Multidisciplinary Microbiology Activities

at

URLs (Underground Research Laboratories)

and

SURF (Sanford Underground Research Facility)

Joseph S.Y. Wang, Berkeley, CA

DURA, Palo Alto, CA, March 5, 2013

Two Updates

- **ISRM (International Society for Rock Mechanics) Commission on URL Networking among**

  Physics Deep Labs, e.g., ApEPC (Astropazrticle Physics European Consortium

  Rad. Waste URLs, e.g., IAEA (Int'l Atomic Energy Agency) Network

  Borehole Complexes URLs, e.g., AGU (Am. Geophysical Union), ARMA (Am. Rock Mechanics Association), ISRM, …. Meetings

  with Focus on Large/Deep Excavations, Damaged/Disturbed Zones along Drifts, Stimulation/Barrier associated with Withdrawal /Injection of Energy Resource Recovery/Environmental Disposal Issues

- **DCO (Deep Carbon Observatory), C-DEBI (Center for Dark Energy Biosphere Investigations), NASA (Nat. Aeronautics and Space Agency)**

  Astrobiology on Deep Life Search

  Evolution and Biodiversity

Commissioners and URLs

Joseph S.Y. Wang, Berkeley

John A. Hudson, IC – ISRM President 2007-2011, DECOVALEX2015 (4 URLs)

Gilles Armand, ANDRA - Haute-Marne

Alessandro Bettini, U. Padua – LSC (LNGS)

Paul Bossart, Swisstopo - Mont Terri

Rolf Christiansson, SKB - Äspö HRL

Maurice Dusseault, U. Waterloo - Slurry Injection

Derek Elsworth, PSU – SURF

Yves Guglielmi, Aix Marseille U. - LSBB (HPPP)

Peter K. Kaiser, Laurentian U./CEMI - SNO, nDMO

Kimmo Kemppianen, Posiva - ONKALA

Chris Laughton, Samsung - Fermi LBNE

Shaojun Li, IRSM - CJPL

Xiangling Li, EURIDICE - HADES

Azra Tutuncu, CSM/UNGI – Unconventional Gas/Oil Production

Xia-Ting Feng (ex officio), ISRM President, IRSM

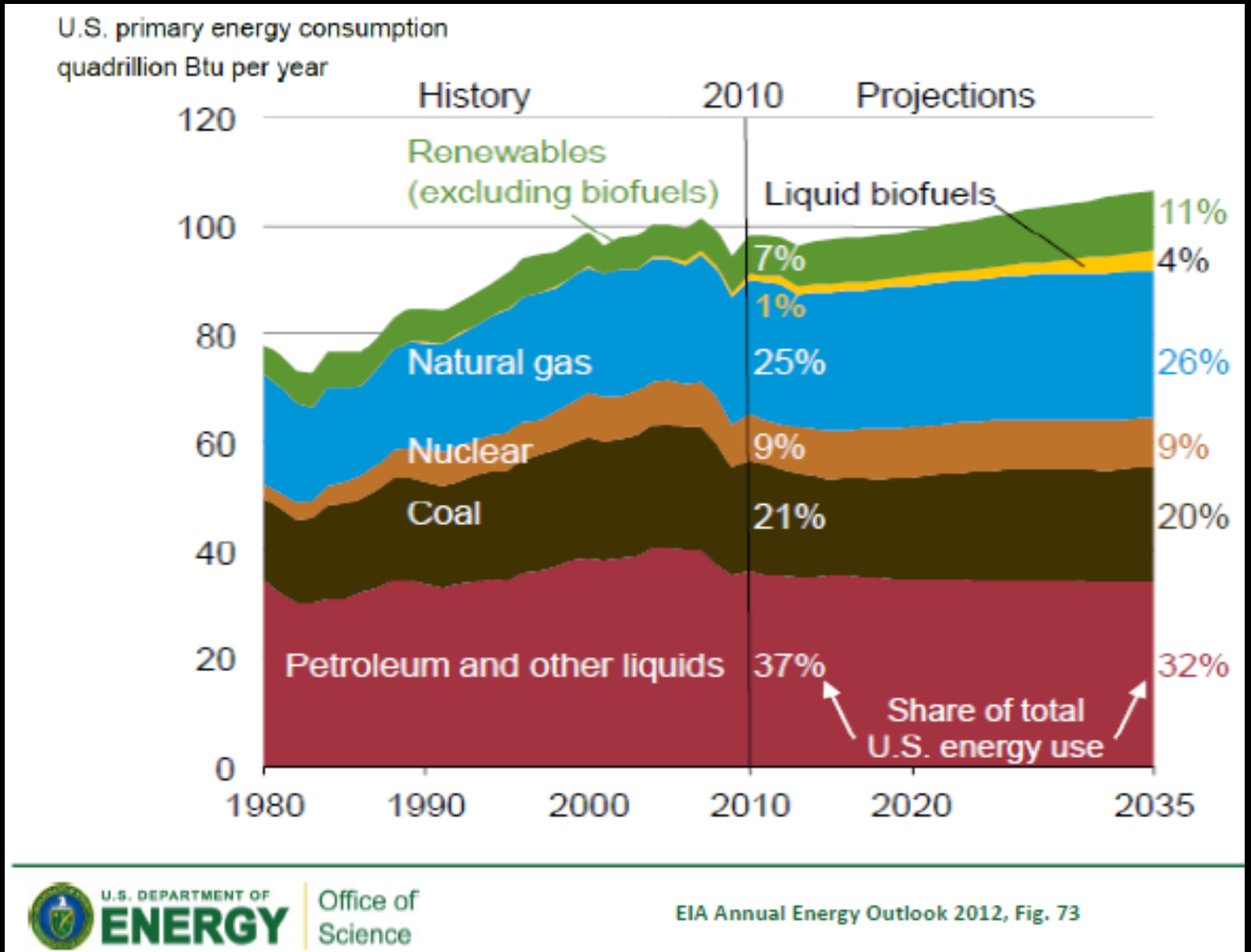
John Tinucci (ex officio), ISRM VP North America, SRK

DEDC/DURA Chair 2010
Derek Elsworth

Some AGU Sessions/Speakers, Dec 2012

- Fluid Dynamics: **SP Neuman**, Arizona U.; **RW Zimmerman**, Imperial College; **LJ Pyrak-Nolte**, Purdue; **D. DePaolo**, UCB; (and JSY Wang, Berkeley, on fracture flow & URLs)
- Energy and Resource Recovery: **WF Brinkman**, DOE Office of Science, **M McNutt**, USGS, **J Ehle**, NRC Research, **M Zoback**, Stanford, **M Hitzman**, Colorado School of Mines, **J Tester**, Cornell , **Sid J Green**, Schlumberger + **Panel**
- URLs: **B Sherwood Lollar**, Toronto, **Y Guglielmi**, Axi-Marseille, **C Nussbaum**, Mont Terri, **D Vardiman**, SURF, HF Wang, Wisconsin, AJ Martin, NAGRA, R Geise, Reiche Zeche, T Mizuno, Horonobe, …
- Biology: **DP Moser**, Desert Research Institute, + 3 Invited Lectures
- Natural Hazards & Earthquakes: (8 Lectures)

History/Projection of Renewables, Biomass, Natural Gas, Coal, Petroleum/Other Liquids (WF Brinkman 2012 AGU)



Example of Petroleum Development and Environmental Concern (M McNutt 2012 AGU)

