

DUSEL Deep Microbiology: Some Cross Cutting Insights and Sentinel Hole Transect

Duane Moser

Desert Research Institute
Las Vegas, NV

DUSEL Workshop

October 2nd, 2009



DRI Environmental Microbiology Lab



Clouds



Desert soils



Ancient materials

Two Complementary Focal Areas for Microbiology at DUSEL

Mine Microbiology

Mine as habitat

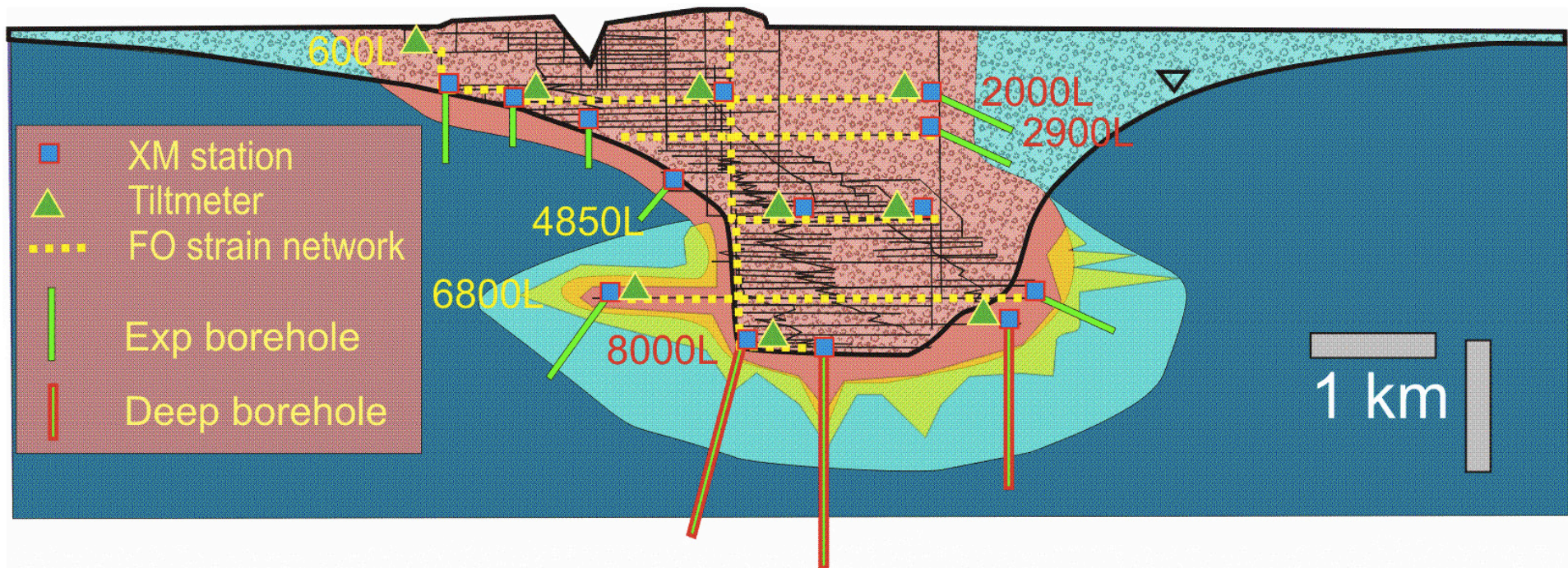


