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Review and Comments on Selected Statements Contained in the November 14, 1989 Letter of the Governor of Nevada to the Secretary of Energy that Bear on Human Interference from a Natural Resources Perspective

Prepared by
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Under Interagency Agreement NRC-02-85-004

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INTRODUCTION

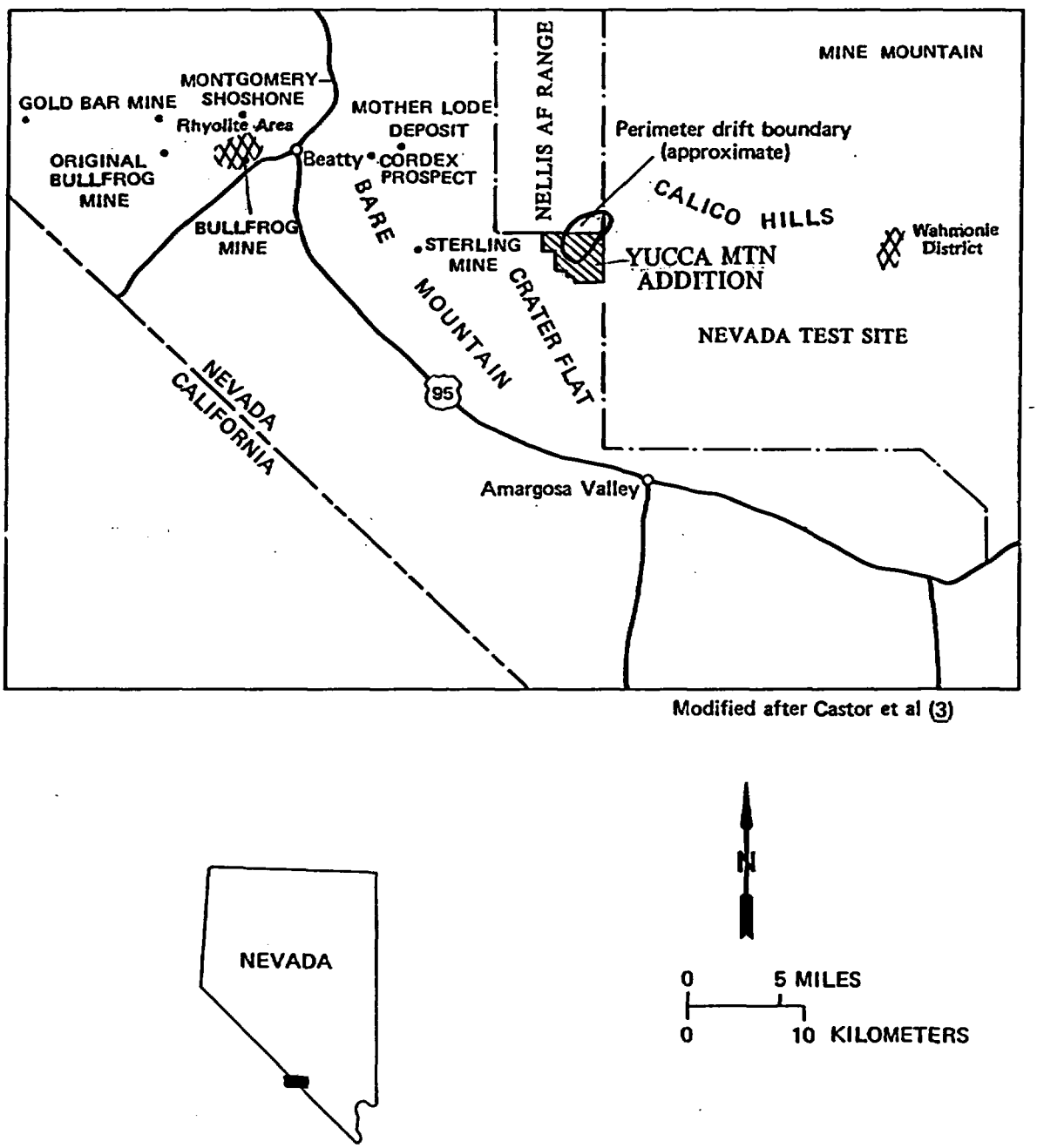
The Bureau of Mines (BOM) was directed by the Nuclear Regulatory Commission (NRC) in Work Directive 023, Task Order 002 under Interagency Agreement NRC-02-85-004, to review and comment on selected, relevant statements contained in the November 14, 1989 letter of the Governor of Nevada to the Secretary of Energy that bear upon human intrusion at the proposed high-Level waste repository at Yucca Mountain from the natural resources perspective and to prepare sufficient illustrations, as appropriate, to accomplish this task.

In partial response to the NRC directives, the following plate and figures have been developed and have been included within the BOM review document:

Plate

Figures

Reviewer's note: While not specifically stated in Governor Bob Miller's letter of November 14, 1989 to James D. Watkins, Secretary of Energy, it is assumed from the text (copy attached) that the Yucca Mountain area (also referred to in the letter variously as the "Yucca Mountain region" or "Yucca Mountain vicinity") is that area extending from Mine Mountain in the east to the Bullfrog Hills in the west, and from the southern part of Timber Mountain in the north to U.S. Highway 95 in the south. For purposes of consistency and clarity, the area defined above will be referred to here as the "Yucca Mountain Area" and includes Mine Mountain, the Calico Hills, Wahmonie area, Yucca Mountain, Crater Flat, Bare Mountain, the Bullfrog Hills, and the Rhyolite area (Figure 1).



Modified after Castor et al (3)

FIGURE 1.– Map showing the location of the Yucca Mountain Addition and of mining districts and other areas discussed in the comments

"Yucca Mountain Site" as used here refers to the underground high-level waste repository facilities at Yucca Mountain proper. The word "Site", as in "Yucca Mountain Site", is defined by Title 10 of the Code of Federal Regulations Part 60.2 (10 CFR Part 60.2) on page 64 as "the location of the controlled area" "Controlled Area (10 CFR Part 60.2, page 63) means a surface location, to be marked by suitable monuments, extending horizontally no more than 10 kilometers in any direction from the outer boundary of the underground facility, and the underlying subsurface, which area has been committed to use as a geologic repository and from which incompatible activities would be restricted following permanent closure."

Statements and Comments

Statement 1. Letter of November 14, 1989, last paragraph, page 8, continued on page 9.

"Numerous Nevada ore deposits demonstrate common geologic features, many of which exist within the Yucca Mountain area. These features include certain types of rock alteration, and a distinct geochemical signature (gold, silver, arsenic, mercury, antimony, molybdenum, zinc, barium, and fluorine). Also these ore deposits are commonly found along and within faults and breccia zones, and are often associated with felsic or granitic dikes, plugs, sills, and stocks. Late stage barite (with or without fluorite) veins is (sic) common. All of these features exist within the immediate Yucca Mountain area."

Reviewer's Comment 1.

Rocks of the Yucca Mountain area are generally characterized by silicic ash-flow tuffs associated with calderas or caldera complexes (Crater Flat-Prospector Pass, Timber Mountain-Oasis Valley, Claim Canyon, Silent Canyon, Black Mountain, and Stonewall Mountain calderas) and underlain by Paleozoic marine sediments. The Yucca Mountain site has many geologic features in common with other areas in terms of structure, volcanic history, or lithology that host significant ore deposits (e.g., Bullfrog, Mother Lode, Gold Bar, Cordex prospect) within the southwestern Nevada volcanic field and elsewhere in Nevada.

Hydrothermal alteration, often in association with anomalous concentrations of gold, silver, arsenic, mercury, antimony, molybdenum, zinc, barium, and fluorine is reported at Bare Mountain about 14 kilometers (km) west of the Yucca Mountain site (1, 2, 3 , 1/).

1/Underlined numbers in parentheses refer to items in the reference list.

Epithermal gold and fluorite mineralization at the Sterling, Mother Lode, Daisy (Crowell) Fluorite, Cordex prospect, and other properties along the northern and eastern margins of Bare Mountain (Figure 2), and probably in the Wahmonie District, is related to subjacent porphyry-type magmatic systems about 13 to 13.5 million years in age (Ma) (4, page 77). Hydrothermal alteration, including argillation, silicification, with strong oxidation and exposures of Tertiary or Mesozoic granitic rocks, is reported by Quade and Tingley (2) in the Wahmonie area; Smith (5) and Hoover (6) report the possible existence of a shallow unexposed pluton at Wahmonie.

Bath and Jaren (as cited in 7, page 1-54) suggest that the subvolcanic basement at the Yucca Mountain site may contain deep-seated granitic rocks that may have provided the heat source for the metamorphism of Upper Devonian and Mississippian argillite, quartzite, conglomerate, and limestone of the Eleana Formation (especially evident in the Calico Hills) and adjacent pre-Cenozoic rocks that may be present. Local gravity and magnetic data have been interpreted by some workers to include a deeply buried pluton that may extend from northern Bare Mountain, under northern Yucca Mountain, to the Calico Hills area (6, 8, 9, 10). Various types and degrees of rock alteration (primarily pervasive silicification) and anomalous trace elements (enrichment in arsenic, antimony, copper, lead, zinc, and traces of silver and gold in Paleozoic shales) are also reported in the Calico Hills (11, page 126) and at other locations surrounding the Yucca Mountain site.

The Yucca Mountain site is further characterized by numerous large and small, generally west-dipping, high-angle normal fault and breccia zones (plate 1; 12, sheets 1 and 2). Further, Castor et al (3, p. 7), citing Scott and Bonk (12), state that these faults may represent the breakaway zone for detachment faulting bounding Bare Mountain 10 km west of the Yucca Mountain Addition. A low-angle detachment is thought to underlie Yucca Mountain and may extend as far east as Mine Mountain (13, 14); at least one detachment fault has been identified at Bare Mountain (15).

Some of the larger faults on Yucca Mountain proper include the Yucca Wash, Paintbrush Canyon, Bow Ridge, Ghost Dance, and Solitario Canyon Faults, as well as the Solitario Canyon breccia zone. Faults and breccia zones have been identified by numerous investigators as potential conduits for mineralizing fluids associated with ore deposits worldwide. Barite, associated with calcite and chlorite, is reported in a thin bed in drill hole USW G-2 (16, cited in 3, page 29).

Statement 2. Letter of November 14, 1989, second paragraph, page 9.

