EDITORIAL

FLUXES: A NEW PARADIGM FOR GEOLOGIC EDUCATION?

by Warren W. Wood[a]

In an editorial in *Geotimes* (Jan. 1995), Gordon Eaton, the current director of the U.S. Geological Survey and former university chancellor, suggests that significant changes in the geoscience curriculum will be necessary if the earth science community is to be relevant in the 21st century. Eaton proposes shifts in emphasis toward the study of geomorphology, hydrology, and surficial geology, and away from some of the more traditional geologic courses. Peter Wyllie's excellent 1993 National Research Council report, *Solid-Earth Science and Society,* endorses a similar emphasis. However, I believe that it will take more than a shift of several critical courses to address the fundamental problem with the geologic curricula, which is a lack of continuity. The curriculum has evolved in response to historical interest and employment thrusts over the last 200 years, and a few tucks and pulls will not address its fundamental weakness.

Formal geologic study originated in the desire to gain an understanding of the age, development of landforms, and composition of the Earth as witnessed by the raging controversy in the 18th century amongst the Neptunists, Vulcanists, and Plutonists. As geologic formations were mapped in detail in the late 18th and early 19th century, it became evident that this information could be of considerable value in exploration for the minerals and coal necessary to fuel the developing industrial revolution. It was in the middle of the 19th century when most of the various national geological surveys were established in recognition of this societal value. The 20th century witnessed an expansion of work in geology, paleontology, and geophysics, to include exploration for petroleum, and later ground water. The 1960s saw the beginning of a focus shift in North American water resources from exploration to management, with a consequent increase in environmental concerns associated with contamination of ground water and siting for toxic and nuclear waste storage. Geologic hazards, while always a problem, have become magnified because of the increase in population density and its geographic distribution.

To integrate this eclectic body of knowledge, I propose that geoscience programs develop a core curriculum built around the processes and principles of mass and energy fluxes. Let me illustrate my view with an example from the area of fluid mass transport. When I look at many ore deposits, I see a fluid dissolving and then transporting ions, followed by some geochemical or physical processes that cause their precipitation from solution. If I look at a process such as regional metamorphism, it appears to me that it is dominated by transport of solutes and heat by fluids. In the ocean we see the role of fluids in hot smokers, cold nonsmokers, mud volcanoes, and formation of gas hydride deposits on the ocean floor. If I look at many geomorphic features, such as those typical of karst terrain, it is clear they are the result of mass transport by fluids. Weathering is largely a function of solute and fluid transport. The activity of rivers and glaciers in shaping the continents are fluid-dominated processes. If we look at carbonate cementation of sandstones, it is fluids that transported the calcium and carbon to the site of deposition. Conversely, secondary porosity development is a direct response of dissolution of solids and transport by fluids. The migration of petroleum from source rock to reservoir is fluid controlled, and some thrust faulting and landslides are controlled by fluid pressure. Yet we persist in thinking of the geology curriculum in terms of separate courses. The approach I am proposing incorporates the study of mass and energy transport, combined with the fundamental and unique geologic contribution of dating, over a range of geologic and environmentally important time frames.

This approach should require significantly fewer courses, and provide some course-load relief for faculty members, as well as a coherent university hiring policy. When a university hires faculty, it is widely acknowledged that it typically hires for 30 years with relatively little flexibility; thus, by concentrating the hiring on those who stress fundamental fluxes, the bulk of the faculty will always provide the critical departmental demands. This later aspect is particularly important for small and medium size departments with relatively little flexibility to follow emerging subspecialties.

Components of today's typical earth science curriculum are spread between processes (fundamental science) and application of the processes for societal needs (applied science). The ratio of these two components has varied over the last 200 years in North America, as a result of society's need for immediate geologic information on minerals and energy, water, waste isolation, geologic hazards, etc., and longer term interest in processes like climate change, plate tectonics, and the origin of the Earth's magnetic field. However, by stressing the flux aspects of these diverse topics, they become a matter of emphasis rather than distinct courses. Within this new curriculum, a balance must be maintained between preparation for professional employment and attainment of fundamental knowledge. I believe this differentiation can be accomplished at the natural undergraduate/graduate break, as most professional positions presently require a master's degree. However, this balance will be difficult to achieve, and the problem is analogous to the conflicting dual role of the university as a center of free inquiry and discourse, yet also the center of intellectual authority.

Will this proposed curriculum change occur? To my knowledge, no current textbooks take this approach. The changes could logically originate from hydrogeologists as they have been trained in fluids and mass flux calculations; however, most of their effort is directed to environment-related ground-water problems rather than fluids in the geologic process. Additionally, most of the university faculty in ground water tend to be at the assistant or associate professor level, with relatively little impact on curriculum committees. There are few department chairs or deans from the field of hydrogeology, nor are there many presidents of universities with a background in hydrogeology who could be expected to support such a change. The challenge is daunting, but I believe it to be necessary if earth sciences are to play a significant role in the next century.

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[a] Warren W. Wood is the Editor-in-Chief of *Ground Water*.

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