2026 Arizona Astrobiology Symposium

Symposium Program Booklet

Friday, March 27th and Saturday, March 28th

University of Arizona

Tucson, AZ

In Person Meeting

Organizing Committee

Lily Robinthal, University of Arizona
Karla Paredes Aguilar, University of Arizona
Hannah Zigo, Arizona State University
Annabelle Zerby, Arizona State University
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Code of Conduct

This symposium is open to all and participation is predicated on following our community agreements. Any misconduct or violation of these community agreements will result in removal from the symposium and may involve a report to your home institution. These community agreements apply to engagement in person, virtually, in Slack, and on social media.

The **members of the organizing committee serve as the community care facilitators** for this symposium. Symposium organizers will be wearing yellow ASU lanyards to help identify them. If you are targeted by or observe discrimination, please communicate the issue to either of them if you're looking for support.

Community Agreements:

1. We are responsible for creating and promoting safe environments for learning. These environments honor privacy and confidentiality and are characterized by integrity, respect, equity, trustworthiness, and transparency.
2. We will treat others with courtesy, respect, and fairness.
3. We will foster an inclusive environment by challenging behavior or culture that is traditionally exclusive.
4. We will act with honesty and hold ourselves and our community accountable for our actions.
5. We will acknowledge the names and roles of those who have aided in our work and made contributions to activities, publications, and achievements.
6. We will refrain from personally critical comments directed at each other, and we will clearly distinguish professional comments from opinions.
7. We are dedicated to learning from each other, and we will listen to each other in curious, genuine ways that promote understanding and transformation.
8. We will ask open-ended questions in conversations of conflict instead of trying to assert an opinion or viewpoint, and we will not interrupt or speak over each other.
9. We will recognize our privilege or power within spaces and use that power to center marginalized voices.
10. Community accountability:
    a. We will be aware of our surroundings and social situations.
    b. If a situation makes someone uncomfortable, or it looks like someone is being targeted, we will recognize that this is a problem and we will be part of a solution to help.
    c. We will take action to diffuse the situation while staying safe (e.g., checking in with the targeted individual(s), recruiting help from friends, diffusing the situation by distracting those causing harm, telling symposium leadership what is happening).
    d. If we are uncertain if there is a problem, we will check in with the targeted individual(s) to see if they are okay or need help.
    e. If we feel comfortable and recognize that there is an issue, we will call out the inappropriate behavior.

Plenary I: Friday, March 27th

Dr. Nathan Hadland, University of Arizona

"Bridging Scales and Disciplines in Astrobiology: From the Field to Exploration"

Astrobiology requires working across vast scales and disciplines—from microbes to planets, from rocks to orbital data, from ecology to engineering. In this talk, I'll share lessons learned from studying life in extreme environments on Earth as analogs for Mars exploration. I'll discuss how asking simple ecological questions—such as when, where, and how microbes colonize fresh lava in Iceland—can build frameworks that inform planetary exploration strategy. More broadly, I'll reflect on navigating an interdisciplinary field: the value of bringing outside perspectives into your subfield, the challenges and rewards of fieldwork in extreme environments, and finding your niche in a field that connects so many different approaches to a single question: how do we search for life elsewhere when Earth remains our only known example? Analog environments provide imperfect but essential testbeds for developing the frameworks we need to answer this question.

Nathan Hadland is a Research Scientist and Programs Coordinator at the Arizona Astrobiology Center. He earned a B.S. degree in Astrobiology at Florida Institute of Technology and his PhD in Planetary Sciences at The University of Arizona's Lunar and Planetary Laboratory. He is broadly interested in microbial ecology in extreme environments and in leveraging those insights to inform astrobiological investigations and biosignature searches on other planetary bodies. His expertise spans environmental microbiology and geobiology across laboratory, field, and computational settings.

Plenary II: Saturday, March 28th

Dr. Luis Welbanks, Arizona State University

"The challenges in characterizing exoplanets around angry stars."

Interpreting exoplanet spectra often feels like reading tea leaves in space—every bump, dip, or wiggle could signal an atmosphere, or simply reflect noise, stellar contamination, or incomplete physics. Around M-dwarfs, this challenge becomes sharper. Many of the small, potentially habitable planets we can study orbit these cool stars, which are frequently magnetically active: they flare, spot, and flood their planets with high-energy radiation. Small planets, complex stellar spectra, and instrument systematics together create features that can look compelling, or misleading, depending on how we model them.

As JWST and upcoming facilities reveal increasingly detailed spectra of worlds orbiting these stars, we face a central question: which features are genuine molecular signatures, and which are spectral illusions?

In this talk, I will outline a framework for evaluating spectral structure in the M-dwarf regime, where expanded model spaces, alternative hypotheses, and physically grounded statistical tools are essential. By examining how stellar activity, modeling assumptions, and statistical choices shape our inferences, we can distinguish robust atmospheric signals from artifacts. The broader goal is to interpret planets around active stars with clarity, and to avoid mistaking noise (or stellar temper tantrums) for evidence of life.

Meeting Schedule

Friday - March 27th - Grand Challenges Building			
12:00 pm	1:00 pm	Lobby	Check In
1:00 pm	1:15 pm	Room 130	Introductory Remarks
1:15 pm	2:00 pm	Room 130	Plenary Speaker - Dr. Nathan Hadland
2:00 pm	2:05 pm	Lobby	Break
2:05 pm	2:55 pm	Room 130	Abstract Workshop*
2:55 pm	3:00 pm	Lobby	Break + Walk to Flandrau
3:00 pm	4:00 pm	Flandrau Science Center & Planetarium	Open Exploration Hour: Flandrau Science Center Exhibits
4:00 pm	5:00 pm	Lobby	Welcome Reception Dinner

1st Floor: Lobby, Room 130

Saturday - March 28th - Kuiper Building			
8:00 am	9:00 am	Lobby	Check In + Breakfast + Poster Set Up
9:00 am	10:00 am	Lobby	Poster Session I
10:00 am	10:15 am	Lobby	Break
10:15 am	12:00 pm	Room 308	Oral Session I
12:00 pm	1:00 pm	Lobby	Lunch Break
1:00 pm	2:00 pm	Lobby	Poster Session II
2:00 pm	2:15 pm	Lobby	Break
2:15 pm	3:45 pm	Room 308	Oral Session II
3:45 pm	4:00 pm	Lobby	Break
4:00 pm	5:00 pm	Room 308	Closing Remarks + Plenary Speaker - Dr.Luis Welbanks

3rd Floor: Lobby
3rd Floor: Room 308

*Whether it's your first time at a symposium or you're looking to refine your approach, this interactive session will help you make the most of the experience. Learn how to effectively present your research, network with peers, and communicate your findings in ways that resonate with your audience. This workshop will equip you with the tools to enhance both your presentation skills and your overall symposium experience.

