7. Survey Results in "Resources and Energy

7.1. Survey Results in "Resources"

7.1.1. Trends in noteworthy domains

(1) Resources development (recovery of resources, advances in exploration technologies, labor saving, and automation)

i) Recent technical trends and topics

a. Exploration technologies

While surface geologic surveys and exploratory drilling are still the most fundamental exploration methods, technological development is in progress in areas such as remote sensing, geophysical exploration and geochemical exploration as a result of advances in information processing technology and improvements in chemical analysis accuracy, and they may possibly become mainstream exploration techniques in the future. Recent achievements include improvements in surface resolution in remote sensing, reductions in device size and weight, improvements in accuracy and analysis speed in geophysical exploration, progress in 3-D analysis and geotomography technology in seismic exploration, and practical application of georadar technology in electromagnetic exploration. In geochemical exploration, research on the practical application of the geogas technique is in progress.

b. Exploratory drilling technologies

The efficiency of exploratory drilling has increased through the development of semiautomatic drilling machines and advances in the reverse-circulation drilling technique. High-precision directional drilling and horizontal drilling techniques have been put to practical use in well drilling for petroleum and gas, contributing to improvements in oil production productivity and recovery efficiency. In Northern Europe and North America, these drilling techniques are being applied to subsea geologic surveys, metal and mineral resource exploration, etc.

c. Development and production technologies

• Mining

Labor saving and speed improvement are making progress in areas such as digging design, production planning and mine ventilation design, thanks to performance improvements in personal computers and sophistication in software. Regarding operation automation, unmanned trucks have been put to practical use at open-pit mines in the United States, South Africa and Japan, with efforts also being made to improve operation precision. With underground mining, practical application experiments on remote control technology for boring, loading and transportation work are under way in Canada, Sweden and Japan, aiming to achieve central control from a control room set up on the ground or inside a mine.

• Mineral dressing

With crushing and grinding processes, the adoption of SAG (Semi Autogenous) mills has become universal, thus saving energy and simplifying the processes. With the separation process, a move to larger flotation machines and the adoption of column flotation machines have made progress, while, with the dewatering process, the introduction of high-efficiency pressure filters has been under way accompanying energy saving and performance improvement effects. With process control, the control of the entire mineral dressing process is becoming a reality through progress in online analysis technology based on fluorescent X-ray analyzers and advances in fuzzy control technology.

• Leaching-SX-EX

Copper production based on the Leaching-SX-EX (leaching-solvent extraction-electrolytic extraction) method is widely used at mines in light rainfall areas in North and South America, as it can greatly reduce production costs compared to the conventional method that goes through mineral dressing and smelting processes. Although it was initially applicable to copper oxides only, its application to vitreous

copper, which, among copper sulfides, is relatively amenable to leaching, is in progress, following recent advances in leaching technology through the use of bacteria etc.

• Solution mining

The use of solution mining — which injects a solvent from the surface into the ground, dissolves a desired metal in the solvent, and recovers it above ground — is being studied in the United States for possible use in copper recovery operations.

ii) Future outlook

In the resources and energy field, the results of the questionnaire survey showed a high level of interest in the recycling of resources as follows: "19: Practical use of economical methods for separating and recycling valuable substances in urban garbage" (degree of importance to Japan (index): 1st, contribution to socioeconomic development: 8th, resolution of global-scale problems: 3rd, and forecasted realization time: 2009) and "17. Practical use of technologies capable of separating useful metals from scrap cars etc. to a purity level of more than 99%" (degree of importance to Japan (index): 2nd, contribution to socioeconomic development: 6th, resolution of global-scale problems: 2nd, and forecasted realization time: 2011). Although recycling-related technological development is under way based on existing mineral dressing and smelting technologies, its progress is not quite satisfactory compared to advances in primary commodity production technologies mentioned above, and this partly explains why recycling costs are higher than primary commodity production costs.

In the future, there seems to be a need to facilitate technological development through greater government involvement in terms of bolstering the research framework and providing more funds, as questionnaire survey results show.

In related areas, a great interest in exploration technologies, such as the following, was noted: "14: Development of exploration technology capable of estimating the economic feasibility of mineral deposits with virtually no drilling" (degree of importance to Japan (index): 9th, resolution of global-scale problems: 4th, and forecasted realization time: 2017) and "12: Development of semiquantitative prospecting technology for mineral resources using artificial satellites" (degree of importance to Japan (index): 8th, resolution of global-scale problems: 8th, and forecasted realization time: 2013). In light of the fact that technological development in remote sensing, geophysical exploration and geochemical exploration has been progressing at a rapid rate, these forecasted realization times seem to be reasonable.

(Terumitsu Kawabata)

(2) Water utilization technologies that can address climate change and natural disasters

In areas such as the development of water resources, prevention of water-related disasters and improvement of water quality, making water use in daily lives and social activities more efficient and comfortable through the optimum control of the global hydrologic cycle is an important task. Advances in the natural sciences and industrial technologies have made Japan's technical standards and progress in the introduction of equipment/facilities in these areas among the best in the world, although they have not quite reached the level where all the problems have been overcome. The nationwide water shortages that gripped Japan in 1994 and 1995 and floods caused by torrential rain that struck Japan's Chubu and Hokuriku Regions in 1995, as well as subsequent debris flows, which occurred in 1996, are still vivid in our memories. It is hoped that research and technological development will be conducted aiming for higher standards in the future, so that such aberrations in natural phenomena can be adequately dealt with. In this regard, the realization times of some of the relevant technologies have been forecasted as follows: "21: Widespread use of accurate rain and precipitation water-balance forecasting" (2010) "34: Widespread use in Japan of seawater desalination to deal with water shortages" (2012) "25. Widespread practice of the recovery and reuse of treated effluent at housing complexes, small-scale industries, etc." (2009) and "30: Significant reduction in the loss of human life in Japan through the improvement and widespread use of landslide and landslip prediction technologies" (2015).

