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GEOLOGICAL SURVEY CIRCULAR 345

RADIOACTIVITY RECONNAISSANCE OF PART OF NORTH-CENTRAL CLEAR CREEK 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 John D. Wells and Jack E. Harrison

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Washington, D. C., 1954

Free on application to the Geological Survey, Washington 25, D. C.

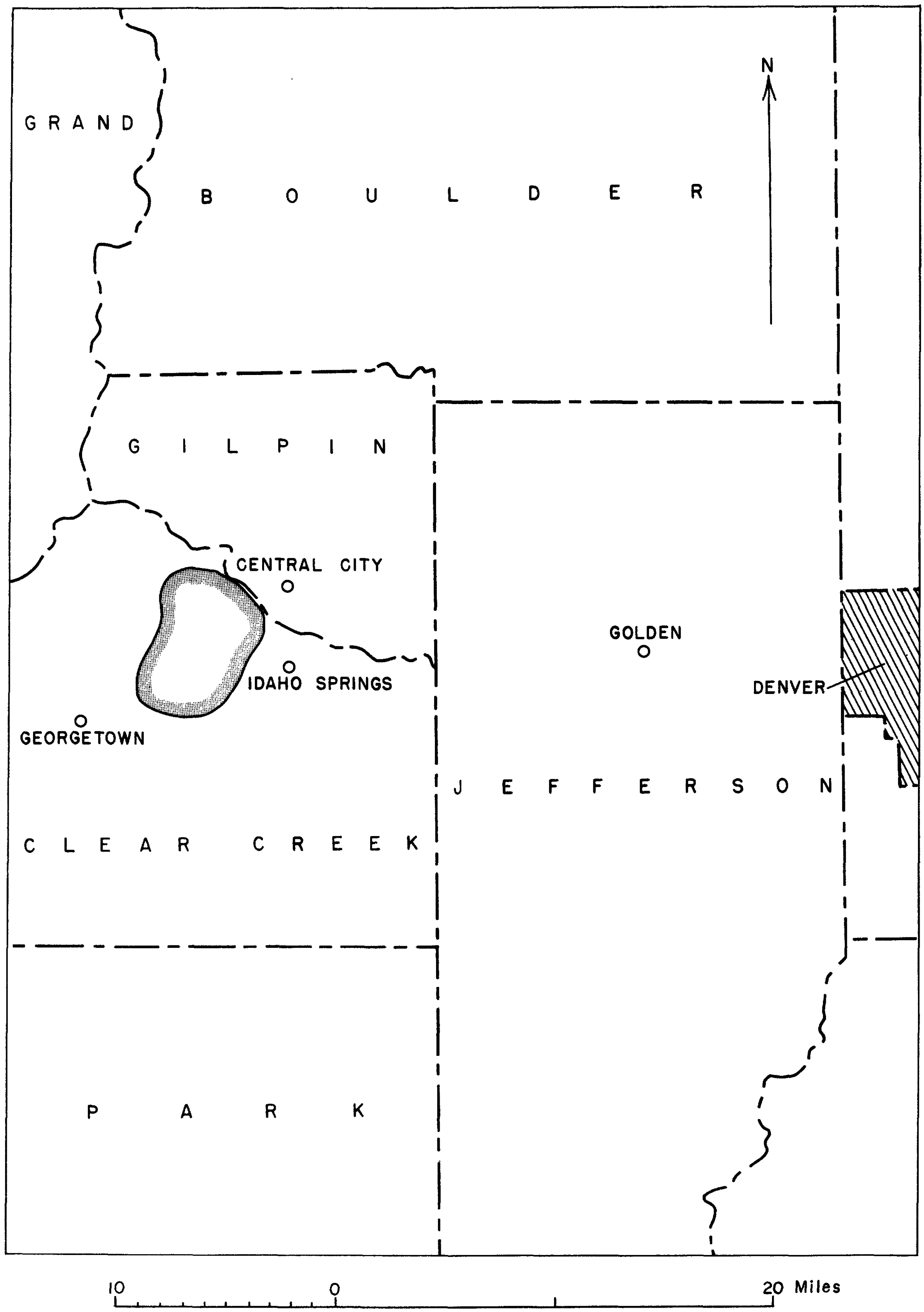

Figure 1. —Index map of central Colorado showing area covered by reconnaissance.

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ABSTRACT

A radioactivity reconnaissance of 334 localities in north-central Clear Creek County, Colo., was made during the field seasons of 1951 and 1952. This reconnaissance, made with a portable scintillation counter and a portable survey meter with a 6-inch gamma-beta Geiger tube, disclosed that seven of the localities contain sufficient uranium to warrant some physical exploration.

Within the area studied, the localities containing chalcopyrite have the highest grade and highest percent of occurrences of significant abnormal radioactivity. Zones of galena-sphalerite veins have approximately the same rate of occurrence of significant abnormal radioactivity as zones of galena-sphalerite with chalcopyrite. Any locality or zone containing pyritic-type veins without chalcopyrite is considered unlikely to contain a uranium deposit.

INTRODUCTION

As a part of the U. S. Geological Survey's investigations of the uranium-bearing deposits in the Central City-Idaho Springs region (fig. 1), a radioactivity reconnaissance was carried on in north-central Clear Creek County in 1951 and 1952. This work was done on behalf of the Division of Raw Materials of the U. S. Atomic Energy Commission.

The purpose of the reconnaissance was to determine the distribution and economic importance of the radioactive occurrences in the region. Three hundred and thirty-four localities—mine dumps and accessible underground workings—were examined with a portable scintillation counter and a portable survey meter with a 6-inch gamma-beta Geiger tube. The methods of the reconnaissance are briefly described, because they might be of use in similar, future studies.

The radioactivity data of this report were collected largely by Wells; Harrison is responsible for most of the information on the Freeland-Lamartine area (Harrison and Wells, manuscript in preparation). F. B. Moore of the Geological Survey collected some of the data on the Fall River area, in the northern part of the area covered by this survey. Radioactivity data from the northeastern part of the Fall River area, published by the Atomic Energy Commission (Smith and Baker, 1951, p. 5-10), has been incorporated in this report.

As classified by Bastin and Hill (1917, p. 105), the veins in the area covered by this report are of three general types: (1) pyritic, containing predominantly quartz and pyrite, with lesser amounts of chalcopyrite; (2) galena-sphalerite, consisting principally of galena, sphalerite, pyrite, and quartz, with subordinate amounts of chalcopyrite; and (3) composite, consisting of veins of type 1 that are crosscut by stringers of type 2. Radioactive minerals are most commonly associated with veins of types 2 and 3.

BACKGROUND RADIOACTIVITY

Background, as defined by Korff (1946, p. 23-24), is the instrument reading at a particular time and place caused by internal contamination of the counter, cosmic radiation, and the natural radioactivity of the surroundings. In precise laboratory determinations of radioactivity, the effects of these three factors are carefully determined. In the field, however, these factors can only be roughly accounted for. A field survey for radioactivity is concerned primarily with the measurement and interpretation of variations in the natural radioactivity of the surroundings; for this purpose, internal contamination of the instruments is negligible and can be ignored. However, the variation in cosmic radiation from day to day and with changes in altitude must be reckoned with. In addition, in north-central Clear Creek County, the variation in the natural radioactivity of the rocks must be considered.

The natural radioactivity of the rocks in north-central Clear Creek County varies widely between pre-Cambrian schistose rocks, mafic rocks, granite gneisses, and Boulder Creek granite, which are low in radioactivity, and the pre-Cambrian Silver Plume granite[1] and the Tertiary intrusive rocks, which are relatively high. The natural radioactivity of most of the veins is low. Certain veins, even though they contain radioactive minerals, have a lower average radioactivity then the Tertiary intrusive rocks and the Silver Plume granite.

In order to distinguish the radioactivity that is average for the Tertiary dikes and Silver Plume granite from the radioactivity that is higher than average for the veins, a low background was chosen and the radioactivity readings separated on the basis of source material. Radioactivity from both sources was higher than background, but only the readings from veins were considered abnormal. The term "background radioactivity," as used in this report, is the average radiation recorded at a given place and time over material known to be low in natural radioactivity. "Abnormal radioactivity" is defined for this report as the radioactivity caused by a concentration of radioactive material in veins. The anomaly recorded from the highly radioactive country rocks will not be discussed further in this report.

[1]From the analyses of many samples, Phair (1952) found that the Tertiary intrusive rocks have an equivalent uranium content ranging from 0.002 to 0.024, but generally this content is less than 0.020 percent. A sample of Silver Plume granite, considered representative, contained 0.006 percent equivalent uranium.

INSTRUMENTS

A portable scintillation detector and a portable survey meter with a 6-inch gamma-beta Geiger tube were used for the reconnaissance. Although both of these instruments measure radioactivity, the characteristics of each instrument are such that one supplements the other.

The portable scintillation detector measures gamma radiation only. Gamma radiation is more penetrating than beta radiation and can be detected through greater thicknesses of rock and at greater distances from the source than beta radiation. In addition, a scintillation counter has a much higher efficiency for the detection of gamma radiation than does a Geiger counter (Brownell, 1950, p. 167). A scintillation detector is well adapted for field use when the purpose is to detect changes in the amount of gamma radiation dependent upon quantity or bulk of radioactive material regardless of grade, and was used in this reconnaissance to locate areas of abnormal radioactivity. The survey meter, on the other hand, is sensitive to a small source area and was used in this reconnaissance to isolate the specific mineral or material causing abnormal radioactivity.

