Ernest Orlando Lawrence Berkeley National Laboratory

Earth Sciences Division

December 10, 2005

Mr. Dave Snyder
Executive Director
South Dakota Science and Technology Authority
hlcp@state.sd.us

Re: Letters of Interest (LOIs) for the Homestake Deep Underground Science and Engineering Laboratory (DUSEL)

Dear Dave:

We at Earth Sciences Division of Lawrence Berkeley National Laboratory (LBNL) are interested to initiate, participate, and organize collaborations in earth sciences and in multidisciplinary crosscutting research areas for experiments at the 4850 Laboratory and in the Homestake DUSEL, with a phase approach. Investigators in (1) hydrogeology, (2) geochemistry, (3) ecology/geomicrobiology, (4) geophysics, and (5) rock mechanics/geotechnical engineering will all have interests in (6) couple process studies and use (7) sensors for data collections. Earth scientists can work together with physicists in (8) cosmic ray and radiation measurements. These potential research activities are described in the eight attachments. Additional inputs will be submitted by collaboration participants.

Activities will (1) start with available site data evaluation, laboratory measurements on samples from the surface and from the core library, and upper level instrumentation during rehabilitation, (2) proceed with in situ sampling, observation and deployment, and grow in scope in laboratory quantification, data collection and analysis/modeling, and (3) design and implement long-term, large-scale studies. All activities will be closely coordinated to develop joint deployment wherever feasible. The potential participants in the LOIs are personal contacts to date in institutions for development of collaborations in each of the potential activities. We expect to work with potential collaborators from other institutions to refine and update the research focuses and participations.

We envision that the collaborations will have spokesperson(s) rotated among participants. The collaboration will interact with other programs or initiatives such as the SECUREarth (Scientific Energy/Environmental Cross-Cutting Underground Research to address urgent solutions to secure Earth's future) to use Homestake DUSEL facility. All activities will contribute to (1) the design and implementation of large-scale, multi-level, coupled process testing to address national energy and environment problems (e.g., SECUREarth issues), (2) deep drilling to probe the limits of life, and (3) deep imaging below the mine to evaluate the evolution of the earth. The experimental details to address these far-reaching goals will be developed once the geo-

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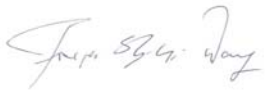
hydro-thermal-chemical-mechanical-biological settings are quantified in sufficient details with testable predictions from different hypotheses, theories, and models.

The well-known “If you build it, they will come” is now “When you build it, we will come”! We the earth scientists in the Homestake Scientific Collaboration look forward to working with the SDSTA and physicists to support the conceptual design of the 4850 Laboratory and the Homestake DUSEL.

Yours truly,



Joseph S.Y. Wang – Ph.D.
Staff Scientist
Group Leader – Ambient Field Testing

Attachments:

1. Hydrogeology Collaboration on Flow Path Delineation and Modification
2. Geochemistry Collaboration for Geochemical Evolution of Fluids in the Homestake Hydrologic System
3. Ecology/Geomicrobiology Collaboration for Microbe Evolution
4. Geophysics Collaboration for Imaging
5. Rock Mechanics and Geoengineering Collaboration for Excavation Research
6. Couple Process Collaboration for Large Block Experiments
7. New Paradigms in Sensing
8. Cosmic Ray Studies

cc: Kevin Lesko
Bill Roggenthen

Letter of Interest to the South Dakota Science and Technology Authority (SDSTA) for the Homestake Deep Underground Science and Engineering Laboratory (DUSEL)

Title: Hydrogeology Collaboration on Flow Path Delineation and Modification

Potential Participants (to be updated during the formation of the collaboration):

Lawrence Berkeley National Laboratory, Hydrogeology Dept., Earth Sciences Division – Rohit Salve, Joe Wang
South Dakota School of Mine and Technology – Arden Davis
New Mexico Institute of Technology – Brian McPherson, John Wilson, Fred Phillips, Robert Bowman, Enrique Vivoni, Jan Hendrickx
Los Alamos National Laboratory – Everett Springer
Oakridge National Laboratory – Tommy Phelps
University of California Berkeley, Civil Engineering Dept. – Steven Glaser
Institute fur Technische Chemie – Gerald Ziegenbalg
University of Hawaii – Steve Martel

