

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

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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)]

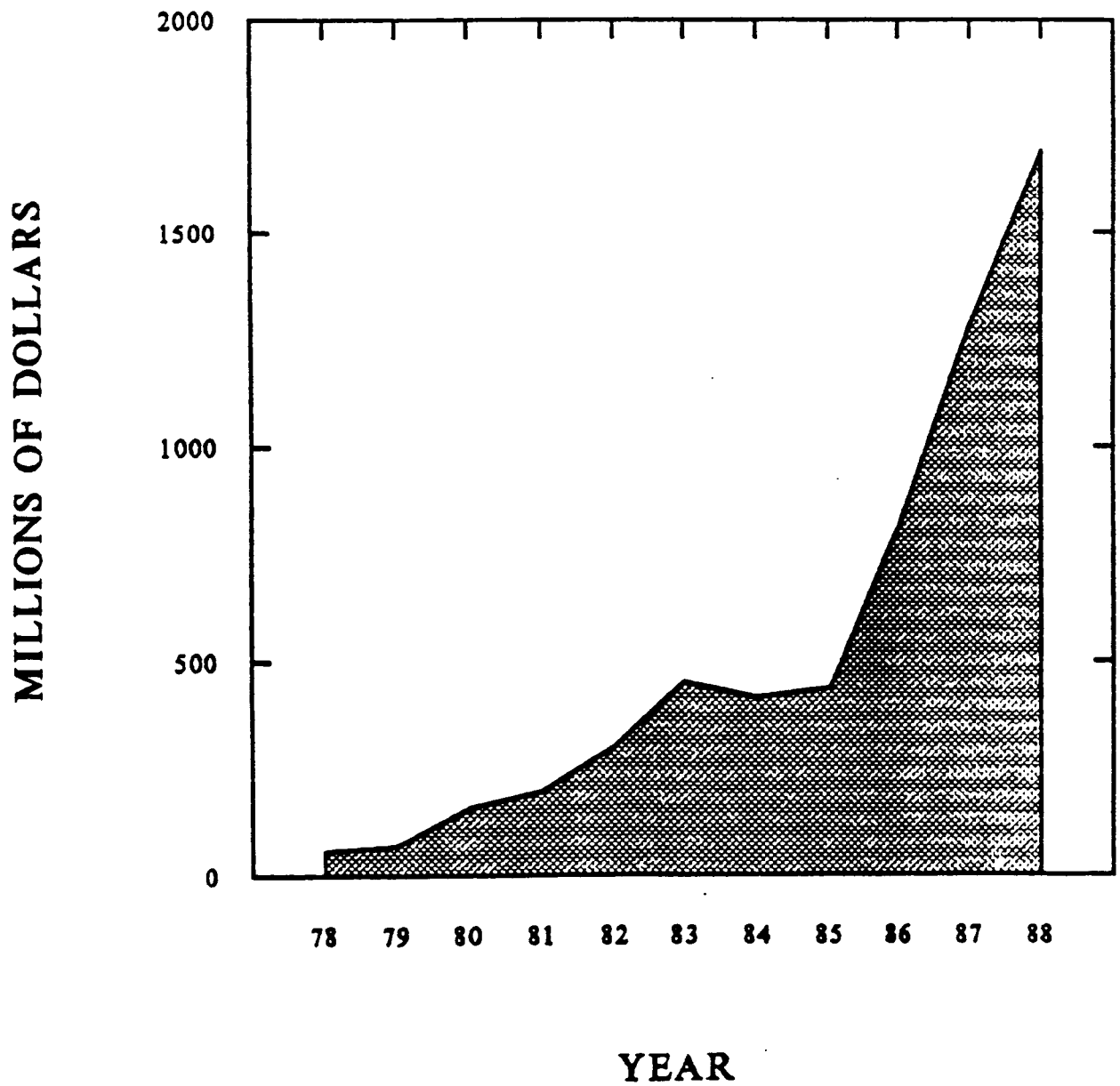
Requires identification and evaluation of natural resources .., the exploitation of which could affect the ability of the geologic repository to isolate radioactive wastes...

