Building Genome-to-Phenome Infrastructure for Regulating Methane in Deep and Extreme Environments (BuG ReMeDEE)

- South Dakota School of Mines & Technology (South Dakota, Lead PI: Rajesh Sani)
- Montana State University (Montana)
- University of Oklahoma (Oklahoma)

Award # 1736255

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BuG ReMeDEE Consortium

LanzaTech — capturing carbon fueling growth

MANGO MATERIALS

Bijson — Experience : You can Trust

EQUUSTOCK

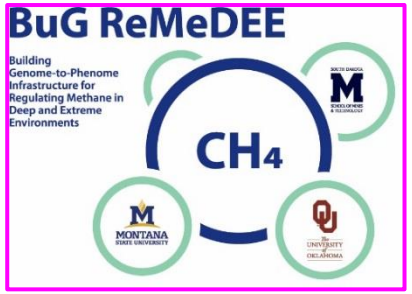
AlgaIR — NutraPharms Pvt. Ltd.

Area addressed by consortium:

"Greenhouse gas regulation in deep and extreme environments"

Main deliverable:

Fundamental knowledge about methane regulation and green technology for developing the gas-based economy



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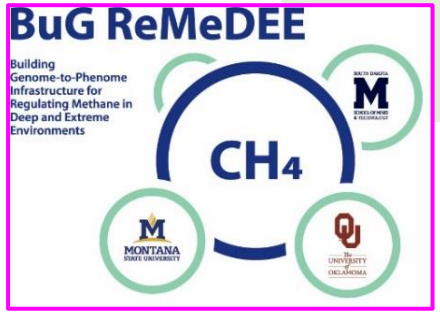
Methanotrophic Activity in the Deep Environment: Enhancement of Methane Catalysis Rates

Overview

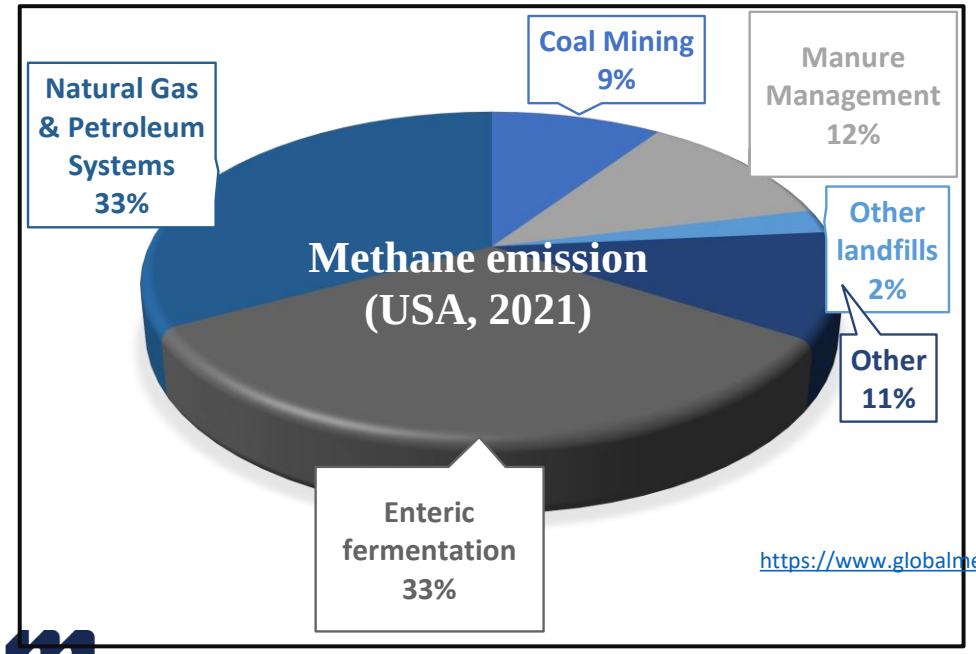
- Background (BuG ReMeDEE consortium and its main goals)
- Methane oxidizing bacteria and their MMO enzymes
- Microbial diversity in SURF mine
- Enhancement of methane catalysis rates
- Summary/Acknowledgements

Methane Regulation



NSF

Background



https://www.globalmethane.org/methane-emissions-data.aspx

Methane:

