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Mineral Resources of the Comanche-Big South, Neota-Flat Top, and Never Summer Wilderness Study Areas, North-Central Colorado

By

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In accordance with the provisions of the Wilderness Act (Public Law 88-577, September 3, 1964) and the Joint Conference Report on Senate Bill 4, 88th Congress, the U.S. Geological Survey and the U.S. Bureau of Mines have been conducting mineral surveys of wilderness and primitive areas. Studies and reports of all primitive areas have been completed. Areas officially designated as "wilderness," "wild," or "canoe" when the Act was passed were incorporated into the National Wilderness Preservation System, and some of them are presently being studied. The Act provided that areas under consideration for wilderness designation should be studied for suitability for incorporation into the Wilderness System. The mineral surveys constituted one aspect of the suitability studies. This report discusses the results of a mineral survey of some national forest lands in the Comanche-Big South, Neota-Flat Top, and Never Summer Wilderness Study Areas, north-central Colorado that are being considered for wilderness designation.

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SUMMARY

A mineral survey was made of three areas in Roosevelt-Arapaho and Routt National Forests, Colorado, that have been proposed for inclusion in the National Wilderness Preservation System. The three areas, which are contiguous to Rocky Mountain National Park in north-central Colorado, are Comanche-Big South (68 mi^2), Neota-Flat Top (12 mi^2), and Never Summer (17 mi^2). The mineral survey was accomplished in 1976 and 1977 as a cooperative investigation by the U.S. Bureau of Mines and the U.S. Geological Survey. The geology was mapped, 450 geochemical samples were collected and analyzed, and aeromagnetic and gravity maps were compiled and interpreted. Mining claims were plotted, and prospect pits, mine workings, and veins were mapped and sampled.

The three study areas are alined in a northeast direction and extend from the Precambrian core of the northern Front Range southwest across the faulted west flank, where the Precambrian rocks have been thrust westward over strata of Mesozoic and Tertiary age. The Comanche-Big South area, in the central part of the Front Range, is composed of micaceous and hornblendic gneisses that have been intruded by granite to quartz diorite--probably part of the 1.7-b.y.-old Rawah batholith--and by 1.45-b.y.-old post-tectonic Silver Plume Quartz Monzonite and Sherman Granite. The gneissic rocks have been deformed by both folds and faults that trend mainly east-northeast to east. The gneisses continue to the southwest and are exposed in the southern part of the Neota-Flat Top area, most of which, however, is covered by andesitic to rhyolitic volcanic rocks that are as young as 28 m.y. old. Farther to the southwest, the Never Summer area is occupied largely by the upper plate of the Never Summer thrust, a thin sheet of Precambrian gneisses that overlies autochthonous sedimentary rocks. The western trace of the thrust lies just west of the study area, and windows eroded through the thrust expose Pierre Shale in the eastern part of the area. The thrust and the rocks above and below it have been arched and pierced by granodiorite and rhyolite-porphyry plutons, both about 28 m.y. old.

The only evidence of possibly significant mineralization in the Comanche-Big South area is a uranium occurrence at the north edge of the area near Spencer Heights, where claims have been staked, a shaft dug, and numerous exploratory holes drilled since its discovery in the early 1950's. Although

this activity resulted in insufficient ore-grade rock to justify opening a mine, the occurrence is significant in that it is localized in one of several major shear zones that cross the area. Each of these shear zones is a potential locus for uranium deposits, and thus each should be examined in more detail than was possible in this investigation. Except for common-variety materials, such as sand, gravel, building stone, feldspar, and quartz, no other mineral resources are known or suspected in the Comanche-Big South area.

The Neota-Flat Top area contains no mining claims, evidence of prospecting, or known mineralized rock. Geochemical analyses show that the rhyolitic volcanic rocks are abnormally high in molybdenum, tin, and zinc, but no evidence was found that these metals are concentrated in a recoverable form or grade. No mineral resources other than common-variety materials are known in the Neota-Flat Top area.

The Never Summer area, in contrast to Comanche-Big South and Neota-Flat Top areas, is mineralized to a considerable extent, and the southern half is considered favorable for the occurrence of stockwork molybdenum deposits of the Climax type. Numerous small veins and innumerable mineralized fractures of the Teller mining district attest to a widespread mineralizing event believed related to the mid-Tertiary Mount Cumulus granite stock. The veins themselves probably contain only insignificant mineral resources. Geochemically, the veins and mineralized fractures are high in silver, arsenic, antimony, zinc, lead, molybdenum, fluorine, and barium. Most of these elements take the form of common sulfides, fluorite, and barite, but no silver mineral was identified. Stream-sediment geochemistry reinforces the conclusions based on rock analyses and on distribution of mineralized rocks. The most strongly mineralized part of the Never Summer area is the southeastern third, which is an extension of the main part of the Teller district in Jack Creek to the south. Specifically, the area around Mount Cindy is more iron stained and fractured than most and is anomalous in several metals. Another mineralized area is on the ridge at the three-way drainage divide separating South Fork Michigan River, Porcupine Creek, and Silver Creek, where the Precambrian gneisses have been silicified and intruded by a few small bodies of Tertiary porphyry. Samples of these silicified rocks are anomalous in silver, arsenic, and molybdenum.

The Mount Cumulus stock is petrologically and geochemically similar to the porphyries associated with the Climax and Henderson molybdenum deposits. The rock is a rhyolite porphyry to equigranular granite that is finely fractured and weathers brown from oxidation of pyrite that was deposited in thin films along the fractures and to a lesser extent disseminated through the rock. Molybdenite is sparsely distributed along fractures and in miarolitic cavities. Fluorite is an abundant accessory, and ilmenorutile is common. Small intrusives of rhyolite, hornfelsing of the Tertiary sedimentary rocks, and geophysical evidence indicate that a stock similar to and perhaps continuous with the Mount Cumulus stock underlies at least the southeastern third of the Never Summer area, as well as adjacent areas, at a depth of less than 2 miles.

Although coal and petroleum are being produced in North Park to the west and northwest of the Never Summer area from sedimentary units that may underlie the Never Summer thrust, it is doubtful that either commodity occurs within the Never Summer area.

INTRODUCTION

In this study we have compiled and evaluated the mineral resources of three roadless areas of National Forest that are contiguous to Rocky Mountain National Park in north-central Colorado. The mineral resource evaluation is part of a broader study of all resources of the three areas that are being considered as possible additions to the National Wilderness Preservation System. The areas were defined as wilderness study areas and their boundaries drawn by the U.S. Forest Service. The fieldwork for this study was completed before the Forest Service finished its compilation of RARE II (Roadless Area Review and Evaluation) lands, and as a result the three study areas are not identical to the corresponding RARE II areas. The Comanche-Big South area encompasses about 80 percent of RARE II area A2-219. The Neota-Flat Top area corresponds to RARE II area 02-120. The Never Summer area is approximately the same as RARE II area A2-111. All three areas were recommended as suitable for conversion to Wilderness status by the Forest Service on January 4, 1979. The location of the three areas with respect to some principal features is illustrated on figure 1.

The Comanche-Big South area, Roosevelt-Arapaho National Forest, is the largest of the three areas, encompassing about 68 mi^2 (175 km^2). It is a crudely U-shaped area, open to the northeast. The southern arm of the U shares a common boundary with Rocky Mountain National Park for 6.4 mi (10.3 km) and extends eastward nearly to South Fork Cache la Poudre River. The northern arm lies generally southeast of Cache la Poudre River at a distance of about 0.5 mi (1 km). The southwestern boundary of the area is in part the Cache la Poudre River in Big South Canyon and in part the ridge west of the canyon. The higher parts, around Comanche Peak (12,702 ft, 3,872 m), are in the Mummy Range, which is a name given a subsidiary group of peaks within the much larger Front Range. The area is typical mountainous terrane of the Colorado Rockies. Timberline is at about 11,000 ft (3,350 m), above which the slopes are moderate and rolling and covered with felsenmeer for the most part, except locally where interrupted by several steep-walled cirques. Small glaciers flowed out of these cirques mainly to the east for as much as 6.8 mi (11 km). One small glacier also flowed south from the west side of Comanche Peak and joined a large glacier that flowed north out of Rocky Mountain National Park and down Cache la Poudre River covering much of the west and north margins of the Comanche-Big South area. Upon melting of the ice, the rocky canyon remained, marked by rugged cliffs as far downstream as the northernmost tip of the area near Home (fig. 1). Between the tops of these cliffs and timberline the country has a dendritic drainage pattern, is heavily forested, and is covered by a heavy mantle of soil and colluvium.

State Highway 14, in the valley of Cache la Poudre River, parallels the northern and northwestern boundary of the Comanche-Big South area at a distance of about 0.5 mi (1 km). The Pingree Park road branches from Highway 14 northeast of the area and skirts its eastern and southeastern sides. Several other roads, some of them 4-wheel-drive trails, branch from the Pingree Park road and parallel or impinge upon portions of the eastern and central parts of the area. The main one is the Crown Point road (fig. 1), a well-graded road that penetrates to the most interior part of the area. The western part of the area is accessible by road to Peterson Lake and by trail through Big South Canyon. Numerous other foot and stock trails traverse the area.

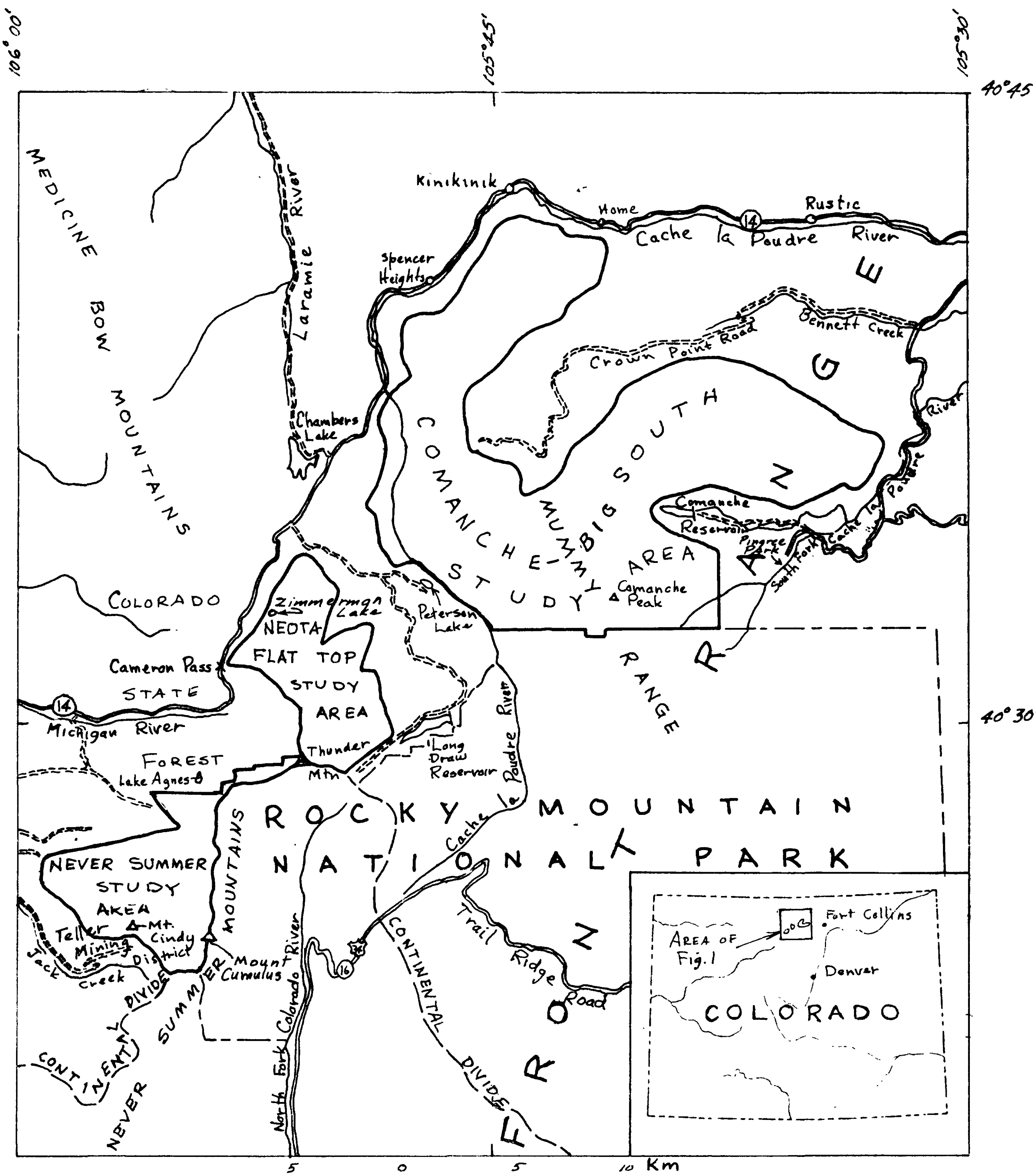


Figure 1.--Index map showing location of Comanche-Big South, Neota-Flat Top, and Never Summer wilderness study areas, Colorado.

The Neota-Flat Top area, Roosevelt-Arapaho National Forest, lies a few miles southwest of Comanche-Big South area. The Neota-Flat Top area is a slightly elongate tract of about 12.5 mi^2 (32 km^2) oriented about north and occupying the east flank of the Never Summer Mountains at its north end. Part of the southern boundary abuts Rocky Mountain National Park for several kilometers along the Continental Divide. The western boundary is the crest of the mountains from Thunder Mountain north to Cameron Pass, which interval is also the boundary between Jackson County on the west and Larimer County on the east. The crest and west side of the Never Summer Mountains from Thunder Mountain northward is largely Colorado State Forest land, but a small part of the west side near Thunder Mountain is a narrow septum of Routt National Forest land that lies between the state forest and the national park. The northern and eastern boundaries are drawn along lower mountain slopes so as to exclude driveable roads and most logged areas. The area is drained by several small subparallel streams that occupy steep-walled glaciated valleys and flow generally northeasterly into streams tributary to Cache la Poudre River. The interstream divides are flat-topped ridges that slope gently down to the northeast.

Highway 14 parallels the northwest margin of the Neota-Flat Top area at a distance of less than 1 km, and the Long Draw road lies between the Neota-Flat Top and Comanche-Big South areas. Access on established trails is limited to an old road to Zimmerman Lake and another up Trap Creek, both of which were closed to vehicular travel at the time of this study.

The Never Summer area, Routt National Forest, lies in Jackson County on the west side of the Never Summer Mountains. It is a small triangular area of about 17 mi^2 (45 km^2) that is bounded by the Colorado State Forest on the north, by Rocky Mountain National Park on the east, and by other Routt National Forest land on the west and south. A narrow strip of the study area extends northeastward to Thunder Mountain, where it is contiguous with Neota-Flat Top area. Most of the area is drained by the headwaters of Silver Creek and South Fork Michigan River. The south boundary lies approximately on the divide between South Fork Michigan River and Jack Creek to the south.

From the west the boundary may be reached by poor roads up Silver Creek and South Fork Michigan River. A good logging road goes most of the way up Porcupine Creek and a fair road goes nearly to the head of Jack Creek. Maintained trails along South Fork Michigan River and Silver Creek are connected by a north-south trail parallel to the crest of the range; the north-south trail leaves the study area at Baker Pass near the southeast corner of the area and continues south down Baker Gulch.

The crest of the Never Summer Mountains, where several peaks exceed 12,500 ft (3,800 m) in altitude, is extremely rugged and in part can be traversed on foot only with great difficulty. Mount Richthofen 12,940 ft (3,944 m), is the highest in the range. West of the crest the upper 1,000-1,300 ft (300-400 m) of the slopes are almost one continuous cirque headwall surfaced with finely jointed outcrop or very steep unstable scree (fig. 2). Although the effects of glaciation continue to be pronounced to the west along the ridges and valley walls for several miles the relief gradually becomes less and the slopes less steep and more timbered.

Few commercial activities have ever taken place within the three study areas. Logging has been done to a limited extent within the boundaries as they are shown on figure 1, particularly in upper Porcupine Creek and adjacent parts of Silver Creek drainage in the Never Summer area and near the Crown Point road in the Comanche-Big South area. Water developments include a dam across the outlet of Zimmerman Lake (Neota-Flat Top area) and the remains of a

Figure 2.--Mount Cumulus, Never Summer wilderness study area. Finely jointed granite weathers readily to form large piles of talus at base of cirque wall and rock glacier (lower right).

dam on Sheep Creek (Comanche-Big South area). The remains of prospecting activity are still evident, mainly in the South Fork Michigan River drainage where numerous small adits and prospect pits are effectively hidden in the heavy spruce timber along the steep valley walls.

Previous studies

Except for the reconnaissance geologic investigations of the territorial surveys, which are now of historic interest only, Beekly (1915) was the first to study the geology in the vicinity; he described the sedimentary rocks of North Park with emphasis on the coal-bearing strata. Spock (1928) first described the crystalline rocks in the study area. His studies included much of the Never Summer Mountains, but he omitted the area of the Never Summer area except for the part along the crest of the range. Some of the rocks for which Spock gives good but brief petrographic descriptions are volcanic and intrusive rocks in the Neota-Flat Top area and in the vicinity of Mount Richthofen. Gorton (1941, 1953) was the first to produce geologic maps in any of the study areas. He discovered the Never Summer thrust and mapped the principal elements of the geology of the Never Summer area. Corbett (1964, 1968) emphasized the petrology of the volcanic and intrusive rocks of the northern Never Summer Mountains, and he interpreted most of the rhyolitic volcanics as welded ash-flow tuffs. Corbett's geologic map was the first of the Neota-Flat Top area. Chevillon (1973) mapped some details of the Precambrian rocks in part of the Never Summer area, and he made a geochemical study that showed the highly anomalous geochemical character of the area around Mount Cindy. O'Neill (1976) expanded on the work of Gorton, Corbett, and Chevillon and completed mapping of the Mount Richthofen quadrangle and adjoining parts of the Fall River Pass quadrangle. Bruce Gamble (1979) has studied the petrography and petrology of the Mount Cumulus stock.

Present investigation

This report presents the results of a cooperative investigation by the U.S. Geological Survey and U.S. Bureau of Mines. In 1975 Pearson sampled for a pilot geochemistry study. In 1976 and 1977 Pearson and Braddock mapped the geology in parts of the area that were not well known before, field checked previous mapping in various parts of the area, and collected samples for geochemical studies, collecting stream-sediment samples systematically and rock samples selectively. C. E. Herald ably assisted Pearson in 1977. Braddock compiled the geologic map from various sources (pl. 1), and Pearson interpreted the geochemical data. The aeromagnetic map was compiled from data obtained in two separate surveys under the direction of Flanigan who also interpreted the aeromagnetic and gravity data. Patten, with the assistance of R. B. Willard and L. V. Coppa, accumulated data on mining claims from the files of the U.S. Bureau of Land Management and from the records of Jackson and Larimer Counties. He also investigated many claims in the field and sampled the dumps of mines and prospects. Pearson and Patten drafted most of the report.

Samples collected by the U.S. Geological Survey were analyzed in Survey laboratories in Golden, Colorado. Spectrographic analyses were made by Jerry Motooka and wet chemical analyses by Craig Curtis. Equivalent uranium was determined on some samples by John Negri. Samples collected by the Bureau of Mines were analyzed in Bureau laboratories in Reno, Nevada.

B. F. Leonard, S. D. Ludington, and P. L. Hauff assisted in mineral identification.

Acknowledgments

Cooperation of personnel of the U.S. Forest Service, U.S. Bureau of Land Management, and mining companies is gratefully acknowledged. Valuable information on exploration activities was provided by K. J. Revis and Earl Aughinbaugh, residents of Cache la Poudre valley; L. D. Milliken, Public Service Company of Oklahoma; and M. H. Bergendahl, Amax Exploration, Inc., Bruce Gamble contributed samples of the Mount Cumulus stock, and Kenneth Shaver supplied a geologic map of the eastern part of the Comanche-Big South area.

GEOLOGY

The three study areas are alined in a northeast direction and extend for (26 mi) 42 km diagonally across the core and western flank of the Front Range, which here is about 35 mi (60 km) wide. Precambrian rocks of various kinds and ages comprise the core of the range, but on the western flank, in the Never Summer and Neota-Flat Top areas, the Precambrian rocks have been thrust westward over Mesozoic and lower Tertiary sedimentary rocks, and both allochthonous and autochthonous rocks were later arched and penetrated by epizonal plutons of mid-Tertiary age. Volcanic rocks--of the same age as the plutons and probably extruded from centers above the plutons--lie on the allochthonous Precambrian rocks in the Neota-Flat Top area and across the trace of the thrust farther west. The geology of the study areas is shown on plate 1.

The project area lies in the general region of several granitic batholiths of Precambrian age (fig. 3). The Medicine Bow Mountains to the northwest are composed almost entirely of a lithologically heterogeneous and structurally complex mass called the Rawah batholith by McCallum and others (1975). An Rb-Sr isochron indicates the Rawah batholith to be about 1.7 b.y. old and hence correlative with the Boulder Creek batholith about 30 mi (50 km) to the south. Many of the granitic rocks in the Comanche-Big South area could be part of the Rawah batholith as it is envisioned by McCallum and others. About 6 mi (10 km) northeast of the Comanche-Big South area is the southwest margin of the Log Cabin batholith, which is 1.42 b.y. old and hence correlative with Silver Plume Quartz Monzonite, also known for exposures farther south in the Front Range. The Longs Peak-St. Vrain batholith of Silver Plume Quartz Monzonite occupies a large area in the southern part of Rocky Mountain National Park. Numerous small bodies correlated with the Silver Plume and perhaps satellitic to the Longs Peak-St. Vrain batholith are in the Comanche-Big South area. One small body of granite is correlated on the basis of lithology with the Sherman Granite, a rock that is more alkalic and very slightly younger than Silver Plume Quartz Monzonite.

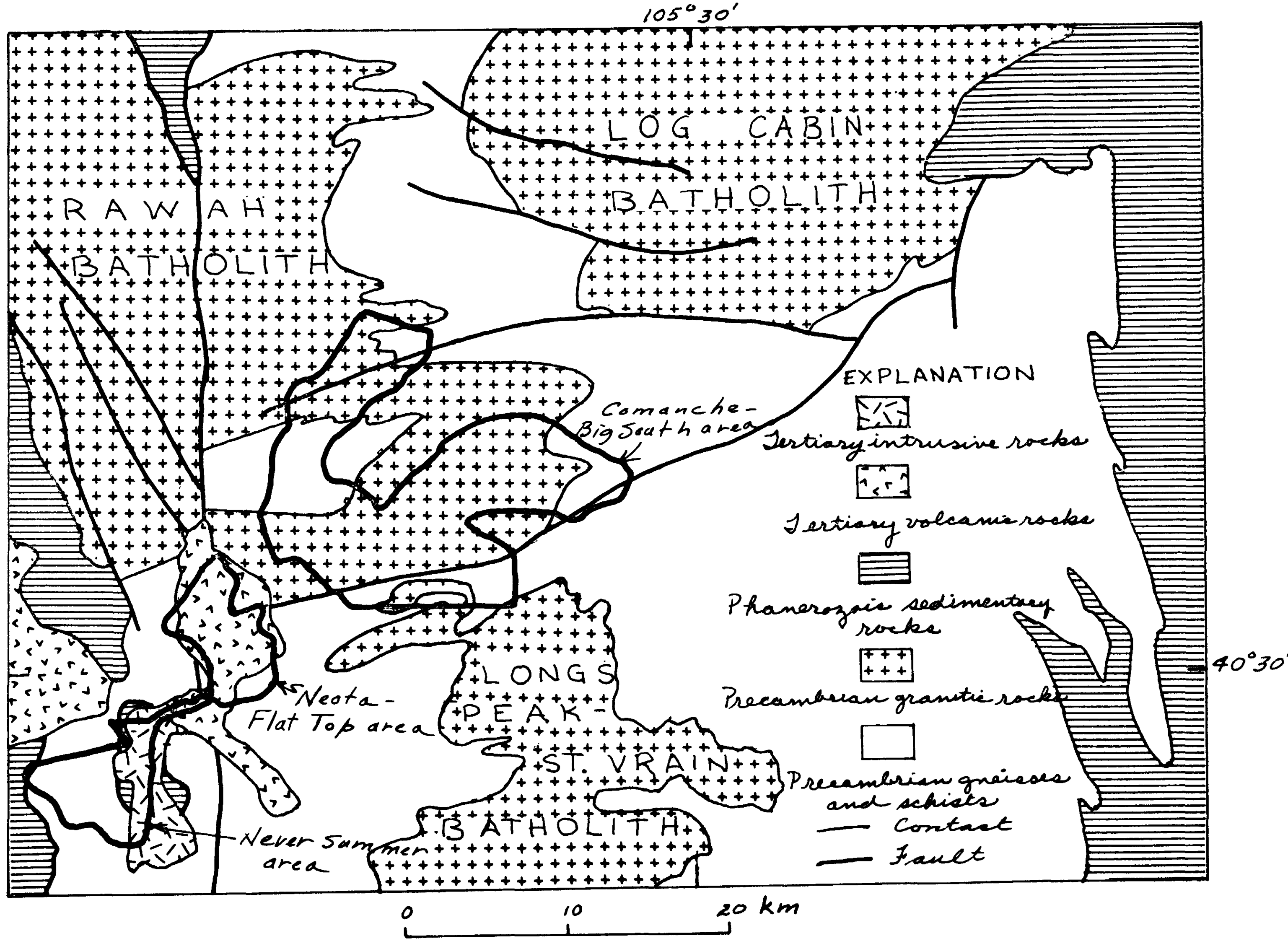


Figure 3.--Generalized geology in the vicinity of Comanche-Big South, Neota-Flat Top, and Never Summer study areas, Colorado. Geology modified from Braddock and Cole (1978).

Rocks

Precambrian rocks

Precambrian rocks constitute about 80 percent of the exposed bedrock in the areas studied. About half of these are schists and gneisses, and the other half are mainly younger granitic rocks.

The oldest rocks in the area are an interlayered sequence of metamorphic rocks of sedimentary and probably volcanic origin of Proterozoic X age, which for the purpose of compiling plate 1, have been divided largely into two units depending on the presence or absence of layers of hornblende gneiss. Quartzo-feldspathic mica schist and gneiss are dominant in both units, but in the mixed unit (Xbh) hornblende gneiss is interlayered in various proportions. Interlayered mica and hornblende gneisses (Xbh) crop out extensively in the northwestern and eastern parts of the Comanche-Big South area and in the western two thirds of the Never Summer area. Three bodies of hornblende gneiss (Xam) in the eastern part of the Comanche-Big South area are shown separately on plate 1. The quartzo-feldspathic mica schist and gneiss unit (Xs) forms a continuous belt across the south side of the Comanche-Big South and Neota-Flat Top areas. Chevillon (1973) and O'Neill (1976) have separated the hornblendic from the micaceous gneisses in the Never Summer area, but they have been lumped on plate 1 of this report These rocks, however, are part of the Never Summer thrust--an allochthonous sheet that has moved laterally at least 6 mi (10 km), presumably from the east--and the rocks in the sheet do not represent a direct continuation of the Precambrian gneisses from the northeast, although they appear to be structurally on line.

The dominant rock in the metamorphic sequence is well-foliated, medium- to coarse-grained biotite-quartz-plagioclase gneiss and schist. The biotite content is moderate to high, but quartz and feldspar generally predominate. Garnet is fairly common in certain layers. Sillimanite and andalusite are uncommon, but in rocks that contain aluminum silicates, muscovite is generally present in addition to biotite. The micaceous gneiss and schist are commonly migmatitic, particularly where associated with the older granitic rocks. Small bodies of pegmatite and gneissic alaskite or granite are present in virtually every outcrop, and many layers of biotite-bearing gneiss that may be of metasedimentary origin cannot be distinguished with assurance from strongly foliated intrusive rocks. Hornblende gneiss is medium-grained, weakly to fairly well layered, and composed dominantly of hornblende and intermediate plagioclase and lesser but variable amounts of biotite and quartz.

Precambrian intrusive rocks include granitic gneisses of Proterozoic X age, small bodies of granite of Proterozoic Y age, a small body of metagabbro near Kinikinik, and several mafic dikes of probable Proterozoic Y age. Pegmatite is present in innumerable small bodies probably related in origin to each of the major granitic units.

