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GEOLOGY AND MINERAL DEPOSITS OF THE GOLD HILLS, HIDALGO AND GRANT COUNTIES, NEW MEXICO

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Abstract—The Gold Hills, located approximately 20 km northeast of Lordsburg, New Mexico, consist principally of Precambrian supracrustal and intrusive rocks. Supracrustal rocks, which are most abundant in the northwestern Gold Hills, are primarily amphibolites and gneisses; intrusive rocks range from diorites to granites. Supracrustal rocks may represent part of the Bullard Peak Series of Hewitt (1959), and larger intrusions of the area are part of the Burro Mountain batholith of Hewitt (1959). Amphibolites and gneisses are moderately foliated, and diorite and granitic rocks are only locally foliated. Contacts between the supracrustal and granitic rocks are often migmatic, and migmatites are sometimes extensive. Minor intrusions are mainly pegmatites, diabase dikes, basaltic dikes and felsic dikes. Diabase dikes parallel the north-northwest-trending foliation in the supracrustal rocks, and basaltic dikes, which trend north by northeast, crosscut the diabase dikes. Niggli numbers and trace elements indicate that the amphibolites are orthoamphibolites, and may represent original ocean floor basalts. Petrography and Niggli values indicate that most of the gneisses are paragneisses, although one isolated occurrence may represent an original andesite. The lack of a coherent stratigraphy and the high grade of metamorphism make any tectonic interpretation extremely tenuous. Metamorphic conditions were approximately 700 ± 50°C and about $4.2–4.5 \pm 1.6$ kb, as determined by garnet-biotite geothermometry and quartz-plagioclase-aluminum silicate geobarometry. Abundant secondary chlorite, muscovite and epidote throughout all of the lithologies of the Gold Hills suggest that a pervasive low-grade event has affected the area. Mineral deposits are principally gold-bearing quartz veins of the Gold Hill mining district, located in the northwestern part of the Gold Hills, and minor deposits of fluorite, REE-enriched pegmatite, scheelite and base metals. The southeasternmost Gold Hills also contain the Bound Ranch (Langford Hills) district, which is a geologic and topographic extension of the Gold Hills.

INTRODUCTION

The Gold Hills occur approximately 20 km northeast of Lordsburg, New Mexico (Fig. 1). They are a northwest-trending range of primarily granitic rocks and are bounded by Quaternary alluvial fans on the west and by Tertiary volcanics on the east. Mineralization consists mainly of gold-bearing quartz veins and small deposits of fluorite, tungsten, REE-enriched pegmatite and base metals. The Gold Hills occur immediately south of the Big Burro Mountains, which were another northwest-trending range of mainly granitic rocks. The summits of the largest mountains in both the Big Burro Mountains and the Gold Hills are generally rounded, and the highest areas are not defined by any particular lithology. Maximum relief in the Gold Hills is about 400 m while much greater relief, 1500 m, is present in the Big Burro Mountains. Together these ranges constitute one of the largest exposures of Precambrian terrain in the southwestern United States.

PREVIOUS WORK

A brief historical account of the Gold Hill mining district was first given by Jones (1904); Lindgren et al. (1910) were the first to describe the geology. Gillerman (1964) also briefly described the area. Hedlund (1978a, b, c) mapped the Gold Hill, Ninety-Six and C-Bar Ranch quadrangles, which cover the entire district, at the scale of 1:24,000. Parts of the Gold Hill district were also included in a lead isotope study of igneous rocks and ore deposits of the southwestern United States (Stacey and Hedlund, 1983), and these results are summarized later in this article. The Gold Hill and Bound Ranch districts were also listed as a silver and gold occurrence by North and McLemore (1986). The central part of the district was studied by Beard (1987), and this article summarizes most of those findings. Previous studies in the Big Burro Mountains, which were relevant to the Gold Hills, include Hewitt (1959) on the northern Big Burro Mountains and Ballman (1960) on the volcanics in the area between the Gold Hills and the Big Burro Mountains.

REGIONAL GEOLOGY

Lithologies of the surrounding region consist of Precambrian granitic and metamorphic rocks, Cretaceous-Tertiary volcanics and sediments, and Upper Tertiary and Quaternary gravels.

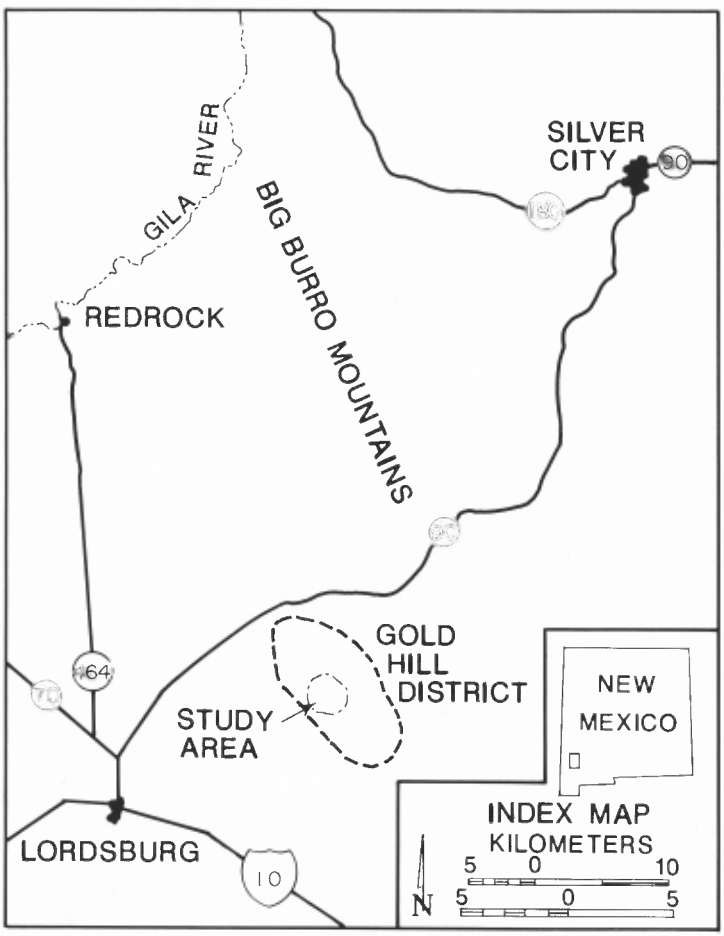


FIGURE 1. Index map of Gold Hill mining district and surrounding area.

