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China Mineral Resources

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Foreword

Under the guidance of Xi Jinping Thought on Ecological Civilization, China has continuously promoted the reform of mineral resources management and green development in mining sector. In order to make people at home and abroad who care about and support natural resources conditions understand Chinese policies and reform progress of mineral resources management, the Ministry of Natural Resources (MNR) organized the compilation of the *China Mineral Resources* (hereinafter referred to as the Report).

This year's Report focuses on the information since 2020 as the new progress made in China's exploration, exploitation and utilization of mineral resources, and survey and evaluation of mineral resources; the new changes in policies and regulations related to mineral resources; the new measures taken in management of mineral resources and protection of ecological environment; the new scientific and technological innovation; the new development made in geoscience theoretical studies as well as the new achievements obtained in the international cooperation on geology and mineral resources with countries participating in the "Belt and Road Initiative".

Till the end of year 2020, a total of 173 kinds of minerals have been discovered in China, including 13 kinds of energy materials, 59 kinds of metals, 95 kinds of nonmetallic minerals and 6 kinds of water and gases. In 2020, the investment in geological exploration decreased by 12.2% compared to the previous year. A total of 96 new deposits were discovered throughout the country, and major strategic breakthroughs were made in oil and gas exploration. The year witnessed decrease by 14.1% in fixed-asset investment in China's mining industry and slowing growth of production of major mineral products.

Mine ecological rehabilitation was actively carried out, and continuous efforts were made to rehabilitate the ecology of abandoned open-pit mines in key river basins and areas. Green exploration and exploitation of mineral resources were facilitated and green development of the mining industry promoted.

The revision of the *Mineral Resources Law (Draft Amendment)* was continued to further strengthen legislation and supervision in the field of mineral resources, facilitate transfer of “clean” mines, make better registration information of mining right transfer accessible to the public, enhance and improve law enforcement related to mineral resources, and keep offering preferential policies on resource tax.

The reform of mineral resources and reserves management was completed successfully with new rules and standards released. Formulation of the *National Mineral Resources Plan (2021-2025)* progressed smoothly, while local mineral resources plans at various levels were also being formulated. The supervision and management of geological exploration activities were strengthened to promote high-quality development of the geological exploration industry.

Basic geological survey was further enhanced. Important breakthroughs were realized in the non-profit survey of oil and gas in areas such as shale gas and coal-bed methane. New progress was made in survey of certain important mineral resources. Efforts were made to fully enable the geological data information management service system and promote open utilization and sharing of services. The ability of geological data management and service has been continuously enhanced.

Remarkable achievements have been made in the research of mineral resources with breakthroughs from many research projects. A number of important national and industrial standards were released, and many key laboratories and engineering and technological innovation centers were recognized.

The MNR actively maintained ties with relevant countries and international organizations through innovative ways of exchange and cooperation, and worked to promote cooperation in geological and mineral projects and further consolidate cooperative relations through international collaboration platforms such as China Mining and ASEAN +3 Senior Mining Official Consultations.

Statistics in the Report are mainly from the MNR and the National Bureau of Statistics of the People’s Republic of China. Statistics from the Hong Kong Special Administration Region, the Macao Special Administrative Region and Taiwan Province are not included in the Report.

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Chapter I

Geological and Mineral Resources Surveys and Evaluations

The level of Basic geological survey was further improved. Major breakthroughs were realized in the non-profit survey of oil and gas, such as shale gas and coal-bed methane. Geothermal and groundwater resources surveys and evaluations were carried out in the Beijing-Tianjin-Hebei region. New progress was made in the survey of certain important mineral resources. Work continued in the basic geological survey and mineral resources survey in territorial waters, and oceanic geological survey.

I. Basic Geological Survey

In 2020, the regional geological survey on a scale of 1 : 50,000 for 33,300 square kilometers was completed with financial fund from the central government, and the total area of regional geological survey reached 4,342,100 square kilometers, occupying 45% of the land area of China. The geochemistry investigation in an area of 16,100 square kilometers with a

scale 1 : 50,000 has completed with financial fund from the central government, with an accumulated completed area of 2,807,400 square kilometers, occupying 29.1% of the land area of China. The aeromagnetic survey of 95,600 kilometers was completed, and the seismic reflection profile of 475 kilometers was measured.

II. Mineral Resources Surveys and Evaluations

1. Oil and gas survey and evaluation

New progress was made in the survey of shale oil and gas in continental facies in the Songliao Basin. The Jili-1[#] shale oil well in the Lishu graben in the southern part of the Songliao Basin obtained for the first time a high-yield industrial flow of 76,000 cubic meters per day in the shale strata of the Shahezi Formation, making a breakthrough in the investigation of continental shale gas in the graben Lake Basin; the Song Shale Oil-3[#] well in the Sanzhao Depression in the northern part of the Songliao Basin obtained a daily industrial oil flow of 3.46 cubic meters per day, making a breakthrough in strategic investigation of new shale oil zones in normal pressure, medium to low heat evolved mud shale reservoirs.

New progress was also seen in the geological survey of shale gas in the Anhui region along the downstream of the Yangtze River Economic Zone, the middle Hunan region along the midstream, and Dagan, Yunnan and Danzhai, Guizhou along the upstream. The two-layer gas testing by hydrofracture in the Silurian system of the Xinsudi 1[#] well on the northwest edge of the Tarim Basin yielded 16,800 and 12,600 cubic meters of industrial gas flow per day, opening up a new formation of oil and gas exploration in the Silurian system of northwest Tarim.

The coal-bed methane survey has achieved an important breakthrough in industrial gas flow from the Heijidi 4[#] well, Heijidi 3[#] well and Heijidi 1[#] well, which were deployed in the coal mining area and mined-out area of the Jixi Basin and deep peripheral layers. It effectively serves efficient control of mine gas and comprehensive utilization of coalbed methane resources, and opens up a new field of exploration and development of unconventional oil and gas resources dominated by coal measure gas.

2. Geothermal resource survey and evaluation

The first case of hot dry rock reservoir construction on a large scale has successfully realized in China. The drilling and completion project of the first directional well of hot dry rock and high temperature hard rock in China was completed. Drilling at a depth of 4,500 meters in Xiong'an New Area uncovered a geothermal well with the largest depth and highest temperature discovered so far in the Beijing-Tianjin-Hebei region.

3. Investigation, evaluation and monitoring of groundwater

The annual investigation and evaluation of change on the resources, quality and reserves of groundwater in every basin over the country and all provinces were completed in 2020.

The integrated survey and evaluation of water resources in the Beijing-Tianjin-Hebei region has been explored, identifying the quantity, quality and change characteristics of water resources, and the working method of integrated water resources evaluation has been developed.

A total of 63,500 site-times of groundwater level measurements were carried out. The trend of groundwater level change, the status and causes of groundwater depression cone in north and northeast China plain, Yellow River and Huaihe River basin, northwest inland basin and other key areas were analyzed.

4. Geological survey and evaluation of other minerals

In 2020, the 1 : 50,000 mineral geological survey of 18,500 square kilometers were completed, with more than 100 prospecting targets delineated. A new large spodumene deposit in Jiada mining area on the periphery of Ma'erkang in western Sichuan was newly discovered, and three new types of sedimentary rare earth ore-fields were discovered in the Weining area of Guizhou. A new rare earth mineralized zone was discovered in the Dalucao mining area of Dechang, Sichuan. A cumulative total of copper and molybdenum ore

bodies (mineralization) were drilled in a single hole in the Zhu'nuo package exploration area in Tibet with an apparent thickness of over 400 meters. Some important prospecting progress has been made in rare metals and fluorspar in the Western Altun, Huichang tin deposit in Jiangxi, GaoBei molybdenum deposit in Yudu, Jiangxi and manganese deposit in Dawan area of Tongren, Guizhou.

Till the end of 2020, China had carried out the potential evaluations of 35 kinds of non-oil and gas solid mineral resources, among which the potential evaluations of niobium, tantalum and germanium were newly completed.

III. Marine Geological Survey

1. Basic marine geological survey

The 1 : 250,000 and 1 : 50,000 marine regional geological surveys in the sea areas under Chinese jurisdiction were continued. The 1 : 250,000 marine regional geological surveys and aero-geophysical surveys were carried out in three key areas in the East China Sea, including Hupi Reef, the offshore of Hainan Island and the Zhongsha Islands.

The 1 : 50,000 marine regional geological surveys were carried out in key areas, and a large-scale marine geological survey technology system was initially established. For the first time, the ultra-deep-water geomagnetic survey was successfully completed across the southwest sub-basin of the South China Sea, and the crust-mantle-scale geological section across the southwest sub-basin of the South China Sea was compiled.

2. Mineral resources survey in territorial waters

For the first time in the South Yellow Sea, the Silurian-Carboniferous fossil oil reservoirs has been discovered, and selected 6 favorable oil and gas zones, delineated 18 key structures, submitted 4 drilling targets, and recommended 7 well locations. It precisely

targeted the oil and gas parameter well locations in the Mesozoic sector in the northeastern South China Sea, selected 2 ~ 3 favorable oil and gas drilling targets in the northern South China Sea.

The Fujian-Taiwan shallow sand resource survey was carried out, with a preliminary estimate of about 69 million cubic meters of sand resources. The survey of sea sand resources in the Dongfang-Ledong sea area of Hainan Province was completed, with a predicted prospective resource of about 2.4 billion cubic meters and a resource of 92.5 million cubic meters was indicated.