"Economically important mineralization within hydrothermal mineral deposits is obvious in several locations in the Yucca Mountain region. This is true in the Bullfrog Hills and at Bare Mountain, and probably at Wahmonie as well. In Bullfrog Hills, ore grade gold/silver mineralization is largely hosted by rocks of the Timber Mountain-Oasis Valley caldera complex and has been in the past, is currently, and will certainly in the future be exploited."

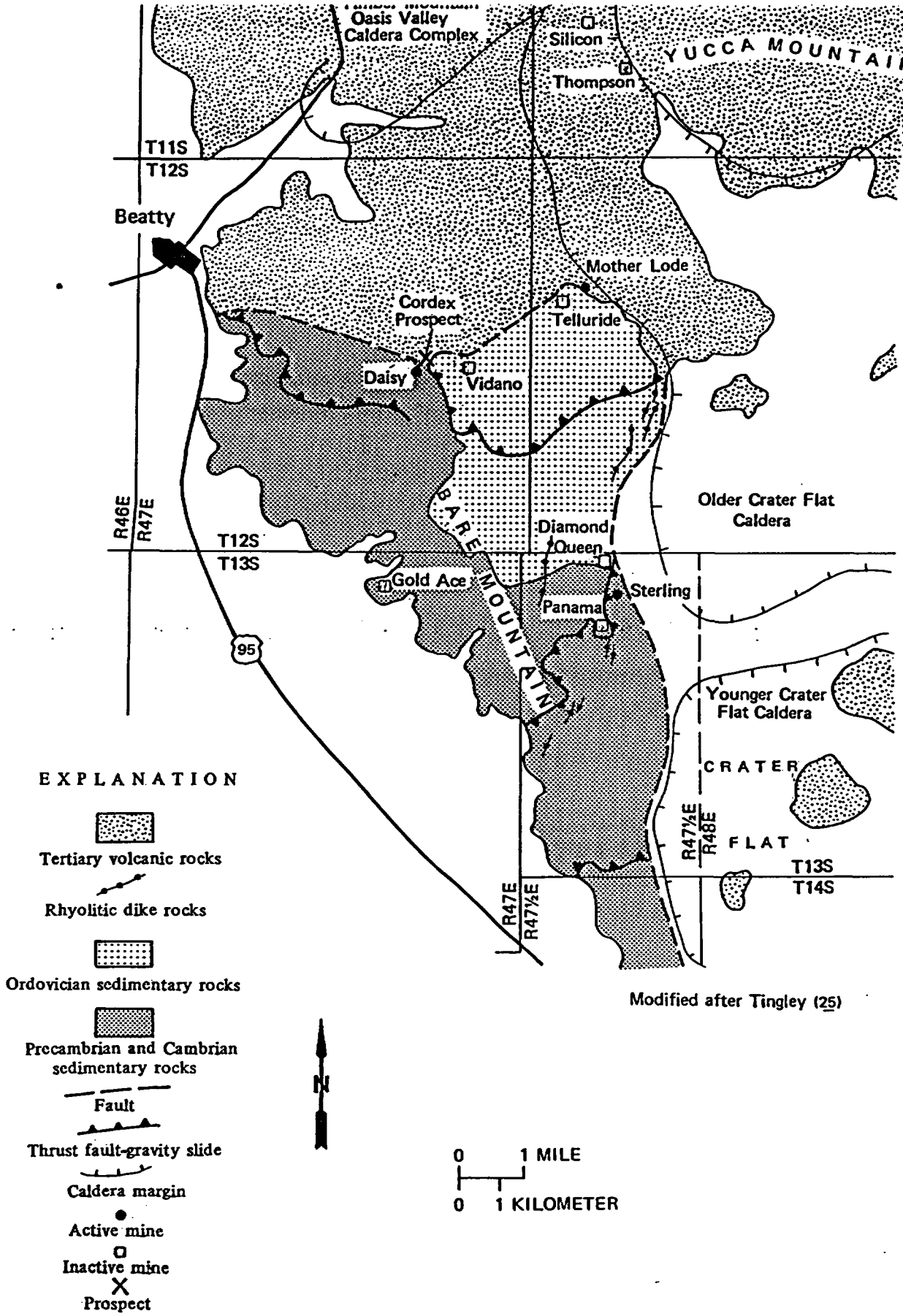


FIGURE 2.– Generalized geologic map of the Bare Mountain (Fluorine) mining district showing principal mines

Reviewer's Comment 2.

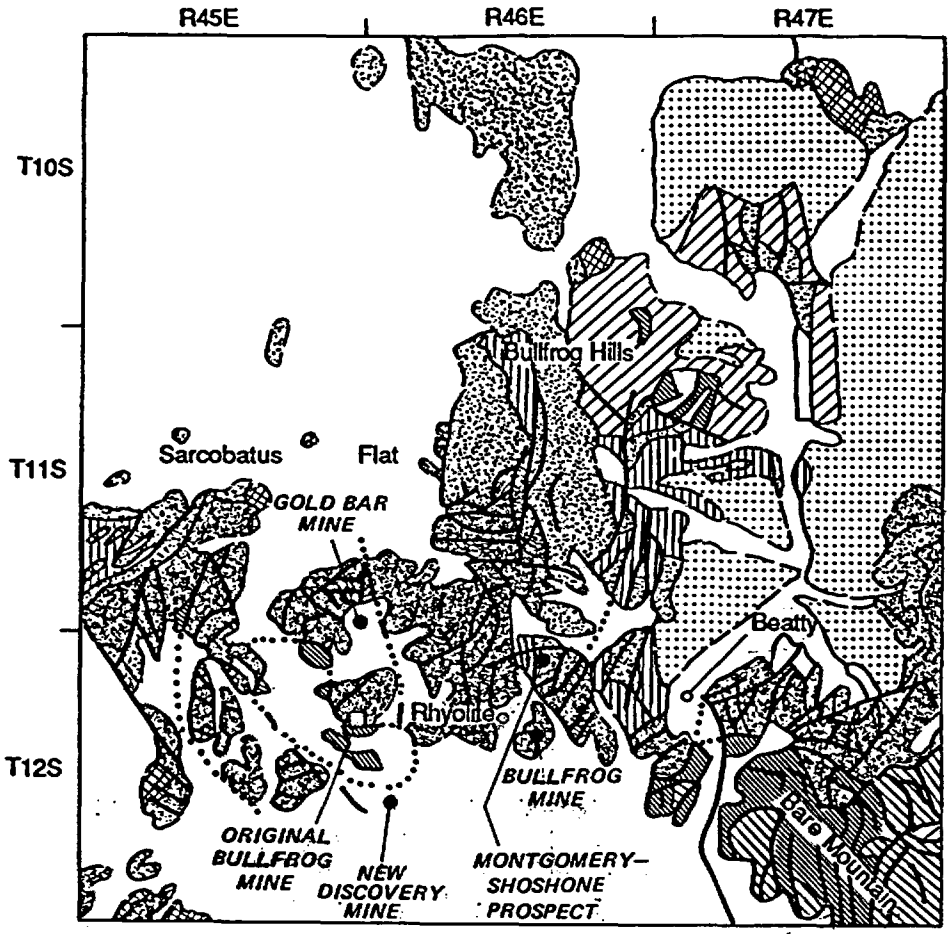
Ore deposits in the Bullfrog Hills generally occur as veins along faults and joints in rhyolitic welded tuffs associated with basalt and quartz latite flows and tuffs (7, page 1-227); the Bullfrog (Rhyolite) District produced more than $3 million of silver and gold between 1905 and 1940 (7, page 1-227). According to Castor and others (3, pages 4-5):

> "Major new mining activity is also underway in the Bullfrog district. In 1982, St. Joe American began evaluation of the district and by 1985 had developed reserves of minable ore at the old Montgomery-Shoshone mine (see Fig. 1) northwest of the old mining camp of Rhyolite. Continued exploration in the district resulted in the discovery of an entirely new orebody near Ladd Mountain 1 km southeast of Rhyolite. Announced reserves are 3,088,000 tons grading 0.072 oz gold per ton at Montgomery-Shoshone and 14,300,000 tons grading 0.110 oz per ton at the New Bullfrog (Bond-Bullfrog, Bullfrog--see reviewer's note following) deposit. Production from these two mines will soon eclipse all historic production from the entire district. In the western part of the Bullfrog district, north of the Original Bullfrog mine, exploration by other companies has outlined 1.23 million tons of gold ore at the Gold Bar mine; this deposit, which was being evaluated in 1987 (NV Bur. Mines and Geol. Spec. Publ. MI-1987, 1988) is now being mined."

Reviewer's note: The Governor of Nevada, in his letter to Secretary Watkins (and other authors in various publications), make references to "Bullfrog", "Bullfrog District", "Bullfrog Hills", "Original Bullfrog", "New Bullfrog", and "Bond-Bullfrog" that are at times confusing. The following discussion, from Nevada Bureau of Mines and Geology Bulletin 77, Geology and Mineral Deposits of Southern Nye County, Nevada by H. R. Cornwall, 1972; Nevada Bureau of Mines Special Publication 10, Major Mines of Nevada, 1989; and U.S. Geological Survey Bullfrog 15 Min. Quadrangle, is presented to put "Bullfrog" nomenclature into perspective.

The "Bullfrog Mining District", also known as the "Rhyolite Mining District" and the "Pioneer Mining District", covers the Bullfrog Hills north and west of Beatty, Nye County, Nevada (Figure 3). Gold was discovered at the Bullfrog mine ("Original Bullfrog", SE1/4 Sec. 12, Twn. 12 S., Rng. 45 E.) at the south end of Bullfrog Mountain (about 11 km west of Beatty within the boundaries of Death Valley National Monument) in 1904. The principal ore body of the Bullfrog District occurred in the Montgomery-Shoshone mine (NE1/4 Sec. 10, Twn. 12 S., Rng. 46 E.) about 5 km west of Beatty. As stated above, St. Joe American recently developed new reserves at the Montgomery-Shoshone and discovered a new ore body near Ladd Mountain ("New Bullfrog", "Bond-Bullfrog", "Bullfrog", Sec. 15, Twn. 12 S., Rng. 46 E.). It appears that St. Joe sold (leased?) its interests to Bond Gold Inc., hence "Bond-Bullfrog." Nevada Bureau of Mines and Geology Special Publication 10 lists on page 21 a "Bullfrog" mine operated by Bond Gold Bullfrog Inc. of Beatty.

