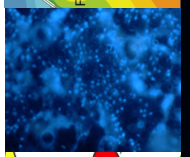
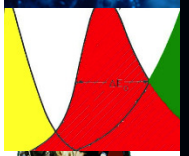
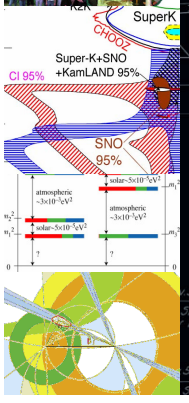
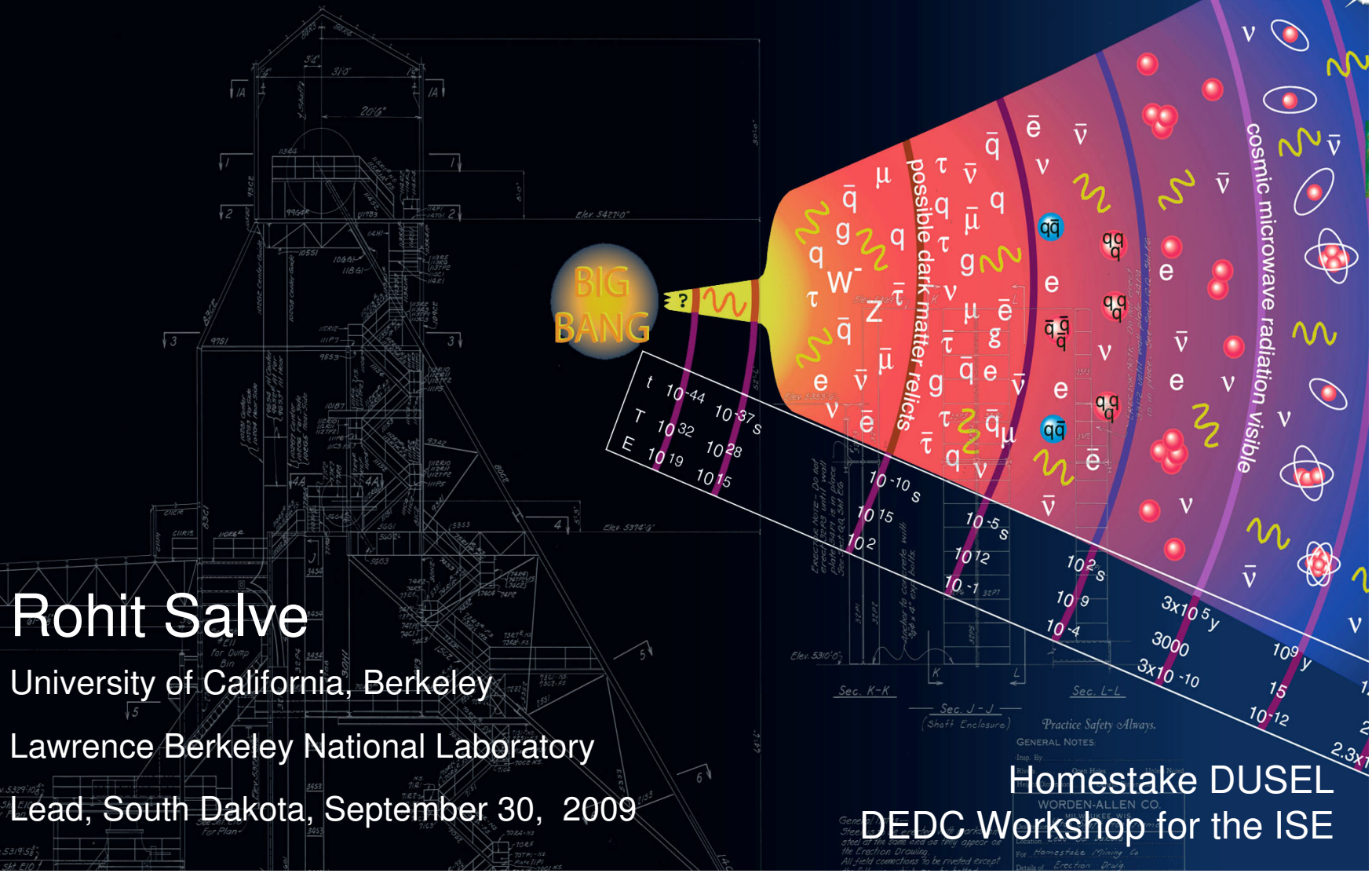
Background Characterization and Monitoring at the Homestake Mine









Rohit Salve

University of California, Berkeley

Lawrence Berkeley National Laboratory

Lead, South Dakota, September 30, 2009

Homestake DUSEL
DEDC Workshop for the ISE

The Need

To maintain a safe working environment, while providing engineers and scientists with fundamental information to enhance the quality and reliability of their activities

