Colorado Scientific Society

The objective of the Society is to promote the knowledge and understanding of Earth science, and its application to human needs

CSS Newsletter, March 2021 Meeting, Thursday, March 25

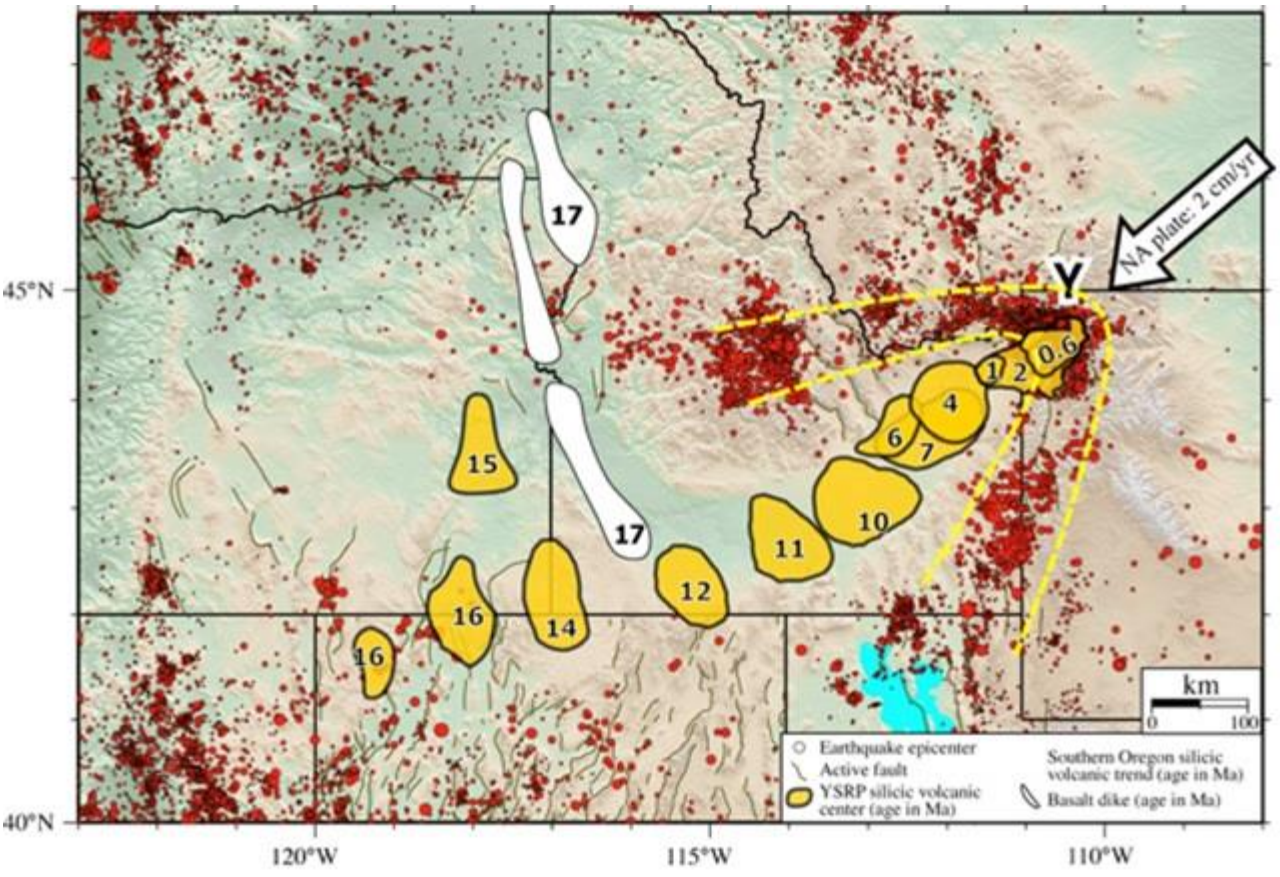
Old Faithful Anatomy and Magma from Earth's Core Fueling the Volcanism of Yellowstone, its Geysers, and Hot Springs