The granitic gneisses (Xgg) are a heterogeneous, complex group of rocks whose characteristics and interrelationships were not determined in detail in this reconnaissance investigation. On every scale the granitic gneisses are interlayered with the country rock paragneiss and contain many inclusions of country rock. Every gradation between country rock and granitic gneiss may be observed. In addition, the granitic gneiss as mapped consists of several varieties of rock, some of which form a plexus or network of small variably foliated bodies that crosscut older phases. Locally, each of these types is fairly homogeneous over areas of 0.4-4 mi^2 (1-10 km^2).

In the northern part of the Comanche-Big South area, particularly where the rocks do not appear to be especially contaminated with remnants of the country rocks, one of the principal and oldest rocks in the granitic gneiss complex is a well-foliated, laminated to thickly layered, porphyritic or porphyroblastic, fine- to medium-grained biotite granite. This type commonly grades in and out of pegmatoid phases. The foliation and layering are straight, folded, or locally swirled. Cutting the strongly foliated and layered type are various other types of granite that are of similar composition but commonly finer grained and less well foliated. Most of these bodies are less than 3 ft (1 m) to more than 100 ft (few tens of meters) across. One body, however, that forms the cliffs along Cache la Poudre River east of the mouth of Sheep Creek is massive, has a biotite content of only about 1-5 percent, and probably exceeds 0.4 mi^2 (1 km^2) in area. The weakly foliated to massive structure of some of these rocks suggests that they may be of Proterozoic Y age. Another distinctive type of deformed granitic rock is exposed along Big South Canyon for about 2.5 mi (4 km). The rock in this body is largely medium-grained, biotite-hornblende quartz diorite. Much of the body is well foliated, but commonly the mafic minerals are concentrated in crinkled lenticles that possess a well-defined lineation and weak foliation. This body is more homogeneous than most of the granitic gneiss complex. Nevertheless, it exhibits some variation in composition and structure, and it is cut by varying amounts of foliated alaskitic granite and pegmatite.

Rocks correlated with Silver Plume Quartz Monzonite (Ysp) (1.45 b.y.) crop out near Comanche Peak as several bodies up to about 0.6 mi (1 km) wide and 3 mi (5 km) long. In the area north of Comanche Peak, small bodies of Silver Plume are so small and numerous that they could not be mapped separately; the area that includes most of these bodies has been circumscribed on plate 1. A body of granite that barely enters the southeast corner of the Comanche-Big South area is tentatively correlated with Sherman Granite (Ysh), a rock that is more alkalic and only slightly younger than Silver Plume Quartz Monzonite.

A body of Proterozoic X metagabbro (Xgh) is exposed on the canyon walls near Kinikinik. South of the river it is 0.4 mi (0.7 km) wide and over 1.2 mi (2 km) long; it extends an unknown distance north of the river. The rock is well exposed along Colorado Highway 14. Contacts with its wall rocks were not observed, but because the metagabbro is nearly massive, is intruded only by pegmatite, seems to send off apophyses into the granitic gneiss, and crosscuts the regional structure, it is believed to be younger than the granitic gneiss. The rock is nearly black to dark greenish gray. It consists of green to colorless hornblende, greenish-brown biotite, oligoclase, perthitic K-feldspar, and augite. The augite is present in remnants of original euhedral crystals.

A short segment of a long thin gabbroic dike crops out east of the southern part of the Neota-Flat Top area where it trends N. 30° W. and cuts metasedimentary rocks. The dike, which is about 65 ft (20 m) thick, is exposed along the Long Draw road near the middle of Long Draw Reservoir. This segment is considered to be part of the "Iron dike" described by Lovering and Goddard (1950). It is now known to be continuous except for minor en echelon offsets from Long Draw southeastward, across Rocky Mountain National Park to the Magnolia mining district, a distance of about 45 mi (70 km). The dike is buried by volcanic rocks northwest of Long Draw, but crops out again along the east flank of the Medicine Bow Mountains. Several smaller mafic dikes crop out in the east-central and northern parts of the Comanche-Big South area.

These dikes range from andesite to fine-grained gabbro and are about 10-30 ft (3-10 m) thick. They trend N. 10°-25° W., which suggests a possible close relationship to the Iron dike.

Mesozoic sedimentary rocks

Sedimentary rocks of Mesozoic age crop out locally in a window in the Never Summer thrust near the crest of the Never Summer Mountains and along the western trace of the thrust just west of the Never Summer area. Most of these outcrops are Pierre Shale of Late Cretaceous age, but the small highly faulted area west of the study area also contains blocks and slices of the Chugwater Formation of Triassic and Permian age, rocks of Jurassic age, and other Cretaceous formations. A brief description of these formations and their stratigraphic relations are shown in table 1.

The Pierre Shale in the window has been intruded, hornfelsed, and largely obliterated by the Mount Richthofen stock. Only isolated patches of the Pierre remain, some of them in fault contact with structurally overlying Precambrian rocks and some of them apparently surrounded by granodiorite of the stock. A few of these inclusions, which are up to 0.3 mi (0.5 km) long, lie on the crest of the range at the highest exposed levels of the stock. At Nokhu Crags just north of the study area, the Pierre is turned up vertically and is continuously exposed through a section 2,070 ft (630 m) thick, as measured by O'Neill (1976).

Paleocene and Eocene Coalmont Formation

The Coalmont Formation of Paleocene and Eocene age (table 1) crops out west of the Never Summer area in the valley of Jack Creek. It is in the lower plate of the Never Summer thrust, a position structurally analogous to the Mesozoic sedimentary rocks farther north that are described above. These rocks were earlier mapped as Pierre Shale by Gorton (1941). The Coalmont along Jack Creek has been hornfelsed, but the metamorphic effects become less farther west and southwest. The hornfelsing was most likely caused by heat from the Mount Richthofen and Mount Cumulus stocks to the east or comparable rocks at depth. The lowest beds of the Coalmont in this area are exposed in the valley of Jack Creek in the core of an anticline. These beds, which are correlated with Middle Park Formation, are sedimentary breccias that contain abundant clasts of mafic volcanic rock.

Tertiary volcanic rocks

Volcanic rocks of mid-Tertiary age cover most of the Neota-Flat Top area to a depth of at least 1,000 ft (several hundred meters). They lie in depositional contact with Precambrian crystalline rock on a surface of considerable relief. Seven Utes Mountain, just off the north edge of the Never Summer area, consists of similar volcanic rocks that also lie in part on Precambrian rocks; they probably bury the trace of the Never Summer thrust and sedimentary rocks west of the thrust as well.

The volcanics in the Neota-Flat Top area were studied first by Spock (1928), who described the petrography of several types of rocks and identified rhyolite, andesite, and basalt. Gorton (1941) mapped the volcanics in part of the area and separated the trachyandesite near Zimmerman Lake from the predominant rhyolitic rocks. Corbett (1964) mapped the volcanics in more detail in the entire Neota-Flat Top area, discussed their origin and

Table 1.--*Sedimentary rock units in and near the Never Summer study area* [Modified from O'Neill, 1976, and Ward, 1957. Underlined formations crop out in or adjacent to the Never Summer study area]

System/Series		Group/Formation		Thickness (feet)	Lithology
EOCENE		COALMONT FORMATION		1,000+	Shale, mudstone, sandstone, and conglomerate.
PALEOCENE					
		Unconformity			
CRETACEOUS	UPPER	PIERRE SHALE	UPPER UNIT	2,100+	Interbedded sandstone, siltstone, and shale.
			LOWER UNIT	?	Shale.
		COLORADO GROUP	NIOBRARA FM.	350-400 (est.)	Shale, grading upwards into sandy, shaly limestone.
			BENTON SHALE		
	LOWER	DAKOTA SANDSTONE		85-135	Sandstone and shaly sandstone.
				0-50	Shale and sandstone.
				5-13	Conglomerate
		Disconformity			
JURASSIC		MORRISON FORMATION		170-185	Variegated shale and marl interbedded with sandstone and limestone.
		SUNDANCE FORMATION		135-185	Crossbedded sandstone.
		Unconformity			
TRIASSIC		CHUGWATER FORMATION		370-560	Siltstone, sandstone, and shale.
PERMIAN		FORELLE LIMESTONE		0-15	Siltstone and silty limestone.
		SATANKA SHALE		0-25	Sandy and silty shale.
		Nonconformity			
PRECAMBRIAN					

petrology, and compared his interpretations with Wahlstrom's earlier work (1944) on Specimen Mountain to the southeast. O'Neill (1976) subdivided the volcanics somewhat differently than Corbett (1964).

Most of the volcanics are rhyolitic lavas and ash-flow tuffs, but poking out from under the rhyolites at several places are mafic to intermediate rocks of several types.

Tertiary intrusive rocks

Two stocks in the Never Summer Mountains and sparse silicic dikes throughout the area constitute the Tertiary intrusive rocks (pl. 1).

The Mount Richthofen stock is a north-trending narrow pluton that forms most of the crest of the Never Summer Mountains in the study area. The main part of the stock, which is about 5 mi (8 km) long and 1.5 mi (2.5 km) wide, is composed of gray equigranular to weakly porphyritic, medium-grained granodiorite. Corbett (1968) reports that parts of the interior of the pluton, particularly around Mount Richthofen, are monzonite or quartz monzonite. These phaneritic phases are in contact with masses of gray porphyritic andesite within and beside the stock. Some masses of andesite are inclusions of older rock, and other identical-appearing andesite is younger than granodiorite, according to O'Neill (1976). The rocks of the stock have been described by Spock (1928), Corbett (1968), and O'Neill (1976).

The south end of the Mount Richthofen stock is intruded by a smaller stock of rhyolite porphyry called the Mount Cumulus stock by O'Neill (1976) and Gamble (1979). The Mount Cumulus stock weathers brown from limonite on all joint surfaces and contrasts strongly with the gray granodiorite of the Mount Richthofen stock. The Mount Cumulus stock is more equidimensional in exposed outline than the Mount Richthofen stock. It is centered east of the crest of the range. Although it is exposed for only about 0.6 mi (1 km) west of the crest, several lines of evidence suggest that the rhyolite continues to the west at fairly shallow depth for several kilometers more.

The rock ranges from rhyolite porphyry with crystalline groundmass to fine- and medium-grained equigranular granite. All phases of the stock are leucocratic. Biotite, which is the most abundant mafic mineral, constitutes 0-3 percent of the rock (O'Neill, 1976). O'Neill's descriptions and analyses (p. 76) further show that the rock is in essence a hypersolvus alkali granite.

A body of rhyolite porphyry, similar to the Mount Cumulus stock barely reaches the surface in the valley of Jack Creek. Although it is buried beneath glacial and alluvial deposits and hence does not crop out, it was found by M. H. Bergendahl, Amax Exploration, Inc., by tracing float upstream. Several drill holes that explored its mineral potential demonstrated that at the bedrock surface this body is perhaps 2,300 ft (700 m) long and 820 ft (250 m) wide. The drilling also showed that the top of the pluton is nearly flat, and hence it underlies at shallow depth a substantially larger area than at the bedrock surface in Jack Creek. The drilling was apparently not extensive enough, however, to determine the size and shape of this pluton or its possible continuation with the Mount Cumulus stock in the subsurface. Gravity data (figs. 4 and 5) suggest that the stock extends at depth northward into the Never Summer area and probably eastward to the Mount Cumulus stock.

Oligocene White River(?) Formation

Arkosic sandstone, some of it pebbly, and clay beds, probably bentonite, crop out near the east edge of the Neota-Flat Top area. Although poorly exposed, these beds occur at a position that seems best interpreted as older than the rhyolitic volcanics. These sediments may represent small erosional remnants of the more extensive but similar deposits near Chambers Lake and Barnes Meadow Reservoir, which were correlated with the White River Formation of Oligocene age by Izett (1975).

Structure

Most of the Precambrian rocks in the area are strongly foliated. The foliation in the Comanche-Big South and Neota-Flat Top areas trends predominantly east-northeast, and in the Never Summer thrust sheet it trends mainly west-northwest. Granitic rocks in the southern and central parts of the Comanche-Big South area that are correlated with Silver Plume Quartz Monzonite (1.45 b.y.) are younger than the main deformation and in this area possess only a primary magmatic foliation. The metagabbro near Kinikinik is very weakly foliated to massive and the few mafic dikes in the northern and eastern part of the Comanche-Big South area are undeformed.

Although no detailed study was made of the structure of the Precambrian rocks, folds in foliation throughout the area imply multiple episodes of deformation. Most of the minor folds observed and a major antiform in Big South Canyon trend about N. 70° E. and probably represent a younger deformation. The antiform is open and upright. Its continuation has not been traced beyond the canyon to the east or west. O'Neill (1976) has mapped several folds in the Precambrian rocks of the Never Summer allochthon. They trend mainly west-northwest and are smaller than the antiform in Big South Canyon.

Faults cut rocks of all ages, and movements took place at various times. Several major shear zones cut the Precambrian rocks in the Comanche-Big South area. The dominant trend of these shear zones is east to east-northeast though some are northwesterly. They are mostly broad, crushed, iron-stained zones locally more than 300 ft (100 m) wide. The zones commonly split and either one branch dies out or merges with another in an acute angle. Most of these shear zones are in the northern part of the Comanche-Big South area and a few are in the southern part. The apparent absence of such structures in the central part may be the result of very poor exposure in that area. The age of movement on these shear zones is not well documented. The zones are overlapped by the White River(?) Formation and younger rhyolites north of Corral Creek, and one of the zones is intruded by a Tertiary dike of quartz porphyry that may be related to the Oligocene rhyolites. These shear zones are similar in trend and general character to many of Precambrian age known in central Colorado (Tweto and Sims, 1963) although Phanerozoic movement, particularly during the Laramide orogeny, may have taken place on many of them.

The principal structural feature in the Never Summer area is the Never Summer thrust first described by Gorton (1941) and later studied by Ward (1957) and O'Neill (1976). The upper plate is a thin slab of Precambrian schists and gneisses, and the lower plate consists of Mesozoic rocks, commonly Pierre Shale, or Tertiary Coalmont Formation. The Coalmont is regarded as Paleocene and Eocene in areas to the west, but it is not known whether the Eocene part is present beneath the thrust. The thrust was arched and intruded by the Mount Richthofen and Mount Cumulus stocks, which are approximately 28 m.y. old. The Never Summer thrust is typical of the sructures along the margins of the Rocky Mountains, and it presumably originated to the east on the west flank of the Front Range, but opinions differ about the mechanism (O'Neill, 1976). Thrusting may have taken place while the younger parts of the Coalmont were still being deposited in the center of the North Park basin.

The Mount Richthofen and Mount Cumulus stocks, the Precambrian rocks of the thrust sheet, and the Coalmont Formation south of the trace of the thrust are broken by several north-trending faults that apparently have small displacement. Many of these faults have been mineralized and are occupied by narrow veins. The most continuous of these trends a few degrees east of north and crosses the entire study area. It has been traced by O'Neill (1976) from Lake Agnes south to Baker Gulch. This fault is mostly in the two stocks but near their west edge. From Lead Mountain northward a parallel fault lies east of the crest of the range and together the two bound a horst that is about 0.6-0.9 mi (1-1.5 km) wide.

INTERPRETATION OF GEOPHYSICAL DATA

By
Vincent J. Flanigan

Introduction

Aeromagnetic and gravity data were interpreted as part of the geologic assessment of the mineral-resource potential of the Comanche-Big South, Neota-Flat Top, Never Summer, and adjacent areas, a total of about 100 mi^2 (250 km^2). The aeromagnetic data shown on plate 3 were compiled from two separate magnetic surveys made by the U.S. Geological Survey in 1970 and 1975 (U.S. Geological Survey, 1978). The magnetic surveys were flown at the same flight elevation (3,960 m barometric), but the data were compiled at different reference levels. Furthermore, the International Geomagnetic Reference Field (IGRF) was removed from the 1975 survey field data but not from the 1970 survey data, hence no attempt was made to tie the data across adjacent boundaries. The gravity data used in this study is largely from the Department of Defense gravity data files. In addition, gravity was measured at about 20 stations in the summer of 1978 to supply additional data along the west slope of the Never Summer Mountains. The gravity data were corrected for terrain effects to a distance of 104 mi (167 km) by methods described by Plouff (1966) and Sandberg (1958).

Regional geology and geophysical data (Lovering and Goddard, 1950; Tweto and Sims, 1963; Zietz and Kirby, 1972; Behrendt and Bajwa, 1974) provided background data for the interpretation of the regional geologic and geophysical setting of the study areas in addition to the present geologic studies.

Regional geophysical setting

Two regional magnetic features on the magnetic map of Colorado (Zietz and Kirby, 1972) are expressed in part on the magnetic map of this report (pl. 3). One is a north-trending magnetic low coincident with a major fault zone in the Laramie River valley. This low ends about 6 mi (10 km) north of the Neota-Flat Top area, although the fault zone probably continues to the south beneath the volcanic rocks of the Neota-Flat Top area. The magnetic properties of the volcanic rocks are largely responsible for the absence of the low in the Neota-Flat Top area. Another magnetic low of regional significance trends about east-northeast across the Comanche-Big South and Neota-Flat Top areas. This low is also associated, at least partly, with major fault zones.

The regional gravity map of the State of Colorado (Behrendt and Bajwa, 1974) indicates that the three study areas lie within an area of steep northeast gravity gradients of about 1.5 milligals per kilometer (mgal/km) and that a 10 mgal gravity low lies just south of the Never Summer area.

Aeromagnetic data

A prominent magnetic high about 6 mi (10 km) long (anomaly 2076) is elongated over the Continental Divide along the eastern edge of the Never Summer area (pl. 3). This area has maximum topographic relief of 2,200 ft (675 m), suggesting that the anomaly may, in part, be induced by topography. However, the westward bulge of the anomaly follows the mapped outcrop of a granodiorite intrusive (the Mount Richthofen stock). The bulge extends farther to the west than the outcrop of the stock, into an area where the rocks at the surface are Precambrian quartzo-feldspathic mica schist and gneiss and hornblende gneiss. Flight-line spacing in this area is not sufficiently close to permit an inference as to whether the metamorphic rocks at the surface or a protrusion of the stock at depth causes the magnetic bulge. North-trending faults in the southern part of the Never Summer area are near the edge of the magnetic anomaly over the granodiorite. These faults and the contact zone may represent a locus of hydrothermal activity or contact metamorphism which could have mineral potential. The entire western contact of the Mount Richthofen stock may be considered to have possible mineral-resource potential. Magnetic anomaly 1708 is part of a large magnetic low that in part is the result of a dipolar effect associated with the magnetic response of the Mount Richthofen stock (anomaly 2076).

Anomalies 1748 and 1778, lying several kilometers east of the Never Summer area, are thought to be the southern extension of the north-trending magnetic anomaly in the Laramie River valley. Two magnetic lows (anomalies 1810 and 1870) lie along the western edge of the Never Summer area. They generally coincide with the mapped boundary of a thrust fault zone, and may represent a thick section of weakly magnetic sedimentary rocks. Magnetic anomaly 1966 lies south of and outside the Never Summer area. This magnetic high is somewhat lower in amplitude than the high associated with the granodiorite porphyry intrusive to the north, and is thought to be the magnetic expression of the Mount Cumulus rhyolite-porphyry stock. The rhyolitic rocks are less mafic than the granodiorite and are probably less magnetic, although magnetite is one of the common accessory minerals.

The northeast-trending regional magnetic low mentioned earlier begins north of the Never Summer area and extends across the entire map (pl. 3). Rocks south of this anomaly are generally more magnetic than rocks to the north. Magnetic anomaly 455 lies on the trend of the regional magnetic low. In part, anomaly 455 may be a dipolar magnetic low associated with the magnetic high (anomaly 1161). The regional magnetic low probably results from destruction of magnetic minerals along fault zones. Such zones have controlled the emplacement of Laramide mineral deposits in the region.

The magnetic pattern over the northern half of the Neota-Flat Top area is largely featureless, and the magnetic intensity increases to the north with a gradient <50 γ/km. A similar gradient continues over much of the Comanche-Big South area. Had a regional gradient been removed from the data, the magnetic pattern would be flat, as expected over granitic gneisses. One exception, anomaly 733, is 1.2 mi (2 km) circular anomaly of about 50 γ amplitude. The geologic map gives no clues to the source of this anomaly, but its small size suggests that the source rock is relatively near the surface. It may represent a small intrusive plug of more magnetic rocks. Alternatively, the anomaly may represent a more magnetic facies of the granitic rocks, or a swarm of dikes of more magnetic rocks.

Gravity data

The gravity data covering most of the study areas are shown on figure 4. The primary purpose of compiling the available gravity data was to attempt to define the western contact of the Mount Richthofen stock in the Never Summer area, but the density contrast between the granodiorite porphyry intrusive and the metamorphic rocks to the west was apparently too low to produce a distinct gravity anomaly. The Mount Cumulus stock in the southeastern part of the Never Summer area is apparently less dense (2.70 g/cm^3) than the surrounding rocks (2.90 g/cm^3) and it produces a distinct gravity low of about 5-10 mgal. The gravity anomaly conforms reasonably well to the southern part of the magnetic anomaly pattern in this area (anomaly 1966, pl. 3) suggesting that rhyolite porphyry is less dense and slightly less magnetic than the granodiorite porphyry to the north, and is considerably larger in the subsurface than the exposed rock indicates. Contact zones of the intrusive rocks that lie within the Never Summer area may have some interest as possible sites of mineralization associated with hydrothermal activity or contact metamorphism.

A regional gradient of about 6 mgal/km was removed from the Bouguer gravity map (fig. 4) and the resultant residual gravity map (fig. 5) accentuates local gravity highs and lows. One of the lows is centered over the Mount Cumulus stock and the other is centered over the buried pluton of rhyolite porphyry in Jack Creek. The gravity trough that includes and connects the two lows suggests that the plutons are connected at depth. From near the southeast corner of the Never Summer area the trough turns northeast and continues for about 10 km where it ends in a 10 mgal low centered west of Specimen Mountain. Precambrian gneisses and volcanic rocks of Specimen Mountain crop out at this low. However, a buried rhyolitic pluton may be present at depth analogous to the other two 10 mgal lows. A local low (anomaly L_1) of about 5 mgal is present in the northeastern part of the Neota-Flat Top area. It is related to less dense volcanic rocks at the surface in this area.

Conclusions

North- and northeast-trending magnetic lows are interpreted to be associated with major regional fault zones. The magnetic high associated with granodiorite of the Mount Richthofen stock has no distinct gravity anomaly associated with it. Faults mapped through the central part of the Never Summer area may be associated with the western contact of the Mount Richthofen

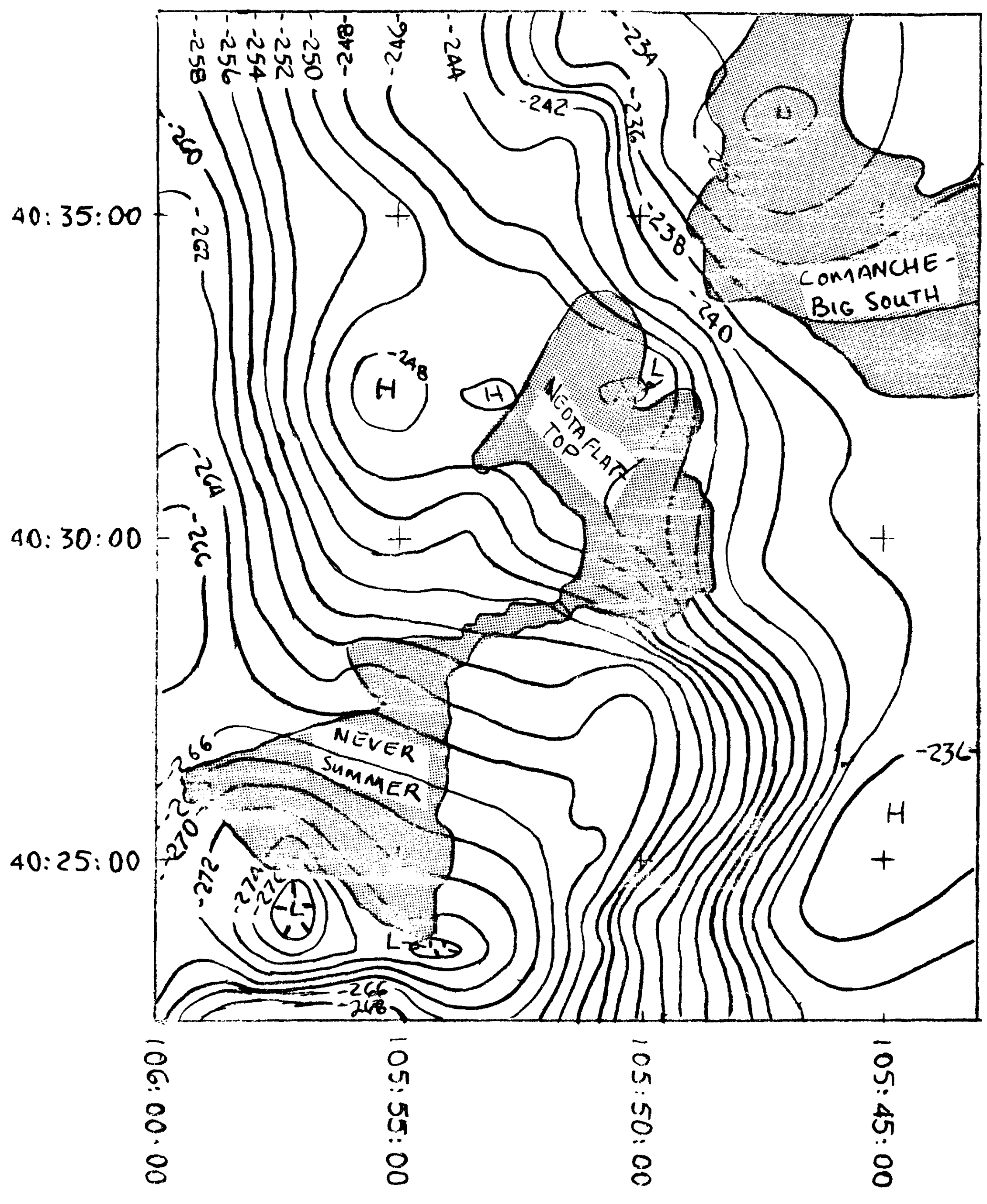


Figure 4.--Complete Bouguer gravity map of the Comanche-Big South, Neota-Flat Top, and Never Summer areas. Contour interval is 2 mgal. L, gravity low; H, gravity high.

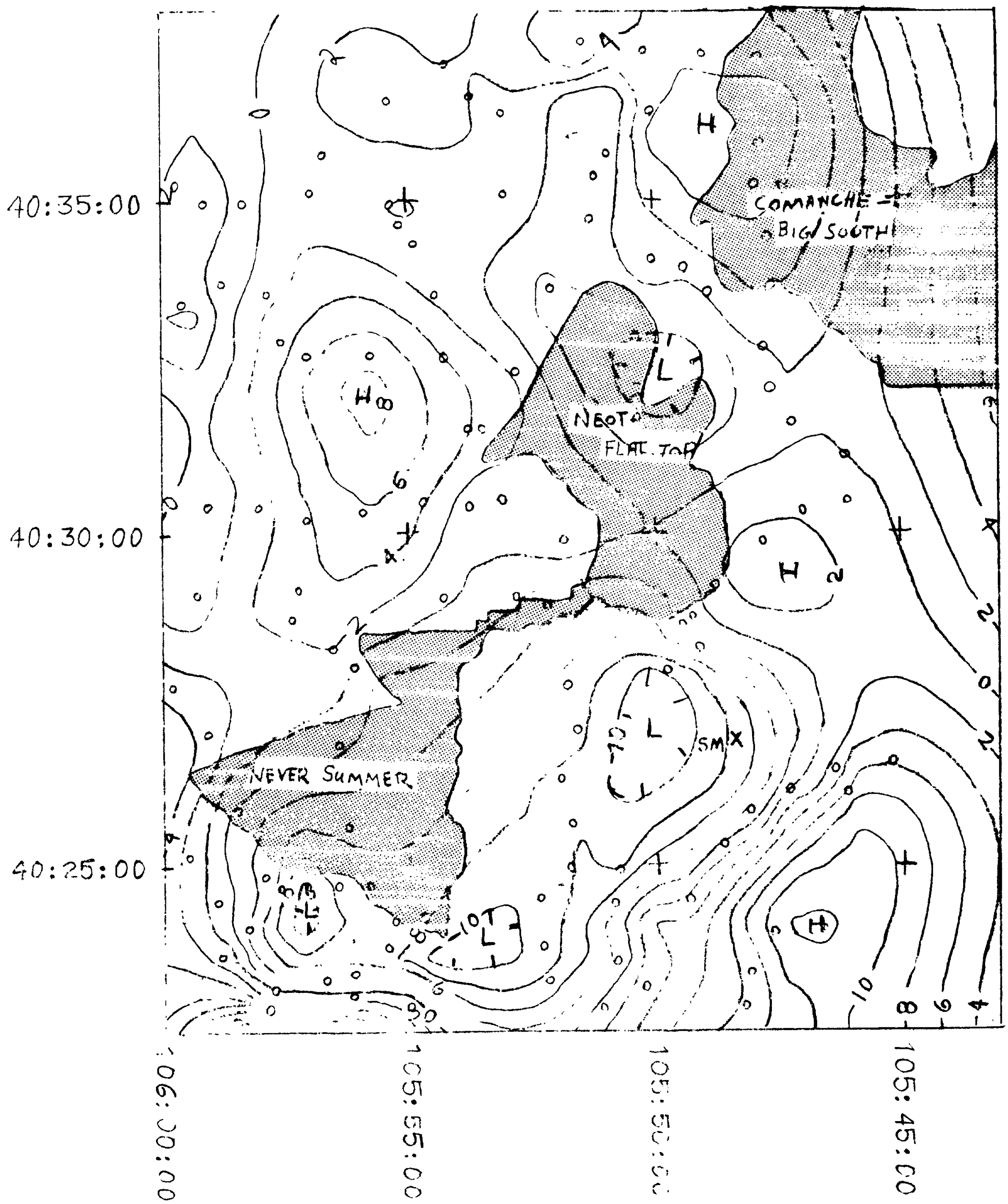


Figure 5.--Residual gravity map of the Comanche-Big South, Neota-Flat Top, and Never Summer study areas. Contour interval 2 mgal. Small circles are gravity stations. SM, Specimen Mountain; L, gravity low; H, gravity high.

stock. A gravity low is related to the rhyolite porphyry of the Mount Cumulus stock in the southern part of the Never Summer area. As expected, the rhyolite is less magnetic and less dense than the granodiorite.