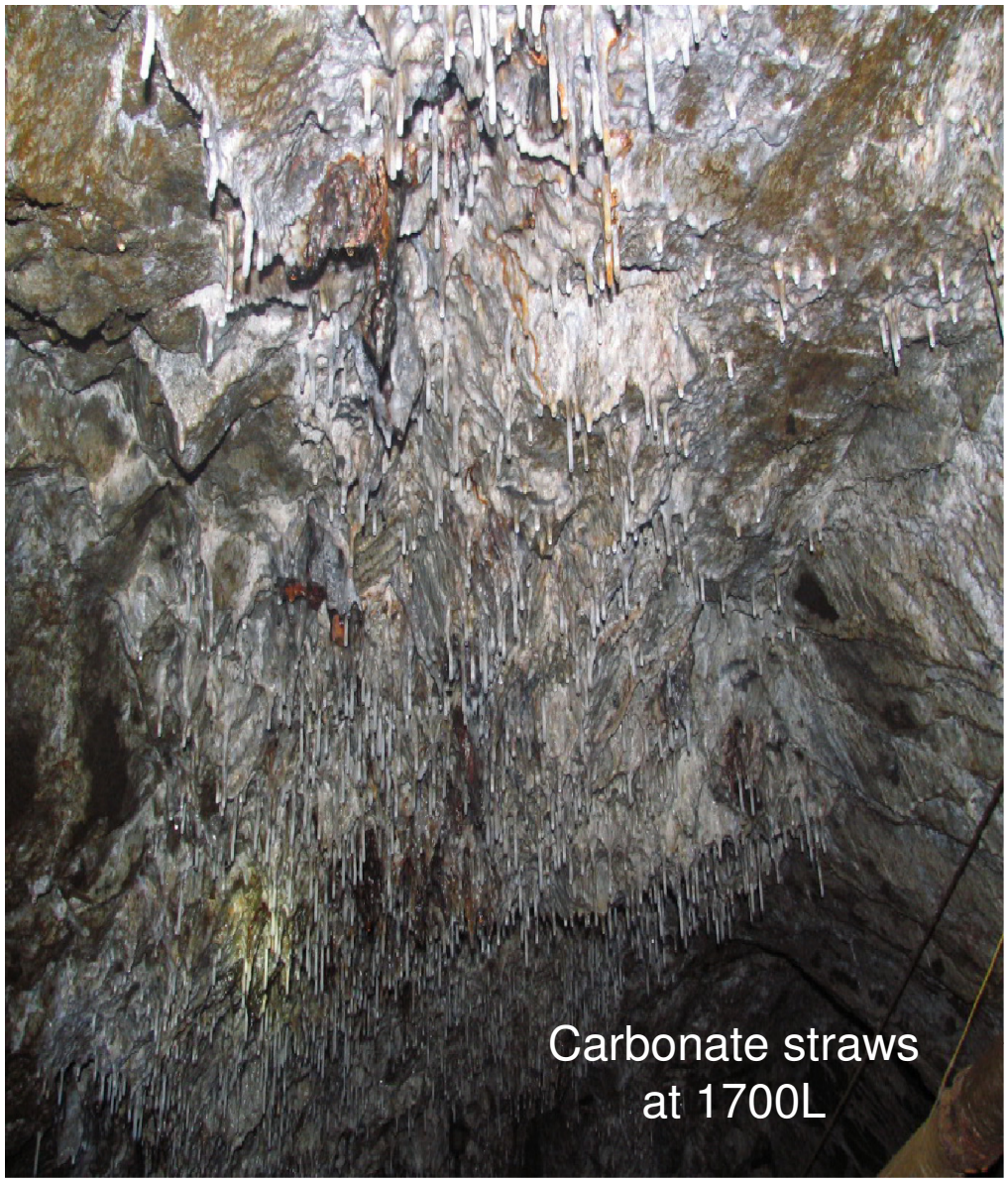
HOMESTAKE

SANFORD UNDERGROUND LABORATORY AT HOMESTAKE

DUSEL

Talk Outline

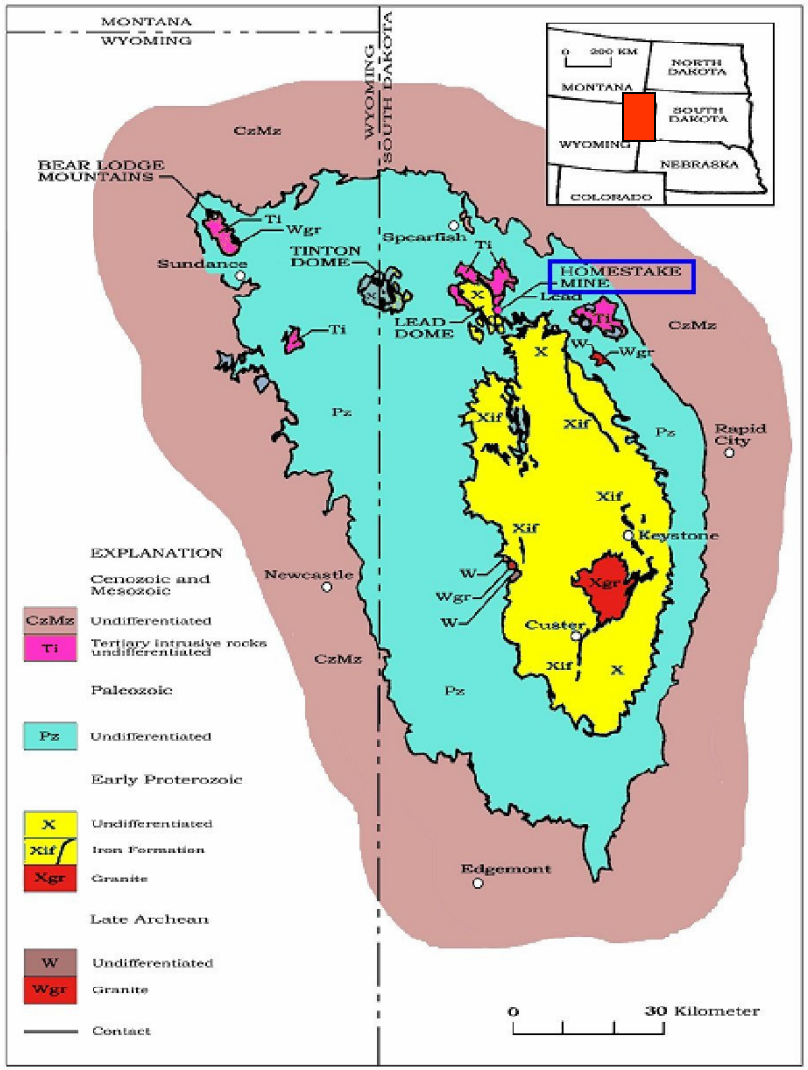
- Geology
- Monitoring and Characterization
  - Radiometric
    - Rock
    - Air
  - Microclimate
    - Temperature
    - Relative Humidity
    - Barometric Pressure
- Resources
  - Vulcan Database
  - Core library
  - 3D-Geology Model



Geology

General

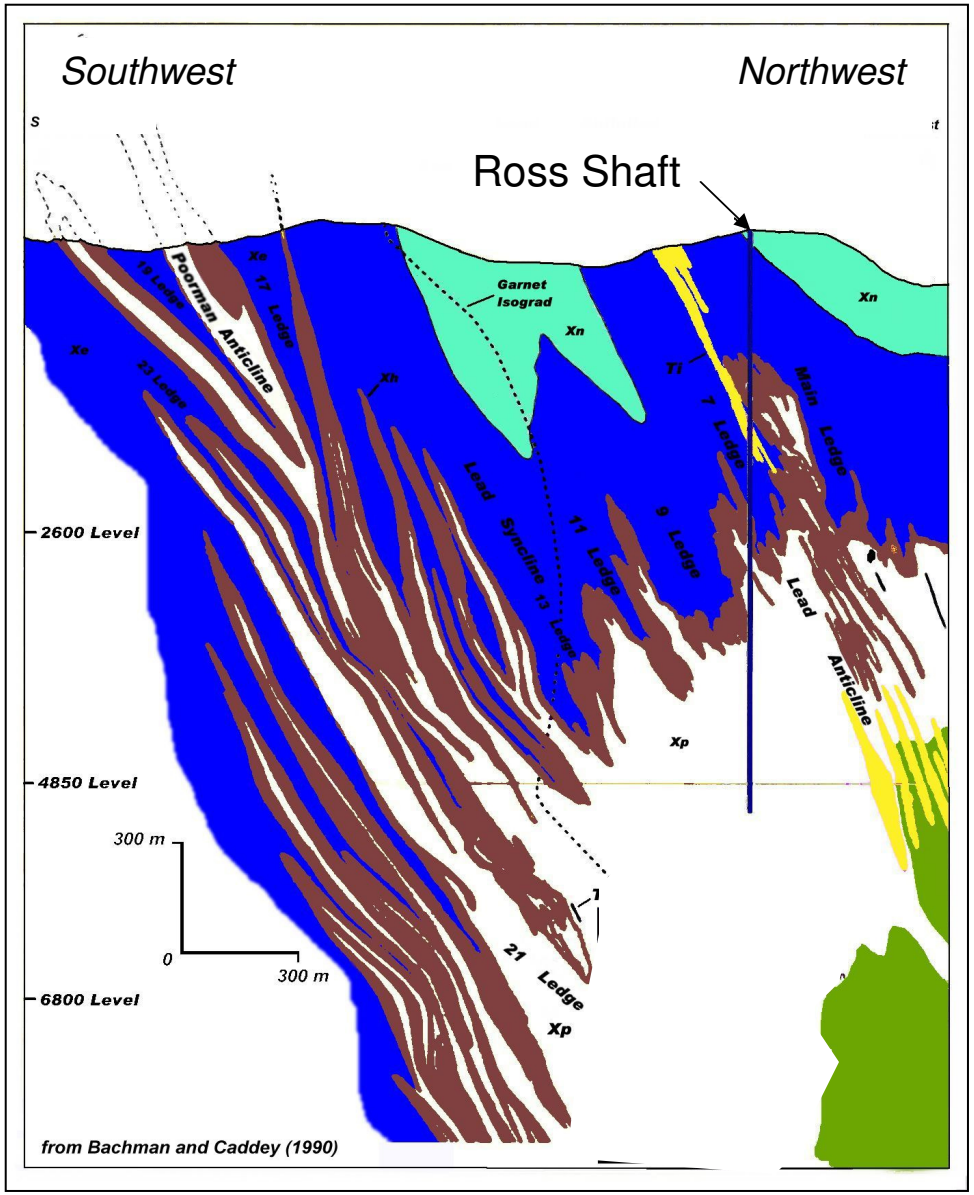
- Located in Northern Black Hills of western South Dakota
- Homestake hosted in Precambrian rock ~2 billion years old
- Precambrian core of the Black Hills uplift exposed as a dome ~100 km long and ~60 km wide.
- The rocks are metamorphic and subdivided into three distinct units Poorman, Homestake, Ellison
- Subsequently intruded by Tertiary volcanic rocks
- Complex deformed geologic terrain



Caddey, et al. (1991)

