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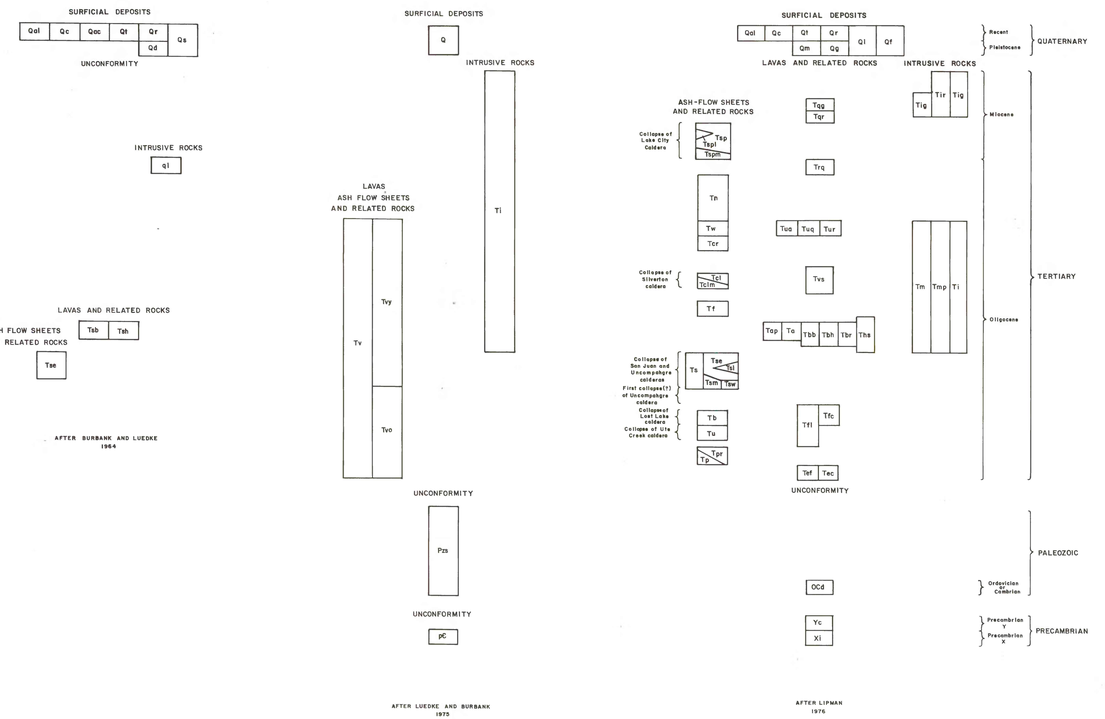
OF 81-599

CORRELATION OF MAP UNITS
SILVERTON AND AMERICAN FLATS PLANNING UNITS



Geochemical and Geostatistical Evaluation of American Flats - Silverton Planning Units, San Juan Volcanic Province, Colorado, 1981, by E. Welland, J. Lindemann, R. Connors, W. Meyers and S. Johnson, with an introduction by W. Beran.

BARRINGER RESEARCH

PLATE II A

CORRELATION MAP AND DESCRIPTION OF ROCK UNITS
SILVERTON AND AMERICAN FLATS PLANNING UNITS

REFERENCES

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LEGEND

AFTER BURBANK AND LUEDKE
1964

Qal ALLUVIUM

Qc COLLUVIUM

Qoc ALLUVIAL CONE DEPOSITS

Qt TALUS

Qr ROCK GLACIER DEPOSITS

Qs LANDSLIDE DEPOSITS

Qd GLACIAL DRIFT

qf Porphyritic quartz latite - Occurs in dikes, sheets, plugs, and irregular-shaped intrusive masses

Tsh HENSON FORMATION - Dark flows, breccias, and tuffs of mainly rhyodacitic composition, but includes rhyolite in Red Mountains area and ancient talus cones (along caldera rim faults) at base of formation in Full Moon Gulch

