Fuel Fabrication: Challenges and Opportunities

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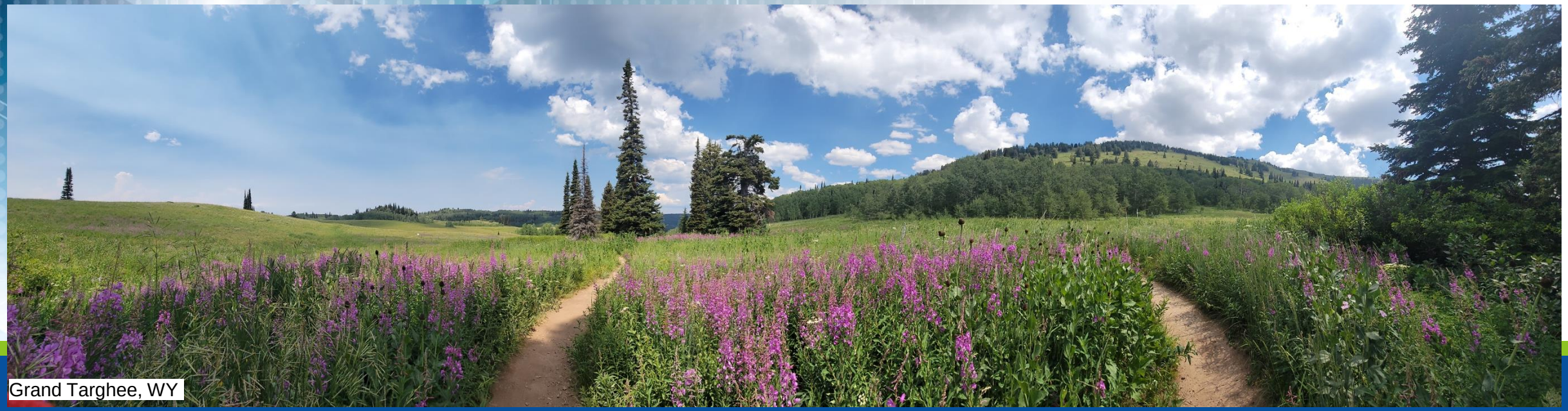
Metallurgical Engineer

Fuel Fabrication division



Grand Targhee, WY

Idaho National Laboratory

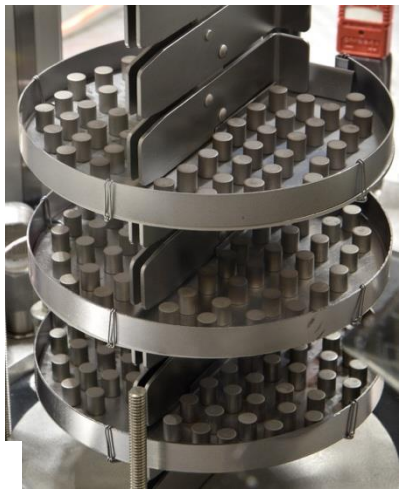
INL/CON-24-77660

Agenda

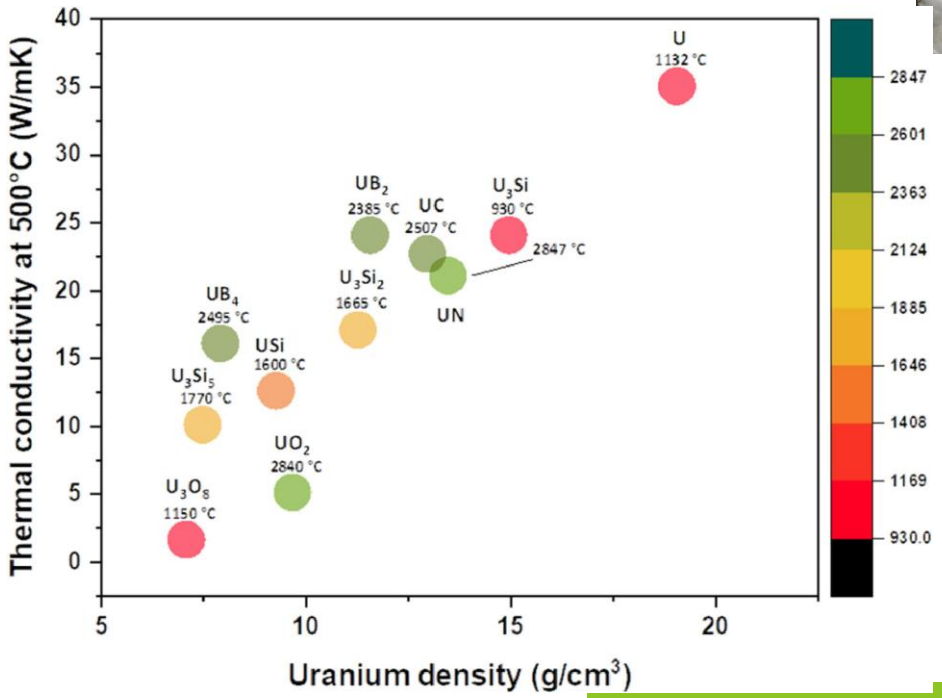
- Fuel Fabrication challenges
- Fuel Types
- Opportunities