Gillerman (1964) included all the Precambrian plutonic rocks of the Gold Hills and the Big Burro Mountains as part of the Burro Mountain batholith complex. The complex is composed primarily of Burro Mountain Granite and has intruded small isolated masses of anorthosite, diorite, metadiabase, syenite and larger masses of quartz diorite gneiss. These older granitic rocks were also intruded by the Tyrone stock, which is a large Laramide quartz monzonite porphyry, and numerous dikes, stocks and plugs of various composition and age. Supracrustal rocks in the Gold Hills were described by Gillerman (1964) as part of the Bullard Peak Series, which was originally described by Hewitt (1959) in the northern Big Burro Mountains. The Bullard Peak Series is composed of both metasedimentary and metaigneous rocks which include gneisses, schists, amphibolites and migmatites.

Cretaceous sediments are not present in the Gold Hills but are present in the northern Big Burro Mountains, and directly overlie the crystalline basement. Elston (1958) described this pre-Cretaceous structural high as the Burro uplift. Tertiary andesites and rhyolites overlie these sediments and mark the southern limit of the Datil volcanic field (Hewitt, 1959). Cretaceous-Tertiary volcanics are also present in the Lordsburg mining district (Lasky, 1938; Flege, 1959), which is 25 km southwest of the Gold Hills.

In summary, the Gold Hills are composed of primarily Precambrian rocks which are bounded by Cretaceous-Tertiary sediments and volcanics and large amounts of Quaternary alluvium. The northwest-trending ranges of the Big Burro Mountains and the Gold Hills are structurally related to the northwest-trending Basin and Range type mountains in