Contact zones of the stocks are not well defined by the geophysical data, but in general the data suggest that the contact zones may be areas of interest as potential mineral exploration targets.

A northeast-trending magnetic low that crosses the southern parts of the Neota-Flat Top and the Comanche-Big South areas may be related to a major fault zone. No mineralization is known to be associated with this zone, but similar zones nearby are mineralized, suggesting that this zone may have mineral potential, particularly for uranium.

MINERAL RESOURCES

Mineral resources of potential interest in the roadless areas under discussion are molybdenum, silver, zinc, lead, uranium, and fluorspar. All of these, except uranium, are known to be present in small veins in the Never Summer area, and molybdenum in somewhat more than trace amounts is disseminated widely in the Mount Cumulus stock. Uranium is known in pegmatites and in a strong fault zone just north of the Comanche-Big South area but has not been found within the study areas. Extensive prospecting in the Never Summer area is evidenced by numerous small mine workings. It may be assumed that for the last century or so prospectors combed the Neota-Flat Top and Comanche-Big South areas as well, but their search was evidently futile, and virtually no evidence of their presence remains.

The mineral resources were investigated by geologic mapping, exploration geochemistry, and geophysical techniques. Prospect workings were examined and sampled. Bureau of Mines personnel compiled all records of claim staking from the courthouses in Walden (Jackson County) and Fort Collins (Larimer County).

The study areas lie about 30 mi (50 km) northwest of the Colorado Mineral Belt, which includes most of the mining districts of the state. The general region of the study area contains several small mining districts, and one, the Teller district, includes part of the Never Summer area. Small districts such as Manhattan, Home, and Mayesville (Lovering and Goddard, 1950) lie within a few kilometers northeast of the Comanche-Big South area, Manhattan being the most significant of these. The Crystal Mountain pegmatite district (Thurston, 1955) lies east of the Comanche-Big South area. The Northgate fluorspar district is about 34 mi (55 km) northwest of the study areas. The sedimentary rocks in North Park to the west have produced petroleum and coal, and some of the formations favorable for these resources may underlie the Never Summer area. No mineral production is known from any of the area studied.

Home is at the end of the northern arm of the Comanche-Big South area. Lovering and Goddard (1950, p. 286-287) describe the Home mining district very briefly by commenting on adits along the south bank of Cache la Poudre River and on ore specimens reported to have come from the district. The specimens "suggest a pyritic copper mineralization." No prospect workings were found in the study area near Home, but a few were found 1 mi (1.5 km) east of Home (pl. 1) that explored east-trending faults. Other small prospect workings north of the highway near Home were not investigated.

Mayesville is described by Lovering and Goddard (1950) as an abandoned settlement 5.6 mi (9 km) east of Home and south of Manhattan. They state further that, in this vicinity a few veins were prospected but no record of production is known; the veins contain quartz, pyrite, chalcopyrite, and galena; and assays indicate 0.3-0.9 oz of gold per ton, the values decreasing with depth. As discussed later on in this report, no gold was detected in samples that we collected. The east-trending veins are probably localized in the major fault system of the same easterly trend.

The Manhattan mining district is 2 mi (3 km) north of the Cache la Poudre River. Veins discovered in 1883 were extensively developed and mined for gold for a decade or so. Lovering and Goddard (1950, p. 285) state that "only a small output has been reported for this period, and little or no ore has been shipped since 1900." West- to west-northwest-trending veins cut Silver Plume Quartz Monzonite and Tertiary porphyries. The porphyries form small stocks and dikes. The primary ore consisted of quartz and pyrite that was generally too lean to be mined, but oxidized ore near the surface was enriched in gold, commonly to about 4 oz per ton, and this constituted the bulk of the mined rock.

In connection with their discussion of these three minor mining districts, Lovering and Goddard (1950, p. 285) suggest that the districts are associated with a belt of intrusive porphyries that extends northeastward from Radial Mountain (6 mi [10 km southwest of the Never Summer area]), through Cameron Pass to the Manhattan mining district. They consider this belt to be similar to the parallel Colorado Mineral Belt in the central part of the Front Range and conclude that although this belt "... has not been extensively prospected, the meager information available suggests that intrusion in it was accompanied by only feeble metalization in most places." Geologic knowledge accumulated since the early 1950's does not support Lovering and Goddard's hypothesis regarding a northeast-trending mineral belt from Radial Mountain to Manhattan. However, their conclusion of "feeble metalization" is still valid except for the Never Summer Mountains, which they did not investigate. Such a belt would pass through the three study areas and would be manifested by structural features, bodies of Tertiary intrusives alined in a northeasterly direction, or concentrations of mineral occurrences or mining districts. None of these features are present, and in fact the mineral occurrences and intrusive bodies seem to be localized by several, probably unrelated structural features.

The Mount Richthofen and Mount Cumulus stocks and the volcanics in the Neota-Flat Top area are petrologically and temporally related to the Oligocene and Miocene(?) Rabbit Ears Volcanics and the numerous intrusive bodies in the Rabbit Ears Range southwest of the Never Summer area. The volcanic centers form a distinct east-trending belt in the Rabbit Ears Range for a distance of about 28 mi (45 km). At Radial Mountain the belt turns north and continues another 16 mi (25 km) along the Never Summer Mountains to its north end. Several intrusive centers in the Rabbit Ears Range, such as the Poison Ridge center (Kinney and others, 1968), are known to be mineralized. Molybdenum and its congeners characterize these mineralized rocks.

The small districts along the Poudre River, on the other hand, are localized along major faults and are not accompanied by major Tertiary igneous-rock assemblages. Small- to medium-sized porphyry intrusives in the Manhattan district are reportedly of a distinctly older age (Malcolm McCallum, oral commun., 1976) than those in the Never Summer Mountains, and the other small districts are accompanied by only a very few small dikes of Tertiary porphyry, whose age is unknown relative to other Tertiary igneous rocks in the vicinity. Furthermore, the type of mineralization in these districts, characterized by gold, is distinctly different from that associated with the rocks and hydrothermal systems in the Rabbit Ears Range and Never Summer Mountains, which is characterized by molybdenum.

Geochemical studies

A geochemical survey was made of the three study areas as a tool in evaluating the mineral-resource potential. Stream-sediment samples were collected from all small streams, rock samples were collected of fresh and altered rocks, and the most mineralized rocks were sampled in prospect workings, on dumps, and in outcropping lodes. About 446 samples were collected and analyzed; 167 of them were stream sediments, and 279 were rock samples. Sample localities are shown on plate 2. Chemical data for those samples considered to contain a significant amount of one or more elements (anomalous samples) are shown in tables 4-9. Complete analytical data on all samples have been released previously (Motooka and others, 1979).

Stream-sediment samples were collected in a few streams as part of a pilot study in 1975; in 1976 and 1977 all small streams were sampled systematically. The finest grained active sediment that could be found was collected. Usually this consisted of mud found in backwaters in the portions of the stream having the lowest gradient. The mud was dried, sieved, and the -180 μm fraction was retained for analysis.

Fresh unaltered rocks were sampled for analysis to provide a comparison for the altered and mineralized rock analyses. Fresh rock samples of all principal rock types were collected. Altered and mineralized rock samples consisted of (1) limonite-stained or clay-altered rocks from faults, (2) fresh rock with limonite-stained joints, (3) rocks with disseminated sulfide minerals, or (4) vein rock, mostly with quartz gangue and commonly with sulfide minerals. Rock samples were ground before analysis.

All samples were analyzed for 30 elements using standard semiquantitative spectrography. Altered and mineralized rocks were also analyzed for arsenic, antimony, and zinc using atomic absorption techniques. The analytical work was performed in U.S. Geological Survey laboratories in Golden, Colo.

The geochemical data will be discussed in connection with each study area.

Comanche-Big South area

Mining claims and mineral prospects

Records from Larimer County and the U.S. Bureau of Land Management disclose that several groups of claims have been staked within a few kilometers of the Comanche-Big South area (fig. 6), but only one group is even partly within the area.

The only significant mineral exploration known within or near the study area is in this last mentioned group of claims, which lies south of Spencer Heights on the canyon wall of Cache la Poudre River (fig. 7). Abnormally high radiation in spring water led to the discovery of uranium here in 1954. S. L. and B. L. Lindsey staked three claims--Spring 1, Spring 2, and Lady Cora Hellen in NE $\frac{1}{4}$ sec. 15, and NW $\frac{1}{4}$ sec. 14, T. 8 N., R. 75 W., about 1,650 ft (500 m) south of Spencer Heights. In 1955 the Revis brothers located 12 other claims, mostly east of the original three. A shaft 20 ft (6 m) deep was sunk near the spring into a broad shear zone that trends about N. 70° E. A small amount of ore-grade rock was discovered in the shaft, but further work showed the uranium to be erratically distributed. According to records of the Defence Minerals Exploration Administration and K. J. Revis (oral commun., 1976), the chances of finding significant quantities of uranium ore were not considered favorable, and the project was discontinued. In 1974, 22 claims of

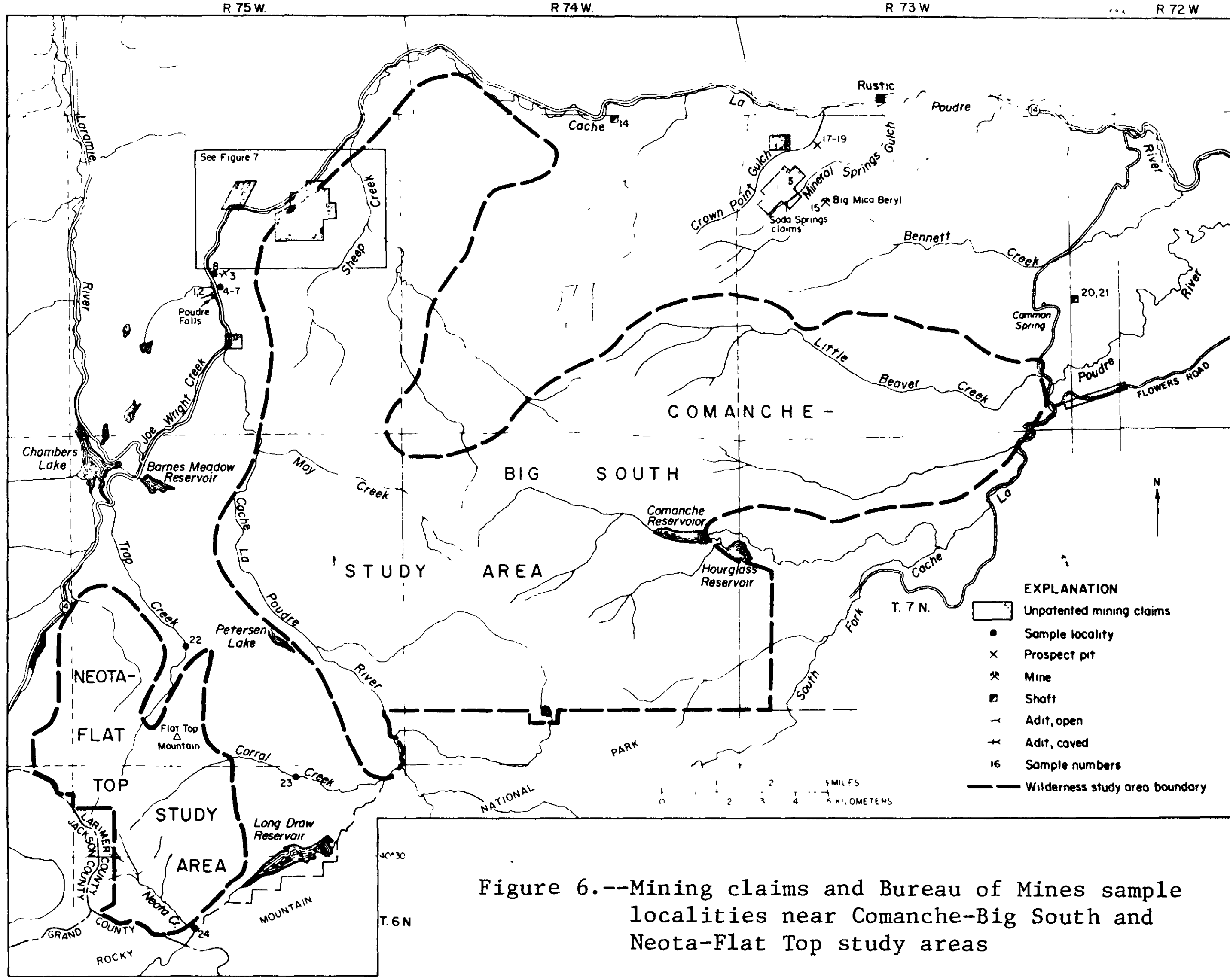


Figure 6.--Mining claims and Bureau of Mines sample localities near Comanche-Big South and Neota-Flat Top study areas

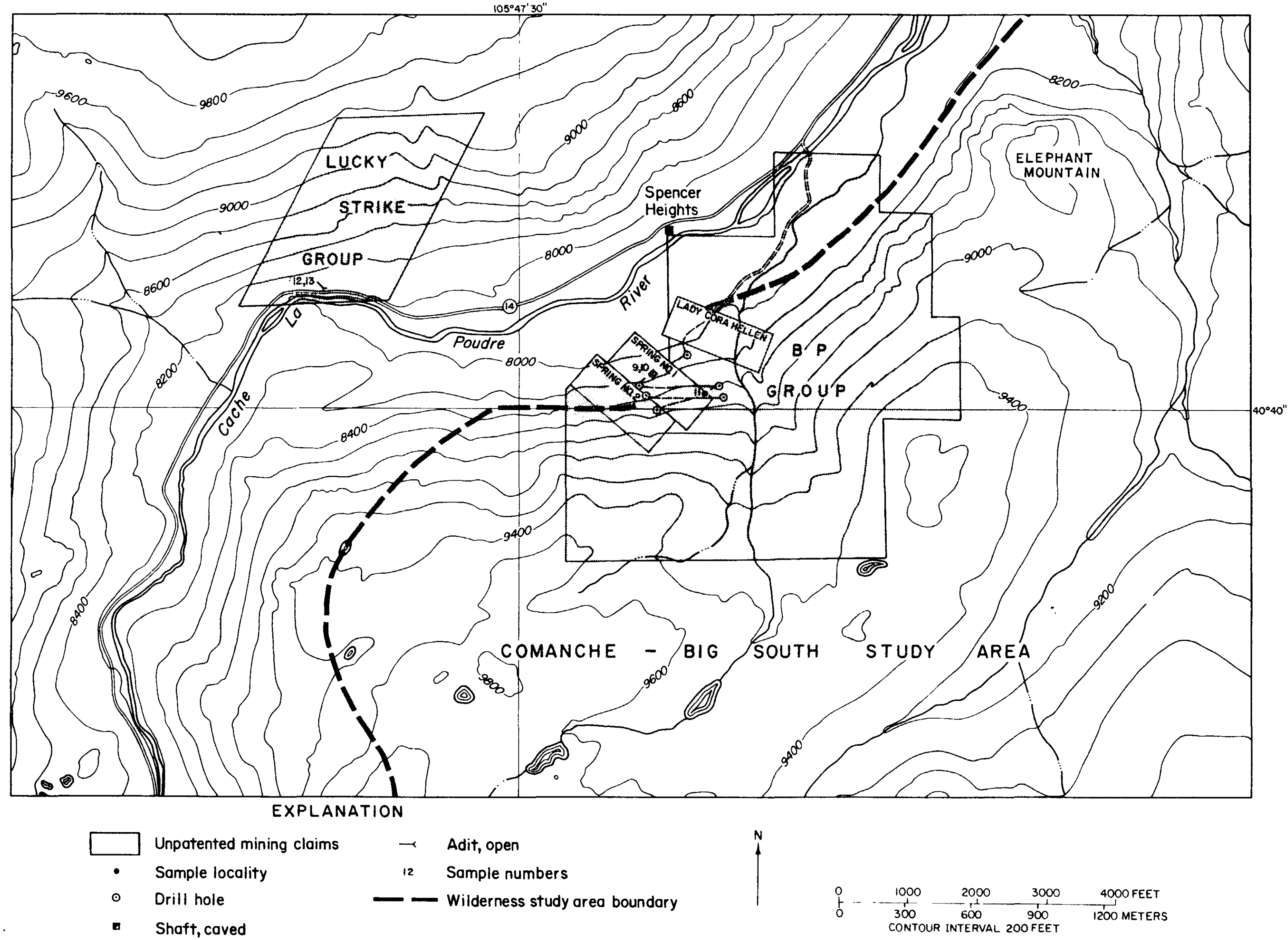


Figure 7.--Mining claims and prospects near Spencer Heights, Comanche - Big South study area.

the BP group were filed by Public Service Company of Oklahoma. These claims were staked over most of the area covered by the older claims. The company explored the prospect mainly by drilling six holes to depths of over 600 ft (180 m). Uranium was found, but the grade was low and the rock was complexly broken in the shear zone, discouraging further work (L. D. Milliken, Public Service Company of Oklahoma, written commun., 1976). Of three samples (9, 10, 11) taken by the Bureau of Mines during this investigation, sample 9 contained a trace of lead, sample 10 contained 0.1 oz silver per ton, and sample 11 contained a trace of gold, 0.1 oz silver per ton, and 0.011 percent uranium (fig. 7, tables 2 and 3).

About 1 mi (1.5 km) west of Spencer Heights (fig. 7), the Lucky Strike group of claims was located in 1955 by Ira L. Scott and Solomon Schlagel. The claimants probably were attracted to small amounts of uranium in pegmatite dikes that cut granitic gneiss. An adit about 13 ft (4 m) long beside and on the north side of Colorado Highway 14 excavated a small discontinuous pegmatite that, according to DMEA records, contained a little ore-grade uranium. Samples taken by the locators are reported to have contained as much as 0.76 percent uranium, although no rock of this grade remains exposed. Two samples (12, 13) of the most highly radioactive rock found were taken above the adit by the Bureau of Mines. Both samples assayed less than 0.002 percent U_3O_8.

A shaft 7 ft deep was dug in granitic gneiss 1 mi. (1.5 km) east of Home (north-central sec. 3, T. 8 N., R. 74 W., fig. 6). An east-trending fault is inferred to lie in the saddle where the shaft was dug, but no evidence of sheared rock was found on the dump. A sample (14) from the dump contained traces of gold, silver, and zinc, and 0.011 percent yttrium.

The Vail group of claims was located in 1958. They are described as being in the canyon of Joe Wright Creek 1.5 mi (2.5 km) northeast of Chambers Lake (fig. 6). No workings were found in that vicinity and no samples were taken.

A 9.3 ft (15 m) zigzag adit was found during this investigation 820 ft (250 m) below Poudre Falls (fig. 6) in the west bank of the river (fig. 8). The adit explores a shear zone in dark-colored gneiss that strikes N. 60° E. and dips steeply. A sample (2) was taken above the portal of the adit, across a narrow vein that strikes N. 65° E. and dips steeply; it contained a trace of lead and zinc. A sample (1) taken across a shear zone near the face contained 0.05 percent bismuth (table 3) and traces of copper, lead, zinc, and yttrium.

A caved adit is present east of the highway bridge about 1,148 ft (350 m) north of Poudre Falls. The adit bears N. 60° E. and explores a steeply dipping shear zone in granitic gneiss. The dump has been removed by erosion. Sample 3 (fig. 6), taken across the shear zone 49 ft (15 m) below the adit, contained 0.057 percent bismuth (table 3) and a trace of lead. This adit is in a large fault zone that dips almost vertically and strikes N. 55° E. Four 60-foot samples (4-7, fig. 6) were collected from the zone by grabs at 10-foot intervals. The samples contained trace amounts of lead and zinc. A pan concentrate sample (8) taken from river gravel below the bridge contained a trace of zinc and 0.014 percent yttrium.

A group of claims was located 1 mi (1.5 km) south of Poudre Falls in the late 1950's (fig. 6). A few small prospect pits were found about 0.3 mi (0.5 km) southeast and 0.6 mi (1 km) south of the mouth of Joe Wright Creek. These pits were excavated into a layer of pyritic garnet gneiss that is 3-6 ft (1-2 m) thick. Samples were collected from the pits, from outcrops nearby,

Table 2.--*Gold and silver assay values in the Comanche-Big South, Neota-Flat Top, and Never Summer study areas*

[Leader (-) indicates nothing found; Tr, trace]

Sample no.	Fire assay ounces/ton		Sample description
	Au	Ag	
1	Tr	-	40-cm chip, gneiss.
2	Tr	-	91-cm chip, gneiss.
3	Tr	Tr	76-cm chip, gneiss.
4	-	0.1	18-cm chip, gneiss and schist.
5	-	Tr	Do.
6	-	-	Do.
7	-	-	18-m grab, gneiss and schist.
8	-	Tr	Panned concentrate.
9	-	-	Dump, aplite.
10	-	.1	3.7-m chip, granite and gneiss.
11	Tr	.1	1.2-m chip, gneiss and granite.
12	-	.2	70-cm chip, pegmatite.
13	Tr	.4	76-cm chip, pegmatite.
14	Tr	Tr	Dump, gneiss.
15	Tr	.1	1.2-m chip, quartz
16	-	.3	61-cm chip, aplite.
17	-	.1	12-cm chip, gneiss.
18	Tr	.1	Dump, gneiss.
19	Tr	-	30-cm chip, gneiss.
20	-	.2	15-cm chip, gneiss.
21	-	.1	46-cm chip, pegmatite.
22	-	.1	Panned concentrate
23	Tr	-	Do.
24	-	-	Do.
25	-	.01	Dump, monzonite.
26	Tr	.1	6-m chip, rhyolite.
27	-	.4	91-cm chip, argillite and rhyolite.
28	Tr	.1	70-cm chip, shale.
29	0.01	.2	61-cm chip, quartz.
30	-	.2	8-cm chip, quartz.
31	-	.1	46-cm chip , andesite and gneiss.
32	Tr	Tr	Panned concentrate
33	.03	-	Do.
34	Tr	.1	61-cm chip, gneiss and schist.
35	-	.1	24-cm chip, gneiss and schist.

Table 2.--*Gold and silver assay values in the Comanche-Big South, Neota-Flat Top, and Never Summer study areas*--Continued

Sample no.	Fire assay ounces/ton		Sample description
	Au	Ag	
36	-	0.1	Dump, sand and clay.
37	Tr	-	Dump, gneiss.
38	Tr	.04	61-cm chip, quartz and gneiss.
39	-	.03	40-cm chip, quartz.
40	-	.1	76-cm chip, schist.
41	-	.1	21-cm chip, quartz.
42	-	.1	9-cm chip, pegmatite.
43	-	Tr	61-cm chip, quartz and schist.
44	-	.1	6-cm chip, quartz and pyrite.
45	-	.2	Dump, quartz.
46	-	.2	Do.
47	-	.2	24-cm chip, argillite and quartz.
48	-	.2	Dump, argillite and quartz.
49	-	-	91-cm chip, dacite.
50	Tr	.2	Dump, dacite porphyry.
51	Tr	.2	Dump, quartz and graywacke.
52	Tr	.4	37-cm chip, argillite.
53	0.01	.4	37-cm chip, argillite.
54	.03	1.9	37-cm chip, argillite and quartz.
55	Tr	-	9-cm chip, quartz.
56	.01	.1	76-cm chip, quartz.
57	-	-	46-cm chip, altered shale?
58	Tr	.2	15-cm chip, argillite.
59	Tr	.1	Dump, argillite.
60	Tr	.4	46-cm chip, altered shale?
61	-	.4	Dump, gneiss.
62	-	-	Do.
63	-	.1	70-cm chip, argillite.
64	Tr	.1	1.1-m chip, argillite.
65	-	.3	Surface grab, gneiss.
66	.02	-	91-cm chip, gneiss.
67	-	.2	Dump, gneiss.
68	-	-	Do.
69	Tr	-	Dump, quartz.
70	Tr	.2	34-cm chip, argillite.

Table 2.--*Gold and silver assay values in the Comanche-Big South, Neota-Flat Top, and Never Summer study areas*--Continued

Sample no.	Fire assay ounces/ton		Sample description
	Au	Ag	
71	-	0.2	Dump, gneiss.
72	-	.2	Do.
73	-	.4	79-cm chip, gneiss.
74	-	.2	Dump, pegmatite and gneiss.
75	-	.1	Dump, gneiss.
76	0.02	.6	30-cm chip, gneiss.
77	Tr	.2	Dump, quartz.
78	.01	.2	Dump, gneiss.
79	.01	-	76-cm chip, gneiss.
80	.14	6.1	Grab, quartz.
81	.03	.9	Dump, gneiss.
82	.02	-	Dump, gneiss and quartz.
83	.03	1.0	73-cm chip, quartz.
84	.03	.3	30-cm chip, quartz.
85	Tr	.3	Dump, gneiss.
86	-	-	Do.
87	-	.3	Surface grab, gneiss.
88	Tr	-	Dump, gneiss.
89	-	-	46-cm chip, altered rhyolite.
90	.01	.1	1.8-m chip, altered rhyolite.
91	Tr	-	Dump, altered rhyolite.
92	.02	-	Dump, gneiss.
93	.02	-	1-m chip, gneiss.
94	.01	-	Dump, gneiss.
95	.02	-	Do.
96	-	-	61-cm chip, altered rhyolite.
97	-	Tr	30-cm chip, quartzite.
98	-	.3	52-cm chip, conglomeritic quartzite.
99	-	.1	Dump, rhyolite.
100	-	.2	Do.
101	-	.2	Dump, breccia.
102	-	.4	Dump, quartz.
103	-	-	7.6-m chip, monzonite.

Table 3.--*Spectrographic and radiometric analyses of selected samples from the Comanche-Big South, Neota-Flat Top, and Never Summer study areas*

[Leaders (-) indicate not detected. See table 4 for sample descriptions.]

