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UNITED STATES GEOLOGICAL SURVEY

MINERAL RESOURCES OF THE WEST ELK WILDERNESS and vicinity, Delta and Gunnison Counties, Colorado

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Contents

Geochemical exploration--continued

Chapter D. Mines, prospects, and mineralized areas of the West Elk Wilderness study area, Delta and Gunnison Counties, Colorado

U.S. Bureau of Mines, 1953-1970, Analyses of tipple and delivered samples of coal (collected during the fiscal years 1952-1969): Repts. of Inv. 4934, 4972, 5085, 5221, 5270, 5332, 5401, 5489, 5615, 5792, 6086, 6300, 6461, 6622, 6792, 6904, 7104, 7219, 7346.

Areas of detailed investigation--Continued

Illustrations

Figures

Tables

SUMMARY

A mineral survey of the West Elk Wilderness and contiguous areas, which cover about 434 mi^2 (1,225 km^2) in west-central Colorado, was made by the U.S. Geological Survey and the U.S. Bureau of Mines during parts of 1971, 1972, 1973, and 1974. The results of the survey indicate that the area has large resources of good grade bituminous coal. The area may contain buried deposits of base and precious metals. The potential for oil and gas discoveries is slight, and no evidence was found to indicate a geothermal resource.

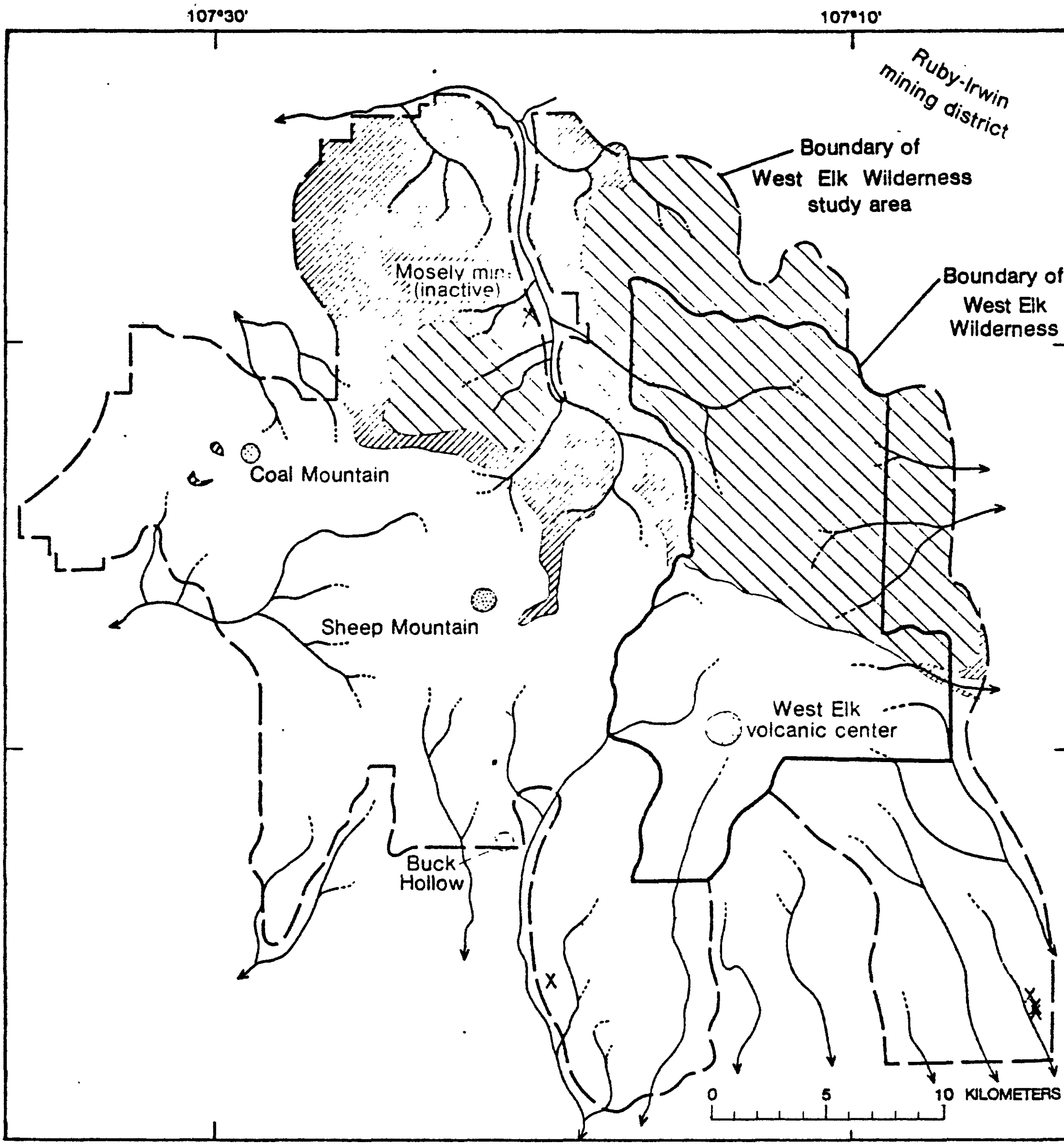
The study area lies along the trend of the Colorado Mineral Belt, and it is locally transected by a major fracture zone connecting with mineralized structures in the nearby Ruby-Irwin mining district. The northern part of the area is characterized by myriad Tertiary igneous bodies that intrude as much as 8,000 ft (2,440 m) of Mesozoic and Tertiary sedimentary strata. Numerous laccolithic mountains form conspicuous topographic eminences. In contrast, the southern part of the area is a deeply dissected pile of Oligocene volcanic and intrusive rocks that includes layered volcaniclastic deposits, lava flows, plugs, plug domes, dikes, vent complexes, and at least one large, deeply eroded strato-volcano of intermediate composition (the West Elk volcanic center). The volcanics overlie an eroded surface on sedimentary strata. The sedimentary rocks thin southward, and in places along the southern margin of the area, the volcanic rocks probably lie on Precambrian crystalline rocks.

The mineral potential of the area was studied by examining mining and mineral production records, claims and exploratory workings, by a geochemical survey, by aeromagnetic and gravity surveys, and by the preparation of a geologic map.

The area contains 117 unpatented mining claims and no patented claims. A few small exploratory workings are widely scattered throughout the study area. The only production from the area is about 1,000 tons (900 t) of coal from the Mosely Mine on the west side of Coal Creek. Small amounts of gold, silver, copper, lead, and zinc have been produced from the nearby Ruby-Irwin mining district (fig. 1).

The geochemical program consisted of the collection and analyses of 1,364 rock, stream-sediment, panned-concentrate, and soil samples. None of the samples contained visible amounts of ore minerals; however, altered rocks at several localities contain anomalous amounts of base and precious metals.

The results of geophysical surveys help to define two intrusive bodies of possible economic interest. One is a hypothetical intrusive body underlying altered rocks at the West Elk volcanic center; and the other, a more favorable target, is the Sheep Mountain laccolith.



EXPLANATION

Measured, indicated, or inferred coal resources (see tables 3 and 4, chapter E) Marginal to very high potential

Inferred to be underlain by coal-bearing rocks of the Mesaverde Formation about 600 m below the surface. Generally in areas of complex structure and widespread igneous intrusion. Low to very low potential

Weakly anomalous metallization associated with granodioritic or rhyolitic intrusive bodies. Light stipple, low to moderate potential; dark stipple, moderate potential

X Small deposits of manganese and other metals in veins and prospect workings. Low potential

Figure 1.--Areas of coal- and mineral-resource potential, West Elk Wilderness study area, Colorado.

Coal is the most important mineral commodity in and near the wilderness. The study area is estimated to contain about 1.6 billion tons (1.5 billion t) of good-grade bituminous coal. In addition, the area contains small manganese deposits. The anomalously high amounts of base and precious metals in altered rocks associated with mid-Tertiary intrusions might signify the presence of buried ore deposits.

Chapter A

Geology of the West Elk Wilderness and vicinity, Delta and Gunnison Counties, Colorado

by

David L. Gaskill,

U.S. Geological Survey

INTRODUCTION

This report describes the geology, known mineral deposits, and mineral potential of the West Elk Wilderness and adjacent areas in the West Elk Mountains of west-central Colorado. The study area covers about 434 mi^2 (1,124 km^2) in the Gunnison National Forest, and all, or parts, of 17 U.S. Geological Survey 7 1/2-minute topographic quadrangle maps (figs. 2 and 3). Plates 1, 2, 3, and 4 include areas outside the study area boundary to provide geologic and geophysical perspective to show the location of adjacent coal mining areas and the Ruby-Irwin metal mining district, and previously published geologic maps.

The study area ranges in altitude from about 6,400 ft (1,950 m) at the mouth of Coal Creek to over 13,000 ft (3,960 m) on West Elk Peak. The northern part of the study area is dominated by laccolithic mountains flanked by precipitous cliffs, extensive talus aprons, forested mesas, canyons, and spacious, well-watered intermountain basins. In contrast, the southern part of the area is a rugged, deeply dissected volcanic plateau that slopes gradually south. The northern edge of this volcanic highland forms an imposing, almost continuous escarpment that culminates in the peaks, spurs, and alpine meadows of the Baldy Mountains-West Elk Peak Ridge.

The area is locally accessible by a network of horse, foot, and game trails that connect with numerous secondary road heads and jeep trails near the study area boundary.

PREVIOUS STUDIES

Previous work on the mineral resources and geology of the West Elk Wilderness study area and vicinity has been focused largely on the coal deposits in the northern part of the study area. The first published geological observations were by Prof. F. Hawn along the northeast margin of the study area in 1873 (Ruffner, 1874). A. C. Peale, Henry Gannett, and W. H. Holmes of the Hayden survey traversed the West Elk Mountains in 1874. Their reports and maps remain an excellent reference to the area (Peale, 1877; and Hayden, 1876, 1881). A geologic folio (Emmons and others, 1894) includes that part of the study area covered by the Anthracite Range and Mt. Axtell quadrangle maps (fig. 2 and pl. 1). Many coal resource reports refer to localities in, or adjacent to, the study area; (Hills 1893; Lee 1912; Dapples 1939; Johnson 1948; Toenges and others 1949, 1952; Berryhill and Averitt 1951; Landis 1959; Hanks 1962; Landis and Cone 1971; Osterwald and others 1972; Hornbaker and Holt 1973). A recent geologic map (Hail, 1972) includes part of the western edge of the study area. Other publications bearing on geology, geophysical surveys, and mineral resources in the West Elk Mountains are listed in the references for Chapters A, B, C, and D of this report.

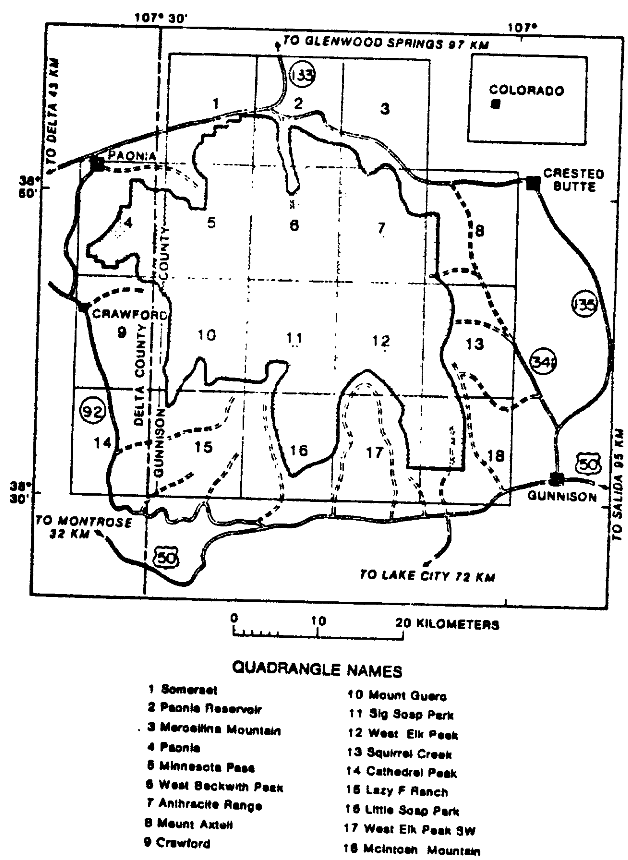


Figure 2.--Index map of 7 1/2-minute quadrangle maps and access roads, West Elk Wilderness study area (stippled).

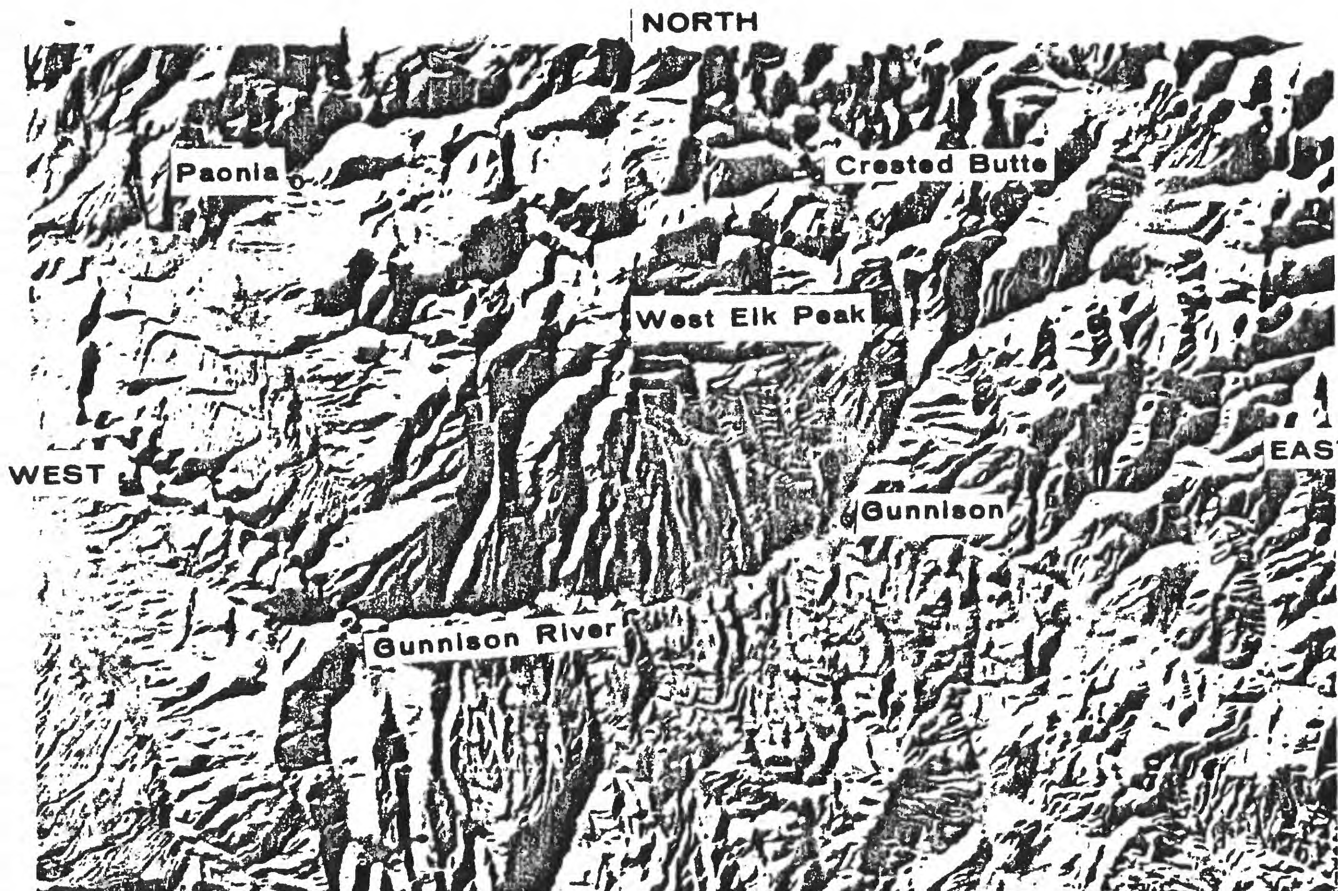


Figure 3.--Shaded relief map of West Elk Wilderness study area and vicinity.

PRESENT INVESTIGATIONS AND ACKNOWLEDGMENTS

Field investigations in the study area by the U.S. Geological Survey, totaling about 24 man-months, were made by D. L. Gaskill and B. L. Bartleson in 1971, 1972, and 1973; by J. C. Kramer in 1971 and 1972; by F. E. Mutschler, F. G. Cornish, and D. L. Peterson in 1973; and by H. D. King, J. B. McHugh, and U Zaw Ko (Directorate of Geological Surveys and Exploration, Union of Burma) in 1974. Aeromagnetic and gravity surveys of the area were made in 1972 and 1973 (pls. 2 and 4).

Field work included geologic mapping and geochemical sampling of stream sediments and bedrock. Stream sediments were collected along all principal streams and most of their major tributaries. Bedrock samples included representative rock types, altered or mineralized rocks and veins, and mineralized fracture zones.

Much of the analytical work was done in a mobile laboratory in the field, and the remainder in the U.S. Geological Survey laboratories in Denver, Colo., and in the rapid rock analyses laboratory in Washington, D. C. Spectrographic analyses were made by R. N. Babcock, J. A. Domenico, C. L. Forn, R. T. Hopkins, Jr., J. M. Matooka, and J. H. Reynolds. Chemical analyses were made by R. B. Carten, C. A. Curtis, P. L. D. Elmore, J. G. Frisken, J. L. Glenn, J. L. Harris, J. D. Hoffman, R. L. Hutchens, James Kelsey, Herbert Kirshenbaum, A. L. Meier, R. L. Miller, J. M. Mitchell, D. G. Murrey, J. C. Negri, S. H. Truesdell, J. D. Sanchez, Hezekiah Smith, Z. C. Stephenson, and E. P. Welsch.

The project has benefited from the help of many colleagues. P. W. Lipman and T. A. Steven were especially helpful in resolving some of the geological problems in the study area.

Grateful appreciation is extended to many people outside the Geological Survey for their aid during this study. Particularly helpful were E. E. Larson of the University of Colorado, who mapped part of the West Elk volcanic center in 1971; Joe Petrarich, Jr., of Paonia, Colo.; Grant and Dellis Ferrier of Crawford, Colo; Rudi Rudibaugh of Parlin, Colo.; and L. R. McGraw of Gunnison, Colo. Personnel of the U.S. Forest Service in Paonia and Gunnison gave valuable advice and made Forest Service facilities available for our use.

GEOLOGIC SETTING

The study area is in the West Elk Mountains on the southeast margin of the Piceance basin, and lies in a transition zone between the Southern Rocky Mountains on the east and the Colorado Plateau on the west. Sedimentary rocks of Mesozoic and Tertiary age in the area are intruded and deformed by dikes, plugs, sills, and laccoliths. Laccolithic peaks and mesas of sedimentary strata characterize the northern part of the area. The West Elk volcanic field of Oligocene age extends over nearly all of the southern part of the study area, and forms a deeply dissected volcanic plateau composed of volcaniclastic rocks, lava flows, and ash flow tuffs. The sedimentary formations are well known from widespread exposures elsewhere in this region, but little information has been published concerning the intrusive and extrusive rocks in the study area. Most of the extrusive rocks were derived locally from volcanoes of intermediate composition that are related to and developed concurrently with similar volcanoes in the San Juan volcanic field south of the Gunnison River (Steven, 1975).

SEDIMENTARY ROCKS

Table 1 summarizes the sedimentary stratigraphy of the West Elk Mountains. Mesozoic and Tertiary sedimentary strata totaling about 8,000 ft (2,440 m) in thickness, are widely exposed in and adjacent to the northern part of the study area, but only the lower 1,500-5,000 ft (460-1,520 m) or so, of the Mesozoic section is present in the southern part. (See section A-A', pl. 1). Older Paleozoic strata shown on table 1 are believed to have been entirely cut out in the study area by an angular unconformity at the base of the Jurassic formations; the inferred beveled edge of the Paleozoic rocks is indicated on figure 5.

VOLCANIC ROCKS

Volcanic formations include the West Elk Breccia and a sequence of ash-flow tuffs that locally overlie the West Elk Breccia along the south side of the study area (pl. 1).

West Elk Breccia

The volcanic rocks are largely included in a single formation--the West Elk Breccia. This formation was derived in large part from the West Elk volcanic center, a deeply eroded composite strato-volcano in the north-central part of the West Elk volcanic field. Other volcanic vent areas are indicated by extrusive domes, plugs(?), and local accumulations of steeply dipping near-vent volcaniclastic rocks south and west of the West Elk volcanic center. Eroded remnants of the West Elk Breccia attain thicknesses of nearly 4,000 ft (1,220 m) in the study area. They overlie a deeply eroded surface of Mesozoic and Tertiary strata and locally overlie Precambrian rocks a few miles south of the study area. Volcanic activity in the area began with eruption of lava flows, lava domes, and minor pyroclastics that formed a basal cone vent facies. Outflow aprons surrounding the basal cone vent facies are largely composed of crudely stratified volcaniclastic rocks and minor interlayered lava flows.

Basal cone vent facies

The oldest and most altered volcanic rocks form a basal cone unit of porphyritic, massive to brecciated, light- to dark-gray, brown, grayish-green, red, and purple rocks that range in composition from basaltic andesite to rhyodacite. Some of the rocks in the core of the West Elk volcanic center are microgranular diorites and quartz

Table 1. Sedimentary rock formations of the West Elk Mountains and vicinity.

Era	System	Series	Stratigraphic unit	General thickness (ft)		Description
Cenozoic	Tertiary	Miocene and Pliocene(?)	Intrusive and extrusive rocks	200-500	Not present in the West Elk Wilderness and vicinity	Basaltic flows, dikes, and gabbroic intrusions in Grand Mesa area; and basaltic flows on Ohio Creek-East River divide.
			Unnamed	500±		Red beds with andesitic conglomerates under basalt flows near Overland Reservoir about 16 miles northwest of study area boundary (J. R. Donnell, oral commun., 1974).
		Upper or middle Eocene	Green River Formation	500±		Sandstone, siltstone, mudstone, and oil-shale at Chalk Mountain about 20 miles northwest of study area boundary (J. R. Donnell, oral commun., 1974).
		Eocene	Wasatch Formation	4,700±		Variegated sandstone, siltstone, shale and conglomeratic sandstone.
			Conglomeratic facies	600±		Ruby Formation of Emmons and others (1894)--Feldspathic sandstone, conglomerate, arkosic sandstone, siltstone, and mudstone. Conglomerates composed of andesitic dacitic, varicolored chert, quartzite, quartz, sandstone, claystone, granitic, and gneissic pebbles; apparently derived from Sawatch highlands to the west.
		Paleocene	Ohio Creek Formation	400±		Medium to coarse-grained feldspathic sandstone, with chert, quartzite and quartz pebble lenses, interbedded with fine- to medium-grained sandstone, shale, and siltstone.
Mesozoic	Cretaceous	? Upper Cretaceous	Mesaverde Formation	2,100±		Interbedded sandstone, shale, coal, and carbonaceous shale. Commercially important coal beds in 550 foot interval above the basal Rollins sandstone member.
			Mancos Shale Juana Lopez Member; Fort Hays Limestone Member	4,000±		Mostly gray, laminated, silty, marine shale. Transitional zone at top includes thin beds of sandy limestone, limy sandstone, and carbonaceous shale. Several thin to massive sandstone beds in upper half of formation. Includes a thick interval of calcareous shale above Fort Hays Limestone. Beds are locally baked and metamorphosed to argillite and hornfels over roofs of igneous intrusions. Fort Hays Limestone Member: fossiliferous limestone and limy shale 0-80 feet thick. Juana Lopez Member: Calcareous shale, and calcareous sandstone.
		Lower Cretaceous	Dakota Sandstone and Burro Canyon Formation	200±		Dakota Sandstone: thin- to thick-bedded quartzose sandstone or orthoquartzite; carbonaceous shale and silty sandstone. Generally a thin chert and quartz-pebble conglomerate at base. Burro Canyon Formation: coarse conglomeratic sandstone chert and quartzite-pebble conglomerate, and discontinuous beds of fine-grained sandstone and shale.
	Jurassic	Upper Jurassic	Morrison Formation	450±		Varicolored claystone, sandstone, siltstone, silty shale, and chert-pebble conglomerate.
			Junction Creek Sandstone Member Wanakah Formation	250±		Silty mudstone, gypsiferous sandstone and mudstone, cherty and silty limestone. Junction Creek Sandstone Member: discontinuous fine-grained, friable, eolian sandstone 0-90 feet thick.
			Entrada Sandstone	0-45±		Fine to very coarse grained, medium to thick bedded quartz sandstone with a few shale partings. Locally conglomeratic at base.
Paleozoic	Permian and Pennsylvanian		Maroon Formation	0-1,200±	Beveled under West Elk Mountains by angular unconformity at base of the Jurassic rocks. Probably not present in the West Elk Wilderness and vicinity.	Arkosic conglomeratic, micaceous siltstone, sandstone, silty shale and conglomerate.
	Pennsylvanian		Gothic Formation of Langenheim (1951)	0-1,900±		Interbedded shale, siltstone, sandstone, conglomerate, limestone, and limestone-pebble conglomerate.
			Belden Formation	0-400±		Sandy, cherty limestone, dolomitic limestone and dolomite, siltstone, sandstone, and carbonaceous shale.
			Molas Formation	0-50±		Argillite, quartzite, sandstone, siltstone, conglomerate, and residual breccia on irregular karst surface.
	Mississippian		Leadville Limestone	0-220±		Limestone, marble, and dolomite. Locally cherty with sandy, shaly zone at base.
	Devonian		Chaffee Formation	0-160±		Dolomite, limestone, and quartzite.
	Ordovician		Fremont Limestone	0-60±		Limestone and dolomitic limestone.
			Harding Sandstone and Manitou Formation	0-150±		Sandy, cherty dolomite, limestone, dolomitic limestone, sandstone and quartzite.
	Cambrian		Peerless Formation and Sawatch Quartzite	0-280±		Quartzite, limestone, dolomitic limestone, shale, siltstone, and limestone conglomerate. Arkosic conglomerate at base.
	Precambrian		Crystalline basement rocks			

p. 10

diorites. As mapped, the unit is mostly an undeciphered complex of lava flows, breccias, dikes, and larger igneous masses. The latter probably represent thick flows and domes of extruded lava, and some may be laccolithic bodies intruded later into the volcanic pile. The unit is widely propylitized, locally pyritized, and silicified. It makes up the core rocks of the West Elk volcanic center and the dike swarm near the head of East Soap and West Elk Creeks. Other less extensive exposures of pervasively altered basal vent facies and dikes that occur along lower Soap Creek, South Castle Creek, at the head of the South Fork of Smith Creek, and elsewhere in the study area are probably equivalent to the core rocks in the West Elk volcanic center. The basal cone unit is more than 2,000 ft (610 m) thick in the volcanic center. Where the base can be seen or inferred it overlies Mancos Shale, except in a few places along the northern edge of the West Elk volcanic field, where it probably overlies the Mesaverde Formation, and possibly overlies Tertiary strata.

Volcaniclastic facies

The volcaniclastic facies of the West Elk Breccia is generally composed of gently dipping, crudely layered tuff breccias, with local ash beds, laharic breccias, lava flows, and minor epiclastic deposits (Frontispiece and figs. 4, 5, and 6). The volcaniclastic facies has a maximum thickness of about 2,000 ft (610 m), and contains the largest volume of volcanic material in the West Elk volcanic field. The volcaniclastic facies overlies basal cone vent facies near volcanic centers, but extends many miles to the south and southeast beyond the limits of the basal cone facies. Lava flows in the volcaniclastic facies diminish in number and thickness outward from the West Elk volcanic center, whereas the proportion of laharic and epiclastic material increases outward. The lava flows and volcaniclastic rocks are porphyritic hornblende andesites, dacites, and rhyodacites similar to the flows and breccias in the basal cone unit. Some of the volcaniclastic material may represent unwelded pyroclastic breccia flows or base-surge material (Sparks and Walker, 1973; Sparks and others, 1973; Crandell and others, 1974).

North and east of the West Elk volcanic center the volcaniclastic facies could be subdivided into at least four mappable units separated by conspicuous unconformities. Each unit appears to represent a discrete eruptive interval consisting of many individual or gradational volcaniclastic layers with alternating fine fragmental and coarse blocky tuff breccias, thin ash beds, lapilli tuffs, and many sharp depositional breaks and minor erosional intervals. Most of the volcaniclastic layers are tuff breccias with angular to subrounded clasts in a crystal-fragment matrix of the same color and composition. Individual layers and units are dominantly composed of one rock type: the lighter toned units are mostly light-gray rhyodacite, and the darker units are andesitic or dacitic rocks. A distinctive basal unit of the volcaniclastic facies, about 300 ft (90 m) thick, locally overlies basal cone vent facies along South Castle Creek and Mill Creek. It is composed of greenish-gray and yellowish-brown sands, pumice tuff, and thin lava flows. Some exotic pebbles and boulders of

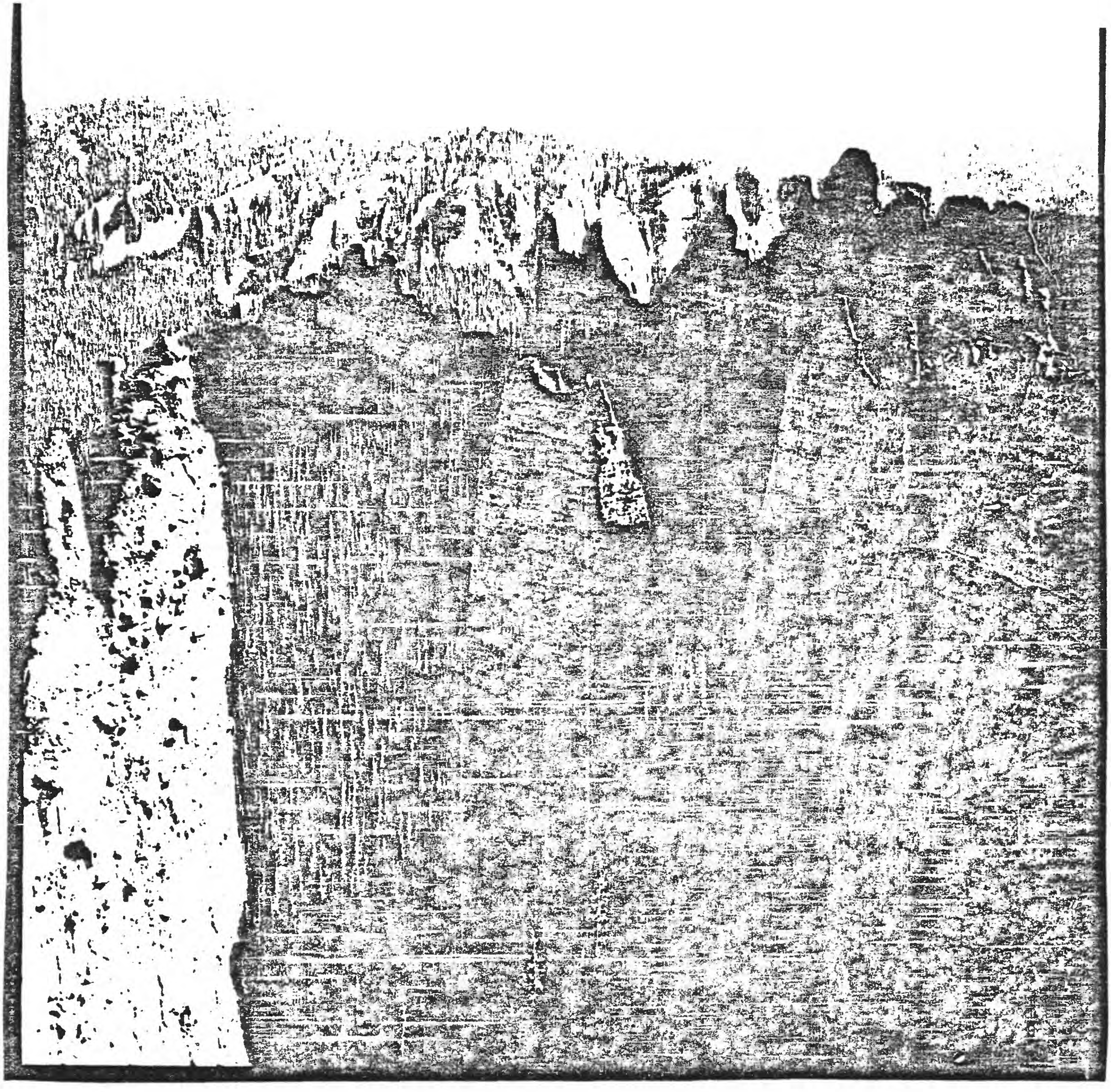


Figure 4.--Pinnacles of West Elk Breccia (volcaniclastic facies) in amphitheatre on north side of Mill Creek canyon (sec. 34, T. 15 S., R. 86 W.). View south-southwest.

Figure 5.--Major unconformity between eruptive units in volcaniclastic facies of the West Elk Breccia. View south down Beaver Creek canyon from Mill Creek divide.

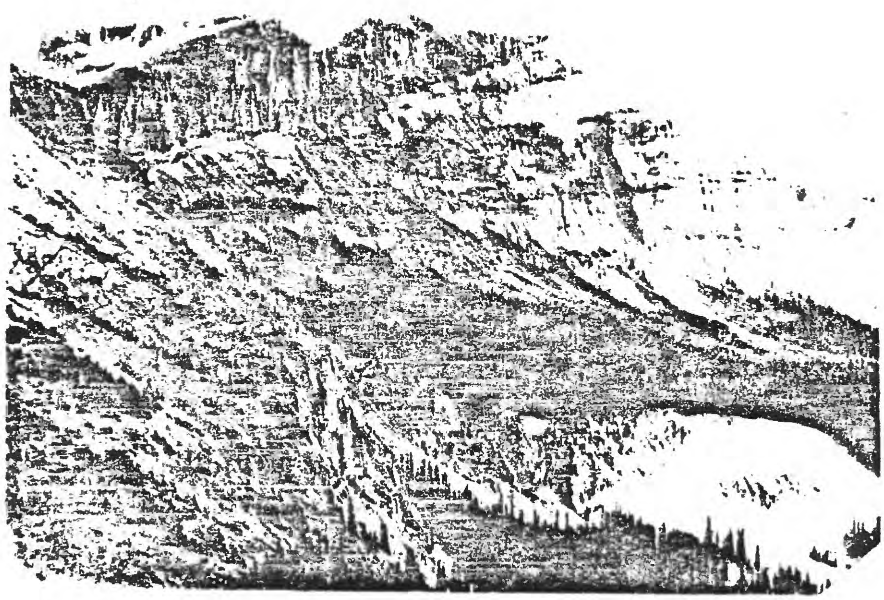


Figure 6.--Angular unconformity in volcaniclastic facies of the West Elk Breccia at the head of Soap Creek and Soap basin. Volcaniclastic layers and lava flows dip northeasterly away from the West Elk volcanic center. Large porphyritic dacite dike in foreground intrudes the volcanic rocks. View south. West Elk Peak on far left.

Precambrian granite; Paleozoic sandstone, limestone, quartzite, marble, and chert; Tertiary hypabyssal porphyries; and densely welded, eutaxitic, crystal tuff were found in channel-fill deposits cut in basal cone-vent facies in South Castle Creek valley, and mixed with ash and tuffaceous debris overlying Wasatch beds at the base of the volcaniclastic facies on Castle Pass. The exotic pebbles were probably derived from the Sawatch-Elk Range highlands east-northeast of the study area.

Ash-flow tuffs

A thick sequence of ash-flow tuffs unconformably overlies the West Elk Breccia in the southeastern part of the study area and adjacent areas (Olson and others, 1968; Hansen, 1971; Hedlund and Olson, 1973, 1974). The tuffs thicken southward and are believed to have been derived from calderas in the San Juan Mountains (Lipman and others, 1970, 1973). One of the ash-flow sheets has been dated at 27 ± 3 m.y. (million years) and 27.8 m.y. (Hansen, 1971; Lipman and others, 1970, 1973). The ash-flow tuffs are locally separated by tuffaceous gravels and tuff breccias.

INTRUSIVE ROCKS

More than 20 asymmetrical to bell-shaped laccoliths and stocks, uncounted thin to very thick sills, several generations of dikes, and pluglike hypabyssal bodies are exposed in the study area.

Laccoliths and sills

Laccoliths and related sills range from rhyodacite porphyry to granodiorite to quartz monzonite porphyry. Most are granodioritic in composition and contain phenocrysts of plagioclase, hornblende, biotite, augite, or hypersthene. Some contain quartz phenocrysts and large crystals of potash feldspar. Locally they intrude all the sedimentary formations in the study area. At least two laccoliths (Saddle and Little Sand Mountains) are floored by Jurassic rocks at or near the Precambrian contact. Most of the laccoliths are emplaced in the Mancos Shale, but the largest intruded the Mesaverde Formation and younger strata. Most are several thousand feet thick. The largest laccolith in the study area, Mount Gunnison, is exposed over an area of about 16 mi^2 (42 km^2), and has a relief of nearly 6,000 ft (1,830 m).

Most of the laccoliths thin on one or more sides into sills, and are commonly surrounded by numerous other sills and small laccoliths. In general, only a thin zone of baked or indurated strata, a few tens of feet thick, immediately overlies the roof and flank of the laccoliths, but locally, the sedimentary rocks in contact with the laccoliths are metamorphosed to hornfels, quartzite, and anthracite coal. In contrast, the composite stocks in the adjacent Ruby Range are surrounded by broad metamorphic aureoles 1/2 mi (0.8 km) or more wide that grade outward from metasomatized and silicified metasediments to slightly baked shales.

Sheep Mountain pluton

Sheep Mountain, at the head of Coal Creek and North Smith Fork, is a distinctive symmetrical laccolith or stock (fig. 7), surrounded by thick sills and laccoliths in the upper part of the Mancos Shale. The central pluton consists of an inner, unaltered core of locally flow-banded rhyodacite porphyry surrounded by altered and mineralized porphyritic granodiorite. The upper portion of the pluton is argillized to a light gray to white and is widely stained reddish brown to yellowish orange from oxidized, disseminated pyrite.

Coal Mountain pluton

The cluster of laccoliths and sills in the northwestern part of the study area (T. 14-15 S., R. 90-91 W.) is marked by a broad magnetic high that trends north-northeast across Coal Mountain (pl. 1). A domal body of granodioritic rock, similar to that at Sheep Mountain, is exposed on the north flank of Coal Mountain. This intrusion has domed the overlying sedimentary rocks and altered them to hornfels. Both the upper portion of the intrusive body and a thick section of Mancos Shale overlying the Coal Mountain pluton contain abundant pyrite.

Dikes

The West Elk volcanic center is cut by a radial swarm of porphyritic andesite, dacite, and rhyodacite dikes of several generations. Many of the dikes extend beyond the altered rocks of the volcanic center, intrude surrounding sedimentary strata, and cut to various levels in the volcaniclastic rocks. The youngest, least altered dikes extend to the eroded top of the West Elk Breccia pile. Some of the dikes are several hundred feet wide, over 6 mi (9.7 km) long, and are exposed over a vertical range of 3,000 ft (915 m).

Similar dikes intrude faults along the Porcupine Cone escarpment and elsewhere in the volcanic pile. Distinctive green to dark-gray, aphanitic, siliceous dikes intrude propylitized chaotic vent-facies volcanics in many places.

A number of large dacitic to granodioritic dikes cut sedimentary strata at the northeast edge of the study area. They connect with the small composite epizonal stocks of the Ruby Range, and are emplaced along a wide fracture zone that probably extends to the West Elk volcanic center.

Plugs and other igneous bodies

The study area contains many igneous bodies that include pluglike intrusives, sills and rhyodacitic domes(?) or hypabyssal(?) intrusions of uncertain genesis (pl. 1).