Presenter Information

Poster Session I		
#1	Andrew Lottig	HERA: A Multi-Sampling System For Distributional Analysis Of Microorganisms Within The Troposphere
#2	Brooklyn Harvey	Shortfin Squid (Illex Illecebrosus) Northwest Atlantic Distribution and Behavior
#3	Sahana Karthikeyan	Cellulose in Halite
#4	Emma Brown	What does organic chemistry look like on ocean worlds in the absence of life?
#5	Zephyr Kennan	Calculating potential cumulative carbon fixed and evolutionary stage for Earthlike planets
#6	Brad Tsosie	The Geochemical Buffet: Evaluating the Influence of Impact-Induced Mixing in Ejecta on Lithotrophic Microbial Diversity at Barringer Crater, Arizona
#7	Austin Gadd	Assessing the difference in microbial communities hosted in shocked Coconino Sandstone affected by meteorite impact at Barringer Crater
#8	Marin Hanson	Microbial Diversity and Evenness Across Moenkopi Subunits of Barringer Crater
#9	Vincent Carter	Modeling Radar Data from RIMFAX in 3-Dimensions Using Julia Software
#10	Duanduan Chen	UV Radiation Environments in Early Martian Surface Waters
#11	Victor Baker	Hypothesis for Co-evolution of Mars and Life
#12	Dante Lauretta	Astrobiological Implications of OSIRIS-REx Sample Analysis

Oral Session I: Origins, Organization and Persistence of Life			
10:15 am	10:30 am	Charly Bisson	Observing the effects of allometric scaling laws in the organization of microbial ecosystems
10:30 am	10:45 am	Sam Nasreldine	Fermentation-based Heterotrophy Bolsters Enceladus' Habitability and Accounts for Plume Chemistry
10:45 am	11:00 am	Yanghuan Yu	A Synthetic Adhesion and Cleavage Toolbox for Engineering Multicellular Life-Cycle Motifs
11:00 am	11:15 am	Adriana Gomez-Buckley	Water Vapor Uptake in Desiccation-Tolerant Arid Soil Microbes
11:15 am	11:30 am	Sawsan Wehbi	Ancient recombination between archaea and bacteria obscures the emergence of tryptophan-tRNA synthetase in archaea
11:30 am	11:45 am	Kylie Hall	Life in the depths: Quantifying the habitability of exoplanets with ultradeep oceans
11:45 am	12:00 pm	Daniel Huang	When Does Reflected Light Matter for Self-Luminous Planets in Roman CGI Bands?

Poster Session II		
#13	Haley Sapers	Geobiology of Barringer Crater: an undergraduate research program
#14	Eli Resnick	Endolithic microbial communities in impact craters and implications for detecting biosignatures on Mars
#15	Ava Lofty	Coordinated Study of Carbonaceous Phases in the Shidian CM2 Meteorite
#16	Clara Apai	Simulating the Evolution of Ancient Protein Folds
#17	Katherine Costello	Assessing Biosignature Detectability in the Near-Infrared for NASA's Habitable Worlds Observatory
#18	Nandini Manepalli	Proteins that emerged after the Great Oxygenation Event used less now-scarce manganese and iron-sulfur clusters, but not less heme
#19	Eleanor Cornish	Inferring the Presence of Oceans on Earth-like Exoplanets with Habitable Worlds Observatory
#20	Olivia Cox	Expanding the Petrologic and Geochemical Record of Luna 16 and 24 Mare Basalt Fragments
#21	Sam Lockhart	Bioinformatic and Geochemical Analysis of Phosphate-Solubilizing Microbes in a Mars-Analog Cold, Perennial Spring System at Gypsum Hill, Axel Heiberg Island
#22	Kate Killebrew	Knock, Knock. Who's There? A Microbial Community Architecture and Biodiversity Study at Barringer Crater, AZ, USA
#23	Joanna Masel	The series of genetic codes that preceded our own
#24	Alfred McEwen	Europa Clipper: Understanding the Habitability of Europa

Oral Session II: Planetary Environments at the Edge of Habitability			
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2:30 pm	2:45 pm	Karla Paredes Aguilar	Where does the Phosphorus Go?
2:45 pm	3:00 pm	Kayla Smith	The Influence of Clouds and Deuterium Burning on Brown Dwarf Habitable Zones
3:00 pm	3:15 pm	William Rosen	Carbonium Ions as Hydronium Analogues in Titan's Lakes
3:15 pm	3:30 pm	Roberto Aguilar	Revealing Ice-Age Sequences in Mars-Analog Glaciers Using Drone-Based Sounding Radar and Photogrammetry
3:30 pm	3:45 pm	Lori Huseby	Ultraviolet Radiation Effects on the Optical Properties of Exoplanet Hazes

Poster Session I Abstracts

Andrew Lottig, Arizona State University

"HERA: A Multi-Sampling System For Distributional Analysis Of Microorganisms Within The Troposphere"

The HERA (High Elevation Research in Aerobiology) platform was engineered to collect microorganisms at tropospheric to lower stratospheric elevations for laboratory analysis of microbial diversity and density via high altitude balloons. The platform features sensors for altitude, humidity, temperature and pressure which are continuously recorded during sampling to provide contextual data for interpreting microbial abundance and diversity. HERA enables systematic investigation of microbial distributions and densities, supporting studies of atmospheric transport, cloud microbiology, and microbial biosignatures which are relevant to astrobiology, agriculture and microbiology. It is known that microorganisms are suspended in the atmosphere but their activity is not fully known, highlighting the importance of our machines sampling capabilities. Here, I present the updated multisampling system and particle flow through a redesigned manifold which is optimized for microorganisms. HERA is important for categorizing what microorganisms are traversing across the troposphere via tropospheric winds. HERA shows what kind of activity microorganisms have and which ones can exist at these altitudes and in specific sampling locations in order to further develop our knowledge of earth's tropospheric ecosystem, which we can extrapolate to model what type of ecosystem might be possible on other types of exoplanets.

Brooklyn Harvey, Arizona State University

"Shortfin Squid (Illex Illecebrosus) Northwest Atlantic Distribution and Behavior"

Illex Illecebrosus is a commercially important shortfin squid in the Northeastern US ocean. Migration patterns, location, short life spans and hard to match data during research, leave a gap in the information known about Illex Illecebrosus. Based on information we have collected through fishing surveys and current ongoing research we hypothesized the following: Illex Illecebrosus have a preference for habitat in warm waters, and canyon seafloors. Here we take public tools such as ROV footage and CTD data from NOAA exploration. Ocean Networks Canada rematches this data which helped us determine their habits off the shelf. This was an exploratory project to test the viability of using this method to study Illex habitat use and behavior off the continental shelf. This was done by reviewing over twenty seven videos (over 210 hours). Squid observations were matched with corresponding location, depth, temperature, salinity, and dissolved oxygen data using the Ocean Networks Canada platform. Exploratory analyses lead to the discovery of squid observations at depths, around a bimodal distribution with the greatest number of observations at 500 and 1000. In addition, we discovered that Illex Illecebrosus were in deeper and colder waters than originally suspected compared to existing scientific surveys. Most squid were observed in dives at Hatteras and Washington canyons along the seafloor. We established that ROV footage can be used to study shortfin behavior and habitat use.

Sahana Karthikeyan, Arizona State University

"Cellulose in Halite"

Discovery of cellulose microfibers preserved within ~250 million-year-old Permian halite demonstrates halite's ability to preserve complex organic macromolecules over geologic timescales. Because evaporitic minerals may act as long-term biosignature repositories in environments such as Mars, this finding is important for astrobiology. Building on this work, the present study analyzes naturally occurring halite crystals from a terrestrial salt mine to evaluate the preservation of primary fluid inclusions and their potential to retain cellulose and other organic materials. The objectives of this project are to identify and characterize primary fluid inclusion assemblages (FIAs) and analyze the contents trapped within them, including fluids, daughter crystals, and any organic material. Halite crystals were mechanically polished into slabs using sandpaper to expose crystal interiors while minimizing surface contamination, enabling identification of internal inclusions. The crystals are from dissolution pipes or crystal pools; dissolution pipes have abundant secondary fluid inclusions, whereas crystal pools have more primary fluid inclusions. Crystal pools also feature chevron bands that display the growth cycle of these crystals. This preparatory phase supports astrobiological efforts to identify mineral environments capable of preserving biosignatures over time. The next steps are to assess cellulose preservation within FIAs using advanced analytical imaging and techniques.

Emma Brown, Arizona State University

"What does organic chemistry look like on ocean worlds in the absence of life?"

