

MAY 06 1991

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MEMORANDUM FOR: Ronald L. Ballard, Chief
Geosciences & Systems Performance Branch Division of
High-Level Waste Management, NMSS

THRU: Philip S. Justus, Section Leader
Geology-Geophysics Section
Geosciences & Systems Performance Branch Division of
High-Level Waste Management, NMSS

FROM: Harold E. Lefevre, Geologist
Geology-Geophysics Section
Geosciences & Systems Performance Branch Division of
High-Level Waste Management, NMSS

SUBJECT: REPORT OF FEBRUARY 11 THROUGH 14, 1991, TRIP TO THE
RENO-CARSON CITY, NEVADA AREA ON THE MCKELVEY MINERAL
RESOURCES FORUM AND MEETINGS WITH REPRESENTATIVES OF STATE
AND FEDERAL AGENCIES

LOCATION AND DATE OF EVENT

Reno, Nevada

1. February 11, 1991 - Nevada Bureau of Mines and Geology at the campus of the University of Nevada.
2. February 11 - 14, 1991 - The U. S. Geological Survey's Seventh Annual V. E. McKelvey Forum on Mineral and Energy Resources.
3. February 13, 1991 - Nevada Historical Society on the campus of the University of Nevada.
4. February 14, 1991 - U. S. Department of the Interior, Bureau of Land Management, Division of Mineral Resources.

Carson City, Nevada

5. February 14, 1991 - State of Nevada, Department of Conservation and Natural Resources, Division of Water Resources.
6. February 14, 1991 - State of Nevada, Department of Transportation.
7. February 14, 1991 - State of Nevada, Nuclear Waste Project Office.

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PURPOSES OF THE TRIP:1. February 12-13, 1991 - McKelvey Forum at Reno

To be appraised of collaborative research between the U.S. Geological Survey and industry, academia and other State and Federal Government agencies in order to identify those activities of possible significance to the proposed repository at Yucca Mountain, Nevada. On-going projects of significance to the Yucca Mountain program include a folio of Nevada maps depicting areas considered favorable for undiscovered mineral deposits (this includes the Yucca Mountain area) and the definition of areas of young (Holocene) fault displacement (Yucca Mountain again). Additional projects are focused on the hydrocarbon potential of Nevada and will include thermal maturation studies and regional structural interpretations based partially on seismic profiles. Current plans call for organic geochemistry analyses to be conducted on samples taken from the Yucca Mountain area.

2. February 11, 13-14, 1991 - State and Federal agencies at both Reno and Carson City

Visits/research/meetings with representatives of various Federal and State of Nevada agencies in order to acquire geotechnical information relative to past, current and future natural resources-related exploration/development in the Yucca Mountain vicinity. Two matters were of particular interest - the nature of current and proposed hydrocarbon exploration to the west and south of the proposed Yucca Mountain site and the identification and nature of deep boreholes (chiefly groundwater wells) penetrating alluvium in the vicinity of Crater Flat and the Amargosa Desert near Lathrop Wells.

DOCUMENTS ACQUIRED DURING THE TRIP

Because both the number of individual documents and the bulk of the materials obtained during the trip preclude attachment to this report, a detailed list identifying these materials and their source (McKelvey Forum or State/Federal agency) has been prepared and is attached as Enclosure A. These documents are available for reference in the Geosciences and Systems Performance Branch files.

RENO, NEVADA ACTIVITIES OF FEBRUARY 11 - 14, 1991February 11, 1991 - Nevada Bureau of Mines and Geology at the campus of the University of Nevada.

Following acquisition of a number of Nevada Bureau of Mines and Geology (NBMG) publications (see Enclosure A, Documents 1, 2, 3 and 7) at the NBMG Sales Office, a meeting was held in the office of Joseph V. Tingley, economic geologist with the Bureau. Mr. Tingley's knowledge of the history and status

of mineral resources development in, and around, the Yucca Mountain site, Nellis Air Force Base and the Nevada Test Site was extremely helpful. In addition to providing copies of two mineral resources reports of Nellis Air Force Range and an early (1947) mining claims map of the same area (see Enclosure A, Documents 4, 5 and 6), Mr. Tingley provided information enabling the staff to acquire a recent (December 14, 1990) report, commissioned by the Department of the Air Force, describing current and proposed defense-related activities in the State of Nevada, including a discussion of the mineral and energy resources of Nellis Air Force Range. This draft document - Special Nevada Report - was submitted by Science Applications International Corporation and Desert Research Institute and is available for consultation at the Geosciences and Systems Performance Branch files.

February 11/14 - U.S. Geological Survey's McKelvey Forum

The Seventh Annual Vincent E. McKelvey Forum, sponsored by the U. S. Geological Survey, was held on February 11-14, 1991, at Bally's Hotel, Reno, Nevada. The general theme of the forum was on domestic and international resource activities and consisted of talks (38) and poster sessions (69). The program of talks (lectures and discussions) has been extracted from U.S. Geological Survey Circular 1062 and is attached (Enclosure B) for reference while Enclosure C identifies the Forum poster sessions. Abstracts of both the talks and poster sessions are included within the above USGS Circular 1062.

Since the majority of the more than 100 oral reports and poster sessions presented at the Forum focused on geographic areas other than Nevada, no attempt has been made to discuss, or to even specifically identify all of the presented papers and poster sessions. However, two of the poster sessions were of considerable relevance to the Yucca Mountain program and are discussed below. For information relative to the remainder of the talks and poster sessions, refer to Enclosures B and C for the paper/poster topic and author, then to USGS Circular 1062 for the appropriate abstract.

- Summaries of The Two Selected Poster Sessions

Title/Authors:

MAPS SHOWING THE ANALYSIS OF MINERAL RESOURCES OF NEVADA
by Edwin H. McKee and others (16 authors)

Summary: "These are prototype maps (12) intended to be published as a folio reporting on the analysis of undiscovered metal-bearing mineral resources of Nevada. The folio does not address non-metallic resources and it does not identify specific locations of undiscovered resources."

"Arbitrarily, we have limited our analysis to the deposits and their permissive geologic environments that occur within the upper one kilometer of the earth's crust."

"Areas or domains are delineated that may contain particular deposit types inferred by analogy with deposits in similar geologic settings elsewhere. In order to construct the boundaries it is necessary to have a geologic map and it is desirable to have mineral occurrence, geophysical, exploration, and geochemical information."

"In order to make the connection of deposit type to geologic environment, it is necessary to recognize and map the relevant geologic settings in Nevada. This is the primary purpose of the sections of this folio that address gravity field, magnetic field, pre-Tertiary geology, Tertiary geology, ages of young volcanic deposits and related mineral deposits, intrusive rocks, neotectonics, known mineral deposits, and mineral resources."

NOTES: (1) The above summary was taken essentially verbatim from portions of the poster session handout. The entire handout is attached as Enclosure D; (2) Enclosure E identifies the maps in the proposed folio by title and author(s).

A cursory examination and assessment of the displayed maps resulted in the following initial impressions regarding their relevance of the following topics to the vicinity of Yucca Mountain:

Mineral Deposits

- a. There are no known occurrences.
- b. The area is favorable for epithermal vein deposits.
- c. The Yucca Mountain site is located within an area permissive for one or more pluton-related mineral deposit types.
- d. There is a suggestion that the magnetic anomaly in the area delineates a body of shallowly buried rock with which certain types of mineral deposits may be associated.

Faulting

- a. Young fault systems and pediments on pre-Cenozoic faults are found in the area.
- b. Yucca Mountain lies within an area of north/south trending fault systems showing varying structure including (1) Holocene surficial movement, (2) suspected (but not confirmed) Quaternary surficial displacement and (3) scarps and lineaments on late Tertiary and/or Quaternary volcanic rocks.