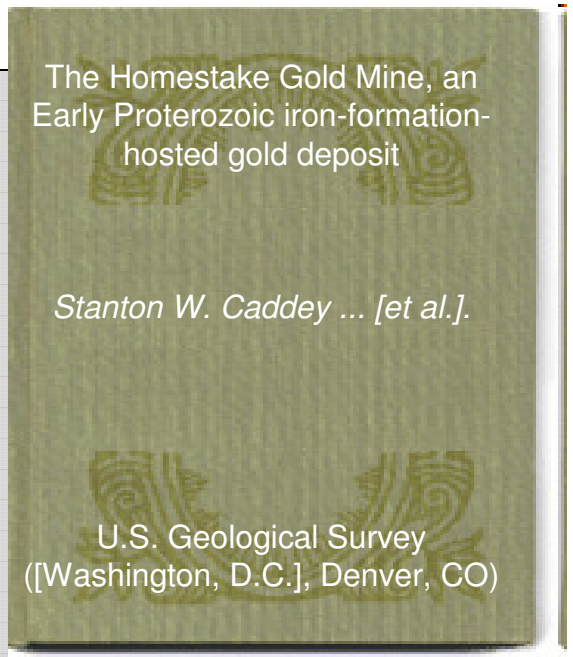
Geology

Vertical x-section

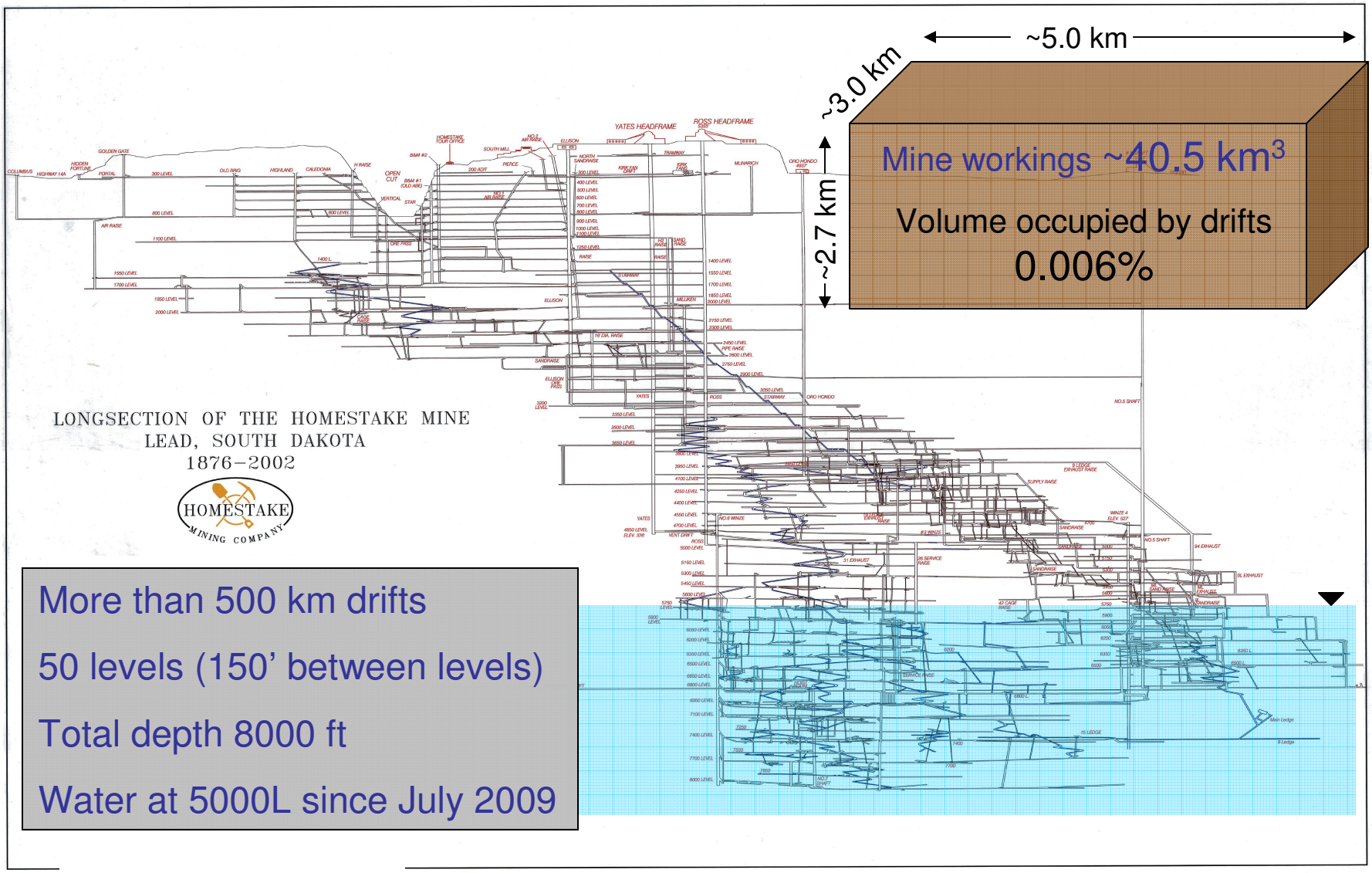


- Tertiary intrusive rock
- Northwestern Formation
- Ellison Formation
- Homestake Formation
- Poorman /Yates Unit

Useful Reference



- Pertinent formation/units
  - Ellison
  - Homestake
  - Poorman
  - Yates
- Tertiary volcanic rocks present
- The geologic structure is nearly vertical
- Nearly every subsurface rock type encountered at surface



More than 500 km drifts

50 levels (150' between levels)

Total depth 8000 ft

Water at 5000L since July 2009

Radiometric Measurements

Natural radioactivity is the spontaneous decay of atoms of certain isotopes into other isotopes.

Decay process usually accompanied by emission of alpha, beta, and gamma radiation.

Measuring radioactivity important for low-energy neutrino and dark matter experiments

Sources of background radioactivity

- Rock
  - Gamma-rays, alpha, neutrons
  - radon
- Muon-induced processes
  - Neutrons
  - Bremsstrahlung

Uranium, Thorium, and Potassium (U, Th, K) affect radioactive backgrounds experienced by detectors

Characterization of the rock required to:

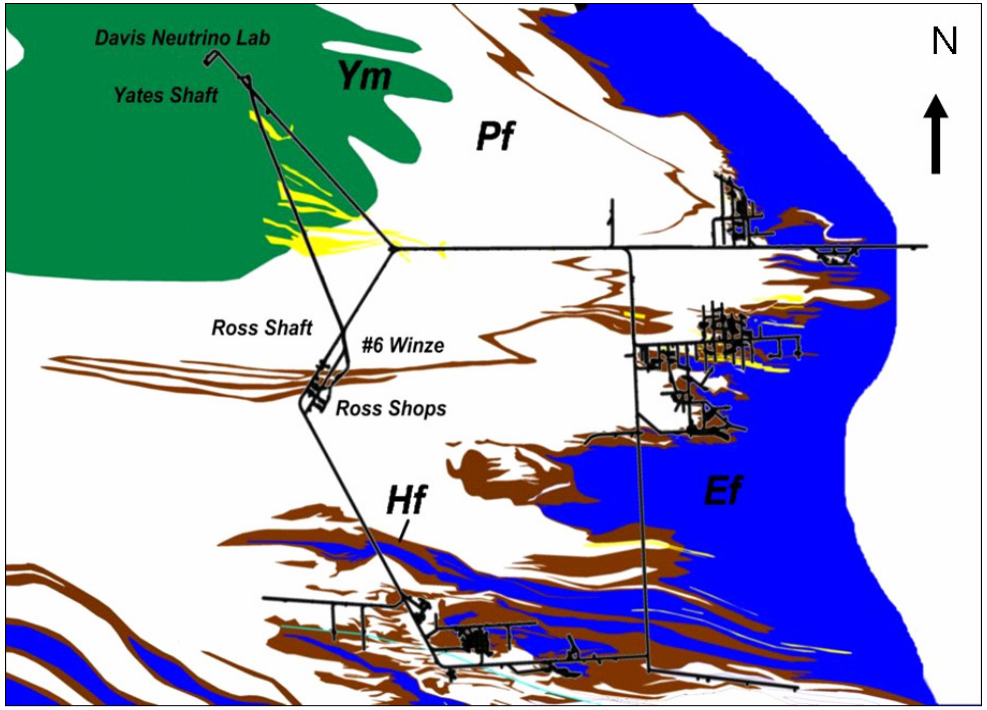
- Evaluate placement of laboratory rooms
- Identify concrete constituents to be used
- Estimate shielding from the country rock

Measurement with Low-BKG high-resolution HPGe detector gamma ray spectrometer to identify gamma-emitters in sample materials

U,Th & K

Radiometric Measurements

	Poorman Fm	Tertiary Rhyolites	Cement (local)	Aggregates: Limestone	Aggregates: Crushed Limestone	Aggregates: Sioux Quartzite	Aggregates: Central Black Hills	SNO Lab.
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



Tertiary intrusive rock

Ef — Ellison Formation

Hf — Homestake Formation

Pf — Poorman Formation

Ym — Yates member

Analysis by Al Smith (LBNL)

- Colorless, odorless, tasteless, naturally occurring, radioactive noble gas with no stable isotopes
- Once the parent nuclei decay into gaseous radon, it will diffuse through the bulk matrix and may reach the open air

Concerns about radon underground:

- Contributions to background radiation from the short and long-lived daughters of radon. (^{210}Pb a ^{222}Rn daughter has a 22 year half life)
- Leading cause of lung cancer among non-smokers

