

April 25th and 26th "Hazen Group Event"

The April 25th and 26th "Hazen Group Event" comprises lectures, seminars, workshops, panel discussion, and reception that collectively will focus on mineral evolution and ecology, "big data geology", and an investigation of the potential application to minerals exploration. DREGS is co-sponsoring this event together with the CSM Department of Geology and Geologic Engineering, the CSM Library/Museum, the Friends of the CSM Geology Museum, and the Colorado Scientific Society. The various activities are summarized below and the results of the associated activities will be presented at the Fall SEG conference in Keystone.

These activities are spearheaded by Dr. Robert M. Hazen (Senior Staff Scientist at the Geophysical Laboratory, Carnegie Institution, Washington, D.C.; Clarence Robinson Professor of Earth Sciences at George Mason University, Fairfax, Virginia; Executive Director of the Deep Carbon Observatory). The currently envisioned group also consists of Dr. Simone Runyon (ore deposits, hydrothermal alteration), from Carnegie and new Economic Geology Professor at the University of Wyoming; Dr. Shaunna Morrison (mineralogy, crystallography, Mars, network analysis), and Chao Liu (isotope geochemistry, Precambrian geology, data analysis), both from Carnegie; and Ahmed Eleish and Anirudh Prabhu (data science, machine learning, data visualization) from Rensselaer Polytechnic Institute (RPI).

The current understanding of the associated activities includes:

Evening Lecture 1, Wednesday, April 25, 2018, 7:00 PM. "Mineral Evolution and Ecology: Tracing Earth's History Through Time and Space" in Berthoud Hall, Room 241, Colorado School of Mines, Golden. Seating is limited; please pre-register at <http://bit.ly/2HO5mIZ>.

ABSTRACT: A fundamental challenge in geology is to understand the evolving diversity and distribution of rocks and minerals through more than 4 billion years of Earth history--changes that reveal much about our planet's co-evolving geosphere and biosphere. Mineral evolution and mineral ecology, which explore mineral occurrences through time and space, exploit large and growing data resources to detect previously hidden patterns in nature. We find dramatic changes in Earth's mineralogy as a consequence of physical, chemical, and most surprisingly biological processes. Powerful analytical and visualization methods are now allowing us to predict Earth's "missing" minerals--a prelude to the discovery of new ore deposits and other natural resources.

Evening Lecture 2, Thursday, April 26, 2018, 7:00 PM. "Big-Data Geology: Visualizing Earth's Co-evolving Geosphere and Biosphere" in Berthoud Hall, Room 241, Colorado School of Mines, Golden. Seating is limited; please pre-register at <http://bit.ly/2pmpGcS>.

ABSTRACT: The distribution of minerals, rocks, and fossils on Earth mimics social networks, as commonly applied to such varied topics as Facebook interactions, the spread of disease, and terrorism networks. Applying network analysis to these natural objects provides a powerful visual approach to understanding the diversity and distribution of species, while revealing patterns that help predict "missing" deposits. These patterns provide new insights into the way planets evolve, especially the co-

evolving geosphere and biosphere, while comparisons of networks for Earth materials with those of Mars and other worlds hint at why Earth is unique.

Book Discussion, Thursday, April 26, 2018, 12:00-1:30 PM. Dr. Hazen will lead a discussion of his book, ***The Story of Earth: The First 4.5 Billion Years, from Stardust to Living Planet*** in the **Boettcher Room, Arthur Lakes Library, Colorado School of Mines, Golden**. Participants are expected to have read the book--available at www.amazon.com. **Lunch will be provided but seating is limited; please RSVP to gevans@mines.edu.**

Seminar, Wednesday, April 25, 2018, 11:00 AM-12:00 PM. "***Mineral Network Analysis: Big Data as Applied to Mineral Systems***" in **Berthoud Hall, Room 241, Colorado School of Mines, Golden**. Presenters will include: Dr. Shaunna Morrison, Carnegie Institute, Washington, D.C.; Ahmed Eleish and Anirudh Prabhu, Rensselaer Polytechnic Institute, Troy, NY. This event is **open to ALL and registration is NOT required.**

ABSTRACT: Advanced analytics and visualization has revolutionized nearly all aspects of our society, from city infrastructure to advertising and from healthcare to our understanding of the cosmos. Growing databases in mineralogy and geochemistry offer the opportunity to apply big data techniques to prominent questions in geology and planetary science. These techniques, such as network analysis, allow exploration of multidimensional trends in complex mineralogical systems. For example, mineral network studies have revealed embedded chemical and temporal axes as well as clustering by composition or paragenetic mode.