Deep Biosphere

Mine as a window into the deep biosphere



Surface to Biosphere Limit Long-term Science Hole Transect



Deep Biosphere Work



Driefontein 9 Shaft, 3.2 kmbls

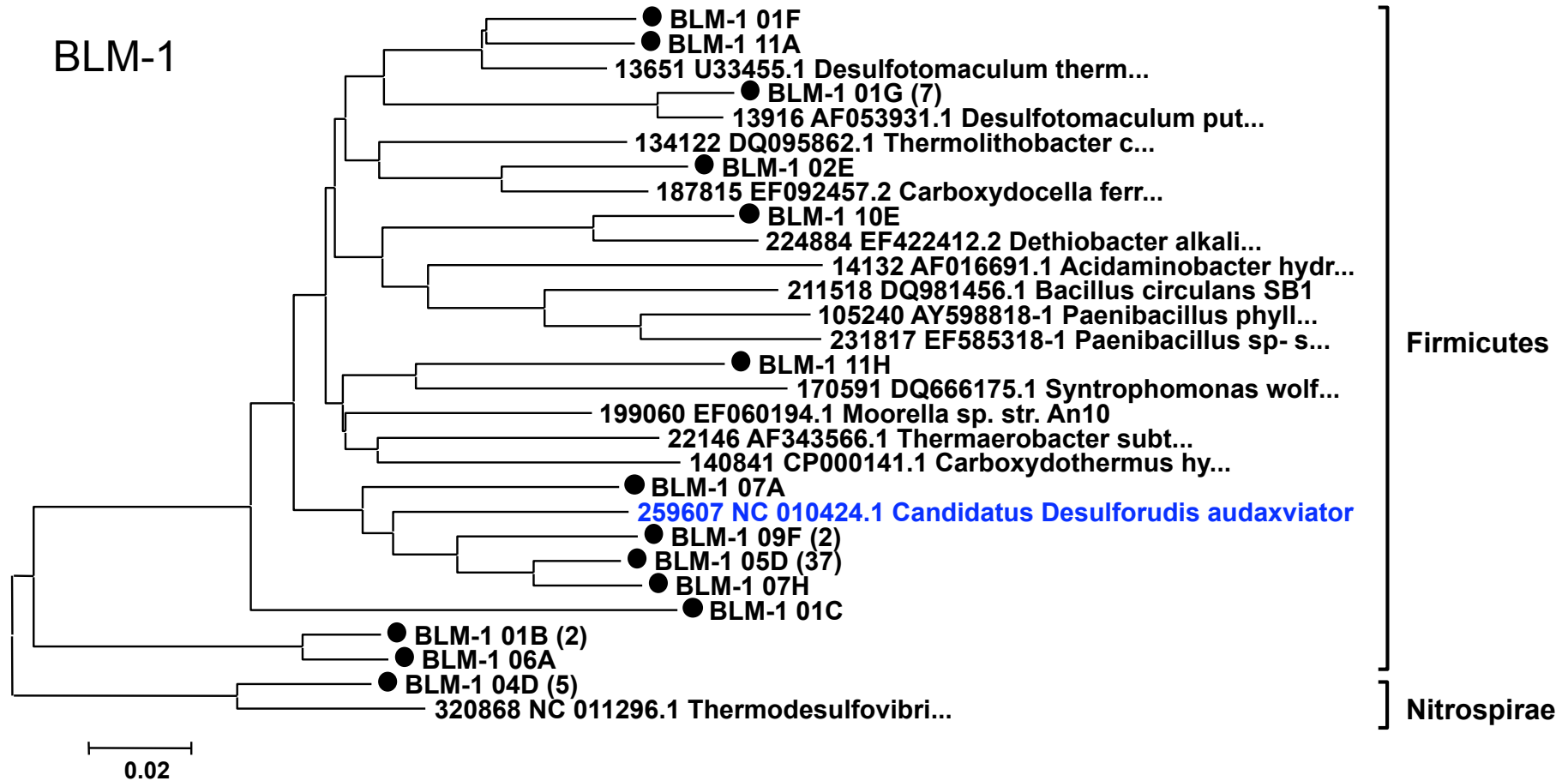


Kidd Creek Mine, Ont., CA April-2009 9,300 ft bls

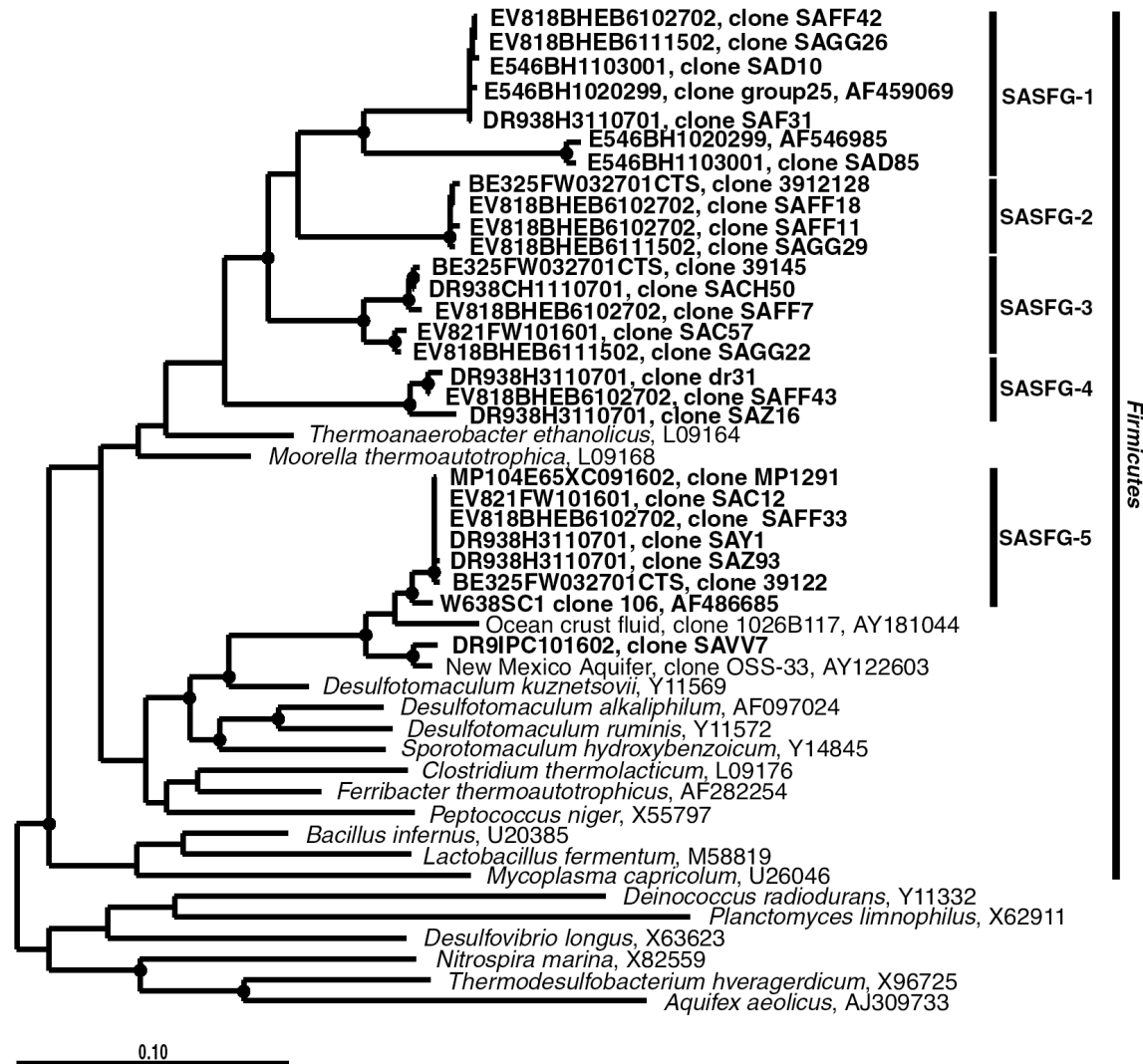


Borehole BLM1 4,400 ft bls

New Firmicutes Groups (BLM1)