Title/Authors:

BASIN EVOLUTION AND PETROLEUM STUDIES IN THE U.S. EASTERN
GREAT BASIN - RELEVANCE TO MINERAL INVESTIGATIONS
by Christopher J. Potter, John A. Grow, Charles H. Thorman,
Harry E. Cook and James A. Peterson

Summary: "The U.S. Geological Survey is undertaking two complementary, multidisciplinary regional projects in the eastern Great Basin (includes eastern Nevada) with the goal of providing a better definition of the geologic framework of hydrocarbon and mineral deposits. Project efforts include systematic studies of Paleozoic through modern sedimentary basins and their tectonic settings and geologic controls on hydrocarbon occurrences. Products will include regional transects consisting of cross-sections and palinspastic restorations and organic geochemical studies associated with regional stratigraphic investigations of major petroleum source rocks producing hundreds of new analytical measurements."

NOTES: (1) The above summary was taken essentially verbatim from the abstract appearing in U.S. Geological Survey Circular 1062.

Current plans call for the organic geochemistry studies, which are aimed at defining the thermal maturity histories of the basins, to include samples taken from boreholes and other locations in the vicinity of Yucca Mountain.

Since the Forum sessions of Thursday, February 14 were devoted to the role of Federal and commercial sectors in international minerals development - principally in the Caribbean and South American regions - the day was spent discussing natural-resources related matters with representatives of several State and Federal agencies both in Reno and in Carson City. Oral presentations were not made on February 11.

February 13, 1991 - Nevada Historical Society on the campus of the University of Nevada

The map archives of the Historical Society were researched in order to document the historical presence/absence of mining claims/mining activity in the immediate vicinity of Yucca Mountain. Other than confirming the location of "Quartz Mountain Camp" on the east flank of Yucca Mountain through a 1919 map and to confirm that the Horn Silver Mine in the vicinity of Wahmonie is some 16 miles east of Yucca Mountain, no indication of mining activity in the near-vicinity of Yucca Mountain was found.

February 14, 1991 - U.S. Department of the Interior, Bureau of Land Management, Division of Mineral Resources

As the primary custodian of public lands in the vicinity of Yucca Mountain, the Bureau of Land Management (BLM) is charged with administering mineral (including hydrocarbons) resource exploration and development on such lands. BLM personnel were consulted in order to identify and obtain, if possible, natural resources information pertinent to Yucca Mountain site characterization activities. John Snow and other personnel in the BLM's Nevada State office, provided considerable information, in the form of (1) applications for permits to drill four oil wells, (2) steps to be taken in order to obtain information on geophysical and drill hole activities, especially with respect to hydrocarbon exploration, (3) information relative to mining operations for precious metals and (4) a State map identifying private and public land

holdings. Documents secured through the auspices of the BLM are identified in Enclosure A.

With respect to the permits for the four oil wells, one permit was issued to the MYJO Oil Corporation of Breckenridge, Texas and is located 11 miles northeast of Beatty while the remaining three were issued to Felderhoff Production Company of Gainesville, Texas. The Felderhoff permits are located from one to seven miles south of Lathrop Wells. The MYJO well site is approximately 15 1/2 miles northwest of the nearest approach of the proposed repository perimeter drift. The nearest of the three Felderhoff well sites is approximately 15 miles south of the perimeter drift. As of February 15, 1991, the MYJO well had reached what may be its final total depth of 2,898 feet. Because of environmental considerations (impact on desert tortoise habitat) drilling has not yet commenced at the Felderhoff sites.

Two Bare Mountain area reports, both issued in 1989, dealing with precious metals mining - the Draft and Final Environmental Assessments, Proposed Mother Lode Project - were provided by Vic Ross of the BLM's Battle Mountain District, Tonopah Resource Area. These reports include sections dealing with a number of matters of direct interest to those involved in the characterization of the Yucca Mountain site. Among others, report topics include: geologic setting, geologic and seismologic hazards and mineral and water resources. The regional groundwater sections of the Draft EA contains information of considerable interest to those involved in the characterization of the Yucca Mountain site. This information includes segments dealing with (1) hydrogeologic units, (2) groundwater basins and their boundaries, (3) regional groundwater movement, and (4) a monitoring program designed to mitigate the potential impacts of groundwater withdrawal resulting from mining operations over the currently-envisioned two year life of the mining project.

CARSON CITY, NEVADA ACTIVITIES OF FEBRUARY 14, 1991

State of Nevada, Department of Conservation and Natural Resources, Division of Water Resources

The objectives of visiting the Division of Water Resources were twofold: (1) to locate water well locations penetrating bedrock within the Crater Flat-Amargosa Desert area, in the vicinity of Yucca Mountain and (2) to obtain information relative to groundwater usage by mine operators near the Crater Flats/Bare Mountain front.

Time constraints did not permit a totally-comprehensive research of available files. The most-pertinent of the information acquired is described below:

1. Completeness of Water Well Record Files

The Division of Water Resources records are not necessarily complete in that data relative to water well locations and details of well construction prior to the 1950's is reportedly spotty, in that, although such submittals were required by Division regulations, ensurance of

compliance of such regulations was not uniformly enforced. As a result, there may be unknown/unidentified wells located within the area of interest.

2. Selected Water Well Data

- a. Beatty Area (T12S, R47E) - Within this area there are seven wells ranging from 110' to 300' in depth, five of which penetrate from four to eighty feet of rock. The rock descriptions are not detailed and include terms such as "rock", "grey rock" and "red sandstone."
- b. Mother Lode Project (T12S, R48E) - One of the wells in this area is 1,600' deep and encountered 1000' of alluvium underlain by 600' of "pink rhyolite". Another well in the same area is 700' deep with 210' of alluvium and 490' of "limestone", "silts" and "intrusives."
- c. Bond Gold Property (T14S, R46E) - Well 1,120' deep including 115' of "sand" and "rock", 705' of "quartz" and 300' of "fractured rock."
- d. Lathrop Wells Area (T15S, R49E)

Oil/Gas Show In Water Well

- I. Well Permittee is Richard Washburn - Well is 968' deep and bottomed in alluvium. Show of oil/gas from depths of 793' through 804'. Drilled in 1958.

NOTE: Two of the three recent (November, 1990) Felderhoff Production Company's permits for oil well drilling are located within these coordinates (T15S, R49E).

Information on Additional Wells

- II. Records researched indicate twelve wells in the vicinity of Lathrop Wells ranging from 50' to 1,014' deep with all penetrating alluvium and none encountering bedrock.

3. Mother Lode Project

- a. Because of U.S. Park Service concerns about projected groundwater withdrawals possibly affecting water levels at two locations within Death Valley National Monument - one portion being ten miles west of the Project and the Devils Hole portion about forty miles southeast of the Project - a groundwater monitoring system to measure such effects was designed and installed by the Project.

The Division of Water Resources restricted water usage, not to exceed 800 acre feet/year, to be withdrawn from seven identified wells.*

*NOTE: For Mother Lode Project water well locations and additional details of the groundwater environment see the Mother Lode Project Draft Environmental Assessment (Enclosure A, p. 2, BLM Document No. 2).

- b. The Division of Water Resources' file for Well Permit #51,555 (one of the seven affected wells, see Enclosure A, above) contains (1) a plot plan (scale 1" = 1 mile) showing the mine location, water well locations, and USW-VH-1 and 2 wells (located in the Black and Red Cone areas and (2) a detailed description of the Death Valley/Devils Hole monitoring program identified in "a" above.

4. Map - Designated Groundwater Basins of Nevada

An undated map identifying hydrographic regions and basins of the State of Nevada (scale of 1:750,000) was purchased through Tony Green of the Division of Water Resources.

State of Nevada, Department of Transportation

Several maps were purchased including a state-wide atlas of modified 30' topographic maps.

See Enclosure A, (p. 2) for the complete listing of maps obtained.

State of Nevada, Nuclear Waste Project Office

A meeting was held with Carl Johnson, Administrator of Technical Programs, in order to exchange information on a variety of Yucca Mountain-related subjects, but focussed on those dealing with natural resources. Principal topics included: (1) historical mining activity in the Bare Mountain/Yucca Mountain area, (2) hydrocarbon exploration in the near-site region and (3) groundwater monitoring necessitated as a result of precious minerals mining/development at the Bond Gold and Mother Lode properties adjacent to Bare Mountain.