From a global perspective, concerns about the outbreak of international conflicts over water because of serious water shortages in some regions in the future have been growing, while the threat of the Yellow River drying up is surfacing in China. With the impact of global-scale climate change attracting growing attention lately, the importance of such a global perspective will increase even more in the future. In this regard, the realization time of "22. Widespread introduction of measures to ensure adequate water resources based on elucidation of mechanism why climatic change causes abnormal rain phenomena" has been forecasted as 2013.

In the latest survey, 20 topics were set in the water resource area encompassing its three aspects — water use, disaster prevention/preparedness and water quality improvement — with water use being the main focus. This is the same number as the last survey. The 2011–15 range represents the most common forecasted realization times for these topics, accounting for 58% of the total, followed by 2006–10 (32%). Namely, most of the topics are forecasted to be realized within about 20 years. These results do seem to strongly reflect the hopes and enthusiasm of those involved in these areas.

The general trend of responses relating to these topics was such that, of the effects expected to be brought about by their realization, "response to people's needs" was most common (65%), followed by the "resolution of global-scale problems" (56%) and the "contribution to socioeconomic development" (21%). Improvements in technologies relating to water use etc. were considered to greatly contribute to improvements in the standard of living. In this regard, the forecasted realization times of some of the topics in which great interest was shown were as follows: "38: Improvement in the water quality of closed water areas such as Tokyo Bay so that people can safely swim there" (2017) "39: Development of an accurate and precise environmental impact prediction technologies for trace water contaminants" (2013) and "37: Drastic improvements in water treatment technologies at water purification plants through the use of new materials and biotechnology" (2011). All of these topics scored around 90% for "response to people's needs" as the expected effect.

However, in terms of the degree of importance index, even the highest "36. Widespread use of wastewater and sewage treatment technologies capable of removing a wide range of pollutants" did not score more than 69 (year 2011). This may mean that, in Japan, problems in the water resource area have generally been solved to an acceptable degree, so that topics to be included as issues of common interest for the near future have been in short supply.

Apart from this, Japan's leading country score was a very substantial 59%, which was greater than the U.S. or EU. This fact seems to partly reflect the region-specific nature of the water resource area.

"Measures the government should adopt" included greater research funding (54%), followed by an enhancement of the personnel exchange promotion system (43%) and human resource development (37%), and this underscores the fact that securing research funds has the highest priority.

(Shoichi Kunikane)

7.1.2. Forecast topic framework

In the course of compiling forecast topics, a framework representing the organization of technologies in tabulated matrix form was drawn up for each field, with objectives and technological domains defining the rows and columns of the table, respectively. The framework is designed to present an overall picture of technological development in each field in terms of future prospects, importance, etc. as seen from the present perspective, and is also used as a working framework for future reviews of forecast topics.

Table 7.1.2-1 Forecast Topic Framework for Mineral Resources Field

Objective \ Domain	Metal	Non-metal	Scarce resources	Common
Exploration, recovery and extraction	01 02 03 04		08 09	12 13 14 15 16 17
Application development/recycling			10 11	
Substitution	05	07		
Environmental protection and safety	06			18 19

* Figures appearing in the table represent topic numbers.

Table 7.1.2-2 Forecast Topic Framework for Water Resources Field

Objective \ Domain	Rainfall	Rivers, lakes and groundwater	Municipal water supply and sewage/drainage services	Seawater	Common
Water resource development technology	20 21 22	23 24	25 26		27 28 29
Flood prevention/preparedness technology	30 31	32	33	34	
Water quality improvement technology		35	36 37	38	39

* Figures appearing in the table represent topic numbers.

7.1.3. Topics with high degree of importance

Degree of importance index scores (Note 1) averaged at 60.6 for topics in the resources field as a whole, with topics in the mineral resources field and water resources field (which together comprised the resources field) scoring 61.2 and 60.0, respectively. The topic with the highest degree of importance index score was 19. Practical use of economical methods for separating and recycling valuable substances in urban garbage (88 points) in the mineral resources field and 36. Widespread use of wastewater and sewage treatment technologies capable of removing a wide range of pollutants (60 points) in the water resources field.

Topics considered of particular importance to Japan (top 10 topics in terms of degree of importance index score) are listed in the table below. In the mineral resources field, 3 topics scored more than 80 points.

Table 7.1.3-1 Top 10 Topics in Terms of Degree of Importance Index

Topic (Mineral resources)	Degree of importance index	Forecasted realization time (year)
19 Practical use of economical methods for separating and recycling valuable substances in urban garbage.	88	2009
17 Practical use of technologies capable of separating useful metals, such as iron, copper andaluminum, from metal-containing wastes, such as scrap cars, discarded electric appliances, to a purity level of more than 99%.	88	2011

