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Education:

- 1997 - present **Ph.D. Geology/Geochemistry**
Virginia Polytechnic Institute and State University, Blacksburg, Virginia
Dissertation: *Field, Experimental and Modeling Studies of the Natural Attenuation of Uranium and Lead, Coles Hill Uranium Deposit, Virginia.*
[Advisor: Dr. A.K. Sinha]
- 1994 - 1997 **M.S. Geology:** Boston College, Chestnut Hill, Massachusetts
Thesis: *Polyphase Metamorphism and Structure of the Tadmuck Brook Schist, Eastern Massachusetts.* [Advisors: Dr. J.C. Hepburn, Dr. J.W. Skehan, S.J.]
- 1989 - 1993 **B.A. Geology:** Guilford College, Greensboro, North Carolina
Thesis: *Petrology of the Todd and Mill Creek Ultramafic Bodies, Ashe County, North Carolina.* [Advisors: Dr. M.L. McCauley, Dr. C.C. Almy Jr.]

Professional Experience:

- 2001 **Research Assistant:** Field-based assessment of uranium transport and retardation at the Coles Hill Uranium deposit, Pb isotope geochemistry;
Virginia Polytechnic Institute and State University (Supervisor: Dr. A. K. Sinha)
- 1997-2001 **Laboratory Instructor:** Physical Geology, Resources Geology;
Virginia Polytechnic Institute and State University
- 2000 **Research Assistant:** Experimental study and geochemical modeling of soil amendment techniques designed to reduce solubility and bioavailability of metal contaminants in a near-surface environment; Environmental Restoration Project, Los Alamos National Laboratory (Supervisor: Dr. Donald Hickmott)
- 1996-1997 **Hydrologist:** Fluid flow in fractured bedrock, production of structure maps of aquifers and aquitards in the region surrounding the DOE Savannah River Site; U.S. Geological Survey, Water Resources Division, Atlanta, Georgia
- 1993 – 1995 **Laboratory Instructor:** Historical Geology, Oceanography; Boston College
- 1992 – 1993 **Laboratory Teaching Assistant:** Mineralogy, Physical Geology, and Historical Geology; Guilford College, Greensboro, North Carolina
- 1991 **Laboratory Assistant and Field Technician:** Radon and asbestos air monitoring; Geo-environmental Consultants, Atlanta, Georgia

Research Interests:

My primary interests and expertise lie in the integration of field-based studies with aqueous geochemistry, environmental mineralogy and petrology. I am also interested in the application of analytical technologies and have experience with secondary ion mass spectrometry (SIMS), thermal ionization mass spectrometry (TIMS) electron microprobe micro-analysis (EMP), scanning electron microscopy (SEM), and inductively coupled plasma mass spectrometry (ICP-MS). My research approach involves the integration of field-based observations and measurements with focused experimental studies and thermodynamic reaction path modeling. My future interests are in continuing to apply this type of systems-based research approach to better understand the chemical and physical processes that control the dispersal of environmental contaminants and economically important chemical species in natural environments.

Publications and Reports:

Jerden, J. L. Jr., Sinha, A. K., 2001, Geology and geochemistry of the Coles Hill uranium deposit, Virginia: a unique example of, hydrothermal apatite-coffinite-pitchblende mineralization, *submitted* to Economic Geology, April, 2001

Jerden, J. L. Jr., Sinha, A. K., 2001, Learning uranium containment from nature (tentative title), invited article written for Geotimes Magazine (Geophenomena section), *in review*

Sinha, A.K. and **Jerden, J.L., Jr.**, 2000, Extent of uranium and lead contamination in groundwaters and surface waters along the Whitethorne Creek, Mill Creek and Selected Reach of the Banister River, Pittsylvania County, Virginia, report submitted to Virginia Department of Health, October, 2000

Falls, F. W., Baum, J. S., Harrelson, L. G., Brown, L. H., and **Jerden, J. L. Jr.**, 1997 Geology and Hydrogeology of Cretaceous and Tertiary Strata, and Confinement in the Vicinity of the U.S. Department of Energy Savannah River Site, South Carolina and Georgia, U.S. Geological Survey, Water-Resources Investigations Report 97-4245

In Preparation:

