

ROMAIN DARNAJOUX, Ph.D.

Associate Research Scholar

CURRICULUM VITAE

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EDUCATION

- 2015 Ph.D. in Biogeochemistry, Université de Sherbrooke, Sherbrooke (QC), Canada (Prof. Bellenger, J.-P.)
“Homeostasis of micronutrients of biological nitrogen fixation in the boreal cyanolichen *Peltigera aphthosa*”
- 2010 M.Sc. Chemistry (Diplôme d'Ingénieur), National Graduate School of Chemistry of Lille (ENSCL), Lille, France
- 2006 B.Sc. in Biology-Geology (“Prépa” CPGE), François I College, Fontainebleau, France

APPOINTMENTS

- 2021-now Research Associate Scholar, Princeton University, Geosciences Dept. (USA) (Zhang lab)**
- 2019-2020 Postdoctoral Research Associate, Princeton University, Geosciences Dept. (USA) (Zhang lab)**
- 2017-2019 Postdoctoral Research Fellow of the [LSRF](#), Princeton University, Geosciences Dept. (USA) (Zhang lab)
- 2016-2017 Postdoctoral Research Fellow of the [LSRF](#), Princeton University, Geosciences Dept. (USA) (Morel lab)
- 2015-2016 Postdoctoral Researcher in Soil Science, Université de Sherbrooke, Biology Dept. (Canada) (Prof. Bradley, R.)
- 2015-2016 Project Coordinator, [Mini-Free-Air CO₂ Enrichment](#), Université de Sherbrooke, Biology Dept. (Canada)
- 2010-2011 Lab Manager, Université Paris Descartes (Paris 5), Chemistry & Biochemistry Practical Laboratory (France)
- 2010 Graduate Researcher (Microbiology and NMR, 6 months), University of Kent, Biosciences Dept. (UK)
- 2007-2010 Short-term technical internships (3 months) in production quality control (TYK, Japan & L'Oréal, France) and organic synthesis of pharmaceutical compound (Institute Pasteur of Lille, France)

PROPOSALS & FUNDING

As PI:

- 2021-2023 Thomas A. and Currie C. Barron Family Biodiversity Research Challenge Fund, High Meadows Environmental Institute (\$100,000) “What Controls the Biodiversity and Function of Cryptogam Microbiomes?” Co-PI: Prof. X. Zhang.**
- 2016-2019 Life Science Research Foundation Postdoctoral Fellowship, sponsored by the Simons Foundation (\$180,000), “Deciphering the genomic and metabolic heterogeneity of biological nitrogen fixation in boreal ecosystems”
Advisors: Prof. F. Lutzoni (Duke University) & Profs. X. Zhang & F.M.M. Morel (Princeton University).

As collaborator:

- 2020-2021 MOST-FNRS Belgium-Taiwan bilateral fund (15,000€) (contributed to proposal writing), “Elucidating the ecological role of lichen and bryophyte microbiomes in Montane Cloud Forests of Taiwan.” PI: Profs. N. Magain & A Vanderpoorten (U.Liege) & Prof. K.-H. Chen (Academia Sinica)**

HONORS & AWARD

- 2016 Registration fellowship for the “12th Workshop on Cyanobacteria” (Tempe, AZ, USA).
- 2015 Honor's list of the Dean, Ph.D. Thesis, Faculty of Sciences (Université de Sherbrooke)
[Excellence certificate](#), Chapitre Saint-Laurent
[Public and Jury Prizes](#) “4 minutes to talk about science”, Chapitre Saint-Laurent (video in french).
- 2014 [“Gene H. Kruger” Excellence Award](#) for academic achievement (Université de Sherbrooke).

