Developing Geology in a Newly Industrialized Economy: The Republic of Korea

by Antony J. Reedman

This article examines briefly the growth of the geological sciences in South Korea during its transition from developing to industrialized status. International technical cooperation, especially between the United Kingdom and South Korea, has played an important role in this process, and the author, who has been associated with British assistance for many years, reviews here some of the problems that arose because of the demands made on Korean geologists and geological institutions. The greatest impact on national geological capability has come from training overseas, and important future tasks include the development of national geoscience data bases. (Ed.)

Introduction

The Republic of Korea (Fig. 1) is a fairly small country with a land area of just under 100,000 km² and a population of 42 million. It is unusual, however, in being one of the very few countries that have evolved from "developing" to "newly industrialized" status during the last few decades. The growth of its economy since the mid-1960's has been remarkable; between 1970 and 1986, for example, the GNP rose from over \$8 billion to \$94 billion, at current prices, and the per capita GNP from \$248 to \$2268. Over the same period the value of exports rose by 3500% to over \$30 billion per annum. By 1986 Korea had become the twelfth largest trading nation in the world, and in the same year a \$4.65 billion trade surplus was recorded. Annual expenditure on scientific research and development had reached \$1.3 billion, or 1.56% of the GNP, by 1985 and was targeted to reach 2% in 1986, comparable with many of the developed countries of the world.

This rapid expansion embraced many activities involving geological knowledge. Most conspicuous were large civil engineering and construction projects: highway, subway, dam, port and nuclear power station construction, land reclamation and irrigation projects. In addition, the huge growth in demand for raw materials stimulated the domestic mining and quarrying industries. Coal production increased by almost 70% to over 20 m tonnes per annum, and limestone production also increased very significantly to sustain growth in cement manufacture (Table 1).

There was continued, and in some cases expanded, production of a variety of ores including tungsten, silver, lead, zinc, iron and talc. Limited reserves, however, dictated that most of the increase in demand for mineral raw materials was met by increased imports. Nevertheless, between 1970 and 1985 the number of people employed in the mining sector rose by over 40% to 164,000. In addition there was increased activity in mineral exploration, both by

Government agencies such as the Geological Survey, the Korean Mining Promotion Corporation and the Daehan Coal Corporation and by the larger Korean mining companies.

Geological Mapping

One measure of a nation's geological development is the progress and standards of the national geological surveying program. The geology of Korea is extremely varied (Fig. 1); almost all the geological systems are represented and, being situated at the east Asian/Pacific margin, it has suffered a long and complicated tectonic history (Reedman and Um, 1975). Precambrian gneisses and schists, some probably of Archaean age, crop out extensively and form the basement

Figure 1: Geological sketch map of the Republic of Korea. 1 - Precambrian, 2 - Palaeozoic strata, 3 - Mesozoic strata, 4 - Mesozoic granites.

upon which lower Palaeozoic shelf carbonate sequences and Upper Carboniferous to Triassic marine to non-marine coal-bearing sequences were deposited. Deeper water lower Palaeozoic siliciclastic sediments, including thick debris flows, were deposited in a zone trending northeast across the peninsula and linked to the Jiangnan facies of the Yangtse area of China.

All the rocks were folded and metamorphosed in late Triassic times and again in the mid-Jurassic 'Daebo' orogeny, following Early Jurassic non-marine sedimentation in small intermontane molasse basins. Batholithic granites were intruded during Middle to Late Jurassic times. However, most non-ferrous metallic mineral deposits are related to the Bulgugsa granite series (Fig. 2) intruded as sub-volcanic complexes of Late Cretaceous to early Tertiary age, mainly in the southeast of the peninsula where a thick sequence of Cretaceous non-marine sediments and calc-alkaline extrusive volcanic rocks accumulated.