In summary, it appears that the "Bullfrog", "New Bullfrog", and "Bond-Bullfrog" are alternate names for the same property in Sec. 15, Twn. 12 S., Rng. 46 E. within the Bullfrog (Rhyolite) mining district in the Bullfrog Hills.



Modified from Cornwall (26)

EXPLANATION

Quaternary — Alluvium

Quaternary/Tertiary — Older alluvium

Tertiary — Basalt, flows and plugs

Tertiary — Timber Mountain Tuff, Paintbrush Tuff, and tuff of Crater Flat

Tertiary — Rhyolite, flows and intrusive masses

Tertiary — Ash-fall tuff and non-welded ash-flow tuff

Tertiary — Welded tuff, ash flows, mostly rhyolitic; locally includes older ash flows

Paleozoic — Paleozoic sedimentary rocks, undivided

Precambrian — Precambrian sedimentary and metamorphic rocks, undivided

● Active mine

□ Inactive mine

N

0 5 MILES

FIGURE 3.– Simplified geologic map of Bullfrog Hills area

Reviewers note: For an in-depth discussion of the Bullfrog and Montgomery-Shoshone mines and the geology and history of the Bullfrog (Rhyolite) mining district, see The Geology, Alteration, and Mineralogy of the Bullfrog Gold Deposit, Nye County, Nevada by D. K. Jorgensen and others, Society of Mining Engineers preprint number 89-135. Also see Geology of Bullfrog Quadrangle and Ore Deposits Related to Bullfrog Hills Caldera, Nye County, Nevada and Inyo County, California by H. R. Cornwall and F. J. Kleinhampl, U.S. Geological Survey Professional Paper 454-J, 1964.

Gold was discovered on the east slope of Bare Mountain about 1905. Production of gold ensued in this area between 1913 and 1915 (3, page 4). The Bare Mountain (Fluorine) District has produced small amounts of mercury; fluorite has been produced at the Daisy (Crowell) (Figure 2) mine more or less continually since 1919.

In 1980, the Bare Mountain (Fluorine) District was revitalized with the discovery of disseminated gold at the Sterling (Panama-Sterling) mine (Figure 4). The deposit has produced between 7,000 and 9,000 oz gold per year since it came on line in 1984 (3, page 4). GEXA Gold Corp. announced the discovery of its Mother Lode deposit on Bare Mountain in 1988. The deposit reportedly has reserves of about 4.4 million tons averaging 0.054 oz gold/ton. The Mother Lode deposit reached commercial production levels in February 1990 when 2308 oz of dore (gold and silver bullion) were poured containing 90 percent gold (17).

Cordex Exploration Co. recently announced the discovery of a new gold/silver deposit near the Daisy (Crowell) Fluorite mine in Fluorspar Canyon on the northern flank of Bare Mountain (Figure 2). Of the three mineralized zones discovered, two occur in Cambrian sedimentary rocks and one in Miocene ash-flow tuffs. The volcanic rocks are strongly propylized, silicified, and argillized. Arsenic, antimony, mercury, and thallium occur in anomalous amounts (18, page 77-78). Figure 4 shows the spatial relationship between Bare Mountain and Yucca Mountain.

The principal mines and prospects in the Bullfrog (Rhyolite) and Bare Mountain (Fluorine) Districts are summarized in Table 1.

Reviewer's note: See Geologic Map of the Bare Mountain Quadrangle, U.S. Geological Survey Map GQ-157 for a detailed description of the area's geology and lithology.

Mines in the Wahmonie District (Figure 1) were discovered in 1847 or 1853 (2, page 31) and rediscovered in 1928 (2, page 31); only minor shipments of precious metals were made (2, page 31). A sample collected by Quade and Tingley (2, page 32) in the Wahmonie area assayed 29.6 oz/ton silver and 0.67 oz/ton gold. This sample was examined on a microprobe and ". . . found to contain cerargyrite, argentite and hessite with anomalous amounts of mercury, bromine, bismuth, and tellurium" (2, page 32). A second sample of quartz vein material assayed 49.89 oz/ton silver and 0.65 oz/ton gold. Two samples, Nos. 1185 and 1902, reportedly from the Wahmonie area, were found in the Mackay School of Mines Museum. "Fire assay results (of a portion of the samples) showed the following: Sample 1185 had 35.08 oz/ton gold and 1271.72 oz/ton silver, while sample 1902 had 42.08 oz/ton gold and 1129.49 oz/ton silver" (2, page 34).

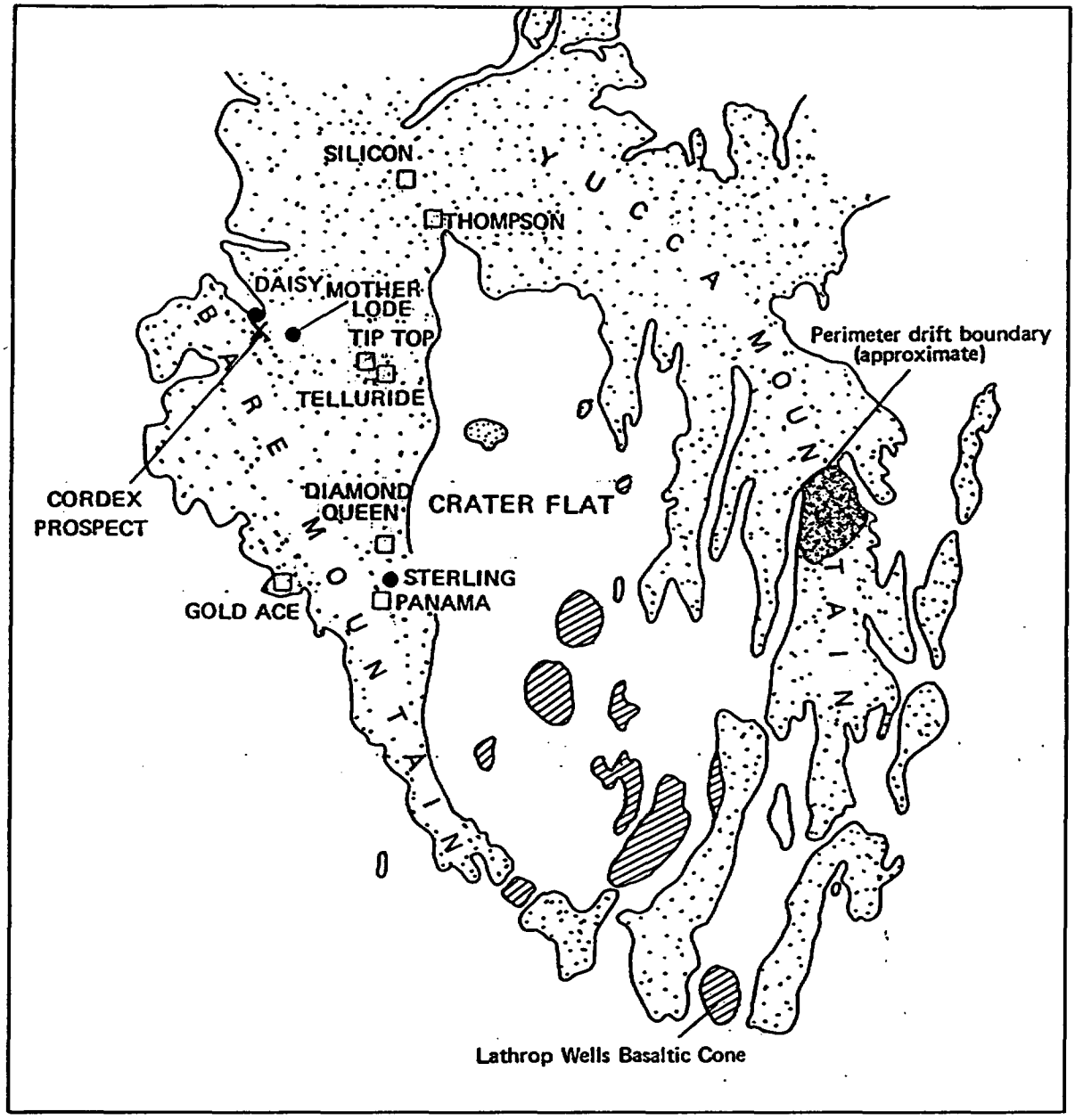


FIGURE 4.– Bedrock map showing spatial relationship of principal mines on Bare Mountain to Yucca Mountain

TABLE 1. Principal Active and Inactive Mines in the Bullfrog (Rhyolite) and Bare Mountain (Fluorine) Mining Districts, Southern Nye County, Nevada

Name	Principal commodity	Status	Location Sec.	Twn.	Rng.
Bullfrog (Bond-Bullfrog)	Gold	Producer 1/	15	12 S.	46 E.2/
Cordex Prospect	Gold	Exploration	13,14	12 S.	47 E.2/
Daisy (Crowell)	Fluorite	Producer 1/	23	12 S.	47 E.2/
Diamond Queen	Gold	Undetermined		Uncertain	3/
Gold Ace	Gold	Idle	3	13 S.	47 E.4/
Gold Bar	Gold	Producer 1/	36	12 S.	45 E.2/
Mother Lode	Gold	Producer 1/	7	12 S.	48 E.5/
Montgomery-Shoshone prospect	Gold	Exploration	10	12 S.	46 E.6/
New Discovery	Bentonite	Producer 1/	19	12 S.	46 E.2/
Panama	Gold	Inactive	8	13 S.	48 E.4/
Silicon	Silica	Undetermined	19	11 S.	48 E.4/
Sterling	Gold	Producer 1/	6	13 S.	48 E.2/
Tip Top	Gold	Idle	7	12 S.	48 E.4/
Telluride (Harvey)	Mercury	Idle	18	12 S.	48 E.4/
Transvaal	Gold	Idle 7/	7	11 S.	48 E.4/
Thompson	Mercury	Idle	29	11 S.	48 E.4/
Vidano	Gold	Idle	13	12 S.	47 E.4/

1/Source: Major mines of Nevada. NV Bur. Mines and Geol. Spec. Publ. 10, 1990, pp. 21-22.
2/Source: U.S. Bureau of Mines Nevada State Liaison Office.
3/Source: Nevada Bureau of Mines and Geology Report 39, 1984, Figure 3, p. 2.
4/Source: U.S. Bureau of Mines Mineral Industry Location System (MILS).
5/Source: Nevada Bureau of Mines and Geology.
6/Source: U.S. Geological Survey Bullfrog 15 min. quadrangle.
7/The Transvaal mine is located about 10 km northeast of Beatty. The mine is not shown on any figure.

