



Mineral resource geology in academia: An impending crisis?

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INTRODUCTION

With continued industrialization in the developing world, prices for metals and other mineral products reached new heights from 2005 to 2008. Though currently at lower levels, prices are likely to rebound sharply when the global economy recovers. A primary driver of high prices was a slowdown in the addition of new supplies via discovery and an inability to expand production from known deposits. Increasing demand also highlighted vulnerabilities in the supply chain of minerals critical for industrial production and national security. Despite these economic and political drivers, the numbers of mineral-resource (“economic”) geologists being trained in the West has decreased significantly over the past three decades. The current downturn is likely to cement this trend.

The decrease in economic geologists is particularly evident in the United States, where long-term trends foreshadow the demise of economic geology education and research in the coming decade. What will happen to U.S. competitiveness, a sustainable supply of mineral resources, and the nation’s ability to engage in scientifically sound planning and land management if economic geology disappears from academia?

ECONOMIC GEOLOGY AND THE U.S. ECONOMY

Economic geology encompasses the study of mineral resources. In current usage, “mineral resources” includes metals, industrial minerals, construction aggregates, and uranium but excludes carbon-based energy resources. With regard to economic value, the United States led the world in non-fuel minerals produced and processed in 2007, at US\$575 billion (U.S. Geological Survey, 2008). These raw materials supported major industries that accounted for more than US\$2 trillion

(~15%) of the 2007 U.S. gross domestic product. The United States is the largest single consumer of mineral products and had a net trade deficit of US\$43 billion in processed mineral materials in 2007—much smaller than the nation’s oil bill, but still roughly one month’s worth of the total U.S. trade deficit.

The United States is striving for increased energy independence, but it should also be concerned about mineral sustainability, as highlighted by the 2008 National Research Council report, “Minerals, Critical Minerals, and the U.S. Economy.” The U.S. Geological Survey (USGS) indicates that the United States imported over 50% of 44 mineral commodities in 2007 and was 100% reliant on imports for 19 mineral commodities. For example, the United States imports all its heavy rare earth elements (HREEs), mainly from China; HREEs are utilized in virtually every computer hard drive.

EVOLUTION OF ECONOMIC GEOLOGY IN THE UNITED STATES

U.S. mineral sustainability can only be achieved if we have the in-country expertise to (1) address critical vulnerabilities in our industrial and military supply chains; (2) help find and responsibly develop, process, and environmentally manage our mineral resources; and (3) accurately assess and contribute to the sustainable development of world mineral supplies.

The field of economic geology developed in the late nineteenth to early twentieth centuries as an outgrowth of mining geology. Economic geology flourished from the end of World War II into the early 1970s, with major academic programs at such schools as Harvard, Yale, Michigan, and Stanford. The USGS and the U.S. Bureau of Mines conducted substantial government research, while the National Science Foundation (NSF) funded research at academic institutions. Several mining companies had major in-house economic geology research groups.

By the mid-1990s, the landscape for economic geology in the United States changed dramatically. A 1994 survey of U.S. and Canadian academia indicated that economic geology faculty were, on average, 50 years old and that many predicted they would not be replaced upon retirement (Einaudi, 1996). There were few hires of young professors, and economic geology was abandoned altogether at many higher-ranked institutions. Mining industry research centers virtually disappeared. Congress abolished the U.S. Bureau of Mines in 1995, and economic geology research at the U.S. Geological Survey shrank significantly.

Table 1. Summary results from 2002 survey of economic geology faculty in U.S. and Canadian universities

2002 Faculty Demographics*	Avg.	S.D.	
Faculty Ph.D. year	1982	8	
Hire year	1985	10	
Expected retirement year	2017	8	
Years of industry employment	4.5	5	
Replacement would be hired in economic geology (probably, certainly)	30%		
Replacement would <i>not</i> be hired in economic geology (certainly not, almost certainly not, probably not)	70%		
Year-to-year comparisons	1982	1992	2002
M.S. students per faculty (avg. yearly)	5.8	4.2	3.3
Ph.D. students per faculty (avg. yearly)	1.9	2.0	2.0
Percent economic geology courses of total taught		33%	24%

Note: Based on 47 responses to an e-mail questionnaire sent to 102 U.S. and 45 Canadian universities by J.H. Dilles. Full survey data is available at www.geosociety.org/pubs/ft2009.htm as GSA Supplementary Data item 2009192. This survey also collected historical data. S.D.—standard deviation.
*n = 47; 42 programs with 57 economic geology faculty.

A follow-up survey in 2002 (Table 1; supplementary data¹) found that most professors who considered their principal specialty to be economic geology did 75% of their teaching in their secondary fields of geochemistry or petrology/mineralogy and relied principally on government grants for research funding. Graduate student numbers had declined, and 70% of these professors predicted their position would not be filled with an economic geologist when they retired in an average of 15 years.

CURRENT STATE OF U.S. ACADEMIC ECONOMIC GEOLOGY

A more recent, less comprehensive poll conducted in 2006 indicated that fewer than 70 of the ~100 economic geology professors at U.S. universities remain active in the field. For comparison, the total number of active U.S. economic geology faculty is equivalent to an engineering department at a large state university. In 2006, ~150 graduate students were working in economic geology in the United States. Given average times for degree completion, this indicates that the United States is graduating fewer than 40 graduate-level economic geologists a year. This is probably less than half the number required to offset annual retirements in the domestic mining industry alone, much less in other organizations that require related expertise.

It is clear that the academic base for the field shrank considerably over the past three decades (Fig. 1). Market forces alone may reinvigorate economic geology in the United States, but there was no evidence of this during the four years of high metal prices. Could we be facing the collapse of the science that underpins the long-term supply and stewardship of the mineral resources on which our nation depends? The United States has one of the world's best mineral endowments and an increasing public and corporate commitment to sustainability; unfortunately, without the necessary expertise, we may be unable to manage and, as appropriate, develop these resources.

