

GRETHE HYSTAD

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Education

- 2009 **Ph.D. Mathematics**, University of Arizona, Tucson, AZ, U.S.A.
Periodic Ising Correlations
- 2006 **M.S. Mathematics**, University of Arizona, Tucson, AZ, U.S.A.
Sum of Lowest Eigenvalues of the Discrete Laplacian
- 2000 **Candidata Magisterii Mathematics**, University of Oslo, Oslo, Norway
- 1999 **Three-year degree in Medical Laboratory Technology**
Østfold University College, Fredrikstad, Norway

Academic Employment

- 2021– Associate Professor of Statistics, Purdue University Northwest
Department of Mathematics and Statistics, Hammond, IN, U.S.A.
- 2015–2021 Assistant Professor of Statistics, Purdue University Northwest
Department of Mathematics and Statistics, Hammond, IN, U.S.A.
- 2010–2015 Lecturer, Aug 2014–Aug 2015
Adjunct Instructor/Instructor, Jan 2010–Aug 2014
University of Arizona, Department of Mathematics, Tucson, AZ, U.S.A.

Awards & Honors

- 2021 2021 Felix Chayes Prize for Excellence in Research in Mathematical Petrology,
International Association for Mathematical Geosciences ([Link](#)) and ([Link](#))
- 2021 Teaching Incentive Program Award, Purdue University Northwest ([Link](#))

Publications

(Refereed articles)

- 2021 Boujibar, A.; Howell, S.; Zhang, S.; Hystad, G.; Prabhu, A.; Liu, N.; Stephan, T.; Narkar, S.; Eleish, A.; Morrison, S. M.; Hazen, R. M.; and Nittler, L. R., Cluster Analysis of Presolar Silicon Carbide Grains: Evaluation of Their Classification and Astrophysical Implications. *The Astrophysical Journal Letters*, 907; L39, 2021. <https://doi.org/10.3847/2041-8213/abd102>
- 2020 Morrison, S. M.; Buongiorno, J.; Downs, R. T.; Eleish, A.; Fox, P.; Giovannelli, D.; Golden, J. J.; Hummer, D. R.; Hystad, G.; Kellogg, L. H.; Kreylos, O.; Krivovichev, S. V.; Liu, C.; Merdith, A.; Prabhu, A.; Ralph, J.; Runyon, S. E.; Zahirovic, S.; and Hazen, R. M., Exploring Carbon Mineral Systems: Recent Advances in C Mineral Evolution, Mineral Ecology, and Network Analysis. *Frontiers in Earth Science*, 8; 208, 2020. <https://doi.org/10.3389/feart.2020.00208>
- 2019 Hystad, G.; Morrison, S. M.; and Hazen R. M., Statistical Analysis of Mineral Evolution and Mineral Ecology: The Current State and a Vision for the Future. Inaugural Issue of *Applied Computing and Geosciences*, 1; 1-5, 2019. <https://doi.org/10.1016/j.acags.2019.100005>
- 2019 Hystad, G.; Eleish, A.; Hazen, R. M.; Morrison, S. M.; and Downs, R. T., Bayesian Estimation of Earth's Undiscovered Mineralogical Diversity Using Noninformative Priors. *Mathematical Geosciences*, 51; 401-417, 2019. <https://doi.org/10.1007/s11004-019-09795-8>
- 2019 Hazen, R. M.; Downs, R. T.; Eleish, A.; Fox, P.; Gagné, O. C.; Golden, J. J.; Grew, E. S.; Hummer, D. R.; Hystad, G.; Krivovichev, S. V.; Li, C.; Liu, C.; Ma, X.; Morrison, S. M.; Pan, F.; Pires, A. J.; Prabhu, A.; Ralph, J.; Runyon, S. E.; and Zhong, H., Data-Driven Discovery in Mineralogy: Recent Advances in Data Resources, Analysis, and Visualization. *Engineering, Special Issue: Deep Matter & Energy*, 5; 397-405, 2019. <https://doi.org/10.1016/j.eng.2019.03.006>
- 2019 Grew, E.; Hystad, G.; Toapanta, M. P. C.; Eleish, A.; Ostroverkhova, A.; Golden, J.; Hazen, R. M., Lithium Mineral Evolution and Ecology: Comparison with Boron and Beryllium. *European Journal of Mineralogy*, 31; 755-774, 2019. <https://doi.org/10.1127/ejm/2019/0031-2862>
- 2018 Liu, C.; Eleish, A.; Hystad, G.; Golden, J. J.; Downs, R. T.; Morrison, S. M.; Hummer, D. R.; Ralph, J. P.; Fox, P.; and Hazen, R. M., Analysis and Visualization of Vanadium Mineral Diversity and Distribution. *American Mineralogist*, 103; 1080-1086, 2018. <https://doi.org/10.2138/am-2018-6274>
- 2017 Grew, E. S.; Hystad, G.; Hazen, R. M.; Krivovichev, S. V.; and Gorelova, L. A., How Many Boron Minerals Occur in Earth's Upper Crust? *American Mineralogist*, 102; 1573-1587, 2017. <https://doi.org/10.2138/am-2017-5897>
- 2017 Liu, C.; Hystad, G.; Golden, J. J.; Hummer, D. R.; Downs, R. T.; Morrison, S. M.; Ralph, J. P.; and Hazen, R. M., Chromium Mineral Ecology. *American Mineralogist*, 102; 612-619, 2017. <https://doi.org/10.2138/am-2017-5900>