Tsb BURNS FORMATION - Medium to dark thick massive flows and flow breccias, tuffs, and fluidal-banded flows of mainly rhyodacite composition

——— Contact - Dashed where approximately located

——— Fault - Dashed where approximately located, dotted where concealed

——— Vein or mineralized fault - Dashed where approximately located, dotted where concealed

——— Mineralized fissure or fault

AFTER LUEDKE AND BURBANK
1975

Q SURFICIAL DEPOSITS - Includes landslide material, rock glaciers, talus and related materials on slopes, alluvium in stream valleys and mountain basins, and unconsolidated glacial debris, all of probably Quaternary age

Ti INTRUSIVE IGNEOUS ROCKS - Includes small irregular-shaped plutons and dikes of mafic to silicic composition, all of late to middle Tertiary age

Tv VOLCANIC AND SEDIMENTARY ROCKS, UNDIFFERENTIATED - Includes lava flows, flow breccias, welded ash-flow tuffs, and tuffaceous sediments of Oligocene and Miocene ages of the Henson, Burns, Picayune, and San Juan Formations, and Eureka Member of the Sapinero Mesa Tuff, and conglomerate beds of the Telluride Conglomerate, all of middle to early Tertiary age

Tvy VOLCANIC ROCKS, YOUNGER - Includes those rock units deposited during and following formation of the San Juan caldera

Tvo VOLCANIC AND SEDIMENTARY ROCKS, OLDER - Includes those rock units deposited before formation of the San Juan caldera

Pzs PALEOZOIC SEDIMENTARY ROCKS - Includes beds of conglomerate, shale, limestone, and dolomite in the Pennsylvanian Molas Formation, Mississippian Leadville Limestone, Devonian Ouray Limestone and Elbert Formation, and Cambrian Ignacio Formation

pC PRECAMBRIAN ROCKS - Includes schist, gneiss, amphibolite, and locally coarse-grained granite all with diabase dikes (d)

——— CONTACT - Dashed where approximately located

—·—·— VEIN OR MINERALIZED FAULT Bar and ball on downthrown side

——— FAULT - Dashed where approximately located; dotted where concealed. Bar and ball on downthrown side

AFTER LIPMAN
1976

SURFICIAL DEPOSITS

HOLOCENE DEPOSITS

Qal Alluvium - Silt, sand, gravel, and peaty material in valley bottoms. Locally includes small alluvial-fan and colluvial deposits at margins of valley bottoms

Qc Colluvium - Poorly sorted silt- to boulder-size material on slopes and in steep valleys. Locally includes small alluvial-fan, talus, landslide, and glacial moraine deposits

Qt Talus deposits - Angular rock fragments as much as 1 m (metre) in diameter, forming talus cones, talus aprons, and scree slopes. Locally well sorted. Grades into colluvium (Qc) with increase in sand and silt content

Qr Rock glacier - Lobate deposits of angular rock fragments, generally lacking fine-grained material on the upper surface. Are the most actively advancing

HOLOCENE AND PLEISTOCENE DEPOSITS

Ql Landslide deposits - Poorly sorted material derived from bedrock and glacial deposits; include small earthflow, block-slump, and block-slide deposits. Locally intergrade with larger earthflow deposits (Qf) and with large block slides and slumps (indicated by hachured pattern)

Qf Earthflow deposits - Poorly sorted material showing conspicuous flowage features, including marginal levees, a steep toe, and longitudinal ridges and valleys. Commonly grades into chaotic blocks(slump and landslide material) near the source

PLEISTOCENE DEPOSITS

Qm Glacial moraine - Terminal moraine of Pinedale age along Lake Fork of the Gunnison River about 4 km (kilometres) north of Lake City, thick till southeast of the Continental Divide, and other terminal and lateral moraines. Material is poorly sorted and has typical hummocky or ridgy topography. Some till has been mapped with colluvium (Qc)