Mr. Johnson indicated that NWPO had received no positive response to its public solicitation (Nevada Geology, Summer, 1990) for information indicating the presence of existing or potential natural resources in the Yucca Mountain area. NRC staff indicated that recent research efforts at the Library of Congress Map Library, Washington, D.C., and more recently at the Nevada Historical Society at Reno had not identified any evidence of previous mining activity at/near Yucca Mountain other than the indication on several early 1900's maps that "Quartz Mountain Camp" was located on the east flank of Yucca Mountain near Fortymile Canyon. The NRC transmitted a copy of each of the maps acquired at the Library of Congress to Mr. Johnson's office by letter of February 19, 1991. A reference to early (1861) gold mining at Bare Mountain was also provided to Mr. Johnson by the staff subsequent to this meeting.

Mr. Johnson was aware of permits for the drilling of four wildcat oil wells in the Yucca Mountain area with one near Beatty and three near Lathrop Wells and provided the NRC with correspondence providing further details on this matter.

Mr. Johnson mentioned that the U.S. National Park Service had insisted upon Bond Gold Bullfrog Inc's installation of a groundwater monitoring system as a condition of Bond Gold's precious metals mining project near the portion of

Death Valley National Monument located west of Beatty. The Bullfrog Mine wellfield will provide as much as 2,000 gallons per minute (gpm) water supply for Bond Gold's mining operations. Mr. Johnson also indicated that it was his understanding that the National Park Service would be requesting that the DOE install a monitoring system for groundwater usage during Yucca Mountain site characterization. The Park Service's concerns focus on (1) the potential for lowering the groundwater table at Devils Hole (located within Death Valley National Monument) which is approximately 33 miles southeast of the southernmost portion of the perimeter drift and (2) on the effect of such lowering on rare fish species inhabiting the pool within the national monument. Subsequent to this meeting, Mr. Johnson provided a copy of the final draft of the surface and subsurface water level monitoring plan as understood by Bond Gold Bullfrog's hydrologic consultant.

Documents provided to the NRC staff by Mr. Johnson are identified in Enclosure A, p. 3.

CONCLUSIONS:

A number of specific points, identified in the indicated portions of this report, and considered to be particularly significant, are high-lighted below. A number of follow-up suggested activities are also identified.

V.E. McKelvey Forum

The folio of mineral resources maps of Nevada (prototypes of which were displayed at the McKelvey Forum Poster Session) will provide, when published, considerable site characterization-applicable information from the perspectives of both minerals assessment and geologic structure (especially regarding Quaternary faulting).

In the interim, prior to folio publication, it may prove beneficial to the overall high level waste program, to discuss and perhaps meet with the U.S. Geological Survey in order to discuss the Survey's basic approach and data bases underlying the development of these maps. Of particular interest would be the Survey's approach in describing the geologic setting within which the Yucca Mountain site is located and analogies of the Yucca Mountain site with similar geologic setting elsewhere.

Developments in the U.S. Geological Survey's programs on basin evolution and petroleum studies, as they relate to the structural and hydrocarbon potential of the Yucca Mountain site characterization program, should be followed closely.

Bureau of Land Management

Contact should be maintained with the Bureau of Land Management regarding the status of the four oil wells currently permitted to be drilled in the vicinity of Yucca Mountain and to maintain cognizance of the availability of subsurface information normally derived from such exploratory holes.

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Inquiries should be made of the Bureau of Land Management Resource Area offices in Las Vegas and Tonopah regarding geophysical and other activities that may have been conducted in the Crater Flat/Amargosa Desert areas adjacent to the Yucca Mountain site.

Nevada's Division of Ground Water Resources

As a result of groundwater requirements associated with mining operations in the Bare Mountain area a considerable body of information is available in the files of the Division offices at Carson City. This information includes, and is not limited to: well logs, water basin boundaries, geologic cross-sections, details of the design of groundwater monitoring systems and data resulting from the monitoring of such systems.

/s/

Harold E. Lefevre, Geologist
Geology-Geophysics Section
Geosciences & Systems Performance Branch Division
of High-Level Waste Management, NMSS

Enclosures:
As stated (5)

DISTRIBUTION:

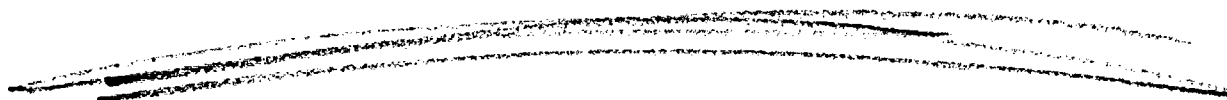
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ENCLOSURES



ENCLOSURE A

ENCLOSURE A

TRIP OF FEBRUARY 11-14, 1991
RENO/CARSON CITY, NEVADA

DOCUMENTS AND OTHER MATERIALS OBTAINED
FROM THE INDICATED SOURCES

Nevada Bureau of Mines and Geology at the Univ. of Nevada, Reno

1. Ransome, F. L., 1907, Mines of Goldfield, Bullfrog and Other Southern Nevada Districts, 1983 reproduction of the 1907 U. S. Geological Survey Bulletin 303: Nevada Publications, Las Vegas, NV, 147 p.
2. Tingley, J. V., 1984, Trace Element Association in Mineral Deposits, Bare Mountain (Fluorine) Mining District, Southern Nye County, Nevada: Nevada Bureau of Mines & Geology Report 39, 28 p.
3. Price, J. G., et al, 1990, The Nevada Mineral Industry, 1989, Nevada Bureau of Mines & Geology Special Publication M1-1989, 55 p.
4. Norberg, J. R., 1977, Mineral Resources in the Vicinity of the Nellis Air Force Base and the Nellis Bombing and Gunnery Range, Clark, Lincoln, and Nye Counties, Nevada: U. S. Department of the Interior, Bureau of Mines, 117 p.
5. Cornwall, H. R. and Norberg, J. R., 1978, Mineral Resources of the Nellis Air Force Base and Gunnery Range, Clark, Lincoln, and Nye Counties, Nevada: Administrative Report, U. S. Geological Survey and U. S. Bureau of Mines, 118 p.
6. Map of Tonopah Bombing Range and Las Vegas Aerial Gunnery Range, Nye, Clark & Lincoln Counties Nevada, 1947.
7. Hess, R. H., 1991, Oil and Gas Wells Drilled in Nevada Since 1986: Nevada Bureau of Mines & Geology NBMG List L-8, 4 p.

U. S. Geological Survey, Seventh Annual McKelvey Forum, Reno

1. Good, E. E., Slack, J. F., and Kotra, R. K., 1991, USGS Research on Mineral Resources - 1991 - Program and Abstracts: U.S. Geological Survey Circular 1062, 99 p.
2. 1991 McKelvey Forum - Poster Sessions. 65 Booths, 7 p.
3. Abstract: Maps Showing the Analysis of Mineral Resources of Nevada, February, 1991. Poster Session - Booths 44 and 45, 9 p.
4. Hoffman, J. D., Gunnells, G. B., and McNeal J. M., 1991, National Geochemical Database: National Uranium Resource Evaluation Data for the Western Conterminous United States, Digital Data Series 91-1: U. S. Geological Survey Information Sheets, 3 p.

U. S. Department of the Interior, Bureau of Land Management,
Division of Mineral Resources - Reno

1. Final Environmental Assessment - Proposed Mother Lode Project, July, 1989: Bureau of Land Management, Battle Mountain District, Tonopah Resource Area, Tonopah, Nevada with the assistance of ENSR Consulting and Engineering, Alameda, California, 12 pages plus appendices.
2. Draft Environmental Assessment - Proposed Mother Lode Project, May, 1989: Bureau of Land Management, Battle Mountain District, Tonopah Resource Area, Tonopah, Nevada with the assistance of ENSR Consulting and Engineering, Alameda, California, 185 pages plus appendices.
3. Four applications for permits to drill oil wells in Nye County, Nevada:
 - a. MYJO Oil Corporation - 11 miles north of Beatty
 - b. Felderhoff Production Company
 - I. 7.1 miles southwest of Lathrop Wells
 - II. 1.8 miles south of Lathrop Wells
 - III. 5.1 miles south of Lathrop Wells
4. Nevada Oil Reporter (Monthly Newsletter and Quarterly Map showing Nevada Oil and Gas Activity for the previous quarter) for January, 1991.
5. Map of State of Nevada - Showing Land Ownership (Public [with administering Agency designated], Private, State and Patented Lode Mining Claims): Bureau of Land Management, 1990, Scale: 1:1,000,000.
6. Map of State of Nevada - Showing Bureau of Land Management Districts and Resource Areas: Bureau of Land Management, 1990, Scale: 1:1,000,000.

