Newly Located Occurrences of Lode Gold Near Table Mountain, Circle Quadrangle, Alaska

By W.D. MENZIE, RENMIN HUA, and H.L. FOSTER

Results of brief studies of the field relations, trace-element geochemistry, mineralogy, and fluid inclusions of new lode gold occurrences near Table Mountain, Circle quadrangle, Alaska, are reported. Similar occurrences probably were the sources of placer gold deposits in the Circle mining district.

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Newly Located Occurrences of Lode Gold Near Table Mountain, Circle Quadrangle, Alaska

By W.D. Menzie, Renmin Hua[1], *and* H.L. Foster

Abstract

Newly located occurrences of lode gold in the vicinity of Table Mountain, Circle quadrangle, are probably similar to those which were sources for placer gold in the Circle district and Faith Creek area. Brief studies were made of the field relations, trace-element geochemistry, mineralogy, and fluid inclusions of the occurrences. Most of the gold-bearing samples are clustered in two areas. The highest concentrations of gold (2.6-140 ppm) occur, just west of Table Mountain, in black biotite schist and in quartz veins adjacent to a fault zone that is intruded by a hypabyssal felsic dike. Five kilometers to the northeast, where a small granite pluton crops out, gold was detected in lesser amounts (0.05-0.2 ppm) in country rocks adjacent to the granite, in the granite adjacent to dikes, and in felsic dikes. The occurrences have a simple mineralogy: pyrrhotite, arsenopyrite, minor chalcopyrite, and rare enargite and sphalerite. They formed from low-saline fluids (10 weight percent NaCl equivalent) whose sulfur fugacities were within the stability field of pyrrhotite. Based upon fluid-inclusion data, we infer that the occurrences formed at moderate temperatures from fluids that initially boiled, over the range 370 to 320 °C, and then gradually cooled. Field relations and estimated depths of formation of contact metamorphic effects and quartz veins indicate that the occurrences formed in an active tectonic environment.

INTRODUCTION

The Circle quadrangle, a major gold producing area of Alaska, has produced at least 850,000 oz of gold (Bundtzen and others, 1984), all from placer deposits. Production has been from four areas (Menzie and others, 1983), the majority coming from the Circle mining district. During regional geologic studies, which were part of the Alaska Mineral Resource Assessment Program (AMRAP), several samples of gold-bearing rock were collected from two areas in the Circle B-4 quadrangle. At one area, near Table Mountain, two samples of fine-grained biotite schist collected adjacent to a fault contained 40 and 140 ppm gold. About 5 km northwest of Table Mountain, low levels of gold (<1 ppm) were detected from samples taken in and adjacent to a small felsic pluton.

Although the streams that drain these two areas have not been mined, the main productive streams of the Circle district are just to the east; a smaller area of placer mining, here called the Faith Creek placer area, lies to the west of Table Mountain (fig. 1). Because occurrences such as those near Table Mountain and the pluton are probably similar to those that were sources for the placer gold, brief studies were made of the field relations, trace-element chemistry, mineralogy, and fluid inclusions. The studies indicate that these gold occurrences, which are characterized by a simple mineral assemblage, probably formed at shallow depths in and adjacent to fractures that were active during the late stages of felsic igneous activity.

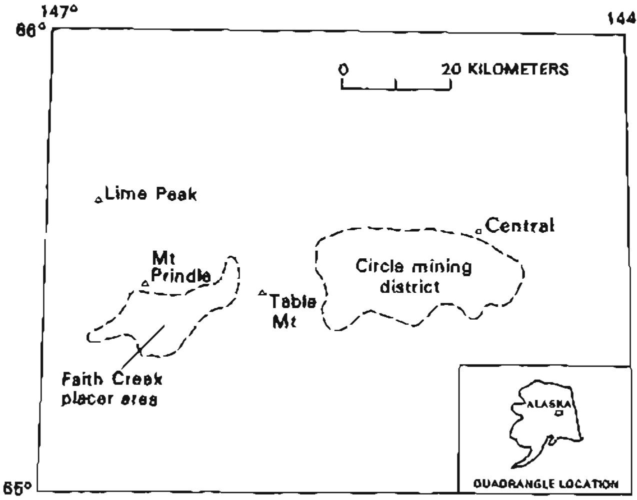

Figure 1. Circle quadrangle showing locations of areas discussed in text.

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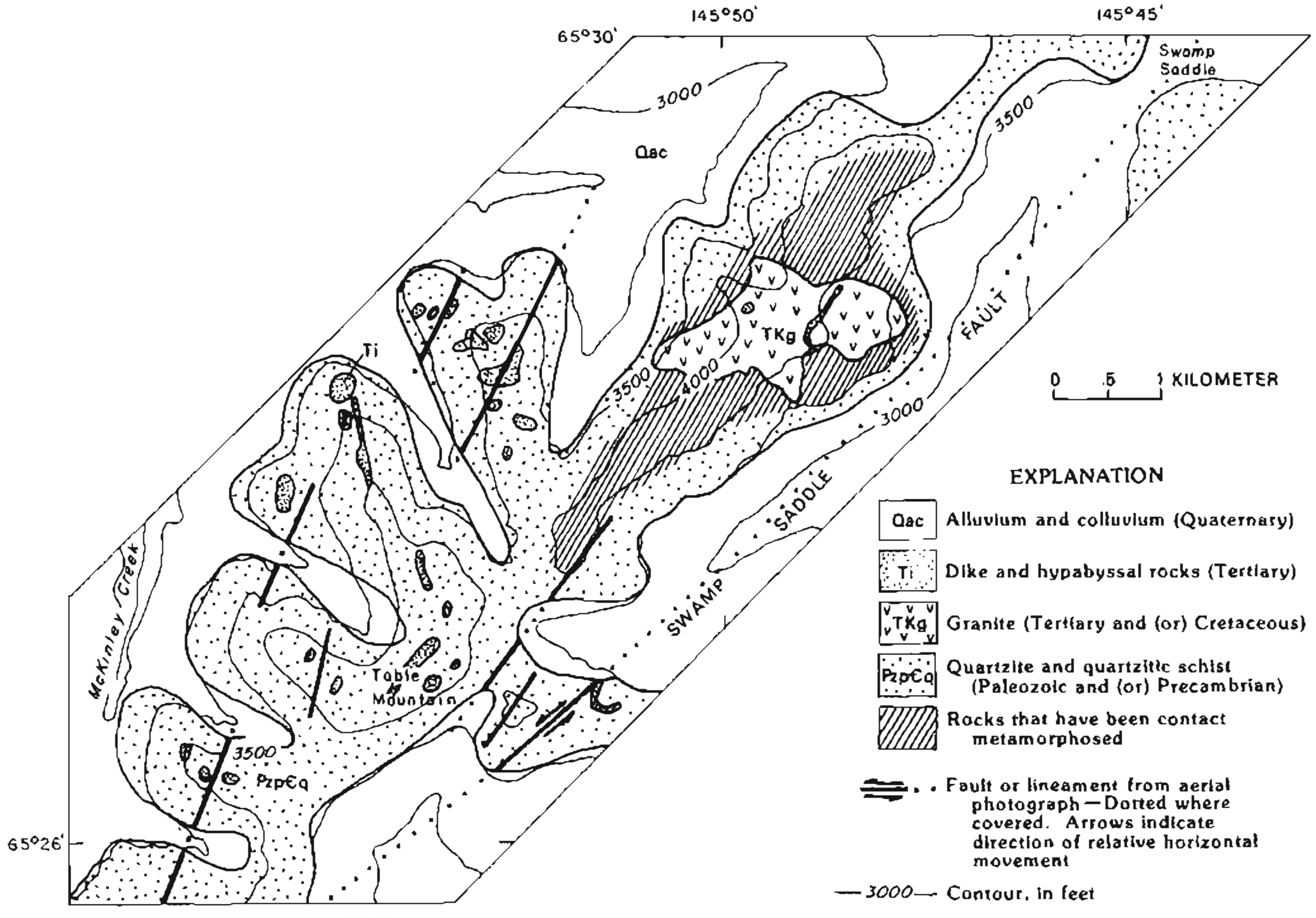
GEOLOGIC SETTING

The Table Mountain area, Circle quadrangle, is in the northeastern part of the Yukon Tanana Upland-- a physiographic province that mostly lies between the Yukon and Tanana Rivers in east-central Alaska. Recent geologic studies include reports by Foster and others (1983), Burack and others (1984), and Burack (1983). The Table Mountain area (fig. 2) is composed primarily of pelitic and quartzitic schists and quartzites that have been regionally metamorphosed to upper greenschist facies, then subsequently intruded and contact metamorphosed by a granite (Streckeisen, 1975) pluton. The rocks were in turn cut by a left-lateral fault (the Swamp Saddle fault) and intruded by felsic hypabyssal rocks, probably in the early Tertiary.