Life in Inner Space:
Subsurface Microbiology in Deep Mines and URLs

B. Sherwood Lollar, U. Toronto

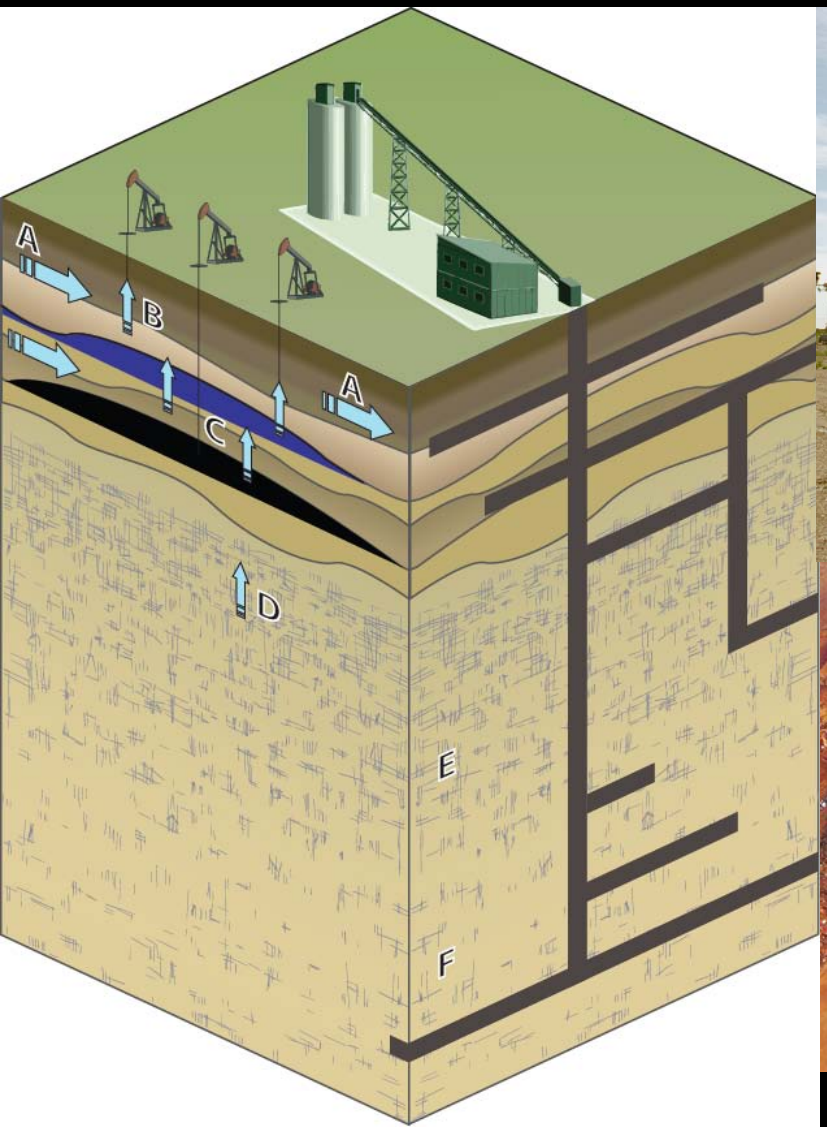
T.C. Onstott, Princeton U.

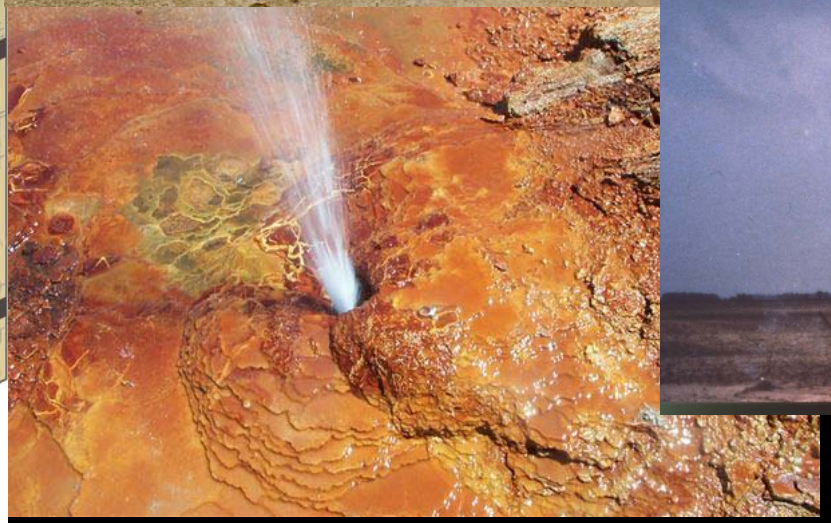
C.J. Ballentine, Manchester, UK

E. van Heerden, Univ. of Free State, SA

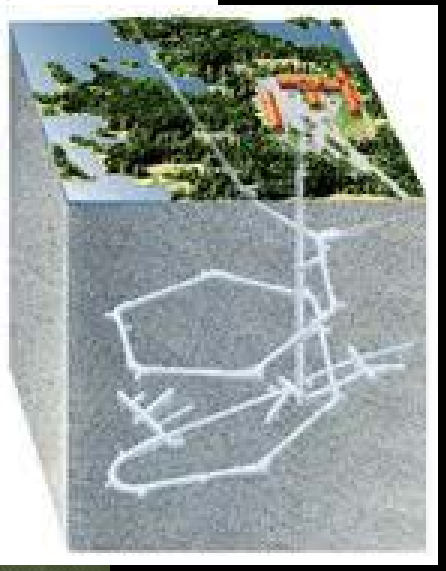
T. Kieft, New Mexico Tech

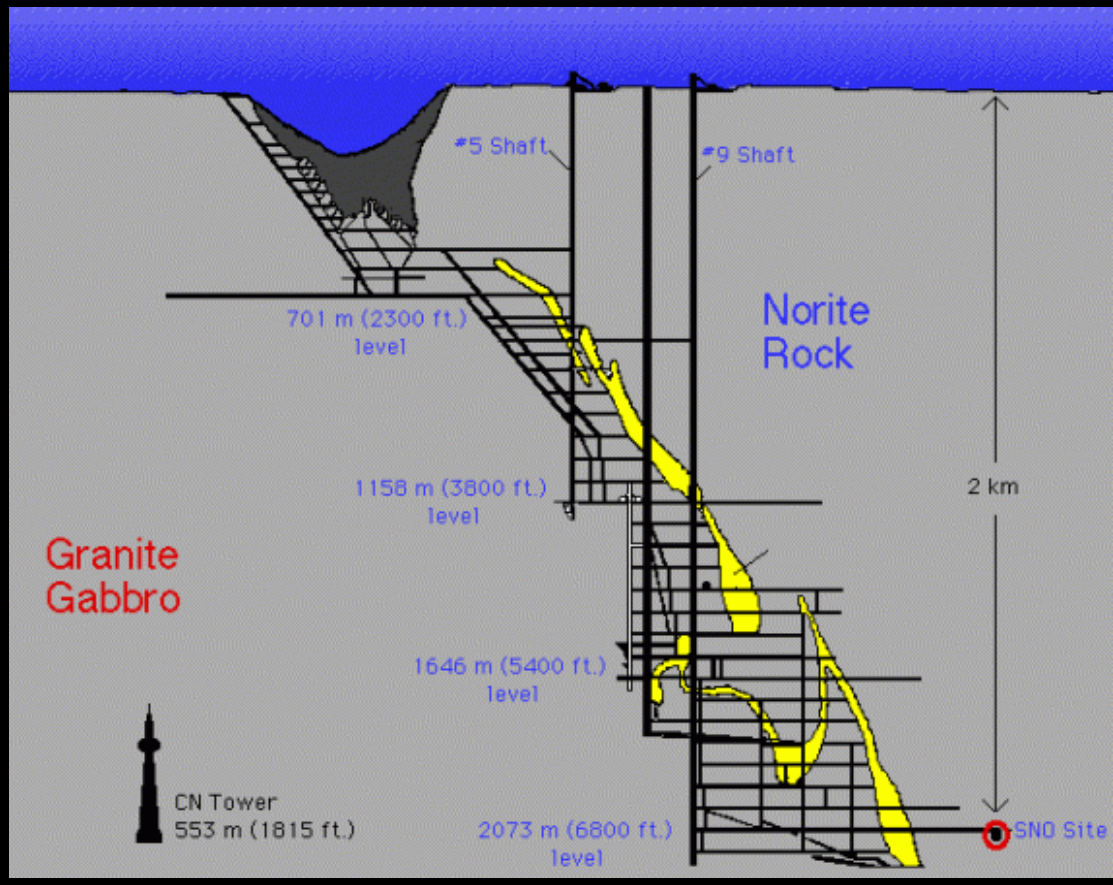
Subsurface life exists beyond the deep hot biosphere …