The demands of the academic environment must be considered if the United States is to reinvigorate economic geology research and education. Increasingly, tenure decisions are

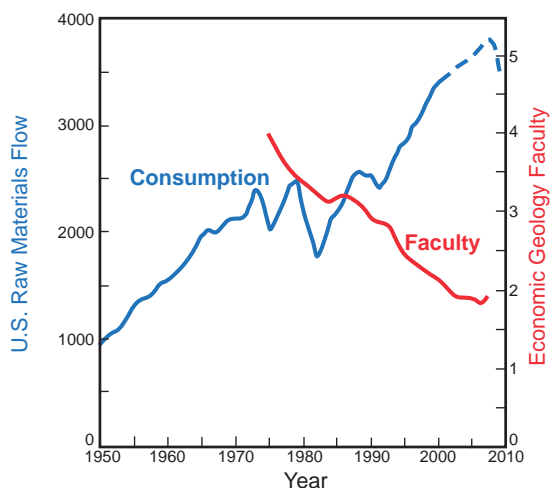


Figure 1. Graph illustrating a steady increase in U.S. consumption of raw materials (Wagner, 2002) and a steady decline in economic geologists as a percentage of total geoscience faculty (AGI, 1975–2007).

based largely on the amount of fully overheaded research funding obtained by individual faculty members. Perhaps more important, decisions about how to fill faculty vacancies are made on the same basis. Given that faculty typically hold tenured positions for decades, loss of expertise cannot be easily or quickly redressed.

Unlike the steadily increasing demand for minerals, NSF research funding for economic geology has stagnated or decreased, perhaps because this research is perceived as applied rather than basic in nature. Federal programs that had provided funding for economic geology projects, such as the Department of Energy's "Industries of the Future" program, have been cut. USGS funding for academic economic geology research has been limited and unpredictable.

Presently, many of the remaining U.S. academic programs in economic geology receive industry funding. However, most corporate-sponsored research is highly applied, limited in time and scope, and frequently does not include full overhead to the academic institution. Such "underfunded" research projects are rarely viewed favorably by academic administrations struggling to make ends meet. Moreover, industry funding is often directed to other countries, such as Canada and Australia, where matching funds from governments are typically available. Although the mining industry can help by increasing research funding, it might be more effective for it to support the restoration of dedicated federal funding, because, in the long run, federal funding directly sustains most academic research, including those fields with direct societal applications, whether biomedicine or mineral resources sustainability.

THE FUTURE

There is no consensus among federal and state agencies, the mining industry, and the U.S. academic community regarding the importance of economic geology to future U.S. competitiveness.

¹GSA supplemental data item 2009192, 2002 survey by John Dilles of economic geologists at U.S. and Canadian universities, is available at www.geosociety.org/pubs/ft2009.htm; copies can also be requested from GSAToday@geosociety.org.

Without such consensus—followed by action—the current downward spiral in U.S. academic economic geology will continue, with the near-term loss of the expertise essential to the discovery, utilization, and management of mineral resources.

We invite the minerals industry, government, and institutions with a stake in mineral resources to initiate a dialogue and develop a new strategy, perhaps mediated by the National Research Council, to take U.S. academic economic geology successfully into the twenty-first century.

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GEOLOGIC PAST

Highlighting articles from past issues of GSA Bulletin

“The Role of Minerals in the Present International Situation”

C.K. Leith, *GSA Bulletin*, March 1939

This essay by C.K. Leith (*GSA Bulletin*, v. 50, p. 433–442) is derived from his Anniversary Day address at GSA’s semicentennial celebration in December 1938. Leith summarizes the “recent efforts of Germany, Italy, and Japan to improve their mineral positions” (p. 435) and examines possible solutions to the mineral resource problems faced by these and other “have not” nations.

“The inequalities of mineral distribution among the nations are stubborn facts which cannot be greatly changed by wishful thinking or political measures,” he writes (p. 439). The United States was not immune to these inequalities: Although the United States was the “world’s largest producer, the largest consumer, and the largest distributor of minerals and their products” (p. 441), its mineral-resource deficiencies (especially “in the ferro-alloy group”) barred the country from self-sufficiency. According to Leith, “If all our imports were cut off, our industry would indeed return to the ‘horse and buggy’ days. We could build neither automobile nor a battleship” (p. 441). Leith continues, “The ramifications of use of all these minerals are so complex in modern industry that the *lack of a single one* often has far-reaching consequences” (p. 442; italics added).

In closing, Leith calls for the United States and “other democratic nations” to not only focus on the defense of their “material and ideologic position” but also on “alleviating the raw material grievances of the ‘have not’ nations in the interest of world

welfare and peace” (p. 442). The role of geologists, he writes, is not to “settle these questions” but to “make highly significant contributions to both the immediate problem and the long-range problem of using our mineral power in trust for the world welfare.” The essay’s concluding sentence warns that this “responsibility should not be avoided” (p. 442).



Charles Kenneth (C.K.) Leith (1875–1956) was president of the Society of Economic Geologists (SEG) in 1925 and of GSA in 1933 and received Penrose Medals from both societies. Leith was head of the University of Wisconsin–Madison geology department for 31 years (having performed graduate work there in 1902 and retiring in 1945), and, after retirement, was a member of the U.S. Atomic Energy Commission’s Combined Development Agency. Among his many papers and books, Leith wrote “The Economic Aspects of Geology” (1921, New York, H. Holt and Company, xv, 457 p. illus. 22 cm, 1921), which was recently re-released as an eBook by Project Gutenberg for free download or online viewing at http://www.gutenberg.org/catalog/world/readfile?fk_files=1066580.