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)

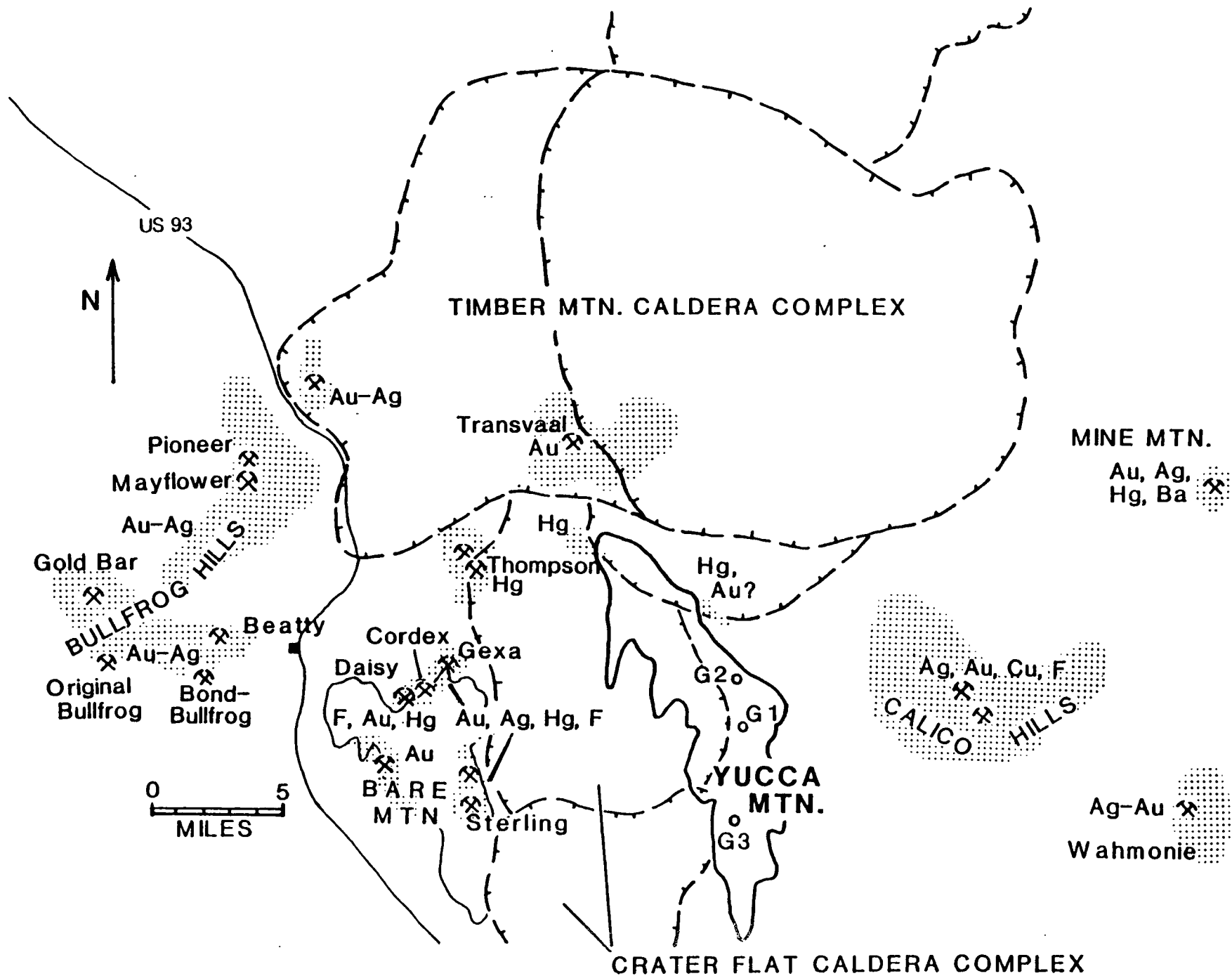
Au RESERVES

	<u>ounces</u>	<u>approx. 1988 \$\$</u>
» STERLING MINE	75,000	30 million
» GOLD BAR MINE	62,000	25 million
» BOND-BULLFROG MINE	3,200,000	1.3 billion
» GEXA MINE	250,000	100 million

