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An Analysis on Research Funding of Geosciences in Korea

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우리나라 지질자원분야 연구예산 지원에 관한 분석연구

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This study analyzed trends in geoscientific research funding provided by the Korea Science and Engineering Foundation (KOSEF) and examined strategies to promote geoscientific research. The strengths of geoscientific research in South Korea include the excellent academic quality of researchers, established research infrastructure, and inter-disciplinary research. Weaknesses include insufficient leadership in related societies and institutes, insufficient research productivity, and the exclusion of the field from nationally supported large-scale research projects. Opportunities for expanded research include environmental issues, the sustainable use of natural resources, the promotion of international research cooperation, and the initiation of national efforts to find solutions for regional problems. However, growth in the geosciences is threatened by prioritized investment in fields such as biotechnology, nanoscience, and information technology, a dismissive attitude toward the growth of basic sciences, and an increased demand for projects with visible economic and societal impacts. In terms of funding, group-based programs receive more support than individual-based programs. Between 1978 and 2006, KOSEF invested 1,744 billion won ($1.873 billion US) in a total of 46,748 basic research projects. Of this amount, 62.1 billion won ($66.7 million US) was allocated to 1,901 projects in the geosciences, which was roughly 2.6-10.6% of the money available in a given year. These funds were used to support research and development, the development and maintenance of necessary infrastructure, and the education and training of geoscientists.

Key words : Geosciences, Korea Science and Engineering Foundation, Research funding

1. Introduction

Research and development (R&D) is classified into basic and applied research. Although there is no internationally accepted definition of basic science, it is generally understood to include natural sciences. The Frascati Manual published by the Organization for Economic Cooperation and Development (OECD, 2003) includes various definitions of basic research; the most widely accepted definition is that basic research is the experimental and theoretical work that is conducted to obtain fundamental knowledge of observable facts and phenomena, without considering specific applications or uses. Basic research does not focus on a particular objective, but rather on devising new theories and extending our knowledge of basic sciences and engineering (Min *et al.*, 2005). From an industrial perspective, this might be defined as not pertaining to specific, commercial knowledge, but as an enhancement of scientific knowledge (NSF, 2004).

The importance of basic research is increasing with advances in technological innovation and knowledge-based industries. Basic research also produces the skilled labor necessary for high-level science and engineering. In addition, the environmental challenges of the 21st century neces-

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sitate increased cooperation in geoscientific research among industries, universities, and research institutes. This kind of approach requires an operating paradigm whereby academia faces no walls or boundaries, allowing internationalization and mobility among academics.

The importance of basic studies in university research has increased as a result of the National Innovation System. Government funding plays a crucial role in the geosciences. As such, it is important to evaluate the amount of funding allocated to universities and the mode by which it is delivered to encourage growth and achievement in geoscientific research.

2. Methodology

Since its foundation in 1978, the Korean Science and Engineering Foundation (KOSEF) has supported a large proportion (30-80%) of the academic research conducted in South Korea. Excluding funds allocated to applied and developmental research programs, the gross expenditure on R&D (GERD) increased from 292 million won ($314,000 US) in 1978 to 158,597 million won ($159 million US) in 2006.

This study evaluated geoscientific research activity through the analysis of funding provided by KOSEF. We compared various research sectors over the past 30 years and examined the number of sector-specific research tasks, the funds allocated, and the alternatives for developing the most appropriate research strategies and systems.

The statistics provided by KOSEF for 1978-2006 were used to examine support for research undertaken by individuals, including new professors, basic researchers, and core-specific researchers, in comparison to support for loan-assisted projects with the International Bank for Reconstruction and Development (IBRD), international cooperative research projects, and group/collective studies, including mission-oriented basic grants and projects for centers of excellence. We examined financial support for training, including scholarships for masters and doctoral candidates, overseas and domestic post-doctoral training, research infrastructure projects, and operational support for special research material banks and research information centers. The statistical data do not agree with the annual accounts and project budgets of KOSEF, because this analysis only included support for research projects and not for small-scale academic activities.