Needle Rock, a plug of rhyodacite porphyry at the west edge of the study area, may represent the eroded conduit of a laccolith.

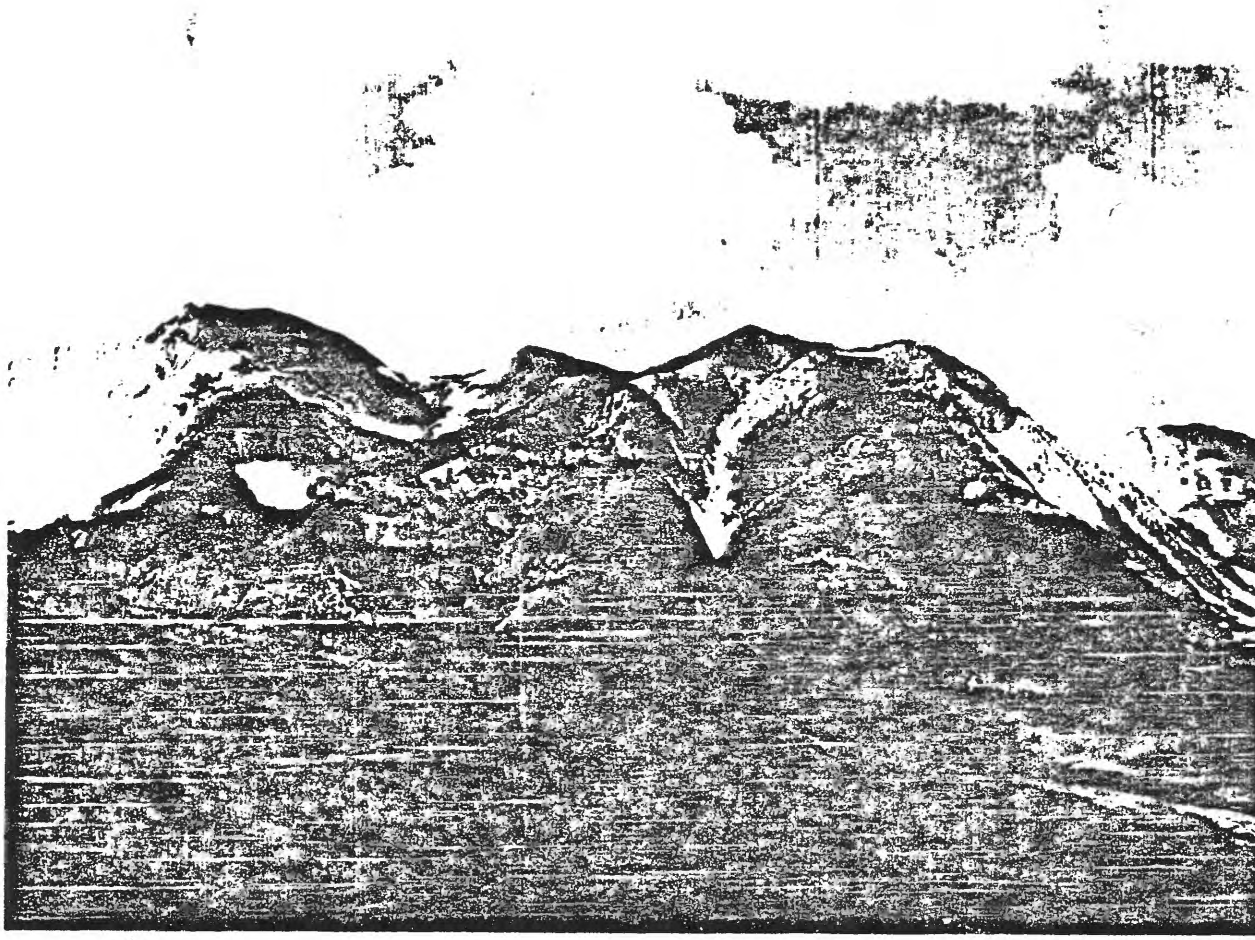


Figure 7.--Sheep Mountain (center); Mount Guero (left). View west from Haystack Mountain. Conspicuous arrow-shaped gulch (Red Gulch) in center of figure cuts mineralized rock of the Sheep Mountain pluton.

A large plug (or volcanic dome?) of yellowish-gray rhyolite, unique to the study area, is exposed in volcanic breccias at Buck Hollow near Big Soap Park. The plug contains pyrite partly altered to limonite along some fractures. Geochemical samples of the rhyolite show traces of molybdenum and other metals.

A thick, altered rhyolite sill in Mancos Shale, along Soap Creek between Big Soap Park and East Soap Creek, intrudes steeply upturned sedimentary rocks adjacent to a rhyodacite dome east of Soap Creek. The dome is locally argillized and contains xenoliths of Precambrian rock; it may be a cupola of a much larger intrusive body at depth. The geologic relationships here are similar to those in the Smooth Canyon area along upper Soap Creek, where a small, argillized felsite plug (or sill?) intrudes Mancos Shale adjacent to a rhyodacitic dome in basal volcanics.

A number of other light-colored hornblende rhyodacitic bodies (labeled rd) are shown on plate 1 within the West Elk volcanic field. These rhyodacitic bodies are very similar in composition and texture to many of the laccoliths and sills along the northwest margin of the volcanic field. Several of these igneous masses appear to have associated dikes, and they may represent both hypabyssal intrusions and volcanic domes.

UNCONSOLIDATED DEPOSITS

Unconsolidated deposits in the study area include broad aprons of active talus, lobed talus streams, and rock glaciers flanking the laccolithic mountains; extensive areas of landsliding and solifluction; and minor glacial, alluvial, and lacustrine deposits. Active and ancient landslides, and associated mud and debris flows, cover many square miles along the western and northeastern margin of the volcanic plateau.

Glacial deposits are generally obscured by colluvium, talus, and vegetation; they are particularly difficult to distinguish in the volcanic terrain. A few well-defined moraines on Mount Gunnison, and scattered deposits of till in Castle Creek valley and elsewhere, are shown by circle symbols on plate 1. Most of the areas of mass movement on plate 1 are indicated by landslide and slump-block scarp symbols with arrows showing direction of movement. Many areas with surficial cover are not delineated on plate 1, particularly in the volcanic terrain.

STRUCTURE AND GEOLOGIC HISTORY

The West Elk Mountains are similar in structure, intrusive rock types, and surrounding sedimentary strata to other laccolithic mountains on the Colorado Plateau, and to the volcanic San Juan Mountains further south. The laccoliths and associated igneous intrusives in the study area cut and deform a thick sequence of flat-lying to gently dipping sedimentary rocks that are locally overlain by extrusive rocks of the West Elk volcanic field. Precambrian basement rocks are covered by younger rocks in the study area, but are exposed along the Gunnison River to the south, where complexly layered and folded metamorphic rocks are intruded by a variety of plutonic igneous rocks (Hunter, 1925; Hansen, 1965, 1971; Hedlund and Olson, 1973, 1974; Hedlund, 1974).

During Paleozoic time, sedimentary strata were intermittently deposited in the study area. Near the end of the Paleozoic era, uplift of the Uncompahgre-San Luis highland resulted in removal of the Paleozoic strata and the gradual reduction of the highland to a low plain (Hansen, 1965, p. 45-46). During Late Jurassic, Cretaceous, Paleocene, and Eocene time, about 11,000 ft (3,350 m) of continental and marine sediments accumulated over a beveled Precambrian surface. Near the end of the Cretaceous, and during Paleocene time, the Gunnison uplift (the area of the present Gunnison River valley) and the Sawatch Range rose to form a horseshoe-shaped upland that shed alluvial debris (Ohio Creek and Wasatch Formations, and younger sediments) west and north into the Piceance basin.

By early Oligocene time, erosion had greatly reduced the Sawatch Range and had cut a relatively smooth surface across the Gunnison uplift. The tilted edges of Mesozoic strata on the north flank of the Gunnison uplift were beveled and several thousand feet of Cretaceous strata were removed from the southern part of the study area (Hansen, 1965, p. 21, fig. 7). Beginning in middle Oligocene time, stocks, dikes, sills, and laccoliths intruded and locally deformed the remaining Mesozoic and Tertiary strata in the West Elk Mountains, and volcanic material was periodically erupted from numerous vents to form the West Elk volcanic field. Igneous activity was intense through Oligocene time, and continued intermittently during Miocene and perhaps Pliocene time. The younger activity is indicated by a 9.7 m.y. age for the basalt cap of Grand Mesa, about 20 mi (32 km) northwest (Marvin and others, 1966), and by intrusion of a granite pluton of Miocene age at Treasure Mountain, northeast of the study area (Mutschler, 1968, 1970).

Post-volcanic erosion in late Cenozoic time removed much of the volcanic center, deeply dissected the underlying sedimentary rocks, and exposed many intrusive bodies and structural features. The higher peaks and valleys of the area were sculptured by glaciers during Pleistocene time.

The sequence of geologic events in the West Elk Mountains seems to have been: initial uplift and intrusion of some stocks, sills, and laccolithic bodies; a period of erosion; then renewed intrusion and contemporaneous volcanism. Radiometric ages and some structural evidence suggest that some of the laccoliths and sills were emplaced prior to extrusion of the West Elk Breccia. In the Smooth Canyon area (cross sec. B-B', pl. 1), the Mancos Shale and intercalated sills dip steeply away from the area of the West Elk volcanic center, and appear to have been truncated by erosion prior to extrusion of overlying volcanic rocks. Boulders of hypabyssal porphyries occur locally at the base of the West Elk Breccia, which also suggests that some intrusive activity in the West Elk Mountains took place prior to extrusion of the West Elk Breccia.

Potassium-argon dates and crosscutting relations of Oligocene intrusions in the West Elk Mountains and adjacent areas indicate a considerable range of intrusive activity (Gaskill and others, 1967; Mutschler, 1968, 1970; Armstrong, 1969; Lipman and others, 1969; Obradovich and others, 1969; and Kramer, 1972).

Figure 8 illustrates some of the major structural features in the West Elk Mountain region. The most conspicuous structural features of the study area are the laccolithic mountains. Though some are nearly bell-shaped laccoliths with steep to nearly vertical contacts, most are asymmetrical, tongue-shaped bodies, which characteristically have gently to steeply dipping overlying strata on one or more sides, and sharply discordant strata along their steeper flanks. Many laccoliths appear to have ruptured upturned strata on one or more sides. Indirect evidence suggests that some of the laccoliths were fed by large dikes, and others by vertical pipelike conduits, or small stocklike masses. Some may be cedar-tree structures intruding different stratigraphic horizons from a single conduit (Gary and others, 1972). Both the roofs and floors of the laccoliths transects the sedimentary strata. The igneous contacts generally follow bedding planes for a short distance, then abruptly step across bedding planes along fractures to higher or lower horizons. For example, the roof of the Marcellina laccolith, north of the area, transects more than 1,000 ft (300 m) of upper Mesaverde strata in a horizontal distance of 2 mi (3.2 km). Structural details of individual laccoliths are discussed by Cross (1894).

Perhaps the most distinctive igneous "structural" feature mapped on plate 1 is the radial dike swarm at the hub of the West Elk volcanic center. The dikes probably radiate from a small stock like those exposed in the adjacent Ruby Range (Socolow, 1955; Godwin and Gaskill, 1964; Aitken and others, 1972; and Kramer, 1972). The Ruby Range stocks and associated dikes are alined along a major south-southwest-trending fracture system that appears to connect with the West Elk volcanic center (fig. 8).

An east-west zone of faults, locally intruded by dikes, has been named the Curecanti fault zone by Gableman and Boyer (1960). The fault zone extends west from the West Elk volcanic center along the northern edge of the volcanic plateau. Some of the faults are well exposed on the escarpment at the head of Coal Creek. The total offset along this zone is unknown. The fault zone seems to be several miles wide and possibly reflects subsidence due to intrusion and volcanism. The zone may have localized the conduits for some of the adjacent laccoliths.

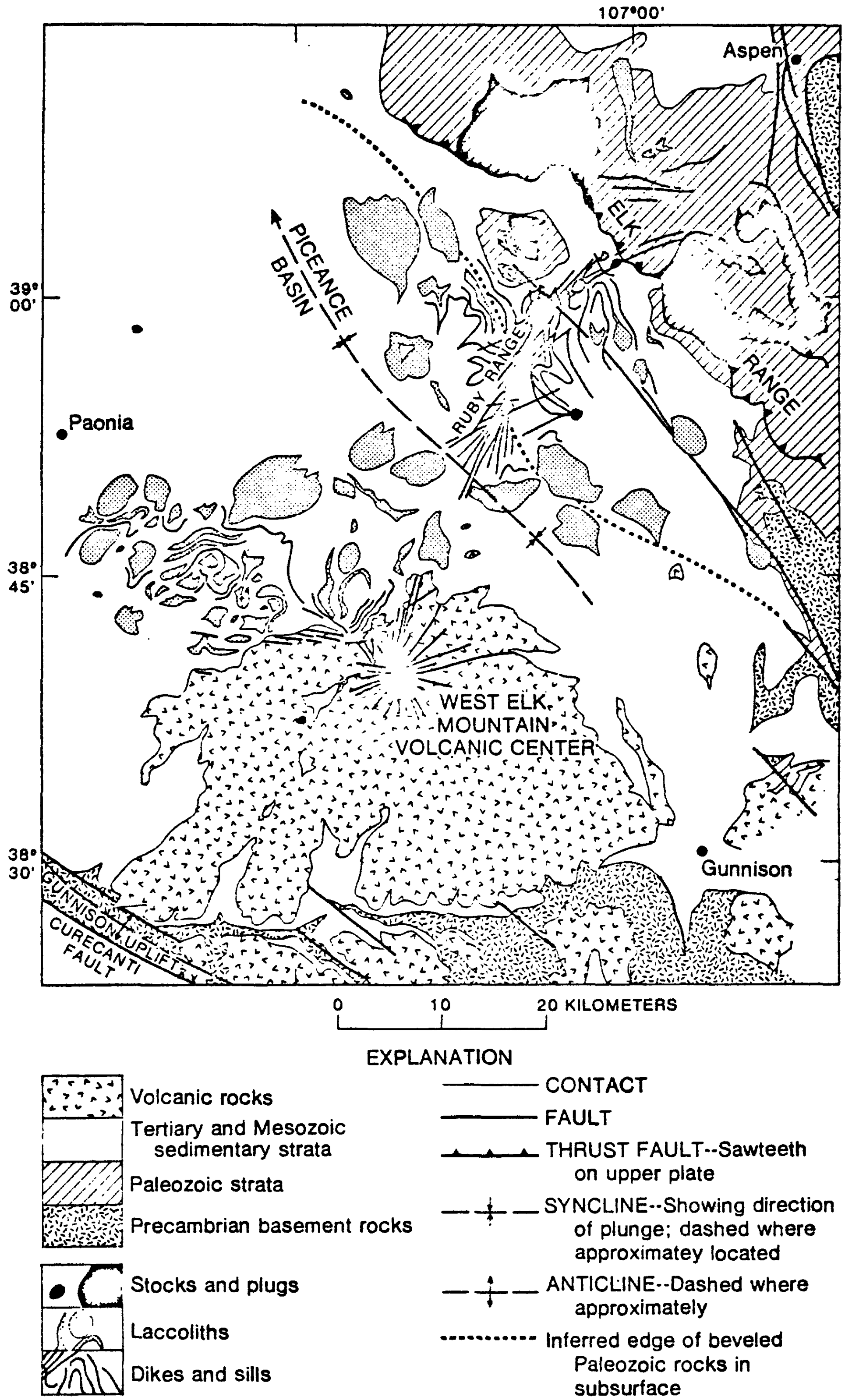


Figure 8.--Map showing some major structures in the West Elk Mountain region, West Elk Wilderness study area.

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Chapter B

Geophysical surveys in the West Elk Wilderness and vicinity, Delta and Gunnison Counties, Colorado

By

Joseph G. Rosenbaum

U.S. Geological Survey

INTERPRETATION OF GEOPHYSICAL DATA

In August 1973, 57 gravity stations were occupied by U.S. Geological Survey personnel, by helicopter and motor vehicle traverses in and around the West Elk Wilderness study area. The data obtained were supplemented with data from 43 stations, obtained from the Department of Defense gravity library in St. Louis, Missouri, to compile a Bouguer gravity map (pl. 4). Vertical and horizontal positions of the gravity stations were determined from control points shown on U.S. Geological Survey topographic maps with scales of 1:24,000. The gravity data were corrected for terrain effects to a distance of 167 km by a method described by Plouff (1966). Terrain corrections ranged from about 3 mgal for stations in the lowlands adjacent to the Wilderness to more than 40 mgal for stations on the high peaks. A density of 2.67 g/cm^3 was assumed for the rock between sea level and the station elevations in reducing the data for the complete Bouguer anamoly map. The gravity data are referenced to the Department of Defense base station (ref. code numbers ACIC 0164-2 and IGB 11986D) at the entrance to the courthouse in Gunnison, Colorado. A value was assumed of 979341.32 mgal for the observed gravity for the base station. Theoretical gravity was computed from the International Formula.

Over the study area, the Bouguer anomaly values decrease northeastward toward the large, northeast-trending gravity low that is coincident with the Colorado mineral belt (Behrendt and Bajwa, 1972). Two northeast-trending gravity ridges are superimposed on the regional gradient across the central part of the map. The northern gravity ridge is most conspicuous near Coal Creek, southeast of Mount Gunnison. The West Elk volcanic center lies on the axis of the southern gravity ridge approximately 1.5 mi (2.4 km) from the northeast end. The axis of the intervening gravity trough lies to the south of the Curecanti fault zone, but the trough widens to include the fault zone and the Sheep Mountain laccolith. Several additional local anomalies are indicated on the map, but the data are so sparse that an interpretation was not attempted.

No gravity anomalies appear to be associated with individual laccolithic mountains. For the most part, the laccolithic bodies seem to surround the northern gravity ridge. In the western part of the wilderness, some laccoliths, such as Little Sand Mountain, Mount Guero, and South Fork Mountain, lie on the axis of the ridge. Several others, such as Taterheap and Storm Ridge, lie on the sides of the ridge. Saddle Mountain is near the ridge axis, but the gravity control is poor in this area. The distribution of the laccoliths around the northern gravity ridge suggests that the ridge may be due to a positive density contrast between a large, elongate intrusive mass (which fed the laccoliths laterally and upward) and the surrounding sedimentary rocks.

The southern gravity ridge is in an area of basal-cone and near-vent volcanic rocks. It may be due to a large intrusive that underlies the exposed volcanic rocks.

An aeromagnetic survey of an area nearly identical with the gravity survey was flown and compiled by the U.S. Geological Survey (pl. 2). The eastern half of the area was flown in 1970, and the western half in 1973. Flight lines were north-south at a barometric elevation of 13,500 ft (4,120 m). The flight line spacing was 1 mi (1.6 km).

A conspicuous group of magnetic highs occupies the northern and western portions of the map (Anomalies 1854, 2293, 2086, 2026, 1750, 2116, 2074, and 1963). All of these anomalies are characterized by short, steep gradients and all occur near the tops of laccolithic mountains. Anomaly 1857, in the central part of the map, is near a topographic high where the exposed rocks are vent facies volcanics. Crude depth estimates made by the method of Vacquier and others (1963) for anomalies 1854, 2293, 2086, 2026, and 2116 ranged from zero to several hundred feet below the surface. These shallow depth estimates confirm that these anomalies are due to the topographic relief of the mountains formed by the laccoliths.

Magnetic highs 2154 and 2245 in the northwest portion of the map occur over a cluster of laccoliths and thick sills which includes the Lamborn, Landsend, and Coal Mountain laccoliths. These anomalies appear to be similar to those described above, but are superimposed on a much larger feature. The larger anomaly is an elongate high trending north-northeast. The southern end of this anomaly lies over laccolithic bodies, but the central and northern portions lie over undisturbed sediments. The long wavelength of this anomaly suggests a source at considerable depth.

Another relatively broad magnetic high (1887) occurs in the north-eastern corner of the aeromagnetic map. The crest of this high lies near a mineralized felsite plug which crops out in Redwell Basin (Oh-Be-Joyful geologic quadrangle). Crude depth estimates place the source of this anomaly at approximately 5,000 feet (1,500 m) below the surface. This plug may be a cupola on top of a larger stock. Drilling of the plug has revealed high concentrations of molybdenum.

An east-west trending magnetic trough occurs near the center of the map and connects lows 1592, 1638, and 1578. Between these anomalies the magnetic trough nearly parallels and overlaps parts of the Curecanti fault zone (pl. 1). Between anomalies 1592 and 1578, the magnetic trough lies within the wide portion of the northeast-southwest gravity trough. Low 1578 is approximately 0.8 mi (1.3 km) east of the mapped fault zone. Near this point the magnetic trough bends to the northeast and continues for another 5 mi (8.0 km). To the west of the mapped fault zone, the magnetic trough bends to the southwest for about 2.5 mi (4.0 km) and then turns west for another 3 mi (4.8 km).

The area around the West Elk center is characterized by many short wavelength magnetic highs and lows. Several of these magnetic highs (1833, 1763, 1732, 1634, and 1709) correspond to topographic highs. The magnetic low, 1407, to the northeast of the West Elk center is characterized by short, steep gradients and a relatively large amplitude. This low may be due to a near-surface body of reverse magnetized rock.

The aeromagnetic data in an area bounded approximately by latitudes 38°35' and 38°52', and by longitudes 107°01' and 107°23' were digitized on a 1 km grid and were projected upward 4 km in order to filter short wavelength features. The resulting map is shown on figure 9. The three large positive anomalies which dominate the northern part of this area are believed to be due to laccolithic mountains. The central and southern part of the area shows a northwest-trending elongate low and a rather equidimensional high. The elongate low may be due to a zone of alteration but geologic evidence does not support this. Alternatively, the low may be simply the polarization low associated with the magnetic high. The West Elk center, which is an area of basal-cone volcanics, lies nearly halfway between the magnetic high and the trough. Near-vent volcanic rocks extend south and west from the center. As previously noted, this volcanic area lies on a northeast-trending gravity ridge. The gravity ridge and magnetic high in the southern part of figure 9 may be expressions of a large intrusive body which underlies the volcanic rocks and radial dikes of the area. Many of the rocks in this area are weakly mineralized with molybdenum, gold, silver, zinc, tungsten, copper, lead, and other metals.

The absence of large magnetic anomalies associated with certain of the laccoliths may be significant. Most of the laccolithic mountains in the area produce strong, positive magnetic anomalies, but Sheep Mountain does not. This lack of magnetic expression may be due to alteration. The central intrusion of Sheep Mountain is highly mineralized, as indicated by geochemical anomalies of molybdenum, silver, zinc, lead, tungsten, gold, mercury, tin, boron, copper, arsenic, and sulfur.

Geophysical evidence in conjunction with geochemical data indicates two bodies of possible economic interest within the study area. One is a hypothetical intrusive underlying the West Elk center and the surrounding near-vent volcanics. The other is the Sheep Mountain laccolith.

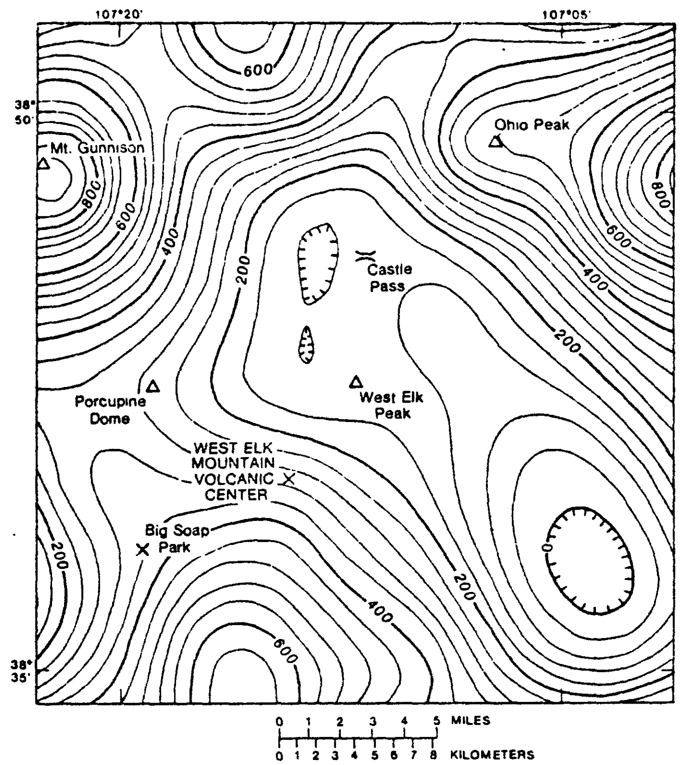

Figure 9.--Magnetic map of the region of the West Elk Mountain volcanic center continued upward to 1,850 m above sea level. Contoured by computer. Hachures indicate closed areas of lower intensity. The data were compiled relative to arbitrary datum. Contour interval is 40 gammas.

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Chapter C

Geological and geochemical evaluation of the mineral resources of the West Elk Wilderness and vicinity, Delta and Gunnison Counties, Colorado

By

David L. Gaskill and Harley D. King

U.S. Geological Survey

MINERAL SETTING

The West Elk Wilderness study area is on the trend of the Colorado Mineral Belt, which contains many of the major mining districts in Colorado (Tweto and Sims, 1963). These districts are localized around porphyry intrusive centers of Late Cretaceous and Tertiary age. Although no metal production has been reported from the West Elk Wilderness study area, the area contains at least one major volcanic center, and several weakly mineralized igneous bodies of possible economic significance. The northeast boundary of the study area is about 5 mi (8 km) southwest of the Ruby-Irwin mining district. Mines in this district, and in other heavily prospected areas northward along the Ruby Range fracture zone, have produced considerable silver, lead, and zinc, and some gold and copper (Endlich, 1878; Emmons and others, 1894; Colorado Bureau of Mines, 1896-1965, 1966-1971; Henderson, 1926; Socolow, 1955; Eckel, 1961). Molybdenum in several of the Ruby Range stocks has stimulated recent drilling for ore deposits by mineral exploration groups.

Part of the Somerset coal field lies within the study area, and parts of the Crested Butte coal field border the northeastern side of the study area (Lee, 1912; Landis, 1959). Coal beds in the study area underlie Snowshoe, Raven, and Coal Creek Mesas, Mount Gunnison, the Beckwith Peaks, and probably the Anthracite Range. Coal beds are widely exposed in the Coal Basin area and presumably extend eastward under several thousand feet of overburden across a structurally complex area in the northern part of the West Elk Wilderness.

GEOCHEMICAL EXPLORATION

Geochemical exploration in the study area included sampling of stream sediments, panned concentrates, fresh, altered, and mineralized bedrock, and soils. The samples were analyzed spectrographically and chemically for selected elements, and the results were evaluated statistically and in context with the geology.

Stream sediments were collected at irregular intervals along all major streams, and at least one sample was taken at the mouths of most of their tributaries. In general, a handful or two of the finest sediments available were collected. However, many samples from streams and gulches with high gradients contained little or no clay or silt-sized material, and only coarser sands were available. As the metals in stream sediments tend to be adsorbed on the finer particles, the coarse sands may not be an effective sample.

All observed outcrops of altered and mineralized rock, veins, and shear zones were sampled. Representative samples of fresh bedrock were collected for background determinations. Rock samples consisted of 1/2 lb (0.23 kg) or more of selected chips. In sampling the altered rocks and veins, an effort was made to sample the material most likely to contain the highest metal values.

A total of 1,364 stream-sediment, bedrock, soil, and panned-concentrate samples from the area were analyzed by semiquantitative spectrographic methods for 30 elements. Most of the samples were analyzed by atomic absorption for gold, copper, lead, and zinc, and a few for tellurium and manganese (table 5-8). Colorimetric methods were used to determine antimony in 457 samples, arsenic in 466 samples, and tungsten in 157 samples. Eight hundred and six samples were checked instrumentally for mercury, 754 samples by specific ion for fluorine, and nine samples were analyzed for oganic sulfur. All of the samples were scanned with a scintillometer for abnormal radiation, and 39 selected samples were analyzed for equivalent uranium. Eight hundred and forty samples were analyzed for citrate-soluble heavy metals, and 43 samples were analyzed chemically by rapid rock methods (Shapiro, 1967). Many samples showing anomalous values were rerun, and many samples were checked by more than one analytical method.

Geochemical investigations in the area of Sheep Mountain and in the hub area of the West Elk volcanic center (pl. 2, insets 1 and 2) were made in 1974 by H. D. King and J. B. McHugh of the U.S. Geological Survey, and U Zaw Ko, Geologist, Directorate of Geological Surveys and Exploration, Union of Burma. At each of these sites the rock which appeared most altered or mineralized was collected for analysis. Two soil samples were collected from each site, one from the surface and another from beneath, to a total depth of 4 in. (10 cm). Soil samples were sieved and the minus-80 mesh fraction was analyzed. Panned-concentrate samples were passed through bromoform to remove light fractions, which were discarded. Magnetite was removed with a hand magnet and a Frantz magnetic separator set at 0.1 ampere. The two fractions which were analyzed, a nonmagnetic fraction and a fraction with low magnetism, were separated with the Frantz separator set at 1.0 ampere. The analytical results for the panned-concentrate samples (prefixed K) from the two areas are not directly comparable with results for panned concentrates given elsewhere in this report because of differences in preparation techniques. Also, the amounts of some of the panned-concentrate samples available for analysis, particularly the nonmagnetic fractions, were very small, and in a few cases were less than the amount normally used in spectrographic analyses (5 mg). In these cases a factor based on the sample weight was used to arrive at the reported value. Thus the values given indicate the presence of the respective element or elements in the drainage area and should not be used as a measure of their abundance.

Analytical results of selected samples (prefixed K) from this independent survey are listed in tables 6 through 8.

Background values of selected elements were determined statistically with the aid of the computer. Where analytical data were sufficient, threshold values, the lower limit at which an element is considered anomalously high, were determined by plotting the cumulative frequency distribution of values on log probability paper. The inflection points on the upper end of the resulting curves define the threshold values listed in table 2 (Levinson, 1974). For some elements, such as gold and silver, the analytical limits of detection were too high to determine

Table 2.--Threshold values of selected elements from the West Elk Wilderness and vicinity, Colorado.

[Threshold values were determined from cumulative frequency plots of the analytical data on log-probability graphs (See Erickson and others, 1970, p. E51-59; Levinson, 1974, p. 214-222). All values at or greater than threshold values are considered anomalous. Parts per million (ppm). D, detectable; G, greater than value shown; leaders (---) indicate no data established or available.]

Element	786 Stream-sediment samples			167 Fresh rock samples 255 Altered rock samples and 94 soil samples			62 Pan concentrate samples		
	Threshold (ppm)	Number and percentage of samples at or above threshold: Number of samples	Percent	Threshold (ppm)	Number and percentage of samples at or above threshold: Number of samples	Percent	Cut-off value (ppm)	Number and percentage of samples at or above cut-off value: Number of samples	Percent
1,2/ Ag	0.2	1	0.1	3/ 0.2	58	11.2	0.2	12	19.4
2,5/ Au	.02	10	1.3	3/ .02	24	4.7	.05	3	4.8
1/ B	70	28	3.6	5/ 70	13	2.5	G5,000	1	1.6
1/ Ba	1,500	10	1.3	4/ 1,500	74	14.3	3,000	3	4.8
1/ Co	50	3	.4	4/ 50	3	.6	50	29	46.8
1/ Cr	150	1	.1	4/ 150	2	.4	150	8	12.9
1/ Cu	70	11	1.4	4/ 70	22	4.3	70	5	8.1
1/ La	100	7	.9	4/ 100	4	.8	100	11	17.7
1,2/ Mn	—	—	—	3/ 5,000	16	3.1	5,000	3	4.8
1/ Mo	5	32	4.0	5/ 5	74	14.3	15	3	4.8
1,2/ Pb	200	1	.1	4/ 90	27	5.2	200	12	19.6
1/ Sc	—	—	--	4/ 30	2	.4	50	9	14.5
1/ Sn	D	3	.4	4/ D	20	3.9	—	—	--
1/ Sr	1,500	3	.4	4/ 1,500	16	3.1	1,500	2	3.2
1/ V	500	25	3.2	4/ 300	7	1.4	700	27	43.5
1/ Y	70	7	.9	4/ 70	3	.6	70	12	19.6
1,2/ Zn	200	23	2.9	5/ 200	12	2.3	300	22	35.4
1/ Zr	700	6	.8	4/ 300	13	2.5	1,000	11	17.7

1/ Spectrographic analyses.

2/ Chemical analyses.

3/ Represents altered or mineralized rock samples, including U.S. Bureau of Mines samples collected from claims and prospects, and one soil sample.

4/ Includes both fresh and altered rock samples, and U.S. Bureau of Mines samples collected from claims and prospects.

5/ Includes both fresh and altered rock samples, soils, and U.S. Bureau of Mines samples collected from claims and prospects.

threshold values by this method; in these cases, threshold values were arbitrarily chosen (table 3) with respect to background values (table 4). Samples that are considered anomalously high in one or more elements are listed in table 5. Some anomalous values, particularly those at or near threshold, may merely reflect differences in analytical or sampling techniques, instrumental errors, or operator bias. This problem was minimized by comparing values obtained by more than one analytical method. A computer tape with all U.S. Geological Survey analytical data derived from these samples is available (McDanal and others, 1976).

The tables of the U.S. Geological Survey sample analyses are arranged according to drainage basins (see index map on pl. 3), or listed by mineralized areas (see inset maps, pl. 3).

Metallic mineral commodities

Manganese

Small vein deposits of manganese oxide occur in the southern part of the study area, mainly along Sun Creek and at the El Ray claim in Soap Creek canyon (see p. , and p.). Samples from these deposits with high manganese concentrations also contain anomalous amounts of many other metals. Only eight samples collected elsewhere in or near the study area showed 5,000 ppm or more manganese (table 1 and 5).

Molybdenum

Figure 10 shows the location of 105 samples containing 5 to 500 ppm molybdenum. Twenty-six are stream-sediment samples, 39 are from altered rocks and soils in the Sheep Mountain area, 22 are from rocks and soils in the West Elk volcanic center, and 18 are scattered rock samples from veins, fractures, intrusive bodies, mineralized sandstone, and tuff breccias. Only three panned-concentrate samples showed anomalous amounts of molybdenum.

No visible molybdenum minerals were recognized in the study area; and most of the anomalous molybdenum values shown on figure 10 are only five to ten times greater than the normal abundance of molybdenum in intermediate to silicic rocks (Parker, 1967). By comparison, large low-grade deposits of disseminated molybdenum under present economic conditions must be greater than 1,000 ppm molybdenum to constitute a potential resource (King, 1964). Molybdenum is widespread in Colorado (King, 1964, 1970), but has been mined from only a few deposits. Molybdenum has been reported from several localities in the Ruby Range northeast of the study area, and from other areas in Gunnison County (Worcester, 1919; Hunter, 1925; Vanderwilt. 1947; Eckel, 1961; King, 1964 and 1970.

According to C. S. Robinson (Charles S. Robinson and Assoc., Inc., Consulting Geologists and Engineers, Golden, Colo., written commun., 1975), a significant molybdenum prospect has been discovered at Redwall basin in the Ruby-Irwin mining district 7 mi (11 km) northeast of the study area (Sharp, 1976).

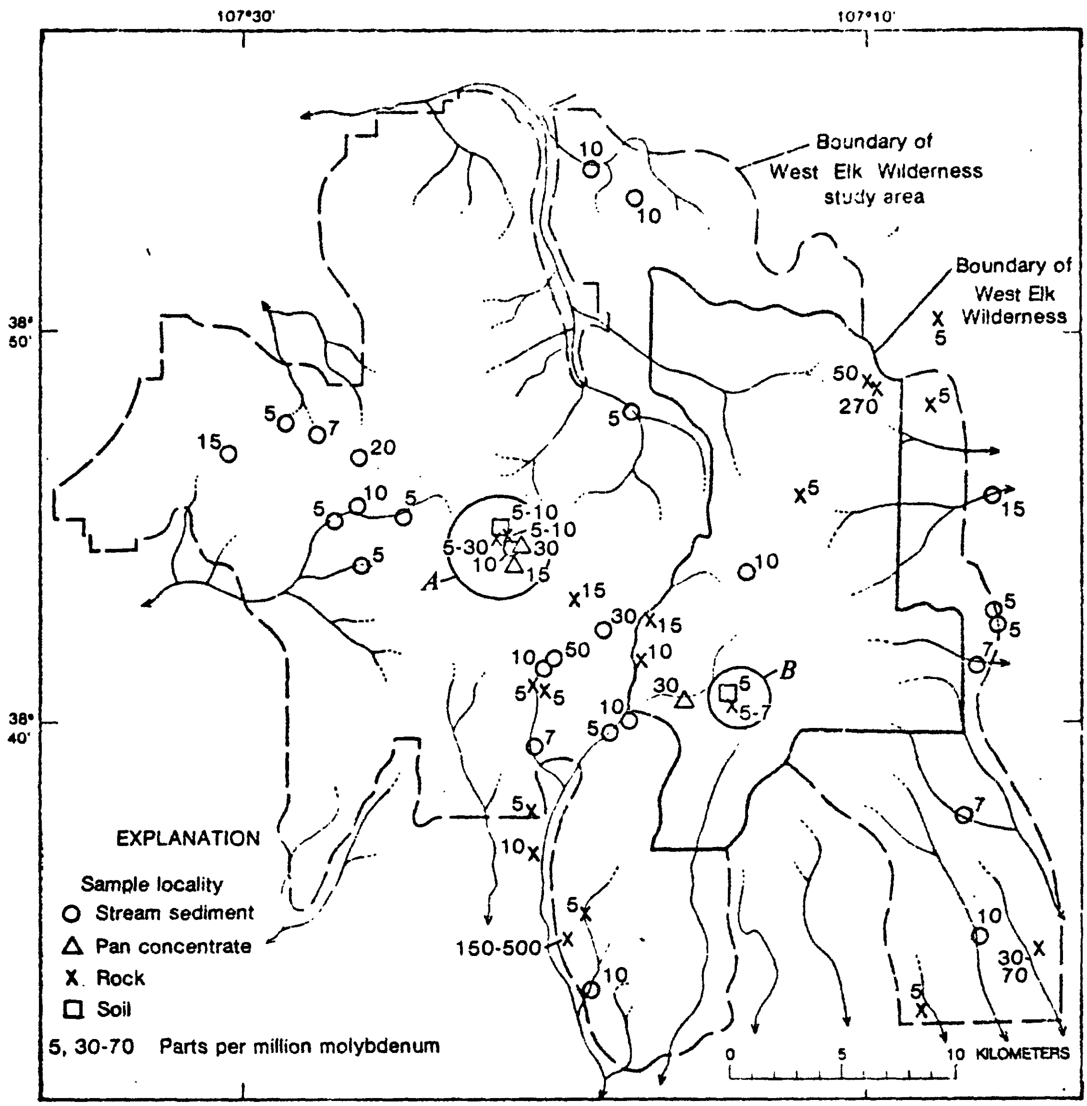

Figure 10.--Sample localities containing 5 ppm or more molybdenum in or near the West Elk Wilderness study area, Colorado. Circle A includes 26 rock samples and 11 soil samples; B includes 15 rock samples and 7 soil samples.

Table 3. Arbitrary threshold values of selected elements and metals from the West Elk Wilderness and vicinity, Colorado. [Threshold values were arbitrarily picked because the data were insufficient to determine threshold values by statistical methods. All values at or greater than the threshold value are considered anomalous. All values are given in parts per million (ppm). D indicates detectable; leaders (---) indicate no data established or available.]