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 AREAS OF HYDROTHERMAL ALTERATION
NEAR YUCCA MOUNTAIN, SW NEVADA VOLCANIC FIELD**



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*

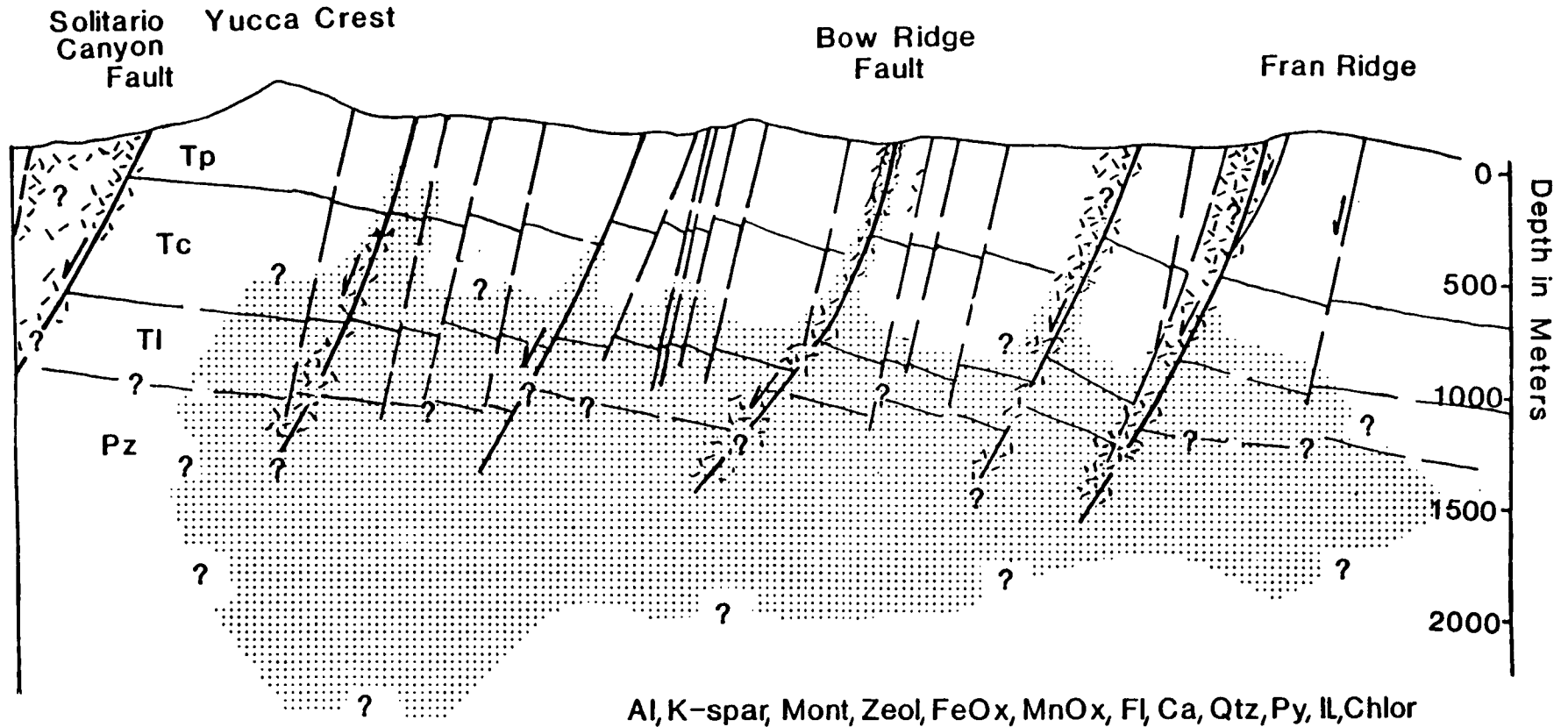
- » MINES IN DEVELOPMENT STAGE:
 - BOND-BULLFROG MINE*
 - GEXA (MOTHER LODE)*

- » 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

EAST



 breccia

Tp Paintbrush Tuff

Tc Crater Flat Tuff

Tl 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)

<i>Au</i>	<i>Ag</i>	<i>As</i>	<i>Hg</i>	<i>Sb</i>	<i>Cu</i>	<i>Mo</i>	<i>Pb</i>	<i>Zn</i>
0.004	0.034	7.93	0.122	<.247	7.16	0.587	7.75	23.8
0.005	0.423	110	0.799	24.6	27.9	65.3	154	33.2
0.002	0.031	7.31	0.147	<.245	4.52	0.422	5.31	19.0
0.004	0.048	15.6	0.373	10.1	11.1	1.23	16.4	90.8
0.001	<.015	5.89	0.349	2.90	2.71	1.80	10.7	147
0.001	0.048	11.2	0.553	6.36	4.11	2.29	14.8	75.5
0.002	0.049	11.2	2.02	2.89	2.95	1.58	46.6	892
0.001	0.141	14.1	3.08	8.69	14.4	2.54	78.6	344

Analyses by ICP methods

CLAIM CANYON AND NORTHWESTERN YUCCA MTN

(PPM)

<i>Au</i>	<i>Ag</i>	<i>As</i>	<i>Hg</i>	<i>Sb</i>	<i>Pb</i>	<i>Zn</i>
0.009	0.063	9.81	0.692	0.918	33.7	37.1
0.055	0.063	16.1	0.479	1.02	31.8	33.2
0.010	0.052	5.16	0.869	0.697	10.5	9.0
0.010	0.05	12.3	0.618	0.730	10.0	8.10
0.001	0.028	3.01	0.452	0.260	7.24	6.63
0.001	0.054	5.89	0.486	0.612	3.50	16.5
0.004	0.037	41.9	<.359	2.19	20.1	32.1
0.004	0.03	2.09	1.77	0.819	19.50	6.24
0.004	0.019	4.14	2.24	<.242	8.38	7.10
0.003	0.037	4.31	0.531	0.656	18.4	11.4

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

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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.
Ph.D.- Economic Geology, University of Wisconsin, Madison,
1962.

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, 1987. \$156,000
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
International Studies Development and Review Board, UNR,
1978-80
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