Although both instruments will detect the presence of radon in a mine, they give little indication of its quantity. In the presence of radon, both instruments will show a gradual increase in amount of radiation recorded, even though the instruments are kept stationary. Even after the instruments are brought out of the mine, higher-than-normal readings will continue for some time.

METHOD OF RECONNAISSANCE

Radioactivity surveys were made on the surface and underground. The general procedure was to determine the background for the instruments, traverse the area, record any abnormal radioactivity, and sample areas that showed more than twice background on the rate meter.

Surface reconnaissance

The first procedure of surface reconnaissance was to determine the local background for the instruments. At the time of the examination, in order to eliminate variations in cosmic radiation, the background for the scintillation counter was determined within a few hundred feet of the area. The background for a rate meter with a gamma-beta probe was determined by holding the probe several feet in the air to eliminate the effect of the rock material. The background was found to be constant at different places and times for the rate meter but variable for the scintillation counter.

The area or dump to be examined was then traversed, using the scintillation counter. Traverses were made about 6 feet apart, holding the counter a few inches from the ground to obtain readings from a maximum depth. The traverses were made slowly to allow the instrument time to make an average radioactivity count of the material being traversed.

Abnormal radioactivity that was more than twice background on the rate meter was considered significant, and the radioactive material was sampled. Abnormal radioactivity that was less than twice background on either instrument is reported in this paper, but the material causing the radioactivity was not sampled. Laboratory determinations of uranium and equivalent uranium were made for all samples that were collected.

Underground reconnaissance

A procedure similar to that for surface reconnaissance was followed for underground reconnaissance. Generally, the background is slightly higher underground than at the surface because of the proximity of a greater surface of the radioactive rock. The background was established underground by recording the instrument reading at least 50 feet from the portal or shaft.

Traverses were made by carrying the instrument at waist height. The scintillation counter repeatedly recorded anomalies from small areas and thin fractures, samples from which commonly assayed as low as 0.006 percent equivalent uranium.

Traversing of mines that contain radon is impractical because the instrument becomes contaminated. Henry Faul (oral communication), of the Geological Survey has eliminated some of this contamination by placing the probe of the instrument in a plastic or rubber bag before entering a mine containing the gas.

RADIOACTIVITY OF DUMP MATERIAL

The assumption is made that the radioactive materials associated with Tertiary veins are in equilibrium. However, results from more than 40 chemical assays show that most of the samples, particularly those collected from dumps, contain less uranium (U) than the radioactivity measurements (eU) of these samples indicates (table, p. 5). Phair and Levine (1952, p. 14) have shown that this disequilibrium can be caused by acid solutions that leach uranium and leave a concentration of less soluble radioactive disintegration products of uranium. Because the uranium is leached rapidly from material on dump surfaces, the radioactivity of a dump sample, rather than the actual uranium content of that sample, is probably more representative of the amount of uranium originally present in the material.

The failure to discover radioactive material on a dump does not necessarily mean that such material does not occur in the mine. The dumps of several inaccessible mines have been reported to show no abnormal radioactivity, but underground examinations following reopening of the mines have revealed significant amounts of abnormal radioactivity.

ABNORMAL RADIOACTIVITY

During the reconnaissance the grade of radioactive material could not be determined accurately because of the limitations of the instruments and because the measurements were made, of necessity, on nonhomogeneous samples of different sizes. Therefore, the laboratory determinations of equivalent uranium and uranium are used in the report. The localities showing abnormal radioactivity are given in the table (p. 5).

Classification

The intensity of abnormal radioactivity (equivalent uranium) is here classified as (1) slight, if the radioactivity is greater than background but less than twice background; (2) low, if the equivalent uranium ranges between 0.005 and 0.020 percent; (3) moderate, if the equivalent uranium ranges between 0.021 and 0.099 percent; and (4) high, if the equivalent uranium is 0.10 percent or more. Localities where abnormal radioactivity was noted are shown on figure 2. This classification is based upon both field instrument readings and laboratory determinations of equivalent uranium, because samples were not collected from localities with abnormal radioactivity less than twice background. As determined by the writers the percent equivalent uranium that is equal to twice background is approximately 0.005. Information on localities containing slight abnormal radioactivity is not given in the table (p. 5).

The upper limit of low abnormal radioactivity was placed at 0.020 percent equivalent uranium, because all of the pre-Cambrian rocks and most of the Tertiary intrusive rocks in the area contain less than 0.020 percent equivalent uranium. The range of low abnormal radioactivity overlaps the range of radioactivity of some of the country rocks (see section on background radioactivity). The moderate abnormal radioactivity class has more equivalent uranium than the country rocks, but less equivalent uranium than present ore-grade material. The high abnormal radioactivity class has equivalent uranium equal to or greater than that of present ore-grade material.

Mineralogic data

The mineral suites identified at the localities included in this report have previously been recognized by Spurr, Garrey, and Ball (1908) and by Bastin and Hill (1917). Bastin and Hill (p. 105) have shown that these mineral suites are characteristic of three vein types: (1) pyritic, predominantly pyrite and quartz with minor amounts of chalcopyrite; (2) galena-sphalerite, predominantly galena, sphalerite, pyrite, and quartz with a subordinate amount of chalcopyrite; and (3) composite, veins in which stringers of type 2 crosscut veins of type 1. This classification, with modification, is used in this report.

Because much of the data in this report were obtained from dumps, the detailed relationships between vein types necessary to identify the composite type of vein are unknown. The composite type of vein, therefore, cannot be discussed here and is not shown on figure 3.

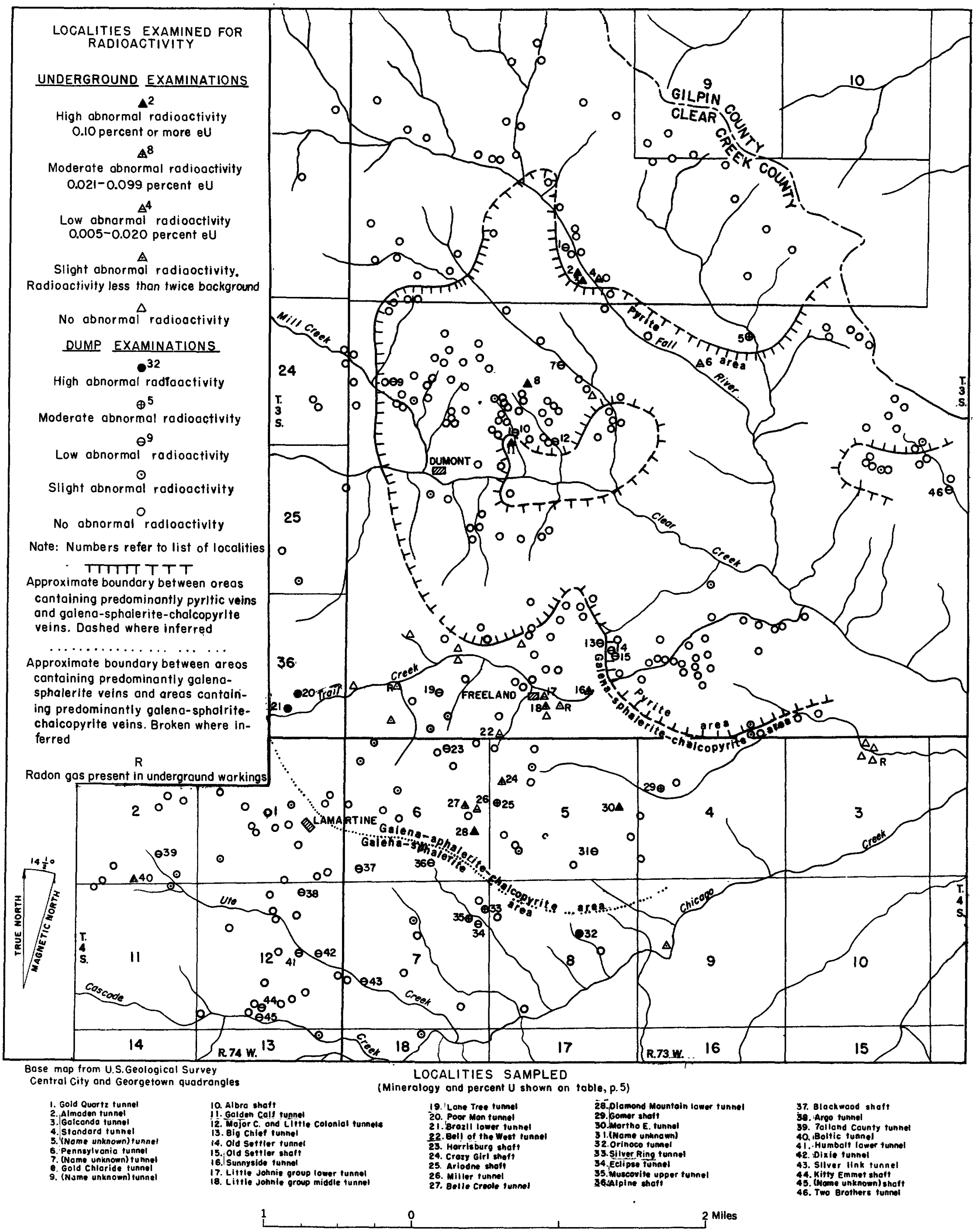


Figure 2. —Map of part of north-central Clear Creek County, Colorado, showing radioactivity of localities examined.