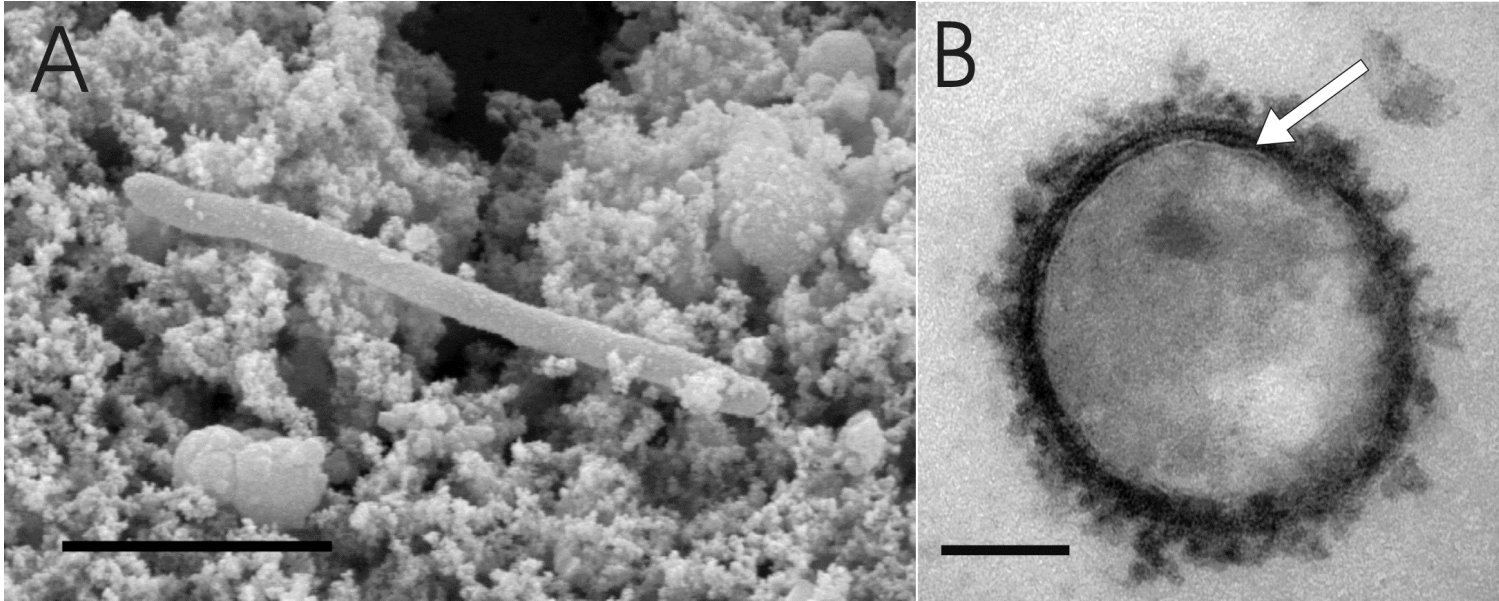


New Firmicutes Groups (South Africa)



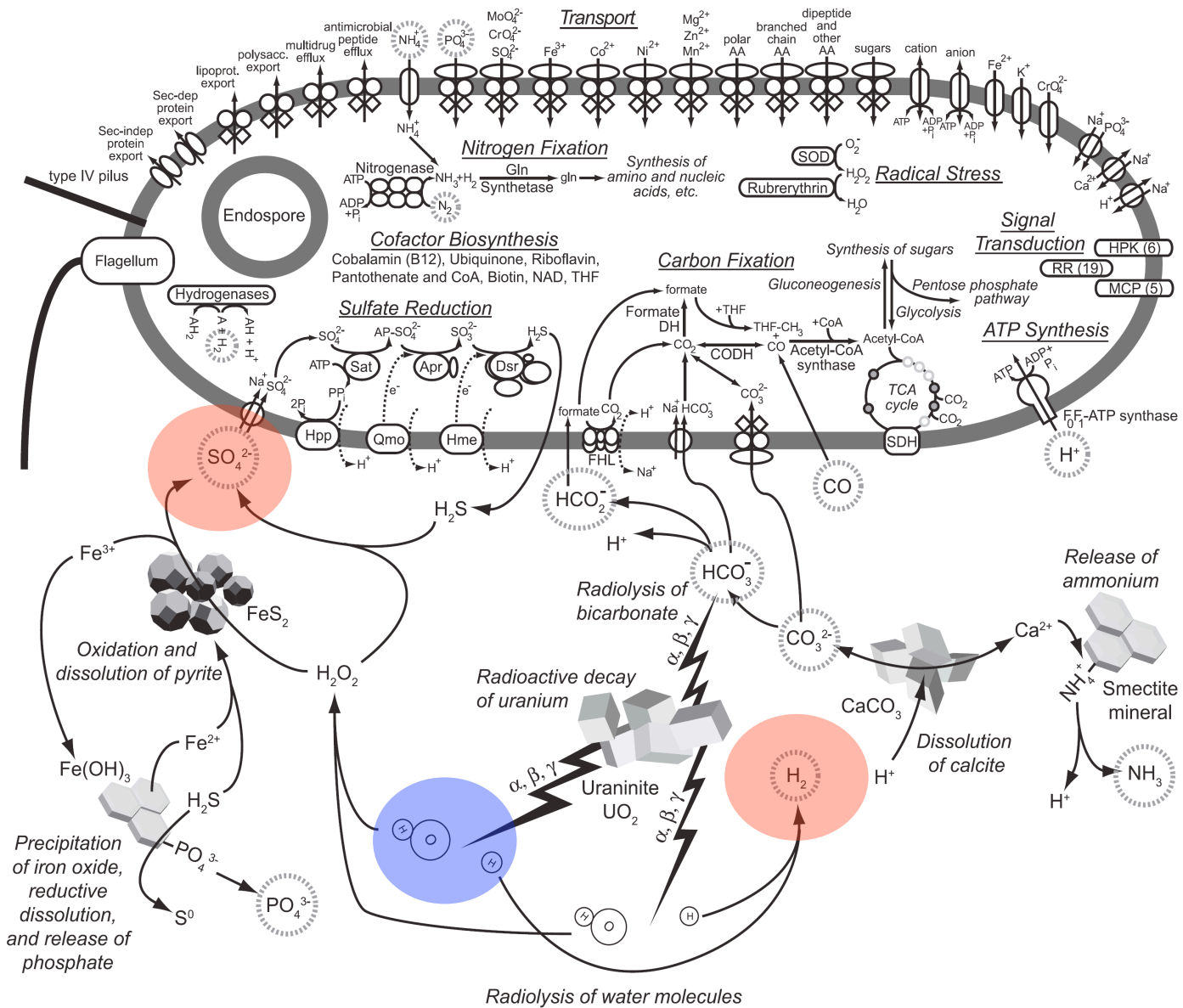
Gihring, T.M., D.P. Moser, L.-H. Lin, et al. 2006. The distribution of microbial taxa in the subsurface water of the Kalahari Shield, South Africa. *Geomicrobiol. J.* 23:415-430.