Member - R. Peele Award Committee, SME,
1979
Registered Professional Geologist (#418) - State of Georgia

NON-ACADEMIC PROFESSIONAL ACTIVITIES

Co-Principal Investigator - Yucca Mt. Project Task III,
1987-present. Nuclear Waste Isolation, Nevada.
ABET - Visitor, Geological Engineering Programs, 1987- .
Consultant, Ranger Exploration, N.L., 1986-1988. Gold
Exploration, Turkey.
Fulbright Senior Professor, 1985-86.
Consultant - British Petroleum Minerals, Brazil, 1983-1987.
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 - Freeport Exploration, R. Robinson and others,
1981, 1982, 1983
Consultant, Sandia Laboratories, 1981, 1982
Consultant - Westcoast Oil and Gas, Summer 1981
Consultant - United Nations Dev. Prog/World Health Org.-
Feb. 1981
Chairman and Member of technical peer review committee-
Nuclear Waste Isolation Program, U.S. Dept. Energy,
1979-83.
Consultant - Home Oil Corp., Canada. Gold Potential of
properties in southeast and western U.S., Summer, 1980
Consultant - United Nations Dev. Program - Turkey. Zinc
exploration and evaluation of resources and Turkish
government exploration efforts. 1979
Administrator and Principal Investigator, Southland
Royalty/U.S. DOE contract for Geothermal Reservoir Case
Study, Nevada. Available time, 1979-80.
Consultant - Noranda Exploration Company. Uranium
exploration in Nevada. Summer, 1978.
Principal Investigator and Administrator, Bendix
Engineering/U.S. DOE contract for Uranium potential of
the Great Basin. Available time, 1977-78.
Partner and geologic consultant - Applied Exploration
Concepts. Designed and implemented copper exploration
program for CONOCO, 1972-75.
Consultant - International Minerals and Chemical Corp.
Copper exploration in Wyoming and Utah. Summer, 1971.
Consultant - Alcoa Corp. Copper/nickel exploration in Main.
Summer, 1970.
Consultant - Duval Corp. and Placer Amex - Copper
exploration, Montana/Idaho, 1969.
Consultant - Union Carbide Nuclear Corp-Oak Ridge National