Proposed Program

We at the Hydrogeology Department, Earth Sciences Division, Lawrence Berkeley National Laboratory are interested to initiate and organize a hydrogeology collaboration for experiments at the 4850 Laboratory and the Homestake DUSEL with a phased approach. (1) The first research focus is on the recharge mechanism and interaction with climate and regional hydrological setting from different depths, including the transient changes of inflows during dewatering operations. Seepage and fast flow path can be characterized, multi-drift tracer tests can be conducted, and engineered controls (e.g., chemical and biological injections) can be tested. (2) The second focus is on the determination if active flows and permeable paths can be maintained under high stress at depths, and if deep circulation of fluids occurs carrying dissolved elements or with free flowing geo-gases. The basic understanding of flow and transport at depths and practical studies of storage capacities are critical for assessments of sequestration and isolation potentials of deep aquifers. Effects of heterogeneity and scaling are addressed in both research areas.

Space Requirement

We envision that the hydrogeology collaboration will work with the SDSTA teams during the rehabitation period to identify zones with observable flows, collect rock and fluid samples along the drifts, and select sites with active flow characteristics suitable for additional experiments. In the test sites, the collaboration can conduct flow path modification experiments with tracers, chemical solutions, microbes, thermal and mechanical stresses to reduce or enhance the formation permeability and storage capacity, for problems associated with energy and environmental challenges. During dewatering phase, the hydrogeology collaboration is interested in studying the processes of water table lowering, multiphase flows associated with desaturation, and mixing mechanisms. The region around and below the open pit with levels connected by ramps above and below the 2000 ft level can be the first-phase zones for studies. Similar zones of ramps and levels accessible at the 4850 ft level and the deep region above the 8000 ft level are also candidate locations for tracer migration study and couple process block testing.

TimeLine (to be coordinated with 4850 and DUSEL Development):

2006-2007 field surveys and sensor installation along the drifts during inspections
2008-2009 upper test block instrumentation, characterization, and testing; dewatering studies
2010-2012 lower block instrumentation, characterization, hydrogeology testing
2013- couple process testing at selected blocks

Collaboration Strategy:

We envision that the collaboration will have spokesperson(s) rotated among participants. Each organization will seek funding for specific tests and tasks individually or collaboratively from agencies and industry. The collaboration will interact with other programs or initiatives such as the SECUREarth (Scientific Energy/Environmental Cross-Cutting Underground Research to address urgent solutions to secure Earth's future) to use Homestake DUSEL facility for flow delineation and modification, and related hydrogeology problems in geochemistry, ecology/geomicrobiology, geophysics, rock mechanics/geoengineering, and couple processes.

Letter of Interest to the South Dakota Science and Technology Authority (SDSTA) for the Homestake Deep Underground Science and Engineering Laboratory (DUSEL)

Title: Geochemistry Collaboration for Geochemical Evolution of Fluids in the Homestake Hydrologic System

Potential Participants (to be updated during the formation of the collaboration):

Lawrence Berkeley National Laboratory – Mark Conrad, Donald DePaolo, Mack Kennedy, John Christensen, Eric Sonnenthal, Carl Steefel
Idaho National Laboratory - Rick Colwell
Massachusetts Institute of Technology – Fred Frey
Stanford University – Page Chamberlain
South Dakota School of Mine and Technology – Ed Duke
University of California, Merced - Martha Conklin
University of Colorado, Boulder – Alexis Templeton
University of Illinois, Chicago – Neil Sturchio
U.S. Geological Survey - Brian Marshall

Proposed Program

Scientific Focus: This Letter of Interest outlines a research program designed to examine the chemical evolution of fluids in the Homestake hydrologic system. The proposed studies will investigate fundamental aspects of chemical and biological interaction between fluids and rocks in the subsurface. Research will address critical issues including water quality, chemical transport, and life in subsurface environments.