3. Oceanic geological survey

The second round of joint China-Pakistan geological survey missions was implemented, and a systematic marine geological survey was carried out in the exclusive economic zone of Pakistan. This work served as an example of cooperation in geoscience on the “21st Century Maritime Silk Road”. We have organized and implemented the deep-sea geological resources and environment survey voyage, carried out multi-channel seismic surveys in the southern part of the Bay of Bengal in the northeast Indian Ocean, and proposed a deep-sea drilling program in Bangladesh. The 10th voyage of the Deep Sea Geological Survey and the 64th voyage of the China Ocean Survey were successfully completed, and important achievements have been made in the new discovery of cobalt-rich polymetallic nodules, contract performance of cobalt-rich crust, deep-sea biological survey and deep-sea exploration technology in the western Pacific Ocean.

Chapter II Mineral Resources

Till the end of year 2020, a total of 173 kinds of minerals have been discovered in China, including 13 kinds of energy minerals, 59 kinds of metals, 95 kinds of nonmetallic minerals and 6 kinds of water and gases.

I. Energy Minerals

Table 2-1 Reserves of Main Energy Minerals in China in 2020

No.	Minerals	Unit	Reserves
1	Coal	Billion tons	162.29
2	Oil	Billion tons	3.62
3	Natural gas	Billion m ³	6266.58
4	Coalbed methane	Billion m ³	331.55
5	Shale gas	Billion m ³	402.62

Note: The data for oil and gas reserves (oil, natural gas, coalbed methane, and shale gas) are remaining proved technical recoverable reserves as per *Classifications for Petroleum Resources and Reserves* (GB/T 19492-2020), and those of other minerals are the total of proved reserves and probable reserves as per *Classifications for Mineral Resources and Mineral Reserves* (GB/T17766-2020).

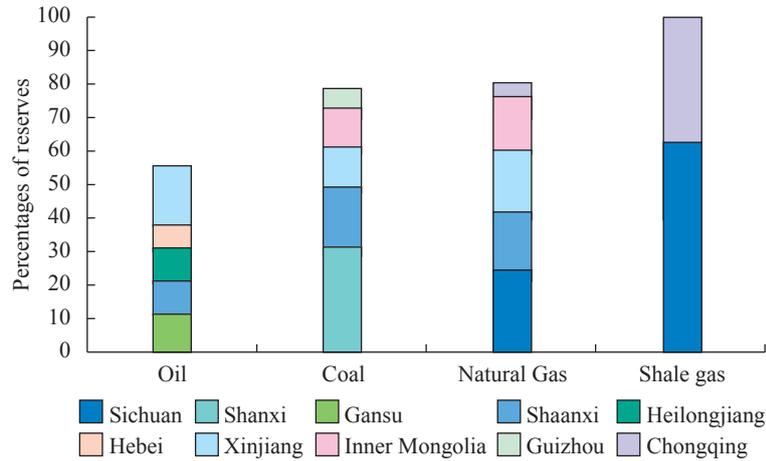


Fig. 2-1 Distribution of Main Energy Minerals in China

II. Metallic Minerals

Table 2-2 Reserves of Main Metallic Minerals in China in 2020

No.	Minerals	Unit	Reserves
1	Iron ore	Billion tons	10.88
2	Manganese ore	Million tons	212.96
3	Chromite	Million tons	2.77
4	Vanadium	Million tons of V ₂ O ₅	9.51
5	Titanium	Million tons of TiO ₂	201.16
6	Copper	Million tons of metal	27.01
7	Lead	Million tons of metal	12.33
8	Zinc	Million tons of metal	30.95
9	Bauxite	Million tons of ore	576.50
10	Nickel	Million tons of metal	4.00
11	Cobalt	Million tons of metal	0.14
12	Tungsten	Million tons of WO ₃	2.22
13	Tin	Million tons of metal	0.72
14	Molybdenum	Million tons of metal	3.74
15	Antimony	Million tons of metal	0.35
16	Gold	Tons of metal	1927.37
17	Silver	Tons of metal	50672.26
18	Platinum-group metals	Tons of metal	126.73
19	Strontium	Million tons of celestite	15.80
20	Lithium	Million tons of Li ₂ O	2.34

III. Nonmetallic Minerals

Table 2-3 Reserves of Main Nonmetallic Minerals in China in 2020

No.	Minerals	Unit	Reserves
1	Magnesite	Million tons of ore	494.76
2	Fluorspar	Million tons of minerals	48.58
3	Refractory clay	Million tons of ore	282.60
4	Pyrite	Million tons of ore	694.71
5	Phosphorite	Billion tons of ore	1.91
6	Potash	Million tons of KCl	280.60
7	Boron	Million tons of B ₂ O ₃	20.90
8	Sodium salt	Billion tons of NaCl	20.71
9	Mirabilite	Billion tons of Na ₂ SO ₄	1.77
10	Barite	Million tons of ore	36.89
11	Limestone for cement	Billion tons of ore	34.27
12	Glass-making siliceous rock	Billion tons of ore	1.13
13	Gypsum	Billion tons of ore	1.55
14	Kaolin	Million tons of ore	571.58
15	Bentonite	Million tons of ore	301.76
16	Diatomite	Million tons of ore	151.14
17	Veneer granite	Billion cubic meters	1.16
18	Veneer marble	Billion cubic meters	0.43
19	Diamond	Kilograms of minerals	1302.36
20	Crystalline graphite	Million tons of minerals	52.32
21	Asbestos	Million tons of minerals	14.90
22	Talc	Million tons of ore	55.81
23	Wollastonite	Million tons of ore	51.49

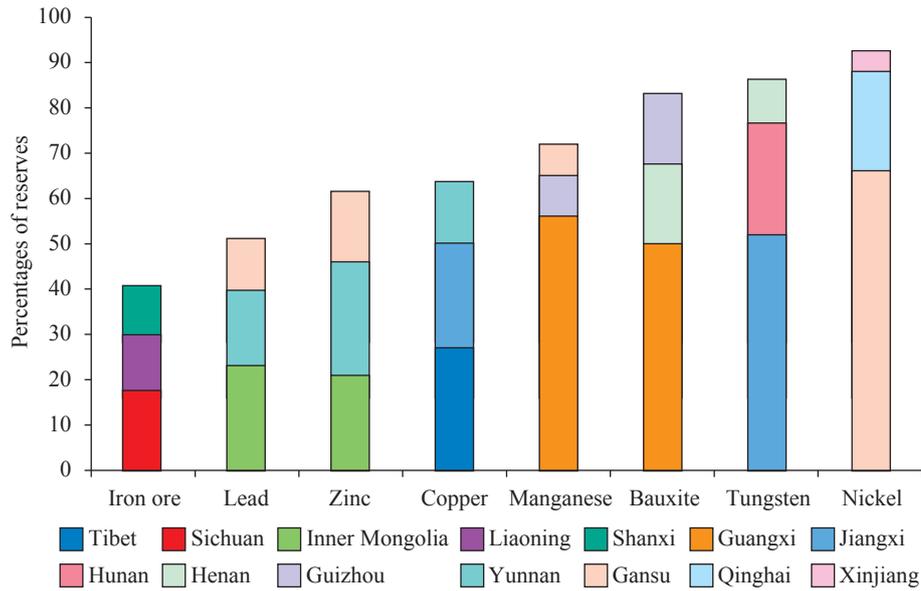


Fig. 2-2 Distribution of Main Metallic Minerals in China

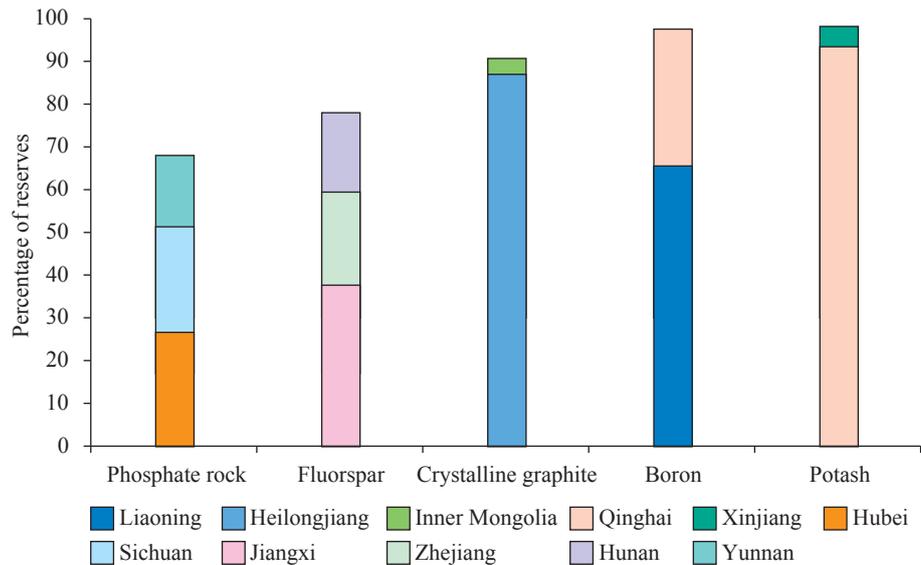


Fig. 2-3 Distribution of Main Nonmetallic Minerals in China

Chapter III

Exploration

In 2020, major breakthroughs were made in exploration of shale gas and other unconventional oil and gas, and remarkable achievements were made in exploration of strategic minerals such as manganese, cobalt, copper and graphite.

I. Investments in Geological Exploration

In 2020, the investments in geological exploration were RMB 87.19 billion in China, a decrease of 12.2% compared with the previous year. Among them, the investments in geological exploration of oil and gas were RMB 71.02 billion, decreased by 13.5%. The investments in geological exploration of non-oil & gas mineral resources were RMB 16.16 billion, decreased by 6.1%, and the decline was aggravated compared with 2019 (Fig. 3-1).

2,956 wells were drilled for oil and gas exploration and the drilling footage reached 8,394.2 kilometers, increased by 2.1% and 2.9% respectively. A total of 30,000 kilometers 2D seismic data was acquired, decreased by 41.6%; and a total of 42,700 square kilometers 3D seismic data was acquired, decreased by 9.3%.