- 2017 Hazen, R. M.; Hystad, G.; Golden, J. J.; Hummer, D. R.; Liu, C.; Downs, R. T.; Morrison, S. M.; Ralph, J. P.; and Grew, E. S., Cobalt Mineral Ecology. *American Mineralogist*, 102; 108-116, 2017. <https://doi.org/10.2138/am-2017-5798>
- 2017 Hystad, G.; Downs, R. T.; Hazen, R. M.; and Golden, J. J., Relative Abundances of Mineral Species: A Statistical Measure to Characterize Earth-like Planets Based on Earth's Mineralogy. *Mathematical Geosciences*, 49; 179-194, 2017. <https://doi.org/10.1007/s11004-016-9661-y>
- 2016 Grew, E. S.; Krivovichev, S. V.; Hazen, R. M.; and Hystad, G., Evolution of Structural Complexity in Boron Minerals. *Canadian Mineralogist*, 54; 125-143, 2016. <https://doi.org/10.3749/canmin.1500072>
- 2016 Hazen, R. M.; Hummer, D. R.; Hystad, G.; Downs, R. T.; and Golden, J. J., Carbon Mineral Ecology: Predicting the Undiscovered Minerals of Carbon. *American Mineralogist*, 101; 889-906, 2016. <https://doi.org/10.2138/am-2016-5546>
- 2015 Hazen, R. M.; Hystad, G.; Downs, R. T.; Golden, J. J.; Pires, A. J.; and Grew, E. S., Earth's "Missing" Minerals. *American Mineralogist*, 100; 2344-2347, 2015. <https://doi.org/10.2138/am-2015-5417>
- 2015 Hazen, R. M.; Grew, E. S.; Downs, R. T.; Golden, J. J.; and Hystad, G., Mineral Ecology: Chance and Necessity in the Mineral Diversity of Terrestrial Planets. *Canadian Mineralogist*, 53; 295-324, 2015. <http://doi.org/10.3749/canmin.1400086>
- 2015 Hystad, G.; Downs, R. T.; Grew, E. S.; and Hazen, R. M., Statistical Analysis of Mineral Diversity and Distribution: Earth's Mineralogy is Unique. *Earth and Planetary Science Letters*, 426; 154-157, 2015. <https://doi.org/10.1016/j.epsl.2015.06.028>
- 2015 Hystad, G.; Downs, R. T.; and Hazen, R. M., Mineral Species Frequency Distribution Conforms to a Large Number of Rare Events Model: Prediction of Earth's Missing Minerals. *Mathematical Geosciences*, 47; 647-661, 2015. <https://doi.org/10.1007/s11004-015-9600-3>
- 2014 Hazen, R. M.; Liu, X.-M.; Downs, R. T.; Golden, J.; Pires, A. J.; Grew, E. S.; Hystad, G.; Estrada, C.; and Sverjensky, D. A., Mineral Evolution: Episodic Metallogenesis, the Supercontinent Cycle, and the Coevolving Geosphere and Biosphere. *Society of Economic Geologists, Inc., Special Publication*, 18; 1-15, 2014.
- 2013 Golden, J.; McMillan, M.; Downs, R. T.; Hystad, G.; Goldstein, I.; Stein, H. J.; Zimmerman, A.; Sverjensky, D. A.; Armstrong, J. T.; and Hazen, R. M., Rhenium Variations in Molybdenite (MoS_2): Evidence for Progressive Subsurface Oxidation. *Earth and Planetary Science Letters*, 366; 1-5, 2013. <http://doi.org/10.1016/j.epsl.2013.01.034>
- 2012 Hazen, R. M.; Golden, J.; Downs, R. T.; Hystad, G.; Grew, E. S.; Azzolini, D.; and Sverjensky, D. A., Mercury (Hg) Mineral Evolution: A Mineralogical Record of Supercontinent Assembly, Changing Ocean Geochemistry, and the Emerging Terrestrial Biosphere. *American Mineralogist*, 97; 1013-1042, 2012. <https://doi.org/10.2138/am.2012.3922>

- 2011 Hystad, G, Periodic Ising Correlations. *Journal of Mathematical Physics*, 52, Issue 1, 013302, 2011. <https://doi.org/10.1063/1.3517425>
- 2010 Palmer, J. and Hystad, G., Spin Matrix for the Scaled Periodic Ising Model. *Journal of Mathematical Physics*, 51, Issue 12, 123301, 2010. <https://doi.org/10.1063/1.3515312>

(Book chapters)

- 2021 Rowberg, K. L.; Hystad, G.; Clarke, M. L.; Gonzalez, J.; and Taylor, J. M., Mixing Chemistry and Pigments: X-ray Fluorescence Spectroscopy as a Nondestructive Technique for Analysis of Pigments in a Painted Japanese Handscroll. *ACS Symposium Series #1386, titled Contextualizing Chemistry in Art & Archaeology: Inspiration for Instructors*, 2021. (ACS Publications)
- 2020 Hazen, R. M.; Bromberg, Y.; Downs, R. T.; Eleish, A.; Falkowski, P. G.; Fox, P.; Giovannelli, D.; Hummer, D. R.; Hystad, G.; Golden, J. J.; Knoll, A. H.; Li, C.; Liu, C.; Moore, E. K.; Morrison, S. M.; Muscente, A. D.; Prabhu, A.; Ralph, J.; Rucker, M. Y.; Runyon, S. E.; Warden, L. A.; and Zhong, H., Chapter 20: Deep Carbon through Deep Time: Data-Driven Insights, Deep Carbon Past to Present. *Cambridge University Press*, 2020. (Cambridge.org)

Work under Review

- 2021 Hystad, G.; Boujibar, A.; Liu, N.; Nittler, L. R.; and Hazen, R. M., Evaluation of the Classification of Presolar Silicon Carbide Grains Using Consensus Clustering with Resampling Methods: An Assessment of the Confidence of Grain Assignments. 2021, under revision.
- 2021 Hummer, D. R.; Golden, J. J.; Hystad, G.; Downs, R. T.; Eleish, A.; Liu, C.; Ralph, J.; Morrison, S. M.; Meyer, B. M.; and Hazen, R. M., The Oxidation of Earth's Crust: Evidence From the Evolution of Manganese Minerals. *Nature Communications*, 2021, accepted.