Rocks on and around Mine Mountain (about 14 km northeast of Yucca Mountain) (Figure 1) include the Devonian Devil's Gate and Nevada Formations (limestones and dolomites with minor sandstone) thrust over argillites and quartzites of the Mississippian Eleana Formation. Mine workings in the area consist of four shallow shafts, four adits, and several groups of prospect pits and trenches (2, page 6). Nearly all of the early mining activity took place in vein systems along high-angle faults in upper plate rocks. "Assays showed barium to be anomalous throughout the district" (2, page 7).

Twelve additional samples taken by Quade and Tingley in the Mine Mountain District were analyzed by fire assay or atomic adsorption. "Although present in trace amounts in some samples, gold did not exceed 0.03 oz/ton for any of these twelve samples. Three of the silver assays exceeded a half ounce per ton, one was greater than 4 ounces per ton, and two samples from the south central adits assayed 16.89 and 20.37 ounces of silver per ton." (2, page 7) 3/.

Statement 3. Letter of November 14, 1989, last paragraph, page 9, continued on page 10.

"The Yucca Mountain area presents a favorable geologic environment in which to find hydrothermal mineral deposits. Hydrothermal activity has taken place as a result of repeated magmatic and volcanic activity. The area has abundant faults, and a complex structural history. Gold Bar, Sterling, Daisy, and Bond-Bullfrog are producing mines in the vicinity of Yucca Mountain. Other mines in the vicinity, such as Gexa's (sic) Mother Lode, are currently in the development stage. Other areas, such as the Cordex claims (Bare Mountain), Transvaal, and Thompson mine northwest of Yucca Mountain, and the Calico Hills, Wahmonie, and Mine Mountain areas within the Nevada Test Site are areas with geochemistry and geologic conditions favorable to mineral exploration."

Reviewer's Comment 3.

Statements in this paragraph have been addressed in Reviewer's Comments 1 and (or) 2 above.

3/Gold values of 0.03 oz/ton are marginal to subeconomic at today's gold prices ($385-$400/oz). Silver values of 4, 16.89, and 20.37 oz/ton are of sufficient grade to be economic provided a large reserve was developed.

Statement 4. Letter of November 14, 1989, second paragraph, page 10.

"Typical host rocks of mineral deposits in the Yucca Mountain area include dacitic to rhyolitic volcanic rocks and Paleozoic sedimentary rocks. Silicification, adularia, and argillic alteration are present and the mines and prospective mines show similar chemical signatures such as elevated concentrations of one or more of the following: gold, silver, barium, arsenic, antimony, lead, copper, zinc, molybdenum, mercury, and fluorine. Favorable structures exist, such as faults, breccias and contacts, and dikes, plugs, and stocks are present in the area."

Reviewer's Comment 4.

Statements in this paragraph have been addressed in Reviewer's Comments 1 and (or) 2 above.

Statements 5a through 5i. Letter of November 14, 1989, last paragraph, page 10, continued on page 11.

"Yucca Mountain contains features that are suggestive of mineral potential. Hydrothermal alteration of the type associated with epithermal mineralization is clearly evident in the very limited published data from the subsurface of Yucca Mountain. In the subsurface, hydrothermal mineral assemblages include quartz, illite, albite, K-feldspar, chlorite, calcite, pyrite, fluorite, and barite. The data available show elevated concentrations of fluorine, barium, zinc and gold in the subsurface. Elevated concentrations of arsenic, antimony, mercury, zinc, molybdenum, lead, and gold are present in altered rocks in Trench 14, less than 1 mile from the repository site. Elevated arsenic, mercury and gold concentrations are also present at the surface of Yucca Mountain in the Prow Pass and Claim Canyon areas. The elevated concentrations of one or more of these elements at various locations demonstrates that the hydrothermal system or systems were metal bearing. Radiometric dating and stratigraphic relations show that hydrothermal activity at Yucca Mountain is the same age as hydrothermal activity and mineralization in the Bullfrog Hills, northern Bare Mountain, Transvaal, Calico Hills, and Mine Mountain areas. The same volcanic rock units of which Yucca Mountain is composed host gold/silver ore at Gold Bar, Bond Bullfrog, the Cordex prospect, and at Mother Lode deposit. Finally, Yucca Mountain contains numerous faults and breccias, and high permeability channels that could have been favorable conduits for hydrothermal fluid circulation and mineral deposition."

Statement 5a. "Yucca Mountain contains features that are suggestive of mineral potential."

Reviewer's Comment 5a.

A number of geologic features at Yucca Mountain, both identified or postulated, may suggest a potential for mineral resources. These include, but are not limited to:

Feature 1. Potentially large fault/breccia zones on Yucca Mountain such as the Solitario Canyon, Dune Wash, and Ghost Dance Faults have been identified on the flanks and cutting Yucca Mountain (plate 1). Other major faults such as the Windy Wash, Bow Ridge, and Fran Ridge Faults have been identified and mapped by Scott and Bonk (12, sheets 1 and 2).

Relationship to mineral potential: These zones, especially those on the margin of Crater Flat (Windy Wash, Solitario Canyon), may have provided channels or conduits for the passage and deposition of mineralizing fluids.

Feature 2. The subvolcanic basement of Yucca Mountain may contain deep-seated granitic rocks (7, page 1-54).

Relationship to mineral potential: The postulated granitic rocks may have provided a source of heat for metamorphism or a source of mineralizing fluids.

Feature 3. The site is underlain at various depths by Paleozoic rocks of undetermined thickness (19).

Relationship to mineral potential: Paleozoic rocks host mineral deposits in areas surrounding Yucca Mountain.

Feature 4. One or more low-angle faults are postulated to exist beneath Yucca Mountain (13, page 411).

Relationship to mineral potential: The faults may represent areas favorable for mineral deposition by hot circulating ground water.

Reviewer's note: The circulating hot water scenario has been suggested by Odt (1) as a possible genetic model for the emplacement of gold deposits in Paleozoic rocks at the Sterling mine on the east flank of Bare Mountain about 14 km west of the Yucca Mountain site.

Statement 5b. Reviewer's note: The following two statements are addressed as a single statement.

"Hydrothermal alteration of the type associated with epithermal mineralization is clearly evident in the very limited published data from the subsurface of Yucca Mountain."

"In the subsurface, hydrothermal mineral assemblages include quartz, illite, albite, K-feldspar, chlorite, calcite, pyrite, fluorite, and barite."

Reviewer's Comment 5b.

According to Siems et al (20, pages 278-279), the kinds of hydrothermal alteration that accompany epithermal precious metal ore bodies, in approximate order of reported occurrences, include: sericitic, silicification, propylitic, advanced argillic, intermediate argillic, alunitic, potassium silicate, sodium silicate, and zeolitic.

Alteration phases observed at Yucca Mountain (7, Table 1-20, page 1-276) include:

Major alteration phases--silica minerals, zeolite, chlorite, calcite, and kaolinite.

Minor alteration phases--disseminated pyrite, albite, fluorite, barite, hematite, illite, and smectite.

The following discussion is from DOE's Site Characterization Plan for Yucca Mountain (7, page 1-282):

> "At depth under Yucca Mountain, higher temperatures of hydrothermal alteration are found at progressively shallower depths from south to north. An abrupt increase in the intensity of alteration, below approximately 3000 feet (914 m), is reported for drillhole USW G-2. The alteration is confined to the Tram Member of the Crater Flat Tuff and lithologic units below the Tram Member in drillhole USW G-2. Similar alteration is confined to units below and including the Bullfrog Member of the Crater Flat Tuff in drillhole USW G-1 below (sic) 1067 m. The hydrothermal alteration may be interpreted as being regional in extent because similar alteration is observed, albeit at different depths, in drillholes USW G-1 and USW G-2, which are greater than 2 km apart. Potassium-argon ages determined on illite/smectite clays from drillholes USW G-1 and USW G-2 are greater than 10 million years old and equivalent to the timing of the Timber Mountain Tuff. The hydrothermal alteration minerals include albite, calcite, potassium feldspar, chlorite, smectite/kaolinite clays, and rare finely disseminated pyrite."

The presence of the clay mineral illite reported above may be significant in that illite is associated with gold mineralization in many sediment- and volcanic-hosted disseminated gold deposits in Nevada and elsewhere (21, page 56).

Core from drillhole USW G-2 reportedly contains fluorite veins and a single, thin barite-calcite-chlorite vein (3, page 29).

Statement 5c. "The data available show elevated concentrations of fluorine, barium, zinc and gold in the subsurface."

Reviewer's Comment 5c

Geologic and petrographic data are available for several drill holes at the Yucca Mountain site, however, very little trace element data have been published. Furthermore, most of the available data are not applicable to base- and precious-metal exploration because specific elements necessary for analysis were not included or because detection limits were too high (3, page 26). In view of the foregoing, an in-depth discussion of "elevated concentrations of fluorine, barium, zinc, and gold" is not possible at this time.

Rare occurrences of fluorite in small veinlets and fracture fillings within tuff have been reported at Yucca Mountain (7, page 1-293). These occurrences were located in drill holes and typically at great depth. Fluorite was detected at 313 meters (m) and 1,464 m in drill hole USW GU-3 and at 970 m and 1097 m in drill hole UE-25b#1H (7, page 1-293). Castor (3, page 29) reports several fractures that contain up to 90 percent fluorite at depths of greater than 249 m in drill hole USW G-3 within the Yucca Mountain Addition. Castor also reports fluorite veins in drill hole USW G-2 about 5 km north of the Yucca Mountain Addition (7, page 29).

One barite occurrence is reported by DOE (7, page 290) in drill hole USW G-2 at a depth of 1,736 m. The 1-centimeter (cm)-thick vein is associated with calcite and quartz.

Castor reports "a few zinc values of up to 235 ppm" (parts per million--grams per metric ton) in drill hole USW G-2 (3, page 29). DOE (7, table 1-18, page 1-270) reports zinc in a number of samples, however, it is not clear whether the samples were taken from the surface, subsurface, or both.