1. Second largest contributor: Climate change
2. Global warming potential: >25-fold larger than CO_2

3. 1 Gt (10^9) removal of methane could reduce 0.21°C

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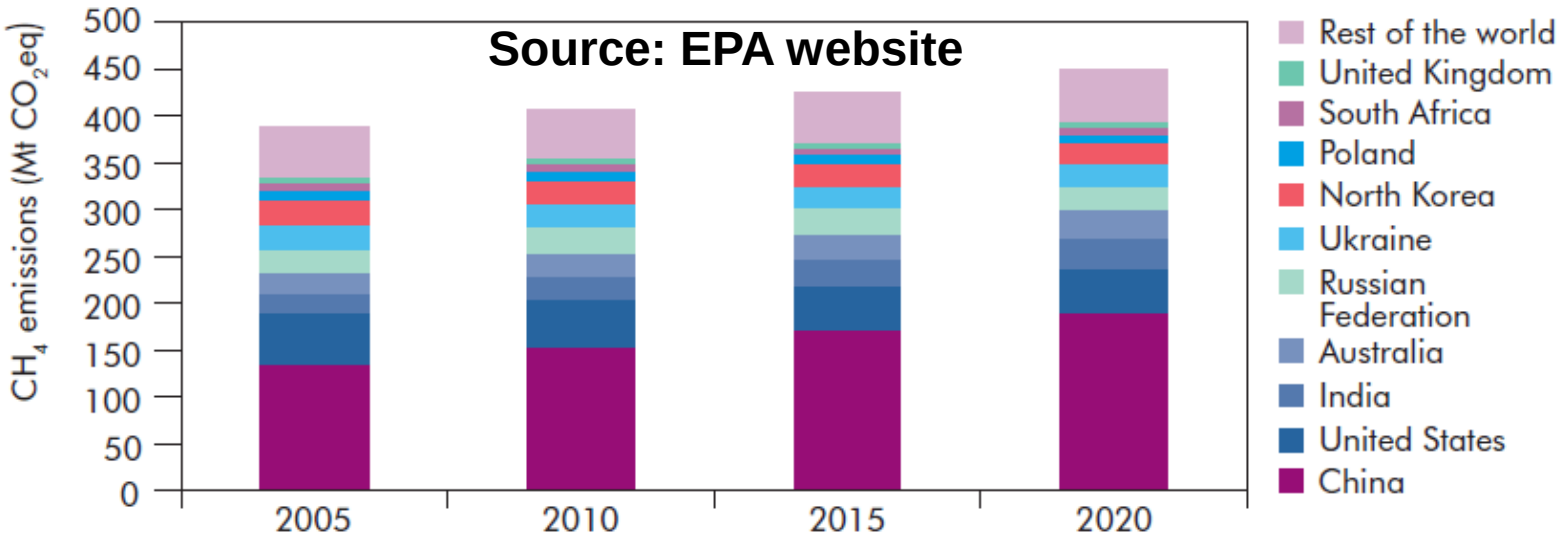
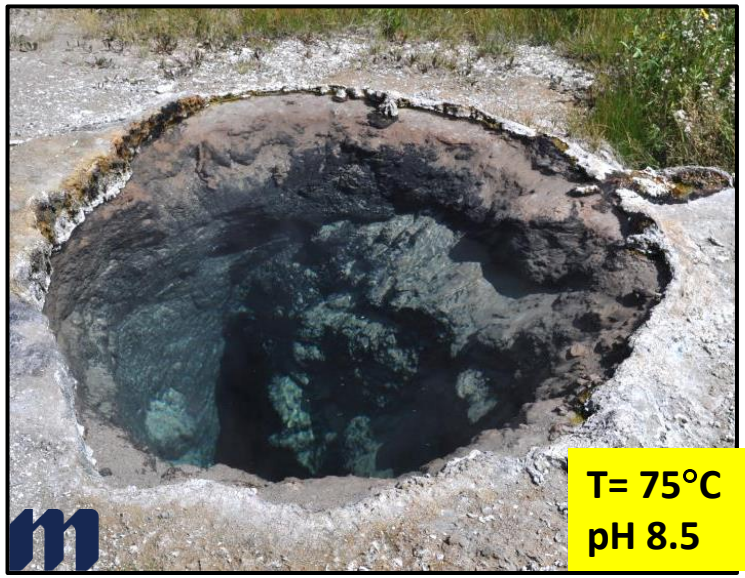


