evidence of slumping after many years. Active tectonism, which is well documented in Jamaica, or perhaps rapid stabilization of ash by vegetation could also account for "perched" bauxite deposits.

Waterman claims that the distribution of bauxite is related to the present distribution of rainfall. A map of both distribution patterns (Fig. 1) shows no such correlation, at least on this generalized display of data. A much stronger correlation has long been observed between bauxite and bedrock lithology. Such a correlation is probably due to bedrock drainage properties and not the absolute amount of rainfall. If rainfall were the primary control on bauxite formation and distribution, the richest deposits should occur at the extreme east and west ends of the island.

Finally, fission track analyses have recently been completed to determine the absolute age of zircon that occurs as a common accessory mineral in Jamaican bauxite. The age of the zircon would represent the age of the parent material since the bauxite has not been buried or reheated. Of the five major bauxite deposits sampled (Tobolski, Claremont, Ewarton, Kendal, and Nain), none contained zircon younger than Miocene (Comer and Naeser, in preparation).

JOHN B. COMER

DEPARTMENT OF EARTH SCIENCES
UNIVERSITY OF TULSA
1133 NORTH LEWIS
TULSA, OKLAHOMA 74110
July 15, 1975

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DISCUSSION ON K-AR RELATIONS OF GRANODIORITE EMPLACEMENT AND TUNGSTEN AND GOLD MINERALIZATION NEAR THE GETCHELL MINE, HUMBOLDT COUNTY, NEVADA—A REPLY

Sir: Several comments are in order regarding the discussion by Joralemon (1975) of our paper (Silberman et al., 1974) on the age relations of granodiorite and tungsten and gold mineralization near the Getchell mine, Humboldt County, Nevada.

We wish to apologize for our oversight in crediting the geological map of the Getchell mine area (fig. 2, Silberman et al., 1974) to Holtz and Willden (1964). The map should have been credited to Joralemon. Joralemon (1951) contributed significantly to the understanding of the Getchell gold deposit, but we feel that he has not been able to take full cognizance of the mining, exploration, and research activities at Getchell since his last association with the mine in the late 1950s. Our paper (Silberman et al., 1974) was the result of extensive fieldwork around the Getchell mine, careful review of detailed geologic and assay maps for the mine, and regional geochemical and geochronological studies. In this reply, we would like to review Joralemon's comments and attempt to resolve confusion resulting from differences between some of Joralemon's interpretations of the geological relations at Getchell and our own. Where differences cannot be reconciled, we will try to place the opposing interpretations in perspective as they bear on the question of age of the gold mineralization at Getchell.

Aerial Distribution of Gold

Disseminated gold mineralization occurs at six localities between the Getchell mine and the Humboldt River, about 32 km to the south. According to Joralemon (1975), there is no granodiorite associated with the occurrences. Although this is true for most of the deposits, granodiorite dikes and porphyry dikes of composition and mineralogy similar to the granodiorite occur at all of the localities, including the Ogee-Pinson mine, 11 km south of Getchell, and the Preble deposit, 30 km to the south (J. Livermore, written commun., 1974). The Ogee-Pinson mine, furthermore, is located only 200 m from the southeast edge of the southern lobe of the Osgood Mountains granodiorite stock.

K-Ar age relations (Silberman et al., 1974; B. R. Berger, B. E. Taylor, and M. L. Silberman, unpub. data) clearly show that the porphyry dikes at Getchell and surrounding area are related to the same intrusive episode as the granodiorite stock. We infer that the intrusive dikes associated with the other gold occurrences are also related to either the Osgood Mountains pluton or to other plutonic pulses identified in north-central Nevada (Silberman and McKee, 1971).

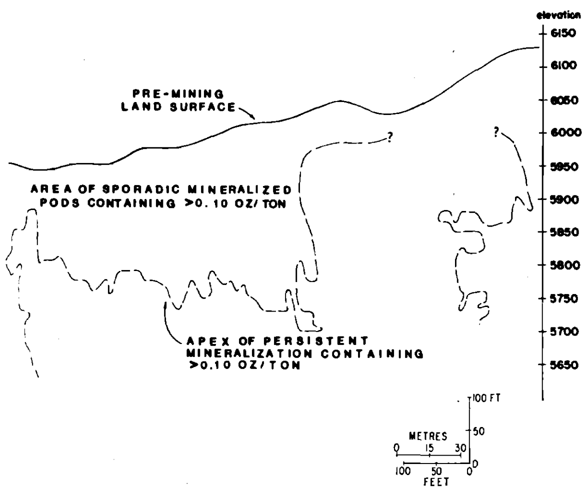

FIG. 1. Longitudinal, vertical projection of ore apex (greater than 0.10 oz/ton) North Pit orebody, Getchell mine. Taken from Getchell mine cross sections N19-N36.