Initial studies will focus on developing a 3-dimensional flow model for the system using geochemical tracers to identify channels of active fluid flow within the mine. To do this, it will be necessary to define the geochemical signatures of potential sources of water within the hydrologic system. The primary tracers we plan to use will be the hydrogen (δD) and oxygen ($\delta^{18}O$) isotope compositions of the water. Other potential tracers include chemical signatures acquired from the soil/rock matrix and/or from biological activity along the fluid pathways. Samples of water seeps within the mine will be collected for geochemical analyses wherever possible. In addition precipitation (rain and snow) will be collected periodically for analyses. Surface water bodies and any available groundwater from the area will also be sampled and analyzed. This stage of the program is expected to last 1-2 years and be coincident with the opening and rehabilitation of the mine to the 4850 level.

The next phase of the program will involve tracer tests conducted in regions of the mine where active fluid pathways were defined during the initial studies. Goals of these studies will include quantifying the effective permeability of the fractured rock system, determining degrees of fracture-matrix interaction, and identifying the types and levels of biological activity in the rock. These tests will utilize both conservative tracers (e.g., deuterium, Cl, Br) and reactive tracers including both organic (sugars, organic acids) and inorganic (nitrate, Sr) compounds. Where significant backgrounds of the reactive tracers exist or it is desirable to identify byproducts of reactions occurring along the fluid pathways, isotopically-labeled tracers will be used. The duration of the tracer tests will vary depending on the objectives of the specific studies.

The main element of this program will consist of long-term experiments conducted in large experimental blocks of rock (10s to 100s of meters on a side). The blocks will be subjected to different conditions such as elevated temperature or high stress to induce fracturing. These blocks will then be available for experiments to study a wide range of subsurface processes including chemical transport, biologically and chemically induced alteration of the rocks, the reactivity of fractured surfaces, and mobility of microorganisms.

Space Requirement

(1) extensive access to underground workings for sampling, (2) coordinated coring and excavation operations to preserve geochemical signatures, (3) large blocks (up to km^3) for coupled process testing, and (4) subsurface and surface laboratories for sample analyses.

TimeLine (to be coordinated with 4850 and DUSEL Development):

2006-2007 field surveys and sample collections along the drifts during inspections
2008-2009 upper test block instrumentation, characterization, and testing; dewatering studies
2010-2012 lower block instrumentation, characterization, geochemical testing
2013- couple process testing at selected blocks

Collaboration Strategy:

We envision that the collaboration will have spokesperson(s) rotated among participants. Each organization will seek funding for specific tests and tasks individually or collaboratively from agencies and industry. The collaboration will interact with other programs or initiatives such as the SECUREarth (Scientific Energy/Environmental Cross-Cutting Underground Research to address urgent solutions to secure Earth's future) to use Homestake DUSEL facility for flow evolution, and related geochemistry problems in hydrogeology, ecology/geomicrobiology, geophysics, rock mechanics/geoengineering, and couple processes.

Letter of Interest to the South Dakota Science and Technology Authority (SDSTA) for the Homestake Deep Underground Science and Engineering Laboratory (DUSEL)

Title: Ecology/Geomicrobiology Collaboration for Microbe Evolution

Potential Participants (to be updated during the formation of the collaboration):

Lawrence Berkeley National Laboratory, Ecology Dept., Earth Sciences Division – Terry Hazen, Gary Anderson, Torok Tame, Mark Conrad
South Dakota School of Mine and Technology – Sookie Bang
Joint Genome Institute – Phil Hugenholtz
Oak Ridge National Lab – Tommy Phelps
University of Tennessee – Susan Pfiffner
New Mexico Institute of technology – Tom Kieft
Princeton University – T.C. Onstott
University of Wisconsin – Eric Roden

Proposed Program

We at the Ecology Department, Earth Sciences Division, Lawrence Berkeley National Laboratory are interested to initiate and organize an ecology and geomicrobiology collaboration for experiments at the 4850 Laboratory and the Homestake DUSEL with a phased approach. (1) The first research focus is on the adaptation and transport of surface microbial communities to deep environments. The extensive excavations over 125 years of mining offer the unique opportunity to evaluate the evolution of underground ecology, from old mine working near the surface to recent drifts and caverns excavated at depths. (2) The second focus is on the characterization of ancient and present day, themophilic, subsurface microbial communities. A multi-institutional, multidisciplinary research team will acquire and process samples from borehole coring and from drift advancement into virgin rock formations.