NSF

BuG ReMeDEE
Building Genome-to-Phenome Infrastructure for Regulating Methane in Deep and Extreme Environments
CH4

BuG ReMeDEE Consortium Research Goals



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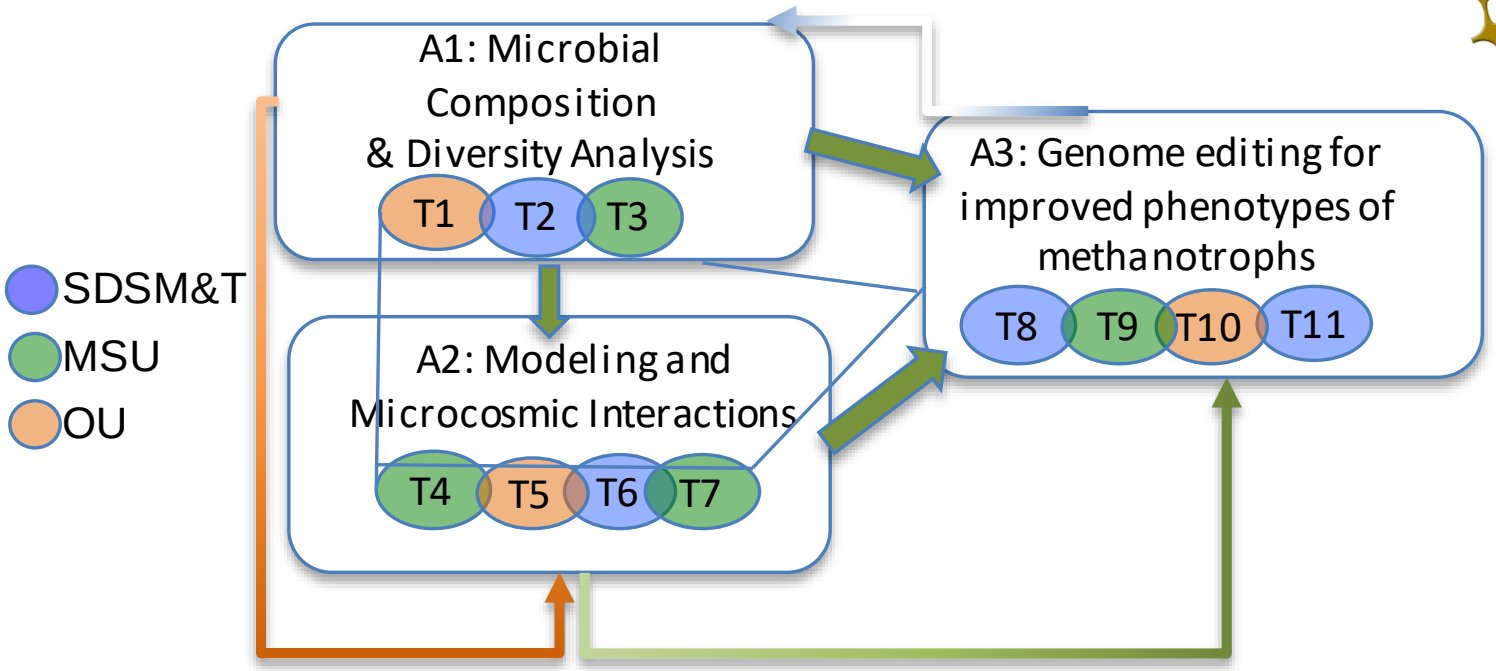
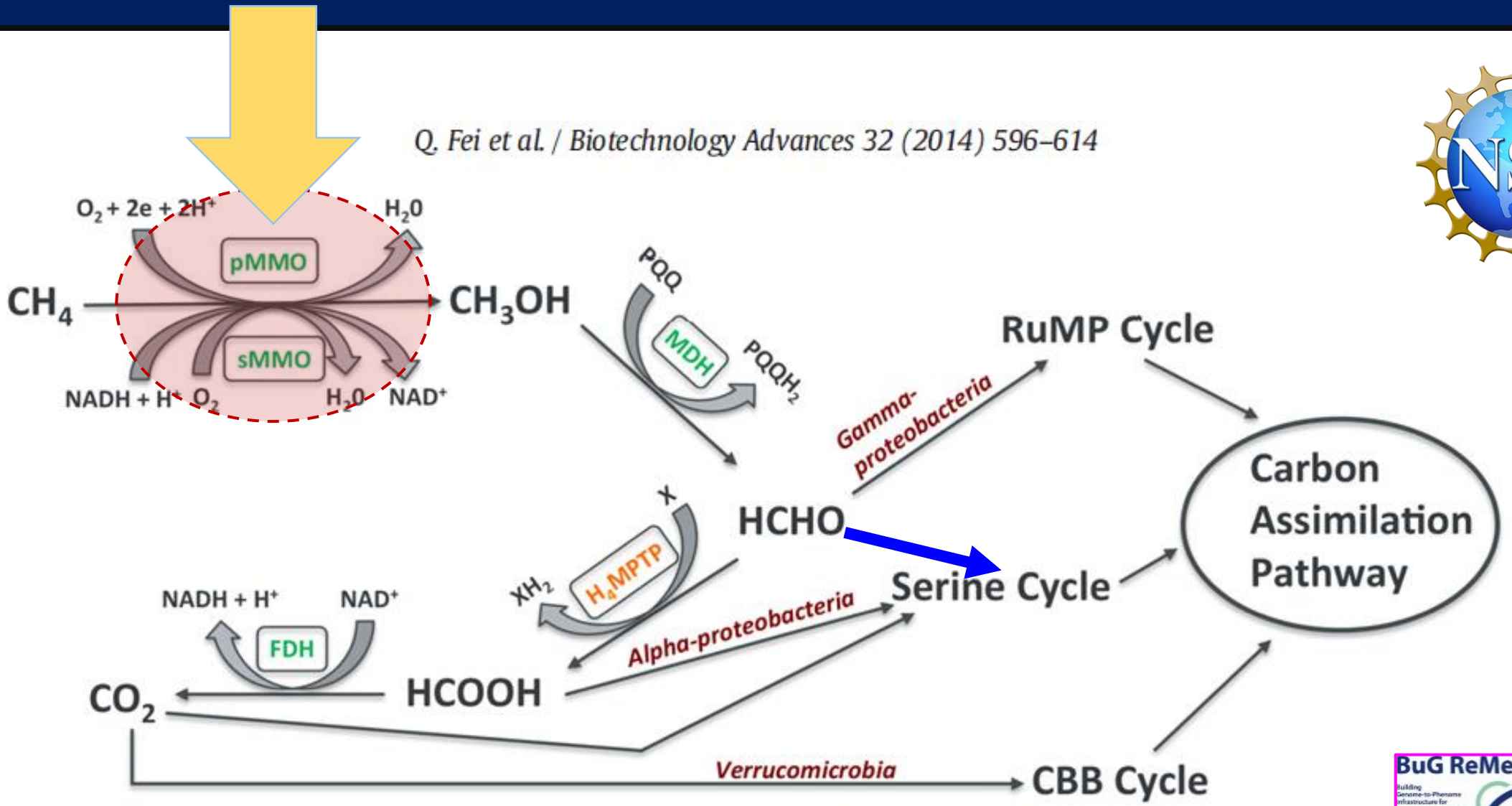


