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Item 2

GEOLOGY OF THE TECOMA DISSEMINATED GOLD AND SILVER DEPOSIT

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ABSTRACT

The Tecoma deposit is in a mineralized low angle, younger-over-older fault zone between the Devonian Guilmette Formation and the Mississippian Chainman-Diamond Peak Formations. Ore is predominantly in silicified carbonate and shale along the fault contact, with lesser amounts of dolomite and shale ore above and below the fault, respectively. The Tecoma deposit contains geologic reserves of approximately 1.5 million tons of 0.05 OPT gold and 3 OPT silver. Ore contains barite, pyrite, hematite, acanthite/argentite, native gold, arsenic oxides, and iron oxides.

The deposit is in the southeastern part of the Tecoma mining district. The only recorded production in the district was from high-grade silver and lead replacement bodies. Ore is in fault zones along the axis of a northwest-trending anticline at the Jackson Mine, 3 miles northwest of the Tecoma deposit. The district contains miogeoclinal rocks of Devonian through Permian age that are complexly faulted and folded, and intruded by ore related Tertiary(?) quartz monzonite porphyry dikes and post-ore Tertiary rhyolite domes. Silicification of carbonate and shale (jasperoid) is common throughout the district and is spatially related to the porphyry dikes.

INTRODUCTION AND PREVIOUS WORK

The Tecoma deposit, located in the Tecoma district, is an epithermal carbonate-hosted disseminated gold and silver deposit

discovered in late 1980 by Noranda Exploration, Inc. It is geologically similar to the Rain and Alligator Ridge gold deposits and the Taylor silver deposit. It is unusual in containing approximately equal dollar value of gold and silver at an approximate ratio of 1:60 Au:Ag.

The district was studied in detail by Ian H. Douglas as part of a master's thesis at Stanford University. The district is mentioned in Regional studies by Hill (1916), Granger et al. (1957), Lovering (1972), and Smith (1976). County maps by Hope and Coats (1970) and Doelling (1980) cover the Elko and Box Elder County sides of the district, respectively.

LOCATION

The Tecoma district is between latitudes $41^{\circ}25'$ and $41^{\circ}30'$ north and longitudes 114° and $114^{\circ}5'$ west in northeastern Elko County, Nevada and western Box Elder County, Utah (Figure 1). It lies within the Jackson Spring 7.5' quadrangle, in T.41N., R.70E. (Nevada) and T.8N. and T.9N., R.19W. (Utah). The district is 15 mi northeast of Montello, Nevada, a town situated along the Southern Pacific Railroad, and 5 mi north of Nevada State Route 233/Utah State Route 30. The area lies at the extreme southern end of the Goose Creek Mountains. The topography consists of gentle foothills intertonguing with flat alluvial pediments of Tecoma Valley. The elevation ranges from 5,100 to 6,567 ft.

HISTORY AND PRODUCTION

The Jackson mines, discovered in 1906 (Hill, 1916), were the principal producers in the Tecoma district. Three thousand tons of argentiferous cerussite ore were mined between 1906 and 1947, and 1,814 tons were mined between 1947 and 1951 (Granger et al, 1957). Total metal content was 72 oz gold, 46,697 oz silver, 5,917 lbs copper and 2,243,512 lbs lead (Granger et al, 1957). The Queen of the West mines, located 1.5 mi east-southeast of the Jackson mines were the only other possible producers in the district.

Noranda Exploration, Inc., acquired its initial land position in the district in August, 1980. The Tecoma deposit was initially sampled in November, 1980, and the first ore hole drilled in September, 1981. A 6 ft shaft of unknown vintage was dug in the footwall of the deposit, 20 ft from the discovery outcrop. Three rotary holes were drilled by an unknown party, one of which was collared in ore.