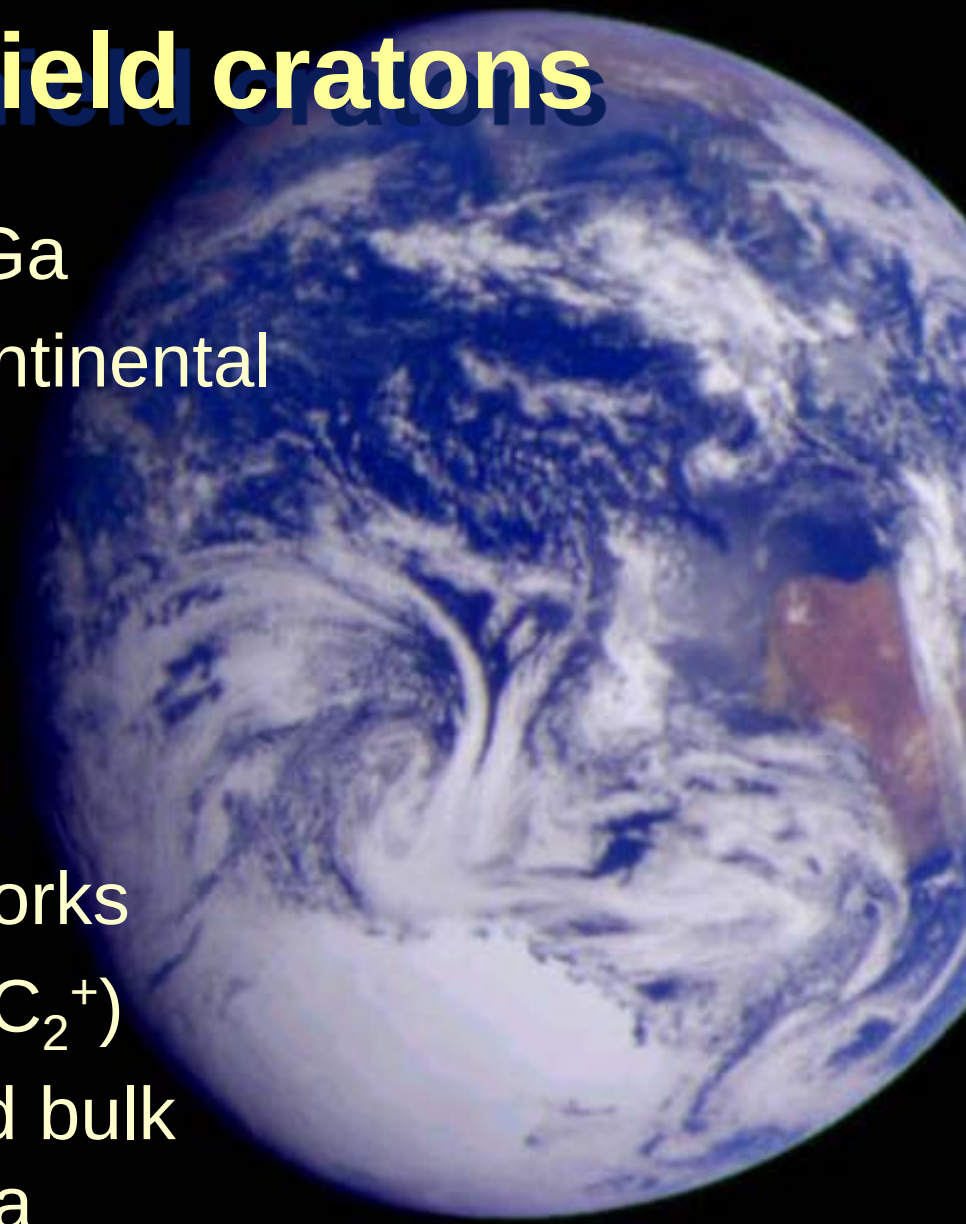
International Underground Research Labs





SNOLab, Sudbury Ontario, Canada

Precambrian Shield cratons



- Oldest rocks on Earth at > 2-3 Ga
- Tectonically quiescent “cool” continental
- Dominated by lower T crustal water-rock interactions (WRI)
- Saline fracture waters where products of WRI accumulate in hydrogeologically isolated networks
- Dissolved gases (mM H_2, CH_4, C_2^+)
- Radiogenic noble gases derived bulk residence times up to tens of Ma

Barbara Sherwood Lollar

University Professor, F.R.S.C.

University of Toronto
Department of Earth Sciences

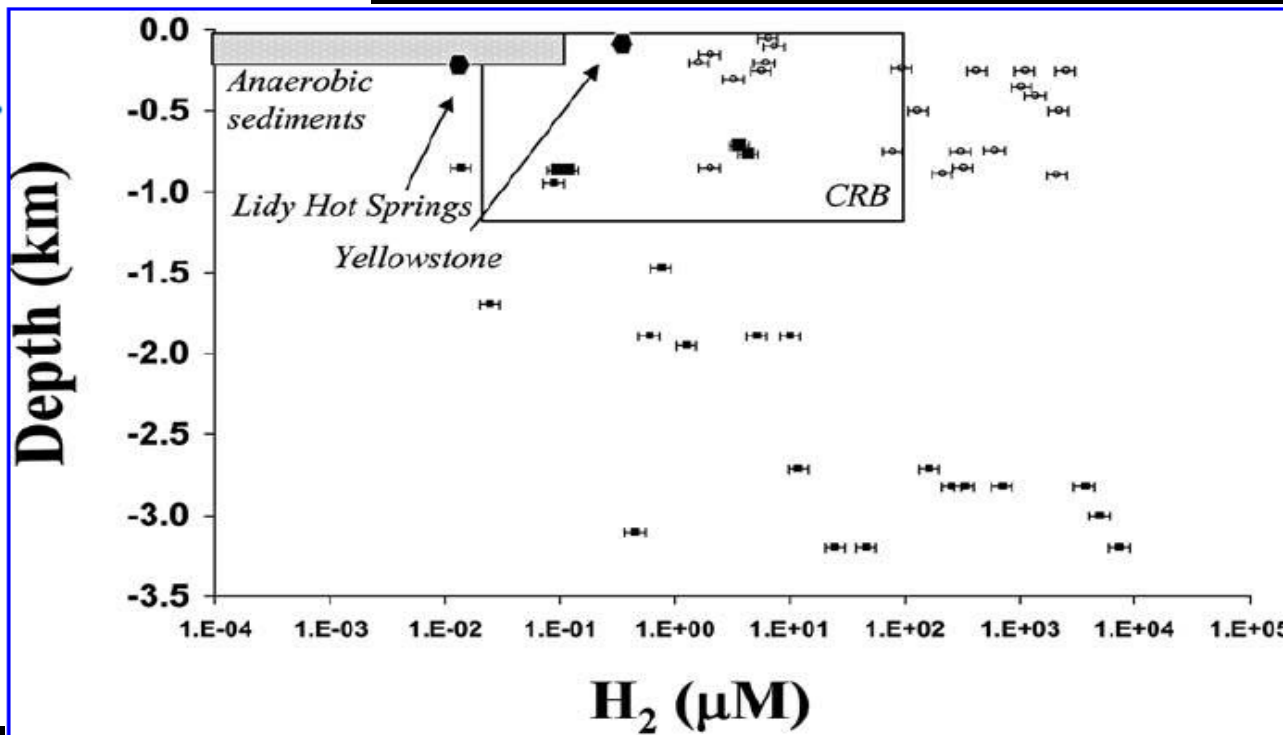
22 Russell Str., Toronto
Ontario, Canada M5S 3B1