Relation of Ore Apex to Present Land Surface

The Getchell gold mineralization is a replacement of limestone and limy shale beds. The mineralization is pervasive along parts of the Getchell fault, and what constitutes ore is wholly dependent upon the economics of mining and recovery. As a result, the geometry of ore pods can vary depending on the chosen cutoff grade. During the periods of opencut mining, detailed assay cross sections of the Getchell mine show a cutoff grade of 0.10 ounces per ton gold. None of these cross section data corroborate Joralemon's conclusion that the orebodies consistently apex 9 to 30 m below the surface, irrespective of the topography. The relation between the top of the north orebody (fig. 2, Silberman et al., 1974) and the surface prior to mining is shown in Figure 1. Small pods of ore and altered rocks cropped out or were exposed in shallow trenches along ancillary faults in the footwall of the North Pit orebody (Witt, 1936b). Where the Center Pit (South Pit of Joralemon, 1975) is now located, silicified gold-bearing ledges up to 45 m high and 24 m thick were traceable for over 900 m to the south (Witt, 1936a) to the South Pit (Fig. 2). Mine reports indicate that an ore width of over 31 m was covered directly by 1 to 6 m of unaltered, unmineralized alluvium in the South Pit area (South Extension Pit of Joralemon, 1975). Five hundred meters south of the South Pit over 15 m width of ore cropped out, and gold ore crops out at the Riley tungsten mine, 2 km south of Getchell.

On the basis of the observations presented above, we believe that Joralemon's conclusion concerning the relation of ore apex to current land surface at Getchell is incorrect. In addition, we disagree with his general conclusion that orebodies with tops lying at shallow depths beneath the present land surface imply a geologically young age of mineralization. The Goldfield mining district provides a well-documented example illustrating that such a generalization can be misleading. According to Ashley (1974), the current erosion cycle has just reached the epithermal lode deposits at Goldfield, as indicated by the almost total lack of placer gold in sedimentary rocks of Miocene to Holocene age surrounding the district. Although the lodes (silicified zones formed by replacement of volcanic rocks) apexed at depths generally less than 60 m and at many localities less than 30 m, they crop out or form subcroppings beneath alluvium or Miocene sedimentary rocks for a distance less than 20 percent of the total length of the surface projection of the lodes (R. P. Ashley, written commun., 1975). The current land surface being one of low relief, thus shows a consistent relation to the ore apex. However, abundant geologic and isotopic evidence (Ashley, 1974; Silberman and Ashley, 1970; Ashley and Silberman, in press) indicates that mineralization is early Miocene and definitely not Holocene.

Maximum Age of Related Mineralization

Joralemon (1975) suggested that the Golconda hot-springs manganese-tungsten deposit, 35 km south of Getchell, was formed at the same time as Getchell. This bedded tungsten deposit is underlain by scheelite-bearing skarn rocks (J. Etchart, personal commun., 1975), and remobilization of the tungsten and arsenic from the skarn could account for all of the metallization associated with the hot-spring water. Although this may indeed be a late Tertiary or Quaternary deposit, there is not necessarily any relation between these hot springs and the Getchell mineralization.

The possibility that hot-spring activity at Golconda may be Pliocene to Holocene raises the question whether mineral deposits of this age are common in northern Nevada. If they are, the very young age suggested by Joralemon for Getchell would be more plausible, even if the Getchell mineralization was an event unrelated to hot-springs activity at Golconda. Many epithermal vein deposits in north-central Nevada have been dated by the K-Ar method on vein adularia as 14 to 16 m.y. old (Silberman and McKee, 1974). This coincides with the onset of Basin-and-Range faulting in the region (McKee and Noble, 1974). O'Neil and Silberman (1974) demonstrated that these vein deposits formed from the action of meteoric water. The mechanism envisioned for formation of these ore deposits involves deep circulation of fluids of meteoric origin, interaction of these fluids with sources of metal at depth, return of the hot ore solutions to the surface along faults, re-

