

Determination of Water Levels and Stress Release in Rock During Dewatering of Homestake DUSEL

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Proposal to the South Dakota Science and Technology Authority

Funds Requested: \$25,068

Project Goals:

The goals of this proposal are 1) to install a pressure instrument at the 8000' level of the mine and utilize the data to determine the level and rate of water rise and fall based on gage pressure, and 2) attached strain gages to the dewatered rock face and utilize the measurements to determine stress release phenomenon related to unloading. Analysis of data will yield information on the hydrogeologic and engineering properties of a rock mass at depth and can aid in the design of large underground excavations.

Scientific and Engineering Justification:

An unprecedented opportunity exists in the Homestake DUSEL facility to study groundwater infilling and the subsequent effects on the rock mass from unloading during dewatering of the massive underground volume. Currently, water is filling the lower levels of the abandoned mine and hard data related to this rise is nonexistent. Information regarding the water level is known only from existing phone lines that become dead, which is inexact and cannot be used for scientific analysis. The safety for reentry parties will partially be based on knowing the exact elevation and location of the water. Once reentry has been achieved and dewatering of the lower flooded levels begins, the rock mass will experience stress release both from fracture drainage and capillarity seepage. Although rock stress is a relatively well understood phenomenon in underground excavations, the effect from a large underground volume (drifts, shafts, and in-situ rock mass) becoming saturated and then dewatered is not known. The total depth of the mine (8000') and the submerged depth (~2000 + feet) offer a unique one time only opportunity to study the behavior of a rock mass volume exposed to these extreme conditions and then released. Thus, there is a need to acquire accurate data regarding the water rise and fall and its subsequent effect to the rock mass. These data can become a critical component to the development of a mine reentry plan for both safety and scientific reasons.

Proposed Experiments:

Experiments to determine the water level are relatively simple and inexpensive. They include

the installation of a pressure gage and a datalogger to record the data. For this experiment, we plan to utilize the No. 6 winze as soon as access to the 4850 level is available. A pressure sensitive gage will be lowered to a depth below the water level and connected to a datalogger. A 300 psi gage will have a limit on the depth below the water line to approximately 690 feet. Thus, it will be necessary to raise the gage as the water level continues to rise. Using the measured water pressure and the known level at the top of the winze, the elevation of the water will be determined.

Power to the datalogger and equipment will be derived from a deep-cycle marine battery located at the site. Pressure measurements will be stored at as fine of a resolution (such as 1 minute intervals) as allowed by the internal storage device on the data logger. Data will be collected monthly from the logger. As soon as access is available to the 6800' level, the experiment can be transferred into the No. 7 shaft so as not to interfere with work that may be continuing in the No. 6 winze. This plan is dependant upon safety of reentry and will remain fluid in design to complement other ongoing activities.

Alternatively, once the pressure gage has been installed and connected to the data logger, signals could be transmitted real-time to the surface via a wire connection. This would allow real-time surface monitoring of the water level in the mine as well as restricting the number of visits to the site to lower the gage.

As dewatering begins, data on the falling level will be collected in the reverse, i.e. as the water level reaches the gage, it will be lowered deeper into the water. From the data readouts, the exact level of the water will be determined as it is pumped out of the mine.

Data analysis on the rising water levels will be performed on an incomplete data set since the water has been rising since about 2003. Analysis from the falling water levels will be performed on a complete data set. There are at least 3 models that can be used to explain the collected data: 1) the rock is completely impermeable and the rising and falling water levels simply reflect the rate at which adits, shafts, and backfilled chambers are filled and subsequently drained, 2) the rising water reflects the recovery of a well that has been pumped, i.e., the classic mirror image of a drawdown curve of a pumped well in a permeable media; conversely, the falling level during the dewatering phase can be modeled as the drawdown of a pumped well, and 3) the rate of water rise and lowering is governed by hydrogeologic parameters in the schist, quartzite, and intrusive rocks in the form of fissures or hydraulic conduits.

In addition, as access to previously submerged rock mass is available, strain gages will be immediately attached to the rock face in an attempt to record any unloading phenomenon related to the rock stress release patterns. We intend on 'chasing' the falling water level and acquiring stress release measurements from the moment a rock face becomes exposed to the point in time where the rock mass has completely relaxed, allowing access availability. Analysis of the strain data will result in the measurement of stress the rock mass was exposed to from the rising water and potential mechanisms that were engaged to account for the increased stress, such as fracture spacing closure, transference of matrix stress to pore water stress, etc. Data will also yield the amount and rate of stress release related to the dewatering. These values have the potential to

yield new and valuable information on bulk rock properties in a deep underground setting and can be beneficial to engineers as design and construction of large openings proceeds in DUSEL.

Infrastructure Requirements and Impact on Other Users:

There are no infrastructure requirements for these experiments other than access to the No. 6 winze from the 4850' level. The impact to others should be low to none. A pressure transducer will be lowered in the No. 6 winze to some point below the water level and connected to a datalogger located near the winze on the 4800' level. A deep-cycle marine battery will supply the power, unless there is direct access to 110 VAC. The space required for the data logger and battery is about 1 m³. Both the data logger and battery will be enclosed in waterproof housings and are able to operate in the ambient temperature regime of the mine.

During the dewatering phase, strain gages will be attached to the exposed rock wall and measurements recorded using mini-data loggers (circuit boards designed and built for that purpose) that will be located at each site. These will be housed in water proof containers and placed on the floor of the drift and marked for easy of identification. Weekly visits to each site will be utilized to collect the recorded data and to replace batteries as needed.