Space Requirement

1) extensive underground workings for sampling, (2) coordinated coring and excavation operations to preserve microorganisms, (3) drilling platform at 8000 ft level for deep coring to ~20,000 ft, 120oC formations to explore the high temperature limit for life forms, (4) subsurface and surface laboratories for sample analyses.

TimeLine (to be coordinated with 4850 and DUSEL Development):

2006-2007 field surveys and sample collections along the drifts during inspections
2008-2009 upper test block instrumentation, characterization, and testing; dewatering studies
2010-2012 lower block instrumentation, characterization, ecology and geomicrobiology testing
2013- couple process testing at selected blocks

Collaboration Strategy:

We envision that the collaboration will have spokesperson(s) rotated among participants. Each organization will seek funding for specific tests and tasks individually or collaboratively

from agencies and industry. The collaboration will interact with other programs or initiatives such as the SECUREarth (Scientific Energy/Environmental Cross-Cutting Underground Research to address urgent solutions to secure Earth's future) to use Homestake DUSEL facility for flow evolution, and related ecology and microbiology problems in hydrogeology, geochemistry, geophysics, rock mechanics/geoengineering, and couple processes.

Letter of Interest to the South Dakota Science and Technology Authority (SDSTA) for the Homestake Deep Underground Science and Engineering Laboratory (DUSEL)

Title: Geophysics Collaboration for Imaging

Potential Participants (to be updated during the formation of the collaboration):

Lawrence Berkeley National Laboratory, Geophysics Dept., Earth Sciences Division – Lane Johnson
South Dakota School of Mine and Technology – Bill Roggenthen
Los Alamos National Laboratory – Mike Fehler
University of Utah – Bill Pariseau
Earthscope Participants

Proposed Program

We at the Geophysics Department, Earth Sciences Division, Lawrence Berkeley National Laboratory are interested to participate in a geophysics collaboration for experiments at the 4850 Laboratory and the Homestake DUSEL with a phased approach. 1) The first research focus is to establish a multi-purpose seismic observatory within the mine capable of recording broadband seismic signals from teleseismic, regional, to local events, as well as monitoring the ground motions caused by various activities within the mine such as drilling, rock bursts, excavations, or daily operations. The seismic observatory provides a facility for performing a wide variety of seismic experiments, such as array measurements of high-frequency phases from distant earthquakes, studying homeland security issues related to the detection and monitoring of activities in underground structures, or fundamental studies of stresses and energies associated with any seismic events that may occur within the mine as it is being rehabilitated and used. (2) The second focus is to on the detecting signals from the mantel and deep crust with high frequency content. The Homestake is the window to probe the continental shield away from techtonically active regions with strong attenuations.

Space Requirement

(1) initial and fellow-up access along with cabling to approximately 10 locations within the underground workings for seismeter installation and maintenance, (2) analysis facilities for collection and processing of the seismic data.

TimeLine (to be coordinated with 4850 and DUSEL Development):

2006-2007 installation of seismic network within 4850 laboratory
2008-2009 monitoring dewatering studies
2010-2012 lower block instrumentation, deep imaging, incorporating EM and other geophysical imaging technique
2013- deep imaging, monitoring couple process testing at selected blocks

Collaboration Strategy:

We envision that the collaboration will have spokesperson(s) rotated among participants. Each organization will seek funding for specific tests and tasks individually or collaboratively from agencies and industry. The collaboration will interact with other programs or initiatives

such as the SECUREarth (Scientific Energy/Environmental Cross-Cutting Underground Research to address urgent solutions to secure Earth's future) to use Homestake DUSEL facility for imaging, and related geophysics problems in hydrogeology, geochemistry, ecology/microbiology, rock mechanics/geoengineering, and couple processes.

