

# Benjamin W Johnson

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## Appointments

- Oct 2017 - present NSF Postdoctoral Fellow, Department of Geological Sciences,  
University of Colorado - Boulder
- Jan 2017- Sept 2017 Postdoctoral Researcher, School of Earth and Ocean Sciences,  
University of Victoria
- Jan-Apr 2017 Sedimentary Geology Instructor, School of Earth and Ocean Sciences,  
University of Victoria

## Education

- 2012-2017 **Ph.D.**, Earth and Ocean Sciences, University of Victoria
- 2007-2009 **M.S.**, Geology and Geophysics, University of Utah
- 2002-2006 **B.S.**, Geology, Biology and Chemistry minor, University of Puget Sound

## Publications

- 2019 **Johnson, Benjamin W.** and Wing, B. A. (under review). Altered ocean crust reveals an  $^{18}\text{O}$ -enriched early Archean ocean. *Nature Geoscience*
- 2018 **Johnson, Benjamin W.** and Goldblatt, C. (2018a). EarthN: a new Earth System nitrogen cycle model. *Geochemistry, Geophysics, Geosystems*, 19(8):2516–2542
- 2017 **Johnson, Benjamin W.**, Poulton, S. W., and Goldblatt, C. (2017). Marine oxygen production and open water supported an active nitrogen cycle during the Marinoan snowball earth. *Nature Communications*, 8(1):1316
- Johnson, Benjamin W.** and Goldblatt, C. (2017). A secular increase in continental crust nitrogen during the Precambrian. *Geochemical Perspectives Letters*, 4:24–28
- Johnson, Benjamin W.**, Drage, N., Spence, J., Hanson, N., El-Sabaawi, R., and Goldblatt, C. (2017). Measurement of geologic N using mass spectrometry, colourimetry, and a newly adapted fluorometry technique. *Solid Earth*, 8(2):307–318

- Hoffman, P. F., Lamothe, K. G., LoBianco, S. J., Hodgskiss, M. S., Bellefroid, E. J., **Johnson, Benjamin W**, Hodgkin, E. B., and Halverson, G. P. (2017). Sedimentary depocenters on Snowball Earth: Case studies from the Sturtian Chuos Formation in northern Namibia. *Geosphere*, 13(3):811–837
- 2016 Stüeken, E., Kipp, M., Koehler, M., Schwieterman, E., **Johnson, Benjamin W**, and Buick, R. (2016). Modeling pN<sub>2</sub> through geologic time: Implications for atmospheric biosignatures. *Astrobiology*, 16(12):949–963
- Hoffman, P. F., Bellefroid, E. J., **Johnson, Benjamin W.**, Hodgskiss, M. S., Schrag, D. P., and Halverson, G. P. (2016c). Early extensional detachments in a contractional orogen: coherent, map-scale, submarine slides (mass transport complexes) on the outer slope of an ediacaran collisional foredeep, eastern kaoko belt, namibia 1. *Canadian Journal of Earth Sciences*, 53(11):1177–1189
- Hoffman, P., Bellefroid, E., Crockford, P., de Moor, A., Halverson, G., Hodgkin, E., Hodgskiss, M., Holtzman, B., Jasechko, E., **Johnson, B.W.**, and Lamothe, K. (2016a). A misfit Cryogenian diamictite in the Vrede domes, Northern Damara Zone, Namibia: Chuos (Sturtian) or Ghaub (Marinoan) Formation? Moraine or Palaeovalley? *Communications of the Geological Survey of Namibia*, 17:1–16
- 2015 **Johnson, Ben W** and Goldblatt, C. (2015). The nitrogen budget of earth. *Earth Science Reviews*, 148:150–173
- 2012 Schauer, A. J., Kunasek, S. A., Sofen, E. D., Erbland, J., Savarino, J., **Johnson, Ben W.**, Amos, H. M., Shaheen, R., Abaunza, M., Jackson, T. L., Thiemens, M. H., and Alexander, B. (2012). Oxygen isotope exchange with quartz during pyrolysis of silver sulfate and silver nitrate. *Rapid Communications in Mass Spectrometry*, 26(18):2151–2157

## Teaching Experience

**Philosophy:** I seek to engage students in a meaningful and exciting way. By guiding students to concepts through activities and interactive questioning, they will procure a more complete understanding of a given topic than if they merely sat through a lecture. A friendly but professional approach to teaching is also paramount, as it encourages students to feel comfortable participating in the class while maintaining an appropriate level of order.