Radioactivity and mineralogic data for localities of high, moderate, and low abnormal radioactivity

[Explanation of abbreviations: ga, galena; sp, sphalerite; cp, chalcopyrite; py, pyrite; qtz, quartz; lm, limonite; pbd, pitchblende; to, torbernite; aut, autunite; ur, uranophane; ba, barite; cc, chalcocite; az, azurite; ma, malachite; cr, carbonate; gos, goslarite; fl, fluorite]

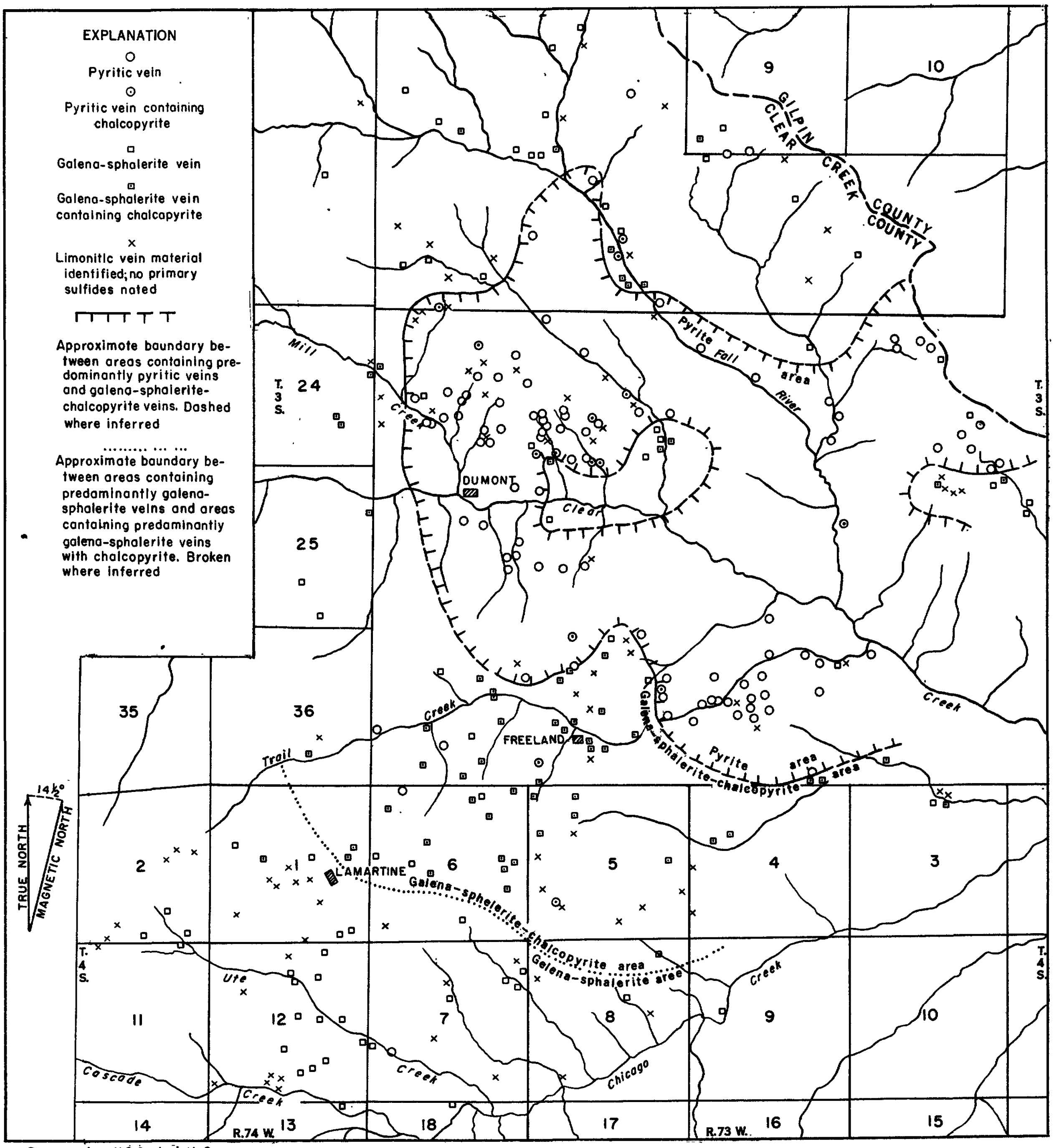
Mine and locality no. (fig. 2)	Source of mineralogic data	Minerals																	Analyses, in percent	
		ga	sp	cp	py	qtz	lm	pbd	to	aut	ur	ba	cc	az	ma	cr	gos	fl	eU	U
High abnormal radioactivity																				
Almaden (2)	Smith and Baker (1951)	X	X	X	X	X	---	X	X	---	---	---	---	---	---	---	---	---	----------	2.04
Golconda (3)	---do---	X	X	X	X	X	---	X	X	---	---	---	---	---	---	---	---	---	----------	.57
Golden Calf (11)	Dump	X	---	X	X	X	X	X	---	---	---	---	---	---	---	---	---	---	0.20	.13
Diamond Mountain (28) (Lanagan).[1]	Underground	X	X	X	X	X	X	---	---	---	---	---	---	---	---	---	---	---	.30	.35
Martha E. (30)	Harrison (1952, p. 4-5)	X	X	X	X	X	X	X	X	X	---	---	---	---	---	---	---	---	.13	.12
Orinoco (32) (Golden Glen).[1]	Dump; also Spurr and others (1908, p. 377).	X	X	---	X	X	X	---	---	---	---	---	---	---	---	---	---	---	.18	.22
Baltic tunnel (40)	Smith (1952)	X	X	---	---	X	---	---	X	X	---	---	---	---	---	---	---	---	----------	.153
Moderate abnormal radioactivity																				
Name unknown (5)	Dump	X	X	---	X	X	X	---	---	---	---	---	---	---	---	---	---	---	0.036	0.004
Gold Chloride (8)	Underground examination.	---	---	---	---	---	X	---	---	---	---	---	---	---	---	---	---	---	.029	.003
Sunnyside tunnel (16)	Underground	X	X	X	X	X	X	---	---	---	---	---	---	---	---	---	---	---	.043	.019
																			.092	.003
Middle tunnel, Little Johnie group (18).	---do---	X	X	X	X	X	X	---	---	---	---	---	---	---	---	---	---	---	.037	.033
Poor Man (20)	Dump	---	---	---	---	---	X	---	---	---	---	---	---	---	---	---	---	---	.028	.023
Brazil (21)	---do---	X	X	X	X	X	X	---	---	---	---	X	---	---	---	---	---	---	.040	.038
Crazy Girl (24)	Underground	X	X	X	X	X	X	---	---	---	---	---	X	X	X	---	---	---	.033	.026
Ariadne (25)	Dump	---	---	---	---	X	---	---	X	---	X	---	---	---	---	---	---	---	.039	.032
Belle Creole (27)	Underground	X	X	X	X	X	X	---	---	---	---	---	---	---	---	---	---	---	.037	.033
Gomer (29)	Dump	X	X	X	X	X	X	---	---	---	---	---	---	---	---	---	---	---	.068	.072
Silver (33) (Silverine).[1]	Dump; also Spurr and others (1908, p. 375-376).	X	X	---	---	X	X	---	---	---	---	---	---	---	---	---	---	---	.028	.028
Muscovite (35)	---do---	X	X	---	---	X	X	---	X	---	---	---	---	---	---	---	---	---	.047	.046
Low abnormal radioactivity																				
Gold Quartz (1)	Dump	X	X	X	X	X	X	---	---	---	---	---	---	---	---	---	---	---	----------	----------
Standard (4)	Smith and Baker (1951, p. 5-10); Bastin and Hill (1917, p. 312-313).	X	X	X	X	X	---	---	---	---	---	---	---	---	---	---	---	---	----------	----------

See footnote at the end of table.

Radioactivity and mineralogic data for localities of high, moderate, and low abnormal radioactivity—Continued