State of Nevada, State Engineer's Office, Department of
Conservation and Natural Resources, Division of Water Resources -
Carson City

1. Map - Designated Groundwater Basins of Nevada (identifies hydrographic regions and basins), Scale: 1:750,000.

State of Nevada, Department of Transportation - Carson City

1. Nevada Map Atlas, Seventh Edition, undated, (State-wide coverage of reductions of 30' quadrangles without the topography)
2. Map of Carson City
3. Map of Reno/Sparks

State of Nevada, Agency for Nuclear Projects, Nuclear Waste
Projects Office - Carson City

1. Letter Report: Final Monitoring Plan for Bullfrog Mine Wellfield, Nye County, Nevada. Report is dated February 25, 1989. Prepared by Hydro-Search, Inc of Reno, Nevada for Bond Gold Bullfrog, Inc. of Beatty, Nevada, 15 p.
2. Cashman, P. H., and Trexler, J. H., Jr., undated, The Mississippian Antler Foreland and Continental Margin in Southern Nevada: the Elena Formation Reinterpreted: University of Nevada, Reno, Department of Geological Sciences and Center for Neotectonic Studies, Mackay School of Mines, 9 p.
3. Letter dated January 17, 1991 from L. T. Larson, D. C. Noble and S. I. Weiss (University of Nevada-Reno) to C. A. Johnson, Administrator of Technical Programs, Nevada Nuclear Waste Projects Office. Subject of letter is: "Recent wildcat oil well drilling, southwestern Nevada," 1 p.

ENCLOSURE B

PROGRAM OF LECTURES AND DISCUSSIONS

MONDAY, FEBRUARY 11, 1991

4:00-9:00 p.m. Registration
7:00-10:00 p.m. POSTER SESSION/Reception

TUESDAY, FEBRUARY 12, 1991

7:30 a.m. Registration
8:30 Welcome and opening remarks
8:40 Introduction to the research programs of the Office of Mineral Resources, U.S. Geological Survey — *Michael P. Fouse*
9:00 Preview of U.S. Geological Survey mineral resources research: Seventh Annual V.E. McKelvey Forum — *William C. Rigby*
9:30 Exploration guide for precious-metal deposits in volcanic domes — *Charles G. Cunningham and George E. Erickson*
10:00 Farah Garan, Saudi Arabia—Bimodal-volcanogenic Zn-Cu-Au mineralization in a Late Proterozoic rift basin, southeastern Arabian Shield—*Jeff L. Doebrich, Arthur A. Bookstrom, and Richard B. Carten*
10:30 COFFEE BREAK AND POSTER SESSION
11:00 KEYNOTE LECTURE: Transitions between epithermal and mesothermal environments — *Richard H. Sillitoe*
12:00 p.m. LUNCH
1:00 Tectonomagmatic settings of Proterozoic metallogenic provinces in the Southwestern United States — *Clay M. Conway*
1:30 Origin of iron, rare-earth elements, copper, and gold in Middle Proterozoic deposits of the midcontinent region, U.S.A. — *W.C. Day, G.B. Sidder, A.E. McCafferty, L.E. Cordell, E.B. Kisvarsanyi, R.O. Rye, and L.M. Nuelle*
2:00 Concentration and zonation of copper and palladium in the Mesozoic Belmont diabase sheet, Culpeper basin, northern Virginia—An exploration guide to enrichment of precious metals in mafic magmatic rocks — *A.J. Froelich, Laurel G. Woodruff, Harvey E. Belkin, and David Gottfried*
2:30 Advances in plumbic prospecting — *Bruce R. Doe*
3:00 COFFEE BREAK AND POSTER SESSION
3:30 The use of lead-isotope geochemistry to evaluate economic potential for gold-silver mineralization—An example from the North Amethyst vein system and the Creede mining district, Colorado — *Nora K. Foley and Robert A. Ayuso*
4:00 The Re-Os isotope system as a tracer in the study of the origin of platinum-group-element and gold deposits — *R.J. Walker, J.W. Morgan, D.D. Lambert, A.J. Naldrett, J.K. Bohlke, and V. Rajamani*
4:30 Synorogenic, auriferous fluids of the Juneau gold belt, southeast Alaska—Stable-isotope evidence for a deep crustal origin — *R.J. Goldfarb and W.J. Pickthorn*
5:00 ⁴⁰Ar/³⁹Ar thermochronology of fracture-controlled mineral deposits of the Idaho batholith—Age, thermal history, and origin — *L.W. Snee, Karen Lund, K.V. Evans, C.H. Gammons, and M.J. Kunk*

TUESDAY EVENING, FEBRUARY 12, 1991

7:30 DIRECTOR'S LECTURE: Tectonic control on the migration of crustal fluids and the formation of regional metallogenic provinces — *David L. Leach*
8:30-10:00 POSTER SESSION/Reception

WEDNESDAY, FEBRUARY 13, 1991

8:30 a.m. Regional structural setting of gold deposits in the Carolina slate belt of North Carolina — *Terry W. Offield and Terry L. Klein*
9:00 Black shales as hosts for unconventional platinum-group-element resources? Examples from southern China and the Yukon, Canada, and implications for U.S. resources — *Richard I. Grauch, Raymond M. Coveney, Jr., James B. Murowchick, and Chen Nansheng*
9:30 Assessment of undiscovered mineral resources, Tongass National Forest, southeastern Alaska — *David A. Brew, Lawrence J. Drew, Jeanine M. Schmidt, David H. Root, and Donald F. Huber*
10:00 Detailed profiles of southeastern Arizona obtained by a truck-mounted magnetometer—A step toward better utilization of the information content of geophysical data — *Mark E. Gettings, Mark W. Bultman, and Frederick S. Fisher*
AND
Geology and mineral-resource assessment of part of the northern Safford basin, southeastern Arizona — *Brenda B. Houser, J.M. Kruger, and Roy A. Johnson*
10:40 COFFEE BREAK AND POSTER SESSION
11:00 Subsurface structure and lithology near the Getchell gold trend, Osgood Mountains, Nevada—Geophysical insights — *V.J.S. Grauch, Donald B. Hoover, and Wayne S. Wojniak*
11:30 Mapping minerals with imaging spectroscopy near Canon City, Colorado — *Roger N. Clark, Andrea J. Gallagher, and Gregg A. Swayze*
12:00 p.m. MCKELVEY FORUM LUNCHEON
LUNCHEON ADDRESS: Making high grade — *Stephen E. Kesler*
2:00 Large sulfide-sulfate mounds, hydrothermal fluids, and altered sediment in Escanaba Trough, southern Gorda Ridge—Elements of a mature hydrothermal system at a sediment-covered spreading axis — *Randolph A. Koski, Janet L. Morton, Robert A. Zierenberg, Wayne C. Shanks III, Andrew C. Campbell, and Keith A. Kvenvolden*
2:30 Marine ferromanganese deposits near the Marshall Islands — *James R. Hein, Jung-Keuk Kang, Marjorie S. Schulz, Suk-Hoon Yoon, and Virginia K. Smith*
3:00 COFFEE BREAK AND POSTER SESSION
3:30 U.S. Geological Survey research on agricultural industrial minerals in the United States—Implications for exploration — *James R. Herring, David Z. Piper, Sherilyn Williams-Stroud, Charles S. Spirakis, and Richard A. Sheppard*

WEDNESDAY, FEBRUARY 13, 1991—Continued

- 4:00 Mercury-sulfur-gypsum mineralization at Crater, California—A suggestion of gold mineralization at depth — *Sherman P. Marsh, Chester T. Wrucke, and Kevin P. Corbett*
- 4:30 Geology and mineral potential of Precambrian basement rocks of the Trans-Hudson orogen, U.S.A. — *P.K. Sims, Zell E. Peterman, and T.G. Hildenbrand*

