CIRC. 320

GEOLOGICAL SURVEY CIRCULAR 320

URANIUM OCCURRENCES IN THE GOLDEN GATE CANYON AND RALSTON CREEK AREAS JEFFERSON COUNTY, COLORADO

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UNITED STATES DEPARTMENT OF THE INTERIOR
Douglas McKay, Secretary

GEOLOGICAL SURVEY
W. E. Wrather, Director

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By J. W. Adams, A. J. Gude 3d, and E. P. Beroni

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ABSTRACT

Pitchblende, associated with base-metal sulfides, has been found at nine localities in the northern part of Jefferson County, Colo., in shear zones that cut pre-Cambrian metamorphic and igneous rocks, chiefly hornblende gneiss, biotite schist, and granite pegmatite. The known deposits are in the vicinity of Ralston Creek and Golden Gate Canyon, in the foothills of the Colorado Front Range and about 15 miles east of the pitchblende-producing area of the Central City district. Two of the pitchblende occurrences were found by a local prospector in 1949; the seven other deposits were found by Geological Survey personnel in 1951-52.

The pitchblende deposits, with one exception, are in major shear zones that contain veinlike bodies of carbonate-rich breccia that ranges from 1 to 5 feet in thickness. The breccias probably are related to the Laramide faults, or "breccia reefs" of similar trend, mapped by Lovering and Goddard (1950). The breccias are composed of fragments of bleached and iron-stained wall rock, usually hornblende gneiss, that have been cut by veins and cemented by carbonate minerals, quartz, and orthoclase(?). Pitchblende and associated ore minerals, chiefly copper sulfides, occur in and along the margins of the breccias and apparently were introduced at a late stage of the carbonate deposition. At one deposit, the Buckman, the pitchblende is in narrow shear zones not closely related to any large breccia bodies.

Secondary uranium minerals are subordinate except at the Schwartzwalder mine, where torbernite and metatorbernite are common. Some alteration of pitchblende to nonopaque materials, believed to be

hydrated oxides, has been noted in ore from two of the deposits.

INTRODUCTION

The recent discovery of nine uranium-bearing vein deposits in pre-Cambrian rocks of northern Jefferson County, Colo., indicates a new district favorable for uranium prospecting. The known deposits are in two small areas in the foothills of the Colorado Front Range, less than 20 miles from Denver (fig. 1) and about 15 miles east from the pitchblende-producing area of the Central City district.

The initial discovery of pitchblende was probably made before 1884, as a note in Mining and Science Press (1884) for that year describes its occurrence in Jefferson County in thin seams but in "too small quantity to be economically valuable." No specific location for the deposit was given.

In the spring of 1949 samples of pitchblende and torbernite ores from the northern, or Ralston Creek, area were brought to the attention of the Atomic Energy Commission by Fred Schwartzwalder of Golden. In 1951, the first of the several occurrences in the Golden Gate Canyon area was found by members of the Geological Survey. More recently additional discoveries in both areas, have been made by members of the Survey; this work was done on behalf of the Division of Raw Materials of the U. S. Atomic Energy Commission. In all the deposits the uranium is associated with copper, and most of the occurrences had been prospected for metals as early as 1894.

Preliminary studies show striking parallelisms in the geology and mineralogy of the several occurrences that are suggestive of a common period of deposition and similar environmental conditions. In general, pitchblende occurs along the walls of fault zones that contain vein fillings of carbonate and potash feldspar rock, presumably of hydrothermal origin, and genetically related to the ore. The wall rock is usually hornblende gneiss that has been severely bleached adjacent to the veins. Breccia fragments in the vein have been wholly or partly replaced by sulfides. Copper minerals are invariably present in the veins, and include chalcopyrite, covellite, bornite, chalcocite, tetrahedrite-tennantite, malachite, and azurite. Pyrite is less abundant than chalcopyrite; galena has been noted at only two localities. Carbonates are generally abundant. Ankerite is the dominant gangue mineral of the carbonate and potash feldspar vein material and is earlier than calcite, which probably is largely postpitchblende.

The fault zones in which the pitchblende deposits occur have a similar trend and possibly are related to the extensive Laramide faults, or breccia reefs mapped by Lovering and Goddard (1950). At least one such breccia reef is present in the Ralston Creek area, 250 feet from, and roughly parallel to, a pitchblende-bearing vein. The individual reefs have not as yet been correlated with those mapped a few miles to the north (Lovering and Goddard, 1950). The relationship between breccia reefs and the uranium-bearing veins possibly is analogous to that of the reefs and certain ore deposits in nearby Boulder County, where the reefs are probably served as deep channels for the ore deposited in adjacent fissures (Lovering and Goddard, 1950, p. 239).

The known uranium deposits will be discussed as those of the Golden Gate Canyon area (fig. 2) and the Ralston Creek area (fig. 6).

GOLDEN GATE CANYON AREA

The known deposits in the Golden Gate Canyon area (fig. 2) are alined along a narrow belt that trends N. 75°-80° E. The trend of this belt is essentially parallel to the trend of the well-developed foliation of the pre-Cambrian metamorphic rocks of the area. The individual deposits, however, with the possible exception of the Buckman, are found at the intersection of northerly-trending, carbonate-bearing fault zones and the N. 75°-80° E.-trending belt.

The rocks in the vicinity of the deposits are predominantly interlayered gneisses and schists of the Idaho Springs formation and include hornblende gneiss, biotite schist, and quartz-biotite gneiss. For this investigation they have been differentiated only megascopically. The hornblende gneiss is a fine-grained black rock containing about 50 percent hornblende and 50 percent quartz and feldspar. It is well foliated and is generally fresh and unaltered in outcrops. Interlaminated with the hornblende gneiss are narrow layers of biotite schist. These layers, which are soft and friable, possibly represent hydrothermally altered gneiss. The hornblende gneiss and biotite schist make up a rock layer or unit that is about 100 feet thick at the Union Pacific prospect.

Stratigraphically above and below this unit the rocks are dominantly gray and foliation is not as well developed. These lighter colored rocks are chiefly fine grained quartz-biotite gneiss in which the quartz, biotite, and feldspar content varies considerably from layer to layer. A few narrow layers of a black, hornblende-rich rock are interbedded with the gray gneiss.

Field studies indicate that the previously mentioned alinement of the pitchblende deposits is due to their occurrence in the hornblende gneiss-biotite schist unit. This layer is the host rock of the four oocurrences of pitchblende in section 19 (fig. 2), and probably includes the pitchblende vein north of the Buckman adit.

It is not yet known whether the occurrence of the uranium deposits in the hornblende gneiss is the result of structural control or of some physical or compositional difference. The carbonate-bearing fault zones generally show a slight anomalous radioactivity. This anomalous radioactivity, together with the proximity of the pitchblende to the fault zones, suggests that they represent the channelways along which the ore solutions moved. Uranium minerals have not been found along all the carbonate-bearing faults that cross the hornblende gneiss-biotite schist unit, but all such intersections may be potentially ore-bearing.

About 700 feet north of the hornblende gneiss-biotite schist unit, anomalous radioactivity has been found at several places along another belt of hornblende gneiss and biotite schist which is parallel to the favorable unit. The radioactivity apparently is confined to narrow beds of bleached biotite schist cut by carbonate-bearing faults. The radioactivity anomalies suggest the existence of another zone of favorable host rocks, although no uranium or copper minerals have as yet