### Sessional Instructor

Spring 2017: University of Victoria, Sedimentary Geology (EOS 201)

### Advising

*University of Colorado - Boulder:* Undergraduate honors thesis (2018-2019): I have funding for and am advising an undergraduate student's honors thesis, which will characterize uplift and erosion history of Archean granites from the Pilbara using apatite thermochronology.

*University of Victoria:* Two undergraduate summer research assistants (2016-2017): One student built a simple nitrogen cycle model to study nitrous oxide, and the other did geochemical lab work in the summer of 2016 to measure geologic nitrogen. As part of her work, we have submitted a paper for peer-review.

### Guest Lectures

*Earth System Evolution:* Proterozoic oxygen levels: trace elements reveal the boring billion;  
The geologic nitrogen cycle

*Earth System Sciences:* Introduction to the Nitrogen Cycle, The Geologic Record and Initiation of Snowball Earth

*Isotopes in Natural Sciences:* Introduction to Stable Isotopes, Introduction to Cosmogenic Isotopes

*Geology of the National Parks:* Geologic History of the Western United States

2012-2016: **Teaching Assistant, University of Victoria** Courses (#): Geochemistry (240); Earth System Evolution (260); Earth Science Field School (300); Paleobiology (330); Isotopes in Natural Sciences (335); Earth System Science (460)

2011-2012: **Tutor, ATAC Tutoring, Seattle, WA, USA:** I taught primarily math and science to a wide variety of students, about 20 total. While the majority of my students were in high school, I also worked with middle and elementary school students. I developed specific plans for each students, and we would work on a wide range of subjects including: chemistry, biology, math, english, history, and general study skills.

2007-2009: **Teaching Assistant, University of Utah** Courses (#): Earthquakes and Volcanoes (two semesters, 1030); Geology of the National Parks (1050); Paleobiology (3180); Exploring Earth (1010); Earth Materials II (3090)

2004-2006: **Teaching Assistant, University of Puget Sound** Courses (#): Dinosaurs and the World They Lived In (111); Geophysics (206); Earth History (305)

## Grants, honors, awards, and scholarships

**University of Colorado - Boulder Geology Department Undergraduate Mentoring** - \$1,000 (2018)

**American Philosophical Society Lewis and Clark Astrobiology Field Work Grant** - \$4,430 (2018)

**National Science Foundation EAR Postdoctoral Fellowship** - \$87,000 per year (2017-2019).

**University of Victoria Fellowship** - \$12,000-\$15,000 (2012-2014).

**University of Victoria Outstanding Graduate Entrance Awards** - \$10,000 (2012).

**University of Utah Geology and Geophysics Department Outstanding Teaching Assistant Award** (2009).

**Geological Society of America Graduate Student Research Grant** -\$1,100 (2008).

**Elected a member of Phi Kappa Phi** (2006).

**Norman A. Anderson Award** University of Puget Sound outstanding graduating geology student (2006).

**University of Puget Sound University Enrichment Committee Award** award for senior thesis analytical work - \$400 (2006).

**University of Puget Sound Undergraduate Summer Research Grant** Grant given to support field work in Utah for my senior thesis project - \$3,000 (2005).

**Elected member of Phi Beta Kappa** as a junior at the University of Puget Sound (2005).

**University of Puget Sound Tuition Exchange Scholarship** Full tuition (2002-2006)

**University of Puget Sound Trustee Scholarship** Full tuition -\$8,000 per year (2002-2006)

**University of Puget Sound Music Scholarship** -\$2,000 per year (2002-2006)

## Research Experience

### *Current Projects*

**Archean seawater chemistry:** Using a well-preserved section of Paleoproterozoic (3.2 Ga) altered ocean crust in the Pilbara region of Australia, I am investigating the seawater chemistry recorded by water-rock interactions in this section. I am using existing O-isotope data in conjunction with whole rock chemistry and inverse modelling to estimate the  $\delta^{18}\text{O}$  value of Paleoproterozoic seawater. This value has important ramifications for interpretations of ocean temperature, with varying camps promoting high or relatively low temperatures. In addition, I will use S- and N-isotopic data to investigate biologic activity during this crucial period.