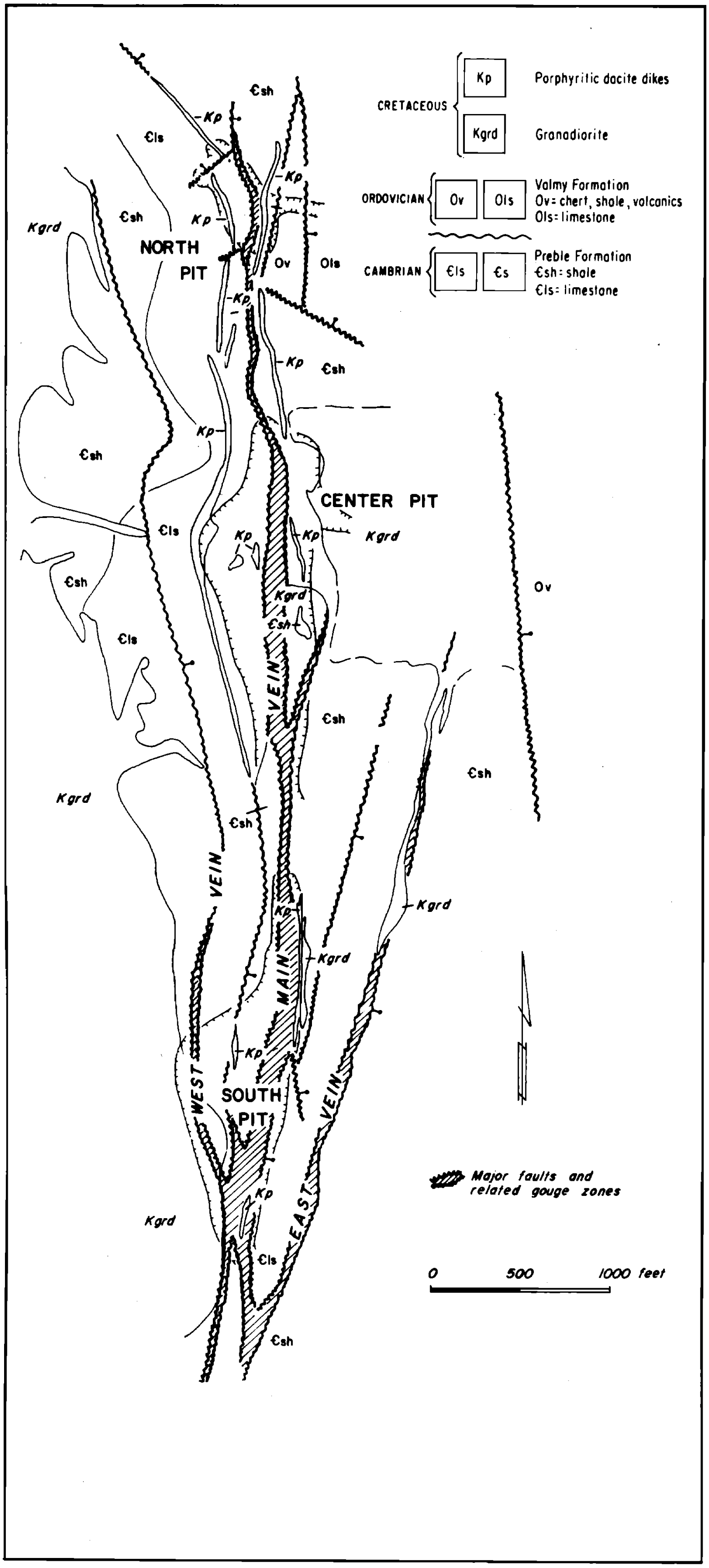

FIG. 2. Geologic map of Getchell mine area. Revised from Silberman, Berger, and Koski (1974, after Joralemon, 1951).

sulting in deposition of the precious-metal-bearing veins. The Golconda tungsten-bearing iron and manganese oxide deposit, which contains jarosite, may be a result of spring activity of Miocene age, although Erickson and Marsh (1974; written commun., 1975) suggest that this deposit is the result of spring activity less than 5 m.y. old. Jarosite from fracture surfaces at the Silver Coin silver prospect, 8 km east of Golconda, yielded a K-Ar age of 15 m.y. (M. L. Silberman and R. L. Erickson, unpub. data). This suggests that hot springs of Miocene age spatially associated with precious-metal (here silver) mineralization occurred near the south end of the mineralization belt extending south from Getchell, although the type of alteration and mineralization are distinctly different from that at Getchell. Although the age of the nearby Golconda tungsten-bearing deposit has yet to be demonstrated, no proven *mineralization* ages younger than Miocene have been found in this region so far.

Ore Textures and Mineralogy

Masses of delicate sulfide ore minerals are present in all of the orebodies at the Getchell mine. If substantial movement has taken place across the entire Getchell fault zone, then the preservation of these crystals over a long period of time is remarkable. However, two aspects of the faulting relations should be pointed out: (1) there is considerable stratigraphic continuity across the main mineralized structure from the Center Pit to south of the South Pit (B. R. Berger, B. E. Taylor, and M. L. Silberman, unpub. data), and (2) ore textures along the main gouge zone in all of the pits indicate that considerable brecciation has taken place since gold mineralization.

