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# Beryllium Biochemistry in a Forested Ecosystem

Stephen A. Norton

*Principal Investigator; University of Maine, Orono, norton@maine.edu*

Charles Thomas Hess

*Co-Principal Investigator; University of Maine, Orono, hess@maine.edu*

Ivan J. Fernandez

*Co-Principal Investigator; University of Maine, Orono, ivanjf@maine.edu*

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**Final Report for Period:** 03/1998 - 07/1999**Submitted on:** 09/13/1999**Principal Investigator:** Norton, Stephen A.**Award ID:** 9725705**Organization:** University of Maine

Beryllium Biochemistry in a Forested Ecosystem

**Project Participants****Senior Personnel****Name:** Norton, Stephen**Worked for more than 160 Hours:** Yes**Contribution to Project:**

Norton was responsible for the overall supervision of all aspects of the research. He was the principal advisor for Kaste's M.S. degree and serves on Pellerin's committee. He has participated in writing four abstracts, coordinated the international exchange between the Czech Republic, and is coordinating the review article on Be.

**Name:** Hess, Charles**Worked for more than 160 Hours:** Yes**Contribution to Project:**

Hess was responsible for the gamma ray analysis of all samples for 7-Be. He installed a second Ge detector during the course of our studies to improve our capabilities. He participated on the trip to the Czech republic, the writing of three abstracts, and will contribute to our summary paper.

**Name:** Fernandez, Ivan**Worked for more than 160 Hours:** Yes**Contribution to Project:**

Fernandez was responsible for much of the design of soil sampling. He participated in the supervision of Kaste's thesis, and is the principal advisor for Pellerin, who also is including Be as part of his soil studies. He has contributed to the writing of three abstracts.

**Post-doc****Graduate Student****Name:** Kaste, James**Worked for more than 160 Hours:** Yes**Contribution to Project:**

Graduate Research Assistantship, \$12,000/year plus tuition  
Field and laboratory work and preparation and defense of M.S. Thesis.

**Name:** Pellerin, Brian**Worked for more than 160 Hours:** Yes**Contribution to Project:**

Field work on soils and laboratory work on soils  
Supported by the Department of Plant, Soils, and Environmental Sciences

**Undergraduate Student****Name:** Perry, Ethan**Worked for more than 160 Hours:** No**Contribution to Project:**

Measurement of 7-Be in peat, soil, and foliage.  
Supported by student wages from the proposal, work study funds, and volunteered time

**Name:** Smith, Colby**Worked for more than 160 Hours:** No**Contribution to Project:**

Field and laboratory assistant for the graduate students.  
Supported by student wages from the grant

**Name:** Herger, James

**Worked for more than 160 Hours:** No

**Contribution to Project:**

Field and laboratory assistant for the graduate student participants.  
Supported by wages from the grant.

**Organizational Partners**

**Czech Academy of Natural Sciences**

Dr. Petr Skrivan, Geological Institute

**Charles University**

Tomas Navratil, graduate student, traveled to visit with us in U.S. and we, in turn, traveled to the Czech Republic. We developed common goals, exchanged data, and are collaborating on field experimtns and in the writing of a major manuscript. The Czech collaboration was paid for partly by International Exchange NSF funds and partly from funds received by the Czech scientists (Vesely and Skrivan) for a proposal to their Department of Education. Vesely and I wrote the proposal. It was funded in part (1 year) in this country and in total for the Czech part.

**Czech Geological Survey**

Dr. Josef Vesely, he has supervised the field and laboratory work on our collaborative research proposal and supervised the graduate student (Tomas Navratil) at Charles University. He spent two weeks here in the United States, along with Navratil. He hosted part of our scientific exchange (Norton, Hess, Kaste)to the Czech Republic in May.

**Other Collaborators or Contacts**

**Activities and Findings**

**Project Activities and Findings:**

The research has been largely empirical. studying the inputs of  $7\text{Be}$  and  $9\text{Be}$  to forested ecosystems, characterizing and quantifying reservoirs of these nuclides within the ecosystem, and identifying and quantifying the flux(and controls on flux) of Be from compartment to compartment and ultimately out of the ecosystem. We have focused on three watersheds in Maine, one with low Be in bedrock and one with high. Parallel studies in the Czech Republic have focused on two watersheds, both with high Be concentration in the bedrock, and one receiving high amounts of Be through the atmosphere. The three PIs from the United States (Maine) were supported by NSF to visit the C.R. where we viewed field studies and laboratory facilities and discussed data. The two Czech PIs (Vesely and Skrivan) visted our field sites, etc. in May 1999.

**Project Training and Development:**

Approximately half of the atmospheric deposition of  $7\text{Be}$  (and thus  $9\text{Be}$  and  $10\text{Be}$ , by inference) is retained by adsorption in the canopy of forested watersheds in Maine. The storage of  $7\text{Be}$  in the canopy reaches steady state within about two months. Thus, throughfall may contain less Be than open precipitation. Inventories within the soil vary spatially over distances less than 1 meter because of uneven wet and dry depposition and throughfall. At leaf scenscence, there is a rapid flux of  $7\text{Be}$ ,  $9\text{Be}$ , and  $10\text{Be}$  to the forest floor. Be moves rapidly into the soil, with significant retention in the O horizon, penetrating 5 to 10 cm into the B horizon, probably as a DOC-complex, where it is precipitated. The residence time of Be there is relatively long, preventing significant migration of  $7\text{Be}$  beyond that point. However,  $9\text{Be}$  (and by inference  $10\text{Be}$ ) are leached from acidic soil profiles and translocated along flow paths to points where pH is higher (typically riparian zones). Episodic acidification at this zone mobilizes all available Be nuclides into stream water. Mobilization from Be derived from the chemical weathering of the bedrock and soils is enhanced by higher concentrations of DOC, F-1, and H+. Stream substrates, inorganic and organic reversibly exchange Be. Be in particulate form in streams with pH between 5 and 6 is commonly associated with  $\text{Al}(\text{OH})_3$  colloidal material. Partition coefficients for Be vary over several orders of magnitude, depending on the pH, DOC, and the nature of the exchanger, even within the same stream.

