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# GSA Looks Again at Earth Science Education: Barriers II

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See table of contents

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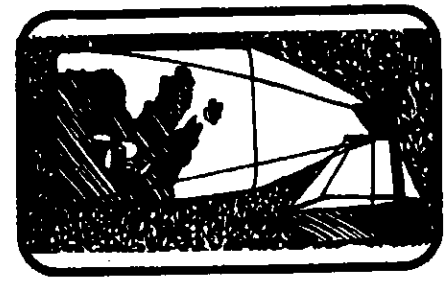
an Archean equivalent to the orthoquartzite-carbonate suite of the Phanerozoic.

After two days in Qinang we returned to Beijing by highway, visiting the Quin Tombs on the way, and lunching on a magnificent ten-course northern Chinese meal at a restaurant near the tombs. As at the Forbidden City, which we had visited previously, and the Great Wall two days later, the site was extremely popular with Chinese tourists.

Back in Beijing, a one-day technical session was held in our hotel. Papers were presented on the Archean of Australia, Brazil, China, Greenland, North Korea, Siberia and South Africa. As was found on the field excursion, language differences were a drawback to free communication. Most of the young Chinese scientists have rudimentary English, although senior scientists (those who are now essentially retired) seemed to be fluent, if rusty, in English. Needless to say, the foreigners were unable to communicate in Chinese.

Interesting papers included one by Bor-ming Jahn (Rennes, France) on the geochemistry of Archean basalts and komatiites and early crust-mantle differentiation and tectonic styles in the Archean. A paper entitled "Whirl Tectonics" by Bai Jin of Tianjin Institute of Geology and Mineral Resources was an interesting attempt at a non-plate tectonic model for Archean tectonics. His model suggests that plates existed in the Early Archean, but were too small to be effectively subducted. Hence, they became pushed together, with, of necessity, considerable relative rotation to produce many curved structures and linears. The title in its English translation is a bit unusual, if not unfortunate. Dirk van Reenen (and others from Rans Afrikaans U.) talked about mylonites in the Limpopo belt, emphasizing that mylonites are the products of deformation and not of "metamorphism," and contrasted them with "straight gneisses," which reflect the effects of (commonly deep) recrystallization under high-grade metamorphism. The South Africans have not copied the "trendy" use of mylonite that has prolifereated in North American literature. Clark Friend (Oxford Polytechnic) and Alan Nutman (ANU) shared the podium on a paper describing the terrane assembly of southern West Greenland, where evidence for accretionary amalgamation of diverse Archean Terranes seems very convincing.

IGCP Project 280 has now ended. A special issue of *Precambrian Research* is planned to document some of the progress made through this project. It has been suggested that a successor project to continue the focus on the world's oldest rocks would be welcomed by the IGCP. Canada is a logical candidate to develop such a successor project.



# GSA Looks Again at Earth Science Education: Barriers II

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**INTRODUCTION**

This Geological Society of America conference at Aspen Lodge, Estes Park, Colorado, 11-13 November 1994 was a successor to an earlier conference, "Barriers I," held at Wingspread near Racine, Wisconsin, in January 1993, and reported in *Geoscience Canada* (Neale, 1993). Of the 45 earth science (ES) teachers, college and university professors, education administrators, and other activists who were invited, 36 had attended the Wingspread meeting. Representing the Canadian Society of Petroleum Geologists and the Canadian Geoscience (Council's) Education Network, I was the only Canadian present.

The conference was designed to summarize progress made during the past two years in breaking down the barriers to K-16 (kindergarten through college) ES education and to develop strategies for the next decade. Despite the efforts of whirlwind GSA organizers Ed Geary and his colleagues, "Barriers II" lacked the excitement of the Wingspread event because an atmosphere of *deja vu* certainly permeated the group. A possible contributing factor was the altitude of Aspen Lodge (*ca.* 3 000 m), which caused headaches and shortness of breath among some normally articulate people who had flown in from sea-level locations! Nonetheless, much useful information sprouted from both formal and informal discussions and from some of the special presentations. There were certainly lessons to be learned and initiatives that could be

followed on our side of the border.