DISTRICT GEOLOGY

Miogeoclinal rocks of Devonian through Permian age are exposed in the Tecoma district. The units consist of the Devonian Guilmette Formation, Mississippian Chainman-Diamond Peak Formations, Pennsylvanian Ely Limestone and Strathearn Formation, and Permian Buckskin Mountain Formation and Pequop Formation. These units generally strike north-northwest and dip 50 to 80° northeastward. They are intruded by Tertiary(?) Quartz monzonite porphyry dikes and post-mineral Miocene Rhyolite domes. Miocene Rhyolite flows and tuffs lie disconformably on, and are faulted against the Paleozoic

section. The units are complexly faulted by high- and low-angle faults. Figure 2 depicts the simplified geology of the Tecoma district.

Six Paleozoic units are exposed in the Tecoma district. The Devonian Guilmette Formation is a thick-bedded, fossil-poor limestone that is at least 800' thick. A regionally correlative arenite is present near the top of the unit and quartzite near the base. At all exposures, the top of the formation is a low-angle fault contact with shales of the Chainman-Diamond Peak Formations (generally silicified) overlying the limestone. The Chainman-Diamond Peak Formations contain both chert-pebble conglomerate interbedded with chert sandstone and siltstone (Diamond Peak Fm.), and mudstone and shale interbedded with cherty sandstone and siltstone (Chainman Fm.). A thin silty limestone is present in the mudstone and shale-rich base of the Formation. A recent conodont date from a sample of this limestone yielded an age of Late Kinderhookian (D. Miller and A. Harris, personal comm.). The Chainman-Diamond Peak Formations are overlain by the Pennsylvanian Ely Limestone. The Ely Ls., a thick-bedded bioclastic and cherty limestone, is more than 800 ft thick at the Queen of the West mines. The district is north of a regional Pennsylvanian highland that caused erosion of the lower Pennsylvanian rocks from adjacent ranges to the south and west (Stevens, 1981). The contact of the Ely Limestone and Strathearn Formation is well exposed at the Queen of the West mines, where it consists of interbedded chert and lime-pebble conglomerate and limestone. The Pennsylvanian Strathearn Formation is composed of more than 200' of chert and

lime-pebble conglomerate that looks very similar to conglomerates of the Chairman-Diamond Peak Formations. The distinguishing characteristic is the presence of limestone pebbles in the Strathearn Formation. The upper contact with the overlying Permian Buckskin Mountain Formation is not exposed in the district. The Buckskin Mountain Formation appears to be in excess of 3,400 ft thick in the Tecoma district and forms a large part of the exposed Paleozoic section. It is composed primarily of calcareous siltstone with interbedded calcareous sandstone and subordinate bioclastic and cherty limestone and weathers a characteristic purplish color. The formation is in turn overlain by the Permian Pequop Formation. The Pequop Formation is in excess of 5,000 ft thick in the Tecoma district and is the most commonly exposed unit. It is composed primarily of silty, thin-bedded limestone with subordinate sandstone, siltstone, and bioclastic limestone. The unit weathers into characteristic light grey plates.

Igneous rocks are divided into three units: Quartz monzonite porphyry dikes, Rhyolite domes, and Rhyolite flows. Tertiary(?) quartz monzonite porphyry dikes intrude the paleozoic section. They contain quartz, k-spar, plagioclase and biotite phenocrysts in a fine-grained quartz/feldspar matrix. The dikes, intensely argillized throughout the district, are composed of kaolinite and quartz and are too altered to date. They are spatially associated with numerous jasperoid bodies throughout the district and are thought to be pre- or syn-ore. They intrude northwest, east, and northeast-trending, high-angle faults. Post-ore Miocene Rhyolite domes also intrude the Paleozoic section, along north-trending

normal faults. They are flow-foliated, crystal-rich and composed of sanidine and quartz phenocrysts in a partially devitrified aphanitic matrix. Miocene Rhyolite flows lie disconformably on and are faulted against the Paleozoic section. The flows contain abundant quartz and sanidine phenocrysts.