Mine and locality no. (fig. 2)	Source of mineralogic data	Minerals																	Analyses, in percent	
		ga	sp	cp	py	qtz	lm	pbd	to	aut	ur	ba	cc	az	ma	cr	gos	fl	eU	U
Low abnormal radioactivity—Continued																				
Pennsylvania (6)	Smith and Baker (1951, p. 5-10); Bastin and Hill (1917, p. 312-313).	---	---	X	X	X	---	---	---	---	---	---	---	---	---	---	X	---	---	---
Name unknown (7)	Dump	---	---	---	---	---	X	---	---	---	---	---	---	---	---	---	---	---	0.011	0.006
Name unknown (9)	do	X	---	---	X	X	X	---	---	---	---	---	---	---	---	---	---	---	.010	.003
Albro (10)	do	---	---	X	X	X	X	---	---	---	---	---	---	---	---	---	---	---	---	---
Major C and Little Colonial (12).	do	---	---	X	X	X	X	---	---	---	---	---	---	---	---	---	---	---	.014	.001
Big Chief (13)	do	X	X	---	X	X	X	---	---	---	---	---	---	---	---	---	---	---	.018	.002
Old Settler tunnel (14).	do	---	---	---	X	X	X	---	---	---	---	---	---	---	---	---	---	---	.009	.006
Old Settler shaft (15).	do	---	---	X	X	X	X	---	---	---	---	---	---	---	---	---	---	---	.008	.008
Lower tunnel, Little Johnie group (17).	Underground	X	X	X	X	X	X	---	---	---	---	---	---	---	---	X	---	X	.017	.013
Lone Tree (19)	Dump	X	X	X	X	X	X	---	---	---	---	---	---	---	---	---	---	---	.006	.005
Bell of the West (22).	Underground	X	X	X	X	X	X	---	---	---	---	---	---	---	---	---	---	---	---	---
Harrisburg (23)	Dump	X	X	X	X	X	X	---	---	---	---	X	---	---	---	X	---	---	.015	.013
Miller (26)	Underground	X	X	X	X	X	X	---	X	---	---	---	---	---	---	---	---	---	.006	.003
Name unknown (31)	Dump	---	---	---	---	---	X	---	---	---	---	---	---	---	---	---	---	---	.009	.007
Eclipse (34)	do	X	X	---	X	X	X	---	---	---	---	---	---	---	---	---	---	---	.006	.003
Alpine (36)	Dump; also Spurr and others (1908, p. 333).	X	X	---	X	X	X	---	---	---	---	---	---	---	---	---	---	---	.008	.002
Blackwood (37)	Dump	---	---	---	---	---	X	---	---	---	---	---	---	---	---	---	---	---	.011	.005
Argo (38)	do	X	X	---	---	X	X	---	---	---	---	---	---	---	---	---	---	---	.014	.006
Tolland County tunnel (39).	do	X	X	---	X	X	X	---	---	---	---	---	---	---	---	---	---	---	.012	.008
Humbolt (41)	Dump; also Spurr and others (1908, p. 370-371).	X	X	---	X	X	X	---	---	---	---	---	---	---	---	---	---	---	.010	.008
Dixie (42)	Dump	---	X	---	---	---	X	---	---	---	---	---	---	---	---	---	---	---	.012	.009
Silver Link (43)	Dump; also Spurr and others (1908, p. 374).	---	---	---	X	X	X	---	---	---	---	---	---	---	---	---	---	---	.007	.002
Kitty Emmet (44)	Dump	---	---	---	---	---	X	---	---	---	---	---	---	---	---	---	---	---	.006	.002
Name unknown (45)	do	---	---	---	---	---	X	---	---	---	---	---	---	---	---	---	---	---	.018	.004
Two Brothers tunnel (46).	do	X	X	---	X	X	X	---	---	---	---	---	---	---	---	---	---	---	.009	<.001

[1]Name in parentheses used in earlier U. S. Geol. Survey publications.



Base map from U.S. Geological Survey
Central City and Georgetown quadrangles

0 — 2 Miles

Figure 3. —Map of part of north-central Clear Creek County, Colorado, showing distribution of vein types.

Leonard (1952) suggests that in the Central City area appreciable quantities of chalcopyrite may occur in the intermediate zone between areas of predominantly pyritic-type veins and areas of predominantly galena-sphalerite-type veins. The vein type occurring at each locality examined during this study is shown on figure 3. The area where veins of the pyritic type predominate has been outlined on figure 3. In the southwestern part of the area of this report, in the vicinity of Ute Creek, galena-sphalerite-type veins that do not contain chalcopyrite predominate. An approximate boundary has been drawn between this part of the area and the part around Freeland, in which galena-sphalerite-type veins that contain chalcopyrite predominate.

Relation between mineralogy and radioactivity

Of the 334 localities investigated, 80 were found to have abnormal radioactivity. Seven of the 80 have high, 12 have moderate, 27 have low, and 34 have slight abnormal radioactivity (fig. 2). The mineralogy of all localities having significant abnormal radioactivity is given in the table (p. 5).

The relation of significant abnormal radioactivity to vein mineralogy is shown in the following tabulation:

Vein type[1]	Percentage of localities with significant abnormal radioactivity
Pyritic	3.4
Galena-sphalerite	15.5
Chalcopyrite with both pyrite and galena-sphalerite	24.0
Chalcopyrite with pyrite	21.0
Chalcopyrite with galena-sphalerite	24.7

[1]Localities showing only limonite are included with the vein type of the geographic area in which they occur.

From the data presented in the preceding tabulation, three observations can be made: (1) The localities where pyrite was the only ore mineral identified have a small percentage of significant abnormal radioactivity. (2) The localities where chalcopyrite has been identified have the greatest percentage of significant abnormal radioactivity. (3) Approximately the same percentage of localities where chalcopyrite and pyrite were identified and where galena-sphalerite and chalcopyrite were identified have significant abnormal radioactivity.

The relation of significant abnormal radioactivity to mineral zones is as follows:

Type of mineral zone[1]	Percentage of localities within zone with significant abnormal radioactivity
Pyritic-type veins	6.3
Galena-sphalerite veins	22.9
Chalcopyrite with galena-sphalerite veins	22.1
Area of galena-sphalerite-type veins with or without chalcopyrite (zones not delimited)	10.1

[1]Localities showing only limonite are included with the vein type of the geographic area in which they occur.

The data in the preceding tabulation are based upon the zones as outlined in figure 3, without regard for the mineralogy at any particular locality. The percentage of the localities with significant abnormal radioactivity in the pyritic zone is lower than that for the remainder of the area studied. Of the 8 localities within the pyritic zone showing significant abnormal radioactivity, 3 have chalcopyrite with the pyrite. The lack of significant abnormal radioactivity in the central part of the pyritic zone is further emphasized by the fact that 6 of the 8 localities are near the margin, and no localities with high and only one with moderate abnormal radioactivity occur within this zone.

Consideration of the localities, either individually or as they are distributed in mineral zones, leads to the conclusion that localities that have the pyritic type of vein without chalcopyrite are poor prospects for radioactive materials. The pyritic zone is favorable for localities showing significant abnormal radioactivity only at its margin. The localities containing chalcopyrite have the highest grade as well as the highest percent of occurrence of significant abnormal radioactivity. Five of the seven localities with high abnormal radioactivity contain chalcopyrite. The other two localities have galena-sphalerite-type veins. No locality with a pyritic-type vein has high or moderate abnormal radioactivity. If the presence of chalcopyrite defines the intermediate zone between the pyritic and galena-sphalerite types of veins, then the intermediate zone, as suggested by Leonard (1952), appears to be the most favorable area for pitchblende prospecting in this part of the Front Range.

Economic significance

Only the 7 localities showing high abnormal radioactivity contain uranium of ore grade; these localities are worthy of at least some exploration. As of May 1954, the Golconda and Almaden mines were being explored, but no uranium ore had yet been shipped. In the Martha E., a 100-foot winze was sunk and some drifting done at its foot, but only small pods of ore were discovered; further exploration is being considered by the owners. The owners of the Diamond Mountain mines are considering exploration. No information is available as to the possibilities of exploration in the Orinoco mine and the Baltic tunnel.

A more objective evaluation of the potentialities of uranium production from this region awaits the results of detailed studies of the uranium occurrences. Additional information from producing mines is necessary to determine the economic significance of the various amounts of abnormal radioactivity and the pattern of its distribution.

LITERATURE CITED

Bastin, E. S., and Hill, J. M., 1917, Economic geology of Gilpin County and adjacent parts of Clear Creek and Boulder Counties, Colorado: U. S. Geol. Survey Prof. Paper 94.

Brownell, G. M., 1950, Radiation surveys with a scintillation counter: Econ. Geology, v. 45, p. 167-174.

INTERPRETING GROUND CONDITIONS FROM GEOLOGIC MAPS

Prepared by the Geologic Division

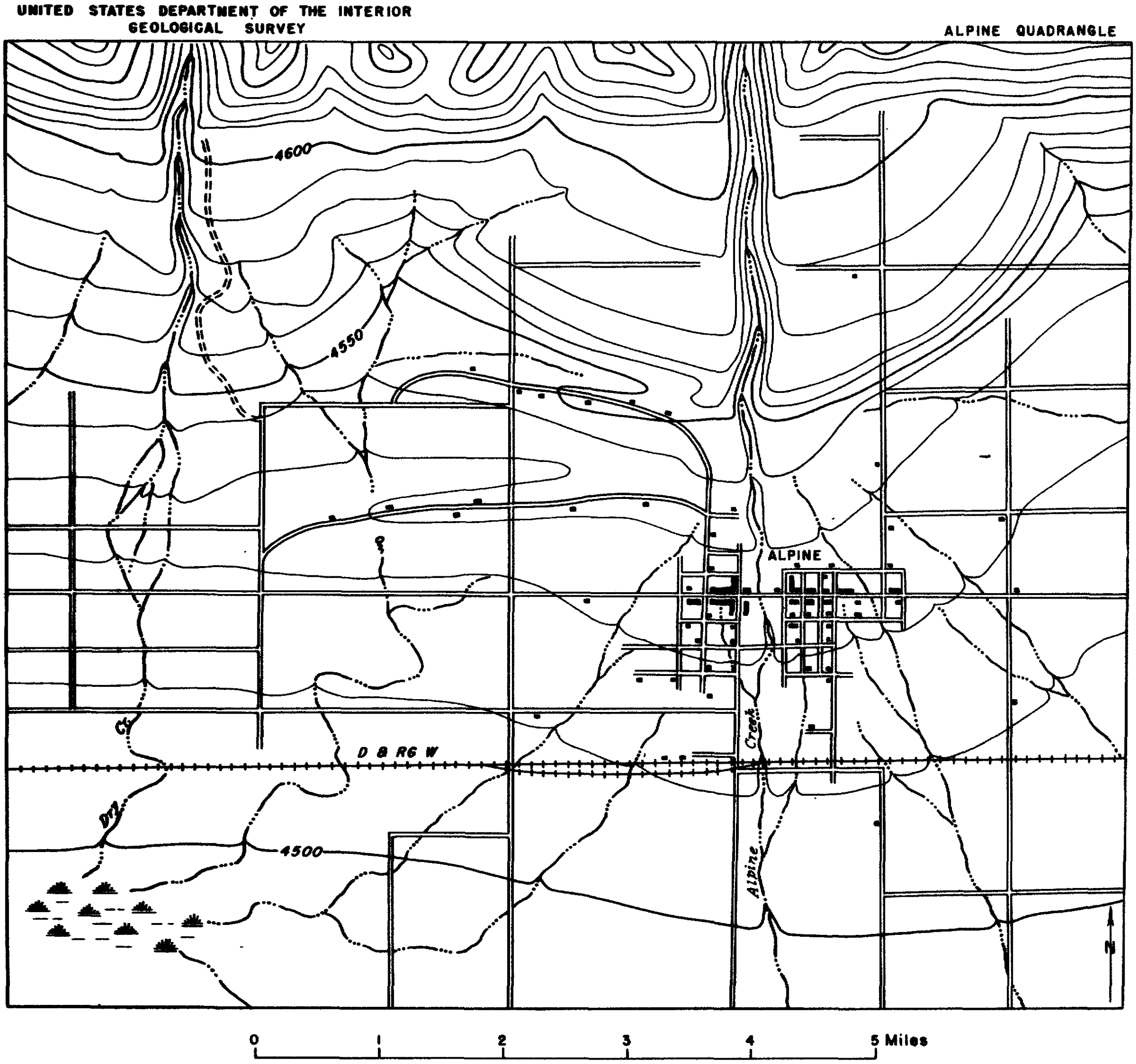
Intelligent planning for heavy construction, water supply, or other land utilization requires advance knowledge of ground conditions in the area. It is essential to know:

1) the topography, that is, the configuration of the land surface;
2) the geology and soils, that is, the deposits that compose the land and its weathered surface; and
3) the hydrology, that is, the occurrence of water whether under or on the ground.

These elements usually are considered in planning land developments that involve much investment; detailed surveys generally are made of the topography, geology, soils, and hydrology at the site selected for development. Such detailed surveys are essential, but equally essential and often overlooked is the need for general surveys prior to site selection.

Only if the general surveys have been made is it possible to know that a particular site is most suitable for the purpose and that no situations in the tributary areas that might affect the project have been overlooked. Moreover, the general regional relations must be known in order to properly interpret the geology, soils, and hydrology at a particular locality. In brief, both the general and the specific are needed in order to avoid costly mistakes either during or after development.

The accompanying maps illustrate how a general geologic map can be used for interpreting ground conditions during a planning stage prior to site selection. The topographic and geologic maps, which provide the basic data, have been simplified from some existing ones. The interpretive sheets are intended to provide some examples of the kinds of information that trained persons can read from such basic maps.

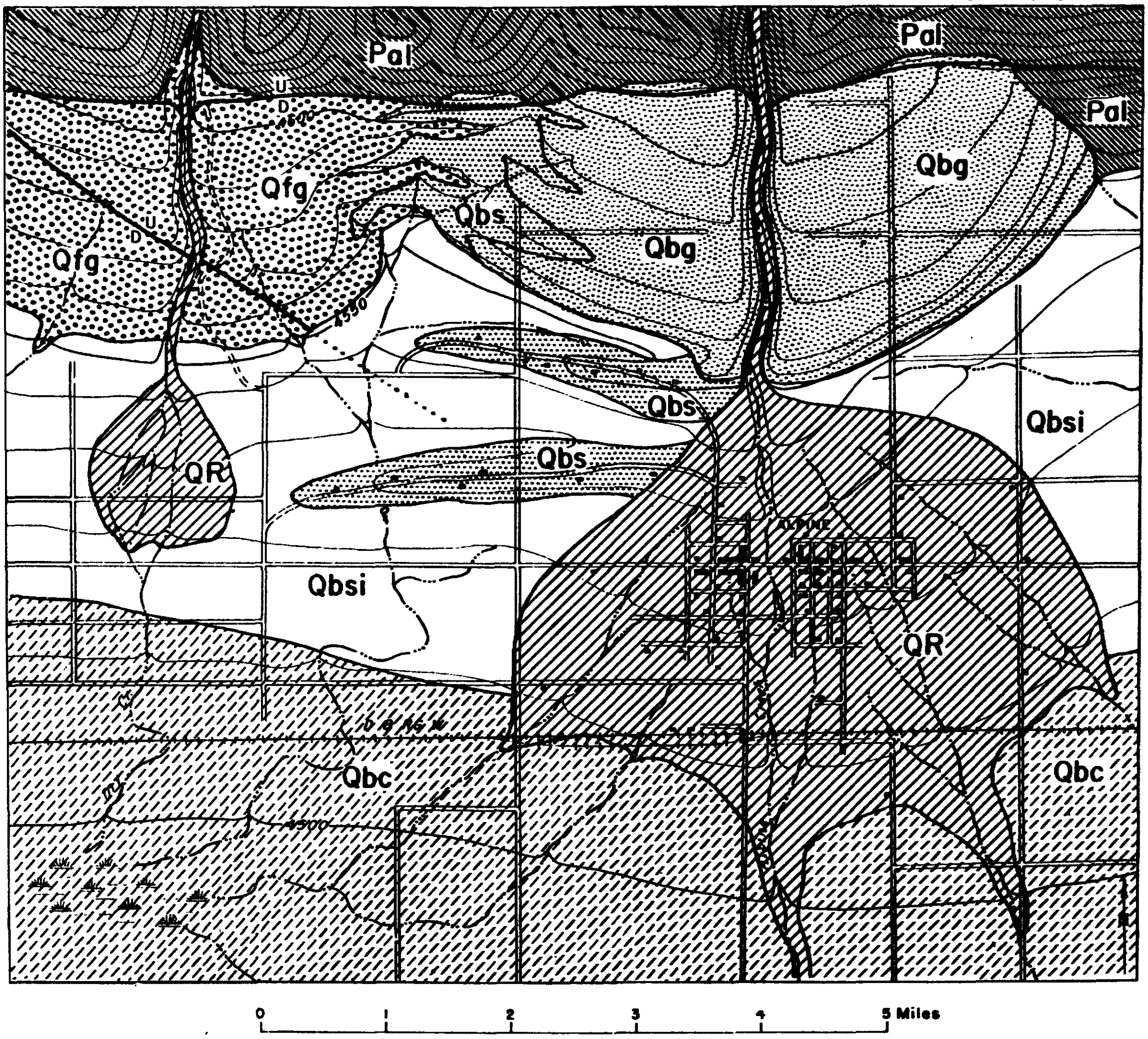


Topographic maps show quantitatively the configuration of the land surface. This is accomplished by drawing contours that represent level lines on the earth's surface. Irregularities in the contour lines reflect the ground plan shape of the land forms; the spacing between the contours measures the amount of slope. In addition, topographic maps show the works of man, such as roads, railroads, and buildings, and drainage features such as perrenial streams, intermittent streams, springs, and marshes.

TOPOGRAPHIC MAP

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

ALPINE QUADRANGLE



EXPLANATION

Recent

QR — Young fan deposits; gravel, with admixed sand, silt, and clay.

Pleistocene

Lake Bonneville deposits

Qbg — Gravel member; gravel and sand in delta deposits. $CO_3 > SO_3 + Cl$

Qbs — Sand member; clean sand; forms offshore bars and delta deposits. $CO_3 > SO_3 + Cl$