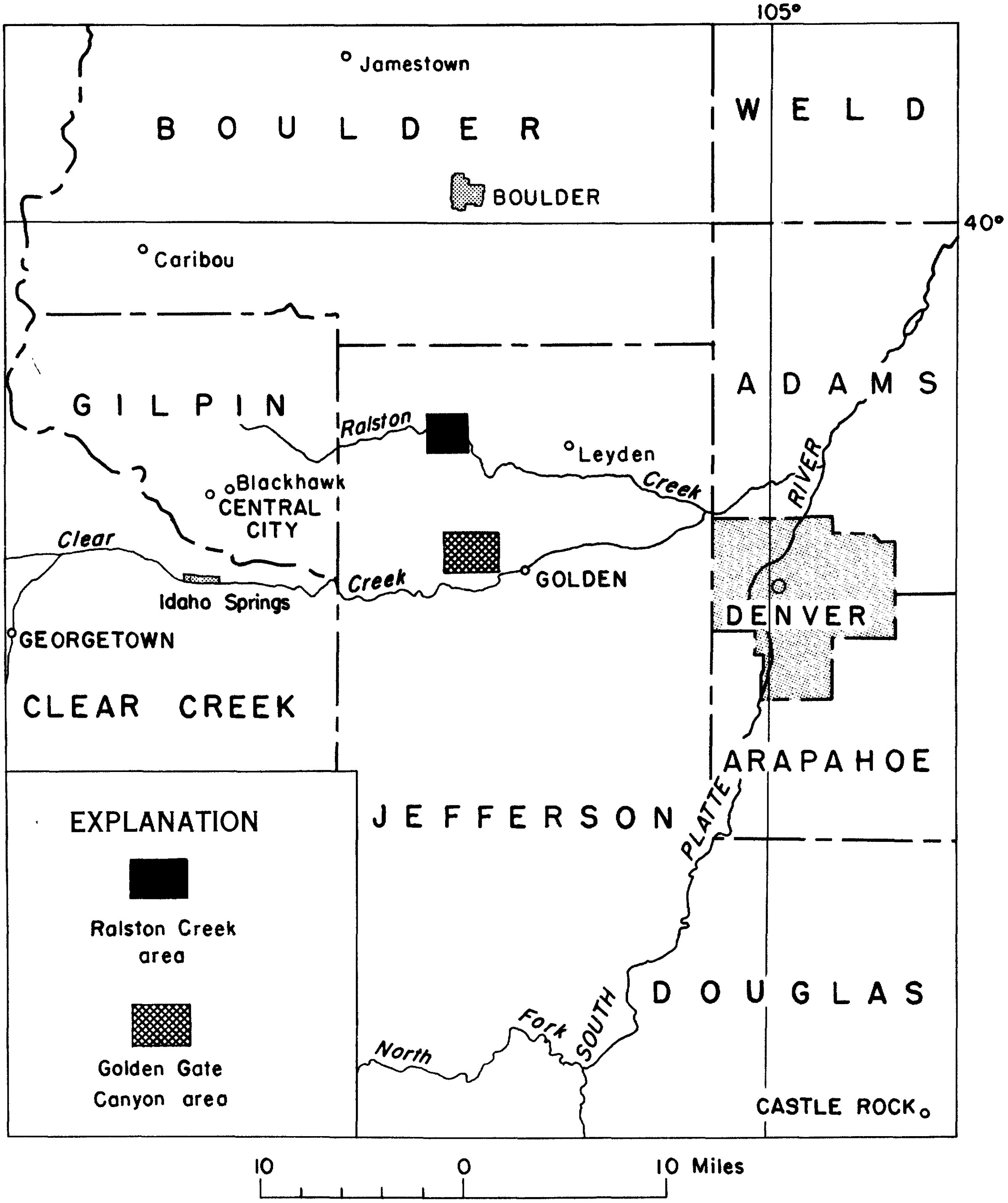

Figure 1. —Index map of central Colorado showing location of Golden Gate Canyon and Ralston Creek areas.

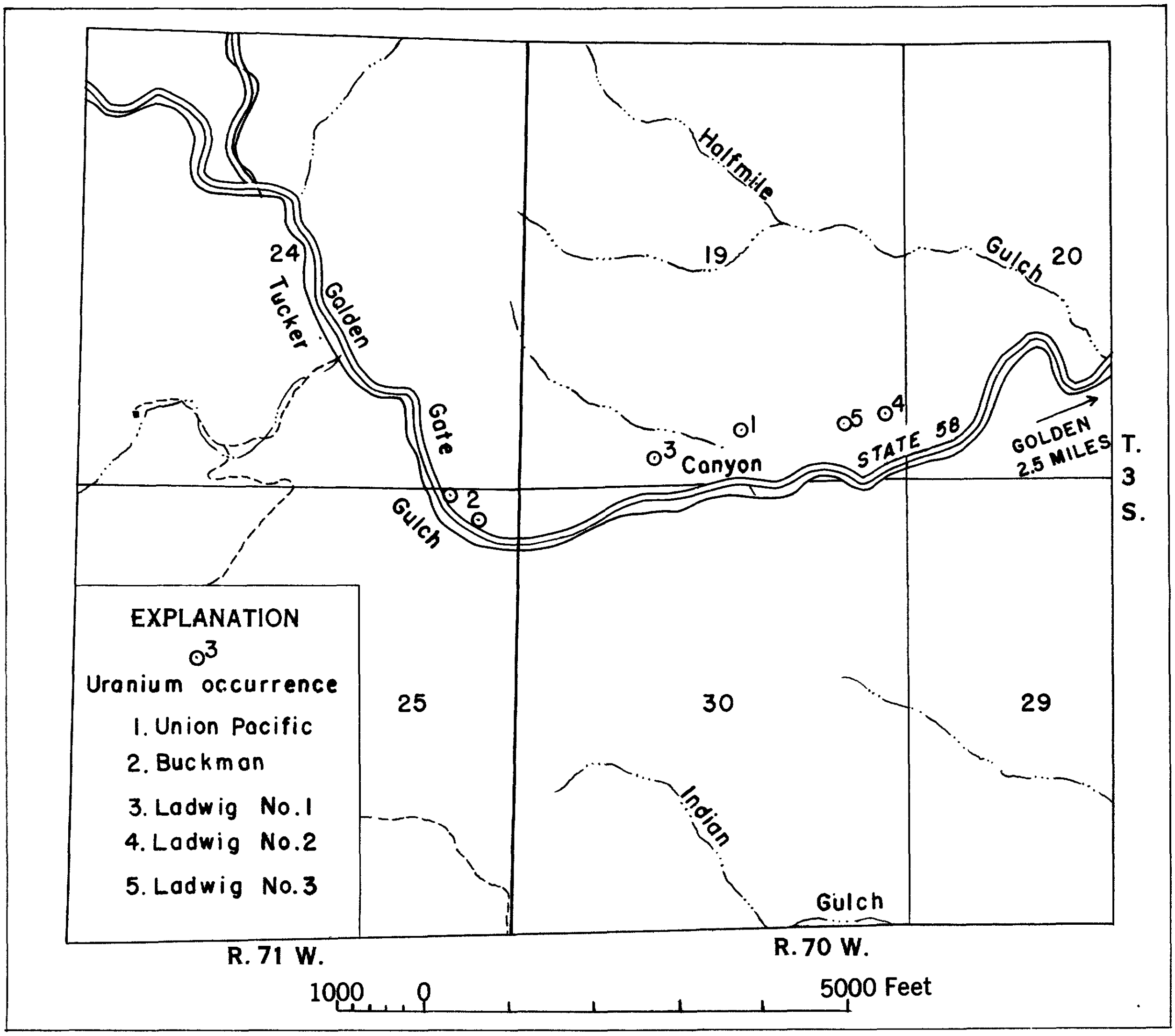

Figure 2.—Index map showing known uranium occurrences in Golden Gate Canyon area, Jefferson County, Colorado.

been observed at these localities. Analyses of samples from the Golden Gate Canyon area are shown in table 1.

Union Pacific prospect

Uranium in the Golden Gate Canyon area was discovered at the Union Pacific prospect (fig. 2), which is on land owned by John Pearce and Thomas Pearce of Golden, Colo. Mineral rights to the property are held by the Union Pacific Railroad Company. The deposit was at one time prospected, presumably for copper, by an inclined shaft, 57 feet deep, from which a short drift extends a few feet into the right wall at the 30-foot level. In December 1951 the shaft was dewatered by the Union Pacific Railroad Company for examination by their geological staff. At that time, samples were collected and the walls of the shaft were mapped by the Geological Survey.

Pitchblende and copper minerals occur along the hanging wall of a 10- to 15-foot fault zone that strikes N. 15°-20° W. and dips about 35° NE. The strike of the fault zone is approximately at right angles to the foliation of the enclosing hornblende gneiss and biotite schist. The fault consists of hanging-wall and footwall zones of sheared and bleached rock and a central unit of wholly or partly cemented breccia. The cemented breccia is composed essentially of small bleached fragments of gneiss in a fine-grained groundmass of ankerite and minor quantities of an unidentified potash feldspar. The ankerite-rich breccia is a dense, light-gray rock that oxidizes readily to an earthy limonitic gossan. The gossan is well exposed along the south wall of the opencut, where it appears as the dark band in the lower part of the breccia zone.