Element	Stream-sediment samples			Rock and soil samples			
	Arbitrary threshold value (ppm)	Number and percentage of samples at or above cut-off value		Arbitrary threshold value (ppm)	Number and percentage of samples at or above cut-off value		Total number and type of samples analyzed for listed element
		Number of Samples	Percent		Number of samples	Percent	
2/ As	10	5	2.6	1,2,4/ 10	54	27.8	225 stream-sediments, 43 fresh rocks, 100 altered rocks, 94 soils, and 4 pan concentrates.
1/ Bi	---	---	---	5/ 30	12	.2	786 stream-sediments, 167 fresh rocks, 255 altered rocks, 94 soils, and 62 pan concentrates. 9/
2/ Cu	40	3	.6	4/ 40	5	2.7	475 stream-sediments, 83 fresh rocks, 100 altered rocks, and 26 pan concentrates.
2/ cxHM	14	34	4.4	4/ 14	13	20.6	775 stream-sediments, 48 fresh rocks, 15 altered rocks, and 33 pan concentrates. 10/
2/ F	---	---	---	4,6/ 900	4	1.5	481 stream-sediments, 56 fresh rocks, 123 altered rocks, and 94 soils.
2/ Hg	0.3	5	1.0	4,7/ 0.3	22	7.4	481 stream-sediments, 63 fresh rocks, 139 altered rocks, 94 soils, and 17 pan concentrates.
2/ S	---	---	---	3/ 1,000	7	100	7 selected rock samples.
1/ Sb	---	---	---	4/ 2,000	3	.8	786 stream-sediments, 167 fresh rocks, 204 altered rocks, and 52 pan concentrates.
2/ Sb	3	7	2.8	3/ 5	4	2.1	250 stream-sediments, 70 fresh rocks, 123 altered rocks, and 14 pan concentrates.
2/ Te	---	---	---	3/ D	3	11.5	26 selected altered and mineralized rocks from the West Elk center area.
2/ W	---	---	---	3,8/ 20	26	17.9	51 altered rocks, and 94 soil samples.
2/ eU	30	14	48.3	3/ 30	9	90	29 selected stream-sediments, and 10 altered rocks.

1/ Chemical analyses.

2/ Spectrographic analyses.

3/ Includes both fresh and altered rock samples, and mineralized Bureau of Mines samples collected from claims and prospects.

4/ Includes one soil sample with bismuth.

5/ Includes one pan concentrate with 70 ppm bismuth.

6/ Includes 2 pan concentrate samples containing 25 ppm or more citrate-soluble heavy metals (cxHM).

7/ Includes 2 soil samples with fluorine.

8/ Includes 12 soil samples with mercury.

9/ Represents only altered or mineralized rock samples including mineralized Bureau of Mines samples.

10/ Includes 23 soil samples with tungsten.

Table 4. Mean values of elements in unaltered rocks, stream-sediments, and pan concentrate samples from the West Elk Wilderness and vicinity, Colorado.
[Leaders (---) indicate no data established or available.]

Element	Unaltered rock samples: Mean (ppm)	Unaltered rock samples: Number of samples	Unaltered rock samples: Percent of samples	Stream-sediment samples: Mean 1/ (ppm)	Stream-sediment samples: Number of samples	Stream-sediment samples: Percent of samples	Pan concentrate samples: Mean of 25 pan concentrate samples (ppm)
S/ Fe	39,500	166	100	51,600	793	100	144,000
S/ Mg	10,370	166	100	11,000	793	100	19,000
S/ Ca	30,000	166	100	22,000	793	100	21,000
S/ Ti	3,050	166	100	5,000	793	100	2/ 27,400
S/ Mn	1,070	166	100	916.3	793	100	3/ 3,370
S/ B	10.4	144	87	19.1	766	97	—
S/ Ba	800	166	100	606.2	793	100	280.7
S/ Be	1.3	146	88	1.4	694	88	—
S/ Co	9.8	143	86	10.8	789	99	36.4
S/ Cr	13	77	46	24.1	602	60	84.3
S/ Cu	14.6	143	86	14.5	789	99	7.6
S/ La	37.9	166	100	33.3	700	88	37.6
S/ Mo	2.8	49	30	8.1	36	5	—
S/ Nb	8.7	68	44	11.9	143	18	—
S/ Ni	5.7	145	93	8.4	785	99	11.6
S/ Pb	15.8	166	100	16.6	787	99	12.8
S/ Sc	10	166	100	12.5	793	100	26.7
S/ Sr	650	166	100	371	792	100	256.7
S/ V	79	166	100	127.5	793	100	649.1
S/ Y	26	166	100	24.7	793	100	26.7
S/ Zn	—	—	—	234	109	13	423.7
S/ Zr	125	166	100	119	793	100	70.5
C/ Hg	0.005	55	87	0.005	459	95	0.004
C/ Cu	7.5	80	96	9.3	475	100	7.0
C/ Pb	8.3	81	97	12.4	475	100	8.7
C/ Zn	33.8	82	99	47.4	475	100	36
C/ cxHM	2.6	48	100	2.3	680	88	1.7
C/ Au	—	—	—	.009	235	32	—
C/ Sb	1.1	70	100	1.4	240	96	1.1
C/ F	187.1	56	100	156.2	480	99	—

Unaltered rock and stream-sediment "Number" and "Percent" columns: Number and percent of samples within detectable limits.

S/ Spectrographic analyses.

C/ Chemical analyses.

1/ Includes 7 pan concentrate samples due to computer program error.

2/ Includes only 19 U.S. Bureau of Mines pan concentrates.

3/ Includes 19 U.S. Bureau of Mines pan concentrates.

Table 5.--Analyses of samples from stream sediments, panned concentrates, and fresh and altered rocks in the West Elk Wilderness study area, Colorado

[For sample locations see plate 3. Data for Ti are in percent; all other data are in parts per million. Numbers in parentheses below the element symbols represent the lower limit of determination for each element. N indicates the element was looked for but not detected. L, the element was detected in amounts below the limit of determination. >, more than the amount shown was determined. ---, no analysis was made. Detectable concentrations of fluorine, tellurium, sulfur, and spectrographic arsenic are reported in the footnotes. Spectrographic gold, antimony, cadmium, and bismuth were not found at or above the level of determination, although antimony and bismuth have been detected occasionally in other spectrographic analyses (see tables 7 and 9). All samples were also analyzed spectrographically for iron, magnesium, calcium, tungsten, and niobium, but these results are not reported here]

Semiquantitative spectrographic analyses (SSA)

Sample	Ti[1] (.002)	B (10)	Ba (10)	Be (1)	Co (5)	Cr (10)	Cu (5)	La (20)	Mn (10)	Mo (5)	Pb (10)	Sc (5)	Sn (10)	Sr (100)	V (10)	Y (10)
A.--Pass Creek Drainage																
[6]392	0.150	L	1,500	1	15	30	20	50	2,000	30	10	10	N	200	100	70
393	>1.000	L	500	N	15	100	L	200	2,000	N	30	10	N	300	300	30
511	.300	10	700	L	7	30	L	50	1,500	N	20	10	N	300	150	30
512	.200	15	700	L	5	15	5	50	1,000	N	20	7	N	300	70	30
520	.150	10	700	L	L	N	L	20	300	5	20	L	N	300	50	L
673	.700	L	500	L	10	15	5	30	1,000	N	10	15	N	500	150	30

[6]Sample 392 showed 200 ppm spec. arsenic.

Sample	Ti[1] (.002)	B (10)	Ba (10)	Be (1)	Co (5)	Cr (10)	Cu (5)	La (20)	Mn (10)	Mo (5)	Pb (10)	Sc (5)	Sn (10)	Sr (100)	V (10)	Y (10)
B.--Castle, Squirrel, and Middle Creeks Drainage																
033	.500	N	700	2	20	N	30	70	1,000	N	50	10	N	1,500	70	15
136	.700	L	1,500	L	30	20	30	20	2,000	N	15	20	N	500	300	30
137	.300	N	1,500	1	10	10	30	70	1,000	N	15	15	N	700	70	30
138	.700	L	1,500	1	30	N	30	50	1,500	N	10	30	N	1,000	150	50
139	1.000	L	1,000	1	50	70	50	50	2,000	N	10	30	N	700	500	50
141	.500	N	1,500	1	N	15	30	70	700	N	15	15	N	700	70	20
142	.500	N	1,000	1	10	30	50	70	1,000	N	15	20	N	700	150	30
146	.700	L	700	1	20	15	20	50	2,000	N	10	30	N	1,000	200	30
147	.700	L	700	1	20	10	70	30	1,500	N	15	20	N	700	200	30
251	1.000	L	700	2	30	N	50	N	2,000	N	20	30	N	700	500	30
252	1.000	L	700	2	30	N	50	N	2,000	N	20	30	N	700	500	30
254	1.000	L	700	1	30	N	50	N	2,000	N	20	30	N	700	500	30
258	.700	10	700	2	10	N	50	50	2,000	N	30	10	N	700	150	30
269	1.000	L	700	1	30	15	50	20	1,500	N	15	30	N	1,000	300	30
272	.700	L	700	2	20	30	50	20	1,500	N	10	20	N	1,000	300	30
273	.700	L	700	2	15	15	30	N	1,500	N	10	15	N	700	150	30
385	.300	L	1,500	N	N	L	L	50	500	N	20	15	N	1,000	100	30
389	.300	30	1,500	1	15	30	10	50	2,000	N	10	15	N	3,000	100	30
390	.200	10	300	1	15	50	5	70	5,000	N	30	15	N	700	100	70
391	>1.000	N	200	N	50	30	5	30	2,000	N	10	10	N	200	500	30
467	>1.000	N	100	N	50	100	7	20	2,000	N	N	20	N	N	700	20
523	.700	L	700	L	15	20	15	30	1,000	15	10	15	N	700	150	30
525	.500	10	700	L	10	20	15	30	1,000	5	10	10	N	300	150	15
526	.500	L	700	L	10	30	15	30	1,000	5	10	15	N	300	150	20
529	.700	10	700	L	7	20	5	30	1,000	N	10	15	N	500	150	30

Sample	Ti[1] (.002)	B (10)	Ba (10)	Be (1)	Co (5)	Cr (10)	Cu (5)	La (20)	Mn (10)	Mo (5)	Pb (10)	Sc (5)	Sn (10)	Sr (100)	V (10)	Y (10)
C.--Mill Creek Drainage																
087	1.000	10	1,000	2	30	N	50	50	1,500	N	10	30	N	1,500	300	50
088	.700	10	1,000	2	20	N	30	50	1,500	N	10	30	N	1,500	150	50
089	1.000	10	700	2	30	N	50	50	2,000	N	20	30	N	1,500	150	50
093	1.000	L	700	1	30	N	50	N	2,000	N	10	30	N	700	300	30
097	.700	L	500	1	15	N	30	50	2,000	N	10	20	N	700	200	30
098	.700	10	700	2	15	N	50	N	1,500	N	20	15	N	700	150	30
100	.700	L	700	2	15	N	30	N	2,000	N	20	20	N	700	150	30
236	.300	L	1,000	2	10	N	30	70	1,500	N	20	10	N	700	70	30
237	.300	L	700	2	7	N	20	70	1,000	N	15	10	N	700	70	20
358	.020	N	30	N	N	N	N	N	100	N	N	N	N	150	N	10
507	.300	L	1,000	N	15	L	15	50	1,500	N	10	30	N	1,000	200	50
509	.500	L	700	N	20	30	20	50	1,500	N	10	30	N	1,500	200	50
513	1.000	N	300	N	30	20	5	20	2,000	N	10	30	N	500	500	30
516	.500	10	700	L	15	N	15	30	700	7	15	15	N	500	150	30
G48	---	N	1,000	N	15	---	7	50	---	---	20	20	N	1,500	100	50

[1]Data in percent (this column only).
[2]Citrate-soluble colorimetric heavy metals test.
[3]Equivalent uranium determined radiometrically.
[4]Instrumental determination of mercury.

Sample	SSA				Colorimetric			Atomic Absorption						Sample description[5]
	Zn (200)	Zr (10)	Ni (5)	Ag (0.5)	As (10)	CxHM[2] (1)	Sb (1)	Cu (5)	Zn (5)	Pb (5)	Au (.02)	eU[3] (30)	Hg[4] (.02)	
							A.--Pass Creek Drainage							
[6]392	N	100	30	N	---	---	6	25	40	10	0.35	---	---	Alt Tw ss
393	300	30	5	N	---	---	0	5	35	15	N	---	---	Pan concentrate
511	N	300	10	N	---	N	2	---	---	---	.40	---	---	Stream sediment
512	N	100	7	N	---	N	5	---	---	---	N	---	---	Do.
520	N	70	L	N	---	2	---	L	40	10	N	---	L	Do.
673	N	150	7	N	---	1	---	5	60	10	.10	---	L	Do.

[6]Sample 392 showed 200 ppm spec. arsenic.

Sample	Zn (200)	Zr (10)	Ni (5)	Ag (0.5)	As (10)	CxHM (1)	Sb (1)	Cu (5)	Zn (5)	Pb (5)	Au (.02)	eU (30)	Hg (.02)	Sample description
							B.--Castle, Squirrel, and Middle Creeks Drainage							
033	N	150	5	N	10	1	1	---	---	---	L	---	---	Bio ash
136	200	150	15	N	---	2	1	10	40	35	N	---	---	Stream sediment
137	N	150	7	N	N	1	L	---	---	---	L	---	---	Bio tuff
138	N	150	7	N	N	3	2	---	---	---	L	---	---	Stream sediment
139	N	150	15	N	N	2	2	---	---	---	L	---	---	Do.
141	N	200	3	N	N	7	L	---	---	---	L	---	---	Alt Tbc
142	N	150	10	N	N	20	L	---	---	---	L	---	---	Do.
146	N	150	5	N	N	20	2	---	---	---	L	---	---	Stream sediment
147	N	100	7	N	N	3	2	---	---	---	L	---	---	Do.
251	N	150	7	N	L	3	L	---	---	---	L	---	---	Do.
252	N	150	7	N	L	2	L	---	---	---	L	---	---	Do.
254	N	150	10	N	L	3	L	---	---	---	L	---	---	Do.
258	N	200	7	N	L	45	L	---	---	---	L	---	---	Do.
269	N	150	7	N	N	20	2	---	---	---	L	---	---	Do.
272	N	150	7	N	N	20	2	---	---	---	L	---	---	Do.
273	N	100	5	N	N	17	L	---	---	---	L	---	---	Do.
385	N	200	N	N	---	---	2	5	30	5	N	---	---	Alt dike
389	N	200	15	N	---	---	2	15	30	15	N	---	---	Tw siltstone
390	N	100	20	N	---	---	---	5	10	15	N	---	---	Do.
391	300	30	5	N	---	---	L	5	35	15	N	---	---	Pan concentrate
467	700	50	15	N	---	---	---	10	40	10	N	---	---	Do.
523	N	50	5	N	---	1	---	L	30	5	N	---	.14	Stream sediment
525	N	100	L	N	---	1	---	5	50	10	N	---	L	Do.
526	N	100	7	N	---	1	---	5	45	10	N	---	L	Do.
529	N	50	N	N	---	1	---	L	35	10	N	30	.30	Do.
							C.--Mill Creek Drainage							
087	N	150	7	N	10	1	1	---	---	---	L	---	---	Stream sediment
088	N	150	5	N	L	1	10	---	---	---	L	---	---	Do.
089	N	150	5	N	10	1	1	---	---	---	L	---	---	Do.
093	N	150	7	N	L	3	3	---	---	---	L	---	---	Do.
097	N	100	5	N	10	17	1	---	---	---	L	---	---	Do.
098	N	150	10	N	10	2	1	---	---	---	L	---	---	Stream sediment
100	N	150	7	N	L	1	3	---	---	---	L	---	---	Do.
236	N	200	10	N	10	2	1	---	---	---	L	---	---	Ash bed
237	N	150	7	N	10	1	1	---	---	---	.02	---	---	Hbl rd dike
358	N	N	N	N	---	---	0	10	5	25	.10	---	---	8" cal-spar vein
507	N	150	5	N	---	---	2	10	35	5	N	---	---	Shear zone
509	N	150	10	N	---	---	2	20	40	10	N	---	---	Do.
513	300	70	7	N	---	---	1	5	25	5	N	---	---	Pan concentrate
516	N	150	5	N	---	2	---	5	40	10	N	40	L	Stream sediment
G48	N	200	N	L	---	---	---	---	---	---	---	---	---	Tuff breccia matrix

[5]Abbreviations used in sample descriptions: alt, altered; and, andesitic; ark, arkosic; bio, biotite; cal, calcite; dac, dacitic; dio, dioritic; gd, granodiorite, rhyodacite, or dacite; hbl, hornblende; int, intrusive; porp, porphyry; py, pyrite, pyritized; pum, pumiceous; rd, rhyodacite; silic, siliceous; ss, sandstone; vn, vein; qtz, quartz; Toc, Ohio Creek Formation; Tw, Wasatch Formation; Tbc, basal cone vent facies of West Elk Breccia.

[6]Sample 392 showed 200 ppm arsenic by spectrographic analysis.

Semiquantitative spectrographic analyses (SSA)

Sample	Ti[1] (.002)	B (10)	Ba (10)	Be (1)	Co (5)	Cr (10)	Cu (5)	La (20)	Mn (10)	Mo (5)	Pb (10)	Sc (5)	Sn (10)	Sr (100)	V (10)	Y (10)
D.--Beaver Creek Drainage																
023	.700	10	500	2	10	N	20	N	1,500	N	30	15	N	200	70	20
025	.500	L	700	2	15	N	L	30	1,500	N	20	10	N	700	70	20
030	>1.000	L	700	1	30	N	50	N	3,000	N	20	30	N	1,000	500	50
031	>1.000	L	700	1	20	30	20	N	3,000	N	10	20	N	1,000	300	30
238	1.000	20	700	2	20	20	30	50	2,000	N	50	20	N	700	200	30
239	1.000	L	700	2	30	N	50	N	2,000	N	30	30	N	700	500	50
240	.700	L	700	2	20	N	50	N	2,000	N	20	20	N	700	300	50
241	1.000	L	700	2	30	N	50	N	2,000	N	30	30	N	700	500	50
242	1.000	L	700	1	30	N	50	N	2,000	N	20	30	N	700	500	50
245	>1.000	L	1,000	1	50	N	70	N	2,000	N	30	30	N	700	200	70
371	>1.000	N	300	N	50	20	L	50	2,000	N	N	30	N	300	500	30
462	>1.000	N	150	N	50	70	5	20	2,000	N	N	30	N	150	700	30
658	.700	L	500	L	15	10	7	30	1,000	7	L	15	N	300	150	20
659	.700	L	300	N	15	10	5	30	1,000	N	L	15	N	200	150	20
662	.500	10	500	L	7	7	20	10	700	10	15	10	N	300	100	30
E.--Steuben Creek Drainage																
605	.007	N	>5,000	3	N	N	L	N	>5,000	N	N	N	N	1,000	300	30
608	N	L	1,500	1	N	N	N	N	3,000	N	N	N	N	N	70	N
628	.300	20	1,000	L	5	20	10	50	1,000	10	20	10	N	300	100	20
649	.700	10	700	L	10	N	L	30	500	10	10	15	N	300	150	20
F.--Red, East Elk, Main Gulch, and Stevens Creek Drainage																
032	.700	N	500	1	30	N	50	50	1,000	N	10	15	N	700	150	20
185	.700	10	500	1	15	N	20	N	1,500	N	10	20	N	500	150	20
369	.200	L	1,000	N	7	N	L	50	1,500	N	10	15	N	1,500	100	30
609	.200	20	300	L	5	10	7	20	700	N	15	5	N	150	70	15
610	.700	15	300	L	7	20	5	30	700	N	15	10	N	300	150	30
614	.150	L	1,500	L	N	N	N	50	200	N	20	L	N	100	30	15
624	.100	10	1,000	1	N	N	N	70	500	5	30	7	N	150	20	20
819	.700	20	1,000	1	15	30	15	50	1,500	N	20	15	N	300	150	70
820	1.000	L	1,000	L	20	30	7	50	2,000	N	20	20	N	700	200	30
G.--West Elk Creek Drainage																
001	.500	L	500	1	20	N	20	70	700	N	10	15	N	700	70	30
005	1.000	L	500	1	30	N	50	N	3,000	N	10	20	N	700	500	30
007	.700	L	300	2	30	N	50	30	1,500	N	15	30	N	700	200	30
008	1.000	L	700	1	30	N	50	N	3,000	N	10	20	N	700	500	30
009	>1.000	L	300	1	30	N	30	N	2,000	N	N	20	N	700	500	30
010	.700	L	500	2	20	N	10	50	1,000	N	15	15	N	700	70	30
013	>1.000	L	700	1	30	50	70	N	3,000	N	20	30	N	700	200	30
014	1.000	L	700	1	30	20	30	N	3,000	N	10	20	N	700	500	30
017	.700	L	500	2	15	N	50	30	1,000	N	10	20	N	700	150	20
019	.500	L	300	1	20	N	15	L	1,500	N	15	7	N	500	70	15
020	1.000	L	300	1	50	N	70	N	1,500	N	15	30	N	700	200	30
123	.500	L	1,000	1	10	1	10	N	700	N	L	20	N	700	150	30
127	.500	L	700	1	5	N	50	20	1,000	N	10	10	N	700	70	20
128	.700	L	1,000	1	15	15	30	50	1,500	N	15	15	N	700	150	30
191	.700	L	700	1	15	N	30	50	1,500	N	15	20	N	1,000	150	50
192	.300	N	300	1	7	N	10	30	1,500	N	10	15	N	500	70	30
193	1.000	N	700	1	30	N	30	30	1,500	N	L	30	N	1,000	500	50
196	>1.000	N	500	N	70	70	50	N	3,000	N	10	50	N	700	700	30
197	.300	N	300	1	7	N	20	20	1,000	N	10	15	N	500	70	30
202	>1.000	10	700	2	20	N	50	N	2,000	N	30	30	N	700	500	50

Sample	SSA				Colorimetric			Atomic Absorption						Sample description[5]
	Zn (200)	Zr (10)	Ni (5)	Ag (0.5)	As (10)	CxHM[2] (1)	Sb (1)	Cu (5)	Zn (5)	Pb (5)	Au (.02)	eU[3] (30)	Hg[4] (.02)	
							D.--Beaver Creek Drainage							
023	N	200	10	N	L	7	3	---	---	---	L	---	---	Stream sediment
025	N	150	L	N	10	1	2	---	---	---	L	---	---	Dac lava flow
030	N	150	5	N	L	9	L	---	---	---	L	---	---	Stream sediment
031	N	150	5	N	L	35	L	---	---	---	L	---	---	Do.
238	N	150	10	N	L	40	1	---	---	---	L	---	---	Do.
239	N	150	10	N	L	45	1	---	---	---	L	---	---	Do.
240	N	150	5	N	L	20	L	---	---	---	L	---	---	Do.
241	N	150	7	N	L	17	L	---	---	---	L	---	---	Do.
242	N	150	7	N	L	2	L	---	---	---	L	---	---	Do.
245	N	200	7	N	L	2	1	---	---	---	L	---	---	Do.
371	500	70	5	N	---	---	0	L	50	5	N	---	---	Pan concentrate
462	500	50	10	N	---	---	0	5	25	5	N	---	---	Do.
658	L	30	5	N	---	1	---	5	25	10	N	---	L	Stream sediment
659	200	20	L	N	---	1	---	5	25	15	N	---	L	Do.
662	N	100	5	N	---	2	---	5	55	30	N	---	L	Do.
							E.--Steuben Creek Drainage							
605	N	10	N	N	---	---	---	5	15	L	N	---	.10	Mang tuff breccia
608	N	N	L	N	---	---	---	N	5	L	N	---	.02	Do.
628	N	150	7	N	---	3	---	10	50	20	N	---	.02	Stream sediment
649	N	50	5	N	---	2	---	5	35	5	N	---	L	Do.
							F.--Red, East Elk, Main Gulch, and Stevens Creek Drainage							
032	N	150	5	N	10	1	1	---	---	---	L	---	---	Dac dike
185	N	150	10	N	N	17	2	---	---	---	L	---	---	Stream sediment
369	N	100	L	N	---	---	2	5	L	5	N	---	---	And lava flow
609	N	50	5	N	---	7	---	30	90	450	N	---	L	Stream sediment
610	N	70	5	N	---	3	---	15	70	150	N	---	L	Do.
614	N	100	L	N	---	---	---	N	L	L	N	---	L	Do.
624	N	100	L	N	---	---	---	N	5	L	N	---	L	Pum tuff breccia
819	L	200	15	N	---	4	---	10	55	20	N	---	.03	Stream sediment
820	200	150	7	N	---	2	---	5	35	5	N	---	.02	Do.
							G.--West Elk Creek Drainage							
001	N	150	5	N	10	1	1	---	---	---	L	---	---	Hbl dac dike
005	N	100	5	N	L	3	1	---	---	---	L	---	---	Stream sediment
007	N	200	7	N	10	1	1	---	---	---	L	---	---	And Tbc
008	N	100	10	N	L	2	1	---	---	---	L	---	---	Stream sediment
009	N	100	7	N	L	3	2	---	---	---	L	---	---	Do.
010	N	150	5	N	10	1	1	---	---	---	L	---	---	And Tbc
013	N	100	20	N	L	3	L	---	---	---	L	---	---	Stream sediment
014	N	100	7	N	L	11	L	---	---	---	L	---	---	Do.
017	N	150	5	N	10	1	2	---	---	---	L	---	---	Alt dike
019	N	150	L	N	10	1	2	---	---	---	L	---	---	Hbl rd dike
020	N	100	7	N	L	1	1	---	---	---	L	---	---	And-dio Tbc
123	N	100	5	N	N	14	L	---	---	---	L	---	---	Alt tuff breccia
127	N	100	5	N	N	30	L	---	---	---	L	---	---	And lava flow
128	N	150	10	N	N	40	L	---	---	---	L	---	---	Lava flow
191	N	150	5	N	N	14	L	---	---	---	L	---	---	Tuff breccia matrix
192	N	70	L	N	N	20	L	---	---	---	L	---	---	Alt sheared Tbc
193	N	150	7	N	N	17	---	---	---	---	L	---	---	Stream sediment
196	N	70	15	N	N	2	1	---	---	---	L	20	---	Pan concentrate
197	N	100	L	N	N	17	L	---	---	---	L	---	---	Ash bed
202	N	150	10	N	L	4	L	---	---	---	L	---	---	Stream sediment

Semiquantitative spectrographic analyses (SSA)

G.--West Elk Creek Drainage--Continued

Sample	Ti[1] (.002)	B (10)	Ba (10)	Be (1)	Co (5)	Cr (10)	Cu (5)	La (20)	Mn (10)	Mo (5)	Pb (10)	Sc (5)	Sn (10)	Sr (100)	V (10)	Y (10)
209	>1.000	10	700	2	20	50	30	N	3,000	N	20	30	N	700	500	50
210	>1.000	L	500	1	30	20	70	N	3,000	N	10	30	N	700	300	30
212	1.000	10	700	2	30	30	10	N	2,000	N	20	30	N	700	500	50
214	1.000	L	500	1	30	20	30	N	2,000	N	20	30	N	700	500	30
215	1.000	10	500	2	30	20	30	N	2,000	N	20	30	N	700	500	30
216	1.000	10	500	2	30	30	70	50	1,500	N	30	30	N	700	500	50
218	.200	N	1,000	1	L	N	50	30	500	N	30	5	N	500	20	20
219	.300	N	1,000	1	L	N	10	50	500	N	200	7	N	700	70	10
221	.700	L	700	1	10	20	50	50	500	N	10	20	N	1,500	150	30
225	1.000	L	700	2	30	N	30	N	2,000	N	10	30	N	1,000	500	50
229	1.000	10	700	2	30	N	20	N	2,000	N	20	30	N	1,000	500	50
230	1.000	10	700	2	30	N	50	50	2,000	N	20	30	N	1,000	500	50
232	>1.000	10	700	2	30	N	50	N	1,500	N	30	30	N	700	500	70
302	1.000	L	700	1	30	30	30	20	1,500	N	L	30	N	700	300	30
306	.700	L	700	1	15	20	30	30	700	N	10	30	N	700	200	30
307	.700	L	700	2	15	50	30	30	1,000	N	20	20	N	700	150	30
324	1.000	N	200	N	50	70	15	20	3,000	N	L	30	N	100	500	10
328	.300	L	700	N	5	N	L	50	2,000	N	10	10	N	500	70	20
406	.500	L	300	N	15	30	7	50	1,500	N	10	20	N	500	200	30
471	.500	L	700	1	20	N	20	30	1,500	N	70	20	20	700	200	30
G24	---	N	1,000	N	15	10	3	50	---	3	5	15	N	1,500	100	50

H.--Lower Soap Creek Drainage

Sample	Ti[1] (.002)	B (10)	Ba (10)	Be (1)	Co (5)	Cr (10)	Cu (5)	La (20)	Mn (10)	Mo (5)	Pb (10)	Sc (5)	Sn (10)	Sr (100)	V (10)	Y (10)
122	.200	L	1,000	1	5	10	50	30	2,000	N	L	7	N	700	50	15
130	.700	N	1,000	2	15	20	30	50	1,500	N	15	20	N	1,000	100	30
131	.500	N	700	1	20	20	100	N	1,500	N	10	20	N	700	150	30
173	.700	70	700	2	15	70	5	50	1,500	N	30	15	N	200	150	30
174	.500	70	700	2	15	70	70	30	1,500	N	10	15	N	300	300	30
186	.500	70	500	2	15	50	30	30	1,000	10	20	15	N	500	150	30
187	.500	70	500	2	7	50	30	50	700	N	30	15	N	300	150	30
395	.700	L	1,500	L	20	20	30	N	1,500	N	20	15	N	500	300	20
480	.300	L	500	N	10	30	5	30	700	N	10	15	N	700	150	20
481	.500	L	500	L	10	30	20	30	1,000	N	L	20	N	500	150	20
486	>1.000	N	150	N	70	150	7	20	2,000	N	N	30	N	N	1,000	50
674	.700	L	500	L	15	30	15	30	1,000	N	15	15	N	700	150	20
675	.200	L	1,500	1	L	N	N	30	500	N	15	7	N	700	70	20
678	.300	10	1,000	L	7	N	10	30	500	10	15	10	N	500	100	20
688	.300	L	1,000	L	L	N	N	30	700	5	20	10	N	1,000	70	20
691	.500	20	700	L	10	50	15	30	1,000	10	20	15	N	500	150	30
839	.500	10	700	L	7	N	10	30	1,000	N	10	15	N	300	150	20
889	.500	10	500	1	5	N	7	30	700	N	20	10	30	300	100	30
890	1.000	L	500	N	20	30	7	30	1,000	N	10	15	N	300	200	20
909	N	N	500	2	50	50	L	N	>5,000	150	N	15	N	3,000	7,000	30
910	.300	L	700	L	L	N	N	30	1,500	N	10	10	N	500	70	20
933	.500	L	1,500	1	5	N	5	50	1,500	N	10	15	N	500	100	30
935	.200	10	1,500	1	L	N	N	100	1,500	N	20	5	N	500	30	20
937	.700	10	700	1	L	N	L	100	2,000	5	10	15	N	700	100	50
[7]1005	.300	15	700	1	L	20	5	30	700	N	30	7	N	150	70	20
1008	.700	50	700	L	10	70	15	30	700	5	30	15	N	200	200	30
M6E	.400	L	673	1.6	6	L	1	31	1,490	35	10	13	3	925	53	26
B10A	.400	L	782	1	9	3	25	34	1,240	2	14	10	3	1,020	71	28

[7]Sample 1005 showed 900 ppm fluorine by chemical analysis.

Sample	SSA				Colorimetric			Atomic Absorption						Sample description[5]
	Zn (200)	Zr (10)	Ni (5)	Ag (0.5)	As (10)	CxHM[2] (1)	Sb (1)	Cu (5)	Zn (5)	Pb (5)	Au (.02)	eU[3] (30)	Hg[4] (.02)	
G.--West Elk Creek Drainage--Continued														
209	N	150	15	N	L	---	2	---	---	---	L	---	---	Stream sediment
210	N	100	7	N	L	2	2	---	---	---	L	---	---	Do.
212	N	150	20	N	L	3	2	---	---	---	L	---	---	Do.
214	N	150	15	N	L	5	1	---	---	---	L	---	---	Do.
215	N	200	15	N	L	17	1	---	---	---	L	---	---	Do.
216	N	150	20	N	L	---	---	---	---	---	L	---	---	Do.
218	N	150	L	N	10	1	1	---	---	---	L	---	---	Rd dike
219	N	150	L	2.0	10	1	1	---	---	---	L	---	---	Alt Tbc
221	N	150	7	N	L	2	1	---	---	---	L	---	---	Do.
225	N	150	10	N	L	2	L	---	---	---	L	---	---	Stream sediment
229	N	150	10	N	L	3	L	---	---	---	L	---	---	Do.
230	N	150	7	N	L	3	L	---	---	---	L	---	---	Do.
232	N	150	10	N	L	5	L	---	---	---	L	---	---	Do.
302	N	150	7	N	N	7	L	---	---	---	.02	---	---	Do.
306	N	100	7	N	N	25	1	---	---	---	L	---	---	Do.
307	N	150	10	N	N	20	L	---	---	---	L	---	---	Do.
324	500	10	20	N	---	---	2	10	30	5	N	---	---	Pan concentrate
328	N	100	L	N	---	---	1	5	65	10	N	---	.30	Alt Tbc
406	200	100	5	N	---	N	---	---	---	---	---	---	---	Stream sediment
471	L	150	L	N	---	3	5	10	30	50	N	---	---	Tuff breccia matrix
G24	N	150	N	L	---	---	---	---	---	---	---	---	---	Lapilli tuff
H.--Lower Soap Creek Drainage														
122	N	70	7	N	N	20	L	---	---	---	L	---	---	Lava flow
130	N	100	10	N	N	40	1	---	---	---	L	---	---	Stream sediment
131	N	100	10	N	N	3	L	---	---	---	L	---	---	Do.
173	N	150	30	N	N	3	3	---	---	---	L	---	---	Do.
174	N	150	30	N	N	---	---	---	---	---	L	---	---	Do.
186	N	150	30	N	N	7	3	---	---	---	L	---	---	Do.
187	N	150	30	N	N	4	2	---	---	---	L	---	---	Do.
395	200	150	10	N	---	3	1	5	50	30	L	---	---	Do.
480	N	100	L	N	---	1	---	25	65	10	N	50	L	Do.
481	N	100	7	N	---	---	---	40	25	5	N	---	.02	Silic and dike
486	300	30	50	N	---	---	---	10	50	15	N	---	L	Pan sample
674	N	70	7	N	---	3	---	15	45	10	N	50	L	Stream sediment
675	N	150	N	N	---	---	---	5	30	10	N	---	.02	Hbl rd int
678	N	70	L	N	---	---	---	10	5	L	N	---	L	Lava flow (Tbc)
688	N	100	N	N	20	---	3	L	25	5	N	---	L	Intrusive rd
691	N	100	10	N	---	2	---	20	65	20	N	50	L	Stream sediment
839	N	150	L	N	---	---	---	15	25	5	N	---	3.90	Alt zone Tbc
889	N	100	L	N	---	1	---	5	35	10	N	L	.05	Stream sediment
890	200	50	7	N	---	1	---	5	45	10	N	L	.04	Do.
909	N	50	10	N	---	---	---	5	30	L	N	--	.08	Manganese vein
910	N	100	L	N	10	---	L	5	5	L	N	---	L	Mang tuff breccia
933	N	150	L	N	---	---	---	5	110	L	N	---	.08	Rd
935	N	150	L	N	---	---	---	5	75	5	N	---	.04	Rhyolite
937	N	150	L	N	---	---	---	5	75	5	N	---	.08	Do.
[7]1005	N	100	10	N	---	---	---	5	100	10	N	---	.35	Alt felsite sill
1008	N	100	20	N	---	1	---	25	100	25	N	---	.18	Stream sediment
M6E	99	215	L	L	---	---	---	---	---	---	---	---	---	Tuff breccia clast
B10A	85	181	L	L	---	---	---	---	---	---	---	---	---	Lava flow

[7]Sample 1005 showed 900 ppm fluorine by chemical analyses.

Sample	Semiquantitative spectrographic analyses (SSA)															
	Ti[1] (.002)	B (10)	Ba (10)	Be (1)	Co (5)	Cr (10)	Cu (5)	La (20)	Mn (10)	Mo (5)	Pb (10)	Sc (5)	Sn (10)	Sr (100)	V (10)	Y (10)
								I.--East Soap Creek Drainage								
153	.500	L	1,000	2	10	10	50	50	1,000	N	10	15	N	1,500	70	30
154	.500	N	1,500	1	10	N	5	50	1,500	N	15	15	N	700	70	30
155	.300	10	1,500	2	5	N	20	70	1,000	N	20	7	N	700	70	30
169	.300	L	500	1	7	15	50	N	700	N	10	15	N	700	70	15
275	1.000	L	700	2	20	30	50	30	1,500	N	20	20	N	500	200	50
276	1.000	15	700	1	30	70	50	30	2,000	N	20	30	N	700	300	30
277	1.000	L	700	2	20	70	50	30	2,000	N	20	30	N	700	300	30
278	.700	L	700	2	15	30	50	30	1,500	N	20	30	N	500	200	30
279	.700	L	1,000	2	20	70	50	50	1,500	N	10	20	N	500	200	30
282	.500	10	700	2	15	50	30	N	1,500	N	30	20	N	500	100	30
283	.700	L	700	1	20	30	70	30	1,500	N	15	30	N	700	200	30
285	.300	15	700	2	7	15	30	30	700	N	20	15	N	500	70	30
291	.500	15	500	1	10	30	10	50	1,500	N	15	15	N	300	150	20
293	>1.000	N	500	N	50	200	7	50	2,000	N	10	30	N	300	500	30
295	1.000	L	300	N	20	50	15	50	1,500	N	10	20	N	300	200	20
296	.500	L	500	N	20	70	15	50	1,500	N	L	15	N	500	200	20
298	1.000	L	300	N	30	50	30	50	1,500	N	10	20	N	300	200	30
332	.300	L	700	N	7	N	L	50	2,000	N	10	15	N	700	100	30
337	.300	50	700	L	15	30	10	50	1,500	N	15	20	N	500	150	30
338	.300	L	700	N	20	50	20	50	2,000	N	15	20	N	1,500	150	30
339	>1.000	N	200	N	50	70	15	20	3,000	N	10	30	N	150	500	15
349	>1.000	N	500	N	70	150	10	20	3,000	N	10	30	N	300	700	20
408	1.000	L	300	N	30	30	20	30	2,000	N	10	30	N	300	200	30
409	.700	L	300	N	20	50	15	50	1,500	N	10	15	N	300	200	20
435	>1.000	N	50	N	100	200	70	N	2,000	N	N	30	N	N	700	N
469	>1.000	L	300	N	100	70	15	N	2,000	N	N	50	N	200	1,500	30
470	>1.000	L	500	N	50	100	15	N	2,000	N	10	30	N	300	1,500	30
928	.700	15	700	L	10	20	30	30	1,000	N	10	15	N	500	150	30
B32	.300	L	652	1	7	5	17	31	1,340	2	13	13	3	1,180	70	23
B38	.500	L	766	1	11	6	23	32	2,050	3	13	16	4	716	119	24
								J.--Upper Soap Creek Drainage								
152	1.000	L	1,500	1	20	30	50	50	2,000	N	15	30	N	700	500	30
157	.700	N	700	1	15	30	30	30	1,500	N	15	20	N	700	200	30
160	1.000	L	1,500	1	15	N	50	50	3,000	N	15	20	N	700	150	30
161	1.000	15	1,000	2	15	50	50	N	3,000	N	15	15	N	500	150	30
162	.700	L	1,500	1	L	N	30	20	1,500	N	100	15	N	500	100	20
164	.700	L	1,000	1	5	N	10	30	700	10	20	15	N	2,000	100	20
176	.700	L	500	1	20	15	70	30	1,500	N	L	20	N	500	300	30
178	.700	L	700	1	10	N	70	30	1,500	N	20	15	N	500	100	15
181	.500	L	700	1	10	L	20	30	1,500	N	15	15	N	700	70	30
182	.200	N	500	2	N	N	20	20	500	N	10	7	N	300	50	15
340	.300	L	1,000	N	10	N	5	50	2,000	N	15	15	N	1,000	70	20
[8]345	.300	N	700	N	N	N	L	50	700	N	100	10	N	700	70	20
346	>1.000	N	200	N	70	70	7	30	2,000	10	15	30	N	L	700	10
351	.700	L	500	N	30	10	15	50	1,500	N	10	20	N	500	150	30
413	>1.000	N	150	N	70	150	10	30	3,000	N	10	50	N	N	700	20
416	.700	L	300	N	20	N	5	30	1,500	N	10	15	N	500	200	30
422	.300	L	1,000	1	7	N	L	50	700	N	100	7	N	500	70	30
423	.300	15	500	L	10	15	7	50	1,000	N	10	15	L	300	100	20
426	>1.000	N	700	N	20	300	10	50	3,000	N	20	30	N	300	1,000	20
430	>1.000	N	200	N	30	100	10	50	3,000	N	10	30	N	100	700	30

[8]Sample 345 contained detectable tellurium (<0.5 ppm).

