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John J. Linehan, Director
Repository Licensing and Quality Assurance
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Division of High Level Waste Management
U.S. Nuclear Regulatory Commission
4-H-3
Washington, DC 20555

TRANSMITTAL OF REQUESTED REPORT

Reference: Letter, Linehan to Stein, dtd. 5/14/90

Enclosed are three copies of the report you requested entitled: "Mineral Evaluation of the Yucca Mountain Addition, Nye County, Nevada." This report, dated December 27, 1989, was prepared by the Nevada Bureau of Mines and Geology in support of the U.S. Department of Energy's request of the U.S. Bureau of Land Management (BLM) for administrative land withdrawal of that portion of BLM lands falling within the Yucca Mountain site.

The enclosed report contains color photocopies in an attempt to fulfill your request for actual photographs of the report figures. The Nevada Bureau of Mines and Geology holds the original photographs and transparencies and these would have to be requested from them.

Additional copies of the subject report are being prepared by the Yucca Mountain Project Office and should be available within a few weeks. If you have any questions, please contact Ardyth M. Simmons of my staff at (702) 794-7998 or FTS 544-7998.

Carl P. Gertz, Project Manager
Yucca Mountain Project Office

YMP:AMS-4088

Enclosure:
"Mineral Evaluation of the Yucca Mountain Addition, Nye County, Nevada"

YMP-5

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MINERAL EVALUATION OF THE YUCCA MOUNTAIN ADDITION, NYE COUNTY, NEVADA

Prepared for:

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December 27, 1989

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INTRODUCTION

PURPOSE

Early in January 1989, the U.S. Department of Energy filed an application with the U.S. Bureau of Land Management for an administrative land withdrawal of 4255.5 acres bordering the western edge of the Nevada Test Site (NTS) and the southern edge of the Nellis Air Force Range. Notice of the withdrawal application was published in the Federal Register (January 13, 1989; vol. 54, no. 9, p. 1452) by the Bureau of Land Management. This land is herein referred to as the Yucca Mountain Addition. Approximately 400 acres in the northeastern part of the Yucca Mountain Addition is within a 1,500-acre area that includes NTS and Nellis Air Force Range land being considered as a potential repository for high-level nuclear waste. BLM land including the Yucca Mountain Addition, along with adjacent parts of Nellis Air Force Range and the NTS, have been the focus of extensive study during the past 10 years. In requesting the withdrawal of this acreage, the Department of Energy stated that as preparations begin for more specific studies on the geology of Yucca Mountain it is essential that the subsurface area be secured from any interference that could hinder research to determine the suitability of Yucca Mountain for a high-level waste repository (DOE News, January 13, 1989).

The Federal Land Policy and Management Act of 1976 (FLPMA) requires that when a request for land withdrawal such as this is made, the requesting agency furnish to Congress "...a report prepared by a qualified mining engineer, engineering geologist, or geologist which shall include but not be limited to information on: general geology, known mineral deposits, past and present mineral production, mining claims, mineral leases, evaluation of future mineral potential, present and potential market demands." The Nevada Bureau of Mines and Geology (NBMG) has performed this mineral evaluation to meet these requirements.

METHODS OF STUDY

The NBMG mineral evaluation was accomplished over a four-month period by three senior scientists, a mineral technician, an analytical technician, a graduate geology student, an office manager, and a secretary-typist. Initial work consisted of a literature search, project planning, and obtaining NTS access.

Remote sensing data were collected and analyzed to determine surface alteration and linear structural patterns for the Yucca Mountain Addition and known precious-metal districts in the region. Ground control data were collected in both the Yucca Mountain Addition and precious-metal mining districts.

Field examination and sample collection in the Yucca Mountain Addition were accomplished over a one month period, and a week was devoted to similar work in the mining districts. Samples were analyzed for selected elements by a commercial laboratory and by the NBMG laboratory. Mineralogy and petrology were determined by X-ray diffraction analyses and thin section examinations. The final stages of the work included computer processing of geochemical data and report writing which together took one month.

ACKNOWLEDGMENTS

D. A. Davis performed field work and prepared thin-sections, and P. M. Goldstrand also performed field work. L. J. Garside reviewed parts of the report. Other NBMG personnel who helped on this project are M. Desilets, D. Meeuwig, and L. E. Jacox.

LOCATION

The proposed Yucca Mountain Addition land withdrawal is located about 30 km southeast of the town of Beatty in southern Nye County, Nevada (Figure 1). The small community of Amargosa Valley lies about 20 km south of Yucca Mountain, and Las Vegas, the closest large city, is about 150 km to the southeast.

The land proposed for closure to public access and withdrawal from mineral entry consists of 4255.5 acres of public land specifically described as all of sections 7, 8, 9; the W/2 of section 10; the W/2 of section 15; all of sections 16, 17; the NE/4 of section 20; the N/2 and the N/2 of the S/2 of section 21; and the NW/4 and the N/2 of the SW/4 of section 22, Township 13 South, Range 49 East, Nye County, Nevada. This proposed withdrawal covers the southern part of Yucca Mountain and extends from the mouth of Windy Wash on the west, across the southern end of Solitario Canyon and the crest of Yucca Mountain, to the lower flanks of the mountain on the east. The northern boundary of this area is the southern boundary of the Nellis Air Force Range; the eastern boundary is the western boundary of the NTS.

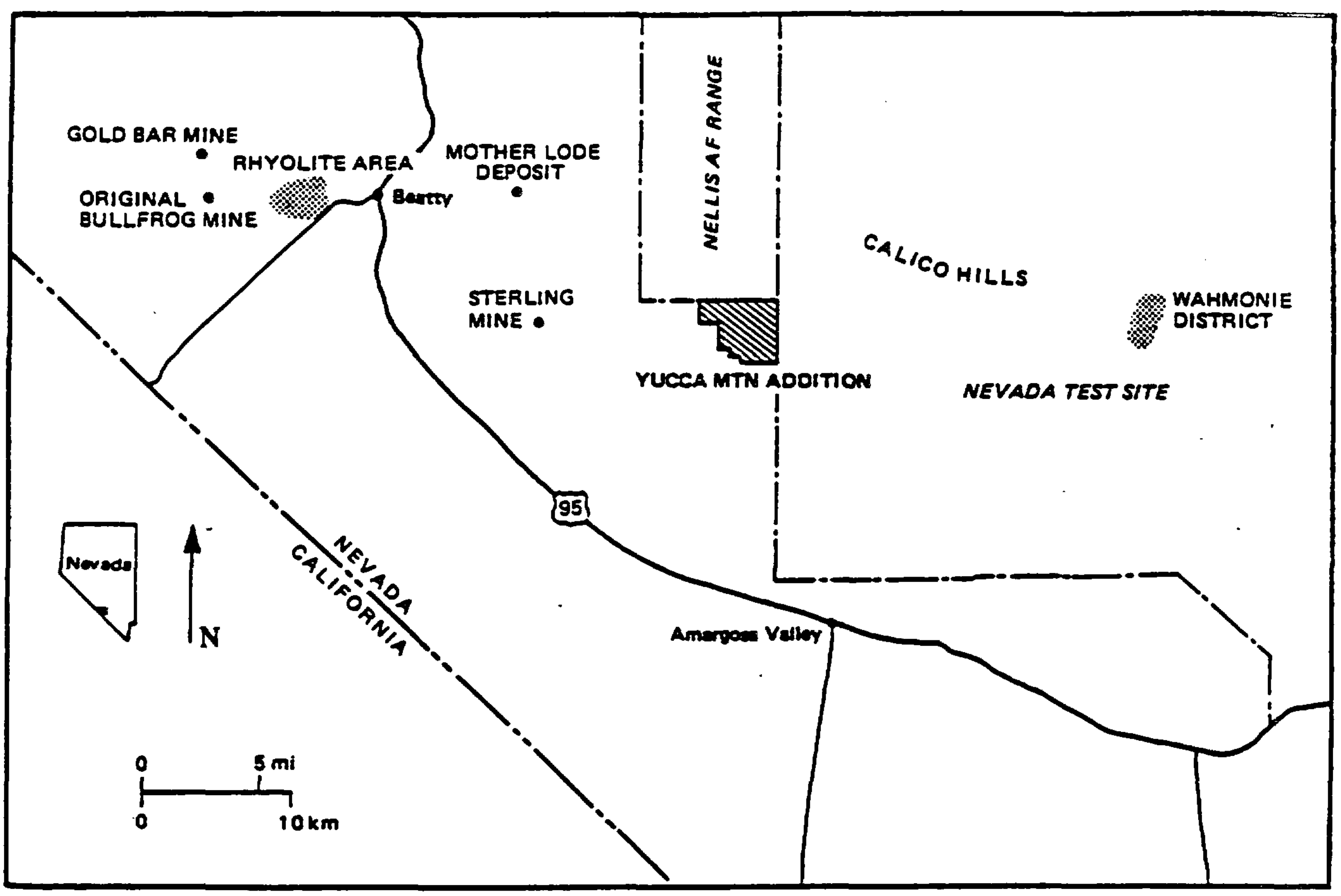
HISTORY AND PRODUCTION

MINING DISTRICTS SURROUNDING THE YUCCA MOUNTAIN ADDITION

Recorded information on the history of the Yucca Mountain Addition and its immediate vicinity is sparse. Cane Springs, about 30 km east of Yucca Mountain, was a watering stop on the Death Valley Emigrant Trail in 1849. The trail descended down Fortymile Wash, passed the south end of Yucca Mountain, and continued into Death Valley southwest of the present-day town of

Amargosa Valley. The earliest mining activity in the area surrounding Yucca Mountain is associated, by popular accounts, with travel along the Emigrant Trail. An article in the Tonopah Daily Times of February 14, 1928 states that "...the old Hornsilver mine [northwest of Cane Springs] had been worked by Mormons in 1853." Ball (1907) visited the Hornsilver mine during a reconnaissance trip through the area in 1905. He made no comments on activity at the mine but, by noting it on his maps, documented that it was known at the time of his visit. Old prospect pits and shafts in the Calico Hills, about 13 km northeast of Yucca Mountain, may also date from the 1905 period of activity. The Bullfrog district, located west of the town of Beatty and about 30 km west of southern Yucca Mountain, is a large district with recorded precious-metals production. The Original Bullfrog mine in the west part of the district was discovered in 1904; production from the district is recorded from 1907 to 1940 and totals about 3 million dollars (Couch and Carpenter, 1943).

Figure 1. Map showing the location of the Yucca Mountain Addition and of mining districts and other areas discussed in the text.



The earliest recorded mining activity in the districts immediately surrounding Yucca Mountain began about 1905 with discoveries of gold ore on the east slope of Bare Mountain. The camp of Telluride sprang up at this site, about 20 km northwest of the south end of Yucca Mountain, and gold ore was produced from 1913 to 1915 (Lincoln, 1923). Mercury was discovered in this same area in 1908 and small amounts of mercury were produced from the district intermittently through 1953 (Cornwall, 1972).

Fluorite was discovered during exploration for precious metals in the northern part of the Bare Mountain mining district in about 1906. Fluorspar has been mined in the district more-or-less continuously since 1919, mainly from the Daisy mine (Papke, 1979), and the total production of fluorspar ore from the district is in excess of 300,000 tons.

In 1928 new discoveries of high-grade silver-gold ore near the Hornsilver mine resulted in a second rush to that area and the boom-camp of Wahmonie sprang up in the flats southeast of the old mine. Claim staking covered an area of several square km and a new, 150-m, shaft was sunk by the Wingfield interests (Goldfield Consolidated Mines Co. of Goldfield, Nevada) (Tonopah Daily Times, February 22, 1928). The boom collapsed quickly, however, and no recorded production resulted from this activity. In 1940, the Wahmonie district and the adjacent Calico Hills area were included within the Tonopah Bombing and Gunnery Range (now known as the Nevada Test Site and Nellis Ranges) and withdrawn from mineral entry. No mineral activity has occurred in the Calico Hills or at Wahmonie since that time.

In the districts west of the proposed Yucca Mountain Addition, precious-metals mining activity revived in 1980 with the discovery of a disseminated gold orebody at the Sterling mine. The Sterling, located across Crater Flat about 11 km due west of Yucca Mountain began gold production in 1984 and has produced from 9000 to 7000 oz gold per year since that time (Nevada Bureau of Mines and Geology, 1984, 1988). In 1988, GEXA Gold Corp. announced discovery of significant reserves of gold ore on its Mother Lode property at the north end of Bare Mountain, about 8 km north of the Sterling mine. Announcements in early 1989 described reserves at the Mother Lode of about 4.4 million tons of ore averaging 0.054 oz/ton gold in a deposit hidden under shallow gravel cover near the old camp of Telluride.

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 mineable ore at the old Montgomery-Shoshone mine northeast of the old 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 gold per ton at the new Bullfrog deposit (Jorgensen et al., 1989). 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 (Nevada Bureau of Mines and Geology, 1988), is now being mined.

In addition to precious-metals exploration and mining on Bare Mountain, the only other active mining operation in the immediate area of Yucca Mountain is recovery of volcanic cinder from cinder cones on the south end of Crater Flat. The deposit currently being mined is adjacent to U.S. Highway 95 about 13 km southwest of Yucca Mountain. Other cinder cones dot this portion of Crater Flat, however, and mining could extend to them at some time in the future.

White montmorillonite clay has been mined since the early 1950's from the New Discovery mine about a mile south of Beatty. In addition, minor clay production has come from claims located just northeast of Beatty. An unknown amount of ceramic silica was mined from from the Silicon mine at the northwest end of Yucca Mountain about 20 km northwest of the Yucca Mountain Addition.

YUCCA MOUNTAIN ADDITION

There is no record or evidence of any historic mining activity within the boundaries of the Yucca Mountain Addition. With the exception of the road in Solitario Canyon, there were probably no roads or trails traversing the area prior to the present period of DOE-related activity. No mining or prospecting excavations of any type were noted during the present study.

On June 29, 1987, Anthony J. Perchetti of Tonopah, Nevada staked a block of 10 lode mining claims (Yucca 1-10) in sections 9, 16, and 21, T13S, R49E. These claims were located end-to-end and generally follow the crest of southern Yucca Mountain within the area now included in the proposed withdrawal. Perchetti located 17 additional lode claims in a block west of his earlier claims 1-3 on December 1, 1988. On December 17, 1988, four lode mining claims, the Lucky 1-4, were located north of the Perchetti claims in section 9, T13S, R49E, by Robert F. Fowler of Lakewood City, California. It is believed that Mr. Fowler is an associate of Mr. Perchetti. In a letter to Mr. Carl Gertz, Waste Management Project Office, U.S. Department of Energy, Las Vegas, Nevada, dated January 6, 1989, Mr. Perchetti stated his belief that his claim block on Yucca Mountain had a likelihood of containing gold deposits similar to those found on GEXA's Mother Lode holdings on nearby Bare Mountain. Other than sampling, apparently no work was done on these claims by Perchetti. We have not seen the Perchetti sample results. In mid-1989 Mr. Perchetti sold his interests to the U. S. Department of Energy, and the U. S. Bureau of Land Management closed the case on all 27 Yucca claims on March 13, 1989. In addition, the U. S. Department of Energy purchased Mr. Fowler's Lucky claims in 1989, but as of October 17, 1989 no notice of closure was reported in the U. S. Bureau of Land Management's index of active mining claims in Nevada.

GEOLOGIC SETTING

REGIONAL LITHOLOGY

The geology of the area around the Yucca Mountain Addition is dominated by the rocks of the southwestern Nevada volcanic field as defined by Byers et al.(1976). Ash-flow tuffs and related rocks from at least four major Miocene calderas comprise this volcanic field, which once covered an area of more than 10,000 km^2 (Byers et. al, 1989). The Tertiary volcanic rocks overlie metamorphic and sedimentary rocks ranging in age from Precambrian to Mississippian.

The earliest extrusions of the southeastern Nevada volcanic field are 16-Ma (million year old) tuffs erupted from the Sleeping Butte caldera about 35 km northwest of the Yucca Mountain Addition (Christiansen et al., 1977). About 13.5 Ma (million years ago), ash flows were erupted that are considered by Carr et al. (1986a) to be from the Crater Flat - Prospector Pass Caldera complex, whose eastern wall is thought to lie beneath the Solitario Canyon area within the Yucca Mountain Addition. At about the same time, lavas and tuffs were deposited in the Calico Hills, 10 km northeast of the Yucca Mountain Addition.

The Paintbrush Tuff, an extensive formation consisting of ash flows and associated air fall units, was erupted approximately 13 Ma from the Claim Canyon caldera about 5 km north of the Yucca Mountain Addition (Byers et al., 1976 and 1989). The upper parts of the Paintbrush Tuff may have originated from the Oasis Valley caldera further to the northwest (Christiansen et al., 1977).

At Wahmonie, about 30 km east of the Yucca Mountain Addition, flows and tuffs with associated intrusives were deposited during the same time period as the Paintbrush Tuff. The andesitic to rhyodacitic Wahmonie rocks differ in composition from most other rocks of the southwestern volcanic field which are predominantly rhyolitic to latitic.

The Timber Mountain Tuff, the most voluminous formation in the southwestern Nevada volcanic field, was erupted about 11 Ma from the Timber Mountain caldera, a large, well-preserved feature centered about 25 km north of the Yucca Mountain Addition (Byers et al., 1976). Post-collapse volcanic activity in the Timber Mountain caldera is thought to have continued until about 10 Ma. Rhyolitic lavas and tuffs in the Bullfrog Hills about 30 km west of the Yucca Mountain Addition have also yielded ages as young as 10 Ma (Jackson, 1988).

Basalt yielding 10 and 4 Ma dates has been drilled beneath Crater Flat 5 to 10 km west of the Yucca Mountain Addition, and basalt flows and cinder cones about 1 Ma occur at the surface on Crater Flat (Carr, 1988a). Lava flows at the Lathrop Wells volcanic center 13 km south of the Yucca Mountain Addition are thought to be less than 100 Ka, and cinder cone deposition at the same site is estimated at less than 15 Ka (Crowe et al., 1988).

REGIONAL STRUCTURE

According to most recent work, structures within the rocks of the southwestern Nevada volcanic field mainly result from two interactive late Cenozoic tectonic processes: extension of the southern Basin and Range province, and caldera subsidence. Numerous west-dipping normal faults, low-angle detachment surfaces, and northwesterly strike-slip faults were formed, as well as fault patterns related to cauldron subsidence and resurgent doming. The southwestern Nevada volcanic field lies within the Walker Lane belt, a 100-km-wide northwesterly zone dominated structurally by lateral shear. Paleozoic and Mesozoic structures have been modified both by the Tertiary calderas and by crustal extension during middle to late Cenozoic time.

Steeply westward-dipping normal faults are abundant in the Yucca Mountain area (Scott and Bonk, 1984), and may represent the breakaway zone for detachment faulting bounding Bare Mountain 10 km east of the Yucca Mountain Addition. According to Hamilton (1988), normal faults at Yucca Mountain occurred above an 11 Ma hinge line between more-or-less flat-lying detachment to the east and moderately westward dipping detachment to the west. Hamilton believes that this detachment surface, which separates Tertiary volcanics from pre-Tertiary rocks, now extends from east of Yucca Mountain in the subsurface, through surface exposures on Bare Mountain and the Funeral Mountains, into Death Valley. On the other hand, Carr (1988a) relates Yucca Mountain normal faulting to reactivation along subsidence-bounding fractures of the proposed 14 Ma Crater Flat-Prospector Pass caldera. Carr (1988b) further speculates that the southwestern Nevada volcanic field calderas were emplaced along a north-south rift in the Walker Lane belt separating detachment faulted terrain to the west from gravitationally caused extensional faulting to the east. Range-bounding faults around Bare Mountain are considered by Hamilton to be part of a low to moderately dipping detachment surface, whereas Carr believes that the fault bounding the east side of Bare Mountain is a steeply dipping feature related mainly to subsidence of the Crater Flat-Prospector Pass caldera.

Geophysical data suggest that the faults bounding the Bare Mountain Precambrian and Paleozoic block dip at 30° or less (Ackermann et al., 1988). The Fluorspar Canyon fault, which forms the northern boundary of Paleozoic rocks in the Bare Mountain area is thought to be an extension of the nearly flat-lying Bullfrog detachment fault between Tertiary and pre-Tertiary rocks at the Original Bullfrog mine 30 km west of the Yucca Mountain Addition. Although surface outcrops along the Fluorspar Canyon fault suggest northerly dips of 60° or more, drilling at the Mother Lode gold deposit near the east end of the fault suggests a northerly dip of about 30° (M. R. Mapa, personal communication, 1989).

YUCCA MOUNTAIN ADDITION GEOLOGY

LITHOLOGY

Within the Yucca Mountain Addition, pre-Quaternary surface lithology consists of only three members of two ash-flow formations with attendant bedded air-fall sequences. The 13.3 Ma Topopah Spring Member of the Paintbrush Tuff (ptu, Plate 1) is the oldest rock unit exposed in the area. It is characterized by the presence of pink to gray lithophysal ash-flow tuff with sparse phenocrysts (generally under 10 percent) overlain by a few meters of red-brown devitrified caprock containing about 15 percent phenocrysts, including distinctive large amber-colored biotite books. Above this is a thin black to reddish-brown vitrophyre with relatively abundant phenocrysts which is included in the Topopah Spring Member caprock by Scott and Bonk (1984).

Within the Yucca Mountain Addition, the Topopah Spring Member is overlain by a sequence composed mainly of nonresistant white to orange or light-purple, nonwelded, pumiceous bedded air-fall tuffs (bt, Plate 1). In the southwestern part of the Yucca Mountain Addition, this unit appears to contain a glassy purplish-gray welded tuff (sample SC 93). Above the nonwelded bedded tuff sequence is a distinctive glassy orange welded tuff (locally gray or bicolored orange and gray) which appears to grade downward into nonwelded orange bedded tuff.

Locally, above the orange welded tuff, is a black to dark-greenish-gray crystal-poor vitrophyre that grades up into glassy to devitrified ash-flow tuff typified by columnar jointing. According to Scott and Bonk (1984), this is the basal unit of the Tiva Canyon Member (pcu, Plate 1) of the Paintbrush Tuff. Most of the overlying Tiva Canyon Member is comprised of flaggy, crystal-poor (averaging less than 10 percent phenocrysts) devitrified gray ash-flow tuff much of which rings when struck (clinkstone zones of Scott and Bonk, 1984). The Tiva Canyon caprock is cliff-forming devitrifed to glassy, gray ash-flow tuff with moderately abundant phenocrysts.

The Rainier Mesa Member of the Timber Mountain Tuff is exposed in the southwestern to central part of the Yucca Mountain Addition, mostly on Plug Hill (Tmr, Plate 1). It is a light-gray to light-pink devitrified ash flow containing relatively abundant quartz and feldspar phenocrysts. It is underlain by nonresistant white to light-pink airfall exposed in places along the wash west of Plug Hill (bt, Plate 1).

Quaternary gravels (QTac, Plate 1) consisting mainly of fanglomerate and alluvium underlie washes and canyons in the Yucca Mountain Addition, and locally occur low on the flanks of some ridges. Caliche cement is common in these gravels, particularly along and adjacent to faults. Some exhumed gravels may be Tertiary.

STRUCTURE

Structure within the Yucca Mountain Addition is almost totally dominated by normal faults that strike north-south to north-northeast and dip steeply west (Scott and Bonk, 1984). Most of the major faults belong to this set (e.g.: the Solitario Canyon fault, a fault along the north-northeast-trending arm of Abandoned Wash; and a fault along the west side of Boomerang Point). A minor subset of north-northwest to northwest faults dipping steeply southwest with apparent normal displacements is also present, particularly in the south central part of the Yucca Mountain Addition (Plate 1). Other fault orientations are rare.

Many of the faults in the Yucca Mountain Addition are marked by resistant silicified breccia (Figure 2). Such faults are especially common west of Yucca Crest near the Solitario Canyon fault, and on the west flank of Boomerang Point. Calcrete-cemented breccia is also very common along faults, and serves as an indicator of poorly exposed faults in some cases. In many instances, fault breccia is cemented by silica and calcrete (Figure 3). Faults with clayey and(or) sandy gouge (Figure 4) are rare in the Yucca Mountain Addition.

ECONOMIC GEOLOGY EVALUATION

This study was designed to test the potential for economic minerals within the Yucca Mountain Addition only. Extension of the findings of this study into other areas encompassed in the Yucca Mountain project and outside the Yucca Mountain Addition are not intended. In addition, because access to subsurface samples was not granted by the DOE due to quality assurance concerns, determinations of economic potential to depths greater than a few hundred meters were not possible.

Because of the presence of the Perchetti claims, and allegations of economic precious-metal potential made publically and privately by Mr. Perchetti, this economic evaluation is focused on a determination of precious-metal potential within the Yucca Mountain Addition. The field and laboratory methods used were mainly directed toward determination of precious-metal potential. However, other commodities were considered that could occur in economic amounts based on the geologic setting.

FIELD EXAMINATION

Fieldwork for the economic minerals evaluation in the Yucca Mountain Addition was begun on May 18, 1989, and completed on June 28, 1989. Outcrops were examined and samples collected along foot traverses made over the entire Yucca Mountain Addition (Plate 2).

Figure 2. Silica-cemented fault breccia near sample location YMSC 51, view to north.

Figure 3. Silica- and calcrete-cemented fault breccia near sample location YMSC 69. Located on the west side of Boomerang Point, view to north.

Figure 4. Gouge zone along Abandoned Wash fault. Fault down-drops devitrified Tiva Canyon Member ash flow on west (back-ground) against Paintbrush Tuff bedded tuff on east (fore-ground). Sample location YMSC 13.

Sample locations were marked on copies of the 1:12,000 scale geologic map of Scott and Bonk (1984) and on 1:12,000 scale enlargements of 7.5 minute quadrangle maps. During sample collection, visual descriptions of mineralogy, lithology, and structures encountered were recorded (Appendix A). Samples were collected mainly from veins, fracture coatings, fault zones, bodies of tectonic breccia, and areas of altered rock. Initially, 200 samples were collected from the Yucca Mountain Addition study area.

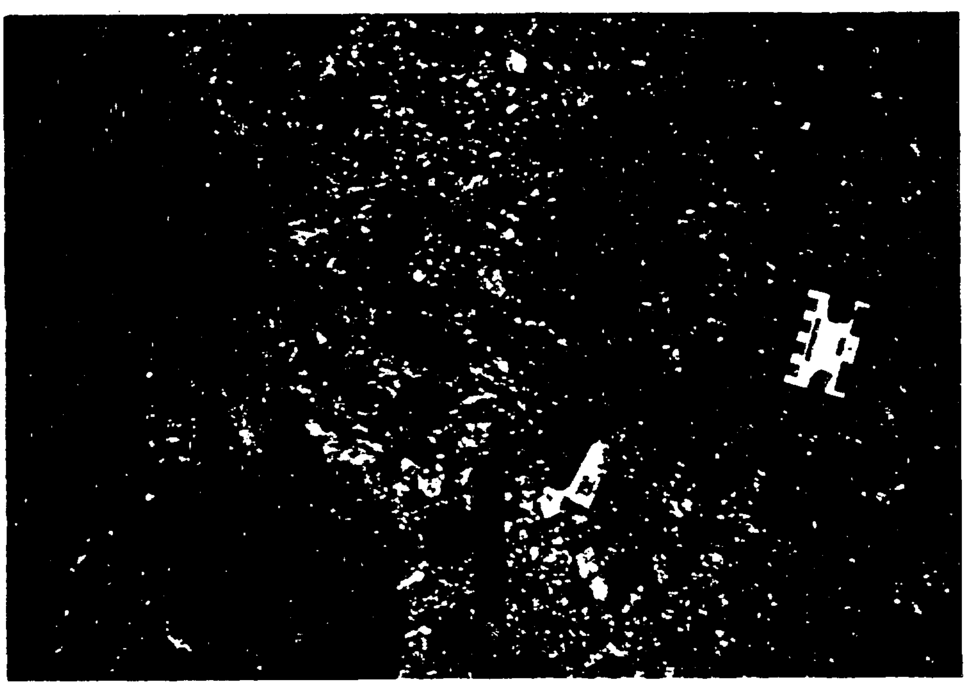
Samples were submitted to Geochemical Services Inc. (GSI), of Rocklin, California, for 15-element inductively-coupled plasma (ICP) emission spectroscopic analyses, and gold analysis by graphite furnace atomic absorption . Sample crushing and pulverization were done using either NBMG bucking facilities, or those of GSI located in Sparks, Nevada. Ten blank quartz samples were submitted initially along with Yucca Mountain samples to monitor possible contamination during sample preparation.

Following receipt of analytical results for the initial samples, 20 samples were submitted for corroborative analyses to the NBMG geochemical laboratory. In addition, 38 sample sites, including all sites that yielded samples with elevated trace element contents, were revisited, resampled, and marked with aluminum tags and red flags (Figure 5). During this resampling work, 22 samples were collected from new sites. Altogether, 260 samples were collected from the Yucca Mountain Addition and subjected to multi-element analyses (Appendix B).

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, a recently discovered gold deposit in the Bare Mountain area, and four abandoned mining areas known to have had past production of gold and silver. 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. A total of 122 samples (including 7 resubmitted blind for control) were analyzed from these areas by GSI with the same techniques used for the Yucca Mountain Addition samples.

Mineralogic and petrographic work was done by NBMG and Desert Research Institute personnel on selected samples from the Yucca Mountain Addition and the precious-metal districts examined. X-ray diffraction analyses were performed on 54 samples from the Yucca Mountain Addition and 29 samples from three of the four precious-metal districts examined (Appendix C). In addition, 8 thin sections of representative veins, breccias, and altered rocks from the Yucca Mountain Addition were analyzed petrographically.

Figure 5. Sample location YMSC 52. A narrow zone of hematitic silicified air-fall tuff (beneath aluminum tag).



GEOCHEMICAL RESULTS

Several samples from the Yucca Mountain Addition were found to contain slightly anomalous amounts of silver, arsenic, bismuth, lead, and(or) thallium; however, the highest contents of most analyzed elements in samples collected from the Yucca Mountain Addition during this study are near or below background values in the earth's crust (Levinson, 1974). Analyses for three elements: palladium, selenium, and tellurium, all fell below detection levels (see Table 1). Most of the anomalous Yucca Mountain Addition samples were taken from the Paintbrush bedded tuff unit (pbt, Plate 1), and these are mainly silicified rock, but one is unaltered glassy air-fall tuff, and one is from a glassy tuff dike.

Perhaps the most interesting sample, in terms of its geochemistry, is YMSC 52, a sample of bright red silicified air-fall tuff (Figure 2) from a northerly vein on the west flank of Yucca Crest. The vein is probably less than 20 cm wide and could only be followed on the surface for a few meters. This sample contains 4 to 8 ppm bismuth and 109 to 145 ppm lead. A single analysis of sample YMSC 92, brown silicified air-fall tuff from a zone approximately parallel to the nearby YMSC 52 vein, yielded a value of 1 ppm bismuth.

Sample YMSC 22, containing 3 to 4 ppm bismuth, 64 to 97 ppm zinc, and 2 ppm thallium, was collected from a 3-cm-wide dike of friable, glassy, pink and white air-fall tuff which dips steeply southwest. This tuff dike cuts an irregular 5- to 10-cm-wide northeasterly zone of gray opalized tuff (sample YMSC 22S) carrying 0.6 to 1.8 ppm bismuth. The host rock at this locality is gray glassy welded tuff which appears to be in the Paintbrush bedded tuff sequence.

Sample YMSC 31, a composite of purplish-gray silicified air-fall tuff and hematitic gouge from a fault dipping steeply west, contains 0.6 to 1.5 ppm bismuth and 60 to 68 ppm zinc. Sample YMSC 31B, hematitic air-fall tuff taken from the hanging wall of this fault, contains 27 ppm arsenic and 0.3 ppm bismuth.

Other anomalous samples within the Paintbrush bedded tuff sequence are YMSC 14C, a bed of fine, well-sorted, and apparently unaltered lapilli tuff containing 0.4 to 0.5 ppm silver; and YMSC 88 from a near vertical northerly calcrete-silica vein system with 1 ppm bismuth.

Only two geochemically anomalous samples were collected from outside the Paintbrush bedded tuff sequence. Sample YMDD 36A, which contains 32 ppm arsenic and 1 ppm bismuth, is purplish-gray silicified breccia with some irregular veins of white opal collected from a fault dipping steeply southwest. Sample YMSC 45, with 0.1 ppm silver, is of calcrete vein material from a poor exposure. The host rock for both occurrences is devitrified ash-flow tuff of the Topopah Spring Member of the Paintbrush Tuff.

None of the samples collected from the Yucca Mountain Addition can be said to have highly anomalous gold contents. The highest gold value for any Yucca Mountain Addition sample reported by GSI is 0.026 ppm (YMSC 66); however, analysis of a blind resubmitted sample resulted in a 0.003 ppm gold value, and gold was not detected in rock obtained by resampling the same outcrop (sample YMSC 66A). The highest gold value for all other samples from the Yucca Mountain Addition analyzed by GSI is 0.009 ppm, equivalent to 0.0003 ounces per ton.

Table 1. Elements analyzed, detection limits, and median values by area. Analyses by Geochemical Services Inc. All values in ppm.

		MEDIAN VALUES (ppm)			
ELEMENT	DETECTION LIMIT (ppm)	Yucca Mtn. Addition	Wahmonie district	Mother Lode dep. area	Rhyolite area
Ag	0.015	0.026	0.148	0.134	0.356
As	1.00	3.07	36.10	44.30	5.88
Au	0.0005	0.001	0.006	0.048	0.113
Cu	0.05	6.88	5.93	4.10	2.70
Hg	0.10	<0.10	<0.10	0.188	<0.10
Mo	0.10	1.02	3.47	2.39	4.50
Pb	0.25	3.68	6.50	5.24	6.80
Sb	0.25	<0.25	1.64	3.05	0.55
Tl	0.50	<0.50	<0.50	<0.50	<0.50
Zn	1.00	22.50	4.31	6.71	13.00
Bi	0.25	<0.25	0.610	<0.25	<0.25
Cd	0.10	<0.10	<0.10	<0.10	<0.10
Ga	0.50	0.66	0.51	0.71	0.65
Pd	0.50	<0.50	<0.50	<0.50	<0.50
Se	1.00	<1.00	<1.00	<1.00	<1.00
Te	0.50	<0.50	1.340	<0.50	<0.50

Analyses performed by the NBMG geochemical laboratory on Yucca Mountain Addition samples yielded higher gold numbers than those obtained by GSI (Table 2). The NBMG analyses were performed by fire assay with atomic absorption finish, a technique which can be expected to yield higher results than that used by GSI, which may not extract all of the gold in the sample during dissolution (P. Lechler, personal communication, 1989). The highest gold value obtained by NBMG on a Yucca Mountain Addition sample is 0.023 ppm, or about 0.0007 troy ounces per ton. A simple regression curve fitted to a plot of NBMG gold analyses versus GSI gold analyses for the same samples shows that the projected maximum NBMG value is 0.0245 ppm, about 0.0007 troy ounces per ton (Figure 6).

STATISTICAL EVALUATION OF GEOCHEMICAL SAMPLING

Statistical calculations of sampling results from the Yucca Mountain Addition evaluation were made using statistical software developed by Koch (1987). In addition to calculations on data from the Yucca Mountain withdrawal, statistical calculations were performed on data from the Mother Lode property, from Rhyolite in the Bullfrog district, and from the Wahmonie district.

Geochemical values were analyzed by district and the results are presented in Tables 3 through 6. Table 1 provides a list of elements analyzed, shows detection limits, and shows median values of each element by area. Tables 3 through 6 show correlation coefficients for elements in samples from each of the four areas.

Correlation coefficients vary from +1 to -1. Correlation coefficient values quantify adequacy of fit to a linear regression curve (values of ±1 correspond to a perfect fit, and those of 0 to no linear fit), and signs indicate if the correlation is positive or negative. The significance of each coefficient was determined using a table for testing the null hypothesis $\rho = 0$ (Snedecor and Cochran, 1967, p. 557). As the number of data pairs increases, the correlation coefficient will be significant at progressively lower values. Correlation coefficients significant at the 95 and 99 percent levels are indicated on Tables 3 through 6. Testing by the above methods may not be valid for data with non-normal distributions (e. g., mercury in Yucca Mountain samples).

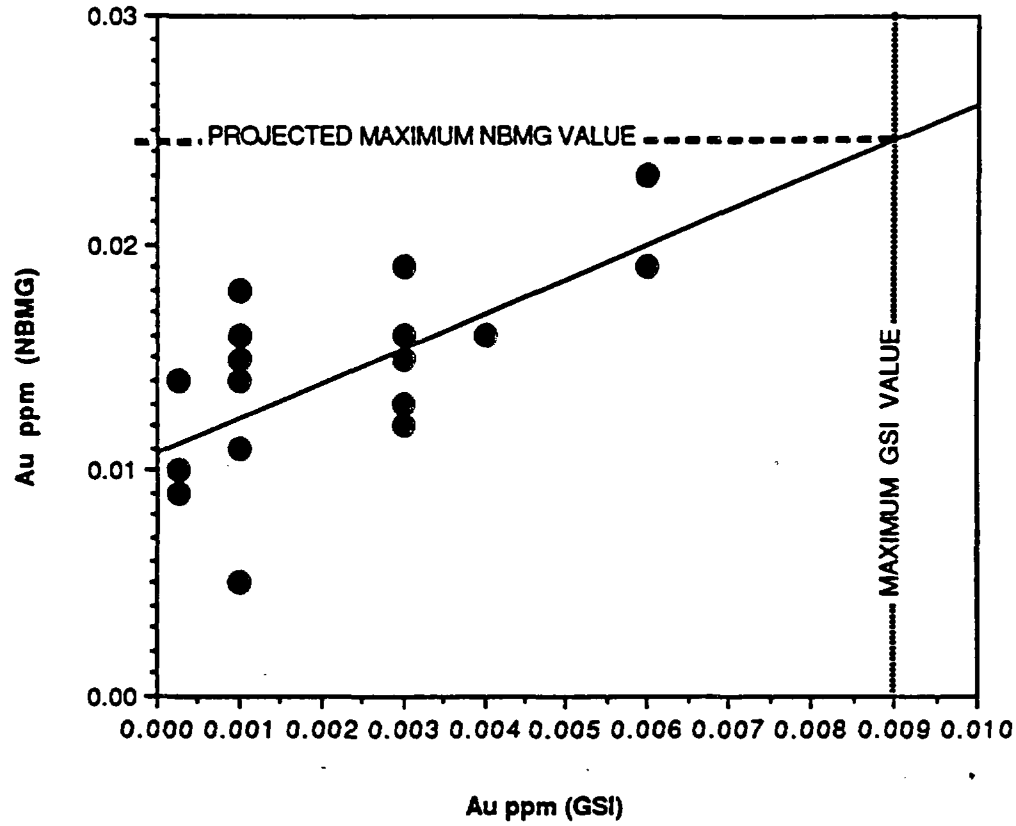
Yucca Mountain Addition

Results from 196 samples collected in the Yucca Mountain Addition study area were used in statistical calculations (all samples taken during initial fieldwork with the exception of 4 samples for which analytical data was obtained too late for inclusion). In this group, gold was reported present above the limit of detection in 101 samples. Mercury was found above the limit of detection in only 14 samples, bismuth was found in only 8, and palladium, selenium, and tellurium were not found in any of the samples at the limit of detection of the analytical methods

Table 2. Comparison of GSI and NBMG analytical results. Twenty samples were analyzed for gold, arsenic, antimony, bismuth, and mercury at both labs. All values in ppm.