Except within the limits of the opencut, the fault is concealed in the mapped area, and its position outside the opencut can only be inferred (fig. 3). However,

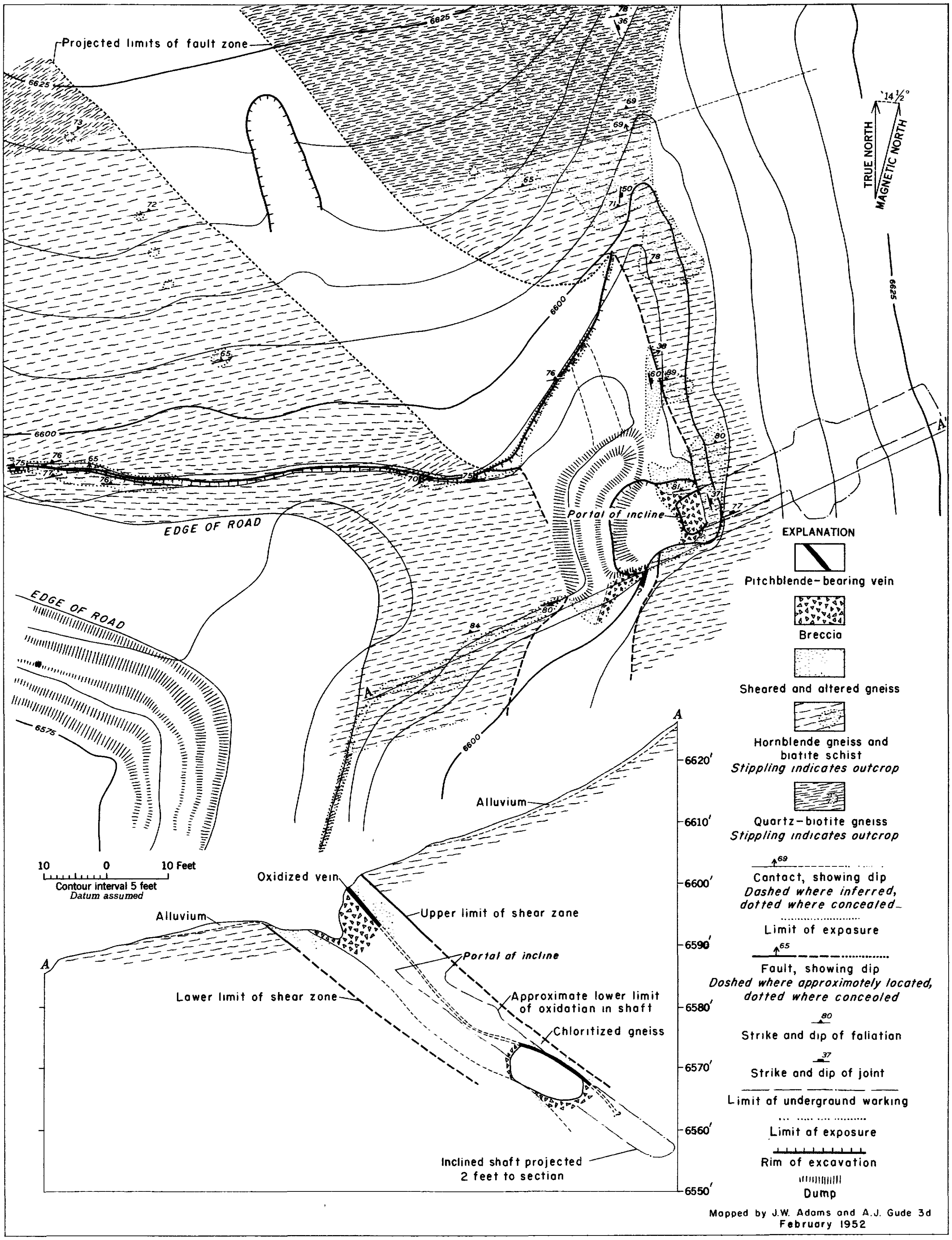

Figure 3.—Geologic map and section of the Union Pacific prospect, Jefferson County, Colorado.

Table 1.—Analyses of samples from Golden Gate Canyon and Ralston Creek area, Jefferson County, Colo.

[Channel samples unless otherwise noted.]

Locality	Field no.	Width of channel (feet)	Material	Equivalent uranium (percent)	Uranium (percent)	Copper (percent)	Lead (percent)	Zinc (percent)	Fe_2O_3 (percent)	Manganese (percent)	Gold (oz./ton)	Silver (oz./ton)	$CaCO_3$ (percent)	Remarks
Union Pacific prospect.	SA-1	(1)	Carbonate-breccia with pitchblende.	0.130	0.110	---	---	---	---	---	---	---	---	Sample from dump.
	UP-1	3.0	Altered gneiss and carbonate-breccia.	.006	.004	---	---	---	---	---	---	---	---	Sample from underground workings.
	UP-2	3.0	----do----------	.006	.003	---	---	---	---	---	---	---	---	Do.
	UP-3	4.0	----do----------	.006	.004	0.21	0.01	0.08	---	---	---	---	8.8	Do.
	UP-4	4.0	----do----------	.005	.003	---	---	---	---	---	---	---	---	Do.
	UP-5	4.4	----do----------	.009	.004	---	---	---	---	---	---	---	---	Do.
	UP-6	4.2	----do----------	.014	.006	.10	.005	.07	---	---	---	---	3.3	Do.
	UP-7	4.0	----do----------	.094	.086	.49		.33	---	---	---	---	---	Do.
	UP-8	4.0	----do----------	.230	.260	.33	0	.50	---	---	Tr.	0.20	---	Do.
	UP-9	3.0	----do----------	.007	.003	.25	0	.95	---	---	Tr.	Tr.	---	Do.
	UP-10	1.0	----do----------	.007	.005	---	---	---	---	---	---	---	---	Do.
	UP-11	2.3	----do----------	.006	.003	---	---	---	---	---	---	---	---	Do.
	UP-12	2.6	----do----------	.006	.004	---	---	---	---	---	---	---	---	Do.
	UP-13	4.3	----do----------	.650	.810	.32	---	.35	---	---	---	---	---	Do.
	UP-14	4.9	----do----------	.014	.011	---	---	---	---	---	---	---	---	Do.
	UP-15	.3	----do----------	5.60	5.84	.29	.04	.45	---	---	Tr.	.72	---	Do.
	UP-16	.8	----do----------	.015	.006	.20	---	.25	---	---	---	---	---	Sample from portal of inclined shaft.
	UP-17	4.0	----do----------	.008	.003	.16	---	.25	---	---	---	---	---	Do.
	UP-18	1.0	----do----------	.009	.003	---	---	---	---	---	---	---	---	Sample taken from outcrop N. 63° W. of portal.
Buckman property----	GGC-3	.5	Pitchblende in gouge----	.250	.260	---	---	---	---	---	---	---	---	Sample from adit.
	GGC-4	.5	Altered gneiss----------	.010	.003	---	---	---	---	---	---	---	---	Do.
	B-1	(1)	Pitchblende in altered gneiss.	1.20	1.23	---	---	---	---	---	---	---	---	Sample from road cut, 300 feet N. of adit.
	RB-4	.5	Pitchblende in fractured quartz.	1.50	.860	.08	.07	.03	4.04	---	Tr.	.04	.2	Sample from adit.
	RB-5	.5	Pitchblende in gouge----	.220	.220	.10	.015	.05	8.19	---	0	0	5.4	Do.
	RB-6	1.0	Pitchblende in gouge; gneiss.	.072	.062	.08	---	---	6.29	---	Tr.	.04	---	Sample includes wall rock adjoining pitchblende shear.
	RB-7	4.0	Schist and pegmatite----	.004	---	.16	---	---	5.22	---	Tr.	Tr.	---	Sample from adit.
	RB-8	.5	Altered pegmatite-------	.032	.013	.01	---	---	3.81	---	Tr.	Tr.	---	Do.
Ladwig No. 1--------	L-1	(1)	Pitchblende in altered gneiss.	.980	1.36	---	---	---	---	---	---	---	---	Sample taken 1 foot below soil zone.
	L-2	(1)	Carbonate-breccia-------	.006	.007	---	---	---	---	---	---	---	---	Sample from dump of copper prospect.
Ladwig No. 2-------	L2-1	(1)	Carbonate-breccia with pitchblende and copper.	.250	.300	8.25	.10	.10	---	---	---	---	.2	Sample from dump.
North Star mine----	NS-3	1.0	Mineralized breccia shear.	.370	.510	5.50	.11	.38	---	---	---	---	.5	Sample from underground workings.
	NS-4	(1)	Breccia with pitchblende.	.720	.850	16.83	---	---	---	---	---	20.30	---	Sample from dump.
	NS-5	1.0	Mineralized breccia shear.	.140	.110	3.08	.10	.10	---	---	---	---	.1	Sample from underground workings.
	NS-6	.5	----do----------	.062	.027	5.74	.10	.10	---	---	---	---	.2	Do.
	NS-7	.5	----do----------	.023	.010	1.84	---	---	---	---	Tr.	1.12	---	Do.
	NS-8	.5	----do----------	.005	.002	.29	---	---	---	---	Tr.	Tr.	---	Do.
	NS-9	.5	----do----------	.007	.002	.02	---	---	---	---	0	0	---	Do.
	NS-10	.5	----do----------	.011	.005	.08	---	---	---	---	0	0	---	Do.
	NS-11	.5	----do----------	.010	.006	4.12	---	---	---	---	Tr.	6.42	---	Do.
Nigger shaft--------	AJG-9	4	Carbonate-breccia-------	.010	.004	---	---	---	---	---	---	---	22.9	Sample from underground workings.
	AJG-10	.2	Carbonate vein with pitchblende.	.320	.220	---	---	---	---	---	---	---	---	Do.
	AJG-11	.2	----do----------	.280	.310	*.29	.015	.06	---	---	---	---	20.4	Do.