TEACHING RECORD

- 2019 Department of Geosciences, Princeton University (Prof. Maloof)**
Design and taught 1h course: “Introduction to R and statistical distributions”
- 2015 Soil biology, Université de Sherbrooke, Biology Dept., Invited (Prof. Bradley)
Designed and taught 1h course: “Importance of V-based nitrogen fixation in boreal forests.”, 15 students
- 2015 Analytical chemistry, Université de Sherbrooke,
Design and taught 1h course: “Multivariate Statistics in Environmental Sciences.”, 10 graduates students

TEACHING RECORD-continued

- 2014-2015 Analytical chemistry, Université de Sherbrooke, Chemistry Dept. Invited (Prof. Segura)
Designed and taught 2h course: "Element quantification in biological tissues with ICP-MS.", 20 students
- 2014-2015 Analytical chemistry practical, Université de Sherbrooke, Chemistry Dept.
Designed and taught 4h course: "Error measurement and statistics.", 150 students
- 2012-2013 General chemistry & Aqueous chemistry practical, Pre-Bsc program, Université de Sherbrooke, Chemistry Dept.
- 2010-2011 Biochemistry practical lab, B.S. & M.S level, University Paris Descartes, Biosciences Dept., 350 students.
- 2010-2011 Chemistry, B.S. level, one-on-one private lessons, 80 hours (Courses designed and taught)

STUDENTS MENTORING (year, resulting publication)

Princeton : **Ezra Zimble (2019, on-going)**, Xinrei Zhang (2018, Darnajoux et al., *submitted*), Kelly Van Balen (2017), Sherbrooke Léo-Janne Paquin (2015, on-going), Marie-Claire Lot (2014), Raphael Cassoulet (2013), Jérôme Constantin (2012, Darnajoux et al. 2014).

FIELDWORK EXPERIENCE

- **2019: 1-month field sampling campaign in Japan (Hokkaido, Honshu, Kyushu). Organization, Logistic, Sampling.**
- 2017: Seven-day field sampling campaign in remote Eastern Canadian boreal forest. Five locations along 600km transect. Logistic, Sites localization, Sampling.
- 2015-2016: Mini-Forced Air Carbon Enrichment facility, Chicoutimi Teaching Research Forest, visited every two weeks. Maintenance, treatment application, and sampling.

ADVANCED TRAINING/WORKSHOPS

- GIS workshop (5 x 2hr sessions), 2018, Princeton University, organizer: William Guthe and Tsering Shawa
- Modeling microbial dynamic and processes from cells to ecosystems, AGU 2018 Scientific Workshop WS30.

LANGUAGE PROFICIENCY

- French: Native
- English: Fluent
- Japanese: Intermediate (speaking & reading), Beginner (writing).

PUBLIC AND PROFESSIONAL SERVICE

Invited speaker

- **Environmental Geology and Geochemistry Seminar Lecture, Geosciences Dept., Princeton University, NJ, USA, (2021) "Biological Nitrogen Fixation: How to bridge the gap between field measurements and ecosystem-level estimates."**
- **Special seminar, Research Faculty of Agriculture, University of Hokkaido, HK, Japan (2019) "Biological nitrogen fixation activity in boreal forests: predictable pattern in mosses and lichens."**
- Environmental Geology and Geochemistry Seminar Lecture, Geosciences Dept., Princeton University, NJ, USA, (2014) "Deciphering the ecological importance of V-based nitrogen fixation in boreal ecosystems."
- Environmental Sciences Grad Student Association Special Seminar, Institute of Earth, Ocean and Atmospheric Sciences, Rutgers University, NJ, USA (2014) "Deciphering the ecological importance of V-based nitrogen fixation in boreal ecosystems."

Synergistic Activities

- **Annual Departmental Advisory Council, representant of Postdoctoral Researcher, Princeton University (2020)**
- Environmental Geology and Geochemistry Seminar Series, co-coordinator, Princeton University (2017-2018)
- Occupational Safety and Health delegate (A.C.M.O.), 2010-2011, Université Paris Descartes (Paris 5)

- Deputy Regional Student Representative for Nord Pas-de-Calais (CROUS, elected) (2008-2009)
- Occupational Safety and Health student delegate, 2008-2010, ENSCL, Lille, France
- Head of the Student Body (Elected), 2007-2008, ENSCL, Lille, France

Reviewer activity

- Catena, Ecology, Ecosystems, Environmental pollution, ES&T, Functional Ecology, Marine Ecology Progress Series, Microbiological Research, Nature Communication, Plant and Soil, PLOS One.

Society membership

- European Geochemical Union, American Association for the Advancement of Science.