Systematic surveying of the geology began with the founding of the Geological Survey of Korea in 1918 (Fig. 3), during the Japanese occupation of the Korean peninsula. By 1938, 61 map sheets had been surveyed and published at a 1:50,000 scale. Of these, 24 sheets were within the boundaries of the present-day Republic of Korea, representing about 7% of its land area, the rest in the Democratic People's Republic of Korea. In 1948, following the Second World War and the partitioning of Korea, a geological survey for the southern part of the peninsula, to be known as the Central Geological and Mineralogical Research Centre (Fig. 3), was established in Seoul, but its development was tragically interrupted by the onset of the Korean War in 1950. In 1956, the Central Geological and Mineralogical Research Centre was combined with the Taejeon Mineral Laboratory and, with its headquarters in Seoul, was renamed the Geological Survey of Korea in 1962. Systematic geological mapping and publication of 1:50,000 maps had recommenced in 1961.

TABLE 1: 1984 Major Mineral Production (in metric tonnes) of Republic of Korea

Iron Ore	553,000	Silver (Refined)	52,000
Tungsten Conc.	4,480	Coal	21,000,000
Lead Ore	20,000	Limestone	31,200,000
Zinc Ore	106,000	Kaolin	212,000

By 1970 the Survey was staffed by about 120 Korean earth scientists, almost equally divided between the General Geology and the Exploration Geology divisions. The former was responsible for geological mapping, coalfield studies, palaeontology, ore deposit geology and mineralogy; the latter comprised geophysical and geochemical exploration sections. The remit of the Survey was "to contribute to the nation's economic development by gaining knowledge of the geologic distribution and occurrence of mineral resources throughout the country, and to conduct research work in the earth sciences." Emphasis was placed on mineral exploration but, although resources and manpower were limited, the Survey did not neglect its responsibility to develop the geological map of Korea as an essential framework for all its other activities. Its subsequent success in the rapid survey and publication of geological maps is one of the Survey's most notable achievements.

Staff numbers in the Survey grew steadily after 1970, as it underwent several changes of name (Fig. 3) and a broadening of its responsibilities to include mineral-dressing, mining and mine-safety research and, with the formation of the Korea Institute of Energy and Resources (KIER), research into the exploitation of wind, solar and tidal energy. However, the section responsible for geological mapping never contained more than 15 geologists and is currently smaller than it was in 1970.

Nevertheless, between 1961 and 1987, 221 1:50,000 map sheets were surveyed, representing over 70% of the total land surface of the Republic, and by the end of 1987, 195 1:50,000 sheets had been published together with short explanatory booklets with Korean text and an English abstract. Furthermore in 1986, with the 1:50,000 survey so well advanced, a program of 1:10,000 surveying of selected areas, with publication at 1:25,000, was started and the first 1:25,000 sheet completed by 1987.

The Role of University and Society Geologists in Mapping

This remarkable achievement by the Survey was facilitated by the establishment of a joint mapping program with the Geological Society of Korea, whereby each year the Society contracted to map several sheets, using geologists drawn from university departments, while the Mapping Section of the Survey was itself responsible for several other sheets. This important example of cooperation between governmental and non-governmental organizations in pursuance of a nationwide survey program arose from a decision taken in

Figure 2: Stonework at Bulgugsa, the temple after which one of the major Mesozoic episodes of granite intrusion in Korea is named. The granites are widely used as facing and paving slabs in the present-day construction industry.

1960 to mobilize a large team of survey and academic geologists, under the umbrella of the Geological Society, to carry out a rapid survey of the stratigraphically important Palaeozoic rocks of the Taebaegsan region. In this region are many of the coal and limestone resources of the country and its largest tungsten deposit (e.g. Fig. 4).

Thirteen 1:50,000 sheets were surveyed in 1961 and published in 1962, and the huge success of this initial scheme led to its establishment as a permanent feature of Korea's systematic mapping program. Currently, each sheet (416 km²) takes two to three geologists two years to complete, with six to ten sheets completed each year. Overall responsibility for approval and publication of the maps lies with the Survey.

Such an ambitious mapping program, undertaken with limited resources, was bound to have some shortcomings. In the early years many of the best maps were made by the university personnel, the majority of whom had previously served with the Geological Survey. In the 1970's, however, standards became more uneven as university departments expanded, teaching pressures increased and, as a consequence, much of the field work on contracted out maps was undertaken by relatively inexperienced students. Accordingly sheets mapped by Survey geologists, who, in addition to their greater experience, were generally able to devote more time to field work, tended to be of a higher standard.