WEDNESDAY EVENING, FEBRUARY 13, 1991

- 5:30–7:00 OPEN HOUSE — Mackay School of Mines, University of Nevada, Reno, and new USGS field office in the Laxalt Strategic Materials Building
- 8:00–9:30 DIRECTOR'S SPECIAL BRIEFING: US-USSR cooperative studies in mineral resources

THURSDAY, FEBRUARY 14, 1991

- Morning Session: The role of Federal and commercial sectors in international minerals development
- Session Chairman: *Dallas L. Peck, Director, U.S. Geological Survey*
- Opening remarks and the role of the USGS in international mineral resources — *Dallas L. Peck, Director, USGS*
- The role of the Bureau of Mines in international mineral resources — *TS Ary, Director, U.S. Bureau of Mines*
- Mellon Bank's role in stimulating international minerals development — *Peter H. Conze, Jr., Senior Vice-President, Mellon Bank*

- The Inter-American Development Bank's role in stimulating minerals development — *Juan Proaño, Inter-American Development Bank*
- Criteria for investment in international exploration — *Jack Parry, Senior Vice-President, Newmont Mining Corporation and Newmont Gold*
- Criteria for investment in international exploration — *John I. Sharpe, Vice-President for Exploration, Battle Mountain Gold Company*
- Opportunities for mineral exploration in Bolivia — *Ing. Marcelo Claure Zapata, Director, Servicio Geológico de Bolivia (GEOBOL)*
- Opportunities for mineral exploration in Chile — *Juan Carlos Parra Espinosa, Subdirector for Geology, Servicio Nacional de Geología y Minería (SERNA-GEOMIN), Chile*

- Afternoon Session: Examples of selected USGS international mineral resource investigations
- Volcanic-hosted epithermal precious-metal desposits in the central Andes—Geology, resources, and exploration strategy — *George E. Erickson, Charles G. Cunningham, and Barbara A. Eisswerth*
- An overview of the mineral resources and USGS activities in Venezuela — *Jeffrey C. Wynn*
- Mineral resources of the Bolivian Altiplano — Results of the GEOBOL-USGS-TDP Mineral Resource Evaluation Project — *Keith Long, S. Ludington, and R. Carrasco*
- Mineral-resource assessment of Puerto Rico — *Gregory E. McKelvey and Walter J. Bawiec*
- Platinum-group-mineral investigations, East and South Kalimantan, Indonesia — *Michael L. Zientek and Bambang Pardiarto*
- Mineral-resource investigations in Saudi Arabia by the U.S. Geological Survey — *Paul L. Williams*



Small-scale hydraulic mining adjacent to the Chicanán River near Kilometer 88, Venezuela. Gold is being extracted from the Uairén Formation of the Roraima Group. Photograph by Jeffrey C. Wynn in January 1989.

ENCLOSURE C

1991 McKelvey Forum - Poster Sessions

Booth 1. Buhler & Associates Inc.:

Booth 2. Buhler & Associates Inc.

3. Actividades del USGS relacionadas con recursos minerales en America Latina (In Spanish)
4. Recent USGS Mineral Resources Publications
5. Bureau of Indian Affairs

International Studies

6. Frances Wahl Pierce and Karen Sue Bolm: Latin American Mineral-Resource Data Available through the U.S. Geological Survey
7. Walter J. Bawiec, Andrew Griscom, Richard D. Krushensky, Sherman P. Marsh, Gregory E. McKelvey, and Kathryn M. Scanlon: Mineral-Resource Assessment of Puerto Rico
8. Sherman P. Marsh, Dan H. Knepper, Jr., Keith R. Long, and John W. Cady: Mineral-Resource Assessment of the Altiplano and Cordillera Occidental, Boliva - A Progress Report
9. Dennis Cox, Raul Carrasco, Orlando André, Alberto Hinojosa, and Keith Long: Copper Deposits in Tertiary Red Beds in Bolivia
10. B. A. Eiswerth, T.L. Bowers, Lucia Cuitino, Felipe Diaz, Hugo Gumucio, Aldo Gutarra, Nestor Jimenez, J.L. Lizca, Ramon Moscoso, Fernando Murillo, Luis Quispesivana, Jaime Rodriguez, L.C. Rowan, Rubén Tejada, and César Vilca: Use of Landsat Thematic Mapper Images for Studying Volcanic-Rock-Hosted Precious-Metal Deposits in the Central Andean Region
11. Fernando P. Miranda, Anne E. McCafferty, and James V. Taranik: Reconnaissance Geologic Mapping Using Digital Aeromagnetic Data and Space-Shuttle Radar Data for a Heavily Forested Area of the Guayana Shield, Northwestern Brazil
12. Gregory E. McKelvey and Jane M. Hammarstrom: A Reconnaissance Study of Gold Mineralization Associated with Garnet Skarn at Nambija, Zamora Province, Ecuador

13. J.C. Wynn, S.D. Olmore, Floyd Gray, W.C. Day, G.B. Sidder and N.J. Page: U.S. Geological Survey Mineral-Resource and Tectonic Studies in Venezuela
14. G.B. Sidder, W.C. Day, R.M. Tosdal, S.D. Olmore, Luis Guzman, and Freddy Prieto: Evolution of an Early Proterozoic Rift Basin in the La Esmeralda Area, Guayana Shield, Venezuela
15. G.B. Sidder, W.E. Brooks, Yasmin Estanga, Fernando Nuñez, and Andres Garcia: Early to Middle Proterozoic Supracrustal Rocks and Mineralization of the Southern Guayana Shield, Venezuela
16. Miles L. Silberman, Anita Moore-Nall, and Brian M. Smith: Gold-Bearing Quartz Veins Along the Mojave-Sonora Megashear Zone, Northern Sonora, Mexico
17. Donald J. Grybeck, Warren J. Nokleberg, and Thomas K. Bundtzen: Comparative metallogeny of the Soviet Far East and Alaska
18. F.L. Wong, B.A. Richmond, H.G. Greene, J.R. Dingler, J.R. Hein, K.A. Kvenvolden, M.S. Marlow, J.L. Morton, D.M. Rubin, D.W. Scholl, and J.G. Vedder: SOPAC - A decade of research on mineral and hydrocarbon resources in the South Pacific
19. Robert J. Kamilli: Geology and genesis of the Baid Al Jimalah and Silsilah tungsten-tin deposits, Kingdom of Saudi Arabia

Mineralizing Processes and Systems

20. Robert J. Kamilli: The Mogollon mining district, southwestern New Mexico - Classic epithermal silver-gold vein deposits revisited
21. Leslie Cox, Brenda B. Houser, Eric R. Force, Mark E. Gettings, Alison Burchell and Frederick S. Fisher: Geologic map of the Sierrita-Mogollon Corridor (Arizona-New Mexico) and implications for mineral resources
22. Eric R. Force: The Bisbee Group of the Tombstone Hills, southeastern Arizona—Stratigraphy, structure, metamorphism, and mineralization
23. Peter J. Modreski and Jon J. Connor: Tourmalinite and iron-formation in the Yellowjacket Formation, Idaho cobalt belt, Lemhi County Idaho
24. George A. Desborough, William H. Raymond, and Karl V. Evans: Anomalous concentrations of fine-grained and native gold in stream sediments of east-central Lemhi County, Idaho