Gold analyses of samples from drillhole USW G-2 include a value of 0.06 ppm gold in zeolitized tuff from a depth of 515 m (3, page 29).

Statement 5d. "Elevated concentrations of arsenic, antimony, mercury, zinc, molybdenum, lead, and gold are present in altered rocks in Trench 14, less than 1 mile from the repository site."

Reviewer's Comment 5d.

The Nevada Nuclear Waste Project Office report containing the analyses documenting the above data from Trench 14 is in preparation and is not available at this time for review and comment.

Statement 5e. "Elevated arsenic, mercury and gold concentrations are also present at the surface of Yucca Mountain in the Prow Pass and Claim Canyon areas."

Reviewer's Comment 5e.

The Nevada Nuclear Waste Project Office report containing the analyses documenting the above data from the Prow Pass and Claim Canyon areas is in preparation and is not available at this time for review and comment.

Statement 5f. "The elevated concentrations of one or more of these elements at various locations demonstrate that the hydrothermal system or systems were metal bearing."

Reviewer's Comment 5f. Analyses of samples taken at Bare Mountain (3, page 19-20), in the Paleozoic shales of Calico Hills (11, page 126), Wahmonie (2, page 32, 3, page 18-19), and Mine Mountain (2, page 7) suggest that some of the hydrothermal systems in these areas are, at least in part, metal-bearing.

Bare Mountain. At the Mother Lode Deposit area on Bare Mountain, Castor reports the following (3, pages 19-20):

> "Thirty-seven samples taken from the Mother Lode Mine area were used for statistical calculations. Gold is present above the detection limit in all 37 samples; silver is present in 34. The mean gold value of our samples is 0.570 ppm; this is equivalent to about 0.02 oz per ton gold and compares favorably with the announced grade of the Mother Lode orebody (0.054 oz/ton) because many of our samples are of unmineralized rock collected from outside the orebody. Median values for arsenic, antimony, and mercury are all high indicating that these elements are enriched in the area sampled."

Calico Hills. Analyses of samples taken from Paleozoic shales in the Calico Hills show enrichment in arsenic, antimony, copper, lead, and zinc along with traces of silver and gold (11, page 126).

Wahmonie. *Reviewer's note: The following discussion was presented in comment 1. It is repeated here, in essence, for the reader's convenience.*

Assays of samples taken in the Wahmonie by Quade and Tingley (2, page 32) indicate a high mineral potential. For example, "Sample 1949 from the Wingfield dump (adjacent to the old Wingfield mine shaft) fire assayed at 29.68 oz/ton silver and 0.67 oz/ton gold. This sample was examined on a microprobe and found to contain cerargyrite, argentite and hessite with anomalous amounts of mercury, bromine, bismuth, and tellurium. Sample 1867 was quartz vein material collected from a dump about 3/4 of a mile north of the main camp. Fire assay results from this sample showed 49.89 oz/ton silver and 0.65 oz/ton gold."

Samples of Wahmonie rocks located at the Mackay School of Mines Museum were fire assayed for silver and gold. Sample 1185 has 35.08 oz/ton gold and 1271.72 oz/ton silver, while sample 1902 has 42.08 oz/ton gold and 1129.49 oz/ton silver (2, page 34). Based on March 30, 1990 gold and silver prices as reported in the Mining Journal (London) (gold--401.25 $/oz; silver--5.13 $/oz), sample 1185 indicated a combined gold/silver value of $20,600/ton ore and sample 1902, $22,679/ton ore.

Mine Mountain. A 1.5-m vein of white barite is exposed along strike for more than 91 m in several prospects on Mine Mountain. Four samples taken within the vein system were "very high in barite, two contained close to a half ounce of silver and one was high in lead and zinc" (2, page 6). Further assays "showed barium to be anomalous throughout the district; (2, page 7). "Twelve samples were analyzed by fire assay or atomic adsorption. Although present in trace amounts in some of the samples, gold did not exceed 0.03 oz/ton for any of these 12 samples. Three of the silver assays exceeded a half ounce per ton, one was greater than 4 ounces, and two samples from the south central adits assayed 16.89 and 20.37 ounces of silver per ton" (2, page 7).

Another sample assay reported by Quade and Tingley (2, page 7) . . . "contained significant amounts of ore minerals. It assayed 10 percent lead, 0.05 percent mercury, and 0.07 percent (Quade and Tingley's term) silver."

Statement 5g. "Radiometric dating and stratigraphic relations show that hydrothermal activity at Yucca Mountain is the same age as hydrothermal activity and mineralization in the Bullfrog Hills, northern Bare Mountain, Transvaal, Calico Hills, and Mine Mountain areas."

Reviewer's Comment 5g.

No information directly correlating the age of hydrothermal activity at the areas mentioned above to that of Yucca Mountain has been located. However:

> "Potassium-argon ages determined on illite/smectite clays from drillholes USW G-1 and USW G-2 (Yucca Mountain site) are greater than 10 Ma and equivalent to the timing of the Timber Mountain Tuff. The hydrothermal alteration minerals include albite, calcite, potassium feldspar, chlorite, smectite/kaolinite clays, and rare finely disseminated pyrite" (7, page 1-282).

The Timber Mountain tuff has been identified at Bullfrog Hills, northern Bare Mountain, Yucca Mountain, Calico Hills, and Mine Mountain (22, plate 1).

Statement 5h. "The same volcanic rock units of which Yucca Mountain is composed host gold/silver ore at Gold Bar, Bond Bullfrog (sic), the Cordex prospect, and at Mother Lode deposit."

Reviewer's Comment 5h.

According to Castor et al (3, page 13), "In addition to field work on the Yucca Mountain Addition, field data and samples were collected from two new gold and silver mines in the Rhyolite-Bullfrog area 4/, a recently discovered gold deposit in the Bare Mountain area 5/, and four abandoned mining areas known to have past production of gold and silver 6/. All of the current, potential, or past producers of precious metals examined have mineralized volcanic rock that is contemporaneous, or nearly so, with Yucca Mountain Addition rocks."

Further, on page 33, Castor states, "The Yucca Mountain Addition is underlain by rock types that are mineralized in the surrounding precious-metal districts. However, exposures (emphasis added) of Tertiary intrusive igneous rocks and pre-Tertiary rocks that occur in the Wahmonie and Bullfrog Districts, and in the Mother Lode deposit area, do not occur (emphasis added) in the Yucca Mountain Addition." While not exposed at Yucca Mountain, igneous intrusive rocks may occur in the subsurface as they do in other areas; pre-Tertiary rocks are known to underlie Yucca Mountain (19, plate 1; 23).

4/Bond-Bullfrog, Gold Bar.
5/Cordex prospect.
6/Two "abandoned mining areas", Wahmonie and Calico Hills, were discussed by Castor. It is not clear from the text as to the names or locations of the remaining two "abandoned mining areas."

Statement 5i. "Finally, Yucca Mountain contains numerous faults and breccias, and high permeability channels that could have been favorable conduits for hydrothermal fluid circulation and mineral deposition."

Reviewer's Comment 5i.

See fifth paragraph of Reviewer's Comment 1 above.

Statement 6. Letter of November 14, 1898, second paragraph, page 11.

"The recent discoveries of mineral deposits in areas near, and even adjacent to, Yucca Mountain reflect increased and successful mineral exploration in the region. Such discoveries and successful exploration efforts make hydrothermally altered areas of the southern part of the southwestern Nevada volcanic field much more attractive to explorationists than was the case in the past."

Reviewer's Comment 6.

Information on recent discoveries adjacent to Yucca Mountain has not been located. However, recent discoveries have been made in the Bullfrog (Rhyolite) District, about 40 km northwest of Yucca Mountain, and on Bare Mountain (Mother Lode and Cordex prospect), about 19 km northwest of the proposed repository. Continued exploration, especially in altered units, is probable.

Statement 7. Letter of November 14, 1989, last paragraph, page 11, continued on page 12.

"In summary, the Yucca Mountain site is within an area of widespread base and precious metal mineralization. Currently there is intense mineral exploration and development in all areas surrounding Yucca Mountain that are open to entry. Because, historically, where known or perceived (emphasis is that of the Governor) mineralization exists, exploration and the resulting human intrusion has always taken place, it must be assumed that will be the case here, and that human intrusion, affecting the Yucca Mountain site, will also take place in the future, certainly during the 10,000 to 100,000 years within which the emplaced spent fuel and high-level waste must be isolated."

Reviewer's Comment 7.

Yucca Mountain is within an area of widespread base- and precious-metal mineralization (comments 1 and 2). Currently, several mining companies (Bond Gold, Cordex, and others) are actively conducting mineral exploration programs and (or) mine development in the Bullfrog (Rhyolite) and Bare Mountain (Fluorine) mining districts. Mineral exploration has been, is presently, and most likely will continue on lands hosting known or perceived resources.

Statement 8. Letter of November 14, 1989, second paragraph, page 12.

"All of the information discussed above suggests that valuable mineral resources in the immediate area surrounding Yucca Mountain must be recognized, along with the potential for resulting human interference and intrusion at the site."

Reviewer's Comment 8.

During site characterization, DOE is directed by 10 CFR Part 60 (24) to make an assessment of the Yucca Mountain site and the "geologic setting" (which, presumably, includes those mineralized areas discussed above) with respect to natural resources. Information acquired as part of this assessment will be used to make a determination of the probability of human intrusion at the site.

Statement 9. Letter of November 14, 1989, second paragraph, page 12.

"Yucca Mountain is surrounded by nearby mineral districts that host at least one world class gold deposit (Bullfrog)."

Reviewer's Comment 9.

Refer to Reviewer's Comments 1 and 2.

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STATE OF NEVADA

EXECUTIVE CHAMBER

Carson City, Nevada 89710

BOB MILLER
Acting Governor

TELEPHONE
(702) 885-5478

November 14, 1989

The Honorable James D. Watkins
Secretary of Energy
1000 Independence Avenue
Washington, D.C. 20585

Dear Secretary Watkins:

In view of your announced current effort to restructure the U. S. Department of Energy Nuclear Waste Policy Act program, I believe it is important that I provide you with some of our information and thoughts on the Yucca Mountain Project that may bear on your upcoming decisions.