SAMPLE	Au(GSI)	Au(NBMG)	As(GSI)	As(NBMG)	Sb(GSI)	Sb(NBMG)	Bi(GSI)	Bi(NBMG)	Hg(GSI)	Hg(NBMG)
SC-2	<0.0005	0.014	<0.999	0.5	<0.249	<0.25	<0.25	0.14	0.228	<0.05
SC-5C	0.004	0.016	6.13	1.8	<0.263	<0.25	<0.263	<0.07	<0.105	0.13
SC-14	0.006	0.023	12.90	8.4	<0.273	<0.25	<0.273	<0.07	<0.109	0.14
SC-22	0.001	0.016	2.59	1.2	0.323	<0.25	3.19	4.34	<0.1	0.06
SC-22S	<0.0005	0.010	3.01	1.9	<0.252	<0.25	0.894	0.61	<0.101	0.06
SC-28	0.003	0.016	16.20	<0.50	<0.252	<0.25	<0.252	<0.07	<0.101	0.08
SC-30	0.003	0.019	5.16	0.9	<0.25	<0.25	<0.25	<0.07	<0.1	0.1
SC-31	0.001	0.011	10.40	7.3	<0.251	<0.25	0.614	1.54	<0.1	<0.05
SC-34	0.001	0.015	16.00	0.9	<0.278	<0.25	<0.278	<0.07	<0.111	0.11
SC-36	<0.0005	0.010	11.90	2.6	<0.251	<0.25	<0.251	<0.07	<0.1	0.12
SC-42	0.003	0.012	7.79	1.5	<0.251	<0.25	<0.251	<0.07	<0.101	0.09
SC-45	0.001	0.014	7.40	2.2	0.304	<0.25	<0.252	<0.07	<0.101	0.27
SC-52	<0.0005	0.009	1.71	0.9	<0.274	<0.25	4.32	8.15	<0.1	0.24
PG-18	0.006	0.019	1.98	1.2	<0.25	<0.25	<0.25	<0.07	<0.1	<0.05
PG-19	0.003	0.013	2.40	<0.50	<0.25	<0.25	<0.25	<0.07	<0.1	0.06
DD-3	0.003	0.012	4.01	0.5	<0.259	<0.25	<0.259	<0.07	<0.104	0.08
DD-5	0.001	0.018	3.81	2.1	0.315	<0.25	<0.252	0.07	<0.101	0.06
DD-21	0.003	0.015	8.20	0.5	0.543	<0.25	<0.259	<0.07	<0.104	0.06
DD-23B	0.001	0.005	<1.00	<0.50	0.608	<0.25	1.22	1.19	<0.101	0.11
DD-36	0.003	0.016	4.63	1	0.459	<0.25	<0.251	<0.07	<0.1	<0.05

Figure 6. Simple regression plot for gold analyses. NBMG versus GSI values for 20 samples. GSI values reported at <0.0005 ppm plotted at 0.00025 ppm.



used (Table 1). All analyzed elements are present in very low concentrations (or are below detection limits) in all samples collected within the Yucca Mountain Addition. Correlation coefficients between elements (Table 3) do not show strong groupings of correlated elements. Arsenic, gold, and cadmium show weak correlations and there is a general grouping of base metals (copper, molybdenum, lead, antimony, and zinc along with bismuth and gallium) that display weak to moderate correlations.

Wahmonie District

Sampling at Wahmonie was less extensive than at the other three areas studied; only 12 samples are available for statistical evaluation. Median values from Wahmonie show definite enrichment of silver and tellurium and lower, but anomalous, concentrations of arsenic. Element correlations (Table 4) are limited to strong correlations between silver and mercury, silver and tellurium,

Table 3. Geochemistry correlation coefficients, Yucca Mountain Addition. No coefficients are shown for Te because Te is below the detection limit in all samples.

	As	Au	Cu	Hg	Mo	Pb	Sb	Zn	Bi	Cd	Ga	Te
Ag	.10	.07	.10	-.12	-.01	-.09	.07	.00	-.11	.17^	.05	
As		.46*	-.16^	-.10	-.36*	-.03	-.07	-.25*	-.06	.26*	-.22*	
Au			-.22*	-.11	-.29*	-.07	-.06	-.26*	-.05	.24*	-.19*	
Cu				.09	.35*	.05	.26*	.11	-.04	-.16^	.10	
Hg					-.04	-.06	.05	-.07	.04	-.07	.04	
Mo						.25*	.27*	.45*	.07	-.30*	.27*	
Pb							.04	.34*	.74*	-.04	.13	
Sb								.02	.12	.07	.32*	
Zn									.25*	-.09	.15^	
Bi										.08	.21*	
Cd											-.03	
Ga												

* Correlation coefficient significant at 99% level

^ Correlation coefficient significant at 95% level

arsenic and cadmium, gold and tellurium, and mercury and tellurium. Based on our sample results, there does not seem to be a base-metals association at Wahmonie.

Mother Lode Deposit Area

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

Table 4. Geochemistry correlation coefficients, Wahmonie district.

	As	Au	Cu	Hg	Mo	Pb	Sb	Zn	Bi	Cd	Ga	Te
Ag	-.18	.39	-.27	.97*	.08	-.32	-.29	.43	-.18	-.08	-.39	.84*
As		-.11	.03	-.12	-.11	-.03	-.04	-.10	.04	.93*	.43	-.10
Au			-.30	.48	-.04	-.40	-.22	-.02	.01	.03	-.45	.70*
Cu				-.15	-.03	.25	.62^	.46	.34	-.07	.28	-.14
Hg					.07	-.32	-.11	.54	-.22	.01	-.35	.86*
Mo						.30	.12	.43	-.30	-.20	.32	.02
Pb							-.12	.00	.09	-.02	.10	-.36
Sb								.55^	-.06	-.18	.50	-.24
Zn									-.32	-.12	.32	.28
Bi										.03	-.39	.19
Cd											.17	-.01
Ga												-.48

* Correlation coefficient significant at 99% level

^ Correlation coefficient significant at 95% level

outside the orebody. Median values for arsenic, antimony, and mercury are all high indicating that these elements are enriched in the area sampled. Correlation coefficients calculated from Mother Lode data (Table 5) show a precious-metals grouping (strong silver-arsenic-gold-copper-tellurium correlations) and a base-metals grouping which includes moderate to strong silver-antimony-lead-zinc correlations, a weak zinc-cadmium correlation, and moderate lead-antimony-zinc-tellurium correlations. Mercury, known to be present in the district from its production history, was found to be present above detection limits in 21 of the 37 samples from the district. Mercury, however, does not correlate well with any of the elements in the precious-metals group and correlates only moderately with copper, molybdenum, and lead in the base-metals grouping.

Table 5. Geochemistry correlation coefficients, Mother Lode property.

	As	Au	Cu	Hg	Mo	Pb	Sb	Zn	Bi	Cd	Ga	Te
Ag	.67*	.82*	.57*	.21	.01	.58*	.49*	.44*	-.09	.31	-.13	.90*
As		.87*	.81*	.36^	.25	.20	.03	.44	-.06	.27	-.11	.78*
Au			.76*	.25	.20	.26	.13	.29	-.06	.21	-.09	.90*
Cu				.34^	.39^	.40^	.30	.27	-.07	.30	-.21	.75*
Hg					.03	.05	.02	.34^	.01	.15	-.21	.18
Mo						-.04	-.03	-.02	.02	.12	-.19	.15
Pb							.95*	.23	.05	.26	-.09	.57*
Sb								.17	-.04	.26	-.11	.45*
Zn									-.10	.52*	-.14	.41*
Bi										-.10	-.01	-.07
Cd											-.04	.38^
Ga												-.08

* Correlation coefficient significant at 99% level

^ Correlation coefficient significant at 95% level

Rhyolite Area

Samples from mines and mineralized outcrops in the area around Rhyolite in the Bullfrog district show high median values for gold and silver. Base-metals values in this area are very low. Examination of the correlation coefficients between elements (Table 6) shows a precious-metals grouping with strong silver-gold correlation and moderate silver-gold-antimony-bismuth-correlations. A broad base-metals association includes moderate copper-antimony-bismuth, molybdenum-lead-cadmium, and zinc-cadmium correlations.

Table 6. Geochemistry correlation coefficients, Rhyolite area.

	As	Au	Cu	Hg	Mo	Pb	Sb	Zn	Bi	Cd	Ga	Te
Ag	.15	.94*	.04	.03	-.02	-.11	.03	-.06	.01	-.08	.00	.02
As		.11	.03	.18	.47*	.40*	.45*	.23	-.15	.20	.19	-.13
Au			.00	.03	-.04	-.05	-.02	-.08	.12	-.11	-.05	.29
Cu				-.14	.00	-.07	.66*	.12	.41*	.32^	.25	-.04
Hg					-.07	-.01	-.07	.15	-.06	.05	.03	.05
Mo						.64*	.26	.14	-.04	.43*	-.12	.03
Pb							.16	.14	.11	.29	-.01	.35
Sb								-.06	.51*	.09	-.11	-.13
Zn									-.20	.52*	.38^	-.12
Bi										-.10	-.20	.51*
Cd											.20	-.05
Ga												-.11

* Correlation coefficient significant at 99% level

^ Correlation coefficient significant at 95% level

Summary and Comparison of Areas

A comparison of element median values shows very substantial enrichments in both gold and silver in the established precious-metal districts relative to the Yucca Mountain Addition (Table 1). Median precious-metals values in samples from Wahmonie, Mother Lode, and Rhyolite are 5 to 100 times the median values found in samples taken within the Yucca Mountain Addition. Tellurium, present in anomalous amounts in two of the three mining districts, was not found to be present above the detection limit in Yucca Mountain samples. With the exception of a moderate arsenic-gold correlation, correlated elements in samples from Yucca Mountain fall into only one general category - a base-metals association. Two groupings of elements are present in samples from the Mother Lode deposit area and from the Rhyolite district. Correlated elements at Wahmonie, however, were found only in the precious-metals grouping (silver-tellurium, gold-tellurium, and mercury-tellurium).

MINERALOGIC AND LITHOLOGIC RESULTS

Although most of the samples considered to be geochemically anomalous are in the Paintbrush bedded tuff sequence, these samples are mineralogically variable. Silicified samples, such as YMSC 22S, YMSC 31, YMSC 52, YMSC 88, and YMSC 92 contain opal and opal-CT as shown by X-ray diffraction (Appendix C). Opal-CT was defined by Jones and Segnit (1971) as opal that yields X-ray diffraction patterns containing some cristobalite and tridymite peaks in addition to the pattern for amorphous silica. Unaltered phenocrysts of plagioclase, potash feldspar, biotite, and clinopyroxene are present, but pumice lapilli and shards are thoroughly replaced by isotropic to faintly birefringent silica (Figure 7).

The tuff dike (YMSC 22), on the other hand, is composed of largely unaltered glass lapilli and shards with unaltered phenocrysts of feldspar, biotite, and clinopyroxene. Minor amounts of finely disseminated montmorillonite and carbonate are present (Figure 8). Sample YMSC 14C is almost completely composed of volcanic glass with little or no calcite, opal, or clay.

Sample YMSC 45A is of calcrete breccia in ash-flow tuff with little or no secondary silica. The calcrete matrix consists of finely divided calcite with rounded granules of dark brown material (Figure 9) and very minor amounts of late opal-CT. Cavities in the matrix contain acicular carbonate (possibly calcite pseudomorphs after aragonite). Similar mineralogies and textures were observed in calcrete samples not considered to have anomalous chemistries (Figures 10 and 11).

Sample YMDD 36A is silicified breccia from a fault cutting ash-flow tuff. It consists mainly of opal-CT and tridymite based on XRD analysis. It also contains late veinlets of white opaline silica containing tridymite and chalcedony probably similar to that shown in Figure 7.

Sample YMDD 36A is macroscopically similar to many other silicified breccia samples taken along faults in the Yucca Mountain Addition (Figure 2 shows a good example of an outcrop of such material). Except for sample YMDD 36A, none of these samples were found to have anomalous chemistries. Descriptions of two thin sections of this type of rock serve to illustrate the mineralogical and textural features of these breccias. Sample YMSC 29 consists of clasts of devitrified ash-flow set in siliceous matrix with local calcite. In thin section, the matrix is seen to consist of wedges of tridymite coated with brown opal-CT (Figure 12) and later local calcite, chalcedony, and possible cristobalite. Sample YMSC 66 is similar, containing a matrix of brown opal-CT coated by chalcedony with local late calcite infilling (Figure 13).

Figure 7. Photomicrograph of sample YMSC 22S. Silicified air-fall tuff with shards and lapilli almost completely replaced by isotropic silica (on bottom) and cut by white tridymite-rich opaline silica vein (top) containing discontinuous layers of birefringent quartz. Field of view about 3 mm x 2 mm. Cross-polarized light.

Figure 8. Photomicrograph of sample YMSC 22. Pumice lapilli in glass shard matrix with some fine birefringent montmorillonite. Field of view about 3 mm x 2 mm. Cross-polarized light.

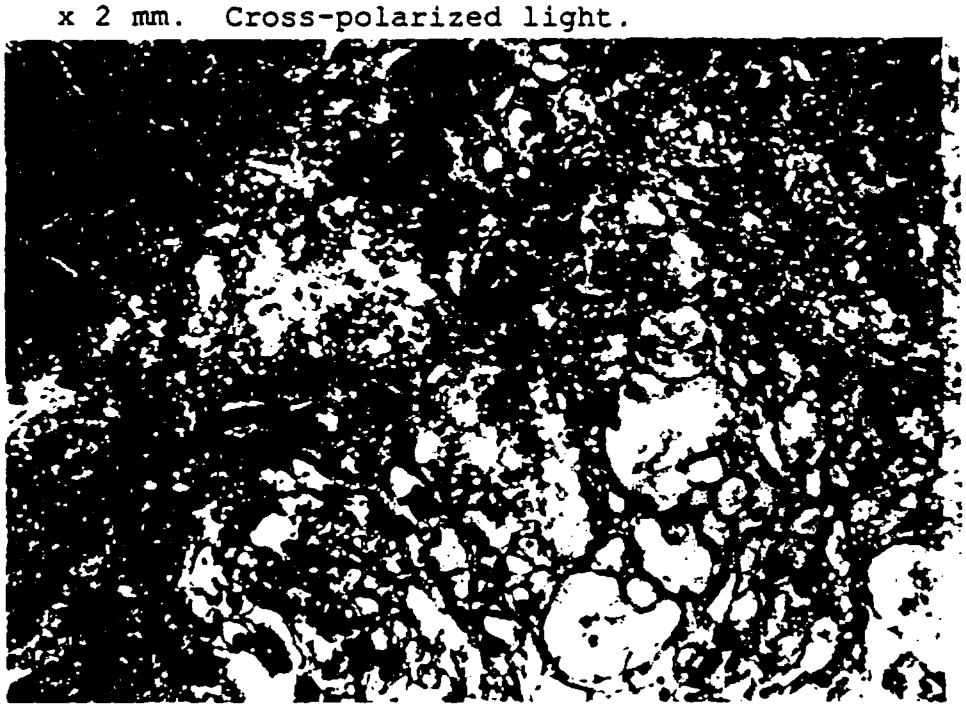


Figure 9. Photomicrograph of sample YMSC 45. Breccia with calcrete matrix and devitrified ash-flow tuff clasts. Note rounded dark granules. Field of view 3 mm x 2 mm. Plane-polarized light.

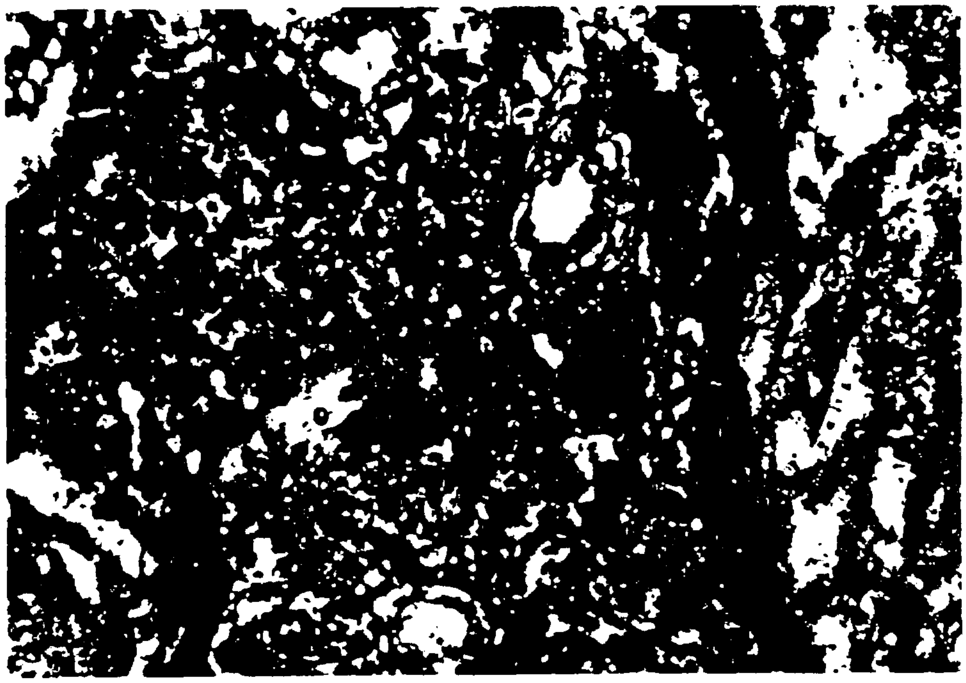
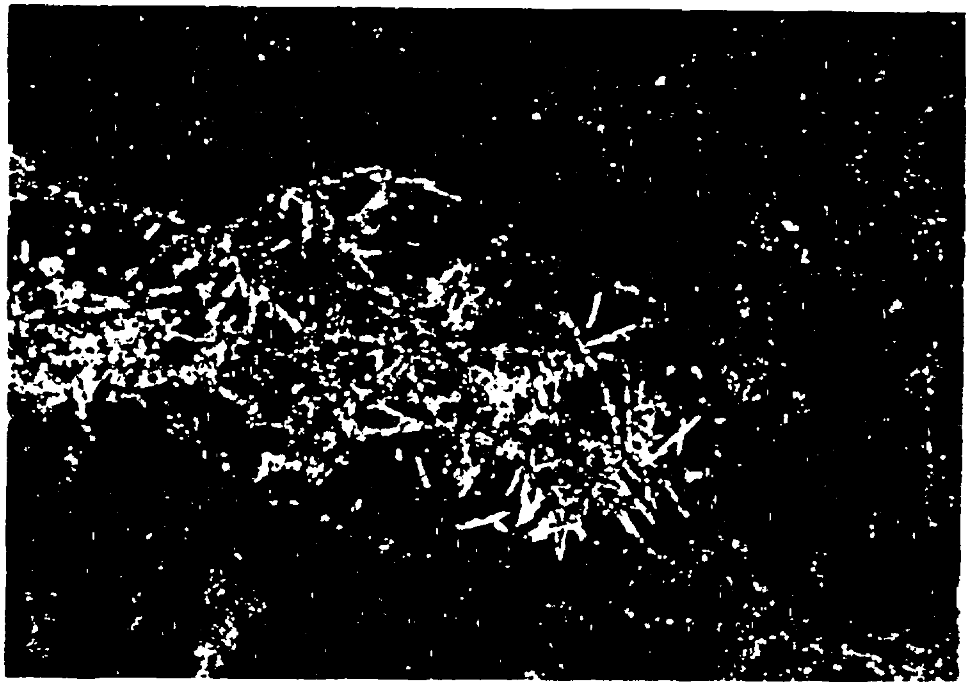


Figure 10. Photomicrograph of sample YMSC 14. Calcrete layer in bedded tuff containing pumice fragments and a partial spherulite in fine calcite with dark granules. Field of view is 3 mm x 2 mm. Plane-polarized light.

Figure 11. Photomicrograph of sample YMSC 14. Cavity in calcrete containing calcite after aragonite(?). Horizontal field approx. 750 microns. Cross-polarized light.



SUBSURFACE DATA

Although geologic and petrographic data are available for three drill holes in the Yucca Mountain Addition, very little trace element data have been published. In addition, most of the data available are not applicable to precious- and(or) base-metal exploration because elements specific for the present work are not included, or because detection limits are too high.

A relatively detailed lithologic log, as well as data on fracture fillings, for drill core to a depth of 1533 m from holes USW G-3 and USW GU-3 are available (Scott and Costellanos, 1984). Based on this log, alteration of units intercepted in these drill holes consists of zeolitic alteration of bedded tuffs at depths of 600 m or more, minor clay alteration below 770 m, more extensive clay alteration below 1100 m, and local disseminated sulfides below 1170 m. Fracture fillings consist of clay, silica, zeolite, carbonate minerals, iron oxides and hydroxides, and fluorite, but zones of severe fracturing have not been noted.

Within the Yucca Mountain Addition, we are aware of only two gold analyses, both below a 0.02 ppm detection limit, on two samples from drill hole USW G-3 (Broxton et al., 1986). A single antimony analysis was below the 0.5 ppm detection limit. The analyses of these samples do not include other precious- or base-metals, or pathfinder elements associated with them. Results of XRD analyses of fracture fillings indicate that most are predominantly composed of silica (quartz, cristobalite, and

Figure 12a. Photomicrograph of sample YMSC 29. Silicified breccia matrix. Wedges of tridymite with brown opal-CT coating and late chalcedony. Field of view abount 1 mm x 1.5 mm. Plane-polarized light.

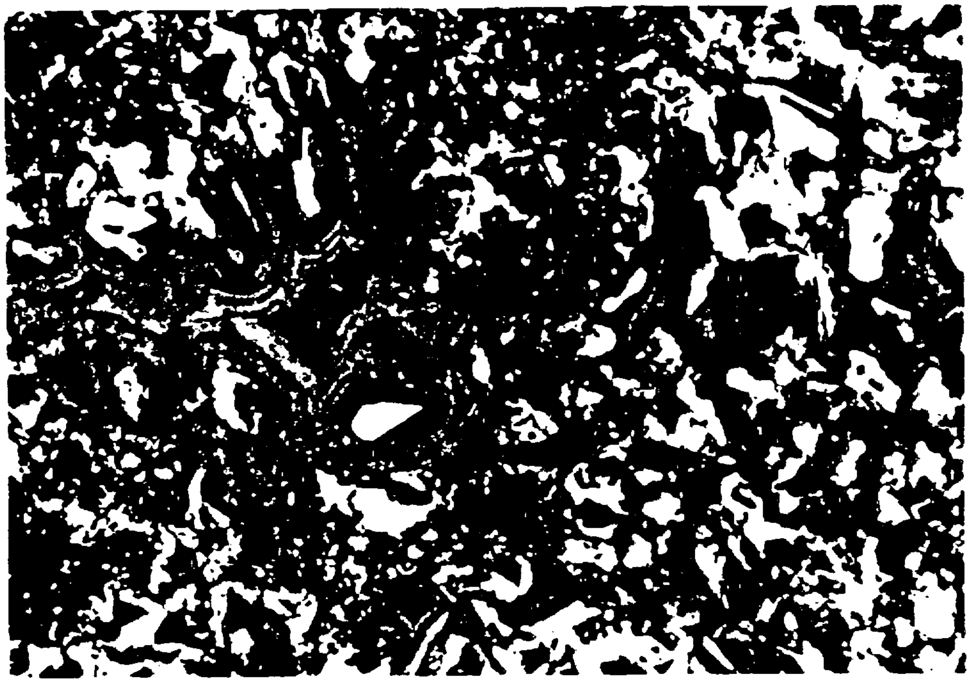


Figure 12b. Photomicrograph of sample YMSC 29. Same view as in Figure 12a, but with cross-polarized light.

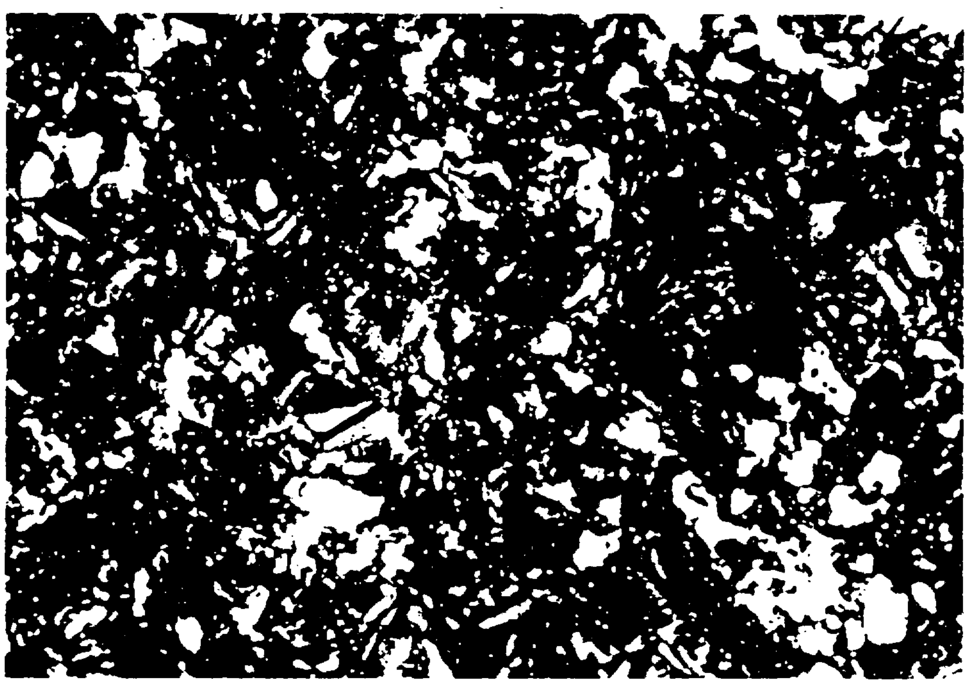


Figure 13a. Photomicrogaph of sample YMSC 66. Matrix of silicified breccia. Brown opal-CT coated with grey birefringent chalcedony. Late carbonate filling. Field of view 1.5 mm x 1 mm. Cross-polarized light.

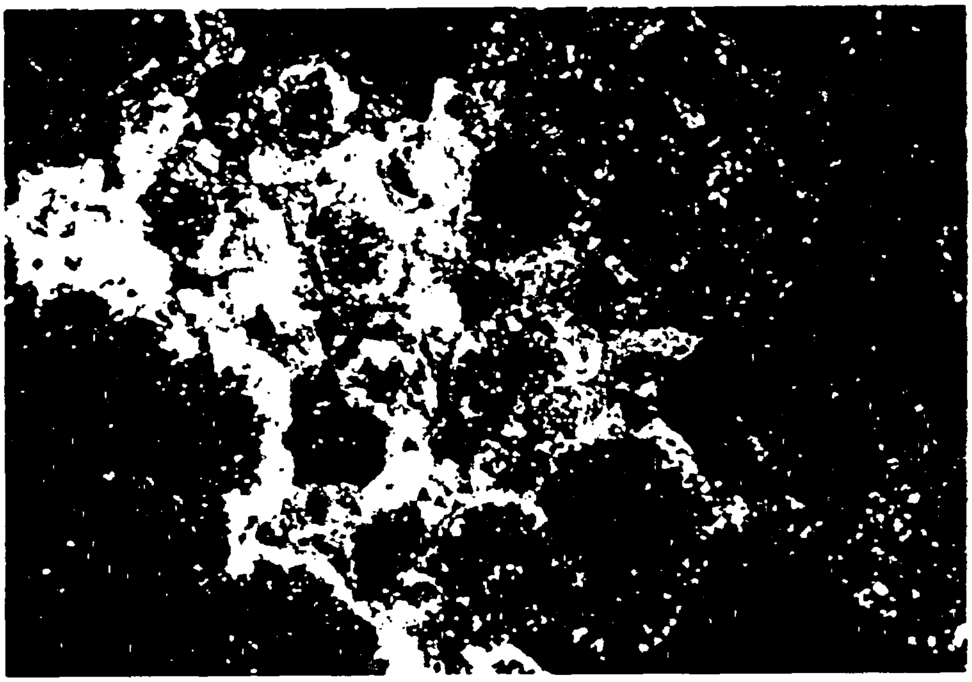
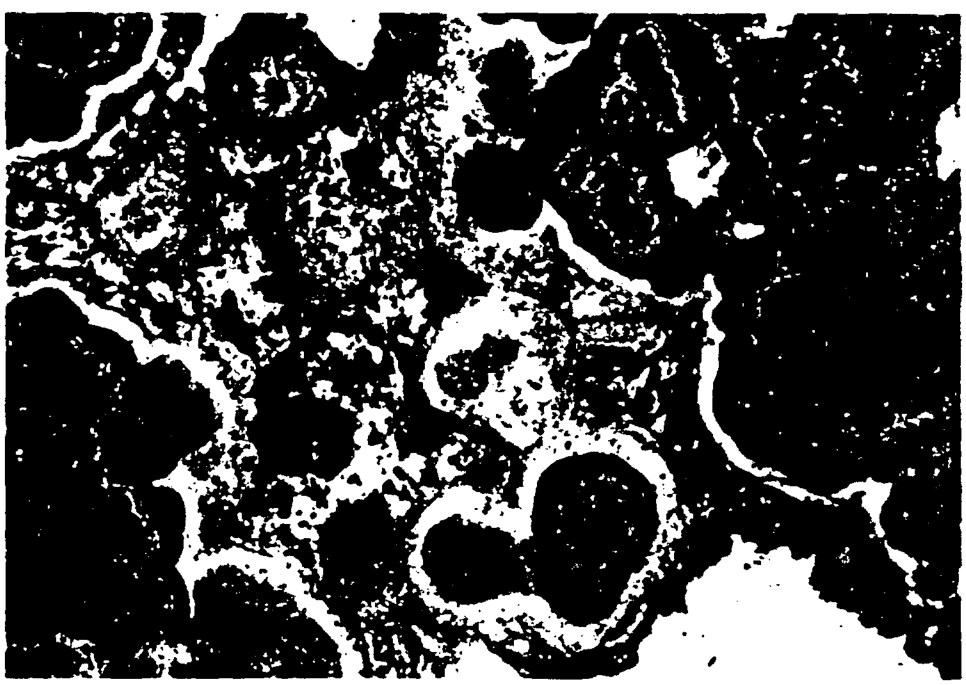


Figure 13b. Photomicrograph of sample YMSC 66. Plane-polarized view of Figure 13a.



tridymite) and(or) calcite. However, several fractures containing up to an estimated 90 percent fluorite were identified at depths greater than 249 m (Scott and Costellanos, 1984).

More than 80 samples from drill hole USW G-1, about 3 km north of the Yucca Mountain Addition, have been analyzed for gold. All were below detection limits; however, for these analyses the gold detection limit was 0.12 ppm or higher. Antimony analyses of these samples were also all below a 1.5 ppm or higher detection limit. The data include a few zinc values of up to 235 ppm (Broxton et al., 1986).

Core from drill hole USW G-2, about 5 km north of the Yucca Mountain Addition, contains minerals characteristic of hydrothermal alteration, such as clay minerals, chlorite, and pyrite at depths of 1000 m or more, as well as fluorite veins and a single thin barite-calcite-chlorite vein (Caporuscio et al., 1982). In addition, gold analyses of samples from this hole include a value of 0.06 gold in zeolitized tuff from a depth of 515 m (Broxton et al., 1986). Two samples from shallower depths have no detectable gold (at a detection limit of 0.02 ppm).

Uraniferous opal fracture fillings up to 1 cm thick were noted in drillcore from hole USW G-3 within the Yucca Mountain Addition, but the highest uranium content measured is 35 ppm (Szabo and Kyser, 1985). Gamma log results indicate that drill holes within the Yucca Mountain Addition did not encounter anomalously radioactive rock (Muller and Kibler, 1985).

COMPARISON WITH SURROUNDING PRECIOUS-METAL DISTRICTS

Areas with precious-metal deposits which were examined and sampled for comparative purposes are the Wahmonie district; the Mother Lode deposit; and the Bullfrog district, a widespread group of past and present producing mines including the Rhyolite area, the Original Bullfrog mine, and the Gold Bar mine (Figure 1). All of these areas contain precious-metal mineralization in southwestern Nevada volcanic field rocks that are contemporaneous, or nearly so, with rocks underlying the Yucca Mountain Addition.

Wahmonie District

precious-metal mineralization in the Wahmonie district occurs in a system of N30°E veins within a similarly oriented 8 km by 4 km elliptical alteration halo containing strongly oxidized argillized and silicified rock. Mineralization ages determined on adularia from altered rock in the Wahmonie district are 12.6 and 12.9 Ma (Jackson, 1988). Vein samples collected from the Wingfield shaft dump contain up to 50 oz silver and 0.67 oz gold per ton. They consist mainly of macrocrystalline quartz with alunite and gypsum; and carry free gold, cerargyrite, argentite, hessite, iron and manganese oxides, and sulfides (Quade and Tingley, 1984). Samples of altered rock and veins collected during this study within a 400-m radius of the Wingfield shaft (samples W-1 through W-12, Appendix 4) contain up to 46 ppm silver and 0.44 ppm gold along with anomalous arsenic, bismuth, mercury, antimony, and tellurium. Gold content ranges between 0.001 and 0.202 ppm. The silver to gold ratio ranges from 5 to more than 200, and averages about 75.

<u>Mother Lode Deposit Area</u>

The Mother Lode deposit is located at the base of the northeast flank of Bare Mountain about 15 km northwest of the Yucca Mountain Addition (Figure 1) near the eastern end of the Fluorite Canyon fault. The deposit, which was located by drilling along an inferred eastward extension of this fault under cover, has not been put into production, but announced reserves are 3.7 million tons at 0.05 oz gold per ton. An additional 0.7 million tons of similar ore about 1000 meters southeast of the Mother Lode deposit were recently announced by GEXA. The deposit does not crop out, but mineralized rock occurs within 1 m of the present surface in a large cross-shaped trench excavated at the locus of the most near-surface part of the deposit determined by drilling.

Two types of mineralized rock, separated by a near vertical northeasterly fault, are exposed in the trench. Altered pumiceous rhyolitic lapilli air-fall tuff occurs west of the fault, and more-or-less altered fine-grained volcanic sandstone with siltstone and limy siltstone interbeds are found east of the fault. The tuff, which is correlative with less altered rock on a hill just west of the deposit, is probably part of a bedded tuff sequence that overlies the Paintbrush Tuff. Examination of the trench walls showed that mineralized rock was originally overlain by 25 cm to 2 m of gravel and(or) caliche.

Alteration mineralogy in both rock types exposed in the trench is dominated by quartz and illite. Jarosite is locally abundant, particularly in the tuff. Sparse, coarsely crystalline, drusy irregular quartz and manganese oxide veins are present, particularly in the siltstone. Manganese oxide and quartz are also present along some faults in the trench.

The trench at the Mother Lode deposit is in the hanging wall of the north-dipping Fluorspar Canyon fault. Samples of limonitized Paleozoic rock and Tertiary dike rock were collected from dumps at old workings south of the fault in the Telluride mining district. The fault is the locus of chalcedonic silica deposition in the Mother Lode area, and is also marked by silicification 3 km to the southwest in Fluorite Canyon. Silicified and alunitized samples from the fault and the Paleozoic rocks south of the fault were dated at 12.2 Ma and 11.2 Ma, respectively (Jackson, 1988).

Thirty-five samples of mineralized and unmineralized rock were collected in the vicinity of the Mother Lode deposit (GEXA 1 through 35), and one sample of silicified breccia (FC-1) was taken from Fluorite Canyon. Gold content of these samples ranges from 0.001 ppm to more than 7 ppm; and elevated silver, arsenic, mercury, antimony, and tellurium contents are present in samples with high gold. The average silver to gold ratio is 0.8.

Rhyolite Area

The Rhyolite area, which lies east of Beatty in the Bullfrog district about 30 km northwest of the Yucca Mountain Addition (Figure 1), contains the largest and highest grade known gold reserves of any area in the southwestern Nevada volcanic field. The bulk of the reserves are in Bond Gold Inc.'s Bond-Bullfrog mine, where a moderately westward-dipping orebody has an overall grade of 0.11 oz gold and 0.24 oz silver per ton. The orebody consists of a central core of silica-flooded ore overlain and underlain by quartz vein stockwork ore (Jorgensen et al., 1989). The ore occurs in rhyolitic tuffs probably equivalent to the Timber Mountain Tuff (Cornwall and Kleinhampl, 1964; and Byers et al., 1976). Vein gangue minerals are cryptocrystalline to coarsely crystalline quartz, calcite, and adularia. Limonite, fluorite, barite, pyrite, argentite, and base-metal sulfides are also present (Jorgensen et al., 1989). Production from the Bond-Bullfrog pit is slated to begin in September 1989 at a planned rate of 200,000 oz gold per year.