Since the research management system at KOSEF does not use a consistent classification, we classified research projects into 11 categories and compiled basic statistics for each. The categories were mineralogy, petrology, paleontology and sedimentary geology, geochemistry, structural geology, mineral deposits, geophysics, economic geology, astronomy and atmospheric sciences, oceanography, and others. In many cases, it was not clear how to classify a specific project. For projects involving more than two researchers, we attempted to identify the interests of the chief researcher. All research funding was rounded off

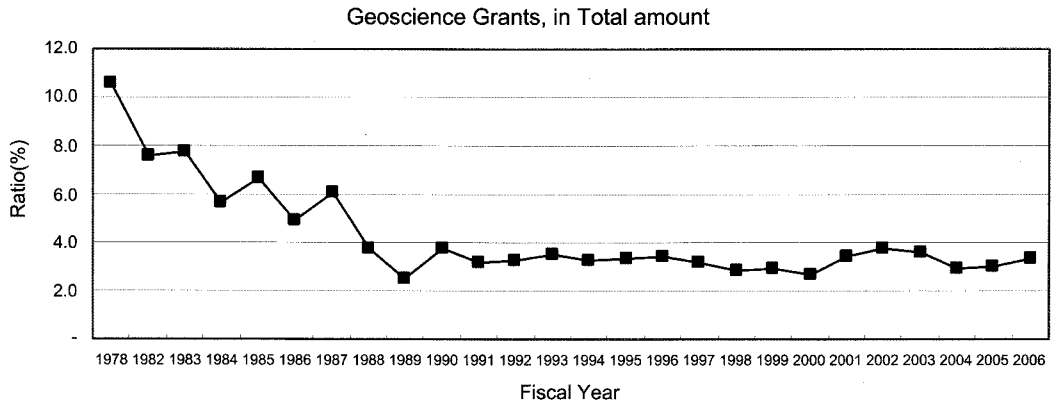

Fig. 1. Ratio of grants in the geosciences to the total funding available from the Korean Science and Engineering Foundation (KOSEF, 1978-2006).

Table 1. Number of research projects and grants in the geosciences supported by the Korean Science and Engineering Foundation (KOSEF).

(Unit : Project, Constant thousand Won)

Year	No. of Project			Expenditure		
	Geosciences (A)	Total (B)	Ratio (A/B, %)	Geosciences (C)	Total (D)	Ratio (C/D, %)
1978	9	81	11.1	30,959	292,400	10.6
1982	38	658	5.8	138,949	1,828,557	7.6
1983	16	328	4.9	88,097	1,133,010	7.8
1984	61	1,113	5.5	239,324	4,194,774	5.7
1985	75	1,262	5.9	388,229	5,841,004	6.6
1986	74	1,441	5.1	359,892	7,345,227	4.9
1987	81	1,316	6.2	668,964	11,015,307	6.1
1988	60	1,158	5.2	428,222	11,340,474	3.8
1989	76	1,747	4.4	487,844	19,389,971	2.5
1990	81	1,964	4.1	664,368	17,799,209	3.7
1991	74	1,841	4.0	999,599	31,597,572	3.2
1992	58	1,455	4.0	1,062,749	33,014,719	3.2
1993	53	1,266	4.2	1,221,496	34,761,333	3.5
1994	88	1,507	5.8	1,550,138	47,444,828	3.3
1995	87	2,105	4.1	2,179,492	65,883,705	3.3
1996	87	2,318	3.8	2,715,096	79,366,614	3.4
1997	87	2,369	3.7	2,998,098	95,178,857	3.1
1998	92	2,560	3.6	2,711,863	95,494,646	2.8
1999	59	1,704	3.5	2,894,659	98,135,134	2.9
2000	68	1,858	3.7	3,384,058	128,312,379	2.6
2001	123	3,283	3.7	5,668,984	166,913,703	3.4
2002	127	3,155	4.0	6,821,097	183,438,292	3.7
2003	117	3,310	3.5	7,411,954	208,462,069	3.6
2004	113	4,048	2.8	7,075,516	243,546,441	2.9
2005	51	1,382	3.7	4,579,719	152,754,202	3.0
2006	46	1,519	3.0	5,307,006	158,596,667	3.3
Total	1,901	46,748	4.1	62,076,372	1,903,081,094	3.3

to the nearest thousand won and the data for each research team were processed using internal data from KOSEF.

3. Results

3.1. Analysis of KOSEF-supported grants

3.1.1. Analysis of research funding trends in the geosciences

National R&D activities started in 1978 with the establishment of KOSEF. R&D funding has increased steadily and, in 2006, reached a record 8.91 trillion won ($89 million US) (MOST, 2007). Between 1978 and 2006, KOSEF invested 1,744 billion won ($1.874 billion US) in a total of 46,748 basic research projects. Of this, 62.1 billion won ($66.7 million US) was used to support 1,901 projects in the geosciences. Over this period, the geosciences received between 2.6 and 10.6% of the grant money available in each year. In 2006, KOSEF allocated an estimated 5.3 billion won ($5.7 million US) to geoscientific research (**Fig. 1**).