Challenges to fuel fabrication

- UO_2 fuel fabrication is relatively easy and straight forward
  - Licensed
  - Fabrication is well-understood
  - Challenge for advanced reactor is uranium density
- High uranium density fuel types
  - UN, UC, U_3Si_2, Metallic types
    - Advantages:
      - More gU/vol.
      - Thermal properties
    - Disadvantages
      - Fabrication
      - Not as well-understood
- Feedstock availability



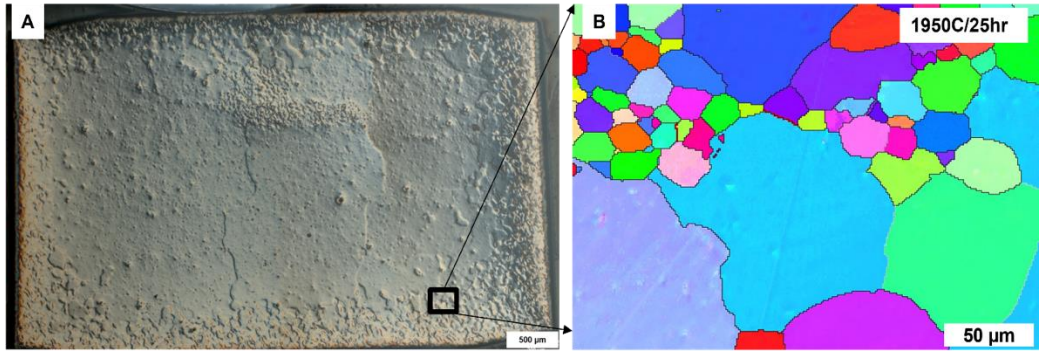
Sintered U_3Si_2 Pellets
~0.5 kg



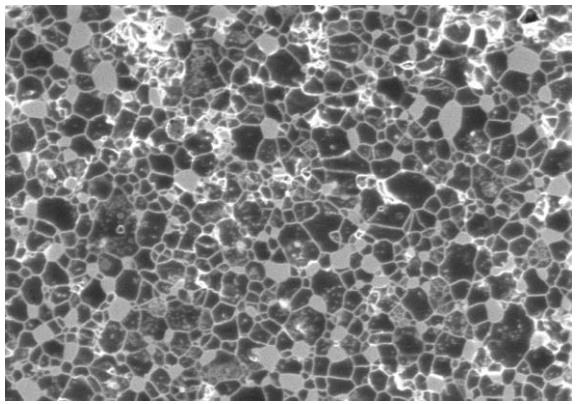
JK Watkins *et al., Challenges and opportunities to alloyed and composite fuel architectures to mitigate high uranium density fuel oxidation: Uranium mononitride,* J. Nuc. Mater. **553**, 153048, (2023)

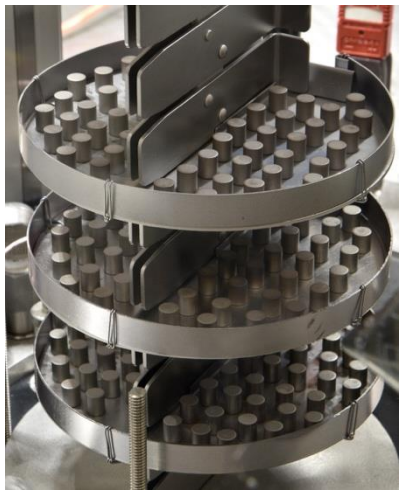
Monolithic fuel types

- Ceramic fuels
  - UO_2
  - UN and UC
    - Arc melting technique (UC)
    - Hydride/Dehydride/Nitride technique (UN)*
    - CTR technique (UC and UN)
  - U_3Si_2, Westinghouse's Encore program
  - UO_2-UB_2 (90/10 wt%) composites**
    - Enhanced thermal conductivity UO_2
- Metallic fuels
  - U-Zr
  - U-Mo



