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GEOLOGY OF KENNECOTT COPPER CORPORATION'S SAFFORD COPPER DEPOSIT

By

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LOCATION AND HISTORY

Kennecott's Safford Development Project is located in the Lone Star Mining District, thirteen miles northeast of the town of Safford, county seat of Graham County, Arizona. The nearest active mining property is Phelps Dodge's Morenci open-pit copper mine, located nineteen airline miles to the northeast (or 60 miles by road). Recorded production from the Lone Star Mining District up to 1907 amounted to only 110,000 lbs. of copper — mainly from the San Juan Mine. This production was mined from small shear zones or veins which occur in quartz-monzonite porphyry, andesite, or rhyolite.

The mining district lies south of the Gila Mountains, which are covered by later unmineralized basalt, andesite, agglomerate and tuff. From 1949 to 1952 Consolidated Copper Mines Corporation and the American Metal Company, Ltd., optioned some of the existing claims, drilled four holes in the outcropping mineralized rhyolites, and five holes through the basalt-covered area. While only low-grade copper mineralization was encountered, some of the mineralization was found to occur as disseminations in the andesites and rhyolites.

In 1955 Bear Creek Mining Company (Kennecott's exploration subsidiary) commenced reconnaissance geological mapping in the Gila Mountains. Although results of the previous drilling were not available to Bear Creek at this time, the sheared, altered and iron-stained outcrops looked encouraging enough to warrant further investigation. The same area was therefore optioned in 1956. After the area was mapped geologically — assisted by geophysical surveying and geochemical sampling — a diamond drilling program was commenced. When drilling indicated the existence of a sizeable low-grade copper deposit underlying the unmineralized later volcanics in the Gila Mountains, the property was purchased by the Company in 1959.

Since this time development work has been carried on at the property. In 1961 a development shaft was sunk to a depth of 804 feet, followed by 1,500 feet of crosscutting and 1,500 feet of drifting on the 3900' level (754 feet from the collar). Both underground and surface drilling is currently being done.

GEOLOGY

The sequence of rocks exposed in the area is shown in the tabulation below:

Sedimentary and Volcanic Rocks

Formation	Rock Types	Thickness	Age
Alluvium, Gila conglomerate	Sands, siltstones & conglomerates	0'-2,000'	Quaternary-Pleistocene
..... Unconformity			
Younger Volcanic rocks	Basalt, tuffs & agglomerates	0'-1,000'	Tertiary (?)
..... Unconformity to disconformity			
Intermediate Volcanic rocks	Andesite, tuffs, flows, agglomerates	0'-2,000 plus	Post-mineral
..... Unconformity A			
Older Volcanic rocks	Andesite, flow-breccia, & tuffs	2,500' plus	Pre-mineral Cretaceous (?)
..... Unconformity			
Quartzite	Quartzite	(?)	Cambrian (?)

Intrusive Rocks

Formation	Age
Basalt dikes	Post-mineral
Latite, quartz-latite, rhyolite and quartz-diorite dikes and plugs	Older than Unconformity A (Intrusive into Older Volcanics and Lone Star pluton)
Quartz-monzonite porphyry	Older than Unconformity A (Intrusive into Older Volcanics)
Lone Star pluton (quartz-diorite, diorite)	Older than Unconformity A (Intrusive into Older Volcanics)

As will be seen from the tabulation, and also from the attached geological map (Fig. 1), the oldest rocks in the area consist of the small outcrops of quartzite of possible Cambrian age. Next younger in age is the group of Older Volcanics, consisting mainly of andesite with some flows and lithic tuffs, strongly sheared by northeast fault zones. Intrusive into the andesite is the Lone Star pluton, consisting of diorite and quartz-diorite. Still later intrusions include a quartz-monzonite porphyry plug (at the San Juan Mine) and numerous northeasterly-trending dikes, and probably three plugs of latite, quartz-latite and rhyolite — only one of which is exposed at the surface. Dikes of these rock types also intersect both the quartzite and the Lone Star pluton.