**ARE WE MOVING FORWARD?**

Much has been accomplished in the last two years, some of it inspired by the first conference. Most important has been a major breakthrough in the development of the National Science Education Standards in the United States. Thanks to activists (who participated in these GSA conferences) ES has now achieved parity with physics, chemistry and biology. The newly emerging standards recognize earth and space science as one of the four sciences that should be available in every grade from K-12. This is discussed in the next section in more detail. Other reports of Wingspread-generated activity included:

1. The Coalition for Earth Science Education (CESE) sprang from a February 1993 meeting at Wingspread. It brought together representatives of many societies and agencies to exchange information about current activities and to plan for joint action (Nowlan and Morgan, 1993). At the time of writing, it is coordinating suggestions and comments on the penultimate draft of the ES component of the National Standards for the United States. It also intends to play a role in implementation of the Standards.
2. Members of the California contingent have conducted open houses at several universities and at the United States Geological Survey (USGS) in Menlo Park, have organized workshops for teachers, and have developed ES resource centres at San José State University and at Menlo Park.
3. The Colorado delegates have worked on the establishment of state standards in ES education, have conducted workshops, initiated newsletters, and have set up regional partnerships to promote systemic change in ES education.
4. The Gulf Coast group has formed an alliance and has introduced ES into Louisiana's environmental science requirements. Austin, Texas now conducts an ES-inspired annual "Science Fun Day" for the public.
5. The New Yorkers are working on a revised ES syllabus and on an ES achievement test that will meet the demands of the impending National Standards.
6. Virginia/Maryland/District of Columbia activists have also worked on an ES achievement test, have developed geological walks for teachers in the Metro Washington, D.C. area, and have established partnerships of teachers and retired scientists. Unfortunately, Virginia's vaunted "V-Quest" science education project has hit a stone wall: Fairfax County, headquarters of the USGS, is considering dropping ES in its schools!

**WHAT ABOUT CANADA?**

It was a pleasure to report that major strides in science awareness activities have been made during the past two years, and that geoscientists from St. John's to Victoria have played key roles.

1. The federal "Innovators-in-the-Schools" initiative, after floundering for a few years, has come alive. It has enlisted established agencies (*e.g.,* The Ontario Science Centre) in each province to serve as co-ordinators. These centres encourage and promote the establishment of science networks and scientist-in-the-school programs. They also help co-ordinate celebrations across the country during our National Science and Technology Week.
2. Reports on the Wingspread conferences, particularly that by Nowlan and Morgan (1993), were helpful in the formative and planning stages of the Canadian Geoscience Council's (CGC) Canadian Geoscience Education Network. The Network now consists of representatives of 30 societies, agencies and institutions. It has taken over CGC's long-established and recently very successful EdGEO program of workshops for teachers. Most important, it has underway a survey and appraisal of ES content in K-12 curricula across Canada. When completed, this study will allow the Network to advise CGC member societies and others of the most appropriate topics to be developed into lesson plan assistance.
3. One couldn't resist a little local hype, namely that the Science Alberta Foundation and the Calgary Science Network, both founded by geoscientists, were among the first to receive Michael J. Smith Awards, named after Canada's recent Nobel Laureate. Also, after receiving a copy of an Austin, Texas guidebook to local science activities, the Calgary Science Network published a best-selling "Science Fun Guide," which included descriptions of a multitude of experiments that could be performed in the kitchen. Not to be outdone, Austin rewrote its guide, using similar experiments and found a corporate sponsor to make the book available, without charge, to school children. Calgary now plans an improved second edition and is looking for a sponsor. There is some merit in competition.

**PROPOSED U.S. NATIONAL STANDARDS IN SCIENCE EDUCATION**

**The Need**

ES in United States' schools consists of geology with varying amounts of geophysics, astronomy, oceanography and meteorology. As mentioned in an earlier report (Neale, 1993), 16,000 independent districts have math and science programs of their own selection. To establish order out of chaos, there have been many attempts at municipal, county, state, and now national levels to establish standards: to determine at what levels we would expect children to know certain things. It is worth describing some of the programs underway before briefly summarizing the national standards as they pertain to ES. First, a few quotes from a lecture given to the National Academy of Sciences by Professor Paul DeHart Hurd of Stanford, a widely acknowledged expert on science education:

> The first chapter in most science textbooks contains a formula for scientific thinking called the scientific method — the longest lasting myth in the history of science.
>
> ...students must learn the language scientists use...technical terms, formulae and symbols for each discipline. In the middle grades and high school courses, this consists of 2 000 to 5 000 new words...words that they likely will never use in a conversation for the rest of their lives. To their advantage, they will probably not have to remember them beyond the next test!
>
> The question most asked by students in science courses is: "What good is all this going to do me?" The most frequent answer is: "You will need it in the next grade or in college."
>
> ...today in the sciences all facts, laws and theories are forever tentative — subject to change without notice. The old concept of *basics* as permanent knowledge is now viewed as a myth.
>
> It has become evident that students engaged in traditional laboratory of 'hands on' activities are limited in their learning by what they have been prepared to observe. They learn more from investigations when they are part of the action, not routine per-

formers of experiments. We require a new cognitive framework for the teaching of science.