The metamorphic rocks in the Table Mountain area belong to the quartzite and quartzitic schist unit of Foster and others (1983) and are composed of light gray quartzite, black biotite schist, fine-grained greenish-gray mafic rocks and light-greenish-gray calc-silicate rocks (Burack, 1983). These rocks were metamorphosed to upper greenschist facies before the intrusion of the granite (Burack, 1983). The intrusion of the granite into the quartzite and quartzitic schist unit locally resulted in the development of biotite porphyroblasts that transect the metamorphic foliation, the resorption of garnet, and the development of a granoblastic texture. Based upon these changes, Burack (1983) concluded that the contact metamorphism took place at between 475 and 515 $^{\circ}$C and at pressures less than 2 kbar, or at a depth of about 6 km.

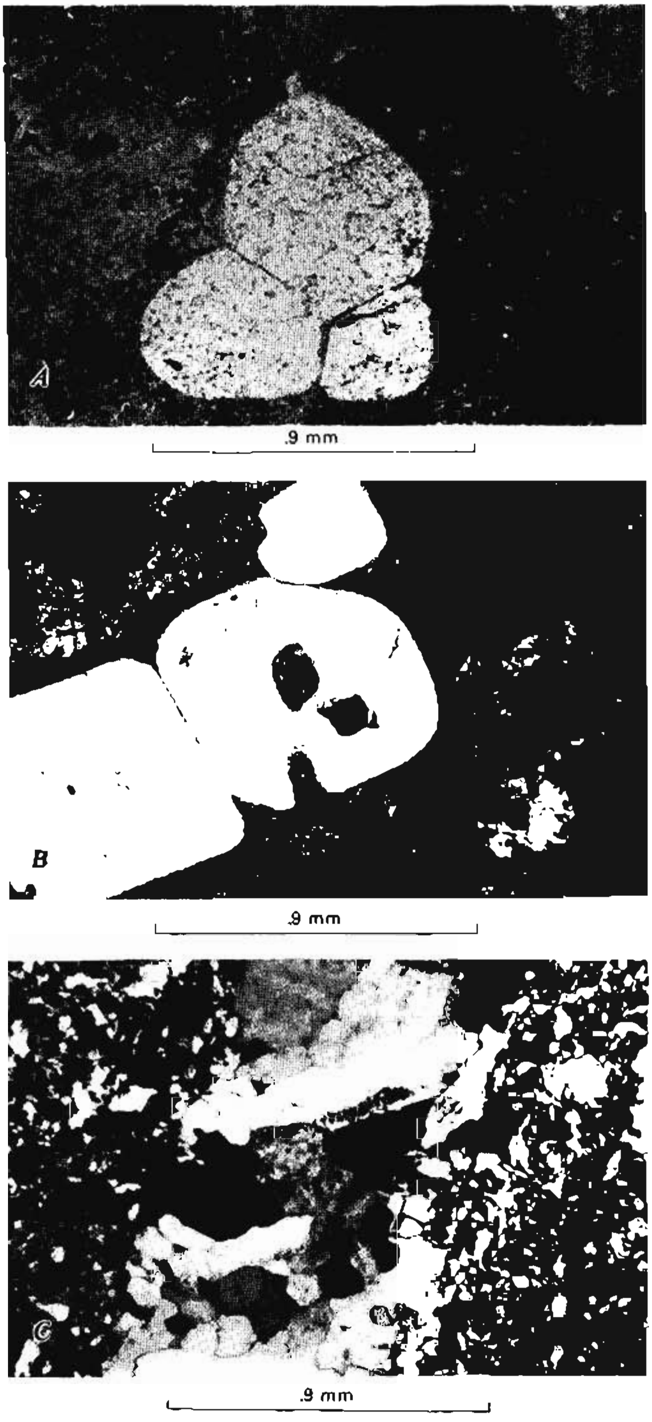
Granite crops out over an area of only about 2 km^2; however, the distribution of contact-metamorphosed rocks suggests that granite underlies much of the Table Mountain area at relatively shallow depths (Burack, 1983). Two phases of the granite are exposed: coarse-grained equigranular biotite granite, and porphyritic biotite granite with a fine-grained groundmass. The coarse-grained granite (Streckeisen, 1975) is composed of 23 percent plagioclase feldspar, 29 percent quartz, 41 percent potassium feldspar, and 7 percent biotite. Plagioclase is altered to white mica, and biotite is altered to chlorite. Because the granite is altered, it has not been dated; similar plutons in the northwest part of the Circle quadrangle have yielded ages of 66 to 57 m.y. B.P. (Wilson and Shew, 1981).



Geology modified from Burack (1983) and Foster and others (1983)

Figure 2. Reconnaissance geologic map of Table Mountain area.

Both the granite and metamorphic rocks have been intruded by dikes and hypabyssal rocks which are most abundant west and southwest of the granite. Most dikes are felsic, but a few are of intermediate composition. Some dikes are aphanitic, others are porphyritic. Phenocrysts in the porphyritic dikes are quartz, potassium feldspar, and plagioclase. The groundmass of the dikes was probably originally plagioclase, potassium feldspar, and quartz, but it is now mainly fine-grained white mica. The quartz phenocrysts have rounded crystal forms suggestive of partial resorption (fig. 3A) and in some cases the quartz phenocrysts are embayed (fig. 3B). Some dikes contain limonite cubes that formed after pyrite(?), and one dike contains minor disseminated purple fluorite in a veinlet. The textures of the dikes suggest that they were emplaced at shallow depths.



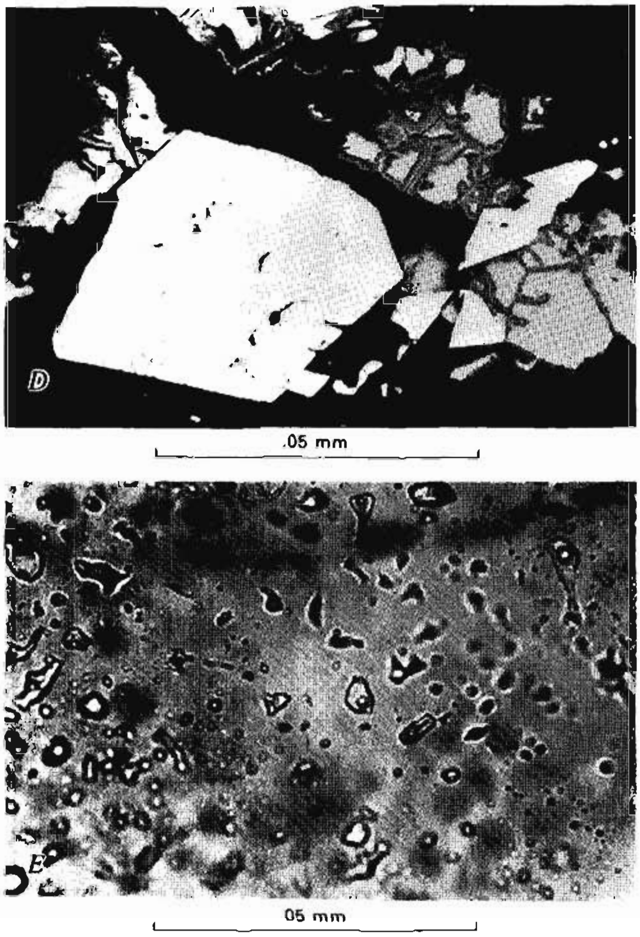


Figure 3. Photomicrographs of selected thin and polished sections from Table Mountain area. A, Rounded quartz phenocrysts in felsic dike. B, Rounded and embayed quartz phenocryst in felsic dike. C, Quartz veinlet in felsic dike. D, Arsenopyrite surrounded by pyrrhotite from margin of quartz vein. E, Fluid inclusions from porphyritic felsic dike.