Robert B. Smith, Distinguished Professor,
Department of Geology and Geophysics, University of Utah
and Founder, Principal Investigator and Coordinating Scientist,
Yellowstone Volcano Observatory, and Yellowstone-Teton-Utah Seismic and GPS Networks,
and
Jamie Farrell
Assistant Research Professor
University of Utah Seismograph Stations

Join our Zoom meetings after 6:45 Mountain Time, with short social time before our **Meeting and Program begin at 7:00.**
The link to join our CSS March Zoom meeting will be: https://mines.zoom.us/j/94308922497?pwd=RXpXSm85U2ZLU093aEgwWDYvT09VUT09#success . Login code 94308922497, password if needed 338159. This information will also be posted on the CSS website; www.coloscisoc.org .

Abstract: Bob Smith's University of Utah research group has monitored Yellowstone since 1983 and continues conducting earthquake, crustal structure and GPS studies as well as continuous real-time monitoring of the world's largest volcano and its tallest geyser, Steamboat. Moreover, we have conducted detailed seismic, GPS and geologic studies of the anatomy of Old Faithful the world renown and iconic Yellowstone geyser to determine its 4D structure and dynamic plumbing and eruption properties. These studies reveal that Old Faithful is located at

the top of a large hydrothermal reservoir only 10 to 60 m deep that is composed of highly fractured rock, hot water and steam located west of the geyser and extending a km beneath the Old Faithful Lodge and other infrastructure. We discovered that Old Faithful eruptions do not have a notable seismic signal but large precursory seismic signals of harmonic tremor every 95 minutes just prior to the eruption and from which we can now predict within seconds. I will also show the initial results from seismic monitoring and imaging of Steamboat Geyser, the world's tallest geyser and of the northern Yellowstone Lake hydrothermal system. Moreover, we show how Yellowstone's immense volcanic system is part of a giant Earth's mantle convection cell originating 1800 miles deep at the core-mantle boundary creating a magmatic plume of partly molten rock rising in a conduit upward to 50 miles deep beneath the North American continent which that then intrudes the lithosphere and fuels magma into two magma reservoirs as shallow as 2-3 miles beneath Old Faithful. Overall these studies demonstrate the geodynamics of the entire 300 mile wide Yellowstone Plateau created by magma-plume buoyancy and that has had a profound impact on the geologic evolution of entire western U.S. since Yellowstone volcanism began 500 miles west of Yellowstone National Park as the mantle plume interacted with the bottom of the North American continent that moved SW at 2.5 cm/yr. 16 million years ago across Idaho, Oregon and Washington.



The Yellowstone Hotspot Track Across the N. American Continent

Biography: Professor **Robert B. Smith** has a distinguished career in geophysics working on earthquake, crustal deformation and education and outreach throughout his career. BS and MS Utah State Univ. PhD University of Utah, Post Doc Columbia University, Visiting Professorships Swiss Federal Institute of Technology and Cambridge University.

Bob Smith has been working in Yellowstone for 63 years, beginning in 1956 even before college. He has been a Geophysics Professor at the University of Utah for 52 years leading a research group of scientists and students working on the dynamics of earthquake and volcano and dynamics of the western American Plate. And Bob has supervised 69 graduate students and dozens of Post Docs and Visiting Professors. Professor Smith served as a Post-Doctoral Scholar at Columbia University, conducted collaborative research as a Guest Professor at the Swiss Federal Institute of Technology for 6 years, and spent a year at Cambridge University studying. His European geophysical and geodetic studies including the evolution and structure of the Alps, Greece, Italy and Mediterranean Sea.

Bob served in an Antarctic expedition as the U.S. Exchange Scientist to the British Antarctic Survey, 1962-63 conducting geophysical surveys of the continent working out of the Halley Bay science station. For his research and service, he received the British Antarctic Survey Gold Emblem and the U.S. Antarctic Medal.