And, finally, a quote from Howard Gardner of Harvard, relayed to us by Professor Darrell Hoff, a lively iconoclast:

> ...the reason reform movements have failed is primarily because we have never abondoned our notions about 'disciplines' and the belief that the purpose of schooling is the mastery of identified content based upon a world view forged in the Middle Ages...

**Some Current Attempts to Meet the Need**

The catalyst for the current efforts at reform in science education was a study initiated in 1987 by the American Association for the Advancement of Science (AAAS) entitled **Project 2061.** Many readers are familiar with its conclusions, published in 1989, with the title "Science for all Americans." It differed from established school curricula by softening the boundaries between the sciences and stressing their links. Also, it required less retention of detail. Ideas and thinking skills were emphasized at the expense of science vocabulary and memorized procedures, capsulized in the slogan "less is more." It presented the scientific endeavour as a social action and placed a premium on students' curiosity and creativity.

Project 2061 sparked changes in many school jurisdictions and inspired several parallel projects such as those described below, including the endeavour to create national standards.

**The scope, sequence and co-ordination** (SS&C) project initiated by the National Science Teachers Association recommends that all secondary school students study science every year for six years. It supports teaching fewer topics and providing greater depth of understanding. Instead of teaching different sciences in different grades, layer-cake fashion, it spreads out the study of each discipline over several years.

There are six national SS&C test sites. One of these is California, where 200 participating schools bring 600 teachers to 40,000 students. A report from Santa Ana High is typically positive. This school includes 90% Hispanic and 6% Asians among its students. There are now 40 sections of "biophysical science" taught at Santa Ana. Students switch from a life science to a physical science emphasis every six weeks and the courses are shared by a two-teacher team. Since its introduction, there has been a 50% increase in students electing to take science.

**Earth systems education** came about between 1988 and 1991, spearheaded by Victor Mayer of Ohio State U. It was designed to provide a more adequate treatment of the planet Earth in the science curriculum. Leadership teams of teachers were prepared in special workshops, and these teams, comprising 180 teachers, then spread the work to colleagues across the United States. Essentially, the message is that any physical, chemical or biological process that citizens must understand in order to be scientifically literate can be taught in the context of its Earth subsystem. As a first step, earth systems education infuses planet Earth into all levels of the K-12 curriculum.

The exemplar of this project is the biological and earth systems science curriculum of the Worthington Board of Education in Ohio. The Worthington teachers, in developing their program (and it is *their* program, not something handed down from on high), took to heart the recommendations of the AAAS Project 2061. The successful, integrated science program that resulted was prescient in that it anticipated the elements of content, teaching and assessment included in the National Standards that are only now being finalized.

**The National Standards**

The United States National Academy of Science, through its research arm, the National Research Council, completed a two-year study in late 1994 that has produced standards for four scientific disciplines in five areas: content, teaching, assessment, program and system. These standards offer a coherent vision of what it means to be scientifically literate: they describe what all students must understand and be able to do. By all students, they mean regardless of background (gender, ethnicity, economic condition, *etc.*) and circumstance (*e.g.*, physical impairment). Use of the term "national" means nationwide agreement (but not federal mandate!) on what defines successful science learning and the practices that support that learning.

Probably of most interest to readers of this report are the content standards for earth and space science.

As a result of their activities in grades K-4, all students should develop an understanding of the properties of Earth materials, and objects in the sky.

As a result of their activities in grades 5-8, all students should develop an understanding of the structure of the Earth system, Earth's history, and Earth in the solar system.

As a result of their activities in grades 9-12, all students should develop an understanding of the energy in the Earth system, geochemical cycles, the origin and evolution of the Earth system, and the origin and evolution of the universe.

Much is made in the text of programs and of educational systems that empower teachers and, to some extent, students in this reform of science education. In other words, a major departure from the hierarchical approach that presently prevails in the United States and Canada in matters concerning curricula.

The standards will be published in final form early in 1995. For more data on them read Molnia (1995) or write to the National Science Education Standards, 2101 Constitution Avenue, N.W., HA 486, Washington, D.C. 20418 U.S.A.

**Implementation of the Standards**

Bonnie Bronkhorst, of California State U., San Bernadino, one of the activists who ensured inclusion of ES in the standards, stated: "Scientists and teachers must strongly support these standards because we can't envision another effort like this unless we think in terms of geological time."

Many impediments face the acceptance of national standards (as there would be in Canada). These include states' rights, scared teachers, conservative boards, and poorly equipped schools that lack the physical means to implement the participatory science recommended.