Desulforudis audaxviator



Based on its rod-like morphology, its apparent use of the dissimilatory sulfate reduction pathway for energy production, and because of the journey this "audaxviator" (bold traveler) undertook to live in the extreme depths of the Earth, we have named this organism "*Candidatus Desulforudis audaxviator*".

Chivian, D., E.J. Alm, E.L. Brodie, *Science*, 2008.



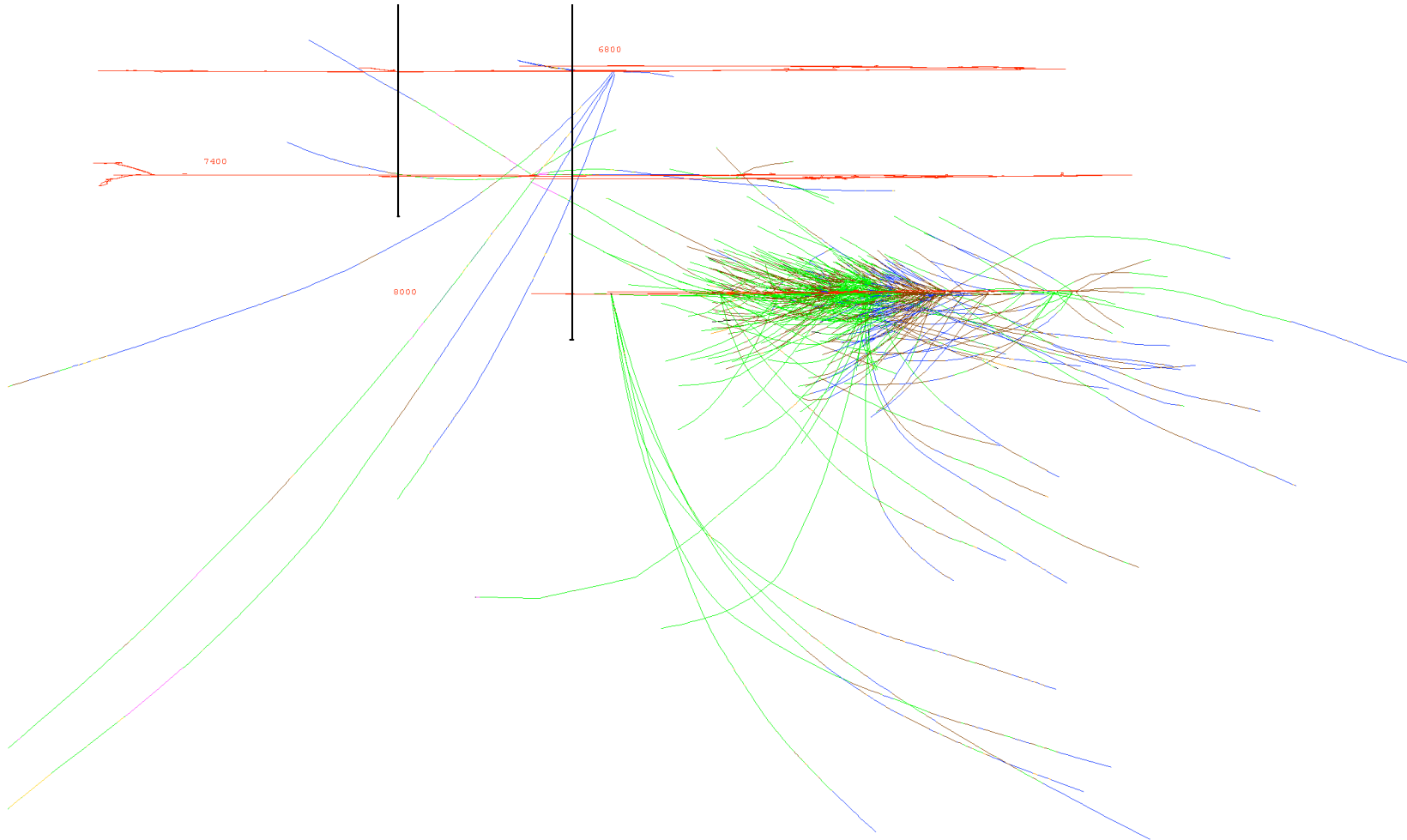
Chivian, D., E.J. Alm, E.L. Brodie, Science, 2008.