As the catalog of chemical data from extraterrestrial bodies grows, measures to prevent false positive signatures of life are becoming increasingly critical. For instance, amino acids - the building blocks of proteins - could serve as potential biosignatures if detected on another planetary body. However, we know amino acids can also be generated without biological activity (i.e., abiotically). Therefore, we must understand the expected chemical background of a given environment in the absence of biology, termed the "abiotic background". To characterize the abiotic fate of organic compounds, we studied the hydrothermal decomposition of a model organic acid and its sodium carboxylate. We varied the temperature and ionic composition to understand how environmental conditions could impact organic decomposition. The presence of salts (NaCl, KCl, $MgCl_2$, $CaCl_2$, and Na_2SO_4) slowed the reaction rate, and in the case of divalent cations, altered the suite of organic products. Performing experiments at a range of temperatures allowed for the extrapolation of kinetic data to lower temperatures. Our results highlight the impact of environmental parameters like temperature, pH, and salinity on the reactivity of a model organic acid and demonstrate the necessity to account for these factors when generating an abiotic background. Additional experiments conducted with other organic compounds are underway to better inform biosignature evaluations.

Zephyr Kennan, Northern Arizona University

"Calculating potential cumulative carbon fixed and evolutionary stage for Earthlike planets"

We propose a novel method for estimating possible biological evolutionary stage on exoplanets based on the hypothesis that biological evolutionary state is a linear function of cumulative carbon fixed (photosynthesis) on an entire planet. We explore the implications of this hypothesis using spatially explicit climate simulations of TRAPPIST-1e, a tidally locked planet within the habitable zone of a red dwarf star ~40 light years away. We estimate that Earth has cumulatively fixed ~9.4 e25 g C carbon, and TRAPPIST 1e (T1e) as an ocean world with 400 ppm CO_2 using photon energy of wavelengths 400 -1100 nm would need 18 Gy years to fix the same amount of carbon. Since T1e's mean estimated age is 7.6 Gyr, we estimate it to be at a potential microbial, but not multicellular life stage. We then apply this technique to 29 nearby exoplanets that may have the conditions suitable for harboring life and using 400-1100nm light, assuming a 30% continent ratio. We identify two planets that surpass Earth's cumulative NPP and which could have both multicellular and intelligent life and 6 planets at the potential multicellular stage.

Brad Tsosie, Northern Arizona University

"The Geochemical Buffet: Evaluating the Influence of Impact-Induced Mixing in Ejecta on Lithotrophic Microbial Diversity at Barringer Crater, Arizona"

Barringer Crater is a well preserved 50,000 year old impact site in Arizona, due to the crater's young age it serves as a vital resource for investigating lithophytic microbial communities through its polymict impact breccia ejecta, a rock composed of fragments from multiple geological layers created by the massive force of the meteorite's impact. This study addresses whether the impact-induced mixing of these geologically distinct units during the process of impact-breccia formation and ejection creates a geochemical buffet that enhances lithotrophic microbial colonization compared to their isolated, stratigraphically separated counterparts. To test this, I will analyze modern microbial communities and mineralogical compositions across isolated units in the crater wall preserving pre-impact stratigraphy and within polymict breccia ejecta facies. My methodology integrates 16S rRNA gene sequencing to profile microbial diversity and taxonomic richness with a combination of mineralogical instruments, including X-ray Diffraction for mineral identification and Fourier Transform Infrared spectroscopy for detecting functional chemical bonds. I hypothesize that the forced convergence of minerals in polymict impact breccias, otherwise naturally separated by hundreds of feet of strata, provides a synergistic nutrient profile that significantly increases microbial alpha diversity by fostering specialized lithotrophic guilds.

Austin Gadd, Northern Arizona University

“Assessing the difference in microbial communities hosted in shocked Coconino Sandstone affected by meteorite impact at Barringer Crater”

Meteorite impacts can serve as a cradle for harboring life, rather than destroying habitats. The impact increases porosity through shock metamorphism, at the micron scale; this effect can increase the pore space within rocks, creating microbial habitats. We’re looking at the Coconino formation at Barringer Crater. It is a prominent, light-colored formation of fine-grained quartz sand. Moderate shock can increase habitat space highest shock decreases porosity and potential space for microbes to inhabit. I’m looking at microbial diversity in variably shocked samples of Coconino Sandstone. We have a high shock flour-like sample, and a less shocked sample that preserves sediment layers.

I want to compare how the porosity and structure of the rock post impact affected the microbial community. I’m using the XRD and FTIR to identify high shock phases in the samples. Then DNA extraction for sequencing to determine the difference in microbial diversity between samples. I hypothesize the moderately shocked Coconino Sandstone will host a more diverse microbial community as the structure of the rock protects against the elements like UV Radiation and desiccation. The highly shocked sample cannot provide that same protection, leaving it more susceptible to the environment. Given the ubiquity of impact craters on rocky and icy bodies in our Solar System, this work will help determine future sites on other planetary bodies with impact craters to study locations for potential habitability.

Marin Hanson, Northern Arizona University

“Microbial Diversity and Evenness Across Moenkopi Subunits of Barringer Crater”

Barringer “Meteor” Crater is an impact crater located in northern Arizona that formed ~50,000 years ago. The crater is composed of three main stratigraphic formations: Coconino Sandstone, Kaibab Limestone, and Moenkopi mudstone (~200 Ma). It is composed of two subunits: Wupatki and Moqui. The lower Wupatki member is composed mainly of cross-bedded quartz siltstone, while the Moqui member is finer-grained, fissile sandstone and siltstone. To evaluate how rock formations influence potential biosignatures, samples of Moenkopi will undergo DNA extraction and 16s rRNA sequencing to compare microbial community differences between its two subunits in the crater. We will also use mineralogical techniques such as X-Ray Diffraction to look for high-pressure minerals, such as Coesite, to assess shock metamorphism. Shock metamorphism differentially affects sedimentary targets, resulting in variable lithophytic habitats. I hypothesize that the finer, less-permeable Moqui Member would have lower microbial diversity and evenness than the Wupatki Member. Analyzing lithology, shock alteration, and microbial distribution provides insight into how impacts and sedimentary environments influence habitability and biosignature preservation in planetary subsurfaces, like Mars.

Vincent Carter, University of Arizona

"Modeling Radar Data from RIMFAX in 3-Dimensions Using Julia Software"

The Radar Imager for Mars' Subsurface Experiment (RIMFAX) is a ground penetrating radar on the Perseverance rover as a part of the Mars 2020 mission (Hamran et al. 2020). RIMFAX has provided information about the surface of Mars by imaging multiple buried layers and outcrops that are also seen on the surface. However, previous studies have only interpreted these subsurface images in 2-dimensions, making it difficult to account for the non-linear path that Perseverance traversed throughout Jezero Crater. Using the Julia coding language, a new model has been developed by Fredrik Andersson at ETH Zürich that can model RIMFAX subsurface images in 3-dimensions, making it easier to match these subsurface images to precise locations of Jezero Crater. The Shenandoah formation is a sedimentary fan on the west side of Jezero crater that has been extensively studied using RIMFAX and other instruments. This new model can be used to reevaluate previous interpretations of the Shenandoah formation and potentially discover new information using the same radar images.

Duanduan Chen, University of Arizona

"UV Radiation Environments in Early Martian Surface Waters"

Ultraviolet radiation can drive prebiotic photochemistry, but the UV environment at the surface of early Mars would have depended strongly on atmospheric attenuation and the chemistry of surface waters. In this project, I model wavelength-dependent UV transmission under plausible early Martian conditions using Beer–Lambert attenuation through the atmosphere and shallow water columns. The analysis focuses on how dissolved species are expected in Martian lacustrine environments, particularly iron- and nitrogen-bearing compounds, modify near-surface UV fluxes. By varying concentrations within geochemically reasonable ranges, I examine when surface and near-surface environments remain relatively UV-transparent versus strongly UV-shielded. These results help evaluate whether early Martian surface water environments could have provided suitable UV conditions, such conditions are relevant for prebiotic chemistry associated with the origin of life, and place constraints on the environmental settings in which such chemistry may have been possible.