BuG ReMeDEE Accomplishments:

- **Unexplored microbial species: Regulate methane in deep and extreme environments**
- **Genome editing of novel (previous unexplored) methane-oxidizing microbes**
- **Fundamental info on industrial techniques of converting CH_4 into value added products (e.g., Methanol, Biopolymer, and Bioelectricity)**

BuG ReMeDEE
Building Genome-to-Phenome Infrastructure for Regulating Methane in Deep and Extreme Environments
CH_4

Methanotrophs – Ecofriendly Industrial Partner (BioGTL)



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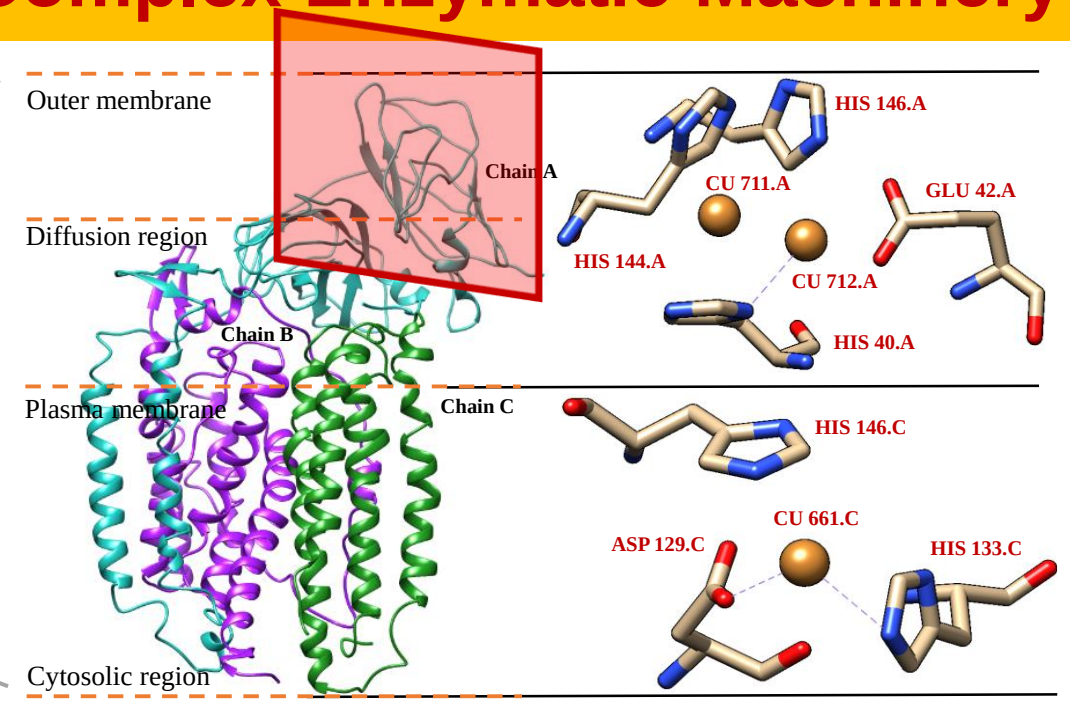
BuG ReMeDEE

Methane Monooxygenases: A Complex Enzymatic Machinery

MMO

Km, 1-12 µM

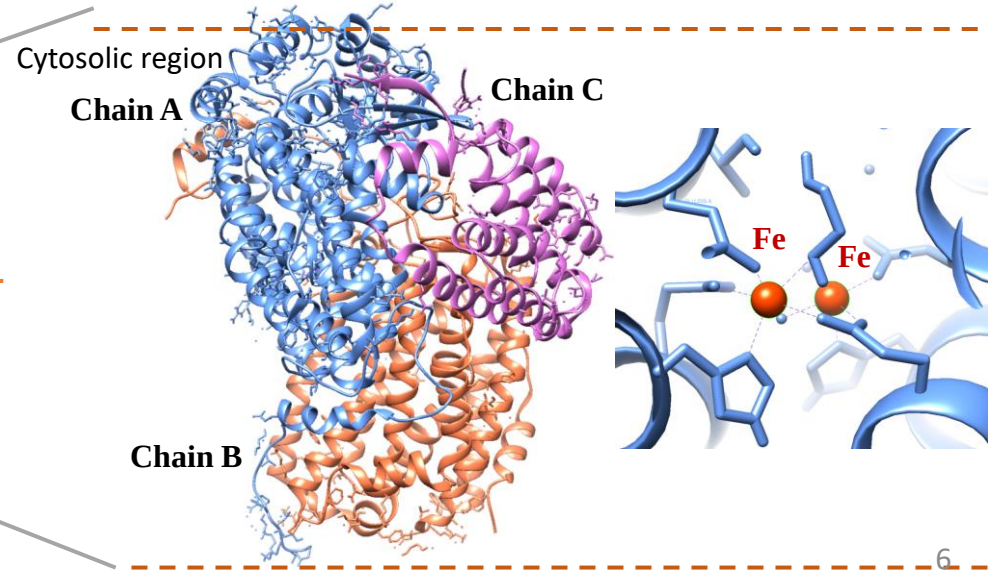
pMMO
- α- subunit *pmoB*
- β- subunit *pmoA*
- γ- subunit *pmoC*



Methylosinus trichosporium OB3b

Km, 30-60 µM

sMMO
- Protein A (hydrolase)
  - α- subunit *mmoX*
  - β- subunit *mmoY*
  - γ- subunit *mmoZ*
- Protein B (Regulatory)
- Protein C (Reductase)