Sinter UN pellet. A) Optical image, B) EBSD inverse pole map


SEM micrograph of a UO_2 – UB_2 composite cross-section after plasma etch in FIB

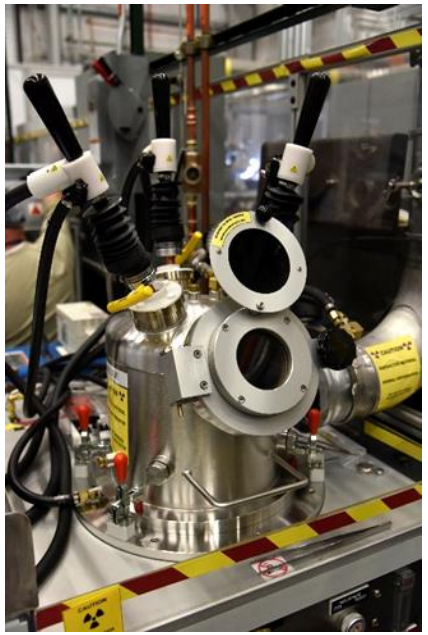

Sintered U_3Si_2 Pellets ~0.5 kg

* BJ Jaques *et al., Synthesis and Sintering of UN-UO_2 fuel Composites*, J. Nuc. Mater., **466**, 745-754, (2015)
JK Watkins *et al., Enhancing Thermal Conductivity of UO_2 with the Addition of UB_2 via Conventional Sintering Techniques,* J. Nuc. Mater. **559, 153421, (2022)

Equipment for powder processing

- **Inert (Ar) atmosphere glovebox with attached sintering furnace**
  - **Furnace**
  - **Can process research quantities up to 5kg**
- **Tri-arc melting system for material synthesis**