Victor Baker, University of Arizona
"Hypothesis for Co-evolution of Mars and Life"

A 1926 paper by Univ, of Arizona geology professor, W. M. Davis, "The Value of Outrageous Geological Hypotheses," advocated questioning "...certain generally established views..." and to "..seek out what conditions would make the outrage permissible and reasonable." In this tradition we hypothesize that co-evolution of the planet Mars with its biosphere can resolve multiple mysteries about its geological history, including: (1) immense outbursts of water from the planetary subsurface; (2) episodic formation and vanishing of an "Oceanus Borealis" and related impact-induced mega-tsunami; (3) episodic atmospheric conditions with associated deep weathering, fluvial network development, highland glaciation, lakes, and inland "seas;" and (4) associated episodic phases of mantle plume-related volcanism. All these phenomena relate to a subsurface biosphere of methanogenic micro-organisms that metabolize H+ generated by radiolysis in a sialic crust, generating methane clathrates in an ice-rich permafrost layer. The resulting "clathrate trigger" could be destabilized by episodic endogenetic heat pulses/volcanism to produce quasi-stable episodes of warm/wet global hydrological cycling.

Dante Lauretta, University of Arizona
"Astrobiological Implications of OSIRIS-REx Sample Analysis"

NASA's OSIRIS-REx mission returned a large, well-preserved sample from the carbon-rich near-Earth asteroid (101955) Bennu, enabling laboratory analyses that probe the chemical inventory of the early solar system and its relevance to the origin of life. Studies of the returned material reveal remarkable molecular and mineralogical diversity, including clays, salts, ammonia-bearing phases, simple sugars, nitrogen- and oxygen-rich organic compounds, and organophosphates. Together, these components encompass many of the key ingredients required for prebiotic chemistry. The identification of soluble salts and reduced nitrogen species indicates that Bennu's parent body experienced extensive aqueous alteration under chemically favorable conditions. The intimate association of organic matter with mineral phases capable of catalysis suggests that carbonaceous asteroids were not merely delivery systems, but active chemical environments that synthesized, processed, and preserved biologically relevant compounds. These results provide strong empirical support for the hypothesis that asteroids contributed essential raw materials to the early Earth, shaping the chemical context in which life emerged.

Oral Session I Abstracts

Charly Bisson, Arizona State University

"Observing the effects of allometric scaling laws in the organization of microbial ecosystems"

A biosignature independent of Earth-specific biochemistry (agnostic) is highly desirable, and would considerably widen our scope of life detection. A new area to consider within this category is a biosignature prevalent at the ecosystem level, resulting from organized structures of species in one environment. With the consideration that cell physiology is known to change with size, a biosignature proposed by previous work is a systematic change in internal elemental composition with particle size, as cells sequester nutrients to the level dictated by their volume. A necessary prerequisite to this biosignature, though, is coexistence between multiple species in order to achieve an ecosystem. Using a differential equation-based model, a simulation was constructed using programming language Julia, aiming to represent a simple microbial ecosystem composed of multiple species of microbes (differing only in cell volume by species) and an environmental resource concentration moderated by constant inflow and outflow rates. The rate of cell mortality rate in achieving coexistence when all species had the same limiting resource was explored, and achieved surprisingly low success despite justification from biological principles. This exploration of ecosystem dynamics helps underscore the specific processes that allow for coexistence, specifically the importance of interspecies interactions, advancing astrobiological interests for both the early Earth and beyond Earth entirely.

Sam Nasreldine, University of Arizona

"Fermentation-based Heterotrophy Bolsters Enceladus' Habitability and Accounts for Plume Chemistry"

Cassini detected abundant H_2 and CH_4 in Enceladus' plume. These gases are often taken as evidence for ongoing water–rock reactions (serpentinization) supplying H_2 to hydrogenotrophic methanogens, but recent work suggests sustained H_2 production may wane as the rocky core becomes altered. We show that a glycine-powered heterotrophic ecosystem can reproduce the observed H_2 and CH_4 escape fluxes while requiring only limited serpentinization. We couple a mechanistic multispecies ecosystem model to a hydrothermal–ocean–plume transport and chemistry framework, and compare predicted plume fluxes to Cassini constraints across broad geochemical priors. In a minimal configuration where glycine is the only introduced electron donor, fermentation matches the Cassini H_2–CH_4 bands for geochemically plausible hydrothermal glycine levels, implying that primordial glycine could in principle sustain the observed fluxes on Gyr timescales. Under serpentinization-agnostic priors, approximate Bayesian computation with random forests (ABC-RF) favors fermenter + acetoclastic methanogen ecosystems over purely hydrogenotrophic ones. Glycine-fed heterotrophy is thus a quantitative, testable alternative to serpentinization-dominated habitability scenarios and motivates targeted searches for associated fermentation products in future plume measurements.

Yanghuan Yu, University of Arizona

"A Synthetic Adhesion and Cleavage Toolbox for Engineering Multicellular Life-Cycle Motifs"

The emergence of multicellularity represents one of the major evolutionary transitions in biology. Several model organisms capturing transitional states have been established and extensively studied. However, our understanding of the shared building principles of multicellularity across different evolutionary lineages remains limited.

Here, we present a bottom-up synthetic multicellular platform to investigate fundamental life-cycle motifs as a complement to traditional model-organism–driven studies. Utilizing our previously established synthetic adhesin toolbox, we engineered a synthetic adhesion-cleavage toolbox that enables the programmable reconstruction of transitions between unicellular and multicellular life cycles. Using this toolbox, we achieved orthogonal and composable multicellular adhesion and disaggregation and implemented adhesion-based and disaggregation-based logic operation to achieve dynamic control of multicellular organization. Leveraging the design space enabled by the adhesion–cleavage toolbox, we conceptually define a set of synthetic multicellular life-cycle motifs that can be engineered through programmable cell–cell interactions.

Together, these results provide theoretical support and quantitative design guidelines for engineering synthetic multicellular life cycles and for studying the unicellular–multicellular transition from a bottom-up perspective.

Adriana Gomez-Buckley, University of Arizona

"Water Vapor Uptake in Desiccation-Tolerant Arid Soil Microbes"

Desiccation-induced dormancy in microbes involves expression of different genes that facilitate survival during desiccation and resuscitate the cell upon rehydration. In desert soils, water vapor fluctuates diurnally, and microbes may be able to use it to rehydrate rather than liquid water or dew. One study has shown positive effects of slow rehydration on resuscitation of desiccated microbes, but this area remains understudied.

Our work shows that desiccated microbes can use water vapor to exit desiccation-induced dormancy with more efficacy than liquid water, resuming arrested transcription and metabolism. We used tritiated water (3H2O) vapor to track microbial water vapor uptake. Arthrobacter cells incubated with 3H2O vapor for 48 hours emitted significantly more radioactivity than a control reading, indicating that cell uptake of water vapor can be quantified. We are continuing experiments to determine uptake rates for various temperatures and relative humidity levels. We hypothesize that we will see slower uptake rates at lesser relative humidities as the saturation of liquid in the air (and thus water activity) is lower.

This work addresses a critical knowledge gap in soil microbiology and has various implications for microbial survival in arid environments on Earth and other worlds. If desiccated microbes can reliably rehydrate using water vapor, this may expand targets in the search for life to environments with water vapor rather than only bulk liquid water.

