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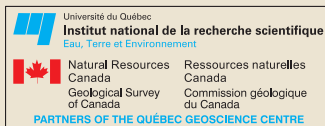
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E. Bruce Watson

## Geoscience Curricula for the 21<sup>st</sup> Century

Because of the rapidly  
changing nature of our  
field, many geoscience  
departments struggle with  
questions concerning the  
appropriate course content  
of today's bachelor's degree

in geology. Those of us who completed our  
undergraduate education prior to 1980 probably  
have in common ~90% of our undergraduate geo-  
science courses, which would likely have  
included a "core" of physical and historical geo-  
logy, mineralogy (2 terms), structural geology,  
sedimentation and stratigraphy, regional geology,  
paleontology, igneous and metamorphic petro-  
logy, sedimentary petrology, geomorphology, and  
a 6–8 week summer field course. Our predecessors  
designed this more-or-less standardized curricu-  
lum to provide essential knowledge in what were  
then largely disparate subfields of geology. All of  
these subjects were considered vital background  
for employment—mainly in the mineral and  
energy industries—and for advanced study in spe-  
cialized graduate programs.

At many colleges and universi-  
ties today, course requirements  
for the geoscience BS degree  
diverge substantially from the  
traditional curriculum described  
above. I work in a small  
department where solid-Earth  
geochemistry and petrology  
are vigorous research areas but,  
remarkably, our undergraduates  
are not actually required to take  
petrology. Our mineralogy requirement is limited  
to just one course (Earth Materials) that lacks an  
in-depth optical component. It could be argued  
that a great deal has been lost at Rensselaer as the  
traditional curriculum evolved to the present one.  
But perhaps a better way to look at the changes is  
to embrace what has been gained rather than  
bemoan what has been lost. Our students spend a  
limited amount of time under our influence; our  
job is to prepare them as best we can for careers  
in the modern geosciences.

What exactly has forced the widespread restructuring  
of geoscience curricula? At the risk of stating the  
obvious, I think there are two factors: (1) the Earth  
sciences have collectively migrated to more systems-  
oriented thinking and (2) entirely new subfields  
have emerged. The "geosystems" approach has  
arisen from the realization that treatment of indi-  
vidual Earth systems in isolation rarely provides a  
complete picture: at the very least, for example, the  
solid Earth interacts with the hydrosphere and the  
biosphere, and the latter two interact with each  
other and also with the atmosphere (see *Elements*  
volume 3, number 5). Many of these interactions  
were unknown when the traditional undergradu-  
ate geology curriculum was conceived, and they  
have spawned—or expanded the scope of—what  
must now be acknowledged as fundamental sub-

disciplines in their own right, e.g. organic geo-  
chemistry, geomicrobiology, chemical hydrology,  
biogeochemistry, and geobiology (perhaps even  
medical mineralogy, the theme of this issue).  
Moreover, the increasing coincidence of frontiers  
in geoscience research with fundamental issues of  
the environment (global climate, contaminant  
fate and transport, water resources) blurs the dis-  
tinction between Earth science and environmental  
science. Many of our graduates find employment  
not in the mineral or fossil-energy field (though  
jobs still exist in these sectors), but with environ-  
mental consulting firms or government agencies  
having environmental oversight or regulation  
responsibility.

Given all this, I think it's worth asking what is the  
"right" geoscience curriculum for the 21<sup>st</sup> century.  
My personal view is that the "classical" fields of  
mineralogy, petrology, and inorganic geochemistry  
(MPG) remain vitally important because they pro-  
vide essential background about Earth's domi-  
nant materials and the geological processes that  
produce and affect them. No matter how much

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gies and paradigms of these  
crucial disciplines—but some-  
how we must also create space  
for the newest ideas and  
applications of our science.  
Perhaps we can benefit by  
recalling how plate tectonics  
was accommodated in the

classical undergraduate geology curriculum. Plate  
tectonics impacted so many subfields of geology  
in the 1960s and 1970s that it was essentially  
infused into existing courses with few if any changes  
in degree requirements: regional geology, petrology,  
structural geology, and other courses were simply  
"modernized" by setting them in the new con-  
text. I think we can use a similar mechanism to  
introduce students to recent developments in MPG  
science. In Earth materials courses, for example,  
time can be devoted to discussion of the role of  
microorganisms in the synthesis and alteration of  
minerals. In introductory geochemistry courses  
we can address the role of microbes in element  
cycling. If existing courses are thus enhanced with  
new material in concert with the development of  
new subdisciplines, perhaps we can view the need  
to sacrifice traditional content in a more favor-  
able light.