Jerden, J. L. Jr., Sinha, A. K., 2001, Fixation of uranium by secondary phosphate mineralization during oxidation of a coffinite-pitchblende-apatite orebody: Coles Hill uranium deposit, Virginia; to be submitted to Chemical Geology, June, 2001

Jerden, J. L. Jr., Sinha, A. K., 2001, Mineralogical controls on uranium dispersal in saturated and unsaturated saprolites and soils: Coles Hill uranium deposit, Virginia; to be submitted to Chemical Geology, July, 2001

Invited Seminars/Presentations:

Jerden, J. L. Jr., 2001, Geochemical and mineralogic aspects of uranium mobility in soils, Department of Geology, Radford University, Radford Virginia (Invited Lecture)

Jerden, J. L. Jr., Sinha, A. K., 2000, Natural attenuation of uranium within an oxidizing, phosphate rich rock-soil-groundwater system: Coles Hill uranium deposit Virginia, Savannah River Ecology Laboratory, University of Georgia (Invited Seminar)

Published Abstracts:

Jerden, J. L. Jr., Sinha, A. K., 2001, Mineralogical fixation of Uranium during Oxidation and Chemical weathering of a coffinite-pitchblende-apatite orebody, Eleventh Annual V. M. Goldschmidt Conference, Hot Springs, Virginia

Jerden, J. L. Jr., Sinha, A. K., 2001, Uranium transport in weathered bedrock: application of environmental petrology, Geological Society of America, Abstracts with Programs (Northeast section meeting), Vol. 33, No.1.

Sinha, A. K., Wilson, J. R. and **Jerden, J. L. Jr.**, 2001, Collision tectonics-correlation between nature and duration of magmatism and pre-collision geometry of continental margins of the Appalachian Orogen, Geological Society of America, Abstracts with Programs (Northeast section meeting), Vol. 33, No.1.

Jerden, J. L. Jr., Sinha, A. K., 1999, Geology, mineralogy and geochemistry of the Coles Hill uranium deposit, Virginia: an example of a structurally controlled, hydrothermal apatite-coffinite-uraninite orebody, Geological Society of America, Abstracts with Programs (National Meeting), v. 31, no. 7, A-69

Jerden, J. L. Jr., Sinha, A. K., 1999, Field based study of radionuclide retardation in a saturated rock-soil system: Coles Hill uranium deposit, Virginia, Geological Society of America, Abstracts with Programs (Southeast Section Meeting), v.31, no.3, p. A-24

Sinha, A. K., **Jerden, J. L. Jr.**, and Crawford, M. L., 1999, Paleozoic magmatic axes of the central Appalachian Geological Society of America, Abstracts with Programs (Southeast Section Meeting), v.31, no.3, p. A-68

Jerden, J. L. Jr., Sinha, A. K., and Beard J., 1998, Radionuclide transport in fluid saturated, fractured crystalline rock and associated soil horizons: Coles Hill uranium deposit, Virginia, Geological Society of America, Abstracts with Programs (Southeast Section Meeting) v. 30 no. 4 p. 19

Jerden, J. L. Jr., Sinha, A. K., and Beard J., 1998, Uranium-cerium-strontium rich apatites from the Coles Hill Uranium deposit, Virginia: Natural Analogs for phosphate based nuclear waste forms, Abstracts with Programs no. 4 p. 19, Geological Society of America, Abstracts with Programs (National Meeting) v. 30 no. 7 p. 19

Jerden, J. L. Jr., and Hepburn, J. C., 1996 The Tadmuck Brook Schist, A phyllonite between the Nashoba terrane and the Merrimack Trough, eastern Massachusetts Geological Society of America, Abstracts with Programs (Northeast Section Meeting) v. 28, no.3 p.68

Professional Short Courses Attended:

- **Uranium: Minerals, Geochemistry and the Environment**, 1999, Burns, P.C and Finch, R., sponsored by the Mineralogical Society of America
- **Applications of Environmental Isotopes in Groundwater Studies**, 1998, Fritz, P. and Clark, I.D, sponsored by the Geological Society of America Hydrogeology Division

Professional Training Courses:

- Chemical Hazards Communication: Los Alamos National Laboratory (summer 2000)
- Chemical Waste Generation: Los Alamos National Laboratory (summer 2000)
- National Safety Council First Aid and CPR

Grants:

- Currently funded by the Virginia Department of Health to assess the extent of uranium contamination in surface and ground waters in the vicinity of the Coles Hill uranium deposit, Virginia.