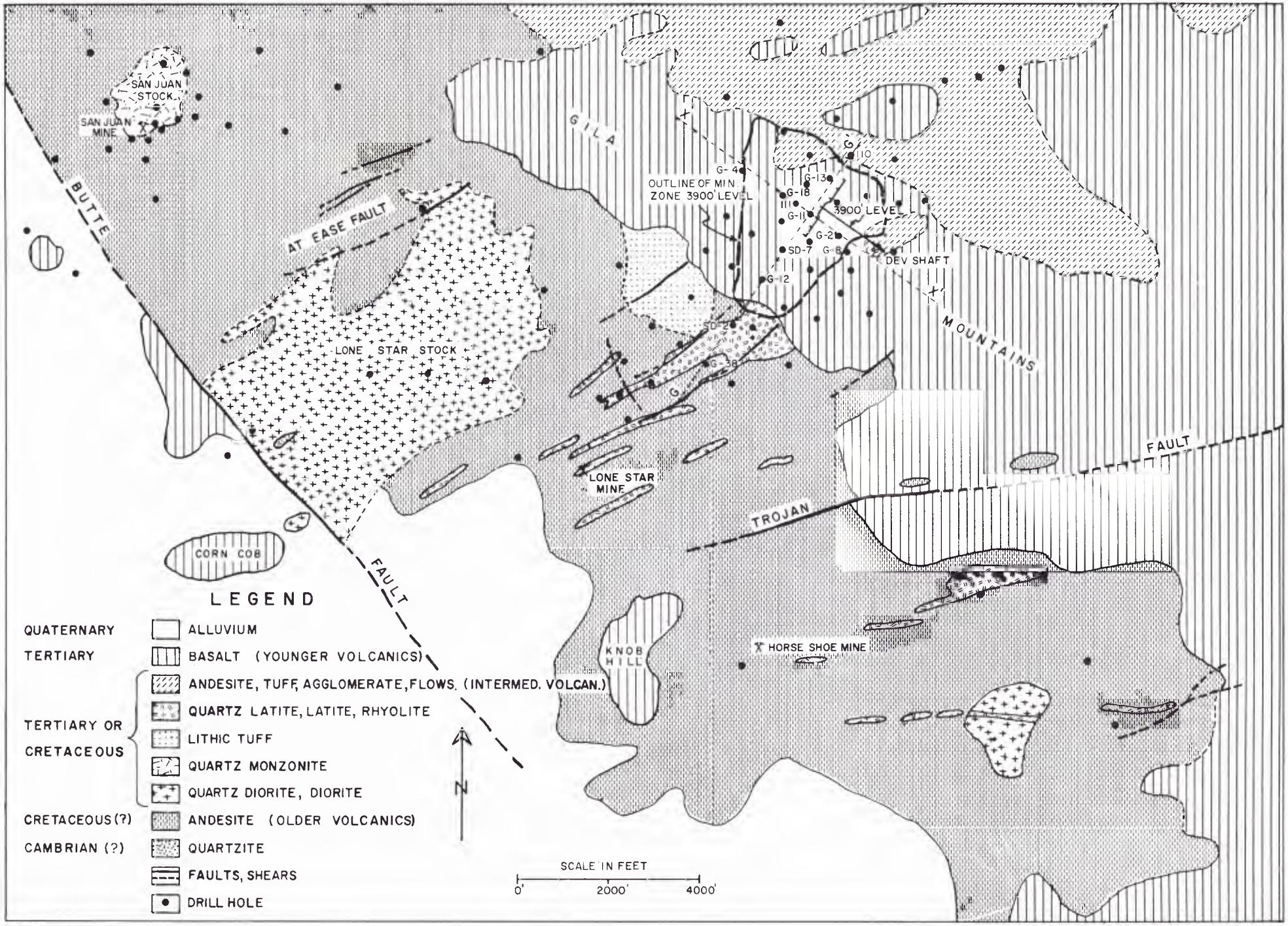

Fig. 1- GENERALIZED GEOLOGICAL MAP, SAFFORD PROJECT AREA

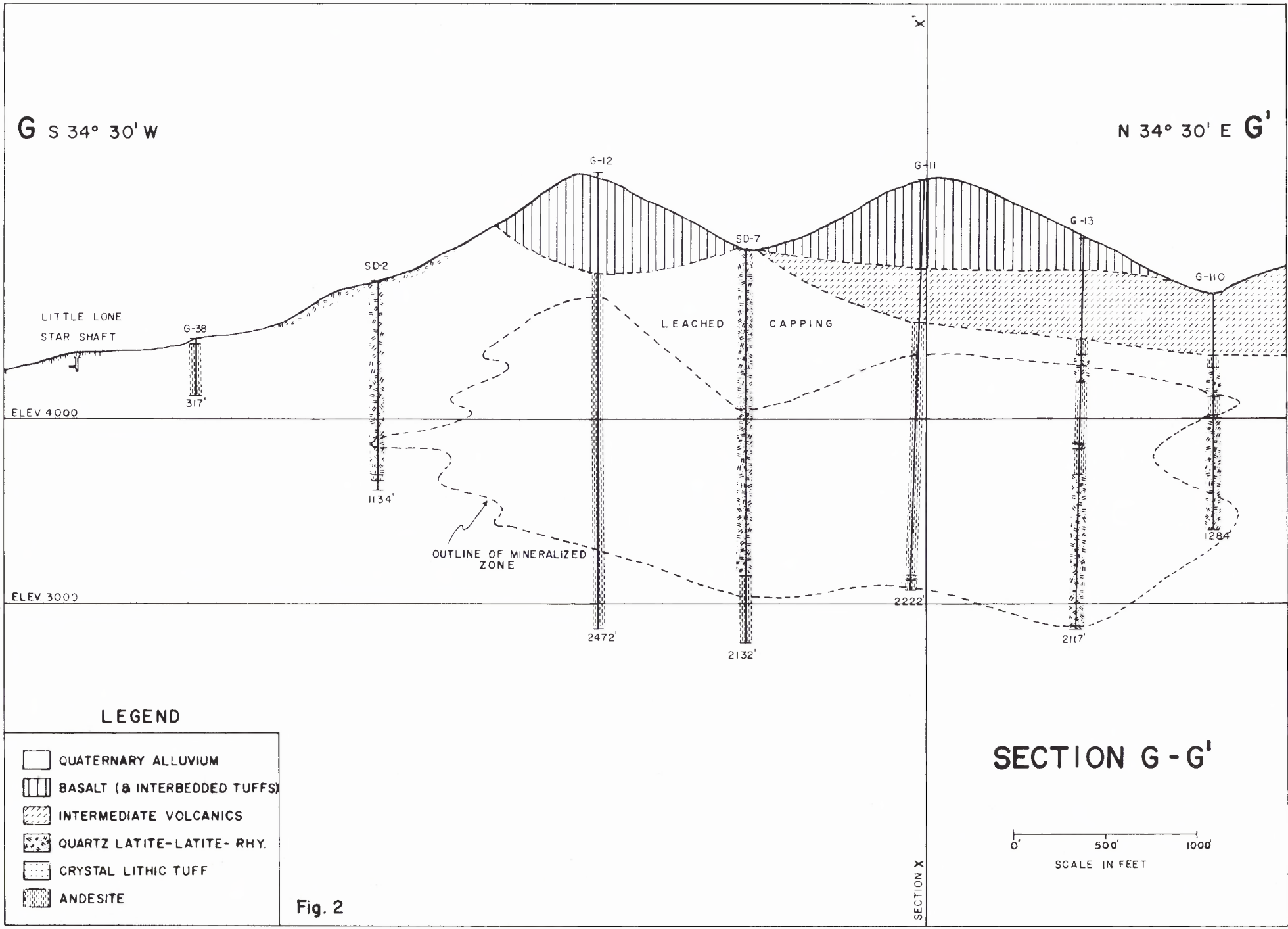
G S 34° 30' W
N 34° 30' E G'
X'
G-12
G-11
G-13
SD-7
SD-2
G-110
LITTLE LONE
STAR SHAFT
G-38
317'
LEACHED
CAPPING
ELEV 4000
1134'
OUTLINE OF MINERALIZED
ZONE
284'
ELEV. 3000
2222'
2472'
2132'
2117'
LEGEND
QUATERNARY ALLUVIUM
BASALT (& INTERBEDDED TUFFS)
INTERMEDIATE VOLCANICS
QUARTZ LATITE-LATITE- RHY.
CRYSTAL LITHIC TUFF
ANDESITE
SECTION X
SECTION G-G'
0'
500'
1000'
SCALE IN FEET