Radiological Environment at DUSEL

	Poorman Fm	Tertiary Rhyolites	Cement (local)	Aggregates				SNO Lab.
				Limestone	Crushed Limestone	Sioux Quartzite	Central Black Hills	
U (ppm)	0.24	8.60	3.00	1.75	1.49	1.06	3.37	1.10
Th (ppm)	0.25	10.80	3.40	0.30	0.36	4.68	10.40	4.90
K (%)	0.77	3.60	0.04	0.05	0.09	0.07	1.16	1.00

Witwatersrand Supergroup 25 – 35 ppm U

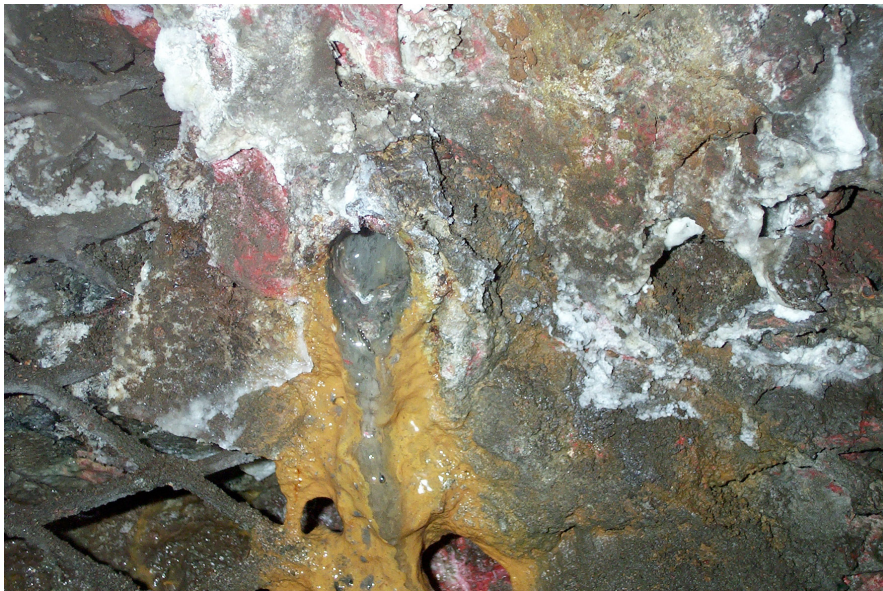
Existing Diamond-drilled Holes



Exploratory holes on 8000 level of Homestake. From Homestake Vulcan, Courtesy of T.C. Onstott

Existing Diamond-drilled Holes

Existing boreholes as windows into the subsurface biosphere?



Old exploratory holes on 8000 level of Homestake

New Holes: Points for Discussion

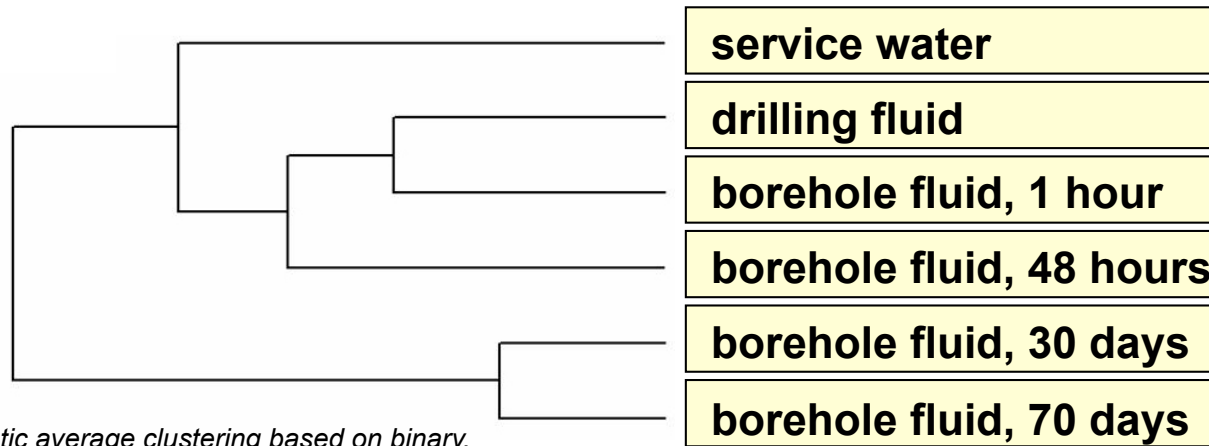
- **Aseptic drilling?**
 - Is this possible?
 - Drill cheap dirty holes and then disinfect or allow to “age”?
- **Drilling at pressure?**
 - Can you get the core out while maintaining pressure?
- **Maintaining redox and salinity while drilling?**
- **Hole development**
 - Steel casings or plastics?
 - Recirculated fluids or unidirectional?
 - Artificial fractures w/synthetic groundwater?
 - Long-term downhole access
- **Location**
 - Which rock types?