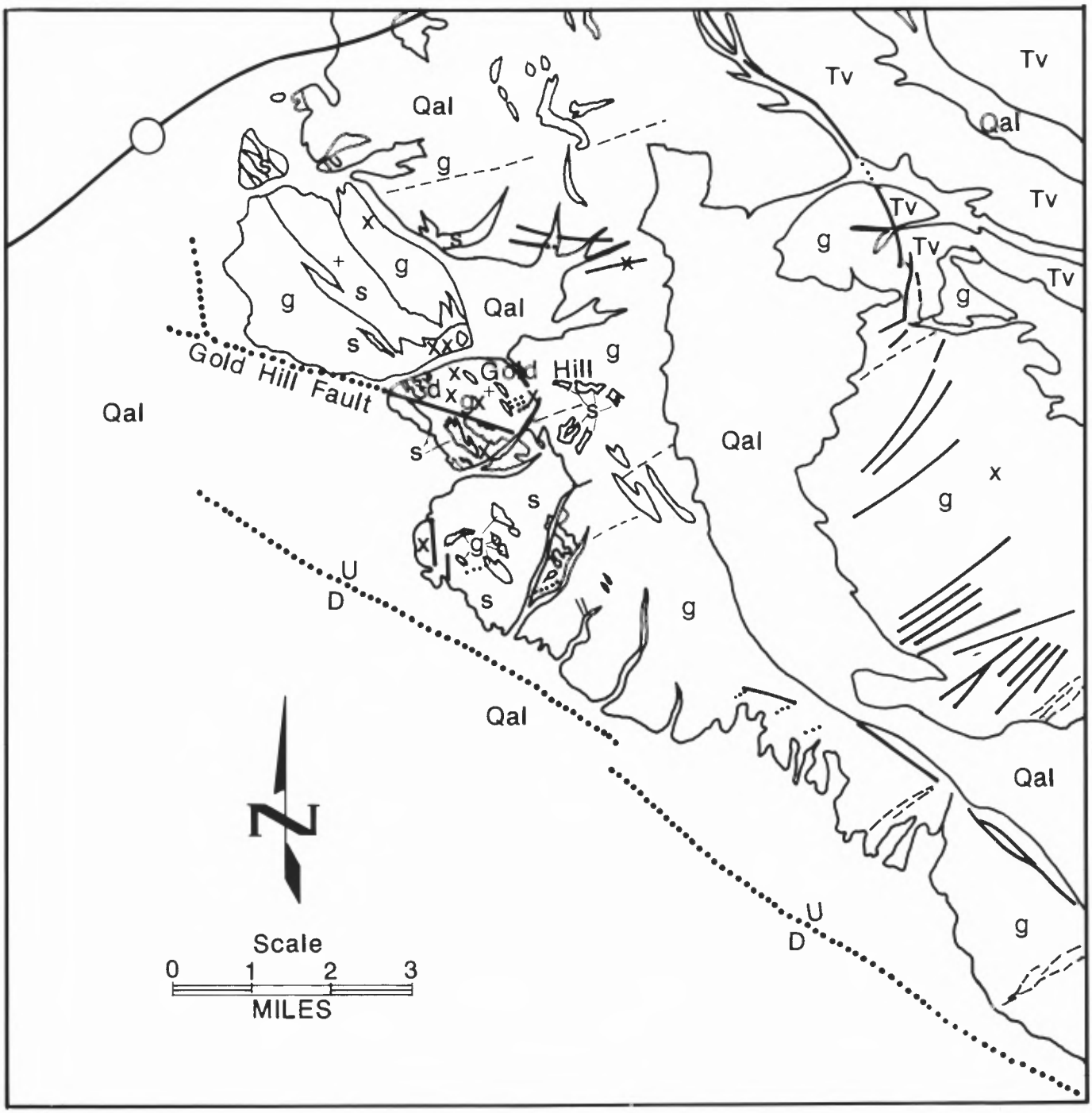


FIGURE 2. Generalized geologic map of the Gold Hills, Hidalgo and Grant Counties, New Mexico. Qal = Quaternary volcanics. Tv = Tertiary volcanics. Dashed line = felsic dikes; dotted lines = basalt dikes; diagonal rule = diabase dikes; d = Precambrian diorite; g = Precambrian granite; s = Precambrian supracrustal rocks (includes amphibolites, gneisses and impure quartzites); heavy lines = faults (dotted where buried, dashed where inferred); X = mine or prospect.

Arizona (Hewitt, 1959). The vast alluvial plains to the west and south of the Big Burro Mountains and Gold Hills that separate them from the mountains to the southwest are also suggestive of Basin and Range geology.

LITHOLOGIES

A generalized geologic map of the Gold Hills is given in Figure 2. The range consists almost entirely of Precambrian granitic rocks, and, although supracrustal rocks are found throughout the area, they are most abundant in the western Gold Hills.

Supracrustal rocks consist principally of amphibolites, gneisses and minor amounts of impure quartzite. Supracrustal rocks generally occur as small pods and xenoliths, and relatively large areas are present in the western part of the Hills. Migmatitic areas are also abundant in the areas of supracrustal rocks and contain virtually all the classic migmatite features described by Mehnert (1968).

The Precambrian granitic rocks have been divided into granite, biotite granite and quartz monzonite. Intrusions of diorite are also present. Granite is by far the most abundant intrusive. The granite is heterogeneous in both mineralogy and texture and varies from white to dark gray to various shades of orange. Plagioclase is generally heavily sericitized, and quartz shows strong undulatory extinction. In addition, microcline in virtually all of the granitic rocks exhibits a rapakivi texture.

The supracrustal rocks and the major intrusions have been intruded by ubiquitous minor intrusions, which include pegmatites, aplite dikes, quartz plugs, diabase dikes, diabase plugs, basalt dikes and felsic dikes. The pegmatites, diabase dikes and the basalt dikes are the most numerous. The composition of the pegmatites is relatively simple and consists mainly of quartz, microcline and plagioclase. The diabase and basalt dikes are distinguished on the basis of textural and mineralogic differences. The diabase dikes are dark green to black, have a subophitic to ophitic texture and consist mainly of clinopyroxene and plagioclase. The basalt dikes are light green to green-gray, very fine grained, porphyritic and consist almost entirely of chlorite and light brown amphibole. Felsic dikes are aphanitic, heavily sericitized and form prominent white ridges throughout the area.

STRUCTURE

The structure of high-grade metamorphic terrains is generally complex, and the Gold Hills are no exception. Stratigraphic relations have been totally obscured by metamorphism and intrusive events, and a coherent stratigraphy was not observed.

Outcrops of supracrustal rocks generally trend northwest, and foliations in the supracrustal and intrusive rocks trend in the same direction. Diabase dikes also generally parallel the supracrustal rocks. Equal area plots of the foliations and the diabase dikes, which were taken from the central part of the district, are given in Figure 3. Foliations are best developed in the amphibolites and are also present, although less apparent, in the gneisses. Foliations are only locally developed in the intrusive rocks and quartz monzonite dikes; pegmatites are not foliated. Due to the ambiguity resulting from the lack of other planar fabrics, it is not known whether this foliation represents primary or transposed layering.

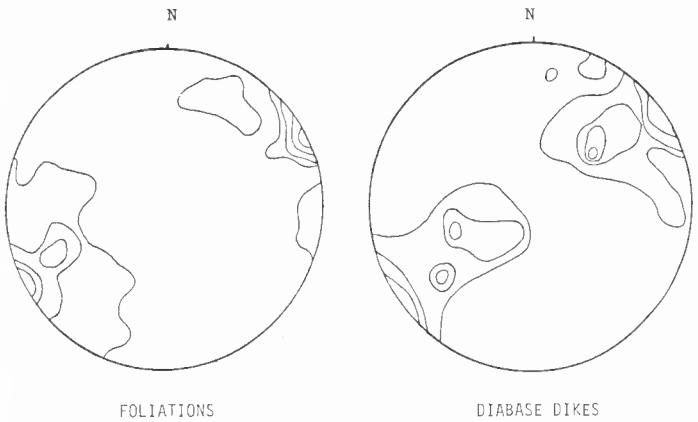


FIGURE 3. Equal area plot of foliations and diabase dikes. For foliations, N = 148, for diabase dikes, N = 35. Contours represent 2-4-8-12 percent areas (see text for detail).

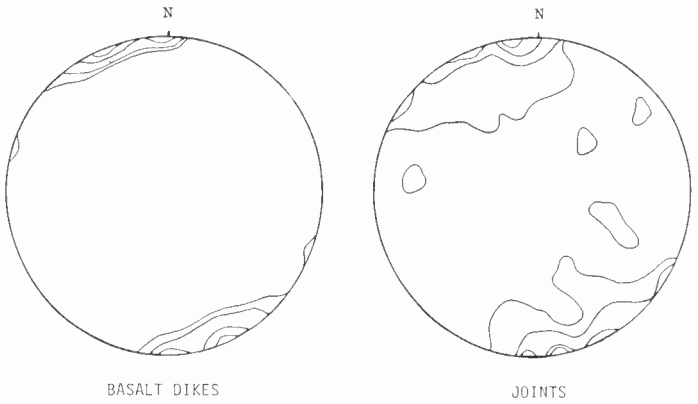


FIGURE 4. Equal area plot of basaltic dikes and joints. For basalt dikes, N = 32; for joints, N = 89. Contours represent 2-4-8-12 percent areas (see text for detail).