**Geologic Nitrogen Cycle:** I am constructing an Earth system box model to investigate the movement of N over Earth history. This model incorporates both geologic and biologic cycling of N, which is key for a full treatment of this whole Earth element. Important fluxes include N fixing and denitrification in the ocean, incorporation into crust during hydrothermal alteration, and volatilization during subduction. My initial results suggest large changes in atmospheric mass over time, driven by evolution of biologic pathways, such as oxygenic photosynthesis.

### *Past projects*

**Glacial Tills and Continental N:** I am using glacial tills as a proxy for the continental crust's N content through time. Large glaciers erode a variety of rock types, and when integrated on a large geographic scale, glacial tills can produce a record of bulk continental crust composition by sampling a wide range of rock types. By measuring a series of samples collected by Gasching et al. (2016) and augmenting them with samples from Canada, we show that the amount of N in the crust has increased over time, while the  $\delta^{15}\text{N}$  value has remained constant.

May 2014 - **Nitrogen cycling during Snowball Earth:** I am interested in nutrient cycling during Neoproterozoic Snowball Earth events. Biologic N cycling leaves distinctive isotopic signatures in sediments, and I combined nitrogen isotope measurements with redox sensitive trace elements and Fe-speciation analyses. This work found that there was active and dynamic nitrogen cycling, oxidative weathering, and oxygenic photosynthesis during this time. The simplest explanation for the data is that there were extensive areas of open water, directly questioning the canonical "hard" Snowball model.

June 2013-August 2016 **Measurement of geologic  $\text{NH}_4^+$ :** I and coworkers adapted a fluorometric technique, common in aquatic sciences, for use in quantifying geologic  $\text{NH}_4^+$  concentrations. The goal of this research is to establish a relatively quick and easy way to analyze this difficult to measure species in rocks and minerals.

May-July 2014: **Field work, Namibia:** I spent two months doing intensive field work on the Neoproterozoic rocks of northwestern Namibia with Dr. Paul Hoffman. The area consists of successions of carbonate platform rocks, thick sequences of siliciclastic, and two large glacial intervals. Scientific tasks included measuring stratigraphic sections, collecting samples, and geologic mapping. We spent most nights out camping, so I became well versed with navigating tough terrain in a pickup truck, camp cooking, and general good field practices.

September 2013-April 2014: **The Nitrogen Budget of Earth:** This project compiled and comprehensively synthesized the published record of N analyses in geologic materials. Based on these analyses, in conjunction with N-Ar systematics in basalts and xenoliths, we show that the majority of N in the Earth is contained in the mantle. This work also calculates a N budget based on comparison to chondrites, and estimates both a core N content and discusses using the moon as an analog for the early Earth mantle. This work has been published in *Earth Science Reviews*, and is posted to arXiv.

2012-2017: **PhD Student, University of Victoria:** My PhD work involved deciphering the geologic nitrogen cycle over Earth history. I am using a variety of techniques (e.g., computer modelling, stable isotope geochemistry) to investigate the nature of and changes to the N cycle over time. We are specifically focusing on developing a more comprehensive N budget for the Earth by measuring the N content of continental crust rocks. I will also incorporate modelling of subduction zone dynamics and Archean biologic N cycling. (Adviser: Dr. Colin Goldblatt, czg@uvic.ca)

2010-2011: **Research Scientist, University of Washington.** I worked in the Department of Atmospheric Sciences at the University of Washington, refining a method for measuring triple oxygen stable isotopes of aerosol and snow/ice sulfates. These measurements reflect oxidative pathways in the atmosphere, which can occur via mass-independent fractionations, and can be incorporated into climate models to garner a more complete view of global climate dynamics. The work was laboratory intensive, and I was in charge of sample processing, lab management, and data processing. Specific advancements include the use of gold sample capsules, cation exchange resins, and improved high-pressure liquid chromatography protocol. (Dr. Becky Alexander, supervisor)

