Henderson DUSEL Capstone Workshop
Stony Brook University, New York
May 5, 2006

Ore Geology, Magmatic-Hydrothermal Processes, Petrochemistry

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**Ore Geology, Magmatic-Hydrothermal Processes, Petrochemistry**

**“OrePets”**

- Progress report for OrePets
- Major research centers – Who’s on board
- Scientific content – Who’s doing what
Progress in OrePets (Nov 20 2005 to May 5 2006)

☑ Contacted major institutions and secured participants for OrePets that are active and globally known researchers (logos)

☑ Compilation and distribution of landmark papers on Urad-Henderson relating to OrePets geoscience

☑ Publication on DUSEL-HUSEP in SEG Newsletter (Jan 2006)

☑ Constructed DUSEL-HUSEP website on AIRIE home page
  [airie.warnercnr.colostate.edu]

☑ Evaluated UNO-1 (DUSEL-001) - 5-page report on ore potential beneath Harrison and Red Mountain (Shannon, Hannah)

☑ Exchanges with David Lambert, NSF

☑ Will look at drill core for DUSEL-002 in May, hole nearly complete
Major Research Centers – HUSEP

Ore Geology, Magmatic-Hydrothermal Processes, Petrochemistry

OrePets Team

(1) Colorado School of Mines, Golden, USA (Jim Shannon)
(2) AIRIE Program, Colorado State University, USA (Holly Stein, Judith Hannah)
(3) University of Oklahoma, Norman, USA (David London)
(4) Arizona State University, Tempe, USA (Ariel Anbar)
(5) Indiana University, Bloomington, USA (Edward Ripley)
(6) New Mexico Tech, Socorro, USA (Shari Kelley)
(7) CREGU, UMR CNRS, Nancy, France (Jean-Louis Vigneresse)
(8) GFZ, Potsdam, Germany (Rolf Romer, Volker Lüders, Birgit Plessen)
(9) Geological Survey of Norway, Trondheim (Bernard Bingen, Bart Hendriks, Holly Stein)
(10) Tectonics Research Centre, University of Western Australia (Frank Bierlein)
(11) CODES, University of Tasmania, Australia (Anthony Harris, David Cooke, Ross Large)
OrePets Expertise and Science

- **Ore Geology, Climax-type porphyry Mo deposits**
  - Jim Shannon, Holly Stein

- **Magmatic-Hydrothermal Processes, Transitions**
  - Anthony Harris, David Cooke, Holly Stein, David London, Ed Ripley

- **Granites, Pegmatites, Emplacement, Cooling, Uplift**
  - David London, Jean Louis Vigneresse, Bart Hendriks, Shari Kelley

- **Petrochemistry, Isotopic Dating and Tracer Studies (+ CNOSH)**
  - Rolf Romer, Judith Hannah, Holly Stein, Bernard Bingen,
    Bart Hendriks, Frank Bierlein, Ed Ripley, Volker Lüders, Birgit Plessen

- **Mo Isotopes, Redox and Biogenic Processes, Rayleigh Fractionation**
  - Ariel Anbar, Judith Hannah, Holly Stein
Why do our proposed OrePets studies require a DUSEL - deep underground excavations - for their success

What kind of science can we do in an underground facility that we cannot do otherwise - limitations of surface and drill hole working environment

(1) What are the pressing questions?
(2) What samples would you collect and why?
(3) Why is vast vertical-horizontal access essential?

Stony Brook Capstone Workshop Meeting, May 4-7, 2006
Most mines around the world recover ore from a vertically limited segment of a porphyry deposit.

Henderson is already known for its vertical extent, from mineralized volcanic neck to sub-volcanic stocks (6000 ft).

High resolution studies on a real-life example, young and vertically intact!
Henderson mine together with DUSEL excavations will permit oriented sampling and a view of the underpinnings of a major ore-forming system.