06 Development of a steelmaking technology that requires fossil fuel consumption less than half of the present level.	83	2014
08 Practical use of economical techniques to recover deep ocean metal resources, such as manganese nodules, colloidal or hydrothermal deposits of heavy metals, and cobalt-rich crusts.	68	2017
13 Discovery and development of new mineral deposits through the accumulation of new geological knowledge which has replaced plate tectonics.	67	2017
09 Development of an economical refining process to extract valuable constituents from deep ocean resources such as manganese nodules.	67	2015
11 Availability of rare-earth materials at prices less than half of the present levels.	66	2014
12 Development of semiquantitative prospecting technology for mineral resources using artificial satellites.	62	2013
14 Development of exploration technology capable of estimating the economic feasibility of mineral deposits with virtually no drilling.	61	2017
03 Practical use of a new reduction method for aluminum melting instead of electrolysis.	61	2015
Topic (Water resources)	Degree of importance index	Forecasted realization time (year)
36 Widespread use of wastewater and sewage treatment technologies capable of removing a wide range of pollutants in addition to common pollutants such as phosphorus and nitrogen compounds.	69	2011
35 Practical use of water treatment technologies that contribute to improvement in the environmental quality of rivers and lakes and facilitate the use of water taken from them over a wide area.	68	2010
22 Elucidation of mechanism why climatic change causes abnormal rain phenomena (very heavy or very light rain), and widespread introduction of measures to ensure adequate water resources in response to changes in precipitation characteristics.	68	2013
24 Widespread of technologies for controlling sand inflows into dammed reservoirs to avoid the accumulation of sands or to remove accumulated sand efficiently, leading to extended service lives of dams and their rejuvenation.	67	2011
33 Practical use of water supply pipes made of new materials that are highly resistant to earthquakes and other disasters and their installation technologies.	66	2010
25 Advancement in sewage and wastewater treatment technologies and widespread practice of the recovery and reuse of treated effluent at housing complexes, small-scale industries, etc.	66	2009
29 Spread of a network interconnecting water systems throughout Japan, ensuring a stable supply of water.	65	2016
23 Advancement in artificial groundwater recharging technology and widespread practice of the conservation and the rationalized use of groundwater.	64	2014
21 Widespread use of accurate rain and precipitation water-balance forecast aiming at effective utilization of rainfall.	63	2010
37 Drastic improvements in water treatment technologies at water purification plants through the use of new materials and biotechnology, enabling people to enjoy safe and tasty tap water.	63	2011

* Unlike other fields, where the top 20 topics are listed, only the top 10 topics are shown here because of the fewer number of topics included.

Note 1: Degree of importance index = (number of "high" responses × 100 + number of "medium" responses × 50 + number of "low" responses × 25 + number of "unnecessary" responses × 0) ÷ total number of degree of importance responses

7.1.4. Forecasted realization times

Forecasted realization times were distributed as shown in the diagram below.

In the mineral resources field, forecasted realization times tended to be concentrated in a relatively narrow period, with no topic forecasted to be realized after 2025. In the water resources field, forecasted realization times were even more concentrated than in the mineral resources field, with the location of the peak coinciding with that of the general trend covering all topics.

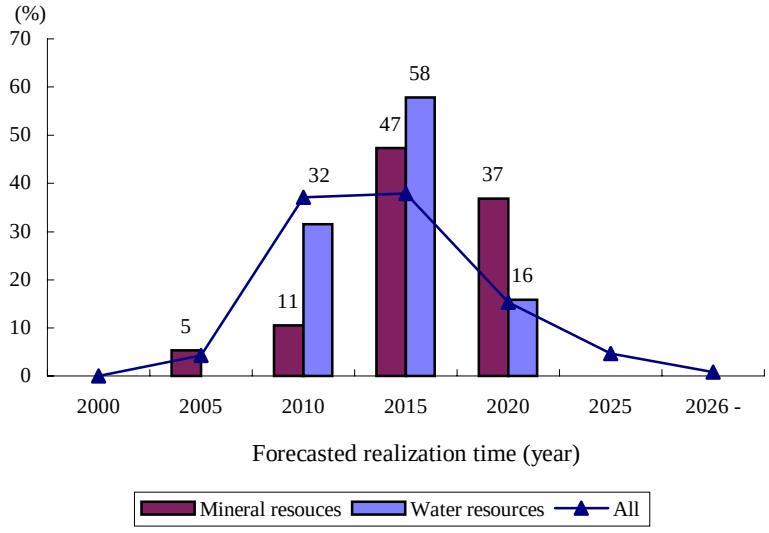

Fig. 7.1.4-1 Trends in Forecasted Realization Times

7.1.5. Current leading countries etc.

Responses to the question concerning current leading countries etc. were as shown in the diagram below. In the water resources field, Japan was named by the greatest number of respondents, followed by the U.S., while, in the mineral resources field, the U.S. ranked No. 1, followed by Japan. In both fields, the two countries were trailed by the EU, the former Soviet Union/Eastern Europe and other countries in that order, with do not know responses outstripping EU responses.

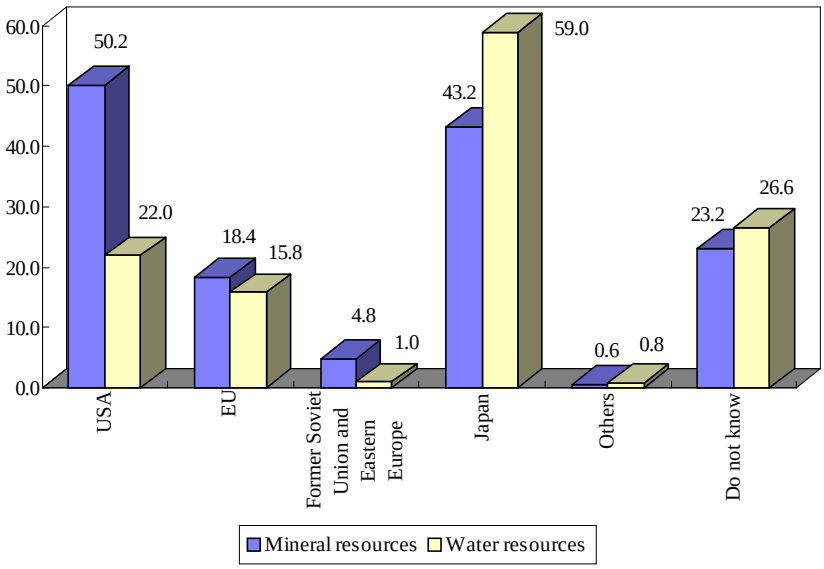

Fig. 7.1.5-1 Current Leading Countries etc. (%)

7.1.6. Comparison with the 5th Survey (previous survey)

In the latest survey, there were a total of 39 topics in the resources field (19 from the mineral resources field and 20 from the water resources field). In the mineral resources field, 10 topics (53%) were identical to the previous survey, 5 (26%) were modified, and 4 (21%) were newly introduced. In the water resources field, on the other hand, 14 (70%) were identical to the previous survey, 3 (15%) were modified, and 3 (15%) were newly introduced. For identical topics, the results of the latest survey were compared with those of the previous survey in terms of degree of importance index scores and forecasted realization times, as shown in the table below.