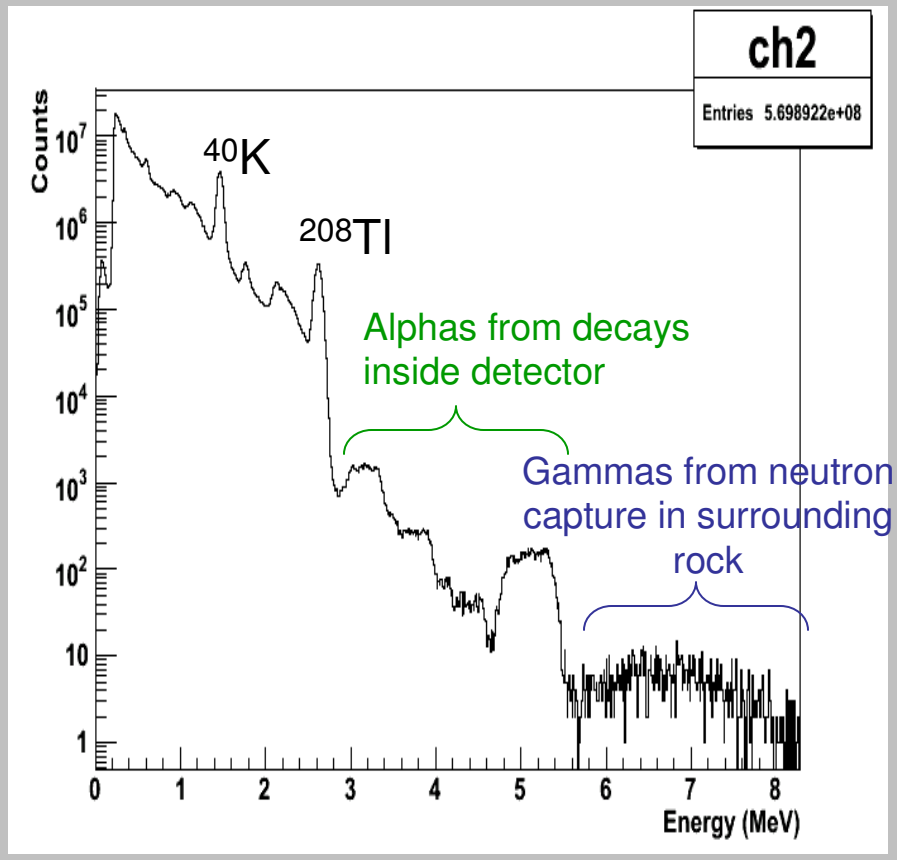
US EPA action level for radon 4 pCi/L…at or above corrective measures recommended.

Level	Location (Formation)	Bq/m^3
300	Ross Station (Ellison)	66
800	Cap magazine room (Ellison, some Homestake)	444
2000	1st Transformer Substation (Ellison)	792
4550	#6 WINZE Hoist Rm. (Poorman)	335
4850	Yates Station	755
4850	Davis Cavern- NE (Yates + Rhyolite)	659
4850	Davis Cavern- Center (Yates + Rhyolite)	585

Jaret Heise et al (Sanford Lab.), Donming Mei et al (USD)

Note: Current ventilation is 33-50% of former production levels

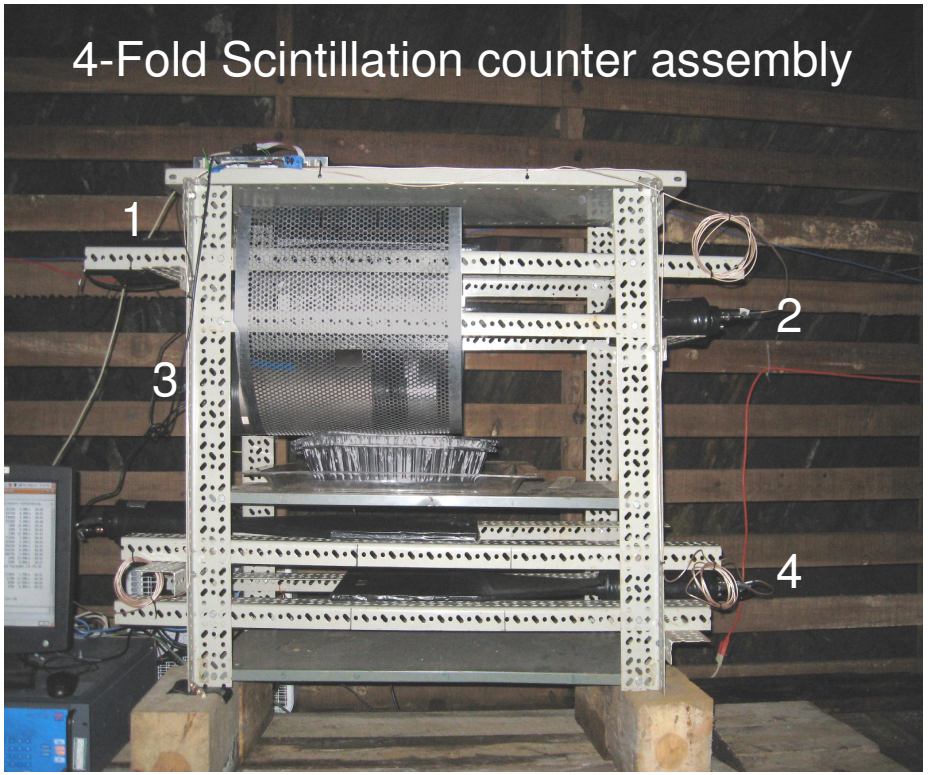
Measured Gamma-Ray Flux Example 800L



Total Gamma-ray fluxes (> 0.1 MeV@ 800L): 2.36 Hz/cm^2

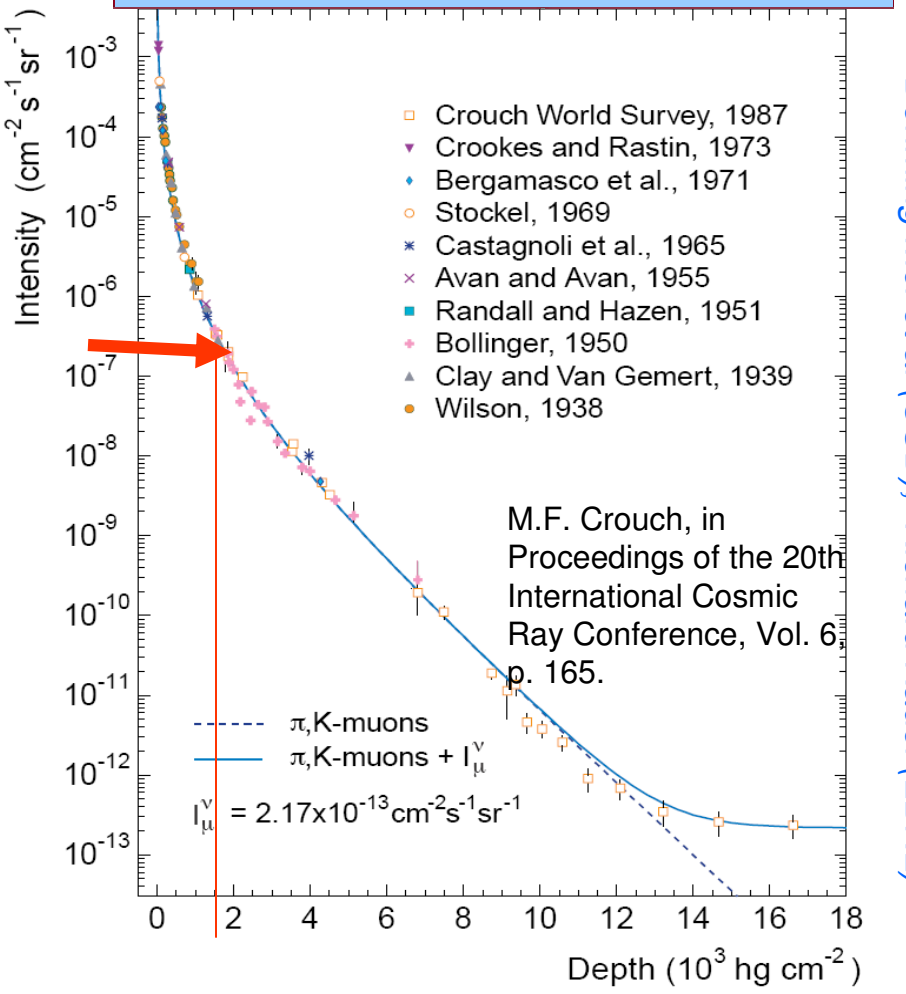
Donming Mei et al. (USD), Richard Kadel (LBNL)

Measured Muon Flux Example 2000L



3 or 4-fold muon coincidence rate:
$3.11 \pm 0.35 \times 10^{-7}$ Hz cm^{-2}sr^{-1}

Comparison with historic data



Donming Mei et al (USD), Richard Kadel (LBNL)

Most country rocks have low levels of U,Th, K

Rhyolite intrusive rocks have substantially higher U,Th, K

Locally available cements also have higher U,Th, K contents than the country rocks