Sample no.	Semiquantitative spectrographic analyses (percent)		Radiometric analyses (percent)
	Bi	La	U_3O_8
1	0.051	-	-
3	.057	-	-
4	-	0.020	-
11	-	-	0.011
15	-	.021	-
16	.070	-	.043
18	-	.035	-
24	-	.041	.048
32	.049	.041	-
73	.042	-	-
74	.045	-	-
87	.044	-	-
88	.042	-	-
91	.042	-	-

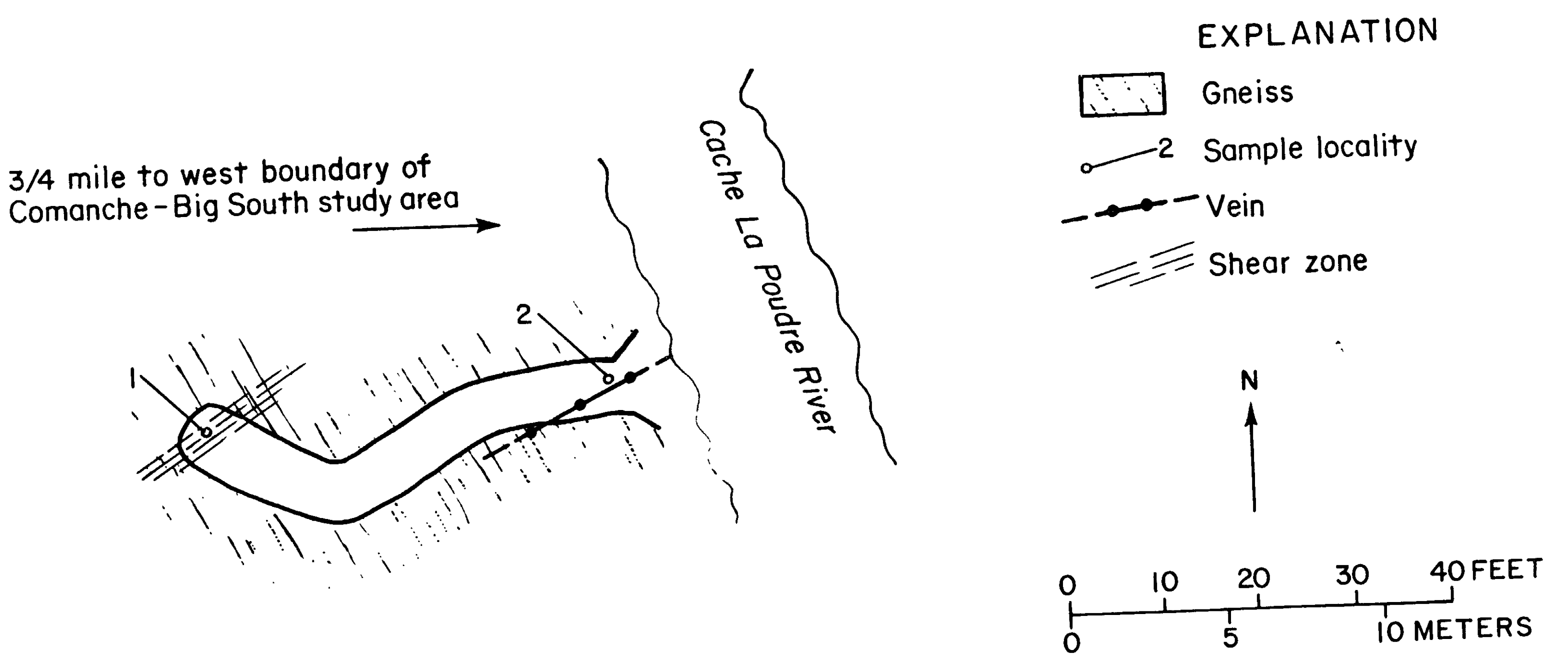


Figure 8.--Plan of adit near Poudre Falls, showing sample localities.

and from a pile of pyrite-rich rock near a cabin southeast of the mouth of Joe Wright Creek. Spectrographic analyses of these samples did not disclose significant contents of metals.

The drainage of Mineral Springs Gulch, southwest of Rustic, contains two prospects in pegmatite that are about 2 mi (3 km) north of the study area boundary (fig. 6). The first is near the divide between Mineral Springs Gulch and Bennett Creek. Several pits have been dug in a pegmatite dike that strikes about N. 30° E. and dips almost vertically. This prospect is on the Big Mica Beryl claims located in 1966. The name of the claims implies that beryl may have been found, although none was identified during this investigation. The dike contains mostly quartz, alkali feldspars, and muscovite. At a few places the dike contains pods from 6 to 9 ft (2 to 3 m) across that are composed of about 50 percent muscovite, probably of scrap grade. A sample (15) from one of the pits consisted mostly of quartz and contained traces of lead and silver (table 2).

A second prospect in this vicinity, about 4,000 ft (1,200 m) northwest of the Big Mica Beryl, is in NE 1/4 sec. 7, T. 8 N., R. 73 W., on a point between Mineral Springs Gulch and Crown Point Gulch. This prospect is on the Soda Springs claim group, located in 1976 and shown on figure 6. Here an open cut about 13 ft (4 m) wide, 33 ft (10 m) long, and 16 ft (5 m) deep explores a pegmatite dike striking northeast and dipping almost vertically. The dike is composed of feldspar, quartz, and a little biotite. Minute fractures in the minerals are coated with the yellow secondary uranium mineral, β-uranophane (identified by P. L. Hauff, written commun., 1977). A Geiger counter reading of 1.5 MR/hr was obtained in the cut. Analysis of sample 16 from the cut showed traces of bismuth, lead, and yttrium, and 0.043 percent U_3O_8 (table 3). Further prospecting might be warranted.

At Mayesville (or Maysville) the remains of several log cabins are present, and several caved adits in the vicinity were sampled. Three samples (17, 18, 19) (fig. 6) contained traces of silver and copper.

Two shafts in gneiss were found northeast of the study area about 0.6 mi (1 km) east of Camman Spring near the township line between sec. 24, T. 9 N., R. 73 W., and sec. 19, T. 8 N., R. 72 W. (fig. 6). One is 33 ft (10 m) deep; the other is caved to 2 m. Samples 20 and 21, from the collars of the shafts, contained only traces of metals.

Two quarries are located along the Flowers Road east of the study area and east of the South Fork Cache la Poudre River in sec. 31, T. 8 N., R. 72 W. (fig. 6). The first is along a large barren quartz vein located in a saddle near the center of the west line of sec. 31 on the Green Quartz Beryl claims, which were located in 1956. Some of the quartz is greenish gray and has been used as a decorative stone called prase and chrysoprase.

The other quarry, called the White Rock quarry, is in the NE 1/4 of the same section. It is on the Quartz Silica Silicon claims, which are not shown on figure 6. The quarry has been developed in a body of white quartz that has also been used as a decorative stone. It may be the quartz core of a pegmatite or a large barren vein.

Interpretation of geochemical data

Few of the geochemical samples from the Comanche-Big South area give analytical results that are higher than might be expected from barren rock. The igneous and metamorphic rocks locally contain as much as 200 ppm copper and 200 ppm zinc (P6-206), 7 ppm molybdenum (314), and 70 ppm lead, and a trace of tin (P6-203). Sample localities are shown on plate 2, and analytical data of anomalous samples are given in table 4. Such amounts are not at all unusual for the kind of rock samples represented by each of these analyses, and, although these amounts may seem to be somewhat unusual, they are not thought to have much significance in the search for mineral deposits. Many of the samples of fault gouge, limonite-stained rock in fault zones, and small veinlets in and near fault zones contain low amounts of several metals. Most of these samples were collected just outside the north boundary of the Comanche-Big South area in the general vicinity of prominent faults. Sample 336, which contains 7 ppm silver, 70 ppm bismuth, 10 ppm molybdenum, and 150 ppm lead, consisted of quartz from veinlets about 1 in. (1-2 cm) thick from a fault zone about 0.7 ft (0.2 m) thick. Such samples clearly indicate that mineralizing solutions passed through some of the faults, but the very low values and the absence of visible lodes of consequential size indicate that the area has only a low probability of containing significant resources. The lodes explored in the Home and Mayesville districts (Lovering and Goddard, 1950) may have been similar.

Several stream-sediment samples from the Comanche-Big South area contain barely detectible amounts of silver, 50 ppm lead, and 100-200 ppm lanthanum (table 5). The lanthanum is probably present in trace minerals in the country rock--such as allanite--that are enriched in the sediment samples as a result of a natural placering action in the streams. Lanthanum is generally two to three times more abundant in the stream sediments than in rocks from the same area. The one stream-sediment sample (P030) that contains 200 ppm yttrium can be explained similarly. A second sample collected about 20 ft from P030 contained only 20 ppm yttrium. Silver and lead are likewise more abundant in stream-sediment samples than in fresh rocks. Both of these elements are present in samples of weakly mineralized rocks along faults, however, and it is possible that the numerous samples containing trace amounts of silver and 50 ppm lead, reflect such mineralization. The absence of any significantly higher values for either silver or lead, the fact that the silver values are below the limit of determination of the spectrographic technique, and the wide areal dispersal of these samples suggest that little importance can be attached to them.

Conclusions

The findings of this study suggest that the Comanche-Big South area has low favorability for the occurrence of metalliferous mineral resources, with the possible exception of uranium. Known lode occurrences of base and precious metals are evidently confined to the major fault zones such as those that cross the northern part of the area and that have been prospected at various places along the Poudre River. None of these prospected lodes, such as in the Home and Mayesville districts, has been productive, and none of the fault zones is known to be appreciably mineralized where they cross the study area. The uranium lode at Spencer Heights, while also not productive to date, is a type of deposit that could prove to be important. It is similar in some respects to the Schwartzwalder deposit in Jefferson County, Colorado. All the fault zones in the Comanche-Big South area are considered to be worthy of additional exploration for uranium.

Neota-Flat Top area

No evidence was found in the official records or on the ground for prospecting or claim staking in the Neota-Flat Top study area. The nearest activities of this kind are near Chambers Lake 2 mi (3 km) north of the area and near Lake Agnes 2 mi (3 km) west of the area.

Interpretation of geochemical data

Geochemical samples of the rhyolites and of stream sediments from streams that drain the rhyolites indicate that these rocks contain notably higher amounts of molybdenum, tin, and zinc (tables 6 and 7) than do the Precambrian crystalline rocks in the project area. Molybdenum content in the rhyolites averages about 10 ppm and has a maximum of 20 ppm. Niobium ranges from 20 to 100 ppm, lanthanum from 100 to 300 ppm. Tin was barely detected in all samples (less than 10 ppm) except for two that contain 10 and 15 ppm tin. Zinc was detected in about half the samples; none of which contains more than 200 ppm. Some samples contain as much as 50 ppm lead as well. Tungsten is commonly associated with these elements in rocks of this type, but it was not detected in the samples of rhyolite or in associated stream sediments; however, a panned concentrate (sample 22, fig. 6) collected from Trap Creek by the Bureau of Mines contained 0.048 percent tungsten. These elements are known to have an affinity for silicic igneous rocks such as rhyolites, and the amounts present in the Neota-Flat Top samples are not considered unusual. The geochemical analyses do not show a concentration of elements that would be of economic interest.

Conclusions

No geological, geophysical, or geochemical evidence was found for mineralization in the Neota-Flat Top area. The area contains no known mineral resources.

Never Summer area

Mining claims, mineral prospects, and recent exploration

The prospected area known as Teller mining district lies largely in the headwaters of Jack Creek just south of the Never Summer study area (fig. 1). Little is known about the Teller district. Apparently prospectors were very active in the area in the late 1870's and early 1880's (Vanderwilt, 1947), and as a result Teller City, which now contains the remains of a few dozen buildings, sprang up along Jack Creek near the western tip of the study area. Teller City represents the overly optimistic hope that the Teller mining district would become another of Colorado's bonanza camps. Teller City was founded in 1879 but it was short lived. The prospects proved disappointing and within a few years the town was abandoned.

Mines and prospects are scattered along the valley of Jack Creek and up the mountain sides north and south of the creek (fig. 9). Most of these are small excavations that investigated mineralized fracture zones. A few veins were evidently of sizable proportions, however, and probably produced some ore that was valued mostly for its silver. Although no record of production has been found, the Endomile mine may have yielded a significant quantity of

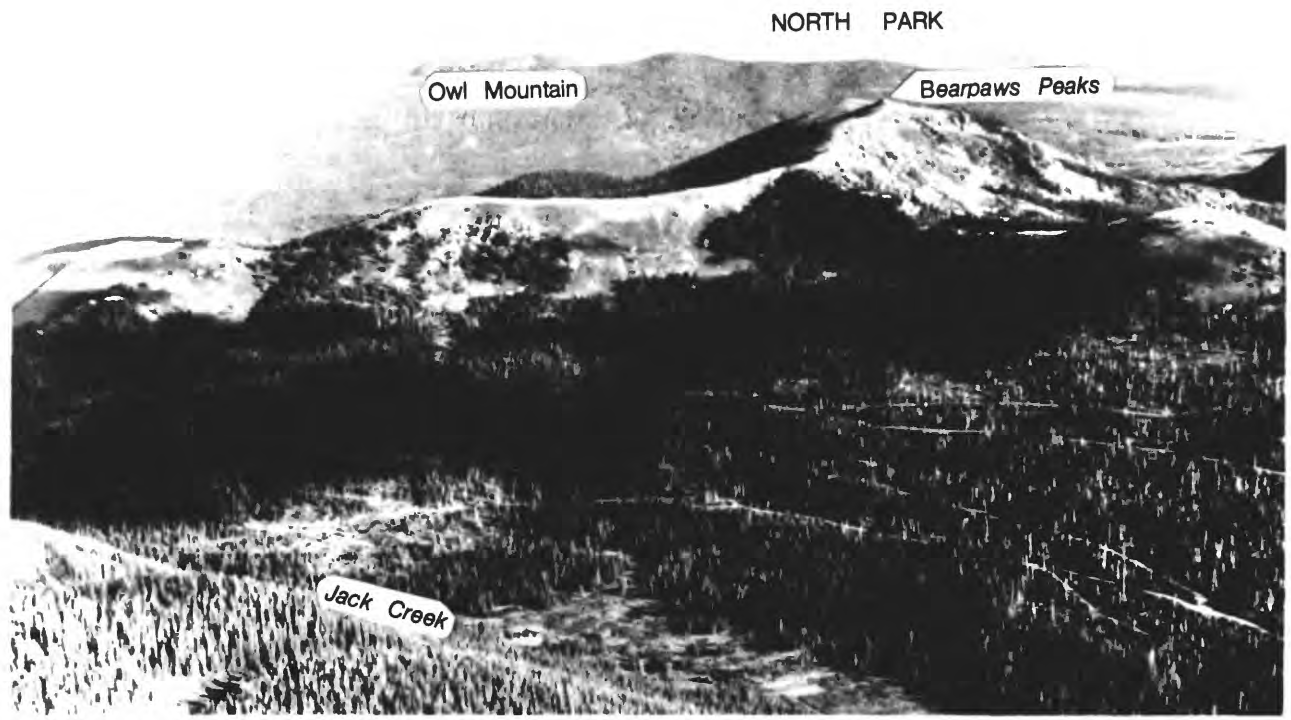


Figure 9.--View to northwest, showing the north slope of upper Jack Creek valley. Basin to right of Bearpaws Peaks is in the Never Summer study area.

silver ore. In 1974, AMAX Exploration, Inc., commenced a drilling program to explore a rhyolite-porphyry plug that is covered by surficial deposits in Jack Creek valley. Five holes had been drilled as of 1976, to judge by drill stations along the road. The results of this exploration have not been made public.

Chevillon (1973) mapped the location of several prospects in the area between Jack Creek and South Fork Michigan River, and we found a few others in the same area, particularly north of Mount Cindy (pl. 1). We also found other prospect workings north of South Fork Michigan River that evidently explored the same zone of north-trending veins that are present south of the river. The area encompassing all of these prospects, is for the purpose of this report, included in the Teller mining district.

About 20 patented mining claims in the Jack Creek drainage (fig. 10) are listed in the records of the Bureau of Land Management, Denver, Colorado.

Several individual unpatented claims and groups of claims are within and near the study area (fig. 11). One of the largest of the claim groups is the ZOT group, which consists of about 55 claims and encompasses much of the headwater area of Jack Creek and thus much of the Teller district. The ZOT group was staked in 1974 by AMAX Exploration, Inc. Another large group of about 26 claims, the CM group, extends north from the vicinity of Baker Pass and Mount Cumulus. This group, which is largely within the study area, was reportedly staked on the basis of the geochemical anomaly over the Mount Cumulus stock.

A block of about 60 claims known as the Bear Paw group straddles South Fork Michigan River for a distance of over 2.4 mi (4 km) near the west boundary of the study area. The Bear Paw group was staked in 1956, 1957, and 1958, purportedly to test for the presence of platinum-group metals in the gravels that cover the broad, flat valley. According to U.S. Forest Service records, a number of bulldozer trenches were dug and a concentrating plant and several auxiliary buildings were erected. At about the same time, a short adit (fig. 12) was driven S. 65° E. about 36 ft (11 m) into the east bank of the river just above the trace of the Never Summer thrust. At the portal the adit penetrates a gray porphyritic dike and continues into Precambrian schist and pegmatite. As a result of being only several feet east of the thrust, all rocks on the dump are sheared and hydrothermally altered to varying degrees. Sample 31 (table 2), collected from a minor fault zone about 16 ft (5 m) in from the portal, contained 0.1 oz of silver per ton. Sample P6-046 (pl. 2) of the altered porphyry dike contained no elements in excess of normal amounts. Only trivial mineralization is evident in the area.

The Bear Paw claims were staked with the expectation that platinum-group metals would be found in the placer ground west of the adit. Mineral examiners of the U.S. Forest Service studied the Bear Paw prospects in the 1960's but found no platinum-group metals. We panned gravels from bulldozer cuts; analyses of the concentrates (samples 32 and 33, table 2, fig. 11) show traces of gold, silver, lead, and yttrium. The gravel also contains appreciable garnet that might be useful as an abrasive, but the grade and quantity are probably insufficient to be of commercial importance.

About 3 mi (5 km) upstream from the west boundary of the study area on the South Fork Michigan River, several prospect workings, mostly short adits, were dug into the steep, heavily timbered slopes just above the blanket of surficial deposits that mantles the valley bottom and lower slopes. These excavations drifted along narrow veins that occupy faults that trend about N. 10°-35° E. and dip steeply. The country rock is Precambrian gneiss and pegmatite.

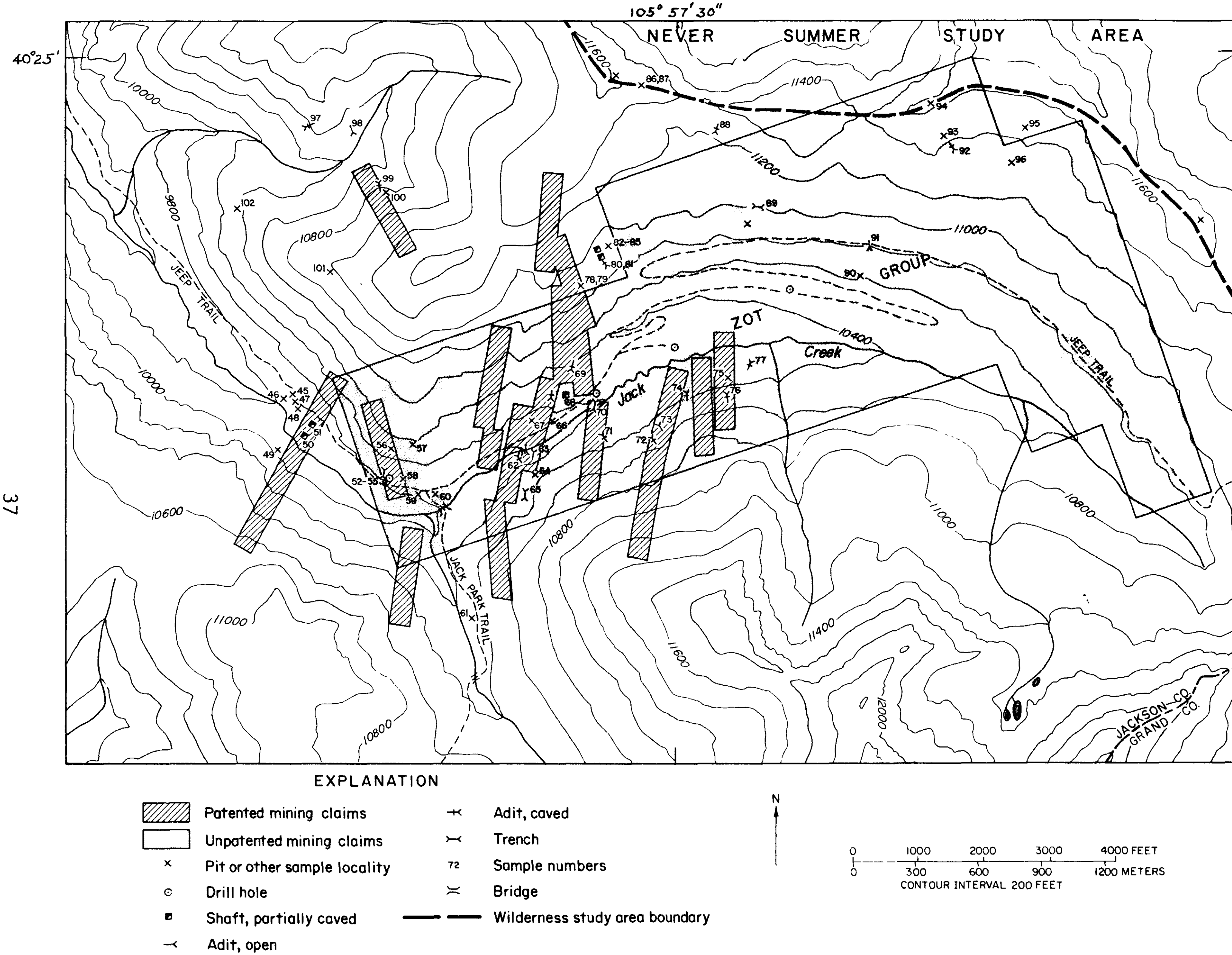


Figure 10.--Patented mining claims and Bureau of Mines sample localities, Teller mining district, Jackson County, Colorado.

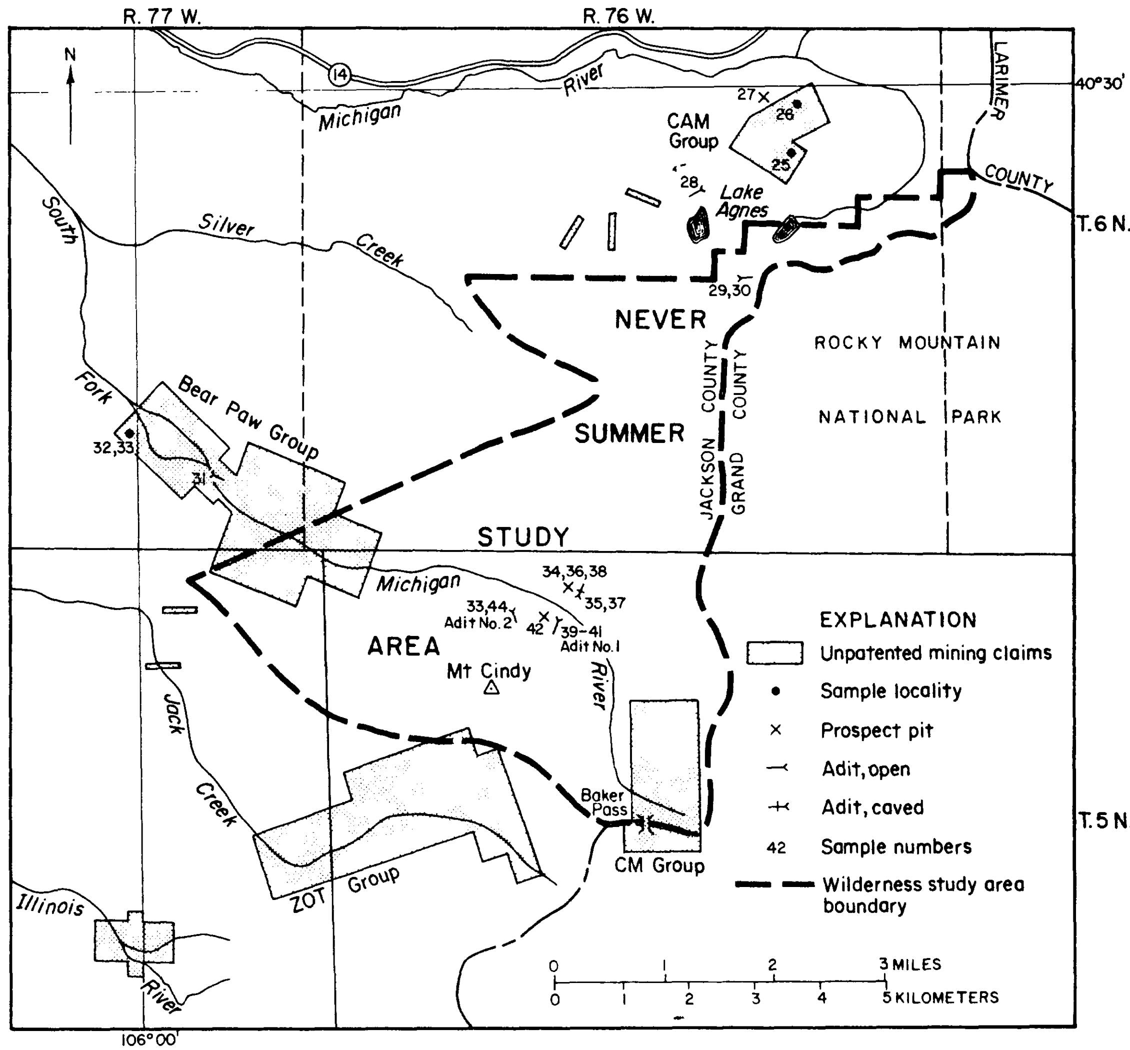


Figure 11.--Unpatented mining claims and Bureau of Mines sample localities, Never Summer study area and vicinity, Jackson County, Colorado.

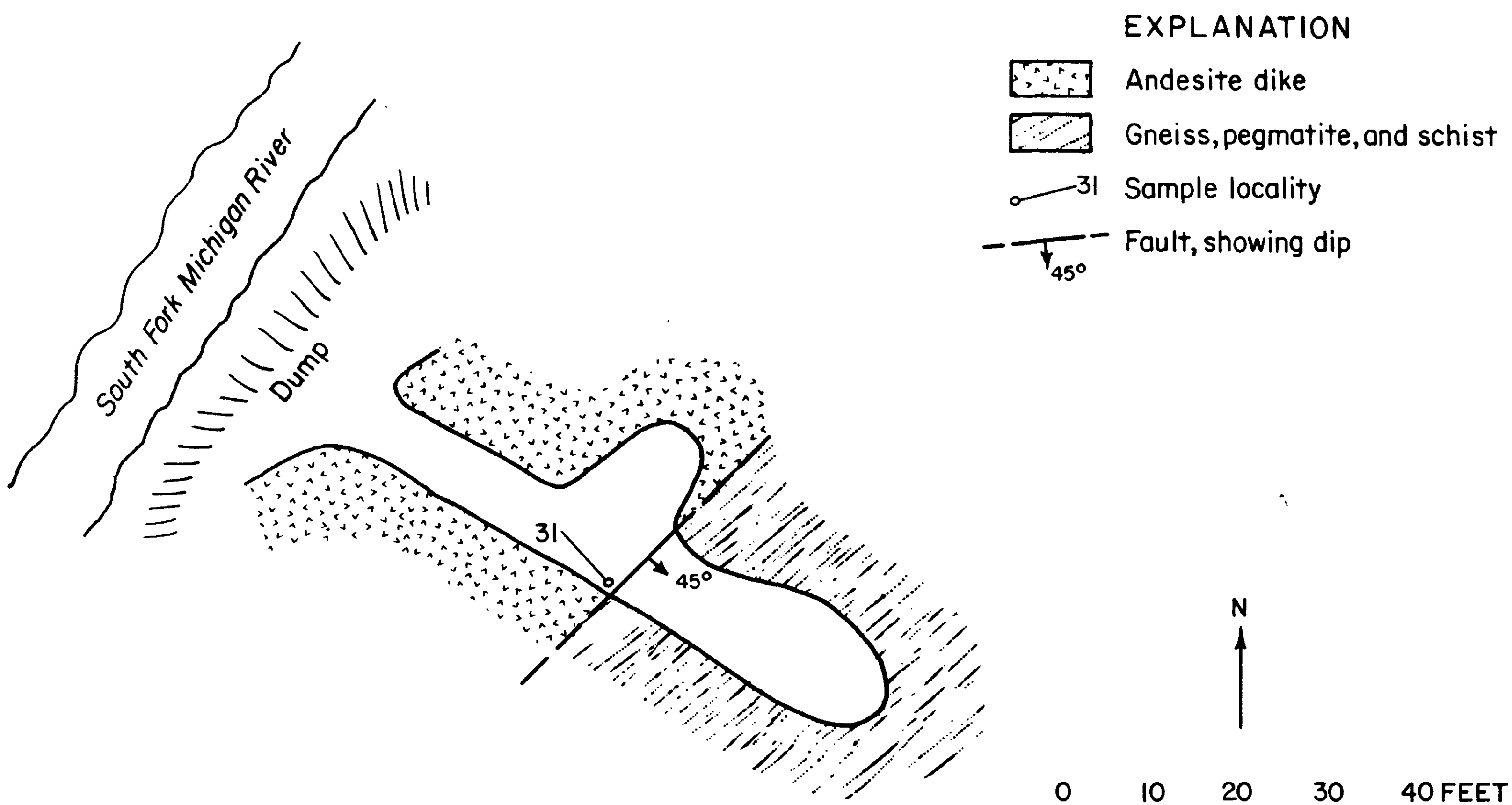


Figure 12.--Plan of the Bear Paw adit, west of the Never Summer study area, showing sample locality.