More seriously, the schedule for completion and publication of each map included no time for the systematic duration of notebooks, field slips, rock specimens and thin sections. As a result, a large part of the data set resulting from the

surveys is now irretrievably lost. Similarly no resources were available for the collection and storage of geological data from the huge number of temporary excavations and boreholes sunk during major civil engineering and other development projects, and there was no legislation requiring information from boreholes, for example, to be notified to the Survey. With hindsight, it could be argued that a policy that accepted a slower rate of geological map production, but placed more emphasis on the acquisition and storage of data, additional to that incorporated into the published maps, would have been preferable. However, this should not

Figure 3: History of the development of the Geological Survey of Korea and its successor organizations, 1918 to the present.

be allowed to detract from the enviable record of the Survey in virtually completing the 1:50,000 survey of the Republic in less than 30 years. The task of 'capturing' ephemeral geological information and establishing and managing a national geosciences database and information system is an urgent problem that remains to be tackled.

The Geological Society of Korea

The Geological Society of Korea was founded in 1947 with an initial membership of nine. This had grown to 260 by 1970 and is currently 650, an indication of the rapid growth of the geological community in Korea. The *Journal of the Geological Society* has been published since 1964, with an increasing proportion of papers (over 50% by 1983) in English. The Society has recently sponsored the first comprehensive account of the geology of Korea to be written, in English, entirely by Korean authors (Lee, 1987).

The growth in specialist interests within the geological community resulted in the founding of the Korean Institute of Mining Geology in 1968 (currently 300 members), the Palaeontological Society of Korea in 1984 (150 members), Mineralogical Society of Korea in 1985 (120 members) and in 1986 the Quaternary Society of Korea.

Geology in the Universities

Confucianist philosophy, which has had a profound influence on Korean thought, lays great emphasis on education. This, together with the introduction of a simple 24 character

alphabet in the fifteenth century, has resulted in Korea having for several centuries one of the highest literacy rates in the world. The new demands of industrialization have seen a huge increase in higher education; by 1985 there were over 870,000 students, about 2% of the population, attending 99 four-year vocational and technical colleges and universities, and a further 63,000 postgraduate students studying for higher degrees.

The first geology department was founded at Seoul National University in 1946. By 1970 there were five departments and about 100 students graduating with first degrees each year. This has now grown to 11 departments with approximately 450 graduating annually (Table 2). Not only has geological education increased in quantity, it has generally improved in quality and variety. This has resulted largely from the recruitment of a younger generation of more specialized staff many of whom have studied overseas. Their experiences have also encouraged relaxation of the previously very formal teacher/pupil relationship based on the strict Confucianist tenets of unquestioning respect for and acceptance of the teacher's wisdom.

Most of the departments have established graduate schools, but so far there has been only a limited attempt to provide advanced training and research opportunities in applied topics, such as Engineering Geology, where current and future employment prospects are good. Such courses require staff with relevant training and practical experience, and only now are they becoming available. A further weakness is the lack of expenditure on the modern equipment required to sustain up-to-date training and research.

Foreign Involvement in Korean Geology

The first well-documented foreign contribution to geological studies in Korea was by a German, O.C. Gottsche, who visited the country at the invitation of the Korean Government in 1884 and published a brief summary of the geology of the peninsula in 1886. Subsequent early studies were mainly by Japanese geologists, and this was almost exclusively the case following the Japanese annexation in 1910 until the end of the Second World War (e.g. Koto, 1903; Kawasaki, 1926; Kobayashi, 1966). Only after the liberation did Korean geologists become primarily responsible for the development of the science in their country.

International cooperation has played an important role in this process, and assistance has been contributed in two forms: bilateral aid on a country to country basis and multi-lateral aid, mainly through the various agencies of the UN. Prior to 1970, most of the bilateral aid in geology came from the U.S.A., under the auspices of the United States Overseas Mission (USOM). The U.S. Geological Survey (USGS) started to collect data on the mineral resources of

TABLE 2: Universities with Geology/Earth Science Departments and Year of Establishment of Department.