Schwartzwalder mine.	RB-9	4	Altered gneiss----------	.021	.011	---	---	---	---	---	---	---	---	Sample taken in adit.
	RB-10	2	Altered breccia with torbernite and pitchblende.	.880	1.07	.32	2.67	---	---	---	---	---	.1	Do.
	RB-11	3	----do------------------	.320	.360	.21	.74	.10	---	.40	Tr.	1.24	.1	Sample taken in adit. Contains 0.13 percent V_2O_5.
	RB-12	4	Altered breccia with torbernite.	.110	.082	---	---	---	---	---	---	---	---	Sample taken in adit.
	RB-13	4	Altered silicified gneiss.	.039	.010	.15	---	---	---	.07	---	---	---	Do.
	RB-17	(1)	Carbonate-breccia with torbernite.	.094	.084	---	---	---	---	---	---	---	---	Sample from upper prospect pit, 52 feet above portal of adit.
	RB-18	(1)	----do------------------	.340	.470	---	---	---	---	.15	---	---	---	Do.
	RB-20	(1)	Altered breccia with pitchblende and torbernite.	.260	.330	---	---	---	---	---	---	---	---	Sample from ore bin.
	RB-21	.5	Altered breccia with pitchblende and sulfides.	1.40	1.94	.09	.53	.13	---	.24	---	---	3.3	Sample taken in adit.
	RB-22	1	Breccia with torbernite-	.084	.058	---	---	---	---	---	---	---	---	Sample from prospect pit 35 feet above portal of adit.
	RB-23	(1)	----do------------------	.59	.790	---	---	---	---	---	---	---	---	Random sample from dump of prospect pit 35 feet above portal of adit.
	RB-24	1.5	----do------------------	.13	.059	---	---	---	---	---	---	---	---	Sample from prospect pit, 52 feet above portal of adit.
	RB-27	(1)	Carbonate-breccia-------	.33	.43	2.0	---	---	---	---	---	---	---	From prospect 1,000 feet northeast of Schwartzwalder mine. Contains 1.10 percent V_2O_5.
	RB-28	1	Altered breccia with pitchblende.	4.1	5.29	---	---	---	---	---	---	---	---	Sample taken in adit, near floor of workings.
	RB-29	(1)	Carbonate-breccia-------	.018	.014	---	---	---	---	---	---	---	---	From prospect 1,000 feet northeast of Schwartzwalder mine.
	H-651	2	Altered schist----------	.44	.59	---	---	---	---	---	---	---	---	From incline.
	H-652	2	Altered breccia with pitchblende.	2.9	4.32	---	---	---	---	---	---	---	---	From incline. Contains 0.14 percent V_2O_5.
	H-653	3	----do------------------	.5	.65	---	---	---	---	---	---	---	---	Do.

[1] Grab sample.

outcrops of carbonate breccia about 300 feet and 700 feet northwest of the mapped area, as well as a shear zone in rocks on the south side of Golden Gate Canyon, probably represent the same structure, and indicate that it has a strike length of at least 1,000 feet.

The surface cut and underground workings at the Union Pacific prospect are entirely within the fault zone in the hornblende gneiss and biotite schist layer previously mentioned as a "favorable bed" for uranium deposition. This layer, which is about 100 feet thick and dips steeply to the north, apparently has been displaced from 10 to 25 feet to the northwest on the west side of the fault.

The southeast wall of the shaft showed anomalous radioactivity from the collar to a few feet below the stub drift. On the southeast wall of the cut a radioactive gossan from 6 inches to 1 foot thick underlies the hanging-wall shear zone, and many of the fracture surfaces in the shear zone itself show strong radioactivity. Anomalous radioactivity was found in much of the soil-covered area between the north rim of the cut and a shallow trench about 75 feet northwest of the shaft. The anomalies occur within the limits of the fault zone as shown on figure 3.

Pitchblende, the only uranium mineral that has been observed in the deposit, is associated with chalcopyrite, tetrahedrite-tennantite, bornite, chalcocite, covellite, and pyrite in a zone that ranges from 6 inches to 1 foot in thickness along the contact between the carbonate-breccia and the hanging-wall shear. The ore minerals are largely concentrated in the altered and sheared hornblende gneiss, but they are also present in the upper few inches of the underlying breccia. The pitchblende occurs chiefly as lustrous, black films along minor shear planes that are roughly parallel to the major structure of the fault. Less conspicuous pitchblende, accompanied by the sulfides, is disseminated through most of the rock in the ore zone; at least some of this pitchblende is a late mineral in carbonate-lined veinlets.

Most of the pitchblende observed in the deposit was found on the walls of the stub drift; samples taken across the shaft walls at points above and below the drift showed a rapid decrease in uranium (fig. 4). It is possible that the radioactive gossan in the southeast wall of the surface cut is an oxidized and leached part of the pitchblende-bearing body exposed underground, and that both represent the north edge of a lenticular ore shoot whose direction of plunge is a few degrees south of the direction of the shaft. The localization of ore on the crest of rolls in the breccia zone is suggested by the relationships observed underground.

Copper minerals are abundant in some samples, but the copper content of the ore zone is low. Zinc was detected in analysed samples, but no zinc minerals have been recognized. Gold, silver, lead, nickel, and cobalt are present in trace amounts only.

The paragenesis of the minerals from the deposits in the area has not been studied sufficiently to be discussed at length in this paper, but it seems probable that the pitchblende was formed after the brecciation of the wall rocks and during the last stage of carbonate deposition.

Buckman property

Pitchblende has been found in an abandoned adit about 15 feet east of the Golden Gate Canyon road (fig. 2, locality 2), on land owned by Nora R. Buckman of Golden, Colo. About 1916 the adit was driven 86 feet in a northeasterly direction roughly parallel to the foliation of steeply-dipping pre-Cambrian biotite schist and gneiss; presumably the adit prospected sulfide-bearing quartz stringers. A winze which is now filled with water, had been sunk to a depth of 25 feet near the heading.

The biotite schist and gneiss exposed in the adit is cut by granite pegmatite dikes and discontinuous quartz bodies that contain local concentrations of pyrrhotite and chalcopyrite. The quartz bodies, which may represent segments of a single quartz vein, are cut by the pegmatites and are assumed to be pre-Cambrian.

Pitchblende occurs at two places along the south wall of the adit (fig. 5). Near the portal, it forms masses as much as one-half inch thick in a shattered, iron-stained quartz vein. The pitchblende shows colloform rim structures around angular quartz fragments. Interstitial to the pitchblende-coated quartz fragments are iron oxides, chalcopyrite, uranophane, and an unidentified green uranium mineral. A hydrated uranium sulfate, uranopilite, was identified by X-ray and optical data obtained by the Geological Survey laboratory. Although the relations are somewhat obscure, the shattered quartz in which the pitchblende is found apparently lies along a prominent shear that strikes N. 15° E., and dips 40° E., but no anomalous radioactivity has been found in the shear away from the quartz body.

About 45 feet along the adit, pitchblende is found in an oxidized shear striking N. 45° E., and dipping 71° SE. Although this shear cuts a quartz vein, the only pitchblende observed occurred a few inches outside of the quartz vein, in the adjacent sheared and silicified gneiss. Anomalous radioactivity was not detected along the shear except where the pitchblende was found.

In spite of the localization of the pitchblende in and adjacent to the quartz veins, it is doubtful that they are genetically related, and a postquartz vein origin seems more probable.

The pyrrhotite and chalcopyrite sparsely disseminated in and along the margins of the quartz veins probably are essentially contemporaneous with the quartz.

About 300 feet northwest of the adit, a pitchblende-bearing vein is exposed in a road cut at the east edge of the highway. The vein is 1 to 3 inches thick, strikes approximately north, and is essentially vertical. Although the radioactive part of the vein is less than 2 feet long, it is remarkably rich, containing surfaces of hard, botryoidal pitchblende one-eighth to one-fourth inch thick that coats a carbonate mineral tentatively identified as calcite. Minor amounts of chalcopyrite also are present in the vein. The vein cuts hornblende gneiss at approximately right angles to the foliation. The gneiss is almost completely bleached for a width of an inch or more along the contacts. Beyond the