The adits on the north side of the South Fork Michigan River are caved; the size of the dumps indicates that they were no more than a hundred or so feet long. The adits and prospect pits in this area are mostly in amphibolite although an outcropping vein 0.5 mi (0.8 km) west of the cluster of prospects follows a felsic dike 10 ft (3 m) wide.

Two adits on the south side of the river are open and were mapped (figs. 13 and 14). Adit number 1 (fig. 13) is flooded at 65 ft (20 m) in from the portal, but it was open for about another 100 ft (30 m). Adit number 2 (fig. 14) follows a fracture that trends about south-southeast and dips about 60° to the west. Assays of samples from these adits show from 0.1 to 0.3 oz of silver per ton and very small amounts of lead and zinc.

All workings in the Jack Creek valley are caved or flooded. The Endomile mine, the large brown dump on the south side of the creek about 1,640 ft (500 m) east of the junction with the road to Jack Park, was probably the largest mine in the district.

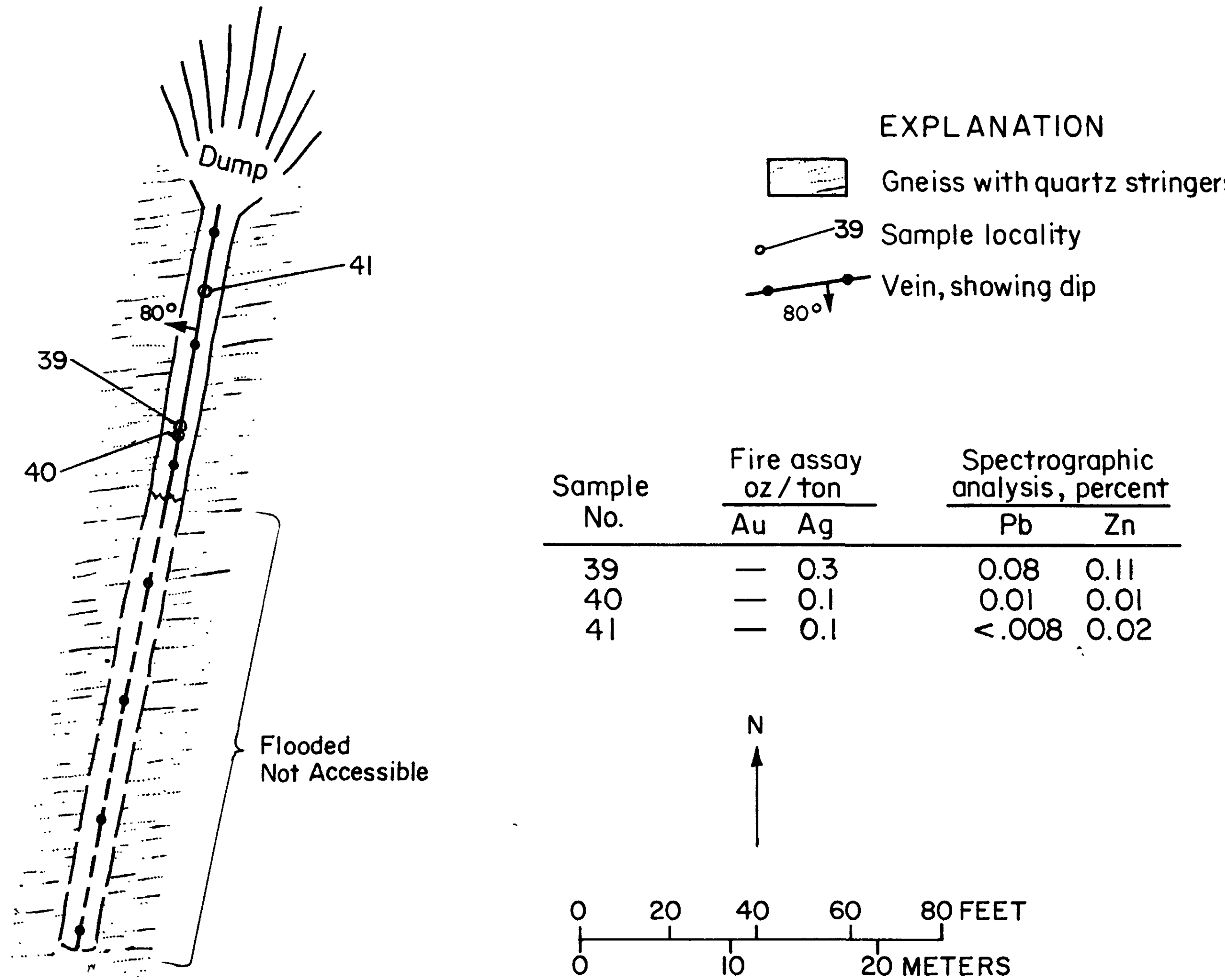
The veins in the Teller district are typical fissure veins exhibiting abundant evidence of open-space filling. They are commonly 0.5-12 in wide. The veins consist predominantly of comb quartz and pyrite; adularia, fluorite, and sericite are common; and carbonate minerals, clay minerals, arsenopyrite, and barite are locally present. Other sulfides found include sphalerite, galena, and at one place chalcopyrite. The distribution of vein minerals is shown on figure 15. The high silver, antimony, and molybdenum values in the analyses (tables 8 and 9) suggest the presence of one or more sulfosalts and of molybdenite, but these minerals were not identified.

A number of mining claims and prospects are in the vicinity of Lake Agnes, just north of the Never Summer area (fig. 11). The CAM group of claims was located in 1969 0.6-1.2 mi (1-2 km) northeast of Lake Agnes. The area of the claims is underlain mostly by Precambrian gneiss in a thin remnant of the upper plate of the Never Summer thrust. Pierre Shale and other Mesozoic formations of the lower plate crop out north and south of the remnant of gneiss. The gneiss, the sedimentary rocks, and the thrust itself are intruded by small fine-grained intrusive bodies. No evidence of significant workings or mineral deposits was found at the claims, but two samples (25, 26) contained traces of gold and silver and 0.1 percent tellurium.

North of the CAM group and just below the Michigan Ditch, several bulldozer cuts have explored a north-trending, vertical fault zone that separates Pierre Shale from intrusive rhyolite. The remains of a possible adit are preserved at the top of the cuts. This prospect is on Colorado State Forest land. No galena was seen at the site, but a specimen 8 in. (20 cm) long, consisting mostly of galena, was shown by a local resident who reported that it came from this prospect. A sample (27, fig. 11) from above the adit in fault gouge and iron-stained crushed shale contained traces of lead and zinc and 0.4 oz of silver per ton.

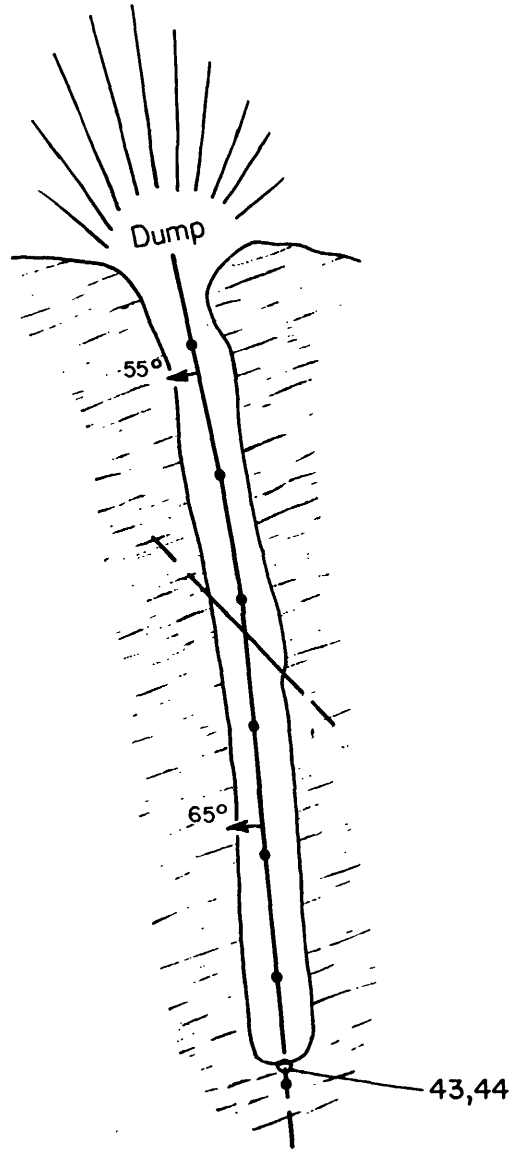
About 1,300 ft (400 m) north of Lake Agnes at an elevation of 10,500 ft (3,200 m), an adit 10 ft (3 m) long has been driven in a southwest direction into iron-stained Pierre Shale. A sample (28) from the face contained a trace of silver.

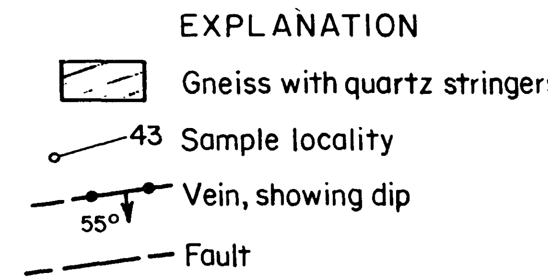
An adit at the base of the cliffs, southeast of Lake Agnes at an altitude of about 11,800 ft (3,600 m) (fig. 16) was driven S. 85° E. a distance of 150 ft (47 m) in quartz monzonite. The adit follows a veinlet about 3 in. (8 m) wide containing quartz crystals, calcite, and epidote. A sample (29) from the back of the adit, 82 ft (25 m) from the portal, contained 0.01 oz of gold per ton and 0.2 oz of silver per ton. A sample (30) from an outcropping narrow vein 20 ft (6 m) southeast of the portal--perhaps the same vein as in the adit--contained 0.2 oz of silver per ton.



Sample No.	Fire assay oz/ton		Spectrographic analysis, percent	
	Au	Ag	Pb	Zn
39	—	0.3	0.08	0.11
40	—	0.1	0.01	0.01
41	—	0.1	<.008	0.02

Figure 13.--Plan of adit No. 1, south side of South Fork Michigan River, Never Summer study area, showing sample localities.





Sample No.	Fire assay oz/ton Au	Fire assay oz/ton Ag
43	—	Tr
44	—	0.1

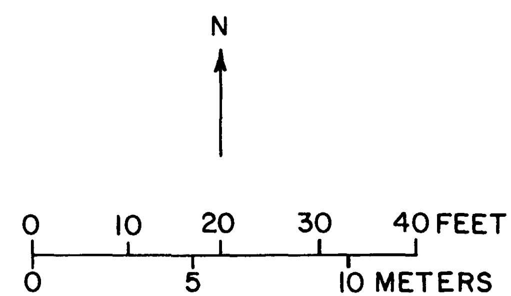


Figure 14.--Plan of adit No. 2, south side of South Fork Michigan River, Never Summer study area, showing sample localities.

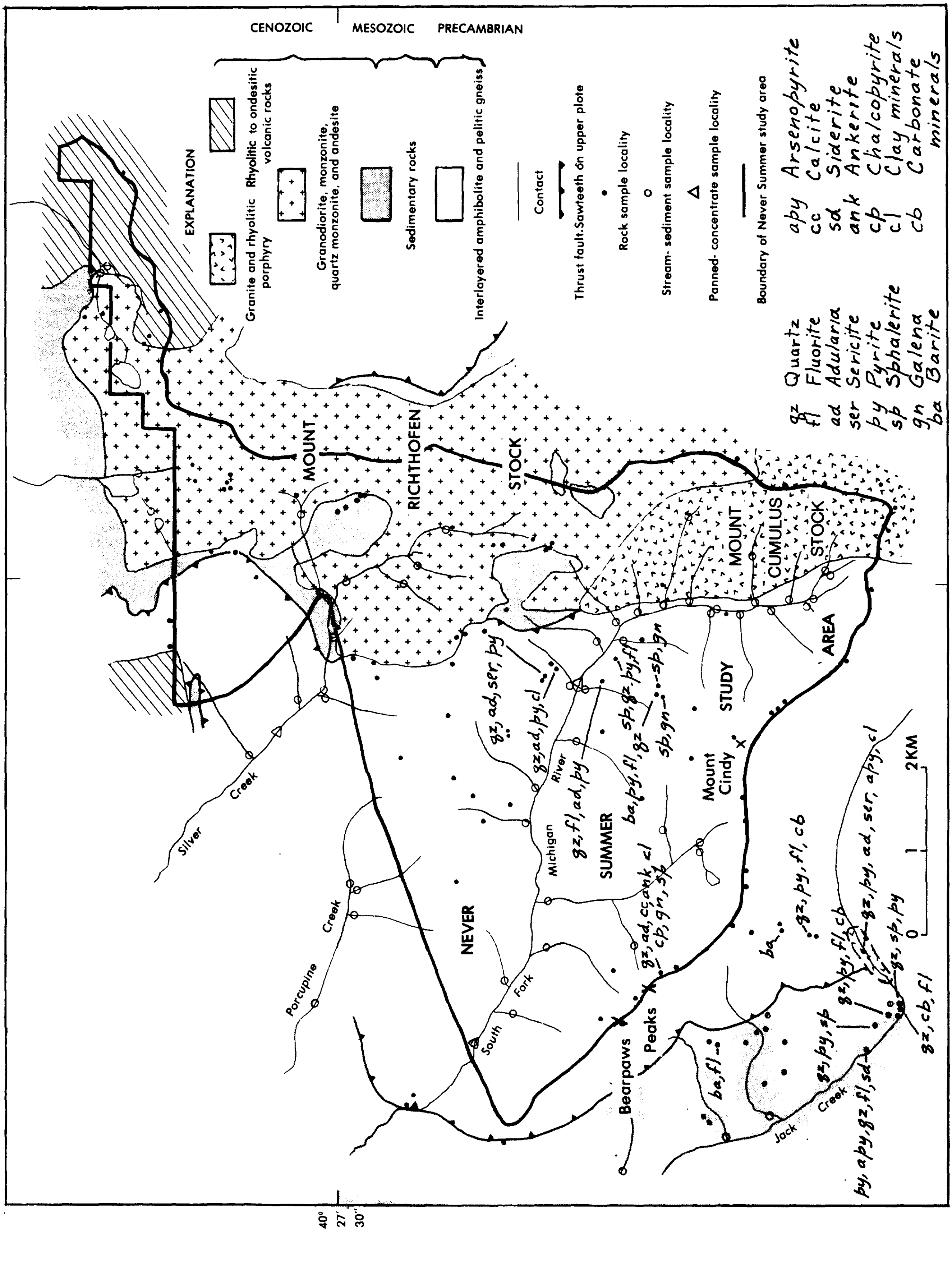


Figure 15.--Distribution of vein minerals at selected localities in the Never Summer study area and adjacent areas.

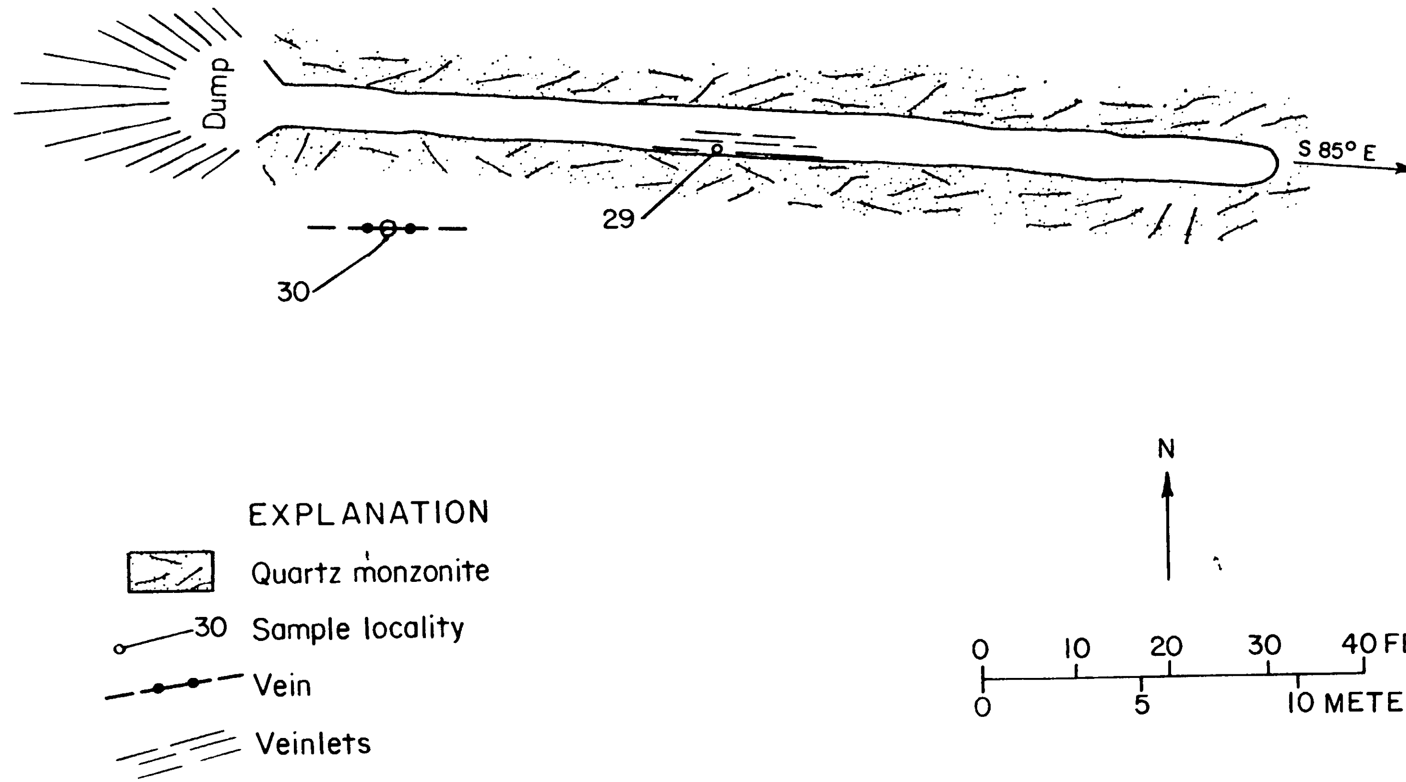


Figure 16.--Plan of adit southeast of Lake Agnes, Never Summer study area, showing sample localities.

Several mining claims have been staked west of Lake Agnes, over iron-stained Pierre Shale. No evidence for mineralization other than the limonitic shale was found.

Numerous muscovite-bearing pegmatites cut the Precambrian gneisses in the vicinity of Baker Pass. One of these bodies has been prospected. Although crystals up to 4 in. (10 cm) across are common in these bodies, imperfections in the crystals cause the quality to be low--probably mostly, if not entirely, of scrap grade. Nevertheless, a very small submarginal resource of mica is present in this part of the Never Summer area.

Interpretation of geochemical data

The Never Summer area, in contrast to the Neota-Flat Top and Comanche-Big South areas, is mineralized to a notable extent, and this fact is reflected in the geochemical data. Chevillon (1973) conducted a geochemical study of part of the Never Summer area. He collected stream-sediment and bank-sediment samples, concentrating on the tributary of the South Fork Michigan River that flows north from the west side of Mount Cindy. These samples were analyzed for copper, lead, zinc, and molybdenum, and the results were generally comparable to ours. He concluded that the anomalous metals in the sediments were derived from mineralized rocks along faults.

Our study included the collection of rock samples as well as stream sediments, and the rock samples included both mineralized and fresh rocks. The analyses (tables 8 and 9) indicate clearly that a mineralizing fluid has percolated along innumerable joints, fractures, and faults depositing small veins or merely trace amounts of several metals. Many of these samples contain anomalous amounts of silver, molybdenum, lead, zinc, arsenic, and antimony. The area that has the highest metal values is the Teller mining district, as defined by the prospected lodes. Mount Cindy is the approximate center of the mineralized area. The richest samples came from dumps, where rocks representing the best veins that have been discovered are available for sampling.

Figures 17 through 22 show the sample localities in and near the Never Summer area and, by symbols, which samples are anomalous. The distribution of anomalous samples indicates that the strongest mineralization was in the South Fork Michigan River and Jack Creek drainages, and that in Silver Creek and other drainages to the north mineralization was weaker. Stream-sediment samples indicate the weaker mineralization to the north more clearly than rock samples do, and certain metals, silver for example, show this more than other metals.

Stream-sediment samples indicate that mineralization is centered in the Mount Cindy-Bearpaws Peaks area and in the Mount Cumulus stock. The citrate-soluble heavy-metals test (cxHM) on 54 samples (fig. 21) gives highly anomalous results on virtually every sample collected from streams draining these areas and very few anomalous results from the northern part of the area. As expected, the results for zinc in stream sediments (fig. 22) are similar since the cxHM test is most sensitive for zinc. Results for lead (fig. 18) are comparable except that the range of values is much lower than for zinc. Silver (fig. 17) and molybdenum (fig. 19) in anomalous amounts in the stream-sediment samples are much more widespread than the other metals, but it is clear that the Mount Cumulus stock is a source of molybdenum. The erratic distribution of molybdenum could be affected by water chemistry although there is no reason to assume that the pH should vary among the streams. Arsenic was barely detected in only one stream-sediment sample (P6-143, table 9) and antimony was detected in none.

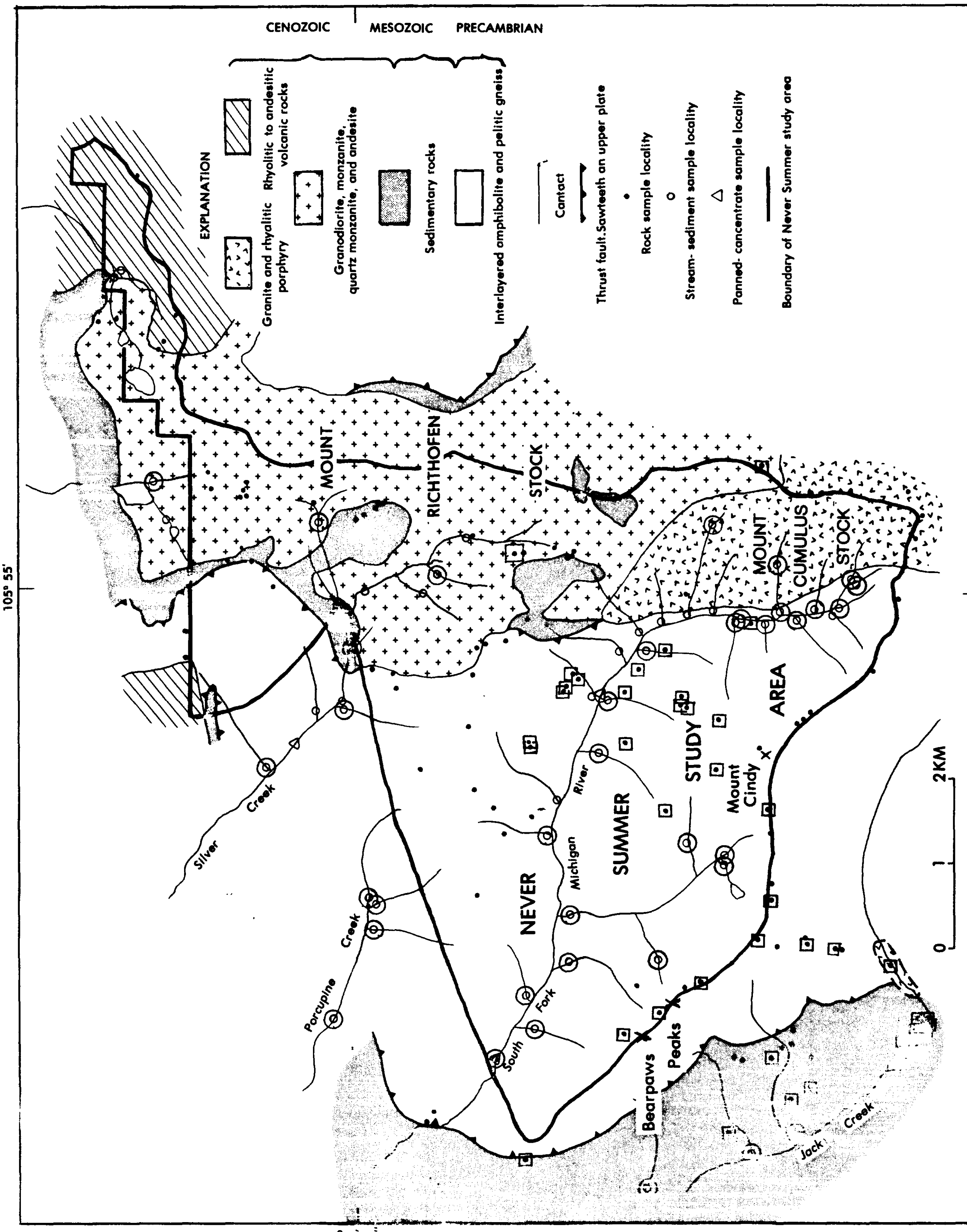


Figure 17.--Geochemical map showing distribution of silver in and near the Never Summer study area. Anomalous stream-sediment samples (large open circles) contain 0.5 ppm or more silver; anomalous rock samples (open squares) 1 ppm or more silver (semiquantitative spectrographic analysis).

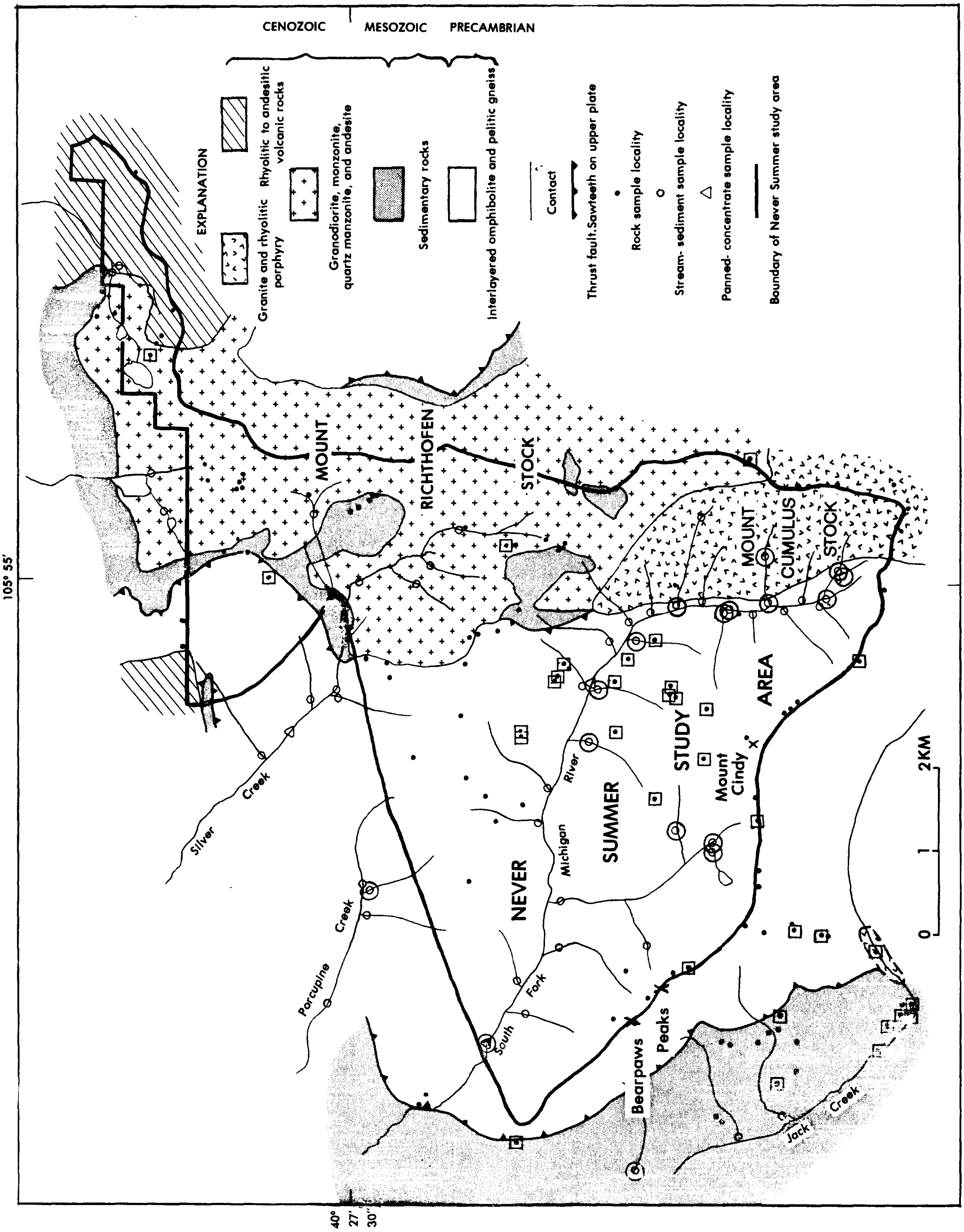


Figure 18.--Geochemical map showing distribution of lead in and near the Never Summer study area. Anomalous stream-sediment samples (large open circles) and rock samples (open squares) contain 100 ppm or more lead (semiquantitative spectrographic analysis).

