NNWPO PRESENTATION TO THE NUCLEAR WASTE TECHNICAL REVIEW BOARD

SUBJECT: Mineral Resource Potential, Yucca Mountain Area, Nevada

DATE: June 26, 1989

PRESENTER: Lawrence T. Larson, Ph.D.

AFFILIATION: Professor and Chair,
Department of Geological Sciences,
Mackay School of Mines, University of Nevada at Reno

TELEPHONE: (702) 784-4002
MAIN ISSUES

» IS THERE POTENTIAL FOR MINERAL RESOURCES?

*Potentially adverse conditions* [10 CFR 60.122 (2) (c), 10 CFR 960.4-2-8-1 (c) (1)]
Presence of, or indications of mineral resources, identified or undiscovered, ...

» WILL THERE BE HUMAN INTERFERENCE AT YUCCA MT. IN SEARCH FOR MINERAL RESOURCES?

*Safety Analysis Report* [10 CFR 60.21 (c)]
Requires identification and evaluation of natural resources ..., the exploitation of which could affect the ability of the geologic repository to isolate radioactive wastes...

EXISTING DATA ARE INSUFFICIENT
SUMMARY

1) YUCCA MTN. IS WITHIN AN AREA OF WIDESPREAD BASE/PRECIOUS METAL MINERALIZATION

2) CURRENTLY THERE IS INTENSE MINERAL EXPLORATION AND DEVELOPMENT IN ALL AREAS SURROUNDING YUCCA MTN. THAT ARE OPEN TO MINERAL ENTRY

3) EXISTING INFORMATION IS INADEQUATE TO EVALUATE THE POTENTIAL FOR MINERAL RESOURCES IN YUCCA MTN. OR IMMEDIATE VICINITY

4) IT IS IMPOSSIBLE AT PRESENT TO RULE OUT THE PRESENCE OF MINERAL DEPOSITS IN YUCCA MTN.

5) HISTORICALLY, WHERE KNOWN OR PERCEIVED MINERALIZATION EXISTS, EXPLORATION/HUMAN INCURSION TAKES PLACE
NEVADA Au+Ag PRODUCTION
ACTIVE Au-Ag MINES NEAR YUCCA MOUNTAIN
(15 - 40 kilometers of the proposed repository)

Au RESERVES

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<th>Mine</th>
<th>Ounces</th>
<th>Approx. 1988 $$</th>
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<td>GOLD BAR MINE</td>
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<td>BOND-BULLFROG MINE</td>
<td>3,200,000</td>
<td>1.3 billion</td>
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<tr>
<td>GEXA MINE</td>
<td>250,000</td>
<td>100 million</td>
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COMMON GEOLOGIC FEATURES OF NEVADA ORE DEPOSITS

» ROCK ALTERATION  
  e.g., Silicification, Adularization, Argillization

» GEOCHEMICAL SIGNATURE  
  e.g., Au, Ag, As, Hg, Sb, Tl, Mo, Zn, Ba, F

» FAULTS, BRECCIAS

» FELSIC ("GRANITIC") DIKES, PLUGS, SILLS, AND STOCKS

» LATE-STAGE BARITE ± FLUORITE VEINS
MINES, PROSPECTS, AND AREA OF HYDROTHERMAL ALTERATION NEAR YUCCA MOUNTAIN, SW NEVADA VOLCANIC FIELD

TIMBER MTN. CALDERA COMPLEX

CRATER FLAT CALDERA COMPLEX
FEATURES OF MINES/PROSPECTS IN AREA OF YUCCA MTN.

» MINERALIZATION TYPES:
  DISSEMINATED, VEINS, SKARN
  Au-Ag, Hg, Cu-Zn-Mo-W, F, Ba

» HOST ROCKS:
  DACITIC TO RHYOLITIC VOLCANIC ROCKS
  PALEOZOIC SEDIMENTARY ROCKS

» HYDROTHERMAL ALTERATION:
  SILICIFICATION
  ADULARIA (HYDROTHERMAL POTASSIUM FELDSPAR)
  ARGILLIZATION ± SERICITE ± ALUNITE