Bob co-founded several major U.S. research institutions including IRIS (Institutions for Research In Seismology), UNACO (University NAVSTAR Consortium for GPS and Geodesy), co-founder and chairing the Southern California Earthquake Center Science Advisory Committee and was the principal founder of the highly successful EarthScope Project.
Bob has served on numerous university, state and federal advisory committees. This included presentations for the prestigious for the U. S. Senate and House Committees on Science and Technology, 2008 and 2009.

Bob has received numerous U.S. and European awards and medals, and continues his Yellowstone research where he makes discoveries every year and where he treats Yellowstone-Teton geology as a *living, breathing, shaking and baking* natural laboratory.

Bob's Book With Co-Author Lee Siegel: "Windows Into The Earth: The Geologic Story of Yellowstone and Grand Teton National Parks, Oxford Univ. Press, 2000, is the most popular geology book on these parks and has sold ~30,000 copies.

Bob has served on numerous committees of the National Academy of Sciences Committee on Seismology, Yellowstone Deep Drilling, Geology, Geophysics and on my contributions to the Yellowstone science. Served on NSF National Advisory Council and on numerous NSF Committees: Geophysics, Active Tectonics, Geology, Computational Earth Science, etc.

He has been the convener of dozens of National and International Meetings and Workshops

Bob Smith's University of Utah Laboratory: The University of Utah Seismology and Active Tectonics Research Group with loads of our data links: www.uusatrg.utah.edu/index.html

Bob Smith's Research Data Links: See University of Utah Yellowstone-Teton real-time earthquake map: http://quake.utah.edu/earthquake-center/quake-map and the Yellowstone-Teton GPS measured ground movements from University of Utah and other GPS stations, borehole strain/tilt data and Lidar via the GAGE UNAVCO data archive: https://www.unavco.org/what-we-do/

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For an additional background summary relating to Bob's talk, see **Anatomy of Old Faithful From Subsurface Seismic Imaging of the Yellowstone Upper Geyser Basin**, by Sin-Mei Wu , Kevin M. Ward , Jamie Farrell , Fan-Chi Lin , Marianne Karplus, and Robert B. Smith, Geophysical Research Letters, 2017, Research Letter 10.1002/2017GL075255. For a link to that complete paper see **Anatomy of Old Faithful From Subsurface Seismic Imaging of the Yellowstone Upper Geyser Basin** https://coloscisoc.org/wp-content/uploads/2021/03/Anatomy-of-Old-Faithful-from-Seismic-Imaging_Wu_Univ-Utah_GRL.pdf .
From that abstract and introduction:

Abstract
The Upper Geyser Basin in Yellowstone National Park contains one of the highest concentrations of hydrothermal features on Earth including the iconic Old Faithful geyser. Although this system has been the focus of many geological, geochemical, and geophysical studies for decades, the shallow (<200 m) subsurface structure remains poorly characterized. To investigate the detailed subsurface geologic structure including the hydrothermal plumbing of the Upper Geyser Basin, we deployed an array of densely spaced three-component nodal seismographs in November of 2015. In this study, we extract Rayleigh wave seismic signals between 1 and 10 Hz utilizing nondiffusive seismic waves excited by nearby active hydrothermal features with the following results: (1) imaging the shallow subsurface structure by utilizing stationary hydrothermal activity as a seismic source, (2) characterizing how local geologic conditions control the formation and location of the Old Faithful hydrothermal system, and (3) resolving a relatively shallow (10–60 m) and large reservoir located ~100 m southwest of Old Faithful geyser.