Bond Gold Inc. also holds reserves of 3.1 million tons of ore at the Montgomery-Shoshone mine, which produced most of the gold in the Bullfrog district in the past, The Montgomery-Shoshone ore is similar to that at Bond-Bullfrog, which lies about 1.5 km to the southwest, and occurs in the same lithologic units (Jorgensen et al., 1989). Adularia from the Montgomery-Shoshone Mine was dated at 9.5 Ma (Morton et al., 1977).

Although we were unable to collect samples from the Bond-Bullfrog pit, samples were taken on Ladd Mountain west of the pit (BH 21 through BH 25, Appendix 1) and from a roadcut northeast of the pit (BH 13 through BH 14, Appendix 1). In addition, samples were collected from a glory hole at the Montgomery-Shoshone mine (MS-1 through MS-7, Appendix 1), from the National Bank mine area 1 km northwest of the Bond-Bullfrog pit (BH 2 through BH 8, Appendix 1); and from the Tramps mine area 2 km northwest of the Bond-Bullfrog pit (BH 9 through 12, and BH 26 through 29V, Appendix 1). All samples were collected from rocks considered correlative with the Paintbrush and Timber Mountain Tuffs (Cornwall and Kleinhampl, 1964; and Byers et al., 1976). The vein samples consist mostly of chalcedonic to coarsely crystalline drusy quartz with dark gray leached calcite and clear to white adularia. Iron and manganese oxides occur in many samples, and free gold was noted at the Tramps Mine. Several samples of silicified breccia were collected. Country rock adjacent to veins is generally silicified and bleached ash-flow tuff. Basalt dikes and(or) flows occur at the Bond-Bullfrog, National Bank, and Montgomery-Shoshone deposits, and are mineralized and altered locally. Montmorillonite-illite was identified in a mass of argillized rock in the Montgomery-Shoshone glory hole.

Analyses of 34 samples collected from the Rhyolite area yielded gold values of up to 13.9 ppm, along with high silver. Many samples are slightly anomalous in molybdenum, particularly those from the Montgomery-Shoshone Mine. A few samples have anomalous arsenic, mercury, and antimony, but Rhyolite area samples are relatively low in these elements compared with those from Wahmonie and the Mother Lode deposit. Only a single sample from the Rhyolite area contains high tellurium.

Original Bullfrog Mine

The Original Bullfrog mine is in the southwest corner of the Bullfrog district about 30 km west-northwest of the Yucca Mountain Addition (Figure 1). The ore consists mostly of a mass of nearly solid quartz some 20 m thick dipping about 20° north, overlain by rhyolite with abundant quartz stringers and underlain by sheared shaly Paleozoic rock (Ransome et al., 1910). Quartz veins do not extend into the underlying shale or associated limestone. A nearly horizontal zone of bleached and intensely sheared rock occurs along a roadcut below the main lode and appears to separate quartz-veined rhyolite in the hanging wall from dark-green shale in the footwall. The quartz vein material consists mostly of coarsely crystalline quartz, with some calcite, malachite, and chrysocolla. Native gold occurs as visible particles with limonite associated with chrysocolla.

Adularia from ash-flow tuff altered to alkali feldspar and montmorillonite and cut by quartz-adularia veinlets was dated at 8.7 Ma (Jackson, 1988). The age of the ash-flow tuff that hosts the Original Bullfrog lode is not known, but it underlies the Bullfrog Member of the Crater Flat Tuff which is considered to be 14.0 Ma (Byers et al.,1976).

Although only five samples were collected from the Original Bullfrog mine (BH 15 through BH 20), results of chemical analyses are sufficiently different from the rest of the Bullfrog district to show that this deposit merits separate discussion. Gold values in Original Bullfrog samples range between 0.02 and 117 ppm, and the silver to gold ratio averages about 12. Other anomalous trace elements are bismuth, copper, and antimony. Molybdenum is anomalous, although at low levels, and single samples were anomalous in cadmium, lead, tellurium, or thallium.

Gold Bar Mine

The Gold Bar mine is a producing silver-gold deposit located about 30 km northwest of the Yucca Mountain Addition in the northwest corner of the Bullfrog district (Figure 1). The orebody consists of a northeasterly zone of brecciated rhyolite and basalt about 300 m by 30 m in plan which dips 65°NW (Ransome et al., 1910). The age of the mineralization and host rock is not known.

Five samples were collected from a muck pile in the Gold Bar pit (GB 1 through GB 5, Appendix 1), but none were found to be of ore-grade material. Gold contents range between 0.006 ppm in unmineralized ash-flow tuff and 0.08 ppm in basalt cut by calcite-quartz veins. The average silver to gold ratio is 11, and other trace element contents are low, with the exception of slightly anomalous antimony. Veins consist of macrocrystalline calcite and drusy quartz. Electrum and gold-bearing pyrite are present (Ransome et al., 1910).

Comparison of the Yucca Mountain Addition with Precious-Metal Districts

Based on ages and correlations discussed above, lithologic units exposed in the Yucca Mountain Addition are older than mineralization in all of the surrounding precious-metal districts, and rocks correlative with Yucca Mountain Addition units contain silver-gold deposits in the Rhyolite area. Precious-metal mineralization in the Yucca Mountain Addition is, therefore, permissive within the constraints of timing and host-rock lithology.

Jackson (1988) suggested that silver-gold mineralization in the southwestern Nevada volcanic field is related to a single episode of widespread hydrothermal activity associated with post-collapse volcanic activity following eruptions from the Timber Mountain caldera. The Yucca Mountain Addition falls within this area of hydrothermal activity. However, based on geochemistry and fluid inclusion data, the Bare Mountain district deposits, including the Mother Lode deposit, are thought to be a near surface expression of a porphyry molybdenum system not clearly related to caldera activity (Noble and Weiss, 1989).

According to Jorgensen et al. (1989), geologic data suggest that silver-gold mineralization in the Bullfrog district formed from hydrothermal solutions migrating along the Bullfrog detachment fault. Several writers (including Hamilton, 1988) have suggested that faults bounding Bare Mountain, including the Fluorite Canyon fault, are the eastward extension of the Bullfrog detachment. The Mother Lode deposit and other gold-silver mineralization in the Bare Mountain area could also be considered to be related to fluid migration along a detachment fault. If, as some believe (e.g., Hamilton,1988), the Bullfrog-Bare Mountain detachment surface extends eastward under Yucca Mountain, precious-metal mineralization could also occur there at depth.

The eastern caldera wall fractures of the proposed Crater Flat-Prospector Pass caldera system may lie beneath Yucca Mountain (Carr, 1984). If this is so, precious-metal mineralization related to post-collapse hydrothermal activity may occur at depth in the Yucca Mountain Addition.

Results of surface examination and sampling in the Yucca Mountain Addition have delineated some important differences between it and the surrounding precious-metal districts. Based on the general absence of hydrothermal alteration, we believe that the data from drill holes G-3 and GU-3 indicate that geology similar to that exposed on the surface extends to a depth of at least 600 m beneath the crest of Yucca Mountain.

The Yucca Mountain Addition is underlain by rock types that are mineralized in the surrounding precious-metal districts. However, exposures 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 in the Yucca Mountain Addition.

Direct surface observations indicate that no areas of hydrothermal alteration similar to those in the Wahmonie and

Bullfrog districts, or at the Mother Lode deposit, occur within the Yucca Mountain Addition. No significant areas of strongly bleached, limonitized, argillized, or silicified rock are present in the Yucca Mountain Addition.

The silicified and(or) calcrete fault breccias, silica and(or) carbonate veins, and small amounts of altered tuff encountered in the Yucca Mountain Addition do not carry anomalous gold, and only a few samples contain slightly anomalous silver, lead, and bismuth. In comparison, veins, breccias, and altered rock from areas with known precious-metal mineralization have moderately to highly anomalous gold and silver, and generally contain anomalous amounts of associated trace metals such as arsenic, mercury, and antimony. In addition, correlations among elements in samples from the Yucca Mountain Addition show little resemblance to elemental correlations from precious-metal districts.

The silica and(or) carbonate veins and breccias which commonly occur along faults in the Yucca Mountain Addition are mineralogically distinct from veins and breccias in the precious-metal districts examined. The siliceous component in these rocks in the Yucca Mountain Addition is mainly opal-CT, tridymite and(or) cristobalite with only minor chalcedonic quartz. Vein and breccia silica in the precious-metal districts is chalcedonic to coarsely crystalline quartz with little or no opal. Carbonate in Yucca Mountain Addition veins and breccias is very fine-grained calcrete, whereas that in the precious-metal districts is coarsely crystalline. Silica veins and breccias in the Yucca Mountain Addition do not contain abundant manganese oxide or limonite, but some contain abundant hematite. By contrast, limonite and manganese oxide are abundant in veins in the precious-metal districts.

REMOTE SENSING ANALYSIS

Remote sensing methods were used to compare fault patterns, lineament patterns, and alteration in the Yucca Mountain Addition to those in the Wahmonie mining district, the Calico Hills area, the Mother Lode deposit area, and the Rhyolite area.

REMOTE SENSING METHODOLOGY

Geologic Structure and Lineaments

Six visible and near infrared bands of Landsat Thematic Mapper (TM) digital imagery and one band of SPOT panchromatic satellite imagery, with resolutions of 30 m and 10 m, respectively, were analyzed on a Terramar MicroImage computer image processing system. Structural features and lineaments were enhanced on a single band of TM imagery and on the SPOT imagery by applying a high-pass filter. The high pass filter performs an edge enhancement and emphasizes linear features by exaggerating differences in brightness values between adjacent picture elements. Directional filters were also applied to both TM and SPOT imagery to emphasize lineaments with north-south, east-west, northeast-southwest, and northwest-southeast orientations. Lineaments were drawn manually on the edge-enhanced images. Because the number of lineaments drawn in each area was too small to show a statistically significant pattern, rose diagrams were not constructed.

The lineaments enhanced and recognized on SPOT and Landsat TM imagery are linear topographic and tonal features and are not unequivocally related to geologic structure. Linear cultural features such as roads and vegetation boundaries are also enhanced by applying filters to satellite imagery. Linear features should be interpreted with care since linear artifacts parallel to the sensor scan line direction may be emphasized, directional exaggerations may be introduced, and spurious linears generated from electronic "ringing" (a shadow or halo around sharp edges) may be produced. None of the linear features recognized on the satellite imagery during this investigation have been checked in the field. Until field checking or drilling data confirm the presence of faults, these lineaments cannot be assumed to be geologic structures.

The direction and length of faults of more than 0.3 km in length were measured on geologic maps of the Yucca Mountain Addition and in surrounding precious-metal mining districts and mineralized areas. For each area, the results were tabulated and plotted on rose diagrams to determine the most prominent fault orientations, and the circular variance was calculated. Lineaments detected on the TM and SPOT imagery were then compared with measured fault orientations in the Yucca Mountain Addition and the surrounding mining districts.

<u>Rock Alteration</u>

Landsat Thematic Mapper imagery of the Yucca Mountain Addition and surrounding mineralized areas was processed to locate and enhance rock alteration which may be associated with mineralization. Distinctive spectral features which have been observed in the visible and near-infrared part of the spectrum on laboratory reflectance curves of pure minerals and which can be identified using Landsat TM bandpasses consist of ferrous and ferric iron, the hydroxyl ion, bound water, and the carbonate and sulfate ions. Even in low concentrations, iron and hydroxyl or water absorption features often dominate rock spectra, since many rock-forming minerals (e.g., quartz and feldspar) do not have distinctive spectra in the visible and near infrared part of the spectrum.

Three-band color ratio composite images of the Yucca Mountain Addition and surrounding mining districts were produced to show areas of argillic and iron oxide alteration. The ratios make use of spectral absorption features characteristic of iron minerals near 450 nm and between 750 and 900 nm and absorption features near 2200 nm which are characteristic of clay minerals. The distinctive spectral characteristics of clay minerals causes areas with clay to appear bright in a TM band 5/TM band 7 ratio image while iron oxide minerals appear bright in a TM band 3/TM band 1 ratio image. Because of spectral features associated with vegetation, vegetation appears bright on a TM band 4/TM band 3 image.

The vegetation, iron oxide, and clay ratio images were combined to form a color composite image where TM4/TM3 was encoded blue, TM3/TM1 was encoded green, and TM5/TM7 was encoded red. Areas with iron oxide alteration appear green; areas with argillic alteration appear red; and areas containing both argillic and iron oxide alteration appear yellow on the imagery.

After the Landsat TM imagery was processed, selected areas that showed evidence of argillic and iron oxide alteration were checked in the field and samples were collected for X-ray diffraction analysis. Reflectance spectra in the visible and near infrared were also recorded in the field and in the laboratory with a Geophysical Environmental Research, Inc. field spectroradiometer.

RESULTS FOR YUCCA MOUNTAIN ADDITION

Faults and Lineaments

The lengths and orientations of faults longer than 0.3 km mapped by Lipman and McKay (1965) in the Yucca Mountain Addition were measured on the 1:24,000-scale map, tabulated, and plotted in 10° increments on rose diagrams as a function of fault frequency (Figure 14) and cumulative length of faults (Figure 15). Similar plots (Figures 16 and 17) were constructed for faults mapped by Scott and Bonk (1984) in the Yucca Mountain Addition (1:12,000-scale map). The orientations of mineralized veins or fractures from which samples were collected and analyzed as part of this investigation, where recorded, were also plotted (Figure 18). For each of the rose diagrams, the total number (n) or cumulative length in kilometers (l) of faults, veins, and fractures is given as well as the circular variance (cv). The circular variance is a measure of the dispersion of the data and varies between 0 and 1. Small values indicate that fault orientations are tightly grouped, and large values indicate a dispersed group of orientations.

In the Yucca Mountain Addition, the maximum number of faults or cumulative fault length, in all five cases, was between north-south and N10°E or north-south and N10°W on the rose diagrams. The orientations with the greatest number of faults also approximately coincide with the orientations of the greatest cumulative length. Mean directions were between N5°W and N1°W, or at N3°E. Circular variance ranged from 0.18 to 0.34. This indicates that many of the faults at the surface in the Yucca Mountain Addition are subparallel and fault intersections would be

Figure 14. Yucca Mountain Addition normalized fault orientation frequency, as measured on the geologic map by Lipman and McKay (1965). The total number of faults measured (0.3 km or longer) is indicated by "n"; "cv" is the circular variance which can vary between 0 and 1.

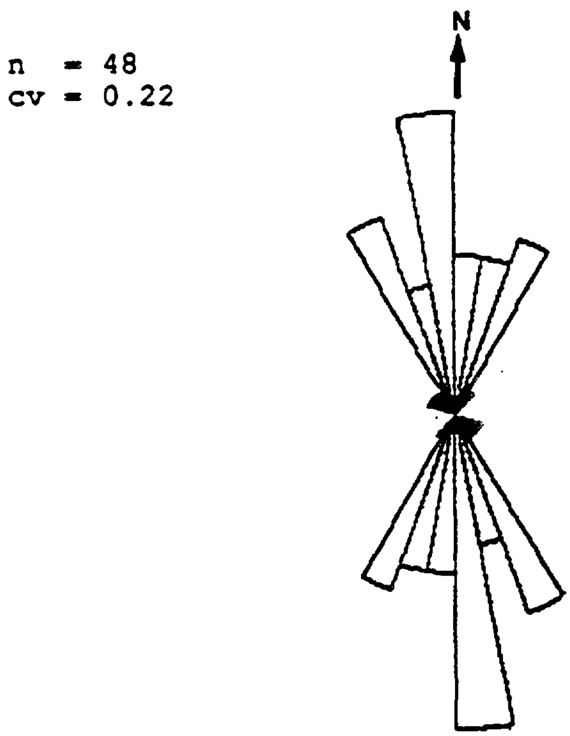


Figure 15. Yucca Mountain Addition orientation of normalized cumulative fault length frequency for faults longer than 0.3 km, as measured on the geologic map by Lipman and McKay (1965). Total fault length measured in kilometers is indicated by "l"; "cv" is the circular variance which can vary between 0 and 1.

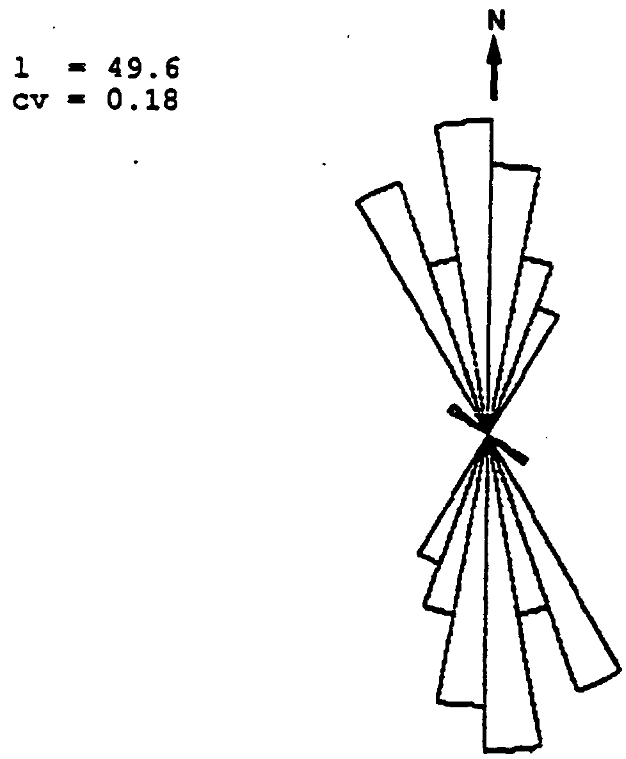


Figure 16. Yucca Mountain Addition normalized fault orientation frequency for faults longer than 0.3 km, as measured on the geologic map by Scott and Bonk (1984). The total number of faults measured is indicated by "n"; "cv" is the circular variance which can vary between 0 and 1.

n = 69
cv = 0.19

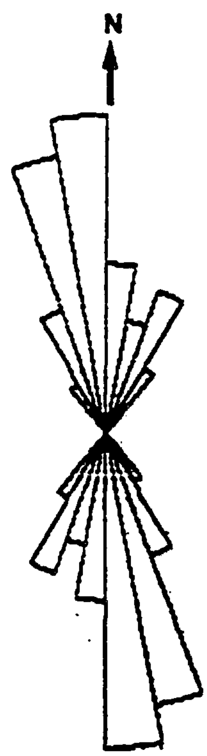


Figure 17. Yucca Mountain Addition orientation of normalized cumulative fault length frequency for faults longer than 0.3 km, as measured on the geologic map by Scott and Bonk (1984). The total fault length measured in kilometers is indicated by "l"; "cv" is the circular variance which can vary between 0 and 1.

l = 43.2
cv = 0.19

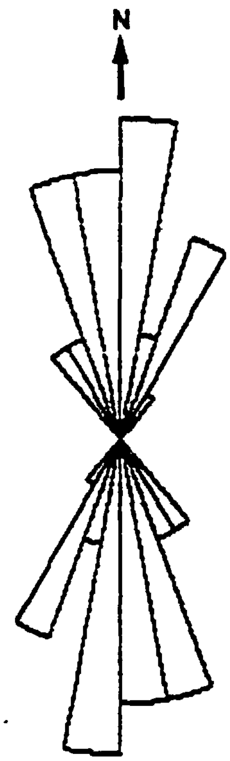
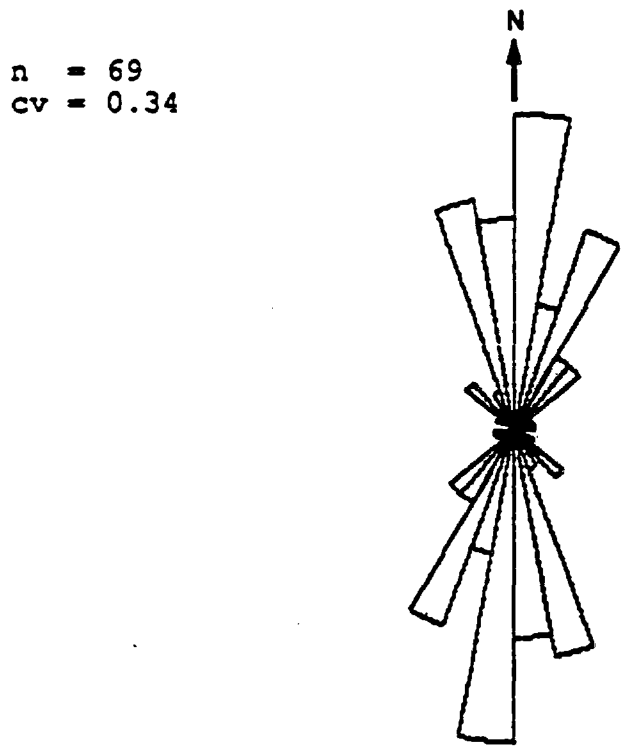


Figure 18. Orientation of normalized frequency of mineralized veins and faults sampled in this investigation in the Yucca Mountain Addition. The total number of veins and faults of known orientation is indicated by "n"; "cv" is the circular variance which can vary between 0 and 1.



less likely to occur than in areas with a greater range of fault orientations.

SPOT digital data of the Yucca Mountain Addition were processed with a high-pass filter (Figure 19) and lineaments were drawn on the resulting image. Directionally filtered images were also produced and lineaments recognized on these (i.e., Figure 20) were transferred to a non-directional biased filtered image with a percentage of the original image added back to the filtered image. Figure 20 was enhanced for northwest-southeast lineaments, but shows lineaments in many other orientations as well. Lineaments drawn on Figure 19 are indicated on Figure 20 with arrows.

Many of the lineaments coincide with mapped faults, and some extend the faults into the alluvium. The northern part of the Solitario Canyon fault does not show up well, but a significant lineament follows the wash in Solitario Canyon. Three east-west lineaments that do not coincide with mapped faults have been recognized, the southernmost one being the most prominent (Figures 19 and 20). If these relatively long lineaments are faults, the number of fault intersections would be higher in the Yucca Mountain Addition than is indicated by geologic mapping. However, none of the lineaments drawn on the images were checked in the field to establish the presence or absence of faults.

Alteration

A Landsat TM color ratio composite was produced from TM4/TM3, TM3/TM1, and TM5/TM7 as blue, green, and red, respectively (Figure 21). The ratio image produced from the Landsat TM imagery is at a smaller scale and lower resolution than the SPOT lineament images. Areas in the Yucca Mountain Addition that are altered show up as yellow, indicating high clay and iron oxide content, and consist primarily of bedded tuffs in or stratigraphically above the Paintbrush Tuff (bt and pbt on Plate 1).

These bedded tuffs were sampled in the field and reflectance spectra were recorded with a field spectroradiometer. The bedded tuffs are iron stained and silicified in places and, based on X-ray diffraction analysis (Appendix C), contain primarily volcanic glass, with some calcite, opal, cristobalite, and montmorillonite. Spectral curves recorded with the spectroradiometer indicated clay absorption features in the bedded tuffs which were absent in the underlying upper unit of the Topopah Spring Member (Figures 22 and 23).

RESULTS FOR PRECIOUS-METAL DISTRICTS AND MINERALIZED AREAS

Wahmonie District

Faults and Lineaments

Mapped fault frequency, length, and orientation were measured on the 1:24,000 geologic map of the Skull Mountain quadrangle (Ekren and Sargent, 1965). The rose diagram of fault frequency (Figure 24) shows that the greatest number of faults are oriented

Figure 19. Lineaments drawn on an enhanced SPOT panchromatic image of the Yucca Mountain Addition. The Yucca Mountain Addition is outlined in red. Lineaments have not been checked in the field to establish the presence or absence of faulting.

Figure 20. Lineaments shown in Figure 19 are indicated with arrows on this SPOT panchromatic image enhanced for northwest lineaments. The Yucca Mountain Addition is outlined in red. This image covers the same area as Figure 19. Lineaments have not been checked in the field to establish the presence or absence of faulting.

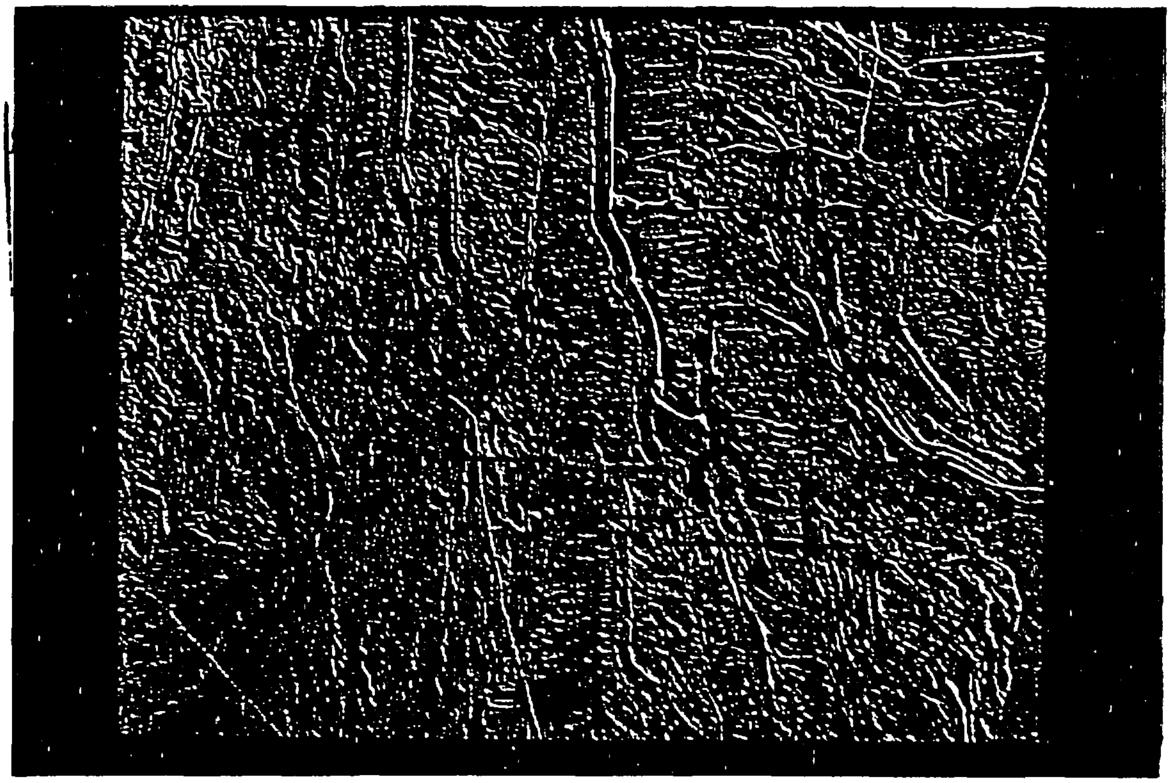


Figure 21. Landsat TM color ratio composite of the Yucca Mountain Addition. The Yucca Mountain Addition is outlined in red. Red on the image indicates areas with argillic alteration, green indicates areas with iron oxide alteration, and yellow areas on the image have been affected by both clay and iron oxide alteration. Yellow areas with altered bedded tuff are outlined in black.

Figure 22. Spectral curve of altered bedded tuff, sample YMSF3 in the Paintbrush Tuff, showing a clay absorption feature near 2200 nm.

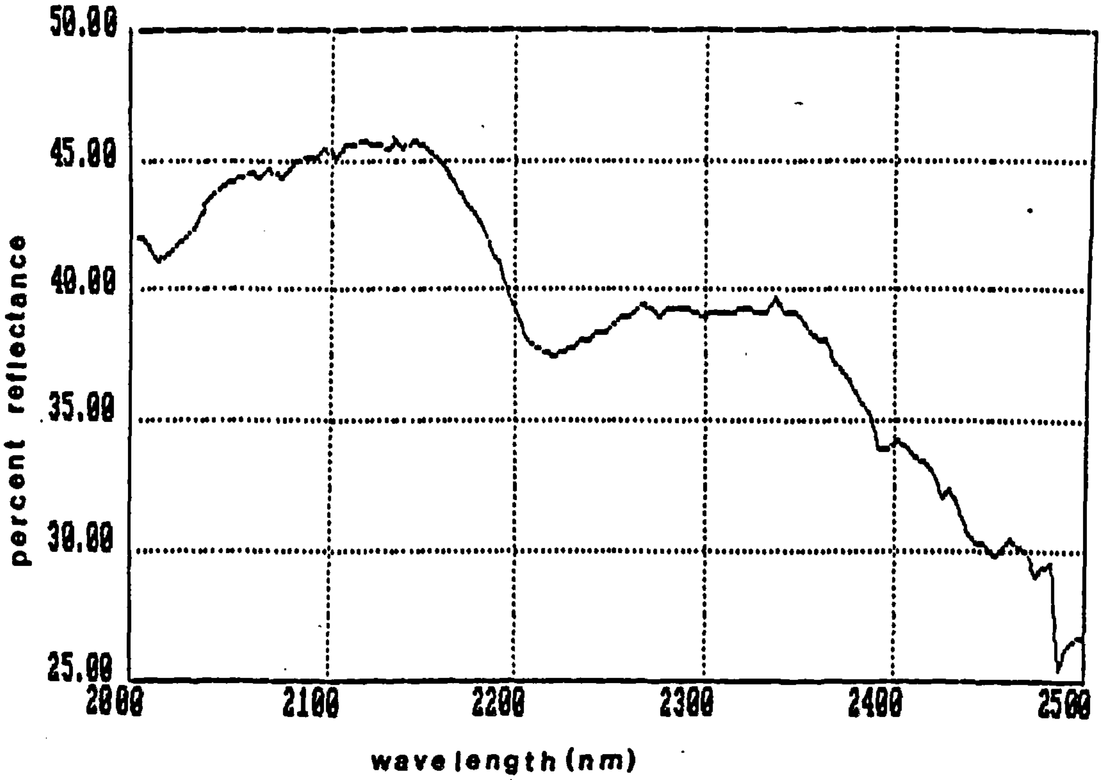


Figure 23. Relatively featureless spectral curve of the unaltered top of the Topopah Spring Member of the Paintbrush Tuff, sample YMSF11.

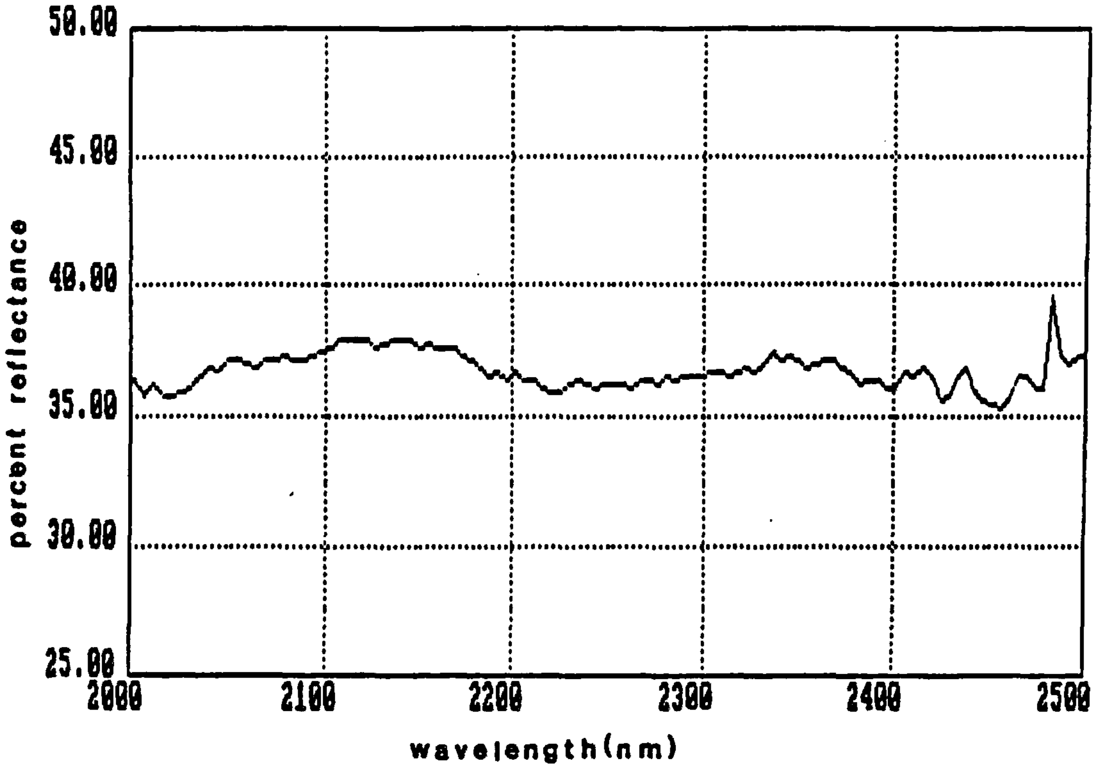
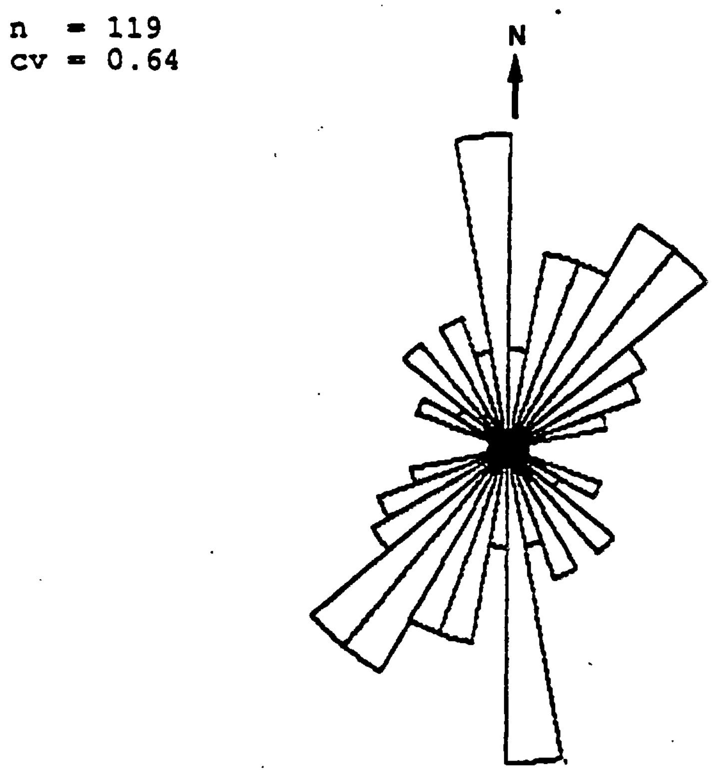


Figure 24. Normalized fault orientation frequency for faults longer than 0.3 km, as measured on the geologic map by Ekren and Sargent (1965) in the Wahmonie mining district. The total number of faults measured is indicated by "n"; "cv" is the circular variance which can vary between 0 and 1.



between north-south and N10°W. A secondary frequency maximum is located between N30°E and N50°E. The Wahmonie district contains a large range of fault orientations in comparison to the Yucca Mountain Addition.

A rose diagram of orientations of cumulative mapped fault length for the Wahmonie district shows that the orientation having the greatest cumulative fault length is between N30°E and N40°E and the circular variance is 0.64 (Figure 25). This coincides with the secondary maximum for fault frequency on Figure 24. Quade and Tingley (1984) noted that the mineralized vein system in the Wahmonie mining district follows a structure that is oriented N30°E.

Since the eastern border of the SPOT satellite image is slightly west of Wahmonie, Landsat TM imagery of the Wahmonie district was processed to enhance lineaments (Figures 26 and 27). The Landsat TM image of the Wahmonie area is at a smaller scale than lineament images of the other mineralized areas and the Yucca Mountain Addition. Within the area of alteration mapped by Ekren and Sargent, which has been outlined on Figure 26, lineaments of diverse orientations were noted. Three long lineaments are the most prominent. The first lineament is oriented north-northeast and curves northwest at its north extent; it coincides with the eastern limit of Tertiary intrusive rocks in the Wahmonie area. Most of the shafts, adits, and prospect pits in the district are located near the southern extent of this lineament. The second lineament is oriented north-south, extends across most of the Landsat TM image, and intersects the first lineament in the area of abundant mine workings. The third lineament extends northwest across the area of alteration and intersect the other two. It coincides with mapped faults which have not been joined together. Other near east-west lineaments have also been noted (Figures 26 and 27). The Wahmonie lineaments have not been checked in the field for correlation with geologic structure.

Alteration

The Landsat TM color ratio composite of the Wahmonie mining district shows an east-northeast-trending zone of argillic and iron oxide alteration (Figure 28). Locations with high concentrations of iron oxide are displayed in green; areas with argillic alteration are shown in red; and areas with both iron oxide and argillic alteration are colored yellow. The alteration shown in Figure 28 includes the alteration mapped by Ekren and Sargent (1965), but provides more information on the specific alteration types.

Illite and montmorillonite were found during this investigation in altered volcanic rocks near the Wingfield shaft by X-ray diffraction analysis (Appendix C). Surface alteration at Wahmonie is not confined to one stratigraphic unit as it is in the Yucca Mountain Addition.

Hydrothermally altered rock units include andesites, dacites, latites, and tuffs of Wahmonie Flats. Granodiorite, andesite, and rhyolite intrude the tuffs and flow rocks.