RESULTS OF INITIAL GEOCHEMICAL SAMPLING

Table 1 lists analytical data for 5-kg grab samples collected during early phases of the study (Foster and others, 1984). Gold was detected in all of the major rock types present in the area: pelitic and quartzitic metamorphic rocks, calc-silicate rocks, altered granite, and felsic dikes. Figure 4 shows the spatial distribution of the 11 gold-bearing and 72 barren samples. The gold-bearing samples are concentrated in two areas: (1) near Table Mountain and (2) in and adjacent to the exposed granite pluton.

Field Relations of the Gold Occurrences

Table Mountain Occurrence

Two samples of tourmaline and sulfide-bearing black biotite schist, which contain 40 and 140 ppm gold, were collected about 3/4 km west of Table Mountain. This area is adjacent to a fault zone, which is characterized by the presence of tourmaline in adjacent rocks (Burack, 1983). During our follow-up study a felsic dike and a sulfide-bearing quartz vein were identified nearby (station 31, fig. 4). The felsic dike rock intrudes schistose quartzite beneath the ridge crest adjacent to the fault. The dike contains phenocrysts of quartz, potassium feldspar, and sericitized plagioclase set in a fine-grained groundmass that has been altered to white mica (fig. 3B,). The dike also contains rare veinlets with disseminated purple fluorite. The margins of the body are brecciated, and the resulting breccia is cut by thin quartz veinlets (fig. 3C). In places, breccia fragments are set in a matrix of limonite. Along the ridge, west of the fault zone, a 2.5- to 5-cm-thick arsenopyrite-bearing quartz vein has been emplaced parallel or subparallel to the foliation of the schistose quartzites. Both the vein and foliation are subhorizontal. The vein contains open spaces and comb structure; arsenopyrite occurs within the vein but is most common as a coating on the outer edges of the vein wall. Tourmaline also occurs locally along the vein wall. We followed the vein for about 100 m along strike until it was lost in rubble. It seems likely that this 2.5- to 5-cm-thick vein underlies much of the ridge west of the fault— an area of 0.1 km^2.

Occurrences in and Adjacent to the Granite

Some samples of altered granite and the adjacent quartzite and quartzitic schist contain low levels of gold (see table 1); the gold-bearing samples were found within the pluton and on the north, east, and south sides of the pluton. Two sites were examined more closely, one near the eastern (station 32) and one near the western (station 33) margins of the granite (fig. 4). On the west edge of the granite, a yellow-stained (arsenic?) hypabyssal felsic dike with potassium feldspar, quartz, and biotite phenocrysts in a very fine grained groundmass cuts the equigranular granite. The dike contains fine-grained sulfides, disseminated and as clots in the groundmass. Adjacent to the dike the granite contains clots of probable arsenopyrite. On the east side of the granite, several dikes are exposed that contain large phenocrysts of potassium feldspar, rounded quartz, and altered plagioclase feldspar set in a fine-grained greenish matrix.

Geochemical Results

Table Mountain Occurrence

Table 2 presents analyses of 5-kg grab samples collected from the Table Mountain occurrences in 1983. The samples were taken from one site, station 31 (fig. 4). Traces of silver and low levels of tin were found in the hypabyssal dike and in an iron-stained sample of the breccia. Two samples of breccia that were not iron stained do not contain silver or tin at detectable levels. Two samples of the quartz vein with sulfides along the vein walls both contained high values of gold, arsenic, and copper. Antimony was detected in both samples.

Occurrences in and Adjacent to the Granite

Gold was detected only in the sulfide-bearing hypabyssal felsic dike (table 2). Silver was detected in the dike and in the granite adjacent to the dike; tin was also detected in these samples. A sample of this dike without sulfides contained detectable tin but not gold or silver, and a sample of a porphyritic phase of the pluton contained 10 ppm tin but also did not contain detectable gold or silver (table 2). A sample of quartzite from adjacent to the pluton did not contain gold, silver, or tin in detectable amounts. A sample of a dike from the eastern side of the pluton was geochemically indistinct.

Petrography of Mineralized Samples

Table Mountain Occurrence

Burack (1983) examined thin sections and a polished section of the gold-bearing black biotite schist in transmitted and reflected light. She reported that they contain abundant biotite, tourmaline, and silver-colored sulfides including arsenopyrite. She also noted that the sulfides cross the weak foliation in the rock and therefore formed after the foliation.

We examined both thin and polished sections of the quartz vein with sulfide-coated outer walls. Sulfides occur within the vein and as a coating with biotite and minor white mica on the outer vein walls. Sulfide minerals identified in and adjacent to the quartz vein were pyrrhotite and arsenopyrite, minor amounts of chalcopyrite, and rarely enargite and sphlalerite. The pyrrhotite is anhedral and cut by cracks along which it is oxidized. Arsenopyrite is euhedral and occurs as bladed crystals which in places appear as islands within the pyrrhotite (fig. 3D). Chalcopyrite is subhedral and in places contains unreplaced pyrrhotite. The enargite is anhedral. The spalerite contains chalcopyrite.

Occurrences in and Adjacent to the Granite

Thin sections of the sulfide-bearing felsic dike and the adjacent sulfide-bearing granite were examined in transmitted light. Sulfides in the felsic dike are very fine grained. They are abundant in the groundmass of the dike and occur both disseminated in the groundmass and in clots. The granite adjacent to the dike contains isolated clots of arsenopyrite on the rims of partially altered plagioclase grains.

Fluid-Inclusion Studies

Fluid inclusions from the quartz vein at the Table Mountain occurrence and from dikes from the occurrences in or adjacent to the pluton were studied by using a heating-freezing stage. Sites for these samples are shown by an asterisk in figure 4. Of the 20 doubly polished plates that were examined, 6 contain a sufficient number of inclusions of a size large enough (>5 µm along their maximum dimension) to make the heating-and-freezing measurements. The samples contain two major types of fluid inclusions: liquid-rich inclusions and vapor-rich inclusions, termed type I and type II, respectively. Liquid-rich inclusions are more common than vapor-rich ones in the samples that contain both types. Inclusions of both types occur as isolated entities and are unrelated to visible microfractures. Type I inclusions are distributed randomly throughout the quartz; type II inclusions are round, occur in clusters, and show no evidence of necking to adjoining type I inclusions. Therefore both types of inclusions are interpreted as being primary and (or) pseudosecondary and where both types are present, as having been trapped at the same time. Most fluid inclusions for which measurements were made belong to type I; these inclusions generally have less than 15-volume-percent vapor phase at room temperature. Salinities of the fluid inclusions were determined by using the depression-of-freezing-point method described by Roedder (1962).

Table Mountain Occurrence

Measurements were made on three samples of the quartz vein from the Table Mountain occurrences. Sample 31L' is white quartz with abundant sulfides; it contains only liquid-rich inclusions. Sample 31J" is sulfide-bearing vein material with clear and white quartz that contains