Introduction
Yellowstone National Park contains the largest concentration of hydrothermal features with over 10,000 geysers, hot springs, fumaroles, etc. (Smith & Siegel, 2000). Most of the hydrothermal features are located within
or on the margins of the 0.63 Ma and youngest Yellowstone caldera where the hydrothermal system has been shown to be driven by the interaction between a deeper mantle-crust magmatic system and the shallow hydrologic system (Christiansen et al., 2007; Smith et al., 2009; Waite et al., 2006). The Upper Geyser Basin (UGB), which hosts Old Faithful geyser and many other active hydrothermal features, is located on the western edge of the Mallard Lake resurgent dome and is located in the Firehole River valley in between the 0.124 Ma and 0.164 Ma postcaldera rhyolite flows. The hydrothermal systems within Yellowstone have been the subject of many geophysical, geochemical, and biological investigations to understand this unperturbed hydrothermal system including a summary by Hurwitz and Lowenstern (2014).

You can read more about all CSS programs on our website, **https://coloscisoc.org/ .**

Recent CSS presentations are recorded on Zoom. Follow the links on the website for each presentation to see abstracts, biographies of the speakers and video recordings of our meetings. [Note: Please ignore the "Transcript". It is wrong too often. Just listen to the video!]

Future Colorado Scientific Society Meetings and Field Trips

Our meetings will be virtual for the upcoming months because of the COVID-19 pandemic.
We normally meet at The Colorado School of Mines, but CSM has closed the use of its facilities by outside groups. CSM currently says: "Events are closed to the public and considered 'private' (open only to the Mines community)".

Thursday, April 15, 7:00 p.m., via Zoom, CSS April Meeting:
Fluvial deposits of the Raton Basin: Implications for paleotopography and paleoclimate
by **Teresa Schwartz**, Colorado School of Mines

Thursday, May 20, Speaker and topic TBA

Other organizations' upcoming meetings:

Tuesday, April 13, Friends of the Mines Museum meeting by WEBEX, 6:30 p.m., "The Smithsonian National Ore and Rock Collections", by Leslie Hale, Collections Manager, Smithsonian National Museum of Natural History.

If you have not yet done so, please pay your dues for 2021 to CSS! You may pay dues online, or print out a pdf of the membership form and mail it to us with a check. Continuing your membership in CSS will enable us to continue all our ongoing programs, including our field trips, virtual meetings, Student Research Grants, and more.

See **https://coloscisoc.org/join-donate/** for the online link to our membership & dues form. Regular CSS dues are $25 (paid after Jan. 31; $20 if paid before the end of January); Corresponding Membership (outside of the Front Range area) $10; Student Membership (any level) $5; Life Membership, $395. Send your membership payment, if not done online through PayPal, to Colorado Scientific Society P.O. Box 150495 Lakewood, CO 80215-0495.
Thank you!

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At the Dec. 17 Annual Meeting, it was announced that the **CSS 2020 Best Paper Award** was given jointly to the two co-presenters, Ian Miller and Tyler Lyson, for their presentation at our September meeting, "Rise of the Mammals: Exceptional Continental Record of Biotic Recovery after the Cretaceous–Paleogene Mass Extinction".

The Colorado Scientific Society officers and councilors:

President, Bruce Trudgill, Colorado School of Mines

President-elect, Ned Sterne, consulting geologist

Past-president, Jim Paces, U.S. Geological Survey

Secretary, Lisa Fisher, Escalante Mines, Inc. (incumbent)

Treasurer, Don Sweetkind, U.S. Geological Survey

Councilors: 2019-2021: Linda Barton Cronoble
2019-2021: Yvette Kuiper, Colorado School of Mines
2020-2022: Joe Sertich, Denver Museum of Nature & Science
2020-2022: Warren Day, U.S. Geological Survey
2021-2023: Lew Kleinhans, independent geologist
2021-2023: Karen Berry, Director, Colorado Geological Survey

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March - Where's That Rock? We'll print the complete answer to last month's photos of a stream-gaging station in the next issue, I promise! But for now, here is a another picture, for March. Where's this rock? Write your answer back to editor Pete Modreski, at pmodreski@aol.com .