External Research Grants

- 2021–2024 *Frequency Distributions in Complex Organic Molecular Mixtures: A Search for Biological Anomalies and Their Meaning*. John Templeton Foundation, Natural Sciences: Math & Physical Sciences. (Collaborating Scientist, in collaboration with Earth and Planets Laboratory at Carnegie Institution of Washington and Center for the Study of Origins at the University of Colorado, Boulder CO), subcontract from the Carnegie Institution of Washington, 2021-2024. Purdue University Northwest amount: \$85390.
- 2020 *Natural Kind Clustering of Minerals*. Carnegie Institution of Washington (#40003127), May 18, 2020- August 14, 2020, \$15000, summer salary.
- 2019 *Statistical Analysis of Mineral Network Data*. Deep Carbon Observatory (#40002776), May 13, 2019-September 30, 2019, \$10000, summer salary.

- 2018–2021 *Statistical Methods and Approaches for Analyzing Mineralogical Data*. The Robert and Margaret Hazen Foundation (#41000452), May 15, 2018-December 31, 2021, \$26500. The grant is divided as follows:
 Summer salary, May 15, 2018-August 14, 2018, \$20000.
 Salary and travel for undergraduate students, June 11, 2018-December 31, 2021, \$6500.
- 2018 *Analysis of Mineral Ecology Data*. The Robert and Margaret Hazen Foundation (#41000433), February 27, 2018-May 15, 2018. Salary for undergraduate student, \$1500.
- 2016–2017 *Statistical Analysis of Mineralogical Data*. Carnegie Institution of Washington (#00209168), May 01, 2016-August 14, 2017, \$17327, summer salary.
- 2016–2017 *Analysis of Errors in LNRE Models as Applied to Mineral Distributions*. Carnegie Institution of Washington (#00209168), May 01, 2016-August 14, 2017, \$20000, summer salary.
- 2015 *Development of Models for Mineral Ecology*. The Robert and Margaret Hazen Foundation, Summer 2015, \$10233, summer salary.
- 2015 *Development of Models for Mineral Ecology*. The Robert and Margaret Hazen Foundation, Spring 2015, Release for one-quarter time research.

External Travel Support

- 2019 (Full) Travel Support, Women in Data Science @ Stanford Earth workshop, Stanford University, Stanford, CA, October 30-November 2, 2019. This travel support was funded by Stanford University.
- 2019 (Full) Travel Support, 2019 Geological Society of America Annual Meeting, Phoenix, AZ, September 22-25, 2019. This travel support was funded by the Robert and Margaret Hazen Foundation.
- 2019 (Full) Travel Support, 2019 Joint Statistical Meetings, Denver, CO, July 28-31, 2019. This travel support was funded by the Robert and Margaret Hazen Foundation.
- 2019 (Full) Travel Support, Meeting with the Templeton Foundation research group, Geophysical Laboratory Washington, D.C., June 17-19, 2019. This travel support was funded by the Robert and Margaret Hazen Foundation.
- 2019 (Full) Travel Support, Meeting with the Mineral evolution research group, University of Arizona, Tucson, AZ, February 6-8, 2019. This travel support was funded by the Robert and Margaret Hazen Foundation.
- 2018 (Full) Travel Support, 2018 Geological Society of America Annual Meeting, Indianapolis, IN, November 4-5, 2018. This travel support was funded by the Robert and Margaret Hazen Foundation.
- 2018 Travel support, 4D Workshop: Deep-time data driven discovery and the evolution of Earth, The Carnegie Institution for Science, Washington D.C., June 4-6, 2018, \$375 and hotel accommodation. This travel support was funded by the Robert and Margaret Hazen Foundation.

- 2018 (Full) Travel Support, 2018 American Statistical Association Conference on Statistical Practice, Portland, OR, February 15-17, 2018. This travel support was funded by the Robert and Margaret Hazen Foundation.
- 2017 (Full) Travel Support, Meeting with the Keck research group, Geophysical Laboratory, Washington, D.C., May 24-27, 2017. This travel support was funded by the Robert and Margaret Hazen Foundation.
- 2017 (Full) Travel Support, U.S. Geological Survey workshop, Reston, VA, May 22-24, 2017. This travel support was funded by the Robert and Margaret Hazen Foundation.
- 2017 (Full) Travel Support, Meeting with the Keck research group, Geophysical Laboratory, Washington, D.C., March 28-31, 2017. This travel support was funded by the Robert and Margaret Hazen Foundation.
- 2016 (Full) Travel Support, 2016 Geological Society of America Annual Meeting, Denver, CO, September 25-28, 2016. This travel support was funded by the Robert and Margaret Hazen Foundation.

Internal Grants

- 2019 *Conservation of a Japanese Cultural Treasure: Analysis of Pigment Morphology in a 13th Century Japanese Handscroll*. Exploratory Grant, Purdue University Northwest, \$4000 (with Kay Rowberg).
- 2018 *The Development of Statistical Models for Application to Mineral Network Data*. Catalyst Grant, Purdue University Northwest, \$7000 (\$6000 for salary+ \$1000 for student salary).
- 2014 *Online Course Development Grant*, Online Education Project (OEP), University of Arizona, \$10000.