This brings me to what may be the biggest cur-  
riculum dilemma in modern geoscience: should  
we require two or more courses in biology *in addition*  
to the six to eight courses we generally require in  
physics, chemistry, and mathematics? We may be  
at a point where it is necessary to provide the

Cont'd on page 372

**THIS ISSUE**

This Medical Mineralogy issue provides illuminating perspectives on the diverse roles of minerals, both natural and unnatural, in the human body. In addition we gain insight into the properties of minerals as they affect biomolecules in soils. Fascinating science!

**THREE YEARS OLD ALREADY**

With this issue, we close our third year of publication. We are pleased with the recognition *Elements* has received in this short span of time, and we are committed to further improvements. As we reach this milestone, we thank all the guest editors and authors who have contributed their time and energy (see list on this page) since volume 1, number 1. Without them, *Elements* would not be here.

When Ian Parsons steps down at the end of 2007, the original team of principal editors will have been entirely replaced. A special thanks to Rod Ewing, Michael Hochella, and Ian Parsons who took the concept of a multi-society thematic magazine and made it into reality.

Our advertising revenue increased markedly in 2007, with the August issue bringing in the most advertising revenue so far. This has allowed us to increase the number of pages per issue from 64 to 72 in 2007.

**ONLINE ACCESS**

One thing we had not planned for is that you, the readers, would clamor for electronic access to *Elements*. Since the magazine's launch, we have posted a single pdf file of every issue with a delay. Initially the delay was one issue. Last year, the Executive Committee asked that the delay be extended to two issues. However, we kept getting requests from libraries stating,

**EDITORIAL** (cont'd from page 371)

option of taking a "bio" specialization as an alternative to a largely physical science-based foundation. Through our deliberations, we need to listen to the students, too. Our current undergraduates at RPI have made it clear that they consider Geographical Information Systems (GIS) to be the most important course in their entire undergraduate program, because this course above all others makes them employable at the BS level. Is GIS fundamental in the traditional sense? probably not; is it important? definitely!

Today there is probably no standard answer to the question of what constitutes an ideal undergraduate geology curriculum. Geoscience departments—especially small ones—should develop curricula that they can deliver effectively given the expertise of the faculty. Emphasis should be placed on critical thinking, acquisition of basic skills, honing those skills on modern applications, and appreciation of the breadth and depth of modern geoscience.

The *Elements* editors try to highlight frontier areas and interfaces of MPG science, including developments in pedagogy (see volume 3, number 2). At the same time, however, we appreciate the need for our science to remain firmly based in the fundamentals of our fields. Sometimes this is a difficult fence to walk. I personally regret the loss from our education programs of skills that I still find valuable (e.g. optical mineralogy), but I think it is crucial to embrace what we have gained in recent decades so we can convey the essence of our fields to our students in the most effective way possible—even if curricula are not standardized across all geoscience departments.

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<sup>1</sup> Bruce Watson was the principal editor in charge of this issue.

very rightly so, that because they subscribe to *Elements*, there should be no delay for them to access the content. This spurred the development of a new webpage with gate access. Subscribers to *American Mineralogist* already have access to this improved web access (<http://www.elements-magazine.org/archives/index.html>). We thank Seth Davies of the Geochemical Society for making a pdf file of each article available for posting. We are working on ways to give all our members access to this site within the next few months.

**GEOSCIENCEWORLD**

As mentioned in the previous issue, *Elements* became the 35<sup>th</sup> journal to join GeoScience-World on December 6. Take the opportunity to check it out during the two-month free viewing period, which will last until the beginning of February 2008. GSW will provide searchable html and pdf files, cross-reference linking, etc. for the thematic articles and pdf files for all non-thematic content.

**COLOR OR COLOUR?**

This is a reminder that both American and British English and style are used in *Elements*. We just try to be consistent within a given contribution. It is a bit of an editorial challenge because no bell rings when the word colour, for example, appears in an American-style text.

**UNSUNG HEROES**

Lots of people read *Elements*, but some read it more than others. Take our talented copy editor, Thomas Clark, for example; he spends 60 to 70 hours per issue poring over every article and proof. We are grateful for his immense volunteer contribution. We also thank Dolores Durant, our volunteer proofreader: she typically finds things everyone else has overlooked. Their work contributes to a high-quality product.

**2005–2007  
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