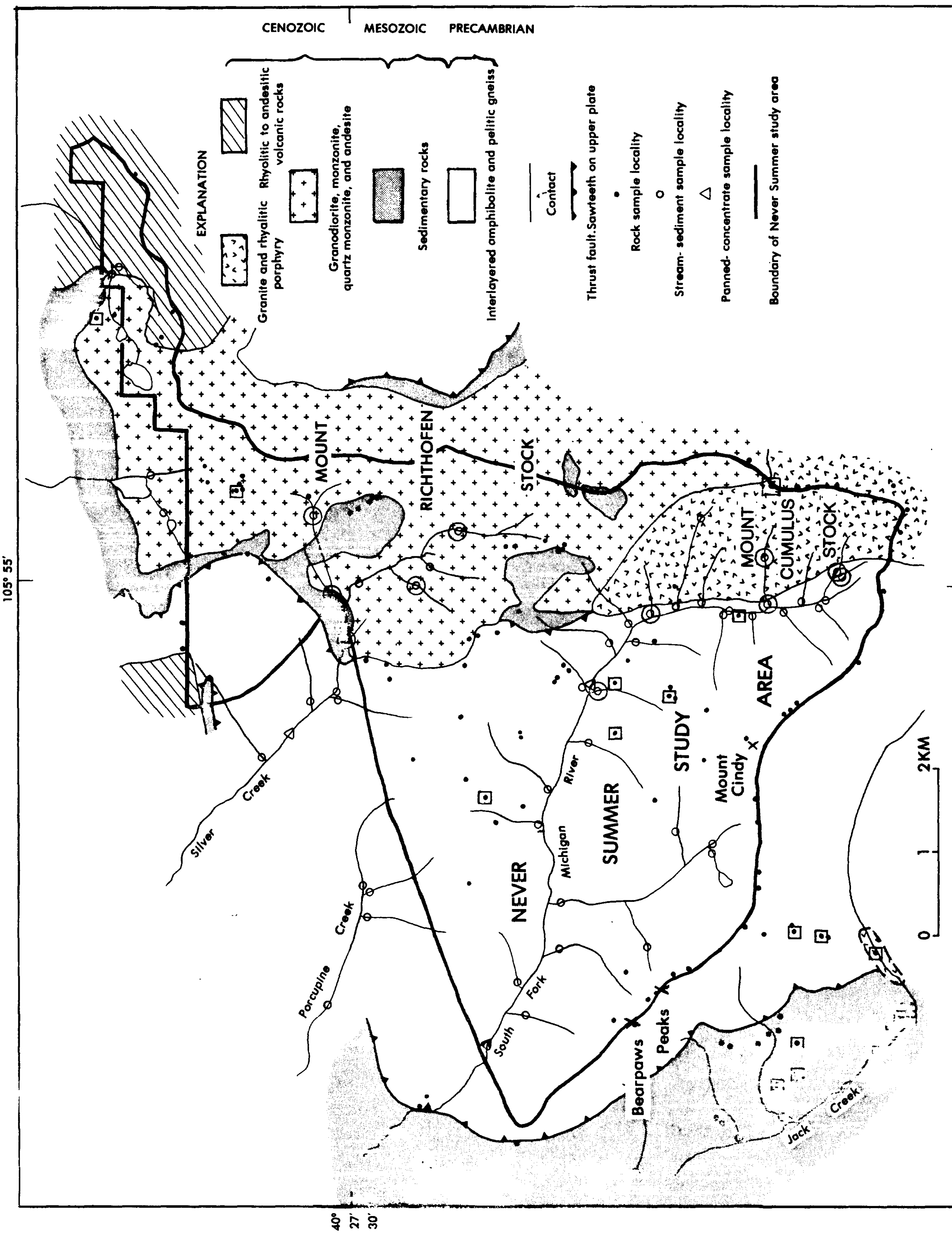


Figure 19.--Geochemical map showing distribution of molybdenum in and near the Never Summer study area. Anomalous stream-sediment samples (large open circles) contain 7 ppm or more molybdenum; anomalous rock samples (open squares) contain 20 ppm or more molybdenum (semiquantitative spectrographic analysis).

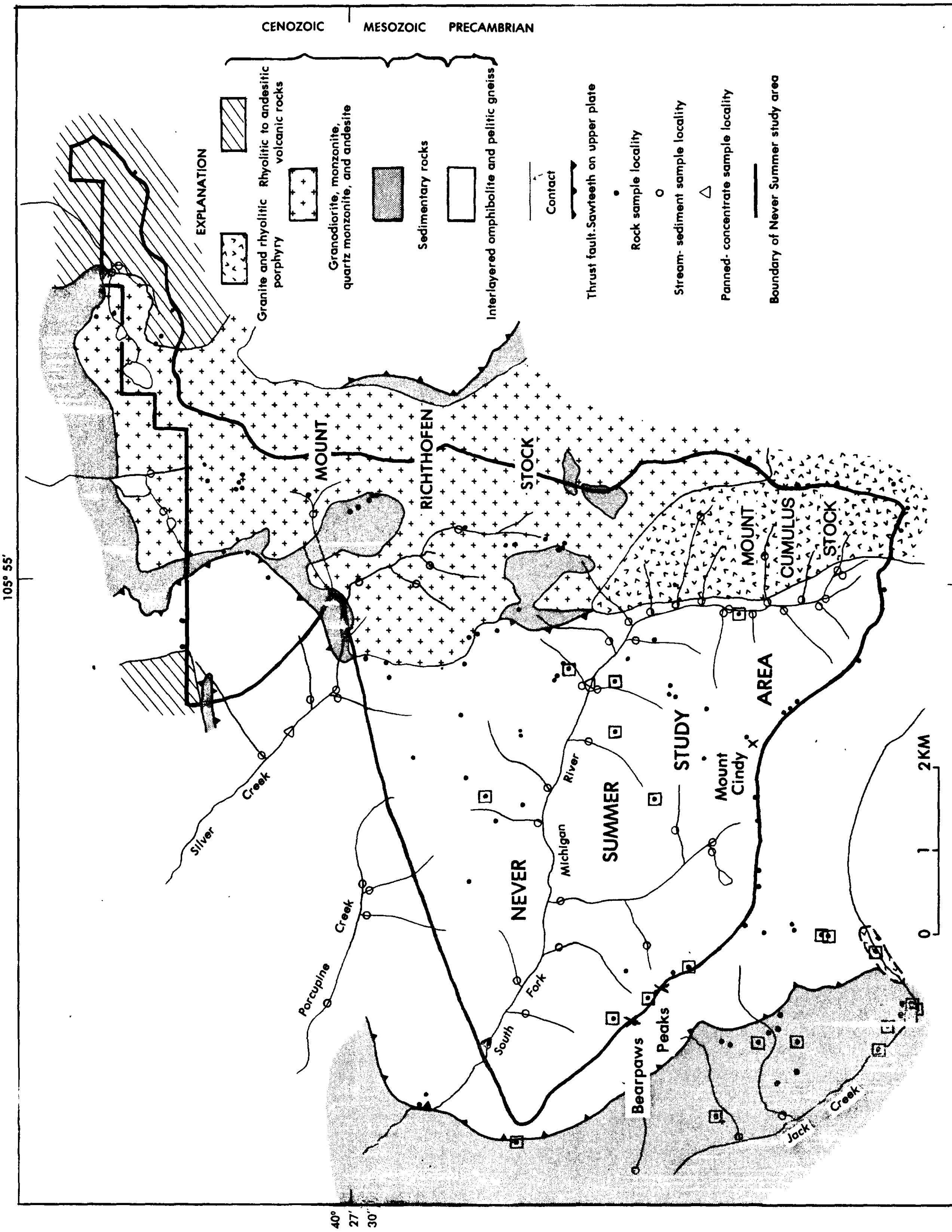


Figure 20.--Geochemical map showing distribution of arsenic in and near the Never Summer study area. Anomalous rock samples (open squares) contain 130 ppm or more arsenic (colorometric analysis).

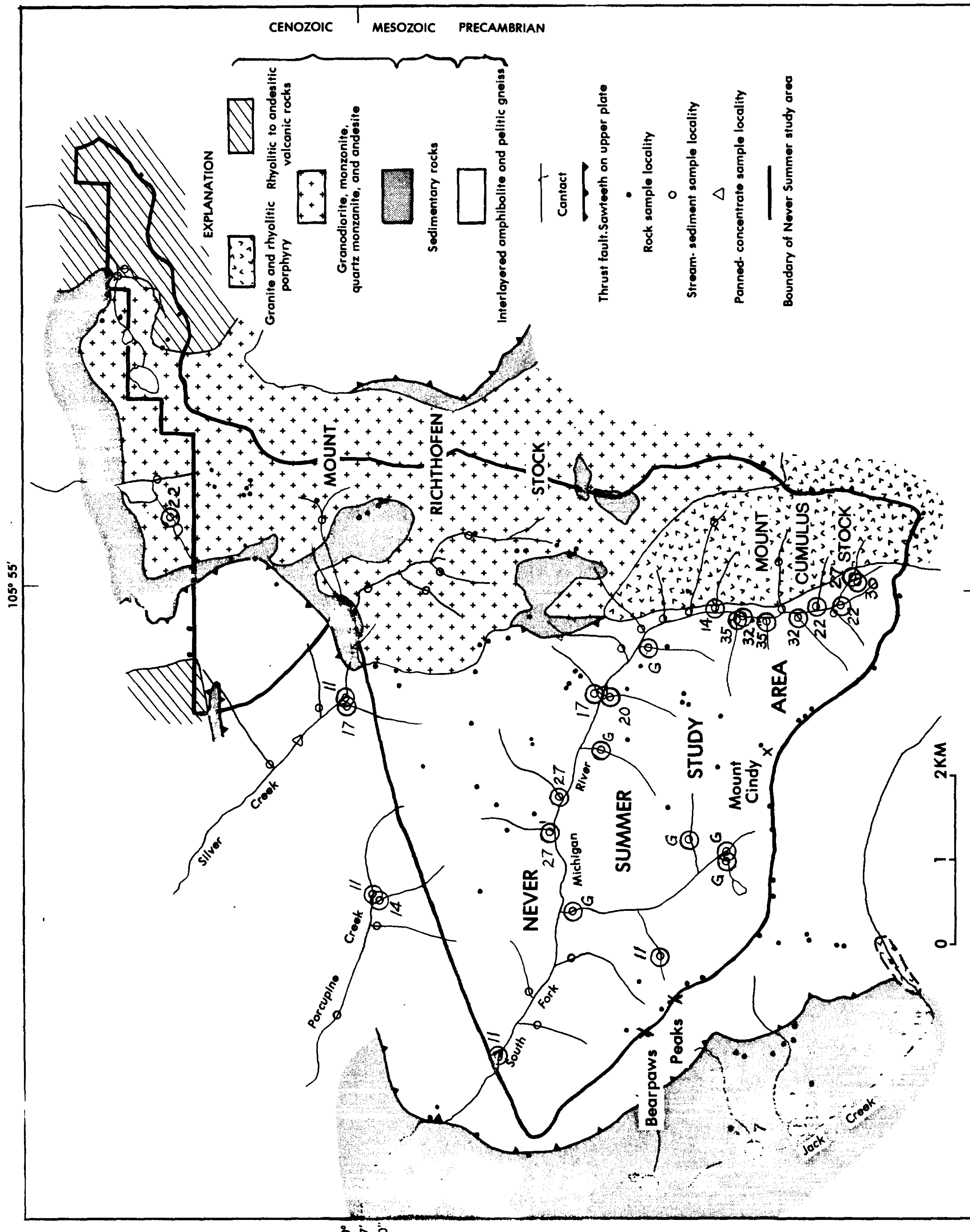


Figure 21.--Geochemical map showing distribution of citrate-soluble heavy metals (cxHM) in stream-sediment samples in and near the Never Summer study area. Values in parts per million. G = >45 ppm.

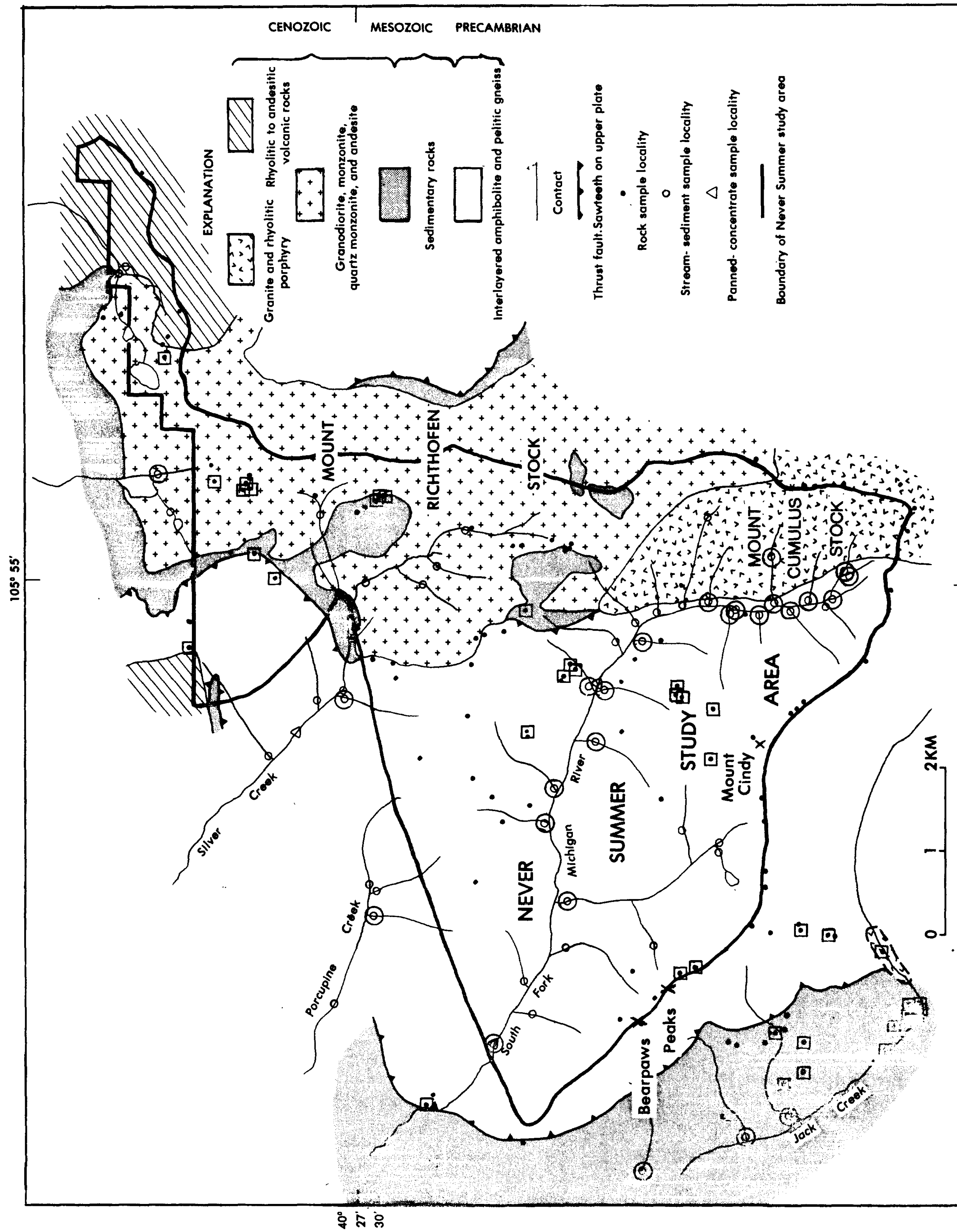


Figure 22.--Geochemical map showing distribution of zinc in and near the Never Summer study area. Anomalous stream-sediment samples (large open circles) contain 200 ppm or more zinc (spectrographic analysis); anomalous rock samples (open squares) contain 110 ppm or more zinc (atomic absorption).

Rock samples, as shown on figures 17-20, show much the same distribution of metals that the stream-sediment samples do. In addition to silver, molybdenum, lead, and zinc, many of the samples of mineralized and altered rock also contain arsenic and antimony. The highest values of most elements are found in samples collected from the principal prospect workings in Jack Creek valley and South Fork Michigan River valley. Arsenic is present in several samples from veins and fracture zones in amounts greater than 1,000 ppm and is present in detectable amounts (40 ppm by atomic absorption) in most samples from the Jack Creek-South Fork Michigan River area. In contrast, only five samples contain more than 500 ppm antimony, and the values of antimony are on average only about one-tenth those of arsenic. Arsenic determined by spectrographic analysis compares closely to arsenic determined by atomic absorption, considering that the lower limit of determination of the spectrographic technique is 200 ppm. Lead determined by spectrography and zinc determined by atomic absorption were found most abundantly in many of the samples that were strongly anomalous in other metals. However, several samples of fracture zones in the northern part of the area contain more than 100 ppm lead and/or zinc, but no other metals in anomalous amounts. Molybdenum and silver are detected in most samples of mineralized and altered rock. Both exceed 100 ppm in several of the more highly mineralized vein samples.

Results of analysis of several rock and stream-sediment samples indicate the presence of a mineralized area on the three-way drainage divide between Silver Creek, Porcupine Creek, and South Fork Michigan River. Narrow quartz veinlets and pervasive replacement by quartz mark the vicinity of the 11,467 ft point on the ridge. Country rock is mainly Precambrian alaskite and pegmatite cut by several small Tertiary porphyry bodies. Stream-sediment sample P6-052 is from the branch of Porcupine Creek that drains the north side of the ridge at this point, and samples P6-140 and P6-141 are from small gullies that drain the south side (pl. 2). Two of the samples contain detectable (0.5 and 1 ppm) silver, two of them, 200 ppm zinc, and one, a trace of molybdenum (table 9). Sample P6-050 of silicified alaskite from the ridge top contains 1 ppm silver, 200 ppm arsenic, and 7 ppm molybdenum. A sample (P6-168) of similar rock from float about 650 ft (200 m) below the ridge contains 2 ppm silver, 700 ppm arsenic, and 30 ppm molybdenum. No evidence of prospecting was noted in this area, but it may warrant exploration and definitely deserves further study.

Most samples of rock from the Mount Cumulus stock contain traces of molybdenum; one contains 5 and another 15 ppm silver, and one sample contains 150 ppm tin in the limonitic rind adjacent to a joint and 20 ppm tin in the fresh interior of the same sample (tables 8 and 10). The low levels of molybdenum were surprising inasmuch as molybdenite was visible in three of the samples.

Seven samples of the stock that exhibited a gray or brown rind were investigated to determine the differences in chemistry between the rind and the interior. The rind is present along nearly every joint and probably results from oxidation of pyrite and possibly manganese-bearing carbonate. Pyrite is still present along many joints but no carbonate was found. The rind was sawed off of the hand specimens, and both rind and interior were analyzed by semiquantitative spectrography. The results (table 10) were not particularly noteworthy for most elements. On average, iron and manganese are about 50 percent and 100 percent higher, respectively, in the rind. The average molybdenum value is about 50 percent higher in the rind; however, many of the determinations were at or below the limit of determination of the technique for molybdenum, and hence their precision may not be high. Too few samples contained detectable silver or tin to decide whether these metals are concentrated in the rind or the interior; however, the one sample in which tin was detected contained 150 ppm in the rind and only 20 ppm in the interior. The data show no consistent differences for such elements as lead, lanthanum, niobium, and yttrium between analyses of the rind and of the interior. Zinc and tungsten were not detected. These limited data suggest that iron, manganese, probably molybdenum, and possibly tin were deposited during a weak hydrothermal episode whereas the other anomalous elements may be in orthomagmatic minerals.

Heavy minerals were separated from four samples of the Mount Cumulus stock. The most common are magnetite, pyrite, fluorite, ilmenorutile, molybdenite, apatite, and zircon. Monazite was found in three samples, allanite in one, and fluocerite in another. Magnetite is altered in part to hematite and maghemite. The minerals were identified by optical, X-ray, and electron microprobe techniques.

Conclusions

The geology and geochemistry of the Never Summer area, provide good evidence that the area has high potential for molybdenum deposits of the Climax type. These deposits would be buried and may be difficult to find. The Mount Cumulus stock is a 28-m.y.-old alkali granite and rhyolite porphyry that contains molybdenite and pyrite in miarolitic cavities and along joints. The top of another rhyolite-porphyry intrusive is known about 0.6 mi (1 km) south of the study area. This body also contains molybdenite and has been drilled in recent years in search of a molybdenum deposit. The presence of small rhyolitic dikes throughout the Mount Cindy-Bearpaws Peaks region and of extensive hornfelsing of the Coalmont Formation between Jack Creek and the trace of the Never Summer thrust indicate that the Mount Cumulus stock is much larger than its outcrop and that the buried portion of the stock lies at no great depth--possibly less than half a mile beneath the valleys of Jack Creek and South Fork Michigan River. The gravity data corroborate this interpretation. The small veins and mineralized fracture zones that form a north-trending belt through the southern and central parts of the Never Summer area probably reflect minor hydrothermal leakage from this buried granite pluton. The minor-element chemistry of the veins, fractures, and rhyolitic intrusives is very similar to that associated with Climax-type molybdenum deposits. In addition to molybdenum itself, fluorine (although fluorine was not analyzed for, its presence in anomalous amounts is indicated by widespread fluorite), lead, zinc, silver, tin, and niobium are clearly anomalous. Manganese and iron have also been introduced.

Although the country rock at Climax and Henderson is largely Precambrian Silver Plume Quartz Monzonite, schist and gneiss like that in the Never Summer area is common at Climax, where it forms an adequate host for ore (Wallace and others, 1968; Wallace and others, 1978). The Coalmont Formation is inferred to underlie the Never Summer thrust in at least part of the area that is anomalous geochemically. This formation is similar to the Middle Park Formation that is mineralized and hydrothermally altered in concentric envelopes in the Rabbit Ears Range. The Coalmont should, therefore, provide an acceptable host in the Never Summer area.

The principal deterrent to exploration in the Never Summer area is the lack of large exposed masses of hydrothermally altered rocks that might provide an exploration target. It is possible that the Mount Cumulus stock was too dry or did not have an appropriate cooling history to produce the large hydrothermal system and resultant alteration envelopes characteristic of the stockwork molybdenum deposits, and if this is the case it is likely that little ore formed either. However, just as the rhyolite plug in Jack Creek valley was judged after its discovery to be a logical exploration target, additional study is expected to disclose other small inconspicuous intrusive bodies, small masses of hydrothermally altered rock, or geophysical anomalies that could lead to the discovery of buried molybdenum deposits. Although the Mount Cumulus and Mount Richthofen stocks intruded through the Never Summer thrust, it seems likely that the thrust could have acted locally as a structural cap for the granite magma or as a dam for ore-forming fluids emanating from that magma below the thrust. The general area of Mount Cindy, especially the fractured, iron-stained, and geochemically anomalous rocks west, southwest, and south of Mount Cindy and the silicified area at the head of Porcupine Creek seem, on the basis of this study, to offer the most promise.

The veins in the Never Summer area seem to be too small to contain significant mineral resources of metals or fluorspar. No coal is known in the Coalmont Formation near the study area, and the chances of petroleum accumulations are poor as a result of the strong thermal metamorphism the sedimentary rocks have undergone, in particular the most likely source rocks such as the Niobrara and Pierre. Muscovite in pegmatites near Baker Pass and Mount Cindy is in small quantity and low quality. No evidence for geothermal energy--such as hot springs or recent volcanism--was found.

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Tables 4-9.--Analyses of selected rock and stream-sediment samples from Comanche-Big South (tables 4 and 5), Neota-Flat Top (tables 6 and 7), and Never Summer (tables 8 and 9) study areas, Colorado

[The following tables of analytical data represent data on samples that were selected because one or more values are considered anomalously high. Analytical data on all samples collected in this study are given in Motooka and others, 1979. See plate 2 for sample localities. s, semiquantitative spectrographic analysis; cm, chemical analysis; a, atomic absorption analysis; Hm, heavy metals (mainly zinc, but also copper, lead, and cobalt) detected by the citrate-soluble test (cx); N, element looked for, but not found; <, element was detected, but was less than amount shown; >, greater than amount shown; --, not determined. Semiquantitative spectrographic analyses are reported to the nearest number in the series 1, 0.7, 0.5, 0.3, 0.2, 0.15, 0.1, and so forth, which represent approximate midpoints of group data on a geometric scale. In tables 4-7 elements looked for but not found, except as footnoted, are: arsenic, gold, bismuth, cadmium, antimony, and tungsten; in tables 8 and 9, elements looked for but not found, except as footnoted, are; gold and tungsten.]

Table 4.—Analyses of selected rock samples from the Comanche-Big South study area, Colorado

Sample	Latitude	Longitude	Fe-pct. s	Mg-pct. s	Ca-pct. s	Ti-pct. s	Mn-ppm s	Ag-ppm s	B-ppm s	Ba-ppm s	Be-ppm s	Co-ppm s	Cr-ppm s	Cu-ppm s	La-ppm s
280	40 41 30	105 41 37	.7	.15	.70	.050	300	N	<10	1,500	1.0	<5	<10	N	<20
284	40 41 26	105 41 20	1.5	.30	.70	.100	300	.7	<10	700	1.0	5	<10	<5	30
303	40 35 14	105 49 12	2.0	.50	2.00	.100	300	<.5	<10	300	<1.0	5	<10	30	N
310	40 40 26	105 46 24	3.0	.30	.70	.100	200	N	<10	1,000	2.0	7	20	50	<20
311	40 40 9	105 47 3	.5	.10	.70	.070	1,000	N	<10	300	1.5	15	10	<5	30
314	40 38 48	105 46 55	5.0	2.00	1.00	.500	700	<.5	<10	300	2.0	15	30	30	20
336 1/	40 41 22	105 45 28	.7	.30	.20	.070	150	7.0	<10	70	1.0	<5	N	15	N
343 2/	40 40 1	105 47 5	3.0	.50	.15	.500	200	N	20	500	3.0	10	50	15	30
353 3/	40 40 56	105 45 44	1.5	.07	.20	.020	70	N	10	150	2.0	<5	N	5	N
P6198	40 40 38	105 36 56	1.0	.15	1.50	.050	200	N	<10	70	3.0	5	N	N	100
P6199	40 40 38	105 36 56	.2	.07	1.50	N	150	N	<10	70	2.0	N	N	N	150
P6203	40 30 4	105 39 42	1.5	.15	.50	.070	300	N	<10	200	5.0	N	N	N	50
P6207	40 37 49	105 37 50	7.0	1.50	5.00	>1.000	1,000	N	20	300	<1.0	50	100	200	20
P6220	40 34 0	105 42 32	1.5	1.00	.10	.007	150	N	<10	50	1.0	5	N	N	N

Sample	Mo-ppm s	Nb-ppm s	Ni-ppm s	Pb-ppm s	Sc-ppm s	Sn-ppm s	Sr-ppm s	V-ppm s	Y-ppm s	Zn-ppm s	Zr-ppm s
280	7	N	<5	20	N	N	500	10	15	N	50
284	N	N	<5	30	5	N	200	30	10	N	100
303	15	N	<5	<10	5	N	300	50	N	N	70
310	10	<20	15	30	5	N	500	30	10	N	100
311	10	N	70	10	5	N	300	20	20	N	100
314	7	N	50	<10	20	N	100	300	50	N	70
336	10	N	5	150	5	N	N	20	<10	N	50
343	<5	<20	20	15	10	N	200	100	20	N	100
353	30	N	5	10	<5	N	150	15	N	N	<10
P6198	N	N	<5	300	5	N	100	10	300	N	300
P6199	N	N	<5	500	N	N	150	10	500	N	1,000
P6203	N	<20	5	70	<5	<10	N	20	70	N	150
P6207	N	<20	50	N	30	N	300	700	70	200	200
P6220	N	<20	5	N	5	<10	N	70	N	N	20

1/ Contains 70 ppm Bi.