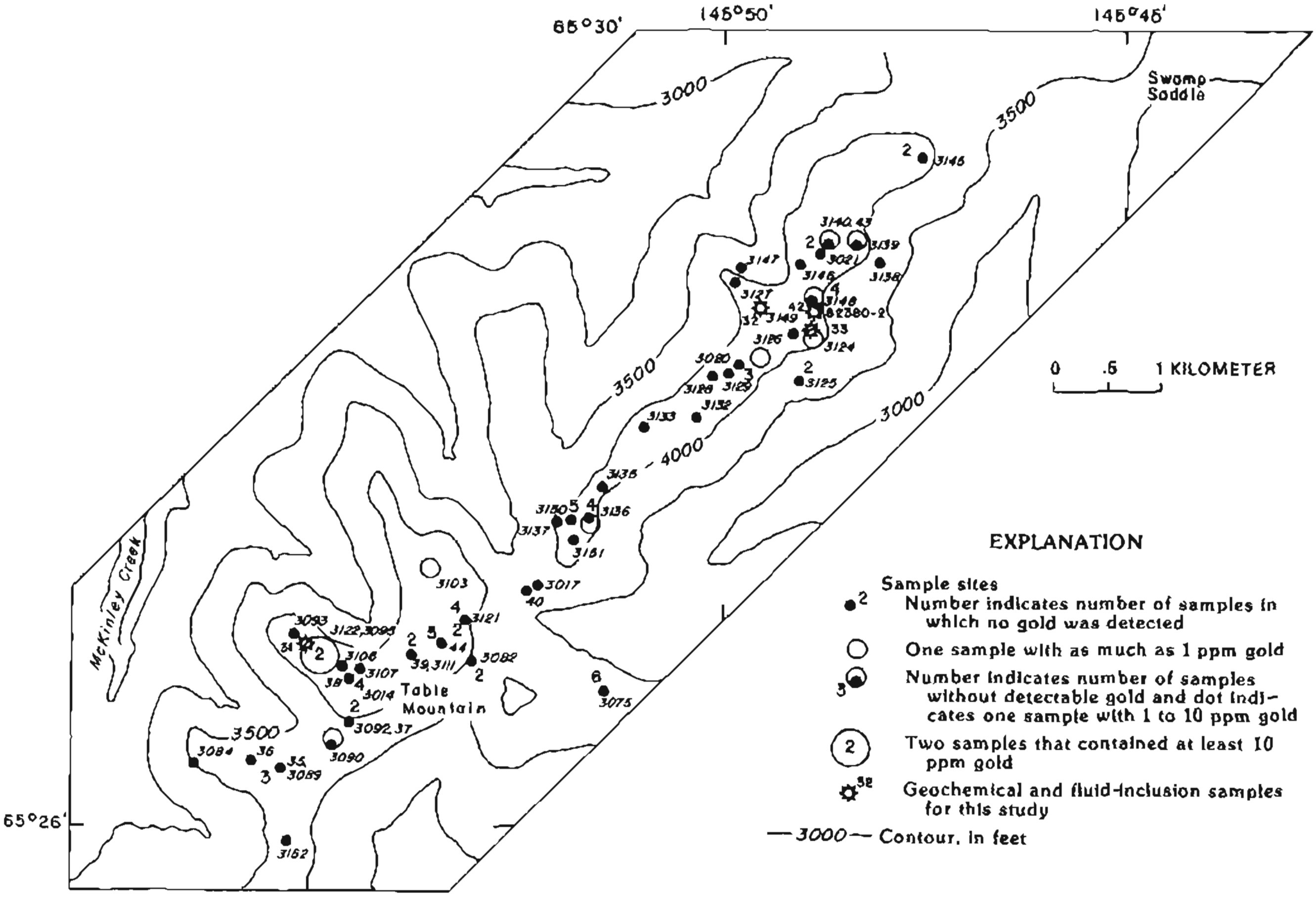


Figure 4. Locations of sample sites (see tables 1 and 2).

Table 1. Analytical data of rocks from the Table Mountain area

[Analysis of Au by atomic absorption; all other analyses by six-step semiquantitative emission spectrographic methods. Fe, Mg, Ca and Ti in percent; all others in parts per million. G, greater than the amount listed; L, less than the amount listed; N, not detected at amount listed. Analysts included R.M. O'Leary, G.W. Day, E.F., Cooley, P. Risoli, A. Gruzensky, G. Ito, S.J. Sutley, J. Hurrell, G.D. Hoffman, R.R. Carlson, W. Martin, F.J. Takacs. D.L. Brown. J.A. Domenico, D. Galland, J.M. McDade, A.L. Meir, D.G. Murrey, A.J. Toevus, and S. A. Wilson]

Station number and sample letter	Rock description	Fe	Mg	Ca	Ti	Mn	Ag	As	B	Ba	Be	Bi	Co
35A	Gray quartzite	2.0	1.00	0.50	0.200	300	0.5N	200N	30	20L	10L	10N	15
35B	Chloritic schist	7.0	2.00	1.50	.700	700	.5N	200N	500	500	15	10N	50
36C	Gray quartzite	1.5	.20	.05	.100	200	.5N	200N	20	150	10	10N	7
37A	Gray quartzite with sulfides	3.0	.30	.20	.200	300	.5	200N	10	50	10L	10N	10
38	Gray quartzite (iron stained)	5.0	2.00	5.00	.500	1,500	.5L	200N	10	50	15	10N	30
39	Calc-silicate	2.0	5.00	10.00	.050	2,000	.5N	200N	70	20N	10L	10N	5
40	Gray quartzite with sulfides	5.0	2.00	2.00	.300	1,000	.5L	200N	10L	30	10L	10N	30
42A	Granite	1.5	3.00	.30	.100	300	.5N	200N	30	500	50	10N	5
43B	Chloritic schist (hornfelsed)	5.0	.10	.20	.500	500	.5L	200N	70	150	10	10N	30
3017C	Mafic schist	5.0	3.00	7.00	.700	1,000	.5L	200N	10L	100	10L	10N	50
3020A	Dike	5.0	2.00	.20	.500	500	.5L	200N	70	300	20	10N	50
3075A	Gray-brown quartzite	1.5	.70	.70	.100	300	.5N	200N	50	700	20	10N	5
3075C	Dike with sulfides	2.0	1.00	.30	.150	300	.5	200N	30	1,500	30	10N	10
3075G	Quartzite (iron stained)	1.5	.07	.05L	.050	100	.5L	200N	20	70	10	10N	15
3075J	Chloritic schist	3.0	1.00	.07	.300	300	.5N	200N	100	700	30	10N	7
3075L	Gray quartzite	1.5	.20	.07	.070	200	.5L	200N	50	100	10L	10N	50
3075N	Gray quartzite	1.0	.15	.50	.070	300	.5L	200N	30	500	10L	10N	7
3082B	Felsic dike with sulfides	1.0	.10	.15	.030	200	1.0	200N	30	150	70	10L	5
3082D	Felsic dike (iron stained)	1.0	.07	.05L	.020	200	1.5	200N	30	150	30	10L	5
3084D	Granite	1.5	.30	.20	.100	300	.5N	200N	70	300	150	10N	7
3089A	Calcareous quartzite with sulfides	.7	.15	3.00	.070	300	.5L	200N	20	300	10	10N	5
3090B	Calc-silicate	1.0	.30	.50	.100	200	.5L	200N	30	150	10	10N	7
3090E	Quartzite with sulfides	1.5	.50	.70	.150	500	.5L	200N	15	200	10	10N	30
3092B	Mafic schist	5.0	5.00	7.00	.700	1,500	.5	200N	10	150	10L	10N	50
3093A	Calc-silicate with sulfides	5.0	2.00	.50	.500	700	.5L	200N	70	300	15	10N	50
3095A	Black biotite schist with sulfides	5.0	1.50	1.00	.500	500	2.0	10,000G	200	300	20	15	50
3103A	Felsic dike	1.0	.10	.15	.020	200	.5L	700	70	300	150	10N	5
3106A	Chloritic schist	5.0	3.00	7.00	.500	1,500	.5L	200N	15	100	15	10N	50
3107A	Black biotite schist	5.0	2.00	.15	.700	200	1.0	200N	2,000G	70	50	10N	30
3107B	Gray quartzite	1.5	.70	1.50	.200	500	.5N	200N	300	300	20	10N	20
3107I	Quartz vein with sulfides	5.0	5.00	10.00	1.000	5,000	0.5L	200N	20	500	30	10N	30
3107L	Dark gray-green quartzite with sulfides	10.0	7.00	10.00	1.000	2,000	.5L	200N	10	300	10	10N	70
3111B	Calc-silicate with sulfides	1.5	10.00	15.00	.050	1,000	.5N	200N	100	20L	1.0L	20	5
3121A	Black biotite schist	7.0	3.00	5.00	1.000	1,500	.5L	200N	20	50	1.0L	10N	30
3121D	Felsic dike	.7	.20	.15	.015	150	1.5	200N	70	30	1.5	10N	5
3121F	Gray quartzite	1.0	.20	.15	.100	200	.5N	200N	10N	200	1.0L	10N	7
3121G	Calc-silicate with sulfides	10.0	1.00	10.00	.070	5,000G	.5L	200N	10	50	10.0	15	30
3122B	Black biotite schist with sulfides	5.0	1.50	2.00	.700	300	1.5L	10.000	1,500	300	1.5	50	70
3124F	Black biotite schist	3.0	1.00	.15	1.000	500	.5N	200N	100	3,000	1.5	10N	20
3125B	Blue-gray quartzite	5.0	2.00	2.00	.700	2,000	.5N	200N	20	100	1.0L	10L	30
3125C	Granite	1.5	.30	.20	.070	200	.5	200N	30	1,500	3.0	15	5
3126E	Black biotite schist with sulfides	5.0	1.50	3.00	1.000	1,500	.5L	200N	15	150	1.0	20	30
3127G	Gray quartzite	3.0	1.50	.07	.500	500	.5N	200N	70	1,000	2.0	10L	30
3128B	Black biotite schist	1.5	.50	.30	.100	300	.5L	200N	150	300	7.0	10N	7
3129A	White quartzite	.7	.30	.20	.200	300	.5N	200N	20	300	1.0	10N	5L
3129E	Quartz veins (breccia?)	1.5	.30	.05L	.150	300	.5N	200N	15	300	1.0	10N	7
3129G	Black biotite schist	2.0	.70	.20	.150	300	.5L	200N	20	200	1.0	10L	7
3132A	Gray quartzite with tourmaline	2.0	.50	.15	.200	500	1.0	200N	2,000	500	2.0	10L	10
3133F	Gray quartzite	1.5	.30	.15	.150	300	.5N	200N	30	300	1.0	10N	7
3135A	Black biotite schist	5.0	3.00	.30	.700	500	.5L	200	150	1,000	2.0	10N	50
3136A	Calc-silicate with sulfides	10.0	5.00	10.00	.100	5,000G	.5N	200N	10L	20	3.0	10N	30
3136B	Calc-silicate with sulfides	7.0	3.00	10.00	.150	5.000G	.5N	200N	10L	100	3.0	10N	20