Sample	SSA				Colorimetric			Atomic Absorption						Sample description[5]
	Zn (200)	Zr (10)	Ni (5)	Ag (0.5)	As (10)	CxHM[2] (1)	Sb (1)	Cu (5)	Zn (5)	Pb (5)	Au (.02)	eU[3] (30)	Hg[4] (.02)	
							I.--East Soap Creek Drainage							
153	N	150	5	N	N	5	L	---	---	---	L	---	---	Hbl rd dike
154	N	150	5	N	N	1	L	---	---	---	L	---	---	Do.
155	N	200	5	N	N	9	L	---	---	---	L	---	---	Lava flow
169	N	70	7	N	20	9	2	---	---	---	L	---	---	Alt dio Tbc
275	N	200	20	N	N	40	2	---	---	---	L	---	---	Stream sediment
276	N	200	20	N	N	20	L	---	---	---	L	---	---	Do.
277	N	150	15	N	N	25	L	---	---	---	L	---	---	Do.
278	N	150	15	N	N	14	L	---	---	---	L	---	---	Do.
279	N	150	15	N	N	25	L	---	---	---	L	---	---	Do.
282	N	200	10	N	N	20	L	---	---	---	L	---	---	Do.
283	N	150	15	N	N	25	L	---	---	---	L	---	---	Do.
285	N	150	7	N	N	25	L	---	---	---	L	---	---	Do.
291	200	200	10	N	---	N	---	---	---	---	---	---	---	Do.
293	N	70	20	N	---	---	2	10	40	10	N	---	.02	Pan concentrate
295	300	70	15	N	---	N	---	---	---	---	---	---	---	Stream sediment
296	300	50	15	N	---	N	---	---	---	---	---	---	---	Do.
298	200	100	15	N	---	N	---	---	---	---	---	---	---	Do.
332	N	70	N	N	---	---	1	30	85	15	N	---	.80	Alt Tbc
337	N	150	5	N	---	---	L	20	45	15	N	---	.60	Stream sediment
338	N	70	7	N	---	---	L	20	40	5	N	---	L	Dac dike
339	300	10	20	N	---	---	2	10	20	5	N	---	N	Pan concentrate
349	200	70	10	N	---	---	2	10	45	10	N	---	L	Do.
408	300	100	15	N	---	N	---	---	---	---	---	---	---	Stream sediment
409	200	100	15	N	---	N	---	---	---	---	---	---	---	Do.
435	700	50	30	N	---	---	L	10	65	5	N	---	N	Pan concentrate
469	300	70	30	N	---	3	1	10	35	30	N	---	---	Do.
470	300	70	20	N	---	1	1	10	40	25	N	---	---	Do.
928	N	150	7	N	---	---	---	40	65	5	N	---	.08	Dio Tbc
B32	84	198	L	L	---	---	---	---	---	---	---	---	---	Hbl dac Tbc
B38	102	219	L	L	---	---	---	---	---	---	---	---	---	Hbl rd dike
							J.--Upper Soap Creek Drainage							
152	N	150	10	N	N	45	1	---	---	---	L	---	---	Stream sediment
157	N	150	10	N	N	20	L	---	---	---	L	---	---	Shear zone Tbc
160	N	300	5	N	N	9	L	---	---	---	L	---	---	Stream sediment
161	N	300	10	N	N	9	4	---	---	---	L	---	---	Do.
162	N	200	7	L	20	4	2	---	---	---	L	---	---	Alt gd sill
164	N	150	5	N	N	1	1	---	---	---	L	---	---	Alt dike
176	N	150	7	N	N	11	L	---	---	---	L	---	---	Silic rd int(?)
178	N	150	7	N	N	5	L	---	---	---	L	---	---	Stream sediment
181	N	150	5	N	N	17	L	---	---	---	L	---	---	Intrusive rd
182	N	100	L	N	N	14	L	---	---	---	L	---	---	Alt Tbc
340	N	70	N	N	---	---	0	L	L	5	N	---	.50	Alt breccia Tbc(?)
[8]345	N	70	N	N	---	---	0	L	10	40	N	---	N	Alt gd sill
346	300	70	20	N	---	---	2	10	45	10	N	---	N	Pan concentrate
351	200	100	10	N	---	N	---	---	---	---	---	50	---	Stream sediment
413	700	30	15	N	---	---	2	5	25	10	N	---	N	Pan concentrate
416	300	70	5	N	---	N	---	---	---	---	---	---	---	Stream sediment
422	300	100	L	.5	---	---	0	5	140	55	N	---	.50	Vein in alt py sill
423	N	100	7	N	---	N	---	---	---	---	---	---	---	Stream sediment
426	300	150	20	N	---	---	2	---	---	---	N	---	.02	Pan concentrate
430	500	150	15	N	---	---	L	5	35	10	N	---	L	Do.

[8]Sample 345 contained detectable tellurium (<0.5 ppm).

Semiquantitative spectrographic analyses (SSA)

Sample	Ti[1] (.002)	B (10)	Ba (10)	Be (1)	Co (5)	Cr (10)	Cu (5)	La (20)	Mn (10)	Mo (5)	Pb (10)	Sc (5)	Sn (10)	Sr (100)	V (10)	Y (10)

J.--Upper Soap Creek Drainage--Continued

450	>1.000	N	70	N	70	70	5	N	2,000	N	N	30	N	N	700	N
494	.500	L	500	L	15	N	15	30	700	30	10	15	N	300	150	30
501	.700	10	500	N	15	N	7	50	2,000	N	10	15	N	500	200	30
803	.700	L	700	L	15	10	7	30	1,000	N	15	15	N	700	150	30
805	.700	10	1,000	L	L	N	7	30	150	N	10	15	N	300	150	15
825	.300	L	1,000	1	L	N	N	30	500	10	10	7	N	500	70	20
838	.200	30	300	L	5	10	7	20	700	N	10	7	N	300	100	15
926	.100	10	1,500	1	N	N	N	20	200	N	20	N	N	200	20	20
927	.500	L	1,000	L	5	N	N	30	1,500	N	10	7	N	500	70	30
1067	.300	L	1,500	L	5	N	L	30	1,500	N	20	7	N	700	100	20
M424	---	N	700	N	10	L	15	50	---	N	N	10	N	700	30	30
M926	.030	N	2,100	1.6	L	2	L	L	421	1	21	2	L	263	L	15

K.--West Soap Creek Drainage

489	.300	70	300	L	7	70	15	30	300	7	30	10	N	150	150	30
490	>1.000	L	200	N	30	50	5	20	3,000	N	N	30	N	100	700	30
538	.700	L	700	N	10	30	10	30	700	50	15	15	N	500	150	20
539	.700	10	700	L	10	10	10	30	1,000	10	15	15	N	500	100	20
540	.500	20	500	L	5	10	7	30	500	5	15	10	N	300	100	20
546	>1.000	L	200	N	50	50	5	20	3,000	N	N	20	N	100	700	30
[9]549	.300	L	700	L	N	N	N	30	200	N	10	5	N	300	50	20
550	.300	10	1,000	L	L	N	L	30	150	5	15	7	N	500	70	20
551	.300	15	700	L	7	N	5	30	700	N	15	10	N	500	100	20
[10]553	.300	10	700	L	5	N	10	30	500	N	10	10	N	500	100	20
[11]800	.700	50	1,000	L	N	N	N	30	100	N	10	7	N	500	70	30
[12]801	.300	50	700	L	N	N	N	30	150	N	L	7	N	500	70	20

[9]Sample 549 showed 10,000 ppm sulfur by chemical analyses.
[10] " 553 " 3,500 " " " " "
[11] " 800 " 13,000 " " " " "
[12] " 801 " 11,000 " " " " "

L.--Curecanti Creek and Dyer Creek Drainage

499	.700	10	500	L	15	10	5	30	700	5	10	10	N	300	150	30
703	.700	10	700	L	15	30	7	100	1,000	N	15	15	N	700	150	20
708	.700	L	700	L	20	50	15	20	1,000	N	10	15	N	500	200	20
715	1.000	L	500	N	20	30	5	30	1,000	N	10	15	N	500	200	20
795	.700	L	500	L	15	10	10	30	1,500	N	20	15	N	500	200	30
808	.500	10	1,500	L	5	N	5	30	500	N	10	10	N	500	100	20
945	.500	L	300	L	30	30	7	30	1,500	N	10	15	N	300	300	20
949	.700	L	700	L	10	10	7	30	1,500	N	20	15	N	700	150	30

M.--Smith Fork Drainage

585	.300	70	500	1	5	70	15	50	300	N	30	7	N	150	100	20
587	.300	70	300	1	5	70	20	30	300	N	30	7	N	L	100	20
589	.300	70	300	1	5	50	15	30	500	N	30	7	N	L	100	20
758	.200	10	1,000	L	N	N	5	20	200	N	15	10	L	500	100	20
759	.200	10	1,500	L	L	50	10	30	700	N	70	7	L	150	100	15
765	.500	70	700	1	7	100	15	30	500	N	30	10	N	100	150	20
777	.200	50	500	1	7	50	15	30	500	15	20	7	N	150	100	20
783	.200	L	1,500	L	N	·10	N	20	700	N	100	7	N	1,000	100	15
851	.150	L	1,500	L	L	N	5	20	1,000	N	15	7	N	700	50	20
855	.200	L	200	1	5	70	20	30	1,000	N	20	10	10	200	100	30

Sample	SSA				Colorimetric			Atomic Absorption						Sample description[5]
	Zn (200)	Zr (10)	Ni (5)	Ag (0.5)	As (10)	CxHM[2] (1)	Sb (1)	Cu (5)	Zn (5)	Pb (5)	Au (.02)	eU[3] (30)	Hg[4] (.02)	
J.--Upper Soap Creek Drainage--Continued														
450	700	30	20	N	---	---	L	5	50	5	.05	---	N	Pan concentrate
494	N	70	L	N	---	1	---	10	40	5	N	---	L	Stream sediment
501	200	70	L	N	---	N	---	---	---	---	---	---	---	Do.
803	N	100	7	N	---	2	---	5	50	20	N	30	L	Do.
805	N	100	L	N	10	---	1	10	20	5	N	---	.02	Alt Tbc
825	N	150	L	N	---	---	---	10	60	20	N	---	L	Hbl dac dike
838	N	70	10	N	---	2	---	10	60	15	N	---	.54	Stream sediment
926	N	50	L	N	---	---	---	5	80	10	N	---	L	Alt felsite
927	N	100	L	N	---	---	---	5	100	5	N	40	.05	Gd sill
1067	N	100	L	N	---	---	---	5	110	15	N	---	N	Stream sediment
M424	N	100	N	2.0	---	---	---	---	---	---	---	---	---	Dac dike
M926	18	38	L	L	---	---	---	---	---	---	---	---	---	Alt felsite
K.--West Soap Creek Drainage														
489	N	150	20	N	---	1	---	20	95	25	N	---	.02	Stream sediment
490	500	70	5	N	---	---	---	5	50	15	N	---	L	Pan concentrate
538	N	70	7	N	---	2	---	5	50	10	N	---	L	Stream sediment
539	N	70	5	N	---	2	---	5	45	10	N	---	.05	Do.
540	N	50	L	N	---	3	---	5	50	10	N	---	L	Do.
546	500	50	7	N	---	---	---	5	55	15	N	---	L	Pan concentrate
[9]549	N	100	N	N	20	---	L	L	40	L	N	60	.02	Alt Tbc
550	N	150	5	N	---	---	---	5	20	L	N	---	L	Do.
551	N	100	L	N	10	---	1	5	50	10	N	---	L	Do.
[10]553	N	100	N	N	N	---	1	10	50	5	N	50	L	Do.
[11]800	N	150	L	N	10	---	L	L	L	5	N	50	.10	Clay in solf zone
[12]801	N	100	L	N	10	---	L	5	10	5	N	40	.10	Do.

[9]Sample 549 showed 10,000 ppm sulfur by chemical analyses.
[10] " 553 " 3,500 " " " " "
[11] " 800 " 13,000 " " " " "
[12] " 801 " 11,000 " " " " "

Sample	Zn (200)	Zr (10)	Ni (5)	Ag (0.5)	As (10)	CxHM (1)	Sb (1)	Cu (5)	Zn (5)	Pb (5)	Au (.02)	eU (30)	Hg (.02)	Sample description
L.--Curecanti Creek and Dyer Creek Drainage														
499	L	100	L	N	---	1	---	5	50	10	N	---	.02	Stream sediment
703	L	100	5	N	---	1	---	5	50	10	N	---	L	Do.
708	200	50	7	N	---	3	---	5	50	10	N	---	L	Do.
715	200	70	5	N	---	2	---	5	45	15	N	---	L	Do.
795	200	50	L	N	---	L	---	5	50	15	N	---	.03	Do.
808	N	100	N	N	---	---	---	5	15	N	N	---	.05	Dac lava flow
945	300	50	7	N	---	L	---	5	35	10	N	---	L	Stream sediment
949	200	70	L	N	---	3	---	5	35	10	N	---	L	Do.
M.--Smith Fork Drainage														
585	N	150	15	N	---	2	---	15	85	20	N	---	L	Stream sediment
587	N	150	20	N	---	4	---	25	100	25	N	---	.04	Do.
589	N	150	20	N	---	4	---	20	90	25	N	---	.03	Do.
758	N	70	L	N	---	---	---	10	5	5	N	---	.02	Alt py sill
759	N	100	7	L	20	---	1	15	50	40	N	---	N	Do.
765	N	150	20	N	---	1	---	30	95	30	N	---	.10	Stream sediment
777	N	100	30	N	---	4	---	20	110	20	N	---	.07	Do.
783	N	70	L	.5	---	---	---	5	35	90	N	---	.02	Alt dac porp
851	N	70	L	N	---	---	---	5	25	5	N	---	.10	Gd
855	N	150	20	N	---	---	---	45	120	30	N	---	.08	Alt shale

Semiquantitative spectrographic analyses (SSA)

M.--Smith Fork Drainage--Continued

Sample	Ti[1] (.002)	B (10)	Ba (10)	Be (1)	Co (5)	Cr (10)	Cu (5)	La (20)	Mn (10)	Mo (5)	Pb (10)	Sc (5)	Sn (10)	Sr (100)	V (10)	Y (10)
856	.050	15	N	L	N	20	L	L	1,500	N	300	N	N	L	20	L
857	.300	70	300	1	5	50	10	20	300	N	15	5	N	150	100	20
858	.300	70	500	1	5	50	10	20	500	N	15	7	N	150	100	20
859	.300	70	300	1	5	50	10	20	300	N	15	7	N	150	100	20
860	.300	70	300	1	5	50	10	20	300	N	15	7	N	150	100	20
895	.300	50	500	1	5	30	20	30	500	5	30	7	N	200	100	20
897	.300	70	500	1	5	50	10	30	200	N	15	7	N	150	100	20
923	.200	70	500	1	5	70	15	30	200	N	30	10	N	L	150	20
924	.200	70	500	1	5	50	15	30	500	N	50	10	N	100	100	20
967	.200	20	300	1	7	15	150	20	500	10	50	7	N	200	50	15
[13]1076	.200	L	300	1	L	50	15	30	300	N	15	7	N	300	70	20
M610	.400	L	797	1	11	1	8	27	2,000	L	10	13	L	939	74	27
1089	.300	30	500	1	7	70	10	30	500	5	20	7	N	200	70	15

[13]Sample 1076 showed 900 ppm fluorine by chemical analysis.

N.--Lone Pine Creek Drainage

Sample	Ti[1] (.002)	B (10)	Ba (10)	Be (1)	Co (5)	Cr (10)	Cu (5)	La (20)	Mn (10)	Mo (5)	Pb (10)	Sc (5)	Sn (10)	Sr (100)	V (10)	Y (10)
590	.200	70	300	1	5	70	15	30	200	N	20	7	N	L	150	20
596	.150	L	1,500	L	L	N	L	20	1,000	N	15	5	N	500	30	15
598	.300	50	700	L	7	70	15	30	500	N	20	7	N	150	150	30
768	.200	L	1,500	1	L	N	5	30	1,000	N	20	7	N	700	50	20
769	.200	10	1,500	1	L	N	5	30	700	N	15	7	N	700	70	20
771	.300	50	500	1	5	50	10	30	500	N	20	7	N	150	70	20
772	.200	50	500	1	5	70	15	50	300	5	15	7	N	150	100	20

O.--Minnesota Creek Drainage

Sample	Ti[1] (.002)	B (10)	Ba (10)	Be (1)	Co (5)	Cr (10)	Cu (5)	La (20)	Mn (10)	Mo (5)	Pb (10)	Sc (5)	Sn (10)	Sr (100)	V (10)	Y (10)
568	.300	50	500	1	5	70	15	30	500	N	20	7	N	200	100	20
753	.200	70	500	1	5	70	15	30	2,000	N	20	7	N	100	100	15
755	.300	200	700	1	5	50	10	30	500	N	20	7	N	100	70	20
849	.200	L	1,500	1	N	N	5	30	300	N	20	7	N	1,000	50	20
850	.200	70	700	N	N	50	5	20	150	L	30	7	N	100	150	15
969	.300	10	700	1	7	20	15	30	700	20	20	10	N	500	150	20
976	.300	L	200	1	7	70	5	30	1,000	N	150	7	N	150	100	20
1120	.300	50	500	1	7	70	15	30	300	5	30	10	N	150	100	20
1122	.300	50	500	1	10	100	15	30	500	7	30	10	N	150	100	20
1124	.300	70	700	1	15	100	20	30	500	N	30	10	N	200	100	30

P.--Coal Creek Drainage

Sample	Ti[1] (.002)	B (10)	Ba (10)	Be (1)	Co (5)	Cr (10)	Cu (5)	La (20)	Mn (10)	Mo (5)	Pb (10)	Sc (5)	Sn (10)	Sr (100)	V (10)	Y (10)
493	.300	L	1,000	L	N	N	N	30	1,000	15	15	5	N	500	50	20
[14]556	.300	50	300	2	5	50	30	30	200	N	10	10	N	200	100	30
579	.300	15	700	1	5	20	15	30	200	N	30	5	N	100	70	20
747	.300	70	500	1	7	50	15	30	150	L	30	7	N	100	100	20
748	.300	70	300	1	5	50	15	30	200	L	20	7	N	L	100	20
749	.300	100	500	1	L	70	7	30	500	N	N	10	L	100	100	20
807	.700	10	700	1	7	20	10	30	1,000	N	10	10	N	300	100	20
826	.700	L	700	N	10	10	15	30	1,500	N	10	15	N	500	150	30
833	.700	L	500	N	20	10	5	30	1,500	N	L	20	N	300	200	30
834	.300	50	500	1	5	100	15	20	300	N	20	10	N	150	100	30
842	.200	10	1,500	1	N	N	N	30	200	N	10	7	N	500	50	20
843	.200	10	1,000	1	N	20	5	20	200	N	L	5	N	300	50	10
844	.150	L	1,500	1	L	N	5	30	1,500	N	30	5	N	700	30	20
845	.150	L	1,500	L	L	N	10	20	500	N	20	5	N	500	50	20
846	.200	L	1,500	1	L	N	10	30	1,000	N	10	5	N	700	30	30

[14]Sample 556 showed 1,000 ppm sulfur by chemical analysis.

Sample	SSA Zn (200)	Zr (10)	Ni (5)	Ag (0.5)	Colorimetric As (10)	CxHM[2] (1)	Sb (1)	Atomic Absorption Cu (5)	Zn (5)	Pb (5)	Au (.02)	eU[3] (30)	Hg[4] (.02)	Sample description[5]
														M.--Smith Fork Drainage--Continued
856	1,000	30	L	L	---	---	---	10	1,000	220	N	---	.10	Sheared cal ss
857	N	150	15	N	---	2	---	15	90	20	N	---	.03	Stream sediment
858	N	150	15	N	---	1	---	15	75	20	N	50	.05	Do.
859	N	100	15	N	---	10	---	15	100	20	N	---	.07	Do.
860	N	100	15	N	---	L	---	15	85	20	N	---	.14	Do.
895	L	100	15	N	---	5	---	40	250	25	1.00	---	N	Do.
897	N	100	15	N	---	1	---	15	75	15	N	---	.07	Do.
923	N	100	20	N	---	2	---	25	100	30	N	---	.03	Do.
924	N	150	20	N	---	1	---	20	100	30	N	---	N	Do.
967	200	150	7	L	N	40	1	150	350	60	N	50	.08	Do.
[13]1076	N	100	7	N	---	---	---	25	100	30	N	---	.16	Hornfels
M610	L	164	L	L	---	---	---	---	---	---	---	---	---	Stream sediment
1089	N	150	7	N	---	1	---	15	90	20	N	---	.06	Lava flow

[13]Sample 1076 showed 900 ppm fluorine by chemical analysis.

Sample	SSA Zn (200)	Zr (10)	Ni (5)	Ag (0.5)	Colorimetric As (10)	CxHM[2] (1)	Sb (1)	Atomic Absorption Cu (5)	Zn (5)	Pb (5)	Au (.02)	eU[3] (30)	Hg[4] (.02)	Sample description[5]
														N.--Lone Pine Creek Drainage
590	N	150	20	N	---	3	---	20	80	25	N	---	N	Stream sediment
596	N	70	L	N	---	---	---	5	50	10	N	---	N	Alt shear in gd
598	N	100	15	N	---	15	---	15	80	20	N	---	.04	Stream sediment
768	N	150	L	N	---	---	---	5	45	10	N	---	.02	Alt gd
769	N	100	L	N	---	---	---	10	10	10	N	---	L	Do.
771	N	150	15	N	---	3	---	10	70	15	N	40	.07	Stream sediment
772	N	150	20	N	---	3	---	15	90	15	N	---	.05	Do.
														O.--Minnesota Creek Drainage
568	N	200	15	.5	---	3	---	15	120	20	N	---	.05	Stream sediment
753	N	100	20	N	---	4	---	20	80	25	N	---	L	Do.
755	L	100	15	N	---	10	---	20	160	20	N	---	.11	Do.
849	N	100	L	N	---	---	---	5	15	15	N	---	.08	Alt py sill
850	N	100	L	N	---	---	---	5	L	15	N	---	.04	Vein in alt py sil
969	N	150	10	N	---	---	---	20	100	15	N	---	.04	Alt py gd
976	300	300	10	1.0	---	---	---	5	200	95	N	---	.04	Py hornfels
1120	N	200	15	N	---	L	---	25	100	35	N	---	.04	Stream sediment
1122	N	200	20	N	---	1	---	20	70	30	N	---	.06	Do.
1124	N	200	20	N	---	1	---	25	90	30	N	---	.04	Do.
														P.--Coal Creek Drainage
493	N	150	L	N	20	---	1	L	35	5	N	---	L	Hbl gd dike
[14]556	N	100	15	N	N	---	1	30	45	10	N	50	.31	Fault gouge
579	N	700	5	N	---	1	---	15	30	10	N	---	.06	Stream sediment
747	N	100	20	N	---	1	---	35	100	35	N	---	.15	Do.
748	N	150	20	N	---	1	---	20	80	25	N	---	.05	Do.
749	N	150	7	N	---	---	---	5	20	5	N	---	N	And Tbc(?)
807	N	100	5	.5	20	---	L	10	40	5	N	---	L	Fault gouge
828	N	100	5	N	---	1	---	20	35	10	N	L	.48	Stream sediment
833	200	30	L	N	---	L	---	5	30	5	N	---	.10	Do.
834	N	150	15	N	---	1	---	15	70	20	N	---	.60	Do.
842	N	70	L	N	---	---	---	5	5	10	N	---	.06	Alt dac porp
843	N	70	L	N	10	---	1	5	10	10	N	---	N	Alt py gd
844	N	70	L	N	---	---	---	5	75	25	N	---	.04	Alt sheared qtz vn
845	N	70	L	N	---	---	---	20	65	15	N	---	.14	Vein py hornfels
846	N	100	L	N	10	---	1	15	55	10	N	---	.16	Alt py gd

[14]Sample 556 showed 1,000 ppm sulfur by chemical analysis.

Sample	Semiquantitative spectrographic analyses (SSA)															
	Ti[1] (.002)	B (10)	Ba (10)	Be (1)	Co (5)	Cr (10)	Cu (5)	La (20)	Mn (10)	Mo (5)	Pb (10)	Sc (5)	Sn (10)	Sr (100)	V (10)	Y (10)
P.--Coal Creek Drainage--Continued																
847	.200	50	700	1	L	N	20	20	1,000	10	200	5	N	300	50	20
870	.300	100	700	1	5	100	20	20	200	N	30	10	N	150	150	20
871	.300	100	300	1	7	70	15	30	200	N	30	7	N	100	100	20
872	.200	10	1,500	1	N	N	5	20	1,000	N	20	5	N	500	50	15
900	.300	10	1,500	1	7	N	10	20	2,000	N	10	7	N	500	70	20
901	.300	20	500	1	L	N	N	20	150	N	20	5	N	200	50	20
902	.500	30	1,000	1	N	15	7	50	150	N	70	10	N	200	100	20
903	.200	L	1,500	1	L	N	15	30	1,000	5	200	5	10	300	50	20
904	.500	10	1,500	1	7	N	L	30	1,500	N	20	10	N	1,500	70	30
905	.200	L	1,000	1	L	N	20	30	2,000	N	50	5	10	500	30	20
906	.200	10	1,500	L	L	N	5	30	200	30	30	5	N	700	30	15
907	.200	L	700	L	N	N	L	20	300	N	50	7	N	500	50	15
925	.300	L	1,500	L	N	N	N	30	1,500	L	N	5	N	500	50	20
1010	.200	30	300	1	5	30	15	30	1,000	N	50	5	N	150	50	15
1011	.300	100	500	1	5	70	15	30	300	N	30	10	N	150	150	20
1012	.200	70	500	1	7	70	20	30	300	N	50	10	N	100	150	20
1018	.300	100	1,000	1	7	70	30	30	300	N	30	10	N	150	100	20
1064	>1.000	N	500	N	50	50	15	30	2,000	N	10	15	N	150	500	20
1127	.300	50	700	1	10	150	20	30	500	L	30	10	N	150	100	20
1157	.700	20	700	L	30	30	30	30	1,500	N	20	15	N	300	200	100
Q.--Robinson Creek Drainage																
042	.200	30	700	2	5	50	20	N	300	N	10	5	N	100	70	20
077	.700	10	150	2	L	20	20	50	70	N	20	10	N	N	150	20
078	.700	10	200	3	5	20	20	150	150	N	30	20	N	300	150	10
081	.300	30	700	2	10	50	30	50	700	N	50	15	N	200	100	30
956	.150	10	1,500	1	N	N	N	30	1,000	N	20	L	N	300	30	30
958	.150	10	1,500	1	N	10	15	20	1,000	N	70	5	N	100	50	20
964	.150	30	300	1	5	30	7	L	200	N	15	5	L	200	50	15
1025	.300	70	700	1	7	70	20	30	300	N	50	7	N	100	100	20
1033	.200	70	300	1	L	30	10	20	500	N	15	7	N	100	70	15
1036	.300	10	1,500	L	5	N	L	30	1,500	N	15	7	N	700	100	30
1078	.300	L	1,500	1	L	L	L	30	1,000	N	20	7	N	500	50	20
1082	.300	30	700	1	7	30	10	30	300	5	30	7	N	100	70	15
R.--Cliff Creek Drainage																
034	.300	L	700	2	20	N	20	50	1,000	N	15	10	N	700	70	20
045	.700	N	500	2	15	N	30	50	1,500	N	10	20	N	700	150	30
049	.300	L	700	2	20	N	10	50	700	N	20	7	N	700	70	15
053	.150	L	500	1	7	N	10	L	150	N	10	L	N	N	50	10
055	.300	20	500	2	5	20	10	50	500	N	20	10	N	300	70	20
058	.500	10	700	2	10	N	30	50	1,000	N	20	15	N	700	100	20
059	1.000	N	700	2	30	20	30	50	1,500	N	20	20	N	500	500	70
065	.500	L	1,000	2	10	N	30	70	1,000	N	30	10	N	700	100	30
067	.700	10	1,000	2	20	20	70	50	1,500	N	50	20	N	700	150	30
068	.700	10	700	2	10	20	20	50	1,000	N	20	10	N	500	150	30
070	.500	20	1,000	2	10	N	50	50	1,000	N	20	10	N	700	100	30
105	.700	30	1,000	2	10	70	30	70	1,000	N	10	15	N	200	70	30
106	.300	10	700	2	5	50	30	100	500	N	20	7	N	200	70	30
107	.700	10	1,000	2	5	30	50	N	500	N	15	7	N	200	70	50
108	.700	10	700	1	5	70	50	50	700	N	30	10	N	150	70	150
109	.300	20	5,000	3	7	30	20	70	700	N	30	15	N	300	70	30
111	.300	L	1,500	2	5	10	30	70	1,000	N	30	10	N	700	70	30
116	.700	10	1,000	2	N	50	30	50	700	N	15	7	N	300	70	20
118	.300	15	1,000	3	5	70	30	100	700	N	15	10	N	200	70	30
119	.700	10	5,000	1	5	70	50	70	700	N	30	15	N	300	150	30

Sample	SSA				Colorimetric			Atomic Absorption						Sample description[5]
	Zn (200)	Zr (10)	Ni (5)	Ag (0.5)	As (10)	CxHM[2] (1)	Sb (1)	Cu (5)	Zn (5)	Pb (5)	Au (.02)	eU[3] (30)	Hg[4] (.02)	
						P.--Coal Creek Drainage--Continued								
847	L	100	L	L	---	3	---	35	200	200	.05	---	.04	Stream sediment
870	N	100	30	L	---	---	---	35	50	40	N	---	.18	Indurated shale
871	N	150	15	N	---	2	---	25	85	35	N	---	.07	Stream sediment
872	N	70	L	N	---	---	---	5	30	15	N	---	.06	Alt gd sill
900	N	150	5	.5	10	---	1	5	40	10	N	---	.10	Alt py gd
901	N	150	L	.5	---	---	---	L	20	10	N	---	.30	Arg py gd
902	N	150	L	.5	20	---	1	5	5	60	N	---	L	Do.
903	500	100	L	.5	---	---	---	15	600	150	N	---	.20	Do.
904	L	150	L	N	---	---	---	5	80	20	N	---	.06	Alt gd breccia
905	300	100	L	1.0	40	---	1	25	400	25	N	---	L	Alt py gd
906	N	70	L	1.0	---	---	---	5	25	20	N	---	.10	Do.
907	N	70	L	1.0	10	---	L	5	50	55	N	---	.09	Do.
925	N	150	N	N	---	---	---	5	110	10	N	---	.02	Gd
1010	L	100	5	N	---	25	---	15	150	30	N	---	.38	Stream sediment
1011	L	100	20	N	---	2	---	20	110	25	N	---	.21	Do.
1012	L	150	20	N	---	1	---	35	110	35	N	---	.16	Do.
1018	L	150	30	N	---	3	---	40	110	30	N	---	.14	Do.
1064	200	50	15	N	---	---	---	10	75	15	N	---	L	Pan concentrate
1127	N	300	15	N	---	1	---	25	80	25	N	---	.08	Stream sediment
1157	L	300	10	N	---	1	---	15	75	25	N	---	.10	Do.
						Q.--Robinson Creek Drainage								
042	N	300	15	N	10	2	2	---	---	---	L	---	---	Stream sediment
077	N	500	5	N	L	1	1	---	---	---	L	---	---	Toc mottled shale
078	N	300	5	N	10	3	1	---	---	---	L	---	---	Toc mudstone
081	N	300	20	N	L	45	N	---	---	---	L	---	---	Stream sediment
956	N	70	L	N	---	---	---	---	95	10	N	---	.08	Alt gd
958	700	50	L	N	---	---	---	---	700	90	N	---	.04	Do.
961	N	100	10	N	---	1	---	---	40	20	N	---	.06	Stream sediment
1025	N	150	30	N	---	4	---	---	100	30	N	---	.11	Do.
1033	N	150	5	N	---	4	---	---	65	15	N	---	N	Do.
1036	N	70	L	N	---	---	---	---	120	10	N	---	.02	Gd
1076	N	150	L	N	---	---	---	---	55	10	N	---	.02	Do.
1082	N	300	10	N	---	N	---	---	60	15	N	---	.10	Stream sediment
						R.--Cliff Creek Drainage								
034	N	150	5	N	10	1	1	---	---	---	L	---	---	Gd
045	N	100	5	N	L	1	L	---	---	---	.04	---	---	Stream sediment
049	N	150	5	N	10	1	1	---	---	---	L	---	---	Gd porp
053	N	150	7	N	10	2	1	---	---	---	L	---	---	Ark Toc ss
055	N	150	15	N	10	1	L	---	---	---	L	---	---	Stream sediment
058	N	150	5	N	L	17	1	---	---	---	L	---	---	Do.
059	N	200	10	N	L	3	L	---	---	---	L	---	---	Do.
065	N	150	7	N	10	1	2	---	---	---	L	---	---	Gd porp
067	N	200	10	N	L	2	2	---	---	---	L	---	---	Stream sediment
068	N	200	10	N	L	30	N	---	---	---	L	---	---	Do.
070	N	200	10	N	L	25	L	---	---	---	L	---	---	Do.
105	N	500	15	N	N	5	2	---	---	---	.20	---	---	
106	N	700	5	N	N	2	L	---	---	---	.04	---	---	Do.
107	N	700	5	N	N	9	1	---	---	---	L	---	---	Do.
108	N	700	10	N	N	1	1	---	---	---	L	---	---	Do.
109	N	200	15	N	N	3	L	---	---	---	L	---	---	Tw mottled siltstone
111	N	150	5	N	N	35	L	---	---	---	L	---	---	Gd porp
116	N	300	5	N	N	2	2	---	---	---	.08	---	---	Stream sediment
118	N	200	7	N	N	2	L	---	---	---	L	---	---	Do.
119	N	700	15	N	N	3	L	---	---	---	L	---	---	Do.

Sample	Ti[1] (.002)	B (10)	Ba (10)	Be (1)	Co (5)	Cr (10)	Cu (5)	La (20)	Mn (10)	Mo (5)	Pb (10)	Sc (5)	Sn (10)	Sr (100)	V (10)	Y (10)
Semiquantitative spectrographic analyses (SSA)																
R.--Cliff Creek Drainage--Continued																
264	.300	10	700	2	7	20	30	30	700	N	30	10	N	300	70	20
265	.300	10	1,500	3	7	20	30	50	700	N	20	10	N	300	70	30
354	.500	L	1,000	L	15	N	20	20	1,500	N	20	15	N	500	150	20
398	.500	L	1,500	1	15	10	30	20	1,500	N	15	15	N	500	200	30
431	>1.000	N	150	N	70	500	5	100	3,000	N	15	20	N	L	700	15
432	>1.000	N	300	N	30	200	5	70	3,000	N	15	30	N	N	500	70
433	>1.000	N	500	N	30	150	5	200	3,000	N	20	15	N	100	500	70
437	.300	10	700	L	N	10	5	30	30	N	10	5	N	100	70	30
572	>1.000	20	300	N	50	50	10	200	2,000	N	15	20	N	150	200	70
S.--Ruby-Anthracite, and Snowshoe Creeks Drainage																
313	.300	10	700	1	15	15	50	50	1,000	N	10	15	N	500	100	30
314	.200	20	300	2	5	30	30	50	500	5	50	5	N	300	70	20
315	.300	10	700	3	7	15	30	100	500	N	50	7	N	700	70	20
356	.300	L	1,000	L	7	50	30	50	2,000	N	50	10	N	1,000	100	30
468	.300	20	1,500	1	7	30	20	N	700	N	50	5	N	150	100	20
475	.300	10	700	N	5	30	10	30	500	10	15	10	N	300	100	15
533	.300	20	700	L	5	10	5	20	500	10	20	5	N	200	50	15
T.--Deep Creek, Sylvester Gulch, and Raven Creek Drainage																
1134	.300	20	700	1	10	20	10	100	700	N	20	5	N	200	50	20
1140	.500	20	1,000	1	10	15	10	100	700	N	15	7	N	200	70	30
1141	.500	20	700	1	10	15	10	50	700	N	15	7	N	200	70	20

Sample	SSA				Colorimetric		Atomic Absorption							Sample description[5]
	Zn (200)	Zr (10)	Ni (5)	Ag (0.5)	As (10)	CxHM[2] (1)	Sb (1)	Cu (5)	Zn (5)	Pb (5)	Au (.02)	eU[3] (30)	Hg[4] (.02)	
						R.--Cliff Creek Drainage--Continued								
264	N	150	7	N	N	40	1	---	---	---	L	---	---	Stream sediment
265	N	500	10	N	N	9	1	---	---	---	L	---	---	Do.
354	L	100	5	N	---	2	L	L	25	25	L	60	---	Do.
398	L	150	7	N	---	2	L	5	35	30	N	---	---	Do.
431	500	200	15	N	---	---	1	5	55	10	N	---	L	Pan concentrate
432	700	500	10	N	---	---	2	5	40	10	N	---	L	Do.
433	500	1,000	10	N	---	---	0	5	30	10	2.50	---	L	Do.
437	N	300	L	N	---	---	1	10	5	10	N	---	---	Silic Toc ss
572	N	300	10	N	---	2	---	10	35	10	N	---	.05	Stream sediment
						S.--Ruby-Anthracite, and Snowshoe Creeks Drainage								
313	N	100	10	N	N	20	L	---	---	---	L	---	---	Gd
314	N	150	10	N	N	5	L	---	---	---	L	---	---	Stream sediment
315	N	200	10	N	N	7	1	---	---	---	L	---	---	Do.
356	L	200	20	N	---	---	2	50	180	55	N	---	---	Vn in alt Tw
468	N	200	10	N	---	2	L	5	35	30	L	---	---	Stream sediment
475	N	200	L	N	---	1	---	5	35	5	N	L	---	Do.
533	N	100	7	N	---	1	---	5	25	10	N	L	---	Do.
						T.--Deep Creek, Sylvester Gulch, and Raven Creek Drainage								
1134	N	150	7	N	---	1	---	10	40	15	N	.02	---	Stream sediment
1140	N	300	7	N	---	1	---	5	30	10	N	.02	---	Do.
1141	N	700	5	N	---	1	---	5	35	10	.05	.02	---	Do.

The trace element occurrences of molybdenum in the study area do not indicate any surface concentration of economic interest, but do show an association with other metals in veins, fractures, and intrusive structures that suggest the possibility of valuable mineral deposits at depth.