Sintering furnace (EFF) usable hotzone
~4 in x 6 in

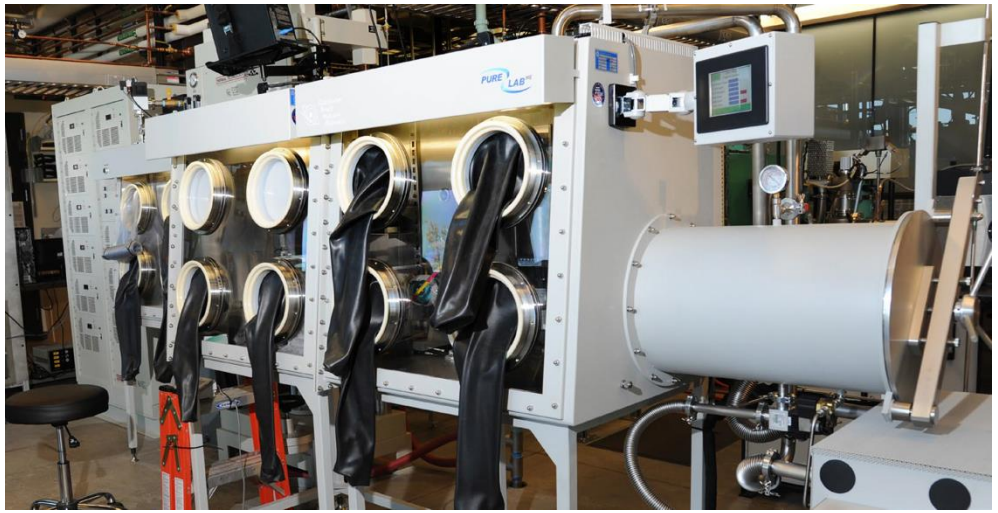


Tri-arc melting
system

Argon glovebox

Opportunities: Advanced manufacturing

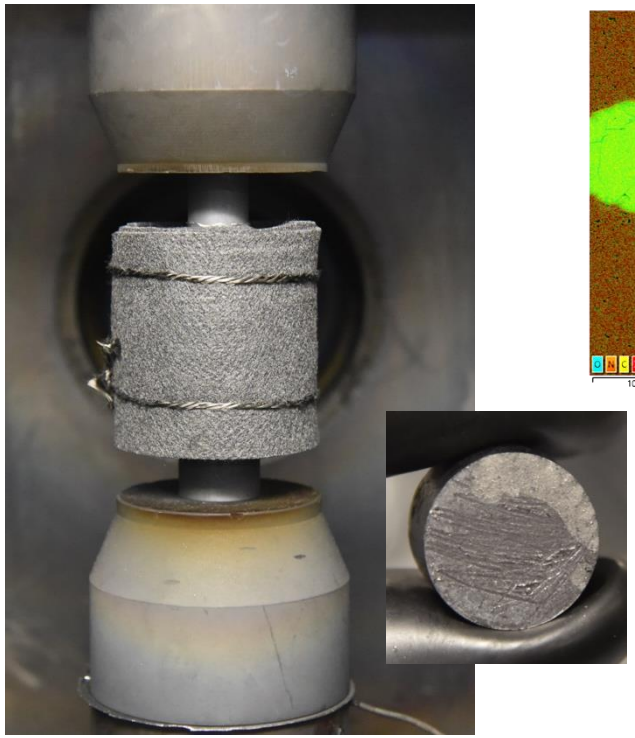
- **EFAS (Electric field assisted sintering):**
  - **Ultra high temperature CerCer and CerMet composites for Nuclear Thermal Propulsion research**
    - **UN/ZrC, UN/W-Re**
    - **Samples have been tested in TREAT to about 2500ºC**