From 1978-2006, the total number of projects increased by a factor of 5.1, and the corresponding research expenditures increased by a factor of 171.2. In 2006, 46 projects in the geosciences (3.0% of all projects) received 5.31 billion won (3.3% of all funds) (**Table 1**). In general, support for the geosciences has increased steadily in relation to the total number of projects, in terms of

Table 2. Types of research programs supported by the Korean Science and Engineering Foundation (KOSEF), and the number of research projects in the geosciences.

(Unit : No. of project)

Year	No. of project		Individual grants programme			Group or centers -supported programme			Research infra-structure programme			Fellowship programme		
	Total (A)	Geosci. (B)	Project (C)	Ratio (C/A, %)	Ratio (C/B, %)	Project (D)	Ratio (D/A, %)	Ratio (D/B, %)	Project (E)	Ratio (E/A, %)	Ratio (E/B, %)	Project (F)	Ratio (F/A, %)	Ratio (F/B, %)
1978	81	9	9	11.1	100.0	0	-	-	0	-	-	0	-	-
1982	658	38	26	4.0	68.4	0	-	-	0	-	-	12	1.8	31.6
1983	328	16	8	2.4	50.0	0	-	-	0	-	-	8	2.4	50.0
1984	1,113	61	51	4.6	83.6	0	-	-	0	-	-	10	0.9	16.4
1985	1,262	75	66	5.2	88.0	0	-	-	0	-	-	9	0.7	12.0
1986	1,441	74	63	4.4	85.1	0	-	-	0	-	-	11	0.8	14.9
1987	1,316	81	65	4.9	80.2	8	0.6	9.9	0	-	-	8	0.6	9.9
1988	1,158	60	44	3.8	73.3	5	0.4	8.3	0	-	-	11	0.9	18.3
1989	1,747	76	50	2.9	65.8	3	0.2	3.9	0	-	-	23	1.3	30.3
1990	1,964	81	58	3.0	71.6	8	0.4	9.9	0	-	-	15	0.8	18.5
1991	1,841	74	43	2.3	58.1	11	0.6	14.9	0	-	-	20	1.1	27.0
1992	1,455	58	41	2.8	70.7	8	0.5	13.8	0	-	-	9	0.6	15.5
1993	1,266	53	38	3.0	71.7	7	0.6	13.2	0	-	-	8	0.6	15.1
1994	1,507	88	38	2.5	43.2	36	2.4	40.9	0	-	-	14	0.9	15.9
1995	2,105	87	44	2.1	50.6	12	0.6	13.8	3	0.1	3.4	28	1.3	32.2
1996	2,318	87	49	2.1	56.3	17	0.7	19.5	3	0.1	3.4	18	0.8	20.7
1997	2,369	87	47	2.0	54.0	15	0.6	17.2	4	0.2	4.6	21	0.9	24.1
1998	2,560	92	45	1.8	48.9	14	0.5	15.2	5	0.2	5.4	28	1.1	30.4
1999	1,704	59	25	1.5	42.4	20	1.2	33.9	6	0.4	10.2	8	0.5	13.6
2000	1,858	68	29	1.6	42.6	28	1.5	41.2	5	0.3	7.4	6	0.3	8.8
2001	3,283	123	43	1.3	35.0	35	1.1	28.5	14	0.4	11.4	31	0.9	25.2
2002	3,155	127	49	1.6	38.6	44	1.4	34.6	21	0.7	16.5	13	0.4	10.2
2003	3,310	117	51	1.5	43.6	33	1.0	28.2	16	0.5	13.7	17	0.5	14.5
2004	4,048	113	50	1.2	44.2	30	0.7	26.5	7	0.2	6.2	26	0.6	23.0
2005	1,382	51	5	0.4	9.8	21	1.5	41.2	11	0.8	21.6	14	1.0	27.5
2006	1,519	46	5	0.3	10.9	29	1.9	63.0	10	0.7	21.7	2	0.1	4.3
Total	46,748	1,901	1042	2.2	54.8	384	0.8	20.2	105	0.2	5.5	370	0.8	19.5

Table 3. Types of research programs supported by the Korean Science and Engineering Foundation (KOSEF), and the value of total research grants allocated to the geosciences.