Degree of importance index scores rose for 3 topics, fell for 18 topics and remained the same for 3 topics. 21. Widespread use of accurate rain and precipitation water-balance forecast saw the greatest drop in importance index score, down 24 points.

Of the 39 topics included in the latest survey, forecasted realization times were pushed back for 22 topics, including 02. Widespread use of biotechnology for extraction and separation of metal elements, which saw its forecasted realization time pushed back most (13 years). Only 2 topics had their forecasted realization times brought forward. These were 14. Development of exploration technology capable of estimating the economic feasibility of mineral deposits with virtually no drilling and 20. Practical use of inducing artificial rain during droughts, by 3 years and 1 year, respectively.

Table 7.1.6-1 Comparison with 5th Survey for Identical Topics

Topic	Degree of importance index / forecasted realization time	
	6th survey	5th survey
02 Widespread use of biotechnology for extraction and separation of metal elements.	49/2017	64/2004
03 Practical use of a new reduction method for aluminum melting instead of electrolysis.	61/2015	61/2014
04 Practical use of a process using apply magnetic force, as non-ferrous metal casting method.	47/2011	43/2008
05 Substantial shift in photography from silver chloride film and photographic paper to electronic cameras, resulting in drastic reduction of demand for silver in this field.	47/2005	47/2003
07 Partial replacement of copper and aluminum by organic electrical conductors such as polymers.	54/2012	65/2005
10 Practical use of method for recovering helium from air to cope with an increased helium demand and diminishing natural resources.	51/2017	50/2009
12 Development of semiquantitative prospecting technology for mineral resources using artificial satellites.	62/2013	69/2006
14 Development of exploration technology capable of estimating the economic feasibility of mineral deposits with virtually no drilling.	61/2017	56/2020
15 Practical use of ultra-deep drilling and excavating technologies applicable to severe condition of up to 400C and a depth of 15 Km.	56/2016	64/2006
19 Practical use of economical methods for separating and recycling valuable substances in urban garbage.	88/2009	93/2001
20 Practical use of inducing artificial rainmarking in event of drought.	57/2014	57/2015
21 Widespread use of accurate rain and precipitation water-balance forecast aiming at effective utilization of rainfall.	63/2010	87/2004
22 Elucidation of mechanism why climatic change causes abnormal rain phenomena (very heavy or very light rain), and widespread introduction of measures to ensure adequate water resources in response to changes in precipitation characteristics.	68/2013	82/2007
23 Advancement in artificial groundwater recharging technology and widespread practice of the conservation and the rationalized use of groundwater.	64/2014	72/2005

Topic	Degree of importance index / forecasted realization time	
	6th survey	5th survey
25 Advancement in sewage and wastewater treatment technologies and widespread practice of the recovery and reuse of treated effluent at housing complexes, small-scale industries, etc.	66/2009	74/2001
27 Widespread use of comprehensive water supply and food control management systems based on snow-melting control and long-term flood forecast.	57/2013	66/2008
28 Practical use of international water transfer systems to make stable supply of water.	29/2020	41/2015
30 Significant reduction in the loss of human life in Japan through the improvement and widespread use of landslide and landslip prediction technologies.	63/2015	84/2008
31 Establishment of technologies enabling accurate forecast of rainfall and practice of effective dam operation in the case of floods.	60/2010	81/2004
32 Widespread use of bankss designed not to break even if overflow happens through the utilization of super banks and new materials.	61/2015	80/2004
35 Practical use of water treatment technologies that contribute to improvement in the environmental quality of rivers and lakes and facilitate the use of water taken from them over a wide area.	68/2010	86/2005
36 Widespread use of wastewater and sewage treatment technologies capable of removing a wide range of pollutants in addition to common pollutants such as phosphorus and nitrogen compounds.	69/2011	85/2005
37 Drastic improvements in water treatment technologies at water purification plants through the use of new materials and biotechnology, enabling people to enjoy safe and tasty tap water.	63/2011	69/2004
38 Improvement in the water quality of closed water areas such as Tokyo Bay so that people can safely swim there.	52/2017	59/2013