» CHEMICAL SIGNATURES
  ELEVATED CONCENTRATIONS OF (ONE OR MORE):
  Au, Ag, Ba, As, Sb, Pb, Cu, Zn, Mo, Hg, F

» FAVORABLE STRUCTURES:
  FAULTS, BRECCIAS, CONTACTS

» PRESENCE OF DIKES, PLUGS, STOCKS
MINERAL POTENTIAL OF YUCCA MTN. AREA

» FAVORABLE GEOLOGIC ENVIRONMENT FOR HYDROTHERMAL MINERALIZATION
  
  REPEATED MAGMATIC AND VOLCANIC ACTIVITY
  ABUNDANT FAULTS, COMPLEX STRUCTURAL HISTORY

» PRODUCING MINES:
  
  GOLD BAR MINE
  STERLING MINE
  DAISY MINE

» MINES IN DEVELOPMENT STAGE:
  
  BOND-BULLFROG MINE
  GEXA (MOTHER LODE)

» PROSPECTS WITH FAVORABLE GEOCHEMISTRY/GEOLOGY:
  
  CORDEX-BERMUDA TRIANGLE (BARE MTN.)
  TRANSVAAL
  THOMPSON MINE (NW YUCCA MTN.)
  CALICO HILLS (NTS)
  WAHMONIE (NTS)
  MINE MTN. (NTS)
GENERALIZED SECTION SHOWING POSSIBLE DISTRIBUTION OF HYDROTHERMAL ALTERATION, YUCCA MTN.

WEST

Solitario Canyon Fault
Yucca Crest

Bow Ridge Fault
Fran Ridge

EAST

0
500
1000
1500
2000
Depth in Meters

Al, K-spar, Mont, Zeol, FeOx, MnOx, Fl, Ca, Qtz, Py, Il, Chlor

breccia

Tp  Paintbrush Tuff
Tc  Crater Flat Tuff
Ti  Lithic Ridge Tuff and older volcanic rocks
Pz  Paleozoic sedimentary rocks
FEATURES PRESENT AT YUCCA MTN. PERTINENT TO MINERAL POTENTIAL

- AREALLY EXTENSIVE HYDROTHERMAL ALTERATION IN SUBSURFACE HYDROTHERMAL MINERAL ASSEMBLAGES INCLUDE:
  - Quartz, Illite, Albite, K-feldspar, Chlorite, Calcite, Barite, Pyrite (Zeolites are in part hydrothermal, not diagenetic)

- VERY LIMITED DATA SHOWS ELEVATED F, Ba, Zn, Au? IN SUBSURFACE AND ELEVATED As, Hg, Au, Mo, Zn, Ag AT SURFACE:
  - N. Yucca Mtn. (Prow Pass, Claim Canyon), Trench 14

  SUGGEST THAT HYDROTHERMAL SYSTEM(S) WAS METAL-BEARING

- AGE OF HYDROTHERMAL ACTIVITY IN YUCCA MTN.: 11-10 Ma

  SAME AGE AS HYDROTHERMAL ACTIVITY AND MINERALIZATION IN BULLFROG HILLS, N. BARE MTN., TRANSVAAL, CALICO HILLS, MINE MTN.?

- VOLCANIC ROCK UNITS OF YUCCA MTN. HOST Au-Ag ORE AT GOLD BAR, BOND-BULLFROG, CORDEX PROSPECT, GEXA(?)

- PRESENCE OF NUMEROUS FAULTS AND BRECCIAS: HIGH-PERMEABILITY CHANNELS FOR HYDROTHERMAL FLUID CIRCULATION
CONCLUSIONS

» RECENT DISCOVERIES AND NEW GEOLOGIC AND CHEMICAL DATA SUGGEST GREATER MINERAL POTENTIAL THAN PREVIOUSLY RECOGNIZED.

» HISTORIC AND CURRENT HIGH LEVELS OF EXPLORATION ACTIVITY IN SW NEVADA AND PRESENCE OF WIDESPREAD HYDROTHERMAL ALTERATION AND MINERALIZATION ASSURE HUMAN INTERFERENCE IF NTS AREA BECOMES ACCESSIBLE TO PUBLIC.

» EXISTING DATA DO NOT EXCLUDE POSSIBILITY OF ECONOMIC MINERALIZATION IN OR NEAR YUCCA MOUNTAIN.