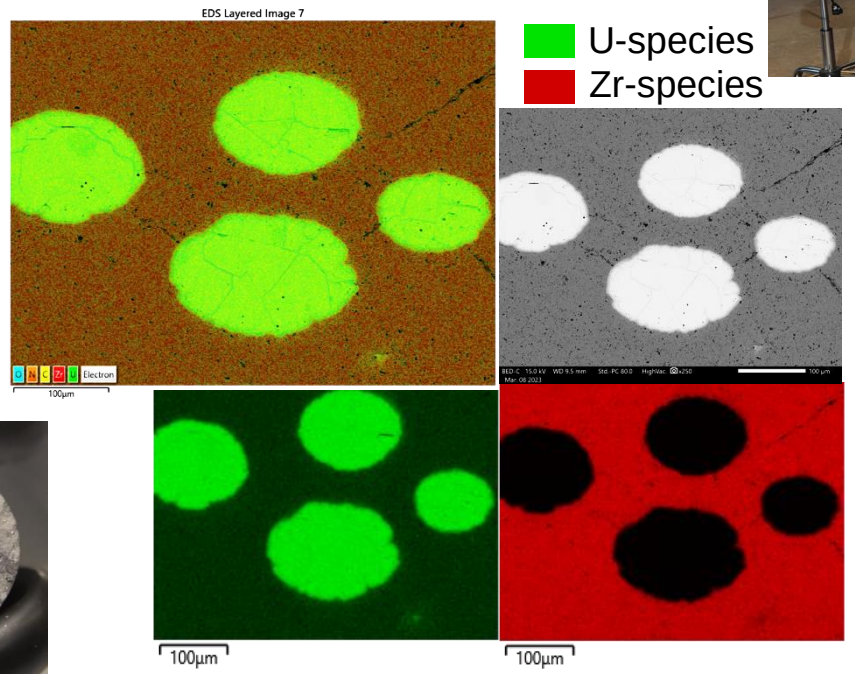


EFAS at MFC

System capabilities

- 25 ton / 10 kA
- 20 – 75 mm sample diameter

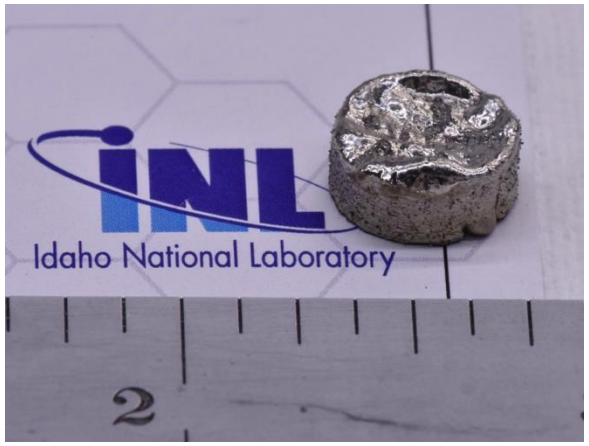




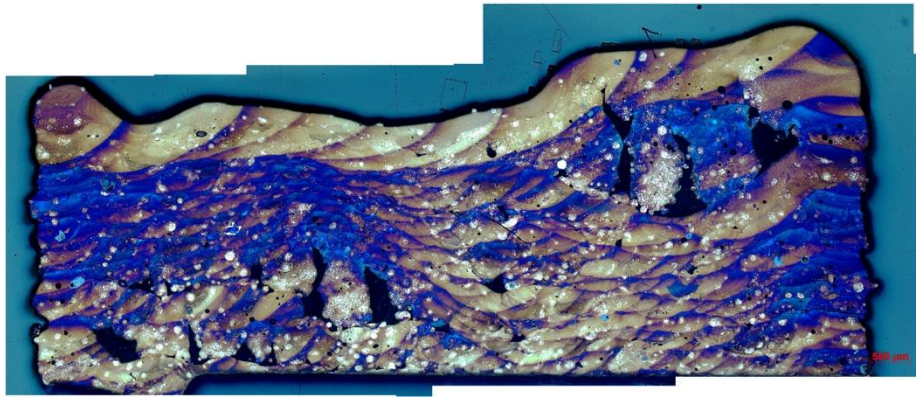
Opportunities: Additive Manufacturing

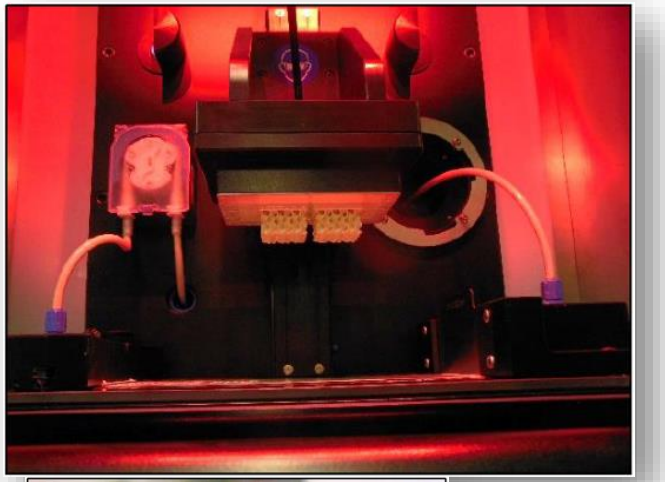
- **AM techniques being pursued at MFC**
  - **Directed Energy Deposition—LENS technique**
  - **Digital Light Processing—Admatech 130**