The structure of the Tecoma district is complex. Four sets of high-angle faults and one set of low-angle faults have been mapped. The oldest appear to be low-angle faults which place Chainman-Diamond Peak shales on Guilmette Fm. These low-angle faults are major faults of regional significance. This same relationship has been observed in the Pilot Mountains to the south by Miller (1982, 1984) and elsewhere. Whether these faults are part of a regional thrust or detachment fault is unresolved. Other faults in the district are, from oldest to youngest, pre-one northeast-trending normal (?), pre-one east-trending reverse, pre-one northwest-trending normal, and post-one north-trending normal. The north-trending normal faults appear to represent the present cycle of Basin and Range extension.

Broad, northwest-trending Mesozoic(?) anticlines are exposed at two places in the district. At the Jackson mines, the anticline is faulted along its axis near the workings. To the northwest of the Jackson mines it plunges northwest, and to the southeast of the mines it plunges southeast. A poorly defined, northeast-plunging anticline is exposed south of the Tecoma deposit and may be covered under alluvium immediately west of the deposit.

GEOLOGY OF THE TECOMA DEPOSIT

INTRODUCTION

The Tecoma deposit is in a mineralized, low-angle fault zone between the Devonian Guilmette Formation and the Mississippian Chainman-Diamond Peak Formations (Figure 3). These units are displaced by a series of high-angle faults and intruded by quartz monzonite porphyry dikes. Ore is predominantly in silicified carbonate and shale along the low-angle fault contact, with lesser amounts of dolomite and shale ore above and below the fault, respectively. The Tecoma deposit contains geologic reserves of 1.5 million tons grading 0.05 OPT Au and 3 OPT Ag.

GEOLOGIC UNITS

Two formations host ore at Tecoma: the Devonian Guilmette Formation and the Mississippian Chainman-Diamond Peak Formation. Other units in close proximity to the ore are the Permian Buckskin Mountain Formation and Tertiary quartz monzonite porphyry dikes (Figure 3).

The Guilmette Formation is a coarse-grained, recrystallized dolomite that was originally a limestone. The dolomite contains few fossils and because of recrystallization, is poorly to nonbedded. An arenite near the top of the unit is composed of well rounded and well sorted quartz grains in a carbonate matrix. It is grain supported, 25 to 40 ft thick, and occasionally has clean

carbonate lenses within it.

The basal Chainman-Diamond Peak is composed of mudstone, shale, and siltstone with thin sandstone stringers, scarce chert-pebble conglomerate beds and a limestone bed near the base. Mudstone and shale are clayey, soft, silty, limonite-stained and rarely carbonaceous where silicification has prevented complete oxidation. Sandstone and siltstone are composed of varicolored, poorly sorted, grain-supported, angular chert grains and well rounded quartz grains in a siliceous or calcareous matrix. Conglomerate is composed of angular to rounded, varicolored chert and quartzite pebbles in a sandy matrix. The limestone is thin-bedded, laminated, silty, has shaley partings and is varicolored. When silicified, the limestone is indistinguishable from silicified shale and mudstone.

The 'Buckskin Mountain Formation, in normal fault contact with the Chainman-Diamond Peak, is composed of red, calcareous, quartz-rich siltstone. The unit forms a gentle hill northeast of the deposit.

Quartz monzonite porphyry dikes are composed of quartz, feldspar, and biotite phenocrysts in a very fine-grained groundmass of quartz and feldspar. Quartz eyes are usually partially resorbed and less than 1/4 in. in diameter though one dike has quartz eyes up to 1 in. in diameter. The dikes are not exposed, but can be traced easily in float and appear to intrude the PN fault (Figure 3). The dikes appear to be pre-ore and possibly the heat source for the hydrothermal system that formed the numerous jasperoid bodies and the Tecoma deposit. The dikes do not form ore but can be enriched in Au, Ag, and trace elements.

STRUCTURE

The Tecoma deposit contains at least five different faults. A low-angle, northwest-trending younger-over-older fault is the dominant, and oldest structure in the deposit. The youngest structure is a north-trending normal fault. Because of lack of crosscutting relationships, the relative ages of the northwest-trending normal faults, east-trending reverse faults, and northeast-trending normal(?) faults are uncertain, though on a district-wide scale the northeast-trending faults are the oldest and the northwest-trending faults are the youngest.