» RESOLUTION OF THIS ISSUE REQUIRES FUNDAMENTAL GEOLOGIC, CHEMICAL AND GEOPHYSICAL INVESTIGATIONS CONDUCTED FROM EXPLORATION PERSPECTIVE.
### TRENCH 14

(PPM)

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Analyses by ICP methods
CLAIM CANYON AND NORTHWESTERN YUCCA MTN

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Analyses by ICP methods
VITA

LAWRENCE T. LARSON

GENERAL DATA

Date and place of birth: December 3, 1930
Waukegan, Illinois
Marital Status: Married
Three adult children

ADDRESSES

Office - Department of Geological Sciences
Mackay School of Mines
University of Nevada
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Home - 340 Sparrow Way
Carson City, NV 89701
Phone: (702) 849-0587

PRESENT POSITION

Professor and Chairman - Geological Sciences (Geology, Geological Engineering, Geophysics, Geochemistry, Hydrology)

EDUCATION

B.S. - Geology (highest honors), University of Illinois, Urbana, 1957.
M.S. - Geology, University of Wisconsin, Madison, 1959.

PUBLICATIONS

See appended listing.

SCHOLASTIC HONORS, FELLOWSHIPS, ETC.

University Honors; Bronze Tablet - University of Illinois
Wisconsin Alumni Research Fellow - 1957-1959
Union Carbide Ore Company Research Fellow - 1959-1961
Phi Kappa Phi
Participant, NSF-AGI studies in Brazil, summer, 1966
Participant, NSF Institute, Sulphide Phase Equilibria, 1967
Fulbright Senior Professor, 1985-86
GRANTS AND CONTRACTS

National Science Foundation, 1969-1970. $12,000
Bendix - U.S. Dept. of Energy, 1977-1978. $125,000
Southland Royalty Corp. - U.S. Dept. of Energy, 1979-80. $154,000
Dept. of Interior, Office of Surface Mining, 1980-1983. $69,000
State of Nevada, Evaluation of Proposed Yucca Mountain Repository, Task III, 1988. $100,000
NATO, Division of Scientific Affairs, 1989. 390,000 Belgian Francs

COLLEGE/UNIVERSITY COMMITTEES

Faculty Development Committee, 1987-present
Sabbatical Leave Committee, 1982-85
Promotion and Tenure Committee - Univ. of Nevada, 1979-81
Ad hoc University Academic Master Plan Committee, 1980-81
Hydrology-Hydrogeology Interdisciplinary Committee, 1976-present
Mackay Mineral Research Institute Advisory Committee, 1979-present
Water Resource Center Technical Advisory Committee, 1977
Ad hoc Committee on Role and Function of Department Chairpersons, UNR, 1978-80
Governor's Committee on MX Missile siting in Nevada, 1981
Others

UNIVERSITY PROFESSIONAL RESPONSIBILITIES

1975-present:

Chairman and Professor of Economic Geology, Mackay School of Mines, University of Nevada, Reno, NV 89557. Responsibilities include direction and administration of the Department of Geological Sciences with a full and part-time faculty of 18 to 20 professionals. Department student enrollment is composed of approximately 70 undergraduate majors and 110 graduate students pursuing degrees in geology, geological engineering, geophysics, geochemistry and hydrogeology/hydrology. From 1975-1979 geography (three faculty) degrees were also given in the Department. Administrative tasks include budget, course offerings and scheduling, graduate student admission, committee assignments, daily operation, faculty evaluation, recommendation for promotion and tenure, etc. Teaching responsibilities include graduate and undergraduate courses in economic geology, mining and exploration geology (including legal and environmental aspects of exploration...
and mining), ore petrology and geochemistry. Additional significant teaching tasks include supervision of graduate student research and the teaching of individual tutorials and seminars in the area of ore deposits. Since 1976 I have also served as administrator and/or principal investigator of funded research projects resulting in published research articles (see bibliography and page 1, vita).