Note: Up until the 5th Survey, realization meant realization in Japan unless otherwise specified. However, this was changed to mean realization somewhere in the world in the 6th Survey. Therefore, care should be taken when comparing forecasted realization times from the two surveys.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)					Expected effect (%)				Forecasted realization time			Leading countries (%)							Measures the government should adopt (%)							Potential problems (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	2001 2006 2011 2016 2021 2026	Will not be realized (%)	Do not know (%)	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Metal	1	Practical use of solution mining, a technology to recover minerals from deep underground deposits by rendering ores such as chalcopyrite and sulfides of lead and zinc into solutions and pumping them up.	1	108	8	15	77	49	19	42	37	3	31	81	2	6		9	17	44	8	9	12	1	46	40	35	21	1	45	7	9	73	10	1	3
			2	90	7	14	79	43	7	55	38	1	32	86	0	6		11	14	48	1	4	9	0	48	48	36	20	0	60	4	4	84	12	0	1
			X	6	100	0	0	46	17	33	50	0	17	100	0	0		33	17	67	0	0	0	0	33	83	50	17	0	67	17	0	83	0	0	0
	2	Widespread use of biotechnology for extraction and separation of metal elements.	1	148	6	20	74	51	20	49	27	4	35	78	2	16		7	11	49	18	5	30	0	30	51	40	15	23	38	2	3	50	14	3	5
			2	120	4	17	79	49	13	60	26	2	31	79	1	16		6	10	60	11	3	33	0	27	55	45	10	22	43	3	2	64	10	1	3
			X	5	100	0	0	50	20	60	0	20	20	80	0	20		20	20	100	40	20	20	0	0	80	80	20	20	40	0	0	40	0	0	0
	3	Practical use of a new reduction method for aluminum melting instead of electrolysis.	1	131	4	24	73	60	34	43	17	6	47	72	0	12		15	16	34	13	5	31	2	36	37	44	13	4	40	2	5	32	3	2	6
			2	101	4	25	71	61	31	54	13	2	47	76	0	11		14	10	38	9	5	33	1	43	28	58	9	1	50	1	4	43	1	3	0
			X	4	100	0	0	56	25	50	25	0	50	75	0	25		50	0	50	25	0	50	0	25	50	50	0	0	50	0	0	50	0	0	0
	4	Practical use of a process using apply magnetic force, as non-ferrous metal casting method.	1	98	4	30	66	51	19	52	26	3	58	44	2	18		6	17	36	22	12	47	0	30	33	48	22	1	34	2	4	15	11	4	5
			2	78	5	26	69	47	8	66	25	1	63	42	3	14		8	9	29	22	13	51	0	27	37	60	15	0	44	3	0	23	14	3	1
			X	4	100	0	0	50	0	100	0	0	100	75	0	0		0	0	50	75	75	75	0	0	50	75	0	0	100	0	0	0	25	0	0
	5	Substantial shift in photography from silver chloride film and photographic paper to electronic cameras, resulting in drastic reduction of demand for silver in this field.	1	208	3	16	81	51	23	38	35	4	51	46	21	8		6	2	56	9	0	83	0	10	17	31	10	1	11	15	9	15	8	18	5
			2	170	1	15	84	47	15	46	37	2	58	46	14	6		4	1	49	3	0	88	0	7	16	45	6	1	10	14	8	15	5	21	2
			X	2	100	0	0	38	0	50	50	0	50	0	0	50		0	0	50	0	0	100	0	0	50	0	0	0	0	0	0	0	0	0	0
	6	Development of a steelmaking technology that requires fossil fuel consumption less than half of the present level.	1	198	10	22	68	80	62	35	3	1	47	88	2	10		8	11	19	19	4	77	1	14	34	51	15	2	47	5	3	30	12	4	3
			2	158	11	23	66	83	66	32	2	0	41	92	2	6		5	6	15	16	1	79	0	13	32	63	12	0	51	3	2	34	9	2	1
			X	17	100	0	0	84	71	24	6	0	35	88	6	18		18	0	35	35	0	88	0	0	59	59	12	0	65	6	0	41	12	0	0
Non-metal	7	Partial replacement of copper and aluminum by organic electrical conductors such as polymers.	1	160	3	22	76	58	26	55	17	3	61	48	10	24		5	8	59	27	2	53	0	24	46	48	14	7	31	6	3	16	10	4	6
			2	125	2	19	79	54	16	72	10	2	62	50	6	17		4	6	60	18	0	54	0	22	52	58	10	4	30	4	1	25	11	2	2
			X	2	100	0	0	75	50	50	0	0	100	0	0	0		0	0	100	50	0	100	0	0	100	100	0	0	50	0	0	50	0	0	0
Scarce resources	8	Practical use of economical techniques to recover deep ocean metal resources, such as manganese nodules, colloidal or hydrothermal deposits of heavy metals, and cobalt-rich crusts.	1	179	8	17	75	68	42	49	8	1	42	83	1	4		6	12	59	17	4	45	0	22	33	40	21	2	59	7	4	57	6	3	4
			2	143	6	17	77	68	39	58	3	1	38	85	1	1		6	9	63	13	0	49	0	22	32	46	16	1	63	6	1	64	2	1	1
			X	8	100	0	0	81	63	38	0	0	25	88	0	0		0	13	88	0	0	88	0	0	50	38	38	0	63	0	0	75	25	13	0
	9	Development of an economical refining process to extract valuable constituents from deep ocean resources such as manganese nodules.	1	148	10	19	71	66	39	47	13	1	45	76	2	5		5	10	54	16	3	50	0	25	36	45	20	3	51	4	3	43	3	1	3
			2	112	9	19	72	67	39	53	6	2	40	82	0	2		4	9	62	13	0	54	0	22	34	56	17	2	59	4	2	54	1	1	1
			X	10	100	0	0	85	70	30	0	0	40	90	0	10		0	0	80	20	0	70	0	0	50	30	30	0	50	0	0	40	10	10	0
	10	Practical use of method for recovering helium from air to cope with an increased helium demand and diminishing natural resources.	1	134	1	25	74	53	26	42	25	8	40	70	2	7		16	14	43	21	2	22	0	41	34	28	18	3	37	1	5	27	4	3	4
			2	109	1	21	78	51	18	56	22	5	37	78	3	2		12	10	50	17	2	20	0	38	39	31	14	1	42	2	4	37	3	2	3
			X	1	100	0	0	50	0	100	0	0	100	100	0	0		0	0	100	0	0	100	0	0	100	100	100	0	0	0	0	0	0	0	0

(Note) See page 7 for the interpretation of the graphs.