The low-angle fault juxtaposes Chainman-Diamond Peak over Guilmette. In the Pilot Range to the south, there is up to 1400 ft. of Mississippian Tripon Pass Limestone between these two units (Miller and Schneyer, 1983). Examination of the cross-section on Figure 3 shows that the fault is cutting downsection in the Guilmette and there is a suggestion that it is also cutting downsection in the Chainman-Diamond Peak. Displacements on all other faults are small in comparison to the low-angle fault. They range between 30 and 50 ft. The northwest-trending Min and PN faults (Figure 3) may have channelled hydrothermal fluids into the low angle fault zone and thus would be at least pre-ore. The north-trending Valley fault is post-ore.

~~ALTERATION~~

ALTERATION

Three types of alteration are present in the Tecoma deposit: silicification, dolomitization, and argillization. Silicification is concentrated in a zone as much as 55 ft thick that parallels the low-angle fault. Intense silicification (jasperoid) is shown in the stippled pattern on Figure 3. Outward from the silicified rock, partial silicification and quartz/barite veinlets are common especially in the dolomite. Silicic alteration decreases away from the fault contact in both directions.

The dolomite in the Tecoma deposit is interpreted to be hydrothermally dolomitized limestone of the Guilmette Formation. Regionally and 2.5 mi to the northwest at the Jackson mines, the Guilmette is a limestone. The dolomite is coarsely recrystallized, veined by quartz and barite and hydrothermally brecciated. Iron and arsenic oxides are concentrated in the carbonate matrix of the breccia. One core hole drilled to 902 ft below the ore shows dolomite breccia dominant to 540 ft, and dolomite present to the bottom of the hole.

Argillic alteration is most intense in quartz monzonite porphyry dikes. The dikes are completely altered to kaolinite and quartz. The shales and mudstones overlying siliceous ore may also be argillized and decarbonized. Regionally, shales of the Chainman-Diamond Peak are very carbonaceous; however, only scarce carbonaceous zones have been seen in drilling at Tecoma indicating widespread bleaching.

MINERALIZATION

Most of the ore at Tacoma occurs in silicified rock above and below the low-angle fault. Approximately 70% of the ore is siliceous and the rest occurs in shale and dolomite. In addition to enrichment in gold and silver, the ore is strongly enriched in arsenic, mercury and barite. The ore contains approximately 5% barite, 5,000 to 10,000 ppm arsenic and 1 to 10 ppm mercury.

Siliceous ore is typically brecciated and multiple episodes of brecciation are common. Barite is very abundant as are arsenic and iron oxides. Arsenic occurs as a pistachio-green supergene mineral, dussertite ($\text{BaFe}_3(\text{AsO}_4)_2(\text{OH})5\text{H}_2\text{O}$), generally coating fractures. In very high-grade portions, copper oxides are present in trace amounts. Siliceous ore is slightly higher than average grade in both gold and silver.

Shale ore looks similar to unmineralized altered shale except that it can contain quartz veinlets, thin silicified zones, and disseminated oxidized sulfides. The oxidized sulfides often have hematite cores rimmed by green (arsenic?) oxides. Shale ore is usually barite-poor and is slightly lower than average grade in gold and considerably lower than average grade in silver.

Dolomite ore is the most variable of the ore types. Brecciation is ubiquitous, though much non-ore is also brecciated. Dolomite ore ranges from brick-red, vuggy, baritic, clayey, and gossany to black-brown clayey gouge to light grey coarse-grained rock. Thin zones of silicification are common as are quartz/barite veinlets and disseminated and vein barite. Dolomite ore is lower

than average grade in gold but average grade in silver.

The low-angle fault is the primary control on ore deposition. Movement along this fault probably increased the permeability of the units around the fault. Hydrothermal fluids flowed up along the high-angle faults such as the northwest-trending normal faults (FN and Min faults) and then flowed out along the permeable fault zone.