Among the investments in non-oil & gas geological exploration, the investments in mineral exploration was RMB 8.25 billion, decreased by 6.3% and accounting for 51.0% of the total;

the investments in basic geological survey was RMB 1.99 billion, decreased by 22.3% and accounting for 12.3% of the total; the investments in hydrogeology, environmental geology and geological disaster survey and evaluation was RMB 3.45 billion, decreased by 0.3% and accounting for 21.4% of the total; the investments in geological science and technology and comprehensive research was RMB 2.20 billion, increased by 11.3% and accounting for 13.6% of the total; the investments in geological data service and digitalization was RMB 0.27 billion, decreased by 33.1% and accounting for 1.7% of the total. See Fig. 3-2 for the proportion of each investment.

Among the investments in non-oil & gas geological exploration, the nationwide fiscal investments reached RMB 11.01 billion, accounting for 68.1% of the national total, including RMB 4.63 billion that was financed by the central government, decreased by 26.8% and accounting for 28.6% of the national total, and RMB 6.39 billion that was financed by local governments, increased by 20.4%, accounting for 39.5% of the national total. RMB 5.15 billion was from social investment, decreased by 7.8% and accounting for 31.9% of the national total. See Fig.3-3 for the proportion of the investment sources.

The investments in non-oil & gas mineral exploration were dominated by minerals such as coal, gold, lead-zinc and copper, totally accounting for 51.7% of total investments in non-oil & gas exploration in China. Compared to 2019, the investments in silver, lead-zinc, nickel, graphite and tungsten dropped significantly (Table 3-1).

In 2020, the provincial funds invested in geological exploration reached RMB 2.98 billion, including RMB 2.25 billion in mineral exploration, which accounts for 27.3% of the total national investments in non-oil & gas mineral exploration (RMB 8.25 billion) and 51.6% of the national fiscal investments in non-oil & gas mineral exploration (RMB 4.36 billion). 439 mineral exploration projects were implemented, and coal, gold, geothermal water, copper and bauxite taking up the largest shares of investment in a descending order.

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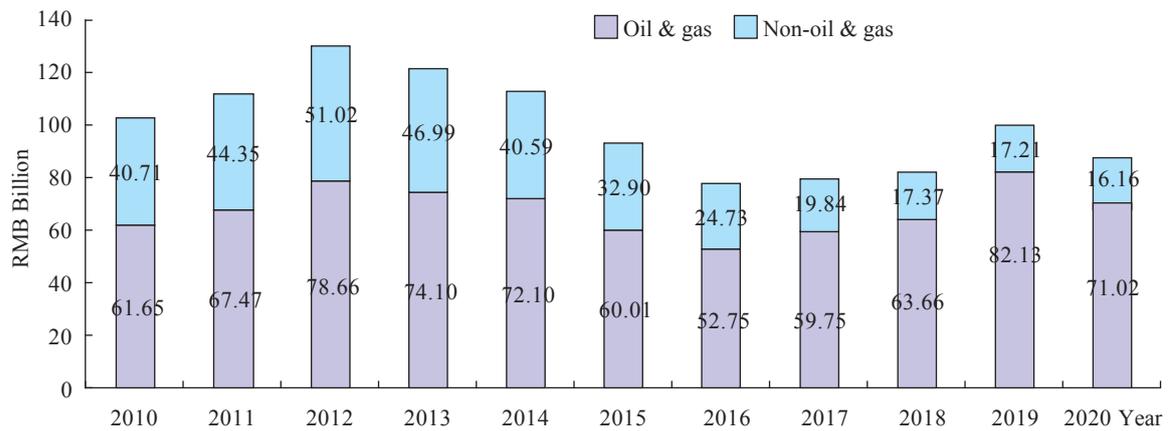


Fig. 3-1 Investment in Geological Exploration in China from 2010 to 2020

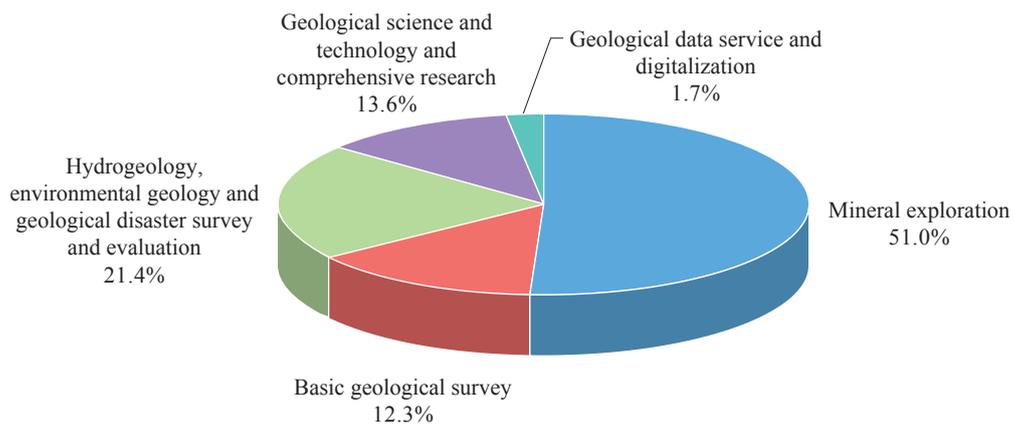


Fig. 3-2 Investment Structure of Non-oil and Gas Geological Exploration (by Category)

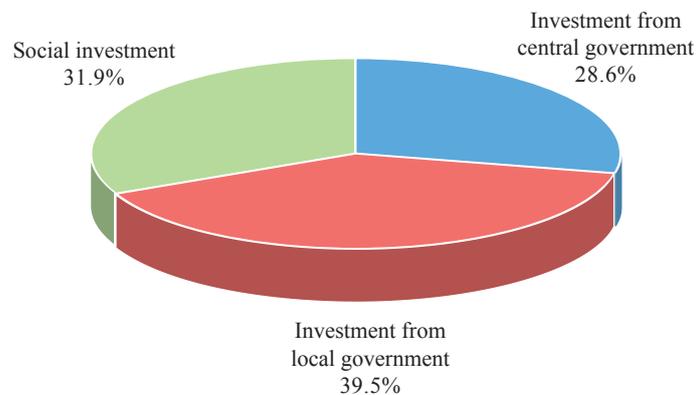


Fig. 3-3 Investment Structure of Non-oil and Gas Geological Exploration (by Fund)

Table 3-1 Major Mineral Exploration Investments and meters Drilled in 2020

Mineral	Investment RMB million	Year-on-year growth/%	Meters drilled million meters	Year-on-year growth/%
Coal	1223	22.3	0.98	27.3
Iron	248	10.7	0.20	17.6
Manganese	154	43.9	0.08	60.0
Copper	613	-2.7	0.34	-30.6
Zinc	641	-40.3	0.46	-46.5
Bauxite	288	89.5	0.32	113.3
Nickel	43	-35.8	0.02	-33.3
Tungsten	159	-21.3	0.12	-36.8
Tin	77	120.0	0.04	33.3
Molybdenum	59	-15.7	0.04	-33.3
Gold	1045	-10.8	0.70	-9.1
Silver	137	-52.3	0.09	-65.4
Phosphate rock	123	105.0	0.09	80.0
Graphite	158	-24.0	0.11	-38.9
Potash	84	-6.7	0.02	0.0

II. Progress in Oil and Gas Exploration

New discoveries were made in new areas and new strata in conventional oil and gas exploration, and major breakthroughs were made in exploration of shale gas and other unconventional oil and gas exploration.

1. Conventional oil and gas exploration

Major breakthroughs were made in ultra-deep oil exploration in the Tarim Basin. In well LE-1[#] (drilling depth to 8,882 meters), high-yield oil and gas flows were found at the depth of 8,200 meters with output of 134 tons of oil and 45,900 cubic meters of natural gas per day. In well MD-1[#], high-yield oil and gas flows were found at the depth of 7,600 meters with output of 624 tons of oil and 370,000 cubic meters per day. Geological reserves of over 100 million tons were identified in the Fuman block. Major breakthroughs were made in ultra-deep wells such as Shunbei 57X and Shunbei 71X.

Well KE-1[#], a venture exploration well in Fukang Sag of Junggar Basin, has made a major breakthrough, and it is expected to form an oil area with a scale of more than 500 million tons in the eastern part of the basin; well HE-1[#], a deep and large structural wild cat well in the middle section of the southern margin of the basin, has obtained high-yield oil and gas flow in Qingshuihe Formation.

Breakthroughs were made in natural gas exploration for the Sinian-Cambrian systems at well PE-1[#] and well JE-1[#] on the north slope of the Middle Sichuan Uplift in the Sichuan Basin. Wild cat well Pingqiao - 1[#], a new Cambrian stratum in eastern Sichuan progressed smoothly.

2. Unconventional oil and gas exploration

Exploration of continental unconventional oil and gas succeeded in continental facies. The output of wells GSOH-1[#] and YS-1HF in the north of the Songliao Basin reached 38.1 cubic

meters of oil and 13,000 cubic meters of natural gas per day, and 36.1 cubic meters of oil and 4,400 cubic meters of natural gas per day respectively in the Qingyi Member.

Important advances were made in exploration in new realms and new plays of oil and gas in the Sichuan Basin. In the Fuxing area of the southeast Sichuan Basin, industrial oil and gas flows were obtained at well FS-10HF with output of 17.6 cubic meters of oil and 55,800 cubic meters of natural gas per day at the Jurassic Dongyuemiao Formation, which was a major breakthrough in the exploration of Jurassic continental shale oil and gas in new fields. In the Wulong area of the southeastern Sichuan Basin, well LS-3HF produced 72,000 cubic meters of natural gas per day on a trial basis at the Wufeng Formation-Longmaxi Formation, which was a breakthrough in exploration of normal-pressure shale gas in new zones. In the Daozhen syncline of the southeast Sichuan Basin, well ZS-1HF produced 74,900 cubic meters of natural gas per day in the normal-pressure strata of the Wufeng Formation-Longmaxi Formation, which was a breakthrough in shale gas exploration in new zones of complex structural areas at the basin margin.