New Holes: Points for Discussion

- **What type of hole?**
 - Core hole or simple drill hole?
 - Would it be possible to maintain a sterile hole (e.g. abiotic control)?
- **Staged drilling?**
 - Drill beyond zone of mine influence?
 - Grout/casing, permanent outlet infrastructure
 - Disinfect
 - Continue on with aseptic drilling

Predictable community development in boreholes



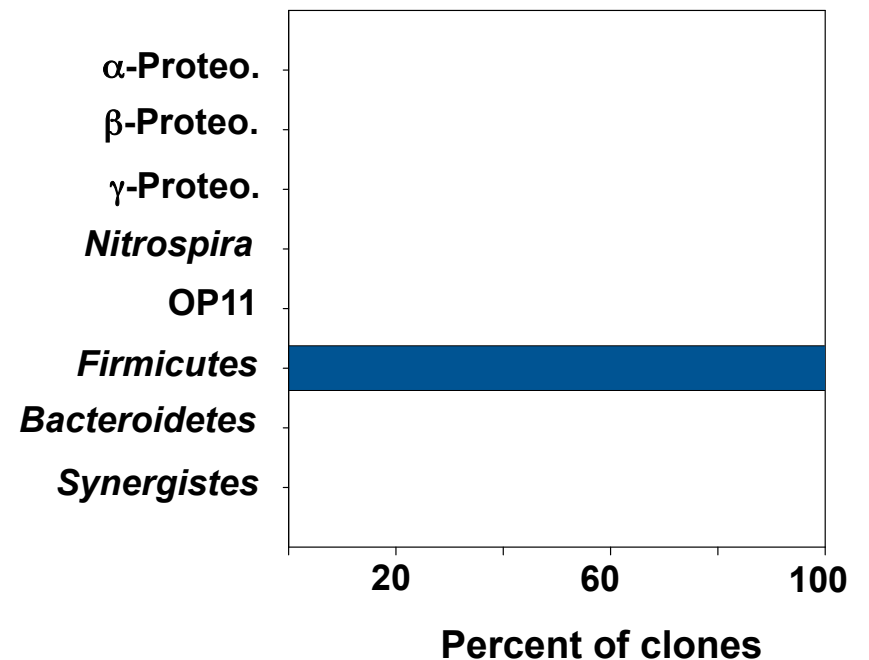
unweighted arithmetic average clustering based on binary, presence/absence distance measures

Borehole fluids, 70 days

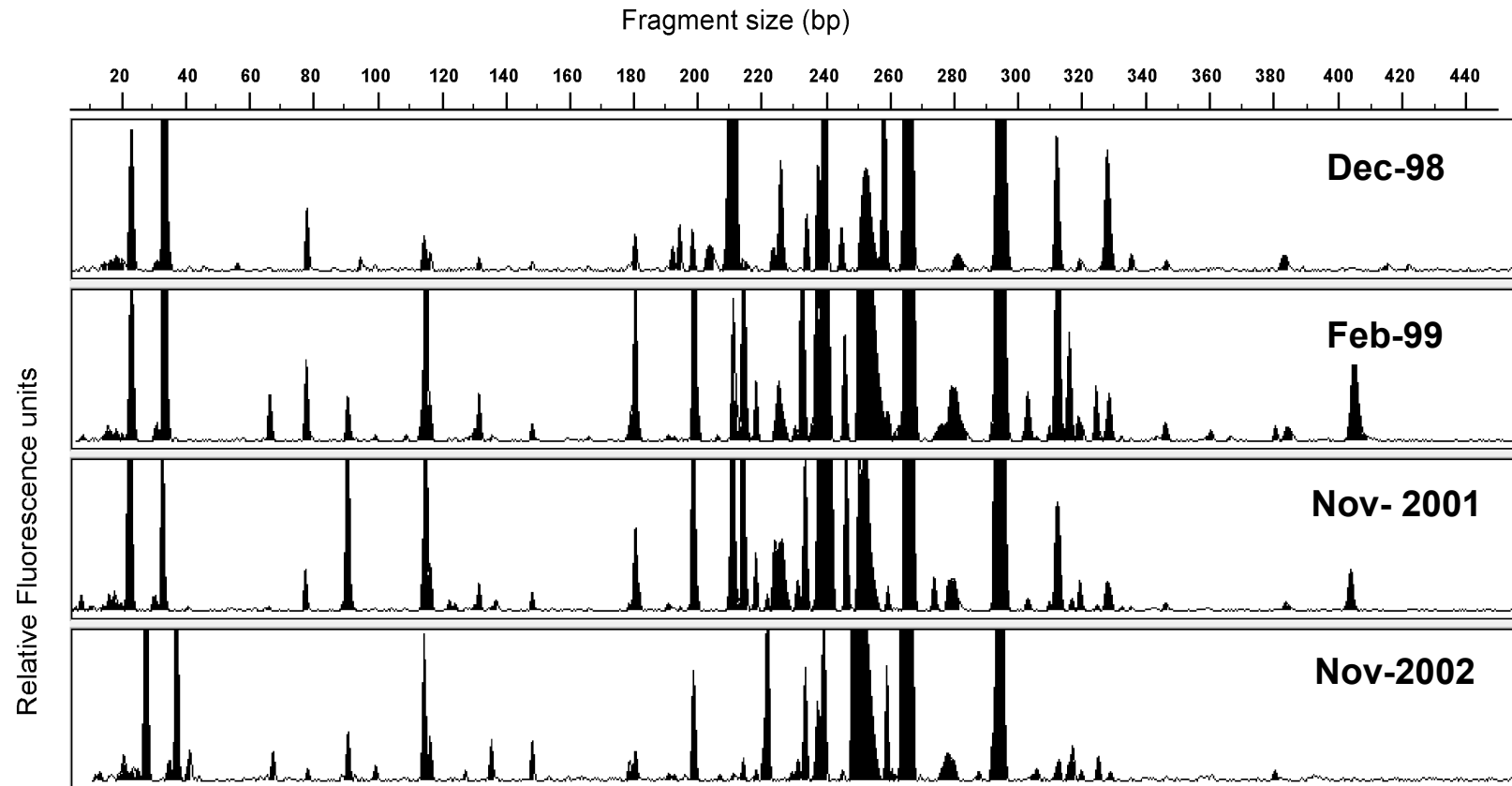
Population has stabilized.

