resources	7
Chapter II Exploration	9
I. Geological Exploration Spending	9
II. Progress in Oil and Gas Exploration	11
III. Progress in Non-oil & Gas Minerals Exploration	14
Chapter III Development and Utilization	16
I. Mining Fixed Assets Investments	16
II. Production and Consumption	17
III. Conservation and Comprehensive Utilization	22
Chapter IV Restoration of Mine Geological Environment and Green Development	24
I. Restoration of Mine Geological Environment	24
II. Green Exploration	27
III. Green Mines	28
Chapter V Policies and Regulations on Mineral Resources	29
I. Policies and Regulations on Mineral Resources	29
II. Reform of Mineral Resources System	32

III. Taxes on Mineral Resources	33
Chapter VI Mineral Resources Management	34
I. Mineral Resources Planning and Management	34
II. Geological Exploration Management	35
III. Management of Mineral Reserves & Resources	36
IV. Mineral Rights Management	39
V. Delineation and Management of Ecological Red Line	41
VI. Protection and Management of Paleontological Fossils	42
Chapter VII Geological and Mineral Resources Surveys and Evaluations	43
I. Basic Geological Surveys	43
II. Mineral Resources Surveys and Evaluations	44
III. Marine Geological Surveys	47
Chapter VIII Geological Data Management and Services	48
I. Geological Data Management	48
II. Geological Data Archiving	49
III. Geological Data Services	50
Chapter IX Scientific and Technological Innovations in Mineral Resources	53
I. Research on Fundamental Geology and Metallogenic Theories	53
II. Mineral Resources Exploration Technology	56
III. Exploitation and Utilization Technologies	59
IV. Scientific and Technological Innovation Plans	60
V. Technical Standards for Geology and Mineral Resources	62
Chapter X International Cooperation	63
I. Bilateral and Multilateral Cooperation Mechanisms	63
II. Opening-up and Cooperation	65
III. International Mining Cooperation Platforms	67

Indexes

Feature 1-1	Significant Growth in Reserves & Resources for Major Minerals Since the Founding of the PRC	4
Feature 2-1	The Growth of Geological Exploration Investment and Remarkable Prospecting Achievements Since the Founding of the PRC	10
Feature 3-1	Changes of Fixed Assets Investment in Mining Industry Since the Founding of the PRC	17
Feature 3-2	Changes in the Production of Major Mineral Commodities Since the Founding of the PRC	20
Feature 5-1	Important Laws and Regulations on Mineral Resource Since the Founding of the PRC	31
Feature 5-2	Changes in Geological and Mineral Management Institution Since the Founding of the PRC	32
Feature 6-1	Changes in Classification Standards for Mineral Resources & Reserves Since the Founding of the PRC.....	38
Feature 7-1	Remarkable Achievements Made in Basic Geological Survey Since the Founding of the PRC	44
Feature 8-1	Great-leap-forward Development Achieved in Geological Data Management Modernization and Service Socialization Since the Founding of the PRC	49
Feature 9-1	Sustainable Development of Geological and Mining Undertakings Promoted by Scientific and Technological Innovations Since the Founding of the PRC	54

Chapter I

Mineral Resources

By the end of 2018, a total of 173 kinds of minerals have been discovered across China, including 13 kinds of energy minerals, 59 kinds of metal minerals, 95 kinds of nonmetal minerals and 6 kinds of water and gas minerals. In 2018, China's proven reserves of important minerals such as natural gas, copper, nickel, tungsten, platinum group metals, lithium, fluorite, graphite and wollastonite increased. New progress was made in the evaluation of the potential of oil, natural gas and other mineral resources.

I. Reserves & Resources

1. Changes in remaining reserves & resources

In 2018, among the major minerals, the remaining reserves & resources of 37 kinds of minerals increased and those of 11 kinds decreased. In particular, coal increased by 2.5%; the remaining technically recoverable reserves of oil increased by 0.9%, and that of natural gas increased by 4.9%; copper increased by 7.9%, nickel 6.2%, tungsten 4.0%, platinum group metal 9.8%, pyrite 4.0%, lithium 12.9%, fluorite 6.4%, crystalline graphite 19.0%, wollastonite 35.2%; while the remaining reserves & resources of gypsum, asbestos, bentonite, chromite, manganese and potash decreased notably (Table 1-1).

China Mineral Resources 2019

Table 1-1 Remaining Reserves & Resources of Major Minerals

No.	Mineral	Unit	2017	2018	Growth rate /%
1	Oil	Billion tons	3.54	3.57	0.9
2	Natural gas	Billion cubic meters	5522.10	5793.61	4.9
3	Coalbed methane	Billion cubic meters	302.54	304.63	0.7
4	Shale gas	Billion cubic meters	198.29	216.02	8.9
5	Coal	Billion tons	1666.67	1708.57	2.5
6	Iron ore	Billion tons of ores	84.89	85.22	0.4
7	Manganese ore	Billion tons of ores	1.85	1.82	-1.6
8	Chromite	Thousand tons of ores	12202.4	11932.7	-2.2
9	Vanadium	Thousand tons of V ₂ O ₅	64281.6	65613.0	2.1
10	Titanium	Million tons of TiO ₂	819	826	0.9
11	Copper	Million tons of metal	106.08	114.43	7.9
12	Lead	Million tons of metal	89.67	92.16	2.8
13	Zinc	Million tons of metal	184.94	187.56	1.4
14	Bauxite	Million tons of ores	5089	5170	1.6
15	Nickel	Thousand tons of metal	11180.7	11878.8	6.2
16	Cobalt	Thousand tons of metal	687.8	696.5	1.3
17	Tungsten	Thousand tons of WO ₃	10304.2	10715.7	4.0
18	Tin	Thousand tons of metal	4500.4	4530.6	0.7
19	Molybdenum	Thousand tons of metal	30067.8	30286.1	0.7
20	Antimony	Thousand tons of metal	3197.6	3276.8	2.5
21	Gold	Tons of metal	13195.56	13638.40	3.4
22	Silver	Thousand tons of metal	316.0	329.1	3.1
23	Platinum group metal	Tons of metal	365.30	401.00	9.8
24	Strontium	Thousand tons of celestine	56440.5	56410.7	-0.1
25	Lithium	Thousand tons of oxides	9673.8	10920	12.9
26	Magnesite	Million tons of ores	3115	3103	-0.4

Continued

No.	Mineral	Unit	2017	2018	Growth rate /%
27	Fluorite	Million tons of minerals	242	257	6.4
28	Refractory clay	Million tons of ores	2592	2638	1.8
29	Pyrite	Million tons of ores	6060	6300	4.0
30	Phosphate rock	Million tons of ores	25284	25282	-0.01
31	Potash	Million tons of KCl	1027	1016	-1.1
32	Boron	Thousand tons of B ₂ O ₃	78172.6	78365.7	0.2
33	Sodium salt	Billion tons of NaCl	1422.49	1424.09	0.1
34	Mirabilite	Billion tons of Na ₂ SO ₄	117.12	117.30	0.2
35	Barite	Million tons of ores	362	373	3.0
36	Cement limestone	Billion tons of ores	137.01	143.24	4.5
37	Glass-making siliceous rock	Million tons of ores	8875	9613	8.3
38	Gypsum	Million tons of ores	98472	82486	-16.2
39	Kaolin	Million tons of ores	3474	3496	0.6
40	Bentonite	Million tons of ores	3062	2996	-2.2
41	Diatomite	Million tons of ores	513	511	-0.4
42	Veneer granite	Million cubic meters	5057	5380	6.4
43	Veneer marble	Million cubic meters	1675	1778	6.1
44	Diamond	kg of minerals	3124.62	3126.60	0.1
45	Crystalline graphite	Million tons of minerals	367	437	19.0
46	Asbestos	Million tons of mineral	95.46	92.59	-3.0
47	Talc	Million tons of ores	289	288	-0.6
48	Wollastonite	Million tons of ores	170	229	35.2

Note: The oil, natural gas, coalbed methane and shale gas here are the remaining technically recoverable reserves. See GB/T 19492-2004 for classification criteria;

The non-oil and gas minerals here are the remaining reserves & resources. See GB/T 13908-2002 for classification criteria.

2. Newly-discovered reserves & resources

In 2018, the newly discovered geological reserves of oil amounted to 959 million tons, natural gas 831.16 billion m³, shale gas 124.68 billion m³. The newly-discovered reserves & resources of coal amounted to 55.61 billion tons, iron ore 993 million tons, copper 2.25 million tons, bauxite 116 million tons, nickel 472,000 tons, gold 719.8 tons, phosphate rock 225 million tons, fluorite 11.58 million tons and crystalline graphite 54.97 million tons (Table 1-2).

Feature 1-1 Significant Growth in Reserves & Resources for Major Minerals Since the Founding of the PRC

Since the founding of the PRC in 1949, the kinds of minerals with proven reserves in China has increased from less than twenty to 162. The reserves of important minerals such as coal, iron, copper and petroleum have increased significantly. Among them, the oil reserves increased 122 times from 29 million tons to 3.573 billion tons; iron ore reserves increased 25 times from 3.32 billion tons to 85.219 billion tons; manganese ore increased 4 times from 408 million tons to 1.816 billion tons; the proven reserves of copper increased 51 times from 2.1893 million tons to 114.4349 million tons; lead increased 77 times from 1.181 million tons to 92.1631 million tons; zinc increased 181 times from 1.031 million tons to 187.5567 million tons; bauxite increased 11 times from 450 million tons to 5.17 billion tons; tungsten increased 4 times from 2.128 million tons to 10.7157 million tons. Mineral resources in China are rich and of a considerable variety.

II. Review and Filing of Reports on Reserves & Resources

In 2018, 2452 reports on mineral resources and reserves were reviewed and filed in China (by the Ministry of Natural Resources and provincial departments of natural resources, the same below), showing a decrease of 5.8% over 2017. Among them, 138 reports were about oil and gas, and 2,314 reports non-oil and gas (Table 1-3). The Ministry of Natural Resources reviewed and filed 227 reports, decreased by 20.6% year-on-year. Provincial departments of natural resources reviewed and filed 2,225 reports, decreased by 4.0% year-on-year. Among the minerals reviewed and filed in 2018, coal (769 reports, accounting for 31.4%), gold (244 reports, accounting for 10.0%), iron ore (183 reports, accounting for 7.5%), oil (101 reports, accounting for 4.1%) and geothermy (95 reports, accounting for 3.9%) ranked top five in terms of number of reports.

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

No.	Mineral	Unit	2017	2018
1	Coal	Million tons	81556	55610
2	Oil	Million tons	877	959
3	Natural gas	Billion cubic meters	555.38	831.16
4	Coalbed methane	Million cubic meters	10480	14708
5	Shale gas	Billion cubic meters	376.76	124.68
6	Iron ore	Million tons of ores	1451	993
7	Manganese ore	Million tons of ores	282	68
8	Copper	Million tons of metal	4.18	2.25
9	Lead	Million tons of metal	6.12	3.72
10	Zinc	Million tons of metal	10.87	5.76
11	Bauxite	Million tons of ores	292	116
12	Nickel	Thousand tons of metal	38.8	472
13	Tungsten	Thousand tons of WO ₃	160.1	278
14	Tin	Thousand tons of metal	86.0	167
15	Molybdenum	Thousand tons of metal	1070.0	282
16	Antimony	Thousand tons of metal	140.4	187
17	Gold	Tons of metal	1104.35	719.8
18	Silver	Thousand tons of metal	51.6	12.0
19	Pyrite	Million tons of ore	105.95	144.50
20	Phosphate rock	Million tons of ores	992	225
21	Fluorite	Million tons of minerals	14.39	11.58
22	Crystalline Graphite	Million tons of minerals	61.48	54.97

Note: The oil, natural gas, coalbed methane and shale gas here are the newly-discovered geological reserves.

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

Reviewed and filed by		2017		2018	
		Number of reports	Proportion %	Number of reports	Proportion %
Ministry of Natural Resources	Solid minerals	83	3.2	89	3.6
	Oil and gas	203	7.8	138	5.6
	Sub total	286	11.0	227	9.3
Provincial departments of natural resources		2318	89.0	2225	90.7
Total		2604	100.0	2452	100.0

Table 1-4 Review and Filing of Reports on Non-oil & Gas Mineral Reserves

Report type	2017		2018	
	Number of reports	Proportion %	Number of reports	Proportion %
Exploration	838	34.9	780	33.7
Verification	1138	47.4	1178	50.9
Overlaid minerals	183	7.6	159	6.9
Production	67	2.8	59	2.5
Mine closure	146	6.1	116	5.0
Others	29	1.2	22	1.0
Total	2401	100.0	2314	100.0

The 2,314 reports on non-oil & gas minerals reviewed and filed in 2018, including 1,178 reserves verification reports, accounting for 50.9%; 780 exploration reports, accounting for 33.7%; 159 reports on overlaid resources, accounting for 6.9%; 116 reports on mine closure, accounting for 5.0%; 59 reports on mine production and geology, accounting for 2.5%; and 22 reports on other types, accounting for 1% (Table 1-4).

III. Potential of Mineral Resources

1. Oil and gas

The geological resources of oil amounted to 125.7 billion tons in China, while those of natural gas amounted to 90 trillion m³. The geological resources of shale gas, buried in depth at 4,500m or shallower, were 122 trillion m³. The geological resources of coalbed methane, buried in depth at 2,000m or shallower, were 30 trillion m³. According to the type and occurrence of natural gas hydrate resources, combined with geological conditions, the natural gas hydrate resources in China's territorial sea were preliminarily estimated to be about 80 billion tons of oil equivalent.

2. Non-oil & gas minerals

China has great potential of non-oil & gas minerals resources. As of the end of 2018, a total of 28 kinds of solid mineral resources have been predicted, and the average measured rate at burial depth less than 2,000 meters is 26.0% (Table 1-5).

China Mineral Resources 2019

Table 1-5 Potential of Important Mineral Resources

No.	Mineral	Unit	Potential resources	Resource measured ratio/%	
1	Coal	Trillion tons	3.88	30.0	
2	Iron ore	Billion tons of ore	196	30.2	
3	Manganese ore	Billion tons of ore	4.8	27.8	
4	Chromite	Million tons of ore	55.6	18.0	
5	Copper	Million tons of metal	304	25.8	
6	Lead	Million tons of metal	260	25.9	
7	Zinc	Million tons of metal	600	23.7	
8	Bauxite	Billion tons of ore	13	28.2	
9	Nickel	Million tons of metal	24.5	31.3	
10	Tungsten	Million tons of WO ₃	29.7	25.7	
11	Tin	Million tons of metal	18.6	19.5	
12	Molybdenum	Million tons of metal	89.6	25.1	
13	Antimony	Million tons of metal	15.2	17.4	
14	Gold	Thousand tons of metal	32.7	28.8	
15	Silver	Thousand tons of metal	730	30.3	
16	Lithium	Hard rock lithium	Million tons of spodumene	8.8	25.51
		Lithium brine	Million tons of LiCl	92.5	19.0
17	Sulphur	Pyrite	Billion tons of ore	18.4	24.8
		Natural sulphur	Billion tons of sulphur	0.2	61.0
18	Phosphate rock	Billion tons of ore	56	31.4	
19	Potash	Billion tons of KCl	2	33.9	
20	Barite	Billion tons of ore	1.4	20.1	
21	Boron	Million tons of B ₂ O ₃	188.6	29.3	
22	Magnesite	Billion tons of ore	13.1	19.2	
23	Fluorite	Million tons of minerals	952.8	20.2	
24	Graphite	Billion tons of minerals	2.1	15.1	
25	Gallium	Million tons of gallium	1.3	20.6	
26	Indium	Thousand tons of indium	75	19.4	

Chapter II

Exploration

In 2018, investments in geological exploration totaled 81.03 billion yuan, which continued the rebound of the previous year by an increase of 3.5%. New breakthrough was made in the exploration of shale gas and natural gas hydrate. Relatively remarkable ore-prospecting achievements were made in such strategic minerals as oil, natural gas, manganese, cobalt, lead-zinc, gold, lithium, graphite and etc.

I. Geological Exploration Spending

In 2018, the investment in geological exploration totaled 81.03 billion yuan in China, which continued the rebound of the previous year by an increase of 3.5%. Among them, the investment in geological exploration of oil and gas minerals was 63.66 billion yuan, increased by 8.9%. The investment in geological exploration of non-oil and gas minerals was 17.37 billion yuan, decreased by 12.4% (Fig. 2-1).