Highly sheared quartz-pyrite-realgar mineralization can be seen along the main gouge zone in all of the pits. Petrographic examination of the materials indicates that considerable mechanical rotation of individual crystals has taken place, resulting in a foliated, mineralized mass parallel to the fault plane. At the north end of the South Pit, a chaotic breccia of granulated ore is exposed. This breccia is beneath a competent hanging wall consisting of arsenic-impregnated ore. Alluvium overlaps both the breccia composed of ore fragments and the competent hanging wall. Incorporated in the alluvium are ash beds as described by Joralemon (1951, 1975) 100 m east of the north orebody. These ash beds are neither spatially nor geochemically related to the orebodies (their average arsenic = 5 ppm; mercury = 110 ppb). No ash beds occur at any of the fine gold deposits south of the Getchell mine.

Another pertinent aspect of the Getchell deposit is that the rocks in the hanging wall of all the pits are highly oxidized, whereas unoxidized sulfide ores occur within the breccia zone and against the footwall. The oxidation is as much as 90 m deep. The only significant tonnages of oxidized gold ore were mined in the upper parts of the Center Pit. The relation between oxidized and unoxidized ores indicates that some displacement has taken place on the Getchell fault since mineralization, as also suggested above by the sheared crystals, gouge, and chaotic breccia. Some minor faults in the hanging wall of the Center Pit contain breccia fragments cemented with cryptocrystalline and amorphous silica. The clay mineral nontronite gives these cemented breccias a greenish cast. We believe that this type of texture, which occurs only in oxidized rocks, is supergene in origin. We know of no instances where the alluvium shows any signs of hydrothermal alteration, though it directly overlies mineralized or highly altered rocks. We suggest that altered clasts in alluvium seen by Joralemon were altered by supergene solutions produced either by nearby ore at higher structural and topographic levels or by unoxidized debris that oxidized in place in the alluvium. R. P. Ashley (written commun., 1975) reports both such phenomena at Goldfield, Nevada.

Joralemon (1975) refers to mineralized alluvium discovered in a drill hole east of the main Getchell orebodies. Three deep water wells were drilled, and the one to which Mr. Joralemon refers contains detectable gold values all the way to 1,200 feet total depth (unpublished Getchell mine data). These wells were drilled using a churn drill, which obscures mineralogic relations. Much of the alluvium downslope from the orebodies contains detectable gold values without accompanying alteration (B. R. Berger, unpub. data). We suggest that all of the gold in the alluvium is placer, derived from the arsenical lode deposits, tactites, and minor lead-zinc-silver veins, which crop out at the surface.

Discussion

In our paper we stated that interpretations of the isotopic age data at Getchell, other than our preferred one that gold mineralization was approximately 90 m.y. old, were possible, including one very similar to that suggested by Joralemon (1975). We quote from Silberman et al. (1974, p. 654), "Another suggestion is that mineralization could have been still younger (e.g., Tertiary), and that all of the GL-3 ages are hybrid, being reset to varying amounts." We went on to describe arguments against this and other alternate interpretations, which will not be repeated here. We viewed and we still view the interpretation of the age of mineralization of approximately 90 m.y. as being most compatible with the geologic, geochemical, and isotopic data available at this time.

One final point: Joralemon states that we concluded on the basis of ". . . potassium-argon studies of sericite in the granodiorite and andesite . . . that gold mineralization at Getchell is at least 80 m.y. old and is closely associated, both genetically and spatially, with the granodiorite." (Joralemon, 1975, p. 405). Sericite was not dated from the andesite, and we stated in our discussion of the K-Ar ages, "We view the entire process of emplacement of the granodiorite pluton, the andesite dikes, the tungsten-tactite deposits, and the hydrothermal gold deposits as all belonging to the same thermal episode.... We wish to stress that our interpretation *does not require* a genetic relation between the pluton and gold deposits." (Silberman et al., 1974, p. 654–655). Neuerberg (1966) suggested a genetic relation between the Osgood Mountain pluton and the gold deposits based on high Au contents of the granodiorite, particularly adjacent to the areas of gold mineralization. This is certainly a reasonable and convenient source for the gold in the Getchell deposits and adds to the plausibility of a genetic association. Our data on age of the alteration associated with mineral deposits certainly support the contention, but we prefer at this time to stay with our statement concerning the thermal episode. In all probability the Osgood Mountain pluton generated a hydrothermal system that was responsible for both tungsten and gold mineralization, perhaps concurrently, certainly closely related in time. The ultimate source of the metals is an unsolved problem.

B. R. BERGER
M. L. SILBERMAN
R. A. KOSKI

B. R. B.
CONTINENTAL OIL COMPANY
1085 E. 2ND STREET
RENO, NEVADA 89502

M. L. S. AND R. A. K.
U. S. GEOLOGICAL SURVEY
345 MIDDLEFIELD ROAD
MENLO PARK, CALIFORNIA 94025
July 28, 1975

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