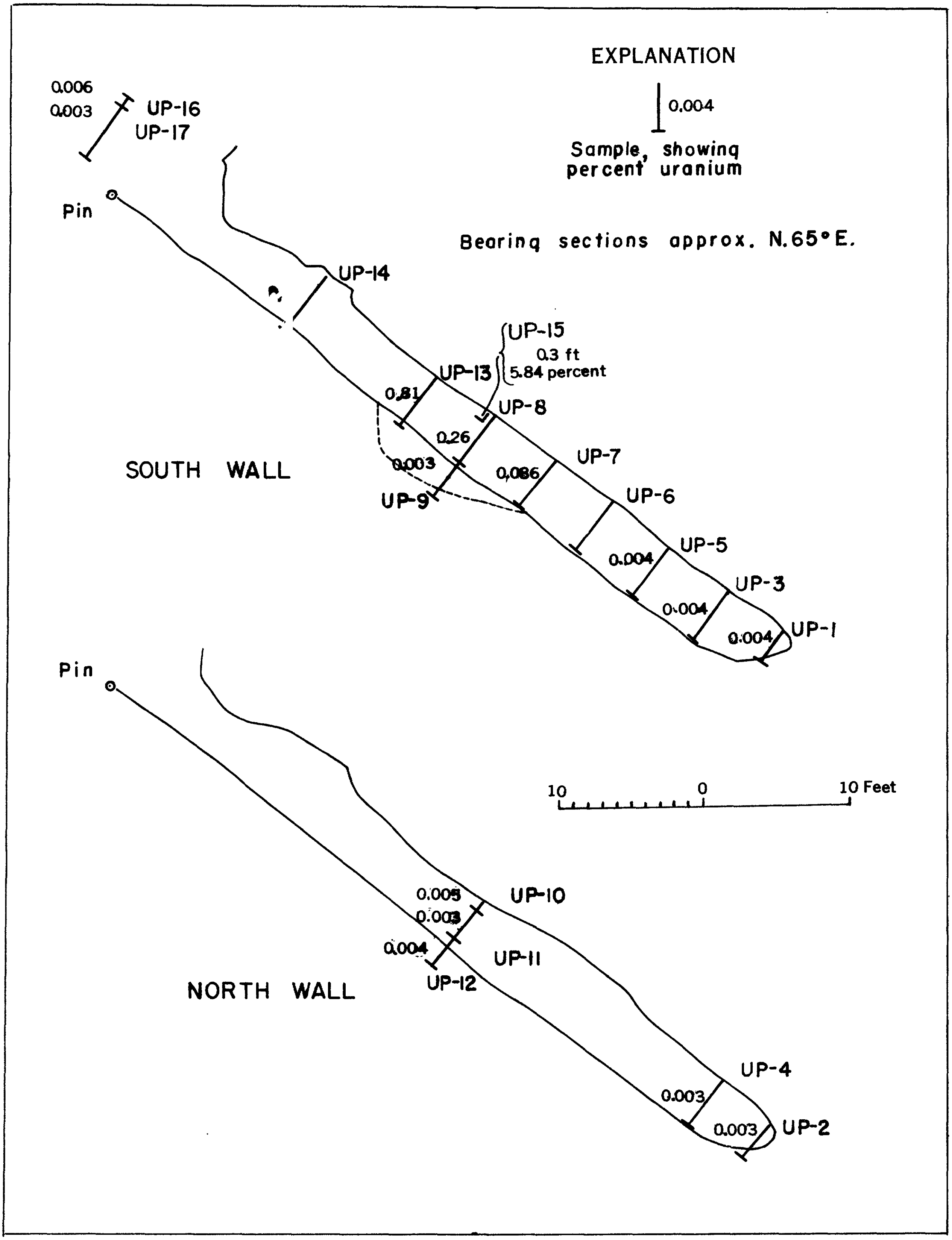

Figure 4.—Assay map of walls of inclined shaft at Union Pacific prospect, Jefferson County, Colorado.

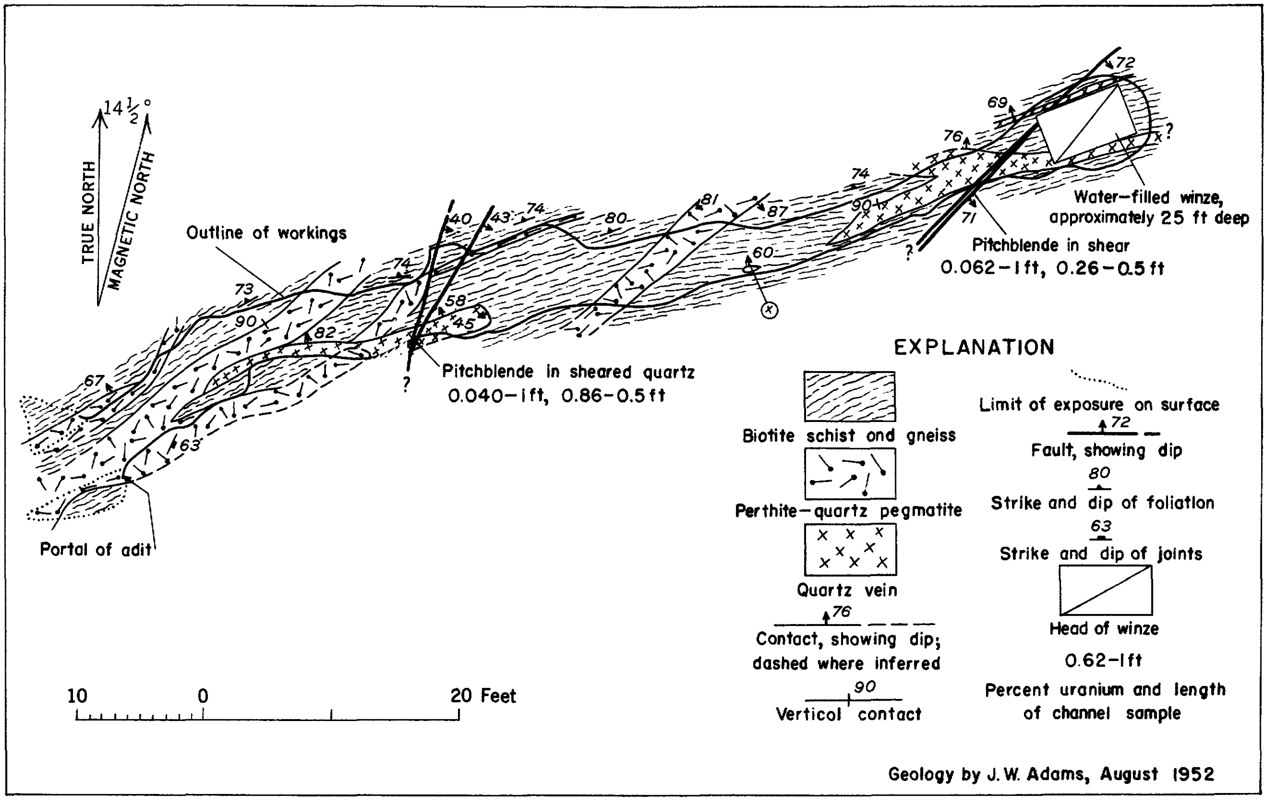

Figure 5.—Geologic map of adit, Buckman property, Jefferson County, Colorado.

pitchblende-bearing area, only a barren fracture marks the course of the vein.

Because of its proximity to the adit, the vein is included in the description of the Buckman property, but its location, so far as can be determined, is so near the north edge of the property that its ownership is uncertain.

The black hornblende-gneiss layer in which the small pitchblende vein occurs may be a westward extension of the favorable bed previously described. This gneiss, where exposed along the highway, is about 100 feet thick, strikes N. 80° E., and dips 62° to 85° N. It has been traced for about 300 feet west of the road to a northwest-trending fault zone that contains large bodies of carbonate-cemented breccia. Anomalous radioactivity is widespread along the fault near its intersection with the gneiss, and although no uranium minerals have been found west of the road, the geologic environment, by analogy with the deposit at the Union Pacific prospect, would appear favorable for an ore body. The small occurrences of pitchblende at the Buckman adit and in the road cut differ from the other known deposits in Golden Gate Canyon in that they show no close relationship to the carbonate-bearing faults, the nearest known fault of this type is at least 300 feet to the west. This variance with the mode of occurrence of the other deposits suggests that the Buckman occurrences may be indicative of a strong uranium mineralization capable of depositing pitchblende at some distance from the faults.

Ladwig No. 1

Strong anomalous radioactivity was detected at the Ladwig No. 1 property (fig. 2) by a gamma scintillation detector. The radioactivity, which is traceable over an area of about 50 square feet, is caused by uranium minerals in rocks concealed under 1 to 3 inches of soil. Torbernite, which coats foliation planes of altered biotite schist, was noted in the few samples that could be collected. A few small fragments in the soil appear to be carbonate breccia, and contain minute grains of pitchblende and an altered yellow uranium mineral that resembles uranophane. Secondary copper minerals are also present. Float of carbonate breccia and exposures of altered rock indicate that the occurrence of uranium minerals is related to a northwesterly-trending fault.

The relative positions of the contacts of the favorable bed of hornblende gneiss with the quartz-biotite gneiss indicate that the fault has an offset of about 100 feet, the west block moving south relative to the east block.

The anomaly is about 330 feet N. 50° W., of a water-filled prospect shaft showing copper minerals on the dump. The shaft was sunk in altered biotite schist cut by a carbonate breccia 1 to 2 feet wide that strikes north and dips about 70° E. Much of the material on the dump is quartz associated with pyrite and limonitic material, and some bornite, covellite, and copper carbonates. In spite of the close association of uranium with copper in the area, no appreciable uranium has been found in ore samples from this locality. It may be significant that although the copper prospect lies along a carbonate-bearing fault, it does not lie within the favorable hornblende gneiss layer.

Mineral rights to the Ladwig No. 1 and two other localities are held by Lyman C. Ladwig of Golden, Colo.