(Unit : Constant million Won)

Year	Expenditure		Individual grants programme			Group or centers -supported programme			Research infra-structure programme			Fellowship programme		
	Total (A)	Geosci. (B)	Amount (C)	Ratio (C/A, %)	Ratio (C/B, %)	Amount (C)	Ratio (C/A, %)	Ratio (C/B, %)	Amount (C)	Ratio (C/A, %)	Ratio (C/B, %)	Amount (C)	Ratio (C/A, %)	Ratio (C/B, %)
1978	292	31	31	10.6	100.0	-	-	-	-	-	-	-	-	-
1982	1,829	139	81	4.4	58.3	-	-	-	-	-	-	57	3.1	41.0
1983	1,133	88	30	2.6	34.1	-	-	-	-	-	-	58	5.1	65.9
1984	4,195	239	186	4.4	77.8	-	-	-	-	-	-	54	1.3	22.6
1985	5,841	388	312	5.3	80.4	-	-	-	-	-	-	77	1.3	19.8
1986	7,345	360	290	3.9	80.6	-	-	-	-	-	-	69	0.9	19.2
1987	11,015	669	329	3.0	49.2	284	2.6	42.5	-	-	-	56	0.5	8.4
1988	11,340	428	201	1.8	47.0	162	1.4	37.9	-	-	-	66	0.6	15.4
1989	19,390	488	209	1.1	42.8	139	0.7	28.5	-	-	-	140	0.7	28.7
1990	17,799	664	245	1.4	36.9	320	1.8	48.2	-	-	-	99	0.6	14.9
1991	31,598	1,000	198	0.6	19.8	654	2.1	65.4	-	-	-	148	0.5	14.8
1992	33,015	1,063	203	0.6	19.1	759	2.3	71.4	-	-	-	100	0.3	9.4
1993	34,761	1,221	257	0.7	21.0	841	2.4	68.9	-	-	-	123	0.4	10.1
1994	47,445	1,550	319	0.7	20.6	1,062	2.2	68.5	-	-	-	169	0.4	10.9
1995	65,884	2,179	440	0.7	20.2	1,202	1.8	55.2	212	0.3	9.7	326	0.5	15.0
1996	79,367	2,715	581	0.7	21.4	1,731	2.2	63.8	144	0.2	5.3	259	0.3	9.5
1997	95,179	2,998	685	0.7	22.8	1,831	1.9	61.1	168	0.2	5.6	314	0.3	10.5
1998	95,495	2,712	680	0.7	25.1	1,476	1.5	54.4	227	0.2	8.4	328	0.3	12.1
1999	98,135	2,895	387	0.4	13.4	2,009	2.0	69.4	374	0.4	12.9	125	0.1	4.3
2000	128,312	3,384	849	0.7	25.1	1,983	1.5	58.6	428	0.3	12.6	124	0.1	3.7
2001	166,914	5,669	1,250	0.7	22.0	3,373	2.0	59.5	589	0.4	10.4	457	0.3	8.1
2002	183,438	6,821	1,305	0.7	19.1	4,723	2.6	69.2	531	0.3	7.8	262	0.1	3.8
2003	208,462	7,411	1,607	0.8	21.7	4,667	2.2	63.0	862	0.4	11.6	276	0.1	3.7
2004	243,547	7,026	1,594	0.7	22.7	4,525	1.9	64.4	521	0.2	7.4	436	0.2	6.2
2005	152,754	4,580	65	0.0	1.4	3,791	2.5	82.8	655	0.4	14.3	69	0.0	1.5
2006	158,597	5,307	54	0.0	1.0	4,630	2.9	87.2	621	0.4	11.7	2	0.0	0.0
Total	1,903,082	62,025	12,388	0.7	20.0	40,162	2.1	64.8	5,332	0.3	8.6	4,194	0.2	6.8