Laboratories. Development of program to study reactor cladding products. Available time, 1963-1969.
Consultant - Tennessee Division of Geology. Study and mapping of mineral resources. Summers and available time, 1962-65, 1967.
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: (Abs), GSA Special Paper 68, 1961, p. 215.

- * Zinc-bearing Todorokite from Philipsburg, Montana: Amer. Mineralogist, v. 47, pp. 59-66, 1962.

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

Field-trip guide to Corundum Hill, North Carolina: in Field Trip Guidebook, Joint ACA-MSA meeting, Gatlinburg, Tennessee, July 1965 (with F. S. Lesure).

- * Mineral Resources Summary of the Waverly Quadrangle, Tennessee: Tenn. Div. of Geology, Geological Map and Mineral Resources Summary (MRS) 30-SE, 1965, 7 p.

- * Mineral Resources Summary of the Standing Rock Quadrangle, Tennessee: Tenn. Div. of Geology, GM and MRS 29-MW, 1965, 15 p. (with R. H. Barnes).

- * Mineral Resources Summary of the Bumpas Mills Quadrangle, Tennessee: Tenn. Div. of Geology, GM and MRS 28-SE, 1965, 17 p.

- * Mineral Resources Summary of the Dover Quadrangle, Tennessee: Tenn. Div. of Geology, GM and MRS 29-NE, 1965, 12 p. (with R. H. Barnes).

- * Mineral Resources Summary of the Hurricane Mills Quadrangle, Tennessee: Tenn. Div. of Geology, GM and MRS 31-NE, 1965, 4 p.

- * Mineral Resources Summary of the Kimmins Quadrangle, Tennessee: Tenn. Div. of Geology, GM and MRS 41-NE, 1965, 17 p.

- Mineral Resources Summary of the Cumberland Furnace Quadrangle, Tennessee: Tenn. Div. of Geology, GM and MRS 302-SE, 1966, 15 p.
- Mineral Resources Summary of the McEwen Quadrangle, Tennessee: Tenn. Div. of Geology, GM and MRS 39-SE, 1966, 6 p.
- Mineral Resources Summary of the Tharpe Quadrangle, Tennessee: Tenn. Div. of Geology, GM and MRS 28-SW, 1967, 17 p. (with others).
- Mineral Resources Summary of the Ashland City Quadrangle, Tennessee: Tenn. Div. of Geology, GM and MRS 304-SE, 1967, 6 p.
- Mineral Resources Summary of the Cheatham Dam Quadrangle, Tennessee: Tenn. Div. of Geology, GM and MRS 304-SW, 1967, 4 p.
- * Determination of the Basal-Pole Orientation in Zirconium by Polarized Light Microscopy: Trans. Met. Soc. of AIME, v. 236, pp. 1104-1106, 1966.
 - * Equipment for the Quantitative Measurement of Reflectivity: Journ. of Scientific Instruments, v. 40, pp. 1088-1092, 1969.
 - * Reflectivity Measurements on Zirconium: Trans. Met. Soc. of AIME, v. 245, pp. 2047-2049, 1969.
 - * Cobalt and Nickel-bearing Manganese Oxides from the Fort Payne Formation, Tennessee: Econ. Geol., v. 65, pp. 952-962, 1970.
 - * 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).
 - * Textural Study of Polycrystalline Pyrrhotite by Reflectance Measurements and X-ray Pole Figures: Econ. Geol., v. 68, pp. 671-680, 1973.
- 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.
- Geochemistry - a Review, 1976. Mining Engineering, Feb. 1977, 6 p.