Qg Glacial outwash gravels - Well-rounded fair- to well sorted stratified terrace deposits ranging in size from sand to well-rounded boulders. Occur only along Lake Fork of the Gunnison River north of the terminal moraine

MIOCENE ROCKS OF THE LAKE CITY CALDERA

INTRUSIVE ROCKS

Tig Granite - Equigranular to porphyritic fine- to medium-grained granitic intrusions within the Lake City caldera. The dominant type is a coarsely porphyritic granite or quartz monzonite containing phenocrysts of K-feldspar and plagioclase as much as 4 cm across in a fine-grained groundmass of quartz and alkali feldspar (locally in granophyric intergrowths); these rocks grade into finer grained types transitional toward the rhyolite (Tir) and quartz latite (Tiq). At relatively high structural levels, the granite tends to form crosscutting bodies, such as the irregular pluton in Cinnamon Gulch. At lower structural levels, the concordant top of a large granite mass is exposed for several kilometres along Silver Creek, and patterns of hornfelsed and hydrothermally altered rock suggest that other large granite bodies are present at shallow depth in adjacent areas, especially along Copper Creek to the northwest. These granites probably caused resurgent doming of the core of the caldera

Tir Rhyolite - Buff, gray, and white plugs, sills, and irregularly shaped intrusions of silicic alkalic rhyolite containing 10-20 percent phenocrysts of quartz, sodic sanidine, and sparse biotite. Brown glassy zones locally preserved near contacts. Vapor-phase topaz and fluorite present in some gas cavities within rhyolite or in adjacent porous country rock; deuteric or secondary concentrations of uranium minerals have been observed in some of the intrusions and in some of the rhyolite bodies. The rhyolite intrusion along the eastern branch of Nellie Creek has been dated at 18.5 m.y. by the K/Ar method and the intrusion south of Engineer Pass, which contains a central silicified breccia pipe, at 15.4 m.y. by K/Ar and fission-track methods

Tiq Quartz latite - Plugs and irregular intrusions of gray porphyritic quartz latite containing 10-30 percent phenocrysts of sanidine, plagioclase,quartz,biotite,and sparse hornblende. Some sanidine phenocrysts are as much as 4 cm across and have rims of oligoclase. The hornblende is mostly altered to chlorite. The plug at Engineer Mountain has been dated by K/Ar and fission - track as 22.3 m.y.; comparable ages have also been obtained on petrographically similar intrusions from within the Silverton caldera.

POST-CALDERA-COLLAPSE LAVA FLOWS - Quartz latitic flows and domes, erupted from vents along the Lake City ring fault, that accumulated within the caldera, perhaps prior to resurgent doming of the caldera core

Tqg Quartz latite of Grassy Mountain - Single unaltered flow, as much as 250 m thick, of light-gray porphyritic quartz latite containing about 30 percent phenocrysts of plagioclase, sanidine, biotite, and augite. Unconformably overlies altered quartz latite of Red Mountain (Tqr), yet has a K/Ar age of 22.8 m.y., analytically indistinguishable from the Sunshine Peak Tuff (22.5 m.y.) that underlies both flows

Tqr Quartz latite of Red Mountain - Thick lava dome and flow of porphyritic quartz latite, petrographically similar to the overlying quartz latite of Grassy Mountain. Core of dome is pervasively altered to quartz-alunite assemblage. Away from altered areas, the distinction between the quartz latites of Red and Grassy Mountains is uncertain, especially in the Round Mountain area

SUNSHINE PEAK TUFF - Rhyolitic ash-flow sheet, erupted from the Lake City caldera 22.5 m.y. ago (K/Ar), and related interlensing caldera-collapse breccias

Tsp Ash-flow member - Silicic alkalic rhyolitic tuff containing 30-50 percent phenocrysts of quartz, sodic sanidine, and biotite. Lithophysal zone typically well developed, owing to devitrification. Outside the caldera the tuff forms a poorly exposed weakly welded light-gray or tan ash-flow sheet no more than 50 m thick and is preserved only where capped by basalt flows of the Hinsdale Formation. In contrast, within the Lake City caldera the tuff is a single multiple-flow cooling unit more than 1 km thick in which zones of dense welding and extensive devitrification grade to dense welding and extensive propylitic alteration. Xenolithic rock fragments are common in the intracaldera accumulation, but are rare in the outflow sheet. Remanent magnetic polarity: reverse