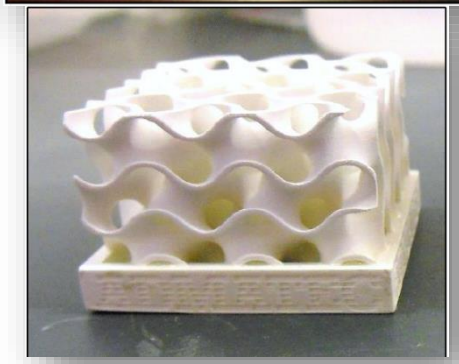
LENS system at MFC



U-10Zr pellet fabricated by LENS technique







Admatech 130 alumina lattice

Contacts

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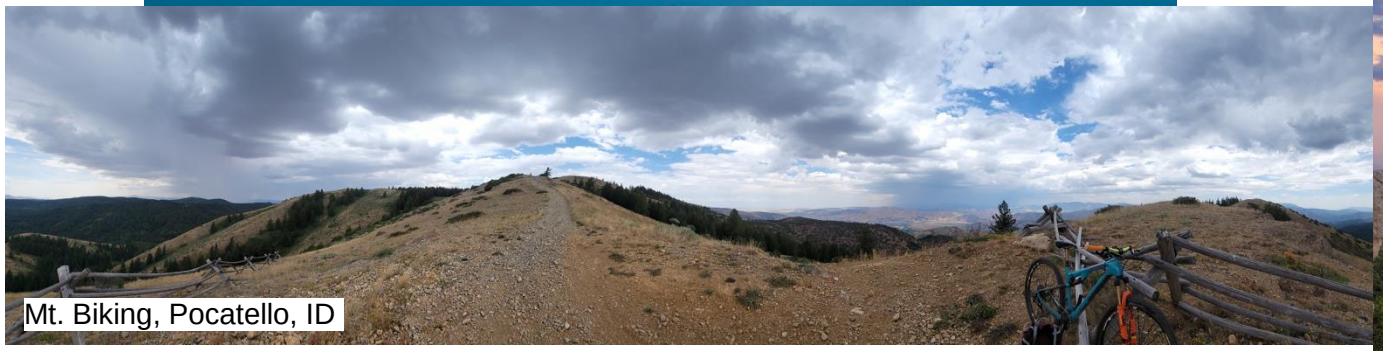
Thank you!


Mount Moran, GTNP


Crystal Park Montana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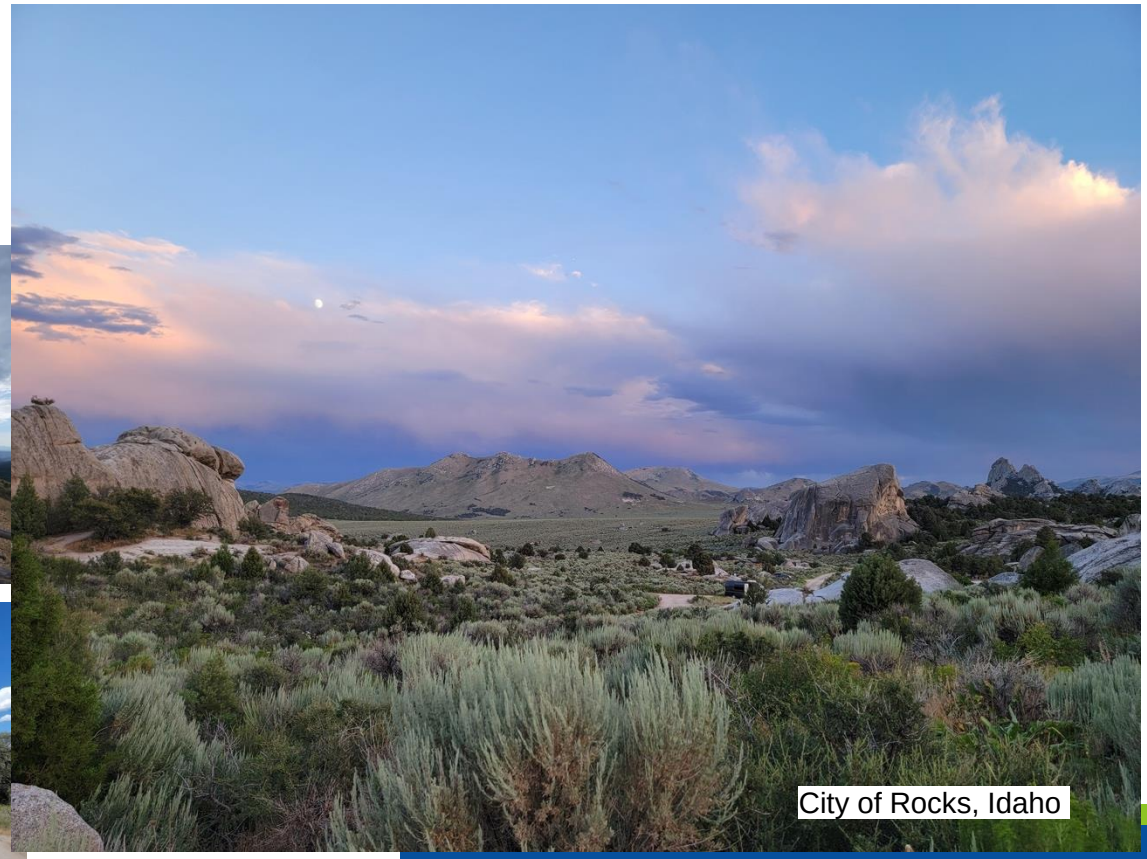
City of Rocks, Idaho


Camping, City of Rocks, ID

Idaho National Laboratory

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