Tel.: 416 978 0770
Fax.: 416 978 3839
e-mail: bslollar@chem.utoronto.ca

Lin et al. (2006) *Science*:
South Africa

Sherwood Lollar et al. (2007) *Astrobiology*:
Canadian Shield, Finland

Sherwood Lollar (2012 *AGU*, *& to be published*):



Tullis Onstott

Department/Program(s):
Geosciences

Position: Active Faculty

Title: Professor of Geosciences.

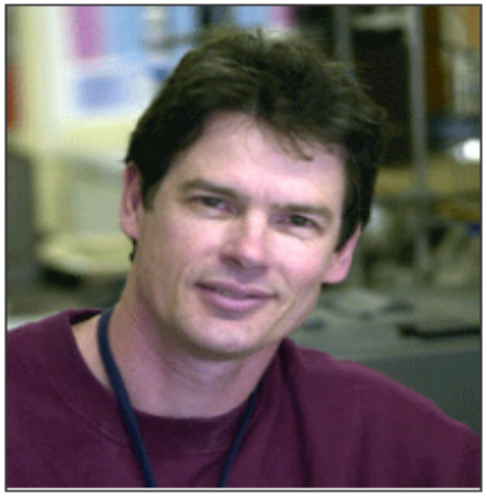
Area(s):
Geobiology

Office: B79 Guyot Hall

Phone: 609-258-7678

Email: tullis@princeton.edu

Homepage: onstott



IPTAI: Arctic permafrost, Mars analog

NELSAM: 3.8 km SA URL

LExEn: South Africa mines

DEDC/DURA: DUSEL

The TIME 100

Here's our list of the 100 men and women whose power, talent or moral example is transforming the world.

Like 415 Tweet 1 12 Share 3

SCIENTISTS & THINKERS

70 of 101
VIEW ALL

Tullis Onstott

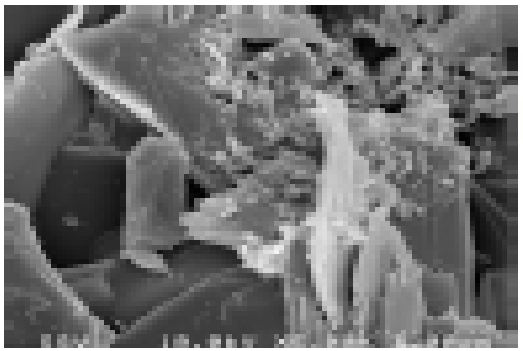
By Carolyn Sayre | Thursday, May 03, 2007

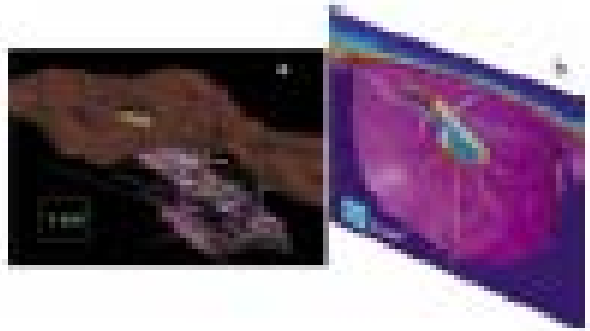
Wondering whether extraterrestrial life exists? Tullis Onstott, 53, has found it—sort of. The fact that the living things he's discovered make their homes nearly two miles below the earth's surface may disqualify them from the extra part of extraterrestrial. But d[illegible]nd fly them off, and there's no [illegible]ight survive. That's the be[illegible]sor of geosciences at Pr[illegible] we collect living aliens, he's showing us they're probably there to be found. Scientists once despaired of discovering even simple otherworldly organisms because they assumed that all life should be like earthly life—built around warmth, light and liquid water. In recent years, however, biology has shown itself to be tougher than that. Investigators have discovered organisms—simple ones—frozen in polar ice and thriving in scalding ocean vents.

Experts have investigated less thoroughly the regions deep within the earth—places where living things could establish a safe redoubt. Uncover such critters on Earth, and you would prove that they might exist elsewhere too. Last year Onstott

BRIAN FINKE / LEVINE AND LEAVITT FOR TIME

Tullis Onstott





Onstott et al (2009) *Microbe*, New Horizon

Thomas L. Kieft

Professor of Biology
New Mexico Tech
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Phone: (575) 835-5321
FAX: (575) 835-5668
E-mail: tkieft@nmt.edu

The Witwatersrand Deep Microbiology Project

from Tullis Onstatt's web site

Dr. Duane P. Moser: Professional Qualifications/CV

Title: Associate Research Professor
Affiliation: Division of Earth and Ecosystem Sciences
Location: DRI Las Vegas
Email: Duane.Moser@dri.edu
Phone: 702.862.5534

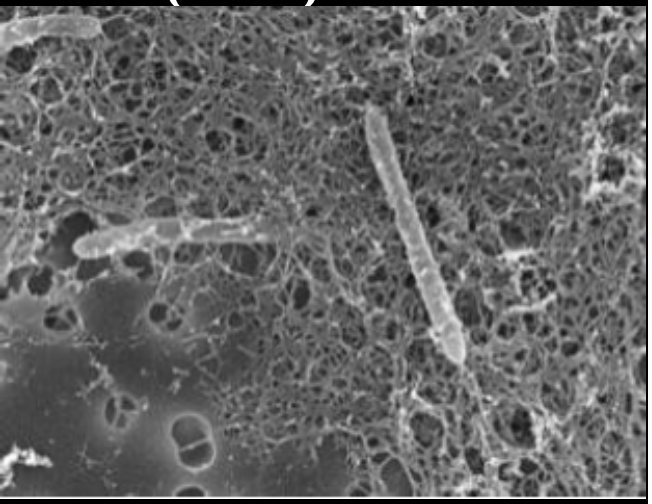
Duane Moser

Great Basin U.S.: NV, CA, SD, ...
NTS, Death Valley. Truckee, …

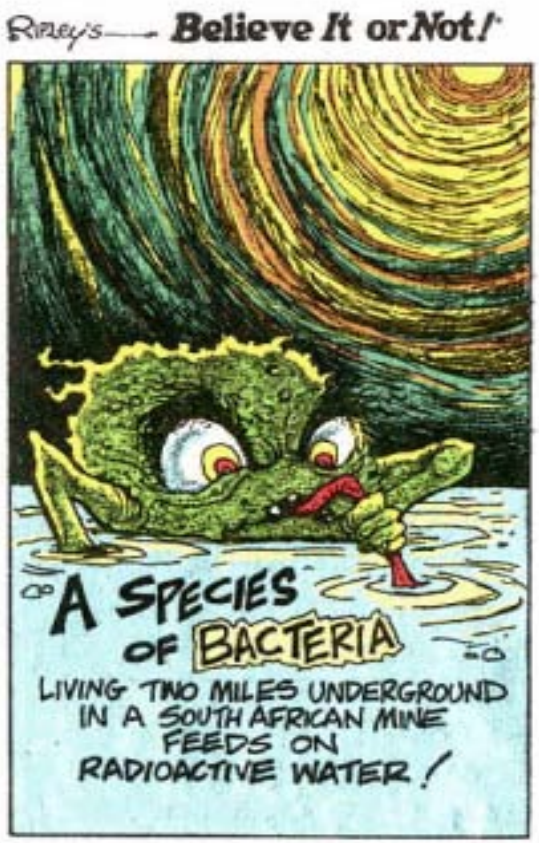
DCO -
Census of Deep Life
NASA Astrobiology -
Life Underground (including SURF)