7 taxa closely-related to *Desulfotomaculum* and deeply-branched *Firmicutes*.

Bacterial 16S rDNA clone distribution



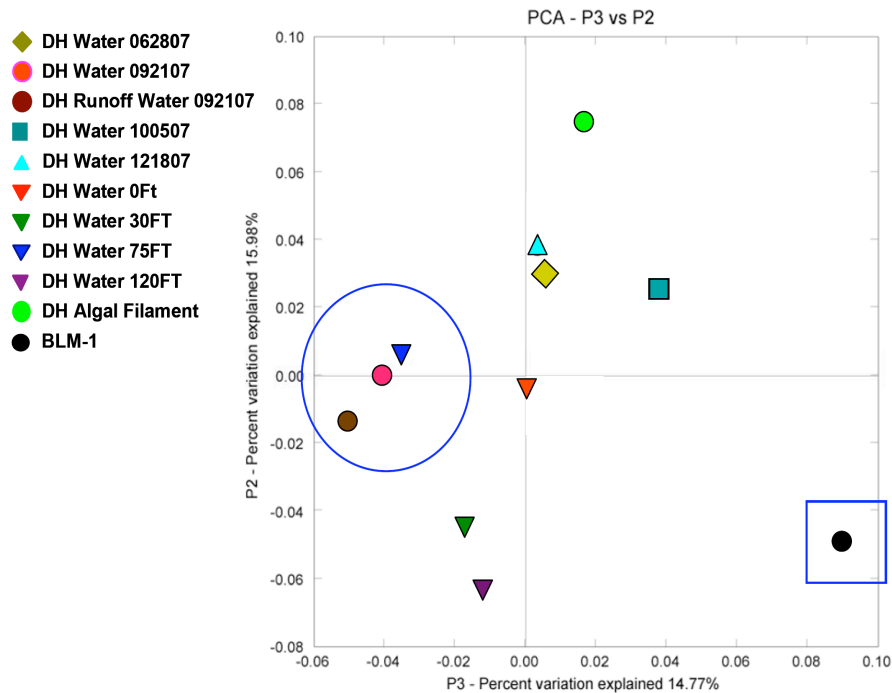
Stable Populations = Indigenous?



Microorganisms as Tracers?



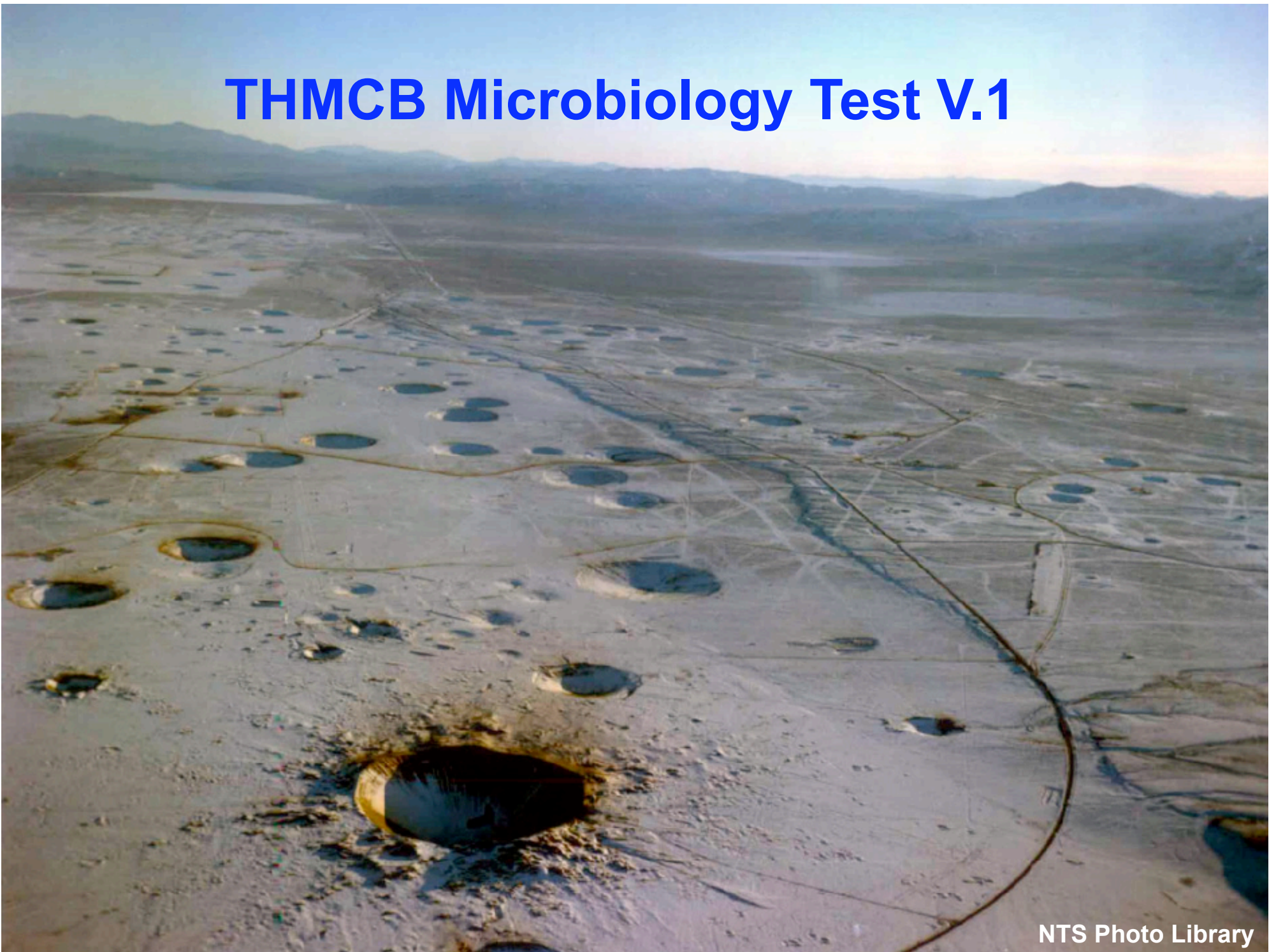
Microorganisms as Tracers?