In 2018, a total of 2,955 wells were drilled for oil and gas exploration in China, up 8.4% from the same period last year. A total of 44,000 km² 2D seismic data was acquired, up 13.5%; and a total of 34,000 km² 3D seismic data was acquired, up 3.3%.

Among the investments in geological exploration of non-oil & gas minerals in 2018, the investment in mineral exploration amounted to 9.28 billion yuan and decreased by 23.1%, accounting for 53.4% of the total amount; basic geological survey 3.28 billion

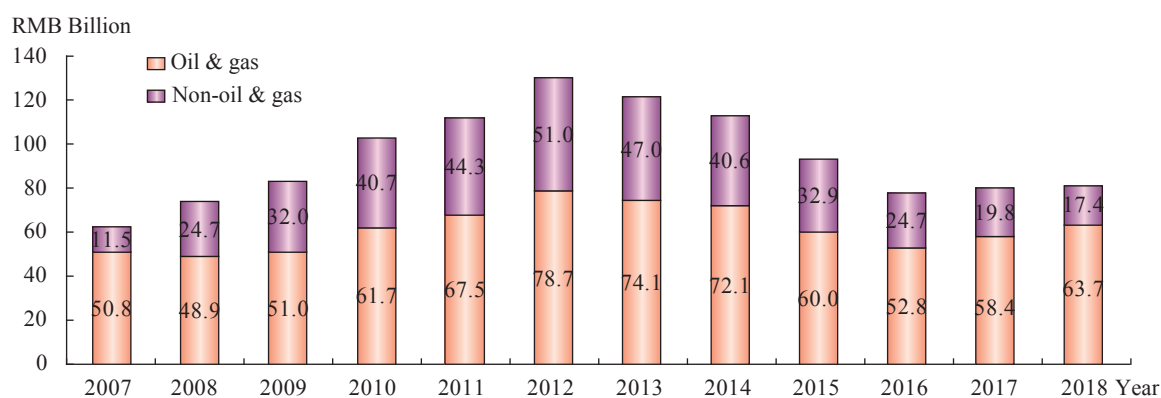


Fig. 2-1 Investments in Geological Exploration in China

Feature 2-1 The Growth of Geological Exploration Investment and Remarkable Prospecting Achievements since the Founding of the PRC

There were lots of work to be done in the early days of the founding of the PRC, and the exploration work was basically at a standstill. China's geological exploration spending was only 640,000 yuan in 1950. The Ministry of Geology was established in 1952, and the costs of geological exploration soared to 130 million yuan in 1953.

During the 1st and 5th Five-year Plans, China organized large-scale exploration for various minerals, resulting in the significant increase of iron ore and coal reserves as well as the establishment of 5 coal bases and 10 iron and steel bases. The discovery of uranium and rare earth deposits provided a resource base for the successful launch of the "Two Bombs and One Satellite" and laid a solid foundation for the dominant mineral status of tungsten, tin, molybdenum, antimony and rare earth. The discovery of a number of oil and gas fields like Daqing has made the country lose the title of "oil-poor country".

The second round of oil survey, the second round of solid mineral survey and two rounds of ore-forming prospect zoning were carried out successively after the 3rd Plenary Session of the 11th CPC Central Committee, and a series of significant progress in the exploration of mineral resources greatly increased the reserves of mineral resources.

Since the beginning of the 21st century, a new round of geological survey and breakthrough strategy for ore prospecting have been implemented and a nationwide survey on the potential evaluation and utilization of mineral resources has also been carrying out. A number of world-class deposits such as the Qulong-Jiama copper mine and Huoshayun lead-zinc mine have been discovered. Ten new resource bases have been initially formed. Major breakthroughs have been made in the exploration and development of new strategic minerals such as shale gas and natural gas hydrate.

The national investment in geological exploration reached a historical high of 129.675 billion yuan in 2012.

yuan and decreased by 4.8%, accounting for 18.9%; hydrogeology, environmental geology and geological disaster survey and evaluation 2.92 billion yuan and increased by 18.3%, accounting for 16.8%; geological science and technology and comprehensive research 1.58 billion yuan and increased by 2.0%, accounting for 9.1%; geological data service and digitalization 321 million yuan and increased by 1.6%, accounting for 1.8%.

Among the investments in geological exploration of non-oil & gas minerals in 2018, 5.83 billion yuan was financed by the central government, accounting for 33.6% of the total amount, and decreasing by 0.6% year on year; 5.38 billion yuan by the local governments, accounting for 30.9% and decreasing by 20.3%; and 6.17 billion yuan was from social investment, accounting for 35.5% and decreasing by 14.7%. Investment of provincial geological exploration funds reached 2.37 billion yuan, including 1.65 billion yuan into mineral exploration, accounting for 17.8% of the total investment in non-oil & gas minerals exploration and 40.3% of the fiscal investment in non-oil & gas minerals exploration nationwide.

In 2018, the investments of non-oil & gas mineral exploration minerals were dominated by gold, coal, lead-zinc and copper, which accounted for 27.1% of the total investment. Compared with 2017, the investment in exploration of nickel, silver, potash and manganese increased by 75%, 41.1%, 19.2% and 6.4% respectively, while the investment in tin, bauxite, tungsten, copper, molybdenum and iron ore decreased notably (Table 2-1).

II. Progress in Oil and Gas Exploration

Unprecedented breakthroughs were made in oil and gas exploration in terms of new areas, new field and new strata, expanded the exploration front and laid a good foundation for increase of reserves and production.

1. Conventional oil and gas exploration

In 2018, more than ten important achievements were made in Hetao Basin, Sichuan Basin, Junggar Basin, Tarim Basin and Bohaiwan Basin. One new 100 million-ton class oil field was discovered, namely Heshui oil field in the Ordos Basin. Three gas fields of 100 billion m³ class were added, namely the Sulige gas field and the Mizhi gas field in the Ordos Basin and the Kelasu gas field in the Tarim Basin.

China Mineral Resources 2019

Table 2-1 Major Mineral Exploration Expenditures and Meters Drilled in 2018

Mineral	Capital investment billion yuan	Year-on-year growth/%	Meters drilled thousand meters	Year-on-year growth/%
Coal	1.27	-21.8%	940	-2.1%
Iron	0.28	-37.0%	240	-20.0%
Manganese	0.15	6.4%	70	0.0%
Copper	0.94	-42.1%	620	-23.5%
Lead-zinc	0.96	-29.5%	840	-9.7%
Bauxite	0.15	-46.7%	180	-37.9%
Nickel	0.11	75.0%	60	100.0%
Tungsten	0.06	-45.7%	80	0.0%
Tin	0.02	-75.6%	20	-33.3%
Molybdenum	0.06	-40.4%	10	-83.3%
Gold	1.55	-28.5%	1170	-15.8%
Silver	0.35	41.1%	210	-8.7%
Phosphorus rock	0.08	-15.2%	140	40.0%
Graphite	0.17	-17.2%	110	-26.7%
Potash	0.14	19.2%	50	150.0%

Major discoveries have been made in oil exploration in the Jilantai structural belt of Linhe Depression in Hetao Basin, with a predicted geological reserves of 116 million tons, which marks a breakthrough after tackling the difficulties in mineral exploration in the basin for 40 years.

Major discoveries were made in Permian natural gas exploration of Yongtan 1[#] Well in western Sichuan Basin, which has a tested production rate of 225,000 m³ of natural gas per day and opened up new fields of exploration in volcanic rock areas. Major discoveries were also made in Yuanba area of Sichuan Basin in the exploration of gas reservoirs in the margin-shoal lithology of the Maokou Formation of Permian for the first time. Venture exploration well Yuanba 7[#] obtained tested production rate of 1.06 million m³ per day, which added inferred geological reserves of natural gas by 152.7 billion m³. Major discoveries were also made from natural gas exploration well Wutan 1[#] in Maokou Formation of East Sichuan. The test production rate is 820,000 m³ of gas per day and favorable exploration area of 73 km² was confirmed, opening up new fields in exploration of rock gas reservoirs in syncline areas of high steep slope structural belts in East Sichuan.

Major new discoveries were made in the oil exploration of Lower Wuerhe Formation in Mahu 1[#] Well Area of Junggar Basin, with a predicted oil-bearing area of 210 km² and an inferred geological reserves of 149 million tons. A major discovery has been made in the petroleum exploration of the Upper Wuerhe Formation of Permian in Shawan Sag, and it is prospective to form a large hydrocarbon enrichment region in Mahu-Shawan Sag.

A major breakthrough was made in venture well Zhongqiu 1[#] in the Qiulitag structural belt of Kuqa Depression, Tarim Basin, which increased 105 billion m³ of inferred geological reserves of natural gas and opened up new fields in exploration and production of oil and gas. Major new discoveries were also made in the Ordovician oil exploration in the Shunbei New Zone (southern section of No. 7 fault zone and of No. 5 fault zone), which increased additional 71.76 million tons of inferred geological reserves.

Through the evaluation of Bozhong sag in Bohai sea area, a packaged condensate gas field with reserves of 100 billion m³ class, the largest in eastern China was found and named Bozhong 19-6; in the highly mature area of Bozhong sag, a 100 million ton class oil field was discovered and named Bozhong 29-6. Major discoveries were made in ultra-high temperature and high pressure natural gas exploration in Ledong District of Yinggehai Basin, which revealed reserves up to 100 billion m³ class.

2. Unconventional oil and gas exploration

Shale oil exploration in Cangdong sag of Bohaiwan Basin revealed large-scale new reserves of 50 million ton. Several wells in Zhuang 183[#] district in Huaqing area of Ordos Basin obtained commercial oil flow, with inferred geological reserves of 155 million tons. Dense natural gas was discovered in the southeast of the basin, which added 55.7 billion m³ of measured geological reserves.

A new 100 billion m³ class shale gas field was found in Weirong district of Sichuan Basin. Major breakthroughs were also made in shale gas exploration in the Jinfo slope in Nanchuan area, eastern Sichuan basin, where geological resources of shale gas up to 196.5 billion m³ were found, laying a good foundation for the construction of the third phase of Fuling shale gas field.

China Geological Survey made breakthrough in shale gas exploration when 2HF well in E'yang mining area, Yichang city, Hubei Province revealed daily production potential of 55,000 m³ from Doushantuo Formation of Sinian System, expanding the shale gas exploration fields.

The construction of a pilot test area for gas hydrate exploration and exploitation was launched in the selected key areas of the northern South China Sea. The drilling revealed natural gas hydrate deposits with large thickness, high purity, rich varieties and multiple-layer distribution for the first time. The exploration of natural gas hydrate resources in the pilot test area in Shenhu sea area continued from last year's effort, identified the spatial distribution characteristics of natural gas hydrate in the pilot area and selected the orebodies with favorable construction conditions and resource endowment as the test mining target in the second round. Land-based gas hydrate investigation continued from last year's effort and discovered important prospecting clues for gas hydrate in Qiangtang and other areas in Tibet.

III. Progress in Non-oil & Gas Minerals Exploration

In 2018, a total of 153 new deposits were found in China, including 51 large-scale, 57 medium-scale and 45 small scale deposits. Coal (20 places), graphite (13 places), gold (12 places), graphite (9 places), iron (8 places) and lead-zinc (8 places) ranked the top among the newly discovered deposits.

Major progress has been made in prospecting for “new areas, new strata, new spaces and new types” of minerals in important metallogenic belts of the country.

The Gaodi manganese deposit discovered in the integrated exploration area of Songtao manganese metallogical belt in Tongren, Guizhou became the first super-large manganese-rich deposit since the founding of the PRC. Thick and large manganese-rich deposits were revealed and verified by drilling in the integrated exploration area of manganese in Zunyi. China’s largest monoblock chromite mine was discovered in Mount Shankar of Robsa, Tibet. More than 10 prospecting target areas have been delineated in the periphery of Huoshaoyun Lead-Zinc Mine in Xinjiang, where more than 23 million tons of accumulative lead-zinc resources were discovered. A total of additional 200,000 tons of tin resources were discovered in Dongpo, Hunan; Vilasto, Inner Mongolia; and Yanbei, Jiangxi. 224 tons of additional gold resources were discovered in Laizhou-Zhaoyuan integrated exploration area in Shandong, further stabilizing East Shandong’s position as a large gold resource base. Super-large phosphorus rock deposit was newly discovered in Yangchang Township, Zhenxiong County, Northeast Yunnan.

New progress was made in geological prospecting of strategic minerals. A total of 2 million tons of lithium oxide resources were discovered in Dahongliutan, Xinjiang; accumulative 4.5 million tons of lithium oxide resources were discovered in Jiajika, Sichuan. Additional 10.22 million tons of crystalline graphite were added in Huangyang mountain integrated exploration area in Qitai County, Xinjiang, the accumulative discovered resources total reached 84.64 million tons, and the forecast prospective resources exceeded 100 million tons.

The National Geological Exploration Fund has implemented 453 projects of mineral exploration, with gold, silver, copper, lead and zinc mines and geothermal water being the largest ones in sequence. There were 80 large and medium-sized mineral deposits being discovered recently. Among them, 23.06 tons of gold were found in Jiangdong Gold Mine in Wangu District, Pingjiang County, Hunan Province; 5,258 tons of silver were found through the general investigation in Fuxingtun Silver-Lead-Zinc Mine in Horqin Right Front Banner, Inner Mongolia; 5.9 million tons of graphite mineral were found through the general investigation in Xujiawan-Lijiaying area, Xichuan County, Henan Province; 69.55 million tons of wollastonite mineral were found through the general investigation of wollastonite mines in Shizhushan-Shanggao Zhangmuqiao mining area, Yushui District, Xinyu City, Jiangxi Province.

Chapter III

Development and Utilization

In 2018, China's demand for mineral commodities remained growing and the energy consumption structure was further optimized. The fixed assets investment in the mining industry began to rebound, and the supply capacity of major mineral commodities was continuously strengthened. The production and consumption of primary energy, crude steel, ten kinds of non-ferrous metals, gold, cement and etc. continued to rank first in the world. Requirements on mining recovery rate, dressing recovery rate and associated minerals comprehensive utilization of 7 kinds of minerals such as coalbed methane, oil shale, etc. were promulgated to strengthen the overall conservation and efficient utilization of mineral resources and to promote ecological civilization; pilot investigation and evaluation of the mineral resources development and utilization was completed and obtained expected results. To promote and evaluate the application of advanced technologies, a total of 334 advanced applicable technologies have been released in 6 batches, which achieved positive results in guiding and encouraging the application of advanced technologies in mines, accelerating technological renovation, promoting enterprise transformation and upgrading, etc.

I. Mining Fixed Assets Investments

In 2018, the fixed assets investment in the mining industry increased for the first time after falling for 4 consecutive years, reaching 958.7 billion yuan, increased by 4.1% year-on-year, 14.1 percentage points higher than the previous year, but still 1.8 percentage points lower than the average of all industries in the country.

Among them, the fixed assets investment in the coal mining, washing and dressing industry

totaled 280.5 billion yuan, increased by 5.9%; oil and gas extraction 263 billion yuan, decreased by 0.7%; ferrous metals mining and dressing 79 billion yuan, increased by 5.1%; non-ferrous metals mining and dressing 102 billion yuan, decreased by 8.0%; non-metal mining and dressing 222.3 billion yuan, increased by 26.7% (Figure 3-1).

Feature 3-1 Changes of Fixed Assets Investment in Mining Industry Since the Founding of the PRC

China's fixed assets investment in mining industry has been increasing rapidly since the founding of the PRC. The fixed assets investment in mining increased from 1.112 billion yuan in 1953 to 958.7 billion yuan in 2018, up 861 times. Among them, the investment in the coal mining and washing industry increased from 358 million yuan to 280.5 billion yuan, up 783 times. The investment in the oil and gas exploration industry increased from 70 million yuan to 263 billion yuan, up 3,756 times. The investment in the ferrous metal mining and dressing industry increased from 277 million yuan to 79 billion yuan, up 284 times. The investment in the non-ferrous metal mining and dressing industry increased from 256 million yuan to 102 billion yuan, up 397 times. The investment in non-metal mining and dressing industry increased from 151 million yuan to 222.3 billion yuan, up 1471 times.

II. Production and Consumption

1. Energy

China is the world's largest energy producer and consumer. In 2018, China's total primary energy production was 3.77 billion tons of standard coal equivalents, increased by 5.0% year-on-year (Figure 3-2); the total consumption 4.64 billion tons of standard coal equivalents, increased by 3.3%; the energy self-sufficiency rate was 81.3%. In 2018, the energy consumption structure was composed of coal, accounting for 59.0%; oil, accounting for 18.9%; natural gas, accounting for 7.8%; and other energy including hydropower, nuclear power, wind power, etc., which accounted for 14.3%.