Sawsan Wehbi, University of Arizona

"Ancient recombination between archaea and bacteria obscures the emergence of tryptophan-tRNA synthetase in archaea"

The standard 20 amino acid genetic code is thought to be complete at the time of the Last Universal Common Ancestor (LUCA). We revisit whether the last amino acid, tryptophan (W), was present in LUCA by studying the origin of tryptophanyl-tRNA synthetase (WRS). WRS charges W to its tRNA and is paralogous to tyrosyl-tRNA synthetase (YRS). We identify an ancient recombination between distant YRS sequences, spanning the stem archaeal and stem bacterial lineages. This partially transferred a recombinant region of archaeal YRS into some bacterial YRSs. After excluding recombinant bacterial YRSs, we infer the tree of the shared YRS/WRS domain, using amino acid sequence and structural information. All rooting methods agree on placing the root between bacterial and archaeal YRS rather than between YRS and WRS, confirming the emergence of WRS in archaea. We also find that ancient bacteria used more W than ancient archaea, relative to LUCA. The bacterial YRS ancestor had four conserved W sites, suggesting that ancient bacteria had a now-extinct, alternative system to translate W, perhaps promiscuously with Y. Last, the W biosynthetic pathway was completed in Bacteria, with two crucial enzymes emerging post-LUCA but before the divergence of crown bacteria. Our results suggest that the translation machinery kept expanding beyond LUCA, highlighting the role of ancient HGT in the convergence of the modern genetic code.

Kylie Hall, University of Arizona

"Life in the depths: Quantifying the habitability of exoplanets with ultradeep oceans"

Exciting new discoveries of exoplanets that may host an abundance of water have raised intriguing questions about the life-hosting potential of these planets. Examples include super-Earths and sub-Neptunes with potential ultradeep oceans. However, because these planets are not like our own, it is unclear to what extent these environments could support life as we know it. The goal of my work is to quantitatively study the habitability of exoplanets with ultradeep oceans by synthesizing knowledge from astronomy and biology. I will discuss ongoing research to apply the Quantitative Habitability Framework (QHF) to exoplanets with ultradeep oceans. QHF is a probabilistic framework that assesses habitat suitability using models of an environment and an organism or metabolic process. I will share the results of my initial validating tests, including modeling deep ocean environments on Earth. I will also discuss the development of models for super-Earth and Hycean candidate exoplanets, including K2-18b, TOI-270d, and TOI-1452 b; and the development of models of various microbes living in the depths of Earth's oceans to explore their viability in the ultradeep oceans of exoplanets. This work will help reveal the potential nature and distribution of life in these oceans, thus informing the biosignatures for which to search in observations of these exoplanets and similar worlds beyond our Solar System.

Daniel Huang, University of Arizona

"When Does Reflected Light Matter for Self-Luminous Planets in Roman CGI Bands?"

The Nancy Grace Roman Space Telescope Coronagraph Instrument (CGI) will directly image exoplanets in four optical bands (0.55–0.87 μm), where observed planet light can include both reflected starlight and intrinsic thermal emission. For self-luminous giant planets ($T_{eff} \gtrsim$ 600 K), thermal emission is often assumed to dominate, but reflection can measurably contribute at optical wavelengths and moderate separations, biasing detectability and exposure-time estimates. We quantify when reflected light becomes non-negligible for Roman CGI targets. Using the PICASO radiative-transfer framework with self-consistent temperature–pressure profiles and cloud models, we generate paired reflected and thermal planet–star contrast spectra for giants spanning T_{eff} = 400–1500 K, semi-major axes of 5–20 AU, and log g = 3.0–4.0. For each CGI band, we compute the band-integrated reflected fraction, $f_{ref} = F_{ref}/(F_{ref} + F_{th})$, and adopt $f_{ref} \geq 0.10$ as a significance criterion. As expected, reflected light dominates for cooler and/or closer systems, while thermal emission increasingly contributes for warmer and/or wider-orbit planets, especially in the redder CGI bands. The transition between reflection-dominated and mixed regimes shifts systematically with T_{eff} and separation. These results define a practical decision boundary for including reflected light in Roman CGI modeling of self-luminous planets, improving observability forecasts, and informing target prioritization.

Poster Session II Abstracts

Haley Sapers, Northern Arizona University

"Geobiology of Barringer Crater: an undergraduate research program"

Through shock metamorphism the process of impact cratering creates microbial habitats on multiple scales. The ~50 000 year old ~1.2 km diameter Barringer Crater in Winslow, AZ represents one of the best-preserved simple impact structures in the word. The target stratigraphy, Permian to Triassic sediments on the Colorado Plateau, consists of three main units: ~265 Ma Coconino sandstone overlain by ~250 Ma dolomitic Kaibab limestone in turn overlain by ~200 Ma Moenkopi mudstone. Based on shock level, sedimentary impact targets are variability 'improved' or 'impoverished' endolithic microbial habitats based on porosity. In addition to shock-induced habitat modification on the micron to millimeter scale, the comminution and juxtaposition of lithologies in polymict breccia ejecta, and exhumation of previously buried strata result in complex and geochemically diverse microbial habitats. This interdisciplinary project brings undergraduate students from multiple backgrounds together to collect field samples, investigate the mineralogical effects of shock metamorphism, and extract DNA from low-biomass rock samples to investigate the influence of impact-related parameters on microbial colonization and diversity with implications for impact habitability and biosignature preservation beyond Earth.

Eli Resnick, Northern Arizona University

"Endolithic microbial communities in impact craters and implications for detecting biosignatures on Mars"

A major step towards detecting microbial life in the Martian subsurface is understanding the microbial communities that exist in analog environments on Earth. Evidence of impact-induced hydrothermal systems on Mars support the idea of crater habitability and solidify Martian impact craters as a site for biosignature detection. Barringer Crater, AZ, with its well-preserved structure, dry environment, and high UV exposure is a great analog for impact craters on Mars. I am studying microbial communities in Barringer Crater through analyzing the composition of the rocks they inhabit and how that influences the community within. I am looking at the diversity, evenness, and distribution of microbes as a function of structural variability across the clast and matrix of the Kaibab breccia, a combination of these rock "clasts" embedded in a "matrix" of finer material. My methods are; X-ray diffraction and Infrared spectroscopy for mineralogical characterization and extracting DNA for 16s rRNA sequencing to determine the difference in microbial diversity across Kaibab clasts and breccia matrix. I expect the clast with its less permeable outer shell would have limited fluid flow and lower nutrient availability, encouraging more chemotrophic metabolisms independent of external resources. In contrast, the matrix having a more homogenous structure with higher permeability would have higher fluid flow, encouraging a greater diversity of metabolisms and more efficient nutrient cycling.

Ava Lofty, University of Arizona

“Coordinated Study of Carbonaceous Phases in the Shidian CM2 Meteorite"

Carbonaceous chondrites are volatile-rich meteorites that preserve carbon, water, and other key ingredients, offering direct evidence for how life-enabling materials were delivered to early Earth. The Shidian meteorite is a petrologic type-2 CM (Mighei-type) carbonaceous chondrite that fell in Yunnan Province, China, in 2017. As a rapidly recovered fall, Shidian offers a rare opportunity to examine a minimally weathered sample that retains much of its original mineralogy from its parent asteroid. Aside from initial work by Fan et al. (2002), Shidian has not yet been classified in detail, leaving significant room for new mineralogical and petrographic studies. This study examines the diversity, distribution, and textures of carbon-rich phases—including organics and carbonates—to better understand the chemical pathways that operated on the Shidian parent body, providing new insights into the evolution of volatile-bearing asteroidal materials in carbonaceous chondrites. We are analyzing and characterizing the textures, composition, and distribution of carbonaceous materials in two thin sections of the meteorite using Keyence optical microscopy, secondary electron microscopy (SEM), and electron microprobe (EPMA). This will allow us to conduct a comprehensive, coordinated analysis of carbon-rich phases in the Shidian meteorite. We will present the results and implications of our study at the meeting.