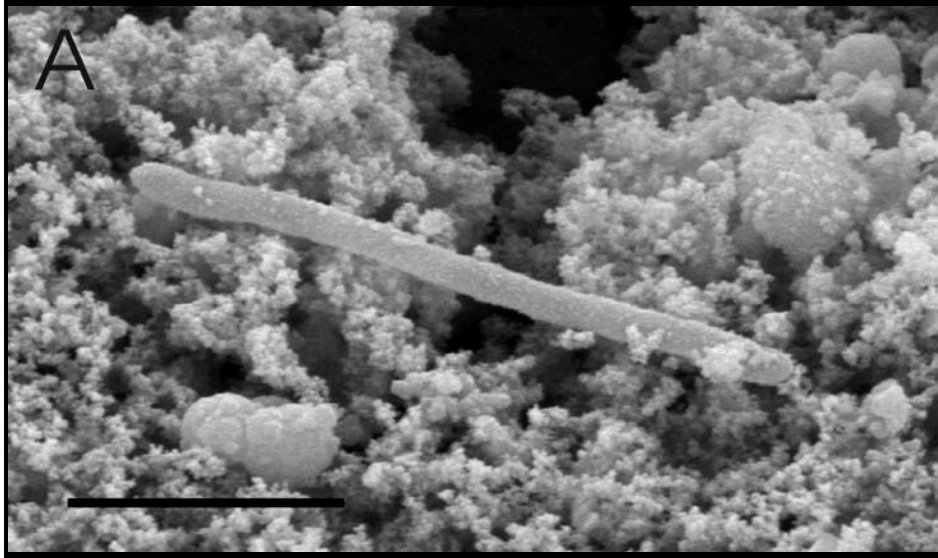
DURA (2012)
Biology at SURF =>

AGU (2012) B31F-08:



> 99% certainty





Desulforudis audaxviator

Chivian, D., E.J. Alm, E.L. Brodie, et al., Science, 2008.
TC Onstott, Tom Kieft, Jim Fredrickson, Fred Brockman

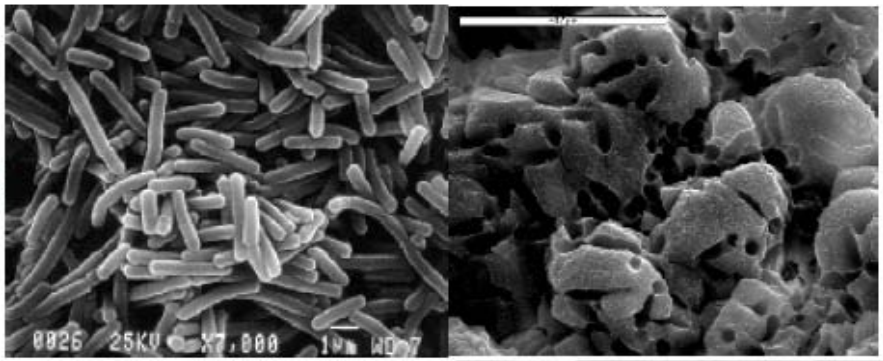
Sookie S. Bang

Professor of Microbiology, Ph.D.

Department of Chemical and Biological Engineering

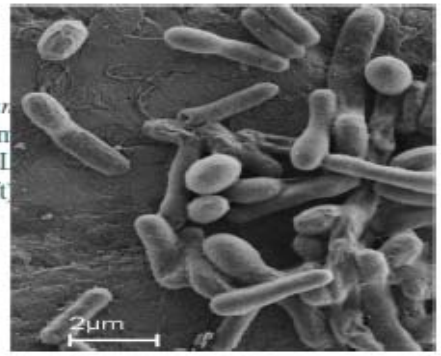
South Dakota School of Mines and Technology

Email: sookie.bang@sdsmt.edu

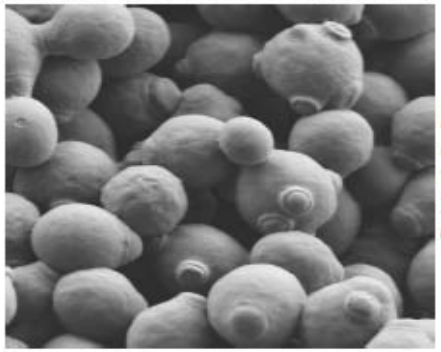


Sporosarcina pasteurii

S. pasteurii-induced calcite precipitation



Geobacillus tibetar G6 isolated from Homestake DUSEL (4,850 ft)



Saccharomyces cerevisiae used for cloning lignocellulolytic enzyme genes

Welcome to Microbiology at the South Dakota School of Mines and Technology.

Bang & Anderson (2010) South Dakota Academy: microbes in Homestake

Meyer et al. (2011) Geo-Frontier: microbiological-induced soil stabilization

Bang, Anderson, Moser (2012) DURA: physical , chemical variables; gas, isotope data; 4B sequence distributions of Homestake water, mud samples

Rajesh K.Sani

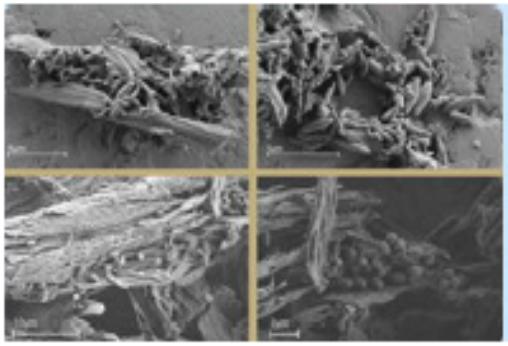
tant Professor of Biology (Industrial Microbiologist & Environmental Biotechnologist)
rtment of Chemical and Biological Engineering
il : rajesh.sani@sdsmt.edu

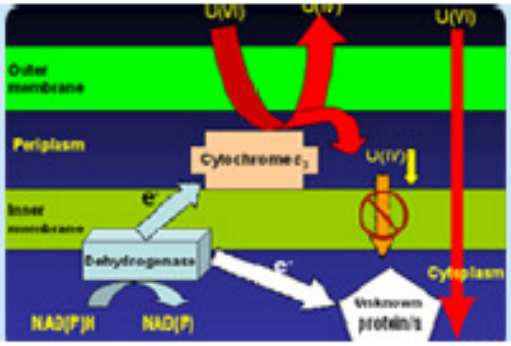
Research Focus

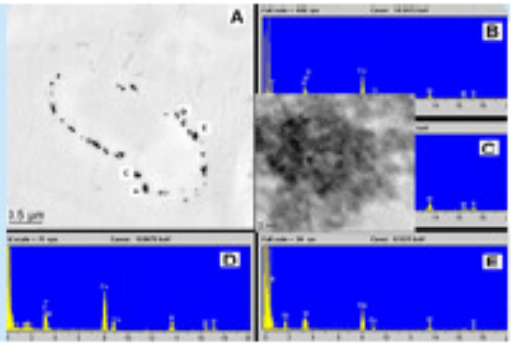
- Extremophilic bioprocessing of lignocellulose-based renewables for biofuels and bioproducts
- Biospecting of extremophilic microorganisms for developing more efficient and cost-effective biofuel production technologies
- In situ and ex situ biocatalyzed heavy metal transformations