Letter of Interest to the South Dakota Science and Technology Authority (SDSTA) for the Homestake Deep Underground Science and Engineering Laboratory (DUSEL)

Title: Rock Mechanics and Geoengineering Collaboration for Excavation Research

Potential Participants (to be updated during the formation of the collaboration):

Lawrence Berkeley National Laboratory, Geophysics Dept., Earth Sciences Division – Seiji Nakagawa, Larry Myer, Jonny Rutqvist
South Dakota School of Mine and Technology –
Fermi National Laboratory –
Lawrence Livermore National Laboratory -
University of California, Civil Engineering – Steven Glaser
University of Minnesota –
University of Wisconsin –
University of Texas –
Industry Partnerships –

Proposed Program

We at the Geophysics Department, Earth Sciences Division, Lawrence Berkeley National Laboratory are interested to initiate and organize (or participate in) a rock mechanics and geoengineering collaboration for experiments at the 4850 Laboratory and the Homestake DUSEL with a phased approach. 1) The first research focus is to establish the depth dependence of stress state, to monitor the stability of excavations, and to support industry for testing new drilling and excavation equipments and methodologies. (2) The second focus is to on the design of large experimental halls deep underground, to monitor the changes associated with rock movements in the surrounding rock mass, and to study the interactions with fluid flows.

Space Requirement

(1) periodic access of extensive underground workings for installing and maintaining sensors, (2) drift complexes for controlled multi-drift and multi-ramp experiments, (3) drilling of borehole clusters along the drifts for measurements, (4) subsurface and surface laboratories for sample analyses.

TimeLine (to be coordinated with 4850 and DUSEL Development):

2006-2007 installation of stress measurement sites within 4850 laboratory
2008-2009 monitoring dewatering studies and stress measurements at deep sites
2010-2012 lower block instrumentation, large excavation design and monitoring
2013- deep and large excavation monitoring

Collaboration Strategy:

We envision that the collaboration will have spokesperson(s) rotated among participants. Each organization will seek funding for specific tests and tasks individually or collaboratively from agencies and industry. The collaboration will interact with other programs or initiatives such as the SECUREarth (Scientific Energy/Environmental Cross-Cutting Underground Research to address urgent solutions to secure Earth's future) to use Homestake DUSEL facility

for rock mechanics studies, and related problems in hydrogeology, geophysics, geochemistry, ecology/microbiology, and couple processes.

Example Experiments:

There are accepted strain estimates for the rock mass behavior as a TBM excavates through the rock. We would like to place displacement devices in small boreholes in a three-dimensional array in advance of TBM excavation. The measured displacement field would allow proper calibration of the FEM results currently in use.

Certain assumptions are made as to the effects of blasting on the surrounding rock. A blast experiment within the 3-D array of bores discussed above could provide hard evidence as the effects of this excavation method. In addition to displacement monitoring, we can place seismic source/reciever instruments to allow imaging of the change in wave velocities, hence stiffness. We would also like to see if blasting changes the local state of stress, i.e. relieving "locked-in" stresses.

Letter of Interest to the South Dakota Science and Technology Authority (SDSTA) for the Homestake Deep Underground Science and Engineering Laboratory (DUSEL)

Title: Couple Process Collaboration for Large Block Experiments

Potential Participants (to be updated during the formation of the collaboration):

Lawrence Berkeley National Laboratory, Earth Sciences Division –
Eric Sonnenthal
South Dakota School of Mine and Technology –
Pennsylvania State University – Derek Elsworth
New Mexico Institute of Technology – Brian McPherson

Proposed Program

We at Earth Sciences Division, Lawrence Berkeley National Laboratory are interested to initiate and organize a couple process collaboration for experiments at the 4850 Laboratory and the Homestake DUSEL with a phased approach. 1) The first research focus is to on coupled processes induced by heat sources, using single heaters to heater arrays in selected blocks (10x10x10 m3) to study thermal-hydro-chemical-mechanical-biological coupled processes. (2) The second focus is on rock alteration, resource genesis, and sequestration potential over reservoir scale (over kilometers), with multi-decade long experiments to evaluate fractured formations for enhancement of production and for sealing leakages.