Analytical Skills:

- Thermal Ionization Mass Spectrometry (TIMS)
- Secondary Ion Mass Spectrometry (SIMS)
- Scanning Electron Microscopy (SEM)
- Electron Microprobe (EMP)
- Atomic Adsorption Spectrometry (AAS)
- Inductively Coupled Plasma Mass Spectrometry (ICP-MS)

Laboratory Skills:

- Sample preparation (physical & chemical) for isotope studies, including clean laboratory procedures (class 100)
- Cation exchange capacity measurements for bulk soils.
- Low temperature mineral synthesis (e.g. uranyl phosphates of the autunite mineral group).
- Toxicity Characteristic Leaching Procedure (TCLP) for inorganic contaminants.
- Batch equilibration experiments to assess the effectiveness of various soil amendment techniques for in-situ stabilization of inorganic contaminants.

Computer Skills:

- GIS software: Arc-Info
- Geochemical reaction & speciation modeling: "Geochemist's Workbench", Minteq A2
- Raster and vector graphics: Adobe Illustrator Adobe Streamline, Adobe Photoshop
- 3-D design software: Adobe Dimensions, MiniCAD, Bryce 4
- Programming: Fortran
- Digital Image Processing: ScnImage, AGIS

Awards:

2001	Tillman Teaching Excellence Award (Virginia Tech departmental award)
2000	Society of Economic Geologists Research Fellowship
1999	Tillman Teaching Excellence Award (Virginia Tech departmental award)
1998	Byron N. Cooper Geoscience Fellowship (Virginia Tech departmental award)
1998	Virginia Museum of Natural History Fellowship
1995	Geological Society of America Research Fellowship (for research at Boston College)
1994	Outstanding Geology Major Award (Guilford College)
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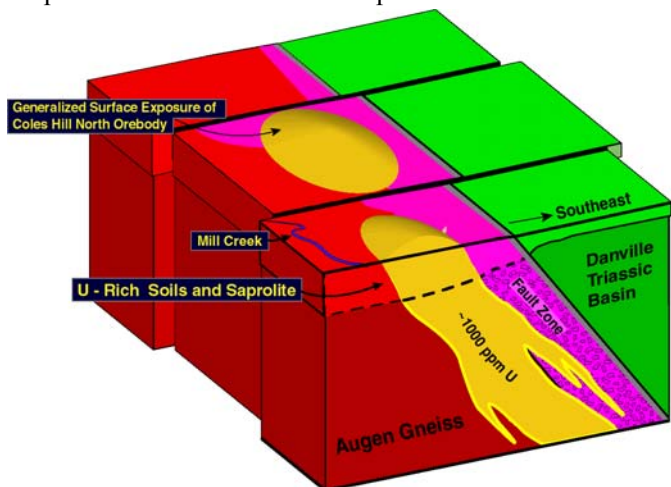
Professional Society Membership:

- Geological Society of America
 - American Geophysical Union
 - American Mineralogical Society
 - American Association for the Advancement of Science
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Technical Summary of Dissertation Research:

Introduction

Uranium geochemistry has been studied intensively over the past fifty years, however, to ensure a sound scientific basis for the design and implementation of containment and remediation strategies as well as predictive transport models for uranium contaminated sites there remains a need for data from representative natural systems. Of particular concern is how the processes that control uranium mobilization vary over geologic time scales within

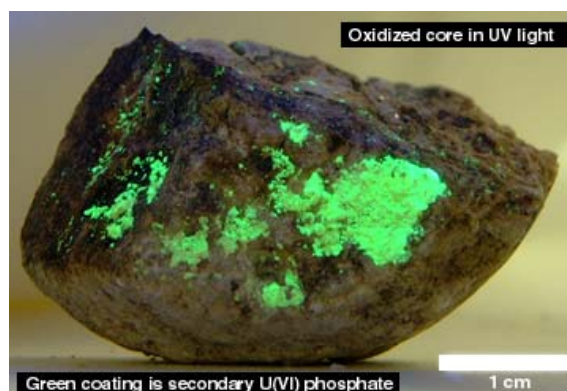


heterogeneous rock-soil-groundwater systems. One of the most unique places in the world to study such phenomena is the Coles Hill uranium deposit located in Virginia. Due to its geologic, geochemical and mineralogic nature as well as its physiographic setting and location, this site is unparalleled for studying uranium dispersal in a dynamic natural system typical of the eastern US. The Coles Hill deposit consists of two connected coffinite-pitchblende-apatite ore zones (Coles Hill north and south ore bodies) hosted in cataclastic zones that cross-cut quartzo-feldspathic augen gneiss of the Piedmont Geologic Province. The cataclastic zones are associated with Mesozoic brittle deformation along the northwest margin of the Danville Triassic Basin. Exploration drill holes indicate that the

