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Engineering geoscience in Korea - from mining to fusion technology

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Abstract: Fusion technology is a key to maximize innovative potential of geoscience for many challenging issues today that require integrated multi-disciplinary approach. Successful fusion technological advance can be achieved when interdisciplinary cooperation is firmly established. In order to establish firm the context of interdisciplinarity that is still feeble, it is urgent to continuously develop geoscientific models and systematic infra for interdisciplinary cooperation such as well-prepared geo-spatial database and knowledge base network that can support multi-lateral cooperation between multiple disciplines and multi-phase international cooperation.

1. Introduction

Korean geoscience has been developed with mining business during past nine decades since it was introduced as a modern mining engineering in the early twentieth century.

Until 1980's, mining business had played significant role of supplier of primary resources to industry during industrialization of Korea. Therefore, geoscientific activities have been mainly focused, from mining-based point of view, on securing and utilization of strategic resources, i.e., investigation, exploration and exploitation, and utilization of mineral and energy resources.

On the other hand, in 1990's when global transformation to post-industrial society accelerated, the industrial structure of Korea has continuously diversified with focusing on higher value-added industries. As a result, the contribution of mining sector to national industrial structure has rapidly decreased while the share of the other sectors such as Construction and SOC sector has steadily increased. In accordance with this circumstance, since 1990, the theme of geoscientific activities have shifted to geo-engineering and environmental issues related to natural hazards and national securities, public health and social safety, resources and environment, etc. in order to expand the scope of geoscience to comprehensive geosystem engineering.

The transition from mining to geosystem engineering started in 1990's is considered successful in that geoscientific disciplines have continuously diversified their horizon. However, challenging issues become more diverse and broaden. Therefore, in order to enhance the potential of geoscientific disciplines, it is urgent to develop geoscientific fusion technologies based on the context of interdisciplinary cooperation.

In this paper, I briefly review the history of geoscience in Korea from the mining point of view and discuss some factors that are necessary for fusion technological advance of geoscientific disciplines.

2. Geology of Korea and distribution of major mineral resources

Geology of Korea consists mainly of Precambrian gneisses and granitic gneisses, Mesozoic granite, and sedimentary rocks of Precambrian, Paleozoic, and Mesozoic age. Precambrian gneisses and Mesozoic granite cover more than half of Korean peninsular. Paleozoic marine sediments deposited in the middle eastern part of North and South Korea. Mesozoic sedimentary basin is deposited southeastern part of South Korea and thick Quaternary basalts are deposited in Mt. Baekdu and Jeju Island.

Tectonically, the Precambrian basement is divided into three massifs by two Paleozoic fold belts. Active tectonic movements were in post-Mesozoic era. Intensive folding, faulting, intrusion of magma, and active volcanism during this period, especially the late Tertiary to the early Quaternary, are considered to form present geomorphologic formations.

Korea is moderately rich in mineral resources (Kim et al., 1972).

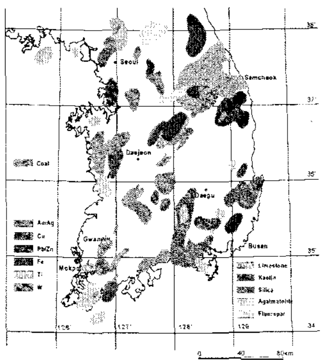

Fig. 1. Distribution of major mineral resources in Korea.

Tungsten, bismuth, anthracite, lead, zinc, iron, talc, kaolin, silica and fluorite are major mineral products in Korea. Gold and silver, copper, molybdenum, graphite, tin, etc. are minor mineral products. The distribution of anthracite is related to the late Paleozoic sediments. The Precambrian igneous activity and Jurassic granitic intrusion are responsible for most of metallic mineral deposits. The Palaeozoic sedimentation has led large limestone deposit around Taebaek area.

3. Historical review on geoscience in Korea

Status of Mining Business

Figure 2a shows annual change of the component ratio that mining industry had possessed in GDP during five decades. The share of mining industry reached its peak in 1960 to 2.1 percent and steadily decreased to 1.3 percent in 1985. In fact, in 1960's, mining industry used to be a primary source of earning foreign exchanges. In 1970's and 1980's, though the share decreased steadily as industrial base was diversifying, it still had played important role of phenomenal economic growth by supplying raw materials to industries.