The diabase dikes are generally intact; although none exhibit a metamorphic fabric, many are intensely fractured parallel to strike. Contacts with the host rocks are generally sharp, but some are gradational, and the dikes have incorporated small amounts of host rock along these contacts. Some of the dikes also form unusual hook-shaped outcrop patterns.

Both the basaltic and felsic dikes trend east-northeast and have near-vertical dips, and their strikes parallel the prominent east-northeast jointing which is present throughout the Gold Hills. Equal area plots (Fig. 4) of attitudes from the central part of the district show that while both the dikes and joints generally trend east-northeast, dikes are generally vertical, but the joints have variable dips.

Major faults in the Gold Hills are shown on the geologic map. Most of these are only apparent by large-scale lithologic discontinuities, and many more which are less apparent undoubtedly exist.

GEOCHEMISTRY

Major and trace element chemistry is from Beard (1987) and is restricted to the area around Gold Hill in the central part of the mining district. These analyses were used principally for determining metamorphic protoliths and classifying major and minor intrusions.

Amphibolite protoliths were determined to be igneous based on Niggli values and chemical similarities to basalts. A Ti-Zr-Y diagram (Fig. 5) after Pearce and Cann (1973) shows that most of the amphibolites fall

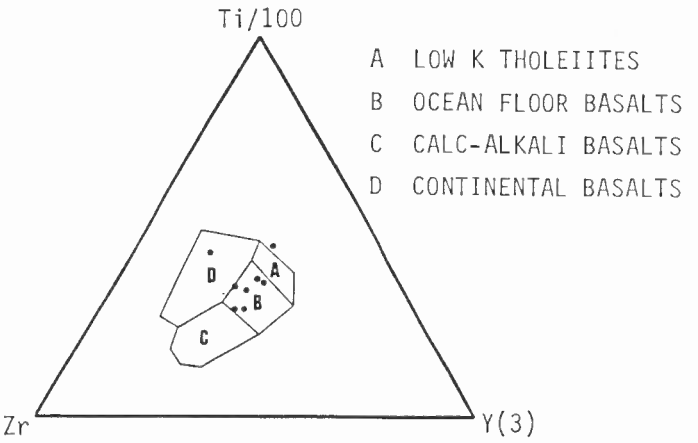


FIGURE 5. Ti-Zr-Y diagram for amphibolites from the northwestern Gold Hills. The figure is modified from Pearce and Cann (1973).

in the field of ocean floor basalts. A Ti-Zr-Sr ternary diagram (Fig. 6) also shows that the amphibolites fall in this area.

Niggli values of most of the gneisses are suggestive of sedimentary protoliths. Leake and Singh (1986) used the diagram shown in Figure 7 to aid in distinguishing orthogneiss from paragneiss. However, this diagram must be used with caution as it depicts elements which may have been significantly mobilized during metamorphism. Most of the Gold Hill gneisses, which are felsic, plot in the sedimentary field, but a biotite gneiss plots along the igneous trend. The overall heterogenous chemistry and petrographic character of the gneisses are perhaps more indicative of a sedimentary protolith. The gneiss which plots along the igneous trend, however, has an overall chemistry similar to an andesite, and a petrographic character which is distinct from the other gneisses.

Diorites are low in silica (48–55 wt%), but most are still quartz normative. Major and trace elements are very similar to gabbro, but it is classified as diorite on the basis of mineralogy. Granitic rocks range from 61–76 wt% SiO_2, and major element variations are the same as those of typical granites. Molecular normative compositions of Qz-Ab-Or are plotted in Figure 8. The points do not fall on the minimum of Tuttle and Bowen (1958), but most are the field of rapakivi granite analyses given by Sahama (1945). This is consistent with the rapakivi character of most of the granitic rocks within the mining district.

Diabase dikes and plugs have uniformly low SiO_2 (40–45 wt%), and nearly all are olivine normative. Basalt dikes are similar in chemistry but are nepheline normative and have a great deal more olivine in their norm. They are also much higher in MgO and TiO_2 than diabase dikes. Felsic dikes are compositionally similar to typical rhyolites.

Chondrite-normalized REE plots are given in Figure 9. The amphibolite composite is relatively flat and has a slight enrichment in LREE. Gneisses show much more variation, especially in HREE. REE patterns of granitic rocks show a great deal of variation, especially in the Eu values. Diorites do not show much variation in any of their REE values. Patterns for the diabase and basaltic dikes are similar to each other, but the basaltic dikes exhibit a slight enrichment in LREE and depletion in HREE relative to the diabase dikes. The felsic dike has a slight enrichment in LREE, but does not show the large negative Eu anomaly which is typical of rhyolites.

METAMORPHISM

All of the supracrustal rocks have been regionally metamorphosed, and contact metamorphic effects from the major and minor intrusions appear negligible. Mineralogic variations are greatest in the gneisses, which contain assemblages typical of pelitic to semi-pelitic rocks. Amphibolite assemblages are typical of metamorphosed mafic igneous rocks. Textural evidence indicates that chlorite, muscovite and epidote are secondary. These minerals are secondary in not only the supracrustal rocks but also the other lithologies of the Gold Hills as well.