Qbsi — Silt member; lake bottom deposit. $CO_3 = SO_3 + Cl$

Qbc — Clay member; lake bottom deposit. $CO_3 < SO_3 + Cl$

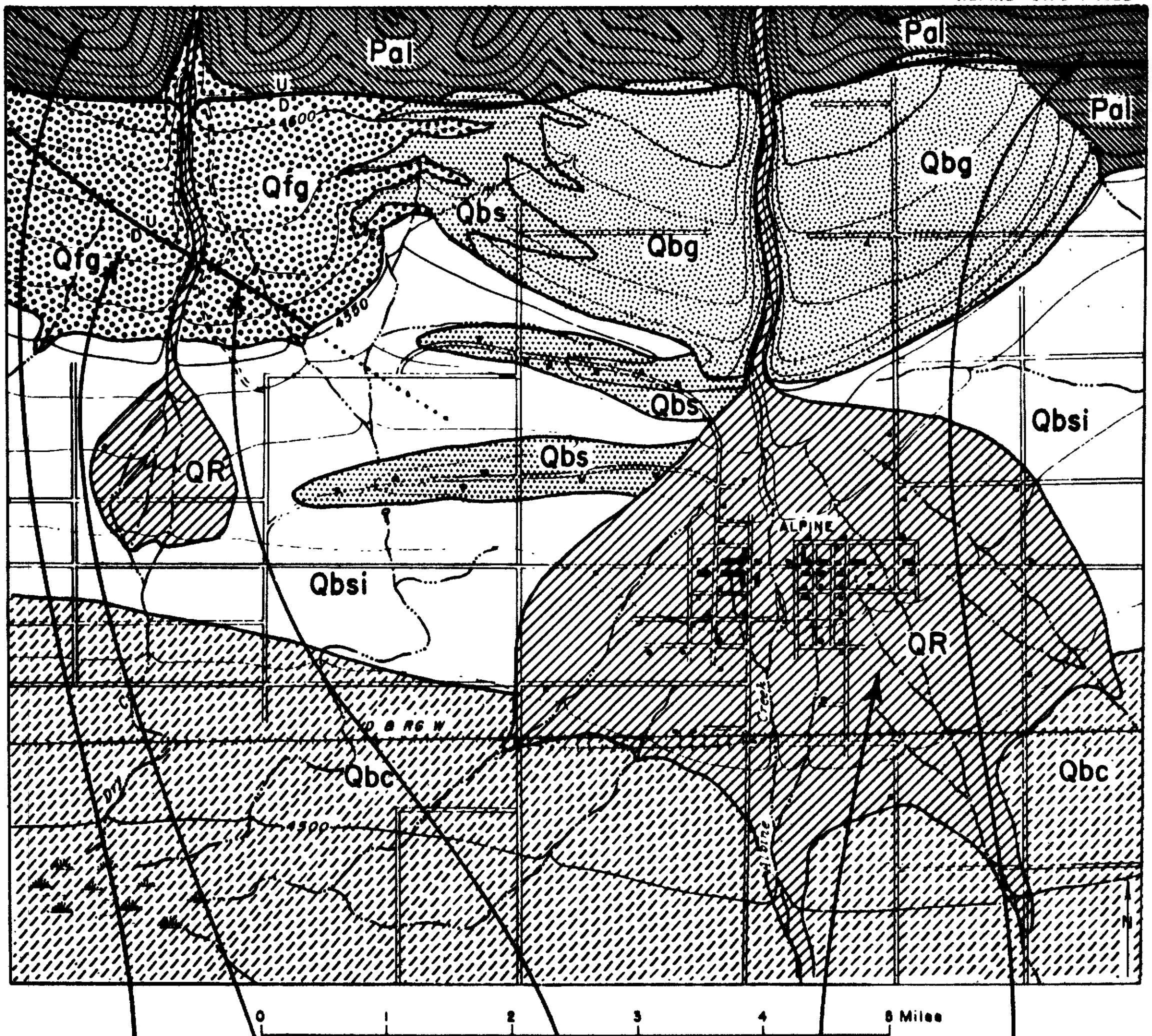
Qfg — Old fan deposits; bouldery gravel with admixed sand, silt, clay. Considerable caliche in upper layers.

Paleozoic

Pal — Bedrock; mostly limestone, some quartzite.

U/D — Fault; dotted where concealed.

GEOLOGIC MAP



FIRST EVENT:
These ancient rocks folded and faulted upward to form mountains.

SECOND EVENT:
This fan built of gravel etc. eroded from mountain.

THIRD EVENT:
This fault became active; 5-10 feet of movement before Lake Bonneville time; fault extends under lake beds and may have recurrent movement anytime.

FOURTH EVENT:
Valley inundated by glacial Lake Bonneville. Delta of gravel (Qbg) built at mouth of Alpine Canyon. Shore currents moved sand (Qbs) westward on delta and in bars in front of delta. Silt (Qbsi) deposited near-shore; clay (Qbc) deposited offshore. These lake deposits are underlain by the pre-Bonneville fans which represent the second event.

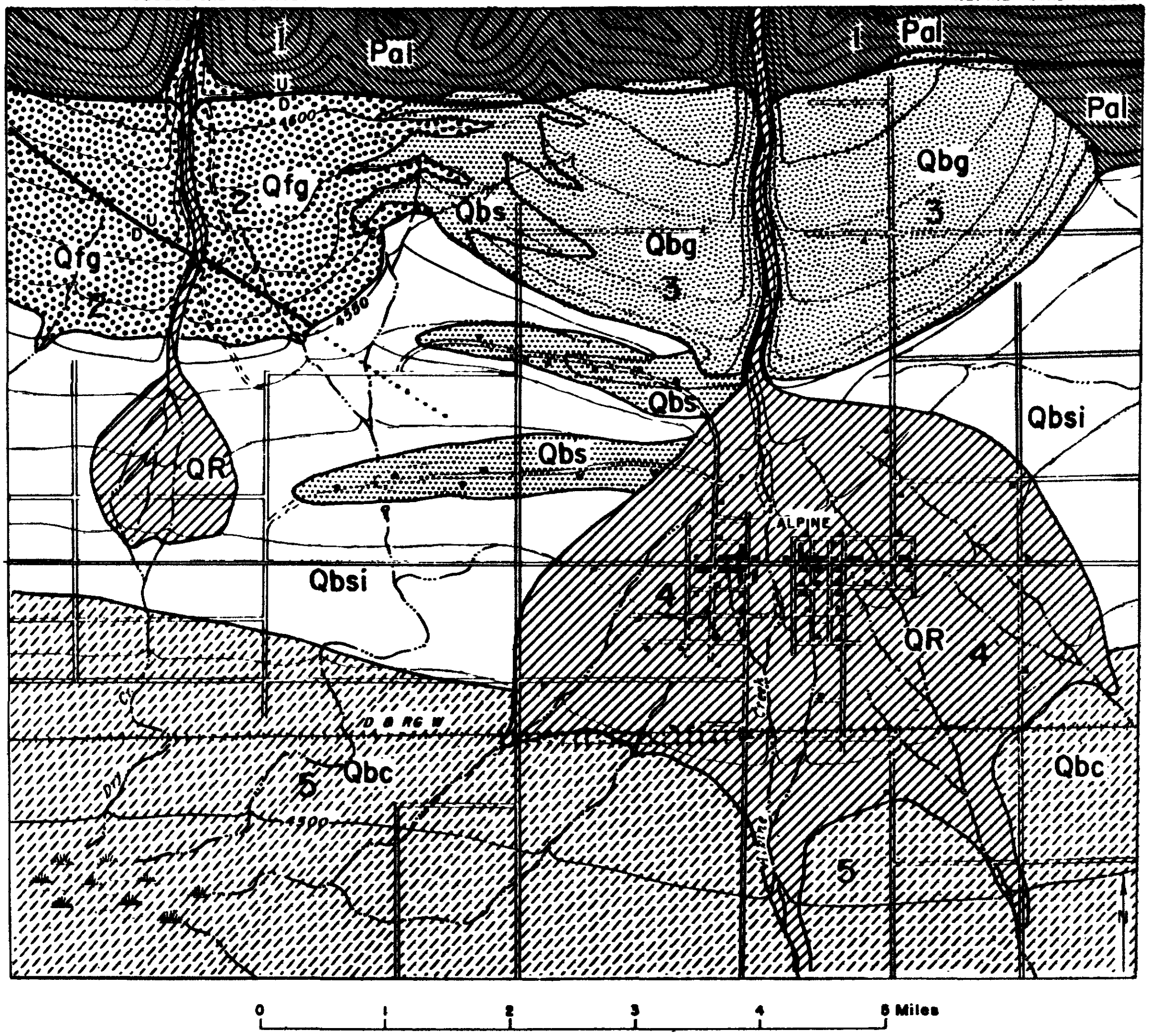
FIFTH EVENT:
This fault again active; 20 feet of displacement.

SIXTH EVENT:
This fan and the small one 3 miles west were built on top of Lake Bonneville deposits after the lake had disappeared. These post-Bonneville fans are still being built.

READING GEOLOGIC HISTORY FROM THE GEOLOGIC MAP

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

ALPINE QUADRANGLE



1 Hard rocks. Good source for limestone or quartzite for building stone, riprap. Quarry operations would require drilling and blasting. Limestone suitable for cement.

2 This gravel is angular but silty; poorly graded and contains considerable secondary lime; not suitable for concrete aggregate; poor source for road metal.

3 This gravel well rounded and well graded but contains considerable lime; not suitable for concrete aggregate; excellent road metal.