Space Requirement

(1) 10 x 10 x 10 m blocks for single heater and heater array experiments, (2) drift complexes for controlled multi-drift and multi-ramp experiments, (3) subsurface and surface laboratories for sample analyses.

TimeLine (to be coordinated with 4850 and DUSEL Development):

2006-2007 block selection and heater experiments within 4850 laboratory
2008-2009 block selection after dewatering operation at deep sites
2010-2012 large block experiment design and instrumentation
2013- deep and large block testing

Collaboration Strategy:

We envision that the collaboration will have spokesperson(s) rotated among participants. Each organization will seek funding for specific tests and tasks individually or collaboratively from agencies and industry. The collaboration will interact with other programs or initiatives such as the SECUREarth (Scientific Energy/Environmental Cross-Cutting Underground Research to address urgent solutions to secure Earth's future) to use Homestake DUSEL facility for couple process studies, and related problems in hydrogeology, geophysics, geochemistry, ecology/microbiology, and rock mechanics and geoengineering.

Letter of Interest to the South Dakota Science and Technology Authority (SDSTA) for the Homestake Deep Underground Science and Engineering Laboratory (DUSEL)

Title: New Paradigms in Sensing (Prof. Steven Glaser, glaser@ce.berkeley.edu)

Potential Participants (to be updated during the formation of the collaboration):

University of California, Civil Engineering – Steven Glaser
Lawrence Berkeley National Laboratory, Geophysics Dept., Earth Sciences Division – Seiji Nakagawa, Larry Myer, Joe Wang
South Dakota School of Mines and Technology – William Roggenthen
Fermi National Laboratory – Chris Laughton
Free University of Berlin – Serge Shapiro
GeoForschungsZentrum Potsdam – Georg Dresen, Sergei Stanchits
University of Wisconsin – Herbert Wang
Penn State University – Derek Ellsworth
All other experiments and construction

Proposed Program

Traditionally sensors have been viewed simply as transduction elements. We have gone from mechanical devices to electromechanical devices, but they have all been macro scale in size. New advances in micro fabrication have provided us with micro electromechanical systems (MEMS). These are electromechanical devices constructed on a micron scale. Such integration of mechanisms and electronics is made possible by utilizing techniques mastered in integrated circuit fabrication. This allows for very small and inexpensive transduction elements, many with linearization, compensation, and digitization built in. We can make use of the many sensors developed by DARPA, the automotive and process industries, and they pay the steep development costs. A great many of these devices are directly applicable to variables we want to measure. Since these devices are small and inexpensive, we can imagine a very dense array of sensors providing us detailed measurements of rock mass properties that we have averaged into continuum approaches.

There has also been a revolution in information and communication technologies, allowing us to change how we view a "sensor." There are now available cheap, powerful, and low power microcontrollers (MCU), such as the TI MSP430 which has an integral 12 bit digitizer. We can now see a seamless integration of transducer and computational elements. This allows a "smart" utilization of the transducer as well as local integration and computation. If we follow the new paradigm of a dense array of thousands of sensors, there will be too much data to rationally handled. Local computation will allow the conversion of data into information, cutting the transmitted volume immensely.

The new type of sensor can also integrate large amounts of on-board memory so the information can be downloaded at convenient intervals. What is more, advances in communications technology allows us to integrate two-way wireless communications between an array of sensors and a central collection point. The transceivers are small, low-cost, and use relatively little energy. Depending on the demand, the devices can communicate from a few meters to many

hundreds of meters. Our experiments have shown that underground openings act as faraday cages, so transmission distance is enhanced as long as there is line of sight between stations.

We now have the new sensor paradigm – a seamless integration of transduction, computation, memory, and communication into a seamless embedded system – a Mote. The networks allow us to form the sensors as individual local information-gathering nodes, or integrate them into arrays to perform integrated tasks such as beam - forming and array processing. We also see that these sensor networks can be adapted to provide information from virtually every activity in DUSE at a relatively low additional cost. We therefore will not need additional space.

Space Requirement:
The sensor networks described in this LOI can be seamlessly integrated into every activity in DUSEL, so no additional space will be required.