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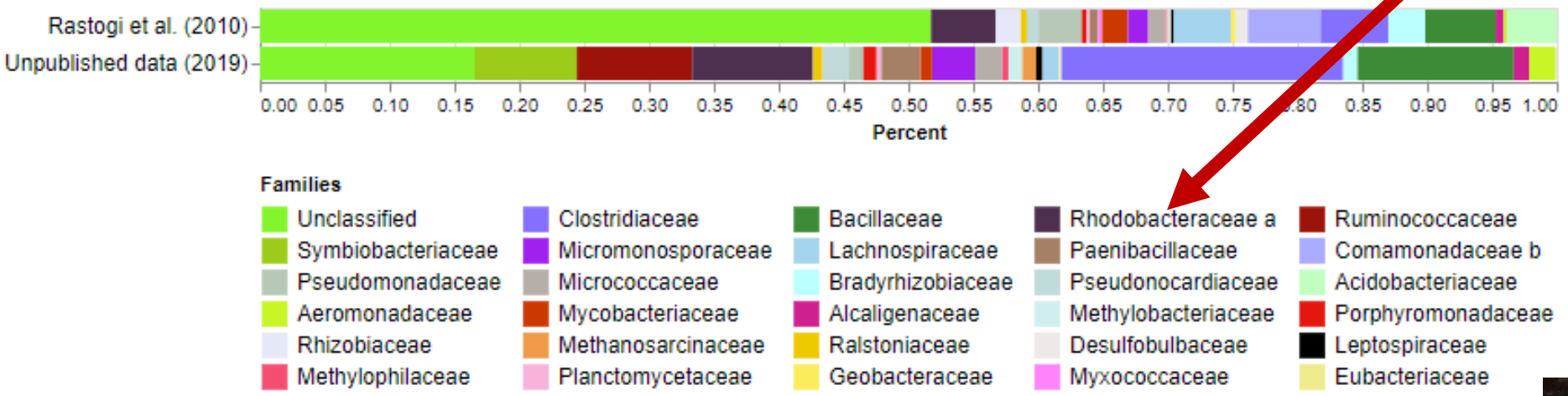
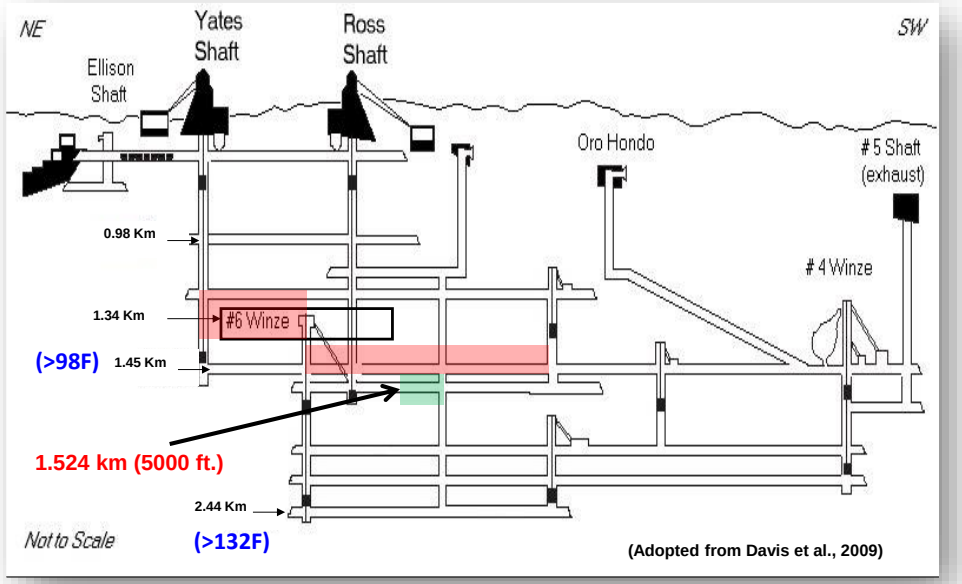
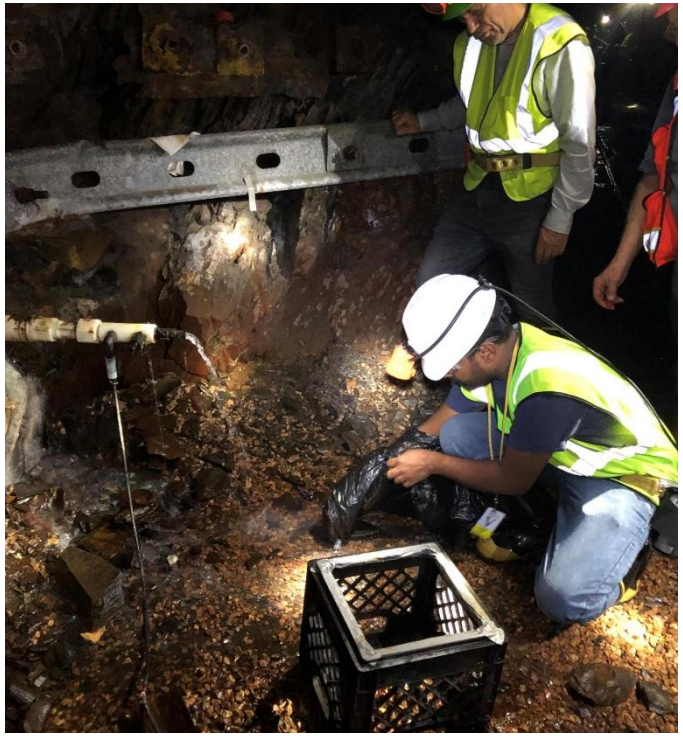
Dominant Bacterial/Archaeal Families Detected in SURF Mine