Tspl Landslide breccia member - Local lenses of landslide debris interlayered with upper part of intracaldera ash-flow tuff. Individual lenses are typically less than 50 m thick but may extend laterally for several hundred metres. Most breccias are relatively small; most are a few centimetres to 1 m in diameter; with increase in clast size the member is transitional into megabreccia member (Tspm). The dominant type is intermediate-composition lava of types common on the caldera walls, but fragments of many of the Oligocene ash-flow sheets are present locally

Tspm Megabreccia member - Chaotic large masses of precaldera rocks, mostly intermediate-composition lava, but including some ash-flow tuffs, that underlie the intracaldera ash-flow member of the Sunshine Peak Tuff (Tsp) and interfinger with its lower part. Some coherent blocks within the megabreccia are at least 100 m across, and parts of this unit would be difficult to distinguish from precollapse caldera flow were it not for the local presence of matrix and interfingering lenses of the petrologically distinctive Sunshine Peak ash-flow material

OLIGOCENE ASH-FLOW SHEETS

Ts NELSON MOUNTAIN TUFF - Moderately gray to moderately welded light-brown quartz latitic ash-flow sheet containing 25-35 percent phenocrysts (mainly plagioclase, sanidine, biotite, and augite). Remanent magnetic polarity: reverse. Erupted about 26.5 m.y. ago from the San Luis Caldera. Thickness 0-200 m

Tw WASON PARK TUFF - Moderately gray to densely welded red-brown ash-flow sheet of low-silica rhyolite containing about 30 percent phenocrysts (plagioclase, sanidine, biotite, and augite). White to tan, partially collapsed pumice fragments are conspicuous in densely welded zones. Remanent magnetic polarity: reverse. Erupted from buried source to east, in vicinity of younger Creede caldera. Thickness 0-40 m

Tcr CARPENTER RIDGE TUFF - Moderately gray to densely welded red-brown rhyolitic ash-flow sheet containing 2-5 percent phenocrysts (mainly plagioclase, sanidine, and biotite). Contains a conspicuous basal vitrophyre and a lithophysal zone which is locally well developed within the densely welded part of ash-flow sheet. Erupted about 27.5 m.y. ago from Bachelor caldera. Remanent magnetic polarity: reverse. Thickness 0-200 m

CRYSTAL LAKE TUFF - Rhyolitic ash-flow sheet, erupted from the Silverton caldera about 27.5 m.y. ago, and related caldera collapse breccia

Tcl Ash-flow member - Moderately gray to densely welded red-brown rhyolitic ash-flow sheet containing 2-5 percent phenocrysts (mainly plagioclase, sanidine, and biotite). Petrographically very similar to the overlying Carpenter Ridge Tuff, but commonly contains more abundant small rock fragments and larger pumice lenses. Remanent magnetic polarity: reverse. Thickness 0-250 m

Tclm Megabreccia member - Local chaotic assemblage in the Bear Creek areas southeast of Ouray, where blocks of Fish Canyon Tuff and pyroxene andesite, as large as 50 m across, float in matrix of nonwelded Crystal Lake Tuff. Probably represents debris slumped from the north wall of the Silverton caldera during collapse

Tf FISH CANYON TUFF - Moderately light-gray to densely welded dark-gray quartz latitic ash-flow sheet containing about 50 percent phenocrysts (mainly plagioclase, sanidine, biotite, and hornblende). Sparse resorbed quartz, accessory sphene, and hornblende without augite are distinctive phenocrysts. Lithophysal zone typically well developed. Remanent magnetic polarity: reverse. Erupted from La Garita caldera. Thickness 0-200 m