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Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)					Expected effect (%)				Forecasted realization time			Leading countries (%)							Measures the government should adopt (%)							Potential problems (%)			
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	2001 2006 2011 2016 2021 2026	Will not be realized (%)	Do not know (%)	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
Scarce resources	11	Availability of rare-earth materials at prices less than half of the present levels.	1	120	8	24	68	68	39	53	8	0	67	62	10	8		15	21	48	21	22	40	9	23	33	43	18	8	34	5	3	31	3	3	4
			2	97	5	25	70	66	34	62	4	0	66	65	6	4		16	14	56	19	15	38	5	25	36	53	14	4	36	4	5	45	1	2	2
			X	5	100	0	0	70	40	60	0	0	80	100	0	20		20	20	80	0	20	80	0	0	80	100	0	0	40	20	0	40	0	0	0
Common	12	Development of semiquantitative prospecting technology for mineral resources using artificial satellites.	1	159	6	11	82	63	33	54	11	1	35	87	3	14		4	13	86	19	15	20	1	12	39	40	25	8	48	3	3	20	10	6	6
			2	128	5	13	83	62	29	62	9	1	29	84	2	12		5	9	85	15	12	17	1	10	36	46	23	6	55	2	1	25	8	2	2
			X	6	100	0	0	67	50	33	0	17	17	83	0	0		50	0	83	17	0	17	0	0	17	33	17	0	33	17	0	33	0	0	0
	13	Discovery and development of new mineral deposits through the accumulation of new geological knowledge which has replaced plate tectonics.	1	108	7	13	80	68	42	45	13	0	33	84	2	20		5	16	63	27	11	27	4	23	52	43	20	10	36	2	3	35	3	5	2
			2	89	4	13	82	67	37	59	5	0	24	87	0	17		8	10	69	17	7	22	0	19	64	44	16	3	42	2	1	42	1	0	0
			X	4	100	0	0	100	100	0	0	0	25	75	0	50		25	0	50	25	25	25	0	25	50	75	25	0	75	25	0	50	0	0	0
	14	Development of exploration technology capable of estimating the economic feasibility of mineral deposits with virtually no drilling.	1	105	10	17	73	62	33	48	18	1	32	81	3	18		16	12	67	20	8	20	1	27	47	42	23	8	47	0	1	20	8	2	3
			2	85	8	16	75	61	29	58	12	1	27	87	0	12		14	9	66	14	6	15	1	27	53	48	16	2	51	2	0	27	6	0	0
			X	7	100	0	0	75	57	29	14	0	14	86	0	43		57	0	43	14	0	14	0	29	57	29	14	0	29	14	0	14	14	0	0
	15	Practical use of ultra-deep drilling and excavating technologies applicable to severe condition of up to 400ºC and a depth of 15 km.	1	109	9	16	75	58	28	48	23	1	37	88	6	22		6	5	63	30	23	26	0	17	28	40	30	6	59	6	3	43	10	2	2
			2	90	8	14	78	56	23	56	20	1	32	82	1	22		6	4	69	27	18	27	0	14	24	52	24	2	63	6	1	50	6	1	0
			X	7	100	0	0	46	14	43	43	0	29	86	0	43		0	0	86	57	71	29	0	0	43	57	57	0	71	0	0	43	14	0	0
	16	Practical use of a "hard-rock" tunnel drifting technique based on water jets.	1	144	6	14	80	52	17	57	25	1	55	53	16	6		1	12	31	19	10	46	0	31	28	45	28	1	40	6	3	42	17	1	2
			2	119	8	14	78	52	16	62	23	0	60	50	10	3		1	8	38	12	4	61	0	21	26	57	20	0	43	5	3	52	13	1	0
			X	9	100	0	0	69	38	63	0	0	22	100	11	11		0	22	44	22	11	78	0	0	56	67	33	0	22	0	0	67	22	0	0
	17	Practical use of technologies capable of separating useful metals, such as iron, copper and aluminum, from metal-containing wastes, such as scrap cars, discarded electric appliances, to a purity level of more than 99%.	1	254	11	20	69	82	66	30	3	1	58	90	10	6		2	6	30	49	1	52	0	20	36	52	22	1	56	28	2	30	7	12	4
			2	201	11	17	72	88	78	20	2	1	55	91	6	3		1	3	29	55	1	56	0	17	32	60	16	1	66	24	2	39	4	7	0
			X	22	100	0	0	93	86	14	0	0	59	91	5	5		9	0	36	73	5	64	0	5	41	59	9	5	64	32	0	23	9	5	0
	18	Practical use of a highly economical unmanned mining technique that combines robot technologies.	1	136	7	12	82	53	20	53	24	2	47	63	22	5		2	9	46	23	4	49	3	22	31	47	18	1	43	4	3	32	14	4	1
			2	108	6	12	82	50	13	64	23	0	52	62	16	3		1	7	54	15	0	53	2	21	31	56	11	0	49	6	1	40	9	4	1
			X	6	100	0	0	58	33	33	33	0	67	100	17	0		0	0	83	17	0	100	0	0	17	83	0	0	50	0	0	50	0	0	0
	19	Practical use of economical methods for separating and recycling valuable substances in urban garbage.	1	284	9	26	65	82	65	32	2	0	56	91	27	2		2	5	20	51	1	52	1	21	34	48	21	2	54	31	2	33	8	14	1
			2	236	8	23	68	88	77	22	1	0	50	89	21	1		3	2	16	55	0	61	0	16	25	60	13	0	61	31	1	40	6	11	0
			X	20	100	0	0	94	89	11	0	0	70	90	25	0		0	0	40	75	0	80	0	0	25	70	20	0	60	40	0	30	5	10	0
Water resource development	20	Practical use of inducing artificial rainmarking in event of drought.	1	177	5	10	85	58	30	45	22	3	24	70	40	8		23	15	37	7	6	27	3	41	45	33	18	6	40	4	2	60	13	8	0
			2	153	3	8	89	57	26	53	19	3	19	78	41	5		20	12	43	5	5	27	1	43	52	32	11	3	47	3	2	74	9	5	0
			X	5	100	0	0	55	20	60	20	0	20	20	80	0		20	0	60	0	20	20	20	0	40	20	40	0	80	0	20	80	20	20	0

(Note) See page 7 for the interpretation of the graphs.