bedrock hosted uranium ore zones extend to depths greater than 350 meters and thus, within the context of the present day hydrochemical cycle, represents an infinite source of uranium. Data collected during exploration of the deposit provides significant geologic and geochemical control on the primary ore zones. However, the deposit was not mined and therefore represents a pristine geologic and hydrochemical system in which processes influencing the paleo and present-day transport and retardation of uranium can be studied.

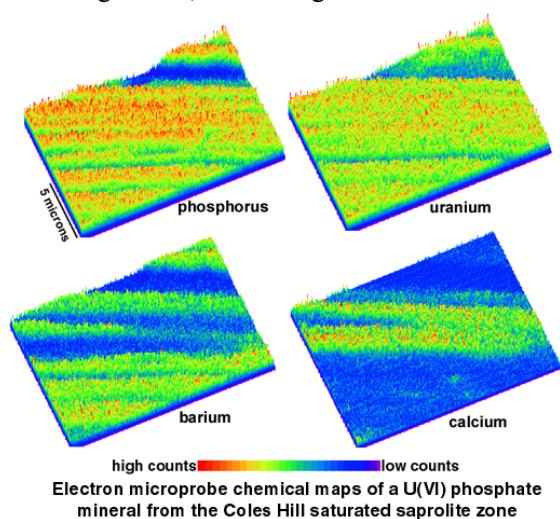
Redox Fronts

Typical ore from the primary Coles Hill deposit contains bulk uranium concentrations of 500 - 1000 ppm and consists of the U(IV) minerals coffinite ($USiO_4 \cdot nH_2O$) and pitchblende (UO_{2+x}) associated with fluorine-rich apatite. Shallow drill core from this site preserve a sharp, continuous ferrous/ferric redox front that separates gray, unweathered, U(IV) bearing bedrock from incipiently weathered core sections that are pervasively coated by iron oxide and oxy-hydroxide minerals. This iron redox front occurs near a major discontinuity in uranium mineralogy with the coffinite and pitchblende assemblages on the unoxidized side and secondary U(VI) assemblages on the oxidizing side. Electron microprobe and x-ray diffraction studies indicate that these U(VI) assemblages are dominated by uranyl phosphates of the meta-autunite mineral group, specifically the barium end-member (meta-uranocircite). These secondary uranyl phosphates have also been found locally as fracture coatings approximately one centimeter below (on unoxidized side) the ferrous/ferric transition. This one centimeter thick interval below iron redox front thus contains both U(VI) assemblages as well as unaltered, primary U(IV) assemblages and therefore, represents a well defined uranium redox transition zone. However, this discontinuity in uranium mineralogy does not represent a major discontinuity in bulk uranium concentrations, with sample groups from both oxidized and unoxidized sides of the interface generally ranging from 500 to 1000 ppm. There are some localized zones of meta-autunite enrichment in oxidized core which contain up to 3000 ppm, but overall there is no consistent enrichment or depletion across the redox front. This observation suggests that the volume of shallow bedrock associated with the Coles Hill uranium deposit has acted as a closed system with respect to uranium mass transport during oxidation and incipient chemical weathering of the primary ore zones.