China's energy consumption structure was continuously improved and the proportion of coal continued to decline. In 2018, the proportion of coal consumption was 1.4 percentage points lower than the previous year and 12.6 percentage points lower than in 2009 (Figure 3-3).

China Mineral Resources 2019

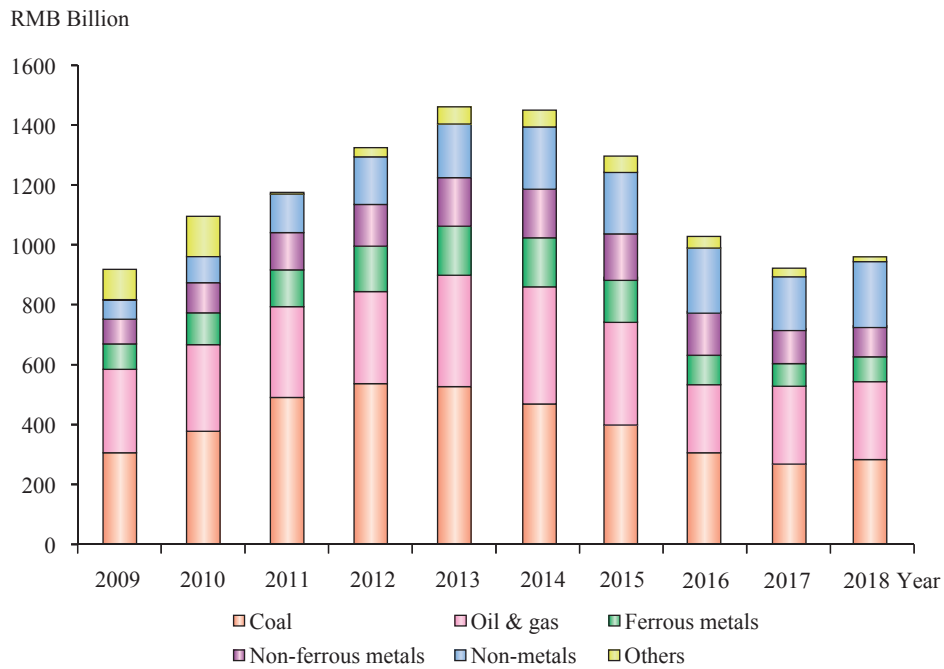


Fig. 3-1 Mining Fixed Assets Investment

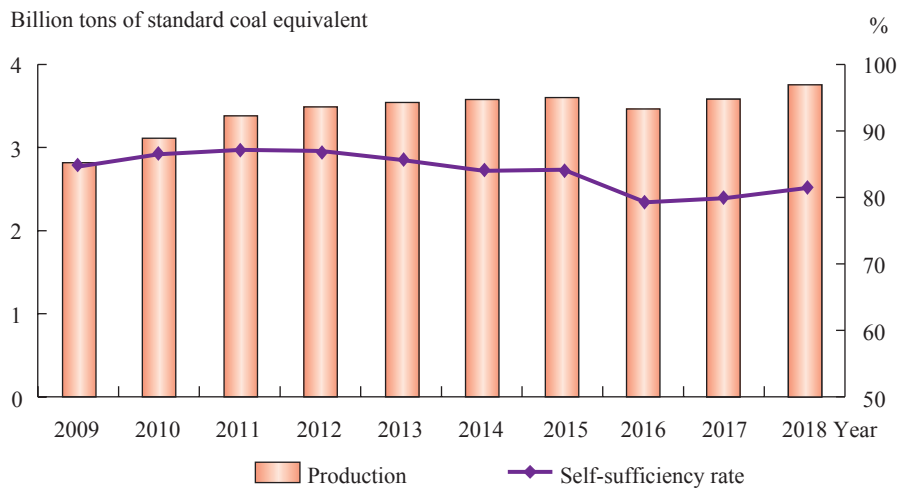


Fig. 3-2 Production of Primary Energy

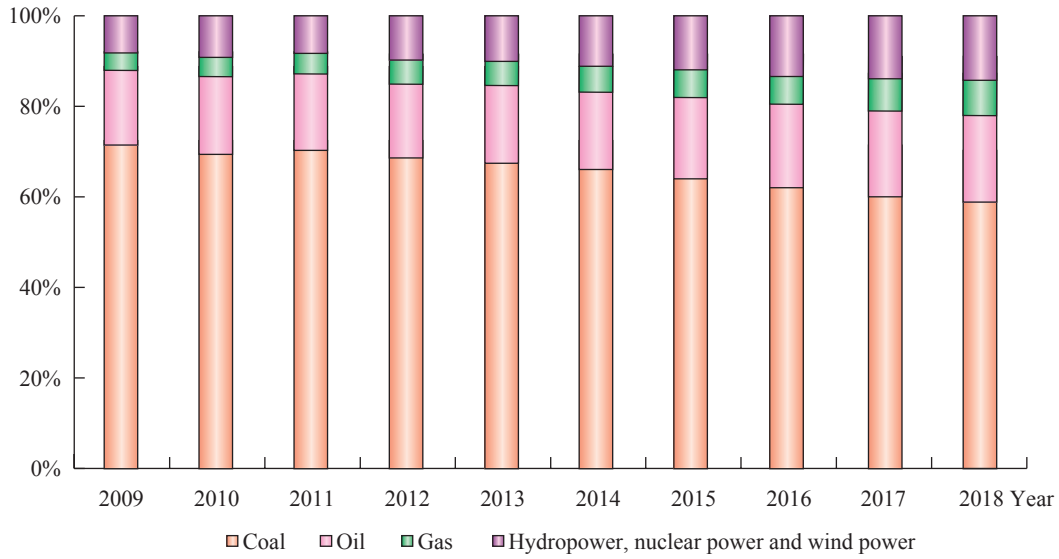


Fig. 3-3 Primary Energy Consumption Structure

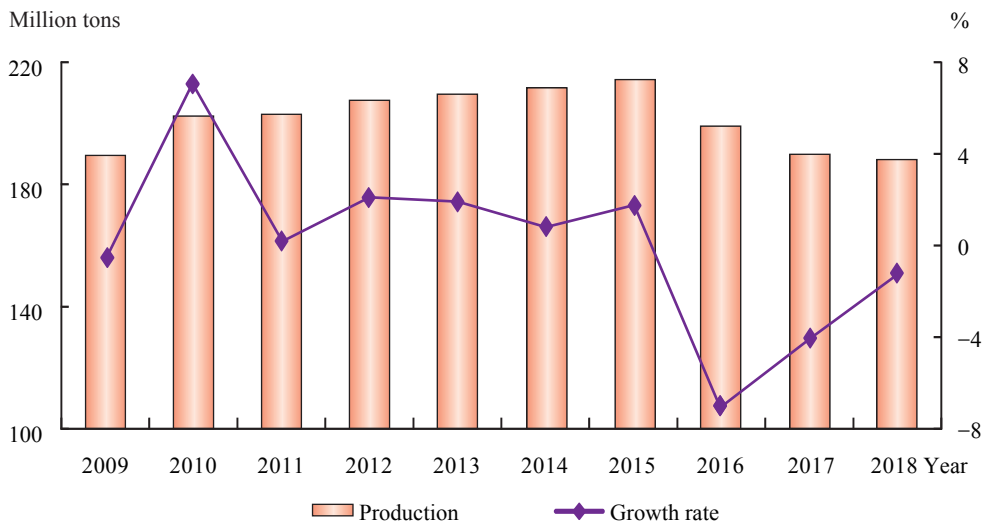


Fig. 3-4 Crude Oil Production

China's coal production ranked first in the world for consecutive years, reaching 3.68 billion tons in 2018, increasing by 4.5% year-on-year; coal consumption 3.89 billion tons, increasing by 1.0%. In the same year, China's oil production ranked seventh in the world, and reached 189 million tons, decreased by 1.3%; apparent consumption 620 million tons, increased by 6.5%. The production of natural gas was ranked sixth in the world, and 160.27 billion cubic meters, increased by 8.3%; apparent consumption 285 billion cubic meters, increased by 17.7%.

2. Metals

In 2018, both the production and the consumption of crude steel, ten kinds of non-ferrous metals and gold ranked first in the world. Among them, the production of iron ore was 760 million tons, decreased by 3.1% year-on-year; apparent consumption 1.37 billion tons (grade 60%); production of crude steel was 930 million tons, increased by 6.6% (Figure 3-5). The production of the ten kinds of non-ferrous metals was 57.027 million tons, increased by 3.7%; in which refined copper 9.029 million tons, increased by 0.7%; and electrolytic aluminum 35.802 million tons, increased by 7.5%. Gold production was 401.1 tons, decreased by 5.9%; gold consumption 1,151.4 tons, increased by 5.7%.

3. Non-metals

In 2018, production of phosphate rock (containing 30% P_2O_5) was 96.326 million tons, increased by 5.8% year-on-year; plate glass 870 million weight cases, increased by 3.7%; and cement 2.21 billion tons, decreased by 5.3% (Figure 3-6).

Feature 3-2 Changes in the Production of Major Mineral Commodities Since the Founding of the PRC

Since the founding of the PRC, the production of primary energy resources increased from 23.74 to 3770 million tons of standard coal equivalents, up 158 times; coal increased from 32 to 3550 million tons, up 110 times; oil increased from 0.12 to 189 million tons, up 1,574 times; natural gas increased from 7 million cubic meters to 161.02 billion cubic meters, up 23,000 times; crude iron increased from 0.25 to 770 million tons, up 3,079 times; crude steel increased from 0.16 to 930 million tons, up 5,812 times; refined copper increased from 0.3923 to 9.029 million tons, up 22 times; refined lead increased from 2600 tons to 2.79 million tons, up 1,072 times; refined zinc increased from 200 tons to 5.67 million tons, up 28,000 times; cement increased from 0.66 to 2180 million tons, up to 3,302 times; plate glass increased from 1.08 to 870 million weight cases, up 805 times.

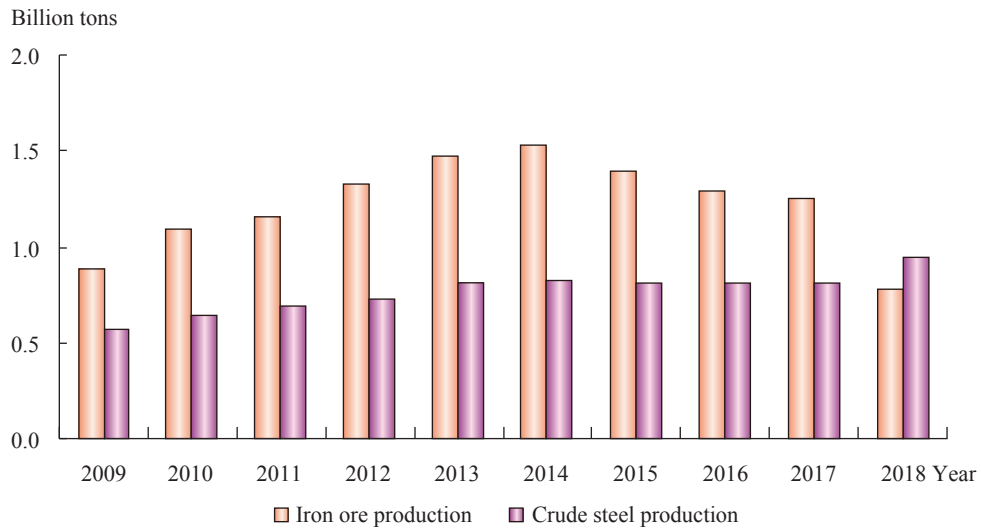


Fig. 3-5 Production of Iron Ore and Crude Steel

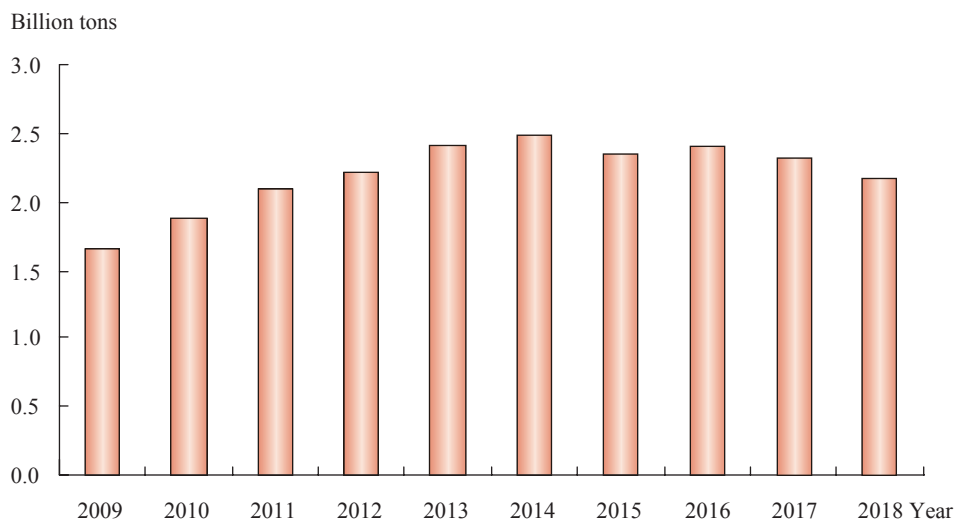


Fig. 3-6 Cement Production

III. Conservation and Comprehensive Utilization

1. Minimum requirements of “three rates” index

On the base of investigation and evaluation of the “three rates” of 39 major minerals including coal, petroleum and iron, the minimum requirements of “three rates” index (*mining recovery rate, dressing recovery rate and comprehensive utilization rate*) (for trial implementation) was formulated in 2018, in accordance with the *Mineral Resources Law of the People’s Republic of China* to regulate the development and utilization of mineral resources and improve the resource utilization efficiency. The development and utilization of mineral resources was regulated and the resource utilization efficiency improved. By the end of 2018, the Ministry of Natural Resources had formulated and issued the minimum requirements of the “three rates” index of 46 (types of) minerals for rational development and utilization.

2. Investigation and evaluation on the development and utilization level of mineral resources

In 2018, pilot investigation and evaluation on the development and utilization level of mineral resources was completed and achieved the expected results. With 11 pilot minerals including oil, natural gas, coal, iron, copper, bauxite, rare earth, gold, fluorite, graphite and limestone, the investigation and evaluation were implemented in 7 provinces (autonomous regions) namely Heilongjiang, Zhejiang, Jiangxi, Shandong, Henan, Hunan and Ningxia, as well as 3 enterprises namely China National Petroleum Corporation, China Petrochemical Corporation, China National Offshore Oil Corporation. Data were collected from a total of 1,379 mines (excluding oil & gas), in which 803 mines (excluding oil & gas) were verified on site. Through investigating and evaluating the development and utilization level, a set of effective index system, work process flow, technical methods and operation mechanism were built for investigation and evaluation of the development and utilization level of mineral resources.

3. Advanced and applicable technologies

Since 2012, in order to implement the strategy of “giving priority to resources conservation”

and “accelerating the transformation of mining development mode”, the former Ministry of Land and Resources and the Ministry of Natural Resources have established a system for publishing the catalog of advanced and applicable technologies and consecutively published the 6 promotion lists of 334 advanced and applicable technologies.

In September 2018, the Ministry of Natural Resources issued the *Notice on the Promotion and Application of Advanced Technologies for the Conservation and Utilization of Mineral Resources* (Letter No. 1133 [2018] of the General Office of the Ministry of Natural Resources) to organize provincial-level natural resources authorities, relevant mining enterprises, and relevant industry associations to evaluate and promote the application of these 334 advanced technologies.

The evaluation results showed that after the release of 334 advanced and applicable technologies, significant benefits in terms of resources, economy and environment were achieved. First, the level of resource utilization was significantly improved, vitalizing 3.31 billion tons of recoverable oil, 164.5 billion cubic meters of natural gas, 800 million tons of coal, 4.07 billion tons of iron ore and 2.1 billion tons of phosphate rock. On average, the mining recovery rate of crude oil increased by 9 percentage points; the mining extraction ratio of solid minerals increased by 8 percentage points; the dressing recovery rate increased by 9.5 percentage points. Second, economic benefits were increased significantly. The output value of the mining industry grew by 204.4 billion yuan and the profits grew by 62.4 billion yuan. Third, the transformation of scientific and technological achievements accelerated. The promulgation and application of the 334 advanced and applicable technologies in 2,818 mining enterprises resulted the incubation of 1,521 patents, 585 national, provincial and ministerial level scientific and technological progress awards, and 328 national and industrial standards. Fourth, remarkable ecological and environmental benefits were obtained. The campaign saved 51,000 mu of land, 10.4 billion kWh of electricity and 830 million tons of water, and recycled 630 million tons of solid waste.