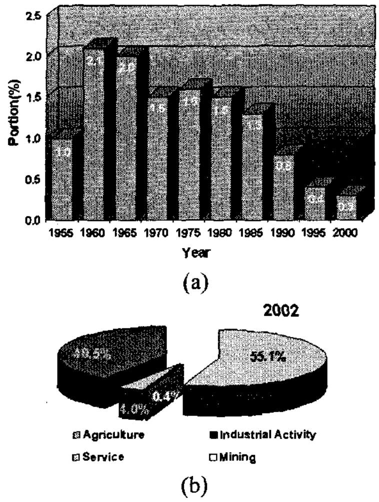

Fig. 2. The share of mining industry in GDP: (a) Historical changes, (b) the component ratio in 2002.

In 1990, however, the share of mining industry had started accounting for less than 1 percent. The share in 2002 accounted for only 0.4 percent (Fig. 2b). Such rapid declination of mining business after 1990 is attributed to the change of social and economical circumstance due to the paradigmatic global transformation to post-industrial information society. In order to adapt to the circumstance, Korean government has continuously tried to diversify industrial base that is higher value-added industry-oriented.

Besides lower weighting on unfavourable marginal-profit industry like mining, the change of demand-supply pattern and policy is another factor responsible for the slowdown of mining business; In addition the demand for minerals and energy resources steadily decreased due to the change of energy consumption pattern, most of the demand began to rely on import. Technically, improved productivity due to the advance of recovery and recycling techniques and the development of new substitutional-goods are also responsible for the decrease of domestic demand for mineral resources.

Mining Academia

Figure 3 is a chronological diagram that describes the change of geoscience educational system since the first mining education started in 1917. The chronological period can be divided into two periods in terms of the phase of development as shown in the figure: (1) the period of subsidiary expansion and (2) the period of interdisciplinary expansion.

During five decades from 1946 to 1995, mining engineering, continuously adding subsidiary disciplines, had expanded to comprehensive mineral and energy resource engineering. In 1960's, several disciplines such as geophysics and applied geology had been reinforced in unison with industrial needs that had increased by governmental support during the first Five-year Develop-ment program. Such a subsidiary expansion continued to the late 1980's. At the end of 1987, for example, the mining engineering department of Seoul National University had expanded to comprehensive discipline that covers more than eight subsidiary disciplines including geochemistry, resource economic, petroleum engineering, and mineral processing, etc.

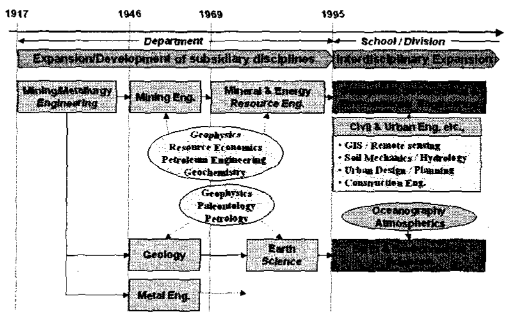

Fig. 3. Historical change of educational system of mining engineering.

On the other hand, the period after 1995 can be called as the period of interdisciplinary expansion. In unison with governmental policy to reform educational system as well as the change of industrial structure, most of academic institutes have reformed geoscience education system from department system to school system. In case of mineral and resource engineering, it has been expanded to geosystem engineering that includes civil and urban engineering in this period.

Research Activities

The history of geoscientific researches since it started as modern science when the Geological Survey has been established in 1918 can be summarized in chronological order as shown in figure 4. However, it can be re-chronologized in terms of research phase into two periods before and after 1990.

The period before 1990 can be described as the period geoscientific researches had developed based on mining. Geoscientific research activities during this period had put their focuses on the development of technology to investigate, explore and exploit, and utilize resources for the purpose of securing and utilization of strategic mineral and energy resources as a primary motive force of national growth. Because of comprehensive investments and R&D, until the end of 1980's, national geoscientific research capability had splendidly advanced to that of other advanced countries.

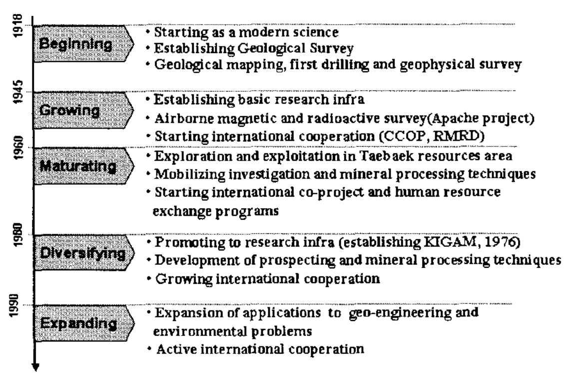

Fig. 4. Brief historical review on geoscientific research activities.