Cr	Cu	La	Mo	Nb	Ni	Pb	Sb	Sc	Sn	Sr	V	W	Y	Zn	Zr	Au
100	20	20L	5N	20N	30	10N	100N	20	10N	100L	150	50N	20	200N	150	0.05N
500	200	70	5N	20L	70	30	100N	70	10	300	300	50L	50	200N	150	.05N
30	20	20	5N	20N	20	10N	100N	5	10N	100L	50	50N	10L	200N	150	.05N
70	300	20	5N	20N	30	10N	100N	20	10N	100	100	50N	20	200N	100	.05N
50	300	20L	5N	20N	30	10N	100N	50	50	300	200	50N	30	200N	70	.05N
15	15	20L	5N	20N	5	10L	100N	5L	10N	100	50	50L	10L	200N	10N	.05N
200	50	20N	5N	20N	30	10L	100N	70	10N	100N	200	50N	20	200N	70	.05N
20	7	30	5N	20L	10	20	100N	7	10N	200	50	50N	15	200N	100	.05N
150	30	20L	5N	20N	50	10	100N	30	10N	100N	200	50N	20	200N	150	.05N
100	100	20	5N	20N	70	10L	100N	100	10L	300	500	50N	50	200L	70	.05N
300	200	70	5N	20L	70	30	100N	70	10N	100	300	50N	50	200L	150	.05N
70	5	100	5N	20L	30	10N	100N	10	10N	150	100	50N	20	200N	150	.05N
100	20	100	5N	20	30	50	100N	15	10N	500	150	50N	30	200L	200	.05N
10	20	20	5N	20N	50	10N	100N	5L	10N	100N	10L	50N	30	200L	70	.05N
200	10	70	5N	20L	20	50	100N	30	10N	150	150	50N	30	200L	100	.05N
30	7	20L	5N	20N	70	10L	100N	5	10N	100N	70	50N	15	200N	150	.05N
30	5	30	5N	20N	15	10N	100N	5	10N	200	50	50N	15	200N	150	.05N
10N	5L	50	5N	30	7	50	100N	5	50	100N	10N	50L	100	200N	100	.05N
10N	5L	20	5N	30	5	50	100N	5L	50	100N	10N	50N	70	200N	100	.05N
50	20	50	15	20L	30	10N	100N	10	14	150	100	50N	30	200N	100	.05N
10	10	20N	5N	20N	10	10L	100N	5L	10N	300	20	50N	10	200N	150	.05N
20	15	50	5N	20N	20	10N	100N	5	10N	100	70	50N	20	200N	150	.05N
70	50	20	5N	20N	50	10N	100N	15	10N	150	150	50N	20	200N	150	.05
300	150	20L	15	20N	70	10L	100N	70	20	150	500	50N	50	200N	100	.05N
300	70	30	5N	20L	70	30	100N	70	20	150	300	50N	30	200	150	.05N
150	300	50	5N	20L	70	10	100N	50	10N	300	200	50	30	200L	150	140.00
10N	7	20	5N	30	7	30	100N	5L	50	100N	15	50N	70	200N	100	.25
70	500	20	5N	20N	50	10L	100N	70	70	300	500	50N	30	200N	70	.05N
300	50	200	5N	20L	70	70	100N	70	70	50	300	50L	100	200L	150	.05N
100	10	50	5N	20N	50	10L	100N	30	10N	300	150	50N	30	200N	150	.05N
50	300	30	5N	20N	50	10L	100N	50	30	700	200	50N	30	200N	70	.05N
70	70	20	5N	20N	70	15	100N	50	20	200	300	50N	50	200N	100	.05N
20	7	20L	5N	20N	15	10L	100N	5	30	300	100	70	10	200N	15	.05N
500	700	50	5N	20L	50	10L	100N	70	30	300	300	50L	30	200L	200	.05N
10N	5	50	5N	30	5	50	100N	5N	50	100N	10N	50N	100	200N	100	.05N
20	5	30	5N	20N	10	10N	100N	5L	10N	100L	70	50N	10	200N	200	.05N
70	150	20L	5N	20N	30	10N	100N	50	100	100	200	150	50	300	100	.05N
300	300	100	5N	20L	70	20	100N	70	30	300	300	50	70	200N	150	40.00
500	100	150	5N	20L	70	30	100N	70	10N	300	500	50N	100	200N	300	.05
300	150	20	5N	20N	70	10L	100N	50	30	100	500	50N	30	200N	200	.05N
30	15	100	200	20L	10	70	100N	5	10N	200	70	50N	20	500	70	.05N
500	200	50	5N	20N	70	10N	100N	70	30	100	300	50N	30	200N	200	.10
300	100	70	5N	20L	70	30	100N	50	10N	100L	200	50N	50	200N	150	.05N
70	7	70	5	20N	30	20	100N	10	10N	150	150	50N	15	200N	150	.05N
20	7	20N	5N	20N	7	10N	100N	5	10N	100L	20	50N	10	200N	200	.05N
30	5L	20L	5N	20N	30	10N	100N	70	10N	100N	70	50L	20	200N	200	.05N
70	700	20	5N	20N	15	10N	100N	15	10N	100L	150	50N	20	200N	100	.05N
50	50	50	5N	20N	15	20	100N	7	10N	100L	70	50N	20	200N	500	.05N
50	10	30	5N	20N	20	10	100N	10	10N	100	70	50N	20	200N	150	.05N
300	500	70	5N	20L	70	30	100N	70	10N	100L	300	50N	70	200L	150	.05N
70	70	50	5N	20L	50	10N	100N	15	100	100	100	500	30	500	100	.05N
200	30	100	5N	20	30	10N	100N	30	70	700	150	50	50	300	150	.05N