Outreach

- [Le Couvert Boréal : Les cyanobactéries en forêt boréale](#) – *Hiver 2022 (in French)*
- [Phys.org: Nature’s backup plan for converting nitrogen into plant nutrients](#) – *November 11, 2019*
- [SEPAQ \(Québec Parks\) Blog: “Lichens & Nitrogen”](#) – *August 15, 2017 (in French)*
- [Magazine Nature Sauvage - no 32 - Summer 2016 - p14: “The pollution line”](#) – *June 22, 2017 (in French)*
- [ASP \(Science Press Agency\) - Environment blog: “The northern limit of air pollution”](#) – *January 26, 2016 (in French)*
- [Chapitre St Laurent, 4 minutes to talk about science: “Discover my Ph.D., deciphering the ecological importance of V-based nitrogen fixation in boreal ecosystems”](#) – *May 26, 2015 (in French)*

PROFESSIONAL REFERENCES

Prof. Jean-Philippe Bellenger (Terrestrial biogeochemistry), Ph.D. advisor, Université de Sherbrooke

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Phone : +1 819 821 7014, e-mail : jean-philippe.bellenger@usherbrooke.ca

Prof. Xinning Zhang (Environmental microbiology), Postdoctoral and Research associate advisor, Princeton University

Department of Geosciences, M47 Guyot Hall, Washington Rd., Princeton, NJ 08544, USA

Phone : +1 609 258 2489, e-mail : xinningz@princeton.edu

Prof. François Lutizoni (Evolutionary biology), Collaborator, Duke University

Department of Biology, 357 Bio. Sci. Bldg, Duke University, Box 90338, Durham, NC 27708, USA

Phone : +1 919 660 7261, e-mail : flutizoni@duke.edu

Prof. François Morel (Aquatic chemistry and biogeochemistry), Postdoctoral advisor, Princeton University

Department of Geosciences, 153 Guyot Hall, Washington Rd., Princeton, NJ 08544, USA

Phone : +1 609 258 2416, e-mail : morel@princeton.edu

Prof. Robert Bradley (Soil ecology), Postdoctoral advisor, Université de Sherbrooke

Département de Biologie D5-205, 2500 Blvd de l’Université, Sherbrooke, QC J1K 2R1, Canada

Phone : +1 819 821 2080, e-mail : robert.bradley@usherbrooke.ca

SCIENTIFIC CONTRIBUTIONS

Refereed papers

2019-2022:

12. **Darnajoux, R.**, Bradley, R., Bellenger, J.P., (2022) *In vivo* temperature dependency of molybdenum and vanadium nitrogenases activity in the heterocystous cyanobacteria *Anabaena variabilis*. *Environ. Sci. Technol.*, 56(4), 2460-2769.
Highlight: *In vivo* specific activity of the vanadium (V) nitrogenase is similar to that of the Mo nitrogenase below a temperature of around 15°C. We identified substrate affinity and solubility, and conformational changes during electron transfer between two sub-units of nitrogenase as the main drivers for change in activity with temperature.
11. Renaudin, M, **Darnajoux, R.**, Bellenger, J.P. (2021) Quantification of moss-associated cyanobacteria biomass using phycocyanin pigment extraction. *Frontiers in Microbiology*, 11, 3294
Highlight: We developed a new, high-throughput method to quantified cyanobacterial abundance on moss and re-examined the relationship between cyanobacterial abundance and nitrogen fixation activity. This result adds to the needed tools to study the role of moss-associated cyanobacteria in forests.
10. Meehan, M. L., Barreto, C., Turnbull, M. S., Bradley, R. L., Bellenger, J.-P., **Darnajoux, R.**, Lindo, Z., (2020) Response of soil fauna to simulated global change factors depends on ambient climate conditions. *Pedobiologia*, 83 150672
Highlight: This study, the first report from the mini-Forced-Air CO₂ Enrichment (Mini FACE) field experiment, investigates the response of soil microarthropod to simulated climate change condition (CO₂, Temperature and N addition). The results highlight that annual rainfall may dictate soil faunal response to simulated climate change.
9. Bellenger J.P., **Darnajoux, R.**, Zhang, X., Kraepiel, A.M.L., (2020) Biological nitrogen fixation by alternative nitrogenases in terrestrial ecosystems: A review. *Biogeochemistry*, 149:53–73
Highlight: This review summarizes current knowledge on the role and importance of alternative nitrogenases in terrestrial ecosystems. Many of the field-based demonstrations of V-nitrogenase contribution to BNF come from my Ph.D. and postdoc research. This review will promote this fast-emerging research topic and ensure the efficient dissemination of my work.
8. **Darnajoux, R.**, Magain, N., Renaudin, M., Lutzoni, F., Bellenger, J.P., Zhang, X. (2019) Molybdenum threshold for ecosystem-scale alternative vanadium nitrogenase activity in boreal forests. *Proceeding of the National Academy of Science of the United States of America*, 116(49) 24682-88.
Highlight: This is the first demonstration of the biome-scale activity of V-nitrogenase in the environment (15-50% of samples nitrogen fixation), and it shows that low Mo availability is the main driver. It calls for a re-evaluation of our nitrogen input estimates and our conceptual model for N fixation in natural, Mo-limited ecosystems.