Ladwig No. 2

At the Ladwig No. 2 property (fig. 2), uranium minerals have been found on the dump of an abandoned prospect shaft and in a small trench 100 feet to the east. The shaft, which is now 12 feet deep but may have been considerably deeper, was sunk in a radioactive carbonate breccia zone, 1 to 2 feet wide, that strikes north and dips steeply to the east. The breccia zone cuts the hornblende gneiss-biotite schist layer that, in the vicinity of the shaft, is extensively sheared and bleached for several feet on the hanging-wall side of the contact. No uranium minerals were found in place, but specimens collected from the dump of the shaft contain pitchblende and torbernite in limonite-stained breccia host rock. Additional radioactive samples, probably derived from another breccia zone, were found in the debris from the lower of two shallow cuts about 100 feet east of the shaft. Copper minerals, notably carbonates, are conspicuous on the dump where the uranium minerals are found.

The radioactive breccia zone is also exposed at the caved portal of an adit 125 feet south of the shaft. Here the breccia zone is 6 feet thick and contains altered but recognizable wall-rock fragments that are several inches in diameter. No uranium or copper minerals were noted at the adit or in the shallow cut that exposes the breccia zone about 40 feet north of the shaft.

Ladwig No. 3

A single specimen of pitchblende and associated copper carbonates was found on the dump of the lower of two small prospect pits at the Ladwig No. 3 property (fig. 2). As at the previously described deposit, the pitchblende and copper minerals occur in or near a north-trending breccia zone. This occurrence is poorly exposed, and at present is chiefly of interest as another example of uranium mineralization along the favorable zone.

RALSTON CREEK AREA

Three pitchblende-bearing deposits are known in a small area in the vicinity of Ralston Creek (fig. 6), about 6 miles north-northwest of the prospects in

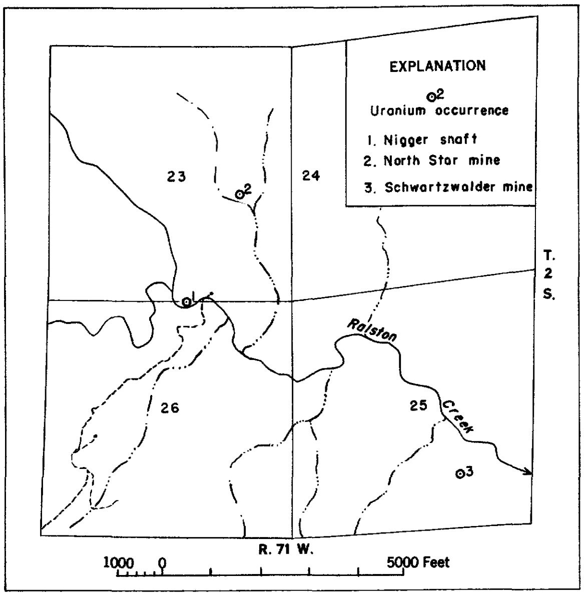

Figure 6.—Index map showing known uranium occurrences in the Ralston Creek area, Jefferson County, Colorado.

Golden Gate Canyon. The deposits are similar to those in Golden Gate Canyon as they are related to north or northwest-trending breccia zones; they do not, however, show a similar alinement in a northeasterly direction. None of the deposits are easily accessible. The North Star and Nigger Shaft deposits can best be reached from the north by a private road to the A. G. Brumm ranch from Coal Creek Canyon. From the end of the ranch road, it is possible to drive 4-wheel drive vehicles to within walking distance of the workings. The Schwartzwalder mine, on the southwest side of Ralston Creek, can be approached by 4-wheel drive vehicles via an access road leading up the creek from Ralston reservoir 5 miles north of Golden. Analyses of samples from this area are shown in table 1.

North Star mine

Pitchblende was discovered at the abandoned North Star mine in April 1952 by geologists of the Geological Survey. The mine is on the ranch of A. G. Brumm and is probably in the south half of section 23, mineral rights of which are held by the Union Pacific Railroad Co. According to Brumm, 4 tons of copper ore was taken from the mine in 1894, and another 12 tons was shipped in 1916.

The mine was worked by a short upper level (fig. 7) and a lower level connecting with a stope that

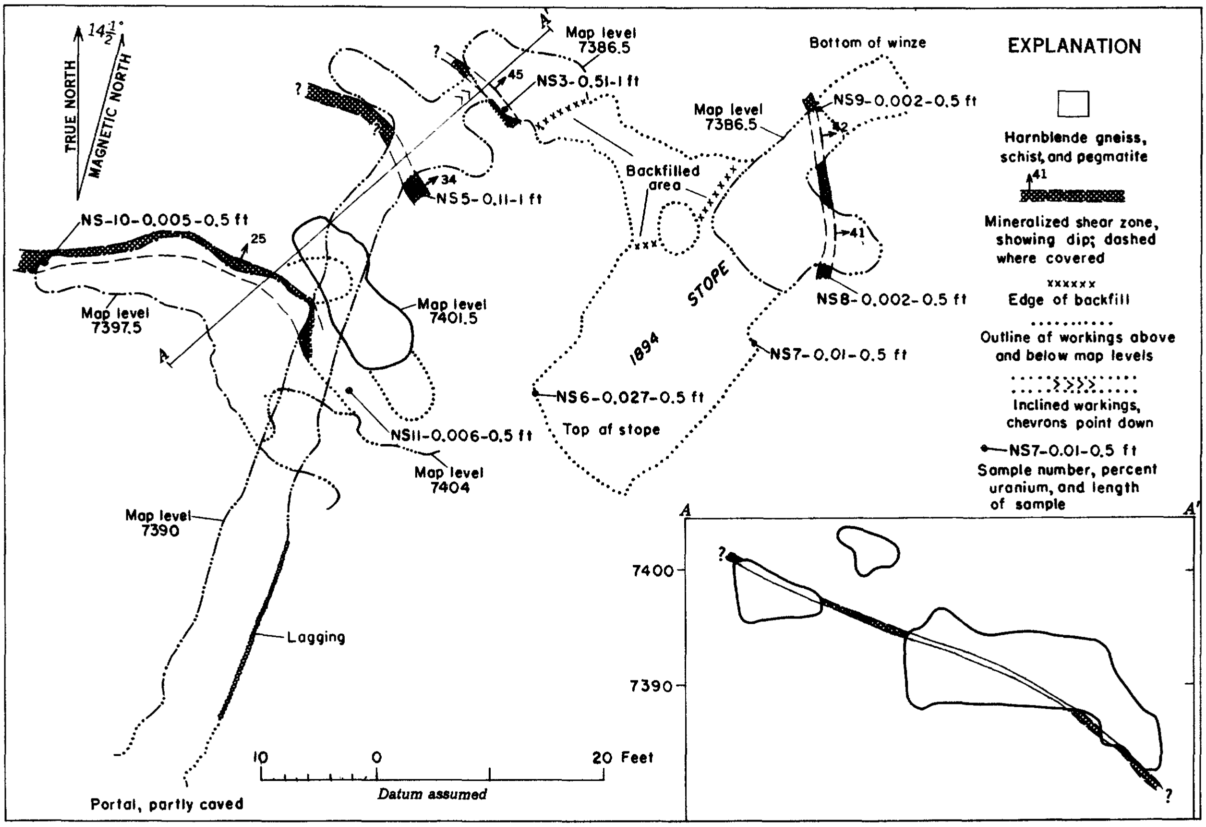

Figure 7.—Map and section of underground workings, North Star mine, Jefferson County, Colorado.

at one time was open to the surface. The portal of the lower level is badly caved, and a backfilled area in the workings makes access to the stope quite difficult. Several other small prospect workings, apparently not on ore, are in the general vicinity of the mine.

The rocks exposed in the area are pre-Cambrian hornblende gneiss, quartz-biotite schist, and granite pegmatite. The foliation of the metamorphic rocks strikes northeast and dips steeply southeast; the pegmatites show a similar northeast trend but are locally discordant. These rocks are cut by a carbonate-orthoclase(?) vein that strikes northwest and dips from 25° to 45° NE. Much of the vein exposed in the mine is altered to a limonitic gossan, but, where fresh, it shows streaks and patches of incompletely incorporated wall-rock fragments, and is a breccia-filling similar to those in the Golden Gate Canyon area.

Uranium and copper minerals occur throughout the vein as fracture fillings and as interstitial material surrounding breccia fragments. The ore minerals are not consistently present along the vein, and the small tonnage of copper ore that was mined probably came from narrow lenses of which little evidence remains. The best copper and uranium ore now showing in the mine (fig. 7) constitutes a zone 6 inches to 1 foot thick above the carbonate vein exposed at track level near the face of the lower adit. Some of the ore observed underground is comparable to the pitchblende-bearing rock found on the upper-level dump. This ore is made up largely of reddish-brown rock fragments, generally less than 1 inch in diameter, cemented by primary and secondary copper and uranium minerals that include bornite, chalcocite, covellite, malachite, azurite, pitchblende, uranophane, and several unidentified uranium minerals. Some of the breccia fragments apparently are hornblende gneiss and granite, but the alteration, particularly the hematite(?) staining, makes identification of the original material difficult. This ore probably came from the small workings of the upper level, where, according to Brumm, the richest copper ore was found. In addition to uranium and copper, the ore contains an appreciable amount of silver (table 1), but no silver minerals have as yet been recognized.