Native gold is the only identified gold-bearing mineral. Visible gold has been seen only once in an outcrop sample of silicified shale containing barite and chalcocite. Acanthite or argentite is the primary silver-bearing mineral and some silver occurs in Mn and Fe oxides. Trace amounts of aguilarite (Ag_4SeS), native silver, and electrum have been identified in S.E.M. studies.

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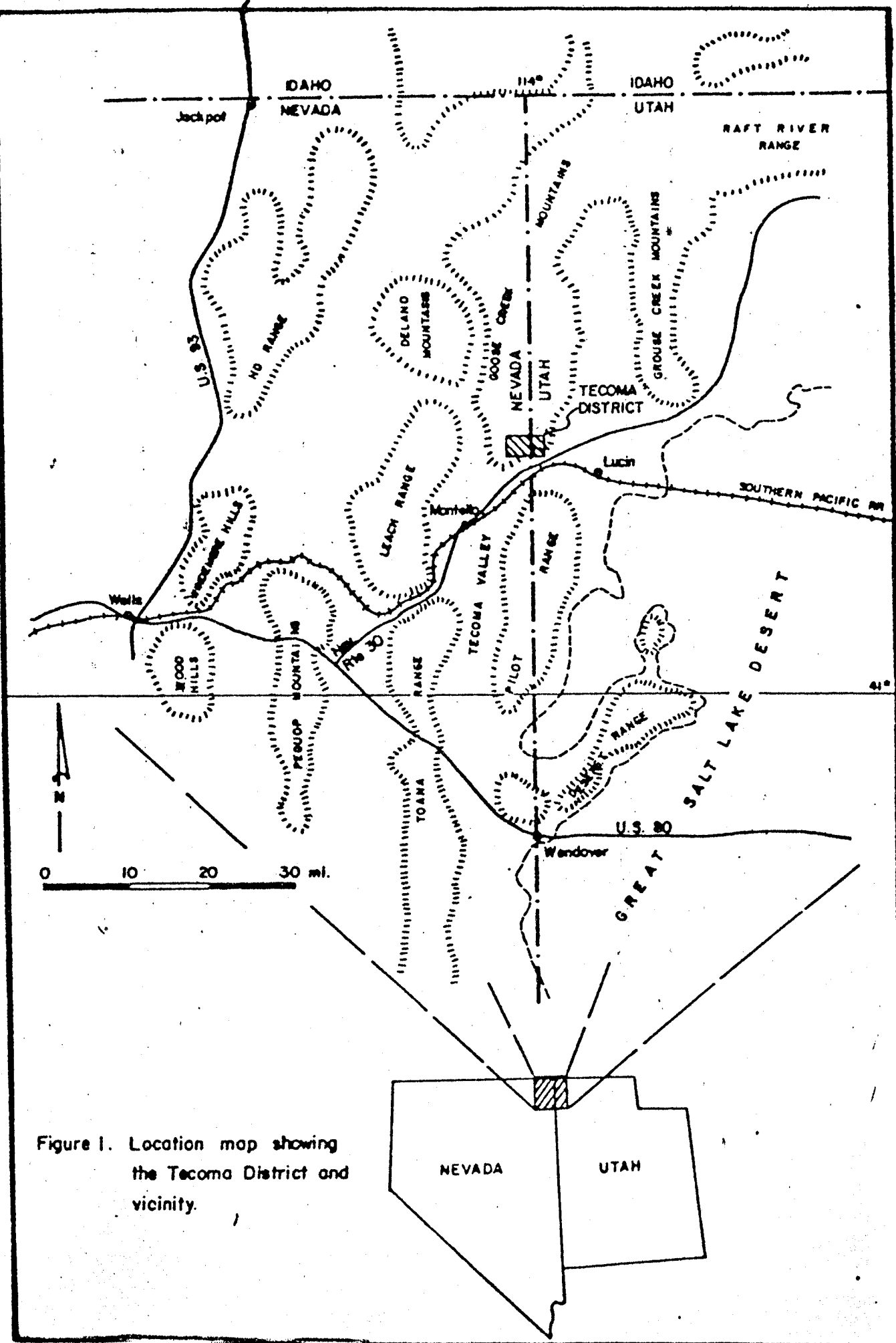


Figure 1. Location map showing the Tecoma District and vicinity.