The gneisses generally consist of microcline, plagioclase and quartz;

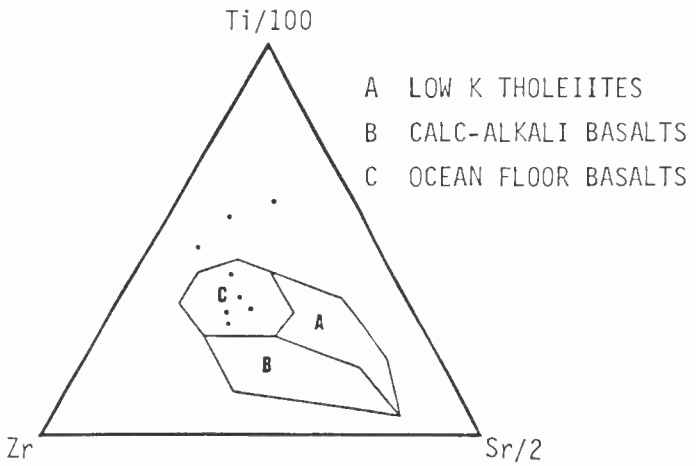


FIGURE 6. Ti-Zr-Sr diagram for amphibolites from the northwestern Gold Hills. The figure is modified from Pearce and Cann (1973).

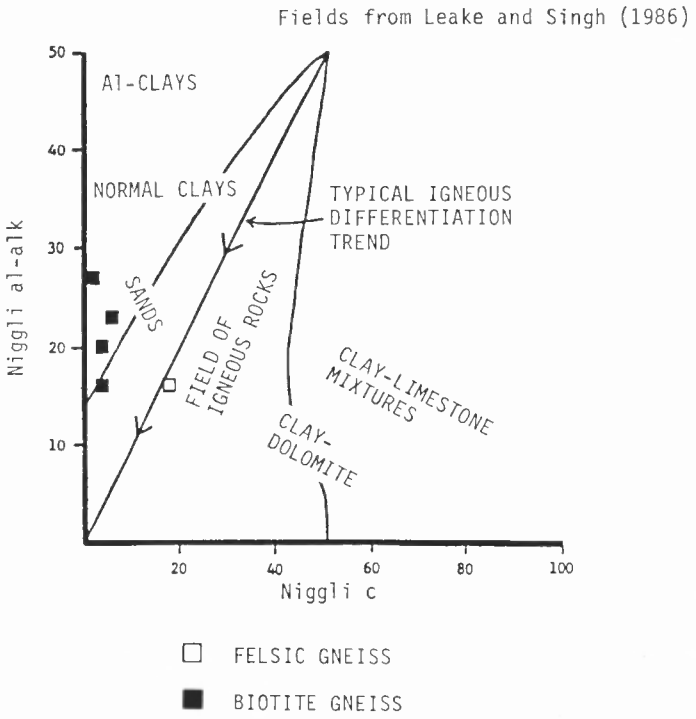


FIGURE 7. Niggli al-alk vs. Niggli c factors for gneisses from the northwestern Gold Hills. Figure is modified from Leake and Singh (1986). See text for discussion.

zones of biotite, garnet and sillimanite are abundant. Hedlund (1978b) also reported andalusite in gneisses at the summit of Apache Mountain, which is in the northern part of the Gold Hill district.

Garnets are almost entirely almandine, have very low contents of Ca, Mn and Mg, and are unzoned with respect to Ca, Mn or Mg. The coexistence of microcline with sillimanite, together with the lack of primary muscovite, is indicative of a high metamorphic grade. Garnet-biotite geothermometry, using the geothermometer of Ferry and Spear (1978), gives temperatures of approximately 700° ± 50°C for a gneiss sample from Gold Hill. The pervasive chloritization and sericitization made it extremely difficult to obtain samples which would yield meaningful analyses. Plagioclase-garnet-aluminum silicate geobarometry (Ghent, 1976; Ghent et al., 1979) yields pressures of 4.2 kb to 4.6

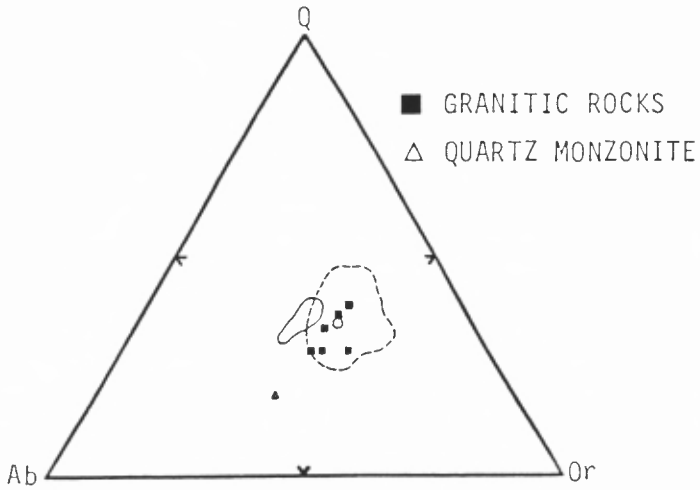


FIGURE 8. Normative composition of Gold Hill granitic rocks plotted on Q-Ab-Or diagram. Solid line indicates outline of the maximum for analyses compiled by Tuttle and Bowen (1958). Dashed line encloses analyses of rapakivi granites by Sahama (1945). Our data are plotted as closed squares (granitic rocks) and open triangle (quartz monzonite). Circle is average of the analyses.