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Water resource development technology	21	Widespread use of accurate rain and precipitation water-balance forecast aiming at effective utilization of rainfall.	1	135	10	11	79	67	38	55	7	1	31	70	56	10		2	4	42	15	1	59	0	23	56	33	23	17	42	4	1	35	16	3	1
			2	125	6	14	80	63	28	69	3	0	21	72	55	5		1	6	47	13	0	64	0	22	65	27	14	7	53	3	0	45	12	2	0
			X	8	100	0	0	81	63	38	0	0	25	50	63	0		13	13	50	13	0	63	0	13	63	25	13	0	63	0	0	50	13	0	0
	22	Elucidation of mechanism why climatic change causes abnormal rain phenomena (very heavy or very light rain), and widespread introduction of measures to ensure adequate water resources in response to changes in precipitation characteristics.	1	137	7	13	80	70	44	50	6	0	27	81	51	20		4	9	48	19	1	46	1	28	59	35	23	16	50	5	1	42	19	3	1
			2	128	5	10	84	68	36	62	2	0	20	80	49	11		2	7	54	13	2	58	0	26	69	32	12	7	57	2	1	54	9	2	0
			X	7	100	0	0	93	86	14	0	0	29	71	57	14		14	14	57	0	0	57	0	14	57	57	0	14	43	0	0	57	14	0	0
	23	Advancement in artificial groundwater recharging technology and widespread practice of the conservation and the rationalized use of groundwater.	1	135	8	16	76	65	38	46	14	2	33	78	47	4		4	11	21	19	3	36	0	39	52	40	18	6	47	17	1	56	16	4	1
			2	116	5	16	78	64	31	61	8	0	19	81	44	2		3	9	22	16	1	47	2	36	57	43	13	3	50	10	2	66	11	3	1
			X	6	100	0	0	75	50	50	0	0	33	67	67	0		17	17	83	17	0	50	0	0	67	50	17	0	17	17	17	83	0	0	0
	24	Widespread of technologies for controlling sand inflows into dammed reservoirs to avoid the accumulation of sands or to remove accumulated sand efficiently, leading to extended service lives of dams and their rejuvenation.	1	128	9	20	70	66	40	46	13	1	35	73	39	4		3	6	15	8	1	59	0	28	31	44	20	2	53	16	2	55	15	2	0
			2	114	8	19	73	67	38	55	6	1	25	77	32	2		2	5	9	5	0	71	0	22	25	47	9	1	65	11	0	62	11	1	0
			X	9	100	0	0	81	63	38	0	0	22	67	44	0		0	0	0	11	0	78	0	0	44	44	11	0	67	0	0	44	11	0	0
	25	Advancement in sewage and wastewater treatment technologies and widespread practice of the recovery and reuse of treated effluent at housing complexes, small-scale industries, etc.	1	217	9	25	66	67	40	49	10	0	36	72	55	1		1	3	17	27	1	53	1	29	28	41	18	1	40	41	2	29	14	14	2
			2	191	6	22	72	66	35	59	6	0	28	74	57	1		1	2	12	29	1	58	2	26	24	48	10	1	50	43	1	35	16	7	1
			X	11	100	0	0	82	64	36	0	0	45	73	45	0		9	0	36	27	0	45	0	0	27	45	18	0	36	55	0	27	27	9	0
	26	Near elimination of leakage from water distribution networks, resulting in an efficient utilization of water resources.	1	154	6	15	79	55	26	44	28	1	21	60	49	1		13	6	6	12	1	44	0	38	17	37	18	3	26	18	7	17	13	5	3
			2	140	4	14	82	57	24	54	22	0	16	67	54	1		9	4	4	14	1	56	0	34	12	51	16	0	40	15	4	20	16	1	1
			X	6	100	0	0	71	50	33	17	0	33	50	83	0		17	0	0	0	17	50	0	33	33	33	67	0	50	17	0	33	0	0	0
	27	Widespread use of comprehensive water supply and food control management systems based on snow-melting control and long-term flood forecast.	1	129	10	13	77	62	33	52	14	1	34	71	53	6		8	4	19	18	5	52	2	34	36	42	19	13	42	9	0	47	16	5	0
			2	117	6	12	82	57	22	64	14	0	18	67	60	3		7	3	12	17	3	60	2	32	38	50	10	7	52	3	0	51	9	2	0
			X	7	100	0	0	71	43	57	0	0	29	43	71	0		14	0	29	0	0	43	0	57	86	43	14	14	71	0	0	29	14	0	0
	28	Practical use of international water transfer systems to make stable supply of water.	1	102	10	12	78	36	12	27	40	20	29	69	47	7		25	11	12	23	2	13	5	45	19	29	5	6	28	16	9	28	12	14	2
			2	88	6	13	82	29	6	20	53	20	18	72	43	3		27	10	7	27	1	11	3	53	18	35	5	1	34	13	6	40	7	6	1
			X	5	100	0	0	40	20	20	40	20	20	80	40	0		40	20	0	40	0	0	0	60	20	0	0	0	20	40	0	40	0	60	0
	29	Spread of a network interconnecting water systems throughout Japan, ensuring a stable supply of water.	1	134	10	17	73	66	42	42	11	5	37	54	60	4		12	8	19	17	1	38	1	30	22	30	13	4	37	40	8	37	14	11	3
			2	120	7	20	73	65	38	46	14	2	25	48	68	3		8	3	16	17	0	50	0	29	18	33	5	2	44	54	3	43	10	3	2
			X	8	100	0	0	84	75	13	13	0	50	63	75	0		0	13	63	13	0	25	0	13	38	13	13	0	38	63	0	38	0	38	0
Flood prevention technology	30	Significant reduction in the loss of human life in Japan through the improvement and widespread use of landslide and landslip prediction technologies.	1	127	6	17	76	63	35	46	18	1	19	19	82	6		9	8	12	9	0	59	2	25	49	39	18	11	52	12	1	26	24	3	1
			2	116	3	12	84	63	30	62	9	0	9	14	87	1		5	7	3	5	0	66	1	24	54	41	11	4	62	7	1	27	16	0	0
			X	4	100	0	0	88	75	25	0	0	25	25	100	0		50	0	25	25	0	100	0	0	25	100	25	0	75	0	0	75	50	0	0