Gold and silver

Figure 11 shows the location of 35 samples containing 0.02 ppm or more gold in rocks, stream sediments, panned concentrates, and one soil sample. Most of the stream-sediment samples show less than 1.0 ppm gold, and only one rock sample (392) showed as much as 3.5 ppm gold. Five stream-sediment samples with anomalous amounts of gold form a dispersion pattern in proximity to the margin of the Anthracite Range laccolith, and sample 392, and Bureau of Mines samples 16 and 17 are from steeply upturned sandstone adjacent to this laccolith. Stream-sediment sample 847, with anomalous gold, zinc, lead, and molybdenum, is from "Red" gulch draining the altered Sheep Mountain pluton. A soil sample on Sheep Mountain (K5) contained 0.05 ppm gold and 80 ppm tungsten. One rock sample (K12) from the Sheep Mountain pluton contained 0.06 ppm gold with anomalous silver, molybdenum, lead, barium, mercury, and arsenic. Gold was also detected ($<$0.02 ppm) in 225 out of a total of 786 stream-sediment samples.

Figure 12 shows the location of 72 samples containing anomalous amounts of silver. Fifty-seven are rock samples containing 0.3 to 35.7 ppm silver, 14 are panned-concentrate samples containing 0.3 to 200 ppm silver, and only one is a stream sediment. These silver values are widely scattered in intrusive bodies, fault zones, and altered sedimentary and volcanic rocks. Sixteen rock samples contain anomalous amounts of both silver and gold, and many with anomalous silver also contain anomalous concentrations of molybdenum, copper, lead, zinc, or other metals in various combinations. Twelve samples containing 0.3 to 6.9 ppm silver, and anomalous amounts of other metals, are of pyritized granodiorite of the Sheep Mountain pluton. According to Parker (1967) 0.5 to 0.7 ppm silver is about the normal abundance for silver in rocks of this type.

Copper

Figure 13 shows the location of 37 samples containing 70 ppm or more copper, determined by spectrographic analyses. No copper minerals were seen in the area, and only one rock sample contained as much as 100 ppm copper. Two panned-concentrate samples, K32 from Sheep Mountain, and K56 from the West Elk center area, contained 500 ppm copper. The copper anomalies generally occur in various combinations with anomalous amounts of other base and precious metals. Mines in the Ruby-Irwin district have produced some copper associated with lead, zinc, gold, and silver from bedded replacement deposits, faults, and veins in Cretaceous and Tertiary strata adjacent to Tertiary intrusive bodies. The study area has a very

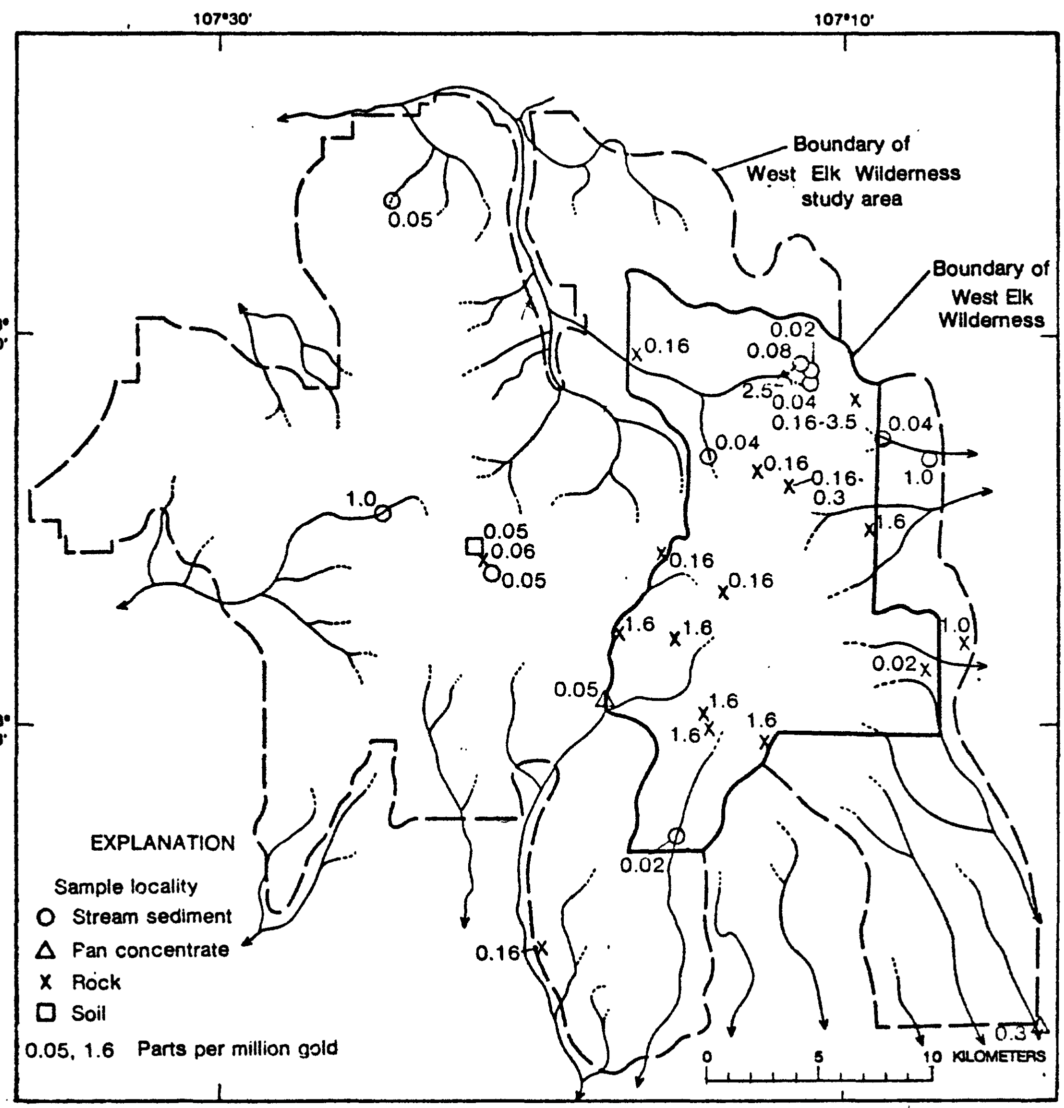

Figure 11.--Sample localities containing .02 ppm or more gold in the West Elk Wilderness study area.

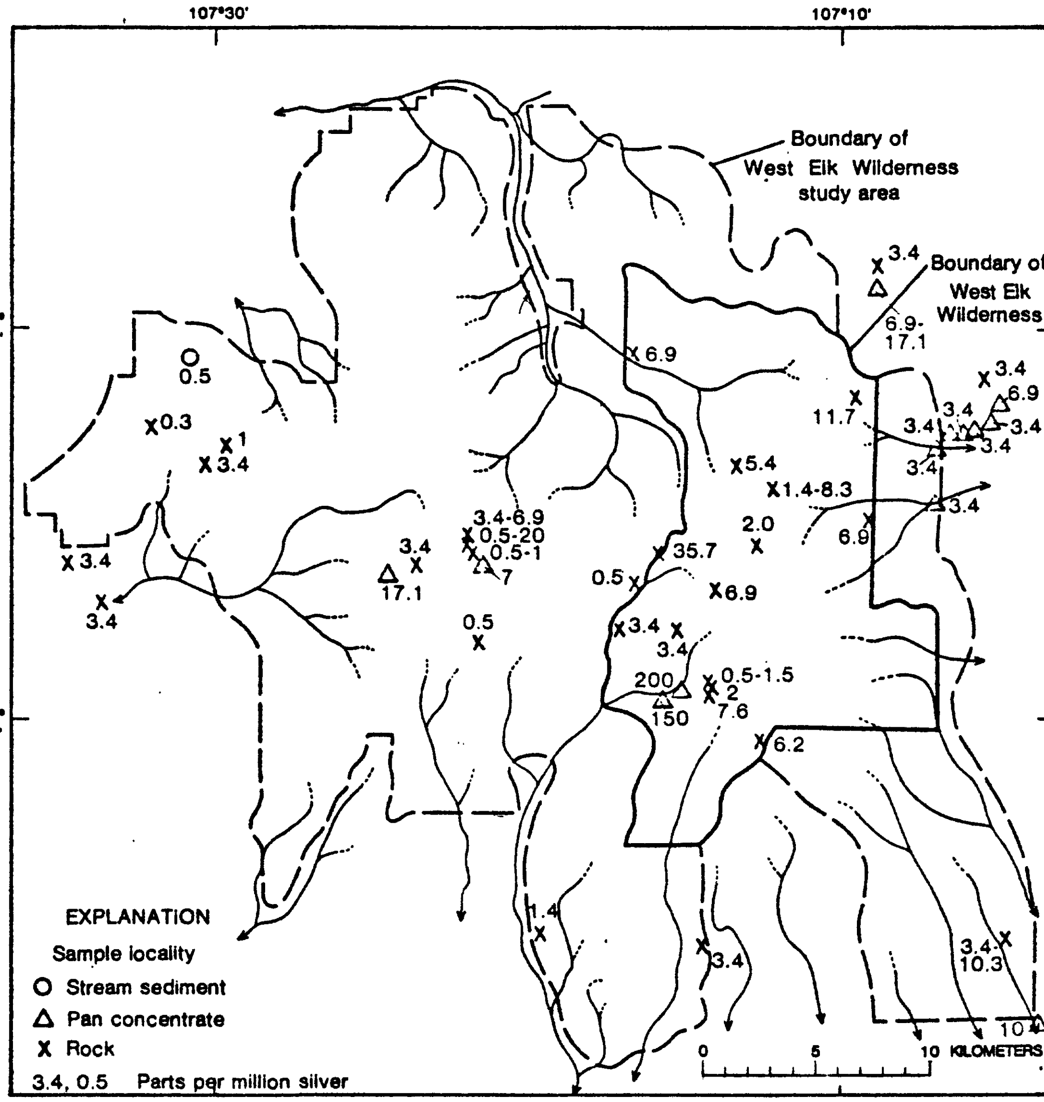

Figure 12.--Sample localities containing 0.3 ppm or more silver in or near the West Elk Wilderness study area.

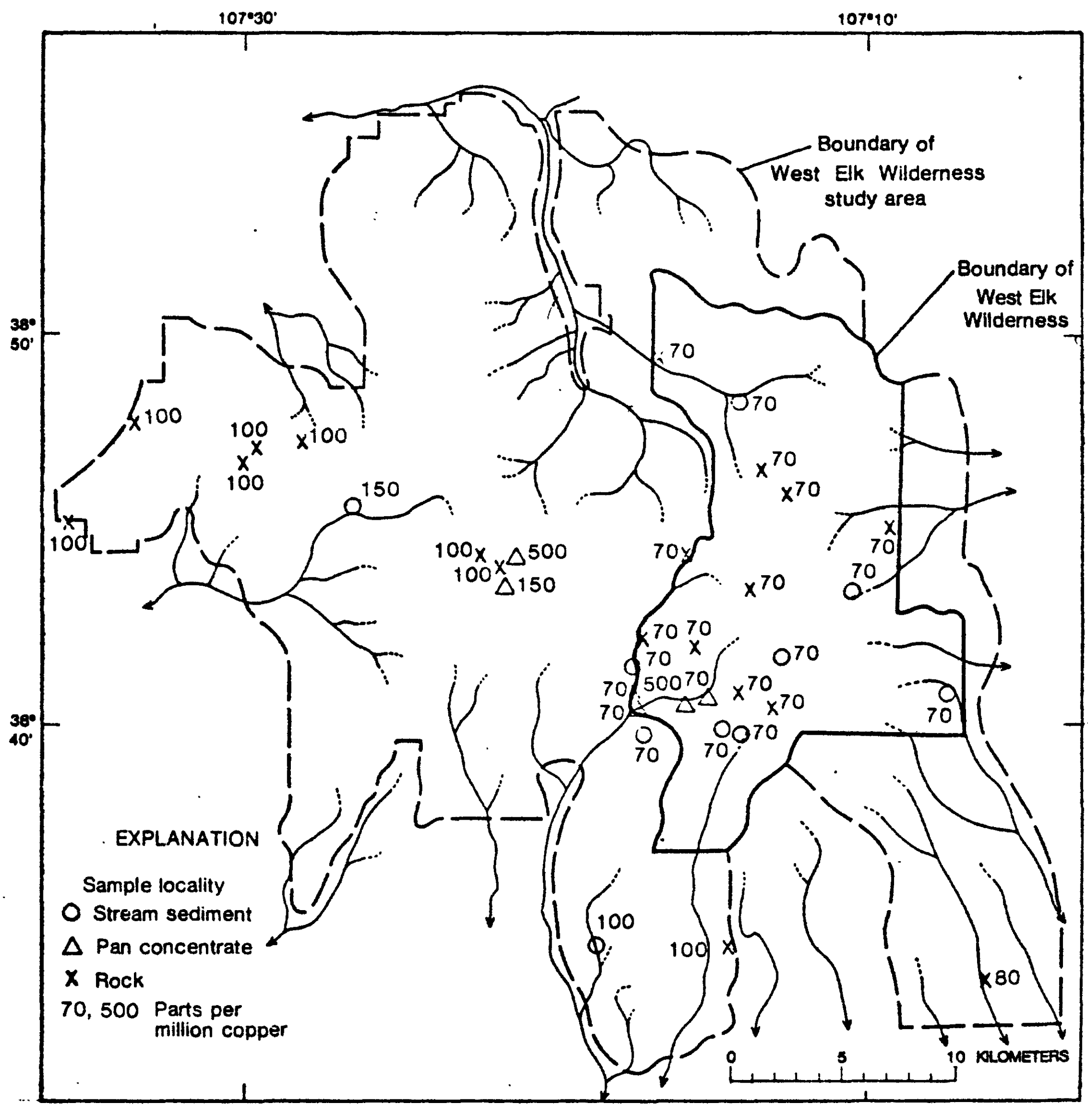

Figure 13.--Sample localities containing 70 ppm or more copper in the West Elk Wilderness study area.

low potential for deposits in which copper is the primary metal, but the association of copper with anomalous amounts of other metals suggests that copper may be present as a by-product in buried polysulfide deposits.

Zinc

Geochemical samples containing 200-10,000 ppm zinc are plotted on figure 14. They include 27 stream-sediment samples, 22 panned-concentrate samples, 12 rock samples, and 2 soil samples. All of the rock samples with anomalous amounts of zinc also contained anomalous amounts of other metals, chiefly lead and silver. Samples 903, 905, K9, and K11, of pyritized rock from Sheep Mountain, contained 400-700 ppm zinc. Two soil samples from Sheep Mountain (K4 and K29) showed 300-375 ppm zinc. Samples 422 (500 ppm zinc) and 958 (700 ppm zinc) are from pyritized sills. Sample 976 (300 ppm zinc) is from pyritized hornfels over the roof of the Coal Mountain pluton, and sample 856 (1,000 ppm zinc) is from fractured sandstone. Most of the samples with 500 ppm or more zinc are panned concentrates.

The broad dispersion pattern of anomalous zinc samples shown on figure 14 suggests that zinc is a very mobile element in this environment. Eight panned samples with high zinc values were reanalyzed with the magnetite fraction removed; none of these samples showed zinc, indicating that much or most of the zinc is in chemical combination with magnetite. No zinc minerals were observed in the study area. The anomalous zinc values appear to have been derived from weakly mineralized veins, fractures, and altered igneous rocks. Zinc, lead, and silver ores are the primary ones produced in the Ruby-Irwin mining district northeast of the study area, where they have been mined from faults and fracture zones in Cretaceous and Tertiary strata near altered and mineralized Tertiary stocks. The study area has a low to moderate potential for buried base and precious metal deposits that may contain recoverable amounts of zinc.

Lead

No lead minerals were seen in the study area. The background content of lead in samples from the area (table 4) appears to be normal for that of igneous rocks (Parker, 1967). Threshold values for lead in the study area appear to be about 70 to 90 ppm. Forty-seven samples that analyzed 90 ppm or more lead in rock samples, 100 ppm or more lead in stream-sediment samples, and 200 ppm or more lead in panned-concentrate samples are plotted on figure 15. Fifteen of these samples are from altered intrusive rocks that contain other anomalous metals. Seven samples are from pyritized rock of the Sheep Mountain pluton, and five samples are from altered or pyritized sills. Only rock sample K12 and three panned-concentrate samples contained as much as 1,000 ppm lead. Lead, like zinc, may be recoverable from buried base and precious metal deposits.

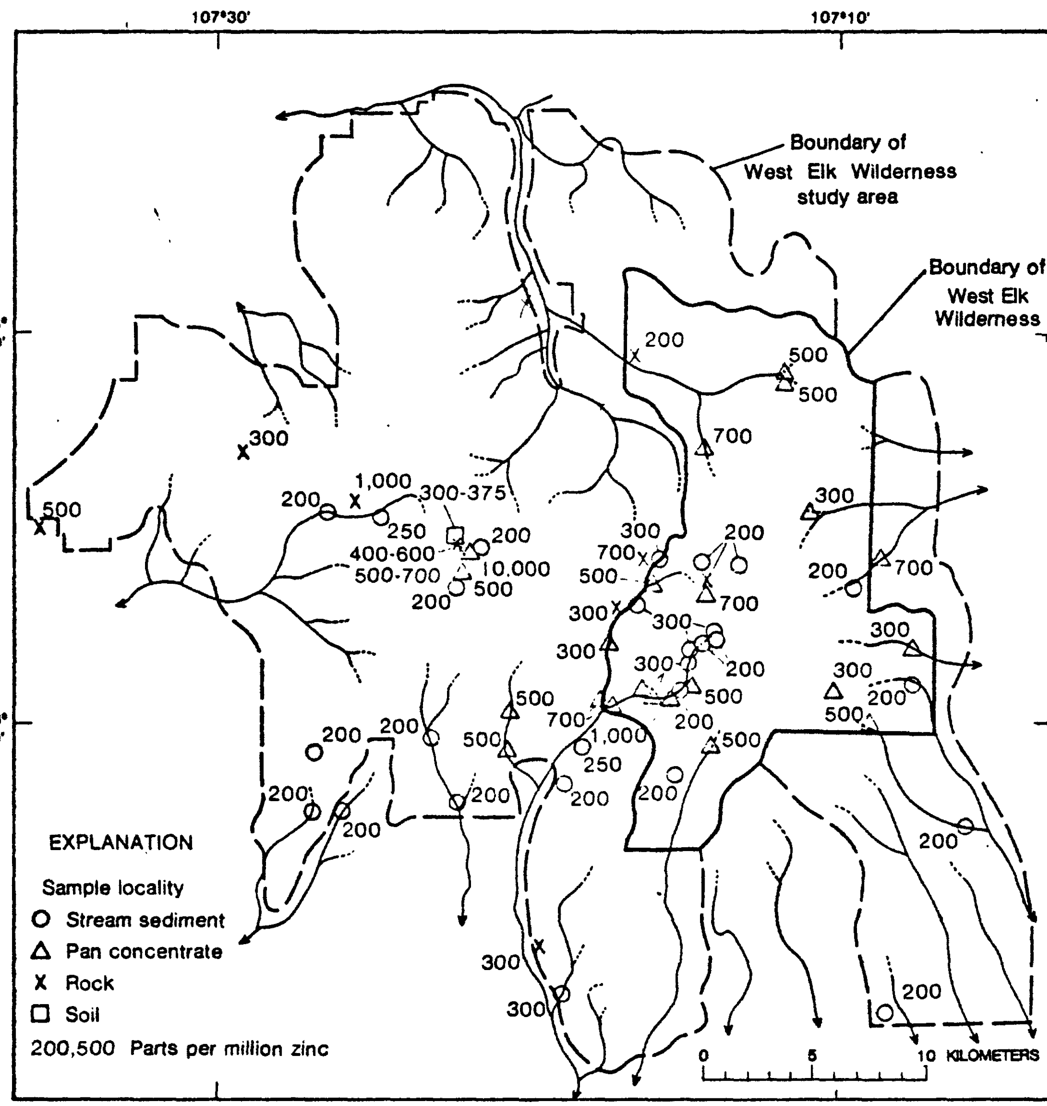

Figure 14.--Sample localities containing 200 ppm or more zinc in stream-sediment and rock samples, and 300 ppm or more zinc in pan-concentrate samples. West Elk Wilderness study area, Colorado.

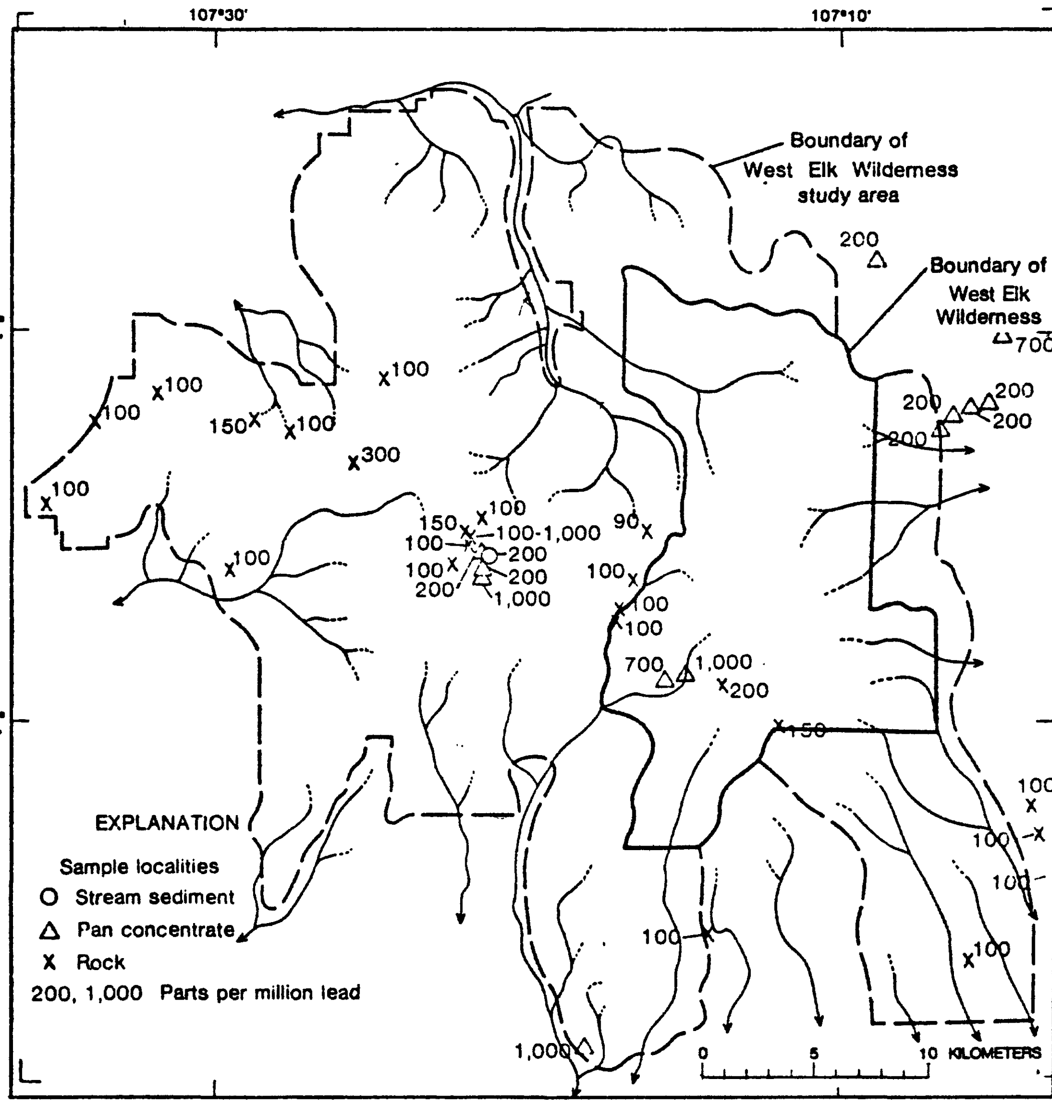

Figure 15.--Sample localities containing 90 ppm or more lead in rock samples, and 200 ppm or more lead in stream-sediment and pan-concentrate samples, in or near the West Elk Wilderness study area, Colorado.

Uranium and Vanadium

All of the geochemical samples were scanned for radioactivity, with negative results. Thirty-nine selected samples of altered or propylitized rocks from basal cone volcanics, and stream sediments were analyzed chemically for equivalent uranium. Twenty-three of these selected samples showed 30-60 ppm equivalent uranium. Five rock samples from solfataric zones in upper West Soap Creek Canyon show 40-60 ppm equivalent uranium. Reconnaissance sampling of some Cretaceous and Tertiary strata in the West Elk Mountains (Blatz, 1955) shows 2 to 20 ppm uranium in carbonaceous shale, sandstone, coal, and ground water.

Most of the uranium deposits of western Colorado are found in Jurassic sandstones, but some are in carbonaceous rocks and vein deposits. Extensive prospecting of Jurassic rocks for uranium in the neighboring Gunnison valley has not been very encouraging. Arkosic sandstones and conglomerates of Tertiary age in the West Elk Mountains locally contain carbonized organic material and small lenses of sulfide mineralization that may be of interest to uranium prospectors. The current data suggest little potential for economic deposits of uranium in the study area.

Figure 16 shows the location of 34 samples that appear to be anomalously high in vanadium. Most are panned concentrates, but several are from altered volcanic rocks of mineralized veins in volcanic rocks. According to Williamson (1958), Hawkes and Webb (1962), and Fischer (1964 and 1973), vanadium is commonly associated with manganese oxides and other metals in sedimentary rocks, particularly some black shales and coal; with titaniferous magnetite deposits; with some gold-quartz veins; with oxidized zones of base and precious metal deposits; and with uranium, lead, zinc, and copper in secondary deposits. Sample 909, and Bureau of Mines samples 42, 43, and 56 are from prospects in thin veins of manganese that show high values of vanadium. Some of these samples also contain anomalous amounts of silver, cobalt, nickel, and gold.

Favorable host rocks for vanadium and uranium (the Morrison Formation, Burro Canyon-Entrada Sandstone, and Dakota Sandstone) occur in subsurface, but are exposed only on Little Sand Mountain at the west edge of the study area. Possibly some of the shale and coal beds in the study area may contain appreciable values of these elements (Tourtelot, 1962; Landis, 1959). Vanadium is associated with titaniferous magnetite deposits in the Powderhorn thorium-rare-earth deposits some 20 mi (32 km) south of the study area. The minor vanadium mineralization at the El Ray and Sun Creek claims (p. 92 and 90) are apparently derived from primary metalliferous veins. The vanadium may in part have been remobilized by volcanic action from vanadate minerals in sedimentary strata underlying the volcanic rocks of the area. Koeberlen (1938) and Keller (1962) suggest that most of the vanadium and uranium have been leached from pyroclastic volcanic rocks. The generally low mobility of vanadium (Hawkes and Webb, 1962) and the relatively high concentration of vanadium in streams draining some of the volcanic and intrusive rocks

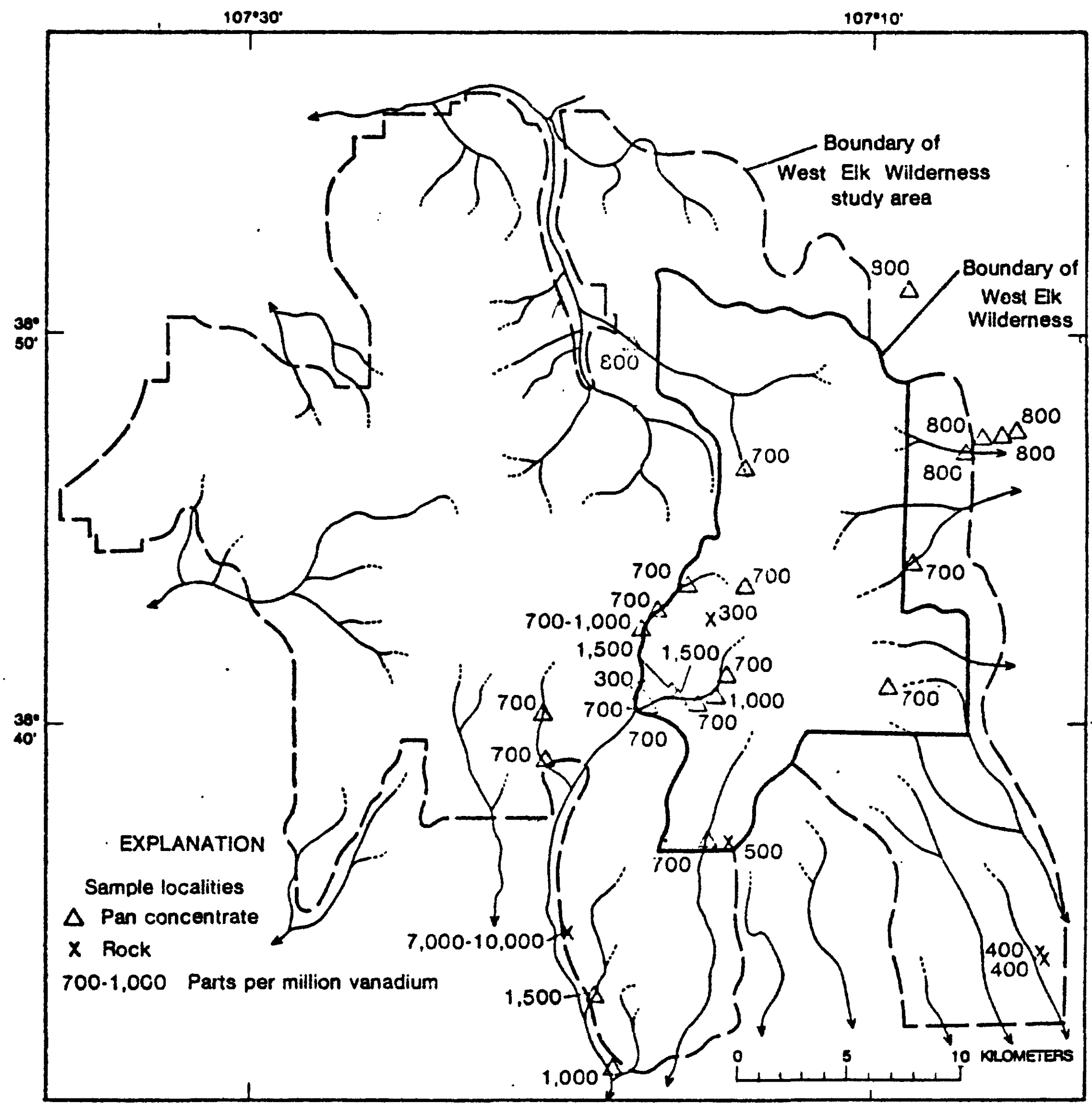

Figure 16.--Sample localities containing 300 ppm or more vanadium in rock samples, and 700 ppm or more vanadium in pan-concentrate samples, in or near the West Elk Wilderness study area, Colorado.

of the study area (particularly the West Elk volcanic center) suggest that vanadium is in part associated with volcanism.

Other metals

Probably none of the following metallic commodities are of economic interest in the study area, except as they may be useful as guides to mineral exploration.

Antimony was detected in only three samples, Bureau of Mines 16, 42, and 43 (150-3,000 ppm antimony), by spectrographic methods (table 3). Three-hundred eighty-eight samples were also chemically analyzed for antimony, but represent a run of unselected samples, most of which are from the West Elk Wilderness area. Most of these samples showed measurable amounts (0.5 ppm or more antimony), but only 10 of these samples showed 3 ppm or more antimony. According to Parker (1967) 3 ppm antimony is about 10-15 times the normal abundance of this metal in intermediate to felsic rocks. Antimony occurs in silver-bearing tetrahedrite in ores of the adjacent Ruby-Irwin mining district (Emmons and others, 1894).

Only nine samples showed more than 2,000 ppm barium, but several show a very high concentration (10,000-40,000 ppm) of barium. These are from manganese oxide veins along Sun Creek, and from panned-concentrate samples from streams draining both the Sheep Mountain pluton and the West Elk volcanic center.

Bismuth was detected in only three samples. Soil Samples (K1) from the top of Sheep Mountain showed 20-30 ppm bismuth and 20-120 ppm tungsten. A panned-concentrate sample (K51) from a tributary of West Elk Creek in the vicinity of the West Elk volcanic center contained 70 ppm bismuth and anomalous amounts of other metals.

Only 42 samples contained 70 ppm or more boron (table 2). Most of these are sediment samples from streams that drain extensive exposures of Mancos Shale. Most of the rock samples with anomalous boron (70-700 ppm) are from the Sheep Mountain area. Some of the boron may have been derived from organic-rich shale (Tourtelot, 1962), and rocks near volcanic vents (Boyle, 1971).

Most of the stream-sediment and panned-concentrate samples were analyzed chemically for cold-extractable or citrate-soluble heavy metals (cxHM). This technique measures only readily soluble metallic elements (mainly zinc, cobalt, copper, and lead, or the amount of these adsorbed on the surfaces of detrital grains in a sediment), but not the total content of these metals in a sample. Only 13 samples analyzed 20 ppm or more cxHM, and only three of these samples showed anomalous metals by other analytical methods.

Three rock samples, three stream-sediment samples, and 29 panned-concentrate samples showed 50 to 300 ppm cobalt (table 2). Two samples (909 and Bureau of Mines sample 56) showed 500 ppm cobalt and anomalously high values of other metals in thin veins of manganese oxide. Most of the samples that contain anomalous amounts of cobalt are from streams draining volcanic rocks, and nearly half of these samples are clustered in the vicinity of the West Elk volcanic center.

No fluorite was observed in the study area, and only five rock samples (1005, 1076, K4, K28, and K55) showed weakly anomalous amounts of fluorine (table 3, explanation and footnotes on table 5). Two of these samples are from altered intrusive rock on Sheep Mountain, and one is from altered basal cone facies near the base of the volcanic pile in the vicinity of the West Elk volcanic center. Most of the samples collected in the eastern part of the study area were not analyzed for this element.

More than half of the geochemical samples collected in the study area were analyzed chemically for mercury, and nearly all of these showed detectable or measurable mercury. Fourteen samples with 0.3-1.5 ppm mercury and other anomalous metal content are from Sheep Mountain.

Only seven samples were analyzed for sulfur. Six of these that contained 1,000-13,000 ppm sulfur are from solfataric zones in volcanic rocks in or near the West Soap Creek drainage basin, and one with 5,400 ppm sulfur is from pyritized rock from the Sheep Mountain pluton.

Tellurium (<0.5 ppm) was detected in three samples, but only 26 samples selected from widely scattered altered and mineralized rocks were analyzed for this metal (see footnotes, table 8).

Seventeen samples showed anomalous tin content between 3.3 and 300 ppm, and six samples showed detectable tin below the limit of analytical determination. Some of these samples represent mineralized rock from manganese prospects that contain anomalous amounts of other metals, and two samples that contained anomalous tin are from mineralized rock of the Sheep Mountain pluton. Tin has been mined in Colorado as a minor byproduct of molybdenum ore at Climax (King, 1964).

Tungsten was detected in only one sample (1038) by spectrographic analyses. Seventeen samples from the Sheep Mountain area, which were analyzed chemically, contained 20 to 120 ppm tungsten, and 9 samples from the area of the West Elk volcanic center showed 20 to 80 ppm tungsten (tables 6, 7). Tungsten is recovered as a byproduct of large-scale mining from the porphyry molybdenum orebody at Climax, Colorado (Hobbs, and Elliott, 1973).

Geochemical patterns

Anomalies of molybdenum, gold, silver, copper, lead, zinc, and other metals shown on figures 10 through 14 show similar distribution patterns. Metal anomalies are clustered on or around the Sheep Mountain pluton, and the vicinity of the West Elk volcanic center. Others appear

Table 6. Analyses of samples of rocks from the Sheep Mountain area and the West Elk volcanic hub area.

[Number following prefix K in sample numbers indicates location shown on plate 2. Numbers in parentheses indicate sensitivity limit of method used. L indicates that an undetermined amount of the element is present below the sensitivity limit; N indicates that the element was looked for but not found. Analysts: semiquantitative spectrographic analyses by J. M. Nisni; gold analyses by J. B. McHugh; mercury, tungsten, and zinc analyses by M. S. Erickson; arsenic and fluoride analyses by J. H. Turner.]

Sample	Semiquantitative spectrographic analyses[1/] (ppm)												
	Ti (20)	Zn (200)	Mn (10)	V (10)	Zr (10)	La (20)	Ni (5)	Cu (5)	Pb (10)	B (10)	Y (10)	Mo (5)	Co (5)
					Rocks from the Sheep Mountain area								
K1R	5,000	N	1,000	150	100	20	L	5	15	10	30	10	L
K2R	3,000	N	700	100	70	20	5	5	10	15	20	5	10
K3R	5,000	N	700	100	70	30	L	5	15	10	30	5	7
K4R	5,000	N	200	150	200	30	50	30	20	70	20	L	15
K5R	3,000	N	1,000	150	100	20	N	20	15	10	20	5	L
K6R1	3,000	N	300	100	150	20	L	20	15	100	15	7	L
K6R2	5,000	N	1,500	150	150	50	N	10	10	L	30	5	10
K7R	3,000	N	300	50	100	L	L	50	10	L	20	5	L
K8R	3,000	N	700	70	150	20	N	5	L	10	20	5	L
K9R	2,000	500	150	70	100	20	5	50	10	10	20	5	10
K10R1	2,000	N	700	50	100	30	N	5	10	L	20	5	L
K10R2	2,000	N	70	70	100	L	5	L	N	50	20	10	7
K11R	3,000	700	300	50	300	20	N	20	100	15	30	7	L
K12R[4/]	3,000	N	300	100	200	70	L	7	1,000	L	20	5	5
K13R	3,000	N	700	100	200	20	L	L	10	10	20	7	N
K14R	3,000	N	1,000	100	150	20	L	L	15	10	30	5	L
K15R	2,000	N	500	70	300	20	N	5	10	700	15	N	N
K16R	2,000	N	100	30	200	L	L	7	10	10	10	5	N
K17R	3,000	N	1,000	70	300	20	L	L	10	10	15	5	N
K18R	3,000	N	500	30	200	N	L	L	L	L	10	5	N
K19R	3,000	N	300	70	100	30	L	15	50	20	30	7	N
K20R	5,000	N	1,500	100	300	50	L	5	15	10	30	5	3
K21R	3,000	N	500	70	150	L	L	7	L	10	10	N	N
K22R	3,000	N	2,000	100	200	30	L	7	15	10	20	7	5
K23R	2,000	N	300	50	200	50	L	L	15	10	20	5	L
K24R	3,000	N	500	70	200	L	L	L	L	L	20	N	N
K25R	3,000	N	500	70	300	20	L	10	L	10	10	N	N
K26R	5,000	N	700	100	200	30	L	10	L	L	30	5	L
K27R	5,000	N	2,000	100	300	30	N	30	20	L	30	5	5
K28R	3,000	N	200	70	300	50	N	L	20	50	30	7	N
K29R	5,000	N	700	200	100	50	L	100	15	10	20	7	N
					Rocks from the West Elk volcanic center, hub area								
K34R	5,000	N	500	150	100	20	L	30	20	70	20	L	L
K35R	3,000	N	500	70	100	20	L	15	L	10	10	L	5
K36R	5,000	N	1,000	200	70	L	L	10	15	20	10	L	L
K37R	5,000	N	2,000	150	500	50	L	10	10	15	30	5	10
K38R	3,000	L	1,000	200	70	20	L	50	10	10	20	5	7
K39R	5,000	N	1,000	150	300	20	L	10	L	10	20	7	15
K40R	5,000	N	1,500	150	200	30	L	20	15	L	30	L	10
K41R	5,000	N	1,000	150	200	20	L	5	10	L	30	7	15
K42R	5,000	N	1,000	150	200	20	L	10	10	L	30	7	15
K43R	5,000	N	700	150	70	L	L	15	15	L	20	L	10
K44R	5,000	N	2,000	100	200	30	L	7	10	L	20	5	10
K45R	3,000	N	700	100	200	20	L	7	10	10	15	7	7
K46R	5,000	N	1,000	100	200	30	L	10	10	L	30	5	10
K47R	3,000	L	1,000	70	200	20	L	30	10	10	15	7	7
K48R	3,000	N	300	100	300	20	L	10	L	10	15	7	5
K49R	3,000	N	700	100	70	N	L	20	15	20	10	5	N
K50R1	2,000	N	700	70	200	20	L	7	15	L	15	7	L
K50R2	2,000	N	500	70	200	30	L	L	15	L	15	7	N
K52R	5,000	N	700	150	300	70	L	30	10	L	30	5	10
K53R1	5,000	N	1,500	200	150	20	L	20	L	L	30	L	10
K53R2	5,000	N	700	200	200	20	L	30	15	L	20	N	15
K54R	5,000	N	1,000	150	200	20	L	L	L	L	15	L	15
K55R	5,000	N	1,000	150	100	20	L	20	L	L	15	L	15
K57R1	5,000	L	1,000	150	150	L	L	20	30	L	15	7	10
K57R2	5,000	N	1,000	150	70	L	L	10	10	20	15	5	15

1/ Also looked for spectrographically, but not found except as noted were: As (200), Au (10), Bi (10), Cd (20), Sb (100), Sn (10), W (50). Fe, Mg, Ca, and Nb determined spectrographically but not included in table.