Table 1. Analytical data of rocks from the Table Mountain area—Continued

Station number and sample letter	Rock description	Fe	Mg	Ca	Ti	Mn	Ag	As	B	Ba	Be	Bi	Co
3136C	Calc-silicate with sulfides	10.0	5.00	10.00	0.100	5,000G	0.5N	200N	10L	20N	5.0	10N	30
3136F	Calc-silicate	5.0	1.50	15.00	.100	5,000	.5N	200N	10L	70	1.5	10N	20
3136H	Calc-silicate	1.0	1.50	20.00	.070	500	.5N	200N	10N	100	1.0L	10N	5
3137D	Gray quartzite with sulfides	5.0	2.00	7.00	.200	3,000	.5	200N	20	100	1.0	10N	30
3139C	Breccia (iron stained)	1.5	.30	.15	.070	200	.5L	200N	10N	150	1.5	10N	5
3139D	Black biotite schist with sulfides	7.0	3.00	.70	.700	2.000	.5L	200N	150	500	1.0	10N	50
3139E	Gray quartzite with sulfides	3.0	1.00	1.00	.500	700	.5L	200N	20	70	1.0L	20	30
3139J	Gray quartzite with sulfides	3.0	1.00	3.00	.300	1,000	.5N	200N	15	30	1.0	20	7
3140I	Black biotite schist with quartz vein and sulfides	5.0	2.00	.20	.700	1,000	.5L	200N	70	500	1.5	10N	30
3145C	Gray quartzite with vein	2.0	.50	.10	.150	300	.5	200N	70	300	1.0	10N	20
3145E	Black biotite schist	5.0	1.50	.07	.700	500	.5L	200N	100	700	2.0	10N	30
3146D	Gray quartzite	3.0	1.00	.10	.500	500	.5L	200N	30	1,000	2.0	10N	20
3147B	Black biotite schist	3.0	1.50	.15	.500	700	.5N	200N	1,000	1,500	3.0	10N	20
3148B	Intermediate dike	1.5	.70	.50	.300	300	.5N	200N	30	1,000	2.0	10N	10
3148C	Intermediate dike	5.0	5.00	5.00	.700	700	.5N	200N	10	1,000	1.0L	10N	50
3148D	Intermediate dike	5.0	5.00	5.00	.700	1,000	.5L	200N	10	700	1.0	10N	30
3148E	Intermediate dike	3.0	1.50	3.00	.700	500	.5	200N	20	1,500	3.0	10N	20
3148F	Granite	10.0	.02	.05L	.070	15	2.0	10,000G	10L	100	1.5	20	30
3149B	Granite	1.5	.30	.05	.070	200	1.0	1,000	30	700	2.0	10N	5
3150D	Quartzite	1.5	.50	1.00	.200	500	.5N	300	20	70	1.0L	10N	10
3150G	Calc-silicate	15.0	1.50	10.00	.300	5,000G	.5L	200	20	100	70.0	30	30
3150H	Calc-silicate with sulfides	5.0	1.50	10.00	.300	5,000	.5L	200N	15	20L	7.0	10L	20
3150I	Calc-silicate with sulfides	7.0	1.50	15.00	.700	5,000G	.5L	200N	10	50	7.0	10N	20
3150K	Calc-silicate	7.0	2.00	5.00	1.000	5,000G	.5N	200N	10L	70	7.0	10N	20
3151C	Blue-green quartzite	1.5	.30	.20	.150	300	.5N	200N	15	100	1.0	10N	10
3152E	Chloritic quartzite	3.0	1.50	5.00	.200	1,000	.5N	200N	20	30	1.0L	10N	20
0044B	Calc-silicate	10.0	1.00	15.00	.500	5,000G	.5N	200N	10L	20L	5.0	50	7
44A	Felsic dike	1.0	.15	.05	.020	500	1.0	200N	15	70	15.0	10L	5L
44B	Gray quartz (iron stained)	3.0	.70	1.00	.200	500	.5	200N	20	200	1.5	10N	50
44C	Calc-silicate with sulfides	10.0	1.00	15.00	.150	5,000	.5N	200N	20	20L	7.0	30	15
44D	Calc-silicate with sulfides	5.0	3.00	10.00	.700	3,000	.5N	200N	30	100	20.0	10L	20

both liquid- and vapor-rich fluid inclusions. Sample 31I is white and clear quartz from the vein. The sample contains both vapor-rich and liquid-rich fluid inclusions. Salinities of fluid inclusions range from 0 to 9.9-weight-percent NaCl equivalent; most are from 3 to 7 percent. Heating data are shown separately in histograms (fig. 5).

The histograms for the homogenization temperatures are strongly unimodal for all three samples and the modal temperature of the type I inclusions is approximately equal in all three samples (sample 31I, 265 °C; sample 31J'', 255 °C; and sample 31L', 275 °C). Homogenization temperatures for type II inclusions, in samples 31I and 31J'', range from 260 to 380 °C—values which coincide with homogenization temperatures for the upper half of type I inclusions (see fig. 5). The majority of the homogenization temperatures for type II inclusions range from 320 to 380 °C. Because type II and some type I inclusions occur together and appear to have formed at the same time, we interpret the data as recording the cooling of an initially boiling aqueous fluid. Boiling appears to have begun at about 370 °C and continued as the system cooled to about 320 °C. Because type I inclusions are more common in the samples than type II inclusions, it appears that most of the vapor phase was lost during boiling. Most of the type I inclusions were trapped below 320 °C when the fluid probably was a liquid. The presence in sample 31I of type II inclusions that have homogenization temperatures below 320 °C are interpreted as being the result of measurement errors that can result from difficulties in observing the exact temperature at which liquid homogenizes in vapor-rich fluid inclusions (see Bodnar and others, 1985, p. 1867). Assuming that the quartz vein was open to the surface (that is, the pressure was hydrostatic) and the fluid was boiling throughout the fluid column, the temperature-depth relationship of Haas (1971) may be used to calculate the depth of formation of the vein. A fluid with a salinity of 5-weight-percent NaCl and a temperature of 320 to 370 °C will boil at depths less than 1,400 to 2,400 m.

Cr	Cu	La	Mo	Nb	Ni	Pb	Sb	Sc	Sn	Sr	V	W	Y	Zn	Zr	Au
150	100	70	5N	20L	50	10N	100N	20	100	100	100	300	50	700	150	0.05L
100	10	70	5N	30L	20	10L	100N	15	150	100	150	50L	30	300	150	.05N
30	10	20N	5N	20N	5	20	100N	5L	10N	1,000	70	50N	15	200N	70	.05N
70	500	30	5N	20N	30	10N	100N	50	10N	300	150	50N	30	200N	100	.05N
30	50	20N	5N	20N	15	10N	100N	10	10N	100N	70	50L	10N	200N	50	.05N
500	300	70	5N	20L	70	30	100N	70	10L	100L	500	50N	70	200L	200	.05N
100	300	20	5N	20N	50	10N	100N	30	10N	100L	200	50N	20	200N	150	.05
100	200	30	5N	20N	30	10N	100N	30	15	100L	150	50L	20	200N	100	.20
300	300	100	10	20L	70	30	100N	70	10N	100L	300	50N	50	200L	200	.05L
50	30	20	5N	20N	50	50	100N	15	10N	100L	100	50N	20	200L	150	.05N
200	70	70	5N	20L	50	30	100N	50	10N	100L	200	50N	50	200L	200	.05N
100	5L	70	5N	20L	50	10	100N	30	10N	150	150	50N	30	200N	200	.05N
300	15	150	5N	20L	50	30	100N	50	50	200	200	50N	70	200L	150	.05N
150	10	100	5N	20L	5	50	100N	15	10	150	100	50N	50	200N	200	.05N
700	20	50	5N	20L	20	15	100N	70	10N	500	200	50N	50	200L	150	.05N
700	20	50	5N	20L	15	20	100N	50	10N	300	200	50N	50	200L	150	.05N
500	20	100	5N	20L	10	50	100N	30	10N	300	150	50N	50	200L	200	.05N
30	5L	20	5N	20L	5L	150	100	10	50	100	50	50L	10	200N	70	.20
30	15	20L	5N	20L	7	70	100N	10	10N	100	70	50N	20	200	70	.05N
70	7	20	5N	20N	30	10N	100N	15	10N	100	100	50N	15	200N	100	.05N
100	500	50	5N	20L	30	10L	100N	20	150	300	150	50N	30	300	150	.05N
200	100	100	5N	20L	50	10L	100N	50	150	300	150	50N	30	300	150	.05N
300	300	100	5N	20	30	10L	100N	50	150	300	150	50N	50	300	200	.05N
200	200	200	5N	50	15	10L	100N	70	150	100N	100	50N	50	200	500	.05N
70	20	20	5N	20N	30	10N	100N	10	10N	100	100	50N	30	200N	150	.05N
200	5L	20L	5N	20N	70	10L	100N	30	10N	100	200	50N	20	200N	150	.05N
20	200	20N	5N	20N	20	20N	100N	5L	150	200	200	50N	15	500	100	.05N
10L	5L	30	5N	30	5	15	100N	5L	50	100N	10L	50N	100	200N	150	.05N
30	700	30	5N	20N	50	10L	100N	7	10	200	30	50N	30	200N	30	.05N
70	30	50	5N	20L	20	10L	100N	7	150	100L	50	50L	15	300	100	.05N
200	100	50	5N	20	70	10L	100N	20	100	700	200	50N	50	200	200	.05N

Occurrences in and Adjacent to the Granite

Measurements were made on three samples from occurrences in and adjacent to the granite. Sample 33B is a porphyritic felsic dike with phenocrysts of potassium feldspar, rounded quartz, and altered plagioclase set in a chloritic groundmass. The quartz phenocrysts contain liquid-rich fluid inclusions. Sample 032C is a sample of yellow-stained, porphyritic felsic dike that contains mostly small liquid-rich fluid inclusions. One or two vapor-rich inclusions were observed, and in one case a liquid-rich fluid-inclusion contains a daughter mineral (fig. 3E). Sample 82380-2-1 is a sample of a felsic dike. Salinities for these samples range from 0.2- to 8.0-weight-percent NaCl equivalent, but most are lower than 2 percent. Heating data are shown as histograms (fig. 6). The histograms for the three samples are bimodal. The lower mode in two of the samples occurs at about 275 ^{o}C; the lower mode in the third sample occurs at about 265 ^{o}C. The upper modes occur at 355, 315 and 295 ^{o}C in the three samples studied using the heating-freezing stage. The data indicate that fluids were trapped at two temperatures, the lower of which was similar to that of type I inclusions in the quartz vein.