Readiness for Deployment – technology:

The technology is relatively simple: a standard pressure gage, wire, data logger, power supply, strain gages, and mini-data loggers. The project PI has a Campbell CR-10 data logger and housing from the Department of Geology & Geological Engineering at SDSM&T that will be used. The pressure transducer, wire, and power supply (battery or 110 VAC) would need to be acquired for the water level monitoring. During dewatering, standard commercially available strain gages will be acquired and attached to the rock to measure both lateral and axial strain. Each location will have a dedicated mini-data logger to record the measurements. Data will be collected by connection to a laptop PC at specified intervals.

Readiness for Deployment – effort and funding:

There is no current funding for this project. The PI has some of the equipment and the balance will need to be acquired through this grant proposal to the SDSTA or another agency. Estimated costs for this projects included on the attached budget sheet and are best estimates at the time of preparation of this proposal. Costs to be incurred by conducting these experiments are low in comparison to the quality and value of the results that are obtainable.

Environment, Safety, and Health:

All of the experimental apparatus will be housed in water proof enclosures that are marked for easy identification. These packages will be set along the side of the drift out of the way from others that may be using the same access way. None of these instruments pose a threat to environmental condition in the mine nor do the pose any adverse health effects to personnel working with or near to them.

UNDERGROUND LABS and SPACE

Experiment or Program Name: Determination of Water Levels and Stress Release in Rock During Dewatering of the DUSEL Underground Facility

Principal Investigator or Contact Person: Dr. Larry D. Stetler, SDSM&T

Brief Summary: Install a pressure gage at the bottom of the mine to monitor water levels during the infilling and dewater phases of the lab. During dewatering, install strain gages on the rock face to determine stress release properties in the rock.

1. Modules or Functional Uses: _____

2. General Information:
Probable Start (year) 2007
Duration 1 year or until dewatering stress release is non-detectable _____
Space (Volume) L x W x H (m³) along drift edge a maximum of 1 m³
Depth/Shielding (mwe) N/A
Occupancy (Peak/Avg) 1/1 _____

3. Mechanical
Temperature X Uncontrolled 20 +/- 5 deg. C (Air Cond.)
 other: _____
Humidity 50% +/- 20% X Uncontrolled other: _____
Air Filtration/Recirculation (describe): N/A

 Low-Radon Background (mBq/m³) N/A
Special Fume Exhaust requirements: N/A
Plumbing
 Industrial Hot/Cold Water
 Potable Hot/Cold Water
 High Purity/DI Water
 Steam/Condensate return
 Safety Shower/Eyewash
 Compressed Air
Cylinder Gases:
 Inert
 Flammable
 Toxic
 Carbon Dioxide

 Nitrogen Gas
 Liquid Nitrogen
 other: _____

4. Electrical
Approx. total power (kW) (Peak/Avg.) _____
Other electrical needs (describe): 110 VAC at No. 6 winze site

5. Chemicals:
 Bases
 Acids
 Solvents
 Radioisotopes
 Chemical inventory storage
 Chemical waste storage
 Biological storage
 Radioisotope storage
 Cryogenics
 Hazardous/Special Handling:

Other chemicals (describe):

6. Architectural: Special needs:
Floors _____
Walls _____
Partitions _____
Clean room _____
Storage _____

7. Special Facilities:
Material Access _____
Access Schedule _____
Cleanliness _____
Security _____
Data Communication:

8. Laboratory, Machine Tools, and Other Equipment:

9. Other Needs or Requests:

SDSM&T PROPOSAL BUDGET

Determination of Water Levels and Stress Release in Rock
 During Dewatering of Homestake DUSEL
 Period: 2007 upon DUSEL 4850 lab opening

Estimated costs and are not approved.

	College Fiscal Year	Effort in Man-Mo Acad Sumr		Monthly Salary Rate	First Period 6/1999-6/2000
A. SENIOR PERSONNEL					
1. Larry Stetler - PI	2007	0.000	1.000	\$7,493	\$7,493
Subtotal Senior Personnel					\$7,493
B. FRINGE BENEFITS:					
1. Staff, 22.0 % of salaries and wages					\$1,648
Subtotal Fringe Benefits					\$1,648
TOTAL SALARIES, WAGES, AND FRINGE BENEFITS:					\$9,141
C. TRAVEL					
1. Domestic					
a. To DUSEL					
1. Mileage: 20 trips at 100 mi/trip: \$0.40/mi					\$800
TOTAL TRAVEL					\$800
D. CAPITAL EQUIPMWNT					
a. 300 psi pressure transducer					\$3,000
b. 3500' of power wire at \$0.5/ft					\$1,750
c. battery					80
d. strain gages					\$2,000
e. mini-data loggers (built at SDSM&T)					\$1,500
TOTAL CAPITAL EQUIPMENT					\$8,330
E. SUPPLIES AND MATERIALS					
a. misc.					\$1,000
TOTAL SUPPLIES AND MATERIALS					\$1,000
F. TOTAL DIRECT COSTS:					\$19,271
G. FACILITIES AND ADMINISTRATION - 44% of Total					
Salaries and Wages					\$3,297
H. TOTAL FUNDS REQUESTED					\$22,568
I. ALTERNATE LIVE READ-OUTS AT SURFACE					
a. 5000' of wire at \$0.5/ft					\$2,500
J. TOTAL FUNDS REQUESTED FOR LIVE READ-OUTS INCLUDED					\$25,068