Chapter IV

Restoration of Mine Geological Environment and Green Development

The restoration of mine geological environment was vigorously carried out, reform and various management systems were improved, policies and measures for encouraging and guiding social capital to invest in geological restoration of mining areas left over by history were studied and formulated, efforts were made to get incentives and subsidies from the central government, major national strategic decisions were implemented, ecological restoration of abandoned open-pit mines in key areas such as the Yangtze River Economic Belt, surrounding areas of Beijing-Tianjin-Hebei Region and Fenhe Plain and Weihe Plain and so forth was deployed and implemented. The research and development of green exploration standards was advanced, and the demonstration work of green exploration projects was pushed forward. Through the formulation and implementation of plans, standards and policies, the construction of green mines was planned, deployed and advanced.

I. Restoration of Mine Geological Environment

In order to establish a governance mode of “speeding up the repayment of old debts and no longer owing new ones”, for production mines, a relatively complete supervision

system was formed by improving the mine geological environment protection and land reclamation plan system, advancing the reform of the deposit system, exploring the establishment of a dynamic supervision system, and promoting the formation of a relatively complete supervision system. For abandoned mines, greater efforts were made to control abandoned mines through striving for special funds from the central government, guiding investment of special funds from provincial governments and strengthening policy incentives and guidance.

1. Improvement and advancement of various systems

The reform tasks of the mine geological environment protection and land reclamation system determined by the Central Comprehensively Deepening Reforms Commission were completed, the “two-in-one” plan review system was improved, the approval process was simplified, and burdens on enterprises were alleviated. The “three-in-one” reform of mineral resources development and utilization plan, mine geological environment protection and land reclamation plan were vigorously advanced, and the systematicness, integrity and scientificity of mine environment management were underscored.

The requirements of delegating power, streamlining administration and optimizing government services were implemented and the system reform of canceling the mine geological environmental management and restoration deposit and establishing the mine geological environmental management and restoration fund was continuously advanced. All local authorities were urged to speed up the refund of enterprise deposits in accordance with the principle of “refund as soon as practicable”. By April 2019, 29.25 billion yuan of deposits had been refunded. Meanwhile, all local authorities were guided to speed up the introduction of relevant measures for mine geological environmental management and restoration fund.

2. Work arrangements of mine ecological restoration

Major arrangements regarding defending the blue sky and the tough battle for ecological protection and restoration of the Yangtze River were implemented. In April 2019, the *Circular of the General Office of the Ministry of Natural Resources on Implementing Ecological Restoration of Abandoned Open Pit Mines Along the Yangtze River Economic Belt* (Letter

No. 33 [2019] of the General Office of the Ministry of Natural Resources) was issued. In May 2019, a task arrangement meeting was held for the ecological restoration of open-pit mines in key areas. The ecological restoration tasks of abandoned open-pit mines were arranged within 10 km on both sides of the trunk stream and main tributaries of the Yangtze River and within 20 km around 34 key cities in 7 provinces (autonomous regions and municipalities), including Beijing-Tianjin-Hebei Region, and Fenhe Plain and Weihe Plain, which will be completed by the end of 2020.

3. Putting in place management funds and carrying out pilot projects

Adhering to the concept of a life community of mountains and rivers, forests, fields, lakes and grasslands, and through the first two batches of pilot projects for ecological protection and restoration of mountains and rivers, forests, fields, lakes and grasslands, arrangements were made for the mine geological environment management project, covering a planned management area of about 25,800 ha.

The competitiveness evaluations on the third batch of pilot projects were jointly completed by the Ministry of Natural Resources, the Ministry of Finance and the Ministry of Ecology and Environment. With the approval of the State Council, the implementation of pilot projects in 14 provinces (autonomous regions and municipalities) including Inner Mongolia were supported. A subsidy of RMB 14 billion covering mine ecological restoration was granted by the central government.

4. Mine restoration and management

In 2018, the newly increased mine restoration area in China was about 65,200 ha, the newly increased land destruction area was about 48,000 ha, and the net increased mine restoration and management area was about 17,200 ha. The restoration and management area of mines under construction and production was about 32,200 ha, accounting for 49.4% of the total, and the restoration area of abandoned mines was about 33,000 ha, accounting for 50.6%. 7,298 mines in total were included in the management, mainly distributed in Inner Mongolia, Shanxi, Shaanxi, Anhui, Shandong, Xinjiang, Hebei, Henan and so forth. Since 2001, the restoration covering a total area of 1 million ha has been completed.

II. Green Exploration

Significant progress was made in compilation of green exploration standards, innovation of technical methods, and construction of management systems in 2018.

1. Research and formulation of green exploration standards

The Inner Mongolia, Shandong, Guizhou, Qinghai and other regions formulated local standards for green exploration to guide their green exploration work. Some enterprises and industry associations formulated internal and group standards. Green exploration pilot projects were deployed in areas with different natural and geographical conditions such as coverage areas, mountain areas, hilly areas and desert areas to start up the development of green exploration industry standards.

2. Promoting demonstration of green exploration projects

The General Office of the Ministry of Natural Resources issued the *Notice on the Demonstration of Green Exploration Projects* (Letter No. 815 [2019] of the General Office of the Ministry of Natural Resources), requiring all local authorities to carry out demonstration of green exploration projects, so as to speed up the establishment of green exploration management system and standard specification system in a new era, innovate the management mode and technical methods of geological prospecting, and realize the all-round green development of geological prospecting. So far, Qinghai, Inner Mongolia, Heilongjiang, Jiangxi, Guangdong, Guangxi, Gansu, Henan, Hunan, Hubei, Hainan, Sichuan, Jilin, Shaanxi, Xinjiang and other provinces (autonomous regions) have carried out pilot demonstration of green exploration and established a green exploration management system. Some large mining enterprises are actively exploring advanced technologies and methods to implement green exploration. Relevant units such as China Geological Survey have developed a series of green exploration equipment. Through pilot projects and demonstration and guidance, a set of standards and norms, advanced technologies and a management system for green exploration, have been basically formed.

III. Green Mines

1. Initiating green mine selection in 2019

In June 2019, the General Office of the Ministry of Natural Resources issued the *Circular of Selection of Green Mines in 2019* (Letter No. 965 [2019] of the General Office of the Ministry of Natural Resources) and deployed to carry out the selection of green mines in 2019. The notice defines the basis, scope and quantity of the selection, and requires all provinces (autonomous regions and municipalities) to carry out the selection according to the procedures of self-evaluation of the mine, third-party evaluation, spot check, material review and publicity, and form a selection list. Mining enterprises meeting the requirements of relevant standards will be released to the public and included in the national list of green mines.

2. Pushing forward the construction of green mines in different regions

The local authorities actively explored, through the formulation and implementation of plans, standards and policies, plans and arrangements, to promote the construction of green mines. In addition to Tianjin and Shanghai, 29 provinces (autonomous regions and municipalities) formulated schemes or plans for the construction of green mines, with clear objectives, tasks, schedules and roadmaps. Shaanxi, Guangxi and other provinces (autonomous regions and municipalities) issued measures for the administration of green mine construction, defining the requirements for green mine construction, evaluation, supervision and management. 13 provinces (autonomous regions and municipalities) including Henan, Shandong, Jiangxi and Chongqing developed and issued local standards. 9 provinces (autonomous regions and municipalities) such as Zhejiang, Qinghai, Shaanxi and Xinjiang quantified evaluation indicators and formulated evaluation methods. Green mine construction gradually changed from administrative requirement to standard. In terms of incentive policies, Guangdong allocated 30 million financial funds to reward the built green mines. Jiangsu made policies weighted toward land quota. Tangling City of Anhui province gave financial incentives to the built green mines. In terms of restraint policies, Qinghai, Jiangxi and Chongqing incorporated the requirements for green mine construction into the management of mining right transfer contracts, stipulating that construction failing to comply with the requirements would lead to accountability for breach of contract.

Chapter V

Policies and Regulations on Mineral Resources

Since 2018, China has continued to promote the legislation amendments and the reform of the administrative approval system on mineral resources, canceled and delegated numbers of administrative approval items. The reforms of real property rights system of natural resources have been improved and the reforms of the mineral resources management system and taxes & fees have been pushed forward.

I. Policies and Regulations on Mineral Resources

1. Laws and regulations

(1) The *Decision of the State Council to Cancel and Delegate to Lower-level Authorities a Group of Administrative Licensing Items* (GF [2019] No.6) on March 6, 2019 canceled the requirement for approvals of overall plans for foreign cooperation projects of oil and natural gas (including coalbed methane) and changed it to filing.

(2) In order to implement the decisions and deployment of the CPC Central Committee and the State Council on reducing certification to create convenience and improving services, according to the relevant requirements of the *Circular of the General Office of the State Council on Cleaning up Certification Items* (GBF [2018] No.47), the Ministry of Natural Resources issued the *Notice on Canceling Numbers of Certification Items* (No.23 [2019]) on May 14, 2019, and canceled 14 certification items. Among them, those involving mineral

resources include ① certifications for no safety and quality accident in the past five years, ② documents certifying the payment of compensation fees by Sino-foreign cooperative enterprises engaged in oil resource exploitation, and ③ certifications for not covering important mineral resources.

(3) On December 26, 2018, the *Resources Tax Law of the People's Republic of China (Draft)* was first submitted to the 7th Session of the 13th NPC Standing Committee for deliberation. *The Resources Tax Law of the People's Republic of China* was adopted by the 12th meeting of the Standing Committee of the 13th National People's Congress on August 26, 2019 and will come into force on September 1, 2020.

(4) On March 2, 2019, the *Regulations on the Protection of Fossils* was amended in the Article 49 of the *Decision of the State Council on Amending Some Administrative Regulations* (State Council of the People's Republic of China Decree No.709) .

2. Policies and opinions

(1) In order to speed up improving the real property rights system of natural resources assets, on April 14, 2019, the General Office of the CPC Central Committee and the General Office of the State Council jointly issued the *Guiding Opinions for the Reform on Coordinating and Promoting Real Property Rights System for Natural Resources Assets*, where the goal of promoting the reform of the real property rights system for natural resources assets and 8 main tasks such as improving the real property rights system for natural resources assets were put forward.

On July 11, 2019, the Ministry of Natural Resources, the Ministry of Finance, the Ministry of Ecology and Environment, the Ministry of Water Resources, and the State Forestry and Grassland Administration issued a notice on the issuance of the Interim Measures for Unified Recognition and Registration of Rights in Natural Resources (hereinafter referred to as the *Measures*). According to the requirements, starting from 2019, it will take five years to basically complete the unified recognition and registration of rights on natural resources in key regions across China.

The Measures clearly stipulate the recognition and registration of rights of mineral resources, carrying out the recognition and registration of rights of mineral reserves & resources. The Ministry of Natural Resources will carry out unified recognition and registration of rights for reserves & resources of oil and natural gas as well as precious and rare minerals. Through the

recognition and registration of rights, the natural conditions such as quantity, quality, scope, type and area of mineral resources, the status of rights such as ownership, representative subjects exercising the rights, agent subjects exercising the rights and rights content and so forth are clearly defined, and relevant information such as prospecting and mining license number and public control requirements are correlated.

(2) On July 24, 2019, the Ministry of Natural Resources issued the *Decision of the Ministry of Natural Resources on the First Batch of Departmental Rules Abolished and Amended*, abolishing 8 departmental rules and amending 15 departmental rules. The amendment involves 12 clauses of 3 measures for geological disaster qualification, focusing on simplifying and optimizing the application procedures and materials for qualification of the geological disaster prevention and control unit. The revision of the 18 clauses of the *Regulations on the Protection of Mine Geological Environment* mainly aims to implement the combination of the geological disaster recovery and treatment plan and the land reclamation plan, so as to effectively alleviate the burden on mining enterprises.

Feature 5-1 Important Laws and Regulations on Mineral Resource Since the Founding of the PRC

On December 22, 1950, the the Administration Council of the Central People's Government adopted the *Provisional Regulations of the People's Republic of China on Mining*.

On March 19, 1986, the *Mineral Resource Law of the People's Republic of China* was adopted at the 15th meeting of the Standing Committee of the 6th National People's Congress and came into force on October 1, 1986.

On November 7, 1992, the *Mine Safety Law of the People's Republic of China* was adopted at the 28th meeting of the Standing Committee of the 7th National People's Congress and came into force on May 1, 1993.

On August 29, 1996, the *Coal Law of the People's Republic of China* was adopted by the 21st meeting of the Standing Committee of the 8th National People's Congress and came into force on December 1, 1996.

On February 26, 2016, the *Law of the People's Republic of China on the Exploration and Development of Resources in Deep Seabed Areas* was adopted at the 19th meeting of the Standing Committee of the 12th National People's Congress and came into force on May 1, 2016.

(3) In July 2019, the Ministry of Natural Resources announced the *Regulations on Administrative Reconsideration of Natural Resources*, which will come into force on September 1, 2019, regulating the acceptance, registration, handling, decision, supervision and legal responsibility of administrative reconsideration cases of natural resources, with the purpose to strengthen and improve the system construction, promote the substantive resolution of administrative disputes, give full play to the strengths of administrative reconsideration in terms of fairness, efficiency and services and convenience for the people, and continuously improve the rule-of-law of natural resources.

II. Reform of Mineral Resources System

1. Transformation of supervision function

In the original plan of the Ministry of Land and Resources on the functions, internal structure and staffing, the contents of supervision and inspection of land supervision were expressed as “land use and management status” of the local governments, while in the plan of the Ministry of Natural Resources on functions, internal structure and staffing, the supervision duties of natural resources were clearly expressed as “supervising the local governments to implement major policies, decisions and arrangements on natural resources and land space planning issued

Feature 5–2 Changes in Geological and Mineral Management Institution Since the Founding of the PRC

In August 1952, the Ministry of Geology of the Central People's Government was established according to the decision made at the 17th Session of the Central People's Government Committee.

In May 1982, the Ministry of Geology and Mineral Resources was established to manage the national geology and mineral resources-related work.

In March 1998, the Ministry of Land and Resources was jointly established by the Ministry of Geology and Mineral Resources, the State Land Administration, the State Oceanic Administration and the State Bureau of Surveying and Mapping. Its main responsibilities included managing the geological exploration industry, mineral resources reserves, mineral resources development, etc.

In March 2018, the Ministry of Natural Resources was established. Its main responsibilities include managing the geological exploration industry, the national geological work, the mineral resources, etc.

by the CPC Central Committee and the State Council as well as laws and regulations according to the authorization of the central government”. It means that the function has been transformed from land inspection to inspection on natural resources.

2. Mineral resources transfer income system

The *Notice on Further Clarifying Issues Related to Collection and Management of Mineral Rights Transfer Income* (CZ [2019] No.11) has clarified issues such as capital occupation fee and late payment of mineral rights transfer income, and proposed that non-profit mining enterprises with special functions, if it is indeed difficult for them to pay the mineral rights transfer income, can defer payment of the payable mineral rights transfer income within a certain period of time with the approval of the Ministry of Finance and the Ministry of Natural Resources.

III. Taxes on Mineral Resources

1. Resources tax

On March 29, 2018, the *Notice on Resources Tax Reduction of Shale Gas* (CS [2018] No.26) issued by the Ministry of Finance stipulated that the resources tax on shale gas (at the prescribed rate of 6%) would be reduced by 30% from April 1, 2018 to March 31, 2021. On March 30, 2018, in order to further standardize the collection and management of resources tax, optimize tax service and prevent tax-related risks, the State Taxation Administration promulgated the *Regulations on Collection and Management of Resources Tax*, which came into force on July 1, 2018.

In 2018, the national resources tax revenue totaled 163 billion yuan, showing an increase of 20.4% year on year, and accounting for 1.04% of the national tax revenue.

2. Special income

In 2018, the special revenue from mineral resources was 73.417 billion yuan, increased by 28.5%, of which the revenue from the transfer of exploration and mining rights (price) was 71.95 billion yuan, increased by 33.7%; revenue from the use fees (occupancy fees) of exploration and mining rights was 897 million yuan, decreased by 42.2%; the revenue from compensation for mineral resources was 570 million yuan, decreased by 68.3%.

Chapter VI

Mineral Resources Management

Preliminary research on new round of planning of mineral resources in China was carried out and completed the mid-term evaluation of the implementation of the *National Mineral Resources Plan (2016-2020)*, strengthened the review and filing of reports on mineral resources & reserves, and established and improved the mineral resources inventory system. In accordance with the requirements of the State Council, the management of mineral rights has been further strengthened, and the disclosure of basic information on mineral rights management has been continuously carried out to strengthen the supervision and protection of mineral resources.