III. Progress in Non-oil and Gas Exploration

A total of 96 new ore-fields were discovered, including 29 large-scale, 36 medium-scale and 31 small-scale deposits. Gold (7 places), geothermal energy (7 places), copper (6 places), ceramic clay (5 places) and limestone for cement (5 places) ranked the top five minerals in terms of newly discovered ore-fields.

The increase in (inferred) resources included 11.96 billion tons of coal, 99 million tons of iron ore, 31.72 million tons of manganese ore, 0.86 million tons of copper, 1.39 million tons of lead-zinc, 374 million tons of bauxite, 1.43 million tons of tungsten, 442.46 tons of gold, 532.13 tons of silver, 96.68 million tons of phosphate rocks and 7.83 million tons of graphite.

Feature 3-1 Achievements of Prospecting Breakthrough Strategic Actions in Ten Years

Since the implementation of the 10-year strategic action plan for prospecting breakthrough (2011-2020), a number of strategic substitute areas of mineral resources had been identified by applying new mechanisms for geological prospecting operations and deepening the reform of mineral resources administration.

A new landscape of oil and gas exploration and development took shape. The newly increased proved petroleum initially in place of oil and natural gas in the past ten years were 10.1 billion tons and 6.85 trillion cubic meters respectively, accounting for about 25% and 45% of the total proven reserves respectively since the founding of New China. Remarkable progress was achieved in shale gas exploration and development represented by the annual output of the South Sichuan Gas Field reaching 11.7 billion cubic meters and that of the Fuling Gas Field reaching 6.7 billion cubic meters as well as the discovery of the Qinshui coalbed methane field with reserves of over 100 billion cubic meters.

Major new breakthroughs were made in prospecting for solid minerals. 32 mineral resource bases were newly developed, and several sandstone-type uranium deposits were identified. China's first 10 million-ton copper mine was found in Duolong, Tibet; Zhuxi and Dahutang tungsten deposits in Jiangxi became the top two tungsten deposits in the world; the Jiaodong gold mine became the third largest gold enrichment area in the world.

The reserves increased significantly of iron, manganese, copper, bauxite, potash, chromite and other bulk minerals in shortage, and remarkable achievements were made in the exploration of strategic emerging mineral resources such as crystalline graphite, nickel, lithium and fluor spar, safeguarding the supply for emerging material resources.

Chapter IV

Development and Utilization

The year of 2020 witnessed decrease in fixed-asset investment in China's mining industry and slowing growth of production of major mineral products, in which oil and gas extraction decreased almost 30%, the production growth rate of major minerals has slowed down, such as coal, natural gas, iron ore and copper etc.

I. Fixed-asset Investment in Mining Industry

In 2020, the fixed-asset investment in the mining industry decreased by 14.1%, and the growth rate of investment slowed down by 38.2 percentage points compared with the previous year and was 17.0 percentage points lower than the national growth rate of fixed-asset investment. Specially, only the non-metallic mining and dressing segment recorded a positive increase of 6.2% in fixed-asset investment in the year; that in the coal mining and washing segment decreased by 0.7% on a year-on-year basis; that in the oil and natural gas extraction segment dropped sharply by 29.6%; the decline in fixed-asset investment in the ferrous and non-ferrous metal mining and dressing segments was eased to 10.3% and 4.0% respectively (Fig. 4-1).

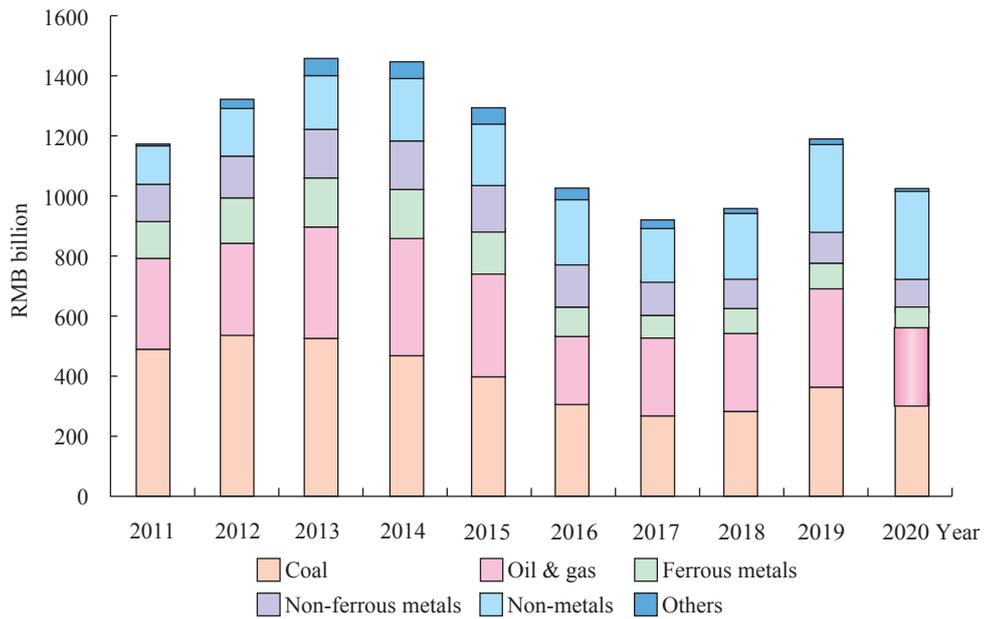


Fig. 4-1 Changes in Mining Fixed-asset Investments

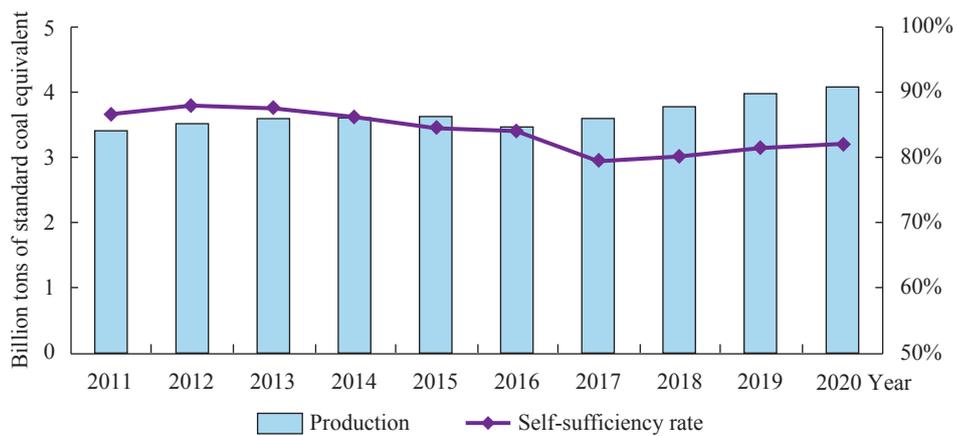


Fig. 4-2 Production of Primary Energy

II. Production and Consumption of Mineral Products

1. Energy

In 2020, China produced primary energy of 4.08 billion tons of coal equivalent, an increase of 2.8% over the previous year (Fig. 4-2), while consumed 4.98 billion tons of coal equivalent, an increase of 2.2%. Its energy self-sufficiency rate was 81.9%. In the energy consumption mix, coal accounted for 56.8%, oil accounted for 18.9%, natural gas accounted for 8.4%, and non-fossil energy such as hydropower, nuclear power and wind power accounted for 15.9% in 2020.

China's energy consumption mix has kept improving. In the past decade, the proportion of coal in primary energy consumption decreased by 13.4 percentage points, while the proportion of non-fossil energy such as hydropower, nuclear power and wind power increased by 7.5 percentage points (Fig. 4-3).

China produced 3.9 billion tons of coal in 2020, increased by 1.4% over the previous year, and consumed 4.3 billion tons, increased by 0.6%. It produced 195 million tons of oil in the year, increased by 1.6% (Fig. 4-4), and consumed 670 million tons, increased by 2.0%. It produced 192.5 billion cubic meters of natural gas in the year, increased by 9.8%, and consumed 330.6 billion cubic meters, increased by 6.9%.

2. Metals

In 2020, China's production of iron ore was 870 million tons, increased by 3.7% over the previous year (Fig. 4-5), and the apparent consumption (domestic production + imports) was 1.42 billion tons (standard ore). Crude steel production was 1.07 billion tons, increased by 7.0%. Ten principal non-ferrous metals were 61.68 million tons, increased by 5.5%. Copper in concentrate was 1.67 million tons, an increase of 3.9%; lead in concentrates 1.33 million tons, an increase of 6.2%; zinc in concentrates 2.77 million tons, a decrease of 1.8%.