2/ Contains <50 ppm W.

3/ Contains 200 ppm As.

Table 5.--Analyses of selected stream-sediment samples from the Comanche-Big South study area, Colorado

Sample	Latitude	Longitude	Fe-pct. s	Mg-pct. s	Ca-pct. s	Ti-pct. s	Mn-ppm s	Ag-ppm s	B-ppm s	Ba-ppm s	Be-ppm s	Co-ppm s	Cr-ppm s	Cu-ppm s	La-ppm s
28630	40 32 5	105 41 35	.5	.15	.3	.20	100	<.5	10	150	3.0	<5	20	20	30
297	40 39 10	105 44 52	3.0	.70	.5	.30	300	<.5	15	300	2.0	15	30	15	30
H6051	40 37 24	105 34 54	2.0	.50	.7	.20	1,000	<.5	20	300	1.0	15	300	20	50
H6052	40 37 26	105 35 13	1.5	.30	.5	.20	500	.5	30	300	1.5	10	70	15	70
H6053	40 37 43	105 35 50	2.0	.50	.7	.15	1,000	<.5	15	300	1.0	15	50	15	30
H6054	40 38 23	105 36 42	3.0	.50	.7	.20	1,000	<.5	15	500	1.0	15	70	15	20
H6055	40 38 10	105 36 55	2.0	.50	.5	.20	1,000	<.5	20	300	1.5	15	100	20	30
H6058	40 38 25	105 39 19	3.0	.70	.7	.20	1,000	<.5	15	300	1.5	15	70	15	50
H6060	40 34 26	105 39 14	2.0	.30	.5	.20	300	<.5	10	300	2.0	10	20	15	30
H6061	40 34 6	105 40 8	3.0	.50	.7	.30	500	<.5	15	300	2.0	10	30	30	50
H6062	40 34 7	105 40 9	1.5	.30	.5	.20	700	<.5	20	300	2.0	10	20	15	30
H6069	40 33 20	105 45 35	3.0	.70	1.0	.30	1,000	<.5	10	300	1.5	15	30	15	20
P018	40 35 57	105 40 12	3.0	1.00	2.0	.20	1,000	N	15	200	2.0	7	100	20	50
P029	40 38 14	105 38 28	7.0	1.50	3.0	.70	1,500	N	15	300	2.0	15	200	15	200
P030	40 37 33	105 38 24	5.0	1.00	3.0	.50	1,000	N	20	300	2.0	15	70	15	100
P6212	40 36 10	105 33 0	1.5	.30	.5	.30	500	<.5	50	300	1.5	10	20	15	30
P6213	40 36 11	105 33 0	2.0	.50	.5	.20	500	<.5	15	300	1.0	15	30	10	30
P6216	40 34 54	105 40 54	1.5	.50	.3	.15	300	.5	20	150	1.5	15	5,000	30	50
P6217	40 34 29	105 41 17	3.0	.70	.7	.30	700	<.5	20	200	2.0	15	70	30	20
P6218	40 34 30	105 41 17	2.0	.50	.7	.30	500	<.5	20	200	1.0	15	30	10	<20
P6261	40 36 19	105 47 22	5.0	1.50	3.0	.30	1,000	<.5	30	500	1.5	15	30	20	20

Sample	Mo-ppm s	Nb-ppm s	Ni-ppm s	Pb-ppm s	Sc-ppm s	Sn-ppm s	Sr-ppm s	V-ppm s	Y-ppm s	Zn-ppm s	Zr-ppm s	Hm-ppm cm-cx
28630	N	N	<5	10	7	N	N	30	20	N	70	—
297	N	<20	15	20	10	N	150	100	50	N	200	—
H6051	N	<20	20	20	10	N	150	70	50	N	200	—
H6052	N	N	15	15	10	N	150	50	70	N	100	—
H6053	5	N	20	20	10	N	200	70	20	N	150	3
H6054	N	N	30	20	10	N	300	100	30	N	150	4
H6055	N	N	20	20	10	N	200	70	30	N	100	5
H6058	N	N	30	20	10	N	300	70	70	N	200	—
H6060	N	N	20	20	10	N	100	70	30	N	150	—
H6061	N	<20	20	50	10	N	100	70	50	<200	300	—
H6062	N	N	15	30	7	N	100	50	20	N	150	—
H6069	N	N	30	50	7	N	300	70	15	N	100	—
P018	N	20	15	15	10	N	200	70	30	<200	100	20
P029	N	20	30	30	20	N	200	100	50	N	150	15
P030	N	20	30	20	10	N	200	100	200	N	200	2
P6212	N	<20	20	15	10	N	150	50	30	N	300	—
P6213	N	N	20	15	10	N	150	70	20	N	150	—
P6216	N	N	70	50	7	N	100	50	20	N	50	—
P6217	N	<20	30	20	15	N	200	100	15	N	150	—
P6218	N	<20	15	20	10	N	300	100	50	N	150	—
P6261	N	<20	30	10	20	N	300	150	30	N	500	—

Table 6. —Analyses of selected rock samples from the Neota-Flat Top study area, Colorado

Sample	Latitude	Longitude	Fe-pct. s	Mg-pct. s	Ca-pct. s	Ti-pct. s	Mn-ppm s	Ag-ppm s	B-ppm s	Ba-ppm s	Be-ppm s	Co-ppm s	Cr-ppm s	Cu-ppm s	La-ppm s
H6033	40 31 20	105 51 30	3.0	.05	.10	.10	200	<.5	15	20	3.0	N	N	5	100
H6034	40 31 40	105 48 36	2.0	.15	.30	.10	200	N	10	300	2.0	N	N	<5	70
H6035	40 31 15	105 51 10	2.0	.03	.10	.07	150	N	10	<20	2.0	N	N	N	20
H6040	40 31 44	105 48 44	2.0	.20	.30	.15	200	N	10	150	5.0	<5	<10	<5	100
H6041	40 31 49	105 48 59	3.0	.20	.30	.10	500	N	10	500	3.0	N	N	<5	70
H6043	40 31 0	105 49 35	2.0	.07	.10	.10	50	N	10	50	3.0	N	N	<5	100
H6045	40 29 59	105 49 26	1.5	.05	.10	.07	70	N	10	N	5.0	N	N	<5	N
H6047	40 30 21	105 48 20	10.0	1.50	5.00	1.00	5,000	N	<10	1,000	1.5	50	500	70	50
P6161	40 28 53	105 51 58	2.0	.10	.70	.20	300	N	N	500	1.5	N	<10	N	100
P6162	40 28 49	105 51 45	7.0	.10	.50	.30	500	N	<10	700	2.0	<5	<10	<5	70
P6163 1/	40 28 56	105 51 35	10.0	.05	.50	.15	>5,000	.7	<10	700	20.0	N	<10	<5	30
P6164	40 29 15	105 51 14	1.0	.10	.50	.20	100	N	<10	150	3.0	N	<10	N	70
P6165	40 29 34	105 51 17	1.0	.15	.10	.01	100	N	10	N	5.0	N	N	N	N
P6172	40 33 0	105 49 59	2.0	.15	.50	.10	700	N	15	300	3.0	N	N	<5	70
P6173	40 32 44	105 50 1	2.0	.20	.30	.15	700	N	15	300	3.0	N	N	<5	70
P6174	40 31 42	105 51 24	1.5	.10	.20	.10	100	N	15	20	3.0	N	N	<5	70
P6175	40 31 35	105 51 32	5.0	.07	.15	.07	150	N	10	<20	5.0	N	N	5	70
P6176	40 31 18	105 51 34	.5	.10	.10	.10	150	N	<10	20	2.0	N	N	N	70
P6177	40 31 7	105 51 27	3.0	.07	.15	.10	70	N	10	<20	2.0	N	N	<5	200
P6178	40 31 0	105 50 55	3.0	.07	.15	.07	100	N	10	<20	3.0	N	N	5	50
P6179	40 31 4	105 50 53	1.5	.05	.10	.07	1,000	N	10	<20	5.0	N	N	<5	50
P6181	40 31 10	105 50 5	1.5	.05	.10	.07	150	N	10	20	3.0	N	N	<5	30
P6182	40 30 58	105 51 37	5.0	.03	.10	.07	200	N	10	<20	5.0	N	N	5	150
P6183	40 30 25	105 51 5	2.0	.02	.10	.07	200	N	10	<20	5.0	N	N	<5	100
P6184	40 30 25	105 50 21	3.0	1.00	.50	.15	200	N	15	50	3.0	N	10	10	300
P6185	40 30 31	105 49 23	3.0	.70	.30	.15	200	.5	20	30	1.5	N	N	7	200
P6188	40 28 59	105 50 18	7.0	.10	.30	.15	1,000	N	10	300	7.0	5	<10	5	150
P6189	40 29 2	105 50 50	7.0	.07	.30	.10	1,500	N	10	200	3.0	<5	N	5	70

Table 6.—Analyses of selected rock samples from the Neota-Flat Top study area, Colorado—Continued

Sample	Mo-ppm s	Nb-ppm s	Ni-ppm s	Pb-ppm s	Sc-ppm s	Sn-ppm s	Sr-ppm s	V-ppm s	Y-ppm s	Zn-ppm s	Zr-ppm s
H6033	15	50	<5	30	<5	<10	N	<10	20	N	500
H6034	5	30	<5	30	<5	<10	100	10	20	N	200
H6035	10	50	<5	30	<5	<10	N	<10	10	N	300
H6040	7	70	10	30	5	<10	N	30	50	N	300
H6041	7	50	5	30	5	<10	150	15	30	N	300
H6043	20	50	5	30	<5	<10	N	<10	30	N	300
H6045	5	50	5	30	<5	<10	N	<10	10	N	200
H6047	N	30	150	<10	20	N	700	500	20	N	200
P6161	<5	20	<5	30	7	<10	150	<10	20	N	1,000
P6162	7	30	<5	30	7	<10	150	10	30	N	1,000
P6163	15	50	N	15	<5	N	N	10	100	300	500
P6164	N	50	N	30	5	<10	<100	<10	30	N	300
P6165	N	100	<5	50	<5	<10	N	<10	15	N	100
P6172	10	30	<5	30	5	<10	150	10	20	N	200
P6173	10	30	<5	30	7	<10	100	10	30	N	200
P6174	10	30	<5	30	5	<10	N	<10	15	N	300
P6175	15	30	<5	30	7	<10	N	<10	20	N	300
P6176	20	50	<5	30	N	<10	N	<10	50	N	700
P6177	10	30	<5	20	7	N	N	<10	50	N	700
P6178	7	30	<5	30	N	<10	N	<10	30	200	300
P6179	5	20	<5	50	N	<10	N	<10	30	N	150
P6181	10	20	<5	50	N	<10	N	<10	20	N	300
P6182	20	30	<5	30	10	<10	N	<10	50	200	500
P6183	10	50	<5	50	<5	<10	N	10	50	N	300
P6184	7	50	<5	20	7	10	<100	20	70	200	700
P6185	5	50	<5	100	5	15	N	<10	70	N	500
P6188	15	50	<5	30	7	<10	100	10	50	<200	500
P6189	15	50	<5	30	7	<10	N	10	20	<200	500

1/ Contains <200 ppm As.

Table 7..—Analyses of selected stream-sediment samples from the Neota-Flat Top study area, Colorado

Sample	Latitude	Longitude	Fe-pct. s	Mg-pct. s	Ca-pct. s	Ti-pct. s	Mn-ppm s	Ag-ppm s	B-ppm s	Ba-ppm s	Be-ppm s	Co-ppm s	Cr-ppm s	Cu-ppm s	La-ppm s
H6031	40 33 2	105 50 17	3.0	.50	.5	.2	1,500	<.5	30	300	1.5	15	30	15	20
H6036	40 31 11	105 50 53	1.5	.15	.2	.2	300	N	15	100	1.5	N	10	<5	100
H6037	40 31 11	105 50 52	2.0	.50	.5	.2	700	N	15	200	2.0	10	20	10	100
H6038	40 31 31	105 50 40	1.0	.20	.2	.2	150	<.5	15	200	2.0	<5	700	7	100
H6039	40 32 8	105 50 25	5.0	1.00	.7	.5	1,000	<.5	10	500	1.0	20	500	20	50
H6046	40 30 16	105 48 51	3.0	.70	.5	.7	1,500	N	15	500	2.0	15	30	20	70
H6067	40 34 8	105 51 35	5.0	.70	.7	.5	1,500	<.5	15	500	2.0	15	30	10	50
H6068	40 34 7	105 51 36	3.0	.70	.7	.3	700	N	15	300	2.0	15	30	15	50
H6069	40 33 20	105 45 35	3.0	.70	1.0	.3	1,000	<.5	10	300	1.5	15	30	15	20
P002	40 31 10	105 49 21	7.0	1.00	2.0	.7	1,500	N	20	300	5.0	15	50	15	100
P003[1]	40 31 9	105 49 19	2.0	.30	.7	.3	700	N	15	200	3.0	7	30	10	100
P007	40 29 34	105 50 18	7.0	.50	2.0	.7	2,000	N	20	700	3.0	5	20	10	100
P008	40 29 34	105 50 18	5.0	.50	2.0	.5	1,500	N	15	1,000	5.0	5	20	7	100
P010	40 29 38	105 50 16	2.0	.30	.7	.5	500	N	20	300	2.0	7	30	15	100
P011	40 29 20	105 49 58	1.5	.10	.5	.2	300	N	10	500	2.0	N	10	<5	70
P6170	40 33 5	105 49 17	3.0	.30	.5	.5	1,000	<.5	15	300	3.0	10	30	7	30
P6187	40 31 30	105 48 27	5.0	.50	1.0	>1.0	1,000	N	<10	500	<1.0	15	10	<5	30
P6263	40 35 48	105 47 56	5.0	1.50	2.0	.5	1,500	<.5	30	500	2.0	15	30	30	20

Sample	Mo-ppm s	Nb-ppm s	Ni-ppm s	Pb-ppm s	Sc-ppm s	Sn-ppm s	Sr-ppm s	V-ppm s	Y-ppm s	Zn-ppm s	Zr-ppm s	Hm-ppm cm-cx
H6031	N	<20	30	20	10	N	100	70	20	<200	150	--
H6036	7	30	<5	20	5	N	N	15	30	N	300	--
H6037	N	20	15	20	10	N	100	50	50	<200	200	--
H6038	N	30	15	20	7	N	<100	30	50	N	200	--
H6039	N	<20	30	20	15	N	150	100	30	<200	200	--
H6046	N	20	30	20	15	N	200	100	30	<200	200	--
H6067	N	20	30	20	15	N	200	100	30	N	200	--
H6068	N	<20	30	15	10	N	200	100	20	<200	150	--
H6069	N	N	30	50	7	N	300	70	15	N	100	5
P002	<5	150	30	20	10	N	200	50	50	<200	500	2
P003	5	30	10	70	7	N	150	50	30	N	300	--
P007	5	200	<5	30	10	N	200	20	30	<200	700	13
P008	<5	200	5	30	10	N	200	30	50	N	500	9
P010	5	50	10	50	7	N	150	50	30	N	300	--
P011	7	30	<5	50	5	N	200	20	30	N	200	--
P6170	N	<20	20	15	10	N	200	100	20	N	200	--
P6187	N	50	<5	15	15	N	500	150	20	N	300	--
P6263	N	N	20	30	20	N	300	150	30	N	300	--

[1] Contains <.05 ppm Au.

Table 8.--Analyses of selected rock samples from the Never Summer study area, Colorado

Sample	Latitude	Longitude	Fe-pct. s	Mg-pct. s	Cs-pct. s	Ti-pct. s	Mn-ppm s	Ag-ppm s	As-ppm s	B-ppm s	Ba-ppm s	Be-ppm s	Bi-ppm s	Cd-ppm s	Co-ppm s
H6002	40 27 28	105 54 19	10.00	1.50	.20	.500	1,000	.7	N	15	200	<1.0	N	N	5
H6004	40 27 23	105 54 15	5.00	.20	.10	.200	1,500	N	N	15	500	5.0	N	N	10
H6005	40 27 22	105 54 15	7.00	.20	.50	.500	1,500	<.5	N	20	50	10.0	N	N	N
H6006	40 27 20	105 54 12	7.00	.20	.10	.500	200	.5	300	15	300	2.0	N	N	N
H6008	40 25 41	105 58 7	10.00	1.00	.15	.700	1,500	2.0	N	20	1,000	5.0	N	N	10
H6011	40 24 44	105 58 35	.07	.15	.10	.200	200	.7	N	15	700	5.0	N	N	N
H6012	40 24 46	105 58 35	.07	.15	<.05	.150	100	N	N	15	700	3.0	N	N	N
H6013	40 24 51	105 58 42	3.00	.10	<.05	.100	100	1.5	>10,000	10	700	5.0	N	N	N
H6014	40 24 54	105 58 40	3.00	.30	.15	.300	200	N	N	<10	500	1.0	N	N	5
H6016	40 25 6	105 59 19	1.50	.20	<.05	.500	150	1.5	2,000	150	700	2.0	N	N	<5
H6017	40 25 4	105 59 22	5.00	.30	.10	.500	1,500	.5	N	150	1,500	5.0	N	N	10
H6018	40 25 3	105 59 22	5.00	.20	.70	.200	700	N	N	15	1,500	2.0	N	N	5
H6023	40 28 47	105 53 4	1.00	.03	.10	.100	500	<.5	N	10	200	5.0	N	N	N
H6024	40 28 44	105 53 5	5.00	3.00	20.00	.150	2,000	.5	N	N	5,000	3.0	N	N	10
H6026	40 26 24	105 56 10	2.00	.10	.10	.500	100	7.0	<200	10	1,500	1.5	N	N	<5
H6027	40 26 24	105 56 9	5.00	.10	.05	.300	100	20.0	1,000	150	1,500	1.0	N	50	<5
H6028	40 26 10	105 55 43	3.00	.10	.10	.500	100	2.0	300	10	1,500	2.0	N	N	5
H6029	40 26 10	105 55 41	3.00	.10	.05	.100	100	50.0	<200	100	2,000	2.0	N	50	5
H6030	40 26 7	105 55 38	20.00	.50	2.00	.100	1,000	20.0	N	<10	70	10.0	N	N	7
P039	40 26 30	105 54 36	2.00	2.00	20.00	.150	1,500	1.5	N	<10	700	2.0	N	100	7
P6002	40 24 14	105 55 31	1.00	.20	.07	.100	70	.7	N	10	300	1.5	N	N	N
P6004	40 24 38	105 55 53	5.00	1.00	.07	.300	1,000	<.5	N	20	500	<1.0	N	N	10
P6005	40 24 40	105 55 57	5.00	.30	.05	.300	500	.7	N	15	500	<1.0	N	N	<5
P6006	40 24 42	105 55 59	.07	.05	<.05	.100	100	.7	N	70	30	1.0	N	N	N
P6007	40 24 57	105 56 10	7.00	.70	.07	.700	500	.7	N	150	500	1.0	N	N	5
P6008	40 25 13	105 56 20	7.00	.15	.05	.200	50	2.0	200	10	500	5.0	N	N	<5
P6009	40 25 13	105 55 57	5.00	.30	<.05	.150	150	3.0	<200	10	700	2.0	N	N	<5
P6010	40 25 24	105 55 51	3.00	.10	.15	.100	50	7.0	<200	<10	500	1.5	N	N	<5
P6011	40 25 25	105 55 51	2.00	.05	15.00	.070	10	7.0	200	<10	>5,000	7.0	N	N	<5
P6012	40 25 26	105 55 46	1.50	.05	.15	.010	20	10.0	200	<10	5,000	1.5	N	N	N
P6013	40 24 5	105 58 45	7.00	.15	.20	.020	1,000	50.0	>10,000	10	700	3.0	N	N	<5
P6014	40 24 5	105 58 45	15.00	.70	10.00	.005	>5,000	30.0	N	<10	300	15.0	N	N	N
P6015	40 24 5	105 58 45	3.00	.15	.20	.150	5,000	500.0	>10,000	50	500	5.0	N	N	5
P6016	40 24 5	105 58 45	2.00	.70	.50	.200	1,500	5.0	200	50	1,000	7.0	N	N	<5
P6017	40 24 0	105 58 34	7.00	.50	.15	.500	300	20.0	500	15	200	2.0	10	N	5
P6018	40 23 56	105 58 28	15.00	.50	15.00	.100	>5,000	70.0	500	<10	100	3.0	N	N	<5
P6019	40 23 52	105 58 29	10.00	.03	.07	.010	1,000	30.0	2,000	<10	500	3.0	N	N	N
P6020	40 23 52	105 58 25	5.00	.20	.15	.200	1,500	1.5	500	15	300	3.0	N	N	5
P6021	40 23 52	105 58 22	7.00	.20	.50	.100	2,000	15.0	700	10	150	2.0	<10	>500	20
P6022	40 23 55	105 58 22	3.00	.30	.07	.300	300	1.0	N	50	1,000	2.0	N	N	<5
P6023	40 24 5	105 57 56	7.00	.05	.30	.200	5,000	7.0	>10,000	<10	500	2.0	N	N	15
P6024	40 24 25	105 57 48	1.50	.10	<.05	.300	200	.7	1,500	<10	300	3.0	N	N	<5
P6025	40 24 27	105 57 48	10.00	.30	10.00	N	>5,000	700.0	1,500	<10	50	2.0	N	N	N
P6026	40 24 37	105 57 47	3.00	.15	5.00	.150	3,000	5.0	<200	10	>5,000	20.0	N	N	N
P6028	40 24 50	105 57 46	2.00	.50	.15	.300	1,000	<.5	N	20	1,500	1.5	N	N	5

Table 8.—Analyses of selected rock samples from the Never Summer study area, Colorado—Continued

Sample	Cr-ppm s	Cu-ppm s	La-ppm s	Mo-ppm s	Nb-ppm s	Ni-ppm s	Pb-ppm s	Sb-ppm s	Sc-ppm s	Sn-ppm s	Sr-ppm s	V-ppm s	Y-ppm s	Zn-ppm s	Zr-ppm s	Au-ppm aa
H6002	150	50	50	N	N	10	20	N	7	N	N	300	30	N	200	N
H6004	50	7	20	5	<20	20	<10	N	7	15	N	100	30	1,500	500	N
H6005	50	20	20	N	<20	N	70	N	5	20	N	100	30	1,000	500	N
H6006	50	70	N	<5	<20	<5	15	N	7	10	N	100	15	1,500	500	N
H6008	100	70	70	N	<20	15	20	N	20	N	N	300	100	N	500	N
H6011	<10	7	100	7	70	<5	20	N	<5	<10	N	<10	50	N	300	N
H6012	<10	<5	150	10	70	<5	10	N	N	<10	N	<10	30	N	300	N
H6013	<10	20	30	15	30	<5	20	100	N	15	N	10	20	N	200	.10
H6014	N	N	20	N	<20	<5	20	N	<5	15	150	15	10	N	200	—
H6016	100	10	50	7	<20	10	20	N	10	N	N	300	20	N	300	N
H6017	150	50	50	10	<20	30	<10	N	15	N	N	300	20	N	300	N
H6018	N	<5	70	N	20	<5	50	N	5	N	300	15	30	200	200	—
H6023	<10	<5	20	N	70	<5	70	N	N	N	N	<10	50	500	300	N
H6024	<10	<5	N	N	N	<5	300	N	<5	N	2,000	50	10	1,000	30	N
H6026	20	200	50	10	20	N	5,000	N	10	N	150	50	15	N	200	N
H6027	50	500	N	N	N	<5	20,000	100	7	N	N	50	N	5,000	150	.10
H6028	30	30	N	15	<20	5	150	N	10	N	300	70	20	N	200	N
H6029	10	2,000	N	N	N	<5	500	N	7	N	N	20	10	10,000	30	N
H6030	15	700	N	N	N	15	300	N	<5	N	N	30	20	1,500	20	N
P039	10	500	20	30	<20	10	1,000	N	7	N	200	70	20	10,000	100	N
P6002	15	10	N	N	20	<5	300	N	<5	N	N	30	15	N	100	N
P6004	150	30	70	N	<20	50	20	N	15	N	N	150	20	300	100	N
P6005	150	10	30	N	<20	10	20	N	20	N	N	150	50	N	300	N
P6006	N	5	N	N	50	<5	N	N	N	N	N	<10	20	N	300	—
P6007	150	50	30	N	<20	10	70	N	20	N	N	200	70	N	200	N
P6008	100	50	N	7	<20	20	300	N	7	N	N	100	15	700	100	N
P6009	50	100	N	7	N	15	700	N	7	N	N	70	20	700	150	N
P6010	20	50	N	5	<20	5	5,000	N	7	N	N	30	15	2,000	100	.05
P6011	10	10	N	300	N	5	1,000	300	5	N	5,000	10	<10	200	50	N
P6012	<10	10	N	10	N	<5	700	N	N	N	<100	<10	30	300	20	N
P6013	<10	70	N	70	N	5	150	300	N	N	N	20	30	N	15	.65
P6014	<10	7	N	30	N	5	20	<100	7	N	300	30	70	N	N	.35
P6015	30	30	N	20	<20	10	200	700	7	N	N	70	30	1,000	100	.50
P6016	10	5	50	10	30	N	30	N	5	N	<100	50	20	N	150	N
P6017	70	70	N	N	<20	15	150	N	7	20	N	70	15	5,000	1,000	N
P6018	10	1,000	N	100	N	15	2,000	100	5	N	N	50	15	>10,000	20	.10
P6019	10	70	N	70	N	5	200	100	5	N	N	50	20	200	N	.25
P6020	50	15	N	5	<20	15	30	N	7	10	N	100	10	N	300	N
P6021	15	500	N	N	N	10	150	N	5	20	N	50	15	>10,000	100	N
P6022	100	15	<20	15	<20	15	50	N	10	15	N	300	15	1,000	200	N
P6023	30	50	N	100	N	20	200	1,500	7	N	N	15	70	700	100	.40
P6024	30	5	N	5	<20	5	15	100	7	N	N	30	10	N	100	N
P6025	N	1,500	N	300	N	5	700	300	7	N	N	30	100	700	N	1.50
P6026	10	30	N	30	<20	<5	150	N	7	N	300	30	30	N	70	<.05
P6028	<10	10	50	5	20	<5	20	N	5	N	100	20	20	N	150	N

Table 8.--Analyses of selected rock samples from the Never Summer study area, Colorado--Continued

Sample	Zn-ppm aa	Sb-ppm aa
H6002	65	<1
H6004	480	N
H6005	500	10
H6006	720	<1
H6008	70	2
H6011	15	2
H6012	45	N
H6013	15	40
H6014	--	--
H6016	90	15
H6017	75	2
H6018	--	--
H6023	250	N
H6024	610	N
H6026	55	1
H6027	2,800	5
H6028	35	<1
H6029	7,500	1
H6030	500	1
P039	--	--
P6002	25	1
P6004	150	N
P6005	20	N
P6006	--	--
P6007	60	N
P6008	370	2
P6009	360	1
P6010	1,400	5
P6011	240	40
P6012	230	4
P6013	65	80
P6014	90	15
P6015	350	140
P6016	55	1
P6017	4,000	3
P6018	3,000	30
P6019	110	40
P6020	100	1
P6021	120,000	3
P6022	350	<1
P6023	500	400
P6024	40	10
P6025	580	60
P6026	160	10
P6028	85	<1

Table 8.--Analyses of selected rock samples from the Never Summer study area, Colorado --Continued