I. Mineral Resources Planning and Management

1. Accelerating the evaluation and summary of planning implementation

The mid-term evaluation of the *National Mineral Resources Plan (2016-2020)* was organized and carried out, the progress made in implementation of the plan, the main existing problems and the situation and challenges faced were summarized and analyzed, and the suggestions to further strengthen implementation of the plan and improve the capability of resources guarantee were put forward. Overall, good progress was made in the planning objectives and tasks, with nearly 70% of the 45 indicators in 3 categories in line with expectations.

2. Deploying the implementation of preliminary work of new round planning

The compilation and deployment of the “14th Five-Year Plan” were put into practice, and the preparatory work for draft of the Plan was started ahead of time. In April 2019, the General Office of the Ministry of Natural Resources issued a notice on the public solicitation of proposals for topics for the preliminary study of the *National Mineral Resources Plan (2021-2025)*, which gathered the wisdom and strength of all sectors of society, further improved the transparency of plan compilation and public participation, and solicited more than 150 proposals for topics for planning. In July 2019, to guide each province to do a good job in the preparation of provincial mineral resources plan in advance, the General Office of the Ministry of Natural Resources issued the *Notice on the Preliminary Work for Preparation of Provincial Mineral Resources Plan (2021-2025)*, which put forward requirements in terms of evaluation of plan implementation, study on key issues, organizational support, etc.

3. Further improving the mineral resources plan information management level

In order to further play the supporting role of mineral resources plan database in the mining administration and improve the existing database, the General Office of the Ministry of Natural Resources issued the *Notice on Accelerating the Establishment and Data Storage of a Unified Mineral Resources Plan Database*, in which the planned spatial layers were sorted out and clarified. Up to now, the establishment of a unified plan database that brings together the planning elements at the provincial, municipal and county levels has been basically completed. At the same time, the supervision system for compilation and implementation of the mineral resources plan, which integrates planning, implementation and supervision, has been basically developed.

II. Geological Exploration Management

1. Carrying out statistical work of the basic situation of the geological exploration industry

In 2018, all levels of government departments in charge of the national geological exploration industry and geological exploration entities (hereinafter referred to as geological exploration entities) closely focused on the strategic deployment of the CPC Central Committee and the State Council on the national energy and resources security and ecological civilization

construction, deepened the reform, found the correct orientation, comprehensively improved the quality and service level of geological exploration, and provided strong support for the management of natural resources.

(1) The geological exploration personnel decreased slightly. By the end of 2018, the number of on-the-job personnel in geological exploration entities in China has undergone a continuous downward trend since 2012, with about only 390,000 people (excluding the former PAP Gold Force Headquarters), decreased by 8.2% year on year. Among them, there are about 200,000 geological exploration personnel, decreased by 7.5%. In 2018, the per capita wage of geological exploration entities in China was 86,800 yuan per year (Figure 6-1).

(2) The total revenue of geological exploration entities in China increased by 0.64% year on year. In 2018, the total revenue of geological exploration entities in China was 161.934 billion yuan, up 0.64% from last year, of which 60.875 billion yuan was from geological exploration, up 1.31%, A total of 1.588 billion yuan was from transfer of mineral rights, 5.988 billion yuan from mineral development, 57.419 billion yuan from engineering survey and construction, and 36.064 billion yuan from others (Figure 6-2).

(3) The total assets of geological exploration entities in China rose slightly, while the net value of prospecting equipment decreased year on year. In 2018, the total assets of geological prospecting entities nationwide were 649.13 billion yuan, increased by 11.0% year on year. The total liabilities were 333.31 billion yuan, with the asset-liability ratio of 51%. The net value of geological exploration equipment was 12.30 billion yuan, decreased by 4.9% (Figure 6-3).

III. Management of Mineral Reserves & Resources

1. Simplifying review of oil and gas reserves

In order to implement the requirements of the central government regarding “delegating power, streamlining administration and optimizing government services”, the management process of oil and gas reserves was optimized and the work efficiency was improved. On November 5, 2018, the General Office of the Ministry of Natural Resources issued the *Notice on Simplifying the Review of Special Circumstances for Handling Registration of Oil and Gas Reserves*, simplifying the registration of oil and gas reserves that meet certain handling conditions. According to the requirements of the new notice, some eligible reserves registration items can be registered without re-examination and filing, supplementing relevant instructions on

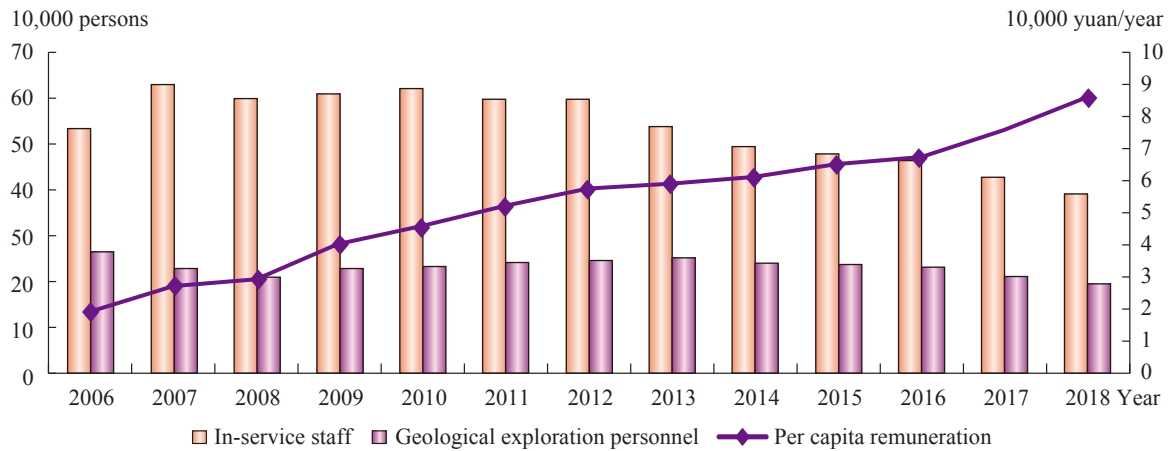


Fig. 6-1 Changes in Geological Exploration Personnel and Labor Remuneration in China (2006–2018)

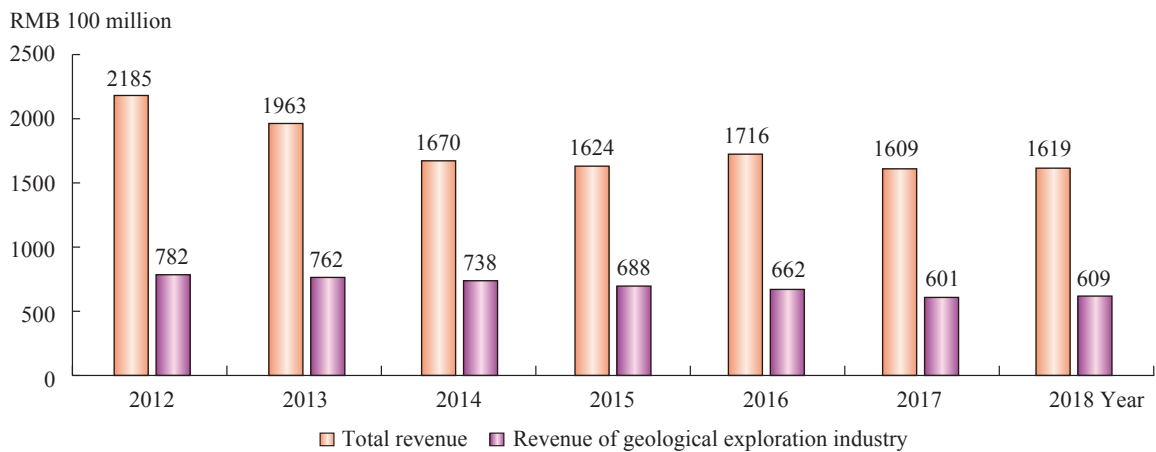


Fig. 6-2 Changes in Revenue of Geological Exploration Entities in China (2012–2018)

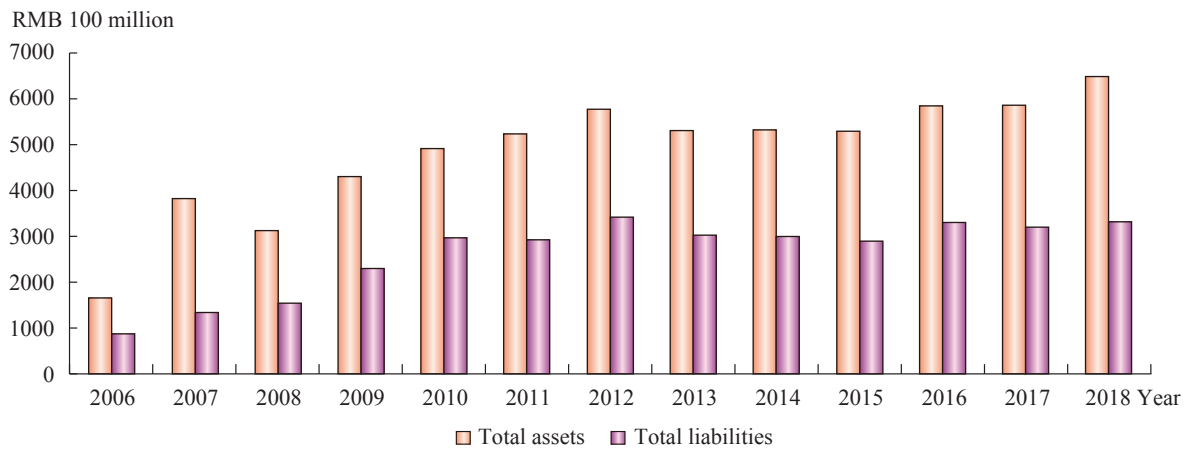


Fig. 6-3 Changes in Assets and Liabilities of Geological Exploration Entities in China (2006–2018)

changes in mineral rights, and after being examined by the review authorities and signed in the registration form. Or if they comply with relevant circumstances, the supplementary instruction for the reserve report shall be prepared and reviewed by experts organized by the review authorities, and supplementary opinions of the review opinions on the basis of the original review and filing shall be provided, so as to handle the reserve registration.

2. Starting the pilot work of national survey of mineral resources

In order to fully know the current situation of mineral resources in China, exercise the responsibility of “two unifications” and establish a unified & standardized natural resources investigation, monitoring and evaluation system, pilot investigations of 12 important minerals such as coal were started in 9 provinces (regions) such as Liaoning Province according to the work arrangements of the Ministry. Based on the main task objectives and requirements of the

Feature 6-1 Changes in Classification Standards for Mineral Resources & Reserves Since the Founding of the PRC

In November 1953, the National Mineral Resources and Reserves Committee was established.

In 1954, the National Mineral Reserves Committee reprinted the Classification of Solid Minerals Reserves (from Soviet Union).

In 1959, the first mineral reserves classification proposal - the Provisional Regulations (General Provisions) on Classification of Metal, Non-metal and Coal Reserves was issued in China. Reserves were divided into recoverable reserves (A_1), designed reserves (A_2 , B and C_1), prospective reserves (C_2) and geological reserves according to the degree of exploration. Reserves were also divided into commercial reserves and non-commercial reserves according to technical and economic conditions.

In 1977, the General Provisions for Geological Exploration of Metallic Deposits and the General Provisions for Geological Exploration of Non-metallic Deposits were issued. Reserves were divided into four levels: A, B, C and D according to the degree of exploration.

In 1992, the General Provisions for Geological Exploration of Solid Minerals were issued, which combined Grades A, B, C and D as identified reserves and Grade E as prospective reserves.

In 1999, the Classification for resources/reserves of solid fuels and mineral commodities (GB/T 17766-1999) based on the classification system of mineral resources/reserves in market economy countries was promulgated and implemented.

investigation work, difficulties and key points were identified, a strict quality assurance system was designed, data collection approaches were rationalized, preparations for technical methods were done, and replicable and propagable experiences were summarized, thereby laying a foundation for the overall deployment of the investigation work.

IV. Mineral Rights Management

1. Basic information about mineral rights

By the end of 2018, there were 16,643 exploration rights in China, with an area of 3.34 million km², decreased by 24.9% and 8.9% respectively. There were 49,063 mining rights, down 14.6% year on year, with a mining area of 258,100 km², increased by 0.8% year on year.

In 2018, 354 new exploration rights were established nationwide with a prospecting area of 19,081 km², and 1,251 new mining rights were established, covering an area of 6,151 km².

2. Further strengthening management of mineral rights

(1) Adjusting the management policy of coal mining rights. In accordance with the requirements of the State Council to speed up the procedures for approval of coal mines that guarantee supply and release advanced production capacity, the *Notice on Adjusting Relevant Provisions on the Opinions of the Ministry of Land and Resources on Supporting Steel and Coal Industries to Resolve Excess Capacity and Achieve Development by Overcoming Difficulties* was issued, and the approval of mining areas delineation for coal mines would no longer be suspended.

(2) In order to protect and rationally develop and utilize superior mineral resources, further standardize and strengthen the approval management of rare earth and tungsten exploration and mining. On December 14, 2018, the Ministry of Natural Resources issued the *Notice on Further Regulating the Approval Administration of Mineral Rights on Rare Earth and Tungsten*, which clearly stipulates the continued suspension of the acceptance of new applications for rare earth exploration and mining registration, the establishment, renewal, change of registration, transfer, reservation, reserve review and filing of rare earth and tungsten exploration rights and mining rights, as well as the principles for determining the total production control quotas of rare earth and tungsten and the distribution of annual production quota in various provinces (autonomous regions and municipalities), further regulates the examination and approval administration of rare earth and tungsten mineral rights, and continuously and effectively controls the new

production capacity of rare earth and tungsten mines.

On February 1, 2019, the *Notice on Total Production Control Quotas for Rare Earth and Tungsten in 2019 (First Batch)* was issued by the Ministry of Natural Resources and the Ministry of Industry and Information Technology, and the total production control quotas for rare earth and tungsten was issued in 2019 to the competent departments of 17 provinces (autonomous regions) including Inner Mongolia and Heilongjiang.

(3) Regulating the mineral rights exchange market. The *Notice on Adjusting Relevant Provisions of the Mineral Rights Exchange Rules* was issued, the deposit list system of enterprises involved was strictly implemented, and the public resources exchange area was actively utilized to jointly punish and regulate the mineral rights market.

(4) Coordinating advance of comprehensive improvement of open pit mines. In order to implement the tasks and requirements of the *Three-Year Action Plan to Win the Blue Sky Defense War* issued by the State Council, the General Office of the Ministry of Natural Resources and the Ministry of Ecology and Environment issued the *Letter on Accelerating the Implementation of Comprehensive Improvement of Open-pit Mines* and put forward new requirements for the coordinated advance of the comprehensive improvement of open pit mines.

3. The reform of oil and gas resources management was standardized, and the management methods were constantly innovated

The approval and registration management of mineral rights for oil and gas was strengthened. Strictly complying with the laws and regulations, active optimization services were provided and the exit of blocks were strictly implemented. By the end of December 2018, there were 924 exploration rights for oil and natural gas (including coalbed methane and shale gas), with an area of 3.0946 million km², and 774 mining rights with an area of 164,900 km². Among them, there were 45 exploration rights and 37 mining rights with foreign cooperation.

We implemented the spirits of the CPC Central Committee and the State Council on deepening the reform of oil and gas system, studied and deepened the reform of the management of oil and gas exploration and exploitation, liberalized the market for oil and gas exploration and exploitation, competed for the transfer of oil and gas exploration rights, and increased the withdrawal of oil and gas prospecting blocks and other policies and measures. We continuously pushed forward the pilot reform of oil and gas exploration and exploitation in Xinjiang and instructed Xinjiang to carry out competitive assignment of three oil and gas exploration blocks. We summarized the construction experiences of shale gas exploration and development demonstration base in Fuling,

Chongqing, and continuously pushed forward the construction of comprehensive shale gas exploration and development pilot areas in northern Guizhou and southern Sichuan. We carried out the competitive assignment of oil and gas exploration rights in the sea area, and conducted the listed assignment of coalbed methane exploration blocks in Shanxi.