Clara Apai, University of Arizona

“Simulating the Evolution of Ancient Protein Folds”

Early genetic codes, with fewer amino acids than the current one, likely affected how proteins folded. Even species with the same genetic code have different amino acid frequencies. This can be driven either by environmental demand (e.g. for more hydrophobic amino acids for thermophiles), or by mutation bias (species with more guanine and cytosine nucleotides (GC content) use more of the amino acids coded by more GC-rich random sequences). Wehbi et al. (2024) inferred the order in which amino acids were added to the genetic code. Masel et al. (in prep) combined this order with the “2-1-3” rule (during code evolution, information was used first in the middle position of a codon, then the first, and then the last) to construct a plausible series of genetic codes. Protein Fold Evolution Simulator (PFES) uses ESMFold to simulate the evolution of folds of randomly generated amino acid sequences (Sahakyan, 2025). We are altering PFES to capture the amino acid frequencies, and mutational patterns, of hypothesized ancestral codes, to determine the effects on the ease of evolving protein folds, and the kinds of folds that evolved. In this poster, I will discuss our methods and preliminary results.

Katherine Costello, University of Arizona

"Assessing Biosignature Detectability in the Near-Infrared for NASA's Habitable Worlds Observatory"

NASA's future Habitable Worlds Observatory (HWO) will be the first telescope designed to use reflected light spectra of Earth-like exoplanets to search for life elsewhere. One element of HWO that needs to be determined is its spectral range. HWO will likely cover a range of wavelengths from near-infrared (NIR) to ultraviolet; however, the optimal NIR cutoff is currently uncertain. We know imperative biosignatures may be lost if a limited NIR cutoff is adopted; however, it is unknown what NIR extension is appropriate and to what extent telescope thermal emission affects the detectability of biosignatures in the longer NIR wavelengths. Using the atmospheric retrieval program, rfast, designed by Robinson and Salvador (2022), in addition to a new, more extensive noise model, we investigated biosignature detectability for extended NIR cutoffs of 2.0 and 2.1 microns. Varying Earth-like atmospheric compositions and telescope noise conditions were used to examine the detectability of carbon dioxide, carbon monoxide, and methane within the NIR. For each set of conditions, biosignature detectability is either characterized as undetectable, an upper limit, or detectable. These results will further HWO mission planning by assisting with the determination of an optimal NIR cutoff in the context of the effects of telescope thermal emission.

Nandini Manepalli, University of Arizona

"Proteins that emerged after the Great Oxygenation Event used less now-scarce manganese and iron-sulfur clusters, but not less heme"

Many proteins bind transition metals, which catalyze biological processes by facilitating electron exchange reactions. The advent of oxygenic photosynthesis triggered the Great Oxidation Event (GOE), a major transition in which oxygen-depleted, reducing oceans transformed to oxidizing conditions. The GOE made some transition metals (e.g. iron and manganese) less soluble and hence less bioavailable, and other metals (e.g. zinc) more soluble. Here, we examine which transition metals were used more often by ancient, pre-GOE protein domains (annotated as Pfams), compared to Pfams that emerged more recently. We use age classifications derived by Wehbi et al. (2024) from Pfam trees reconciled with species trees. Patterns of transition metal adoption could be driven either by supply (changing abundance with the GOE) or functional demand. We find that younger Pfams are less likely to bind manganese, supporting the supply hypothesis. However, younger Pfams use more iron, despite its scarcity following the GOE, supporting the functional demand hypothesis. Older Pfams use iron more often via iron-sulfur clusters, and less often via heme, consistent with a sulfur-rich ancient world, and with heme's greater resistance to oxidative stress. Preliminary results on zinc show a temporal trend supporting the supply hypothesis, while high zinc usage by even ancient Pfams suggests that pre-GOE zinc might have been more bioavailable than is suggested by geochemical models.

Eleanor Cornish, University of Arizona

“Inferring the Presence of Oceans on Earth-like Exoplanets with Habitable Worlds Observatory”

Future NASA missions searching for extraterrestrial life require methods to detect environments that can potentially support life. Liquid water is considered essential for life as we know it and is therefore one of the most desirable features that astrobiologists look for on other worlds. Detecting water remotely from spatially unresolved observations of distant planets is a challenge, but glint signatures caused by ocean glint could provide evidence of surface oceans. To facilitate the discovery of liquid water on other planets, this project validated a model for detecting ocean signatures in data from future NASA missions. This project assessed the feasibility and accuracy of detecting ocean glint using simulated data from the proposed NASA Habitable World Observatory (HWO). It validated a glint remote sensing tool against a high-fidelity Earth model and then explored and quantified the detectability of glint signatures for Earth-like exoplanets. We completed retrievals across a grid of different phase angles and signal to noise ratios on simulated HWO observations of Earth-like exoplanets to determine the achievability of glint detection and the potential for false positives. The project offers the opportunity to shape future space missions by providing critical information on the types and parameters of data collection necessary to find water on other worlds.

Olivia Cox, University of Arizona

“Expanding the Petrologic and Geochemical Record of Luna 16 and 24 Mare Basalt Fragments”

Volatile elements, including H, influence the physicochemical properties of minerals and magmas, are important for the transport of economically-key elements within the crust, and play a vital role in the development of habitable environments. The Moon, as Earth’s nearest neighbor and a one-plate body, is a reference point for understanding the origin and distribution of volatiles during the evolution of rocky planets. Still poorly understood are the character and distribution of volatiles in mantle reservoirs formed during the evolution of the lunar magma ocean (LMO). We are analyzing the mineralogy and petrology of mare basalt fragments from the Luna 16 and 24 Soviet sample-return missions as a first step to exploring lunar mantle volatile signatures outside the Procellarum KREEP Terrane. Building on a previous assessment of 13 Luna 16 and 24 basalt fragments (Morin et al. 2021), we present ongoing petrologic and geochemical analysis of additional thin sections from both missions using optical petrography, BSE imaging, elemental X-ray mapping, and EPMA. These results establish a textural and chemical foundation needed for future secondary ion mass spectrometry (SIMS)-based analyses. Situating Luna basalts within the broader context of Apollo samples, lunar meteorites, and recent Chang'e mission basalts, this study will add to scientific understanding of lunar mantle sources and the processes that affected volatile distribution and inventory of the lunar interior.

Sam Lockhart, Northern Arizona University

“ Bioinformatic and Geochemical Analysis of Phosphate-Solubilizing Microbes in a Mars-Analog Cold, Perennial Spring System at Gypsum Hill, Axel Heiberg Island”

Planetary analog systems provide environments for studying the possibility of extraterrestrial biosignature detection, and act as a proxy of planetary surface and subsurface conditions. Gypsum Hill (GH) is a cold, anoxic, hypersaline, perennial spring system hosting a surface representation of an otherwise subsurface microbial community. GH’s community is largely composed of sulfur-cycling Bacteria. Sulfur-cycling taxa have been described and are known to play a role in phosphate biomineralization. GH’s springs are analogous to putative subsurface Martian brines. Phosphate biomineralization is known to occur in planetary analog systems, and Perserverance’s detection of Martian phosphates at Jezero Crater has elicited interest in biosignature detections. We will travel to GH and perform 16S rRNA analyses targeting taxa associated with phosphate biomineralization, and metagenomic analyses targeting sequences associated with phosphate cycling, biomineralization, and metabolism. If feasible, we will preserve rRNA samples for transcriptomic analyses of phosphate-associated genes actively utilized by GH’s community. We will also conduct geochemical analyses of carbon, nitrogen, and phosphorus-bearing species in GH’s spring fluids and sediments. We intend to ascertain whether phosphorus is the limiting nutrient in GH, determine the abundance of phosphorous-bearing biominerals, and analyze how phosphorous species interact with microbes inhabiting GH and planetary analog systems.