Before 2019:

7. **Darnajoux, R.**, Bradley, R., Houle, D., Bellenger, J.P. (2018) Predictable spatial patterns of biological nitrogen fixation in forest floor mosses: Color matters! *Soil Biology and Biochemistry*, 122, 160-62.
Highlight: The phenotype “color” of moss shoots is a good predictor of their nitrogen status and can help predict the heterogeneity in the biological N fixation activity of boreal moss mats at the plot scale. This phenotype will allow for more robust sampling designs and opens up the possibility of developing remote sensing tools for probing N input at the biome scale.
6. **Darnajoux, R.**, Zhang, X., McRose, D., Miadlikowska, J., Lutzoni, F., Kraepiel, A.M.L., & Bellenger, J.P. (2017) Alternative nitrogenase contribute to biological nitrogen fixation in boreal cyanolichens. *New Phytologist*, 213(2), 680-89.
5. Zhang, X., McRose, **Darnajoux, R.**, Bellenger, J.P., Morel, F.M.M., & Kraepiel, A.M.L. (2016) Alternative nitrogenase activity in the environment and nitrogen cycle implications. *Biogeochemistry*, 127(2), 189-98.
Highlight: Publications 5 and 6 uses evidence from genomics, metal homeostasis, and isotopic biogeochemistry to provide the first proof of activity of V-nitrogenase in the environment. Substantial V-Nase activity in the *Nostoc* partner of boreal cyanolichens calls for a re-evaluation of our conceptual model linking trace metal (Mo, V, Fe) and major nutrient (N and C).
4. Jouogo-Noumsi, C., Pourhassan, N., **Darnajoux, R.**, Deicke, M., Wichard, T., Burrus, V. & Bellenger, J.P. (2016) Effect of organic matter on nitrogenase metal cofactor homeostasis in *Azotobacter vinelandii* under diazotrophic condition. *Environmental Microbiology Report*, 8, 76–84
Highlight: The presence of DOM (tannic acid) in culture media strongly influences metal acquisition and rearranges the order of nitrogenase preference during diazotrophic growth. This result demonstrates that our knowledge from in vitro laboratory condition need to be updated to understand the behavior of key metabolism in complex environmental samples

3. **Darnajoux, R.**, Lutzoni, F., Miadlikowska, J., & Bellenger, J.P. (2015). Determination of elemental baseline using peltigeralean lichens from Northeastern Canada (Québec): Initial data collection for long term monitoring of the impact of global climate change on boreal and subarctic area in Canada. *Science of the Total Environment*, 533, 1-7.

Highlight: *Most of the northeastern Canadian boreal forest floor receives low elemental atmospheric deposition levels, i.e., as low as in remote or high elevation areas (e.g., Alps, Antarctica). This finding affects our understanding of C and N cycling in the boreal ecosystems, which rely on atmospheric deposition for their micronutrient (e.g., Mo, Fe, Cu) sources.*

2. **Darnajoux, R.**, Constantin, J., Miadlikowska, J., Lutzoni, F., & Bellenger, J.P. (2014). Is vanadium a biometal for boreal cyanolichens? *New Phytologist*, 202(3), 765-71.