25. Dawn J. Madden-McGuire and Sherman P. Marsh: Recognition of distinct terranes in lower Paleozoic host rocks in the Getchell gold trend, Humboldt County, Nevada
26. W.S. Wojniak and D.B. Hoover: The Getchell gold trend, northwestern Nevada—Geologic structure delineated by further processing of electromagnetic data collected during a helicopter survey.
27. D.J. Grimes, W.H. Ficklin, J.B. McHugh, and A. Meier: Geochemical investigation of ground water associated with disseminated gold deposits along the Getchell trend, northern Nevada
28. D.E. Detra, S.M. Smith, P.K. Theobald, and P.M. Theodorakos: Element dispersion in alluvium covering gold deposits in the Kelley Creek valley, Getchell gold trend, Humboldt County, Nevada
29. R.A. Schweickert, J.H. Stewart, J.H. Dilles, L.J. Garside, R.C. Greene, R.F. Hardyman, D.S. Harwood, and N.J. Silberling: Triassic-Jurassic magmatic arc of western Nevada and eastern California— Part I: Geology
30. R.M. Senterfit and D.P. Klein: Triassic-Jurassic magmatic arc of western Nevada and eastern California— Part II: Audio-magnetotelluric survey near Reno and Carson City, Nevada
31. J.L. Doebrich, L.J. Garside, D.R. Shawe, J.H. McCarthy, Jr., R.L. Turner, R.F. Hardyman, J.A. Erdman, H.F. Bonham, and J.V. Tingley: Triassic-Jurassic magmatic arc of western Nevada and eastern California— Part III: Mineral deposits
32. D.L. Sawatzky, G.L. Raines, J.L. Doebrich, R.L. Turner, L.J. Garside, and J.H. McCarthy, Jr.: Triassic-Jurassic magmatic arc of western Nevada and eastern California— Part IV: A model for the evaluation of Cenozoic basins for concealed mineral systems
33. J.H. McCarthy, Jr., R.L. Turner, J.A. Erdman: Triassic-Jurassic magmatic arc of western Nevada and eastern California—Part V: Exploration Geochemistry
34. Peter Popenoe and Frank T. Manheim: Phosphorite deposits of the northern Blake Plateau as observed from the NR-1 submarine and Delta minisubmersible
35. L.J. Poppe and J.A. Commeau: Silt-fraction mineralogy of unconsolidated sediment samples from the continental shelf, slope, and rise off the northeastern United States

36. **Thomas P. Frost and Stephen E. Box:** Lithologic and tectonic controls on mercury mineralization in the Bethel 1° X 3° quadrangle, southwestern Alaska
37. **William F. Cannon and Teresa A. McGerver:** Mineral deposits of the Midcontinent Rift, Lake Superior region, United States and Canada

Mineral Resource Assessments

38. **Theresa M. Cookro, Michael A. Shubat, and Janet L. Jones:** Preliminary assessment of the mineral resources of the Cedar City 1° X 2° quadrangle, Utah
39. **H. Richard Blank:** Geophysical applications in mineral-resource assessments, Cedar City 1° X 2° quadrangle, southwestern Utah
40. **J.E. Kilburn, S.E. Box, R.J. Goldfarb, J.E. Gray, and J.L. Jones:** Mineral-resource assessment of the Goodnews 1° X 3° quadrangle and parts of the Hagemeister Island and Nushagak Bay quadrangles, southwestern Alaska
41. **D.J. Madden-McGuire and G.R. Winkler:** Areas of mineral-resource favorability (with emphasis on gold and chromite) in the Anchorage 1° X 3° quadrangle, southern Alaska
42. **J.R. Riehle, S.E. Church, and L.B. Magoon:** Resource assessment of the Mount Katmai 1° X 2° quadrangle and adjacent parts of the Naknek and Afognak quadrangles, Alaska Peninsula
43. **S.M. Karl, R.J. Goldfarb, K.D. Kelley, D.M. Sutphin, C.A. Finn, A.B. Ford, and D.A. Brew:** Mineral-resource potential of the Sitka 1° X 3° quadrangle, southeastern Alaska
44. **Edwin H. McKee and others (16 authors):** Maps showing the analysis of mineral resources of Nevada (12 maps)
45. **Edwin H. McKee (Same as #44)**

Geochemical and Geophysical Investigations

46. **Philip H. Nelson, David J. Johnston, Henry G. Kreis, and Jon L. Mikesell:** Geophysical logs in an oxide copper deposit near Casa Grande, Arizona
47. **Anne E. McCafferty and Viki Bankey:** Regional aeromagnetic and gravity data bases for studies centered on the Idaho batholith and Challis volcanic field

48. John W. Cady, Viki Bankey, Keenan Lee, A.E. McCafferty, James A. Pitkin and W.D. Stanley: Synthesis of geophysical and geological data centered on the Idaho batholith and the Challis volcanic field, Idaho
49. David F. Barnes and John S. Kelley: Applications of gravity data to study of framework geology, evaluation of mineral deposits, and mineral prospecting in northwestern Alaska
50. R.J. Horton, W.C. Day, T.L. Klein and B.D. Smith: Geophysical and geological studies of the Roseau 1° X 2° quadrangle, Minnesota and Ontario
51. Robert J. Horton, Bruce D. Smith, Victor F. Labson, and Robert J. Bisdorf: Interpretation of new geophysical data obtained by airborne instruments for the Effie-Coon Lake area, Minnesota
52. James A. Pitkin: Preliminary results of geochemical investigations of aerial gamma-ray anomalies in the Getchell gold trend, Humboldt County, Nevada
53. Robert A. Ayuso and Joseph G. Arth: Geochemistry and metallogeny of granitic rocks from the Appalachian Mountains—Examples from the Northeast Kingdom batholith, Vermont, and the Lucerne and Deblois batholiths, Maine
54. H.V. Alminas, J.B. McHugh and E.C. Perry, Jr.: Geochemical evidence for near-surface precious- and base-metal disseminated and vein deposits in the west-central Vermilion district, northeastern Minnesota
55. W.R. Miller, W.H. Ficklin, and J.B. McHugh: Hydrogeochemical exploration in areas of thin glacial overburden, northeastern Minnesota
56. R.P. Ashley, Russell C. Evarts, and William R. Miller: Chemistry of natural waters in the St. Helens mining district, Washington—A test of hydrogeochemical prospecting methods in the Cascade Range
57. G. Plumlee, Walter H. Ficklin, and Stephen A. Wilson: Cyanide speciation and degradation in heap-leach mineral processing
58. David B. Smith, Donald B. Hoover, and Richard F. Sanzolone: Development and testing of the CHIM electrogeochemical exploration method
59. J.E. Gray, D.E. Detra, R.J. Goldfarb, and K.E. Slaughter: Geochemical exploration criteria for epithermal cinnabar and stibnite deposits, southwestern Alaska

60. D.M. Hopkins, J.E. Gray, and K.E. Slaughter: Low-level gold determinations by use of flow injection analysis-atomic absorption spectrophotometry—An application to precious-method-resource assessment in the Iditarod 1° X 3° quadrangle, southwestern Alaska
61. Thelma F. Harms: Seasonal variation in the silver concentration in mesquite (Prosopis juliflora) collected near Globe, Arizona
62. J.A. Erdman, Falma Moye, and P.K. Theobald: Biogeochemical and geochemical expression of poorly exposed epithermal mineralization in the southeastern Challis volcanic field, Idaho
63. R.G. Eppinger, L.G. Closs, A.L. Meier, and J.M. Motooka: Can trace and rare-earth elements in fluorite be useful in geochemical exploration? Encouraging evidence from the Sierra Cuchillo area, New Mexico

General Topics and New Techniques

64. Warren W. Wood and Ward E. Sanford: The origin of evaporite deposits—A model based on a hydrologically open system
65. Christopher J. Potter, John A. Grow, Charles H. Thorman, Harry E. Cook, and James A. Peterson: Basin evolution and petroleum studies in the U.S. eastern Great Basin—Relevance to mineral investigations
66. Sandra H.B. Clark: Geologic setting of barite deposits as indicators of the potential for other types of mineral deposits
67. Gregory E. McKelvey and James D. Bliss: Application of grade and tonnage models to the development of strategies for mineral deposit exploration
68. Douglas E. Crowe, Wayne C. Shanks, III., and John W. Valley: Laser-microprobe studies of sulfur isotopes in stockwork and massive sulfide ores, Rua Cove mine, south-central Alaska
69. J.D. Hoffman, Gregory B. Gunnels, and James M. McNeal: National geochemical database: National uranium resource evaluation data for the western conterminous United States, Digital Data Series 91-1
70. Curtis E. Larsen: Heavy-mineral placers at the Fall Zone
71. William H. Langer: Natural aggregates—Mining challenge of the 1990's
72. Buhler & Associates Inc.

ENCLOSURE D

Maps Showing the Analysis of Mineral Resources of Nevada

February 1991

INTRODUCTION

These are prototype maps intended to be published in a folio reporting on the analysis of undiscovered metal-bearing mineral resources of Nevada. The analysis began in January 1988 as a cooperative project by the U. S. Geological Survey and the Nevada Bureau of Mines and Geology. The folio does not address non-metallic resources and it does not identify specific locations of undiscovered resources.