Kate Killebrew, Northern Arizona University

“Knock, Knock. Who’s There? A Microbial Community Architecture and Biodiversity Study at Barringer Crater, AZ, USA”

Impact craters are found on all rocky and icy bodies in our Solar System. Researching the ubiquitous process of impact cratering on Earth can give us insight into how microbial communities can colonize these structures. Barringer “Meteor” Crater, an impact site in Winslow, AZ, comprises three main stratigraphic units: Coconino, Kaibab, and Moenkopi. The Barringer impact event created novel environmental niches by exposing previously buried rock layers making them available for colonization by surficial microbes. Using in-situ samples that preserve the pre-impact stratigraphy collected from the crater wall, I am investigating how the chemical makeup of the three stratigraphic units influences the diversity of the colonizing lithophytic microbial communities. Samples will be sent out for geochemical analysis through IC-PMS analysis by Act Labs. I will use XRD and FTIR to determine mineralogy and high shock mineral phases. I will process my samples using a revised protocol to optimize our DNA recovery allowing us to isolate our samples DNA while minimizing cross contamination and removing PCR inhibitors. I will perform 16S rRNA amplicon sequencing to determine the diversity of the microbial communities. I anticipate that samples that are more chemically complex will have higher observed biodiversity and that each strata will have statistically significant differences in the community architecture due to the unique geochemistry each layer provides as an energy source to microbes.

Joanna Masel, University of Arizona

“The series of genetic codes that preceded our own”

To infer an evolutionary series of 64-codon codes leading up to our own, we added amino acids according to the degree to which they were enriched/depleted in the Last Universal Common Ancestor (LUCA), and combined parsimony with the “2-1-3 rule” that information tended to appear first at the middle codon position, then the 1st, and then the 3rd, with purine vs pyrimidine distinctions preceding distinctions between purines or between pyrimidines. Balancing these considerations suggests an ancestral promiscuity between valine/isoleucine/methionine, and between alanine/threonine, to produce “statistical proteins”. The same promiscuities make cladograms of the Class I and Class II aminoacyl-tRNA synthetase catalytic domains align perfectly with the amino acid order of appearance. Cladograms suggest that valine/isoleucine/methionine promiscuity was not resolved until after LUCA. An older hypothesis for the order of amino acid recruitment from Trifonov et al. 2000 produces both a worse fit to the 2-1-3 rule, and discordance of synthetase trees with the order. Our trees and intermediate codes also align with observed promiscuous activities of synthetases. Our hypothesized order of events can be further tested in at least 3 ways: synthesis/simulation of peptides expected from hypothesized previous vs. control codes, ancestral synthetase reconstructions, and the fitting of non-equilibrium models of codon and amino acid evolution.

Alfred McEwen, University of Arizona

“Europa Clipper: Understanding the Habitability of Europa”

NASA's Europa Clipper spacecraft will arrive at Jupiter in 2029 to make 49 close flybys of the Galilean satellite Europa, which is believed to have a subsurface water ocean. Using radar (REASON) and magnetometers (ECM) with calibration of plasma effects (PIMS), Clipper will confirm the ocean's presence, depth, salinity, and thickness of the ice shell. Spectrometers (MISE, Europa-UVS) will identify organic molecules, salts, and other elements on the surface and in plumes. A thermal imager (E-THEMIS) will search for geothermal anomalies. High-resolution cameras (EIS) will map surface features like craters, fractures, and chaos terrain, showing how material might be exchanged between the ocean and surface. EIS and others investigations will make a thorough search for plumes or other signs of activity. By flying through potential water plumes, gas and dust mass spectrometers MASPEX and SUDA will look for evidence of ocean chemistry, or that of water trapped in the ice shell. LPL will be heavily involved with REASON via Professor Lynn Carter and students and with EIS via Professor Alfred McEwen along with professional associates Sarah Sutton, Jason Perry, and others. A key task will be the production of digital terrain models (DTMS) that directly inform us about Europa's geology and also enable characterization of the clutter from surface slopes that complicates analysis of subsurface structures by REASON.

Oral Session II Abstracts

Devika Band, Arizona State University

"FPGA-Powered Edge AI: Real-Time Neural Network Inference for Hazardous Asteroid Detection"

This project presents a real-time edge AI system that deploys a neural network directly on an FPGA to enable low-latency, high-throughput inference for mission-critical applications. Traditional neural network implementations often rely on cloud or CPU-based processing, introducing delays that limit their use in real-time environments such as space systems or autonomous platforms. By quantizing and mapping a trained binary classifier onto a Xilinx FPGA, the system leverages hardware-level acceleration to achieve efficient and deterministic execution. Inference results are streamed to a host system over Ethernet using a lightweight UDP protocol, bypassing CPU bottlenecks and enabling real-time visualization and feedback. This architecture demonstrates an effective hardware–software co-design approach for deploying neural networks at the edge, where speed, reliability, and independence from cloud infrastructure are essential.

Karla Paredes Aguilar, University of Arizona

"Where Does the Phosphorus Go?"

Alkaline lakes are dynamic and complex biogeochemical systems, with high concentrations of dissolved inorganic carbon (DIC), and extreme aqueous geochemistry. Their unique environmental conditions allow for mineral precipitation to dictate brine evolution, with some having the ability to concentrate phosphorus (P). As P is essential for life, alkaline lakes serve as valuable analogs for understanding prebiotic chemistry, ancient and present extraterrestrial brines, and the conditions for the origin of life and habitability. In recent studies, Last Chance Lake (LCL), an alkaline lake in British Columbia has been identified as an analog site to deepen the understanding of dissolved phosphorus in aqueous systems. However, no studies to date have addressed the fate of dissolved P in the solid phase after evaporation of the brine. Our coordinated in-situ analysis research study explores the phosphorus-bearing minerals that precipitate in natural evaporites inLCL, as well as in experimental evaporites formed by controlled evaporation of LCL brine. Utilizing scanning electron microscopy (SEM) and energy-dispersive x-ray spectroscopy (EDS), electron-probe microanalysis (EPMA) and X-ray diffraction (XRD), we analyzed and characterized mineral assemblages including phosphate phases found in both, natural-occurring and in experimental samples. At the meeting, we will report on the bulk mineralogy of the natural sample and showcase early results of which phosphorus phases precipitate.

Kayla Smith, University of Arizona

“The Influence of Clouds and Deuterium Burning on Brown Dwarf Habitable Zones”

We present new equilibrium temperature evolution tracks to assess the potential habitability of planets orbiting brown dwarfs. Unlike previous studies that relied on analytic luminosity–cooling scalings, our analysis employs modern brown dwarf evolution models that incorporate deuterium burning, cloud formation and dissipation, and updated atmospheric opacities. We find that cloud-regulated cooling can extend habitable zone (HZ) lifetimes by tens to hundreds of millions of years. In addition, deuterium burning creates mass-dependent “sweet spots” in which planets at the same orbital distance around brown dwarfs of different masses remain in the HZ for comparable durations. For example, at 0.01 AU, planets orbiting 12 and 20 MJ brown dwarfs remain habitable for approximately 170–180 Myr. We also present a preliminary HZ analysis for an Earth-like planet orbiting a brown dwarf using a one-dimensional climate model following the framework of Kopparapu et al. (2013), but employing realistic, wavelength-dependent brown dwarf spectra. Unlike main-sequence stars, brown dwarfs evolve rapidly with age, causing their habitable zones to shift significantly over time even at fixed mass. Together, these results highlight the critical role of substellar evolution physics and spectral realism in determining the extent and longevity of habitable zones around brown dwarfs.