You will find attached to this letter a brief description of three elements regarding the geotechnical suitability of Yucca Mountain for a geologic repository which the State of Nevada believes should cause the site to be disqualified from further consideration. These are in the areas of (1) the potential for future human intrusion, (2) tectonics, including faulting and vulcanism, and (3) groundwater travel time. Each of these topics has been discussed in past State of Nevada comments on the Draft Environmental Assessment for Yucca Mountain, the Consultation Draft Site Characterization Plan, and most recently, the Site Characterization Plan. However, because of the importance of these issues, I believe they should be brought directly to your attention during your current program evaluation and restructuring.

As you will see from the attached discussion, there is no question that Yucca Mountain is located within a rich mining district that will remain attractive for exploration and development for many years in the future. Because of this location, it is essentially assured that Yucca Mountain and its nearby surroundings, at some time in the future, will be intruded in search of valuable mineral resources, regardless of what any current natural resources evaluation at the site might conservatively conclude. Such a potential for future human intrusion simply cannot be eliminated or even mitigated through either engineering means or passive controls over the long period

of time required for waste isolation. This attribute of Yucca Mountain, alone, is sufficient reason for you to find, now, that the Yucca Mountain Site is disqualified pursuant to the intent of Section 112(a) of the Nuclear Waste Policy Act, and the DOE siting guidelines (10 CFR Part 960) which were promulgated to implement that section of the Act.

The existing information regarding the number and ages of geologic faults intersecting and associated with the Yucca Mountain Site, coupled with the extremely complex tectonic and hydrologic setting of the site, should certainly serve as a warning that there is significant risk of disruption of repository performance during the waste isolation period. It is also highly questionable whether geophysical technology exists, or can become available by the time needed, to test the site parameters necessary for characterization of the tectonic setting and site performance assessment. If the standards of conservative technical judgment and the use of reasonably available technology called for in the DOE siting guidelines are applied, as they must be, once again, there exists now, sufficient reason for disqualification of the site pursuant to the guidelines.

In the area of hydrology, as related to groundwater travel time evaluations, the DOE appears to have abandoned any pretext of conservative scientific assumptions, and has embraced with enthusiasm an unwarranted optimism.

While a thick unsaturated zone surrounding a geologic repository may appear beneficial to waste isolation in a generic sense, characterizing that zone at Yucca Mountain sufficiently to assure an understanding of present groundwater movement is beyond available hydrologic modelling and testing capabilities. Furthermore, the ability to validate such models, as is required for use in long-term performance assessment relative to the site hydrology, does not exist at present, and likely cannot be achieved within the time period available for site characterization. The scientific community acknowledges that the science of unsaturated zone hydrology necessary for characterization and modelling of future performance is in its infancy. It further recognizes that it will take considerable basic research and time, first in settings less complex than Yucca Mountain, to bring this discipline to a level of maturity and validation sufficient for acceptable application to the Yucca Mountain project.

Aside from the problem of hydrologic modelling of the unsaturated zone, Nevada's previous reviews and comments have pointed out that conservative calculations using DOE's Yucca Mountain data can show that the NRC's groundwater travel time standard for licensing would be violated, even if DOE's optimistically postulated slow matrix flow condition prevails. Evaluation of existing data shows that the faster, fracture flow condition exists, and suggests that it likely prevails. Therefore,

the DOE guidelines requiring use of both reasonably available technology and the application of conservative technical judgment cannot be met, again providing sufficient reason now for you to determine, pursuant to the guidelines, that the Yucca Mountain site is disqualified.

In addition to the evidence attached and summarized above which should result in your immediate disqualification of the Yucca Mountain site, there are further factors which I would like to bring to your attention prior to your announcement of decisions regarding restructuring of the Nuclear Waste Policy Act program.

As I am sure you are aware, it has been my belief that the Nevada Legislature's adoption, and my signature of Assembly Joint Resolutions Number 4 and 6, in early 1989, constituted a Notice of Disapproval of the Yucca Mountain site, pursuant to the Nuclear Waste Policy Act. The Notice became effective once these resolutions opposing, and refusing State consent for, a repository were transmitted to the Congress as required by law. In order to reassure myself on this matter, I requested an opinion from the Nevada Attorney General regarding the validity of the resolutions as a Notice of Disapproval. For your information, I have attached a copy of the Attorney General's Opinion, which finds that the Notice is valid and that the Congress failed to respond in the manner required by the Nuclear Waste Policy Act. Therefore, it is Nevada's position that the Yucca Mountain site has been lawfully vetoed, and that the DOE's authority from Congress to pursue the Yucca Mountain site as a nuclear waste repository has terminated.

As you are also aware, there are numerous obstacles that have already, or likely will continue to halt or impede progress on the Yucca Mountain Project, only some of which are within your ability to control and resolve within the Department of Energy. The following are a few examples of obstacles in addition to those discussed in the attachments to this letter: there are at least two unrelated endangered species issues which must be reconciled with the federal agency of jurisdiction; acquisition of protested, although needed water rights from the State of Nevada for the Yucca Mountain project must be accomplished; numerous lawsuits regarding both the DOE's programmatic implementation of the Nuclear Waste Policy Act and the Yucca Mountain Project are pending, any one of which could invalidate key past actions of the DOE and cause significant further delays and reversals; and, there are significant unresolved issues regarding the compatibility of the missions of the Nevada Test Site and the Nellis Air Force Range with acceptable nuclear waste management and isolation at Yucca Mountain.

I must also remind you that it is of more than passing interest that the people of the State, joined by the Legislature, are firmly resolved to oppose the imposition on Nevada of a disposal site for the nation's commercial nuclear waste. The

singling out a state for imposition of such an unwanted federal intrusion is without precedent in our nation's history, and rightfully so. I, as Governor, cannot permit Nevada's rights as a state to be so-abridged without exhausting every available challenge.

In light of your responsibilities as the federal official charged by law with implementation of the Nuclear Waste Policy Act and prudent administration of the ratepayer-funded Nuclear Waste Fund, I believe you are compelled now to exercise your duty under the Nuclear Waste Policy Act and inform the Congress, and the Governor and legislature of Nevada, that you have removed the Yucca Mountain site from further consideration as a high-level nuclear waste repository.

It is my hope that you will consider seriously the matters I have presented in this letter before proceeding with any decisions to restructure the Nuclear Waste Policy Act program and the Yucca Mountain Project.

Sincerely,

Bob Miller

Bob Miller
Governor

Attachments (2)

SUMMARY STATEMENT OF GEOLOGIC AND HYDROLOGIC DEFICIENCIES SUPPORTING DISQUALIFICATION OF THE YUCCA MOUNTAIN POTENTIAL NUCLEAR WASTE REPOSITORY SITE

INTRODUCTION

Section 113(c)(3) of the Nuclear Waste Policy Act, as amended by the NWPAA of 1987, provides, in part, as follows:

> "If the Secretary at any time determines the Yucca Mountain site to be unsuitable for development as a repository, the Secretary shall -
>
> (A) terminate all site characterization activities at such site;
>
> (B) notify the Congress, the Governor and the legislature of Nevada of such termination and the reasons for such termination;
>
> (C) . . .
>
> (D) take reasonable and necessary steps to reclaim the site and to mitigate any significiant adverse environmental impacts caused by site characterization activities at such site;
>
> (E) . . .
>
> (F) report to Congress not later than 6 months after such determination the Secretary's recommendations for further action to assure the safe, permanent disposal of spent nuclear fuel and high-level radioactive waste, including the need for new legislative authority."

Sufficient information exists to compel the conclusion that Yucca Mountain is unsuitable for development as a repository and thus to invoke the provisions of §113(c)(3). This information has been developed by the Department of Energy (DOE) itself, or its contractors, and thus is found in the agency's records, or has been developed or brought to DOE's attention by the State of Nevada, the Nuclear Regulatory Commission (NRC), or others, and is thus reasonably available to the Secretary. This Statement will set forth that information, and demonstrate how it requires that the site be found unsuitable.

Before proceeding a disclaimer is necessary, however. Nevada's primary message in this Statement is that under the Secretary's final guidelines for siting nuclear waste repositories, adopted as required by the NWPA, disqualifying factors clearly exist. Further efforts to demonstrate the site's suitability would prove fruitless, and thus characterization should not proceed and work at and in support of the Yucca Mountain site should be terminated under the provisions of §113(c)(3) of the NWPA, as amended. The State believes that those guidelines are invalid under the NWPA, and has challenged them under §119 of the Act in the Ninth Circuit Court of Appeals. See Nevada v. Watkins, No.

85-7308 (managed under EPI v. Watkins, No. 84-7854).[1] In showing unsuitability under those guidelines in this Statement, Nevada, in no way intends to concede their validity or operative effect as to the State, or to retreat from any of the positions stated in its Petition for Review which is pending before the Ninth Circuit. Even though they may not be applied to the disadvantage of the State of Nevada, until those guidelines are declared invalid by the courts, they bind the Secretary in his conduct of the repository siting and development program. Even under those guidelines, invalid as they may be, sufficient information exists in the current record, or is reasonably available to the Secretary, to conclude that Yucca Mountain is disqualified under his own siting guidelines, and thus to compel his abandonment of any further efforts to characterize the site.

Recent events make crystal clear that the Department's repository siting program has arrived at the point where prudence dictates that no further expenditure of federal, or state, time and effort, or rate-payers' money, is warranted on attempting to qualify the Yucca Mountain site under the Secretary's own siting

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[1] In that challenge, Nevada, as well as the other petitioners, assert that the Secretary's final guidelines do not go far enough; that they do not contain enough disqualifying factors, that certain potentially adverse conditions should in reality constitute disqualifying factors, and that certain other considerations required under §112 of the NWPA, which would themselves mandate disqualification of the Yucca Mountain site, are missing from the guidelines entirely. We thus take the position, in that litigation, that had the Secretary in 1984 adopted guidelines strictly in compliance with the requirements of the NWPA the Yucca mountain site would not have gotten as far as it has in this process.

guidelines. The camel will simply not pass through the eye of the regulatory needle. The State hopes that this document will show, to the informed and objective reader, that in three specific areas at least, the site is, and will remain disqualified.