Invited Presentations

- 2021 Hystad, G., Data-Driven Discovery in Mineralogy: Modeling the Diversity and Distribution of Minerals on Earth and other Planets. Awards presentations: Felix Chayes Prize, International Association for Mathematical Geosciences virtual event, August 25, 2021. <http://iamgconferences.org/IAMGDays2021.html>
- 2019 Hystad, G., Minerals of Earth: Modeling Natural Distributions. Keynote speaker to the inaugural Women in Data Science @ Stanford Earth workshop, Stanford University, Stanford, CA, November 1, 2019. <https://earth.stanford.edu/news/outstanding-research-outstanding-women#gs.zjzb0s>
- 2018 Hystad, G.; Eleish, A.; Hazen, R. M.; Morrison, S. M.; and Downs, R. T., Future and Current Approaches for Modeling the Distribution of Minerals on Earth and Other Planets. 2018 Geological Society of America Annual Meeting, Indianapolis, IN, November 4-7, 2018, Geological Society of America Abstracts with Programs, Vol. 50, No. 6, Abstract No: 10-9. <https://gsa.confex.com/gsa/2018AM/webprogram/Paper319754.html>

- 2017 Hystad, G., A Bayesian Approach to Estimating Earth's Undiscovered, Mineralogical Diversity. Mathematics Colloquium, Eastern Illinois University, Charleston, IL, November 3, 2017. https://www.eiu.edu/math/pdf/colloquium/Grethe_Hystad_Nov_3_2017.pdf
- 2015 Hystad, G., Statistical Analysis of Natural Systems. Trinity College, Hartford, CT, February 2015.
- 2011 Hystad, G., The Periodic Ising Model. Applied Mathematics Colloquium, Illinois Institute of Technology, Chicago, IL, March 10, 2011. <http://math.iit.edu/pipermail/seminar-coll/2011-March/000287.html>

Published Abstracts and Presentations

- 2020 Boujibar, A.; Zhang, S.; Howell, S.; Prabhu, A.; Narkar, S.; Hystad, G.; Eleish, A.; Morrison, S. M.; Liu, N.; Stephan, T.; Alexander, C. M. O'D.; Hazen, R. M.; and Nittler L. R., Cluster Analysis and Classification of Presolar Silicon Carbide Grains. 51st Lunar and Planetary Science Conference, Lunar Planet. Sci. LI, #2070, Woodlands, TX, March 16-20, 2020 (conference canceled due to Covid-19). <https://presolar.physics.wustl.edu/abstracts-2020/>
- 2019 Morrison, S. M.; Eleish, A.; Prabhu, A.; Narkar, S.; Pan, F.; Huang, F.; Fox, P. A.; Hystad, G.; Liu, C.; Buongiorno, J.; Zhang, S.; Ma, X.; Ralph, J.; Krivovichev, S. V.; Giovannelli, D.; Runyon, S. E.; Hummer, D. R.; Golden, J. J.; Downs, R. T.; and Hazen, R. M., Exploring Carbon Mineralogy and Mineral Evolution Through Deep Time with Advanced Analytics and Visualization. American Geophysical Union Fall meeting, San Francisco, CA, December 9-13, 2019. <https://agu.confex.com/agu/fm19/meetingapp.cgi/Paper/589466>
- 2019 Boujibar, A.; Zhang, S.; Howell, S.; Prabhu, A.; Narkar, S.; Hystad, G.; Eleish, A.; Morrison, S. M.; Hazen, R. M.; and Nittler, L. R., Natural Kind Clustering of Presolar Silicon Carbides and its Astrophysical Implications. American Geophysical Union Fall meeting, San Francisco, CA, December 9-13, 2019. <https://agu.confex.com/agu/fm19/meetingapp.cgi/Paper/556586>
- 2019 Tripathi, S. and Hystad G., Exponential Random Graph Models for Mineral Network Data. 2019 Geological Society of America Annual Meeting, Phoenix, AZ, September 22-25, 2019. <https://gsa.confex.com/gsa/2019AM/webprogram/Paper334822.html>
- 2019 Hummer, D. R.; Wood, J.; Pratt, C.; Christ, D.; Downs, R. T.; Golden, J. J.; Hystad, G.; and Hazen, R. M., The Carbon Mineral Challenge: A Look Back on a Four-Year Experiment in Big Data Mineralogy. 2019 Geological Society of America Annual Meeting, Phoenix, AZ, September 22-25, 2019. Geological Society of America Abstracts with Programs, Vol. 51, No. 5, Abstract No: 234-6. <https://gsa.confex.com/gsa/2019AM/meetingapp.cgi/Paper/339899>
- 2019 Hystad, G.; Eleish, A.; Hazen, R. M.; Morrison, S. M.; and Downs, R. T., A Bayesian Approach for Estimating Earth's "Missing" Minerals. Joint Statistical Meetings, Contributed Speed Session on Food, Environment, Biomedical Imaging and Physical System Visualization/Learning, Part 1, Denver, CO, July 27-August 1, 2019.