... there is no profit for a company to drill barren rock associated with an ore body to understand its making ...
SCIENTIFIC CONTENT – Anthony Harris and David Cooke

Construct space-time profile for magmatic-hydrothermal system intimately associated with silicic magmatism, highlighting evolution with time, and metal zonation (Mo, Sn, Cu, W, Bi, Ag, Zn, Pb, Au)

Evolution of ore-fluid across the magmatic-hydrothermal transition – tracing magmatic fluids from source to sink

Significance of research lies in spatial, temporal and chemical understanding of magmatic-hydrothermal systems
Effect of partial melting on geophysical imagery (seismic, electric, magnetic)

Calibration of porosity-permeability measurements to fill gap between lab scale and kilometer scale measurements

Degree of crystallinity and temperature of incoming magmas

Relation of temperature, volume, shape, and size of intrusion at time of emplacement

Quantify zonation of minerals (K-feldspar and plagioclase) as a monitor of successive magma injections
DUSEL-HUSEP fits well with a new internal GFZ initiative --
Behavior of Li, B, and Cl in fluid-fluid and fluid-rock systems

Their initiative utilizes a low, medium, and high temperature system –
High T study planned for Climax, but will change to Henderson

- Pb-Sr systematics
- Fluid composition through time (C, O, N, dissolved elements)
- Li-B-Cl systematics (isotopic fractionation during fluid-fluid and fluid-rock interaction and speciation of elements in the fluid and during fluid unmixing)
- Dating ores (e.g. fluid inclusion dating, huebnerite dating)
Overarching Science for OrePets

(1) What physical conditions control emplacement of shallow-level magmas?
   - What are the physical-chemical conditions of magmas at the time of intrusion? How does crystallization proceed? What controls pluton geometry? **EMPLACEMENT**

(2) What triggers the magmatic to hydrothermal transition?
   - How are metals transferred from silicate melt to a vapor-rich medium that breaks through the lithostatic load? What initiates sulfide deposition? **TRANSPORT**

(3) How long does it take to create a major porphyry-style ore body?
   - What is the age and duration of magmatism-mineralization at the ore body scale and in the context of the regional magmatic-tectonic temporal history? **TIME SCALES**

(4) Where do metals ultimately come from and tracing their source?
   - Do metals originate in the crust, from the mantle wedge, asthenospheric mantle, or from subducting or foundered slab material? Does the full metal endowment at a deposit have the same origin? What terminates the ore-forming process? **SOURCES**
Comparative Chronology at Urad-Henderson ~

Dating discrete episodes of stockwork mineralization using Re-Os dating of molybdenite

To be compared with crystallization ages for magmatic stocks using U-Pb dating of zircon and other suitable accessory minerals

To be compared with time-space cooling ages for the full magmatic-hydrothermal system using $^{40}\text{Ar}/^{39}\text{Ar}$ dating of micas (muscovite and biotite) and potassium feldspar

To be compared with uplift rates determined by fission track dating of apatite and other suitable minerals

To be compared with cooling and uplift rates using (U-Th)/He thermochronometry
Comparative Chronology at Urad-Henderson ~

Timing, emplacement, evolution, duration, source, cooling history of the entire magmatic-hydrothermal system

Intercomparison of four geochronometric techniques
Why Henderson should become the DUSEL ~

- Henderson is a pristine deposit, ideal for examining first-order processes in porphyry-style, granite-related mineralization site.
- Henderson is the perfect venue to address timely topics in OrePets (emplacement, transport, timing, duration, source) science.
- Molybdenum is a commodity receiving intense exploration interest (can't hurt the cause!) global relevance.
- Offers opportunity to REALLY link industry-academic interests broader impacts, application.
- Offers opportunity for multi-use with industry hand-off to long-term research facility broader impacts, sustainability.
- Offers opportunity for hands-on three-dimensional geologic learning broader impacts, education.
Let's Build a DUSEL at Henderson!