2/ Au detected chemically in all samples in table, but less than 0.05 ppm, except as noted.

Semiquantitative spectrographic analyses (ppm)						Chemical analyses [2] (ppm)					Sample description [3]
Be (1)	Sc (5)	Cr (10)	Ba (20)	Sr (100)	Ag (0.5)	Zn (5)	As (2)	Hg (0.02)	F (40)	W (20)	
Rocks from the Sheep Mountain area											
2	7	L	1,500	1,000	N	70	L	0.06	510	N	gd,po,alt,F
2	10	L	1,500	700	N	50	L	.02	500	N	do.
2	15	L	1,500	1,000	N	65	L	.02	540	20	do.
3	15	100	500	200	N	165	9	.08	940	N	km,shale,F
1.5	10	L	2,000	700	N	45	L	.02	640	N	gd,po,mod,alt,tr py,F
2	10	30	700	500	N	50	8	N	320	N	km,bx,alt,O.C.
1.5	15	N	1,000	700	N	110	L	.60	530	N	km,alt,w abun finely dissem
1.5	10	N	1,000	700	N	20	390	.25	200	N	gd,alt,w py, O.C.
1.5	10	L	1,500	700	N	55	L	.10	370	N	gd,alt,F
1	7	10	1,000	700	L	395	79	.60	370	N	gd,alt, w finely dissem py.
1.5	7	N	1,000	700	L	50	6	.50	370	N	gd,alt,w abun finely dissem py
2	10	10	700	N	L	10	17	.40	770	N	do.
1.5	10	N	1,000	500	0.7	310	L	.98	670	N	gd,alt,w dissem py,O.C.
1	10	L	2,000	1,000	3	65	13	.40	280	N	gd,alt,w abun dissem py
1.5	10	L	2,000	700	N	35	11	.02	290	N	gd,alt,F
2	10	L	3,000	1,000	N	30	57	.04	400	N	do.
1.5	7	L	1,500	500	N	25	64	1.0	300	N	km,alt,w py,O.C.
1	5	L	1,500	500	N	15	15	.02	150	N	km,alt,w py,F
1.5	7	L	1,000	700	N	15	6	.04	430	N	km,alt,O.C.
1.5	5	N	1,000	700	N	35	7	N	290	N	gd,alt,O.C.
2	10	L	1,000	500	N	15	4	.10	320	N	gd,alt,F
2	10	L	1,500	1,000	N	35	14	1.0	470	N	gd,alt,w abun finely dissem py
1	7	L	700	300	N	30	2	.08	350	N	gd,alt,w py,F
1.5	10	N	1,500	1,500	N	40	55	1.0	470	N	gd,alt,w abun finely dissem py
1	7	N	1,000	1,000	N	25	9	1.1	350	N	gd,alt,tr py,O.C.
1.5	7	N	1,000	700	N	65	47	.04	360	N	gd,alt,w py,O.C.
1	5	15	700	300	N	20	3	.02	290	N	gd,alt,w py and angular frag km,O.C.
1	10	10	1,000	1,000	N	40	20	1.5	360	N	gd,alt,w py,O.C.
1	10	N	1,000	700	N	85	800	1.0	440	N	gd,alt,O.C.
1	7	N	1,000	500	N	60	8	.02	880	N	do.
N	15	150	1,500	260	20	50	7	.02	350	N	km,bx,O.C.
Rocks from the West Elk volcanic center, hub area											
1	15	10	1,000	300	.7	55	L	N	360	L	int,ig,alt,vf dissem py,FeO st,F-str
1.5	7	L	700	500	L	100	5	N	400	L	int,ig,alt,FeO st,F-str
1.5	20	L	300	500	.7	130	L	N	850	L	int,ig,alt,tr py,F
1.5	15	L	1,000	1,000	N	100	L	L	630	L	int,ig,alt,tr py,F
1.5	15	L	700	500	1	130	8	N	760	L	int,ig,alt,sl FeO st,F
1.5	10	L	700	500	L	55	4	.04	550	80	int,ig,sl FeO st,F
1.5	15	L	700	700	1.5	60	L	L	520	L	int,ig,mod prop alt,sl tr py,F
1.5	15	L	700	1,000	N	100	8	.02	650	L	int,ig,sl tr py,FeO & MnO st,F
1.5	15	L	500	700	L	75	L	.02	720	L	int,ig,sl prop alt,FeO st,F
1.5	15	N	500	500	L	65	L	L	510	L	int,ig,FeO &MnO st,F
1.5	10	L	1,000	700	N	75	8	L	660	L	int,ig,mod alt,F
1.5	7	20	1,000	500	L	60	7	N	460	L	int,ig,alt,FeO st,F
1.5	10	L	1,000	700	1	60	5	L	530	L	int,ig,O.C.
1.5	7	L	700	500	N	85	3	N	460	L	int,ig,alt,F
1.5	7	L	700	700	N	35	7	.02	560	L	int,ig,alt,dissem py,F
1.5	7	10	500	300	1	55	8	N	620	L	int,ig,alt,dissem py & FeO,F
1.5	7	N	1,000	700	.5	45	12	N	260	L	int,ig,alt,abun dissem py,FeO st,O.C
1	7	N	1,000	500	N	30	11	N	290	20	int,ig,alt,FeO st
1.5	15	L	500	500	L	70	4	N	550	L	int,ig,alt,abun fine dissem py,FeO s
1.5	15	L	500	500	N	65	45	.06	370	L	int,ig,dissem py,FeO & MnO st
1.5	15	L	300	500	1	80	28	N	370	L	int,ig, dissem py, FeO st, F-str
1.5	15	L	500	500	N	75	L	N	690	L	int,ig,FeO st,F
1.5	15	L	700	500	N	75	L	N	960	L	int,ig,FeO & MnO st,F
1.5	10	L	500	500	L	95	10	N	460	L	int,ig,FeO st,F
1.5	15	10	500	500	N	55	L	N	350	L	int,ig,dissem FeO,F-str

[3] Abbreviations used in table:
gd, granodiorite; km, Cretaceous Mancos Shale; po, porphyritic;
bx, breccia; py, pyrite; ig, igneous; int, intermediate;
alt, altered or alteration; FeO, iron oxide; MnO, manganese oxide;
dissem, disseminated; st, stain; F, float; O.C., outcrop;
F-str, float from stream bed; tr, trace; sl, slight;
prop, propylitic; mod, moderate; w, with; abun, abundant;
vf, very fine

[4] 0.06 ppm Au.

Table 7. Analyses of samples of soils from the Sheep Mountain area and the West Elk volcanic center hub area.

[Numbers following prefix K in sample number indicates location shown on plate 2. Numbers in parentheses indicate sensitivity limit of method used. L indicates that an undetermined amount of the element is present below the sensitivity limit; N indicates that the element was looked for but not found. Analysts: semiquantitative spectrographic analyses by J. M. Nishi; gold analyses by J. B. McHugh; mercury, tungsten, and zinc analyses by M. S. Erickson; arsenic, and fluoride analyses by J. H. Turner.]

Sample	Semiquantitative spectrographic analyses 1/ (ppm) Ti (20)	Zn (200)	Mn (10)	V (10)	Zr (10)	La (20)	Ni (5)	Cu (5)	Pb (10)	B (10)	Y (10)	Mo (5)	Co (5)	Be (1)	Sc (5)	Cr (10)	Ba (20)	Sr (100)	Ag (0.5)	Chemical analyses 3/ (ppm) Zn (5)	As (2)	Hg (0.02)	F (40)	W (20)
Soils from the Sheep Mountain area																								
K151 2/, 4/, 5/	5,000	N	1,500	100	500	L	10	20	20	30	20	L	10	1.5	7	30	500	200	N	100	6	0.08	500	20
K152	5,000	N	1,000	70	500	L	5	15	15	20	15	L	5	1.5	7	20	500	200	N	135	9	.06	540	120
K251	7,000	N	700	100	500	20	20	30	15	50	20	L	10	1.5	7	50	500	100	N	125	4	.06	600	20
K252	3,000	N	500	100	500	20	10	20	15	50	15	L	7	1	7	50	300	L	N	135	2	.08	580	20
K351	7,000	N	500	150	500	30	20	30	20	50	20	5	7	1.5	10	70	500	100	N	140	2	.08	530	120
K352	7,000	N	500	150	500	20	20	30	20	50	20	5	10	1.5	10	70	500	100	N	95	3	.08	540	60
K451	5,000	N	500	70	500	L	10	20	15	30	15	N	5	1.5	7	50	300	L	N	375	2	.10	540	40
K452	5,000	N	500	100	500	L	15	20	15	50	20	L	7	1.5	7	70	500	100	N	90	3	.06	560	40
K551 6/	3,000	N	1,500	50	200	L	7	10	15	20	15	N	10	1.5	7	30	500	200	N	130	3	.06	620	120
K552	2,000	N	1,500	50	300	L	7	15	15	20	15	N	10	1.5	7	20	300	200	N	135	4	.04	610	80
K651	3,000	N	700	70	500	20	7	15	20	50	20	5	5	1	7	70	500	150	N	75	2	.08	380	20
K652	3,000	N	700	70	300	20	7	10	15	50	20	5	5	1.5	7	30	500	150	N	55	3	.02	400	20
K851	5,000	N	1,000	150	500	20	10	20	20	20	30	10	7	1.5	10	50	500	300	N	75	2	.02	530	N
K852	3,000	N	1,000	70	300	L	10	15	20	20	20	5	5	1.5	7	20	300	200	N	100	3	.02	540	N
K1352	5,000	N	700	70	300	20	5	20	20	30	20	L	L	1	7	50	300	300	L	85	2	.04	510	N
K1451	5,000	N	1,000	70	500	20	7	30	20	50	20	N	5	L	7	30	500	200	L	60	3	.10	380	N
K1551	5,000	N	700	50	200	L	7	20	15	30	20	L	5	1.5	7	30	300	150	L	120	3	.38	460	N
K1552	3,000	N	1,000	50	300	L	10	20	15	50	10	L	5	1	7	30	500	150	N	95	2	.08	510	N
K1651	10,000	N	1,000	100	300	L	10	20	15	50	15	L	5	1	7	50	500	300	N	85	2	.12	460	N
K1652	5,000	N	700	70	500	20	7	10	10	20	10	L	L	1	7	50	300	200	N	85	1	.06	440	N
K1751	3,000	N	700	50	500	L	7	10	15	30	10	N	L	1	5	30	500	200	N	100	2	.02	450	N
K1752	5,000	N	500	70	500	L	10	15	15	30	10	L	L	1.5	7	30	500	200	N	85	2	.02	480	N
K1851	3,000	N	300	50	300	L	5	7	15	30	10	L	L	1.5	7	20	500	300	N	60	2	.02	420	20
K1852	10,000	N	300	30	500	L	5	7	20	20	15	N	N	1	5	50	1,000	200	N	50	2	.02	450	N
K1951	5,000	N	500	100	500	30	7	15	30	30	10	L	L	1	7	50	700	200	N	45	5	.12	500	N
K1952	5,000	N	700	100	500	20	10	20	30	50	15	L	5	1	7	20	700	300	N	50	2	.08	500	N
K2051	5,000	N	700	70	300	L	7	15	20	20	10	N	L	1	7	50	500	200	N	95	2	.18	430	60
K2052	5,000	N	700	100	700	20	10	20	15	30	15	5	5	1.5	10	70	500	200	N	85	2	.10	390	60
K2151	2,000	N	300	30	200	N	L	7	L	10	10	N	N	L	5	10	500	100	N	55	2	.08	420	20
K2351	5,000	N	1,500	70	300	L	5	20	15	20	20	5	5	1.5	10	30	500	300	N	65	3	.02	580	N
K2352	2,000	N	1,500	50	150	N	L	15	15	15	15	5	L	L	7	20	500	200	N	55	3	.16	580	N
K2451	2,000	N	700	70	300	L	5	20	15	30	10	N	L	1.5	7	30	500	200	N	60	4	.12	470	N
K2452	3,000	N	500	70	300	30	5	20	10	30	15	L	L	1.5	7	30	700	300	N	40	4	.08	540	N
K2651	3,000	N	500	70	300	L	10	10	10	50	15	L	L	1	7	30	300	150	N	80	2	.08	500	N
K2652	5,000	N	500	70	200	20	10	10	15	30	20	5	L	1	10	50	300	200	N	75	1	.10	490	N
K2751	3,000	L	1,500	50	300	L	L	20	50	15	15	L	L	1.5	5	20	500	200	N	95	2	.04	720	N
K2752	3,000	L	2,000	50	300	L	L	20	30	15	15	N	L	1.5	7	20	500	200	N	110	3	.25	820	N
K2851	3,000	L	500	50	300	20	5	15	50	30	15	L	L	1	5	20	500	200	N	85	1	.04	660	N
K2852	5,000	N	500	70	500	30	7	15	70	50	20	5	L	1.5	5	20	700	200	L	65	1	.02	720	N
K2951	7,000	L	1,000	150	500	20	20	20	20	50	20	L	15	1.5	10	70	500	100	L	105	1	.02	510	N
K2952	7,000	300	700	150	500	20	20	20	20	50	20	L	15	2	10	70	500	100	L	110	1	.10	540	N
Soils from the West Elk volcanic center hub area																								
K3451	2,000	N	700	50	200	N	L	15	L	15	10	L	L	1	5	20	200	150	L	95	L	N	420	20
K3452	3,000	N	700	50	200	N	L	15	10	20	10	N	L	1	5	20	300	100	L	95	2	.02	450	20
K3552	3,000	N	1,500	100	200	L	7	20	15	20	15	L	5	1.5	7	30	500	200	L	95	2	N	560	20
K3752	5,000	N	1,000	100	500	L	15	20	10	20	15	5	10	1	7	70	500	150	L	100	2	N	470	20
K3852	5,000	N	700	100	300	L	10	20	15	20	15	5	15	1	10	30	300	200	L	85	2	.02	490	N
K3952	5,000	N	500	100	300	L	7	20	10	20	10	5	7	1	7	50	300	150	L	70	L	N	410	N
K4052	3,000	N	700	100	300	L	10	20	10	20	15	5	10	1	7	50	300	150	L	80	2	N	460	N
K4252	3,000	N	1,500	100	300	L	10	15	15	30	15	L	10	1.5	7	50	500	150	L	60	3	N	400	20
K4351	3,000	N	5,000	50	200	N	5	10	15	20	10	N	5	1	5	30	300	100	N	110	2	N	420	N
K4352	5,000	N	2,000	100	300	N	5	10	15	20	10	L	7	1.5	7	30	300	150	L	90	2	N	470	N
K4651	5,000	N	1,000	100	300	L	10	20	15	30	7	5	7	1.5	10	50	500	200	N	70	L	.02	510	N
K4652	7,000	N	1,500	70	500	N	5	30	15	20	5	L	5	1	L	50	300	100	N	60	L	N	450	20
K4951	3,000	N	2,000	70	300	N	7	15	10	20	7	L	5	1	10	30	500	150	N	90	2	N	570	N
K4952	5,000	N	1,500	100	200	N	7	20	10	20	5	5	5	1.5	7	30	500	200	N	80	3	N	730	N
K5052	3,000	N	2,000	100	300	N	7	20	10	20	7	L	7	1.5	7	30	500	200	N	70	2	N	440	N
K5252	7,000	N	1,000	150	300	20	10	20	10	15	10	5	15	1.5	15	50	500	500	N	60	L	N	470	N
K5351	2,000	N	2,000	70	100	N	7	20	15	20	7	L	L	1	7	30	300	150	L	125	2	N	410	N
K5352	3,000	N	2,000	150	150	L	10	20	10	30	7	L	10	1	10	50	500	200	L	120	2	N	490	N
K5451	3,000	N	1,500	30	150	N	5	20	10	20	7	N	L	L	5	30	300	150	N	80	2	N	360	20
K5452	5,000	N	1,500	100	500	N	7	20	10	30	7	N	5	1	10	50	500	150	N	60	3	N	370	N
K5651	3,000	N	500	20	300	N	L	7	L	15	5	N	L	L	5	15	200	100	N	50	3	N	330	N
K5652	3,000	N	500	70	300	N	5	20	15	20	7	L	5	L	5	50	300	150	N	55	2	.02	350	N

1/ Also looked for spectrographically, but not found except as noted were: As (200), Au (10), Bi (10), Cd (2), Sb (100), Sn (10), W (50). Fe, Mg, Ca, and Nb determined spectrographically but not included in table.

2/ Last digit in sample number identifies sample as follows: 1, upper soil sample from 0-1 in. (0-3 cm) depth; 2, lower soil sample from 1-4 in. (3-10 cm) depth.

3/ Au detected chemically in all samples in table but less than 0.05 ppm, except as noted.

4/ 30 ppm Bi.

5/ 20 ppm Bi.

6/ 0.05 ppm Au.

to be alined with, or related to, two broad linear patterns of anomalous samples that intersect at the West Elk volcanic center. One such pattern trends northeasterly from the El Ray claims along lower Soap Creek over the West Elk volcanic center and the Ruby Range fracture zone (fig. 8). The other pattern of anomalous samples trend northwesterly from the manganese deposits along Sun Creek, over the West Elk volcanic center, the Curecanti fault zone, the Sheep Mountain pluton and the vicinity of the Coal Mountain pluton. Most of these samples contain anomalous amounts of several metals, and most of them seem to be related to intrusive rocks, or to postulated vent areas in the volcanic rocks.

Mineralized areas of possible explorational interest

The relationship of anomalous metal values to geologic and inferred geophysical structures in the study area suggest a few target areas for mineral exploration (fig. 1).

Sheep Mountain area

The widespread hydrothermal alteration and the assemblage of disseminated trace metals in the Sheep Mountain pluton (fig. 1) suggest a possible buried ore deposit (see Chapter A, p. 16). The Sheep Mountain pluton is well exposed over a vertical distance of about 1,800 ft (549 m) along Red Gulch (fig. 7) on the eastern side of Sheep Mountain. The exposed part of the pluton is locally bleached, argillized, and contains abundant pyrite.

Samples collected from Sheep Mountain that contain anomalous amounts of one or more metals include 16 with 0.03 to 20 ppm silver, 3 with 0.05 to 0.06 ppm gold, 16 with 5 to 30 ppm molybdenum, 15 with 100 to 1,000 ppm lead, 12 with 300 to 10,000 ppm zinc, 17 with 20 to 120 ppm tungsten, 4 with 100 to 500 ppm copper, and others that contain generally weakly anomalous values of mercury, boron, tin, bismuth, arsenic, cobalt, fluorine, barium, chromium, and strontium. A stream-sediment sample (847) and a panned sample (k32) from Red Gulch showed generally high values of nearly all of these metals (tables 5 and 8). The mineral association in the Sheep Mountain area is similar to that in mineral deposits of the Ruby-Irwin mining district.

The geologic environment, alteration, and mineralization at Sheep Mountain suggest the possibility of an ore deposit at depth, perhaps within a vertical distance of several thousand feet under the exposed part of the Sheep Mountain pluton.

West Elk volcanic center

The dike swarm radiating from the hub of the West Elk volcanic center (pl. 1; fig. 1; and p. 16) indicates a buried stock. The volcanic center appears to be connected by dikes and a wide fracture zone with

Table 8.—Analyses of samples of panned concentrates from the Sheep Mountain area and the West Elk volcanic center hub area.

[Number following prefix K in sample numbers indicates location shown on plate 2. Numbers in parentheses indicate sensitivity limit of method used. The symbol > indicates that an undetermined amount of the element is present above the number shown; L indicates that an undetermined amount of the element is present below the sensitivity limit; N indicates that the element was looked for but not found. Semiquantitative spectrographic analyses by J. M. Nishi.]

Sample	Semiquantitative spectrographic analyses 1/ (ppm)																			(percent)			
	Zn (500)	Mn (20)	V (20)	Zr (20)	La (50)	Ni (10)	Cu (10)	Pb (20)	B (20)	Y (20)	Mo (10)	Co (10)	Be (2)	Sc (10)	Cr (20)	Ba (50)	Sr (200)	Ag (1)	Nb (50)	Fe (0.1)	Mg (0.05)	Ca (0.1)	Ti (0.005)
SHEEP MOUNTAIN AREA																							
Non-magnetic fraction																							
K30PCNM	N	1,500	L	>2,000	L	N	L	1,000	>5,000	>500	N	N	N	N	L	3,000	N	N	N	7	1	15	>2
K31PCNM	N	2,000	150	>2,000	300	N	L	200	L	>500	N	N	N	N	L	300	L	N	150	2	0.7	20	>2
K32PCNM 2/	10,000	200	30	>2,000	100	10	70	150	50	150	30	70	N	N	70	10,000	200	1.5	L	50	.1	2	1.5
Slightly magnetic fraction																							
K30PCM	500	1,500	150	700	2,000	100	150	100	100	100	15	30	3	30	20	200	N	N	N	30	1.5	1.5	.3
K31PCM	L	2,000	100	100	2,000	L	15	20	L	150	N	30	2	50	L	70	L	N	N	20	2	3	.5
K32PCM	2,000	3,000	100	100	1,000	L	500	200	20	100	L	20	N	20	20	700	500	7	N	30	1.5	1.5	.7
WEST ELK VOLCANIC CENTER HUB AREA																							
Non-magnetic fraction																							
K51PCNM 3/	N	1,000	70	>2,000	1,000	N	10	20	L	>500	L	L	N	20	50	10,000	1,000	N	N	3	.7	30	2
K52PCNM	500	1,000	50	>2,000	500	N	15	L	20	>500	L	L	N	20	50	1,000	500	N	N	2	.5	20	2
K53PCNM	N	1,000	50	>2,000	300	N	70	L	30	>500	L	300	N	20	30	1,500	300	N	L	15	.3	15	>2
K55PCNM	N	3,000	100	>2,000	1,000	N	L	1,000	L	>500	N	N	N	N	50	L	1,000	200	N	1	.5	30	1.5
K56PCNM	1,000	1,500	50	>2,000	500	N	500	700	L	>500	30	N	N	N	L	300	1,500	150	N	1.5	1.5	30	1.5
Slightly magnetic fraction																							
K51PCM	N	3,000	300	200	100	15	50	20	20	70	N	70	N	70	70	100	L	N	N	30	7	7	2
K52PCM	N	5,000	700	150	L	30	20	N	L	70	N	70	N	100	150	200	200	N	L	30	10	10	>2
K53PCM	N	3,000	300	150	200	10	30	20	30	100	N	50	N	30	50	150	500	N	L	20	5	7	2
K55PCM	N	3,000	1,000	200	150	20	30	L	L	70	N	70	N	50	70	200	200	N	N	30	7	7	>2
K56PCM	N	5,000	700	150	L	20	50	N	L	70	N	50	N	150	100	100	L	N	N	30	10	10	2

1/ Also looked for spectrographically, but not found except as noted were: As (200), Au (10), Bi (10), Cd (20), Sb (100), Sn (10), W (50).

2/ 100 ppm Cd.

3/ 70 ppm Bi.

mineralized stocks in the Ruby Range (fig. 8); and perhaps other mineralized areas, such as the Sheep Mountain pluton (see Geochemical patterns, p. 67).

Weakly anomalous trace elements (primarily molybdenum, silver, copper, zinc, gold, tungsten, and lead) in geochemical samples from this area may represent a leakage halo that reflects metal deposits at depth associated with a concealed stock. Such a postulated stock under the West Elk volcanic center may be an analogue of those exposed in the Ruby Range to the northeast. According to Sillitoe (1973), the tops of many porphyry stocks, and their associated ore deposits, are on the order of several kilometers beneath the summits of stratovolcanos. The West Elk volcanic center apparently represents the eroded remnant of such a volcano.

Sun Creek manganese deposits

Small deposits of manganese oxide were prospected in the late 1800's along the forks of Steuben Creek in the southwestern part of the study area (Penrose, 1890; see Sun Creek prospects, p. 90-92). These deposits occur in tuff breccias and tuffaceous conglomeratic sands of the West Elk Breccia, and in the overlying Sapinero Mesa or Fish Canyon(?) tuffs of Olson and others (1968). The manganese occurs as black, siliceous psilomelane (manganese oxide) in fractures, cavities, calcite veins, seams, nodules, and irregular replacement masses in the volcanic rocks (Harder, 1910; Muilenburg, 1919; and Jones, 1921). The main workings on Sun Creek seem to be alined along a perlitic dike and fault. According to Muilenburg, these deposits are found in many places in this locality, but their distribution is extremely irregular. The deposits occur beneath an ash-flow tuff, appear to decrease in size and purity with depth, and are thought by Muilenburg to be secondary concentrations leached from the overlying tuffs. They may, however, represent hydrothermal or hot spring deposits. Dorr and others (1973, p. 391-393) state that such volcanogenic or hypogene manganese deposits are characteristically small, and that there is little likelihood of finding significant hypogene oxide deposits at depths greater than 328 ft (100 m).

The following analyses from this area are given in Penrose (1890), and Muilenburg (1919):

Mn	36.60 - 34.30%
Si	35.32 - 36.97%
Fe	5.64 - 6.71%
S	.13%
P	0.1 - .06%
Manganese peroxide	- 52.30%

Chemical analyses of seven samples (BM42-49) from prospects in the Sun Creek area showed 12,900-277,000 ppm manganese associated with high values of antimony, tin, and barium, and anomalous amounts of molybdenum, silver, vanadium, and chromium. Manganese also occurs in thin veins containing up to 564,000 ppm manganese and anomalous amounts of molybdenum, zinc, silver, gold, vanadium, cobalt, and strontium in tuff breccias at the El Ray prospect (samples 909, and BM55-56).

Coal Mountain pluton and other mineralized areas

The occurrence of rock alteration, disseminated pyrite, and scattered anomalous values of molybdenum, zinc, copper, silver, and other metals, associated with a broad magnetic high that trends north-northwest across the granodiorite body of Coal Mountain (p. 26 and 97), suggest it may be a prospect for further exploration.

Other areas of possible mineral exploration interest might include the rhyolite bodies in Buck Hollow and Smooth Canyon; a possible volcanic vent area in West Soap Creek canyon; and perhaps the rhyodacitic "domes" and other vent areas in the West Elk volcanic field. Extensive exploration and drilling would be needed to determine the existence of blind ore deposits in these areas.

Nonmetallic commodities

Many coal beds occur in the northern part of the study area. Plate 1 shows the mapped and inferred extent of the coal-bearing Mesaverde Formation, coal workings, prospects, and the location of some coal exposures and inferred coal horizons. Much of the coal is deeply buried under laccolithic bodies (see cross sections, pl. 1), or is in structurally complex areas intruded by igneous rocks, or underlies areas of difficult access. Large reserves of coal in the area, however, are so situated as to be a present economic resource.

The coal resources and potential for oil, gas, and other nonmetallic commodities are discussed in Chapter D of this report.

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Chapter D

Mines, prospects, and mineralized areas of the West Elk Wilderness study area, Delta and Gunnison Counties, Colorado

By

Henry C. Meeves and Carl L. Bieniewski

U.S. Bureau of Mines

INTRODUCTION

In 1971, the U.S. Bureau of Mines made a mineral survey of the 61,400-acre (24,870 ha) West Elk Wilderness in the Gunnison National Forest of west-central Colorado. In 1973 and part of 1974, a mineral survey was made of an additional 215,700 acres (87,360 ha) adjacent to the Wilderness. The study area (pl. 1) of 277,100 acres (112,230 ha) in northwestern Gunnison and southeastern Delta Counties has been proposed for inclusion in the National Wilderness Preservation System. Rolling to rough mountainous terrain dominates the region, with altitudes ranging from 6,400 to 13,035 feet (1,952 to 3,976 m). The boundaries of the area are readily accessible by unpaved roads and Forest Service trails off U.S. Highway 50 and State Highways 92 and 135.

Previous Studies

Most of the literature on the geology and mineral resources of the study area deals with the coal resources in and adjacent to the area. Reference is made to such literature in the appropriate sections of this report.

In 1956, the U.S. Bureau of Mines made a reconnaissance of the mineral resources of the proposed Curecanti unit, which consists of a series of reservoir sites along the Gunnison River. One of the proposed sites, which has since become the Blue Mesa Reservoir (pl. 1), is just south of the study area. None of the mineral occurrences mentioned in the unpublished report are within three miles (4.8 km) of the West Elk Wilderness study area.

The Bureau of Mines made a similar study for a proposed reservoir site (pl. 1) in Big Soap Park. Part of this site is within the study area. According to the unpublished report, there are no valuable mineral occurrences within 3.5 miles (5.6 km) of the site, and the chances of a discovery in the vicinity are remote.

Present Investigation

The Bureau of Mines investigation of the West Elk Wilderness study area included a review of relevant literature; an examination of Bureau of Land Management land-status plats for patented mining claims and Federal mineral leases; an examination of State records for State mineral leases; a search for location notices of unpatented mineral claims recorded in Delta and Gunnison Counties; a field examination of known mining claims, mines, prospect workings, and mineral deposits; and a general reconnaissance of the area. The field work was facilitated by the assistance of R. G. Abbeloos, R. A. Beach, T. K. Matson, P. M. Mesard, F. E. Stufft, and R. C. Weisner. Travel was by four-wheel-drive vehicle, on horseback, on foot, and by limited use of a helicopter.

Acknowledgments

Assistance received from personnel of the U.S. Forest Service and the Delta and Gunnison County Clerk's Office was most helpful. Appreciation is expressed to the many local residents, coal company officials, and claim owners who contributed valuable information.

HISTORY AND PRODUCTION

Mineral activity in the West Elk Wilderness study area has been very limited. Because of its proximity to the Ruby and Elk Mountain mining districts, the study area undoubtedly received some attention from the early prospectors. Only coal prospectors found much of interest. No mineral production has been recorded from the West Elk Wilderness. Output from the study area outside the wilderness is limited to less than 1,000 tons (900 mt) of coal from the Mosley mine on the west side of Coal Creek in the center of section 10, T. 14 S., R. 89 W.

Mineral development in the surrounding region dates from 1872 when metalliferous deposits were discovered about five miles (8.1 km) northeast of the study-area boundary near the abandoned townsite of Irwin. Recorded production from this mining district through 1973 amounts to about $775,000 in gold, silver, copper, lead, and zinc; all but $135,000 was produced between 1876 and 1910.

Coal development east of the study area began in 1872 in the Baldwin area of the Crested Butte coal field in the northwest part of T. 15 S., R. 86 W. Anthracite coal was mined from the Floresta area in the Crested Butte coal field northeast of the study area from 1893 to 1910. Production in the Somerset coal field began in 1903. According to the reports of the Colorado State Inspector of Coal Mines (1891-1973), cumulative coal production from the general region of the study area through 1973 was about 32 million tons (29 million mt).

Coal production in 1973 near or adjacent to the study area came from the Bear, Hawksnest, Old King, and Somerset mines near Somerset in the Somerset coal field and from the Ohio Creek No. 2 mine near Baldwin in the Crested Butte coal field. The output in 1973 from the Somerset area was about one million tons (900,000 MT) and from the Baldwin area about 2,900 tons (2,600 mt). Most of the coal from the Somerset area was used to make coke for producing steel; the balance was used for electric-power generation, other industrial uses, and local domestic purposes. The output from the Baldwin area was used for local domestic purposes.

Considerable oil and gas leasing has taken place in and around the study area since 1922, and a number of holes have been drilled for oil or gas north, east, and west of the study area.

Current mineral activity in the study area is confined to drilling for coal. Since 1971, Atlantic Richfield Co. has been drilling for coal in the Lone Pine Gulch-Sylvester Gulch-Dry Fork Minnesota Creek area in the northwest part of the study area. The drilling program was to establish coal reserves and to outline an area for developing these reserves. The company expected to complete the drilling program by late 1974.

MINING CLAIMS

No patented mining claims are in the study area. Location notices for about 117 unpatented mining claims, on record in the Delta and Gunnison

County courthouses, describe the claims as being at places in or partly in the study area. The earliest record notices date back to 1902 and the most recent ones to 1969. Many claims probably have been located within the study area, but only those with descriptions adequate to plot are shown on plate 5.

SAMPLING AND ANALYTICAL METHODS

During the field investigation, 90 samples were taken. Most were chip samples; the others were either grab samples from dumps or panned concentrates of stream sediments. Eighty-eight samples were analyzed spectrographically and two samples of coal were analyzed. Of the 88 samples, 68 were fire assayed, and 13 were further analyzed by either chemical or atomic absorption methods. The analytical results are in table 9, except for two coal analyses shown in table 10.

AREAS OF DETAILED INVESTIGATION

During the field investigation, examinations were made at 33 localities. Figure 17 shows the relationship of the localities to the study area and lists the samples taken at each locality. Surface evidence of mineralized zones are surprisingly meager in the West Elk study area. Alteration of varying degrees has occurred along most of the contacts of Tertiary intrusives. Some prospect pits and trenches had been excavated in the zones of alteration. In the southeastern corner of the area, several prospect workings had been dug to explore calcite-manganese veins in tuff breccia. All known workings were sampled and numerous stream-sediment and outcrop samples (mostly in zones of alteration) were taken. Brief descriptions of the localities follow.

Ruby Anthracite Creek (Locality 1)

Locality 1 is about 1 mile (1.6 km) east of the study area in the northwestern part of T. 14 S., R. 87 W. Four samples were taken:

Sample number	Sample description
1	A 25-foot (7.6 m) random chip sample across a porphyritic hornblende diorite dike that intrudes the Wasatch Formation.
2	A 10-foot (3.1 m) random chip sample across a weakly altered zone near a quartz monzonite dike that intrudes the Wasatch Formation.
3	A panned-concentrate sample of stream sediment from Ruby Anthracite Creek.
4	A panned-concentrate sample of stream sediment from Bracken Creek.

Gold values ranged from nil to a trace of gold; silver values ranged from a trace to 0.5 ounce per ton.

TABLE 9. - Analyses of samples from the West Elk Wilderness and adjacent areas

[Samples were analyzed by the semiquantitative spectrographic method by either the U.S. Bureau of Mines Reno Metallurgy Research Center or the U.S. Geological Survey, Denver, Colo. Fire assaying, atomic absorption, and chemical analyses were done either by the Reno Metallurgy Research Center or C. O. Parker & Co., Denver, Colo. The numbers in parenthesis beneath the element symbols represent the estimated lower limit of detection for that element. Symbols used: †, additional data given by sample number in footnote at end of table; T.R.S. designates location of sample by township (T), north of the New Mexico Principal Meridian or south of the 6th Principal Meridian, range (R) west of both Meridians, and section (S); *, location approximate; -, looked for but not detected; T, trace amounts under Au and Ag; <, less than amount shown; >, greater than amount shown; M, major quantity (greater than 40,000 ppm for Mn and 7 percent for Fe); n.a., not analyzed for. The following elements were looked for but were not detected or were found in amounts normal for rocks of the type sampled, except as in footnote at end of table: Al, B, Ba, Be, Bi, Ca, Cd, Co, Cr, Ga, Hf, In, La, Mg, Mo, Na, Nb, Ni, P, Pt, Re, Sb, Sc, Si, Ta, Te, Tl, W, Y, and Zn.]

		Fire assay ounce per ton		Semiquantitative spectrographic analyses (ppm)					(percent)		
Sample	Location T. R. S.	Au	Ag	Cu (20)	Pb (100)	Mn (30)	V (60)	Zr (70)	Fe (.004)	Ti (.001)	Remarks
1	14-87- 5*	-	0.1	30	<100	20,000	<60	<100	4.0	0.2	Outcrop-chip-25 ft (7.6 m).
2	14-87- 5*	-	T	40	<100	20,000	<60	<100	5	.2	Outcrop-chip-10 ft (3.1 m).
3	14-87- 8*	T	.5	20	200	4,000	800	2,000	M	3	Stream-panned concentrate.
4	14-87- 8*	T	.2	20	200	4,000	800	2,000	M	2	Do.
5	14-87-22*	-	.1	40	<100	500	100	<100	4	.2	Pit-dump-grab.
6	14-87-22*	-	T	30	<100	500	100	<100	3	.1	Trench-dump-grab.
7	14-87-23*	T	-	20	700	1,000	100	1,000	.7	.8	Stream-panned concentrate.
8	14-87-26*	T	.2	20	100	4,000	400	1,000	M	2	Do.
9	14-87-34*	T	.1	30	200	4,000	800	2,000	M	3	Do.
10	14-87-34*	T	.1	30	200	4,000	800	2,000	M	3	Do.
11	14-87-33*	T	.1	30	200	4,000	800	2,000	M	3	Do.
12	14-87-33*	0.01	.1	20	200	4,000	800	2,000	M	3	Do.
13	15-87- 4*	T	T	20	100	4,000	400	300	M	3	Do.
14	15-87- 9*	T	.1	20	<100	4,000	400	300	M	3	Do.
15	15-88- 7*	.005	.20	70	<100	500	150	150	7	.5	Pit-dump-grab.
16†	14-87-30*	.005	.34	30	<100	300	150	150	M	.3	Pit-face-chip-9 in (23 cm).
17†	14-87-30*	.005	T	30	<100	300	<60	100	1.5	.3	Pit-face-chip-2 ft (61 cm).
18	14-89-13	T	-	40	100	4,000	800	2,000	M	3	Stream-panned concentrate.
19	14-88-19*	T	-	20	100	2,000	400	100	M	3	Do.
20	14-88-19*	.005	.20	70	<100	1,000	150	100	7	.3	Pit-combined grab and chip.
21	15-88-31*	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	See table 2 for coal analyses.
22	15-88-31*	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	See table 2 for coal analyses.
23	15-88- 3*	.005	.16	70	<100	1,500	100	150	7	.7	Pit-face-chip-3 ft (92 cm).
24†	15-88-11*	.005	.22	70	<100	5,000	200	200	7	.3	Outcrop-chip-6 ft (1.8 m).
25	15-88-11*	.005	.22	70	<100	700	100	150	3	.3	Adit-dump-grab.
26	15-88-11*	T	.24	30	<100	1,500	100	150	5	.5	Trench-dump-grab.
27	15-88-11*	.01	.08	70	<100	3,000	70	150	5	.5	Outcrop-chip-25 ft (7.6 m).
28†	15-88-21*	.005	.20	70	<100	300	200	150	5	.5	Outcrop-chip-2 ft (61 cm).
29	15-88-18*	.005	1.40	70	<100	5,000	<60	<100	1.5	.07	Do.
30	15-88-25*	.005	.10	70	<100	1,500	200	150	7	.7	Outcrop-chip-20 ft (6.1 m).
31	15-89-36	T	-	20	-	4,000	1,000	200	M	6	Stream-panned concentrate.
32	15-88-32*	.005	.10	70	<100	1,500	300	100	7	.5	Outcrop-chip-4 ft (1.2 m).
33	51- 3-18*	.005	.22	70	<100	1,500	70	150	3	.3	Outcrop-chip-40 ft (12.2 m)
34	51- 3-19*	.005	T	20	<100	1,500	70	150	5	.3	Outcrop-chip-6 ft (1.8 m).
35	51- 3-21*	.005	.18	50	<100	1,500	100	150	7	.7	Outcrop-chip-20 ft (6.1 m).
36†	15-86-36	n.a.	n.a.	20	<100	100	100	<100	2	.1	Pit-chip-15 ft (4.6 m).
37	51- 2- 3*	n.a.	n.a.	40	100	1,000	<60	300	2	.2	Outcrop-chip-15 ft (4.6 m).
38	50- 2-11*	n.a.	n.a.	40	100	2,000	60	300	5	.4	Pit-dump-grab.
39	50- 2-14*	n.a.	n.a.	40	400	2,000	60	300	5	.4	Outcrop-chip-10 ft (3.1 m).
40†	50- 2-35*	T	T	20	100	2,000	200	600	M	2	Stream-panned concentrate.
41	50- 2-35*	T	-	20	100	2,000	100	100	M	2	Do.
42†	50- 2-27*	T	.1	40	-	M	400	-	2	.1	Adit-dump-grab.
43†	50- 2-27*	-	.1	60	-	M	400	-	1	.01	"Orepile," 300 lb (136 kg)-grab.
44†	50- 2-27*	-	.3	40	-	30,000	60	100	4	.2	Adit-face-vein-chip-8 in (20 cm).
45†	50- 2-27*	-	.1	40	-	30,000	60	300	4	.4	Adit-roof-vein-chip-6 in (15 cm).
46†	50- 2-27*	.005	.3	40	-	30,000	60	300	4	.4	Adit-roof-vein-chip-4 in (10 cm).
47†	50- 2-27*	T	.2	<20	-	1,000	<60	<100	.1	.05	Drift-face-vein-chip-4 ft (1.2 m).
48†	50- 2-27*	.005	.3	40	-	30,000	60	200	3	.2	Drift-wall-vein-chip-1 ft (31 cm).
49†	50- 2-27*	-	.1	20	-	40,000	60	200	3	.2	Adit-roof-chip-6 ft (1.8 m).
50	49- 2- 3	.01	-	20	100	2,000	200	1,000	M	2	Stream-panned concentrate.
51	49- 2- 3	T	-	20	100	2,000	100	100	M	2	Do.
52†	50- 2-27*	n.a.	n.a.	80	100	2,000	60	200	4	.4	Pit-dump-grab.
53	50- 3-19*	-	.1	100	100	2,000	60	100	5	.4	Outcrop-chip-6 ft (1.8 m).
54	49- 4- 8	-	-	20	-	4,000	1,000	<100	M	6	Stream-panned concentrate.
55†	50- 4-20*	.005	T	30	<100	5,000	300	150	7	.7	Trench-wall-chip.