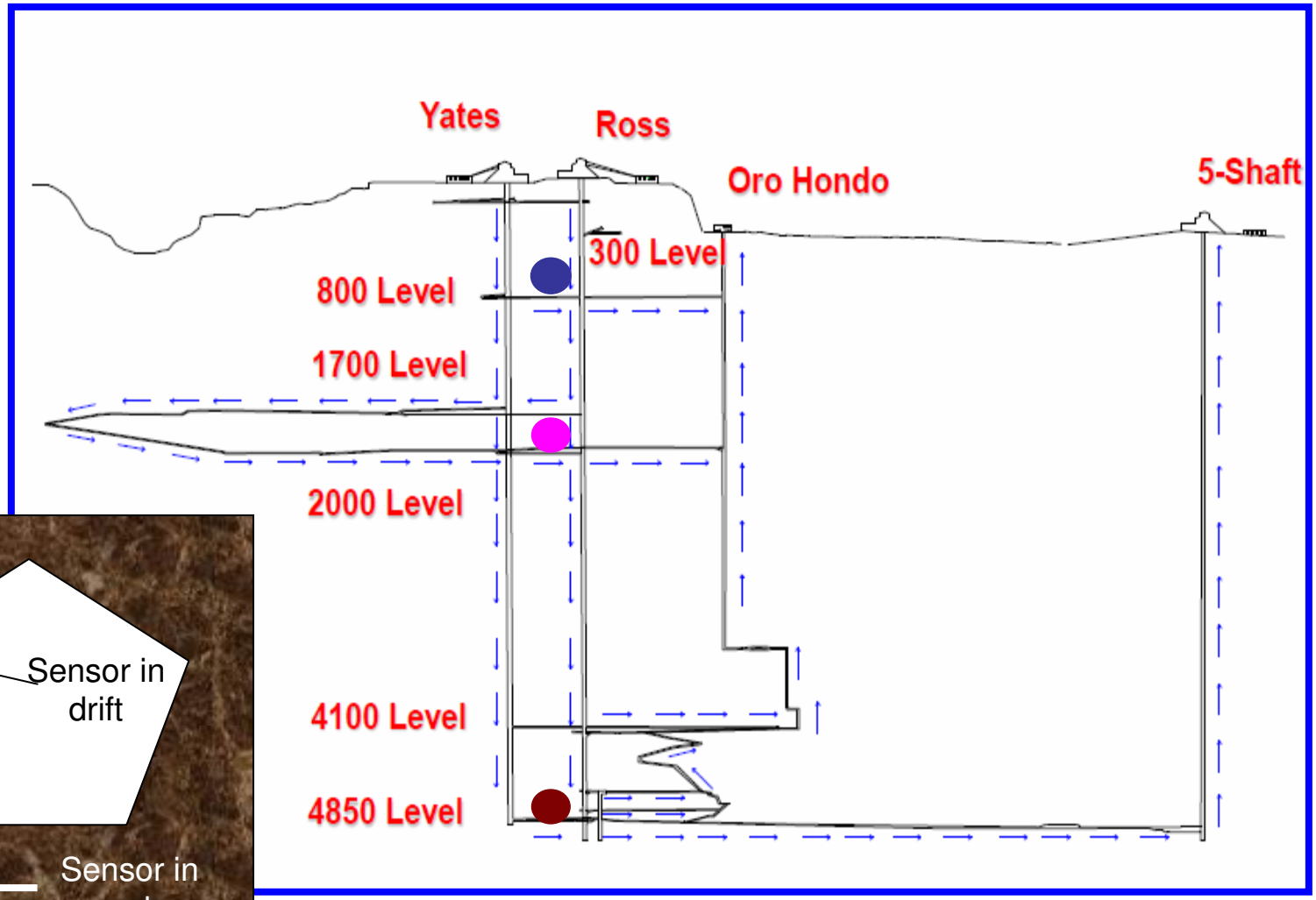
Manufactured sand derived from local limestones have the lowest U,Th, K contents