William Rosen, Northern Arizona University

“Carbonium Ions as Hydronium Analogues in Titan's Lakes”

Hydronium ions (H3O+) are a key part of the acid-base chemistry regulating many essential biochemical processes on Earth. In order for life to emerge in Titan’s hydrocarbon lakes, an equivalent process must be investigated. Carbonium ions such as methanium (CH5+) and ethanium (C2H7+) are a strong candidate for a hydronium equivalent. To test this possibility, we modeled these ions in a solution of methane using ab-initio molecular dynamics in the microcanonical ensemble at 90 K and 1.5 atm to best approximate Titan’s polar lakes. Given that a hydronium-water proton transfer is expected to occur on the order of 5 ps, any proton transfer from the carbonium ions to the surrounding methanes was predicted to occur at a similar timescale. Even after 100 ps, no such reaction was observed with either ion. Given how much slower carbonium chemistry under Titan conditions appears to be, any biochemistry on Titan likely cannot rely on a carbonium proton transfer reaction the way Earth-based life relies on hydronium chemistry.

Roberto Aguilar, University of Arizona

"Revealing Ice-Age Sequences in Mars-Analog Glaciers Using Drone-Based Sounding Radar and Photogrammetry"

Debris-covered glaciers (DCGs) at the mid latitudes of Mars preserve ice accumulated in multiple episodes of high obliquity during the Amazonian age. The englacial debris layers formed during interglacials are of interest for astrobiological and paleoclimate studies. However, retrieving detailed internal stratigraphy with NASA's Shallow Radar (SHARAD, 15–25 MHz) remains challenging. One way to overcome this limitation is to use drone-based ground-penetrating radar (GPR) systems that can operate near the surface.
Following the success of the Ingenuity Mars helicopter, drones have emerged as a promising platform for future geophysical surveys on Mars. We evaluated the potential of a drone-based GPR to map the subsurface of a Mars-analog glacier in Wyoming. By combining subsurface mapping with repeated drone photogrammetry, we calculated the age of englacial debris layers and analyzed the relationship of their outcropping locations with traverse-flow surface ridges.

Lori Huseby, University of Arizona

"Ultraviolet Radiation Effects on the Optical Properties of Exoplanet Hazes"

Temperate sub-Neptune and terrestrial exoplanets could contain large inventories of water in various phases, in atmospheres or even oceans. Observations have shown that many exoplanets likely contain photochemically-generated hazes, which were also hypothesized to be found on early Archean Earth. Hazes may have shielded early Earth from harmful UV radiation to allow for life to survive. In addition, haze particles are a key source of organic matter and may impact the evolution or origin of life; their optical properties are imperative for interpreting observations through theoretical atmospheric modeling. However, these planets receive large amounts of radiation, especially during flaring events, which may accelerate atmospheric escape and affect atmospheric compositions. Critically, it remains unknown how stellar flaring affects hazes and the subsequent transmission spectra of exoplanets. We present optical constants of experimentally-generated sub-Neptune haze analogs before and after UV irradiation. We find that UV-irradiation alters haze optical constants, which become more absorbing in this wavelength range, and we see a change in the resulting transmission spectrum between irradiated and unaltered haze that should be observable within current JWST capabilities.

Additional Resources

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Accessibility

Both the Grand Challenges Research Building (GCRB) and the Gerard P. Kuiper Space Sciences Building feature wheelchair-accessible entrances and ADA-compliant restrooms on each floor. Elevators are available in both buildings.

Location and Parking

Friday's events will take place in the Grand Challenges Research Building, on the 1st floor. All of Saturday's events will take place in the Gerard P. Kuiper Space Sciences Building, directly north across the lawn from GCRB.

Parking on campus is $9/day on Cherry Avenue Garage (Cherry Garage in image below). For those staying at Aloft Hotel, parking is $10/day. From Aloft Hotel to Gerard P. Kuiper Building is about 0.6 miles (~12 min walk).

Acknowledgements

Funding & Institutional Support
UA's Arizona Astrobiology Center
ASU School of Earth and Space Exploration
NASA TWSC (Topical Workshops, Symposiums, and Conferences)
Grant #80NSSC25K7732

Code of Conduct Additional Information

Misconduct

1. Title IX Violation
    a. The collective term used for incidents involving discrimination, harassment, sexual harassment, sexual violence, stalking, dating violence, domestic violence, and/or retaliation.
2. Discrimination
    a. Whether intentional or not, unequal or unfair treatment as it relates to marginalized identities, including but not limited to:
        i. Race, Gender, Sexual orientation, Ability, Religion, Age, National origin, Documentation status, Education
3. Harassment
    a. Unwanted actions, words, or physical conduct, which may include epithets, slurs, or negative stereotyping based on identity. Harassment often makes the receiving person feel uncomfortable or unsafe and has the purpose or effect of violating, marginalizing, and interfering with an individual, their dignity, or their work performance, creating an intimidating, threatening, hostile, degrading, humiliating, or offensive environment.
    b. Harassment can also include microaggressions, which are everyday verbal, nonverbal, and environmental slights, snubs, or insults which communicate hostile, derogatory, or negative messages to target persons based on their marginalized identity. Microaggressions are less overt and may also occur in well-intentioned individuals who are unaware that they have engaged in an offensive act or made an offensive statement.
4. Violence
    a. Sexual, Physical, Verbal, Emotional
5. Stalking
    a. Repeatedly following, harassing, threatening, or intimidating another person via phone, mail, electronic communication, or social media.
6. Bullying
    a. The repeated use of force, threat, or coercion to abuse, intimidate, or purposefully dominate others based on a real or perceived power imbalance. These actions can include abusive criticism, humiliation, the spreading of rumors, physical and verbal attacks, isolation, undermining, and exclusion of individuals through any means.
7. Retaliation
    a. Adverse employment, academic consequences, or other actions against anyone reporting a violation of this policy.

Support for those affected by misconduct

1. If you are targeted or observe discrimination at the symposium (in person or virtual) you can communicate it to any of the symposium organizers.
    a. We will have a private conversation removed from the symposium spaces (both in person and virtually).
    b. We will listen, validate, and affirm you and your experience, and if you are not the person who was harmed, we will ask you if the person who was harmed would also like to receive our support.
    c. We will ask if the person who was harmed would like the person who did the harm to be held accountable, and if so, what that would look like.
    d. We will not speak to or act directly with the person who did the harm without explicit consent from the person who was harmed.
2. We recognize that not everyone is protected if they report their experience. So, if you would like to **report misconduct anonymously, please fill out this google form:** https://forms.gle/PT1sWKRjgWwCDK256
    a. The information provided in this report will not be disseminated and access to the form will be limited to the community care facilitators.
    b. Any personal information provided will be kept confidential and the person who did the harm will not be approached without explicit consent from the person who was targeted.
    c. All information reported will be deleted upon completion of the symposium.
3. For those affected by the above misconduct, please seek affirmation and support from your community and those you can trust.
    a. We know communicating about experiences is not an option for everyone and another way to receive support is through already established relationships with close friends and/or (chosen) family.

Emergency Resources

If you are in need of help at any point during the symposium, please refer to the following resources.

1. In the event of a medical emergency or life-threatening situation, please call 911 immediately.
2. Don’t Call the Police Phoenix Resources
    a. Alternatives to calling the police and resources for supporting the immediate needs of people in crisis in AZ
3. Crisis Response Network
    a. 24/7 AZ crisis call, text, and online chat lines as well as warm line interactions with crisis intervention specialists
    b. Mobile crisis dispatchers available to provide immediate in person assistance if necessary
4. La Frontera Arizona
    a. 24/7 AZ crisis, sexual assault, and veteran hotline
    b. Mobile Crisis Team is available to provide face to face services in Tempe if immediate assistance is necessary
5. StrongHearts Native Helpline
    a. 24/7 confidential and anonymous culturally-appropriate domestic and sexual violence call or online chat helpline for Native Americans
6. 988 Suicide & Crisis Hotline
    a. 24/7 national call or text crisis line with resources for specific marginalized identities
7. THRIVE Lifeline
    a. 24/7 international text-based crisis line staffed by and for people with marginalized identities in STEMM
8. Direct Communication in Conflict
    a. How to have an effective conversation when in conflict with another person.