A microscopic study of pitchblende at the North Star mine shows alteration from the opaque isotropic mineral to a brown transluscent to transparent material that is very weakly anisotropic and has an index of refraction of about 1.87. The brown mineral, which is locally abundant in some specimens of the ore, has a radial structure reflecting the original rounded or spherical surfaces of the original pitchblende. It is thought to be a hydrated uranium oxide, but its identity is still uncertain.

The position and attitude of the vein in the stope and at the same map level (fig. 7) in the lower adit indicate either that there are two veins or that postvein faulting has taken place. Geologic mapping of the underground workings, although not complete, indicates that the vein is probably faulted.

Anomalous radioactivity was found at a small prospect trench on the hillside about 600 feet southeast of the North Star workings. The few radioactive samples found on the dump contain secondary copper minerals.

Schwartzwalder (Ralston Creek) mine

The Schwartzwalder (Ralston Creek) mine (fig. 6) is on a heavily wooded, steep slope southwest of Ralston Creek, at an altitude of about 7,000 feet. Surface and mineral rights to the property are owned by Paul White of Golden, Colo. The uranium deposit at the mine currently is being explored by Fred Schwartzwalder of Golden, who discovered secondary uranium minerals at a caved adit on the property early in 1949.

The deposit was investigated for the Atomic Energy Commission by Anderson[1] and Baker[2].

The caved adit and three shallow pits nearby remained from earlier attempts to mine copper at the locality by the Golden Mining Company, during and before October 1897. Mr. Schwartzwalder has excavated the caved adit as an opencut and has driven a new adit and incline (fig. 8). The new workings were begun where the secondary minerals were found and continued in rocks showing abnormal radioactivity and concentrations of secondary uranium minerals. Pitchblende was first found about 40 feet from the portal, where the adit intersects a fault zone which trends northwest and dips at a low angle to the southwest. The fault was followed downdip by an incline to the present (1953) extent of the workings.

The rocks at the Schwartzwalder property are quartzose gneiss and mica schist of the pre-Cambrian Idaho Springs formation. The foliation of the schist, as noted in the underground workings, strikes N. 80° E. and dips 77° S. The gneiss and schist exposed in the workings have been highly altered and faulted, and appear to have been invaded by a large body of massive quartz. Much of the quartz is distinctly smoky in color. The gneiss, schist, and massive quartz have been cut by a fault that is marked by an iron-stained breccia consisting mostly of shattered quartz.

The uranium minerals are mostly concentrated in the fault zone that is as much as 5 feet thick where exposed in the incline. Pitchblende is found almost exclusively in the shattered quartz of the fault zone, whereas secondary uranium minerals are common in all the fractured wall rocks. The pitchblende is finely disseminated and partly sooty. Secondary uranium minerals identified from the deposit include torbernite, metatorbernite, and autunite. Associated with the uranium minerals are minor quantities of chalcopyrite, tetrahedrite-tennantite, bornite, galena, pyrite, limonitic material, malachite, azurite, ankerite, calcite, barite, and an unidentified potash feldspar. The sulfides and associated gangue minerals generally are extremely fine grained.

A strongly radioactive, northerly-trending quartz breccia similar to that exposed in the mine is exposed in a shallow pit 34 feet above and a short distance southwest of the portal of the adit. This breccia, which is about 4 feet thick, contains visible torbernite and malachite along fracture surfaces.

A third exposure of radioactive quartz breccia is in an old excavation 52 feet above the mine adit. About 100 feet above and 150 feet south-southeast of the mine adit, an old shaft 18 feet deep also exposes similar radioactive rock. All these exposures of radioactive breccia probably represent a single fault zone. Continuation of this zone south of the prospected area is indicated by breccia float, in which fine-grained rock fragments are cemented by carbonates. Relationships of uranium minerals to a breccia reef in the Schwartzwalder mine area are analogous to most of the other deposits described. The quartzose character of the breccia is probably due to local composition of the wall rocks rather than to a more siliceous ore-bearing solution.

Pitchblende(?) associated with base-metal sulfides and secondary copper carbonates was noted in another breccia shear zone on the east side of Ralston Creek, about 1,000 feet northeast of the Schwartzwalder (Ralston Creek) mine. This shear zone trends northwest and dips steeply to the northeast. Two samples, RB 27 and RB 29, from this locality contained 0.43 and 0.014 percent uranium respectively.

Nigger shaft (Hoffmeister prospect)

Pitchblende was first recognized in the Ralston Creek area in 1949 at an abandoned copper prospect, locally known as the Nigger shaft. The discovery was made by Fred Schwartzwalder of Golden, Colo., who submitted samples of the radioactive rocks to the Atomic Energy Commission. The prospect, worked between 1912-14 by Hoffmeister, consists of a 20-foot inclined shaft connected to a small stope (fig. 9). A short adit was driven from a point about 130 feet southeast of the shaft, presumably to intersect the vein below the shaft level.

The ownership of the deposit is unknown because the workings are situated on or very close to the boundary line between sections 23 and 26. If the deposit is in section 23, the mineral rights are owned by the Union Pacific Railroad Co. Surface and mineral rights to the adjacent land in section 26 are owned by Oscar Dahlberg of Golden.

The rocks in the vicinity of the Nigger shaft are pre-Cambrian hornblende gneiss, biotite schist, granite pegmatite, and aplite. These rocks are cut by a northerly-trending breccia reef that probably is an extension of one of the major Laramide fault zones mapped three-quarters of a mile to the north by Lovering and Goddard (1950, pl. 2). The reef, bordered by sheared and altered rocks, crops out 250 feet northeast of the shaft, and can be traced by float and outcrops for 1,000 feet or more to the northwest.

[1] Anderson, J. P., 1950, Preliminary reconnaissance, Atomic Energy Comm. Rept. 35. [Unpublished.]

[2] Baker, K. E., 1953, Preliminary report on uranium occurrence at the Ralston Creek mine, Jefferson County, Colo. [Report in files of the Atomic Energy Commission.]

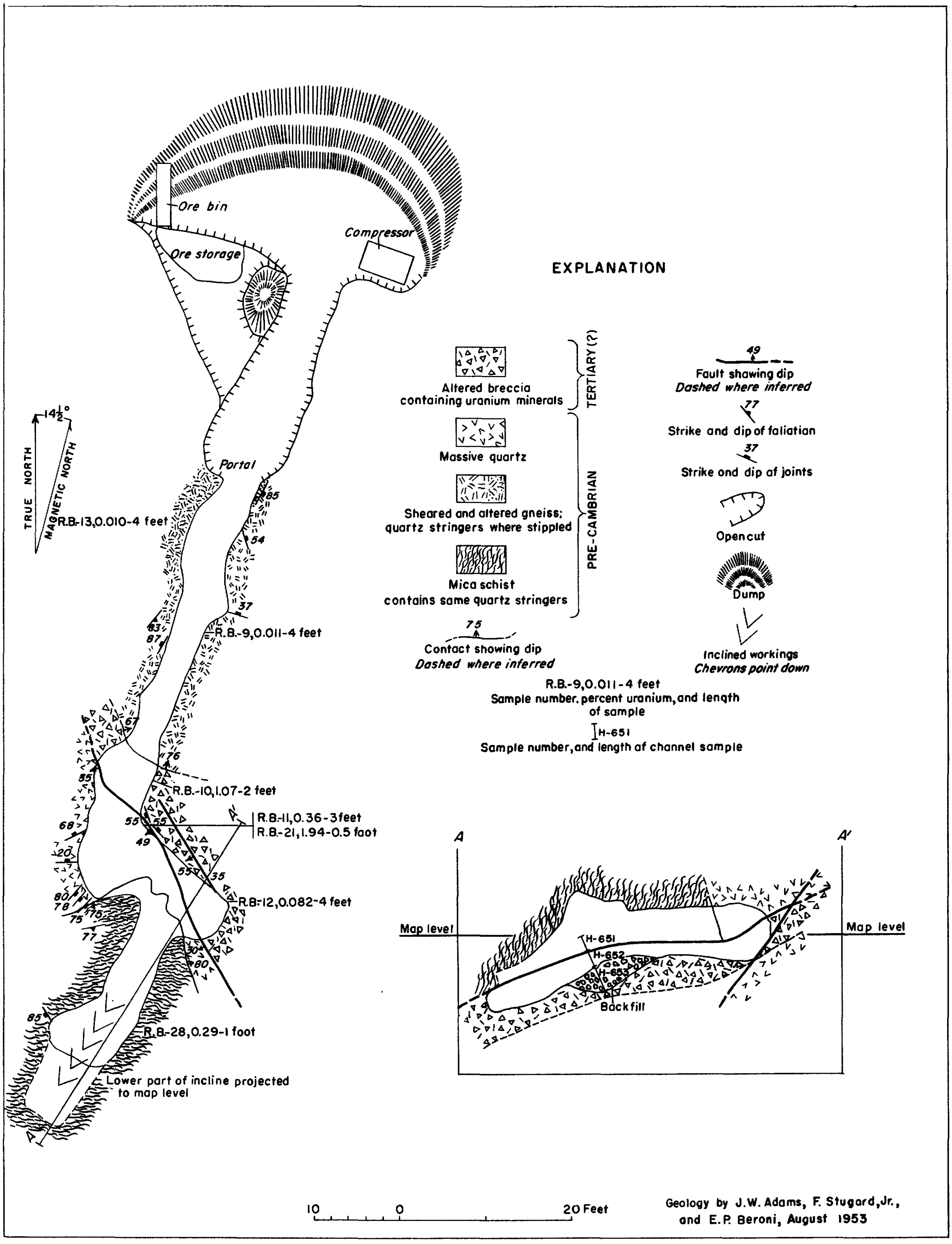

Figure 8.—Geologic map and section of the Schwartzwalder mine, Jefferson County, Colorado.