Sample	Latitude	Longitude	Fe-pct. s	Mg-pct. s	Ca-pct. s	Ti-pct. s	Mn-ppm s	Ag-ppm s	As-ppm s	B-ppm s	Ba-ppm s	Be-ppm s	Bi-ppm s	Cd-ppm s	Co-ppm s
P6029	40 24 57	105 57 42	2.00	.50	.10	.300	200	1.5	N	15	700	2.0	N	N	N
P6030	40 24 54	105 57 22	3.00	.70	.07	.300	300	1.0	N	15	700	1.5	N	N	5
P6031	40 24 53	105 57 15	5.00	.30	.05	.300	100	.5	N	20	500	1.0	N	N	<5
P6032	40 24 50	105 56 52	5.00	.30	.05	.500	200	.7	N	15	700	1.5	N	N	<5
P6033	40 24 52	105 56 40	7.00	1.00	.10	.700	500	2.0	N	30	700	1.5	N	N	5
P6038	40 25 22	105 58 9	2.00	.30	.15	.300	700	<.5	N	10	300	2.0	N	N	5
P6039	40 25 18	105 58 8	5.00	.15	.05	.070	1,500	5.0	1,000	15	1,500	2.0	N	N	7
P6050	40 26 44	105 56 31	3.00	.05	.07	.500	100	1.0	200	10	1,500	2.0	N	N	N
P6058	40 23 56	105 54 16	3.00	.05	.15	.070	300	<.5	N	10	100	15.0	N	N	N
P6059	40 24 3	105 54 4	1.50	.10	.30	.100	200	N	N	N	70	5.0	N	N	N
P6060	40 24 24	105 54 5	3.00	.15	<.05	.070	500	.5	200	200	200	10.0	N	N	N
P6066	40 24 37	105 53 52	3.00	.10	.30	.200	1,500	50.0	N	70	100	7.0	500	N	7
P6074	40 25 1	105 55 9	3.00	.20	<.05	.300	70	5.0	500	15	300	5.0	N	N	10
P6087	40 28 33	105 55 26	15.00	5.00	>20.00	.100	2,000	N	N	<10	20	1.5	N	N	15
P6090	40 28 19	105 54 42	5.00	.20	>20.00	.100	2,000	.7	N	<10	500	2.0	N	N	7
P6092	40 28 10	105 54 42	5.00	.70	.30	.500	1,500	N	N	15	500	3.0	N	N	15
P6093	40 27 58	105 55 0	3.00	.15	1.00	.300	1,500	<.5	N	<10	1,000	5.0	N	N	10
P6097	40 27 23	105 55 34	3.00	1.00	.30	1.000	500	.7	N	15	1,500	1.5	N	N	10
P6098	40 27 16	105 55 37	7.00	1.50	.50	>1.000	700	.5	N	15	1,500	1.0	N	N	7
P6103	40 26 33	105 55 19	7.00	.15	<.05	.200	200	7.0	N	<10	300	3.0	N	N	<5
P6104	40 26 25	105 55 8	3.00	.20	.20	.300	700	10.0	N	200	700	5.0	N	N	10
P6105	40 26 46	105 55 36	2.00	.30	.20	.300	300	<.5	N	10	500	7.0	N	N	5
P6106	40 26 46	105 56 3	1.50	.20	.05	.300	100	<.5	N	<10	2,000	3.0	N	N	N
P6107	40 25 43	105 55 33	5.00	.03	.10	.100	70	30.0	300	<10	700	2.0	N	70	20
P6113	40 28 12	105 54 10	7.00	2.00	.30	1.000	2,000	N	N	<10	700	3.0	N	N	7
P6115	40 28 13	105 54 8	7.00	2.00	1.00	1.000	1,500	.5	N	<10	500	1.0	N	N	70
P6116	40 28 14	105 54 10	7.00	.20	15.00	.100	1,500	.7	N	<10	>5,000	3.0	N	N	5
P6117	40 27 46	105 54 15	7.00	.20	10.00	.500	2,000	<.5	N	10	700	5.0	N	N	10
P6120	40 26 23	105 59 33	3.00	.20	.10	1.000	700	3.0	3,000	30	700	2.0	<10	N	5
P6121	40 25 57	105 58 52	10.00	2.00	<.05	.700	500	N	N	10	150	N	N	N	20
P6122	40 25 46	105 58 33	7.00	.15	.07	.300	300	7.0	5,000	10	700	7.0	N	N	5
P6124	40 25 33	105 58 22	5.00	.50	.05	.300	500	1.5	1,000	10	500	2.0	N	N	10
P6126	40 24 44	105 59 2	5.00	.30	.20	.200	3,000	10.0	N	100	150	3.0	N	70	10
P6127 1/	40 24 36	105 58 57	3.00	.05	.15	.150	500	2.0	<200	50	70	3.0	N	N	<5
P6128	40 24 36	105 58 41	7.00	.10	.15	.150	1,000	.7	>10,000	<10	500	20.0	N	N	5
P6129	40 24 43	105 58 29	1.00	.10	.10	.150	500	.7	<200	10	700	3.0	N	N	<5
P6130	40 24 43	105 58 29	1.50	.30	.15	.500	300	.7	N	100	700	7.0	N	N	5
P6131	40 25 4	105 58 43	7.00	.70	.30	1.000	500	.7	N	15	1,500	2.0	N	N	5
P6132	40 25 2	105 58 43	.70	N	N	.010	10	N	N	N	>5,000	<1.0	N	N	N
P6136	40 28 25	105 54 7	7.00	3.00	>20.00	.200	2,000	N	N	<10	3,000	2.0	N	N	10
P6146	40 25 33	105 55 23	7.00	.20	.30	.200	700	3.0	N	10	2,000	3.0	N	50	<5
P6147	40 25 48	105 55 44	15.00	.15	>20.00	.500	1,000	70.0	1,000	<10	700	2.0	N	N	70
P6148	40 25 48	105 55 44	15.00	.10	7.00	.300	700	50.0	700	<10	500	1.0	N	N	50
P6149	40 25 48	105 56 9	10.00	.07	.10	.150	50	5.0	700	<10	500	1.0	N	N	30
P6150	40 25 48	105 56 9	7.00	.10	.15	.200	200	30.0	500	10	500	7.0	N	500	10

Table 3.--Analyses of selected rock samples from the Never Summer study area, Colorado --Continued

Sample	Cr-ppm s	Cu-ppm s	La-ppm s	Mo-ppm s	Nb-ppm s	Ni-ppm s	Pb-ppm s	Sb-ppm s	Sc-ppm s	Sn-ppm s	Sr-ppm s	V-ppm s	Y-ppm s	Zn-ppm s	Zr-ppm s	Au-ppm aa
P6029	70	30	20	N	<20	5	70	N	10	N	N	70	70	N	150	N
P6030	100	70	20	N	<20	30	<10	N	10	N	N	150	15	N	70	N
P6031	150	50	20	N	<20	10	10	N	10	N	N	150	15	N	200	N
P6032	150	50	20	N	<20	10	150	N	15	N	N	150	15	N	200	N
P6033	200	100	20	N	20	50	70	N	20	N	100	300	30	N	300	N
P6038	20	<5	N	N	<20	5	20	N	15	N	N	50	20	300	150	N
P6039	<10	70	30	10	N	15	1,000	150	10	N	N	20	50	1,000	100	N
P6050	<10	15	50	7	50	<5	50	N	7	N	<100	30	30	N	500	N
P6058	<10	<5	30	10	70	<5	30	N	5	15	N	<10	50	N	150	N
P6059	N	N	70	N	50	<5	30	N	N	10	N	10	50	N	300	—
P6060	<10	<5	N	10	70	<5	20	N	<5	70	N	<10	50	N	150	N
P6066	30	20	50	5	<20	7	700	N	7	N	100	70	30	N	150	N
P6074	50	10	N	200	<20	30	70	N	5	N	N	70	<10	N	70	<.05
P6087	30	5	N	N	N	70	50	N	15	N	100	200	30	300	10	N
P6090	<10	10	N	N	N	15	70	N	7	N	<100	70	70	N	70	<.05
P6092	300	20	N	N	<20	70	20	N	15	N	<100	150	20	300	150	N
P6093	10	15	200	5	30	30	200	N	7	N	100	150	100	1,000	200	N
P6097	30	<5	50	5	30	15	15	N	10	N	700	200	15	N	300	N
P6098	10	50	100	5	50	7	20	N	20	N	1,000	300	30	N	500	N
P6103	20	700	N	N	N	<5	70	N	10	N	N	30	20	N	100	N
P6104	100	1,000	70	N	<20	20	50	N	10	N	N	200	50	300	300	N
P6105	100	15	N	N	20	7	30	N	15	N	N	150	15	N	150	N
P6106	<10	7	100	7	50	N	30	N	5	N	<100	20	20	N	500	N
P6107	30	3,000	N	10	N	10	15,000	<100	5	N	N	20	N	>10,000	20	N
P6113	10	30	70	N	30	<5	15	N	15	N	1,500	200	70	500	300	N
P6115	150	50	N	N	N	100	20	N	50	<10	500	500	100	500	150	N
P6116	<10	<5	N	70	N	5	50	N	5	N	700	100	15	N	30	N
P6117	10	<5	70	10	30	5	10	N	15	N	150	150	70	N	300	N
P6120	15	5	N	N	N	10	100	N	5	10	N	30	<10	N	10	N
P6121	200	<5	30	N	<20	100	15	N	10	N	N	200	10	<200	200	—
P6122	700	10	30	<5	N	7	15	N	30	N	100	300	15	N	70	.10
P6124	30	15	50	5	<20	15	20	<100	20	N	N	50	50	N	300	.05
P6126	50	2,000	N	30	N	30	15,000	<100	7	30	N	200	20	>10,000	200	N
P6127	30	70	N	70	N	10	50	N	N	100	N	70	<10	200	150	N
P6128	50	50	50	20	N	70	30	300	10	N	N	150	50	700	100	N
P6129	<10	15	50	10	100	<5	100	N	<5	15	N	10	50	N	500	N
P6130	70	15	20	N	<20	5	150	N	10	15	N	150	20	<200	500	N
P6131	<10	50	20	N	70	<5	30	N	10	20	500	150	20	N	500	N
P6132	<10	N	N	N	N	N	30	N	N	N	>5,000	N	N	N	N	N
P6136	<10	N	20	10	N	5	10	N	5	N	200	100	30	N	50	N
P6146	10	300	N	N	N	<5	3,000	N	7	N	N	10	20	7,000	150	N
P6147	300	1,000	N	300	<20	100	500	200	30	N	N	200	100	N	50	N
P6148	100	70	N	>2,000	<20	70	7,000	500	15	15	N	150	20	N	30	N
P6149	10	70	N	500	N	50	150	N	<5	N	N	10	N	1,500	150	N
P6150	50	70	N	70	<20	10	>20,000	<100	7	N	N	20	50	>10,000	100	N

Table 8.—Analyses of selected rock samples from the Never Summer study area, Colorado —Continued

Sample	Zn-ppm aa	Sb-ppm aa
P6029	85	1
P6030	50	<1
P6031	35	<1
P6032	90	1
P6033	55	5
P6038	170	1
P6039	280	40
P6050	35	3
P6058	75	N
P6059	—	—
P6060	80	1
P6066	60	<1
P6074	70	5
P6087	170	2
P6090	100	N
P6092	200	<1
P6093	630	2
P6097	40	N
P6098	65	<1
P6103	55	1
P6104	150	<1
P6105	30	N
P6106	5	<1
P6107	14,000	3
P6113	270	<1
P6115	240	1
P6116	120	2
P6117	100	1
P6120	25	10
P6121	—	—
P6122	35	40
P6124	80	25
P6126	12,000	15
P6127	260	3
P6128	120	40
P6129	45	10
P6130	150	10
P6131	70	2
P6132	N	10
P6136	120	<1
P6146	4,400	1
P6147	130	35
P6148	170	300
P6149	750	2
P6150	28,000	10

Table 8.—Analyses of selected rock samples from the Never Summer study area, Colorado —Continued

Sample	Latitude	Longitude	Fe-pct. s	Mg-pct. s	Ca-pct. s	Ti-pct. s	Mn-ppm s	Ag-ppm s	As-ppm s	B-ppm s	Ba-ppm s	Be-ppm s	Bi-ppm s	Cd-ppm s	Co-ppm s
P6151	40 25 33	105 56 42	15.00	.15	.10	.200	100	5.0	2,000	<10	700	3.0	N	N	N
P6154	40 29 6	105 52 32	7.00	.10	.20	.100	500	<.5	200	10	300	15.0	N	N	N
P6155	40 29 2	105 52 45	3.00	.30	.15	.150	500	N	N	15	700	7.0	N	N	N
P6156	40 29 8	105 52 45	5.00	.03	.30	.150	300	N	200	30	200	10.0	N	N	N
P6159	40 28 44	105 52 55	1.50	.50	5.00	.700	1,500	N	N	100	5,000	N	10[1]	N	<5
P6168	40 26 37	105 56 41	5.00	.15	.07	.200	100	2.0	700	10	500	10.0	N	N	N
P6169	40 26 5	105 55 36	10.00	1.50	.20	.700	1,500	5.0	N	15	1,500	1.0	N	N	30

Sample	Cr-ppm s	Cu-ppm s	La-ppm s	Mo-ppm s	Nb-ppm s	Ni-ppm s	Pb-ppm s	Sb-ppm s	Sc-ppm s	Sn-ppm s	Sr-ppm s	V-ppm s	Y-ppm s	Zn-ppm s	Zr-ppm s	Au-ppm aa
P6151	20	50	N	50	<20	N	200	300	30	N	N	50	30	N	300	N
P6154	<10	<5	150	15	200	N	50	N	<5	N	N	10	50	N	300	N
P6155	<10	N	30	10	150	N	50	N	<5	N	N	10	50	N	300	N
P6156	<10	70	N	100	100	N	30	N	<5	N	N	10	20	N	300	N
P6159	<10	<5	N	15	20	N	N	N	<5	N	200	10	N	N	500	N
P6168	<10	7	N	30	<20	<5	50	N	<5	N	N	10	200	N	200	.15
P6169	500	500	N	N	N	100	70	N	20	N	100	300	20	2,000	70	N

Sample	Zn-ppm aa	Sb-ppm aa
P6151	100	60
P6154	40	1
P6155	70	N
P6156	25	4
P6159	10	N
P6168	20	35
P6169	850	3

1/ Contains 50 ppm W.

Table 9.—Analyses of selected stream-sediment samples from the Never Summer study area, Colorado

Sample	Latitude	Longitude	Fe-pct. s	Mg-pct. s	Ca-pct. s	Ti-pct. s	Mn-ppm s	Ag-ppm s	As-ppm s	B-ppm s	Ba-ppm s	Be-ppm s	Bi-ppm s	Cd-ppm s	Co-ppm s
H6009	40 26 8	105 57 57	5.0	.70	.7	.5	1,500	2.0	N	50	500	3.0	N	N	15
H6010	40 26 20	105 58 30	5.0	.70	.7	.5	1,500	2.0	N	30	300	1.5	N	N	15
H6019	40 28 2	105 56 25	7.0	.70	.5	.5	1,000	.5	N	20	700	1.0	N	N	10
H6020	40 25 57	105 56 13	5.0	.70	.7	.5	1,500	<.5	N	50	500	3.0	N	N	10
H6021	40 26 8	105 57 32	5.0	.70	.5	.5	2,000	.5	N	50	500	15.0	N	N	20
H6022	40 26 23	105 58 13	5.0	.70	.7	.5	1,500	.7	N	30	500	1.5	N	N	15
P032	40 27 36	105 55 2	3.0	1.00	2.0	.5	300	N	N	20	300	2.0	N	N	7
P033	40 27 36	105 55 2	10.0	1.50	3.0	1.0	1,000	N	N	50	700	2.0	N	N	20
P041	40 26 48	105 54 31	5.0	.70	.7	.5	500	N	N	15	500	2.0	N	N	10
P042	40 26 59	105 54 48	2.0	1.00	.7	.5	200	<.5	N	20	300	1.5	N	N	7
P066	40 25 26	105 55 2	5.0	1.00	1.5	.5	1,000	N	N	20	300	5.0	N	N	10
P067	40 25 26	105 55 2	10.0	1.00	2.0	.7	2,000	N	N	20	300	5.0	N	N	15
P6034	40 25 24	105 56 55	5.0	.50	.7	.3	2,000	<.5	N	20	500	3.0	N	N	5
P6035	40 25 9	105 57 3	7.0	.70	.5	.7	3,000	.7	N	30	700	7.0	N	N	70
P6036	40 25 9	105 57 5	5.0	.50	.5	.3	2,000	.5	N	15	300	10.0	N	N	7
P6037	40 25 34	105 57 55	1.0	.15	.5	.2	1,000	<.5	N	15	200	3.0	N	N	<5
P6040	40 24 42	105 59 18	5.0	.70	.7	.5	1,500	1.5	N	100	700	5.0	N	N	10
P6041	40 24 57	105 59 30	2.0	.30	.7	.5	1,000	.7	N	20	300	5.0	N	N	<5
P6042	40 25 38	105 59 49	5.0	.70	1.0	.5	2,000	1.0	N	100	700	5.0	N	N	7
P6045	40 26 35	105 58 44	5.0	.70	1.0	.7	1,500	.5	N	15	700	7.0	N	N	10
P6047	40 27 36	105 58 26	5.0	.70	1.0	.7	1,500	.7	N	50	700	2.0	N	N	10
P6051	40 27 22	105 57 28	5.0	.70	1.0	.7	1,500	1.0	N	50	700	2.0	N	N	7
P6052	40 27 23	105 57 25	3.0	.70	1.0	.5	1,500	.5	N	50	700	2.0	N	N	10
P6054	40 27 22	105 57 40	7.0	1.00	1.0	.7	1,500	2.0	N	70	700	3.0	N	N	10
P6067	40 25 16	105 54 21	5.0	.70	.7	.7	700	<.5	N	15	500	7.0	N	N	7
P6068	40 24 51	105 54 40	3.0	.30	.2	.2	1,000	.7	N	50	300	15.0	N	N	<5
P6069	40 24 23	105 54 48	7.0	.50	.3	.5	1,500	.7	N	50	500	15.0	N	N	7
P6070	40 24 23	105 54 48	7.0	.70	.3	.3	1,000	3.0	N	50	300	30.0	N	N	5
P6071	40 24 28	105 55 0	7.0	1.00	.5	.5	1,500	<.5	N	50	700	2.0	N	N	30
P6072	40 24 36	105 55 2	.7	.20	.3	.3	700	.5	N	20	150	50.0	N	N	N
P6073	40 24 48	105 55 5	10.0	.70	.7	.3	2,000	.5	N	30	500	10.0	N	N	20
P6075	40 25 15	105 55 4	5.0	.30	.5	.3	1,500	N	N	30	300	20.0	N	N	<5
P6076	40 25 35	105 55 9	7.0	1.00	1.5	1.0	1,500	N	N	10	1,000	5.0	N	N	20
P6080	40 25 6	105 55 7	10.0	.70	.7	.7	1,500	.5	N	50	700	3.0	N	N	10
P6081	40 25 5	105 55 6	10.0	.70	.3	.5	1,500	<.5	N	20	500	10.0	N	N	10
P6082	40 24 56	105 55 9	10.0	.70	.5	.5	1,500	.5	N	30	500	5.0	N	N	10
P6083	40 24 44	105 55 6	7.0	.70	.5	.5	1,500	<.5	N	20	500	3.0	N	N	10
P6094	40 27 35	105 55 53	7.0	.50	.7	.5	1,500	.7	N	50	700	3.0	N	N	10
P6095	40 27 35	105 55 51	5.0	.30	.7	1.0	1,000	N	N	30	1,000	3.0	N	N	7
P6108	40 27 26	105 54 57	5.0	.50	1.5	1.0	1,000	N	N	30	1,000	2.0	N	N	7
P6110	40 27 30	105 55 25	3.0	.30	.5	.5	700	.5	N	30	700	2.0	N	N	5
P6111	40 27 43	105 54 23	7.0	.50	1.0	1.0	1,000	<.5	N	50	1,000	5.0	N	N	10
P6138	40 28 47	105 54 3	7.0	.50	.7	.7	1,000	<.5	N	50	700	2.0	N	N	10
P6140	40 26 15	105 55 54	5.0	.50	.7	.7	1,500	1.0	N	30	700	7.0	N	N	15
P6141	40 26 12	105 56 38	7.0	.50	.7	.5	1,500	N	N	20	300	2.0	N	N	15

Table 9.—Analyses of selected stream-sediment samples from the Never Summer study area, Colorado--Continued

Sample	Cr-ppm s	Cu-ppm s	La-ppm s	Mo-ppm s	Nb-ppm s	Ni-ppm s	Pb-ppm s	Sb-ppm s	Sc-ppm s	Sn-ppm s	Sr-ppm s	V-ppm s	Y-ppm s	Zn-ppm s	Zr-ppm s	Hm-ppm cm-cx
H6009	100	50	70	N	<20	70	70	N	30	N	200	200	70	N	300	7
H6010	50	70	70	<5	<20	30	30	N	30	N	100	200	70	N	200	5
H6019	150	70	300	N	<20	70	20	N	20	N	100	200	100	N	500	9
H6020	100	50	70	N	<20	50	150	N	30	N	<100	200	70	700	300	>45
H6021	100	50	150	N	<20	150	70	N	20	N	<100	200	70	1,500	300	>45
H6022	100	50	200	5	<20	70	30	N	30	N	150	200	70	N	500	9
P032	20	20	50	N	50	10	30	N	7	N	200	70	20	<200	200	4
P033	50	30	100	10	50	30	30	N	15	N	500	100	30	<200	500	5
P041	15	15	50	20	20	10	50	N	7	N	200	100	15	N	500	--
P042	20	20	50	5	<20	10	30	N	7	N	300	70	20	N	200	--
P066	20	20	70	7	100	10	50	N	7	N	200	50	50	<200	100	3
P067	30	30	50	15	200	10	100	N	10	N	200	100	100	<200	100	5
P6034	50	30	50	N	N	10	100	N	10	N	<100	70	50	N	200	>45
P6035	150	100	100	N	<20	100	200	N	15	N	100	200	70	200	300	>45
P6036	70	70	50	N	N	20	200	N	10	N	N	70	50	N	100	>45
P6037	15	7	30	N	N	<5	30	N	5	N	N	20	20	N	70	11
P6040	70	50	100	N	<20	50	70	N	20	N	100	200	70	700	300	25
P6041	30	15	100	N	N	10	30	N	10	N	100	70	70	N	200	17
P6042	100	70	70	<5	<20	30	200	N	15	N	100	200	100	300	300	>45
P6045	70	50	50	<5	30	30	100	N	20	N	200	200	70	700	300	11
P6047	100	50	50	N	20	50	30	N	30	N	150	200	70	N	300	9
P6051	100	30	300	N	<20	20	100	N	30	N	150	200	100	N	500	14
P6052	100	50	50	N	<20	50	70	N	15	N	150	200	50	N	300	11
P6054	150	50	50	N	<20	70	50	N	30	N	150	200	100	300	300	7
P6067	20	30	30	5	20	10	50	N	15	N	150	200	50	N	200	14
P6068	20	20	150	20	70	5	150	N	5	15	100	50	200	300	300	17
P6069	50	50	150	15	50	30	200	N	10	10	100	100	100	700	700	30
P6070	30	50	700	15	50	15	300	N	7	50	<100	50	700	1,000	150	27
P6071	150	50	100	N	20	100	100	N	30	N	100	300	70	500	700	25
P6072	20	7	70	N	N	<5	30	N	5	N	N	15	150	300	70	22
P6073	100	70	150	10	20	100	100	N	30	N	<100	200	150	300	500	9
P6075	50	20	200	5	<20	15	50	N	10	N	N	50	150	200	300	14
P6076	30	20	70	N	30	<5	50	N	15	10	1,000	200	30	N	300	5
P6080	100	70	70	N	20	70	300	N	20	N	100	200	70	700	300	35
P6081	100	50	70	N	20	100	100	N	20	N	<100	200	70	500	200	32
P6082	100	50	70	N	20	100	70	N	30	N	100	300	50	1,000	300	35
P6083	100	50	150	N	<20	100	70	N	30	N	100	200	70	700	300	32
P6094	100	70	70	N	20	70	70	N	20	N	200	150	50	300	300	17
P6095	30	10	50	7	30	10	50	N	10	N	500	150	15	N	300	11
P6108	20	5	70	15	30	10	50	N	15	N	700	150	30	N	500	2
P6110	30	50	100	20	20	10	30	N	10	N	300	100	30	N	300	7
P6111	30	50	100	10	30	15	70	N	15	N	300	200	30	N	500	5
P6138	30	50	100	5	30	15	50	N	15	N	300	300	50	500	500	9
P6140	50	50	50	N	20	70	70	N	15	N	150	150	50	200	500	27
P6141	50	20	50	<5	20	30	70	N	15	N	150	150	30	200	300	27

Table 9.--Analyses of selected stream-sediment samples from the Never Summer study area, Colorado --Continued

Sample	Latitude	Longitude	Fe-pct. s	Mg-pct. s	Ca-pct. s	Ti-pct. s	Mn-ppm s	Ag-ppm s	As-ppm s	B-ppm s	Ba-ppm s	Be-ppm s	Bi-ppm s	Cd-ppm s	Co-ppm s
P6142	40 25 58	105 55 46	5.0	.70	.7	.7	1,500	N	N	20	500	1.5	N	N	15
P6143	40 25 55	105 55 46	7.0	.70	.5	.5	1,500	.5	<200	20	700	5.0	N	N	30
P6145	40 25 40	105 55 23	7.0	.70	.7	.7	1,500	.7	N	50	700	5.0	N	N	15

Sample	Cr-ppm s	Cu-ppm s	La-ppm s	Mo-ppm s	Nb-ppm s	Ni-ppm s	Pb-ppm s	Sb-ppm s	Sc-ppm s	Sn-ppm s	Sr-ppm s	V-ppm s	Y-ppm s	Zn-ppm s	Zr-ppm s	Hm-ppm cm-cx
P6142	70	30	70	N	20	50	70	N	30	N	150	200	50	200	1,000	17
P6143	70	70	50	15	20	50	300	N	30	N	<100	150	50	1,000	150	20
P6145	70	50	100	N	20	30	300	N	30	N	100	200	70	2,000	300	>45

Table 10.--Semiquantitative spectrographic analyses of samples of the Mount Cumulus stock

[N, not detected; L, detected but below limit of determination]

Sample No.	Percent				Parts per million										
	Fe	Mg	Ca	Ti	Mn	Ag	Ba	Be	La	Mo	Nb	Pb	Sr	Y	Zr
76NS107[1/]	1.5	0.3	0.3	0.3	300	15	300	3	150	L	30	30	150	30	300
76NS107R[1/]	3	.3	.15	.2	700	N	300	3	100	15	20	50	150	30	300
76NS110	.7	.07	.3	.15	200	5	300	3	50	10	30	30	100	30	150
76NS110R	1.5	.07	.3	.15	300	5	300	3	70	10	30	30	100	30	150
76NS112	.3	.02	.3	.7	70	N	150	5	30	5	30	30	N	70	100
76NS112R	.7	.02	.3	.7	150	N	70	7	30	10	50	30	N	50	150
76NS115	.7	.07	.5	.1	150	N	300	3	70	5	30	30	L	30	150
76NS123	.7	.05	.3	.7	70	N	100	5	50	L	30	30	N	70	100
76NS123R	1.5	.07	.2	.2	150	N	200	3	100	L	30	30	N	20	100
76NS127	1.5	.03	.7	.3	200	N	150	3	150	10	50	50	L	30	150
76NS124	1	.03	.3	.15	150	N	150	3	70	5	30	30	N	50	200
76NS124R	.7	.05	.2	.1	500	N	200	5	70	5	70	30	N	30	150
76NS131A	.7	L	.3	.05	300	N	N	7	70	70	50	30	N	100	150
76NS131B	.3	L	.3	.02	200	N	L	7	50	L	30	30	N	70	200
76NS150	2	.07	.5	.1	300	N	150	3	70	L	30	20	L	30	200
76NS150R	1	.07	.3	.1	300	N	200	5	50	5	30	30	N	30	150
76NS116	2	.07	.3	.1	300	N	300	3	50	L	30	30	L	30	200
76NS135	1	.02	.3	.07	150	N	100	5	50	5	50	30	N	150	150
76NS137	.3	.03	.15	.07	30	N	100	3	30	5	30	30	N	30	100
76NS137R	.7	L	.1	.07	50	N	70	5	70	7	30	30	N	30	70
76NS138	2	L	.3	.07	300	N	70	7	50	7	70	30	N	50	150
76NS146	1.5	.02	.3	.07	200	N	30	5	50	L	30	30	N	50	200
76NS148	1.5	.03	.3	.07	300	N	50	7	50	L	30	30	N	50	150

[1/] Sample 76NS107 contains 20 ppm tin and sample 76NS107R contains 150 ppm tin. No other sample shown in this table contained detectable tin.