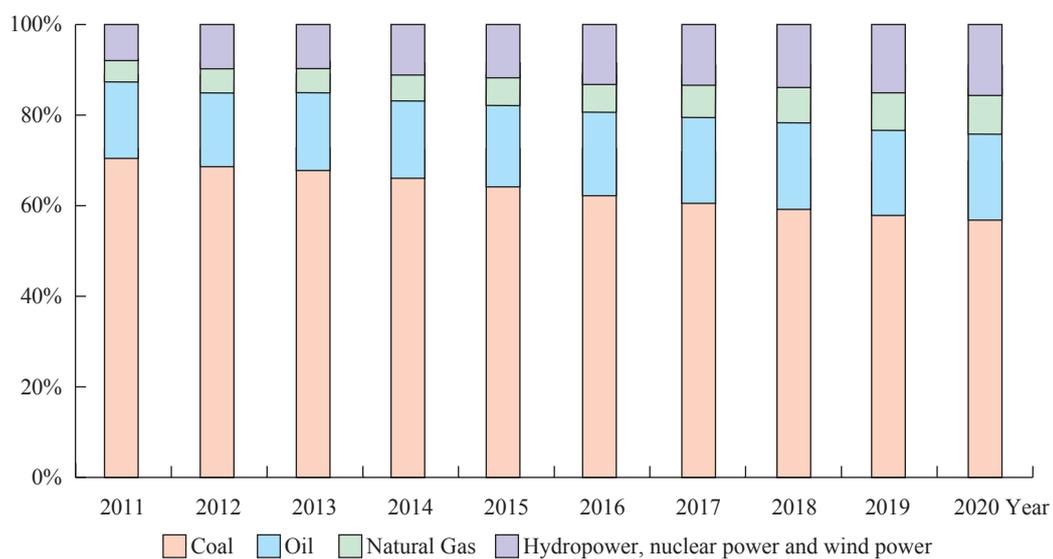


Fig. 4-3 Primary Energy Consumption Structure

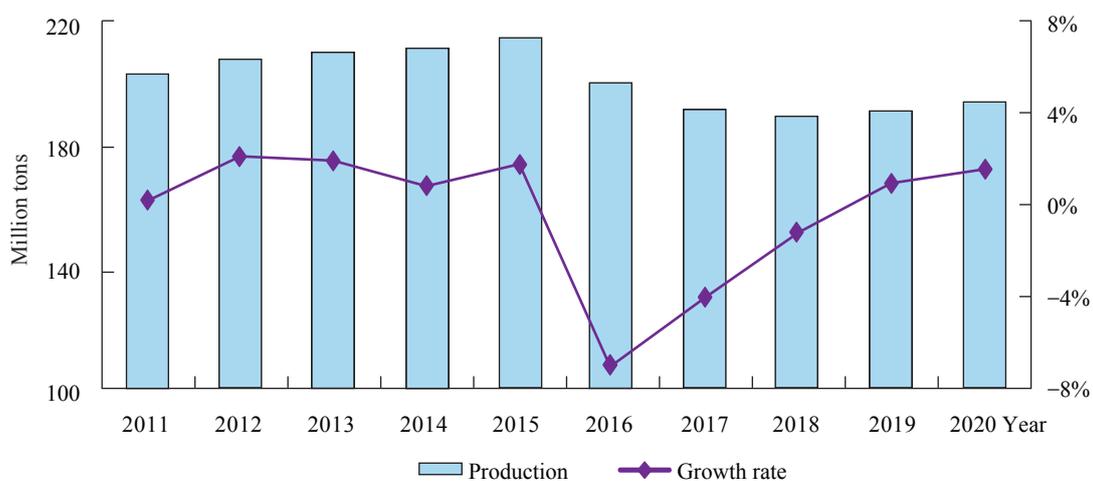


Fig. 4-4 Crude Oil Production

3. Nonmetals

In 2020, China produced 88.93 million tons of phosphate rocks (30% of P_2O_5), increased by 1.3% over the previous year, and 2.40 billion tons of cement, increased by 2.5% (Fig. 4-6).

III. Conservation and Comprehensive Utilization of Mineral Resources

1. Conservation and comprehensive utilization advanced steadily

The percentage of large and medium-sized mines in China exceeded 20%, and the concentration of the mining industry increased steadily. The productivity of labor force in mineral resources development (other than oil and gas) increased dramatically from 1,310 tons/person-year to 2,120 tons/person-year, which was a remarkable progress. Despite the rising difficulty in raw ore mining and dressing and generally degrading of mined ore, most of the main mining and dressing indicators remain stable or increase slightly. For example, the average extract recovery rate of iron ore by underground mining was 86.7%, and the average recovery rate in dressing reached 76.5%.

2. 9th batch of minerals released with requirements for “three rates” for reasonable development and utilization

In April 2021, the *Ministry of Natural Resources’ Announcement of the Minimum Requirements of “Three Rates” for Reasonable Development and Utilization of Mineral Resources Like Tripoli (for trial implementation)* was released, giving the requirements for the extract recovery rate, recovery rate in dressing, and comprehensive utilization rate (known as the “three rates”) of 36 mineral sources, including tripoli, geothermal energy and carbon dioxide gas. By that time, the “three rates” had been formulated and released for a total of 124 kinds of mineral resources over the nine years, covering all the minerals involved in the mines in production.

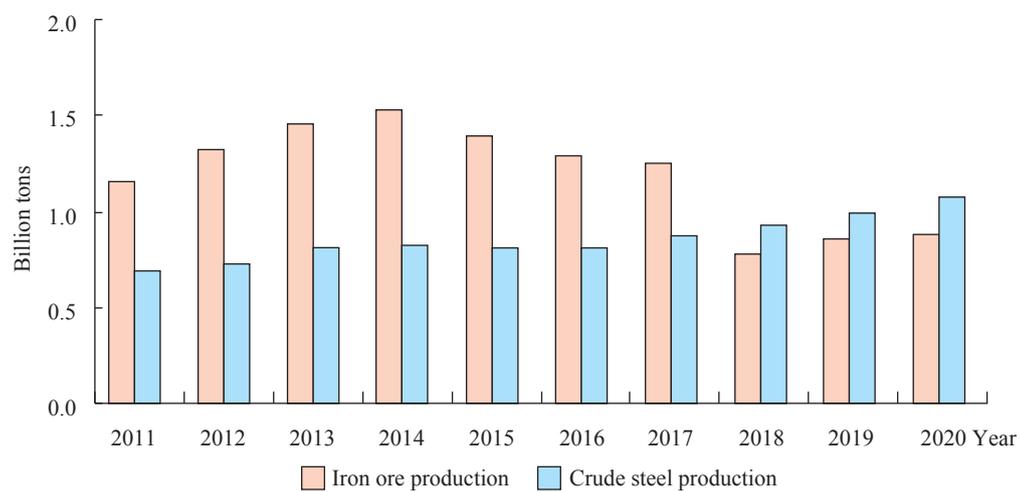


Fig. 4-5 Iron Ore and Crude Steel Production

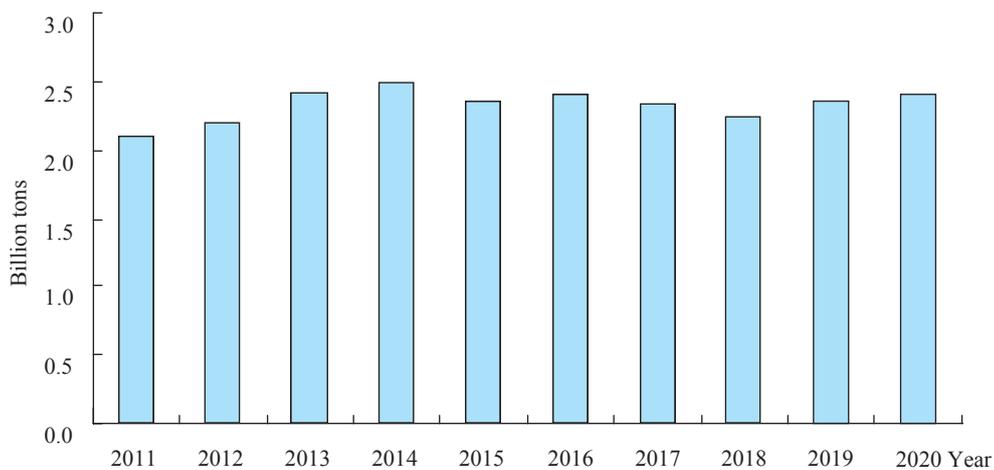


Fig. 4-6 Cement Production

Chapter V

Restoration of Mine Geological Environment and Green Development

Mine ecological rehabilitation was actively carried out, various management systems were reformed and improved. Continuous efforts were made to rehabilitate the ecology of abandoned open-pit mines in key river basins and areas. The *Specification for Minimizing Environmental Impacts of Field Operations in Geological Survey and Mineral Exploration* was formulated and projects for demonstration of green exploration were further carried out. Green mines of the year were selected for motivating the construction of demonstration areas for green mine development.

I. Ecological Rehabilitation in Mines

1. Central government continued financial support to mine ecological rehabilitation

Since 2020, the central government has allocated a total of RMB 2 billion in two batches to support 12 provinces/autonomous regions to carry out the ecological rehabilitation and

treatment of mines left over from history in the Yellow River Drainage and Qinghai-Tibet Plateau, and focused on solving the problems of mines left over from history, in which play an important role in ensuring national ecological security, have a wide range of ecological benefits and seriously affect people's work and life.

2. Progress of ecological rehabilitation and treatment in mines

Based on remote sensing monitoring, statistical data shows that approximately 41.6 thousand hectares of mine sites were newly rehabilitated around the country in 2020, of which 11.1 thousand hectares was part of the mines under construction or in operation, accounting for 26.7% of the total, and the land of 30.5 thousand hectares is part of abandoned mines, accounting for 73.3% of the total.

II. Green Exploration

1. Industry standards and specifications formulated

The *Specification for Minimizing Environmental Impacts of Field Operations in Geological Survey and Mineral Exploration* was released to fill a blank in green exploration standards in China. The draft *Specification for Quality Management of Geological Exploration Activities (Draft Amendment)* has been publicly released for comments.

The industry exploration specifications for 15 kinds of minerals, such as iron ore, manganese ore, chromite and pyrite, provide for green exploration, and the *Specification for Compilation of Geological Reports on Mineral Exploration* has added sections on green exploration. Natural resources authorities in Guizhou, Qinghai, Shandong, Inner Mongolia, Ningxia and other provinces and autonomous regions have developed local (provincial) standards in light of local characteristics.