SAPINERO MESA TUFF - Rhyolitic ash-flow sheet, erupted from the San Juan and Uncompahgre calderas about 28 m.y. ago, and related caldera-collapse breccia

Ts Outflow member - Moderately gray to densely welded red-brown rhyolitic ash-flow sheet containing 2-5 percent phenocrysts (mainly plagioclase, sanidine, and biotite). Conspicuous basal vitrophyre. Lithophysal zone typically well developed within densely welded interior. Lithic fragments very sparse. Locally strong lineation defined by drawn-out pumice lenses in upper densely welded part. Remanent magnetic polarity: reverse. Thickness 0-125 m

Tse Eureka Member (intracaldera only) - Partly welded gray to densely welded red-brown tuff containing 5-10 percent phenocrysts of plagioclase, sanidine, and biotite. Commonly greenish-gray owing to propylitic albite-chlorite-calcite-epidote alteration in lower part. Typically contains numerous small angular fragments of andesite and sparse blocks of older welded tuffs. Maximum thickness more than 800 m

Tsl Landslide breccia member - Local lenses of landslide debris interlayered with upper part of Eureka Member. Individual lenses are typically less than 50 m thick, but may extend laterally for several hundred metres. Most clasts in the breccias are a few centimetres to 1 m in diameter. Member is transitional into Picayune Megabreccia Member (Tsm) with an increase in clast size. The dominant clast type is composed of lava of intermediate composition of types common in the caldera walls, but fragments of many of the Oligocene ash-flow sheets are present locally

Tsm Picayune Megabreccia Member - Chaotic large masses of precaldera rocks, mostly intermediate-composition lavas, that underlie the Eureka Member and interfinger with its lower part. Some coherent blocks within the megabreccia are as much as 500 m across, and parts of this unit would be difficult to distinguish from precollapse caldera flow were it not for the local presence of matrix and interfingering lenses of ash-flow material of the Eureka Member. Interpreted as the product of slumping from oversteepened walls of the Uncompahgre and San Juan calders during initial subsidence

Tsw Welded-tuff megabreccia member - Chaotic megabreccia within southeastern part of San Juan caldera (southwest corner of mapped area) consisting largely of blocks of densely welded, locally lineate outflow member of Sapinero Mesa Tuff (Ts), but otherwise similar to Picayune Megabreccia Member in structural and stratigraphic relations

Tb BLUE MESA TUFF - Moderately gray to densely welded red-brown rhyolitic ash-flow sheet containing about 5 percent phenocrysts (mainly plagioclase, sanidine, and biotite). Conspicuous basal vitrophyre and lithophysal zone. Spherulitic-crystal-covered outcrops of densely welded devitrified tuffs are characteristic. Remanent magnetic polarity: reverse. Probably erupted from the Lost Lake caldera. Thickness 0-250 m

Tu UTE RIDGE TUFF - Moderately gray to densely welded gray-brown and red-brown quartz latitic ash-flow sheet containing about 30 percent phenocrysts (mainly plagioclase, sanidine, biotite, and augite). Pumice lenses and lithic and xenolitic fragments in few centimetres across are locally conspicuous. K/Ar age 28.4 m.y. Remanent magnetic polarity: reverse. Erupted from Ute Creek caldera. Thickness 0-300 m

RHYOLITE OF POLE CREEK - Local rhyolitic ash-flow sheet and a petrographically similar, overlying rhyolitic lava flow

Tpr Lava-flow member - Large single rhyolitic lava flow as much as 250 m thick and traceable laterally for 15 km. Light-tan finely flow-laminated rhyolite containing 1-3 percent phenocrysts (plagioclase, sanidine, and biotite)

Tp Ash-flow member - Pinkish-brown nonwelded to moderately welded phenocryst-poor rhyolitic ash-flow tuff that is petrographically similar to the immediately overlying lava flow. Contains locally abundant small angular red-brown lithic rock fragments. Thickness 0-35 m