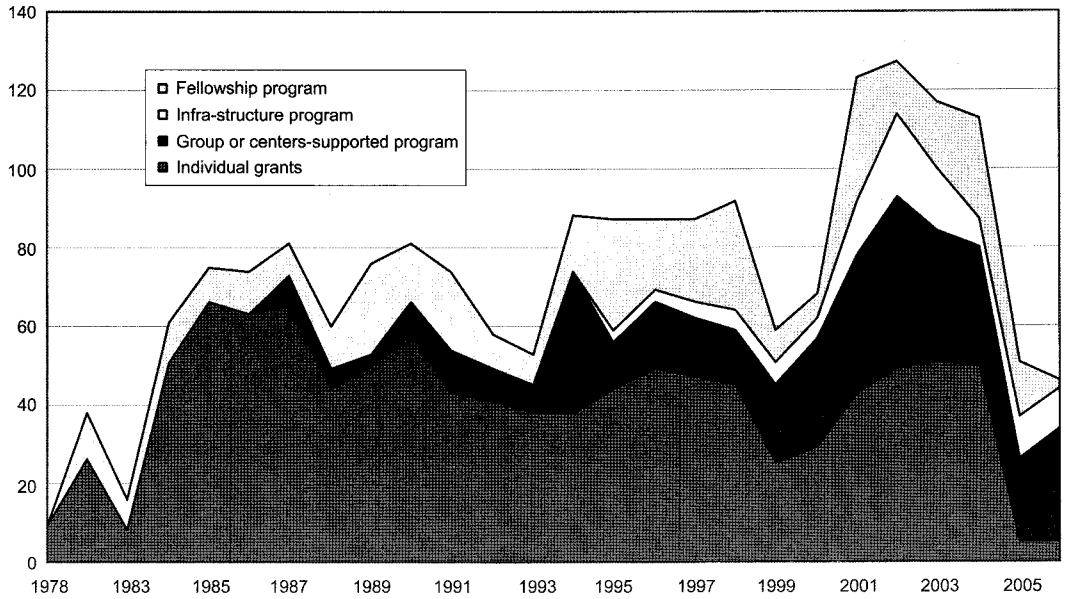

Fig. 2. Types of research programs supported by the Korean Science and Engineering Foundation (KOSEF), and the number of geoscientific research projects.

both the number of projects and the level of funding.

3.1.2. Analysis of research trends in the geosciences by research type

We examined support for individual research projects, group/collective research projects, research infrastructure, and research manpower training. Of the 1,901 projects in the geosciences from 1978-2006, 1,042 (54.8%) were individual projects, 384 (20.2%) were group/collective research projects, 105 (5.5%) were research infrastructure projects, and 370 (19.5%) were manpower training projects. Overseas post-doctoral and graduate fellowship programs were administered by the Korean Research Foundation (KRF), under the Ministry of Education (MOE).

Before 1990, over 70% of research projects involved group studies, and only a few significant projects were initiated by individuals. By contrast, only 26-63% of the projects since 2000 involved group or center-supported programs. In 2006, five grants were given for individual projects, amounting to 10.9% of the total funds allocated to geosciences (**Table 2, Fig. 2**).

Between 1978 and 2006, the geosciences received 62.0 billion won (3.3%) from a budget of 1,903.1 billion won. Of these funds, 12.388 billion won (20.0%) went to individual research programs, 40.162 billion won (64.8%) went to group research, 5.332 billion won (8.6%) went to research infrastructure programs, and 4.194 billion won (6.8%) went to manpower training programs (**Table 3**).

3.1.3. Analysis of research funding trends in the geosciences by sub-field

We examined support for specific sub-fields in the geosciences, including mineralogy, petrology, paleontology and sedimentary geology, geochemistry, structural geology, mineral deposits, geophysics, economic geology, astronomy and atmospheric sciences, oceanography, and others. Of the 5.307 billion won available in 2006, 119 million won (2.2%) went to mineralogy, 351 million won (6.6%) went to petrology, 300 million won (5.7%) went paleontology and sedimentary geology, 530 million won (10.0%) went to geochemistry, 91 million won (1.7%) went to structural geology, 90 million won (1.7%) went to mineral deposits, 190 million won (3.6%) went to geophysics, 18 million won (0.3%) went to economic geology, 2,340 million won (44.1%) went to astronomy and atmospheric sciences, 681 mil-

Table 4. Sub-fields and research grants in the geosciences supported by the Korean Science and Engineering Foundation (KOSEF). (Unit: Constant thousand Won)

Sub-field \ Year	1978	1982	1985	1990	1995	2000	2001	2002	2003	2004	2005	2006 Amount	2006 %
Mineralogy	-	5,800	37,940	52,693	69,120	286,000	214,000	413,000	435,000	192,000	245,000	119,000	2.2
Petrology	-	31,689	43,049	32,000	165,137	134,000	517,024	391,200	255,068	432,012	130,000	350,500	6.6
Paleontology & Sedimentary	11,600	14,014	38,900	50,973	168,271	475,340	520,310	619,959	700,433	578,795	429,000	300,000	5.7
Geochemistry	-	13,030	11,000	51,400	204,800	1,076,141	1,087,367	1,018,467	626,322	1,015,160	541,200	529,631	10.0
Structural Geology	-	3,971	10,000	30,500	152,587	276,000	199,000	274,000	454,000	385,040	101,100	91,000	1.7
Mineral Deposits	-	5,000	32,940	124,058	760,000	38,000	37,000	136,000	93,000	93,000	-	90,000	1.7
Geophysics	10,259	14,977	35,030	126,000	131,198	101,640	306,679	262,280	330,351	219,575	120,000	190,000	3.6
Economic Geology	-	14,402	6,000	66,344	88,740	65,430	22,753	105,129	34,182	11,982	2,314	18,000	0.3
Astronomy & Atmospheric	9,100	12,685	38,123	18,000	161,446	104,000	1,353,307	1,998,266	2,570,972	2,534,725	2,159,000	2,340,200	44.1
Oceanography	-	23,381	103,564	112,400	278,193	685,849	893,817	1,284,207	1,452,500	1,462,023	823,104	681,000	12.8
etc	-	-	-	-	-	141,658	517,727	318,589	460,126	151,204	29,001	597,675	11.3
Total	30,959	138,949	356,546	664,368	2,179,492	3,384,058	5,668,984	6,821,097	7,411,954	7,075,516	4,579,719	5,307,006	100.0