Radon levels may be higher than when ventilation system working at full capacity

Muon flux (*at 2000L*) compares well with historical data

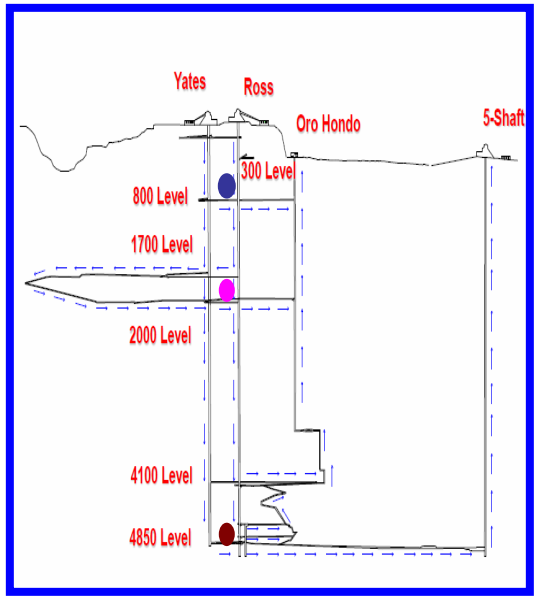
Microclimate

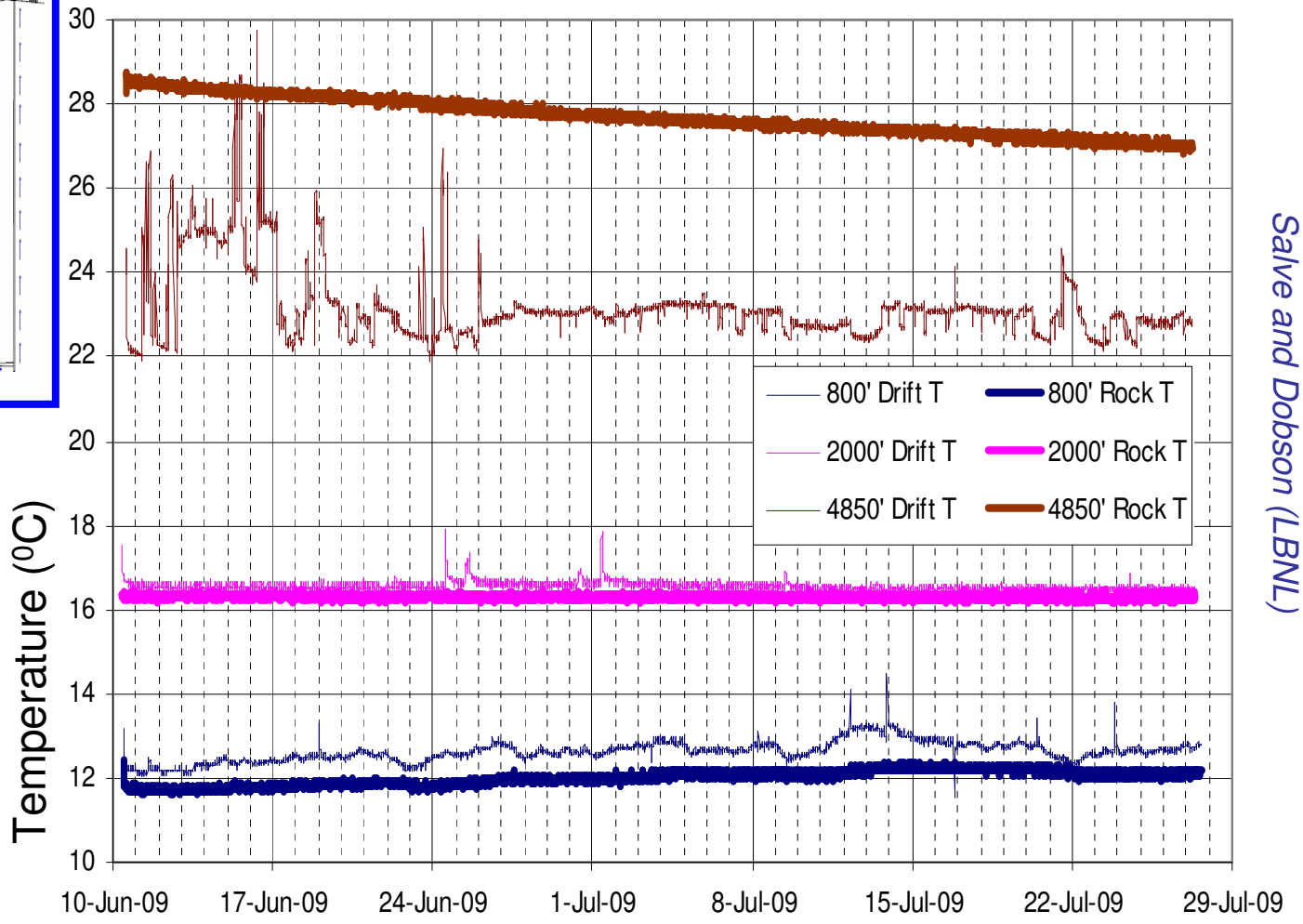
Location of stations



Microclimate

Temperature

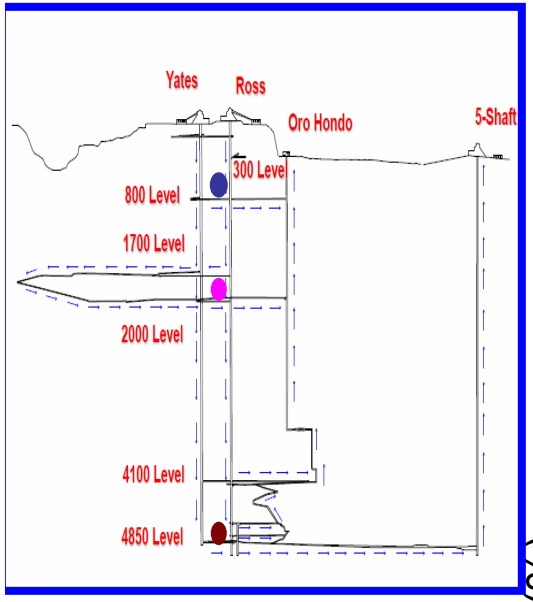


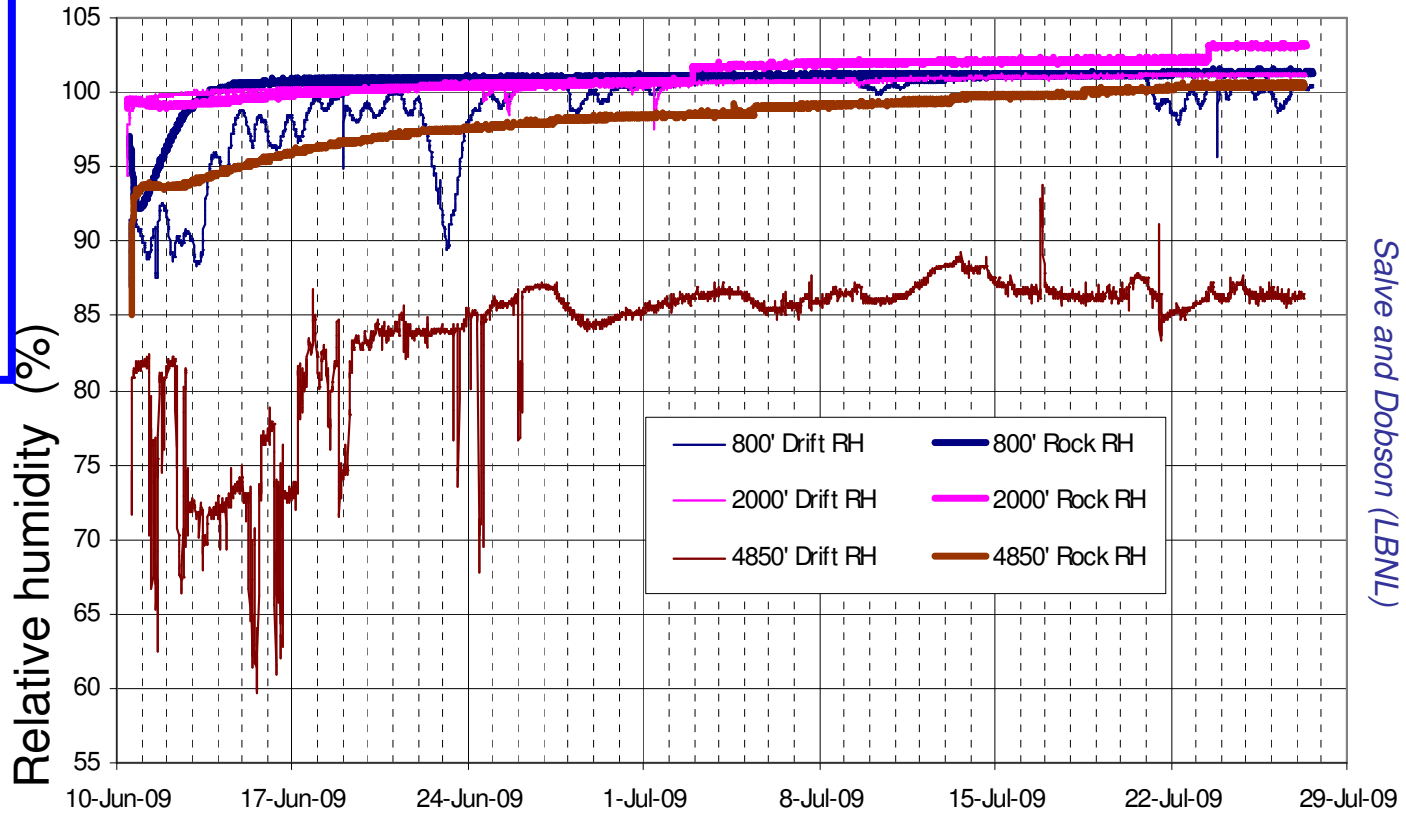


Salve and Dobson (LBNL)

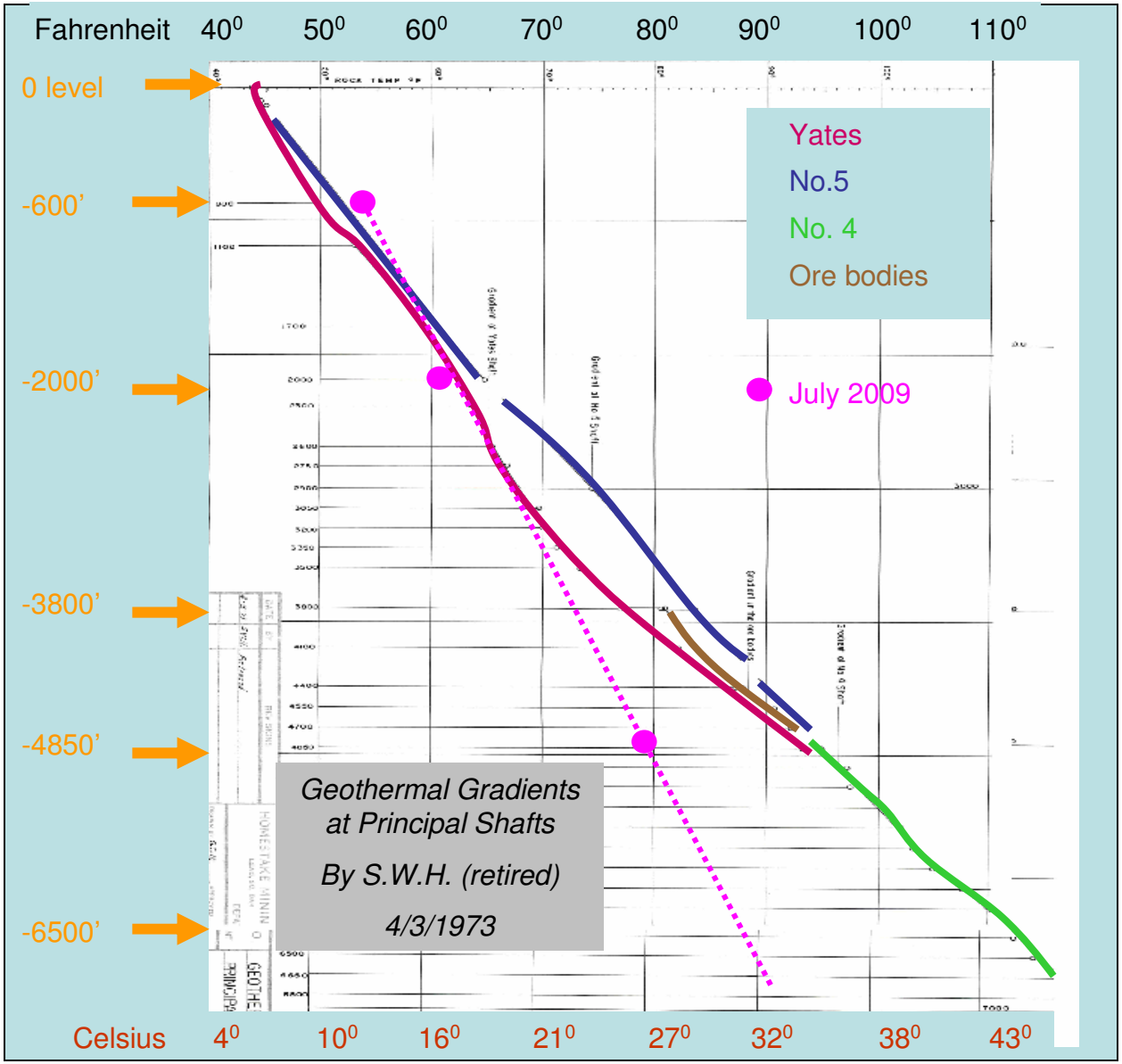
Microclimate

Relative humidity





Temperature measurements *(1973 versus 2009)*



- Mine temperature:
  - Influenced by ventilation (near drift environment)
  - A function of depth
- Non-ventilated areas have high relative humidity