- 2018 Hummer, D. R.; Hazen, R. M.; Eleish, A.; Liu, C.; Morrison, S. M.; Downs, R. T.; Golden, J. J.; Pires, A. J.; Hystad, G.; and Meyer, M., Ecology and Evolution of Manganese Minerals: Implications for the Redox History of Earth and Life. 2018 Geological Society of America Annual Meeting, Indianapolis, IN, November 4-7, 2018. Geological Society of America Abstracts with Programs, Vol. 50, No. 6, Abstract No: 10-6. <https://gsa.confex.com/gsa/2018AM/webprogram/Paper323624.html>
- 2018 Hystad, G.; Eleish, A.; Hazen, R. M.; Morrison, S. M.; and Downs, R. T., Estimating Earth's Undiscovered, Mineralogical Diversity Using a Bayesian Approach. 2018 Geological Society of America Annual Meeting, Indianapolis, IN, November 4-7, 2018 (poster presentation). Geological Society of America Abstracts with Programs, Vol. 50, No. 6, Abstract No: 35-2. <https://gsa.confex.com/gsa/2018AM/webprogram/Paper324286.html>
- 2018 Grew, E. S.; Hystad, G.; Ostroverkhova, A.; Golden, J. J.; Krivovichev, S. V.; and Hazen, R. M., Can Lithium Minerals be Counted? Comparison with Boron and Beryllium. XXII Meeting of the International Mineralogical Association, Melbourne, Australia, August 13-17, 2018, Book of Abstracts. p. 180.
- 2018 Grew, E. S.; Hystad, G.; Toapanta, M. P. C.; Ostroverkhova, A.; Golden, J.; and Hazen, R. M., Lithium Mineral Evolution and Ecology. Lithium 200 years, The Swedish Mineralogical Society, Museum of Natural History, Stockholm, Sweden, June 14, 2018.
- 2018 Golden, J. J.; Pires, A. J.; Rolf, J.; Hystad, G.; Morrison, S. M.; Ma, X.; Hummer, D.; Liu, C.; Eleish, A.; Prabhu, A.; Runyon, S.; Downs, R. T.; and Hazen, R. M., The Mineral Evolution Database and Data Model Derived Visualizations. 4D Workshop: Deep-time Data Driven Discovery and the Evolution of Earth, The Carnegie Institution for Science, Washington D.C., June 4-6, 2018 (poster presentation). https://docs.wixstatic.com/ugd/0de8cd_7c7baa755c654af8b86de0f37e17ebd3.pdf
- 2018 Hummer, D.; Hazen, R. M.; Eleish, A.; Liu, C.; Morrison, S. M.; Downs, R. T.; Golden, J. J.; Pires, A.; Hystad, G.; and Meyer, M. B., Ecology and Evolution of Manganese Minerals: Implications for the Redox History of Earth and Life. 4D Workshop: Deep-time Data Driven Discovery and the Evolution of Earth, The Carnegie Institution for Science, Washington D.C., June 4-6, 2018 (poster presentation). https://docs.wixstatic.com/ugd/0de8cd_7c7baa755c654af8b86de0f37e17ebd3.pdf
- 2018 Hystad, G.; Eleish, A.; Hazen, R. M.; Morrison, S. M.; and Downs, R. T., A Bayesian Approach to Estimating Earth's Undiscovered, Mineralogical Diversity. 4D Workshop: Deep-time Data Driven Discovery and the Evolution of Earth, The Carnegie Institution for Science, Washington D.C., June 4-6, 2018 (poster presentation). https://docs.wixstatic.com/ugd/0de8cd_7c7baa755c654af8b86de0f37e17ebd3.pdf
- 2018 Ma, X.; Fox, P.; Hazen, R. M.; Hummer, D.; Golden, J. J.; Downs, R. T.; Hystad, G.; and Muscente, A. D., A Justification on the Need to Build a Machine-Readable Knowledge Base of Deep Time. 4D Workshop: Deep-time Data Driven Discovery and the Evolution of Earth, The Carnegie Institution for Science, Washington D.C., June 4-6, 2018 (poster presentation). https://docs.wixstatic.com/ugd/0de8cd_7c7baa755c654af8b86de0f37e17ebd3.pdf

- 2018 Hystad, G., Approaches and Techniques for Estimating the Total Number of Species in a Population: with Emphasis on Application to Mineral Species. 2018 American Statistical Association Conference on Statistical Practice, Portland, OR, February 15-17, 2018, Abstract No: 303540. <https://ww2.amstat.org/meetings/csp/2018/onlineprogram/AbstractDetails.cfm?AbstractID=303540>
- 2017 Grew, E. S.; Hystad, G.; Hazen, R. M.; Krivovichev, S. V.; and Golden, J. J., Estimating Earth's Endowment of Beryllium Minerals: Insight from Counting Boron Minerals. The 200th Anniversary Meeting of the Russian Mineralogical Society, Saint Petersburg, Russia, October 9-12, 2017, RMS-DPI code 2017-1-244-1, p. 213-215. <http://www.minsoc.ru/2017-1-244-1/>
- 2016 Meyer, M.; Downs, R. T.; Falkowski, P. G.; Fox, P.; Hazen, R. M.; Knoll, A. H.; Sverjensky, D. A.; Golden, J. J.; Hao, J.; Hystad, G.; Hummer, D. R.; Jelen, B.; Kolankowski, S.; Liu, C.; Ma, X.; Moore, E. K.; Morrison, S. M.; Muscente, A. D.; Pires, A. J.; Zednik, S.; and Zhong, H., The Co-Evolution of the Geo- and Biospheres: An Integrated Program for Data-Driven, Abductive Discovery in the Earth Sciences. 2016 Geological Society of America Annual Meeting, Denver, CO, September 25-28, 2016, Geological Society of America Abstracts with Programs, Vol. 48, No. 7., Abstract No: 255-3 (poster presentation). <https://gsa.confex.com/gsa/2016AM/webprogram/Paper283932.html>
- 2016 Hystad, G.; Hazen, R. M.; Downs, R. T.; and Golden, J. J., Prediction of Earth's Missing Minerals and the Relative Abundances for the Mineral Species on Earth; A Statistical Measure to Characterize Earth-Like Planets. 2016 Geological Society of America Annual Meeting, Denver, CO, September 25-28, 2016, Geological Society of America Abstracts with Programs, Vol. 48, No. 7., Abstract No: 191-12. <https://gsa.confex.com/gsa/2016AM/webprogram/Paper284145.html>
- 2016 Grew, E. S.; Hystad, G.; Hazen, R. M.; Krivovichev, S. V.; and Gorelova, L. A., Counting Boron Minerals in Earth's Crust: Can Contradictory Evidence be Reconciled? 2016 Geological Society of America Annual Meeting, Denver, CO, September 25-28, 2016, Geological Society of America Abstracts with Programs, Vol. 48, No. 7., Abstract No: 191-11. <https://gsa.confex.com/gsa/2016AM/webprogram/Paper278913.html>
- 2016 Morrison, S. M.; Downs, R. T.; Golden, J. J.; Pires, A. J.; Fox, P.; Ma, X.; Zednik, S.; Eleish, A.; Kolankowski, S.; Liu, C.; Hummer, D. R.; Meyer, M.; Ralph, J.; Hystad, G.; and Hazen, R. M., Mineral Ecology: Social Network Analysis and Sociograms of Mineral Connections, Distributions, and Segmentation. 2016 Geological Society of America Annual Meeting, Denver, CO, September 25-28, 2016, Geological Society of America Abstracts with Programs, Vol. 48, No. 7., Abstract No: 255-5 (poster presentation). <https://gsa.confex.com/gsa/2016AM/webprogram/Paper285340.html>
- 2016 Morrison, S. M.; Downs, R. T.; Golden, J. J.; Pires, A. J.; Fox, P.; Ma, X.; Zednik, S.; Eleish, A.; Kolankowski, S.; Hummer, D. R.; Liu, C.; Meyer, M.; Ralph, J.; Hystad, G.; and Hazen, R. M., Social Network of Copper Minerals: A Mineral Ecology Study. 2016 Geological Society of America Annual Meeting, Denver, CO, September 25-28, 2016, Geological Society of America Abstracts with Programs, Vol. 48,