Table 5. Expenditures for academic research and development in the United States of America categorized by field of research (1973-2003). (Unit: Millions of dollars)

Field	1973	1980	1990	1995	1998	1999	2000	2001	2002	2003 Amount	2003 %
					Millions of current dollars						
All fields	2,884	6,063	16,286	22,170	25,855	27,530	30,067	32,797	36,370	40,077	100.0
Science	2,551	5,201	13,630	18,655	21,786	23,269	25,513	27,778	30,848	34,079	85.0
Earth, atmospheric, and ocean sciences	209	508	1,069	1,434	1,624	1,692	1,765	1,831	2,020	2,188	5.5
Earth sciences	NA	188	355	457	514	545	563	555	640	724	1.8
Atmospheric sciences	NA	76	173	208	269	288	288	301	341	396	1.0
Ocean sciences	NA	176	377	473	546	604	633	675	720	774	1.9
Other	209	68	164	295	296	254	281	300	318	294	0.7
Physical sciences	328	677	1,807	2,256	2,483	2,605	2,712	2,804	3,016	3,273	8.2
Mathematics	37	78	222	279	310	313	341	360	388	429	1.1
Computer sciences	36	124	515	682	747	861	876	956	1,125	1,304	3.3
Life sciences	1,530	3,218	8,725	12,188	14,596	15,630	17,468	19,216	21,421	23,764	59.3
Psychology	74	110	253	371	444	464	517	583	672	769	1.9
Social sciences	231	339	703	1,019	1,131	1,252	1,299	1,442	1,586	1,661	4.1
Other sciences	106	146	336	427	449	451	535	586	620	691	1.7
Engineering	333	862	2,656	3,515	4,069	4,261	4,554	5,019	5,522	5,999	15.0

NA=not available

NOTES: Detail may not add to total because of rounding. See appendix table 4-1 for gross domestic product implicit price deflators used to convert current dollars to constant 2000 dollars.

SOURCES: National Science Foundation, Division of Science Resources Statistics, *Academic Research and Development Expenditures: Fiscal Year 2003* (forthcoming); and Integrated Science and Engineering Resources Data System (WebCASPAR), http://webcaspar.nsf.gov.

Science and Engineering Indicators 2006

Table 5. Continued.

Field	1973	1980	1990	1995	1998	1999	2000	2001	2002	2003	
										Amount	%
					Millions of current dollars						
Aeronautical/astronautical	NA	53	164	241	250	260	257	339	343	402	1.0
Bioengineering/biomedical	NA	NA	NA	NA	102	137	174	213	282	314	0.8
Chemical	NA	61	218	297	327	349	376	415	431	454	1.1
Civil	NA	83	284	431	495	529	601	664	717	776	1.9
Electrical/electronic	NA	183	663	819	1,042	1,017	1,118	1,163	1,306	1,402	3.5
Mechanical	NA	140	391	521	568	625	633	687	781	822	2.1
Materials	NA	NA	274	330	391	384	399	453	468	535	1.3
Other	333	341	663	877	894	960	998	1,085	1,195	1,295	3.2

Table 6. Discovery Grants[1] awarded in Canada categorized by field of research (1996-2007).
Expenditures

(Unit: Millions of dollars)