Saprolites and Soils

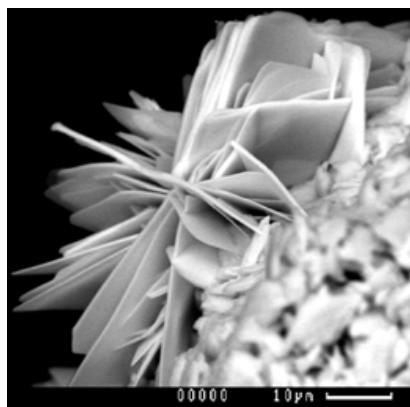
Ground water-saturated saprolites overlying the bedrock zones contains 500 – 1400 ppm uranium also associated with abundant U(VI) phosphates of the autunite and meta-autunite mineral groups. However, unlike the meta-autunite grains from the oxidized bedrock zone, crystals from the saturated saprolites are compositionally heterogeneous, containing micron-scale interlayers of calcium and/or strontium. The top of this U(VI) phosphate-bearing zone is marked by the water table, which fluctuates seasonally and represents a major discontinuity in uranium mineralogy. Above this zone no discrete U(VI) minerals have been detected; however, the bulk uranium concentrations remain greater than 200 ppm. The uranium in this unsaturated zone is associated with phosphate adsorbed to (or co-precipitated with) iron oxyhydroxide mineral coatings and a uranium bearing aluminum phosphate mineral (1.3 wt.% UO_3) of the crandallite group. These data suggest that the key interval of uranium mobilization is within the oxidized soil column at the dynamic interface between the saturated and unsaturated zones. Furthermore, these observations suggests that the Coles Hill vadose zone has reached a steady state with respect to uranium retardation capacity and thus records the finite limit of uranium that can be fixed within this system given ambient physical and chemical conditions.



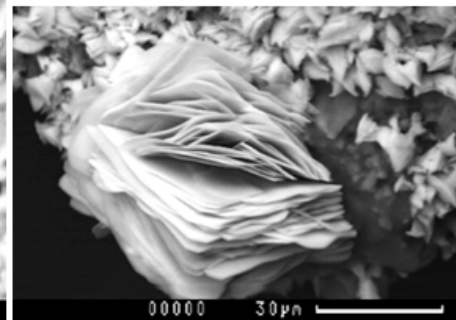
The top of this U(VI) phosphate-bearing zone is marked by the water table, which fluctuates seasonally and represents a major discontinuity in uranium mineralogy. Above this zone no discrete U(VI) minerals have been detected; however, the bulk uranium concentrations remain greater than 200 ppm. The uranium in this unsaturated zone is associated with phosphate adsorbed to (or co-precipitated with) iron oxyhydroxide mineral coatings and a uranium bearing aluminum phosphate mineral (1.3 wt.% UO_3) of the crandallite group. These data suggest that the key interval of uranium mobilization is within the oxidized soil column at the dynamic interface between the saturated and unsaturated zones. Furthermore, these observations suggests that the Coles Hill vadose zone has reached a steady state with respect to uranium retardation capacity and thus records the finite limit of uranium that can be fixed within this system given ambient physical and chemical conditions.

Experiments and Geochemical Modeling

Ground water samples extracted from the saturated soil zone overlying the deposit have dissolved uranium concentrations ranging from 5 to 15 ppb. This indicates that natural waters from zones containing the U(VI) phosphate minerals have dissolved uranium values that are lower than the proposed drinking water standard of 20 ppb (US-EPA, Fact-Sheet, Radionuclides in Drinking Water, 1991). This observation further illustrates the effectiveness of the natural attenuation processes operating at this site. Results from the field based studies have also been supplemented by focused batch experimental studies as well as speciation and equilibrium reaction modeling. The experiments indicate that when the Coles Hill primary ore assemblage (coffinite, pitchblende, apatite) is reacted with oxidizing, phosphate rich fluids similar to those that may be found in some natural systems the U(IV) phases alter to U(VI) phosphate minerals in approximately one month. The thermodynamic modeling studies, which were performed using measured ground water compositions from the Coles Hill site, suggest that in addition to Eh and pH the most important parameter controlling the stability of the secondary uranium minerals within this system is the activity ratio of dissolved carbonate to dissolved phosphate. Model predictions agree with the field observations that, for oxidizing systems with relatively low dissolved carbonate/phosphate ratios, uranium may be immobilized by secondary uranium phosphate precipitation and sorption processes.



back scatter electron images of U(VI) phosphates formed on coffinite during alteration experiments using Coles Hill ore (~5 weeks reaction time)



Conclusion

Integration of data from these field-based, experimental and modeling studies thus constrain a set of geochemical and physical processes responsible for the natural attenuation of uranium within an oxidizing, fluid rich environment. These results have implications for the design and implementation of scientifically sound and cost effective remediation and long-term containment strategies for radionuclides and heavy metal contaminants.