Technical Workshop: "Mineral Network Analysis I," Wednesday, April 25, 1-4 PM in **Berthoud Hall, Room 306, Colorado School of Mines, Golden**. **Workshop seating is limited; please pre-register at rwendlan@mines.edu.**

Technical Workshop: "Mineral Network Analysis II" Thursday, April 26, 8-11 AM in **Marquez Hall, Room 322, Colorado School of Mines, Golden**. **Workshop seating is limited; please pre-register at rwendlan@mines.edu.**

ABSTRACT: The workshops are intended to start by introducing general principles of big data analysis and techniques, after which the facilitators will give some examples of use case with practical advice on how to address different scientific questions using data resources. After this introduction, we will get feedback from the participants on projects that they may be interested in or currently working on. From there, we will break into small groups in order to advance these different projects, with the facilitators available to help guide the building of resources, scientific questions, and to discuss visualization and analytical capabilities. The idea is to have everyone come away with an idea of what is possible and how to get started with individual projects; also to come up with completely new ideas about exciting directions to pursue. The "big data" approach is so new to many of us in Earth sciences that there's a real sense of inventing this direction as we go along.

Seminar, Thursday, April 26, 2018, 12:00 PM-1:00 PM. "***Coarse Muscovite Veins in the Roots of Porphyry Copper and Porphyry Molybdenum-Copper Systems within the Laramide Arc in Arizona as***

well as at the Yerington district in Nevada" in Berthoud Hall, Room 241, Colorado School of Mines, Golden. Presenter is Dr. Simone Runyon (ore deposits, hydrothermal alteration and new Economic Geology Professor at the University of Wyoming). This event is **open to ALL and registration is NOT required.**

ABSTRACT: The roots of ore deposits offer clues to hydrothermal processes unavailable at higher levels and the style, intensity, and mineral assemblages of deep forms of hydrothermal alteration vary from district to district. Coarse muscovite veins and alteration occur in the roots of porphyry copper and porphyry molybdenum-copper systems within the Laramide arc in Arizona as well as at the Yerington district in Nevada. Coarse muscovite alteration in these systems is documented using mineral assemblages, mineral compositions, spatial and temporal relationships, fluid-inclusion data, and hydrogen isotopic compositions. Coarse muscovite-forming fluids are likely predominately of magmatic-hydrothermal origin and commonly exsolved from late-stage, fractionated melts of the larger pluton that sourced porphyry stocks and dikes responsible for porphyry copper mineralization.

Panel Discussion, Thursday, April 26, 2018, 2:00 PM-1:00 PM. ***"Application of "Big Data" Tools to Minerals Exploration"*** in **Brown Building, Room BB-280W, Colorado School of Mines, Golden.** **Doors open at 1:45 PM.** The discussion will largely address the application of mineral network and other "big data" analysis and visualization tools to minerals exploration, with a discussion of the applications of these techniques to other mineralogical studies based on audience input. The objective is to come away with a basic understanding of the applicability of these tools to minerals exploration (and perhaps other geo-scientific endeavors); of the pitfalls, challenges, issues; and the directions of future research. Panel members, many of whom wear multiple hats, currently include: Dr. Robert Hazen (Carnegie), Dr. Simone Runyon (University of Wyoming and Carnegie), Dr. Shaunna M. Morrison (Carnegie), Ahmed Eleish (Rensselaer Polytechnical Institute), Anirudh Prabhu (Rensselaer Polytechnical Institute), Dr. M. Stephen Enders (CSM), Sandra Perry (Perry Remote Sensing) and Dr. Jeffrey Mauk (USGS). This activity is **open to the public, but particularly relevant to mineral industry professionals and to academic geologists, including students.** **Registration is NOT required.**

Reception, Thursday, April 26, 2018, 4:30 PM-6:30 PM. A reception for members of the Hazen Group will be held in the Colorado School of Mines Museum before his final lecture.

Additional Lead Speaker Information

Dr. Robert M. Hazen, Senior Staff Scientist at the Carnegie Institution's Geophysical Laboratory and Clarence Robinson Professor of Earth Sciences at George Mason University, received the B.S. and M.S. in geology from the Massachusetts Institute of Technology, and the Ph.D. at Harvard University in earth science. He is author of 400 scientific articles and 25 books, including *Genesis: The Scientific Quest for Life's Origin* and *The Story of Earth*. He was the 2016 Roebling Medalist and a former President of the Mineralogical Society of America, Hazen's recent research focuses on the role of minerals in the origin of life, the co-evolution of the geo- and biospheres, and the application of "big data" to understanding mineral diversity and distribution. He is also Executive Director of the Deep Carbon Observatory, a 10-year project to study the chemical and biological roles of carbon in Earth's interior. Hazen is active in

presenting science to nonscientists through writing, radio, TV, public lectures, and video courses. In 2016 Hazen retired after a 45-year career as a professional symphonic trumpeter. Some associated informative links are as follows:

Dr. Hazen's personal web site: <http://hazen.gl.ciw.edu>

DCO website: deepcarbon.net

4-D Workshop website: www.4d-workshop.net

Keck Deep-Time Project website: <http://dti.carnegiescience.edu>

For additional event and activity information, please contact Mike Smith (m_l_smith@earthlink.net), Ric Wendlandt (rwendlan@mines.edu), Lew Kleinhans (lewis.oysterclub@gmail.com) or Jim Piper (geopros@clanmurray.org).