Application[2]	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07p
Advancement of knowledge	1.5	3.3	7.6	8.3	11.9	12.9	14.7	16.4	24.6	30.3	34.9
- Earth sciences	2.4	3.8	4.7	5.8	7.2	7.3	8.1	8.7	9.3	9.9	10.5
- Life sciences (including biotechnology)	30.1	29.3	28.2	30.6	34.7	34.0	37.1	38.4	36.2	37.4	37.3
- Physical sciences	32.4	25.8	32.0	32.1	35.5	34.9	38.3	40.0	35.8	35.6	32.7
- Space and astronomy	2.0	1.6	2.3	4.0	4.4	4.6	4.8	5.7	5.3	5.7	5.6
- Mathematical sciences	9.1	8.7	9.3	10.3	11.0	10.6	11.5	13.4	13.1	13.6	13.6
- Engineering	2.3	3.4	4.4	5.6	6.8	7.2	8.3	10.0	10.1	10.2	10.0
Agriculture and Primary Food Production	11.3	10.1	10.0	9.7	8.8	8.1	9.1	9.7	9.6	10.6	10.6
Natural Resources (Economic Aspects)	4.4	4.6	5.7	5.3	6.4	6.5	7.2	7.4	6.8	6.8	6.0
Energy Resources (Including Production, Exploration, Processing, distribution and use)	6.9	6.9	7.9	8.5	8.9	8.7	9.5	9.4	9.8	10.2	10.6
Environment	21.1	19.9	21.0	22.1	22.2	22.1	24.0	23.8	24.2	25.0	26.2
Manufacturing Processes and Products	36.3	32.5	32.9	30.6	28.0	27.1	28.9	30.2	31.1	34.5	35.2
Construction, Urban and Rural Planning	4.9	4.8	5.6	5.7	5.5	5.4	6.1	6.0	5.6	5.8	5.7
Transportation Systems and Services	2.9	2.7	2.9	3.0	3.1	3.3	3.5	3.6	4.3	5.0	5.5
Information and Communication Services	12.3	14.1	16.8	20.3	26.0	26.2	29.0	32.1	33.6	36.6	37.5
Commercial Services	1.9	1.7	1.7	1.4	1.3	1.1	1.2	1.4	1.2	1.3	1.4
Northern Development	0.7	0.6	0.5	0.5	0.4	0.3	0.5	1.5	2.2	2.9	3.2
Health, Education And Social Services	3.4	4.4	10.5	13.6	16.4	18.2	21.4	22.5	23.6	27.3	29.7
Not Reported	14.5	24.0	20.3	22.3	21.0	15.3	12.6	11.4	9.9	11.1	13.8
TOTAL	200.5	202.3	224.1	239.8	259.2	253.7	275.6	291.5	296.3	319.7	330.1

p. Preliminary

1. Includes all Discovery Grants and Subatomic Physics Discovery Grants.

2. New area of applications effective in 1997-98, and data for previous 9 years have been converted.
http://www.nserc.gc.ca/about/Table2005-2006_e.xls

lion won (12.8%) went to oceanography and 598 million won (11.3%) went to other types of research, including polar sciences (**Table 4**).

3.2. Overseas Research Funding Benchmarking

Our analysis of academic funding in the USA revealed that of the total funds available in 2003 ($40.1 billion), $724 million (1.8%) were allocated to earth sciences and $2.188 billion (5.5%) were allocated to all geosciences, including atmospheric sciences, ocean sciences, and others(NSF, 2006). We noted an increasing trend in the annual funding of geosciences: $0.209, $1.069, $1.765, and $2.188 billion in 1973, 1990, 2000, and 2003, respectively. These figures roughly correspond to data for South Korea (**Table 5**). The Directorate for Geosciences (GEO) of the National Science Foundation (NSF) supports over 11,000 individuals (FY 2003), including senior researchers, postdoctorates, teachers, students, and trainees. In 2004, approximately 63% of the budget ($432 million US) was used to support ideas and people. The GEO actively participates in and contributes to priority areas, including biocomplexity in the environment (BE), information technology research (ITR), nanoscience, mathematical sciences, and human and social dynamics. The primary goals of the GEO are to understand and predict the environment of the earth, which are reflected in their efforts to improve education and training, advance knowledge, and enhance research infrastructure in the geosciences.

Our analysis of academic funding provided by the National Science and Engineering Research Council of Canada (NSERC) shows that of a total of $330 million Canadian (2006-2007), $10.5 million (3.2%) were allocated to the earth sciences and $34.9 million (10.6%) were allocated to advancing knowledge, including the life sciences, physical sciences, space and astronomy, mathematics, engineering, and others. Once again, the annual funding for earth sciences tended to increase: $2.4, $7.2, $8.7, and $10.5 million in 1996-1997, in 2000-2001, 2003-2004, and 2006-2007, respectively(NSERC, 2007). These figures also roughly correspond to data for South Korea (**Table 6**).