Crushing Experiments

A crushing stage was used to investigate the noncondensible gases in the fluid inclusions (Roedder, 1970; 1984). In a first test, materials from the six samples examined in the heating and cooling experiments were crushed in an immersion oil (nD=1.515) mounting fluid. Upon crushing, gases were liberated from the fluid inclusions and formed bubbles in the oil. The gas bubbles moved into the liquid at moderate speeds. This test indicates that the vapor phase of the inclusions contains a noncondensible gas in addition to water vapor, and that the pressures inside the fluid inclusions are considerably above 1 atmosphere but are not so high as to cause the gases to

Table 2. Analytical data of rocks from stations 31, 32, and 33 in the Table Mountain area collected in 1983

[Analysis of Au by atomic absorption; all other analyses by six-step semiquantitative emission spectrographic methods. Fe, Mg, Ca, and Ti in percent; all others in parts per million. G, greater than the amount listed; L, less than amount listed; N, not detected at amount listed. Analyst R.M. O'Leary]

Station number and sample letter	Rock description	Fe	Mg	Ca	Ti	Mn	Ag	As	B	Ba	Be	Bi	Co
31A	Felsic dike	0.7	0.10	0.20	0.030	700	1.5	200N	50	70	10	10N	5N
31B	Breccia (iron stained)	.7	.50	.05L	.100	200	.5	200N	50	150	2	10N	5L
31C	Breccia from near felsic dike	1.0	.70	5.00	.100	1,000	.5N	200N	20	150	3	10N	5
31D	Breccia with gray material	5.0	2.00	15.00	.200	2,000	.5N	200N	10L	20	3	10N	10
31E	Arsenopyrite-bearing vein	7.0	2.00	.50	.500	500	1.0	10,000	100	200	1	10L	50
31H	Arsenopyrite-bearing vein	1.5	.20	.20	.100	200	1.0	10,000G	50	30	1	10N	10
32A	Felsic dike with sulfides	1.0	.20	.05	.100	150	7.0	200N	15	1,000	7	50	5N
32B	Equigranular granite with sulfides (adjacent to 32A)	1.0	.50	.20	.100	300	.7	200N	20	700	7	10	5N
32C	Felsic dike	.7	.20	.05	.070	200	.5N	200N	20	500	10	10N	5N
32D	Granite porphyry with fine-grained groundmass	1.0	.70	.70	.150	700	.5N	200N	20	1,000	7	N	5
32E	Quartzite	5.0	1.50	.07	.500	700	.5N	200N	150	500	2	N	15
33A	Altered intermediate dike	3.0	3.00	3.00	.700	1,000	.5N	200N	10L	1,000	2	N	30
33B	Porphyritic intermediate dike	2.0	1.50	.70	.30	1,000	.5N	200N	10L	1,500	2	N	10

be expelled explosively. In order to determine if carbon dioxide is in the vapor phase of the fluid inclusions, a 10 percent barium chloride solution was used as a mounting fluid. Upon crushing, some of the vapor bubbles that were expelled from the fluid inclusions dissolved immediately into the barium chloride solution. When the mounting fluid was acidified by the addition of dilute hydrochloric acid, the bubbles that were expelled from the fluid inclusions did not disappear. The results indicate that carbon dioxide is present but distributed unevenly in the vapor phase of the fluid inclusions (see Roedder, 1984, p. 212-219). However, carbon dioxide probably is not present in sufficient amounts to form a separate liquid carbon dioxide phase. The presence of the carbon dioxide in the fluids associated with mineralization calls into question depth estimates using a boiling NaCl-H_2O fluid (see Roedder, 1984). Nevertheless, based on geologic relations, the approximate depths calculated by the methods described by Haas (1971) are probably a good estimate for mineralization in the Table Mountain area.

DISCUSSION

The available data on the field relations, trace-element geochemistry, mineralogy, and fluid inclusions suggest (1) these occurrences, like other low-sulfide gold deposits and occurrences (see Boyle, 1979, p. 279-290), have simple mineralogies that are associated with low-saline fluids having sulfur fugacities within the stability field of pyrrhotite; (2) the occurrences formed at moderate temperatures, and the fluids boiled; (3) the occurrences formed at relatively shallow depths; (4) the occurrences formed in an active tectonic environment; and (5) occurrences similar to these may have been the sources of placer gold in the Circle quadrangle.

The mineralogy and geochemistry of the occurrences near Table Mountain, as well as in and adjacent to the granite, are similar to other low-sulfide quartz vein deposits. The most common sulfides are arsenopyrite and pyrrhotite; minor sulfides and sulfosalts include enargite, chalcopyrite and sphalerite. Gold is associated with arsenic and is more abundant than silver. Studies of fluid inclusions suggest the fluids that deposited the metals were low salinity (10-weight-percent NaCl equivalent); the presence of pyrrhotite instead of pyrite constrains the sulfur fugacity of the fluid.

The occurrences formed at moderate temperatures and in part from fluids that boiled. Boiling is indicated by the presence of cogenetic liquid-rich and vapor-rich fluid inclusions in the quartz vein west of Table Mountain (station 31, fig. 4). The majority of filling temperatures of vapor-rich inclusions from this occurrence are from 320 to 380 °C. The average filling temperatures of liquid-rich fluid inclusions from this occurrence are from 255 to 275 °C. Together, the fluid inclusions appear to record a cooling of fluids in the vein that was accompanied by the deposition of sulfides and quartz. Samples from occurrences in and adjacent to the granite (station 32, 33, and 82380-2) do not contain vapor-rich fluid inclusions. Filling temperatures of liquid-rich fluid inclusions from samples of felsic dikes are bimodal. The upper temperature mode varies with the sample. The lower mode in the samples ranges from 265 to 275 °C, temperatures similar to those for samples of the quartz vein from near Table Mountain.

Cr	Cu	La	Mo	Nb	Ni	Pb	Sb	Sc	Sn	Sr	V	W	Y	Zn	Zr	Au
10N	5L	50	5N	70	5	50	100N	5N	50	100N	10L	50N	150	200N	100	0.05N
10	7	20N	5	30	15	50	100N	5	15	100N	70	50N	50	200N	70	.05N
15	10	20N	5N	20N	20	10N	100N	7	10N	100N	70	50N	20	200N	50	.05N
50	15	20N	15	20N	30	15	100N	10	10N	1,000	150	50L	50	200N	70	.05N
100	500	20N	5N	20N	70	15	100L	20	10N	100N	200	50L	20	200N	150	2.60
15	150	20N	5N	20N	20	10	100L	7	10N	100N	100	50L	10N	200	30	12.60
10	70	20N	20	20N	5	30	100N	5	20	100N	50	50N	10N	200N	70	.05L
15	5L	30	5	20N	5	50	100N	5	10	100	50	50N	30	200N	100	.05N
10L	5L	20N	15	20N	5	30	100N	5N	10L	100L	20	50N	50	200	50	.05N
20	5	50	5N	30	10	30	100N	7	10	200	70	50N	50	N	100	.05N
100	20	50	5N	20	30	20	100N	20	10N	100N	150	50N	100	N	200	.05N
200	5	70	5N	20	10	30	100N	30	10N	300	150	50N	70	N	150	.05N
50	5	100	5N	30	10	50	100N	7	10	100N	50	50N	70	N	200	.05N

The inference that the occurrence formed at shallow depth is supported by two pieces of evidence: (1) using the method of Haas (1971), a fluid with a salinity of 5 weight percent and a temperature of 320 to 380 °C will boil at a depth of 1,400 to 2,400 m if it is open to the surface. (2) The presence of detectable gold in felsic dikes (station 32, 3103 and 31) and the presence of arsenopyrite in the granite adjacent to a felsic dike (station 32) suggests involvement of the dikes in the hydrothermal activity. The textures of the dikes suggest that they crystallized in a shallow environment.