The Great Basin Geologic Framework and Uranium Favorability. A Report to Bendix Corp., 3 vols. (226 p. Text and 696 p. Bibliography) plus Geologic, Geochemical, Geochronologic Map Folio 211 p. (189 maps + 22 stratigraphic columns) open filed, April, 1978. (Senior Author, with others).

- * Uranium Potential of Zeolites in Volcanically Derived Sediments, Northern Reese River Valley, NV. AIME Preprint and Trans., 13 p., 1980 (with P. Basinski).

Geothermal Reservoir Assessment Case Study, Northern Basin and Range Province: U.S.-DOE Document, Contract No. DE-AC08-79E27006, 223 p. (with several other authors).

Geochemical Exploration for Precious Metals in the Great Basin Using Fe/Mn Oxide Joint Coatings. AIME Meeting and PREPRINT, Nov. 1981 (with W. Crone).

Overview of Energy and Mineral Resources for the Nevada Nuclear Waste Storage Investigations, Nevada Test Site, Nye County, NV: U.S. Dept. of Energy Report, NVO-250, 64 p. + maps (with E. Bell).

Annotated Bibliography, Overview of Energy and Mineral Resources for the Nevada Nuclear Waste Storage Investigations, Nevada Test Site, Nye County, NV: U.S. Dept. of Energy Report NVO-251, 30 p. (with E. Bell).

In A Peer Review of the Nevada Nuclear Waste Storage Investigations: August 24-28, 1981: NVO 196-27 (DE84007255), Office of Scientific and Technical Information, U.S. Dept. of Energy, p. 38-43 and 144-155.

- * A Comparison of Iron Oxide-rich Joint Coatings and Rock Chips as Geochemical Sampling Media in Exploration for Disseminated Gold Deposits: Journal of Geochemical Exploration, v. 20, pp. 161-178, 1984 (with others).

- * Latest Miocene Hydro-Thermal Activity at the Willard and Scossa Mining Districts, Pershing County, North-western Nevada: Isochron/West, 1987, with D. C. Noble and E. H. McKee.

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

ABSTRACTS (partial listing)

The Stratigraphic and Petrologic Controls of the Economics of a Pottsville Sandstone, Caryville, TN: GSA Special Paper, 1966 (with T. Freeman), National Distribution.

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.

Geochemistry of Co and Ni in Southern Appalachian Massive Sulphide Ores: Prog. for the 1968 annual meeting of the S.E. Section of G.S.A., p. 51. 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.

Textural Study of Polycrystalline Pyrrhotite by Reflectance Measurements and X-ray Pole Figures: Prog. for the 1970 National Meeting, G.S.A. National 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.

Basin Evolution and Mississippi Valley Type Ore Deposits: Abs. Northwest Mining Association, 1975. Regional Distribution.

Basin Evolution and the Distribution of Mississippi Valley Type Deposits: G.S.A., Southeast Section, 1975. Regional Distribution.

Geochemical Exploration for Precious Metals in the Great Basin Using Fe/Mn Oxide Joint Coatings. Abstracts with Program, AIME, Denver, 1981 (with W. Crone, R. Carpenter, and T.T. Chao).

Timber Mountain Magmato-Thermal Event: An Intense Widespread Culmination of Magmatic and Hydrothermal Activity at the S.W. Nevada Volcanic Field, 1987 (with Jackson, Noble and Weiss).

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