Teaching Focus

- Integration of Engineering Sciences with Biological Science

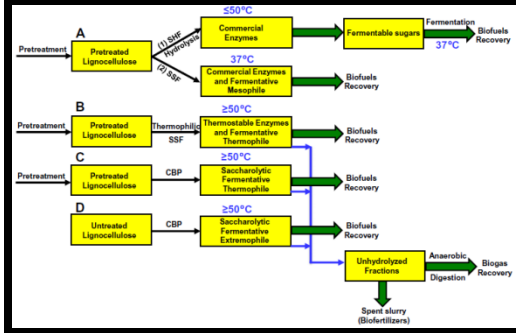






Bhalla et al (2013)
Bioresource Tech:
biofuels

Rastogi et al (2013
Frontier in Micro
-biology:
ethonol and
1,3-propanediol



Black Hills State University

- Cynthia Anderson, Ph.D.
- SD BRIN Programs Coordinator
- Cynthia.Anderson@bhsu.edu

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History

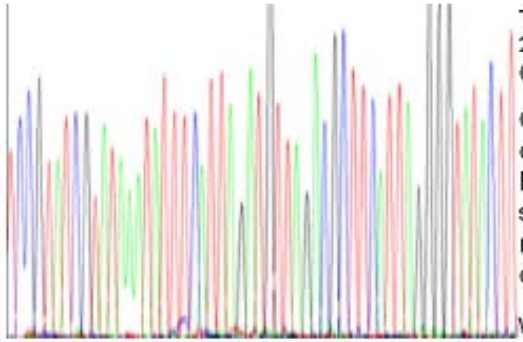
WestCore Mission statement

ccbrxxx
center for the conservation of biological resources

WestCore
western south dakota dna core facility

About Us | History

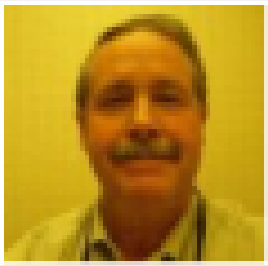
WestCore History



The Western South Dakota DNA Core Facility (WestCore) was established in 2003 as part of the South Dakota Biomedical Research Infrastructure Network (SD-BRIN). We complement the Proteomics and Genomics BRIN core facilities.

Our primary services include DNA sequencing, genotyping, marker developing, library construction, Wildlife Forensic Testing and Bison testing. Priority is given to SD-BRIN/INBRE research, but services are also provided to non-BRIN/INBRE university researchers as well as government agencies and some private organizations.

Westcore is a fully staffed laboratory with automated DNA instrumentation, and has a federally approved quality management plan.



David Vardiman

Project Engineer - Excavation Design
Homestake
Lead, South Dakota (Rapid City, South Dakota

REQUEST FOR PROPOSAL
Architectural and Engineering Services for
Excavation Design and Site Investigation
South Dakota Science and Technology Authority Support of the
Long Baseline Neutrino Experiment Far Site Conventional Facilities Project
SDSTA Contract # 2013-01
December 3, 2012

Residents say lab could be bigger than Homestake

David Vardiman of the DUSEL team answers questions about the underground underground laboratory. Pioneer photo by Wendy Pitlick

Black Hills Pioneer

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Sanford Lab Geotechnical Site Investigations

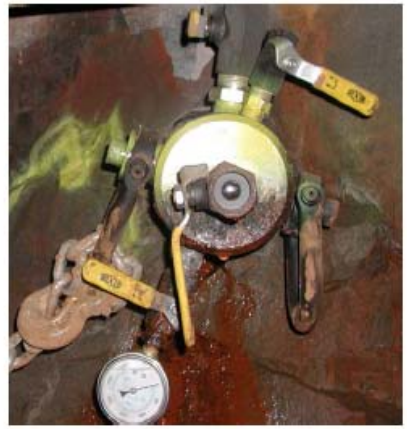
David Vardiman – SDSTA Project Engineer
Geotechnical and Excavation

December 7, 2012

Groundwater Monitoring

- Initial inflow <1 L/min
- Declined over time
- Geochemical sampling

Pressure Monitoring
1100 psi



David F. Boutt

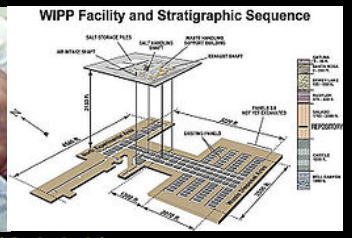
Associate Professor, Hydrogeology

Department of Geosciences, UMass-Amherst

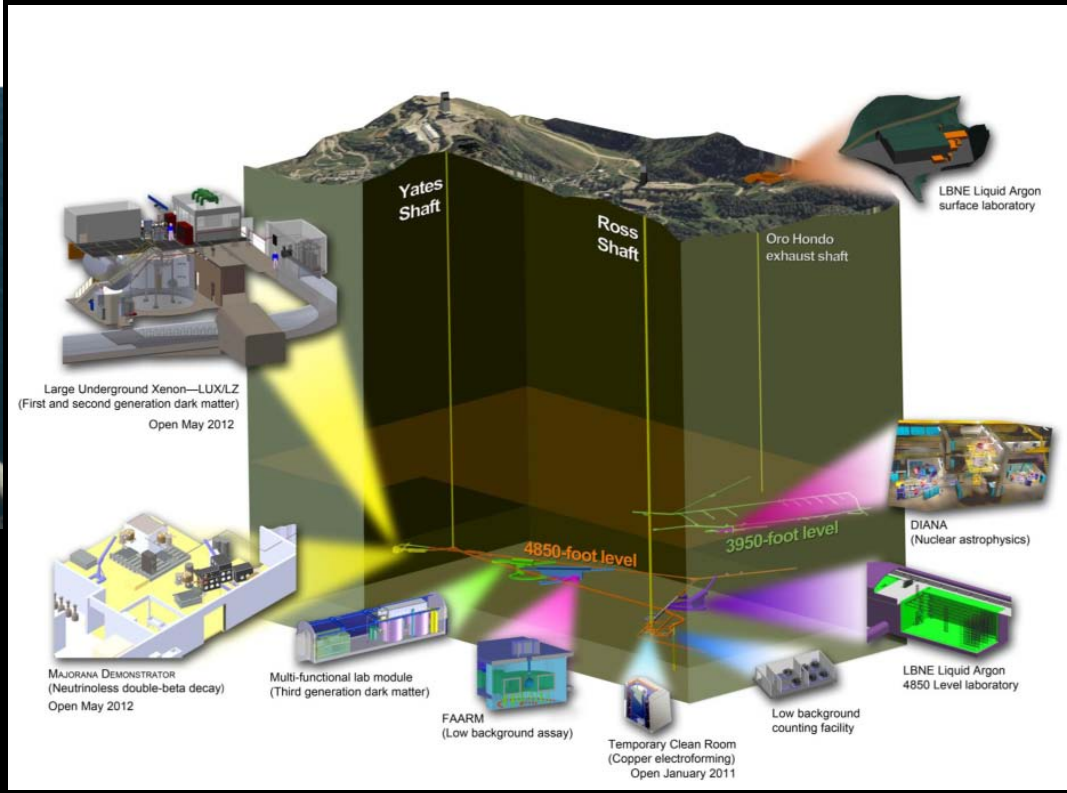
B.S., Env. Geosciences, Michigan State University, 1997