Figure 25. Orientation of normalized cumulative fault length frequency for faults longer than 0.3 km, as measured on the geologic map by Ekren and Sargent (1965) in the Wahmonie mining district. The total fault length measured in kilometers is indicated by "l"; "cv" is the circular variance which can vary between 0 and 1.

l = 108.8
cv = 0.61

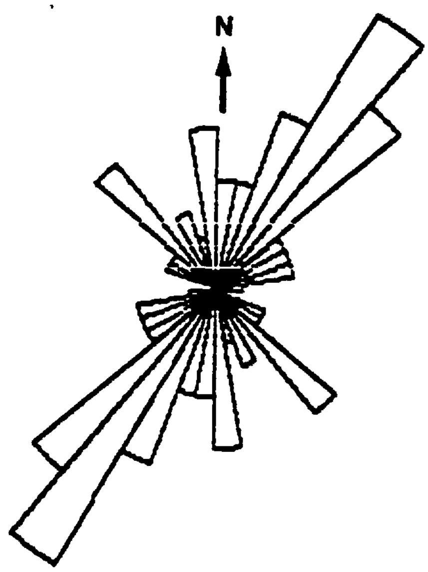
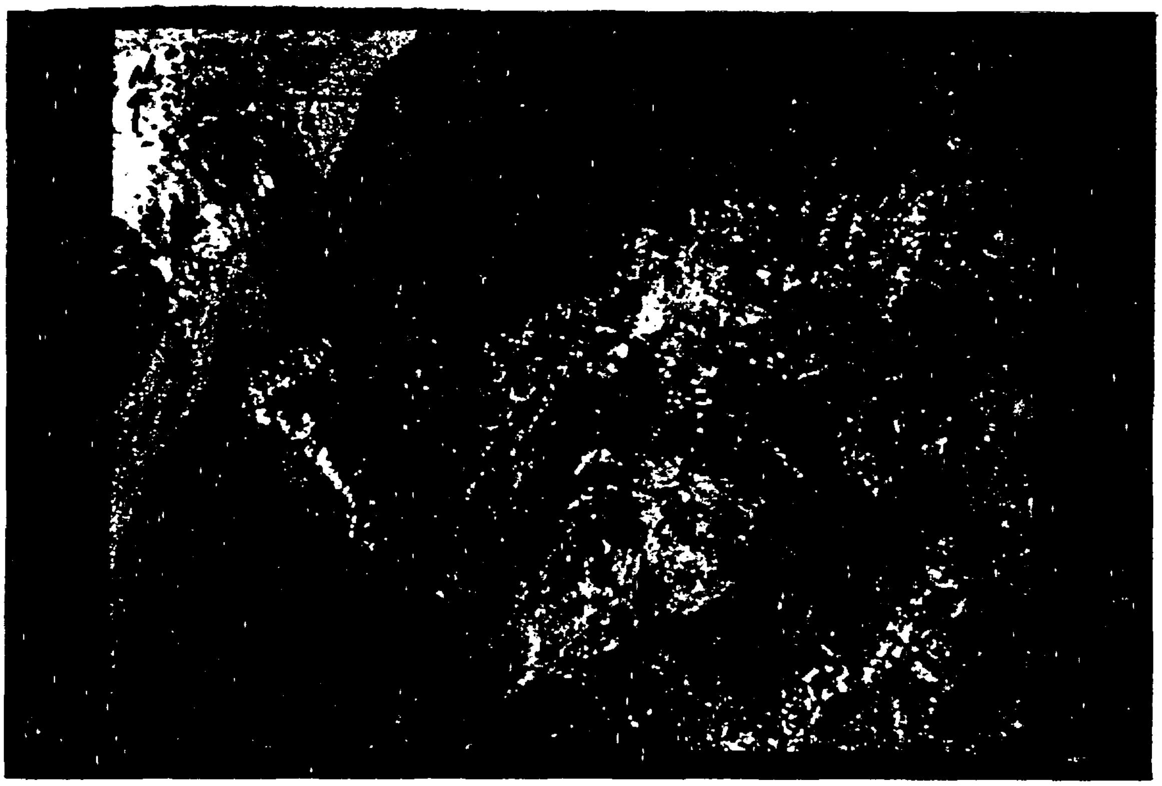


Figure 26. Lineaments drawn on the enhanced Landsat TM filtered image of the Wahmonie mining district. The altered area has been outlined in red. This lineament image is at a smaller scale and lower resolution than those for other areas. Lineaments have not been checked in the field to establish the presence or absence of faulting.

Figure 27. Lineaments shown in Figure 26 are indicated with arrows on this Landsat TM image of the Wahmonie mining district which has been enhanced for northwest lineaments. The altered area has been outlined in red. This lineament image is at a smaller scale and lower resolution than those for other areas. Lineaments have not been checked in the field to establish the presence or absence of faulting.

Figure 28. Landsat TM color ratio composite of the Wahmonie mining district. Red on the image indicates areas with argillic alteration, green indicates areas with iron oxide alteration, and yellow areas on the image have been affected by both clay and iron oxide alteration.



Calico Hills

Faults and Lineaments

Fault orientation and length in the altered rocks of the Calico Hills were measured on the 1:24,000 geologic maps of the Topopah Spring and Jackass Flats quadrangles (Orkild and O'Connor, 1970; McKay and Williams, 1964). The fault-frequency maximum on the rose diagram occurs between N20°W and N30°W. Large numbers of faults occurs within 20° on both sides of this maximum and a secondary maximum is located at between N30°E and N40°W. The circular variance is 0.77. The wide distribution of faults of all orientations is apparent on Figure 29.

The greatest cumulative fault length is oriented between north-south and N10°W (Figure 30). This is 20° east of the fault frequency maximum. A secondary maximum is located between N40°E and N50°E. The circular variance is 0.80 and there is a wide range of fault directions as there was in Figure 29.

SPOT imagery was used to enhance lineament patterns in the Calico Hills area. The lineaments drawn on the filtered SPOT images were primarily northeast lineaments, which coincided with mapped faults along part of their length (Figures 31 and 32). The lineaments in the Calico Hills area have not been field checked to confirm the presence or absence of faults.

Alteration

The Calico Hills, which lie east of Yucca Mountain, are the closest exposed area of widespread hydrothermal alteration to the Yucca Mountain Addition. Altered rocks include the Topopah Spring Member of what McKay and Williams (1964) mapped as the Piapi Canyon Formation and of what Orkild and O'Connor (1970) mapped as the Paintbrush Tuff, as well as older rhyolite flows, tuffaceous beds, and intrusions of the Calico Hills. The area of altered tuffs partially surrounds Carboniferous Eleana Formation and Devonian limestone and dolomite intruded by rhyolite.

The Landsat TM color ratio composite of the Calico Hills area (Figure 33) shows a semicircle of alteration around the east, west, and south margins of the Paleozoic exposures. Argillic alteration (red), is interspersed with argillic and iron oxide alteration (yellow); some patchy iron oxide alteration (green) is located primarily east and west of the Paleozoic rocks. As in the Wahmonie mining district, and in contrast to the Yucca Mountain Addition, the alteration is not confined to bedded tuff or to a single geologic unit.

Mother Lode Deposit Area

Faults and Lineaments

GEXA's Mother Lode gold deposit is located beneath less than 1 m of alluvium at the north end of Bare Mountain. The host rocks are an unnamed Tertiary tuff and a sedimentary unit of questionable age.

Figure 29. Normalized fault orientation frequency for faults longer than 0.3 km, as measured on the geologic map by Orkild and O'Connor (1970) and McKay and Williams (1964) in the Calico Hills. The total number of faults measured is indicated by "n"; "cv" is the circular variance which can vary between 0 and 1.

n = 191
cv = 0.77

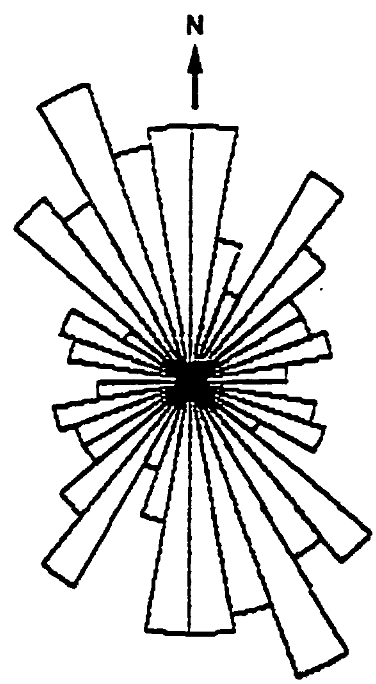


Figure 30. Orientation of normalized cumulative fault length frequency for faults longer than 0.3 km, as measured on geologic map by Orkild and O'Connor (1970) and McKay and Williams (1964) in the Calico Hills. The total fault length measured in kilometers is indicated by "l"; "cv" is the circular variance which can vary between 0 and 1.

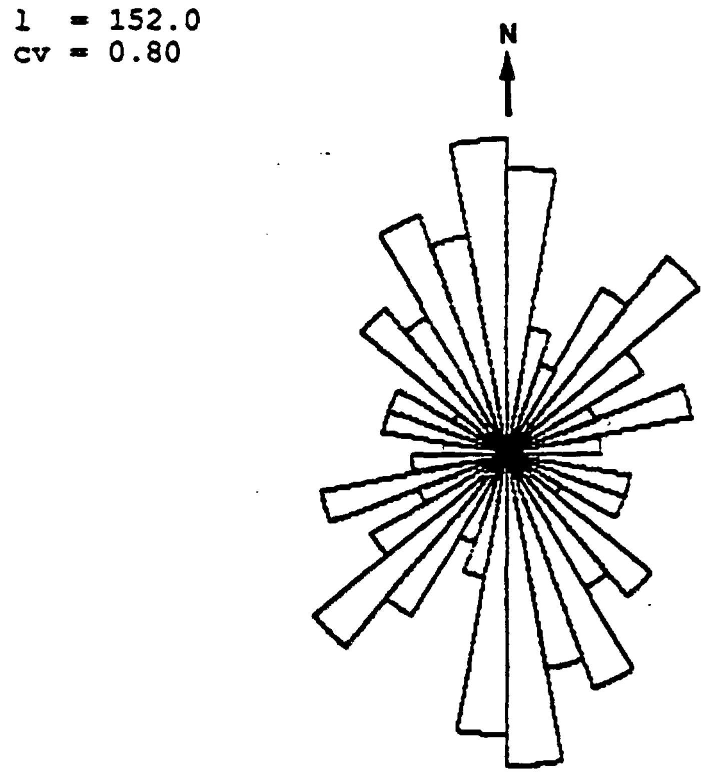
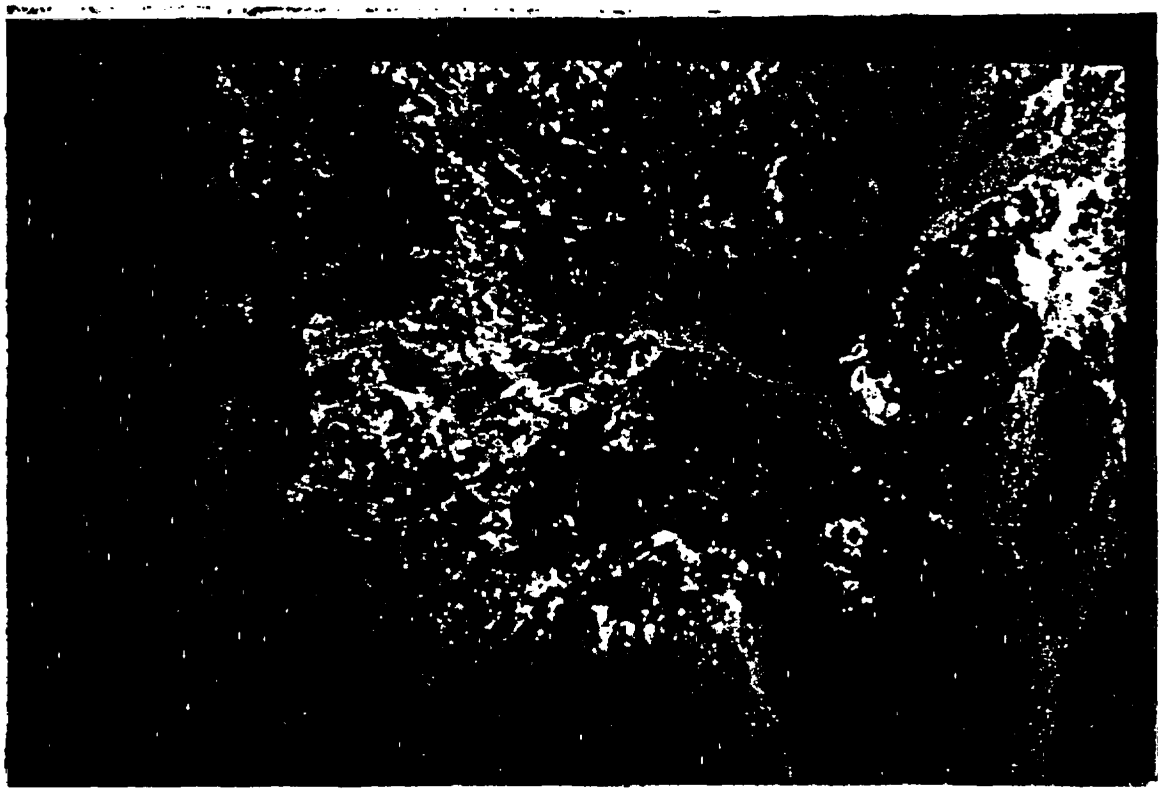


Figure 31. Lineaments drawn on an enhanced SPOT panchromatic image of the Calico Hills. Lineaments have not been checked in the field to establish the presence or absence of faulting.

Figure 32. Lineaments shown in Figure 31 are indicated with arrows on this SPOT panchromatic image of the Calico Hills which has been enhanced for northeast lineaments. This image covers the same area as Figure 31. Lineaments have not been checked in the field to establish the presence or absence of faulting.

Figure 33. Landsat TM color ratio composite of the Calico Hills. Red on the image indicates areas with argillic alteration, green indicates areas with iron oxide alteration, and yellow areas on the image have been affected by both clay and iron oxide alteration. The area covered by the SPOT lineament images is outlined in red.



The most detailed published map of the area is at a scale of 1:62,500 (Cornwall and Kleinhampl, 1961). Mapped faults in the vicinity of the deposit are either confined to Paleozoic rocks or are concentrated west and north of the deposit. Because few faults were mapped in the vicinity of the Mother Lode deposit, no analysis of fault orientations was performed.

On the SPOT image enhanced for lineaments, the most prominent lineament extends northeast across the image (Figures 34 and 35). This lineament coincides, in part, with a 4-km-long fault mapped by Cornwall and Kleinhampl (1961) in volcanic rocks northwest of the Mother Lode deposit. The Mother Lode deposit area has not been field checked to establish if there is a correlation between the lineaments shown on Figures 34 and 35 and geologic structure.

Alteration

Hydrothermal alteration is not evident on the Landsat TM color ratio composite in the vicinity of the Mother Lode deposit (Figure 36). This is expected since the deposit is covered by alluvium. However, a bright spot appears just west of the deposit, suggesting the presence of altered tuff. Cornwall and Kleinhampl (1961) have mapped a northeast-trending dike in the Paleozoic rocks, which if extended into the alluvium, would pass through or near the Mother Lode deposit.

Mineralized samples collected from a trench in the deposit contain quartz, opal, illite, and montmorillonite. Unmineralized altered tuff samples from a hill just west of the deposit contain alunite, kaolinite, and montmorillonite (Appendix 4).

Rhyolite Area, Bullfrog Mining District

Faults and Lineaments

Fault orientations and lengths were measured on the 1:48,000 map of the Bullfrog quadrangle produced by Cornwall and Kleinhampl (1964). Rose diagrams of both fault frequency and cumulative fault length showed a maxima at N10°E to N20°E and a large angular distribution with circular variances of 0.79 and 0.76, respectively (Figures 37 and 38).

Prominent lineaments on a filtered SPOT image of the Rhyolite area are oriented primarily northeast and northwest (Figures 39 and 40). The Bullfrog detachment fault, an east-west-trending feature cited by Jorgensen et al. (1989) and previous workers, extends across the bottom of the image beneath the alluvium. It does not appear as a lineament on the SPOT imagery. The lineaments in the Rhyolite area have not been checked in the field for correlation with geologic structure.

Alteration

According to Jorgensen et al. (1989), mineralization in the Bullfrog district is confined to a 3-km-wide zone along and north of the Bullfrog detachment fault. This mineralized zone is included in the lower half of the Landsat TM alteration image in Figure 41. Mineralization in the district occurs in fault-veins,

Figure 34. Lineaments drawn on the enhanced SPOT panchromatic image in the vicinity of the Mother Lode deposit. Lineaments have not been checked in the field to establish the presence or absence of faulting.

Figure 35. Lineaments shown in Figure 34 are indicated with arrows on this SPOT panchromatic image of the Mother Lode deposit enhanced for northwest lineaments. Lineaments have not been checked in the field to establish the presence or absence of faulting.

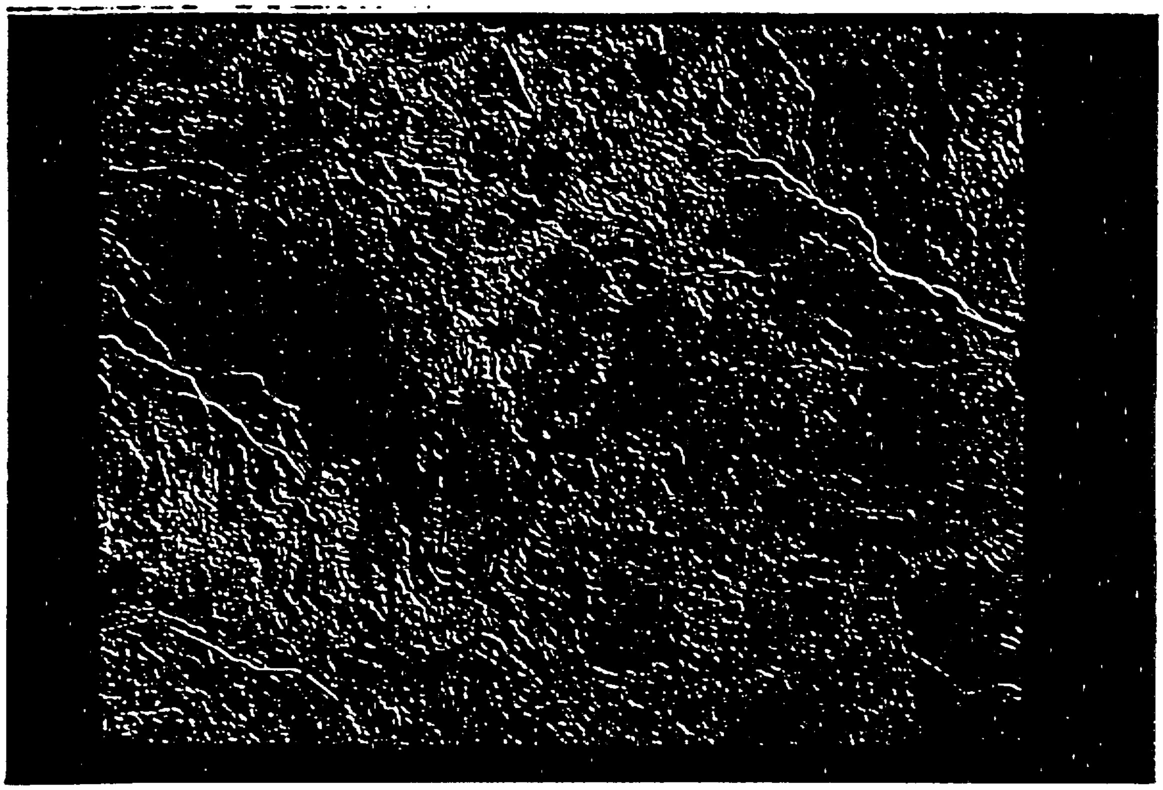


Figure 36. Landsat TM color ratio composite in the area of the Mother Lode deposit. Red on the image indicates areas with argillic alteration, green indicates areas with iron oxide alteration, and yellow areas on the image have been affected by both clay and iron oxide alteration. The area covered by the SPOT lineament images is outlined in red.

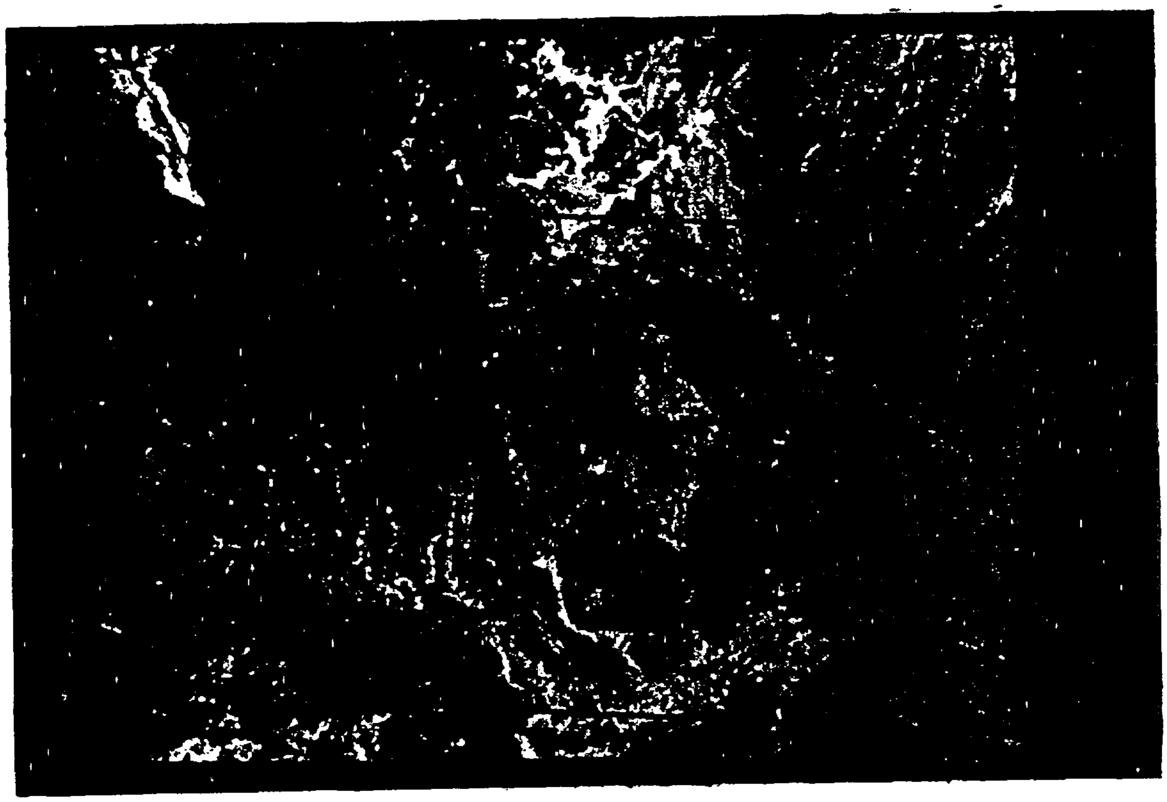


Figure 37. Normalized fault orientation frequency for faults longer than 0.3 km, as measured on the geologic map by Cornwall and Kleinhampl (1964) in the Bullfrog mining district. The total number of faults measured is indicated by "n"; "cv" is the circular variance which can vary between 0 and 1.

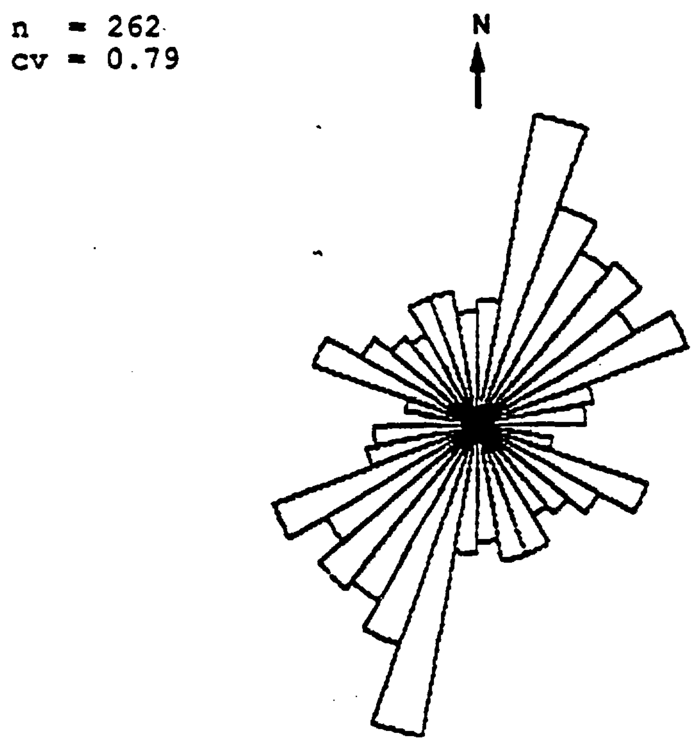


Figure 38. Orientation of normalized cumulative fault length frequency for faults longer than 0.3 km, as measured on the geologic map by Cornwall and Kleinhampl (1964) in the Bullfrog mining district. The total fault length measured in kilometers is indicated by "l"; "cv" is the circular variance which can vary between 0 and 1.

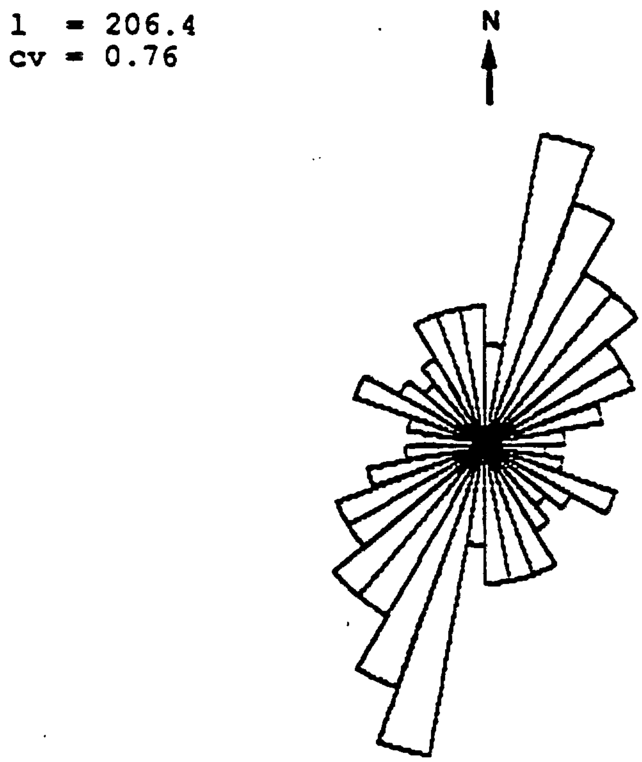
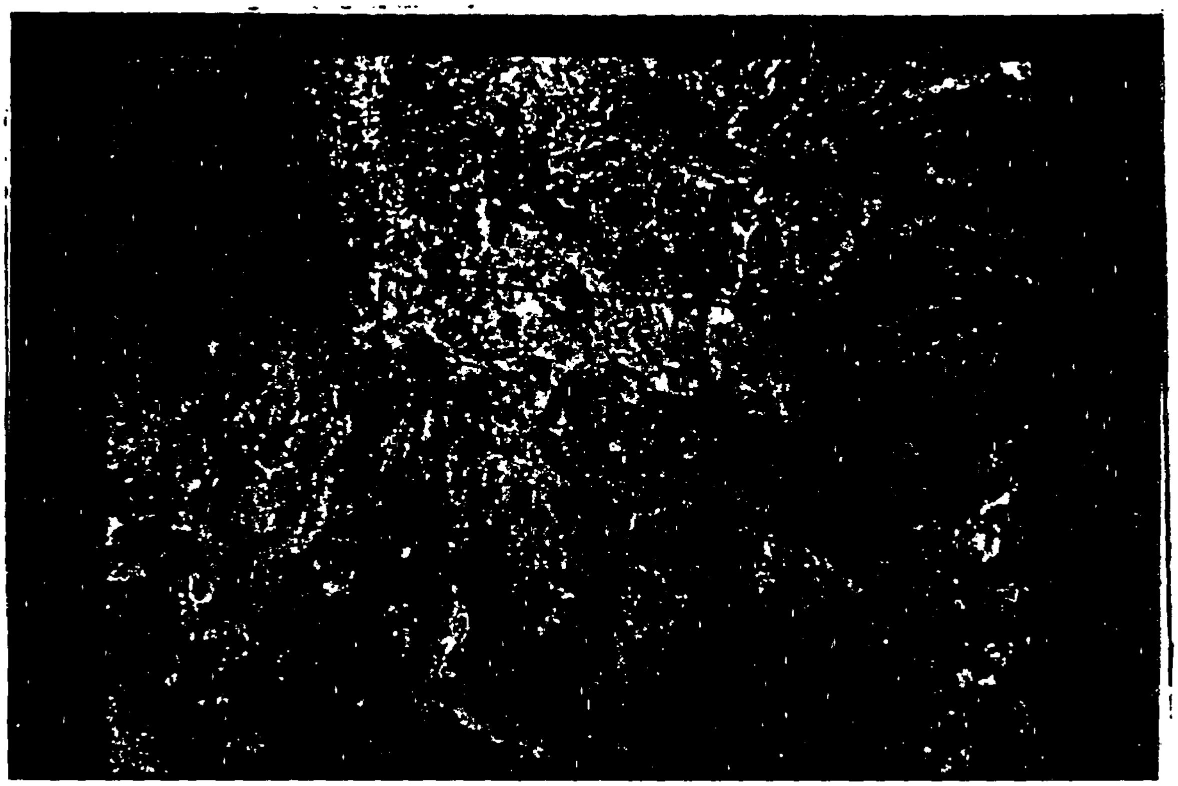


Figure 39. Lineaments drawn on the enhanced SPOT panchromatic image of the Bullfrog mining district. Lineaments have not been checked in the field to establish the presence or absence of faulting.

Figure 40. Lineaments shown in Figure 39 are indicated with arrows on this SPOT panchromatic image of the Bullfrog mining district enhanced for northeast lineaments. This image covers the same area as Figure 39. Lineaments have not been checked in the field to establish the presence or absence of faulting.

Figure 41. Landsat TM color ratio composite of the Bullfrog mining district. Red on the image indicates areas with argillic alteration, green indicates areas with iron oxide alteration, and yellow areas on the image have been affected by both clay and iron oxide alteration. The area covered by the SPOT lineament images is outlined in red.



veinlets, and stockworks (Jorgensen et al., 1989). Shallow intrusives have been mapped in the area by Ransome et al. (1910) and Cornwall and Kleinhampl (1961).

On the Landsat TM alteration image (Figure 41), argillic and iron oxide alteration do not appear widespread in the Rhyolite area, although the rocks are light-colored and bleached (Figure 39). The alteration zone and mineralization at Bond Gold Inc.'s Bullfrog mine was below the alluvium and did not crop out extensively at the surface. Although argillic alteration is associated with precious-metal mineralization in the Rhyolite district, silicification and potassic alteration, which are not detectable by the remote sensing techniques used during this investigation, are probably more important (Jorgensen et al.,1989; and Jackson, 1988).

SUMMARY OF REMOTE SENSING ANALYSIS

Rose diagrams and circular variance calculations for fault orientation and cumulative fault length in the Yucca Mountain Addition showed significant differences from those for surrounding precious-metal districts. Faults in the Yucca Mountain Addition are tightly grouped around a near north-south orientation and the circular variance is low (between 0.18 and 0.34). This indicates that many of the faults exposed at the surface in the Yucca Mountain Addition are subparallel and, therefore, fault intersections are less likely than in areas with greater circular variance. Fault intersections relate to structural preparation, or the lack or it, for mineralization.

In the surrounding precious-metal districts, circular variance of fault orientations ranged between 0.61 and 0.80. This is much greater variance that in the Yucca Mountain Addition, and suggests greater opportunity for the existence of fault intersections and structural preparation favorable for mineralization.

The lineament images, which were prepared from filtered digital SPOT and Landsat TM imagery, showed extensions of previously mapped faults and indicated additional lineament trends that may have structural significance. Structural significance of lineaments, however, needs to be established from surface field checking or drill hole data.

Alteration images prepared from Landsat TM satellite data showed rock alteration patterns in the Yucca Mountain Addition and in the nearby mining districts and mineralized areas. In the Yucca Mountain Addition, alteration is confined to two bedded tuff units. In the mining districts, alteration crosses many lithologic units.

APPRAISAL OF MINERAL RESOURCES

BASE-METALS RESOURCES

The volcanic rock section that underlies Yucca Mountain is unfavorable for the development of base-metals resources. Our surface geochemical sampling of faults and fracture zones does, however, show weak correlations between several base-metal elements and we could be sampling a very distal geochemical halo around a concentration of base metals in the deep subsurface. The closest deposits of base metals, at Bare Mountain about 15 km to the west, and at Mine Mountain about 40 km to the northeast, are found in Paleozoic carbonate rocks. If these rocks are present at depth beneath Tertiary volcanic rocks at Yucca Mountain, they are probably at depths in excess of 1,500 m. Base metal deposits of the types expected to be present in Paleozoic carbonate rocks include polymetallic replacement deposits or, if intrusive rocks are also present, tungsten, copper, and lead-zinc skarn deposits (Cox and others, 1989; Cox and Singer, 1986). Under present economic conditions, these types of deposits, if present at depths around the minimum estimate of 1,500 m, would not be mineable using standard, accepted mining technology. Base-metals potential within the Yucca Mountain Addition is rated very low.

The types of volcanic rocks underlying the Yucca Mountain Addition are favorable for mercury deposits. However, our sampling indicates that mercury is not present in the area at levels above the detection level of our analytical procedures.

PRECIOUS-METALS RESOURCES

The absence of subsurface trace element geochemical data applicable to precious-metals exploration renders unequivocal determinations of mineral potential within the Yucca Mountain Addition impossible. However, we believe that the geochemical, lithologic, and mineralogic data collected from the surface of the Yucca Mountain Addition, in conjunction with remote sensing data, preclude the presence of surface or shallow deposits of precious metals mineable under current economic conditions, and utilizing presently available technology.

The highest gold content of samples collected during this study is 0.023 ppm, or 0.0007 troy ounces per short ton ($0.28 per short ton at $400 per ounce). Silver contents are similarly low, with the highest value at about 0.5 ppm (about 0.015 troy ounces per short ton, or $0.15 per short ton at $10 per ounce).

Gold and silver deposits that are currently producing, have been exploited in the past, or have established future potential do occur in rocks correlative with Yucca Mountain area units to the west, northwest, and east of the Yucca Mountain Addition within a 35 km radius. However, samples of silica-carbonate veins and breccias collected from in or around these deposits have different mineralogies from carbonate, silica, and silica-carbonate veins or breccias collected from the Yucca Mountain Addition. In addition, rock samples from within or near the precious-metal deposits yielded gold, silver, and pathfinder element values at much higher over-all levels than samples from the Yucca Mountain Addition.

INDUSTRIAL MINERALS AND MATERIALS

There are no identified industrial minerals and materials resources within the Yucca Mountain Addition (this includes salable, stakable, and leasable solid or fluid minerals). Within the restricted area of the proposed withdrawal, there are only two general geologic environments with possibilities for the occurrence of industrial minerals and materials.

Gravel-covered pediments have potential for sand and gravel deposits. Most sand and gravel produced in Nevada goes to the highway construction industry for portland and bituminous concrete aggregate, base, or fill material, and to the building industry for construction aggregate. As in the past, sand and gravel operations in Nevada will continue to be developed as close to consuming areas as possible. Because of their low unit value, sand and gravel deposits will not permit much transportation of any kind. Sand and gravel deposits, while possibly present within the Yucca Mountain Addition, do not have any unique value over similar material occurring in other areas in southern Nevada and their potential for development is rated very low.

Rhyolitic volcanic flows and tuffs are potential hosts for a number of industrial minerals including zeolites, montmorillonitic clays, perlite, and pumice. Deposits of perlite or lightweight aggregate are unlikely because specifically favorable rock types have not been identified. Because of the remoteness of the area from population centers, only high-value commodities would have much probability of economic production. This would, in effect, limit possible commodities to zeolites and montmorillonite. Both of these high-value materials are commercially produced in Nevada. Within the area proposed for withdrawal, however, both montmorillonitic clays and zeolites are present only in minor amounts as alteration and secondary minerals at the surface or near the surface. Drill hole data indicate that zeolites of unknown quality occur about 600 m below the crest of Yucca Mountain in the Yucca Mountain Addition, and smectite clay occurs in significant amounts below 1,100 m. Because the total relief within the Yucca Mountain Addition is less than 400 m, it is highly unlikely that either of these materials is economically exploitable.

ENERGY RESOURCES

Oil and Gas Resources

Nevada's petroleum potential can be predicted in a very general fashion on the basis of known production, shows of oil and gas, and proximity to areas of potential source and reservoir rocks. Areas of medium to high potential are located in the eastern part of the state, where most source rocks are found, and where these rocks have not been heated beyond the petroleum generation "window" to temperatures at which hydrocarbons have been destroyed. Although the Yucca Mountain Addition is in an area that has prospective potential for oil and gas (Smith and Gere, 1960), it lies within areas considered to have low oil and gas potential according to the most thorough regional studies available (Sandberg, 1983; and Garside et al., 1988). Therefore, the Yucca Mountain Addition is considered to have low potential for oil and gas resources.

Mississipian shales, which are thought to be the source rocks for most of the producing oilfields in Nevada (Poole and Claypool, 1984), are exposed 10 km west and 10 km or more northeast of the Yucca Mountain Addition. Mississipian rocks about 30 km northeast of the Yucca Mountain Addition have marginal source rock geochemistry (Center for Neotectonic Studies, 1989). These rocks yielded conodont color-alteration index (CAI) values of 1.5 to 2 (Harris et al., 1979; and S. P. Nitchman, personal communication, 1989), which are considered to be within the oil generation window (Poole and Claypool, 1984). Samples of Ordovician to Mississippian rocks within 15 km of the Yucca Mountain Addition to the east, northeast, and northwest, including borehole samples from depths of 1,300 m to 1,800 m, have yielded CAI values ranging between 3 and 6 (Harris et al., 1979; Carr et al.; 1986b, and Center for Neotectonic Studies, 1989). CAI values greater than 2 indicate temperatures above the oil-generation window, and values of 3 or higher indicate temperatures above the limit of oil preservation (Poole and Claypool, 1984). Nitchman (personal communication, 1989), believes that Mississippian source rocks on Bare Mountain yield high CAI values due to a heating episode related to overthrusting, and speculates that mature Mississippian source rocks comprise part of a parautochthonous upper Paleozoic sequence beneath the volcanic section in the Yucca Mountain area. Chamberlain (1989) believes that such rocks may have had the same depositional and thermal histories as Mississippian rocks in the productive Railroad Valley and Pine Valley oilfields about 150 km to the northeast of the Yucca Mountain Addition.