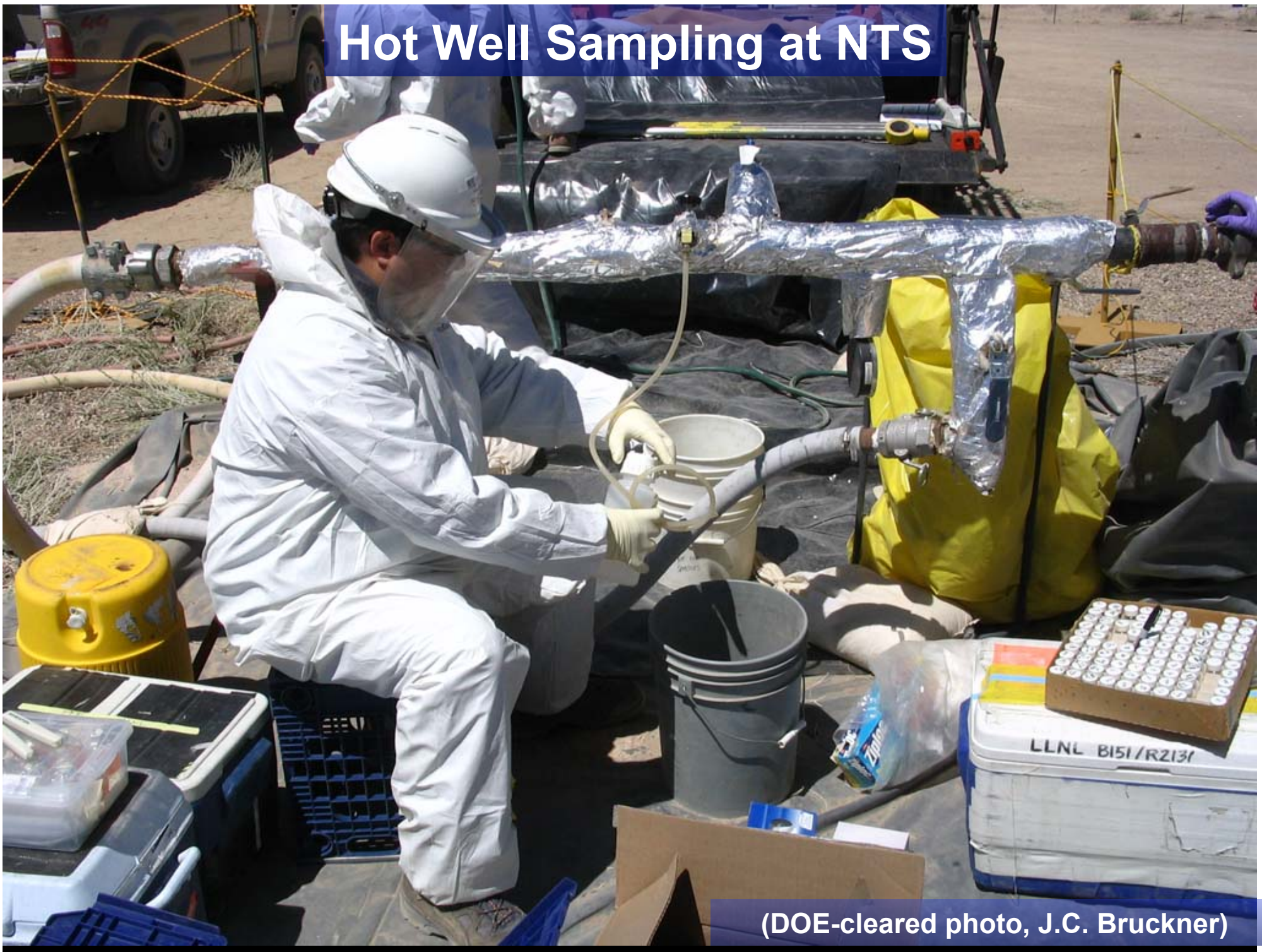
- Fast flow path from surface
 - *Seasonal pulse*
 - *Tailings pond*
- Mine water between levels
- Expulsion of flood water during dewatering
- Zones of subsurface infiltration in water column of 6 shaft

Data from J.C. Bruckner, DRI

THMCB Microbiology Test V.1



Hot Well Sampling at NTS



(DOE-cleared photo, J.C. Bruckner)

Conclusions

- Existing holes are a huge opportunity
- Careful thought needs to go into development of new holes and hole-associated infrastructure
- BioGeo sciences at DUSEL will allow exploration of a major largely unaddressed terrestrial rock type

Ultimate goal is a multi-decadal resource, unique in the world, enabling subsurface biogeochemical investigations from surface to lower biosphere limit