M.S., Hydrogeology, Michigan State University, 1999

Ph.D., Hydrology, New Mexico Institute of Mining and Technology, 2004

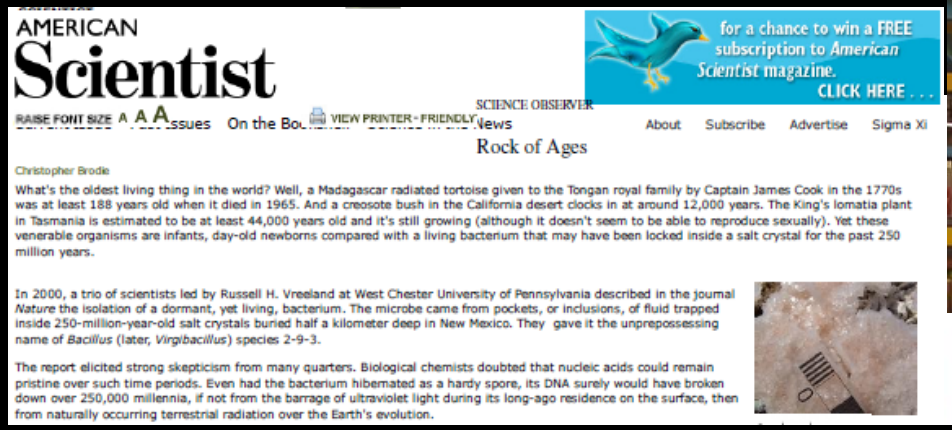


Site Visits to SURF and Soudan



Also Vreeland et al (2000) *Nature:*

WIPP salt inclusion, 250 Ma bacteria



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Rock of Ages

Christopher Brodie

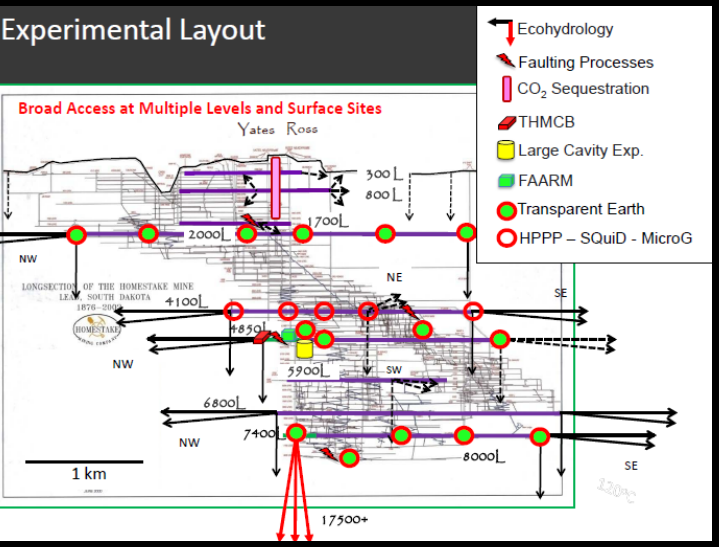
What's the oldest living thing in the world? Well, a Madagascar radiated tortoise given to the Tongan royal family by Captain James Cook in the 1770s was at least 188 years old when it died in 1965. And a creosote bush in the California desert clocks in at around 12,000 years. The King's lomatia plant in Tasmania is estimated to be at least 44,000 years old and it's still growing (although it doesn't seem to be able to reproduce sexually). Yet these venerable organisms are infants, day-old newborns compared with a living bacterium that may have been locked inside a salt crystal for the past 250 million years.

In 2000, a trio of scientists led by Russell H. Vreeland at West Chester University of Pennsylvania described in the journal *Nature* the isolation of a dormant, yet living, bacterium. The microbe came from pockets, or inclusions, of fluid trapped inside 250-million-year-old salt crystals buried half a kilometer deep in New Mexico. They gave it the unprepossessing name of *Bacillus* (later, *Virgibacillus*) species 2-9-3.

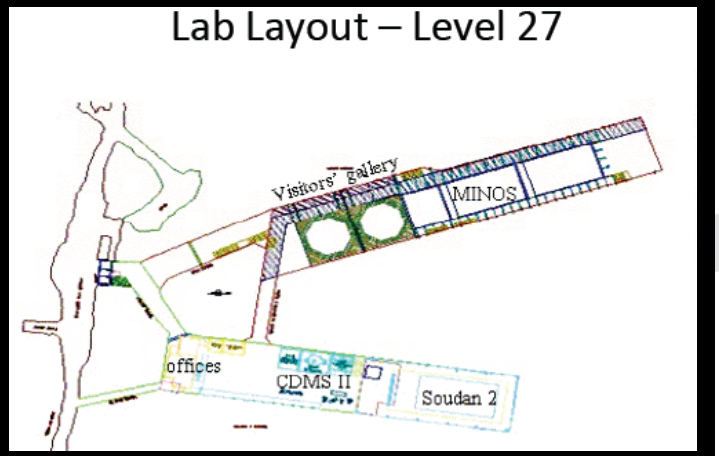
The report elicited strong skepticism from many quarters. Biological chemists doubted that nucleic acids could remain pristine over such time periods. Even had the bacterium hibernated as a hardy spore, its DNA surely would have broken down over 250,000 millennia, if not from the barrage of ultraviolet light during its long-ago residence on the surface, then from naturally occurring terrestrial radiation over the Earth's evolution.

The Soudan Underground Laboratory is the leading deep underground science and engineering laboratory in the United States today. Scientists from around the world have been working at Soudan for 25 years trying to answer basic questions about the Universe in which we live: Is matter completely stable? What is the nature of the fundamental forces? Can we identify the Dark Matter that seems to permeate our Universe?

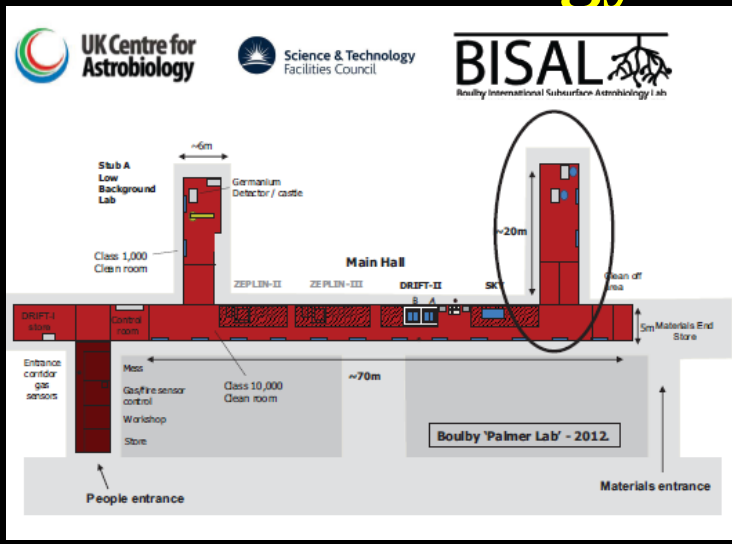
2012 Dec ASPERA-2 on SURF & URLs Microbiology