2. Demonstration of green exploration projects continued

The second batch (77) of green exploration demonstration projects was selected. A new green exploration management mechanism of “prevention at the source, process control, post-treatment and whole-process supervision” has been established on a preliminary basis.

III. Construction of Green Mines

1. Selection and evaluation of green mines

In January 2021, the *Announcement on Including Caijiaying Zinc Mine of Hebei Hua’ao Mining Development Co., Ltd., etc. into the National List of Green Mines (No.2 of 2021)* was released with 301 mines added to the national list of green mines.

At present, there are 1249 green mines in the national list of green mines, including 775 large mines, accounting for 62.0%; 358 medium-sized mines, 28.7%; and 116 small mines, 9.3%.

2. Promotion of construction of green mining development demonstration zones

In December 2020, the *Announcement on Publishing the List of Green Mining Development Demonstration Zones (No.81 of 2020)* was released with a list of 50 green mining development demonstration zones such as Chengde of Hebei Province. Efforts were made to build green mining development model zones with reasonable layout, intensive and efficient land-use, superior environment, harmony between mines and local communities, and sound development of regional economy.

Chapter VI

Policies and Regulations on Mineral Resources

The revision of the *Mineral Resources Law (Draft Amendment)* was continued to further strengthen legislation and supervision in the field of mineral resources, enhance and improve law enforcement related to mineral resources, and keep offering preferential policies on resource tax.

I. Laws and Regulations

Since 2020, the MNR has cooperated with the Ministry of Justice to carry out the legislation such as soliciting comments on the *Mineral Resources Law (Draft Amendment)* (Draft for Review), and listened to the opinions and suggestions of relevant departments and units, local governments, research institutions and relevant mining enterprises on the revision of the *Mineral Resources Law*, and further revised and improved the *Mineral Resources Law (Draft Amendment)*.

On April 29th, 2020, the 17th session of the Standing Committee of the 13th National People's Congress reviewed and approved the draft amendment to the *Law of the People's Republic of*

China on Prevention and Control of Solid Waste Pollution. It stipulates that mining enterprises should adopt scientific mining methods and beneficiation technologies, reduce the output and storage of mining solid wastes such as tailings, coal gangue and waste rock, and encourage the adoption of advanced technologies for their comprehensive utilization, effective from September 1, 2020.

On May 1, 2020, the *Opinions of the Ministry of Natural Resources on Promoting the Reform of Mineral Resources Management (Trial)* was formally implemented.

On July 15, 2021, the *Notice of the General Office of the Ministry of Natural Resources on Strengthening and Improving Mineral Law Enforcement* was issued, requiring mineral law enforcement departments at all levels, in strict accordance with laws and regulations related to mineral resources, to strictly investigate and punish illegal activities such as unlicensed exploration and mining, cross-border exploration and mining, and destructive mining, seriously investigate and punish prominent problems of illegal mining, further the analysis and judgment of situation, strengthen the detection and prevention, deepen the mineral law enforcement, and focus on correcting the problem of lax mineral law enforcement.

II. Taxes on Mineral Resources

In 2020, the national resources tax revenues totaled RMB 175.5 billion, showing a decrease of 3.7% year on year, and accounting for 1.1% of the national tax revenues. The revenues from transfer of mining rights totaled RMB 112.32 billion, increased by 19.3%, and the charges for use (appropriation) of prospecting rights and mining rights totaled RMB 2.85 billion, decreased by 20.9%.

Since September 1, 2020, the *Resource Tax Law of the People's Republic of China* (No. 33 Order of the President) has come into effect, and the provinces have issued the specific applicable tax rates in their own regions. According to the national weighted average, the resource tax rate was basically the same before and after the implementation, among which the middle and heavy rare earth and molybdenum mines decreased by 7 and 3 percentage points respectively.

According to the *Announcement of the Ministry of Finance and the State Taxation Administration on Continued Implementation of Preferential Policies for Resource Tax*, the sand, gravel and other materials collected and used by the Qinghai-Tibet Railway Company and its affiliated units during the operation period continued to be exempted from resource tax; and

- from April 1, 2018 to March 31, 2021, the shale gas resource tax was reduced by 30%;
- from January 1, 2019 to December 31, 2021, for small-scale VAT taxpayers, resource tax could be reduced within 50% of the tax amount;
- from December 1, 2014 to August 31, 2023, the resource tax was reduced by 50% for the coal replaced by filling mining.

The new resource tax law no longer uniformly stipulates the preferential treatment for associated, low-grade and tailings utilization, but the provinces (autonomous regions and municipalities) make their own provisions according to the actual situation.

Chapter VII

Mineral Resources Management

In 2020, the reform of mineral resources and reserves management was completed successfully with new rules and standards released. Formulation of the *National Mineral Resources Plan (2021-2025)* progressed smoothly, while local mineral resources plans at various levels were also being formulated. The supervision and management of geological exploration activities were strengthened, and the safety production management of geological exploration industry was enhanced. The reform of the mining right transfer system was accelerated and the registration information of mining right transfer was made accessible to the public.

I. Mineral Resources Planning

1. Preparation of mineral resources planning advanced smoothly

The MNR formulated the *National Mineral Resources Plan (2021-2025)* (draft for comment) in collaboration with the National Development and Reform Commission, Ministry of Industry and Information Technology, Ministry of Finance, Ministry of Ecology and Environment and Ministry of Commerce. Comments were extensively solicited from relevant ministries,

commissions, industry associations and local natural resources authorities, and the expert examination and third-party evaluation have been completed. The draft plan has been submitted for approval.

2. Compilation of local planning at all levels promoted comprehensively

According to the requirements of the *Notice on the Preparation of Mineral Resources Plan (2021-2025)* issued by the MNR, and in accordance with the principle of top-down, upper and lower linkage, and close progressing, the preparations of provincial, municipal and county planning is right underway. At present, the provincial draft planning for mineral resources of 31 provinces, autonomous regions and municipalities directly under the central government and Xinjiang Production and Construction Corps have all been harmonized with the *National Mineral Resources Plan (2021-2025)*, and entered the preparation stage for approval. According to incomplete statistics, 350 cities and more than 1,600 counties have carried out the preparation of planning for mineral resources at their own levels, basically achieving the full coverage of mining activities in the whole country.

II. Geological Exploration Management

1. Basic situation of geological exploration sector

In 2020, there were 2,484 geological exploration entities in China, with about 450 thousand employees and total revenues of about RMB 356.7 billion.

During the 13th Five-Year Plan, at non-oil and gas exploration entities, the per capita wage rose steadily, the revenues of the entities grew gradually, and their total assets increased slowly. Meanwhile, the scale of the geological exploration workforce was gradually reduced, the income from mining right transfer was decreasing year by year, and the net value of geological exploration equipment dropped.

2. Guiding and promoting high-quality development of geological exploration sector

On May 10, 2021, the *Guidelines of the Ministry of Natural Resources on Promoting the High-quality Development of the Geological Exploration Sector* was released to guide local governments to actively yet prudently carry out the reform for separation of enterprises from public institutions, explore reform incentive policies, expand into new fields, strengthen the supervision and management system, maintain order in the sector, and jointly promote the high-quality development of geological exploration.

3. Supervision management of geological exploration strengthened

On June 8, 2021, the *Notice of the General Office of the Ministry of Natural Resources on Printing and Distributing the Measures for Supervision and Management of Geological Exploration Activities (Trial)* was issued, clarifying that the supervision and management of geological exploration activities should adhere to the principles of statutory duties, credit constraints, collaborative supervision and social co-governance, and by strengthening supervision and control, strive to construct a social co-governance pattern of geological exploration unit autonomy, industry self-discipline, social supervision and government control.

4. Safety production management of geological exploration sector enhanced

On March 22, 2021, the *Guidelines of the Ministry of Natural Resources on Strengthening the Safety Production and Management of Geological Exploration and Surveying and Mapping Sector* was issued. By further consolidating the concept of safety production, implementing the main responsibility of safety production, and strengthening the safety risk management of key links, the safety and development of geological exploration industry were coordinated, the integration and complementarity of safety production and business management were realized, and the foundation of safety production was constantly consolidated.

III. Mineral Resources Reserves Management

1. Completion of reform of mineral resources and reserves management

In 2020, in order to fully implement the requirements for reform under the *Opinions of the Ministry of Natural Resources on Promoting the Reform of Mineral Resources Management (Trial)*, the ministry released a number of corresponding measures of reform for mineral resources and reserves management, successfully completed the tasks of reform, and established a new system of rules and standards for reserves management.

2. A system of standards based on the new classification of mineral resources and reserves

59 national and industry standards, including *Classifications for Mineral Resources and Reserves* and *Classifications for Petroleum Resources and Reserves*, were released to create a system of standards based on the new methodology for classification of mineral resources and reserves, which is of great significance for scientifically identifying the mineral resources, rationally utilizing the resources and safeguarding the rights and interests of the state and businesses.

3. Improved management system for reviewing and filing mineral resources and reserves

The management system for reviewing and filing mineral resources and reserves has been improved by clearly providing that review and filing are administrative acts as an important basis for the state to regulate mineral resources and reserves. The *Circular of the General Office of the Ministry of Natural Resources on Matters Concerning the Management of Mineral Resources and Reserves Review and Filing* and other documents clearly define the scope and authority of review and filing, streamline the procedures, reduce the application requirements, shorten the time frame for review and filing, open the online system for review and filing, and actively promote “Internet + government services”.

4. Completion of data conversion between the new and old classification standards

The database cleaning, registration supplementing and digitalization of assessment filing since the establishment of the former Ministry of Land and Resources were organized and carried out, data conversion between the new and old classification standards across the country was fully arranged, and the provinces and mining enterprises were guided to carry out conversion and verification. In combination with compilation of the statistics of mineral resources and reserves and annual report of mine reserves in 2020, the conversion of data under the new classification standards was completed for 2020.