No. 7., Abstract No: 191-7. <https://gsa.confex.com/gsa/2016AM/webprogram/Paper279379.html>

- 2016 Liu, C.; Hazen, R. M.; Hystad, G.; Golden, J. J.; Hummer, D. R.; Downs, R. T.; Morrison, S. M.; and Ralph, J., Chromium and Vanadium Mineral Ecology. 2016 Geological Society of America Annual Meeting, Denver, CO, September 25-28, 2016, Geological Society of America Abstracts with Programs, Vol. 48, No. 7., Abstract No: 191-10. <https://gsa.confex.com/gsa/2016AM/webprogram/Paper279329.html>
- 2016 Hystad, G.; Downs, R. T.; and Hazen, R. M., Mineral Species Frequency Distribution and the Prediction of Earth's Missing Minerals. Joint Statistical Meetings, Contributed Speed Session on Physical and Engineering Sciences, Chicago, IL, July 30-August 4, 2016. <https://www.amstat.org/meetings/jsm/2016/onlineprogram/AbstractDetails.cfm?abstractid=319949>
- 2015 Hazen, R. M.; Hummer, D. R.; Downs, R. T.; Hystad, G.; and Golden, J. J., Carbon Mineral Ecology: Predicting the Undiscovered Minerals of Carbon. American Geophysical Union Fall meeting, San Francisco, CA, December 14-18, 2015. <https://agu.confex.com/agu/fm15/meetingapp.cgi/Paper/82200>
- 2015 Hummer, D.; Hazen, R. M.; Hystad, G.; Golden, J. J.; and Downs, R. T., Mineral Ecology and Evolution of Manganese: Using Redox Sensitive Minerals to Probe Earth's History. 2015 GSA Annual Meeting, Baltimore, MD, November 1-4, 2015, Geological Society of America Abstracts with Programs, Vol. 47, No. 7, p.271. <https://gsa.confex.com/gsa/2015AM/webprogram/Paper270678.html>
- 2015 Hazen, R. M.; Hystad, G.; Downs, R. T.; and Golden, J. J., Mineral Ecology of Carbon: Prediction of "Missing" Minerals. Goldschmidt Abstracts, 2015 1212, Prague, CZ, August 16-21, 2015.
- 2014 Hazen, R. M.; Downs, R. T.; Golden, J. J.; Hystad, G.; and Grew, E. S., Planetary Stoichiometry, Mineral Ecology, and the Rise of Habitability. American Geophysical Union Fall meeting, San Francisco, CA, December 15-19, 2014.
- 2014 Hazen, R. M.; Grew, E. S.; Downs, R. T.; Golden, J. J.; Hystad, G.; and Sverjensky, D. A., Geochemical Society Ingerson Lecture: Chance and Necessity in the Mineral Evolution of Terrestrial Planets. 2014 GSA Annual Meeting, Vancouver, British Columbia, October 19-22, 2014, Geological Society of America Abstracts with Programs, Vol. 46, No. 6, p.413. <https://gsa.confex.com/gsa/2014AM/webprogram/Paper242965.html>
- 2012 Hystad, G., Periodic Ising model and Ising Correlations. Joint Mathematics Meetings, AMS Contributed Paper Session on Mechanics and Mathematical Physics, II, Boston, MA, January 4-7, 2012. http://jointmathematicsmeetings.org/amsmtgs/2138_abstracts/1077-82-1752.pdf

Campus and Departmental Presentations at Purdue University Northwest (PNW)

- 2021 Rowberg, K. L.; Hystad, G.; Clarke, M. L.; Gonzalez, J.; and Taylor, J. M., Early Pigments: Insights from Chemistry and Statistical Analysis. PNW Days of Discovery, Spring 2021 (online pre-recorded poster presentation).