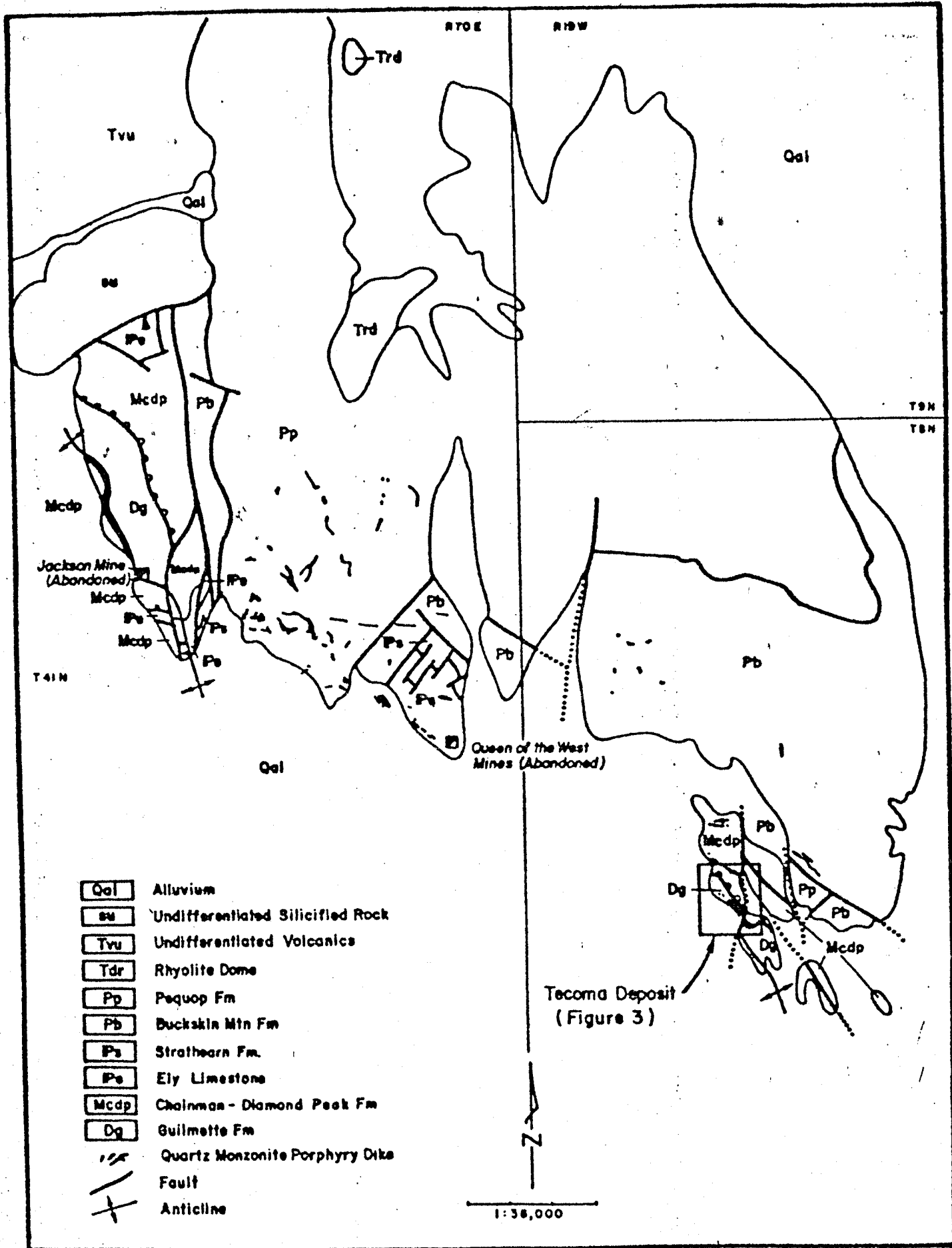


FIGURE 2.