TimeLine (to be coordinated with 4850 and DUSEL Development):

2006-2007 installation of measurement sites within 4850 laboratory
2008-2012 monitoring measurements at deep sites
2013- deep and large excavation monitoring

Collaboration Strategy:

We have mentioned a few collaboration partners in the opening segment of this LOI. This list is limited to the P.I.'s personal collaborations to date. In fact we would expect to work with all or most of the investigations to be made at DUSEL. The science of this proposal will be pushed by the many and diverse needs of the DUSEL community.

Example Experiments:

Integration of MEMS ionized radiation transducers into Motes

Measuring air velocity on multiple scales, including eddy behavior.

Development and proof-testing of MEMS-based strain measurement

Developing MEMS high-fidelity acoustic emissions sensors so as to install large arrays of microseismic monitors.

Smart convergence and tilt devices.

Miniature intelligent seismic stations

Etc.

Letter of Interest to the South Dakota Science and Technology Authority (SDSTA) for the Homestake Deep Underground Science and Engineering Laboratory (DUSEL)

Title: Cosmic Ray Studies

Potential Participants (to be updated during the formation of the collaboration):
Lawrence Berkeley National Laboratory, Earth Sciences Division – Joe Wang
Lawrence Berkeley National Laboratory, Nuclear Sciences Division – Kevin Lesko
South Dakota School of Mines and Technology –

Proposed Program
Scientific Focus: (1) The first research focus is on the attenuation and distribution of muon fluxes generated by cosmic ray interactions with the atmosphere and cosmic ray associated spallation products underground. This is necessary for physics experiments to determine the background and for potential development of a new geophysical tool by inversion to detect underground openings. (2) The second focus is on the dependence of gene mutation rates on radiation levels. This is to design and conduct microbiology tests to test the hypothesis that life originates in the earth interior and evolves with mutations from exposure to radiation from cosmic rays.

A sensor assembly is proposed to include a cosmic ray detector for 3-D mapping of muon flux, a radon detector (e.g, Alphaguard), and a relative humidity/temperature/pressure sensor. The assembly will be mounted on a wheeled-based platform with sufficient/expandable room for other aucillary counters (for neutron, beta, gamma), video/camera, seepage collectors, sample grabbers, data acquisition systems, wireless transmission systems, and geo-hydro-chemical-biological sensors. The assembly will be designed for quick deployment in the field, in anticipation of opportunities associated with reopening of existing mines, dewatering operations, rehabilitation operations, and underground excavation at Homestake.

Our colleagues in physics have the needs and know-how for building and deployment of cosmic ray detectors and coincidence counting with ancillary neutron, beta, and gamma detectors in large underground rooms for large-volume neutrino and other particle detectors. Radon counting is also an underground measure for radiation safety and health protections in both earth science and physics underground activities. Both earth scientists and physicists will work together on the sensor assembly to further enhance the synergies between these different disciplines.

The sensor assembly will be also designed for moisture sensing, visual observation, rock and water sampling, and other geo-hydro-chemical-biological sensors. We can study the potential for studying muon and radiation effects on biological mutation activities. In Gran Sasso National Laboratory of Italy, cultures of yeast and rat cells were studied both underground in GSNL and on the surface at the University of Rome. The cells grown in low background environment at depth are less protected from mutational damages. We plan to conduct basic studies on more primitive cells potentially surviving at depths, or sustaining by geogases such as hydrogen and methane from the earth interior, using the genome sequencing capabilities established at the Joint Genome Institute.

Facility Need: (1) underground locations at different depths and lateral extents to deploy sensor stations in the underground workings, (2) computational centers for inverse data processing and geophysical interpretations, (3) assembly facilities for equipment assembly, and (4) subsurface and surface laboratories for geomicrobiological and geochemical sample analyses.

TimeLine (to be coordinated with 4850 and DUSEL Development):

2006-2007 stationary muon measurements at 4850 level and other available upper levels
2008-2012 stationary muon and radiation measurements at lower levels
2013- muon and radiation measurements along the drifts with mobile units in all levels