1961-1975:
Assistant (1961-1966), Associate (1966-1971) and Professor (1971-1975) of Geology, University of Tennessee, Knoxville, Tn. Responsibilities included teaching, research and graduate research supervision. Courses taught included Principles of Economic Geology; Metallic Mineral Deposits; Non-metallic Mineral Deposits; Geology of Fuels; Ore Microscopy; Regional Studies in Economic Geology; Introductory Physical Geology; Geology for Engineers, and various seminars in Sulphide Phase Equilibria; Massive Sulphide Deposits; Mississippi Valley Pb/Zn deposits; Geochemistry of Ore Forming Solutions, Metallogenic Provinces, etc. Directed the graduate research leading to two Ph.D. and 16+ M.S. degrees. Served on a number of Departmental, College and University committees. Performed publishable research (see bibliography).

CONTINUING EDUCATION/PREPARATION

1981-1982:
American Council on Education - Departmental Leadership and the Academic Chairperson. Two 4-day intensive training sessions by the ACE on planning management and leadership. Decision making, budgets, responsibilities, grievances, faculty evaluation(s), counseling, etc.

PROFESSIONAL ASSOCIATIONS

Fellow - Geological Society of America
Member - Society of Economic Geologists
Canadian Institute of Mining and Metallurgy
Northwest Mining Association
IAGOD - International Association on the Genesis of Ore Deposits
AGID - Association of Geologists for International Development
American Institute of Mining, Metallurgical and Petroleum Engineering
- Society of Mining Engineers
Member and Chairman (1978-79) Geochemical Committee
Member - Executive Committee, SME, 1981
Member - Jackling Award Committee, SME, 1980
Non-Academic Professional Activities

ABET - Visitor, Geological Engineering Programs, 1987- .
Fulbright Senior Professor, 1985-86.
General Chairman, Geological Society of America, 1984 Annual Meeting
Invited Speaker, Peruvian Geological Congress, July 1983
Administrator and Principal Investigator, USBM Grant to investigate Geochemical Exploration for precious metals using Fe/Mn oxide joint coatings, 1980-83.
Member, NSF Post Doctoral Fellowship Review Committee, 1982
Consultant - Sabine Production Company, 1980, 81, 82
Consultant, Sandia Laboratories, 1981, 1982
Consultant - Westcoast Oil and Gas, Summer 1981
Consultant - United Nations Dev. Program - Turkey. Zinc exploration and evaluation of resources and Turkish government exploration efforts. 1979
Consultant - Union Carbide Nuclear Corp-Oak Ridge National


Consultant - Several firms such as American Zinc, U.S. Borax and Chemical, Grealbeal Interests, etc. - Short (1 week to 1 month) contracts. 1961-present.

PUBLICATIONS * = reviewed publication

L. T. Larson - sole author unless otherwise indicated.

* Rotation Properties of Certain Anisotropic Ore Minerals: Econ. Geol., v. 56, pp. 569-583, 1961 (with others).


* Geology and Mineralogy of Certain Manganese Oxide Deposits, Philipsburg, Montana: Econ. Geol., v. 59, pp. 54-78, 1964.


* Two Sources of Error in Low Temperature Inclusion Homogenization Determination, and Corrections on Published Temperatures for the East Tennessee and Laisvall Deposits: Econ. Geol., v. 68, pp. 113-116, 1973 (with others).


A Short Course on Opaque Minerals: a Text Published for the 1973 S. E. Geol. Soc. of Amer. Meeting (with R. H. Carpenter), 203 p.


Geology and Gold Exploration in Western Turkey:, 1989. AIMME Preprint. 89-55, 5 pages, 9 illus.
ABSTRACTS (partial listing)


Preliminary Electron Microscope Studies of West Tennessee Ceramic Clays: Prog. for the 1967 annual meeting of S.E. Section of G.S.A. Regional Distribution.

Mineralogy of Certain West Tennessee Ceramic Clays: Prog. for the 1967 meeting of the S.E. Section of G.S.A. (with C. E. Merschat). Regional Distribution.


Cobalt and Nickel-bearing Manganese Oxides from the Fort Payne Formation, Tennessee: Prog. for the 1969 annual meeting, S.E. Section of G.S.A. Regional Distribution.


Disseminated Sulphides in Late Precambrian Metamorphic Rocks: Prog. of the S.E. Section of G.S.A., 1972 (with C.E. Merschat). Regional Distribution.


Hypersaline and Liquid CO2-bearing fluid inclusions suggest Candelaria sediment-hosted Ag deposit is related to a porphyry system, 1987 (with Foster and Noble).