On the other hand, the 1990's can be described as the period when the horizon of geoscientific researches expanded to geosystem engineering including geo-engineering and environmental sectors. In 1990's, as needs for geoscientific solution to various engineering and environmental issues grew, geoscientific researches has focused on the development of advanced technologies to widen the applicability of geoscientific methodologies. These include technologies for prediction and mitigation of natural hazards, advanced site investigation for constructional sites, improved mineral processing and recycling, characterization and remediation of contaminated sites, and for developing and utilizing underground spaces and facilities, as well as construction of integrated geospatial database.

Table 1. Typical technical issues and cooperative geoscientific disciplines and technologies.

Typical Issues	Interdisciplinary Cooperation
Urban, Civil & Geotechnics □ Noise & vibration monitoring □ Urban geological / geophysical mapping (Lithology, geologic structure, depth to bedrock / water table) □ Subsidence, stability and safety of structure / NDT	Geophysical imaging, remote sensing, geologic mapping, geotechnics, civil engineering, archaeology, history, materials engineering, sedimentlogy, soil / rock physics
Environmental Applications □ Air quality and gas emission monitoring □ Contamination and remediation of water / groundwater / soil □ Municipal waste management □ Material processing and recycling	Geology, geophysics, water engineering, geotechnics, aqueous chemistry, engineering, microbiology, toxicology, hydrogeology, fluid transport modeling, environmental law, geophysical imaging, reactivity modeling, soil mechanics, engineering geology, pollution chemistry, fluid dynamics, radiometry/gas emanometry
Public health / Social Safety □ Forensic / crime scene investigation □ Geochemical / medical factor for pubic health □ Safe repositories for toxic wastes	Toxicology, medical statistics, geochemistry, geophysics, engineering, geophysical imaging, medical engineering, toxicology
Natural Hazards / Security □ Landslide, volcanic eruption, Earthquake, Catastrophic flood □ Sea-level variation, global warming □ Induced seismicity due to nuclear weapon experiment □ Sea-water intrusion	Volcanology, seismology, mathematical modeling, geophysical imaging, engineering, geography-GIS, fluid dynamics, stratigraphy, paleobiology, atmospheric physics, seismic monitoring
Resource Development & Management □ Development of new resources (gas hydrates, geothermal, etc.) and materials □ Evaluation of impacts of geoscientific technologies	Mining, geophysics, geochemistry, geology, material engineering, resource economics

4. Challenges and Fusion technology

There are many challenging issues awaiting the future geoscientific approach. As society develops and becomes more complex, such issues become more extensive and manifold. In order to propose effective solution to these issues and to continuously exploit potential issues it is urgent to develop geoscientific fusion technology based on the integrated multi-disciplinary purpose-oriented cooperation. Cooperative geoscientific disciplines and technologies applicable to typical issues today, as an example, are grossly listed in table 1.

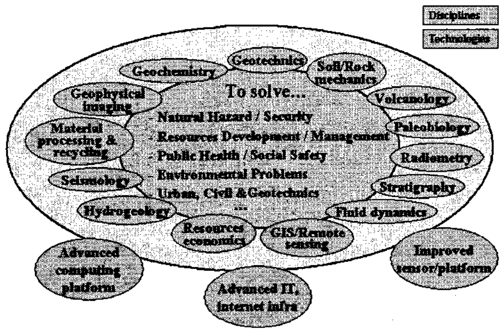

Fig. 5. Conceptual model of interdisciplinary cooperation and convergence of technology.

The regime of interdisciplinary cooperation, however, is now only developing and thus still feeble. Therefore, in order to establish interdisciplinary cooperation system, it is urgent to continuously develop interdisciplinary cooperation models through multi-lateral cooperation between disciplines and multi-phase international cooperation. In addition to establishing cooperation model, it is also necessary to establish systematic infra that can support interdisciplinary cooperation activities; web-based communication channels, well-prepared and well-organized geoscientific database, and web base knowledge management system, etc. Figure 5 illustrate a conceptual model of interdisciplinarity supported by cooperative disciplines and advanced technologies. Considering the significance of advanced technology in interdisciplinary cooperation model, continuous alert for the development of other advanced technologies and intensive analysis on them are another important factor for geoscientific evolution to fusion technology.

5. Conclusions

The 1990's was one of remarkable epoch in the history of geoscience in Korea in that the technology previously developed based on mining has expanded its horizon to geosystem engineering including geo-engineering and environmental application. However, despite of remarkable development in 1990's, many challenging issues today are urging geoscience to evolve fusion technology based on firm interdisciplinary cooperation. Considering that the interdisciplinarity is now only developing and still feeble, it is urgent to establish a firm regime of interdisciplinarity. This can be achieved by multi-lateral interdisciplinary communication and multi-phase international cooperation those are to be well supported by systematic infra for interdisciplinarity such as well-organized geo-spatial database and knowledge base communication network.

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