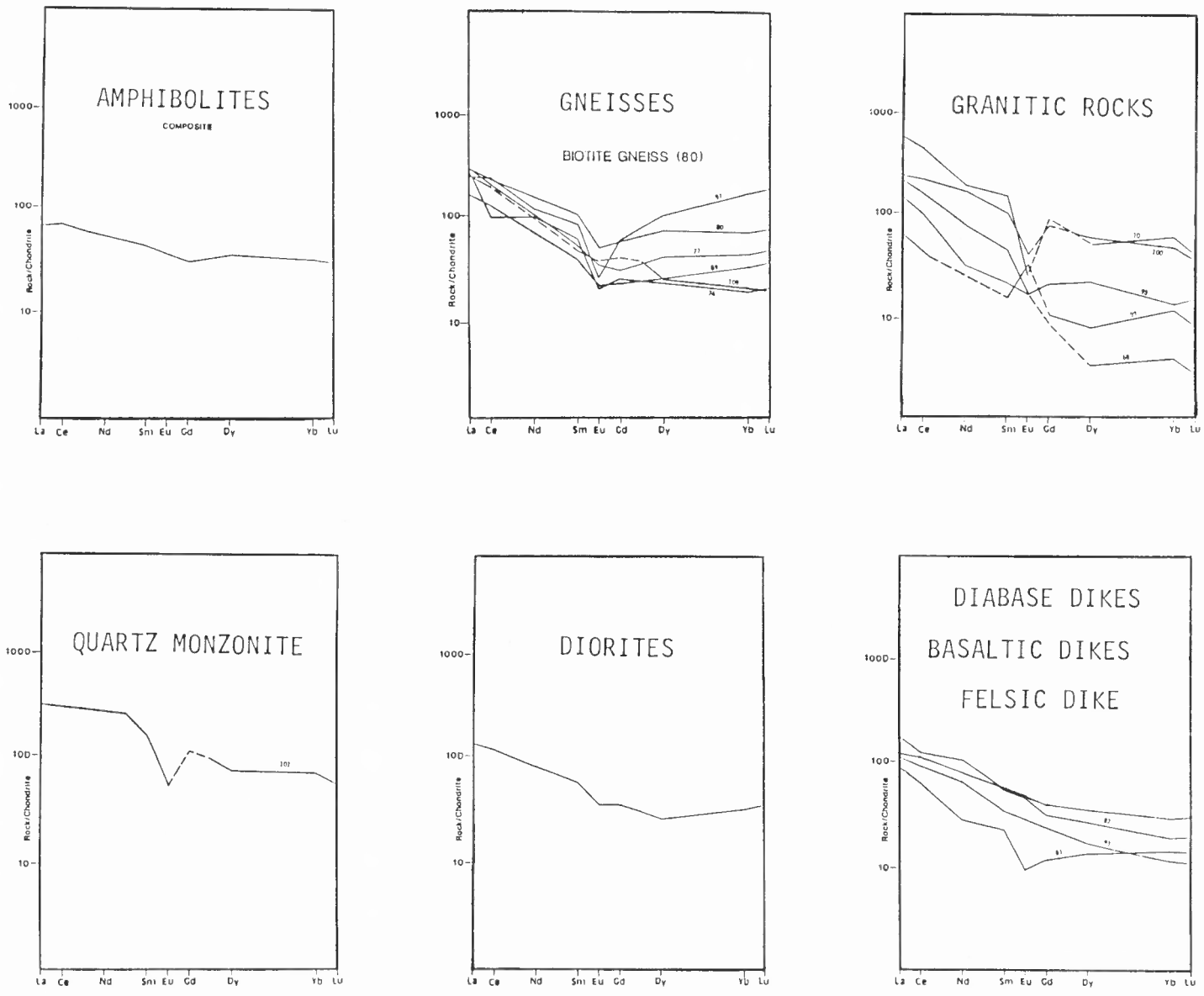


FIGURE 9. Rare earth element (REE)/chondrite distribution plots (vs. atomic number of REE) for Gold Hills rocks. See text for discussion.

kb ± 1.6 kb for the same sample. Estimated temperature and pressure are thus consistent with the high-grade metamorphic assemblage present in the gneisses.

GEOCHRONOLOGY

The first workers in the Gold Hills (Lindgren et al., 1910; Gillerman, 1964) assumed that the granitic and metamorphic rocks of the area were Precambrian, based on the dominance of Precambrian basement in the surrounding regions. This section summarizes the available ages for the Gold Hills and related areas. Unless otherwise noted, the following are all U-Pb zircon ages.

Although none of the supracrustal rocks in the Gold Hills have been dated, a biotite gneiss from the Bullard Peak Series in the Big Burro Mountains gives an age of 1550 my (Stacey and Hedlund, 1983). They regarded this as a minimum estimate. This is younger than an age of 1690 my determined for a felsic sill within the Pinal Schist (Silver, 1963, 1978) of southeastern Arizona. Ages of supracrustal rocks in northern and central New Mexico were calculated to be 1700 my (Williams et al., 1986) and 1650 my (Bowring and Condie, 1982; Bowring et al., 1983), respectively. Supracrustal rocks older than 1650 my have not been shown to crop out south of Santa Fe.

Granite in the Gold Hill district has been dated at 1450 my by Stacey and Hedlund (1983). Precambrian plutonism in southeastern Arizona has been dated at 1420 my to 1440 my (Silver, 1968, 1978), and this is believed to be part of a wide belt that extends northeast across the entire North American continent (Silver et al., 1977). The 1450 my age determined by Stacey and Hedlund (1983) is consistent with this. However, a granophyre from the Kingston area of southwest New Mexico has been dated at 1655 ± 15 my (Stacey and Hedlund, 1983). This is much older and suggests that not only older plutonic rocks may be present, but older supracrustal rocks as well (Bauer and Lozinsky, 1986).

The diorite, quartz monzonite and pegmatites have not been dated. The diabase dikes have yielded a zircon U-Pb age of 1500 my (Stacey and Hedlund, 1983), but this date may be meaningless due to the small amount of zircon and lead obtained from this sample. Crosscutting relationships indicate that the diabase dikes are younger than the 1450 my granite.