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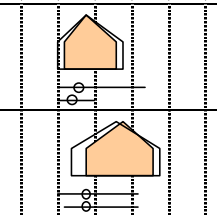
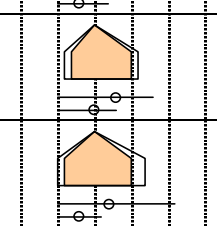
Flood prevention technology	31	Establishment of technologies enabling accurate forecast of rainfall and practice of effective dam operation in the case of floods.	1	124	14	10	76	62	33	50	16	2	25	49	68	2		2	4	27	10	2	57	0	26	36	44	19	17	44	8	2	34	19	1	2
			2	108	12	10	78	60	26	62	12	0	18	45	75	0		2	1	27	9	1	67	0	21	43	46	14	10	58	3	0	39	15	0	0
			X	13	100	0	0	77	58	33	8	0	23	38	85	0		8	0	31	0	0	77	0	15	85	46	23	15	69	0	0	15	23	0	0
	32	Widespread use of banks designed not to break even if overflow happens through the utilization of super banks and new materials.	1	89	15	11	74	61	32	49	15	3	37	29	74	1		4	8	13	10	1	54	1	33	33	42	18	2	45	18	4	36	19	2	2
			2	76	12	11	78	61	26	69	5	0	28	16	87	0		4	4	5	11	0	68	0	28	26	53	11	0	62	12	3	41	14	0	3
			X	9	100	0	0	78	56	44	0	0	22	11	100	0		0	0	11	11	0	89	0	11	33	56	11	0	56	22	22	11	22	0	0
	33	Practical use of water supply pipes made of new materials that are highly resistant to earthquakes and other disasters and their installation technologies.	1	146	6	16	78	63	34	51	13	1	43	23	77	2		3	5	16	6	1	64	0	21	32	45	19	2	46	27	2	12	25	2	5
			2	127	3	15	82	66	35	59	6	0	41	14	83	2		2	3	12	4	1	72	0	22	29	52	13	1	60	25	1	8	31	0	2
			X	4	100	0	0	69	50	25	25	0	25	0	100	0		0	0	25	0	0	75	0	0	25	50	25	0	50	50	0	0	0	0	25
	34	Widespread use in Japan of seawater desalination to deal with water shortages due to drought, etc.	1	259	8	19	73	50	22	38	37	4	37	59	63	3		14	8	27	15	3	61	6	22	21	35	18	2	44	16	7	33	12	4	2
			2	228	5	19	76	47	15	46	36	3	24	57	70	2		11	5	27	9	2	67	5	19	18	40	14	0	55	16	4	37	10	2	2
			X	11	100	0	0	59	36	36	18	9	45	55	82	0		9	0	55	18	0	73	9	0	45	45	9	0	55	27	9	18	18	0	9
Water quality improvement technology	35	Practical use of water treatment technologies that contribute to improvement in the environmental quality of rivers and lakes and facilitate the use of water taken from them over a wide area.	1	230	11	25	64	70	44	49	6	0	32	70	60	2		2	4	23	28	2	66	0	21	34	47	23	7	56	26	2	37	7	7	2
			2	194	6	22	72	68	39	56	5	1	23	70	64	1		1	3	23	32	1	72	0	19	34	51	18	3	68	22	2	44	6	3	1
			X	12	100	0	0	92	83	17	0	0	42	67	75	0		0	0	42	50	0	75	0	17	50	67	25	0	50	17	0	58	8	8	0
	36	Widespread use of wastewater and sewage treatment technologies capable of removing a wide range of pollutants in addition to common pollutants such as phosphorus and nitrogen compounds.	1	199	8	25	67	69	43	48	8	1	25	70	61	3		3	6	21	30	2	61	1	23	38	45	24	6	51	29	1	33	8	6	3
			2	169	5	18	78	69	41	56	3	1	20	72	68	1		4	4	19	32	1	66	1	21	38	47	22	4	57	28	1	35	7	4	2
			X	8	100	0	0	94	88	13	0	0	50	75	75	0		0	0	38	50	0	75	0	0	38	63	25	0	38	38	0	38	0	13	0
	37	Drastic improvements in water treatment technologies at water purification plants through the use of new materials and biotechnology, enabling people to enjoy safe and tasty tap water.	1	192	8	19	72	65	38	48	13	1	33	45	79	2		4	4	29	22	1	64	2	22	40	44	27	11	48	20	1	25	11	9	2
			2	163	6	14	80	63	32	57	11	1	25	37	88	1		3	2	24	22	0	71	0	18	40	50	23	6	57	20	0	28	11	5	1
			X	9	100	0	0	78	56	44	0	0	22	33	89	0		0	0	44	56	0	78	0	0	56	44	56	0	56	22	0	11	22	11	0
	38	Improvement in the water quality of closed water areas such as Tokyo Bay so that people can safely swim there.	1	156	6	19	75	53	21	50	28	1	17	52	80	1		10	6	17	13	1	62	0	27	30	32	15	8	44	30	4	29	10	10	2
			2	130	3	12	85	52	16	58	26	0	9	45	90	1		8	2	13	10	0	68	0	22	26	31	11	5	59	31	3	34	8	4	2
			X	4	100	0	0	56	25	50	25	0	0	25	100	0		0	0	50	50	0	100	0	0	25	25	0	0	25	50	25	25	25	0	0
	39	Development of an accurate and precise environmental impact prediction technologies for carcinogenic or otherwise harmful trace water contaminants.	1	123	5	20	76	62	32	52	15	1	17	41	85	8		2	6	56	33	1	52	0	13	48	40	21	23	48	13	1	24	14	11	2
			2	107	3	14	83	60	23	69	7	0	9	38	89	4		2	4	61	27	0	59	0	15	59	47	14	17	55	14	0	26	11	6	0
			X	3	100	0	0	83	67	33	0	0	33	67	100	33		0	0	67	0	0	33	0	0	100	67	0	0	33	33	0	33	0	0	0

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