The inference that the occurrences formed in the active tectonic environment that accompanied the late stages of the felsic igneous activity is supported by field relations, including probable movement on the Swamp Saddle fault. Differences in postulated depth of formation of the contact metamorphic effects and of the quartz vein west of Table Mountain provide additional evidence of tectonic activity.

Gold occurrences west of Table Mountain (stations 3095, 3122 and 31) suggest control by the adjacent fault. The presence of tourmaline in the fault zone and in gold-bearing samples adjacent to the fault (stations 3095 and 3122), as well as locally from the outer walls of the quartz vein (station 31), links the fault and the gold-bearing samples.

The difference between the estimated depth of formation of the contact effects related to the intrusion of the granite (6 km), and the depth of formation of the quartz vein west of the Table Mountain as estimated from the method used by Haas (1971) (1.4 - 2.4 km), implies substantial regional uplift. The time period over which the uplift took place is uncertain, because neither the granite nor the felsic dikes that are associated with the gold occurrences have been dated successfully. However, similar plutons in the northwest Circle quadrangle have yielded ages between 66 and 57 m.y. B.P. (Wilson and Shew, 1981). Felsic dikes and hypabyssal rocks similar to those in the Table Mountain area exist in or adjacent to other plutons in the region. The only occurrence of similar rocks that are not closely associated with a pluton occur in the Faith Creek area, where they occur along the trend of an aeromagnetic low that also underlies the Table Mountain area. These relationships suggest that the felsic dikes and hypabyssal rocks are comagmatic with the granite and place some constraints upon the time period over which the uplift took place. Thus it seems reasonable to suggest that the Table Mountain area was being uplifted at a rate of 3.6 to 4.6 km per 10 m.y. just before the start of the hydrothermal activity that formed the gold occurrences. This rate of uplift can be compared with the rate of 6 km in 60 m.y. that Forbes and Turner (1975) calculated for the Yukon Tanana Upland on the basis of argon-blocking temperatures in biotite.

The Swamp Saddle fault, which offsets regional metamorphic isograds about 8 km (Foster and others, 1983) and offsets dike rocks from the pluton, probably was a major locus of tectonic activity in the Table Mountain area.

The possibility that occurrences such as those west of Table Mountain (stations 3095, 3122 and 31) might act as sources of gold elsewhere in the Circle quadrangle is probably best assessed by estimating the amount of gold in the occurrences. If the quartz vein at station 31 does underlie the small hill on the west end of the ridge (an area of approximately 0.1 km^2), averages 3.75 cm in thickness, and has an average gold content of 7 ppm, it would contain over 1,400 oz of

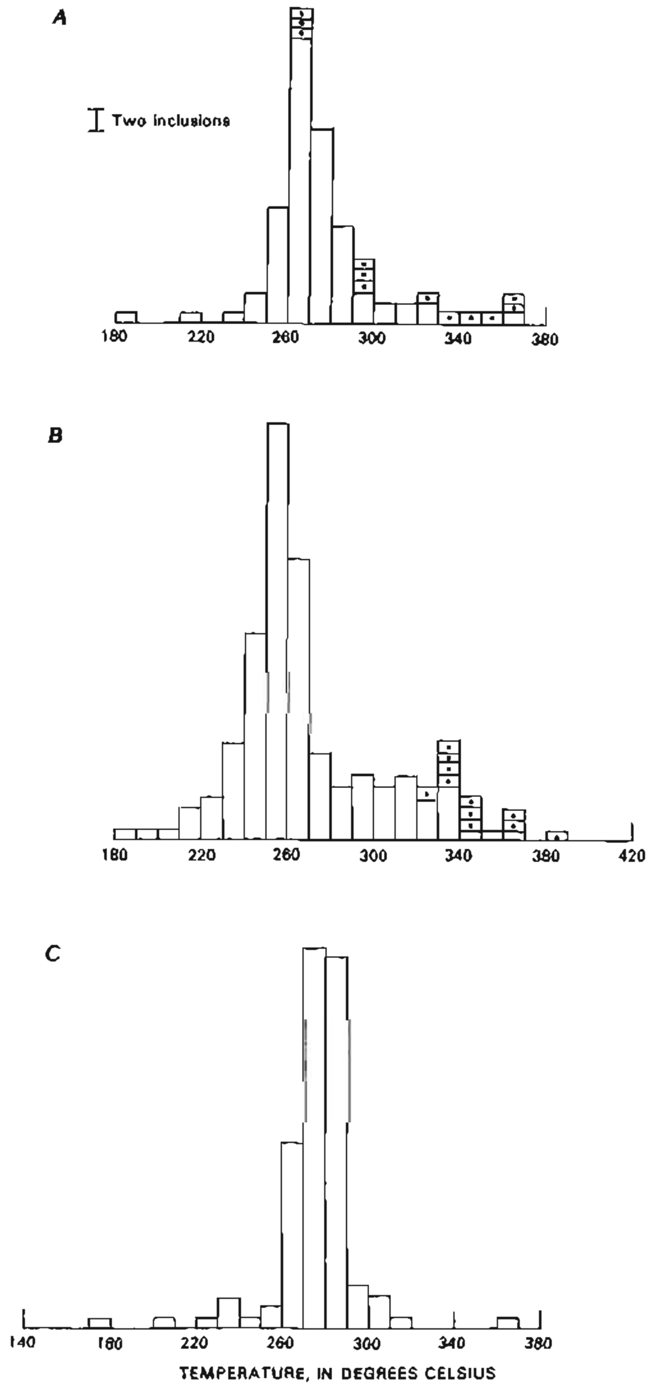


Figure 5. Histograms of homogenization temperatures of fluid inclusions from samples from Table Mountain occurrence. Open area, data for type I inclusion; area with dot, type II inclusion. A, Sample 31L B, Sample 31J. C, Sample 31L.

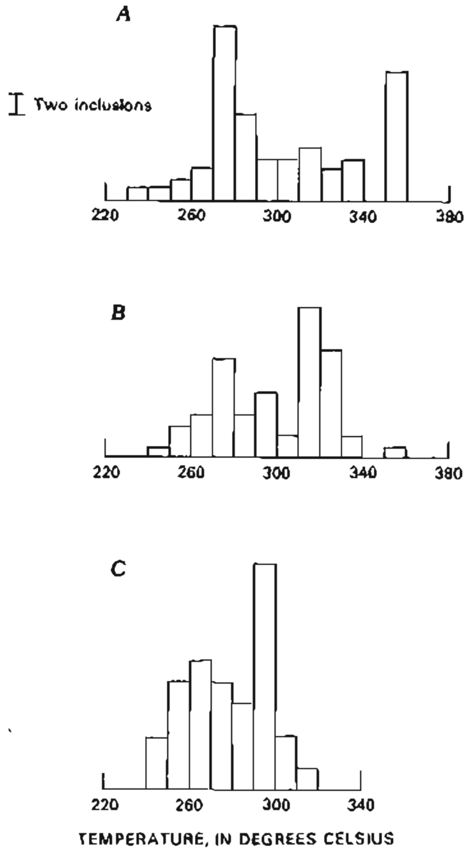


Figure 6. Histograms of homogenization temperatures of fluid inclusions from samples from occurrences in and adjacent to the granite. All data are for type I inclusions. A, Sample 32C. B, Sample 33B. C, Sample 82380-2-1.

gold. Such a figure is probably a conservative estimate of the gold available in the area west of Table Mountain, because it neglects gold from the black biotite schist adjacent to the fault and does not consider the possibility of additional veins beneath the hill. Although the occurrence does not contain a large amount of gold, especially when compared to that mined in the Circle quadrangle, it seems likely that there were many similar occurrences within the quadrangle. Thus, much of the gold in the Circle quadrangle probably was derived from small local gold occurrences that are characterized by a simple mineralogy, and formed at shallow depths in and adjacent to faults that were active during the last stages of felsic igneous activity.

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