Nevada's position as the nation's largest silver producer 120 years ago and as the largest gold producer in 1988 is striking considering that over 50 percent of Nevada's 286,200 km² surface is covered by apparently barren rocks and sediments. Because the majority of mineral deposits exposed at the surface are believed to have already been found, a prime concern has been the nature of and the depth to possible mineralized systems under this cover.

The goal of this folio is to provide an analysis of Nevada's mineral resources that can be used to help plan economic development, consider alternate uses of land, plan exploration, and estimate the availability of minerals under different conditions. Due to the extent of cover, a very important condition affecting the value of minerals in Nevada is the depth of the deposits. Depth affects: (1) the chances of discovery in that deeper deposits are much more difficult (and therefore more costly) to discover, and (2) economic viability in that deeper deposits are significantly more costly to mine. Arbitrarily, we have limited our analysis to the deposits and their permissive geologic environments that occur within the upper one kilometer of the earth's crust. This limit means that if any part of a deposit exists in the upper 1 km., it is counted; thus, deposits that extend below 1 km could be mined if economics permit.

The three part resource assessment form is used because of its ability to respond to each of the diverse problems mentioned and it allows the use

a variety of information and resource assessment methods. In the three part assessment form:

1. Areas are delineated according to types of deposits their geology will permit;
2. The amount of metal and some characteristics of ore are estimated by means of grade and tonnage models; and,
3. The number of deposits of each type in delineated areas is estimated.

Areas or domains are delineated that may contain particular deposit types as inferred by analogy with deposits in similar geologic settings elsewhere. In order to construct the boundaries it is necessary to have a geologic map and it is desirable to have mineral occurrence, geophysical, exploration, and geochemical information. This information must be integrated with information about the geologic environment of different types of mineral deposits to perform the delineation. The keystone to combining the diverse information is the mineral deposit model. Documented deposit models in Bulletin 1693, 'Mineral Deposit Models' (Cox and Singer, 1986) allow linkage of deposit types to geologic environments.

In order to make the connection of deposit type to geologic environment, it is necessary to recognize and map the relevant geologic settings in Nevada. This is the primary purpose of the sections of this folio that address gravity field, magnetic field, pre-Tertiary geology, Tertiary geology, ages of young volcanic deposits and related mineral deposits, intrusive rocks, neotectonics, known mineral deposits, and mineral resources.

The geologic maps used in this folio are modified from that published by Stewart and Carlson (1978). Rock units are grouped to represent geologic environments permissive for different types of mineral deposits. It also includes new information on the age of igneous rocks and some changed contacts and unit designations. Because the geologic map

represents the geology that is exposed and therefore best known, it is the foundation for most of the other studies reported here.

Analysis of regional gravity data is used here (Jachens and Moring, this folio) to estimate the thickness of young cover and to produce a gravity map from which the effects of thick deposits of young rock and unconsolidated sediments have been removed. This map is used to help identify the lithology of the concealed basement, to delineate major crustal structures and boundaries, and to identify calderas and concealed plutons, all of which can reflect geologic environments permissive for certain types of mineral deposits.

The analysis of magnetic data (Blakely, this folio) focuses on the distribution of near-surface magnetic sources in order to delineate bodies of shallowly buried magnetic rock. Typically these are Tertiary and Quaternary volcanic rocks. The three-dimensional information provided by the analysis affects the mineral resource analysis in that certain types of mineral deposits are associated with magnetic rocks.

Many kinds of mineral deposits are genetically related to intrusive igneous rocks. Knowledge of where these plutonic rocks occur is critical in identifying where these types of deposits could exist. A new geophysical tool relying primarily on magnetic data is used to locate unexposed plutonic rocks (Grauch, this folio).

In order to explicitly consider depth in this study, we must deal with volumes of rock and must combine the rock units such that they represent consistent geologic environments. A new type of geologic map is required to portray these rock groups because a number of different geologic environments may overlap in the one kilometer beneath any given locality on the surface. The complexity of display requires two different maps. The first map of the Pre-Tertiary geology (Ludington and Leonard, this folio), shows older rocks that may host mineral deposits related to later igneous activity or may contain mineral deposits that formed at the same time as the rocks. The second map, Tertiary geology of Nevada, is not presented here.

Ages of young volcanic rocks (McKee, this folio) when compared with the ages of different kinds of mineral deposits provide key information about the development and nature of the mineral deposits and also provide new light on the geologic development of Nevada.

Geological, geomorphic, geophysical, and well-log data are analyzed to infer the approximate subsurface geometry of fault-bounded basins in Nevada. This neotectonic analysis (Dohrenwend, Schell, Moring, Menges, and McKittrick, this folio) provides information about the depth of environments permissive for older deposits and about the spatial distributions of younger rocks that may be associated with the mineral deposits formed at shallow depths, possibly near faults related to the basins.

Types of mineral deposits and occurrences that have already been found in specific geologic environments in Nevada (Sherlock, Cox, Tingley, and Huber, this folio) not only confirm that the environments are permissive for the same deposit types, but also suggest the possibility of genetically related deposit types. For the first time, a large number (1401) of mineral deposits and occurrences are classified by deposit type. As noted above, specific geologic environments suggest the possibility of certain types of mineral deposits. The converse is also true; the distribution of different types of known mineral deposits suggest the presence of geologic environments that may not be evident from existing geologic maps.

The mineral resource analysis portions presented here consist of two maps showing tracts delineated as permissive for most metal-bearing deposit types (Cox, Ludington, Singer, Sherlock, and Tingley, this folio). Deposit types not on these maps include sediment-hosted gold (Carlin) and syngenetic types.

Some of the results of this project have been made available in a number of published or soon to be published reports that are listed below under references and project reports.

ACKNOWLEDGEMENTS

Numerous experts gave generously of their time and knowledge to make this report possible, and we thank them: Jack Stewart, Bob Christiansen, Roger Ashley, Bryon Berger, Jaime Gutzman, Misac Nabighian, Jim Rytuba, Joe Duval, David John, Bill Bagby, Dan Shawe, Ted Theodore, Elizabeth Jones, Richard Hardyman, and Norm Silberling. In addition, we are grateful for the support of Jonathan Price, Director, Nevada Bureau of Mines and Geology, and the following mining companies for information or mine tours: Bond Gold Bullfrog, Inc., Coeur-Rochester, Inc., Newmont Exploration Limited, Santa Fe Pacific Mining, Inc., and Western Goldfields Co.

REFERENCES AND PROJECT REPORTS

- Best, M.G., Christiansen, E.H., Dieno, A.L., Grommé, C.S., McKee, E.H., and Noble, D.C., (equal authorship), 1989, Eocene through Miocene volcanism in the Great Basin of the Western United States: in Guidebook for International Association of Volcanology and Chemistry of the Earth's Interior, 1989, Mtg. Santa Fe, New Mexico, Memoir 47, p. 91-133.
- Blakely, R.J., and Jachens, R.C., 1990, Concealed mineral deposits in Nevada: Insights from three-dimensional analysis of gravity and magnetic anomalies: [abs] in Geology and ore-deposits of the Great Basin, sponsored by Geological Society of Nevada and U. S. Geological Survey, Programs with abstracts, p. 52-53.
- Cox, D.P., and Singer, D.A., eds., 1986, Mineral deposit models: U. S. Geological Survey Bulletin 1693, 379p.
- Cox, D.P., Ludington, Steve, Sherlock, M.G., Singer, D.A., Berger, B. R., and Tingley, J.V., 1990, Mineralization patterns in time and space in the Great Basin of Nevada: [abs] in Geology and ore-deposits of the Great Basin, sponsored by Geological Society of Nevada and U. S. Geological Survey, Programs with abstracts, p. 53-54.

Cox, D.P., Ludington, Steve, Sherlock, M.G., Singer, D.A., Berger, B. R., Blakely, R.J., Dohrenwend, J.C., Huber, D.F., Jachens, R.C., McKee, E.H., Menges, C.M., Moring, B.C., and Tingley, Joe, 1989, Methodology for analysis of concealed mineral resources in Nevada: A progress report: [abs] in Schindler, K. S. ed., U. S. Geol. Survey research on mineral resources—1989 program and abstracts; Fifth annual V. E. McKelvey forum on mineral and energy resources: U. S. Geol. Survey Circular 1035, p. 10-11.