2007-2009: **M.S. Student, University of Utah** I obtained my M.S. degree in Geology from the University of Utah. My thesis was a geochemical and petrographic investigation of the assembly history of the Alta Stock, a small granitic pluton in the Wasatch Mountains of Utah. Analyses of  $\delta^{18}\text{O}$  ratios of whole rock samples and mineral separates and Ti-quartz geothermometry were utilized as proxies for the assembly history of the stock. Through extensive field and detailed geochemical laboratory work, we gained insight into fundamental processes of pluton assembly. An online copy of my thesis can be found by clicking here. (Dr. John Bowman, adviser)

Fall 2007: **Field Work, Azerbaijan.** I traveled to Azerbaijan for two weeks to engage in field work at the request of Dr. Cari Johnson. The work involved measuring stratigraphic sections, gathering ash samples for dating, and mapping/correlating disparate outcrops. As the lone American on the trip, it was a challenging and fun opportunity to work with Azeri geologists on a common project. (Dr. Cari Johnson, principal investigator)

2005-2006: **Senior Thesis Project, University of Puget Sound** Completed a senior thesis research project entitled: Stable Isotope Stratigraphy of a Therizinosaur-section of the Tropic Shale near Big Water, Utah. The project consisted of field mapping, XRD and stable isotope analyses, collaboration with faculty and students from Stanford and Northern Arizona, and presentation of results at GSA sectional conference as well as for my undergraduate science peers. I also participated extensively in another student's senior thesis project in southern Utah. I assisted with field work, which was primarily mapping/stratigraphy work, but also with overall organization of both my and his thesis projects as a whole. We were both recipients of University of Puget Sound science grants (\$3000) used towards our research. (Dr. Travis Horton, adviser)

Summer 2004: **Biologic Technician, USDA Forest Service, Santa Fe, NM, USA:** I worked on a wildlife monitoring project in the Santa Fe City Watershed. The forest was being thinned, and we monitored the effects on the wildlife. Duties included daily bird surveys and point counts, small mammal trapping surveys, insect collection and vegetation surveys.

**Tools and Techniques** I am proficient in the use of many pieces of scientific equipment, including: Mass spectrometers (have measured N, O, and C); High pressure liquid chromatography; pipetters; isotope extraction lines and laser ablation techniques, electron microprobes; SEM; absorbance and fluorometric spectrometers; rock saws/thin section equipment; petrographic microscopes; paleomagnetic drills; X-ray diffraction; X-ray fluorescence; and mineral separation techniques (Frantz, HF treatment, heavy liquid, clean lab centrifuge, dental drill, etc.).

## Reviewer responsibilities

### Journal Reviews

I have reviewed articles in the following journals:

Geochemical Perspectives Letters

Astrobiology

Earth and Planetary Science Letters

Geostandards and Geoanalytical Research

### Panel reviews

I have participated in NASA reviews in the areas of Habitability and Microbiology.

### Invited Lectures

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| 2017: | <p><b>A new Earth system nitrogen cycle model</b> St. Andrew's University: Seminar given to the geobiology research group detailing my work on nitrogen cycle modelling incorporating geologic fluxes</p> <p><b>Nitrogen in the Earth System: from planet birth to Snowball Earth</b> University of Leeds</p>   |
| 2016: | <p><b>Nitrogen in the Earth System: from planet birth to Snowball Earth</b> This was a seminar given at the University of Puget Sound to all science departments. I discussed aspects of my PhD research, including the N budget of Earth and N cycling during Snowball Earth, as well as putting the terrestrial N cycle into a planetary context.</p> |