Finally, our analysis of academic funding in Australia shows that a total of $478 million Australian (2004-2005) was allocated to the earth sciences. These funds were contributed by the government ($230 million), the business sector ($120 million), and institutions of higher education ($128 million) (Australian Bureau of Statistics, 2005) (**Table 7**).

4. Discussion

Basic research provides society with practical information, new forms of mechanization and

Table 7. Expenditure on research and development in Australia categorized by sector and field of research (2004-2005).
(Unit : Millions of current Austalian dollars)

Field	Business	Government			Higher Education	Private Non-profit	Total
		Common-wealth	*State /territory*	Total			
Mathematical Sciences	14	29	9	38	90	NA	142
Physical Sciences	41	127	-	128	151	-	320
Chemical Sciences	212	99	13	113	186	NA	511
Earth Sciences	120	207	23	230	128	NA	478
Biological Sciences	193	165	140	306	451	96	1,046
Information, computing & comm. Sci.	2,209	124	9	133	204	2	2,548
Engineering & technology	4,820	410	17	426	474	NA	5,720
Agricultural, veterinary & Environ. Sci.	225	282	480	762	292	NA	1,279
Architecture, urban environ.& building	22	3	2	5	32	-	59
Medical & health sciences	548	50	240	290	1,082	357	2,277
Human & Social Sciences	42	78	44	120	1,193	38	1,393
Total	8,446	1,574	977	2,551	4,283	493	15,773

NA = not available

methodologies, skilled manpower, and a systematic organizational structure based on expertise and technological solutions to problems, and leads to the creation of new companies (Nature, 1996). As a result, research funding has been the fastest growing item in the national budget. However, the geosciences will inevitably require more stable longer-term investment than that offered to other fields. Stable academic and research opportunities are required to prevent the brain drain of promising new researchers and graduates. Furthermore, it is necessary to strengthen our research competitiveness in order to entice our brightest minds to return to Korea and occupy positions of leadership in society and research institutes.

We analyzed both the strengths and weaknesses of the research environment within South Korea, as well as the opportunities and threats posed by the external environment, in relation to other academic fields. In comparison with other fields, the geosciences are not far behind the most advanced countries in terms of skilled manpower, the advanced level of research facilities, and research and technological capabilities.

However, the internal research environment has a number of severe limitations. First, relatively little effort has been made to strengthen relationships between different academic fields or to generate new inter-disciplinary areas; this is because the relevant societies and research institutes have failed to assume leadership in this respect. Second, research endeavors undertaken by universities have not diversified and have, instead, been grouped according to the specific background of each university. Third, few government officials, such as ministers and vice-ministers, are qualified to take part in the decision-making process regarding geoscientific research; this is in contrast to other areas, such as the social sciences, physics, chemistry, life sciences, and engineering. Furthermore, opportunities for these officials to do so have been limited considerably.

As interest in the global environment increases, the external environment will offer more opportunities to expand geoscientific research. Many international cooperative research projects are presently underway, which is made possible by the relatively small gap in research capabilities, even in relation to the most scientifically advanced nations. However, the external environment may also pose a threat in that stable, creative long-term research activities have not been implemented smoothly in such visible areas as the National 10 Growth Propulsion Power and Technology Guidance Projects.

5. Concluding Remarks

Given the severe environmental problems facing the world, geoscientific research is critical for training those who will contribute much-needed solutions. The main goals for geoscientific research in South Korea should be advancing knowledge concerning geological systems, enhancing research facilities, and improving education and training.

In general, funding for the geosciences has increased steadily since 1978, in terms of both the number of projects and the level of funding. Between 1978 and 2006, KOSEF invested 62.1 billion won in a total of 1,901 projects in the geosciences. Over the period studied, the geosciences received between 2.6 and 10.6% of the grant money available in a given year. From 1978 to 2006, the total number of projects increased by a factor of 5.1, whereas the corresponding research expenses increased by a factor of 171.2.

Geoscientific research in South Korea has several notable strengths, including the excellent quality of researchers, well-established research infrastructure, cooperation among the sub-fields, and various inter-disciplinary research trends. The following initiatives are required to further encourage geoscientific research in South Korea: 1) the formulation of mid- and long-term research strategies; 2) the development of a database cataloging manpower in related fields; 3) the promotion of top-down research topics and increases in individual research grants; 4) the development of national programs to promote basic research; 5) the organization of a committee to oversee policy-formation and cooperation within related societies; and 6) a system to fairly evaluate output from research activities.

Productivity and applicability are two important factors that need to be considered in science and technology. Publications and patents are two visible outputs of R&D productivity. Researchers in the geosciences need to increase their productivity

based on the goals of a government-supported research program.

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