Resources

Available Data and Information

Workings

a. Sills (*drifts*)
b. Ramps (*drifts between levels*)
c. Stopes (*all mined out areas)*

Geology

a. Diamond drill holes: Approximately 24,000 holes
b. Geologic mapping: 1996-2001, additional old mapping has been digitized as deemed necessary
c. Geologic Interpretations: Plan maps, every level-surface
Cross-section maps, entire length of mine at 50 foot intervals

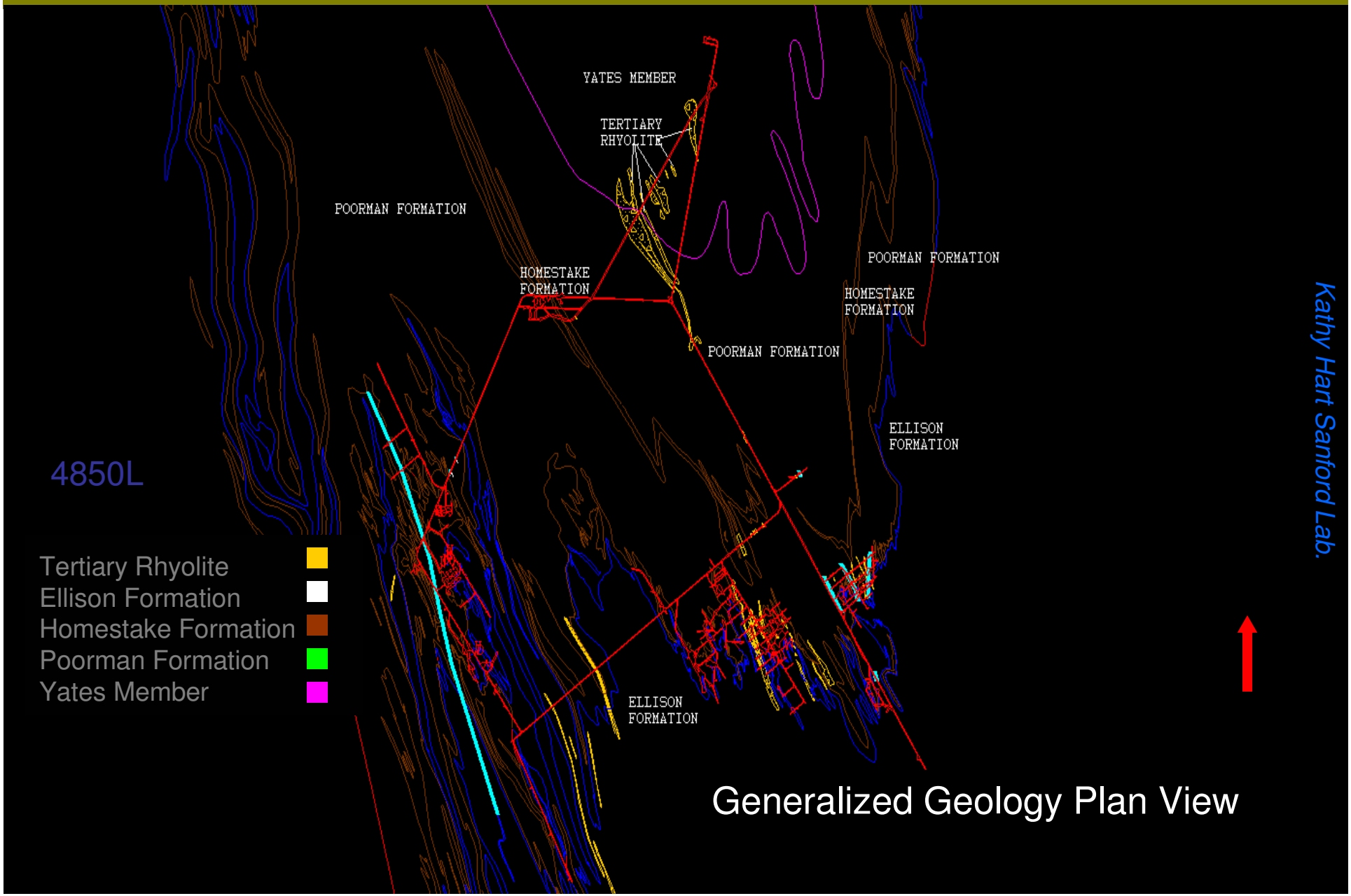
Reference System

a. Boreholes, sandlines, electrical system, walls

Kathy Hart Sanford Lab.

Resources

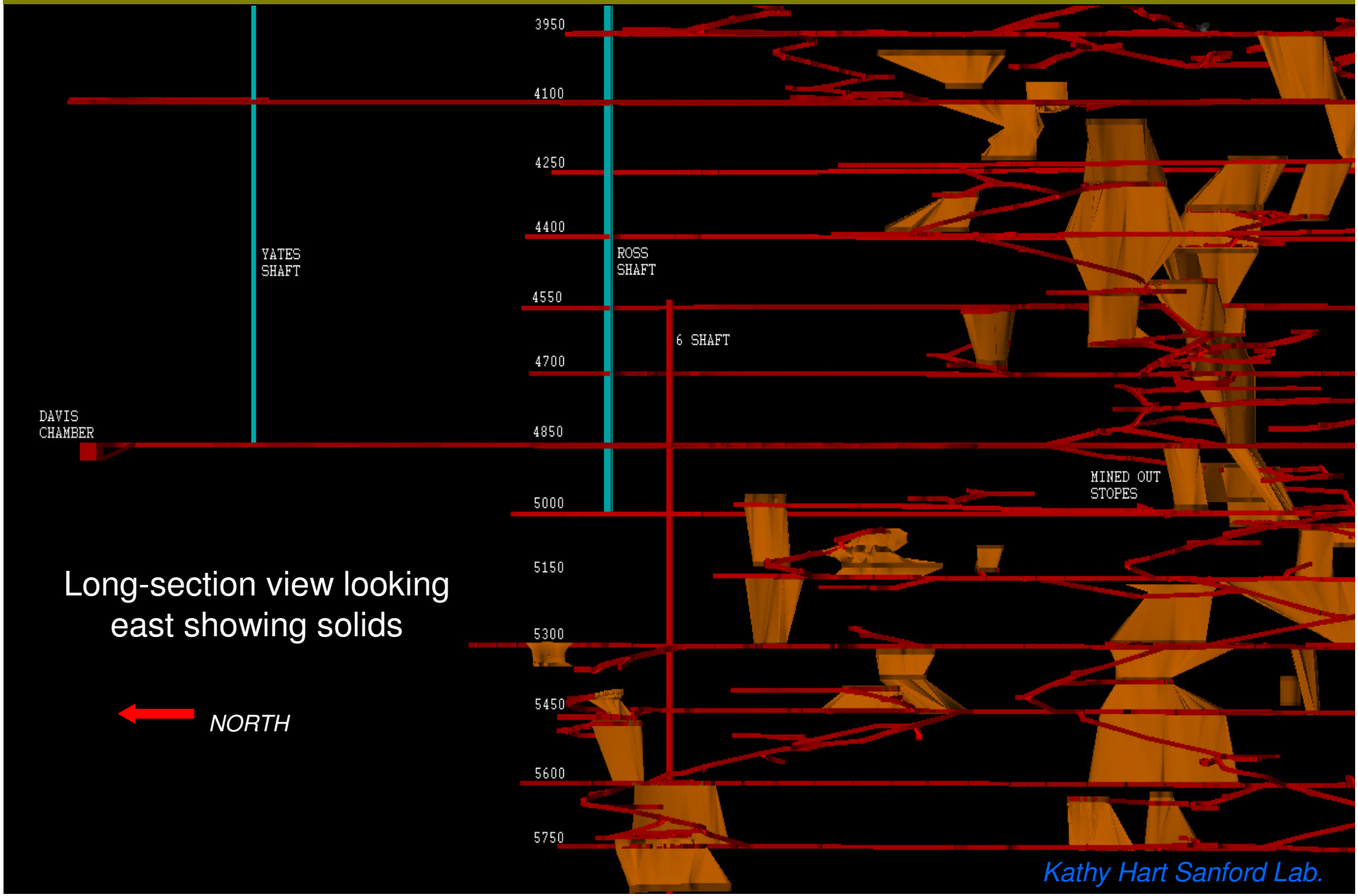
Vulcan Database



Generalized Geology Plan View

Resources

Vulcan Database



Long-section view looking east showing solids

Kathy Hart Sanford Lab.