SEOUL NATIONAL UNIVERSITY	(1946)
PUSAN NATIONAL UNIVERSITY	(1957/9)
KYONGBUK NATIONAL UNIVERSITY	(1957/9)
YONSEI UNIVERSITY	(1965)
KOREA UNIVERSITY	(1969)
KANGWON NATIONAL UNIVERSITY	(1979)
CHUNGNAM NATIONAL UNIVERSITY	(1979)
CHONNAM NATIONAL UNIVERSITY	(1979)
PUSAN FISHERY UNIVERSITY	(1982)
CHONBUK NATIONAL UNIVERSITY	(1985)
ANDONG UNIVERSITY	(1988)
Department of Applied Geology	

Korea during the military occupation in 1946. A detailed geological study of the coalfields of South Korea was made by USGS geologists in collaboration with the Geological Survey of Korea in 1949 and 1950 (Baldwin, 1957; Brill, 1957; Reinemund, 1957).

Following the Korean War, in the 1960's, USOM sponsored an extensive series of surveys of Korean mineral deposits and mineralized regions by American consultants working under the auspices of Mineral Industries Engineers Incorporated (Seoul). These studies were carried out in collaboration with the Geological Survey of Korea, but as a series of separate operations that were never fully integrated into the Survey's program. For this reason, although they provided a wealth of useful data contained in numerous unpublished USOM reports, they had less impact on the development of the Survey than might otherwise have been the case.

Figure 4: Recumbent fold in Permian coal-bearing strata of the Gangneung Coalfield illustrating the complex structural conditions found in many Korean coalfields.

During the 1960's, again in collaboration with the Geological Survey, geologists from West Germany undertook a rapid assessment of several coalfields and of the Sangdong tungsten deposit (Gabert and Vinken, 1964, 1967). Later the Federal Institute of Geoscience and Mineral Resources of West Germany (BGR) cooperated in a seismic survey aimed at revealing possible seaward extensions of coal seams and the hydrocarbon potential off the east coast of Korea (Schlüter and Chun, 1974). More recently there have been modest technical assistance programs provided by Japan and some extensive airborne geophysical surveys under the auspices of the UNDP.

British Geological Assistance

Geological aid to Korea from Britain, financed by the Ministry of Overseas Development (ODM), began in 1971 and resulted in the development of a close relationship between the Geological Survey of Korea and the Institute of Geological Sciences (now the British Geological Survey) that continues to the present day. The evolution of this relationship is particularly interesting for it records the transition from "aid" to "collaborative research" as the intellectual and economic resources of Korea were rapidly developed. The joint programs fall into three categories, with the emphasis successively moving from long-term or "residential" Technical Cooperation (TC) projects to short-term TC projects and consultancies, and finally to the programs of joint research and Korean funded consultancies, which superseded the "Aid" program (Fig. 5).

From 1971 to 1976, BGS staff seconded to ODM and resident in Korea, worked alongside their counterparts in the Geo-

logical Survey of Korea and its successor organization (Fig. 3). Four geologists and a geophysicist spent a total of eight years in Korea working initially on multidisciplinary regional mineral exploration and mapping projects (Fig. 6) and then on coalfield mapping and sedimentological studies. "On the job" training for Korean geologists was an important element of the program. To facilitate this the projects were conducted entirely from the appropriate section of the Geological Survey of Korea, thus providing daily contact not only with counterparts wholly dedicated to the projects, but also with a wide range of Survey geologists.

In addition to training in Korea, staff of the Survey were sent to BGS laboratories in the U.K. to gain experience in specialized areas, including clay mineralogy, geological curation, analytical chemistry and the organization of surveys for industrial minerals. In areas where a major gap in Korean geological research was recognized such as geochemistry, engineering geology, late Palaeozoic and Mesozoic palaeobotany, and structural geology, qualified members of the Survey were sent with support from the British Council to U.K. universities for postgraduate studies. To date, 13 geologists have completed postgraduate training in areas recognized to be a high priority during the period of residential TC projects (Fig. 5), three being awarded MSc and five PhD, degrees. Other Survey geologists have gained higher degrees in the U.S.A., Japan, West Germany, Australia and France.

The long-term residential TC resulted in the publication in Korea of two books of wider scope than the immediate objectives of the projects. First, growing out of structural geology courses run by the BGS team, a book on the description and analysis of minor structures in folded sequences, using entirely Korean examples, was published in Korean and English (Fletcher, 1975). The second book, a comprehensive geology of the Republic of Korea (Reedman and Um, 1975) and the first to be published in English, has been widely used in Korean universities as a standard text.