Highlight: *Using samples of cyanolichen collected over the boreal belt, we demonstrate that vanadium is actively enriched in the cyanobacterial symbiont of boreal cyanolichen. Further, V regulation over increasing levels of metal exposure is similar to the homeostasis of Mo and V in the model cyanobacterium *Anabaena variabilis*, which contains a vanadium nitrogenase.*

1. Allard, P., **Darnajoux, R.**, Phalyvong, K., & Bellenger J.P. (2013). Effects of tungsten and titanium oxide nanoparticles on the diazotrophic growth and metals acquisition by *Azotobacter vinelandii* under molybdenum limiting condition. *Environmental Science & Technology*, 47(4), 2061–2068.

Highlight: *Metallophores (i.e., metal-binding biomolecules), produced by certain diazotrophs during metal (e.g., Fe, Mo) limitation, considerably speed up the dissolution of W and increase the inhibitory effect of W nanoparticles on diazotrophic growth. This research illustrates how microbes interact with emerging pollutants and can increase their toxicity.*

Manuscripts submitted.

- **Darnajoux, R.**, Reji, L., Zhang, R., Luxem, K. & Zhang X., The ammonium sensitivity of biological nitrogen fixation in sulfate-reducing diazotrophs and coastal salt marsh sediments. *In review*

Highlight: *We studied the time response and sensitivity of anaerobic sulfate reducers to fixed-N addition in pure culture and coastal sediments. We found compelling evidence that N fixation in those ecosystems is sensitive to low concentrations of NH_4^+ , contradicting multiple reports on the presence of nitrogen fixation in N rich sediment.*

Conference Presentations (*speaker)

2019-2022:

1. Bellenger, J.-P.*, **Darnajoux, R.**, Magain, N., Renaudin, M., Lutzoni, F., and Zhang, X.: “Ecosystem scale evidence for the contribution of vanadium-based nitrogenase to biological nitrogen fixation.”, [Oral presentation at the European Geochemical Union Assembly](#), Vienna, Austria (Avril 2021).

2. **Darnajoux, R.***, Zhang, R., Luxem, K., Zhang, X. “The fixed nitrogen sensitivity of biological nitrogen fixation in sulfate-reducing salt marshes sediments from the northeastern United States.” [Online presentation delivered at the European Geochemical Union online 2020](#), (May 2020)

3. **Darnajoux, R.***, Bradley, R.*, Le Monier, P., Houle, D., Bellenger, J.-P. “Drivers of spatial heterogeneity of biological nitrogen fixation in northeastern Canadian boreal forest.”. Oral presentation delivered by co-author RB on my behalf at the *European Geochemical Union meeting, Vienna, Austria* (April 2019)

Before 2019:

4. **Darnajoux, R.***, Zhang, R., Zhang, X. “The fixed nitrogen sensitivity of biological nitrogen fixation in the sulfate-reducing diazotroph, *Desulfovibrio vulgaris*.” [Poster presentation](#) delivered at the *American Geochemical Union fall meeting, Washington, USA* (December 2018)

5. **Darnajoux, R.***, Renaudin, M., Magain, N., Lutzoni, F., Bellenger, J.-P., Zhang, X. “Vanadium nitrogenase in boreal cyanolichens: biome level activity and regulation.”. Oral presentation delivered at the *13th European Nitrogen Fixation Conference, Stockholm, Sweden* (August 2018)

6. **Darnajoux, R.***, Renaudin, M., Magain, N., Lutzoni, F., Bellenger, J.-P., Zhang, X. “Vanadium nitrogenase in boreal cyanolichens: biome level activity and regulation.”. Oral presentation delivered at the *17th International Society for Microbial Ecology Symposium, Leipzig, Germany* (August 2018)