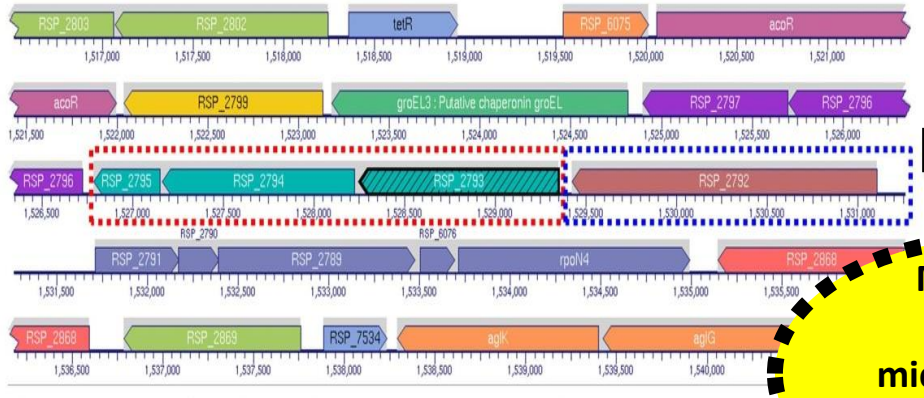
Sanford Underground Research Facility (SURF)







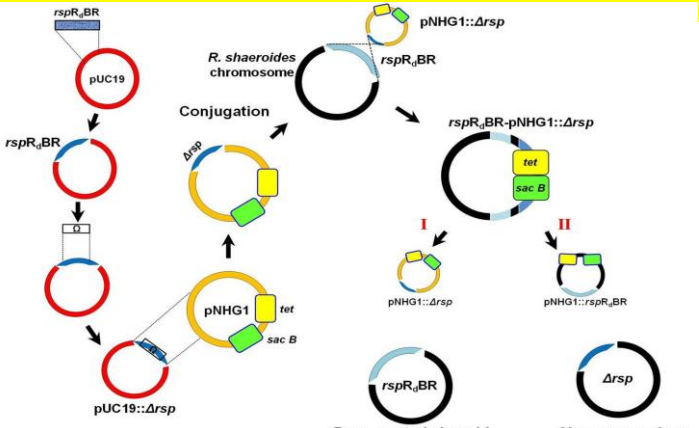
Project: Genome Editing of Novel Methanotrophs for Improved Phenotypic Properties and Conversion of Methane To Value-added Products



sMMO (α, β, and reductase)