4. Strengthening handling of administrative licensing matters

On October 8, 2018, the Ministry of Natural Resources promulgated the *Announcement on Handling Administrative Licensing Matters* to centralize the on-site handling of other administrative licensing matters, except for some classified surveying and mapping matters, into the administrative service hall of the Ministry of Natural Resources. Among them, mineral resources management matters include preliminary examination of construction projects and examination and approval of construction projects covering important mineral deposits, examination and approval of exploration of mineral resources, examination and approval of mining mineral resources, Grade A qualification examination and approval of geological disaster prevention and control units, examination and approval of excavation of major fossils under protection, and examination and approval of entry and exit of major fossils under protection.

5. Continuously carry out the basic information disclosure of mineral rights management

In 2018, a total of 44,120 items of public information were released, including 983 items of announcement on transfer of mineral rights through bidding, auction and listing, 862 items of public notice on transfer results through bidding, auction and listing, 186 items of public notice on transfer of mineral rights through agreement, 608 items of public notice on transfer of mineral rights, 621 items of public notice on acceptance of new mineral rights, 39,119 items of public notice on approval results of mineral rights, and 1,651 items of announcement on basic information of mineral rights within the validity period.

V. Delineation and Management of Ecological Red Line

The ecological red line refers to the area with special important ecological functions and must be strictly protected in the ecological space, which is the bottom line for ensuring and maintaining the national ecological security. In 2018, the Ministry of Natural Resources and the Ministry of Ecology and Environment, on the basis of their original work, reviewed

and demonstrated the red line delineation scheme for ecological protection in 16 provinces (autonomous regions) including Shanxi.

When the ecological red line is delineated, the important mineral resources in the delineated area shall be sorted out, investigated and evaluated. For legal mineral rights, the national planned mining areas and the above-medium-sized mineral areas with strategic mineral reserves as specified in the *National Mineral Resources Plan* shall not be included in the ecological red line in principle.

VI. Protection and Management of Paleontological Fossils

1. Paleontological fossil monitoring system

The Ministry of Natural Resources and the General Administration of Customs have realized the online verification of the exit documents of fossils, and jointly issued the *Announcement on Implementing the Online Verification of the Exit Documents of Fossils* (No.150 [2018]). The system has been put into operation officially since October 22, 2018. The electronic data of the exit documents of fossils can be transmitted to the Customs in real time, automatically verified and quickly released. Through the optimization of the exit approval process of fossils and inter-ministerial cooperation, the approval efficiency and the level of customs clearance facilitation have been greatly improved.

2. Paleontological fossil excavation and entry/exit approval

In 2018, a total of 3 fossil excavations were approved and 14 appraisal approvals involving the entry and exit of fossils and the detection of illegally traded fossils by the Public Security, Customs and other departments were accepted, with 472 specimens identified.

3. Paleontological fossil localities and specimen management

By the end of 2018, 550 important fossil localities were investigated nationwide. The registration of fossil specimens was guided and advanced in Gansu, Anhui, Hunan, Liaoning, Inner Mongolia, Heilongjiang, Shandong, Guizhou, Zhejiang and other provinces, and the deployment of fossil specimen database systems was completed in 44 nodes in Shandong, Heilongjiang, Zhejiang and other places. A total of 82,000 specimens were registered for storage.

Chapter VII

Geological and Mineral Resources Surveys and Evaluations

In 2018, the level of basic geological survey was further improved, including the completed regional geological survey, land quality geochemical survey, remote sensing comprehensive survey and aeromagnetic survey areas. In the aspect of mineral resources investigation, basic investigation of oil and gas and strategic area selection were carried out based on the “new areas, new strata, new fields and new types” of oil and gas. Mineral geological survey was carried out for the key metallogenic belts, assembled prospecting areas, important ore-concentrated areas and large-scale resource bases. Regional geological surveys were systematically carried out in the sea areas under jurisdiction, and surveys of oil and gas resources continuously conducted in new areas and strata in key sea areas such as the southern Yellow Sea and the northern South China Sea.

I. Basic Geological Surveys

In 2018, funded by the central government, regional geological survey of 1:50,000 covering an area of 111,000 km² was completed, with a cumulative area of 4.119 million km², accounting for 42.91% of the land area of China.

In 2018, a geochemical survey of soil quality was completed, which covered an area of

203.9 thousand km². Till then, accumulatively 2626.8 thousand km² of land were surveyed geochemically, accounting for 27.36% of the national total land area.

In 2018, the comprehensive remote sensing survey covering 17,000 km² was completed, with a cumulative area of 9605.3 thousand km², accounting for 99.6% of the total land area.

In 2018, the 1:50,000 aeromagnetic survey covering 73,000 km² was completed, with a cumulative area of 4924.1 thousand km², accounting for 51.1% of the total land area.

Feature 7-1 Remarkable Achievements Made in Basic Geological Survey Since the Founding of the PRC

Before the founding of the PRC, there were only sporadic large-scale geological mapping and small and medium scale geological route survey. Large scale systematic regional geological survey has officially been carrying out since 1949, with brilliant achievements made. Up to now, small-scale 1:1,000,000 regional geological survey has almost covered all land and sea areas throughout the country, medium-scale 1:250,000 and 1:200,000 regional geological survey has almost covered all land areas of China, and large-scale 1:50,000 regional geological survey has been completed for 4,119,000 km² nationwide, covering 42.91% of the land area. National lithostratigraphic sequence and spatial and temporal distribution framework of magmatic rock have been established, deepening the understanding of the composition and structure inside the earth, and a tectonic framework has been set up, greatly improving the knowledge of geological background. Since the 18th National Congress of the CPC, reform of regional geological survey has been carried out to fully implement the "Three Transformations", the theoretical method of geological mapping has been innovated, and a modern technical standard system has been established, thus, product development and application has been strengthened, and the service capability has been improved significantly, providing a large amount of data and scientific basis for major national strategies and ecological conservation.

II. Mineral Resources Surveys and Evaluations

1. Oil and gas surveys and evaluations

In 2018, basic oil and gas surveys and strategic area selection were carried out in the terms of "new areas, new strata, new fields and new types", completing 3,110 km of two-dimensional

seismic survey, 1,700 km of gravity, magnetic and electric integrated geophysical survey, 35 geological survey wells/63,883 m, 9 parameter wells/20,742 m and 4 horizontal wells/7,700 m.

In terms of conventional hydrocarbons, major breakthroughs were made in Yin-E Basin, Qaidam Basin and Bogda piedmont zone in Junggar Basin. Mengercaan 3 Well in Yin-E Basin produced industrial oil flow in Carboniferous-Permian, Xinjican 1 Well in Junggar Basin obtained over 50,000 m³ of industrial gas flow in Permian, and Chaiye 2 Well acquired Carboniferous gas flow in Qaidam Basin. New progress was made in the investigation of the deep geological structure and oil and gas in the Tarim Basin. 4 prospective areas and 8 favorable zones of hydrocarbon were selected, and the hydrocarbon resources of Sinian and Cambrian systems reached 24.2 billion tons.

In terms of unconventional hydrocarbons, high-yield shale gas flow were obtained in the Sinian, Cambrian and Silurian strata in Yichang region in the middle reaches of the Yangtze River, with a total 11.68 trillion m³ of preliminary resources of shale gas. It will be built into a new shale gas prospecting and development base. Several geological wells in the upper and lower reaches of the Yangtze River had good show of shale gas in Sinian, Cambrian, Silurian, Devonian, Carboniferous, Permian and other horizons, confirming the huge potential of shale gas resources along the Yangtze River Economic Belt. Breakthrough progress was made in continental shale oil in Songliao Basin, in which Songye 2HF Well produced 10.3 m³ of oil per day, whilst the Songye 1HF Well and Jiye 1HF Well had a good show of oil and gas in multiple strata.

2. Non-oil and gas geological surveys and evaluations

In 2018, mineral geological survey was carried out in the key metallogenic belts, assembled prospecting areas, important ore-concentrated areas and large-scale resource bases in China, completing 1: 50,000 mineral geological survey covering 118,000 m² and delineating more than 400 prospecting targets. In terms of the geological survey of manganese, tin and other major minerals in shortage, 5 new manganese-bearing horizons were discovered in Maerkansu region, Xinjiang, and thick and large manganese-rich bodies were newly discovered in Chengkou of Chongqing, Tongren and Zunyi of Guizhou and other places. For the first time, magmatic hydrothermal type independent cobalt minerals were discovered in the Devonian Huashiguan Formation strata in the Shijiahe-Dengjiagou area of Xihe County, Gansu Province, and it is potential to form large and medium-sized deposits. New progress was made in the prospecting of lithium deposits in Dahongliutan of western Kunlun in Xinjiang and Weilasituo

in the Greater Khingan Mountains. Over 40 m thick copper ore bodies were discovered in the depth of Hongnipo copper deposit coverage zone in Huili-Huidong mining area, and 5 nickel mineralized ultrabasic rocks were discovered in Baitongchang area.

3. Groundwater surveys, evaluations and monitoring

In Wumeng Mountain, Yimeng Mountain area, Dabie Mountains, southwestern karst mountainous areas and northwestern ecologically vulnerable regions, 21,000 km² of 1:50,000 hydrogeological survey and 46,000 km² of 1:250,000 hydrogeological survey were carried out. Water wells for poverty alleviation were drilled; totally, 27,000 m of hydrogeological drilling was completed, 146 exploration and production wells were constructed, and a total of 108,000 m³ of water can be produced each well per day, providing a stable and high-quality drinking water source for nearly 1.1 million people in poor and water-deficient areas. A total of 69 water-rich sections covering an area of 5,000 km² were delineated in Wumeng Mountain, Yimeng Mountain area, Dabie Mountains and southwestern karst mountainous areas. Strontium-rich and zinc-rich mineral water with a strontium content of 0.27~6.96 mg/L was found in Yimeng Mountain, Shaanxi-Gansu-Ningxia Old Liberated Area, Qaidam Basin and other places. According to preliminary estimation, the recoverable resources exceed 10 million m³ per year.

The National Groundwater Monitoring Programme (NGWP) built 10,168 groundwater monitoring stations, all of which realized the automatic collection and transmission of water level and temperature monitoring data. The construction of the national groundwater monitoring information system was established, with the functional modules of groundwater monitoring well management, data reception, analysis & application, simulate calculation, and resource sharing, as well as interconnection with 31 provincial-level geological environment monitoring institutions.

4. Geothermal resource surveys and evaluations

The most productive geothermal well in the Beijing-Tianjin-Hebei region was found when drilling into the first deep thermal reservoir (Wumishan Formation) in Xiong'an New Area. With a wellhead temperature of 108.9°C, it is the geothermal well with the highest temperature in the current geothermal field as well as the most productive geothermal well in the Beijing-Tianjin-Hebei region. The geothermal well in Huizhou, Guangdong Province found 127°C high temperature hot water resources at the depth of 3,009 m, realizing a major breakthrough in

geothermal resources exploration in Guangdong.

The comprehensive cascade development and utilization base for geothermal resource of Beijing-Tianjin-Hebei region was initially built. It is capable of generating 280 kilowatts of geothermal power for geothermal heating covering an area of 30,000 m², thus establishing a new model for efficient use of deep geothermal reservoirs in carbonatite in Beijing-Tianjin-Hebei Region.

III. Marine Geological Surveys

1. Basic marine geological survey

The summary, organization and comprehensive study were systematically carried out for the measured data of 20 mapsheets of 1:1,000,000 regional marine geological survey in the sea areas under China's jurisdiction, 27 mapsheets of three major categories were revised and improved, including topographic maps, geomorphological maps, geological maps and structural maps, and compiled the *1:1,000,000 Regional Geological Survey Report in Sea Areas under China's Jurisdiction*, which basically identified the basic geological conditions in the sea areas under China's jurisdiction and preliminarily summarized a number of original achievements and new understandings. 8 mapsheets of 1:250,000 regional marine geological survey, including 3 in the southeast of Rushan in the southern Yellow Sea, 4 in the East China Sea and 1 in Sanya City in the South China Sea, were completed, with high-precision geological and geophysical data acquired, which could be used for the ecological environment protection and major engineering construction.

2. Oil and gas surveys in sea areas

Surveys of oil and gas resources were continuously carried out in new areas and strata in key sea areas such as the southern Yellow Sea and the northern South China Sea. The demonstration of drilling well location, geological design and engineering design of parameter wells in the southern Yellow Sea were carried out to complete preparations before drilling. Two key structures were delineated in Chaoshan depression in the northern South China Sea, and drilling well locations for 2 Mesozoic parameter wells were proposed, laying a foundation for Mesozoic oil and gas exploration and discovery in the northern South China Sea.

Chapter VIII

Geological Data Management and Services

In 2018, the types of archived geological data collected by the National Geological Archives (NGA) amounted to 169,200 types, and all of the paper archives were digitalized. The NGA has provided 483 entities with geological data services, including 24.2 thousand sets and 396.5 thousand pieces of geological data. The annual total number of visits to the “GeoCloud 2.0 Online Service” reached 4,406,000 times, which consists of 462,000 by the Geological Survey network and 3,944,000 by the Internet. The number of the GeoCloud registered users reached 17,000.

I. Geological Data Management

In 2018, in order to thoroughly upgrade the socialized service level of geological data and provide better service and support for the security of national energy and mineral resources, ecological civilization construction and high-quality economy growth, the *Directive Opinions of the Ministry of Natural Resources on Further Enhancing Socialized Service of Geological Data* was issued, in which provincial (regional and municipal) natural resource departments are required to promote their awareness of the importance of the public service of geological data, deepen the opening and sharing of geological data and information, construct the national big data system of geological data and effectively strength the capacity building of geological data services.

II. Geological Data Archiving

1. Final geological data and original geological data

By the end of 2018, in the National Geological Archives (NGA), there had been 169,200 types of final archived geological data, 10,400 types of original geological data and 168,600 types of

Feature 8-1 Great-leap-forward Development Achieved in Geological Data Management Modernization and Service Socialization Since the Founding of the PRC

In the early days of the founding of the PRC, the geological data management in China was implemented a mode integrating both administrative and multiple career functions. In 1952, the Ministry of Geology was established and organized into the Department of Geological Data, which was responsible for collecting and managing all kinds of geological and mineral data across China. In June 1955, the Department of Geological Data of the Ministry of Geology was renamed as the National Geological Data Bureau.

In 1988, the Measures for Submission and Management of National Geological Data was promulgated, and the geological data collection and administration were gradually separated. The Ministry of Land and Resources was established in 1998, and the Department of Mineral Resources and Reserves of the Ministry of Land and Resources assumed the responsibility for submission and management of geological data. On December 18, 2001, the National Geological Archives (NGA), the Physical Geological Data Center and other organizations were affiliated to the China Geological Survey. The Ministry of Natural Resources was established in 2018. The Department of Mineral Resources Protection Supervision is responsible for supervising the submission, storage and utilization of geological data.

So far, a geological data administrative management system composed of national-, provincial-, municipal- and county-level geological data administrative departments and a geological data collection and service system composed of NGA, provincial-level (autonomous regions and municipalities) geological data collection agencies and entrusted custody agencies have been established in China. The service modes mainly include window borrowing, web browsing and special and emergency services. Collection agencies at all levels in China have taken the initiative to provide emergency services for earthquake relief and drought relief, thereby providing data support for railway route selection, national groundwater quality monitoring project, national ecological environment construction and other major projects such as that ensuring people's livelihood.

archived digital geological data, with the data size up to 194TB. 5,447 types of final geological data were newly added in 2018, with the total data size up to 52.74TB; 3,361 types of original geological data were added, with the data size up to 37.18TB.

2. Physical geological data

By the end of 2018, an accumulative number of 537 thousand meters of cores, 26 thousand pieces of specimens, 47.4 thousand pieces of polished slices, 16.8 thousand pieces of samples and 41.8 thousand bags of cuttings had been kept by the Cores and Samples Center of Land & Resources. Among them, 62.3 thousand meters of cores, 779 pieces of specimens, 930 pieces of polished slices and 2,491 bags of cutting were newly added in 2018. Additionally, 385.3 thousand meters of type I cores, over 1.25 million pieces of samples and 13 thousand pieces of polished slices were kept dispersedly by the cores banks of provincial collection agencies and basal geological exploration entities.

3. Geological data digitalization

By the end of 2018, the digitalization of all archived paper-based geological data in the National Geological Archives had been realized. The Cores and Samples Center of Natural Resources had completed the image scanning of 389.6 thousand meters of core surface (with the data size up to 1,869.35GB) and the high-definition color photography of 23,397 pieces of specimens (with the data size up to 1,116.24GB).