Repository Contents

Estimated ~400K feet of core drilled within the Homestake Mine and Northern Black Hills

Consists of underground cores drilled from the 1930's to the late 1990's

Represents core extending from the surface to the 12,000+ equivalent level within the Homestake Mine

Ongoing drilling (2009) at 4850L will add another ~6K feet of core

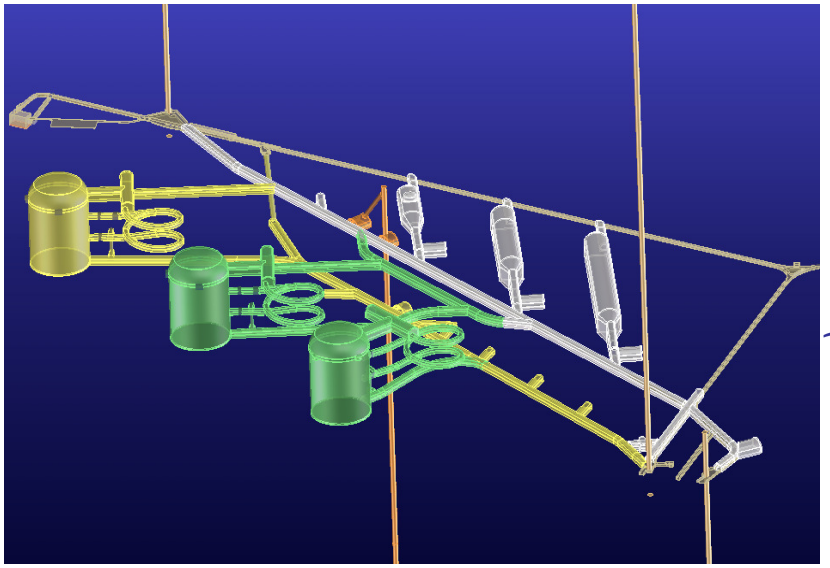
3-D Structural Geology Model For Location Of Large Cavities

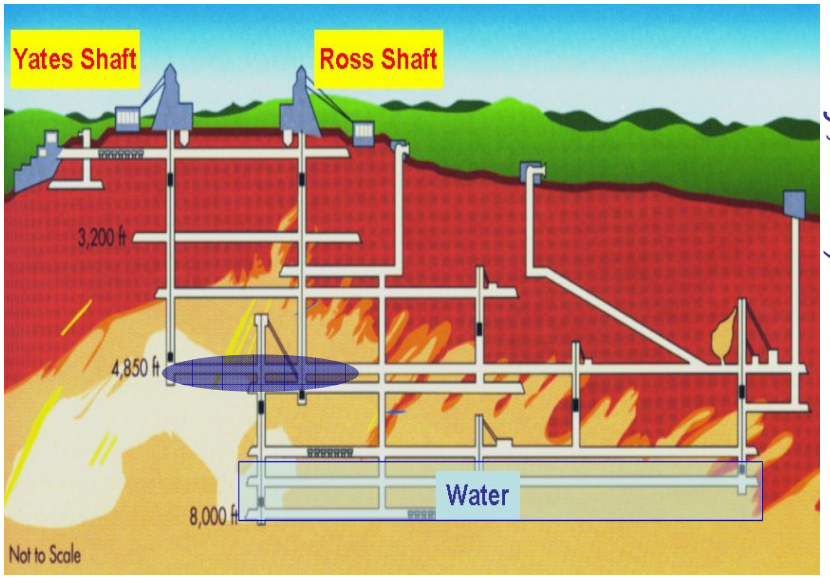
To locate:

- Main rock types
- Shear zones and fault zones
- Contacts between Rhyolite dikes-host rock
- Foliation and/or any cross-cutting features
- Main joint sets

Area of Interest

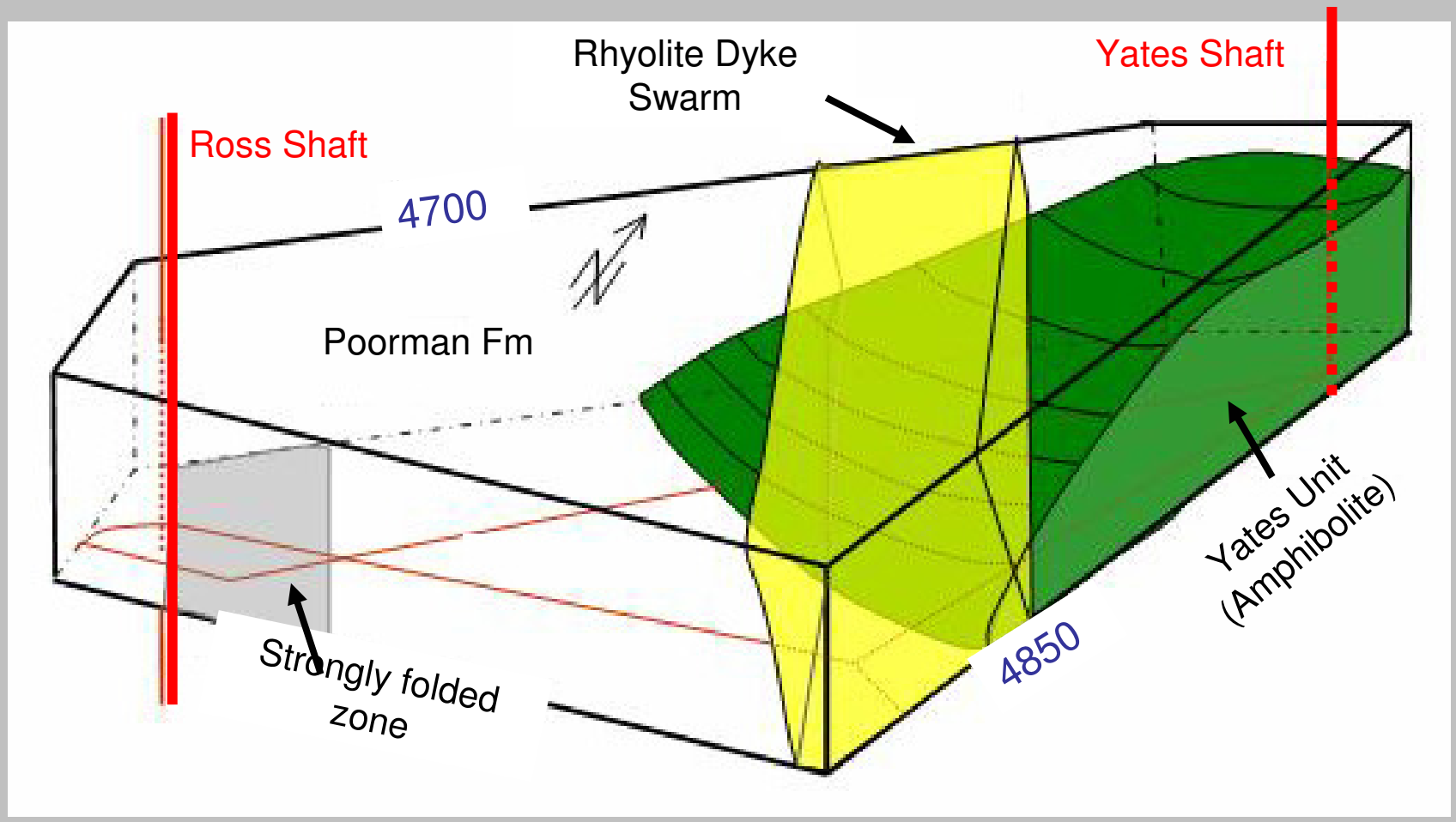
- Between 4100 and 5000 Levels
- Between, and northwest of, the Yates and Ross shafts





(Lisenbee and Terry, 2009)

3D Geology of Large Cavity Study Area



(Lisenbee and Terry, 2009)

In conclusion…

- Extensive information available about regional and local geology……..Additional information being collected (e.g. Yates unit at the 4850L)
- Ongoing characterization and monitoring activities are useful for engineering design, development of experiments and mine safety strategies
- Resources such as the Vulcan database and core library provide relatively easy access to a wide range of information about the subsurface environment
- There are other efforts, both ongoing (e.g., seismic studies [*Roggenthen et al.*], environmental magnetic surveys [*Bryam et al.*]), and planned