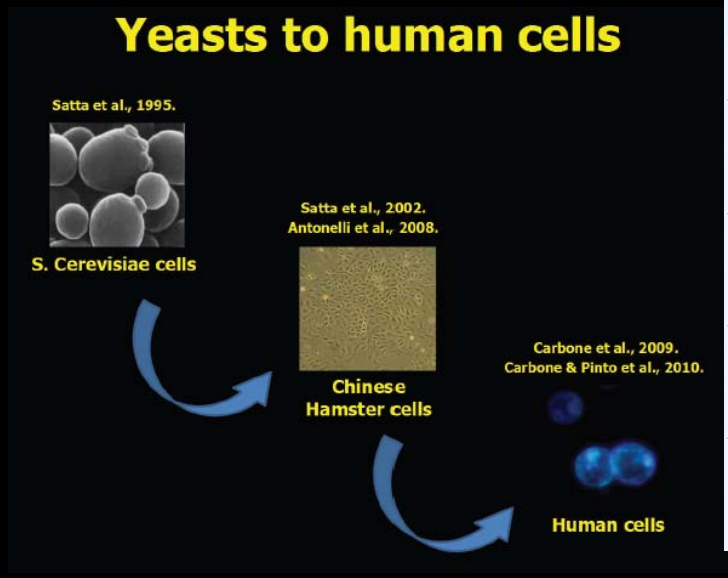
Elsworth et al on SURF BGE



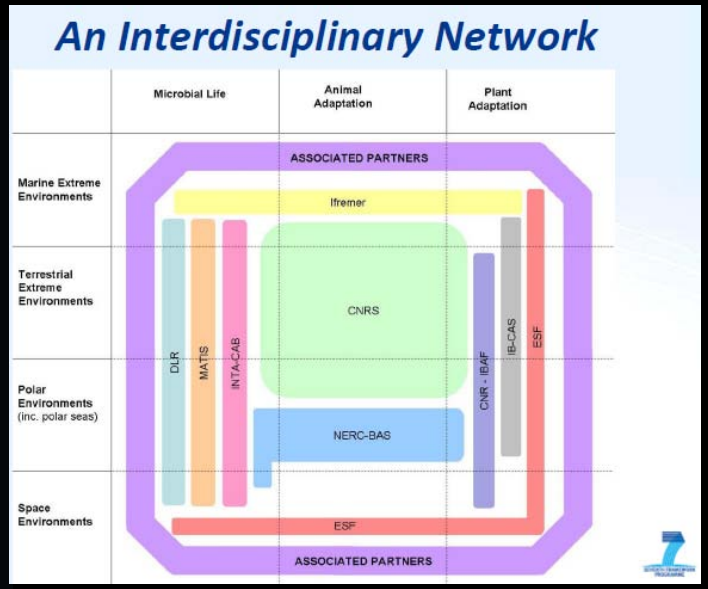
Villano on SOUDAN



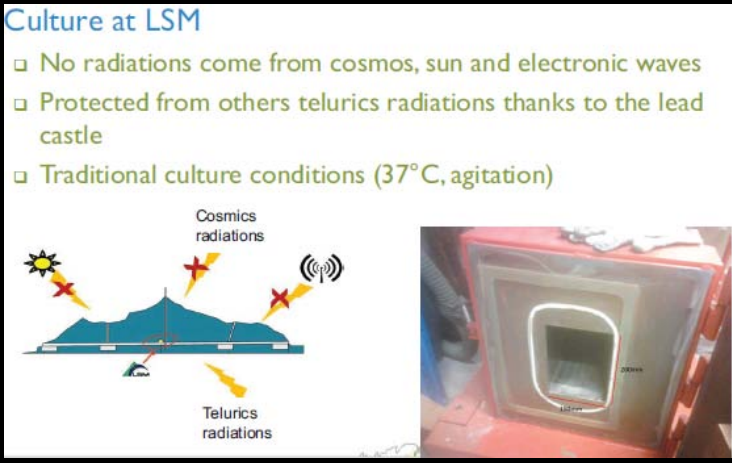
Cockell et al on Boulby BISAL



Fratini on LNGS cells

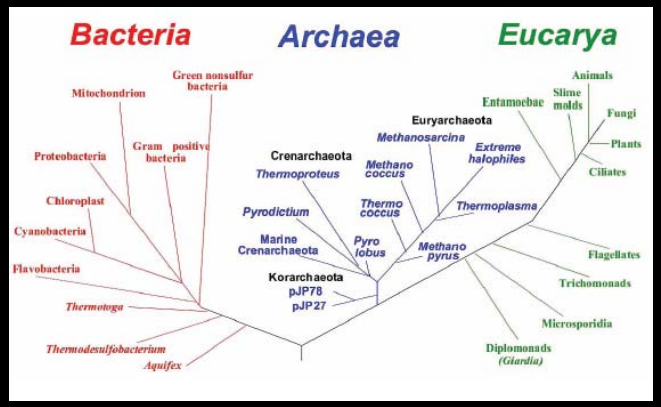


Walker on FP7 CAREX

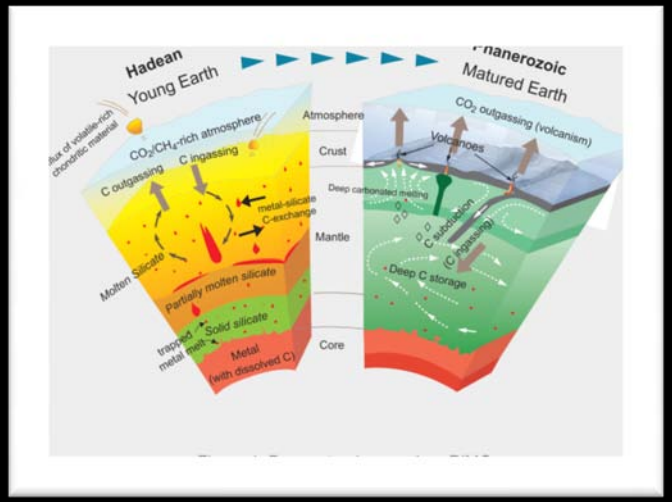


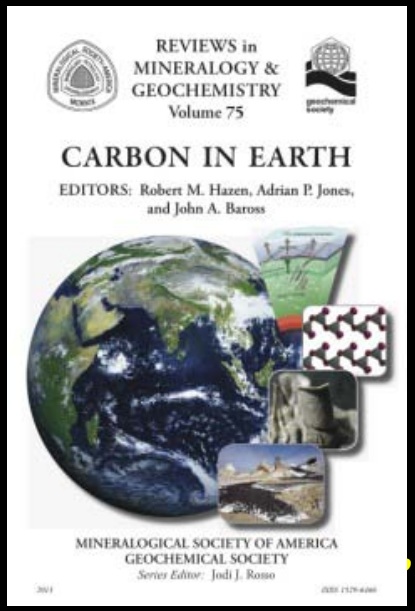
Micheau et al on LSM E Coli

Synopsis



Moser (2009)





DCO Newsletter February 2013

, with E Brodie)

URLs, including SURF, contribute to determination if the total underground biomass rivals the total biomass of all life on the surface; & if life can be sustained without photo- synthesis (i.e., by radiation, hydrogen, sulphur, methane, …).

Evolution & Biodiversity

Acknowledgements: Contributions from Barbara Sherwood Lollar, Duane P Moser, Sajesh K Sani are greatly appreciated. I also take the liberty of adopting the web site, literature search , presentation , and early email information of Cynthia Anderson, Sookie S Bang, David F Boutt , William F Brinkman, Eoin L Brodie, Charles Cockell, Derek Elsworth, Emillano Fratini, Terry Hazen, Tom L Kieft , Xavier Mayali, Marcia K McNutt, Pierre Micheau, Tullis C Onstott. Wendy Pitlick, Nichola Walter, David Varidman, Russel H Vreeland , and Antonny N Villano. Helps from fellow Commissioners are also greatly appreciated.