III. Geological Data Services

1. Archiving service

In 2018, the National Geological Archives provided 483 entities with geological data services, including 24.2 thousand sets and 396.5 thousand pieces of geological data (viewing and processing). 9,045 sets and 66.5 thousand pieces of data were replicated and processed. Among them, 1.4 million pages of text reports and 100.96 thousand sheets of geological maps were replicated and processed, with the data size of 708.9GB. The number of clicks on the national

website was 7.05 million (including 2.82 million times of data retrieval), and the number of visits reached 1.22 million (including 500 thousand times of data retrieval), with 2.13 million of Web API visits. The number of visitors that were received through telephones, E-mails and online customer service reached 13.2 thousand, and the number of issued *Borrowing and Replicating Certificates of Confidential Geological Data* amounted to 79. Totally 266 visitors from 22 batches of domestic and foreign groups were received for site visits and technology exchanges.

The Cores and Samples Center of Natural Resources received 2,907 person-times for onsite visits and participating in training and investigation. 87.5 thousand meters of cores were utilized, and 11.1 thousand pieces of sampled were taken. The number of the visits to the website of the China Geological Sample Information reached 55.82 thousand person-times. Observation and sampling services, including observing and sampling the cores from the Chinese Continent Scientific Drilling (CCSD), the cores from SK-2 Well and the cores from the geological survey on oil and gas, for national research projects, survey on oil and gas resources, etc., with 55 thousand meters of utilized cores and about 12 thousand pieces of samples. The public were provided with the popularization service of science.

2. GeoCloud 2.0 online service

In the China Mining Conference held on October 18, 2018, “GeoCloud 2.0” was officially launched for providing services. The system of the “GeoCloud” nodes in totally 29 entities directly under the China Geological Survey was completely covered, and more than 160 national key geological databases were uploaded and shared. Additionally, real-time data, including the data from geological disaster monitoring, underground water monitoring, the oil, gas and geothermal drilling and coastal zone monitoring were accessed; 4,905 authoritative geological data products (accumulated to 7,287) were added. Nearly 140 thousand files and over 4.4 million geological data were accessed by the GeoCloud, realizing the inquire on the GeoCloud platform, the online browsing of public geological data and online order services; 100 thousand drilling data were added, and the cumulative quantity of issued data reached 900 thousand; the image information of over 30 thousand

meters of drill cores were added, and, cumulatively, the information of up to 290 thousand meters of drill cores was kept. The retrieval service of 0.89 billion geoscience documents was provided.

In 2018, the total number of the visits to “GeoCloud” was 4.4 million, with 462 thousand by the Geological Survey network and 3.94 million by the Internet. The number of registered GeoCloud users reached 17,024. For the 12 types of the big data on national geological survey and 8 types of authoritative key data products of “GeoCloud”, the number of the user downloads reached 79 thousand, among which the numbers of “geological maps” and “technological methods and standards” downloads ranked top 2; the proportions of viewing geoscience popularization information and geological maps were the largest.

“GeoCloud” has comprehensively integrated the information system of resource and environment carrying capacity and the evaluation of national land space suitability, the information system of urban geology, the information service platform of national underground water monitoring and the information system of geological disasters to provide the cloud service for governments at all levels in terms of ecological construction, disaster prevention and control, planning and monitoring, etc. The smart geological survey system enlarged demonstrative applications, facilitated the building of modernized geological survey modes and upgraded the business management efficiency and refinement levels of geological survey.

The construction of “GeoCloud” has improved the convenient sharing of geological data and upgraded the scales and levels of geological information socialization services, achieving significant service effects and social benefits. The “GeoCloud 2.0 Online Service” was selected as one of the “2018 Top Ten Geological Sci-tech Progresses of China Geological Survey (CGS) and Chinese Academy of Geological Sciences (CAGS)” and reported widely by CCTV and other media.

Chapter IX

Scientific and Technological Innovations in Mineral Resources

In 2018, significant results were yielded in the research on fundamental geology; the metallogenic theories, prospecting models and exploration methods were innovated; a number of technological instruments and equipment for geological survey were developed or integrated.

I. Research on Fundamental Geology and Metallogenic Theories

1. Remarkable results of fundamental geological research

Researches on deep Earth exploration. The drilling depth of 7018 m in the China Continental Scientific Drilling Project (CCSD) Songke Well No.2 was completed successfully. It is found that the deep part of Songliao Basin has a good exploration and development potential of the two kinds of clean low-carbon energy, i.e. shale gas and geothermal energy. Three important evidences follow by the world's most complete and continuous Cretaceous terrestrial formation record, the main control factors of climate changes and the major events of climatic fluctuation were discovered, which can be used to meticulously depict the Cretaceous terrestrial paleoclimatic revolution law, create the "golden pillar" standard cross-section profile of Songliao Basin terrestrial formation, and establish the new evolution mode of Songliao Basin, which propose new understanding of the multi-factor enrichment of organic matter in Songliao Basin. Additionally, the Himalayan 3D geodynamic model and the Gangdise tectono-magmatic-metallogenic framework model were rebuilt; the understanding that the large

Tethys-Himalayas slip-shear zone is the most important terrain boundary of the Himalayas was proposed; The subduction, accretion and collision orogeny processes in the Early Paleozoic orogenic system on the northern edge of the Tibetan Plateau, which was related to Proto-Tethys evolution, were remolded. Two new mantle minerals were discovered and made a declaration to the Commission on New Minerals, Nomenclature and Classification of the International Mineralogical Association (IMA-CNMNC).

Researches on stratigraphic paleontology. An Anurognathus fossil was newly discovered in the Jiufotang Formation in Lamadong Town, Jianchang County, Liaoning Province. The Early Triassic marine vertebrate fossils were discovered for the first time in Nanpanjiang Basin, southwestern China. The important geological evidence of the ancient ocean oxygenation event that occurred 1570 Ma was discovered.

Research on tectonic evolution. The existence of Cambrian-Ordovician ancient oceanic basin in the Lajishan area and the rock associations of trench-arc-basin system were confirmed. The relationship between the Early Paleozoic tectonic evolution in the Lajishan area and the Proto-Tethys Ocean was rebuilt. The Yangtze continental nucleus in the Early pre-Cambrian sequences were redefined, the sedimentary – magmatic - tectonic framework of the Yangtze block in pre-Devonian conjunction and separation processes was preliminarily built, the Neoproterozoic arc-basin evolution model of the southeastern edge of the Yangtze block was proposed, and the new mode of the Cathaysian Neoproterozoic-Mesozoic tectonic evolution

Feature 9-1 Sustainable Development of Geological and Mining Undertakings Promoted by Scientific and Technological Innovations Since the Founding of the PRC

Since the founding of the PRC, the basic geology and ore-forming theories have been continuously innovated, whilst the exploration and prospecting technologies have developed rapidly. From the development of theories such as geomechanics to the gradual improvement of basic theories such as continental dynamics and earth system science, from the establishment of continental hydrocarbon generation theory to the theories of intraplate metallogenesis, collision metallogenesis and minerogenetic series, and from the development of traditional geophysical, geochemical and remote exploration techniques to the integration of star, outer space, earth and sea exploration techniques and systems, the innovation of geological science and technology has played an important leading and supporting role in the field of mineral resources.

was established. The subduction-accretion rock complex tectonic attribute of “Lancang Group” was determined. The distribution diagrams (1 : 5,000,000) of active faults in China and adjacent sea areas were prepared.

2. Innovative metallogenic theories

Theoretical research on oil and gas reservoir. The distribution and contributing factors of the Cambrian and Silurian organic rich shales in Yichang, western Hubei Province, the shale gas reservoirs and the gas-bearing and the corresponding restraining factors of these reservoirs were systematically summarized. The new theory that “Platform depression is the basis, the organic content is the guarantee, and the perfect match between the basement uplift and organic evolution is the key” on the shale gas accumulation in the paleo-uplift margin was proposed. Two shale gas conservation and enrichments modes, i.e. “the Cambrian basement controlled reserve” and “the Silurian fault controlled reserve”, were established. The shale gas controlled reserve mode of “paleo-uplift margins” was deepened, and the accumulation mode of the Sinian “paleo-uplift + thrust nappe mixed-type” was created, which can provide a significant achievement of the research on the shale gas in western Hubei, Shaanxi, etc. Shale gas enrichment mode of “sources controlled by sediments, reserves controlled by decollement and diagenesis controlled by high-steep structures” in Sichuan Basin was established, which can guide for the survey and evaluation of the shale gas in eastern Sichuan. The “late-stage, multi-type” accumulation theoretical knowledge for the Carboniferous in Qaidam Basin was proposed innovatively, and the Carboniferous was confirmed for the first time as the fourth hydrocarbon-bearing system in Qaidam Basin. The polymorphic, multiphase oil and gas accumulation mode for the large overlapping basins characterized by “three complete combinations of source-reservoir-cap association – polygenic hydrocarbon generation – multiphase hydrocarbon charging – multiple caps – accumulation in stability zones” was proposed. The hydrate accumulation mechanism of “accumulation distribution controlled by the geotemperature-geopressure field – organic pyrolysis gas sources provided by the deep – microbiogenic gas sources provided by the shallow – fluid migration dredged by the fault structure – the zoned accumulation surrounding mud-volcanic structures” was proposed, and the near-surface natural gas hydrate was discovered for the first time under the guidance.

Metallogenic theories on solid minerals. The mineralization controlled by the “intra-basinal uplift margin” structures, the “source-bed controlled by red-black rock series, orefield

controlled by structures and sand bodies, and mineralization controlled by physicochemical interfaces”, and “sedimentary environment, ore-controlling structures, ore-formation fluid and integrated information”, so called “3+1” integrated prospecting forecasting model for sandstone-type uranium deposits was proposed. The fact that there were 3 stages of uranium metallogenesis and 3 metallogenic types in Huayangchuan, Shaanxi Province was proposed, and the “one-step dense media separation processes” and the “microwave roasting and nanofiltration purification technology” for the uranium deposits in Huayangchuan were initiated. The geochronology evidence, that the large-scale W-Sn mineralization of the Late Jurassic in Nanling was significantly later than the emplacement time of ore-bedded granite, was found; the close relationship between the tungsten mineralization and the latent Late Jurassic granite in the region was verified, and the temporal and genetic relationship between the tungsten mineralization and the Caledonian large granite batholite was denied. The theory of the vertical migration of elements in deep-penetrating exploration geochemistry was established for the first time and was verified through the drilling depth of 3,200 m in Jiaodong, Shandong Province and 2,000 m in Shanggong, Henan Province; and the 3D geochemical models for the Jiaojia-type gold deposits, porphyry copper deposits and volcanic rock type uranium deposits were established.

Research on groundwater resources. the groundwater resources evaluative models for subterranean stream multiple-karst water-bearing media were established. The water resource evaluative conceptual models of the Haiyang-Zhaidi subterranean river system in Guilin, Guangxi Zhuang Autonomous Region and the Daxiaoqing subterranean river system in Guizhou Province were established. The pondage modes for the groundwater in the batholith areas of Mount Taihang and Mount Yimeng were built.

II. Mineral Resources Exploration Technology

1. Research and development of a number of geological prospecting technical instruments and equipment

Deep drilling technical equipment. The large-diameter coring technology system for ultra-deep wells was established innovatively, the major technological problems in deep geophysical exploration (such as the ultra-high-temperature drilling technology) were tackled. These technology and equipment were successfully supported the achievement of four world records on the drilling of the CCSD Songke Well No.2. Permanent magnetic direct top-driving electric

drilling rigs were developed and manufactured independently; the key technological problems, including the problems in well structure design for the high-temperature hard rock drilling, high-temperature drilling fluids, vicious leakage, caving and chipping and high-temperature well cementation, were tackled; and the deep geothermal survey and evaluation in Huizhou, Guangdong Province were supported. The vibration impact coring drill and high-strength impact-resistance coring diaborit were successfully developed and manufactured, improving the drill-core recovery of the fractured formation core. One set of AC variable-frequency electric geological core drilling rig that was provided with H-specification drills and had the drilling depth capacity of 4,000 m was developed, and the proper bore size series and drill string schemes for small-diameter ultra-deep hole wire-line coring drilling were created preliminarily.

Deep geological exploration equipment. The deep exploration instruments, such as the first independently and successfully developed domestic ultra-high temperature and high-pressure rheometer, and the developed ultra-high-temperature borehole trajectory measuring instruments, were engineered. The producibility and commercial servitization of the instruments such as core spectroscopy scanners, field spectrometers and small imaging spectrometers were realized. The integrated sensor with the temperature resistance of 150°C and the pressure resistance of 60 MPa was developed, realizing the stable signal transmission in 6,000 m-depth wells. The deep multi-parameter groundwater in-situ online monitoring instruments were developed, realizing the wide-range high-precision measurement of the specific conductance within the scope of 0-200 ms/cm.

Geological experimental equipment. Car-borne field analysis and testing system for the gas contents in shales was preliminarily established, realizing the conjunction measurements of the shale gas content and composition, and the corresponding technical regulations were prepared. CNX-808 WED spectroscopy-energy spectrum complex X-ray fluorescence spectrometers were developed independently; the first domestic off-line sampling device for oxygen and nitrogen isotopes in nitrates with the high-temperature pyrolysis method was developed and manufactured.

2. Significant progress made in resource exploration technologies

Survey and evaluation technologies of clean energy resources. Multiple measures, including multi-beam in-situ laser raman testing, geological trawling, submarine photography, deck testing and submarine drilling, were innovated and integrated, the “integrated” detecting, drilling and collecting technology system for exploring shallow surface hydrates in the

maritime space was formed. The sand-control tools and instruments used for natural gas hydrates in the sea and the new separated-layer slip casting water sealing technology were developed. The oil-gas comprehensive geophysical survey technological system for Songliao Basin and its peripheral volcanic rock overlay areas was established, which was applied to distinguish the frameworks of main structural units including Tongyu fault depression and Xiushui Basin, and the Neopaleozoic stratigraphic distribution of the western edge of Songliao Basin.

Strategic emerging minerals survey and evaluation technologies. The survey mode, that combination of “remote sensing interpretation – gravity and magnetic measurement – electric positioning – radar probing and portable sampling”, is applicable for the regions covered by regolith and meadow was established. The Gyabjeka rocks-minerals-ores spectrum databases were improved. The new selective enrichment technology of rare earth elements (REE) and the comprehensive utilization technology of “deep-sea” REE were established; through the utilization of the former technology, the major breakthroughs, i.e. higher than 85% of REE leaching rate and less than 5% of the leaching rate of each main impurity (such as aluminum, iron, titanium and silicon) in the comprehensive utilization of “sedimentary” REE deposits in Guizhou Province, were achieved. The technology of manufacturing magnesium sulphate products by using salt lake epsomite deposits was developed, achieving the intermediate trial success and effectively making use of the sluggish magnesium resources in the Lop Nur salt lake, Xinjiang Uygur Autonomous Region.

Deep space to ground detecting technology. The 2 m/8 m optical high-resolution remote sensing operational satellite constellation was built and put into operation, improving the ground observation capability, and the system of totally 77 types of products, including standard data products, basic data products, common products and special products, was preliminarily established. The measurement accuracy of aeromagnetic three-component exploration technology was significantly improved, and the dynamic noise fourth-order difference statistics value was increased to the value better than 10 nT from the 30 nT in the “The 12th Five Year Plan” period. The engineering application of independently - developed helicopter time-domain AEM system was realized for the first time, and the research and demonstration of the aerogeophysical technology for typical overlay areas and the deep resources forecasting system technology were implemented.

Geological experimental technologies. Lithium isotopes were used in research on the fluids in mineralization for the first time, and the new evidence from Lithium isotope, that great amount of magmatic source fluid was involved in mineralization, was proposed. The “bacterial

denitrification measuring method using ppm (parts per million, 10^{-6}) trace nitrogen and oxygen isotopes in nitrate” was developed and established in China initiatively. The simultaneous determination method of garnet U-Pb dating and main trace elements, the analysis method of scheelite in-situ Sr isotopes and the U-Th-Pb dating method of baddeleyite in-situ LA-ICP-MS were established. 3 types of the first class national standard matter and 2 types of scheelite Sr isotope standard matter for strontium ores composition analysis were developed. High-efficiency environment-friendly serial analysis methods were established for the low-cycle polycyclic aromatic, its derivant and the short-chain chlorinated paraffin in groundwater, the derivant of polycyclic aromatic and its parent body, nitrobenzene compounds, etc.