5. Efforts for smooth implementation of various reforms and systems

Various efforts were made to publicize the reform achievements by holding national training sessions via video conferencing, publishing interviews and interpretations on *China Natural Resources News*, issued 300 *Questions on Interpretation of Technical Standards of Mineral Resources and Reserves*, organizing national exchange activities on review work, conducting surveys and discussions in different regions across the country, with more than 40,000 participants, and guiding Hubei, Henan, Gansu and other provinces to deliver training to promote the implementation of reforms.

IV. Mining Rights Management

1. Comprehensively promoting the competitive transfer of mining rights while strictly controlling transfer under agreement

Since the implementation of the *Opinions of the Ministry of Natural Resources on Promoting the Reform of Mineral Resources Management (Trial)*, local authorities have conscientiously implemented and coordinated efforts to promote the reform of the mining right transfer system throughout the country, implemented the requirements for competitive transfer of mining rights, strictly controlled transfer made under agreement, and completely stopped transfer of prospecting rights to first applicants. Compared with 2019, among the newly

offered prospecting rights in 2020, the proportion of rights transferred through competition such as bidding, auction and listing increased from 43% to 73%, and that of rights transferred under agreement decreased by 26% with most for deep exploration projects at existing mines. In 2020, over 80% of the newly offered mining rights were transferred through competition such as bidding, auction and listing, and the mining rights transferred under agreement only accounted for 2%. From the implementation of Document No.7 on May 1, to the end of June 2021, a total of 263 prospecting rights and 1598 mining rights have been transferred in a competitive manner across the country. It has become a consensus to acquire mining rights through fair competition.

2. Combined oil and gas exploration and production

When an oil and gas prospecting right holder discovers oil and gas resources that can be exploited, the firm may exploit the resources once it has reported the discovery with a competent authority for registration of natural resources. Under the system combining oil and gas exploration and production, it is possible to go through the procedures for exploration and production and directly start extraction without suspending the field work when oil and gas resources are discovered. This system is adapted to the technical necessities in exploration and production of oil and gas resources, facilitates harmonized planning by mining rights holders, allows rational arrangements of production and construction activities, ensures smooth transition from exploration to production, reduces costs, accelerates construction and production, and facilitates oil and gas exploration and production.

3. Promotion of “net mining right” transfer

In order to implement the decision-making arrangements of the CPC Central Committee and the State Council on the reform of mining right transfer system and deepen the reform to “streamline administration and delegate power, improve regulation, and upgrade services”, the MNR actively promoted the transfer of “net mining rights” by completing procedures for space avoidance of all kinds of prohibited and restricted exploration and mining areas as well as related matters in accessing land, forest, grass and sea in the early stage of mining right transfer. The joint examination and approval mechanism of “net mining right” transfer, the reform policy of mining land and the establishment of mining land system suitable for the exploration and exploitation of mineral resources in the *Mineral Resources Law*

were studied, and documents for promoting the transfer of “net mining rights” were being drafted.

4. Information on mining rights transfer publicized further

A good job was continued in publicizing the registration of mining rights transfer nationwide. In 2020, the portal website of the MNR publicized a total of 35,592 items of public information including mining right transfer registration, among them, there were 31,320 publicities of mining right approval results, 1,649 notices concerning transfer by tender, auction and listing, 1,400 publicities of results of transfer by tender, auction and listing, 198 publicities of agreement-based transfer, 602 publicities of transfer, and 423 publicities of newly-established mining right handling.

5. Establishment of a mining right transfer project database

To promote the reform of the mining right transfer system, and prepare for work related to mining right transfer, a “mining right transfer database” for oil and gas and non-oil and gas projects has been established and improved gradually. In February 2021, the MNR released an online announcement soliciting proposals on blocks for mining right transfer. It clearly provides that natural resources authorities at all levels, relevant institutions, enterprises, research institutes and the public may submit proposals on blocks of oil and gas and non-oil and gas for mining rights transfer via the section “Proposal on Blocks for Mining Rights Transfer” of the service portal of the MNR at <http://zwfw.mnr.gov.cn> from February 1, 2021.

6. The management of sand, gravel and clay mines improved

In order to promote the healthy and orderly development of the sand and gravel industry, a large number of mining rights of large-scale sand and gravel mines have been put into the market successively, further optimized the layout of sand and gravel development, accelerated the formation of high-quality sand and gravel production capacity, promoted the mining and utilization of sea sand in an orderly manner, supported the comprehensive utilization of waste rock tailings, and promoted the overall utilization of sand and gravel in engineering construction.

7. The management of mercury mines under the Mercury Convention pushed forward

We organized the 2020 national survey of mercury mining rights, established mercury mining right management ledger, participated in the research and drafting of relevant materials of the *National Coordination Group for the Implementation of Stockholm Convention and the National Coordination Group for the Implementation of Mercury Convention in 2019 and the Key Work Plan for the Implementation in 2020*, participated in the “Third Coordinator Meeting of the National Coordination Group for the Implementation of the Mercury Convention”, and deploy and advance the work related to the management of mining rights under the Mercury Convention.

V. Ancient Fossils Protection Management

The examination and verification of paleontological fossil excavation were strictly regulated, and 4 fossil excavations were approved. The provincial paleontological fossil expert committee was demonstrated, led, drove and established, and the review on protection and planning of the origin of paleontological fossils was carried out. According to the actual situation of epidemic prevention and control, experts were organized to review and approve the application for paleontological fossil excavation by means of remote video, on-site verification of approved projects was timely organized, on-site guidance was conducted and problems arising in the excavation process were urged to rectify, and relevant provincial departments and offices were well coordinated in excavation-related management.

The arrangements and requirements of the State Council were implemented, and the exit approval documents of paleontological fossils were included into the “single window” of the customs departments. The identification and recovery of suspected Chinese paleontological fossils intercepted by the United States and Chile were organized, and the identification of suspected Chinese paleontological fossils was carried out abroad once, and one sample was identified. We assisted in carrying out the National Inter-Ministerial Joint Conference on Comprehensive Control of Anti-smuggling and the Inter-ministerial Joint Conference on Cultural Relics Safety, and participated in the identification of involved fossils seized by public security, customs departments other departments for 10 times, with 533 samples identified.

Chapter VIII

Geological Data Management and Services

In 2020, natural resources authorities at all levels, geological data collection institutions and geological data entrusted storage entities nationwide worked together to fight the pandemic, strengthen the collection and delivery management of geological data, solidly promote the supplementary delivery of oil and gas geological data, fully enable the geological data information management service system and promote open utilization and sharing of services. The ability of geological data management and service has been continuously enhanced.

I. Geological Data Management System

The Notice of the General Office of the Ministry of Natural Resources on the Full Launch of the Geological Data Management Service System, the Notice of the General Office of the Ministry of Natural Resources on Further Improving the Management of Geological Data Collection and Delivery, and the Notice of the General Office of the Ministry of Natural Resources on Improving the Digitization and Information Sharing of Rock Cores and other documents were released to strengthen the supervision during and after the exchange of geological data,

promote the “Internet + geological data” government service, establish the credit system of geological data exchange, and further standardize and improve the management system of geological data.

II. Geological Data Collection

1. Achievements and original geological data

By the end of 2020, geological data collection institutions at the ministerial and provincial levels had a total collection of 653,400 files of geological data achievements and 49,100 files of original geological data. The entrusted units received a total of 882,700 files of original geological data, and kept a cumulative total of 1,151,300 files of original geological data.

2. Physical geological data

By the end of 2020, geological data collection institutions at the ministry and provincial levels kept a total of 2,447,900 meters of cores, 219,700 bags of cuttings, 101,100 specimens, 249,900 pieces of polished section and thin section, and 6,071,800 bags/bottles of samples.

The entrusted units received physical geological data including totally 729,600 meters of cores and 10,042,400 bags of cuttings, and accumulative entrusted custody of 893,800 meters of cores and 20,246,500 bags of cuttings.

III. Geological Data Services

1. Collection service

Geological data collection institutions at the national ministry and provincial levels received 14,600 visits from users, provided data utilization services 6,715,600 times, provided 44.7 TB of data duplication, and provided 521,400 geological data catalogues online. The volume of geological data online services of all levels of collection institutions increased significantly, and

the number of geological data website service visits reached 10,370,600, an increase of 90% over 2019. It actively promoted “online reservation and online acceptance” for data collection and delivery, “online order and online application” for data services, and provided business consultation and borrowing services through various means such as the Internet, telephone and mail, and fully guaranteed geological data services during the pandemic.

The disclosure of information on geological data management and services has been promoted in an orderly manner. 1,730 delivery voucher information of geological data of prospecting rights were provided to the national e-government information sharing and exchange platform in 2020. Information on the collection and delivery of geological data for 72,000 mining rights and geological work projects from 2012 to 2020 was publicized, 98,000 pieces of various management information, such as delivery vouchers, no-data commitments, delivery within a time limit and exception lists were made public.

The construction of the National Geological Information Data Centre has been steadily progressing. The geological data information management service system has been applied nationwide, realizing the interconnection and business collaboration among the physical center, 31 provincial libraries, the headquarters of four oil and gas companies and 35 entrusted storage units.

2. Geological cloud online service

“Geology Cloud 3.0” was officially launched to build a “big map” of geoscience data covering 11 categories, 98 core databases and 2,717 layers. It has added 7,000 authoritative information products on resources and environment, more than 2.7 million national geochemical survey data, more than 50,000 geological borehole data, 45,000 meters of physical core image data, 83,000 geological profiles, 200,000 pieces of public geological data, 228,000 ore-fields data, 110,000 geological books since the founding of the country, and other authoritative geological information products.