TABLE 9. - Analyses of samples from the West Elk Wilderness and adjacent areas--Continued

		Fire assay ounce per ton		Semiquantitative spectrographic analyses (ppm)					(percent)		
Sample	Location T. R. S.	Au	Ag	Cu (20)	Pb (100)	Mn (30)	V (60)	Zr (70)	Fe (.004)	Ti (.001)	Remarks
56†	50- 4-20*	0.005	0.04	15	-	<5,000	10,000	100	7	0.015	"Orepile," 500 lb (227 kg)-grab.
57	51- 4-31*	-	T	40	<100	2,000	100	<100	7	.4	Pit-chip-3 ft (92 cm).
58†	51- 4-19*	n.a.	n.a.	20	-	500	<60	300	3	.4	Outcrop-chip-15 ft (4.6 m).
59	51- 5-16*	n.a.	n.a.	20	-	1,000	<60	100	6	.4	Pit-dump-grab.
60	15-90-36*	-	-	30	<100	2,000	<60	<100	4	.4	Outcrop-chip-2 ft (61 cm).
61	15-90-34*	n.a.	n.a.	20	<100	1,000	<60	<100	2	.2	Pit-dump-grab.
62	15-90-25*	T	.5	40	100	5,000	<60	300	4	.2	Stream-panned concentrate.
63	15-90-25*	n.a.	n.a.	30	<100	2,000	<60	<100	5	.4	Outcrop-chip-15 ft (4.6 m).
64	15-90-24*	-	.1	<20	<100	1,000	<60	<100	1	.2	Outcrop-chip-10 ft (3.1 m).
65	15-90-24*	-	.1	30	<100	2,000	<60	<100	6	.4	Outcrop-chip-5 ft (1.5 m).
66	15-89-30	-	-	30	100	1,000	<60	<100	5	.4	Outcrop-chip-15 ft (4.6 m).
67	15-89-20	-	-	30	<100	1,000	<60	<100	2	.4	Outcrop-chip-10 ft (31 m).
68	15-89-20	-	-	40	100	500	<60	200	3	.2	Outcrop-chip-5 ft (1.5 m).
69†	15-89-20	-	.1	40	100	500	<60	300	4	.2	Do.
70	15-89-19	-	-	40	100	500	<60	200	4	.2	Do.
71	15-89-20	-	.1	20	100	1,000	<60	200	3	.2	Do.
72	15-89-19	-	.1	40	-	500	<60	200	4	.2	Do.
73	15-89-19	-	.2	100	100	2,000	<60	100	3	.2	Outcrop-chip-10 ft (3.1 m).
74	15-89-20	-	T	30	100	1,000	<60	<100	2	.2	Pit-dump-grab.
75	15-90- 2*	-	T	30	<100	1,000	100	<100	4	.2	Pits-dumps-grab.
76	14-90-26	-	-	20	100	2,000	<60	<100	4	.4	Pit-dump-grab.
77	14-90-10	n.a.	n.a.	40	-	500	<60	100	2	.2	Outcrop-grab-specimen.
78	14-90- 9	n.a.	n.a.	20	-	8,000	<60	200	3	.2	Do.
79	14-91-25	n.a.	n.a.	40	-	2,000	<60	200	4	.2	Pit-dump-grab.
80	14-90-33	n.a.	n.a.	100	100	2,000	60	200	5	.4	Do.
81	15-90- 6*	T	T	100	-	1,000	60	100	4	.2	Outcrop-chip-10 ft (3.1 m).
82	15-90- 6*	-	-	20	-	2,000	60	100	4	.2	Pit-face-chip-4 ft (1.2 m).
83	15-90- 6*	-	.1	100	-	2,000	60	200	5	.4	Pit-dump-grab.
84	15-90- 6*	n.a.	n.a.	40	-	1,000	60	300	5	.4	Do.
85	15-90-19*	n.a.	n.a.	40	100	1,000	<60	300	3	.2	Outcrop-chip-15 ft (4.6 m).
86	14-91-33	-	-	100	100	2,000	60	300	4	.4	Outcrop-chip-20 ft (6.1 m).
87	15-91-17	n.a.	n.a.	100	100	2,000	60	500	5	.4	Outcrop-chip-10 ft (3.1 m).
88	15-91-21	-	.1	20	-	100	<60	<100	1	.2	Outcrop-chip-20 ft (6.1 m).
89	15-91-27	-	.1	20	<100	2,100	100	<100	4	.05	Outcrop-chip-10 ft (3.1 m).
90	15-91-27	-	-	30	<100	2,000	100	<100	5	.1	Outcrop-chip- 1 ft (31 cm).

Sample 16 contained 0.012 percent U_3O_8, 0.043 percent As, 0.009 percent Sb, and 0.027 percent Mo.
Sample 17 contained 0.004 percent U_3O_8.
Sample 24 contained 100 ppm La, 70 ppm Y, 5 ppm Mo.
Sample 28 contained 150 ppm Cr, 50 ppm Ni, and 200 ppm Zn.
Sample 36 contained <0.001 percent U_3O_8.
Sample 40 contained 300 ppm Cr.
Sample 42 contained 40,000 ppm Ba, 27.7 percent Mn, 200 ppm Sn, 30 ppm Mo, 2,000 ppm Sb.
Sample 43 contained 20,000 ppm Ba, 43.2 percent Mn, 300 ppm Sn, 70 ppm Mo, 3,000 ppm Sb.
Sample 44 contained 3.42 percent Mn, 20 ppm Sn.
Sample 45 contained 4.42 percent Mn, 20 ppm Sn.
Sample 46 contained 2.12 percent Mn.
Sample 47 contained 1.29 percent Mn.
Sample 48 contained 8.41 percent Mn, 40 ppm Sn.
Sample 49 contained 4.93 percent Mn, 40 ppm Sn.
Sample 52 contained 200 ppm Cr.
Sample 55 contained 1.70 percent Mn, <0.002 percent U_3O_8, 0.041 percent V_2O_5.
Sample 56 contained 0.018 percent Mo, 56.46 percent Mn, 50 ppm Ni, <0.002 percent U_3O_8, 0.23 percent V_2O_5, 300 ppm Zn, 500 ppm Co, 70 ppm Y.
Sample 58 contained 0.94 percent S.
Sample 69 contained 0.54 percent S.

Table 10.--Analyses of coal samples 21 and 22
(U.S. Bureau of Mines Pittsburgh Energy Research Center)

Sample	Condition of sample 1/	Proximate, percent					Btu/lb 2/
		Moisture	Volatile matter	Fixed carbon	Ash	Sulfur	
21	A	15.2	22.4	21.8	40.6	0.4	4,990
	B		26.4	25.7	47.9	0.4	5,880
	C		50.7	49.3		0.9	11,280
22	A	19.9	30.1	30.1	19.9	0.7	6,940
	B		37.5	37.7	24.8	0.8	8,660
	C		49.9	50.1		1.1	11,520

1/ A, as received; B, moisture free; C, moisture and ash free.

2/ British thermal units per pound.

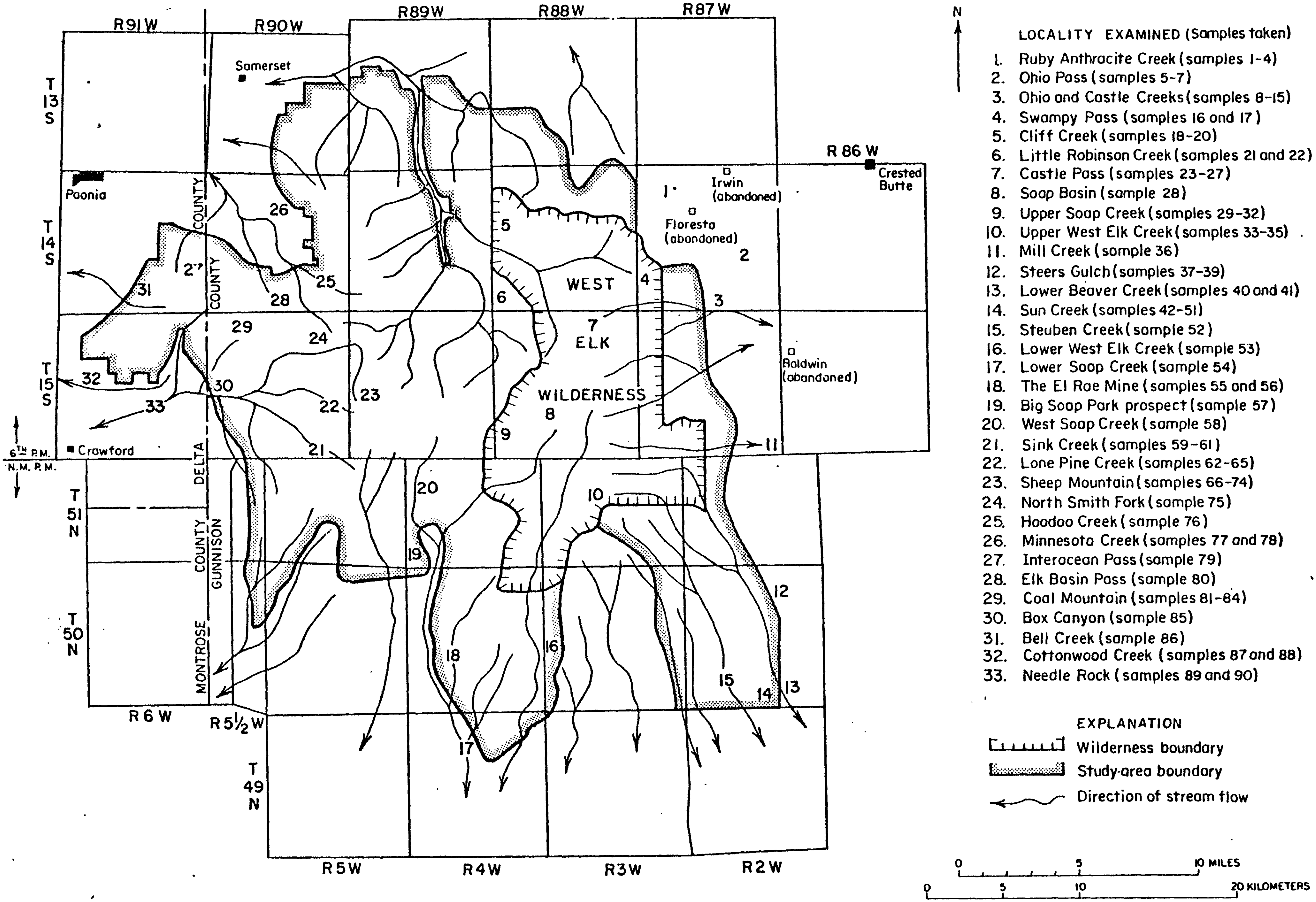
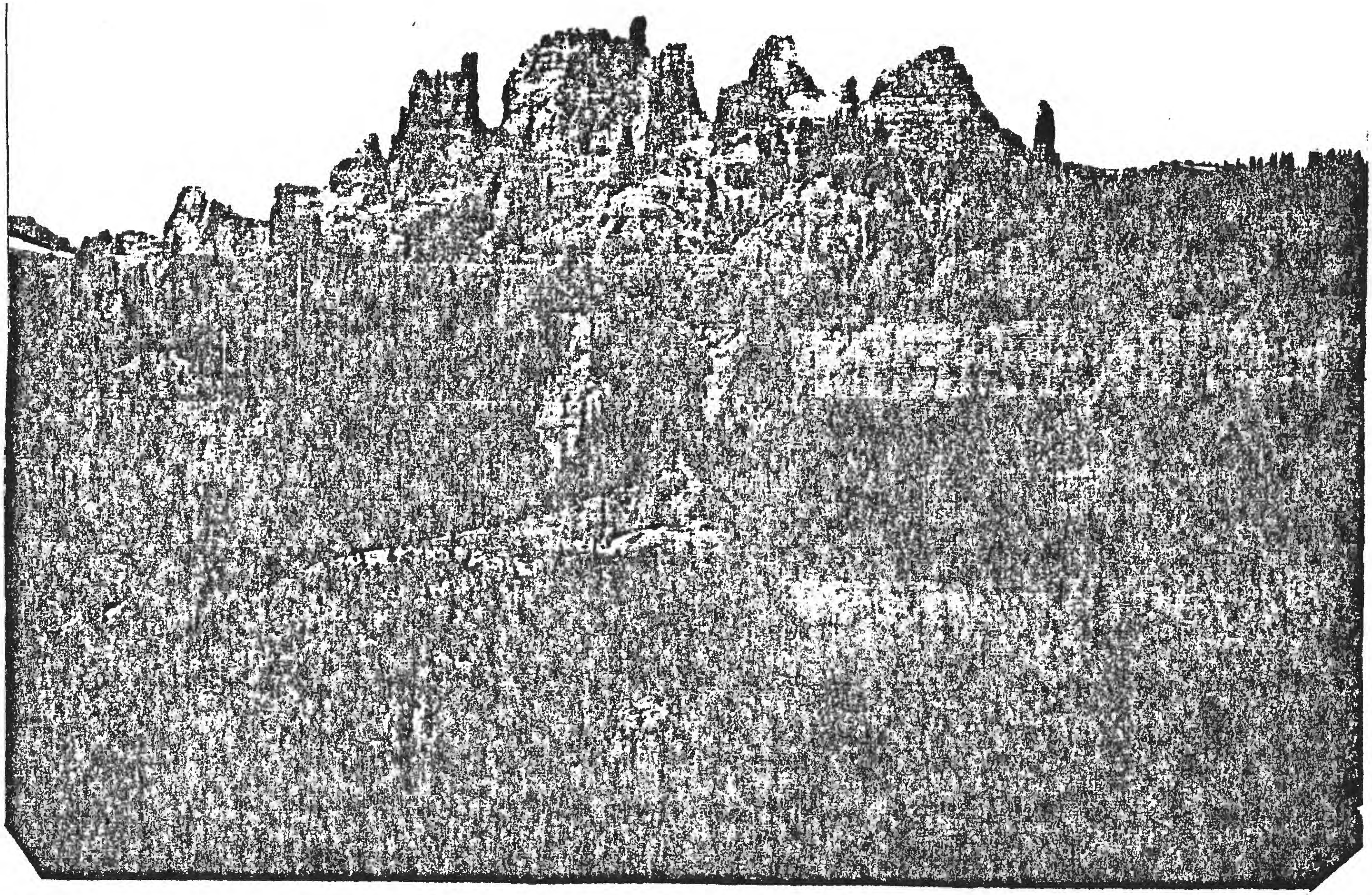


FIGURE 17. Map showing localities examined in and near the West Elk Wilderness study area.



Frontispiece. The Castles, erosional remnants of the West Elk Breccia forming a conspicuous promontory along the northeast edge of the West Elk volcanic field. Cliff at base is composed of varicolored, pervasively altered and silicified, chaotic basal cone vent facies cut by feeder dikes. Overlying light-colored rocks include friable, epiclastic sandstones interbedded with pumiceous lapilli tuff and ash beds, lenses of conglomerate, and a few thin lava flows. The Castles are composed of layered crystal-tuff breccias. View west from small lakes in South Castle Creek valley. Photo by Willis T. Lee (1912, plate 12B) from a glass plate negative.

Ohio Pass (Locality 2)

Locality 2 is approximately 2 miles (3.2 km) east of the study area in the east central part of T. 14 S., R. 87 W. Some weak alteration occurs in the Ohio Creek Formation a short distance from a granodiorite porphyry intrusive. Three samples were taken:

Sample number	Sample description
5	A grab sample of conglomerate from the dump of a small prospect pit in the Ohio Creek Formation.
6	A grab sample from the dump of a caved adit and an 80-foot (24 m)-long trench in the Ohio Creek Formation. The material sampled was the same as that of sample 5.
7	A panned-concentrate sample of stream sediment from Ohio Creek.

Except for sample 5 that contained 0.1 ounce of silver per ton, all other gold and silver assay values were either nil or traces.

Ohio and Castle Creeks (Locality 3)

Locality 3 extends from just within the study area to as much as 1.5 miles (2.4 km) east of the area boundary. The locality is in the south-central part of T. 14 S., R. 87 W. Three samples were taken:

Sample number	Sample description
13	Panned-concentrate samples of stream sediment from tributaries of Ohio Creek. Samples 8-11 are up to 1.5 miles (2.4 km) east of the study area; sample 12 and 13 are just within it.
14	A panned-concentrate sample of stream sediment from Castle Creek just within the study area.
15	A grab sample from the dump of a small prospect pit that was sunk on a latite (?) dike just inside the wilderness.

Assay values ranged from a trace to 0.01 ounce gold per ton and from a trace to 0.2 ounce silver per ton.

Swampy Pass (Locality 4)

Locality 4 is in the northeastern corner of the wilderness in the southwestern part of T. 14 S., R. 87 W. Two samples were taken from the two largest of six prospect workings:

Sample number	Sample description
16	A chip sample across a 9-inch (23 cm) limonitic and carbonaceous sandstone exposed in a 35-foot (10.7 m)-long trench.
17	A 2-foot (61 cm) chip sample of a greenish-gray graywacke.

Sample 16 contained 0.012 percent U_3O_8, 0.34 ounce silver per ton, 0.043 percent arsenic, 0.027 percent molybdenum, and 0.009 percent antimony. Sample 17 contained 0.004 percent U_3O_8.

Cliff Creek (Locality 5)

Locality 5 is on the boundary of the wilderness in the west-central portion of T. 14 S., R. 87 W. Three samples were taken:

Sample number	Sample description
18	A panned-concentrate sample of stream sediment from Cliff Creek 1 mile (1.6 km) below the wilderness boundary.
19	Panned-concentrate sample of stream sediment from Cliff Creek about 1 mile (1.6 km) below the site of sample 18.
20	A 5-foot (1.5 m) chip sample across altered granodiorite porphyry that has intruded the Mesaverde Formation exposed in the face of a prospect pit just within the wilderness combined with a grab sample from the dump.

Assay values ranged from a trace to 0.005 ounce gold per ton and from nil to 0.20 ounce silver per ton.

Little Robinson Creek (Locality 6)

Locality 6 is in the study area in the southwest corner of T. 14 S., R. 88 W. Several coal prospects are reported to be in the Little Robinson Creek area (Lee, 1912, p. 117-139). An outcrop showing some coal was examined near the top of the south-facing slope of the ridge between Little Robinson Creek and a tributary to Robinson Creek in the southwest corner of T. 14 S., R. 88 W. The showing is outside the wilderness but within the study area. The outcrop, in descending order, exposes: 10 inches (25 cm) of shaly coal; 12 feet (3.7 m) of interbedded sandstone and shale; 2 feet (0.6 m) of coal; 6 inches (15 cm) of limonitic, carbonaceous shale; 18 inches (46 cm) of coal; and 15 inches (38 cm) of carbonaceous shale. The beds, which trend N. 42° W. and dip 12° NE., crop out along the ridge for approximately one-quarter mile (403 m). Samples 21 and 22 were taken from the coalbeds. Sample 21 is a 6-inch (15 cm) channel cut across the upper coalbed. Sample 22 was a similar sample taken from the lower coalbed. Table 2 shows the analyses of the two samples. It should be noted that samples 21 and 22 are from weathered outcrops that probably are of lower quality than the unweathered parts of the coalbeds.

Castle Pass (Locality 7)

Locality 7 is in the wilderness in the north-central part of T. 15 S., R. 88 W. Five samples were taken:

Sample number	Sample description
23	A 3-foot (92 cm) chip sample across altered granodiorite porphyry exposed in a prospect pit.
24	A 6-foot (1.8 m) chip sample across altered, silicified shale above the portal of a caved adit bearing N. 60° W.; adit is about 2 miles (3.2 km) east of the site of sample 23.
25	A grab sample from the dump of the caved adit. Size of dump indicates adit to be about 45 feet (13.7 m) in length.
26	A grab sample from the dump of a trench in granodiorite porphyry northeast of the site of samples 24 and 25.
27	A 25-foot (7.6 m) random chip sample of silicified shale (Wasatch Formation) and a red conglomerate (Wasatch Formation) near the site of samples 24 and 25.

Assay values ranged from a trace to 0.01 ounce gold per ton and from 0.08 to 0.24 ounce silver per ton.

Soap Basin (Locality 8)

Locality 8 is in the wilderness in the south-central part of T. 15 S., R. 88 W. A 2-foot (61 cm) chip sample (28) was taken of carbonaceous Mancos Shale trending N. 10° E. and dipping 33° NW. The sample assayed 0.005 ounce gold and 0.10 ounce silver per ton.

Upper Soap Creek (Locality 9)

Locality 9 is on the west boundary of the wilderness in the southwest corner of T. 15 S., R. 88 W. Four samples were taken:

Sample number	Sample description
29	A chip sample across an extremely altered 2-foot (61 cm) section containing limonite in the middle of 20 feet (6.1 m) of limy Mancos Shale. The sample was taken 5 feet (1.5 m) south of a nearly vertical fault between shale and West Elk Breccia.
30	A 20-foot (6.1 m) random chip sample of an iron-stained zone along the southwestern contact of a 12-foot (3.7 m) diorite porphyry dike and West Elk Breccia.
31	A panned-concentrate sample of stream sediment from Coffeepot Creek.
32	A 4-foot (1.2 m) random chip sample of an iron-stained altered zone in West Elk Breccia along the southwestern contact of a 25-foot (7.6 m) hornblende diorite porphyry dike and the breccia.

Sample 29 assayed 1.40 ounce silver per ton; other assay results were negligible.

Upper West Elk Creek (Locality 10)

Locality 10 is in the wilderness near the center of T. 51 N., R. 3 W. Three samples were taken:

Sample number	Sample description
33	A random chip sample across a 40-foot (12.2 m) exposure of slightly altered diorite porphyry trending S. 79° W. with a nearly vertical dip in West Elk Breccia.
34	A 6-foot (1.8 m) chip sample across an aplite dike trending N. 10° W. and dipping 32° SW. The dike parallels on the west an 8-foot (2.4 m) basaltic dike that in turn, parallels on the west a 30-foot (9.2 m) hornblende diorite porphyry dike; the series intrudes altered Mancos Shale. The sample is about 1 mile (1.6 km) south of the site of sample 33.

35	A 20-foot (6.1 m) random chip sample across a hornblende diorite dike trending N. 27° E. with a near vertical dip in West Elk Breccia. The sample is about 2 miles (3.2 km) east of the site of sample 34.

All the samples assayed 0.005 ounce gold per ton; silver values ranged from a trace to 0.22 ounce per ton.

Mill Creek (Locality 11)

Locality 11 is 2 miles (3.2 km) east of the study area in the southeast corner of T. 15 S., R. 87 W. A 15-foot (4.6 m) random chip sample (36) was taken in the west wall of a prospect pit in a sandstone member of the Mesaverde Formation; no anomalous values were detected by the spectrographic analysis of the sample.

Steers Gulch (Locality 12)

Locality 12 is adjacent to the east boundary of the study area in the north-central portion of T. 50 N., R. 2 W. Three samples were taken:

Sample number	Sample description
37	A 15-foot (4.6 m) random chip of welded tuff.
38	A grab sample of welded tuff from the dump of a prospect pit.
39	A 10-foot (3 m) random chip of welded tuff.

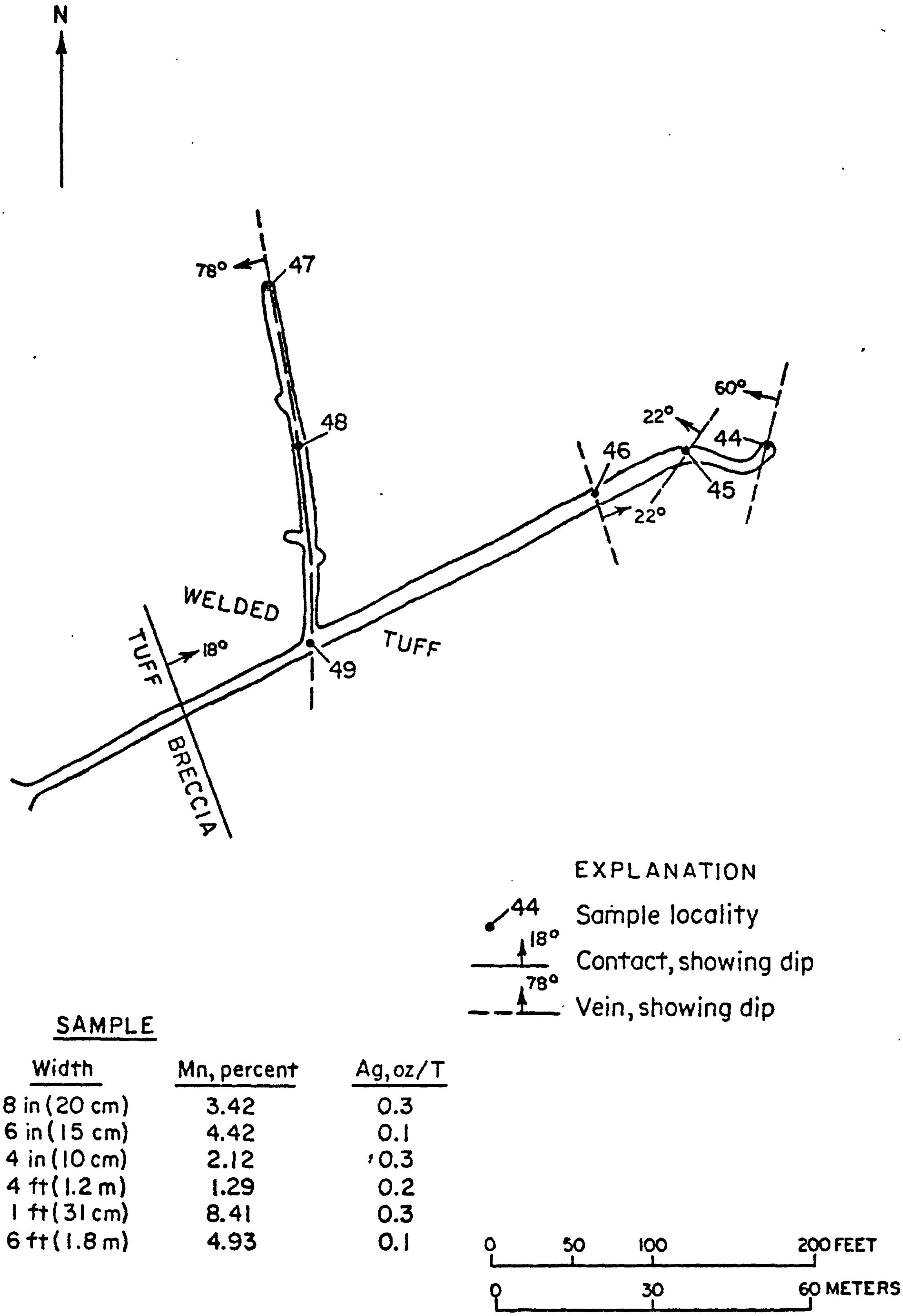
Spectrographic analyses of the samples revealed no anomalous values.

Lower Beaver Creek (Locality 13)

Locality 13 is near the southeast corner of the study area in the southeastern part of T. 50 N., R. 2 W. Two panned-concentrate samples (40 and 41) of stream sediment from Beaver Creek were taken. Traces of gold and silver were the highest assay values.

Sun Creek (Locality 14)

Locality 14 is at the southeast corner of the study area in the south-central part of T. 50 N., R. 2 W. Several prospect workings, including the Sun Creek adit (fig. 18), on the east side of Sun Creek explore calcite-manganese veins that trend northerly in a tuff breccia at the base of a welded tuff. On the west side, the veins parallel a 15-foot (4.6 m) perlite dike; the veins and dike are in a fault zone. Ten samples were taken, including panned concentrate, two and three miles south of the prospect workings.



SAMPLE

No.	Width	Mn, percent	Ag, oz/T
44	8 in (20 cm)	3.42	0.3
45	6 in (15 cm)	4.42	0.1
46	4 in (10 cm)	2.12	0.3
47	4 ft (1.2 m)	1.29	0.2
48	1 ft (31 cm)	8.41	0.3
49	6 ft (1.8 m)	4.93	0.1

FIGURE 18.–Map of Sun Creek adit.

Sample number	Sample description
42	A grab sample from an 80-ton (72 mt) dump of manganese-bearing rock by a caved adit.
43	A grab sample from a 300-pound (136 kg) "orepile" by an open cut.
44-49	Chip samples taken from the Sun Creek adit.
50-51	Panned-concentrate samples of stream sediment from Sun Creek.

Sample 42 and 43 assayed 27.7 and 43.2 percent manganese, respectively. Samples 44-49 ranged from 1.29 to 8.41 percent manganese. Silver values of samples 42-49 ranged from 0.1 to 0.3 ounce per ton; the highest gold value was 0.005 ounce per ton. The manganese veins could be an indication of possible buried deposits containing barite, fluorite, base-metal sulfide minerals, and associated gold and silver. Hewett (1968) discusses such a possibility in a study of hypogene manganese deposits. Sample 50 assayed 0.01 ounce gold per ton and sample 51 a trace of gold; neither sample contained any silver.

Steuben Creek (Locality 15)

Locality 15 is in the southeast corner of the study area in the southwest part of T. 50 N., R. 2 W. A grab sample (52) was taken from the dump of a small prospect pit dug on a small chalcedony vein bearing easterly with a vertical dip. Analyses of the sample showed no unusual values.

Lower West Elk Creek (Locality 16)

Locality 16 is in the south-central part of the study area in the west-central part of T. 50 N., T. 3 W. A 6-foot (1.8 m) random chip (sample 53) of a large hornblende diorite dike in West Elk Breccia assayed 0.1 ounce silver per ton; the dike bears N. 17° E. and dips vertically.

Lower Soap Creek (Locality 17)

Locality 17 is adjacent to the southern end of the study area in sec. 8, T. 49 N., R. 9 W. A panned-concentrate sample (54) of stream sediment from Soap Creek contained neither gold nor silver values.

El Ray Mine (Locality 18)

Locality 18 is in the south-central part of the study area near the center of T. 50 N., R. 4 W. The U.S. Geological Survey Little Soap Park quadrangle map indicates a uranium mine at the location of the El Ray mine. The workings consist of three excavations, the largest is a bulldozed trench 50 feet (15.3 m) long. Two samples were taken:

Sample number	Sample description
55	A composite of chip samples taken every 3 feet (91 cm) along a 50-foot (15.3 m) length in an altered zone of West Elk Breccia along the north wall of the largest working.
56	A grab sample from an "ore" stockpile about 500 feet (152.5 m east of the upper pit. The stockpile was estimated at less than 1,000 pounds (453 kg).

Each sample assayed less than 0.002 percent uranium. Sample 55 assayed 1.70 percent manganese and 0.041 percent vanadium. Sample 56 contained 56.46 percent manganese, 0.23 percent vanadium, 0.018 percent molybdenum, 500 ppm cobalt, 300 ppm zinc, and 50 ppm nickel. The sample data and indications of mineralization suggest the area may have at least a low potential for ferroalloy mineral commodities. Considerable exploration work is needed to determine the nature and extent of the deposits.

Big Soap Park (Locality 19)

Locality 19 is in the south-central part of the study area in the southwest corner of T. 51 N., R. 4 W. About one-half mile (805 m) west of Soap Creek a pit 30 feet (9.2 m) long, 10 feet (3.1 m) wide, and 15 feet (4.6 m) deep, was excavated N. 43° W. along a series of 1- to 4-inch (2.5 to 10 cm) wide chalcedony and calcite veinlets in West Elk Breccia. A 3-foot (91 cm) chip sample (57) in the north face of the pit contained no gold and a trace of silver.

West Soap Creek (Locality 20)

Locality 20 is in the south-central part of the study area in the northwest corner of T. 51 N., R. 4 W. High on the east side of West Soap Creek, a 200-foot (61 m) diameter sulfurous fumarole deposit in altered West Elk Breccia contains limonite-stained fractures and some limonite pseudomorphs after pyrite. A 15-foot (4.6 m) random chip sample (58) taken near the center, contained 0.94 percent sulfur; other assay values were negligible.

Sink Creek (Locality 21)

Locality 21 is in the southwest part of the study area in the southeast part of T. 15 S., R. 90 W. and north-central part of T. 51 N., R. 5 W. Three samples were taken:

Sample number	Sample description
59	A grab sample from a dump of a small prospect pit in West Elk Breccia at the head of South Smith Fork Creek.

60	A 2-foot (61 cm) chip sample across an alteration zone along the contact between Mancos Shale and a 40-foot (12.2 m) granodiorite porphyry dike near the junction of South Smith Fork and Sink Creeks.
61	A grab sample from a dump of a small prospect pit in granodiorite porphyry near the head of Sink Creek.

Assay results were negligible.

Lone Pine Creek (Locality 22)

Locality 22 is in the southwest part of the study area in the east-central part of T. 15 S., R. 90 W. Four samples were taken:

Sample number	Sample description
62	A panned-concentrate sample of stream sediment from Lone Pine Creek.
63	A 15-foot (4.6 m) random chip sample of slightly altered granodiorite porphyry on the Smith Fork group of claims.
64	A 10-foot (3.1 m) random chip sample taken near the middle of a 300-foot (91.5 m) alteration zone in granodiorite porphyry, about one-half mile (805 m) northeast of the site of sample 63.
65	A 5-foot (1.5 m) random chip sample of an alteration zone in granodiorite porphyry, about 75 feet (22.8 m) west of metamorphosed Mancos Shale and one-quarter mile (403 m) southeast of the site of sample 64.

Sample 62 assayed a trace of gold and 0.5 ounce silver per ton, and samples 64 and 65 assayed 0.1 ounce silver per ton; other results were negligible.

Sheep Mountain (Locality 23)

Locality 23 is near the center of the study area in the west-central part of T. 15 S., R. 89 W. Extreme red and yellow coloration of the intrusives and sediments indicate considerable alteration. In Spencer Basin, separating Mount Guero and Sheep Mountain, granodiorite porphyry intrudes Mancos Shale. On Sheep Mountain, the granodiorite porphyry intrudes the Mancos Shale and the Mesaverde Formation. On the east slope in a gulch, locally known as Red Gulch, a small rhyolite plug intrudes granodiorite porphyry. The Grouse, Submarine, and Torpedo group of claims and eight individual claims have been located in this locality. Nine samples were taken:

Sample number	Sample description
66	A 15-foot (4.6 m) random chip sample across the contact of porphyry and shale in Spencer Basin.
67	A 10-foot (3.1 m) random chip sample of slightly altered granodiorite taken high on the south side of Red Gulch; fresh pyrite and limonite-stained jointing are present.
68	A 5-foot (1.5 m) random chip sample of extremely altered granodiorite taken about 200 feet (61 m) northwest of the site of sample 67; fresh pyrite and highly stained-limonite jointing are present.
69	A 5-foot (1.5 m) random chip sample of altered granodiorite taken about 75 feet (22.9 m) north of the site of sample 68; fresh pyrite, elemental sulfur, and limonite-stained jointing are present.
70	A 5-foot (1.5 m) random chip sample across a breccia zone between Mancos Shale and granodiorite taken near the top of Red Gulch; considerable limonite and some hematite are present.
71	A 5-foot (1.5 m) random chip sample of slightly altered granodiorite taken in the bottom of Red Gulch; fresh pyrite and limonite-stained jointing are present.
72	A 5-foot (1.5 m) random chip sample across the contact of Mancos Shale and granodiorite porphyry high on the north side of Red Gulch; the porphyry is highly altered and some limonite pseudomorphs after pyrite are present, especially in the porphyry.
73	A 10-foot (3.1 m) random chip sample of altered granodiorite porphyry, about 50 feet (15.3 m) below Mancos Shale was taken near the top of Sheep Mountain; hematite-stained jointing is present.

Sample number	Sample description
74	A grab sample of excavated material from a prospect pit about 1 mile (1.6 km) northeast of the site of sample 73; the site was in a limonite zone in granodiorite porphyry

Assay results ranged up to 0.2 ounce silver per ton; other results were negligible.

North Smith Fork (Locality 24)

Locality 24 is in the west-central part of the study area in the northeast corner of T. 15 S., R. 90 W. A composite grab sample (75) of excavated material from three prospect pits contained a trace of silver. The three pits were dug along a north-trending contact between Mancos Shale and slightly altered granodiorite porphyry.

Hoodoo Creek (Locality 25)

Locality 25 is in the west-central part of the study area in the southeast corner of T. 14 S., R. 90 W. Analysis of a grab sample (76) of granodiorite porphyry from the dump of a 25-foot (7.6 m)-long trench showed no minerals of significance.

Minnesota Creek (Locality 26)

Locality 26 is adjacent to the west end of the study area in the central part of T. 14 S., R. 90 W. Two samples were taken:

Sample number	Sample description
77	A grab sample of limonite-stained sandstone of the Mesaverde Formation from the dump of a small prospect pit.
78	A grab sample of dark brown sandstone of the Mesaverde Formation from the dump of a small prospect pit on the Manganese group of claims.