7. **Darnajoux, R.***, Bradley, R., Le Monier, P., Houle, D., Bellenger, J.-P. “Drivers of spatial heterogeneity of biological nitrogen fixation in northeastern Canadian boreal forest.”. [Poster presentation](#) delivered at the *Ecological Society of America 2018 meeting, New Orléans, LA, USA* (August 2018)
8. **Darnajoux, R.***, Zhang, X., Magain, N., McRose, D., Miadlikowska, J., Kraepiel, A., Lutzoni, F., Bellenger, J.-P. “Vanadium nitrogenase in boreal cyanolichens: activity and regulation.”. [Poster presentation](#) delivered at the *Goldschmidt 2017, Paris, France* (August 2017)
9. **Darnajoux, R.***, Zhang, X., McRose, D., Miadlikowska, J., Kraepiel, A., Lutzoni, F., Bellenger, J.-P. “A glimpse at the lichen symbiosis; from metal homeostasis to ecosystems function.”. Oral presentation delivered at the *Northeastern Geobiology Symposium 2017, Storrs, Connecticut, USA* (March 2017)
10. **Darnajoux, R.***, Zhang, X., McRose, D., Miadlikowska, J., Kraepiel, A., Lutzoni, F., Bellenger, J.-P. “The importance of vanadium-based nitrogen fixation in boreal cyanolichens: a case study using *Peltigera aphthosa* (L.) Willd. s. l.”. [Poster presentation](#) delivered at the *8th International Association of Lichenology Symposium, Helsinki, Finland* (August 2016)
11. **Darnajoux, R.***, Bradley R., and Bellenger, J.-P. “In vivo characterization of nitrogenase kinetics in *Anabaena variabilis* ATCC 29413 using cavity ring-down spectroscopy”. Oral presentation delivered at the *12th Workshop on Cyanobacteria, Tempe, AZ, USA* (May 2016)
12. **Darnajoux, R.***, Houle, D., Bellenger, J.-P., and Bradley Robert. “Fixation d’azote dans les pessières à mousse : Quand la couleur importe !”. Oral presentation delivered at the *10^{ème} Colloque du Centre d’Étude de la Forêt, Montréal, Qc, Canada* (May 2016)
13. Jouogo Nouns C*., **Darnajoux R.**, Pourhassan N., Deicke M., Wichard T., Burrus V. and Bellenger J.P. “Effect of natural organic matter on metal acquisition and nitrogenase use by *Azotobacter vinelandii*.” Oral presentation delivered at the *International Symposium on Interactions of Soil Minerals with Organic Components and Microorganisms (ISMOM), Montréal, Qc, Canada.* (July 2015)
14. **Darnajoux, R.***, Morin, H., Lindo, Z., Bradley R., and Bellenger, J.-P. « The Boreal mini-FACE project: l’effet des changements climatiques globaux sur la fixation d’azote en forêt boréale.” [Poster presentation](#) delivered at the 19^{ème} Colloque annuel du Chapitre Saint-Laurent, Sherbrooke, Qc, Canada. (June 2015)
15. **Darnajoux R.***, Miadlikowska J., Lutzoni F. and Bellenger J.-P. “Le grand nord québécois demeure l’une des régions les moins contaminées en métaux de la planète”. Oral presentation delivered at the 19^{ème} Colloque annuel du Chapitre Saint-Laurent, Sherbrooke, Qc, Canada. (June 2015)
16. **Darnajoux R.***, Miadlikowska J., Lutzoni F. and Bellenger J.P. “Study of the importance of vanadium based nitrogen fixation in the tripartite boreal cyanolichen : *Peltigera aphthosa*.” Oral presentation delivered at the 18^{ème} Colloque annuel du Chapitre Saint-Laurent, Quebec, QC, Canada. (June 2014)
17. **Darnajoux, R.***, Miadlikowska, J., Lutzoni, F. and Bellenger, J.-P.*, “Metal homeostasis in the foliose lichen *Peltigera aphthosa* from northern hemisphere.” [Poster presentation](#) delivered by co-author JPB on my behalf at the *European Geochemical Union meeting, Vienna, Austria* (April 2014)
18. **Darnajoux, R.***, Bellenger, J.-P. (2014). “Investigating temperature dependency of nitrogen fixation in cyanobacteria using acetylene reduction assay cavity ring-down laser absorption spectroscopy (ARACAS).” [Poster presentation](#) delivered at the *Mer Bleue Workshop, McGill University, Montréal, Qc, Canada.* (March 2014)
19. **Darnajoux, R.***, Miadlikowska, J., Lutzoni, F. and Bellenger, J.-P. “Determination of baseline contamination of foliose lichens in Eastern Canada (Québec)” Oral presentation delivered at the *96th Canadian Chemistry Conference, Québec, Qc, Canada.* (May 2013)