The geologic history of the Yucca Mountain Addition is largely unfavorable for the preservation of large hydrocarbon accumulations that may have been generated from Paleozoic source rocks during the Mesozoic (as postulated by Chamberlain). Extensive Miocene calderas within 5 km of the Yucca Mountain Addition were probably related to large magma chambers that would have created subsurface temperatures high enough to have destroyed any large oil accumulations that may have existed in the area.

This is supported by the CAI data for Paleozoic rocks surrounding the Yucca Mountain Addition which indicates that they were subjected to temperatures between 140°C (Carr et al., 1986b) and more than 300°C (Epstein et al., 1977).

In the absence of deep drill data beneath Yucca Mountain to test speculations regarding the presence of possible source rocks, estimates of hydrocarbon potential in the Yucca Mountain Addition must be based on surface and shallow drill data. Available data indicate hydrocarbon favorability is low, but not nil.

Geothermal Resources

Geothermal resources in Nevada are widespread and varied; the state has about 900 reported thermal springs and wells (Garside and Schilling, 1979). The higher-temperature resources are concentrated in northern Nevada, but many areas of the state have potential for low- to moderate-temperature resources. Data from thermal springs, water wells, and geothermal exploration wells listed in Garside and Schilling (1979), and Trexler and others (1983) have been used to define areas of the state that have potential for geothermal resources.

Warm springs in Oasis Valley about 20 km west of the Yucca Mountain Addition have surface water temperatures as high as 43°C (Garside and Schilling, 1979), and the Yucca Mountain Addition is within an area defined as prospectively valuable for geothermal resources (Godwin et al., 1967). However, based on temperatures measured in drill holes, thermal water (water with temperatures above those expected for a normal temperature gradient at the depth sampled) is not present in the Yucca Mountain Addition. Temperatures measured in drill holes below the static water level in the Yucca Mountain Addition range up to 54°C at a depth of 1,200 m (Sass et al., 1988).

Geothermal exploration based on temperature gradients in shallow drill holes is often considered sufficient to indicate the presence of a geothermal area, with gradients over most economically attractive areas in excess of 7°C per 100 m (Combs and Muffler, 1973). Temperature profiles from drill holes in the Yucca Mountain area range up to 6°C per 100 m, and average about 3°C (Sass et al., 1988). The average conductive heat flow in the Yucca Mountain area is anomalously low with respect to the regional heat flow, probably due to groundwater flow beneath the depth of exploration (Sass et al., 1988).

Based on the above information, the Yucca Mountain Addition does not appear to have potential for the discovery of geothermal resources.

Uranium Potential

Low-grade uranium deposits occurring in volcanic rocks are associated with rhyolite intrusions or occur in the ring fracture zone or moat areas of calderas. Such features are not known to occur in the Yucca Mountain Addition. Radioactive rock was not found during radiometric analysis of drill holes, and fracture fillings in drill hole USW G-3 contain very low uranium contents (up to 35 ppm) in comparison to ore from economic uranium deposits which contains several hundred ppm or more uranium. The potential for surface or shallow economic uranium deposits is low in the Yucca Mountain Addition.

SUMMARY OF MINERAL POTENTIAL

There are no identified mineral resources within the Yucca Mountain Addition. The potential for mineral deposits for which rock types underlying the area are favorable is rated very low.

The structural preparation of the Yucca Mountain Addition for mineralization, when compared with that for nearby mining districts, was rated as low from an analysis of the orientations of faults exposed at the surface. In the Yucca Mountain Addition, alteration is confined to two thin glassy bedded tuffs, whereas in the mining districts it crosses formation boundaries. Shallow intrusive rocks and pre-Tertiary rocks are exposed in the mining districts, but not in the Yucca Mountain Addition.

Base metal deposits that could be present in the deep subsurface (at depths of 1,500 meters or more) would not be mineable using standard, accepted mining technology. Surface exposures have very low mercury contents, indicating that economic deposits of this element, which are found in volcanic rocks, are not present.

Although the southwestern Nevada volcanic field does host economic near-surface disseminated gold-silver deposits, our work indicates that such deposits are not present within the Yucca Mountain Addition. Potential for precious-metal deposits mineable under current economic conditions, using presently available technology, is very low.

Potential for economic deposits of industrial minerals is also very low. Economic deposits of zeolites or clay are considered unlikely, although both have been encountered by drilling. Sand and gravel deposits present within the Yucca Mountain Addition have no unique value.

Based on presently available data, the Yucca Mountain Addition has low potential for energy resources including oil and gas, geothermal power, and uranium.

Determinations of potential for deeply buried mineral deposits under the Yucca Mountain Addition which could be mineable under future economic conditions, or using new technologies, are not within the scope of this investigation.

REFERENCES CITED

Ackermann, H. D., Mooney, W. D., Snyder, D. B., and Sutton, V. D., 1988, Preliminary interpretation of seismic-refraction and gravity studies west of Yucca Mountain , California and Nevada: U. S. Geological Survey Bulletin 1790, p. 23-34.

Ball, S. H., 1907, A geologic reconnaissance in southwestern Nevada and eastern California: U. S. Geological Survey Bulletin 308, 218 p.

Bish, D. L., and Vaniman, D. T., 1985, Mineralogic summary of Yucca Mountain, Nevada: Los Alamos National Laboratory Report LA-10543-MS, 55 p.

Broxton, D. E., Warren, R. G., Hagan, R. C., and Luedemann, G., 1986, Chemistry of diagenetically altered tuffs at a potential nuclear waste repository, Yucca Mountain, Nye County, Nevada: Los Alamos National Laboratory Report LA-10802-MS, 160 p.

Byers, F. M. Jr., Carr, W. J., Orkild, P.P,, Quinliven, W. D., and Sargent K. A., 1976 Volcanic suites and related cauldrons of Timber Mountain-Oasis Valley Caldera Complex, Southern Nevada: U. S. Geological Survey Professional Paper 919, 70 p.

Byers, F. M. Jr., Carr, W. J., and Orkild, P. P., 1989, Volcanic centers of southwestern Nevada: evolution of understanding, 1960-1988: Journal of Geophysical Research, v. 94, no. B5, p. 5908-5924.

Caporuscio, F. A., Vaniman, D. T., Bish, D. L., Broxton, D. E., Arney, B., Heiken, G. H., Byers, F. M., Jr., Gooley, R., and Semarge, E., 1982, Petrologic studies of drill cores USW-G2 and UE25b-1H, Yucca Mountain, Nevada: Los Alamos National Laboratory Report LA-9255-MS, 111 p.

Carr, W. J., 1984, Regional structural setting of Yucca Mountain, southwestern Nevada, and late Cenozoic rates of tectonic activity in part of the southwestern Great Basin, Nevada and California: U. S. Geological Survey Open-File Report 84-854, 114 p.

Carr, W. J., 1988a, Volcano-tectonic setting of Yucca Mountain and Crater Flat, southwestern Nevada: U. S. Geological Survey Bulletin 1790, p. 35-49.

Carr, W. J., 1988b, Styles of extension in the Nevada Test Site region, southern Walker Lane belt: an integration of volcano-tectonic and detachment fault models: Geological Society of America Abstracts with Programs, v. 20, no. 3, p. 148.

Carr, W. J., Byers, F. M., Jr., and Orkild, P. P., 1986a, Stratigraphic and volcano-tectonic relations of Crater Flat tuff and some older volcanic units, Nye County, Nevada: U.S. Geological Survey Professional Paper 1323, 28 p.

Carr, M. D., Waddell, S. J., Vick, G. S., Stock, J. M., Monsen, S. A., Harris, A. G., Cork, B. W., and Byers, F. M. Jr, 1986b, Geology of drill hole UE25p 1: a test hole into pre-Tertiary rocks near Yucca Mountain, southern Nevada, U. S. Geological Survey Open-File Report 86-175, 56 p.

Center for Neotectonic Studies, 1989, Task 8 progress report, 7/1/88-9/30/89 (in) Evaluation of the geologic relations and seismotectonic stability of the Yucca Mountain area, Nevada, nuclear waste site investigation, final report, 30 September, 1989: unpublished report, Center for Neotectonic Studies, Mackay School of Mines, University of Nevada, Reno NV

Chamberlain, A. K., 1989, Fallout from Yucca Mountain (letter): Geotimes, v. 34, no. 3, p. 3-4.

Christiansen, R. L., Lipman, P. W., Carr, W. J., Byers, F. M., Jr., Orkild, P. P., and Sargent, K. A., 1977, Timber Mountain-Oasis Valley caldera complex of southern Nevada: Geological Society of America Bulletin, v. 88, p.943-959.

Combs, J., and Muffler, L. J. P., 1973, Exploration for geothermal resources (in) Geothermal Energy (Kruger, P., and Otte, C., editors): Stanford University Press, Stanford, CA, p. 95-128.

Cornwall, H. R., 1972, Geology and mineral deposits of southern Nye County, Nevada: Nevada Bureau of Mines and Geology Bulletin 77, 49 p.

Cornwall, H. R., and Kleinhampl, F. J., 1961, Geology of the Bare Mountain quadrangle: U. S. Geological Survey Map GQ-157, 1:62,500 scale.

Cornwall, H. R., and Kleinhampl, F. J., 1964, Geology of the Bullfrog quadrangle and ore deposits related to Bullfrog Hills caldera, Nye County, Nevada, and Inyo County, California: U. S. Geological Survey Professional Paper 454-J, 25 p.

Couch, B. F., and Carpenter, J. A., 1943, Nevada's metal and mineral production: Nevada Bureau of Mines and Geology Bulletin 38, 159 p.

Cox, D. P., and Singer, D. A., eds, 1986, Mineral deposit models: U.S. Geological Survey Bulletin 1693, 379 p.

Cox, D. P., Ludington, S., 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, J., 1989, Methodology for analysis of concealed mineral resources in Nevada; a progress report, in U. S. Geological Survey research on mineral resources, 1989, program and abstracts, Fifth annual V. E. McKelvey Forum on Mineral Resources, p. 10-11.

Crowe, B., Harrington, C., McFadden, L., Perry, F., Wells, S., Turrin, B., and Champion, D., 1988, Preliminary geologic map of the Lathrop Wells volcanic center; Los Alamos Report LA-UR-88-4155, 7 p.

Ekren, E. B., and Sargent, K. A., 1965, Geologic map of the Skull Mountain quadrangle, Nye County, Nevada: U. S. Geological Survey Map GQ-387, 1:24,000 scale.

Epstein, A. G., Epstein, J. B., and Harris, L. D., 1977, Conodont color alteration - an index to organic metamorphism: U. S. Geological Survey Professional Paper 995, 27 p.

Garside, L. J., and Schilling, J. H., 1979, Thermal waters of Nevada: Nevada Bureau of Mines and Geology Bulletin 91, 163 p.

Garside, L. J., Hess, R. H., Fleming, K. L., and Weimer, B. S., 1988, Oil and gas developments in Nevada: Nevada Bureau of Mines and Geology, Bulletin 104, 136 p.

Godwin, L. H., Johnson, E., Sun, S., Throckmorton, M., and Brook, C., 1967, Lands valuable for geothermal resources, Nevada (map, updated 1970-1983): U. S. Geological Survey Conservation Division, Western Region, Office of the Area Geologist, Pacific area.

Hamilton, W. B., 1988, Detachment faulting in the Death Valley region, California and Nevada: U. S. Geological Survey Bulletin 1790, 51-85.

Harris, A. G., Warlaw, B. R., Rust, C. C., and Merrill, G. K., 1979, Maps for assessing thermal maturity (conodont color alteration maps) in Ordovician through Triassic rocks in Nevada and Utah and adjacent parts of Idaho and California: U. S. Geological Survey Map I-1249.

Heald, P., Filey, J. K., and Hayba, D. O., 1987, Comparative anatomy of volcanic-hosted epithermal deposits: acid-sulfate and adularia-sericite types: Economic Geology, v. 82, no. 1, p. 1-26.

Jackson, M. R., Jr., 1988, The Timber Mountain magmato-thermal event: an intense widespread culmination of magmatic and hydrothermal activity at the southwestern Nevada volcanic field: University of Nevada, Reno - Mackay School of Mines, Reno, Nevada, M. S. Thesis, 46 p.

Jorgensen, D. K., Rankin, J. W., and Wilkins, J., Jr., 1989, The geology, alteration, and mineralogy of the Bullfrog gold deposit, Nye County, Nevada: Society of Mining Engineers Preprint 89-135, 13 p.

Jones, J. B., and Segnit, E. R., 1971, The nature of opal, I. nomenclature and constituent phases: Journal of the Geological Society of Australia, v. 18, no. 1, p. 57-68.

Koch, G. S., Jr., 1987, Exploration-geochemical data analysis with the IBM PC: New York, Van Nostrand Reinhold, 179 p.

Levy, S. S., 1984, Petrology of samples from drill holes USW H-3, H-4, and H-5, Yucca Mountain, Nevada: Los Alamos National Laboratory Report LA-9706-MS, 77 p.

Levinson, A. A., 1974, Introduction to exploration geochemistry: Willmette, IL, Applied Publishing, Ltd., 614 p.

Lincoln, F. C., 1923, Mining districts and mineral resources of Nevada: Reno, Nevada Newsletter Publishing Co., 295 p.

Lipman, P. W., and McKay, E. J., 1965, Geologic map of the Topopah Spring SW quadrangle, Nye County, Nevada: U. S. Geological Survey Map GQ-439, 1:24,000 scale.

Maldonado, F., and Koether, S. L., 1983, Stratigraphy, structure, and some petrographic features of Tertiary volcanic rocks at the USW G-2 Drill Hole, Yucca Mountain, Nye County, Nevada: U. S. Geological Survey Open-File Report 83-732, 83 p.

McKay, E. J., and Williams, W. P., 1964, Geology of the Jackass Flats quadrangle: U. S. Geological Survey Map GQ-368, 1:24,000 scale.

Morton, J. L., Silberman, M. L., Bonham, H. F., Garside, L. J., and Noble, D. C., 1977, K-Ar ages of volcanic rocks, plutonic rocks, and ore deposits in Nevada and eastern California: Isochron\West, no. 20, p. 19-29.

Muller, D. C., and Kibler, J. E., 1985, Preliminary analysis of geophysical logs from the WT series of drill holes, Yucca Mountain, Nye County, Nevada: U.S. Geological Survey Open-File Report OF 86-0046, 30 p.

Nevada Bureau of Mines and Geology, 1985, The Nevada mineral industry, 1984: Nevada Bureau of Mines and Geology Special Publication MI-1984, 32 p.

Nevada Bureau of Mines and Geology, 1988, The Nevada mineral industry 1987: Nevada Bureau of Mines and Geology Special Publication MI-1987, 54 p.

Noble, D. C., and Weiss, S. I., 1989, High-salinity fluid inclusions suggest that Miocene gold deposits of the Bare Mtn. district, NV, are related to a large buried rare-metal rich magmatic system: Geological Society of America Abstracts with Programs, v. 20, no. 3, p. 123.

Orkild, P. P., and O'Connor, 1970, Geologic map of the Topopah Spring quadrangle, Nye County, Nevada: U. S. Geological Survey Map GQ-849, 1:24,000 scale

Papke, K. G., 1979, Fluorspar in Nevada: Nevada Bureau of Mines Bulletin 93, 77 p.

Poole, F. G., and Claypool, G. E., 1984, Petroleum source-rock potential and crude-oil correlation in the Great Basin, (in) Woodward, J., Meissner, F. F., and Clayton, J. L., eds., Hydrocarbon source rocks of the Greater Rocky Mountain region: Rocky Mountain Association of Geologists, 1984 Symposium, Denver, CO, p. 179-231.

Quade, J., and Tingley, J. V., 1984, A mineral inventory of the Nevada Test Site and portions of Nellis Bombing and Gunnery Range, southern Nye County, Nevada: Nevada Bureau of Mines and Geology Open-File Report 84-2, 68 p..

Ransome, F. L., Emmons, W. H., and Garrey, G. H., 1910, Geology and ore deposits of the Bullfrog district, Nevada: U. S. Geological Survey Bulletin 407, 129 p.

Sass, J. H., Lachenbruch, A. H., Dudley, W. W. Jr., Priest, S. S., and Munroe, R. J., 1988, Temperature, thermal conductivity, and heat flow near Yucca Mountain, Nevada: Some tectonic and hydrologic implications: U. S. Geological Survey Open-file Report 87-649, 118 p.

Sandberg, C. A., 1983, Petroleum potential of wilderness lands in Nevada: U. S. Geological Survey Circular 902 H, 11 p.

Scott, R. B., and Bonk, J., 1984, Preliminary geologic map of Yucca Mountain, Nye County, Nevada, with geologic sections: U. S. Geological Survey Open-File Report 84-494, 1:12,000 scale.

Scott, R. B., and Castellanos, M., 1984, Preliminary report on the geologic character of the drill holes USW GU-3 and USW G-3: U. S. Geological Survey Open-File Report 84-491, 121 p.

Scott, R. B., and Castellanos, M., 1984, Stratigraphic and structural relations of volcanic rocks in drill holes USW GU-3 and USW G-3, Yucca Mountain, Nye County, Nevada: U. S. Geological Survey Open-File Report 84-491, 121 p.

Smith, M. B., and Gere, W. C., 1960, Lands valuable for oil and gas, Nevada (map, updated 1983)): U. S. Geological Survey Conservation Division, Western Region, Office of the Area Geologist, Pacific area.

Snedecor, G. W., and Cochran, W. C., 1967, Statistical methods, sixth edition: Ames, Iowa, Iowa State University Press, 593 p.

Szabo, B. J., and Kyser, T. K., 1985, Uranium, thorium isotopic analyses and uranium-series ages of calcite and opal, and stable isotope compositions of calcite from drill cores UE25a 1, USW G-2, and USW G-3/GU-3, Yucca Mountain, Nevada: U. S. Geological Survey Open-File Report 85-0224, 30 p.

Tingley, J. V., 1984, Trace element associations in mineral deposits, Bare Mountain (Fluorine) mining district, southern Nye County, Nevada: Nevada Bureau of Mines and Geology Report 39, 28 p.

Trexler, D. T., Flynn, T., Koenig, B. A., and Ghusn, G. Jr., 1983, Geothermal resources of Nevada: National Oceanic and Atmosphere Administration, 1:500,000-scale map.

APPENDIX A. SAMPLE DESCRIPTIONS FROM FIELD NOTES, YUCCA MOUNTAIN ADDITION AND SURROUNDING MINING DISTRICTS

SAMPLE NO	DATE TAKEN	DESCRIPTION	REMARKS
YMSC-1	May 19, 1989	Brecciated pink ash flow along N25E, 80W fault zone about .5 m wide. Just to S is blk. to red vitrophyre overlain by lt. grey to rusty airfall, bedding N35W, 80S. Grey clinkstone tuff on ridge to S. Probably a N35W fault here (good photolinear).	
YMSC-2	May 19, 1989	Red-brn. silic. ash flow or vitrophyre grab from breccia zone (along N35W, 80S fault?). About 10 m S of YMSC-1.	June 24, 1989 - Resampled as YMSC 2A, marked.
YMSC-3	May 19, 1989	Red-brn. to purple silic. and argillized(?) ash-flow tuff along Solitario Cyn. Fault (N05W, 65W).	
YMSC-4	May 19, 1989	Shear plane and bx. zone in purple ash flow N15E, 72 W cut by subparallel cream-colored silica vn. 1-5 cm wide.	
YMSC-5C	May 19, 1989	Chip spl. across 60 cm wide clay(?)-ct.-silica zone in hanging wall of Solitarion Cyn. Fault. Wht. to cream color, well indurated opal and punky ct. cutting gravel in trench to W. Fault N15W, 54 W. Some subparallel ct. vns. in gravel W of fault.	June 24, 1989 - Resampled as YMSC-5A, marked.
YMSC-5H	May 19, 1989	Grab of hard cream-colored opaline silica in ct. zone of YMSC-5C. Taken from a 2-cm-wide vein about 7 m S of SC-5C on S wall of trench.	June 24, 1989 - Resampled as YMSC-5B.
YMSC-6	May 19, 1989	Dark purplish-brn. siliceous rock along fault beneath YMSC-5C. Unaltered country rock is greenish black vitrophyre.	
YMSC-7	May 20, 1989	Bx of pinkish-grey unaltered Tiva Cyn. mbr. ash flow in white ct. matrix. Bx. zone irreg. and about 30 cm wide with N-S trend.	June 23, 1989 - Relocated on map and resampled as YMSC-7A, marked.
YMSC-8	May 20, 1989	Area of silic.(?) bx. with clasts of pinkish-grey Tiva Cyn. mbr. ash flow. Bx. is in 3- to 6-m-wide zone which appears to trend NNE.	
YMSC-9	May 20, 1989	Breccia zone consisting of unaltered pinkish-grey clasts of Tiva Cyn. ash flow in white to cream ct. and opaline silica matrix. Zone is about 12 m wide and trends N-S.	
YMSC-10	May 20, 1989	Area of bx. with pink brecciated ash flow containing black glass flamme cutting grey lithophysal devit. ash flow tuff.	
YMSC-11	May 20, 1989	Grey lithophysal ash-flow tuff, country rock for YMSC-10.	
YMSC-12	May 20, 1989	Welded vitrophyric orange-grey air fall or ash flow. Shards are flattened, orange-amber color. Some brn. to blk. shards and flattened glass frags. Also contains lt. tan flattened pumice frags. Upper 30 cm variably devit. (no spl.).	
YMSC-13	May 20, 1989	Bx and fault gouge 60 cm to 1 m thick from footwall of N08W, 78W fault with near horiz. slicks. Matrix of bx. is lt grey comminuted rock. Hanging wall is purplish grey devit. ash flow. To E of bx./gouge is bedded airfall.	
YMSC-14	May 20, 1989	White fine-gnd. layer approx. 2 cm thk. in v. lt. grey lapilli airfall tuff sequence. Layer contains some v. lt. brn. to cream opaline silica. Bedding = N10W, 20 E. Glassy orange/brn. air fall overlies the grey lapilli unit.	June 23, 1989 - Resampled as YMSC-14A, marked.
YMSC-14B	Jun 23, 1989	Taken 15-20 ft N 15 E of spl 14 & 14A. Spl consists of lt. brown to white calcrete layer in bedded tuff with minor opaline silica. It is 2-8 cm. thick with att. approximately N-S, 25 E.	
YMSC-14C	Jun 23, 1989	Lt. grey, well-sorted lapilli tuff approximately 30 cm thick overlying calcrete layer of YMSC-14B. Overlain in turn by lt. red-brown to lt. ochre brown air fall containing pumice frags to 1 cm diam.	

SAMPLE NO	DATE TAKEN	DESCRIPTION	REMARKS
YMSC-15	May 20, 1989	Unaltered Tiva Cyn ash flow member, "clinkstone" submember.	
YMSC-16	May 20, 1989	Unaltered glassy welded air-fall(?) tuff beneath orange tuff.	
YMSC-17	May 20, 1989	Sample from a locally dominant fracture in Tiva Cyn ash flow. N 10W, vert. No visible alteration.	
YMSC-18	May 20, 1989	Zone of red-brown ash flow, locally bx with white opaline silica. Zone is approx. 5 m wide and trends N 20E.	
YMSC-19	May 20, 1989	Red-brn., grey, and white siliceous breccia. Some clear chalcedony(?), and local granular white silica matrix. Most is silic. red-brn. biot. ash flow. Silic. rock is in irreg. area about 15 m diam. and is in 20 m wide zone with abund. white silica.	
YMSC-20	May 21, 1989	Orange tuff cut by bx. zones & carbonate veins (calcite). Chip spl. from area 5 m in diameter.	
YMSC-21	May 21, 1989	Red brown ash flow with white silica along fractures, some clear opal/chalced botryoidal crusts. Host rock resembles that at YMSC-19. Silica on fractures appears to occur in NW zone about 50 cm. wide.	
YMSC-22	May 21, 1989	3-cm-wide vn., N 55 W, 75 SW, cutting grey lithic welded tuff. Vein is composed of lt. pinkish brown & white friable airfall tuff.	June 25, 1989 - Resampled as 22A. Relocated, marked.
YMSC-22 S	May 21, 1989	5-10 cm wide irregular silica zone, N 30 E, with some white silica on fractures cut by YMSC 22 vn.	June 25, 1989 - Resampled as 22SA. Relocated, marked.
YMSC-23	May 21, 1989	Unaltered grey columnar ash flow from fract. zone, N 40 W 70 SW.	
YMSC-24	May 21, 1989	White to v lt. brown silica/calcrete vns & encrustations, irregular. Cut grey lithic-rich ash flow.	Relocated approx 100' to NE, resampled as YMSC-24A. Marked.
YMSC-25	May 21, 1989	Fault(?) bx. 25 cm wide, pinkish grey ash flow in white carbonate matrix. Fault att. is N-S, 80 W.	June 25, 1989 - Location O.K. Resampled as YMSC-25A. Marked.
YMSC-26	May 22, 1989	Red-brown ash flow with botryoidal chalcedony encrustations. Zone lying between lt. red brown ash flow and dark greenish brown vitrophyre. Grab spl. loose rock.	
YMSC-27	May 22, 1989	Red-brown to dark grey & white silicified bx 30-50 cm. thick on E side of N-S, 72 W fault.	
YMSC-28	May 22, 1989	Glassy welded airfall or ashflow, grey with veins & veinlets of carbonate - some with bright green mineral. West side of fault at YMSC-27.	Resampled as YMSC-28A. Marked.
YMSC-29	May 22, 1989	35 m x 15 m area of silicified grey breccia in cc on top of resistant unit, abund. caliche to NW.	
YMSC-30	May 22, 1989	Float of bx., white opaline silica matrix, some lt. brown opaline clasts.	Loose chunk of silic rock spld. as YMSC-30A, marked. No analysis (May not be orig. location) Location moved approx. 250 ' W of original spot on map.

SAMPLE NO	DATE TAKEN	DESCRIPTION	REMARKS
YMSC-31	May 22, 1989	Fault N-S, 65 W, purple agglomerate with scoria clasts (footwall) & lt reddish brown lapilli tuff (hanging wall). Spl. of resistant footwall tuff (silic?) & gougy hematitic hanging wall. Chip spl. represents more than 30 cm. thickness.	June 25, 1989 - Relocated and resampled as YMSC-31A, marked.
YMSC-31B	Jun 25, 1989	Red hematitic air fall.	
YMSC-32	May 22, 1989	Small area 10 m diameter with grey silicified bx loose on surface. Grab of loose material.	
YMSC-33	May 22, 1989	Small area 5 m diameter with silicified float.	
YMSC-34	May 22, 1989	Vertical caliche vein, N end scraped area.	June 23, 1989 - Resampled as YMSC-34A: 1-2 cm thick N 5 W, vert. or v. steep calcrete/opaline silica vn. Cuts red-brown glassy ash flow in trench. Marked.
YMSC-35	May 22, 1989	Grey silic. ash flow clast in caliche from middle of E side scaped area.	
YMSC-36	May 22, 1989	Brown silicic calcrete cutting red-brown ash flow, middle of E side scraped area just S of YMSC-35.	Resampled as YMSC-36A. Marked.
YMSC-37	May 23, 1989	5-6 m thick white silica-calcrete breccia vn. N 25 E, vert.	
YMSC-38	May 23, 1989	Irregular N-S calcrete bx. vein cutting grey lithophysal ash flow. Vn. up to 7 cm thick.	
YMSC-39	May 23, 1989	Breccia zone more than 1.5 m wide, NS - NNE, vertical to steep W. Cuts lt. purplish grey ash flow.	
YMSC-40	May 23, 1989	Breccia with purplish grey ash flow in grey calcrete cement. Occurs on E side of N-S notch along Ghost Dance Fault.	
YMSC-41	May 23, 1989	Breccia vein, approx. N-S, at least 50 cm thick. Matrix is white carbonate. Difficult to get attitude, but looks near vertical.	
YMSC-42	May 23, 1989	Top of Yucca Mtn. in road cut. Abund. v. lt. brown to white carbonate fracture fillings. Sample contains some white opaline silica. Cuts grey devit. ash flow.	Resampled as YMSC-42A.
YMSC-43	May 23, 1989	1-cm-thick silicified fracture cutting grey ash flow. Found on loose blocks on relatively flat surfaces.	
YMSC-44	May 23, 1989	Veins of v. lt. brown to white carbonate cutting grey ash flow tuff at low to high angles. Some silica with ct.	
YMSC-45	May 24, 1989	Pearly white carbonate cutting grey ash flow below resistant layer. Attitude of ct. vn. uncertain.	Resampled as YMSC-45A, marked.
YMSC-46	May 24, 1989	Several samples collected from base of Tiva Cyn. mbr., unalt. spls: O m = near top orange welded air fall(?); +1 m = base grey vit.; +6 m = in black/grey vit.; +9 m = base of devit. unit; -8 m = fine lt. grey airfall from bt; -30 m = blk. vit..	Composite sample YMSC-46A analyzed.

SAMPLE NO	DATE TAKEN	DESCRIPTION	REMARKS
YMSC-47	May 24, 1989	Chip spl. across 1 m wide silicified bx zone along fault. Fault att. approx. N 15 E, 75 W.	
YMSC-48	May 24, 1989	Grab of silic. bx. along fault, N 20 W, 70 W. Cuts red brown to pink biotite-rich lithic ash flow.	
YMSC-48C	May 24, 1989	Host rock for YMSC-48.	
YMSC-49	May 24, 1989	Opaline silica & carbonate along fault, N 30 E, steep W. Exposed in gulley. Cuts purplish brown ash flow.	
YMSC-49C	May 24, 1989	Purplish brown ash flow. Hosts YMSC-49. New rock type - must be lowest unit seen to date.	
YMSC-50	May 24, 1989	Breccia zone, N-S, 55 W. Footwall is 25 cm red brown silic. bx.	June 24, 1989 - Resampled as YMSC-50SA. Location O.K., marked.
YMSC-50CS	May 24, 1989	Mixed ct. & silica veining from 40 cm zone overlying YMSC-50S.	June 24, 1989 - Resampled as YMSC-50CSA. Marked.
YMSC-50CS 2	May 24, 1989	Bx of grey ash flow clasts in ct. & sil. matrix. Overlies YMSC-50CS.	June 24, 1989 - Resampled as YMSC-50CSA2.
YMSC-51	May 24, 1989	Grab spl. of silica & ct. bx. along fault, N 5 W, 65W. Zone is at least 1.5 m thick.	
YMSC-52	May 24, 1989	Vein(?) of bright red silicified bedded tuff in approx. N-S zone of purplish red indurated and altered tuff.	Resampled as YMSC-52A. Marked.
YMSC-53	May 24, 1989	Grab of silic. shear zone, N 40 E, 55 NW. Zone contains some black vitrophyre clasts.	
YMSC-54	May 25, 1989	Grab of silicified fault bx. with lt. purplish grey ash flow clasts. Fault approx. N 10 E, 75 W. Hanging wall = bedded tuff.	
YMSC-55	May 25, 1989	Grab approx 20 m down gully from YMSC-54: fault bx. with ct. matrix, clasts = orange tuff. Fault approx. N 15 W, vt.	
YMSC-56	May 25, 1989	Grab of bx. with ct. matrix & ash flow clasts along fault, N-S, 75 W.	
YMSC-57	May 25, 1989	Grab of bx. with ct. matrix & ash flow clasts along fault, N 85 E, 85 N.	
YMSC-58	May 25, 1989	Grab of unaltered grey lithosphysal tuff.	
YMSC-59	May 25, 1989	Chip spl. across 30 cm+ wide breccia along fault, N 25 E, 70 W. Bx. contains ash flow clasts in silica & ct. matrix.	

SAMPLE NO	DATE TAKEN	DESCRIPTION	REMARKS
YMSC-60	May 25, 1989	Wide bx. zone: dk. grey ash flow clasts in white to lt. brown ct. + silica matrix. Breccia zone approx. 40 m. wide - very nicely exposed in gulley. To W of bx. in gulley is fanglomerate with abund. caliche.	
YMSC-61	May 25, 1989	65-cm-thick bx. & vn. zone - shear planes with vt. slickensides. Att. of zone = N 25 E, 75 W.	
YMSC-62	May 25, 1989	Grab from silic. bx., att. approx. N 10 W, vert. Zone is at least 1 m wide.	
YMSC-63	May 25, 1989	Grab from silic. + ct. bx., N 15 E, 80 W, at least 3 m wide.	
YMSC-64	May 25, 1989	Unaltered lt. pinkish grey ash flow tuff.	
YMSC-65	May 25, 1989	Grey to purplish grey silicified bx. in 3-m-wide zone. Possible att. = N 10 W, 60 W.	
YMSC-66	May 25, 1989	Grey to purplish grey silicified bx., poss. some ct. matrix, in 1 m+ wide zone, N-S, steep W.	Resampled as YMSC-66A. Location O.K. Part of a N-S to NNE wide silica - ct. bx. zone. Spl. from bottom of small wash. Marked.
YMSC-67	May 25, 1989	Chip across 25 cm-45 cm wide dike or vein. Grey opaline silica cutting brown airfall, N 47 E, vert.	
YMSC-68	May 25, 1989	Grab of airfall tuff dike, white, glassy pumice in 15 cm wide dike, N 42 E, 85 SE. Cuts same airfall as YMSC-67 & is about 2 m NW of it. Part of bedded tuff unit.	
YMSC-69	May 25, 1989	Calcite + silica cemented bx., N 5 W, vt., gravel to W with abund. caliche.	Resampled as YMSC-69A. Location approx. Marked.
YMSC-70	May 25, 1989	Grab from silic. bx. zone N 10-15 W, 60-70 W. Zone approx. 1.2 m thick.	
YMSC-71	May 25, 1989	Calcrete bx. with some silic. clasts along N 15 E, 60-80 W bx zone in bedded tuff. Grab spl. from 3 m thick bx.	
YMSC-72	Jun 1, 1989	Float from N 25 E - trending zone silic. ash flow, grey color. minor ct.	
YMSC-73	Jun 1, 1989	Float of silic. ash flow & some calcrete veining.	
YMSC-74	Jun 1, 1989	Silica & calcrete bx. in purplish grey ash flow with large dark grey spherulitic flamme.	
YMSC-75	Jun 1, 1989	Silica and calcrete bx. zone approx. 3 m wide, N 15-20 E. Grab spl.	
YMSC-76	Jun 1, 1989	Silica & calcrete bx. in N 20 E(?) zone. Poorly exposed.	

SAMPLE NO	DATE TAKEN	DESCRIPTION	REMARKS
YMSC-77	Jun 1, 1989	Poorly exposed silic. fault bx.	
YMSC-78	Jun 1, 1989	N 20 W fault bx zone, silic (?).	
YMSC-79	Jun 1, 1989	Fault bx. zone, silic(?).	
YMSC-80	Jun 1, 1989	Unaltered caprock.	
YMSC-81	Jun 1, 1989	Silic. fault bx. along zone separating purplish grey ash flow from pink bedded tuff. Att. approx. N-S, 45 E. Silic. bx. at least 60 cm. thick.	
YMSC-82	Jun 1, 1989	Red brown silic. bx. block in bedded tuff - possible fault sliver.	
YMSC-83	Jun 1, 1989	Red brown silic. bx. float, possible fault through saddle.	
YMSC-84	Jun 1, 1989	Float from shear zone(?).	
YMSC-85	Jun 23, 1989	Calcrete layer parallel to bedding in bedded tuff. Pink fine grained tuff with white calcite. Thin (1-2 mm.) silica veins in calcrete. Overlain & underlain by orange lapilli tuff, coarse, most pumice frags 0.5 to 1 cm. diameter or more.	
YMSC-86	Jun 23, 1989	Fault gouge and bx. in 5-cm-wide fracture in ash flow in hanging wall of fault separating ash flow from bedded tuff. Fracture N 65 W, 75 SW.	
YMSC-87	Jun 24, 1989	1-2-cm-thick grey opal vein, irregular, approximately N 50 W, at contact between black & red brown vitrophyre (footwall) and coarse grey lapilli tuff (hanging wall). Located about 3 m S of YMSC-2.	
YMSC-88	Jun 24, 1989	White calcrete & silica veins in purple air fall. Veins in N 10 W, 80 NE zone. Marked.	
YMSC-89	Jun 24, 1989	Coarse silic. bx. zone 30 cm. thk., N 15 W, 65 SW. Cuts purple ash flow. Located about 50 m N 10 W of YMSC-88	Fault - with coarse breccia N. 15 W. 65 S.W. approximately 30 cm. thick silic with in purple ash flow tuff. Breccia appears S 102. Sample located approx. 150' N. 10 W. of
YMSC-90	Jun 24, 1989	Silic. bx. along fault, N 20 W, 80 W. About 40 m S 30 E of YMDD-36.	
YMSC-91	Jun 24, 1989	Grab spl. of bx. with ct. matrix - lt. purplish grey color. Not v. hard. Wide zone approx. NNW. Steep indiv. shears N 20 W, 85 E; N 30 W, 60 E; N 10 W, 80 W.	
YMSC-92	Jun 24, 1989	Brown silic. air fall spld. 5 m N 45 W of YMSC-52. This rock type is in a zone parallel to red silic. material of YMSC 52.	
YMSC-93	Jun 25, 1989	Lt. purplish grey ash flow(?) or welded air fall, vitric, country rock for YMSC 22 veins. Located about 2 m W of YMSC-22S.	