### Conference Sessions Chaired

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| 2018      | Goldschmidt Annual Meeting - Theme 7 (Co-evolution of Earth and Life through time) Organizer  |
| 2018      | Goldschmidt Annual Meeting - The rise of complex multicellular life and ecologies and their role in the Earth System, both past and present |
| 2014-2018 | AGU Fall Meeting - Evolution of the Earth System  |
| 2016      | Goldschmidt Annual Meeting - The Deep Nitrogen Cycle and the Evolution of Planetary Atmospheres   |

### Conference abstracts

\* - talk

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| 2018 | <p>*<b>Johnson, Benjamin W.</b> and Wing, B. A. (2018). Altered ocean crust from the Archean Panorama District, Australia, as a repository of ocean temperature, nutrients, and habitability. In <i>AGU Fall Meeting Abstracts</i></p> <p>*<b>Johnson, Benjamin W.</b> and Wing, B. A. (2018). Hydrothermally altered ocean crust constrains the oxygen isotope composition of 3.2 Ga seawater, Pilbara Craton, Australia . In <i>Goldschmidt Annual Meeting</i></p> |
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- Johnson, Benjamin W.** and Goldblatt, C. (2018b). EarthN: a new Earth System nitrogen cycle model. *Gordon Geobiology Conference*
- 2017 \***Johnson, Benjamin W** and Goldblatt, C. (2017a). A new model of the Earth system nitrogen cycle: how plates and life affect the atmosphere. In *Habitable Worlds*
- \***Johnson, Benjamin W** and Goldblatt, C. (2017b). A new model of the Earth System nitrogen cycle through time: how biology, plate tectonics, and the atmosphere interact to influence planetary habitability and nutrient cycles. In *Astrobiology Science Conference*
- 2016 **Johnson, B.W.** and Goldblatt, C. (2016). Modelling the Earth system nitrogen cycle: feedbacks between biology, plate tectonics, and atmospheric evolution. *American Geophysical Union Fall Meeting*
- Johnson, B.W.**, Hoffman, P. F., and Goldblatt, C. (2016). Oxygen and Nitrogen Under the Ice: Trace Elements and  $\delta^{15}\text{N}$  Evidence for Oxic Weathering and Oxygenated Waters during the Snowball Earth Marinoan Glaciation, Ghuab Formation, Namibia. *Goldschmidt Annual Meeting*
- Hoffman, P. F., Bellefroid, E. J., Hodgins, E., Hodgkiss, M., Jasechko, G., **Johnson, B.W.**, and Lamothe, K. (2016b). Glacial overdeeps and giant composite moraines imaged by closely-spaced measured sections in the Cryogenian of Namibia. *Geological Society of America Annual Meeting*
- 2015 **Johnson, Benjamin W**, Hanson, N., El-Sabaawi, R., and Goldblatt, C. (2015). Analyses of ammonium in geologic samples: comparison of indophenol-blue and fluorometric methods. *American Geophysical Union Fall Meeting*
- \***Johnson, Benjamin W** and Goldblatt, C. (2015). Nitrogen budget of earth: Insights into volatile cycling in the deeper planet. *Goldschmidt Annual Meeting*
- Hoffman, P. F., Bellefroid, E. J., **Johnson, Benjamin W**, and Schrag, D. P. (2015a). Lost and found: Islay C IE is unrelated to Sturtian glaciation in Namibia. *AGU-GAC-MAC-UGC Joint Assembly*
- Hoffman, P. F., Hodgins, E., Bellefroid, E. J., Crockford, P., Jasechko, G., Johnson, B. W., San-Jofre, P., and Schrag, D. P. (2015b). Expanded records of early Ediacaran carbonate  $\delta^{13}\text{C}$  from Namibia: synchronous foredeep initiation bordering the Kaoko and Damara belts? *AGU-GAC-MAC-UGC Joint Assembly*
- 2014 A Cryogenian-early Ediacaran carbonate shelf break dominated by glacial paleotopography, Fransfontein Ridge, Kunene Region, Namibia, Hoffman, Paul F; Bellefroid, E; Hodgins, Eben B. **Johnson, Benjamin W.**; Kunzmann, Marcus ; San-jofre, Pierre; Strauss, Justin V.; and Schrag, Daniel P.