Fig. 2

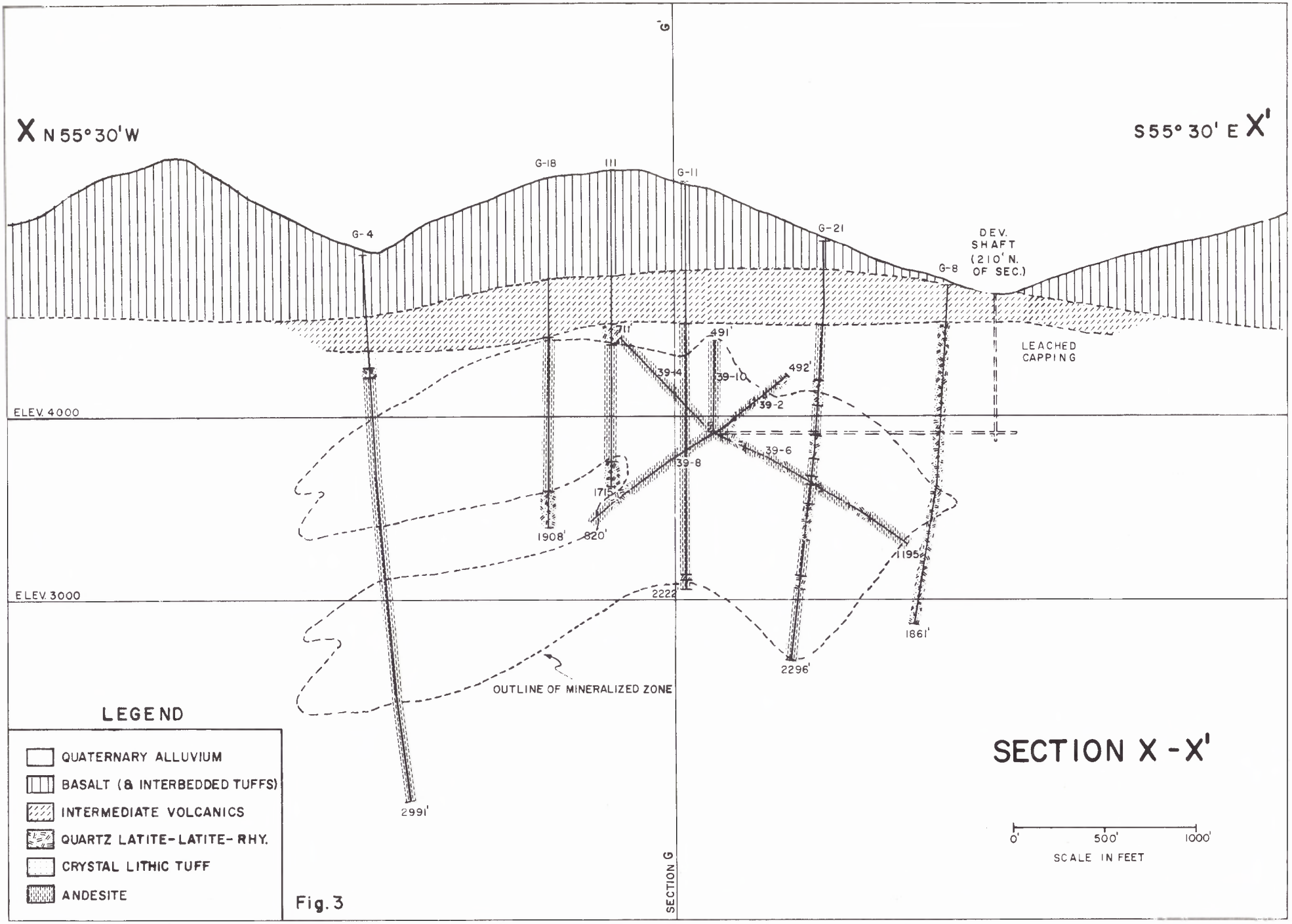
X N 55° 30' W
S 55° 30' E X'
G'
G-4
G-18
111
G-11
G-21
G-8
DEV. SHAFT (210' N. OF SEC.)
LEACHED CAPPING
ELEV. 4000
ELEV. 3000
711'
491'
492'
39-4
39-10
39-2
39-6
39-8
1715'
1908'
820'
1195'
2222'
1861'
2296'
2991'
OUTLINE OF MINERALIZED ZONE
SECTION G
LEGEND
QUATERNARY ALLUVIUM
BASALT (& INTERBEDDED TUFFS)
INTERMEDIATE VOLCANICS
QUARTZ LATITE-LATITE-RHY.
CRYSTAL LITHIC TUFF
ANDESITE
SECTION X-X'
0'
500'
1000'
SCALE IN FEET

Fig. 3

Shearing and fracturing along the northeast shear zones continued after the later intrusions. Following this, the area was hydrothermally altered and mineralized — principally with iron and copper-bearing sulfides. In time the deposit probably became enriched by the formation of a chalcocite blanket. Subsequently it was covered by the so-called Intermediate Volcanics (andesite, tuffs and flows) and the Younger Volcanics (basalt, tuffs and agglomerates). Northwest block-faulting then took place, resulting in the uplift and tilting of the Gila Mountains to the east and further oxidation of the presumably previously-enriched ore deposit.