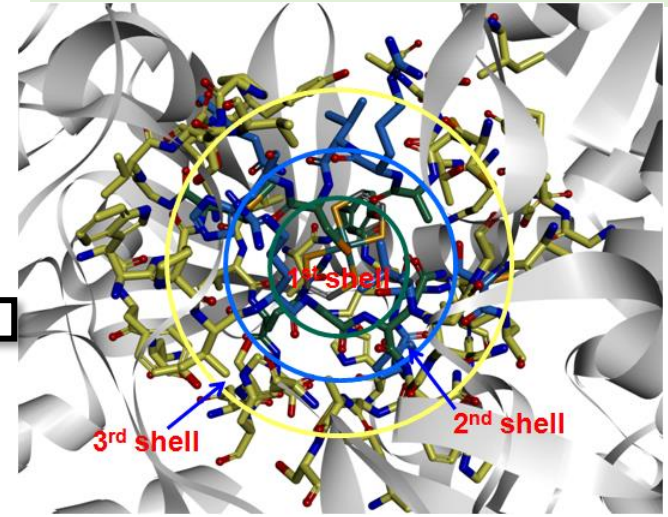
Methane-oxidizing microbes from Focus areas A1 and A2

Task: Generation of Null Background



Methanol

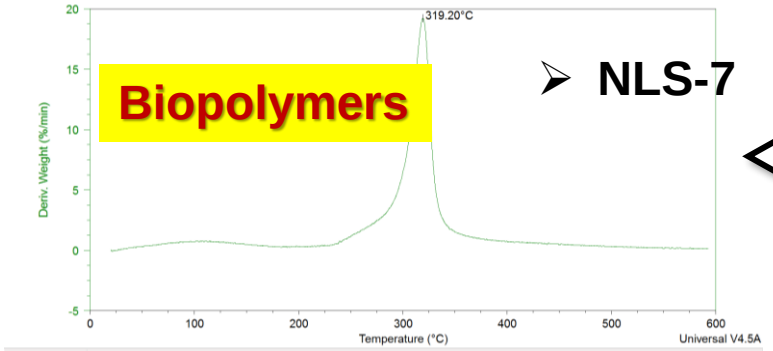
Task: Phenotypic Improvement Through In-silico Studies



Task: Engineering a Novel Methanotroph for Tailoring the Monomer Composition of Biopolymer and Electrochemical Strategies for Higher Yield

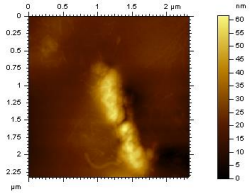
Biopolymers

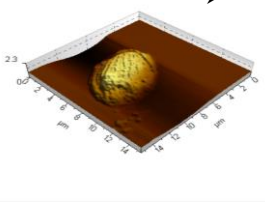
- NLS-7



Task: Electron Transfer Mechanisms of Phenotypically Improved Novel Methanotrophs at the Electrode-Electrolyte Interfaces

- RSP





Summary

- Unexplored microbial species may play important roles in regulation of methane in deep biosphere of SURF Mine

- Genome editing of model and novel (previous unexplored) methane-oxidizi microbes
  - Methane oxidation rates

➢ By combining both strategies (mutation and overexpression) – we could achieve the methane consumption rates of ~60 µmoles/mole CH_4 (per day)
(Methane oxidation rate - 0.3 µM/day (i.e., 0.04 PPM),
https://www.nature.com/articles/s42003-020-0838-z

- Fundamental info could be used to convert CH_4 into value added products (e.g., Methanol, Biopolymer, Bioelectricity, and OTHERS)

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Agency	Title	Amount	Duration	Role
National Science Foundation (Current)	Building Genome-to-Phenome Infrastructure for Regulating Methane in Deep and Extreme Environments	$6,000,000	8/17-11/22	PI
National Science Foundation (Current)	**Building on the 2020 Vision: Expanding Research, Education, and Innovation in South Dakota**	**$20,000,000**	**9/19-8/24**	**SP**
National Science Foundation (Current)	**BioWRAP (Bioplastics with Regenerative Agricultural Properties): Spray-on bioplastics with growth synchronous decomposition and water, nutrient, and agrochemical management**	**$5,999,428**	**3/22-2/26**	**SP**
National Science Foundation (Current)	**Data-Driven Material Discovery (DDMD) Center for Bioengineering Innovation**	**$6,000,000**	**8/19-7/23**	**SP**
National Science Foundation (Current)	**Bio-Mediated Technique to Control Phase Changes of Porous Media in Seasonally Frozen Ground**	**$453,047**	**9/21-8/24**	**Co-PI**
National Science Foundation (Current)	**Accelerated carbon mineralization sequestration in cation-rich rock formations via microbial augmentation and stimulation**	**$300,000**	**1/21-12/23**	**Co-PI**

Thank You. Questions/Discussion?