K-Ar ages of 950 my and 1550 my were reported by Hedlund (1978a) for granite in the Gold Hills. An Rb-Sr age of 1250 my was also reported by Hedlund (1978a). The differences in these ages may well be due to the effects of sericitization and chloritization with the granite.

The basaltic dikes and felsic dikes of the Gold Hills have not been radiometrically dated, but field relations show that they postdate the other lithologies of the mining district. Marvin et al. (1978) determined fission-track ages for two basaltic andesites (54.9 ± 2.7 my and 57.9 ± 2.7 my) and a felsic dike (52.7 ± 2.7 my) in the Pyramid Mountains immediately south of Lordsburg. These rocks are unmetamorphosed volcanic and intrusive rocks. The similarities between these volcanics and structural attitudes in the Lordsburg district and the Gold Hills suggest that the basaltic and felsic dikes in the Gold Hills are correlative with the igneous activity in the Lordsburg area.

A K-Ar age of 33.7 ± .8 my for the Kneeling Nun Tuff, which is exposed in the northeastern Gold Hills, was calculated for a biotite separate by Hedlund (1978a). The basaltic and felsic dikes which are so prevalent in the rest of the Gold Hills are not present in the Kneeling Nun Tuff or other volcanics of the eastern Gold Hills. This indicates that the basaltic and felsic dikes are almost certainly older than those volcanics. Three galena samples from veins of the Gold Hill district were also dated by Stacey and Hedlund (1983). They were isotopically similar to the present-day whole-rock lead-isotope ratios of the granite, and Stacey and Hedlund (1983) stated this indicated that the mineralization was Cenozoic and definitely not Precambrian.

MINERAL DEPOSITS

Mineralization in the Gold Hill mining district consists of gold-bearing quartz veins, REE-bearing pegmatites and small deposits of fluorite, tungsten and base metals. Small placer deposits are also reported. The gold-bearing quartz veins are the most important deposits, and production from all other deposits has been negligible. The Bound Ranch district contains small deposits of tungsten and fluorite, but production has been minimal.

Quartz veins

Quartz veins are found throughout the Gold Hills and are most abundant in the central part of the district, around Gold Hill. The veins are generally massive white quartz and contain variable amounts of Fe-oxides and sulfides. They range up to a meter wide but are generally much narrower. Strike lengths range up to 0.5 km. Gillerman (1964) stated that the early miners initially worked the near-surface oxidized ores above the water table, and that activity in the district collapsed shortly after the primary sulfides were reached. The most productive mines include the Standard, Golden Chief and Nancy Lee; many of the other mines which have produced cannot be identified today. The oxidized ores generally have gossan texture and are composed largely of quartz, Fe-oxides and Mn-oxides. Unoxidized ores consist of massive white quartz and minor pyrite.

Values of gold and silver from 51 prospect and vein samples from Beard (1987), which were taken in the central part of the district, range from below the detection limit (.001 oz/ton) to 0.46 oz/ton. The highest values are from veins which occur along the northwest-striking diabase dikes. Generally, with the exception of some veins from the eastern part of the district, veins that strike east-northeast and/or occur along the basaltic dikes have low or no values in both gold and silver.

Individual abundances of elements most commonly recognized as pathfinder elements (Au, Ag, As, Sb, Hg, Se, Cs, W, Mo, Cu, Mn and Ba) were analyzed for selected samples from the above veins and prospects, and vary from sample to sample. Very little Sb or Hg is present in these deposits, but As does appear to be higher in the veins with Au greater than 0.01 oz/ton. Tungsten is also higher in veins with Au greater than 0.01 oz/ton. This does not reflect on the total amount of gold in the sample, as the samples with the highest gold values do not show the highest W or As values.

Copper values are all relatively low, with the exception of one sample which contained visible copper mineralization. Molybdenum values are all relatively low. The highest Mn and Ba values occur in the most oxidized samples. In general, the greater the concentration of Au, the greater the overall abundance of trace elements.

Some of the veins of the district have produced more silver than gold. The Co-op Mine, located on the eastern side of the district, is perhaps the best example and is described by Gillerman (1964). The vein differs from most of the other productive veins in the district in that the mineralization is mainly silver and lead, and it trends east-northeast. Hedlund (1978b) also described other silver-bearing veins, such as the Ruby Silver, which also trend east-northeast.

Lead isotopes from the galena of some of the silver-bearing veins indicate that the quartz veins may be Laramide in age and are also the least radiogenic of the leads which were studied throughout southwestern New Mexico by Stacey and Hedlund (1983). This is of interest because the least radiogenic leads are often favorable indicators for large ore deposits (Doe and Stacey, 1974; Zartman, 1974). The apparent absence of any large ore bodies in the Gold Hills may then be due to the erosion of the ore-bearing horizons. With the exception of the mineralized veins and pervasive sericitization, no indication of any large ore bodies at the surface or at depth is present.

Other deposits

Although pegmatites are found throughout the Gold Hills, very few contain many minerals of economic interest. The White Rock Pegmatites and those in the area of the Co-op Mine have been prospected for REE-bearing minerals, which are reported to be euxenite, allanite, samarskite and cyrtolite (Hedlund, 1978b). These pegmatites are described in detail by Gillerman (1964). Some of the other pegmatites of the district have also been prospected, but very few of the pegmatites contain any of the REE-bearing minerals.

Fluorite deposits are almost entirely restricted to the eastern and southern sides of the Gold Hills. Hedlund (1978a, b, c) briefly described the occurrences, and Gillerman (1964) also discussed them briefly. The deposits generally occur along faults within the granite and sometimes fill small breccia zones. Black calcite also occurs with some of the fluorite (Hedlund, 1978a). The deposits are all relatively small, and production has been minimal.