- 2020 Hystad, G., A Bayesian Approach for Estimating Earth's Mineralogical Diversity. PNW Days of Discovery, Spring 2020 (online poster presentation).
- 2020 Hystad, G., Modeling Natural Distributions: Minerals of Earth and the Characterization of Earth-Like Planets. Biology seminar, PNW, January 31, 2020.
- 2019 Hystad, G., Modeling Observations from Nature: How do we Estimate Earth's "Missing" Mineral Species, CEP Welcome Convocation, PNW, September 13, 2019.
- 2019 Hystad, G.; Eleish, A.; Hazen, R. M.; Morrison, S. M.; and Downs, R. T., A Bayesian Approach to Estimating the Total Number of Mineral Species in Earth's Crust. PNW Days of Discovery, April 2, 2019 (poster presentation).
- 2018 Hystad, G., Estimation of Earth's Undiscovered, Mineralogical Diversity using a Bayesian Approach. Purdue University Northwest, Department of Mathematics, Statistics, and Computer Science, November 15, 2018.
- 2018 Hystad, G.; Eleish, A.; Hazen, R. M.; Morrison, S. M.; and Downs, R. T., Estimating Earth's undiscovered, Mineralogical Diversity using a Bayesian approach. PNW Days of Discovery, April 4, 2018 (poster presentation).
- 2017 Hystad, G.; Hazen, R. M.; and Downs, R. T., The Characterization of Earth Like Planets from an Analysis of the Mineral Frequency Distribution. PNW, Hammond, IN, March, 2017 (poster presentation).
- 2015 Hystad, G., Mineral Frequency Distribution, Characterization of Earth-Like Planets, and Prediction of Earth's Missing Minerals. Purdue University Calumet, Hammond, IN, November 2015 (poster presentation).

Teaching Related Presentations

- 2014 A Brief Overview of Teaching and Learning Online (with G. Gibbs). Mathematics Instruction Colloquium, University of Arizona, Tucson, AZ, April 2014.
- 2014 Problem Solving for Precalculus. Mathematics Educator Appreciation Day Conference, Tucson, AZ, January 2014.
- 2014 Supplemental Instruction in Precalculus. Joint Mathematics Meetings, MAA General Contributed Paper Session on Teaching Introductory Mathematics, Baltimore, MD, January 15-18, 2014 (was unable to attend). http://jointmathematicsmeetings.org/meetings/national/jmm2014/2160_presenters.html
- 2013 Precalculus as an Inquiry Based Course. AMATYC Southwest Regional Conference, Flagstaff, AZ, June 2013.
- 2012 Precalculus Supplemental Instruction Seminar: Math 196L (with D. Wood). Mathematics Instruction Colloquium, University of Arizona, Tucson, AZ, February 2012.

Research with Students

2018–2021 I have had five undergraduate students (two of them later as graduate students) working with me on research grants from an external private foundation and two internal grants (Catalyst grant and an interdisciplinary internal Exploratory grant). The projects led to one co-authored journal article, one co-authored book chapter, and one co-authored published abstract with students. Two of my undergraduate students have given talks at the Geological Society of America Annual Meeting (GSA) (2018, 2019).

Invited Workshops

2020 4D Initiative Virtual Datathon Workshop, Earth and Planets Laboratory, The Carnegie Institution for Science, August 20-21, 2020 (virtual).

2019 Deep-time Data Science Mini-workshop, Moscow, ID, May 28-June 1, 2019 (Was unable to attend).

2018 4D Workshop: Deep-time Data Driven Discovery and the Evolution of Earth, The Carnegie Institution for Science, Washington D.C., June 4-6, 2018. <https://www.4d-workshop.net/>

2017 Mining Data Mining: Big Data and Mineral Resource Potential, U.S. Geological Survey/Keck Workshop, Reston, VA, May 22-24, 2017.

Press Releases

My research has received several press releases including the following:

2021 [Purdue Northwest Professor Awarded 2021 Felix Chayes Prize](#), by Purdue University Northwest, May 6, 2021.

2019 [Stanford EARTH, Interview](#) and [Outstanding Research by Outstanding Women](#), by Elenita M. Nicholas, Nov 22, 2019.

2018 EARTH, [Data-Driven Discovery Reveals Earth's Missing Minerals](#), by Timothy Oleson, May 1, 2018.

2015 Morgensbladet, [Livets Krystaller](#), by Henrik H. Svensen, Sept 4, 2015.

2015 Science, ["By the Numbers"](#), volume 349, Issue 6251, page 908, Aug 28, 2015.

2015 R&D News, [Earth's Mineralogy Unique in the Cosmos](#), by the Carnegie Institute of Science, Aug 26, 2015.

2015 AstroBiology Magazine, [Earth's Mineralogy Unique in the Cosmos](#), Aug 26, 2015.

2015 Science Daily, [Earth's Mineralogy Unique in the Cosmos](#), Aug 26, 2015.

2015 Quanta Magazine, [How Life and Luck Changed Earth's Minerals](#), by Roberta Kwok, Aug 11, 2015.

2012 Science Daily, [Mercury Mineral Evolution Tied to Supercontinent Assembly Over Last 3 Billion Years](#), June 25, 2012.

Recognition

- 2019 My research has appeared in the following book: Hazen R. M., *Symphony in C. Carbon and the Evolution of (Almost) Everything*. W. W. Norton & Company, New York, NY, 2019. A description of my biography and research is given on p 47-48 and p 75-76.