III. Exploitation and Utilization Technologies

1. Enhanced oil recovery (EOR) technology for heterogeneous combination of post-polymer-flooding reservoirs

The EOR technology for heterogeneous combination of post-polymer-flooding reservoirs is a tertiary oil recovery technology for oil fields and has achieved 24 national patents, 1 U.S. patent, and 2 provincial and ministerial awards in China. The corresponding pilot experiment was completed in the Shengli oilfield, and the technology was applied in the Gudao oilfield, which resulted in good economic benefits and increased the recovery ratio by 8.5%. Since new technologies for increasing recovery ratios are urgently needed for the Chinese oilfields, the technology has a wide range of prospects for popularization and application.

2. Mining and beneficiation efficiencies were optimized and improved through the iron-increasing and silicon-decreasing beneficiation process

During the iron-increasing and silicon-decreasing beneficiation process, the technological problems for fine-grained, hard-to-mill ores were tackled. Beneficiation technologies were optimized by focusing on the application of high-performance tower mills for fine milling, supplying good effects for utilizing hard-to-beneficiate ores and improving both mining and beneficiation efficiencies. In this way, the essential problem of the difficult quality control for fine-grained and hard-to-beneficiate ores was solved, which is a significant breakthrough. For technology optimization, the new technologies and new equipment developed in recent years were utilized and had great adaptability for fine-grained and hard-to-mill ores, which provided significant achievements and easy to promote.

3. Key technologies in large-scale mining for large underground mines

Although the key scale mining technology for large underground mines is difficult, it is highly innovative, mature and reliable, and has a good reproducibility and strong applicability. The promotion and application of the technology in the underground mining of metallic mines can lead to considerable economic benefits. It has advanced technological indicators and distinct intellectual property, and could provide significant resource, environmental, safety and economic benefits. Furthermore, it can certify that the mine recovery indicators can be increased significantly while there is no land surface depression, and it can be easily promoted and applied for the same type mines.

4. Key technology for pressurization pre-oxidation in arsenic-bearing refractory gold ores

The whole set of pressurization pre-oxidation technologies and equipment for arsenic-bearing refractory gold ores with organic carbon have been developed and manufactured through the key pressurization pre-oxidation technology for arsenic-bearing refractory gold ores, which has realized the effective connection of advanced technologies and efficient equipment and successfully solved the problem of the low recovery from the direct extraction of the refractory for gold ores. The technology has been applied in production and brought in significant effects by virtue of its innovativeness and advancement. It can be widely applied to refractory for As-, Sb- and C-bearing gold ores and can significantly improve the development and utilization level of refractory gold ores in China.

IV. Scientific and Technological Innovation Plans

1. Introduction of scientific and technological innovation talent incentives

In 2018, consistent with the requirements of the relevant national documents about the scientific and technological system reforms and the requirements of reforming and improving scientific and technological innovation efficiency and building the three high-caliber innovative scientific and technological personnel echelons in the field of natural resources, the Implementation Opinions of the Party Organization of Ministry of Natural Resources (MNR) of PRC on Deepening Science and Technology System Reform and Improving Science and Technology Innovative Efficiency (ZRZDF [2018] No.31) was issued; in order to fully apply the current personnel, and introduce urgently needed talents and enhance the personnel

echelon construction, the Several Measures of the Party Organization of Ministry of Natural Resources(MNR) of PRC on Innovative Scientific and Technological Personnel Incentive (ZRZDF [2019] No.2) was issued.

A total of 4 scientific and technological officers in the system were selected as the leading talents supported by the National special support program for high-level personnel recruitment (or “10,000-talent plan”) , and 2 persons were selected as the “tip-top young talents”; 2 awards of the “National Natural Science Foundation of China (NSFC) Distinguished Young Scholars” in the field of nature, and 5 awards of “Excellent Young Fund” were won. The selection for the third batch of high-caliber innovative scientific and technological personnel cultivation program (for the fields of land resources, geological minerals and geological environment) was implemented by the Organization and Development Department; 23 “Leading Talents”, 35 Excellent Young Talents and 8 Innovation Groups, including the pre-production innovation group for natural gas hydrates in the maritime space, were selected. Additionally, 8 scientists in the department system were listed in the 2018 Global Highly Cited Researchers, and the number of the listed scientists ranked the third in the earth planetary science list among all the Chinese experts and scholars outside of colleges and universities. The China Geological Survey awarded 6 persons as “Li Siguang Scholars”, including 5 “Excellent Geological Talents” and 1 “Urgently-needed High-caliber Talent”, 10 “Excellent Geological Talents” and 33 “Excellent Geological Talents”.

2. Release of the medium and long-term outline of scientific and technological innovation and development plan

According to the new responsibilities, new targets and demands of natural resources management, on the basis of integrating, optimizing and condensing existing science and technology innovation planning in the fields of territory, ocean, mapping and forestry, the overall pattern and implementation routes of science and technology innovation development in the field of natural resources, were planned, and the Outline of Scientific and Technological Innovation and Development Plan of Natural Resources was prepared and issued. In the Outline, it was specified that the major science and technology innovation strategy in the field of natural resources with “One Core, Two Deep Explorations and Three Systems” as the main body would be implemented. Specifically, the major body consisting of establishing the science core theory support for the Earth system (“One Core”), leading the international science in deep Earth exploration and deep sea exploration (“Two Deep Explorations”) and

establishing the survey and monitoring system of natural resources, management and control system of territory space and ecological protection and restoration system (“Three Systems”). In this way, the scientific support for the high-quality economic growth and ecological civilization construction can be comprehensively enhanced, and the scientific and technological contribution rate can be continuously improved, and the modernization of the governing system and governing capacity of natural resources can be driven, which helped to ascend China to the advanced countries in the main fields of natural resources science and technology innovation. Currently, the key responsibility is to organize and implement the research and operation by improving the scientific theories of mineral resources, propelling the implementation of major deep geophysical exploration projects, researching and developing the survey and observation equipment for full-sea-depth resources, building natural gas hydrate drilling vessels, enhancing the research and development of key exploration and evaluation technologies of the oil and gas resources in the maritime space, tackling core technological problems in the green utilization of mineral resources and clean energy resources, etc.

V. Technical Standards for Geology and Mineral Resources

The standard for the green mine construction was enhanced and propelled. For standard preparation, the Green Mine Construction Specification has been subjected to the initiation reply organized by the Standardization Administration of the People’s Republic of China. The standards for 9 mineral industries, i.e., non-ferrous metal, chemical industry, gold, coal, sandstone, onshore petroleum and natural gas mining, cement, smelting and nonferrous metal, have been issued and implemented, which provide the technological support for 2019 green mine selection deployed and launched by the MNR and demonstration for the preparation of local standards. Several local standard authorities have refined and established local standards for green mine construction according to the actual requirements of local mineral industry development. For example, Zhejiang, Henan, Shandong, Anhui provinces and Guangxi Zhuang Autonomous Region have established their local standards for green mine construction. The “green mine construction standard system” project was carried out, and progress has been made in the current period. Currently, the main industries have been covered, and the green mine standard system under the coordination of national, industrial and local standards has been preliminarily formed, providing the technological instruction for the green mine construction of nationwide mineral enterprises and the strong technological security for the overall propelling of green mine construction in China.

Chapter X

International Cooperation

With the implementation of China's overall diplomatic strategy, active response was made to the "Belt and Road Initiative", and the bilateral and multilateral cooperation in the fields of geology and mineral resources was comprehensively promoted. Through international exchange platforms such as China Mining, and China - ASEAN Mining Cooperation Forum, geological survey cooperation projects were actively carried out, and mining exchanges and cooperation with relevant countries were further expanded.

I. Bilateral and Multilateral Cooperation Mechanisms

1. Bilateral cooperation

The outcomes of the Forum on China-Africa Cooperation (FOCAC) Beijing Summit were implemented, the cooperation with African countries, such as Tanzania, Mali, Morocco, Nigeria, Sierra Leone and Sudan, was actively propelled, and the practical project cooperation was carried out. In the intergovernmental bilateral cooperation framework, the high-level coordination mechanism in the mineral fields in the countries, including Chile, Argentina, Canada, Pakistan, Kazakhstan, Tajikistan, Turkey, Papua New Guinea and Indonesia, was densified unceasingly, and the cooperative relationship in the fields such as geoscience research, geological survey, mineral resource management, mine environment protection and mineral investment cooperation, was further progressed.

Eight cooperation agreements were signed with foreign geological survey agencies. More efforts were made to promote key bilateral cooperation projects between China and other countries, such as USA, Germany, Canada, Australia, Italy and Korea. The cooperation covered basic geological survey, deep exploration, marine geology, natural gas hydrate, shale gas, geological disasters, karst geology, hydrologic geology, geothermal development, wetland protection and other fields. Until now, 230 memorandums of understanding or project cooperation agreements have been signed with geologic surveys, scientific research institutes or universities from 63 countries.

2. Multilateral cooperation

The initiative of “jointly building geoscience cooperation center”, proposed by Premier Li Keqiang at the 21st China-ASEAN Summit was implemented. at the China-ASEAN Mining Cooperation Forum 2018 (9th), the leaders of the Ministry of Natural Resources of PRC, the Government of the Guangxi Zhuang Autonomous Region, and the representatives from geological and mining departments in 8 ASEAN countries, i.e. Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Thailand and Vietnam, attended the opening ceremony of the “China-ASEAN Geoscience Cooperation Center”. In the coordination with the “Lancang-Mekong Week” activity in 2018, the first Geosciences Forum for Lancang-Mekong Cooperation Countries was hold, demonstrating the achievements of the geoscience cooperation between China and Lancang-Mekong countries and condensing the cooperation agreement.

The Ministry of Natural Resources attended the 6th APEC Meeting of the Ministers Responsible for Mining , and *the Statement of the 6th APEC Meeting of the Ministers Responsible for Mining* was deliberated and approved. The Ministry of Natural Resources attended the 11th ASEAN +3 Senior Mining Officials Meeting to plan and deploy the cooperation between China and the ASEAN in the fields of geology and minerals, attended the 54th CCOP Annual Meeting and the 71th meeting of the Steering Committee to participate in the preparation of CCOP working plans, actively participated in the preparation of the regulations of the International Seabed Authority (ISA) on the mineral resource development within the international sea-bed area and performed the relevant commitments in the *Minamata Convention on Mercury* to build a responsible image of

a major country in the world. The Ministry also brought the platform functions of the UNESCO International Center on Karst and UNESCO International Center on Global-Scale Geochemistry into full play, further implemented the international large-scale scientific plans, such as “Chemical and Earth”, actively participated in the IGCP and ICDP and led the implementation of the relevant international geoscience cooperation projects.

II. Opening-up and Cooperation

1. New progress of resources cooperation with countries participating in the “Belt and Road Initiative”

An active response was made to the “Belt and Road Initiative” by promoting opening-up and cooperation in the fields of resources, strengthening policy communication and information sharing. The outcomes of President Xi Jinping’s talks with the president of Rwanda were put into practice actively, and the feasibility research on aid project for national potential evaluation of mineral resources in Rwanda was completed; the implementation of the foreign aid projects on the geological survey in Nepal and Laos was propelled. New progress was made in satellite remote sensing interpretation in the countries and regions participating in the “Belt and Road Initiative”; the offshore cooperation system was established with some countries along the “Maritime Silk Road”, effectively promoting the marine geoscience cooperation in multiple fields; the personnel communication and training were carried out.

China’s advantages in geochemistry, satellite remote sensing and airborne geophysical prospecting were brought into full play, and substantive geological survey cooperation with 23 countries participating in the “Belt and Road Initiative” was carried out, mainly involving geological mapping, geochemical mapping, technical training, technical cooperation and research, metallogenic theory research and cooperative mapping. In 2018, a total of 24 international cooperation projects on geological survey were carried out, with a total annual capital of 135 million yuan, and the global geological and mineral resources information system was further improved.

2. International correspondence of reserves & resources classification schema

On September 28, 2018, the Ministry of Natural Resources of PRC and the United Nations Economic Commission for Europe (UNECE) jointly issued the *Document on the Correspondence between China's National Standard of the Classification for Resources/Reserves of Solid Fuels and Mineral Commodities (GB/T 17766-1999) and the United Nations Framework Classification for Resources (UNFC)* and the *Document on the Correspondence between China's National Standard of the Classifications for Petroleum Resources/Reserves (GB/T 19492-2004) and UNFC*. In these documents, the corresponding relation between the relevant national standards of China and the UNFC mineral reserve classification and coding was detailed. The joint issuance of these documents marked the success of China's national standards' correspondence with the UN technological documents for the first time. The outcomes of these documents on correspondence are conducive to the deep China-UNECE exchanges and cooperation in the field of sustainable energy and will propel the UN 2030 sustainable development agenda and the international cooperation under the "Belt and Road Initiative" framework.

3. Training course on geology and mineral resources for foreign trainees

A total of 25 training courses on geological survey for foreign geological and mineral officials and technicians were organized, and the training fields covered digital geological survey, geochemistry, airborne remote sensing, geophysical technology, water resources and environment, energy resources, marine geology, etc. Totally 668 geological and mineral officials and technicians from more than 50 countries and regions in Asia, Africa, Latin America and Central and Eastern Europe participated in the training courses, which established extensive cooperative relations, and laid a solid foundation for expanding bilateral and multilateral cooperation.

III. International Mining Cooperation Platforms

1. China Mining 2018

More than 11,000 representatives from 69 countries and regions participated in the China Mining 2018. The theme of the China Mining 2018 was “New Pattern of Opening, New Model for Cooperation”; the General Secretary Xi Jinping’s concept of propelling building a community of shared future for mankind was followed, the new era development theme of China was propagated, and the international mining capacity cooperation between China and the countries participating in the “Belt and Road Initiative” was used as the pointcut, so as to enhance the exchanges and cooperation with other countries in mining and the international capacity cooperation between enterprises from China and the countries participating in the “Belt and Road Initiative”. During the conference, the Ministry of Natural Resources conducted mining management and policy dialogues and exchanges with the mineral resources management departments of 8 major resource countries, i.e. Argentina, Chile, Mali, Morocco, Papua New Guinea, Nigeria, Sierra Leone and Sudan, and exchanged opinions on further enhancing information sharing, talent cultivation, scientific research and the policy guidance and support for mining enterprises.

2. China – ASEAN Mining Cooperation Forum 2018

More than 1,600 and more than 4,000 representatives from the mining departments, geological exploration systems and mining enterprises of 33 countries, e.g. China and the countries from ASEAN, Central Asia, West Asia, Africa, Europe and America, participated in the conference and the exhibition of the China - ASEAN Mining Cooperation Forum 2018 (9th). The forum theme was “Focus on the Silk Road Cooperation and Develop Green Mining”. In the forum, the discussion was carried out on the green development policies and practices of mining, mining projects and technological cooperation, the development and utilization of important mineral resources, geoscience cooperation mechanisms, mining information service and minerals and geology online database construction and other topics, and the agreement was achieved on many aspects, including regional mining development status, geoscience research and information sharing service, which further

enhanced the conventional friendship between China, ASEAN countries and the countries participating in the “Belt and Road Initiative” and densified the exchanges and cooperation between these countries.

3. Geosciences Forum for Lancang–Mekong Cooperation Countries

In the first Geosciences Forum for Lancang-Mekong Cooperation Countries, the *5-year Lancang-Mekong Cooperation Plan* issued in the 2nd Lancang-Mekong Cooperation Leaders’ Meeting in January, 2018 was implemented, and the routes and modes for enhancing geoscience cooperation were discussed based on the present status of geoscience cooperation. During the forum, the Forum for Geoscience Cooperation Status and Development in Lancang-Mekong Countries and the Forum for Hydrogeology and Environgeology of Lancang-Mekong Countries were held; in these forums, cooperation demands were discussed, and future cooperation was prospected. In the first Roundtable on Geoscience Cooperation of Lancang-Mekong Countries, the agreement was achieved on the cooperation in cross-border geologic correlation, hydrologic and environmental geology, geological informationization, satellite remote sensing, etc.

4. International Symposium on Deep Geophysical Exploration and Application (DEEP – 2018)

300 scientists engaged in the scientific research on deep exploration from more than 20 countries and regions, including the USA, Canada, Russia, Australia, Italy, Japan, the UK, Germany, Denmark, Spain, India, Poland, Sweden and China, participated in the International Symposium on Deep Geophysical Exploration and Application. In the symposium, the latest deep geophysical exploration outcomes were exchanged, the international cooperation fields and cooperation contents were expanded, the new implementation schemes and technological routes of the deep geophysical exploration in China were deliberated, the routes on extending to underground space and comprehensively utilizing deep underground resources and energy through the implementation of natural resource management were explored, the multidimensional 3D management of natural resources was promoted, and the possibility and feasibility of international deep geophysical exploration plans were discussed.