LAVAS AND INTRUSIVE ROCKS OF THE
OLIGOCENE WESTERN SAN JUAN CALDERAS

QUARTZ LATITE OF RAMBOUILLET PARK - Lava flows and related intrusive rocks that overlie Nelson Mountain Tuff along the east side of Uncompahgre caldera

Trq Lava flows - Thick flows of light-gray to brown quartz latite containing 20-30 percent phenocrysts of plagioclase, biotite, and augite. Single flows are typically 15-50 m thick and have well-developed basal flow breccias, lower vitrophyres, and overlying flow-layered devitrified zones

VOLCANICS OF UNCOMPAHGRE PEAK - Lava flows of intermediate to silicic composition and related volcaniclastic sedimentary rocks within the northern and eastern parts of the Uncompahgre caldera

Tuo Andesite - Thin flows of dark-gray dense andesite and some rhyodacite containing 5-10 percent small phenocrysts of plagioclase and augite. Biotite is sparse or absent

Tuq Quartz latite - Thick flow-layered flows of red-brown porphyritic quartz latite, probably including some rhyodacite. Typically contains 10-25 percent phenocrysts of plagioclase, biotite, and augite

Tur Rhyolite - Thick flows and domes of light-tan to white flow-laminated phenocryst-poor rhyolite. Includes local breccia and bedded tuff. Contains 1-5 percent phenocrysts, mostly plagioclase and sanidine and sparse biotite. Especially susceptible to acid-sulphate alteration

SILVERTON VOLCANICS - Lava flows of intermediate to silicic composition and related volcaniclastic sediments that accumulated with and adjacent to the San Juan and Uncompahgre calderas after the collapse, but before subsidence of the Silverton caldera

Pyroxene andesite member - Andesitic lava flows that largely overlie the Burns Member but locally interfinger complexly with it, especially in the southeastern part of the San Juan caldera

Tsp Porphyritic andesite - Dark-gray coarsely porphyritic andesite containing 15-25 percent phenocrysts of plagioclase and augite. Thin tabular flows averaging 10-25 m thick that occur exclusively in northern parts of the Uncompahgre and San Juan calderas and attain a maximum thickness of about 250 m in the vicinity of Engineer Pass

Ts Aphanitic andesite - Dark-gray dense andesite containing no phenocrysts or only sparse small phenocrysts of plagioclase and augite. Forms thicker flows than the porphyritic andesite, locally as much as 100 m thick, that occur exclusively within the San Juan caldera from Cinnamon Pass southward. Complexly interlayered with hornblende rhyodacite of the Burns Member south of Minnie Gulch. Capping flow on Niagara Peak is a mixed lava of aphanitic andesite and rhyodacite magmas latite (similar to that of the Burns Member). Maximum thickness 300 m

Burns Member - Relatively silicic lava flows ranging from hornblende rhyodacite to biotite rhyolite.

Tbb Biotite-quartz latite - Light to dark-gray thick flows and domes containing 15-30 percent phenocrysts of plagioclase, biotite, and augite. At the head of Henson Creek a single flow is at least 300 m thick

Tbh Hornblende rhyodacite - Light to dark-gray flows and domes containing 10-20 percent phenocrysts of plagioclase, hornblende, and sparse biotite. Occurs below the biotite-quartz latite in Burns Gulch - the type locality of the member. A single flow near the head of Rocky Gulch is at least 250 m thick

Tbr Rhyolite - Local flow of light-gray rhyolite in the northeastern part of the San Juan caldera. Contains less than 5 percent phenocrysts of plagioclase and biotite. Well-developed flow lamination in interior and locally conspicuous marginal spherulitic zone

Henson Member - Volcaniclastic sedimentary rocks that interfinger complexly with both the Burns Member and the Pyroxene andesite member

Tbs Tuffaceous sandstone - Green-gray tuffaceous sandstone containing abundant grains of plagioclase, augite, and andesitic rock fragments. Local interbeds of dark-gray shale, brown laminated freshwater limestone, and green-brown-gray lapilli tuff. Maximum thickness greater than 200 m