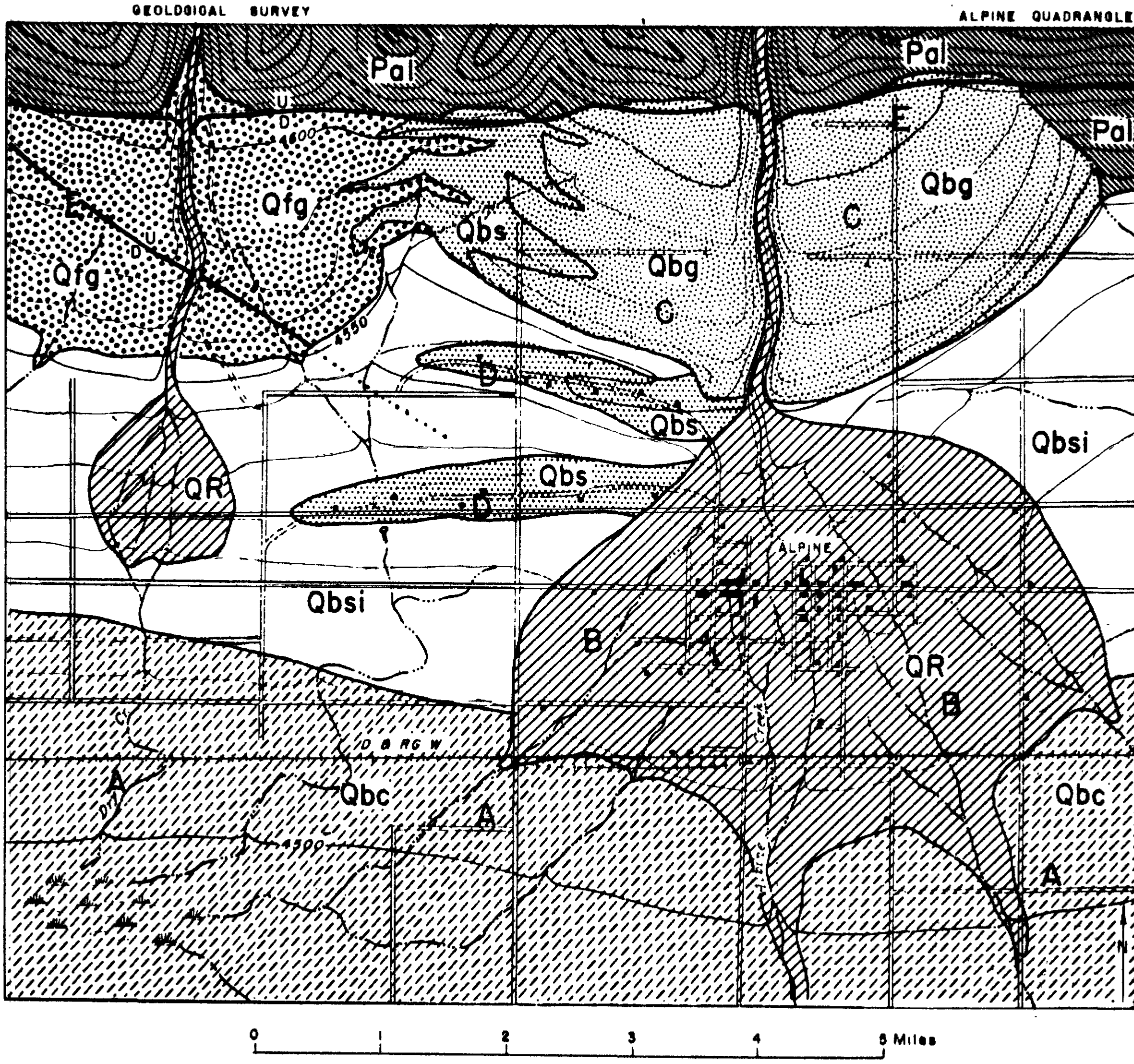
4 This gravel poorly graded; fragments in part angular and in part well rounded; deposit is free of secondary lime; best source for concrete aggregate.

5 Clay deposit contains lime and other water-soluble salts; fair source for structural clay; good source for seal clay; not suitable for high grade ceramic purposes.

THE GEOLOGIC MAP AS A GUIDE TO CONSTRUCTION MATERIALS

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

ALPINE QUADRANGLE



A Clay ground; poor surface drainage; no subsurface drainage; road metal and fill for subgrades must be hauled from area B or C. Ground easily excavated by power shovel or dozer operation. Will require subdrains.

B Gravelly and silty ground; fairly adequate surface and subsurface drainage. Good foundation for roads or buildings. Basement excavations must be shallow to avoid intersecting the groundwater perched on the underlying impermeable Lake Bonneville beds. This area lies across the projection of one of the recently active faults (see E).

C Gravelly ground with excellent subsurface drainage; ground easily excavated by power shovel or dozer. Excellent road foundation; the deposit rests against one of the recently active faults so buildings should be constructed to withstand shocks of intensity 8, R-F scale (see E).

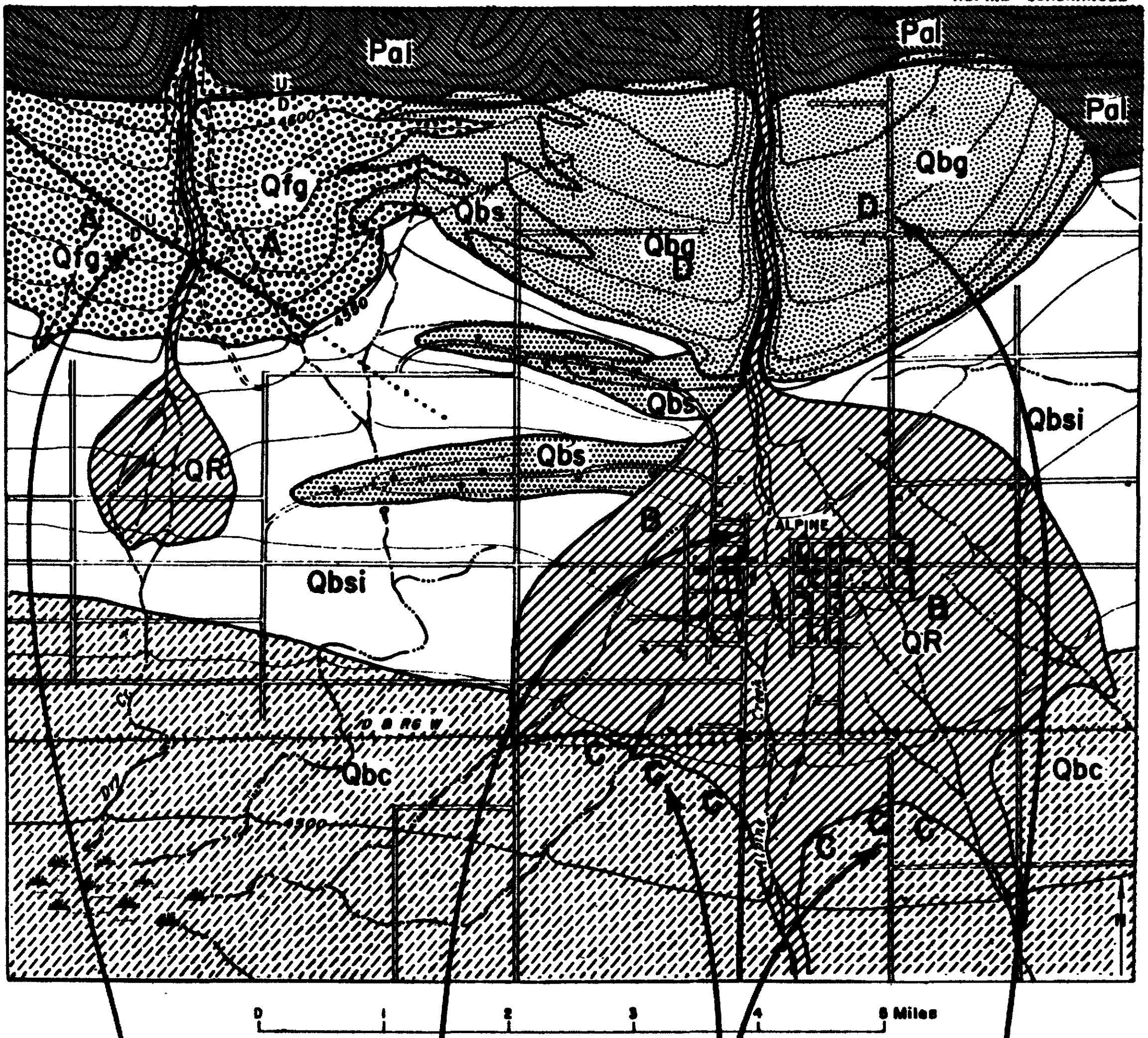
D Sandy ground underlain by silt at depths less than 8 feet; good surface drainage down to the silt. Easily excavated by hand tools. Basement excavations must be shallow to avoid intersecting groundwater perched on the silt. Good foundation for roads but clay is needed for binding sand.

E Two recently active faults. Movement on either one may be renewed at any time causing earthquakes. Buildings within a mile or so of the faults or their projection should be constructed to withstand shocks of intensity 8, R-F scale. Five miles from the faults the shocks would not be expected to exceed intensity 5.

THE GEOLOGIC MAP AS A GUIDE TO FOUNDATION
AND EXCAVATION CONDITIONS

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

ALPINE QUADRANGLE



A

This old fan deposit underlies all Lake Bonneville deposits. It is an aquifer that can be reached by drilling in the south part of the area.

B

Groundwater is perched on the impermeable lake beds 10-15 feet below the surface of this young fan deposit. This groundwater however is subject to pollution by town sewage.

C

Zone of seeps at edge of young fan deposits where shallow groundwater (see box B) emerges at surface. Seeps polluted.