SAMPLE NO	DATE TAKEN	DESCRIPTION	REMARKS
YMSC-94	Jun 25, 1989	Bx. along fault, N 50 W, 80 SW, approx. 25 cm thick, grey with silica/calcrete matrix. May be fault between grey ash flow to E & bedded tuff to W. However, overall trend of contact between bx. & ash flow approx. N 20 W here.	
YMSC-95	Jun 25, 1989	Silic. fault cutting bedded tuff, N-S, 62 W; N-S, 68 W. Marked.	
YMSC-96	Jun 26, 1989	Horizontally layered caliche with a few ash flow clasts in N wall trench, 5 m N 45 E of YMSC-34. Spl. represents about 50 cm thickness . Photo.	
YMSC-97	Jun 26, 1989	White opaline silica in calcrete veins cutting ash flow. Photo. 35 m S 15 W of YMPG-23.	
YMPG-1	May 20, 1989	Breccia, well indurated, in massive to platy, lt. pink to lt. gray welded ash flow. Feldspar phenos approx. 5%, white crushed pumice frags 10-15%. Breccia zone poorly exposed, approximately 0.5 m wide N 45 E vert. (see remarks).	Breccia contains fragments of surrounding tuff up to 10 cm. Silica and opal cement.
YMPG-2	May 20, 1989	Purple silica bx. similar to YMPG-1 in 0.25 m wide zone approximately N 35 E, vertical. Cuts platy lt. purple ash flow.	
YMPG-3	May 20, 1989	Lt. purple-gray breccia within crude columnar jointed gray welded tuff with abundant crushed pumice. Vuggy breccia zone, 1-12 cm wide, not a lot of displacement, N 35 E, 86 SE. Breccia well indurated.	
YMPG-3A	May 20, 1989	Fault breccia from several small faults N 12 W, 80 SW; N 45 W, 90. 4 m west of YMPG-3.	
YMPG-4	May 20, 1989	Breccia zone similar to YMPG-3, low in columnar zone. N 8 W, 81 W, approximately 1 meter down to W displacement.	
YMPG-5	May 20, 1989	Fault gouge & breccia 4-8 cm. wide, well indurated, white with columnar tuff. Fault +0.5 m down to west, N 28 W, 76 SW	
YMPG-6	May 20, 1989	Purple & white bx. along fault with 3-4 m. displacement down to W, zone .5 to .1 m. thick, N 20 E, 66 NW. Breccia of surrounding rx - purple ash flow with flattened pumice - unit just above orange vitrophyre and bedded tuff (see remarks)	Sample is gouge and breccia with some calcrete but mainly silica cement.
YMPG-7	May 20, 1989	Purple breccia with silica & opal cement. Breccia in subcrop appears to juxtapose bedded ash and vitrophyre. Approx. N 20 W strike of fault.	
YMPG-8	May 20, 1989	Purple breccia with silica cement along fault in wash 20 m south of YMPG-7. Fault between ash fall and purple welded ash flow, N 12 W, 90. This is on trend with YMPG-7 (see remarks).	Several faults with same trend and breccia zone 4-5 m. wide. Both silica and calcrete cement. Very coarse breccia, up to 35 cm. frags.
YMPG-9	May 20, 1989	Opal breccia 30 m south of YMPG-8 - prob. same fault zone. Exposed in wash.	
YMPG-10	May 21, 1989	Sub-crop of breccia with silica and calcrete cement, opal common. Host rock lt. gray qtz., plag, biot. rhyolite.	
YMPG-11	May 21, 1989	Subcrop of coarse grey breccia with silica cement. Host rock lt. gray platy clinkstone unit.	
YMPG-12	May 21, 1989	Dk. grey breccia. Fault not exposed - appears to slightly drop east side down - bdd tuff against vitrophyre. Breccia found in float at contact. Shear planes in bdd tuff, N 10 W, 48 W.	

SAMPLE NO	DATE TAKEN	DESCRIPTION	REMARKS
YMPG-13	May 21, 1989	Calcrete breccia with opal in small fault in vitrophyre just above bedded tuff. Fault N 8 E, 45 W.	
YMPG-14	May 21, 1989	Gouge and bx. from fault, down to east, cuts red ash unit and vitrophyre here - forms small gulch with calcrete breccia common in vitrophyre. Fault trends N 45 W.	
YMPG-15	May 21, 1989	Fault breccia, poorly exposed calcrete in vitrophyre.	
YMPG-16	May 21, 1989	Small fault with calcrete-cemented breccia of platy purple & gray ash-flow tuff.	
YMPG-17	May 21, 1989	Calcrete and opal-cemented bx. in lt. gray vuggy ash flow.	
YMPG-18	May 21, 1989	Fine fault breccia and gouge, 30 cm - 5 cm wide, N 5 E, 65 W, within columnar unit.	June 23, 1989 - Relocate on map and respl as YMPG-18A. Marked.
YMPG-19	May 21, 1989	Calcrete within platy and vuggy purple tuff along 1-2 cm wide fault zone.	June 23, 1989 - Resampled. Location good. Marked.
YMPG-20	May 21, 1989	*Silica-cemented breccia in purple vuggy tuff with flattened pumice.*	
YMPG-21	May 21, 1989	Calcrete-cemented breccia in purple platy clinkstone unit.	
YMPG-22	May 21, 1989	Silica-cemented bx. in purple platy clinkstone unit.	
YMPG-23	May 21, 1989	Purple silica-cemented bx.	
YMPG-24	Jun 23, 1989	In scraped area top of Yucca Mtn. Silica-calcrete vein in purple vitric tuff. Vein material white to lt. brown, banded. E - W, vertical.	
YMDD-1	May 22, 1989	Grab sample of silicic coating on joint in lithophysal tuff. Surrounding rock is lithophysal tuff showing little silicification. No veins.	
YMDD-2	May 22, 1989	Botryoidal chalcedony(?) in bedded tuff. Grab sample from float of silica and host rock. No veins.	
YMDD-3	May 22, 1989	*Calcrete with sparse reddish opaque xls. (hematite?). Grab sample of float. Surrounding* rock is tuff. No veins.	June 25, 1989. Resampled as YMDD-3A. Marked.
YMDD-4	May 23, 1989	Float chips of silicified calcrete. Forms crusts, minor breccia, vug filling. Forms no veins and is generally sparse. Country rock is gray devitrified tuff.	
YMDD-5	May 23, 1989	Grab sample float. Breccia with partly silicified calcrete matrix. Host is gray devitrified tuff. Calcrete locally forms outer crust.	June 25, 1989. Resampled as YMDD-5A. Marked.

SAMPLE NO	DATE TAKEN	DESCRIPTION	REMARKS
YMDD-6	May 23, 1989	Fault breccia with matrix - host rock is gray devitrified tuff. Also forms minor veins.	
YMDD-7	May 23, 1989	Fault breccia with matrix and green mineral in fractures.	
YMDD-8	May 23, 1989	Chips of fault(?) breccia with matrix. Little outcrop - mostly talus. Small show in fault zone at top of ridge. Host rock is gray devtrified tuff.	
YMDD-9	May 24, 1989	Breccia with partly silicified calcrete matrix. Host rock is gray, somewhat vuggy, devitrified tuff. Grab sample float.	
YMDD-10	May 24, 1989	Grab sample from outcrop. Breccia with white calcrete matrix. Host rock is gray devitrified tuff. Outcrop exposure about 5 m wide in draw.	
YMDD-11	May 24, 1989	Chips from outcrop. Fault not seen. Breccia with white calcrete matrix. Host rock is gray, divitrified tuff with abundant lithophysae.	
YMDD-12	May 24, 1989	Chips from outcrop. No fault or breccia. White calcrete & silica veins or joint fillings. Host rock is vuggy devitrified pumiceous tuff.	
YMDD-13	May 24, 1989	Grab samples of float. Thin coating on some rocks. Breccia exposed has no matrix. Host rock gray divitrified tuff with some vugs. Actual fault is covered.	
YMDD-14	May 24, 1989	Grab sample of outcrop. Discontinous calcrete coating on surface . Host rock is reddish brown siliceous devitrified tuff.	
YMDD-15	May 24, 1989	Grab sample of breccia with white silicified calcrete matrix and minor green mineral. Outcrops for 20-30 m. Host rock is both reddish brown and black siliceous devitrified tuff; contact between two rock colors is breccia zone.	
YMDD-16	May 24, 1989	Grab sample from outcrop. Silicified breccia. Host rock is lt. brown partly silicified devitrified tuff. Fault not obvious.	
YMDD-17	May 24, 1989	Grab samples of float. Partly silicified limy white matrix of breccia. Host rock is lt. brown, partly silicified, devitrified tuff. No veins.	June 24, 1989. Resampled as YMDD-17A. Light colored bx., N 35 W, 60 SW. Marked.
YMDD-18	May 24, 1989	Grab sample from outcrop. Breccia with partly silicified, limy white matrix. Host rock is gray, siliceous, devitrified tuff. Fault not obvious. No veins.	
YMDD-19	May 24, 1989	Grab sample from outcrop. Breccia with minor partly silicified, limy, white matrix. Host rock is gray, partly devitrified tuff. No obvious faults. No veins.	
YMDD-20A	May 24, 1989	Breccia with partly silicified, limy white matrix, grab sample from east side of fault between brown silicified tuff (east side), and grey, partly silicified tuff, (west side). Scarp N 8 E, 53 W.	
YMDD-20B	May 24, 1989	Chip sample of breccia from west side of YMDD-20A fault.	
YMDD-21	May 24, 1989	Locally silicified calcrete.	June 24, 1989. Resampled as YMDD-21A. Marked in road.

SAMPLE NO	DATE TAKEN	DESCRIPTION	REMARKS
YMDD-22	May 25, 1989	Grab sample from outcrop of breccia with discontinuous siliceous coating in cracks. Host rock - partly silicified, devitrified brown tuff.	Opaline silica bx in brown vitrophyre at base of bedded tuff. Bx is in irregular NNW zone of uncertain size.
YMDD-23A	May 25, 1989	Grab sample from outcrop. Siliceous coating on surface and in fractures in brown, siliceous, devitrified tuff.	June 24, 1989. Resampled as YMDD-23C. Location O.K. Opal bx. in brown vitrophyre at base of bedded tuff. Marked
YMDD-23B	May 25, 1989	Grab sample from outcrop. Silicous coating on surface and in several fractures in airfall tuff.	
YMDD-24	May 25, 1989	Grab sample siliceous white coating on surface of silicified, brown devitrified tuff. No veins or fault breccia.	
YMDD-25	May 25, 1989	Siliceous white coating on surface of silicified brown devitrified tuff. North wall of fault. Little brecciation, no veins. Grab sample from outcrop.	Resampled as YMDD-25A. Location may not be same, but close. Silicified bx at fault contact btw. Topopah Spr. tuff on N and bedded tuff on S.
YMDD-26	May 25, 1989	Grab sample of brown vuggy, silicified, devitrified tuff in fault zone. Mildly brecciated. Minor silicified fracture fillings. No surface coatings.	
YMDD-27	May 25, 1989	White limy coating on fracture surfaces in partly silicified gray devitrified tuff. No veins. Minor brecciation. Near fault which is covered. Grab sample.	
YMDD-28	May 25, 1989	Grab sample from outcrop. Siliceous white coating on brownish red, silicified, devitrified tuff. No veins.	
YMDD-29	May 25, 1989	Grab sample from outcrop. Partly silicified, white coating and vein filling in fault breccia. Host rock is brown, partly silicified, devitrified tuff. North wall of fault.	
YMDD-30	May 25, 1989	Chips from small outcrop of breccia with limy white matrix. Host rock is gray, devitrified, vuggy tuff. No veins. No fault obvious.	
YMDD-31	May 25, 1989	Grab sample from outcrop. White partly silicified carbonate filling large fractures in light gray devitrified tuff. Some brecciation but no obvious fault. Main fracture attitude N 5 W, 81 W.	
YMDD-32	May 25, 1989	Grab sample from outcrop. White carbonate filling several large parallel fractures in pink devitrified tuff. Local search produced no sign of fault. Fracture att. N 22 E, 70 N.	
YMDD-33	May 25, 1989	Grab sample from outcrop. Breccia along fault zone with white, partly silicified(?) limy matrix. Host rock is silicified, gray, devitrified tuff.	
YMDD-34	May 25, 1989	Grab sample from outcrop. Breccia along fault zone with white carbonate filling in fractures. Host rock is brown devitrified tuff.	
YMDD-35	May 25, 1989	Grab sample from fault surface. Breccia with white siliceous fracture filling. Fault attitude N 40 W, 70 SW Runs about 30-40 m and scarp is about 0.5 m high on NE side.	
YMDD-36	May 25, 1989	Grab sample from outcrop. Breccia with white calcrete matrix. Host rock is gray, silicified devitrified ash-flow tuff. Fault not obvious.	
YMDD-36A	Jun 24, 1989	Silic. bx. from fault, N 40 W, 70 SW, in ash-flow tuff. Marked.	

SAMPLE NO	DATE TAKEN	DESCRIPTION	REMARKS
YMDD-37	Jun 7, 1989	Partly silicified calcrete in silicified, devitrified tuff. Good outcrop in dry wash. Calcrete contains some clasts. Grab sample from outcrop.	
YMDD-38	Jun 7, 1989	Calcrete breccia. Calcrete may be locally silicified. Clasts are silicified, devitrified brown-gray tuff. Grab sample of float. Calcrete locally forms veins	
YMDD-38A	Jun 27, 1989	Calcrete and silica-cemented bx. from gulley. Marked.	
YMDD-39	Jun 7, 1989	Calcrete breccia, clasts are silicified, devitrified, brown-gray tuff. Grab sample from outcrop.	
YMDD-40	Jun 7, 1989	Calcrete breccia. Clasts are partly silicified, devitrified tuff. Grab sample from outcrop. Breccia zone seems fairly wide from YMSC-39 to here and outcrops near here also show in main draw.	
YMDD-41	Jun 7, 1989	Float that runs along contour for approximately 100-200 ft. Calcrete breccia. Clasts are partly silicified devitrified gray tuff. Grab sample of float. Mostly as coating on loose fragments.	
YMDD-42	Jun 7, 1989	Grab sample of country rock. Gray, vuggy devitrified tuff. Locally silicified(?).	
YMDD-43	Jun 7, 1989	Outcrops good but no sign of fault. Sample is grab of calcrete breccia float. Clasts are silicified, devitrified gray tuff. Found no outcrop of this material but float is very common in vicinity of mapped fault. Some calcrete is silicified.	
YMDD-44	Jun 7, 1989	Grab sample from outcrop of country rock. Gray, vuggy, devitrified tuff with silicified rind.	
YMDD-45	Jun 7, 1989	Calcrete breccia. Clasts are partly silicified, devitrified, brownish gray tuff. Grab sample from outcrop. Calcrete mostly veins filling in joints.	June 27, 1989. Resampled as YMDD-45A. Calcrete bx. Relocated. Marked.
YMDD-46	Jun 7, 1989	Partly silicified calcrete breccia. Chip sample from outcrop. Clasts are partly silicified, devitrified gray tuff. Fault not obvious.	
YMDD-47	Jun 7, 1989	Partly silicified(?) calcrete breccia. Chips from float and poor outcrop. No sign of fault. Bx. only occurs as float on hill where shown on map. Clasts are partly silicified devitrified gray tuff (see remarks).	Calcrete breccia locally outcrops. Bx. mostly float for approximately 100 m along east bank of drainage.
YMDD-48	Jun 7, 1989	Partly silicified calcrete breccia. Clasts are gray silicified devitrified tuff. Mostly float, some outcrop. Grab sample from float.	
YMDD-49	Jun 7, 1989	Calcrete breccia. Clasts are gray, partly silicified, devitrified tuff. Grab sample from float.	
YMDD-50	Jun 7, 1989	Gray silicified ash flow in NNE, 25 E zone with assoc. calcrete bx. Grab samples.	
YMDD-51A	Jun 11, 1989	Light gray, xl.-rich, lithified, devitrified tuff. Grab sample. West side of fault, N 7 W, 88 W, west side down. No gouge or breccia. Exposed for approximately 5 m.	
YMDD-51B	Jun 11, 1989	E Side of YMDD-51A fault. Light pinkish gray, lithified, devitrified tuff with large pumice frgaments. Grab sample.	

SAMPLE NO	DATE TAKEN	DESCRIPTION	REMARKS
YMDD-52	Jun 11, 1989	Along fault trend from YMDD 51. Fault is obscure and probably splays. Little brecciation. Chip sample of partly silicified(?) calcrete vein near fault, N 31 W, 88 E.	
YMDD-53	Jun 11, 1989	Grab sample from partly silicified calcrete breccia and vein zone. Clasts are partly silicified, gray devitrified tuff. Major vein attitude N 7 E, 71 W.	
YMDD-54	Jun 11, 1989	Grab sample of caprock: light pinkish gray, lithic, devitrified, pumiceous tuff.	
YMDD-55A	Jun 11, 1989	Grab sample from east side of fault trending approximately N 7 E - same as caprock of YMDD54. Little brecciation.	
YMDD-55B	Jun 11, 1989	Grab sample from west side of YMDD-55A fault. Light pinkish gray devitrified lithified tuff.	
YMDD-55C	Jun 11, 1989	Partly silicified calcrete breccia. Grab sample. Fault not exposed, calcrete chips very common along its mapped trace and on ridgetop to north.	
YMDD-56	Jun 11, 1989	Grab sample of calcrete breccia - partly silicified. Clasts of brownish gray, partly silicified, devitrified tuff. This is a continuation of zone sample YMDD-53 collected from.	
YMDD-57	Jun 11, 1989	Grab sample. Partly silicified calcrete breccia and veins. Main vein attitude N 4 E, 76 W Clasts partly silicified, devitrified, brownish gray tuff.	
YMDD-58	Jun 11, 1989	Grab sample from small outcrop of calcrete breccia, partly silicified. Clasts are partly silicified light purplish gray, devitrified tuff. Main vein N 34 W, 87 E.	
YMDD-59	Jun 11, 1989	Silicified(?) calcrete breccia grab sample. Clasts are gray, devitrified tuff, partly silicified.	
YMDD-60	Jun 11, 1989	Along unexposed fault. Minor local brecciation. Fractures N 18 W, 83 E. Grab sample of light tan, devitrified, pumiceous tuff with silicified rind.	
YMJT-1	Jun 27, 1989	Grey opalized ash flow with bronze mica. Possible Mn oxide. About 40 m N 50 W of YMPG-23.	
YMJT-2	Jun 27, 1989	40-cm-wide silic. fault bx. zone, grey, N 35 E, 70 W.	Location marked.
YMJT-3	Jun 27, 1989	About 4 m S 35 W of YMJT-2. Calcrete veining in grey silic. fault bx. similar to JT-2.	
YMJT-4	Jun 27, 1989	2-3 cm thick white opaline silica vn. along face of silic. fault bx., N 20 E, 70 W. [illegible] wider zone (approx. 3 m) of grey to brown silic. bx.	
BH-1	Jun 8, 1989	Cornwall's ash flow unit #4 - bleached and limonitic.	
BH-2	Jun 8, 1989	Silic. zone, chalcedonic with some coarse qtz., in N 70 E, 55 N shear system. Country rock shattered, esp. below zone.	

SAMPLE NO	DATE TAKEN	DESCRIPTION	REMARKS
BH-3	Jun 8, 1989	White altered air-fall tuff from prospect pit.	
BH-4	Jun 8, 1989	Vein system in adit, N 20 E, 20-25 W. Abundant sub-parallel qtz. veins with some drusy cavities. Veins in shallow zone approximately 2 m thk.	
BH-5	Jun 8, 1989	About 2 m above base of Cornwall's ash flow #4	
BH-6	Jun 8, 1989	Drusy quartz vn., near top of hill.	
BH-7	Jun 8, 1989	Silicified bx. zone, N 40 W, 45 SW, 10-25 cm thk.	
BH-8	Jun 8, 1989	N 15 W, 45 W zone of qtz. and Mn oxide veins.	
BH-9	Jun 8, 1989	Tramps Mine. 75 m N 35 W from portal. Vn. N 30 W, 65 W, 6-10 cm thick.	
BH-10	Jun 8, 1989	Tramps Mine. 85 m N 35 W from portal. Shear zone with silica N 40 W, 35 W.	
BH-11	Jun 8, 1989	Tramps Mine. Vein at inclined stope 22 m N 75 E of Y in adit. Loose rock from ore chute.	
BH-12	Jun 8, 1989	Breccia vein across from chute at incline, N 35 W, 75 W, 30 cm thick. Assoc. with sub-parallel veins in 2 m thk. zone.	
BH-13	Jun 8, 1989	2 cm white chalcedony vein in altered tuff. N 15 E, 55 W. Tuff in this roadcut o/c is bleached and contains yellow to brown limonite. Approx. 30 ft. to NW is another vein, N-S, 35 W. Other orientations of qtz vns also present.	
BH-13A	Jun 28, 1989	Coarse qtz. vn. from same o/c which yielded BH-13.	
BH-14	Jun 8, 1989	1-2 cm bx. vein, irregular, predates qtz. veining. Same o/c as BH-13.	
BH-15	Jun 8, 1989	Propylitic alteration, including blue-grey chloride, in volcanic(?) rock cut by qtz.-ct. veins. Original Bullfrog Mine (OBM).	
BH-18	Jun 9, 1989	Altered rhyolite with abundant low angle qtz. veins approx. N 10 W, 32 W. OBM.	
BH-16	Jun 8, 1989	Hematite-rich rock with abund. qtz. vns. *OBM.*	
BH-19	Jun 9, 1989	Calcite vein from small pit (loose). OBM.	

SAMPLE NO	DATE TAKEN	DESCRIPTION	REMARKS
BH-17	Jun 8, 1989	Loose chunk of qtz.-adularia-ct. vein material cutting altered volcanic rock. OBM.	
BH-20	Jun 9, 1989	Qtz.-copper oxide vn. material with visible Au. Loose in small pit at OBM.	
BH-21	Jun 9, 1989	Unbleached grey brown rhyolite ash flow (Ransome's r8) with sparse veins. S end Ladd Mtn.	
BH-21-B	Jun 9, 1989	Bleached sample of same rock as BH-21.	
BH-22	Jun 9, 1989	0.5 cm thick qtz.-limonite vein on W side Ladd Mtn. near S end. Associated rhyolite is brown, silicified.	
BH-23	Jun 9, 1989	0.5 cm. thick qtz.-Mn oxide vn. on E side Ladd Mtn. near S end.	
BH-24	Jun 9, 1989	Silic. bx. in pink tuff. Ladd Mtn.	
BH-25	Jun 9, 1989	Pink tuff. Ladd Mtn.	
BH-26	Jun 9, 1989	Chip spl. across 6 m wide qtz.-ct. vn. in short cross cut 60 m above Tramps Mine haulage tunnel and overlooking Tiger Mine waste pile.	
BH-27	Jun 9, 1989	Bleached ash flow or welded air fall. Tramps Mine area.	
BH-28	Jun 9, 1989	Silicified ash flow adjacent to vein. Tramps Mine area.	
BH-29	Jun 9, 1989	Nelson vn., punky dark brown material (oxidized ct. ?). Tramps haulage adit.	
BH-29B	Jun 9, 1989	Altered country rock slivers in Nelson vein.	
BH-29V	Jun 9, 1989	Spl. of qtz vn. (Nelson vn.).	
BH-30	Jun 9, 1989	Ransome's r1, xl-rich, purple, banded. Locally chloritic. Bullfrog Mtn.	
BH-31	Jun 10, 1989	Qtz veins in r1, loose rock near top hill. Bullfrog Mtn.	
BH-32	Jun 10, 1989	Pinkish or purplish grey airfall with abundant lithic frags. Bullfrog Mtn.	

SAMPLE NO	DATE TAKEN	DESCRIPTION	REMARKS
BH-33	Jun 10, 1989	Lt. grey air-fall tuff. Bullfrog Mtn.	
BH-34	Jun 10, 1989	Ransome's r5(?) near base. Bullfrog Mtn.	
BH-34G	Jun 10, 1989	Ransome's r5 basal vitrophyre. Bullfrog Mtn.	
BH-35	Jun 10, 1989	Ransome's r3. Bullfrog Mtn.	
BH-36	Jun 10, 1989	Opaline silica vn. in Ransom's r4 near top Bullfrog Mtn.	
BH-37	Jun 10, 1989	Ransome's r5 top, vapor phase crystallization with abund. bronze mica. Bullfrog Mtn.	
BH-38	Jun 10, 1989	Ransome's t3. Bullfrog Mtn.	
BH-39	Jun 10, 1989	Pink tuff, devitrified welded air fall or ash flow. Bullfrog Mtn.	
BH-40	Jun 10, 1989	Blk. vitrophyre base of Ransom's r8. Bullfrog Mtn.	
BH-41	Jun 10, 1989	Ransome's r8, devitrified, just W of DVNM border. Bullfrog Mtn.	
BH-42	Jun 10, 1989	Opaline silica vns. in Ransome's r8. Bullfrog Mtn.	
BH-43	Jun 10, 1989	Ransome's r9 basal vitrophyre, brown with faintly chatoyant blue alt. fspar. xls.	
MS-1	Jun 9, 1989	Montgomery-Shoshone (M-S) glory hole. Qtz. veins in alt. ash flow.	
MS-2	Jun 9, 1989	Clay alteration, M-S glory hole.	
MS-3	Jun 9, 1989	Vein spl. from sheated zone of silica vns. approx. N 10 W, 80 E. S side of M-S glory hole.	
MS-4	Jun 9, 1989	Drusy qtz. vein with limonite & leached ct. M-S glory hole.	
MS-5	Jun 9, 1989	Altered rock. W side M-S glory hole.	

SAMPLE NO	DATE TAKEN	DESCRIPTION	REMARKS
MS-6	Jun 9, 1989	Basalt dike. M-S glory hole.	
GEXA-1	Jun 6, 1989	Dark grey silicified siltstone, grab. Mother Lode Prospect (ML) trench.	
GEXA-2	Jun 6, 1989	Sandstone(?) with interbedded siltstone. ML trench.	
GEXA-3	Jun 6, 1989	Altered rhyolite with qtz. phenos. ML trench.	
GEXA-4	Jun 6, 1989	Same as GEXA-3, but limonitic. ML trench.	
GEXA-5	Jun 6, 1989	Fault zone material, contains Mn oxide and opal. ML trench.	
GEXA-6	Jun 6, 1989	Sandstone(?), contains layers and clasts of siltstone. ML trench.	
GEXA-7	Jun 6, 1989	Lt. grey altered sandstone(?) or air-fall tuff(?). ML trench.	
GEXA-8	Jun 6, 1989	Mn oxide - rich pocket in white bleached rhyolitic rock with minor limonite. ML trench.	
GEXA-9	Jun 6, 1989	Irregular drusy qtz. vn. or bx. filling with late Mn ox. at contact between siltstone and sandstone. ML trench.	
GEXA-10	Jun 6, 1989	Nodule of silic. calcareous siltstone from same location as GEXA-9.	
GEXA-11	Jun 6, 1989	White nonwelded pumiceous air-fall tuff. Hill W of ML trench.	
GEXA-11A	Jun 6, 1989	Same as GEXA-11, but unique yellow color.	
GEXA-12	Jun 6, 1989	Altered qtz. latite from dump. Hill S of ML trench.	GEXA-12A is similar rock from lower dump.
GEXA-13	Jun 6, 1989	Irregular clay vein spl. from adit. Attitude variable. Thickness up to 3 m. Country rock is limestone. Hill S of ML trench.	
GEXA-14	Jun 6, 1989	Caliche above altered sandstone. ML trench, 35 m along E arm from center. S side arm. 1 m below original surface.	
GEXA-15	Jun 6, 1989	Caliche above altered rhyolite. ML trench 12 m along W arm on S side. 60 cm below original surface.	

SAMPLE NO	DATE TAKEN	DESCRIPTION	REMARKS
GEXA-16	Jun 6, 1989	5 cm thick caliche vein 1.5 m below original surface. ML trench, S arm trench, E side 8 m from center.	
GEXA-17	Jun 6, 1989	Altered tuff with no limonite. ML trench.	
GEXA-18	Jun 6, 1989	Bedded tuff with purple oxidized layers, E-W, 40 N. Hill W of ML trench.	
GEXA-19	Jun 6, 1989	Limonitic siltstone from dump of adit approx. 15 m to SE. SW of ML trench.	
GEXA-20	Jun 6, 1989	Unaltered sandstone. SE of ML trench.	
GEXA-21	Jun 6, 1989	Silicified cgl. or bx. Hill NW of ML trench.	
GEXA-22	Jun 6, 1989	Limonitic silic. bx. - both GEXA 21 & 22 are silic. bx. or cgl. which overlies grey to white airfall tuff. Near GEXA-21	
GEXA-23	Jun 6, 1989	Limonitic opalized airfall tuff from hill NW of ML trench. This hill is opalized, whereas area containing GEXA 21 & 22 is chalcedonic.	
GEXA-24	Jun 28, 1989	Alt rhyolite from ML trench, S wall, near W end of W arm.	
GEXA-25	Jun 28, 1989	Zone of silic. gravel or bx. just W of small trench. Zone trends NW. On hill SW of ML trench.	
GEXA-26	Jun 28, 1989	Opalized airfall. Hill SW of ML trench.	
GEXA-27	Jun 29, 1989	Surface caliche from drill road 1200 m SW of ML trench.	
GEXA-28	Jun 29, 1989	Brecciated limestone with ct. - silica veinlets. Hill SW of ML trench.	
GEXA-29	Jun 29, 1989	Brecciated limestone with ct.- silica veinlets. Near GEXA 28	
GEXA-30	Jun 29, 1989	Silicified limestone along major N 60 E, 60 N fault. Near GEXA 29.	
GEXA-31	Jun 29, 1989	Calcrete vein from silica in excavated notch. Along same fault as GEXA 30. Hill SW of ML trench.	
GEXA-32	Jun 29, 1989	Silica from notch. Same location as GEXA-31.	

SAMPLE NO	DATE TAKEN	DESCRIPTION	REMARKS
GEXA-33	Jun 29, 1989	Silicified conglomerate along same fault as GEXA-30. Hill SW of ML trench.	
GEXA-34	Jun 29, 1989	Gossan in Paleozoic rock from dump. Hill SW of ML trench.	
FC-1	Jun 29, 1989	Grab of limonitic bx. from outcrop along road in Fluorite Cyn. About 2 mi. SW of ML trench.	
GB-1	Jun 9, 1989	Gold Bar Mine. Country rock with minor veining. Loose from muck pile.	
GB-2	Jun 9, 1989	Altered country rock. Gold Bar Mine. Loose from muck pile.	
GB-3	Jun 9, 1989	Breccia of bleached rhyolite in drusy qtz.-cl. matrix. Gold Bar Mine. Loose from muck pile.	
GB-4	Jun 9, 1989	Basalt with fine-grained qtz. veins. Gold Bar Mine. Loose from muck pile.	
GB-5	Jun 9, 1989	Basalt with cl. veins. Gold Bar Mine. Loose from muck pile.	
W-1	Jun 26, 1989	Altered volcanic rock approx. 320 m ENE of Wingfield shaft. (Shaft is at end of loop road).	
W-2	Jun 27, 1989	Limonitic altered volcanic rock approx. 250 m NE of Wingfield shaft.	
W-3	Jun 27, 1989	Grab of 1-m-wide silic. zone approx. 220 m NE of Wingfield shaft, abund. limonite.	
W-4	Jun 27, 1989	Grab of qtz. vein in silic. volc. approx. 200 m NE of Wingfield shaft.	
W-5	Jun 27, 1989	Grab of qtz. vein approx. 25 m NE of Wingfield shaft. Vein is white fine-grained qtz. approx. 30 cm wide, trending N 25 E.	
W-6	Jun 27, 1989	Altered volcanic rock approx. 30 m WNW of Wingfield shaft, abund. limonite on fractures.	
W-7	Jun 27, 1989	Sulfide-rich breccia vn. from dump NW of Wingfield shaft.	
W-8	Jun 27, 1989	Altered rock approx. 100 m NW of Wingfield shaft.	
W-9	Jun 27, 1989	Grab of qtz. vein zone approx. 200 m NW of Wingfield shaft, trend N 25 E.	

SAMPLE NO	DATE TAKEN	DESCRIPTION	REMARKS
W-10	Jun 27, 1989	Altered volcanic rock and qtz. vein from Wingfield shaft Dump.	
W-11	Jun 27, 1989	Same as above.	
W-12	Jun 27, 1989	Same as above.	
YMSF1	Jun 26, 1989	Light tan pumice/bedded tuff from east side of Yucca Mountain in Abandoned Wash; contains bedded carbonate and opaline silica; pbt unit of Paintbrush Tuff.	
YMSF2	Jun 26, 1989	Light tan pumice/bedded tuff from vicinity of YMSF1; pbt unit of Paintbrush Tuff.	
YMSF3	Jun 26, 1989	Medium reddish-brown pumice/bedded tuff from vicinity of YMSF1 and 2; pbt unit of Paintbrush Tuff.	
YMSF4	Jun 26, 1989	Medium reddish-brown pumice/bedded tuff from vicinity of YMSF1, 2, and 3; pbt unit of Paintbrush Tuff.	
YMSF5	Jun 26, 1989	Medium reddish-tan vitric tuff with brown and black glass fragments; moderately welded; sparse alkali feldspar phenocrysts; lower unit of Tiva Canyon Member of Paintbrush Tuff.	
YMSF6	Jun 27, 1989	Grayish-brown breccia with angular pebble- to cobble-sized clasts; silicified with some caliche; in Topopah Spring Member of Paintbrush Tuff; located 20 m S5E of SC 66; up to 6 m wide and is a continuation of breccia zone at SC 66.	Location marked.
YMSF7	Jun 26, 1989	Medium reddish-brown devitrified tuff with alkali feldspar phenocrysts; some very large pumice fragments; eutaxitic structure; upper unit of Topopah Spring Member of Paintbrush Tuff.	
YMSF8	Jun 26, 1989	White to light tan caliche/bedded carbonate with opaline material from scraped area at top of Yucca Mountain.	
YMSF9	Jun 26, 1989	White to light tan bedded caliche/bedded carbonate and opaline material from scraped area at top of Yucca Mountain.	
YMSF10	Jun 26, 1989	Medium reddish-brown vitric tuff with alkali feldspar and minor green mineral phenocrysts; black glass fragments and oxybiotite; densely welded with eutaxitic structure; from scraped area top of Yucca Mountain.	
YMSF11	Jun 27, 1989	Medium reddish-brown densely welded, devitrified tuff from west side of Yucca Mountain; eutaxitic structure; alkali feldspar and minor green mineral phenocrysts; oxybiotite; uppermost unit of Topopah Spring Member of Paintbrush Tuff.	
YMSF12	Jun 27, 1989	White to light tan pumice/bedded tuff from west side of Yucca Mountain, above YMSF11.	
YMSF13	Jun 27, 1989	Medium orangish-brown pumice/bedded tuff with fragments of black volcanic glass; pbt unit of Paintbrush Tuff; stratigrapically above YMSF12.	
YMSF14	Jun 27, 1989	White to light gray pumice/bedded tuff with alkali feldspar and minor green mineral phenocrysts; pbt unit of Paintbrush Tuff; stratigraphically above YMSF13.	

SAMPLE NO	DATE TAKEN	DESCRIPTION	REMARKS
YMSF15	Jun 27, 1989	Reddish-brown pumice/bedded tuff with alkali feldspar phenocrysts and black volcanic glass; pbt unit of Paintbrush Tuff.	
YMSF16	Jun 27, 1989	Medium tan to orangish-tan bedded tuff composed mostly of pumice; pbt unit of Paintbrush Tuff; stratigraphically above YMSF15.	
YMSF17	Jun 27, 1989	White calcium carbonate deposit in tuff from trench cutting Solitario Canyon fault.	
WSF1-1	Jun 26, 1989	White to light tan tuff or shallow intrusive rock from vicinity of middle Wahmonie shaft at end of road NW of tank; feldspar phenocrysts; red brown glass fragments; intensely altered.	
WSF1-2	Jun 26, 1989	Light tan to dark orangish-brown volcanic rock from same location as WSF1-1; quartz and feldspar phenocrysts; intensely altered.	
GXSF1	Jun 28, 1989	Light gray to light tan iron oxide-stained tuff from Mother Lode trench wall; sparse quartz phenocrysts; argillically altered.	
GXSF2	Jun 28, 1989	Dark brown to medium orange to medium tan iron oxide-stained volcaniclastic rock from Mother Lode trench; highly altered.	
GXSF3	Jun 28, 1989	Dark brown to medium orangish-tan volcaniclastic rock from Mother Lode trench; altered.	
GXSF4	Jun 28, 1989	White to medium tan tuff from Mother Lode trench; quartz phenocrysts; highly altered.	
GXSF5	Jun 28, 1989	White vitric tuff from small hill SW of Mother Lode trench; quartz and alkali feldspar phenocrysts; highly altered.	
GXSF6	Jun 28, 1989	Medium reddish-brown vitric tuff from same hill as GXSF5; quartz and alkali feldspar phenocrysts; altered pumice fragments.	
GXSF7	Jun 28, 1989	Light yellow vitric tuff from same hill as GXSF5 and 6; quartz and alkali feldspar phenocrysts and pumice fragments; fragments of black volcanic glass; pumice fragments highly altered.	
GXSF8	Jun 28, 1989	White to light tan vitric (?) tuff from same hill as GXSF5, 6, and 7 with v. large pumice fragments; small quartz and alkali feldspar phenocrysts; altered.	
GXSF9	Jun 28, 1989	Colluvium from same hill as GXSF5, 6, 7, and 8; fragments of tuff in which phenocrysts and some of pumice fragments have been leached out; one tuff fragment exhibits slickensides.	
GXSF10	Jun 28, 1989	Light to dark gray breccia capping knob west of Mother Lode trench; breccia has angular clasts and is composed of a sedimentary unit which has been silicified.	
GXSF11	Jun 28, 1989	Dark brown to black argillite from vicinity of GXSF10.	
TRSF1	Jun 28, 1989	White tuff from vicinity of Tramps mine, Rhyolite area; alkali feldspar phenocrysts, lithic fragments, pyrite; silicified.	