THE ROLE OF THE GUIDELINES

Section 112(a) of the NWPA, 42 USC 10132, requires the Secretary to adopt guidelines which:

> "shall specify detailed geologic considerations that shall be primary criteria for the selection of sites in various geologic media. Such guidelines shall specify factors that qualify or disqualify any site from development as a repository, including factors pertaining to the location of valuable natural resources, hydrology, geophysics, seismic activity, and atomic energy defense activities, proximity to water supplies, . . . ". (Emphasis supplied

The Secretary did adopt such guidelines, roughly a year and a half later than the statute required. 10 CFR Part 960. The guidelines contain various qualifying, disqualifying, favorable and potentially adverse conditions. This Statement will foc primarily on three disqualif ng conditions, in the areas c

mineral resources (human intrusion), tectonics, and hydrology (ground water travel time).

The guidelines contain, as good science and prudence would require, a significant constraint on the Secretary's handling of the scientific information developed in the course of the siting process. That is, conservative assumptions must be throughout. Section 960.3-1-4-2, which is part of §960.3-1-4, Evidence For Siting Decisions, provides, in part, as follows:

> "In developing the above-mentioned bases for evaluation, as may be necessary, assumptions that approximate the characteristics or conditions considered to exist at a site, or expected to exist or occur in the future, may be used. These assumptions will be realistic but conservative enough to under-estimate the potential for a site to meet the qualifying condition of a guideline; that is, the use of such assumptions should not lead to an exaggeration of the ability of the site to meet the qualifying condition." (Emphasis supplied)

That provision is explained in the supplementary information to the guidelines themselves, at 49 FR 47728, (12/06/84) as follows:

> "Included in the provision for evidence is a discussion about the use of assumptions. Before site characterization is completed, preliminary assessments of the potential of the site to meet the qualifying conditions

must necessarily employ judicious assumptions where definitive data are missing. Many commentors were concerned that consistent optimism in such assumptions would create benefits out of deficiencies in the scope of field testing and research undertaken by the DOE. Accordingly, §960.3-1-4 only allows the use of assumptions that would tend to underestimate the ability of a site to meet the qualifying conditions. Such assumptions are commonly termed 'conservative' because they are chosen to minimize the possibility that later findings will prove the assumptions to be wrong. This is a commonly used approach in engineering and in scientific predictions. Where some data exists, a statistical range of uncertainty may constrain the latitude of such assumptions. Even where no direct data exist, it is often possible to establish a sufficient conservative range of values by examining comparable situations in nature and by inference from related phenomena."
(Emphasis supplied)

Unfortunately, as many commentors (including Nevada) suggested even in 1983 and 1984, consistent optimism in DOE's assumptions continues to pervade the Department's entire technical program. In the simplest terms, Nevada's argument can be summarized as follows: The Secretary is required, not only by good science and the prudence required of him as fiduciary, but his own guidelines, to apply conservative assumptions where uncertainty exists in the data available to him at any stage in the siting process. The application of such conservative assumptions, at least in the areas of natural resources (human intrusion), tectonics and hydrology, require him to conclude, at this stage, that not only will the qualifying conditions of the guidelines not be met at the conclusion of site characterization, but that the disqualifying conditions applicable in each of those cases currently exist.

NATURAL RESOURCES (HUMAN INTRUSION)

Two guidelines sections are directly applicable, and require a determination, based on the current record, that the Yucca Mountain site is unsuitable for development as a repository.

Section 960.4-2-8, Human Interference, reads as follows:

> "The site shall be located such that activities by future generations at or near the site will not be likely to affect waste containment and isolation. In assessing the likelihood of such activities, the DOE will consider the estimated effectiveness of the permanent markers and records required by 10 CFR Part 60, taking into account site specific factors, as stated in §§960.4-2-8-1 and 960.4-2-8-2, that could compromise their continued effectiveness."

The natural resource postclosure disqualifying condition, §960.4-2-8-1(d), reads in part as follows:

> "The site shall be disqualified if -
> (1) . . .
> (2) Ongoing or likely future activities to recover presently valuable natural mineral resources outside the controlled areas would be expected to lead to an inadvertent loss of waste isolation."

This section provides that a site must be located in a place where "activities by future generations at or near the site will not be likely to affect waste containment and isolation." The record currently indicates, as will be demonstrated, that the Department must assume that some exploration activities by future generations will take place, if not at, then certainly near the site. The Department must also assume that those activities may affect waste containment and isolation. Likewise, the Department must assume that the estimated effectiveness of the permanent markers and records required by 10 CFR Part 60 will be less than 100 percent - that they will be unable to prevent all human intrusion. Again, with respect to the disqualifying condition, the Department must assume, based on the present information available to it, that future exploration will take place to recover valuable natural resources outside of the controlled area, and that those activities should be expected to lead to some inadvertent loss of the waste isolation capability of the site.

Numerous Nevada ore deposits demonstrate common geologic features, many of which exist within the Yucca Mountain area. These features include certain types of rock alteration, and a distinct geochemical signature (gold, silver, arsenic, mercury, antimony, molybdenum, zinc, barium, and fluorine). Also these ore

deposits are commonly found along and within faults and breccia zones, and are often associated with felsic or granitic dikes, plugs, sills, and stocks. Late stage barite (with or without fluorite) veins is common. All of these features exist within the immediate Yucca Mountain area.

Economically important mineralization within hydrothermal mineral deposits is obvious in several locations in the Yucca Mountain region. This is true in the Bullfrog Hills and at Bare Mountain, and probably at Wahmonie as well. In Bullfrog Hills, ore grade gold/silver mineralization is largely hosted by rocks of the Timber Mountain-Oasis Valley caldera complex and has been in the past, is currently, and will certainly in the future be exploited.

The Yucca Mountain area presents a favorable geologic environment in which to find hydrothermal mineral deposits. Hydrothermal activity has taken place as a result of repeated magmatic and volcanic activity. The area has abundant faults, and a complex structural history. Gold Bar, Sterling, Daisy and Bond Bullfrog are producing mines in the vicinity of Yucca Mountain. Other mines in the vicinity, such as Gexa's Mother Lode, are currently in the development stage. Other areas, such as the Cordex claims (Bare Mountain), Transvaal and Thompson Mine northwest of Yucca Mountain, and the Calico Hills, Wahmonie, and

Mine Mountain areas within the Nevada Test Site are areas with geochemistry and geologic conditions favorable to mineral exploration.

Typical host rocks of mineral deposits in the Yucca Mountain area include dacitic to rhyolitic volcanic rocks and Paleozoic sedimentary rocks. Silicification, adularia, and argillic alteration are present and the mines and prospective mines show similar chemical signatures, such as elevated concentrations of one or more of the following: gold, silver, barium, arsenic, antimony, lead, copper, zinc, molybdenum, mercury, and fluorine. Favorable structures exist, such as faults, breccias and contacts, and dikes, plugs, and stocks are present in the area.

Yucca Mountain contains features that are suggestive of mineral potential. Hydrothermal alteration of the type associated with epithermal mineralization is clearly evident in the very limited published data from the subsurface of Yucca Mountain. In the subsurface hydrothermal mineral assemblages include quartz, illite, albite, K-feldspar, chlorite, calcite, pyrite, fluorite, and barite. The data available show elevated concentrations of fluorine, barium, zinc and gold in the subsurface. Elevated concentrations of arsenic, antimony, mercury, zinc, molybdenum, lead, and gold are present in altered rocks in Trench 14, less than

1 mile from the repository site. Elevated arsenic, mercury and gold concentrations are also present at the surface of Yucca Mountain in the Prow Pass and Claim Canyon areas. The elevated concentrations of one or more of these elements at various locations demonstrate that the hydrothermal system or systems were metal bearing. Radiometric dating and stratigraphic relations show that hydrothermal activity at Yucca Mountain is the same age as hydrothermal activity and mineralization in the Bullfrog Hills, northern Bare Mountain, Transvaal, Calico Hills, and Mine Mountain areas. The same volcanic rock units of which Yucca Mountain is composed host gold/silver ore at Gold Bar, Bond Bullfrog, the Cordex prospect, and at Mother Lode deposit. Finally, Yucca Mountain contains numerous faults and breccias, and high permeability channels that could have been favorable conduits for hydrothermal fluid circulation and mineral deposition.

The recent discoveries of mineral deposits in areas near, and even adjacent to, Yucca Mountain reflect increased and successful mineral exploration in the region. Such discoveries and successful exploration efforts make hydrothermally altered areas of the southern part of the southwestern Nevada volcanic field much more attractive to explorationists than was the case in the past.

In summary, the Yucca Mountain site is within an area of

widespread base and precious metal mineralization. Currently there is intense mineral exploration and development in all areas surrounding Yucca Mountain that are open to entry. Because, historically, where known or perceived mineralization exists, exploration and the resulting human intrusion has always taken place, it must be assumed that will be the case here, and that human intrusion, affecting the Yucca Mountain site, will also take place in the future, certainly during the 10,000 to 100,000 years within which the emplaced spent fuel and high-level waste must be isolated.

All of the information discussed above suggests that valuable mineral resources in the immediate area surrounding Yucca Mountain must be recognized, along with the potential for resulting human interference and intrusion at the site. Yucca Mountain is surrounded by nearby mineral districts that host at least one world class gold deposit (Bullfrog).

The presence of extensive subsurface rock alteration, a feature characteristic of hydrothermal mineral deposits, and being within an area already containing valuable working mines, means that the Yucca Mountain area will unquestionably attract exploration in the future. Explorationists, as history has proven time and time again, are much more likely to test even those areas

with the least promising surface characteristics when they find themselves in such a prolific area. In fact, in any particular area exploration is rarely a one shot effort. Repeated testing, often separated by years or decades, by successive companies, is the norm rather than the exception. This is particularly true during times of favorable metal prices, a factor which is and will remain, totally outside of the control of DOE.

The Department should recognize the evidence it has at hand and disqualify the Yucca Mountain site on the basis of the human interference guideline.

TECTONICS

The tectonics disqualifying condition, §960.4-2-7(d) reads as follows:

> "A site shall be disqualified if, based on the geologic record during the Quaternary period, the nature and rates of fault movement or other ground motion are expected to be such that a loss of waste isolation is likely to occur."

