An Ore Deposit from Underside Up: A Collaborative Deep-Underground Lab

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In an unprecedented opportunity, geoscientists will collaborate with physicists, engineers, and microbiologists in the design of a Deep Underground Science and Engineering Laboratory (DUSEL, www.dusel.org). Deep underground labs are a necessity for physicists performing experiments requiring shielding from cosmic radiation. Well-known facilities such as Kamioka in Japan and Gran Sasso in Italy are presently performing physics experiments, and a neutrino observatory is under construction at the SNOLab in Inco’s Creighton Ni mine near Sudbury, Canada. Perhaps the most famous underground experiment led to the detection of neutrinos. Other pressing physics experiments in need of a deep underground facility focus on neutrino mixing studies, dark matter searches, nucleon decay, and astrophysics.

Building on an initiative emanating from the physics community, the U.S. National Science Foundation (NSF) has acknowledged the need for a new lab in the United States to house this next generation of experiments. NSF is organizing the initiative and funding the design stages, and has expanded the proposal solicitation to include geoscience, biology, and engineering. The lifespan for the facility will be at least 30 years, and the cost—a cool $300-$400 million for construction and initial experiments. The facility will employ perhaps 200 persons and maintain an annual budget estimated at $50 million.

Initially, eight sites in the United States were under consideration. Not surprisingly, a number of sites were associated with mines, where partial entry underground was already available. The two finalists are the operating Henderson mine, site of the world-renowned Climax-type Urad-Henderson porphyry molybdenum orebodies, and the Homestake mine, site of an historical gold mine. Both sites offer unique opportunities for geologists and biologists, whereas the experimental needs of the physicists call only for a deep underground excavation with less regard for host rock type. Of course, three-dimensional expanses of competent host rock without inhomogeneities that could introduce rock failure are critically important to the engineering, construction, and safety of the facility. An array of political, economic, and logistic considerations will play a role in the decision between Henderson and Homestake. But, because many geology (and biology) experiments are site specific, so too, will the proposals for experiments from the geoscience community be a factor in the decision. The deadline for submittal of each site’s conceptual design to NSF is June 23, 2006. One site will be selected to prepare a full technical design, which must then be approved by NSF’s Science Board and funded by Congress. If funded, construction could begin as early as 2009.

The Henderson site is being developed by the HUSEP collaboration (Henderson Underground Science and Engineering Project). Eight principal investigators (Co-PIs) from five universities advanced the HUSEP proposal, representing interests in physics, engineering, geoscience, biology, and education and outreach. These Co-PIs and their working groups collectively form the broad collaborative teams that define the scientific core of HUSEP. They are supported by members of the Henderson mine staff, CNA Consulting Engineers, and the Arapaho Project, a local nonprofit science and engineering outreach group long interested in collaborative use of the Henderson mine. The mine and surface property are owned by Climax Molybdenum Company, a subsidiary of the Phelps Dodge Corporation. After a projected 20 years more of mining operation, the company is poised to be part of a history-making mine closure that will permit continued use of the underground infrastructure for scientific studies.

Judith Hannah (jhannah@warnercnr.colostate.edu), head of geosciences at Colorado State University, is a Co-PI on the HUSEP proposal to NSF and represents all HUSEP Geoscience. Four working groups have been established under the geoscience banner, including “Ore Geology, Magmatic-Hydrothermal Processes, and Petrochemistry” (Holly Stein, working group convener, hstein@warnercnr.colostate.edu). This team bears the abbreviated name of OREPETS, and includes isotopic dating and tracer studies as well. The working groups for various geoscience subdisciplines will engage international institutions and leading scientists to carry out key studies that depend on access to the deep underground. At present, the OREPETS working group has accepted proposals from a global team of leading geoscientists from eight institutions: CODES at the University of Tasmania, GFZ in Potsdam-Germany, University of Oklahoma, Colorado School of Mines, Geological Survey of Norway, CREGU in Nancy-France, University of Western Australia, and Colorado State University.

The proposed DUSEL at Henderson will include experimental sites (camps) at several levels, with the deepest 7,400 ft (2260 m) below the surface (Fig. 1). To accommodate a state-of-the-art underground neutrino observatory or UNO, the Central Campus will include the largest ever underground excavation, 60 × 60 × 180 m. Construction of these campuses calls for drifting inclines that switch back beneath the Henderson orebody. Since mining companies are focused on profit, few drill holes penetrate very far into barren rock beneath an orebody. A DUSEL at Henderson lends an obvious and unprecedented opportunity to look beneath a well-defined and well-studied molybdenum orebody. As part of the design process, the geoscience community will have the chance...
to propose additional drifts and drill holes from the deep ramps (Fig.1) to probe the underpinnings of one of the world’s giant porphyry-style Climax-type ore deposits.

This unique opportunity to view the deep architecture of a Climax-type magmatic system will expose the transition from the magmatic to the hydrothermal environment. In total, from the top of Red Mountain to the deepest proposed ramps below the Henderson orebodies, a nearly continuous transect through a Climax-type ore system will be available for study, via underground access to the Henderson orebody, existing drill core, and proposed drilling and excavation via the HUSEP proposal. This transect includes the Urad orebody (preserved in drill core) in the upper part of the volcanic neck that vented through Red Mountain. From the lower campus, deep drill holes that reach an additional 3,000+ ft (900+ m) into the magmatic system that created this orebody are also possible, extending the vertical view to more than 10,000 ft (3050 m). Such an opportunity to view about 2 miles (3 km) of vertical exposure and core has never presented itself to the ore geology community, and breakthroughs in our understanding of how Climax-type molybdenum deposits develop are a certain outcome. This new understanding can be applied to other porphyry-style deposits, since all share physical characteristics (e.g. stockwork veining) created by similar processes in dynamically evolving shallow level intrusions emplaced into brittle crust.

The OrePETs working group is soliciting participants and ideas for studies that would benefit from or make full use of the vertical and three-dimensional exposures afforded through HUSEP. Top scientists from both United States and international institutions are welcome to propose geoscience studies for the DUSEL, and will be considered for collaborating partners. If the DUSEL is funded, the initial award will support construction of the facility, synconstruction mapping and sampling, and an initial round of experiments in physics, geoscience, biology, and engineering. For more information, please visit the HUSEP website (http://ale.physics.sunysb.edu/husep/), or contact the authors directly.

**FIGURE 1.** Schematic of possible layout for the DUSEL (Deep Underground Science and Engineering Laboratory) at Henderson, Colorado. Levels and elevations shown are feet above sea level.