SAMPLE NO	DATE TAKEN	DESCRIPTION	REMARKS
OBSF1	Jun 28, 1989	Light tan tuff from vicinity of Original Bullfrog mine; intensely altered.	
BOSF1	Jun 28, 1989	Light tan tuff from road cut north of Bond-Bullfrog mine; quartz and alkali feldspar phenocrysts; obsidian fragments; iron oxide staining; altered.	

APPENDIX B. CHEMICAL ANALYSES, IN PPM, OF SAMPLES FROM THE YUCCA MOUNTAIN ADDITION AND SURROUNDING MINING DISTRICTS

SAMPLE NO.	Ag	As	Au	Cu	Hg	Mo	Pb	Sb	Tl	Zn	Bi	Cd	Ga	Pd	Se	Te
YMSC 1	0.020	3.79	0.001	10.20	<0.099	2.380	3.740	<0.249	<0.497	22.20	<0.249	0.413	0.900	<0.497	<0.994	<0.497
YMSC 2	<0.015	<1.00	<0.0005	14.50	0.228	1.600	2.820	0.297	<0.500	21.00	<0.250	<0.100	0.616	<0.500	<0.999	<0.500
YMSC 2A†	0.036	<0.99	<0.0005	1.44	<0.099	0.472	1.890	<0.247	<0.494	26.40	<0.247	0.115	<0.494	<0.494	<0.987	<0.494
YMSC 3	0.025	<1.00	<0.0005	13.90	0.112	1.400	1.670	<0.251	<0.501	20.60	<0.251	<0.100	<0.501	<0.501	<1.000	<0.501
YMSC 4	0.028	5.52	0.002	10.90	<0.100	0.982	1.400	<0.251	<0.502	9.93	<0.251	0.202	<0.502	<0.502	<1.000	<0.502
YMSC 5A†	0.039	6.63	<0.0005	4.04	<0.098	0.487	1.090	<0.246	<0.491	4.66	<0.246	<0.098	<0.491	<0.491	<0.982	<0.491
YMSC 5B†	0.037	5.56	<0.0005	4.17	<0.098	0.316	1.200	0.259	<0.488	4.35	<0.244	<0.098	<0.488	<0.488	<0.976	<0.488
YMSC 5C	0.028	6.13	0.004	6.86	<0.105	0.213	1.900	<0.263	<0.526	5.31	<0.263	0.118	0.612	<0.526	<1.050	<0.526
YMSC 5H	0.022	3.97	0.002	7.98	<0.112	0.211	0.834	0.301	<0.561	2.78	<0.281	0.140	<0.561	<0.561	<1.120	<0.561
YMSC 6	0.023	<1.00	<0.0005	15.80	<0.100	1.650	2.420	0.294	<0.502	22.50	<0.251	<0.100	0.636	<0.502	<1.000	<0.502
YMSC 7	0.036	8.29	0.001	10.60	<0.101	1.070	7.650	<0.252	<0.505	22.40	<0.252	0.136	<0.505	<0.505	<1.000	<0.505
YMSC 7A†	0.040	9.00	0.001	3.71	<0.098	0.316	3.760	0.369	<0.492	10.20	<0.246	0.120	<0.492	<0.492	<0.984	<0.492
YMSC 8	0.031	7.70	0.001	9.28	<0.101	1.100	6.180	<0.252	<0.503	33.10	<0.252	<0.101	<0.503	<0.503	<1.000	<0.503
YMSC 9	0.034	3.14	0.001	12.60	<0.100	1.370	8.120	0.397	<0.501	33.70	<0.251	0.102	0.642	<0.501	<1.000	<0.501
YMSC 10	0.026	1.62	<0.0005	11.70	0.131	1.220	5.010	<0.250	<0.501	29.70	<0.250	0.108	0.633	<0.501	<1.000	<0.501
YMSC 11	0.021	1.08	<0.0005	14.30	<0.100	1.680	5.060	<0.251	<0.502	29.90	<0.251	<0.100	<0.502	<0.502	<1.000	<0.502
YMSC 12	0.023	<1.00	0.001	5.27	<0.100	0.551	4.890	<0.251	<0.501	24.90	<0.251	0.260	<0.501	<0.501	<1.000	<0.501
YMSC 12X	0.019	1.66	0.001	5.34	<0.100	0.789	10.100	<0.250	<0.500	34.30	<0.250	0.166	1.130	<0.500	<0.999	<0.500
YMSC 13	0.026	1.44	0.002	12.90	<0.100	1.670	7.270	<0.251	<0.501	32.40	<0.251	<0.100	<0.501	<0.501	<1.000	<0.501
YMSC 14	0.032	12.90	0.006	5.08	<0.109	0.286	1.260	<0.273	<0.546	18.00	<0.273	0.215	<0.546	<0.546	<1.090	<0.546
YMSC 14A†	0.042	11.10	0.003	3.56	<0.098	0.288	1.460	0.269	<0.492	20.10	<0.246	0.221	<0.492	<0.492	<0.984	<0.492
YMSC 14B	0.042	10.80	0.006	4.94	<0.096	0.734	1.890	0.328	<0.481	8.26	<0.240	0.241	<0.481	<0.481	<0.962	<0.481
YMSC 14C	0.367	1.36	<0.0005	2.59	<0.099	0.468	2.290	<0.246	<0.493	27.70	<0.246	0.134	0.515	<0.493	<0.985	<0.493
YMSC 14C*	0.520	1.53	0.003	3.77	<0.099	0.505	2.630	0.273	<0.496	35.60	<0.248	0.172	1.330	<0.489	<0.978	<0.496
YMSC 15	0.028	2.58	0.001	10.10	<0.100	1.420	9.070	<0.250	<0.500	35.20	<0.250	<0.100	<0.500	<0.500	<0.999	<0.500
YMSC 16	0.021	<1.00	<0.0005	5.64	<0.100	0.663	2.760	<0.250	<0.500	20.00	<0.250	0.101	0.517	<0.500	<0.999	<0.500
YMSC 17	0.052	4.73	<0.0005	15.00	<0.101	1.600	8.430	<0.251	<0.503	31.30	<0.251	<0.101	0.665	<0.503	<1.000	<0.503
YMSC 18	0.022	<1.00	<0.0005	12.00	<0.101	1.250	1.640	<0.251	<0.503	15.60	<0.251	0.109	0.620	<0.503	<1.000	<0.503
YMSC 19	0.025	<1.00	<0.0005	13.80	<0.101	1.410	2.630	<0.251	<0.503	19.00	<0.251	0.107	<0.503	<0.503	<1.000	<0.503
YMSC 20	0.027	3.94	0.001	5.13	<0.099	0.462	3.330	<0.248	<0.496	23.30	<0.248	0.115	0.592	<0.496	<0.992	<0.496
YMSC 21	0.021	<1.00	0.001	14.70	<0.100	1.430	3.280	0.257	<0.499	24.00	<0.250	<0.100	0.702	<0.499	<0.998	<0.499
YMSC 22	0.019	2.59	0.001	9.13	<0.100	1.120	20.300	0.323	1.840	63.60	3.190	0.263	1.400	<0.499	<0.998	<0.499
YMSC 22A†	0.032	2.88	0.008	2.57	<0.098	0.523	22.500	0.309	1.990	96.70	3.620	0.273	1.870	<0.488	<0.976	<0.488
YMSC 22S	0.019	3.01	<0.0005	8.79	<0.101	0.799	8.360	<0.252	<0.503	38.40	0.894	0.110	0.560	<0.503	<1.000	<0.503
YMSC 22SA†	0.022	3.43	0.001	0.89	<0.100	0.234	23.700	<0.249	<0.498	56.10	1.840	0.156	<0.498	<0.498	<0.996	<0.498
YMSC 23	0.034	1.40	0.002	15.50	<0.101	1.830	5.060	0.294	<0.503	27.80	<0.252	<0.101	<0.503	<0.503	<1.000	<0.503
YMSC 24	0.033	5.12	0.002	7.56	<0.101	0.495	0.859	<0.252	<0.504	13.90	<0.252	0.102	<0.504	<0.504	<1.000	<0.504
YMSC 24A†	0.029	6.45	<0.0005	2.74	<0.098	0.275	2.330	<0.245	<0.489	13.50	<0.245	0.101	<0.489	<0.489	<0.978	<0.489
YMSC 25	0.021	9.14	0.002	8.79	<0.103	0.650	2.370	<0.256	<0.513	13.20	<0.256	<0.103	<0.513	<0.513	<1.020	<0.513
YMSC 25A†	0.030	10.30	0.003	3.53	<0.098	0.411	3.480	0.269	<0.488	20.60	<0.244	0.105	<0.488	<0.488	<0.977	<0.488
YMSC 26	0.017	<1.00	<0.0005	15.20	<0.100	1.500	6.010	<0.250	<0.501	17.60	<0.250	<0.100	0.978	<0.501	<1.000	<0.501

* reanalysis of original sample
† analysis of resampled material

SAMPLE NO.	Ag	As	Au	Cu	Hg	Mo	Pb	Sb	Tl	Zn	Bi	Cd	Ga	Pd	Se	Te
YMSC 27	0.020	<1.00	<0.0005	13.20	<0.100	1.250	2.260	<0.250	<0.501	13.80	<0.250	<0.100	0.924	<0.501	<1.000	<0.501
YMSC 28	0.051	16.20	0.003	1.95	<0.101	0.138	2.380	<0.252	<0.504	4.09	<0.252	0.343	<0.504	<0.504	<1.000	<0.504
YMSC 28A†	0.052	6.58	0.002	2.00	<0.097	0.364	3.800	<0.243	<0.486	17.70	<0.243	0.159	<0.486	<0.486	<0.972	<0.486
YMSC 29	0.027	2.11	<0.0005	12.20	<0.100	1.080	2.210	<0.250	<0.501	26.90	<0.250	<0.100	0.837	<0.501	<1.000	<0.501
YMSC 30	0.028	5.16	0.003	8.48	<0.100	0.284	0.479	<0.250	<0.501	2.18	<0.250	<0.100	<0.501	<0.501	<1.000	<0.501
YMSC 31	0.020	10.40	0.001	9.60	<0.100	1.460	21.800	<0.251	0.580	59.60	0.614	0.133	1.770	<0.502	<1.000	<0.502
YMSC 31A†	0.027	1.77	0.002	1.92	<0.098	1.020	29.100	<0.246	<0.491	67.90	0.916	0.099	0.981	<0.491	<0.982	<0.491
YMSC 31B	0.041	26.70	<0.0005	1.44	<0.099	0.296	5.230	0.271	<0.497	4.71	0.334	0.105	1.320	<0.497	<0.993	<0.497
YMSC 32	0.020	<1.00	<0.0005	13.90	<0.100	1.480	2.130	<0.251	<0.501	31.80	<0.251	<0.100	0.719	<0.501	<1.000	<0.501
YMSC 33	<0.015	2.41	<0.0005	11.60	<0.100	1.080	1.210	<0.251	<0.502	31.80	<0.251	<0.100	0.743	<0.502	<1.000	<0.502
YMSC 34	0.037	16.00	0.001	8.85	<0.111	0.256	6.000	<0.278	<0.556	10.50	<0.278	0.120	0.783	<0.556	<1.110	<0.556
YMSC 34A†	0.039	17.90	0.002	7.32	<0.099	0.252	5.830	<0.247	<0.493	8.03	<0.247	0.105	<0.493	<0.493	<0.986	<0.493
YMSC 35	0.023	3.91	<0.0005	9.86	<0.101	0.906	2.610	<0.252	<0.503	22.80	<0.252	<0.101	1.110	<0.503	<1.000	<0.503
YMSC 36	0.042	11.90	<0.0005	6.15	<0.100	0.318	1.670	<0.251	<0.501	5.46	<0.251	0.102	0.632	<0.501	<1.000	<0.501
YMSC 36A†	0.029	16.10	0.001	5.28	<0.100	0.233	1.450	<0.249	<0.498	4.06	<0.249	<0.100	<0.498	<0.498	<0.995	<0.498
YMSC 37	0.029	3.64	<0.0005	10.80	<0.100	1.040	4.770	<0.250	<0.501	27.30	<0.250	0.146	0.730	<0.501	<1.000	<0.501
YMSC 38	0.049	4.45	0.001	9.73	<0.100	0.750	3.950	<0.251	<0.501	26.20	<0.251	0.147	0.652	<0.501	<1.000	<0.501
YMSC 39	0.031	3.03	<0.0005	9.88	<0.100	1.300	8.440	<0.250	<0.500	39.50	<0.250	<0.100	0.721	<0.500	<0.999	<0.500
YMSC 40	0.022	4.14	0.001	7.53	<0.101	0.929	6.300	<0.251	<0.503	36.00	<0.251	0.111	0.874	<0.503	<1.000	<0.503
YMSC 41	0.029	3.51	<0.0005	14.50	<0.100	1.410	6.610	<0.250	<0.500	27.40	<0.250	<0.100	0.943	<0.500	<1.000	<0.500
YMSC 42	0.026	7.79	0.003	6.03	<0.101	0.254	0.674	<0.251	<0.503	7.36	<0.251	<0.101	<0.503	<0.503	<1.000	<0.503
YMSC 42A†	0.050	12.30	0.001	7.82	<0.100	0.326	2.000	0.294	<0.499	11.90	<0.249	0.122	<0.499	<0.499	<0.997	<0.499
YMSC 43	0.026	1.97	<0.0005	13.50	<0.100	1.470	2.720	<0.250	<0.500	32.30	<0.250	0.146	0.839	<0.500	<1.000	<0.500
YMSC 44	0.032	4.12	0.001	6.41	<0.100	0.258	0.567	<0.251	<0.501	6.67	<0.251	<0.100	<0.501	<0.501	<1.000	<0.501
YMSC 45	0.114	7.40	0.001	6.90	<0.101	0.223	1.560	0.304	<0.505	8.47	<0.252	0.143	0.875	<0.505	<1.000	<0.505
YMSC 45A†	0.092	7.28	<0.0005	3.19	0.141	0.268	1.050	0.332	<0.499	11.20	<0.249	<0.100	<0.499	<0.499	<0.997	<0.499
YMSC 46A	0.017	<1.00	0.001	4.47	<0.100	0.407	4.920	<0.250	<0.500	12.00	<0.250	0.155	<0.500	<0.500	<1.000	<0.500
YMSC 47	<0.015	<1.00	<0.0005	10.90	<0.100	1.140	1.430	<0.250	<0.501	19.50	<0.250	<0.100	0.958	<0.501	<1.000	<0.501
YMSC 48	0.019	<1.00	<0.0005	13.00	<0.100	1.530	1.250	<0.251	<0.501	25.80	<0.251	<0.100	0.862	<0.501	<1.000	<0.501
YMSC 48C	0.027	1.33	0.001	10.20	<0.100	1.180	1.180	<0.250	<0.501	30.70	<0.250	<0.100	1.000	<0.501	<1.000	<0.501
YMSC 49	0.028	4.41	<0.0005	10.50	<0.100	1.110	7.020	<0.251	<0.502	17.30	<0.251	<0.100	0.737	<0.502	<1.000	<0.502
YMSC 49C	0.022	2.47	<0.0005	11.20	<0.100	2.710	3.690	<0.250	<0.500	21.00	<0.250	<0.100	1.450	<0.500	<0.999	<0.500
YMSC 50S	0.029	2.12	<0.0005	17.40	<0.101	2.390	4.190	0.275	<0.505	18.60	<0.252	<0.101	1.220	<0.505	<1.000	<0.505
YMSC 50SA†	0.049	1.80	<0.0005	3.28	<0.100	1.160	5.310	0.340	<0.499	21.90	<0.249	<0.100	0.819	<0.499	<0.997	<0.499
YMSC 50CS	0.021	5.52	<0.0005	7.88	<0.101	0.234	0.743	<0.252	<0.504	5.18	<0.252	<0.101	0.561	<0.504	<1.000	<0.504
YMSC 50CSA†	0.032	6.33	<0.0005	6.52	<0.100	0.474	2.130	<0.250	<0.499	13.90	<0.250	0.102	0.756	<0.499	<0.998	<0.499
YMSC 50CS2	0.024	1.81	<0.0005	11.60	<0.100	1.040	1.240	<0.251	<0.501	20.00	<0.251	<0.100	1.010	<0.501	<1.000	<0.501
YMSC 50CS2A†	0.042	2.71	0.001	3.56	<0.099	0.365	2.280	0.251	<0.497	20.90	<0.248	<0.099	<0.497	<0.497	<0.993	<0.497
YMSC 51	0.035	1.65	0.001	12.20	<0.100	1.210	1.550	0.321	<0.502	19.30	<0.251	<0.100	0.717	<0.502	<1.000	<0.502
YMSC 52	<0.015	1.71	<0.0005	10.50	<0.100	2.870	109.000	0.274	<0.501	39.20	4.320	<0.100	1.280	<0.501	<1.000	<0.501

† analysis of resampled material

SAMPLE NO.	Ag	As	Au	Cu	Hg	Mo	Pb	Sb	Tl	Zn	Bi	Cd	Ga	Pd	Se	Te
YMSC 52A†	0.028	1.92	<0.0005	2.41	<0.099	4.030	145.000	0.300	<0.497	59.30	6.100	<0.099	1.930	<0.497	<0.993	<0.497
YMSC 53	0.017	1.47	<0.0005	9.73	<0.100	1.050	2.890	<0.250	<0.500	27.80	<0.250	<0.100	0.668	<0.500	<0.999	<0.500
YMSC 54	<0.015	1.38	<0.0005	9.24	<0.100	0.977	0.774	<0.250	<0.501	23.10	<0.250	<0.100	0.661	<0.501	<1.000	<0.501
YMSC 55	0.022	2.02	<0.0005	3.52	<0.100	0.266	1.460	<0.250	<0.501	14.20	<0.250	0.109	<0.501	<0.501	<1.000	<0.501
YMSC 56	0.025	3.11	<0.0005	7.55	<0.100	1.030	15.300	<0.251	<0.502	29.20	<0.251	0.108	1.620	<0.502	<1.000	<0.502
YMSC 57	0.023	1.34	<0.0005	7.16	<0.100	4.490	10.200	<0.251	<0.502	35.50	<0.251	<0.100	2.650	<0.502	<1.000	<0.502
YMSC 58	0.029	2.80	<0.0005	11.80	<0.100	1.390	2.870	<0.251	<0.502	20.50	<0.251	<0.100	0.799	<0.502	<1.000	<0.502
YMSC 59	0.023	1.82	<0.0005	13.80	<0.100	1.900	2.240	<0.251	<0.502	13.00	<0.251	0.122	0.790	<0.502	<1.000	<0.502
YMSC 60	0.042	5.78	<0.0005	18.20	<0.100	1.840	5.520	0.255	<0.501	23.00	<0.250	<0.100	0.653	<0.501	<1.000	<0.501
YMSC 61	0.020	3.41	<0.0005	10.30	<0.100	1.100	1.640	<0.251	<0.501	8.20	<0.251	<0.100	<0.501	<0.501	<1.000	<0.501
YMSC 62	0.025	2.15	0.001	12.10	<0.100	1.330	1.760	<0.251	<0.501	15.60	<0.251	<0.100	0.557	<0.501	<1.000	<0.501
YMSC 63	0.029	1.27	<0.0005	16.30	<0.100	1.660	1.160	0.287	<0.501	14.60	<0.250	<0.100	0.503	<0.501	<1.000	<0.501
YMSC 64	0.021	2.15	<0.0005	12.30	<0.100	1.250	9.190	<0.250	<0.500	19.10	<0.250	<0.100	0.801	<0.500	<1.000	<0.500
YMSC 65	<0.015	3.37	<0.0005	2.46	<0.097	1.550	7.950	<0.244	<0.487	30.40	<0.244	<0.097	<0.487	<0.487	<0.975	<0.487
YMSC 66	0.026	2.56	0.026	2.07	<0.097	1.980	6.260	<0.242	<0.483	24.80	<0.242	<0.097	<0.483	<0.483	<0.966	<0.483
YMSC 66*	0.025	1.57	0.003	2.35	<0.096	0.619	6.210	<0.241	<0.481	28.60	<0.241	<0.096	0.702	<0.481	<0.962	<0.481
YMSC 66A†	0.018	1.60	<0.0005	1.71	<0.100	0.776	6.350	0.305	<0.500	26.50	<0.250	<0.100	<0.500	<0.500	<0.999	<0.500
YMSC 66A*	0.020	1.17	0.002	1.43	<0.099	0.644	5.440	<0.247	<0.494	22.50	<0.247	<0.099	<0.494	<0.494	<0.988	<0.494
YMSC 67	0.026	6.87	0.001	1.88	<0.099	0.639	3.330	<0.248	<0.496	10.90	<0.248	0.126	0.651	<0.496	<0.992	<0.496
YMSC 68	<0.015	4.95	0.001	1.48	<0.097	0.670	4.480	0.514	<0.487	7.58	<0.243	0.642	<0.487	<0.487	<0.974	<0.487
YMSC 69	0.028	12.00	0.001	2.47	<0.100	0.909	6.080	<0.249	<0.498	18.90	<0.249	0.115	0.626	<0.498	<0.996	<0.498
YMSC 69*	0.021	3.42	0.002	2.30	0.110	0.575	7.120	0.348	<0.492	25.70	<0.246	<0.098	0.972	<0.492	<0.984	<0.492
YMSC 69A†	0.033	5.18	<0.0005	2.15	<0.100	0.672	6.810	<0.250	<0.500	22.50	<0.250	<0.100	<0.500	<0.500	<0.999	<0.500
YMSC 70	0.033	3.41	0.002	2.38	<0.096	2.020	6.070	<0.239	<0.479	24.70	<0.239	<0.096	0.587	<0.479	<0.958	<0.479
YMSC 71	0.030	3.11	0.002	2.94	<0.096	0.724	5.260	<0.240	<0.481	29.90	<0.240	0.135	0.528	<0.481	<0.962	<0.481
YMSC 72	0.079	1.27	0.001	2.18	<0.099	2.940	5.370	<0.248	<0.497	31.40	<0.248	<0.099	0.497	<0.497	<0.993	<0.497
YMSC 73	0.030	4.70	0.002	4.19	<0.097	1.090	5.450	<0.243	<0.485	27.30	<0.243	<0.097	<0.485	<0.485	<0.971	<0.485
YMSC 74	0.024	3.08	0.001	2.26	<0.096	2.970	6.970	0.794	<0.479	28.80	<0.239	<0.096	3.320	<0.479	<0.958	<0.479
YMSC 75	0.025	4.10	0.001	3.12	<0.096	1.780	7.240	0.239	<0.478	28.20	<0.239	0.126	0.627	<0.478	<0.955	<0.478
YMSC 76	0.030	3.38	0.002	4.53	<0.098	2.280	8.440	0.547	0.583	34.30	<0.245	<0.098	0.860	<0.489	<0.978	<0.489
YMSC 77	0.035	2.04	0.001	2.73	<0.096	1.230	1.370	<0.239	<0.479	27.70	<0.239	0.114	0.806	<0.479	<0.958	<0.479
YMSC 78	0.043	3.27	0.001	2.73	<0.100	2.130	1.980	0.351	<0.498	44.30	<0.249	0.156	0.970	<0.498	<0.996	<0.498
YMSC 79	0.020	<0.99	0.001	1.30	<0.099	2.100	2.040	0.278	<0.496	17.30	<0.248	0.126	0.882	<0.496	<0.992	<0.496
YMSC 80	0.028	2.18	<0.0005	2.51	<0.099	1.650	2.030	1.510	<0.496	31.90	<0.248	0.141	0.832	<0.496	<0.991	<0.496
YMSC 81	0.025	1.33	0.001	1.29	<0.099	1.590	1.530	<0.247	<0.494	19.20	<0.247	<0.099	0.677	<0.494	<0.987	<0.494
YMSC 81*	<0.015	<0.99	<0.0005	0.87	<0.099	0.351	1.650	<0.247	<0.493	17.30	<0.247	<0.099	0.553	<0.493	<0.986	<0.493
YMSC 82	0.024	2.18	0.001	1.47	<0.097	1.560	1.410	<0.242	<0.483	25.90	<0.242	<0.097	0.821	<0.483	<0.966	<0.483
YMSC 83	0.022	<0.98	0.001	1.21	<0.097	1.800	1.610	<0.244	<0.487	13.30	<0.244	<0.097	0.649	<0.487	<0.975	<0.487
YMSC 84	0.039	5.21	0.001	2.93	<0.096	1.300	6.670	<0.241	0.696	27.50	<0.241	<0.096	<0.482	<0.482	<0.963	<0.482
YMSC 85	0.034	6.35	0.005	2.82	0.360	<0.099	2.840	<0.247	0.969	7.52	0.289	0.433	0.728	<0.494	<0.988	<0.494

* reanalysis of original sample

† analysis of resampled material

SAMPLE NO.	Ag	As	Au	Cu	Hg	Mo	Pb	Sb	Tl	Zn	Bi	Cd	Ga	Pd	Se	Te
YMSC 85*	0.051	7.12	0.005	3.58	<0.099	0.165	3.100	<0.248	0.683	7.86	<0.248	0.475	0.858	<0.495	<0.990	<0.495
YMSC 85*	0.092	7.74	0.005	3.91	<0.098	0.191	3.030	0.370	0.713	7.55	<0.245	0.487	1.180	<0.489	<0.978	<0.489
YMSC 86	<0.015	1.98	0.002	1.86	<0.100	0.284	5.400	<0.249	<0.498	28.90	<0.249	<0.100	0.715	<0.498	<0.995	<0.498
YMSC 87	<0.015	3.06	<0.0005	0.59	0.186	0.144	2.330	<0.245	<0.490	15.00	0.353	<0.098	0.735	<0.490	<0.980	<0.490
YMSC 88	0.017	3.94	<0.0005	2.83	0.105	0.324	1.670	0.256	<0.499	15.00	0.993	0.145	1.750	<0.499	<0.998	<0.499
YMSC 89	0.021	1.71	<0.0005	2.03	<0.096	0.820	4.460	<0.241	<0.482	12.70	<0.241	<0.096	1.010	<0.482	<0.963	<0.482
YMSC 90	<0.015	1.16	<0.0005	1.33	0.126	0.899	2.660	<0.246	<0.492	10.90	<0.246	<0.098	0.761	<0.492	<0.984	<0.492
YMSC 91	<0.015	<0.99	0.001	1.06	<0.100	0.414	1.070	<0.247	<0.493	27.80	<0.247	0.270	0.559	<0.493	<0.986	<0.493
YMSC 92	<0.015	<0.98	0.001	0.97	<0.097	0.614	3.320	<0.244	0.908	12.60	0.948	<0.097	0.847	<0.487	<0.975	<0.487
YMSC 93	<0.014	<0.97	0.001	0.97	<0.097	0.156	2.350	<0.241	<0.483	17.60	<0.241	<0.097	0.947	<0.483	<0.965	<0.483
YMSC 94	<0.015	1.16	0.001	1.86	<0.098	0.473	6.340	<0.244	<0.489	38.20	<0.244	0.170	0.672	<0.489	<0.978	<0.489
YMSC 95	<0.015	1.55	<0.0005	1.25	<0.100	0.252	1.670	<0.250	<0.500	19.90	<0.250	<0.100	1.000	<0.500	<0.999	<0.500
YMSC 96	0.029	5.82	0.005	4.80	<0.100	0.163	1.590	0.440	<0.499	9.22	<0.250	<0.100	0.723	<0.499	<0.998	<0.499
YMSC 96*	0.035	5.07	0.003	4.03	<0.099	0.182	1.490	<0.247	<0.494	6.34	<0.247	<0.099	0.650	<0.494	<0.987	<0.494
YMSC 97	0.040	6.33	0.003	3.22	<0.970	0.109	1.130	0.348	<0.485	6.62	<0.242	<0.097	0.759	<0.485	<0.970	<0.485
YMPG 1	0.033	1.46	0.001	19.10	<0.101	2.230	7.140	<0.251	<0.503	27.60	<0.251	<0.101	<0.503	<0.503	<1.000	<0.503
YMPG 2	0.029	1.29	<0.0005	14.50	<0.100	1.520	7.430	<0.251	<0.502	24.20	<0.251	<0.100	0.570	<0.502	<1.000	<0.502
YMPG 3	0.028	<1.01	<0.0005	7.00	<0.101	0.878	5.150	<0.253	<0.506	26.70	<0.253	0.112	0.557	<0.506	<1.010	<0.506
YMPG 3A	0.031	1.30	<0.0005	7.14	<0.100	0.820	4.880	<0.250	<0.501	27.20	<0.250	0.127	0.642	<0.501	<1.000	<0.501
YMPG 4	0.028	1.37	<0.0005	6.71	<0.100	0.761	7.300	<0.250	<0.500	28.00	<0.250	0.115	0.744	<0.500	<1.000	<0.500
YMPG 5	0.027	3.64	<0.0005	10.40	<0.100	0.997	8.680	<0.250	<0.500	38.00	<0.250	0.105	0.881	<0.500	<1.000	<0.500
YMPG 6	0.026	3.54	<0.0005	14.20	<0.100	1.630	8.890	0.295	<0.501	32.00	<0.251	0.115	<0.501	<0.501	<1.000	<0.501
YMPG 7	0.023	1.88	<0.0005	14.90	<0.100	1.750	7.180	0.258	<0.500	25.10	<0.250	<0.100	<0.500	<0.500	<1.000	<0.500
YMPG 7*	0.027	2.08	<0.0005	15.30	<0.100	1.830	7.340	<0.250	<0.501	26.30	<0.250	<0.100	<0.501	<0.501	<1.000	<0.501
YMPG 8	0.020	2.09	<0.0005	11.70	<0.100	1.480	5.900	0.272	<0.501	23.60	<0.250	0.105	<0.501	<0.501	<1.000	<0.501
YMPG 9	0.036	1.65	<0.0005	21.10	<0.100	2.150	6.160	0.407	<0.501	27.30	<0.251	<0.100	0.556	<0.501	<1.000	<0.501
YMPG 10	0.026	3.06	<0.0005	10.70	<0.100	1.040	5.170	<0.251	<0.501	23.70	<0.251	<0.100	0.631	<0.501	<1.000	<0.501
YMPG 11	0.028	1.37	<0.0005	13.20	<0.100	1.470	6.570	<0.251	<0.501	22.40	<0.251	<0.100	<0.501	<0.501	<1.000	<0.501
YMPG 12	0.027	1.32	<0.0005	15.00	0.102	1.660	6.950	<0.251	<0.502	23.30	<0.251	<0.100	0.786	<0.502	<1.000	<0.502
YMPG 13	0.019	1.19	<0.0005	14.10	<0.100	1.390	5.270	<0.250	<0.501	24.90	<0.250	<0.100	<0.501	<0.501	<1.000	<0.501
YMPG 14	0.022	3.86	0.002	10.20	<0.101	0.949	12.300	<0.252	<0.504	31.90	<0.252	0.119	1.320	<0.504	<1.000	<0.504
YMPG 15	0.024	1.60	<0.0005	9.58	<0.100	0.996	8.030	<0.250	<0.500	23.30	<0.250	<0.100	1.040	<0.500	<1.000	<0.500
YMPG 16	0.021	2.22	0.002	6.78	<0.100	0.809	5.330	<0.251	<0.502	23.80	<0.251	0.121	0.719	<0.502	<1.000	<0.502
YMPG 17	0.035	6.23	0.002	9.97	0.106	0.578	2.310	<0.252	<0.504	14.70	<0.252	0.120	0.807	<0.504	<1.000	<0.504
YMPG 18	0.022	1.98	0.006	9.84	<0.100	1.160	8.820	<0.250	<0.501	29.30	<0.250	<0.100	0.878	<0.501	<1.000	<0.501
YMPG 18A†	<0.015	1.72	0.004	1.27	<0.097	0.417	7.480	<0.243	<0.486	29.70	<0.243	<0.097	0.675	<0.486	<0.973	<0.486
YMPG 19	0.017	2.40	0.003	4.15	<0.100	0.220	2.540	<0.250	<0.500	14.30	<0.250	0.130	0.545	<0.500	<1.000	<0.500
YMPG 19A†	0.018	3.25	0.001	2.14	<0.096	0.318	3.390	<0.240	<0.481	22.10	<0.240	<0.096	<0.481	<0.481	<0.962	<0.481
YMPG 20	0.036	2.01	0.001	8.20	<0.100	0.933	5.470	<0.251	0.659	30.50	<0.251	0.114	0.891	<0.501	<1.000	<0.501
YMPG 21	0.030	3.61	<0.0005	6.08	<0.101	0.670	3.950	<0.251	0.565	25.40	<0.251	0.127	0.719	<0.503	<1.000	<0.503
YMPG 22	0.037	4.99	<0.0005	15.70	<0.100	1.780	6.370	0.477	<0.501	29.10	<0.250	<0.100	0.779	<0.501	<1.000	<0.501

* reanalysis of original sample
† analysis of resampled material

SAMPLE NO.	Ag	As	Au	Cu	Hg	Mo	Pb	Sb	Tl	Zn	Bi	Cd	Ga	Pd	Se	Te
YMPG 23	0.032	1.92	<0.0005	15.90	<0.100	1.690	4.790	0.413	<0.501	30.30	<0.250	<0.100	0.858	<0.501	<1.000	<0.501
YMPG 24	0.018	13.20	0.004	5.12	<0.097	0.211	0.849	<0.242	<0.484	3.59	<0.242	<0.097	<0.484	<0.484	<0.969	<0.484
YMDD 1	0.027	1.01	<0.0005	9.25	0.102	1.020	1.250	0.365	<0.501	36.70	<0.250	<0.100	0.961	<0.501	<1.000	<0.501
YMDD 2	0.028	3.29	0.001	9.35	<0.100	0.837	1.360	<0.251	<0.501	24.80	<0.251	<0.100	0.685	<0.501	<1.000	<0.501
YMDD 3	0.065	4.01	0.003	6.00	<0.104	0.174	0.806	<0.259	0.958	5.23	<0.259	0.119	0.760	<0.518	<1.030	<0.518
YMDD 3A†	0.050	10.30	0.009	11.10	<0.100	0.309	0.962	<0.250	<0.499	4.15	<0.250	0.136	<0.499	<0.499	<0.998	<0.499
YMDD 4	0.032	3.57	0.001	14.00	<0.101	1.010	3.850	<0.252	<0.503	32.10	<0.252	0.111	0.645	<0.503	<1.000	<0.503
YMDD 5	0.076	3.81	0.001	18.80	<0.101	1.570	6.030	0.315	<0.505	26.10	<0.252	0.119	0.769	<0.505	<1.000	<0.505
YMDD 5A†	0.024	2.98	<0.0005	2.72	<0.100	0.766	7.490	<0.249	<0.499	32.00	<0.249	<0.100	<0.499	<0.499	<0.997	<0.499
YMDD 6	0.031	3.98	0.002	12.80	<0.100	1.270	6.270	0.260	<0.502	29.30	<0.251	0.110	0.812	<0.502	<1.000	<0.502
YMDD 7	0.031	2.50	0.002	9.41	<0.100	1.340	6.150	<0.250	0.633	42.70	<0.250	<0.100	0.774	<0.501	<1.000	<0.501
YMDD 8	0.035	3.31	<0.0005	12.20	<0.100	1.120	6.540	0.322	<0.502	24.80	<0.251	0.110	0.908	<0.502	<1.000	<0.502
YMDD 9	0.033	3.24	0.002	15.70	<0.100	1.660	7.060	<0.250	<0.500	31.20	<0.250	<0.100	0.764	<0.500	<1.000	<0.500
YMDD 10	0.042	3.48	0.002	19.00	0.137	2.100	5.600	0.387	<0.501	29.20	<0.251	0.100	1.010	<0.501	<1.000	<0.501
YMDD 11	0.040	4.26	0.001	8.65	<0.101	0.810	3.300	0.293	<0.503	16.20	<0.251	0.111	1.040	<0.503	<1.000	<0.503
YMDD 12	0.024	5.97	0.001	9.92	<0.100	1.020	1.230	0.399	<0.501	34.90	<0.251	<0.100	0.953	<0.501	<1.000	<0.501
YMDD 13	0.029	1.52	<0.0005	13.40	<0.100	1.470	6.260	0.307	<0.500	28.70	<0.250	<0.100	0.733	<0.500	<1.000	<0.500
YMDD 14	<0.015	1.32	<0.0005	13.40	0.110	1.360	1.790	<0.250	<0.500	20.10	<0.250	<0.100	1.020	<0.500	<1.000	<0.500
YMDD 15	0.019	3.81	0.001	6.65	<0.100	0.624	1.300	<0.251	<0.502	24.30	<0.251	<0.100	0.740	<0.502	<1.000	<0.502
YMDD 16	0.027	2.25	<0.0005	15.80	<0.100	2.350	4.090	0.398	<0.501	21.70	<0.251	<0.100	1.390	<0.501	<1.000	<0.501
YMDD 17	0.041	8.41	0.002	7.72	<0.101	0.301	4.710	<0.252	<0.503	7.16	<0.252	0.116	0.716	<0.503	<1.000	<0.503
YMDD 17A†	0.022	1.96	<0.0005	1.46	<0.099	0.797	11.700	<0.248	<0.496	19.00	1.370	0.108	<0.496	<0.496	<0.991	<0.496
YMDD 18	0.029	7.15	<0.0005	10.10	<0.101	1.020	1.860	0.253	<0.505	18.30	<0.253	<0.101	1.000	<0.505	<1.010	<0.505
YMDD 19	0.026	1.44	<0.0005	13.00	<0.100	1.360	1.800	<0.251	<0.502	31.00	<0.251	<0.100	0.866	<0.502	<1.000	<0.502
YMDD 20A	<0.015	3.50	<0.0005	11.70	<0.100	1.360	6.030	0.366	<0.502	32.70	<0.251	<0.100	0.757	<0.502	<1.000	<0.502
YMMD 20B	0.015	4.94	<0.0005	9.39	<0.100	2.190	2.510	0.513	<0.501	17.60	<0.250	<0.100	1.350	<0.501	<1.000	<0.501
YMMD 21	0.027	8.20	0.003	11.60	<0.104	0.316	0.840	0.543	<0.518	4.67	<0.259	<0.104	0.736	<0.518	<1.030	<0.518
YMDD 21A†	0.020	7.05	0.001	4.77	<0.098	0.380	3.110	0.486	<0.490	11.90	<0.245	<0.098	0.910	<0.490	<0.979	<0.490
YMMD 22	0.017	1.11	<0.0005	11.40	<0.100	1.260	1.580	0.476	<0.500	19.70	<0.250	0.133	1.040	<0.500	<1.000	<0.500
YMMD 23A	0.034	1.06	<0.0005	17.30	<0.100	1.860	2.250	0.557	<0.502	17.30	<0.251	0.183	1.260	<0.502	<1.000	<0.502
YMDD 23B	0.016	<1.00	0.001	3.46	<0.101	0.487	2.730	0.608	<0.504	20.30	1.220	0.155	2.260	<0.504	<1.000	<0.504
YMDD 23C†	0.030	1.61	<0.0005	1.65	<0.098	0.579	3.660	<0.245	<0.490	19.90	<0.245	0.172	<0.490	<0.490	<0.980	<0.490
YMDD 24	0.027	1.04	<0.0005	11.40	<0.100	1.210	1.460	0.563	<0.501	18.80	<0.250	0.119	1.110	<0.501	<1.000	<0.501
YMDD 25	0.026	1.39	<0.0005	12.20	0.150	1.250	2.910	0.729	<0.501	14.90	<0.251	<0.100	0.995	<0.501	<1.000	<0.501
YMDD 25A†	0.028	21.50	<0.0005	2.23	<0.099	0.648	75.900	0.380	<0.497	28.80	0.647	0.114	<0.497	<0.497	<0.994	<0.497
YMDD 26	0.029	1.47	<0.0005	17.10	<0.100	1.980	5.390	0.638	<0.501	32.00	<0.251	<0.100	0.848	<0.501	<1.000	<0.501
YMDD 27	0.035	2.01	<0.0005	15.70	<0.100	2.010	5.200	0.544	<0.501	36.10	<0.251	<0.100	0.963	<0.501	<1.000	<0.501
YMDD 28	0.029	<1.00	<0.0005	11.80	<0.100	1.290	1.470	0.433	<0.500	14.10	<0.250	0.101	1.040	<0.500	<1.000	<0.500
YMDD 29	0.027	2.83	<0.0005	10.20	<0.100	1.110	1.780	0.440	<0.501	19.90	<0.251	0.104	0.924	<0.501	<1.000	<0.501
YMDD 30	0.037	2.41	<0.0005	9.90	<0.100	1.020	2.080	0.426	<0.500	23.10	<0.250	0.143	1.020	<0.500	<1.000	<0.500