STRUCTURE

The most prominent structural element exposed is the strong and dominant northeast trend of shearing in the Older Volcanics. This has also been borne out by underground development. The early age of this shearing is suggested by the probability that it guided the emplacement of the Lone Star and San Juan plutons, as well as the quartz-latite, latite and rhyolite dikes. It also guided and localized alteration and mineralization. Movement on some of the faults was late enough to displace the Tertiary basalts — i. e., the Trojan fault, on which there is 170 feet of throw.

While the northeast shearing is most intense in the area straddling the Lone Star Mine (approximately 1,500 feet on each side), it also persists less intensely for 5,000 feet south of the Trojan fault. To the northwest it is also less intense inside the Lone Star pluton. However, on the northwest flank of this intrusive it increases in intensity (as in the At Ease fault zone) but falls of again towards the San Juan quartz-monzonite porphyry.

While the northwest trend of the Gila Mountains is considered to have been created by block faulting, the Butte fault is the only major fault found to be parallel with the range. Based on the difference in elevation of the base of the basalt on each side of this fault, the displacement here may be as much as 2,000 feet.

No extensive breccias occur within the main mineralized section, but a tectonic breccia (500 feet by 100 feet) does occur northwest of the San Juan quartz-monzonite. A few structural breccias and breccia pipes (1-6 feet in width), and also small pebble dikes, occur in the vicinity of the Lone Star pluton. Around the San Juan intrusive some of the breccias are mineralized with chalcopyrite — making them pre-sulfide mineralization in age.

From surface and underground mapping, as well as underground drilling on the Safford Project, there appear to be three main plugs of rhyolite (with attendant dikes) intrusive into the andesite. The rhyolite also intruded a lithic tuff of similar composition. This tuff may have originated earlier from the same vent or vents up which the rhyolite plugs were intruded later. The ore deposit occurs in the rhyolite plugs and adjoining areas of andesite, whereas the lithic tuff is only slightly mineralized.

ALTERATION AND MINERALIZATION

Four hypogene alteration zones have been recognized on the property from surface exposures, diamond drilling and underground mapping, namely:

(1) Zone of strong sericitization and silicification.
(2) Zone of strong biotitization.
(3) Zone of chloritization.
(4) Zone of propylitic alteration or unaltered rocks.

The orebody occurs in zones (1) and (2), depending on which rock type is present. Sericitization is restricted to rhyolites, latites and quartz-latites, whereas biotitization is mainly limited to the andesites. These two zones, occupying an area of approximately 7,000 by 7,000 feet, consequently may be regarded as being equal high intensity zones of potash introduction.

Where exposed, the zone of chloritization forms a partial halo 1,000-2,000 feet in width around the zones of sericitization and biotitization. Within this zone — which grades into the zone of propylitic alteration and unaltered rock — strong sericitization occurs locally along mineralized veins, shear zones, or dikes.

Supergene alteration has resulted in the development of kaolinite, quartz, limonite, some sericite, and local alunite and gypsum. While evidence of supergene effects is found at depth in most drill holes, the supergene minerals usually can be distinguished from the hypogene alteration products.

Alteration within the San Juan quartz-monzonite porphyry intrusive has a roughly concentric configuration, and consists of a central silicified, sericitized zone 2,500 feet in diameter. Adjoining andesites are biotitized in a halo for an additional 1,500 - 2,000 feet, followed by an incomplete halo of chloritization approximately 1,000 feet wide.

As previously mentioned, the Safford Project copper deposit occurs in the first two zones of alteration. However, a pyritized zone some 20,000 feet in length and 4,000 - 9,000 feet in width is associated with the ore, overlapping into the chloritized zone. A similar zone 3,000 - 6,000 feet in extent is present around the San Juan intrusive. Small amounts of gold also occur in quartz veins situated 1,000 feet south of the orebody. Some galena was found near Corncob Hill — 4,000 feet southwest of the center of the mineralized zone.

As stated above, the orebody occurs in the Older Volcanics, which were later covered by unmineralized Intermediate and Younger Volcanics. Below the unmineralized volcanics is a leached zone 20 - 900 feet thick. Hypogene mineralization consisted predominantly of pyrite and chalcopyrite occurring in veinlets or disseminations. Very minor quantities of bornite, molybdenite, sphalerite, galena, magnetite, and specularite also occur.

During later supergene enrichment, chalcocite and covellite were formed by replacement of chalcopyrite and pyrite. Because of the later uplift of the Gila Mountains, oxidation to great depths occurred and produced the mixed oxide-sulfide orebody being developed today. The most characteristic and abundant copper mineral in the deposit is chrysocolla, with important amounts of brochantite. Lesser quantities of cuprite, pseudo-malachite, native copper, antlerite, turquoise, and malachite are also present.

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