Between 1973 and 1978, 15 short-term TC projects were funded by ODM within the Geological Survey of Korea and its successor organizations (Fig. 5). These projects involved

RESIDENTIAL (LONG-TERM) TECHNICAL COOPERATION		SHORT-TERM TECHNICAL COOPERATION
1971	↑ GEOLOGICAL MAPPING AND MINERAL EXPLORATION (4) <u>65</u>	
1972		
1973	↓ MINERAL EXPLORATION (1) <u>15</u>	Electronics laboratory; gravity network (1) <u>4</u>
1974		Mine geology; analytical chemistry; applied geochemistry (3) <u>17</u>
1975	↑ COALFIELD GEOLOGY (1) <u>15</u>	Mine geology; compilation of Geology of Korea (1) <u>12</u>
1976		Exploration geophysics; Oil appraisal (2) <u>9</u>
1977		Exploration geophysics; engineering geology; seismic surveys (5) <u>6.5</u>
1978		Seismic surveys (1) <u>4</u>
1979	COLLABORATIVE RESEARCH	
	Advanced workshops - mapping volcanic sequences Research on Cretaceous-Pleistocene explosive volcanism and volcanogenic mineralisation	

Figure 5: British assistance to the Geological Survey of Korea and its successor organizations and collaborative research between the BGS and KIER. Figures in round brackets refer to the number of British geologists involved, and figures in square brackets are total time spent on project in months.

British earth scientists spending between one and four months in Korea, either to undertake a very specific technical task, such as connecting the Korean gravity network to the International Gravity Reference System, or to carry out a specific training exercise such as upgrading techniques in analytical geochemistry, or to make an economic appraisal such as the assessment of the oil and gas potential of the Gyeongsang Basin. Many of the earlier projects resulted from the evolving requirements of the long-term residential projects, but latterly most resulted from requests made directly by the Korean Government, and in some cases involved follow-up work to multinational projects such as the UNDP airborne geophysical surveys. These short term TC projects, came to an end in 1978 when British bilateral assistance to Korea was virtually terminated due to the latter's improved economic status.

With the end of this bilateral assistance, the relationship between BGS and the Korean Research Institute of Geoscience and Mineral Resources Survey (later KIER) had to be based on different financial arrangements. A memorandum of understanding between the two organizations, expressing the intention of developing mutually financed research links, was signed in 1979. Since that time a modest program of joint research into explosive volcanism and volcanogenic mineralization has been developed. This has involved the attachment of Korean geologists to a BGS team investigating classic Ordovician volcanic sequences and associated mineralization in North Wales (e.g. Reedman et al., 1985), and BGS geologists working on Cretaceous to Pleistocene volcanism (Fig. 7) and mineralization in Korea (Kim et al., 1986; Reedman et al., 1987). The program has been variously funded by BGS and the Royal Society on the British side and by KIER, the Ministry of Science and Technology, and the Asian Development Bank on the Korean side.

The British Council, the body responsible for fostering Britain's overseas scientific and cultural links, has continued to fund postgraduate and postdoctoral studies by KIER staff at British universities. It has also sponsored workshops in structural geology, conducted by British experts. Taken together with the bilateral training schemes of other countries, much has been achieved in improving Korea's geological capabilities. A measure of the overall increase in expertise between 1970 and 1987 can be seen from the fact that one out of 120 staff members of the Geological Survey of Korea in 1970 held a Ph.D. degree compared to 57 out of 230 staff in the Resources Laboratory of KIER in 1987.

In a few cases in recent years KIER has also secured the services of BGS staff, at full economic cost, on a consultancy basis. This arrangement is strictly commercial and separate from any collaborative research arrangements.

Figure 6: A BGS Landrover being ferried across a river together with more traditional means of transport in 1971.

Planning Technical Cooperation

Most Koreans would probably admit to being taken completely by surprise by the sustained pace of economic growth in their country since the mid-1960s, and particularly in the early years of that period. In 1971, when the author first arrived in Korea, the offices of the Geological Survey, situated at the side of the noisy main Seoul to Pusan railway line, were small and overcrowded, and experienced scientific staff were paid little more than a subsistence wage. Though there was plenty of enthusiasm for geology as a science, there was no widespread vision concerning the growth that was to ensue, and this situation extended across the whole geological community. Accordingly, no overall strategy was ever formulated for developing the educational facilities and the various national geological institutions to cope with the likely demand for particular geological services, generated by the continuous rapid growth of the economy.