Tungsten occurs in scheelite and wolframite in only a few deposits, and most of these are in the southeast part of the district (Hedlund, 1978a). The scheelite and wolframite occur within narrow quartz veins, which also contain minor pyrite and very minor gold, in the Precambrian rocks.

Hedlund (1978c) also described a base metal deposit in the Bound Ranch district of the southernmost part of the Gold Hills. The deposit consists of sparse pyrite and chalcopyrite mineralization associated with abundant travertine along a northwest-striking fault. The deposit has not been developed, and only very minor prospecting has been done on it.

CONCLUSIONS

A summary of the geologic history of the area is given in Table 1. This table gives the chronologic order and approximate age for the major geologic events from the Proterozoic to Quaternary. Previous tectonic interpretations for the Precambrian rocks of the region have included extensional environments (Condie and Budding, 1979) and island arc successions (Stacey and Hedlund, 1983). Condie et al. (1985) and Condie and Copeland (1986) described Proterozoic rocks of the Pinal Schist as originating in an island arc environment as well. Stacey and Hedlund (1983) based their interpretation primarily on lead isotopes, and the interpretations of Condie et al. (1985) are based primarily on geochemistry and preserved sedimentary structures. The chemistry of the Gold Hill amphibolites indicates that they do not represent island arc basalts, but possibly ocean floor basalts. The lack of metamorphosed arkoses and metagraywackes also suggests that this area is not a remnant of an island arc terrane. The amount of deformation and the lack of a coherent stratigraphy between the individual supracrustal units make any tectonic interpretations of the Gold Hills extremely tenuous, and it is also possible that different tectonic regimes existed throughout the time represented by these different lithologies.

Grambling et al. (in review) described the boundaries between different Proterozoic tectonic stratigraphic terranes in northern New Mexico as bedding-parallel ductile thrusts and shear zones, and suggested that the terranes may have been assembled by deep-seated ductile imbrication. Grambling et al. (in review) also stated that if this interpretation is generalized to other areas of medium- to high-grade metamorphic

TABLE 1. Proterozoic to Quaternary geologic history of the Gold Hills area.

GEOLOGIC HISTORY: PROTEROZOIC TO QUATERNARY
1. Deposition of sandy sediments and ocean floor basalts.
2. Burial, deformation, and upper amphibolite grade metamorphism of supracrustal rocks. Total number of deformation unknown (minimum age 1550 my).
3. Intrusion of diorite (syntectonic and/or pretectonic, age unknown).
4. Intrusion of granitic rocks and formation of migmatite (syntectonic and/or pretectonic, age 1450 my).
5 Formation of pegmatites and quartz plugs (age unknown, but are probably similar in age to granitic rocks).
6. Pervasive retrograde event which chloritized, sericitized, and epidotized the supracrustal rocks and diorites. Granitic rocks were not as affected due to lack of mafic minerals (age unknown).
7. Intrusion of diabase dikes and plugs (Precambrian, exact age unknown).
8. Start of Burro Uplift (Early Cretaceous).
9. Beginning of intense volcanic activity (Early Tertiary) which persisted throughout the first part of the Tertiary.
10. Formation of gold-bearing veins (age unknown) along selected diabase dikes.
11. Intense northeast by east fracturing, and intrusion of basaltic and felsic dikes (Early Tertiary?).
12. Continued uplift of Burro Mountains region, and eventual stripping of sedimentary and volcanic cover.
13. Minor faulting. Continued erosion of highlands throughout the Quaternary, resulting in rounded topography.

rocks, then zones of multiply-folded rocks commonly may be isolated from underlying and overlying rocks by ductile thrusts. Similar tectonic contacts may exist between the supracrustal rocks in the Gold Hills and Big Burro Mountains.

The occurrence of gold-bearing quartz veins along the contacts of mafic and felsic rocks has been well documented in the Gold Hill district (Gillerman, 1964; Hedlund, 1978b). However, these authors have described the mafic rocks along the contacts of gold-bearing quartz veins as ranging from mafic dikes to amphibolite. Beard (1987), in the study of the central part of the district, observed only mafic dikes along the strike of the gold-bearing veins, and no gold-bearing veins were found at the contacts of amphibolite or diorite with the other lithologies. Most of the dikes which have gold-bearing quartz veins along their strike have dips of less than 60°, and very few of the vertical dikes have veins with the higher gold values. The intrusion of the dikes may have set up a fracture system which allowed the mineralizing fluids to penetrate the host rock, and the gently dipping dikes may have provided closure for the deposits. The vertical dikes, however, may have allowed the fluids to disperse or escape along their contacts. The source of the fluids is unknown, but since the field relations are consistent with the Laramide age proposed by Stacey and Hedlund (1983), it seems likely that the fluids may be related to Laramide intrusive activity in the region. North and McLemore (1987) also classified the veins of the Gold Hill district as Laramide. Although the Laramide age was determined for only the galena-bearing veins, the field relations of the gold-bearing veins with their host rocks are also consistent with a Laramide age.

Further exploration work in the district should be geared toward locating the veins which occur along the diabase dikes. The central part of the district has been prospected the most heavily, as evidenced by a greater concentration of shafts, adits and pits. The geology outside of the central area is similar to that within it, so the potential for locating more of these gold-bearing quartz veins may still exist. Pegmatite, fluorite, tungsten and base metal deposits are all relatively small and are not indicative of any undiscovered larger deposits. The lack of water inhibits working any of the placer deposits, and the abundant granitic debris has undoubtedly diluted the stream gravels with vast amounts of light material. However, the potential for placers in areas to the west of the Gold Hills is largely unexplored at present.

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