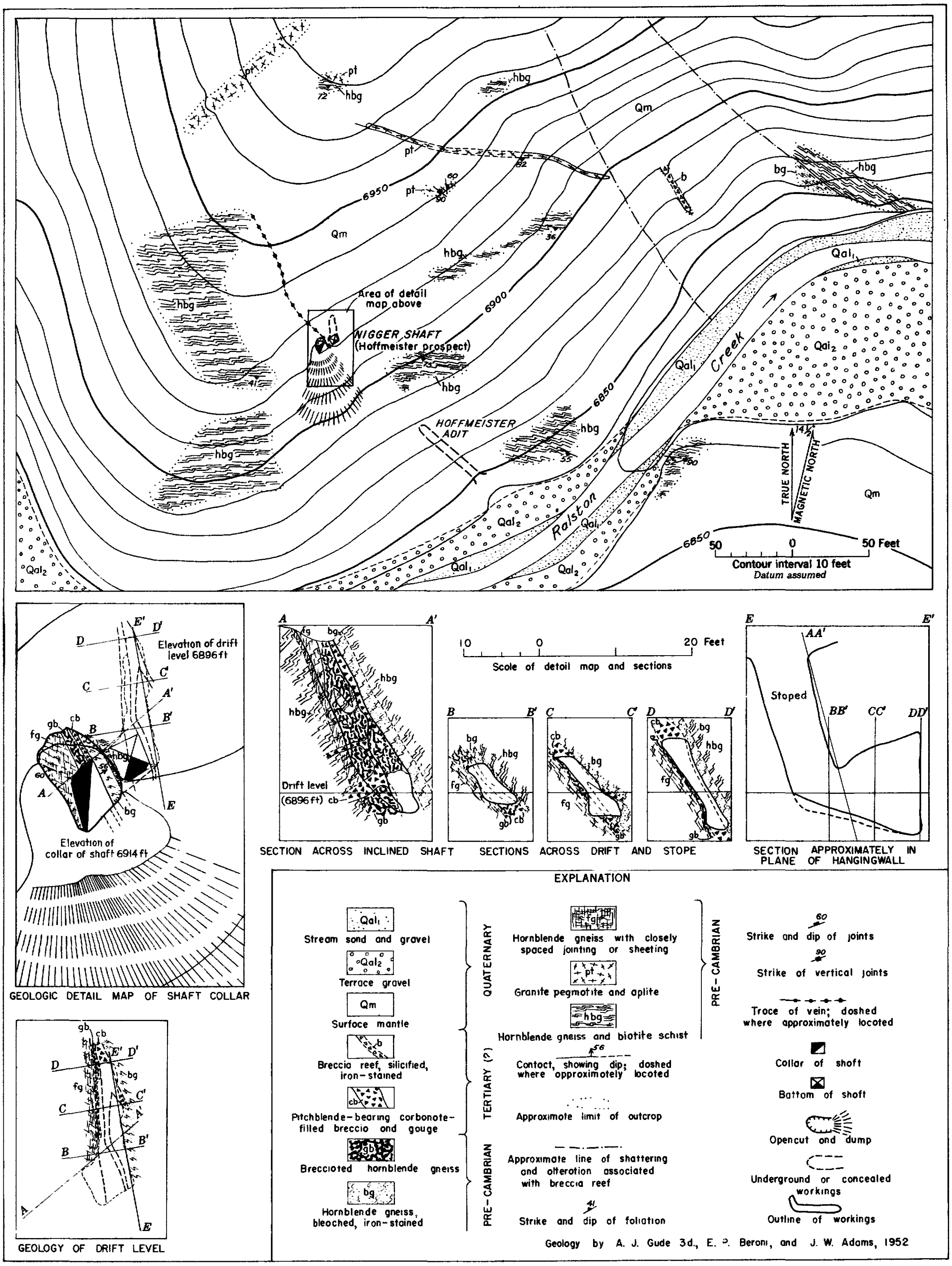

Figure 9.—Geology of Nigger shaft (Hoffmeister prospect), Jefferson County, Colorado.

The pitchblende deposit of the Nigger shaft is in a shear zone that is roughly parallel to the breccia reef. The shear exposed in the workings strikes N. 3° E. and dips 50°-60° E., but the surface exposures and radioactivity data indicate that the general trend of the shear is northwest. The shear zone is from 4 to 8 feet thick and consists of brecciated and sheared hornblende gneiss that is cut by an irregular body of carbonate-rich rock which contains the ore. This rock, which averages about 2 feet in width, apparently represents that part of the shear zone that was invaded by the ore-bearing solutions. It is made up of bleached and altered gneiss fragments intricately cut by veins and cemented principally by carbonates; it constitutes a stockwork of dense, hard, light-brown rock that in surface exposures appears as a brick-red gossan.

The sheared gneiss along the hanging wall of the vein has been bleached by hydrothermal action for as much as 2 feet outward from the vein, but the brecciated gneiss in the footwall of the shear zone appears to be relatively fresh.

The vein has been traced by radioactivity for 100 feet to the northwest, but it is almost entirely concealed by soil. Pitchblende and copper minerals were recovered from the soil in an area of high anomalous radioactivity about 50 feet from the shaft.

Pitchblende occurs in the deposit chiefly as thin seams in carbonate veinlets along the margins of the stockwork. The seams of pitchblende which range from 0.05 to 0.5 millimeter in thickness, form rims around earlier crystals of carbonate and orthoclase(?). Later carbonate and sulfides fill the center of the veinlets. The botryoidal upper surface of the seams suggests that they were developed by the coalescence of many individual hemispherical bodies, such as occur singly or in groups where the seams are discontinuous.

Sulfide minerals, including covellite, chalcopyrite, bornite, chalcocite, pyrite, and galena, have been identified in polished sections of the ore. Except for pyrite and some chalcopyrite, they occur within the carbonate veinlets. Most of the sulfides appear to have been deposited later than the pitchblende. Detailed mineragraphic studies have not been made, however, to determine the paragenetic sequence of the ore minerals.

Calcite, ankerite, and quartz are the dominant gangue minerals in the pitchblende-bearing veins. The sequence of their deposition has not been definitely established, but preliminary studies show that the iron-rich carbonate formed both before and after the deposition of the pitchblende. Calcite is interstitial to ankerite and quartz and apparently is the last gangue mineral to be formed. All the quartz, so far as known, is younger than the pitchblende.

Crystals of a nearly uniaxial mineral of negative sign and low birefringence occur along the edges of the pitchblende-bearing veinlets. These crystals, thought to be orthoclase, were deposited before the pitchblende. A dark-green mineral, tentatively identified as chlorite, forms radial aggregates in the postpitchblende vein filling.

Most of the pitchblende in the veinlets is surrounded by an orange-brown layer, about 0.02 millimeter wide that may be in direct contact with the pitchblende or is developed entirely in the adjacent gangue minerals. The layer may end abruptly at an interface between two carbonate crystals or between a carbonate crystal and quartz. The material forming the layer has not been identified, but its distribution and color suggest that it is made up of finely dispersed iron oxides formed in ankerite as a product of radiation from the pitchblende. It has not been observed in quartz, and, where present in one carbonate and not another, it is assumed that the barren carbonate is calcite.

A mineral tentatively identified as a hydrated uranium oxide occurs sparsely in oxidized and leached breccia. It is light to dark brown, transparent, isotropic, and has an index of refraction of about 1.75. Qualitative texts show that it contains uranium and lead. This mineral was probably derived from pitchblende exposed to supergene solutions by the partial removal of enclosing carbonates, and is analogous to the brown material found in more abundance at the North Star mine.

Several secondary copper minerals are present in the ore; they are not abundant and are chiefly confined to cavities in the veinlets.

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