Dohrenwend, J.C., and Moring, B.C., in press, Reconnaissance photogeologic map of young faults in the Lovelock 1° x 2° quadrangle, Nevada: U. S. Geol. Survey Misc. Field Map MF- , scale 1:250,000.

Dohrenwend, J.C., and Moring, B.C., in press, Reconnaissance photogeologic map of young faults in the McDermitt 1° x 2° quadrangle, Nevada: U. S. Geol. Survey Misc. Field Map MF- , scale 1:250,000.

Dohrenwend, J.C., and Moring, B.C., in press, Reconnaissance photogeologic map of young faults in the Vya 1° x 2° quadrangle, Nevada: U. S. Geol. Survey Misc. Field Map MF- , scale 1:250,000.

Dohrenwend, J.C., and Moring, B.C., in press, Reconnaissance photogeologic map of young faults in the Winnemucca 1° x 2° quadrangle, Nevada: U. S. Geol. Survey Misc. Field Map MF- , scale 1:250,000.

Dohrenwend, J.C., McKittrick, M.A., and Moring, B.C., in press, Reconnaissance photogeologic map of young faults in the Wells 1° x 2° quadrangle, Nevada: U. S. Geol. Survey Misc. Field Map MF- , scale 1:250,000.

Dohrenwend, J.C., Schell, B.A., and Moring, B.C., in press, Reconnaissance photogeologic map of young faults in the Millett 1° x

2° quadrangle, Nevada: U. S. Geol. Survey Misc. Field Map MF- , scale 1:250,000.

Dohrenwend, J.C., Jachens, R.C., Blakely, R.J., and Moring, B.C., 1990, Subsurface geometry and stratigraphy of basins in the Western Great Basin: Implications for the analysis of concealed mineral resources in Nevada: [abs] in *Geology and ore-deposits of the Great Basin*, sponsored by Geological Society of Nevada and U. S. Geological Survey, Programs with abstracts, p. 50.

Dohrenwend, J.C., McKittrick, M.A., Schell, B.A., and Moring, B.C., in press, Reconnaissance photogeologic map of young faults in the Goldfield 1° x 2° quadrangle, Nevada: U. S. Geol. Survey Misc. Field Map MF- , scale 1:250,000.

Dohrenwend, J.C., Menges, C.M., Schell, B.A., and Moring, B.C., in press, Reconnaissance photogeologic map of young faults in the Las Vegas 1° x 2° quadrangle, Nevada: U. S. Geol. Survey Misc. Field Map MF- , scale 1:250,000.

Dohrenwend, J.C., Schell, B.A., McKittrick, M.A., and Moring, B.C., in press, Reconnaissance photogeologic map of young faults in the Elko 1° x 2° quadrangle, Nevada: U. S. Geol. Survey Misc. Field Map MF- , scale 1:250,000.

Dohrenwend, J.C., Schell, B.A., McKittrick, M.A., and Moring, B.C., in press, Reconnaissance photogeologic map of young faults in the Ely 1° x 2° quadrangle, Nevada: U. S. Geol. Survey Misc. Field Map MF- , scale 1:250,000.

Dohrenwend, J.C., Schell, B.A., McKittrick, M.A., and Moring, B.C., in press, Reconnaissance photogeologic map of young faults in the Lund 1° x 2° quadrangle, Nevada: U. S. Geol. Survey Misc. Field Map MF- , scale 1:250,000.

Dohrenwend, J.C., Jachens, R.C., Blakely, R.J., Moring, B.C., and Menges, C.M., 1989, Geological and geophysical analysis of the subsurface geometry of basins in the central and western Great

Basin: Implications for the analysis of concealed mineral resources in Nevada: [abs] in Schindler, K. S. ed., U. S. Geol. Survey research on mineral resources—1989 program and abstracts; Fifth annual V. E. McKelvey forum on mineral and energy resources: U. S. Geol. Survey Circular 1035, p. 14.

Jachens, R.C., and Moring, B.C., 1990, Maps of the thickness of Cenozoic deposits and the isostatic residual gravity over basement for Nevada: U. S. Geol. Survey Open-File Report 90-404, 2 sheets, scale 1:1,000,000, 15p.

Jachens, R.C., Blakely, R.J., and Moring, B.C., 1989, Analysis of concealed mineral resources in Nevada: Constraints from gravity and magnetic studies: [abs] in Schindler, K. S. ed., U. S. Geol. Survey research on mineral resources—1989 program and abstracts; Fifth annual V. E. McKelvey forum on mineral and energy resources: U. S. Geol. Survey Circular 1035, p. 35-36.

Ludington, Steve, Cox, D.P., Sherlock, M.G., Singer, D.A., 1990, Spatial and temporal analysis of precious-metal deposit models for a mineral resource assessment of Nevada: [abs] in 8th IAGOD Symposium, Program with Abstracts, Ottawa, August 12-18, 1990, Ottawa, Canada, p. A100-101.

McKee, E.H., and Blakely, R.J., 1990, Tectonic significance of linear, north-trending anomalies in north-central Nevada:[abs] in Geology and ore-deposits of the Great Basin, sponsored by Geological Society of Nevada and U. S. Geological Survey, Programs with abstracts, p. 49.

McKee, E.H., Jachens, R.C., and Blakely, R.J., 1990, Major crustal differences between the northwestern part of the Great Basin and other parts of the province:[abs] in Geology and ore-deposits of the Great Basin, sponsored by Geological Society of Nevada and U. S. Geological Survey, Programs with abstracts, p. 100.

Singer, D.A., 1990, Development of grade and tonnage models for different deposit types: [abs] in 8th IAGOD Symposium, Program

with Abstracts, Ottawa, August 12-18, 1990, Ottawa, Canada, p. A99-100.

Singer, D.A. and Jachens, R.C., 1990, Analyzing Nevada's undiscovered resources: in U. S. Geol. Survey Yearbook Fiscal Year 1988, p.55-58

Stewart , J.H., and Carlson, J.E., 1978, Geologic map of Nevada: U. S. Geol. Survey, scale 1:500,00.

ENCLOSURE E

1991 McKelvey Forum - Poster Sessions

Booths 44 and 45

MAPS SHOWING THE ANALYSIS OF MINERAL RESOURCES OF NEVADA
by
Edwin H. McKee and others

<u>MAP #</u>	<u>TITLE</u>
1 & 2	Known Deposits and Occurrences in Nevada Authors: Maureen G. Sherlock, Dennis P. Cox, Joseph V. Tingley, and Donald F. Huber
3	Cenozoic Volcanic Rocks & Mineral Deposits of Nevada Author: Edwin H. McKee
4	Three-Dimensional Analysis of Magnetic Anomalies From Nevada Author: Richard J. Blakely
5	Tract Delineations of Epithermal Deposits of Nevada Authors: Dennis P. Cox, Stephen D. Ludington, Donald A. Singer, Maureen G. Sherlock, and Joseph V. Tingley
6	Tract Delineations of Intrusive-Related Deposits of Nevada Authors: Dennis P. Cox, Stephen D. Ludington, Donald A. Singer, Maureen G. Sherlock, and Joseph V. Tingley
7	Pediment and Young Faults in Nevada Authors: John C. Dohrenwend, Barry C. Moring, Mary Anne McKittrick
8	Young Faults in Nevada Authors: John C. Dohrenwend, Bruce A. Schell, Barry L. Moring, Christopher M. Menges, and Mary Anne McKittrick
9	Generalized Pre-Tertiary Map Authors: Stephen D. Ludington and Kenneth R. Leonard
10	Tertiary Geology Map of Nevada (not presented at session) Author(s): Not identified
11	Aeromagnetic Interpretation of Granitoid Plutons in Nevada Author: V. J. S. Grauch

MAP #TITLE

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Thickness of Cenozoic Deposits and the Isostatic
Residual Gravity over Basement
Authors: Robert C. Jachens and Barry C. Moring