In Chapter 1 of its SCP DOE acknowledges that there are 32 active (Quaternary) faults that either transect or immediately surround the Yucca Mountain site. Such faults are found within the repository block itself. Additionally, late Pleistocene/Holocene volcanic activity exists in the near vicinity of the site. It is not acceptable to assume, under the guidelines, that any of the active faults, particularly those transecting the repository block itself, can be described in sufficient detail to ever resolve with reasonable assurance whether the nature of the present system is such that waste can be safely isolated. Most significantly, future movement on the active faults transecting and bounding the repository block (and some must be conservatively assumed) presents an unacceptable condition for predicting, with reasonable assurance that there will be no loss of waste isolation. Movement on faults will alter the repository geometry in an unpredictable manner. This, for example, could result in open pathways for water movement into and through the repository, thus destroying the integrity of the natural barrier and creating significant pathways to the accessible environment, along with extremely short ground water travel times.

Any movement on these active faults, whether from seismic creep, significant earthquakes on other nearby fault systems, or induced stress from DOE's underground nuclear explosions at the adjacent Nevada Test Site, has the distinct potential for causing

or continuing a condition where waste isolation will be adversely affected, or lost entirely. The nature of the changes brought about by these kinds of conditions is entirely unpredictable, and it is impossible to demonstrate that they will not occur.

NRC regulations (10 CFR 60, 10 CFR 100, Appendix A), and the methodologies and principles employed therein, also provide a de facto disqualifier in this area. Under 10 CFR 60.122(c)(4) and (11) the presence of active (Quaternary) faulting is a potentially adverse condition. Such a condition may compromise the ability of the repository to meet the performance objectives relating to waste isolation. Unless such faulting can be thoroughly investigated (10 CFR 60.122(a)(2)(i)), adequately evaluated using conservative assumptions (10 CFR 60.122(a)(2)(ii)), and shown not to affect significantly the waste isolation capability of the site, it should be considered, as a practical matter, taking into account historical NRC treatment of active faulting near nuclear facilities, unlicensable, and thus disqualified.

The preclosure guidelines also contain a disqualifying tectonic condition, §960.5-2-11(d), which reads as follows:

"The site shall be disqualified if, based on the expected nature and rates of fault movement and other ground

motion, it is likely that engineering measures that are beyond reasonably available technology will be required for exploratory-shaft construction or for repository construction, operation, or closure."

The presence of active faults transecting and bounding the proposed repository block presents a formidable engineering problem. Furthermore, the Department has not demonstrated that there is "reasonably available technology" to deal with those problems now, nor is it likely to be available in the near future. Of particular concern are the hazards associated with possible fault rupture during repository construction and operation.

Several other major problems exist. For example, the sealing problem may be one that cannot be demonstrated to have been resolved. Once the nature of the disturbed zone surrounding all repository openings including faults has been sufficiently characterized (assuming this is possible) between the repository horizon and the saturated ground water system there is the much more difficult problem of developing and demonstrating the adequacy of seals for the faults, as well as for the extensive number of bore holes that will be required to describe them. In developing the sealing program it must be conservatively assumed that movement will occur on one or more of these faults within the next 10,000 to 100,000 years ((§960.4-2-1(b)(2) and §960.4-2-1(d)). Further problems exist with respect to the faults and the disturbed zone

surrounding them relative to canister placement, performance allocation and performance assessment. Because the physical configuration of each emplacement hole and the spacing between holes must be assumed, conservatively, to change unpredictably with time, and because it must be assumed that any such changes will affect waste isolation, realistic performance allocation and assessment will be impossible.

HYDROLOGY (GROUND WATER TRAVEL TIME)

The disqualifying condition for ground water travel time, §960.4-2-1(d), reads as follows:

> "The Site shall be disqualified if the pre-waste emplacement ground-water travel time from the disturbed zone to the accessible environment is expected to be less than 1,000 years along any pathway of likely and significant radionuclide travel." (Emphasis supplied)

The available evidence not only supports, but literally demands, a finding that this disqualifying condition exists at the Yucca Mountain site.

The Department's conceptual model of the Yucca Mountain hydrogeologic system is simplistic and not conservative in nature. It assumes that rock matrix flow (water flow within the interconnected pore spaces of the rock itself) will not only dominate, but fracture flow (water flow along ruptures or breaks in the rock) will be absent. It assumes uniformly distributed infiltration from the surface, an absence of existing water, such as perched water or locally saturated zones within the vadose (unsaturated) zone, and it assumes that there will be essentially no net recharge available (less than 1 mm/yr). Based on these optimistic assumptions, extremely long predicted ground-water travel times are calculated by the Department.

The Department was shown, as long ago as March of 1985, when the State submitted its comments on the Draft Yucca Mountain Environment Assessment, that travel times may be much shorter, on the order of 970 years, <u>even while using</u> the Department's preferred matrix flux conceptual model (see <u>Nevada's comments on DOE's Draft EA, Volume II, Specific Comments of the Water Resources Center, Desert Research Institute, The University of Nevada System</u>, at pages 36-39). Even if the Department's rather simple conceptual model of the hydrologic system is applied, conservative calculations would lead to ground-water travel times less than those required in the disqualifying condition.

The Department should recognize the evidence that indicates fracture flow, and assume that it predominates, if not throughout the repository block, then certainly in some portions of the vadose zone. It should further assume that some of these fractures or fracture networks are interconnected from the surface to the repository horizon and from there to the ground-water table.

Water has been encountered within the vadose zone (which is typically more than 60 percent saturated) in the form of perched water or zones of saturation. This leads to the conclusion that fracture flow likely will produce pre-waste emplacement ground-water travel times along a pathway (and no more than one is required under the guideline), of less than 1,000 years. And, it is probably impossible to demonstrate that this is not the case.

The Department currently has ample evidence for the existence of fracture flow in the vadose zone. Fracture flow has been demonstrated to exist in similar tuffs at Rainier Mesa, where an extensive database exists. (Russell, C. E. 1987, "Hydrogeologic Investigations of Flow In Fractured Tuffs, Rainier Mesa, NTS," MS Thesis, University of Nevada, Las Vegas; and Thordarson, W., 1965, "Perched Groundwater In Zeolitized-Bedded Tuff In Rainier Mesa and

Vicinity, NTS", NV.; U.S. Geological Survey Preliminary Report TEI862).

Recent Chlorine-36 data from Yucca Mountain indicate fracture flow from the surface to a depth of approximately 500 feet over relatively short periods of time in borehole UZ1 (North, A. E., 1989, "The Use of Chlorine Isotope Measurements To Trace Water Movements At Yucca Mt.," LA-UR-89-2573, in press-proceedings of American Nuclear Society Topical Meeting-Focus 89, September, 1989).

The Department has demonstrated water within the vadose zone capable of being transported through the repository to the water table, and from there to the accessible environment. DOE drilling has encountered saturation within the vadose zone, in drillhole UZ4, UZ1, and H1. Free water was directly observed in core from UZ4 in September of 1984 by Nevada scientists. Reports for UZ1 and H1 show the presence of saturation as well. The presence of liquid water is direct evidence of fracture flow.

The Department should conservatively assume a reasonable net recharge to the hydrologic system. USGS studies prior to the repository program estimate a net recharge for the area of about

4.5 mm/yr. The Department has acknowledged that if vertical flux is greater than about 1 mm/yr, fracture flow will likely occur, if not predominate. The 4.5 mm/yr rate itself is a reasonable, but not overly conservative estimate. A conservative assumption would hold the 4.5 mm/yr estimate to be a modern climate value only, and that future infiltration and corresponding flux rates will, at least at times, be greater during climatically wetter periods, similar to those well documented during the Quaternary in the region. This, coupled with the 1 mm/yr fracture flow threshold, should disqualify the site.

Authigenic mineralization in the fracture system at Yucca Mountain also indicates that fracture flow exists. The minerals would not have formed without the presence of fracture flow. The presence of minerals such as zeolites located just below the repository horizon indicates massive water interaction with the volcanic glass. Therefore, mineralological evidence suggests that vadose zone water is being transported in fractures in the stratigraphic zone between the surface of Yucca Mountain and the Calico Hills formation below the repository horizon. The Calico Hills formation has been shown to be highly fractured, and therefore must be assumed to have the capability to transport these vadose zone waters to the saturated zone in a short period of time.

The Department recognizes that fracture flow will be fatal to the project. As recently as December 13, 1988, in an address to the 20th Annual Meeting of the NRC's Atomic Safety and Licensing Board Panel, Dr. Maxwell Blanchard of the Yucca Mountain Project staff said:

> "Also, the current evidence indicates that water flow is mostly confined to rock matrix. And I want to talk a little bit about that later, because, that is a fundamental characteristic of waste isolation in the unsaturated zone. If that is not true, we probably do not have a viable site." (Emphasis supplied)

The Department should recognize the existence of fracture flow and acknowledge, for that reason along, that Yucca Mountain is not a "viable site".

The existing data base also suggests that there is active soil gas circulation in the vadose zone at the Yucca Mountain site. If that is the case, then clearly such active upward gas circulation will represent the fastest path to the accessible environment at the ground surface immediately above the repository. Such soil gas circulation will surely provide a means for rapid radionuclide migration (C 14, I 129, Tritium) from failed canisters to the accessible environment well faster than the required minimum

1,000 year travel time. Any site with such a known or suspected condition does not merit further consideration as a repository.

CONCLUSION

The technical deficiencies which are pointed out here can only become more acute with further study of the Yucca Mountain site. The active faults transecting and bounding the repository will remain, and their age will not change. The fact that some movement on those faults might occur is almost inescapable, and must therefore be anticipated. The extensive fracturing in the vadose zone at Yucca Mountain will continue to exist, and the affect of those fractures cannot be compensated for in performance assessment. The mineralization in the immediate area of Yucca Mountain will not disappear, and basic human drives for resource exploration will likewise remain. There is no question that as the nation's mineral resources become scarcer and the need for them grows, areas even less promising than the Yucca Mountain vicinity will become targets for mineral exploration.

Section 960.3-1-5 provides that:

> "A site shall be disqualified <u>at any time</u> during the siting process if the evidence supports the finding by the DOE that a disqualifying condition exists or the qualifying condition of any system or technical guideline

cannot be met." (Emphasis supplied)

The evidence supports such a finding for each of the disqualifying conditions discussed in this statement. The time has come to disqualify this site, and to initiate the action required by §113(c)(3) of the NWPA, as amended.

THIS PAGE IS AN OVERSIZED DRAWING OR FIGURE, THAT CAN BE VIEWED AT THE RECORD TITLED:

"PLATE 1.- Simplified geologic map of Yucca Mountain in the vicinity of the perimeter drift"

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