On the positive side are the several successful experiments presently underway, some of which have been described above. It seems likely that workshops at state and local levels, involving teachers and volunteer resource people, will be the route to devising methods and curricula to attain the content standards in the various disciplines.

The newly formed American Coali-

tion for Earth Science Education proposes to devote its next meeting to implementation programs. Also, GAS and other societies in the United States will place implementation high on their agendas. The SSA Aspen conference also set up a task force to explore the problems of implementation of the proposed earth and space science standards.

## MORE CONFERENCE GEMS

When an optimum number of like-minded earth science people foregather in a culturally and physically rarefied atmosphere, one can expect precipitation of nacreous gems. Following are the pearls I picked from a multitude:

***The demon research.*** Bob Diamond, Assistant Vice-Chancellor at Syracuse U., has been heading a study of university reward systems for several years. His surveys have included 55,000 faculty members (including many from Canadian universities). He finds that the only activity that is adequately rewarded is research. Teaching and service work is largely overlooked. ES ranks among the prime offenders in this regard. Analyzing published research shows that in one discipline (not ES) 90% of the papers are not cited by anyone, including the author, during a five-year period following publication. Even in the discipline with the best record (not ES), 30% of the published papers are not cited in the first five years. Diamond says that if universities persist in counting research publications as the sole criterion for reward, the public will soon interfere with a heavy hand.

***More on research.*** Small colleges that have traditionally concentrated on teaching excellence have suddenly been surprised (and flattered!) to find top-flight young researchers applying for their vacancies. Jobs are scarce in academe. As a disturbing number of participants pointed out, these young hot shots are now trying to change revered liberal arts colleges into research powerhouses.

***And still more.*** Talking with Geoffrey Briggs, a State of New York high school teacher, I learned that he and his colleagues receive no credit or remission of teaching for the time they devote to research papers, curriculum revision, and other attempts to change the status quo. This has to change. It was put eloquently by Vic Mayer of Ohio State U. in his report to GSA Aspen:

> ...all future programs require teachers as professionals...This requires a fundamental change in the nature and structure of schools and the attutudes of university faculty. It means that teachers have a portion of their time every day to plan and interact with fellow teachers within and across schools and districts...It means that teachers possess the authority to change the curriculum and to make decisions in the schools...Educational managers will disappear from the scene and be replaced by these teacher leaders...We shall see the disappearance of the educational administrator.

This message should be heard in at least some parts of Canada. In Alberta, for example, where master teachers recently played an important role in devising an enlightened science curriculum, we are again bashing teachers and moving toward elitist charter schools and an all-powerful central bureaucracy. It's scary!

***Give your manuscript to potential readers.*** Ed Nehfer from U. of Colorado showed me a neat, very readable booklet produced by the American Institute of Professional Geologists entitled "The Citizen's Guide to Geologic Hazards." "Do you know why it is so readable," he asked. "We gave it to a group of 15- and 16-year-olds as the critical readers and final arbiters."

***Space scientists.*** Astronomers are not amused by the discipline designation "earth and space science" in the new National Standards. They would like to drop the term "space science" which, they say, makes them appear to be satellite jockeys. Until a more suitable term is agreed upon, they would prefer to be listed under "earth science." Could it happen in Canada?

***The Nebraska ES education network.*** This can stand as a model of co-operation between university professors, state survey scientists, museum staff, and teachers. Founded in 1992, it now has a full-time co-ordinator. Activities include summer workshops for teachers, distribution of teaching materials, an electronic bulletin board, and a quarterly newsletter. With state (read provincial) surveys always located in university towns, this Lincoln, Nebraska example of teamwork bears close examination. Telephone (402) 472-0073 for information.

A prime model of industrial involvement in ES education also received mention in private conversations. This was the Sandia National Laboratories in Albuquerque, New Mexico, where Ken Eckelmeyer and his colleagues have produced a superb series of papers on effectively working with teachers and students in the classroom.

***An Institute for alliances.*** We heard from Manert H. Kennedy, Executive Director of the Colorado Alliance of Science, about this new institute that is setting up similar alliances whenever and wherever interested activists ask for help. Manert says that sustainable change will only occur if the time and place are right and if there are committed stakeholders available to bring it about. He adds that alliances (networks in Canada) must involve a wide segment of the community: scientists, teachers, media and service club representatives. In Canada, networks have tended to forget this last important element.

## FINALLY

There were many valuable messages at this conference for those Canadian geoscience societies which, albeit slowly, are beginning to shift their emphasis to stay in tune with the needs of their members and the Canadian public. Amen.

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