Teaching Experience

- 2015– **Courses taught at Purdue University Northwest**
- Introduction to Cluster Analysis (online) (S21)
3-credit independent study course on model-based cluster analysis with applications in R
- Integrated Calculus and Analytic Geometry I (online) (F20, S21, F21)
5-credit undergraduate course on calculus I
- Biostatistics (in class and online) (2017–2021)
3-credit undergraduate course on introductory statistics with applications to biology
- Statistics/Statistical Methods (S16, S18, S19, S20)
3-credit undergraduate course/graduate course on introductory statistics (calculus based)
- Probability and Statistics II (in class and online) (F19, F20)
3-credit undergraduate course/graduate course on multivariate probability, statistical estimation and Bayesian statistics
- Elementary Statistical Methods (in class and online) (F15, S16, F16, F17, F18, S19, F19, S21, F21)
3-credit undergraduate course on introductory statistics (algebra based)
- Applied Statistics (S18, S20)
3-credit undergraduate course/graduate course on simple and multiple linear regression, experimental design, and categorical data analysis
- Statistical Analysis of Network Data (S20)
1-credit independent study course on manipulating and visualizing network data and statistical analysis for network graphs using the statistical software package, R, with applications to real world data
- Mathematical Research (S19)
1-credit independent study course on the statistical analysis for network graphs. The student read research papers about exponential random graph models and applied these models to a mineral species network data set using the statistical software package, R.
- Statistics and Contemporary life (F15, F16, F17, F18)
3-credit undergraduate course on basic statistics
- An Introduction to Mathematical Sciences (Co-taught) (F21)
1-credit General Education-First-Year Experience course
- 2003–2015 **Courses taught at the University of Arizona**
Instructor/Lecturer (2010–2015)

Graduate Teaching Assistant/Associate (2003–2009)

Statistics for Research (online)

3-credit graduate course on introductory statistics (interdisciplinary)

Introduction to Probability Theory

3-credit undergraduate course on distributions of discrete and continuous random variables, multivariate probability, and transformations

Discrete Mathematics in Computer Science

3-credit undergraduate course on topics in discrete mathematics

Statistics for Teaching

3-credit undergraduate course on introductory statistics (calculus based)

Introduction to Statistics and Biostatistics

3-credit undergraduate course on introductory statistics with applications to biology

Calculus Concepts for Business Majors

3-credit undergraduate course on calculus with business applications

Precalculus Supplemental Instruction Seminar

1-credit inquiry-based undergraduate course on solving applied precalculus problems. The students worked on the problems in groups

Basic Statistics

3-credit undergraduate course on introductory statistics (algebra based)

Calculus I with Applications

5-credit undergraduate course

Calculus II

3-credit undergraduate course

Calculus Preparation

3-credit undergraduate course

Plane Trigonometry

3-credit undergraduate course

Elements of Calculus

3-credit undergraduate course

College Algebra (in class and online)

3-credit undergraduate course

Serving on an Editorial Board

2019– I am serving on the Editorial Board for the journal, Applied Computing and Geosciences. ([Link](#))

Session Organizer and Session Chair

2019 Co-organized and co-chaired the Geological Society of America's (GSA) technical session, Recent Advances in Mineralogy/Crystallography, Phoenix, AZ, September 25, 2019 (together with Daniel R. Hummer - Southern Illinois University). <https://gsa.confex.com/gsa/2019AM/webprogram/Session48726.html>

- 2018 Co-chaired the breakout Session: Data-Driven Discovery Techniques with the topic: What are Critical Needs and Opportunities to Improve Analytical and Visualization Methods used in Data-Driven Discovery? 4D Workshop: Deep-time Data Driven Discovery and the Evolution of Earth, The Carnegie Institution for Science, Washington D.C., June 6, 2018. https://c6ca51e6-31ac-4e2c-9b1b-90ab0c7472ce.filesusr.com/ugd/0de8cd_57e59e3f60f84512a72aa7c6b701b90d.pdf
- 2012 Chair of the AMS Contributed Paper Session on Mechanics and Mathematical Physics, II, Joint Mathematics Meetings, Boston, MA, January 2012.

Panel Discussion

- 2019 I was part of a panel discussion at the Women in Data Science @ Stanford Earth workshop, Stanford University, Stanford, CA, November 1, 2019. <https://earth.stanford.edu/news/outstanding-research-outstanding-women#gs.zjzb0s>

Reviewer

Reviewed book chapters/proposals for

Cambridge University Press

Macmillan Learning

Committees

- 2019–2021 College of Engineering and Sciences Council Member, Purdue University Northwest. Secretary, October 2020-May 2021.
- 2015– Statistics Program Development Committee, Purdue University Northwest. The committee has developed a new bachelor of science in Applied Statistics. The program started in fall 2019.
- 2015– Statistics Course Committee, Purdue University Northwest.

Other University Services

- 2020/2021 Reviewed proposals for the Undergraduate Research Grant, PNW, Spring 2020 and Spring 2021.
- 2019/2020 Judge in the Days of Discovery student competition, PNW, April 2019 and April 2020.
- 2019 Reviewed proposals for the Catalyst Grant, PNW, Fall 2019.
- 2019 Participated in the College/Major Fair, Hammond Campus, September 23, 2019.
- 2019 Participated in the “Welcome Rallies” at PNW, Hammond Campus, August 22, 2019.

- 2019 Department representative for “Preview PNW” meetings for prospective students, Westville campus, March 23, 2019.
- 2018/2020 Reviewed proposals for the Indiana Space Grant Undergraduate Research Program, PNW, Fall 2018 and Fall 2020.
- 2018 Participated in the College/Major Fair, Alumni Hall, Hammond Campus, September 17, 2018.
- 2013–2015 Organized the Mathematics Instruction Colloquium at the University of Arizona; Bi-weekly talks on topics related to the teaching of mathematics; Bi-weekly reading groups on topics related to the scholarship of teaching and learning, Fall 2013-Spring 2015.
- 2012/2013 Mathematics Coordinator for the New Start Summer Program at the University of Arizona. Supervised and organized training sessions for instructors for a six week summer program in teaching College Algebra and Precalculus, Summer 2012 and Summer 2013.

Professional Membership

- 2020– International Association for Mathematical Geosciences
- 2015– The American Statistical Association