By the end of 2020, the number of registered users reached 65,000, with 3.66 million visits, 862,000 views and 503,000 downloads of data products in 2020.

Chapter IX

Scientific and Technological Innovations in Mineral Resources

In 2020, remarkable achievements have been made in the research of mineral resources with breakthroughs from many research projects. A number of important national and industrial standards were released, and many key laboratories and engineering and technological innovation centers were recognized.

I. Technological Milestones in Field of Mineral Resources

1. Major improvements

China successfully completed the second round of trial extraction of natural gas hydrate at sea. It mastered the core technology of horizontal well drilling and extraction in shallow soft strata in deep sea, and took a major leap from exploratory trial production to experimental trial production. This made China the first country in the world to produce natural gas hydrate at sea with horizontal well drilling and extraction technology.

Breakthroughs were made in high-efficiency fracturing with fracture and shock control in hot dry rock, and multi-target precise directional drilling in high-temperature hard rock.

Large-scale fracturing and reserve creation with hot dry rock succeeded in the Gonghe Basin, Qinghai Province.

Guided by the continental collision metallogenic theory, the first 3,000-meter scientific deep drilling of solid minerals was successfully completed in the Jiama mining area of the Qinghai-Tibet Plateau, where copper-molybdenum orebodies in thick porphyry were discovered. By innovating the deep exploration technology and methods, enriching and improving the deep gold mineralization theory, the total resources of the Jiaojia Gold Mine were increased to more than 2,500 tons through deep drilling verification.

2. Major achievements

Significant achievements were made in basic fields of geological research. Leveraging the national key research and development program of “Deep Structure and Metallogenic Process of Collision Orogenic and Metallogenic System in Qinghai-Tibet Plateau”, researchers meticulously depicted the crustal structure of the Gangdisi collision zone, suggested the growth mechanism and metallogenic coupling mechanism of extremely thick crust, uncovered the three-dimensional structure of the main collision metallogenic system, identified the metallogenic “source-transfer-storage” system, visualized the three important ore concentration areas on a preliminary basis, and achieved major breakthroughs in prospecting.

Important breakthroughs have been made in shale gas theory, methods, key technologies and equipment. Favorable litho-facies and enrichment mechanism were clarified for marine facies, marine-continental interactive facies, and continental shale gas formation, and accumulation model of “seven phases, four evolutions, seven reservoir-controlling” was proposed. A classification and systematization of shale gas resource evaluation method system and parameter system suitable for the country was established. Rapid analysis of organic geochemistry and three-dimensional quantitative characterization of micro-nano-scale pore structure and composition was formed for the highly evolved shale gas. The in-situ testing technology was conquered of formation pressure in a 3000-meter deep well. A vehicle-mounted fast multi-parameter comprehensive analysis system was developed for shale gas.

A number of key core technologies were conquered, such as vertical deviation compensation based on the gravity field model and accurate extraction of weak gravity signals. The aviation gravity/vector gravity survey system with completely independent intellectual property rights has been developed. Airborne gravity measurement accuracy reaches 0.58mGal, almost the same with the international advanced level, and its airborne gravity and vector gravity exploration systems reached the world's leading level. Methods and software for processing and interpretation of airborne gravity measurement data were developed. For the first time, airborne gravity measurement was carried out in the Mount Everest region, filling the gravity gap in Mount Everest and its surrounding areas, increasing the accuracy of the quasi-geoid model by 3.0cm, and providing technical support for the precise measurement of the elevation of Mount Everest. Full tensor aeromagnetic gradiometer systems were successfully developed for super-conducting under low and high temperature.

II. Technical Standards in the Field of Mineral Resources

61 industrial standards were released in connection with geology and mineral resources and 11 change orders for national standards and industrial standards were released in 2020.

Encompassing mineral resource exploration and dynamic reserve management of, according to the requirements for reform related to standards on classification of mineral resources and reserves, the ministry released 46 industrial standards, including the *Specification for Compilation of Geological Reports on Mineral Exploration*, *Specification for Mineral Exploration Iron, Manganese and Chromium* and *Regulation of Shale Gas Resources and Reserves Estimation*, and change orders for national standards *Specification for Exploration of Solid Mineral Resources* and *Specification for Comprehensive Exploration and Evaluation of Mineral Resources* and industrial standards including *Specification for Uranium Mineral Exploration* and *Specification for Vanadium Mineral Exploration*. In addition, two industrial standards, i.e. *Graphic Illustration of Mineral Resources Planning* and *Minerals Programming Database Standard Format*, were released.

6 industrial standards, including the *Gravity Survey Technical Specification for Marine Geological Survey*, *Magnetic Survey Technical Specification for Marine Geological Survey* and *Navigation and Positioning Specification for Marine Geological Survey*, were released to support the strategy of building China into a maritime power; the industrial standard of *Specification for Engineering Geological Survey (1 : 50000)* was released for engineering geological survey activities to appropriately determine the zoning evaluation units, indicators and methods; 7 industrial standards, such as *Technical Specification for Resistivity Sounding*, *Shallow Seismic Exploration Technology Specifications* and *Specification of Geochemical Detailed Survey*, were released for effectively promoting the application of geological and mineral exploration technologies and methods.

III. Technological Innovation Platforms in Field of Mineral Resources

In November 2020, the *Measures for Administration of Technological Innovation Platforms Recognized by the Ministry of Natural Resources (Trial)* were released. In March 2021, 52 field scientific observation and research stations were included in the base of technological innovation platforms recognized by the MNR. In August 2021, the ministry announced a list of 42 newly recognized key laboratories.

Key laboratories and engineering and technology innovation centers gathered high-end talents, undertook key innovation tasks, implemented reform of the scientific research system and mechanism, and made a wide range of scientific and technological achievements. Among them, the Engineering and Technology Innovation Center of Natural Gas Hydrate Exploration and Development organized research tasks on trial extraction of natural gas hydrate, which strongly supported the success of trial production of natural gas hydrate in the Shenhu sea area.

Chapter X

International Cooperation

In 2020, despite the significant impact of the COVID-19 pandemic on international cooperation in the field of mineral resources, the ministry actively maintained ties with relevant countries and international organizations through innovative ways of exchange and cooperation, and kept promoting cooperation in geological and mineral projects and further consolidate cooperative relations through international exchange platforms such as China Mining and ASEAN +3 Senior Mining Official Consultations.

I. Bilateral and Multilateral Cooperation Mechanisms

1. Bilateral cooperation

The ministry actively promoted pragmatic cooperation with Saudi Arabia, Pakistan, Nepal, Liberia, Rwanda, Russia, Poland, Germany, Turkey and other countries in the field of geology and mineral resources, and further strengthened cooperation in geoscience research, geological survey, mineral resources development and management, mineral exploration technology and methods, mining investment, etc. An agency under the ministry successfully won the contract for “High-Precision Geochemical Exploration of Sediments and Heavy Sand Samples of River

Systems in Saudi Arabian Shield”, which enriched the cooperation between China and Saudi Arabia under the “Belt and Road Initiative”. The assistance from China for geology survey in Nepal, Rwanda and Liberia delivered new progress and served the betterment of the people’s livelihood of these countries.

The ministry entered a number of cooperation arrangements with foreign geological survey institutions in fields such as basic geological survey, marine geology, mineral resources research and geological disasters. For example, it signed a memorandum of understanding on cooperation with Germany, a project cooperation agreement with Thailand, and letters of intent for cooperation with Russia and Italy.

2. Multilateral Cooperation

The ministry signed a memorandum of understanding with the International Union of Geological Sciences (IUGS), agreeing that the secretariat of IUGS will continue to be stationed in China from 2021 to 2028. IUGS appreciates China’s sense and spirit of responsibility in promoting the development of international geosciences.

The International Research Center on Karst under the auspices of UNESCO held an international seminar on “Karst Resources, Environment and Ecological Industry” online for the first time, which laid a solid foundation for multilateral cooperation in the karst field in China. The UNESCO International Centre on Global-Scale Geochemistry organized online international seminars to share China’s advanced geochemical mapping technology.

The ministry participated in the 13th ASEAN +3 Senior Mining Official Consultations, which studied the work plan for the second phase (2021-2025) under the “ASEAN Mining Cooperation Action Plan”. The ministry participated in the 56th Annual Meeting and the 74th and 75th Steering Committee Meetings of the Coordinating Committee for Geoscience Programs in East and Southeast Asia (CCOP), and participated in the preparation of CCOP 2021-2025 Strategic Plan and Work Plan, which further defined the cooperation needs in the next five years.

The ministry participated in the 52nd and 53rd Steering Committee Meetings of the Group on Earth Observations (GEO), organized the work of GEO in an all-round way as the rotating presidency in 2020, guided the GEO Secretariat to conduct annual audits, and reviewed relevant implementation plans of GEO.

II. International Mining Cooperation Platforms

By overcoming the impact of the COVID-19 pandemic, China Mining 2020 was held in “offline + online” forms as scheduled. On the theme of “Responsibility, Innovation and Governance”, the conference consisted four parts: opening ceremony, forums, cloud exhibition and cloud promotion. Leaders from the ministry and Tianjin, diplomatic envoys in China from Peru, Brazil, Guinea, Tanzania, Argentina, Chile, Madagascar and South Africa, and representatives from nearly 100 enterprises, financial institutions and trade associations at home and abroad attended the opening ceremony. Enterprises and exhibitors from 35 countries and territories attended the conference and exhibition.

Encompassing on the new trends and changes in the international mining industry and the new imperatives of the “Belt and Road Initiative” for international mining cooperation, the conference held one theme forum, six specialized forums, four national promotion sessions and twelve mining project promotion sessions. The cloud platform showcased and promoted a total of 82 overseas mining projects, which were widely distributed in countries along the “Belt and Road Initiative”, laying a solid foundation for pragmatic cooperation between Chinese and foreign mining enterprises.