† analysis of resampled material

SAMPLE NO.	Ag	As	Au	Cu	Hg	Mo	Pb	Sb	Tl	Zn	Bi	Cd	Ga	Pd	Se	Te
YMDD 31	0.026	5.61	0.001	8.64	<0.100	0.715	1.340	0.517	<0.502	8.32	<0.251	0.113	0.928	<0.502	<1.000	<0.502
YMDD 32	0.022	7.81	0.002	6.10	<0.100	0.405	1.400	0.305	<0.502	4.22	<0.251	<0.100	0.911	<0.502	<1.000	<0.502
YMDD 34	0.019	3.14	0.002	9.33	<0.100	1.820	2.540	0.352	<0.500	17.30	<0.250	<0.100	1.150	<0.500	<1.000	<0.500
YMDD 35	0.029	1.32	0.001	14.60	<0.100	1.740	2.760	0.556	<0.500	17.30	<0.250	<0.100	1.090	<0.500	<1.000	<0.500
YMDD 36	0.024	4.63	0.003	8.85	<0.100	0.728	3.860	0.459	<0.501	13.60	<0.251	<0.100	1.150	<0.501	<1.000	<0.501
YMDD 36A	0.018	32.30	<0.0005	2.11	0.158	0.413	123.000	<0.245	<0.491	41.10	1.050	0.130	0.809	<0.491	<0.981	<0.491
YMDD 37	0.035	4.55	0.003	3.81	<0.099	1.740	6.820	<0.249	<0.497	26.00	<0.249	<0.099	<0.497	<0.497	<0.994	<0.497
YMDD 38	0.072	6.70	0.003	4.40	<0.097	0.744	4.570	0.251	<0.484	9.63	<0.242	<0.097	0.766	<0.484	<0.967	<0.484
YMDD 38*	<0.015	2.56	0.002	1.44	<0.097	0.835	6.930	<0.243	<0.487	33.80	<0.243	<0.097	<0.487	<0.487	<0.974	<0.487
YMDD 38A	0.016	<0.99	0.001	2.41	<0.099	0.835	8.230	<0.247	<0.493	32.80	<0.247	<0.099	0.629	<0.493	<0.986	<0.493
YMDD 39	0.084	3.22	<0.0005	6.56	<0.096	1.550	8.350	<0.239	<0.478	35.40	<0.239	<0.096	0.485	<0.478	<0.957	<0.478
YMDD 40	0.017	3.62	<0.0005	5.35	<0.096	1.470	7.370	<0.241	<0.482	30.20	<0.241	0.110	<0.482	<0.482	<0.964	<0.482
YMDD 41	0.024	3.08	0.001	5.07	<0.100	1.050	6.460	<0.249	<0.498	43.10	<0.249	0.128	0.504	<0.498	<0.995	<0.498
YMDD 42	0.020	2.19	<0.0005	1.56	<0.096	1.190	1.700	<0.240	<0.481	30.20	<0.240	<0.096	<0.481	<0.481	<0.962	<0.481
YMDD 43	<0.015	7.16	0.001	5.55	<0.100	0.221	0.912	<0.249	<0.498	13.10	<0.249	<0.100	<0.498	<0.498	<0.995	<0.498
YMDD 43*	0.021	8.77	<0.0005	5.92	0.099	0.142	0.971	<0.245	<0.489	9.25	<0.245	<0.098	<0.489	<0.489	<0.978	<0.489
YMDD 44	<0.015	1.72	<0.0005	1.45	<0.098	1.310	1.870	<0.245	<0.490	33.40	<0.245	<0.098	<0.490	<0.490	<0.980	<0.490
YMDD 45	0.022	8.84	0.004	7.08	<0.099	0.322	3.540	<0.247	<0.495	7.82	<0.247	0.158	<0.495	<0.495	<0.989	<0.495
YMDD 45A†	<0.015	6.68	0.001	4.05	<0.098	0.516	4.070	<0.246	<0.492	18.20	<0.246	<0.098	<0.492	<0.492	<0.983	<0.492
YMDD 46	0.020	4.37	0.001	2.42	<0.097	1.880	3.690	<0.242	<0.484	28.70	<0.242	<0.097	<0.484	<0.484	<0.968	<0.484
YMDD 47	<0.015	4.09	<0.0005	2.65	<0.097	1.390	8.720	<0.242	<0.484	40.90	<0.242	<0.097	<0.484	<0.484	<0.969	<0.484
YMDD 48	<0.014	5.23	0.001	2.81	<0.097	1.390	5.630	<0.242	<0.483	36.50	<0.242	<0.097	<0.483	<0.483	<0.966	<0.483
YMDD 49	0.017	2.87	<0.0005	4.81	<0.097	1.030	7.510	<0.243	<0.485	31.70	<0.243	<0.097	0.512	<0.485	<0.971	<0.485
YMDD 50	<0.015	1.92	<0.0005	2.40	<0.099	2.550	4.000	<0.247	<0.495	63.80	<0.247	<0.099	<0.495	<0.495	<0.989	<0.495
YMDD 51 A	<0.015	1.82	0.001	5.08	<0.099	0.995	3.030	<0.247	<0.494	15.50	<0.247	<0.099	0.764	<0.494	<0.988	<0.494
YMDD 51 B	<0.015	2.74	0.001	2.72	<0.098	2.020	1.980	<0.244	<0.489	14.90	<0.244	<0.098	0.868	<0.489	<0.978	<0.489
YMDD 52	0.019	3.71	0.001	4.26	<0.097	1.050	1.830	<0.242	<0.483	13.00	<0.242	0.097	0.783	<0.483	<0.966	<0.483
YMDD 53	0.015	9.41	0.003	17.90	0.116	0.499	1.060	<0.242	<0.483	12.00	<0.242	0.124	<0.483	<0.483	<0.966	<0.483
YMDD 54	0.027	1.57	0.001	3.94	<0.096	1.570	4.400	<0.239	<0.478	12.20	<0.239	<0.096	0.968	<0.478	<0.956	<0.478
YMDD 55 A	0.018	6.18	<0.0005	3.52	<0.096	1.040	1.970	<0.240	<0.480	28.50	<0.240	0.134	0.640	<0.480	<0.961	<0.480
YMDD 55 B	<0.014	1.28	0.001	3.89	<0.096	1.130	1.770	<0.240	<0.481	7.36	<0.240	<0.096	0.633	<0.481	<0.962	<0.481
YMDD 55 C	<0.015	7.75	0.001	3.25	<0.099	0.826	1.060	<0.247	<0.495	21.00	<0.247	<0.099	<0.495	<0.495	<0.989	<0.495
YMDD 56	0.015	9.26	<0.0005	3.14	<0.099	0.396	1.310	<0.249	<0.497	12.50	<0.249	<0.099	<0.497	<0.497	<0.994	<0.497
YMDD 56*	0.044	5.29	0.002	5.93	0.099	0.241	1.270	<0.239	<0.479	22.80	<0.239	<0.096	0.619	<0.479	<0.958	<0.479
YMDD 57	0.030	6.98	0.003	13.90	<0.097	0.762	1.800	<0.241	<0.483	16.40	<0.241	0.172	0.749	<0.483	<0.965	<0.483
YMDD 58	0.019	4.35	0.001	2.72	<0.095	0.860	0.856	<0.238	<0.477	6.27	<0.238	<0.095	<0.477	<0.477	<0.953	<0.477
YMDD 59	0.033	5.48	0.001	2.40	<0.097	0.397	3.380	<0.242	<0.484	22.50	<0.242	0.148	<0.484	<0.484	<0.967	<0.484
YMDD 60	0.022	1.81	0.001	3.20	<0.098	1.200	2.570	<0.245	<0.490	9.81	<0.245	0.107	0.656	<0.490	<0.979	<0.490
YMJT 1	<0.015	3.60	0.001	1.74	<0.100	0.170	28.700	<0.250	<0.500	22.00	<0.250	<0.100	0.519	<0.500	<0.999	<0.500
YMJT 2	0.016	2.01	0.001	1.55	<0.097	0.529	7.210	<0.241	<0.483	26.10	<0.241	0.136	0.622	<0.483	<0.965	<0.483

* reanalysis of original sample

† analysis of resampled material

SAMPLE NO.	Ag	As	Au	Cu	Hg	Mo	Pb	Sb	Tl	Zn	Bi	Cd	Ga	Pd	Se	Te
YMJT 3	0.021	5.59	0.001	6.36	<0.099	0.158	2.080	<0.246	<0.493	9.76	<0.246	0.137	0.501	<0.493	<0.985	<0.493
YMJT 4	<0.015	7.43	0.001	4.57	<0.099	0.141	0.824	<0.247	<0.493	4.40	<0.247	0.130	<0.493	<0.493	<0.986	<0.493
YMJT 5	<0.015	1.64	<0.0005	2.06	0.101	0.475	6.240	<0.242	<0.484	21.20	<0.242	<0.097	<0.484	<0.484	<0.969	<0.484
YMSF 6	0.015	2.29	<0.0005	1.46	<0.097	0.638	6.920	<0.243	<0.486	27.50	<0.243	<0.097	0.576	<0.486	<0.972	<0.486
BH 1	<0.015	4.97	0.001	1.34	<0.097	5.180	10.700	<0.243	<0.487	16.90	<0.243	<0.097	1.310	<0.487	<0.974	<0.487
BH 2	0.821	1.63	0.030	15.00	<0.096	6.120	5.220	<0.241	0.730	33.20	<0.241	0.172	<0.482	<0.482	<0.964	<0.482
BH 3	0.032	<0.96	0.017	0.92	<0.096	2.190	10.800	<0.239	<0.478	6.80	<0.239	<0.096	<0.478	<0.478	<0.956	<0.478
BH 4	5.610	<0.96	4.990	3.07	0.171	4.430	24.700	<0.240	<0.480	6.70	0.335	<0.096	<0.480	<0.480	<0.961	10.900
BH 5	0.171	7.32	0.098	1.84	<0.098	10.100	5.650	0.324	<0.489	10.40	<0.245	<0.098	<0.489	<0.489	<0.978	<0.489
BH 5**	0.179	84.50	0.113	3.11	0.114	5.130	6.560	2.920	<0.485	12.80	<0.242	<0.097	1.070	<0.485	<0.970	<0.485
BH 6	0.163	<0.99	0.189	1.95	<0.099	3.170	6.800	<0.248	<0.495	7.00	<0.248	<0.099	<0.495	<0.495	<0.990	<0.495
BH 7	0.356	2.47	0.110	2.52	<0.099	9.240	5.190	<0.248	<0.496	13.30	<0.248	<0.099	<0.496	<0.496	<0.991	<0.496
BH 8	0.268	3.15	0.144	1.53	1.430	8.960	10.200	<0.244	<0.488	20.40	<0.244	<0.098	0.759	<0.488	<0.977	<0.488
BH 8**	0.292	6.84	0.139	2.38	<0.099	4.440	14.900	0.562	<0.494	21.30	<0.247	<0.099	1.360	<0.494	<0.987	<0.494
BH 9	0.305	<0.96	0.150	2.14	0.186	12.600	0.620	<0.240	<0.480	4.30	<0.240	<0.096	<0.480	<0.480	<0.961	<0.480
BH 10	0.484	18.10	1.310	1.54	0.133	3.780	8.560	0.367	<0.488	75.70	<0.244	<0.098	0.542	<0.488	<0.976	<0.488
BH 11	0.046	5.88	0.023	1.76	<0.097	8.990	10.400	<0.241	<0.483	28.00	<0.241	<0.097	1.630	<0.483	<0.965	<0.483
BH 12	0.075	<0.96	0.047	1.63	<0.096	5.070	2.330	<0.241	<0.482	49.90	<0.241	<0.096	<0.482	<0.482	<0.963	<0.482
BH 13	0.032	6.30	0.005	1.83	<0.096	8.350	12.100	<0.240	<0.480	5.00	<0.240	<0.096	0.506	<0.480	<0.961	<0.480
BH 13A	0.223	24.30	0.014	3.33	0.107	2.350	21.800	1.370	<0.482	22.00	<0.241	<0.096	1.680	<0.482	<0.963	<0.482
BH 14	0.034	8.13	0.002	2.02	<0.099	2.480	9.370	0.314	<0.493	12.00	<0.247	<0.099	0.862	<0.493	<0.986	<0.493
BH 14**	0.069	19.00	0.004	3.28	<0.100	1.350	16.900	0.944	<0.499	13.00	<0.250	<0.100	1.570	<0.499	<0.998	<0.499
BH 15	0.464	2.16	0.020	27.90	<0.099	5.590	8.690	1.050	0.890	18.70	0.929	<0.099	<0.493	<0.493	<0.985	<0.493
BH 16	1.790	7.71	0.079	121.00	<0.099	4.480	8.120	1.970	0.766	16.90	1.290	<0.099	<0.494	<0.494	<0.988	<0.494
BH 18	3.860	11.70	0.023	63.30	<0.098	8.520	6.210	1.730	1.250	18.90	0.801	0.118	<0.490	<0.490	<0.980	5.020
BH 19	1.630	15.30	0.106	87.20	<0.098	3.180	3.350	3.360	0.530	28.90	<0.244	0.260	<0.488	<0.488	<0.976	<0.488
BH 20	1100.000	355.00	117.000	5160.00	<0.100	8.100	91.300	494.000	<0.500	26.60	19.100	1.420	<0.500	<0.500	<1.000	<0.500
BH 21	4.230	30.30	1.350	26.70	<0.098	5.490	9.340	4.890	<0.488	10.50	<0.244	<0.098	<0.488	<0.488	<0.977	<0.488
BH 21B	5.700	<0.98	0.171	34.20	<0.098	7.750	5.140	6.280	0.556	2.70	0.516	<0.098	<0.489	<0.489	<0.978	<0.489
BH 22	2.530	3.36	0.463	4.57	0.268	3.990	9.850	0.717	0.551	10.80	<0.244	<0.097	<0.487	<0.487	<0.975	<0.487
BH 23	1.090	5.73	0.060	7.28	<0.096	9.260	15.500	1.350	1.330	58.60	<0.241	0.213	<0.482	<0.482	<0.964	<0.482
BH 24	0.669	17.50	0.466	2.97	<0.097	6.260	7.310	3.190	0.556	15.80	0.298	<0.097	<0.486	<0.486	<0.973	<0.486
BH 25	0.417	<0.96	0.025	3.16	<0.096	4.810	6.670	0.628	0.509	4.40	<0.239	<0.096	<0.478	<0.478	<0.956	<0.478
BH 25**	0.090	4.30	0.012	2.55	<0.097	1.040	4.830	0.549	<0.484	5.90	<0.242	<0.097	1.080	<0.484	<0.969	<0.484
BH 26	0.678	<0.98	1.220	1.82	<0.098	3.960	1.680	<0.244	0.657	3.40	<0.244	<0.098	<0.488	<0.488	<0.976	<0.488
BH 27	0.258	4.46	0.003	2.67	<0.099	2.650	5.400	0.561	<0.493	6.00	<0.247	<0.099	1.000	<0.493	<0.986	<0.493
BH 28	1.290	26.00	0.300	4.14	<0.100	3.660	12.500	0.995	<0.498	19.80	<0.249	<0.100	0.648	<0.498	<0.996	<0.498
BH 29	0.170	44.00	0.087	3.35	1.080	2.450	10.000	1.190	<0.481	33.40	<0.241	<0.096	1.410	<0.481	<0.962	<0.481
BH 29B	0.370	32.50	0.466	3.27	1.220	2.980	6.810	1.190	<0.494	26.30	<0.247	0.100	1.160	<0.494	<0.987	<0.494

** reanalysis of hand sample

SAMPLE NO.	Ag	As	Au	Cu	Hg	Mo	Pb	Sb	Tl	Zn	Bi	Cd	Ga	Pd	Se	Te
BH 29V	0.412	5.74	0.421	2.70	<0.097	3.140	1.740	0.849	<0.487	11.90	<0.243	<0.097	1.010	<0.487	<0.974	<0.487
BH 29V**	0.949	2.43	1.520	2.68	<0.098	2.210	1.290	0.527	<0.489	7.50	<0.245	<0.098	0.530	<0.489	<0.978	<0.489
BH 30	0.089	9.01	0.012	4.22	<0.096	1.570	13.600	0.851	0.520	52.30	<0.241	0.109	5.370	<0.482	0.966	<0.482
BH 31	0.207	25.40	<0.0005	11.30	<0.099	3.670	12.100	2.100	<0.494	39.80	0.429	<0.099	1.830	<0.494	<0.988	0.587
BH 32	0.031	2.70	0.001	2.19	<0.099	0.670	8.040	0.783	<0.494	26.70	<0.247	0.147	2.510	<0.494	1.060	<0.494
BH 33	0.037	2.89	0.001	2.21	<0.097	1.190	12.000	0.844	<0.487	9.50	<0.244	<0.097	1.490	<0.487	<0.975	<0.487
BH 34	0.035	3.87	<0.0005	1.47	<0.097	0.990	9.900	0.451	<0.486	33.70	<0.243	<0.097	1.510	<0.486	<0.972	<0.486
BH 34G	0.044	1.87	<0.0005	2.22	<0.098	1.160	5.060	0.389	<0.490	11.40	<0.245	<0.098	1.540	<0.490	<0.979	<0.490
BH 35	0.053	9.16	<0.0005	1.82	<0.100	1.100	8.370	0.676	<0.500	19.60	<0.250	<0.100	2.000	<0.500	<1.000	<0.500
BH 37	0.059	15.80	<0.0005	2.43	<0.098	1.240	16.700	1.640	<0.492	64.00	<0.246	<0.098	3.170	<0.492	<0.983	<0.492
BH 36	<0.015	<0.97	0.001	3.59	0.106	8.780	53.000	<0.242	<0.485	48.90	<0.242	2.030	1.160	<0.485	<0.970	<0.485
BH 38	0.051	5.42	<0.0005	13.70	0.216	0.580	4.690	0.560	<0.483	39.90	<0.241	<0.097	1.920	<0.483	<0.965	<0.483
BH 39	0.852	4.23	1.050	2.74	<0.096	0.810	24.600	0.609	<0.482	7.40	<0.241	<0.096	1.930	<0.482	<0.964	<0.482
BH 39**	0.026	7.90	0.012	2.20	<0.097	1.900	15.300	0.519	<0.487	8.20	<0.243	<0.097	1.660	<0.487	<0.974	<0.487
BH 40	0.037	1.50	<0.0005	0.98	<0.097	0.760	5.690	0.290	<0.485	6.60	<0.242	<0.097	1.190	<0.485	<0.970	<0.485
BH 41	0.052	3.85	<0.0005	1.79	<0.098	1.860	6.620	0.737	<0.491	10.80	<0.246	<0.098	1.350	<0.491	<0.982	<0.491
BH 42	0.042	5.73	<0.0005	2.39	<0.098	1.070	15.600	0.594	<0.491	13.60	<0.245	<0.098	1.490	<0.491	1.030	<0.491
BH 43	0.034	2.41	<0.0005	0.86	<0.098	1.130	6.740	0.405	<0.488	8.20	<0.244	<0.098	1.550	<0.488	<0.977	<0.488
GEXA 1	0.190	121.00	0.031	4.10	<0.100	4.840	4.110	6.930	<0.500	33.80	<0.250	0.124	0.819	<0.500	1.010	<0.500
GEXA 2	0.165	122.00	0.029	4.25	<0.098	3.820	4.090	8.220	<0.491	33.50	<0.246	0.129	0.753	<0.491	<0.982	<0.491
GEXA 3	1.990	713.00	3.510	4.75	0.246	0.950	8.360	23.400	0.999	2.60	<0.243	<0.097	2.060	<0.485	<0.971	1.810
GEXA 4	0.081	521.00	0.048	7.37	0.405	2.390	7.110	19.700	<0.488	31.20	<0.244	<0.098	1.680	<0.488	1.660	<0.488
GEXA 5	3.870	3874.00	7.470	33.10	4.020	13.500	21.900	64.500	5.150	171.00	<0.243	0.378	0.993	<0.486	2.030	5.220
GEXA 6	0.305	550.00	0.783	10.00	0.188	2.190	17.900	23.300	1.270	87.50	<0.248	0.137	1.290	<0.496	1.160	0.585
GEXA 7	0.283	117.00	0.462	2.25	0.103	0.820	9.570	16.200	<0.500	4.50	<0.250	<0.100	1.280	<0.500	<1.000	0.701
GEXA 8	1.380	696.00	0.276	3.99	0.712	1.570	7.990	21.300	0.997	247.00	<0.242	0.109	1.310	<0.484	<0.968	0.564
GEXA 9	2.260	328.00	1.070	17.60	0.890	5.150	93.700	2077.000	3.570	91.20	<0.244	0.440	<0.487	<0.487	<0.975	2.700
GEXA 10	2.400	289.00	1.590	16.30	1.890	3.460	32.400	673.000	0.780	45.60	<0.246	0.123	<0.491	<0.491	<0.982	1.320
GEXA 11	0.029	7.53	0.010	1.27	<0.099	0.450	4.120	14.300	<0.497	3.60	<0.249	<0.099	1.710	<0.497	<0.994	<0.497
GEXA 11A	0.047	12.70	0.013	1.04	<0.096	0.830	9.150	6.250	<0.482	3.80	<0.241	<0.096	20.000	<0.482	<0.964	<0.482
GEXA 11A **	<0.015	8.42	0.016	1.21	<0.099	1.260	6.290	<0.248	<0.497	1.90	<0.248	<0.099	11.900	<0.497	<0.993	<0.497
GEXA 12	0.162	339.00	0.003	7.19	5.250	2.010	10.200	7.630	<0.499	33.10	<0.249	<0.100	<0.499	<0.499	<0.997	<0.499
GEXA 12A	0.544	1581.00	0.110	6.70	4.780	3.310	15.100	21.400	<0.497	95.40	<0.249	0.149	<0.497	<0.497	8.320	<0.497
GEXA 13	0.038	156.00	0.026	4.60	4.030	6.110	2.130	9.170	<0.479	261.00	<0.239	0.651	<0.479	<0.479	<0.958	<0.479
GEXA 14	0.071	68.20	0.237	6.09	0.110	0.910	2.800	3.340	<0.488	6.70	<0.244	<0.098	<0.488	<0.488	<0.977	<0.488
GEXA 15	0.241	89.30	0.175	6.02	<0.100	0.360	3.060	2.470	<0.500	4.90	<0.250	0.102	<0.500	<0.500	<1.000	<0.500
GEXA 16	0.769	38.70	0.172	2.58	0.361	0.430	5.240	3.050	<0.494	11.60	<0.247	0.639	<0.494	<0.494	<0.988	<0.494
GEXA 17	0.033	5.77	0.006	1.26	<0.099	1.380	3.860	0.515	<0.494	3.20	<0.247	<0.099	<0.494	<0.494	<0.988	<0.494
GEXA 18	0.045	17.00	0.005	1.32	<0.098	4.110	2.910	1.750	<0.490	3.00	<0.245	<0.098	4.530	<0.490	<0.980	<0.490
GEXA 19	0.121	44.30	0.001	2.85	0.368	8.610	4.490	1.730	<0.496	51.10	<0.248	1.030	3.290	<0.496	5.080	0.553
GEXA 20	0.025	14.00	0.002	5.35	<0.097	1.200	17.700	0.867	<0.487	32.20	<0.243	<0.097	<0.487	<0.487	<0.974	<0.487

** reanalysis of hand sample

SAMPLE NO.	Ag	As	Au	Cu	Hg	Mo	Pb	Sb	Tl	Zn	Bi	Cd	Ga	Pd	Se	Te
GEXA 21	0.065	2.49	0.004	5.22	<0.100	8.510	3.470	1.440	<0.498	6.00	<0.249	<0.100	<0.498	<0.498	<0.996	<0.498
GEXA 22	0.220	1.63	0.001	2.72	<0.099	5.100	9.240	0.492	<0.493	3.10	<0.247	<0.099	<0.493	<0.493	<0.986	<0.493
GEXA 23	0.038	12.50	0.001	2.30	<0.099	5.930	6.820	0.733	<0.494	4.80	<0.247	<0.099	5.180	<0.494	<0.988	<0.494
GEXA 24	0.297	27.30	0.869	1.62	<0.098	0.520	6.850	1.230	<0.490	BD	<0.245	<0.098	<0.490	<0.490	<0.979	<0.490
GEXA 25	0.134	8.49	0.003	2.97	<0.098	4.630	0.580	<0.246	<0.492	1.20	<0.246	<0.098	0.838	<0.492	<0.983	<0.492
GEXA 26	<0.014	17.40	0.006	1.84	<0.096	2.160	4.120	0.284	<0.482	2.40	<0.241	<0.096	2.070	<0.482	<0.964	<0.482
GEXA 27	0.046	5.08	0.035	4.04	<0.098	1.030	2.360	<0.245	<0.491	7.30	<0.245	<0.098	0.886	<0.491	<0.981	<0.491
GEXA 28	0.060	4.42	0.018	1.35	0.483	16.300	1.520	1.340	<0.500	4.10	<0.250	<0.100	<0.500	<0.500	<1.000	<0.500
GEXA 29	0.170	10.00	0.152	2.56	1.050	32.900	2.810	2.690	<0.491	13.70	<0.246	0.127	<0.491	<0.491	<0.982	<0.491
GEXA 30	0.167	44.40	0.091	5.69	0.317	45.200	4.420	2.970	<0.495	10.60	<0.247	<0.099	<0.495	<0.495	<0.989	<0.495
GEXA 31	0.096	5.00	0.271	7.35	5.870	1.950	1.690	1.110	<0.492	5.50	<0.246	<0.098	0.706	<0.492	<0.983	<0.492
GEXA 33	<0.015	53.70	0.054	2.71	1.090	7.510	14.400	6.270	<0.487	BD	1.680	<0.097	1.290	<0.487	1.470	<0.487
GEXA 34	0.312	2225.00	3.070	41.50	1.640	34.400	10.400	41.000	<0.480	18.90	<0.240	0.282	<0.480	<0.480	5.510	1.620
FC 1	<0.015	35.10	0.223	2.10	0.449	2.070	9.350	3.250	<0.486	40.70	<0.243	<0.097	0.616	<0.486	<0.973	<0.486
MS 1	95.500	31.30	13.900	4.70	0.133	8.910	4.440	0.709	<0.489	13.90	<0.244	<0.098	0.806	<0.489	1.910	<0.489
MS 2	4.280	45.40	0.908	3.30	<0.099	4.520	14.600	1.180	<0.496	30.20	<0.248	<0.099	2.200	<0.496	<0.992	<0.496
MS 3	12.700	13.70	3.140	3.31	<0.098	5.670	2.330	0.960	<0.491	17.80	<0.245	<0.098	0.673	<0.491	<0.981	<0.491
MS 3**	6.640	24.00	0.730	2.99	0.145	2.650	6.390	0.450	<0.497	24.60	<0.249	<0.099	2.380	<0.497	<0.994	<0.497
MS 4	4.880	12.40	0.239	3.46	0.344	8.300	5.950	0.621	<0.488	49.50	<0.244	<0.098	0.752	<0.488	<0.976	<0.488
MS 5	3.720	5.09	0.067	2.01	0.199	4.810	2.280	0.852	<0.500	10.80	<0.250	<0.100	<0.500	<0.500	<0.999	<0.500
MS 5VN	1.120	71.70	0.115	4.52	<0.098	429.000	37.600	3.120	<0.492	34.60	<0.246	0.157	<0.492	<0.492	<0.984	<0.492
MS 6	0.095	18.40	0.011	25.80	<0.098	4.500	5.790	0.477	<0.492	64.00	<0.246	0.133	9.550	<0.492	<0.984	<0.492
GB 1	0.053	5.39	0.006	2.48	<0.098	0.530	7.480	<0.245	<0.490	24.00	<0.245	<0.098	<0.490	<0.490	<0.980	<0.490
GB 2	0.331	1.82	0.016	4.38	<0.097	3.650	11.100	0.488	<0.484	12.00	<0.242	<0.097	<0.484	<0.484	<0.968	<0.484
GB 3	0.266	3.02	0.019	3.49	<0.100	2.810	12.200	0.418	<0.499	14.40	<0.250	<0.100	<0.499	<0.499	<0.998	<0.499
GB 4	0.244	5.08	0.080	14.40	<0.098	0.750	2.550	1.000	<0.488	34.40	<0.244	<0.098	5.110	<0.488	<0.976	<0.488
GB 5	0.144	1.65	0.018	13.10	<0.100	0.700	2.570	0.810	<0.500	34.40	<0.250	0.127	4.060	<0.500	<1.000	<0.500
W 1	0.148	1.13	0.004	2.80	<0.097	2.980	1.820	0.495	<0.487	1.10	<0.243	<0.097	<0.487	<0.487	<0.974	<0.487
W 2	0.048	48.70	0.010	5.93	<0.097	6.760	17.800	2.140	<0.487	14.90	0.703	<0.097	0.575	<0.487	<0.974	1.070
W 3	0.142	36.10	0.002	45.00	0.193	4.640	22.500	3.720	<0.489	19.50	1.140	<0.098	0.529	<0.489	1.390	1.920
W 4	0.108	42.70	0.006	29.00	0.160	3.470	4.860	9.870	<0.490	19.50	0.610	<0.098	0.527	<0.490	<0.979	0.790
W 5	3.470	8.44	0.445	5.20	0.293	3.870	2.150	1.570	<0.495	3.50	1.600	<0.099	<0.495	<0.495	<0.990	6.240
W 6	0.080	23.20	0.004	3.14	<0.097	3.180	6.500	1.640	<0.484	4.30	<0.242	<0.097	0.675	<0.484	<0.969	0.546
W 7	1.340	360.00	0.080	10.40	0.180	2.940	9.170	1.030	<0.491	5.60	1.290	0.268	0.514	<0.491	2.000	2.600
W 8	0.076	106.00	0.002	13.00	<0.098	8.340	9.960	3.010	<0.492	10.10	<0.246	<0.098	1.050	<0.492	1.720	1.480
W 9	0.174	11.20	0.001	4.49	<0.098	4.060	30.500	0.246	<0.489	BD	1.450	<0.098	<0.489	<0.489	1.100	0.806
W 10	0.404	117.00	0.013	12.20	<0.099	1.680	5.480	3.110	<0.495	3.80	0.502	<0.099	0.782	<0.495	1.120	1.340
W 11	2.210	49.30	0.012	24.30	<0.100	2.610	6.850	1.910	<0.500	1.40	6.470	<0.100	<0.500	<0.500	1.070	4.450
W 12	45.900	7.38	0.202	2.24	1.820	4.690	1.450	0.742	<0.497	20.20	<0.248	<0.099	<0.497	<0.497	<0.993	10.300

** reanalysis of hand sample

APPENDIX C. MINERALOGIC RESULTS FROM X-RAY DIFFRACTION, YUCCA MOUNTAIN ADDITION AND SURROUNDING MINING DISTRICTS

YUCCA MOUNTAIN ADDITION

Sample #	Minerals in Approx. Order of Abundance*
YMSC 2	KF, O-CT, B
YMSC 5C	Ca
YMSC 5B	Ca, T, O
YMSC 14	Ca, VG
YMSC 14C	VG, KF, Cr
YMSC 22 (clasts)	VG, M, Ca?
YMSC 22 (matrix)	VG, KF, PF, B, M
YMSC 22S (grey opal)	O-CT, KF, Q?, Cl?
YMSC 22S (white opal)	T, O-CT, Q?
YMSC 28	Ca
YMSC 29 (bx. matrix)	Ca, O-CT?, T, KF
YMSC 30	Ca, O-CT, Q
YMSC 31A	Cr, KF, PF
YMSC 31B (clasts)	VG, Ca, KF, Q
YMSC 31B (matrix)	VG, KF?, M
YMSC 34	Ca, Cr
YMSC 36	Ca
YMSC 42	Ca, T, O
YMSC 45	Ca, T?
YMSC 51 (clasts)	KF, Cr, H
YMSC 51 (matrix)	Ca
YMSC 51B	KF, Cr
YMSC 52	O, Cr, KF

* A = alunite, B = biotite, Ca = calcite, Cl = clinoptilolite, Cr = cristobalite, H = hematite, I = illite, I-M = interstratified illite-montmorillonite, J = jarosite, KF = potash feldspar, M-I = montmorillonite-illite, M = montmorillonite, O = opal, O-CT = opal-CT, PF = plagioclase feldspar, Q = quartz, T = tridymite, and VG = volcanic glass.

YUCCA MOUNTAIN ADDITION (CONT.)

Sample #	Minerals in Approx. Order of Abundance*
YMSC 66 (bx. matrix)	O-CT, KF, Q, Ca
YMSC 85	VG, KF, Ca
YMSC 87	O-CT, KF
YMSC 88	Ca, Cr, KF, M
YMSC 91	KF, Cr
YMSC 92	Cr, KF
YMSC 97	O-CT, T
YMDD 3	Ca, O-CT
YMDD 5	Ca, O-CT
YMDD 21	Ca
YMDD 23B	Ca, Cr, T
YMDD 36	Ca, Cr, T
YMDD 36A	O-CT, T, KF
YMPG 18	Cr, KF, T, M
YMPG 19	Ca, T
YMSF1	Ca, O, VG, M
YMSF2	VG, M
YMSF3	VG, M
YMSF4	VG, M
YMSF5	VG, M
YMSF7	Ca, KF, Cr
YMSF8	Ca, O, VG
YMSF9	Ca
YMSF11	KF, Cr, I
YMSF12	VG, M
YMSF13	VG, M
YMSF14	VG, M, KF
YMSF15	VG, M, KF
YMSF16	VG, M
YMSF17	Ca

WAHMONIE MINING DISTRICT

Sample #	Minerals in Approx. Order of Abundance*
WSF1-1	Q, PF, KF, I, M
WSF1-2	Q, PF, KF, I

MOTHER LODE DEPOSIT AREA

Sample #	Minerals in Approx. Order of Abundance*
GEXA 3	Q, I, J
GEXA 7	Q, I
GEXA 11A	VG, A, Q
GEXA 23	O-CT
GXSF1	Q, KF, I
GXSF2	Ca, Q, I
GXSF3	Q, T?, I, I-M
GXSF4	Q, KF, J, I-M
GXSF5	Ca, A, VG
GXSF6	VG, K, Q, KF
GXSF7	VG, A, Q
GXSF8	VG, A, Q
GXSF9	VG, A, Q, K, M
GXSF10	Q
GXSF11	Ca, Q

ORIGINAL BULLFROG MINE

Sample #	Minerals in Approx. Order of Abundance*
BH 36	Q
OBSF1	Q, PF, I, K

RHYOLITE AREA

Sample #	Minerals in Approx. Order of Abundance*
BH 4	Q, KF
BH-8	Q, KF, PF, M?
BH 24	Q, KF
BH 26	Q, KF, Ca
MS 1	Q, KF
MS 3	Q, KF
MS 5	Q, M-I
TRSF1	Q, KF, PF

* A = alunite, B = biotite, Ca = calcite, Cl = clinoptilolite, Cr = cristobalite, H = hematite, I = illite, I-M = interstratified illite-montmorillonite, J = jarosite, KF = potash feldspar, M-I = montmorillonite-illite, M = montmorillonite, O = opal, O-CT = opal-CT, PF = plagioclase feldspar, Q = quartz, T = tridymite, and VG = volcanic glass.