- The Nitrogen Budget of Earth, **Johnson, Ben W** and Goldblatt, Colin. *Goldschmidt Conference*
- 2013 The Geologic Nitrogen Cycle, **Johnson, Ben W** and Goldblatt, Colin. *AGU Fall Meeting*
- 2009 \***Johnson, Ben W**, Bowman, J. R., Nash, B., Valley, J., and Bartley, J. M. (2009b). Oxygen isotope, TitaniQ, and cathodoluminescence analyses of the Alta Stock, UT: Preliminary insights into pluton assembly. In *Geological Society of America Abstracts with Programs*, volume 41, page 43
- Johnson, Ben W**, Bowman, J., Valley, J., and Bartley, J. (2009a). Oxygen isotope, TitaniQ, and cathodoluminescence analyses of the Alta Stock, UT: Preliminary insights into pluton assembly. In *AGU Spring Meeting Abstracts*, volume 1, page 03
- 2006 **Johnson, Ben W**, Gillette, D. D., and Horton, T. W. (2006). Stable isotope stratigraphy of a therizinosaur-bearing section of the Tropic shale near Big Water, Utah. In *102nd Annual Meeting of the Cordilleran Section, GSA, 81st Annual Meeting of the Pacific Section, AAPG, and the Western Regional Meeting of the Alaska Section, SPE*
- Loewen, M., Brown, M., Cohen, J., Manthei, C., Eiriksson, D., **Johnson, Ben W**, Phelps, D. E., and Tepper, J. (2006). Petrology of Eocene dike swarm in Corbaley Canyon, central Cascades, Washington. In *102nd Annual Meeting of the Cordilleran Section, GSA, 81st Annual Meeting of the Pacific Section, AAPG, and the Western Regional Meeting of the Alaska Section, SPE*, volume 38, page 95
- Phelps, D. E., **Johnson, Ben W**, and Horton, T. W. (2006). Stable isotope paleotopography of the Central Colorado Plateau/Basin and Range transition zone. In *Geological Society of America Abstracts with Programs*, volume 38, page 34
- McCormick, K., Horton, T., **Johnson, Ben W**, and Gillette, D. (2006). Depositional environment and taphonomy of a therizinosaurid (Dinosauria) from the tropic shale (Cenomanian-Turonian), Kane County, Utah. In *Journal of Vertebrate Paleontology*, volume 26, pages 98A–98A. Society of Vertebrate Paleontology

## Committees and Organizations

2015: **Member** Search committee graduate student representative for School of Earth and Ocean Sciences

2014-present: **Member** Geochemical Society

2013-2014: **Representative** Graduate Student Society for Earth and Ocean Sciences

2008-present: **Member** American Geophysical Union

2005-present: **Member** Geological Society of America

2007-2009: **Member and acting co-chair** Graduate Student Advisory Committee, University of Utah. As acting co-chair of Graduate Student Advisory Committee, I collected student opinion for a Tenure review and a Retention review for two faculty members. I also organized gathered opinion into a formal report submitted to the faculty. I also participated in faculty search/hire for a new Vertebrate Paleontology Position at the University of Utah

2005-2006: **President** Geology Club, University of Puget Sound

## Short courses and training

**NASA NExSS Astrobiology Winter School** - This week-long short course served to orient young scientists from a variety of backgrounds in the basic aspects of geology, astronomy, physics, and biology as they are applicable to astrobiology. We learned through lectures, field trips, but most importantly through a mock-grant proposal bringing together people with various expertise.

**Lab safety training** - University of Victoria: Workplace Hazardous Material Information System (WHMIS), general safety training. University of Washington: General lab safety training, compressed gas cylinder safety

## Community Outreach

2016: **What does it take to hammer a rock on another planet?** I presented an overview of solar system geology and recent NASA missions to a group of students, aged 10-18 at a local, independent school.

2012-2016: **School Climate Lab visits** At the University of Victoria, we regularly had class visits from students in grades 4-5. During these visits, we did science demonstrations illustrating important concepts relating to weather and climate

2009: **Peruvian Lodge, Alta Ski Area, Utah** Spoke to a general audience about the geologic history of Utah and my M.S. thesis work.