GEOLOGY OF THE TECOMA DISTRICT

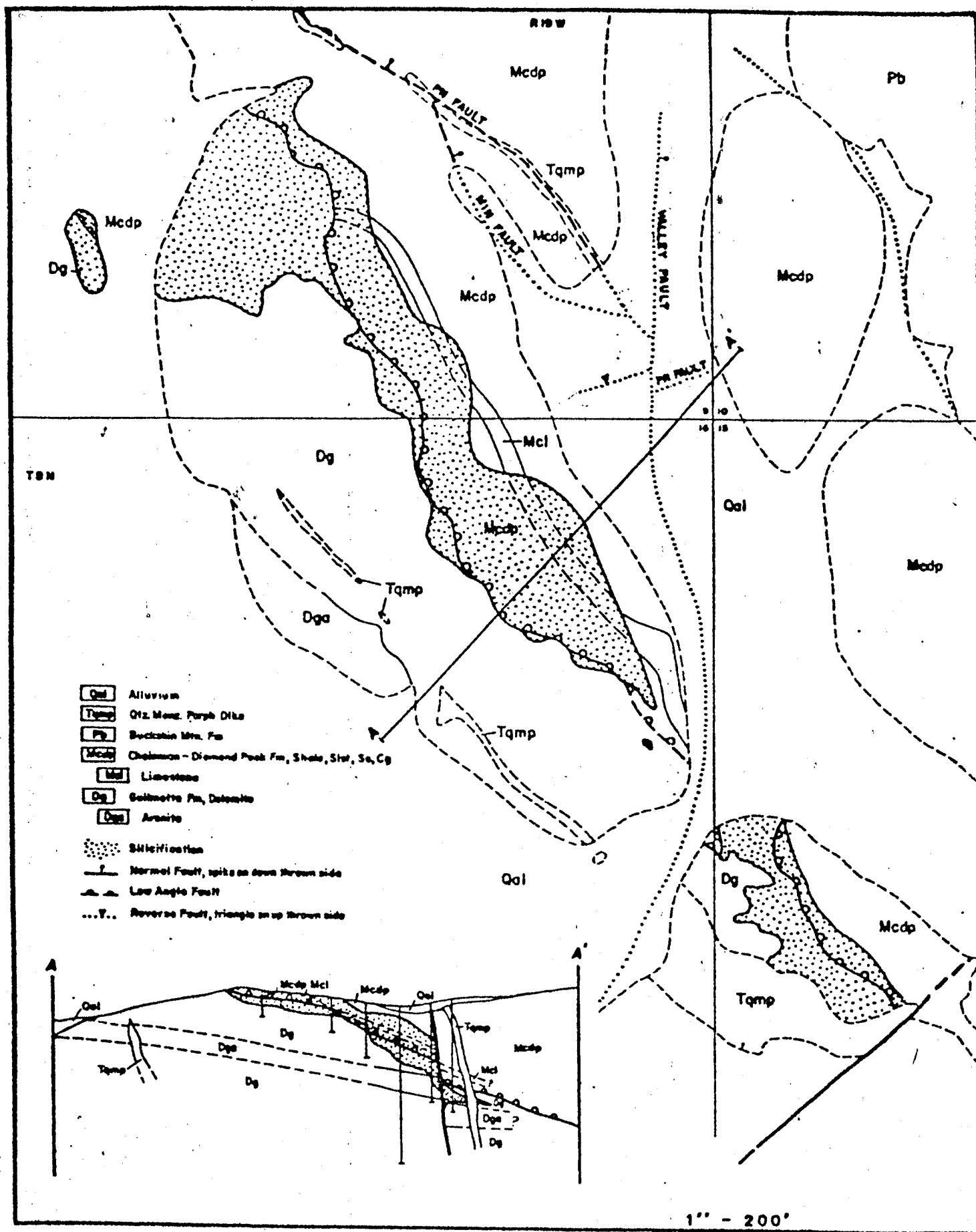


FIGURE 3. GEOLOGIC MAP OF THE TECOMA DEPOSIT