Summary of Masters Thesis Research:

For this study I was able to successfully unravel the complex geologic history of a poly-metamorphosed, poly-deformed micaceous, aluminosilicate rock formation (the Tadmuck Brook Schist). This unit represents the high-strain zone of the Clinton-Newbury fault zone, which forms the western margin of a tectonically important exotic Terrane (the Nashoba Belt) in eastern Massachusetts. The work involved quadrangle, outcrop and thin-section scale petrologic and structural analyses of textural relationships between pressure-temperature sensitive mineral assemblages and deformational rock fabrics. The metamorphic reaction sequence involved an early event characterized by the syn-tectonic growth of andalusite, this assemblage was subsequently overprinted by a higher temperature event characterized by the pseudomorphic transformation of andalusite to sillimanite. Both of these assemblages were overprinted by later syn-tectonic retrograde events involving pervasive chlorite growth and the formation of three distinct deformational fabrics. Kinematic analyses of these late-stage deformational events was performed using oriented rock samples in which brittily deformed sillimanite crystals could be used to discern the direction of maximum extension. This analyses indicated that the late stage rock fabrics formed by repeated strain lock-up mechanisms during normal faulting (extensional tectonics) along the western margin of the Nashoba Terrane during the late Paleozoic era. Thus, by integrating reaction texture analyses with mineral chemical data and Al_2SiO_5 phase equilibria I was able to constrain the relative pressure-temperature-time path of the region of interest, leading to a better understanding of the geologic evolution of northeastern US.

Research and Teaching Background:

Field mapping	Extensive experience producing geologic maps and cross-sections for a variety of lithologic systems, such as: metamorphic rocks of the Blue Ridge province of North Carolina, volcanic and sedimentary rocks, Cascade range, Washington state, polydeformed metamorphic rocks in eastern Massachusetts, polydeformed quartzo-feldspathic gneiss, Piedmont Province, Virginia.
GIS & Remote Sensing	Experience using Arc-Info GIS to produce structure and thickness maps for major aquifers and aquitards in coastal plain sediments surrounding the DOE Savannah River Site. Mapping of geologic features on the southwestern shelf of Puerto Rico by digital image processing and bathymetric surveying (NASA, JOVE program for undergraduate research).
Rock-Soil-Saprolite Petrology & Mineralogy:	Extensive experience integrating observations and measurements made by polarized light microscopy, scanning electron microscopy, electron microprobe mineral analyses, x-ray diffraction and bulk geochemical and isotopic analyses to determine the petrologic history and present-day properties of rock systems (i.e. relative ages of mineral assemblages, reaction histories, chemical and physical heterogeneity at various scales). I have also successfully used this approach to constrain the geochemical and mineralogical dynamics of chemical weathering including phenomena controlling the solubility, transport and retardation of environmental contaminants.
Ground Water & Surface Water Geochemistry	Extensive experience using cation and anion concentrations and isotopic compositions of surface and subsurface fluids to constrain the nature and extend of rock/fluid and soil/fluid interactions and their influences on water quality (speciation and mineral saturation modeling of fluids).
Hydrogeology & Structural Geology	Experience mapping and performing stereographic analyses of hydrologically active structures (joint sets, foliations, faults) within bedrock aquifers. Experience using borehole geophysical techniques to assess water-bearing structures. Experience with well installation and ground water sampling techniques.
Low Temperature Experimental Geochemistry	Successfully designed and performed batch equilibration experiments coupled with reaction path modeling to assess in-situ soil amendment remediation techniques. Experience with low temperature mineral synthesis (e.g. U(VI) phosphates of the autunite group). Extensive experience assessing aqueous speciation of metals and anions as well as preparing activity-activity and Eh-pH diagrams for systems of interest.
Isotope Geochemistry	Extensive experience using thermal ionization mass spectrometry to measure and interpret Pb and Sr isotopic compositions of bulk rock, bulk soil and natural waters samples. Experience using these isotopic signatures as dynamic tracers of geochemical processes that control the transport and retardation of heavy metals within the environment. Experience using secondary ion mass spectrometry to measure U-Pb radiometric ages of zircon crystals and use that information to constrain the geologic histories of rock systems.
Geoscience Education	Nine years experience teaching geoscience classes (mineralogy, physical geology, resources geology, historical geology, oceanography) to undergraduate college students. Received Tillman Teaching Excellence Award from Virginia Tech, Department of Geological Sciences, 1999 and 2001.

References:

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