Analysis of sample 78 showed 0.8 percent manganese; other results were insignificant.

Interocean Pass (Locality 27)

Locality 27 is in the western part of the study area in the southeast part of T. 14 S., R. 91 W. Spectrographic analysis of a grab sample (79) of iron-stained granodiorite porphyry from the dump of a small prospect pit revealed no anomalous values.

Elk Basin Pass (Locality 28)

Locality 28 is in the west-central part of the study area in the south-central part of T. 14 S., R. 90 W. A small prospect pit has been excavated in a zone of surface alteration of granodiorite porphyry. No anomalous values were contained in a spectrographic analysis of a grab sample (80) from the dump of the pit.

Coal Mountain (Locality 29)

Locality 29 is in the west-central part of the study area in the northwest corner of T. 15 S., R. 90 W. Four samples were taken:

Sample number	Sample description
81	A 10-foot (3 m) random chip sample across aplitic granodiorite containing pyrite pseudomorphs on the summit of Coal Mountain.
82	A chip sample across the 4-foot (1.2 m) face of a 20-foot (6.1 m)-long trench excavated along the contact of Mancos Shale and slightly altered granodiorite porphyry. The trench is one-half mile (805 m) southwest of the site of sample 81.
83	A grab sample from the dump by the trench where sample 82 was taken.
84	A grab sample from the dump by a small prospect pit excavated in slightly altered granodiorite porphyry about one-fourth mile (403 m) south of the trench where sample 82 and 83 were taken.

Sample 81 assayed traces of gold and silver, and sample 83 contained 0.1 ounce silver per ton; assay results of the other samples showed nothing of significance.

Box Canyon (Locality 30)

Locality 30 is on the western edge of the study area in the west-central part of T. 15 S., R. 91 W. The Charlie Todd group of claims covers the contact of a limy shale member of the Mesaverde Formation and a granodiorite dike. Assay results of a 15-foot (4.6 m) random chip (sample 85) across the contact contained neither gold nor silver values.

Bell Creek (Locality 31)

Locality 31 is in the western end of the study area in the south-central part of T. 14 S., R. 91 W. Taken next to the contact with Mancos Shale, a 20-foot (6.1 m) random chip (sample 86) across altered granodiorite porphyry containing some quartz veinlets revealed nothing of interest on analysis.

Cottonwood Creek (Locality 32)

Locality 32 is adjacent to the west end of the study area in the western part of T. 15 S., R. 91 W. Two samples were taken:

Sample number	Sample description
87	A 10-foot (3 m) random chip sample across the contact of a granodiorite porphyry dike and Mancos Shale.
88	A vertical 20-foot (6.1 m) random chip sample of a 45-foot (14 m) thick bed of gypsiferous Mancos Shale.

Except for sample 88 that contained 0.1 ounce silver per ton, assay values were insignificant.

Needle Rock (Locality 33)

Locality 33 is about 3 miles (4.8 km) west and 1 mile (1.6 km) south of the study area near the center of T. 15 S., R. 91 W. A plug-like intrusive of rhyodacite, known as Needle Rock, crops out at this location. Two samples were taken:

Sample number	Sample description
89	A 20-foot (6.1 m) random chip sample across an altered area on the north side of Needle Rock.
90	A chip sample across a 1-foot (30 cm) fault on the east side of Needle Rock.

Except for sample 89, which contained 0.1 ounce silver per ton, assay values were insignificant.

MINERAL FUELS

Geologic data, coal production, and exploration for coal indicate that the northern part of the study area may have a very good potential for coal resources. Available information about oil and gas in the same area indicates a low potential for these mineral fuels. The southern part of the study area is overlain mostly by Tertiary volcanic rocks that may be several thousand feet thick in some places. This area conceivably could be underlain by favorable formations containing coal deposits; but exploration would be extremely costly. Furthermore, although the extensive cover of the volcanics greatly reduces the possible presence of oil and gas, favorable geologic structures for oil and gas could be present at considerable depth below the thick volcanic cover. Again, however, exploration to find such structures would be expensive and risky.

Coal

The northern part of the West Elk Wilderness study area is underlain by bituminous coal beds. Most of the northern part is in the Somerset coal field and the remainder in the Crested Butte coal field. These two major coal fields have been described by Emmons and others (1894), Lee (1912), and Johnson (1948). Reserve estimates have been made by Landis (1959), Landis and Cone (1971), and Hornbaker and Holt (1973).

The Somerset and Crested Butte coal fields adjoin; thus, for this report, the division between the fields is the township line between R. 87 W. and R. 88 W. The Somerset coal field was once considered part of the Grand Mesa coal field. Parts of the Somerset coal field have been called the Paonia and Paonia-Somerset coal field. The Crested Butte coal field was once known as the Slate River coal field. Parts of the Crested Butte coal field have been called the Floresta (also the Ruby or Irvin) coal field and the Mount Carbon (also Baldwin) coal field. The latest studies of Colorado coal fields (Landis and Cone, 1971; Hornbaker and Holt, 1973) only use the names Somerset and Crested Butte.

The only coal production from the study area was less than 1,000 tons (907 t) from the Moseley mine on the west side of Coal Creek near the center of sec. 10, T. 14 S., R. 89 W.; the coal was mined between 1900 and 1910. Considerable coal has been produced from nearby underground mines outside the study area. From 1884 through 1973, 32.3 million tons (29.3 million t) had been produced from 28 mines five miles (8.1 km) or less from the study area. About 86 percent of the production came from the Somerset coal field; the balance was from the Crested Butte coal field. Coal mines with production exceeding 50,000 tons (45,000 t) for the 1884-1973 period are identified on plate 3. Mines with production of 1,000,000 tons (900,000 t) or more, in order of output, are the Somerset, Bear, Old King, Alpine No. 1, Oliver, and Hawksnest; all, except the Alpine No. 1, are in the Somerset coal field.

The coal beds in the Somerset and Crested Butte coal fields are restricted to a stratigraphic interval 100-600 feet (30-183 m) thick in the lower part of the Mesaverde Formation above a thick basal sandstone unit called the Rollins Sandstone Member. Successively overlying the Rollins sandstone are the Bowie (lower coal) Member, the Paonia (upper coal) Member, and the barren member. Coalbeds in the Lower and Upper Coal Members range from a few inches to 25 feet (7.6 m) thick (Lee, 1912). Locally some coal beds split, coalesce, or wedge out completely. In general the beds dip northerly 0-12°, although wide local variations exist. Figure 19 shows the extent of the Mesaverde Formation in the study area and the structure contours on the base of the coal-bearing rocks.

In the Somerset coal field the coal beds crop out low on the slopes of the valley of the North Fork of the Gunnison River and its tributary canyons and gulches where three to six beds of coal 4 feet (1.2 m) or more thick are generally present. Locally some of the coal beds are as much as 10-15 feet (3-4.6 m) thick (Lee, 1912; Johnson, 1948). The coal-bearing strata extend southward and southeastward from the North Fork into the study area as far as the eroded edge of the Mesaverde Formation (fig. 19). Some of

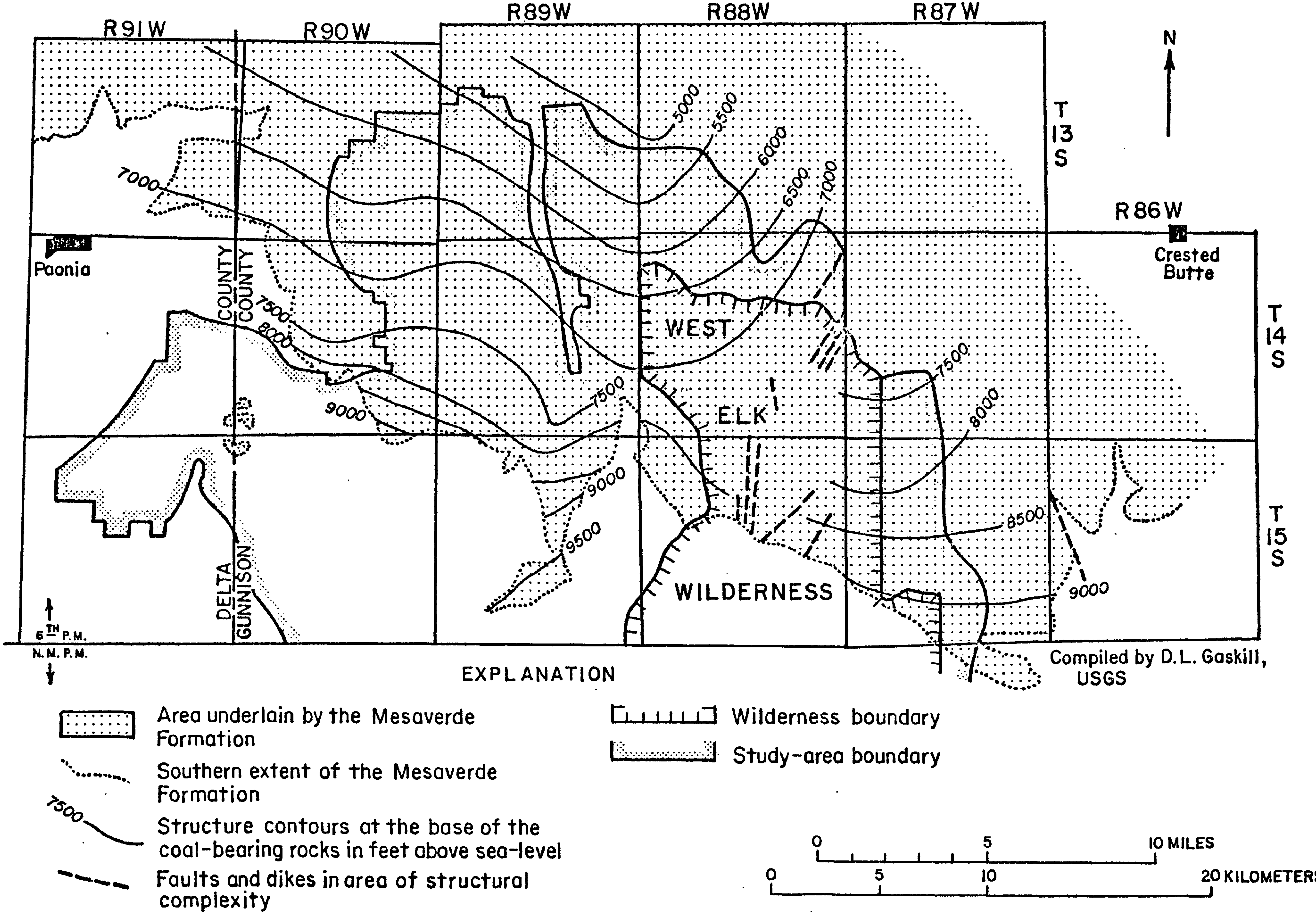


FIGURE 19.—Map showing extent of the coal-bearing Mesaverde Formation in the West Elk Wilderness study area, and structure contours on the base of the coal-bearing rocks.

the coal in the southeastern part of the Somerset coal field was metamorphosed to semianthracite rank by igneous intrusions; the tonnage is low, however, and Landis (1959, p. 146) did not separate the anthracite from the more abundant bituminous coal in making his reserve estimates.

According to Emmons and others (1894), Lee (1912), and Dapples (1939), the mines in the Mount Carbon-Baldwin-Ohio Creek area of the Crested Butte coal field exploited two or three beds of subbituminous to high-volatile bituminous coal and anthracite coal. The coal beds range from 2-11 feet (0.6-3.3 m) thick in a stratigraphic interval about 300 feet (91 m) thick overlying the basal sandstone of the Mesaverde Formation (Emmons and others, 1894; Lee, 1912). Exposures of coal in this area that are nearest to the study area are in the Mill Creek Valley in sec. 36, T. 15 S., R. 87 W., where Lee (1912) described a 7-9 foot (2.1-2.7 m) thick coal bed at one of the mines.

Anthracite coal was mined between 1893 and 1910 at the Ruby-Anthracite mine in the former Floresta coal mining district in the northern part of the Crested Butte coal field. The anthracite is restricted to a single bed 1-5 feet (0.3-1.5 m) thick overlying a laccolith on the north slope of the Anthracite Range about 1.5 miles (2.4 km) north of the study area in T. 14 S., R. 87 W., (Emmons and others, 1894; Lee, 1912). This bed was metamorphosed to anthracite by heat from the underlying intrusive body (Dapples, 1939). There is no evidence that the anthracite extends into adjacent parts of the study area.

Most of the coal near the study area is high volatile B and C bituminous with a low sulfur content; some of this coal has good coking characteristics. Coal analyses from drill holes, mines, and prospects in and adjacent to the study area are reported by Emmons and others (1894), Lee (1912), Toenges and others (1947 and 1952), and numerous U.S. Bureau of Mines publications (see references). Hornbaker and Holt (1973) give the following range of analyses of coal from the lower coal group in the Somerset coal field:

As-received basis	Range of analyses
Moisture, percent	7.4 - 13.6
Ash, percent	2.4 - 11.4
Sulfur, percent	0.5 - 0.8
Btu per lb	10,400 - 12,600
Fusion temperature, °F	2,470 - 2,810

and from the upper coal group in the same coal field:

As-received basis	Range of analyses
Moisture, percent	10.6 - 22.4
Ash, percent	4.3 - 13.9
Sulfur, percent	0.3 - 0.8
Btu per lb	8,160 - 10,610
Fusion temperature, °F	2910+

They also showed the following range of analyses of coal from the upper coal group in the Crested Butte coal field:

As-received basis	Range of analyses
Moisture, percent	2.5 - 13.3
Ash, percent	3.2 - 9.1
Sulfur	0.4 - 1.9
Btu per lb	11,400 - 14,170
Fusion temperature, ^{o}F	2,130 - 2,480

Considerable data are available to aid in estimating the quantity and quality of coal existing in the northern part of the West Elk Wilderness study area. As part of an investigation of western coal deposits, the U.S. Bureau of Mines conducted a diamond drilling program between 1943 and 1948 south of the Dry Fork of Minnesota Creek (Toenges and others, 1949) and in the Coal Creek area (Toenges and others, 1947 and 1952). Drill holes in and bordering the northwest corner of the study area in T. 13-14 S., R. 90 W. show three to eight coal beds 4-15 feet (1.2-4.6 m) thick in a stratigraphic interval about 500 feet (152 m) thick overlying the basal sandstone of the Mesaverde Formation (Toenges and others, 1949; Johnson, 1948). According to Toenges (1949, p. 33) there are at least four to six minable coal beds in this area.

Drill hole data in the lower Coal Creek-Snowshoe Creek area in T. 13 S., R. 89 W. indicate 108.5 million tons (98.4 million t) of metallurgical coking coal in this part of the study area (Toenges and others, 1952; Johnson, 1948). According to N. W. Bass (oral communication, 1976) of the U.S. Geological Survey, these drill holes did not penetrate the 330-foot (100 m) thick interval above the basal (Rollins) sandstone unit--an interval that also contains thick coal beds.

Several thick beds of coal crop out locally along upper Coal Creek and its tributaries in the Coal Basin area. Lee (1912, p. 112-139) describes numerous coal showings and prospects in T. 14-15 S., R. 89 W., including some low and medium-volatile coals. According to N. W. Bass (oral communication, 1976) and mapping by Johnson (1948), there are three to five coal beds 3-8 feet (0.9-2.4 m) or more thick in these townships.

The "Phillips" prospect in sec. 6, T. 15 S., R. 90 W., has produced coal from a steeply inclined bed on the west flank of Coal Mountain (Lee, 1912). Some coal crops out on Coal Mountain in sec. 31, T. 14 S., R. 90 W.

All of the above areas, except for those on Coal Mountain and a small area in T. 15 S., R. 89 W., are classified as a "Known Coal Leasing Area" by the U.S. Geological Survey. This "Known Coal Leasing Area" also includes lands under lease for coal, oil and gas, and several parcels of private or coal patent-entry lands in the study area.

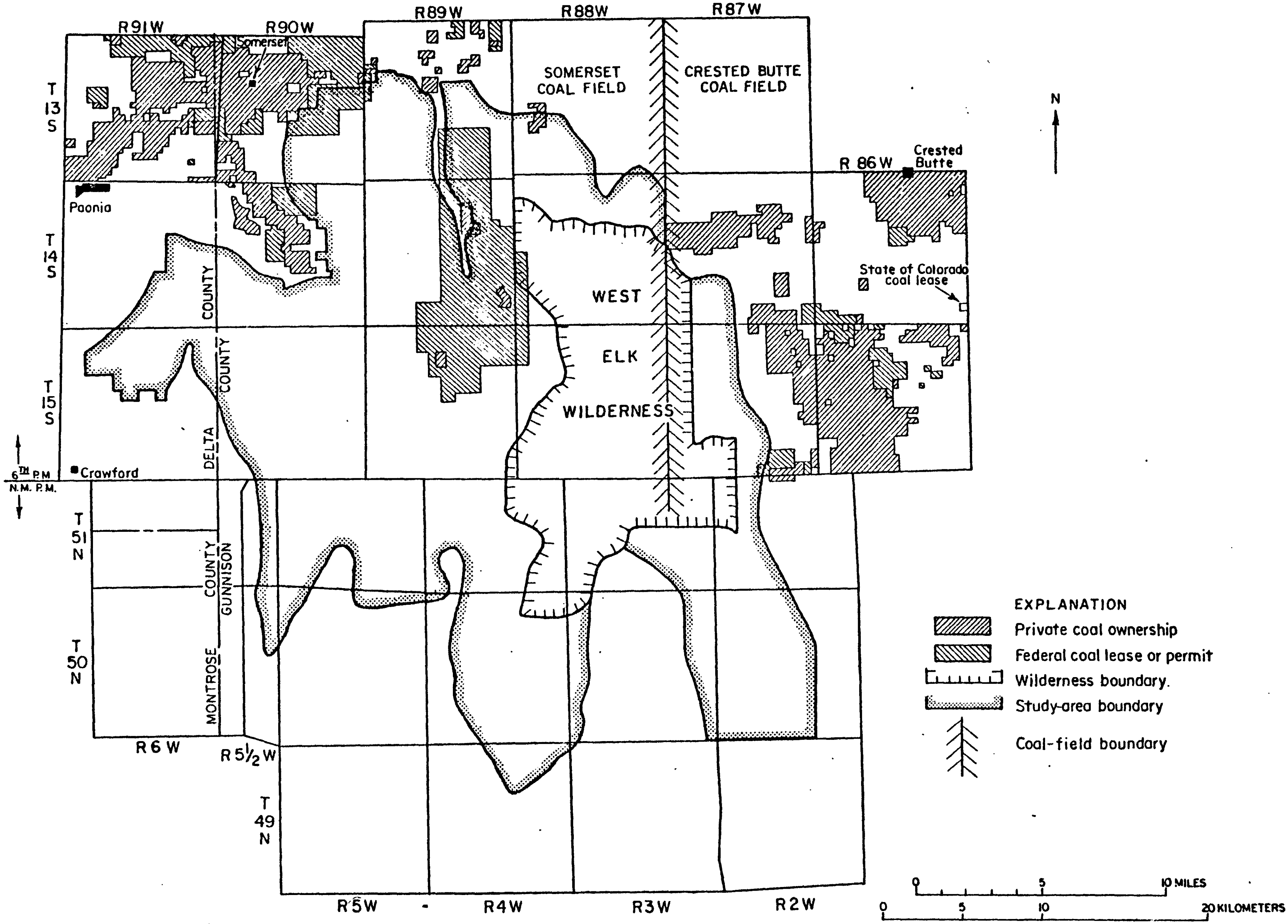


FIGURE 20. Coal ownership of the known coal resources in and near the West Elk Wilderness study area.

Of the Federal coal permits and leases shown on figure 20, only those for secs. 3, 4, 9, 10, 16, and 21, T. 14 S., R. 90 W., and secs. 11-14, T. 14 S., R. 89 W. were still in effect in 1973. The only State coal lease (fig. 20) near the study area was for part of sec. 36, T. 14 S., R. 86 W.

Parts of T. 13-15 S., R. 87-88 W. within the study area are also classified as valuable coal lands by the U.S. Geological Survey as follows: parts of sections 19 and 30, T. 13 S., R. 88 W. were classified as coal lands as of September 6, 1967; all of 12 sections and parts of 11 sections in T. 14 S., R. 88 W., as of June 4, 1910, although the present study indicates that only about four sections in the southwest corner of T. 14 S., R. 88 W. contain inferred reserves of coal; parts of sections 5, 6, and 7, T. 15 S., R. 88 W., as of June 11, 1910; all of sections 28, 29, 33, and parts of sections 18, 19, 30, 31, and 32, T. 14 S., R. 87 W., as of June 4, 1910, although the present study suggests that the lands in T. 15 S., R. 88 W., and T. 14 S., R. 87 W. might better be reevaluated to noncoal status; all of sections 4, 5, 9, and 16, and parts of sections 8, 17, 20, 21, 22, 27, and 28, T. 15 S., R. 87 W., as of June 4, 1910.

Estimates of Colorado coal resources by townships were made by Landis (1959) and later updated by Landis and Cone (1971). Table 11 lists the coal resources in and near the study area by townships and an estimate of these resources in the study area. The resource quantities for the townships are based on those of Landis and Cone (1971) except for T. 14-15 S., R. 88 W., for which no estimates had been made by them. Estimates of the resources for T. 14-15 S., R. 88 W., were made from information reported by Lee (1912) and that obtained during the field investigation of the study area. However, these two townships probably contain considerable more coal because the estimates are only based on the exposure of two coal beds. The resources in the table 11 have been categorized according to the classification of mineral resources shown in table 12; this classification was jointly adopted by the U.S. Bureau of Mines and the U.S. Geological Survey in 1974.

Total measured, indicated, and inferred resources of about 1.6 billion tons (1.4 billion t) of bituminous coal are estimated to be within the West Elk Wilderness study area (table 11). Much of this coal belongs in the reserve category; however, the basic data used in previous resources studies would have to be reevaluated to determine the quantity. As near as can be estimated from geologic evidence and projections, the hypothetical or speculative coal resources within the study area are probably less than twice the estimated identified resources.

Nearly all the coal in the study area is deeply buried and would have to be recovered by underground mining or *in situ* coal gasification techniques. Some strippable coal may exist between Coal Creek and Kaufman-Robinson Creeks in T. 14-15 S., R. 89 W. and between Robinson and Little Robinson Creeks in T. 14 S., R. 88 W. However, available data are insufficient to properly evaluate the quantity of coal that is strippable.

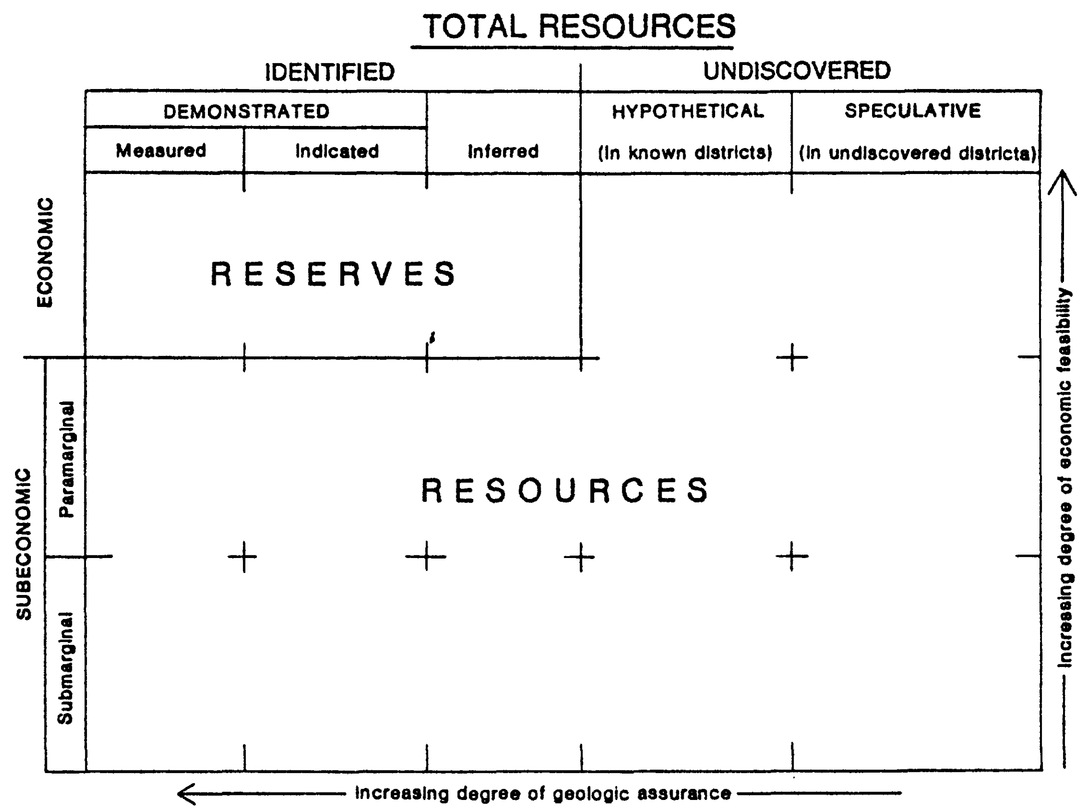
Oil and Gas

Some potential exists for the discovery of oil and gas in the study area, although the chance for a major discovery is slight. No oil seeps are known

Table 11.--Bituminous coal resources in the West Elk Wilderness study area, in thousand tons (thousand metric tons)

Township T	Township R	Township resources estimated to be in study area (percent)	Identified: Measured and indicated, Township	Measured and indicated, Study area	Inferred, Township	Inferred, Study area	Total, Township	Total, Study area
13S	87W	0	0	0	0	0	0	0
13S	88W	15	0	0	24,070 (21,840)	3,610 (3,270)	24,070 (21,840)	3,610 (3,270)
13S	89W	65	243,330 (220,750)	158,160 (143,480)	214,220 (194,340)	139,240 (126,320)	457,550 (415,090)	297,400 (269,800)
13S	90W	35	511,890 (464,390)	179,160 (162,530)	766,680 (695,530)	268,340 (243,440)	1,278,570 (1,159,920)	447,500 (405,970)
13S	91W	0	101,820 (92,370	0	265,730 (241,070)	0	367,550 (333,440)	0
14S	86W	0	36,770 (33,360)	0	46,710 (42,370)	0	83,480 (75,730)	0
14S	87W	15	0	0	0	0	0	0
14S	88W	100	0	0	5,340 (4,840)	5,340 (4,840)	5,340 (4,840)	5,340 (4,840)
14S	89W	100	60,350 (54,750)	60,350 (54,750)	197,820 (179,460)	197,820 (179,460)	258,170 (234,210)	258,170 (234,210)
14S	90W	65	310,370 (281,570)	201,740 (183,020)	387,300 (251,360)	251,750 (228,390)	697,670 (532,930)	453,490 (411,410)
15S	86W	0	44,110 (40,020)	0	42,710 (38,750)	0	86,820 (78,770)	0
15S	87W	50	11,900 (10,790)	5,950 (5,400)	23,070 (20,930)	11,540 (10,470)	34,970 (31,720)	17,490 (15,870)
15S	88W	100	0	0	2,100 (1,910)	2,100 (1,910)	2,100 (1,910)	2,100 (1,910)
15S	89W	100	25,180 (22,840)	25,180 (22,840)	51,970 (47,150)	51,970 (47,150)	77,150 (69,990)	77,150 (69,990)
	Total		1,345,720 (1,220,840)	630,540 (572,020)	2,027,720 (1,839,550)	931,710 (845,250)	3,373,440 (3,060,390)	1,562,250 (1,417,270)

Table 12.--Classification of mineral resources



GLOSSARY OF RESOURCE TERMS

Resource--A concentration of naturally occurring solid, liquid, or gaseous materials in or on the earth's crust in such form that economic extraction of a commodity is currently or potentially feasible.

Identified resources--Specific bodies of mineral-bearing material whose location, quality, and quantity are known from geologic evidence supported by engineering measurements with respect to the demonstrated category.

Undiscovered resources--Unspecified bodies of mineral-bearing material surmised to exist on the basis of broad geologic knowledge and theory.

Reserve--That portion of the identified resource from which a usable mineral and energy commodity can be economically and legally extracted at the time of determination. The term ore is also used for reserves of some minerals.

The following definitions for measured, indicated, and inferred are applicable to both the Reserve and Identified-Subeconomic resource components.

Measured--Material for which estimates of the quality and quantity have been computed, within a margin of error of less than 20 percent, from analyses and measurements from closely spaced and geologically well-known sample sites.

Indicated--Material for which estimates of the quality and quantity have been computed partly from sample analyses and measurements and partly from reasonable geologic projections.

Demonstrated--A collective term for the sum of materials in both measured and indicated resources.

Inferred--Material in unexplored but identified deposits for which estimates of the quality and size are based on geologic evidence and projection.

Identified-Subeconomic resources--Known deposits not now minable economically.

Paramarginal--The portion of subeconomic resources that (a) borders on being economically producible or (b) is not commercially available solely because of legal or political circumstances.

Submarginal--The portion of subeconomic resources which would require a substantially higher price (more than 1.5 times the price at the time of determination) or a major cost reducing advance in technology.

Hypothetical resources--Undiscovered materials that may reasonably be expected to exist in a known mining district under known geologic conditions. Exploration that confirms their existence and reveals quantity and quality will permit their reclassification as a Reserve or identified-subeconomic resource.

Speculative resources--Undiscovered materials that may occur either in known types of deposits in a favorable geologic setting where no discoveries have been made, or in as yet unknown types of deposits that remain to be recognized. Exploration that confirms their existence and reveals quantity and quality will permit their reclassification as reserves or identified-subeconomic resources.

to occur in the study area. The sedimentary rock section includes strata that are reservoirs for oil and gas elsewhere, but the section is much thinner here than in other parts of the Piceance basin. Igneous intrusions are widely emplaced through most of the study area.

No oil or gas production has been reported from the West Elk Wilderness study area. The nearest oil fields--Wilson Creek in T. 3 N., R. 94 W., and Nine Mile in T. 2 N., R. 92 W.--are about 90 miles (144.9 km) to the north; both fields had production in 1974. The nearest gas fields--Black Canyon in T. 15 S., R. 94 W. and Happy Hollow in T. 14 S., R. 95 W.--are 18 miles (29.0 km) and 24 miles (38.6 km) to the west, respectively; neither field has had any recent production. The nearest gas fields with recent production (1974) are Wolf Creek in T. 8 S., R. 90 W.; Divide Creek in T. 8 S., R. 91 W.; and Buzzard Creek in T. 9 S., R. 93 W.; these fields are about 30 miles (48.3 km) to the north. A gas well in T. 11 S., R. 90 W. about 14 miles (22.5 km) to the north had been reported to have had an open flow potential of 1.2 million cubic feet (34,000 cum) of gas per day (Petroleum Information, 1965); however, no production has been reported since the well was completed in late 1963.

The locations of the oil and gas leases issued in and near the study area are shown on figure 21. The leasing activity dates back to 1922 but, as of 1973, all the leases in the study area had been either terminated or cancelled.

Between 1910 and 1925, location notices of oil and oil shale placer claims were filed in Delta and Gunnison Counties. The location of these claims is shown on plate 3. The claims in the study area in T. 14-15 S., R. 87 W., were staked almost entirely on thick deposits of surficial debris (talus, rubble streams, morainal material, colluvium, and landslides), and on the igneous mass of the Anthracite Range laccolith. Those in T. 49-50 N., R. 2 W., are on volcanic rocks that either overlie a very thin section of sedimentary strata, or rest directly on crystalline Precambrian basement rocks. The claims in T. 14-15 S., R. 91 W., were staked largely on Mancos Shale. No oil shale (Green River Formation) is known to exist in or near the study area and the potential for oil and gas in the underlying sedimentary rocks is not known.

No drilling for oil and gas has been done in the study area. However, seven holes have been drilled within 6 miles (9.7 km) of the area. Three dry holes and one hole with an oil showing were drilled in sec. 28, T. 15 S., R. 86 W. In 1922, the dry hole in the NE1/4NW1/4 was drilled to a depth of 600 feet (183 m), and in 1924 the dry hole in the SE1/4NE1/4 was drilled to a depth of 1,900 feet (579 m); the formations penetrated by the holes were not reported. The dry hole in the center of the NE1/4NE1/4 was drilled in 1962 to a depth of 3,696 feet (1,127 m); the hole was started in Mancos Shale and bottomed in Dakota Sandstone. In the NE1/4SW1/4, the hole with the oil showing was drilled to a depth of 3,406 feet (1,039 m) in 1960. The hole, started in the Mancos Shale, penetrated the Dakota Sandstone at 3,050 feet (930 m) and the Morrison Formation at 3,355 feet (1,023 m).

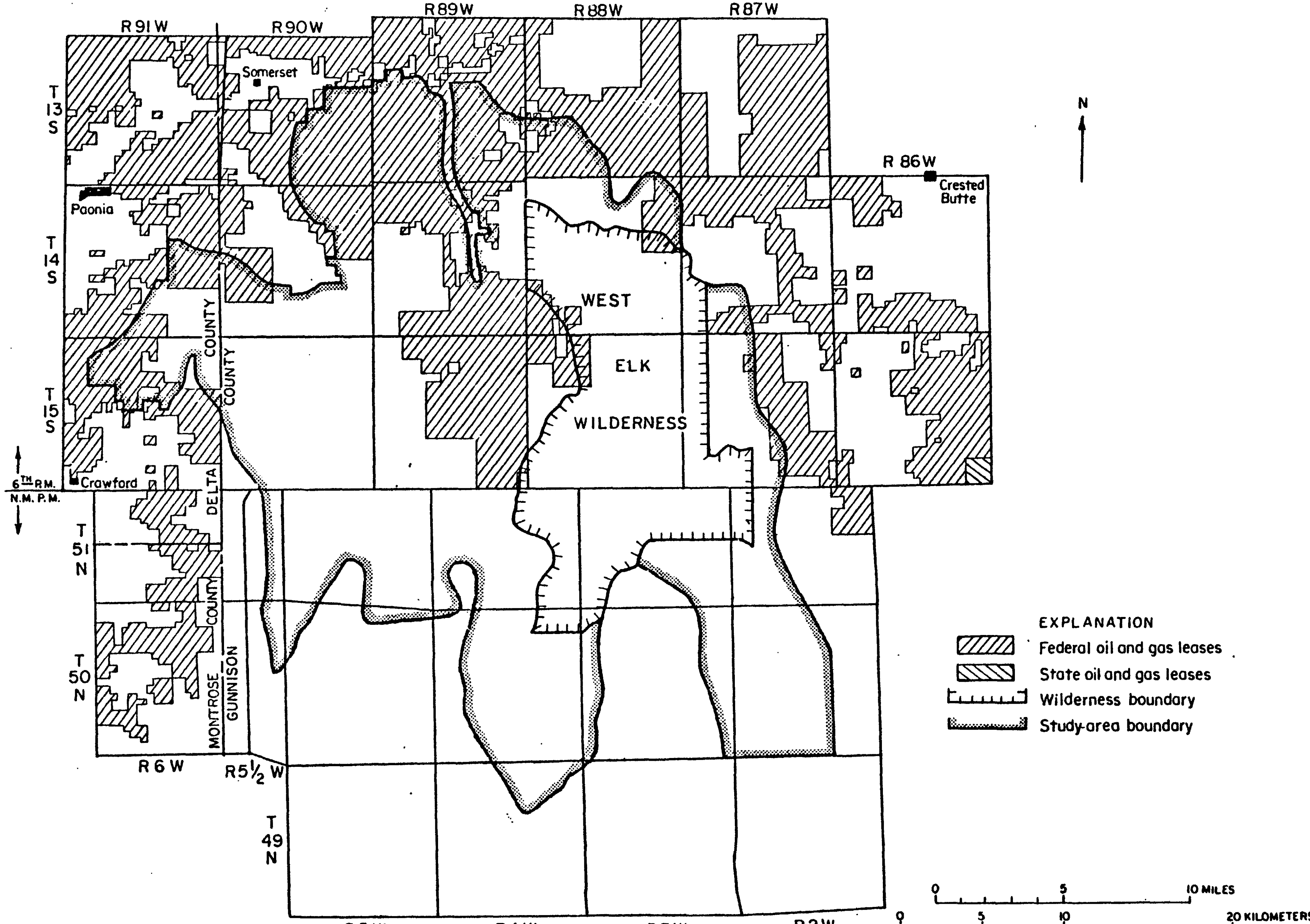


FIGURE 21. Map showing the location of oil and gas leases in and near the West Elk Wilderness study area.

A dry hole in the southeast corner of SW¼NE¼ sec. 8, T. 13 S., R. 89 W. was drilled to a depth of 1,008 feet (307 m) in 1954. Started in the Mesaverde Formation, the hole penetrated the Mancos Shale at 969 feet (295 m).

In the southwest corner of SE¼NW¼ sec. 28, T. 15 S., R. 91 W., a dry hole 1,100-feet (335 m) deep was started in the Mancos Shale and penetrated the Morrison Formation; the Dakota Sandstone was reported at a depth of 895 feet (273 m). Drilling commenced in 1929 and ended in 1930.

A dry hole in the center of SE¼SE¼ sec. 28, T. 14 S., R. 91 W. was started in Mancos Shale and bottomed in the Morrison Formation at 620 feet (189 m). Drilling was started in 1952 and ended in 1953.

Between 1944 and 1948, during the investigation of the Coal Creek district in T. 13 S., R. 89 W. for coal resources, the Bureau of Mines drilled 22 diamond-drill holes (Toenges and others, 1947 and 1952). The depths of the holes ranged from 576 to 2,188 feet (176 to 667 m). All the holes bottomed in the Rollins Sandstone member of the Mesaverde Formation. A small amount of oil and some gas was encountered at 400 feet (122 m) in hole No. 6; the depth of this hole was only 772 feet (236 m). The oil was a low-gravity, napthenic oil that contained no gasoline or kerosene and had no lubricating qualities. Gas was encountered in other holes, probably mostly methane associated with coal in the Mesaverde Formation.

OTHER MINERAL COMMODITIES

Common building materials in the study area are probably of little commercial interest. Sand and gravel in small alluvial or glacial deposits are of only local interest. The region surrounding the study area is well endowed with building and decorative stone more readily accessible to markets. Deposits of clay, volcanic ash and pumice in the study area are small, impure, and probably of little commercial value. Volcanic glass (perlite-vitrophyre) and pumiceous tuffs of the bedded ash-flow deposits are widespread in Gunnison County outside the study area boundary.

There are no hot springs, evidence of recent volcanism, or other known parameters in the study area that would suggest a geothermal resource potential.

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STUDIES RELATED TO WILDERNESS

In accordance with the provisions of the Wilderness Act (Public Law 88-577, Sept. 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, as well as adjacent wilderness study areas, 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 constitute one aspect of the suitability studies. This report discusses the results of a mineral survey of some national forest lands in the West Elk Wilderness study area, Colorado, that is being considered for wilderness designation. The area studied is in Gunnison and Delta Counties in west-central Colorado.

MINERAL RESOURCES OF THE WEST ELK
WILDERNESS AND VICINITY,
Delta and Gunnison Counties, Colorado

A. Geology of the West Elk Wilderness and vicinity, Delta and Gunnison Counties, Colorado
By David L. Gaskill, U.S. Geological Survey

B. Geophysical surveys in the West Elk Wilderness and vicinity, Delta and Gunnison Counties, Colorado
By Joseph G. Rosenbaum, U.S. Geological Survey

C. Geological and geochemical evaluation of the mineral resources of the West Elk Wilderness and vicinity, Delta and Gunnison Counties, Colorado
By David L. Gaskill and Harley D. King, U.S. Geological Survey

D. Mines, prospects, and mineralized areas of the West Elk Wilderness and vicinity, Delta and Gunnison Counties, Colorado
By Henry C. Meeves, and Carl L. Bieniewski, U.S. Bureau of Mines