VOLCANICS OF LOST TRAIL CREEK - Local intermediate composition lava flows and volcaniclastic sedimentary rocks which interfinger with the Ute Ridge and Blue Mesa Tuffs near their inferred source calderas (Ute Creek and Lost Lake)

Tfl Lava flows - Greenish-gray biotite-hornblende rhyodacite and dark-gray sparsely porphyritic plagioclase-augite andesite

Tfc Volcaniclastic sedimentary rocks - Mostly heterolithologic mudflow breccias containing clasts of dark andesite and rhyodacite

INTRUSIVE ROCKS

Tm Monzonite - Fine- to medium-grained equigranular to slightly porphyritic gray intrusive rocks containing variably altered pyroxene (commonly both orthopyroxene and clinopyroxene) and sparse biotite. Occurs mainly as stocks and plugs; texturally transitional into monzonite porphyry (Tmp). Commonly contains some interstitial granophyric intergrowths of quartz and alkali feldspar

Tmp Monzonite porphyry - Gray moderately to coarsely prophyritic intrusive rocks having phaneritic fine-grained groundmass. Phenocrysts are mostly plagioclase, in places accompanied by augite

Ti Porphyro-aphanitic rocks - Varied fine-grained dense rock ranging from andesite to rhyolite. Occur mostly as dikes and small plugs

OLIGOCENE EARLY INTERMEDIATE-COMPOSITION
LAVAS AND RELATED ROCKS

Tef LAVA FLOWS - Mostly lava flows and flow breccias of aphanitic to porphyritic andesite, rhyodacite, and quartz latite erupted from several volcanic centers. Phenocrysts of plagioclase are common, typically accompanied by hornblende and in places augite; biotite is present in the more silicic flows

Tes VOLCANICLASTIC FACIES (SAN JUAN FORMATION) - Mostly crudebedded conglomerates, sandstones, and mudflow breccias containing clasts of dark andesite and rhyodacite. Accumulated as clastic aprons on flanks and between penecontemporaneous volcanoes

PREVOLCANIC ROCKS

OCd MAFIC DIKES (ORDOVICIAN OR CAMBRIAN) - Large dark-gray dikes as much as 50 m thick that occupy generally north-west-trending fractures in the granite of Cataract Canyon. Mineralogy was originally mainly plagioclase and augite intergrown in fine-grained diabasic texture, but over wide areas dikes are somewhat recrystallized to fine-grained assemblages of sericite, chlorite, albite, epidote, and calcite. Quartz veins are locally persistent along margins of dikes. Age assignment is tentative, based on analogy with petrographically similar radiometrically dated dikes in the Black Canyon of the Gunnison River, 75 km to the north

Yc GRANITE OF CATARACT CANYON (PRECAMBRIAN Y) - Massive light-pink two feldspar granite or quartz monzonite. Medium- to coarse-grained rock with local weak foliation or lineation defined by aligned tablets of microcline. Where observed, the foliation is typically steep, but in many outcrops the dominant fabric is a gently plunging lineation and any foliation is obscure

Xi IRVING FORMATION (PRECAMBRIAN X) - Interlayered amphibolitic and plagioclase-rich gneiss and schist in southwest part of mapped area; probably metavolcanic and metasedimentary rocks. A possibly correlative mass occurs within the granite of Cataract Canyon on the northeast slope of Whitecross Mountain

——— CONTACT - Long dashed where approximately located. Short dashed contacts are between conspicuous lava flows within map units

——— UNCONFORMITY ALONG CALDERA WALLS - Dashed where approximately located; dotted where concealed.

——— FAULT OR VEIN - Dashed where approximately located; dotted where concealed or occupied by intrusive rocks. Bar and ball on downthrown side

·····BLOCK-SLUMP FAULT - Hachures indicate direction of slumping. Dashed where approximately located