**Research Training:**

Kaste (graduate student) - Has learned a considerable amount about forest soils, water collection and analysis (AA graphite furnace and ICP), speciation modeling (e.g., MINEQL), and gamma ray analysis. He has given one Geological Society of America oral paper and will give one more in October, 1999.

Pellerin (graduate student) - same as Kaste. He will present a paper at the Soil Science Society of America national meeting in November,

1999.

The three undergraduate students have participated in the more straight forward field collections and laboratory analyses, including gamma ray analysis. One of the undergraduate students is developing a data set on <sup>7</sup>-Be in vegetation and will present this material to the Geological Society of Maine annual meeting in April 2000.

#### **Outreach Activities:**

I have developed some ideas and protocols for the collection of large numbers of foliage samples to map atmospheric deposition of <sup>7</sup>-Be (and by inference other radionuclides) on a sub-continental scale. I have proposed that the GLOBE NSF program be involved. I was dismayed to hear that there might be resistance to this project because parents and teachers in K-12 might view such a collection procedure as placing their children in harm's way of radioactivity. (This was not the view of NSF personnel). If that indeed is true, one of the most important contributions I could make as an educator is to demonstrate to students/teachers/parents the existence of many naturally occurring radionuclides in our lives, and how we have managed to survive in spite of this background radiation.

### **Journal Publications**

#### **Books or Other One-time Publications**

#### **Web/Internet Sites**

**URL(s):**

**Description:**

#### **Other Specific Products**

**Product Type:** M.S. Thesis

#### **Product Description:**

Kaste, J. M., 1999, Dynamics of cosmogenic beryllium-7 and bedrock-derived beryllium-9 in forested ecosystems in Maine, U.S.A.: M. S. Thesis, Department of Geological Sciences, University of Maine, 96p.

Published Abstracts (Presentations)

Kaste, J., Norton, S., Hess, C., and Fernandez, I., 1998, Dynamics of <sup>7</sup>Be in forested ecosystems (abs.): Geol. Soc. America, Ann. Mtg., Toronto.

Kaste, J. M., Norton, S. A., Fernandez, I. J., and Hess, C. T., 1999, Delivery of cosmogenic beryllium-7 to forested ecosystems in Maine, U.S.A.: Geol. Soc. America, Ann. Mtg., Denver.

Kaste, J. M., Norton, S. A., Pellerin, B. A., Fernandez, I. J., and Hess, C. T., 1999, Sinks and mobilization of cosmogenic beryllium-7 and bedrock-derived beryllium-9 in forested watersheds in Maine, U.S.A. U.S.A.: Geol. Soc. America, Ann. Mtg., Denver.

Pellerin, B., Kaste, J., Fernandez, I., Norton, S., and Kahl, J., 1999, Soil cation distribution in the near-stream zone of New England forested watersheds: Soil Soc. America Ann. Mtg.

#### **Sharing Information:**

Published abstracts (in print or press)

In preparation - invited paper:

Norton, S. A., Kaste, J. M., Hess, C. T., and Fernandez, in preparation, invited paper to be included in 'Beryllium: Mineralogy, Petrology, and Geochemistry', Edited by Edward Grew, Mineralogical society of America: Reviews in Mineralogy.

### Contributions

#### **Contributions within Discipline:**

We have expanded knowledge about the flux of  $^7\text{Be}$  from the atmosphere to forested catchments through various ecological compartments to streams. We have investigated and shed some light on controls on  $^7\text{Be}$  mobility within forested catchments. The controls include the acidity of soils, flow paths, vegetation, stream substrate interactions with stream water, and total water chemistry. We have enhanced the usefulness of  $^7\text{Be}$  as a tracer for soil-forming processes.

Parallel studies of  $^9\text{Be}$ , originating from the watershed, combined with the  $^7\text{Be}$  studies have enabled us to make a preliminary model of the biogeochemistry of Be.

#### **Contributions to Other Disciplines:**

By studying  $^7\text{Be}$ , a nearly perfect surrogate for  $^{10}\text{Be}$ , we will be able to refine the use of  $^{10}\text{Be}$  in aging soils, and lake and marine sediments.

We have also been able to determine a very significant role for vegetation in trapping dry deposition of Be, storing it, and then releasing it during leaf senescence.

#### **Contributions to Human Resource Development:**

James Kaste spent one year researching various aspects of  $^7\text{Be}$  and  $^9\text{Be}$  and produced and defended his M. S. thesis in 1999. He is now enrolled in the PhD program at Dartmouth College.

Graduate student Brian Pellerin has gathered considerable data for Be in forested soils in Maine and has developed a model of how Be (among others) is distributed in soil profiles and released to stream waters. He will complete his M.S. thesis in 2000.

Three undergraduates at the University have participated in various aspects of this research.

One graduate student at Charles University (Czech republic), Tomas Navratil, has collaborated with us and performed parallel studies on different systems in the C.R.

#### **Contributions to Science and Technology Infrastructure:**

Partly as a result of this research, the University of Maine has invested in additional gamma laboratory counting facilities, increasing our sample throughput and improving detection limits.

#### **Beyond Science and Engineering:**

### Categories for which nothing is reported:

Any Journal

Any Book

Contributions: Beyond Science or Engineering