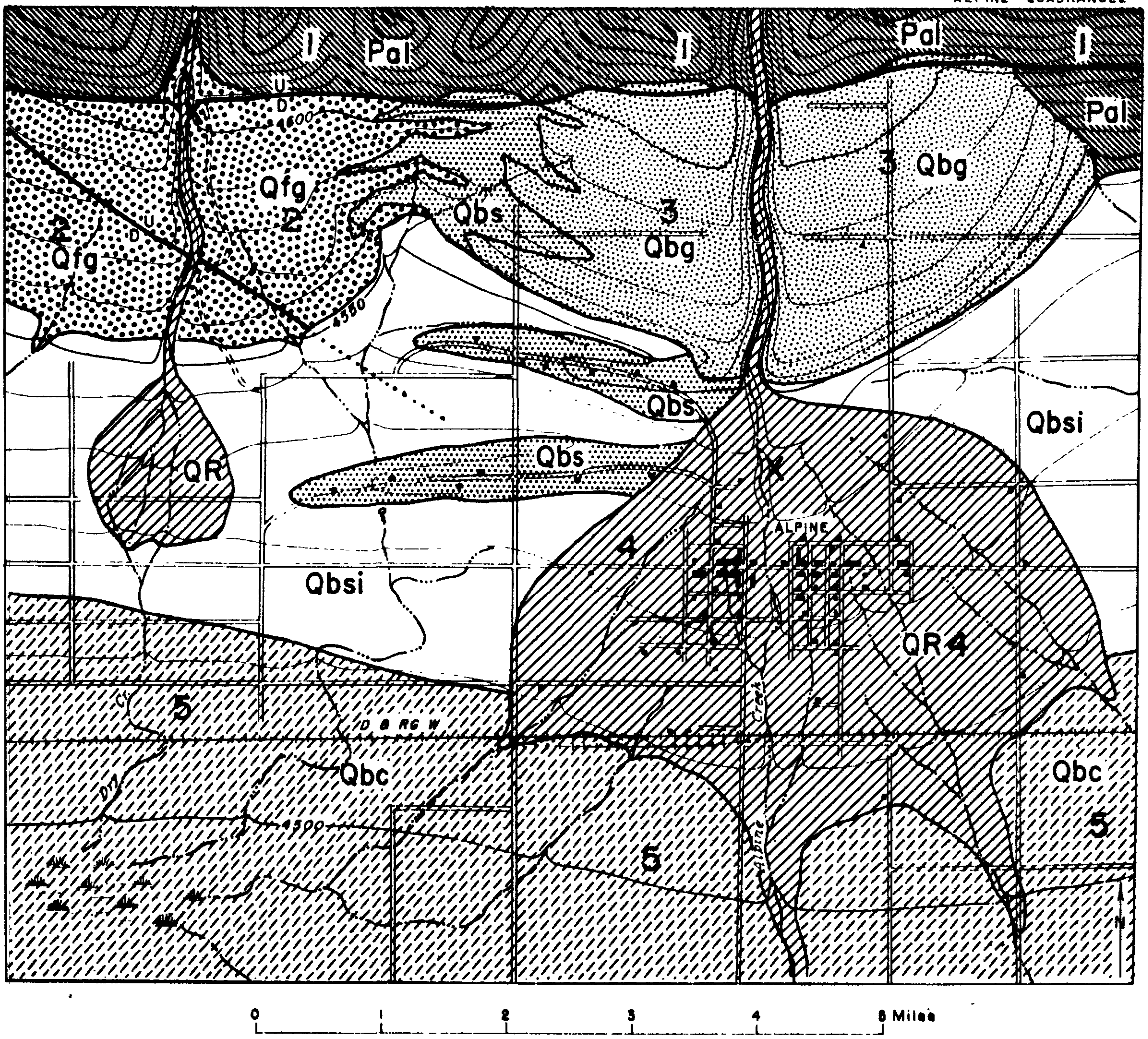
D

Moderate quantities of good quality groundwater available at base of this delta deposit, about 40 feet below surface.

THE GEOLOGIC MAP AS A GUIDE TO PROBLEMS OF UNDERGROUND WATER SUPPLY AND SANITARY ENGINEERING

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

ALPINE QUADRANGLE



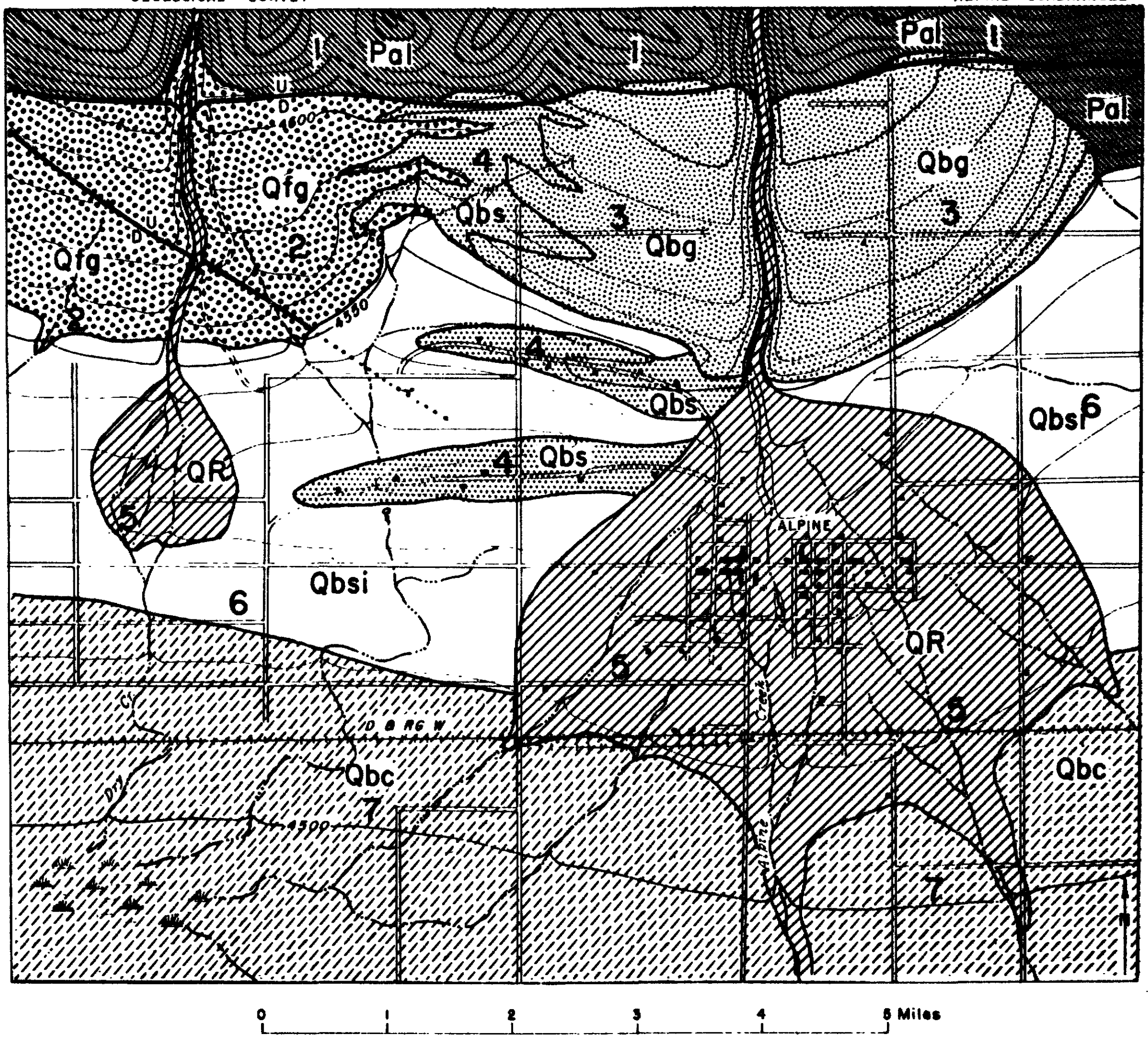
Area	Permeability and slope of ground	Runoff conditions	Flood control, drainage and canal problems
1	Impermeable; slopes steep.	Maximum coefficient of runoff.	Principal source of floods that would be hazardous in valley.
2	Moderately permeable; slopes moderate	Little runoff during moderate storms; considerable runoff during severe storms.	Subject to floods from canyon; during severe storms may discharge floods from surface runoff. Moderate seepage losses can be expected from canals.
3	Highly permeable, gentle slopes.	Practically no runoff even following most severe storms.	No flood control problem. Reservoirs and canals require sealing to avoid excessive seepage losses.
4	Moderately permeable; low slopes.	Moderate runoff during severe storms.	Subject to flash floods from canyon. Moderate seepage losses can be expected from reservoirs and canals.
5	Impermeable and ground nearly flat.	Water stands in pools for long periods after rains.	Ground readily flooded and difficult to drain. No seepage losses from reservoirs or canals.

X Lower limit of perennial flow in streams draining mountain.

THE GEOLOGIC MAP AS A GUIDE TO SURFACE WATER PROBLEMS SUCH AS FLOOD CONTROL, DRAINAGE, CANAL CONSTRUCTION ETC

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

ALPINE QUADRANGLE



1 Mountainous area; soil generally thin and stoney. Locally there is a fossil soil having 10 feet of leached clay (an excellent source of structural clay). Principal watershed supplying valley area. Forested.

2 Stoney and in part bouldery ground. In places covered by fossil soil (See 1); locally the leached clay has been eroded exposing strongly lime-enriched gravel and silt.

3 Stoney ground. Top foot is brown windblown silt containing well rounded gravel; common large size 1 - 2 inches diameter. Five to ten feet of lime-enriched gravel beginning a foot below the surface.

4 Clean quartz sand; grains ½-1 mm diameter, well rounded, stained by iron-oxide. No silt matrix, some lime carbonate cement. Locally blown into low dunes.

5 Stoney ground, silt matrix. Slightly lime-enriched zone less than a foot thick under surface layer of leached silt and gravel 6 inches thick.

6 Silt ground. Contains about 3% of water-soluble salts -- 1.5% of calcium carbonate and 1.5% of sulfates and chlorides of sodium and potassium. These salts leached from top 6 inches, and redeposited in next foot.

7 Clay ground. Contains about 4% of water-soluble salts -- 1% of calcium carbonate and 3% of sulfates and chlorides of sodium and potassium. These salts locally form surface crusts around moist depressions.

THE GEOLOGIC MAP AS A GUIDE TO SOILS AND LAND UTILIZATION PROBLEMS