Figure 7: Dissected tuff cone at Ilchulbong, Cheju Island, currently the subject of collaborative research between geologists from BGS and KIER. The crater rim is 70 m above the water.

Certain individual institutions, such as the Geological Survey, undertook a series of 'forward-looks' at their own programs, as required by successive five-year economic plans, but in general the changing emphasis given to different activities developed as largely *ad hoc* responses to changes in the external economic and political climate. The most important of these was the steep rise in oil prices in 1973, which resulted in a renewed emphasis on coal exploration and the search for domestic oil and gas resources, leading to a significant increase in the offshore surveys of the Geological Survey (Chough, 1983).

Inevitably, the international aid program has also been responsive rather than innovative. It undertook those tasks of geological investigation and provided the training that the geological administrators of the time considered most relevant. However, managers in all government organizations tend to be conservative, and the pace of industrial and economic change far exceeded the rate at which newly trained counterparts could expect promotion to positions where they could influence policy. Accordingly, the various aid programs did not have any immediate effect on the way the national geological institutions perceived, or responded to, the demands of national development.

Reviewing the British aid program, for example, it can be said that all the training activities were useful in increasing that capability and confidence of the counterparts involved, but these were mainly aimed at strengthening areas of current activity. Only in two instances was a major impetus given to the development of expertise in new or neglected areas (structural geology and engineering geology), and in

both cases suitable staff were identified and sent to the U.K. for postgraduate training. The subsequent movement of some of these staff from the Survey to teaching positions in universities has magnified the effect by providing relevant training for new generations of Korean geologists.

The Cultural Factor

Technical cooperation does not take place in a vacuum; participants must be sensitive to the cultural environment within which they operate. This may be stating the obvious, but it is surprising how often the need for an appreciation of the national personality is either forgotten or viewed with an impatience verging on intolerance. This can have serious consequences for the long-term success of projects.

For example, Koreans have a developed sense of "nunch'i," literally "eye-measure," which demands circumspection in responding to new situations. This ensures the most appropriate response, rather than the immediately most logical or reasonable course of action, bearing in mind the paramount importance of the human relationships involved. In Korea, feelings of goodwill should never be sacrificed solely for scientific efficiency. To do so would be to court the possibility of a polite, but firm withdrawal of cooperation. Such lessons are best learned, and the necessary close relationships established, within the framework of long-term projects closely integrated into an appropriate institution, as was the case with the early British projects. It is from this base that successful collaborative research projects have evolved after the end of the "aid" program.

The Need for a National Geoscience Database

Geological surveys of many developed nations periodically stress their vital role as the national repository for geoscience information. This is the area in which none of the various technical cooperation programs in Korea has had any lasting impact, and which remains to be adequately addressed by KIER, as the appropriate public institution.

There are two reasons why there is no such repository of unpublished geological information in Korea, other than some geochemical and regional onshore and offshore geophysical databases. First there has been a historic lack of provision of resources to collect and store the huge amount of ephemeral data available during the lives of the multiplicity of large construction and exploration projects undertaken in Korea in the last two decades. Second there has been no underpinning legislation that requires borehole and other information to be provided to an appropriate public body. The construction and management of such a database, using modern electronic methods, will be vital in providing information both for feasibility and planning studies of future projects and for environmental protection.

Geoscience Education

Expansion of earth science education in the Universities over the last 30 years has more than coped with the rise in demand for trained earth scientists. Korea currently graduates geologists at an annual rate of one per 90,000 of the population, virtually the same rate as in Western Europe (one per 93,000). No accurate employment statistics are available, but many find employment outside geology. This expansion has taken place in the context of a mixed private and public sector university system, growth in the former being dictated by the capacity to attract fee-paying students rather than by any overview of ultimate demand from public and private industry.

Viewed solely from the viewpoint of vocational utility, there is currently a need for good postgraduate courses in most branches of applied geology. There is also a requirement to build up the self confidence of postgraduate schools, which often regard their own courses as second best to overseas studies. Closer links with overseas departments and interchanges between staff supervising both foreign and Korean research students working on problems of Korean geology

would be a stimulating way forward. Equally, the concentration of more resources into the provision of good equipment in existing departments, rather than the formation of yet more new ones should be a priority.

Finally, it may be noted that in moving from "developing" to "newly industrialized" status, the major problems currently facing the geological community are precisely those now causing such debate in the United Kingdom. These are the means of providing the best and most relevant earth science education and the organization and funding of a 'Geological Survey' capable of sustaining and developing the national geosciences database. It will be instructive a decade or so hence to compare the Korean and British solutions.

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References

- Baldwin, E.M., 1957. Coalfields of the Republic of Korea, Part 2, Geology of Hambak coalfield. U.S. Geological Survey Bulletin, 1041-D, p. 49-73.
- Brill, K.G., 1957. Coalfields of the Republic of Korea, Part 2, Geology of Tanyang coalfield. U.S. Geological Survey Bulletin, 1041-E, p. 75-99.
- Chough, S.K., 1983. Marine Geology of Korean Seas. International Human Resources Development Corporation, Boston, U.S.A., 157p.
- Fletcher, C.J.N., 1975. Structures in folded rocks. Geological and Mineral Institute of Korea, Seoul, 77p.
- Gabert, G. and Vinken, R., 1964. Die Scheelitlagerstätte Sangdong (Sudkorea), ihre Genese und ihr geologisch-tektonischer Rahmen. Geologischen Rundschau, v. 54, no. 2, p. 906-925.
- Gabert, G. and Vinken R., 1967. Steinkohlenlagerstätten im Taebaek-Gebiet (Sudkorea). Bundesanstalt für Bodenforschung und Geologische Landesämter. Geologisches Jahrbuch v. 84, p. 463-484.
- Gottsche, C., 1886. Geologische Skizze von Korea. Preussische Akademie der Wissenschaften zu Berlin, 36, p. 875-876.
- Kawasaki, S., 1926. Geology and Mineral Resources of Korea. Geology and Mineral Resources of the Japanese Empire, pt. 2, 109p.
- Kim, D.H., Hwang, J.H., Hwang, S.K., Howells, M.F. and Reedman, A.J., 1986. Tuff rings and cones on Jeju Island, Korea. Journal of the Geological Society of Korea, v. 22, no. 1, p. 1-9.
- Kobayashi, T., 1966. Stratigraphy of the Chosen Group in Korea and South Manchuria and its relation to the CambroOrdovician Formations of other areas. The CambroOrdovician formations and faunas of South Korea. Part 10 - Section A. The Chosen Group of South Korea. Journal of the Faculty of Science of Tokyo University, Section 2, v. 16, pt. 1, p. 21-84.
- Koto, B., 1903. An orographic sketch of Korea. Journal of the College of Science, Imperial University of Tokyo, v. 19, article 1.
- Lee Dai-Sung, (ed.), 1987. Geology of Korea. Geological Society of Korea. The Kyohak-Sa Publishing Co., Seoul, Korea, 514p.
- Reedman, A.J., Colman, T.B., Campbell, S.D.G. and Howells, M.F., 1985. Volcanogenic mineralization related to the Snowdon Volcanic Group (Ordovician), Gwynedd, N. Wales. Journal of the Geological Society of London, v. 142, pt. 5, p. 875-888.
- Reedman, A.J., Park, K.H., Merriman, R.J. and Kim, S.E., 1987. Welded tuff infilling a volcanic vent at Weolseong, Republic of Korea. Bulletin of Volcanology, v. 49, no. 3, p. 541-546.
- Reedman, A.J. and Um, S.H., 1975. The Geology of Korea. Geological and Mineral Institute of Korea, Seoul, 139p.
- Reinemund, J.A., 1957. Coalfields of the Republic of Korea, Part 2, Geology of Macha-ri coalfield. U.S. Geological Survey Bulletin, 1041-C, p. 11-47.
- Schlüter, H.U. and Chun, W.C., 1974. Seismic survey off the east coast of Korea. UN ECAFE. Technical Bulletin, no. 8, p. 1-15.